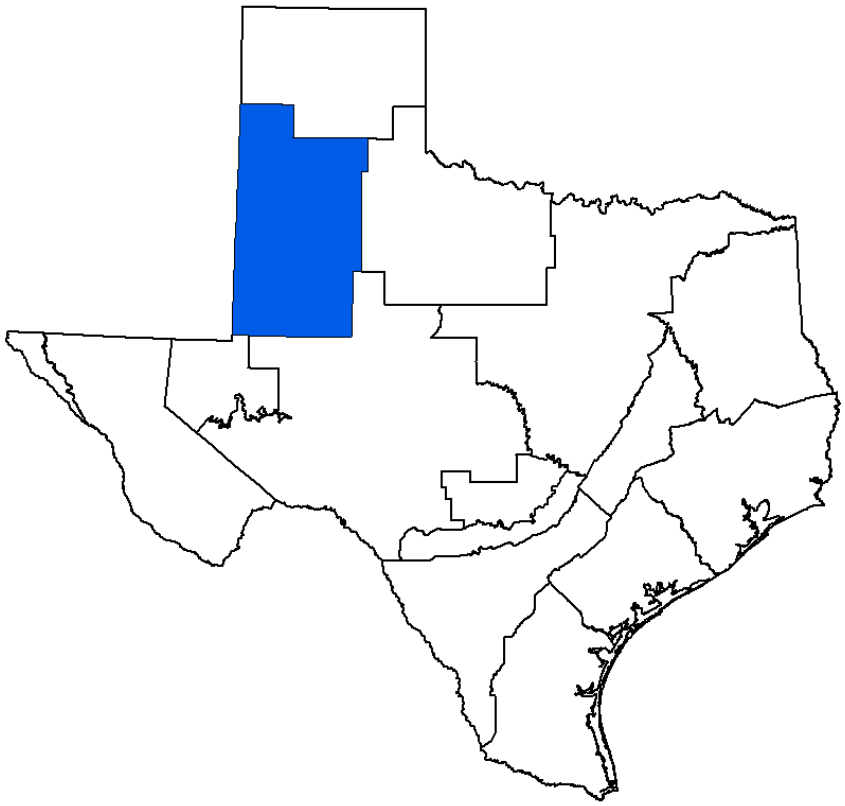
# Preliminary Explanatory Report
# For Proposed Desired Future Conditions (Draft 2)
# Ogallala, Edwards-Trinity (High Plains), and Dockum Aquifers
# Groundwater Management Area 2



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# 1.0 Groundwater Management Area 2

Groundwater Management Area 2 is one of sixteen groundwater management areas in Texas, and covers a large portion of the southern plains portion of west Texas (Figure 1).

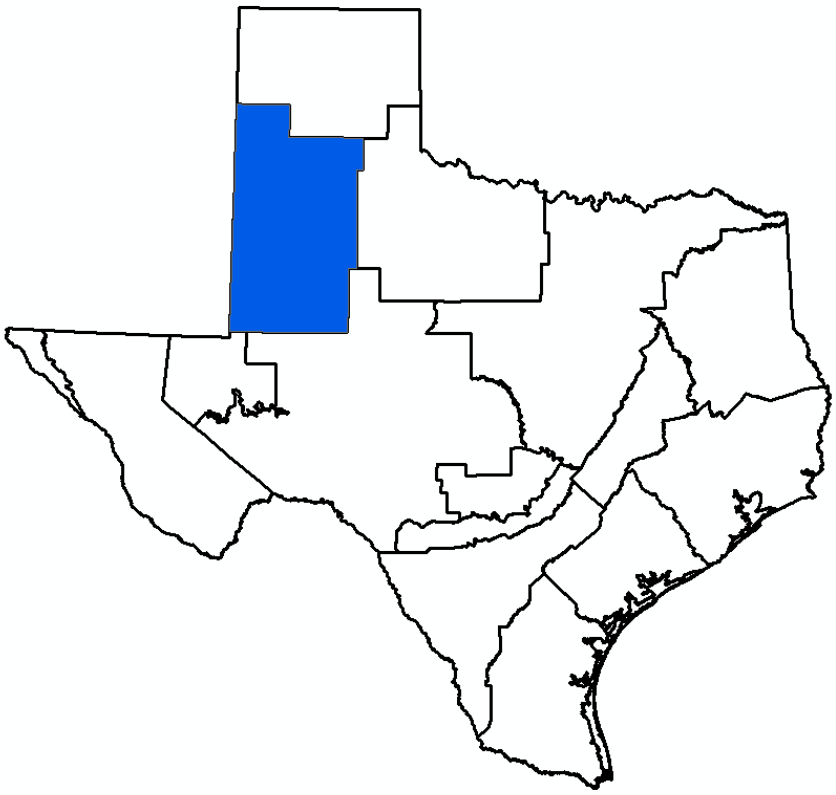

**Figure 1. Groundwater Management Area 2**

Groundwater Management Area 2 covers all or part of the following counties: Andrews, Bailey, Borden, Briscoe, Castro, Cochran, Crosby, Dawson, Deaf Smith, Floyd, Gaines, Garza, Hale, Hockley, Howard, Lamb, Lubbock, Lynn, Martin, Parmer, Swisher, Terry, and Yoakum (Figure 2).

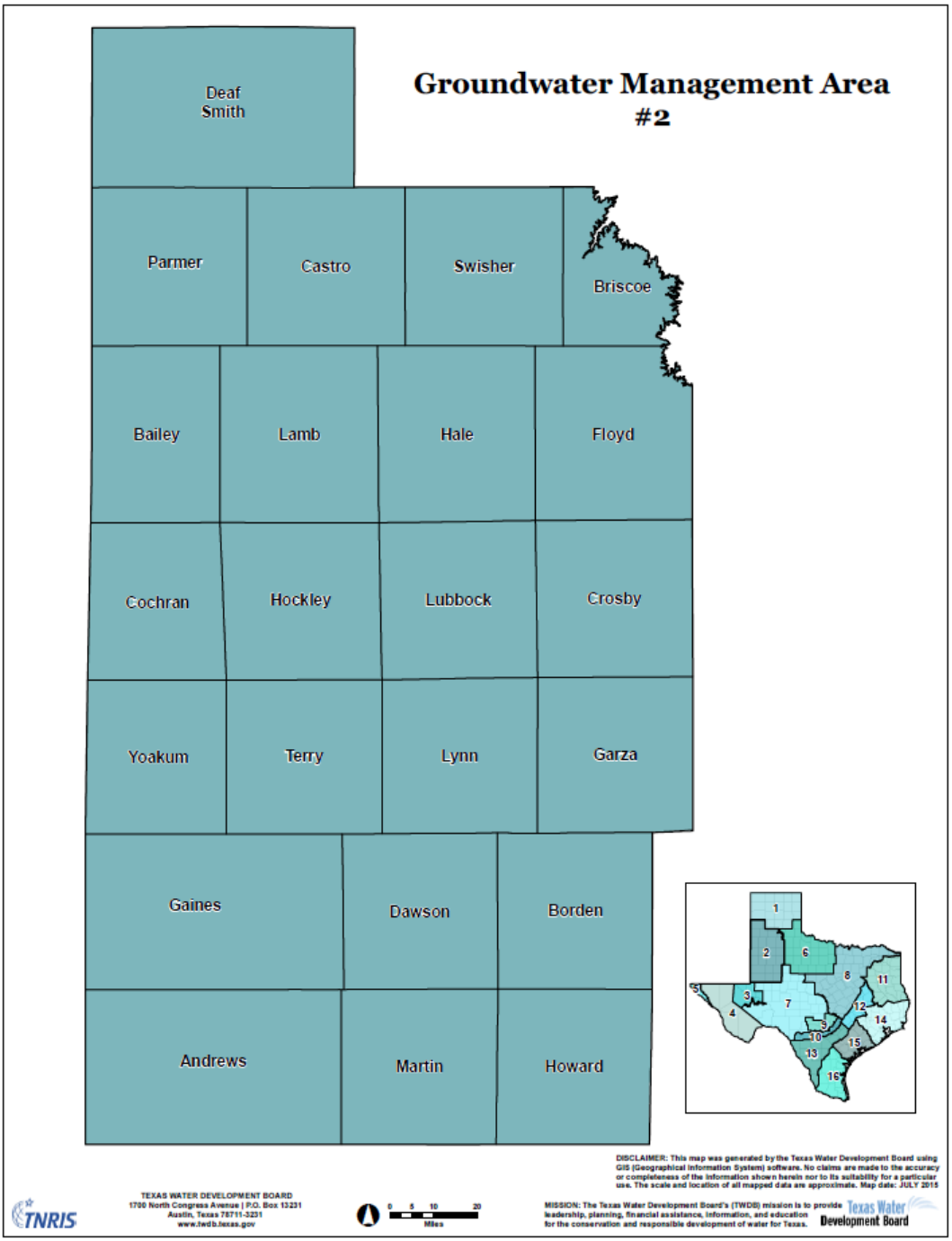


**Figure 2. GMA 2 Counties (from TWDB)**

There are seven groundwater conservation districts in Groundwater Management Area 2: Garza UWCD, High Plains UWCD No. 1, Llano Estacado UWCD, Mesa UWCD, Permian Basin, UWCD, Sandy Land UWCD, and South Plains UWCD.

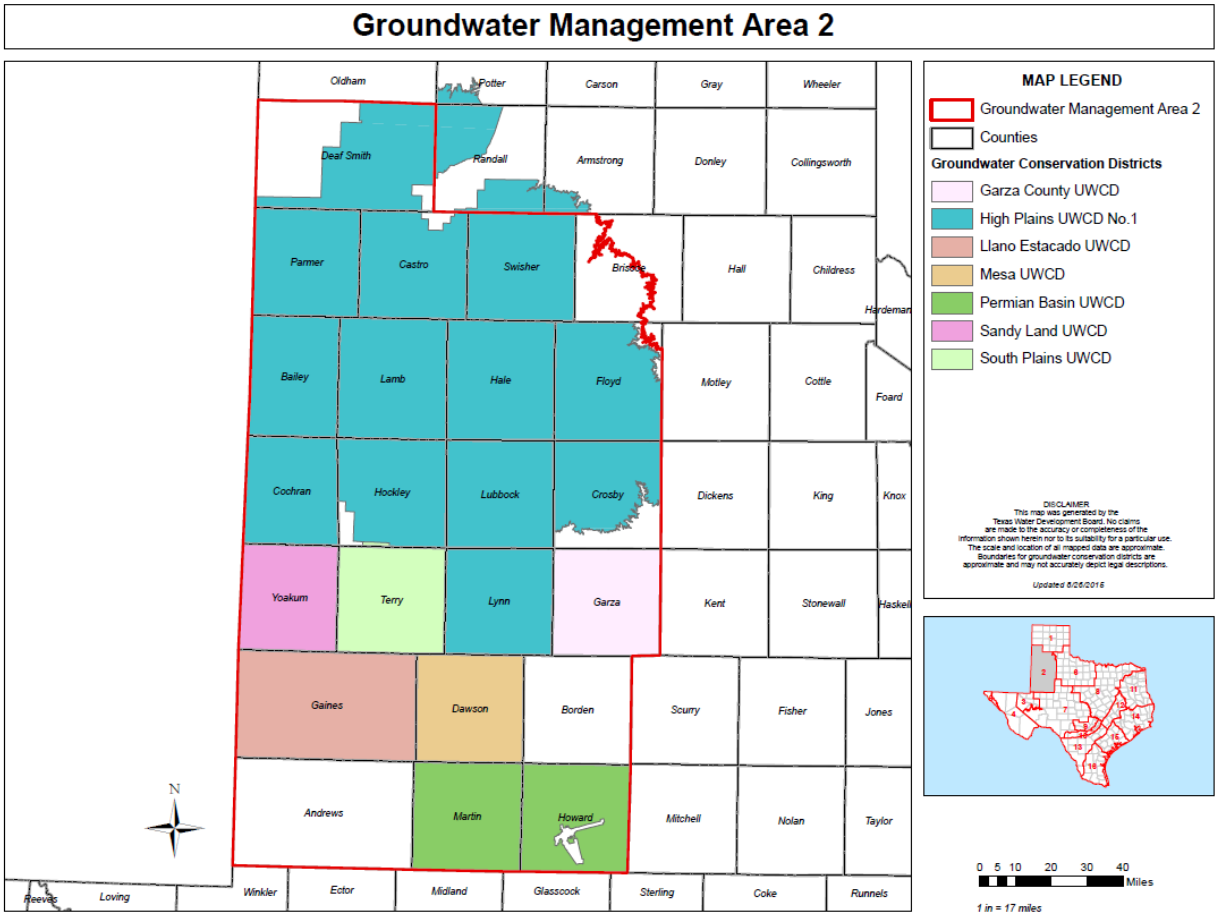


**Figure 3. Groundwater Conservation Districts in GMA 2 (from TWDB)**

# 2.0 Proposed Desired Future Condition

For this preliminary explanatory report, this section covers the proposed DFC. This report is intended to be a resource document for the public comment period that follows the adoption of a proposed DFC. Once final DFCs are adopted, the explanatory report will be updated, finalized and submitted to TWDB.

## 2.1 Background

In GMA 2, the Ogallala Aquifer and the underlying Edwards-Trinity (High Plains) Aquifer are managed together. Historic pumping has caused groundwater level declines to the point that individual well pumping rates in many areas of the Ogallala Aquifer have been reduced. In the future, pumping is expected to continue primarily for irrigation, and pumping rates will continue to decline as groundwater levels drop further. Water conservation techniques and irrigation technologies have advanced over the years, and are expected to improve in the future to mitigate the economic effects of lower well production.

In GMA 2, groundwater from the Dockum Aquifer has been pumped to relatively small amounts, largely due to poor water quality. However, increased pumping from the Dockum Aquifer is expected in the future as envisioned in the 2016 Region O Plan.

The Texas Water Code and the Texas Water Development Board require that desired future conditions be a quantified condition of the aquifer in the future. The desired future condition cannot be expressed in terms of how much can be pumped from an aquifer. In GMA 2, the continued declines in groundwater levels in the Ogallala Aquifer will result in reductions in pumping rates. Thus, the drawdown that will occur in the future and the pumping rates that will decline in the future are linked.

Once a desired future condition is adopted by the groundwater conservation districts in GMA 2, the Texas Water Development Board will use the new groundwater availability model to estimate the pumping that will achieve the desired future condition, or the modeled available groundwater (MAG).

## 2.2 2010 Desired Future Conditions

In 2010, GMA 2 adopted desired future conditions for the Ogallala and Edwards-Trinity (High Plains) aquifers that reflected the concept of managed decline of groundwater levels. In the High Plains UWCD area, the DFC was 50 percent of storage remaining after 50 years (50/50), and in the other areas of GMA 2, the DFC was expressed as a decadal decline rate. In the High Plains UWCD area, pumping was adjusted in the GAM simulations to hit 50 percent storage remaining in each county of the district. Although this approach treated every county within the district equally, it ignored the inherent variability of the aquifer in terms of saturated thickness and hydraulic conductivity. Future pumping in some counties was reduced to match the 50/50 goal,

while other counties had artificial increases in pumping above historic amounts simply to reach the 50/50 goal.

The adopted DFC could be viewed as somewhat arbitrary in that a specific reduction in groundwater levels was selected without the ability to fully understand the relationship between declining groundwater levels and reduced pumping rates. The decision to adopt these DFCs was, to a degree, based on the limitations of the Groundwater Availability Model that was then used. The DFC was also based on a concept where equality in outcome was a higher consideration than a management approach that first considered the hydraulic characteristics of the aquifer, the hydraulics of pumping wells in an unconfined aquifer where groundwater levels are dropping, and the associated economics of pumping groundwater for irrigation in an area where groundwater levels are dropping.

## 2.3 Proposed Desired Future Conditions

### *2.3.1 Ogallala and Edwards-Trinity (High Plains)*

The proposed desired future condition for the Ogallala and Edwards-Trinity (High Plains) aquifers is average drawdown of between 23 and 27 feet for all of GMA 2. The drawdown is calculated from the end of 2012 conditions to the year 2070.

The drawdown is expressed as a range due to the link between future pumping and future rainfall. As documented in GMA 2 Technical Memorandum 15-01 and GMA 2 Technical Memorandum 16-01, historic pumping is higher in dry years than in wet years. Since most of the water use in GMA 2 from the Ogallala Aquifer is for irrigation, producers pump more groundwater in dry years than in normal or wet years. The simulations assumed that initial pumping rates in the future would be between 100 percent and 150 percent of 2012 pumping rates. Essentially, in average or wet years, initial annual pumping would be approximately the same as 2012 pumping rates. In dry years, initial annual pumping rates could be as high as 150 percent of 2012 pumping rates based on the variation of pumping rates in the recent past.

Figure 4 presents the pumping results from the simulation for Scenario 8 from GMA 2 Technical Memorandum 15-01, and Scenario 16 from GMA 2 Technical Memorandum 16-01, and Figure 5 presents the drawdown associated with Scenarios 8 and 16. Scenario 8 assumes initial future pumping rates are 100 percent of 2012 pumping rates (average and wet conditions), and Scenario 10 assumes initial future pumping rates are 150 percent of 2012 pumping rates (dry conditions). Please note that by about 2045, the total pumping is expected to be about the same.

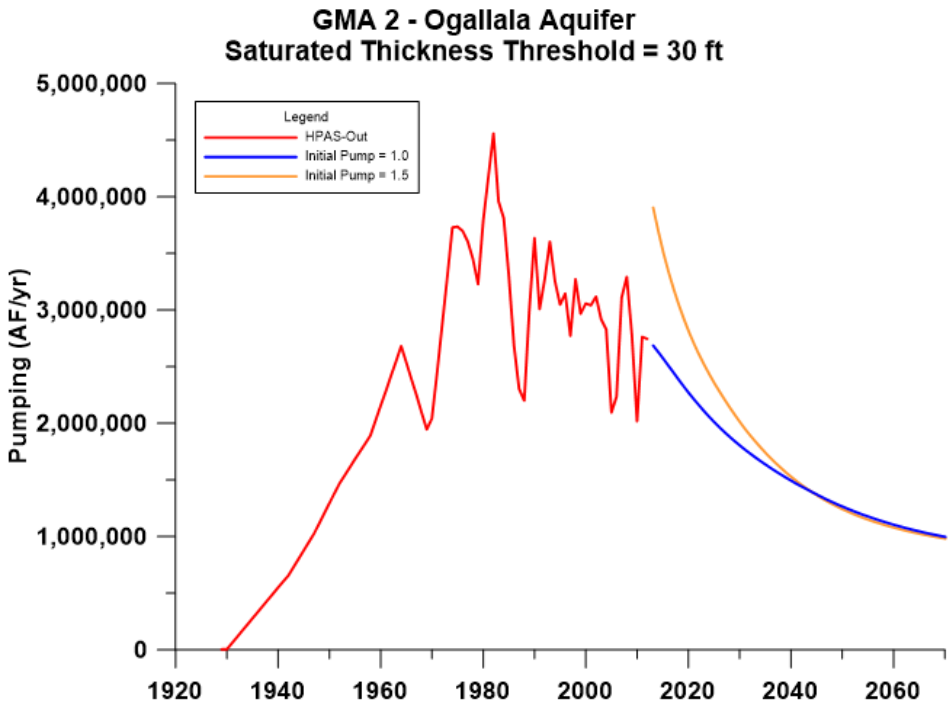


**Figure 4. Historic and Simulated Future Pumping – Ogallala and Edwards-Trinity (High Plains) Aquifers in GMA 2**

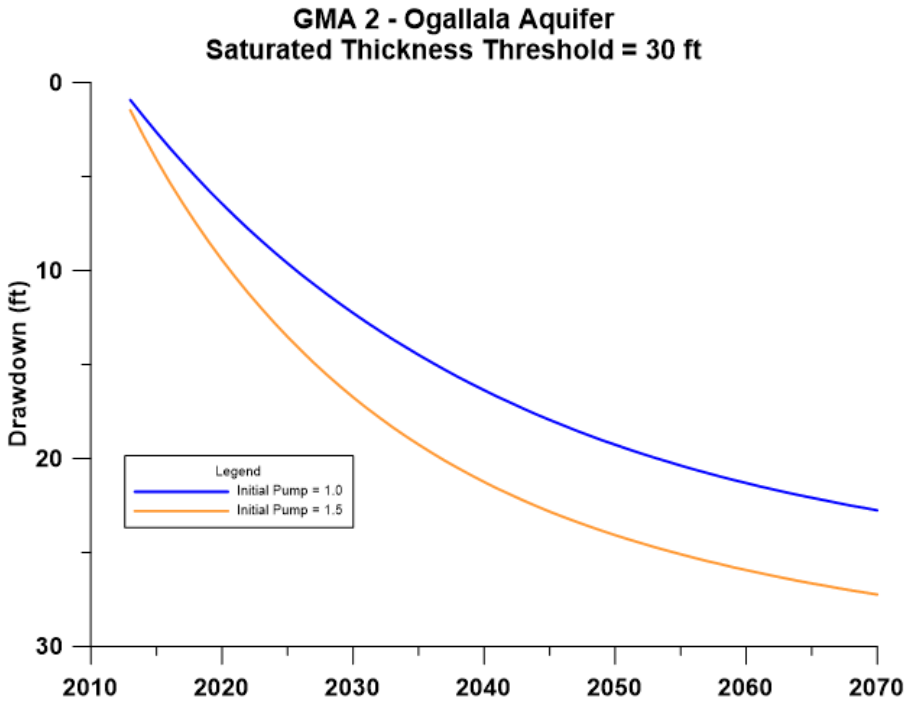


**Figure 5. Simulated Average Drawdown – Ogallala and Edwards-Trinity (High Plains) Aquifers in GMA 2**

### *2.3.2 Dockum Aquifer*

The proposed desired future condition for the Dockum Aquifer is average drawdown of 27 feet for all of GMA 2. The drawdown is calculated from the end of 2012 conditions to the year 2070, and is based on Scenario 16 as documented in GMA 2 Technical Memorandum 16-01.

The average drawdown was calculated over the entire extent of the modeled area (not just the official aquifer boundary as defined by TWDB). Much of the area of the Dockum Aquifer in GMA 2 is brackish groundwater with salinity of over 3,000 mg/l total dissolved solids. Typically, TWDB does not recognize these areas as part of the official aquifer boundary. However, the groundwater conservation districts in GMA 2 have included these areas and expect that this resource will be developed in the future.

Historic and simulated future pumping from the Dockum Aquifer is presented in Figure 6, and the simulated drawdown associated with the simulated future pumping is presented in Figure 7.

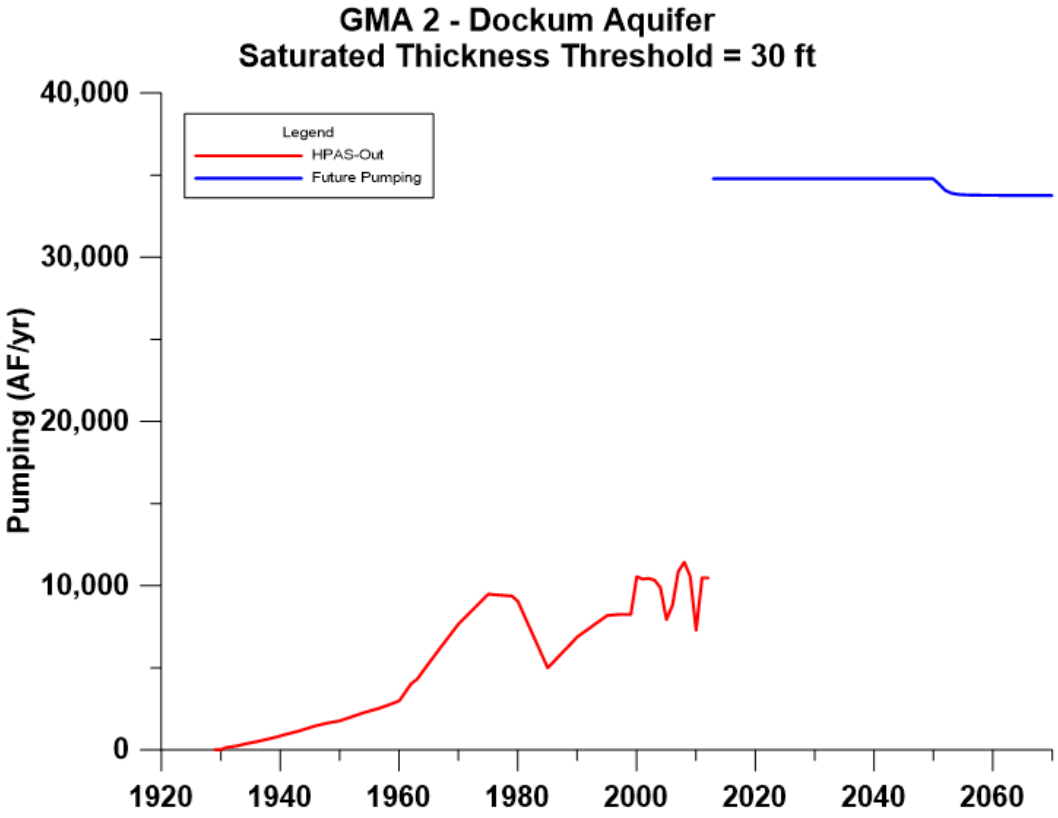


**Figure 6. Historic and Simulated Future Pumping - Dockum Aquifer in GMA 2**

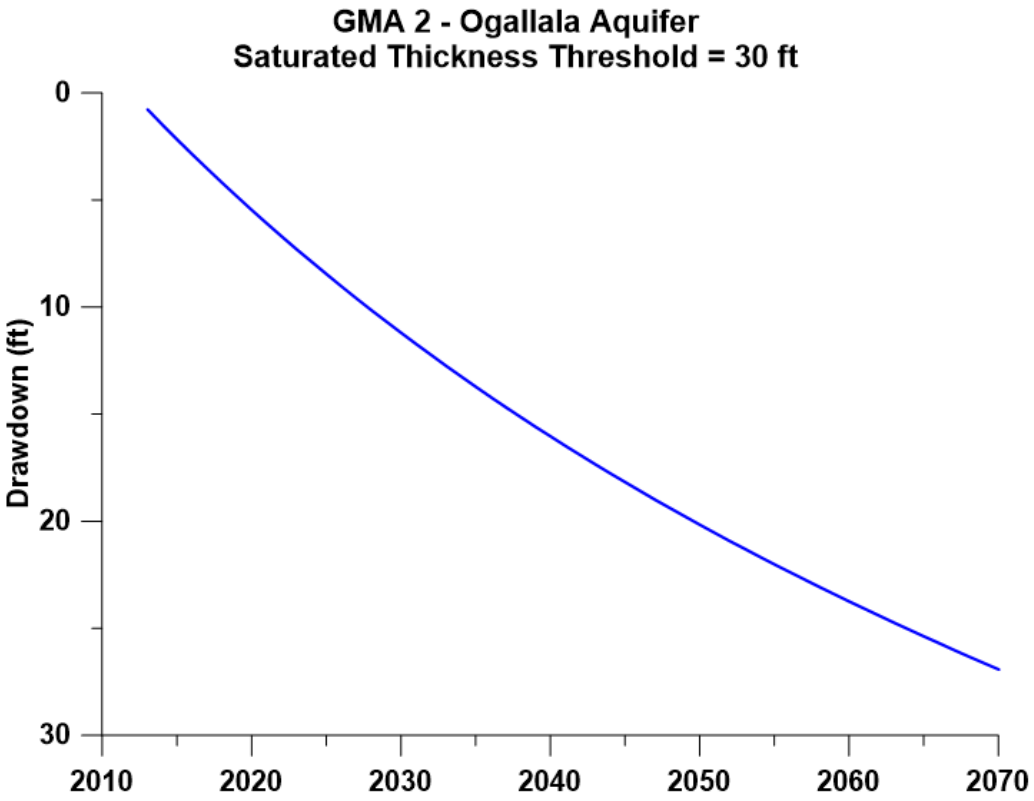


**Figure 7. Simulated Average Drawdown - Dockum Aquifer in GMA 2**

# 3.0 Policy Justification

As developed more fully in this report, the proposed desired future condition was adopted after considering:

- Aquifer uses and conditions within Groundwater Management Area 2
- Water supply needs and water management strategies included in the 2012 State Water Plan
- Hydrologic conditions within Groundwater Management Area 2 including total estimated recoverable storage, average annual recharge, inflows, and discharge
- Other environmental impacts, including spring flow and other interactions between groundwater and surface water
- The impact on subsidence
- Socioeconomic impacts reasonably expected to occur
- The impact on the interests and rights in private property, including ownership and the rights of landowners and their lessees and assigns in Groundwater Management Area 2 in groundwater as recognized under Texas Water Code Section 36.002
- The feasibility of achieving the desired future condition
- Other information

In addition, the proposed desired future condition provides a balance between the highest practicable level of groundwater production and the conservation, preservation, protection, recharging, and prevention of water of groundwater in Groundwater Management Area 2.

As discussed earlier, the DFC that was adopted for the High Plains UWCD area of GMA 2 for the Ogallala Aquifer in 2010 was based on a concept where equality in outcome was emphasized more than a management approach that considered the hydraulic characteristics of the aquifer, the hydraulics of pumping wells in an unconfined aquifer where groundwater levels are dropping, and the associated economics of pumping groundwater for irrigation in an area where groundwater levels are dropping. The proposed DFC that is described in this explanatory report puts more emphasis on aquifer hydraulics, economics, and property rights than were considered before, at least in High Plains UWCD area of GMA 2 for the Ogallala Aquifer.

# 4.0 Technical Justification

The proposed desired future conditions were developed based, in part, on simulations of alternative scenarios of future pumping using the new Groundwater Availability Model (GAM) of the Ogallala, Edwards-Trinity (High Plains) and Dockum aquifers (Deeds and Jigmond, 2015). This model utilizes a recently released finite-difference code by the US Geological Survey that dynamically simulates the effect of declining groundwater levels on well production rates. Consequently, this model was used to evaluate the expected pumping rate declines in GMA 2 in the future under a wide variety of alternatives.

The new Groundwater Availability Model report was released in August 2015 (Deeds and Jigmond, 2015), and the files were made available by the TWDB in November 2015. GMA 2 completed 15 alternative simulations to understand the relationship between declining groundwater levels and reduced pumping rates. This analysis was documented in three technical memoranda (Hutchison, 2015a, 2015b, and 2015c). Based on the review of the results of Scenario 1 to 15, GMA 2 directed that a final simulation be completed (Scenario 16) as follows:

- GMA 2 requested that initial (beginning of 2013) Ogallala pumping be set to 150 percent of 2012 pumping and set the saturated thickness threshold to 30 feet to be consistent with the value used during the calibration period of the model. This essentially corresponds to the approach taken in Scenario 10 in GMA 2 Technical Memorandum 15-01. GMA 2 representatives also asked that results from the Ogallala and Edwards-Trinity (High Plains) aquifers be combined. This corresponds to layers 1 and 2 of the GAM in GMA 2. The DFC that was adopted for GMA 2 in 2010 combines the two aquifers, and the aquifers are managed as a single unit.

- Initial (2013) pumping for the Edwards-Trinity (High Plains) was set to either 150 percent of 2012 pumping or on the historic maximum depending on county. Scenarios 10 used a consistent 150 percent of 2012 pumping, but historic pumping was higher in earlier years. GMA 2 representatives requested that pumping in those counties correspond to the historic maximum.

- Pumping in the Dockum Aquifer was also set to either 150 percent of 2012 pumping or historic maximum. In addition, areas with no historic pumping were assigned pumping. These counties typically fall outside the official TWDB boundaries of the Dockum Aquifer, but were included in the model.

The results for Scenario 16 are documented in Hutchison (2016). In reality, pumping withdrawals vary according to rainfall. This is observed in the model calibration plots, where cyclical patterns of withdrawal are evident. The range of expected pumping in the developed of the desired future condition accounts for uncertainty and timing of drought periods.

As discussed in the documentation for Scenario 16, development of DFCs on a county scale based on the GAM is inappropriate based on a review of the results for several counties. The GAM provides reasonable results on a regional scale (i.e. GMA 2). Thus, the limitations of the GAM were used and acknowledged in the development of these proposed DFCs.

# 5.0 Factor Consideration

Section 36.108(d) of the Texas Water Code requires that groundwater conservation districts include documentation of how nine listed factors were considered prior to proposing a desired future condition, and how the proposed desired future condition impact each factor. This section of the explanatory report summarizes the information that the groundwater conservation districts used in its deliberations and discussions.

## 5.1 Aquifer Uses and Conditions

For the purposes of the development of a proposed desired future condition, the groundwater conservation districts in Groundwater Management Area 2 considered the following in the category of aquifer uses (i.e. pumping):

- Estimates of 1930 to 2012 input and output pumping from the GAM (Deeds and Jigmond, 2015)
- Estimates of pumping from 1980 and 1984 to 2013 from the TWDB groundwater pumping database
- Current modeled available groundwater for 2010 to 2060
- Estimates of pumping from the initial predictive simulation that was completed for GMA 1 as part of the contract to develop the GAM for 2013 to 2070

These estimates were summarized, presented and discussed at the April 29, 2015 meeting of GMA 2. The estimates associated with the GAM (historic and future) were based on the preliminary model, and much of the discussion was preparing comments for the draft model.

The discussion of these estimates also included comparing the historic pumping to the current modeled available groundwater, and how the new GAM was capable of better simulating the expected continued declines in pumping rates associated with declining groundwater levels in the Ogallala Aquifer. Finally, the discussion reviewed the inherent problems of establishing a 50/50 DFC given the historic aquifer uses, expected future uses, and aquifer conditions across GMA 2.

The presentation that was used during the April 29, 2015 meeting is included in this explanatory report as Appendix A.

## 5.2 Water Supply Needs and Water Management Strategies

The 2016 Region O Plan lists recommended water management strategies, some of which are for local groundwater development. The underlying basis for the proposed DFC is that pumping in the Ogallala Aquifer would increase to 150 percent of estimated 2012 pumping in 2013. The elevated level of 2012 pumping represents a scenario of increased usage during drought conditions. Future reductions in pumping through 2070 would be as a result of declining groundwater levels and the associated change in the hydraulics of pumping wells.

The recommended strategies are generally relatively small amounts of increased groundwater pumping in the Ogallala of up to about 2,600 AF/yr (most are a few hundred acre-feet per year). The Ogallala DFC is consistent with these strategies.

The recommended strategies also include the development of brackish groundwater. The Dockum DFC explicitly included increased pumping for the Dockum to accommodate these strategies, including areas of the Dockum that are not currently within the official boundaries of the Dockum Aquifer (as defined by TWDB) due to poor water quality.

## 5.3 Hydrologic Conditions within Groundwater Management Area 2

As required by statute, the groundwater conservation districts in Groundwater Management Area 2 considered total estimated recoverable storage, average annual recharge, inflows, and discharge prior to adopting a proposed desired future condition.

### *5.3.1 Total Estimated Recoverable Storage (TERS)*

As required by statute, the Texas Water Development Board provided the groundwater conservation districts in Groundwater Management Area 2 with estimates of total recoverable storage (Kohlrenken and others, 2013). The report is included as Appendix B.

The TWDB storage estimates were developed based on the hydrogeologic framework and aquifer parameters of the old GAMs. The release of the new GAM (Deeds and Jigmond, 2015) postdated the report. In working with storage volumes in the simulation results, the new GAM was used.

It is also noteworthy that the TERS estimates were taken from the last year of model calibration. For the Ogallala and Edwards-Trinity (High Plains), the TERS calculation was year 2000. The Dockum TERS estimates are based on 1997 data.

### *5.3.2 Average Annual Recharge, Inflows and Discharge*

The average groundwater budget for Groundwater Management Area 2 for the Ogallala and Edwards-Trinity (High Plains) aquifers based on the calibrated GAM (Deeds and Jigmond, 2015) for the historic period 1930 to 2012 alongside the groundwater budget for the proposed DFC from 2013 to 2070 is summarized in Table 1.

The average groundwater budget for Groundwater Management Area 2 for the Dockum Aquifer based on the calibrated GAM (Deeds and Jigmond, 2015) for the historic period 1930 to 2012 alongside the groundwater budget for the proposed DFC from 2013 to 2070 is summarized in Table 2.

Time-series plots of each component of the water budget for all years are presented in Hutchison (2016), the documentation for Scenario 16 upon which the DFCs are based. These graphs provide context to the changes in each component over time and as a result of changes to pumping.

## Table 1. Groundwater Budget for the Ogallala and Edwards-Trinity (High Plains) Aquifers in Groundwater Management Area 2

| Inflow Component | 1930 to 2012 Average Flow (AF/yr) | 2013 to 2070 Average Flow Under the Proposed DFC (AF/yr) |
|---|---|---|
| Recharge from Precipitation | 334,028 | 679,308 |
| Inflow from Surface Water | 48,907 | 94,752 |
| Inflow from New Mexico | 9,261 | 12,385 |
| Inflow from GMA 1 | | 2,283 |
| Inflow from GMA 6 | | 491 |
| Vertical Inflow from Dockum | | 10,959 |
| Total Inflow | 392,196 | 800,178 |

| Outflow Component | 1930 to 2012 Average Flow (AF/yr) | 2013 to 2070 Average Flow Under the Proposed DFC (AF/yr) |
|---|---|---|
| Pumping | 2,234,585 | 1,794,502 |
| Springs | 53,678 | 34,857 |
| Evapotranspiration | 17,022 | 8,832 |
| Outflow to GMA 1 | 9,907 | |
| Outflow to GMA 3 | 210 | 208 |
| Outflow to GMA 6 | 4,504 | |
| Outflow to GMA 7 | 1,757 | 2,432 |
| Vertical Outflow to Dockum | 3,955 | |
| Total Outflow | 2,325,618 | 1,840,832 |

| | | |
|---|---|---|
| Inflow - Outflow | -1,933,421 | -1,040,654 |
| Storage Change from Model | -1,933,422 | -1,040,654 |
| Model Error | 1 | 0 |

## Table 2. Groundwater Budget for the Dockum Aquifer in Groundwater Management Area 2

| Inflow Component | 1930 to 2012 Average Flow (AF/yr) | 2013 to 2070 Average Flow (AF/yr) |
|---|---|---|
| Recharge from Precipitation | 14,097 | 19,982 |
| Vertical Inflow from Ogallala | 3,955 | |
| Total Inflow | 18,052 | 19,982 |

| Outflow Component | 1930 to 2012 Average Flow (AF/yr) | 2013 to 2070 Average Flow (AF/yr) |
|---|---|---|
| Pumping | 5,442 | 34,485 |
| Springs | 4,337 | 4,774 |
| Discharge to Surface Water | 12,612 | 14,830 |
| Evapotranspiration | 6,307 | 7,293 |
| Outflow to New Mexico | 258 | 289 |
| Outflow to GMA 1 | 1,817 | 1,848 |
| Outflow to GMA 3 | 64 | 65 |
| Outflow to GMA 6 | 1,447 | 1,031 |
| Outflow to GMA 7 | 640 | 673 |
| Vertical Outflow to Ogallala | | 10,959 |
| Total Outflow | 32,924 | 76,249 |

| | | |
|---|---|---|
| Inflow - Outflow | -14,872 | -56,266 |
| STOR | -14,871 | -56,263 |
| Model Error | -1 | -3 |

## 5.4 Other Environmental Impacts, Including Spring Flow and Other Interactions between Groundwater and Surface Water

The evaluation of all water budget components was discussed in Section 5.3.2 above.

## 5.5 Subsidence

Subsidence has not been an issue historically in these aquifers in GMA 2.

## 5.6 Socioeconomic Impacts

Texas Tech and Texas AgriLife Extension Services published a report in 2011 that assessed the economics of proposed groundwater management strategies in Groundwater Management Area 2 (Weinheimer and others, 2011). This report stated that the declining saturated thickness would result in 33 percent fewer irrigated acres over the next 50 years as the region converts to dryland production. The study also found that the aggregate economic impacts from the selected water management policies implemented by the districts will have "very little negative impact relative to the baseline scenario".

Please note that this conclusion was based on the 2010 DFC, which included a 50/50 concept for the High Plains UWCD area of GMA 2. It was noted in the report that it was possible that individual farms could be impacted by the "proposed strategies", especially those with very high wells yields and the ability to apply irrigation water over a long period of time.

The areas that would be impacted include those where pumping is artificially and arbitrarily limited to achieve an equal 50/50 condition across the entire area. The concept of equal outcomes was specifically rejected as part of the development of the proposed DFC for the Ogallala discussed in this explanatory report. The proposed DFC implicitly recognizes the variability of the aquifer (e.g. saturated thickness and well yields), and recognizes that differences in pumping in various areas of GMA 2 are, in part, the result of the economics of pumping groundwater for beneficial use.

Thus, the limited economic impacts found in Weinheimer and others (2011) are substantially eliminated by this proposed DFC.

## 5.7 Impact on Private Property Rights

The impact on the interests and rights in private property, including ownership and the rights of landowners and their lessees and assigns in Groundwater Management Area 2 in groundwater are recognized under Texas Water Code Section 36.002.

The proposed DFC is consistent with protecting property rights. As discussed in the socioeconomic impacts discussion in Section 5.6, under the 50/50 concept, Weinheimer and others (2015) found a limited condition where there could be impacts as the result of the imposition of an equal outcome management concept. The proposed DFC has eliminated that concern since the DFC implicitly recognizes that the aquifer conditions vary across the region, and that property

rights are best protected when the pumping is limited only by the physics of groundwater flow and by the economics of pumping groundwater for a beneficial use.

## 5.8 Feasibility of Achieving the Desired Future Condition

Groundwater levels are routinely monitored by the districts and by the TWDB in GMA 2. Evaluating the monitoring data is a routine task for the districts, and the comparison of these data with the model results that were used to develop the DFCs is covered in each district's management plan. These comparisons will be useful to guide the update of the DFCs that are required every five years.

## 5.9 Other Information

GMA 2 did not consider any other information in developing the proposed DFCs.

# 6.0 Discussion of Other Desired Future Conditions Considered

During the development of the proposed DFCs, a total of sixteen GAM simulations were evaluated and considered. As described earlier, the initial fifteen simulations were used to develop Scenario 16, which was the basis for the proposed DFC.

Also considered was continuation of a 50/50 concept. However, as described in more detail above, this approach was rejected in favor of proposed DFCs that implicitly considered aquifer conditions and aquifer variability, economics of pumping groundwater in light of declining groundwater levels, and property rights over an arbitrary approach that emphasizes equal outcomes on a county scale.

# 7.0 Discussion of Other Recommendations

This section of the explanatory report will be completed after the public hearings that will be held during the comment period by each groundwater conservation district. The comment period is 90 days during which each groundwater conservation district is required to hold a public hearing on the proposed desired future condition (after a 10-day notice).

During the public comments period, each district shall make available in its office:

- A copy of the proposed desired future condition (essentially the resolution)
- Any supporting materials, such as the documentation of the nine factors (this report)
- Groundwater availability model run results (Hutchison, 2015a, 2015b,2015c, and 2016)

After the public hearing, each groundwater conservation district is required to compile a summary report that includes a summary of all relevant comments, suggested revisions to the proposed desired future condition, and the basis for those revisions. This summary report is to be then transmitted to the Groundwater Management Area 2 coordinator.

This section of the report is reserved to present and discuss the accepted or rejected revisions to the proposed desired future condition, and the reasons for acceptance or rejection. Therefore, a key discussion item at the Groundwater Management Area 2 meeting that will be held after the public hearings at each groundwater conservation district are the elements of this section.

# 8.0 References

Deeds, N.E. and Jigmond, M., 2015. Numerical Model Report for the High Plains Aquifer System Groundwater Availability Model. Prepared by INTERA Incorporated for Texas Water Development Board, 640p.

Hutchison, W.R., 2015a. Ogallala Aquifer: Initial Predictive Simulations. GMA 2 Technical Memorandum 15-01, Draft 1, Prepared for Groundwater Management Area 2. December 22, 2015, 61p.

Hutchison, W.R., 2015a. Ogallala Aquifer: Initial Predictive Simulations. GMA 2 Technical Memorandum 15-01, Draft 1, Prepared for Groundwater Management Area 2. December 22, 2015, 61p.

Hutchison, W.R., 2015b. Edwards-Trinity (High Plains) Aquifer: Initial Predictive Simulations. GMA 2 Technical Memorandum 15-02, Draft 1, Prepared for Groundwater Management Area 2. December 22, 2015, 26p.

Hutchison, W.R., 2015c. Dockum Aquifer: Initial Predictive Simulations. GMA 2 Technical Memorandum 15-03, Draft 1, Prepared for Groundwater Management Area 2. December 22, 2015, 27p.

Kohlrenken, W., Boghici, R., and Jones, I., 2013, GAM Task 13-026: Total Estimated Recoverable Storage for Aquifers in Groundwater Management Area 2. Texas Water Development Board, Groundwater Resources Division, Groundwater Availability Modeling Section, September 19, 2013, 26p.

Weinheimer, J. Johnson, P., Johnson, J, Guerrero, B., and Amosson, S., 2011. Economic Assessment of Proposed Groundwater Management Strategies in Groundwater Management Area 2. Final Report submitted 8/31/2011, Department of Agricultural and Applied Economics, Texas Tech University and Texas AgriLife Extension Service, 73p.