REQUEST FOR QUALIFICATIONS NO. 580-22-RFQ-0009

FOR

DEVELOPMENT OF NUMERICAL MODEL FOR THE CROSS TIMBERS AQUIFER

CLASS-ITEM CODE(S): 961-95 MODELING SERVICES

RELEASE DATE: APRIL 6, 2022

DEADLINE FOR SUBMISSION: MAY 18, 2022, NO LATER THAN 2:00 PM (CST)

Solicitation Point of Contact:
Lauren Grooms-Meyers, Contract Specialist
lauren.grooms-meyers@twdb.texas.gov

You, the Respondent, are responsible for checking the Electronic State Business Daily (ESBD) website, http://www.txsmartbuy.com/esbd, for any addenda to this Solicitation. Please search under Agency Code 580 (Texas Water Development Board). Respondent's failure to periodically check the ESBD will in no way release that Respondent from addenda or additional information resulting in additional requirements of the Solicitation

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SECTION I – EXECUTIVE SUMMARY, DEFINITIONS AND AUTHORITY

1.1 EXECUTIVE SUMMARY

The Texas Water Development Board (TWDB) requests responses to this Request for Qualifications for the award of developing the Cross Timbers Aquifer Numerical Model ("the Project"). The Cross Timbers Aquifer was designated as a new minor aquifer in December 2017. The aquifer consists of six Paleozoic-age water-bearing formations including, from oldest to youngest, the Atoka, Strawn, Canyon, Cisco, Wichita, and Clear Fork groups. The aquifer is primarily composed of limestones, shales, and sandstones.

The Project will develop the numerical model using either MODFLOW-USG (Panday and others, 2017) or MODFLOW 6 (Langevin and others, 2021). The Project will use the structural framework, study area, proposed aquifer extent, and model grid produced in the Cross Timbers Conceptual Model (Blandford and others, 2021). The structural model framework will be verified and documented by analyzing available well logs and/or geophysical logs. Four milestone meetings and reviews between the consultant and TWDB staff will be scheduled as follows: after the draft model design is completed; after the draft transient model is calibrated; at the completion of the draft final report; and after comments on the draft report have been addressed.

At a minimum, the model must be calibrated from 1980 to 2020 and the first stress period must be steady-state. Model statistics must be analyzed for the unconfined and confined model layers over the entire model domain. The model must be tested to ensure it meets objectives of the Groundwater Modeling Program as outlined in Appendix A. A predictive simulation using current modeled available groundwater estimates must be run for Groundwater Management Areas 6, 7, and 8. Additionally, water budgets must be completed and reported for each county in Groundwater Management Areas 6, 7, and 8 for the final stress period and for the entire model domain. The historical average water budget for each groundwater conservation district must be reported per Texas Water Code, Section 36.1071, Subsection (h).

The contract has several contractual deliverables which are described further in Section II and Section III. These deliverables include monthly progress reports, stakeholder communication presentations and summaries, and various model files as described in Section III. There are four formal contractual document deliverables: the draft Model Design; the draft transient calibrated model; the draft final Model Report; and the final Model Report. These documents are described in detail in Appendix A (Section 3.4.2).

TWDB will consider qualifications from business entities that demonstrate the ability to complete the Project within the guidelines of this Solicitation and any applicable federal, state, and local laws, rules, and regulations. Respondents must execute **Content Item 1**, *Execution of Response to the Request for Qualifications*, and complete other items listed under 4.1.B, Contents, to be considered. Additional information on TWDB and its programs can be found at http://www.twdb.texas.gov

1.2 DEFINITIONS

"Addendum" means a written clarification or revision to the Request for Qualifications issued by the Texas Water Development Board. Respondents must acknowledge receipt of any addenda in the submission of the Solicitation Response.

"BRACS" means Brackish Resources Aquifer Characterization System

"Contract Documents" means all documents which govern this Solicitation and any resulting contract including without limitation, the Project Manual, this Solicitation, the Architect/Engineer's specifications and drawings, the Uniform General and Supplementary Conditions, Special Conditions, and all bonds and insurance.

"Contractor" means Respondent(s) awarded a contract under this Solicitation.

"ESBD" means the Electronic State Business Daily, http://www.txsmartbuy.com/esbd.

"ESRI" means Environmental Systems Research Institute.

"GAM" means Groundwater Availability Model, or Groundwater Availability Modeling.

"HUB" means Historically Underutilized Business as defined byTexas Government Code Chapter 2161.

"HUB Subcontracting Plan" or "HSP" means the form required by Texas Government Code §2161.252 and 34 Texas Administrative Code §20.285 for each contract with an expected value of $100,000 or more, in which Respondent must demonstrate a Good Faith Effort to subcontract with HUBs. The HSP must be included with the Solicitation Response.

"PIA" means the Public Information Act, Texas Government Code Chapter 552

"Project" means all work solicited under this Solicitation.

"Respondent" means the entity responding to this Solicitation.

"RFQ" means Request for Qualifications.

"Solicitation" means this RFQ.

"Solicitation Response" means Respondent's entire response to this Solicitation, including all documents requested.

"SOQ" means Statement of Qualifications, the Respondents response to the RFQ requirements as stated in section 2.2.

"Stakeholder" means a person with an interest or concern in the results of the Cross Timbers Numerical Model.

"State" means the State of Texas and any state agency; the Texas Water Development Board or state agency identified in this Solicitation, its officers, employees, or authorized agents.

"TAC" means Texas Administrative Code.

"TWDB" means the Texas Water Development Board.

1.3 AUTHORITY

TWDB is posting this Solicitation pursuant to the State Purchasing and General Services Act, Texas Government Code Chapter 2151; Texas Water Code § 6.190; and Texas Water Code, § 16.012.

1.4 CONTRACT TERM

Service for the Project must begin upon execution of the Contract and be completed within two years. Any changes to the Project completion date are at the sole discretion of TWDB. Early submittal of completed deliverables is permissible after approval from the TWDB assigned contract manager and with at least one months' advance notification.

1.5 BACKGROUND

TWDB GAMs are computer-based, three-dimensional, numerical groundwater flow models used to simulate groundwater flow systems at a regional scale. The models are based on hydrogeologic principles, actual aquifer measurements, and input from stakeholders. By statute, TWDB is tasked with developing numerical groundwater flow models of the major and minor aquifers in Texas.

The selected Contractor will primarily perform hydrogeologic model development, model calibration, and predictive model simulations. TWDB plans to select a Contractor with expertise in areas including but not limited to geology, hydrology, programming, modeling, database administration and documentation, multivariate statistics, and technical writing.

1.6 REFERENCES

Blandford, T.N., Clause, V., Lewis, A., Standen, A.R., Donnelly, A., Calhoun, K., Botros, F., and Umstot, T. 2021, Conceptual Model Report for the Cross Timbers Aquifer.

Langevin, C.D., Hughes, J.D., Banta, E.R., Provost, A.M., Niswonger, R.G., and Panday, Sorab, 2021, MODFLOW 6 Modular Hydrologic Model version 6.2.2: U.S. Geological Survey Software Release, 30 July 2021 https://doi.org/10.5066/F76Q1VQV

Panday, Sorab, Langevin, C.D., Niswonger, R.G., Ibaraki, Motomu, and Hughes, J.D., 2017, MODFLOW-USG version 1.4.00: An unstructured grid version of MODFLOW for simulating groundwater flow and tightly coupled processes using a control volume finite-difference formulation: U.S. Geological Survey Software Release, 27 October 2017, https://dx.doi.org/10.5066/F7R20ZFJ

2.1 SCOPE OF SERVICES REQUESTED

The awarded Contractor may be required to complete some or all of the following tasks:

A. Project Management: In addition to oversight of the project, monthly progress reports must be produced and provided to the TWDB assigned contract manager no later than the 5th business day of each month. Monthly progress reports must outline progress from the previous monthly billing cycle per task, percent accomplished per task, projection of tasks to be performed for the next billing cycle, and any issues or concerns. Any issues or concerns must be discussed directly with the TWDB-assigned contract manager as soon as possible. At a minimum, TWDB staff expects to meet with the project team at the beginning of the project, when the draft model design is completed, when the draft transient model is completed, and after the draft final model is completed. Coordination with TWDB staff will be critical throughout the project. Additional meetings or teleconferences must be arranged as needed throughout the project.

B. Stakeholder Communication: Stakeholder participation is critical to the success of the (GAM) 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. At least two stakeholder meetings must be held: at the beginning of the project and after the final draft deliverables are submitted. Additional stakeholder meetings may be required and will be added per agreement with the TWDB contract manager. An attendance sign-up sheet including attendees' name, affiliation, and contact information must be provided and completed at each stakeholder meeting. At a minimum, GAM Standards must be followed (Appendix A). Memo reports submitted to TWDB (in Microsoft Word and Adobe Acrobat-compatible formats) must summarize the presentation, the questions and comments that arose from stakeholder advisory forum attendees, how the questions were or will be addressed, and the list of attendees and their affiliation. These memo reports will be posted on the TWDB website for public viewing along with the presentation in .pdf format. All stakeholder materials to be posted on the TWDB website must comply with Web Content Accessibility Guidelines (WCAG) 2.0 and PDF/UA (Universal Access, or ISO 14289) or later.

C. Model Design: The model design must include the grid node attributes to ensure model output will be compatible with official state boundaries, preliminary model files (in MODFLOW and Groundwater Vistas), draft chapters introducing the purpose of the model, updates to the conceptual model, and the model overview and packages utilized of the Numerical Model Report, and final GAM Source geodatabase with metadata.

D. Model Calibration: The transient model must start with the steady-state model for the first stress period and stop at the end of the most recent year with calibration data (at least to 2015). Particular attention must be paid to accurately representing water levels and fluxes during times of drought and in areas with large drawdowns. At a minimum, GAM Standards must be followed (as outlined in Appendix A).

E. Model Objective Testing: Predictive simulation using the current modeled available groundwater estimates must be run for Groundwater Management Areas 6, 7, and 8. In

addition, water budgets per county for the final stress period and for the model domain must be completed and reported, as well as the historical average water budget for each groundwater conservation district per Texas Water Code § 36.1071(h). GAM Standards must be followed (as outlined in Appendix A).

F. Documentation and Deliverables: See Section III.

2.2 REQUIREMENTS

Respondents to this RFQ are required to have the following knowledge, skills, and abilities:

A. Project staff experience in technology transfer including staying on schedule and within budget.

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

C. Experience with and knowledge of documenting geophysical logs.

D. Experience with MODFLOW-USG or MODFLOW 6 code and Groundwater Vistas.

E. Demonstrated approach for investigating, documenting, and modeling framework, aquifer geometry, groundwater-surface water interactions, aquifer properties. and effective recharge to the aquifer.

F. Internal progress-monitoring procedures and quality assurance processes.

G. Demonstrated approach for organizing and managing the Project, including coordination with TWDB staff; communication between the contractor and the stakeholder advisory forum for the model; and including regional water planning groups and groundwater conservation districts.

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

I. Ability to produce specific and usable deliverables discussed.

J. Ability and commitment to perform the services requested within the project completion deadline.

K. Demonstration of financial capability through submission of financial records that will substantiate the financial soundness of your business.

L. Project staff must have either a current Professional Geoscientist or Professional Engineer license in the State of Texas.

M. References - Respondent must request at least (1) vendor reference on a similar project be sent directly to the Texas Water Development Board at lauren.grooms-meyers@twdb.texas.gov.by the Deadline for Submission date located in Section 4.4, SCHEDULE OF EVENTS. The envelope must be marked with the RFQ number, 580-22-RFQ-0009.

2.3 SUBCONTRACTORS

Subcontractors providing services must meet the same requirements and level of experience as required of Respondent. No subcontract should relieve the primary Respondent of responsibility for the service. If Respondent uses a subcontractor for any or all work required, the following conditions must apply under the listed circumstances:

A. Respondents planning to subcontract all or a portion of the work must identify the proposed subcontractors on the HUB Subcontracting Plan.

B. Subcontracting must be at Respondent's expense.

C. TWDB retains the right to check a subcontractor's background and decide to approve or reject the use of submitted subcontractor. A subcontractor may not be compensated for any work prior to the approval date of the subcontract agreement between the Contractor and the Subcontractor by TWDB.

D. Respondent will be the only contact for TWDB and subcontractors. Respondent must list a designated point of contact for all TWDB and subcontractor inquiries.

2.5 COMPENSATION

The total project cost will not exceed $800,000. Funds will be disbursed following the completion of interim deliverables, further explained in Section III, 3.1.C. Failure to arrive at mutually agreeable terms of a contract with the most qualified respondent will constitute a rejection of TWDB's offer and may result in subsequent negotiations with the next most qualified respondent. TWDB reserves the right to reject any or all responses.

The awarded Contractor(s) will only receive compensation once a task has been completed, reviewed, and accepted by TWDB, and an invoice is submitted requesting funds for that approved task.

2.6 LIQUIDATED DAMAGES

If a selected Contractor breaches its obligation to provide deliverables in accordance with the schedule in Section 3.1, the selected Contractor may be subject to up to $500.00 per day for each day of delay as liquidated damages. The parties agree that quantifying losses arising from a selected Contractor's delay is inherently difficult, and stipulate that the sum agreed upon for liquidated damages is not a penalty, but rather a reasonable measure of damages based on the parties' experience in the industry and the nature of the losses that may result from delay.

3.1 CONTRACT DELIVERABLES

A. Monthly Progress Reports must be submitted to TWDB outlining the progress of the project per task by the 5th business day of each month. The progress report must include the project schedule and clearly show any changes or adjustments to the schedule with an explanation. Any issues or concerns must also be noted, and the TWDB contract manager contacted to discuss possible solutions or ways to address the issues or concerns. A copy of the monthly progress report must accompany the associated invoice and must also be sent directly to the assigned TWDB contract manager. The TWDB contract manager may, at his/her discretion, contact the contractor to request an informal meeting to review items of concern or to review and verify the progress of the work.

B. The following deliverables must be submitted to TWDB for review:

Deliverable	**When**	**Description ofdeliverables**
1. Draft Model Design	After completion of the draft model design and prior to model calibration. Six (6) months after beginning of contract.	Includes the grid node attributes to ensure model output will be compatible with official state boundaries, preliminary model files (in MODFLOW and Groundwater Vistas), draft Chapters 1,2, and 3 of the Numerical Model Report, and final GAM Source geodatabase with metadata.
2. Calibrated Transient Model and interim model report	This must be submitted before fifteen (15) months after the start of the contract.	Includes final grid node attributes, calibrated transient model files (in MODFLOW and Groundwater Vistas), draft Chapter 4 of the Numerical Model Report, and updated geodatabase with target files, stress period table, and all calibration statistics
3. Draft model and Draft Final Report of the numerical flow model	No later than Project Completion Date, six (6) months after completion of the interim model report.	Includes everything in deliverable 2 including full report (including predictive run), responses to previous comments, all model files, and final GAM Source geodatabase/logs.

4. Final model and Final Report of the numerical flow model.	90-days after the Project Completion Date / Draft Report Deadline.	All final deliverables noted above with all revisions as requested by TWDB and any additional responses to review comments from deliverable 3.

C. The Final deliverables must be accompanied by a transmittal letter.
D. All draft and final chapters of the Numerical Model Report must be delivered in Microsoft Word and PDF formats.
E. At a minimum, the Executive Summary and Chapters 1, 2, and 6 to 11 of the Numerical Model Report must be designed with the general public as the audience and Chapters 3 to 5 of the Numerical Model Report must be designed for other modelers as the audience (See Appendix A: GAM Standards for more detail).
F. Consistent geologic, hydrologic, and technical terminology must be used throughout the report. including TWDB nomenclature for aquifers and no acronyms except TWDB and model packages.
G. All final reports must be sealed by a professional geoscientist or engineer licensed to practice in Texas.
H. All draft and final source geodatabases must contain all relevant source data, including metadata that documents the content, data structure, source(s), date(s), quality, and other characteristics of the data within the geodatabases. Metadata must be created using the Federal Geographic Data Committee (FGDC) metadata editor within ESRI's ArcCatalog. The TWDB-provided schemas include some basic metadata, which must be extended by the Contractor's project manager to completely document all source and derivative data.
I. Acceptance of the Final Report and associated data by TWDB indicates the successful completion of the Project.

SECTION IV – GENERAL INFORMATION

4.1 RFQ REQUIREMENTS

A brief transmittal letter which includes the Contents described in Section 4.1.B, summarizing the Statement of Qualification's key points and signed by an authorized representative who is responsible for committing the firm's resources must accompany each response. The only material that will be considered with a submittal must correspond with the Content Items (and page limitations) shown below in Section B. The font size must be no smaller than Cambria 12 point.

A. Submittals: Respondent must submit an original electronic copy of the SOQ as follows:
1. One (1) complete ORIGINAL SOQ in Portable Document Format (.pdf) submitted through email to bid-room@twdb.texas.gov with a copy to lauren.grooms-meyers@twdb.texas.gov.
2. SOQ pages must be numbered and contain an organized, paginated table of contents corresponding to the section and pages of the SOQ. File size is limited to 100mb.

3. Proposals must be clearly marked **RESPONSE TO RFQ 580-22-RFQ-0009** and delivered electronically to the address noted above.

B. Contents: Respondent must submit all information listed below, in the order given, as the response to this RFQ. The response will only be considered if all items are submitted as required. Incomplete/late responses to this RFQ will not be considered.

1. Item 1: Signed/dated Execution of Response to the Request for Qualifications *(one (1) page maximum)*
2. Item 2: Company Profile Summary and History *(two (2) pages maximum)*
   Response should include the following:
   a. Company name, address, phone number, and legal status (corporation, partnership, joint venture, sole proprietorship).
   b. Company W-9 or individual W-9 form
   c. Name and title of person submitting the response with the authority to bind the company.
   d. Name, phone number, and email address of contact person for any questions on the response.
   e. Describe the general nature of previous work, the number of years in business, size and scope of operation.
3. Item 3: Resumes of Individuals - Submit resumes for each individual *(three (3) pages maximum per individual)* who will work on the project.
   PLEASE NOTE: Resumes do NOT count towards total response page maximums.
4. Item 4: Historically Underutilized Businesses Subcontracting Plan (HUB-SUB)
   PLEASE NOTE: HUB-SUB Plans do NOT count towards total response page maximums.
5. Item 5: Name(s) and Social Security Number(s) of Each Person with at least 25 Percent Ownership of the Business Entity submitting the response to the RFQ *(one (1) page maximum)*
6. Item 6: Prior Project Experience – Include the following items for each project description *(five (5) pages maximum)*:
   a. Project Title
   b. Client Organization Name, address, contact person, phone number, and email address. If experience describes subcontracted work, include both prime contractor and overall client information.
   c. Project Start and End Dates, month and year.
   d. Project Budget. If applicable, identify both study/design fees and construction fees.
   e. Project Description
7. Item 7: Technical Approach *(fifteen (15) pages maximum)*

4.2 PROPOSAL SUBMISSION

A. All responses must be received at TWDB by the deadline in Section 4.4 Schedule of Events. TWDB will not accept late submittals.

B. It is Respondent's responsibility to appropriately mark and deliver the proposal to TWDB by the specified date and time.

C. Receipt of all addenda to this RFQ should be acknowledged by returning a signed copy of each addendum with the submitted response**.**

NOTE: Failure to return the required items with the response will result in rejection of your Statement of Qualifications. TWDB will not be responsible for locating or securing information that is not included in your Statement of Qualifications.

4.3 DELIVERY OF SUBMISSION

The SOQ may be submitted to TWDB using the following method:

Electronic Delivery via email to bid-room@twdb.texas.gov with a copy to lauren.grooms-meyers@twdb.texas.gov. File size is limited to 100MB. Please compress the files whenever possible.

4.4 SCHEDULE OF EVENTS

The solicitation process for this RFQ will proceed according to the following schedule:

EVENT	**DATE/TIME (CST)**
Solicitation Release Date	April 6, 2022
Deadline for Submitting Questions	April 20, 2022, by 2:00pm CST
Deadline for TWDB to Respond to Submitted Questions	May 4, 2022
Deadline for submission of Solicitation Responses [NOTE: Responses must be RECEIVED by TWDB by the deadline.]	May 18, 2022, by 2:00pm CST
Evaluation Period	May 19, 2022 through June 29, 2022
Anticipated Contract Start Date	August 29, 2022

4.5 REVISIONS TO SCHEDULE

TWDB reserves the right to change the dates in the Schedule of Events above upon written notification to prospective Respondent(s) as an addendum posted on the Electronic State Business Daily.

4.6 RESPONSE SUBMITTAL

All submitted responses become the property of TWDB after the submittal deadline. Responses submitted constitute an offer for a period of ninety (90) days or until selection is made by TWDB, whichever occurs first.

4.7 RESPONSE PREPARATION COSTS

Respondents are responsible for all costs incurred in the preparation and delivery of the Statement of Qualifications to TWDB.

4.8 TRAVEL EXPENSES

Any travel requirements under this contract may include travel throughout the State of Texas to perform the tasks therein. Any travel expenses will be reimbursed in accordance with the state travel and per diem allowances detailed at https://fmx.cpa.texas.gov/fmx/travel/.

4.9 MEETINGS

Any meetings and or/conference calls will be held on regular business days, Monday through Friday, during regular business hours (8 a.m. – 5 p.m.), or on other mutually agreed dates and times.

4.10 INQUIRIES

A. Point of Contact

All requests, questions, or other communications about this Solicitation must be made in writing to the TWDB Purchasing Department, addressed to the person listed below.

Name:	Lauren Grooms-Meyers, Contract Specialist
Email :	bid-room@twdb.texas.gov with a copy to lauren.grooms-meyers@twdb.texas.gov
Subject:	Ensure the RFQ number is included in all correspondence.

B. Clarifications

TWDB will allow written requests for clarification of this Solicitation. Questions may be e-mailed to the contact listed above. Respondents' names will be removed from questions when the written answers are released. Questions must be submitted in the following format. Submissions that deviate from this format may not be accepted:

a. Identifying Solicitation number
b. Section number
c. Text of passage being questioned
d. Question
e. Provide company name, address, phone number, e-mail address, and name of contact person when submitting questions.

C. Responses

All accepted questions will result in a written response posted to the ESBD at: http://www.txsmartbuy.com/esbd. Responses will be posted as an Addendum to the Solicitation. It is Respondent's responsibility to check the ESBD for updated responses.

D. Prohibited Communications

On issuance of this Solicitation, except for the written inquiries described in Section 4.10 INQUIRIES, TWDB, its representative(s), or partners will not answer questions or otherwise discuss the contents of this Solicitation with any potential Respondent or their representative(s). Attempts to ask questions by phone, email, or in person will not be allowed. Failure to observe this restriction may disqualify Respondent. Respondent should rely only on written statements and information issued through or by TWDB's purchasing staff. This restriction does not preclude discussions between affected parties for the purposes of conducting business unrelated to this Solicitation.

4.11 PROPOSAL EVALUATION AND AWARD

A. A committee will be established by TWDB (including TWDB employees) to evaluate the Statement of Qualifications.

B. The committee will review the Respondent(s) past performance via the Vendor Performance Tracking System (VPTS). The selected Respondent will be evaluated on performance during and at the conclusion of the contract. The committee will consider the existing VPTS scores of the prime contractor and any proposed subcontractors designated as a part of the project team during their evaluation of qualifications. Contractor performance information is located on the CPA web site at: http://www.txsmartbuy.com/vpts

C. The evaluation committee will determine best value by applying the following criteria:

POINTS AVAILABLE	CATEGORY
0-40	Explanation of the proposed methodology that will be used to develop this numerical model, including staying on-schedule and within budget. Explanation of prior experience with this methodology proposed.
0-30	Experience and knowledge of TWDB groundwater geodatabase schema for documenting source data.
0-20	Experience with MODFLOW-USG or MODFLOW 6 code and Groundwater Vistas.
0-10	Internal progress monitoring procedures and quality assurance process.
0-20	Approach for organizing and managing the project including coordination with TWDB staff and communication with stakeholders.
0-10	Ability to clearly communicate the results of requested analyses in graphical, written, and oral formats.
0-20	Experience and past performance (VPTS) in sourcing, working with, and producing datasets in a wide variety of formats efficiently, including staying on schedule and within budget.
150	**TOTAL**

4.12 CONTRACT AWARD

It is the intent of TWDB to award one contract under this Solicitation. An award notice will be sent to the selected Respondent(s). Any award is contingent upon the successful negotiation of final contract terms and upon approval of the TWDB Executive Administrator. Negotiations will be confidential and not subject to disclosure to competing Respondents unless and until an agreement is reached. If contract negotiations cannot be concluded successfully, TWDB may negotiate a contract with the next highest scoring Respondent or may withdraw this Solicitation.

5.1 GENERAL TERMS AND CONDITIONS

Any contract awarded as a result of this RFQ will contain the general terms and conditions provided in this document. Subcontractors must also comply, if applicable. TWDB will consider exceptions to terms and conditions during the contract negotiation phase; see Section 4.12 Contract Award. The Contractor is required to make any information created or exchanged with the state pursuant to this contract, and not otherwise excepted from disclosure under the Texas Public Information Act, available in a format that is accessible by the public at no additional charge to the state.

5.2 PATENTS OR COPYRIGHTS

The selected Contractor agrees to protect the State and TWDB from claims involving infringement of patents or copyrights. TWDB will not consider any RFQ that bears a copyright. RFQs will be subject to the Texas Public Information Act, Texas Government Code Chapter 552, and may be disclosed to the public upon request. Subject to the Act, Respondents may protect trade and confidential information from public release. Trade secrets or other confidential information submitted as part of a SOQ must be clearly marked in **boldface type and at least 14-point font.**

5.3 CONTRACTOR ASSIGNMENTS

Respondent hereby assigns to TWDB any and all claims for overcharges associated with the contract arising under the antitrust laws of the United States, 15 U.S.C.A. Section 1 et seq. , and the antitrust laws of the State of Texas, Tex. Bus. & Com. Code § 15.01 et seq.

5.4 HISTORICALLY UNDERUTILIZED BUSINESSES SUBCONTRACTING PLAN

It is the policy of TWDB to make a good faith effort to achieve the annual program goals by contracting directly with HUBs or indirectly through subcontracting opportunities in accordance with Texas Government Code Chapter 2161, Subchapter F, and HUB Rules promulgated by the Comptroller of Public Accounts (CPA), 34 TAC Chapter 20.

Any contract(s) awarded as a result of this RFQ must include reporting responsibilities related to Historically Underutilized Business (HUB) subcontracting. Awarded contractors may not change any subcontractor without submitting a revised HUB Subcontracting Plan (HSP) to TWDB. Any change to a subcontractor and revised HSP must be approved in writing by TWDB prior to implementation.

HUBs are strongly urged to respond to this RFQ. Under Texas law, state agencies are required to make a good faith effort to assist HUBs in receiving certain percentages of the total value of contract awards. Contractors who meet the qualifications are strongly encouraged to apply for certification as HUBs.

ALL CONTRACTORS RESPONDING TO THIS RFQ, INCLUDING THOSE THAT ARE HUB CERTIFIED OR THOSE WHO DO NOT PLAN TO SUBCONTRACT, MUST COMPLETE A HUB SUBCONTRACTING PLAN (HSP) IN ACCORDANCE WITH THE STATE'S POLICY ON UTILIZATION OF HUBs. THE HSP MUST BE INCLUDED AS PART OF THE PROPOSAL TO THIS RFQ. FAILURE TO COMPLETE THE HSP AS INSTRUCTED MAY RESULT IN DISQUALIFICATION

OF THE PROPOSAL FROM CONSIDERATION. Please review the HSP forms carefully and allow sufficient time to identify and contact HUBs and allow them to respond. Note that the contractors must demonstrate a good faith effort to contract with new HUBs if currently proposed HUBs have performed as subcontractors to the contractor for more than five (5) years. If the contractor does not plan to subcontract, the contractor must state that fact in their plan. The completed plan will become part of the contract that may be awarded as a result of this RFQ.

5.5 HUB RESOURCES AVAILABLE

A list of certified HUBs is available on the Texas Comptroller of Public Accounts (CPA) Web site at: https://mycpa.cpa.state.tx.us/tpasscmblsearch/tpasscmblsearch.do. For additional information, contact the CPA's HUB program office at StatewideHUBProgram@cpa.texas.gov. If contractors know of any businesses that may qualify for certification as a HUB, they should encourage those businesses to contact the CPA HUB program office.

5.6 REQUIRED AFFIRMATIONS AND CERTIFICATIONS

A. Antitrust. Respondent represents and warrants that, in accordance with Texas Government Code § 2155.005, neither Respondent nor the firm, corporation, partnership, or institution represented by Respondent, or anyone acting for such firm, corporation, partnership or institution, has (1) violated any provision of the Texas Free Enterprise and Antitrust Act of 1983, Texas Business and Commerce Code Chapter 15, or the federal antitrust laws; or (2) communicated directly or indirectly the contents of its proposal to any competitor or any other person engaged in the same line of business as Respondent.

B. Child Support Obligation. Under Texas Family Code § 231.006, Respondent certifies that the individual or business entity named in its proposal is not ineligible to receive the specified payment and acknowledges that this contract may be terminated, and payment may be withheld if this certification is inaccurate.

C. COVID-19 Vaccine Passport Prohibition. Respondent certifies that it does not require its customers to provide any documentation certifying the customer's COVID-19 vaccination or post-transmission recovery on entry to, to gain access to, or to receive service from the Respondent's business. Respondent acknowledges that such a vaccine or recovery requirement would make Respondent ineligible for a state-funded contract.

D. Dealings with Public Servants. Pursuant to Texas Government Code § 2155.003, Respondent represents and warrants that it has not given, offered to give, nor intends to give at any time hereafter any economic opportunity, future employment, gift, loan, gratuity, special discount, trip, favor, or service to a public servant in connection with the goods or services being supplied.

E. Debts and Delinquencies. Respondent agrees that any payments due under the Contract will be applied towards any debt or delinquency that is owed to the State of Texas, including but not limited to delinquent taxes, delinquent student loan payments and delinquent child support.

F. Energy Company Boycotts. Respondent represents and warrants that: (1) it does not, and will not for the duration of the contract, boycott energy companies or (2) the verification required by Texas Government Code § 2274.002 does not apply to the contract. If circumstances relevant to this provision change during the course of the contract, Respondent must promptly notify TWDB.

G. Entities that Boycott Israel. Pursuant to Texas Government Code § 2271.002, Respondent certifies that either (i) it meets one of the exemption criteria under Texas Government Code § 2271.002; or (ii) it does not boycott Israel and will not boycott Israel during the term of the contract resulting from this Solicitation. Respondent must state any facts that make it exempt from the boycott certification in its Response.

H. Excluded Parties. Respondent certifies that it is not listed on the federal government's terrorism watch list as described in Executive Order 13224.

I. Executive Head of a State Agency. Under Texas Government Code § 669.003, Respondent certifies that it does not employ, or has disclosed its employment of, any former executive head of TWDB. If Texas Government Code § 669.003 applies, Respondent must provide the following information:

Name of Former Executive: _____
Name of State Agency: _____
Date of Separation from State Agency: _____
Position with Respondent: _____
Date of Employment with Respondent: _____

J. Financial Participation Prohibited. Pursuant to Texas Government Code § 2155.004(a), Respondent certifies that neither Respondent nor any person or entity represented by Respondent has received compensation from TWDB or any agency of the State of Texas for participation in the preparation of the specifications for this bid or proposal. Pursuant to Texas Government Code § 2155.004(b), Respondent certifies that the individual or business entity named in this bid or response is not ineligible to receive the specified contract and acknowledges that the contract may be terminated, and payment withheld if this certification is inaccurate.

K. Firearm Entities and Trade Associations Discrimination. Respondent verifies that: (1) it does not, and will not for the duration of the contract, have a practice, policy, guidance, or directive that discriminates against a firearm entity or firearm trade association or (2) the verification required by Texas Government Code § 2274.002 does not apply to the contract. If circumstances relevant to this provision change during the course of the contract, Respondent must promptly notify TWDB.

L. Foreign Terrorist Organizations. Respondent represents and warrants that it is not engaged in business with Iran, Sudan, or a foreign terrorist organization, as prohibited by Texas Government Code § 2252.152.

M. Human Trafficking Prohibition. Under Texas Government Code § 2155.0061, Respondent certifies that the individual or business entity named in this Response or Contract is not ineligible to receive the specified contract and acknowledges that this Contract may be terminated, and payment withheld if this certification is inaccurate.

N. Lobbying Prohibition. Respondent represents and warrants that TWDB's payments to Respondent and Respondent's receipt of appropriated or other funds under the contract are not prohibited by Texas Government Code §§ 556.005 or 556.0055, related to the prohibition on payment of state funds to a lobbyist or for lobbying activities.

O. No Conflict of Interest. Respondent represents and warrants that the provision of goods and services or other performance under the Contract will not constitute an actual or potential conflict of interest or reasonably create an appearance of impropriety.

P. Prior Disaster Relief Contract Violation. Texas Government Code §§ 2155.006 and 2261.053 prohibit state agencies from accepting a Response or awarding a contract that includes proposed financial participation by a person who, in the past five years, has been convicted of violating a federal law or assessed a penalty in connection with a contract involving relief for Hurricane Rita, Hurricane Katrina, or any other disaster occurring after September 24, 2005, as defined by Texas Government Code § 418.004. Under Texas Government Code §§ 2155.006 and 2261.053, Contractor certifies that the individual or business entity named in this Response or contract is not ineligible to receive the specified contract and acknowledges that this contract may be terminated, and payment withheld if this certification is inaccurate.

Q. Suspension and Debarment. Respondent certifies that it and its principals are not suspended or debarred from doing business with the state or federal government as listed on the State of Texas Debarred Vendor List maintained by the Texas Comptroller of Public Accounts and the System for Award Management (SAM) maintained by the General Services Administration.

R. Texas Bidder Affirmation. Respondent certifies that if a Texas address is shown as the address of Respondent on its Response, Respondent qualifies as a Texas Bidder as defined in Texas Government Code § 2155.444(c).

5.7 INDEMNIFICATION

RESPONDENT AGREES TO DEFEND, INDEMNIFY AND HOLD HARMLESS THE STATE OF TEXAS AND TWDB, AND/OR THEIR OFFICERS, AGENTS, EMPLOYEES, REPRESENTATIVES, CONTRACTORS, ASSIGNEES, AND/OR DESIGNEES FROM ANY AND ALL LIABILITY, ACTIONS, CLAIMS, DEMANDS, OR SUITS, AND ALL RELATED COSTS, ATTORNEY FEES, AND EXPENSES ARISING OUT OF, OR RESULTING FROM ANY ACTS OR OMISSIONS OF RESPONDENT OR ITS AGENTS, EMPLOYEES, SUBCONTRACTORS, ORDER FULFILLERS, OR SUPPLIERS OF SUBCONTRACTORS IN THE EXECUTION OR PERFORMANCE OF THE CONTRACT AND ANY PURCHASE ORDERS ISSUED UNDER THE CONTRACT. THE DEFENSE MUST BE COORDINATED BY RESPONDENT WITH THE OFFICE OF THE TEXAS ATTORNEY GENERAL WHEN TEXAS STATE AGENCIES ARE NAMED DEFENDANTS IN ANY LAWSUIT, AND RESPONDENT MAY NOT AGREE TO ANY SETTLEMENT WITHOUT FIRST OBTAINING THE CONCURRENCE FROM THE

OFFICE OF THE TEXAS ATTORNEY GENERAL. RESPONDENT AND TWDB AGREE TO FURNISH TIMELY WRITTEN NOTICE TO EACH OTHER OF ANY SUCH CLAIM.

5.8 ADDITIONAL TERMS

Any terms and conditions attached to your SOQ will not be considered unless specifically referred to in this RFQ and may result in disqualification of your SOQ.

5.9 DISPUTE RESOLUTION

The dispute resolution process provided for in Texas Government Code Chapter 2260 must be used by TWDB and Respondent to attempt to resolve all disputes arising under any contract resulting from this Solicitation.

5.10 NON-APPROPRIATION OF FUNDS

Any contract resulting from this Solicitation is subject to termination or cancellation without penalty to TWDB, either in whole or in part, subject to the availability of state funds.

5.11 PUBLIC INFORMATION ACT

Information, documentation, and other material in connection with this Solicitation or any resulting contract may be subject to public disclosure pursuant to Texas Government Code Chapter 552 (the "Public Information Act"). In accordance with Texas Government Code § 2252.907, Respondent is required to make any information created or exchanged with the State pursuant to the Solicitation or Contract and not otherwise excepted from disclosure under the Public Information Act available in a format that is accessible to the public at no additional charge to the State.

5.12 GOVERNING LAW AND VENUE

Any contract resulting from this Solicitation will be governed by the laws of the State of Texas, without regard to the conflicts of law provisions. The venue of any suit arising under a contract resulting from this Solicitation is fixed in any court of competent jurisdiction of Travis County, Texas, unless the specific venue is otherwise identified in a statute which directly names or otherwise identifies its applicability to TWDB.

5.13 ETHICS

Under Texas Government Code § 2155.003, an individual who interacts with public purchasers in any capacity is required to adhere to the guidelines established in Section 1.2 of the state of Texas Procurement Manual, which outlines the ethical standards required of public purchasers, employees, and bidders who interact with public purchasers in the conduct of state business, and with any opinions of or rules adopted by the Texas Ethics Commission. Entities who are interested in seeking business opportunities with the state must be mindful of these restrictions when interacting with public purchasers of TWDB or purchasers of other state agencies. Specifically, a TWDB employee may not have an interest in, or in any manner be connected with a contract or bid for a purchase of goods or services by an agency of the state; or in any manner, including by rebate or gift, accept or receive from a person to whom a contract may be awarded, directly or indirectly, anything of value or a promise, obligation, or contract for future reward or compensation.

5.14 FRAUD STATEMENT

Respondents understand that TWDB does not tolerate any type of fraud. TWDB's policy is to promote consistent, legal, and ethical organizational behavior by assigning responsibilities and providing guidelines to enforce controls. Any violations of law, agency policies, or standards of ethical conduct will be investigated, and appropriate actions will be taken. Contractors are expected to report any possible fraudulent or dishonest acts, waste, or abuse to the agency's Internal Audit division at 512-463-7978 or Nicole.Campbell@twdb.texas.gov.

5.15 CONFLICT OF INTEREST

A Respondent will not be selected if there is a conflict of interest that will or may arise during the performance of its obligations under any Contract resulting from this Solicitation. For this reason, the submission in response to this RFQ must disclose all business interests and all relationships that could reasonably be considered to pose possible conflicts of interest in Respondent's performance of the contract obligations. In addition, respondents must represent and warrant in the response to this RFQ and in the contract that in the performance of services under the contract, (1) Respondent does not have and will not have any actual or potential conflict of interest, and (2) Respondent will take whatever reasonable actions may be necessary and prudent to avoid even the appearance of impropriety.

5.16 RIGHT TO AUDIT

The state auditor may conduct an audit or investigation of any entity receiving funds from the state directly under a contract or indirectly through a subcontract under the contract. The acceptance of funds under a contract or subcontract acts as acceptance of the authority of the state auditor, under the direction of the legislative audit committee, to conduct an audit or investigation in connection with those funds. Under the direction of the legislative audit committee, an entity that is the subject of an audit or investigation by the state auditor must provide the state auditor with access to any information the state auditor considers relevant to the investigation or audit.

5.17 CONTRACT ADMINISTRATION

TWDB will designate a project manager for the contract. The project manager will serve as the point of contact between TWDB and the selected contractor. The TWDB project manager will supervise TWDB's review of the contractor's technical work, deliverables, draft reports, 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.

5.18 CONTRACT AMENDMENT/TERMINATION

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 must, unless the notice directs otherwise, immediately discontinue all work in connection with the performance of the contract and promptly cancel all existing orders insofar as such orders are chargeable to the contract. Contractor must submit a statement showing in detail the work performed under the contract to the date of termination. TWDB will pay Contractor for the work actually performed under the contract, less all payments that have been previously made. Thereupon, copies of all work accomplished under the contract must be delivered to TWDB.

5.19 STOP WORK ORDER

The Executive Administrator may issue a Stop Work Order to the contractor at any time. Upon receipt of such order, the contractor must discontinue all work under the contract and cancel all orders pursuant to the 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 contract is terminated in accordance with the foregoing provisions.

5.20 DISASTER RECOVERY PLAN Upon request of TWDB, Respondent must provide descriptions of its business continuity and disaster recovery plans.

5.21 DEFAULT

If the contractor is found to be in default under any provision of the contract, TWDB may cancel the contract without notice and either re-solicit or award the contract to the next best responsive and responsible Respondent. In the event of abandonment or default, the contractor will be responsible for paying damages to TWDB, including but not limited to re-procurement costs, and any consequential damages to the State of Texas or TWDB resulting from the contractor's non-performance. The defaulting contractor will not be considered in the re-solicitation and may not be considered in future solicitations for the same type of work unless the specification or scope of work is significantly changed.

5.22 FORCE MAJEURE

Neither Respondent nor TWDB will be liable to the other for any delay in or failure of performance of any requirement included in the contract caused by force majeure. The existence of such causes of delay or failure will 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, fires, explosions, hurricanes, floods, failure of transportation, 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.

5.23 OWNERSHIP/INTELLECTUAL PROPERTY, INCLUDING RIGHTS TO DATA, DOCUMENTS AND COMPUTER SOFTWARE

For the purposes of the contract, the term "Work" is defined as all reports, statistical analyses, work papers, work products, materials, approaches, designs, specifications, systems, documentation, methodologies, concepts, research, materials, and intellectual property or other property developed, produced, or generated in connection with the contract. All work performed pursuant to the contract is made the exclusive property of TWDB. All right, title and interest in said property will vest in TWDB upon creation and will be deemed to be a work for hire and made in the course of the services rendered pursuant to the contract. To the extent that title to any such work may not, by operation of law, vest in TWDB, or such work may not be considered a work made for hire, all rights, title and interest therein are hereby irrevocably assigned to TWDB. TWDB has the right to obtain and to hold in its name any and all patents, copyrights, registrations, or such other protection as may be appropriate to the subject matter, and any extensions and renewals thereof. The contractor must give TWDB and/or the state of

Texas, as well as any person designated by TWDB and/or the state of Texas, all assistance required to perfect the rights defined herein without any charge or expense beyond those amounts payable to the contractor for the services rendered under the contract.

Contractor must maintain and retain supporting fiscal and any other documents relevant to showing that any payments under the contract funds were expended in accordance with the laws and regulations of the state of Texas, including but not limited to, requirements of the Comptroller of the state of Texas and the State Auditor. The contractor must maintain all such documents and other records relating to the contract and the State's property for a period of four (4) years after the date of submission of the final invoices or until a resolution of all billing questions, whichever is later. Contractor must make available at reasonable times, upon reasonable notice, and for reasonable periods, all documents and other information related to the "Work" as defined as work products developed by the contractor and subcontractor using funds provided under the contract or otherwise rendered in or related to the performance in whole or part of the 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. Contractor and any subcontractor(s) must provide the State Auditor with any information that the State Auditor deems relevant to any investigation or audit. Contractor must retain all work and other supporting documents pertaining to the contract, for purposes of inspecting, monitoring, auditing, or evaluating by the TWDB and any authorized agency of the state of Texas, including an investigation or audit by the State Auditor.

Contractor must cooperate with any authorized agents of the state of Texas and must provide them with prompt access to all of such State's work as requested. Contractor's failure to comply with this Section will constitute a material breach of the contract and will authorize TWDB and the State of Texas to immediately assess appropriate damages for such failure. Pursuant to Texas Government Code § 2262.003, the acceptance of funds by Contractor or any other entity or person directly under the contract, or indirectly through a subcontract under the contract, constitutes acceptance of the authority of the State Auditor to conduct an audit or investigation in connection with those funds.

5.24 DRUG-FREE WORKPLACE POLICY

Contractor must comply with the applicable provisions of the Drug-Free Workplace Act of 1988 (Public Law 100-690, Title V, Subtitle D; 41 U.S.C. 701 et seq.) and maintain a drug-free work environment. The final rule detailing requirements for drug-free workplace (grants) issued by the Office of Management and Budget and the Department of Defense (32 CFR Part 280, Subpart F) to implement the provisions of the Drug-Free Work Place Act of 1988 is incorporated by reference, and Contractor must comply with the relevant provisions thereof, including any amendments to the final rule that may hereafter be issued.

5.25 FALSE STATEMENTS

If Respondent signs its bid or response with a false statement or it is subsequently determined that Respondent has violated any of the representations, guarantees, warranties, certifications, or affirmations included in its bid or response, Respondent will be in default under the Contract and TWDB may terminate or void the Contract.

5.26 INSURANCE AND OTHER SECURITY

Respondent represents and warrants that it will obtain and maintain for the term of any contract resulting from this Solicitation all insurance coverage required to ensure proper fulfillment of the Contract and its liabilities thereunder, including but not limited to professional liability coverage in a minimum amount of $1,000,000 per occurrence and $2,000,000 in general liability. Respondent must insure any of its motor vehicles used to fulfill its duties under the Contract and ensure that its subcontractors do the same.

Respondent represents and warrants that all the above coverage will be with companies licensed in the state of Texas, with "A" rating from A.M. Best, and authorized to provide the corresponding coverage. Respondent represents and warrants that it will maintain the above insurance coverage during the term of any contract resulting from this Solicitation and will provide TWDB with an executed copy of the policies immediately upon request.

5.27 ORDER PRECEDENCE

In the event of conflicts or inconsistencies between the contract and its exhibits or attachments, such conflicts or inconsistencies will be resolved by reference to the documents in the following order of priority: Signed Contract (or Notice of Award), Attachments to the Contract (or Notice of Award), Request for Qualifications, and Respondent's Response to Request for Qualifications.

5.28 PUBLIC DISCLOSURE

No public disclosures or news releases pertaining to the Contract may be made without prior written approval of TWDB.

5.29 TAXES

Respondent represents and warrants that it will pay all taxes or similar amounts associated with any contract resulting from this Solicitation, including but not limited to any federal, state, or local income, sales or excise taxes of the contractor or its employees. TWDB will not be liable for any taxes resulting from the Contract.

5.30 INTERESTED PARTIES

When applicable, all non-governmental contractors are required to submit a Certificate of Interested Parties at the time the signed Contract is submitted to TWDB. The Certificate of Interested Parties (Form 1295) is a sworn statement by the contracting business entity and must be submitted even if there is no interested party in the transaction. The Form 1295 and instructions for completing and submitting the form are available at: https://www.ethics.state.tx.us/filinginfo/1295/ . TWDB is prohibited from executing a contract unless the contracting business entity submits a completed Form 1295. Any contract resulting from a TWDB procurement with a business entity will be void if the Certificate of Interested Parties is not submitted within 30 days of submitting an executed contract.

5.31 CONFIDENTIALITY AND SECURITY

Contractor must maintain and protect any information it receives, compiles, or creates as a result of a Contract resulting from this Solicitation in accordance with any federal, state, or local laws and regulations that apply. Contractor must establish a method to secure the confidentiality of records and other information relating to TWDB in accordance with applicable federal and state laws, rules, and regulations.

5.32 ASSIGNMENT PROHIBITED

Respondent may not assign the Contract or assign, transfer or delegate, in whole or in part, any of its interest in, or rights or obligations under, the Contract without the prior written consent of TWDB, and any attempted or purported assignment, transfer or delegation thereof without such consent will be null and void.

5.33 BUY TEXAS

Respondent agrees to comply with Texas Government Code § 2155.441, requiring the purchase of products and materials produced in the State of Texas in performing service contracts.

5.34 E-VERIFY PROGRAM

Respondent certifies that for contracts for services, Respondent will utilize the U.S. Department of Homeland Security's E-Verify system during the term of a contract resulting from this Solicitation to determine the eligibility of: (1) all persons employed by Respondent to perform duties within Texas; and (2) all persons, including subcontractors, assigned by Respondent to perform work pursuant to the Contract within the United States of America.

5.35 CYBERSECURITY TRAINING.

If Respondent has access to any state computer system or database, Respondent must complete cybersecurity training and verify completion of the training program to TWDB pursuant to and in accordance with Texas Government Code § 2054.5192. Respondent must provide a unique email address for every employee who will be working under the Contract and must notify TWDB's Contract Manager upon completion of the training.

CONTENT ITEM 1
EXECUTION OF RESPONSE
to the
REQUEST FOR QUALIFICATIONS

Company Name: _____

Contact Name: _____

Address: _____

_____

Vendor ID: _____
(aka: Texas Taxpayer ID)

HUB Status: _____

Phone Number: _____

E-Mail: _____

I, _____, am the above-referenced company's representative and I am authorized to submit this response and sign future Contract documents. By signing below, the representative certifies that if a Texas address is shown as the address, Respondent qualifies as a Texas Bidder as defined in Texas Government Code § 2155.444.

_____ _____
Authorized Signature Date

_____
Title:

CONTENT ITEM 2
COMPANY PROFILE SUMMARY AND HISTORY

(to be provided by Respondent)

CONTENT ITEM 3
RESUMES OF INDIVIDUALS

(to be provided by Respondent)

CONTENT ITEM 4
HISTORICALLY UNDERUTILIZED BUSINESSES SUBCONTRACTING PLAN

Please see SECTION IV, GENERAL INFORMATION, 4.1.B, Item 4

All HUB Subcontracting Plan Forms must be completed and submitted with the Response.

The forms are entitled and can be found at:
https://comptroller.texas.gov/purchasing/vendor/hub/forms.php

HUB Subcontracting Plan Form
HUB Subcontracting Plan Form, SECTION 2 continuation sheet
HUB Subcontracting Plan Good Faith Effort - Method A (Attachment A)
HUB Subcontracting Plan Good Faith Effort - Method B (Attachment B)
HUB Subcontracting Opportunity Notification Form

CONTENT ITEM 5
OWNERSHIP OF BUSINESS ENTITY
Name(s) and Social Security Number(s) of Each Person with at least 25 Percent Ownership of the Business Entity Submitting the RFQ

_____
Name

_____
Last four digits of Social Security Number

_____
Name

_____
Last four digits of Social Security Number

_____
Name

_____
Last four digits of Social Security Number

_____
Name

_____
Last four digits of Social Security Number

CONTENT ITEM 6
PRIOR PROJECT EXPERIENCE

(to be provided by Respondent)

CONTENT ITEM 8
TECHNICAL APPROACH

(to be provided by Respondent)

APPENDIX A: GAM STANDARDS

1.0 INTRODUCTION

The Texas Water Development Board (TWDB) develops numerical groundwater flow models of the major and minor aquifers in Texas. In addition, the numerical groundwater flow models developed through the GAM Program are meant to be "living tools" that can be updated as new information becomes available, adapted to reflect changing aquifer conditions, or refined to better address the needs and concerns of the groups using them. The GAM 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. For example, at a minimum, models should be able to successfully complete statutorily required tasks such as average historical water budgets for groundwater conservation districts and predictive simulations, such as desired future conditions.

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.

Additional information on the various aspects and components required, as applicable to the scope of the project, is discussed in more detail in Appendix A, Attachments 1-4.

The major subheadings below (Stakeholder Participation, 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 GAM 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 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 by email. Stakeholder advisory forum participants without email accounts are notified by letter. Stakeholder advisory forum participants with email 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 within 60 days after the project begins—that describes several points:

- 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, investigating unconfined portions of the aquifer(s) that behave as confined, revising the model (if appropriate), and/or extending the model calibration period;
- 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).

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 draft model design**,**
- After the model is calibrated, and
- After the model has been developed, as applicable.

Additional stakeholder advisory forums may be scheduled at the project manager’s discretion. Contracted project managers submit copies of the stakeholder advisory forum Microsoft 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 must 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 to the TWDB contract manager:

- Memo report that summarizes presentation and includes question and answers from attendees,
- Copy of the stakeholder advisory forum presentation,
- Attendance sign-up sheet, and
- Typed attendee and affiliation list.

An attendance sign-up sheet must be provided at each meeting, which includes attendee name, affiliation, and contact information. The list of attendees and their affiliation must be given to the TWDB in the memo report for posting on the TWDB web page for each stakeholder advisory forum. New and revised stakeholder contact information must be reviewed and updated, as applicable, and provided to the TWDB contract manager for updating the database of stakeholder contact information. Memo reports (submitted to the TWDB in Microsoft Word- and Adobe Acrobat-compatible formats) summarize the presentation, the questions and comments that arose from the stakeholder advisory forum attendees, how the questions were or will be addressed, and the list of attendees with their affiliation. 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 Microsoft 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, including presentations, 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 email limitations, the Adobe Acrobat-compatible format deliverables should not exceed 8 megabytes in size. Therefore, some deliverables may need to be submitted in parts.

3.0 DOCUMENTATION

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

- Source and derived information from the development of the conceptual model in an ESRI ArcGIS (version 10.2 or later) file geodatabase format (Attachment 2);
- Any additional interpretation of new geophysical logs or adjustments to existing analysis of geophysical logs must be provided in a format compatible with the BRACS database (Attachment 4), see contract for exceptions;
- Source and derived pumpage information calculated for each model grid cell in an

ESRI ArcGIS (version 10.2 or later) file geodatabase format (Attachment 2), as applicable;
- Model input and associated files in both MODFLOW 6 or more recent version (with TWDB approval) in ASCII format and Groundwater Vistas (version 7.x) format, as applicable; and
- The final report for the numerical model must be submitted in both Microsoft Word 2010 compatible format and Adobe Acrobat 10.0 PDF format. The final model report may incorporate updates to the conceptual model in a chapter of the report (Attachment 1). This will be specific to each project and will be discussed and determined with the TWDB contract manager assigned to the project.

In addition to the discussion below, TWDB has prepared data models in an ESRI file geodatabase format for the projects (Attachment 2).

3.1 SOFTWARE REQUIREMENTS

All computer files and formats must be 100 percent compatible with personal computer (IBM-PC) type systems. Electronic files may be physically shipped using external hard drives. In addition, files may be zipped with a self-extracting software program such as WINZIP.

Project managers must deliver a digital copy of the final draft numerical model report (see contract for any exceptions). All files and data must be transferred to the TWDB in ready-to-use format. Formats of all computer files provided to the TWDB by the project managers must be fully compatible with the widely distributed versions of the following programs:

- Word processor files—Microsoft Word (MS Office 2010 or later),
- Geodatabases data—ESRI ArcGIS (version 10.2 or later),
- Spreadsheet files—Microsoft Excel (MS Office 2010 or later),
- Graphs, bar charts, pie-charts—Microsoft Excel (MS Office 2010 or later),
- Internet-ready, accessible reports in PDF format in parts not to exceed 10 megabytes—Adobe Acrobat (10.0),
- Turn-key models, if applicable—Groundwater Vistas (version 7.x) and MODFLOW 6 or more recent version—ASCII data files. In addition, contractors must provide georeferenced model orientation information; grid node/cell centroid spatial information that includes grid node/cell ID, county, basin, groundwater conservation district, aquifer (identify as confined or unconfined), groundwater management area, GAM X and Y coordinates, latitude/longitude, regional water planning area, layer (if applicable), grid dimensions (if variable), active or inactive node/cell, and any other field(s) as needed; table of stress periods with time intervals; and target(s) file that identifies node/centroid and target information. ***Please note that the grid node/centroid spatial information must be submitted to TWDB for review and acceptance prior to model calibration***.
- 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.
- Geophysical log files and associated depth calibration files can be delivered in

.tif,,.las, .xml, .lic, or .dra file formats.

The project manager must request approval from the TWDB contract manager for alternative software. Project managers must provide ESRI ArcGIS (version 10.2 or later) compatible files for all geographic information system information. All drawings and graphs included in all reports must be provided separately to TWDB in their native file format. In addition, all figures must be provided separately to TWDB in .jpeg formatted files with 300 dpi or greater resolution.

3.2 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 GAM's for groundwater conservation districts, regional water planning groups, groundwater management areas, TWDB, and other users to support ongoing management issues and research. Therefore, TWDB must receive all source data used in the development of the model with sufficient metadata to decipher parameters and units reported. For example, TWDB must receive all point data used to develop spatially distributed parameters. If map information was digitized from an existing scanned or paper document, TWDB must 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, TWDB must receive 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. Contractor's project manager must seek prior approval from the GAM contract manager to use proprietary data which cannot be distributed to the public.

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 must be delivered to TWDB in the appropriate format (see Attachment 2). Spatial information must be projected into the GAM coordinate system with units of measure in feet prior to and during any spatial analysis (see Attachment 2).

Examples of source data for the study area include datasets in geographic information systems, in tabular form, and raw data.

Geographic Information Systems (GIS):

- 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 area boundaries, groundwater management area boundaries, groundwater conservation district boundaries, physiographic delineations, river basins, and active model boundaries;
- Geographic information system raster and/or feature datasets of the topographic elevations in the study area (digital elevation model source data and the contours in

units of feet relative to mean sea level);
- Geographic information system feature datasets of the surface geology;
- 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;
- Geographic information system raster and/or feature datasets of the distributions of transmissivity, hydraulic conductivity, and storativity 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 the TWDB, and end of the transient calibration run 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, as applicable, and their units of measure) if different from distributions assembled during the conceptual model

Geographic Information Systems (GIS) and Tabular:

- 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;
- 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;
- 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 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;

Tabular:

- 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 the historical pumping at the resolution used to develop the model

input datasets and their units of measure;
- 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;

Other:
- Taw data and plots used to calculate hydraulic conductivity, transmissivity, and storativity and their units of measure; and
- Tny other data used to develop the model and their units of measure.

Point data must be delivered in ESRI ArcGIS (version 10.2 or later) feature classes. Interpreted data (for example, contoured data) must be delivered in ESRI ArcGIS (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 2). All tabular data and geographic information system raster and feature datasets must be delivered to TWDB within the GAM source geodatabase schema(s) provided to the project manager. The GAM source geodatabase schema(s) defines file-naming protocol, database organization, and documentation of the tables, databases, and geographic information system spatial data (Attachment 2). TWDB must be able to recreate all information from initial source to final derived data; therefore, metadata must contain sufficient information for replicating any processing used.

3.3 MODEL FILES

All MODFLOW 6 or more recent MODFLOW code input files must be submitted in ASCII format and the file format for Groundwater Vistas 7.x or later. The files for Groundwater Vistas must also include Groundwater Vistas map files of the ArcGIS shapefiles of the:
- model boundary;
- county boundaries;
- rivers, streams, reservoirs, and other hydraulic features simulated in the model;
- Any other boundary conditions associated approved through the TWDB contract manager;
- A table listing each stress period and corresponding time frame will be provided with the model files; and
- All targets used for calibration will be identified and clearly marked so verification of statistics may be performed.

Future users must be able to:
- run the model using MODFLOW 6 or more recent MODFLOW code from the command prompt with the files provided,
- run the model using Groundwater Vistas with the Groundwater Vistas files provided, and
- match results using MODFLOW and Groundwater Vistas.

3.4 FINAL REPORTS

The final reports must include the details of the conceptual model, input datasets, model construction, calibration, sensitivity analysis, and model results, depending on the objective of the project. There may be up to three or more final reports, determined by the Contract Manager, depending of the scope of work—conceptual model report, model calibration report, predictive scenarios report, and/or special studies (see contract for specifics for deliverable requirements). The final reports will follow TWDB guidelines and must be clearly written without spelling or grammatical errors. Final approved reports must follow Texas Board of Professional Geoscientists (see www.tbpg.state.tx.us) and/or Texas Board of Professional Engineers (see engineers.texas.gov) guidelines. All Microsoft Office documents must comply with federal standards for people with disabilities. Additional information is available through the following web site: gov.texas.gov/organization/disabilities/accessibledocs

3.4.1 Report Format and Figures

Each section of the submitted reports must address the data and analysis described in attachment 1, depending on the scope of the project. Additional sections and subsections may be added to the submitted reports to address aquifer-specific issues after discussing this with the TWDB contract manager.

Drafted figures must 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. Any color figures should be designed in a manner such that there is no loss of legibility when printed with a black and white printer. All interval or ratio data (data measuring continuous phenomena, with each color representing an equal interval) need to be displayed either in a graded scale of a single color or should use symbols or patterns to distinguish intervals.

Minimum requirements for figures include the following:

- Figures must be designed such that a black and white printout is readable and understandable
- Maps must include a north arrow and a bar scale
- Figures and maps must include legends showing related features
- Each figure must have a caption that includes reference sources for the base map or the included information
- For unmodified illustrations, the reference source must be preceded by the word “from”
- For illustrations modified less than 15 percent of the original, the reference source must be preceded by the word ‘after’
- For illustrations modified more than 15 percent of the original, the reference source must be preceded by the words ‘modified from’)
- Figures must follow Texas Board of Professional Geoscientists or Texas Board of Professional Engineers guidelines (https://tbpg.state.tx.us/tbpg/rules).

Sources of data/basemaps must be clearly indicated on the figure or in the figure caption. Additional information may be added as needed.

At a minimum, the **final NUMERICAL MODEL report** must be designed with the public (Chapters 1 and 2) and a groundwater modeler as the audience (the remainder of the report). A checklist detailing the format of the report, including figures and tables that are required, is included inAttachment 1.

The following units must be used in all data presentations:

- Land area in square miles (mi^2),
- 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 (ft^2/d),
- Conductance in feet squared per day (ft^2/d),
- Specific storage in units of inverse length using feet (1/ft),
- Recharge volumes in acre-feet (ac-ft), and
- Total dissolved solids concentration in milligrams per liter (mg/l).

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

3.4.2 Milestones and Deliverables

For projects documenting the update to an existing model or models, the following milestones will be required:

Milestone	Deliverable
After completion of the model **design** and prior to model calibration—the goal of this milestone deliverable is to ensure that the TWDB has sufficient information to replicate the model design and that the preliminary model meets the goals of the program.	Chapter 3 of the draft model report discussed in Attachment 1 (see checklist). TWDB staff will provide comments to be addressed in the draft final deliverable. In addition, the grid node attributes, preliminary model files (in MODFLOW and Groundwater Vistas), and geodatabase will be submitted. TWDB staff will review the grid node attributes to ensure model output will be compatible with official state boundaries. This deliverable is to be re-submitted until an acceptable product is produced.
After completion of the **calibrated** transient model—the goal of this milestone deliverable is to ensure TWDB	Chapter 4 of the draft model report must be submitted with information listed in Attachment 1 checklist for the Model Calibration Report TWDB staff will provide comments to be addressed in the draft final

has a model that meets the objectives of the program,	deliverable. In addition, model files in MODFLOW and Groundwater Vistas (version 7.x), attributed grid file, target files, stress period table, and all calibration statistics will be submitted for review. This deliverable is to be re-submitted until an acceptable product is produced.
Draft numerical model deliverable	Draft final Numerical Model report must include information listed in Attachments 1 to 4, as applicable) that includes the sensitivity analysis and predictive run(s) that use the current modeled available groundwater estimates. In addition, all review comments from the TWDB review of Chapters 1 to 4 and milestone deliverables and public review comments of the conceptual model are addressed with responses in an appendix of the report. The report will be posted for public review and comment for 30 days.
Final numerical model deliverable	The report must include Numerical Model Report information listed in Attachment 1, source data with metadata discussed in Attachment 2, and BRACS data discussed in Attachment 4. In addition, all review comments from the TWDB and public review of the draft deliverables are addressed with responses in an appendix of the report;

For the draft conceptual model report, or draft model and predictive scenarios report, the project manager must deliver to TWDB:

- An Adobe Acrobat (PDF) file of the draft conceptual model report or draft numerical model and predictive scenario (if applicable) report for posting on the TWDB website (broken into parts not to exceed 8 megabytes each) and the Microsoft Word 2010 format including figures—see Attachment 3 for formatting guidelines;
- All related documented source and derived data in the appropriate geodatabase and BRACS database (see Attachments 2 and 4), see contract for any exceptions;
- Model input files for model calibration and predictive scenario(s) in MODFLOW 6 or more recent version and Groundwater Vistas (7.x), as applicable; and
- All computer programs (source code, executable, and scripts—with TWDB preapproval) that are used during the conceptual model and/or model development.

The stakeholder advisory forum participants have a 30-day review period and TWDB has a 45-day review period comment on the conceptual report. Stakeholder advisory forum participants and TWDB have the same amount of time to comment on the draft model and predictive scenarios report. The project manager will have at least 30 days 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 Contractor's project manager must deliver to TWDB:

- Digital copy of the final conceptual or final model/predictive scenarios reports including all figures (in Microsoft Word 2010 format)—see Attachment 3 for formatting guidelines;
- Adobe Acrobat (PDF) file(s) of final conceptual or final model/predictive scenarios reports 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;
- Digital copies of all source and derived model data in digital format in the appropriate geodatabase with proper documentation and formatting (see Attachment 2);
- Digital copies of all geophysical log files in the BRACS database with proper documentation and formatting (see Attachment 4), see contract for any exceptions;
- Digital copies of the Model input files (MODFLOW 6 or a later version and Groundwater Vistas 7.x) and supporting calibration and model related files, as applicable;
- Digital copies of all computer programs (source code, executable, and scripts—with TWDB preapproval) that are used during the conceptual and/or model development; and
- For models contracted out by TWDB, digital copies of all software application (with preapproval from TWDB of the software code used) that extracts and manipulates water budgets to satisfy the groundwater districts' management plan reporting requirements. Per Texas Water Code § 36.1071 (h), the application must have the ability to 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 that the delivered reports be of high quality and that TWDB receives the proper files. Consistent geologic, hydrologic, and technical terminology must be used throughout each report. No acronyms may be used except for Texas Water Development Board (TWDB) after it is introduced in the text and the abbreviations for model files. Any references to aquifers in Texas must use the nomenclature used by TWDB. Each report must have an authorship list of persons responsible for the studies; firm or agency names as authors are not acceptable. Final approved reports must follow Texas Board of Geoscientists guidelines (see www.tbpg.texas.gov) and must be sealed by either a Professional Engineer or Professional Geoscientist, as applicable. The TWDB logo or state seal may not be used on final reports.

3.5 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 TWDB in promoting the modeling efforts and informing the public (in Microsoft PowerPoint and Adobe Acrobat [PDF] formats). Geodatabases, MODFLOW files (and Groundwater Vistas), and the report may all be posted on the TWDB website or Amazon iCloud and will be distributed to interested parties. TWDB will maintain centralized ownership and maintenance of the models. Because of the posting of key model related documents on the web, the presentations and documents must all comply with Web Content Accessibility Guidelines (WCAG) 2.0 and PDF/UA (Universal Access, or ISO 14289) or later.

4.0 PROJECT MANAGEMENT

Contractor must provide monthly letter reports for the duration of the modeling projects summarizing progress on the project. Any concerns must be documented in the progress reports and brought to the TWDB contract manager's attention as soon as possible. The TWDB contract manager may schedule appointments with the project manager and team members to gauge progress on the project. The Contractor's project manager must also hold project review meetings with TWDB, including:

- The beginning of the project,
- After delivery of the model design milestone,
- After delivery of the model calibration milestone, 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 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 must also be invited and attend all the stakeholder advisory forums.

5.0 PROJECT SCHEDULE

All deliverables must be completed by the dates noted in the Contract. The draft conceptual or numerical model report (as applicable to the contract,), as well as all associated data and model files, must be delivered by the date noted in the Contract.

ATTACHMENT 1: Numerical Model Guidelines

1.0 MODEL ARCHITECTURE

The models must use MODFLOW 6 (Langevin and others, 2021) or a more recent MODFLOW code with pre-approval by email 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) must be fully compatible with Groundwater Vistas 7.x (or later), a proprietary pre- and post-processor to the MODFLOW code. The final model must 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.

1.1 CELL SIZE, ORIENTATION, LAYERING, AND PARAMETER ASSIGNMENT

The models must 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.

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

Lateral grid cell size must be *no greater than* 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 must be oriented with the prominent grain of the hydrostratigraphic structure and/or regional groundwater flow paths, as much as possible. The x-y coordinates for the lower left corner of the model grid (and the angle of rotation from true north, if applicable) must be noted within the model report and noted in the metadata of the geographic information system feature dataset within the geodatabase.

Layers must 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;
- are convertible, unless otherwise directed by TWDB;
- Include transmissivity calculated according to the modeled saturated

thickness; and
- Correspond to specific hydrostratigraphic units or groups of hydrostratigraphic units.
- Layers must not be of arbitrary thickness consisting of all hydrostratigraphic units within that thickness without prior written approval from the TWDB contract manager.

Hydraulic property values used for model construction must be based on field measurements and consistent with the conceptual model. It is the responsibility of the Contractor's project manager to review all available data and to correctly define the hydraulic property values. If certain properties are assigned to the model on cell-by-cell basis, then spatial data must be interpolated to model cells using an appropriate interpolation procedure. For MODFLOW 6 family codes, the Contractor must identify whether the storativity or specific storage is used. And, for the latter, the contractor must document how the specific storage is calculated.

1.2 MODEL EXTENTS AND BOUNDARIES

The extent of the models must follow natural boundaries as much as possible. The report must describe the rationale for the boundaries in the model for aquifers that extend outside of Texas. The Contractor's project manager must 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.

1.3 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 Contractor's project manager must obtain written permission from the TWDB Contract Manager to use a package other than the MODFLOW Recharge package to simulate recharge in the GAM. The chosen method must 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. 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 6 or later version packages to consider, depending on scale and flow conditions, 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.

It is extremely important to realistically model the effects of withdrawals on water levels in aquifers. Contractor's Project manager 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 must 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,). Contractor's Project manager may use the River or Drain package for rivers and streams if they can demonstrate to TWDB GAM staff that model predictions will not be affected. Like recharge, 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). Discussing or implementing an approach to model or link models for surface water-groundwater interactions is encouraged if the data supports the additional complexity.

1.4 PUMPING

Groundwater pumpage must 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 Contractor's 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 must document why and how the adjustment is made.

2.0 MODEL CALIBRATION

Calibrations of the models must be both steady-state and transient. The steady-state calibration must be performed to predevelopment conditions. The mean absolute error or root mean squared error between measured hydraulic-head and simulated hydraulic head must be less than 10 percent of the measured hydraulic-head drop across the model area for each model layer. Any error must not be spatially biased (For example, not by areas with more control points than other areas). Final calibration results must 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) must be less than 1(one) percent and ideally less than 0.1 percent for each model layer within each county. Initial parameters for the models must 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) must 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 must meet with TWDB staff to discuss how to proceed with the model. TWDB will not accept over-calibrated models.

The transient model must 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 must not be greater than one year. Particular attention must 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 must be matched as closely as possible during the transient calibration. Long-term hydrographs comparing measured hydraulic head and simulated hydraulic heads must 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 must 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) must also be calibrated and matched to within 10 percent of measured values.

The model must 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 must 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 that 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, outcrop and subcrop, and for the individual layers must be included in the final report. This water-budget table must 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
- Changes in storage

The water-budget table must include budget information for the steady-state model and transient model. The Contractor's project manager must 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, must be included in the final report.

To confirm the model is compatible with current model objectives an additional water budget analysis must be done. Per Texas Water Code, § 36.1071 (h), the application must 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.

In addition, there must 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 Contractor's project manager must have a strategy for addressing dewatered cells during calibration simulations. If the aquifer has not historically gone dry, then the aquifer must 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 Contractor's 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 must 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.

3.0 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 must 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 must 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); and
- Boundary conditions for transport models.

Model parameters must 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 must 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 must be conducted (for example, confined storativity). Results of the sensitivity analysis must 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 must 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 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.

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.

Langevin, C.D., Hughes, J.D., Banta, E.R., Provost, A.M., Niswonger, R.G., and Panday, Sorab, 2021, MODFLOW 6 Modular Hydrologic Model version 6.2.2: U.S. Geological Survey Software Release, 30 July 2021 https://doi.org/10.5066/F76Q1VQV

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.

Final Draft	Final		Numerical Model Report Checklist
		Report deliverable:	
			Received electronic version of report (word version).
			Received separate copies of figures.
			Received pdf of report/figures combined in sections not to exceed 10 MB.
			Appropriate units of measure used (See GAM Standards, ***Section .3.4.1***).
		Document formatting:	
			12-point Cambria for all text.
			Single-spaced text.
			Left justification for paragraph text.
			18-point bold for first-level headings.
			14-point bold for second-level headings.
			Page numbers are centered at the bottom of the page.
			Page setup should use one-inch margins on all four sides.
		Report Content:	
		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 Updates to the conceptual model	
			Please refer to checklist for conceptual model for the topic and associated figures needed
			Include original block diagram (if applicable) and updated block diagram if conceptualization of flow has changed.
		3.0 Model overview and packages	
			Discuss the general attributes of MODFLOW including code, processor and packages (see Numerical Model Section 1.0).
			All MODFLOW input and output packages should be included in a name file.
			Summary of all model input packages and filenames. All MODFLOW packages

			used by the model should be documented in a separate section including packages not explicitly listed below (for example horizontal flow barrier package)
			Contractor must document how the parameters are defined and if the parameters are consistent with the conceptual model. Contractor must contact TWDB first before inconsistent parameters may be used for the model construction and calibration
			Summary of model output files and filenames
		3.1 Basic package	
			Maps showing the location of active/inactive cells in each of the model layers and related hydrogeologic units
		3.2 Discretization package	
			Table of stress periods with time interval and related year and/or month
			At least two cross-section figures (perpendicular to each other) showing the numerical layers and related hydrogeologic units
		3.3 Layer-property flow package or equivalent	
			Map (e.g. raster image) of each of the property values for all model layers used by the layer-property flow (LPF) or other property package (e.g. BCF)
			Tables of statistical summary of all property values at model cells used by the property package and their comparison with the related field measurements and conceptual model
			If different zones are used for the same hydrogeologic unit, the summary table(s) must also reflect the zones
		3.4 Well package	
			Map(s) (e.g., raster image) showing well locations and if possible extraction/injection rate per model cell for each 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
		3.5 Drain package	
			Map showing the drain locations and type of hydraulic features simulated by drains
			Summary table of drain heads and conductance values as well as associated model layer/row/column and hydraulic features
		3.6 General-head boundary package	
			Map showing the general head boundary (GHB) location and type of hydraulic features simulated by the GHB

			Table of GHB head and conductance values as well as associated model layer/row/column and hydraulic features
		3.7 Recharge package	
			Map(s) (e.g. raster image) of 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 must also be presented on separate maps.
			Table(s) of total recharge per county per stress period for each type of recharges, if applicable.
		3.8 Stream or river package	
			Map(s) showing locations of streams or rivers in the model
			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
		3.9 Evapotranspiration (ET) package	
			Map(s) showing distribution of ET rates and any other pertinent information
			Table(s) showing average root depths for vegetation types
		3.10 Output control file	
			Contractor can use either words or numeric codes to specify the output control file.
			The output control file must 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.
			The output control file must be consistent with the name file if numeric codes are used.
		3.11 Solver	
			Type of solver
			Head change and residual convergence criteria
			The criteria must 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.
		4.0 Model calibration and results	
			This section should summarize the procedure/method used for model calibration and calibration results (see Numerical Model, Section 2.0). Model calibration must include both steady-state and transient conditions. Details discussed in Numerical Model, Section 2 must be included.
		4.1 Calibration procedure	
			Contractor must state what measured or calculated targets are used for the

			model calibration.
			Contractor must do a QA/QC on the targets and select the reliable ones for the model calibration
			Contractor must provide reasoning if some targets are eliminated from the calibration process
			Contractor must document calibration results separately for steady-state and transient conditions
			Contractor must describe parameters adjusted during calibration of the model (for example, recharge, hydraulic conductivity, storativity, vertical hydraulic conductivity)
		4.2 Model simulated versus measured heads	
			Contractor 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
			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 statistical summary of residuals on the plots or in separate tables
			For transient model, maps must be shown for selected stress periods showing the head residuals at head target locations per layer for selected stress periods approved by TWDB
			Histogram of the frequency of residuals in each model layer
			Hydrographs at head targets with both simulated and measured heads including a map showing locations.
			Maps showing the simulated head contours and flow directions superposed on measured/interpolated head contours
			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
		4.3 Model versus measured fluxes	
			Map(s) showing locations of flux targets (such as springs, seeps, etc.) per model layer
			Scatter plots of modeled versus measured flux for all flux targets with statistical summary of residuals on the plots and in separate tables
			Scatter plot of modeled versus measured flux per layer with statistical summary of residuals on the plots or in separate tables.
			Hydrographs at flux targets with both simulated and measured fluxes
		4.4 Model water budgets	

			Discuss water budget by county and groundwater conservation districts (Tables should be included in Appendix A).
			Table of steady-state calibration net water budget overall and summed per aquifer layer(s)
			Figures of transient overall net water budgets by flow component and subdivided by summed aquifer layer(s)
			Water budgets per Texas State Water Code, Section 36.1071, Subsection (h), the application must 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.
		5.0 Sensitivity analysis	
		5.1 Procedure of sensitivity	
			See Numerical Model, Section 3.0
		5.2 Results of sensitivity analysis	
			Sensitivity plots of how water levels or appropriate fluxes (for example, baseflow, springflow) are affected by changes in all aquifer parameters (see Mace and others (2000) for the format of the plot) also include additional plots, as applicable, discussed in Numerical Model, Section 3.0.
			Several hydrographs demonstrating the sensitivity of water-level and flux fluctuations to changes in important hydrologic properties of the model, also include additional plots, as applicable, discussed in Numerical Model, Section 3.0.
		6.0 Predictive Simulation(s)	
			Table with desired future condition compared to the results from the new model by county, aquifer, and/or desired future condition. Must include column with modeled available groundwater. Discuss baseline and final year used in the calculation (must match current desired future condition assumptions.
			Discuss in text all assumptions used in the predictive simulation.
		7.0 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.
		8.0 Summary and conclusions	
			Summarize the modeling project and its results.

		9.0 Future improvements	
			Indicate where additional improvements could be made to the model. Recommendations for how these issues could be addressed will be appreciated and may result in future studies.
		10.0 Acknowledgments	
			Acknowledge those organizations or specific individuals that assisted in the modeling project.
		11.0 References:	
			All references cited in the report must be included in the 'References' section following TWDB format.
		APPENDIX A	
			Water budgets by county and layer.
			Water budget for groundwater conservation districts
		APPENDIX B	
			Tables including head target name, coordinates, 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
			Other calibration results
		Figures check - photocopy all figures in black and white:	
			Figures must be designed such that a black and white printout is readable and understandable;
			Maps include a north arrow and a scale;
			Each figure has a caption that includes reference sources for the basemap or the included information; and
			Figures must follow Texas Board of Geoscientists guidelines.
			Figures within margin of one-inch page margins
			Figure captions below figures
			Table captions above tables.
		Model data	
			Model ESRI Arc/GIS 10ArcGIS 10.2 (or later) geodatabase
			MODFLOW 2005 or later ASCII format files (steady-state & transient)

				Groundwater Vista Files (steady-state & transient) & ESRI GIS shapefiles of the:
				• model boundary;
				• county outlines; and
				• rivers, streams, and lakes.
				Stress period table
				Model(s) run
				Model(s) match results in report- water budget (overall and by county), statistics, hydrograph plots, contours, and residuals.
				Check:
				Recharge
				Rivers
				Drains
				Streams
				Hydraulic Properties
				Boundaries (GHB)
				ET
				Rewetting
				Framework
				HFB
				Reservoir
				Other packages
				Other packages
				Initial Heads
				Targets
				Grid Attribute Table
				Predictive model run

ATTACHMENT 2: Geodatabase/Data Model for the Groundwater Availability Models

1.0 INTRODUCTION

To capture the various data types and information sources that go into s GAM, TWDB has developed a GAM data model. A data model is a logical construct for the storage, organization, documentation, and retrieval of digital information. The GAM data model is built upon the Environmental Systems Research Institute, Inc. (ESRI) ArcGIS 10.2 (or later) file geodatabase, optimized to manage GAM related spatial and non-spatial data. A file geodatabase is an organized collection of folders for storing geographically referenced datasets as well as tabular and image data files. The GAM data model consists of two principal geodatabase products expected from each GAM project: (1) the Source Geodatabase consisting of conceptual model source and unique derivative datasets used for the project, and (2) the MODFLOW Geodatabase for the final MODFLOW numerical model input data values. The Source Geodatabase consists 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 input values. The MODFLOW Geodatabase consists of the model grid referenced input values used for the final steady-state and transient numerical model calibration, sensitivity analysis, and predictive simulations.

Before starting the modeling project, the project manager(s) must request copies of the most current GAM Geodatabases. which are maintained and periodically updated by TWDB. It is extremely important and a requirement that all spatially referenced source data for a GAM project be used within the GAM Geodatabase coordinate system prior to generating any derivative and/or numerical model grid input data sets. The GAM Geodatabase coordinate system uses the Albers Equal-Area projection to minimize the statewide spatial distortion of area and to maintain areal proportions true to the surface of the earth. The GAM Geodatabase projection parameters shown in Table A3-1 must be used for all GAM project related spatial data throughout the project. The GAM Geodatabase file geodatabase schemas will be provided preset with the correct GAM coordinate and projection parameters and any imported spatial data with a predefined coordinate system will be automatically projected into the GAM coordinate system during data loading.

Table A3-1. Projection parameters used for the GAM Geodatabase coordinate system.

Projection :	Albers Equal-Area	
Units of Measure :	U.S. Survey Feet	
Horizontal Datum :	NAD83	North American Datum 1983
Vertical Datum :	NAVD88	North American Vertical Datum 1988
Spheroid :	GRS80	
Longitude of Origin :	-100.00000°	100° 00’ West
Latitude of Origin :	31.25000°	31° 15’ North
Lower Standard Parallel 1 :	27.50000°	27° 30’ North
Upper Standard Parallel 2 :	35.00000°	35° 0’ 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 non-spatial data will be generated by a GAM modeling study. Each contracted project manager must request from the TWDB contract manager an empty file geodatabase schema to organize and store all the source and derivative information used for the conceptual model, and/or for the MODFLOW numerical model grid input values.

ESRI ArcGIS (version 10.2 or later) software is required to work with the TWDB GAM file geodatabases. The file geodatabase schemas will contain empty feature datasets, feature classes, object classes, tables, and raster datasets ready to be loaded with project data. The GAM project manager must use the geodatabase schemas for organizing, processing, and archiving all GAM project data. The GAM geodatabases are extendable, but prior written approval from the TWDB Groundwater Division, Groundwater Modeling department manager must 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 the derivation processes in the final project report, can be used to reproduce all the model grid referenced input values in the numerical model. A MODFLOW Geodatabase is intended to store all the input data used to run the final calibrated steady-state and transient numerical model calibration, sensitivity analysis, and predictive simulations with reference to the MODFLOW code model grid cells. Written pre-approval from the TWDB Groundwater Modeling department manager is required if for any reason the source or derivative data is

not compatible with the geodatabase schema.

1.1.1 SOURCE GEODATABASE SCHEMA

Source and unique derivative information must be organized in the GAM Source 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 GAM Source Geodatabase to reproduce critical numerical model input values. Vector spatial data must be contained in feature classes that are organized into feature datasets. Each feature dataset contains thematically related point, line, and polygon feature classes. Non-spatial tabular data must 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 and georeferenced map graphics, logs, and cross-sections) must be managed in the geodatabase as raster datasets or raster catalogs.

1.1.2 MODEL GRID FEATURE DATASET

A model grid feature dataset must be located within the Source Geodatabase Boundary Feature Class and consist of a vector polygon feature class of model grid cells and a point feature class of model grid cell nodes. The polygon feature class must consist of a rectangular grid structure of polygons representing a finite difference model grid with cells no larger than 1 mile by 1 mile. The point features must 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 must 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 GAM projects are limited to the following:

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

For MODFLOW USG grids, the unique CELL_ID must be sequential for each later and compatible with Environmental Simulations Incorporated (ESI) Groundwater Vistas version 7 or later pre and post processor MODFLOW modeling software.

1.1.3 MODFLOW GEODATABASE SCHEMA

The GAM 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 6 or later version of MODFLOW input values and for time-series

variables linked with relationship classes.

1.2 DATA QUALITY ASSURANCE AND CONTROL

Basic data quality assurance tactics are listed here and should be the minimum performed to find gross typos, errors, illogical geologic features, and inconsistencies in the geospatial data for the study.

- A project snap grid raster should be developed for each project using the GAM Geodatabase coordinate system, Albers Equal-Area projection described above. Each GIS raster file developed for a project should be snapped to this grid to ensure every grid cell in all rasters stack on top of each other without any offset.
- Check the extents of spatial datasets against your snap grid for incorrectly plotted data. A negative sign may be left off an XY coordinate resulting in location errors.
- Interpolated values in a raster dataset need to reflect the source point data used in the interpolation process.
- Raster surfaces for stratigraphic tops and/or bottoms should only have cell values within the horizontal extent of the formation they are representing. For example, there should not be raster values for a formation updip of its outcrop.
- Check stratigraphic tops and/or bottom raster surfaces for negative thicknesses.
- Visually scan interpolated raster surfaces for anomalies. If something looks strange but is valid, please discuss it in the report.
- The accumulative thickness of a lithology raster, such as net sands, cannot be greater than the stratigraphic raster for the formation of interest.
- Document the sources, processing steps, interpolation methods, and field definitions for geospatial data in the metadata.

1.3 DATA DOCUMENTATION

All datasets used for GAM projects must include metadata that documents the content, data structure, descriptions of table fields, units of measure for numerical data, categorical definitions for nominal data, data source(s), date(s), quality, and other characteristics of the data within the geodatabases. Metadata must be created using the Federal Geographic Data Committee (FGDC) metadata editor within ESRI's ArcCatalog. If the source data was obtained without FGDC compliant metadata, the project manager must create the metadata within the ArcCatalog using ESRI ISO metadata standards. The TWDB-provided schemas include some basic metadata, which must be extended by the contracted project manager to completely document all source and derivative data. The contracted project manager must 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.

Metadata for leapfrog dataset(s) should be included for each of the Objects and/or Tables within each of the Folders in the Project Tree. At a minimum, all Objects and attribute fields within a Table should have adequate descriptions of the Data Type and units of measure as applicable. The metadata may be created within a Microsoft Word document or Excel spreadsheet

1.4 REFERENCES

Federal Geographic Data Committee: https://www.fgdc.gov/metadata/csdgm/

Langevin, C.D., Hughes, J.D., Banta, E.R., Provost, A.M., Niswonger, R.G., and Panday, Sorab, 2021, MODFLOW 6 Modular Hydrologic Model version 6.2.2: U.S. Geological Survey Software Release, 30 July 2021 https://doi.org/10.5066/F76Q1VQV

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

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 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 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.

No acronyms must be used except for Texas Water Development Board (TWDB) after it is introduced in the text or the abbreviations for model files. Any references to aquifers in Texas must use the nomenclature used by TWDB. The TWDB logo or state seal must not be

used without prior approval by TWDB.

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.

The title page must include the title of the report and TWDB contract number. Each report must have an authorship list of persons responsible for the studies; firm or agency names as authors are not acceptable. Final approved reports must follow Texas Board of Geoscientists guidelines (see www.tbpg.texas.gov) and must be sealed by either a Professional Engineer or Professional Geoscientist, as applicable.

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. 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 must 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 Text	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 ACKNOWLEDGEMENTS

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.

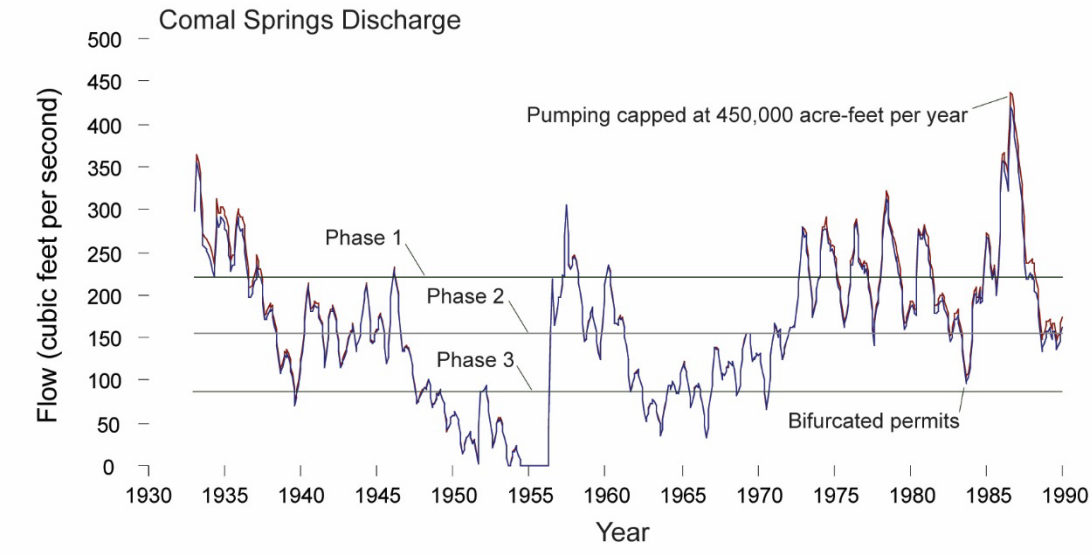

Figure 1. A sample figure showing only the information needed to help the reader understand the data. Font size for figure callouts or labels should never be less than 6 point.

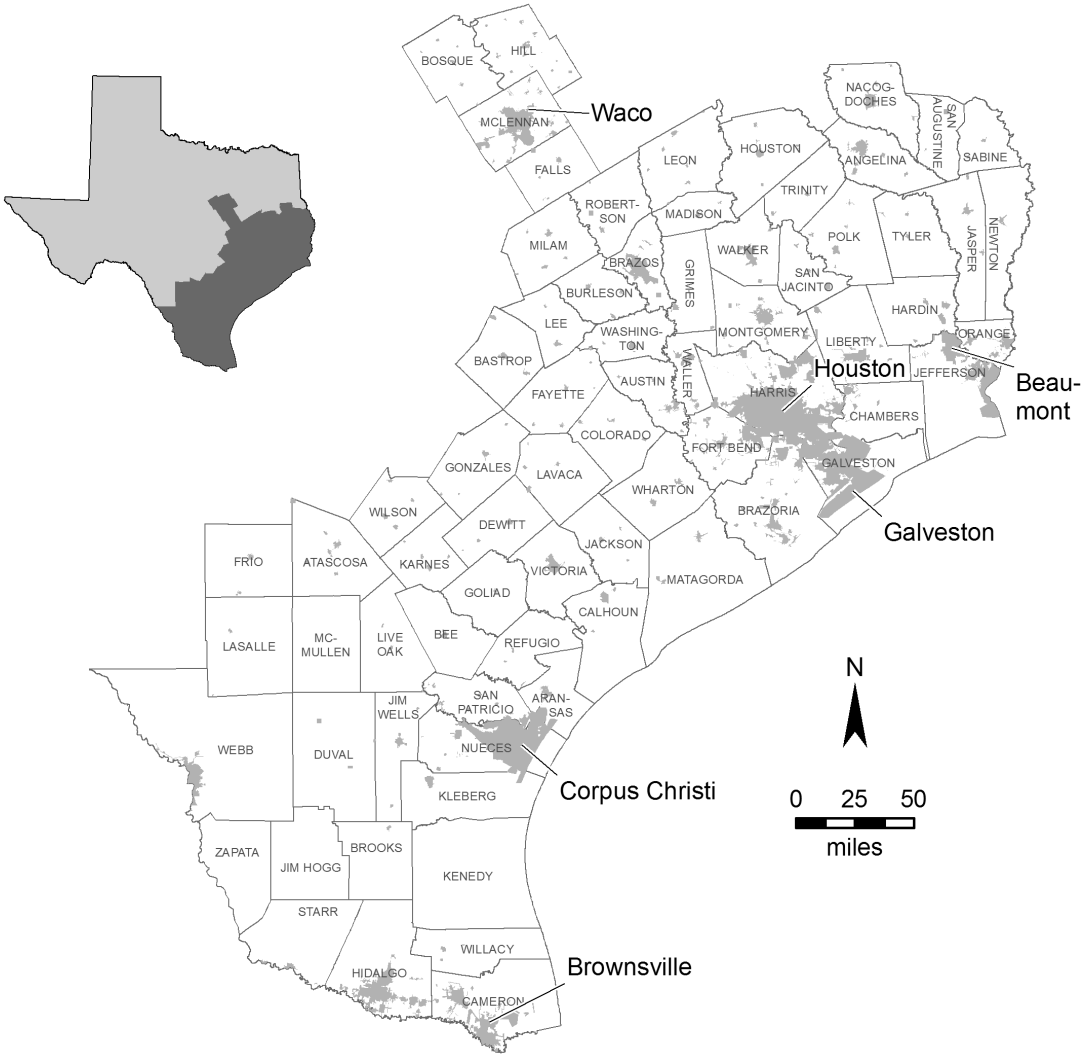

Figure 2. A sample subject area map, giving the reader enough information to understand the location being discussed in this conference. For map figures, be sure to include a north arrow to orient the reader, a scale, and, if needed, a submap that places the figure in greater geographic context. Be sure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

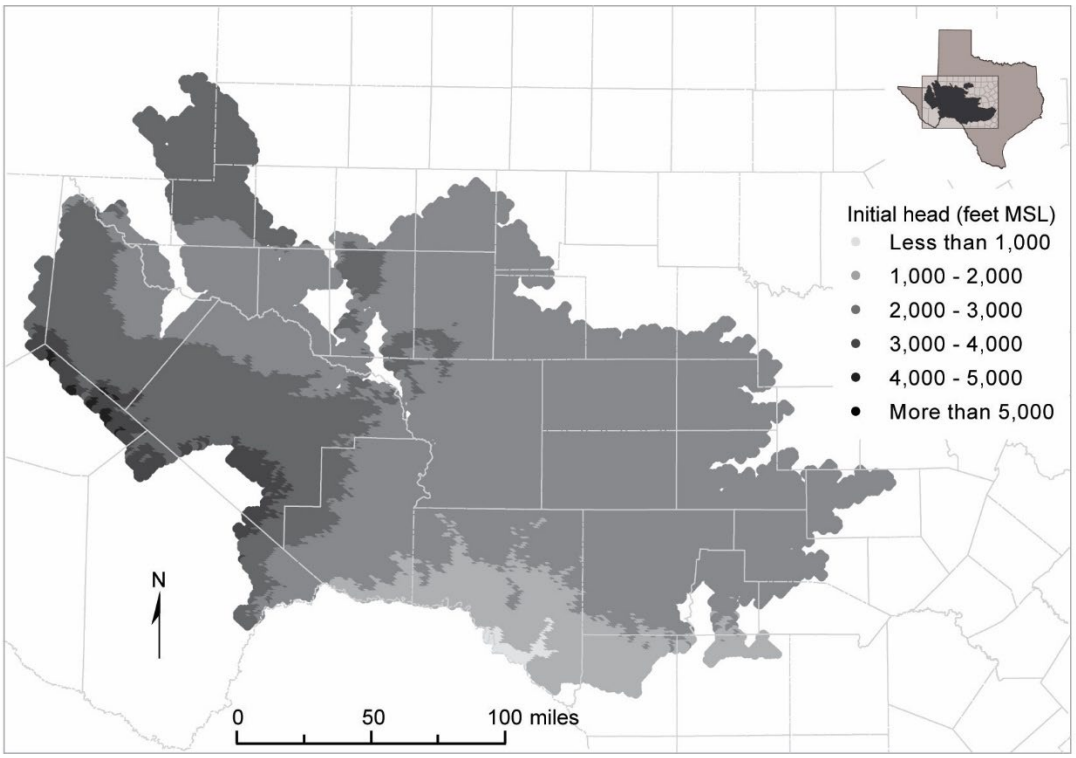

Figure 3. Initial hydraulic heads used in model simulations for layer 1. Note the use of grayscale shading to show differences.

ATTACHMENT 4: BRACS database

Please see http://www.twdb.texas.gov/innovativewater/bracs/database.asp for latest data dictionary and to download the database.

1.0 INTRODUCTION

The purpose of this document is to describe the required format and organization of well data submitted to the Texas Water Development Board (TWDB) Brackish Resources Aquifer Characterization System (BRACS) database. Using these standards will assist in the transmission, review, archival, and future use of the well data provided.

2.0 ORGANIZING SOURCE WELL CONTROL INFORMATION

Diligent data management is key to maintain control, organization, and usefulness of information as complicated as the multiple relationships between wells, various names for the same well, location information, well construction, logging, and analysis of the logs.

2.1 BASIC REQUIREMENTS

All data and information provided to TWDB must be non-confidential since it will be posted for public consumption. All well attributes should be added to the BRACS Database. All well reports, geophysical well logs, and other well information used in a project must be provided to TWDB. Digital formats include:

- Well reports, PDF
- Geophysical well logs, TIFF and LAS (if available)
- Depth registration (calibration) files (acceptable formats: xml, lic, dra).

2.2 DATA STORAGE FOLDER STRUCTURE

All well reports and geophysical well logs must be filed using this folder structure:

- Water well and supporting data will be filed in a folder named DrillerWellLogs with subfolders named by state_county codes.
- Geophysical well logs will be filed in a folder named GeophysicalWellLogs with subfolders named by state_county codes.
- State_County code: example 42_029 for Bexar County. TWDB can provide a Microsoft Excel spreadsheet with the state and county codes.

2.3 DIGITAL FILE NAMES

Q-logs from the Railroad Commission of Texas Groundwater Advisory Unit: Example: Q123_029.tif. If there are multiple logs per well, add log1, log2, … to file name as a suffix. If more than one well is assigned the same Q number, add letters a, b, c, … to Q number, example Q123a_029.tif, Q123b_029.tif.All other well control must have the State and County code prefix added to the filename (Example: 42029_123456.pdf.The digital file name, file type, and folder name will be recorded in the BRACS Database table tblGeophysicalLog_Header or tblBracsWaterWellReports.

2.4 DUPLIATE WELLS

The database is designed to hold one record per well. Duplicate wells should be

avoided, and every attempt should be made to ensure that this does not occur. Well name and number attributes should be added to the table tblForeignKey that will support identification of duplicate wells.

2.5 PURCHASING WELL LOGS

All well data purchased for a project should be documented in an Excel spreadsheet that will include:

- (1) the BRACS Well ID for the well record,
- (2) API number of the well (if available),
- (3) well number,
- (4) raster image filename,
- (5) depth calibration filename,
- (6) number and type of log curves digitized (for LAS files), and
- (7) unit cost per log.

The spreadsheet will be submitted to TWDB with a folder containing the log files so TWDB can determine (1) if all of the logs have been submitted, (2) the quality of the logs, (3) potential duplication of logs, and (4) the cost of the logs for invoice evaluation.

Contractor will not be reimbursed for a log if the log already exists in the BRACS Database or was provided to the contractor from the TWDB unprocessed log collection except under the following circumstances: a better quality log is submitted; a more complete log is submitted; a log with different tool suites is submitted; a LAS file is submitted where one did not exist in the BRACS Database; a depth calibration file for the log is submitted where one did not exist in the BRACS Database.

Contractor will not be reimbursed for a log if it is illegible or missing key components such as tool scales or log header data. Exceptions may be made for logs from key wells used for stratigraphic interpretation.

3.0 THE BRACS DATABASE

The BRACS database is a Microsoft Access database developed and evolved to manage well data since 2009 and is publicly available for download from the TWDB website.

3.1 BASIC REQUIREMENTS

All new well control will be added to a copy of the BRACS Database. If the contractor would prefer to provide each of the tables in Microsoft Excel as opposed to Microsoft Access, please contact the TWDB Contract Manager.

- New data tied to existing well control in the BRACS Database, such as geology records (lithology; stratigraphic picks; porosity calculations; salinity zones) will have applicable tables updated.

- Download the latest version of the BRACS Database and data dictionary for well control using this web address:

http://www.twdb.texas.gov/innovativewater/bracs/database.asp

- Use Brackish Resources Aquifer Characterization System Database Data Dictionary (TWDB Open File Report 12-02, Third Edition, April, 2017) to understand table relationships, field names, and data types.
- New well control provided by a contractor will begin with a specified well _id. Coordinate with TWDB BRACS staff for this starting well_id number. As a contractor appends new well control to their copy of the BRACS Database, TWDB staff will continue to update the official BRACS Database. When the project is complete, TWDB staff will take all new project well control records and append them to the official BRACS Database.
- If the Contractor has any database questions, please contact TWDB staff prior to investing a large amount of time on a task. It is better for all parties to complete the task correctly the first time.

3.2 WELL IDENTIFICATION NAMES AND NUMBERS

- New well control added to the BRACS Database will have all well identification names or numbers added to the BRACS Database table tblBRACS_ForeignKey.
- The BRACS Database table tblLkFK_ID_Name is a list types of foreign keys. This table is updated constantly as new sources of data are encountered. Consult with TWDB staff if this table needs updating during a project.
- Wells used in a project cross section will have a record added to the BRACS Database table tblBRACS_ForeignKey using a very specific format. See this table for formatting.

3.3 WELL LOCATION

- Latitude and longitude in decimal degree format will be used for each well.
- NAD 83 horizontal datum will be used for each well.
- Elevations using 30 meter DEM will be used.
- Location attributes will be recorded in the BRACS Database table tblWell_Location.

3.4 GEOPHYSICAL WELL LOG DATA

- All new geophysical well log data used for a project will be provided to TWDB as a deliverable. Paper documents will be scanned in TIFF format and filed in the appropriate state_county code folder in the GeophysicalWellLogs folder. Well control will be added to the BRACS Database, the digital file name and additional attributes will be added to the table tblGeophysicalLog_Header, and log tools will be added to the table tblGeophysicalLog_Suite.
- Depth calibration files will be submitted to TWDB.
- LAS files for logs will be submitted to TWDB.
- Digital geophysical well logs should be legible and scanned in at least 300 dots per

inch or greater. If the original paper document was in color, the scanning must be in color. If the original was in poor condition and the scanned image is the best available, note this in the table tblGeophysicalWellLog_Header, field [remarks].

3.5 GEOLOGIC FORMATION LITHOLOGY AND STRATIGRAPHY

- Geologic formation lithology and stratigraphic top/bottom depth values will be appended to the table tblWell_Geology.
- Geologic formation lithology from driller well reports is converted to a simplified lithology using the BRACS Database table tblLkLithologicName_to_SimplifiedLithologicName. This table is updated constantly as new terms are encountered.
- Interpretation of sand/clay from geophysical well logs will use either a two tier (sand, clay) or a four-tier classification system consisting of the following terms and sand percentages:
    - sand (100 percent sand)
    - sand with clay (65 percent sand)
    - clay with sand (35 percent sand)
    - clay (0 percent sand)
- Lithology interpreted from geophysical well logs will begin approximately 100 feet shallower than the top of the geological formation of interest and end approximately 100 feet deeper than the base of the geological formation of interest. No gaps in lithology will be permitted unless the geophysical well log includes a gap in tool coverage; in this situation, label the depth range as “no record” and list the reason in the remarks field.
- Lithologic interpretation is not possible in the cased portion of a well with no geophysical tool curves. The portion of the cased hole should be labeled “no record” with the top and bottom depths recorded.
- Stratigraphic interpretation is not possible in the cased portion of a well with no geophysical tool curves. For example, if the top of the geological formation is within the cased portion, do not provide a top depth value for the geological formation. Exceptions to this may be made where stratigraphic interpretations are made from Gamma Ray curves with significant character in cased sections of a well.
- Stratigraphic interpretation is not possible below the bottom depth of a well. For example, when the logging terminates at bottom depth of the well above the geological formation bottom, do not provide a bottom depth value for the geological formation.
- Lithologic and stratigraphic data provided for a well implies the data originated from the well, for example formation descriptions from the well driller or interpretations made from geophysical well logs. Do not back-calculate lithologic or stratigraphic data to wells from other sources. If this must be done, provide this information in a separate table of similar design to the table tblWell_Geology and indicate the exact source of the information, methods used, assumptions made, and

reasons why this method was used to back-calculate the data. Examples include existing cross-sections or geological formation surfaces prepared from other studies.

- If stratigraphic or lithologic values must be created based on best professional judgement to aid in the interpolation process, create a separate table and shapefile. This will prevent them from being mistaken as log interpretations.
- Porosity values can have significant impacts on water quality calculations from geophysical well logs and volume calculations. These data can be difficult to locate. A thorough literature review and log search is required. Contact TWDB staff for literature suggestions or if tables in the BRACS database to assist in porosity calculations from geophysical well logs are desired.

3.6 WATER QUALITY DATA

- All water quality data that is not in the TWDB Groundwater Database will be provided to TWDB as a deliverable. Paper documents will be scanned in pdf format and filed in the appropriate state and county folder in the DrillerWellLogs folder. Water quality well control will be added to the BRACS Database, and a digital file name for the pdf well documents will be added to the table tblBracsWaterWellReports.
- Water quality data will be evaluated to ensure that samples are accurately assigned to the correct aquifer and/or geologic formation in a systematic and reproducible technique. The BRACS team refers to this as "Aquifer Determination".
- Water quality data, if not from the TWDB Groundwater Database, will be appended to tables tblBRACSWaterQuality and tlbBRACSInfrequentConstituents in the BRACS Database.

3.7 INTERPRETING TOTAL DISSOLVED SOLIDS FROM GEOPHYSICAL WELL LOGS

There will be a dearth of measured water quality samples in various regions of the aquifer. Water quality can be interpreted from geophysical well logs and recorded in the BRACS database to fill some of these gaps.

- The methods (computational, empirical) used to interpret total dissolved solids concentration from geophysical well logs will be fully documented in the technical report. All well records, input and output values, correction factors, and assumptions will be recorded in the BRACS Database. Links to water quality samples for specific depth zones within an aquifer will be provided with the geophysical well log record. If a new technique (or modification of an existing technique) is used, tables will be designed to link to the existing BRACS Database design to store the above mentioned parameters. A data dictionary description will be provided for the new table design. All geophysical well logs, if not in the BRACS Database, will be provided to TWDB.
- A number of geophysical well log interpretation techniques are described in: *Estepp, J.D., 1998, Evaluation of ground-water quality using geophysical logs: Texas*

Natural Resource Conservation Commission, unpublished report, 516 p.

3.8 GROUNDWATER SALINITY CLASSIFICATION

Groundwater salinity classification	Salinity zone code	Total dissolved solids concentration (units: milligrams per liter)
Fresh	FR	0 to 1,000
Slightly saline	SS	1,000 to 3,000
Moderately saline	MS	3,000 to 10,000
Very saline	VS	10,000 to 35,000
Brine	BR	Greater than 35,000

- Use classification by:
  Winslow, A.G., and Kister, L.R., 1956, Saline-Water Resources of Texas, U. S. Geological Survey Water Supply Paper 1365, 105 p.
- The salinity zone code will be used for GIS file naming.
- Technical report figures showing salinity zones or well control showing total dissolved solids concentration will use these colors.
- Brackish groundwater is considered slightly and moderately saline (total dissolved solids concentration 1,000 to 10,000 milligrams per liter).