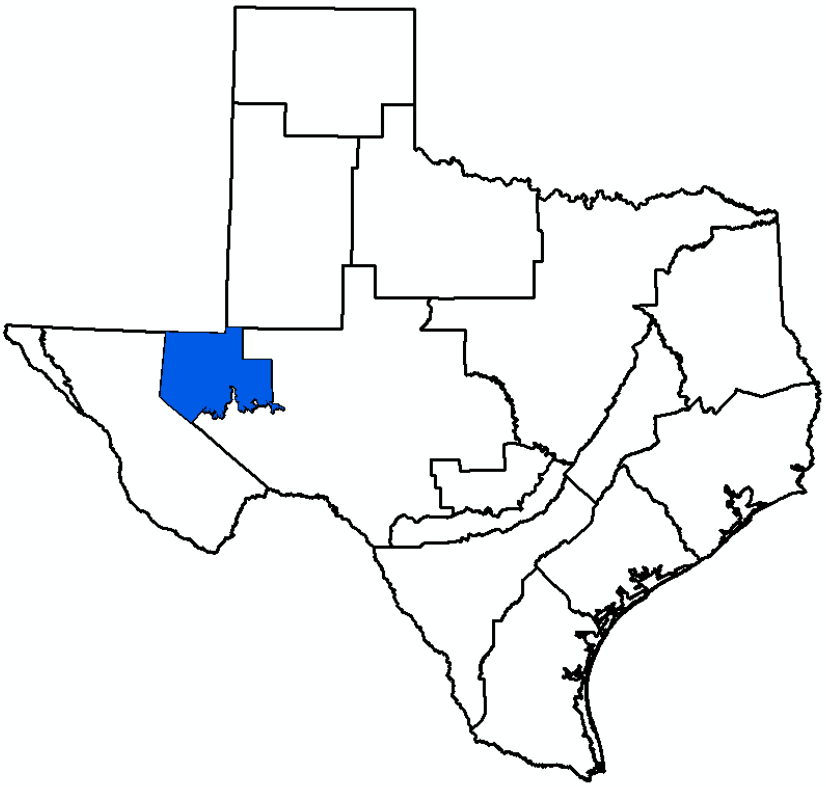
GMA 3 Technical Memorandum 16-05
Final

Dockum Aquifer:
Initial Predictive Simulations with HPAS



Prepared for:
Groundwater Management Area 3

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GMA 3 Technical Memorandum 16-05 (Final)
Dockum Aquifer: Initial Predictive Simulations with HPAS

Geoscientist and Engineering Seal

This report documents the work and supervision of work of the following licensed Texas Professional Geoscientist and licensed Texas Professional Engineers:

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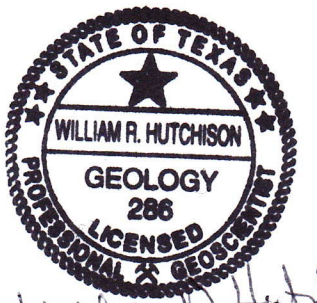
William R Hutchison
2/13/2017



William R Hutchison
2/13/2017

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1.0 Introduction and Objective

This technical memorandum documents initial simulations using the recently released High Plains Aquifer System Groundwater Availability Model (Deeds and Jigmond, 2015). The model is also known as the HPAS GAM, or simply the GAM. The GAM includes the Ogallala, Edwards-Trinity (High Plains), and Dockum aquifers. This technical memorandum covers the results of 15 initial predictive simulations of the Dockum aquifers in GMA 3 (Scenarios 1 to 15), and a final scenario that was completed after GMA 3 reviewed the initial results (Scenario 17). The scenario numbering is not consecutive since Scenario 16 using this GAM was completed for GMA 2, and the results were not relevant to GMA 3.

The objective of these simulations was to take advantage of a feature in the recently released model that differs from the previous version of the GAM. Earlier versions of the GAM required external adjustment of input groundwater pumping rates to avoid dry cells. The new version of the GAM uses the Newton Formulation and the upstream weighting package which automatically reduces pumping as heads drop in a particular cell as defined by the user (Niswonger and others, 2011). This feature provides a means to simulate the declining production of a well as saturated thickness decreases.

Deeds and Jigmond (2015) further enhanced the utility of this new feature by changing the threshold specification of saturated thickness when pumping reductions occur during a simulation. Niswonger and others (2011) used a fraction of cell thickness. As explained by Deeds and Jigmond (2015, pg. 2-27), a disadvantage of this approach is that cells that have an initially high saturated thickness, pumping reduction would occur to rapidly as compared to cells with less saturated thickness. Deeds and Jigmond (2015) modified the code to include a specification of an absolute value of saturated thickness at which pumping would be reduced. During development and calibration of the GAM, Deeds and Jigmond (2015) used a value of 30 feet as the threshold value of saturated thickness.

Scenarios 1 to 15 described in this technical memorandum considered two sets of basic alternatives: 1) varying the value of saturated thickness threshold, and 2) varying the initial pumping for each cell. Scenario 17 represented modifications to initial pumping in all GMA 3 counties and in Reagan County and Pecos County in GMA 7 in the Dockum Aquifer.

Scenarios 1 to 15 provided a means to understand the sensitivity of increasing and decreasing the saturated thickness threshold value used in the development and calibration of the model (30 feet). For these simulations, the three threshold values were used: 20 feet, 30 feet, and 40 feet. Scenario 17 used a threshold value of 30 feet.

Scenarios 1 to 15 also provided a means to understand the effect of increasing current pumping and, alternatively, reducing current amounts of pumping on long term well production and groundwater level declines. Because the groundwater levels in the Ogallala Aquifer have been declining over recent decades, and because it is recognized that current levels of pumping are likely to decline in future decades due to decreased saturated thickness, these simulations are useful as part of understanding the balance of groundwater conservation and development over a long period of time (58 years). This new version of the GAM represents the first time that a modeling tool can simulate

the declining production rates associated with decreasing saturated thickness without user intervention and multiple iterations to avoid dry cells.

2.0 Description of Simulations

Simulations were run for 58 years (2013 to 2070). Model files for the scenarios were taken from INTERA's deliverable to the TWDB for predictive runs in GMA 1. The only modification to these files for these simulations were the WEL file (input pumping amounts) as described below.

A base case was developed using a saturated thickness threshold of 30 feet (as was used during the development and calibration of the GAM), and pumping equal to 2012 amounts (the last year of model calibration). Other threshold values for saturated thickness (PHIRAMP) that would result in decreased pumping were 20 feet and 40 feet. Other values of initial pumping were 50 percent of 2012 pumping (on a cell by cell basis), 75 percent of 2012 pumping, 125 percent of 2012 pumping and 150 percent of 2012 pumping.

As a result, 15 simulations were run as shown in Table 1.

Table 1. Summary of Simulations

Scenario	Initial Pumping Rate (as a percentage of 2012 pumping)	Saturated Thickness Threshold (PHIRAMP)
1	0.50	20
2	0.75	20
3	1.00	20
4	1.25	20
5	1.50	20
6	0.50	30
7	0.75	30
8 (Base Case)	1.00	30
9	1.25	30
10	1.50	30
11	0.50	40
12	0.75	40
13	1.00	40
14	1.25	40
15	1.50	40

Scenario 17 modified the input pumping for the Dockum Aquifer in all counties in GMA 3 and in Pecos County in GMA 3 by setting the pumping to the current values of modeled available

groundwater adopted in 2010. Scenario 17 pumping for the Dockum Aquifer in Reagan County was set to 2,000 AF/yr.

3.0 Scenario 1 to 15 Results

Results for the 15 simulations are summarized by county in appendices and summary tables.

3.1 Summary of Pumping and Drawdown Results

Table 2 summarizes the drawdown in 2070 for all 15 simulations. Please note that the choice of saturated thickness threshold resulted in essentially the same results.

Appendix A presents graphs of pumping and drawdown, and is organized as follows:

- The cover sheet includes a map of GMA 3 counties for reference purposes.
- Each subsequent page summarizes results for a particular county.
- The upper graph shows the pumping from 1930 to 2012 (from the calibrated GAM), the pumping from Scenarios 6 to 10 (the pumping simulations associated with a saturated thickness threshold of 30 feet) for the years 2013 to 2070. The current modeled available groundwater (MAG) is also shown for reference purposes for the years 2010 to 2060.
- The lower graph shows the county-average drawdown from 2013 to 2070 of Scenarios 6 to 10 (the pumping simulations associated with a saturated thickness threshold of 30 feet). The current DFC in terms of drawdown from 2010 to 2060 is also shown for reference purposes.

3.2 Discussion of Results

Please note that in all counties, the modeled available groundwater is considerably higher than the historic pumping. Because pumping in Scenarios 1 to 15 was limited to between 50 and 150 percent of 2012 pumping, the drawdowns are considerably less than the desired future condition established in 2010.

Table 2. Summary of Drawdown for Dockum Aquifer

Dockum Aquifer
Simulated Drawdown (ft) from 2012 to 2070
Average Drawdown by County - GMA 3

Scenario	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Saturated Thickness Threshold (ft)	20					30					40				
Initial Pumping Factor (applied to 2012 pumping in HPAS GAM)	0.50	0.75	1.00	1.25	1.50	0.50	0.75	1.00	1.25	1.50	0.50	0.75	1.00	1.25	1.50
County															
Crane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Loving	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Pecos	11	12	12	13	14	11	12	12	13	14	11	12	12	13	14
Reeves	3	4	4	5	6	3	4	4	5	6	3	4	4	5	6
Ward	6	6	7	7	7	6	6	7	7	7	6	6	7	7	7
Winkler	4	4	4	5	5	4	4	4	5	5	4	4	4	5	5

5.0 Scenario 17 Results

The initial 15 scenarios were reviewed at the GMA 3 meeting on March 16, 2016. As a result of this review, Scenario 17 was developed in response to two specific requests. In Pecos County and all of GMA 3, Middle Pecos GCD requested that pumping in the Dockum Aquifer be set to the modeled available groundwater that was established in 2010. These values were considerably higher than the pumping in Scenarios 1 to 15, which relied on historic pumping.

In addition, Santa Rita GCD requested that pumping from the Dockum Aquifer in Reagan County (in GMA 7) be set at 2000 AF/yr, which is the approximate pumping in 1999. Pumping from the Dockum Aquifer in Reagan County has been considerably less than the historic maximum from 2000 to 2012. The Dockum Aquifer had been classified as not relevant for purposes of joint planning in Reagan County by GMA 7 in 2010.

Decadal pumping and drawdown results are summarized in Table 3.

Table 3. Summary of Scenario 17 Results - Dockum Aquifer

Pumping (AF/yr) by Decade

Year	2020	2030	2040	2050	2060	2070
County						
Crane	1,870	1,870	1,870	1,870	1,870	1,870
Loving	891	891	891	891	891	891
Pecos	17,976	17,976	17,976	17,976	17,976	17,888
Reeves	4,995	4,995	4,995	4,995	4,995	4,995
Ward	6,960	6,960	6,960	6,960	6,960	6,960
Winkler	9,994	9,994	9,994	9,994	9,994	9,994

Drawdown (ft) from 2012

Year	2020	2030	2040	2050	2060	2070
County						
Crane	0	0	0	0	0	0
Loving	3	3	4	4	5	5
Pecos	20	32	39	44	48	52
Reeves	11	15	17	19	19	20
Ward	14	21	24	27	29	30
Winkler	9	14	17	19	20	22

6.0 References

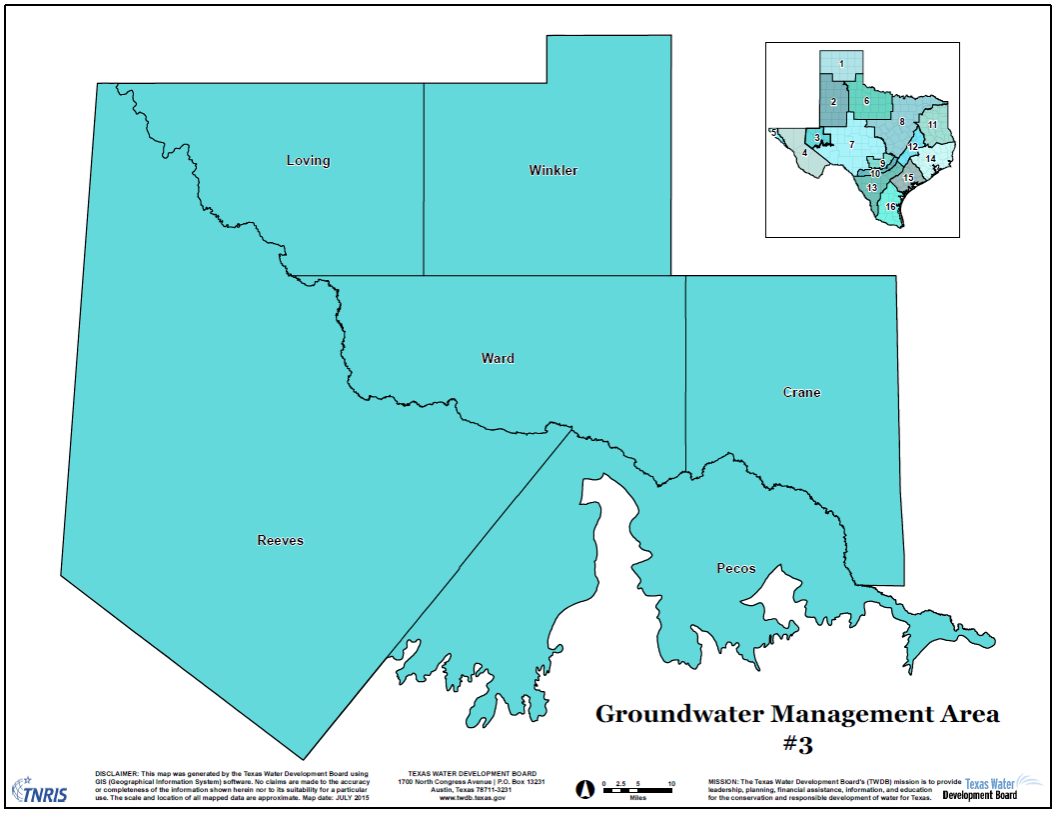
Deeds, N.E. and Jigmond, M., 2015. Numerical Model Report for the High Plains Aquifer System Groundwater Availability Model. Prepared by INTERA Incorporated for Texas Water Development Board, 640p.

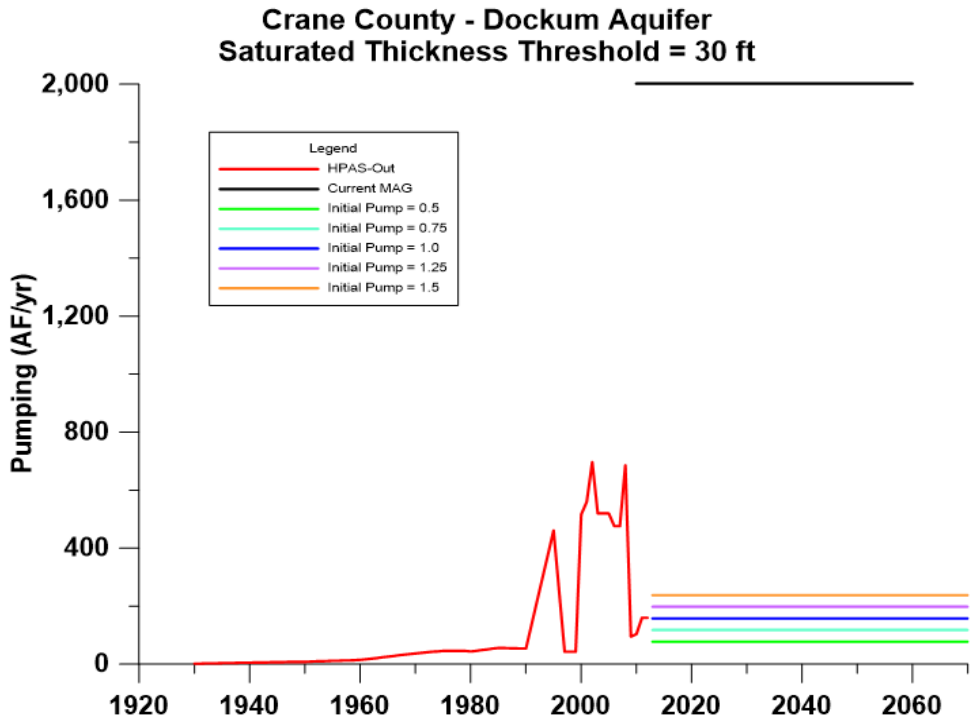
Niswonger, R.G., Panday, S., and Ibaraki, M., 2011. MODFLOW-NWT, A Newton Formulation for MODFLOW-2005.

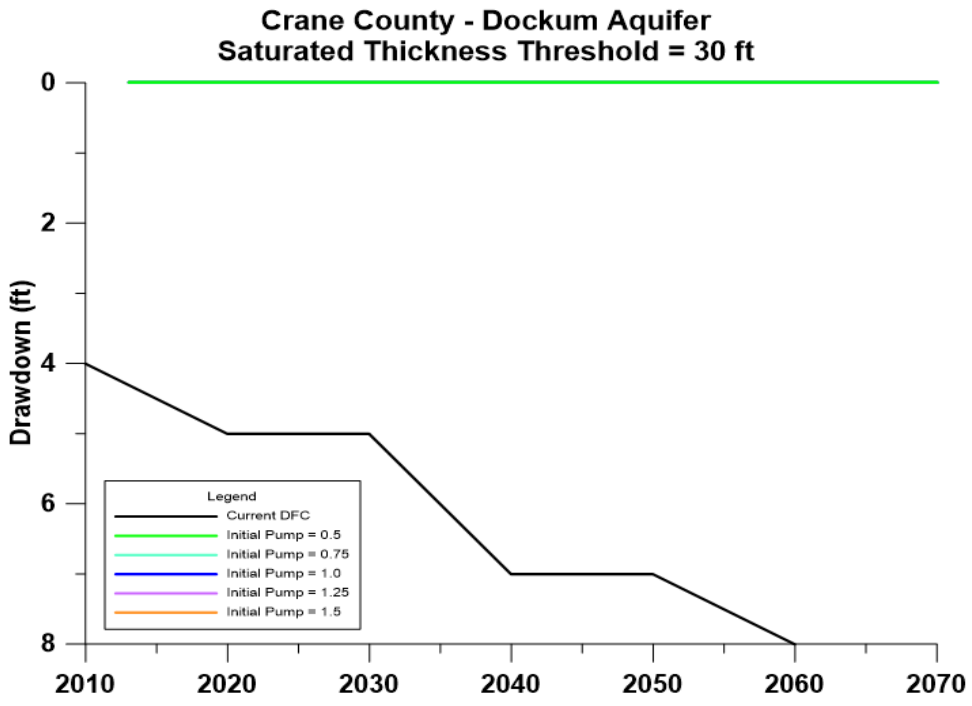
Appendix A

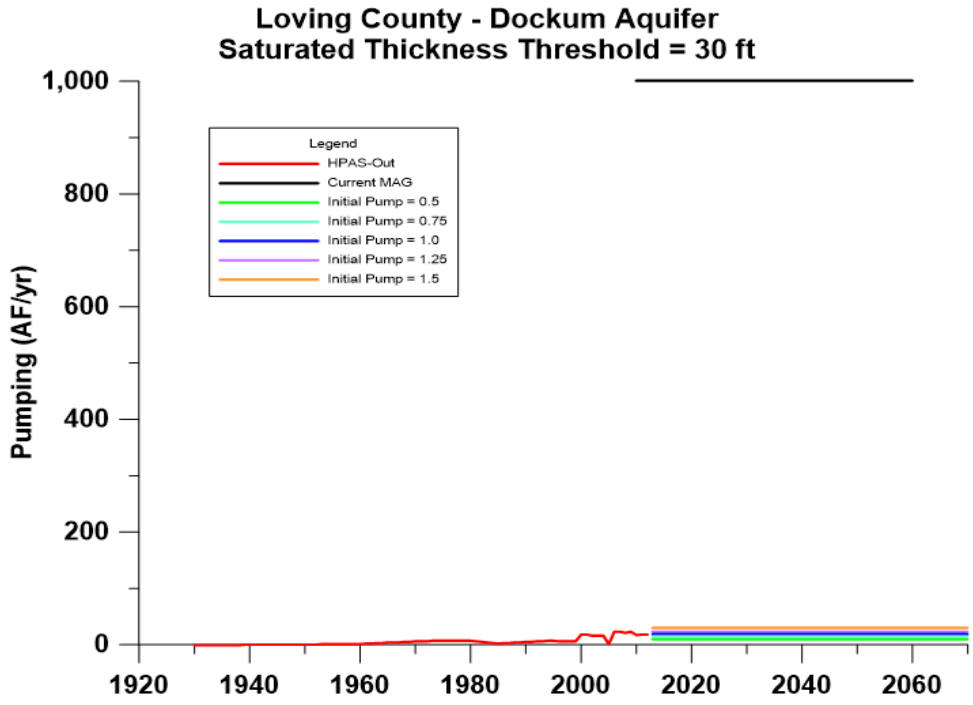
Dockum Aquifer

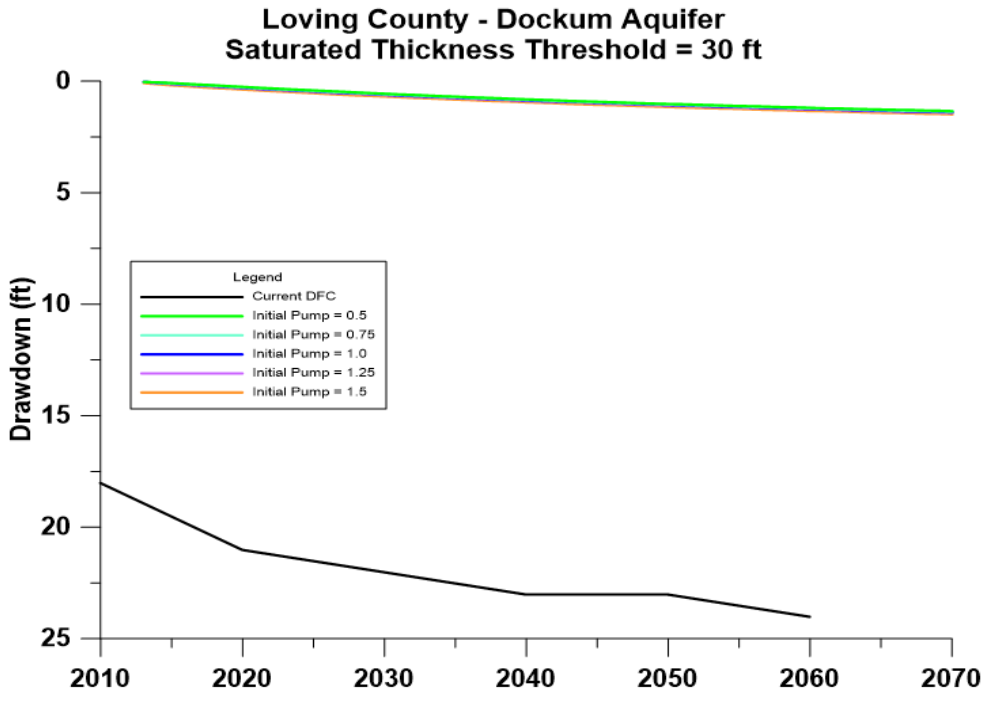
Hydrographs of Pumping and Drawdown for Each County in GMA 3

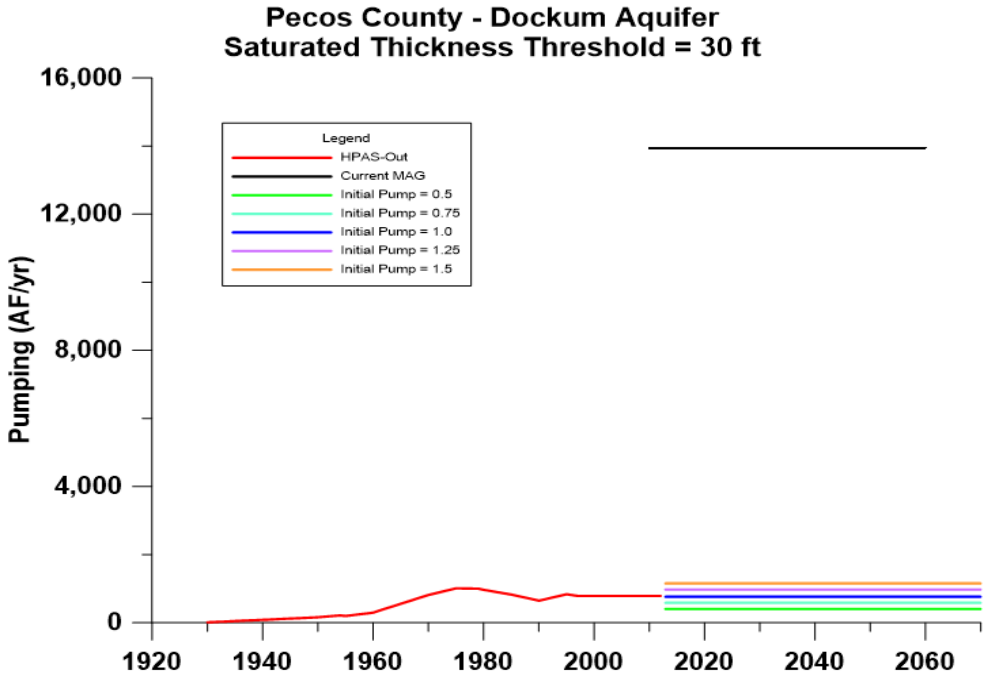


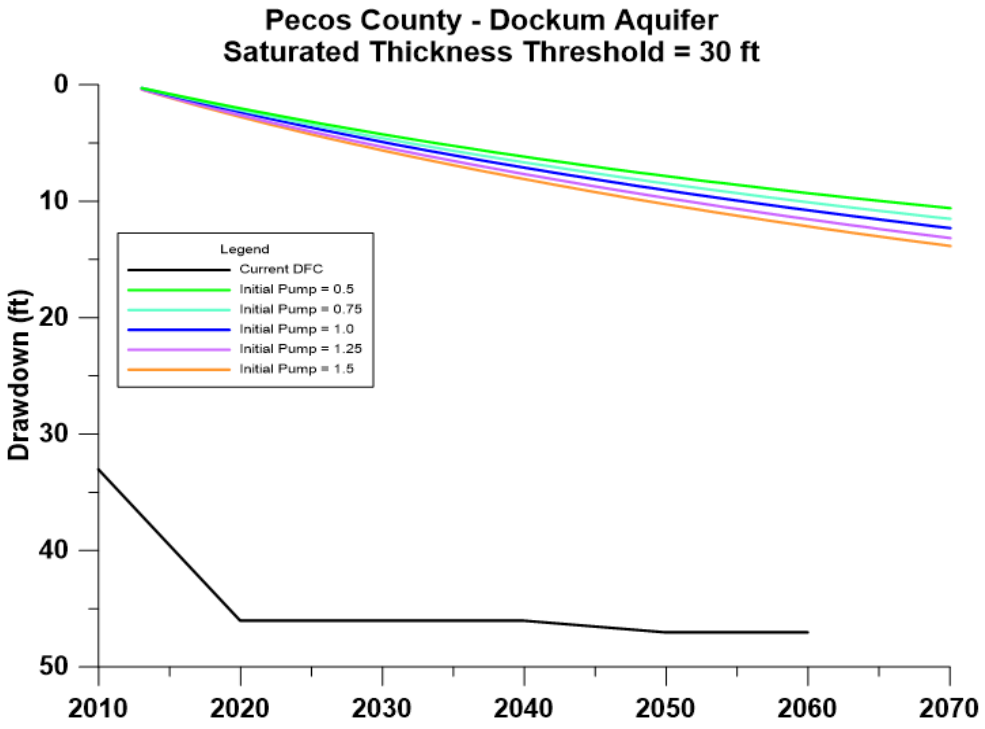

Crane County - Dockum Aquifer
Saturated Thickness Threshold = 30 ft
Pumping (AF/yr)
2,000
1,600
1,200
800
400
0
1920
1940
1960
1980
2000
2020
2040
2060
Legend
HPAS-Out
Current MAG
Initial Pump = 0.5
Initial Pump = 0.75
Initial Pump = 1.0
Initial Pump = 1.25
Initial Pump = 1.5

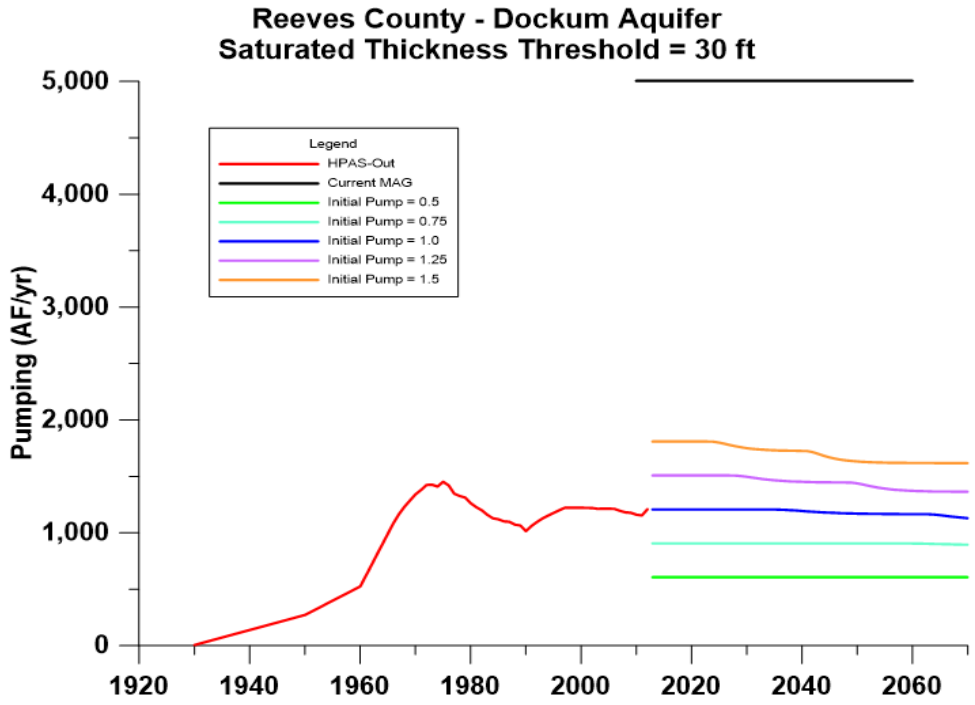

Crane County - Dockum Aquifer
Saturated Thickness Threshold = 30 ft
Drawdown (ft)
0
2
4
6
8
2010
2020
2030
2040
2050
2060
2070
Legend
Current DFC
Initial Pump = 0.5
Initial Pump = 0.75
Initial Pump = 1.0
Initial Pump = 1.25
Initial Pump = 1.5

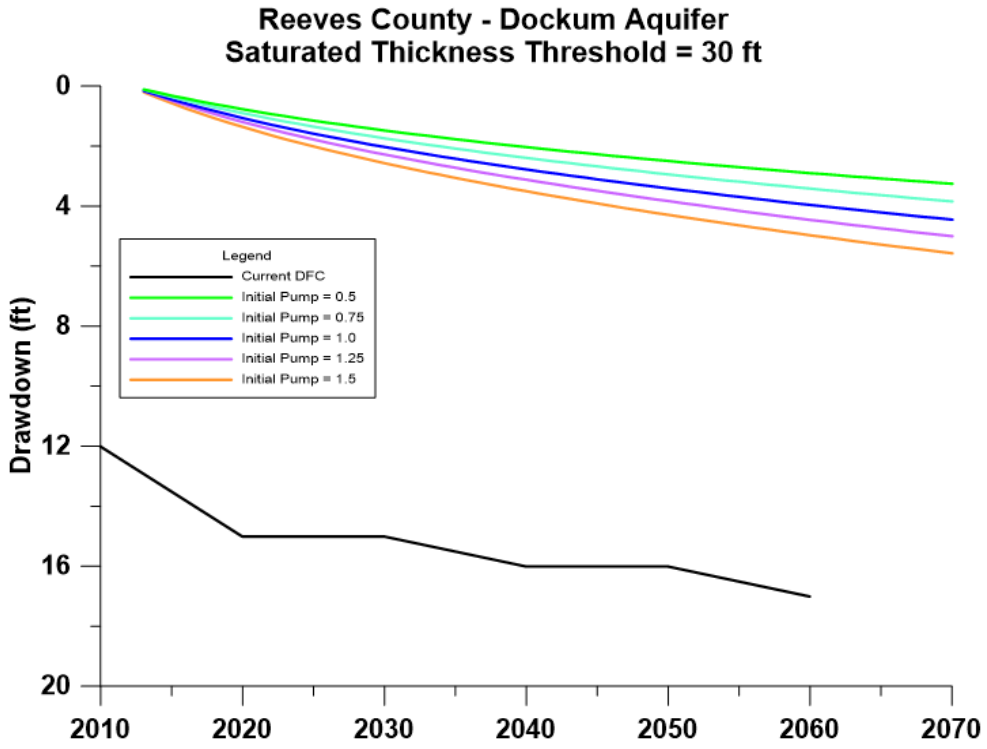

Loving County - Dockum Aquifer
Saturated Thickness Threshold = 30 ft
Pumping (AF/yr)
1,000
800
600
400
200
0
1920
1940
1960
1980
2000
2020
2040
2060
Legend
HPAS-Out
Current MAG
Initial Pump = 0.5
Initial Pump = 0.75
Initial Pump = 1.0
Initial Pump = 1.25
Initial Pump = 1.5

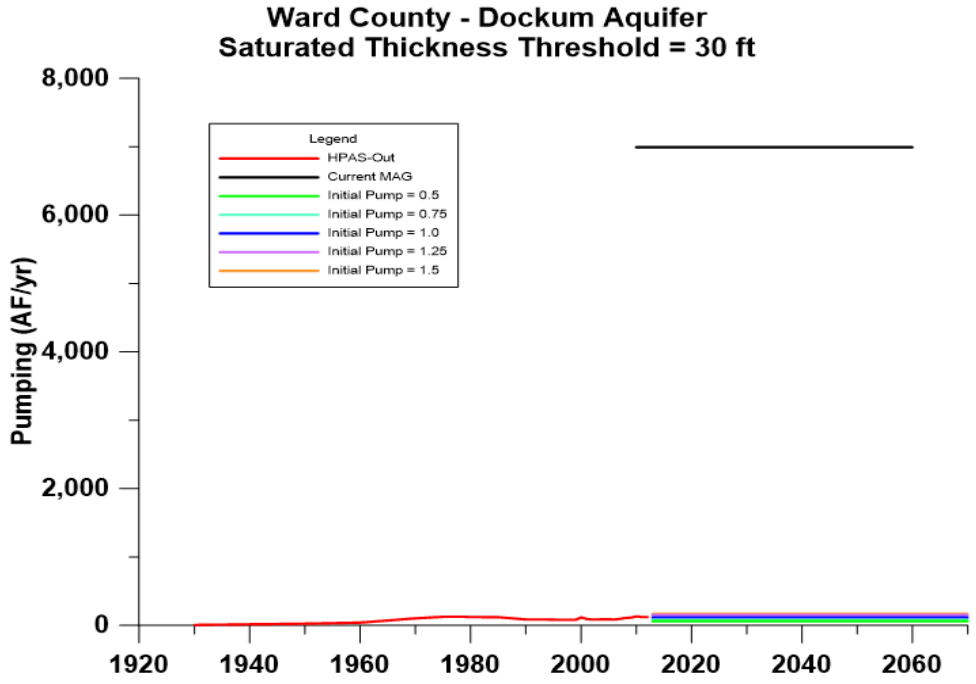

Loving County - Dockum Aquifer
Saturated Thickness Threshold = 30 ft
Drawdown (ft)
0
5
10
15
20
25
2010
2020
2030
2040
2050
2060
2070
Legend
Current DFC
Initial Pump = 0.5
Initial Pump = 0.75
Initial Pump = 1.0
Initial Pump = 1.25
Initial Pump = 1.5

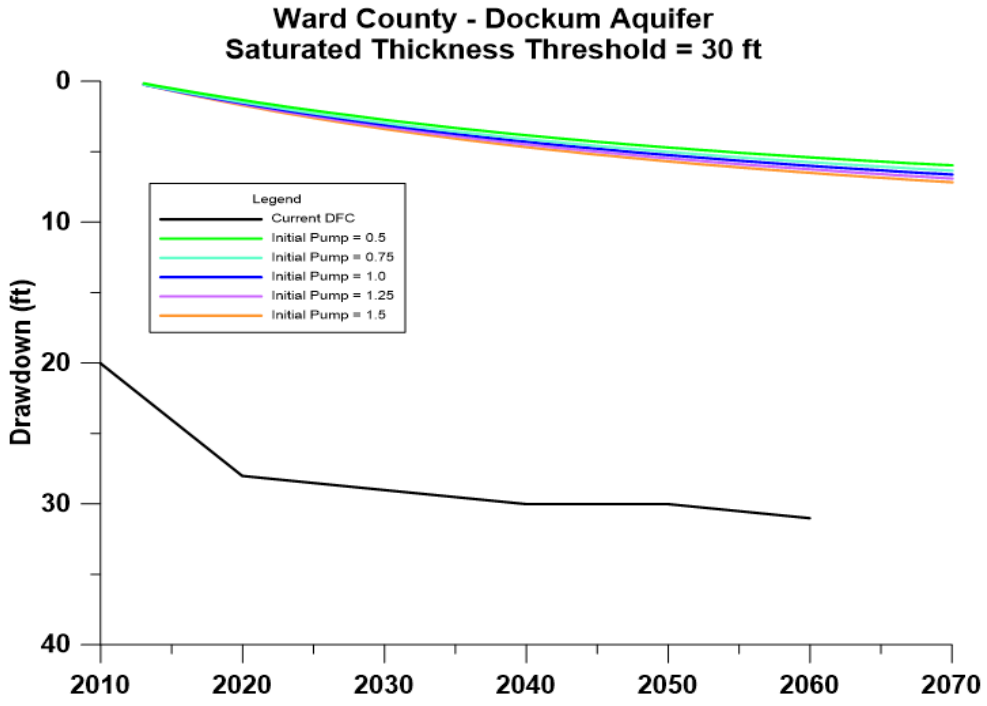

Pecos County - Dockum Aquifer
Saturated Thickness Threshold = 30 ft
Pumping (AF/yr)
16,000
12,000
8,000
4,000
0
1920
1940
1960
1980
2000
2020
2040
2060
Legend
HPAS-Out
Current MAG
Initial Pump = 0.5
Initial Pump = 0.75
Initial Pump = 1.0
Initial Pump = 1.25
Initial Pump = 1.5

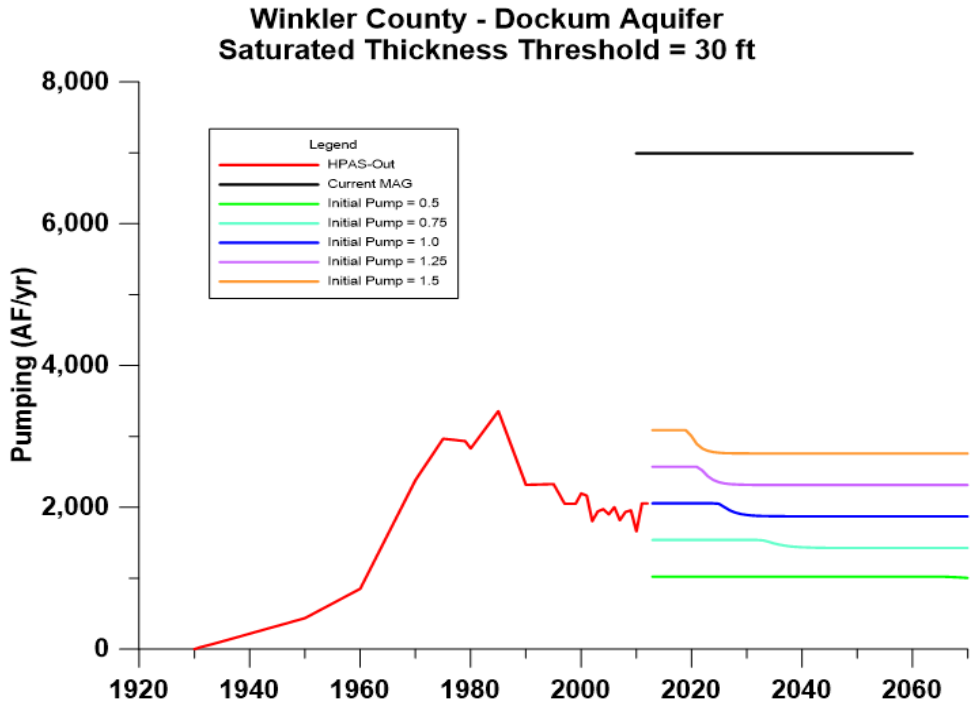

Pecos County - Dockum Aquifer
Saturated Thickness Threshold = 30 ft
Drawdown (ft)
0
10
20
30
40
50
2010
2020
2030
2040
2050
2060
2070
Legend
Current DFC
Initial Pump = 0.5
Initial Pump = 0.75
Initial Pump = 1.0
Initial Pump = 1.25
Initial Pump = 1.5

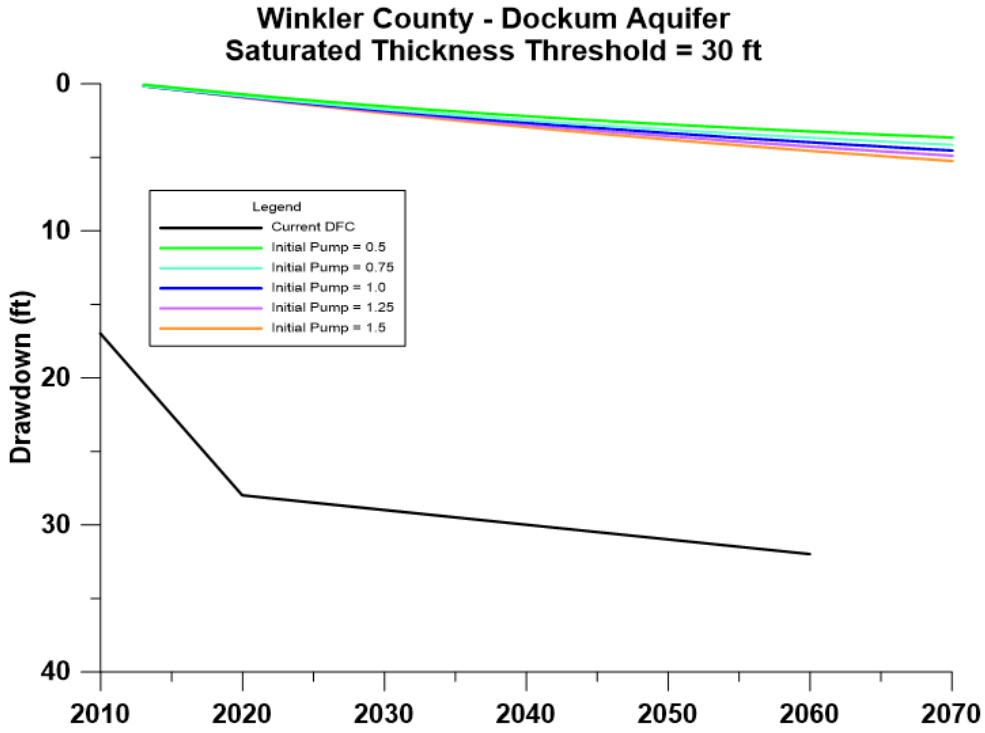

Reeves County - Dockum Aquifer
Saturated Thickness Threshold = 30 ft
Pumping (AF/yr)
5,000
4,000
3,000
2,000
1,000
0
1920
1940
1960
1980
2000
2020
2040
2060
Legend
HPAS-Out
Current MAG
Initial Pump = 0.5
Initial Pump = 0.75
Initial Pump = 1.0
Initial Pump = 1.25
Initial Pump = 1.5


Reeves County - Dockum Aquifer
Saturated Thickness Threshold = 30 ft
Drawdown (ft)
0
4
8
12
16
20
2010
2020
2030
2040
2050
2060
2070
Legend
Current DFC
Initial Pump = 0.5
Initial Pump = 0.75
Initial Pump = 1.0
Initial Pump = 1.25
Initial Pump = 1.5


Ward County - Dockum Aquifer
Saturated Thickness Threshold = 30 ft
Pumping (AF/yr)
8,000
6,000
4,000
2,000
0
1920
1940
1960
1980
2000
2020
2040
2060
Legend
HPAS-Out
Current MAG
Initial Pump = 0.5
Initial Pump = 0.75
Initial Pump = 1.0
Initial Pump = 1.25
Initial Pump = 1.5


Ward County - Dockum Aquifer
Saturated Thickness Threshold = 30 ft
Drawdown (ft)
0
10
20
30
40
2010
2020
2030
2040
2050
2060
2070
Legend
Current DFC
Initial Pump = 0.5
Initial Pump = 0.75
Initial Pump = 1.0
Initial Pump = 1.25
Initial Pump = 1.5


Winkler County - Dockum Aquifer
Saturated Thickness Threshold = 30 ft
Pumping (AF/yr)
8,000
6,000
4,000
2,000
0
1920
1940
1960
1980
2000
2020
2040
2060
Legend
HPAS-Out
Current MAG
Initial Pump = 0.5
Initial Pump = 0.75
Initial Pump = 1.0
Initial Pump = 1.25
Initial Pump = 1.5


Winkler County - Dockum Aquifer
Saturated Thickness Threshold = 30 ft
Drawdown (ft)
0
10
20
30
40
2010
2020
2030
2040
2050
2060
2070
Legend
Current DFC
Initial Pump = 0.5
Initial Pump = 0.75
Initial Pump = 1.0
Initial Pump = 1.25
Initial Pump = 1.5