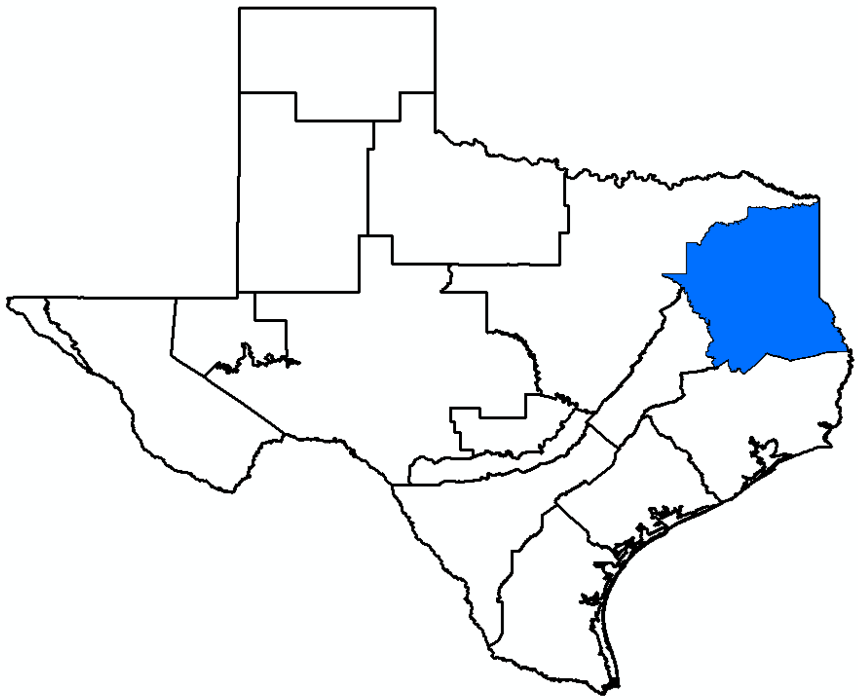
GMA 11 Technical Memorandum 26-02 (Draft 1)

Documentation of GMA 11 Pumping Scenarios to Simulate Reduction in Queen City and Carrizo-Wilcox Pumping Relative to Scenario 33 Pumping



Prepared for:
Groundwater Management Area 11

Prepared by:
William R. Hutchison, Ph.D., P.E., P.G.
Independent Groundwater Consultant
909 Davy St
Brenham, TX 77833
512-745-0599
billhutch@texasgw.com

February 26, 2026

Table of Contents

List of Figures

List of Tables

Professional Engineer and Professional Geoscientist Seals

This report was prepared by William R. Hutchison, Ph.D., P.E., P.G., who is licensed in the State of Texas as follows:

- Professional Engineer (Geological and Civil) No. 96287
- Engineering Firm Registration No. 14526
- Professional Geoscientist (Geology) No. 286

Draft – To be Signed and Stamped When Final

1.0 Introduction and Background

1.1 GMA 11 Meeting of October 14, 2025

At the GMA 11 meeting of October 14, 2025, the GAM simulation that formed the basis for the current desired future condition (Scenario 33) was reviewed. The review included evaluating simulation output related to estimated dry well impacts and surface water-groundwater impacts. In summary, the significant groundwater pumping increase (as compared with historic groundwater pumping) that is associated with Scenario 33 would result in about 568 dry wells (13 percent of the 4,217 wells available in the database) and about 184,089 AF/yr of the 255,370 AF/yr pumping increase would be sourced from surface water (about 72 percent of the pumping increase).

1.2 Updated Dry Well Analysis for Scenario 33

The TWDB database contains the locations of 5,786 wells in GMA 11. Of these, 4,217 wells had good data on well depth. These 4,217 wells were then located on the model grid, including which layer the bottom of the well is completed. The locations of these 4,217 wells is presented in Figure 1.

These wells, of course, and not all the wells in GMA 11. However, the number of wells and geographic distribution are adequate to assess the impact of increased or decreased pumping on whether the well remains productive or "goes dry". For the purposes of this analysis, if the groundwater level in the wells drops to the point where there is less than 20 feet of water in the well, it is considered "dry".

An update to the Groundwater Availability Model for the northern portion of the Carrizo-Wilcox, Queen City, and Sparta aquifers (Panday and others, 2020) has been completed and is documented in Hutchison (2026). In summary, specific yield values in the alluvial layer (layer 1) were specified as 0.1 in the updated model. This update resulted in slightly different dry well counts for Scenario 33 as compared to those reported at the GMA 11 meeting of October 14, 2025 as presented in Table 1.

Table 2 presents the dry well count by county using the updated GAM. Please note that Scenario 33 suggests that the dry well rate in nine counties would be over 10 percent in 2080.

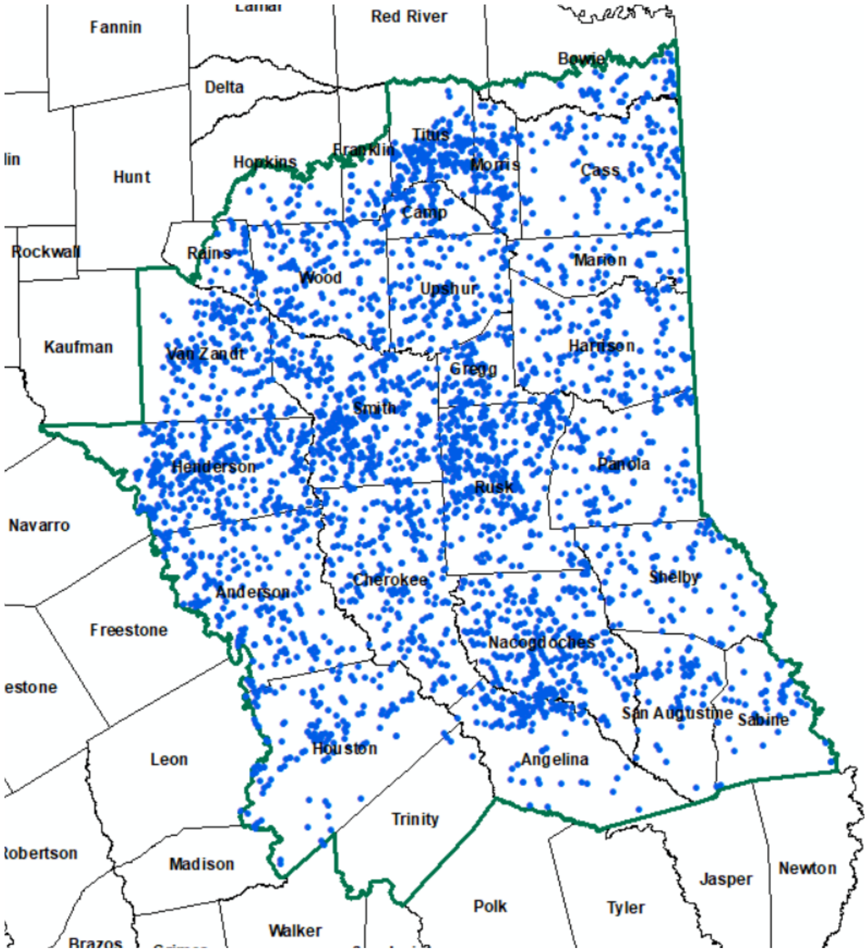


Figure 1. Location of 4,217 Wells in GMA 11 (TWDB Database)

Table 1. Summary of Dry Well Counts for Scenario 33: Original GAM and Updated GAM

Aquifer	Well Count	Original Scenario 33 (Basis for DFC)		Updated Scenario 33 (Adjusted Specific Yield Values)	
		Dry Wells in 2080 (Count)	Dry Wells in 2080 (% of Well Count)	Dry Wells in 2080 (Count)	Dry Wells in 2080 (% of Well Count)
Sparta	155	7	5	7	5
Queen City	288	139	48	133	46
Carrizo-Wilcox	3405	340	10	297	9
All	4217	568	13	515	12

Table 2. Summary of Dry Well Counts by County for Scenario 33 (Updated GAM)

County	Well Count	Average Depth (ft)	Dry Wells in 2080 (Count)	Dry Wells in 2080 (% of Count)
Anderson	237	699	22	9
Angelina	118	1243	0	0
Bowie	50	207	3	6
Camp	80	415	4	5
Cass	162	366	28	17
Cherokee	255	408	84	33
Franklin	40	343	10	25
Gregg	107	457	12	11
Harrison	188	255	11	6
Henderson	370	444	44	12
Hopkins	25	357	1	4
Houston	155	756	1	1
Marion	61	334	3	5
Morris	98	292	21	21
Nacogdoches	315	439	25	8
Panola	136	263	2	1
Rains	31	203	3	10
Rusk	428	448	39	9
Sabine	55	831	1	2
SanAugustine	65	543	0	0
Shelby	105	360	3	3
Smith	375	645	105	28
Titus	190	275	41	22
Trinity	3	518	0	0
Upshur	150	473	17	11
VanZandt	218	371	16	7
Wood	200	462	19	10

1.3 Updated Scenarios

At the October 14, 2025 meeting, GMA 11 approved additional simulations to evaluate the effects of reducing groundwater pumping in the Queen City and Carrizo-Wilcox aquifers as compared with Scenario 33. This technical memorandum documents these simulations. Also, this technical memorandum documents a baseline simulation (pumping from 2013 repeated annually from 2014 to 2080). Finally, after evaluating the results, a final simulation (named Scenario 26.1) that involved targeted reductions in pumping to limit the dry wells in each county to less than 10 percent.

The results of these simulations focused on reducing the number of dry wells and reducing the surface water impact of increased pumping. Of note is that the groundwater budget analysis has been revised. The groundwater budget analysis presented at the GMA 11 meeting of October 14, 2025 used the entirety of GMA 14 as the area of interest. The groundwater budgets presented in this Technical Memorandum are presented for each river basin in GMA 11 to better characterize areas of concern.

Please note that all files associated with this Technical Memorandum are available for download at:

https://drive.google.com/drive/folders/1OVEA0S6SDPB4NG1XkS4u0AG82QZsTd1w?usp=sharing

2.0 Pumping Reduction Scenarios

2.1 Baseline Simulation

Prior to developing the pumping reduction scenarios, a baseline scenario was developed that assumed that 2013 pumping (the last year of the model calibration period) was repeated from 2014 to 2080. This baseline simulation provides a more stable set of results to compare and assess changes associated with other predictive simulations.

2.2 Initial Bounding Simulations

The pumping reduction scenarios started with Scenario 33 (the basis for the current DFC). Nine scenarios of pumping reduction in the Carrizo-Wilcox Aquifer (CW) were developed and nine scenarios of pumping reduction in the Queen City Aquifer (QC) were also developed. A pumping reduction factor was applied on a cell-by-cell basis for each scenario with the caveat that pumping could not drop below 2013 pumping (as defined in the calibrated model) for a specific cell. Table 3 summarizes the scenarios.

Table 3. Pumping Reduction Scenarios

Factor Applied	CW Scenario	QC Scenario
1.0	Scenario 33	
0.9	CW9	QC9
0.8	CW8	QC8
0.7	CW7	QC7
0.6	CW6	QC6
0.5	CW5	QC5
0.4	CW4	QC4
0.3	CW3	QC3
0.2	CW2	QC2
0.1	CW1	QC1

2.2.1 Dry Well Analysis Results of Initial Bounding Simulations

Summary results of the pumping reduction scenarios included tracking the number of dry wells in the Queen City and Carrizo-Wilcox Aquifers. Figure 2 presents the summary for Queen City wells. Figure 3 presents the summary for Carrizo-Wilcox wells. Please note that as pumping decreases, the number of dry wells decrease (expressed as a percentage of all wells).

Also, please note that when pumping is reduced in the Queen City Aquifer, not only is there a reduction in dry wells in the Queen City Aquifer, the number of Carrizo-Wilcox dry wells also is decreased. Similarly, when pumping is reduced in the Carrizo-Wilcox Aquifer, not only is there a reduction in dry wells in the Carrizo-Wilcox Aquifer, the number of Queen City dry wells is also reduced. These results highlight the vertical connection between formations in GMA 11.

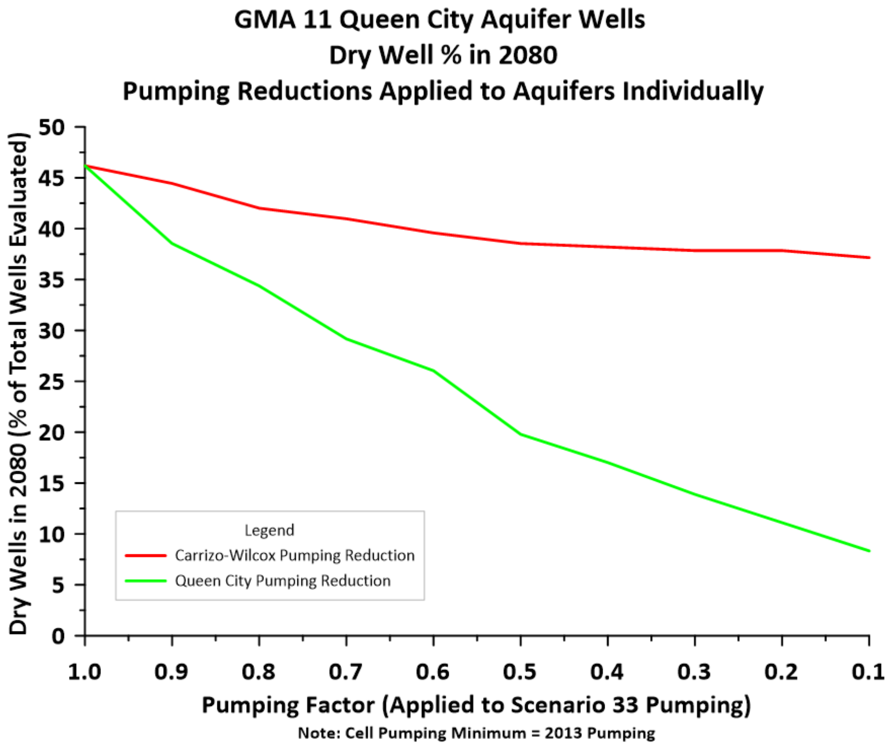


Figure 2. Initial Bounding Simulations Dry Well Analysis: Queen City Wells

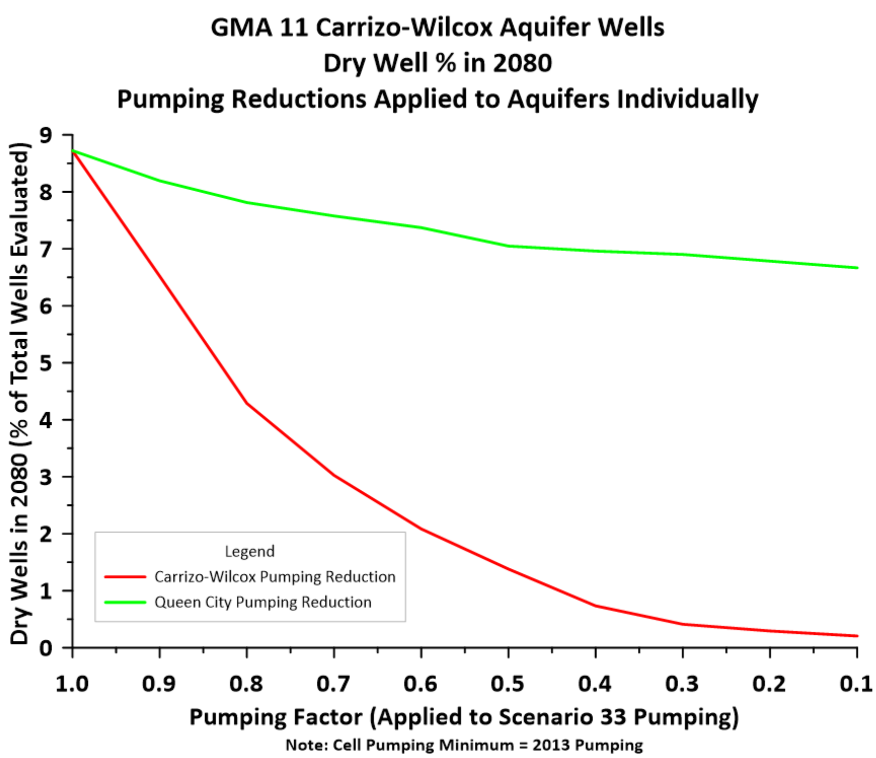


Figure 3. Initial Bounding Simulations Dry Well Analysis: Carrizo-Wilcox Wells

Table 4 presents the county summary of dry wells for Scenario QC1. Please note that the analysis includes all wells and Carrizo-Wilcox wells. Please note that several counties have more than 10 percent of their wells go dry under this scenario.

Table 4. Dry Wells Analysis by County - Scenario QC1

County	Count	Avg Depth (ft)	Scenario QC1					
			Dry Wells	Dry Well %	CW Count	CW Dry Wells	CW Dry Well %
Anderson	237	699	12	5	184	7	4
Angelina	118	1243	0	0	92	0	0
Bowie	50	207	3	6	46	2	4
Camp	80	415	3	4	72	3	4
Cass	162	366	5	3	115	1	1
Cherokee	255	408	51	20	154	39	25
Franklin	40	343	10	25	40	10	25
Gregg	107	457	3	3	100	1	1
Harrison	188	255	6	3	169	5	3
Henderson	370	444	24	6	314	16	5
Hopkins	25	357	1	4	25	1	4
Houston	155	756	1	1	40	0	0
Marion	61	334	0	0	36	0	0
Morris	98	292	12	12	68	7	10
Nacogdoches	315	439	16	5	229	11	5
Panola	136	263	2	1	133	2	2
Rains	31	203	3	10	30	3	10
Rusk	428	448	32	7	415	31	7
Sabine	55	831	1	2	31	1	3
SanAugustine	65	543	0	0	29	0	0
Shelby	105	360	3	3	103	3	3
Smith	375	645	33	9	282	22	8
Titus	190	275	39	21	187	37	20
Trinity	3	518	0	0	0	0	0
Upshur	150	473	9	6	129	7	5
VanZandt	218	371	9	4	209	8	4
Wood	200	462	10	5	173	10	6

2.2.2 Pumping in Scenario QC1

While all pumping reductions yield fewer dry wells, the reductions in the Queen City Aquifer pumping have the most benefit, not only to Queen City wells, but also to Carrizo-Wilcox wells. It should be noted that Scenario QC1 (a 90 percent reduction in Queen City pumping from Scenario 33 pumping) still represents a large increase in historic pumping as shown in Table 5.

Table 5. Queen City Pumping Comparison (Baseline, Scenario 33, and Scenario QC1)

Queen City Aquifer

County	Baseline (AF/yr	Current MAG (Scen 33)		Scen QC1	
		AF/yr	% of Baseline	AF/yr	% of Baseline
Anderson	626	16,580	2,649	1,727	276
Angelina	83	1,094	1,318	109	131
Camp	64	1,593	2,489	191	298
Cass	504	16,468	3,267	1,818	361
Cherokee	944	8,806	933	1,425	151
Gregg	204	2,510	1,230	328	161
Harrison	342	3,535	1,034	501	146
Henderson	652	10,663	1,635	1,220	187
Houston	188	2,294	1,220	340	181
Marion	147	7,384	5,023	781	531
Morris	116	3,276	2,824	355	306
Nacogdoches	282	2,944	1,044	298	106
Rusk	25	59	236	26	104
Smith	1,048	32,556	3,106	3,393	324
Upshur	1,238	12,156	982	1,673	135
VanZandt	228	2,341	1,027	308	135
Wood	1,537	6,505	423	1,545	101
Total	**8,228**	**130,764**	**1,589**	**16,038**	**195**

2.3 Scenario 26.1

The pumping reduction scenarios described above relied on global pumping reductions applied over an entire aquifer. The analysis showed that Scenario QC1 still represents an increase in pumping compared to historic pumping in the Queen City Aquifer. However, there are still several counties with a relatively high percentage of dry wells.

Scenario 26.1 was developed with the objective of reducing pumping on a county basis such that no county would have more than 10 percent dry wells (all wells and Carrizo-Wilcox Aquifer wells). Limiting the dry wells to 10 percent is an example of avoiding an undesirable effect that is central to the definition of sustainable yield.

The 10 percent standard could be considered arbitrary, but it appears a reasonable point to balance the maximum practicable use of groundwater and conservation of groundwater required in the Texas Water Code for joint planning. Wells represent a significant property right for most rural residents of GMA 11 and the impact of dry wells would certainly fit into the category of socioeconomic impacts. Both property rights and socioeconomic impacts are factors in joint planning.

2.3.1 Sparta Pumping

Scenario 26.1 pumping for the Sparta Aquifer is presented in Table 6 and remains unchanged from Scenario 33 (the basis for the current DFC). Pumping in the Sparta Aquifer is generally low and the dry well rate is below the acceptable threshold used for this analysis.

Table 6. Scenario 26.1 Pumping - Sparta Aquifer

Sparta Aquifer

County	Baseline (AF/yr	Current MAG (Scen 33)		Scen 26.1	
		AF/yr	% of Baseline	AF/yr	% of Baseline
Anderson	39	307	787	307	787
Angelina	292	390	134	390	134
Cherokee	192	351	183	351	183
Houston	683	1,481	217	1,481	217
Nacogdoches	228	362	159	362	159
Sabine	47	49	104	49	104
SanAugustine	20	166	830	166	830
Trinity	15	152	1,013	152	1,013
Total	**1,516**	**3,258**	**215**	**3,258**	**215**

2.3.2 Queen City Pumping

Scenario 26.1 pumping for the Queen City Aquifer is presented in Table 7 and is the same as Queen City Aquifer pumping from Scenario QC1 presented and discussed above.

Table 7. Scenario 26.1 Pumping – Queen City Aquifer

Queen City Aquifer

County	Baseline (AF/yr	Current MAG (Scen 33)		Scen 26.1	
		AF/yr	% of Baseline	AF/yr	% of Baseline
Anderson	626	16,580	2,649	1,727	276
Angelina	83	1,094	1,318	109	131
Camp	64	1,593	2,489	191	298
Cass	504	16,468	3,267	1,818	361
Cherokee	944	8,806	933	1,425	151
Gregg	204	2,510	1,230	328	161
Harrison	342	3,535	1,034	501	146
Henderson	652	10,663	1,635	1,220	187
Houston	188	2,294	1,220	340	181
Marion	147	7,384	5,023	781	531
Morris	116	3,276	2,824	355	306
Nacogdoches	282	2,944	1,044	298	106
Rusk	25	59	236	26	104
Smith	1,048	32,556	3,106	3,393	324
Upshur	1,238	12,156	982	1,673	135
VanZandt	228	2,341	1,027	308	135
Wood	1,537	6,505	423	1,545	101
Total	**8,228**	**130,764**	**1,589**	**16,038**	**195**

2.3.3 Carrizo-Wilcox Pumping

Scenario 26.1 pumping in the Carrizo-Wilcox Aquifer is presented in Table 8. Please note that counties with pumping reductions (as compared with the current MAG) are highlighted in yellow.

Table 8. Scenario 26.1 Pumping – Carrizo-Wilcox Aquifer

Carrizo-Wilcox Aquifer

County	Baseline (AF/yr	Current MAG (Scen 33)		Scen 26.1	
		AF/yr	% of Baseline	AF/yr	% of Baseline
Anderson	4,689	27,006	576	7,500	160
Angelina	21,628	27,592	128	27,592	128
Bowie	2,712	9,638	355	9,638	355
Camp	1,142	3,859	338	3,859	338
Cass	2,306	13,633	591	8,500	369
Cherokee	8,231	15,231	185	9,500	115
Franklin	592	5,728	968	1,500	253
Gregg	2,789	6,068	218	6,068	218
Harrison	3,395	9,090	268	9,090	268
Henderson	6,579	7,217	110	7,217	110
Hopkins	2,605	4,749	182	3,500	134
Houston	831	2,354	283	2,354	283
Marion	1,133	1,965	173	1,965	173
Morris	1,106	2,569	232	1,500	136
Nacogdoches	13,661	20,845	153	20,845	153
Panola	2,645	4,996	189	4,996	189
Rains	682	1,410	207	682	100
Rusk	6,364	14,009	220	14,009	220
Sabine	721	1,387	192	1,387	192
SanAugustine	700	587	84	587	84
Shelby	2,502	6,315	252	5,500	220
Smith	13,886	25,529	184	18,000	130
Titus	1,719	7,531	438	1,900	111
Trinity	28	267	954	100	357
Upshur	4,877	6,653	136	6,653	136
VanZandt	4,458	6,927	155	5,000	112
Wood	5,071	17,890	353	10,000	197
Total	**117,052**	**251,045**	**214**	**189,442**	**162**

3.0 Dry Well Analysis (Scenario 33 and Scenario 26.1)

Table 9 presents the dry well analysis organized by aquifer for Scenario 33 and Scenario 26.1. Please note that in Scenario 33, over 46 percent of the wells go dry in the Queen City Aquifer, and over 12 percent of the wells go dry overall. The yellow shading represents exceedance of the 10 percent threshold discussed above. However, in Scenario 26.1, all aquifers meet the threshold of less than 10 percent dry wells. The Queen City is the highest at about 5 percent, as noted by the green shading.

Table 9. Dry Well Analysis - Scenario 26.1 (Aquifer Based)

Aquifer	Total Wells	Scen 33 (current DFC)		Scen 26.1	
		Dry Wells	Dry Well %	Dry Wells	Dry Well %
Sparta	155	7	4.5	3	1.9
Queen City	288	133	46.2	15	5.2
Carrizo-Wilcox	3405	297	8.7	56	1.6
All (including other formations)	4217	515	12.2	87	2.1

Table 10 presents the dry well analysis organized by county for Scenario 33 and Scenario 26.1. Please note that in Scenario 33, the dry well threshold of 10 percent is exceeded in nine counties for all wells, and in five counties in Carrizo-Wilcox wells, as noted by the yellow shading. However, in Scenario 26.1, all counties have met the 10 percent dry well threshold. The highest dry well percentage for both all wells and Carrizo-Wilcox wells is Cherokee County.

Table 10. Dry Well Analysis - Scenario 26.1 (County Based)

County	Count	Avg Depth (ft)	Scen 33 (Current DFC)					Scen 26.1 (Current DFC)				
			Dry Wells	Dry Well %	CW Count	CW Dry Wells	CW Dry Well %	Dry Wells	Dry Well %	CW Count	CW Dry Wells	CW Dry Well %
Anderson	237	699	22	9.3	184	9	4.9	6	2.5	184	1	0.5
Angelina	118	1243	0	0.0	92	0	0.0	0	0.0	92	0	0.0
Bowie	50	207	3	6.0	46	2	4.3	3	6.0	46	2	4.3
Camp	80	415	4	5.0	72	3	4.2	0	0.0	72	0	0.0
Cass	162	366	28	17.3	115	1	0.9	2	1.2	115	0	0.0
Cherokee	255	408	84	32.9	154	54	35.1	16	6.3	154	11	7.1
Franklin	40	343	10	25.0	40	10	25.0	0	0.0	40	0	0.0
Gregg	107	457	12	11.2	100	5	5.0	2	1.9	100	0	0.0
Harrison	188	255	11	5.9	169	5	3.0	4	2.1	169	4	2.4
Henderson	370	444	44	11.9	314	30	9.6	7	1.9	314	4	1.3
Hopkins	25	357	1	4.0	25	1	4.0	1	4.0	25	1	4.0
Houston	155	756	1	0.6	40	0	0.0	0	0.0	40	0	0.0
Marion	61	334	3	4.9	36	0	0.0	0	0.0	36	0	0.0
Morris	98	292	21	21.4	68	7	10.3	5	5.1	68	2	2.9
Nacogdoches	315	439	25	7.9	229	11	4.8	12	3.8	229	7	3.1
Panola	136	263	2	1.5	133	2	1.5	1	0.7	133	1	0.8
Rains	31	203	3	9.7	30	3	10.0	1	3.2	30	1	3.3
Rusk	428	448	39	9.1	415	38	9.2	13	3.0	415	12	2.9
Sabine	55	831	1	1.8	31	1	3.2	1	1.8	31	1	3.2
SanAugustine	65	543	0	0.0	29	0	0.0	0	0.0	29	0	0.0
Shelby	105	360	3	2.9	103	3	2.9	2	1.9	103	2	1.9
Smith	375	645	105	28.0	282	36	12.8	6	1.6	282	3	1.1
Titus	190	275	41	21.6	187	39	20.9	0	0.0	187	0	0.0
Trinity	3	518	0	0.0	0	0	0.0	0	0.0	0	0	0.0
Upshur	150	473	17	11.3	129	9	7.0	3	2.0	129	2	1.6
VanZandt	218	371	16	7.3	209	11	5.3	2	0.9	209	2	1.0
Wood	200	462	19	9.5	173	17	9.8	0	0.0	173	0	0.0

4.0 Groundwater Budget Analyses

Groundwater budgets quantify the inflows to, outflows from, and storage change within an specified geographic area. During the GMA 11 meeting of October 14, 2025, the groundwater budgets that had been presented in the 2021 GMA 11 Explanatory Report were discussed. These groundwater budgets defined the geographic area as GMA 11 (with the alluvial layer as separate zone). In order to provide a more granular analysis for this effort, the zones were redefined by river basin and GMA.

4.1 Zone Definition

Each cell in the model was given a three-digit code. The first digit is based on the basin, or state (for cells outside Texas):

- 1 = Arkansas
- 2 = Brazos Basin
- 3 = Cypress Basin
- 4 = Louisiana
- 5 = Neches Basin
- 6 = Sabine Basin
- 7 = San Jacinto Basin
- 8 = Sulphur Basin
- 9 = Trinity Basin

The second and third digits were the GMA (for Texas cells) or a two-digit code for Arkansas and Louisiana:

- 08 = GMA 8
- 11 = GMA 11
- 12 = GMA 12
- 14 = GMA 14
- 98 = Arkansas
- 99 = Louisiana

The Fortran program named *GMA11Zone.exe* was written to assign zone numbers. The USGS program ZoneBudget was used to develop groundwater budgets for each zone.

Appendix A contains the groundwater budgets for each basin in GMA 11 and includes maps that shows the geographic extent of each basin.

Among the analyses presented in this Technical Memorandum are the general character of the alluvium (layer 1 of the model) interactions with the bedrock aquifers (layers 2 to 9) and the interbasin movement of groundwater.

4.2 Groundwater Pumping and Inflow from Alluvium Results

The upper part of Table 11 summarizes the groundwater pumping by basin for four scenarios. The lower part of Table 11 summarizes the inflow from the alluvium by basin for the same four scenarios.

Table 11. Summary of Groundwater Pumping and Inflow from Alluvium

Basin	Groundwater Pumping (AF/yr)			
	Scenario			
	Baseline	Scenario 33	Scenario QC1	Scenario 26.1
Cypress Basin	14,611	81,967	47,953	33,612
Neches Basin	69,405	183,651	130,962	102,959
Sabine Basin	28,411	87,048	64,142	51,554
Sulphur Basin	5,478	15,806	15,337	12,598
Trinity Basin	8,888	16,593	11,961	8,016
Total GMA 11	126,794	385,065	270,355	208,739

Basin	Inflow from Alluvium (AF/yr)			
	Scenario			
	Baseline	Scenario 33	Scenario QC1	Scenario 26.1
Cypress Basin	-15,897	38,812	8,550	-2,582
Neches Basin	-10,590	58,852	17,050	6,933
Sabine Basin	-16,327	34,464	13,920	1,759
Sulphur Basin	513	11,293	10,871	7,962
Trinity Basin	-5,770	5,386	2,276	-4,212
Total GMA 11	-48,071	148,807	52,667	9,860

Based on these data, the groundwater pumping for each basin can be summarized as follows, depending on scenario:

- Cypress Basin: 12 to 21 percent of GMA 11 pumping
- Neches Basin: 48 to 55 percent of GMA 11 pumping
- Sabine Basin: 22 to 25 percent of GMA 11 pumping
- Sulphur Basin: 4 to 6 percent of GMA 11 pumping
- Trinity Basin: 4 to 7 percent of GMA 11 pumping

Please note that the inflow from the alluvium in the baseline is negative in all basins (except the Sulphur Basin). The negative number represents an outflow from the bedrock aquifers to the alluvium and suggests net gaining stream conditions. In contrast, all basins have positive numbers for Scenario 33 (the basis for the current DFC) and Scenario QC1. Finally, Scenario 26.1 shows net gaining stream conditions in the Cypress and Trinity basins. The net losing stream conditions for the other basins in Scenario 26.1 are mitigated by the reduced pumping. For example, the increased pumping Neches Basin (the majority of the pumping in GMA 11) induces about 69,000

AF/yr from the alluvium into the bedrock aquifers, but only about 18,000 AF/yr is induced in Scenario 26.1.

In the 2021 GMA 11 Explanatory Report, it was noted that about 72 percent of the pumping increase was sourced from surface water. These groundwater budgets do not lend themselves to a clean analysis of the source of the increased pumping due to changes in interbasin movement of water, which is a significant component of the groundwater water budgets. However, it is reasonable to conclude that these groundwater budgets demonstrate that most of the groundwater pumping is sourced from surface water rather than from groundwater storage.

4.3 Interbasin Flow

Interbasin flows from the groundwater budgets presented in Appendix A are discussed below by river basin (in alphabetical order).

4.3.1 Cypress Basin

Table 12 presents a summary of pumping and interbasin flow for the Cypress Basin.

Table 12. Groundwater Pumping and Interbasin Flow - Cypress Basin

Scenario	Cypress Basin		
	Pumping (AF/yr)	Inflow from Sabine (AF/yr)	Inflow from Sulphur (AF/yr)
Baseline	14,611	258	1,518
Scenario 33	81,967	-1,373	6,022
Scenario QC1	47,953	-1,729	5,590
Scenario 26.1	33,612	-780	3,957

During the baseline simulation, there is a net inflow from the Sabine Basin to the Cypress Basin. In all the other scenarios, groundwater flow is from the Cypress Basin to the Sabine Basin.

The changes in inflow from the Sulphur Basin correlate to changes in pumping in the Cypress Basin (more inflow with more pumping). This suggests that some of the increased pumping in the Cypress Basin is sourced from the Sulphur Basin.

4.3.2 Neches Basin

Table 13 presents a summary of pumping and interbasin flow for the Neches Basin.

Table 13. Groundwater Pumping and Interbasin Flow - Neches Basin

Scenario	Neches Basin		
	Pumping (AF/yr)	Inflow from Sabine (AF/yr)	Inflow from Trinity (AF/yr)
Baseline	69,405	4,156	4,731
Scenario 33	183,651	8,435	23,671
Scenario QC1	130,962	8,292	22,336
Scenario 26.1	102,959	5,638	11,765

Please recall that the majority of GMA 11 pumping is in the Neches Basin. Under all scenarios, there is inflow from the Sabine and Trinity basins. The changes in pumping correlate with the changes in inflow, which suggests that a relatively large amount of pumping in the Neches Basin is sourced from the Sabine and Trinity basins.

4.3.3 Sabine Basin

Table 14 presents a summary of pumping and interbasin flow for the Sabine Basin.

Table 14. Groundwater Pumping and Interbasin Flow - Sabine Basin

Scenario	Sabine Basin				
	Pumping (AF/yr)	Inflow from Cypress (AF/yr)	Inflow from Neches (AF/yr)	Inflow from Sulphur (AF/yr)	Inflow from Trinity (AF/yr)
Baseline	28,411	-258	-4,156	-109	147
Scenario 33	87,048	1,373	-8,435	-227	264
Scenario QC1	64,142	1,729	-8,292	-230	260
Scenario 26.1	51,554	780	-5,638	-11	256

The Sabine Basin border all of the other four basins in GMA 11. In general, flow to and from the Sulphur and Trinity are minor.

Under baseline conditions, there is outflow from the Sabine to the Cypress, but changes to inflow in the other three scenarios. Correlation between pumping and inflow from Cypress is moderate.

Outflow from the Sabine to the Neches occurs in all scenarios, and as noted above, Sabine Basin groundwater is a source of the increased pumping in the Neches Basin.

4.3.4 Sulphur Basin

Table 15 presents a summary pumping and interbasin flow for the Sulphur Basin.

Table 15. Groundwater Pumping and Interbasin Flow - Sulphur Basin

Scenario	Sulphur Basin		
	Pumping (AF/yr)	Inflow from Cypress (AF/yr)	Inflow from Sabine (AF/yr)
Baseline	5,478	-1,518	109
Scenario 33	15,806	-6,022	227
Scenario QC1	15,337	-5,590	230
Scenario 26.1	12,598	-3,957	11

The inflow from the Sabine to the Sulphur Basin is relatively low. As noted above, the outflow from the Sulphur Basin to the Cypress Basin is due to the increased pumping in the Cypress Basin.

4.3.5 Trinity Basin

Table 16 presents a summary of pumping and interbasin flow for the Trinity Basin.

Table 16. Groundwater Pumping and Interbasin Flow - Trinity Basin

Scenario	Trinity Basin		
	Pumping (AF/yr)	Inflow from Neches (AF/yr)	Inflow from Sabine (AF/yr)
Baseline	8,888	-4,731	-147
Scenario 33	16,593	-23,671	-264
Scenario QC1	11,961	-22,336	-260
Scenario 26.1	8,016	-11,765	-256

The Trinity Basin covers a relatively small part of GMA 11 on its western boundary, and pumping is relatively small. As noted above, some of the increased pumping in the Neches Basin is sourced from outflow from the Trinity into the Neches Basin.

5.0 Average Drawdown Calculations

GMA 11 has historically expressed desired future conditions (DFCs) as average drawdown by county and aquifer at the end of the planning period. In 2021, the DFCs used 2080 as the end of the planning period. TWDB has provided guidance that DFCs for the current round of joint planning should again use 2080 as the end of the planning period. New requirement from HB 2078 also require "intermediate" (decadal) DFCs.

Average drawdown values were calculated from the output of Scenario 26.1 using the Fortran program *getdd.exe*, which calculated area-weighted average for each county for the Sparta, Queen City, and Carrizo-Wilcox aquifers.

The decadal average drawdown results are presented as follows:

- Table 17: Sparta Aquifer
- Table 18: Queen City Aquifer
- Table 19: Carrizo-Wilcox Aquifer

Table 17. Average Drawdown by County - Sparta Aquifer, Scenario 26.1

Scenario 26.1 Average Drawdown (ft) by Decade
Sparta Aquifer (2013 Baseline)

County	2030	2040	2050	2060	2070	2080
Anderson	6	6	6	6	6	6
Angelina	3	3	3	3	3	3
Cass	8	8	9	9	9	9
Cherokee	3	3	3	3	3	3
Houston	2	2	2	2	2	2
Marion	5	5	5	5	5	5
Nacogdoches	5	5	5	5	5	5
Rusk	18	20	22	22	23	23
Sabine	1	1	1	1	1	1
SanAugustine	2	2	2	2	2	2
Shelby	7	9	9	10	10	10
Smith	3	3	3	3	3	3
Trinity	3	3	3	3	3	3
Upshur	2	2	2	2	2	2
Wood	2	2	2	2	2	2

Table 18. Average Drawdown by County – Queen City Aquifer, Scenario 26.1

Scenario 26.1 Average Drawdown (ft) by Decade
Queen City Aquifer (2013 Baseline)

County	2030	2040	2050	2060	2070	2080
Anderson	4	4	4	4	4	4
Angelina	11	11	11	11	11	11
Camp	2	2	2	2	2	2
Cass	3	3	3	3	3	3
Cherokee	3	3	3	3	3	3
Gregg	6	7	7	7	7	8
Harrison	2	2	2	2	2	2
Henderson	2	3	3	3	3	3
Houston	3	3	3	3	3	3
Marion	4	4	4	4	4	4
Morris	5	5	5	5	5	5
Nacogdoches	8	8	8	8	8	8
Rusk	8	9	9	10	10	10
Sabine	3	3	3	3	3	3
SanAugustine	5	5	5	5	5	5
Shelby	6	6	7	7	7	7
Smith	4	5	5	5	5	5
Titus	1	1	1	1	1	1
Trinity	7	7	7	7	7	7
Upshur	5	5	5	5	5	5
VanZandt	2	2	2	2	2	2
Wood	2	2	2	2	2	2

Table 19. Average Drawdown by County – Carrizo-Wilcox Aquifer, Scenario 26.1

Scenario 26.1 Average Drawdown (ft) by Decade
Carrizo-Wilcox Aquifer (2013 Baseline)

County	2030	2040	2050	2060	2070	2080
Anderson	34	36	37	37	38	38
Angelina	42	42	43	43	43	43
Bowie	12	13	13	13	13	13
Camp	32	34	36	37	37	37
Cass	41	41	41	42	42	42
Cherokee	43	46	47	48	49	50
Franklin	15	16	17	18	18	18
Gregg	44	47	49	51	51	52
Harrison	20	21	22	22	22	22
Henderson	31	34	36	37	38	39
Hopkins	12	13	14	15	15	15
Houston	28	29	30	30	30	30
Marion	23	24	24	24	24	24
Morris	25	26	26	26	26	26
Nacogdoches	47	49	49	50	50	50
Panola	20	21	21	21	21	21
Rains	2	2	3	3	3	3
Rusk	45	48	51	52	53	54
Sabine	8	8	8	8	8	8
SanAugustine	17	17	17	17	17	17
Shelby	17	17	17	18	18	18
Smith	67	71	74	75	77	77
Titus	9	9	9	10	10	10
Trinity	26	27	27	27	27	27
Upshur	44	48	50	51	52	52
VanZandt	18	20	22	23	23	24
Wood	35	38	39	40	40	41

Please note that in many instances, drawdowns reach an equilibrium level and do not change in the last few decades. However, in many instances, drawdowns continue to increase throughout all decades, which means that equilibrium levels have not yet been achieved by 2080. As an example of this phenomenon, Figure 4 presents the annual average drawdown in the Carrio-Wilcox Aquifer for Anderson, Cherokee, and Houston counties.

Please note that an equilibrium level would be reached in Houston County by 2050 under the pumping conditions of Scenario 26.1. However, the Anderson County equilibrium level is not reached until 2070. Finally, an equilibrium level has not been reached by 2080 in Cherokee County. However, from 2040 to 2080, the average drawdown dropped by about one foot per decade.

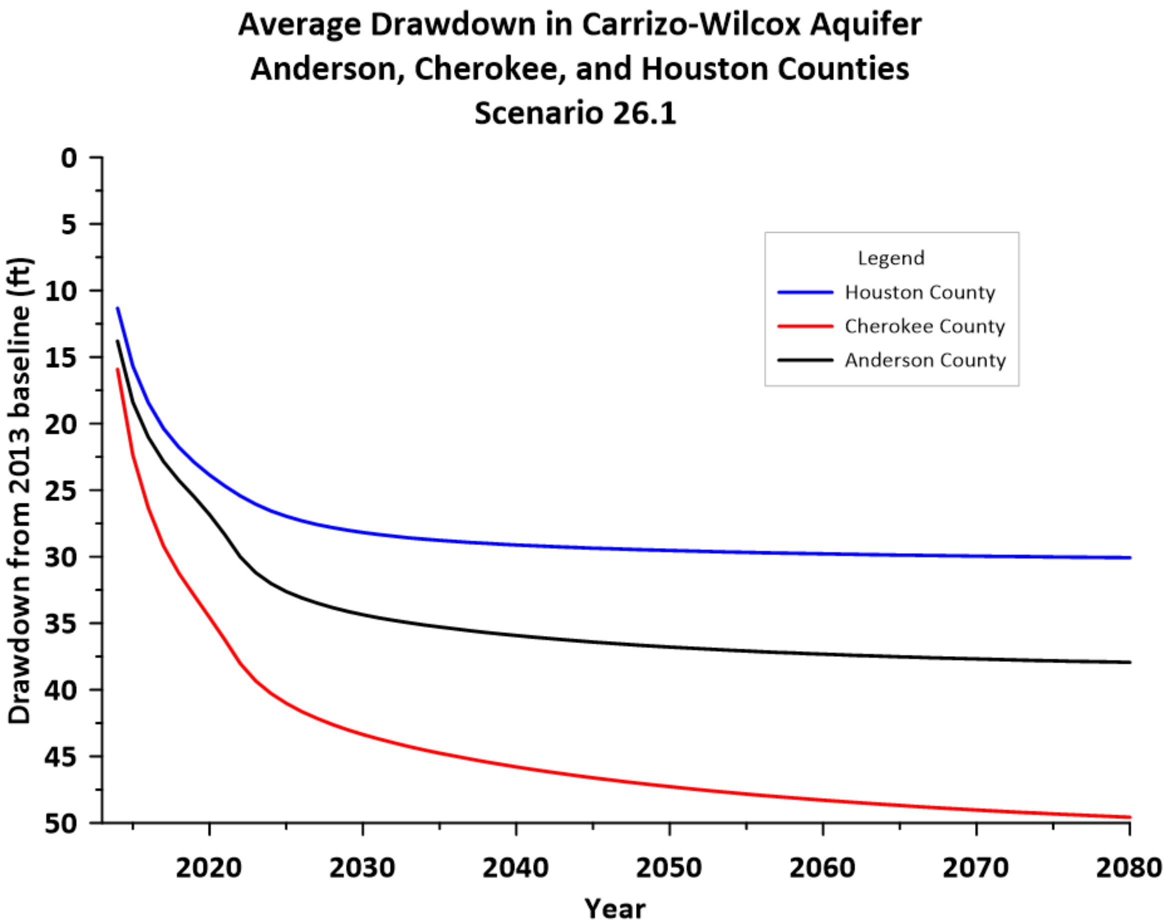


Figure 4 Hydrograph of Carrizo-Wilcox Average Drawdown for Selected Counties, Scenario 26.1

Table 20 presents a comparison of the 2080 county average drawdowns from Scenario 26.1 for the Carrizo-Wilcox Aquifer with the current DFCs and the average drawdowns from Scenario 33. As noted on the table, the current DFC and the average drawdown for Scenario 33 are slightly different. A minor difference is because the average drawdowns in Scenario 33 are from the updated GAM. A more significant difference is due to the fact that the current DFCs are not area-weighted averages and Scenario 33 (and Scenario 26.1) average drawdowns are area-weighted averages.

The current GAM has a variable sized grid. Thus, a non-weighted average would be an over representation of small cells and an under representation of large cells. The average drawdowns for Scenario 33 and 26.1 correct that limitation.

Table 20. Comparison of Current Carrizo-Wilcox DFC and 2080 Drawdown for Scenarios 33 and 26.1

County	Average Drawdown (ft) 2013 to 2080		
	Current DFC	Scenario 33	Scenario 26.1
Anderson	155	180	38
Angelina	67	65	43
Bowie	12	18	13
Camp	85	100	37
Cass	79	92	42
Cherokee	176	177	50
Franklin	102	120	18
Gregg	109	116	52
Harrison	26	36	22
Henderson	106	155	39
Hopkins	61	80	15
Houston	86	83	30
Marion	32	53	24
Morris	78	95	26
Nacogdoches	73	80	50
Panola	21	26	21
Rains	17	25	3
Rusk	86	96	54
Sabine	9	10	8
SanAugustine	22	24	17
Shelby	17	25	18
Smith	265	263	77
Titus	66	87	10
Trinity	56	54	27
Upshur	149	144	52
VanZandt	55	89	24
Wood	122	161	41

Notes:

Current DFC values are from original GAM and not area weighted averages

Scen 26.1 and Scen 33 is based the updated model and are area weighted averages

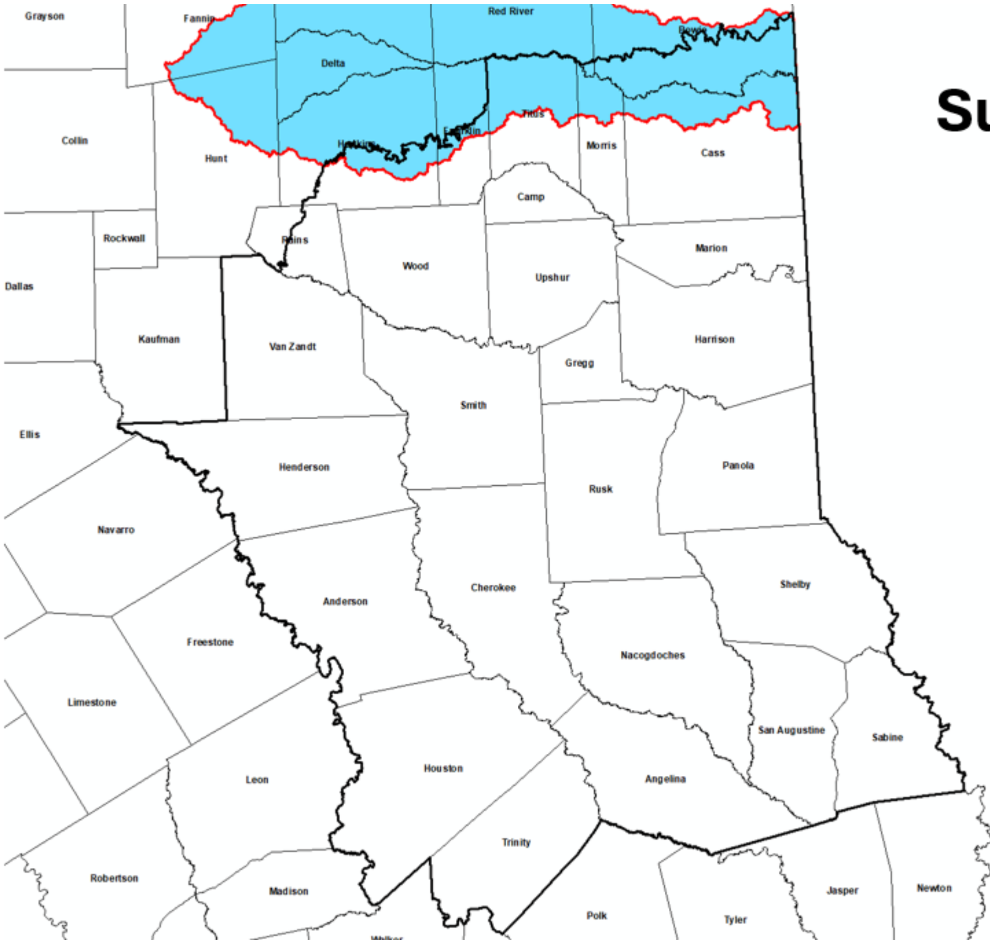
6.0 References

Hutchison, W.R, 2026. Documentation of Updated Specific Yield Values for the Groundwater Availability of Northern Portion of the Queen City, Sparta, and Carrizo-Wilcox Aquifers. GMA 11 Technical Memorandum 26-01, January 28, 2026, 9p.

Panday, S., Rumbaugh, J., Hutchison, W.R., Schorr, S., 2020. Numerical Model Report: Groundwater Availability Model for the Northern Portion of the Queen City, Sparta, and Carrizo-Wilcox Aquifers. Final Report prepared for Texas Water Development Board, Contact Number #1648302063. 198p.

Appendix A

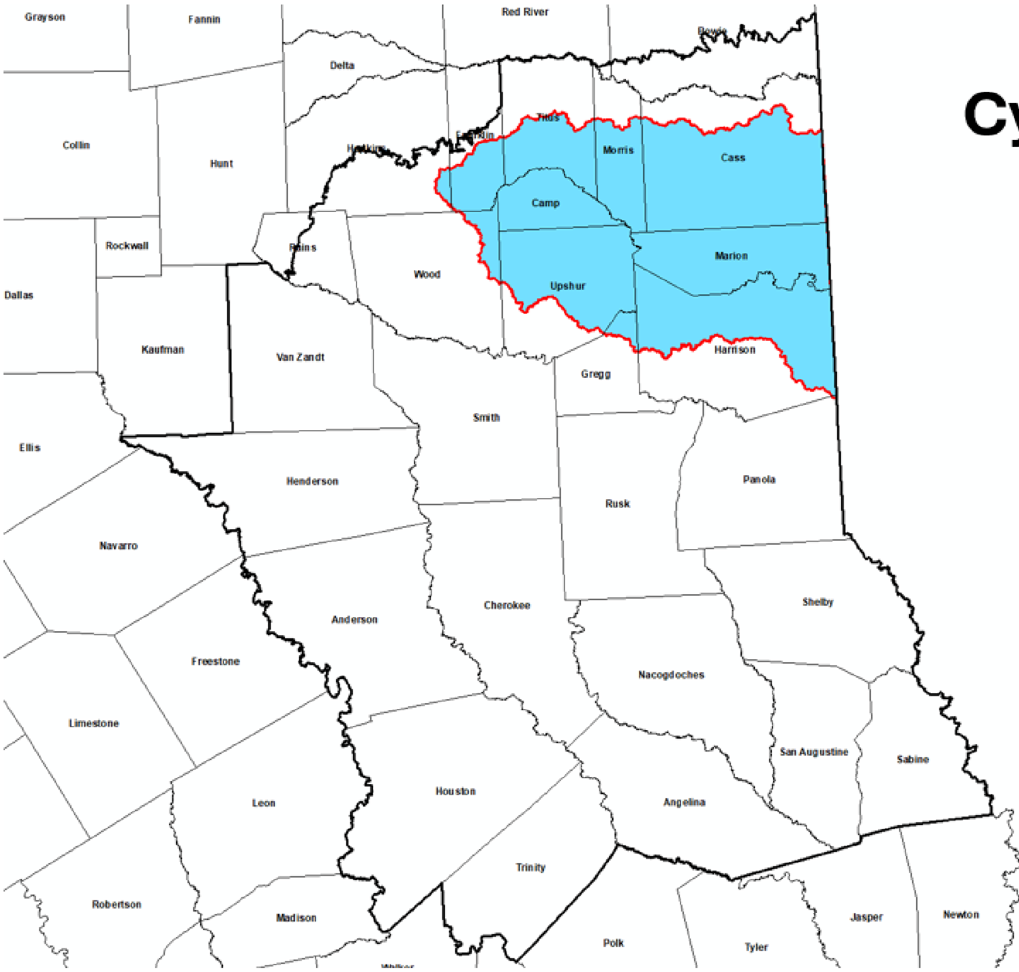
Groundwater Budgets for Five River Basins within GMA 11


Grayson
Fannin
Red River
Delta
Collin
Hunt
Morris
Cass
Camp
Rockwall
Rains
Wood
Marion
Dallas
Upshur
Kaufman
Van Zandt
Harrison
Gregg
Smith
Ellis
Henderson
Panola
Rusk
Navarro
Shelby
Cherokee
Anderson
Freestone
Nacogdoches
Limestone
San Augustine
Sabine
Houston
Leon
Angelina
Trinity
Robertson
Madison
Jasper
Newton
Polk
Tyler

Sulphur

Sulphur Basin Groundwater Budgets
All Values in AF/yr

		Baseline	Scenario 33 (Current DFC)	Scen QC1	Scenario 26.1
Inflow					
	Recharge	10,660	10,660	10,660	10,660
	Alluvium (Zone 1)	513	11,293	10,871	7,962
	Arkansas (Zone 198)	0	548	473	239
	Sabine (Zone 611)	109	227	230	11
	GMA 8 Sulphur (Zone 808	7	6	6	7
Total Inflow		11,289	22,735	22,240	18,879
Outflow					
	Pumping	5,478	15,806	15,337	12,598
	Evapotranspiration	3,821	1,111	1,496	2,359
	Arkansas (Zone 198)	471	0	0	0
	Cypress (Zone 311)	1,518	6,022	5,590	3,957
Total Outflow		11,288	22,939	22,423	18,914
Storage Change					
	Confined	0	-8	-7	-2
	Unconfined	1	-197	-175	-33
Total Storage Change		1	-205	-183	-35
Inflow - Outflow		1	-205	-183	-35
Model Error		0	0	0	0

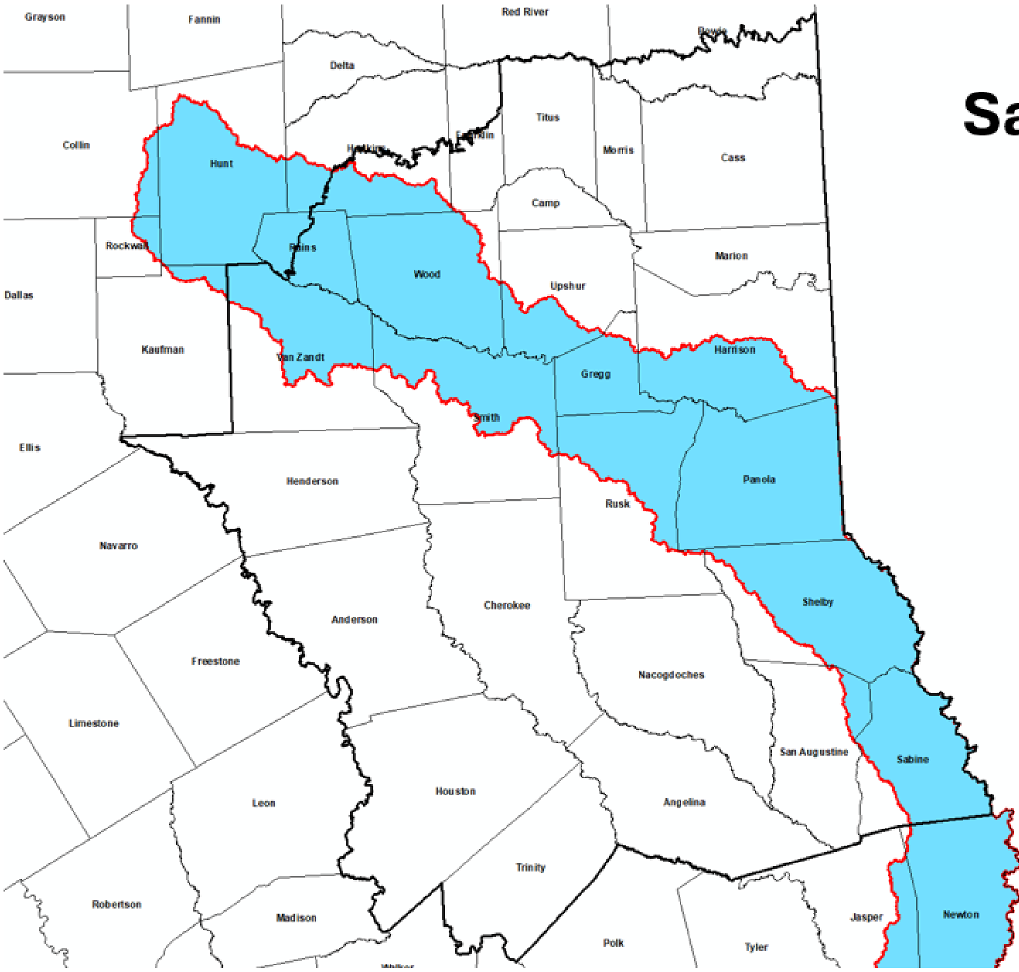

Grayson
Fannin
Red River
Delta
Titus
Collin
Hunt
Morris
Cass
Camp
Rockwall
Rains
Wood
Marion
Dallas
Upshur
Kaufman
Van Zandt
Harrison
Gregg
Smith
Ellis
Henderson
Panola
Rusk
Navarro
Cherokee
Shelby
Anderson
Freestone
Nacogdoches
Limestone
San Augustine
Sabine
Leon
Houston
Angelina
Trinity
Robertson
Madison
Jasper
Newton
Polk
Tyler

Cypress

Cypress Basin Groundwater Budgets
All Values in AF/yr

	Baseline	Scenario 33 (Current DFC)	Scenario QC1	Scenario 26.1
Inflow				
Recharge	48,254	48,254	48,254	48,254
Alluvium (Zone 1)	0	32,812	8,550	0
Arkansas (Zone 198)	0	1,135	704	197
Louisiana (Zone 499)	0	240	0	0
Sabine (Zone 611)	258	0	0	0
Sulphur (Zone 811)	1,518	6,022	5,590	3,957
Total Inflow	50,030	88,463	63,097	52,408
Outflow				
Pumping	14,611	81,967	47,953	33,612
Evapotranspiration	18,343	6,486	13,959	15,232
Alluvium (Zone 1)	15,897	0	0	2,582
Arkansas (Zone 198)	392	0	0	0
Louisiana (Zone 499)	789	0	40	368
Sabine (Zone 611)	0	1,373	1,729	780
Total Outflow	50,033	89,826	63,681	52,574
Storage Change				
Confined	0	-89	-64	-28
Unconfined	-4	-1,274	-520	-138
Total Storage Change	-4	-1,363	-584	-165
Inflow - Outflow	-3	-1,363	-584	-166
Model Error	-1	0	0	0

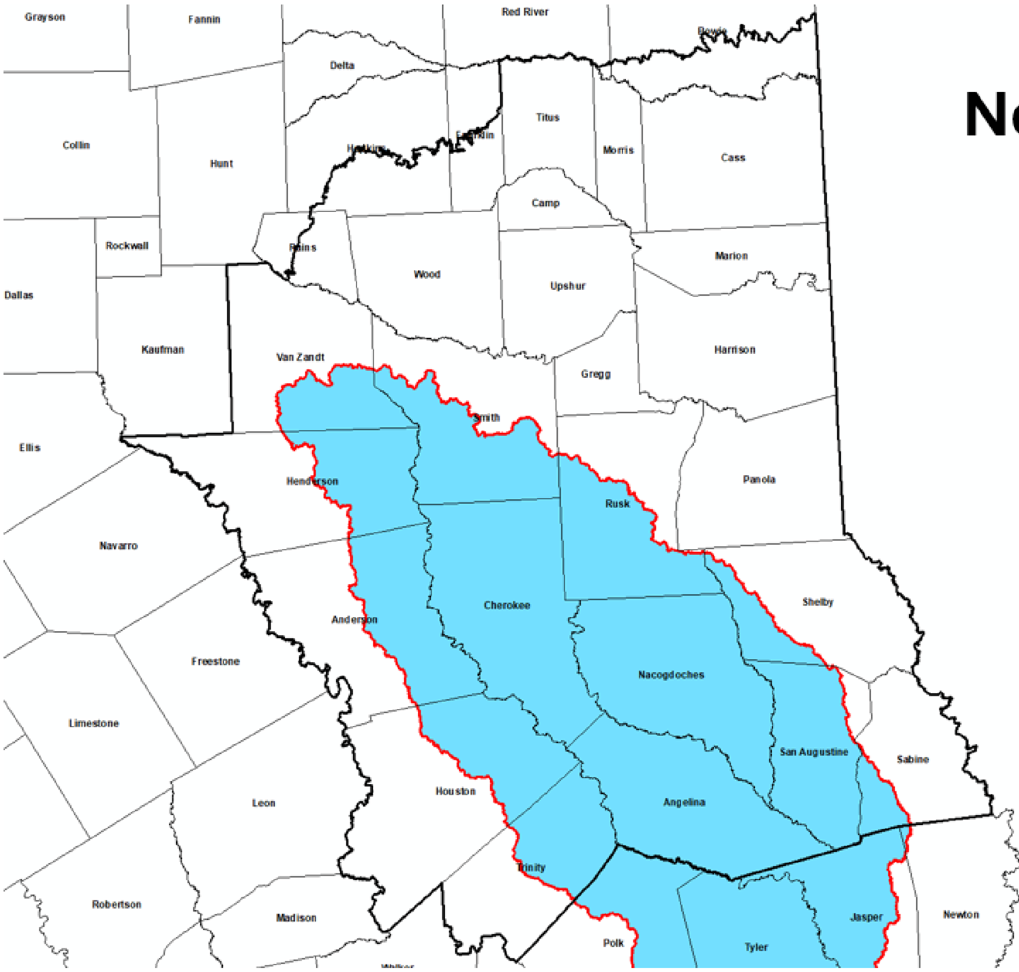
Sabine



Grayson
Fannin
Red River
Bowie
Delta
Titus
Collin
Franklin
Hopkins
Morris
Cass
Hunt
Camp
Rockwall
Rains
Wood
Marion
Dallas
Upshur
Kaufman
Harrison
Van Zandt
Gregg
Smith
Ellis
Henderson
Panola
Rusk
Navarro
Shelby
Anderson
Cherokee
Freestone
Nacogdoches
Limestone
San Augustine
Sabine
Leon
Houston
Angelina
Trinity
Robertson
Madison
Jasper
Newton
Polk
Tyler

Sabine Basin Groundwater Budgets
All Values in AF/yr

		Baseline	Scenario 33 (Current DFC)	Scenario QC1	Scenario 26.1
Inflow					
	Overlying Formations (GHB)	117	146	145	141
	Recharge	67,100	67,100	67,100	67,100
	Alluvium (Zone 1)	0	34,464	13,920	1,759
	Cypress (Zone 311)	0	1,373	1,729	780
	Louisiana (Zone 499)	588	1,159	1,148	1,057
	GMA 8 Sabine (Zone 608)	0	1	1	0
	Sabine (Zone 614)	216	292	292	290
	Trinity (Zone 911)	147	264	260	256
Total Inflow		68,168	104,799	84,595	71,382
Outflow					
	Pumping	28,411	87,048	64,142	51,554
	Evapotranspiration	18,873	10,814	12,906	14,543
	Alluvium (Zone 1)	16,327	0	0	0
	Cypress (Zone 311)	258	0	0	0
	Neches (Zone 511)	4,156	8,435	8,292	5,638
	GMA 14 Neches (Zone 511)	26	46	45	41
	Sulphur (Zone 811)	109	227	230	11
Total Outflow		68,160	106,570	85,615	71,787
Storage Change					
	Confined	2	-152	-122	-56
	Unconfined	6	-1,618	-897	-348
Total Storage Change		8	-1,771	-1,020	-405
Inflow - Outflow		8	-1,771	-1,020	-405
Model Error		0	0	0	0

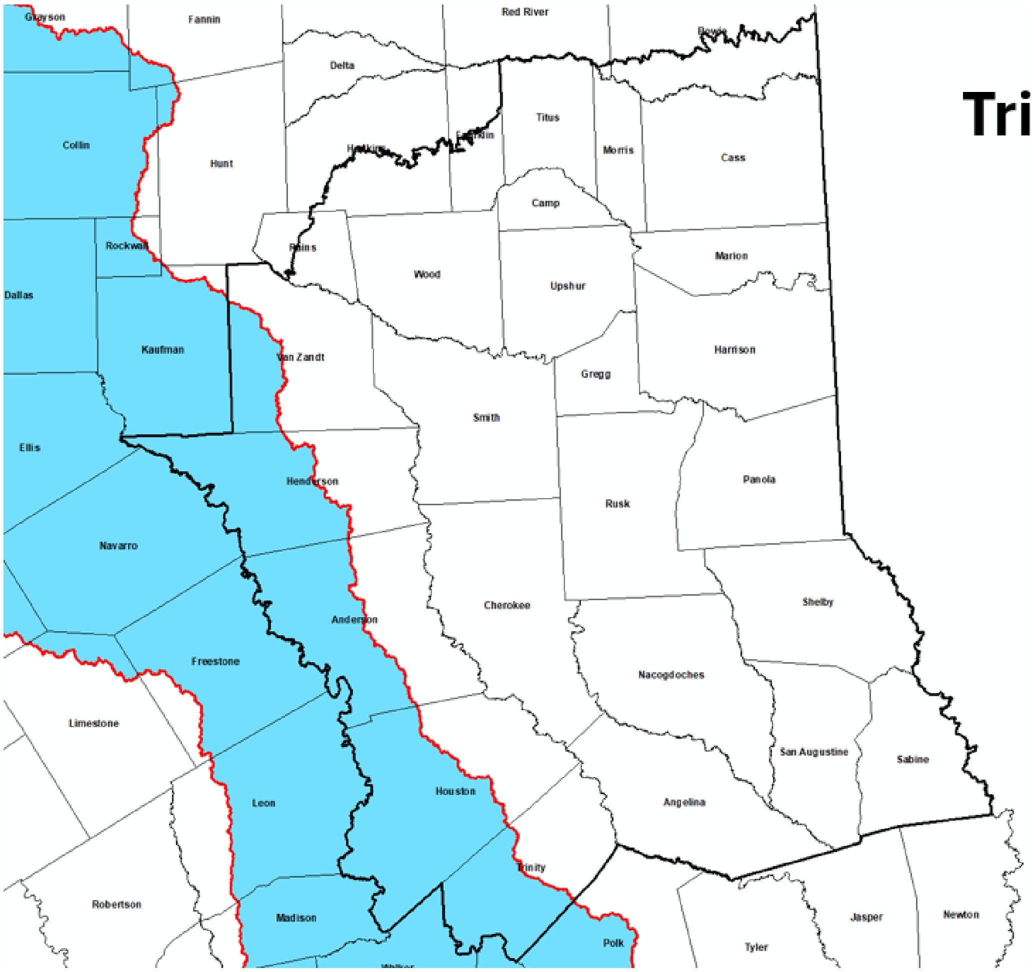

Grayson
Fannin
Red River
Bowie
Delta
Titus
Franklin
Hopkins
Collin
Hunt
Morris
Cass
Camp
Rockwall
Rains
Wood
Upshur
Marion
Dallas
Kaufman
Van Zandt
Harrison
Gregg
Smith
Ellis
Henderson
Panola
Rusk
Navarro
Cherokee
Shelby
Anderson
Freestone
Nacogdoches
Limestone
San Augustine
Sabine
Leon
Houston
Angelina
Trinity
Robertson
Madison
Jasper
Newton
Polk
Tyler

Neches

Neches Basin Groundwater Budgets
All Values in AF/yr

	Baseline	Scenario 33 (Current DFC)	Scenario QC1	Scenario 26.1
Inflow				
Overlying Fomations (GHB)	1,811	3,732	3,091	2,877
Recharge	89,945	89,945	89,945	89,945
Alluvium (Zone 1)	0	58,852	17,050	6,933
GMA 14 - Neches (Zone 514)	4,554	9,266	9,071	8,061
Sabine (Zone 611)	4,156	8,435	8,292	5,638
GMA 14 - Sabine (Zone 614)	2	2	2	2
Trinity (Zone 911)	4,731	23,671	22,336	11,765
Total Inflow	105,199	193,903	149,786	125,221
Outflow				
Pumping	69,405	183,651	130,962	102,959
Evapotranspiration	25,191	14,209	21,122	22,950
Alluvium (Zone 1)	10,590	0	0	0
Total Outflow	105,186	197,859	152,083	125,908
Storage Change				
Confined	11	-638	-547	-246
Unconfined	1	-3,318	-1,751	-441
Total Storage Change	12	-3,957	-2,298	-687
Inflow - Outflow	13	-3,957	-2,298	-687
Model Error	0	0	0	0

Trinity


Grayson
Fannin
Red River
Delta
Titus
Morris
Cass
Collin
Hunt
Camp
Rockwall
Rains
Wood
Upshur
Marion
Dallas
Kaufman
Van Zandt
Gregg
Harrison
Smith
Ellis
Henderson
Rusk
Panola
Navarro
Cherokee
Shelby
Anderson
Freestone
Nacogdoches
Limestone
San Augustine
Sabine
Leon
Houston
Angelina
Trinity
Robertson
Madison
Jasper
Newton
Polk
Tyler

Trinity Basin Groundwater Budgets
All Values in AF/yr

		Baseline	Scenario 33 (Current DFC)	Scenario QC1	Scenario 26.1
Inflow					
	Overlying Formations (GHB)	1,419	2,279	2,140	1,976
	Recharge	19,373	19,373	19,373	19,373
	Alluvium (Zone 1)	0	5,386	2,276	0
	GMA 12 Trinity (Zone 912)	5,480	12,935	12,478	7,330
	GMA 14 Trinity (Zone 914)	638	3,557	3,383	2,050
Total Inflow		26,910	43,531	39,650	30,729
Outflow					
	Pumping	8,888	16,593	11,961	8,016
	Evapotranspiration	7,373	3,618	5,536	6,577
	Alluvium (Zone 1)	5,770	0	0	4,212
	Neches (Zone 511)	4,731	23,671	22,336	11,765
	Sabine (Zone 611)	147	264	260	256
Total Outflow		26,908	44,146	40,093	30,827
Storage Change					
	Confined	2	-156	-141	-48
	Unconfined	-1	-459	-302	-50
Total Storage Change		1	-615	-442	-98
Inflow - Outflow		2	-615	-442	-98
Model Error		0	0	0	0