

**Monthly Letter Progress Report # 5:
August 6, 2016-September 2, 2016
Study of Brackish Aquifers in Texas – Project No. 4 –
Trinity Aquifer
TWDB Contract No. 1600011950**

1.0 Budget and Expenses

This report summarizes the project costs for the billing period from Contract Approval Date (January 6, 2016) through the end of Period 12 of Fiscal Year 2016 (September 2, 2016). The total expenses through this period are \$59,683.74. A breakdown of the budget by task is provided in Table 1. A copy of the progress report has been sent to Texas Water Development Board (TWDB) along with the monthly invoice.

2.0 Progress on Tasks

This report summarizes activities on project tasks during Fiscal Year 2016, Period 12 (encompassing August 6, 2016 – September 2, 2016) and represents the fifth progress report on this contract.

Task 1: Project Management

During the reporting period, progress was made on setting up the subcontracts with INTERA, as well as on the agreements with the two in-kind teaming partners, Edwards Aquifer Authority (EAA) and Barton Springs Edwards Aquifer Conservation District (BSEACD). It was determined that the Bureau of Economic Geology (BEG) will no longer be participating in this project. TWDB has been alerted of this and we have taken steps to transfer the workload and funding intended for the BEG over to SwRI¹.

Based on discussions with our teaming partner INTERA, the Northern Trinity and the Hill Country Trinity Aquifer regions will be divided for the majority of this project. SwRI will be responsible for the Hill Country region and the area between the Hill Country and Northern Trinity Groundwater Availability Models (GAMs). INTERA will be responsible for the Northern Trinity region. At the end of the project, both regions will be combined into one deliverable.

¹ BEG planned to assist SwRI with the following tasks: acquisition and analysis of well logs, developing a stratigraphic and lithologic model, developing techniques for estimation of total dissolved solids (TDS) from geophysical logs, and combining geophysical log, stratigraphic, and salinity interpretations to map fresh, brackish, and saline groundwater. This work will now be performed by SwRI without assistance from BEG.

Task 2: Data Acquisition and Method Development

Task 2 has been subdivided into four subtasks. Progress on activities for the subtasks is as follows:

Subtask 2.1 Acquisition and Initial Analysis of Groundwater Samples

Water quality data were gathered from TWDB's groundwater database and reformatted to accommodate future statistical analyses. Specifically, five .txt files (i.e. 'WaterQualityMajor', 'WaterQualityMinor', 'WaterQualityCombination', 'WaterQualityOtherUnassigned', and 'WellMain') were combined and further parsed to create a water quality database within the acquisition domain. In addition to the aforementioned water quality database, spatial queries continued on Brackish Resources Aquifer Characterization System (BRACS)/TWDB databases. Other sources of information were evaluated, including groundwater conservation districts, oil and gas databases, and water supply wells.

Subtask 2.2 Acquisition and Initial Analysis of Geophysical Logs

A total of 146 scanned gamma ray logs were sent to Well Green Tech for digitization. These were processed by Well Green Tech, and the digitized logs have been received by SwRI. Digitized logs are evaluated to support development of an interpretation approach. Figure 1 shows a comparison of the digital logs and scanned logs for two wells, and demonstrates that there is good agreement between the two.

Development of a database with spatial attributes of all available logs [e.g. BRACS, Information Handling Services Markit (IHS Markit), BEG], with care to adhere to BRACS format, has continued. Other sources of relevant information including published literature, Groundwater Conservation Districts, Oil and Gas databases, water supply wells, Texas Commission on Environmental Quality (TCEQ) Public Supply, and United States Geological Survey (USGS) Produced Water databases have continued to be gathered and evaluated. A project database of water quality data relevant to the project domain and a preliminary hydrochemical facies analysis for the project domain has continued to be developed using TWDB's groundwater database. A license for the Gulf Coast IHS Markit database has been purchased by SwRI (using SwRI funds rather than project funds), and staff are being trained on how to use this database which will be utilized in the project. Key well² information was requested from our contacts in the groundwater industry (e.g., geologists or hydrogeologists employed by TWDB, EAA, or other groundwater-related companies), and information that has been gathered from these contacts to date is under review by the project team.

² A key well is a well that is tightly constrained in terms of identification, position information, well geometry, pick information in measured depth, wireline log data tied to interval picks in measured depth, and formational water chemistry.

Subtask 2.3 Develop Technical Approach for Estimating Total Dissolved Solids from Geophysical Logs

Efforts towards developing a method for correlating TDS data and geophysical log attributes have been initiated. Given its technical complexity, work on this task will continue for most of the duration of the project. Interpretation of logs for stratigraphy has begun, as well as estimation of TDS/Salinity from logs.

Subtask 2.4 Use Geophysical Log Interpretation to Analyze Stratigraphy and Map Fresh, Brackish, and Saline Groundwater

Gamma ray logs are being utilized for stratigraphic analysis. Resistivity and spontaneous potential (SP) curves will later be utilized for salinity analysis. Digitized well logs are being evaluated and the development of our interpretation approach has begun. Significant progress on this subtask has already occurred, however work is expected to continue during the next several reporting periods.

Task 3: Develop a Stratigraphic Framework Model of the Trinity Aquifer and Calculate Brackish Water Volumes

Task 3 has been subdivided into two subtasks. Progress on activities for the subtasks is as follows:

Subtask 3.1 Extend Stratigraphy for the Hill Country Trinity

Information on stratigraphy is being collected and evaluated based on the extent of the data acquisition domain. The literature search and assessment of relevant literature continues. Literature is being assessed for useful stratigraphic and structural information (e.g., cross-sections, fence diagrams, structure contour maps, well header information, stratigraphic horizon picks from wells, and fault maps).

Well logs from the BRACS well database have stratigraphic information, including stratigraphic horizon picks and lithologic information. The data will be evaluated to determine whether stratigraphic picks are consistent with those from other logs in the region, and/or with picks from a known reliable source such as a Key Well (see footnote 2). Log information from the IHS database will be evaluated once the SwRI team has received training on its use and has begun utilizing the database.

Subtask 3.2 Determine Volumes of Fresh, Brackish, and Saline Groundwater

Evaluation of the relationship between electrical resistivity and fluid salinity has continued during this period. It is recognized that articulating this relationship will be challenging due to the confounding influences of electrically conductive clay zones, but this work will be central to delineating the extent of brackish water in the Trinity Aquifer because geophysical logs will be the primary source of information used in this subtask.

Task 4: Delineate Potential Production Areas

Progress on this task is contingent on completion of the previous tasks.

Task 5: Determine the Amount of Brackish Groundwater that can be Produced without Causing Impact on Lateral and Vertical Fresh Water

Progress on this task is contingent on completion of the previous tasks.

Task 6: Stakeholder Communication

Progress on this task is contingent on completion of the previous tasks.

Task 7: Reporting

Task 7 has been subdivided into 2 subtasks. Progress on the subtasks is as follows:

Subtask 7.1 Project Monitoring Procedures

The project timeline has been reviewed periodically and frequently. The project budget has been monitored on a weekly basis using the SwRI Project Cost System. Project activity for each period is summarized in status reports for review by TWDB.

Subtask 7.2 Project Deliverables

Progress on this task during this reporting period has included preparing and delivering “Monthly Letter Progress Report #4: Period 11, Fiscal Year 2016.”

3.0 Planned Activities for the Next Reporting Period (Fiscal Year 2016, Period 12)

Task 1: Project Management

Subcontracts with the subcontractor, INTERA, as well as the agreements with the two in-kind teaming partners, EAA and BSEACD, will be finalized during the next reporting period.

Anticipating the finalization of the subcontract with INTERA before the end of Period 13, projected progress by INTERA during the next period is included below.

Task 2: Data Acquisition and Method Development

Task 2 has been subdivided into four subtasks. Planned activities for the subtasks are as follows:

Subtask 2.1 Acquisition and Initial Analysis of Groundwater Samples

Data on water quality from within the data acquisition domain will continue to be gathered during the next reporting period. This evaluation will be ongoing for most of the project.

Spatial queries will continue on BRACS/TWDB databases. Analysis and results of the groundwater data will continue. Collection of data on water quality will continue, as will evaluation of other sources of information, such as groundwater conservation districts, oil and gas databases, and water supply wells.

INTERA plans to initiate an inventory of water wells with water quality measurements in the Northern Trinity study area. INTERA will start assessing screen completions in terms of aquifer units.

Subtask 2.2 Acquisition and Initial Analysis of Geophysical Logs

Additional gamma logs will be provided to Well Green Tech for digitization in order to fill in gaps from the first round of digitization. Digitized logs provided by the vendor will continue to be evaluated to support development of an interpretation approach. Development of a database with spatial attributes of all available logs (e.g., BRACS, IHS, BEG), with care to adhere to BRACS format, will continue. Other sources of relevant information including literature, Groundwater Conservation Districts, Oil and Gas databases, water supply wells, TCEQ Public Supply, and USGS Produced Water databases will continue to be gathered and evaluated. A project database of water quality data relevant to the project domain and preliminary hydrochemical facies analysis for the project domain will continue to be developed using TWDB's groundwater database. Staff will continue to be trained on how to use the IHS database. Key well information will continue to be reviewed.

INTERA plans to inventory existing geophysical logs in the Northern Trinity footprint from the Northern Trinity GAM development, determine which logs have sand/limestone/shale picks (from Scott Hamlin at the BEG), and determine which logs have been digitized to LAS files. INTERA will also inventory available geophysical logs (e.g., short/long resistivity, spontaneous potential). Additionally, they will initiate determination of whether proximity of existing logs is sufficient for water well/geophysical log pairings.

Subtask 2.3 Develop Technical Approach for Estimating Total Dissolved Solids from Geophysical Logs

Efforts towards developing a method for correlating TDS data and geophysical log attributes will continue. Interpretation of logs for stratigraphy will continue.

Subtask 2.4 Use Geophysical Log Interpretation to Analyze Stratigraphy and Map Fresh, Brackish, and Saline Groundwater

Digitized well logs will continue to be evaluated, and the development of an interpretation approach will continue as well. Progress on this subtask is expected to continue during the next several reporting periods. Resistivity and SP curves will be evaluated with regard to potential digitization, to be utilized for salinity analysis in the future.

Task 3: Develop a Stratigraphic Framework Model of the Trinity Aquifer and Calculate Brackish Water Volumes

Task 3 has been subdivided into two subtasks. Planned activities for the subtasks are as follows:

Subtask 3.1 Extend Stratigraphy for the Hill Country Trinity

Progress on this subtask will continue in the next reporting period with the assessment of relevant data.

Subtask 3.2 Determine Volumes of Fresh, Brackish, and Saline Groundwater

Evaluation of the relationship between electrical resistivity and fluid salinity will continue during the next period. It is recognized that articulating this relationship will be challenging due to the confounding influences of electrically conductive clay zones, but this work will be central to delineating the extent of brackish water in the Trinity Aquifer because geophysical logs will be the primary source of information used in this subtask.

Task 4: Delineate Potential Production Areas

No work is expected to occur in the next reporting period.

Task 5: Determine the Amount of Brackish Groundwater that can be Produced without Causing Impact on Lateral and Vertical Fresh Water

No work is expected to occur in the next reporting period.

Task 6: Stakeholder Communication

No work is expected to occur in the next reporting period.

Task 7: Reporting

Task 7 has been subdivided into 2 subtasks. Planned activities for the subtasks are as follows:

Subtask 7.1 Project Monitoring Procedures

The project timeline will continue to be reviewed periodically and frequently. The project budget will continue to be monitored on a weekly basis using the SwRI Project Cost System. Project activity will continue to be summarized in status reports for review by TWDB.

Subtask 7.2 Project Deliverables

The fifth progress report (covering Period 12) will be submitted to TWDB during Fiscal Year 2016, Period 13.

4.0 Problems/Issues and Actions Required/Taken

In the 4th Progress Report, we identified potential inconsistencies in the stratigraphy between the domains of the Northern Trinity GAM and the Southern/Hill Country GAM. We requested

guidance from TWDB in resolving this issue. During this reporting period, SwRI staff conferred with TWDB staff to resolve this technical uncertainty. Most of the uncertainty was resolved by delineating appropriate data to use when developing a consistent and geologically correct stratigraphic framework model supported by well correlations and surface outcrops. A decision was made to use the “North Trinity GAM Upper Trinity log picks” rather than the “Northern Trinity GAM Glen Rose Structure Contours” when developing the stratigraphic framework model. The contours are recognized as extrapolations generated from a grid that was calculated from the data points and should not be used as a primary data source. SwRI will add new correlations to create a consistent stratigraphic framework model between the Hill Country Trinity and Northern Trinity aquifers. In this process, SwRI may need to correct or modify previous interpretations that have been used to create the surfaces used in previous GAM models if such action is supported by the data. Figure 2 from the 4th Progress Report has been revised to reflect these clarifying modifications. As illustrated in Figure 2 in the current report, discrepancies between the top of Trinity Aquifer surfaces of the Northern Trinity Aquifer GAM and the Hill Country Trinity Aquifer GAM still exist. However, as discussed above, SwRI will develop a consistent stratigraphic framework model between both the Hill Country and Northern Trinity aquifers using available data and correlations. Discussions between TWDB and SwRI staff have identified how to adequately resolve potential inconsistencies in the stratigraphy between the domains of the Northern Trinity GAM and the Southern/Hill Country GAM, and the resulting plan will be implemented going forward to completion of this analysis.

Table 1. Project Budget Versus Expenses

Task	Description	Budget (from Project Cost System)	Invoices			Remaining Budget
			Current	Previous	Total	
1	Project Management	\$22,640.00	\$86.41	-\$1,617.36	\$16,353.13	\$6,286.87
2	Data Acquisition and Method Development	\$134,555.00	\$20,192.82	\$8,559.99	\$39,570.01	\$94,984.99
3	Develop a Stratigraphic Framework Model of the Trinity Aquifer and Calculate Brackish Water Volumes	\$116,878.00	\$0.00	\$0.00	\$0.00	\$116,878.00
4	Delineate Potential Production Areas	\$40,001.00	\$0.00	\$0.00	\$0.00	\$40,001.00
5	Determine the Amount of Brackish Groundwater that can be Produced without Causing Impact on Lateral and Vertical Fresh Water	\$56,740.00	\$0.00	\$0.00	\$0.00	\$56,740.00
6	Stakeholder Communication	\$35,631.00	\$0.00	\$0.00	\$0.00	\$35,631.00
7	Reporting	\$13,555.00	\$1,951.65	\$1,808.95	\$3,760.60	\$9,794.40
Total		\$420,000.00	\$22,230.88	\$8,751.58	\$59,683.74	\$360,316.26

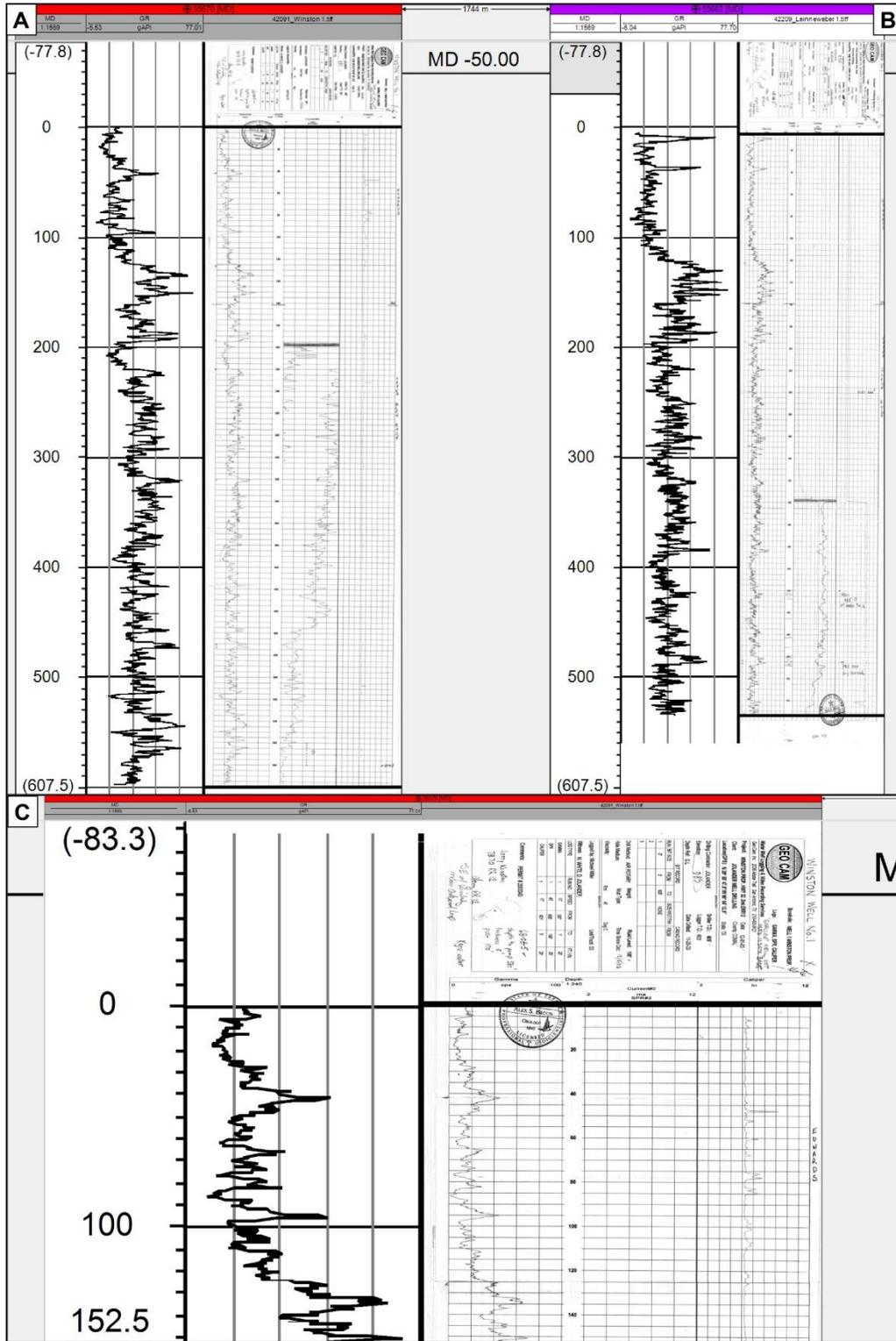


Figure 1. Comparison of the digital logs and scanned logs for wells #55670 (A) and #55662 (B). (C) Enlargement of upper portion of logs for well #55670 .

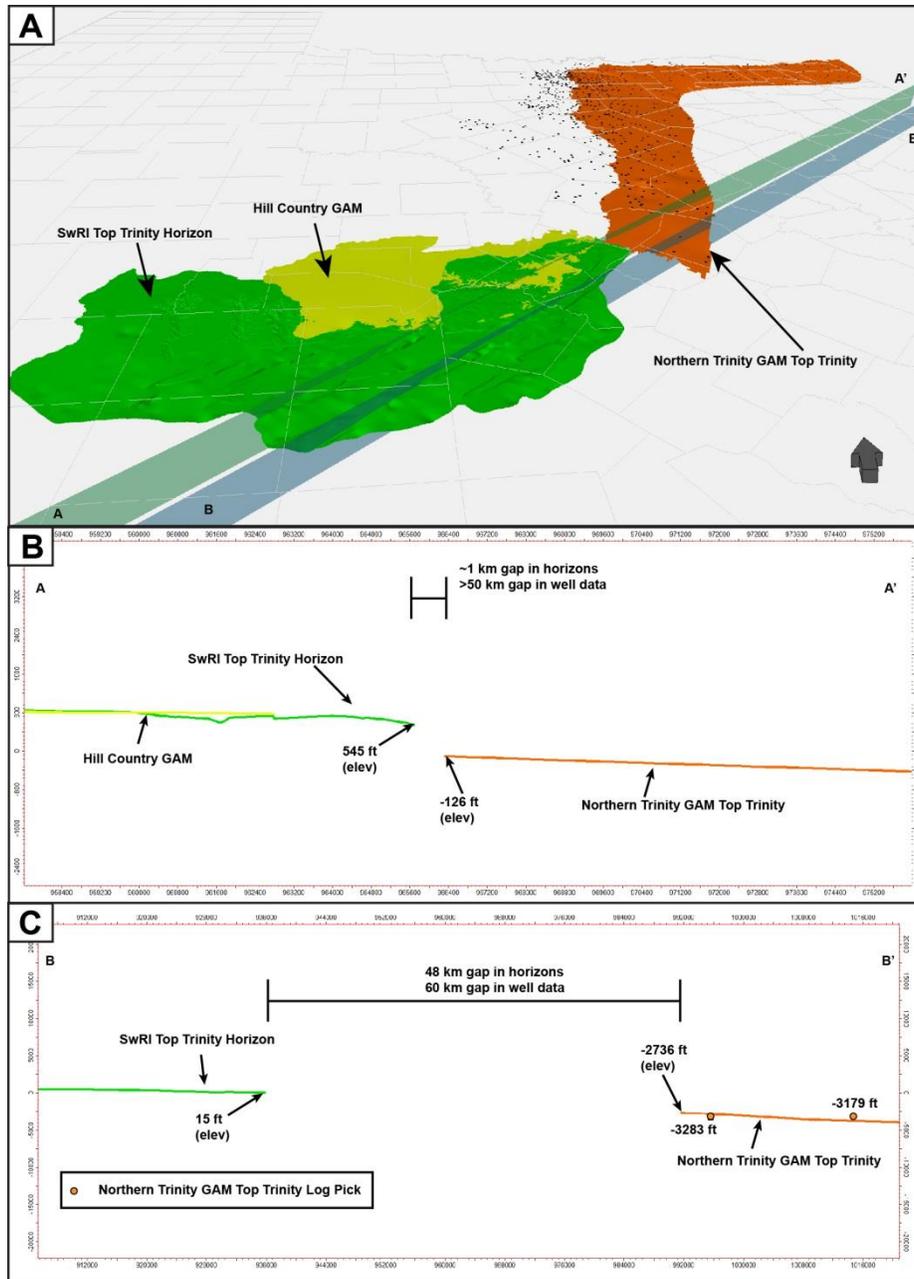


Figure 2. Perspective view of map and cross-sections comparing stratigraphy between the domains of the Northern Trinity GAM and the Southern/Hill Country Trinity GAM described in Section 4. (A) 3D view of all top Trinity horizon data currently accessible for this project along with positions of cross-section profiles A-A' and B-B'. (B) Section A-A' is a southwest-northeast cross-section illustrating the data gap and vertical offset between the Hill Country GAM and the Northern Trinity GAM. (C) Section B-B' is a southwest-northeast cross-section, down-dip from A-A', illustrating the data gap between the Hill Country GAM and the Northern Trinity GAM that will be infilled during this project using additional well information.