Groundwater Availability Modeling (GAM) for the Lipan Aquifer

LBG-GUYTON Associates

texas water development board

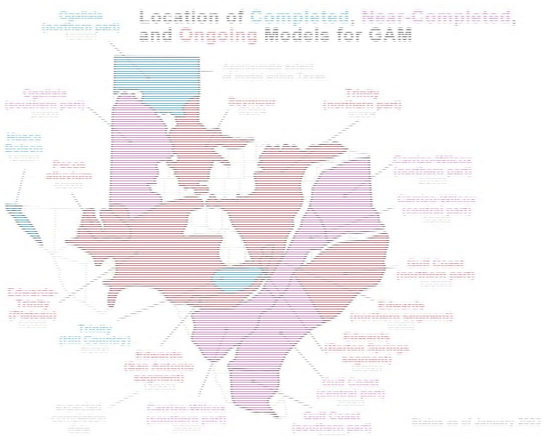
Presented to

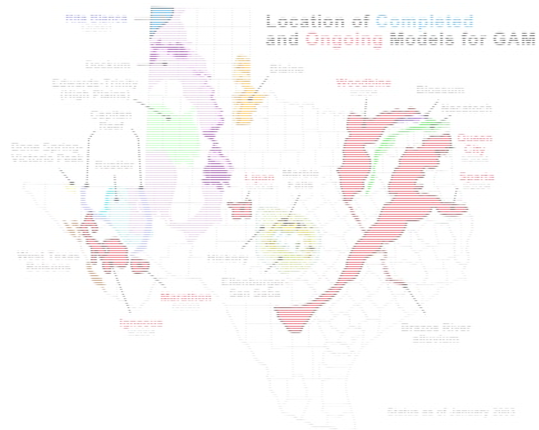
Stakeholder Advisory Forum

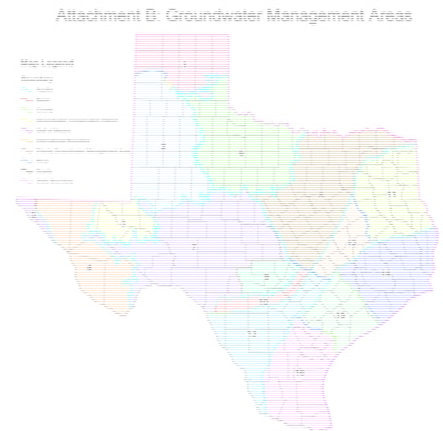
San Angelo, Texas

April 24, 2003

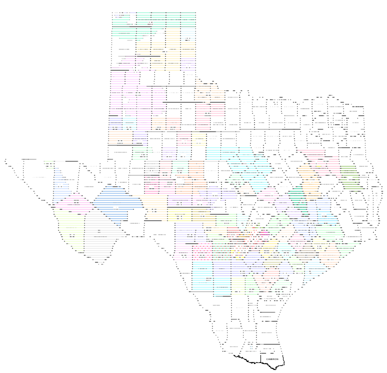
Groundwater Availability Modeling

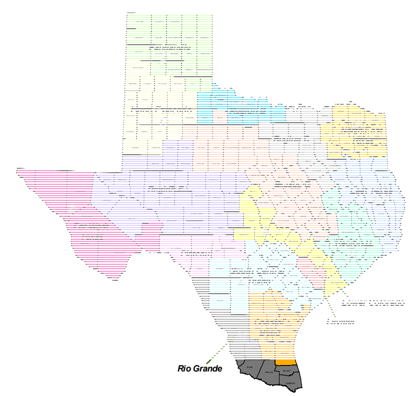




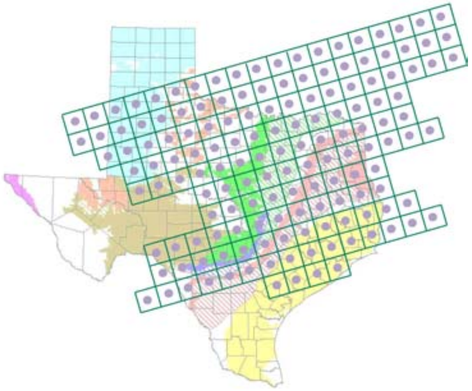


Contract Manager



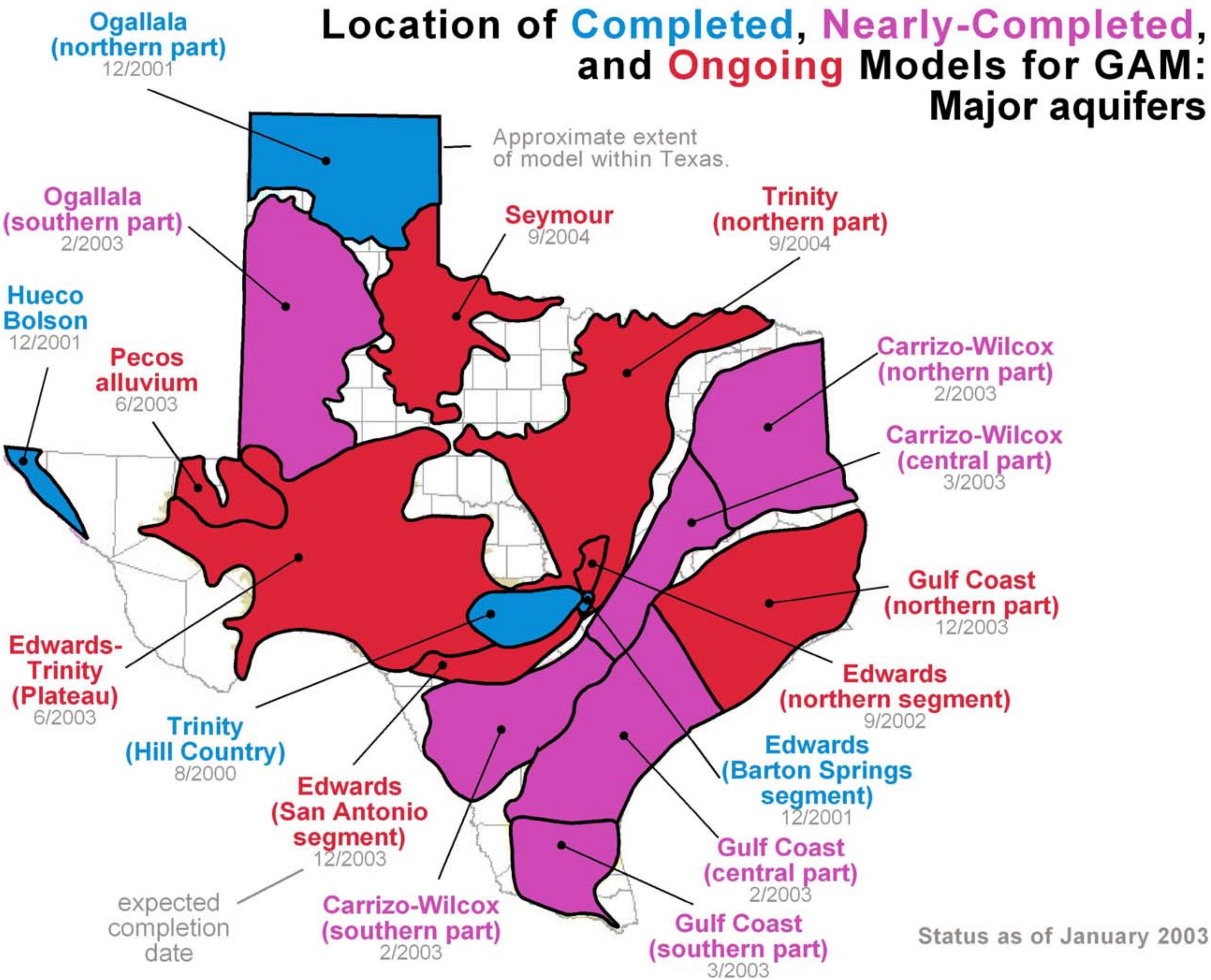


Texas Water Development Board



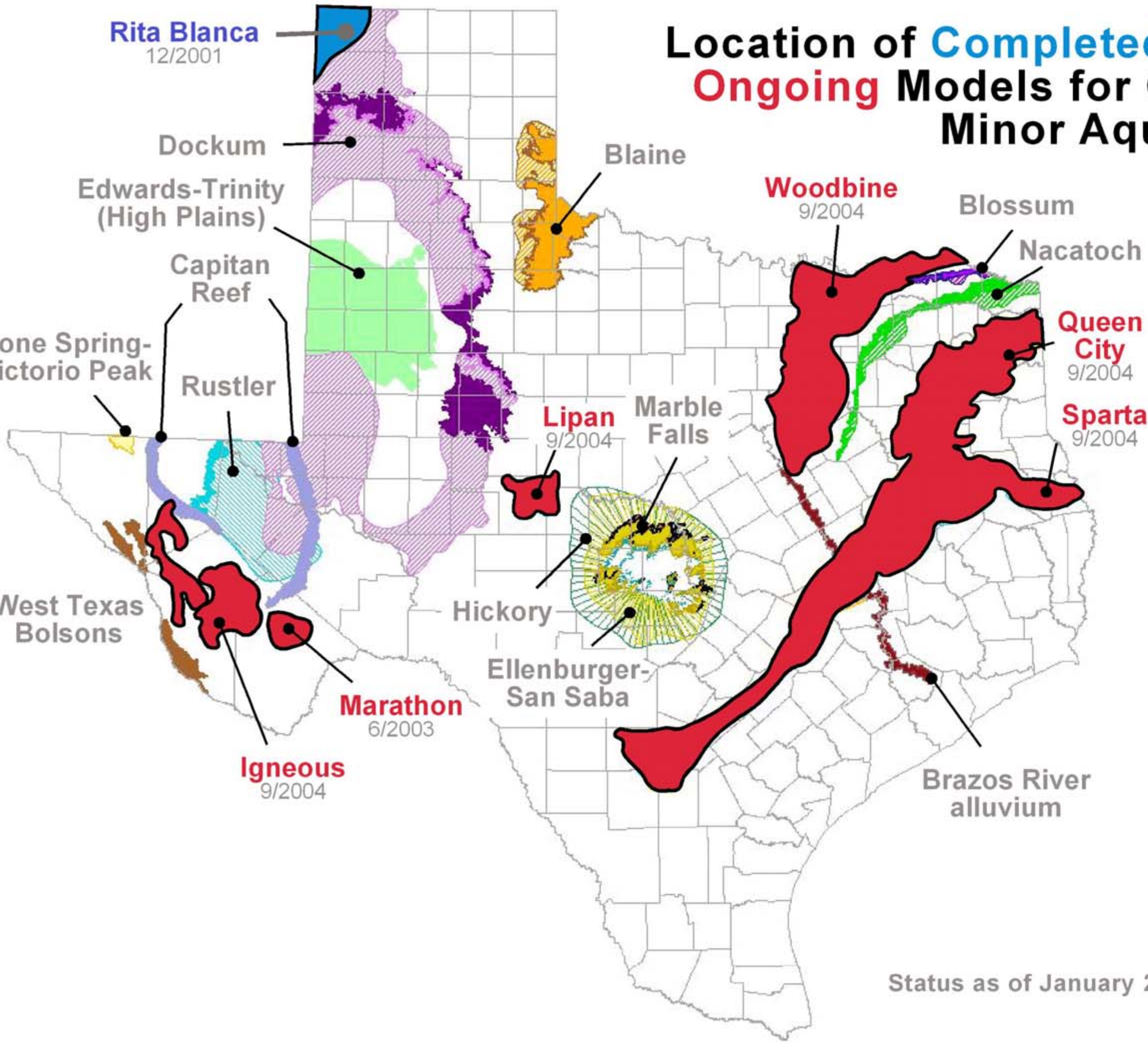
GAM

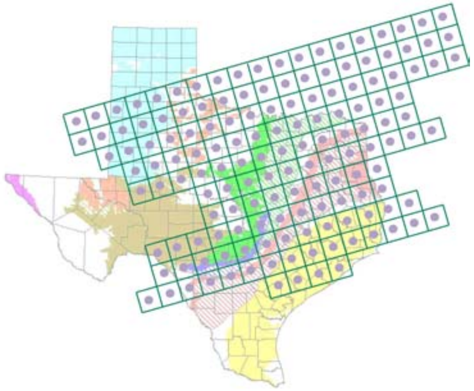
- Purpose: to develop the best possible groundwater availability model with the available time and money.
- Public process: you get to see how the model is put together.
- Freely available: standardized, thoroughly documented, and available over the internet.
- Living tools: periodically updated.



Location of Completed, Nearly-Completed, and Ongoing Models for GAM: Major aquifers
Ogallala (northern part) 12/2001
Approximate extent of model within Texas.
Ogallala (southern part) 2/2003
Seymour 9/2004
Trinity (northern part) 9/2004
Hueco Bolson 12/2001
Pecos alluvium 6/2003
Carrizo-Wilcox (northern part) 2/2003
Carrizo-Wilcox (central part) 3/2003
Gulf Coast (northern part) 12/2003
Edwards-Trinity (Plateau) 6/2003
Edwards (northern segment) 9/2002
Trinity (Hill Country) 8/2000
Edwards (Barton Springs segment) 12/2001
Edwards (San Antonio segment) 12/2003
Gulf Coast (central part) 2/2003
expected completion date
Carrizo-Wilcox (southern part) 2/2003
Gulf Coast (southern part) 3/2003
Status as of January 2003

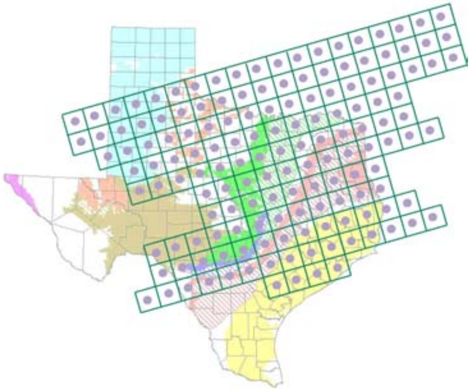
Location of Completed and Ongoing Models for GAM: Minor Aquifers





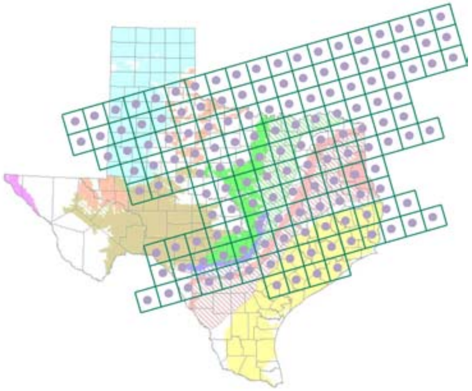
What is groundwater availability?

- …the amount of groundwater available for use.
- The State does not decide how much groundwater is available for use: GCDs and RWPGs decide.
- A GAM is a tool that can be used to assess groundwater availability once GCDs and RWPGs decide how to define groundwater availability.



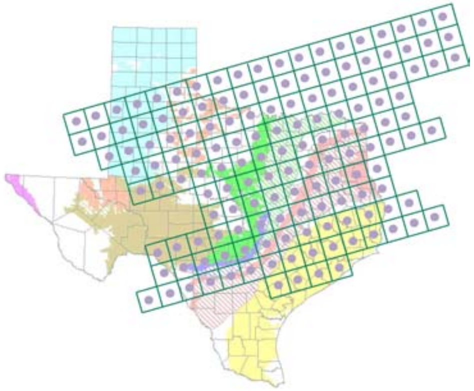
Do we have to use GAM?

- Water Code & TWDB rules require that GCDs use GAM information. Other information can be used in conjunction with GAM information.
- TWDB rules require that RWPGs use GAM information unless there is better site specific information available



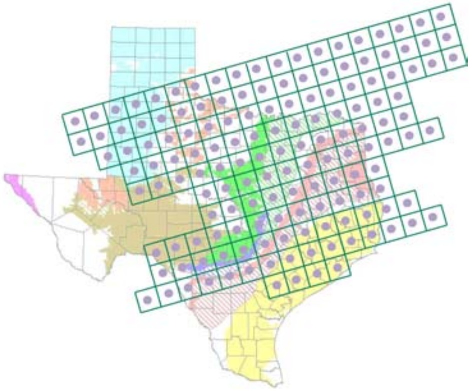
How do we use GAM?

- 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
  - Robert Mace
  - Richard Smith

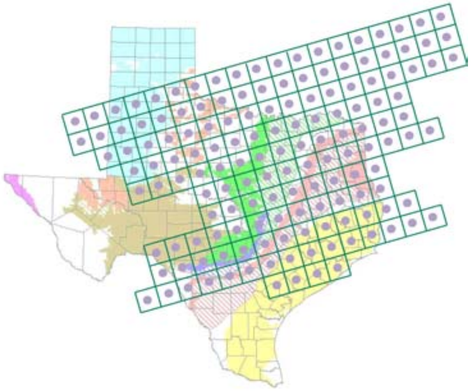
Comments:

Richard Smith

richard.smith@twdb.state.tx.us

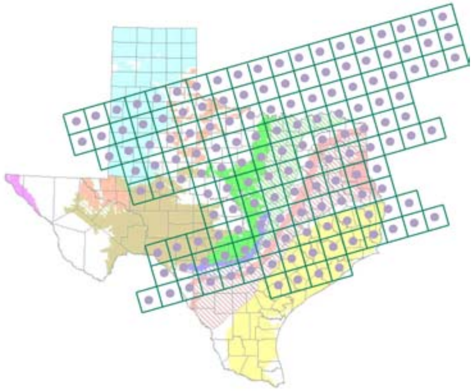
(512)936-0877

www.twdb.state.tx.us/gam



Presentation Outline

- Review of GAM Objectives and Expectations
- Basics of Groundwater Flow Modeling
- Conceptual Groundwater Flow Model

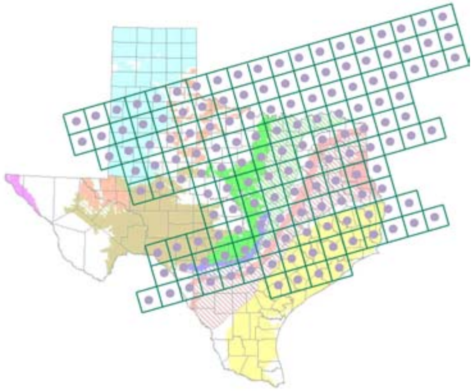


GAM Objectives

- Provide reliable and timely information on GW availability to ensure adequate supplies or recognize inadequate supplies through 2050

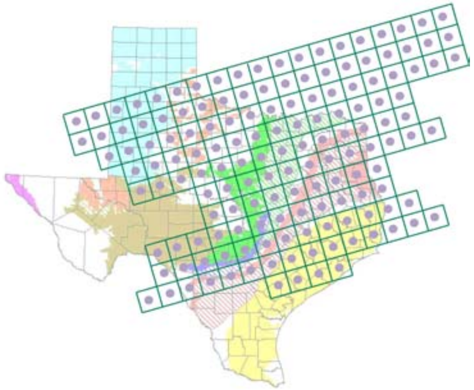
- Develop realistic and scientifically accurate GW flow models representing the physical characteristics of the aquifer and incorporating the relevant processes

- The models are designed as tools to help assess GW availability through 2050 based on current projections of groundwater demands



What a GAM IS.

- Tool to meet the TWDB GAM objectives as specified by Texas Legislature.
- Tool to perform regional evaluation for long-term water supply.
- Tool developed from an assimilation and interpretation of significant research and different types of data.



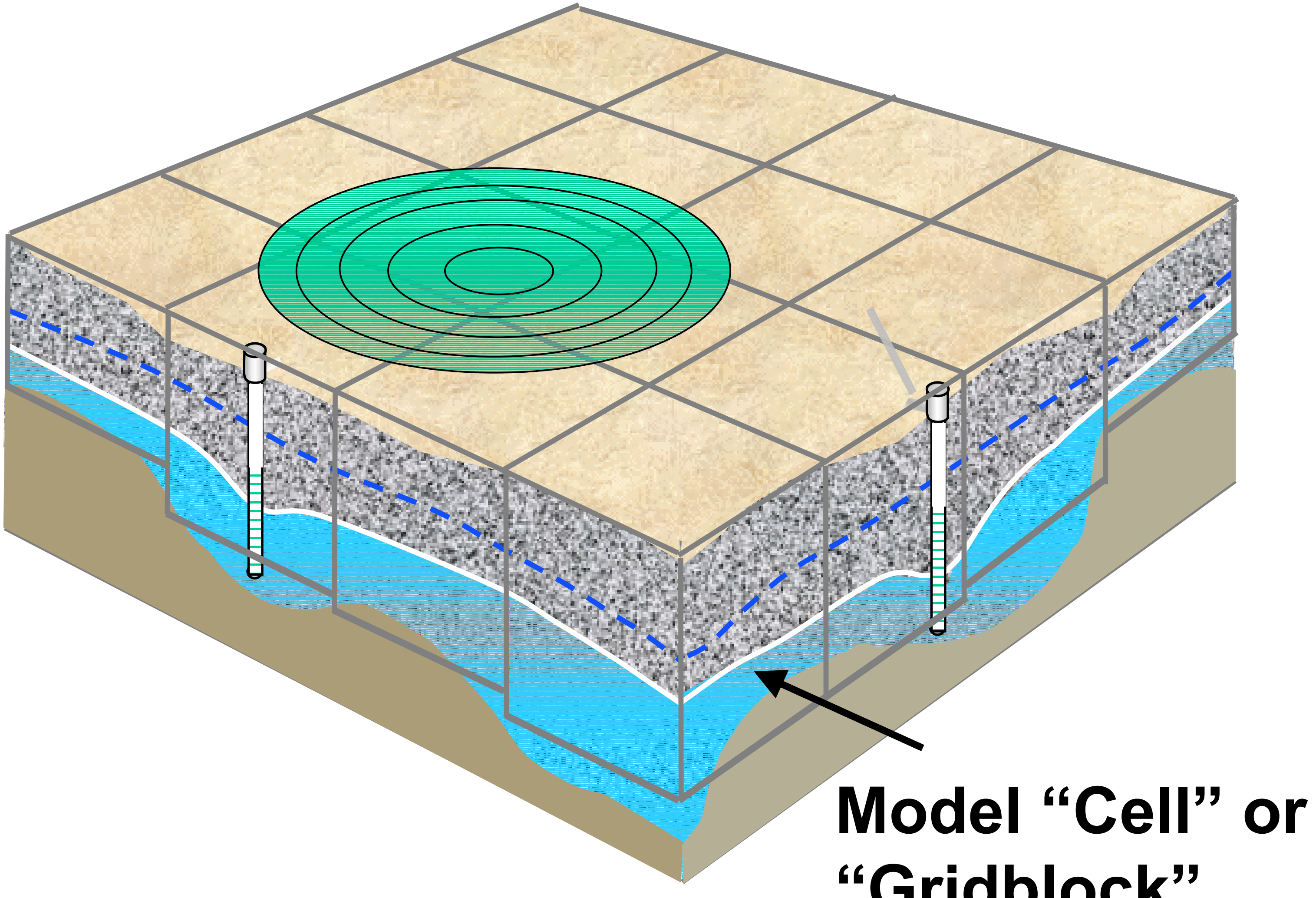
What a GAM is NOT.

- Something that can tell you the water level in your backyard well to the nearest hundredth of a foot every minute of the day.
- Icon on a desktop computer that can be easily used and correctly interpreted by anyone.
- The definition of groundwater availability.

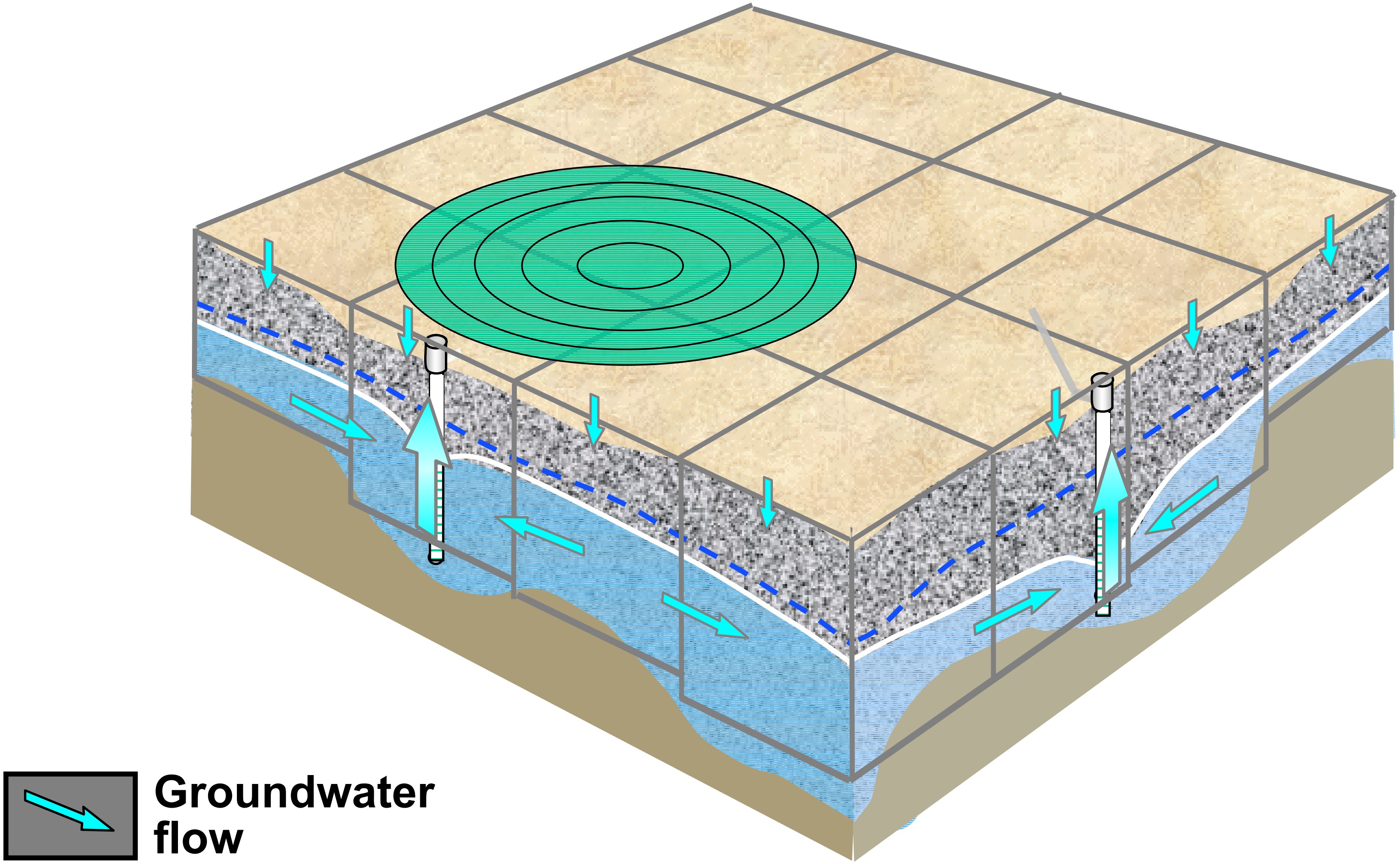
Numerical GW Flow Modeling

- A numerical groundwater flow model is the mathematical representation of the physical aquifer
- A numerical model calculates the water level at specific locations based on aquifer characteristics, pumping, recharge, etc.
- Calculated water levels can be compared to measured water levels in wells

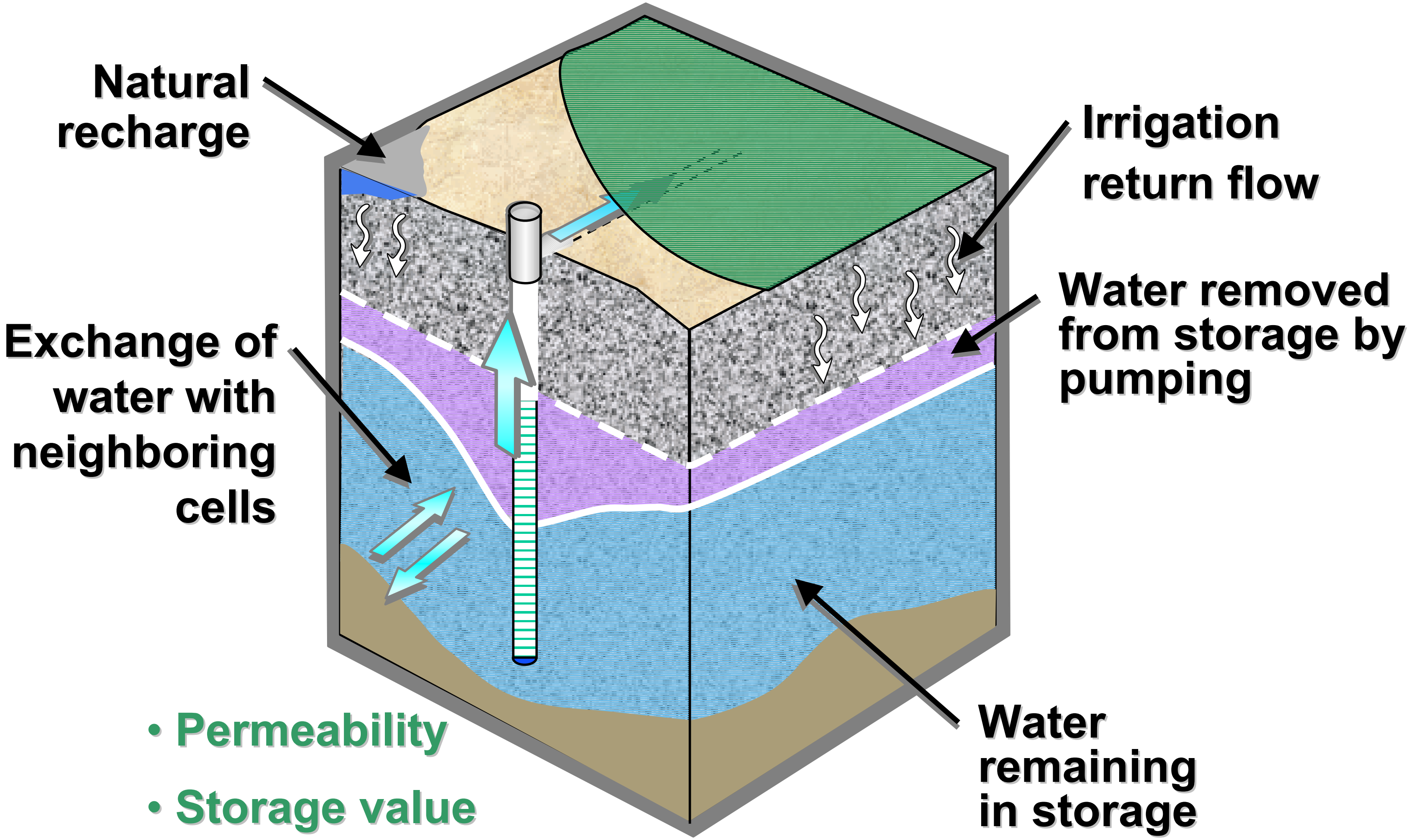
Groundwater Flow Modeling



Cells “Communicate”



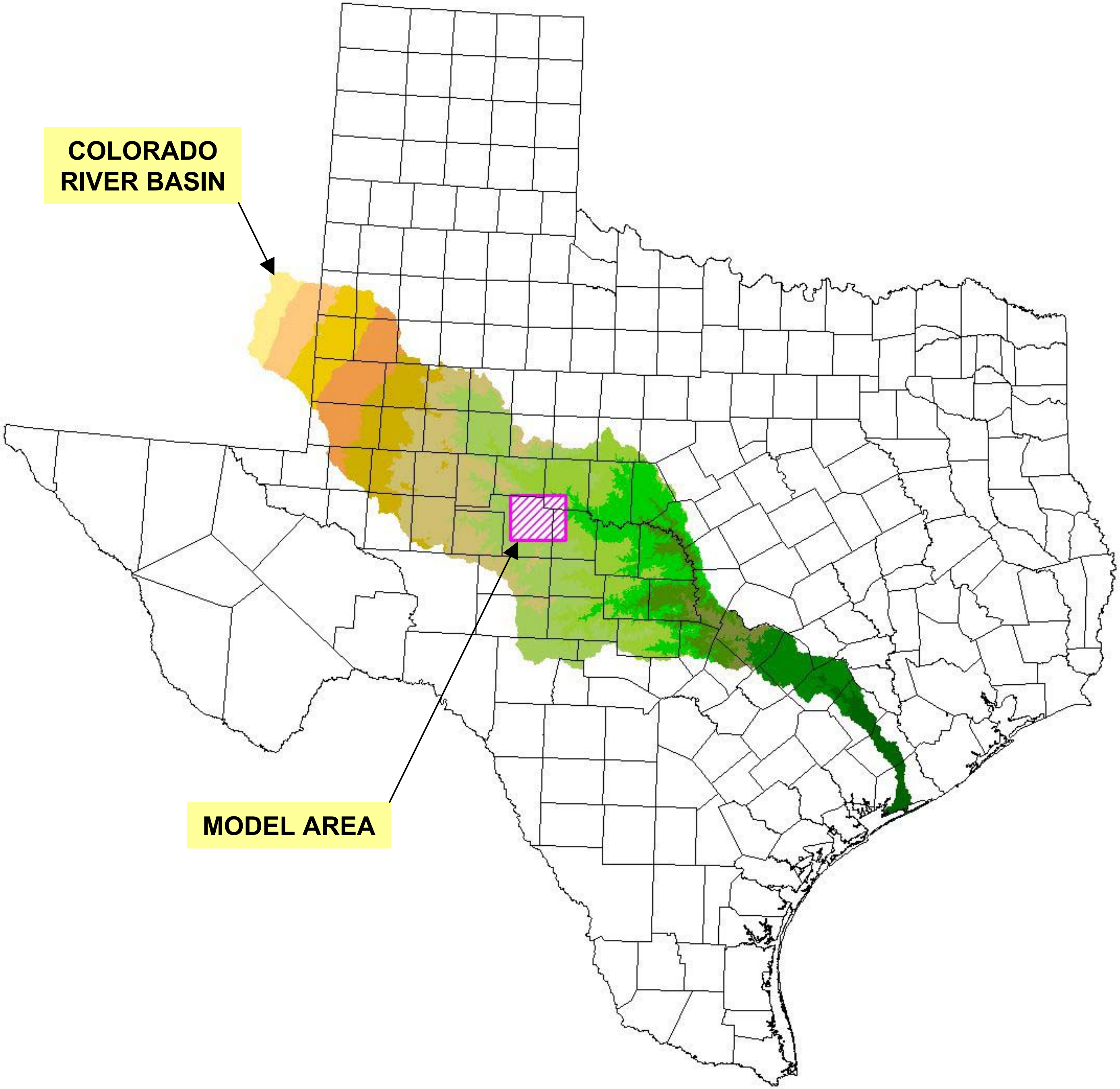
Gridblock Accounting



- Permeability
- Storage value
- Thickness

What is a Conceptual Model?

- A Compilation of All Data Required by the Numerical Model
- An Understanding of the Quality of this Data
- An Understanding of the Expected Sensitivity of the Numerical Model to this Data
- A Detailed Understanding of the Processes and Interactions Influencing the Groundwater Flow System


COLORADO
RIVER BASIN
MODEL AREA

Study Area

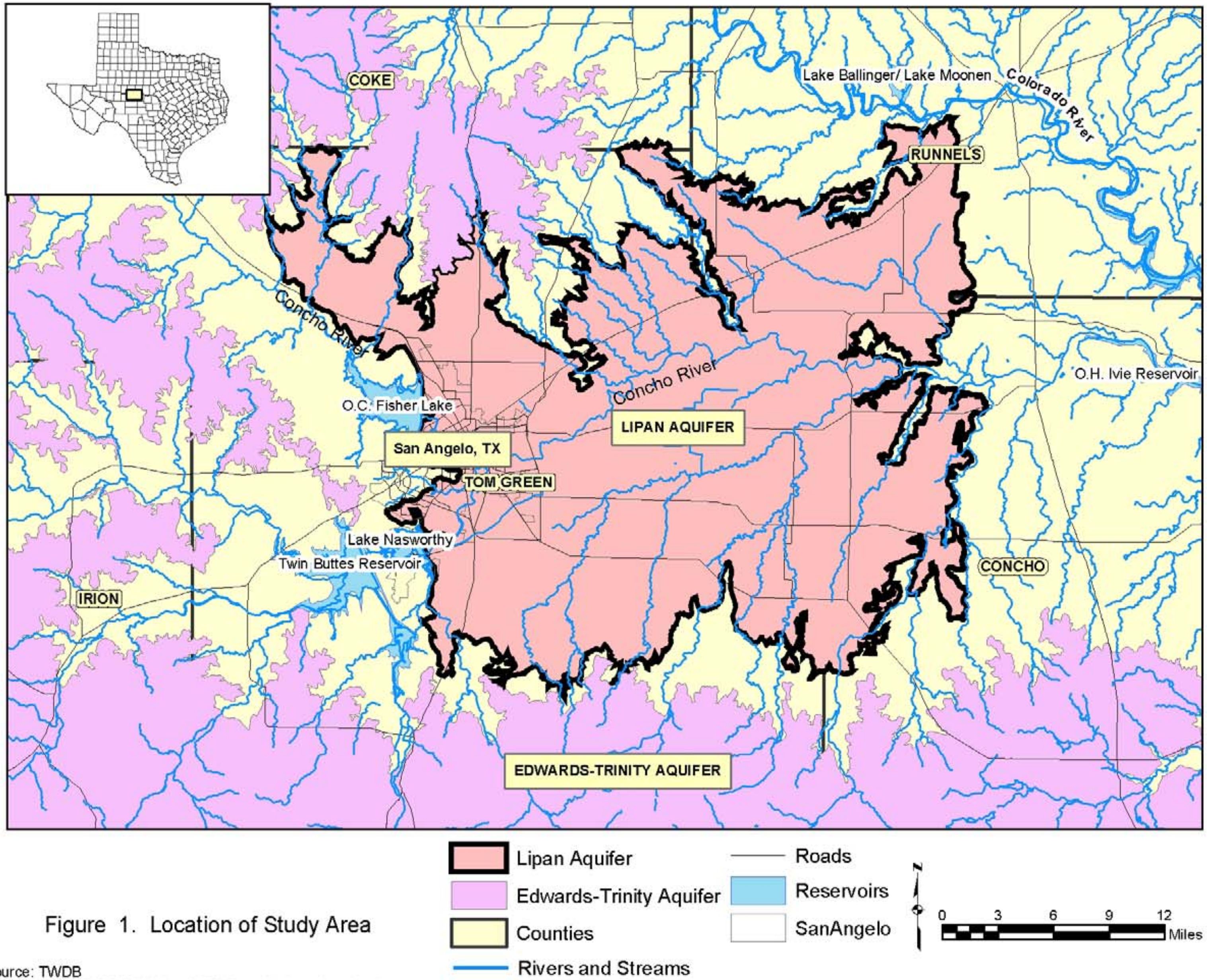


Figure 1. Location of Study Area

Data Source: TWDB
Data: S:\Projects\GAM02\GAMLipan\LEON\scrdata\<various locations>
Location: S:\Projects\GAM02\GAMLipan\LEON\LEON_StudyArea.mdx

Regional Water Planning Groups

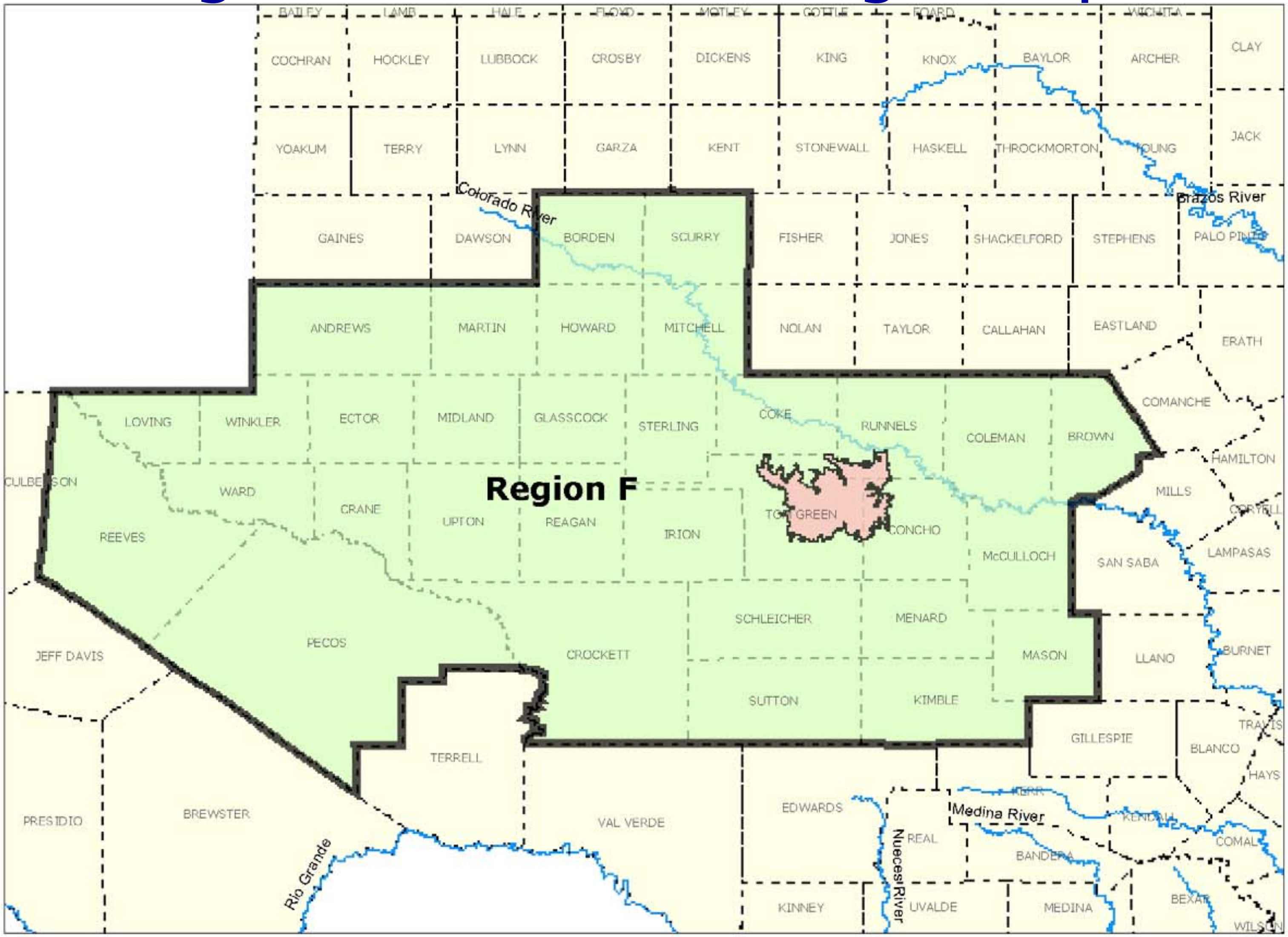
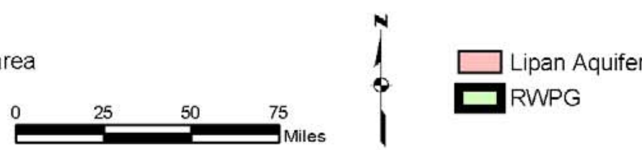
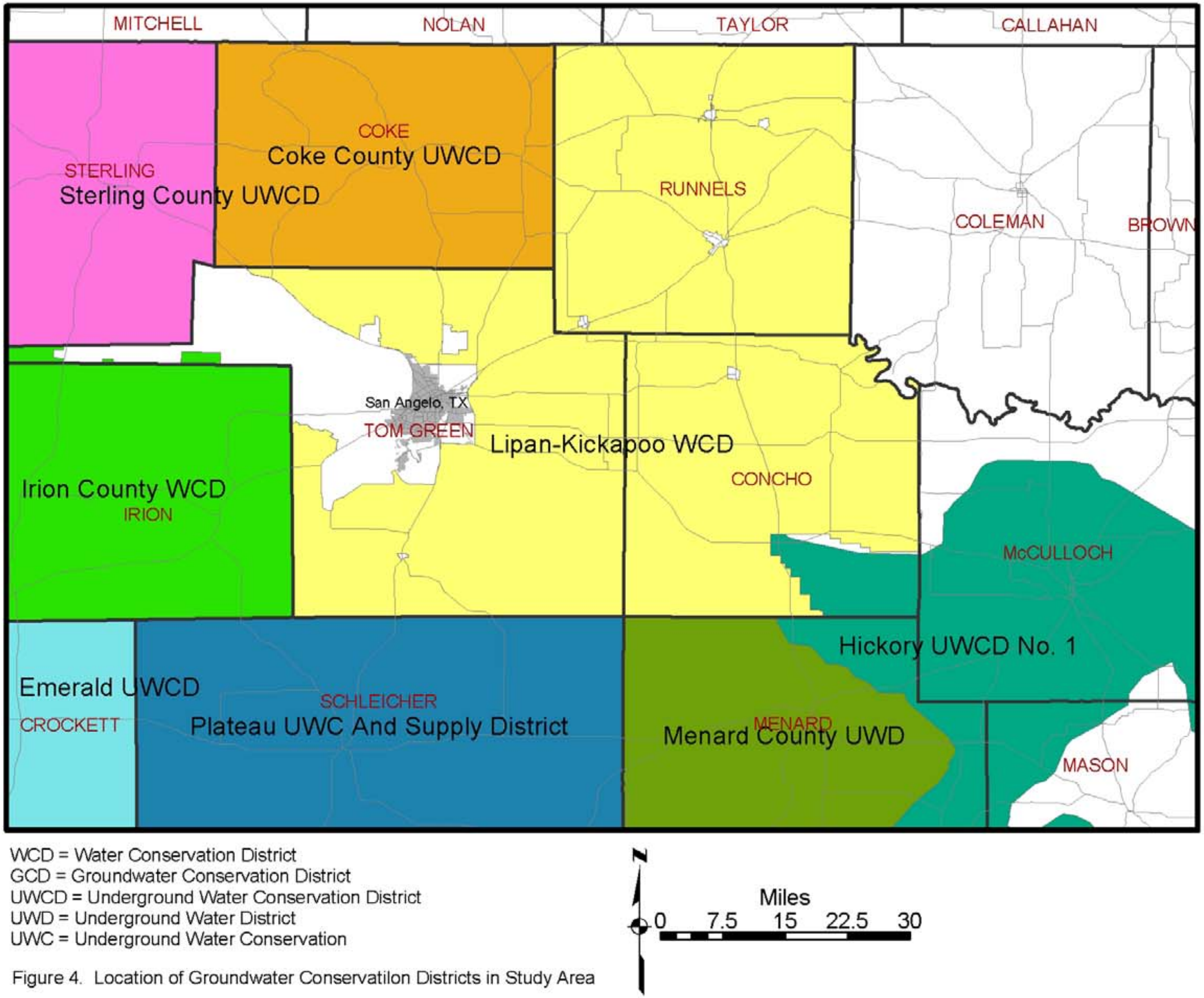


Figure 3. Location of Regional Water Planning Groups (RWPG) in area

Source: http://www.twdb.state.tx.us/mapping/gisdata.htm
Location: S:\Projects\GAM02\GAM Lipan\LEON\LEON_RWPG.mxd



Groundwater Conservation Districts



WCD = Water Conservation District
GCD = Groundwater Conservation District
UWCD = Underground Water Conservation District
UWD = Underground Water District
UWC = Underground Water Conservation

Figure 4. Location of Groundwater Conservatilon Districts in Study Area

Source: http://www.twdb.state.tx.us/mapping/gisdata.htm
Location: S:\Projects\GAM02\GAM Lipan\LEON\LEON_GWCD.mxd

Wells with Driller's Logs

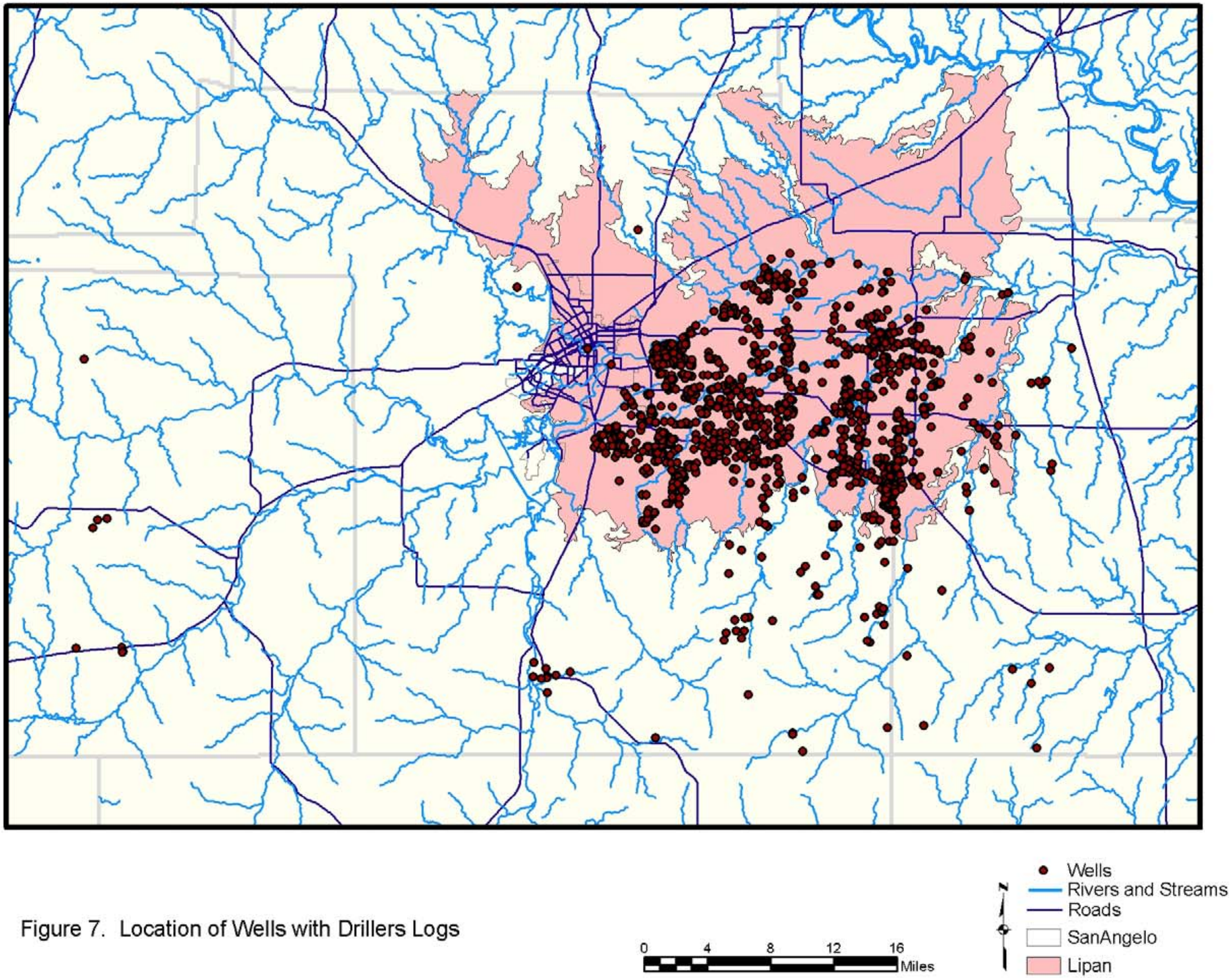


Figure 7. Location of Wells with Drillers Logs

Source: S:\Projects\GAM02\GAMLipan\Prelim_Model\Database\Lipan.mdb
Location: S:\Projects\GAM02\GAMLipan\LEON\LEON_geop.mdx

Production Capacity of Wells

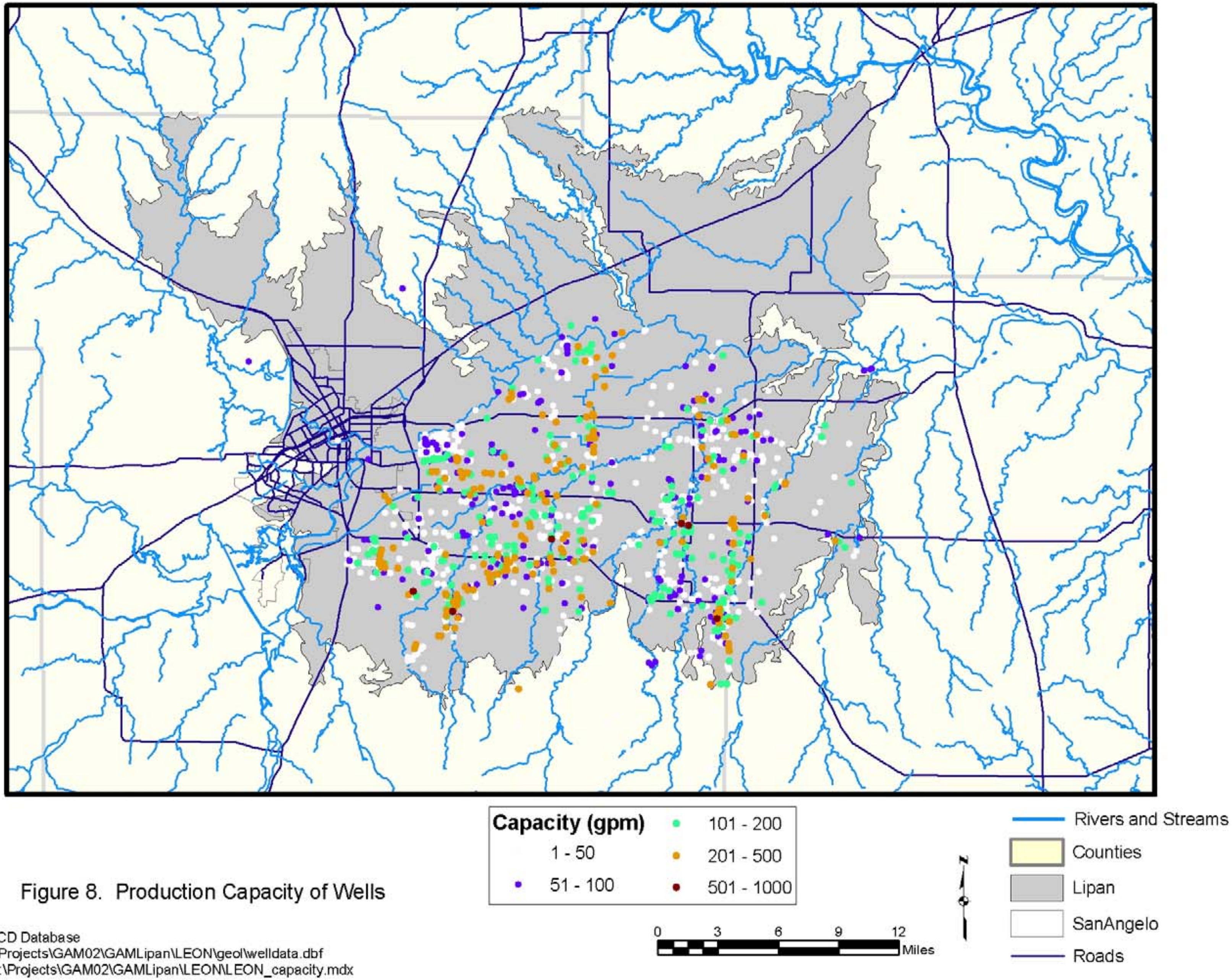


Figure 8. Production Capacity of Wells

Data: LKWCD Database
Source: S:\Projects\GAM02\GAMLipan\LEON\geol\welldata.dbf
Location: S:\Projects\GAM02\GAMLipan\LEON\LEON_capacity.mdx

Production Capacity of Wells –Close up

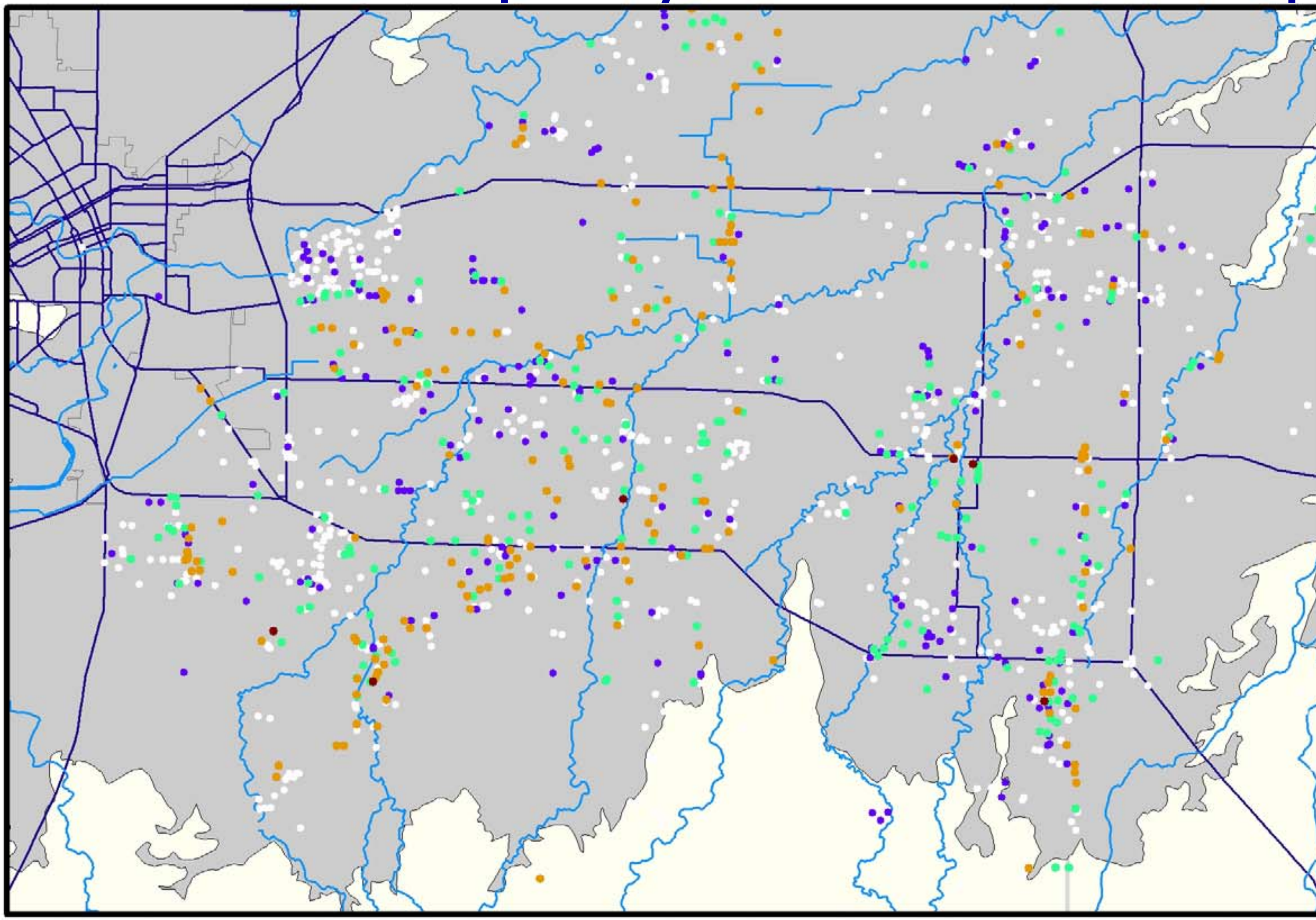


Figure 8. Production Capacity of Wells (close up)

Data: LKWCD Database
Source: S:\Projects\GAM02\GAMLipan\LEON\geol\welldata.dbf
Location: S:\Projects\GAM02\GAMLipan\LEON\LEON_capacity.mdx

Location of Geophysical Logs

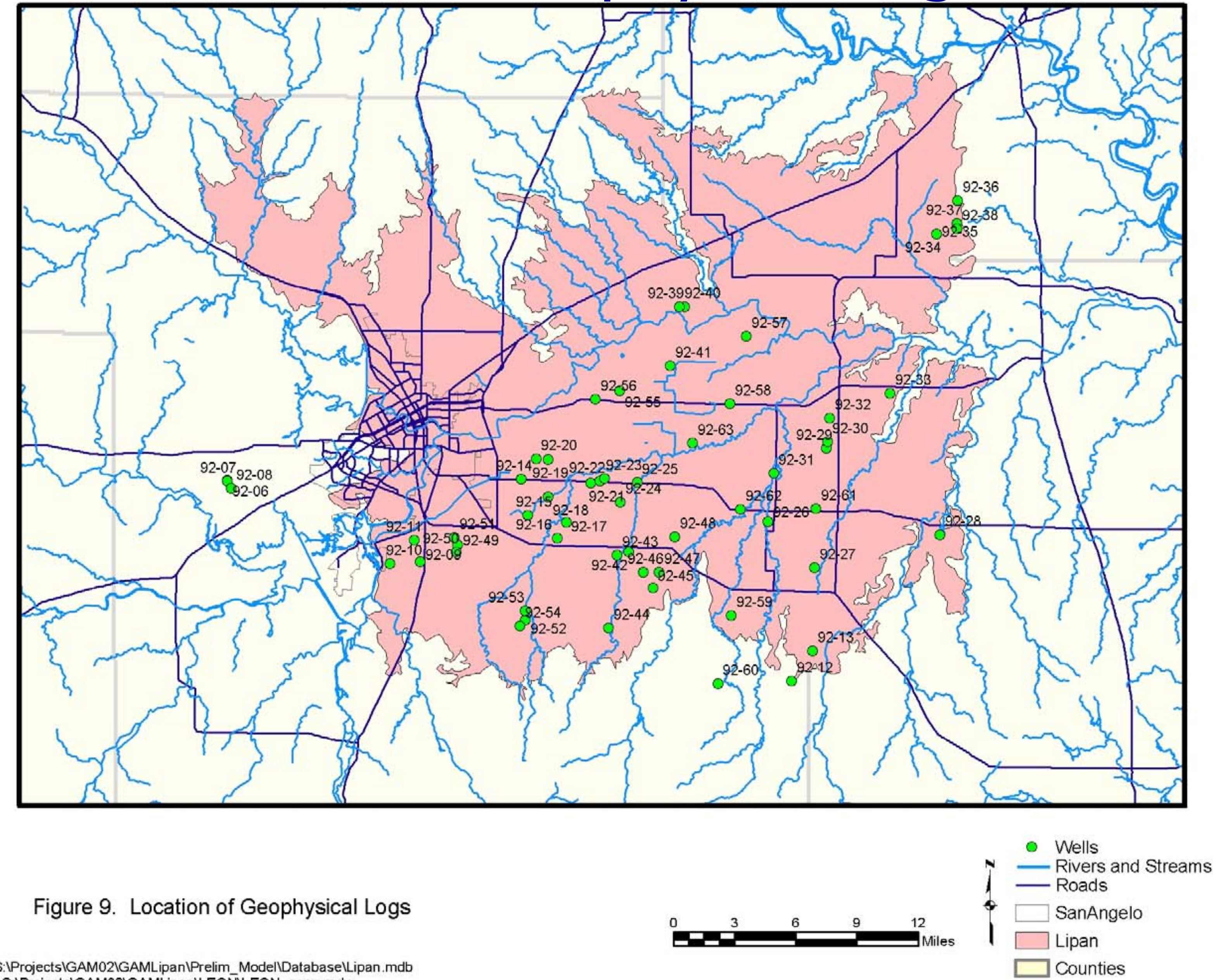


Figure 9. Location of Geophysical Logs

Source: S:\Projects\GAM02\GAMLipan\Prelim_Model\Database\Lipan.mdb
Location: S:\Projects\GAM02\GAMLipan\LEON\LEON_geop.mdx

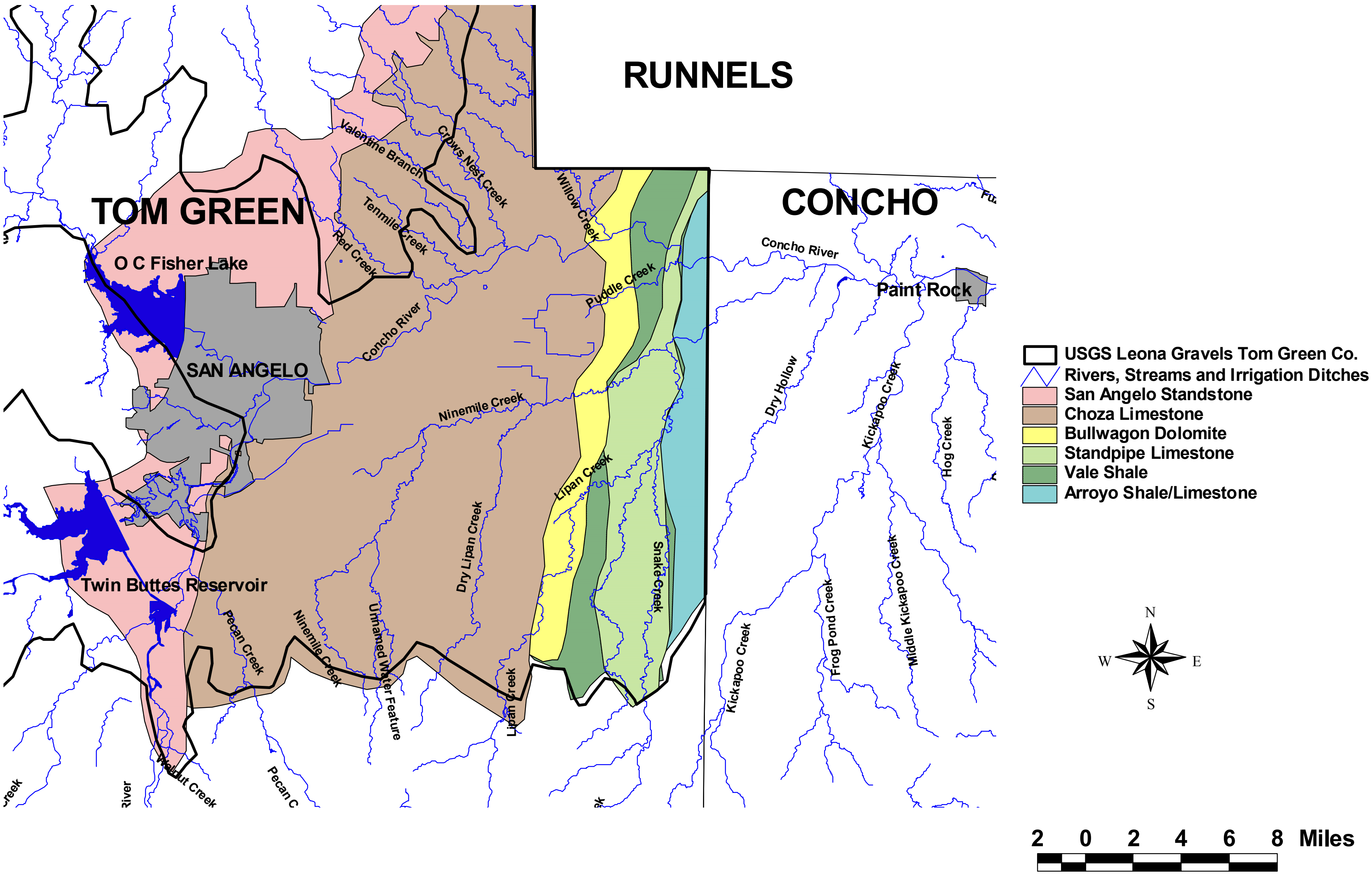
Stratigraphic and Hydrostratigraphic Section of the Lipan Aquifer

Age	Formation	Thickness	Hydrologic Unit	Description and Water-Bearing Characteristics
Quaternary	Leona Formation and Alluvium	0 - 125 feet	Leona Aquifer	Gravel and Stream Channel Deposits with conglomerate of Limestone cemented with sandy lime. Some layers of caliches and clay. Yields sufficient water for irrigation where thickness is suitable.
Permian	**San Angelo Sandstone**	250 feet	San Angelo Aquifer	Bright red sandstone with some clay and gypsum. Conglomerate at base. Yields small quantities of water.
	Choza Formation	625 feet	Choza Aquifer	Gray dolomitic limestone with clay and some silty clay layers. Yields small quantities of water.
	Bullwagon Dolomite	75 feet	Bullwagon Aquifer	Massive yellow to gray dolomitic limestone and green and red shale layers. Yields sufficient water for irrigation.
	Vale Formation	140 feet	Vale Aquifer	Shale at top. Rest is red sandy shale with thin streaks of green shale. Yields small quantities of water.
	Standpipe Limestone	15 feet	Standpipe Aquifer	Yellowish to light gray marly limestone. Yields small quantities of water.
	Arroyo Formation	60+ feet	Arroyo Aquifer	Alternating layers of shale and limestone. Yields small quantities of water from the limestone horizons.

Figure 10. Stratigraphic and Hydrostratigraphic Section of the Lipan Aquifer

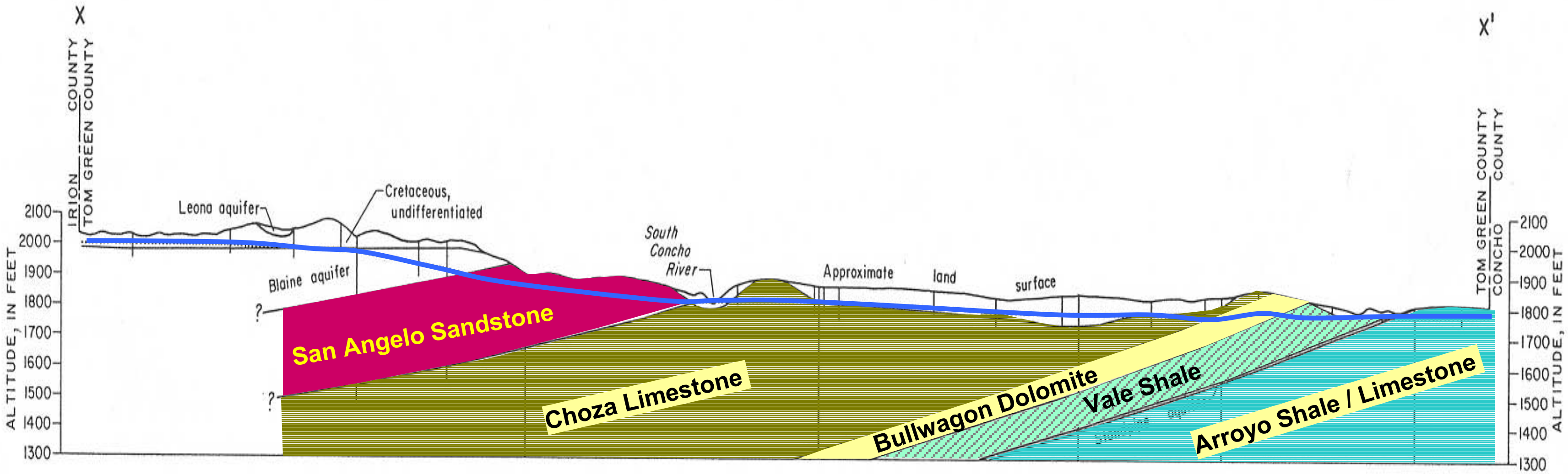
Data: After Lee (1986) "Shallow Ground-Water Conditions, Tom Green County, Texas

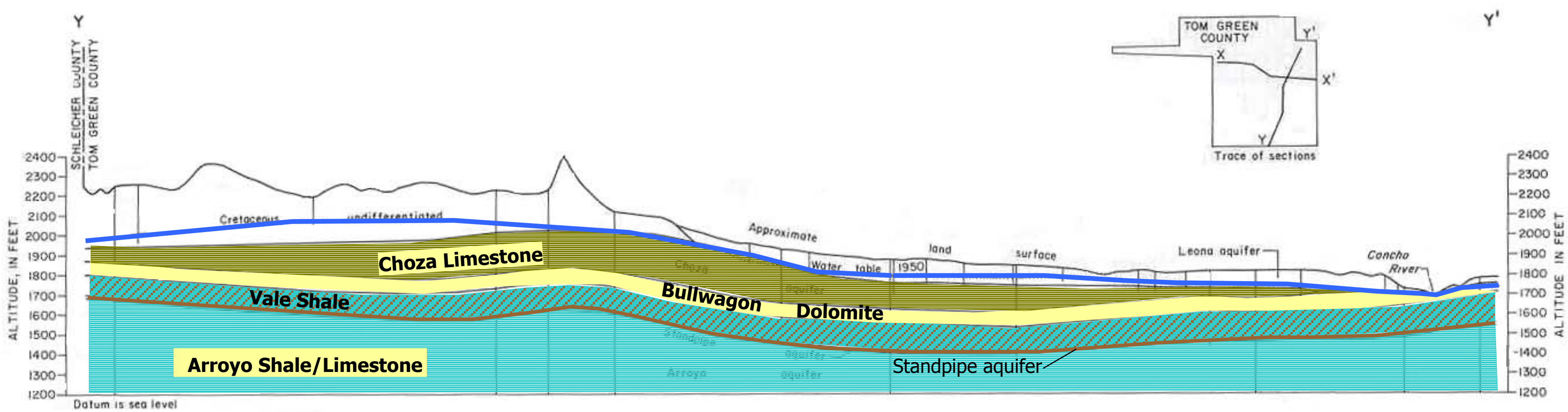
Location: S:\Projects\GAM02\GAMLipan\LEON\scrdata\geol\Strat_section.xls



Modern Day Drainages and the Geologic Formations Underlying the Leona Gravels in Tom Green County

Geologic Cross-Sections (after Lee, 1986)





Pre-Development Water Levels (ca. 1950)

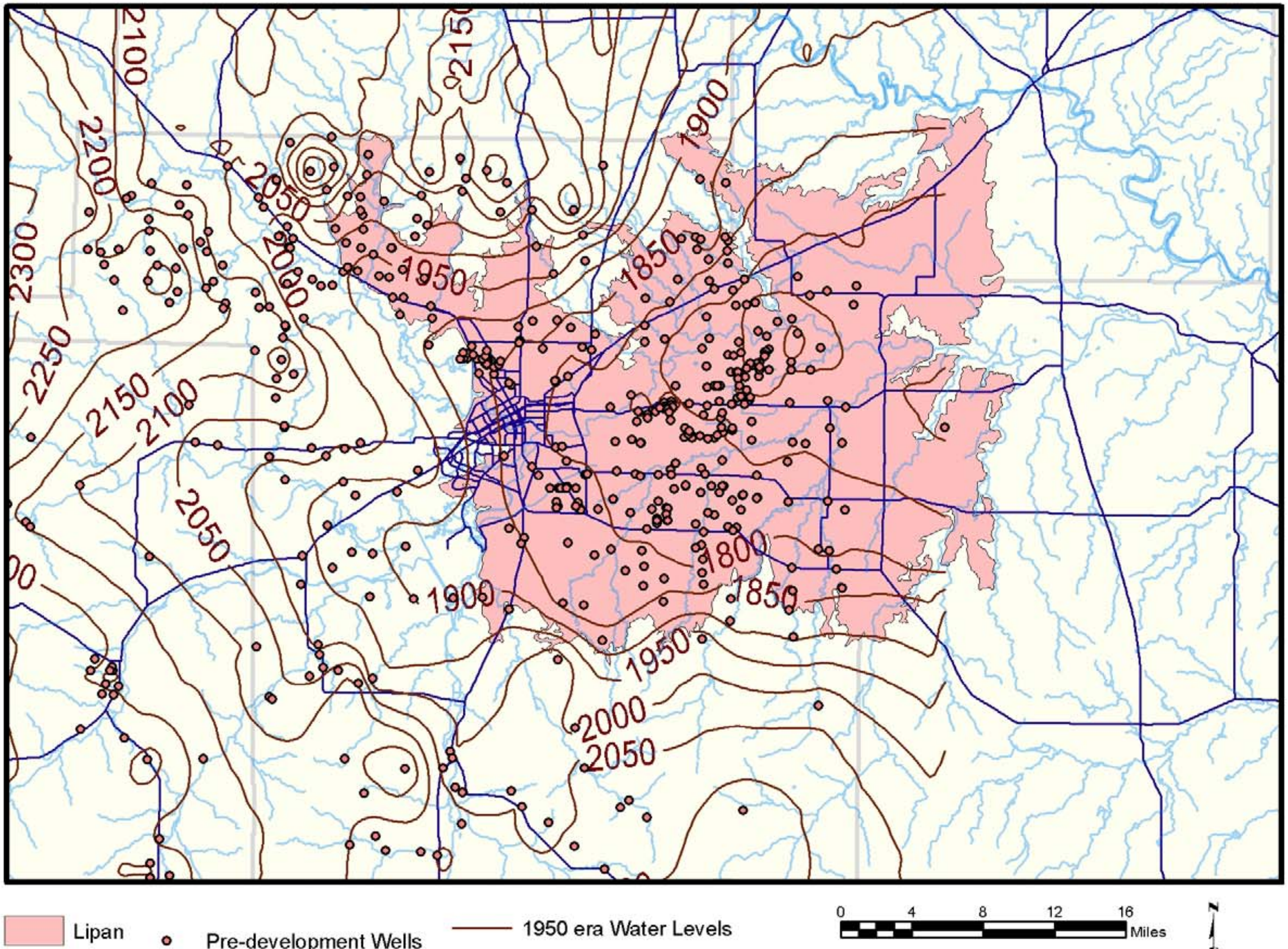


Figure 17. Pre-Development Groundwater Elevations (Circa 1950) from TWDB Database

Data Source: TWDB Groundwater Database (GWDB.mdb)
Data: S:\Projects\GAM02\GAMLipan\LEON\scrdata\subhyd\LipanWL.xls
Location: S:\Projects\GAM02\GAMLipan\LEON\LEON_PreDevWL.mdx

1981 Water Levels

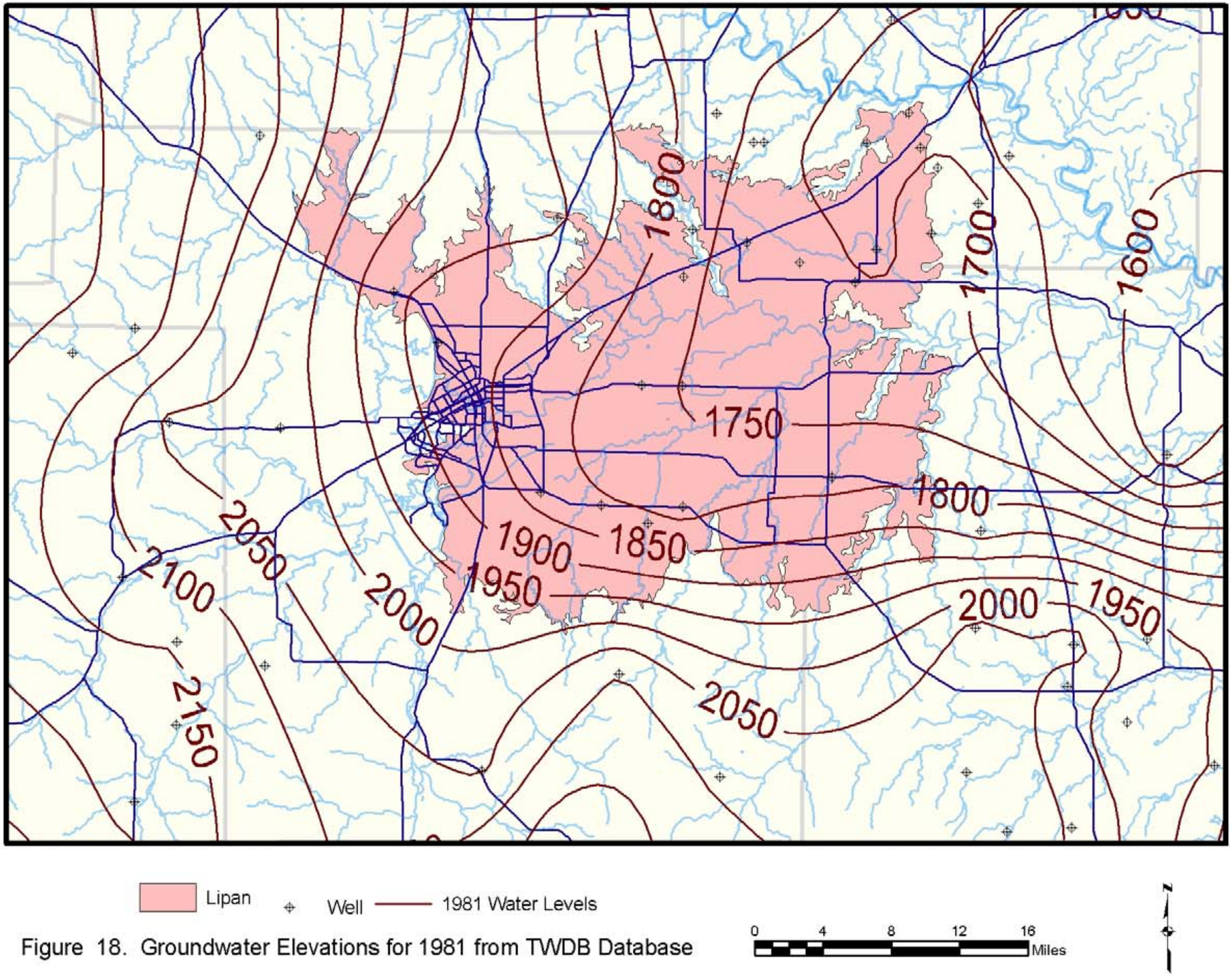


Figure 18. Groundwater Elevations for 1981 from TWDB Database

Data Source: TWDB Groundwater Database (GWDB.mdb)
Data: S:\Projects\GAM02\GAMLipan\LEON\scrdata\subhyd\LipanWL.xls
Location: S:\Projects\GAM02\GAMLipan\LEON\LEON_wl1981.mdx

1990 Water Levels

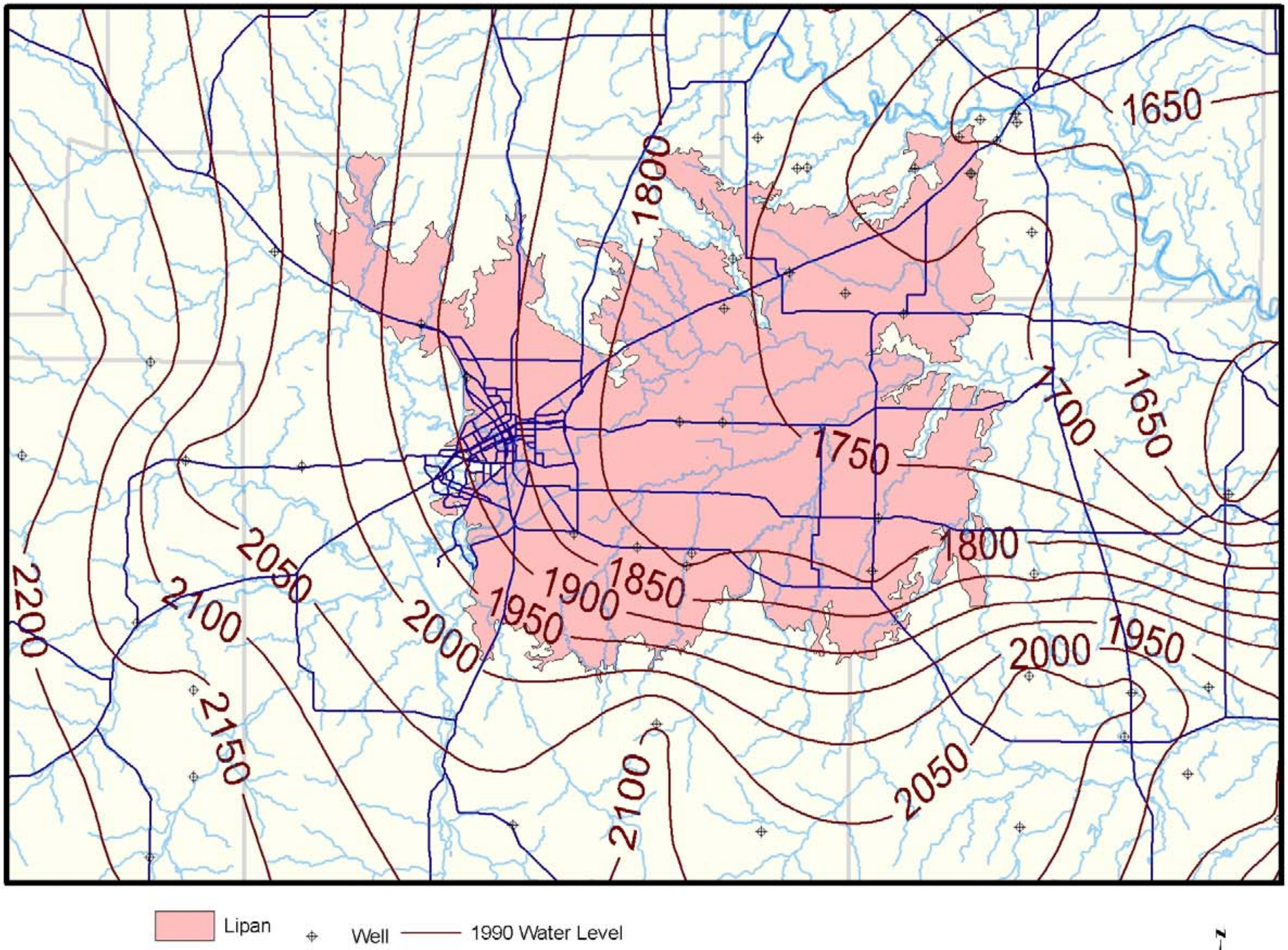


Figure 19. Groundwater Elevations for 1990 from TWDB Database

Data Source: TWDB Groundwater Database (GWDB.mdb)
Data: S:\Projects\GAM02\GAMLipan\LEON\scrdata\subhyd\LipanWL.xls
Location: S:\Projects\GAM02\GAMLipan\LEON\LEON_wl1990.mdx

2000 Water Levels

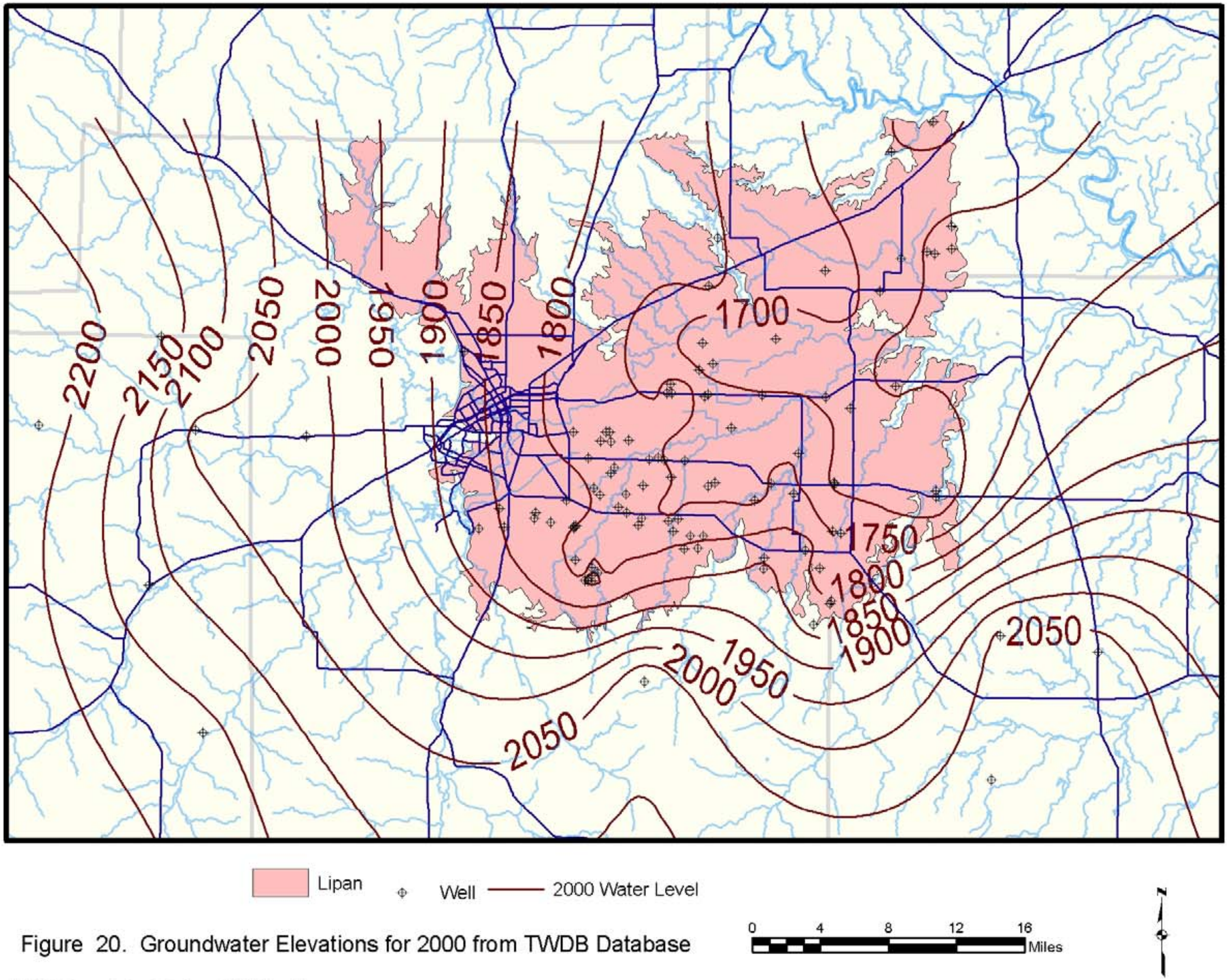


Figure 20. Groundwater Elevations for 2000 from TWDB Database

Data Source: TWDB Groundwater Database (GWDB.mdb)
Data: S:\Projects\GAM02\GAMLipan\LEON\scrdata\subhyd\LipanWL.xls
Location: S:\Projects\GAM02\GAMLipan\LEON\LEON_wl2000.mdx

Hydrographs for Wells in the Study Area

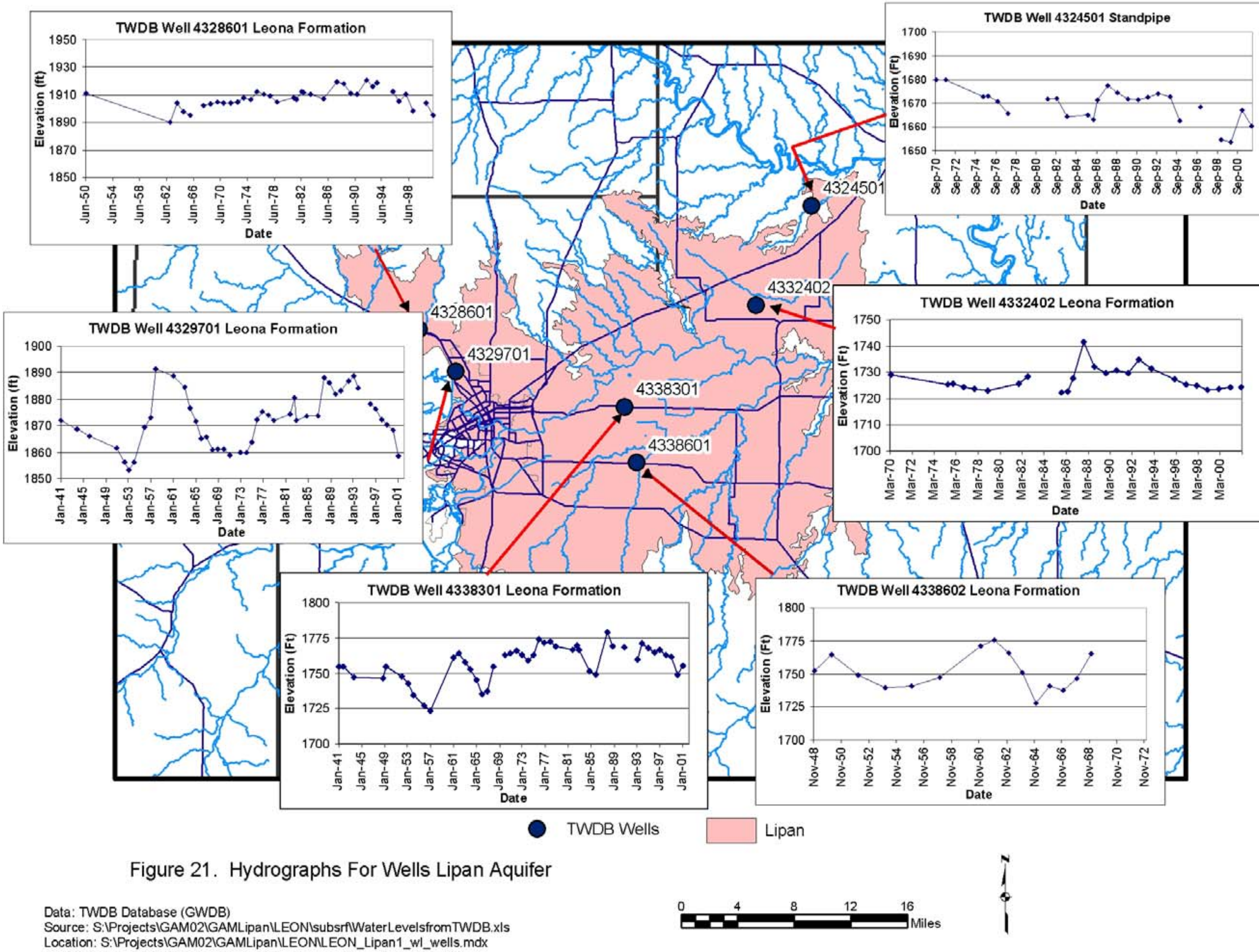
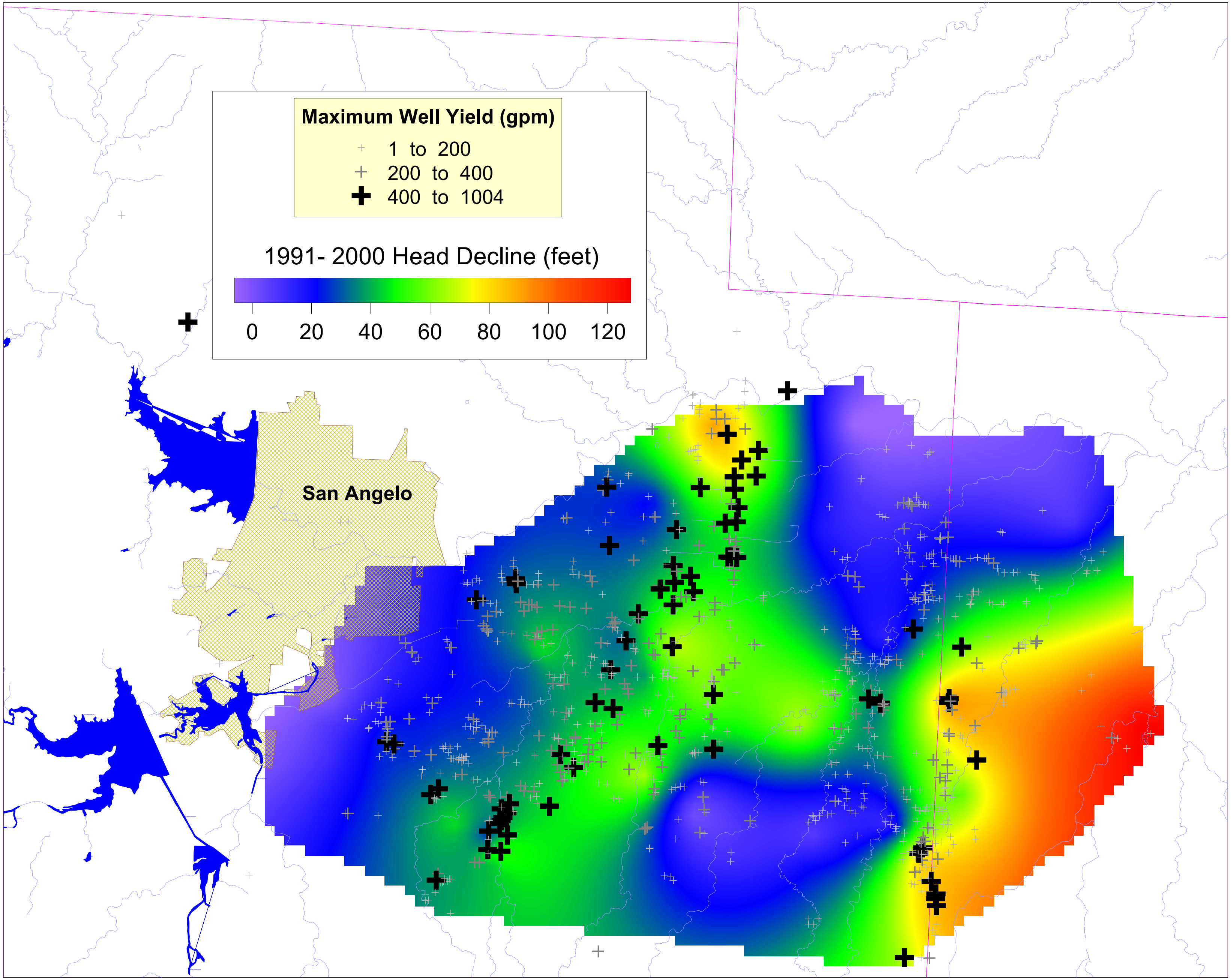


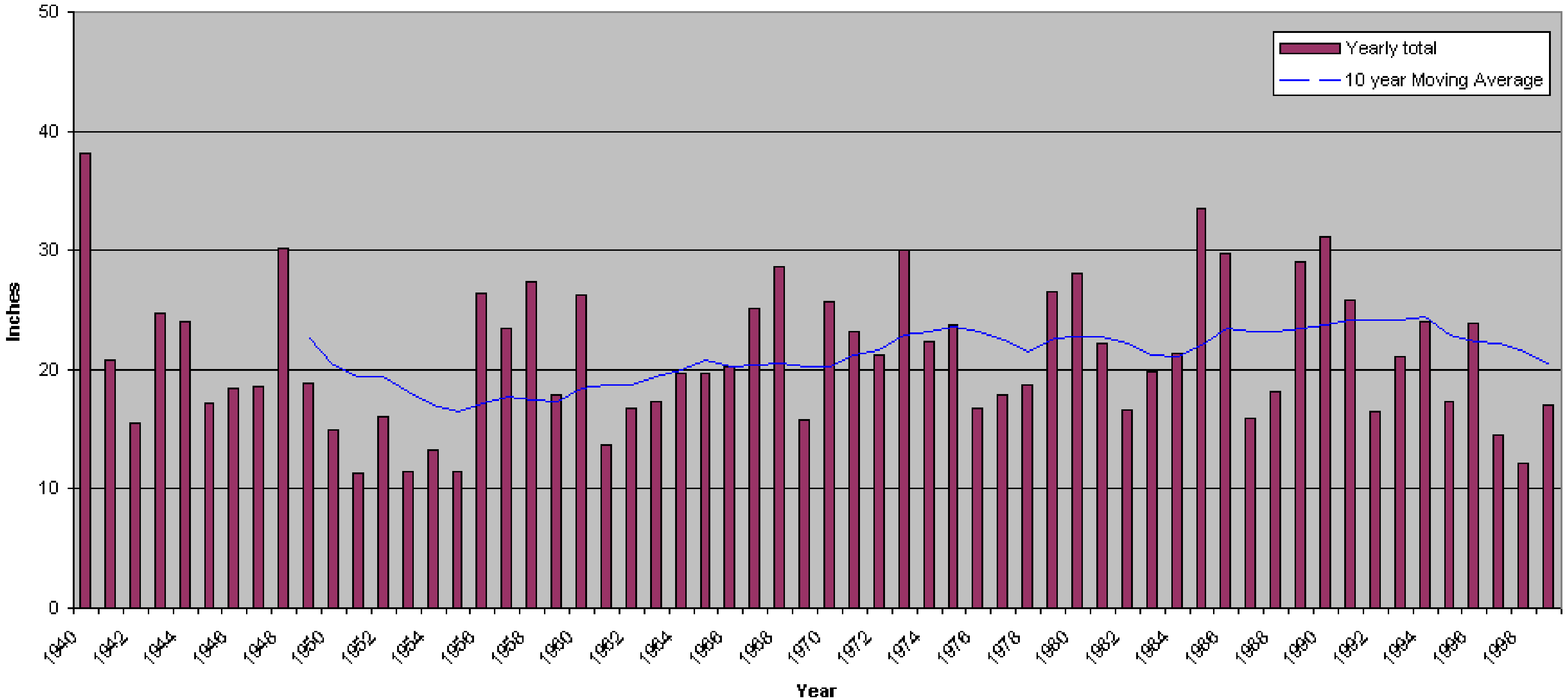
Figure 21. Hydrographs For Wells Lipan Aquifer

Data: TWDB Database (GWDB)
Source: S:\Projects\GAM02\GAMLipan\LEON\subsrf\WaterLevelsfromTWDB.xls
Location: S:\Projects\GAM02\GAMLipan\LEON\LEON_Lipan1_wl_wells.mdx

Observed Head Declines in LKWCD



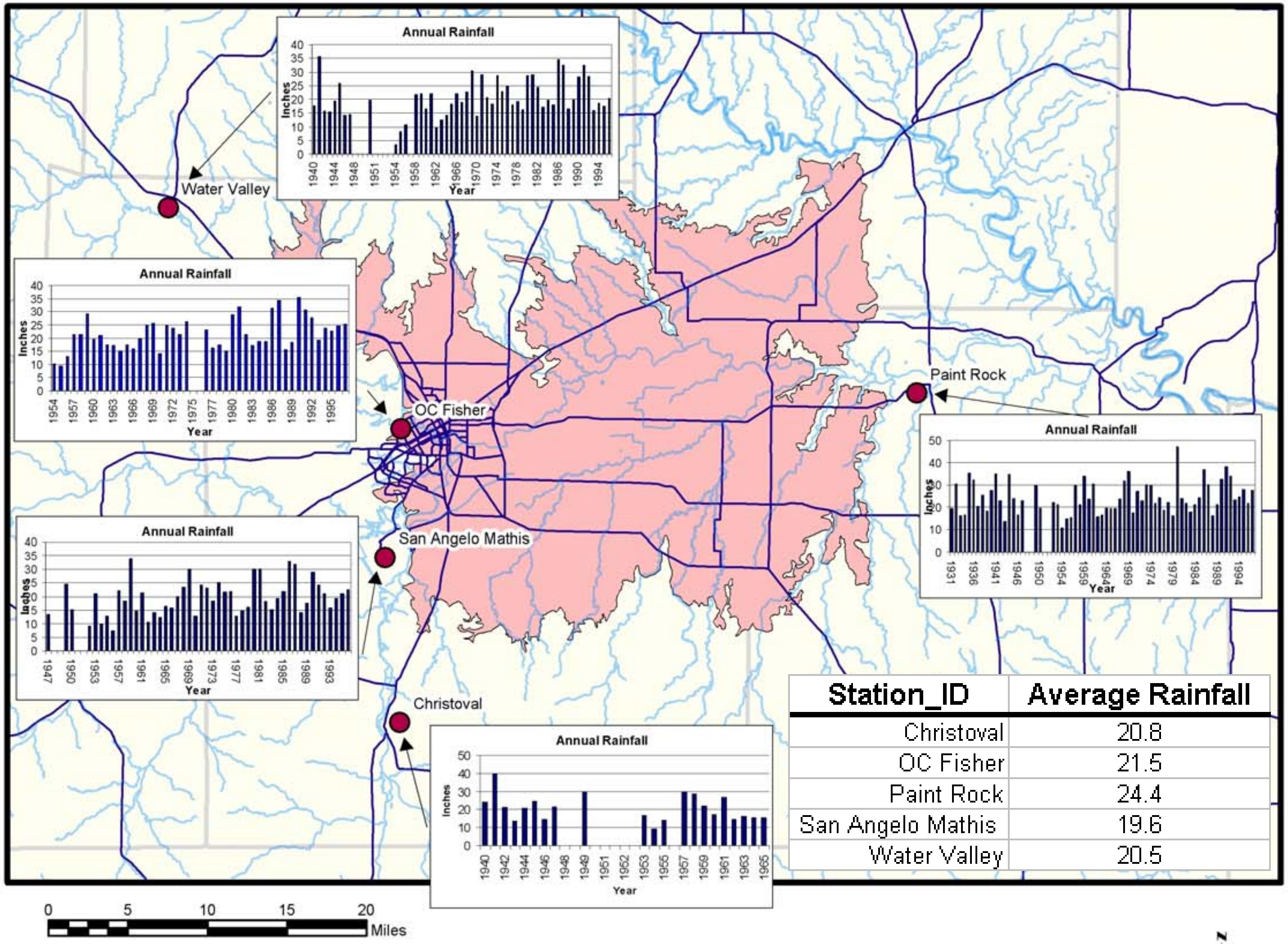
Total Annual Precipitation (1915 – 2000)



Data Source: http://www.twdb.state.tx.us/data/surfacewater/surfacewater_toc.htm

Location: S:\Projects\GAM02\GAMLipan\LEON\scrdata\clim\Precip\MonthlyRain.xls | MonthlyrainbyQuad

Regional Rain Gages



Station_ID	Average Rainfall
Christoval	20.8
OC Fisher	21.5
Paint Rock	24.4
San Angelo Mathis	19.6
Water Valley	20.5

Figure 28. Location of Regional Rain Gages with Historic Annual Rainfall

Lipan

Rain Gage Locations

Data Source: NOAA
Data: S:\Projects\GAM02\GAMLipan\LEON\scrdata\clim\monthlyRain.xls.xls
Location: S:\Projects\GAM02\GAMLipan\LEON\LEON_rainfall.mdx

LKWCD Rain Gages

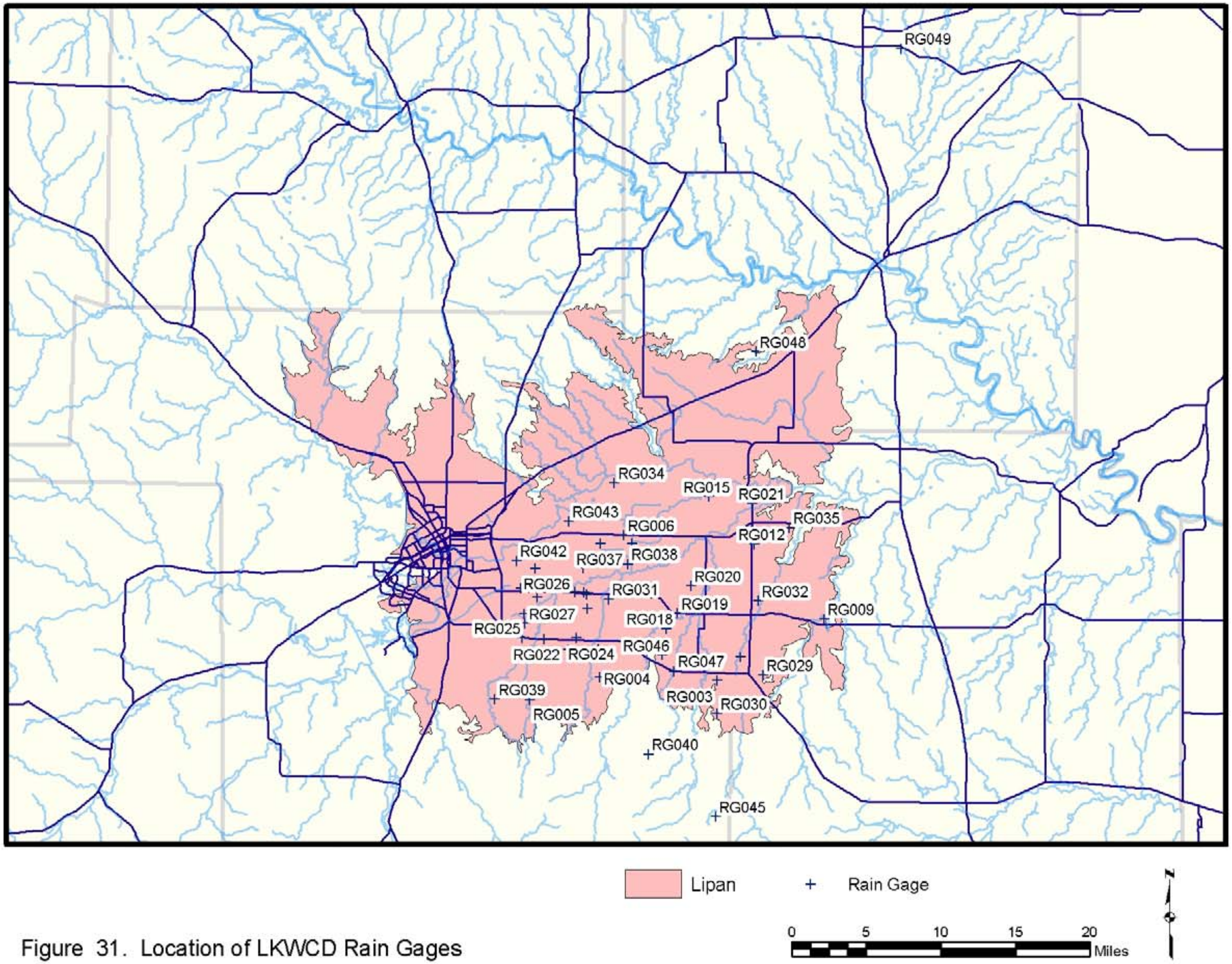


Figure 31. Location of LKWCD Rain Gages

Data Source: LKWCD
Data: S:\Projects\GAM02\GAMLipan\LEON\scrdata\clim\Precipitation.mdb (Rainfall2002total table)
Location: S:\Projects\GAM02\GAMLipan\LEON\LEON_raingage.mdx

2000 Rainfall Distribution

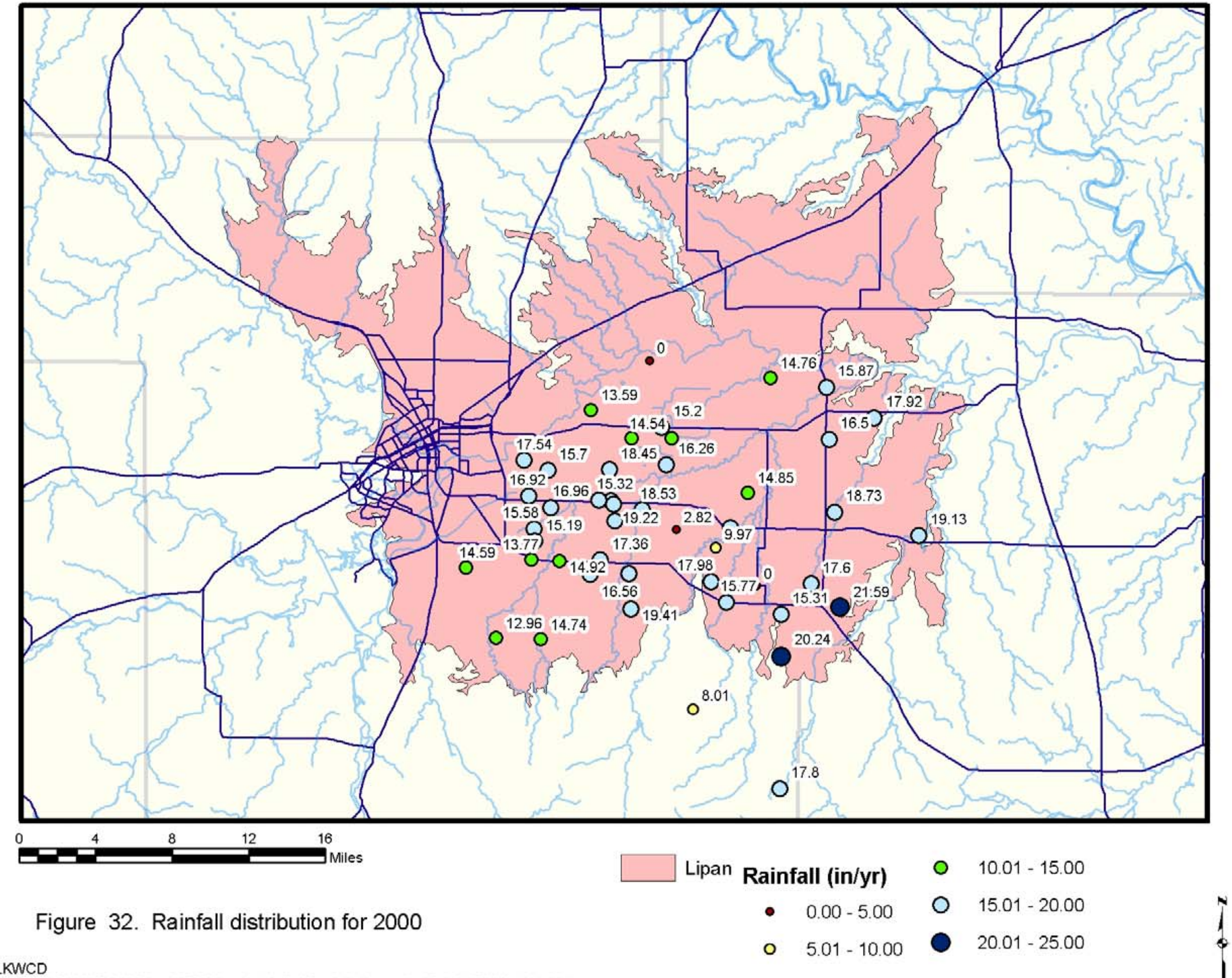


Figure 32. Rainfall distribution for 2000

Source: LKWCD
Data: S:\Projects\GAM02\GAMLipan\LEON\scrdata\clim\Precipitation.mdb (Rainfall2000total table)
Location: S:\Projects\GAM02\GAMLipan\LEON\LEON_rain2000.mdx

2001 Rainfall Distribution

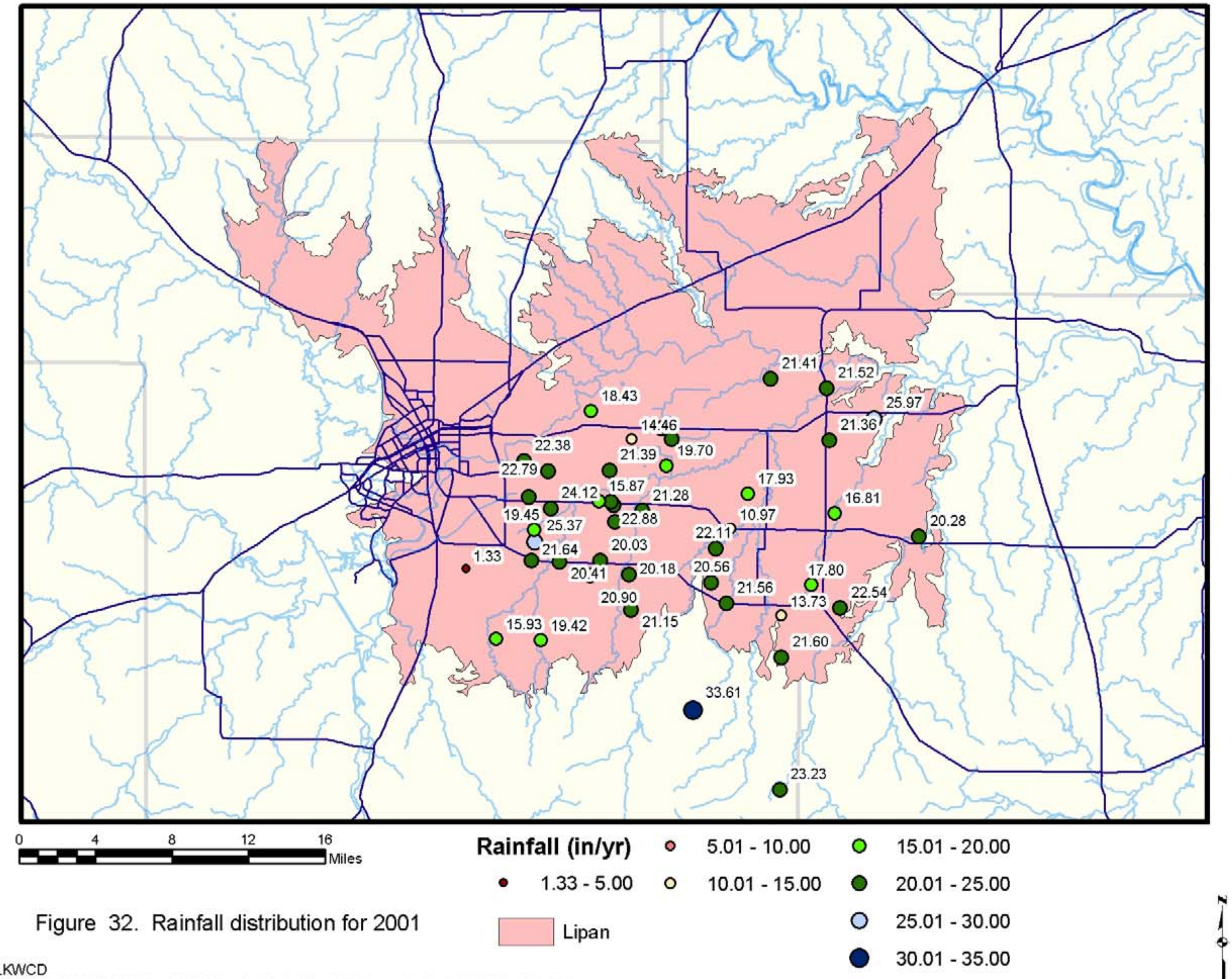


Figure 32. Rainfall distribution for 2001

Source: LKWCD
Data: S:\Projects\GAM02\GAMLipan\LEON\scrdata\clim\Precipitation.mdb (Rainfall2001total table)
Location: S:\Projects\GAM02\GAMLipan\LEON\LEON_rain2001.mdx

2002 Rainfall Distribution

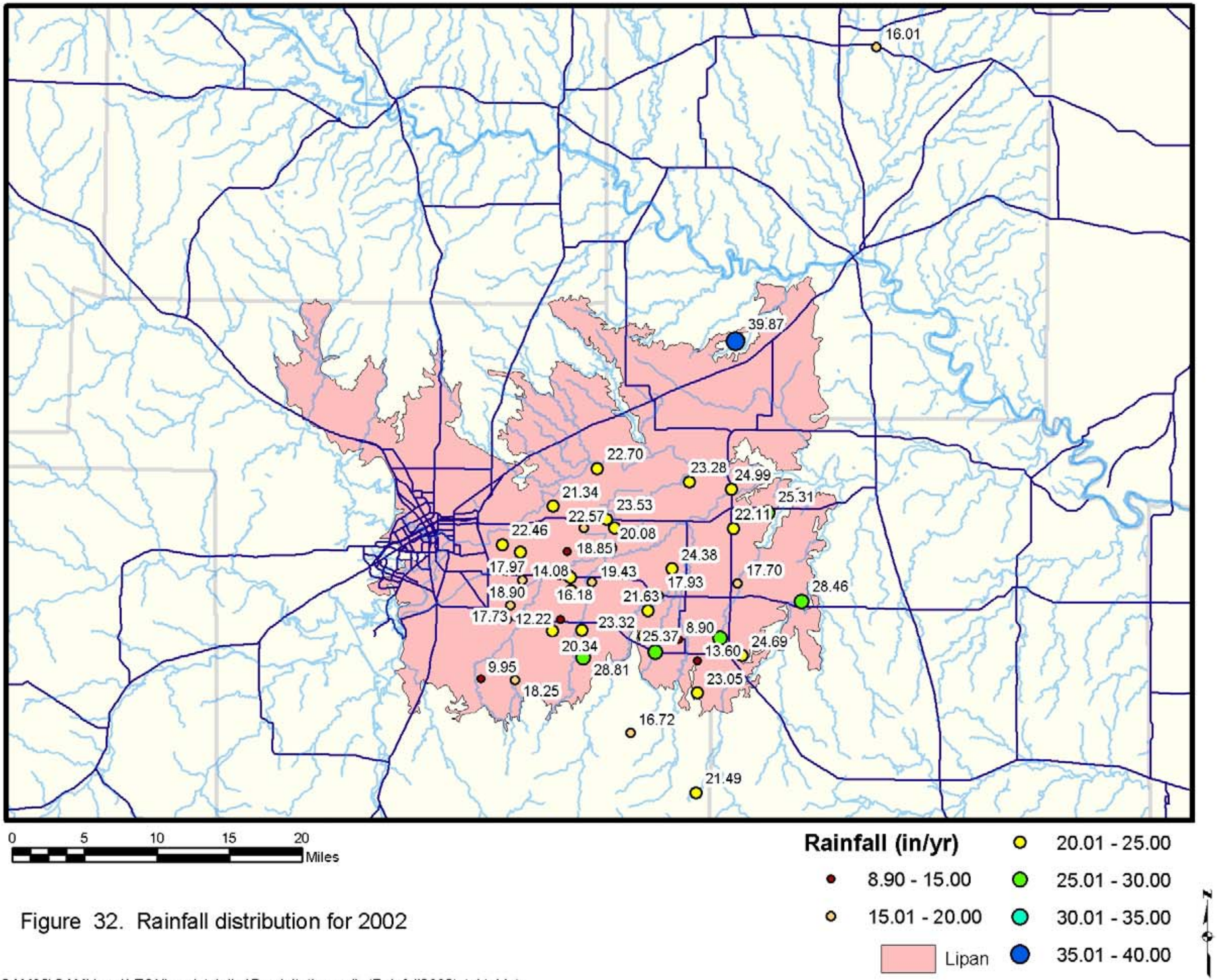
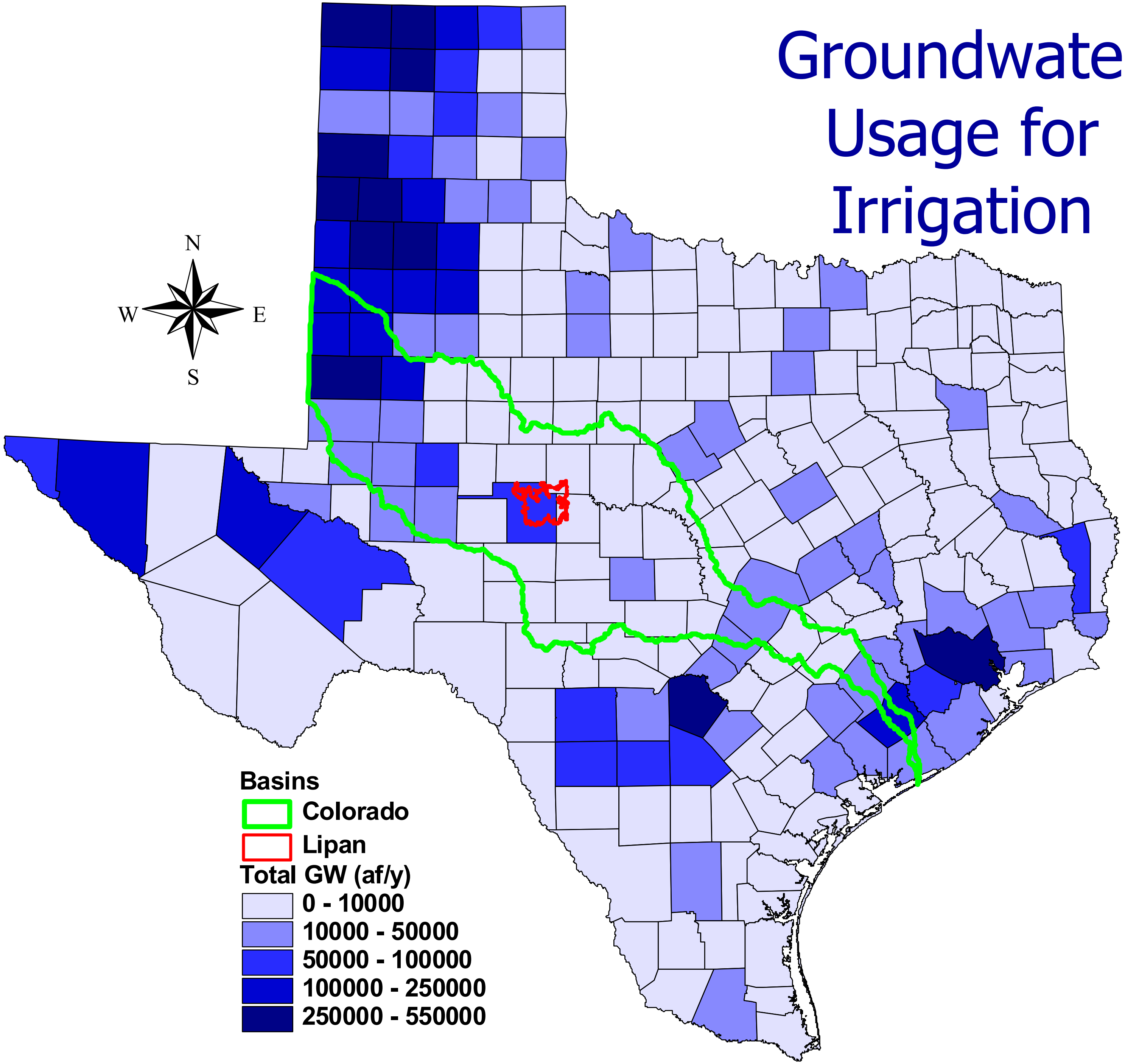


Figure 32. Rainfall distribution for 2002

S:\Projects\GAM02\GAMLipan\LEON\scrdata\clim\Precipitation.mdb (Rainfall2002total table)
Location: S:\Projects\GAM02\GAMLipan\LEON\LEON_rain2002.mdx

Groundwater Usage for Irrigation



Irrigation 1989

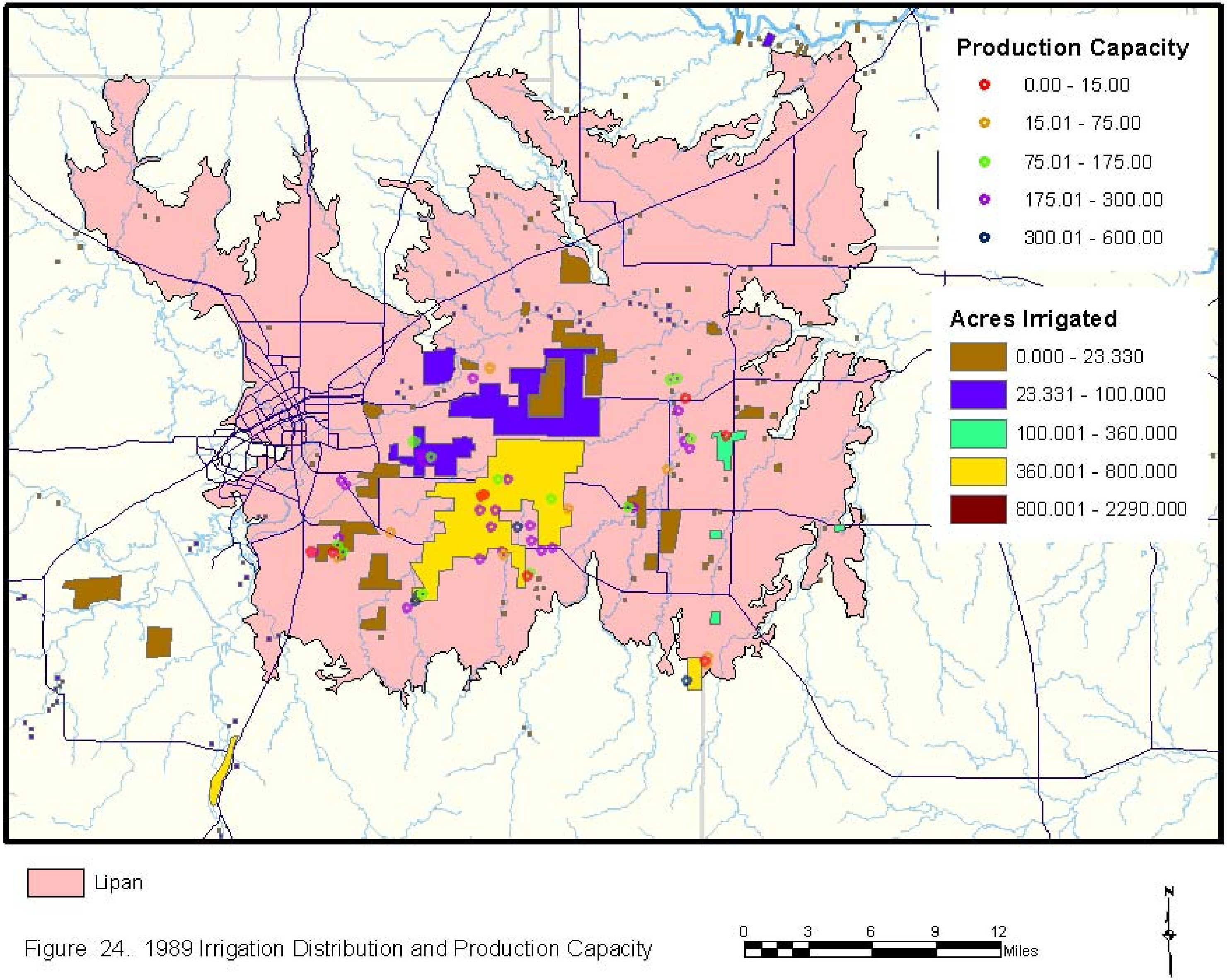


Figure 24. 1989 Irrigation Distribution and Production Capacity

Data Source: LKWCD Database
Data: S:\Projects\GAM02\GAMLipan\LEON\scrdata\subhyd\WaterUse.xls (Irr94.dbf)
Location: S:\Projects\GAM02\GAMLipan\LEON\LEON_Irr94.mdx

Irrigation 1994

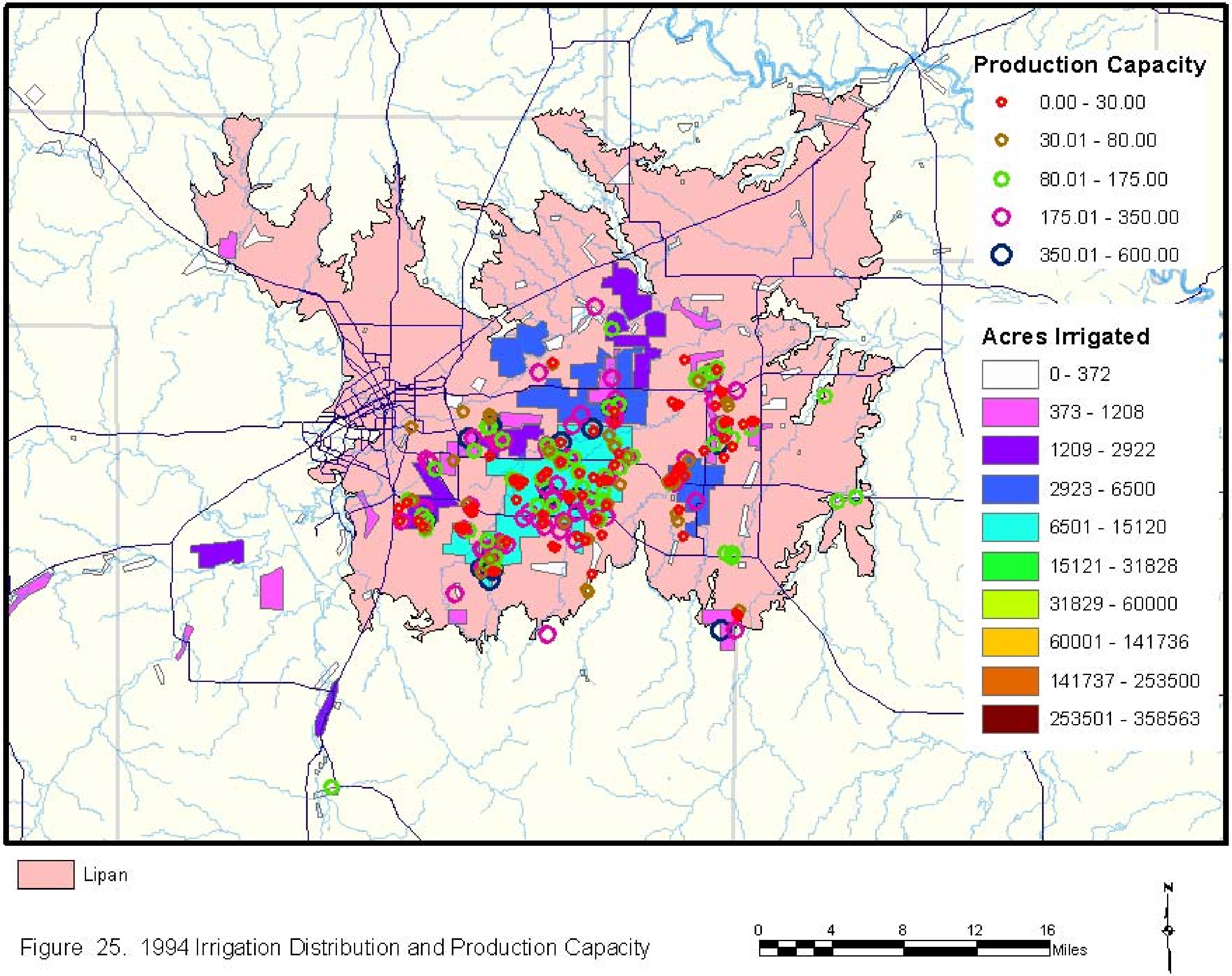
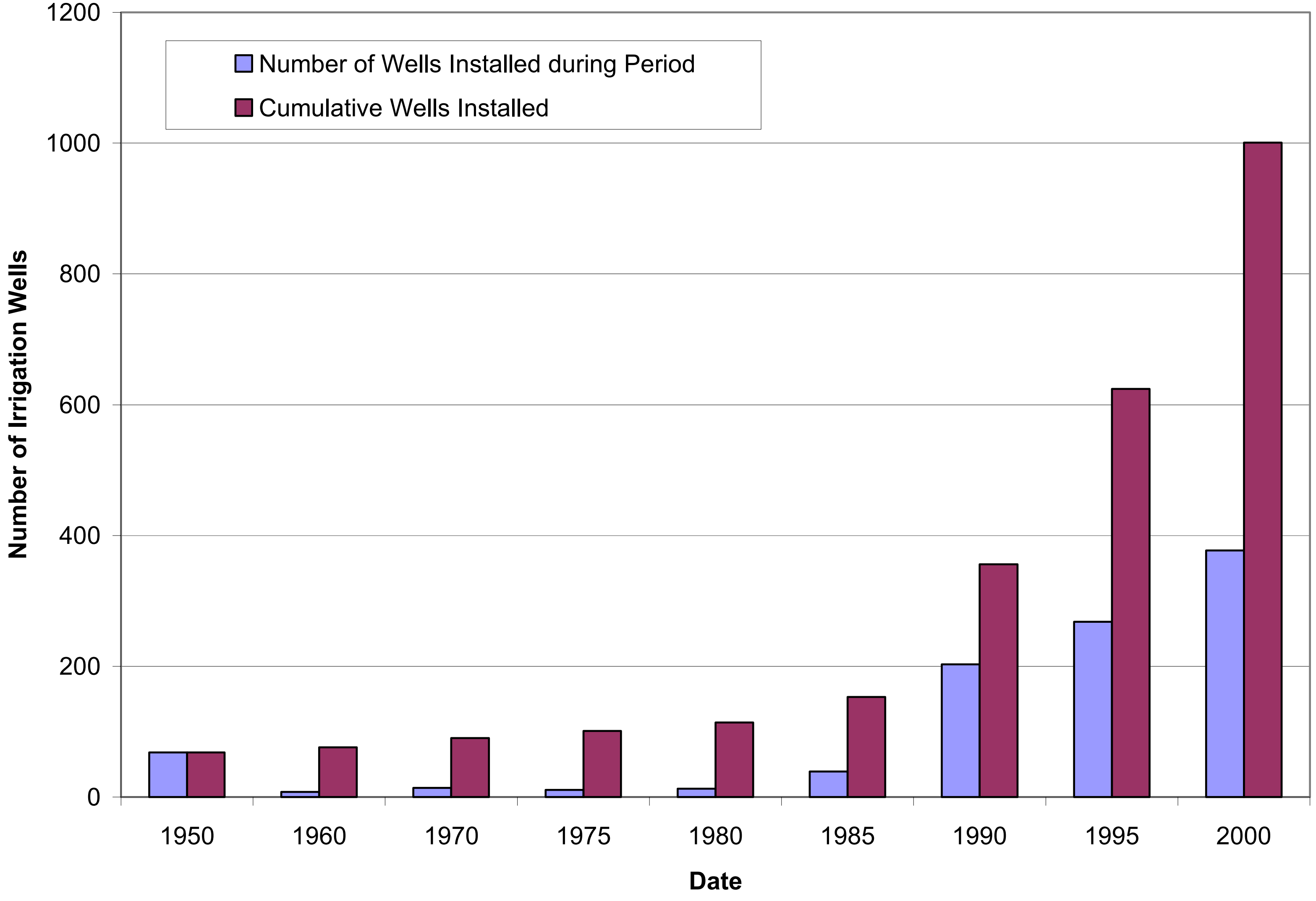


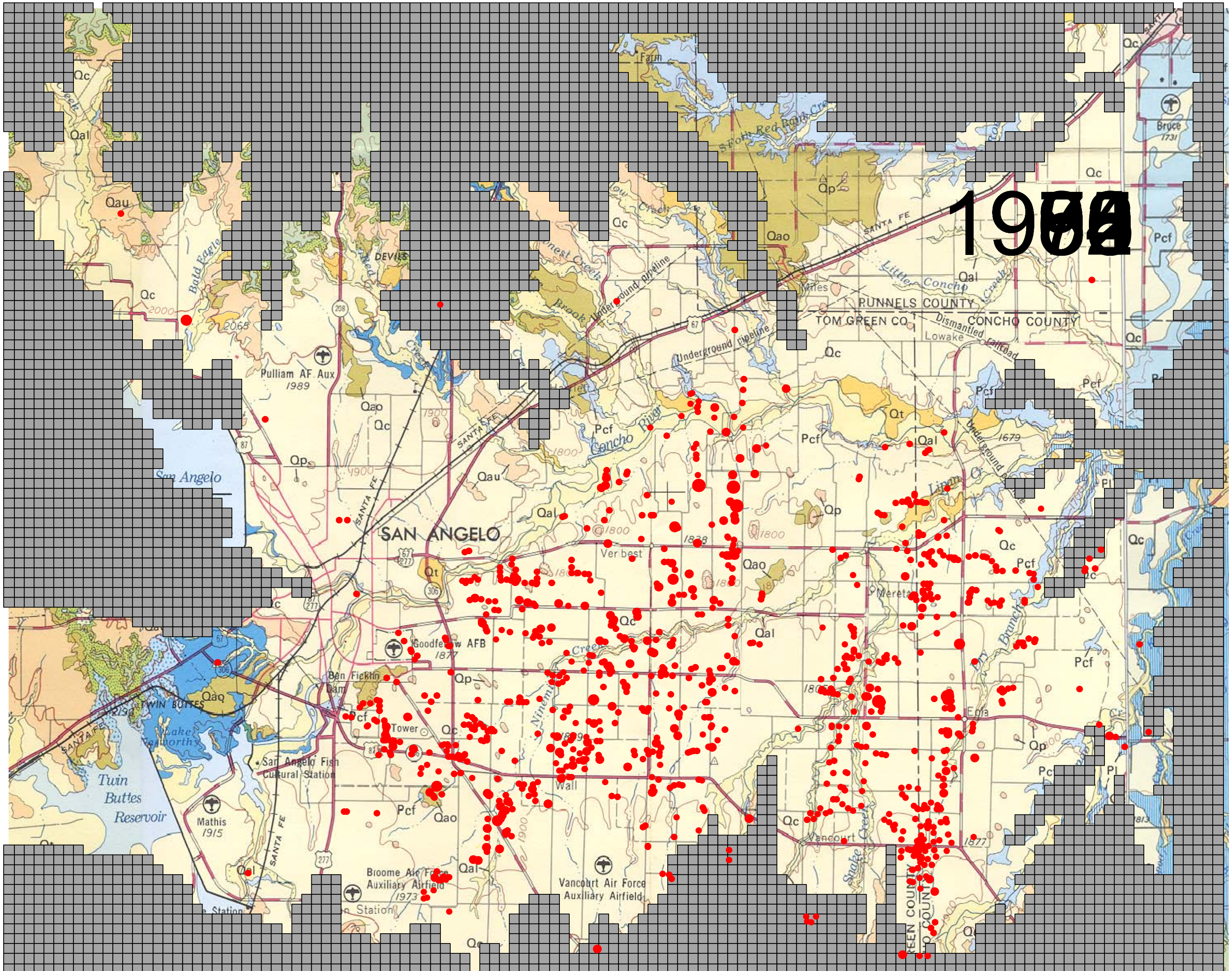
Figure 25. 1994 Irrigation Distribution and Production Capacity

Data Source: LKWCD Database
Data: S:\Projects\GAM02\GAMLipan\LEON\scrdata\subhyd\WaterUse.xls (Irr94.dbf)
Location: S:\Projects\GAM02\GAMLipan\LEON\LEON_Irr94.mdx

Irrigation Wells

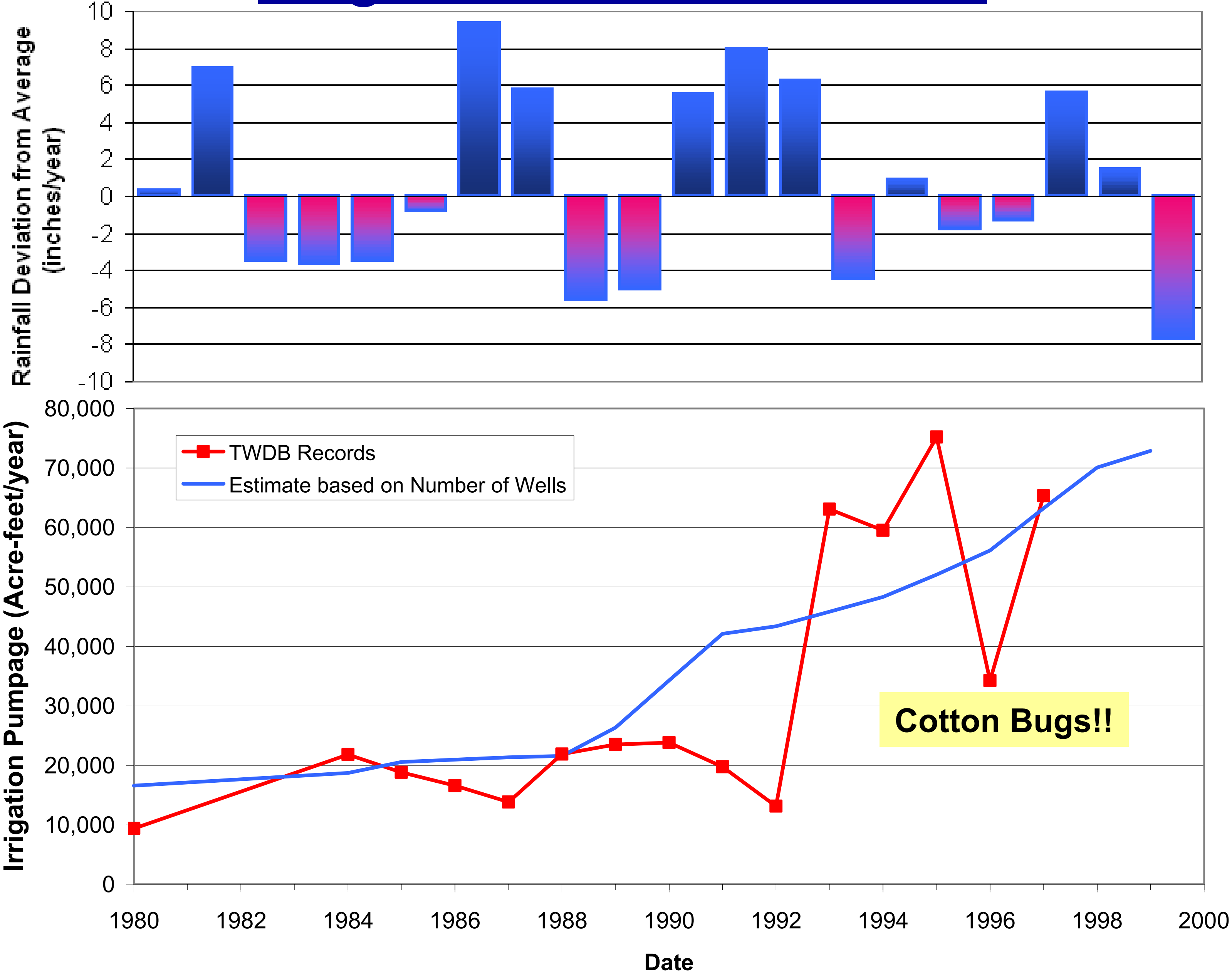


Irrigation Well Distribution

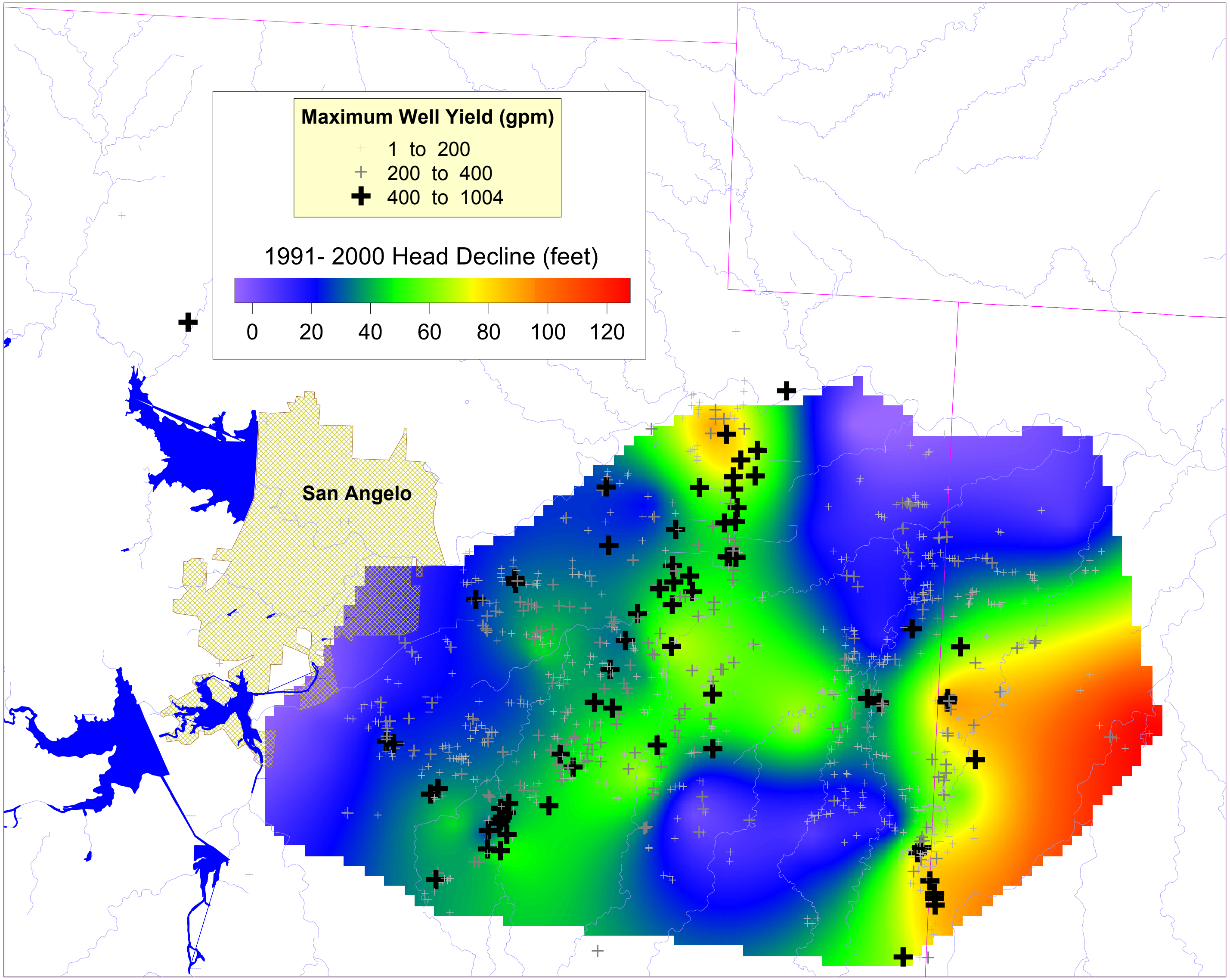


Data from Lipan-Kickapoo Water Conservation District

Irrigation and Weather



Observed Head Declines in LKWCD



USGS Stream Gage Locations

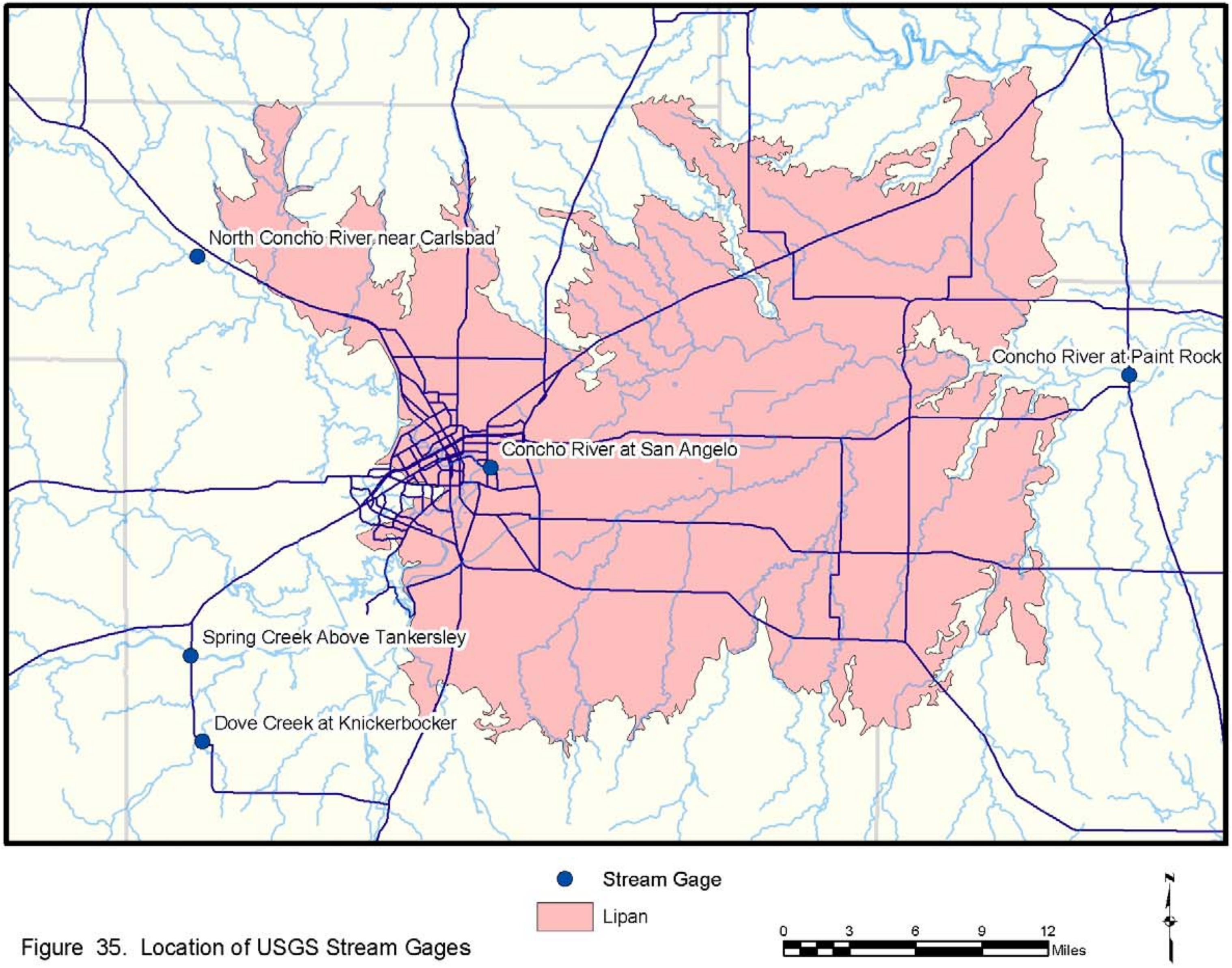


Figure 35. Location of USGS Stream Gages

Data Source: http://waterdata.usgs.gov/tx/nwis/discharge
Data: S:\Projects\GAM02\GAMLipan\LEON\scrdata\surhyd\Streamflow\GageLocations.xls
Location: S:\Projects\GAM02\GAMLipan\LEON\LEON_streamgage.mdx

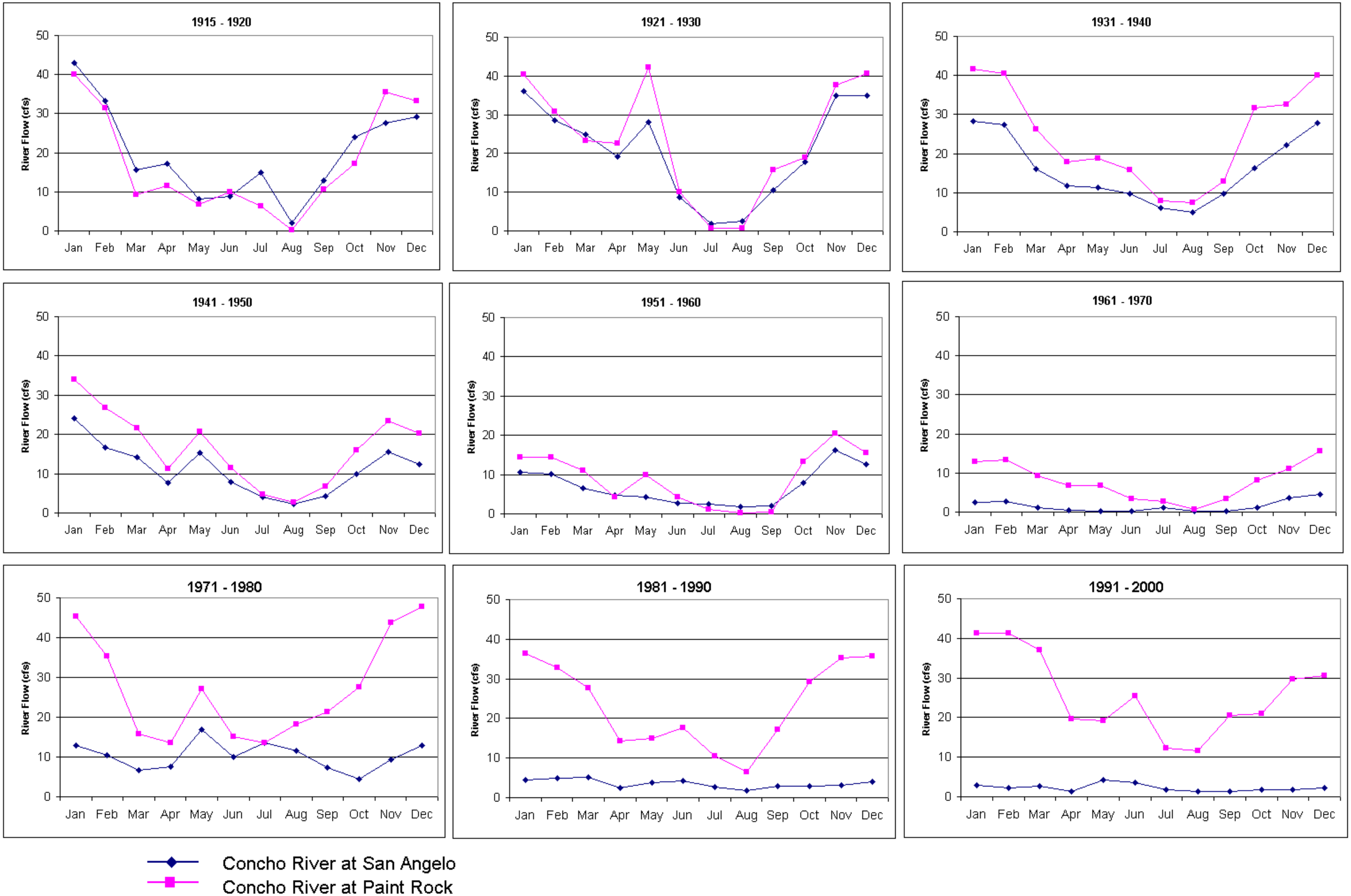


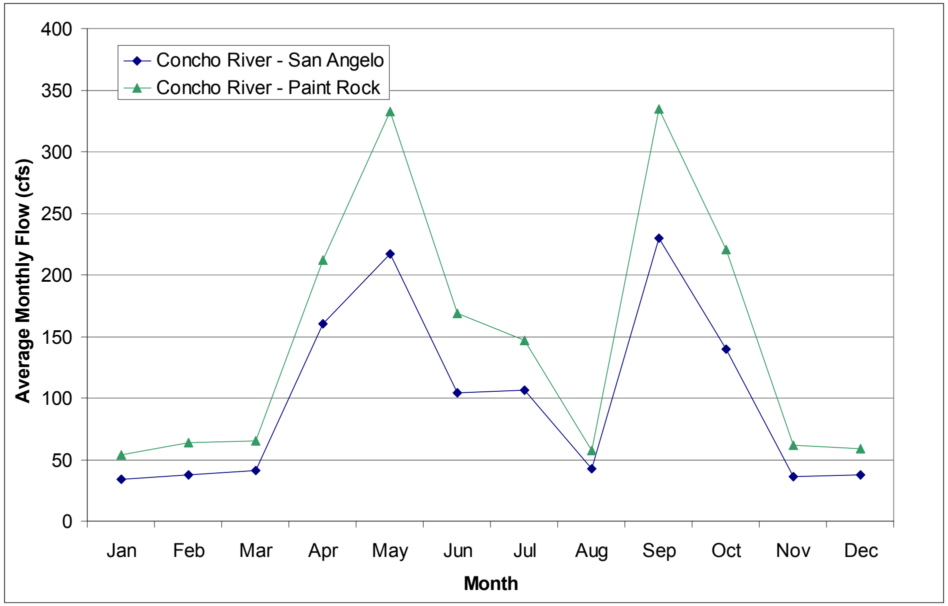
Figure 41. Comparison of Streamflow at San Angelo and Paint Rock Gaging Stations by Decade

Data Source: USGS
Location: S:\Projects\GAM02\GAMLipan\LEON\scrdata\surhyd\Streamflow\stream_gage_data_Lipan.xls

Stream Discharge

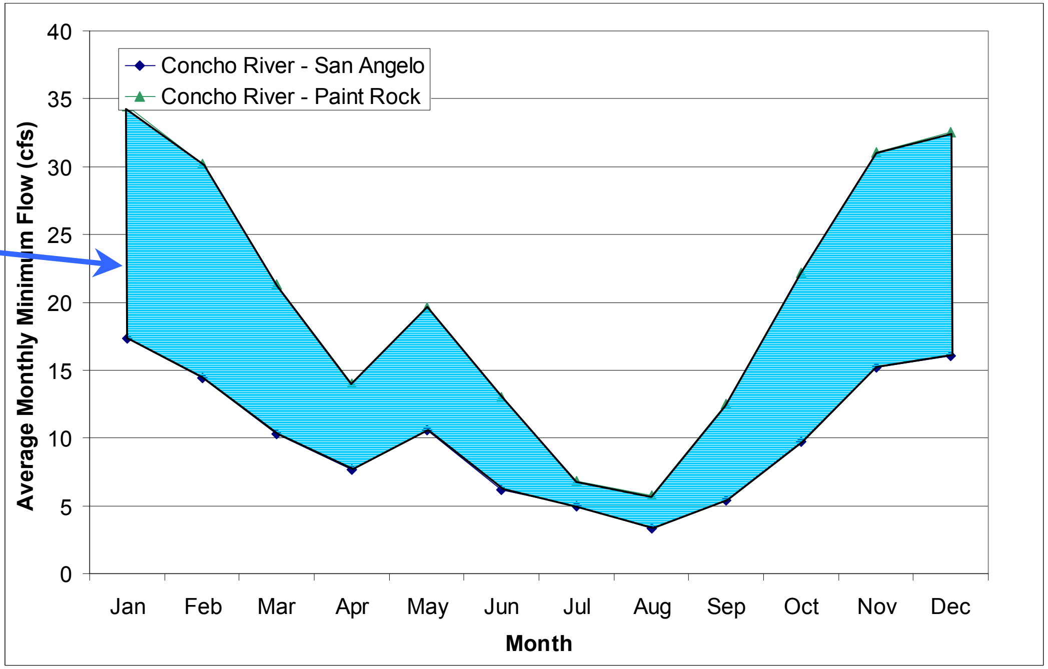
1915-1998

Average Monthly Flows



Average Monthly Minimum Flows

10 cfs
~7250 Acre-feet per year



Springs in the Study Area

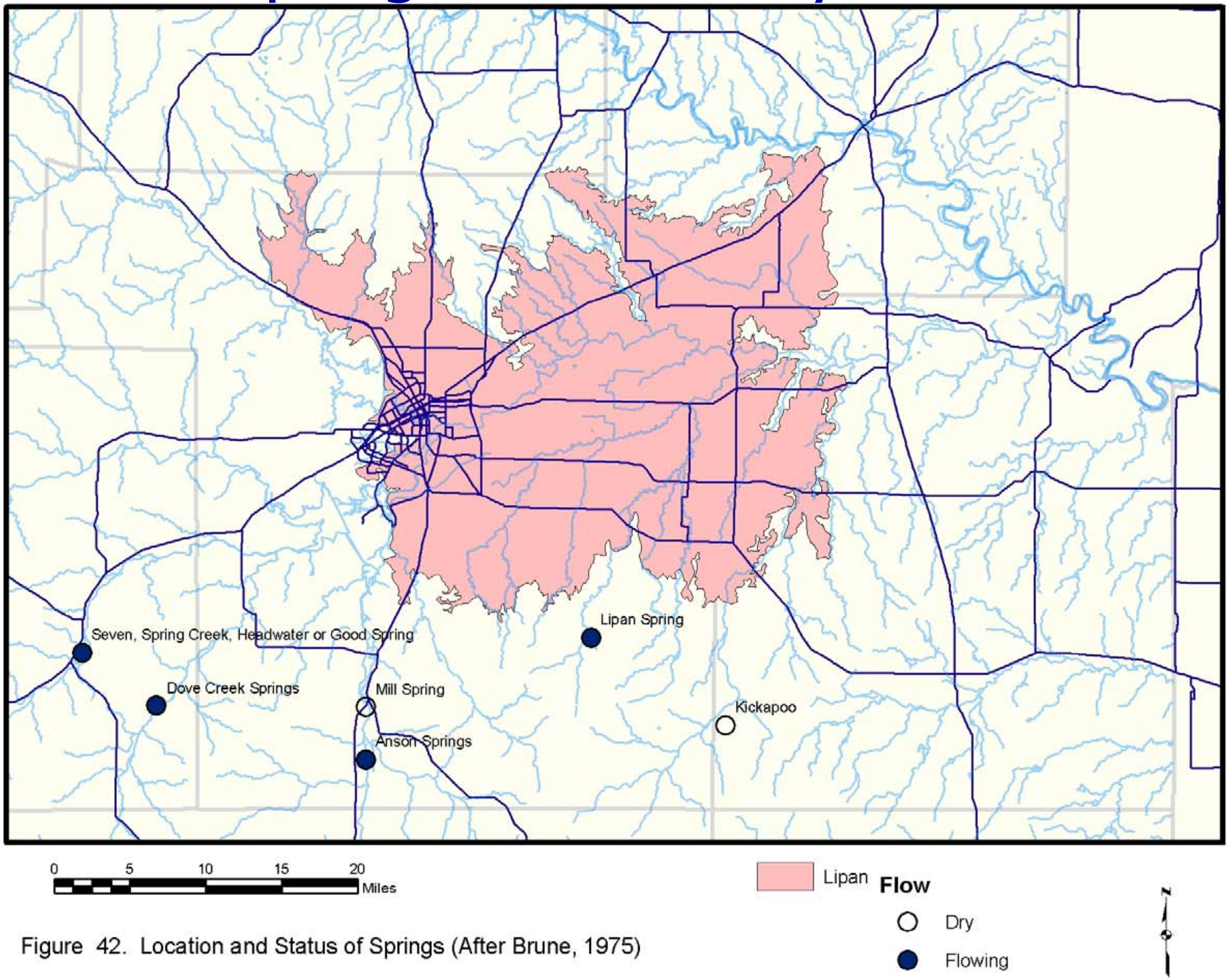
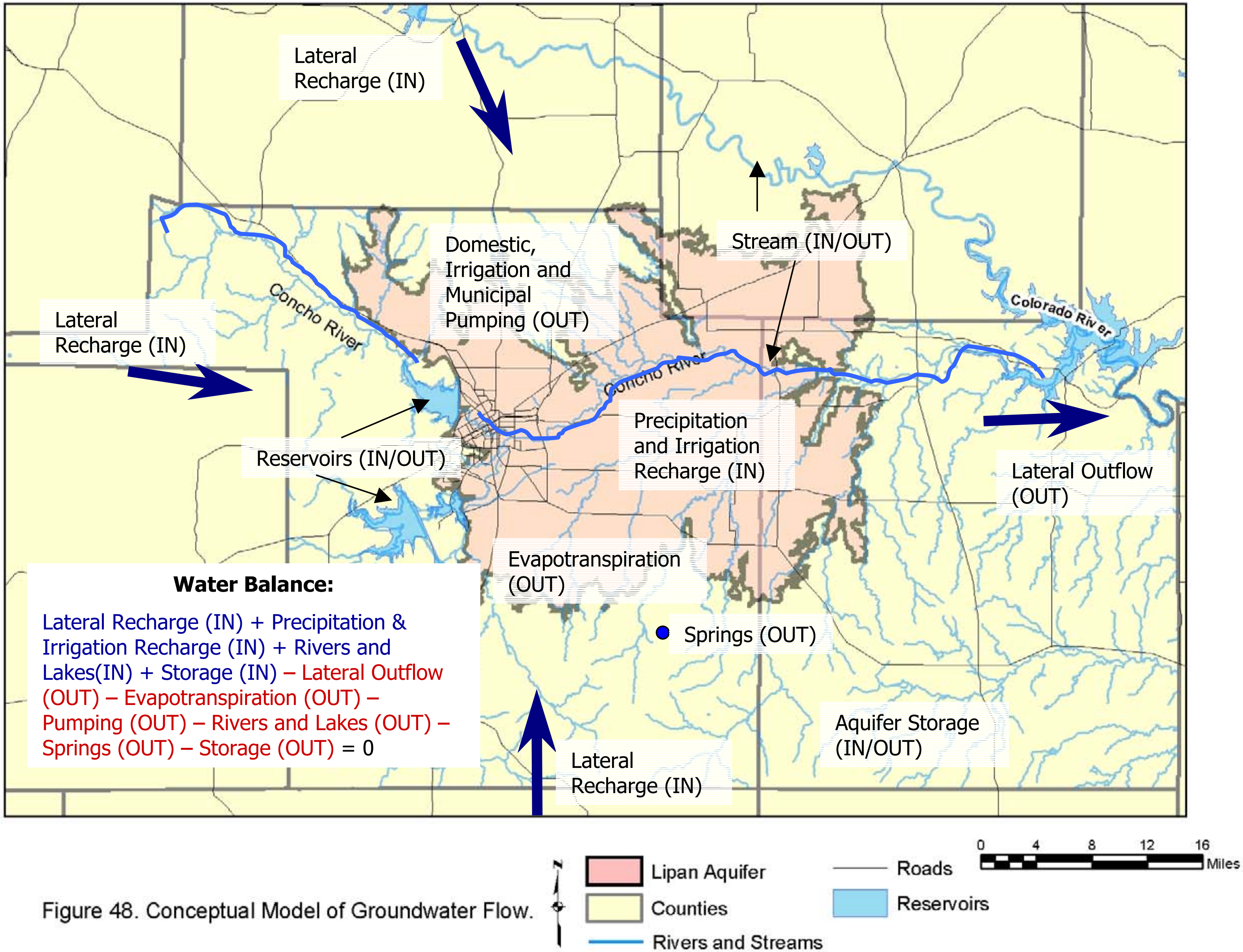


Figure 42. Location and Status of Springs (After Brune, 1975)

Data Source: TWDB Report 189, "Major and Historical Springs of Texas
Data: S:\Projects\GAM02\GAMLipan\LEON\scrdata\surhyd\Springs.xls
Location: S:\Projects\GAM02\GAMLipan\LEON\LEON_springs.mdx

Conceptual Groundwater Flow Model



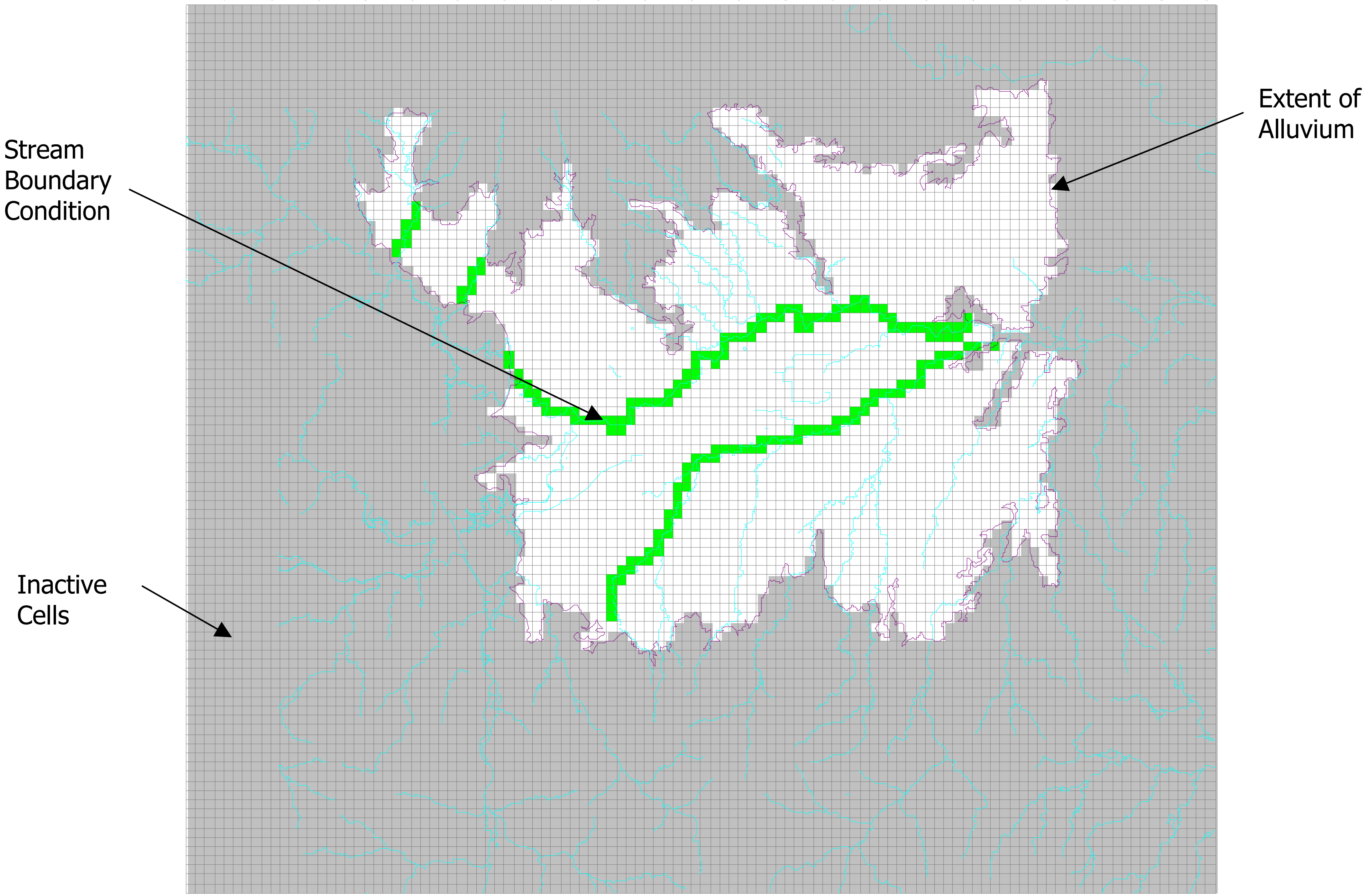
Water Balance:

Lateral Recharge (IN) + Precipitation & Irrigation Recharge (IN) + Rivers and Lakes(IN) + Storage (IN) – Lateral Outflow (OUT) – Evapotranspiration (OUT) – Pumping (OUT) – Rivers and Lakes (OUT) – Springs (OUT) – Storage (OUT) = 0

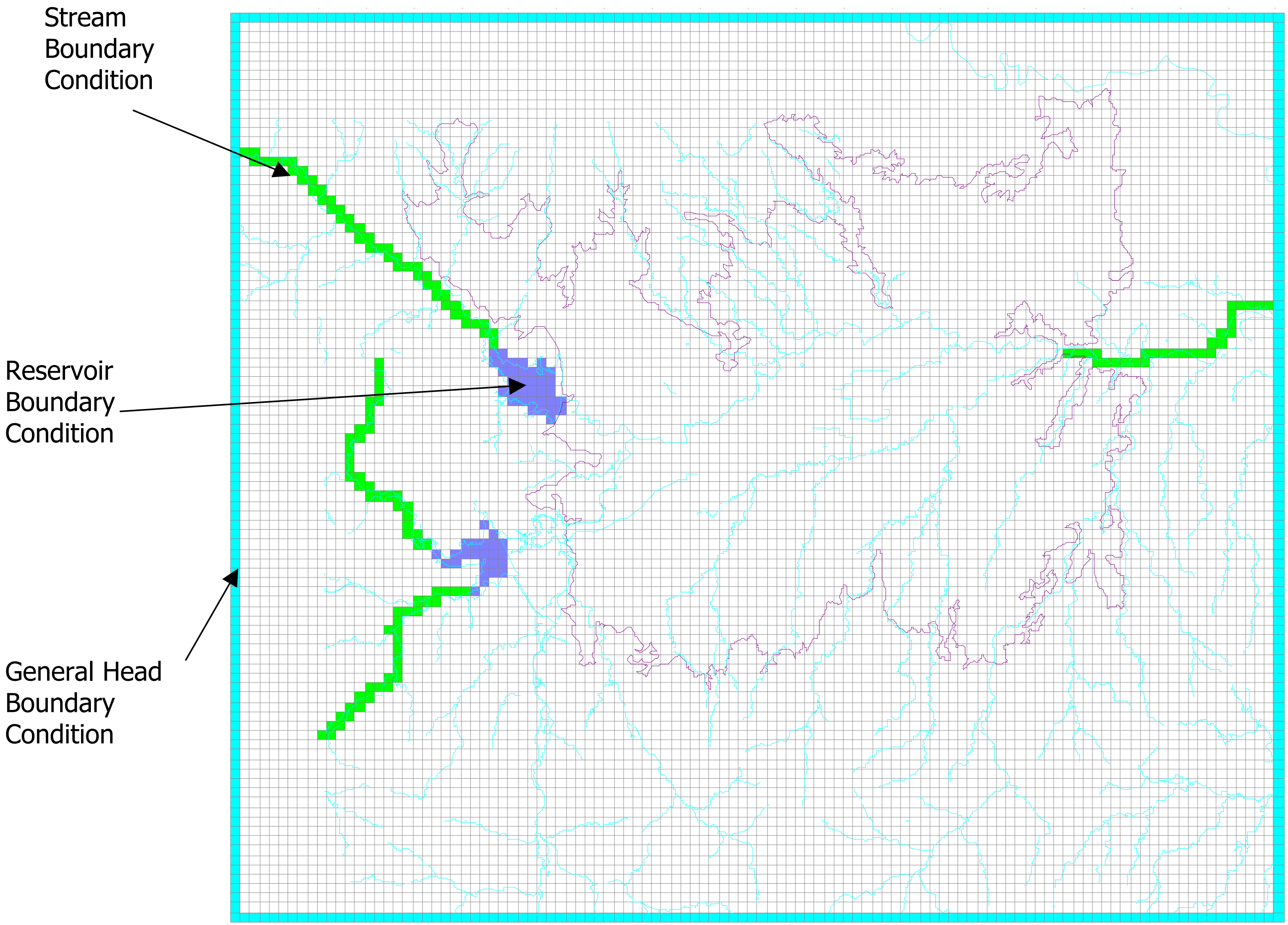
Figure 48. Conceptual Model of Groundwater Flow.

Location: S:\Projects\GAM02\GAMLipan\LEON\LEON_Concept.mdx

Preliminary Model grid Layer 1



Preliminary Model grid Layer 2



Project Schedule

Task	Date and Project Month																					
	Sep-02	Oct-02	Nov-02	Dec-02	Jan-03	Feb-03	Mar-03	Apr-03	May-03	Jun-03	Jul-03	Aug-03	Sep-03	Oct-03	Nov-03	Dec-03	Jan-04	Feb-04	Mar-04	Apr-04	May-04	Jun-04
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Stakeholder Input	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
TWDB Review Meetings				√			√			√				√				√		√		
SAF Meetings					√			√			√				√				√			
Conceptual Model Development	■	■	■	■	■	■	■															
Data Collection	■	■	■	■	■	■	■															
a) Physiography	■	■	■																			
b) Geology	■	■	■	■	■	■	■															
c) Water Levels	■	■	■	■	■	■	■															
d) Recharge	■	■	■	■	■	■	■															
e) Surface Water	■	■	■	■	■	■	■															
f) Aquifer Characteristics	■	■	■	■	■	■	■															
g) Discharge	■	■	■	■	■	■	■															
Model Development				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■				
a) Architecture				■	■	■	■	■														
b) Steady-State Calibration							■	■	■	■												
c) Transient Calibration									■	■	■	■	■									
d) Verification													■	■	■							
e) Sensitivity Analysis																■						
Predictions																	■	■				
Documentation	■	■	■	■	■	■	■	■	■	■	■	Draft	■	■	■	■	■	■	Draft	■	■	Final

SAF Schedule

SAF Meeting	Date	Topics
1	Jan 14, ’03	Introduction & Modeling Approach
2	April, ’03	Data Evaluation & Conceptual Model
3	July, ’03	Model Architecture & Steady-State Calibration
4	Nov, ’03	Transient Calibration & Sensitivity
5	March, ’04	Predictions and Final Presentation
Model Training	June, ’04	Hands-on Stakeholder Training Seminar
Final Report	June 30, ’04	Final Report Due to TWDB

Attendees of the 2nd Stakeholder Advisory Forum
for the Lipan GAM
April 24, 2003

Name	**Affiliation**
Richard Smith	TWDB
Scott McWilliams	UCRA
Bill Lange	Lange Drilling Co.
John Begnaud	TCE
John Walker	TAES
Allan Lange	Lipan-Kickapoo WCD
Michael Hoelscher	Hoelscher Pump
Will Wilde	City of San Angelo
LeRoy Olsak	Irrigated Land Owner, Pecan Grower

Lipan Aquifer
Groundwater Availability Model (GAM)

Second Stakeholder Advisory Forum (SAF) Meeting

April 24, 2003
San Angelo, Texas

Meeting Summary

The second Stakeholder Advisory Forum (SAF) meeting for the Lipan Aquifer Groundwater Availability Model (GAM) was held on April 24th from 7:00 to 9:00 PM at the Texas A&M Research Center in San Angelo, Texas. Richard Smith of the TWDB introduced LBG-Guyton Associates as the consulting team that is contracted to perform the modeling project.

James Beach and Stuart Burton of LBG-Guyton made a presentation to an audience consisting of nine attendees. The presentation, along with a list of participants who signed up at the meeting, is available at the TWDB GAM website (www.twdb.state.tx.us/gam). The presentation was structured according to the following outline:

- Review of GAM Objectives and Expectations
- Basics of Groundwater Flow Modeling
- Conceptual Groundwater Flow Model

The questions and answers from the SAF are presented below.

Questions and Answers

Q: *How will recharge be applied to the model and can it vary laterally as well as temporally?*

A: Recharge may be assigned to each cell individually. It can vary laterally within the model but is uniform within a cell. Recharge can also vary temporally from stress period to stress period but is constant during a stress period. The Lipan model will consist of yearlong stress period for seven years in a decade and the other three years having monthly stress periods.

Q: *Will the model include recharge from the Edwards – trinity to the south?*

A: Yes. Recharge from and discharge to adjacent water-bearing units will be incorporated into the model. This will be accomplished through the use of General Head Boundary (GHB) condition nodes at the model edges.