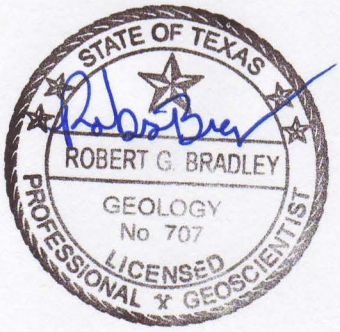
Aquifer Assessment 10-40 MAG: Analytical Model Estimates of Modeled Available Groundwater For the Edwards Aquifer Within Frio County in Groundwater Management Area 13

by Robert G. Bradley, P.G. and Sarah Backhouse
Texas Water Development Board
Groundwater Resources Division
Groundwater Technical Assistance Section
(512) 936-0870
August 20, 2012



Robert G. Bradley, P.G. 707, authorized the seal appearing on this document on August 20, 2012.

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AQUIFER ASSESSMENT 10-40 MAG: ANALYTICAL MODEL ESTIMATES OF MODELED AVAILABLE GROUNDWATER FOR THE EDWARDS AQUIFER WITHIN FRIO COUNTY IN GROUNDWATER MANAGEMENT AREA 13

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EXECUTIVE SUMMARY:

The estimated modeled available groundwater for the Edwards Aquifer within Frio County as a result of the desired future condition (DFC) adopted by members of Groundwater Management Area (GMA) 13 is 23,213 acre-feet per year from 2010 to 2070.

REQUESTOR:

Mr. Mike Mahoney of the Evergreen Underground Water Conservation District acting on behalf of the member groundwater conservation districts of Groundwater Management Area 13.

DESCRIPTION OF REQUEST:

In a letter received September 2, 2010, Mr. Mahoney provided the Texas Water Development Board (TWDB) with the DFC of the Edwards Aquifer within Frio County adopted by the members of Groundwater Management Area 13. The DFC for the Edwards Aquifer, as described in Resolution No. 2010-02 and adopted August 12, 2010 by the groundwater conservation districts in Groundwater Management Area 13 is described below:

> Maintain a minimum artesian flow of 500 gallons per minute from wells producing from the Edwards Aquifer in Frio County.

In response to receiving the adopted desired future condition, TWDB has estimated the modeled available groundwater that achieves the above desired future condition for Groundwater Management Area 13.

METHODS:

Groundwater Management Area 13, located in South Central Texas, includes part of the Edwards Aquifer. The amount of data for the Edwards Aquifer in Frio County is limited; the Evergreen Underground Water Conservation District provided data for seven permitted wells located in northern Frio County. Data included well records, production rates, and flow rates (EUWCD, 2010).

The Jacob-Lohman flowing well equation (Jacob and Lohman, 1952) is used to simulate the desired future conditions within the Edwards Aquifer within Frio County. Well information supplied by Evergreen Underground Water Conservation District (EUWCD, 2010) and from the Texas Well Report Submission and Retrieval System (TDLR, 2011) support the estimates used in this assessment.

The Jacob and Lohman (1952), as referenced in Kruseman and de Ridder (2000) free flowing well equation was used for determining the modeled available groundwater from the desired future condition. It can be approximated as:

$$Q = \frac{4\pi T s_w}{2.3 Log(\frac{2.25Tt}{r_{ew}^2})}$$

where,

T = Transmissivity

s_w = the constant drawdown measured as the difference between the static shut-in head and the discharge opening of the well.

t = time since discharge started

r_{ew} = effective radius of the well (estimated as the actual well radius)

Q = discharge

PARAMETERS AND ASSUMPTIONS:

Assumptions for the Jacob-Lohman free flowing well method are:

- the aquifer is confined;
- the aquifer has infinite areal extent;
- the aquifer is homogeneous, isotropic, and of uniform thickness over the area;
- prior to pumping, the piezometric surface is horizontal over the area;
- at the beginning of the test (t = O), the water level in the free-flowing well is lowered instantaneously. At t > O, the drawdown in the well is constant, and its discharge is variable;
- the well penetrates the entire thickness of the aquifer and receives water by horizontal flow;
- The flow to the well is in an unsteady state,

For details please refer to Jacob and Lohman (1952) and Kruseman and deRidder (2000).

Additional assumptions for this assessment are:

- Calculations assume there is one well for this assessment;
- Aquifer thickness is assumed to be 700 feet based on well records (EUWCD, 2010);
- Minimum hydraulic conductivity was estimated at 400 ft/day (Lindgren and others, 2004);
- Transmissivity estimated at 280,000 feet^2/day based on aquifer thickness and hydraulic conductivity;
- Time is estimated as 60 years to cover the water planning period (the formula is not very sensitive to time, and 50 or 70 years gave similar results);

- To maintain the DFC throughout the period, the constant drawdown (s_w) is estimated at 20 feet or approximately 25% of the measured head in the study area.

RESULTS:

The estimated modeled available groundwater for the Edwards Aquifer within Frio County in Groundwater Management Area 13 consistent with the adopted desired future condition is approximately 23,213 acre-feet per year. Table 1 summarizes the information used to calculate this value.

Table 1. Values used in determining the modeled available groundwater estimate.

Parameter	Value
Aquifer thickness (ft)	700
Hydraulic conductivity (ft/day)	400
Transmissivity (ft^2/day)	280,000
Time (days)	21,900
Effective radius (ft)	0.35
Estimated constant drawdown in well (ft)	20
Total estimated discharge (acre-feet/year)	23,213

This pumping has been divided by county, regional water planning area, and river basin for each decade between 2010 and 2070 for use in the regional water planning process (Table 2). The area is also wholly within the Evergreen Underground Water Conservation District.

Table 2. Modeled available ground by decade for the Edwards Aquifer in groundwater management area 13. Results are in acre-feet per year and are divided by county, regional water planning area, and river basin

County	Region	Basin	Year						
			2010	2020	2030	2040	2050	2060	2070
Frio	L	Nueces	23,213	23,213	23,213	23,213	23,213	23,213	23,213

LIMITATIONS:

Additional data are needed to create improved estimates; these estimates are a basic interpretation of the requested conditions. This analysis assumes homogeneous and isotropic aquifers; however, conditions for the Edwards Aquifer may not behave in a uniform manner as the head declines and flows decrease.

This analysis was determined to be the best method to calculate a modeled available groundwater estimate; however, this method has limitations and should be replaced with better tools, especially including this area in groundwater models and additional data that are not currently available, whenever possible. This analysis assumes that the aquifer is in a state of declining head over the assessment period; however, the aquifer does exhibit rapid recovery of the head after recharge events. This assumption needs to be considered and compared to actual future data when evaluating achievement of the desired future condition.

Given these limitations, users of this information are cautioned that the modeled available groundwater estimates should not be considered a definitive, permanent description of the amount of groundwater that can be pumped to meet the adopted desired future condition. The TWDB makes no warranties or representations relating 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 future groundwater pumping and water levels to know if they are achieving their desired future conditions. Because of the limitations and assumptions in this analysis, it is important that the groundwater conservation districts work with the TWDB to refine these modeled available groundwater numbers given the reality of how the aquifer responds to the actual amount and location of pumping now and in the future.

MODELED AVAILABLE GROUNDWATER AND PERMITTING:

As defined in Chapter 36 of the Texas Water Code, "modeled available groundwater" is the estimated average amount of water that may be produced annually to achieve a desired future condition.

Groundwater conservation districts are required to consider modeled available groundwater, along with several other factors, when issuing permits in order to manage groundwater production to achieve the desired future condition(s).

The other factors districts must consider include annual precipitation and production patterns, the estimated amount of pumping exempt from permitting, existing permits, and a reasonable estimate of actual groundwater production under existing permits. The estimated amount of pumping exempt from permitting, which the Texas Water Development Board is now required to develop after soliciting input from applicable groundwater conservation districts, will be provided in a separate report.

REFERENCES:

Jacob, C.E. and S.W. Lohman 1952. Non-steady flow to a well of constant drawdown in an extensive aquifer: Transactions, American Geophysical Union, volume. 33, pp. 559-569.

Kruseman G.P. and de Ridder N.A., 2000, Analysis and evaluation of pumping test data second edition (completely revised): International Institute for Land Reclamation and Improvement, Publication 47, 377p.

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Lindgren, R.J., Dutton, A.R., Hovorka, S.D., Worthington, S.R.H, and Painter, S., 2004, Conceptualization and Simulation of the Edwards Aquifer, San Antonio Region, Texas: U.S. Geological Survey Scientific Investigations Report 2004-5277, 143 p.

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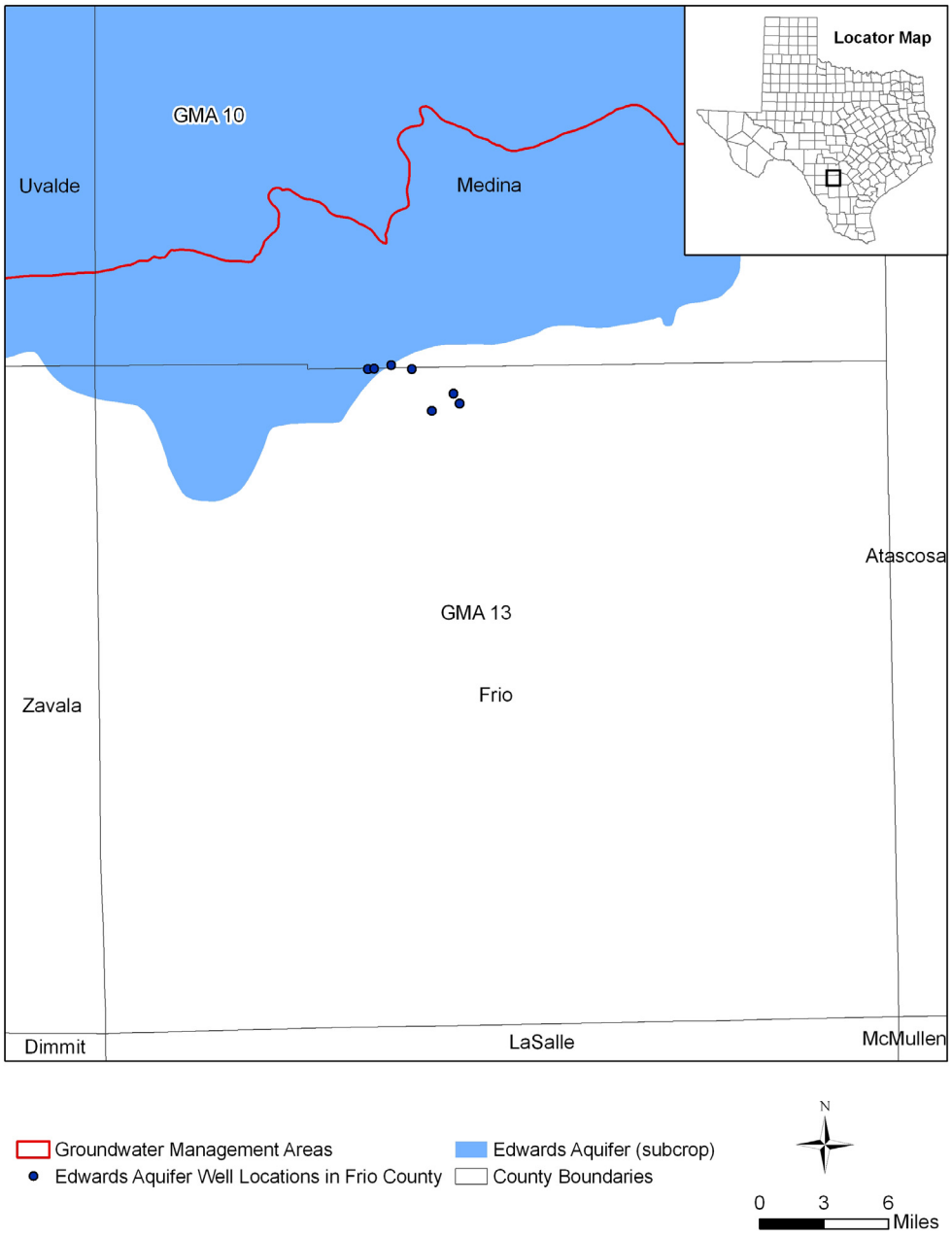

Figure 1. Map showing the groundwater management areas, extent of the Edwards Aquifer as delineated by TWDB and location of the flowing Edwards wells in Frio County. Well locations provided by Evergreen UWCD (2010).

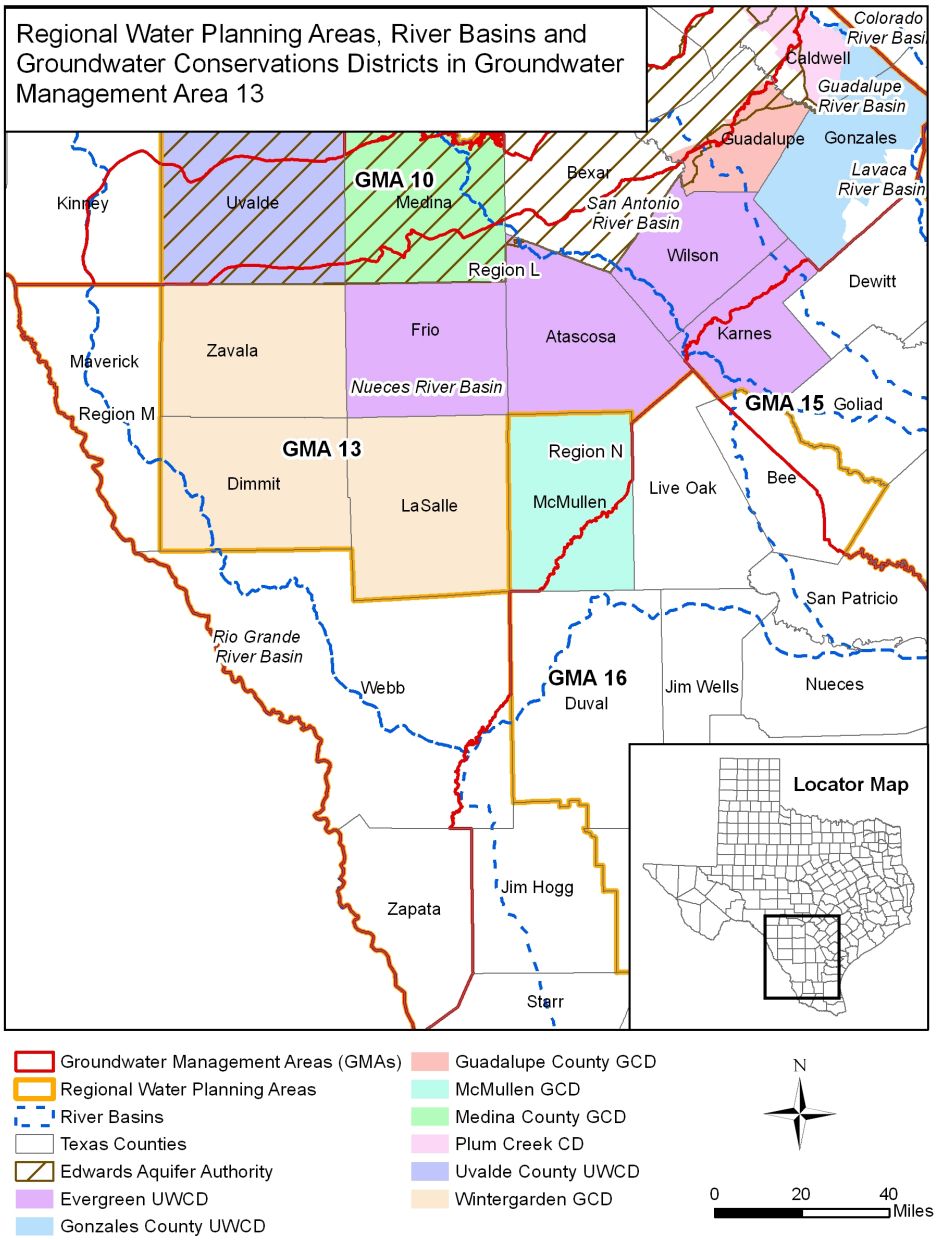

Figure 2. Map showing regional water planning areas, river basins, groundwater conservation districts, and counties in and neighboring groundwater management area 13. CD = conservation district, GCD = groundwater conservation district, UWCD = underground water conservation district.