STATE OF TEXAS

TWDB Contract No. 1648302063

COUNTY OF TRAVIS

Research and Planning Fund
Research Grant
GSI Environmental, Inc.

This Contract, (hereinafter "CONTRACT"), between the Texas Water Development Board (hereinafter "TWDB") and GSI Environmental, Inc. (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 l. 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 – GSI Environmental, Inc.

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

4. PARTICIPANT(S) – GSI Environmental, Inc.

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

6. RESEARCH PROJECT – Update The Existing Groundwater Availability Model For The Northern Portion Of The Queen City, Sparta, and Carrizo-Wilcox Aquifers

7. TWDB APPROVAL DATE – November 2, 2016

8. DEADLINE FOR CONTRACT EXECUTION – March 31, 2017

9. CONTRACT INITIATION DATE – November 2, 2016

10. CONCEPTUAL MODEL DEADLINE – June 28, 2018

11. CALIBRATED MODEL DEADLINE – June 27, 2019

12. FINAL REPORT DEADLINE – October 31, 2019

13. TOTAL STUDY COSTS – $800,000

14. TWDB SHARE OF THE TOTAL STUDY COSTS – the lesser of $800,000 or 100 percent of the total study costs or individual payment submission. Not to exceed $800,000 or 100% percent of the total study cost or individual voucher submission.

15. PAYMENT SUBMISSION SCHEDULE – Monthly

16. OTHER SPECIAL CONDITIONS AND EXCEPTIONS TO STANDARD AGREEMENT OF THIS CONTRACT – with regards to the project, the model update period is extended to the year 2015 or later, upon data availability.

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 letter 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 prior to the FINAL REPORT DEADLINE shall constitute completion of the terms of this CONTRACT.

3. The CONTRACTOR will submit the conceptual model, all data associated with the development of the conceptual model, and a draft copy of the conceptual model sections of the final report (this includes the 'Study Area,' 'Previous Work,'

'Hydrologic Setting,' and 'Conceptual Model of Groundwater Flow in the Aquifer' sections of the report [see Section 4.4 of Exhibit B, Attachment I]) by the CONCEPTUAL MODEL DEADLINE.

4. The CONCEPTUAL MODEL will include:
   A. four printed copies of the conceptual model part of the report;
   B. one Adobe Acrobat (pdf) file of the conceptual 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 geodatabases.

   After a 60-day review period, the EXECUTIVE ADMINISTRATOR will return review comments to the CONTRACTOR

5. The CONTRACTOR will submit the calibrated model, all model files associated with the development of the calibrated model, a draft copy of the calibrated model report [see Section 4.4 of Exhibit B, Attachment I]), and updated conceptual model report and files by the CALIBRATED MODEL DEADLINE:

   A. The CALIBRATED MODEL will include:
      i. 4 printed copies of the draft model report;
      ii. 1 Adobe Acrobat (pdf) file of the draft model report for posting on the TWDB web site (broken in parts not to exceed 10 megabytes) ;
      iii. 1 Adobe Acrobat (pdf) file of the updated conceptual model report with any adjustments due to model calibration and appendix with TWDB review comments with responses for posting on the TWDB web site (broken in parts not to exceed 10 megabytes);
      iv. 1 digital copy of the model files (input files for MODFLOW and Groundwater Vistas); and
      v. 1 electronic copy of all the related documented source and derived data in the appropriate geodatabases (TWDB GAM), grid file, and any Leapfrog related datasets.

   After at least a 60-day review period, the EXECUTIVE ADMINISTRATOR will return review comments to the CONTRACTOR.

5. The CONTRACTOR will consider incorporating comments from the EXECUTIVE ADMINISTRATOR and other commenter's on the conceptual model report and model report. The CONTRACTOR will include a copy of the EXECUTIVE ADMINISTRATOR's comments in the final reports.

   A. At the end of the study, the CONTRACTOR shall deliver to the TWDB:
      i. 9 bound double-sided printed copies of the final reports (conceptual and model),
      ii. 3 separate digital copies (Microsoft Word) of the final reports (conceptual, model, and predictive),

iii. 3 separate copies of an Adobe Acrobat pdf file of the final reports (conceptual, model, and predictive) for posting on the TWDB Web site (broken in part not to exceed 10 megabytes),
iv. 3 separate digital copies of each of the figures in the reports,
v. 3 separate digital copies of all related documented and derived source data (TWDB GAM geodatabase), model output data, and model grid data in the appropriate digital geodatabase format, and model files (MODFLOW and Groundwater Vistas).

The TWDB plans to publish the final reports on the TWDB web site; therefore, 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.

7. The CONTRACTOR will submit letter reports with submittal of payment requests 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.

8. The EXECUTIVE ADMINISTRATOR can extend the FINAL REPORT DEADLINE upon written approval. The CONTRACTOR should notify the EXECUTIVE ADMINISTRATOR in writing within 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 changes 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 Article II, Item 3.
   In addition, the following documentation which documents the TOTAL STUDY COSTS for the reporting period even if the TOTAL STUDY COSTS are zero for reimbursement by the TWDB to the CONTRACTOR for the TWDB's SHARE OF THE TOTAL STUDY COSTS shall be submitted by the CONTRACTOR to the EXECUTIVE ADMINISTRATOR for reimbursement billing:

   A. A completed “Current Reimbursement Worksheet” Payment Request Checklist tab, or an invoice which includes the following information:
      i. TWDB Contract Number;
      ii. Billing period; beginning (date) to ending (date);
      iii. Total Expenses for this period;
      iv. Total In-kind services, if applicable;

v. Less Local Share of the total study costs for the billing period, if applicable;
vi. Total TWDB's share of the total study costs for the billing period;
vii. Total costs to be reimbursed by the TWDB for the billing period; and
viii. 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.
   i. Salaries and Wages, Fringe, Overhead, and Profit.
   ii. Other Expenses: Copies of detailed, itemized invoices/receipts for other expenses (credit card summary receipts or statements are not acceptable).
   iii. 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.
   i. Salaries and Wages, Fringe, Overhead, and Profit.
   ii. Other Expenses: Copies of detailed, itemized invoices/receipts for other expenses (credit card summary receipts or statements are not acceptable).
   iii. 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 contractor.

6. Reimbursement Requests that lack required documentation will be denied or short paid if deficiencies are not resolved within ten (10) business days. Denied Reimbursement Requests or eligible expenses that were short paid must be resubmitted by the CONTRACTOR with the required documentation to be reconsidered for reimbursement.

7. 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 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;

2. 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;

3. 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;

4. 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;

5. 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;

6. 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

7. 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.

8. 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.

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.

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

2. STANDARDS OF PERFORMANCE.

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

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

C. Antitrust. The CONTRACTOR represents and warrants that neither the CONTRACTOR nor any firm, corporation, partnership, or institution represented by the CONTRACTOR, or anyone acting for such firm, corporation, partnership, or institution has (1) violated the antitrust laws of the State of Texas under the Texas Business & Commerce Code, Chapter 15,

of the federal antitrust laws; or (2) communicated directly or indirectly the proposal resulting in this CONTRACT to any competitor or other person engaged in such line of business during the procurement process for this CONTRACT.

D. Conflict of Interest. The CONTRACTOR 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.

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

F. 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.

G. Accurate and Timely Record Keeping. The CONTRACTOR warrants and represents that he will keep timely, accurate and honest books and records relating to the work performed and the payments received under this CONTRACT according to generally accepted accounting standards. Further,

the CONTRACTOR agrees that he will create such books and records at or about the time the transaction reflected in the books and records occurs.

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

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

ARTICLE XI. CORRESPONDENCE

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

For the **TWDB:**

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

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

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

For the **CONTRACTOR:**

Contract Issues:
Ann P. Smith, P.E., BCEE
GSI Environmental Inc.
9600 Great Hills Trail, Suite 350E
Austin, TX 78759
Email: apsmith@gsi-net.com

Payment Request Submission:
Julie Spencer, P.G.
GSI Environmental Inc.
9600 Great Hills Trail, Suite 350E
Austin, TX 78759
Email: jaspencer@gsi-net.com

Physical Address:
GSI Environmental Inc.
9600 Great Hills Trail, Suite 350E
Austin, TX 78759

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

TEXAS WATER DEVELOPMENT BOARD

Jeff Walker
Executive Administrator

Date: 3.28.17

GSI ENVIRONMENTAL, INC.

Ann P. Smith, P.E., BCEE
Vice President

Date: _____

EXHIBIT A

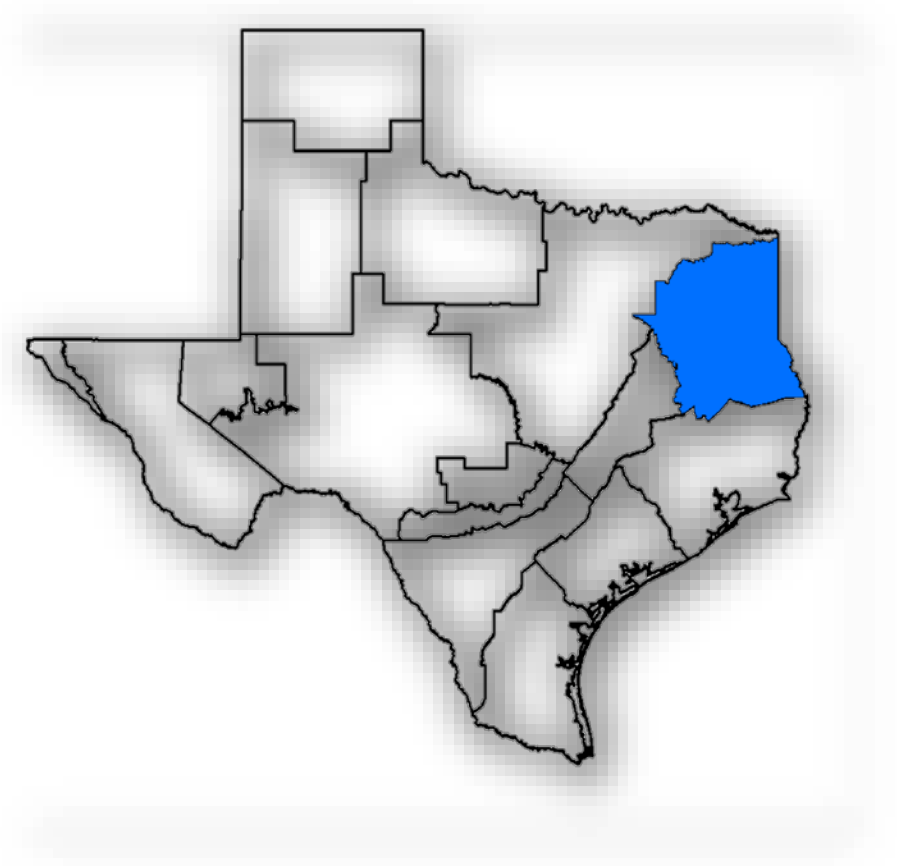
ORIGINAL GRANT APPLICATION

ORIGINAL

Statement of Qualifications

Response to Request for Qualifications No. 580-16-RFQ0027

UPDATE THE EXISTING GROUNDWATER AVAILABILITY MODEL FOR THE NORTHERN PORTION OF THE QUEEN CITY, SPARTA, AND CARRIZO-WILCOX AQUIFERS



Due: 11 August 2016, 2:00 PM (CT/CDT)

Prepared for: **Texas Water Development Board**
Austin, Texas

GSI Environmental Inc.

9600 Great Hills Trail, Suite 350E, Austin, TX 78759 ■ T: 512.346.4474 ■ F: 512.346.4476

10 August 2016

Texas Water Development Board
ATTN: Angela Wallace
700 N. Congress Avenue, 6th Floor Reception Desk
Austin, TX 78701

RE: Response to RFQ #580-16-RFQ0027, Update the Existing Groundwater Availability Model for the Northern Portion of the Queen City, Sparta, and Carrizo-Wilcox Aquifers

Dear Ms. Wallace:

The GSI Environmental (GSI) Team is pleased to submit the attached proposal to the Texas Water Development Board (TWDB) for professional services to update the existing Groundwater Availability Model (GAM) for the northern portion of the Queen City, Sparta and Carrizo-Wilcox aquifers (NPQCSCWA). The GSI Team has been assembled to specifically provide the TWDB with excellence in all aspects of developing an updated GAM for the NPWCSCWA and consists of GSI, Bill Hutchison, Montgomery & Associates, and Environmental Simulations Incorporated (ESI). Team members have decades of experience working together on several projects and recently have all been working seamlessly to evaluate impacts of brackish water pumping in the Lower Rio Grande Valley for the TWDB under Contract No. 1548301854. The GSI Team brings the following unique level of experience to the project:

- GSI is a leader in development of models for groundwater management and surface-water/groundwater interactions, and has been involved in development of the MODFLOW-NWT and MODFLOW-USG codes.
- Bill Hutchison, is an independent consultant, intimately familiar with the hydrogeology and previous GAM models of the area, the rules and requirements of the GAM program, and the goals and objectives of the models.
- Montgomery & Associates are also familiar with the hydrogeology of the area and are a world renown leader in development and visualization of complex geological conceptual models.
- ESI who are the developers of the Groundwater Vistas (GWV) software that will be used for this project.

The following points highlight the unique capabilities we offer to this project:

- The Team is highly qualified to conduct all aspects of model update; understand and overcome conceptual, numerical and computational difficulties; construct a model that is useful to stakeholder needs; and improve on the existing model in order to advance the

- GAM program. We have an in-depth understanding of the hydrogeology and GAMs of the area, and knowledge of TWDB groundwater geodatabase schema for documenting source data.
- We will develop a conceptual model and propose to utilize Leapfrog software to visualize model results;
- We have an unsurpassed understanding of the enhanced schemes and capabilities offered by the MODFLOW-NWT and MODFLOW-USG codes due to our direct involvement in their development. We propose to test all three codes (MODFLOW2005, MODFLOW-NWT and MODFLOW-USG) and involve TWDB and stakeholders in selection of the best code to address any previous model deficiencies, as well as suit the needs of the project and the GAM program.
- We offer a comprehensive approach for developing the model using superior geologic modeling and visualization tools to conceptualize aquifer geometry, surface water features and their interactions with groundwater.
- We are ready to address previous areas of difficulty including model calibration in outcrop and down-dip areas, which will be evaluated such that the entire model is representative of the regional groundwater flow system; accurately represent pinch-out layers in the numerical model; and appropriately represent surface-water interactions with groundwater, considering available data and significance.
- We understand the conceptual approximations of the various enhanced modeling packages as well as the associated numerical considerations/difficulties; therefore, we will develop an optimal model implementing the appropriate packages and using appropriate spatial and temporal scales, suitable for addressing the GAM requirements.
- Stakeholder engagement/communication will include meetings and consultations to receive input on needs and objectives so that the model is useful for regional planning, joint planning and groundwater conservation district management activities.
- We use established and proven internal progress monitoring procedures, quality assurance processes and communication methods (internally and with TWDB staff). In addition, we have an outstanding track record managing multiple contracts within time and on budget.

We welcome the challenges presented by this project and look forward to hearing from you in the near future.

Regards,

Ann P. Smith, P.E., BCEE
Vice President

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-RFQ0027

UPDATE THE EXISTING GROUNDWATER AVAILABILITY MODEL FOR THE NORTHERN PORTION OF THE QUEEN CITY, SPARTA, AND CARRIZO-WILCOX AQUIFERS

RFQ NO:	580-16-RFQ0027	**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

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CONTENT ITEM 1

Execution of Statement of Qualifications to the Request for Qualifications

Company Name:	GSI Environmental Inc.
Address:	9600 Great Hills Trail, Suite 350E
	Austin, TX 78759
Phone Number:	512.346.4474
E-Mail:	apsmith@gsi-net.com

I, Ann P. Smith, PE, BCEE, 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
Ann P. Smith, Vice President

Date

CONTENT ITEM 2

Company Profile Summary and History

COMPANY NAME AND ADDRESS

GSI Environmental Inc.
9600 Great Hills Trail, Suite 350E
Austin, TX 78759
512.346.4474
Corporation

BINDING AUTHORITY

Ann P. Smith, P.E., BCEE, Vice President

CONTACT PERSON

Julie Spencer, P.G.; jaspencer@gsi-net.com

NATURE OF PREVIOUS WORK

GSI Environmental Inc. is an environmental engineering consulting firm with over 29 years of experience specializing in environmental strategic planning, data management and analysis, software development and the assessment and modeling of groundwater flow for the oil and gas industry, chemical industry, manufacturing industry, government agencies, research and development organizations, utilities, trade organizations and law firms. From our offices in Texas and California, our more than 80 employees have worked worldwide, providing industry with innovative solutions to soil, groundwater, surface water and air pollution problems and associated regulatory issues. We emphasize careful data collection and analysis, and technical ingenuity in all our work to provide solutions that are both efficient and effective.

Since 1986, GSI has completed over 4,000 projects and is recognized as an industry leader in the research and development of innovative technologies and software products including a comprehensive Sustainable Groundwater Management (SGMA) model to forecast and plan groundwater conditions considering groundwater/surface-water interactions, complex basin boundaries and geology, managed aquifer recharge, drought, and changes in land use including urbanization and changes in agricultural practices; and the Water Balance and Shale Gas Sustainability Toolkits developed for the oil and gas industry. Whether the project calls for application of a complex groundwater/surface-water model or a water supply reliability assessment with changing climatic conditions, our professional hydrogeologists and engineers provide a wide array of expertise in water resources modeling and have the skills to meet the challenge. Our nationally recognized experts have been engaged as consulting and testifying experts in water resources related cases in both State and Federal court, including the U.S. Supreme Court.

GSI has expertise in a variety of unique model applications including high-resolution groundwater flow, saltwater intrusion, integrated groundwater/surface-water interactions, non-isothermal,

compositional, multiphase flow and transport, subsurface vapor flow, vadose zone flow and transport, and air transport. GSI's innovations are communicated through our expertise in web and conventional training programs, technical report and guidance writing and presentations at symposia and conferences.

GSI has established a reputation of delivering innovative solutions to vexing technical problems. Our proposed Principal Investigator/Project Manager, Dr. Sorab Panday, co-authored the most recent version of MODFLOW with the U.S. Geological Survey (USGS) (MODFLOW-USG). This new code can solve difficult modeling challenges with unmatched speed and accuracy, increasing overall efficiency.

FINANCIAL CAPABILITY

GSI's revenue has grown steadily since our incorporation in 1986, and in 2015 it was in excess of $19M. GSI has established processes, procedures and accounting capabilities that allow us to quickly respond to multiple and concurrent contracts while delivering quality, accurate and timely deliverables.

GSI has successfully managed contracts of similar size and scope as the proposed project for over 29 years. We have concurrently managed numerous similarly and larger sized projects for both federal and commercial customers, with many of these having client-specific financial and invoicing requirements.

Currently, GSI is successfully managing TWDB Contract No. 1548301854, with an award of nearly $750,000. Our ongoing management of TWDB Contract No. 1548301854, along with its requirement to pay our subcontractors prior to reimbursement by the TWDB, demonstrates our financial capability to successfully manage concurrent TWDB contracts.

CONTENT ITEM 3

Resumes of Individuals

Sorab Panday, PhD

Principal Investigator/ Project Manager

GSI ENVIRONMENTAL

HIGHER EDUCATION

PhD, Civil & Environmental Engineering, Washington State University, Pullman, Washington, 1989
MS, Civil Engineering, University of Delaware, Newark, Delaware, 1986
B. Tech., Civil Engineering, Indian Institute of Technology, Bombay, India, 1984

CERTIFICATIONS/AFFILIATIONS

American Geophysical Union
National Ground Water Association
International Association of Hydrogeologists
Groundwater Resources Association of California

BIOGRAPHICAL SUMMARY

Dr. Panday is a Principal Engineer at GSI Environmental with over 26 years of experience in directing, managing, developing, reviewing and troubleshooting flow and transport models for groundwater evaluations and water resource management. He has worked on modeling projects spanning a wide range of schedules and budgets, multiple spatial and temporal scales, complex geological settings, diverse climatic conditions, unique water/salt/contaminant management issues and challenging numerical conditions. Sorab has helped to develop several of the industry's state-of-the-art water resource modeling codes and is the lead author on MODFLOW-USG, and a contributing author on MODFLOW-NWT released by the USGS. He has published articles in reputed journals, provides review and support to industry publications and associations, and conducts short courses and workshops on water resource and contaminant transport modeling.

CODE DEVELOPMENT

Lead Developer of the MODFLOW-USG Groundwater Flow Model, U.S. Geological Survey, Reston, VA. Co-investigator for development of the MODFLOW-USG code which is an enhancement of MODFLOW to use unstructured grids.

Co-Developer of the MODFLOW-NWT Groundwater Flow Model, U.S. Geological Survey, Reston, VA. Co-investigator for development of the MODFLOW-NWT code which is an enhancement of MODFLOW 2005 in terms of handling drying and wetting of model cells. The code uses upstream weighting and Newton Raphson linearization with advanced solver routines to enhance the robustness and efficiency of solution to unconfined problems with large water level fluctuations or steep gradients.

Principal Developer of MODFLOW-SURFACT and MODHMS Codes till 2007. HydroGeoLogic Inc., Reston, VA Principal Developer of the MODFLOW-SURFACT and MODHMS codes from inception through 2007. The USGS MODFLOW code was greatly enhanced to include hydrologic cycle and vapor phase simulations of flow and transport among several other advanced modeling capabilities.

PROJECT EXPERIENCE

Groundwater/Surface-Water Interaction Model, Los Angeles County Sanitation Districts, CA. Project manager and principal investigator for developing and applying a flow and transport Groundwater/ Surface-Water Interaction Model (GSWIM) of the Upper Santa Clara River watershed to address chloride TMDL issues. All available data in the domain was evaluated to develop a thorough and detailed basin conceptual model including surface-water and groundwater flows and salt loadings from point and non-point sources over a period of 31 years. An associated numerical model was developed representing the conceptual system understanding for surface and subsurface flow. The model was calibrated to the assimilated data for groundwater levels, stream flows, groundwater chloride levels and stream chloride measurements for daily-averaged rainfall stresses over the analysis period. The model was applied to examine the effects of various scenarios on chloride levels within the basin. The model is currently being used to evaluate impacts of alternative discharge plans on surface and groundwater quality.

Groundwater Modeling Impact Analysis at Red Gap Ranch, City of Flagstaff, AZ. Principal Modeler for construction and calibration of a groundwater model simulating groundwater pumping and management scenarios from future wells in the C-Aquifer at RGR. The 100-year drawdown and associated uncertainty were evaluated to demonstrate groundwater availability for the 100-year projected demands as per ADWR's Adequate Supply Program and proposed Hydrologic Guidelines and Proposed Rulemaking Changes. The modeled scenarios consider a mixed use of surface water, groundwater and reuse to meet its projected requirements.

Regional Groundwater Modeling for Water Supply Planning, Northwest Florida Water Management District, Havana, FL. Project manager and principal investigator for development and application of a District-wide MODFLOW model and two density-dependent saltwater intrusion sub-models. The Districtwide model of Escambia, Santa Rosa, Okaloosa and Walton Counties, was developed to evaluate surface-water and drawdown impacts of pumping and the sub-models were developed to address concerns of up-coning of deeper saline waters and of saltwater intrusion from the Gulf of Mexico.

Water Resources Assessment Program HCWRAP2, Southwest Florida Water Management District, Brooksville, FL. Directed the development of MODFLOW-based regional groundwater flow and saltwater intrusion models used in conjunction with management optimization techniques to determine optimal locations of wells/recharge basins to minimize impacts on surface water and on the movement of the saltwater/freshwater interface. Several models were developed and calibrated which were then used with the well optimization simulations to investigate various objectives of the District.

JOURNAL PUBLICATIONS

"Incorporating the effect of gas in modelling the impact of CBM extraction on regional groundwater systems", D. Herckenrath, J. Doherty, and S. Panday, Journal of Hydrology 523, 587–60, 2015.

"A method for estimating spatially variable seepage and hydraulic conductivity in channels with very mild slopes", M. Shanafield, R.G. Niswonger, D. E. Prudic, G. Pohll, R. Susfalk and S. Panday, Hydrological Processes, DOI: 10.1002/hyp.9545, 2014.

"Future of Groundwater Modeling", C. D. Langevin, and S. Panday, Invited article for Column Theme: 50th Year Tribute to Modeling: Past, Current, and Future, Groundwater, Vol. 50, No. 3, p. 333-339, doi: 10.1111/j.1745-6584.2012.00937.x, May-June 2012.

"Impact of Sea Level Rise on Groundwater Salinity in a Coastal Community of South Florida", Guha, H., and S. Panday, Journal of the American Water Resources Association 1-19. DOI: 0.1111/j.1752-1688.2011.00630.x, 2012.

"Simulating Dynamic Water Supply Systems in a Fully Integrated Surface–Subsurface Flow and Transport Model." S. Panday, N. Brown, T. Foreman, V. Bedekar, J. Kaur, and P. S. Huyakorn. Vadose Zone Journal. 8: 858-872. Nov. 1 2009.

William Hutchison, PhD, PE, PG

Principal Hydrogeologist

INDEPENDENT GROUNDWATER CONSULTANT

HIGHER EDUCATION

PhD, Environmental Science and Engineering, University of Texas at El Paso
MS, Hydrology, University of Arizona
BS, Soil and Water Science, University of California, Davis

CERTIFICATIONS/AFFILIATIONS

Professional Engineer: Texas
Professional Geoscientist: Texas
Professional Geologist: Mississippi

BIOGRAPHICAL SUMMARY

Dr. Hutchison has over 35 years of experience in groundwater resources development and planning, utility planning and operations, numerical flow and solute transport modeling, and litigation support. He has extensive experience in the development and application of Groundwater Availability Models throughout Texas. He was primarily responsible for hydrogeologic and modeling investigations related to the design, construction and initial operation of the brackish groundwater desalination plant in El Paso, Texas.

REPRESENTATIVE EXPERIENCE

Technical Consultant for Groundwater Management Area 11 (GMA 11). Completed Groundwater Availability Model (GAM) runs for the groundwater conservation districts of Groundwater Management Area 11 (Northern Carrizo-Wilcox Area) as part of GMA 11's development of proposed desired future conditions in early 2016. The simulations started at the end of the calibration period (1999) and continued through the planning period to 2070. Because 1999 was a dry year and the simulation assumed average recharge conditions, the model predicted rising water levels in many outcrop areas between 2000 to 2070. To address this issue, I attempted to extend the calibration period of the model to 2013, but the attempt was unsuccessful. The model would not calibrate as well as the 1975 to 1999 period of the original model. A deeper look into the model indicated that the rising water levels may also be due to overestimates of recharge and an inability of the model to move large volumes of water from outcrop to subcrop areas. (2015 to present)

Technical Consultant for Groundwater Management Area 13 (GMA 13). Completed Groundwater Availability Model (GAM) runs for the groundwater conservation districts of Groundwater Management Area 13 (Southern Carrizo-Wilcox Area) as part of GMA 13's development of proposed desired future conditions in early 2016. A total of 51 simulations were completed during this process. A key finding of the effort was identifying the limitation of the current GAM in the outcrop area. The groundwater conservation districts wanted to focus their attention on the outcrop area to evaluate impacts of increased pumping on shallow wells and surface water-groundwater interactions. One of the technical recommendations made was to improve the GAM process by demonstrating good calibration statistics in outcrop areas to improve the usefulness of the GAM to address specific joint planning requirements, such as private property rights (shallow well owners) and surface water-groundwater interactions. (2012 to present)

Groundwater Availability Model Development using MODFLOW-USG. As a consultant to the Hickory Underground Water Conservation District No. 1, Dr. Hutchison is working with staff of the Texas Water Development Board in the development of the Groundwater Availability Model for the Llano Uplift Aquifers. This model is being developed with MODFLOW-USG. (2013 to present)

Hydrogeologic Study of Val Verde County, Texas. Completed a hydrogeologic study of the Edwards-Trinity (Plateau) Aquifer in Val Verde County for the County of Val Verde and City of Del Rio. The study included developing, calibrating, and applying a groundwater flow model of the area to assess impacts of proposed pumping on local spring flow and Rio Grande flows. (2013 to 2014)

Groundwater Availability Model Updates in Texas. Completed updates to groundwater availability models in support of the Joint Groundwater Planning Process in Texas. Updated models included: Dockum Aquifer, Edwards-Trinity (Plateau) Aquifer and Pecos Valley Aquifer, Barton Springs Segment of the Edwards (Balcones Fault Zone) Aquifer, Kinney County portions of the Edwards (Balcones Fault Zone) Aquifer and Edwards-Trinity (Plateau) Aquifer, and Southern Gulf Coast Aquifer (GMA 16 portion). These models were updated because the existing models proved to be inadequate for assisting the groundwater conservation districts in developing desired future conditions. (2009 to 2010)

Groundwater Model of the Dell City, Texas Area. Developed a regional groundwater flow model covering a large area in Hudspeth and Culberson Counties, Texas and Otero County, New Mexico. This objective of this groundwater model was to develop a more complete understanding of the hydrogeology of the karstic aquifer in the region, and develop data and information related to acquiring property and water rights for a potential groundwater importation project for the City of El Paso. The model was submitted to the Texas Water Development Board for consideration as the Groundwater Availability Model for the Bone Spring-Victorio Peak Aquifer. (2001 to 2008)

Hueco Bolson Evaluation, Texas. Completed analyses of groundwater flow and groundwater quality of the Hueco Bolson covering west Texas, southern New Mexico and northern Chihuahua. These analyses included evaluating historic groundwater flow patterns, mapping current groundwater quality in three dimensions, evaluating historic groundwater quality changes caused by pumping, and changes in the groundwater budget including induced inflow from the Rio Grande. Prepared comprehensive report of findings that was peer reviewed by a 5-member panel. Results included the finding that the reduction in groundwater pumping from 1989 to 2002 had fundamentally changed conditions in the Hueco Bolson. Moreover, the assumptions that were the foundation of a conclusion made in a 1979 analysis (depletion of fresh groundwater by 2030) were no longer applicable. (2001-2004)

Brackish Groundwater Well Location, El Paso, Texas. Completed analyses of the Hueco Bolson related to locations of new wells for use in the Kay Bailey Hutchison Desalination Plant, a joint project between El Paso Water Utilities and Fort Bliss. After initial concerns were raised by Fort Bliss, an investigation was completed in cooperation with the US Army Corps of Engineers to evaluate five alternative well field locations that would produce brackish groundwater to be treated in the planned reverse osmosis plant. Based on this analysis, an alternative was selected and agreed upon. (2003)

Staffan Schorr

Principal Geologist

MONTGOMERY & ASSOCIATES

HIGHER EDUCATION

BS, Geology, University of Arizona, 1997
MS, Hydrology, University of Arizona, 2005

ADDITIONAL TRAINING

2013: MODFLOW-USG workshop
2012: Fundamental and Advanced Techniques of Leapfrog Hydro
2010: Advanced Techniques for Aquifer Test Analysis Featuring AQTESOLV; Fundamentals of Leapfrog Hydro
2009: HEC-RAS 3-Day Short Course
2008: Advanced Techniques for Aquifer Test Analysis Featuring AQTESOLV
2008: Calibration, Uncertainty Analysis, and Optimization — A Seminar on Groundwater Vistas

BIOGRAPHICAL SUMMARY

Mr. Schorr manages M&A's GIS staff and specializes in watershed planning, GIS application development, and GIS and database support for hydrogeologic investigations and modeling projects. He is proficient with a variety of modeling tools, including MODFLOW, FEFLOW, PEST, MODFLOW-SURFACT, MT3D, HEC-RAS, WINFLOW, Leapfrog Hydro, Leapfrog Geo, and Groundwater Vistas. He also uses various GIS tools —ArcView, ArcGIS, Spatial Analyst, and 3D Analyst.

PROJECT EXPERIENCE

Geospatial Model Development, U.S., Mexico, Peru, Argentina, Chile, Various Clients. Developed or supervised the development of more than 18 three-dimensional geospatial/geologic models for hard rock and basin-fill alluvium groundwater systems using ArcGIS and Leapfrog software.

GIS Development & Application, U.S., Mexico, Chile, Peru, Argentina, Bolivia, Various Clients. Developed GIS inventories of wells, infrastructure, water use, land use, and other related features; developed geodatabases for project data management and sharing; prepared cartographically correct maps and figures; and used ArcGIS applications to construct and evaluate three-dimensional geologic models for many hydrogeologic investigations and modeling projects.

Hydrogeologic Characterization and Data Management, Lower Rio Grande Valley, Texas. Developed conceptual model for the Lower Rio Grande Valley Groundwater Transport Model being prepared for the Texas Water Development Board (TWDB); compiled publicly available data including TWDB's Groundwater database and Brackish Resources Aquifer Characterization System (BRACS) database; conducted hydrogeologic assessments; developed spatial and relational databases in support of conceptual and numerical model development; supervised the development of three-dimensional geologic model for visualization of aquifer system and for input to groundwater model; and prepared input datasets for the numerical model.

Hydrogeologic Characterization and Data Management, Third-Party Model Review, Confidential Client, New Mexico, Texas, Northern Mexico. Developed conceptual model for the lower Rio Grande basin; conducted hydrogeologic assessments and water budget analyses; developed spatial and non-spatial databases; developed regional three-dimensional geologic model for visualization and

input to groundwater flow model; verified and evaluated methods used to develop previous groundwater flow models; and prepared secure online database in support of litigation activities.

Groundwater Flow Model and Data Management, Hueco Bolson, El Paso Water Utility, El Paso County, Texas. Developed conceptual model for Hueco Bolson; updated hydrogeologic sections with new borehole data and geophysical well logs; compiled and evaluated data from the TWDB groundwater database; constructed wells database; developed three-dimensional geologic model for visualization and input to groundwater flow model; and constructed and calibrated a groundwater flow model to support wellfield and water resource management.

Pit Modeling, Collahuasi Mine, Compañía Minera Doña Inés de Collahuasi SMC, Northern Chile. Developed conceptual model for Rosario operations; constructed wells database; developed GIS methods for assigning geologic zones to numerical model grid; designed and constructed groundwater flow model to support dewatering operations and predict the environmental impacts associated with a large, open-pit mine in a complex mountain aquifer system.

James Rumbaugh, PG

Principal Modeler

HIGHER EDUCATION

MS, Geology, Pennsylvania State University, 1983
Graduate Work, Research Fellow at the Desert Research Institute, University of Nevada-Reno
BA, Graduated Summa Cum Laude with Honors in Geology, Susquehanna University, 1980

CERTIFICATIONS/AFFILIATIONS

Professional Geologist: Florida, # 492
Professional Geologist: Pennsylvania, #76

BIOGRAPHICAL SUMMARY

Mr. Rumbaugh is a national leader in the field of groundwater modeling and has performed modeling studies in the USA, Caribbean, Australia, Europe, and Japan. Jim was co-founder of Geraghty & Miller's Modeling Group and was Technical Director for Modeling Services. He founded Environmental Simulations, Inc. (ESI) in late 1994. He is President of ESI and provides a variety of groundwater modeling services to clients worldwide.

Mr. Rumbaugh is a member of the American Society for Testing and Materials (ASTM) where he is a past Chairman of ASTM Subcommittee D18.21 on Groundwater and Vadose Zone Investigations. Subcommittee D18.21 was funded by U.S. EPA to develop standards for groundwater modeling practice. As part of his work at ASTM, Mr. Rumbaugh authored the first modeling standard (D5447). ASTM presented Mr. Rumbaugh with several standards development awards and three special achievement awards for his work in developing groundwater modeling standards.

Mr. Rumbaugh has written some of the most popular groundwater modeling software in use today and co-authored the software Groundwater Vistas. He has taught numerous groundwater modeling seminars to private industry and to government clients. He teaches all ESI seminars in the U.S. and is a guest lecturer at ESI seminars in Europe as well.

Mr. Rumbaugh is a long-time member of the National Groundwater Association (NGWA) and is a current member of the editorial review board for Ground Water Journal. He was honored by NGWA with the 1999 John Hem Excellence in Science and Engineering Award and the 2014 Technology Award. The Hem Award is given to those who have made a significant, recent scientific or engineering contribution to the understanding of groundwater. The Technology Award is presented to an individual who has made a significant contribution to the groundwater industry in the development of ideas, tools and equipment, along with exemplary service to co-workers throughout the industry in sharing these developments.

PROJECT EXPERIENCE

Principal Modeler for the Lower Rio Grande Valley Groundwater Transport Model, Texas Water Development Board. This project is ongoing with the conceptual model recently provided to TWDB. Mr. Rumbaugh and Dr. Panday are now working on development of the density-dependent flow and transport model for this project.

Principal Modeler for the District Wide Groundwater Model (DWRM), Southwest Florida Water Management District, Tampa, Florida. DWRM is a combination of a regional groundwater flow model and a software system to assist District staff in evaluating consumptive use permits. The model has been evolving since 2002. Current work is focusing on version 4, which is being developed in MODFLOW-USG with connected linear networks (CLN) for rivers and springs. The software system included development of a Focus Telescopic Mesh Refinement process in Groundwater Vistas to quickly create submodels designed to evaluate individual well permits within the context of the regional groundwater model. Mr. Rumbaugh also provides periodic training sessions to District staff on the use of the regional model and associated software.

Principal Modeler for a regional groundwater flow model of the Powder River Basin in eastern Wyoming and southern Montana. This project is in the fourth phase of modeling for the US Bureau of Land Management to assess the impacts of coal mining and coal bed natural gas development in the basin. The model covers all coal mines and all coal bed natural gas wells in the state. The current phase of modeling is focused on coal mining due to the recent decline in the production of natural gas. Future predictive simulations have been modified to take into account this recent trend.

Consultant for model calibration of the Paducah Gaseous Diffusion Plant in Kentucky. The modeling effort is being conducted for the US Department of Energy to assess future migration of contaminants from this closed facility. The previous modeling was highly criticized by US EPA, primarily in the degree of calibration quality. Mr. Rumbaugh is assisting the project team to create an improved calibration through the use of new types of observation data including flow direction observations for better plume movement and censored targets in areas of limited data and poor data quality.

SOFTWARE DEVELOPMENT

Groundwater Vistas. A complete groundwater modeling environment for Microsoft Windows. Currently under development, Groundwater Vistas supports pre- and post-processing of MODFLOW, MODPATH, MT3D, PEST, MODFLOW-SURFACT, and MODFLOWT models. Groundwater Vistas was chosen as the standard groundwater modeling interface by England's Environment Agency.

MODFLOW-SURFACT Visual Modeling System. ESI has collaborated with HydroGeoLogic, Inc. to develop a visual modeling system and enhancements to the MODFLOW model. The visual portion of the system, Groundwater Vistas, is developed by ESI. MODFLOW-SURFACT, developed by HydroGeoLogic includes unsaturated flow modeling, transport modeling, and numerous other features that extend the functionality of MODFLOW.

PROFESSIONAL SEMINARS

Introduction to Groundwater Modeling. This is a general course offered periodically to the public as an overview of groundwater modeling using ESI's Groundwater Vistas software. The course is usually taught at least twice per year and has also been taught to organizations including the Texas Water Development Board, South Florida Water Management District, Southwest Florida Water Management District, St. Johns River Water Management District, and other private companies.

Model Calibration with PEST and Groundwater Vistas. PEST is the most advanced calibration tool for groundwater models and Groundwater Vistas supports more features and options in PEST than any other MODFLOW interface. The seminar the basics of PEST and Groundwater Vistas in calibrating models. These introductory topics will then lead into the more advanced features, including pilot points, Singular-Value Decomposition, and Null Space Monte Carlo techniques.

MODFLOW-USG Webinar. Mr. Rumbaugh teaches this 2 week webinar series on the use of MODFLOW-USG with the code's author, Sorab Panday. The webinar presents the features of both the USGS version and the advanced features of the beta version. Practical applications are discussed along with the implementation in Groundwater Vistas.

Julie Spencer, PG

Project Administrator

GSI ENVIRONMENTAL

HIGHER EDUCATION

BS, Geological Sciences, University of Texas at Austin, 1995

CERTIFICATIONS/AFFILIATIONS

Professional Geoscientist: Texas, #166, 2003
Professional Geoscientist: Louisiana, #160, 2014

BIOGRAPHICAL SUMMARY

Ms. Spencer is a Managing Geologist with GSI. She has more than 20 years of experience in the environmental industry. Her experience includes extensive project management and supervision of site investigation project teams, management and execution of RCRA Facility Investigations and environmental site assessments, and preparation of numerous cost estimates/ proposals, Affected Property Assessment Reports, work plans, sampling plans, and various LPST reporting. Ms. Spencer has experience negotiating with the USEPA, Region 6, the USACE Forth Worth and Tulsa Districts, TCEQ, ADEQ, RRC of Texas, and TWDB, which has led to regulatory closure of several sites in Texas and Arkansas. Her field experience includes execution of soil and groundwater investigations, characterization of site conditions and contaminants, performance of due diligence, supervision of UST and hydraulic lift removals, monitor well installation, soil core logging, and extensive soil and groundwater sampling.

PROJECT EXPERIENCE

Water Research for Groundwater Availability Modeling Program, Lower Rio Grande Valley Groundwater Transport Model. Serving as the administrative project manager for a project to develop, calibrate, and use a groundwater flow and transport model of the Lower Rio Grande Valley to evaluate the potential impacts of pumping brackish groundwater. Responsible for overall project oversight, which includes coordination between the TWDB and our project team whom are located across the country, communication with the project Stakeholders, coordination of Stakeholder Advisory Forum meetings, and preparation of project subcontracts, monthly progress reports and detailed invoices on the $740,000 award.

Shale Gas Development, Research Partnership to Secure Energy for America (RPSEA), Sugarland, Texas. Serving as the administrative project manager for a project to assess advanced analytical methods for air and stray gas emissions and produced brine characterization. Responsible for procuring and managing the ~1.9 M project with multiple teaming partners and subcontractors located across the country. Tasks include tracking the project budget (including cost share), reviewing and preparing detail invoices, and preparing monthly status reports.

Environmental Remedial Process Optimization (ERP-O) Support, Air Force Center for Engineering and the Environment (AFCEE), San Antonio, Texas. Served as the administrative project manager for optimization of remedial processes at Air Force Bases nationwide. Responsible for managing the

~4.9 M project with multiple tasks while leveraging multiple personnel with a variety of technical capabilities located in offices across the country. These tasks included tracking the project budget and schedule, reviewing invoices, conducting team meetings and coordinating, leading and often performing ERP-O site visits to ensure that each facility was operating optimally and working toward its ultimate remedial goals.

Environmental Process Optimization Support, U.S. Environmental Protection Agency. Provided administrative support to the EPA Office of Superfund Remediation Technology Innovation (OSRTI) for optimization of remedial processes at several Superfund sites within the U.S. and its Territories. Tasks included participation and documentation of team meetings between OSTRI, Superfund Project Managers and regulators; providing management support to OSTRI Team Leads; and providing technical expertise related to AFCEE ERP-O.

Little Rock Air Force Base (LRAFB), Little Rock, Arkansas. Served as the project manager for a ~1.19 M Performance Based Contract (PBC). Responsible for tracking project budget, reviewing invoices, subcontracting, and coordinating, leading and performing long-term monitoring (LTM) activities at a capped landfill. Prepared an overall Project Management Plan, and two detailed workplans for one LTM and seven Interim Measures (IM) sites. Each workplan included an addendum to the LRAFB Data Collection Quality Assurance Plan, Health and Safety Plan, and Waste Management Plan. LTM activities include semi-annual groundwater monitoring, monthly site inspections, periodic site maintenance, and direct communications with teaming partners, LRAFB personnel and the USACE Tulsa District. Successful management of the project resulted in closure of all seven IM Sites by the ADEQ and qualified for all contracted incentive payments, as well as numerous commendations from LRAFB, USACE Tulsa District and the ADEQ. The project was also awarded a National Safety Council award for operating 6,000 employee hours without occupational injury or illness involving days away from work.

Phase II ESA, El Paso Water Utilities, El Paso, Texas. Managed a Phase II ESA to assess environmental conditions prior to utility upgrades in El Paso County, Texas. The Phase II ESA was conducted along an approximately 3,250 foot corridor containing known solvent and petroleum hydrocarbon contamination in soil and groundwater. As a result of the Phase II ESA, current soil and groundwater conditions along the proposed utility alignment were identified and the information was utilized to modify the location of proposed manholes, develop proper Health and Safety requirements, and determine characteristics of wastes to be generated during construction activities. Work authorized under the project totaled $146,305 with completion of all activities in July 2008.

LRAFB Five-Year Review for Multiple Sites, Little Rock, Arkansas. Served as the project manager for preparation of the first five-year review reports for 15 individual sites at LRAFB. Each report was prepared in accordance with CERCLA, LRAFB Remedial Action Decision Document (RADD), EPA, U.S. Air Force, and Arkansas Department of Environmental Quality requirements. Oversaw preparation of a Project Management Plan and Field Health and Safety Plan, managed project accounting and prepared Five-Year Review Reports for several sites for inclusion in the overall document. U.S. Army Corps of Engineers, Tulsa District awarded the contract for a total of $237,256.12, with GSI's portion totaling $158,494.03. Three subsequent consultation hour awards brought GSI's total contract value to $174,032.26.

CONTENT ITEM 4

Historically Underutilized Businesses Subcontracting Plan

Rev. 09/15

HUB Subcontracting Plan (HSP)

QUICK CHECKLIST

While this HSP Quick Checklist is being provided to merely assist you in readily identifying the sections of the HSP form that you will need to complete, it is very important that you adhere to the instructions in the HSP form and instructions provided by the contracting agency.

➤ **If you will be awarding all of the subcontracting work you have to offer under the contract to only Texas certified HUB vendors, complete:**

- ☐ Section 1 - Respondent and Requisition Information
- ☐ Section 2 a. - Yes, I will be subcontracting portions of the contract.
- ☐ Section 2 b. - List all the portions of work you will subcontract, and indicate the percentage of the contract you expect to award to Texas certified HUB vendors.
- ☐ Section 2 c. - Yes
- ☐ Section 4 - Affirmation
- ☐ GFE Method A (Attachment A) - Complete an Attachment A for each of the subcontracting opportunities you listed in Section 2 b.

➤ **If you will be subcontracting any portion of the contract to Texas certified HUB vendors and Non-HUB vendors, and the aggregate percentage of all the subcontracting work you will be awarding to the Texas certified HUB vendors with which you do not have a *continuous contract** in place for more than five (5) years *meets or exceeds* the HUB Goal the contracting agency identified in the "Agency Special Instructions/Additional Requirements", complete:**

- ☐ Section 1 - Respondent and Requisition Information
- ☐ Section 2 a. - Yes, I will be subcontracting portions of the contract.
- ☐ Section 2 b. - List all the portions of work you will subcontract, and indicate the percentage of the contract you expect to award to Texas certified HUB vendors and Non-HUB vendors.
- ☐ Section 2 c. - No
- ☐ Section 2 d. - Yes
- ☐ Section 4 - Affirmation
- ☐ GFE Method A (Attachment A) - Complete an Attachment A for each of the subcontracting opportunities you listed in Section 2 b.

➤ **If you will be subcontracting any portion of the contract to Texas certified HUB vendors and Non-HUB vendors or only to Non-HUB vendors, and the aggregate percentage of all the subcontracting work you will be awarding to the Texas certified HUB vendors with which you do not have a *continuous contract** in place for more than five (5) years *does not meet or exceed* the HUB Goal the contracting agency identified in the "Agency Special Instructions/Additional Requirements", complete:**

- ☒ Section 1 - Respondent and Requisition Information
- ☒ Section 2 a. - Yes, I will be subcontracting portions of the contract.
- ☒ Section 2 b. - List all the portions of work you will subcontract, and indicate the percentage of the contract you expect to award to Texas certified HUB vendors and Non-HUB vendors.
- ☒ Section 2 c. - No
- ☒ Section 2 d. - No
- ☒ Section 4 - Affirmation
- ☒ GFE Method B (Attachment B) - Complete an Attachment B for each of the subcontracting opportunities you listed in Section 2 b.

➤ **If you will not be subcontracting any portion of the contract and will be fulfilling the entire contract with your own resources (i.e., employees, supplies, materials and/or equipment, including transportation and delivery), complete:**

- ☐ Section 1 - Respondent and Requisition Information
- ☐ Section 2 a. - No, I will not be subcontracting any portion of the contract, and I will be fulfilling the entire contract with my own resources.
- ☐ Section 3 - Self Performing Justification
- ☐ Section 4 - Affirmation

***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.*

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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.*

No additional instructions were provided

SECTION-1 RESPONDENT AND REQUISITION INFORMATION

a. Respondent (Company) Name: GSI Environmental Inc. State of Texas VID #: 17601957065

Point of Contact: Ann P. Smith, P.E., BCEE Phone #: 512-346-4474

E-mail Address: apsmith@gsi-net.com Fax #: 512-346-4476

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

c. Requisition #: 580-16-RFQ0027 Bid Open Date: 07/07/2016 (mm/dd/yyyy)

Enter your company's name here: GSI Environmental Inc. Requisition #: 580-16-RFQ0027

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	Groundwater Modeling	0 %	0 %	100 %
2		%	%	%
3		%	%	%
4		%	%	%
5		%	%	%
6		%	%	%
7		%	%	%
8		%	%	%
9		%	%	%
10		%	%	%
11		%	%	%
12		%	%	%
13		%	%	%
14		%	%	%
15		%	%	%
	Aggregate percentages of the contract expected to be subcontracted:	0 %	0 %	100 %

(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: GSI Environmental Inc. Requisition #: 580-16-RFQ0027

SECTION-2 RESPONDENT's SUBCONTRACTING INTENTIONS (CONTINUATION SHEET)

This page can be used as a continuation sheet to the HSP Form's page 2, Section 2, Item b. Continue listing 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.**
16		%	%	%
17		%	%	%
18		%	%	%
19		%	%	%
20		%	%	%
21		%	%	%
22		%	%	%
23		%	%	%
24		%	%	%
25		%	%	%
26		%	%	%
27		%	%	%
28		%	%	%
29		%	%	%
30		%	%	%
31		%	%	%
32		%	%	%
33		%	%	%
34		%	%	%
35		%	%	%
36		%	%	%
37		%	%	%
38		%	%	%
39		%	%	%
40		%	%	%
41		%	%	%
42		%	%	%
43		%	%	%
	Aggregate percentages of the contract expected to be subcontracted:	**%**	**%**	**%**

***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: GSI Environmental Inc. Requisition #: 580-16-RFQ0027

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)
	Ann P. Smith, P.E., BCEE	Vice President	08/10/2016

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 A (Attachment A)

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Enter your company's name here: GSI Environmental Inc. Requisition #: 580-16-RFQ0027

IMPORTANT: If you responded "*Yes*" to **SECTION 2, Items c** or **d** of the completed HSP form, you must submit a completed "HSP Good Faith Effort - Method A (Attachment A)" 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-a.pdf

SECTION A-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: _____ Description: _____

SECTION A-2: SUBCONTRACTOR SELECTION

List the subcontractor(s) you selected to perform the subcontracting opportunity you listed above in SECTION A-1. Also identify whether they are a Texas certified HUB and their Texas Vendor Identification (VID) Number or federal Employer 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
	☐ - Yes ☐ - No		$	%
	☐ - Yes ☐ - No		$	%
	☐ - Yes ☐ - No		$	%
	☐ - Yes ☐ - No		$	%
	☐ - Yes ☐ - No		$	%
	☐ - Yes ☐ - No		$	%
	☐ - Yes ☐ - No		$	%
	☐ - Yes ☐ - No		$	%
	☐ - Yes ☐ - No		$	%
	☐ - Yes ☐ - No		$	%
	☐ - Yes ☐ - No		$	%
	☐ - Yes ☐ - No		$	%
	☐ - Yes ☐ - No		$	%
	☐ - Yes ☐ - No		$	%
	☐ - Yes ☐ - No		$	%
	☐ - Yes ☐ - No		$	%
	☐ - Yes ☐ - No		$	%
	☐ - Yes ☐ - No		$	%
	☐ - Yes ☐ - No		$	%
	☐ - Yes ☐ - No		$	%
	☐ - Yes ☐ - No		$	%
	☐ - Yes ☐ - No		$	%

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 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.

HSP Good Faith Effort - Method B (Attachment B)

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Enter your company's name here: GSI Environmental Inc. Requisition #: 580-16-RFQ0027

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: Groundwater Modeling

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?
Datacom Design Group, LLC	1352371150800	07/07/2016	☐ - Yes ☑ - No
Lonestar State Environmental Services	1300289426200	07/07/2016	☐ - Yes ☑ - No
Terra Associates, Inc.	1760000348100	07/07/2016	☐ - 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?
Southwest Minority Supplier Development Council	07/07/2016	☐ - Yes ☑ - No
Women's Business Council - Southwest	07/07/2016	☐ - Yes ☑ - No

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

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Enter your company's name here: GSI Environmental Inc. Requisition #: 580-16-RFQ0027

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: Groundwater Modeling

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 Employer 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
Errol L. Montgomery & Associates, Inc.	☐ - Yes ☑ - No		$ 225,000	28 %
Environmental Simulations, Inc.	☐ - Yes ☑ - No		$ 70,000	9 %
William R. Hutchison, PhD, PE, PG	☐ - Yes ☑ - No		$ 170,000	21 %
	☐ - 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):

GSI chose our teaming partners based on their knowledge of the specific groundwater modeling programs required to complete this project. One of our chosen teaming partners co-authored the Groundwater Vistas model, a required program for this project. Our other two teaming partners are experts in the field of groundwater modeling.

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: GSI Environmental Inc.
State of Texas VID #: 17601957065
Point-of-Contact: Ann P. Smith, P.E., BCEE
Phone #: 512-346-4474
E-mail Address: apsmith@gsi-net.com
Fax #: 512-346-4476

SECTION: B CONTRACTING STATE AGENCY AND REQUISITION INFORMATION

Agency Name: Texas Water Development Board (TWDB)
Point-of-Contact: Angela Wallace
Phone #: 512-463-7979
Requisition #: 580-16-RFQ0027
Bid Open Date: 07/07/2016 (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 5:00 PM (Central Time) on 07/19/2016 (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:

Texas Water Development Board Request for Qualifications to Update the Existing Groundwater Availability Model for the Northern Portion of the Queen City, Sparta, and Carrizo-Wilcox Aquifers.

3. Required Qualifications: ☐ - Not Applicable

GSI seeks subcontractors who have experience with hydrogeology, TWDB Groundwater Availability Modeling, MODFLOW-2005, MODFLOW-NWT, MODFLOW-USG, SEAWAT, and Groundwater Vistas including variable density flow modeling approaches. In addition, the subcontractor must be able to create metadata using the FGDC metadata editor within ESRI's ArcCatalog and have knowledge of the Northern Portion of the Queen City, Sparta, and Carrizo-Wilcox Aquifers.

4. Bonding/Insurance Requirements: ☐ - Not Applicable

The subcontractor must carry the following insurance coverage: Workers Compensation and Employers Liability: Workers Compensation - Minimum $1M; Employers Liability, Each Accident - Minimum $1M; Disease - Each Employee $1M; Disease - Policy Limit $1M. Commercial General Liability Insurance - Occurrence Based: Bodily Injury and Property Damage - $1M; Aggregate Limit - $2M; Medical Expense each person - $5,000; Personal Injury and Advertising Liability - $1M; Products/Completed Operations Aggregate Limit - $2M; Damage to Premises Rented to You - $50,000.

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

CONTENT ITEM 6

Technical Approach

A. Project Staff Qualifications.

The GSI Team consists of professionals who are at the forefront of groundwater modeling in the 21st century and have been selected to provide the best staff for this project.

- **Dr. Sorab Panday** is the proposed **Principal Investigator/Project Manager.** Sorab is the primary author of MODFLOW-USG, and the second author of MODFLOW-NWT. He is also involved in further upgrades to the MODFLOW family of codes and is unsurpassed in understanding and application of the various MODFLOW upgrades, convergence behavior and solver settings.
- **Dr. Bill Hutchison** is the **Principal Hydrogeologist.** Bill is the technical consultant for Groundwater Management Area 11 (Northern Carrizo-Wilcox) and Groundwater Management Area 13 (Southern Carrizo-Wilcox).
- **Mr. Staffan Schorr** is the **Principal Geologist** for this project. Staffan has extensive experience in developing complex hydrogeological and hydrostratigraphic models using geographical information system (GIS) and three-dimensional (3D) tools that interface with Groundwater Vistas and other data applications for flow and transport modeling. Staffan is also an expert in conceptual model development using Leapfrog software, which we propose for use on this project. Leapfrog has proven to be extremely efficient and robust in constructing, updating, and visualizing geologic models.
- **Mr. Jim Rumbaugh** is the proposed **Principal Modeler.** Jim is the developer of Groundwater Vistas, the industry standard pre- and post-processor for MODFLOW codes and a requirement for TWDB models. He has extensive experience in building and calibrating large complex models throughout the United States, and has provided training to TWDB staff on groundwater modeling in the past.
- **Ms. Julie Spencer** is the proposed **Project Administrator** for this work. Julie is a geologist with 20 years of experience in coordinating and managing schedules and costs for projects of this nature, and is currently managing TWDB Contract No. 1548301854.

This Team will be supported by staff that includes hydrogeologists, modelers, GIS specialists, and administrative personnel experienced with the tasks and tools required for this work.

B. Experience as it relates to the research topic (hydrogeology/knowledge of the Carrizo-Wilcox, Queen City, and Sparta aquifers).

Dr. Bill Hutchison is the technical consultant for two of the Groundwater Management Areas (GMAs) that cover the Carrizo-Wilcox, Queen City and Sparta aquifers (GMAs 11 and 13). As part of the efforts to advise the groundwater conservation districts of these GMAs, Dr. Hutchison has completed over 15 reports and technical memoranda covering topics such as historic pumping, impacts of future pumping, specifics of water management strategies, availability of groundwater data, comparisons of groundwater data with model predictions, surface-water/groundwater interactions in the area, and the effect of pumping downdip wells

on outcrop areas. He has presented findings at numerous public meetings of GMA 11 and GMA 13.

In addition, Dr. Hutchison was the lead editor of TWDB Report 374 (Aquifers of the Upper Coastal Plains of Texas) in 2009. This publication covers 79 counties that overlie the Carrizo-Wilcox, Yegua-Jackson, Sparta, Queen City, and Brazos River Alluvium aquifers.

C. Project staff experience in contract management and technology transfer including ability to meet short and strict deadlines within budget.

While executing TWDB Contact No. 1548301854, the staff proposed for this project has demonstrated the ability to manage a TWDB contract, transfer the technology we have developed, meet strict project deadlines and maintain the project budget, and we will build upon this experience to manage any additional TWDB contracts. In addition to our current TWDB contract and several other similarly sized and scoped projects, our proposed Project Administrator, Julie Spencer, is currently managing a $1.6M project for the federal government that includes 14 subcontractors and extensive reporting, scheduling, invoicing and technology transfer requirements. She has 20 years of experience managing multiple contracts with complex, client-specific administrative requirements, and will utilize this vast experience to manage the proposed project.

Since we perform research and development as consultants, we are constantly involved with technology transfer and meeting short strict deadlines within budget. As part of technology transfer, our technical team has provided training webinars/workshops/courses to government, industrial, and private entities on numerous environmental topics including groundwater modeling and the use of GWV, MODFLOW-NWT and MODFLOW-USG. These professional seminars include 1) an Introduction to Groundwater Modeling, which has been taught by ESI to the TWDB, South Florida Water Management District (WMS), Southwest Florida WMD, St. Johns River WMD, and other private companies; 2) Model Calibration with PEST and Groundwater Vistas, which focuses on the basics of PEST and GWV in calibrating models and leads into the more advanced features, including pilot point, Singular-Value Decomposition, and Null Space Monte Carlo Techniques; and 3) MODFLOW-USG Webinar, which is a 2 week webinar series taught by GSI and ESI to present features and applications of the model along with the implementation in Groundwater Vistas.

In addition, our project team is acutely aware of project schedules and budgets. Our team is appropriately staffed to manage and meet short and strict deadlines and has the capacity to bring in additional resources, as needed, to meet project deadlines within budget.

D. Experience and knowledge of TWDB groundwater geodatabase schema for documenting source data.

Mr. Staffan Schorr has experience in developing and supervising the development of GIS and database applications used for data management, analysis, and visualization; and in pre- and post-processing data for hydrologic modeling of groundwater and surface-water systems. He developed spatial and relational databases for the Lower Rio Grande Valley Groundwater Transport Model, which is currently being developed for the TWDB, using the TWDB

Groundwater Geodatabase Schema for documenting source data. Mr. Schorr will manage the large amount of spatial and non-spatial data that will be generated for this modeling project as well. The TWDB GAM data model, which is contained within the Environmental Systems Research Institute (ESRI) ArcGIS personal geodatabase platform, will be used to store the variety of data types and sources that are used to develop the groundwater model. This data model provides a logical construct for storing, organizing, documenting, and retrieving digital information related to the project. The data model consists of three components: 1) a Source geodatabase which will contain the conceptual model source and derivative datasets, 2) a Pumpage geodatabase which will contain the pumping source and derivative datasets, and 3) a Final Model geodatabase which will contain specific model input files.

The source and derivative datasets within the data model are natural and anthropogenic spatial features which are associated with time-series information, as well as any other non-spatial data used to develop the conceptual model and generate numerical model input files. Source information refers to original, publically-available or otherwise non-proprietary information collected and used for this project; while derivative information refers to information derived from source information. The source and derivative pumpage values consist of source data provided by TWDB within the Pumpage geodatabase and all derivative model pumping values used for final model calibration. Final model files will be formatted for GWV. The model grid values contained within the data model will be the final grid cell input used for the calibrated steady-state and transient numerical models. All spatial data used/developed in this modeling project will be geo-referenced to the GAM coordinate system statewide mapping system.

TWDB will provide empty geodatabase schemas. The schemas will include empty feature datasets, feature classes, object classes, tables, and raster datasets that will be ready to populate with project data. The schemas will also include rules to constrain and standardize project data. Approval from the TWDB Groundwater Resources Division, Groundwater Availability Modeling Section Manager will be obtained prior to making any modifications to the geodatabases. The main objectives for using these geodatabase schemas are: 1) to provide all basic data and metadata used to develop the conceptual model in a format for reproducing all input parameters in the model grid; 2) to provide all pumping data in a format that can be transferred directly to the model; and 3) to provide all model input datasets needed to run the final calibrated steady-state and transient models. Any source or derivative datasets that are not compatible with the geodatabase schema will be provided to TWDB in another pre-approved format.

The TWDB Pumpage geodatabase schema has pre-developed tools to calculate spatially distributed pumpage volumes, distribute point-specific pumping to individual wells, and maintain important identifying fields for relating output data with associated input data. Spatial distribution of pumping will occur within the Pumping geodatabase. Prior approval from TWDB will be obtained if other options are needed for organizing and processing model pumping for this project.

Model grid feature datasets will consist of a polygon feature class of model grid cells and a point feature class of model grid cell nodes. A unique cell identifier or relationship/index key will be used to link polygon and point features with any associated parameter values and time-

series datasets. The unique cell identifier will be a seven-digit integer based on the cell location. The model properties dataset will also be attributed with the model grid cell identifier.

All datasets used for this project will include metadata for documenting the content, data structure, sources, dates, quality, and other data characteristics within the geodatabases. Metadata will conform to the Federal Geographic Data Committee's (FGDC) Content Standard for Digital Geospatial Metadata, Version 2 (FGDC-STD-001-1998) or later.

E. Understanding of groundwater availability models and related studies for project area.

Dr. Bill Hutchison is the technical consultant for two of the GMAs that cover the Carrizo-Wilcox, Queen City and Sparta aquifers (GMAs 11 and 13). As part of his work, he has identified a key limitation of the current Groundwater Availability Model for GMA 11, and has made recommendations to improve the development of model updates.

As part of the effort to develop desired future conditions for GMA 11, predictive simulations were completed using the current GAM. The simulations started at the end of the calibration period (1999) and continued through the planning period to 2070. Because 1999 was a dry year and the predictive simulation assumed average recharge conditions, the model predicted rising water levels in many outcrop areas between 2000 and 2070. To address this issue, Dr. Hutchison attempted to extend the calibration period of the model to 2013, but the attempt was unsuccessful. The model would not calibrate as well as the 1975 to 1999 period of the original model. A deeper look into the model indicated that the rising water levels may also be due to overestimates of recharge and an inability of the model to move large volumes of water from outcrop to subcrop areas.

In GMA 13, 51 predictive simulations were completed as part of the process to develop desired future conditions. A key finding of the effort was identifying the limitation of the current GAM in the outcrop area. The groundwater conservation districts wanted to focus their attention on the outcrop area to evaluate impacts of increased pumping on shallow wells and surface-water/groundwater interactions. One of the technical recommendations made was to improve the GAM process by demonstrating good calibration statistics in outcrop areas to improve the usefulness of the GAM to address specific joint planning requirements, such as private property rights (shallow well owners) and surface-water/groundwater interactions.

F. Justification for upgrading the model to MODFLOW-2005 or MODFLOW-NWT code.

The existing GMA 11 model uses the MODFLOW96 version of the MODFLOW family of models. This is one of the oldest versions and has been categorized by the USGS as a legacy model. When the USGS puts a model into legacy status, it is no longer supported and no longer part of active development within the USGS. While Groundwater Vistas still supports MODFLOW96, most new developments are also focused on the newest versions of MODFLOW, including MODFLOW2005 MODFLOW-NWT, and MODFLOW-USG. We propose to test all three of these codes and select the best alternative that suits the current GMA 11 modeling effort.

The fact that MODFLOW96 is such an old code is probably justification enough for switching to the newest version. However, there are several other reasons why upgrading to a newer version of MODFLOW makes sense. GMA 11 utilizes the stream routing, sources/sinks for wells, and rewetting packages of MODFLOW96, all of which have been improved in more recent MODFLOW codes. Each of the three potential codes listed above has taken a slightly different approach to these and other aspects of the GMA 11 model.

The MODFLOW96 rewetting option is part of the Block-Centered Flow (BCF) package and was designed to rewet cells that go dry during the simulation. It is a rather crude approach to cell resaturation and can slow or hinder model convergence. MODFLOW-NWT and MODFLOW-USG incorporate cell resaturation in a more seamless way using an upstream weighting formulation and Newton Raphson linearization which make the model more stable and improves run time.

The stream routing package (STR) has been significantly upgraded in MODFLOW2005, MODFLOW-NWT, and MODFLOW-USG to a new package called surface flow routing (SFR). The SFR package is designed work with Lakes and can simulate stream leakance when cells go dry, something that STR cannot handle. MODFLOW-USG adds another option in the Connected Linear Network (CLN) package, which simulates conduits and streams as a series of linear segments that are independent of the MODFLOW grid. This makes it simple to add refinements to the model or make major changes to the grid without having to revise the stream network. Both CLN and SFR allow for disconnection of the groundwater from streams; in addition, the CLN package improves robustness due to a full implicit coupling of the groundwater and surface-water domains.

MODFLOW2005 and MODFLOW-NWT further include a multi-node well (MNW) package to simulate the impact of wells and pumping within an aquifer, while MODFLOW96 only allowed for sources and sinks to be simulated within a groundwater grid-block using the WEL package. The advantage of the MNW package is that each well is separately simulated and not just represented as a lumped source or sink within a groundwater grid-block. Analytical solutions provide the drawdown within each well and therefore, the solution is further independent of the groundwater grid-block size. In addition, where a well is pumping from multiple layers, the MNW package distributes the pumping among layers dynamically as part of the solution to flow and does not require a prior estimation for pumping among layers. This is significant since the GMA 11 models are ultimately used to manage pumping from wells and therefore, simulating the impact of wells in a correct manner is critical. MODFLOW-USG also simulates the impact of wells using the CLN package and includes analytical solutions to drawdown within a well and provides a fully implicit coupling of the wells to the groundwater domain to improve solution robustness.

Only about 52 percent of the finite-difference grid cells are active in the existing GMA 11 model. The solver in MODFLOW-NWT is designed to more efficiently simulate models with numerous inactive cells. In the case of MODFLOW-USG, these inactive cells can simply be omitted from the model, making an even more significant decrease in model run time. MODFLOW-USG also allows aquifers to pinch out, while all other versions of MODFLOW

require layers to be continuous. This may be particular importance in GMA 11 due to the use of "dummy" layers in the GMA 11 model of the Wilcox Aquifer.

These more recent versions of MODFLOW have the option of adaptive gridding, where the model can be refined in areas of interest without having to rebuild the original model. In the case of MODFLOW2005 and MODFLOW-NWT, this is done through the Local Grid Refinement (LGR) versions, although these are not directly supported by Groundwater Vistas. MODFLOW-USG and Groundwater Vistas can be used to add nested grids into a regional model to accomplish the same thing. In this case, however, the nests can be turned off and on to very quickly simulate more refinement in areas of interest.

Given all of these recent developments that would seem to improve the GMA 11 model, we propose to test all three versions (MODFLOW2005, MODFLOW-NWT, and MODFLOW-USG) in the early phases of modeling to see how they perform. We would then meet with TWDB staff to present the findings so that a consensus decision can be made as to which MODFLOW code best meets the needs of the project and best simulates the aquifer systems in GMA 11.

G. Approach for investigating and documenting framework, aquifer geometry, surface water features, and aquifer properties.

Conceptual model development, including updating hydrostratigraphy, will be Task 1 of this project. Hydrostratigraphy refers to the layering of aquifers and associated confining units of a study area. The hydrostratigraphic framework is the elevation surfaces of the top and bottom of the hydrostratigraphic units. The hydrostratigraphic framework and geometry for the proposed model will be principally based on the current GAM for the northern Sparta, Queen City, and Carrizo-Wilcox aquifers, developed by Kelley and others (2004), and aquifer data obtained from the TWDB for this aquifer system. The hydrostratigraphic framework in the current GAM will be verified and updated, where necessary, using lithologic and/or geophysical well logs obtained from TWDB file and other agencies. The aquifer system comprises seven hydrostratigraphic units with distinct hydraulic properties. From youngest to oldest, the hydrostratigraphic units include recent sediments, Sparta Sand, Weches Formation, Queen City Sand, Reklaw Formation, Carrizo Sand, and the Wilcox Group.

A three-dimensional (3D) geologic model will be developed for the aquifer system using ESRI's ArcGIS software and Leapfrog software, developed by ARANZ Geo Ltd. Leapfrog is a leading 3D geologic modeling software for the mining, exploration, and groundwater industries. Leapfrog software efficiently incorporates borehole data, GIS datasets, hydrogeologic sections, hydrogeochemical data, and geophysical well logs to identify and delineate contacts between geologic units, such as aquifer units or sand intervals, and to generate a solid 3D geologic model for visualization and export. The geology of a stratified aquifer system is modeled using deposit and stratigraphic sequencing tools. Pinchouts, such as clay lenses, are modeled using a vein tool with pinchout, along with minimum and maximum thickness options. The vein surfaces are then used to define the deposit. For this project, the Leapfrog geologic model will provide the hydrostratigraphic framework for input to the numerical groundwater model. Leapfrog seamlessly communicates with Groundwater Vistas

to incorporate the geospatial data into a MODFLOW model grid. Leapfrog is able to generate a MODFLOW grid using the surfaces of the deposits included in the geologic model, including pinchout units. Data and surfaces used to develop the geologic model for the final calibrated numerical model will be exported from Leapfrog and imported into the TWDB groundwater geodatabase schema for archive and delivery. The geologic model will be shared with the project team and TWDB via the free, user-friendly Leapfrog Viewer software.

Groundwater/surface-water interactions are an important component of the hydrologic system in the study area. Surface-water features (including rivers, streams, springs, and reservoirs) specified in the current GAM (Kelley and others, 2004) will be evaluated and updated for this model. These surface-water features will be incorporated in the model appropriately to account for the approximation of groundwater/surface-water interactions. The model will allow for discharge to the stream during gaining conditions, and for stream channel leakage during losing conditions. For example, recharge can be induced through stream losses when groundwater pumping results in declining groundwater levels under a stream reach. This recharge is further affected when groundwater levels fall below the bottom of the stream. Recent flow and/or stage measurements will be obtained from the USGS or other agencies and incorporated into this model. Several previous studies have been conducted on stream flow characteristics in the study area. The methods and results of these studies were summarized in Kelley and others (2004). A literature review will be conducted for this project to compile and summarize results of any relevant studies completed in recent years.

Aquifer hydraulic properties for the hydrostratigraphic units will be evaluated and updated for this project. Pinchout areas will be identified and handled in Groundwater Vistas or Leapfrog. These properties include transmissivity, hydraulic conductivity, storativity, and specific yield. Results of available aquifer tests for the study area will be compiled and evaluated. Information on hydraulic properties from previous studies will also be compiled and incorporated into the current project, as appropriate. Specific capacity data will be compiled from TWDB files and from the Texas Commission on Environmental Quality (TCEQ). Transmissivity will be estimated by using an analytical or empirical technique relating transmissivity to specific capacity, such as Theis (1963) or Mace (2001). Completion zones of the test wells will be assessed for relating aquifer properties to specific hydrostratigraphic units. Aquifer properties will be statistically analyzed for each hydrostratigraphic unit. If adequate information is available, effective hydraulic properties will be estimated based on known geologic characteristics of the aquifer unit, such as net sand and clay content. Geologic characteristics will be evaluated using available well logs.

The conceptual model will be implemented into the Groundwater Vistas pre- and post-processing software for development of the numerical model. Groundwater Vistas allows for easy implementation of all of the MODFLOW codes and therefore, the simulation capabilities (robustness, efficiency, convergence and speed) of MODFLOW2005, MODFLOW-NWT, and MODFLOW-USG will all be tested before selecting an appropriate code for the GMA 11 model. Other advantages and disadvantages of the codes will also be evaluated in conjunction with TWDB staff before final selection.

Spatial and temporal resolution selection will be performed in consultation with TWDB personnel. The grid sizes will be variable to accommodate finer resolution near surface-water features and wells. The largest grid size will be no more than one mile in the horizontal direction. The calibration time period will include a pseudo steady state period in order to provide a consistent set of initial conditions for the transient period. The transient period for calibration will extend to 2013 or later as data allow. Annual or seasonal stress periods will be used for this analysis consistent with the long-term planning objectives of the GAMs.

Significant surface-water features will be represented explicitly in the model. The advanced stream packages (SFR or CLN) will be used to represent these features because these updated packages handle the interaction in a more realistic manner; for instance, when there is an unsaturated zone between the groundwater and stream. The DRN or RIV packages of MODFLOW will be used along segments of less significance, or where it is determined that use of these packages does not significantly impact computation of groundwater/surface-water interactions.

Model parameterization will be based on field measurements and consistent with the geologic conceptual model that will be directly imported from Leapfrog into GWV. The material parameters will be spatially variable and consistent with values and ranges observed in the field. The numerical model will be calibrated using model-independent parameter estimation and uncertainty analysis (PEST). Spatial weighting will consider data density to eliminate biasing the calibration to any one area or aquifer unit. Target weighting will also consider drought and low-flow periods as critical time periods for evaluation. Spatial interpolation functions needed to represent site conditions will be implemented into GWV such that generation of the parameter fields is automated and parameter estimation can be performed from within the GWV framework. For example, if data on sand and clay content in each cell are sufficiently defined during the conceptual model development, calibration can focus on sand and clay conductivity values. Calculations can then be automated to calculate effective horizontal and vertical conductivity that better reflect the spatial variability in the area.

Multiple calibration targets will be selected (groundwater elevations, spring-flows, and surface-water flows) based on available information. Qualitative targets will include visual matching of areal hydraulic head contour plots at various times, observations of spatial bias on residual maps, and comparing graphs of observed and simulated hydrographs at wells.

Quantitative targets will include absolute and relative error statistics between measured and simulated hydraulic heads, water level fluctuations, stream-flow, spring discharges, and flow directions and velocities inferred from water level (hydraulic head) differences. Water level elevations as well as changes (drawdown or mounding) will be evaluated for flow calibration. Calibration statistics for the outcrop area will be reported separately from the downdip area, which exceeds the current TWDB requirements for GAM calibration. This is of particular importance in GMA 11 given the limitations of the current GAM.

The calibrated model will reproduce the general distribution flow behavior of the aquifers for the simulation period and will be capable of evaluating future water management scenarios involving changes in pumping, precipitation, or surface-water interactions. Demonstration of the suitability of the GAM to simulate future scenarios will be made by running the model

using pumping data from the last stress period, and average values for parameters such as recharge and river flow. This test simulation will be run to the year 2070 to evaluate model performance (i.e. trends in groundwater levels) during the period of interest for predictive simulations.

Sensitivity analyses will be conducted as a part of model calibration, as well as in post-calibration. American Society of the International Association for Testing and Materials (ASTM) standards will be followed in evaluating the results of sensitivity analyses to determine the predictive capability of the model. Model development, calibration, sensitivity analysis and application will be documented as per ASTM standards for groundwater model documentation and will be in accordance with TWDB Guidelines. This includes adjusting model parameters plus or minus 10 percent and plus or minus 50 percent from calibrated values and reporting mean error between calibrated water levels and the simulated water levels.

H. Approach for modeling effective recharge to the aquifer.

Potential sources of recharge in the study area include areal recharge of rainfall, irrigation return flows, and stream or reservoir leakage. Recharge estimates from previous studies are summarized by Kelley and others (2004). In the current GAM, recharge from rainfall (diffuse recharge) varies from year to year and is spatially distributed based on rainfall, topography, and geology. A recent attempt by Dr. Hutchison to update the model calibration period through 2013 was unsuccessful due to rising water levels resulting from overestimated recharge in outcrop areas and the inability of the model to move large volumes of water from outcrop to downdip portions of the model layers.

For this project, recharge in the current GAM will be evaluated and adjusted, where appropriate, to improve model calibration. For example, there are potential issues with the link between the steady-state and transient recharge estimates (i.e. transient recharge is higher than steady-state). This needs further review and analysis as part of the update of the GAM. Annual recharge in this model will be extended through at least 2013. Information on precipitation, irrigation application estimates, and differences in flow between stream gages will be established to note baseflow or stream losses for further use in model calibration.

Much of the recharge from rainfall is consumed by evapotranspiration (ET) at shallow depths. This ET reduces with depth to water causing what is termed rejected recharge. The current GAM uses ET model parameters using the SWAT (Soil Water Assessment Tool) model that was developed for the United States Department of Agriculture (USDA) Agricultural Research Service. These parameters will be evaluated for this project, and updated, where appropriate, to improve model calibration. Rejected recharge may also occur due to interactions with the land surface and surface-water features. Depth to water will be evaluated throughout the model domain to determine if further rejected recharge considerations are required.

Recharge from stream channel leakage will vary in the model depending on available flow in the stream and groundwater levels adjacent to the channel. MODFLOW's streamflow routing (SFR) or connected linear network (CLN) packages will be used to approximate groundwater/surface-water interactions along surface-water features in the model. Water in the stream that is not lost to channel leakage continues to flow in the stream and is available for

channel leakage (recharge) along downstream reaches if adequate aquifer storage space is present in the underlying aquifer.

I. Proven internal progress monitoring procedures and quality assurance process.

As demonstrated under TWDB Contact No. 1548301854, GSI has proven internal progress monitoring procedures and quality assurance processes in place to manage additional TWDB projects. As with our current TWDB contract, progress of the project will be monitored on a weekly basis through weekly project meetings. The team will coordinate every week to evaluate progress as per the scope, schedule, and budget outlined in the final work plan submitted with the contract. Discussions will include headway, hurdles, and next steps. We will use standard project and budget management tools to break work into component phases and tasks, regulate workflow, allocate resources, detect changes, make management decisions, and control cost and schedule in a timely fashion.

The biggest hurdle to timely completion of a modeling project is having to revisit the model development or calibration stages due to omission or errors with key model elements. Therefore, we will implement technical quality assurance (QA) checks from the beginning and throughout the duration of the project to catch errors in a timely manner and address them as needed. Also, we will keep open communication with TWDB and stakeholders to ensure that data is available and that concerns are being addressed as the model is being built. Stakeholder participation throughout the project also ensures their buy-in due to their continual involvement in the modeling process.

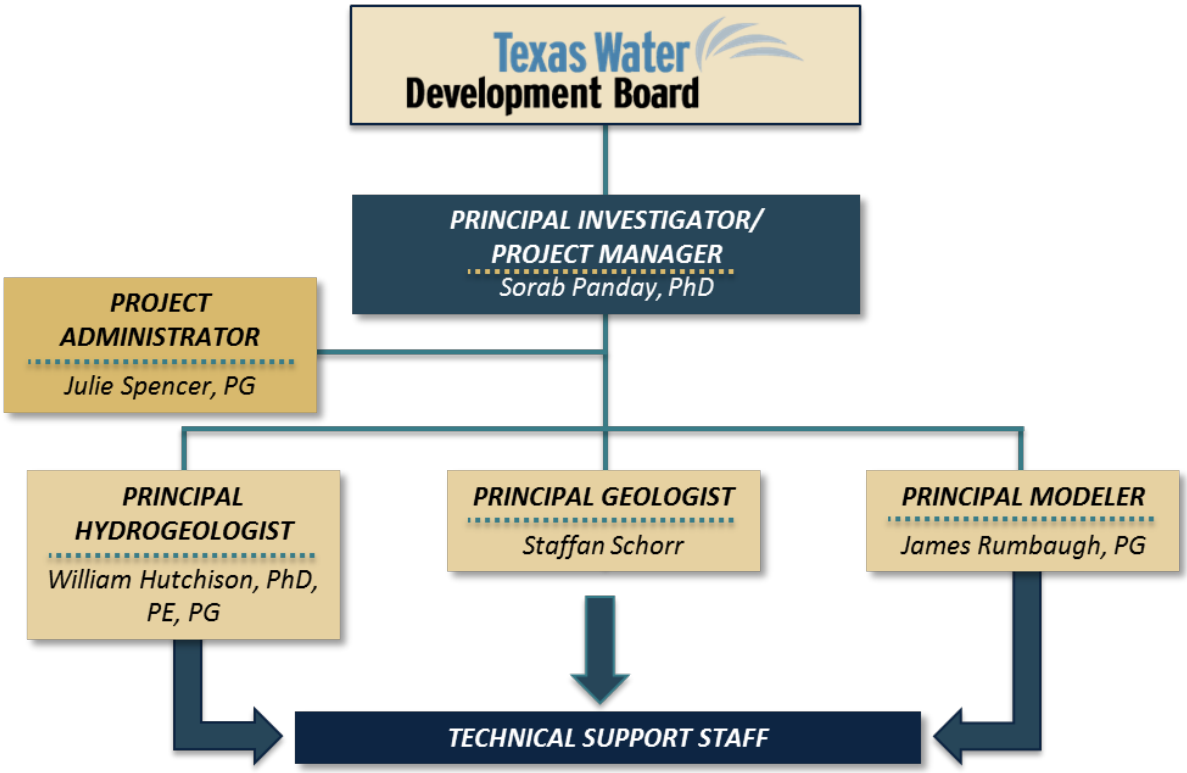
J. Approach for organizing and managing the Project, including coordination with TWDB staff.

Dr. Sorab Panday will be the **Principal Investigator/Project Manager** for the work and will be involved with all aspects of this project, including ensuring that GSI resources are available and that quality deliverables are produced in a timely manner. His primary technical focus will be in design of the numerical model (grid, surface-water features, and boundary conditions) and in model calibration and application. He will be assisted by three key technical personnel and one experienced administrative lead who will be involved with all aspects of the project and provide specific technical focus and support:

- **Dr. Bill Hutchison** will be the **Principal Hydrogeologist** to the project and will provide input on site issues and conditions.
- **Mr. Staffan Schorr** will be the **Principal Geologist** for this work and will be key in constructing a conceptual model of flow and transport and in developing a geo-stratigraphic 3D model of the subsurface for import to Groundwater Vistas.
- **Mr. Jim Rumbaugh** will be a **Principal Modeler** for this work and will be key in importing the conceptual model into Groundwater Vistas, creating the MODFLOW numerical flow model, and extracting appropriate information from model results for examination or presentation. He will also assist with model calibration and application. GIS, technical and administrative staff will assist these persons for associated tasks such as data review/entry, model runs, visualization, or preparation of presentations and reports.

- **Ms. Julie Spencer** will be the **Project Administrator** and will monitor progress, schedules and budgets. Julie will also coordinate with TWDB and stakeholders regarding meetings and progress reports.

An organizational chart for this project is shown below



Upon initiation of the project, the project manager will establish lines of communication with the TWDB. A communication protocol will be established with the TWDB to discuss objectives, scope, stakeholder interaction, schedules, budgets, progress, hurdles and results. The project will proceed as per the scope, schedules and budgets set up in the final work plan executed with the contract.

The team will communicate on a weekly basis to keep abreast of all project-related activities and progress, and will be in-touch, as needed, to keep the project workflow moving. We have the infrastructure to connect and work remotely from several locations including internal networks for storing and accessing project directories from a single location in Austin, webinars/go-to-meetings for discussions and technical evaluations, and project related FTP-sites for large file transfers.

We will provide the TWDB with monthly letter reports for the duration of the modeling project summarizing progress and outlining next steps. Each of the project tasks will be described in detail consistent with the budget description. Any concerns will be documented in the progress reports and brought to the TWDB contract manager's attention as soon as possible.

We will also hold project review meetings with the TWDB at important points in the conceptual and numerical modeling process. At a minimum, the project team will meet with TWDB staff at the beginning of the project and after TWDB receipt of the Draft Source Geodatabase and Draft Conceptual Model Report. Additional meetings or webinars will be conducted to discuss project progress, understand the challenges encountered, and seek solutions in a collaborative manner. Further, TWDB may visit our offices or conduct web meetings on occasion to gauge progress on the project.

K. Ability to communicate clearly with stakeholders during advisory forums for the model, 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.

Stakeholder participation will be a key component of the model development effort. A Stakeholder Advisory Forum (SAF), which may include regional water planning groups, groundwater conservation districts, TCEQ, Texas Parks and Wildlife Department, Texas Department of Agriculture, water utilities, educational groups, agricultural interests, environmental interests, private landowners, industry, and groundwater consultants will be formed for this project in consultation with TWDB staff. These various water planning groups, groundwater conservation districts, state agencies, private entities and groundwater consultants will provide valuable input and information to ensure that the model addresses important questions of concern.

Under TWDB Contract No. 1548301854, the GSI team has demonstrated our ability to clearly and successfully communicate with stakeholders by preparing several PowerPoint presentations that outline the objectives of the project, summarize the project progress, and solicit information from the SAF participants. Under the proposed project, key milestone meetings will again be held with the SAF discuss progress and solicit comments. GSI's project administrator will work with the TWDB Contract Manager or other appropriate TWDB staff to coordinate meeting dates and locations. The GSI project administrator will notify the SAF participants of upcoming meetings by e-mail. SAF participants without e-mail accounts or with a preference other than receiving e-mail will be notified by letter. In order to maximize SAF participation, meeting notifications will be sent 21 days before the meeting along with a reminder 7 days before the meeting, and will include information about the meeting as well as an outline of what will be discussed.

As part of the proposed project, the first meeting with the SAF will be held within two months after the contract starts and will describe basics of groundwater flow in the aquifer, concepts of numerical groundwater flow modeling, experience from previous models of the aquifer, the planned approach, a request for local scientific data and model input information, a proposed schedule, and expectations of the model. Additional meetings will be scheduled after delivery of the conceptual model and after the model has been developed.

A memo report (in Word and Adobe Acrobat-compatible formats), copy of the presentation and attendance sign-up sheet will be submitted to TWDB after each SAF meeting. The report will include a presentation summary, list of questions and issues that arose at the meeting, and a discussion on how those questions and issues will be addressed. Presentations will be submitted within three business days of the meeting in Microsoft PowerPoint and Adobe Acrobat formats in English with tabbed figures, for posting on the TWDB website. The Adobe Acrobat files will be less than 8 megabytes in size; therefore, deliverables may be submitted in multiple parts for easier web access and to avoid email limitations. The sign-up sheet for each SAF meeting will include a list of attendees and their affiliation. New and/or revised information will be reviewed and the SAF member list updated.

L. Ability to clearly communicate the results of requested analyses in graphical, written, and oral formats.

Under TWDB Contract No. 1548301854, the GSI Team has demonstrated the ability to clearly communicate the results of requested analyses in graphical and written formats with completion of our Draft Conceptual Site Model Report, which contained more than 75 figures/graphics, 5 tables and 42 pages of written text to clearly communicate the impacts of brackish groundwater pumping by the current and recommended future desalination plants in the Lower Rio Grande Valley of Texas.

In addition, we have demonstrated our ability to clearly communicate our results in oral format with the project updates we have presented at two SAF meetings held in Weslaco, Texas as described in Section K above; and the professional seminars our technical team has provided to government, industrial, and private entities on numerous environmental topics including groundwater modeling and the use of GWV, MODFLOW-NWT and MODFLOW-USG.

To ensure that results of our analysis developed under the proposed project are clearly communicated, graphical and written formats will be developed and delivered in accordance with the software requirements, source information, model file, and final report requirements as outlined in Section 4.1 of the GAM Standards. This will include delivering all computer files and formats that are 100 percent compatible with personal computer (IBM-PC) type systems and fully compatible with the widely distributed versions of the following programs:

- Word Processor Files – Microsoft Word (MS Office 2010),
- 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.

M. Project Deliverables.

GSI will deliver project data and reports as outlined in Section III of RFQ No. 580-16-RFQ0027. This will include monthly progress reports, SAF documentation, a Draft Source

Geodatabase and Draft Conceptual Model Report, and Final Source Geodatabase and Draft Final Conceptual Model Report.

Monthly progress reports will be produced and provided to the TWDB Contract Manager no later than the 10th day of each month. Monthly progress reports will outline progress from the previous monthly billing cycle per task, percent accomplished per task, projection of tasks to be performed during the next billing cycle, and address any issues or concerns. Such issues or concerns shall be discussed directly with the TWDB Contract Manager as soon as identified. A copy of the monthly progress report shall also accompany the associated invoice.

Reporting and deliverables for the SAF meetings will include the meeting presentations, a memo discussing the meeting and comments raised, and the attendance sheet. The comments will be discussed with TWDB staff and addressed in a timely manner.

A Draft Source Geodatabase and Draft Conceptual Model Report describing the conceptual model of the northern portion of the Queen City, Sparta, and Carrizo-Wilcox aquifers will be delivered approximately halfway through the project, which is anticipated to be on June 28, 2018. Draft deliverables will be submitted for review and comment by TWDB, and these comments will be addressed in the Final Conceptual Model Report.

A Final Source Geodatabase and Draft Final Conceptual Model Report with revisions as requested by TWDB (and any adjustments as a result of model calibration) that describes the conceptual model of the northern portion of the Queen City, Sparta, and Carrizo-Wilcox aquifers will be delivered no later than June 27, 2019. All final reports will be sealed by a professional geoscientist or engineer licensed to practice in Texas. The Final Conceptual Model Report will be designed with the general public as the audience and the Final Numerical Model Report will be designed with other modelers as the audience.

Our team understands that thorough documentation of the models is extremely important in ensuring their continued use. Therefore, all models developed as part of this project will be thoroughly documented and made available to the public upon completion of the project. Documentation of work performed as part of this project will include the following 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 provided in a format compatible with TWDB databases,
- Source and derived pumpage information calculated for each model grid cell in an ESRI ArcGIS version 10.2 or later file geodatabase format,
- Model input and associated files in MODFLOW-2005, MODFLOW-NWT, and/or MODFLOW-USG (as determined in consultation with TWDB) in ASCII format and Groundwater Vistas (version 6.0 or later) 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.

N. Demonstrate the ability to meet project completion deadlines (as there will be no contract extensions) as well as resources to sustain a project of this size through the duration of the contract.

The staff proposed for this project has demonstrated the ability to meet project completion deadlines and manage resources to sustain a project of this size while executing TWDB Contact No. 1548301854.

GSI consists of nearly 70 technical employees and we have assembled a project team of experts with the unique capabilities to help successfully sustain the project through the duration of the contract. The GSI project team consists of a highly experienced Principal Investigator/Project Manager and Project Administrator, each with 20+ years of experience managing multiple projects of this size or larger. This experience will ensure that the project is adequately staffed and project schedules are constantly monitored. Moreover, GSI has established processes/procedures to quickly respond to multiple and concurrent projects, meet project completion deadlines, and deliver quality, efficient results.

Since our entire project team performs research and development as consultants for a variety of government and private industry clients, we are constantly mindful of staying on schedule and meeting project completion deadlines. Upon award, we will use all of these abilities to allocate appropriate resources and meet project deadlines as outlined in the final scope of work and contract developed for this project.

EXHIBIT B

SCOPE OF WORK

See Pages 34 thru 48 of EXHIBIT A

and

ATTACHMENT 1:

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 fifteen[1] of the sixteen-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, Model Development, 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, investigating faults, revising the model (if appropriate), and/or extending the model calibration period to the unconfined portions of the aquifer(s) that display reactions as if confined,
- 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 forums should be scheduled as follows:

- After the conceptual model report is delivered, and
- After the model has been developed.

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

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 Model Development

The basic steps in model development and completion include:

- Developing the conceptual model,
- Defining the model architecture,
- Calibrating the model,
- Conducting sensitivity analyses, and
- Simulating predictive scenarios.

3.1 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 4.0). 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 4.4 for requirements of the final report.

3.1.1 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.

3.1.2 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.

3.1.3 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.

3.1.4 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 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.

3.1.5 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 (information on the transient calibration period is included in Section 3.3).

The pre-development condition 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.

3.1.6 Recharge

Texas Water Code §36.001, subdivision 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.

3.1.7 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).

3.1.8 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 files, and from 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.

3.1.9 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, discussed, and, if possible, quantified (surface water features are discussed in Section

3.1.7). 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.

3.1.10 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.

3.2 Model Architecture

The models shall all use MODFLOW-2005 or a more recent MODFLOW code with pre-approval from the TWDB contract manager. All models will use MODFLOW components that are freely available (that is, proprietary modules or codes shall not be used). However, the final model (including supporting graphics) shall be fully compatible with Groundwater Vistas 6.0 (or later), a proprietary pre- and post-processor to the MODFLOW code. The final model shall be able to run on a personal computer under the Microsoft Windows-disk operating system (DOS) (Microsoft Windows 2007 or later). Length units for model input will be in feet and time units will be in days.

3.2.1 Cell Size, Orientation, Layering, and Parameter Assignment

The models should be designed to be able to reasonably perform the following objectives:

A. Develop estimates of Modeled Available Groundwater, which is the total volume of water produced on an average annual basis to achieve a desired future condition;
B. Develop values of Total Estimated Recoverable Storage for each aquifer in each groundwater management area. Total Estimated Recoverable Storage is the estimated amount of groundwater within an aquifer that accounts for recoverable storage scenarios that range between 25 percent and 75 percent of the porosity-adjusted aquifer volume; and
C. Develop estimates of the annual amount of recharge from precipitation, if any, to the groundwater resources within each groundwater conservation districts; for each aquifer within the district, the annual volume of water that discharges from the aquifer to springs and any surface water bodies, including lakes, streams, and rivers; and the annual volume of flow into and out of the district within each aquifer and between aquifers in the district.

Lateral grid cell size shall be <u>no greater than</u> one-mile-by-one-mile for the aquifer model. We recommend lateral grid cell size be reduced in order to mitigate model instabilities or if the density of available source data supports a smaller grid size. The grid shall be oriented with the prominent grain of the hydrostratigraphic structure and/or regional groundwater flow paths, as much as possible. The x-y coordinate for the model grid (and the angle of

rotation from true north, if applicable) shall be noted within the model report and noted in the metadata of the geographic information system feature dataset within the geodatabase.

Layers shall be assigned for the models such that layers are:

- either confined or unconfined depending on the position of the water level relative to the top of the formation;
- transmissivity is calculated according to the modeled saturated thickness, and
- layers should correspond to hydrostratigraphic units or groups of hydrostratigraphic units.

Storativity values shall be assigned according to the saturated thickness based on the specific storage values. However, due to limited information in some of the minor aquifers, project managers may elect to use constant transmissivity and storativity layer assignments. Model parameters determined through development of the conceptual model shall be assigned to the appropriate model cells. Spatial data shall be interpolated to model cells using an appropriate interpolation procedure.

3.2.2 Density Flow Models

If applicable to the project, the project managers will conduct their own analysis to select the appropriate spatial and temporal discretization in the model. Variable-density simulation results may be sensitive to grid cell size and time stepping based on the grid-Peclet and Courant number criterion. Therefore, the project manager shall describe the approach that may be used to select the grid cell size in both the horizontal and vertical direction as well as time stepping intervals. In any case, the model grid cell size shall be no more than one mile in the horizontal direction. The project manager shall also describe the process used to select the solver packages for both flow and transport and the solver criterion. In case of convergence issues with the numerical scheme, the project manager shall describe how they may rectify the issues by changing the solver criterion, the grid cell size, the time discretization, or other parameters. Particle tracking schemes such as method of characteristics (MOC) which is part of the transport code, MT3DMS, are discouraged since they are not stringent on mass convergence criterion. The project manager shall provide a detailed explanation if they propose to use particle tracking schemes. The use of flux limiter schemes such as the third order total variation diminishing (TVD) scheme is also discouraged. The total variation-diminishing scheme has a stringent mass balance criterion; however, the solver time stepping is limited thereby making simulations run slower. The project manager shall provide a detailed explanation if they propose to use the flux limiter scheme.

Hydraulic and solute transport property values used for model construction should be based on field measurements and consistent with the conceptual model. It is the project manager's responsibility to review all available data and correctly define the hydraulic and solute transport property values. If certain properties are assigned to the model on a cell-by-cell basis, then spatial data shall be interpolated to model cells using an appropriate interpolation procedure. The project manager must identify whether the storativity or specific storage is used. Additionally, the project manager must document how the specific

storage and dispersivity values are calculated. The project manager must obtain written permission from the Groundwater Availability Modeling section manager to utilize a shallow non-hydrostratigraphic layer(s) for specifically simulating surface water-groundwater interactions.

3.2.3 Cells that Convert to Dry

An HDRY value of 9999 should be utilized to indicate cells that convert to dry.

3.2.4 Recharge and Surface Water

It is extremely important that recharge and surface water-groundwater interaction be modeled in a realistic manner appropriate for historical and future predictive conditions. Constant head cells in recharge zones will not be accepted as an appropriate final method of simulating recharge. The project manager must obtain written permission from the Groundwater Availability Modeling section manager to use a package other than the MODFLOW Recharge package to simulate recharge in the groundwater availability model. The chosen method shall provide recharge for local as well as regional flowpaths and allow for local discharge. The method chosen for simulating recharge must include the concept and effect of rejected recharge as discussed in section 3.1.6. A recharge method that includes rejected recharge will allow the effective recharge (or flow) to the confined aquifer to increase as water levels decline. Some MODFLOW-2005 or later version packages to consider, depending on scale and flow conditions, may include:

- Recharge Package,
- Evapotranspiration Package,
- Evapotranspiration Segments Package,
- Riparian Evapotranspiration Package,
- River Package,
- Stream Package,
- Streamflow-Routing Package,
- Drain Package,
- Drain Return Package, and
- Reservoir Package.

This is extremely important for realistically modeling the effects of withdrawals on water levels in aquifers. Project managers must consider that recharge rates may have changed over time owing to changes in land use and irrigation return flow.

All-important rivers, streams, springs, and reservoirs shall be included in the model and considered realistically, using the appropriate MODFLOW package (for example, the streamflow-routing or river package for rivers and streams and the drain package for springs,). Project managers may use the River or Drain package for rivers and streams if they can demonstrate to TWDB Groundwater Availability Modeling staff that model predictions will not be affected. Similar to recharge (see Section 3.1.6), it is extremely important that rivers and streams are simulated realistically if water levels in the aquifer fall below the base of these rivers or streams (for example, they produce realistic downward fluxes of water).

3.2.5 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.

3.2.6 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. For density flow models, it is recommended that the project manager make an effort to collect total dissolved solids (or surrogate) data corresponding to brackish groundwater pumping for density dependent flow models as it may be helpful in calibrating the model. 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

3.3 Model Calibration

There shall be steady state and transient calibrations of the models. The steady-state calibration shall be performed to predevelopment conditions as defined in section 3.1.5. The mean absolute error or root mean squared error between measured hydraulic-head and simulated hydraulic head shall be less than 10 percent of the measured hydraulic-head drop across the model area for each model layer, and better if possible. The error shall not be spatially biased (For example, not by areas with more control points than other areas). Final calibration results shall report the mean absolute error, root mean squared error and the mean error (Anderson and Woessner, 1992, p. 238-241).

The difference between the total simulated inflow and the total simulated outflow (that is, the water balance) shall be less than one percent and ideally less than 0.1 percent for each model layer within each county. Initial parameters for the models shall be derived from the data generated during the development of the conceptual models. Parameters adjusted

during calibration (for example, recharge, hydraulic conductivity, and vertical hydraulic conductivity) shall be within defensible limits within the framework of the conceptual model such that the resulting model has realistic values and realistic spatial distributions of parameters. Any changes to model parameters must be thoroughly documented in the final report. If unrealistic hydrologic parameters must be used to calibrate the model or the model cannot be calibrated to the above calibration criterion for matching hydraulic head or the error on the water balance, the project manager shall meet with TWDB staff to discuss how to proceed with the model. The TWDB does not want over-calibrated models.

The transient model shall start with the steady-state model for the first stress period and stop at the end of the most recent year with calibration data. Stress periods may be of variable length according to the density of information on pumping and recharge, but the stress periods for the transient historical calibration period shall not be greater than one year. Particular attention shall be paid to accurately representing water levels and fluxes during times of drought and in areas with large drawdowns. Mean absolute error or root mean squared error between measured hydraulic head and simulated hydraulic head should be less than 10 percent of the maximum hydraulic-head drop across the model area and better, if possible, for specified years during the transient calibration period as selected in cooperation with the TWDB (or surrounding years depending on abundance of data) and at the end of the transient calibration period.

The range of hydraulic head fluctuations in the observation wells shall be matched as closely as possible during the transient calibration. Long-term hydrographs comparing measured hydraulic head and simulated hydraulic heads shall be developed and included in the report. The location of the wells used to generate the hydrographs should not biased—spatially or vertically; however, as much as possible the wells selected should provide enough coverage to analyze the calibration of the model on a county level. A plot of the residuals and data points during and at the end of the transient calibration period shall be made for each layer and included in the final report. Larger known fluxes out of the aquifer (for example, springs and base flow to streams) shall also be calibrated and matched to within 10 percent of measured values.

The model shall reproduce the general distribution of water levels and the magnitude of water-level variations in the aquifer. Cross-plots of observed and calculated water levels for all targets at all times will be constructed. Symbols will indicate which model layer or hydrostratigraphic unit each target represents. If it is difficult to see targets per layer then cross-plots of observed and calculated water levels for all targets at all times per model layer will produced. Calibration statistics will be calculated for all times in the entire model and for each hydrostratigraphic unit or model layer.

If the model does not perform well during the calibration period (in other words, if the model error is greater than 10 percent of the maximum hydraulic head drop across the study area during and at the end of the transient calibration period), the calibration and perhaps the conceptual model shall be revisited to improve the fit. It is important that the performance of the model during the calibration period and the strategies employed to improve the fit, if necessary, be thoroughly documented as they offer insight into the

uncertainty of predictions made by the model. It is imperative TWDB staff have a calibrated model in both MODFLOW formatted files and Groundwater Vistas. If the model does not converge, do not select the option in Groundwater Vistas that is labeled "continue MODFLOW simulation even if convergence not achieved". Check the model input datasets (and the conceptual model, if necessary) for errors instead.

A detailed table summarizing the water budget for the entire model and for the individual layers shall be made and included in the final report. This water-budget table shall include:

- recharge to the outcrop,
- gains or losses to rivers in the outcrop,
- discharge to springs at the outcrop,
- other natural discharge to the outcrop (for example, evapotranspiration),
- flow to the confined aquifer (if applicable),
- cross-formational flow,
- discharge to wells, and
- changes in storage.

This table shall include budget information for the steady-state model and transient model. The project managers shall also extract the water budget per county and per groundwater conservation district for the end of the transient calibration. This information, as well as an analysis of how well the model simulates measured targets at the end of the transient calibration per county, shall be included in the final report.

In addition, there shall be an accounting of the number of cells that go dry during a simulation (or water levels that fall below the base of the aquifer), if applicable. The project manager shall have a strategy for addressing dewatered cells during calibration simulations. If the aquifer has not historically gone dry, then the aquifer shall not go dry during the calibration period. If parts of the aquifer have gone dry in the past but have subsequently re-saturated, then the project manager must have a plan for allowing cells in the model to re-saturate or remain saturated.

The steady state and transient calibration models shall be contained in the same model (that is, include the steady-state model as the first stress at the beginning of the transient model). Including the steady-state model as part of the transient model ensures that any changes made to the model during the transient calibration will propagate to the steady-state model. It is important to verify that once the steady state and transient calibration models are combined that a sufficient number of stress periods are included to transition from little to no pumpage in the predevelopment steady-state to the transient calibration model. It is also important to confirm that steady state has been achieved as changes are made during the transient calibration and propagated to the steady-state model.

3.4 Sensitivity Analysis

After the steady state (predevelopment or pre-desalination conditions for density flow models) and transient models are calibrated, a sensitivity analysis on each major parameter in the model shall be performed (see, for example, Mace and others, 2000; Anderson and

Woessner, 1992, Figure 8.15). Sensitivity analysis quantifies the uncertainty of the calibrated model to the uncertainty in the estimates of aquifer parameters, stresses, and boundary conditions (Anderson and Woessner, 1992, p. 246) and is an essential step in modeling (Freeze and others, 1990). Sensitivity analysis assesses the adequacy of the model with respect to its intended purpose (ASTM, 1994) and can offer insights into the non-uniqueness of the calibrated model. Sensitivity analysis also identifies which hydrologic parameters most influence changes in water levels, flows to springs, streams, and rivers, and can identify parameters that justify additional future study.

Sensitivity analysis shall be performed by globally adjusting each model parameter and assessing its impact on water levels and fluxes (for example, spring flow, base flow, and cross-formational flow). Model parameters include:

- Horizontal hydraulic conductivity,
- Vertical hydraulic conductivity,
- Confined storativity,
- Specific yield,
- Recharge,
- Pumping,
- Hydraulic head assigned at any constant head and general head boundaries,
- Conductance values for drains, rivers, general head boundaries, or any other packages for each layer,
- Hydrodynamic dispersion through dispersivity values (density flow models),
- Initial total dissolved solids values (density flow models),
- Boundary conditions for transport models, and
- Grid discretization or an explanation of how it is optimized and does not have a significant impact on model results.

Model parameters shall be adjusted plus or minus 10 percent and plus or minus 50 percent from calibrated values and the mean error between the calibrated water levels and the simulated water levels as well as mean normalized absolute errors between simulated and measured total dissolved solids for density dependent values at the calibration points for the adjusted parameter shall be determined (for example, see Anderson and Woessner, 1992, Figure 8.15). Where appropriate, the sensitivity of the model to order-of-magnitude changes in model parameters shall be conducted (for example, confined storativity). Results of the sensitivity analysis shall be presented as in the Mace and others (2000) report on the groundwater model developed for the Trinity (Hill Country) Aquifer. A similar sensitivity analysis shall be done for transient simulations where the impacts of varying flow and transport parameters on water level (and water quality fluctuations in density flow models) will be demonstrated. Sensitivity analyses on different conceptual models (for example, recharge, pumping distribution, and boundary conditions) are encouraged where appropriate. Additional sensitivity analyses to address sub-regional or local issues are encouraged (for example, a specific stream or near a water-pumping center). Sensitivity analyses on groups of parameters (such as adjusting recharge and hydraulic properties or transport properties together) are also strongly encouraged.

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 calculated for each model grid cell in an ArcGIS version 10.2 or later file geodatabase format,
- Model input and associated files in both MODFLOW-2005 or more recent version (with TWDB approval) in ASCII format and Groundwater Vistas (version 6.x) 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 draft model/calibration report, and
- The final model/calibration report, and
- Predictive scenarios report, if applicable.

Project managers shall deliver four hard copies of the draft conceptual report, eight copies of the final conceptual report, four hard copies of the final draft report, and then eight hard copies of the final report (see contract for any exceptions). All files and data shall be transferred to the TWDB in ready-to-use format. 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),

- Turn-key models—Groundwater Vistas (version 6.x), MODFLOW-2005 or more recent version, and SEAWAT (version 4) or more recent versions (if applicable)—ASCII data files, 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 Environmental Systems Research Institute 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, 4.4, 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's 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;
- Tabular data for dispersivity (for density flow projects) and initial TDS values (for density flow projects) and their units of measure;
- Raw data and plots used to calculate hydraulic conductivity, transmissivity, and storativity and their units of measure;
- Raw data and plots used to calculate dispersivity (for density flow projects) and initial TDS values and their units of measure;
- Geographic information system raster and/or feature datasets of the distributions of transmissivity, hydraulic conductivity, dispersivity 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, dispersivity 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 Model Files

4.3.1 MODFLOW-2005 input files

All MODFLOW-2005 or more recent version input files shall be submitted in ASCII format and the file format for Groundwater Vistas 6.0 or later. The files for Groundwater Vistas shall also include ESRI geographic information system shape files of the:
- Model boundary,
- County outlines,
- Rivers, streams, reservoirs, and other hydraulic features simulated in the model, and
- Boundary conditions with their input parameters including pumping wells and available injection wells.

In addition, an attributed grid file shall be developed using data requested thru the Contract Manager. A table listing each stress period and corresponding time frame will be provided with the model files. In addition all targets used for calibration will be identified and clearly marked so verification of statistics may be performed.

Future users shall be able to:

- run the model using MODFLOW-2005 from the command prompt with the files provided,
- run the model using Groundwater Vistas with the Groundwater Vistas files provided, and
- Results should match and agree using MODFLOW and Groundwater Vistas.

4.4 Final Reports

The final reports shall include the details of the conceptual model, input datasets, model construction, calibration, sensitivity analysis, and model results. There may be up to three or more final reports—conceptual model report, model calibration report, predictive scenarios report, and/or special studies. 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/).

4.4.1 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 onto 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% of the original, the reference source shall be preceded by the word “after”,
    - for illustrations modified more than 15% 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 **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 provides 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 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
See Appendix A Section 3.1.1 and 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

See Appendix A Section 3.1.2 and 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 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 3.1) in the following subsections:

4.1 Hydrostratigraphy and Hydrostratigraphic Framework

See Appendix A Sections 3.1.3 and 3.1.4 and 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

See Appendix A Section 3.1.5 and 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, and

- 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

See Appendix A Section 3.1.6 and 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

See Appendix A Section 3.1.7 and include the following figures:

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

4.5 Hydraulic Properties

See Appendix A Section 3.1.8 and 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

See Appendix A Section 3.1.9 and 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 summed over each county shall be included in the report,
- 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,
- Location of existing desalination plants, as applicable to the project, and
- Location of Class II injection wells with permits to store within the model domain, as applicable to the project.

4.7 Water Quality

See Appendix A Section 3.1.10 and 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 will 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 TWDB format.

At a minimum, the **final model report** shall include the following sections and subsections and shall be designed with a groundwater modeler as the audience:

Executive summary

Provide a brief summary of the model development and calibration.

1.0 Introduction and Purpose of the Model

Describe the importance of the GAM program, how the model relates to planning for groundwater resources, and provides a general outline of the modeling study and

report. Includes the following maps:

- Location map of study area/related aquifer(s) within model domain.

2.0 Model overview and packages

Briefly describe the conceptual model and the associated block diagram from the conceptual model report (see Section 5.0 of the CONCEPTUAL MODEL REPORT). If changes have been made since the conceptual model report, the project manager must document these changes and provide data and analyses to support the changes. The project manager also needs to explain how the conceptual model is translated to the numerical model.

Final block diagram showing the hydrogeologic units and summarizing the flows within the model and how the conceptual model was translated into the computer model (for example, see Mace and others, 2000, fig. 50) updated with any changes (from the conceptual model report), if needed.

2.1 Basic (BAS) Package

Includes the following maps:

- Maps showing the location of active/inactive cells in each of the model layers and related hydrogeologic units.

2.2 Discretization (DIS) Package

Includes the following table and figures:

- Table of stress periods with time interval and related year and/or month, and at least two cross-section figures (perpendicular to each other) showing the numerical layers and related hydrogeologic units.

2.3 Layer-Property Flow (LPF) Package

Includes the following maps and tables:

- Map of each of the property values for all model layers used by the layer-property flow (LPF) package,
- Tables of statistic summary of all property values at model cells used by the LPF package and their comparison with the related field measurements and conceptual model, and
- If different zones are used for the same hydrogeologic unit, the summary table(s) shall also reflect the zones.

2.4 Well (WEL) Package

Includes the following map and table(s):

- Map(s) showing well location and if possible extraction/injection rate per model cell for each model layer for the selected stress period(s),
- Table of total pumping (i.e., groundwater extraction) per county per stress period for each layer,
- Table of total injection per county per stress period for each layer, if applicable, and
- Include total dissolved solids data, as applicable.

2.5 Drain (DRN) Package

Includes the following map and table:

- Map showing the drain locations and type of hydraulic features simulated by drains within each model layer, and
- Summary table of drain heads and conductance values as well as associated model layer/row/column and hydraulic features.

2.6 General-Head Boundary (GHB) Package

Includes the following map and table:

- Map showing the general head boundary (GHB) location and type of hydraulic features simulated by the GHB within each model layer,
- Table of GHB head and conductance values as well as associated model layer/row/column and hydraulic features, and
- Include total dissolved solids data, where applicable.

2.7 Recharge (RCH) Package

Includes the following maps and tables:

- Map(s) showing distribution of total recharge for the selected stress period(s). The associated model layers and hydrogeologic units that receive the recharge must be identified on the maps. In addition, different types of recharge shall also be presented on separate maps;
- Table(s) of total recharge per county per stress period for each type of recharge, if applicable; and
- Include total dissolved solids data, where applicable.

2.8 River (RIV) Package

Includes the following maps and tables:

- Map(s) showing locations of streams or rivers in the model within each model layer,
- Table(s) of water level, riverbed elevation, stream flow as well as other input information for each of the streams or rivers in the model, and
- Include total dissolved solids data, where applicable.

2.9 Evapotranspiration (EVT) Package

Includes the following maps and tables:

- Map(s) showing distribution of ET rates and any other pertinent information within each model layer, and
- Table(s) showing average root depths for vegetation types.

2.10 Time-Varying Constant Head (CHD) Package (for Transport Models)

Includes the following maps and tables:

- Map(s) showing locations of time-varying constant head cells in the model within each model layer,

- Table(s) of equivalent freshwater heads or heads with respect to start and end of stress period information, and
- Include concentration/density data, where applicable.

2.11 Output Control File

Project manager can use either words or numeric codes to specify the output control file. The output control file shall define at least head and cell-by-cell flux saved per stress period. If multiple time steps are used for a stress period, the last time step of the stress period should be used to save the model outputs. The budget files should be saved as non-compact format and the output control file shall be consistent with the name file if numeric codes are used.

2.12 Flow and Transport Solver Packages (SIP, SOR, PCG, GCG, as applicable)

Includes the following information:

- Type of solver for flow simulation,
- Head change and residual convergence criteria,
- The criteria shall be chosen small enough to ensure the volumetric mass balance for each stress period to meet the calibration goals as described in the "Model Calibration" section,
- Type of solver for transport simulation (if applicable),
- Concentration change and residual convergence criteria, and
- The criteria shall be chosen small enough to ensure the mass balance for each stress period to meet the calibration goals as described in the "Model Calibration" section.

2.13 Basic Transport (BTN) Package, (for density-dependent models)

Includes the following information:

- Basic overview and explanation of the parameters selected, and
- An explanation of the time-stepping parameters.

2.14 Advection (ADV) Package, (for density dependent models)

Includes the following information:

Explanation of the coupling criterion selected.

2.15 Dispersion (DSP) Package, (for density dependent models)

Includes the following information:

Basic overview and explanation of the parameters selected.

2.16 Source/Sink Mixing (SSM) Package, (for density dependent models)

Includes the following information:

- Map(s) showing locations of source/sink boundary types within each model layer;
- Table(s) of various source/sink boundary types in the model; and
- Include total dissolved solids/concentration data, where applicable.

2.17 Variable-Density Flow (VDF) Package, (for density dependent models)
Includes the following information:
Basic overview and explanation of the parameters selected.

2.18 Viscosity (VSC) Package, (for density dependent models)
It is recommended that the project manager use the viscosity package and include the following information:
Basic overview and explanation of the parameters selected.

For all of the input parameters used by the SEAWAT packages described above, project manager must document how the parameters are defined and if the parameters are consistent with the conceptual model. Project manager must contact the TWDB first before inconsistent parameters may be used for the model construction and calibration. If other SEAWAT package(s) would be used, project manager shall first consult the TWDB and expects to follow the same guidelines as described above. For all SEAWAT input packages, TWDB will only accept files configured as standard U.S. Geological Survey MODFLOW/SEAWAT files. The models delivered should be able to run using a command line and Groundwater Vistas and produce the same results.

3.0 Model Calibration and Results
This section should summarize the procedure/method used for model calibration and calibration results (see Appendix A Section 3.3). Model calibration shall include both steady-state and transient conditions. Details shall be included in the sub-sections 3.1 through 3.6.

3.1 Calibration Procedure
- Project manager shall consult with contract manager on the calibration targets and time period before proceeding with the calibration of the model.
- Project manager shall recommend to contract manager, measured or calculated targets to be used for the model calibration. Calibration targets shall then be selected by the contract manager in consultation with the project manager.
- Project manager shall do a further QA/QC on the agreed upon calibration targets and select the reliable ones out of the agreed upon calibration targets for final model calibration. If the number of final calibration targets differ from the number of agreed upon targets by more than 20 percent, the project manager shall consult with the contract manager (who may request for more calibration targets to be selected) before proceeding with the calibration.
- Project manager shall provide reasoning for eliminating agreed upon calibration targets from the final calibration.
- Project manager shall describe parameters adjusted during calibration of the model (for example, recharge, dispersivity, initial water quality (total dissolved solids) input, grid discretization, hydraulic conductivity, storativity, vertical hydraulic conductivity).

3.2 Model Simulated Versus Measured Heads
- Map(s) showing locations of head targets per model layer;

- Scatter plots of simulated hydraulic head and measured hydraulic head for all head targets with statistic summary of residuals on the plots or in separate tables;
- Scatter plot of simulated hydraulic head and measured hydraulic head per layer with statistic summary of residuals on the plots or in separate tables;
- For transient model, scatter plots shall be used for selected stress periods approved by the Maps showing the head residuals at head target locations per layer for selected stress periods approved by the TWDB;
- Histogram of the frequency of residuals in each model layer;
- Hydrographs at head targets with both simulated and measured heads;
- Maps showing the simulated head contours and flow directions superposed on measured/interpolated head contours;
- Project manager must show that the calibration is not biased laterally and vertically, and the simulated regional groundwater flow is consistent with the measurement and the conceptual model; and
- Maps showing the change of water levels between pre-development and the beginning of the transient and the change of water levels between pre-development and the end of the transient.

3.3 Model Simulated Versus Measured Fluxes

- Map(s) showing locations of flux targets (such as springs, seeps, and so on) per model layer;
- Scatter plots of simulated versus measured flux for all flux targets with statistic summary of residuals on the plots and in separate tables;
- Scatter plot of simulated versus measured flux per layer with statistic summary of residuals on the plots or in separate tables; and
- Hydrographs at flux targets with both simulated and measured fluxes.

3.4 Model Simulated Water Budgets

Also discuss water budget by county or surrounding state/country and groundwater conservation districts included in Model Report Appendix A.

- Mean error, mean absolute error for mass balances throughout entire simulation and discussion in case of higher than anticipated values,
- Table of steady-state calibration net water budget overall and summed per aquifer layer(s), and
- Figures of transient overall net water budgets by flow component and subdivided by summed aquifer layer(s).

4.0 Sensitivity Analysis

See Appendix A Section 3.4.

4.1 Procedure of Sensitivity

Describe approach used for sensitivity analysis.

4.2 Results of Sensitivity Analysis

- Sensitivity plots of how water levels or appropriate fluxes (for example, base flow, spring flow) are affected by changes in all aquifer parameters (see Mace and others, 2000, for the format of the plot) including transport parameters such as dispersivity (if applicable). Also include additional plots, as applicable, discussed in Section 3.4; and
- Several hydrographs and long-term salinity graphs (for density dependent models) demonstrating the sensitivity of water level and flux fluctuations to changes in important hydrologic and transport properties of the model (if applicable), also include additional plots, as applicable, discussed in Section 3.4.

5.0 Model Limitations

Discuss the limitations of the model. A general description of where and for what the model is applicable is needed as well as a discussion of how assumptions might affect model results, especially how they relate to predictions of water levels.

6.0 Summary and Conclusions

Summarize the modeling project and its results.

7.0 Future Improvements

Indicate where additional improvements could be made to the model. Recommendations for how these issues could be addressed will be appreciated.

8.0 Acknowledgments

Acknowledge those organizations or specific individuals that assisted in the modeling project.

9.0 References

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

APPENDIX A

Water budgets by county, groundwater conservation district, and layer.

APPENDIX B

- Tables including head target name, coordinate, well depth, modeled head, measured head, head residual, land surface elevation, and associated model layer/row/column/stress period/date;
- Head hydrographs for individual head targets including measured values presented as dots and modeled values presented as line;
- Tables including flux target name, coordinate (if applicable), modeled flux, measured flux, flux residual, land surface elevation (if applicable), and associated model layer/row/column/stress period/date/hydraulic feature;
- Flux hydrographs for individual flux targets including measured values presented as dots and modeled values presented as line;

- Total dissolved solids hydrographs for individual salinity targets including measured values presented as dots and modeled values presented as line, as applicable; and
- Other calibration results.

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),
- Stream flows and reservoir releases in cubic feet per second (cfs),
- Spring flow 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.

4.4.2 Report Deliverables

There are three 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 4.4.1),
- After completion of the transient model, if applicable, draft report(s) shall include information listed in Section 4.4.1 for the Model Calibration Report, if applicable, and
- After completion of the project (final conceptual model and numerical modelreports shall include information listed in Section 4.4.1).

For the draft conceptual model report, and then later for the draft model and predictive scenarios reports (if applicable), 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 2),
- Model input files for model calibration and predictive scenarios, if applicable (for SEATWAT and/or MODFLOW-2005 or more recent version and Groundwater Vistas with the draft report deliverable), 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:
- Eight (8) hard copies of the final conceptual model and numerical model reports;
- Digital copies of the final conceptual, model, and predictive scenarios reports including all figures (in Word 2010 format);
- Adobe Acrobat (pdf) file(s) of the final conceptual model and numerical model 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 4.1 for details);
- All source and derived model data in digital format in the appropriate geodatabase (see Attachment 1);
- Model input files (for SEAWAT, version 4, or a later version and/or MODFLOW-2005 or a later version and for Groundwater Vistas 6.x or a later version);
- All computer programs (source code and executable) that are used during the model development; and
- For models contracted out by the TWDB, a software application that extracts and manipulates water budgets to satisfy the groundwater districts' management plan reporting requirements. Per Texas State Water Code, Section 36.1071, Subsection (h), the application shall extract at a minimum the following budget terms:
    - the annual amount of recharge from precipitation to the groundwater resources within the district, if any;
    - for each aquifer within the district, the annual volume of water that discharges from the aquifer to springs and any surface water bodies, including lakes, streams, and rivers; and
    - the annual volume of flow into and out of the district within each aquifer and between aquifers in the district.

It is important to us 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.

4.4.3 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, SEAWAT and/or MODFLOW files, 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.

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 consultant on occasion to gauge progress on the project. These important points include:

- Beginning of the project;
- After interim study, as applicable;
- After draft conceptual model update;
- After model calibration; and
- After we have reviewed the draft final deliverables.

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 [see Appendix A Section 4.4.1]) 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.

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

Freeze, R. A., Massmann, J., Smith, L., Sperling, T., and James, B., 1990, Hydrogeological decision analysis- 1. 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

1.0 Introduction

The purpose of this document is to describe the required format of contract reports submitted to the Texas Water Development Board (TWDB). Our reason for standardizing the format of contract reports is to provide our customers a consistent, and therefore familiar, format for contract reports (which we post online for public access). Another reason for standardizing the format is so that we can more easily turn a contract report into a TWDB numbered report if we so choose. Remember that your report will not only be seen by TWDB staff, but also by any person interested in the results of your study. A professional and high quality report will reflect well on you, your employer, and the TWDB. Available upon request, we will provide a Microsoft Word template (used to write these instructions) that gives the fonts, spacing, and other specifications for the headings and text of the report. Please follow this template as closely as possible.

2.0 Formatting your report

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

2.1 Text

The best way to format your document is to use the styles described and embedded in the template document (Authors_Template.dot) that is available on request from the TWDB. To use the Authors_Template.dot file, open it in Word (make sure *.dot is listed under Files of type) and save it as a .doc file. Advanced users can add the .dot file to their computers as a template.

Make sure the formatting bar is on the desktop (to open, go to View→Toolbars→Formatting) or, to view all of the formatting at once, go to Format→Styles and Formatting and select Available Styles from the dropdown box at the bottom of the window. The formatting in the template document provides styles (such as font type, spacing, and indents) for each piece of your report. Each style is named to describe what it should be used for (for example, style names include Chapter Title, Body Text, Heading 1, References, and Figure or Table Caption). As you add to your report, use the dropdown list on the Formatting Toolbar or the list in the Styles and Formatting window to adjust the text to the correct style. The Authors_Template.dot file shows and lists the specifications for each style.

2.1.1 Title

Give your report a title that gives the reader an idea of the topic of your report but is not terribly long. In addition to the general subject (for example, "Droughts"), you may include a few additional words to describe a place, methodology, or other detail focused on throughout the paper (for example, "Droughts in the High Plains of Texas" or "Evaluating the effects of drought using groundwater flow modeling"). Please capitalize only the first letter of each word except 'minor' words such as 'and' and 'of'. Never use all caps.

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

2.2 Figures and photographs

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

All graphics shall be submitted in two forms:

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

2.2.1 Other graphics specifications

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

2.2.2 Creating publication-quality graphics

When designing a graphic, make sure that the graphic (1) emphasizes the important information and does not show unnecessary data, lines, or labels; (2) includes the needed

support material for the reader to understand what you are showing; and (3) is readable (see Figures 1 and 2 for examples). Edward R. Tufte's books on presenting information (Tufte, 1983; 1990; 1997) are great references on good graphic design. Figures 1 through 3 are examples of properly formatted, easy to understand graphics. Do not include fonts that are less than 6 points.

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

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

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

2.2.3 Using other people's graphics

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

2.3 Tables

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

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

Table Text	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, 2 sheets.
Mace, R. E., Chowdhury, A. H., Anaya, R., and Way, S.-C., 2000, A numerical groundwater flow model of the Upper and Middle Trinity aquifer, Hill Country area: Texas Water Development Board Open File Report 00-02, 62 p.
Maclay, R. W., and Land, L. F., 1988, Simulation of flow in the Edwards aquifer, San Antonio Region, Texas, and refinements of storage and flow concepts: U. S. Geological Survey Water-Supply Paper 2336, 48 p.
For more examples of references, see p. 239-241 of "Suggestions to Authors of the Reports of the United States Geological Survey" at http://www.nwrc.usgs.gov/lib/lib_sta.htm.

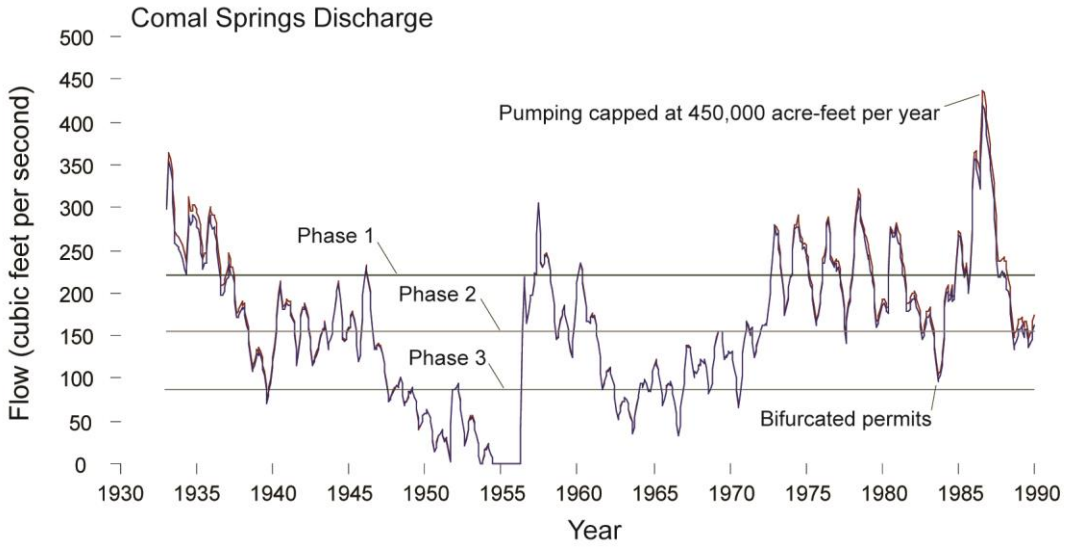

Figure 1. A sample figure showing only the information needed to help the reader understand the data. Font size for figure callouts or labels should never be less than 6 point.

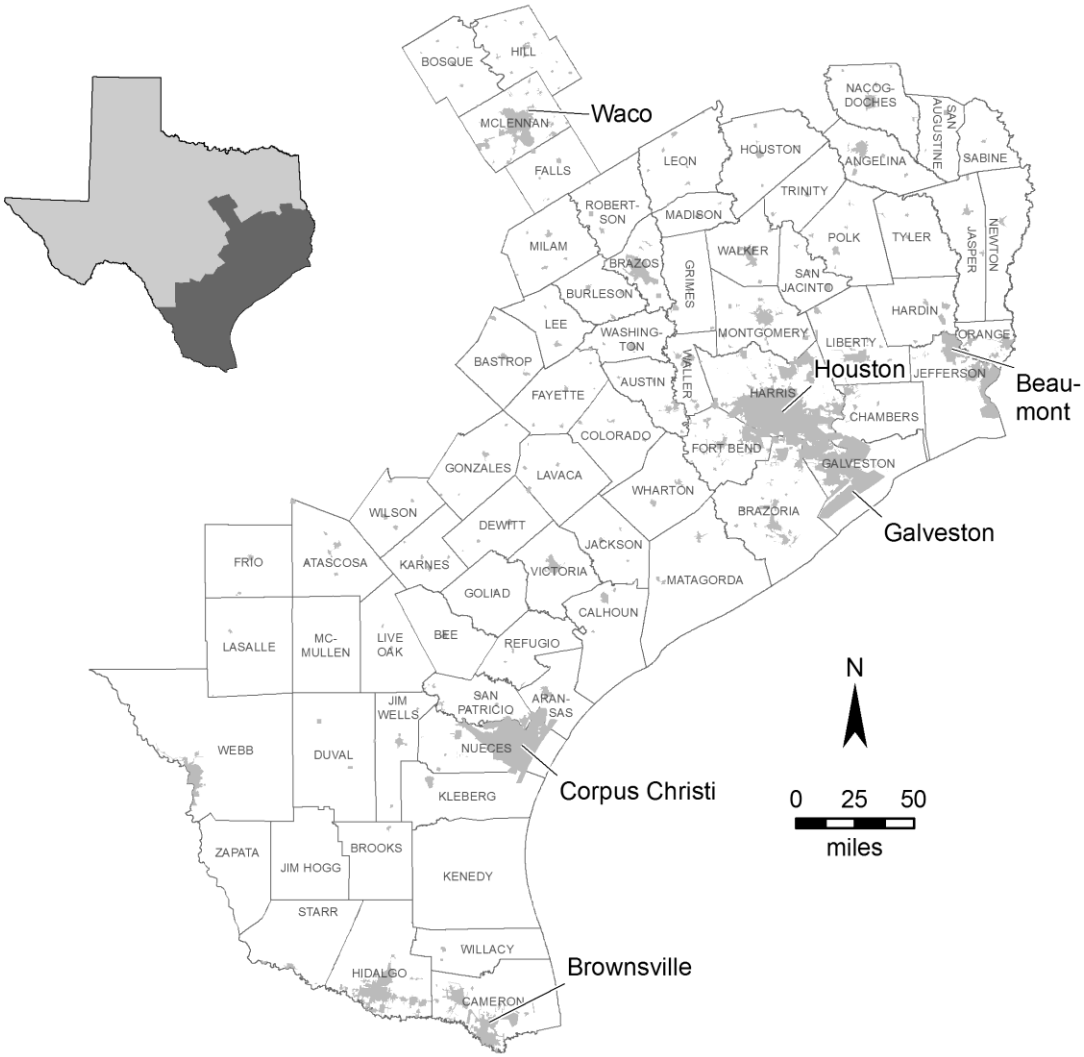

Figure 2. A sample subject area map, giving the reader enough information to understand the location being discussed in this conference. For map figures, be sure to include a north arrow to orient the reader, a scale, and, if needed, a submap that places the figure in greater geographic context. Be sure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

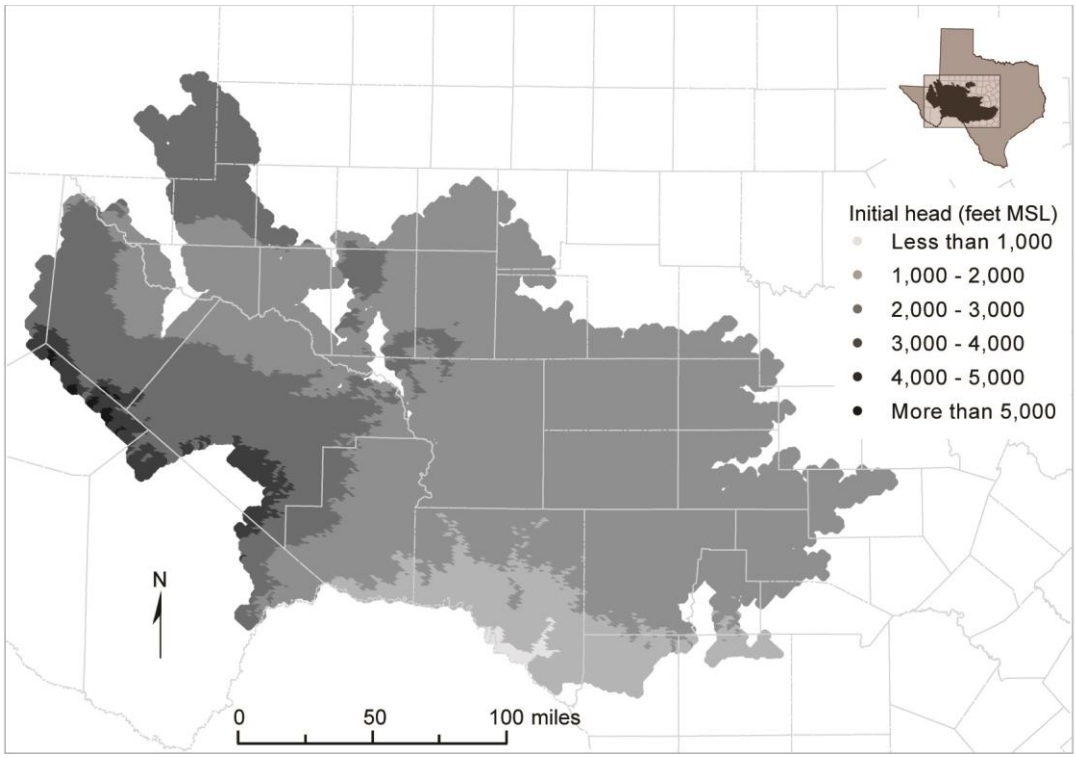

Figure 3. Initial hydraulic heads used in model simulations for layer 1. Note the use of grayscale shading to show differences.

EXHIBIT C

TASK AND EXPENSE BUDGETS

TASK BUDGET

TASK	DESCRIPTION	AMOUNT
1	Conceptual Model Development	$276,000.00
2	Numerical Model Development	170,500.00
3	Model Calibration and Sensitivity Analysis	194,000.00
4	Meetings and Reporting	159,500.00
TOTAL		**$800,000.00**

EXPENSE BUDGET

CATEGORY	AMOUNT
Salaries & Wages[1]	$77,146.95
Fringe[2]	111,901.65
Travel[3]	5,000.00
Other Expenses[4]	0.00
Subcontract Services	505,000.00
Overhead[5]	28,678.67
Profit	72,272.73
TOTAL	**$800,000.00**

[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/)