GAM Run 15-003: Clearwater Underground Water Conservation District Management Plan

by Roberto Anaya, P.G.
Texas Water Development Board
Groundwater Resources Division
Groundwater Availability Modeling Section
(512) 463-6115
November 24, 2015

STATE OF TEXAS
Roberto Anaya
Geology
No. 480
LICENSED
PROFESSIONAL GEOSCIENTIST

This page is intentionally blank

GAM RUN 15-003: CLEARWATER UNDERGROUND WATER CONSERVATION DISTRICT MANAGEMENT PLAN

by Roberto Anaya, P.G.
Texas Water Development Board
Groundwater Resources Division
Groundwater Availability Modeling Section
(512) 463-6115
November 24, 2015

EXECUTIVE SUMMARY:

Texas State Water Code, Section 36.1071, Subsection (h), states that, in developing its groundwater management plan, a groundwater conservation district shall use groundwater availability modeling information provided by the executive administrator of the Texas Water Development Board (TWDB) in conjunction with any available site-specific information provided by the district for review and comment to the executive administrator. Information derived from groundwater availability models that shall be included in the groundwater management plan includes:

- 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.

This report — Part 2 of a two-part package of information from the TWDB to Clearwater Underground Water Conservation District — fulfills the requirements noted above. Part 1 of the two-part package is the Estimated Historical Water Use/State Water Plan data report. The district will receive, or received, this data report from the TWDB Groundwater Technical Assistance Section. Questions about the data report can be directed to Mr. Stephen Allen, Stephen.Allen@twdb.texas.gov, (512) 463-7317.

The groundwater management plan for the Clearwater Underground Water Conservation District should be adopted by the district on or before January 14, 2016 and submitted to the executive administrator of the TWDB on or before February 13, 2016. The current management plan for the Clearwater Underground Water Conservation District expires on April 13, 2016.

This report discusses the methods, assumptions, and results from a model run using the most current groundwater availability models for the Trinity (northern portion) and Woodbine aquifers, version 2.01 (Kelley and others, 2014) and the northern segment of the Edwards (Balcones Fault Zone) Aquifer (Jones, 2003). This model run replaces the results of GAM Run 10-009 (Hassan, 2010) that used version 1.01 of the groundwater availability model for the Trinity (northern portion) and Woodbine aquifers (Bené and others, 2004). Tables 1 and 2 summarize the groundwater availability model data required by statute to be included in the district's groundwater conservation management plan, and Figures 1 and 2 show the areas of the model from which the values in the table were extracted. If after review of the figures, Clearwater Underground Water Conservation District determines that the district boundaries used in the assessment do not reflect current conditions, please notify the TWDB at your earliest convenience.

METHODS:

In accordance with the provisions of the Texas State Water Code, Section 36.1071, Subsection (h), the updated groundwater availability model for the northern portion of the Trinity and Woodbine aquifers (Kelley and others, 2014) and the original groundwater availability model for the northern segment of the Edwards (Balcones Fault Zone) Aquifer (Jones, 2003) was used for this analysis. Water budgets for the Clearwater Underground Water Conservation District were extracted for the historical model calibration periods of 1980-2012 for the Trinity Aquifer and 1980-2000 for the Edwards (Balcones Fault Zone) Aquifer using ZONEBUDGET Version 3.01 (Harbaugh, 2009). The average annual water budget values for recharge, surface water outflow, inflow to the district, outflow from the district, net inter-aquifer flow (upper), and net inter-aquifer flow (lower) for the portion of the aquifers located within the district are summarized in this report.

PARAMETERS AND ASSUMPTIONS:

Northern portion of the Trinity Aquifer and Woodbine Aquifer

- We used the updated groundwater availability model for the northern portion of the Trinity Aquifer and Woodbine Aquifer (Version 2.01). See

Kelley and others (2014) for assumptions and limitations of the updated groundwater availability model.

- The groundwater availability model includes eight layers, that generally correspond to:
  - the surficial outcrop area of the units in layers 2 through 8 and the younger formations overlying the downdip portions of the Woodbine Aquifer and Washita and Fredericksburg groups (Layer 1),
  - the Woodbine Aquifer (Layer 2),
  - the Washita and Fredericksburg groups (Layer 3),
  - the Paluxy Aquifer (Layer 4),
  - the Glen Rose Formation (Layer 5),
  - the Hensell Sand (Layer 6),
  - the Pearsall Formation (Layer 7), and
  - The Hosston Formation (Layer 8).
- The Trinity Aquifer is a major source of groundwater in the Clearwater Underground Water Conservation District. Most of the Trinity Aquifer occurs as subcrop within the district boundaries. A small amount of the aquifer outcrops in the western portion of the district. All of the eight numerical layers in the model are designated as active in the Clearwater Underground Water Conservation District. The Trinity Aquifer is represented by Model Layers 1 through 8 in the outcrop area and by Model Layers 4 through 8 in the subcrop area. These layers were combined to calculate water budget values for the Trinity Aquifer in the district.
- Groundwater in the Trinity Aquifer within the Clearwater Underground Water Conservation District is primarily fresh water, with total dissolved solids concentrations less than 1,000 milligrams per liter (see Figures 4.4.11 through 4.4.15 in Kelley and others (2014)).
- The Woodbine Aquifer does not exist within the Clearwater Underground Water Conservation District and thus water budgets for this aquifer were not calculated or included for this report.

- The model was run with MODFLOW-NWT (Niswonger and others, 2011).

Northern Segment of the Edwards (Balcones Fault Zone) Aquifer

- We used the original groundwater availability model for the northern segment of the Edwards (Balcones Fault Zone) Aquifer (Version 1.01). See Jones (2003) for assumptions and limitations of the groundwater availability model.

- The groundwater availability model includes one layer, that generally corresponds to:

  - The Edwards (Balcones Fault Zone) Aquifer.

- The Edwards (Balcones Fault Zone) Aquifer is a major source of groundwater in the Clearwater Underground Water Conservation District. Most of the Edwards (Balcones Fault Zone) Aquifer occurs as outcrop within the district boundaries (72 percent). The remainder of the aquifer subcrops to the southwest. The single numerical layer in the model is designated as active in the Clearwater Underground Water Conservation District. This layer was used to calculate water budget values for the Edwards (Balcones Fault Zone) Aquifer in the district.

- Groundwater in the Edwards (Balcones Fault Zone) Aquifer within the Clearwater Underground Water Conservation District is primarily fresh water, with total dissolved solids concentrations less than 1,000 milligrams per liter (see pages 37 through 39 in Jones (2003)).

- The model was run with MODFLOW-96 (Harbaugh and McDonald, 1996).

RESULTS:

A groundwater budget summarizes the amount of water entering and leaving the aquifer according to the groundwater availability model. Selected groundwater budget components listed below were extracted from the model results for the Trinity Aquifer and Edwards (Balcones Fault Zone) Aquifer located within the district and averaged over the duration of the calibration and verification portion of the model run, as shown in Tables 1 and 2.

- Precipitation recharge—the areally-distributed recharge sourced from precipitation falling on the outcrop areas of the Trinity Aquifer or Edwards (Balcones Fault Zone) Aquifer (where the aquifers are exposed at land surface) within the district.

- Surface water outflow—the total volume of water discharging from the aquifer (outflow) to surface water features such as streams, reservoirs, and drains (springs).
- Flow into and out of district—the lateral flow within the aquifers between the district and adjacent counties.
- Flow between aquifers—the net vertical flow between aquifers or confining units. This flow is controlled by the relative water levels in each aquifer or confining unit and hydraulic properties of each aquifer or confining unit. In the Clearwater Underground Water Conservation District, this net vertical flow represents the net groundwater flow between the Trinity Aquifer and the immediate geologic unit overlying the aquifer in the subcrop area or the net groundwater flow between the Edwards (Balcones Fault Zone) Aquifer and the immediate geologic units overlying and underlying the aquifer in the subcrop area.

The information needed for the Clearwater Underground Water Conservation District's management plan is summarized in Tables 1 and 2. It is important to note that sub-regional water budgets are approximate. This is due to the size of the model cells and the approach used to extract data from the model. To avoid double accounting, a model cell that straddles a political boundary, such as a district or county boundary, is assigned to one side of the boundary based on the location of the centroid of the model cell. For example, if a cell contains two counties, the cell is assigned to the county where the centroid of the cell is located (Figures 1 and 2). Please note that the results of this model run are different from the results of the model run 10-009 that were obtained from the older groundwater availability model for the Trinity Aquifer. The changes can be attributed to several characteristics of the new model, such as differences in model layering, geologic boundaries, hydraulic properties distribution, and the use of different MODFLOW modeling packages.

TABLE 1: SUMMARIZED INFORMATION FOR THE TRINITY AQUIFER THAT IS NEEDED FOR THE CLEARWATER UNDERGROUND WATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

Management Plan requirement	*Aquifer or confining unit*	*Results*
Estimated annual amount of recharge from precipitation to the district	Trinity Aquifer	2,816
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Trinity Aquifer	11,131
Estimated annual volume of flow into the district within each aquifer in the district	Trinity Aquifer	7230
Estimated annual volume of flow out of the district within each aquifer in the district	Trinity Aquifer	5659
Estimated net annual volume of flow between each aquifer in the district	From younger overlying Washita and Fredericksburg Confining Units into the Trinity Aquifer	5,587

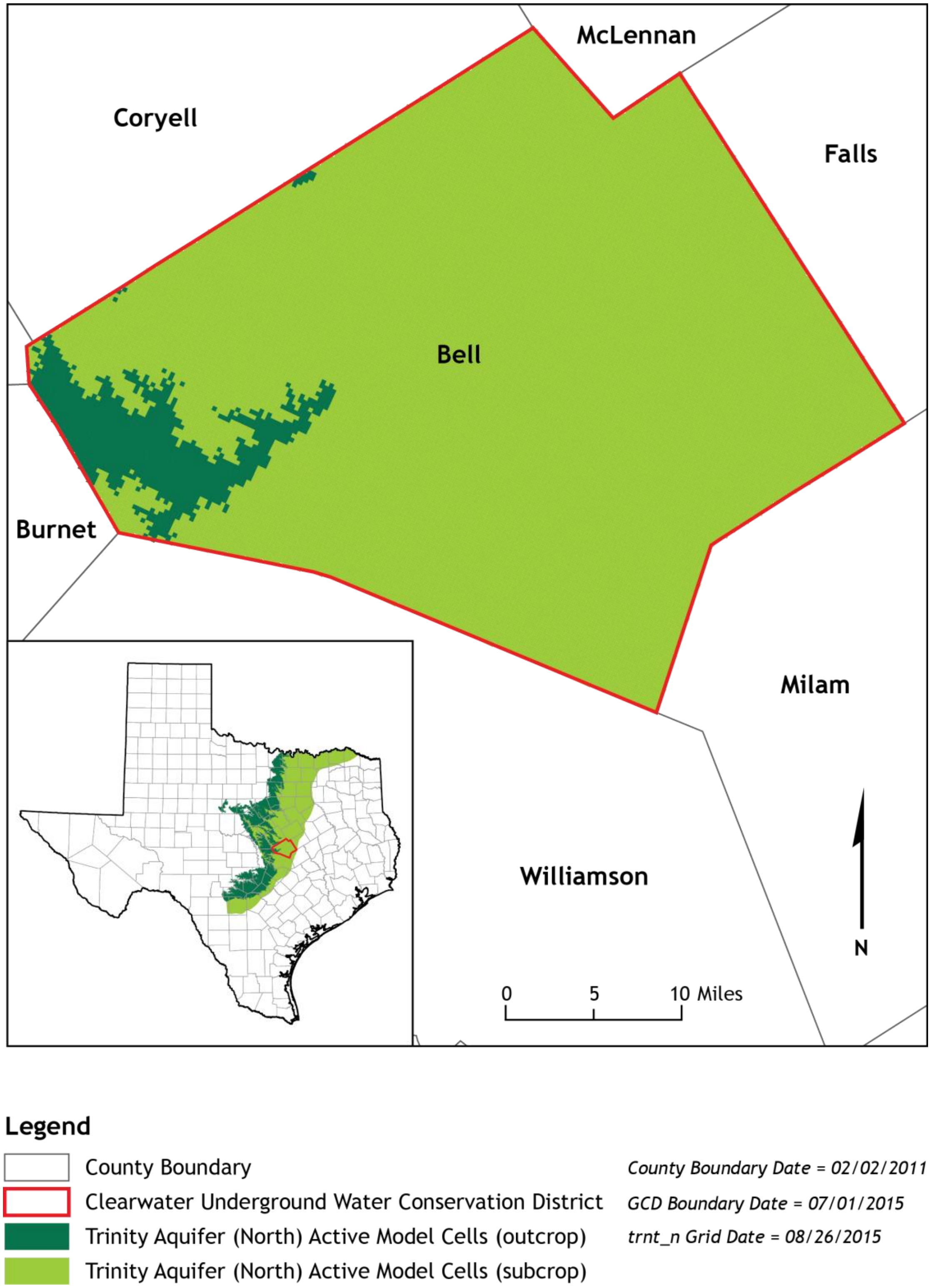
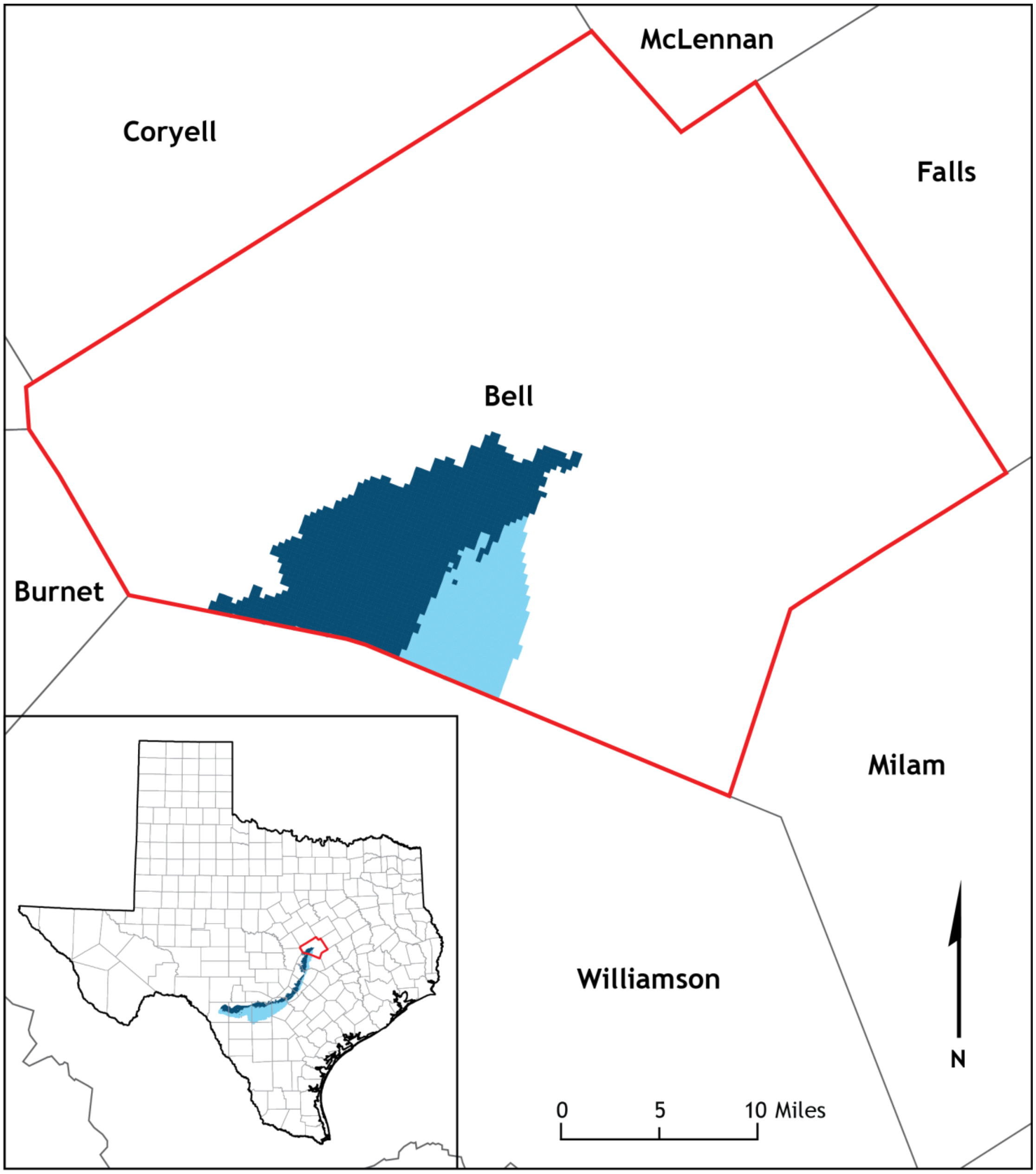


FIGURE 1: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE NORTHERN PORTION OF THE TRINITY AQUIFER AND WOODBINE AQUIFER FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED (THE TRINITY AQUIFER FOOTPRINT EXTENT WITHIN THE DISTRICT BOUNDARY).

TABLE 2: SUMMARIZED INFORMATION FOR THE EDWARDS (BALCONES FAULT ZONE) AQUIFER THAT IS NEEDED FOR THE CLEARWATER UNDERGROUND WATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

Management Plan requirement	*Aquifer or confining unit*	*Results*
Estimated annual amount of recharge from precipitation to the district	Edwards (Balcones Fault Zone) Aquifer	27,565
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Edwards (Balcones Fault Zone) Aquifer	27,566
Estimated annual volume of flow into the district within each aquifer in the district	Edwards (Balcones Fault Zone) Aquifer	5,853
Estimated annual volume of flow out of the district within each aquifer in the district	Edwards (Balcones Fault Zone) Aquifer	1,090
Estimated net annual volume of flow between each aquifer in the district	From Edwards (Balcones Fault Zone) Aquifer to the overlying younger units	121
	From Edwards (Balcones Fault Zone) Aquifer to the downdip portion of the Edwards (Balcones Fault Zone) Aquifer	3,957*

***** The model extends beyond the TWDB official Edwards (Balcones Fault Zone) Aquifer boundary. This is the amount of saline groundwater (greater than 1,000 total dissolved solid) that exits in the downdip boundary limit of the aquifer within the district boundaries and into deeper portions of the Edwards Group formations.



Legend

County Boundary		*County Boundary Date = 02/02/2011*
Clearwater Underground Water Conservation District		*GCD Boundary Date = 07/01/2015*
Edwards Aquifer (North) Active Model Cells (outcrop)		*ebfz_n Grid Date = 08/26/2015*
Edwards Aquifer (North) Active Model Cells (subcrop)		

FIGURE 2: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE NORTHERN SEGMENT OF THE EDWARDS (BALCONES FAULT ZONE) AQUIFER FROM WHICH THE INFORMATION IN TABLE 2 WAS EXTRACTED (THE EDWARDS (BALCONES FAULT ZONE) AQUIFER FOOTPRINT EXTENT WITHIN THE DISTRICT BOUNDARY).

LIMITATIONS

The groundwater model used in completing this analysis is the best available scientific tool that can be used to meet the stated objectives. To the extent that this analysis will be used for planning purposes and/or regulatory purposes related to pumping in the past and into the future, it is important to recognize the assumptions and limitations associated with the use of the results. In reviewing the use of models in environmental regulatory decision making, the National Research Council (2007) noted:

> *"Models will always be constrained by computational limitations, assumptions, and knowledge gaps. They can best be viewed as tools to help inform decisions rather than as machines to generate truth or make decisions. Scientific advances will never make it possible to build a perfect model that accounts for every aspect of reality or to prove that a given model is correct in all respects for a particular regulatory application. These characteristics make evaluation of a regulatory model more complex than solely a comparison of measurement data with model results."*

A key aspect of using the groundwater model to evaluate historic groundwater flow conditions includes the assumptions about the location in the aquifer where historic pumping was placed. Understanding the amount and location of historic pumping is as important as evaluating the volume of groundwater flow into and out of the district, between aquifers within the district (as applicable), interactions with surface water (as applicable), recharge to the aquifer system (as applicable), and other metrics that describe the impacts of that pumping. In addition, assumptions regarding precipitation, recharge, and interaction with streams are specific to particular historic time periods.

Because the application of the groundwater models was designed to address regional scale questions, the results are most effective on a regional scale. The TWDB makes no warranties or representations related to the actual conditions of any aquifer at a particular location or at a particular time.

It is important for groundwater conservation districts to monitor groundwater pumping and overall conditions of the aquifer. Because of the limitations of the groundwater model and the assumptions in this analysis, it is important that the groundwater conservation districts work with the TWDB to refine this analysis in the future given the reality of how the aquifer responds to the actual amount and location of pumping now and in the future. Historic precipitation patterns also need to be placed in context as future climatic conditions, such as dry and wet year precipitation patterns, may differ and affect groundwater flow conditions.

REFERENCES:

Bené, J., Harden, B., O'Rourke, D., Donnelly, A., and Yelderman, J., 2004, Northern Trinity/Woodbine Groundwater Availability Model: contract report to the Texas Water Development Board by R.W. Harden and Associates, 391 p., http://www.twdb.texas.gov/groundwater/models/gam/trnt_n/TRNT_N_Model_Report.pdf.

Harbaugh, A. W., and McDonald, M. G., 1996, User's documentation for MODFLOW-96, an update to the U.S. Geological Survey modular finite-difference groundwater-water flow model: U.S. Geological Survey Open-File Report 96-485, 56 p.

Harbaugh, A. W., 2009, Zonebudget Version 3.01, A computer program for computing subregional water budgets for MODFLOW ground-water flow models, U.S. Geological Survey Groundwater Software.

Hassan, W., 2010, GAM Run 10-009: Texas Water Development Board, GAM Run 10-009 Management plan data for Clearwater Underground Water Conservation District Report, 7 p., http://www.twdb.texas.gov/groundwater/docs/GAMruns/GR10-09.pdf.

Jones, Ian. C., 2003, Groundwater Availability Modeling: Northern Segment of the Edwards (Balcones Fault Zone) Aquifer, Texas: Numerical Simulations through 1999- Model Report, 196 p., http://www.twdb.texas.gov/publications/reports/numbered_reports/doc/R358/Report%20358%20Northern%20Edwards.pdf.

Kelley, V.A., Ewing. J., Jones, T.L., Young, S.C., Deeds, N., and Hamlin, S., 2014, Updated Groundwater Availability Model of the Northern Trinity and Woodbine Aquifers: contract report prepared for North Texas GCD, Northern Trinity GCD, Prairielands GCD, and Upper Trinity GCD by INTERA Incorporated, Bureau of Economic Geology, and LBG-Guyton Associates, 990 p., http://www.twdb.texas.gov/groundwater/models/gam/trnt_n/Final_NTGAM_Vol%20I%20Aug%202014_Report.pdf.

Niswonger, R.G., Panday, S., and Ibaraki, M., 2011, MODFLOW-NWT, a Newton formulation for MODFLOW-2005: USGS, Techniques and Methods 6-A37, 44 p.

National Research Council, 2007, Models in Environmental Regulatory Decision Making Committee on Models in the Regulatory Decision Process, National Academies Press, Washington D.C., 287 p., http://www.nap.edu/catalog.php?record_id=11972.

Texas Water Code, 2011, http://www.statutes.legis.state.tx.us/docs/WA/pdf/WA.36.pdf