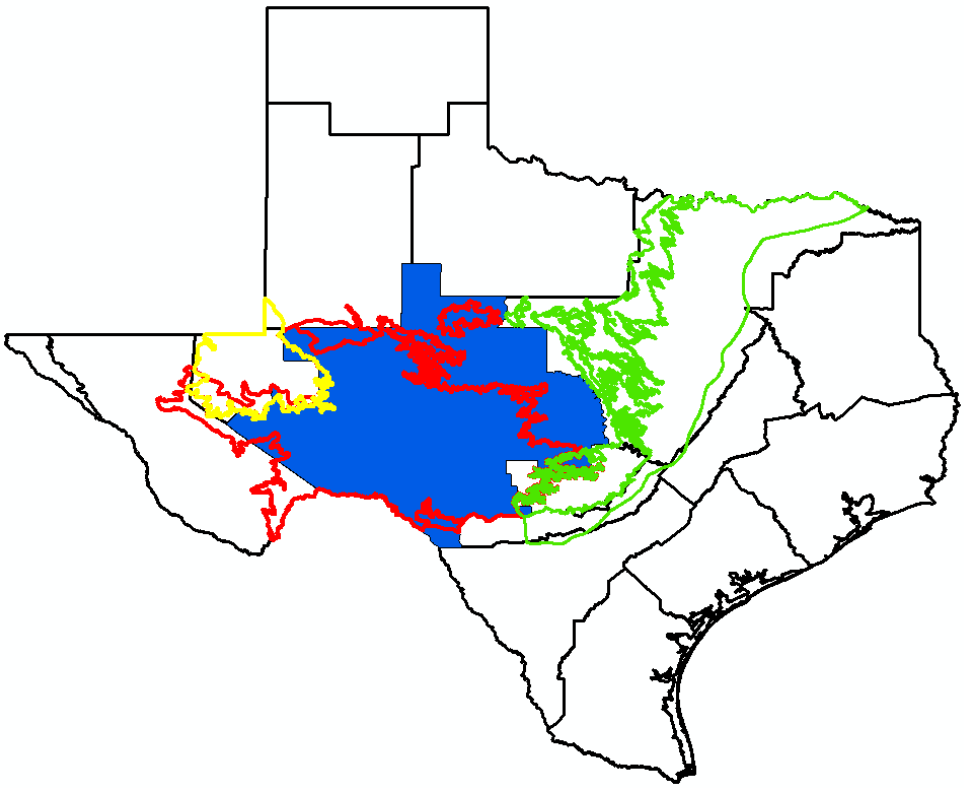
GMA 7 Technical Memorandum 15-06
Draft 2

Edward-Trinity (Plateau), Pecos Valley and Trinity Aquifers: Nine Factor Documentation and Predictive Simulations



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Groundwater Management Area 7

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1.0 Introduction and Objective

This technical memorandum documents data and information related to the nine factors that GMA 7 considered before developing and adopting a proposed desired future condition for the Edwards-Trinity (Plateau), Pecos Valley and Trinity aquifers on April 21, 2016. This technical memorandum will become part of a more complete draft preliminary explanatory report that will be completed prior to the GMA 7 meeting currently scheduled for September 2015.

This technical memorandum also presents summary results from predictive simulations using the alternative to the groundwater availability model of the Edwards-Trinity (Plateau) and Pecos Valley aquifers, commonly known as the one-layer model (Hutchison and others, 2011), which also includes pertinent portions of the Trinity Aquifer in Gillespie, Real and Uvalde counties. The predictive simulations presented here can either form the quantitative basis of an updated desired future condition, or be modified to run additional simulations after review and discussion of these results.

1.1 Aquifer Descriptions

As described in George and others (2011):

> ***The Edwards-Trinity (Plateau) Aquifer*** *is a major aquifer extending across much of the southwestern part of the state. The water-bearing units are composed predominantly of limestone and dolomite of the Edwards Group and sands of the Trinity Group. Although maximum saturated thickness of the aquifer is greater than 800 feet, freshwater saturated thickness averages 433 feet. Water quality ranges from fresh to slightly saline, with total dissolved solids ranging from 100 to 3,000 milligrams per liter, and water is characterized as hard within the Edwards Group. Water typically increases in salinity to the west within the Trinity Group. Elevated levels of fluoride in excess of primary drinking water standards occur within Glasscock and Irion counties. Springs occur along the northern, eastern, and southern margins of the aquifer primarily near the bases of the Edwards and Trinity groups where exposed at the surface. San Felipe Springs is the largest exposed spring along the southern margin. Of groundwater pumped from this aquifer, more than two-thirds is used for irrigation, with the remainder used for municipal and livestock supplies. Water levels have remained relatively stable because recharge has generally kept pace with the relatively low amounts of pumping over the extent of the aquifer. The regional water planning groups, in their 2006 Regional Water Plans, recommended water management strategies that use the Edwards Trinity (Plateau) Aquifer, including the construction of a well field in Kerr County and public supply wells in Real County.*
>
> ***The Pecos Valley Aquifer*** *is a major aquifer in West Texas. Water-bearing sediments include alluvial and windblown deposits in the Pecos River Valley. These sediments fill several structural basins, the largest of which are the Pecos Trough*

in the west and Monument Draw Trough in the east. Thickness of the alluvial fill reaches 1,500 feet, and freshwater saturated thickness averages about 250 feet. The water quality is highly variable, the water being typically hard, and generally better in the Monument Draw Trough than in the Pecos Trough. Total dissolved solids in groundwater from Monument Draw Trough are usually less than 1,000 milligrams per liter. The aquifer is characterized by high levels of chloride and sulfate in excess of secondary drinking water standards, resulting from previous oil field activities. In addition, naturally occurring arsenic and radionuclides occur in excess of primary drinking water standards. More than 80 percent of groundwater pumped from the aquifer is used for irrigation, and the rest is withdrawn for municipal supplies, industrial use, and power generation. Localized water level declines in south-central Reeves and northwest Pecos counties have moderated since the late 1970s as irrigation pumping has decreased; however, water levels continue to decline in central Ward County because of increased municipal and industrial pumping. The Region F Regional Water Planning Group recommended several water management strategies in their 2006 Regional Water Plan that would use the Pecos Valley Aquifer, including drilling new wells, developing two well fields in Winkler and Loving counties, and reallocating supplies.

***The Trinity Aquifer**, a major aquifer, extends across much of the central and northeastern part of the state. It is composed of several smaller aquifers contained within the Trinity Group. Although referred to differently in different parts of the state, they include the Antlers, Glen Rose, Paluxy, Twin Mountains, Travis Peak, Hensell, and Hosston aquifers. These aquifers consist of limestones, sands, clays, gravels, and conglomerates. Their combined freshwater saturated thickness averages about 600 feet in North Texas and about 1,900 feet in Central Texas. In general, groundwater is fresh but very hard in the outcrop of the aquifer. Total dissolved solids increase from less than 1,000 milligrams per liter in the east and southeast to between 1,000 and 5,000 milligrams per liter, or slightly to moderately saline, as the depth to the aquifer increases. Sulfate and chloride concentrations also tend to increase with depth. The Trinity Aquifer discharges to a large number of springs, with most discharging less than 10 cubic feet per second. The aquifer is one of the most extensive and highly used groundwater resources in Texas. Although its primary use is for municipalities, it is also used for irrigation, livestock, and other domestic purposes. Some of the state's largest water level declines, ranging from 350 to more than 1,000 feet, have occurred in counties along the IH-35 corridor from McLennan County to Grayson County. These declines are primarily attributed to municipal pumping, but they have slowed over the past decade as a result of increasing reliance on surface water. The regional water planning groups, in their 2006 Regional Water Plans, recommended numerous water management strategies for the Trinity Aquifer, including developing new wells and well fields, pumping more water from existing wells, overdrafting, reallocating supplies, and using surface water and groundwater conjunctively.*

1.2 Existing Desired Future Conditions

GMA 7 adopted a desired future condition for the Edwards-Trinity (Plateau), Pecos Valley and Trinity aquifers on July 29, 2010 as follows:

1. An average drawdown of 7 feet for the Edwards-Trinity (Plateau) aquifer, except for the Kinney County GCD, based on Scenario 10 of the TWDB GAM run 09-035, which is incorporated in its entirety into this resolution; and
2. In Kinney County, that drawdown which is consistent with maintaining at Las Moras Springs, and annual average flow of 23.9 cfs and a median flow of 24.4 cfs based on Scenario 3 of the Texas Water Development Board's flow model presented on July 27, 2010; and
3. The Edwards-Trinity aquifer is not relevant for joint planning purposes within the boundaries of the Lipan-Kickapoo WCD, the Lone Wolf GCD, and the Hickory Underground Water Conservation District No. 1; and
4. The Trinity (Hill Country) portion of the aquifer is not relevant for joint planning purposes within the boundaries of the Uvalde County UWCD in GMA 7.

1.3 Overview of Process to Adopt a New Desired Future Condition

Senate Bill 660, adopted by the legislature in 2011, changed the process by which groundwater conservation districts within a groundwater management area develop and adopt desired future conditions. The new process includes nine steps as presented below:

- The groundwater conservation districts within a groundwater management area consider nine factors outlined in the statute.
- The groundwater conservation districts adopt a "proposed" desired future condition
- The "proposed" desired future condition is sent to each groundwater conservation district for a 90-day comment period, which includes a public hearing by each district
- After the comment period, each district compiles a summary report that summarizes the relevant comments and includes suggested revisions. This summary report is then submitted to the groundwater management area.
- The groundwater management area then meets to vote on a desired future condition.
- The groundwater management area prepares an "explanatory report".
- The desired future condition resolution and the explanatory report are then submitted to the Texas Water Development Board and the groundwater conservation districts within the groundwater management area.
- Districts then adopt desired future conditions that apply to that district.

The nine factors that must be considered before adopting a proposed desired future condition are:

1. Aquifer uses or conditions within the management area, including conditions that differ substantially from one geographic area to another.

2. The water supply needs and water management strategies included in the state water plan.
3. Hydrological conditions, including for each aquifer in the management area the total estimated recoverable storage as provided by the executive administrator (of the Texas Water Development Board), and the average annual recharge, inflows and discharge.
4. Other environmental impacts, including impacts on spring flow and other interactions between groundwater and surface water.
5. The impact on subsidence.
6. Socioeconomic impacts reasonably expected to occur.
7. The impact on the interests and rights in private property, including ownership and the rights of management area landowners and their lessees and assigns in groundwater as recognized under Section 36.002 (of the Texas Water Code).
8. The feasibility of achieving the desired future condition.
9. Any other information relevant to the specific desired future condition.

In addition to these nine factors, statute requires that the desired future condition provide a balance between the highest practicable level of groundwater production and the conservation, preservation, protection, recharging, and prevention of waste of groundwater and control of subsidence in the management area.

Legislation in 2013 set the deadline for a proposed desired future condition as May 1, 2016.

2.0 Nine Factor Information

2.1 Groundwater Demands and Uses

Groundwater demands and uses from 2000 to 2012 in the Edwards-Trinity (Plateau), Pecos Valley, and Trinity aquifers are presented in Appendix A. Data were obtained from the Texas Water Development Board historic pumping database:

http://www.twdb.state.tx.us/waterplanning/waterusesurvey/historical-pumpage.asp

The Modeled Available Groundwater values for the Edwards-Trinity Aquifer are summarized below in Table 1. In the Pecos Aquifer, the modeled available groundwater in Crockett County is 31 AF/yr, is 113 AF/yr in Ector County, is 1,448 in Pecos County, and is 2 AF/yr in Upton County. In the Trinity Aquifer, the modeled available groundwater in Gillespie County is 2,482 AF/yr, and is 52 AF/yr in Real County. Hydrographs that compare the historic pumping and the modeled available groundwater values are presented in Appendix B.

Table 1. Modeled Available Groundwater for the Edwards-Trinity (Aquifer)

County	Modeled Available Groundwater (2010 to 2070) (Acre-feet/yr)	County	Modeled Available Groundwater (2010 to 2070) (Acre-feet/yr)
Coke	998	Pecos	115,938
Crockett	5,426	Reagan	68,278
Ector	5,422	Real	7,477
Edwards	5,638	Schleicher	8,050
Gillespie	2,514	Sterling	2,497
Glasscock	65,213	Sutton	6,438
Irion	2,293	Taylor	489
Kimble	1,283	Terrell	1,421
Kinney	70,338	Tom Green	426
McCulloch	4	Upton	22,379
Menard	2,194	Uvalde	1,635
Midland	23,251	Val Verde	24,988
Nolan	693	Total	445,283

2.2 Groundwater Supply Needs and Strategies

Total future demand estimates from the Texas Water Development Board are summarized in Table 2.

Recommended strategies in the 2011 Region F Water Plan for desalination, new groundwater, and well replacement are shown in Table 3.

Two alternative water supply strategies are listed for the Edwards-Trinity (Plateau) Aquifer in the 2011 Region F Water Plan. In Kimble County, a 1,000 AF/yr strategy for manufacturing is listed for the years 2010 to 2060. In Schleicher County, a 12,000 AF/yr strategy for municipal supply for the City of San Angelo is listed for the years 2040 to 2060.

2.3 Hydrologic Conditions, including Total Estimated Recoverable Storage

The groundwater budget as presented by Hutchison and others (2011) the Edwards-Trinity (Plateau) Aquifer is presented in Table 4.

Jones and others (2013) documented the total estimated recoverable storage for the aquifers in GMA 7. Table 5 presents storage for the Edwards-Trinity (Plateau) Aquifer. Table 6 presents storage for the Pecos Aquifer. Table 7 presents storage for the Trinity.

2.4 Other Environmental Impacts, including Impacts on Spring Flow

Table 4 (referenced above) includes groundwater budget estimates of spring flow as estimated by Hutchison and others (2011). Additional information on impacts to spring flow will be provided when presenting the results of future simulations.

2.5 Other Factors

Subsidence is not an issue in the Edwards-Trinity (Plateau), Pecos Valley, or Trinity aquifers in GMA 7. The factors related to socioeconomic impacts and private property rights will be covered in the draft preliminary explanatory report.

Table 2. Future Water Demands

County	Water Use (AF/yr)						Change (2020 to 2070)
	2020	2030	2040	2050	2060	2070	
Coke	2806	2823	2808	2811	2839	2848	42
Coleman	3335	3319	3274	3255	3241	3233	-102
Concho	11586	11535	11433	11335	11250	11173	-413
Crockett	5229	5563	5144	4770	4529	4541	-688
Ector	44084	48868	53855	59381	65707	72767	28,683
Edwards	1230	1211	1193	1184	1173	1166	-64
Gillespie	9142	9424	9658	9973	10338	10709	1,567
Glasscock	60554	59780	58603	57440	56409	55659	-4,895
Irion	5134	5261	4287	3317	2511	2109	-3,025
Kimble	4943	4871	4794	4722	4679	4647	-296
Kinney	8406	8397	8384	8380	8378	8378	-28
Llano	9499	9638	9563	9434	9543	9663	164
Mason	11493	11274	10907	10640	10412	10207	-1,286
McCulloch	15535	14986	13247	12230	11449	10830	-4,705
Menard	4468	4434	4298	4161	4043	3940	-528
Midland	75263	76803	79343	82052	85072	88465	13,202
Mitchell	19575	19622	19297	18942	18611	18347	-1,228
Nolan	25413	35845	35841	35883	35919	35979	10,566
Pecos	133971	134725	135119	135287	135455	135633	1,662
Reagan	24397	23330	22112	20785	19624	19007	-5,390
Real	913	890	870	855	843	835	-78
Runnels	6605	6581	6494	6441	6399	6363	-242
San Saba	9448	9323	8988	8740	8577	8442	-1,006
Schleicher	3453	3561	3371	3179	3005	2889	-564
Scurry	10891	11078	11015	10884	10785	10746	-145
Sterling	2394	2532	2349	2018	1726	1558	-836
Sutton	4134	4456	4488	4284	4081	3931	-203
Taylor	28806	29355	29801	30284	30868	31396	2,590
Terrell	1511	1604	1556	1416	1283	1178	-333
Tom Green	119070	120885	121841	122946	124361	125908	6,838
Upton	14974	14309	13442	12399	11515	11054	-3,920
Uvalde	75595	73694	71705	69993	68451	67179	-8,416
Val Verde	16777	17664	18519	19398	20262	21127	4,350
Total	770634	787641	787599	788819	793338	801907	31,273

Table 3. Recommended Groundwater Strategies in 2011 Region F Water Plan

Entity	County Used	Basin Used	Total Capital Cost	1st Decade Unit Cost	Supply (Ac-ft/yr)						2060 Unit Cost
					2010	2020	2030	2040	2050	2060	
Desalination											
City of Andrews	Andrews	Colorado	$6,717,000	$1,163	0	950	950	950	950	950	$546
CRMWD			$131,603,990	$0	0	0	0	9,500	9,500	9,500	$251
San Angelo			$75,440,000	$0	0	0	0	5,600	5,600	5,600	$473
Total			**$213,760,990**	**$1,163**	**0**	**950**	**950**	**16,050**	**16,050**	**16,050**	**$346**
New Groundwater											
Colorado City	Mitchell	Colorado	$17,855,000	$0	0	2,200	2,200	2,200	2,200	2,200	$445
City of Menard	Menard	Colorado	$1,684,000	$1,664	140	139	140	140	141	141	$610
County-Other	Menard	Colorado	$0	$0	20	21	20	20	19	19	$0
City of Midland	Midland	Colorado	$168,507,000	$0	0	0	13,600	13,600	13,600	13,600	$342
CRMWD	Multiple	Colorado	$76,268,000	$0	0	0	6,000	6,000	6,000	6,000	$251
San Angelo	Tom	Colorado	$173,307,000	$0	0	6,700	10,000	12,000	12,000	12,000	$1,670
Total			**$437,621,000**	**$1,664**	**160**	**9,060**	**31,960**	**33,960**	**33,960**	**33,960**	**$3,318**
Replacement Wells											
City of Eden	Concho	Colorado	$1,800,000	NA	0	0	0	0	0	0	NA
Richland SUD	McCulloc	Colorado	$1,701,000	NA	0	0	0	0	0	0	NA
CRMWD	Multiple	Colorado	$10,440,000	NA	0	0	0	0	0	0	NA
Total			**$13,941,000**	**NA**	**0**	**0**	**0**	**0**	**0**	**0**	**NA**

Table 4. Groundwater Budget of Edwards-Trinity (Plateau), Pecos Valley, and Trinity Aquifers from One-Layer Model

	Water Budget 1930-1939 (acre-feet per year)	Water Budget 1940-1949 (acre-feet per year)	Water Budget 1950-1959 (acre-feet per year)	Water Budget 1960-1969 (acre-feet per year)	Water Budget 1970-1979 (acre-feet per year)	Water Budget 1980-1989 (acre-feet per year)	Water Budget 1990-1999 (acre-feet per year)	Water Budget 2000-2005 (acre-feet per year)
Inflow								
Rivers	993,229	1,009,160	1,054,950	1,107,275	1,092,402	1,048,220	1,033,690	1,033,726
Inter-aquifer Flow	1,095,795	1,100,269	1,112,419	1,123,952	1,135,663	1,131,445	1,137,506	1,136,281
Recharge	1,641,803	1,688,928	1,545,021	1,621,125	1,680,625	1,671,631	1,669,556	1,703,227
Total Inflow	3,730,827	3,798,357	3,712,390	3,852,352	3,908,690	3,851,296	3,840,752	3,873,234
Outflow								
Pumpage	-194,233	-570,080	-947,024	-1,210,949	-935,718	-651,331	-706,359	-677,860
Springs	-1,216,432	-1,210,615	-1,129,334	-1,082,433	-1,092,612	-1,101,266	-1,120,187	-1,093,636
Rivers	-1,893,959	-1,841,710	-1,767,816	-1,722,471	-1,715,415	-1,741,168	-1,756,911	-1,755,300
Inter-aquifer Flow	-560,262	-557,538	-546,381	-532,124	-526,554	-531,894	-533,580	-535,091
Total Outflow	-3,864,885	-4,179,943	-4,390,555	-4,547,978	-4,270,298	-4,025,658	-4,117,038	-4,061,887
In-Out	-134,058	-381,585	-678,165	-695,626	-361,608	-174,362	-276,286	-188,653
Storage Change	-133,865	-372,190	-678,034	-695,534	-358,631	-166,175	-250,497	-188,648
Model Error	-194	-9,395	-131	-92	-2,977	-8,187	-25,789	-5
Model Error (Percent)	-0.01	-0.25	0.00	0.00	-0.08	-0.21	-0.67	0.00

Table 5. Total Estimated Recoverable Storage - Edwards-Trinity (Plateau) Aquifer

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Coke	120,000	30,000	90,000
Concho	79,000	19,750	59,250
Crockett	1,500,000	375,000	1,125,000
Ector	220,000	55,000	165,000
Edwards	5,000,000	1,250,000	3,750,000
Gillespie	430,000	107,500	322,500
Glasscock	270,000	67,500	202,500
Irion	420,000	105,000	315,000
Kimble	1,100,000	275,000	825,000
Kinney[20]	4,400,000	1,100,000	3,300,000
Mason	51,000	12,750	38,250
McCulloch	93,000	23,250	69,750
Menard	250,000	62,500	187,500
Midland	240,000	60,000	180,000
Nolan	170,000	42,500	127,500
Pecos	3,100,000	775,000	2,325,000
Reagan	560,000	140,000	420,000
Real	1,600,000	400,000	1,200,000
Schleicher	890,000	222,500	667,500
Sterling	150,000	37,500	112,500
Sutton	1,800,000	450,000	1,350,000
Taylor	78,000	19,500	58,500
Terrell	4,500,000	1,125,000	3,375,000
Tom Green	250,000	62,500	187,500
Upton	550,000	137,500	412,500
Uvalde	1,000,000	250,000	750,000
Val Verde	10,000,000	2,500,000	7,500,000
Total	38,821,000	9,705,250	29,115,750

[20] Total storage values for Kinney County are based on the alternative model by Hutchison and others (2011), the other total storage values were based on the groundwater availability model by Anaya and Jones (2009).

Table 6. Total Estimated Recoverable Storage - Pecos Valley Aquifer

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Crockett	160,000	40,000	120,000
Ector	5,900,000	1,475,000	4,425,000
Pecos	910,000	227,500	682,500
Upton	4,400,000	1,100,000	3,300,000
Total	11,370,000	2,842,500	8,527,500

Table 7. Total Estimated Recoverable Storage - Trinity Aquifer

County	*Total Storage (acre-feet)*	*25 percent of Total Storage (acre-feet)*	*75 percent of Total Storage (acre-feet)*
Gillespie	270,000	67,500	202,500
Real	23,000	5,750	17,250
Uvalde	230,000	57,500	172,500
Total	523,000	130,750	392,250

3.0 Predictive Simulation Results

In 2010, GMA 7 evaluated the results of 10 alternative predictive scenarios using the alternative one-layer model of the Edwards-Trinity (Plateau) and Pecos Valley aquifers. The model is documented in Hutchison and others (2011), and the simulation results are documented in Hutchison (2010). Hutchison (2010) includes an eleventh scenario that was used in the development of the desired future condition for GMA 3. Hutchison (2010) is included in this reported as Appendix C.

Drawdowns calculated in Hutchison (2010) were for predictive simulations through the year 2060. The proposed desired future conditions that must be adopted prior to May 1, 2016, the Texas Water Development Board has required that any predictive simulations be completed through the year 2070.

For purposes of discussion at the April 23, 2015 GMA 7 meeting, a simulation was completed that simply extended the time period of Scenario 10 of Hutchison (2010). This was designated Scenario 1. After discussion and review of the results, adjustments to pumping were made in Irion County, and the model was run again and designated as Scenario 2. Table 8 summarizes the results of the pumping, drawdown in 2060 and drawdown in 2070 on a county-by-county basis for both scenarios.

Table 8. Summary of Drawdown in feet from 2010 Conditions
Edwards-Trinity (Plateau) and Pecos Valley Aquifer Groundwater Model
(One Layer Model, GMA 7 Area Only)
Edwards-Trinity (Plateau), Pecos Valley and Trinity Aquifers
Simulation for period 2006 to 2070, comparison to 2010 DFC (2010 to 2060)

County	Scenario 10 (Existing DFC)		Scenario 1		Scenario 2	
	Pumping (AF/yr)	Drawdown in 2060 (ft)	Pumping (AF/yr)	Drawdown in 2070 (ft)	Pumping (AF/yr)	Drawdown in 2070 (ft)
Coke	1,000	0	1,000	0	1,000	0
Concho	490	0	490	0	490	0
Crockett	5,475	9	5,475	10	5,475	10
Ector	5,534	7	5,534	8	5,534	8
Edwards	5,659	2	5,659	2	5,659	2
Gillespie	5,000	5	5,000	5	5,000	5
Glasscock	65,177	34	65,177	40	65,177	40
Irion	2,300	10	2,300	10	3,300	10
Kimble	1,400	1	1,400	1	1,400	1
Kinney	65,000	0	65,000	0	65,000	0
McCulloch	150	0	150	0	150	0
Mason	20	0	20	0	20	0
Menard	2,580	1	2,580	1	2,580	1
Midland	23,243	10	23,243	12	23,243	12
Nolan	700	0	700	0	700	0
Pecos	240,000	11	240,000	12	240,000	12
Reagan	68,243	37	68,243	41	68,243	42
Real	7,533	4	7,533	4	7,533	4
Schelicher	8,060	8	8,060	8	8,060	8
Sterling	2,500	6	2,500	7	2,500	7
Sutton	6,450	6	6,450	6	6,450	6
Taylor	490	0	490	0	490	0
Terrell	1,443	2	1,443	2	1,443	2
TomGreen	2,800	2	2,800	2	2,800	2
Upton	22,375	13	22,375	16	22,375	16
Uvalde	2,000	2	2,000	2	2,000	2
ValVerde	25,000	1	25,000	1	25,000	1
GMA 7	**570,622**	**7**	**570,622**	**8**	**571,622**	**8**

4.0 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, 113p.

George, P.G., Mace, R.E., and Petrossian, R., 2011. Aquifers of Texas. Texas Water Development Board Report 380, July 2011, 182p.

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