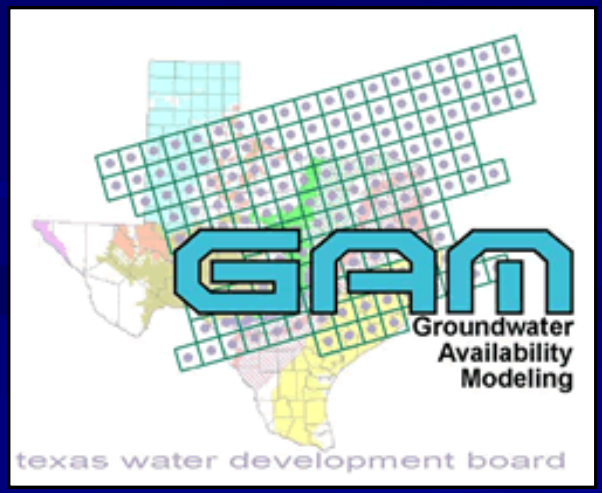
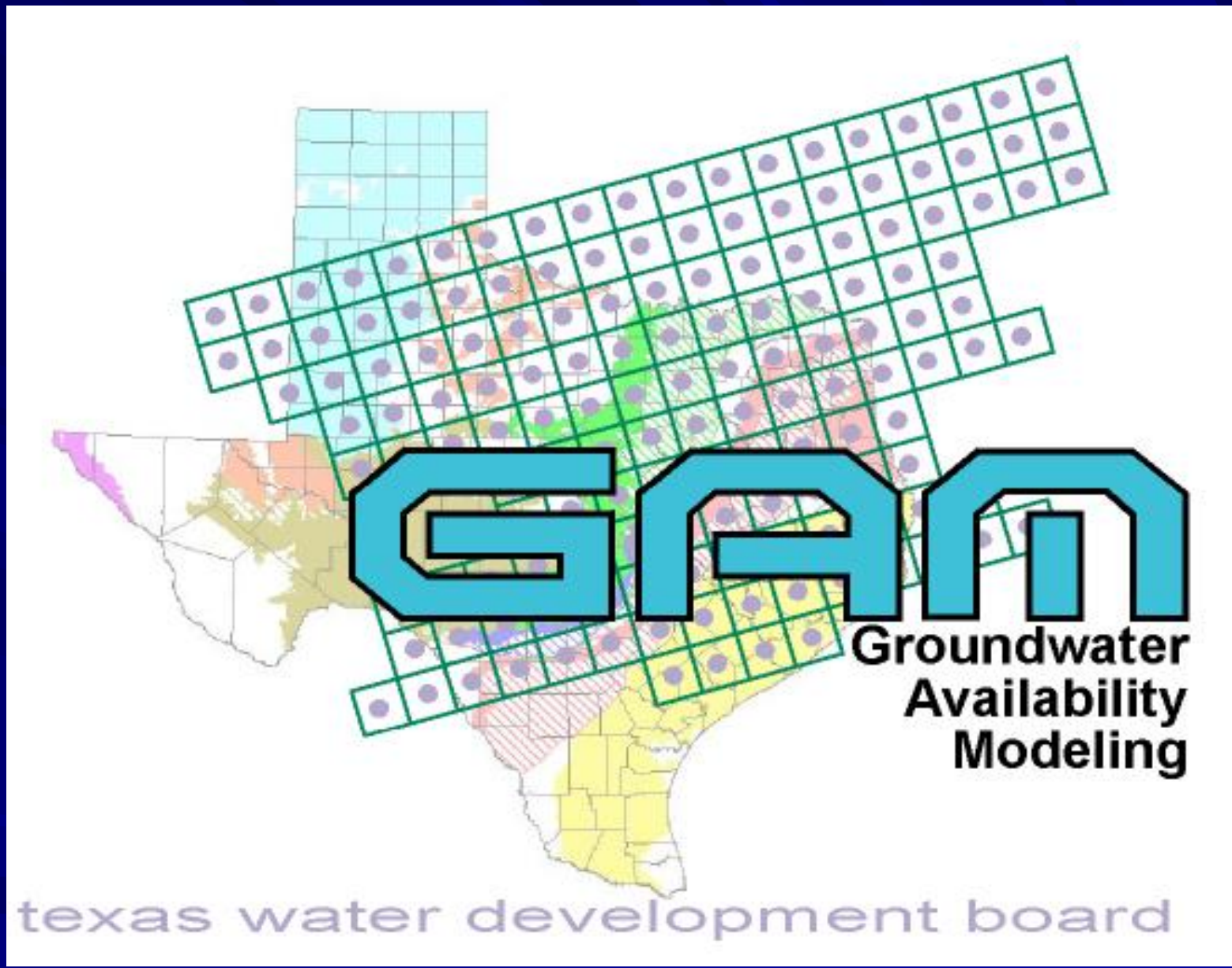
# Groundwater Availability Model (GAM) for the Dockum Aquifer

**Stakeholder Advisory Forum (SAF#1)**
**Lubbock, Texas**
**July 20th, 2006**

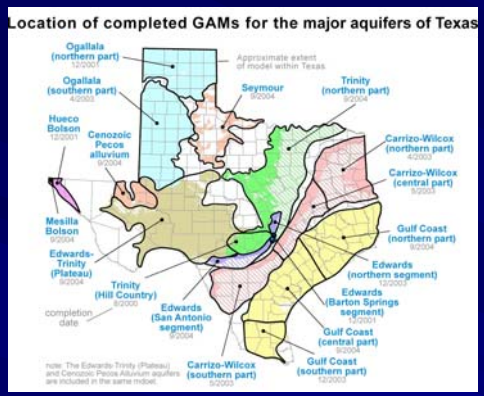


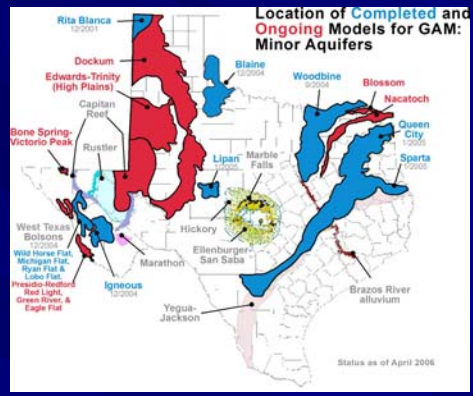

**John Pickens**
INTERA

**John Ashworth**
LBG GUYTON


GAM
Groundwater
Availability
Modeling
texas water development board

# Groundwater Availability Modeling

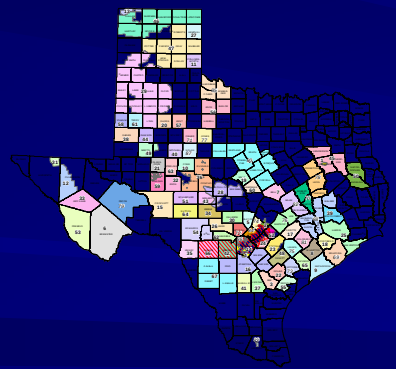


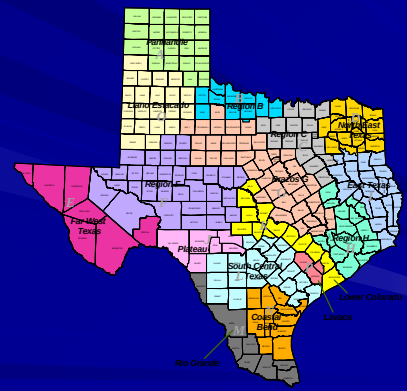





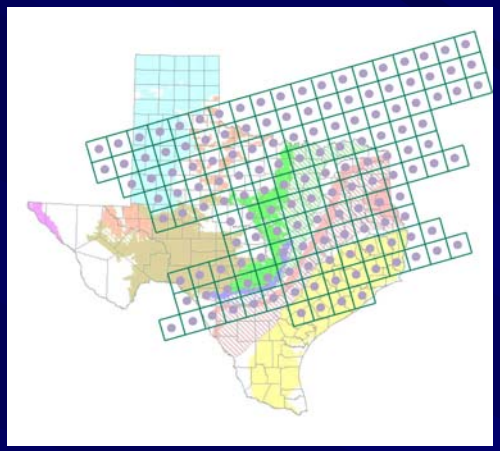
Contract Manager

Ian Jones





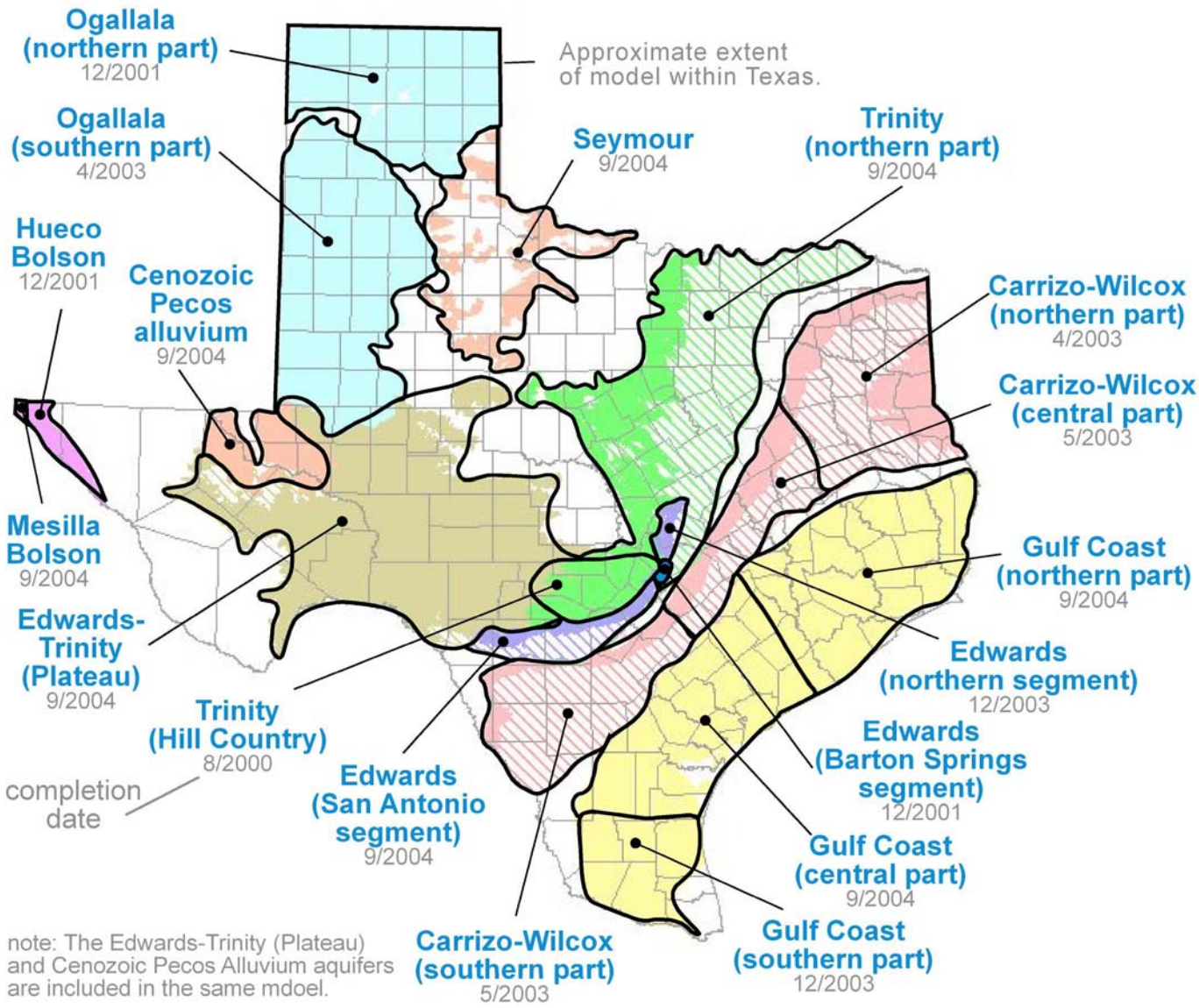
Texas Water Development Board

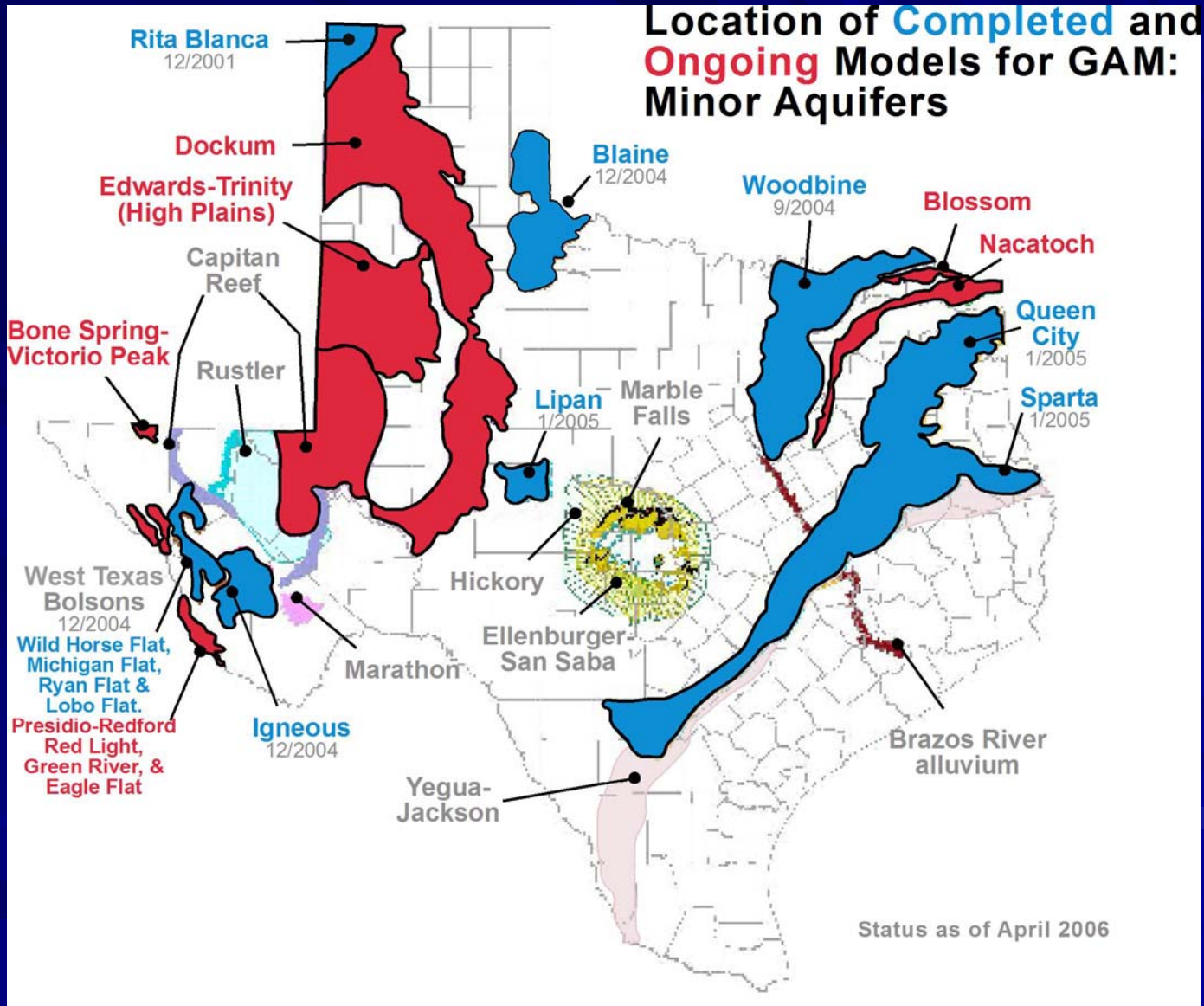


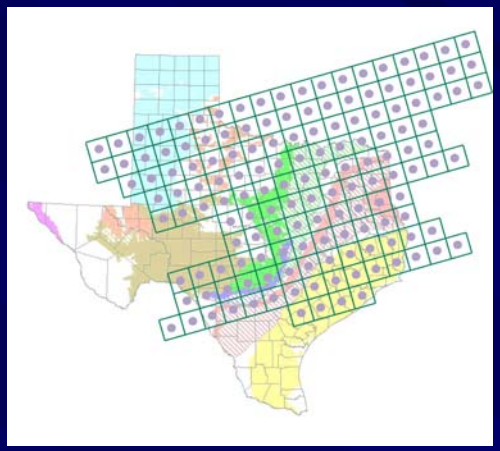
# GAM

- Purpose: To develop tools that can be used to help GCDs, RWPGs, and others assess groundwater availability.
- Public Process: You get to see how the model is put together.
- Freely Available: Standardized, thoroughly documented, and available upon request.
- Living Tools: Periodically updated.

# Location of completed GAMs for the major aquifers of Texas

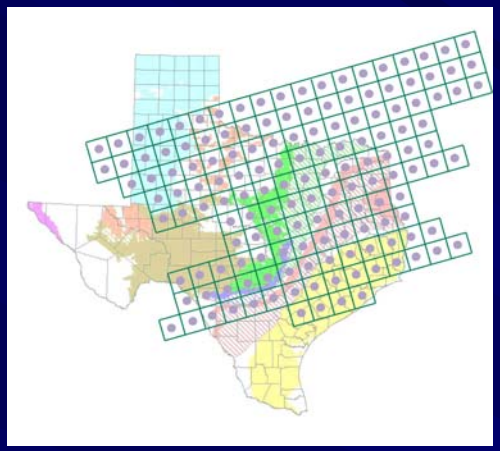



Location of Completed and Ongoing Models for GAM: Minor Aquifers
Rita Blanca
12/2001
Dockum
Edwards-Trinity (High Plains)
Capitan Reef
Bone Spring-Victorio Peak
Rustler
Blaine
12/2004
Woodbine
9/2004
Blossom
Nacatoch
Queen City
1/2005
Sparta
1/2005
Lipan
1/2005
Marble Falls
Hickory
Ellenburger-San Saba
West Texas Bolsons
12/2004
Wild Horse Flat, Michigan Flat, Ryan Flat & Lobo Flat.
Presidio-Redford
Red Light, Green River, & Eagle Flat
Marathon
Igneous
12/2004
Yegua-Jackson
Brazos River alluvium
Status as of April 2006



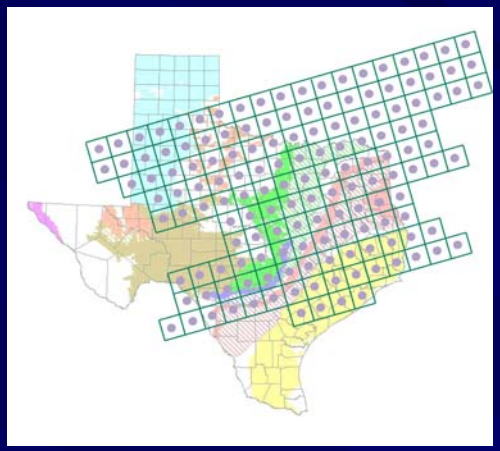
# What is Groundwater Availability or MAG?

- Managed available groundwater (MAG)…the amount of groundwater available for use.
- The State does not directly decide how much groundwater is available for use: GCDs will through GMA process.
- A GAM is a tool that can be used to assess groundwater availability once GCDs and GMAs decide on the desired future condition of the aquifer.



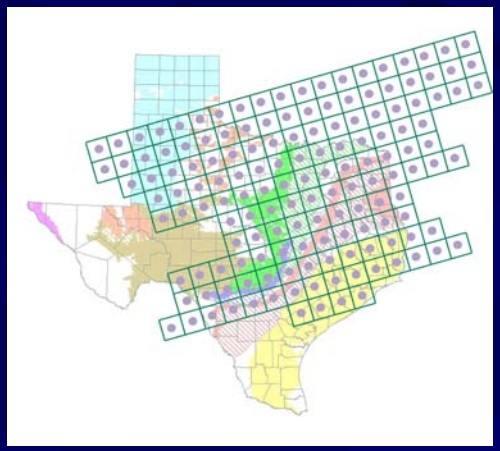
# Do we have to use GAM?

- Water Code & TWDB rules require that GCDs use GAM information, if available, for their management plans.
- TWDB rules require that RWPGs use managed available groundwater estimates, if developed in time for the planning cycle



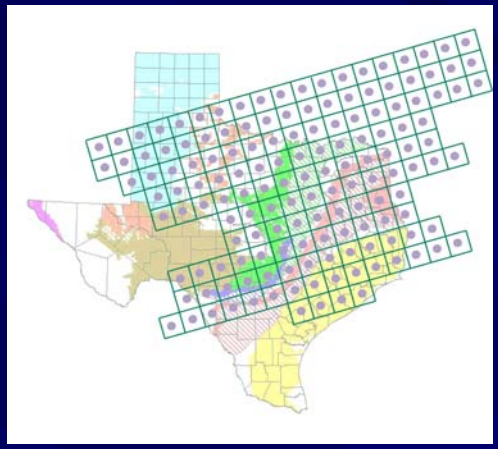
# How do we use GAM?

- The Model
  - Predict water levels and flows in response to pumping and drought
  - Effects of well fields
- Data in the Model
  - Water in storage
  - Recharge estimates
  - Hydraulic properties
- GCDs and RWPGs can request runs



# Living Tools

- GCDs, RWPGs, TWDB, and others collect new information on aquifer.
- This information can enhance the current GAMs.
- TWDB plans to update GAMs every five years with new information.
- Please share information and ideas with TWDB on aquifers and GAMs.



# Participating in the GAM Process

- SAF meetings
  - Hear about progress on the model
  - Comment on model assumptions
  - Offer information (timing is important!)
- Report review
  - At end of project
- Contact TWDB
  - Contract manager

# Comments:

**Contract Manager**

**ian.jones@twdb.state.tx.us**

**(512) 936-0848**

**www.twdb.state.tx.us/gam**

# Outline

- Introduction of GAM team & roles
- GAM project objectives/deliverables
- Basics of groundwater flow
- Overview of Dockum aquifer
- Concept of numerical groundwater modeling
- GAM specifications and model development
- Data source review
- Identification of data needs
- GAM schedule

# Dockum GAM Team - Roles

- INTERA – Primary roles:
  - Project management
  - SAF meetings
  - Heads and calibration targets
  - Hydraulic property implementation
  - Recharge implementation
  - Surface water / groundwater interaction
  - Model calibration
  - Reporting
  - Project deliverables
- LBG-Guyton – Primary roles:
  - Geologic structure
  - Hydraulic properties data
  - Pumping data & implementation
  - Water quality
- LBG-Guyton – Support roles:
  - SAF meetings
  - Model calibration
  - Reporting
- BEG – Primary Role:
  - Recharge conceptualization & estimation

# Dockum GAM Team – Roles (cont'd)

- Expert Input and Review
  - Dr. Marios Sophocleous
  - Mr. David Johns
- TWDB:
  - Dr. Ian Jones
    Contract Manager

# SAFs

- First SAF to introduce basic information and request data for the model
- Future meetings (3)
  - provide updates on progress (after: conceptual model development, model calibration, & draft final report)
  - opportunity to obtain feedback from stakeholders
- SAF presentations and questions & responses from meetings will be posted at http://www.twdb.state.tx.us/gam/dckm/dckm.htm

# GAM Objectives

- Develop realistic and scientifically accurate GW flow models representing the physical characteristics of the aquifer and incorporating the relevant processes.
- Promote stakeholder participation which is critical to the success of the GAM program.

# GAM Objectives (cont'd)

- Provide a standardized and thoroughly documented data base and model, available to the public.
- The models are designed as tools to help GCDs, RWPGs, and other interested parties assess groundwater availability.

# GAM Deliverables

- Calibrated computer model
- Data base (data model) to support the GAM
- Final report with presentation and discussion of the data and the GAM
- All of the above will be publicly available through the TWDB

# Groundwater Flow - Definitions

- Aquifer – Water saturated permeable geologic unit that can transmit significant quantities of water (e.g., sands & gravels).
  - Unconfined – water table forms the upper boundary
  - Confined – has overlying/underlying lower permeabilty layers
- Water table – The top of the saturated zone.
- Hydraulic head – The water level in a well expressed as an elevation.

# Groundwater Flow – Definitions (cont'd)

- Hydraulic conductivity (permeability) – A physical property of the geologic media representing its ability to transmit water.
- Specific yield – The volume of water that an unconfined aquifer releases from storage per unit surface area of aquifer per unit decline in water table elevation.
- Storativity – The volume of water that a confined aquifer releases from storage per unit surface area of aquifer per unit decline in head.

# Groundwater Flow – Definitions (cont'd)

- Recharge – The entry of water to the saturated zone at the water table:

  Recharge = (precipitation + stream loss) minus (runoff + evapotranspiration).

- Cross-formational flow – Groundwater flow between separate geologic formations.
- Stream losses or gains – The water that is either lost or gained through the base of the stream or river.

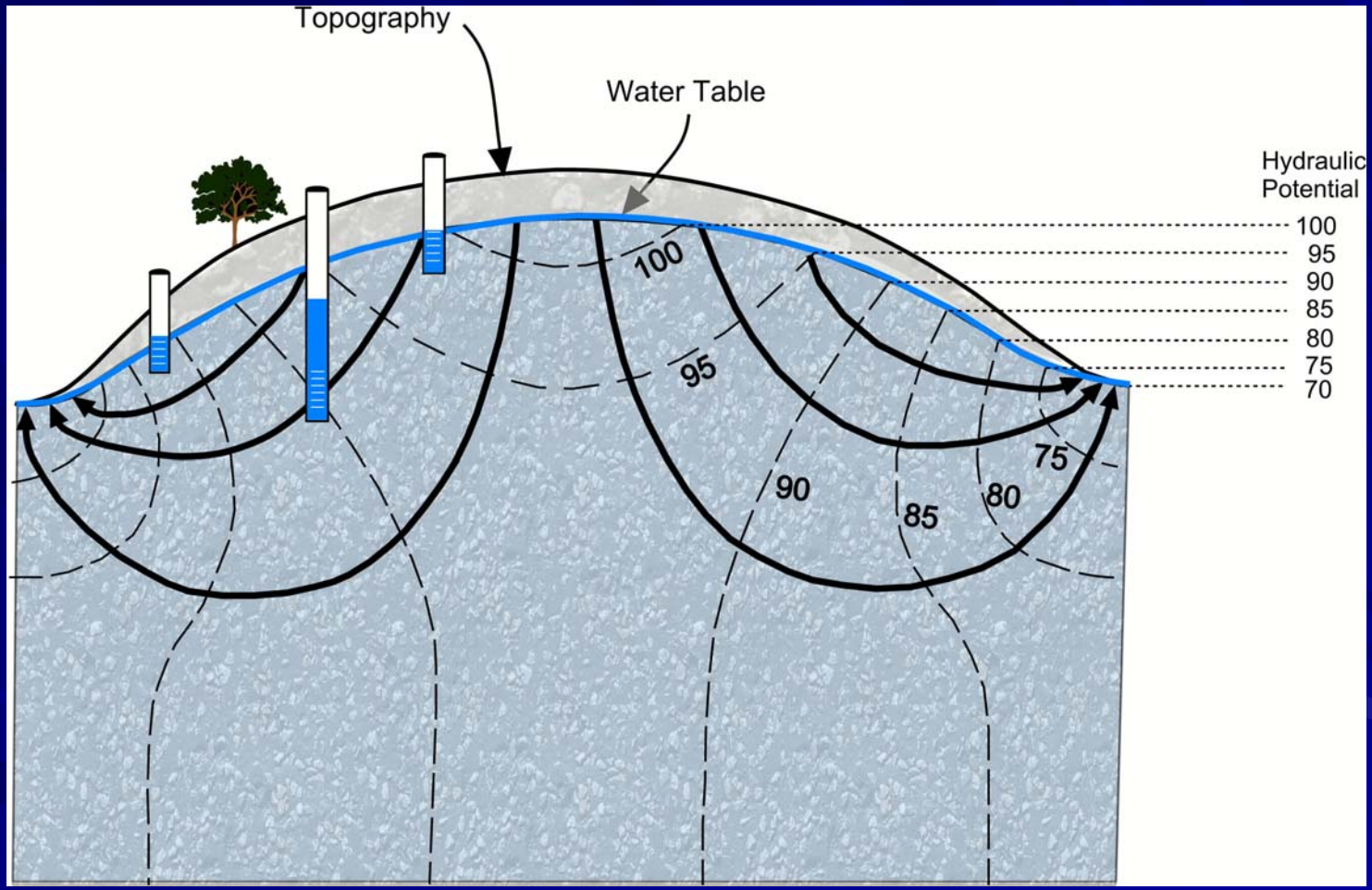
# Basic Principles of GW Flow

- The primary observable quantity describing groundwater flow is the water level as measured in a well.
- The water level expressed as elevation is termed the hydraulic head.
- The difference in hydraulic head between adjacent wells determines the direction of GW flow (from higher heads towards lower heads).
- The water table is typically a subdued replica of the topography.

# Basic Principles of GW Flow (cont'd)

- The thickness and hydraulic conductivity of the aquifer material define volumetric flow rates (e.g., for pumping)
  - The larger the hydraulic conductivity and thickness, the greater the flow.

# Schematic Cross Section of Groundwater Flow



# Overview of Dockum Aquifer

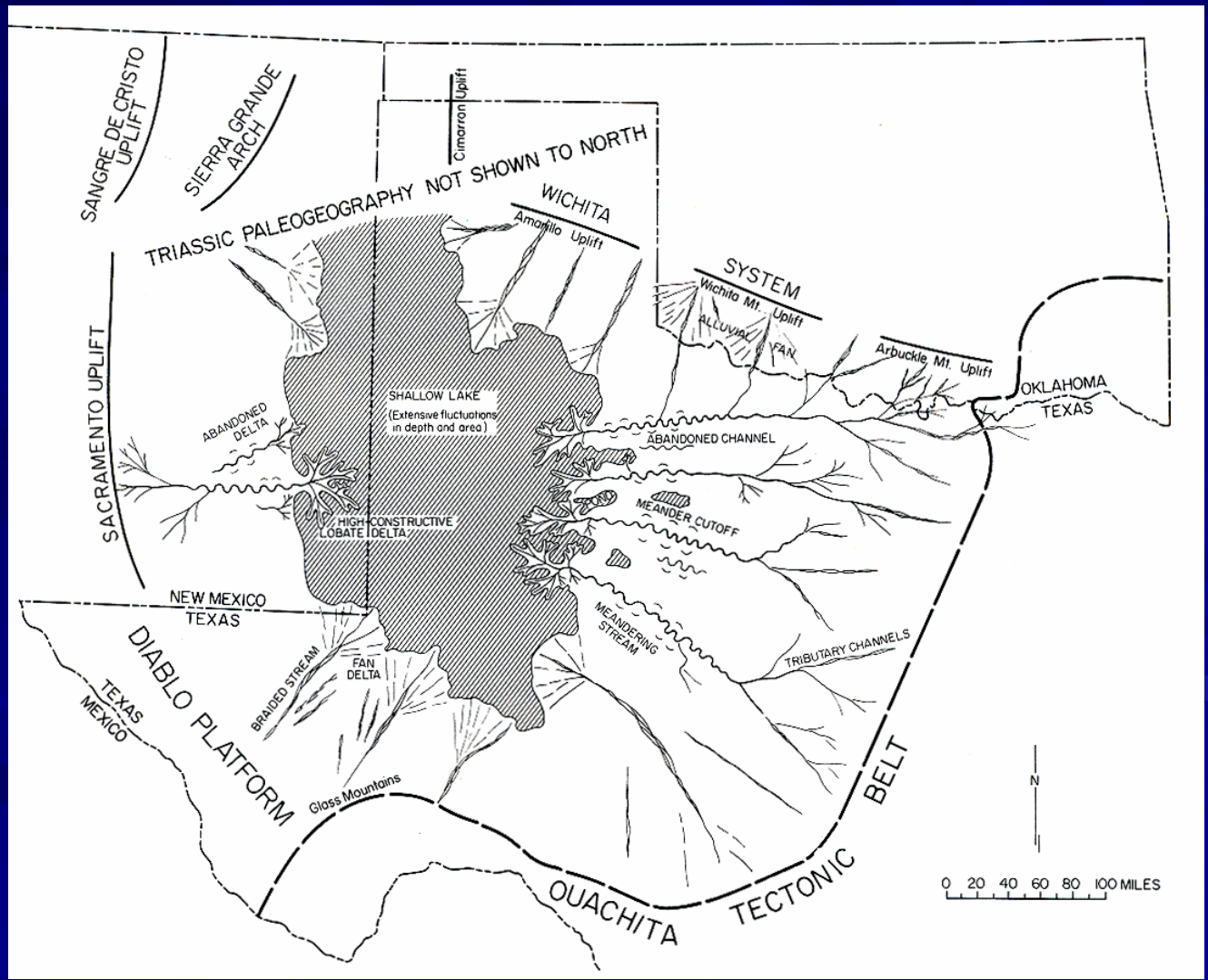
- “Dockum Group” is composed of mudstone, sandstone, and conglomerates that were deposited in fan, fluvial deltaic, and lacustrine environments in a continental basin.
- Typically lower sand-rich unit (aquifer) and upper mud-rich unit (confining layer).
- Wide variety of nomenclature adopted by different investigators.
- GAM will include Dockum downdip areas with > 5,000 mg/L TDS.

# Geologic Data Sources

- McKee et al. (1959) – USGS Misc. Geol. Invest. Map 1-300
- McGowen et al. (1979) – BEG ROI 97
- Dutton & Simpkins (1986) – BEG ROI 161
- Johns (1989) – BEG ROI 182
- Bradley & Kalaswad (2001) – TWDB 356 (Ch.12)
- Bradley & Kalaswad (2003) – TWDB 359
- TX (TWDB) and NM (BGMR) county reports

# Depositional Environment

## (from B.E.G. Report No. 97-1979)

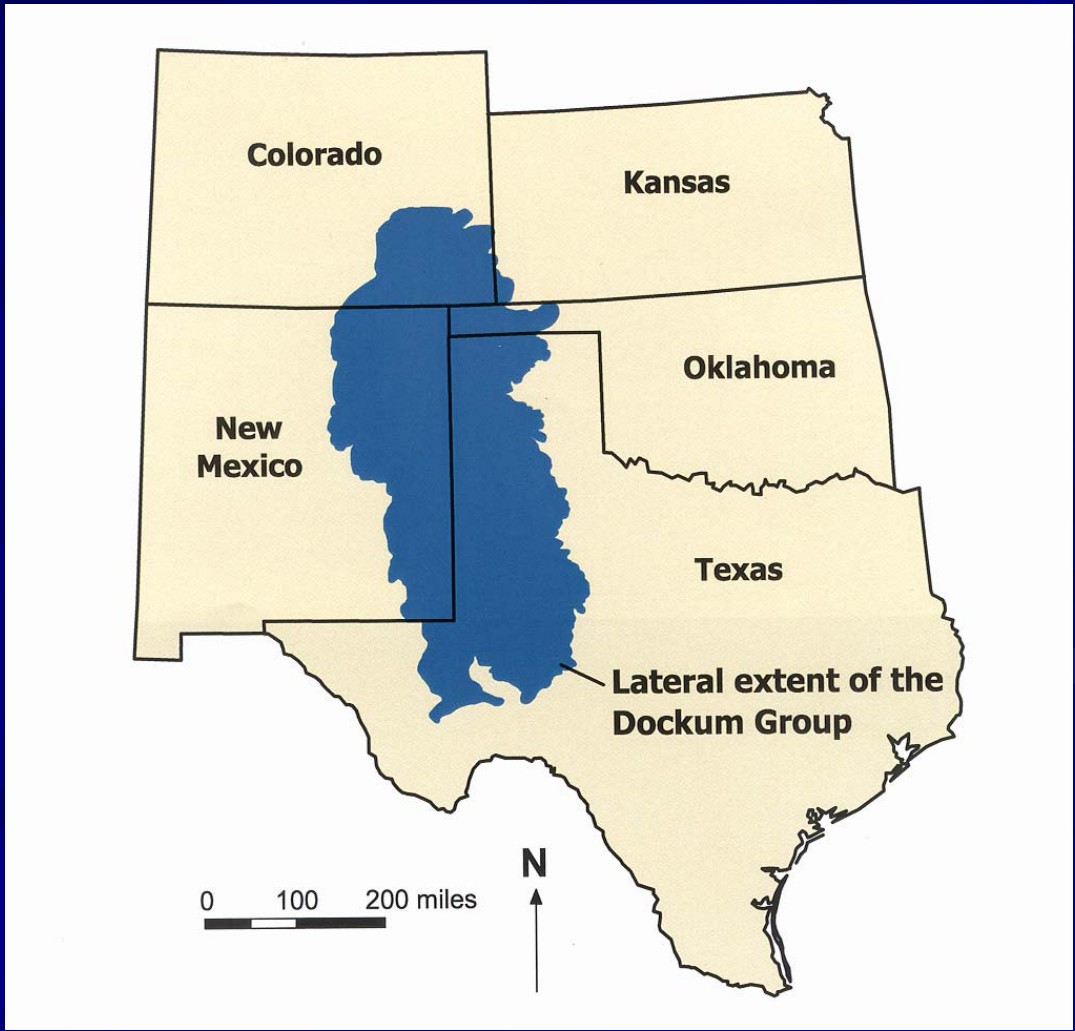


# Nomenclature for Dockum Group
## (from Bradley & Kalaswad, 2003)

| Cummins (1890) | Gould (1907) | Adams (1929) | Adkins (1932) | Reeside and others (1957) | | McGowen and others (1977, 1979) | Lucas and Anderson (1992, 1993, 1994, 1995) | | | Lehman (1994a, 1994b) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Not Recognized | Dockum Group: Trujillo Formation | Dockum Series: Chinle Formation | Chinle Formation | Not Described | Chinle Formation | Dockum Group: Upper | Chinle Group | Dockum Formation | Bull Canyon Member | Dockum Group | Cooper Canyon Formation |
| Sandstone | | Santa Rosa Sandstone | Trujillo Formation | Trujillo Formation | Santa Rosa Formation | | | | Trujillo Member | | Trujillo Sandstone |
| Red Clay | Tecovas Formation | | Tecovas Formation | Tecovas Formation | Tecovas Formation | Lower | | | Tecovas Member | | Tecovas Formation |
| | | | | | | | | | Colorado City Member | | |
| Conglomerate | | | Camp Springs Conglomerate | Camp Springs Conglomerate | Camp Springs Conglomerate | | | | Camp Springs Member | | Santa Rosa Formation |

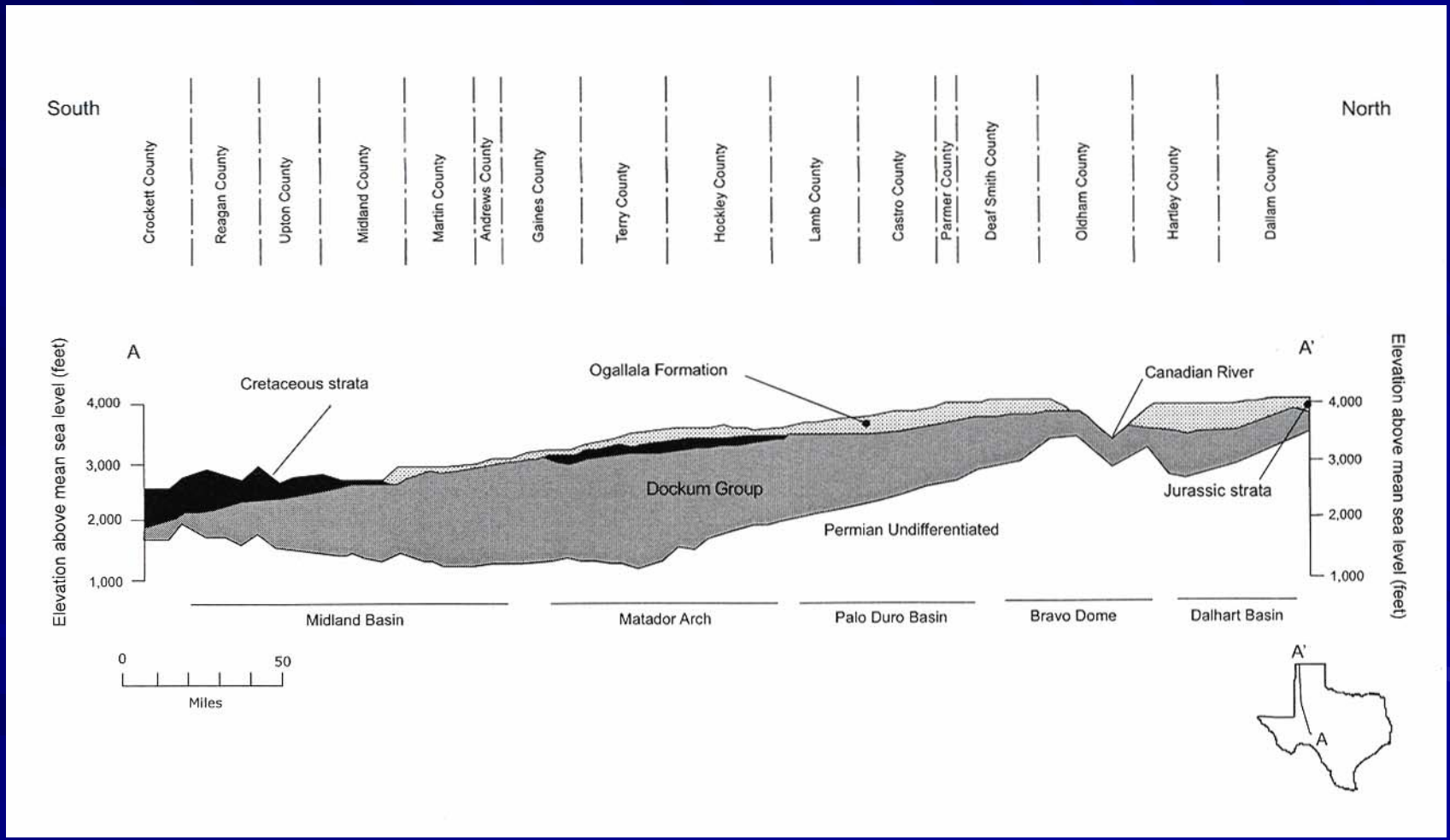
# Lateral Extent of Dockum Group in SW U.S.

**(adapted from TWDB Report 359)**



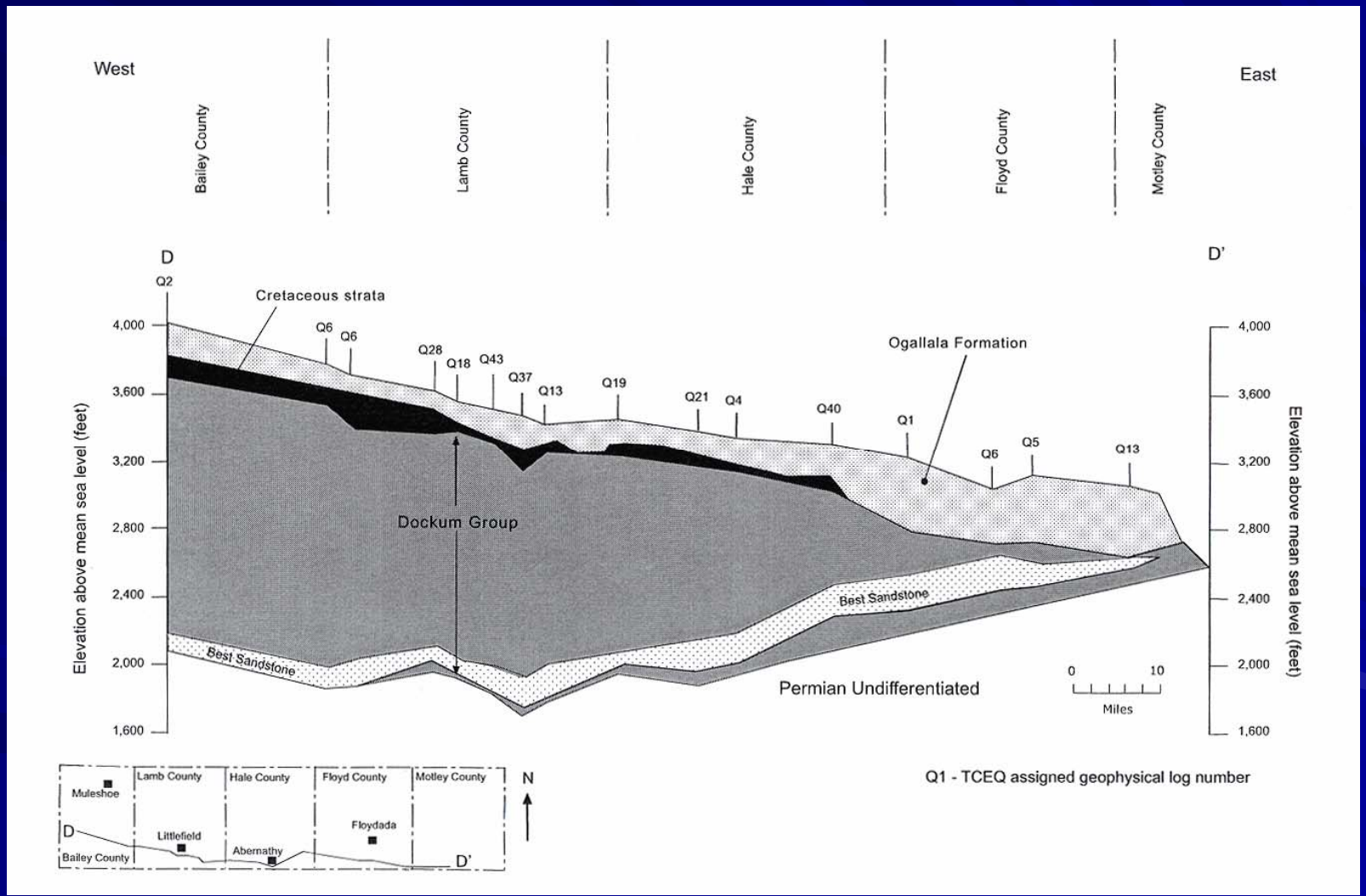
# South-North Cross Section A – A’

**(from TWDB Report 359)**



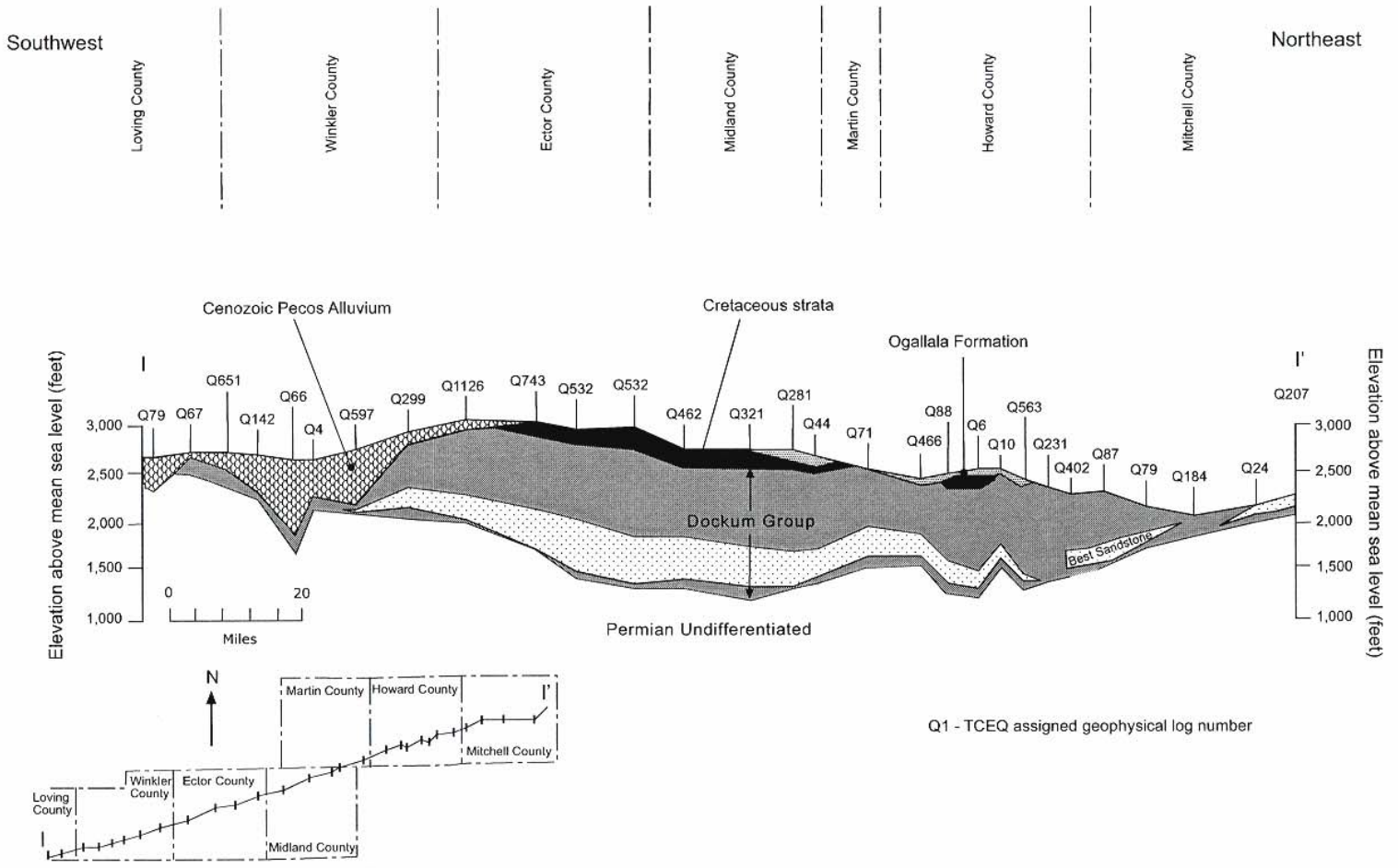
# West-East Cross Section D – D’

**(from TWDB Report 359)**

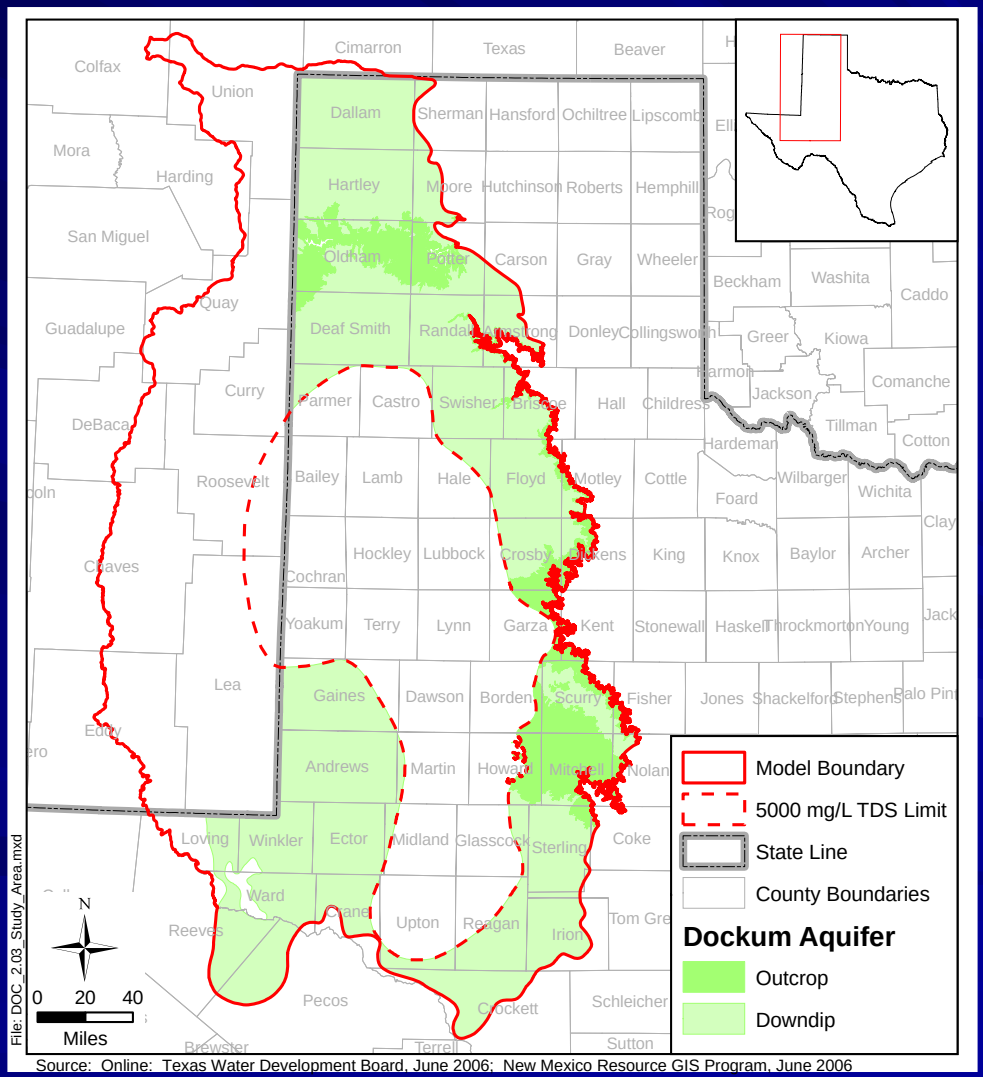


# SW-NE Cross Section I – I'

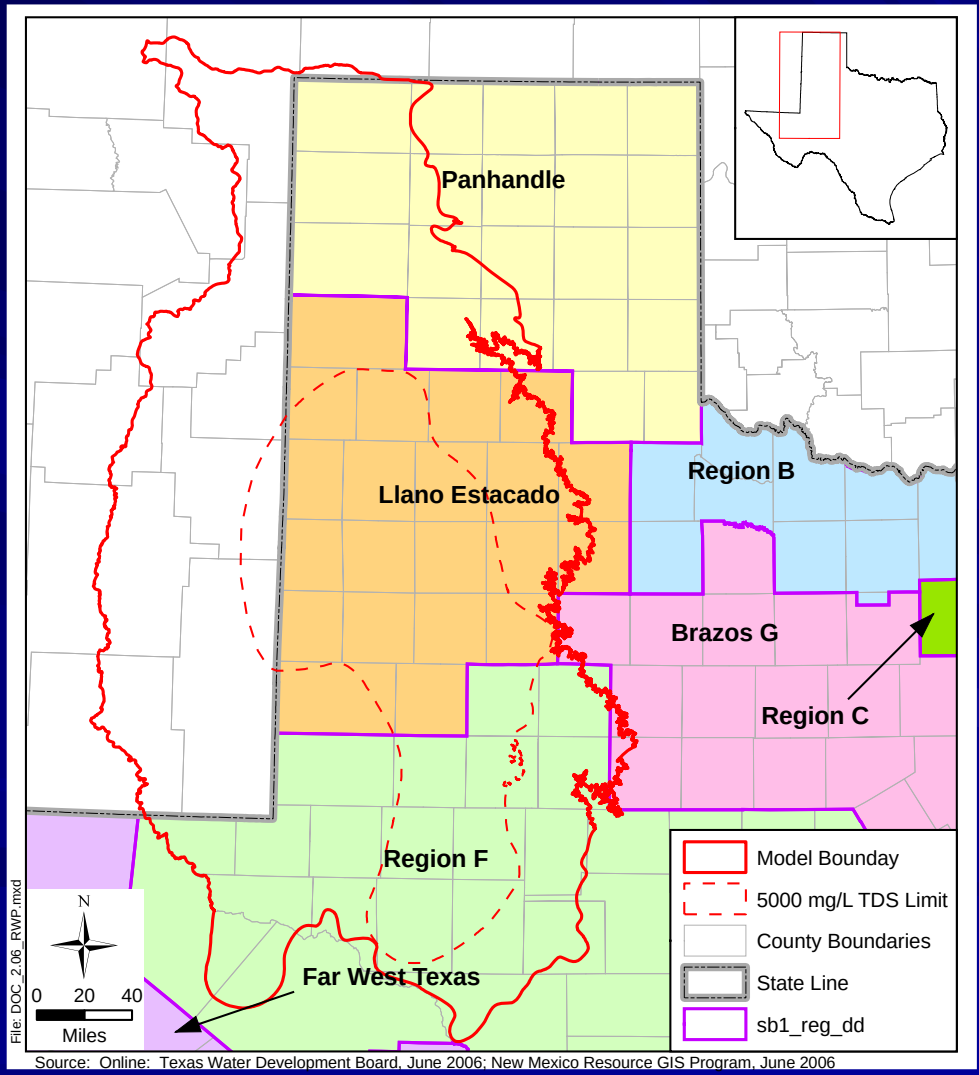
## (from TWDB Report 359)



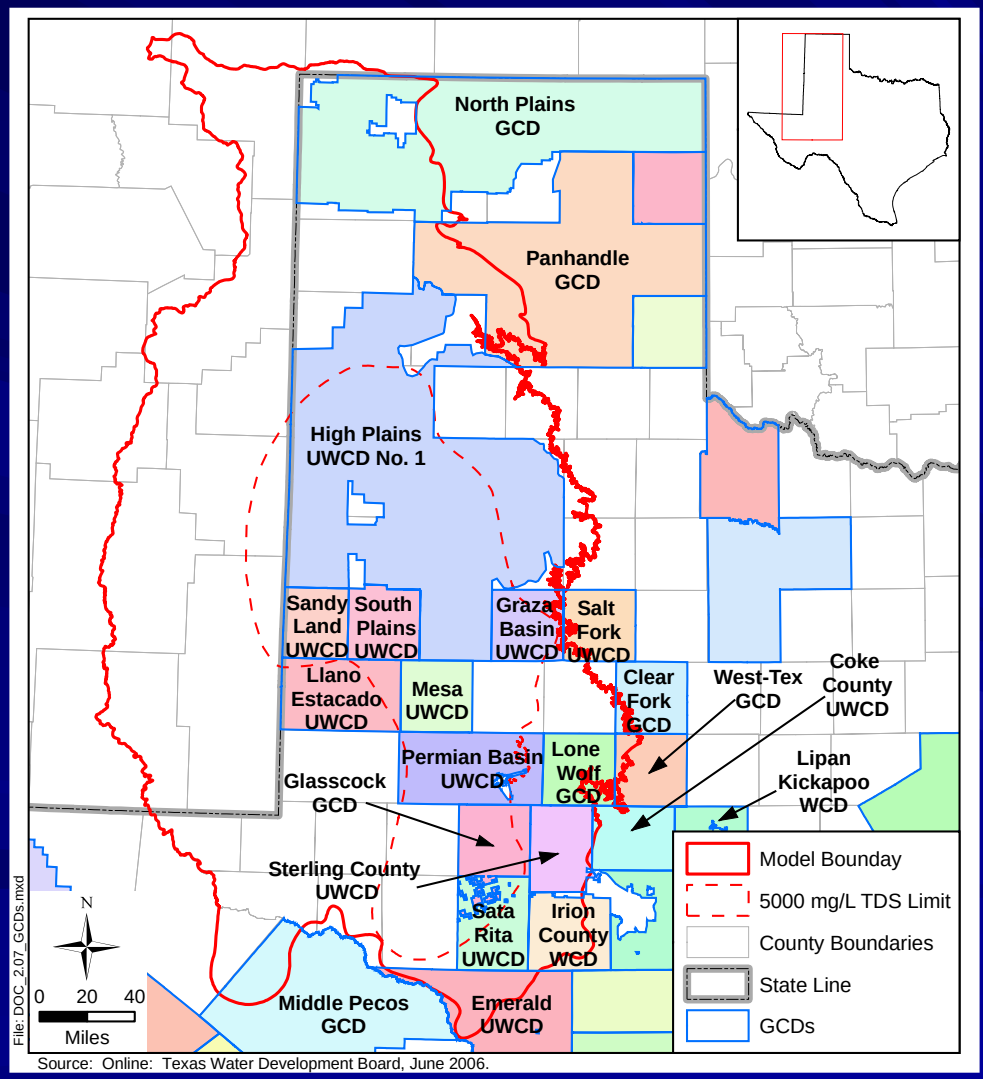
# Proposed Boundary for Dockum Aquifer GAM



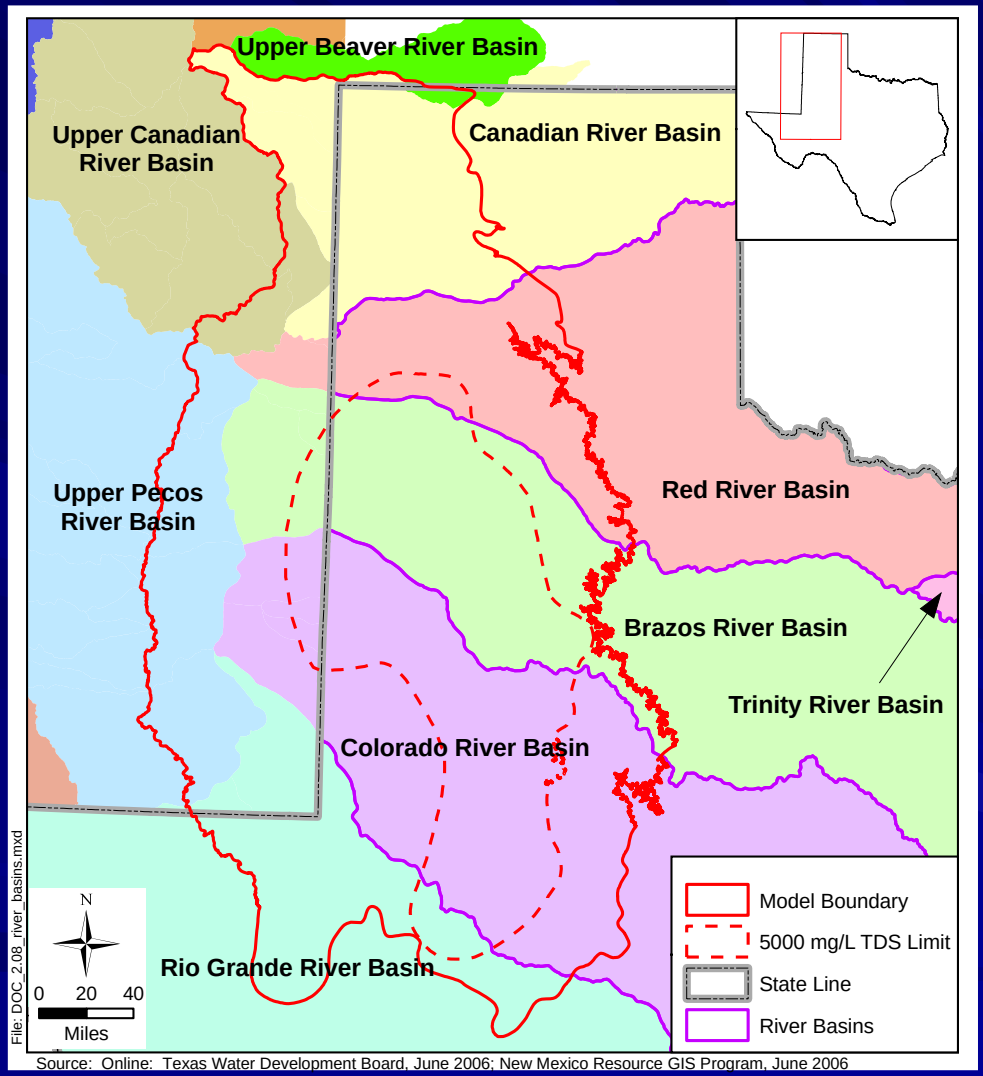
# Regional Water Planning Groups (RWPGs)



# Groundwater Conservation Districts (GCDs)



# River Basins



# Definition of a Model

Domenico (1972) defined a model as a representation of reality that attempts to explain the behavior of some aspect of reality and is always less complex than the real system it represents.

Wang & Anderson (1982) defined a model as a tool designed to represent a simplified version of reality.

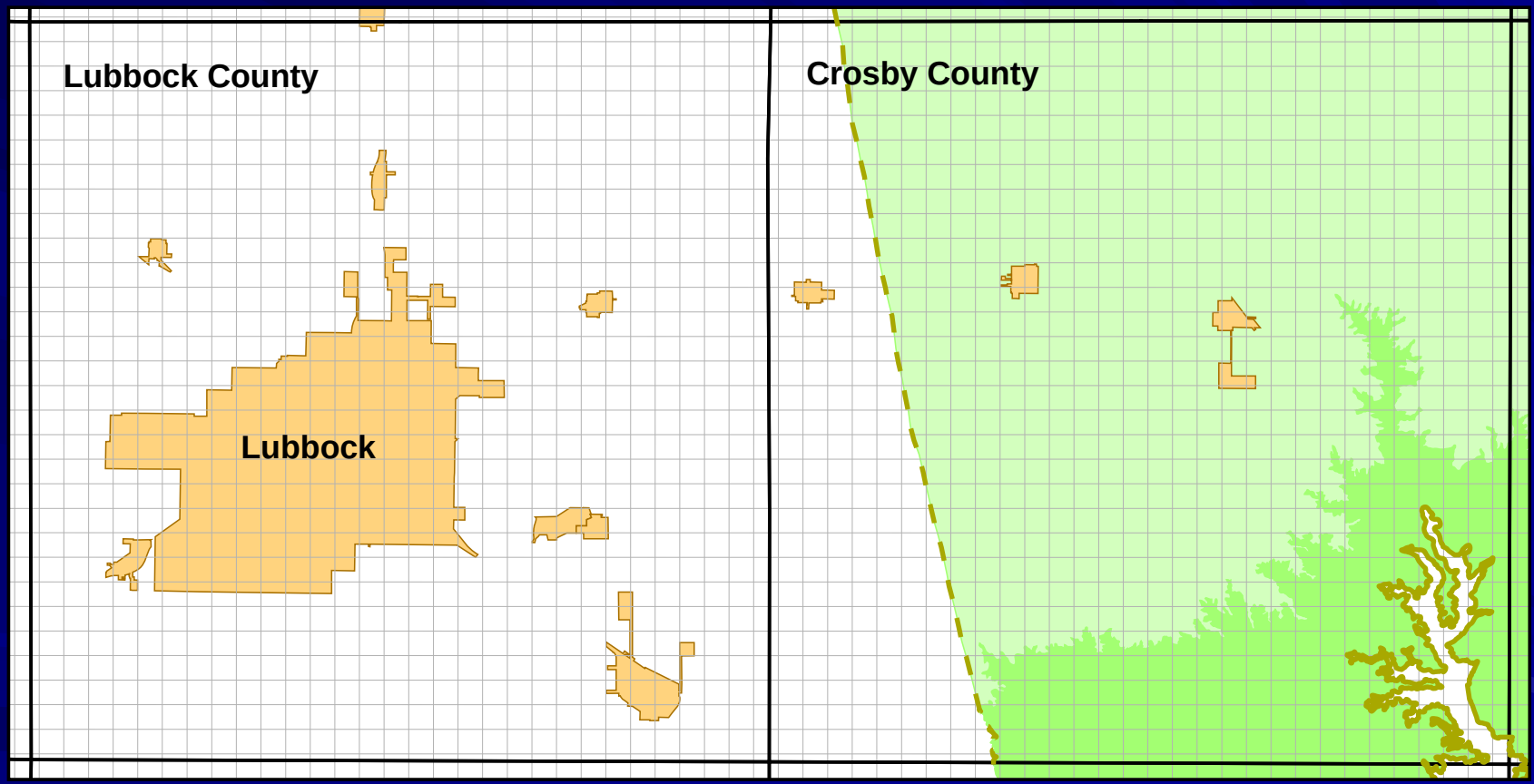
# Why Groundwater Flow Models?

- In contrast to surface water, groundwater flow is difficult to observe.
- Aquifers are typically complex in terms of spatial extent and hydrogeological characteristics.
- A groundwater model provides the only means for integrating available data for the prediction of groundwater flow at the scale of interest.

# Numerical Flow Model

- A numerical groundwater flow model is the mathematical representation of an aquifer.
- It uses the basic laws of physics that govern groundwater flow.
- In the model domain, the numerical model calculates the hydraulic head at discrete locations (determined by the grid).
- The calculated model heads can be compared to hydraulic heads measured in wells (termed model calibration).

# Model Grid Scale



# GAM Specifications

- Groundwater model (MODFLOW-2000)
- Groundwater Vistas
- Grid spacing no greater than 1 mile
- Grid must match southern part of Ogallala aquifer GAM
- Implement
  - recharge & cross-formational flow
  - groundwater/surface water interaction
  - pumping
- Calibration to observed water levels (heads) in selected wells
  - Predevelopment (steady state)
  - Transient (1980 to 1997)

# Modeling Protocol (steps)

- Define model objectives & tools*
- Data compilation & analysis **
- Conceptual model development **
- Model design **
- Model calibration
  - Predevelopment (steady-state)
  - 1980 to 1997 (transient)
- Model sensitivity analyses
- Reporting
- [Future use – evaluate water management strategies]

**** defined by TWDB***

***** steps in progress today***

# MODFLOW Groundwater Model

- Computer based model developed by the U.S. Geological Survey
- Selected by TWDB for all GAMs
- Handles the relevant processes
- Comprehensive documentation
- Public domain – non-proprietary
- Most widely used groundwater model
- Supporting interface programs available (e.g., Groundwater Vistas)

# Model Inputs

- Top & bottom elevation surfaces for each layer
- Aquifer Properties:
  - Hydraulic Conductivity
  - Storativity or specific yield (transient model)
- Initial water table elevations
- Recharge (in outcrop areas)
- Cross-formational flow (from above Dockum)
- Stream characteristics
- Pumping

# Model Limitations

- The Dockum aquifer is heterogeneous vertically and laterally.
- Data availability (e.g., geology, wells, pumping) may be limited in some regions.
- The GAM is a tool for making groundwater availability assessments on a regional basis only (grid cells are 1 mile x 1 mile).
- The GAM is not capable of predicting aquifer responses at small scales (e.g., individual wells). Such evaluations would require a refined model.

# Key Data Sources

- TWDB & predecessors reports
- U.S. Geological Survey reports
- UT Bureau of Economic Geology reports
- New Mexico Bureau of Mines & Mineral Resources groundwater reports
- TCEQ - drillers logs & specific capacity data
- Brune (1975) - spring locations & flows

# Key Data Sources (cont'd)

- TWDB website
  - wells
  - heads
  - pumping
  - water quality
  - aquifer boundary in Texas
- U.S. Geological Survey website
  - topography
  - stream locations and flows
  - land use / land cover

# Key Data Sources (cont'd)

- U.S. EPA website
  - stream characteristics
- National Climatic Data Center website
  - precipitation

# Current Data Needs

- Dockum data for areas with sparse information
  - Geologic logs
  - Water levels (elevations)
  - Aquifer hydraulic properties
- Relevant data not in the TWDB data base. Data provided must be documented and publicly available.
- Request data be provided in next 2 months (by October 20, 2006).

# Current Data Needs (cont'd) – Who to Contact?

- Ian Jones
  Texas Water Development Board
  P.O. Box 13231
  Austin, TX 78711
  (512) 936-0848
  ian.jones@twdb.state.tx.us
- John Pickens
  INTERA Inc.
  9111A Research Blvd
  Austin, TX 78758
  (512) 425-2030
  jpickens@intera.com

# GAM Schedule

- Project start – May 2006
- Draft Conceptual Model Report – April 2, 2007
- Draft Final Report to TWDB – March 31, 2008
- Model Training Seminar – May 2008
- Final Model Report to TWDB – July 31, 2008

- Note: SAFs are scheduled periodically as milestone meetings

# Meeting Wrap-Up

- Discussion / comments / questions
- SAF#2 schedule - after completion of conceptual model development

**Dockum Aquifer GAM**
**1st Stakeholder Advisory Forum**
**July 20, 2006**
**Lubbock, Texas**

| Name | Affiliation |
|---|---|
| John Ashworth | LBG-Guyton & Associates |
| H.P. Brown | Region O |
| Ken Carver | Permian Basin UWCD |
| Jason Coleman | South Plains UWCD |
| Jim Conkwright | High Plains Water UWCD |
| Amy Crowell | Panhandle GCD |
| Harvey Everheart | Mesa UWCD |
| Kendall Harris | Collingsworth County UWCD |
| Kevin Hopson | Daniel B. Stephens & Associates |
| Ian Jones | TWDB |
| Temple McKinnon | TWDB |
| John Pickens | INTERA Incorporated |
| Judy Reeves | |
| Becky Stewart | Wes-Tex GCD |
| Ben Weinheimer | Texas Cattle Feeders Association |
| John Williams | Canadian River MWA |
| Sue Young | Lone Wolf GCD |

**Dockum Aquifer GAM**
**1st Stakeholder Advisory Forum**
**Comments and Responses**
**July 20, 2006**
**Lubbock, Texas**

Q. *What information sources were used to determine the extent of the Dockum?*
A. Land surface exposures have been mapped by geologists for many years, while subsurface extents, both vertically and laterally, have mostly been identified using geophysical logs from primarily oil and gas wells. Data from a few water wells have also been useful.

Q. *Some wells, primarily in the north, have been completed in both the Ogallala and the Dockum. How will you determine the top of the Dockum (base of Ogallala) in these areas?*
A. We will first consider the base of Ogallala as it was defined in the Ogallala GAM. If we find any inconsistencies, we will review the wells used by the Ogallala GAM team to create their base and then work with the TWDB to remedy the inconsistency.

Q. *Is all of the Dockum saturated?*
A. Although the immediate subsurface may be wet as recharge moves through these sediments, it is only the portion below the water table that is considered saturated in terms of water production potential.

Q. *What defines the base of the Dockum?*
A. Geologically, the base is defined as the contact between the overlying Triassic-age Dockum and the underlying Permian-age formations. Because these units both generally consist of clay or shale, it is sometimes a bit difficult to determine the contact on geophysical logs. From a water well perspective, a driller would probably consider the bottom of the main water-producing sand as being the base. For modeling purposes, we will define a lower Dockum layer that allows minimal flow out.

Q. *What is the typical thickness of the principal sand unit in the Dockum?*
A. Approximately 100 to 200 feet and thinning toward the outer extent.

Q. *Is there flow through the overlying clay unit to the underlying sand unit?*
A. The vertical flow would be very minimal; however, the flow volume will be handled in the model as a calibration parameter.

Q. *Will you model water quality?*
A. The TWDB contract does not call for water quality modeling; however, water quality will be evaluated and discussed in the conceptual model portion of the project report.

Q. *Will you be refining the water quality contours on existing maps?*
A. Yes, we will attempt to refine the contours if sufficient data is available.

Q. *Will you quantify water quality?*
A. It is possible to use a model to quantify groundwater volumes within the aquifer that occurs between contour intervals, or within other designated boundaries such as county borders.

Q. *Will the results of the GAM be useful in evaluating Regional Water Planning Strategies that identify the Dockum as a source for use instead of the Ogallala?*
A. Yes. Quantity and possibly quality can be estimated for any specific location within the extent of the modeled area.

Q. *How much data acquisition will occur in New Mexico?*
A. We have obtained groundwater reports from New Mexico state agencies (i.e., NM Bureau of Mines and Mineral Resources) and have access to databases. INTERA has an Albuquerque office, which routinely addresses similar data acquisition needs in New Mexico.

Q. *What will be the grid size of the model?*
A. 1 x 1 mile, same as the Ogallala model grid.

Q. *Will there be an evaluation of interformational flow between aquifers?*
A. Yes, and in the case of overlying units, we will be coordinating this exchange with modeling teams that are working on the Ogallala and the Edwards-Trinity (High Plains) aquifers.

Q. *Can the GMA future desired conditions deadline be extended to include the results of the Dockum GAM?*
A. The absolute deadline is not until 2010, so there will be sufficient time to use the GAM to assist in quantifying the conditions. However, the Dockum GAM may not be ready in time to meet the timeline for input into the next round of regional planning.

*Offered Data/Information Suggestions:*

- A Texas Tech M.S. thesis on the Dockum has recently been completed.
- Seagraves may need to consider the Dockum as an alternative water supply source in the future.
- We should coordinate with the Edwards-Trinity (High Plains) GAM team who is pursuing surface casing data.
- High Plains UWCD has previously initiated a data collection study on the Dockum. They will review what data they had collected and make it available.