EXHIBIT B

SCOPE OF WORK

Task 1 –Project Management. The INTERA Team's Project Manager, Dr. Neil Deeds, P.E., will serve as the single point of contact for the TWDB, and will provide prompt and comprehensive information on the project's schedule, budget, and technical work. With proven experience on many TWDB projects and a wide-range of experience modeling brackish waters in Texas, California, and Florida, Dr. Deeds possesses the technical and management expertise needed for successful project completion. As his resume in Appendix A indicates, Dr. Deeds' experience includes managing regional groundwater flow projects, such as developing models under the TWDB's GAM Program, and applying both numerical and analytical solutions to develop and verify practical modeling approaches for brackish water for the Lower Colorado River Authority –San Antonio Water System Project (LSWP) (see Project 1).

Dr. Deeds will meet with TWDB staff at the beginning of the project for a kickoff meeting and at least every three months thereafter until the project is completed. A formal discussion of the results will be presented to the TWDB staff at the end of the project. The INTERA Team will submit monthly progress reports to the TWDB summarizing the task activities and expenditures.

Task 2 – Technical Tasks. The technical tasks comprise three primary subtasks. The first subtask, which will be divided into two parts, concerns the literature review that provides the basis for the decision matrix development in the second and third subtasks. The second and third subtasks provide the necessary information and decision-making methodology to guide a modeler toward selecting a practical and efficient tool for modeling brackish aquifers.

Subtask 2a – Literature Review. The INTERA Team will perform a literature review in two parts. The first part will be concerned with variable-density groundwater modeling codes. The second part will review the literature involving the effects of aquifer geometry and geologic structure on salinity distribution and migration. Both of these parts are described in more detail below.

Variable-Density Groundwater Modeling Codes. Our review of variable-density modeling codes will consist of three phases. In the first phase, we will identify the groundwater modeling codes that offer variable-density capabilities. We will develop our list of candidate codes by reviewing the professional literature, with an emphasis on previous surveys of variable-density groundwater modeling codes. Examples of existing surveys of variable-density modeling codes are those performed by Sorek and Pinder (1999), who review 15 computer codes, by Baer and others (1999), who also review 15 codes, and by Langevin and others (2004), who review four commonly used MODFLOW-based tools.

In addition, we will contact state and federal agencies involved with brackish water supply to determine what, if any, codes are routinely used by these agencies. Some examples of personnel who will be contacted for this information are groundwater modelers working for the USGS, personnel at water districts and municipalities located near coastal aquifers, and engineering firms operating desalinization plants and/or aquifer storage facilities.
In the second phase, we will select from the list of codes those that are applicable for brackish aquifer modeling to develop a subset of models with well-documented user manuals or reports that describe the development and the procedure for applying the model. The purpose of this phase is to generate a set of codes for which we have sufficient information to carry out the third phase. For codes that are not in the public domain, we will contact the primary company/organization or developer of the model to obtain a copy of the user manual. If a user manual for such propriety codes cannot be obtained at a reasonable cost, these propriety codes will either be removed from the list or will have a limited review during the third phase. We anticipate that this second phase of work will result in 10 to 15 codes that will be suitable for assessment in the third phase.

In the third phase, we will assess the status and applicability of the groundwater modeling codes assembled during the second phase. As part of the assessment, we will make several attempts to contact the primary developer of each code and update TWDB on any recent code changes. To provide a consistent and balanced assessment of each code, we will complete the same information matrix for each. Prior to finalizing the nature and extent of the information matrix, we will meet with TWDB staff to present our ideas and receive comments for improvements and additions. The issues that will be addressed within the information matrix are described below.

- **The User Manual** – We will summarize how thoroughly the user manual documents the groundwater modeling code's numerical formulation, simulation capabilities, input formats, example application, and verification simulations.
- **Availability of Source Code and Cost of Licensing** – We will provide information on the availability of the source code and the cost of licensing the code.
- **Development History** – We will summarize the historical development of the code and provide appropriate references.
- **Numerical Formation for Groundwater Flow** – We will indicate whether the code solves an analytical solution, semi-analytical or a numerical solution and we will provide information on the numerical descritization scheme (also known as finite difference, finite element, finite volume, analytical element) used to solve the groundwater flow equation.
- **Numerical Formation for the Variable-Density/Solute Component** – We will discuss the approach used to simulate the migration of the dissolved solutions and how it is integrated with the flow solution.
- **Numerical Solution Technique** – We will note the code's solution scheme and available matrix solvers. Of particular importance is whether or not the model supports a conjugant gradient solver option and/or supports a Newton-Raphson solution technique, which are typically needed to solve highly non-linear and complex flow and transport problems.
- **Notable Capabilities** – We will list any potentially important capabilities that could potentially be beneficial for some brackish model application. Example of these capabilities include options to support a telescopic numerical grid, advanced formulation for flow to a pumping well, and implicit coupling with surface water flow modules.
- **Input and Output Format** – We will summarize the options for creating model input data files and for outputting key model results into files that can be readily processed using conventional third party software including graphical user interfaces (GUIs).

- **GUIs** – We will list what GUIs are available for the model.
- **Available Technical Assistance** – We will summarize the available options for learning how to apply the code in model development such as self-guide tutorials, example problems in the user's manual, and/or short courses, and we will identify the types of technical assistance the code developer provides for users.

Effects of Aquifer Geometry and Geologic Structure on Salinity Distribution and Migration. For this portion of the literature review, we will gather information on how aquifer geometry and structure can potentially affect the occurrence and flow of brackish groundwater. This type of information can be helpful to the modeler when developing the conceptual model by providing insight into some of the unknown salinity characteristics of the groundwater based on known structure or geometry.

A good example of how aquifer geometry can affect the occurrence of brackish water is in the Carrizo-Wilcox Aquifer. In the southern portion of the aquifer, the 10,000 mg/L TDS line occurs up to 50 miles from the outcrop (e.g., Kelley and others, 2004). Moving north into Gonzales County, where the aquifer begins to dip steeply, the 10,000 mg/L line occurs within about 20 miles of the outcrop. So the dip of the aquifer has a strong effect on flow paths of fresh water from the outcrop and thus the occurrence of brackish water. Some authors have considered the aquifer dip angle and its relation to the angle of the fresh/saline water interface (e.g., Ma and others, 2005).

Structural features can also affect the occurrence and flow of brackish groundwater. For example, Hamlin (2006) notes that salt domes have the potential to increase groundwater salinities by both direct dissolution and transport of soluble salts, and by providing pathways for mixing between shallow fresh water aquifers and deeper, more brackish aquifers. Faults are another feature that can have an effect, where offsets can bring brackish water against fresh water, or sealing faults reduce deep recharge of fresh water, creating zones of brackish water near the faults.

Subtask 2b – Applicability Evaluation of Groundwater Flow Models. For this subtask, we will recommend conditions under which a specific type of groundwater flow code or codes might be applicable. We will accomplish the task by generating and discussing two information matrices. Prior to finalizing the structure of these matrices, we will discuss the proposed matrices with TWDB and make appropriate changes based on TWDB comments.

The code-type matrix will associate each selected code (that is in the model information matrix developed during the third phase of Subtask 2a) with a category available for each type of attribute. Examples of the kind of code-type groups that will be considered are provided below.

- **Analytical or Numerical** – We will identify the code as either analytical or numerical and determine whether it can provide a steady-state or transient solution.
- **Flow Solution Approach** – We will categorize the models based on the approach used to solve the groundwater flow equations. Possible groupings include whether or not simplifying assumptions have been made (such as the Dupuit assumption) or what specific numerical formulation(s) was used to solve the flow equations.
- **Variable-Density Solution Approach** – We will group the codes as either a sharp-interface type, a density-dependent flow and transport type, or some mixed type.

- **MODFLOW Compatibility** – We will group the codes based on how compatible they are with different MODFLOW versions. For example, we can consider whether a code is based on MODFLOW. This will be useful since input files for a constant-density groundwater availability model can be easily adapted to a variable-density model if both models use MODFLOW input files. Another possible consideration is whether the grid structure is compatible with MODFLOW. Again, a constant density groundwater availability model can be adapted more readily to this type of variable-density code because both models will use a grid-centered, finite difference numerical mesh.

The example model-type groupings described above are provided for illustrative purposes and will be modified and expanded based on the project results. For each of the categories listed in the matrix, we will list the options and explain why the different categories can be important to modeling brackish flow. For instance, under the flow solution approach described above, two available options are finite difference and finite element. Finite element schemes are sometimes considered to have a benefit over finite difference schemes because they provide more flexibility in representing complex aquifer geometries such as pinch-outs of geologic formations. This explanation will be provided in the documentation of our matrix.

The code-application matrix will assign a ranking for every model for a series of conditions. The ranking will reflect the capability of a particular model to accurately model the condition. An example of a ranking scheme is 1 to 5, with 1 indicating that the code is not applicable and 5 indicating the code is most applicable. Examples of the kind of generic conditions that will be evaluated are provided below.

- **Geological conditions** – These conditions will consider aquifer pinch-outs, steeply dipping strata, major faulting, karst features, large or small vertical anisotropy rations in the hydraulic conductivity field, and large or small scale heterogeneity in the aquifer properties.
- **Brackish distribution conditions** – These conditions will characterize the magnitude and the spatial distribution of the TDS concentration in the groundwater. The general distribution conditions will consider if there are dipping intervals of brackish groundwater, thin or thick intervals of brackish groundwater, saltwater interfaces with a relatively thick or thin interface of brackish groundwater, and if inverted brackish distributions exist where the groundwater with the higher TDS concentration is above groundwater with lower TDS concentration.
- **Pumping conditions** – These conditions will include the range of different strata the well or wells intersect, the rate of pumping relative to the transmissivity of the aquifer, the stratification of the brackish and freshwater across the well screen(s), and the proximity of two or more wells to each other.

The example conditions are provided for illustrative purposes and may be modified and expanded based on the project results. For each of the conditions listed in the matrix, we will provide a brief explanation of how a code will be ranked. For example, a finite difference code will receive a lower ranking than a finite element code for modeling the condition of an aquifer pinch-out. As another example, a sharp-interface code will receive a lower ranking than a model that solves the advective-dispersive flow equation for cases with an inverted concentration profile (i.e., higher concentrations in the shallower regions), since the sharp-interface assumptions are not appropriate for this configuration.

Subtask 2c – Development of a Decision Process for Model Selection. As noted in ASTM D6170-97, "Standard Guide for Selecting a Ground-Water Modeling Code," there are two basic steps in a systematic code-selection process. One step involves defining the requirements for the particular modeling application. The other step involves ranking the various codes according to their ability to meet these requirements. In Subtask 2b, we create the information matrices that describe the basic attributes of the codes and their applicability under a variety of conditions, hydrogeologic and otherwise.

Then, in Subtask 2c, once the project-specific brackish water modeling requirements have been properly defined, the user can take the information from Subtask 2b, along with additional considerations, to perform the code ranking and decide which code is most applicable.

The systematic decision process is described below in the context of these two basic steps.

1. **Define the purpose of the modeling**—In defining requirements for a given modeling project, the modeler must first consider the overall purpose of the modeling exercise. For example, the modeling may be for design, planning, or some combination of both. The purpose is important in defining how accurate a result is required, and thus how potentially complex the model will be. Unnecessary complexity will add effort and cost to a project.

This is the step in which stakeholders should be involved. Stakeholders may envision additional purposes for the model that were not part of the original modeling scope.

2. **Define the physical processes that must be simulated**—For the purposes of this proposal, we assume that brackish water flow must be simulated. We also must consider whether other physical processes, such as geomechanical or thermal processes must be considered. Perhaps the interaction between surface water and groundwater is important, and must be simulated. Change in water quality may also be important, and simulating this process could be a requirement. The modeler must review the hydrogeologic characteristics of the site, develop a site conceptual model, and determine what physical processes are essential for adequate simulation.

3. **Define any other essential needs**—Other essential needs might be specific to the viability of the modeling project but may not be specific physical processes. For example, perhaps integration with an existing model is necessary given project resources. If an existing model is built using MODFLOW, then it might be essential that the variable-density codes be mostly compatible in terms of grid structure or other characteristics. Another potential need is that the code be in the public domain or that it be low-cost for stakeholders.

4. **Define any other non-essential needs**—Non-essential needs describe those that are preferred by the modeler or stakeholders but are not defined in the necessary physical processes. This can include the availability of a GUI, or built in optimization capabilities, etc.

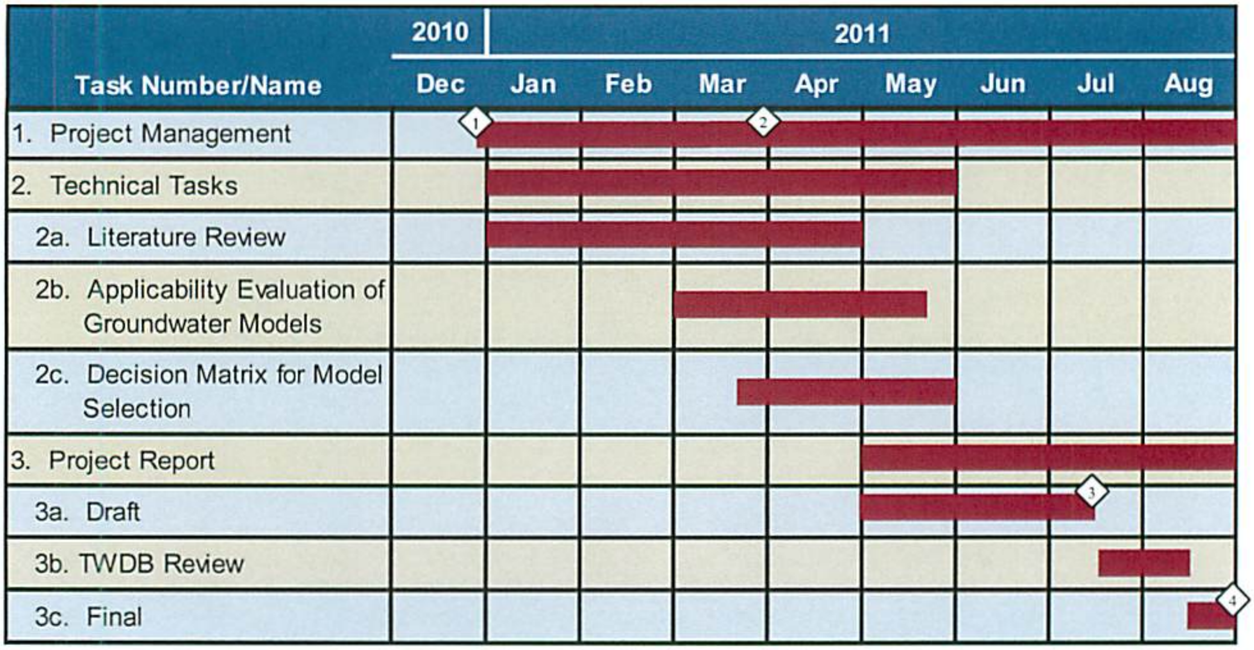
5. **Create a decision matrix for ranking the codes by their applicability**—A decision matrix provides a summary of the needs and how well each code meets these needs. A code must meet all of the essential needs in order to be considered. The relative importance of the non-essential needs can be characterized by assigning weighting factors to each. This is a subjective process, but the sum score of the weights allows a straightforward ranking of the codes. **Table 3** on the following page, shows an example of a portion of a simplified decision matrix for code selection.

Task 3 – Project Report. The INTERA Team has over 35 years of experience in the documentation of groundwater studies, including 10 years of experience with preparing reports according to TWDB guidelines. At the conclusion of Task 2, we will prepare a report that documents the work performed. The report will be prepared in a manner consistent with the format content defined by the TWDB in the RSQ and consistent with standards currently employed at the TWDB. The report will be delivered to the TWDB in both hardcopy and electronic form. Pending TWDB approval, a technical report will be provided in both Microsoft Word and Portable Document Format (PDF) and the number of hardcopies that will be delivered will be specified by the contract terms.

Table 3: Simplified Example of a Decision Matrix for Code Selection

	Essential Needs				Non-Essential Needs		
		Physical Processes					
Code	Required Accuracy	Variable-Density Flow	Unconfined Flow	Solute Transport	Groundwater Vistas Compatible	Less than $500 license	Score
Model A	yes	yes	yes	yes	2	1	3
Model B	yes	yes	yes	yes	2	0	2
Model C	no	yes	yes	no	0	0	0
Model D	yes	yes	yes	yes	0	0	0

Estimated Schedule for Assessment of Groundwater Modeling Approaches to Brackish Aquifers



[1]Kickoff meeting
[2]Progress meeting to discuss matrices
[3]Draft report delivery
[4]Final report delivery