Documentation: GAM Runs for Groundwater Conservation District Groundwater Management Plans

Texas Water Development Board
Groundwater Modeling Department
Last Updated: August 2026

INTRODUCTION

Texas Water Code § 36.1071(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.

The groundwater availability modeling information provided by the TWDB for each groundwater conservation district includes:

1. the annual amount of recharge from precipitation, if any, to the groundwater resources within the district;
2. the annual volume of water that discharges from the aquifer to springs and any surface-water bodies, including lakes, streams, and rivers, for each aquifer within the district; and
3. the annual volume of flow into and out of the district within each aquifer and between aquifers in the district.

MODELS AND AQUIFERS

The following lists provide the basic information for each groundwater availability model including the aquifer or aquifers represented by the models.

Groundwater availability model for the Bone Spring-Victorio Peak Aquifer

- Version 1.01 (Hutchison, 2008).
- The model is run with MODFLOW-2000 (Harbaugh and others, 2000).
- Water budgets are extracted for the historical calibration period (1980 through 2002) using ZONEBUDGET Version 3.01 (Harbaugh, 2009).
- The model is used to analyze the following aquifer:
    - Bone Spring-Victorio Peak

Groundwater availability model for the Brazos River Alluvium Aquifer

- Version 1.01 (Ewing and Jigmond, 2016).
- The model is run with MODFLOW-USG (Panday and others, 2013).
- Water budgets are extracted for the historical calibration period (1980 through 2012) using ZONEBUDGET USG Version 1.00.
- This model is used to analyze the following aquifer:
    - Brazos River Alluvium

Groundwater availability model for the Capitan Reef Complex Aquifer

- Version 1.01 (Jones, 2016).
- The model is run with MODFLOW-2005 (Harbaugh, 2005).
- Water budget terms are extracted for the historical calibration period (1980 through 2005) using ZONEBUDGET Version 3.01 (Harbaugh, 2009).
- This model is used to analyze the following aquifer:
    - Capitan Reef Complex

Groundwater availability model for the central portion of the Carrizo-Wilcox, Queen City, and Sparta aquifers

- Version 3.02 (Young and Kushnereit, 2020).
- The model is run with MODFLOW-USG-Transport Version 2.01 (Panday and others, 2013).
- Water budgets are extracted for the historical calibration period (1980 through 2010) using ZONEBUDGET USG Version 1.00.
- This model is used to analyze the following aquifers:
    - Carrizo-Wilcox
    - Queen City
    - Sparta

Groundwater availability model for the northern portion of the Carrizo-Wilcox, Queen City, and Sparta aquifers

- Version 3.01 (Panday and others, 2020).
- The model is run with MODFLOW 6 (Langevin and others, 2017).
- Water budgets are extracted for the historical calibration period (1981 through 2013) using ZONEBUDGET for MODFLOW 6 (Langevin and others, 2021).
- This model is used to analyze the following aquifers:
    - Carrizo-Wilcox
    - Queen City
    - Sparta

Groundwater availability model for the southern portion of the Carrizo-Wilcox, Queen City, and Sparta aquifers

- Version 3.1 (Hutchison, 2025; Panday and others, 2023).
- The model is run with MODFLOW 6 (Langevin and others, 2017).
- Water budgets are extracted for the historical calibration period (1981 through 2017) using ZONEBUDGET for MODFLOW 6 (Langevin and others, 2021).
- This model is used to analyze the following aquifers:
    - Carrizo-Wilcox
    - Queen City
    - Sparta

Groundwater availability model for the Cross Timbers Aquifer

- Version 1.01 (Harmon and others, 2025)
- The model is run with MODFLOW 6 (Langevin and others, 2017).
- Water budgets are extracted for the historical calibration period (1980 through 2022) using ZONEBUDGET for MODFLOW 6 (Langevin and others, 2021).
- This model is used to analyze the following aquifer:
    - Cross Timbers

Groundwater availability model for the Barton Springs segment of the Edwards (Balcones Fault Zone) Aquifer

- Version 1.01 (Scanlon and others, 2001).
- The model is run with MODFLOW-96 (Harbaugh and McDonald, 1996).
- Water budget terms are extracted for the historical calibration period (1989 through 1999) using ZONEBUDGET Version 3.01 (Harbaugh, 2009).
- This model is used to analyze the following aquifer:
    - Edwards (Balcones Fault Zone)

Groundwater availability model for northern segment of the Edwards (Balcones Fault Zone) Aquifer

- Version 2.1 (Jones, 2026a).
- The model is run with MODFLOW-2005 (Harbaugh, 2005).
- Water budget terms are extracted for the historical calibration period (1980 through 2015) using ZONEBUDGET Version 3.01 (Harbaugh, 2009).
- This model is used to analyze the following aquifers:
    - Edwards (Balcones Fault Zone)

Groundwater flow model of the Kinney County area

- Version 1.01 (Hutchison and others, 2011).
- The model is run with MODFLOW-2000 (Harbaugh and others, 2000).
- Water budget terms are extracted for the historical calibration period (1980 through 2005) using ZONEBUDGET Version 3.01 (Harbaugh, 2009).
- This model is used to analyze the following aquifers:
    - Edwards (Balcones Fault Zone)
    - Edwards-Trinity (Plateau) Aquifer

Groundwater Simulation Program (GWSIM-IV) Model of the San Antonio Segment of the Edwards (Balcones Fault Aquifer)

- Version 2 (Thorkildsen and McElhaney, 1992; Klemt and others, 1979).
- The model is run with the Groundwater Simulation Program (GWSIM-IV; Knowles, 1983).
- Water budget terms are extracted for the historical calibration period (1980 through 1989).
- This model is used to analyze the following aquifer:
    - Edwards (Balcones Fault Zone)

Groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers

- Version 1.01 (Anaya and Jones, 2009)
- The model is run with MODFLOW-96 (Harbaugh and McDonald, 1996).
- Water budgets are extracted for the historical calibration period (1981 through 2000) using ZONEBUDGET Version 3.01 (Harbaugh, 2009).
- This model is used to analyze the following aquifer:
    - Edwards-Trinity (Plateau) Aquifer
    - Pecos Valley

Groundwater availability model for the Minor Aquifers of the Llano Uplift

- Version 1.01 (Shi and others, 2016)
- The model is run with MODFLOW-USG (Panday and others, 2013).
- Water budgets are extracted for the historical calibration period (1980 through 2010) using ZONEBUDGET for MODFLOW USG Version 1.0.
- This model is used to analyze the following aquifers:
    - Marble Falls Aquifer
    - Ellenburger-San Saba Aquifer
    - Hickory Aquifer

Groundwater Management Area 16 groundwater flow model

- Version 1.01 (Hutchison and others, 2011).
- The model is run with MODFLOW-2000 (Harbaugh and others, 2000).
- Water budget terms are extracted for the historical calibration period (1980 through 1999) using ZONEBUDGET Version 3.01 (Harbaugh, 2009).
- This model is used to analyze the following aquifer:
    - Gulf Coast Aquifer System

Groundwater availability model for the central portion of the Gulf Coast Aquifer System

- Version 1.01 (Chowdhury and others, 2004).
- The model is run with MODFLOW-96 (Harbaugh and McDonald, 1996).
- Water budget terms are extracted for the historical calibration period (1981 through 1999) using ZONEBUDGET Version 3.01 (Harbaugh, 2009).
- This model is used to analyze the following aquifer:
    - Gulf Coast Aquifer System

Groundwater availability model for the central and southern portions of the Gulf Coast Aquifer System (pending release)

- Version 1.1 (Dowlearn and others, 2025; Shi and Boghici, 2023).
- The model is run with MODFLOW-USG-Transport (Panday, 2023; Panday and others, 2013).
- Water budgets are extracted for the historical calibration period (1981 through 2015) using ZONEBUDGET USG Version 1.00.
- This model is used to analyze the following aquifer:
    - Gulf Coast Aquifer System

Groundwater availability model for the northern portion of the Gulf Coast Aquifer System

- Version 4.1 (Keester and others, 2025; Ellis and others, 2023)
- The model is run with MODFLOW 6 (Langevin and others, 2017).
- Water budgets are extracted for the historical calibration period (1980 through 2018) using ZONEBUDGET for MODFLOW 6 (Langevin and others, 2021).
- This model is used to analyze the following aquifer:
    - Gulf Coast Aquifer System

Groundwater availability model for the southern portion of the Gulf Coast Aquifer System

- Version 2.01 (Chowdhury and Mace, 2007).
- The model is run with MODFLOW-96 (Harbaugh and McDonald, 1996).
- Water budget terms are extracted for the historical calibration period (1981 through 2000) using ZONEBUDGET Version 3.01 (Harbaugh, 2009).
- This model is used to analyze the following aquifer:
    - Gulf Coast Aquifer System

Groundwater availability model for the West Texas Bolsons (Wild Horse Flat, Michigan Flat, Ryan Flat and Lobo Flat) and Igneous Aquifers

- Version 1.01 (Beach and others, 2004).
- The model is run with MODFLOW-96 (Harbaugh and McDonald, 1996).
- Water budget terms are extracted for the historical calibration period (1980 through 2000) using ZONEBUDGET Version 3.01 (Harbaugh, 2009).
- This model is used to analyze the following aquifers:
    - Igneous
    - West Texas Bolsons (Wild Horse Flat, Michigan Flat, Ryan Flat, and Lobo flat)

Groundwater availability model for the Igneous and West Texas Bolsons aquifers (pending release)

- Version 2.01 (Jones, 2026b)
- The model is run with MODFLOW-2005 (Harbaugh, 2005).
- Water budget terms are extracted for the historical calibration period (1981 through 2020) using ZONEBUDGET Version 3.01 (Harbaugh, 2009).
- This model is used to analyze the following aquifers:
    - Igneous
    - West Texas Bolsons

Groundwater availability model for Lipan Aquifer

- Version 1.01 (Beach and others, 2004).
- The model is run with MODFLOW-96 (Harbaugh and McDonald, 1996).
- Water budget terms are extracted for the historical calibration period (1980 through 1998) using ZONEBUDGET Version 3.01 (Harbaugh, 2009). The last year in the historical calibration, 1999, is not included because of incorrect pumping values applied to the model.
- This model is used to analyze the following aquifer:
    - Lipan

Groundwater availability model for the Nacatoch Aquifer

- Version 1.01 (Beach and others, 2009).
- The model is run with MODFLOW-2000 (Harbaugh and others, 2000).
- Water budget terms are extracted for the historical calibration period (1980 through 1997) using ZONEBUDGET Version 3.01 (Harbaugh, 2009).
- This model is used to analyze the following aquifer:
    - Nacatoch

Groundwater availability model for the High Plains Aquifer System

- Version 1.02 (Cawthon and Wade, 2025; Deeds and Jigmond, 2015)
- The model is run with MODFLOW-NWT (Niswonger and others, 2011).
- Water budgets are extracted for the historical calibration period (1980 through 2020) using ZONEBUDGET Version 3.01 (Harbaugh, 2009).
- This model is used to analyze the following aquifers:
    - Ogallala Aquifer
    - Dockum Aquifer
    - Rita Blanca
    - Edwards-Trinity (High Plains)

Groundwater availability model for the Rustler Aquifer

- Version 1.01 (Ewing and others, 2012).
- The model is run with MODFLOW-NWT (Niswonger and others, 2011).
- Water budget terms are extracted for the historical calibration period (1980 through 2008) using ZONEBUDGET Version 3.01 (Harbaugh, 2009).
- This model is used to analyze the following aquifer:
    - Rustler

Groundwater availability model for the Seymour and Blaine aquifers

- Version 1.01 (Ewing and others, 2004)
- The model is run with MODFLOW-2000 (Harbaugh and others, 2000).
- Water budgets are extracted for the historical calibration period (1980 through 1999) using ZONEBUDGET Version 3.01 (Harbaugh, 2009).
- This model is used to analyze the following aquifers:
    - Seymour Aquifer
    - Blaine Aquifer

Groundwater availability model for the Seymour Aquifer in Haskell, Knox, and Baylor Counties

- Version 1.01 (Jigmond and others, 2014)
- The model is run with MODFLOW-2000 (Harbaugh and others, 2000).
- Water budgets are extracted for the historical calibration period (1980 through 1999) using ZONEBUDGET Version 3.01 (Harbaugh, 2009).
- This model is used to analyze the following aquifer:
    - Seymour Aquifer

Groundwater availability model for the Hill Country portion of the Trinity Aquifer

- Version 2.01 (Jones and others, 2011).
- The model was run with MODFLOW-96 (Harbaugh and McDonald, 1996).
- Water budgets were extracted for the historical calibration period (1981 through 1997) using ZONEBUDGET Version 3.01 (Harbaugh, 2009).
- This model was used to analyze the following aquifers:
    - Edwards-Trinity (Plateau)
    - Trinity

Groundwater availability model for the northern portion of the Trinity Aquifer and the Woodbine Aquifer

- Version 3.01 (Ellis and others, 2025).
- The model is run with MODFLOW 6 (Langevin and others, 2017).
- Water budget terms are extracted for the historical calibration period (1980 through 2020) using ZONEBUDGET for MODFLOW 6 (Langevin and others, 2021).
- This model is used to analyze the following aquifers:
    - Trinity
    - Woodbine

Groundwater availability model for the southern portion of the Trinity Aquifer (pending release)

- Version 3.01 (Harding and Wade, 2026).
- The model is run with MODFLOW 6 (Langevin and others, 2017).
- Water budget terms are extracted for the historical calibration period (1981 through 2020) using ZONEBUDGET for MODFLOW 6 (Langevin and others, 2021).
- This model is used to analyze the following aquifers:
    - Trinity

Groundwater availability model for the West Texas Bolsons (Red Light Draw, Green River Valley, and Eagle Flat) Aquifer

- Version 1.01 (Beach and others, 2008).
- The model is run with MODFLOW-2000 (Harbaugh and others, 2000).
- Water budget terms are extracted for the historical calibration period (1900 through 2006) using ZONEBUDGET Version 3.01 (Harbaugh, 2009).
- This model is used to analyze the following aquifers:
    - West Texas Bolsons (Red Light Draw, Green River Valley, and Eagle Flat)

Groundwater availability model for the West Texas Bolsons (Presidio and Redford) Aquifer

- Version 1.01 (Wade and Jigmond, 2013).
- The model is run with MODFLOW-2000 (Harbaugh and others, 2000).
- Water budget terms are extracted for the historical calibration period (1980 through 2008) using ZONEBUDGET Version 3.01 (Harbaugh, 2009).
- This model is used to analyze the following aquifers:
    - West Texas Bolsons (Presidio and Redford)

Groundwater availability model for the Yegua-Jackson Aquifer

- Version 1.01 (Deeds and others, 2010).
- The model is run with MODFLOW-2000 (Harbaugh and others, 2000).
- Water budgets are extracted for the historical calibration period (1980 through 1997) using ZONEBUDGET Version 3.01 (Harbaugh, 2009).
- This model is used to analyze the following aquifer:
    - Yegua-Jackson

BUDGETS

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 groundwater availability model results:

1. Precipitation recharge - the areally distributed recharge sourced from precipitation falling on the outcrop areas of the aquifers (where the aquifer is exposed at land surface) within the district.
2. Surface-water outflow - the total water discharging from the aquifer (outflow) to surface-water features such as streams, reservoirs, and springs.
3. Flow into and out of district - the lateral flow within the aquifer between the district and adjacent counties.
4. Flow between aquifers - the net vertical flow between the aquifer and adjacent aquifers or confining units. This flow is controlled by the relative water levels in each aquifer and aquifer properties of each aquifer or confining unit that define the amount of leakage that occurs.

LIMITATIONS

The groundwater models used in completing these analyses are the best available scientific tools 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 a 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 historical 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 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 groundwater models 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

Anaya, R., and Jones, I., 2009, Groundwater Availability Model for the Edwards-Trinity (Plateau) and Pecos Valley Aquifers of Texas: Texas Water Development Board Report 373, 103 p., https://www.twdb.texas.gov/groundwater/models/gam/eddt_p/ET-Plateau_Full.pdf.

Beach, J. A., Huang, Y., Symank, L., Ashworth, J. B., Davidson, T., Vreugdenhil, A. M., and Deeds, N. E., 2009, Final Report-Nacatoch Aquifer Groundwater Availability Model, 304 p., https://www.twdb.texas.gov/groundwater/models/gam/nctc/NCTC_Model_Report.pdf.

Beach, J.A., Ashworth, J.B., Finch, S.T., Chastain-Howley, A., Calhoun, K., Urbanczyk, K., Sharp, J.M., and Olson, J., 2004, Groundwater Availability Model for the Igneous and parts of the West Texas Bolsons (Wild Horse Flat, Michigan Flat, Ryan Flat, and Lobo Flat) Aquifers, 407 p., http://www.twdb.texas.gov/groundwater/models/gam/igbl/IGBL_Model_Report.pdf

Beach, J.A., Burton, S., and Kolarik, B., 2004, Groundwater availability model for the Lipan Aquifer in Texas: final report prepared for the Texas Water Development Board by LBG-Guyton Associates, 246 p., www.twdb.texas.gov/groundwater/models/gam/lipn/LIPN_Model_Report.pdf

Beach, J.A., Symank, L., Huang, Y., Ashworth, J.B., Davidson, T., Collins, E.W., Hibbs, B.J., Darling, B.K., Urbanczyk, K., Calhoun, K., and Finch, S., 2008, Groundwater Availability Model for the West Texas Bolsons (Red Light Draw, Green River Valley, and Eagle Flat) Aquifer in Texas, 320 p., http://www.twdb.texas.gov/groundwater/models/gam/wtbl/WTBL_Model_Report.pdf

Cawthon, T., and Wade, S., 2025, Extension of the Groundwater Availability Model for the High Plains Aquifer System through 2020 (version 1.02),1187 p., https://www.gw-models.s3.amazonaws.com/Download_GAMs/hpas/hpas_report_final_June2025.pdf

Chowdhury, A. and Mace, R., 2007, Groundwater Resource Evaluation and Availability Model of the Gulf Coast Aquifer in the Lower Rio Grande Valley of Texas: Texas Water Development Board Report 368 (June 2007), 129 p., https://www.twdb.texas.gov/publications/reports/numbered_reports/doc/R368/R368_GulfCoastGAM.pdf?d=4733.1000000122.

Chowdhury, Ali. H., Wade, S., Mace, R.E., and Ridgeway, C., 2004, Groundwater Availability Model of the Central Gulf Coast Aquifer System: Numerical

Simulations through 1999- Model Report, 114 p., http://www.twdb.texas.gov/groundwater/models/gam/glfc_c/TWDB_Recalibration_Report.pdf.

Deeds, N. E. and Jigmond, M., 2015, Numerical Model Report for the High Plains Aquifer System Groundwater Availability Model, 640 p. http://www.twdb.texas.gov/groundwater/models/gam/hpas/HPAS_GAM_Numerical_Report.pdf

Deeds, N. E., Yan, T., Singh, A., Jones, T. L., Kelley, V. A., Knox, P. R., and Young, S. C., 2010, Groundwater availability model for the Yegua-Jackson Aquifer: Final report prepared for the Texas Water Development Board by INTERA, Inc., 582 p., http://www.twdb.texas.gov/groundwater/models/gam/ygjk/YGJK_Model_Report.pdf.

Dowlearn, G., Wade, S., and Hardwick, D., 2025, Draft Numerical Model Recalibration: Groundwater Availability Model for the Central and Southern Portions of the Gulf Coast Aquifer System (Version 1.1), Texas Water Development Board, 132 p.

Ellis, J., Prieto-Estrada, A., Osborne, A., Deeds, N., White, J., and Keester. M., 2025, Hydrogeology and Documentation of the Northern Trinity and Woodbine Aquifer System Groundwater Availability Model (NTGAM), Prepared for the North Texas Groundwater Conservation District and Groundwater Management Area 8 by INTERA Inc., 351 p., https://gw-models.s3.amazonaws.com/Download_GAMs/trnt_n/trnt_n_v301/NTGAM_Final_Report.pdf

Ellis, J.H., Knight, J.E., White, J.T., Sneed, M., Hughes, J.D., Ramage, J.K., Braun, C.L., Teeple, A., Foster, L., Rendon, S.H., and Brandt, J., 2023, Hydrogeology, land-surface subsidence, and documentation of the Gulf Coast Land Subsidence and Groundwater-Flow (GULF) model, southeast Texas, 1897–2018 (ver. 1.1, November 2023): U.S. Geological Survey Professional Paper 1877, 425 p., https://www.doi.org/ 10.3133/ pp1877.

Ewing, J. E., Kelley, V. A., Jones, T. L., Yan, T., Singh, A., Powers, D. W., Holt, R. M., and Sharp, J. M., 2012, Groundwater availability model report for the Rustler Aquifer: Prepared for the Texas Water Development Board by Intera Inc., 460 p. https://www.twdb.texas.gov/groundwater/models/gam/rslr/rslr.asp

Ewing, J.E., and Jigmond, M., 2016, Final Numerical Model Report for the Brazos River Alluvium Aquifer Groundwater Availability Model: Contract report to the Texas Water Development Board, 357 p., http://www.twdb.texas.gov/groundwater/models/gam/bzrv/BRAA_NM_REPORT_FINAL.pdf?d=1502891797831.

Ewing, J.E., Jones, T.L., Pickens, J.F., Chastain-Howley, A., Dean, K.E., and Spear, A.A., 2004, Groundwater availability model for the Seymour Aquifer: Final report

prepared for the Texas Water Development Board by INTERA, Inc., 533p., http://www.twdb.texas.gov/groundwater/models/gam/symr/SYMR_Model_Report.pdf.

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., water.usgs.gov/nrp/gwsoftware/zonebud3/zonebudget3.html.

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 ground-water flow model: U.S. Geological Survey Open-File Report 96–485, 56 p., https://www.water.usgs.gov/software/MODFLOW-96/.

Harbaugh, A.W., 2005, MODFLOW-2005, the U.S. Geological Survey modular ground-water model -- the Ground-Water Flow Process: U.S. Geological Survey Techniques and Methods 6-A16

Harbaugh, A.W., Banta, E.R., Hill, M.C., and McDonald, M.G., 2000, MODFLOW-2000, The U.S. Geological Survey modular ground-water model-User guide to modularization concepts and the ground-water flow process: U.S. Geological Survey, Open-File Report 00-92.

Harding, J. and Wade, S., 2026, Draft Report: Groundwater Availability Model for the Southern Portion of the Trinity Aquifer, Texas Water Development Board, 146 p.

Harmon, R., Miller, S., Moore, S., White, J., and Ellis, J., 2025, Groundwater Availability Model for the Cross Timbers Aquifer: Final report prepared for the Texas Water Development Board by INTERA, Inc 219 p., Cross Timbers Aquifer Groundwater Availability Model | Texas Water Development Board

Hutchison, W. R., Hill, M. E., Anaya, R., Hassan, M. M., Oliver, W., Jigmond, M., Wade, S., and Aschenbach, E., 2011, Groundwater Management Area 16 Groundwater Flow Model.

Hutchison, W.R., 2008, Preliminary groundwater flow model Dell City area, Hudspeth and Culberson counties, Texas: EPWU hydrogeology report 08-01, 480p. http://www.twdb.texas.gov/groundwater/models/gam/bsvp/bsvp_report.pdf.

Hutchison, W.R., Shi, J., and Jigmond, M, 2011, Groundwater Flow Model of the Kinney County Area, Texas Water Development Board, 138 p.

Hutchison, W.R., 2025, Documentation of GMA 13 Model (2025 version): Update to Groundwater Availability Model for the Southern Portion of the Carrizo-Wilcox, Queen City and Sparta Aquifers, Prepared for Groundwater Management Area 13, 124 p., https://gw-models.s3.amazonaws.com/Download_GAMs/czwx_s/czwx_s_qcsp_v3.1/Southern%20Carrizo-Wilcox%20v3.1%20Final%20Report.pdf

Jigmond, M., Hutchison, W. R., and Shi, J., 2014, Final Report: Groundwater Availability Model of the Seymour Aquifer in Haskell, Knox, and Baylor Counties, 185 p., https://www.twdb.texas.gov/groundwater/models/gam/symr_hkb/Seymour_HKB_GAM_Report_Sealed_021414.pdf.

Jones, I., 2016, Groundwater Availability Model: Eastern Arm of the Capitan Reef Complex Aquifer of Texas: Texas Water Development Board, 494 p. https://www.twdb.texas.gov/groundwater/models/gam/crcx/crcx.asp

Jones, I.C., Anaya, R., and Wade, S.C., 2011, Groundwater Availability Model: Hill Country Portion of the Trinity Aquifer of Texas, Texas Water Development Board Report, 175 p., www.twdb.texas.gov/groundwater/models/gam/trnt_h/R377_HillCountryGAM.pdf

Jones, I.C., 2026a, Groundwater Availability Model: Northern Segment of the Edwards (Balcones Fault Zone) Aquifer of Texas: Version 2.10, 228 p., https://gwmodels.s3.amazonaws.com/Download_GAMs/ebfz_n/ebfz_n_v2.1/N%20Edwards%20%28BFZ%29%20v2.1%20Report.pdf

Jones, I.C., 2026b, Groundwater Availability Model: Igneous and West Texas Bolsons Aquifer of Texas, v2.01, Texas Water Development Board Report, 252 p.

Keester, M.R., Webster, P., Beach, J., Drabek, C., and Chen, Y.H., 2025, Northern Portion of the Gulf Coast Aquifer System Groundwater Availability Model for Groundwater Management Area 14 Joint Planning, Report prepared in Cooperation with Lone Star Groundwater Conservation District, 3,797 p., https://gw-models.s3.amazonaws.com/Download_GAMs/glfc_n/glfc_n_v4.1/Northern%20Gulf%20Coast%20v4.1%20Final%20Report.pdf

Klemt, W. B., Knowles, T. R., Elder, G. and Sieh, T., 1979, Ground-water resources and model applications for the Edwards (Balcones Fault Zone) aquifer in the San Antonio region, Texas: Texas Department of Water Resources Report 239, 88 p., http://www.twdb.state.tx.us/publications/reports/GroundWaterReports/GWReports/R239/R239.pdf.

Knowles, T., 1983, Ground-Water Simulation Program, Program Documentation and User's Manual, Texas Department of Water Resources, https://www.twdb.texas.gov/publications/reports/manuals/GWSIM-IV.pdf?d=12271.5

Langevin, C.D., Hughes, J.D., Banta, E.R., Provost, A.M., Niswonger, R.G., and Panday, S., 2021, ZONEBUDGET for MODFLOW 6, 14 p., https://doi.org/10.5066/F76Q1VQV

Langevin, C.D., Hughes, J.D., Banta, E.R., Provost, A.M., Niswonger, R.G., and Panday, S., 2017, MODFLOW 6 Modular Hydrologic Model: U.S. Geological Survey Software, https://doi.org/10.5066/F76Q1VQV

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., https://www.nap.edu/catalog/11972/models-in-environmental-regulatory-decision-making.

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.

Panday, S., Langevin, C.D., Niswonger, R.G., Ibaraki, M., and Hughes, J.D., 2013, MODFLOW–USG version 1: 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 Techniques and Methods, book 6, chap. A45, 66 p., https://pubs.usgs.gov/tm/06/a45/.

Panday, S., Rumbaugh, J., Hutchison, W., and Schorr, S., 2020, Numerical Model Report: Groundwater Availability Model for the Northern Portion of the Queen City, Sparta, and Carrizo-Wilcox Aquifers, 201 p., http://www.twdb.texas.gov/groundwater/models/gam/czwx_n/2020_12_08_Numerical_Model_Report_Accessible.pdf

Panday, S., 2023, USG-Transport Version 2.1.0: Transport and Other Enhancements to MODFLOW-USG, GSI Environmental, Jan 2023 http://www.gsi-net.com/en/software/free-software/USG-Transport.html

Panday, S., Wyckoff, R., Martell, G., Schorr, S., Zivic, M., Hutchinson, W.R., and Rumbaugh, J., 2023, Update to the groundwater availability model for the southern portion of the Queen City, Sparta, and Carrizo-Wilcox aquifers: Final numerical model report prepared for the Texas Water Development Board by GSI Environmental, Inc., 388 p., http://www.twdb.texas.gov/groundwater/models/gam/czwx_s/South_QCSCW_ModelRpt_Final_w_appendicies.pdf

Scanlon, B., Mace, R., Smith, B., Hovorka, S., Dutton, A., and Reedy, R., 2001, Groundwater Availability of the Barton Springs Segment of the Edwards Aquifer, Texas—Numerical Simulations through 2050: The University of Texas at Austin, Bureau of Economic Geology, final report prepared for the Lower Colorado River Authority, under contract no. UTA99-0.

Shi, J., Boghici, R., Kohlrenken, W., and Hutchison, W.R., 2016, Numerical Model Report: Minor Aquifers of the Llano Uplift Region of Texas (Marble Falls, Ellenburger-San Saba, and Hickory). Texas Water Development Board Report, 435 p., https://www.twdb.texas.gov/groundwater/models/gam/llano/Llano_Uplift_Numerical_Model_Report_Final.pdf.

Shi, J. and Boghici, R., 2023, Numerical Model Report: Groundwater Availability Model for the Central and Southern Portions of the Gulf Coast Aquifer System in Texas. Texas Water Development Board, 143p., http://www.twdb.texas.gov/groundwater/models/gam/glfc_c_s/Central_Southern_Gulf_Coast_Aquifer_System_Numerical_Model_Report_Final.pdf

Texas Water Code § 36.1071

Thorkildsen, D., and McElhaney, P.D., 1992, Model Refinement and Applications for the Edwards (Balcones Fault Zone) Aquifer in the San Antonio Region, Texas: Texas Water Development Board Report 340, 33 p., http://www.twdb.state.tx.us/publications/reports/GroundWaterReports/GWReports/Individual%20Report%20htm%20files/Report%20340.htm.

Wade, S.C. and Jigmond, M., 2013, Groundwater Availability Model of the West Texas Bolsons (Presidio and Redford) Aquifer, Texas Water Development Board, 100 p., http://www.twdb.texas.gov/groundwater/models/gam/prbl/PRBL_ModelFinalReport.pdf

Young, S., and Kushnereit, R., 2020, GMA 12 Update to the Groundwater Availability Model for the central portion of the Sparta, Queen City, and Carrizo-Wilcox Aquifers: Update to Improve Representation of the Transmissive Properties of the Simsboro Aquifer in the Vicinity of the Vista Ridge Well Field, 30 p., https://www.twdb.texas.gov/groundwater/models/gam/czwx_c/PE_Report_GMA12_final_october_2020_merge.pdf?d=28007