CONTRACT ADMINISTRATION
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STATE OF TEXAS

COUNTY OF TRAVIS

TWDB Contract No. 1648302061

Research and Planning Fund
Research Grant
Southwest Research Institute

This Contract, (hereinafter "CONTRACT"), between the Texas Water Development Board (hereinafter "TWDB") and Southwest Research Institute (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 – Southwest Research Institute

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

4. PARTICIPANT(S) – Intera Incorporated

5. REQUIRED INTERLOCAL AGREEMENT(S) – N/A

6. RESEARCH PROJECT – Conceptual model for extending the groundwater availability model for the Hill Country portion of the Trinity Aquifer

7. TWDB APPROVAL DATE – November 2, 2016

8. DEADLINE FOR CONTRACT EXECUTION – March 31, 2017

9. CONTRACT INITIATION DATE – November 2, 2016

10. STUDY COMPLETION DATE – May 31, 2018

11. FINAL REPORT DEADLINE – September 28, 2018

12. TOTAL STUDY COSTS – $355,000

13. TWDB SHARE OF THE TOTAL STUDY COSTS – the lesser of $355,000 or 100 percent of the total study costs or individual payment submission. Not to exceed $355,000 or 100% percent of the total study costs or individual voucher submission.

14. PAYMENT SUBMISSION SCHEDULE – Monthly

15. OTHER SPECIAL CONDITIONS AND EXCEPTIONS TO STANDARD AGREEMENT OF THIS CONTRACT

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 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(l) as appropriate, and associated rules of the Texas Administrative Code, Chapter 355, Sections 355.1-355.11, Subchapter A; Exhibit A, the original grant application, 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 report, including results to date, will be provided to the EXECUTIVE ADMINISTRATOR monthly, throughout the project. Special interim reports on special topics and/or results will be provided as appropriate.

ARTICLE III. SCHEDULE, REPORTS, AND OTHER PRODUCTS

1. The CONTRACTOR has until the DEADLINE FOR CONTRACT EXECUTION to execute this CONTRACT 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 TWDB APPROVAL DATE and shall expire on the FINAL REPORT DEADLINE. Delivery of an acceptable final report and associated data deliverables prior to the FINAL REPORT DEADLINE shall constitute completion of the terms of this CONTRACT.

3. The CONTRACTOR will complete the Scope of Work and will deliver to the TWDB no later than the STUDY COMPLETION DATE:
   A. four printed copies of the draft report;

B. one Adobe Acrobat (pdf) file of the draft report for posting on the TWDB web site (broken in parts not to exceed 10 megabytes) , and
C. one electronic copy of all the related documented source and derived data in the appropriate geodatabase(s).

After a 60-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 commenter's on the draft final report and associated data deliverables into a final report. The CONTRACTOR will include a copy of the EXECUTIVE ADMINISTRATOR's comments in the final report. At the end of the study, the CONTRACTOR shall deliver to the TWDB:
   A. nine bound double-sided printed copies of the final report,
   B. three separate digital copies of the final report including all figures,
   C. three separate copies of an *Adobe Acrobat* pdf file of the final report for posting on the TWDB Web site (broken in part not to exceed 10 megabytes),
   D. three separate digital copies of each of the figures in the report,
   E. three separate digital copies of all related documented and derived source data, in the appropriate digital geodatabase format.

   It is important that the delivered reports are of high quality and that we receive the proper files to publish the studies. Consistent geologic, hydrologic, and technical terminology must be used throughout each report. Each report shall have an authorship list of persons responsible for the studies: firm or agency names as authors will not be acceptable. The reports shall be sealed as required by Texas Occupation Code, Title 6, Chapter 1002.

   In compliance with Texas Administrative Code Chapters 206 and 213 (related to Accessibility and Usability of State Web Sites), the digital copies of all stakeholder materials, draft and final reports will comply with the requirements and standards specified in statute.

5. The CONTRACTOR will submit monthly letter reports with submittal of payment requests by task according to the PAYMENT SUBMISSION SCHEDULE. Letter 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. The CONTRACTOR will contact the TWDB designated PROJECT MANAGER as soon as any problems are encountered.

6. The EXECUTIVE ADMINISTRATOR can extend the STUDY COMPLETION DATE and the FINAL REPORT DEADLINE 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 FINAL REPORT DEADLINE 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 TWDB shall reimburse the CONTRACTOR for ninety percent (90%) of the TWDB's share of each payment request pending the CONTRACTOR's performance, completion of a Final Report and associated deliverables, and written acceptance of said final report and associated deliverables 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 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. 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 or you can contact Contracts@twdb.texas.gov for a personalized payment request spreadsheet and along with a progress report as described in Exhibit E.

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 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.

5. 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 D). 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 CONTRRACTOR.

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.

10. The CONTRACTOR is responsible for submitting any final payment request and documentation for reimbursement, along with a request to release any retained funds, no later than 120 days following the CONTRACT EXPIRATION DATE. If 120 days have passed since the CONTRACT EXPIRATION DATE and the CONTRACTOR has not submitted a final payment request and/or release of any retained funds, the EXECUTIVE ADMINISTRATOR has the discretion to disburse and release retained funds (if any) and formally close out the CONTRACT. Once the CONTRACT is closed, all other remaining funds provided under this CONTRACT (or you could say remaining funds from the TWDB SHARE OF THE TOTAL STUDY COSTS) will be lapsed and liquidated. No further requests for payment by the CONTRACTOR will be considered after that time.

ARTICLE V. INTELLECTUAL PROPERTY, OWNERSHIP, PUBLICATION, AND ACKNOWLEDGEMENT

1. "Use" of a work product, whether a 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 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 agree 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 Works 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,
   A. 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;
   B. 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
   C. 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. No public disclosures or news releases pertaining to this CONTRACT shall be made without prior written approval of the TWDB.

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.

3. Neither party shall be liable in damages or have the right to terminate this Agreement for any delay or default in performing hereunder if such delay or default is caused by conditions beyond its control including, but not limited to Acts of God, Government restrictions (including the denial or cancellation of any export or other necessary license), wars, insurrections and/or any other cause beyond the reasonable control of the party whose performance is affected.

ARTICLE VII. SUBCONTRACTS

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

1. a clause stating that 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;

2. 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;

3. 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 A, Paragraph 5 hereof;

4. 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 A, Paragraph 1 hereof;

5. 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;

6. 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 B, Paragraph 8;

7. 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

8. 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 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 under this CONTRACT.

3. 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.

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.

a. 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.

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.

a) Conflict of Interest. The CONTRACTOR agrees to not continue existing contracts or enter into new contracts with persons or entities other than the Board and Regional Water Planning Groups for groundwater supply and

availability studies involving the groundwater modeling area of this contract while working on this Board contract without a prior no conflict of interest determination by the Board and written authorization by the Board. The CONTRACTOR shall make available all project files to the Board to determine such determination.

The 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.

d. 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 BOARD or applicable governmental entity, whose consent shall not be unreasonably withheld.

e. Public Information Act. The CONTRACTOR acknowledges and agrees that all public information, in any media and on any device, that is written, produced, collected, assembled, or maintained in the performance of work conducted under this CONTRACT is subject to public disclosure under the Public Information Act, Texas Government Code, Chapter 552. The CONTRACTOR agrees to provide public information to the TWDB in PDF format upon TWDB's request. The CONTRACTOR shall produce the requested public information within two (2) business days when the information is required to comply with a request for information under the Public Information Act.

f. 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.

g. 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.

h. 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:
Ronald Green
Southwest Research Institute
6220 Culebra Road
San Antonio, Texas 78238-5166
Email: Contract@swri.org

Payment Request Submission:

Southwest Research Institute
6220 Culebra Road
San Antonio, Texas 78238-5166
Email: Contract@swri.org

Physical Address:
Southwest Research Institute
6220 Culebra Road
San Antonio, Texas 78238-5166

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

TEXAS WATER DEVELOPMENT BOARD	SOUTHWEST RESEARCH INSTITUTE
Jeff Walker Executive Administrator	R.B. Kalmbach Executive Director, Contracts
Date: 3/1/17	Date: February 23, 2017

EXHIBIT A

ORIGINAL GRANT APPLICATION

Texas Water Development Board

P.O. Box 13231, 1700 N. Congress Ave.
Austin, TX 78711-3231, www.twdb.texas.gov
Phone (512) 463-7847, Fax (512) 475-2053

ADDENDUM to RFQ NO. 580-16-RFQ0028
CONCEPTUAL MODEL FOR EXTENDING THE GROUNDWATER AVAILABILITY MODEL FOR THE HILL COUNTRY PORTION OF THE TRINITY AQUIFER

RFQ NO:	580-16-RFQ0028	**ADDENDUM NO. :**	1
Deadline for Submission for RFQ:	2:00 PM, Thursday, August 11, 2016		
Contact: Angela Wallace	Phone: 512-463-7979 Email: contracts@twdb.texas.gov		

PURPOSE OF ADDENDUM

CLARIFICATION ONLY:

- **RESPONSES DUE: THURSDAY, August 11, 2016 at 2:00 PM (CT/CDT)**

End of Addendum No. 1

IN THE SUBMISSION OF RFQ, RESPONDENT SHOULD ACKNOWLEDGE RECEIPT OF THIS ADDENDUM; OTHERWISE THE SUBMISSION MAY NOT BE GIVEN CONSIDERATION. RESPONDENT MAY ACKNOWLEDGE RECEIPT BY RETURNING A SIGNED COPY WITH THEIR SUBMISSION.

RESPONDENT NAME **AUTHORIZED SIGNATURE**

Our Mission

To provide leadership, information, education, and support for planning, financial assistance, and outreach for the conservation and responsible development of water for Texas

Board Members

Bech Bruun, Chairman | Kathleen Jackson, Board Member | Peter Lake, Board Member

Jeff Walker, Executive Administrator

A Proposal For

RESPONSE TO TEXAS WATER DEVELOPMENT BOARD RFQ 580-16-RFQ0028

Conceptual Model for Extending the Groundwater Availability Model for the Hill Country Portion of the Trinity Aquifer

Class-Item Code(s): 961/95

SOUTHWEST RESEARCH INSTITUTE®
6220 Culebra Road
San Antonio, Texas 78238

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Cover and header images:
Glen Rose Limestone exposed in Canyon Lake Gorge (Photo by Larry Walther (SwRI) – Contact David Ferrill (dferrill@swri.org) for additional information)

Introduction

Regulation of the Edwards Balcones Fault Zone (BFZ) Aquifer and increased development have created renewed interest in developing water resources from the Hill Country portion of the Trinity Aquifer underlying the Edwards BFZ Aquifer. The Texas Water Development Board (TWDB) issued a Request for Qualifications to develop an updated conceptual model of the Hill Country portion of the Trinity Aquifer. Southwest Research Institute® (SwRI®) is pleased to submit this Statement of Qualifications to update the conceptual model of the Hill Country portion of the Trinity Aquifer. To assist us in the update and extension of the Conceptual Model, SwRI has enlisted the support of specialists from INTERA Incorporated (INTERA). SwRI is a recognized leader in groundwater resource assessment in central Texas, while INTERA is a recognized leader in groundwater modeling and is responsible for developing more Groundwater Availability Models (GAM) under the TWDB Groundwater Availability Modeling Program than any other contractor. Collaborations with the Edwards Aquifer Authority (EAA) and the Barton Springs Edwards Aquifer Conservation District will provide added regional technical support with added emphasis on the hydraulic interactions between the Edwards BFZ and Hill Country Portion of the Trinity Aquifer.

The functional organization of the SwRI Team, including our key qualifications and roles for characterizing and developing a conceptual model of the Hill Country portion of the Trinity Aquifer is provided in Figure 1.

Why the Southwest Research Institute Team? Given our proven experience in assessing the groundwater resources of the Trinity Aquifer and in performing similar brackish resource evaluations, combined with our consistent history of on-time, on-budget delivery of results, the TWDB can be certain of the successful completion of this Legislature-mandated project. In addition, SwRI and INTERA are the key hydrogeologic consultants for Groundwater Management Areas 8 and 10, which cover the Northern and Hill Country portions of the Trinity Aquifer, the focus of the proposed work. This gives the SwRI Team a familiarity with the stakeholders throughout the Trinity Aquifer footprint that will ensure the attention and commitment to the stakeholder process that is so vital to TWDB projects. The SwRI team will produce the highest quality conceptual model given the available funding for this project. To substantiate this belief, we bring a number of key assets that are described in more detail throughout our Statement of Qualifications.

Proven Performance in Evaluating Water Resources in the Trinity Aquifer and throughout Texas. SwRI has led the evaluation of the water resources of the Edwards, Trinity, Edwards-Trinity, Carrizo-Wilcox, Leona Gravels, Buda, and Austin Chalk aquifers in Texas and is currently working expansions of several of these studies for a number of clients. One of these projects is the evaluation of the brackish water resources of the Trinity Aquifer which was commissioned by the TWDB in early 2016. This project has advanced the SwRI Team's experience in the Trinity Aquifer and similar aquifer systems in Texas.

Of central interest to this proposal is a project recently completed by SwRI to develop a refined conceptual and numerical model of the San Antonio segment of the Edwards BFZ Aquifer (Fratesi et al., 2015). The domain of this model includes the confined, recharge, and contributing

zones of the Edwards Aquifer and in doing so, this model is the first Edwards Aquifer model to explicitly incorporate all three zones of the aquifer. By including the Edwards BFZ Aquifer contributing zone, which includes the upper Trinity Aquifer, this 2015 refined Edwards Aquifer model has particular relevance to the update of the Hill Country Trinity Aquifer GAM in that it includes a significant portion of the existing and extended Hill Country Trinity Aquifer Aquifer. Hence, the SwRI team has already developed a refined conceptual model of the Glen Rose in the expanded Hill Country portion of the Trinity Aquifer domain that can be extended vertically to incorporate the remainder of the Trinity Aquifer.

Key team member INTERA recently performed a comprehensive hydrogeologic assessment of the Northern Trinity and Woodbine aquifers and developed the State-approved groundwater availability model based on that assessment. INTERA has additional broad experience with a number of aquifers throughout Texas, including the Carrizo-Wilcox Aquifer, Gulf Coast Aquifer, and the Trinity (Hill Country) Aquifer.

Figure 1. SwRI Team.

The SwRI Team has worked with multiple Groundwater Conservation Districts (GCDs) and Groundwater Management Areas (GMAs) to more generally evaluate other both local and regional aquifers throughout the State. Through this experience as both a developer and user of key technologies that support hydrogeologic assessments, the SwRI Team knows exactly what it takes to produce a high-quality assessment of water resources, both in terms of quantity and quality. Previous and ongoing studies provide significant leverage to advance this project. These include SwRI's recently completed model of the San Antonio segment of the Edwards Aquifer (Fratesi et al., 2015) and INTERA's ongoing evaluation of water resources in the Carrizo-Wilcox Aquifer region of GMA-13. These projects have required the synthesis of hydrostratigraphic frameworks from thousands of well logs. SwRI and INTERA have developed workflow processes to streamline the interpretation of geophysical logs whether they be in digital or image format.

Statement of Qualifications Organization

The remainder of this SOQ is organized to follow the content requirements defined in Section 4.1 of the TWDB's Request for Qualifications (RFQ). Accordingly, there are six main sections,

and consistent with the requirements, the Technical Approach (Section 6) does not exceed 15 pages. Literature references cited in our Technical Approach (Section 6) are included in Attachment C. To facilitate the TWDB's review of our SOQ with respect to the evaluation criteria defined in the RFQ (Section 4.11, page 8), the following table provides the location of information in our SOQ to be evaluated under each criteria.

Cross-Reference of Evaluation Criteria and Corresponding Location of Information in SOQ

Evaluation Criteria	Location(s) Where Addressed in the SOQ
Qualifications and Experience (Criteria 1-5)	Section 3 and Attachment A Resumes of Individuals and Project Experience
Technical Approach	Section 6.1 Technical Approach
Approach to Selecting Boundary Conditions	Section 6.1, Task 4 Geologic Interpretation and Section 6.1 Task 6 Conceptual Model Synthesis
Approach to Analyzing and quantifying flows across Balcones Fault Zone and cross-formational flows	Section 6.1, Task 6, Subtask 5.3 Discharge
Approach for mapping Trinity Aquifer between Uvalde and Kinney counties	Section 6.1, Task 4 Geologic Interpretation and Section 6.1 Task 6 Conceptual Model Synthesis
Interval Progress Monitoring Procedures and QA process	Section 6.2 Organization and Management and Section 6.3 Project Monitoring Procedures
Organization and Management	Section 6.2 Organization and Management
Stakeholder Communications	Task 6 Stake holder Communications
Communication of Results	Section 3 and Attachment A Resumes of Individuals and Project Experience.
Deliverables	Section 6.5 Deliverables
Project completion deadlines and resources	Section 6.2.1 Project Schedule and Budget and Section 6.3 Project Mointoring Procedures
Financial capability	Section 2 Company Profile Summary

Section 1 – Execution of Statement of Qualifications

Texas Water Development Board
REQUEST FOR QUALIFICATIONS NO. 580-16-RFQ0028
Conceptual model for extending the groundwater availability model for the
Hill Country portion of the Trinity Aquifer

CONTENT ITEM 1

EXECUTION OF STATEMENT OF QUALIFICATIONS
to the
REQUEST FOR QUALIFICATIONS

Company Name: Southwest Research Institute

Address: 6220 Culebra Road

San Antonio, Texas 78238-5166

Phone Number: 210/522-2231

E-Mail: contract@swri.org

I, R. B. Kalmbach, 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

August 9, 2016
Date

for R. B. Kalmbach
Printed Name

Executive Director, Contracts
Title:

Section 2 – Company Profile Summary and History

Legal name of applicant
Southwest Research Institute®
6220 Culebra, San Antonio, Texas 78238
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Phone: (210) 522-5305

Legal name of each participant(s)
INTERA Incorporated – Project Participant
1812 Centre Creek Drive, Suite 300, Austin, Texas 78754
Point of Contact: Neil Deeds
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Applicant's Official Binding Representative
Ronald Kalmbach, Executive Director-A&G
6220 Culebra, San Antonio, Texas 78238
Phone: (210) 522-2216; Fax: (210) 522-3559
E-mail: ron.kalmbach@swri.org
Vendor ID: 1741070544000

Southwest Research Institute® (SwRI®), headquartered in San Antonio, Texas, is one of the oldest and largest independent, nonprofit, applied research and development (R&D) organizations in the United States. Founded in 1947, SwRI provides contract research and development services to industrial and government clients in the United States and abroad. The Institute is governed by a board of directors, which is advised by approximately 100 trustees. SwRI offers multidisciplinary, problem-solving services in a variety of areas in the engineering and the physical sciences. Historically, more than 4,000 projects are open at SwRI at any one time. These projects are funded almost equally between the government and commercial sectors. SwRI's total revenue for fiscal year 2015 was $592 million. In 2015 SwRI managed more than 73 projects with expenditures of more than $7.2 million to its internally sponsored R&D program, which is designed to encourage new ideas and innovative technologies. SwRI's headquarters occupies more than 2 million square feet of office and laboratory space on more than 1,200 acres in San Antonio. At the close of fiscal year 2015, the staff numbered 2,771, including 294 professionals who hold doctorate degrees and 508 with master's degrees. SwRI® is a nonprofit 501(c)(3) entity.

The Geosciences and Engineering Division of SwRI is a center of excellence in earth sciences and engineering. Internationally recognized for innovative solutions to complex problems in the earth, material, and planetary sciences and allied engineering disciplines, the Geosciences and Engineering Division creates multidisciplinary teams to solve client problems within a framework of risk assessment, system studies, and regulatory analyses. The division's extensive experience base and understanding of engineering and science fundamentals also assists clients

by identifying emerging technical issues. The Geosciences and Engineering Division conducts its vigorous research and development program through two departments, the Center for Nuclear Waste Regulatory Analyses (CNWRA®) and the Department of Earth, Material, and Planetary Sciences. Internally funded research and development projects enable the Geosciences and Engineering Division to serve its clients better through continuous technological innovation.

INTERA was founded in 1974 as a technology-based consulting firm specializing in the development and application of decision support tools for the environmental and petroleum industries. Since our inception, we have earned a reputation for developing best-in-class solutions to difficult problems facing industry and governmental institutions. INTERA is a Texas Corporation headquartered in Austin with additional U.S. offices in Albuquerque and Santa Fe, New Mexico; Denver, Colorado; Tampa, Gainesville, and Jacksonville, Florida; and Richland, Washington and international offices in Lyon, France and Baden, Switzerland. We have been involved in high-profile groundwater projects both domestically and internationally for over 40 years. Many of INTERA's senior staff are recognized in their respective fields and are retained to provide expert-witness testimony and litigation support in the areas of water resources management and groundwater and subsurface contamination. We currently have 125 professionals specializing in geology, hydrogeology, hydrology, water resource and environmental engineering, geostatistics, remote sensing, and geographic information systems (GIS) technology. We are registered to perform geoscientific and engineering services in the State of Texas by the Texas Boards of Professional Geoscientists and Engineers. INTERA has 35 groundwater and surface water professionals located in Texas, including 6 registered Texas Professional Engineers and 13 registered Texas Professional Geoscientists. In addition, many of our geoscientists are nationally licensed as Certified Ground Water Professionals.

Section 3 – Resumes of Individuals

The Team offers the most experienced group of hydrogeologists and water-resource engineers focused on evaluating water resources and other quantitative decision support tools to address water-resource planning and management issues in the State of Texas. To develop a refined conceptual model of the Hill County portion of the Trinity Aquifer, we have assembled an outstanding team of management and technical personnel that bring the expertise and proven performance to ensure project success. Resumes for team personnel are included in Attachment B. This section is excluded from the 15-page limit for Statement of Qualifications.

Section 4 – HUB Plans and Forms

In accordance with the TWDB policy, SwRI has made a good faith effort to notify historically underutilized businesses (HUBs) regarding subcontracting opportunities under the scope of work of this project. Attachment D contains the HUB subcontracting plan and associated forms which do not count towards the total page count of the request for qualifications. Notifications to HUBs and trade groups and their responses are included in Attachment D.

Section 5 – Company Ownership Statement

Southwest Research Institute® is a 503(c)(3) nonprofit organization. Accordingly, there are no shareholders or individuals with ownership. INTERA Incorporated is an employee-owned geosciences and engineering consulting firm with headquarters in Austin, Texas. In summary, there are no persons on the team with at least 25 percent ownership of the business entity submitting the SOQ.

Section 6 – Technical Approach

The SwRI team's technical approach for developing a conceptual model of groundwater flow for the Hill Country portion of the Trinity Aquifer is predicated on several decades of combined experience studying and characterizing the groundwater resources and geology of the Trinity Aquifer and the Edwards BFZ Aquifer. This section describes technical issues related to development of the Hill Country portion of the Trinity Aquifer conceptual model including project task structure, and the organizational and management approach we will use to complete the tasks, reports, and other documentation that we will deliver to the TWDB.

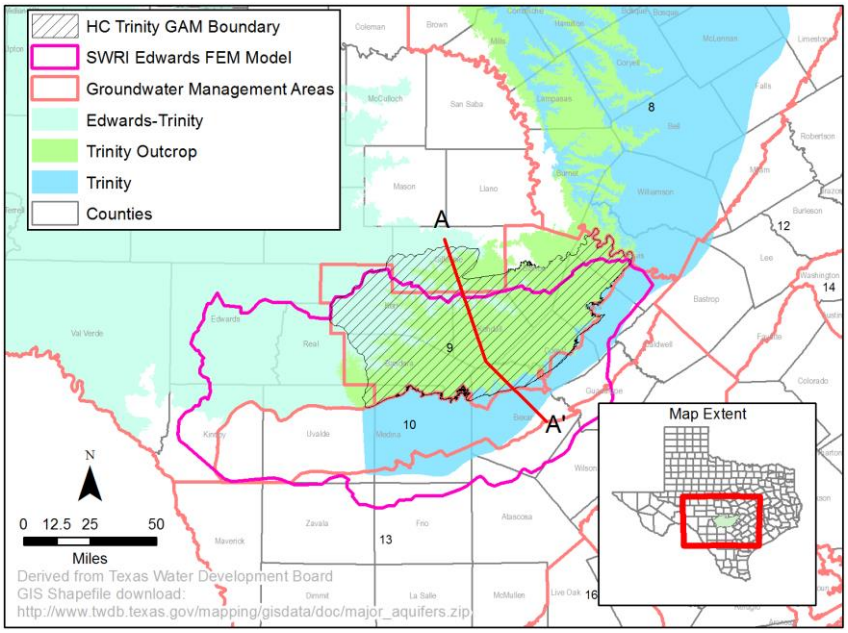


Figure 2. Extent of the Trinity Aquifer illustrating Groundwater Management Areas 8, 9, and 10 and the current Hill Country Groundwater Availability Model boundary.

The Hill Country portion of the Trinity Aquifer has seen renewed interest as development continues in and around San Antonio, Austin, and along the I-35 corridor between San Antonio and Austin (Figure 2). Quarry and aggregate plants have created additional pressure on the Hill Country portion of the Trinity Aquifer as they seek alternative sources of water to the Edwards BFZ Aquifer. The TWDB is updating the GAM of the Hill Country portion of the Trinity Aquifer. Prior to development of a numerical model, a conceptual model must be developed to reflect the additional accumulated knowledge of the Hill Country portion of the Trinity Aquifer and an expansion of the model boundaries to include portions of the aquifer in Uvalde and Kinney counties.

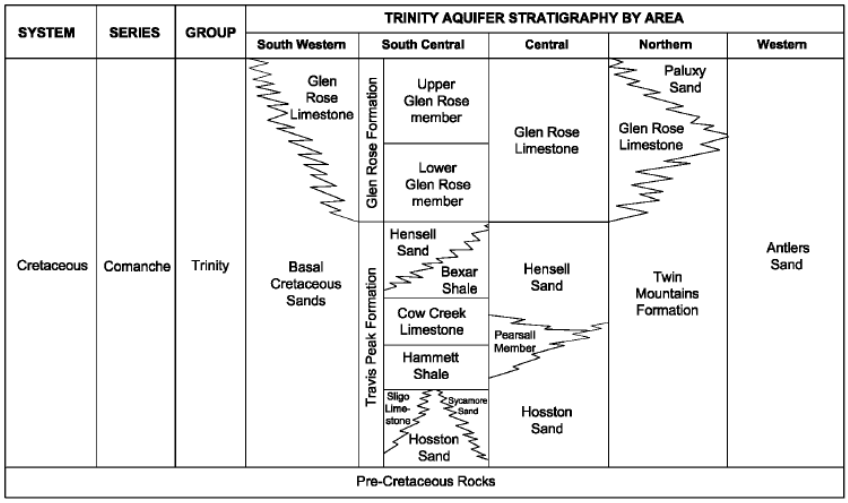


Figure 3. Stratigraphic correlation of the Trinity Aquifer (LBG-Guyton, 2003).

The currently defined Hill Country portion of the Trinity Aquifer begins south of Austin and extends to the west terminating arbitrarily

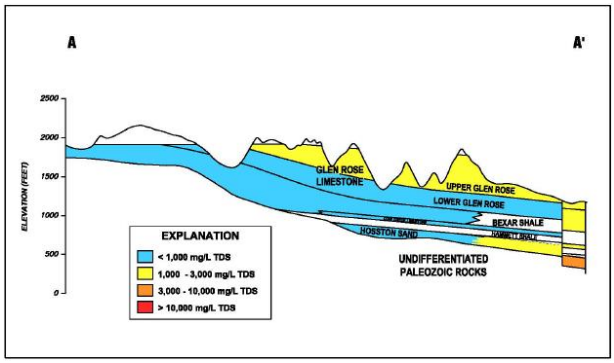
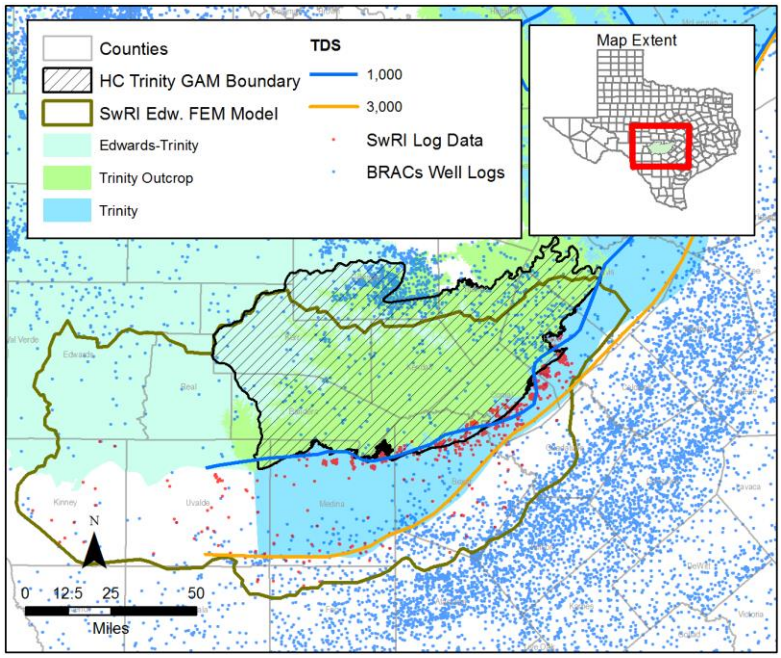


Figure 4. Simplified vertical cross section A-A′ of the Hill Country Trinity Aquifer with generalized water quality ranges (LBG-Guyton, 2003).

at the eastern side of Uvalde County Figure 2. The stratigraphy of the Trinity Group is complicated (Figure 3), in part because of the large area that it covers. The down-dip extent of the Trinity Aquifer is defined by the TWDB where the total dissolved solids concentration in the aquifer transitions to 10,000 mg/L (Figure 4 and **Error! Reference source not found.**) (LBG-Guyton, 2003). However, the current Hill Country Trinity Aquifer GAM is limited to the southern terminus of the outcrop portion of the Trinity Aquifer (Figure 2). Groundwater flow is generally from these outcrop areas to the east or southeast, in a down-dip direction (Figure 2, 4, and 5).

Because the Trinity Aquifer is comprised of several individual smaller layered aquifers, the location of slightly-to-moderately saline water within the aquifer is quite variable. Water of poor quality may be found at one location above and/or beneath another layer of good water quality. In general, because of the poorer water quality, lower production, and increasing well depths, almost no water wells are constructed in the Trinity Aquifer down-dip, brackish water areas. As illustrated in Figure 5 and implied in Figure 4, there are few water quality samples available to indicate where water quality transitions from fresh-to-brackish-to-saline (LBG-Guyton, 2003). The limits of fresh, brackish, and saline water in the entire Trinity Aquifer is currently being investigated as part of the TWDB Brackish Resources Aquifer Characterization System (BRACS) program.



The down-dip boundary of the current Trinity (Hill Country) Aquifer GAM only includes water with up to 1,000 mg/L total dissolved solids (Jones et al., 2011). For this region, a hydro-stratigraphic framework model will need to be extended to include Trinity hydrostratigraphic units below the Edwards BFZ Aquifer.

Figure 5. Preliminary geophysical log coverage of the Trinity Aquifer (TDS lines after LGB-Guyton, 2003).

6.1 Technical Issues and Scope of Work

The contents of a conceptual model for the purposes of a GAM are outlined in the GAM standards included as Appendix A in the Request for Qualifications (TWDB, 2016). The SwRI Team will apply well tested methods for developing each of the following components of the Conceptual Model for the Hill Country portion of the Trinity Aquifer.

1. Physiography and climate,
2. Geology,
3. Hydrostratigraphy,
4. Hydrostratigraphic framework,
5. Water levels and regional groundwater flow,
6. Recharge,
7. Rivers, streams, reservoirs, springs, and other surface water features,
8. Hydraulic properties
9. Subsidence (if applicable)
10. Discharge, and
11. Water quality.

The technical approach for development of the conceptual model has been divided into seven tasks, including project management (Task 1), stakeholder communication (Task 2), data acquisition and data management (Task 3), geologic interpretation and hydrostratigraphic modelling (Task 4), hydraulic data analysis (Task 5), conceptual model synthesis (Task 6), and reporting (Task 7).

Task 1 — Project Management

Development of a conceptual model of an aquifer with the complexity and geographic breadth of the Hill Country portion of the Trinity Aquifer requires a diverse team of geologists, hydrogeologists/hydrologists, data-management technicians, and GIS technicians. SwRI Team's project manager, Dr. Ronald Green, will serve as the point-of-contact for the TWDB and stakeholders. Dr. Green's project management responsibility will be to provide prompt and comprehensive information to the TWDB and stakeholders regarding the project's schedule, budget, and technical considerations. With over 30 years of water-resource evaluation experience and 20 years of leading projects to characterize the water resources of Texas that include karstic Edwards, Trinity, and Edwards-Trinity carbonate aquifers, Dr. Green possesses the technical and management expertise necessary to successfully lead the SwRI team's efforts on this project. A graphical delineation of the project organization and management approach is provided in Figure 6.

Given the complexity of the work and budget constraints, SwRI has divided the tasks amongst the project team to ensure timely project execution. SwRI will lead the project and carry the burden of synthesizing the final conceptual model along with the remaining data management and analysis tasks. Team member Mr. Nate Toll will lead the SwRI data analysis effort. INTERA will complete several important data management tasks, literature reviews, and analysis. Team member Dr. Neil Deeds will lead the INTERA team effort. The goal will be to create a unified workflow where possible, but allow variation in the technical approach where necessary to best accommodate the strengths in capabilities and knowledge of the individual team members.

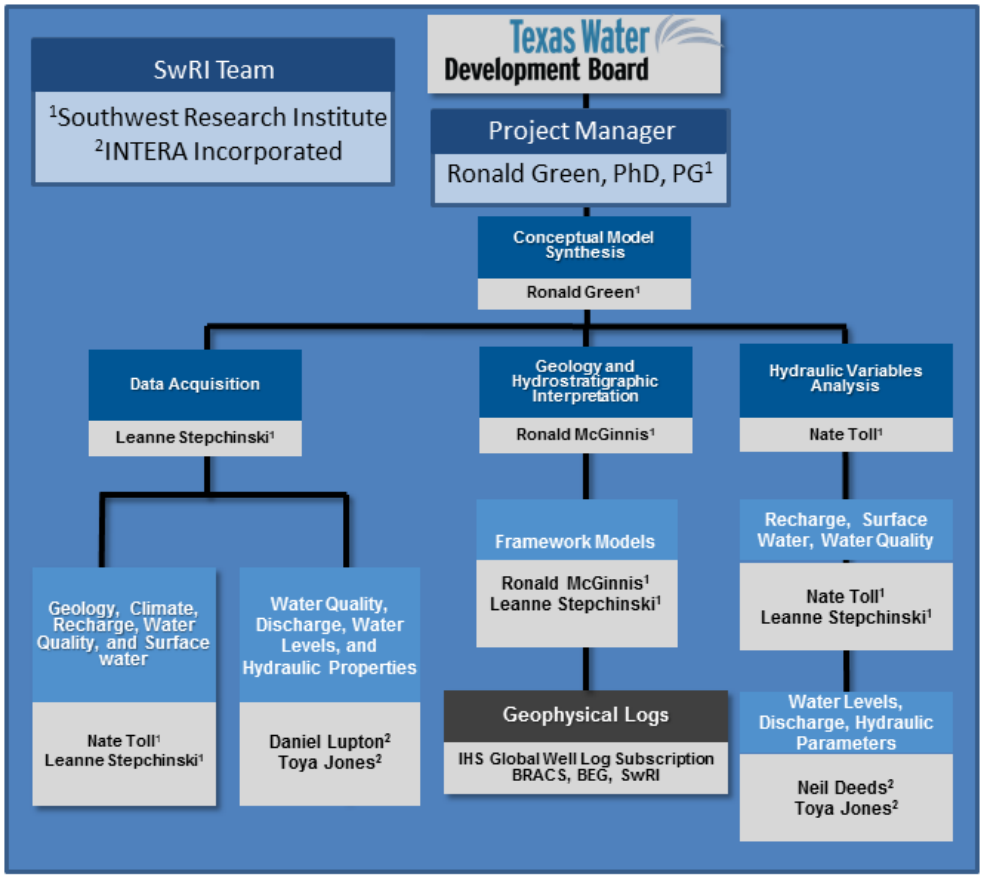


Figure 6. SwRI Team organizational structure diagram.

Task 2 — Stakeholder Communication

Stakeholder communication and input are critical to ensure that the GAMs are developed in a transparent manner and are responsive to stakeholder's needs. Information accrued during the project will be used ultimately by the TWDB, Regional Water Planning Groups (RWPG), GMAs, GCDs, state agencies, and planners, groundwater users, private citizens, and consultants to assess groundwater availability. As a result, the stakeholders must be included in the development process, and must be informed and confident in the conceptual model on which the GAM is predicated. Our experience in working with the TWDB, and numerous RWPGs, GMAs, and GCDs, provides us with a clear understanding of the key requirements for successful stakeholder communication. The SwRI Team will participate in a stakeholder advisory forum. SwRI will record the forum attendees and their affiliations. Questions raised during the forum will be documented along with the response or proposed response. This information will be communicated to the TWDB in a Memo report. SwRI will engage with stakeholders to gain any pertinent project information, data, and feedback on elements of the conceptual model. The stakeholder advisory forum will be scheduled by the TWDB project manager.

Task 3 — Data Acquisition and Data Management

Data acquisition will build on the existing data collected for the Trinity (Hill Country) Aquifer GAM and the TWDB BRACS project. In Task 3, data on physiography, climate, precipitation, geology, hydraulic properties, geophysical logs, water levels, surface water features, discharge (pumping), and water quality will be acquired from publicly available information or information that can be made available to the public. Information will be acquired for a period up to 2015. The update to the conceptual model requires an expansion in both temporal and spatial extent. Accordingly, defining the approximate domain for the GAM update will be completed at project inception to ensure data are collected across the entire domain. The model domain boundary will be discussed with the TWDB as it is critical to the project requirements.

Task 4 –Geologic Interpretation and Hydrostratigraphic Modeling

Geophysical log interpretation will be central to providing information relating to the upper and lower Trinity Formation boundaries and fault locations for each hydrogeological framework model layer. Geophysical logs will be accessed from the BRACS database, the Texas Commission for Environmental Quality (TCEQ) Public Works Systems records, the existing dataset of geophysical logs for the Trinity (Hill Country) Aquifer GAM, Texas Railroad Commission Q-logs, the Bureau of Economic Geology (BEG) Subsurface Library, and logs supplied via an agreement with IHS Global Well Log. GCDs in the study area will be asked to provide additional geophysical logs that are not part of these primary sources. Note that a commercial log company informed the SwRI Team under written agreement that any acquired logs used for the project will be released to the TWDB and therefore to the larger public domain. These logs will be limited to zones other than oil and gas production horizons. An initial distribution of known log locations is shown in **Error! Reference source not found.**.

The current Trinity (Hill Country) Aquifer GAM boundary appears to be based on the boundary of Trinity Aquifer outcrop so the stratigraphy for the area below the Edwards Aquifer Balcones Fault Zone (BFZ) is not fully developed. Additionally, the western boundary of the GAM terminates at the eastern edge of Uvalde County. The starting point for extending the stratigraphy will be the "Hydrogeologic Atlas of the Hill Country Trinity Aquifer, Blanco, Hays and Travis Counties, central Texas" (Wierman et al., 2010). Surface geology and additional geophysical logs will be needed to help define stratigraphy to the west and down dip. From Figure 4 we can see that there is BRACS database coverage to extend the Hill Country portion of the Trinity Aquifer. The BRACS geophysical logs and logs from other sources will be used to extend the stratigraphy of the Hill Country portion of the Trinity Aquifer. Although the coverage appears dense, many of these logs are too shallow to reach the Trinity Aquifer.

At the southwestern border of Bexar County, the top of the Lower Trinity Aquifer is at a depth of approximately 4,000 feet (Bebout, 1977). An examination of the bottom logging intervals for the BRACS wells indicates that some portion of those logs extend to that depth, but most logs do not extend into the lower Trinity (i.e. the Sligo/Hosston) Aquifer. It is uncertain whether the lower Trinity Aquifer is likely to have significant available water in that region, but we will attempt to establish a stratigraphic framework that includes these units. Data are expected to be more consistently available for the upper and middle portions of the Trinity Aquifer.

SwRI is currently leading a team that includes INTERA, BEG, Edwards Aquifer Authority, and the Barton Springs-Edwards Aquifer Conservation District to quantify the brackish water resources of Trinity Aquifer for the TWDB. This effort requires an interpretation of geophysical logs and to extend the stratigraphy to the depth of the Hill Country portion of the Trinity Aquifer. The results of this work will enhance the Hill Country portion of the Trinity Aquifer conceptual model and will be incorporated into the GAM geodatabase. In addition, SwRI was engaged by the Edwards Aquifer Authority to develop an alternative finite-element model of the Edwards Aquifer (Fratesi et al., 2015). As part of this effort, a hydrostratigraphic framework model that includes the Glen Rose and Edwards aquifers for the entire domain of the Hill Country portion of the Trinity Aquifer was constructed(Figure 7). SwRI has a significant database of logs and stratigraphic contacts from this framework model that will be available for development of a hydrostratigraphic model of the Hill Country portion of the Trinity Aquifer.

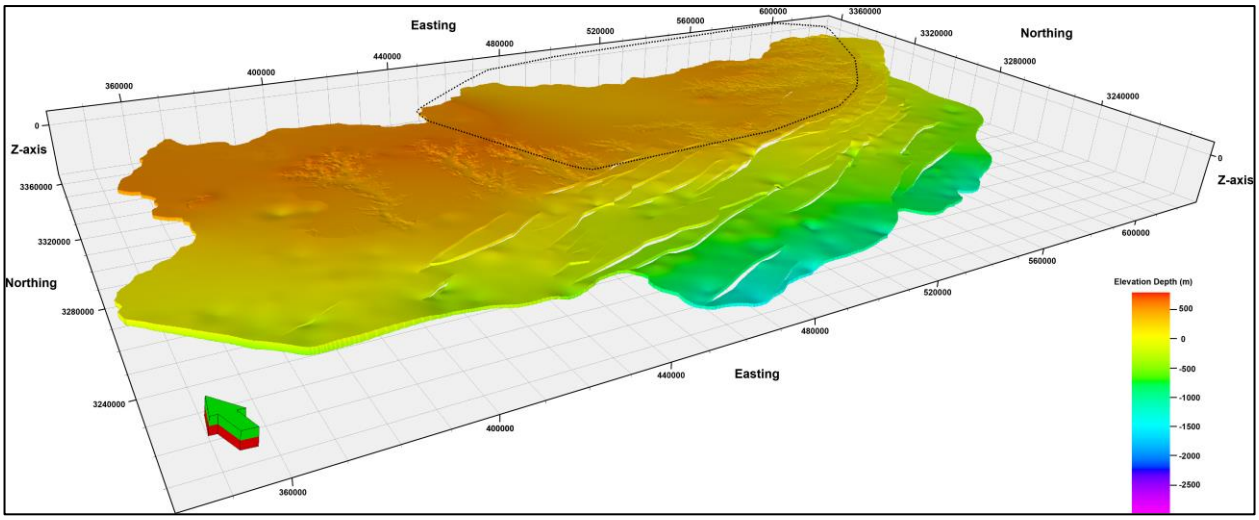


Figure 7. SwRI Hydrostratigraphic Framework model of the Glen Rose Limestone constructed for the Edwards Aquifer Authority Finite Element Model (Fratesi, 2015). The black line outline shows the extent of the current Trinity (Hill Country) Aquifer GAM.

The domain of the updated Hill Country portion of the Trinity Aquifer model will be determined during the development of the hydrostratigraphic framework model by integrating geologic data with hydrologic data. Factors to help determine the down-dip extent are salinity, stratigraphy, and the dip of the down-dip Trinity Aquifer. Considerations will be given to identifying a groundwater divide resulting from a structural-hydraulic boundary in eastern Kinney County (Green et al., 2006; Fratesi et al., 2015). If no natural hydraulic boundary is identified on the western boundary of the Hill Country portion of the Trinity Aquifer, an alternative boundary between the Hill Country portion of the Trinity Aquifer and the Edwards-Trinity Aquifer may be arbitrarily prescribed.

Three software packages will be used for developing the hydrostratigraphic framework model: (i) Microsoft Excel 2010, (ii) ESRI ArcGIS, and (iii) Schlumberger PETREL. These packages will be used to organize tabulated data, assemble and analyze geographically distributed data and interpretations, and for three-dimensional hydrostratigraphic framework

modeling. Microsoft Excel 2010 will be used to compile well data including locations, wellhead elevation, stratigraphic picks, and formation thickness information. Published geologic maps will be used to extract elevations for mapped geologic contacts that define hydrologic boundaries to provide control on boundaries in areas of limited or no well data. Geologic maps used in this fashion include maps published by the BEG (Bureau of Economic Geology) and the U.S. Geological Survey. ESRI ArcGIS will be used to assemble topography, geologic maps, structural data, and other geographically distributed data. These data will be used as the basis for defining the model domain and constructing the hydrostratigraphic framework model. Well picks will be evaluated using published maps and point shapefiles. PETREL will be used to construct the hydrostratigraphic framework model. This software package allows surface and subsurface data to be assimilated from multiple sources and perform stratigraphic and structural geologic interpretation.

Task 5 — Approach to Hydraulic Data Analysis

Subtask 5.1 – Recharge

Recharge is clearly one the most critical components to the conceptual model. Recharge varies spatially and temporally across the Hill Country portion of the Trinity Aquifer. Recharge from infiltration of precipitation into the aquifer is dependent on a variety of factors including rate and intensity of precipitation, evapotranspiration, and antecedent moisture conditions. Collecting this information across the Hill Country portion of the Trinity Aquifer domain at sufficiently high spatial and temporal resolution is important to developing a conceptual model of the aquifer. SwRI will use several public data sources to develop a database of the parameters that are required to calculate recharge. Precipitation data will be sourced from NOAA, Prism (Prism Climate Group, 2015), and the TWDB. NEXRAD precipitation data are available for periods since 2000. SwRI has developed automated GIS tools for the calculation of recharge from gridded NEXRAD data (Fratesi et al., 2015; Green et al., 2015, 2016). Evaporation data, soil parameters, and aquifer outcrop locations will be sourced from the TWDB, Texas Natural Resource Information System (TNRIS), United States Department of Agriculture (USDA), BEG, and the U.S. Geological Survey. Other sources of recharge such as stream loss, irrigation return, and possibly injection wells are referred to as focused recharge. Focused recharge will be identified from literature and analysis of water-level data. Focused recharge from losing streams will be calculated from stream-gauge data where possible. The Texas Railroad Commission database will be queried to locate any Class II injection wells that may be injecting in the Hill Country portion of the Trinity Aquifer domain. TCEQ data will be queried for other classes of injection wells. If any injection wells exist within the domain, the injection rates will be included in the conceptual model geodatabase.

SwRI will work with TWDB to establish the temporal resolution required for calculating recharge from direct infiltration of precipitation. The temporal resolution is dictated by the stress periods anticipated in the ultimate GAM. SwRI has developed ArcGIS scripts that facilitate the calculation of recharge from gridded precipitation data such as processed NEXRAD data. Input variables to the SwRI recharge model include evaporation rates, precipitation, soil types, and aquifer outcrop maps.

Subtask 5.2 – Water Levels and Regional Groundwater Flow

Mapping aquifer water levels and regional groundwater flow requires long-term measurements of static groundwater elevations at wells that provide reasonable spatial coverage of the study area. Unfortunately, there are relatively few wells drilled into the Hill Country portion of the Trinity Aquifer and thus a limited number of groundwater-level measurements. An initial query of the TWDB groundwater database for wells completed solely in the Hill Country portion of the Trinity Group yielded nearly 3,800 wells. While most of those (almost ¾) have at least one water-level measurement, only about 10-percent have 10 or more measurements over 10 or more years. A small subset of these wells (approximately 250) are completed solely in the Trinity Aquifer underneath and within the footprint of the Edwards Aquifer, but only nine wells have 10 or more water-level measurements taken more than 10 times.

Water-level measurements from previous studies will be compiled into a single consistent dataset for the Hill Country portion of the Trinity Aquifer study area. The water-level dataset will be updated using queries for more recent water-level data from both the TWDB groundwater database and U.S. Geological Survey National Water Information System database to represent the most up-to-date water levels in the region. In addition, GCDs and municipalities will be queried to solicit additional water-level data that were either not incorporated in the original models, or were collected since their publication.

While collecting transient water-level data is necessary for building and calibrating any future groundwater model, it is equally important to first establish a steady-state groundwater surface, which represents the expected stable groundwater elevation under unperturbed conditions in the study area. Jones et al. (2011) used groundwater elevations from the period 1977 through 1985 to represent steady-state conditions in the Hill Country portion of the Trinity Aquifer. Anaya and Jones (2009) selected the first winter measurements of each available well record, excluding measurements taken during the 1930s and 1950s drought years, to represent steady-state conditions in the Edwards and Trinity hydrostratigraphic units of the Edwards-Trinity (Plateau) Aquifer. Based on this proposed comprehensive water-level measurements compilation, as well as comparison to other steady-state, water-level indicators such as spring locations, a reasonable definition for steady-state conditions will be developed to produce a steady-state, water-level surface for the study area. Interpolated surfaces of groundwater elevations will be created for various time periods to inform the conceptual model.

Subtask 5.3 – Discharge

Groundwater production represents a small component of the overall discharge from the Hill Country portion of the Trinity Aquifer. According to Jones et al. (2011), discharge from the Hill Country portion of the Trinity Aquifer is dominated by discharge to streams and springs, followed by lateral subsurface flow and diffuse upward leakage to the Edwards (Balcones Fault Zone) Aquifer. Discharge by pumping from the aquifer is significantly less than discharge to springs and streams, and discharge by interformational flow.

The two components required for characterizing discharge due to pumping are annual volumes and production location. The majority of Trinity Aquifer water wells in the region are used for either domestic water use or public water supply. Jones et al. (2011) compiled a pumping dataset

based on the TWDB Water Use Survey pumping estimates from 1980-1997, and Anaya and Jones (2009) compiled a dataset based on the same source from 1980-2000. These pumping dataset will be updated to at least 2010. GCDs in the study area will be queried for well-specific metered pumping data. These data will be used to distribute pumping to individual wells within the study area. Otherwise, spatial distribution of pumping values from the updated pumping dataset will largely follow the methodology used in Jones et al. (2011). Municipal and manufacturing pumping will be distributed on the basis of known well locations and pumping data from the TWDB Water Use Survey. Rural domestic pumping will be distributed on the basis of the spatial distribution of population outside major urban areas. The other uses (irrigation and livestock) will be distributed throughout the region based on land use/land cover classifications available from the U.S. Geological Survey.

Aquifer discharge to streams as baseflow can be quantified through analysis of streamflow measurements. Jones et al. (2011) collected stream-gauge data for the period up to 2000 for seven streamflow targets in the Hill Country portion of the Trinity Aquifer. Anaya and Jones (2009) compiled stream-gauge data for the period up to 2004 for streamflow targets in the Edwards-Trinity (Plateau) Aquifer model, nine of which appear to fall in or near the proposed study area. Available stream baseflow data will be compiled using the U.S. Geological Survey National Water Information System to bring the streamflow dataset up-to-date. Hydrograph separation analyses on available streamflow data will be evaluated (Green and Bertetti, 2010; Green et al., 2012) to better constrain the amount of streamflow sourced directly from aquifer discharge, as opposed to runoff.

Available spring discharge data will be compiled, beginning with information available in previous models. Spring-discharge data in Texas include models by Jones et al. (2011) and Hutchison et al. (2011), the U.S. Geological Survey National Water Information System, compilations of Texas spring data (Heitmuller and Reece, 2003; Brune, 2002) and the TWDB groundwater database, will be assessed for use in the model. After spring and streamflow discharge, the next significant discharge component is interformational flow to the Edwards (Balcones Fault Zone) Aquifer. Groundwater from the Trinity Aquifer can discharge to the Edwards Aquifer in two ways: (i) as subsurface cross-formational inflow across the up-dip margin of the Balcones Fault Zone where the Trinity Aquifer is juxtaposed with the down-faulted Edwards Aquifer and (ii) as upward flow from the Trinity Aquifer into the Edwards Aquifer along faults, fractures, and dissolution enhanced conduits. In addition, there is water that discharges to the Edwards Aquifer recharge zone from the Trinity Aquifer as surface flow. The volume of discharge as groundwater is difficult to determine and is typically estimated or constrained using numerical groundwater flow models and water-balance calculations.

There has been continued refinement in estimates and calculations of how much water is discharged from the Trinity Aquifer to the Edwards Aquifer. This refinement is due, in part, to improved conceptualization of the Trinity-Edwards Aquifer interface based on a variety of perspectives including multi-well testing (Smith and Hunt, 2009, 2010, 2011), tracer testing (Johnson et al., 2010, 2012; Schindel and Johnson, 2011), gain-loss studies (Slade et al., 2002; Green et al., 2011), enhanced characterization of the geologic structure and hydrogeology (Ferrill et al., 2003, 2004, 2005, 2008), and refinements in groundwater models that include the Trinity Aquifer-Edwards Aquifer interface (Klemt et al., 1979; Maclay and Land, 1988; Lindgren et al.,

2004, Jones et al., 2011). The model by Jones et al. (2011) estimated cross-interformational flow rates as 660 acre-ft/yr in the west, 2,400 acre-ft/yr in the central area, and 350 acre-ft/yr in the east of the model domain (Figure 8).

Subtask 5.4 – Surface-Water Features

Surface-water features that have a major effect on the Hill Country portion of the Trinity Aquifer will be identified during the data acquisition task. These features include rivers, streams, creeks, springs, and reservoirs. The geometry of the features will be acquired digitally from public sources or digitized from maps if not available in georeferenced digital form. If any surface water features lose water to the Trinity Aquifer or receive water from the aquifer, information on gain/loss will be acquired from literature and public sources. The analysis of gain/loss from surface-water features will be completed in the recharge and discharge analysis tasks.

Subtask 5.5 – Hydraulic Properties

Estimates of aquifer hydraulic conductivity are ideally based on measurements derived from long-term aquifer tests and specific capacity tests of these wells (Mace, 2001). The TWDB model for the Hill Country section of the Trinity Aquifer (Jones et al., 2011) compiled transmissivity and hydraulic conductivity values from several sources, including values derived from long-term aquifer pump tests, literature estimates and values calculated from specific capacity tests. The conceptual model for the Edwards-Trinity (Plateau) Aquifer (Anaya and Jones, 2009) treats the Trinity Group in the western portion of the current study area as a component of the Edwards-Trinity (Plateau) Aquifer rather than its own aquifer. However, they do provide information derived specifically from wells in the "Trinity hydrostratigraphic unit" that we can apply to the proposed study.

For the proposed Hill Country portion of the Trinity Aquifer conceptual model, hydraulic conductivity point values from these previous models will be compiled into a single consistent dataset for the study area. Because long-term aquifer tests appropriate for calculating hydraulic conductivity values are uncommon, distributions of hydraulic conductivity in previous reports rely heavily on transmissivity values calculated from specific capacity measurements, which are much more common. A review comparing available values from long-term aquifer tests to available values from specific capacity tests will then be undertaken. If this analysis shows that the specific-capacity-developed values are reasonable, the existing set of specific capacity test data with any additional recent data from both the TCEQ public water supply (PWS) records and through requests to GCDs will be augmented. Hydraulic conductivity values for these additional wells will then be calculated using methods in Mace (2001).

If, however, the analysis does not provide confidence in the specific-capacity-derived hydraulic conductivity values, an alternative approach for developing hydraulic conductivity values will be developed. A method that combines the model-calibrated spatial coverages developed in the previous models (Anaya and Jones, 2009; Jones et al., 2011; Hutchison et al., 2011) will be explored to develop one consistent spatial coverage that covers the entire study area. This is the method that will be used for vertical hydraulic conductivity coverage, as well as for storage properties (specific yield and specific storage) because additional information for these

properties is not likely. Both the eastern model (Jones et al., 2011) and the western model (Anaya and Jones, 2009) produced model-calibrated coverages of these properties that will be relevant to that proposed analysis.

Subtask 5.6 – Water Quality

The SwRI Team will collect water quality data from publicly available sources as part of Task 3—Data Collection and Data Management. Data will be gathered from various sources, including, but not limited to, the TWDB Groundwater Database, relevant U.S. Geological Survey reports, and data collected by GCDs in the Hill County portion of the Trinity Aquifer. Because one of the principal purposes of the revised conceptual model is to recommend appropriate extended boundaries for the present Trinity (Hill Country) Aquifer GAM to include all of GMA 9, the collected water quality data will include a spatial extent beyond the GMA 9 boundaries and will incorporate data from the Edwards-Trinity (Plateau) Aquifer as well as the Edwards (Balcones Fault Zone) Aquifer.

The SwRI team will conduct an analysis of the water quality data, including total dissolved solids and other dissolved constituents of interest, to understand spatial variations, variations with depth and hydrostratigraphic layers, and possible temporal variations of the data. Maps of water quality data will be prepared for the conceptual model domain, and these will include maps for each hydrostratigraphic layer as well as maps depicting significant water quality variations over time. The SwRI team will prepare graphical summaries of water quality data for total dissolved solids and other constituents of interest. Graphs will be prepared for wells that have distinct water quality variations over time, and the locations of these wells will be identified on the water quality maps. Besides providing a mechanism to gauge the groundwater availability of an aquifer, analysis of water quality data can be an important tool to assess and identify areas in which cross-formational flow may occur and provide corroborating evidence for the determination of appropriate conceptual model boundaries (Figure 8). The EAA has embarked on a multi-year study to investigate and quantify potential cross-formational flow between the Trinity Aquifer and the Edwards (Balcones Fault Zone) Aquifer (e.g., Gary et al., 2013). The EAA has engaged SwRI to develop an appropriate, targeted sampling strategy and then analyze and model the collected water quality data to identify and quantify flow where evidence of cross-formational flow exists. Information derived as part

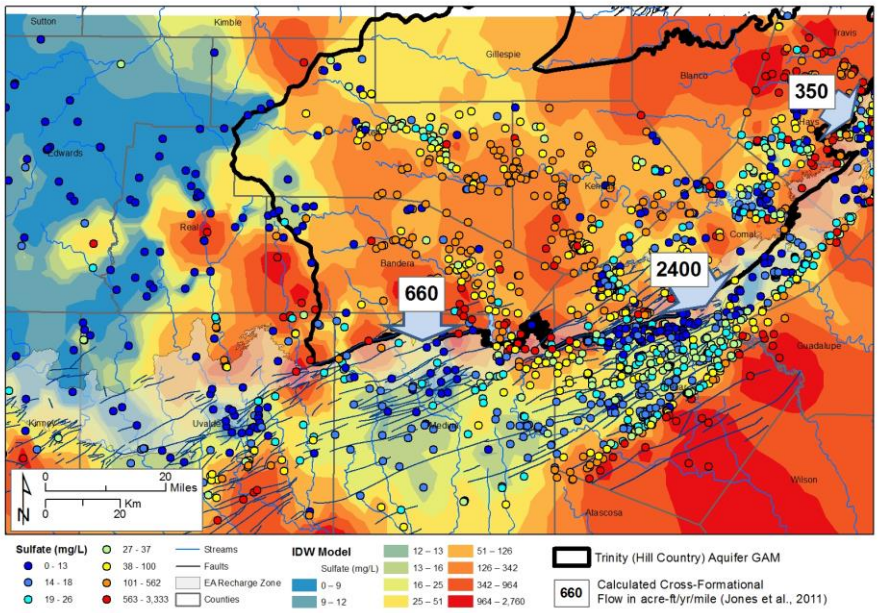


Figure 8. Map of measured and predicted sulfate concentrations for Trinity and Edwards aquifer waters in the region of the Trinity (Hill Country) Aquifer GAM. Cross-formational flow from the Trinity Aquifer to the Edwards Aquifer shown (acre-ft/yr) (Jones et al., 2011).

of this EAA-funded project can be leveraged to aid in the understanding and development of the conceptual model for the Hill Country portion of the Trinity Aquifer.

The SwRI team has also used analysis and modeling of water quality data to provide evidence for the delineation of appropriate boundaries for aquifer conceptual models (Green et al., 2006b, 2012b). Similar approaches may be particularly useful for the proposed project. For example, a geostatistical model of water quality data for various constituents from Trinity and Edwards Aquifer wells [including wells from the Edwards-Trinity (Plateau), Trinity (Hill Country), and Edwards (Balcones Fault Zone) Aquifers] provides a distinct demarcation of the spatial trends in water wells utilizing Trinity Aquifer water instead of Edwards Aquifer water in the region of Uvalde, Kinney, and Real Counties. Analyses of this type, especially when combined with geological mapping and hydrostratigraphic modeling outlined in Task 4, can be of significant use in establishing a technical basis for the western conceptual model boundary. The SwRI Team has extensive and proven experience conducting the detailed water quality analyses required for this type of application and integration of the data into a robust conceptual model for the Hill Country portion of the Trinity Aquifer.

Task 6 — Conceptual Model Synthesis

The collection of data and interpretation of discrete parts of an aquifer system does not constitute a complete conceptual model of the groundwater system. A conceptual model for the Hill County portion of the Trinity Aquifer will be developed that reflects the input from Tasks 2 through 5. The SwRI team will develop a conceptual model that describes groundwater flow in the Hill Country portion of the Trinity Aquifer from recharge, through its path in the aquifer, to discharge at wells, springs, or rivers. The conceptual model will be constructed using information and data extracted from the past and current Trinity (Hill Country) Aquifer GAMs (Mace et al., 2000; Anaya and Jones, 2011), a recent model of the Edwards Aquifer BFZ that extends into the Hill Country portion of the Trinity Aquifer (Fratesi et al., 2015), and any other relevant studies and documents (i.e., the ongoing TWDB BRACS study of the Trinity Aquifer conducted by SwRI and INTERA).

In 2015, SwRI completed development of a comprehensive, refined numerical model of the San Antonio segment of the Edwards Aquifer (Figure 2) (Fratesi et al., 2015). The 2015 Edwards Aquifer model spans the Edwards Aquifer from the groundwater divide separating the San Antonio segment from the Barton Springs segment of the Edwards Aquifer on the east to the groundwater divide separating the Mud Springs from Pinto Springs on the west. Most noteworthy is that the 2015 Edwards Aquifer model domain includes the confined, recharge, and contributing zones of the Edwards Aquifer and in doing so, this model was the first Edwards Aquifer model to incorporate all three zones of the aquifer. Important to this proposal, by including the contributing zone of the Edwards Aquifer, the 2015 Edwards Aquifer model essentially includes the Hill Country portion of the Trinity Aquifer model domain and the Hill Country portion of the Trinity Aquifer/Edwards Aquifer interface.

In addition to including the Edwards Aquifer contributing zone, the 2015 Edwards Aquifer model was noteworthy in that the refined conceptual model on which the numerical model was built incorporated the results of local and regional technical studies from the previous decade that

were conducted to reduce uncertainty in the manner in which the physical system is represented in models. These enhancements included refinement of the western boundary of the San Antonio segment (Green et al., 2006), clearer understanding of the hydraulic relationship of the major rivers and streams that transect the Edwards Aquifer contributing and recharge zones (Green et al., 2008a, 2009b, 2012b), improvements in estimating recharge to the contributing zone of the Edwards Aquifer (Green and Bertetti, 2010; Green et al., 2012) and particularly, a refined and expanded hydrostratigraphic framework model of the San Antonio segment of the Edwards Aquifer and extending north to include the contributing zone (Fratesi et al., 2015).

During development of the 2015 Edwards Aquifer model, inspection and inclusion of the individual watersheds that form the contributing zone of the Edwards Aquifer brought to light the significance of variable hydraulic properties and characteristics assigned to the river channels and how the hydraulic properties are manifest in the model (Fratesi et al., 2015). For example, it is important to recognize the different hydraulic properties exhibited by river channels as diverse as Cibolo Creek, with virtually no baseflow, versus the Guadalupe River with significant baseflow and continuous flow. The diversity exhibited by the different watersheds cannot be captured in the numerical model if the conceptual model of the watersheds is not sufficiently representative of the physical system. The conceptual model and the associated hydrostratigraphic framework model from the 2015 Edwards Aquifer model will form the foundation to the Hill Country portion of the Trinity Aquifer conceptual and hydrostratigraphic framework models. Although the 2015 Edwards Aquifer model (Fratesi et al., 2015) only provided resolution to the upper Trinity Formation (Figure 7), substantial information on the lower Trinity Formation, including the basal sands, was compiled during development of the framework model database and is available for use in the proposed project.

Included in the Conceptual Model Report will be a schematic block model that describes the key elements of the Hill Country portion of the Trinity Aquifer. SwRI has decades of experience creating block models to communicate geologic and hydrogeologic concepts. For the Hill Country portion of the Trinity Aquifer, the conceptual-block model will be developed using an iterative design process with SwRI media and production designers and the project investigators.

Task 7 — Reporting

Monthly or Fiscal Year 4-week progress reports will be submitted to the TWDB outlining progress of the project and include the original or adjusted schedule and detail how the Project is progressing relative to this yardstick. Project invoices will include detailed descriptions of the progress made by tasks. Each of the project tasks will be described in detail consistent with the budget description. Any issues will be reported to the TWDB Project Manager immediately as they appear. Close coordination with the TWDB will be maintained throughout the project and will be critical. All draft and final reports will be delivered in Microsoft Word and PDF formats. Draft deliverables will be submitted for review and comment by TWDB. These comments will be addressed in the final report and a copy of the comments will be incorporated into the final deliverables. Acceptance of the Final Report will indicate the successful completion of the project.

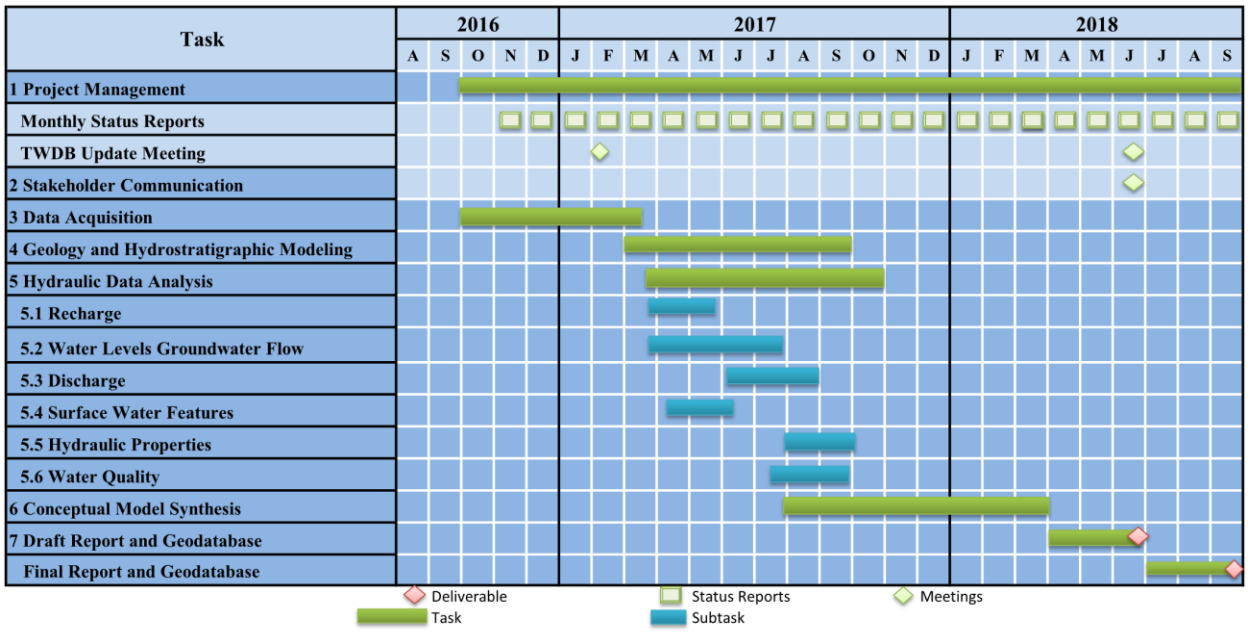
6.2 Organization and Management

Through completion of hydrogeological assessment contracts for a variety of commercial and governmental clients, including TWDB, the SwRI team offers a proven approach to successful project management. The project manager, Dr. Ronald Green, has over 30 years of evaluating the water resources of local- and regional-scale aquifers for a broad range of governmental clients whose mandates include the governance, assessment, and management of local and regional water resources in Texas and elsewhere.

6.2.1 Project Schedule and Budget

The SwRI team's proposed project schedule for developing a conceptual model of the Hill Country portion of the Trinity Aquifer is shown in Table 1. As the schedule shows, the tasks will be completed over the course of 20-24 months from contract award. For purposes of developing our schedule and timeline, we are assuming a start date of September 28, 2016. As stated in the RFQ, this project has a completion date of September 28, 2018 that is firm and non-negotiable. Given the acknowledged ambitious schedule and timeline of the project, it is imperative the team selected to execute this project be capable of achieving the objectives of a project of this scope within the designated timeline. The team has a solid track record of completing challenging projects subject to defined funding levels and strict timelines.

Table 1. Schedule summary for developing a conceptual model for the extended Hill Country Trinity Aquifer.



6.3 Project Monitoring Procedures

The SwRI team will monitor project progress using the same procedures that have enabled us to meet scheduled deliverables on other high-profile, water-resource evaluation projects. Monthly status reports, including the technical progress of the Trinity Aquifer evaluation in the preceding

month, will be provided to TWDB. The monthly report will summarize project progress relative to the schedule. Cost summaries, by task and subcontractor, will be provided to the TWDB with our monthly invoices. Monthly project reports will be used as a means of documenting issues, either technical or programmatic, which require consultation with the TWDB. Important project points where these meetings will be held include project initiation, after selection of the model study area, and after providing TWDB with the final draft deliverables. In addition, we anticipate regular communications with the TWDB's project manager and other TWDB staff during the project. These additional meetings will be held either in person, through a webinar, or teleconference.

At SwRI, project management and control functions are carried out in accordance with a well-established system. The Deltek Costpoint accounting software is used to support project management, accounting, reporting, and compliance. The software integrates time keeping, accounting, and accounts receivable. The project manager can monitor project hours and charges in real time because time is entered on a daily basis. This system provides for detailed tracking of resources and schedules and allows early identification of problem areas so that any required corrective measures can be applied in a timely manner. As discussed in Section 6.1, we have divided the Trinity Aquifer evaluation work scope into seven primary tasks. These tasks are divided into subtasks that further break out the work scope.

6.5 Deliverables

Thorough documentation of the Hill Country portion of the Trinity Aquifer conceptual model development project is required for transparency and effective use. All data deliverables and documentation for the conceptual model update will be prepared in a manner consistent with the format and content defined by TWDB in Appendix A, GAM Standards and Section 3.1 (Contract Deliverables) of the RFQ. Interim deliverables include monthly status reports and a draft report by the SwRI team for geophysical well log interpretation of total dissolved solids concentration. The interim draft report will provide the SwRI team and the TWDB Board the opportunity to discuss the proposed techniques. Deliverables are as follows:

- Monthly Status Reports
- Draft Source Geodatabase
- Draft Conceptual Model Report (including 3D Schematic Conceptual Block Model)
- Final Source Geodatabase
- Final Conceptual Model Report (including 3D Schematic Conceptual Block Model)

The draft and final reports will summarize the data collection and evaluation, model conceptualization, and hydraulic analysis. All source data will be delivered as part of the source geodatabases. Reports will be delivered in both Microsoft Word and PDF formats.

WRITTEN ASSURANCES

SwRI assures that our proposed water research does not duplicate previously completed or ongoing research. If a contract for updating the conceptual model of the Hill Country portion of the Trinity Aquifer is awarded to the SwRI team, we agree to discontinue existing contracts and not enter into new contracts with persons or entities other than the TWDB and RWPGs for groundwater supply and availability studies involving the Hill Country portion of the Trinity Aquifer region while working on the TWDB project without a prior no conflict of interest determination and written authorization by TWDB.

ATTACHMENT A. Qualifications and Experience of Project Staff

SwRI has assembled an outstanding team of management and technical personnel to evaluate the brackish groundwater resources of the Trinity Aquifer in Texas. Our team brings experience in all of the required areas including general hydrology and hydrogeology of Texas, the hydrogeology of the Trinity Aquifer, gathering existing water-chemistry data, geophysical log interpretation, development of a hydrostratigraphic framework model, and hydraulic analysis using analytical and numerical techniques, communicating with the public, and technology transfer. In addition to having the technical qualifications, our personnel have published the results of work similar in scope to this effort in leading groundwater journals and conference proceedings, and have presented this work at technical conferences.

This section provides overviews of the SwRI Team companies, the qualifications and experience of our proposed personnel, a selected bibliography for our personnel including relevant and current publications and presentations, and our project team personnel's project experience that is relevant to evaluating the brackish groundwater resources of the Trinity Aquifer in Texas.

A.1 The SwRI Team

SwRI has assembled a team that offers the TWDB unparalleled capabilities and qualifications to evaluate the brackish groundwater resources of the Trinity Aquifer. Each of our team members is highly motivated to contribute to this project, and each member is committed to the success of the TWDB's program to evaluate the brackish water resources of the State of Texas. Our team integrates the proven experience and strengths of SwRI and INTERA.

Southwest Research Institute

SwRI, headquartered in San Antonio, Texas, is one of the oldest and largest independent, nonprofit, applied research and development (R&D) organizations in the United States. Founded in 1947, SwRI provides contract research and development services to industrial and government clients in the United States and abroad. The Institute is governed by a board of directors, which is advised by approximately 100 trustees.

SwRI Campus in San Antonio

SwRI's headquarters occupies more than 2 million square feet of office and laboratory space on a more than 1,200-acre site in San Antonio. The Institute has business offices in Washington; and technical offices and laboratories in Ann Arbor, Michigan.; Atlanta, Georgia; Beijing, China; Boulder, Colorado; Hill Air Force Base, Utah; Hanover and Rockville, Maryland; Layton, Utah; Minneapolis, Minnesota; Oklahoma City, Oklahoma; Warner Robins, Georgia; and Lorton, Virgina.

Unique Capabilities and Characteristics

SwRI offers the following distinct advantages over other organizations bidding on this contract:

- *SwRI is a 501(c)(3) nonprofit organization*. The Institute has no shareholders. Our nonprofit status provides for objectivity on projects where other companies might have a conflict of interest. Our net income is used for new facilities, advanced scientific equipment, and internally sponsored research. This reinvestment allows SwRI to remain at the leading edge of developing technologies and fulfills our charter to develop and further the advancement of new technologies. As a nonprofit organization, SwRI maintains a moderate fee structure which we use to improve our inherent capabilities, which results in greater value to clients. Nonprofit status also enables us to focus on providing clients the best solution possible instead of focusing on bottom-line factors such as profit margins, share price, and shareholder satisfaction.
- *SwRI is independent and impartial.* We are not affiliated with any government agency, educational institution, or corporate entity, nor do we endorse products or services. SwRI provides completely independent, impartial and objective analysis, assessments, recommendations and advice to clients.
- *SwRI has a unique patent rights policy.* As part of a long-held tradition, full patent and data rights arising from externally sponsored research are often assigned to the client without restriction.
- *SwRI is nationally recognized as a technology leader.* The Institute holds more than 980 patents awarded to its staff members. The Institute has earned 30 R&D 100 Awards from R&D Magazine. In 2004, Popular Science magazine names two of our staff to the top 10 most brilliant young scientists in America today. SwRI has been inducted into the U.S. Space Foundation's Space Technology Hall of Fame and has received two DOD James S. Cogswell Outstanding Industrial Security Achievement Awards. In 2003, we received NASA's Software of the Year Award. Since our founding in 1947 we have been awarded 818 patents.
- SwRI is certified to the Software Engineering Institute (SEI) Capability Maturity Model (CMM) Level 3 and we are moving to CMMI Level 4. In addition, several of SwRI's technical and support divisions have achieved certification or accreditation to Quality Management Systems including ISO 9001, 14001, 17025 and 13485. The Ford Motor Company has designated SwRI as a Tier 1 supplier and has awarded the Institute its Q1-2000 award.

SwRI consists of 10 technical divisions that offer multidisciplinary, problem-solving services in a variety of areas in engineering and the physical sciences. More than 4,000 projects were active at the Institute at the close of fiscal year 2015. These projects were funded almost equally between the government and commercial sectors. SwRI's total revenue for this fiscal year was $592 million. During 2015, SwRI provided $7.2 million to fund innovative research through its

internally sponsored R&D program, which is designed to encourage new ideas and innovative technologies.

SwRI's headquarters occupies more than 2 million square feet of office and laboratory space on more than 1,200 acres in San Antonio. The Institute has technical offices and laboratories in Ann Arbor, Michigan; Atlanta and Warner-Robins, Georgia; Boulder, Colorado; Durham, New Hampshire; Ogden, Utah; Oklahoma City, Oklahoma; Hanover and Rockville, Maryland; Minneapolis, Minnesota; Lorton, Virginia; Beijing, China; and other locations. At the close of fiscal year 2015, the staff numbered 2,708, including 280 professionals who hold doctorate degrees and 497 with master's degrees.

The Institutes 10 technical divisions cooperate on multidisciplinary approaches to problem-solving. A partial listing of research areas includes: advanced electronics; aircraft structural integrity; antennas, radio wave propagation, and electromagnetic modeling; automation, robotics, and intelligent systems; automotive engineering; avionics and support systems; ballistics and explosion hazards; bioengineering, biomechanics, and biomaterials; chemistry and chemical engineering; communications systems and signal processing; corrosion and electrochemistry; cyber security and information assurance; Earth and planetary sciences; engineering mechanics; environmental and health sciences; fire technology; fluid systems and fluid machinery; fracture mechanics; fuels and lubricants; geochemistry and radiochemistry; geological and mining engineering; geophysical and geological investigations; hydrology and geohydrology; information and electronic warfare; intelligent transportation systems and vehicles; internal combustion engine emissions research; manufacturing technology; marine technology; materials sciences; medical information systems; modeling and simulation; nondestructive evaluation; oil and gas exploration and development; optics and sensor technology; penetration and armor mechanics; pipeline technology; probabilistic mechanics and uncertainty quantification; risk and hazard assessment; signal exploitation and geolocation; software engineering; space science; space instrumentation and spacecraft systems; structural engineering; surface modification and coatings; surveillance technology, training systems and simulators; unmanned aerial vehicles and systems; vehicle, engine and powertrain design, research and development.

Geosciences and Engineering Division (GED) is a division of SwRI with expertise in a broad range of earth sciences and related disciplines. With a core staff of approximately 32 earth scientists and engineers and state-of-the-art computer modeling facilities, GED has extensive experience and capabilities in hydrogeological investigation, water-resource assessment, geophysical evaluation, geologic characterization, and geochemical analysis. GED staff is well equipped to employ these skills for a variety of problem solving and water-resource management needs. With regard to this proposed project, GED has conducted a number of projects related to water-resource evaluation and management for GCDs and water authorities throughout Texas.

Texas aquifers included in these studies are the Edwards, Edwards-Trinity, Trinity, Buda, Austin Chalk, Leona Formation, and the Carrizo-Wilcox aquifers. Significant effort has been spent evaluating the water resources of the aquifers and to understanding the hydraulic relationships among these different aquifers. The importance of relationships among aquifers is quickly being recognized by the various water authorities because the discharge from one aquifer system is likely the source of recharge for another. Therefore, actions taken by water authorities to

manage their water resources must be made with the appreciation of how their actions affect downstream users.

Hydraulic relationships among these aquifers include both surface water and groundwater interactions. These relationships can be complex and variable over time. The project team has used multidisciplinary approaches to evaluate these relationships both within singular aquifers and with regard to multiple aquifers (Green et al., 2006, 2008a,b, 2009a,b,c). The integrated use of structural geologic assessments, geophysical imaging of the subsurface, geochemical analysis of different surface waters and groundwaters, and hydrogeologic and hydraulic analyses has proven to be effective in discerning these complex relationships.

GED staff has extensive experience in hydrologic investigations for a variety of hydrogeological settings, including fluvial/alluvial, fractured rock, and karstic aquifers. GED provides a full range of technical expertise in the earth sciences, including hydrogeology, structural geology, geochemistry, geophysics, GIS support, and general geology. GED performs work for local, national, and international clients in these technical areas. A discussion of GED expertise relevant to hydrogeology and groundwater management follows.

GED staff has used the full range of hydrogeological assessment tools to analyze groundwater availability in several aquifers in south-central Texas (Green et al., 1998; Green, 2006; Green et al., 2006, 2008a,b) including the Trinity and Edwards-Trinity aquifers (Green et al., 2010, 2012, 2014; Sun et al., 2010, 2012). Assessments of the Edwards, Edwards-Trinity, Trinity, Austin Chalk, Carrizo-Wilcox, and a number of minor aquifers have been performed using analysis of aquifer performance testing, water chemistry, groundwater flow regime evaluation, structural controls on groundwater flow, surface water/groundwater interaction, water-budget assessment, and geophysical characterization of the subsurface. Results from these analyses are now used by water authorities and G to effectively and responsibly manage the water resources under their jurisdictions. GED staff has found that integrated hydrogeological evaluations provide water resource assessments that are more comprehensive and more defensible than assessments performed using a limited range of analytical tools. GED has developed and uses sophisticated analytical techniques and tools to allow thorough assessment of multiple data sets.

INTERA Incorporated

INTERA was founded in 1974 as a technology-based consulting firm specializing in the development and application of decision support tools for the environmental and petroleum industries. Since our inception, we have earned a reputation for developing best-in-class solutions to difficult problems facing industry and governmental institutions including:

- Predicting future hydrologic-system states to support water resource management in the areas of groundwater availability, optimal water-use strategies and water-demand forecasting through the application of statistics, numerical models, and remote sensing technology
- Modeling surface-groundwater interaction including the development of integrated surface-groundwater modeling tools that couple MODFLOW and HSPF
- Developing customized GIS software designed to manage, maintain, and analyze site-specific hydrologic and environmental data under an ArcGIS umbrella

- Using remote sensing data such as NEXRAD and LANDSAT7 in hydrologic modeling and analysis
- Acquiring and interpreting hydrologic data in difficult well-testing environments (deep and/or fractured aquifer systems)
- Designing state-of-the-art methods and techniques to investigate, characterize, and remediate contaminated sites
- Optimizing groundwater remedial design systems through the use of contaminant fate and transport models in fractured and nonfractured aquifer systems

INTERA is a Texas Corporation headquartered in Austin with additional U.S. offices in Albuquerque and Santa Fe, New Mexico; Denver, Colorado; Tampa, Gainesville, and Jacksonville, Florida; and Richland, Washington and international offices in Lyon, France and Baden, Switzerland. We have been involved in high-profile groundwater projects both domestically and internationally for over 40 years. Many of INTERA's senior staff are recognized in their respective fields and are retained to provide expert-witness testimony and litigation support in the areas of water resources management and groundwater and subsurface contamination. We currently have 125 professionals specializing in geology, hydrogeology, hydrology, water resource and environmental engineering, geostatistics, remote sensing, and GIS technology. We are registered to perform geoscientific and engineering services in the State of Texas by the Texas Boards of Professional Geoscientists and Engineers (Geosciences Registration Number 50189 and Engineering Registration Number 4722). INTERA has 35 groundwater and surface water professionals located in Texas including 6 registered Texas Professional Engineers and 13 registered Texas Professional Geoscientists. In addition, many of our geoscientists are nationally licensed as Certified Ground Water Professionals.

INTERA's legacy of high caliber groundwater and modeling expertise dates back to the 1970s when we developed the first fully three-dimensional groundwater flow and transport simulator, SWIP, for the U.S. Geological Survey. This legacy continues through our involvement in some of the highest profile site-characterization and modeling projects in the country and the development of first-of-a-kind numerical simulation and visualization tools (e.g., nSights, PaCalc, mView).

INTERA specializes in developing cost-effective solutions to the most complex technical problems. Our solutions result from the right combination of theoretical expertise and practical hands-on experience. We offer an international reputation as a leader in the development and application of quantitative modeling techniques for groundwater flow and contaminant transport problems. Over the last 39 years, INTERA has developed public domain groundwater flow and transport modeling programs such as SWIFT and SWIFT-II. These models were the first capable of treating variable fluid density, dual porosity (i.e., fractured), multi-chain radioactive transport in three-dimensional cartesian or two-dimensional radial coordinates. We developed the first fully three-dimensional direct (i.e., adjoint) sensitivity analysis software, GRASP, and have applied this tool to regional groundwater modeling projects across the U.S. to assist in model calibration through sensitivity analysis and to identify data needs.

For the past 16 years, INTERA has focused our tradition of quantitative problem solving and code development on water resource issues. For Tampa Bay Water, we developed an improved

integrated surface water groundwater model that couples MODFLOW and HSPF under a Windows™ environment. We have also evaluated and developed artificial neural networks (ANNs) as tools for forecasting short-term, water-level fluctuations (multiple days and weeks) in the surficial and Floridian aquifers monitor wells in southwest Florida. We have used a combination of geostatistics and unit response functions with Multi-Attribute Utility Theory (MAUT) to develop optimal monitoring wells for hydrologic and environmental impacts. INTERA used MODFLOW-2000 with the HUF2 Package along with Parallel-PEST to calibrate a hydrostratigraphic unit (HSU) based GAM in the Española Basin and the Santa Fe Embayment in New Mexico.

In the area of groundwater availability modeling, INTERA has developed, or is developing, under funding and the direction of the TWDB, 13 GAMs. These include the southern and northern Carrizo-Wilcox Aquifer GAMs (2 models); the Queen City Aquifer and Sparta Aquifer GAMs (3 models); the Yegua-Jackson Aquifer GAM; the Dockum Aquifer GAM; the Rustler Aquifer GAM; the Seymour Aquifer GAM which also includes the Blaine Aquifer in a first order treatment; a refined Seymour Aquifer GAM for a specific portion of the aquifer; the High Plains Aquifer System GAM (currently in progress); and the Brazos River Alluvium GAM (also in progress). We also supported the development of the Nacatoch Aquifer GAM. We also have experience in updating and revising existing GAMs including the models of the Northern Trinity and Woodbine, Northern Ogallala, and Edwards-Trinity aquifers. All of this experience and the valuable lessons we have learned in completing these projects, is directly relevant and transferable to evaluating the brackish groundwater resources of the Trinity Aquifer.

A.2 Project Staff

To evaluate the brackish groundwater resources of the Trinity Aquifer, our team brings the experience of personnel that have led or contributed to previous water-resource evaluation projects for the TWDB and other water agencies. As the SwRI Team's project organizational structure (included in Task 1 - Project Management) shows, our project manager will be supported by technical staff that will oversee data gathering and analyses and documentation and technology transfer.

Both our Project Manager and Technical Staff have ready access to a group of Technical Leads and Specialists in the areas of aquifer properties, gathering and interpretation of historical pumping and water levels, geophysical log analysis, fault evaluation and conceptualization, aquifer test interpretation, model calibration and sensitivity analyses, model conversion and testing, data management, reporting, and stakeholder interaction.

Name	Proposed Role	Education (highest degree)	RELEVANT QUALIFICATIONS AND EXPERIENCE										
			General hydrogeology	Hydrogeology of Trinity Aquifer	Interpreting and using geophysical well logs	Use of TWDB GAMs for Water Availability	Groundwater modeling to evaluate potential production	GIS files, use, and metadata documentation	Communicating with the public and other stakeholders	Technology transfer	Producing high quality technical reports	Using the TWDB BRACS and Groundwater databases	Management of projects to meet completion deadlines and within budget
Ron Green, PhD, PG	Project Manager-Technical Expert - Hydrogeology	PhD/Hydrology	■	■	■	■	■	■	■	■	■	■	■
Paul Bertetti, PG	Senior Technical Expert-Log Analysis; Technical Specialist – Chemistry	MS/Hydrology	■	■	■	■	■	■	■	■	■	■	■
Nate Toll	Task Manager - Technical Expert-Model Calibration, Recharge	MS/Hydrology	■	■	■	■	■	■	■	■	■	■	■
Ron McGinnis	Senior Technical Expert-Structural Geology	MS/Geology	■	■	■	■	■	■	■	■	■	■	■
Leanne Stepchiski	Geologist	BS/Geology	■		■			■			■	■	■
Neil Deeds, PhD, PE	Task Manager Technical Data Analysis, Water Levels, Discharge, Hydraulic Properties	PhD/Civil Engineering	■	■	■	■	■	■	■	■	■	■	■
Daniel Lupton, PG	Technical Specialist - Delineation of Fresh, Brackish, and Saline Groundwater	MS/Hydrogeology	■	■	■	■	■	■	■	■	■	■	■
Toya Jones, PG	Technical Specialist – Data Analysis	MS/Hydrogeology	■	■	■	■	■	■	■	■	■	■	■

Figure A-1. Qualifications and experience of the SwRI Team Personnel. Resumes for key Team members are included in ATTACHMENT B.

Figure A-1 provides an overview of the qualifications and expertise of our proposed project personnel in the areas of particular relevance to evaluating the brackish groundwater resources of the Trinity Aquifer. As the figure shows, our team offers experience in all of the requisite areas to ensure that this project's goals and objectives are achieved.

Collectively, our proposed personnel bring over 70 years of experience in developing GAMs under TWDB's Groundwater Availability Modeling Program. Our team brings a depth of expertise that will ensure that the highest quality updated model is produced for the TWDB. Finally, with the inclusion of several technical experts, our team has a peer review capability built into the project structure to provide added confidence to the TWDB and all involved stakeholders that the update of the Hill Country Trinity Aquifer conceptual model. Figure A-2 provides a summary of relevant project experience. Select project data sheets are provided to give a snapshot of the team's experience on related projects.

Project Name, Client, Location	Relevant Areas of Experience												
	General hydrogeology (hydrostratigraphy, aquifer properties, conceptual models, etc.)	Hydrogeology of the Trinity Aquifer	Interpretation and use of geophysical well logs (delineate hydrostratigraphic units, fresh and brackish groundwater, etc.)	Use of data from TWDB GAMs and other TWDB contracted studies	Delineation/Quantification of fresh and brackish groundwater	Delineation of hydrogeologic barriers and evaluation of impacts on groundwater flow and water quality	Modeling to determine groundwater availability	Use of TWDB BRACS and Groundwater databases	Development and use of GIS (visualize hydrostratigraphic units, estimate fresh and brackish groundwater, etc.)	Communication with public and other stakeholders	Technology transfer	Production of reports	Completion on schedule and within approved budget
Identification of potential Brackish Groundwater Production Areas – Trinity Aquifer	■	■	■	■		■	■	■	■	■	■	■	+
Alternative Groundwater Availability Model for the San Antonio Segment of the Edwards Aquifer for the Edwards Aquifer Authority	■	■	■	■	■	■	■	■	■	■	■	■	■
Groundwater Availability Model for the Northern Trinity and Woodbine Aquifers	■	■	■	■	■	■	■	■	■	■	■	■	■
Investigation of the Water Resources of the Western Edwards-Trinity Aquifer	■	■		■		■	■	■	■	■	■	■	■
Groundwater planning support for GMA-10	■	■		■	■			■		■	■	■	+
Availability Assessment of Fresh and Brackish Groundwater for Corpus Christi, TX	■		■	■	■		■	■		■	■		
Groundwater Availability Assessment in the Carrizo-Wilcox Aquifer in the Presence of Faulting, Texas	■		■	■		■	■	■	■		■	■	+
Development of Tectonic Framework of Texas	■	■	■			■					■	■	
Evaluation of the Water Resources of the Carrizo-Wilcox Aquifer for the Wintergarden Groundwater Conservation District	■		■	■	■	■		■	■	■	■	■	■
Evaluation of the Water Resources of Uvalde and Kinney Counties for the Edwards Aquifer Authority	■		■	■	■	■		■	■	■	■	■	■
Development of a Groundwater Flow Model for the Edwards-Trinity Aquifer in the Devils River Watershed	■	■	■	■	■	■	■	■	■	■	■	■	+

Note: + signifies project still ongoing

Figure A-2. Summary of Project Qualifications and Experience of the SwRI Team

Project Name, Client, Location	Relevant Areas of Experience												
	General hydrogeology (hydrostratigraphy, aquifer properties, conceptual models, etc.)	Hydrogeology of the Trinity Aquifer	Interpretation and use of geophysical well logs (delineate hydrostratigraphic units, fresh and brackish groundwater, etc.)	Use of data from TWDB GAMs and other TWDB contracted studies	Delineation/Quantification of fresh and brackish groundwater	Delineation of hydrogeologic barriers and evaluation of impacts on groundwater flow and water quality	Modeling to determine groundwater availability	Use of TWDB BRACS and Groundwater databases	Development and use of GIS (visualize hydrostratigraphic units, estimate fresh and brackish groundwater, etc.)	Communication with public and other stakeholders	Technology transfer	Production of reports	Completion on schedule and within approved budget
Brackish Water Availability in the Presence of Faulting for the Trinity Aquifer in Comal County	■	■	■	■	■	■	■	■	■			■	■
Development of Geochemical Sampling Plan and Data Analysis for Interformational Flow (IFF) Study	■	■	■	■	■	■	■	■	■	■	■	■	+
Hydrogeologic Support for the Upper Trinity Groundwater Conservation District	■	■	■	■		■	■	■	■	■	■	■	+
Mapping Fresh, Brackish, and Saline Groundwater in Aquifers in GMA 13	■	■	■	■	■	■	■	■	■	■			+
Delineation of Fresh and Brackish Groundwater Production Zones in San Patricio County	■		■	■	■	■	■	■	■	■			■
Impacts of Pumping Brackish Groundwater from a Wellfield near Lake Jackson, TX	■		■	■	■	■	■	■	■		■	■	■
Estimated Volume and Availability of Brackish Groundwater in Matagorda County, Texas	■		■	■	■		■	■	■	■	■	■	■
Aquifer Storage and Recovery Feasibility Study in the Trinity Aquifer in Comal County	■	■	■		■	■		■	■			■	■
Impaired Water Study for Tarrant Regional Water District	■		■	■	■		■	■	■	■	■	■	■
Aquifer Storage and Recovery Feasibility Study for the Northern Trinity Aquifer in Tarrant County	■	■		■	■				■	■	■	■	■
Hydrogeologic Support for Barton Springs Edwards Aquifer Conservation District	■	■		■	■		■		■		■		■
Use of Geochemical Data to Improve Groundwater Flow Models of the Gulf Coast Aquifer, Texas	■			■	■		■	■	■		■	■	
Impacts of Faults on Groundwater Flow During Uranium Mining Operations in the Goliad County	■		■	■		■	■	■	■		■	■	
Groundwater modeling to support planning for GMA-8	■	■		■			■		■	■	■	■	■

Figure A-2. Summary of Project Qualifications and Experience of the SwRI Team (Cont.)

Proposed Staff's Experience on Similar Projects

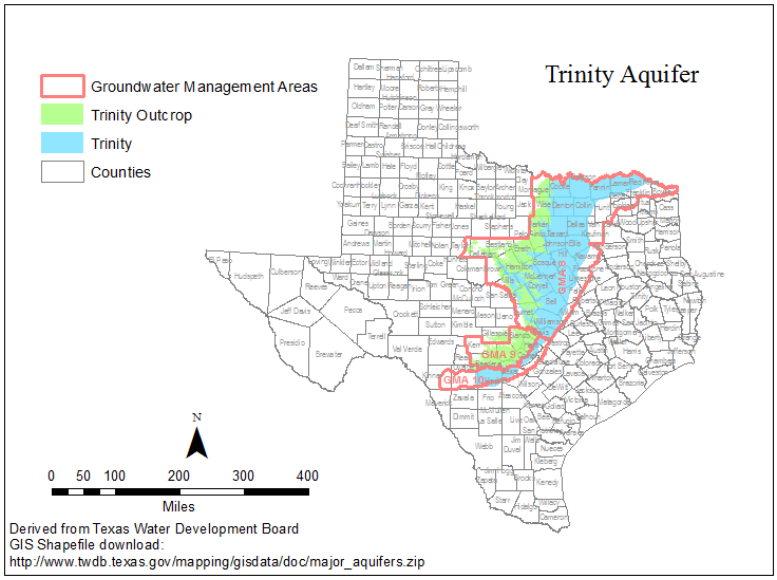
PROJECT

Identification of Potential Brackish Groundwater Production Areas – Trinity Aquifer

Client: Texas Water Development Board
Period of Performance: January 6, 2016 – August 31, 2017
Cost: $420,000
Proposed Personnel That Worked on Project and Role:
Leanne Stepchinski/Project Manager
Ronald McGinnis/Geologist
Ron Green/Principal Investigator
Paul Bertetti/Water Chemist
Nate Toll/Modeler

Southwest Research Institute® is in the process of evaluating the brackish water resources of the Northern Trinity Aquifer and the Trinity (Hill Country) Aquifer. Groundwater analytical results and geophysical well logs will be used to delineate fresh, brackish, and saline groundwater both vertically and horizontally in these aquifers. A technique for estimating total dissolved solids (TDS) in the aquifers will be developed to classify groundwater salinity based on the TDS concentrations. Methods will also be established to calculate and quantify the volume of available fresh, brackish, and saline groundwater in the Northern and Hill County Trinity aquifers.

Potential production areas will be delineated, including those separated by hydrogeologic barriers that prevent significant impacts to water availability or water quality in any part of the same or other fresh water aquifers. A stratigraphic framework model will be developed to determine the volume of brackish groundwater that the potential production areas are capable of producing without causing significant impact to water quality and quantity over a 30-year and a 50-year period.



PROJECT

Modeling Groundwater Dominated by Preferential Flow: Devils River Watershed, South Texas, USA

Client: Nueces River Authority

Period of Performance: 2014 to 2015

Cost: $135,000

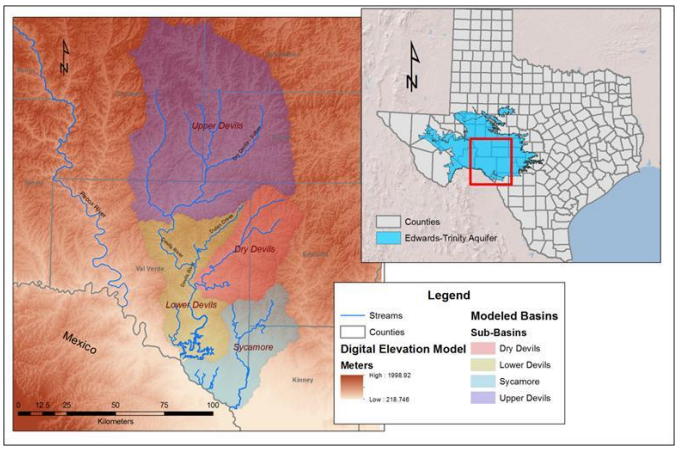
Proposed Personnel That Worked on Project and Role:

Ronald Green/Project Manager Nate Toll/Modeler

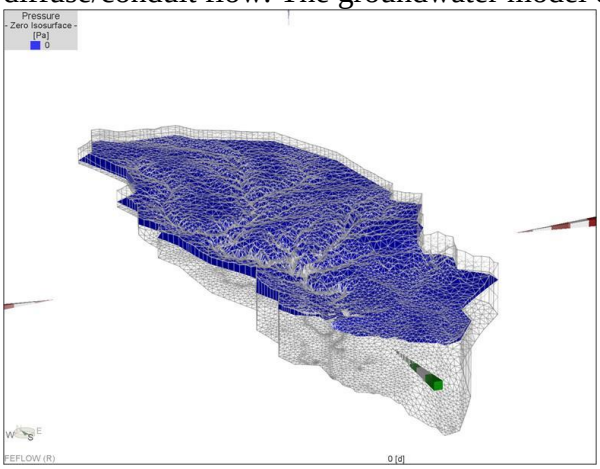
Paul Bertetti/Water Chemist

A groundwater flow model has been developed to simulate the hydraulic response of the Devils River watershed in south-central Texas, a karst aquifer located in a semi-arid environment with preferential flow paths aligned along the major river channels. The Devils River watershed provides an average of 263,000 acre-ft/yr to Amistad Reservoir, even though the watershed is in a semi-arid environment. The river channel exhibits a defined 50-mile reach of live water of the 140-mile long river. The upper 90 miles of Devils River are typically dry with occasional flow only during periods of significant precipitation.

Development of the conceptual model and construction of the numerical model are predicated on an assortment of data and analyses including well capacity/location correlation, geophysical survey to image the subsurface of river channels, groundwater elevations, and aquifer hydraulic response to recharge events. Annual precipitation in the area varies widely, but is typically under 50 mm/yr (20 in/yr), a common demarcation when specifying a semi-arid environment.



The numerical model was developed using FEFLOW, a sophisticated and flexible finite-element groundwater flow simulator that includes numerous options to accommodate coupled diffuse/conduit flow. The groundwater model domain is defined to be coincident with the surface watershed. Although groundwater basins and surface watersheds are not necessarily coincident, particularly in karst carbonate aquifers, there are no compelling data or information that support establishing groundwater basin boundaries different than the surface watershed boundaries. Recharge was calculated from precipitation records. Long-term monthly precipitation values were used to establish steady-state hydraulic conditions. Daily precipitation data extracted from NEXRAD were used to model the transient period of November 2014 to August 2015.



PROJECT

Development of a Finite-Element Method Groundwater Flow Model for the Edwards Aquifer

Client: Edwards Aquifer Authority

Period of Performance: 2012 to 2015

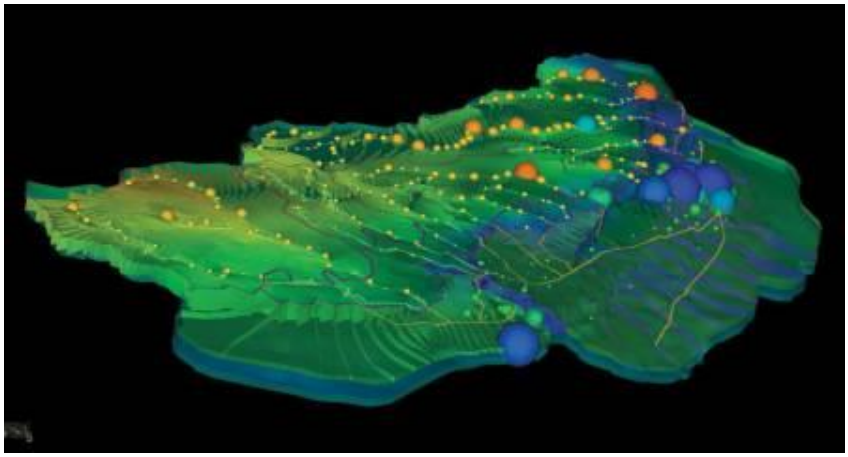
Cost: $1,090,000

Proposed Personnel That Worked on Project and Role:

Ronald Green/Project Manager — Nate Toll/Modeler

Paul Bertetti/Water Chemist — Ronald McGinnis/Geologist

Southwest Research Institute® developed an alternative groundwater flow model of the San Antonio segment of the Edwards Aquifer to provide an independent numerical tool against which to compare with the existing Edwards Aquifer groundwater availability model. The alternative model was developed to be conceptually independent from existing models. The fundamental difference between the alternative model and past is the method used to input recharge. Previous groundwater models of the Edwards Aquifer included only the Recharge and Confined zones. This finite-element model includes the Contributing Zone and calculates recharge directly from precipitation. The model includes a three-layer model in the Contributing and Recharge Zones. Inclusion of the Upper and Lower Glen Rose Formations allows for subsurface recharge to be conveyed from the Contributing Zone to the Recharge Zone without having to estimate recharge at the upgradient boundary of the Recharge Zone.



The major river basins in the Contributing Zone were characterized as hydraulically independent. By doing this, surface-water and ground-water flow from each basin to adjoining basins was minimized. This characterization honored the conceptual model developed for the Contributing Zone in which surface water and ground-water flow in each basin was mostly restricted to each basin. The alternative model successfully replicated the general response of the Edwards Aquifer. The alternative model was successful in matching low discharge at the two springs. Matching low discharge is recognized to be more important than matching high discharge in model performance. Agreement between simulations and observations is encouraging when compared with existing models, given that the alternative model has the additional constraint imposed by the recharge model and a decreased degree of freedom due to the fact that recharge is calculated solely on precipitation and is not a specified, calibrated input variable. These attributes of the alternative model qualify it for future use to provide the Edwards Aquifer Authority with an independent numerical tool to evaluate aquifer responses to different spatial and temporal patterns of precipitation, recharge, and pumping.

PROJECT

Focused Groundwater Flow in a Carbonate Aquifer in a Semi-Arid Environment

Client: Coypu Foundation

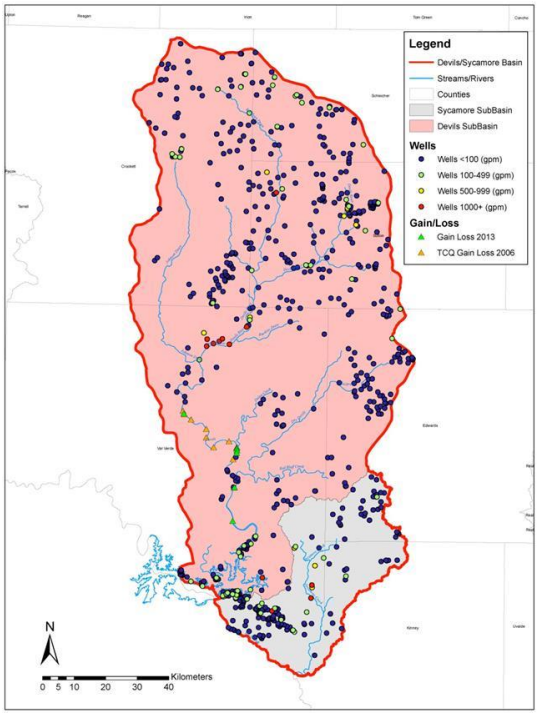
Period of Performance: 2014 to 2015

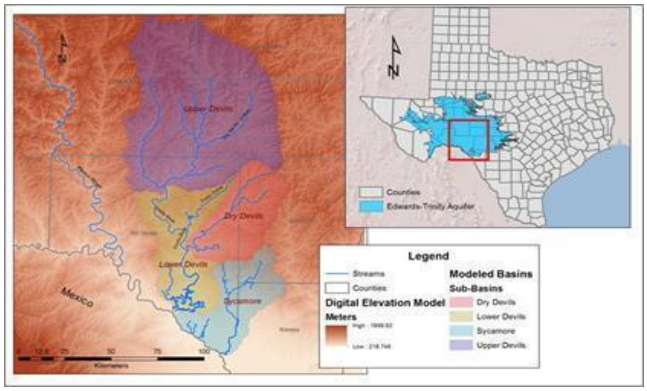
Cost: $50,000

Proposed Personnel That Worked on Project and Role:

Ronald Green/Project Manager Paul Bertetti/Water Chemist

An efficient conveyance system for groundwater is shown to have formed in a karst carbonate watershed located in a semi-arid environment. This conveyance system comprises preferential flow pathways that developed coincident with river channels whose locations appear to date to the early days of regional uplift and exhumation of the carbonate formations. A strong correlation between wells with high pumping capacity and proximity to higher-order river channels (i.e., within 2.5 km) was used as evidence of preferential flow pathway presence. The principle factors that contributed to development of the preferential flow paths are the presence of a limestone-rich formation and recharge that has been geomorphologically focused toward river channels.





Flow measurements in the Devils River measured under relatively high- and low-flow conditions supports the hypothesis that the river is gaining in downstream reaches at a rate that exceeds the added size of the watershed. This characteristic leads to perennial river flow being restricted to only the lower reach of the river. Lastly, water-budget analysis of the Devils River watershed supports the interpretation that essentially all of the recharge to Amistad Reservoir that is derived from the Devils River watershed is contributed as surface flow from the river and that there is minimal underflow or cross-formational flow from the watershed at the point the watershed abuts the reservoir. Recognition of these preferential pathways in proximity to river channels provides a basis to determine where high capacity wells are likely (and unlikely) and suggests that groundwater flow within the watershed is relatively rapid, consistent with flow rates representative of karstic aquifers. This understanding provides a basis for better informed decisions regarding water-resources management in a semi-arid environment.

PROJECT

Hydraulic Assessment of Karstic Carbonate Aquifers

Client: Coypu Foundation

Period of Performance: 2014 to 2015

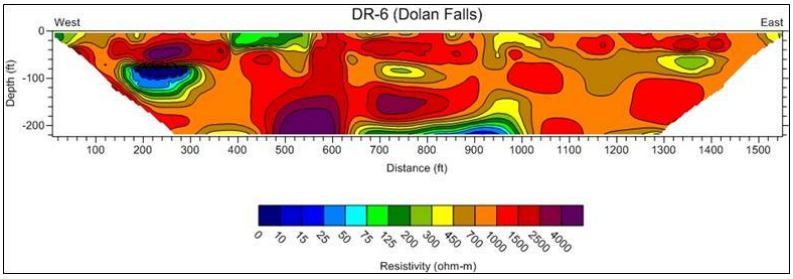
Cost: $50,000

Proposed Personnel That Worked on Project and Role:

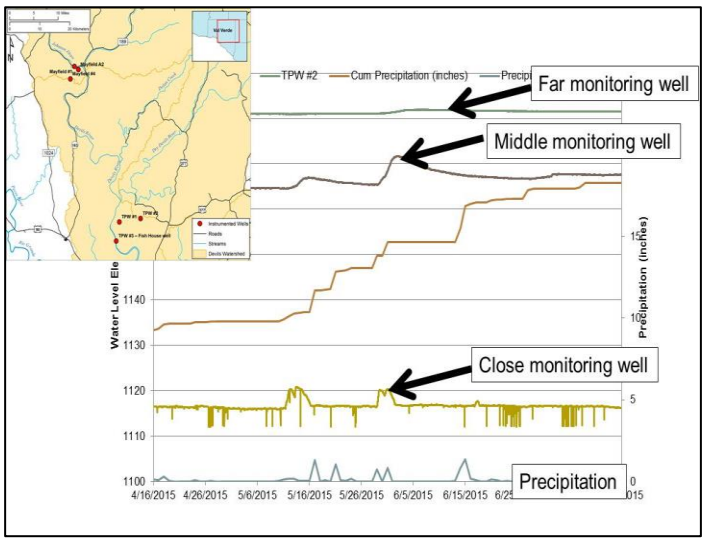
Ronald Green/Project Manager — Nate Toll/Modeler

Paul Bertetti/Water Chemist — Ronald McGinnis/Geologist

The water resources of the Devils River and lower Pecos River watersheds were last comprehensively evaluated over 40 years ago. Although these evaluations were comprehensive at that time, advances in technology; improvements in understanding the regional hydrogeology of south central Texas; and refinements is measurements of recharge, discharge, and water budgets allow for more accurate assessment of the water resources than was possible at that time. Representatives of Val Verde County would be better positioned and prepared to make decisions regarding management of its water resources if its water resources were assessed using these advancements in technology and hydrogeology.



An assortment of field surveys and supporting analyses have been performed to improve an understanding of the hydro-geology of the karstic Edwards-Trinity Aquifer. Field surveys and analyses included well capacity/location correlation, geophysical survey to image the subsurface of river channels, groundwater elevations, and aquifer hydraulic response to recharge events. Two networks of groundwater elevation monitoring stations were installed in the Devils River watershed to monitor changes in groundwater elevation in response to significant rain events. In each network, three wells were monitored. One well was located close to the river or draw channel, one well was located on the mesas at a distance of 2-3 miles from the channel, and the third well was located approximately midway between the proximal and distal wells. In this way, the three wells have been able to detect whether there is a more rapid response in the subsurface near the river channels (e.g., near the preferential flow paths aligned with major rivers) compared with the hydraulic response distal from the river channels. This project is ongoing.



PROJECT

Assessment of Groundwater Ages, Flow Rates, and Flow Paths in the Carrizo-Wilcox Aquifer, Wintergarden District

Client: Wintergarden Groundwater Conservation District

Period of Performance: 2015 to 2016

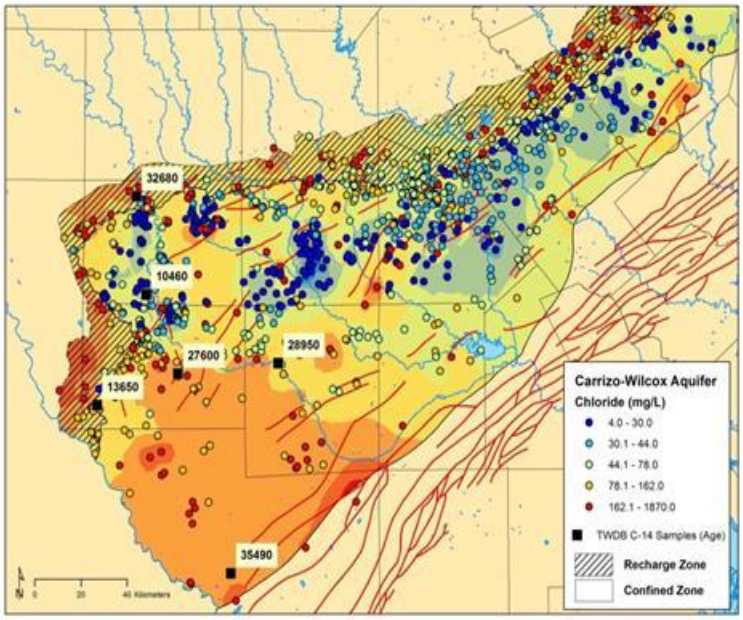
Cost: $463,000

Proposed Personnel That Worked on Project and Role:

Ronald Green/Project Manager — Nate Toll/Modeler

Paul Bertetti/Water Chemist — Ronald McGinnis/Geologist

The Wintergarden Groundwater Conserva-tion District has historically relied on the Carrizo-Wilcox Aquifer as the principle source of water. Although this resource is relatively abundant, large-scale pumping for irrigation during the 20th century depressed the potentiometric surface by as much as 400 ft when compared with pre-development conditions. Although the large pumping rates experienced during the 1965-1985 period have been significantly decreased, current pumping rates from the Carrizo-Wilcox Aquifer in the Wintergarden Groundwater Conservation District still exceed the estimated rate of recharge (Green et al., 2009). Added to this imbalance in the water budget, the advent of unconventional oil and gas development in the Eagle Ford play has imposed greater stress on the Carrizo-Wilcox Aquifer as its relatively inexpensive and fresh quality water has been used to support the large water demands by hyrdraulic fracturing.



Recent studies of the Carrizo-Wilcox aquifer in the Wintergarden Groundwater Conservation District and southern Uvalde County suggest that the source of recharge to the aquifer in northern Zavala County is primarily from the Edwards Aquifer with different contributors to recharge in western Zavala County. Based on historical data, the sources of recharge also appear to vary across the region (from Atascosa to Zavala Counties). Given that the Carrizo-Wilcox aquifer is the primary source of drinking and irrigation water in the Wintergarden District and the known rate of drawdown due to groundwater use, it is important to confirm the nature and timing of recharge in the aquifer. Similarly, developing an understanding of the flow paths and flow rates within the aquifer will assist in managing this resource by indentifying critical recharge pathways. A broader understanding of the nature and potential changes in recharge to the Carrizo-Wilcox due to changing climatic conditions would be of general benefit. This project is ongoing.

PROJECT

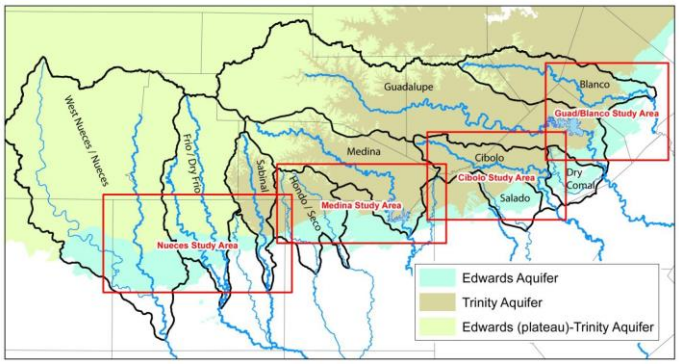
Development of a Geochemical Sampling Plan and Data Analysis for Interformational Flow (IFF) Study

Client:	Edwards Aquifer Authority (EAA)
Period of Performance:	2016 - 2018
Cost:	$300,200

Proposed Personnel That Worked on Project and Role:

Paul Bertetti/Geochemist

Southwest Research Institute® (SwRI®) is currently developing a detailed and targeted water quality sampling plan and geochemical analysis approach to help meet the objectives of the Edwards Aquifer Authority (EAA)'s Interformational Flow (IFF) Study, which seeks to quantify the volume of groundwater that flows from the Trinity Aquifer to the Edwards Aquifer in four study areas. The sampling plan will define the types, quantities, and frequencies of geochemical data necessary for a successful study, and includes a preliminary analysis of potential areas in which interformational flow may occur.



Following collection and chemical analysis of the water samples, SwRI will conduct detailed geochemical and geostatistical analyses and modeling to develop evidence for the existence of interformational flow. Data from the new sampling will be assessed along with historical water quality data. Differing analytical approaches will be employed over the three-year project. These approaches include spatial analyses coupled with statistical evaluations, such as principal component analysis and cluster modeling, as well as time-series analysis of data from well transects. Equilibrium and reaction path geochemical modeling will be used to identify and characterize potential flow paths. For areas where interformational flow is evident, an estimate of the annual volume of groundwater flow between the Edwards and Trinity aquifers will be calculated. Results of the analyses and modeling will be presented in a summary report at project's completion.

PROJECT

Evaluation of the Effect of Salt-Water Injection Wells on Groundwater

Client: Wintergarden Groundwater Conservation District

Period of Performance: 2012 to 2015

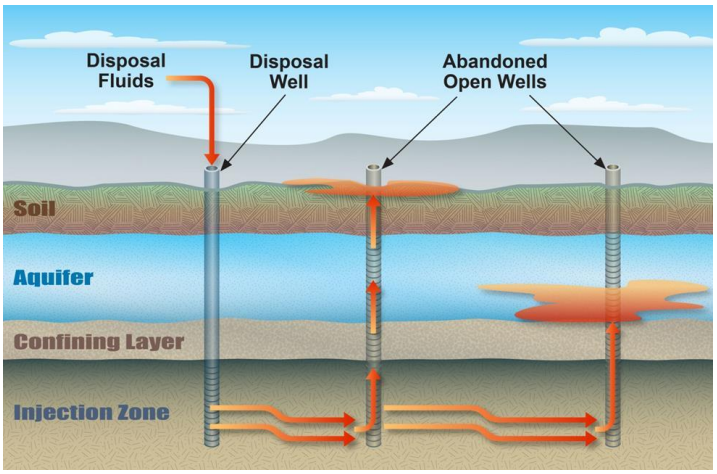
Cost: $250,000

Proposed Personnel That Worked on Project and Role:

Ronald Green/Project Manager Nate Toll/Modeler

Paul Bertetti/Water Chemist

Advances in unconventional oil/gas development have led to rapid growth of hydraulic fracturing of gas shales and tight sands. The increase in drilling activity has raised concerns regarding the environmental impacts of these innovative technologies. Debate continues regarding the environmental threats posed by hydraulic fracturing with little consensus in the risks posed by this developing activity. Hydraulic fracturing activities generate liquid wastes through several mechanisms. The liquid waste includes flowback (the water-based solution that flows back to the surface during and after the completion of hydraulic fracturing), produced water (water that is produced along with the oil and gas), and formation waters.). In the United States, most of produced water and much of the flowback is disposed through deep underground injection. Injection wells are used to dispose most of hydraulic fracturing waste liquids in Texas, a state that accounts for a sizeable fraction of unconventional oil/gas development. In 2007, there were more than 216,000 active oil and gas wells and more than 50,000 permitted oil and gas injection and disposal wells in Texas. As of 2011, 12,610 of these were permitted disposal wells.



Threats arise when injecting flowback and produced water into spent oil and gas formations or other locations where there are existing wells that penetrate the target disposal horizon, and these wells are either not plugged, improperly abandoned, defective in terms of competent casing, improperly or ineffectively grouted, or simply with unknown status. Such existing wells are a threat because they can provide pathways for injected fluids to migrate from the horizon of injection to the groundwater, surface, or, into a usable aquifer. Upward migration of waste fluids can be either within the casing of defective wells or within the annular space of improperly or ineffectively grouted wells that still might be operational. This inadvertent release of waste fluids is referred to as breakout.

Southwest Research Institute provides rigorous analysis of the potential for injection wells to cause contamination of existing groundwater resources due to breakout or other inadvertent outcomes from injection. Evaluations include hydraulic analysis, geophysical log interpretation, water-chemistry analysis, stratigraphic interpretations, and groundwater modeling.

PROJECT

Investigation of the Groundwater Systems in the Wintergarden Groundwater Conservation District

Client: Wintergarden Conservation District

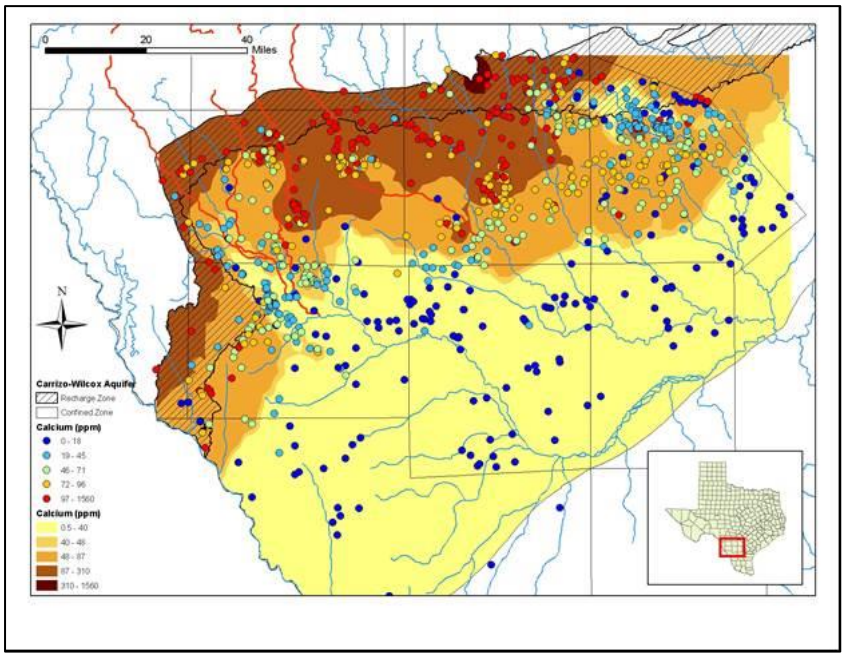
Period of Performance: 2007 to 2008

Cost: $140,000

Proposed Personnel That Worked on Project and Role:

Ronald Green/Project Manager
Paul Bertetti/Water Chemist
Ronald McGinnis/Geologist

Southwest Research Institute® conducted an evaluation of the groundwater systems in the Wintergarden Groundwater Conservation District (WGCD) located in Zavala, Dimmit, and LaSalle Counties, Texas. The Carrizo-Wilcox Aquifer is the principal source of water in the WGCD and was the primary focus of both phases of this evaluation. The objective of the evaluation I was to perform a focused investigation to improve understanding of the Carrizo-Wilcox Aquifer recharge mechanisms, and from the improved understanding, provide a new estimate of recharge rates.



Field inspections and resistivity surveys were conducted in selected areas where floodplains cross the Carrizo-Wilcox Aquifer recharge zone to determine the capacity of each river and floodplain system to recharge the Carrizo-Wilcox Aquifer and to determine the sources and rates of recharge of the Carrizo-Wilcox Aquifer in the WGCD. Results from these surveys indicated that recharge of the Carrizo-Wilcox Aquifer is dominated by recharge focused in the Nueces and Leona river floodplains, with minimal focused recharge in the floodplains of Elm, Turkey, and other creeks that cross the Carrizo-Wilcox Aquifer recharge zone, and with minimal distributed recharge over the Carrizo-Wilcox Aquifer recharge zone. Evaluation of water chemistry suggests groundwater flow is toward the south and east in Zavala, Frio, and Atascosa Counties, and more eastward flow in Dimmit County and southern Zavala County. There may be mixing of waters in southern Dimmit and Webb and LaSalle Counties, but there is less mixing and more eastward flow near the Dimmit/Zavala and LaSalle/Frio county lines.

PROJECT

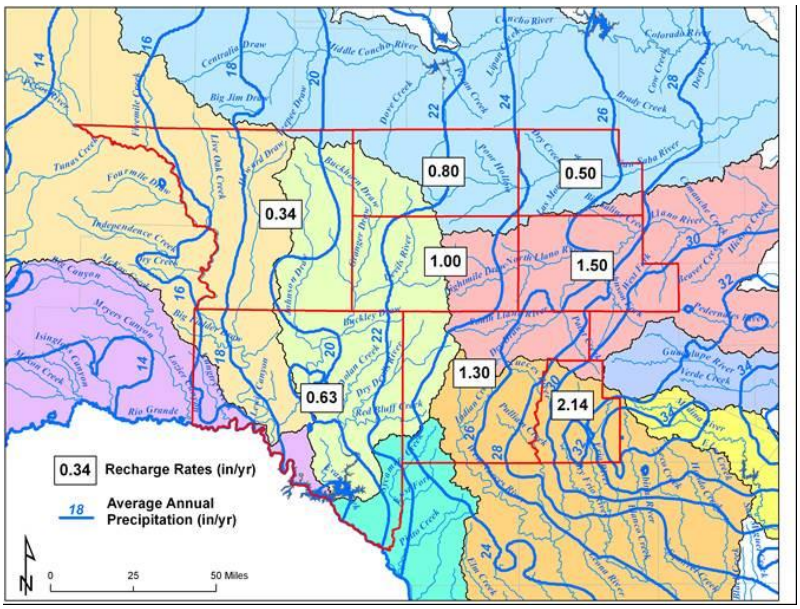
Investigating the Water Resources of the Western Edwards-Trinity Aquifer

Client:	Sutton County Underground Water Conservation District
Period of Performance:	2009 to 2010
Cost:	$75,000

Proposed Personnel That Worked on Project and Role:

Ronald Green/Project Manager Paul Bertetti/Water Chemist

Southwest Research Institute® conducted a comprehensive assessment of the hydrogeology of the Edwards-Trinity Aquifer was undertaken to provide independent determination of "desired future conditions" for the western Edwards-Trinity Aquifer as required by HB 1976. The Texas Water Development Board requested that a Texas Water Development Board approved groundwater management model (GAM) be used in the process of establishing Desired Future Conditions, but will accept alternative methodologies when uncertainty in GAM results is high. An acceptable alternative methodology is a quantitative water budget analysis. Water budget analyses were performed for an eight county area over the western Edwards-Trinity Aquifer. The eight counties included in the project were Crockett, Edwards, Kimble, Menard, Real, Schleicher, Sutton, and Val Verde. The assessments relied on water budget analyses of hydrologically distinct sub-areas in the western Edwards-Trinity Aquifer.



River discharge measurements provided an opportunity to calculate recharge for the area that contributes to baseflow in the river. Long-term river discharge measurements were corrected for baseflow using an automated discharge recession separation algorithm. This analysis provided the fraction of total discharge that is attributed to baseflow. Long-term average annual river discharge values corrected to baseflow were converted to estimates for recharge for each contributing area analyzed. Recharge values were correlated with precipitation in the study area. The percentage of precipitation that recharged the Edwards-Trinity Aquifer varied from 7 percent in the eastern side of the study area where average annual precipitation is as high as 33 inch/year to 2 percent in the western side of the study area where average annual precipitation is 15 inch/year. Recharge for each county in the study area was calculated for average precipitation conditions and predicted for periods when precipitation was reduced by 10, 20, and 30 percent. Calculated and predicted recharge is compared with recharge values assigned to the 2004 Edwards-Trinity Aquifer GAM and the groundwater availability documented in the 2007 Texas State Water Plan.

PROJECT

Evaluation of the Edwards Aquifer in Kinney and Uvalde Counties, Texas

Client: Edwards Aquifer Authority

Period of Performance: 2005 to 2006

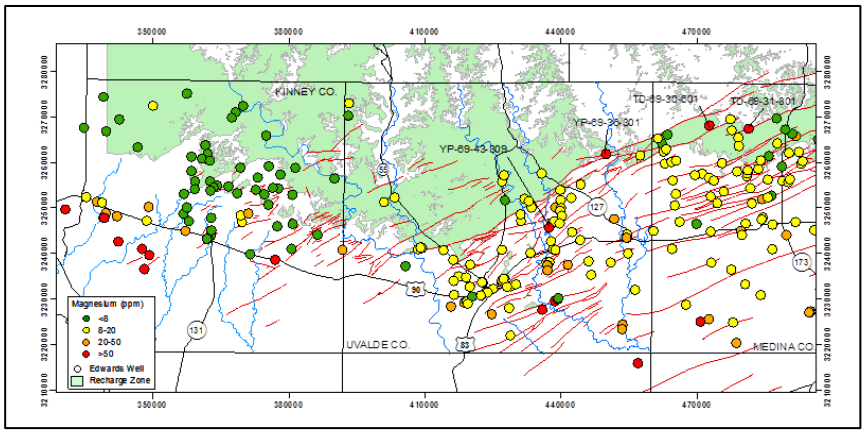
Cost: $240,000

Proposed Personnel That Worked on Project and Role:

Ronald Green/Project Manager — Paul Bertetti/Water Chemist

Ronald McGinnis/Geologist — Alan Morris/Geologist

Southwest Research Institute® develop an updated conceptual model for the groundwater systems of Uvalde and Kinney counties in central Texas that (i) incorporates existing and newly collected data on hydrology, geochemistry, and structural geology, and (ii) clearly defines the hydraulic and hydrogeologic relationship between the Uvalde pool and the San Antonio pool of the Edwards Aquifer.



Refined, or new, conceptual models of the groundwater systems were developed for Kinney and Uvalde counties as part of this project. Assessment of the stratigraphic and facies geology, structural geology, water chemistry, and hydrogeology provided the basis to the designation of a separate pool in the Edwards Aquifer in Kinney County. This pool, referred to as the Kinney County pool, extends from a groundwater divide between Mud and Pinto creeks on the west to a zone of low permeability near the Kinney County/Uvalde County line on the east. Although the elevations of groundwater are higher in eastern and central Kinney County than in Uvalde County, a structural hydraulic barrier impedes the eastward flow of groundwater in the Edwards Aquifer from Kinney to Uvalde counties. Evidence suggests that most of the recharge from the West Nueces River basin recharges the Kinney County pool, not the Uvalde pool. This new conceptual model does not assert that there is no groundwater flow from the Kinney County pool to the Uvalde pool, only that there is limited or minimal flow.

Progress results indicated a large volume of water is discharged from the Edwards Aquifer via the Nueces River and Frio River floodplains. The structure of the Knippa Gap was evaluated to help understand groundwater flow in Uvalde County. Geologic structural maps of the Edwards Aquifer developed during this project provided an improved understanding of the principal components to groundwater flow through the Knippa Gap, a 4-mile wide constriction to groundwater flow in central Uvalde County. Refinements in the conceptual model for the groundwater systems in Uvalde and Kinney counties indicated that sources of recharge and volumes of discharge assumed in previous water-budget calculations require adjustment.

PROJECT

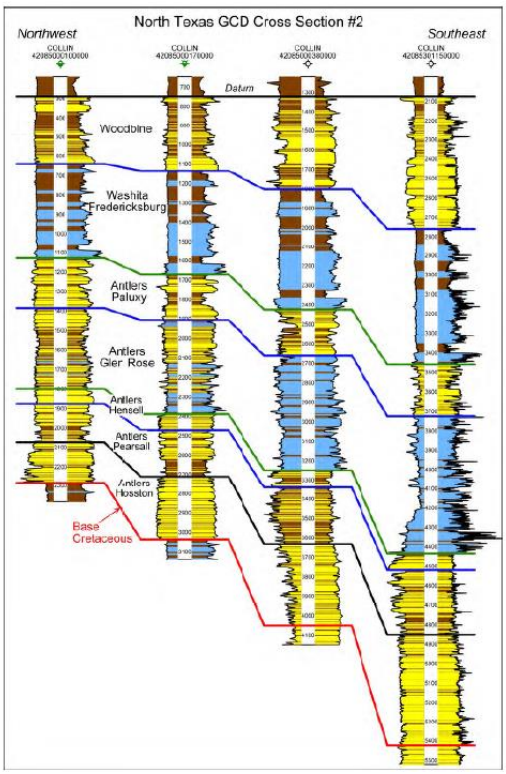
Groundwater Modeling to Support Planning for GMA-8

Client: GMA-8 GCDs

Period of Performance: 2015

Cost: $100,000

Proposed Personnel That Worked on Project and Role:
Neil Deeds/Modeler



INTERA and the Bureau developed new conceptual and numerical models for the Northern Trinity and Woodbine Groundwater Availability model. The conceptual model included a complete reassessment of stratigraphy, lithology, and water quality in the Northern Trinity and Woodbine aquifers. Over 1,500 geophysical logs were compiled in a database, for determination of stratigraphy, lithology, and water quality. Log analysis was performed by Scott Hamlin of the Bureau. Stratigraphic surfaces were created from the geophysical log picks. New estimates of aquifer productivity were made based on aquifer tests and specific capacity information. The analysis of over 1,700 wells for water quality was performed in order to determine hydrogeochemical facies (providing information about the likely evolution of the groundwater system), as well as creating aquifer-specific maps of total dissolved solids and chloride. Areas where brackish water existed were identified in each formation that comprises the Trinity Aquifer.

A numerical model with 8 layers and over 12,000,000 grid cells was developed based on the conceptual model. The relatively fine grid resolution of ¼ mile allows highly resolved placement of stream and spring boundaries, as well as pumping locations. A surficial layer was included that allowed for scale-appropriate simulation of shallow recharge and discharge to surface water features. The numerical model was calibrated with PEST primarily by adjusting hydraulic parameters within ranges defined during the conceptualization. Calibration targets consisted of approximate water age (looking at water quality versus simulated water age), artesian head conditions in predevelopment, and measured water levels. The numerical model is currently being used to support planning in GMA-8.

PROJECT

Update of the Northern Trinity and Woodbine Groundwater Availability Model for GMA 8

Client: Subset of GCDs in GMA-8

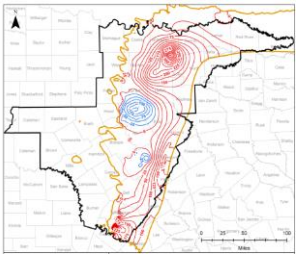
Period of Performance: 2012 to 2014

Cost: $1,500,000

Proposed Personnel That Worked on Project and Role:

Scott Hamlin / Well Analyst Neil Deeds/Modeler

Daniel Lupton / Well Analyst



INTERA has performed groundwater modeling with the updated Northern Trinity and Woodbine Groundwater Availability model to support planning in GMA-8. This is the same model that is proposed to be used to estimate brackish availability for the northern portion of the Trinity Aquifer. Proposed modeler Neil Deeds has performed many of the simulations for GMA-8 using the NTWGAM model. These simulations have included analysis of impacts, both drawdown and groundwater capture, of increased pumping on adjacent counties and hydrogeologic units. Postprocessing has included calculation of groundwater availability by county, as well as average remaining volumes of water available. These calculations are automated using the ArcGIS Python libraries. This improves reproducibility and efficiency. This work is continuing as GMA-8 prepares for the 2016 round of planning.

PROJECT

Methods and Tools for Stream-lining Analysis and Management of Aquifer Test Data in GMA 8

Client: TWDB

Period of Performance: 2010 to 2012

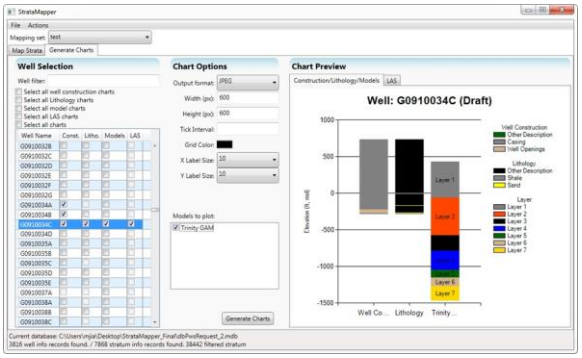
Cost: $200,000

Proposed Personnel That Worked on Project and Role:

Neil Deeds/Programming and GIS

Daniel Lupton / Well Analyst

INTERA developed a database and suite of visualization tools to support the analysis of information from approximately 1,000 aquifer tests and 4,000 public water supply wells located in GMA 8. Information was obtained from the TCEQ PWS Program. The well information includes more than 100,000 scanned pages, which were assembled into seven PDF document types that include driller‘s logs, well construction sheets, tabulations of borehole lithology, aquifer test results, laboratory reports of water quality, and geophysical logs. From the tabulated pumping rates and drawdown values in the aquifer test documents, text files for over 900 aquifer tests were generated.



In addition to the PDF documents and the aquifer test data files, project data includes a version of the Access database that TCEQ maintains to identify and characterize PWS wells, which are located across 45 counties. To facilitate the analysis of the project information, the project deliverables include shapefiles, visualization tools, and analysis tools that are compatible with ArcMap—the main component of ESRI's ArcGIS suite of geospatial processing programs, which is commonly used to view, edit, create, and analyze geospatial data. The shapefiles can be used to identify wells with different sets of information and attributes. The analysis tools provide the capability to develop charts showing well construction, lithology, layers in groundwater models, and measured drawdowns from aquifer tests. The visualization tool can be used to view the PDF documents as well as charts generated by the analysis tools.

PROJECT

Brackish Water Availability in the Presence of Faulting for the Trinity Aquifer in Comal County

Client: Texas General Land Office (INTERA sub to Arcadis)

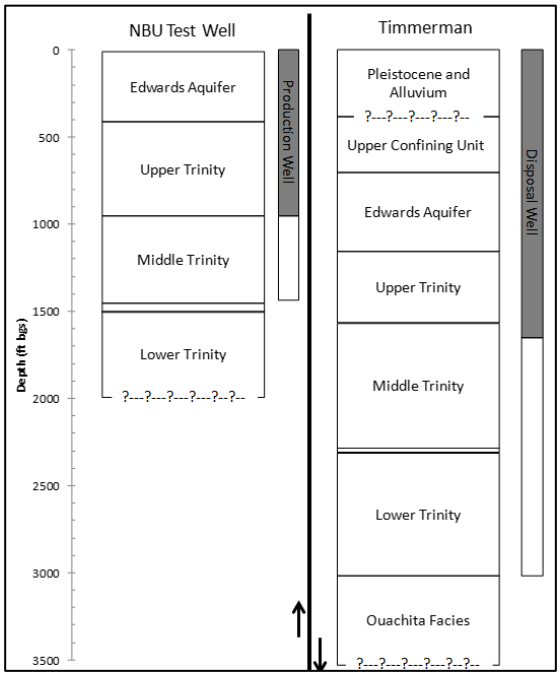
Period of Performance: 2013

Cost: $40,000

Proposed Personnel That Worked on Project and Role:

Daniel Lupton / Well Analyst

Neil Deeds / Modeler



INTERA, as a subcontractor to an A&E firm, provided hydrogeological technical support for a Texas General Land Office project to evaluate the feasibility of desalinating brackish groundwater in Comal County. INTERA's role included determining the expected brackish water production rate, the water quality of this raw source (including estimating concentrations of scalants and other specific constituents), and the feasibility of disposing of the saline waste stream using a deep injection well. INTERA also provided preliminary cost estimates for construction and operation of the production and disposal wells. The hydrogeology of the site was complex, with a significant fault running very near the location of the proposed well. INTERA determined through modeling that this fault was likely to increase drawdown and may affect the quality of the raw water supply. INTERA proposed locating the disposal well on the other side of the fault, to increase the likelihood of isolation of the concentrate from brackish water resources updip of the fault.

The capital costs of the production and disposal wells were estimated to be about 30% of the total capital costs, and about 40% of operational costs. Estimated unit costs for water ranged between $6 and $7 per 1,000 gallons.

PROJECT

Hydrogeologic Support for the Upper Trinity Groundwater Conservation District

Client: Upper Trinity Groundwater Conservation District

Period of Performance: 2006 to Present

Cost: $250,000

Proposed Personnel That Worked on Project and Role:

Daniel Lupton / Well Analyst

Neil Deeds / Modeler

INTERA has provided hydrogeologic support for the Upper Trinity Groundwater Conservation District (UTGCD) for over 8 years. INTERA's support for UTGCD has also included review and assessment of well permit applications. A key component of some of these applications is determination of whether sufficient hydrogeologic barriers exist between the proposed well and existing wells in the region, so that existing wells would not see significant impacts from pumping in the proposed well. This assessment typically requires characterizing the vertical conductivity of units that separate the proposed well from existing wells, and performing groundwater modeling to assess drawdown impacts at the existing wells.

PROJECT

Aquifer Storage and Recovery Feasibility Study in the Trinity Aquifer in Comal County

Client: New Braunfels Utility (INTERA sub to Arcadis)

Period of Performance: 2012-2013

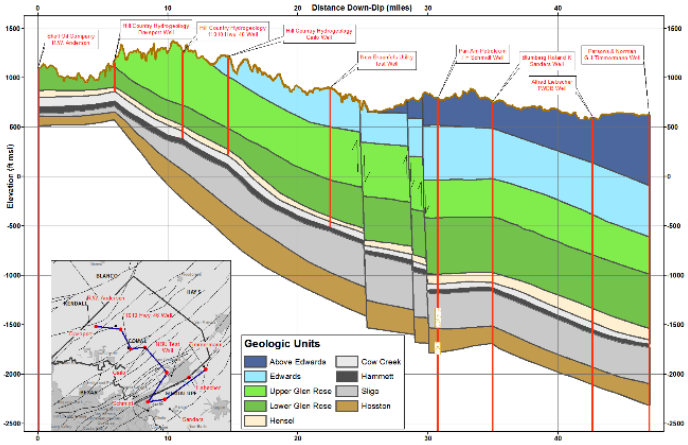
Cost: $35,000

Proposed Personnel That Worked on Project and Role:

Daniel Lupton / Well Analyst

Neil Deeds / Modeler

INTERA provided hydrogeological expertise and analyses as a key member of a consulting team that completed a feasibility assessment of the potential for ASR to serve as a water management strategy for New Braunfels Utility (NBU). While NBU has a diverse inventory of surface and groundwater supplies, most of the supply sources are subject to cutbacks during times of drought. In fact, the annual supply can be reduced by as much as 50% during a repeat of the drought of record (DOR). This project evaluated ASR as a means of supplementing the various NBU supply sources through a repeat of the DOR. INTERA performed a study of the hydrogeology of the region to provide guidance on the productivity and suitability of aquifers and other formations. This included a survey of the characteristics of existing wells in the area (in the Trinity Aquifer) and the review and analysis of geophysical logs to help evaluate deeper units (such as the Hosston-Sligo) that are not currently being pumped. INTERA also analyzed the hydrogeology of the brackish portion of the Edwards Aquifer in the region as a potential ASR site. This included determining the probable brackish water production rate, the water quality of this raw source, and the feasibility of disposing of the saline waste stream through a deep injection well. We also provided initial cost estimates for construction and operation of the production and disposal wells. Results of the assessment determined that ASR is a technically feasible solution warranting further development through the implementation of a pilot-phase project. The pilot-phase project will begin after regulatory discussions between NBU and Edwards Aquifer Authority have been finalized.



PROJECT

Incorporation of Geochemical Data to Improve Groundwater Models of the Gulf Coast Aquifer in GMAs 14, 15, and 16, TX

Client: Texas Water Development Board

Period of Performance: 2011 to 2013

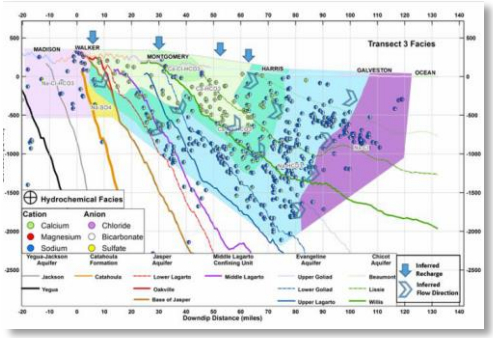
Cost: $385,000

Proposed Personnel That Worked on Project and Role:

Neil Deeds / Modeler

Daniel Lupton / Hydrogeologist

From 2011 to 2013, INTERA staff assembled and analyzed geochemical measurements from approximately 13,000 wells to confirm, and refine or modify, as appropriate, the conceptual flow model(s) for the aquifers in GMAs 14, 15, and 16. The geochemical data include both inorganic major ion chemistry and isotopic analyses. We developed work plans for and completed the sampling of groundwater wells for ions, stable isotopes, and radiocarbon in all three GMAs. The flow system, as determined by the geochemical approach, was compared to the interpretation of the groundwater flow on an intra-aquifer and an inter-aquifer basis. INTERA provided quantitative and qualitative estimates for the mixing of different source waters, the evolution of geochemical changes along a flow path, and the age of groundwater. This research was used to evaluate GAMs that have been previously developed for the Gulf Coast Aquifer and to provide an integrated hydrogeochemical conceptual framework for future groundwater flow models. Also as part of this study, INTERA staff investigated whether there are differences in the origin of brackish water in the inner coastal and the inland areas by comparing the geochemical signature of brackish water to the geochemical signature of the possible sources for brackish water.



PROJECT

Impacts of Faults on Groundwater Flow During Uranium Mining Operations in Goliad County, TX

Client: Uranium Energy Corporation

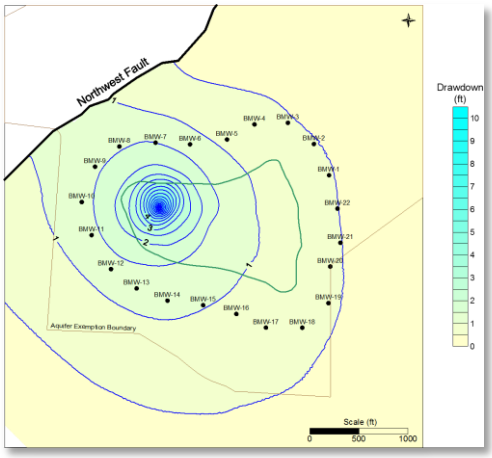
Period of Performance: 2012 to 2013

Cost: $65,000

Proposed Personnel That Worked on Project and Role:

Neil Deeds / Modeler

In 2012 and 2013, INTERA personnel supported Uranium Energy in a contested-case hearing regarding the effects of uranium mine operations on groundwater flow in Goliad County. Mr. Kelley and Mr. Deeds analyzed the hydrogeology of the local area, developed a fully-three dimensional model of the injection and extraction network, and provided expert testimony support in a State Office of Administrative Hearings (SOAH) action regarding the impact that the fault zone has on groundwater flow. INTERA argued that the fault zone provides hydraulic resistance to flow in ore body sands because of sand against clay juxtaposition as a result of the fault throw, and also because of mineralization within the fault zone. The INTERA experts supported the argument by defining the properties of the up-gradient fault zone through (1) structural surfaces and cross section development, (2) analysis of multi-level piezometer head data measured on both sides of the fault zone, (3) analysis of long-term aquifer tests designed to investigate fault zone transmissivity, and (4) development and calibration of a three-dimensional numerical model. The model was calibrated to both steady-state conditions and to two interference pumping tests conducted on opposite sides of the injection extraction field. Water level



responses were monitored in the pumping well and in twenty-six (26) observation wells located in the production zone within a radius of 2000 feet. Recoveries were also monitored and used as calibration data. We utilized MODFLOW-2000 to develop the model and the calibration was completed using Parallel PEST, including the steady state conditions and both interference aquifer tests head targets in the objective function.

PROJECT

Groundwater Availability Assessment in the Carrizo-Wilcox Aquifer in the Presence of Faulting, TX

Client: Confidential Client

Period of Performance: 2013 to 2014

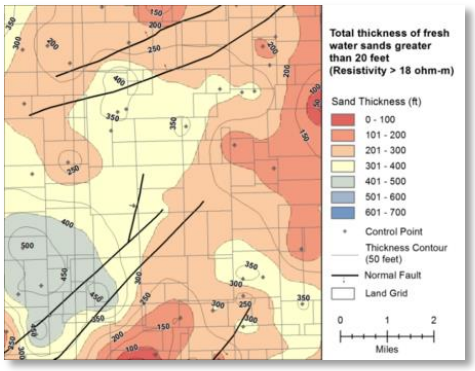
Cost: $150,000

Proposed Personnel That Worked on Project and Role:

Scott Hamlin / Well Analyst

Daniel Lupton / Well Analyst

Groundwater quality in the Carrizo-Wilcox Aquifer becomes very complex in the eastern portion of Texas. INTERA evaluated the groundwater availability and water quality in a study area consisting of approximately 485 square miles in Anderson, Cherokee, and Houston counties. Our project Team assessed 287 geophysical logs to perform a detailed local scale study of the hydrostratigraphy involving mapping of sand thicknesses, faulting, and water quality of the Carrizo-Wilcox Aquifer. Faulting played a significant role in the occurrence and distribution of fresh-water sands in the Simsboro Formation, and to a lesser degree, in the Carrizo Formation. Figures detailing the distribution of fresh-water sands greater than 40 feet deep clearly show that fresh-water sands in the Simsboro were most prevalent updip of the two main faults in the western portion of the study area. It is plausible that the faulting has reduced transmissivity of the Simsboro across the fault zone in that particular area by juxtaposing permeable units against nonpermeable units. The study clearly identified the potential target areas that would provide the highest potential production capacity while meeting the water quality constraints. INTERA also developed the cost for an aquifer testing program consisting of two test wells and two observation wells.



ATTACHMENT B. Resumes

RONALD T. GREEN, Ph.D., P.G.
Institute Scientist
Department of Earth, Material, and Planetary Sciences
Geosciences and Engineering Division

Ph.D., Hydrology, University of Arizona, 1986
M.S., Geophysics, University of Utah, 1981
B.S., Geology, Grand Valley State University, 1978
B.S., Industrial Engineering, University of Michigan, 1972

Dr. Green is a groundwater hydrologist with research experience in groundwater resource assessment, multiphase and groundwater modeling, development and execution of laboratory- and field-scale experiments, and environmental geophysics. He has evaluated the hydraulic and hydrogeological aspects of glacial sediments, unconsolidated media, and fractured consolidated rock, with particular emphasis on karst terrains. Study areas have included central and south Texas, the Florida peninsula, the Caribbean, the Basin and Range Province in the western United States and northern Mexico, and the upper Midwest of the United States. Recent work has focused on characterization, water-budget analyses, and modeling of aquifers in south and central Texas with particular emphasis in evaluating recharge in semi-arid and temperate environments. This expertise has been extended to assessing the potential effects of unconventional oil and gas development using hydraulic fracturing on water resource availability and quality.

Dr. Green provides technical expertise in groundwater hydrology and environmental geophysics. He has served as the principal lead for karst hydrology investigations, including analyses of the dynamic hydraulic interaction among karst and fluvial groundwater systems and modeling groundwater flow through karst terranes. Dr. Green was the principal investigator for an internal research and development to design, build, and deploy a neutrally buoyant sensor to remotely map the pathway and morphology of karst conduits and to measure the velocity of groundwater flow in the conduits. This invention was recognized as one of the top 100 innovations in 2009 by R&D Magazine.

As the principal lead for environmental and hydrogeological geophysical services, Dr. Green has conducted DC resistivity, magnetics, and ground conductivity surveys. He has been active analyzing and modeling nonisothermal multi-phase flow through fractured porous media. Dr. Green was principal investigator of an in-depth study of thermally driven moisture through partially saturated porous media associated with a proposed high-level radioactive waste repository. This entailed designing and conducting laboratory-scale experiments to assess non-dimensional analysis and numerical modeling of heat and mass transfer mechanisms. Characterization methodologies included laboratory-based measurement of the material and hydraulic (saturated and unsaturated) properties of both consolidated and unconsolidated media and *in situ* measurement of saturated and unsaturated hydraulic conductivity and moisture content. Other contributions include water-resource projects in which aquifer pump tests, groundwater modeling, and hydrogeological characterization techniques were used to evaluate groundwater resources.

Before coming to Southwest Research Institute, Dr. Green conducted a range of hydrogeological investigations as an environmental consultant. These investigations addressed aquifer hydraulics, analytical and numerical modeling of groundwater flow and solute transport, and geophysical applications to hydrogeology.

PROFESSIONAL CREDENTIALS: Licensed Professional Geoscientist (Geology), in the State of Texas

PROFESSIONAL CHRONOLOGY: University of Arizona, Department of Hydrology and Water Resources: research associate, 1982–5; Fishbeck, Thompson, Carr and Huber, Engineers and Scientists: senior hydrogeologist, 1986–9; Southwest Research Institute: 1989-[senior research scientist, 1989-97; principal scientist, 1997-2002; staff scientist, 2002–7; institute scientist, 2007-present].

MEMBERSHIPS: American Geophysical Union; Geological Society of America (Fellow); South Texas Geological Society; San Antonio Geophysical Society; National Cave and Karst Research Institute (Board Member).

SELECTED PUBLICATIONS

Başağaoğlu , H., L. Gergen, and R.T. Green. 2015. Assessing the effects of the epikarst on groundwater recharge and regional fast -flow pathways in a karstic aquifer via impulse-response functions. *Journal of Hydrologic Engineering*. 20(11), 04015021.

Jennings, J.A. and R.T. Green. 2014. Rain Enhancement of Aquifer Recharge across the West Texas Weather Modification Association Target Area. *Journal of Weather Modification*. Vol 45. pp. 45–57.

Green, R.T., F.P. Bertetti, and M.S. Miller. 2014. Focused Groundwater Flow in a Carbonate Aquifer in a Semi-Arid Environment. *Journal of Hydrology*. 517:284–297. doi: 10.1016/j.jhydrol.2014.05.015

Green, R.T. and B. Abbott. 2013. Surveying flooded caves with neutrally-buoyant sensors. *BCRA Cave Radio & Electronics Group*. 83. pp. 11–14.

Green, R., F. Bertetti, and M. Hernandez. 2012. Recharge Variability In Semi-Arid climates. *Nature Education Knowledge* 3(10):34. http://www.nature.com/scitable/knowledge/library/recharge-variability-in-semi-arid-climates-26169682

Sun, A. Y., R. Green, S. Swenson, and M. Rodell. 2012. Toward calibration of regional groundwater models using GRACE data. *Journal of Hydrology*. 422:1–9. doi:10.1016/j.jhydrol.2011.10.025

Green, R.T., F.P. Bertetti, and M.O. Candelario 2011. Field Assessment and Analytical Assessment of the Hydraulic Relationship between the Trinity and Edwards Aquifers. Presented at the Karst Conservation Initiative, Austin, Texas

Green, R.T. and F.P. Bertetti. 2010. Investigating the Water Resources of the Western Edwards-Trinity Aquifer. Contract Report Prepared for the Sutton County Groundwater Conservation District. 79 p.

Sun, A.Y., R. Green, M. Rodell, and S. Swenson. 2010. Inferring aquifer storage parameters using satellite and in situ measurements: Estimation under uncertainty *Geophys. Res. Lett.*, *37*(L10401) 10.1029/2010GL043231

Sauter, M, M. Covington, L. Florea, F. Gabrovsek, Y. Gao, R. Green, J. Gulley, R. Harmon, E. Herman. P-Y, Jeanin, W. Jones, T. Kincaid, P.J. Moore, J. Mylroie, I.D. Sasowsky, E. Cranton, and C.M. Wicks**.** 2008. Focus Group on Karst Hydrology – Conceptual models, aquifer characterization, and numerical modeling, *in* Martin, J. and White, W.B. (eds)., *Frontiers in Karst Research*, Special Publication 13, Karst Waters Institute, Leesburg, Virginia: 37-48

Ferrill, D.A., A.P. Morris, D.W. Sims, R.T. Green, N. Franklin, and D.J. Waiting. 2008. Geologic controls on interaction between the Edwards and Trinity Aquifers, Balcones Fault System. *Bulletin of the South Texas Geological Society.* 68(8). Pp 21-45.

Green, R.T., J.R. Winterle, and J.D. Prikryl. 2008. Discharge from the Edwards Aquifer through the Leona River Floodplain, Uvalde, Texas. *J of American Water Resources Association.* 44(4):887-901. DOI: 10.1111/j.1752-1688.2008.00187.x.

Green, R.T., S. L. Painter, A. Sun, and S.R.H. Worthington. 2006. Groundwater Contamination in Karst Terrains. *Water, Air, and Soil Pollution: Focus*. DOI: 10.1007/s11267-005-9004-3. Vol 6. Nos. 1-2. pg 157-170.

LEANNE M. STEPCHINSKI
Scientist
Department of Earth, Material, and Planetary Sciences
Geosciences and Engineering Division

B.S., Geosciences, Trinity University, 2015

Ms. Stepchinski uses laboratory and field investigations to evaluate, and understand regional groundwater systems. At SwRI, Ms. Stepchinski is responsible for planning and executing field excursions, including conducting sampling and experiments. She conducts literature reviews and researches experimental methods. Ms. Stepchinski also designs and executes experiments in the field and in the lab.

Prior to joining SwRI, Ms. Stepchinski conducted research related to sedimentology and basin analysis with the Trinity University Geoscience Department. Her focuses included stratigraphy and carbonate geology. She participated in a month-long field study identifying and analyzing carbonate rocks, as well as mapping and creating stratigraphic sections of the Yangtze Platform margin in South China. During her research, she utilized thin section petrography to identify carbonate grain types and diagenetic features of carbonate rocks, conducted point counting, analyzed point count data, and prepared stratigraphy columns and gamma ray log columns.

PUBLICATIONS: Ms. Stepchinski is included as a coauthor on one peer-reviewed paper and on three abstracts. She has presented the results of her work at Geological Society of America-South Central conferences and at the American Association of Petroleum Geologists annual conference.

PROFESSIONAL CHRONOLOGY: Trinity University: Student Researcher, 2014-2015; Southwest Research Institute: Technical Assistant, Scientist, 2015-present.

F. PAUL BERTETTI
Principal Scientist
Geology and Geochemistry
Geosciences and Engineering Division

M.S., Geology, University of Texas at San Antonio, 1999
B.S., Geology, University of Texas at San Antonio, 1991

Mr. Bertetti's primary expertise is in field and experimental investigations that evaluate, model, and understand the relationships between the aqueous geochemistry, hydrology, and mineralogy of the subsurface. Mr. Bertetti uses hydrochemical data, experiments, and modeling to understand the hydrogeology of regional aquifer systems and to study the transport of inorganic contaminants. He has conducted multiple studies of groundwater chemistry to characterize flow systems, recharge, and interconnectivity of major aquifers, such as the Edwards, Edwards-Trinity, and Carrizo-Wilcox Aquifers, in southwest Texas. In addition, he regularly leads field-based investigations of water quality.

Mr. Bertetti is responsible for conducting geochemical investigations to address the research and regulatory needs of Southwest Research Institute (SwRI) clients. Mr. Bertetti conducts laboratory studies to examine and model the sorption and ion-exchange behavior of dissolved constituents on mineral surfaces under varying geochemical conditions including broad ranges of pH, ionic strength, and redox. He has developed models for the sorption behavior of dissolved actinides in groundwater and thermodynamic models for the ion-exchange behavior of cations on zeolites. His regulatory work includes reviewing license applications, developing regulatory documents, and providing technical guidance for performance assessment tools. Mr. Bertetti was principal investigator for activities related to Radionuclide Transport in the Saturated Zone as part of the U.S. Nuclear Regulatory Commission high-level radioactive waste repository safety program. His recent work includes technical support for several international radioactive waste disposal programs, including those of Canada, France, and Sweden.

Before joining SwRI, Mr. Bertetti directed the development of a National Science Foundation-funded, interactive, computer-based geoscience curriculum for secondary schools and investigated the influence of growth stimulation of indigenous microflora on the hydraulic characteristics of sediments at sites contaminated with organic and inorganic compounds. He also served in the U.S. Navy as a nuclear power engineer onboard ballistic missile submarines.
Mr. Bertetti has published many reports, peer-reviewed articles, and book chapters on sorption of radionuclides, ion-exchange behavior of zeolites, and hydrogeology of regional aquifer systems. He has made numerous presentations on radionuclide transport studies, the use of water chemistry to delineate groundwater flow patterns, and potential groundwater issues related to hydraulic fracturing at professional conferences and groundwater district board meetings.

PROFESSIONAL CREDENTIALS: Professional Geoscientist, in the State of Texas

PROFESSIONAL CHRONOLOGY: U.S. Navy: nuclear power plant engineer, 1983–9; University of Texas at San Antonio, Division of Earth and Physical Sciences: technical staff assistant, 1989-90; Southwest Research Institute: student scientist, 1990–1; University of Texas

at San Antonio, Division of Earth and Physical Sciences: research associate, 1991–3; Southwest Research Institute: research scientist, 1993–5; Cambrian Systems, Inc.: project manager, 1995–9; Southwest Research Institute: 1999-[research scientist, 1999-2002; senior research scientist, 2002–7; principal scientist, 2007-present].

MEMBERSHIPS: Geochemical Society; Geological Society of America; National Ground Water Association.

September 2015

NATHANIEL J. TOLL
Senior Research Scientist
Department of Earth, Material, and Planetary Sciences
Geosciences and Engineering Division

M.S., Hydrogeology, University of Georgia, 2005
B.S., Geology, Tufts University, 1999

Mr. Toll has more than 15 years of experience in water resources investigations, repository site characterization, environmental site characterization, environmental remediation, environmental risk assessment, and mine water disposition issues. He applies numerical models to groundwater and surface water systems to inform water management decisions. He is an expert in deep borehole testing in low permeability environments.

At SwRI, Mr. Toll investigates local and regional groundwater systems using a variety of field, desktop, and numerical techniques. He creates large deterministic numerical models of complex hydrogeologic systems to address water management issues in Texas and neighboring states, and considers the effects of uncertainties on the resulting analyses.

Prior to joining SwRI, Mr. Toll held senior and principal level technical positions in the mining industry. He worked at Rio Tinto's Bingham Canyon mine developing and implementing programs to reduce slope pore pressures and consequently increase slope stability. At Bingham Canyon, he modernized their data acquisition and analysis capabilities to provide critical slope stability information to the mine management in a timely manner. He also worked for Rio Tinto at their Ranger Uranium mine in Northern Australia as the manager of the Water Sciences group. At Ranger, he oversaw the monitoring and statutory reporting of surface water and groundwater to ensure the protection of the surrounding Kakadu world heritage site. He oversaw a program to test the effectiveness of mine closure plans with respect to protecting the environment for 10,000 years after closure. Mr. Toll's use of performance assessment (PA) methods, which he learned while a senior scientist at Sandia National Laboratories, enhanced Rio Tinto/ERA's reputation with regulators and stakeholders.

At Sandia National Laboratories, Mr. Toll served as the well test lead for the Waste Isolation Pilot Plant (WIPP). In this role, he designed, planned, and executed long-term aquifer tests in the Culebra Formation above the WIPP repository horizon. He also designed and built several downhole instruments for collecting and conducting pressure testing in deep low permeability formations. These instruments continue to be used in geologic repository programs in the USA, Canada, Japan, Australia and South Korea.

As a Research Assistant at the University of Georgia, Mr. Toll was tasked with developing novel solutions to sinusoidal aquifer tests conducted in the Culebra Formation at the WIPP site. His thesis work expanded to include refining methods for the removal of barometric and earth-tide influences on groundwater level and pressure data. Before graduate school, Mr. Toll worked on a consulting team characterizing large CERCLA sites for the US Air Force. His work consulting to the Air Force led to several innovative remediation projects.

PUBLICATIONS: Mr. Toll has published one peer reviewed paper related to groundwater characterization and co-authored four papers related to varve chronology. He has written dozens of technical reports including reports submitted in hearings in the Australian House of Parliament.

PROFESSIONAL CHRONOLOGY: Earthtech: geologist, 1999-2005; University of Georgia: research assistant, 2003-5; Sandia National Laboratories: senior member of the technical staff, 2005-8; Rio Tinto: senior hydrogeologist, principal hydrogeologist, technical manager, 2008-12; Braemar Iron: managing director, 2012-14; Southwest Research Institute: senior research scientist, 2015-present.

September 2015

RONALD N. McGINNIS, JR.
Principal Scientist
Department of Earth, Material, and Planetary Sciences
Geosciences and Engineering Division

M.S., Geology, University of Texas at San Antonio, 2005
B.S., Geology, University of Texas at San Antonio, 2002

Mr. McGinnis is a structural geologist whose research has included quantitative and qualitative analyses of the origins of structural geologic and tectonic features occurring in the French Alps, the flood basalts of Southern Idaho, the Basin and Range Province of the western United States, the northern Rocky Mountains, the Ouachita and Laramide orogenies of west Texas, the Balcones fault system of central Texas, and the Devils River Trend and Maverick Basin of central and south Texas. His work includes structural geological analysis of groundwater aquifers, characterization of faulted and fractured hydrocarbon reservoirs, seismic interpretation, and cross-section construction through structurally complex hydrocarbon reservoirs and groundwater aquifers. In addition, Mr. McGinnis prepares and teaches training courses for the energy industry. He is currently investigating mechanical stratigraphy and the control it has on natural deformation features, which affect hydraulic fracturing programs in unconventional reservoirs.

Mr. McGinnis also conducts geophysical surveys for the purpose of understanding the subsurface geology. These investigations support a wide range of purposes, including general site characterization, assessment of the presence and risk of caves and underground conduits, karst hydrology, structural geological controls on petroleum resources, the presence and evolution of permafrost conditions, and planetary science. Study sites include the Edwards and Barton Springs aquifer systems of Texas; mesas of the western desert of Egypt; karst features on the island of Barbados; fluvial deposits of sand and gravel aggregate resources in Arkansas, Louisiana, and Texas; the Bishop Tuff sequence in California; aeolian dunes in the Alaskan arctic; and permafrost distribution in southeastern Alaska. Mr. McGinnis uses a wide-range of surveying techniques for stratigraphic, hydrogeologic, geophysical, and structural mapping. These include real-time kinematic differential GPS, geodetic GPS, total station, and ground based spatial scanning. He is proficient in the use of Res2/3dinv, EarthImager™, Surfer®, ArcGIS, Lithotect, PETREL, and Trimble RealWorks to create and visualize 2D and 3D models of geologic systems.

PUBLICATIONS: Mr. McGinnis has authored or co-authored 30 peer reviewed technical articles and 45 published abstracts.

PROFESSIONAL CHRONOLOGY: Southwest Research Institute: 2002-[graduate student scientist, 2002–5; scientist, 2005–7; research scientist, 2007–2011; senior research scientist, 2011-present].

MEMBERSHIPS: American Association of Petroleum Geoscientists

September 2015

Years of Experience: 21

Education:

- PhD, 1999, Civil Engineering, University of Texas
- MS, 1997, Civil Engineering, University of Texas
- BS, 1994, Environmental Engineering, University of Oklahoma

Professional Registrations/Affiliations:

- Professional Engineer, Texas, 2003, No. 92741

Professional History:

2014 – present	Vice President, Senior Water Resources Engineer – INTERA Inc., Austin, TX
2009 – 2014	Group Lead, Senior Water Resources Engineer – INTERA Inc., Austin, TX
2006 – Present	Adjunct Professor – Department of Petroleum and Geosystems Engineering, University of Texas at Austin, Austin, TX
1999 – 2009	Water Resources Engineer – INTERA Inc., Austin, TX

Specialized Training & Software:

Neil Deeds has 21 years of research and applied experience in modeling and analysis of hydrologic systems, including water availability, flow, and transport. He has experience applying codes such as MODFLOW and its variants, MT3DMS, SEAWAT, SWIFT II, SWAT, NUFT, UTCHEM, and UTSTREAM for fluid-flow modeling and GTFM/nSIGHTS for well test analysis. He has 15 years of experience in uncertainty, importance, and risk analyses as applied to physical modeling studies and has developed and used numerous uncertainty analysis and optimization codes, such as PEST, UCODE, mCalc, and GoldSim. Dr. Deeds has 16 years of experience working with desktop geographic information systems (GIS) software, including ArcGIS and GRASS. Over the last three years, he has developed web-based GIS applications using both ESRI's ArcGIS for Server and open source solutions, such as Geoserver. Dr. Deeds has been involved in more than 40 modeling projects and has taken a project management and/or technical lead role in many water resources modeling studies, including groundwater availability models (GAMs) of aquifers throughout Texas. He has served as a technical manager or technical lead in quantifying processes such as recharge, hydraulic conductivity, and surface water/groundwater interaction in support of regional and sub-regional groundwater modeling projects. Dr. Deeds has been the technical lead in data management and organization and has developed data models for several water resources projects. Dr. Deeds has 12 years of experience in preparing communication materials and interacting with agencies and interested stakeholders in Texas, including the Texas Water Development Board (TWDB), Lower Colorado River Authority (LCRA), regional water planning groups and groundwater conservation districts (GCDs).

Project Experience – Water Resources

Update of the Northern Trinity and Woodbine Groundwater Availability Model for GMA 8, Selected GCDs, TX. 2011 – 2014. Hydrogeologist and Modeler. Supported the development of conceptual and numerical models for the update to the Northern Trinity and Woodbine Groundwater Availability model. Conceptual model included a complete reassessment of stratigraphy, lithology, and water quality in the Northern Trinity and Woodbine aquifers. Over 1,500 geophysical logs were compiled in a database, for determination of stratigraphy, lithology and water quality. Log analysis was performed by Scott Hamlin of the Bureau. Supported creation of stratigraphic from log picks. Supported determination of aquifer productivity, and analysis of over 1,700 wells for water quality in order to determine hydrogeochemical facies (providing information about the likely evolution of the groundwater system), as well as creating aquifer-specific maps of total dissolved solids and chloride. Areas where brackish water existed were identified in each formation that comprises the Trinity Aquifer.

Assessment of Groundwater Monitoring Approaches to Brackish Aquifers, Texas Water Development Board (TWDB), TX. 2010 – 2011. Project Manager and Technical Lead. Reviewed existing literature and documentation for variable-density codes to determine when particular codes are appropriate for particular hydrogeologic conditions relevant to production of brackish water. One of the goals of the Brackish Resources Aquifer Characterization System (BRACS) program at the TWDB is building replicable numerical groundwater flow models for estimating aquifer productivity. Performed a literature review to assess existing information on the status and applicability of various types of flow models for brackish aquifers and the influence of aquifer geometry and geological structure on salinity distribution and brackish groundwater movement. Recommended and documented conditions under which a specific type of groundwater flow model or models might be applicable. Developed a screening tool that enabled users to determine the most appropriate groundwater flow model for an aquifer.

Feasibility Study for Brackish Water Production and Desalination near New Braunfels for the Texas General Land Office, TX. 2012. Hydrogeologist. The Texas General Land Office (GLO) is the owner of property in Comal County, TX. In order for development to occur on the property, a reliable water supply must be established. One possible supply option is brackish groundwater combined with a desalination facility. Performed hydrogeologic analyses to support a preliminary feasibility study for this option. Determined the probable brackish water production rate, the water quality of this raw source, and the feasibility of disposing of the saline waste stream through a deep injection well. One of the primary considerations for availability was the presence of a large fault near the proposed brackish water production zone. Provided initial cost estimates for construction and operation of the production and disposal wells. Findings were reported to GLO staff in the form of a technical memo.

Initial Evaluation of Locations for Aquifer Storage and Recovery (ASR) in Comal County, New Braunfels Utility, TX. 2011 – 2012. Hydrogeologist. To support an evaluation of ASR as a potential method of improving water supply capabilities during drought conditions, supported scoping study of the hydrogeology of the region to provide guidance as to the productivity and suitability of aquifers and other formations. This has included a survey of the characteristics of existing wells in the area (in the Trinity Aquifer) and a review of geophysical logs to help evaluate deeper units (such as the Hosston-Sligo) not currently being pumped. Reviewed hydrogeology of the brackish Edwards in the region southeast of Interstate 35 for ASR site potential. Reported findings to New Braunfels Utility. Pilot program is planned for the near future, pending discussions between NBU and Edwards Aquifer Authority about regulatory considerations.

Geochemical Modeling of Gulf Coast Aquifer, Texas Water Development Board (TWDB), TX. 2011 – 2013. Modeler. Modeled geochemical data for the Texas Gulf Coast aquifer to define and describe the groundwater flow system for Groundwater Management Areas (GMAs) 14, 15, and 16. Performed particle tracking simulations to evaluate groundwater flow patterns and groundwater age. Created time-lapse visualizations of particle movement for the three groundwater models used for the particle tracking, including the Northern, Central, Southern GAMs.

Development of a Groundwater Availability Model (GAM) for the High Plains Aquifer System, Texas Water Development Board, TX, NM, OK, CO, and KS. 2012 – 2015. Project Manager. Lead efforts to build a groundwater model that combines the Northern Ogallala, Southern Ogallala

(including the Edwards Trinity High Plains and Rita Blanca Aquifers), and Dockum GAMs. The study area is the largest in the history of Texas Water Development Board GAMs, encompassing all or part of 95 counties in Texas, New Mexico, Oklahoma, Colorado, and Kansas. The conceptual model report included a general assessment of the climatic and hydrologic conditions in the study area, as well as detailed studies of geologic structure (based on analysis of over 2,000 geophysical logs), properties, recharge, natural discharge, pumping, and water quality. As part of the project, all geophysical logs and the results of the log analyses were imported to the BRACS database for delivery to TWDB. Worked closely with TWDB staff to ensure that the integration of the logs was consistent with the schema of the BRACS database.

The conceptual model was used as a basis for developing the numerical model. A numerical model was developed with half-mile-square grid cells and 4 layers, with approximately one million active grid cells. The numerical model was calibrated using PEST, with pilot point multiplier fields for recharge and horizontal hydraulic conductivity of the Ogallala Aquifer. Those parameters were the most important to both heads and flow rates. The final model provides good insight into the interaction of the Ogallala Aquifer and the minor aquifers in the system, and will be used as a tool for state water planning.

Update to the Edwards Aquifer Fault Zone (Barton Springs Segment) Model, Barton Spring Edwards Aquifer Conservation District, TX. 2014-present. Lead Modeler. Performed minor update to Edwards Aquifer (Barton Springs Segment) model. In the first update, extended the active area of the model downdip, using structure data from a recent USGS Edwards Aquifer model (San Antonia segment). The goal of updating the model is to eventually allow simulation of variable density flow and transport, to investigate the effects of potential brackish water production or aquifer storage recovery in the brackish Edwards.

Development of a Variable-Density Cross-Sectional Model in the Lower Colorado River Basin, Lower Colorado River Authority (LCRA), TX. 2007 – 2008. Modeler, Various Technical Leads. Work on the LCRA-SAWS Water Project included various modeling tasks. Created a two-dimensional, variable-density model in SEAWAT to assess the conceptualization of the downdip boundary in the constant density model. Also used the cross-sectional model to estimate the effects of pumping in Matagorda County on the location of the saline water interface. Other work with variable density modeling included comparison of a sharp interface analytical upconing solution to a three-dimensional SEAWAT model of a single pumping well.

Daniel Lupton has over ten years of professional experience in water resources and geological sciences. His research and professional experience range from geophysical well log analysis to evaluation of groundwater and surface water system interactions, and encompass both field and numerical techniques. He has employed field techniques such as geophysical logging/correlation, water level sampling, and spring discharge surveys in conjunction with groundwater modeling to develop an improved understanding of complex flow systems. Much of Mr. Lupton's research experience has involved evaluations of groundwater basins to quantify local-, intermediate- and regional-flow regimes. He co-developed a method for evaluating areas of recharge and discharge based on correlations of naturally occurring features. Mr. Lupton's project experience has centered on aquifer characterization techniques ranging from aquifer hydraulics to lithology/water quality. Additionally, Mr. Lupton has considerable experience in the evaluation and characterization of brackish water resources and the geologic units that contain these brackish resources. Mr. Lupton's current focus in on the analysis of geophysical logs in an attempt to evaluate water quality trends within groundwater basins. Much of this work involves the construction of geologic models using interpolation algorithms that are reflective of paleo-depositional environments. This work has afforded Mr. Lupton the opportunity to evaluate brackish groundwater resources extensively in a number of aquifers within Texas, New Mexico, and Oklahoma.

Years of Experience: 10

Education:

- MS, 2009, Hydrogeology, University of Texas at San Antonio
- BS, 2006, Resource and Environmental Studies (Geology Emphasis), Texas State University

Professional Registrations/Affiliations:

- Professional Geoscientist, Texas, 2012, No. 11354
- Professional Geoscientist, Indiana, 2014, No. 2512
- Technical Advisor, Well Aware
- Member, Geological Society of America, Hydrogeology Division
- Member, National Ground Water Association
- Member, American Association of Petroleum Geologists
- Member, Austin Geological Society

Professional History:

2010 – Present	Hydrogeologist – INTERA Inc., Austin, TX
2010	Independent Contractor – Lupton Hydrologic, Austin, TX
2009	Intern – Bee Cave Water Well Drilling Services, Austin, TX
2007 – 2009	Research Assistant – University of Texas, San Antonio, TX
2007 – 2008	Teaching Assistant – University of Texas, San Antonio, TX
2006 – 2007	Technician – Selby Geologic, Austin, TX
2005 – 2006	Research Assistant – Texas State University, San Antonio, TX
2005 – 2009	Backflow Technician – Lupton Backflow, Kyle, TX
2005	Intern – Koke's Resource Conservation Program, Kaua'i, HI

Specialized Training:

- PetroSkills 40 hour Sequence Stratigraphy Course
- (Instructor: Dr. Clyde H. Moore)
- PetroSkills 40 hour Well Log Interpretation Course (Instructor: Dr. E.C. Thomas)
- 40-Hour General Site Workers Training, OSHA 29 CFR 1910.120(e)(3), 2011
- 8-Hour Refresher, OSHA 29 CFR 1910.120 (e), 2014
- CPR, First Aid, and Blood borne Pathogens Training, OSHA 29 CFR 1910.1030, 2013

Project Experience – Water Resources

Evaluation of the Effects of Faulting on Groundwater Flow, Post Oak Savanah Groundwater Conservation District. 2014-present. Geologist. Post Oak Savanah Groundwater Conservation District (POSGCD) wanted to know the impacts of not integrating faults into the regional Groundwater Availability Model (GAM) that they used to model their Desired Future Conditions (DFCs) as required by Texas law. The project to date has involved the acquisition of over 600 geophysical logs in an attempt to resolve the base of the Carrizo-Wilcox aquifer system. All structural picks will be brought together and incorporated into a surface that reflects the

significant faulting affecting the area. Hydraulic simulations using this surface will be run, and the effects of faulting on the groundwater system will be investigated.

Brackish Resource Assessment, City of Corpus Christi, San Patricio, Nueces and Aransas Counties, TX. 2013. Geologist. The water resource manager for the city of Corpus Christi contacted INTERA about the possibility of using brackish groundwater for their future water supplies. The project was set up into multiple phases. Phase I Involved the construction of a Petra database that included all of the existing geologic/hydrogeologic information for the area, along with more than 100 strategically placed oil and gas geophysical logs. The logs were subsequently digitized and evaluated for lithology and water quality parameters. Results were compared with water wells in the area, and corrections were made. The resulting dataset provided insight into the depth and quality of accessible groundwater within San Patricio and Nueces counties. The next phase of the project involved specific testing of areas designated from the results of the water quality and lithology distribution. Test wells were drilled, logged, tested, and sampled. Upon completing the test well phase, improvements to the water quality conceptual model were made as necessary.

Evaluation of Water Quality and Stratigraphy, Panola County Groundwater Conservation District, TX. 2013. Geologist. The Panola County Groundwater Conservation District (GCD) is responsible for the protection, conservation, and enhancement of groundwater resources in Panola County. As part of that mandate, INTERA was hired to evaluate the stratigraphy and groundwater quality distribution throughout the county. Project responsibilities included the creation of structural surfaces for the base of the Wilcox aquifer and the base of useable-quality water, which were visually depicted in a series of eight (four along dip and four along strike) cross sections and a composite fence diagram. In addition, picks from the Texas Rail Road Commission were evaluated to check agreement and consistency with documented sources for the base of the Wilcox aquifer. Upon receiving a detailed report and presentation, the client immediately began to appropriate funds for a second, more detailed analysis of the aquifer stratigraphy and water quality distribution.

Evaluation of Stratigraphy, Lithology and Water Quality of the Dockum Formation, Confidential Client, Irion County, TX. 2013. Geologist. Client wanted a full scale hydrogeologic flow model of the Santa Rosa Formation of the Dockum Aquifer. Project responsibilities included working with the client to build a Petra database of all the logs, outcrop information, cuttings, and any other associated geologic information. Once the database was built, formation tops were picked on more than 400 logs. Additionally, petrophysical analysis was implemented to characterize water quality and lithology of the formation.

Feasibility Study for Aquifer Storage and Recovery, New Braunfels Utility, New Braunfels, TX. 2012. Hydrogeologist. INTERA was asked to evaluate the practical aquifer storage and recovery (ASR) applications that might be beneficial to the New Braunfels Utility (NBU) (a municipally owned public utility) and its service area; to gather pertinent information on NBU's water system and future plans; and to conduct a preliminary feasibility study to assess the viability of ASR as an NBU water management strategy. INTERA's primary role was evaluating the hydrogeology of the area, determining the best formations for injection and production, and designing a test plan for the next phase of the project. Personal responsibilities included evaluation of geophysical logs and surface geology in anticipation of developing a cross section through the project area. In addition,

porosity logs and down-dip oil and gas logs were evaluated for up-dip projections of trends in the study area.

Feasibility Study for Brackish Groundwater Desalination, Texas General Land Office, Comal County, TX. 2012. *Hydrogeologist*. The Texas General Land Office (GLO) is the owner of property in Comal County, TX. In order for development to occur on the property, a reliable water supply must be established. One possible supply option is brackish groundwater combined with a desalination facility. INTERA was engaged by the GLO to perform a preliminary feasibility study for this option. INTERA's primary role was determining the probable brackish water production rate, the water quality of this raw source, and the feasibility of disposing of the saline waste stream through a deep injection well. In addition, INTERA provided initial cost estimates for construction and operation of the production and disposal wells. Personal responsibilities consisted of evaluating the formation characteristics for production/injection potential.

Development of a Groundwater Availability Model (GAM) for the High Plains Aquifer System, Texas Water Development Board, TX, NM, OK, CO, and KS. 2012 – Present. *Geologist*. The Texas Water Development Board (TWDB), along with various other funding agencies, tasked INTERA with the creation of a new GAM for the High Plains aquifer system. The study area is the largest in the history of TWDB GAMs, encompassing all or part of 95 counties in Texas, New Mexico, Oklahoma, Colorado, and Kansas. The project includes the creation of a geophysical well log database that will be used to make structural, lithologic, and water quality picks that will be incorporated into the model to provide the TWDB with a more in-depth understanding of the groundwater flow dynamics within the High Plains aquifer system. Responsibilities include picking the base of the Ogallala Aquifer on more than 2,000 geophysical well logs. Additionally, a log based lithologic analysis was implemented. Led the integration of the log information with the BRACS database. Worked closely with TWDB staff to ensure that the BRACS import was completed consistent with the schema.

Geophysical Log Analysis of Antlers Aquifer, Choctaw and Chickasaw Tribes, OK. 2012 – Present. *Hydrogeologist*. Responsible for selection and subsequent integration of resistivity and spontaneous potential well logs in anticipation of picking the various Cretaceous transgressive/regressive sequences in northern Texas and southern Oklahoma that will be integrated into a model being created for the Northern Trinity Aquifer GAM. Upon completion of the structural picks, water quality and lithology were also analyzed where possible.

Years of Experience: 30

Education:

- MS, 1987, Geology, Texas A&M University
- BS, 1985, Geology, Texas A&M University

Professional Registrations/Affiliations:

- Professional Geoscientist, Texas, 2003, No. 2497
- Professional Geoscientist, Louisiana, 2016, No. 923

Professional History:

2002 – Present	Senior Hydrogeologist – INTERA Inc., Austin, TX
2000 – 2002	Senior Hydrogeologist – Duke Engineering & Services, Austin, TX
1995 – 2000	Project Manager, Staff Hydrogeologist – Duke Engineering & Services, Austin, TX
1992 – 1995	Project Manager, Staff Hydrogeologist – INTERA Inc., Austin, TX
1989 – 1992	Staff Hydrogeologist – INTERA Inc.,

Toya Jones has 30 years of experience in the areas of aquifer characterization and the development and application of numerical models to water resources, environmental restoration, hazardous and radioactive waste disposal, and regulatory compliance projects. Using the numerical codes TOUGH2, SWIFT-II, GRASP II, MODFLOW, ECLIPSE, and nSIGHTS (well-test simulator), she has modeled single- and multi-phase flow and transport, density effects on fluid flow and solute migration, and transport through porous and fractured media and has interpreted data from well and tracer tests. Her experience with water resource evaluations includes the collection and synthesis of data to develop conceptual models based on site-specific hydrogeologic information; the implementation of conceptual models into numerical models; and the assessment of groundwater and surface water vulnerability, considering intrinsic properties, external threats, and consequences of contamination. She serves in key technical roles for the development of groundwater availability models, where her efforts include compiling and analyzing aquifer water-level data, establishing regional groundwater flow and pre-development aquifer conditions, developing historical head surfaces, evaluating cross-formational flow, evaluating groundwater and surface water interaction, evaluating natural aquifer discharge, estimating historical pumping trends, and developing conceptual models. Ms. Jones has experience in developing and accessing transport parameters for large-scale regional groundwater transport models and assessing environmental impacts to groundwater from historical disposal of radioactive waste. She has groundwater flow and transport modeling experience in carbonate and evaporite sequences for site characterization related to waste isolation projects. In support of environmental restoration projects, she has developed site-specific numerical models to evaluate the fate and transport of contaminants in the subsurface. Representative examples of this experience include analyzing the effects of sorption and biodegradation on the migration of chlorinated benzene plumes, determining the radiation dose from operations of a mixed-oxide fabrication facility, modeling nitrate migration from disposal ponds, and developing transport parameters (i.e., effective porosity and dispersivity) for modeling the migration of contaminants resulting from underground nuclear tests. She has 20 years of experience in conducting characterization and modeling associated with the geologic disposal of radioactive wastes. Ms. Jones has participated in large field hydrogeologic characterization programs involving tracer test design, field implementation, and test interpretation. She has conducted modeling efforts to evaluate the potential for fluid flow through geologic repository shaft seals and the effects of gas

generation, brine flow, and salt creep in and around waste disposal drifts. She has also applied her modeling expertise to assist in obtaining environmental permits, including conducting modeling for no-migration demonstrations for permitting of hazardous waste disposal wells and unsaturated zone flow and transport modeling to support licensing of radioactive waste disposal facilities.

Project Experience – Water Resources

Groundwater Availability Modeling, Texas Water Development Board (TWDB), Austin, TX. 2002 – Present. *Senior Hydrogeologist.* Senate Bill 2 (77th Legislature in 2001) mandated that the TWDB obtain or develop groundwater availability models (GAMs) for all of the major and minor aquifers in Texas in coordination with Groundwater Conservation Districts and Regional Water Planning Groups. The mission of the TWDB GAM program is to provide the citizens of Texas with reliable and timely data on the availability of groundwater to ensure adequate supplies or identify inadequate supplies over a 50-year planning period. In support of the program, INTERA has developed nine GAMs and is currently working on two additional GAMs. The GAMs involve developing a conceptual model for the aquifer, calibrating the model to observed aquifer conditions, and conducting sensitivity analyses. Early GAMs also included model validation and predictive simulations for 50 years. The GAMs developed by INTERA are currently used as tools for regional water planning. The following describe the activities conducted in support of developing the conceptual models for most of the INTERA GAMs.

- Supporting development of the conceptual model for the Brazos River Alluvium Aquifer GAM. Activities include investigation of historical and current water-level conditions in the aquifer, investigation of aquifer interaction with underlying formations, development of steady-state and transient calibration targets, development of estimates for historical pumping, and development of a conceptualization of groundwater flow within the aquifer.
- Supported development of the conceptual and numerical models for the High Plains Aquifer System GAM. Activities included investigation of historical and current water-level conditions in the aquifer, investigation of interaction between the aquifers, development of steady-state and transient calibration targets, development of historical pumping from the aquifers, and implementation of steady-state and transient calibration targets and historical pumping in the numerical model.
- Supported development of the conceptual model for the Rustler Aquifer GAM. Activities included investigation of historical and current water-level conditions in the aquifer, investigation of aquifer interaction with underlying units, development of steady-state and transient calibration targets, investigation of aquifer discharge, investigation of aquifer interaction with surface water, investigation of the quality of the groundwater in the aquifer, and development of the conceptualization of groundwater flow within the aquifer.
- Supported development and calibration of the Yegua-Jackson Aquifer GAM. Activities included generation of predevelopment hydraulic conditions in the aquifer, development of steady-state and transient calibration targets, and investigation of aquifer interaction with overlying hydrogeologic units.
- Development of the conceptual model for the refined GAM of the Seymour Aquifer in Haskell, Knox, and Baylor counties, Texas. Activities included investigating the correlation between land use changes and water-level changes observed in the aquifer, historical usage of the aquifer, development of transient calibration targets, investigation of seasonal fluctuations in water levels in the aquifer, investigation of aquifer interaction with

underlying units, investigation of aquifer discharge, investigation of aquifer interaction with surface water, and development of the conceptual model for the aquifer.

- Development of the conceptual model for the Dockum Aquifer GAM. Activities included investigation of the historical usage of the aquifer, generation of predevelopment hydraulic conditions in the aquifer, development of steady-state and transient calibration targets, investigation of aquifer interaction with overlying hydrogeologic units, investigation of aquifer discharge, investigation of aquifer interaction with surface water, investigation of aquifer hydraulic properties, and development of the conceptual model for the aquifer.
- Supported the development and calibration of the GAM for the entire Seymour Aquifer. This modeling also included the underlying Blaine Aquifer. Activities included investigation of the historical usage of the aquifers, generation of predevelopment hydraulic conditions in the aquifers, development of steady-state and transient calibration targets for both aquifers, investigation of interaction between the two aquifers and with the underlying hydrogeologic unit, investigation of interaction of the aquifers with surface water, and conceptual model design.
- Supported the development and calibration of the northern, central, and southern GAMs for the Queen City/Sparta Aquifer System. Activities included investigation of the historical usage of the aquifer, generation of predevelopment hydraulic conditions in the aquifer, development of steady-state and transient calibration targets, and investigation of aquifer interaction with overlying hydrogeologic units.
- Supported the development and calibration of the northern and southern GAMs for the Carrizo-Wilcox Aquifer. Activities included investigation of the historical usage of the aquifer, generation of predevelopment hydraulic conditions in the aquifer, development of steady-state and transient calibration targets, and investigation of aquifer interaction with overlying hydrogeologic units.

Technical Support for Water Planning, Upper Trinity Groundwater Conservation District, Springtown, TX. 2008 – Present. *Senior Hydrogeologist.* Provides as-needed hydrogeological support to the Upper Trinity Groundwater Conservation District (UTGCD). The UTGCD is a new district aimed at conserving groundwater within a four-county region just west of the Dallas-Fort Worth Metroplex. Historically, the Northern Trinity Aquifer has experienced significant drawdown, and the region has most recently been designated as a Priority Management Groundwater Area by the Texas Commission on Environmental Quality. The counties within the UTGCD are experiencing urbanization as well as groundwater production associated with the Barnet Shale.

ATTACHMENT C. Cited Literature References

Anaya, R. and I. Jones, 2009, Groundwater Availability Model for the Edwards-Trinity (Plateau) and Pecos Valley Aquifers of Texas, Texas Water Development Board, Report 373, April 2009.

Ashworth, J. B., and J. Hopkins. 1995. Aquifers of Texas: Texas Water Development Board Report 345, 69 p.

Ashworth, J.B. 1983. Groundwater availability of the lower Cretaceous formations in the Hill Country of South-Central Texas: Texas Department of Water Resources Report 273, 65 p.

Baker, B., G. Duffin, R. Flores, and T. Lynch. 1990. Evaluation of water resources in part of Central Texas: Texas Water Development Board Report 319, 65 p.

Baker, B., G. Duffin, R. Flores, and T. Lynch. 1990. Evaluation of water resources in part of North-Central Texas: Texas Water Development Board Report 318, 67 p.

Bebout, D.G. 1977. Sligo and Hosston depositional patterns, subsurface of south Texas, in Bebout, D.G. and Loucks, R.G., eds., Cretaceous carbonated of Texas and Mexico, applications to subsurface exploration: Austin, University of Texas, Bureau of Economic Geology Report of Investigations 89. p. 79-96.

Brune, G., and G.L. Duffin. 1983. Occurrence, availability, and quality of groundwater in Travis County, Texas: Texas Department of Water Resources Report 276, 231 p.

Brune, G. 2002, Springs of Texas, volume 1: Texas A&M University Press, Texas A&M University Agriculture series, No. 5, 2nd edition.

Collier, H. A. 1993. Borehole geophysical techniques for determining the water quality and reservoir parameters of fresh and saline water aquifers in Texas, , Volume I: Texas Water Development Board, Report 343, 414 p., 1 Appendix, 5 plates.

Duffin, G., and S.P. Musick. 1991, Evaluation of water resources in Bell, Burnet, Travis, Williamson, and parts of adjacent counties, Texas: Texas Water Development Board Report 326, 105 p.

Estepp, J. 1998. Evaluation of ground-water quality using geophysical logs: Texas Natural Resource Conservation Commission, unpublished report, 516 p.

Estepp, J. 2010. Determining groundwater quality using geophysical logs: Texas Commission on Environmental Quality, unpublished report, 85 p.

Ferrill, D.A., D.W. Sims, A.P. Morris, D.J. Waiting, and N. Franklin. 2003. Structural Controls on the Edwards Aquifer/Trinity Aquifer Interface in the Camp Bullis Quadrangle, Texas Final report prepared for the Edwards Aquifer Authority and the US Army Corps of Engineers.

Ferrill, D.A., D.W. Sims, D.J. Waiting, A.P. Morris, N. Franklin, and A.L. Schultz. 2004. Structural Framework of the Edwards Aquifer recharge zone in south-central Texas. Geological Society of America Bulletin 116, 407-418.

Ferrill, D.A., D.W. Sims, N. Franklin, A.P. Morris, and D.J. Waiting. 2005. Structural Controls on the Edward Aquifer/Trinity Aquifer Interface in the Helotes Quadrangle, Texas. Final report prepared for the Edwards Aquifer Authority and the US Army Corps of Engineers.

Ferrill, D.A., A.P. Morris, D.W. Sims, R. Green, F.N., and D.J. Waiting. 2008. Geologic Controls on Interaction Between the Edwards and Trinity Aquifers, Balcones Fault System, Texas. South Texas Geological Society Bulletin, April 2008, 21-45.

Fogg, G. E., and P. E. Blanchard. 1986. Empirical relations between Wilcox groundwater quality and electric log resistivity, Sabine Uplift area, in W. R. Kaiser et al., Ed., Geology and Ground-water Hydrology of Deep-basin Lignite in the Wilcox Group of East Texas: Special Publication, The University of Texas at Austin, Bureau of Economic Geology, p. 115-118.

Fratesi, S.E., R.T. Green, F.P. Bertetti, R.N. McGinnis, N. Toll, H. Başağaoğlu, L. Gergen, J. Winterle, Y. Cabeza, and J. Carrera. 2015 Development of a finite-element method groundwater flow model of the Edwards Aquifer: Final Report. Southwest Research Institute. Conducted for the Edwards Aquifer Authority. 180 p.

Green, R.T., N. Toll, and F.P. Bertetti. 2016. Develop a Groundwater Flow Model to Understand the Groundwater Resources of the Lower Pecos River Watershed. Contract Report for the City of Laredo. Final Report.

Green, R.T., N. Toll, and F.P. Bertetti. 2015. Sustainable Yield of a Carbonate Aquifer Dominated by Preferential Flow: Devils River Watershed, South Texas, USA. Final Report. Contract Report for the Nueces River Authority.

Green, R.T., F.P. Bertetti, and M.S. Miller. 2014. Focused Groundwater Flow in a Carbonate Aquifer in a Semi-Arid Environment. *Journal of Hydrology*. 517:284–297. doi: 10.1016/j.jhydrol.2014.05.015

Green, R., F. Bertetti, and M. Hernandez. 2012. Recharge Variability In Semi-Arid climates. *Nature Education Knowledge* 3(10):34. http://www.nature.com/ scitable/knowledge/ library/recharge-variability-in-semi-arid-climates-26169682

Green, R.T. and F.P. Bertetti. 2010. Investigating the Water Resources of the Western Edwards-Trinity Aquifer. Contract Report Prepared for the Sutton County Groundwater Conservation District. 79 p.

Green, R.T., F.P. Bertetti, and R.L. McGinnis. 2009a. Analysis of the water resources of the area centered within and near Uvalde and Zavala Counties and review of a report on a potential well

field and pipeline in Uvalde County, Texas. Contract report for the City of Uvalde and the Wintergarden Groundwater Conservation District. 53 p.

Green, R.T., F.P. Bertetti, and R.N. McGinnis. 2009b. Measureing floodplain hydraulics of the Frio River where it overlies the Edwards Aquifer. Contract project conducted for the Edwards Aquifer Authority. 40 p.

Green, R.T., F. P. Bertetti, and R.N. McGinnis. 2009c. Investigation of the Secondary Aquifers in Uvalde County. Southwest Research Institute. Contract project conducted for the Uvalde County Underground Water Conservation District. 74 p.

Green, R.T., F. P. Bertetti, B.P. Wilcox, and R.N. McGinnis. 2008a. Investigation of the Groundwater Systems in the Wintergarden Groundwater Conservation District—Phase II. Southwest Research Institute. Contract Report to the Wintergarden Groundwater Conservation District.

Green, R.T., J.R. Winterle, and J.D. Prikryl. 2008b. Discharge from the Edwards Aquifer through the Leona River Floodplain, Uvalde, Texas. *J of American Water Resources Association.* 44(4):887-901. DOI: 10.1111/j.1752-1688.2008.00187.x.

Green, R.T., S. L. Painter, A. Sun, and S.R.H. Worthington. 2006. Groundwater Contamination in Karst Terrains. *Water, Air, and Soil Pollution: Focus*. DOI: 10.1007/s11267-005-9004-3. Vol 6. Nos. 1-2. pg 157-170.

Green, R.T. 2006. Preliminary Investigation of the Groundwater Systems in the Wintergarden Groundwater Conservation District. Southwest Research Institute. Conducted for the Wintergarden Groundwater Conservation District.

Green, R.T., G.W. Wittmeyer, and J.R. Winterle. 1998. Uvalde Aquifer Test Analysis. Proprietary Report prepared for Presentation to the Uvalde County Underground Water Conservation District.

Heitmuller, F.T. and B.D. Reece, 2003, Database of historically documented springs and spring flow measurements in Texas: United States Geological Survey, Open-File Report 03-315, digital dataset available at http://pubs.usgs.gov/of/2003/ofr03-315/.

Hutchison, W.R., J. Shi, and M. Jigmond, 2011. Groundwater Flow Model of the Kinney County Area. Texas Water Development Board, August 26, 2011.

Johnson, S., G. Schindel, and G Veni. 2010. Dye tracer tests in the Edwards Aquifer, Balcones Fault Zone, San Antonio Segment, Bexar County, Panther Springs Creek. Edwards Aquifer Authority. Report 10-01. 112 pp.

Johnson, S., G. Schindel, G. Veni, N. Hauwert, B. Hunt, B. Smith, and M. Gary. 2012. Tracing groundwater flowpaths in the vicinity of San Marcos Springs, Texas. Edwards Aquifer Authority. Report No. 12-01. 99 pp + attachments.

Jones, I.C., R. Anaya, and S.C. Wade. 2011. Groundwater Availability Model: Hill Country Portion of the Trinity Aquifer in Texas. Texas Water Development Board. Report 377.

Kelley, V.A., J. Ewing, T.L. Jones, S.C. Young, N. Deeds, S. Hamlin, M. Jigmond, J. Harding, J. Pinkard, T.T. Yan, B. Scanlon, R. Reedy, J. Beach, T. Davidson, and K. Laughlin. 2014. FINAL REPORT: Updated Groundwater Availability Model of the Northern Trinity and Woodbine Aquifers. Contract report for the Texas Water Development Board. 990 p.

Klemt, W.B., T. R. Knowles, G.R. Edler, and T.W. Sieh. 1979. Ground-water resources and model applications for the Edwards (Balcones fault zone) aquifer in the San Antonio region: Texas Water Development Board Report 239, 88 p.

Laubach, S.E. 1997. Tectonic Map of Texas. Bureau of Economic Geology, The University of Texas at Austin.

LBG-Guyton Associates. 2003. Brackish groundwater manual for Texas regional water planning groups: Contract report prepared for the Texas Water Development Board, Austin, Texas, 188 p. Available at (http://www.twdb.state.tx.us/RWPG/rpgm_rpts /2001483395.pdf).

Lindgren, R.J., A.R. Dutton, S.D. Hovorka, S.R.H. Worthington, and S. Painter. 2004 Conceptualization and simulation of the Edwards Aquifer, San Antonio region, Texas. Scientific Investigation Report 2004-5277. U.S. Geological Survey.143 p.

Mace, R.E., A.H. Chowdury, R. Anaya and S.-C. Way. 2000. Groundwater Availability of the Trinity Aquifer, Hill Country Area, Texas: Numerical Simulations through 2050. Texas Water Development Board. Report 353.

Mace, R.E. 2001. Estimating transmissivity using specific-capacity data: The University of Texas at Austin, Bureau of Economic Geology Geological Circular No. 01-2, 44 p.

Maclay, R.W. and L.F. Land. 1988. Simulation of flow in the Edwards Aquifer, San Antonio Region, Texas, and refinement of storage flow concepts. U.S. Geological Survey Water-Supply Paper2336, 48 pp.

Meyer, J. E., M. R. Wise, and S. Kalaswad. 2012. Pecos Valley Aquifer, West Texas: Structure and Brackish Groundwater, Texas Water Development Board Report 382, 86 p.

Meyer, J., A. Croskey, M. R. Wise, and S. Kalaswad. 2014. Brackish groundwater in the Gulf Coast aquifer, lower Rio Grande Valley, Texas: Texas Water Development Board Report 383, 169 p.

Nicot, J.-P., S. Walden, L. Greenlee, and J. Els. 2005. A desalination database for Texas: Report prepared for the Texas Water Development Board, Austin, Texas, 35 p. Available at (http://www.twdb.state.tx.us/RWPG/rpgm_rpts/2004483021_Desal_Database_Texas.pdf).

Nordstrom, P.L. 1982. Occurrence, availability, and chemical quality of groundwater in the Cretaceous aquifers of North-Central Texas: Texas Department of Water Resources Report 269, 2 vols.

Nordstrom, P.L. 1987. Groundwater resources of the Antlers and Travis Peak formations in the outcrop area of North-Central Texas: Texas Water Development Board Report 298, 297 p.

Prism Climate Group. 2015. 30 year normal, precipitation data download. Retrieved from http://www.prism.oregonstate.edu/explorer/ on August 17, 2015.

Ridgeway, C. and H. Petrini. 1999. Changes in Groundwater Conditions in the Edwards and Trinity Aquifers, 1987-1997, for Portions of Bastrop, Bell, Burnet, Lee, Milam, Travis and Williamson Counties, Texas. Texas Water Development Board. Report 350.

Rose, P.R. 1972. Edwards Group, surface and subsurface, central Texas: Austin, University of Texas, Bureau of Economic Geology Report of Investigations 74, 198 p.

R.W. Harden and Associates and others. 2004. Northern Trinity/Woodbine aquifer groundwater availability model. TWDB contract 2003483483.

Ryder, P.D. 1996. Ground Water Atlas of the United States. Oklahoma, Texas. U.S. Geological Survey. Hydrologic Atlas 730-E.

Slade, R.M., J.T. Bentley, and D. Michaud. 2002. Results of streamflow gain-loss studies in Texas, with emphasis on gains from and losses to major and minor aquifers. U.S. Geological Survey Open-File Report 02–068. 136 p.

Smith, B.A., and B.B. Hunt. 2009. Potential hydraulic connections between the Edwards and Trinity Aquifers in the Balcones Fault Zone of central Texas. Bulletin of the South Texas Geological Society, L, 2:15–34.

Smith, B.A., and B.B. Hunt. 2010. Flow potential between stacked Karst Aquifers in Central Texas, USA. In Advances in Research in Karst Media Environmental Earth Sciences, eds. B. Andreo, F. Carrasco, J.J. Duran, and J.W. LaMoreaux. p. 43–48.

Smith, B.A., and B.B, Hunt. 2011. Potential for vertical flow between the Edwards and Trinity Aquifer, Barton Springs Segment of the Edwards Aquifer. In *Interconnection of the Trinity (Glen Rose) and Edwards Aquifers along the Balcones Fault Zone and Related Topics, Proceedings from Karst Conservation Initiative Meeting*. p.11–14.

Sun, A. Y., R. Green, S. Swenson, and M. Rodell. 2012. Toward calibration of regional groundwater models using GRACE data. *Journal of Hydrology*. 422:1–9. doi:10.1016/j.jhydrol.2011.10.025

Sun, A.Y., R. Green, M. Rodell, and S. Swenson. 2010. Inferring aquifer storage parameters using satellite and in situ measurements: Estimation under uncertainty *Geophys. Res. Lett.*, *37*(L10401) 10.1029/2010GL043231

Texas Commission on Environmental Quality. Downloaded November 4th, 2015 from http://www.tceq.texas.gov/assets/public/gis/exports/pws_wells_intakes.zip

Texas Commission on Environmental Quality. 2004. Drinking water standards governing drinking water quality and reporting requirements for public water systems: Texas Commission on Environmental Quality, 30 TAC Chapter 290, Subchapter F: TCEQ RG-346, 99 p.

Texas Water Development Board. Downloaded on November 4th, 2015 from http://www.twdb.texas.gov/groundwater/data/gwdbrpt.asp

Texas Water Development Board. 2002. Water for Texas—2002 State Water Plan: Texas Water Development Board, v. 1, 155 p. http://www.twdb.state.tx.us/publications/reports/ State_Water_Plan/ 2002/FinalWaterPlan2002.asp).

University of Texas, Bureau of Economic Geology. 1979. Geologic atlas of Texas, Seguin sheet: Austin, scale 1:250,000.

University of Texas, Bureau of Economic Geology. 1981a. Geologic atlas of Texas, Austin sheet: Austin, scale 1:250,000.

University of Texas, Bureau of Economic Geology. 1981b. Geologic atlas of Texas, Llano sheet: Austin, scale 1:250,000.

University of Texas, Bureau of Economic Geology. 1983. Geologic atlas of Texas, San Antonio sheet: Austin, scale 1:250,000.

USGS O&G Produced water database: Downloaded November 4th, 2015 http://energy.usgs.gov/Portals/0/Rooms/produced_waters/tabular/USGSPWDB_v2.1.xlsx

Warner, D. L. 2001. Technical and economic evaluations of the protection of saline ground water under the safe drinking water act and the UIC Regulations: Report submitted to the Ground Water Protection Research Foundation, 44 p. (http://www.gwpc.org/uic/ State_App3).

Wierman, D.A., A.S. Broun, and B.B. Hunt. 2010. Hydrogeologic Atlas of the Hill Country Trinity Aquifer, Blanco, Hays, and Travis Counties, Central Texas: Prepared by the Hays-Trinity, Barton Springs/Edwards Aquifer, and Blanco Pedernales Groundwater Conservation Districts, July 2010, 17 Plates + DVD.

William F. Guyton and Associates 1979. Geohydrology of Comal, San Marcos, and Hueco Springs: Texas Department of Water-Resources Report 234, 85 p.

ATTACHMENT D. Historically Underutilized Businesses Subcontracting Plan and Responses

Rev. 09/15

HUB Subcontracting Plan (HSP)

In accordance with Texas Gov't Code §2161.252, the contracting agency has determined that subcontracting opportunities are probable under this contract. Therefore, all respondents, including State of Texas certified Historically Underutilized Businesses (HUBs) must complete and submit this State of Texas HUB Subcontracting Plan (HSP) with their response to the bid requisition (solicitation).

NOTE: Responses that do not include a completed HSP shall be rejected pursuant to Texas Gov't Code §2161.252(b).

The HUB Program promotes equal business opportunities for economically disadvantaged persons to contract with the State of Texas in accordance with the goals specified in the 2009 State of Texas Disparity Study. The statewide HUB goals defined in 34 Texas Administrative Code (TAC) §20.13 are:

- ***11.2 percent for heavy construction other than building contracts,***
- ***21.1 percent for all building construction, including general contractors and operative builders' contracts,***
- ***32.9 percent for all special trade construction contracts,***
- ***23.7 percent for professional services contracts,***
- ***26.0 percent for all other services contracts, and***
- ***21.1 percent for commodities contracts.***

- - Agency Special Instructions/Additional Requirements - -

*In accordance with 34 TAC §20.14(d)(1)(D)(iii), a respondent (prime contractor) may demonstrate good faith effort to utilize Texas certified HUBs for its subcontracting opportunities if the total value of the respondent's subcontracts with Texas certified HUBs meets or exceeds the statewide HUB goal or the agency specific HUB goal, whichever is higher. When a respondent uses this method to demonstrate good faith effort, the respondent must identify the HUBs with which it will subcontract. If using existing contracts with Texas certified HUBs to satisfy this requirement, only the aggregate percentage of the contracts expected to be subcontracted to HUBs with which the respondent **does not** have a **continuous contract*** in place for **more than five (5) years** shall qualify for meeting the HUB goal. This limitation is designed to encourage vendor rotation as recommended by the 2009 Texas Disparity Study.*

SECTION-1 RESPONDENT AND REQUISITION INFORMATION

a. Respondent (Company) Name: Southwest Research Institute — State of Texas VID #: 1741070544000

Point of Contact: Nathaniel Toll — Phone #: 210-522-2991

E-mail Address: ntoll@swri.org — Fax #: 210-522-5155

b. Is your company a State of Texas certified HUB? ☐ - Yes ☑ - No

c. Requisition #: 580-16-RFQ0028 — Bid Open Date: 08/11/2016 (mm/dd/yyyy)

Enter your company's name here: Southwest Research Institute Requisition #: 580-16-RFQ0028

SECTION-2: RESPONDENT's SUBCONTRACTING INTENTIONS

After dividing the contract work into reasonable lots or portions to the extent consistent with prudent industry practices, and taking into consideration the scope of work to be performed under the proposed contract, including all potential subcontracting opportunities, the respondent must determine what portions of work, **including contracted staffing, goods, services, transportation and delivery will be subcontracted.** Note: In accordance with 34 TAC §20.11, a "Subcontractor" means a person who contracts with a prime contractor to work, to supply commodities, or to contribute toward completing work for a governmental entity.

a. Check the appropriate box (Yes or No) that identifies your subcontracting intentions:

☑ - *Yes*, I will be subcontracting portions of the contract. (If *Yes*, complete Item b of this SECTION and continue to Item c of this SECTION.)

☐ - *No*, I will not be subcontracting any portion of the contract, and I will be fulfilling the entire contract with my own resources, including employees, goods, services, transportation and delivery. (If *No*, continue to SECTION 3 and SECTION 4.)

b. List all the portions of work (subcontracting opportunities) you will subcontract. Also, based on the total value of the contract, identify the percentages of the contract you expect to award to Texas certified HUBs, and the percentage of the contract you expect to award to vendors that are not a Texas certified HUB (i.e., Non-HUB).

Item #	Subcontracting Opportunity Description	HUBs		Non-HUBs
		Percentage of the contract expected to be subcontracted to HUBs with which you do not have a continuous contract* in place for more than five (5) years.	Percentage of the contract expected to be subcontracted to HUBs with which you have a continuous contract* in place for more than five (5) years.	Percentage of the contract expected to be subcontracted to non-HUBs.
1	GIS, GIS Programming, 3D data interpretation, Trinity Aquifer SME	%	%	31 %
2		%	%	%
3		%	%	%
4		%	%	%
5		%	%	%
6		%	%	%
7		%	%	%
8		%	%	%
9		%	%	%
10		%	%	%
11		%	%	%
12		%	%	%
13		%	%	%
14		%	%	%
15		%	%	%
	Aggregate percentages of the contract expected to be subcontracted:	%	%	31 %

(Note: If you have more than fifteen subcontracting opportunities, a continuation sheet is available online at http://window.state.tx.us/procurement/prog/hub/hub-subcontracting-plan/)

c. Check the appropriate box (Yes or No) that indicates whether you will be using **only** Texas certified HUBs to perform **all** of the subcontracting opportunities you listed in SECTION 2, Item b.

☐ - *Yes* (If *Yes*, continue to SECTION 4 and complete an "HSP Good Faith Effort - Method A (Attachment A)" for **each** of the subcontracting opportunities you listed.)

☑ - *No* (If *No*, continue to Item d, of this SECTION.)

d. Check the appropriate box (Yes or No) that indicates whether the aggregate expected percentage of the contract you will subcontract **with Texas certified HUBs** with which you **do not** have a **continuous contract*** in place with for **more than five (5) years**, **meets or exceeds** the HUB goal the contracting agency identified on page 1 in the "**Agency Special Instructions/Additional Requirements.**"

☐ - *Yes* (If *Yes*, continue to SECTION 4 and complete an "HSP Good Faith Effort - Method A (Attachment A)" for **each** of the subcontracting opportunities you listed.)

☑ - *No* (If *No*, continue to SECTION 4 and complete an "HSP Good Faith Effort - Method B (Attachment B)" for **each** of the subcontracting opportunities you listed.)

***Continuous Contract**: Any existing written agreement (including any renewals that are exercised) between a prime contractor and a HUB vendor, where the HUB vendor provides the prime contractor with goods or service, to include transportation and delivery under the same contract for a specified period of time. The frequency the HUB vendor is utilized or paid during the term of the contract is not relevant to whether the contract is considered continuous. Two or more contracts that run concurrently or overlap one another for different periods of time are considered by CPA to be individual contracts rather than renewals or extensions to the original contract. In such situations the prime contractor and HUB vendor are entering (have entered) into "new" contracts.*

Enter your company's name here: Southwest Research Institute Requisition #: 580-16-RFQ0028

SECTION-3 SELF PERFORMING JUSTIFICATION (If you responded "No" to SECTION 2, Item a, you must complete this SECTION and continue to SECTION 4.)

If you responded "No" to SECTION 2, Item a, in the space provided below **explain how** your company will perform the entire contract with its own employees, supplies, materials and/or equipment, to include transportation and delivery.

SECTION-4: AFFIRMATION

As evidenced by my signature below, I affirm that I am an authorized representative of the respondent listed in SECTION 1, and that the information and supporting documentation submitted with the HSP is true and correct. Respondent understands and agrees that, if awarded any portion of the requisition:

- The respondent will provide notice as soon as practical to all the subcontractors (HUBs and Non-HUBs) of their selection as a subcontractor for the awarded contract. The notice must specify at a minimum the contracting agency's name and its point of contact for the contract, the contract award number, the subcontracting opportunity they (the subcontractor) will perform, the approximate dollar value of the subcontracting opportunity and the expected percentage of the total contract that the subcontracting opportunity represents. A copy of the notice required by this section must also be provided to the contracting agency's point of contact for the contract no later than ten (10) working days after the contract is awarded.
- The respondent must submit monthly compliance reports (Prime Contractor Progress Assessment Report – PAR) to the contracting agency, verifying its compliance with the HSP, including the use of and expenditures made to its subcontractors (HUBs and Non-HUBs). (The PAR is available at http://www.window.state.tx.us/procurement/prog/hub/hub-forms/progressassessmentrpt.xls).
- The respondent must seek approval from the contracting agency prior to making any modifications to its HSP, including the hiring of additional or different subcontractors and the termination of a subcontractor the respondent identified in its HSP. If the HSP is modified without the contracting agency's prior approval, respondent may be subject to any and all enforcement remedies available under the contract or otherwise available by law, up to and including debarment from all state contracting.
- The respondent must, upon request, allow the contracting agency to perform on-site reviews of the company's headquarters and/or work-site where services are being performed and must provide documentation regarding staffing and other resources.

Signature	Printed Name	Title	Date (mm/dd/yyyy)
	Nathaniel Toll	Sr. Research Scientist	08/7/2016

Reminder:

- If you responded **"Yes"** to **SECTION 2, Items c or d**, you must complete an "HSP Good Faith Effort - Method A (Attachment A)" for each of the subcontracting opportunities you listed in SECTION 2, Item b.
- If you responded **"No" SECTION 2, Items c and d**, you must complete an "HSP Good Faith Effort - Method B (Attachment B)" for each of the subcontracting opportunities you listed in SECTION 2, Item b.

HSP Good Faith Effort - Method B (Attachment B)

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Enter your company's name here: Southwest Research Institute Requisition #: 580-16-RFQ0028

IMPORTANT: If you responded "*No*" to **SECTION 2, Items c** and **d** of the completed HSP form, you must submit a completed "HSP Good Faith Effort - Method B (Attachment B)" for **each** of the subcontracting opportunities you listed in **SECTION 2, Item b** of the completed HSP form. You may photo-copy this page or download the form at http://window.state.tx.us/procurement/prog/hub/hub-forms/hub-sbcont-plan-gfe-achm-b.pdf.

SECTION B-1: SUBCONTRACTING OPPORTUNITY

Enter the item number and description of the subcontracting opportunity you listed in SECTION 2, Item b, of the completed HSP form for which you are completing the attachment.

Item Number: 1 Description: GIS, GIS Programming, 3D data interpretation, Trinity Aquifer SME

SECTION B 2: MENTOR PROTÉGÉ PROGRAM

If respondent is participating as a Mentor in a State of Texas Mentor Protégé Program, submitting its Protégé (Protégé must be a State of Texas certified HUB) as a subcontractor to perform the subcontracting opportunity listed in **SECTION B-1**, constitutes a good faith effort to subcontract with a Texas certified HUB towards that specific portion of work.

Check the appropriate box (Yes or No) that indicates whether you will be subcontracting the portion of work you listed in SECTION B-1 to your Protégé.

☐ - Yes (If *Yes*, continue to SECTION B-4.)

☑ - No / Not Applicable (If *No* or *Not Applicable*, continue to SECTION B-3 and SECTION B-4.)

SECTION B 3: NOTIFICATION OF SUBCONTRACTING OPPORTUNITY

When completing this section you MUST comply with items a, b, c and d, thereby demonstrating your Good Faith Effort of having notified Texas certified HUBs and trade organizations or development centers about the subcontracting opportunity you listed in SECTION B-1. Your notice should include the scope of work, information regarding the location to review plans and specifications, bonding and insurance requirements, required qualifications, and identify a contact person. When sending notice of your subcontracting opportunity, you are encouraged to use the attached HUB Subcontracting Opportunity Notice form, which is also available online at http://www.window.state.tx.us/procurement/prog/hub/hub-subcontracting-plan.

Retain supporting documentation (i.e., certified letter, fax, e-mail) demonstrating evidence of your good faith effort to notify the Texas certified HUBs and trade organizations or development centers. Also, be mindful that a working day is considered a normal business day of a state agency, not including weekends, federal or state holidays, or days the agency is declared closed by its executive officer. The initial day the subcontracting opportunity notice is sent/provided to the HUBs and to the trade organizations or development centers is considered to be "day zero" and does not count as one of the seven (7) working days.

a. Provide written notification of the subcontracting opportunity you listed in SECTION B-1, to three (3) or more Texas certified HUBs. Unless the contracting agency specified a different time period, you must allow the HUBs at least seven (7) working days to respond to the notice prior to you submitting your bid response to the contracting agency. When searching for Texas certified HUBs and verifying their HUB status, ensure that you use the State of Texas' Centralized Master Bidders List (CMBL) - Historically Underutilized Business (HUB) Directory Search located at http://mycpa.cpa.state.tx.us/tpasscmblsearch/index.jsp. HUB status code "**A**" signifies that the company is a Texas certified HUB.

b. List the **three (3) Texas certified HUBs** you notified regarding the subcontracting opportunity you listed in SECTION B-1. Include the company's Texas Vendor Identification (VID) Number, the date you sent notice to that company, and indicate whether it was responsive or non-responsive to your subcontracting opportunity notice.

Company Name	Texas VID (Do not enter Social Security Numbers)	Date Notice Sent (mm/dd/yyyy)	Did the HUB Respond?
Hicks & Company	1742532120900	07/18/2016	☐ - Yes ☑ - No
Horizon Environmental Services	1742480982400	07/18/2016	☐ - Yes ☑ - No
Medina Consulting Company	1141843448300	07/18/2016	☐ - Yes ☑ - No

c. Provide written notification of the subcontracting opportunity you listed in SECTION B-1 to two (2) or more trade organizations or development centers in Texas to assist in identifying potential HUBs by disseminating the subcontracting opportunity to their members/participants. Unless the contracting agency specified a different time period, you must provide your subcontracting opportunity notice to trade organizations or development centers at least seven (7) working days prior to submitting your bid response to the contracting agency. A list of trade organizations and development centers that have expressed an interest in receiving notices of subcontracting opportunities is available on the Statewide HUB Program's webpage at http://www.window.state.tx.us/procurement/prog/hub/mwb-links-1/.

d. List **two (2) trade organizations or development centers** you notified regarding the subcontracting opportunity you listed in SECTION B-1. Include the date when you sent notice to it and indicate if it accepted or rejected your notice.

Trade Organizations or Development Centers	Date Notice Sent (mm/dd/yyyy)	Was the Notice Accepted?
Hispanic Contractors Association de San Antonio	07/18/2016	☑ - Yes ☐ - No
Houston Minority Supplier Development Council	07/18/2016	☑ - Yes ☐ - No

HSP Good Faith Effort - Method B (Attachment B) Cont.

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Enter your company's name here: Southwest Research Institute Requisition #: 580-16-RFQ0028

SECTION B-4: SUBCONTRACTOR SELECTION

Enter the item number and description of the subcontracting opportunity you listed in **SECTION 2, Item b,** of the completed HSP form for which you are completing the attachment.

a. Enter the item number and description of the subcontracting opportunity for which you are completing this Attachment B continuation page.

Item Number: 1 Description: GIS, GIS Programming, 3D data interpretation, Trinity Aquifer SME

b. List the subcontractor(s) you selected to perform the subcontracting opportunity you listed in **SECTION B-1**. Also identify whether they are a Texas certified HUB and their Texas Vendor Identification (VID) Number or federal Emplioyer Identification Number (EIN), the approximate dollar value of the work to be subcontracted, and the expected percentage of work to be subcontracted. When searching for Texas certified HUBs and verifying their HUB status, ensure that you use the State of Texas' Centralized Master Bidders List (CMBL) - Historically Underutilized Business (HUB) Directory Search located at http://mycpa.cpa.state.tx.us/tpasscmblsearch/index.jsp. HUB status code "A" signifies that the company is a Texas certified HUB.

Company Name	Texas certified HUB	Texas VID or federal EIN Do not enter Social Security Numbers If you do not know their VID / EIN leave their VID / EIN field blank	Approximate Dollar Amount	Expected Percentage of Contract
Intera Inc.	☐ - Yes ☑ - No		$ 110,000	31 %
	☐ - Yes ☐ - No		$	%
	☐ - Yes ☐ - No		$	%
	☐ - Yes ☐ - No		$	%
	☐ - Yes ☐ - No		$	%
	☐ - Yes ☐ - No		$	%
	☐ - Yes ☐ - No		$	%
	☐ - Yes ☐ - No		$	%
	☐ - Yes ☐ - No		$	%
	☐ - Yes ☐ - No		$	%

c. If any of the subcontractors you have selected to perform the subcontracting opportunity you listed in **SECTION B-1** is **not** a Texas certified HUB, provide written justification for your selection process (attach additional page if necessary):

Over three HUB certified businesses and several trade organizations were notified of this opportunity. None of them responded with interest in the Opportunity. Accordingly, we sought out a non-HUB business with the appropriate qualifications and experience.

REMINDER: As specified in SECTION 4 of the completed HSP form, if you (respondent) are awarded any portion of the requisition, you are required to provide notice as soon as practical to **all** the subcontractors (HUBs and Non-HUBs) of their selection as a subcontractor. The notice must specify at a minimum the contracting agency's name and its point of contact for the contract, the contract award number, the subcontracting opportunity it (the subcontractor) will perform, the approximate dollar value of the subcontracting opportunity and the expected percentage of the total contract that the subcontracting opportunity represents. A copy of the notice required by this section must also be provided to the contracting agency's point of contact for the contract no later than ten (10) working days after the contract is awarded.

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HUB Subcontracting Opportunity Notification Form

In accordance with Texas Gov't Code, Chapter 2161, each state agency that considers entering into a contract with an expected value of $100,000 or more shall, before the agency solicits bids, proposals, offers, or other applicable expressions of interest, determine whether subcontracting opportunities are probable under the contract. The state agency I have identified below in **Section B** has determined that subcontracting opportunities are probable under the requisition to which my company will be responding.

34 Texas Administrative Code, §20.14 requires all respondents (prime contractors) bidding on the contract to provide notice of each of their subcontracting opportunities to at least three (3) Texas certified HUBs (who work within the respective industry applicable to the subcontracting opportunity), and allow the HUBs at least seven (7) working days to respond to the notice prior to the respondent submitting its bid response to the contracting agency. In addition, at least seven (7) working days prior to submitting its bid response to the contracting agency, the respondent must provide notice of each of its subcontracting opportunities to two (2) or more trade organizations or development centers (in Texas) that serves members of groups (i.e., Asian Pacific American, Black American, Hispanic American, Native American, Woman, Service Disabled Veteran) identified in Texas Administrative Code, §20.11(19)(C).

We respectfully request that vendors interested in bidding on the subcontracting opportunity scope of work identified in **Section C, Item 2**, reply no later than the date and time identified in **Section C, Item 1**. Submit your response to the point-of-contact referenced in **Section A**.

SECTION: A PRIME CONTRACTOR'S INFORMATION

Company Name: Southwest Research Institute
State of Texas VID #: 1741070544000
Point-of-Contact: Nathaniel Toll
Phone #: 210-522-2991
E-mail Address: ntoll@swri.org
Fax #: 210-522-5155

SECTION: B CONTRACTING STATE AGENCY AND REQUISITION INFORMATION

Agency Name: Texas Water Development Board
Point-of-Contact: Angela Wallace
Phone #: 512-463-7979
Requisition #: 580-16-RFQ0028
Bid Open Date: 08/11/2016 (mm/dd/yyyy)

SECTION: C SUBCONTRACTING OPPORTUNITY RESPONSE DUE DATE, DESCRIPTION, REQUIREMENTS AND RELATED INFORMATION

1. Potential Subcontractor's Bid Response Due Date:

If you would like for our company to consider your company's bid for the subcontracting opportunity identified below in Item 2, we must receive your bid response no later than 2:00pm (Central Time) **on** 08/02/2016 (Date (mm/dd/yyyy)).

In accordance with 34 TAC §20.14, each notice of subcontracting opportunity shall be provided to at least three (3) Texas certified HUBs, and allow the HUBs at least seven (7) working days to respond to the notice prior to submitting our bid response to the contracting agency. In addition, at least seven (7) working days prior to us submitting our bid response to the contracting agency, we must provide notice of each of our subcontracting opportunities to two (2) or more trade organizations or development centers (in Texas) that serves members of groups (i.e., Asian Pacific American, Black American, Hispanic American, Native American, Woman, Service Disabled Veteran) identified in Texas Administrative Code, §20.11(19)(C).

(A working day is considered a normal business day of a state agency, not including weekends, federal or state holidays, or days the agency is declared closed by its executive officer. The initial day the subcontracting opportunity notice is sent/provided to the HUBs and to the trade organizations or development centers is considered to be "day zero" and does not count as one of the seven (7) working days.)

2. Subcontracting Opportunity Scope of Work:

SwRI requires technical consulting services from a geosciences and engineering firm, with specialties in geostatistics, geographic information systems (GIS) programming, and working with 3-D GIS datasets. The services will included acquisition of existing geologic data from literature and other sources, interpretation of geophysical logs to identify the transitions of various formations of the Trinity Aquifer in Texas, the 3-D interpolation of point data to create surfaces, and identification and delineation of faults in the Trinity formation.

3. Required Qualifications: ☐ - Not Applicable

Qualified firms must be registered in Texas for both geosciences and engineering. Qualified firms must have experience developing Python code for both geostatistical analyses and automating GIS tasks. Qualified firms must be composed primarily of staff must be registered in Texas as professional geoscientist or professional engineers. Qualified firms must have at least three years of experience in identification and interpretation of geology in the Glen Rose formation.

4. Bonding/Insurance Requirements: ☐ - Not Applicable

Subcontractor is solely responsible for obtaining sufficient insurance in accordance with the general standards and practices of the industry or governmental entity.

5. Location to review plans/specifications: ☐ - Not Applicable

Request for Qualifications is available on the Texas Water Development Board website at: http: //www.twdb.texas.gov/about/contract_admin/request/index.asp or The July 1, 2016 edition of the Texas Register at : http://www.sos.state.tx.us/texreg/index.shtml.

Lora Neill

From:	Lora Neill
Sent:	Monday, July 18, 2016 1:05 PM
To:	'hicks@hicksenv.com'
Cc:	Nathaniel Toll; Ron Green; Lora Neill
Subject:	Subcontracting Opportunity
Attachments:	HUBSubcontractingOpportunityNotificationFormGIS3.pdf

Hicks & Company

SOUTHWEST RESEARCH INSTITUTE

Southwest Research Institute
6220 Culebra
San Antonio, Texas 78238

RE: Subcontracting Opportunity

Dear Sandra E. Hicks:

Southwest Research Institute® (SwRI®) is responding to a solicitation from the Texas Water Development Board (TWDB) to update the conceptual model of groundwater flow in the Trinity Aquifer of Texas. Per the TWDB's Request for Qualifications, SWRI is soliciting subcontracting services from certified Historically Underutilized Businesses (HUBs) on the Centralized Master Bidders List (CMBL). We are currently developing a subcontracting plan wherein HUB firms are identified that may be selected to work under this contract. This letter has been sent to solicit your interest in performing the identified scope of work (a HUB Subcontracting Opportunity Notification Form is attached) on this project as a subcontractor to SwRI. While we recognize that the scope and required qualifications are very specific in nature, we view this expertise and experience as critical to winning, and subsequently executing, this project. If there is interest, and you have the capabilities and experience to perform the scope, please email a written statement to Nathaniel Toll (ntoll@swri.org). SwRI will, at its sole discretion, determine which firms are selected for opportunities under this contract. The scope of work and requirements are listed below.

> SwRI requires technical consulting services from a geosciences and engineering firm, with specialties in geostatistics, geographic information systems (GIS) programming, and working with three-dimensional (3-D) GIS datasets. The services will include acquisition of existing geologic data from literature and other sources, interpretation of geophysical logs to identify the transitions of various formations of the Trinity Aquifer in Texas, the 3-D interpolation of point data to create surfaces, and identification and delineation of faults in the Trinity formation.
>
> Qualified firms must be registered in Texas for both geosciences and engineering. Qualified firms must have experience developing Python code for both geostatistical analyses and automating GIS tasks. Qualified firms must be composed primarily of staff registered in Texas as professional geoscientists or professional engineers. Qualified firms must have at least 3 years of experience in identification and interpretation of geology in the Glen Rose formation.

In order to evaluate and subsequently incorporate subcontractor qualifications/experience into SWRI's Statement of Qualifications to TWDB, please confirm your interest within **7** working days of receiving this notice (and **no later than 2:00 p.m. on Tuesday August 2, 2016).** We look forward to your response.

Lora Neill
Staff Administrative Assistant
Geosciences and Engineering Division
210-522-5157
lneill@cnwra.swri.edu

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HUB Subcontracting Opportunity Notification Form

In accordance with Texas Gov't Code, Chapter 2161, each state agency that considers entering into a contract with an expected value of $100,000 or more shall, before the agency solicits bids, proposals, offers, or other applicable expressions of interest, determine whether subcontracting opportunities are probable under the contract. The state agency I have identified below in Section B has determined that subcontracting opportunities are probable under the requisition to which my company will be responding.

34 Texas Administrative Code, §20.14 requires all respondents (prime contractors) bidding on the contract to provide notice of each of their subcontracting opportunities to at least three (3) Texas certified HUBs (who work within the respective industry applicable to the subcontracting opportunity), and allow the HUBs at least seven (7) working days to respond to the notice prior to the respondent submitting its bid response to the contracting agency. In addition, at least seven (7) working days prior to submitting its bid response to the contracting agency, the respondent must provide notice of each of its subcontracting opportunities to two (2) or more trade organizations or development centers (in Texas) that serves members of groups (i.e., Asian Pacific American, Black American, Hispanic American, Native American, Woman, Service Disabled Veteran) identified in Texas Administrative Code, §20.11(19)(C).

We respectfully request that vendors interested in bidding on the subcontracting opportunity scope of work identified in Section C, Item 2, reply no later than the date and time identified in Section C, Item 1. Submit your response to the point-of-contact referenced in Section A.

SECTION: A PRIME CONTRACTOR'S INFORMATION

Company Name: Southwest Research Institute
State of Texas VID #: 1741070544000
Point-of-Contact: Nathaniel Toll
Phone #: 210-522-2991
E-mail Address: ntoll@swri.org
Fax #: 210-522-5155

SECTION: B CONTRACTING STATE AGENCY AND REQUISITION INFORMATION

Agency Name: Texas Water Development Board
Point-of-Contact: Angela Wallace
Phone #: 512-463-7979
Requisition #: 580-16-RFQ0028
Bid Open Date: 08/11/2016 (mm/dd/yyyy)

SECTION: C SUBCONTRACTING OPPORTUNITY RESPONSE DUE DATE, DESCRIPTION, REQUIREMENTS AND RELATED INFORMATION

1. Potential Subcontractor's Bid Response Due Date:

If you would like for our company to consider your company's bid for the subcontracting opportunity identified below in Item 2, we must receive your bid response no later than 2:00pm (Central Time) on 08/02/2016 (Date (mm/dd/yyyy)).

In accordance with 34 TAC §20.14, each notice of subcontracting opportunity shall be provided to at least three (3) Texas certified HUBs, and allow the HUBs at least seven (7) working days to respond to the notice prior to submitting our bid response to the contracting agency. In addition, at least seven (7) working days prior to us submitting our bid response to the contracting agency, we must provide notice of each of our subcontracting opportunities to two (2) or more trade organizations or development centers (in Texas) that serves members of groups (i.e., Asian Pacific American, Black American, Hispanic American, Native American, Woman, Service Disabled Veteran) identified in Texas Administrative Code, §20.11(19)(C).

(A working day is considered a normal business day of a state agency, not including weekends, federal or state holidays, or days the agency is declared closed by its executive officer. The initial day the subcontracting opportunity notice is sent/provided to the HUBs and to the trade organizations or development centers is considered to be "day zero" and does not count as one of the seven (7) working days.)

2. Subcontracting Opportunity Scope of Work:

SwRI requires technical consulting services from a geosciences and engineering firm, with specialties in geostatistics, geographic information systems (GIS) programming, and working with 3-D GIS datasets. The services will included acquisition of existing geologic data from literature and other sources, interpretation of geophysical logs to identify the transitions of various formations of the Trinity Aquifer in Texas, the 3-D interpolation of point data to create surfaces, and identification and delineation of faults in the Trinity formation.

3. Required Qualifications:

☐ - Not Applicable

Qualified firms must be registered in Texas for both geosciences and engineering. Qualified firms must have experience developing Python code for both geostatistical analyses and automating GIS tasks. Qualified firms must be composed primarily of staff must be registered in Texas as professional geoscientist or professional engineers. Qualified firms must have at least three years of experience in identification and interpretation of geology in the Glen Rose formation.

4. Bonding/Insurance Requirements:

☐ - Not Applicable

Subcontractor is solely responsible for obtaining sufficient insurance in accordance with the general standards and practices of the industry or governmental entity.

5. Location to review plans/specifications:

☐ - Not Applicable

Request for Qualifications is available on the Texas Water Development Board website at: http: //www.twdb.texas.gov/about/contract_admin/request/index.asp or The July 1, 2016 edition of the Texas Register at : http://www.sos.state.tx.us/texreg/index.shtml.

Lora Neill

From: Mail Delivery Subsystem <MAILER-DAEMON@swri.org>
To: hicks@hicksenv.com
Sent: Monday, July 18, 2016 1:06 PM
Subject: Relayed: Subcontracting Opportunity

Delivery to these recipients or groups is complete, but no delivery notification was sent by the destination server:

hicks@hicksenv.com

Subject: Subcontracting Opportunity

Lora Neill

From: Karyn Batson <kbatson@hicksenv.com>
Sent: Monday, July 18, 2016 1:34 PM
To: Lora Neill
Subject: Read: Subcontracting Opportunity

Lora Neill

From:	Lora Neill
Sent:	Monday, July 18, 2016 1:07 PM
To:	'lee_sherrod@horizon-esi.com'
Cc:	Nathaniel Toll; Ron Green; Lora Neill
Subject:	Subcontracting Opportunity
Attachments:	HUBSubcontractingOpportunityNotificationFormGIS3.pdf

Horizon Environmental Services

SOUTHWEST RESEARCH INSTITUTE

Southwest Research Institute
6220 Culebra
San Antonio, Texas 78238

RE: Subcontracting Opportunity

Dear Lynda Sherrod:

Southwest Research Institute® (SwRI®) is responding to a solicitation from the Texas Water Development Board (TWDB) to update the conceptual model of groundwater flow in the Trinity Aquifer of Texas. Per the TWDB's Request for Qualifications, SWRI is soliciting subcontracting services from certified Historically Underutilized Businesses (HUBs) on the Centralized Master Bidders List (CMBL). We are currently developing a subcontracting plan wherein HUB firms are identified that may be selected to work under this contract. This letter has been sent to solicit your interest in performing the identified scope of work (a HUB Subcontracting Opportunity Notification Form is attached) on this project as a subcontractor to SwRI. While we recognize that the scope and required qualifications are very specific in nature, we view this expertise and experience as critical to winning, and subsequently executing, this project. If there is interest, and you have the capabilities and experience to perform the scope, please email a written statement to Nathaniel Toll (ntoll@swri.org). SwRI will, at its sole discretion, determine which firms are selected for opportunities under this contract. The scope of work and requirements are listed below.

> SwRI requires technical consulting services from a geosciences and engineering firm, with specialties in geostatistics, geographic information systems (GIS) programming, and working with three-dimensional (3-D) GIS datasets. The services will include acquisition of existing geologic data from literature and other sources, interpretation of geophysical logs to identify the transitions of various formations of the Trinity Aquifer in Texas, the 3-D interpolation of point data to create surfaces, and identification and delineation of faults in the Trinity formation.
>
> Qualified firms must be registered in Texas for both geosciences and engineering. Qualified firms must have experience developing Python code for both geostatistical analyses and automating GIS tasks. Qualified firms must be composed primarily of staff registered in Texas as professional geoscientists or professional engineers. Qualified firms must have at least 3 years of experience in identification and interpretation of geology in the Glen Rose formation.

In order to evaluate and subsequently incorporate subcontractor qualifications/experience into SWRI's Statement of Qualifications to TWDB, please confirm your interest within **7** working days of receiving this notice (and **no later than 2:00 p.m. on Tuesday August 2, 2016).** We look forward to your response.

Lora Neill
Staff Administrative Assistant
Geosciences and Engineering Division
210-522-5157
lneill@cnwra.swri.edu

Rev. 09/15

HUB Subcontracting Opportunity Notification Form

In accordance with Texas Gov't Code, Chapter 2161, each state agency that considers entering into a contract with an expected value of $100,000 or more shall, before the agency solicits bids, proposals, offers, or other applicable expressions of interest, determine whether subcontracting opportunities are probable under the contract. The state agency I have identified below in Section B has determined that subcontracting opportunities are probable under the requisition to which my company will be responding.

34 Texas Administrative Code, §20.14 requires all respondents (prime contractors) bidding on the contract to provide notice of each of their subcontracting opportunities to at least three (3) Texas certified HUBs (who work within the respective industry applicable to the subcontracting opportunity), and allow the HUBs at least seven (7) working days to respond to the notice prior to the respondent submitting its bid response to the contracting agency. In addition, at least seven (7) working days prior to submitting its bid response to the contracting agency, the respondent must provide notice of each of its subcontracting opportunities to two (2) or more trade organizations or development centers (in Texas) that serves members of groups (i.e., Asian Pacific American, Black American, Hispanic American, Native American, Woman, Service Disabled Veteran) identified in Texas Administrative Code, §20.11(19)(C).

We respectfully request that vendors interested in bidding on the subcontracting opportunity scope of work identified in **Section C, Item 2**, reply no later than the date and time identified in **Section C, Item 1**. Submit your response to the point-of-contact referenced in **Section A**.

SECTION: A PRIME CONTRACTOR'S INFORMATION

Company Name: Southwest Research Institute
State of Texas VID #: 1741070544000
Point-of-Contact: Nathaniel Toll
Phone #: 210-522-2991
E-mail Address: ntoll@swri.org
Fax #: 210-522-5155

SECTION: B CONTRACTING STATE AGENCY AND REQUISITION INFORMATION

Agency Name: Texas Water Development Board
Point-of-Contact: Angela Wallace
Phone #: 512-463-7979
Requisition #: 580-16-RFQ0028
Bid Open Date: 08/11/2016 (mm/dd/yyyy)

SECTION: C SUBCONTRACTING OPPORTUNITY RESPONSE DUE DATE, DESCRIPTION, REQUIREMENTS AND RELATED INFORMATION

1. Potential Subcontractor's Bid Response Due Date:

If you would like for our company to consider your company's bid for the subcontracting opportunity identified below in Item 2, we must receive your bid response no later than 2:00pm (Central Time) on 08/02/2016 (Date (mm/dd/yyyy)).

In accordance with 34 TAC §20.14, each notice of subcontracting opportunity shall be provided to at least three (3) Texas certified HUBs, and allow the HUBs at least seven (7) working days to respond to the notice prior to submitting our bid response to the contracting agency. In addition, at least seven (7) working days prior to us submitting our bid response to the contracting agency, we must provide notice of each of our subcontracting opportunities to two (2) or more trade organizations or development centers (in Texas) that serves members of groups (i.e., Asian Pacific American, Black American, Hispanic American, Native American, Woman, Service Disabled Veteran) identified in Texas Administrative Code, §20.11(19)(C).

(A working day is considered a normal business day of a state agency, not including weekends, federal or state holidays, or days the agency is declared closed by its executive officer. The initial day the subcontracting opportunity notice is sent/provided to the HUBs and to the trade organizations or development centers is considered to be "day zero" and does not count as one of the seven (7) working days.)

2. Subcontracting Opportunity Scope of Work:

SwRI requires technical consulting services from a geosciences and engineering firm, with specialties in geostatistics, geographic information systems (GIS) programming, and working with 3-D GIS datasets. The services will included acquisition of existing geologic data from literature and other sources, interpretation of geophysical logs to identify the transitions of various formations of the Trinity Aquifer in Texas, the 3-D interpolation of point data to create surfaces, and identification and delineation of faults in the Trinity formation.

3. Required Qualifications:

☐ - Not Applicable

Qualified firms must be registered in Texas for both geosciences and engineering. Qualified firms must have experience developing Python code for both geostatistical analyses and automating GIS tasks. Qualified firms must be composed primarily of staff must be registered in Texas as professional geoscientist or professional engineers. Qualified firms must have at least three years of experience in identification and interpretation of geology in the Glen Rose formation.

4. Bonding/Insurance Requirements:

☐ - Not Applicable

Subcontractor is solely responsible for obtaining sufficient insurance in accordance with the general standards and practices of the industry or governmental entity.

5. Location to review plans/specifications:

☐ - Not Applicable

Request for Qualifications is available on the Texas Water Development Board website at: http: //www.twdb.texas.gov/about/contract_admin/request/index.asp or The July 1, 2016 edition of the Texas Register at : http://www.sos.state.tx.us/texreg/index.shtml.

Lora Neill

From: Mail Delivery Subsystem <MAILER-DAEMON@swri.org>
To: lee_sherrod@horizon-esi.com
Sent: Monday, July 18, 2016 1:16 PM
Subject: Relayed: Subcontracting Opportunity

Delivery to these recipients or groups is complete, but no delivery notification was sent by the destination server:

lee_sherrod@horizon-esi.com

Subject: Subcontracting Opportunity

Lora Neill

From: Lee Sherrod <lee_sherrod@horizon-esi.com>
To: Lora Neill
Sent: Monday, July 18, 2016 1:12 PM
Subject: Read: Subcontracting Opportunity

Your message

To:
Subject: Subcontracting Opportunity
Sent: Monday, July 18, 2016 1:12:19 PM (UTC-06:00) Central Time (US & Canada)

was read on Monday, July 18, 2016 1:11:49 PM (UTC-06:00) Central Time (US & Canada).

Lora Neill

From:	Lora Neill
Sent:	Monday, July 18, 2016 1:09 PM
To:	'kmcgookey@medinacci.com'
Cc:	Nathaniel Toll; Ron Green; Lora Neill
Subject:	Subcontracting Opportunity
Attachments:	HUBSubcontractingOpportunityNotificationFormGIS3.pdf

Medina Consulting Company, Inc.

SOUTHWEST RESEARCH INSTITUTE

Southwest Research Institute
6220 Culebra
San Antonio, Texas 78238

RE: Subcontracting Opportunity

Dear Katherine McGookey:

Southwest Research Institute® (SwRI®) is responding to a solicitation from the Texas Water Development Board (TWDB) to update the conceptual model of groundwater flow in the Trinity Aquifer of Texas. Per the TWDB's Request for Qualifications, SWRI is soliciting subcontracting services from certified Historically Underutilized Businesses (HUBs) on the Centralized Master Bidders List (CMBL). We are currently developing a subcontracting plan wherein HUB firms are identified that may be selected to work under this contract. This letter has been sent to solicit your interest in performing the identified scope of work (a HUB Subcontracting Opportunity Notification Form is attached) on this project as a subcontractor to SwRI. While we recognize that the scope and required qualifications are very specific in nature, we view this expertise and experience as critical to winning, and subsequently executing, this project. If there is interest, and you have the capabilities and experience to perform the scope, please email a written statement to Nathaniel Toll (ntoll@swri.org). SwRI will, at its sole discretion, determine which firms are selected for opportunities under this contract. The scope of work and requirements are listed below.

> SwRI requires technical consulting services from a geosciences and engineering firm, with specialties in geostatistics, geographic information systems (GIS) programming, and working with three-dimensional (3-D) GIS datasets. The services will include acquisition of existing geologic data from literature and other sources, interpretation of geophysical logs to identify the transitions of various formations of the Trinity Aquifer in Texas, the 3-D interpolation of point data to create surfaces, and identification and delineation of faults in the Trinity formation.
>
> Qualified firms must be registered in Texas for both geosciences and engineering. Qualified firms must have experience developing Python code for both geostatistical analyses and automating GIS tasks. Qualified firms must be composed primarily of staff registered in Texas as professional geoscientists or professional engineers. Qualified firms must have at least 3 years of experience in identification and interpretation of geology in the Glen Rose formation.

In order to evaluate and subsequently incorporate subcontractor qualifications/experience into SWRI's Statement of Qualifications to TWDB, please confirm your interest within **7** working days of receiving this notice (and **no later than 2:00 p.m. on Tuesday August 2, 2016).** We look forward to your response.

Lora Neill
Staff Administrative Assistant
Geosciences and Engineering Division
210-522-5157
lneill@cnwra.swri.edu

Rev. 09/15

HUB Subcontracting Opportunity Notification Form

In accordance with Texas Gov't Code, Chapter 2161, each state agency that considers entering into a contract with an expected value of $100,000 or more shall, before the agency solicits bids, proposals, offers, or other applicable expressions of interest, determine whether subcontracting opportunities are probable under the contract. The state agency I have identified below in Section B has determined that subcontracting opportunities are probable under the requisition to which my company will be responding.

34 Texas Administrative Code, §20.14 requires all respondents (prime contractors) bidding on the contract to provide notice of each of their subcontracting opportunities to at least three (3) Texas certified HUBs (who work within the respective industry applicable to the subcontracting opportunity), and allow the HUBs at least seven (7) working days to respond to the notice prior to the respondent submitting its bid response to the contracting agency. In addition, at least seven (7) working days prior to submitting its bid response to the contracting agency, the respondent must provide notice of each of its subcontracting opportunities to two (2) or more trade organizations or development centers (in Texas) that serves members of groups (i.e., Asian Pacific American, Black American, Hispanic American, Native American, Woman, Service Disabled Veteran) identified in Texas Administrative Code, §20.11(19)(C).

We respectfully request that vendors interested in bidding on the subcontracting opportunity scope of work identified in Section C, Item 2, reply no later than the date and time identified in Section C, Item 1. Submit your response to the point-of-contact referenced in Section A.

SECTION: A PRIME CONTRACTOR'S INFORMATION

Company Name: Southwest Research Institute
State of Texas VID #: 1741070544000
Point-of-Contact: Nathaniel Toll
Phone #: 210-522-2991
E-mail Address: ntoll@swri.org
Fax #: 210-522-5155

SECTION: B CONTRACTING STATE AGENCY AND REQUISITION INFORMATION

Agency Name: Texas Water Development Board
Point-of-Contact: Angela Wallace
Phone #: 512-463-7979
Requisition #: 580-16-RFQ0028
Bid Open Date: 08/11/2016 (mm/dd/yyyy)

SECTION: C SUBCONTRACTING OPPORTUNITY RESPONSE DUE DATE, DESCRIPTION, REQUIREMENTS AND RELATED INFORMATION

1. Potential Subcontractor's Bid Response Due Date:

If you would like for our company to consider your company's bid for the subcontracting opportunity identified below in Item 2, we must receive your bid response no later than 2:00pm (Central Time) on 08/02/2016 (Date (mm/dd/yyyy)).

In accordance with 34 TAC §20.14, each notice of subcontracting opportunity shall be provided to at least three (3) Texas certified HUBs, and allow the HUBs at least seven (7) working days to respond to the notice prior to submitting our bid response to the contracting agency. In addition, at least seven (7) working days prior to us submitting our bid response to the contracting agency, we must provide notice of each of our subcontracting opportunities to two (2) or more trade organizations or development centers (in Texas) that serves members of groups (i.e., Asian Pacific American, Black American, Hispanic American, Native American, Woman, Service Disabled Veteran) identified in Texas Administrative Code, §20.11(19)(C).

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2. Subcontracting Opportunity Scope of Work:

SwRI requires technical consulting services from a geosciences and engineering firm, with specialties in geostatistics, geographic information systems (GIS) programming, and working with 3-D GIS datasets. The services will included acquisition of existing geologic data from literature and other sources, interpretation of geophysical logs to identify the transitions of various formations of the Trinity Aquifer in Texas, the 3-D interpolation of point data to create surfaces, and identification and delineation of faults in the Trinity formation.

3. Required Qualifications: ☐ - Not Applicable

Qualified firms must be registered in Texas for both geosciences and engineering. Qualified firms must have experience developing Python code for both geostatistical analyses and automating GIS tasks. Qualified firms must be composed primarily of staff must be registered in Texas as professional geoscientist or professional engineers. Qualified firms must have at least three years of experience in identification and interpretation of geology in the Glen Rose formation.

4. Bonding/Insurance Requirements: ☐ - Not Applicable

Subcontractor is solely responsible for obtaining sufficient insurance in accordance with the general standards and practices of the industry or governmental entity.

5. Location to review plans/specifications: ☐ - Not Applicable

Request for Qualifications is available on the Texas Water Development Board website at: http: //www.twdb.texas.gov/about/contract_admin/request/index.asp or The July 1, 2016 edition of the Texas Register at : http://www.sos.state.tx.us/texreg/index.shtml.

Lora Neill

From: Mail Delivery Subsystem <MAILER-DAEMON@swri.org>
To: kmcgookey@medinacci.com
Sent: Monday, July 18, 2016 1:14 PM
Subject: Relayed: Subcontracting Opportunity

Delivery to these recipients or groups is complete, but no delivery notification was sent by the destination server:

kmcgookey@medinacci.com

Subject: Subcontracting Opportunity

Lora Neill

From: Katherine McGookey <kmcgookey@medinacci.com>
To: Lora Neill
Sent: Monday, July 18, 2016 1:16 PM
Subject: Read: Subcontracting Opportunity

Your message

To:
Subject: Read: Subcontracting Opportunity
Sent: Monday, July 18, 2016 1:13:42 PM (UTC-06:00) Central Time (US & Canada)

was read on Monday, July 18, 2016 1:16:18 PM (UTC-06:00) Central Time (US & Canada).

Lora Neill

From: Lora Neill
Sent: Monday, July 18, 2016 1:10 PM
To: 'brenda.davis@geo-search.com'
Cc: Nathaniel Toll; Ron Green; Lora Neill
Subject: Subcontracting Opportunity
Attachments: HUBSubcontractingOpportunityNotificationFormGIS3.pdf

Geosearch

SOUTHWEST RESEARCH INSTITUTE

Southwest Research Institute
6220 Culebra
San Antonio, Texas 78238

RE: Subcontracting Opportunity

Dear Mr. Scott Davis:

Southwest Research Institute® (SwRI®) is responding to a solicitation from the Texas Water Development Board (TWDB) to update the conceptual model of groundwater flow in the Trinity Aquifer of Texas. Per the TWDB's Request for Qualifications, SWRI is soliciting subcontracting services from certified Historically Underutilized Businesses (HUBs) on the Centralized Master Bidders List (CMBL). We are currently developing a subcontracting plan wherein HUB firms are identified that may be selected to work under this contract. This letter has been sent to solicit your interest in performing the identified scope of work (a HUB Subcontracting Opportunity Notification Form is attached) on this project as a subcontractor to SwRI. While we recognize that the scope and required qualifications are very specific in nature, we view this expertise and experience as critical to winning, and subsequently executing, this project. If there is interest, and you have the capabilities and experience to perform the scope, please email a written statement to Nathaniel Toll (ntoll@swri.org). SwRI will, at its sole discretion, determine which firms are selected for opportunities under this contract. The scope of work and requirements are listed below.

> SwRI requires technical consulting services from a geosciences and engineering firm, with specialties in geostatistics, geographic information systems (GIS) programming, and working with three-dimensional (3-D) GIS datasets. The services will include acquisition of existing geologic data from literature and other sources, interpretation of geophysical logs to identify the transitions of various formations of the Trinity Aquifer in Texas, the 3-D interpolation of point data to create surfaces, and identification and delineation of faults in the Trinity formation.
>
> Qualified firms must be registered in Texas for both geosciences and engineering. Qualified firms must have experience developing Python code for both geostatistical analyses and automating GIS tasks. Qualified firms must be composed primarily of staff registered in Texas as professional geoscientists or professional engineers. Qualified firms must have at least 3 years of experience in identification and interpretation of geology in the Glen Rose formation.

In order to evaluate and subsequently incorporate subcontractor qualifications/experience into SWRI's Statement of Qualifications to TWDB, please confirm your interest within **7** working days of receiving this notice (and **no later than 2:00 p.m. on Tuesday August 2, 2016).** We look forward to your response.

Lora Neill
Staff Administrative Assistant
Geosciences and Engineering Division
210-522-5157
lneill@cnwra.swri.edu

Rev. 09/15

HUB Subcontracting Opportunity Notification Form

In accordance with Texas Gov't Code, Chapter 2161, each state agency that considers entering into a contract with an expected value of $100,000 or more shall, before the agency solicits bids, proposals, offers, or other applicable expressions of interest, determine whether subcontracting opportunities are probable under the contract. The state agency I have identified below in Section B has determined that subcontracting opportunities are probable under the requisition to which my company will be responding.

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We respectfully request that vendors interested in bidding on the subcontracting opportunity scope of work identified in Section C, Item 2, reply no later than the date and time identified in Section C, Item 1. Submit your response to the point-of-contact referenced in Section A.

SECTION: A PRIME CONTRACTOR'S INFORMATION

Company Name: Southwest Research Institute
State of Texas VID #: 1741070544000
Point-of-Contact: Nathaniel Toll
Phone #: 210-522-2991
E-mail Address: ntoll@swri.org
Fax #: 210-522-5155

SECTION: B CONTRACTING STATE AGENCY AND REQUISITION INFORMATION

Agency Name: Texas Water Development Board
Point-of-Contact: Angela Wallace
Phone #: 512-463-7979
Requisition #: 580-16-RFQ0028
Bid Open Date: 08/11/2016 (mm/dd/yyyy)

SECTION: C SUBCONTRACTING OPPORTUNITY RESPONSE DUE DATE, DESCRIPTION, REQUIREMENTS AND RELATED INFORMATION

1. Potential Subcontractor's Bid Response Due Date:

If you would like for our company to consider your company's bid for the subcontracting opportunity identified below in Item 2, we must receive your bid response no later than 2:00pm (Central Time) on 08/02/2016 (Date (mm/dd/yyyy)).

In accordance with 34 TAC §20.14, each notice of subcontracting opportunity shall be provided to at least three (3) Texas certified HUBs, and allow the HUBs at least seven (7) working days to respond to the notice prior to submitting our bid response to the contracting agency. In addition, at least seven (7) working days prior to us submitting our bid response to the contracting agency, we must provide notice of each of our subcontracting opportunities to two (2) or more trade organizations or development centers (in Texas) that serves members of groups (i.e., Asian Pacific American, Black American, Hispanic American, Native American, Woman, Service Disabled Veteran) identified in Texas Administrative Code, §20.11(19)(C).

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2. Subcontracting Opportunity Scope of Work:

SwRI requires technical consulting services from a geosciences and engineering firm, with specialties in geostatistics, geographic information systems (GIS) programming, and working with 3-D GIS datasets. The services will included acquisition of existing geologic data from literature and other sources, interpretation of geophysical logs to identify the transitions of various formations of the Trinity Aquifer in Texas, the 3-D interpolation of point data to create surfaces, and identification and delineation of faults in the Trinity formation.

3. Required Qualifications: ☐ - Not Applicable

Qualified firms must be registered in Texas for both geosciences and engineering. Qualified firms must have experience developing Python code for both geostatistical analyses and automating GIS tasks. Qualified firms must be composed primarily of staff must be registered in Texas as professional geoscientist or professional engineers. Qualified firms must have at least three years of experience in identification and interpretation of geology in the Glen Rose formation.

4. Bonding/Insurance Requirements: ☐ - Not Applicable

Subcontractor is solely responsible for obtaining sufficient insurance in accordance with the general standards and practices of the industry or governmental entity.

5. Location to review plans/specifications: ☐ - Not Applicable

Request for Qualifications is available on the Texas Water Development Board website at: http: //www.twdb.texas.gov/about/contract_admin/request/index.asp or The July 1, 2016 edition of the Texas Register at : http://www.sos.state.tx.us/texreg/index.shtml.

Lora Neill

From: Mail Delivery Subsystem <MAILER-DAEMON@swri.org>
To: brenda.davis@geo-search.com
Sent: Monday, July 18, 2016 1:16 PM
Subject: Relayed: Subcontracting Opportunity

Delivery to these recipients or groups is complete, but no delivery notification was sent by the destination server:

brenda.davis@geo-search.com

Subject: Subcontracting Opportunity

Lora Neill

From:	Lora Neill
Sent:	Monday, July 18, 2016 1:35 PM
To:	'admin@hcadesa.org'
Cc:	Nathaniel Toll; Ron Green
Subject:	RE: Subcontracting Opportunity
Attachments:	HUBSubcontractingOpportunityNotificationFormGIS3.pdf

Tracking:	**Recipient**	**Read**
	'admin@hcadesa.org'	
	Nathaniel Toll	Read: 7/18/2016 1:36 PM
	Ron Green	Read: 7/18/2016 1:38 PM

Sorry, here is the attachment.

From: Lora Neill
Sent: Monday, July 18, 2016 1:11 PM
To: 'admin@hcadesa.org'
Cc: Nathaniel Toll; Ron Green; Lora Neill
Subject: Subcontracting Opportunity

Hispanic Contractors Association de San Antonio

SOUTHWEST RESEARCH INSTITUTE
Southwest Research Institute
6220 Culebra
San Antonio, Texas 78238

RE: Subcontracting Opportunity

Dear Mr. Roy Attwood:

Southwest Research Institute® (SwRI®) is responding to a solicitation from the Texas Water Development Board (TWDB) to update the conceptual model of groundwater flow in the Trinity Aquifer of Texas. Per the TWDB's Request for Qualifications, SWRI is soliciting subcontracting services from certified Historically Underutilized Businesses (HUBs) on the Centralized Master Bidders List (CMBL). We are currently developing a subcontracting plan wherein HUB firms are identified that may be selected to work under this contract. This letter has been sent to solicit your interest in performing the identified scope of work (a HUB Subcontracting Opportunity Notification Form is attached) on this project as a subcontractor to SwRI. While we recognize that the scope and required qualifications are very specific in nature, we view this expertise and experience as critical to winning, and subsequently executing, this project. If there is interest, and you have the capabilities and experience to perform the scope, please email a written statement to Nathaniel Toll (ntoll@swri.org). SwRI will, at its sole discretion, determine which firms are selected for opportunities under this contract. The scope of work and requirements are listed below.

> SwRI requires technical consulting services from a geosciences and engineering firm, with specialties in geostatistics, geographic information systems (GIS) programming, and working with three-dimensional (3-D) GIS datasets. The services will include acquisition of existing geologic data from literature and other sources, interpretation of geophysical logs to identify the transitions of various formations of the Trinity Aquifer in Texas, the 3-D interpolation of point data to create surfaces, and identification and delineation of faults in the Trinity formation.

Qualified firms must be registered in Texas for both geosciences and engineering. Qualified firms must have experience developing Python code for both geostatistical analyses and automating GIS tasks. Qualified firms must be composed primarily of staff registered in Texas as professional geoscientists or professional engineers. Qualified firms must have at least 3 years of experience in identification and interpretation of geology in the Glen Rose formation.

In order to evaluate and subsequently incorporate subcontractor qualifications/experience into SWRI's G:\Lora\HUBSubcontractingOpportunityNotificationFormGIS3.pdfStatement of Qualifications to TWDB, please confirm your interest within 7 working days of receiving this notice (and **no later than 2:00 p.m. on Tuesday August 2, 2016).** We look forward to your response.

Lora Neill
Staff Administrative Assistant
Geosciences and Engineering Division
210-522-5157
lneill@cnwra.swri.edu

Rev. 09/15

HUB Subcontracting Opportunity Notification Form

In accordance with Texas Gov't Code, Chapter 2161, each state agency that considers entering into a contract with an expected value of $100,000 or more shall, before the agency solicits bids, proposals, offers, or other applicable expressions of interest, determine whether subcontracting opportunities are probable under the contract. The state agency I have identified below in Section B has determined that subcontracting opportunities are probable under the requisition to which my company will be responding.

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We respectfully request that vendors interested in bidding on the subcontracting opportunity scope of work identified in Section C, Item 2, reply no later than the date and time identified in Section C, Item 1. Submit your response to the point-of-contact referenced in Section A.

SECTION: A PRIME CONTRACTOR'S INFORMATION

Company Name: Southwest Research Institute
State of Texas VID #: 1741070544000
Point-of-Contact: Nathaniel Toll
Phone #: 210-522-2991
E-mail Address: ntoll@swri.org
Fax #: 210-522-5155

SECTION: B CONTRACTING STATE AGENCY AND REQUISITION INFORMATION

Agency Name: Texas Water Development Board
Point-of-Contact: Angela Wallace
Phone #: 512-463-7979
Requisition #: 580-16-RFQ0028
Bid Open Date: 08/11/2016 (mm/dd/yyyy)

SECTION: C SUBCONTRACTING OPPORTUNITY RESPONSE DUE DATE, DESCRIPTION, REQUIREMENTS AND RELATED INFORMATION

1. Potential Subcontractor's Bid Response Due Date:

If you would like for our company to consider your company's bid for the subcontracting opportunity identified below in Item 2, we must receive your bid response no later than 2:00pm (Central Time) on 08/02/2016 (Date (mm/dd/yyyy)).

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3. Required Qualifications: ☐ - Not Applicable

Qualified firms must be registered in Texas for both geosciences and engineering. Qualified firms must have experience developing Python code for both geostatistical analyses and automating GIS tasks. Qualified firms must be composed primarily of staff must be registered in Texas as professional geoscientist or professional engineers. Qualified firms must have at least three years of experience in identification and interpretation of geology in the Glen Rose formation.

4. Bonding/Insurance Requirements: ☐ - Not Applicable

Subcontractor is solely responsible for obtaining sufficient insurance in accordance with the general standards and practices of the industry or governmental entity.

5. Location to review plans/specifications: ☐ - Not Applicable

Request for Qualifications is available on the Texas Water Development Board website at: http: //www.twdb.texas.gov/about/contract_admin/request/index.asp or The July 1, 2016 edition of the Texas Register at : http://www.sos.state.tx.us/texreg/index.shtml.

Lora Neill

From: Lora Neill
Sent: Monday, July 18, 2016 1:12 PM
To: 'angela.freeman@hmsdc.org'
Cc: Nathaniel Toll; Ron Green; Lora Neill
Subject: Subcontracting Opportunity
Attachments: HUBSubcontractingOpportunityNotificationFormGIS3.pdf

Houston Minority Supplier Development Council

SOUTHWEST RESEARCH INSTITUTE
Southwest Research Institute
6220 Culebra
San Antonio, Texas 78238

RE: Subcontracting Opportunity

Dear Ms. Angela Freeman:

Southwest Research Institute® (SwRI®) is responding to a solicitation from the Texas Water Development Board (TWDB) to update the conceptual model of groundwater flow in the Trinity Aquifer of Texas. Per the TWDB's Request for Qualifications, SWRI is soliciting subcontracting services from certified Historically Underutilized Businesses (HUBs) on the Centralized Master Bidders List (CMBL). We are currently developing a subcontracting plan wherein HUB firms are identified that may be selected to work under this contract. This letter has been sent to solicit your interest in performing the identified scope of work (a HUB Subcontracting Opportunity Notification Form is attached) on this project as a subcontractor to SwRI. While we recognize that the scope and required qualifications are very specific in nature, we view this expertise and experience as critical to winning, and subsequently executing, this project. If there is interest, and you have the capabilities and experience to perform the scope, please email a written statement to Nathaniel Toll (ntoll@swri.org). SwRI will, at its sole discretion, determine which firms are selected for opportunities under this contract. The scope of work and requirements are listed below.

> SwRI requires technical consulting services from a geosciences and engineering firm, with specialties in geostatistics, geographic information systems (GIS) programming, and working with three-dimensional (3-D) GIS datasets. The services will include acquisition of existing geologic data from literature and other sources, interpretation of geophysical logs to identify the transitions of various formations of the Trinity Aquifer in Texas, the 3-D interpolation of point data to create surfaces, and identification and delineation of faults in the Trinity formation.
>
> Qualified firms must be registered in Texas for both geosciences and engineering. Qualified firms must have experience developing Python code for both geostatistical analyses and automating GIS tasks. Qualified firms must be composed primarily of staff registered in Texas as professional geoscientists or professional engineers. Qualified firms must have at least 3 years of experience in identification and interpretation of geology in the Glen Rose formation.

In order to evaluate and subsequently incorporate subcontractor qualifications/experience into SWRI's Statement of Qualifications to TWDB, please confirm your interest within **7** working days of receiving this notice (and **no later than 2:00 p.m. on Tuesday August 2, 2016).** We look forward to your response.

Lora Neill
Staff Administrative Assistant
Geosciences and Engineering Division
210-522-5157
lneill@cnwra.swri.edu

Rev. 09/15

HUB Subcontracting Opportunity Notification Form

In accordance with Texas Gov't Code, Chapter 2161, each state agency that considers entering into a contract with an expected value of $100,000 or more shall, before the agency solicits bids, proposals, offers, or other applicable expressions of interest, determine whether subcontracting opportunities are probable under the contract. The state agency I have identified below in Section B has determined that subcontracting opportunities are probable under the requisition to which my company will be responding.

34 Texas Administrative Code, §20.14 requires all respondents (prime contractors) bidding on the contract to provide notice of each of their subcontracting opportunities to at least three (3) Texas certified HUBs (who work within the respective industry applicable to the subcontracting opportunity), and allow the HUBs at least seven (7) working days to respond to the notice prior to the respondent submitting its bid response to the contracting agency. In addition, at least seven (7) working days prior to submitting its bid response to the contracting agency, the respondent must provide notice of each of its subcontracting opportunities to two (2) or more trade organizations or development centers (in Texas) that serves members of groups (i.e., Asian Pacific American, Black American, Hispanic American, Native American, Woman, Service Disabled Veteran) identified in Texas Administrative Code, §20.11(19)(C).

We respectfully request that vendors interested in bidding on the subcontracting opportunity scope of work identified in Section C, Item 2, reply no later than the date and time identified in Section C, Item 1. Submit your response to the point-of-contact referenced in Section A.

SECTION: A PRIME CONTRACTOR'S INFORMATION

Company Name: Southwest Research Institute
State of Texas VID #: 1741070544000
Point-of-Contact: Nathaniel Toll
Phone #: 210-522-2991
E-mail Address: ntoll@swri.org
Fax #: 210-522-5155

SECTION: B CONTRACTING STATE AGENCY AND REQUISITION INFORMATION

Agency Name: Texas Water Development Board
Point-of-Contact: Angela Wallace
Phone #: 512-463-7979
Requisition #: 580-16-RFQ0028
Bid Open Date: 08/11/2016 (mm/dd/yyyy)

SECTION: C SUBCONTRACTING OPPORTUNITY RESPONSE DUE DATE, DESCRIPTION, REQUIREMENTS AND RELATED INFORMATION

1. Potential Subcontractor's Bid Response Due Date:

If you would like for our company to consider your company's bid for the subcontracting opportunity identified below in Item 2, we must receive your bid response no later than 2:00pm (Central Time) on 08/02/2016 (Date (mm/dd/yyyy)).

In accordance with 34 TAC §20.14, each notice of subcontracting opportunity shall be provided to at least three (3) Texas certified HUBs, and allow the HUBs at least seven (7) working days to respond to the notice prior to submitting our bid response to the contracting agency. In addition, at least seven (7) working days prior to us submitting our bid response to the contracting agency, we must provide notice of each of our subcontracting opportunities to two (2) or more trade organizations or development centers (in Texas) that serves members of groups (i.e., Asian Pacific American, Black American, Hispanic American, Native American, Woman, Service Disabled Veteran) identified in Texas Administrative Code, §20.11(19)(C).

(A working day is considered a normal business day of a state agency, not including weekends, federal or state holidays, or days the agency is declared closed by its executive officer. The initial day the subcontracting opportunity notice is sent/provided to the HUBs and to the trade organizations or development centers is considered to be "day zero" and does not count as one of the seven (7) working days.)

2. Subcontracting Opportunity Scope of Work:

SwRI requires technical consulting services from a geosciences and engineering firm, with specialties in geostatistics, geographic information systems (GIS) programming, and working with 3-D GIS datasets. The services will included acquisition of existing geologic data from literature and other sources, interpretation of geophysical logs to identify the transitions of various formations of the Trinity Aquifer in Texas, the 3-D interpolation of point data to create surfaces, and identification and delineation of faults in the Trinity formation.

3. Required Qualifications:

☐ - Not Applicable

Qualified firms must be registered in Texas for both geosciences and engineering. Qualified firms must have experience developing Python code for both geostatistical analyses and automating GIS tasks. Qualified firms must be composed primarily of staff must be registered in Texas as professional geoscientist or professional engineers. Qualified firms must have at least three years of experience in identification and interpretation of geology in the Glen Rose formation.

4. Bonding/Insurance Requirements:

☐ - Not Applicable

Subcontractor is solely responsible for obtaining sufficient insurance in accordance with the general standards and practices of the industry or governmental entity.

5. Location to review plans/specifications:

☐ - Not Applicable

Request for Qualifications is available on the Texas Water Development Board website at: http: //www.twdb.texas.gov/about/contract_admin/request/index.asp or The July 1, 2016 edition of the Texas Register at : http://www.sos.state.tx.us/texreg/index.shtml.

Lora Neill

From: postmaster@HMSDC.ORG
To: 'angela.freeman@hmsdc.org'
Sent: Monday, July 18, 2016 1:13 PM
Subject: Delivered: Subcontracting Opportunity

Your message has been delivered to the following recipients:

'angela.freeman@hmsdc.org' <mailto:angela.freeman@hmsdc.org>

Subject: Subcontracting Opportunity

Lora Neill

From: Angela Freeman <angela.freeman@HMSDC.ORG>
To: Lora Neill
Sent: Monday, July 18, 2016 1:49 PM
Subject: Read: Subcontracting Opportunity

Your message

To:
Subject: Subcontracting Opportunity
Sent: Monday, July 18, 2016 1:49:14 PM (UTC-06:00) Central Time (US & Canada)

was read on Monday, July 18, 2016 1:48:52 PM (UTC-06:00) Central Time (US & Canada).

Lora Neill

From:	Lora Neill
Sent:	Monday, July 18, 2016 1:13 PM
To:	'maggie@smsdc.org'
Cc:	Nathaniel Toll; Ron Green; Lora Neill
Subject:	Subcontracting Opportunity
Attachments:	HUBSubcontractingOpportunityNotificationFormGIS3.pdf

Southwest Minority Supplier Development Council

SOUTHWEST RESEARCH INSTITUTE

Southwest Research Institute
6220 Culebra
San Antonio, Texas 78238

RE: Subcontracting Opportunity

Dear Ms. Maggie Trevino:

Southwest Research Institute® (SwRI®) is responding to a solicitation from the Texas Water Development Board (TWDB) to update the conceptual model of groundwater flow in the Trinity Aquifer of Texas. Per the TWDB's Request for Qualifications, SWRI is soliciting subcontracting services from certified Historically Underutilized Businesses (HUBs) on the Centralized Master Bidders List (CMBL). We are currently developing a subcontracting plan wherein HUB firms are identified that may be selected to work under this contract. This letter has been sent to solicit your interest in performing the identified scope of work (a HUB Subcontracting Opportunity Notification Form is attached) on this project as a subcontractor to SwRI. While we recognize that the scope and required qualifications are very specific in nature, we view this expertise and experience as critical to winning, and subsequently executing, this project. If there is interest, and you have the capabilities and experience to perform the scope, please email a written statement to Nathaniel Toll (ntoll@swri.org). SwRI will, at its sole discretion, determine which firms are selected for opportunities under this contract. The scope of work and requirements are listed below.

> SwRI requires technical consulting services from a geosciences and engineering firm, with specialties in geostatistics, geographic information systems (GIS) programming, and working with three-dimensional (3-D) GIS datasets. The services will include acquisition of existing geologic data from literature and other sources, interpretation of geophysical logs to identify the transitions of various formations of the Trinity Aquifer in Texas, the 3-D interpolation of point data to create surfaces, and identification and delineation of faults in the Trinity formation.
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> Qualified firms must be registered in Texas for both geosciences and engineering. Qualified firms must have experience developing Python code for both geostatistical analyses and automating GIS tasks. Qualified firms must be composed primarily of staff registered in Texas as professional geoscientists or professional engineers. Qualified firms must have at least 3 years of experience in identification and interpretation of geology in the Glen Rose formation.

In order to evaluate and subsequently incorporate subcontractor qualifications/experience into SWRI's Statement of Qualifications to TWDB, please confirm your interest within **7** working days of receiving this notice (and **no later than 2:00 p.m. on Tuesday August 2, 2016).** We look forward to your response.

Lora Neill
Staff Administrative Assistant
Geosciences and Engineering Division
210-522-5157
lneill@cnwra.swri.edu

Rev. 09/15

HUB Subcontracting Opportunity Notification Form

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Company Name: Southwest Research Institute
State of Texas VID #: 1741070544000
Point-of-Contact: Nathaniel Toll
Phone #: 210-522-2991
E-mail Address: ntoll@swri.org
Fax #: 210-522-5155

SECTION: B CONTRACTING STATE AGENCY AND REQUISITION INFORMATION

Agency Name: Texas Water Development Board
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3. Required Qualifications: ☐ - Not Applicable

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Subcontractor is solely responsible for obtaining sufficient insurance in accordance with the general standards and practices of the industry or governmental entity.

5. Location to review plans/specifications: ☐ - Not Applicable

Request for Qualifications is available on the Texas Water Development Board website at: http: //www.twdb.texas.gov/about/contract_admin/request/index.asp or The July 1, 2016 edition of the Texas Register at : http://www.sos.state.tx.us/texreg/index.shtml.

Lora Neill

From: Carol Thomas <carol@smsdc.org>
To: Lora Neill
Sent: Tuesday, July 19, 2016 10:53 AM
Subject: Read: Subcontracting Opportunity

Your message

To:
Subject: Subcontracting Opportunity
Sent: Tuesday, July 19, 2016 10:53:39 AM (UTC-06:00) Central Time (US & Canada)

was read on Tuesday, July 19, 2016 10:53:17 AM (UTC-06:00) Central Time (US & Canada).

Lora Neill

From: Carol Thomas <carol@smsdc.org>
Sent: Tuesday, July 19, 2016 10:54 AM
To: Lora Neill; Maggie Trevino
Cc: Nathaniel Toll; Ron Green
Subject: RE: Subcontracting Opportunity

Good Morning Lora;

Thank you for your subcontracting opportunity notice. I regret to inform you Maggie Trevino passed in November of last year. Please update your contact information.

All my best,

Carol

Carol M. Thomas
Operations Director & Corporate Member Advisor
Southwest Minority Supplier Development Council
Serving Southwest Texas, Oklahoma & New Mexico
912 S. Hwy 183, Suite 101
Austin, TX 78741
O: 512.386.8766
Headquartered in Austin and offices in El Paso, San Antonio & Oklahoma City
www.smsdc.org

SMSDC
Southwest Minority Supplier
Development Council

"Your Value Add Council"

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Upcoming 2016 Events

July 28, 2016 – New Frontier Buyer's Breakfast Roundtable & Regional Awards Ceremony
Hard Rock Hotel & Casino Tulsa, 777 West Cherokee St., Catoosa, OK

September 8, 2016 – Diversity at the Border Buyer's Breakfast Roundtable & Regional Awards Ceremony
Doubletree Hotel, 600 N. El Paso St., El Paso, TX

October 13, 2016 – Rio Grande Valley Buyer's Breakfast Roundtable
TBD

November 10, 2016 – Midland/ Odessa Buyer's Breakfast Roundtable
TBD

From: Lora Neill [mailto:lneill@swri.org]
Sent: Monday, July 18, 2016 1:13 PM
To: Maggie Trevino <maggie@smsdc.org>
Cc: Nathaniel Toll <ntoll@swri.org>; Ron Green <rgreen@swri.org>; Lora Neill <lneill@swri.org>
Subject: Subcontracting Opportunity

Southwest Minority Supplier Development Council

SOUTHWEST RESEARCH INSTITUTE
Southwest Research Institute
6220 Culebra
San Antonio, Texas 78238

RE: Subcontracting Opportunity

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Lora Neill
Staff Administrative Assistant
Geosciences and Engineering Division
210-522-5157
lneill@cnwra.swri.edu

EXHIBIT B
Scope of Work

The contents of a conceptual model for the purposes of a GAM are outlined in the GAM standards included as Appendix A in the Request for Qualifications (TWDB, 2016). The SwRI Team will apply well tested methods for developing each of the following components of the Conceptual Model for the Hill Country portion of the Trinity Aquifer.

1. Physiography and climate,
2. Geology,
3. Hydrostratigraphy,
4. Hydrostratigraphic framework,
5. Water levels and regional groundwater flow,
6. Recharge,
7. Rivers, streams, reservoirs, springs, and other surface water features,
8. Hydraulic properties,
9. Subsidence (if applicable),
10. Discharge, and
11. Water quality.

The technical approach for development of the conceptual model has been divided into seven tasks, including project management (Task 1), stakeholder communication (Task 2), data acquisition and data management (Task 3), geologic interpretation and hydrostratigraphic modelling (Task 4), hydraulic data analysis (Task 5), conceptual model synthesis (Task 6), and reporting (Task 7).

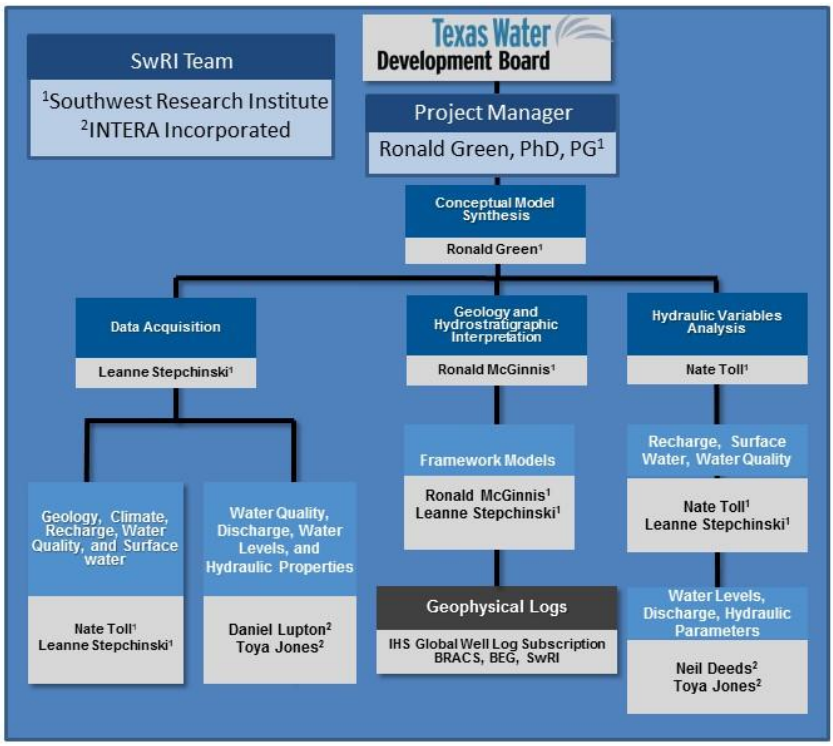
Task 1 — Project Management

Development of a conceptual model of an aquifer with the complexity and geographic breadth of the Hill Country portion of the Trinity Aquifer requires a diverse team of geologists, hydrogeologists/hydrologists, data-management technicians, and GIS technicians. SwRI Team's project manager, Dr. Ronald Green, will serve as the point-of-contact for the TWDB and stakeholders. Dr. Green's project management responsibility will be to provide prompt and comprehensive information to the TWDB and stakeholders regarding the project's schedule, budget, and technical considerations. With over 30 years of water-resource evaluation experience and 20 years of leading projects to characterize the water resources of Texas that include karstic Edwards, Trinity, and Edwards-Trinity carbonate aquifers, Dr. Green possesses the technical and management expertise necessary to successfully lead the SwRI team's efforts on this project. A graphical delineation of the project organization and management approach is provided in Figure 6.

Given the complexity of the work and budget constraints, SwRI has divided the tasks amongst the project team to ensure timely project execution. SwRI will lead the project and carry the burden of synthesizing the final conceptual model along with the remaining data management and analysis tasks. Team member Mr. Nate Toll will lead the SwRI data analysis effort. INTERA will complete several important data management tasks,

literature reviews, and analysis. Team member Dr. Neil Deeds will lead the INTERA team effort. The goal will be to create a unified workflow where possible, but allow variation in the technical approach where necessary to best accommodate the strengths in capabilities and knowledge of the individual team members.

Figure 6. SwRI Team organizational structure diagram.



Task 2 — Stakeholder Communication

Stakeholder communication and input are critical to ensure that the GAMs are developed in a transparent manner and are responsive to stakeholder's needs. Information accrued during the project will be used ultimately by the TWDB, Regional Water Planning Groups (RWPG), GMAs, GCDs, state agencies, and planners, groundwater users, private citizens, and consultants to assess groundwater availability. As a result, the stakeholders must be included in the development process, and must be informed and confident in the conceptual model on which the GAM is predicated. Our experience in working with the TWDB, and numerous RWPGs, GMAs, and GCDs, provides us with a clear understanding of the key requirements for successful stakeholder communication. The SwRI Team will participate in a stakeholder advisory forum. SwRI will record the forum attendees and their affiliations. Questions raised during the forum will be documented along with the response or proposed response. This information will be communicated to the TWDB in a Memo report. SwRI will engage with stakeholders to gain any pertinent project information, data, and feedback on elements of the conceptual model. The stakeholder advisory forum will be scheduled by the TWDB project manager.

Task 3 — Data Acquisition and Data Management

Data acquisition will build on the existing data collected for the Trinity (Hill Country) Aquifer GAM and the TWDB BRACS project. In Task 3, data on physiography, climate, precipitation, geology, hydraulic properties, geophysical logs, water levels, surface water features, discharge (pumping), and water quality will be acquired from publicly available information or information that can be made available to the public. Information will be acquired for a period up to 2015. The update to the conceptual model requires an expansion in both temporal and spatial extent. Accordingly, defining the approximate domain for the GAM update will be completed at project inception to ensure data are collected across the entire domain. The model domain boundary will be discussed with the TWDB as it is critical to the project requirements.

Task 4 –Geologic Interpretation and Hydrostratigraphic Modeling

Geophysical log interpretation will be central to providing information relating to the upper and lower Trinity Formation boundaries and fault locations for each hydrogeological framework model layer. Geophysical logs will be accessed from the BRACS database, the Texas Commission for Environmental Quality (TCEQ) Public Works Systems records, the existing dataset of geophysical logs for the Trinity (Hill Country) Aquifer GAM, Texas Railroad Commission Q-logs, the Bureau of Economic Geology (BEG) Subsurface Library, and logs supplied via an agreement with IHS Global Well Log. GCDs in the study area will be asked to provide additional geophysical logs that are not part of these primary sources. Note that a commercial log company informed the SwRI Team under written agreement that any acquired logs used for the project will be released to the TWDB and therefore to the larger public domain. These logs will be limited to zones other than oil and gas production horizons. An initial distribution of known log locations is shown in **Error! Reference source not found.**.

The current Trinity (Hill Country) Aquifer GAM boundary appears to be based on the boundary of Trinity Aquifer outcrop so the stratigraphy for the area below the Edwards Aquifer Balcones Fault Zone (BFZ) is not fully developed. Additionally, the western boundary of the GAM terminates at the eastern edge of Uvalde County. The starting point for extending the stratigraphy will be the "Hydrogeologic Atlas of the Hill Country Trinity Aquifer, Blanco, Hays and Travis Counties, central Texas" (Wierman et al., 2010). Surface geology and additional geophysical logs will be needed to help define stratigraphy to the west and down dip. From Figure 4 we can see that there is BRACS database coverage to extend the Hill Country portion of the Trinity Aquifer. The BRACS geophysical logs and logs from other sources will be used to extend the stratigraphy of the Hill Country portion of the Trinity Aquifer. Although the coverage appears dense, many of these logs are too shallow to reach the Trinity Aquifer.

At the southwestern border of Bexar County, the top of the Lower Trinity Aquifer is at a depth of approximately 4,000 feet (Bebout, 1977). An examination of the bottom logging intervals for the BRACS wells indicates that some portion of those logs extend to that depth, but most logs do not extend into the lower Trinity (i.e. the Sligo/Hosston) Aquifer. It is uncertain whether the lower Trinity Aquifer is likely to have significant available water

in that region, but we will attempt to establish a stratigraphic framework that includes these units. Data are expected to be more consistently available for the upper and middle portions of the Trinity Aquifer.

SwRI is currently leading a team that includes INTERA, BEG, Edwards Aquifer Authority, and the Barton Springs-Edwards Aquifer Conservation District to quantify the brackish water resources of Trinity Aquifer for the TWDB. This effort requires an interpretation of geophysical logs and to extend the stratigraphy to the depth of the Hill Country portion of the Trinity Aquifer. The results of this work will enhance the Hill Country portion of the Trinity Aquifer conceptual model and will be incorporated into the GAM geodatabase. In addition, SwRI was engaged by the Edwards Aquifer Authority to develop an alternative finite-element model of the Edwards Aquifer (Fratesi et al., 2015). As part of this effort, a hydrostratigraphic framework model that includes the Glen Rose and Edwards aquifers for the entire domain of the Hill Country portion of the Trinity Aquifer was constructed(Figure 7). SwRI has a significant database of logs and stratigraphic contacts from this framework model that will be available for development of a hydrostratigraphic model of the Hill Country portion of the Trinity Aquifer.

The domain of the updated Hill Country portion of the Trinity Aquifer model will be determined during the development of the hydrostratigraphic framework model by integrating geologic data with hydrologic data. Factors to help determine the down-dip extent are salinity, stratigraphy, and the dip of the down-dip Trinity Aquifer.

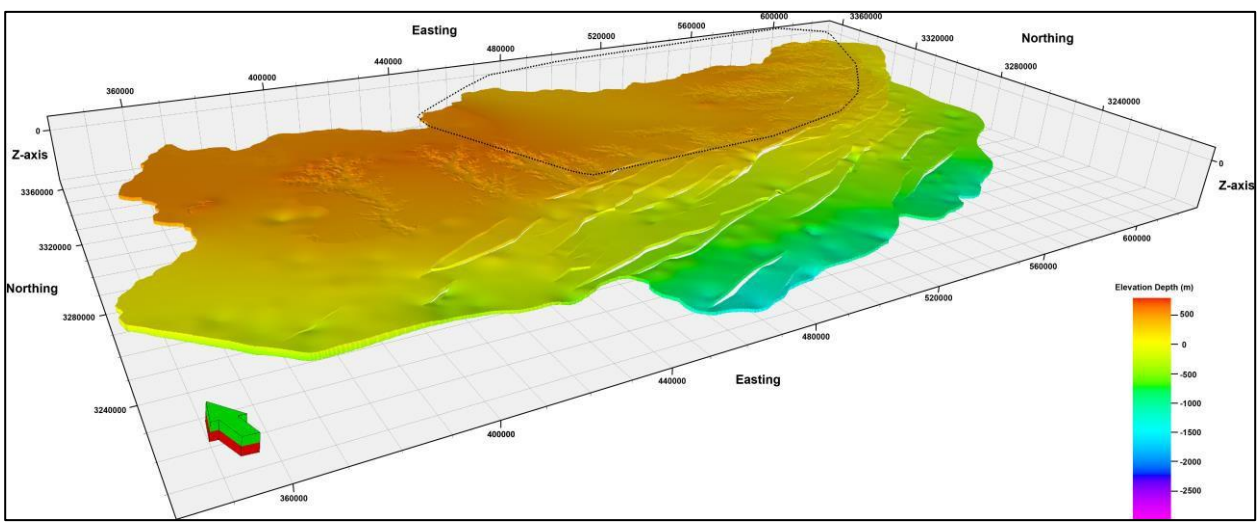


Figure 7. SwRI Hydrostratigraphic Framework model of the Glen Rose Limestone constructed for the Edwards Aquifer Authority Finite Element Model (Fratesi, 2015). The black line outline shows the extent of the current Trinity (Hill Country) Aquifer GAM.

Considerations will be given to identifying a groundwater divide resulting from a structural-hydraulic boundary in eastern Kinney County (Green et al., 2006; Fratesi et al., 2015). If no natural hydraulic boundary is identified on the western boundary of the Hill Country portion of the Trinity Aquifer, an alternative boundary between the Hill

Country portion of the Trinity Aquifer and the Edwards-Trinity Aquifer may be arbitrarily prescribed.

Three software packages will be used for developing the hydrostratigraphic framework model: (i) Microsoft Excel 2010, (ii) ESRI ArcGIS, and (iii) Schlumberger PETREL. These packages will be used to organize tabulated data, assemble and analyze geographically distributed data and interpretations, and for three-dimensional hydrostratigraphic framework modeling. Microsoft Excel 2010 will be used to compile well data including locations, wellhead elevation, stratigraphic picks, and formation thickness information. Published geologic maps will be used to extract elevations for mapped geologic contacts that define hydrologic boundaries to provide control on boundaries in areas of limited or no well data. Geologic maps used in this fashion include maps published by the BEG (Bureau of Economic Geology) and the U.S. Geological Survey. ESRI ArcGIS will be used to assemble topography, geologic maps, structural data, and other geographically distributed data. These data will be used as the basis for defining the model domain and constructing the hydrostratigraphic framework model. Well picks will be evaluated using published maps and point shapefiles. PETREL will be used to construct the hydrostratigraphic framework model. This software package allows surface and subsurface data to be assimilated from multiple sources and perform stratigraphic and structural geologic interpretation.

Task 5 — Approach to Hydraulic Data Analysis

Subtask 5.1 – Recharge

Recharge is clearly one the most critical components to the conceptual model. Recharge varies spatially and temporally across the Hill Country portion of the Trinity Aquifer. Recharge from infiltration of precipitation into the aquifer is dependent on a variety of factors including rate and intensity of precipitation, evapotranspiration, and antecedent moisture conditions. Collecting this information across the Hill Country portion of the Trinity Aquifer domain at sufficiently high spatial and temporal resolution is important to developing a conceptual model of the aquifer. SwRI will use several public data sources to develop a database of the parameters that are required to calculate recharge. Precipitation data will be sourced from NOAA, Prism (Prism Climate Group, 2015), and the TWDB. NEXRAD precipitation data are available for periods since 2000. SwRI has developed automated GIS tools for the calculation of recharge from gridded NEXRAD data (Fratesi et al., 2015; Green et al., 2015, 2016). Evaporation data, soil parameters, and aquifer outcrop locations will be sourced from the TWDB, Texas Natural Resource Information System (TNRIS), United States Department of Agriculture (USDA), BEG, and the U.S. Geological Survey. Other sources of recharge such as stream loss, irrigation return, and possibly injection wells are referred to as focused recharge. Focused recharge will be identified from literature and analysis of water-level data. Focused recharge from losing streams will be calculated from stream-gauge data where possible. The Texas Railroad Commission database will be queried to locate any Class II injection wells that may be injecting in the Hill Country portion of the Trinity Aquifer domain. TCEQ data will be

queried for other classes of injection wells. If any injection wells exist within the domain, the injection rates will be included in the conceptual model geodatabase.

SwRI will work with TWDB to establish the temporal resolution required for calculating recharge from direct infiltration of precipitation. The temporal resolution is dictated by the stress periods anticipated in the ultimate GAM. SwRI has developed ArcGIS scripts that facilitate the calculation of recharge from gridded precipitation data such as processed NEXRAD data. Input variables to the SwRI recharge model include evaporation rates, precipitation, soil types, and aquifer outcrop maps.

Subtask 5.2 – Water Levels and Regional Groundwater Flow

Mapping aquifer water levels and regional groundwater flow requires long-term measurements of static groundwater elevations at wells that provide reasonable spatial coverage of the study area. Unfortunately, there are relatively few wells drilled into the Hill Country portion of the Trinity Aquifer and thus a limited number of groundwater-level measurements. An initial query of the TWDB groundwater database for wells completed solely in the Hill Country portion of the Trinity Group yielded nearly 3,800 wells. While most of those (almost ¾) have at least one water-level measurement, only about 10-percent have 10 or more measurements over 10 or more years. A small subset of these wells (approximately 250) are completed solely in the Trinity Aquifer underneath and within the footprint of the Edwards Aquifer, but only nine wells have 10 or more water-level measurements taken more than 10 times.

Water-level measurements from previous studies will be compiled into a single consistent dataset for the Hill Country portion of the Trinity Aquifer study area. The water-level dataset will be updated using queries for more recent water-level data from both the TWDB groundwater database and U.S. Geological Survey National Water Information System database to represent the most up-to-date water levels in the region. In addition, GCDs and municipalities will be queried to solicit additional water-level data that were either not incorporated in the original models, or were collected since their publication.

While collecting transient water-level data is necessary for building and calibrating any future groundwater model, it is equally important to first establish a steady-state groundwater surface, which represents the expected stable groundwater elevation under unperturbed conditions in the study area. Jones et al. (2011) used groundwater elevations from the period 1977 through 1985 to represent steady-state conditions in the Hill Country portion of the Trinity Aquifer. Anaya and Jones (2009) selected the first winter measurements of each available well record, excluding measurements taken during the 1930s and 1950s drought years, to represent steady-state conditions in the Edwards and Trinity hydrostratigraphic units of the Edwards-Trinity (Plateau) Aquifer. Based on this proposed comprehensive water-level measurements compilation, as well as comparison to other steady-state, water-level indicators such as spring locations, a reasonable definition for steady-state conditions will be developed to produce a steady-state, water-level surface for the study area. Interpolated surfaces of groundwater elevations will be created for various time periods to inform the conceptual model.

Subtask 5.3 – Discharge

Groundwater production represents a small component of the overall discharge from the Hill Country portion of the Trinity Aquifer. According to Jones et al. (2011), discharge from the Hill Country portion of the Trinity Aquifer is dominated by discharge to streams and springs, followed by lateral subsurface flow and diffuse upward leakage to the Edwards (Balcones Fault Zone) Aquifer. Discharge by pumping from the aquifer is significantly less than discharge to springs and streams, and discharge by interformational flow.

The two components required for characterizing discharge due to pumping are annual volumes and production location. The majority of Trinity Aquifer water wells in the region are used for either domestic water use or public water supply. Jones et al. (2011) compiled a pumping dataset based on the TWDB Water Use Survey pumping estimates from 1980-1997, and Anaya and Jones (2009) compiled a dataset based on the same source from 1980-2000. These pumping dataset will be updated to at least 2010. GCDs in the study area will be queried for well-specific metered pumping data. These data will be used to distribute pumping to individual wells within the study area. Otherwise, spatial distribution of pumping values from the updated pumping dataset will largely follow the methodology used in Jones et al. (2011). Municipal and manufacturing pumping will be distributed on the basis of known well locations and pumping data from the TWDB Water Use Survey. Rural domestic pumping will be distributed on the basis of the spatial distribution of population outside major urban areas. The other uses (irrigation and livestock) will be distributed throughout the region based on land use/land cover classifications available from the U.S. Geological Survey.

Aquifer discharge to streams as baseflow can be quantified through analysis of streamflow measurements. Jones et al. (2011) collected stream-gauge data for the period up to 2000 for seven streamflow targets in the Hill Country portion of the Trinity Aquifer. Anaya and Jones (2009) compiled stream-gauge data for the period up to 2004 for streamflow targets in the Edwards-Trinity (Plateau) Aquifer model, nine of which appear to fall in or near the proposed study area. Available stream baseflow data will be compiled using the U.S. Geological Survey National Water Information System to bring the streamflow dataset up-to-date. Hydrograph separation analyses on available streamflow data will be evaluated (Green and Bertetti, 2010; Green et al., 2012) to better constrain the amount of streamflow sourced directly from aquifer discharge, as opposed to runoff.

Available spring discharge data will be compiled, beginning with information available in previous models. Spring-discharge data in Texas include models by Jones et al. (2011) and Hutchison et al. (2011), the U.S. Geological Survey National Water Information System, compilations of Texas spring data (Heitmuller and Reece, 2003; Brune, 2002) and the TWDB groundwater database, will be assessed for use in the model. After spring and streamflow discharge, the next significant discharge component is interformational flow to the Edwards (Balcones Fault Zone) Aquifer. Groundwater from the Trinity Aquifer can discharge to the Edwards Aquifer in two ways: (i) as subsurface cross-formational inflow across the up-dip margin of the Balcones Fault Zone where the Trinity Aquifer is juxtaposed with the down- faulted Edwards Aquifer and (ii) as upward flow from the Trinity Aquifer into the Edwards Aquifer along faults, fractures, and dissolution enhanced

conduits. In addition, there is water that discharges to the Edwards Aquifer recharge zone from the Trinity Aquifer as surface flow. The volume of discharge as groundwater is difficult to determine and is typically estimated or constrained using numerical groundwater flow models and water-balance calculations.

There has been continued refinement in estimates and calculations of how much water is discharged from the Trinity Aquifer to the Edwards Aquifer. This refinement is due, in part, to improved conceptualization of the Trinity-Edwards Aquifer interface based on a variety of perspectives including multi-well testing (Smith and Hunt, 2009, 2010, 2011), tracer testing (Johnson et al., 2010, 2012; Schindel and Johnson, 2011), gain-loss studies (Slade et al., 2002; Green et al., 2011), enhanced characterization of the geologic structure and hydrogeology (Ferrill et al., 2003, 2004, 2005, 2008), and refinements in groundwater models that include the Trinity Aquifer-Edwards Aquifer interface (Klemt et al., 1979; Maclay and Land, 1988; Lindgren et al., 2004, Jones et al., 2011). The model by Jones et al. (2011) estimated cross-interformational flow rates as 660 acre-ft/yr in the west, 2,400 acre-ft/yr in the central area, and 350 acre-ft/yr in the east of the model domain (Figure 8).

Subtask 5.4 – Surface-Water Features

Surface-water features that have a major effect on the Hill Country portion of the Trinity Aquifer will be identified during the data acquisition task. These features include rivers, streams, creeks, springs, and reservoirs. The geometry of the features will be acquired digitally from public sources or digitized from maps if not available in georeferenced digital form. If any surface water features lose water to the Trinity Aquifer or receive water from the aquifer, information on gain/loss will be acquired from literature and public sources. The analysis of gain/loss from surface-water features will be completed in the recharge and discharge analysis tasks.

Subtask 5.5 – Hydraulic Properties

Estimates of aquifer hydraulic conductivity are ideally based on measurements derived from long-term aquifer tests and specific capacity tests of these wells (Mace, 2001). The TWDB model for the Hill Country section of the Trinity Aquifer (Jones et al., 2011) compiled transmissivity and hydraulic conductivity values from several sources, including values derived from long-term aquifer pump tests, literature estimates and values calculated from specific capacity tests. The conceptual model for the Edwards-Trinity (Plateau) Aquifer (Anaya and Jones, 2009) treats the Trinity Group in the western portion of the current study area as a component of the Edwards-Trinity (Plateau) Aquifer rather than its own aquifer. However, they do provide information derived specifically from wells in the "Trinity hydrostratigraphic unit" that we can apply to the proposed study.

For the proposed Hill Country portion of the Trinity Aquifer conceptual model, hydraulic conductivity point values from these previous models will be compiled into a single consistent dataset for the study area. Because long-term aquifer tests appropriate for calculating hydraulic conductivity values are uncommon, distributions of hydraulic conductivity in previous reports rely heavily on transmissivity values calculated from

specific capacity measurements, which are much more common. A review comparing available values from long-term aquifer tests to available values from specific capacity tests will then be undertaken. If this analysis shows that the specific-capacity-developed values are reasonable, the existing set of specific capacity test data with any additional recent data from both the TCEQ public water supply (PWS) records and through requests to GCDs will be augmented. Hydraulic conductivity values for these additional wells will then be calculated using methods in Mace (2001).

If, however, the analysis does not provide confidence in the specific-capacity-derived hydraulic conductivity values, an alternative approach for developing hydraulic conductivity values will be developed. A method that combines the model-calibrated spatial coverages developed in the previous models (Anaya and Jones, 2009; Jones et al., 2011; Hutchison et al., 2011) will be explored to develop one consistent spatial coverage that covers the entire study area. This is the method that will be used for vertical hydraulic conductivity coverage, as well as for storage properties (specific yield and specific storage) because additional information for these properties is not likely. Both the eastern model (Jones et al., 2011) and the western model (Anaya and Jones, 2009) produced model-calibrated coverages of these properties that will be relevant to that proposed analysis.

Subtask 5.6 – Water Quality

The SwRI Team will collect water quality data from publicly available sources as part of Task 3—Data Collection and Data Management. Data will be gathered from various sources, including, but not limited to, the TWDB Groundwater Database, relevant U.S. Geological Survey reports, and data collected by GCDs in the Hill County portion of the Trinity Aquifer. Because one of the principal purposes of the revised conceptual model is to recommend appropriate extended boundaries for the present Trinity (Hill Country) Aquifer GAM to include all of GMA 9, the collected water quality data will include a spatial extent beyond the GMA 9 boundaries and will incorporate data from the Edwards-Trinity (Plateau) Aquifer as well as the Edwards (Balcones Fault Zone) Aquifer.

The SwRI team will conduct an analysis of the water quality data, including total dissolved solids and other dissolved constituents of interest, to understand spatial variations, variations with depth and hydrostratigraphic layers, and possible temporal variations of the data. Maps of water quality data will be prepared for the conceptual model domain, and these will include maps for each hydrostratigraphic layer as well as maps depicting significant water quality variations over time. The SwRI team will prepare graphical summaries of water quality data for total dissolved solids and other constituents of interest. Graphs will be prepared for wells that have distinct water quality variations over time, and the locations of these wells will be identified on the water quality maps. Besides providing a mechanism to gauge the groundwater availability of an aquifer, analysis of water quality data can be an important tool to assess and identify areas in which cross-formational flow may occur and provide corroborating evidence for the determination of appropriate conceptual model boundaries (Figure 8). The EAA has embarked on a multi-year study to investigate and quantify potential cross-formational flow between the Trinity Aquifer and the Edwards (Balcones Fault Zone) Aquifer (e.g., Gary

et al., 2013). The EAA has engaged SwRI to develop an appropriate, targeted sampling strategy and then analyze and model the collected water quality data to identify and quantify flow where evidence of cross-formational flow exists. Information derived as part of this EAA-funded project can be leveraged to aid in the understanding and development of the conceptual model for the Hill Country portion of the Trinity Aquifer.

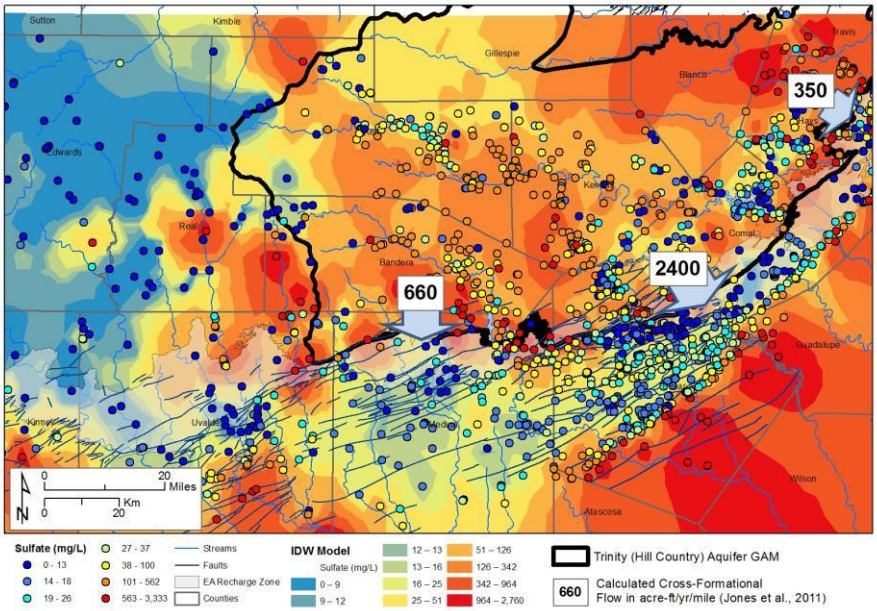


Figure 8. Map of measured and predicted sulfate concentrations for Trinity and Edwards aquifer waters in the region of the Trinity (Hill Country) Aquifer GAM. Cross-formational flow from the Trinity Aquifer to the Edwards Aquifer shown (acre-ft/yr) (Jones et al., 2011).

The SwRI team has also used analysis and modeling of water quality data to provide evidence for the delineation of appropriate boundaries for aquifer conceptual models (Green et al., 2006b, 2012b). Similar approaches may be particularly useful for the proposed project. For example, a geostatistical model of water quality data for various constituents from Trinity and Edwards Aquifer wells [including wells from the Edwards-Trinity (Plateau), Trinity (Hill Country), and Edwards (Balcones Fault Zone) Aquifers] provides a distinct demarcation of the spatial trends in water wells utilizing Trinity Aquifer water instead of Edwards Aquifer water in the region of Uvalde, Kinney, and Real Counties. Analyses of this type, especially when combined with geological mapping and hydrostratigraphic modeling outlined in Task 4, can be of significant use in establishing a technical basis for the western conceptual model boundary. The SwRI Team has extensive and proven experience conducting the detailed water quality analyses required for this type of application and integration of the data into a robust conceptual model for the Hill Country portion of the Trinity Aquifer.

Task 6 — Conceptual Model Synthesis

The collection of data and interpretation of discrete parts of an aquifer system does not constitute a complete conceptual model of the groundwater system. A conceptual model for the Hill County portion of the Trinity Aquifer will be developed that reflects the input from Tasks 2 through 5. The SwRI team will develop a conceptual model that describes groundwater flow in the Hill Country portion of the Trinity Aquifer from recharge, through its path in the aquifer, to discharge at wells, springs, or rivers. The conceptual model will be constructed using information and data extracted from the past and current Trinity (Hill Country) Aquifer GAMs (Mace et al., 2000; Anaya and Jones, 2011), a recent model of the Edwards Aquifer BFZ that extends into the Hill Country portion of the Trinity Aquifer (Fratesi et al., 2015), and any other relevant studies and documents (i.e., the ongoing TWDB BRACS study of the Trinity Aquifer conducted by SwRI and INTERA).

In 2015, SwRI completed development of a comprehensive, refined numerical model of the San Antonio segment of the Edwards Aquifer (Figure 2) (Fratesi et al., 2015). The 2015 Edwards Aquifer model spans the Edwards Aquifer from the groundwater divide separating the San Antonio segment from the Barton Springs segment of the Edwards Aquifer on the east to the groundwater divide separating the Mud Springs from Pinto Springs on the west. Most noteworthy is that the 2015 Edwards Aquifer model domain includes the confined, recharge, and contributing zones of the Edwards Aquifer and in doing so, this model was the first Edwards Aquifer model to incorporate all three zones of the aquifer. Important to this proposal, by including the contributing zone of the Edwards Aquifer, the 2015 Edwards Aquifer model essentially includes the Hill Country portion of the Trinity Aquifer model domain and the Hill Country portion of the Trinity Aquifer/Edwards Aquifer interface.

In addition to including the Edwards Aquifer contributing zone, the 2015 Edwards Aquifer model was noteworthy in that the refined conceptual model on which the numerical model was built incorporated the results of local and regional technical studies from the previous decade that were conducted to reduce uncertainty in the manner in which the physical system is represented in models. These enhancements included refinement of the western boundary of the San Antonio segment (Green et al., 2006), clearer understanding of the hydraulic relationship of the major rivers and streams that transect the Edwards Aquifer contributing and recharge zones (Green et al., 2008a, 2009b, 2012b), improvements in estimating recharge to the contributing zone of the Edwards Aquifer (Green and Bertetti, 2010; Green et al., 2012) and particularly, a refined and expanded hydrostratigraphic framework model of the San Antonio segment of the Edwards Aquifer and extending north to include the contributing zone (Fratesi et al., 2015).

During development of the 2015 Edwards Aquifer model, inspection and inclusion of the individual watersheds that form the contributing zone of the Edwards Aquifer brought to light the significance of variable hydraulic properties and characteristics assigned to the river channels and how the hydraulic properties are manifest in the model (Fratesi et al., 2015). For example, it is important to recognize the different hydraulic properties exhibited by river channels as diverse as Cibolo Creek, with virtually no baseflow, versus

the Guadalupe River with significant baseflow and continuous flow. The diversity exhibited by the different watersheds cannot be captured in the numerical model if the conceptual model of the watersheds is not sufficiently representative of the physical system. The conceptual model and the associated hydrostratigraphic framework model from the 2015 Edwards Aquifer model will form the foundation to the Hill Country portion of the Trinity Aquifer conceptual and hydrostratigraphic framework models. Although the 2015 Edwards Aquifer model (Fratesi et al., 2015) only provided resolution to the upper Trinity Formation (Figure 7), substantial information on the lower Trinity Formation, including the basal sands, was compiled during development of the framework model database and is available for use in the proposed project.

Included in the Conceptual Model Report will be a schematic block model that describes the key elements of the Hill Country portion of the Trinity Aquifer. SwRI has decades of experience creating block models to communicate geologic and hydrogeologic concepts. For the Hill Country portion of the Trinity Aquifer, the conceptual-block model will be developed using an iterative design process with SwRI media and production designers and the project investigators.

Task 7 — Reporting

Monthly or Fiscal Year 4-week progress reports will be submitted to the TWDB outlining progress of the project and include the original or adjusted schedule and detail how the Project is progressing relative to this yardstick. Project invoices will include detailed descriptions of the progress made by tasks. Each of the project tasks will be described in detail consistent with the budget description. Any issues will be reported to the TWDB Project Manager immediately as they appear. Close coordination with the TWDB will be maintained throughout the project and will be critical. All draft and final reports will be delivered in Microsoft Word and PDF formats. Draft deliverables will be submitted for review and comment by TWDB. These comments will be addressed in the final report and a copy of the comments will be incorporated into the final deliverables. Acceptance of the Final Report will indicate the successful completion of the project.

7.1 Organization and Management

Through completion of hydrogeological assessment contracts for a variety of commercial and governmental clients, including TWDB, the SwRI team offers a proven approach to successful project management. The project manager, Dr. Ronald Green, has over 30 years of evaluating the water resources of local- and regional-scale aquifers for a broad range of governmental clients whose mandates include the governance, assessment, and management of local and regional water resources in Texas and elsewhere.

7.2 Project Schedule and Budget

The SwRI team's proposed project schedule for developing a conceptual model of the Hill Country portion of the Trinity Aquifer is shown in Table 1. As the schedule shows, the tasks will be completed over the course of 20-24 months from contract award. For purposes of developing our schedule and timeline, we are assuming a start date of September 28, 2016. As stated in the RFQ, this project has a completion date of September 28, 2018 that is firm and non-negotiable. Given the acknowledged ambitious schedule and timeline of the project, it is imperative the team selected to execute this project be capable of achieving the objectives of a project of this scope within the designated timeline. The team has a solid track record of completing challenging projects subject to defined funding levels and strict timelines.

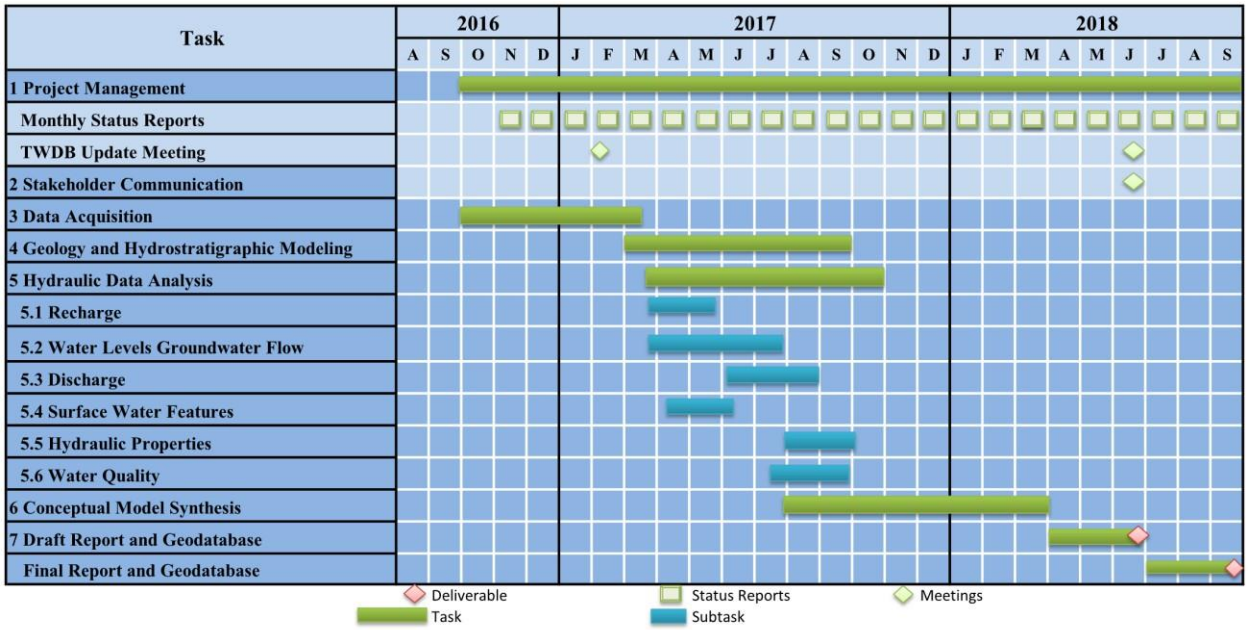


Table 1. Schedule summary for developing a conceptual model for the extended Hill Country Trinity Aquifer.

7.3 Project Monitoring Procedures

The SwRI team will monitor project progress using the same procedures that have enabled us to meet scheduled deliverables on other high-profile, water-resource evaluation projects. Monthly status reports, including the technical progress of the Trinity Aquifer evaluation in the preceding month, will be provided to TWDB. The monthly report will summarize project progress relative to the schedule. Cost summaries, by task and subcontractor, will be provided to the TWDB with our monthly invoices. Monthly project reports will be used as a means of documenting issues, either technical or programmatic, which require consultation with the TWDB. Important project points where these meetings will be held include project initiation, after selection of the model study area, and after providing TWDB with the final draft deliverables. In addition, we anticipate regular communications with the TWDB's project manager and other TWDB staff during the project. These additional meetings will be held either in person, through a webinar, or teleconference.

At SwRI, project management and control functions are carried out in accordance with a well-established system. The Deltek Costpoint accounting software is used to support project management, accounting, reporting, and compliance. The software integrates time keeping, accounting, and accounts receivable. The project manager can monitor project hours and charges in real time because time is entered on a daily basis. This system provides for detailed tracking of resources and schedules and allows early identification of problem areas so that any required corrective measures can be applied in a timely manner. As discussed in Section 6.1, we have divided the Trinity Aquifer evaluation work scope into seven primary tasks. These tasks are divided into subtasks that further break out the work scope.

Thorough documentation of the Hill Country portion of the Trinity Aquifer conceptual model development project is required for transparency and effective use. All data deliverables and documentation for the conceptual model update will be prepared in a manner consistent with the format and content defined by TWDB in Appendix A, GAM Standards and Section 3.1 (Contract Deliverables) of the RFQ. Interim deliverables include monthly status reports and a draft report by the SwRI team for geophysical well log interpretation of total dissolved solids concentration. The interim draft report will provide the SwRI team and the TWDB Board the opportunity to discuss the proposed techniques. Deliverables are as follows:

- Monthly Status Reports
- Draft Source Geodatabase
- Draft Conceptual Model Report (including 3D Schematic Conceptual Block Model)
- Final Source Geodatabase
- Final Conceptual Model Report (including 3D Schematic Conceptual Block Model)

The draft and final reports will summarize the data collection and evaluation, model conceptualization, and hydraulic analysis. All source data will be delivered as part of the source geodatabases. Reports will be delivered in both Microsoft Word and PDF formats.

EXHIBIT B

SCOPE OF WORK

ATTACHMENT 1:

Requirements of Groundwater Availability Models for the Trinity and Edwards-Trinity (Plateau) Aquifers in Texas

1.0 Introduction

One of the purposes of the Groundwater Availability Modeling (GAM) Program is to provide scientific analyses of policy-derived desired future condition of aquifers determined by the groundwater conservation districts in 15[1] of the 16 groundwater management areas across Texas. The groundwater availability modeling effort produces numerical computer models and supporting data sets of the major and minor aquifers in Texas. The groundwater availability modeling process includes substantial stakeholder input and results in standardized, thoroughly documented, and publicly available numerical groundwater flow models and supporting information. The models, source information, and final reports are posted and distributed on the Internet or via other electronic means.

This document has considerable details because of the:

- Need for standardization between the different models;
- Planned public dissemination of the models, supporting information, and results; and
- Assurance that the TWDB deliverables meet program requirements.

The major subheadings below (Stakeholder Participation, Conceptual Model, Documentation, Project Management, and Project Schedule) list TWDB expectations and requirements for the modeling projects.

2.0 Stakeholder Participation

Stakeholder participation is critical to the success of the Groundwater Availability Modeling Program and the development of the models. This includes participation from all levels of the public and private sector including regional water planning groups, groundwater conservation districts, Texas Commission on Environmental Quality, Texas Parks and Wildlife Department, Texas Department of Agriculture, water utilities, educational groups, agricultural interests, environmental interests, private landowners, industry, and groundwater consultants. These groups will be relied upon to voice issues and provide information that will ensure that the models can address the important water resource questions for each aquifer. Project managers are responsible for meeting with a Stakeholder Advisory Forum of the above stakeholders, for holding key milestone meetings to discuss progress of the modeling effort, and for soliciting stakeholder comments and data. It is extremely important that regional water planning groups and groundwater

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1 Groundwater Management Area 5 currently does not have any groundwater conservation districts within its boundaries.

conservation districts are informed about the models because they can use the models to assess groundwater availability or evaluate water management strategies. Stakeholder advisory forum attendees participate voluntarily with no compensation. The modeling projects have a stakeholder advisory forum database maintained through TWDB staff.

Stakeholder advisory forums are open to the public. The project managers work with the TWDB contract manager or other appropriate TWDB staff to coordinate meeting dates and locations. It is the project manager's responsibility to notify the stakeholder advisory forum participants of upcoming meetings. The preferred method of notification is by e-mail. Stakeholder advisory forum participants without e-mail accounts or with a preference other than receiving e-mail are notified by letter. Stakeholder advisory forum participants with e-mail accounts are notified at least 21 days before the meeting and reminded again at least 7 days before the meeting. Stakeholder advisory forum participants that have to be or prefer to be notified by letter are mailed one notice at least 21 days before the meeting. The stakeholder advisory forum notice includes information about the meeting as well as an outline of what will be discussed at the meeting.

The first stakeholder advisory forum is a general meeting—held no more than two months after the project starts—that describes:

- Basics of groundwater flow in the aquifer,
- Concepts of numerical groundwater flow modeling,
- Experience from previous models of the aquifer, if applicable,
- Planned approach; for example, mapping the Trinity Aquifer, flux across Balcones Fault Zone, and extending the model calibration period to the most recent year with adequate data availability,
- Request for local scientific data and model input information,
- Proposed schedule for the modeling project, and
- Expectations of the model (what the model will or will not do) are also discussed.

It is extremely important to provide a well-defined schedule to the stakeholders on when solicited input and data are needed for the model. A well-defined schedule will help ensure that stakeholders' expectations are managed and project managers will not have to work with late-arriving data. At a minimum, the remaining stakeholder advisory forum shall be scheduled after the conceptual model report is delivered.

Additional stakeholder advisory forums may be scheduled at the project manager’s discretion. Contracted project managers submit copies of the stakeholder advisory forum PowerPoint presentations to the TWDB contract manager to preview at least 48 hours prior to the scheduled stakeholder advisory forum meeting. Presentations need to be easy to understand and informative to a non-scientific audience as much as possible. Although attendees are generally knowledgeable about groundwater, most do not hold degrees in geology, hydrology, engineering, or geostatistics. However, technically minded stakeholders are encouraged to ask technical questions and project managers shall answer these questions at the same technical level of the question. In addition, technical questions should also be 'translated' for the non-technical audience.

After each meeting the following is submitted:

- Memo report,
- Copy of the stakeholder advisory forum presentation, and
- Attendance sign-up sheet and typed attendee and affiliation list.

Memo reports (submitted to TWDB in Microsoft Word and Adobe Acrobat-compatible formats) summarize the presentation, the questions and comments that arose from the stakeholder advisory forum attendees, and how the questions were or will be addressed. These memo reports will be posted by the TWDB on the TWDB web page for public viewing .

Digital copies of final presentations at each stakeholder advisory forum meeting (in both PowerPoint and Adobe Acrobat compatible formats) are also given to the TWDB for posting on the web within three (3) business days of the stakeholder advisory forum meeting. For people with disabilities, the documents should meet common accessibility standards, such as Web Content Accessibility Guidelines (WCAG) 2.0 and PDF/UA (Universal Access, or ISO 14289) or later; for example, figures should be tagged and the language identified as English. For easier website accessibility and due to e-mail limitations, the Adobe Acrobat-compatible format deliverables should not exceed 8 megabytes in size. Therefore, some deliverables may need to be submitted in parts.

An attendance sign-up sheet shall be provided at each meeting, which includes attendee name, affiliation, and contact information. The list of attendees and their affiliation shall be given to TWDB for posting on the TWDB web page for each stakeholder advisory forum. New and revised stakeholder contact information shall be reviewed and updated, as applicable, and provided to the TWDB contract manager for updating the database of stakeholder contact information.

3.0 Conceptual Model

The conceptual model is a description of the best understanding of how groundwater moves through the aquifer system. In developing the conceptual model, the information necessary for developing the numerical model is compiled, organized, and described. The conceptual model includes information on:

- Physiography and climate,
- Geology,
- Hydrostratigraphy,
- Hydrostratigraphic framework,
- Water levels and regional groundwater flow,
- Recharge,
- Rivers, streams, reservoirs, springs, and other surface water features,
- Hydraulic properties,
- Subsidence (if applicable),
- Discharge, and
- Water quality.

During the development of the conceptual model, the TWDB (including the Texas Natural Resources Information System), Texas Commission on Environmental Quality, regional water planning groups, Texas Parks and Wildlife Department, Texas Railroad Commission, U.S. Geological Survey, groundwater conservation districts, river authorities, or other appropriate entities are contacted for relevant information. Published papers and reports on the aquifer are compiled, reviewed, and documented. Earlier modeling efforts on the subject aquifer or adjacent aquifer(s) are thoroughly reviewed and documented.

Development of the conceptual model and any information entered into the numerical model uses only publicly available information or information that can be made publicly available at project completion. Each element of the conceptual model is thoroughly described, documented, and referenced in the final report (see Section 4.3.1). In addition, any assumptions are stated and adequately justified. Development of the conceptual model is based on documented field data as much as possible or published work. The conceptual model is visually summarized with a block diagram demonstrating major components of flow in the aquifers (that is, recharge, cross-formational flow, flow directions, boundary conditions). See Section 4.3 for requirements of the final report.

3.0.1 Physiography and Climate

Physiography (the study of physical features of the Earth's surface) and climate of the study area shall be described and include descriptions and maps or graphs of:

- Physiographic delineations and features,
- Topography,
- General climate characteristics,
- Spatial and temporal variability of precipitation,
- Spatial and temporal variability of temperature,
- Spatial and temporal variability of evaporation, and
- Evapotranspiration.

This section shall also describe the aerial extent of the study area and also include research on vegetation and soil properties as it relates to evapotranspiration.

3.0.2 Geology

The general geology and structural geology of the study area shall be described and include:

- Detailed stratigraphic chart showing lithostratigraphic units and facies correlations;
- Description of each of the geologic formations that includes the formation thickness characteristics, depositional environment, and rock composition;
- Map of the surface geology;
- Sufficient cross-sections throughout the study area to demonstrate the structural framework of the subsurface geology;
- Brief discussion of the geologic and tectonic history including regional and local structural features; and

- Previous studies conducted in the model area should be carefully reviewed and referenced as sources of information for this section.

3.0.3 Hydrostratigraphy

Hydrostratigraphy (the layering of aquifers and confining units) for the study area shall be presented and discussed. The discussion shall include:

- Detailed hydrostratigraphic chart showing aquifer and aquitard units,
- Rationale for the delineation of hydrostratigraphic units,
- At a minimum, the hydrostratigraphic units that underlay or interact with the modeled aquifer,
- Any exceptions and additions should be thoroughly documented and pre-approved by TWDB staff, and
- Previous studies should be carefully reviewed and referenced as sources of information for this section.

3.0.4 Hydrostratigraphic Framework

The hydrostratigraphic framework shall describe the elevation of the top and bottom of each of the hydrostratigraphic units. For each layer in the model, an elevation map of the top and bottom shall be generated that includes the location of the data used in the interpolation. Land-surface elevations shall be used as the top of the model domain. Land-surface elevation shall be defined by United States Geology Survey (USGS) 1-arc-second (30-meter) or appropriate finer resolution digital elevation models (DEMs). Thickness maps for each hydrostratigraphic unit shall also be developed. All information used to develop the hydrostratigraphic framework surfaces shall be fully documented as to data source, data interpolation techniques, and data quality.

3.0.5 Water Levels and Regional Groundwater Flow

Water levels and water-level maps describe general groundwater flow directions, hydrologic boundaries, and provide information for the calibration of the model. At least four water-level maps shall be generated for each of the hydrostratigraphic units included in the model:

- For the pre-development historical conditions prior to significant well pumping,
- For the beginning of the transient calibration period,
- During the transient calibration period (at a time-period chosen in cooperation with the TWDB), and
- For the end of the transient calibration period.

The pre-development conditions maps shall be based on historical water-level information, but may include more modern information to help guide water-level interpretation. Long-term historical hydrographs shall also be developed for the study area, as the data permit. These hydrographs will help define water-level fluctuations throughout the model area, and will also serve as calibration targets for the transient model.

Project managers shall document and describe the following, if appropriate:

- Hydraulic-head differences between hydrostratigraphic units,
- Nature of the vertical connection between hydrostratigraphic units,

- Areas of water-level declines, and
- General water-level behavior in the aquifer.

Regional groundwater flow paths shall be identified as well as any features that affect flow paths such as surface water/groundwater interaction, significant well pumping, faulting, and cross-formational flow. Any information on cross-formational flow shall also be investigated, documented, and discussed.

3.0.6 Recharge

Texas Water Code §36.001, Item 26, defines recharge as the amount of water that infiltrates to the water table of an aquifer. Depending on the aquifer, this may include precipitation infiltrating by percolation, irrigation return flow, injection wells such as Class II injection wells (http://water.epa.gov/type/groundwater/uic/class2/), and stream losses. Important factors related to how the aquifer is recharged and the effects of seasonal variations shall be examined and discussed. Previous studies on recharge in the model area should be carefully reviewed. Recharge shall be distributed according to infiltration characteristics of the aquifer outcrop (for example, soil properties, water table depth, and topography), precipitation rates, and losing streams, if applicable. Maps of recharge potential or recharge coefficients (for example, see Mace and others, 2000) shall be generated for the model area.

Recharge can be influenced by water table fluctuation due to seasonal change or groundwater extraction. As a result, the conceptual model and the numerical model must include the concept and effect of 'rejected recharge' (for example, see Theis, 1940, summarized in Domenico and Schwartz, 1990, p. 200-202). The groundwater model should realistically predict the effect of large cones of depression on local flowpaths (that is, capture of rejected recharge) in the aquifer. Therefore, the model should be capable of simulating changing flow patterns due to changing aquifer conditions. This may be accomplished by modeling evapotranspiration and surface water/groundwater interactions, for example.

3.0.7 Rivers, Streams, Springs, and Reservoirs

Surface water features, such as rivers, streams, irrigation canals, springs, and reservoirs, can interact with groundwater and thus must be addressed. The primary surface water features in the model area shall be identified and described along with historical flows. For rivers and streams, reaches with net gains and losses shall be identified and, if possible, quantified. Information from the previous modeling studies in the area may be incorporated into the model, as applicable. Any specific or general information on streambed conductance shall also be addressed. Elevations of riverbeds, streambeds, irrigation canals, spring orifices, and reservoir levels shall be determined from the best-documented available sources. All surface water features that are important elements of the hydrologic flow system shall be incorporated into the model with an appropriate MODFLOW package (for example, the General Head Boundary package should not be used to simulate surface water features).

3.0.8 Hydraulic Properties

Hydraulic properties of hydrostratigraphic units that help define the flow characteristics of

the aquifer must be addressed. These include the transmissivity, hydraulic conductivity, storativity, and specific yield. Results from available aquifer tests for the model area shall be compiled and assessed including any information from the groundwater conservation districts. Additionally, information on hydraulic properties from previous modeling studies may be incorporated in the current project, as appropriate. Specific capacity tests shall also be compiled from TWDB and Texas Commission on Environmental Quality files, and transmissivity and hydraulic conductivity estimated using analytical or empirical techniques (for example, Mace, 2001). Project managers are encouraged to conduct, analyze, and use additional aquifer tests, if they believe the budget can support them.

Transmissivity, hydraulic conductivity, storativity, and specific yield shall be statistically analyzed for each hydrostratigraphic unit. Special care must be taken in considering the completion zones of the test wells and how they relate to the aquifer. Maps of the spatial distribution for these properties shall be presented for each hydrostratigraphic unit using the appropriate interpolation techniques given the amount of data and apparent trends (for example, geostatistical techniques). If the information is available, hydraulic properties shall be related to and distributed according to the known geologic characteristics of the aquifer (for example, texture and net-sand thickness possibly associated with cut banks and point bars or correlated sedimentary facies). Specific or general information on vertical hydraulic conductivity for each hydrostratigraphic unit shall be compiled and/or calculated and related to known geologic and hydrogeologic conditions. If possible, vertical hydraulic conductivity and storativity shall be distributed according to geologic information (for example, texture, net-sand thickness, horizontal beddings, and sedimentary facies). Horizontal anisotropy shall also be defined, discussed, and estimated, if appropriate.

3.0.9 Discharge

Discharge describes the flow of water out of the aquifer either through cross-formational flow; baseflow to streams, springs, or other surface water bodies; and pumping. Cross-formational flow, baseflow to streams, and discharge to springs shall be identified and discussed. Additional information regarding historical pumping from the groundwater conservation districts located in the study area shall be requested, reviewed, and used, as applicable. It is the project manager's responsibility to use the existing models, associated data, and other public data sources to quantify the groundwater discharge. Previous modeling study in the model area, if applicable, may be a helpful source of information on discharge for many of the modeling projects.

3.0.10 Water Quality

Although the models will not explicitly model water quality and solute transport, it will be important to document water quality of the aquifer so later users can more accurately gage groundwater availability. Therefore, total dissolved solids and other constituents of concern should be presented as part of the conceptual model. Analysis of fresh versus brackish water derived from geophysical log interpretation should be documented, as applicable.

3.0.11 Model Extents and Boundaries

The extent of the models should follow natural boundaries as much as possible. The

submitted response and report shall describe the rationale for the boundaries in the model for aquifers that extend outside of Texas. The project manager shall describe the process to select the model base boundary location based on the hydrostratigraphic framework (and/or water quality criteria) as well as the boundary condition used to simulate the model base boundary.

3.0.12 Pumping

Groundwater pumpage shall be defined and assigned, as applicable, according to TWDB water use categories: industrial (manufacturing), power, mining, irrigation, municipal, livestock, and rural domestic (county other). It is the project manager's responsibility to evaluate the pumping data from the TWDB water use survey and adjust them, if necessary, so that the groundwater pumping is simulated correctly by the model. Project managers should document why and how the adjustment is made. Project managers are also required to retain regional water planning water user group (WUG) identification fields throughout data processing and the spatial assignment of pumpage, as much as possible. Standardized water user group identification fields and data that shall be retained include:

- WUG_ID—water user group identification number
- WUG_NAME—water user group name
- DATA_CAT—water user group category
- WUG_RWPG—water user group regional water planning group
- WUG_COUNTY_NAME—water user group county name
- WUG_BASIN_NAME—water user group surface water basin name
- CITY_ID—city identification number
- WUG_COUNTY_ID—water user group county identification
- WUG_BASIN_ID—water user group surface water basin identification

4.0 Documentation

Thorough documentation of the models is extremely important in ensuring their continued use. Each of the models shall be thoroughly documented and made available to the public upon completion of the project. Documentation shall include four to five major products:

- Source and derived information from the development of the conceptual model in an ArcGIS version 10.2 or later version file geodatabase format,
- Any additional interpretation of new geophysical logs or adjustments to existing analysis of geophysical logs shall be provided in a format compatible with the BRACS database,
- Source and derived pumpage information in an ArcGIS version 10.2 or later file geodatabase format, and
- Final reports in both Microsoft Word 2010 compatible format and Adobe Acrobat 10.0 PDF format for the conceptual model report and numerical model report.

In addition to the discussion below, we have prepared data models in Environmental Systems Research Institute (ESRI) personal geodatabase format for the projects (Attachment 1).

4.1 Software Requirements

All computer files and formats shall be 100 percent compatible with personal computer

(IBM-PC) type systems. Electronic files may be physically shipped using digital video discs (DVD), external hard drives, or flash drives. In addition, files may be zipped with a self-extracting software program such as WINZIP. Project managers shall deliver three sets (on separate digital video discs) of all electronic files of documented source data and model files (when appropriate) used during the development of the:

- Draft conceptual report,
- Final conceptual report, and
- Source geodatabase.

Project managers shall deliver four hard copies of the draft conceptual report, and eight copies of the final conceptual report (see contract for any exceptions) to TWDB. All files and data shall be transferred to the TWDB in ready-to-use formats. Formats of all computer files provided to the TWDB by the project managers shall be fully compatible with the widely distributed versions of the following programs:

- Word Processor Files—Microsoft Word (MS Office 2010),
- Geodatabases data—ESRI ArcGIS (version 10.2 or later),
- Spreadsheet files—Microsoft Excel (MS Office 2010),
- Graphs, bar charts, pie charts—Microsoft Excel (MS Office 2010),
- Internet-ready reports in pdf format in parts not to exceed 10 megabytes—Adobe Acrobat (10.0), and
- Scanned files—uncompressed TIFF (8-bit for black and white and 24-bit color for gray/color with at least 300 dpi or greater, if needed, to resolve image resolution) for geophysical logs or associated data files.

The project manager shall seek the approval from the Groundwater Availability Modeling Section Manager as to the compatibility of alternative software. Project managers need to provide ESRI ArcGIS compatible files for all geographic information system information. All drawings and graphs included in all reports shall be provided separately to TWDB in their native file format. In addition, all figures shall also be provided separately to TWDB in JPEG formatted files with 300 dpi or greater resolution.

4.2 Source Information

Important products from the modeling studies include not only the models but also the source information used to develop the models. These source data have potential use beyond the initial groundwater availability models for groundwater conservation districts, regional water planning groups, groundwater management areas, TWDB, and other users to support ongoing management issues and research. Therefore, we expect to receive all source data used in the development of the model with sufficient metadata to decipher parameters and units reported. For example, we expect to receive all point data used to develop spatially distributed parameters. If map information was digitized from an existing scanned or paper document, we expect to receive the final geographic information system files of the digitized map(s) with metadata documentation citing the source of the digitized maps. If information from geologic cross-sections within a published document is used, we expect a scanned image file or digitized vector file of the cross-section(s) with metadata

documentation of their original source. The source data also allows alternative interpretations of parameter distributions to be investigated in future studies.

Source data refer to the tabular, point, line, polygon, and/or raster information developed or used to create model input files. All the source data shall be delivered to the TWDB in the appropriate format (see Sections 4.1, 4.2, and Attachment 1). Spatial information shall be projected into the groundwater availability modeling coordinate system with units of measure in feet prior to and during any spatial analysis (see Attachment 1).

Examples of source data for the study area include:

- Properly projected geographic information system feature datasets of the boundary of the study area including major towns and cities, county boundaries, major rivers and streams, major reservoirs, major roadways, regional water planning group boundaries, groundwater management area boundaries, groundwater district boundaries, physiographic delineations, river basins, and active model boundaries;
- Geographic information system raster and/or feature datasets of the topographic elevations in the study area (digital elevation model source data and the contours in units of feet relative to mean sea level);
- Tabular data and geographic information system raster and/or feature datasets of average annual precipitation (including gage locations and associated time-series data and their units of measure);
- Tabular data and geographic information system raster and/or feature datasets of net lake or pan evaporation and their units of measure;
- Geographic information system feature datasets of the surface geology;
- Tabular data and geographic information system raster and/or feature datasets of the net sand maps in units of feet relative to mean sea level, if applicable;
- Geographic information system feature datasets of the major structural and tectonic features;
- Geographic information system raster and/or feature datasets of the top and bottom elevations for each model layer in units of feet relative to mean sea level;
- Tabular data and geographic information system raster and/or feature datasets of the water level maps in units of feet relative to mean sea level;
- Tabular data and geographic information system raster and/or feature datasets of the water quality maps and their units of measure;
- Tabular data for the historical hydrographs and their units of measure;
- Tabular data for the long-term water quality graphs and their units of measure;
- Tabular data for the stream-flow hydrographs and their units of measure;
- Tabular data for the springflow hydrographs and their units of measure;
- Tabular data for the lake level hydrographs and their units of measure;
- Tabular data for the hydraulic conductivity, transmissivity, and storativity and their units of measure;
- Raw data and plots used to calculate hydraulic conductivity, transmissivity, and storativity and their units of measure;
- Geographic information system raster and/or feature datasets of the distributions of transmissivity, hydraulic conductivity, and storativity and their units of measure;

- Tabular data for the historical pumping at the resolution used to develop the model input datasets and their units of measure;
- Tabular data and geographic information system raster and/or feature datasets of population density and their units of measure;
- Tabular data and geographic information system raster and/or feature datasets of the recharge rates and their units of measure;
- Tabular data and geographic information system raster and/or feature datasets of historical pumping information and their units of measure;
- Geographic information system raster and/or feature datasets of water levels for the steady-state run and the beginning, during the transient run at a time negotiated with TWDB, and end of the transient calibration run in units of feet relative to mean sea level;
- Tabular data of calibration targets including target name, GAM coordinate, model row/column/layer, related hydrogeologic unit, measured value, and associated stress period and date in units of feet relative to mean sea level;
- Geographic information system raster and/or feature datasets of final model parameters (e.g. horizontal hydraulic conductivity, vertical hydraulic conductivity, recharge, pumping rates, and their units of measure) if different from distributions assembled during the conceptual model; and
- Any other data used to develop the model and their units of measure.

Point data shall be delivered in two formats:
- Microsoft Access 2010
- ESRI Arc/GIS version 10.2 or later

Interpreted data (for example, contoured data) shall be delivered in ESRI Arc/GIS version 10.2 or later format. Any information associated with a state identification number (such as the state well number for located wells and the water use group [WUG] number and related fields [county, basin, region] for water users) must maintain that association in the final databases (Attachment 1). All tabular data and geographic information system raster and feature datasets shall be delivered to the TWDB within the groundwater availability modeling source geodatabase schema(s) provided to each project manager. The groundwater availability modeling source geodatabase schema(s) define file-naming protocol, database organization, and documentation of the tables, databases, and geographic information system spatial data (Attachment 1).

4.3 Final Reports

The final reports shall include the details of the conceptual model and input datasets. The final reports will be a reflection of the TWDB as well as the project managers and shall be well written, containing little to no spelling or grammatical errors. Final approved reports must follow Texas Board of Professional Geoscientists guidelines (see http://www.tbpg.state.tx.us/) and/or Texas Board of Professional Engineers (see http://www.tbpe.state.tx.us/).

4.3.1 Report Format and Figures

Each section of the submitted reports shall address the data and analysis described in

Section 3. Additional sections and subsections may be added to the submitted reports to address aquifer-specific issues.

Drafted figures shall be similar in design to each other and include a legend and a descriptive figure caption and must fit on 8.5 by 11-inch paper. If you use color figures, please keep in mind that the report may be photocopied or printed from the .pdf using a black and white printer. For this reason, you should use symbols or patterns or make sure that colors print as different shades in grayscale. 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.

Minimum requirements for figures include:

- Figures shall be designed such that a black and white printout is readable and understandable,
- Maps include a north arrow and a bar scale,
- Figures and maps shall include legends showing related features,
- Each figure has a caption that includes reference sources for the base map or the included information, and
  - for unmodified illustrations, the reference source shall be preceded by the word "from",
  - for illustrations modified less than 15 percent of the original, the reference source shall be preceded by the word "after",
  - for illustrations modified more than 15 percent of the original, the reference source shall be preceded by the words "modified from"), and
- Figures must also follow Texas Board of Professional Geoscientists or Texas Board of Professional Engineers guidelines.

Sources of data/base maps shall be clearly indicated on the figure or in the figure caption. Additional figures may be added as needed.

At a minimum, the draft and **final conceptual MODEL report** shall include the following sections, subsections, and figures and designed for the general public as the audience:

Executive summary:
Provide a brief summary of the conceptual model.

1.0 Introduction
Describe the importance of the aquifer to the region and provide a general outline of the modeling study and report.

2.0 Study Area
Discuss the study area and include the following maps:

- Maps of the study area showing major towns and cities, county boundaries, major rivers and streams, major reservoirs, major roadways, location of the study area within Texas or any bordering states (if applicable), and the model boundaries,

- Map showing the location of the different regional water planning groups in the area and the groundwater management area in the area,
- Map showing the location of groundwater conservation districts in the area (documented with the date of the source reference), and
- Map of the major river basins and major surface water features.

2.1 Physiography and Climate

Please include the following maps:

- Map of the delineated physiographic provinces and sub-provinces as delineated by the Texas Bureau of Economic Geology,
- Map of topographic elevation,
- Map of climate divisions for the study area as delineated by the National Climatic Data Center,
- Map of average annual precipitation over the study area in inches per year (1981 to 2010 or later),
- Map of average annual temperature over the study area in degrees Fahrenheit (1981 to 2010 or later),
- Map with several plots of average monthly precipitation measured at rain gages in the study area in inches per year (1981 to 2010 or later),
- Map of average annual net lake or pan evaporation over the study area in inches per year (1981 to 2010 or later),
- Map of average evaporation (include years used to average),
- Map of vegetation types (root depths if available or estimated),
- Maps of soil properties including infiltration (or permeability) and water capacity, and
- Map of estimated potential and actual evapotranspiration, if available.

2.2 Geology

Please include the following maps:

- Map of the surface geology at a minimum scale of 1:250,000,
- Maps of spatially distributed geologic information used during the modeling study (showing the control data if possible),
- Map of the major structural and tectonic features in the area,
- Detailed stratigraphic chart of the geologic formations in the study area and their geologic (lithostratigraphic) correlations, and
- Several geologic cross-sections through the study area that show the general framework of the subsurface geology.

3.0 Previous Work

Describe the previous studies of the study area. Studies related to groundwater extraction, groundwater levels, river flow, precipitation, water quality and their correlations should be thoroughly investigated and documented. If there have been previous groundwater flow models for the aquifers in the region, review and describe those models. These models may not necessarily cover exactly the same area or have the same objective; however, the previous groundwater models and their associated data sources may provide useful

information for this project. Thus, the existing models and related databases/files shall also be reviewed and investigated.

4.0 Hydrologic Setting

Discuss the information compiled and analyzed for developing the conceptual model as discussed in Appendix A, Section 3.08, in the following subsections:

4.1 Hydrostratigraphy and Hydrostratigraphic Framework

Please include the following maps/figures:

- Schematic of the geologic units in the study area and the hydrostratigraphic units used in the model - The corresponding model layer should be included in the final report. For example, the geologic age of the strata, group names (with group correlations if applicable), formation names (with formation correlations if applicable), brief geologic descriptions, hydrogeologic delineations (aquifer/aquitard), and the corresponding model layer should be provided,
- Maps of top and bottom elevations for each of the hydrostratigraphic units as well as model layers, in case they are different, including the control points, and
- Maps of layer thickness for each of the model layers including the control points.

4.2 Water Levels and Regional Groundwater Flow

Please include the following maps/figures:

- Maps of the potentiometric surface for each hydrostratigraphic unit as well as model layer, in case these are different, for the pre-development calibration, the beginning of the transient calibration, during the transient calibration at a time period agreed-upon with TWDB, and at the end of the transient calibration including the control points,
- Several historical hydrographs demonstrating water-level fluctuations (including seasonal, if available) in the aquifer with a map indicating location of the wells, and
- Historical hydrograph selections should represent unconfined (and also confined portions if applicable) of the aquifer(s) from each county in the study if data is available.

4.3 Recharge

Please include the following:

- A discussion of the approach used to estimate recharge rates and map(s) of estimated recharge rates, potential, factors, and/or coefficients.

4.4 Rivers, Streams, Springs, Reservoirs, and Other Surface Hydraulic Features

Please include the following figures:

- Representative streamflow hydrographs for the major rivers and any significant perennial streams or tributaries in the study area with a map indicating their gage locations,
- Springflow hydrographs if appropriate with a map indicating spring locations, and
- Hydrographs of reservoir levels if appropriate.

4.5 Hydraulic Properties

Please include the following:

- A discussion of the approach used to estimate hydraulic properties,
- Histograms of hydraulic conductivity, specific yield (if appropriate), storativity/ for each hydrostratigraphic unit as well as model layer, in case they are different,
- Map of spatially distributed hydraulic conductivity, specific yield (if appropriate), storativity for each hydrostratigraphic unit as well as model layer, in case they are different,
- Net sand thickness maps, if applicable, and
- Map of geologic sedimentary facies and paleo-geography, if applicable.

4.6 Discharge

Please include the following figures, maps, and tables:

- Bar chart(s) of yearly total historical groundwater usage,
- Map of rural population density,
- Tables of the historical pumping data according to major user group and totaled for each county shall be included in the report, and
- Maps of pumping distributions for each hydrostratigraphic unit as well as model layer, in case these are different, for the pre-development calibration, the beginning of the transient calibration, during the transient calibration at a time period agreed-upon with TWDB, and at the end of the transient calibration according to major user group.

4.7 Water Quality

Please include the following maps:

- Maps of water quality (total dissolved solids and any other constituents of concern) for each hydrostratigraphic unit as well as model layer, in case they are different, for the pre-development calibration, the beginning of the transient calibration, during the transient calibration at a time agreed-upon with TWDB, and at the end of the transient calibration including the control points, and
- Long-term water quality graphs demonstrating water quality fluctuations (including seasonal, if available) in the aquifer with a map indicating location of the wells.

5.0 Conceptual Model of Groundwater Flow in the Aquifer

Describe the concepts and assumptions of the aquifer used to guide the construction of the computer model. These concepts should include (1) identifying the modeled layers and confining units, (2) describing the movement of water from recharge areas to discharge areas through the aquifer, and (3) discussing important controls on groundwater flow (for example, structural framework, faulting, lithology, and boundaries) and on groundwater quality (for example, boundaries, cross-formational flow, pumping, groundwater ages, if available). Please include the following figure:

- Block diagram showing the hydrogeologic units and summarizing the flows within the conceptual model and how the conceptual model was translated into the computer model (for example, see Mace and others, 2000, fig. 50).

6.0 Future Improvements

Indicate where additional improvements could be made to the conceptual model in collecting more data or additional studies. Recommendations for how these issues could be addressed would be appreciated.

7.0 Acknowledgments

Acknowledge those organizations or specific individuals that assisted in the conceptual modeling project by supplying data, providing thoughtful discussion, or contributing more directly to the study.

8.0 References

All references cited in the report shall be included in the 'References' section following the TWDB format.

The following units shall be used in all data presentations:

- Land area in square miles (mi2),
- Water volume in acre-feet (ac-ft),
- Elevations relative to mean sea level (ft-AMSL),
- Demand and supply rates in acre-feet per year (ac-ft/yr),
- Streamflows and reservoir releases in cubic feet per second (cfs),
- Springflow in cubic feet per second (cfs),
- Pumping rates in gallons per minute (gpm) or million gallons per day (mgd),
- Recharge rates in inches per year (in/yr),
- Annual precipitation in inches per year (in/yr),
- Evaporation in inches per year (in/yr),
- Evapotranspiration in inches per year (in/yr),
- Hydraulic conductivity in feet per day (ft/d),
- Transmissivity in feet squared per day (ft2/d),
- Conductance in feet squared per day (ft2/d),
- Specific storage in units of inverse length using feet (1/ft),
- Recharge volumes in acre-feet (ac-ft),
- Dispersivity in feet (ft), as applicable,
- Total dissolved solids concentration milligrams per liter (mg/l), and
- Groundwater density in grams per liter (g/l), as applicable.

Information may also be co-reported in other units such as metric equivalents.

4.3.2 Report Deliverables

There are two (2) times when TWDB shall receive electronic copies of data used for the modeling effort and the deliverable report for review:

- After completion of the draft conceptual model (report shall include Conceptual Model Report information listed in Section 4.3.1), and
- After completion of the project (final conceptual report shall include information listed in Section 4.3.1).

For the draft conceptual model report, the project manager shall deliver to the TWDB:

- Four (4) hard copies of the draft conceptual model report or draft model and predictive scenarios (if applicable) reports,
- Adobe Acrobat (pdf) file of the draft conceptual model report, draft report, and predictive scenario (if applicable) report for posting on the TWDB web site (broken into parts not to exceed 8 megabytes each) and the Word 2010 format including figures,
- All the related documented source and derived data in the appropriate geodatabase (see Attachment 1), and
- All computer programs (source code and executable) that are used during the conceptual model development.

The Stakeholder Advisory Forum participants and the TWDB shall have two months to comment on the conceptual report. Stakeholder Advisory Forum participants and the TWDB shall have another two months to comment on the draft model and predictive scenarios reports. The project manager will have two months to address comments from the draft model and predictive scenarios reports (as well as the comments from the conceptual model review period) before issuing the final report.

At the end of the study, the project manager shall deliver to the TWDB:

- Nine (9) hard copies of the final conceptual report;
- Digital copies of the final conceptual report including all figures (in Word 2010 format);
- Adobe Acrobat (pdf) file(s) of the final conceptual report for posting on the TWDB web site (broken in part not to exceed 10 megabytes);
- Individual digital copies of each of the figures in the reports (see Section 4.3.1 for details);
- All source data in digital format in the appropriate geodatabase.

It is important that the delivered reports are of high quality and that we receive the proper files. Consistent geologic, hydrologic, and technical terminology must be used throughout each report. Each report shall have an authorship list of persons responsible for the studies: firm or agency names as authors will not be acceptable. Final approved reports must follow Texas Board of Geoscientists guidelines (see http://www.tbpg.state.tx.us/index.html) and shall be sealed by either a professional engineer or professional geoscientist.

4.3.3 Presentations and Web Publishing

During the course of the project, the project manager will provide digital copies of presentations related to the model to assist us in promoting the modeling efforts and informing the public (in PowerPoint and Adobe Acrobat formats). Geodatabases and the report may all be posted on the TWDB web site and will be distributed to interested parties on compact discs or digital video discs. TWDB will maintain centralized ownership and maintenance of the models source data (geodatabase) and conceptual model report.

5.0 Project Management

The TWDB shall receive monthly letter reports for the duration of the modeling projects summarizing progress on the project. Any concerns should be documented in the progress

reports and brought to the contract manager attention as soon as possible. The project manager shall also hold project review meetings with the TWDB at important points in the modeling process. TWDB may visit the consultant on occasion to gauge progress on the project. These important points include:

- Beginning of the project;
- After interim study, as applicable; and
- After draft conceptual model update.

Advancement of the project to the next phase of work described above is contingent on TWDB Executive Administrator approval of the efforts at each formal meeting. Each meeting will include discussions on the work that has been completed and the approach for the next phase of work. TWDB staff will also attend the Stakeholder Advisory Forums.

6.0 Project Schedule

We expect that the conceptual model, all data collection associated with the development of the conceptual model, and the draft conceptual model report (this includes the 'Study Area,' 'Previous Work,' 'Hydrologic Setting,' and 'Conceptual Model of Groundwater Flow in the Aquifer' sections of the report) will be completed by the date noted in the contract. The draft model report will be delivered by the date noted in the contract, as well as all associated data and model files.

7.0 References

Anderson, M. P., and Woessner, W. W., 1992, Applied groundwater modeling—Simulation of flow and advective transport: Academic Press, Inc., San Diego, 381 p.

ASTM, 1994, Standard guide for conducting a sensitivity analysis for a ground-water flow model application: American Society for Testing and Materials Standard D5611-94e1, 6 p.

Domenico, P.A., and Schwartz, F.W., 1990, Physical and Chemical Hydrogeology: John Wiley and Sons, Inc., New York, p. 200-202.

Freeze, R. A., Massmann, J., Smith, L., Sperling, T., and James, B., 1990, Hydrogeological decision analysis- . A framework: Ground Water, v. 28, no. 5, p. 738-766.

Mace, R. E., Chowdhury, A. H., Anaya, R., and Way, S.-C., 2000, Groundwater availability of the Middle Trinity aquifer in the Hill Country area of Texas-Numerical simulations through 2050: Texas Water Development Board Report.

Mace, R. E., 2001, Estimating transmissivity using specific-capacity data (Geological circular): Bureau of Economic geology, University of Texas at Austin, 44 p.

EXHIBIT B

SCOPE OF WORK

ATTACHMENT 2:

Data Model for the Groundwater Availability Models

1.0 Introduction

To capture the various data types and sources that go into groundwater availability models (GAM), we have developed the groundwater availability modeling data model. A data model is a logical construct for storage, organization, documentation, and retrieval of digital information. The groundwater availability modeling data model is built upon the Environmental Systems Research Institute, Inc. (ESRI) ArcGIS file geodatabase, optimized to manage related spatial and nonspatial data. The groundwater availability modeling data model consists of three principal data products expected from each GAM project: (1) the conceptual model source and unique derivative datasets within a Source geodatabase, (2) the source and unique derivative model grid pumpage values within a Pumpage geodatabase, and (3) the final MODFLOW geodatabase for specific input data files. The source and unique derivative datasets consist of natural and anthropogenic spatial features and associated time-series information, as well as any other spatial or non-spatial data used to develop the conceptual model and/or to generate numerical model grid values. The source and unique derivative model grid pumpage values consist of source data and all derivative model grid pumpage values used for the final model calibration. The final MODFLOW specific data files consist of data files formatted for both MODFLOW-2005 or the later version of MODFLOW and Groundwater Vistas. The grid values consist of the final grid-cell input data used for the calibrated steady state and transient numerical models.

Project managers shall use the GAM coordinate statewide mapping system to geo-reference all spatial data used in the modeling project. It is extremely important and a requirement that all source data be projected into the GAM coordinate statewide mapping system prior to generating any derivative and/or model input data sets. The GAM coordinate statewide mapping system provides complete statewide coverage with an equal-area projection that minimizes the spatial distortion of area. The projection parameters shown in Table A2-1 shall be used for the GAM coordinate statewide mapping system. The groundwater availability modeling file geodatabase schemas shall be preset with the correct coordinate and projection parameters so that spatial data with a predefined coordinate system will be automatically projected into the GAM coordinate system during data loading.

Table A2-1. Projection parameters to be used for the groundwater availability modeling coordinate statewide mapping system.

Groundwater availability modeling coordinate statewide mapping system

Projection :	Albers Equal-Area		
Units of Measure :	U.S. Survey Feet		
Horizontal Datum :	NAD83	or	North American Datum 1983
Vertical Datum :	NAVD88	or	North American Vertical Datum 1988
Spheroid :	GRS80		
Longitude of Origin :	-100.00000	or	100° : 00' West
Latitude of Origin :	31.25000	or	31° : 15' North
Lower Standard Parallel 1 :	27.50000	or	27° : 30' North
Upper Standard Parallel 2 :	35.00000	or	35° : 00' North
False Easting :	4,921,250 (U.S. survey feet)		
False Northing :	19,685,000 (U.S. survey feet)		

1.1 Data Content and Organization

An enormous amount of spatial and nonspatial data will be generated by each GAM project. To facilitate management and public distribution of project datasets, the TWDB will provide each project manager with empty file geodatabase schemas to organize and store source and derivative information for the conceptual model, and for model grid pumpage values.

ESRI ArcGIS (versions 10 or 10.2) software is required to work with file geodatabases. The schemas will contain empty feature datasets, feature classes, object classes, tables, and raster datasets ready to be loaded with project data. The project manager shall use the geodatabase schemas for organizing, processing, and archiving all GAM project data. The GAM geodatabases are extendable, but prior written approval from the Groundwater Division, Groundwater Availability Modeling Section Manager shall be obtained before any changes to the preset schemas may be made. The object of the Source geodatabase is to provide all basic data and metadata used to conceptualize the model, which along with written descriptions of derivation processes in the report, can be used to reproduce all input parameters for the gridded data in the model. The Pumpage geodatabase facilitates spatial distribution of pumpage from statewide TWDB datasets to a format that can be directly transferred to model grid cells. A MODFLOW geodatabase, intended to store all the input data needed to run the final calibrated steady state and transient groundwater availability modeling models with the MODFLOW-2005 or later version of MODFLOW code, will be made available upon request. If for any reason the source or derivative data is not compatible with the geodatabase schema, then that information shall be provided to TWDB in another format pre-approved by the Groundwater Division, Groundwater Availability

Modeling Section Manager that complies with software requirements noted in Appendix A, Section 4.1.

1.1.1 Source and Derivative Geodatabase Schema

Source and unique derivative information shall be organized in the GAM Source Data Geodatabase. Source information is defined as original information collected and used to develop the final conceptual model of the aquifer system and to develop the gridded values used for the calibrated steady state and transient numerical models. Depending on the aquifer and methodologies used, we recognize that source and derivative data will be different for each project. Therefore, TWDB staff will review final contracts to identify the appropriate source and derivative data needed for the source geodatabase to reproduce critical model input. Vector spatial data shall be contained in feature classes that are organized into feature datasets. Each feature dataset contains thematically related point, line, and polygon feature classes. Nonspatial tabular data shall be stored in geodatabase tables or object classes, which are not contained within feature datasets but participate in relationships with corresponding spatial features. Raster data (such as interpolated or gridded surfaces; digital elevation models; satellite or other airborne imagery; and digitally scanned map graphics, logs, and cross-sections) shall be managed in the geodatabase as raster datasets or raster catalogs.

1.1.2 Pumpage Geodatabase Schema

Pumpage shall be processed and distributed spatially within a GAM pumpage geodatabase. The geodatabase should maintain traceability between input source data (well records, master water-use tables) and output tables and spatial features. The geodatabase comprises tables, spatial features, and any geoprocessing (GP) tools used to develop the pumpage distributions. Vertical distribution of pumpage to model layers and assignment of pumpage volumes to grid cells shall be included within the Pumpage geodatabase. Note: other options may be considered with pre-approval by the TWDB Groundwater Division, Groundwater Availability Modeling Section Manager.

1.1.3 MODFLOW Specific Data Files

The MODFLOW specific data files shall be organized into two primary directories or folders, one for MODFLOW-2005 or later version of MODFLOW standard ASCII files (Harbaugh, 2005) and the other for Groundwater Vistas 6.0 compatible files (Rumbaugh and Rumbaugh, 2014). Each directory or folder shall also contain: (1) a “files.txt” file containing a full list of each of the files in the directory or folder, (2) a “stress-periods.txt” file listing each stress period and its associated time length and date, and (3) a “readme.txt” file with a discussion of special instructions, tips, or information needed to use the files.

1.1.4 Model Grid Feature Dataset

A model grid feature dataset shall be located within the Source and derivative geodatabase and consist of a polygon feature class of model grid cells and a point feature class of model grid cell nodes. The polygon feature class shall consist of square polygons representing a finite difference model grid with uniform sized cells no larger than 1 mile by 1 mile. The point features shall be centered on each of the polygon grid cells. A unique Cell_ID or relationship/index key consisting of a nine-digit integer data type and based on the layer, row, and column shall be used to link the polygon and point feature classes with any

parameter values and time series variables. For example, a Cell_ID value of 200040025 would refer to the grid-cell or grid-cell node for layer 2, row 4, and column 25. Consequently, the maximum model grid dimensions for groundwater availability modeling projects are limited to the following:

- Layers: 9
- Rows: 9999
- Columns: 9999

1.1.5 MODFLOW Geodatabase Schema

Using a geodatabase schema to organize (if applicable) and store model grid values is optional. The groundwater availability modeling MODFLOW geodatabase consists of a polygon feature class of model grid cells, a point feature class of model grid cell nodes, and tables/object classes for the final calibrated MODFLOW-2005 or later version of MODFLOW input parameters and for time-series variables linked with relationship classes.

1.2 Data Documentation

All datasets used for GAM projects shall include metadata that documents the content, data structure, source(s), date(s), quality, and other characteristics of the data within the geodatabases. Metadata shall be created using the Federal Geographic Data Committee (FGDC) metadata editor within ESRI's ArcCatalog. The TWDB-provided schemas include some basic metadata, which shall be extended by the project manager to completely document all source and derivative data. The project manager shall be responsible for ensuring that all data is accurately documented and in compliance with the Federal Geographic Data Committee 's Content Standard for Digital Geospatial Metadata, Version 2 (FGDC-STD-001-1998) or later.

1.3 References

Harbaugh, A. W., 2005, MODFLOW-2005, the U.S. Geological Survey modular ground-water model—the Ground-water flow process: U.S. Geological Survey Techniques and Methods 6-A16, 253 p., http://pubs.usgs.gov/tm/2005/tm6A16/PDF/TM6A16.pdf

Rumbaugh, J. O., and Rumbaugh, D. B., 2014, Online User Manual: Groundwater Vistas http://www.groundwatermodels.com/Groundwater_Vistas.php.

EXHIBIT B

SCOPE OF WORK

ATTACHMENT 3:
Guidelines for Authors Submitting Contract Reports
to the Texas Water Development Board

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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.

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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:

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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	1940	1950	1960	1970	1980	1990	2000	%GW
Table Text	15	441	340	926	196	522	83	97.4
Table Texas	64	944	626	373	356	171	516	99.99
TOTAL	79	1385	966	1099	552	693	599	

* A footnote should look like this using 10 point Cambria.
%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.htm (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, two 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.htm.

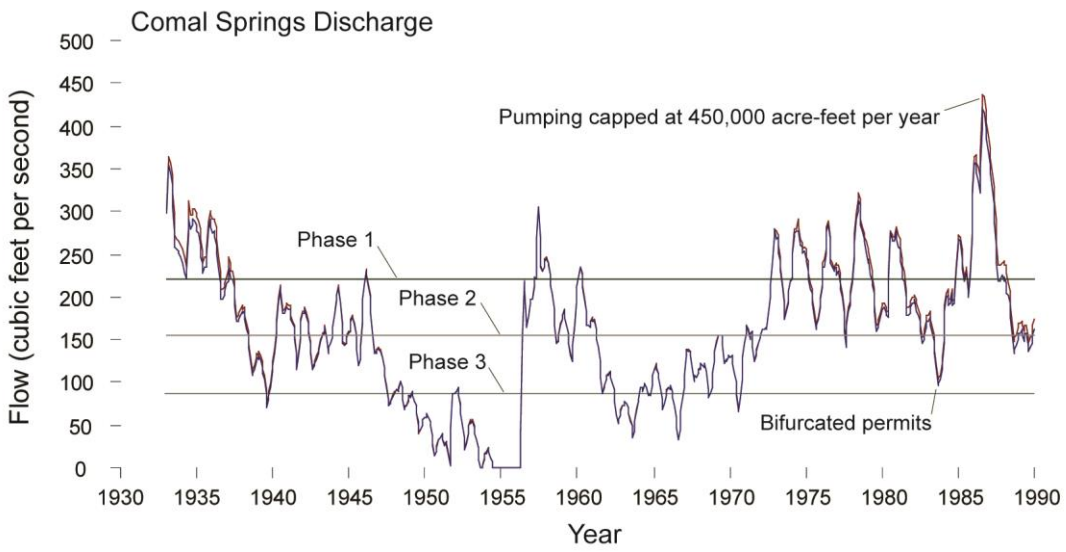

Figure 1. A sample figure showing only the information needed to help the reader understand the data. Font size for figure callouts or labels should never be less than 6 point.

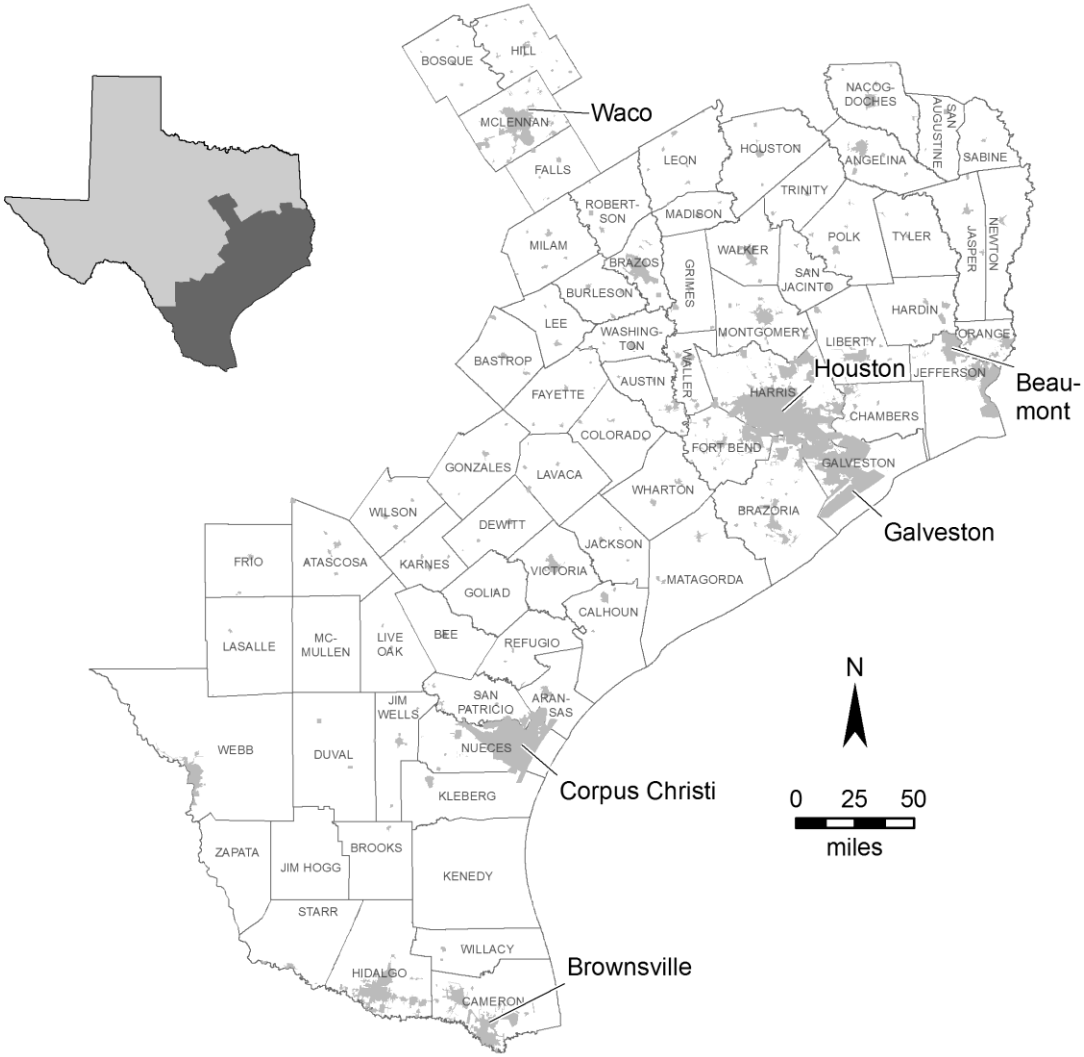

Figure 2. A sample subject area map, giving the reader enough information to understand the location being discussed in this conference. For map figures, be sure to include a north arrow to orient the reader, a scale, and, if needed, a submap that places the figure in greater geographic context. Be sure 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.

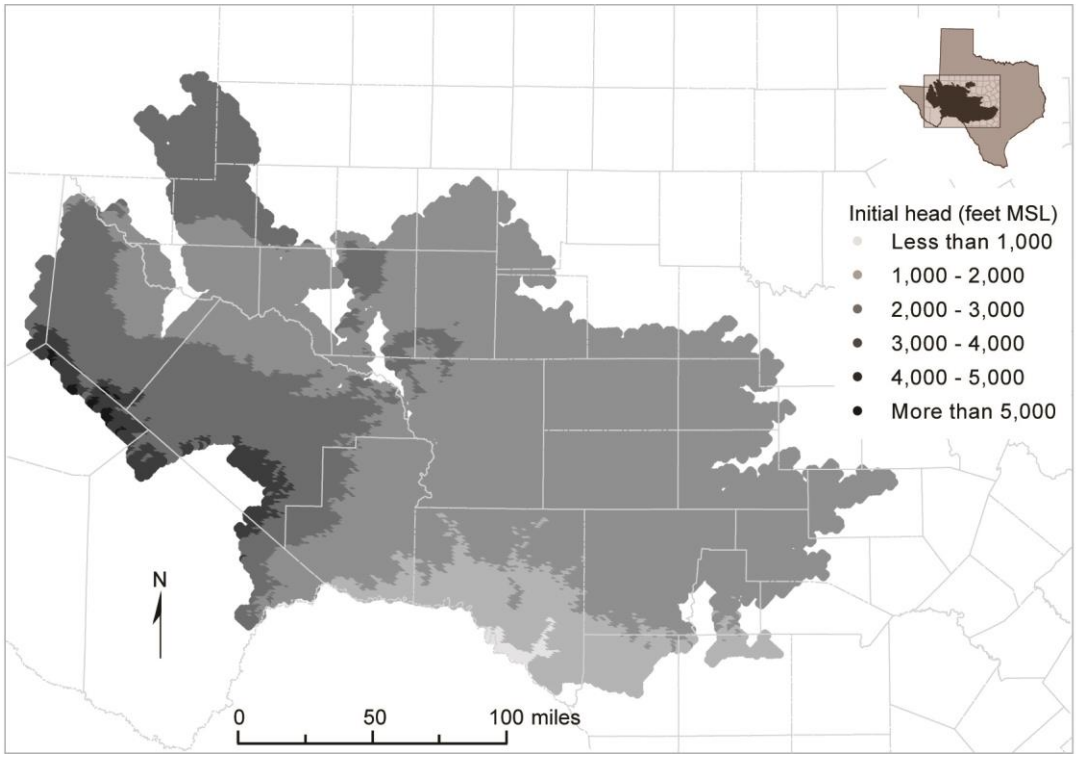

Figure 3. Initial hydraulic heads used in model simulations for layer 1. Note the use of grayscale shading to show differences.

EXHIBIT B

SCOPE OF WORK

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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	1940	1950	1960	1970	1980	1990	2000	%GW
Table Text	15	441	340	926	196	522	83	97.4
Table Texas	64	944	626	373	356	171	516	99.99
TOTAL	79	1385	966	1099	552	693	599	

* A footnote should look like this using 10 point Cambria.
%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.htm (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, two 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.htm.

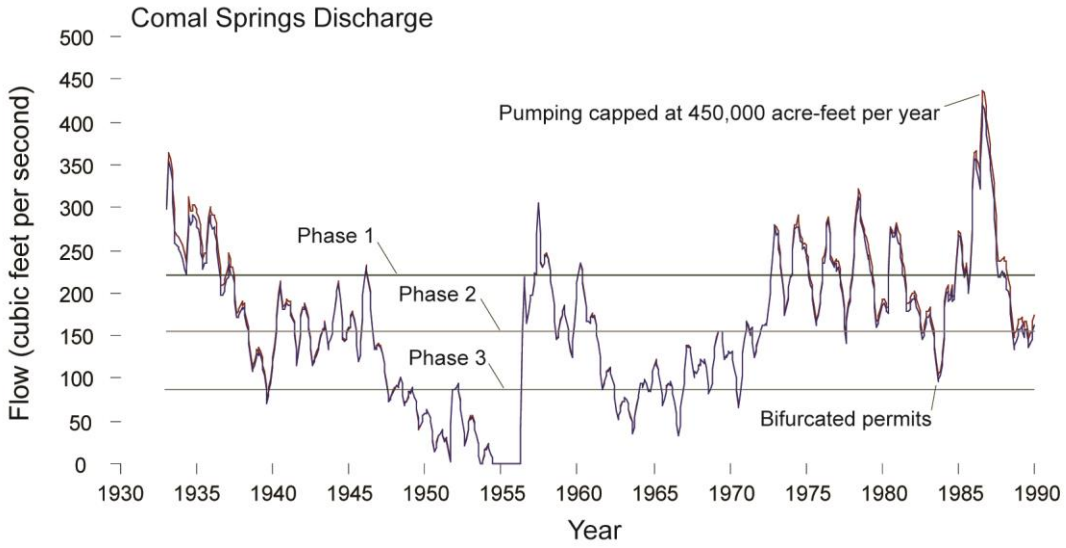

Figure 1. A sample figure showing only the information needed to help the reader understand the data. Font size for figure callouts or labels should never be less than 6 point.

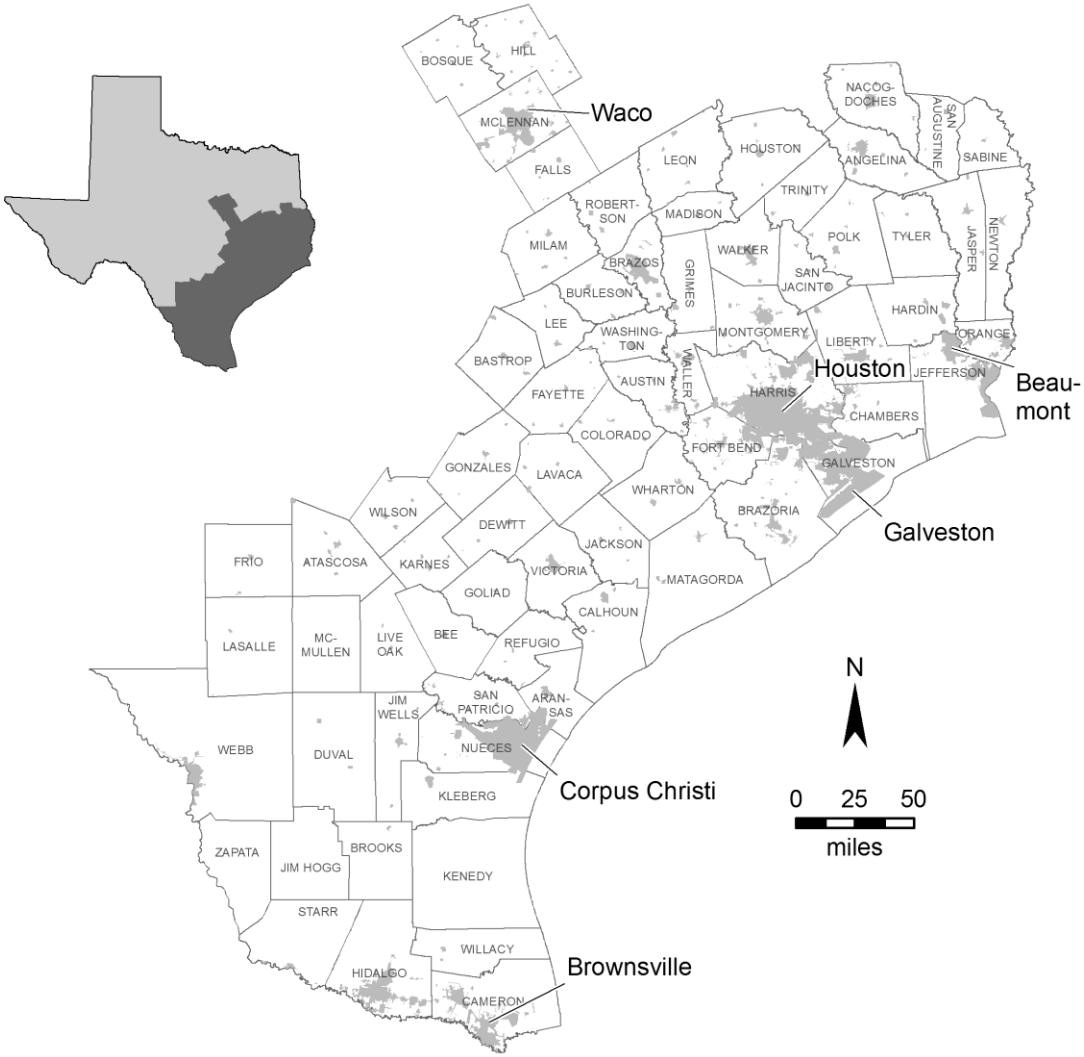

Figure 2. A sample subject area map, giving the reader enough information to understand the location being discussed in this conference. For map figures, be sure to include a north arrow to orient the reader, a scale, and, if needed, a submap that places the figure in greater geographic context. Be sure 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.

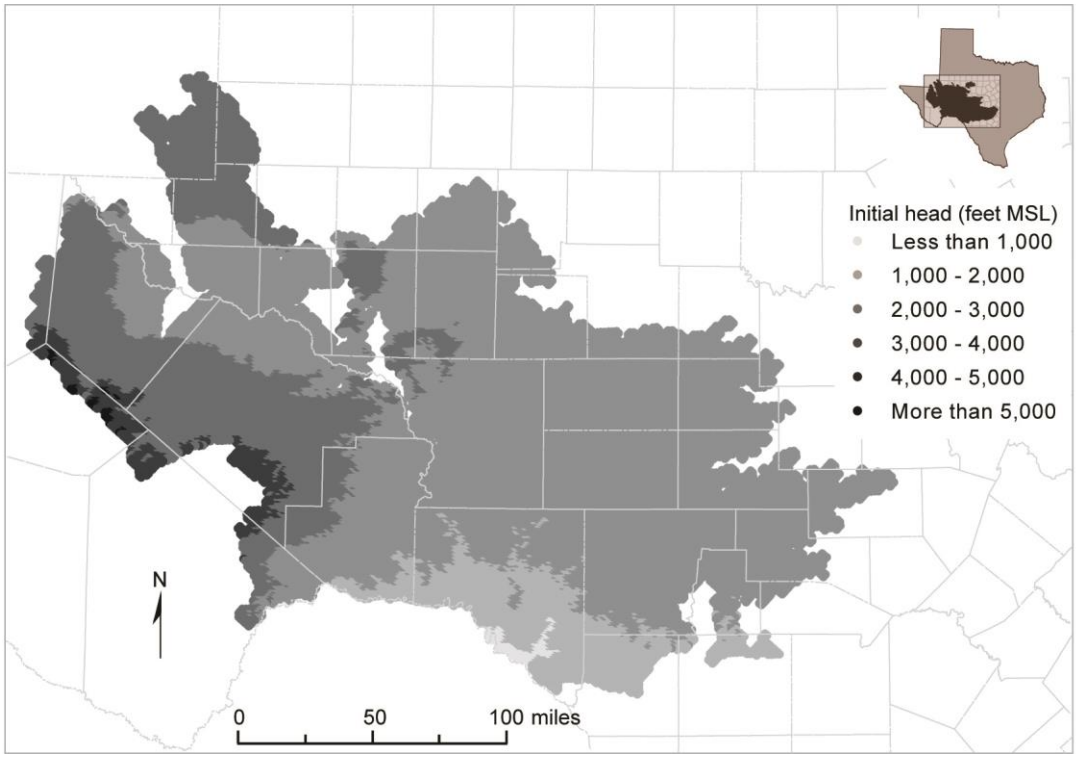

Figure 3. Initial hydraulic heads used in model simulations for layer 1. Note the use of grayscale shading to show differences.

EXHIBIT C

TASK AND EXPENSE BUDGETS

TASK BUDGET

TASK	DESCRIPTION	AMOUNT
1	Project Management	$8,190.00
2	Stakeholder Communication	10,988.00
3	Data Acquisition and Data Management	27,320.00
4	Geologic Interpretation and Hydrostratigraphic Modeling	63,845.00
5	Approach to Hydraulic Data Analysis	154,124.24
6	Conceptual Model Synthesis	56,342.00
7	Reporting	34,190.76
TOTAL		**$355,000.00**

EXPENSE BUDGET

CATEGORY	AMOUNT
Salaries & Wages[1]	$61,793.00
Fringe[2]	30,896.00
Travel[3]	837.00
Other Expenses[4]	42,543.00
Subcontract Services	109,998.00
Overhead[5]	86,998.00
Profit	21,935.00
TOTAL	**$355,000.00**

[1] Salaries and Wages is defined as the cost of salaries of engineers, draftsmen, stenographers, surveymen, 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, 2015, 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.

EXHIBIT D
HUB SUBCONRACTING PLAN PROGRESS ASSESSMENT REPORT

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

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 subcontractors 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.