Comparing Groundwater Elevation Data and Groundwater Model Results in the Context of Desired Future Conditions

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Topics

• Joint Planning
  – GCD, GMA, DFC, GAM and MAG
• Model Runs in the Development of DFCs
• Example of Comparing DFCs (Model Results) with Actual Data
Joint Planning

- Desired Future Condition (DFC)
  - Adopted by Groundwater Conservation Districts (GCD) within a Groundwater Management Area (GMA)

- Modeled Available Groundwater (MAG)
  - Calculated by Texas Water Development Board
  - Pumping that will achieve a DFC
  - Often accomplished with Groundwater Availability Models (GAM)
Desired Future Condition (DFC)

• Quantified conditions of groundwater resources
• Specified time or times in the future
• Broad Policy Goal
  – Drawdown
  – Spring flow
  – Storage volumes
• Updated at least every 5 years
Modeled Available Groundwater (MAG)

- TWDB calculates based on DFC
  - Models
  - Water budget calculations
  - District provided data and information
- Included in GCD Management Plans
- One factor in permitting decisions
- Replaces “Groundwater Availability” in Regional Water Plans
Model Runs (“Predictions”)

- Simulations of changes in:
  - Groundwater pumping and/or
  - Drought conditions

- Output examples:
  - Drawdown
  - Spring Flows
  - Storage Volumes
Model Runs ("Predictions")

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Role of Models

• Models are constrained by
  – Computational limitations
  – Assumptions
  – Knowledge gaps

• Tools to help inform decisions

• Models do not generate truth or make decisions
Important to Remember

• Groundwater management is more than just science
• Model results are not data
• Model results should be used by decision-makers to understand range of conditions
Objective

• Compare model results from DFC simulations with actual data
• Identify trends in “compliance”
• Identify areas with “deviations” and assess
  – Pumping assumptions (historic and projected)
  – Aquifer parameters
  – Boundary condition influence
• Use findings in next round of Joint Planning
“Compliance” and “Deviation”

• No formal requirement to report on DFC “compliance” or “deviation”
  – Local management vs. state oversight
  – Statute provides for petition process with TCEQ if DFC is not being met or district is not managing to DFC

• Good practice to evaluate in the context of next round of Joint Planning
Applications

- Completed work in GMA 13
  - Shown today as an example
- Similar work completed in part of GMA 11
- Similar work near completion in
  - GMA 9 (excluding Kerr County)
  - Kinney County (parts of GMA 7 and GMA 10)
- Similar work about to start in Val Verde County (part of GMA 7)
GMA 13
Southern Carrizo-Wilcox Aquifer
GMA 13

- GMA 13 adopted a Desired Future Condition (DFC) for the Carrizo-Wilcox, Queen City and Sparta aquifers on April 9, 2010.
- DFC establishment relied on results from several model simulations.
  - DFC = GMA-wide average drawdown (23 ft)
    - Measured from end of 1999.
  - Based on Scenario 4 of GAM Run 09-034.
    - 61 year simulation (2000 to 2060).
    - Assumed a starting point: end of 1999.
DFC and GAM Run

• Scenario 4 of GAM Run 09-034
  – Assumed average recharge each year for 61 years
  – Distribution and timing of pumping
    • Increase from 1999 amounts in some areas/layers
    • About the same as 1999 amounts in some areas/layers
    • Decrease from 1999 amounts in some areas/layers
Evaluate “DFC Assumptions” from 2000 to 2011

- Pumping locations
- Timing and amount of pumping increases
- Timing and amount of pumping decreases
- Adequacy of GAM to predict drawdown
- Appropriateness of average recharge assumption
DFC and GAM Run

• How to measure DFC “compliance” with “idealized” model run?
• How to compare “average” drawdown over entire GMA (23 ft) with individual well measurements?
Point-by-Point Comparison

- Extract predicted groundwater levels/drawdown from model files
- Compare to actual monitoring data
- Comparisons at discrete locations
- Limited use of averages
GAM for GMA 13

- Southern Carrizo-Wilcox, Queen City, Sparta
GAM for GMA 13

- One square mile grid cells
  - 112 Rows
  - 217 Columns
  - 8 Layers
  - 194,432 cells
  - 93,549 no-flow cells
  - 100,883 active cells
- GMA 13 = 82,029 active cells (~81% of model)
Calculation of “Average” Drawdown

- Each active cell (one square mile) groundwater elevation calculated at end of each “stress period” (one year)
  - Drawdown in each cell = groundwater elevation at the end of the year of interest minus the groundwater elevation at the initial time (end of 1999)
  - Sum the drawdowns for an area of interest (e.g. county, layer, county-layer, entire GMA)
  - Divide sum of drawdowns by the number of cells
For GMA 13

- DFC = 23 feet of drawdown in 2060
  - Average of 82,029 individual drawdown estimates
- Note that there are drawdown estimates each year (61 years)
  - Over 5 million individual drawdown estimates in GMA 13
Hypothetical Example of Average Drawdown

\[
\begin{array}{cccccc}
2 & 4 & 6 & 4 & 2 \\
4 & 6 & 8 & 6 & 4 \\
6 & 8 & 10 & 8 & 6 \\
4 & 6 & 8 & 6 & 4 \\
2 & 4 & 6 & 4 & 2 \\
\end{array}
\]

Avg = 5.2 ft
Hypothetical Example of Average Drawdown

 Avg = 6.6 ft
Point-by-Point Comparison

- GAM Data
  - Top and bottom elevations of 8 layers for each cell (one square mile)
- Useful to identify layer completion of wells in TWDB database
TWDB Database

- Well location (latitude and longitude)
- Well depth
- Completion data (screen top and bottom)
- Groundwater elevation data
  - GMA 13 statistics
    - 1906 to 2012
    - 31,247 groundwater level measurements
    - 6,956 wells
GMA 13 Wells in TWDB Database

• 6,956 wells
  – 5,112 have no details of screened interval
    • Most of these have an aquifer designation
  – 1,844 have screen top and bottom
Integrate TWDB Database Wells with GAM

• 1,844 Wells with completion data
  – Locate each well in model grid (row and column)
• Identify appropriate layer(s) for the well
• Extract model data for each cell with a well
  – Aquifer parameters
  – Pumping
  – Groundwater elevations
Wells in a Single Model Layer

- 748 Wells in GMA 13
  - 92 with 10 or more groundwater level measurements with at least one past 2000 (hydrographs in the report)
  - 70 wells with late 1999/early 2000 measurement and at least one measurement at the end of year/beginning of year from late 2000/early 2001 to late 2011/early 2012 (drawdown comparison)
Compare Drawdowns in 70 Wells with DFC Drawdowns

- Calculate drawdown from late 1999/early 2000 measurement
- 628 measurements
- Compare drawdown with DFC drawdown
Method

• DFC Drawdown minus Actual Drawdown for any given year
  – Positive number means that actual groundwater level is higher than DFC groundwater level
    • DFC drawdown  = 10 ft
    • Actual drawdown =  8 ft
    • Difference     =   2 ft
  – Negative number means that actual groundwater level is lower than DFC groundwater level
Summary of Year-by-Year

• 2000 to 2011
• Three groups to summarize by year
  – Green = > 3 ft difference
  – Yellow = difference is within +/- 3 ft
  – Red = < -3 ft difference
GMA 13
Comparison of Actual Drawdown with DFC Drawdown by Year

- 2000
- 2001
- 2002
- 2003
- 2004
- 2005
- 2006
- 2007
- 2008
- 2009
- 2010
- 2011

- Actual > 3 ft below DFC
- Actual within 3 ft of DFC
- Actual > 3 ft above DFC

Number of Wells
Summary of Year-by-Year

- Take average difference for each year
- Compare to precipitation
GMA 13
DFC Drawdown minus Actual Drawdown
Average by Year
GMA 13
DFC Drawdown minus Actual Drawdown
Average by Year

Year

DFC Drawdown minus Actual Drawdown (ft)

-20
-15
-10
-5
0
5
10
15
20

Precipitation

- Annual Precipitation from State Climatologist Website
  - Corpus Christi
  - Del Rio
  - San Antonio
- Sum of three stations
- Express as percent average of sum of average precipitation of three stations
GMA 13
DFC Drawdown minus Actual Drawdown
Average by Year

Year
Precipitation as % Average

DFC Drawdown minus Actual Drawdown (ft)
-20 -15 -10 -5 0 5 10 15 20

Precipitation as % Average

2000: 90
2001: 101
2002: 113
2003: 96
2004: 132
2005: 74
2006: 86
2007: 142
2008: 74
2009: 76
2010: 132
2011: 45
Observations

• Actual drawdown less than DFC drawdown
• Exception in 2010 and 2011
  – Increased use due to drought and increased pumping from hydraulic fracturing?
  – Decreased recharge due to drought?
  – Skewed by wells with data?
• Suggests that simulations of something other than “average” recharge for 61 years would be appropriate
Current Round of Joint Planning

- Completed this analysis in late 2012
- Draft report/final report in early 2013
- Results useful for guiding current joint planning effort
Issues for Current Round of Joint Planning

• Improvements in pumping from 2000 to present
  – Model calibration ended in 1999
  – Change in starting point to DFC drawdown?
  – Work in progress

• Pumping from present to 2060 (2070?)
  – Hydraulic fracturing estimates
  – Groundwater export estimates
Issues for Current Round of Joint Planning

• How to better incorporate actual well data in DFC statement
  – Specific indicator wells (unconfined, confined) to supplement and complement averages derived from model simulations
  – Recognize that the GAM will be used by TWDB to develop MAG
  – Ongoing discussion in GMA 13
Questions?

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