STAKEHOLDER ADVISORY FORUM (SAF) MEETING

JUNE 5, 2001

AGENDA

- GROUND-WATER FLOW MODELS
- FLOW IN EDWARDS AQUIFER
- EDWARDS AQUIFER MODEL
- PROJECT SCHEDULE

GROUND-WATER FLOW MODELS

WHAT IS A GROUND-WATER FLOW MODEL ?

- Numerical computer ground-water flow model
- A set of mathematical equations that represents the physical aquifer system
- Computer code -- MODFLOW
- Based on conceptual model of aquifer system

WHAT IS A GROUND-WATER FLOW MODEL ?

- Model is an approximation of physical aquifer system
  - requires assumptions and simplifications
- Uses of model
  - test and refine conceptual model
  - predictive tool

MODEL INPUT/DATA SETS

- Aquifer structure
- Hydraulic properties
- Recharge
- Discharge

MODEL INPUT/DATA SETS

- Boundary conditions
  - inflow to modeled area
  - outflow from modeled area
  - no flow

MODEL OUTPUT

- Hydraulic heads (water levels)
- Flow rates
  - spring discharge, leakage to streams
- Water budget of inflows and outflows

MODEL LIMITATIONS

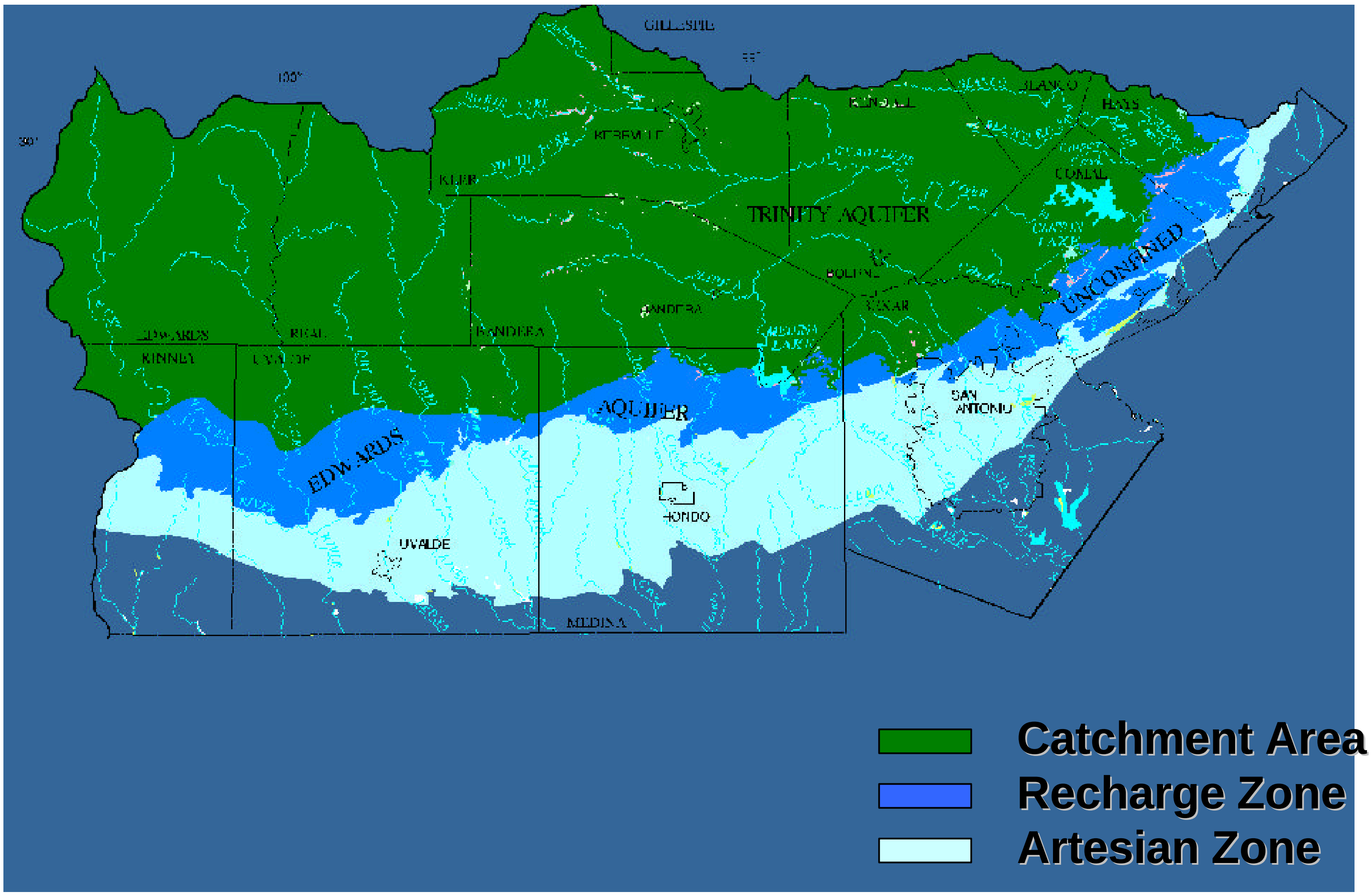
- Model scale (cell size)
  - regional scale vs. local features
- Available information
  - aquifer structure, hydraulic properties, recharge, discharge

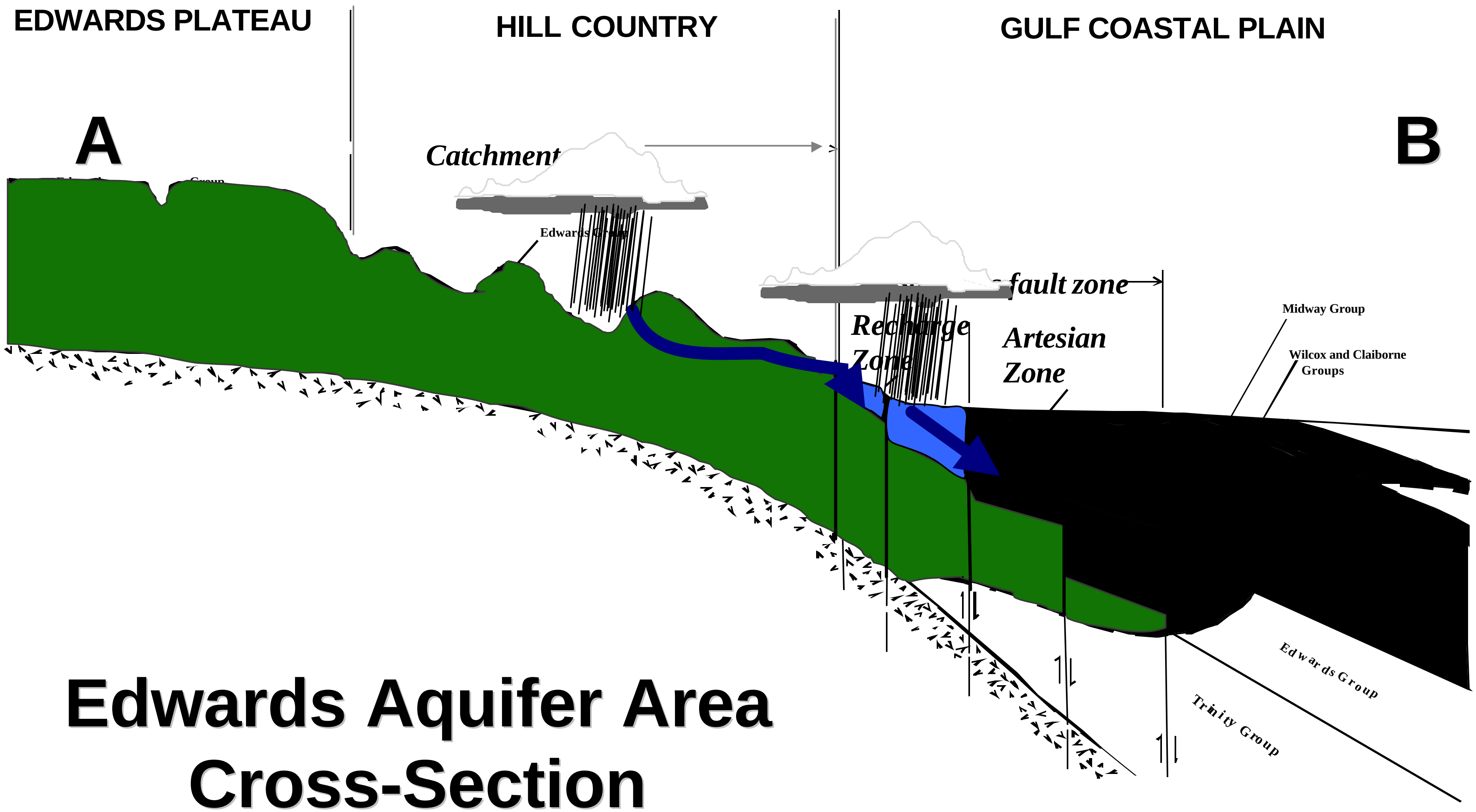
STAGES IN MODELING PROCESS

- Conceptual model
- Model construction
- Calibration
  - match measured and simulated hydraulic heads and flows
- Verification
  - compare measured and simulated hydraulic heads and flows
- Prediction

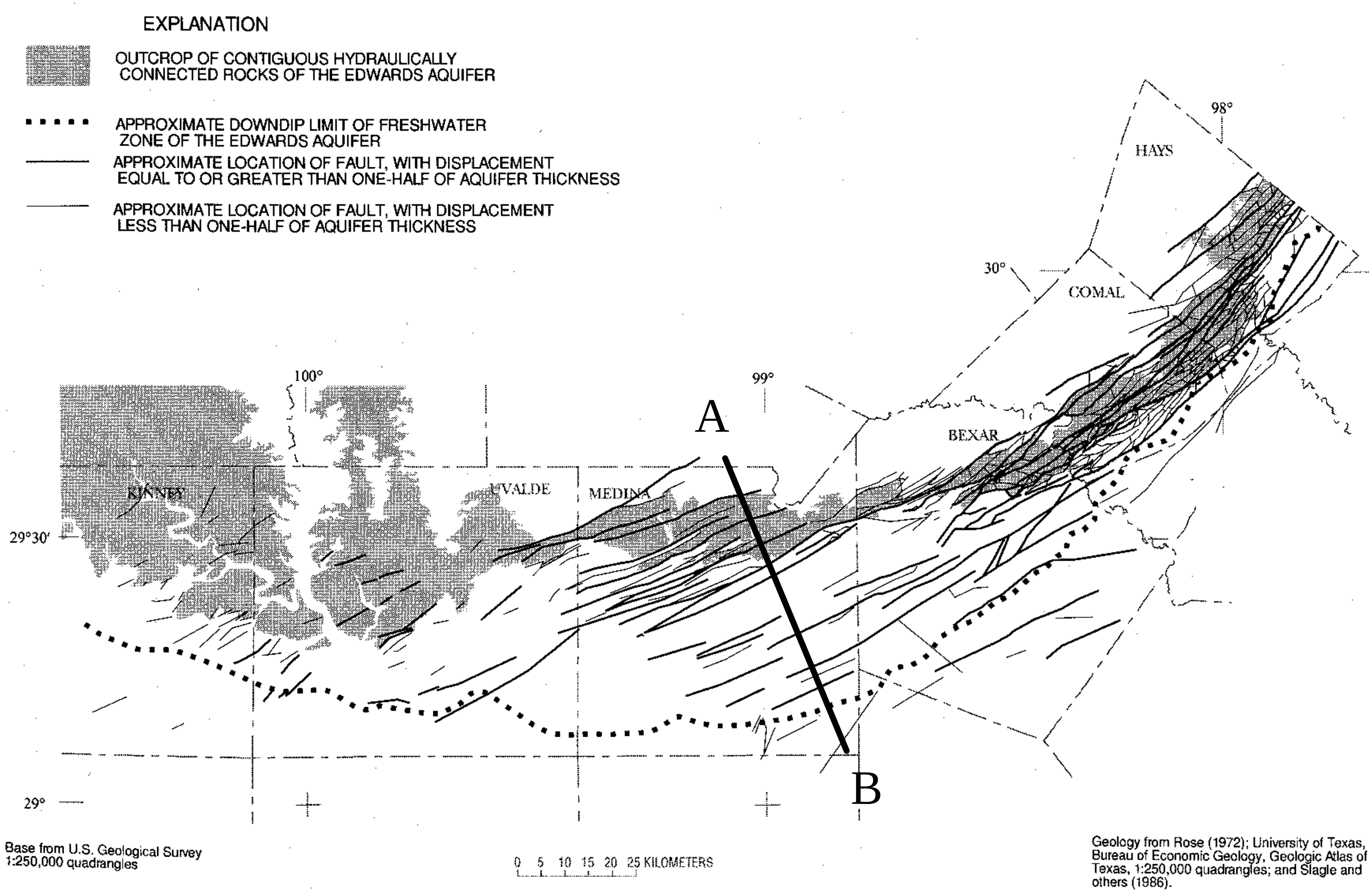
FLOW IN EDWARDS AQUIFER (CONCEPTUAL MODEL)

Edwards Aquifer

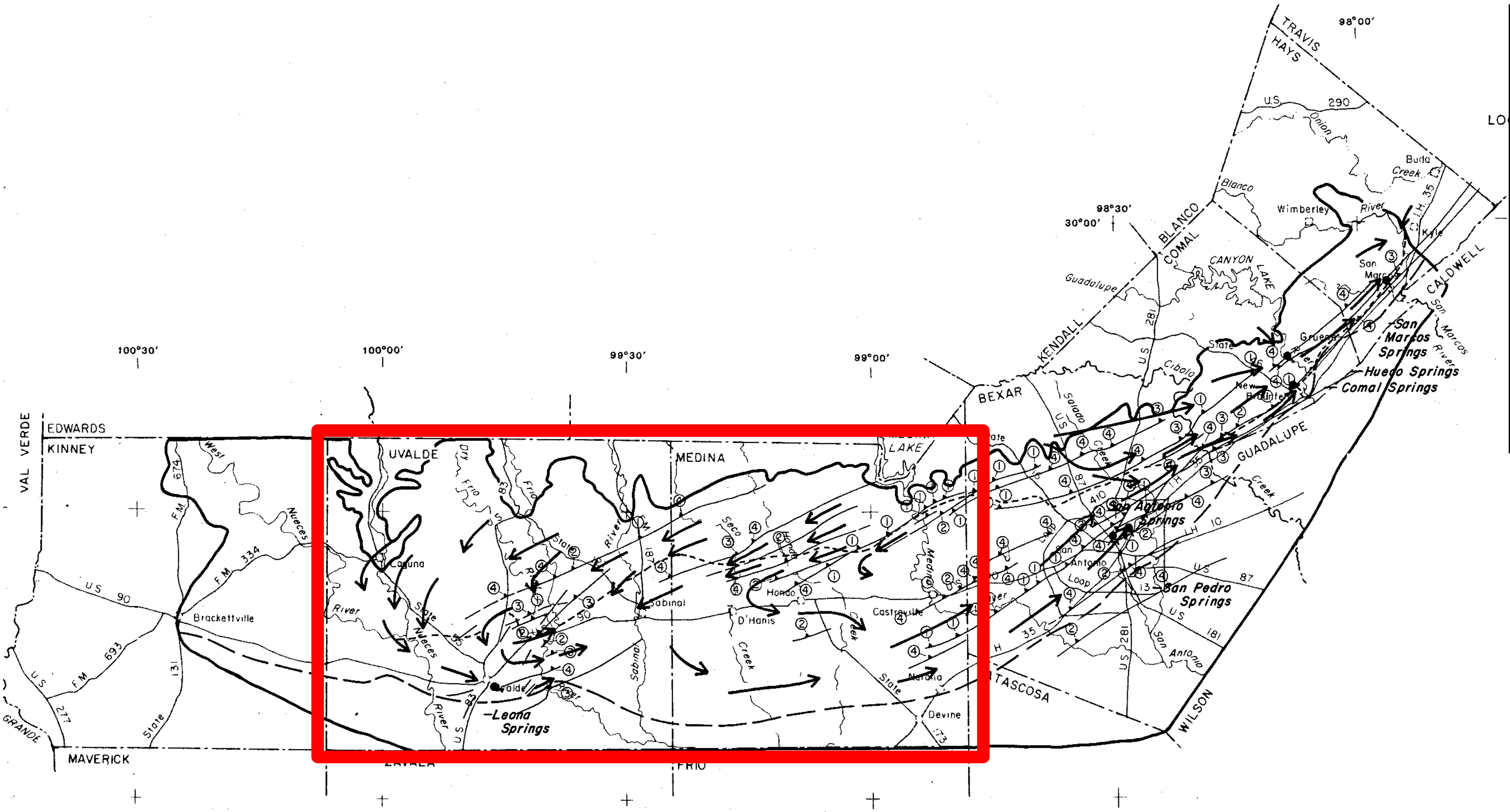




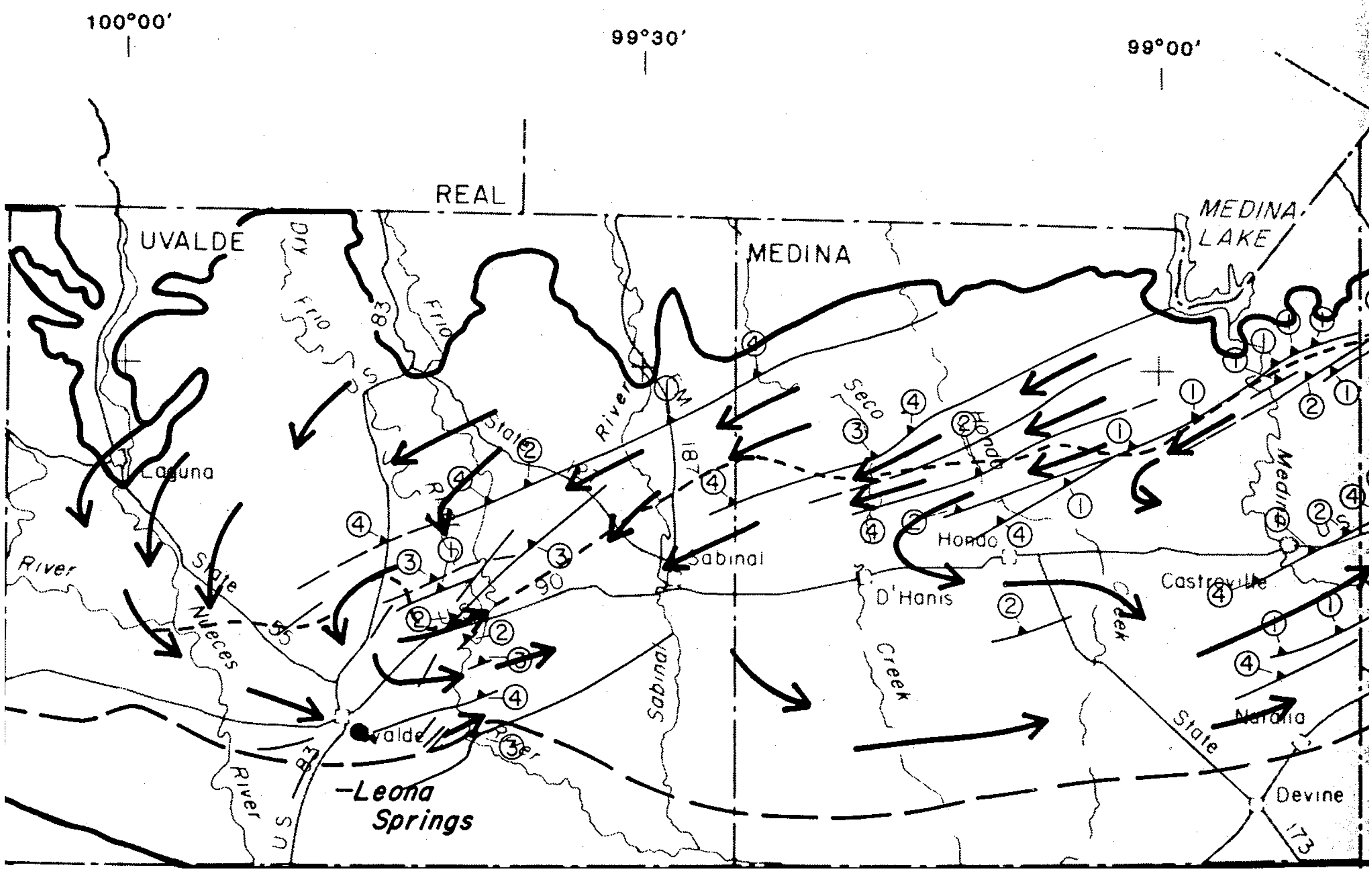
Edwards Aquifer Area Cross-Section



EXPLANATION
OUTCROP OF CONTIGUOUS HYDRAULICALLY CONNECTED ROCKS OF THE EDWARDS AQUIFER
APPROXIMATE DOWNDIP LIMIT OF FRESHWATER ZONE OF THE EDWARDS AQUIFER
APPROXIMATE LOCATION OF FAULT, WITH DISPLACEMENT EQUAL TO OR GREATER THAN ONE-HALF OF AQUIFER THICKNESS
APPROXIMATE LOCATION OF FAULT, WITH DISPLACEMENT LESS THAN ONE-HALF OF AQUIFER THICKNESS
98°
HAYS
30°
COMAL
100°
99°
A
BEXAR
KINNEY
UVALDE
MEDINA
29°30′
B
29°
Base from U.S. Geological Survey 1:250,000 quadrangles
0 5 10 15 20 25 KILOMETERS
Geology from Rose (1972); University of Texas, Bureau of Economic Geology, Geologic Atlas of Texas, 1:250,000 quadrangles; and Slagle and others (1986).

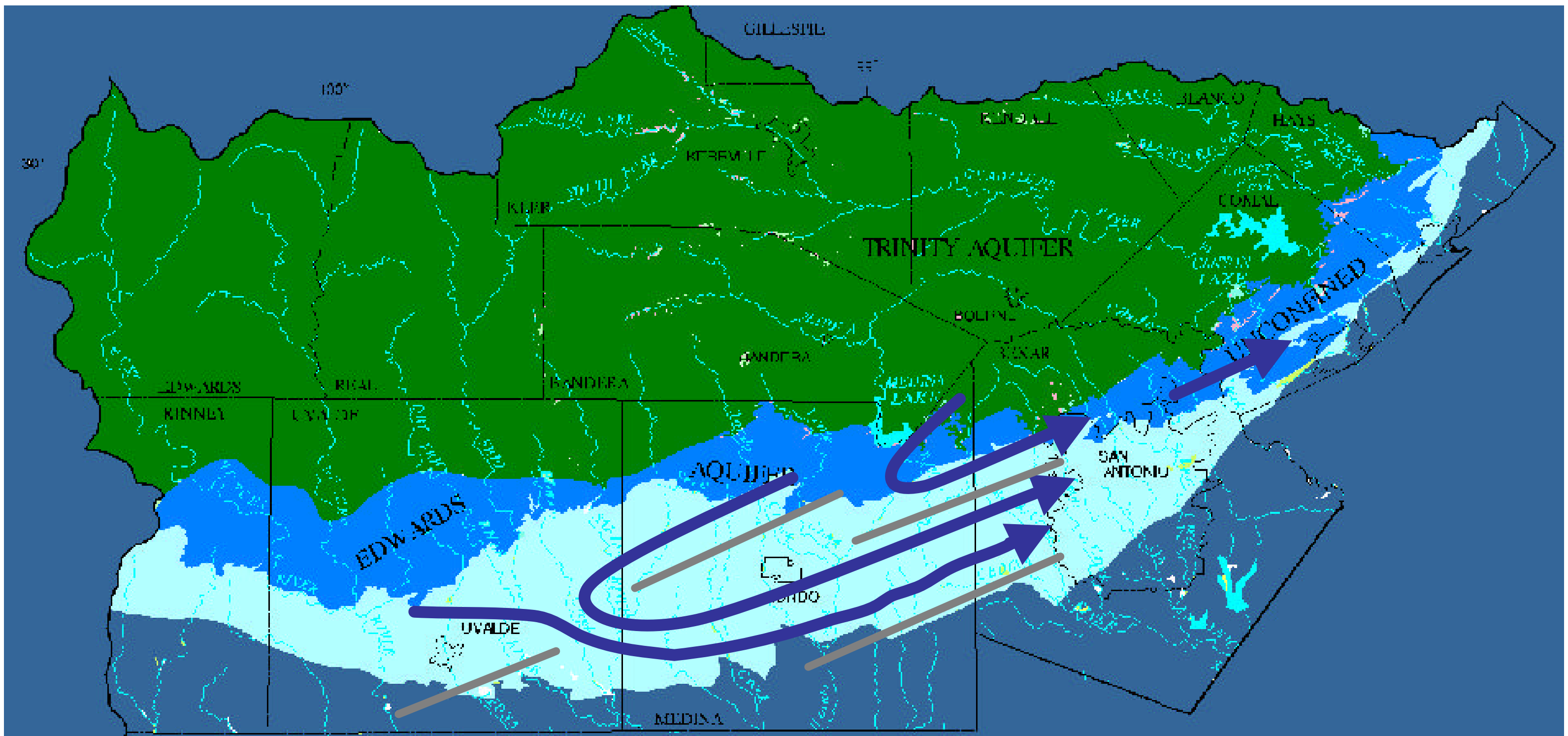


TRAVIS
HAYS
98°00'
U.S. 290
Onion
Buda
Creek
Blanco
Wimberley
River
I.H. 35
Kyle
98°30'
30°00'
BLANCO
COMAL
CANYON LAKE
Guadalupe
San Marcos
CALDWELL
KENDALL
Gruene
San Marcos Springs
Hueco Springs
Comal Springs
New Braunfels
Cibolo
BEXAR
Salado
Creek
GUADALUPE
San Antonio Springs
San Antonio
Loop
San Pedro Springs
Creek
100°30'
100°00'
99°30'
99°00'
VAL VERDE
EDWARDS
KINNEY
UVALDE
MEDINA
MEDINA LAKE
West
Nueces
F.M. 674
F.M. 334
US 90
Brackettville
Camp Wood
Dry Frio
Frio
River
Seco
Hondo
Medina
Sabinal
Hondo
D'Hanis
Castroville
Creek
Natalia
Devine
Uvalde
Leona Springs
River
F.M. 693
131
US 277
State
GRANDE
MAVERICK
ZAVALA
FRIO
ATASCOSA
WILSON



100°00'
99°30'
99°00'
REAL
UVALDE
MEDINA
MEDINA LAKE
Laguna
Hondo
Sabinal
D'Hanis
Castroville
Natalia
Devine
Uvalde
Leona Springs
Nueces River
Frio River
Dry Frio
Sabinal River
Seco Creek
Hondo Creek
Medina
State 55
State 173
US 83
US 90
187

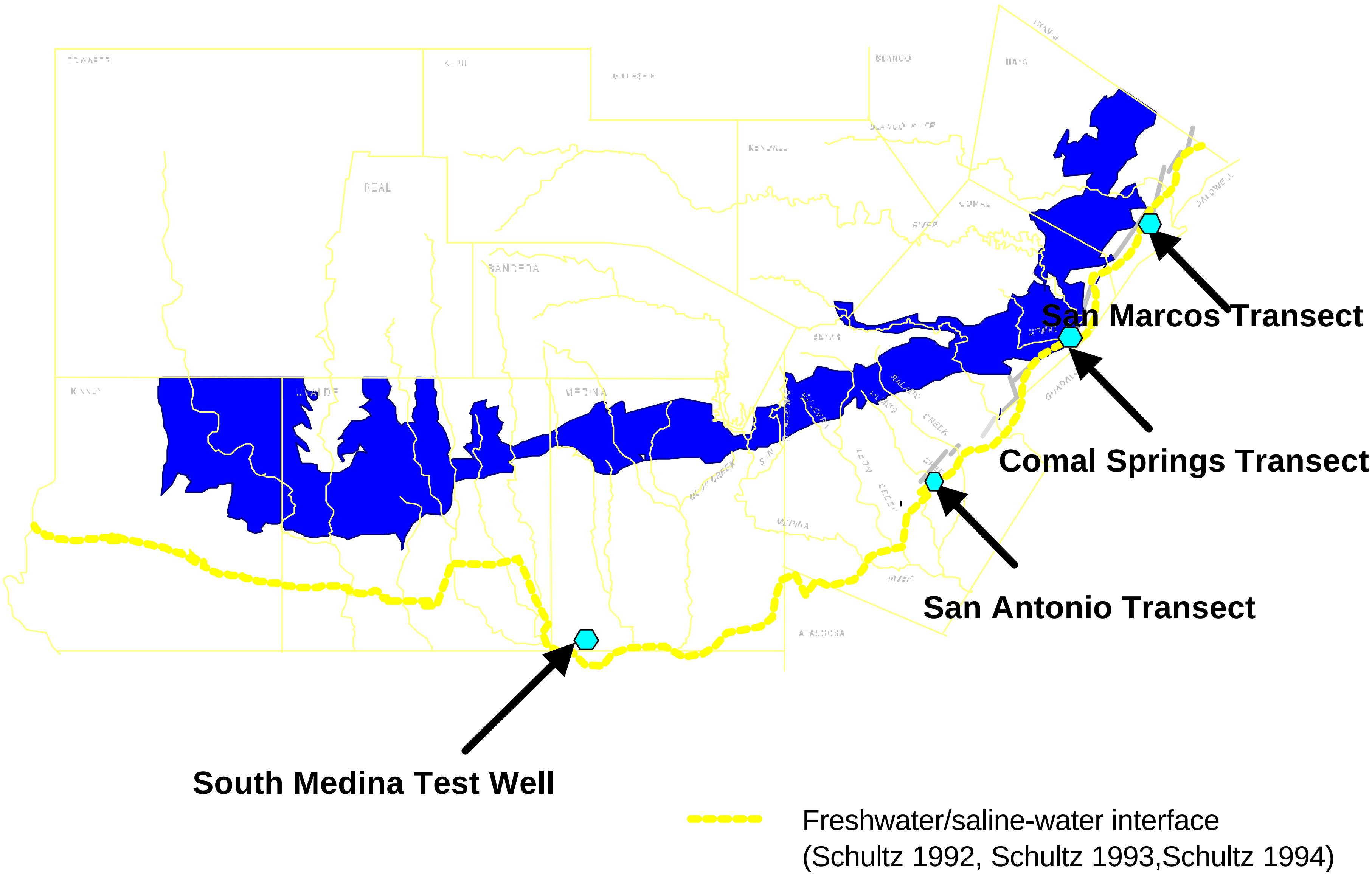
Edwards Aquifer



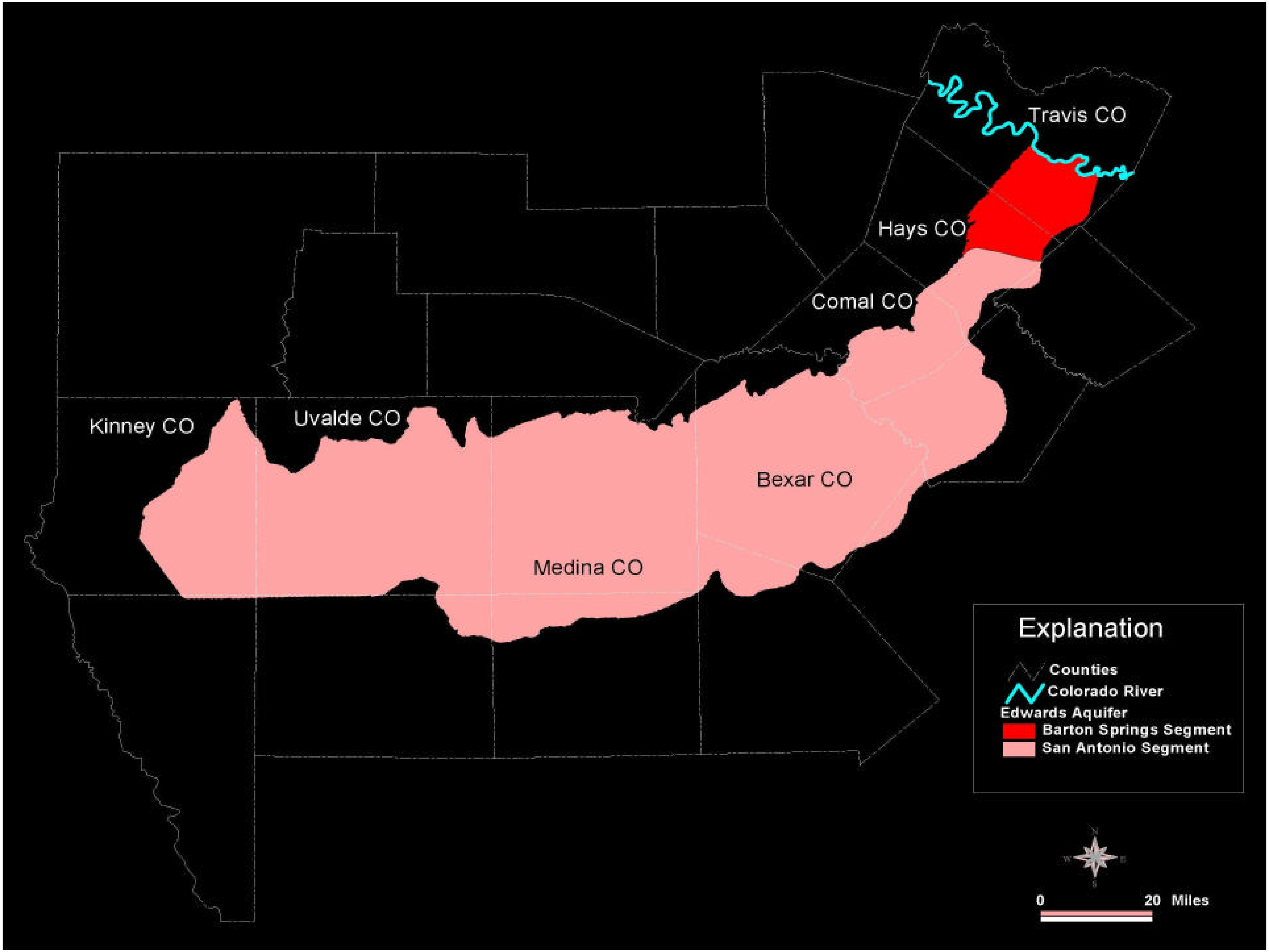
Major Flowpaths

Catchment Area
Recharge Zone
Artesian Zone

Downdip limit of freshwater



EDWARDS AQUIFER MODEL



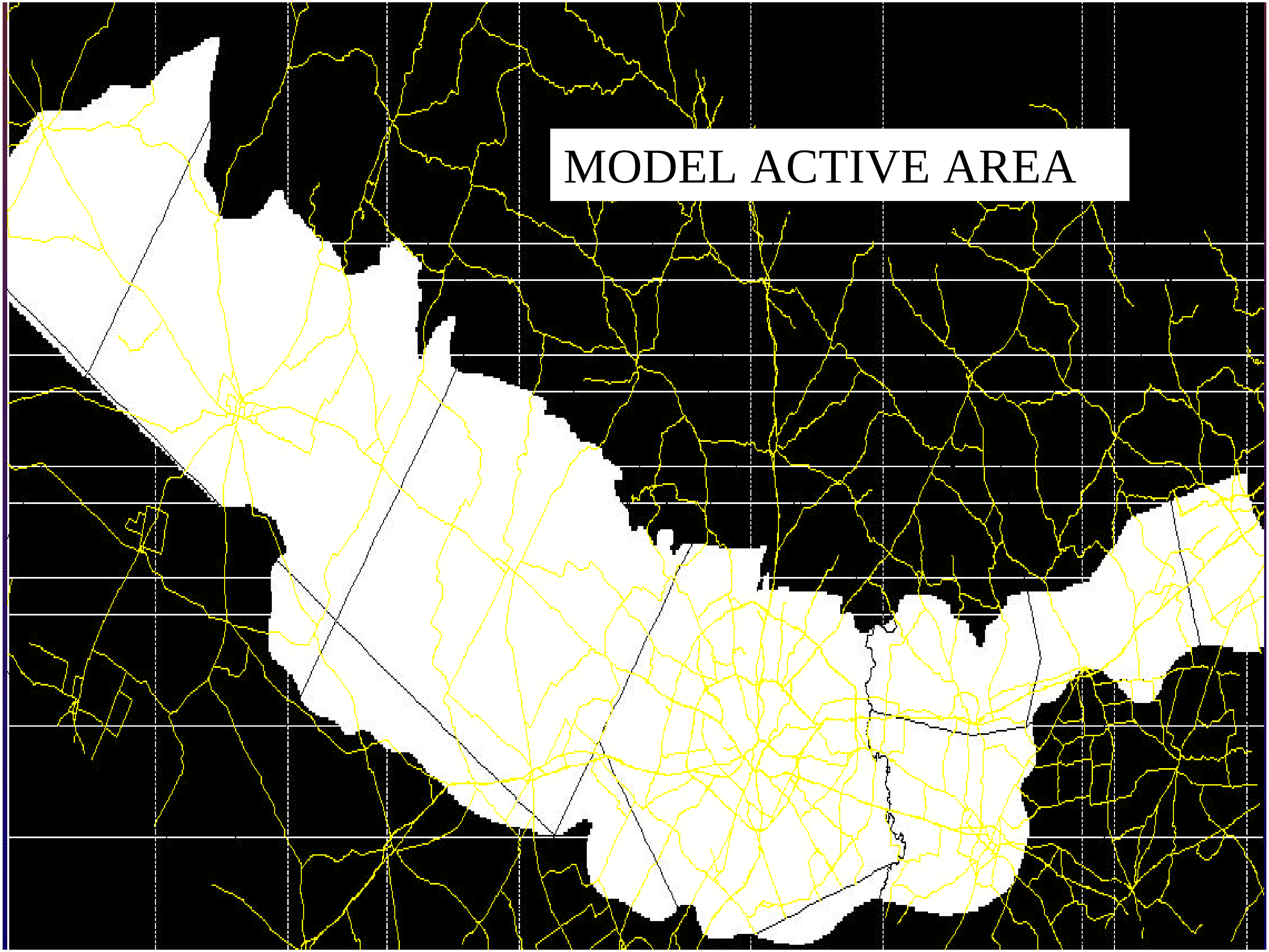
Travis CO
Hays CO
Comal CO
Kinney CO
Uvalde CO
Bexar CO
Medina CO
Explanation
Counties
Colorado River
Edwards Aquifer
Barton Springs Segment
San Antonio Segment
0
20 Miles

PREVIOUS MODELS

- San Antonio segment
  - Klemt and others (1979)
  - Thorkildsen and McElhany (1992)
  - Maclay and Land (1988)
- Barton Springs segment
  - Slade and others (1985)
  - Scanlon and others (2000)

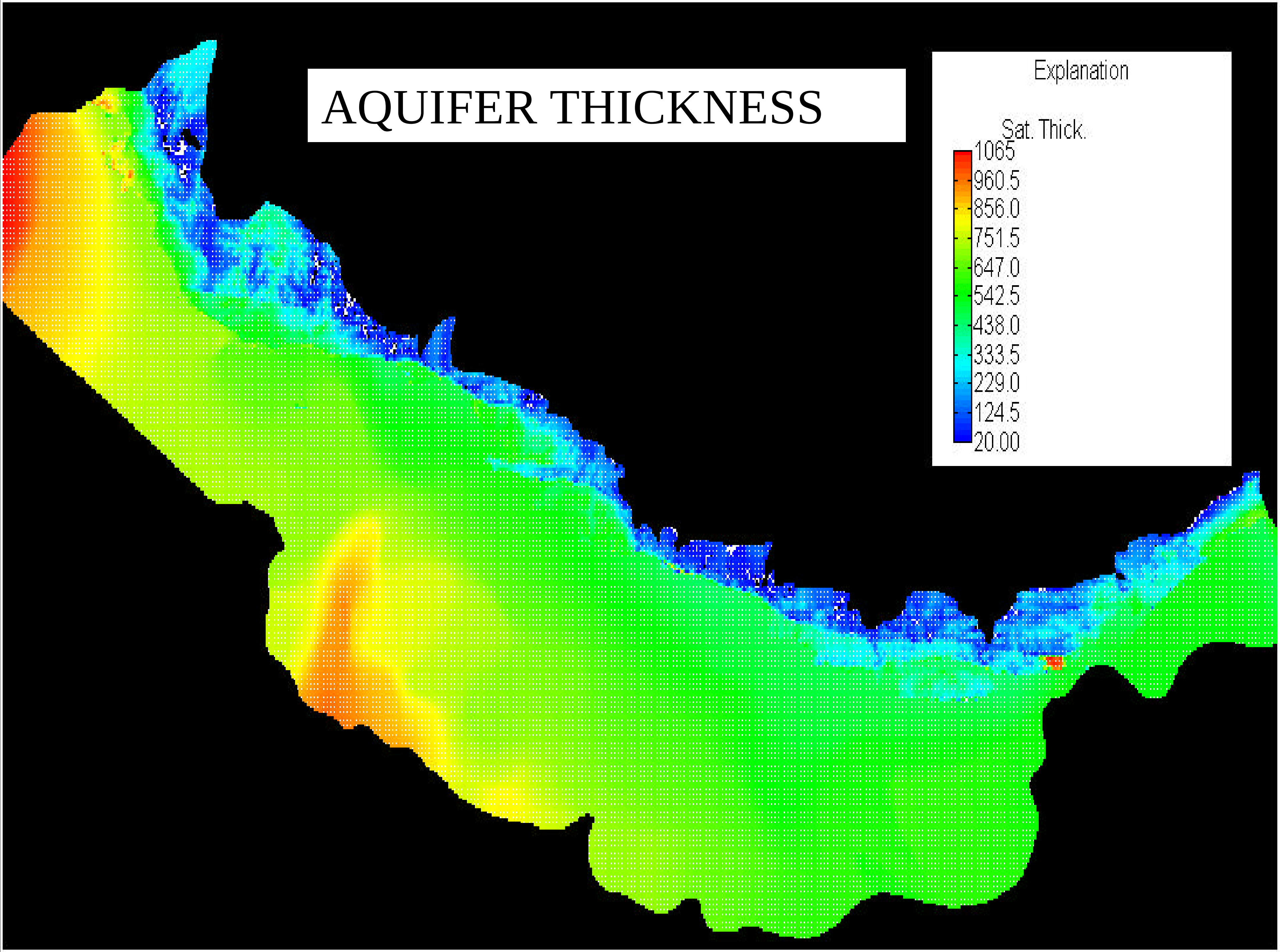
EDWARDS AQUIFER MODEL

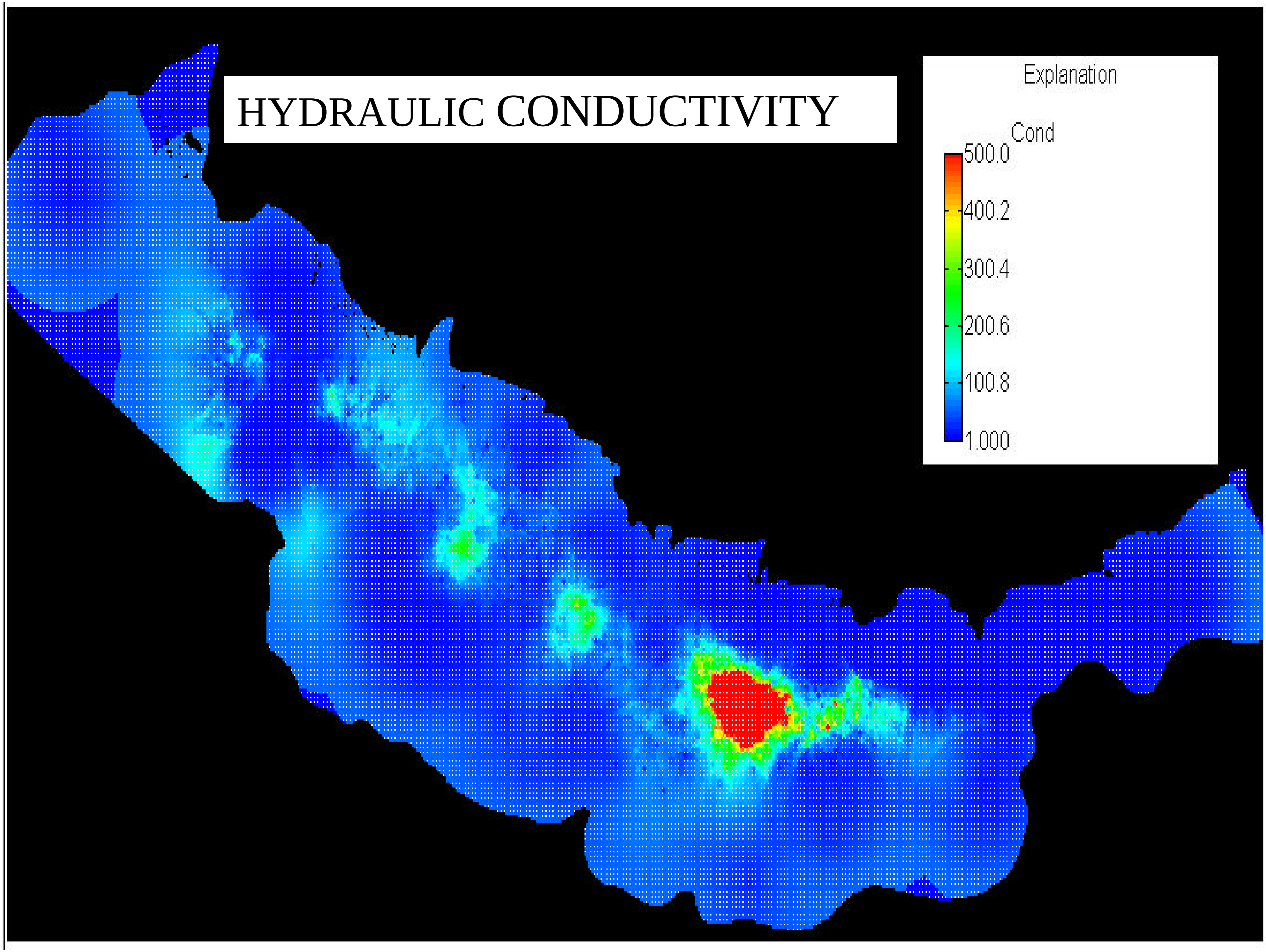
- Uniform ¼-mi grid
- 370 rows; 700 columns; 259,000 cells
- One layer
- Grid alignment:
  - Major faults and flow near Comal and San Marcos Springs


MODEL ACTIVE AREA

AQUIFER STRUCTURE AND HYDRAULIC PROPERTIES

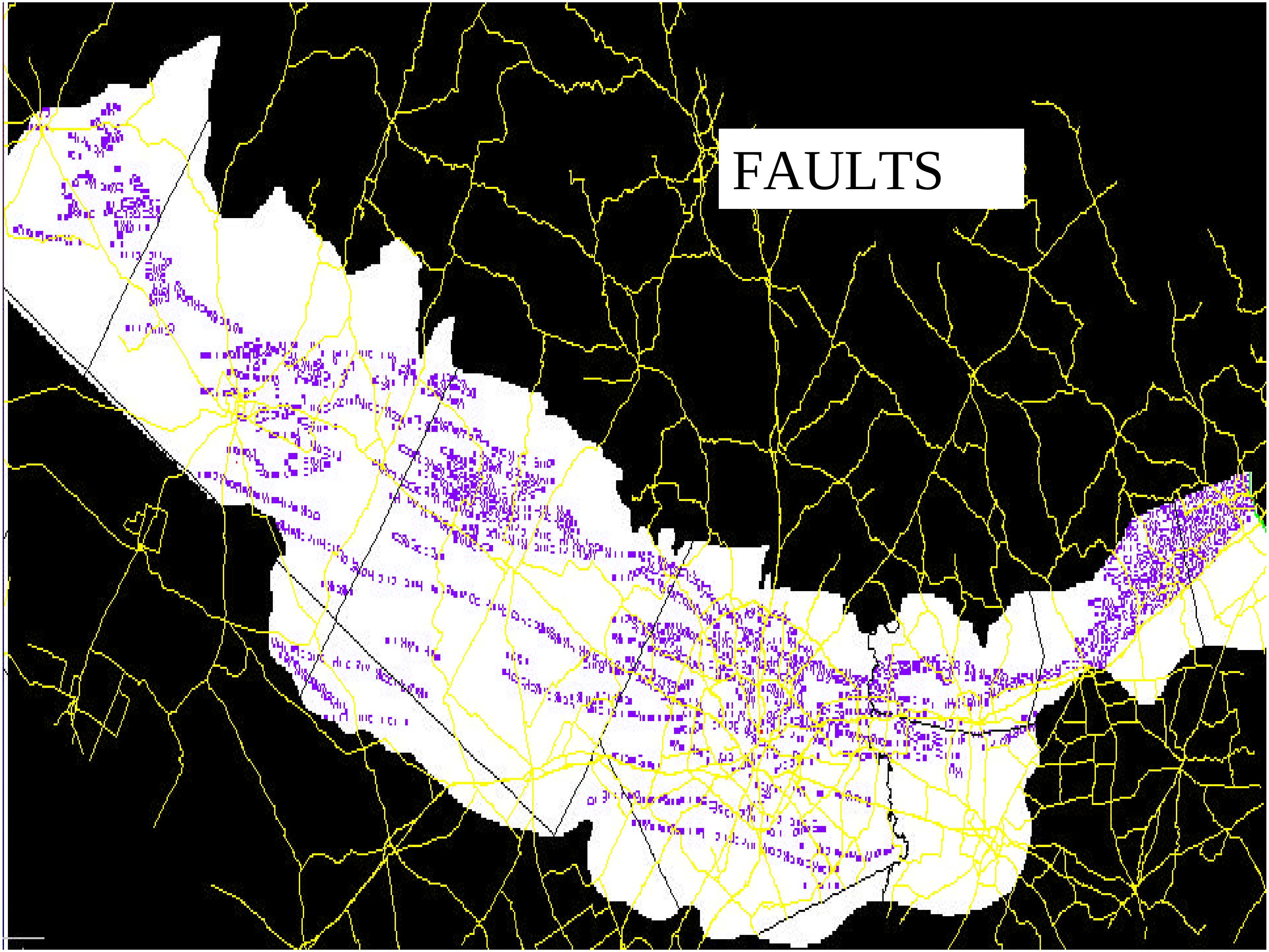
- Aquifer top elevation
- Aquifer bottom elevation
- Faults
- Hydraulic conductivity

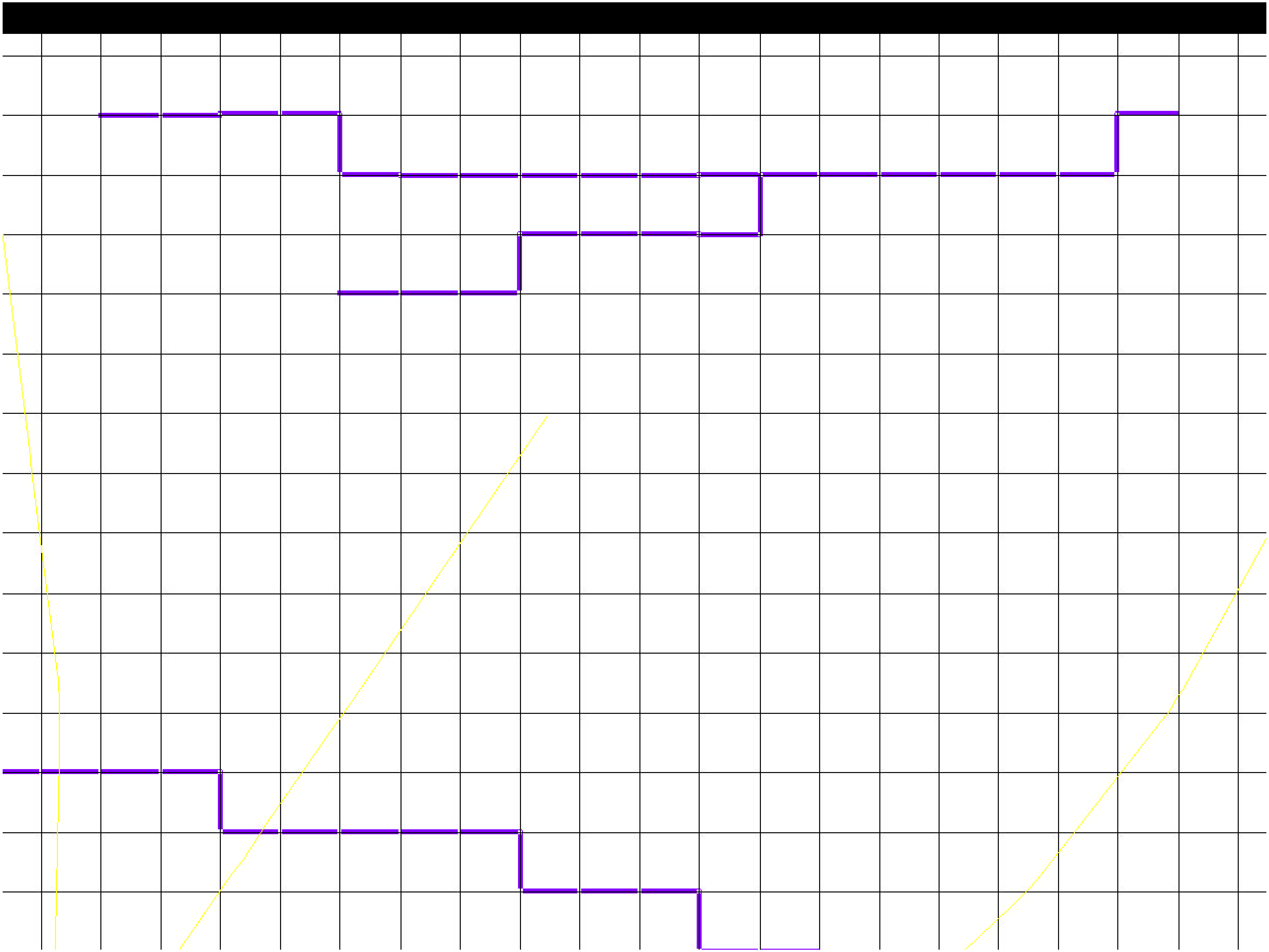

AQUIFER THICKNESS
Explanation
Sat. Thick.
1065
960.5
856.0
751.5
647.0
542.5
438.0
333.5
229.0
124.5
20.00


HYDRAULIC CONDUCTIVITY
Explanation
Cond
500.0
400.2
300.4
200.6
100.8
1.000

FAULTS

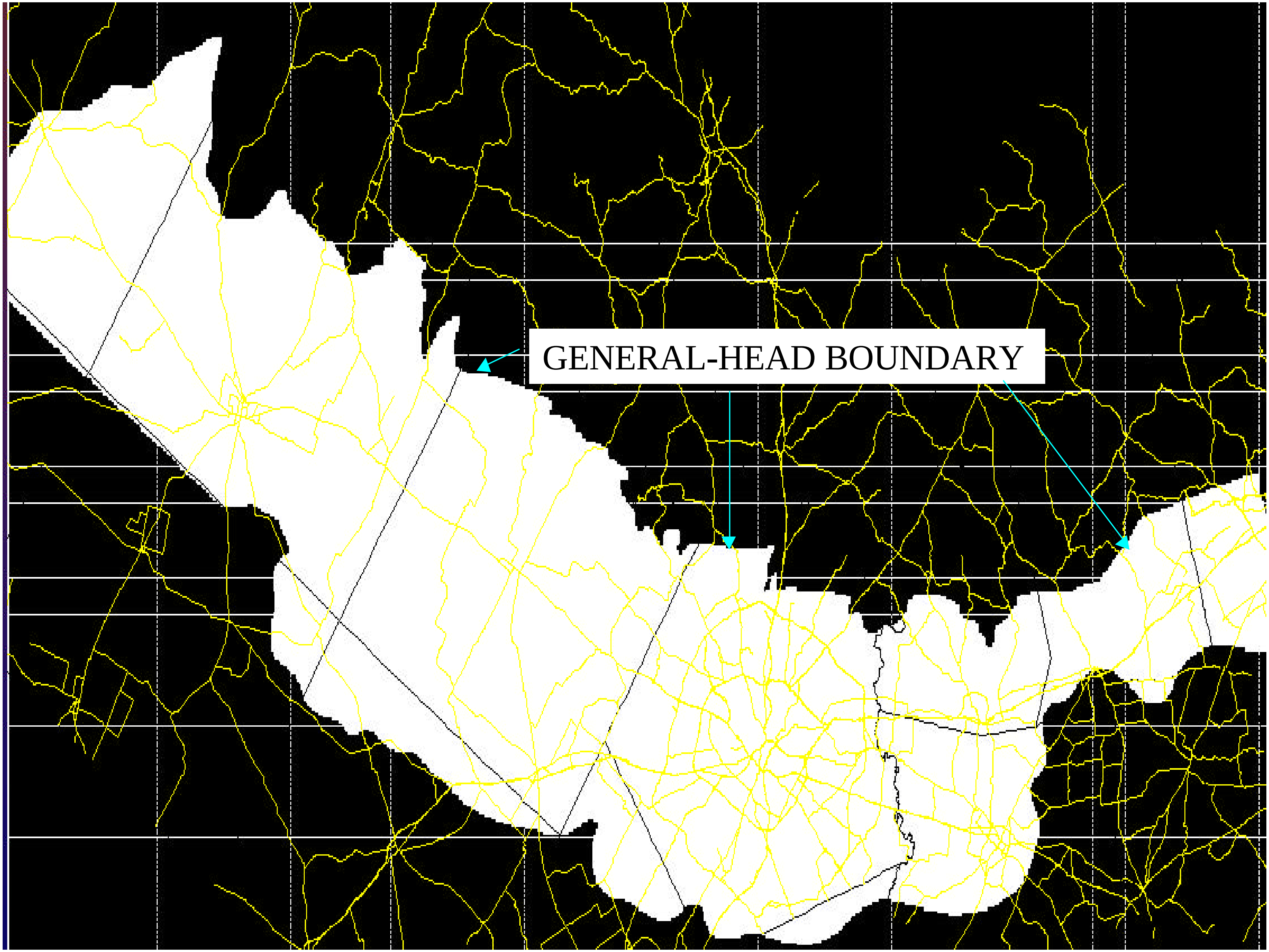
- Simulated using Horizontal Flow Barrier Package
- Model inputs:
  (a) fault location
  (b) hydraulic characteristic (C)
    - hydraulic conductance term
- Assumption: hydraulic characteristic (C) is a function of fault displacement
    - inversely proportional


FAULTS



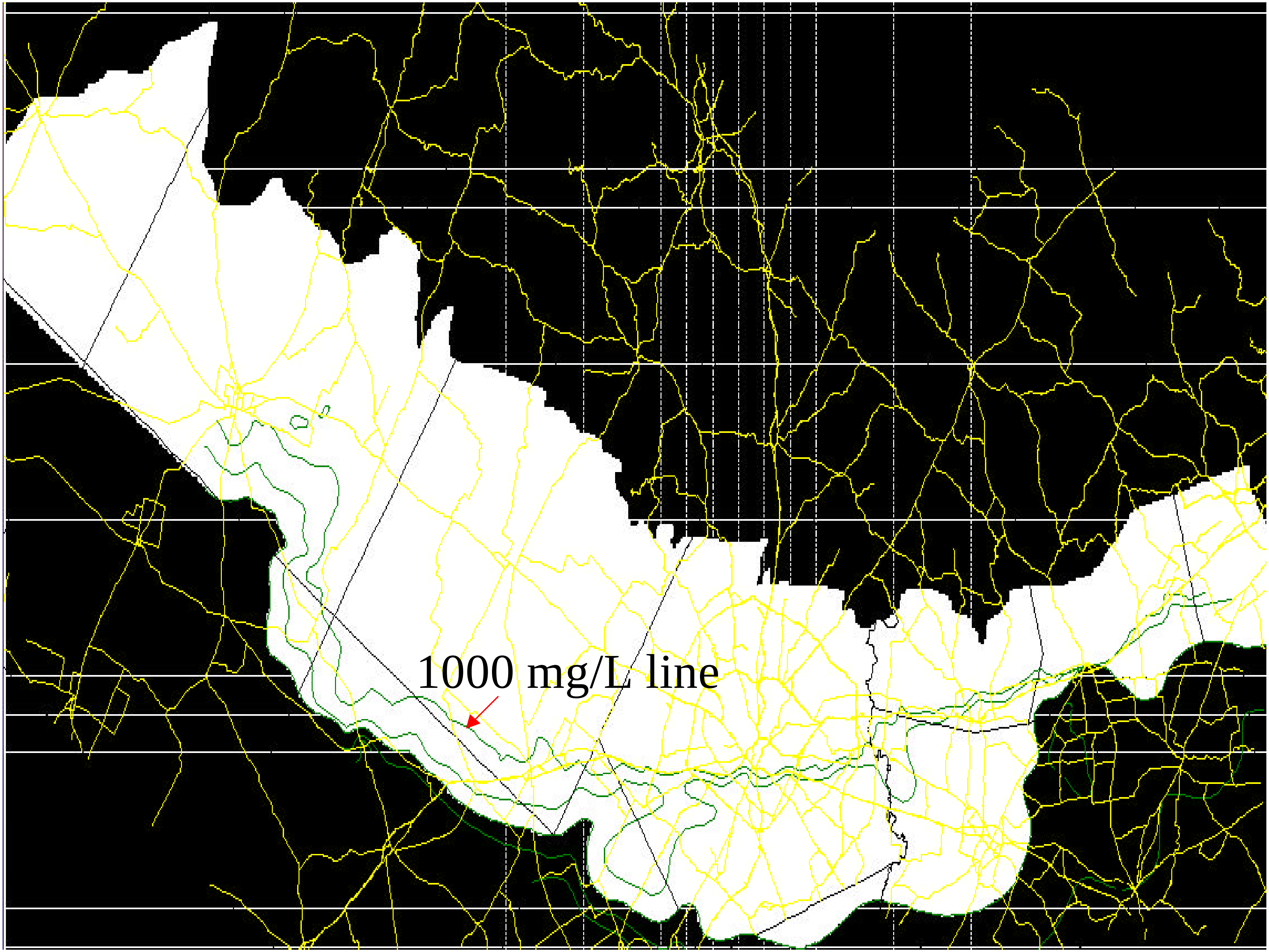
BOUNDARY CONDITIONS
NORTHERN BOUNDARY

- General-head boundary condition
- Will allow simulation of inflow from Trinity aquifer
- Reasonableness of model-computed inflow
  - compare with model-computed outflow from Trinity aquifer from TWDB model of Trinity aquifer


GENERAL-HEAD BOUNDARY

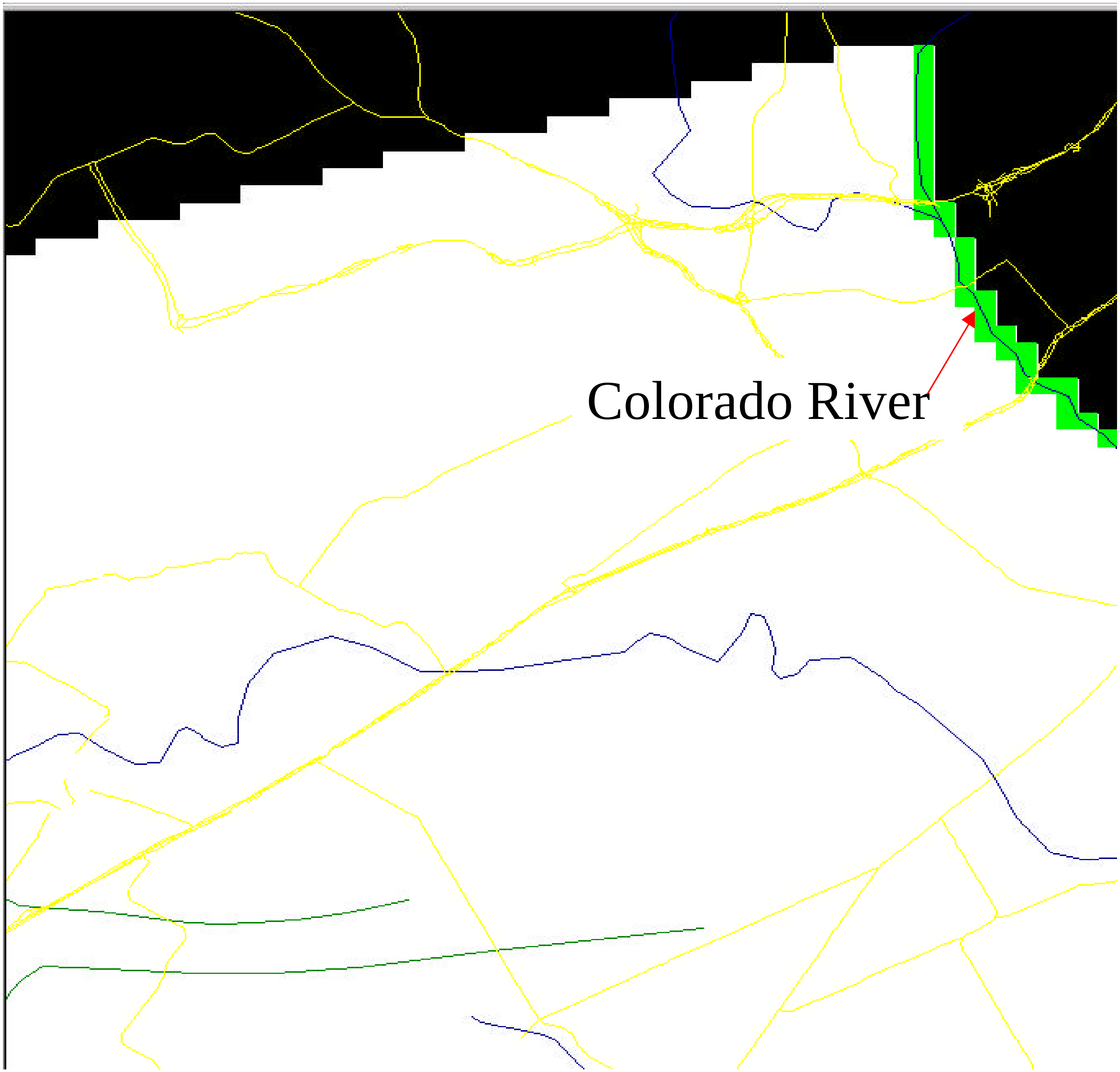
BOUNDARY CONDITIONS
SOUTHERN BOUNDARY

- No-flow boundary
- Located at 10,000 mg/L saline water line
  - conservative in terms of potential flow across boundary
- Previous models used 1,000 mg/L line
- Final placement determined by model calibration


1000 mg/L line

BOUNDARY CONDITIONS
EASTERN BOUNDARY

- Located at Colorado River
  - regional ground-water discharge point
  - well-defined hydrogeologic boundary
  - Colorado River simulated using River Package
- Previous models used g-w divide near Kyle in Hays County
  - poorly defined spatially and temporally


Colorado River

BOUNDARY CONDITIONS
WESTERN BOUNDARY

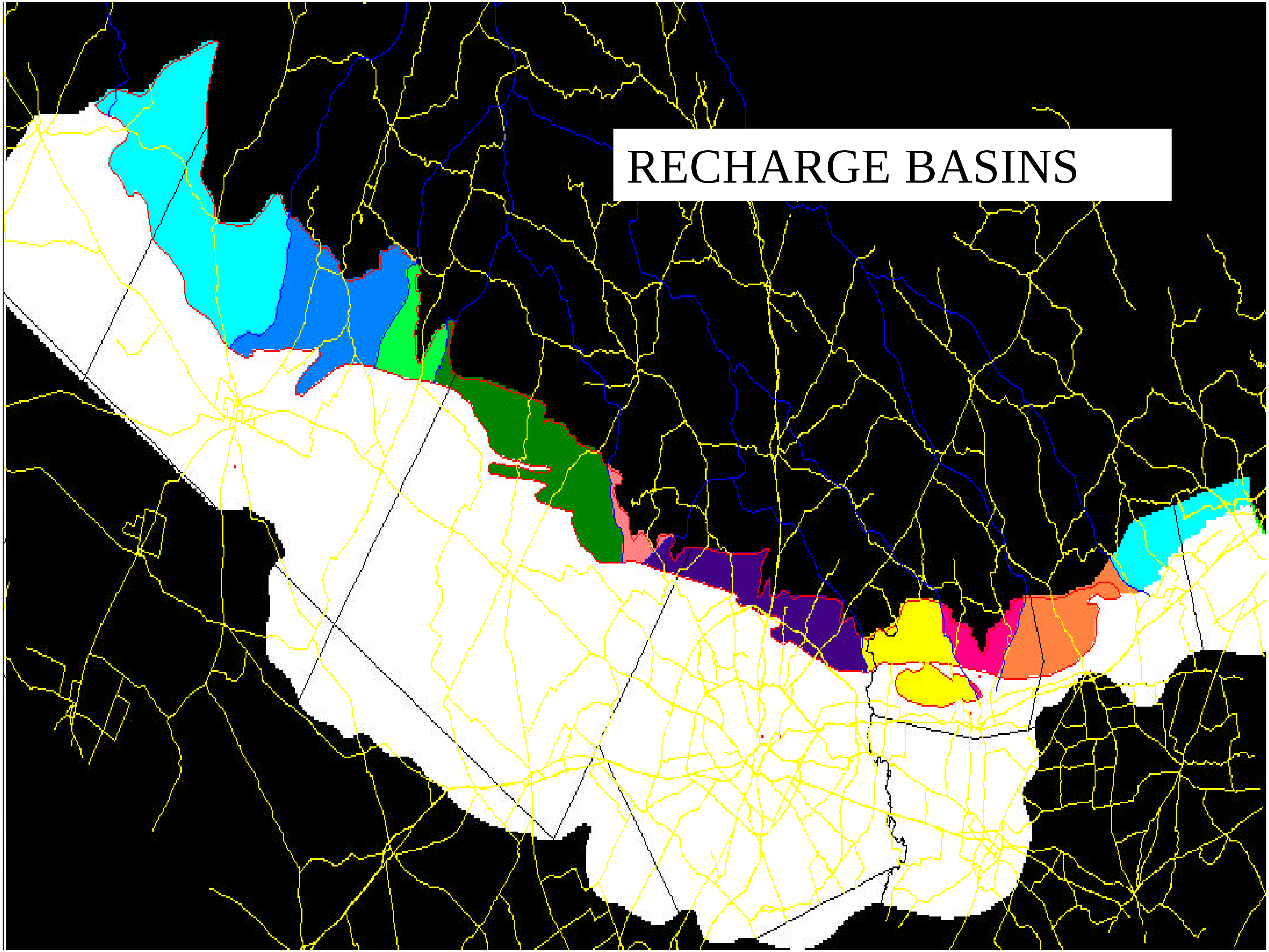
- No-flow boundary
- Located at g-w divide near Brackettville in Kinney County
- Same drawbacks as g-w divide near Kyle
  - no other well-defined hydrogeologic boundary within reasonable distance
  - further removed from principal areas of interest

RECHARGE

- Recharge to Edwards aquifer occurs in outcrop area
- Recharge basins delineated by USGS
- Monthly recharge rates calculated by USGS
  - 1934 to present

RECHARGE DISTRIBUTION

- Initially uniformly distributed over each recharge basin
- Initial rate = Annual recharge/ Recharge basin area
- Refinement: partition recharge into a stream channel component and areal component
- Areal component
  - infiltration of precipitation
  - distributed based on hydrogeologic variability within recharge basin


RECHARGE BASINS

SPRINGS

- 5 springs simulated:

  San Marcos San Pedro

  Comal San Antonio

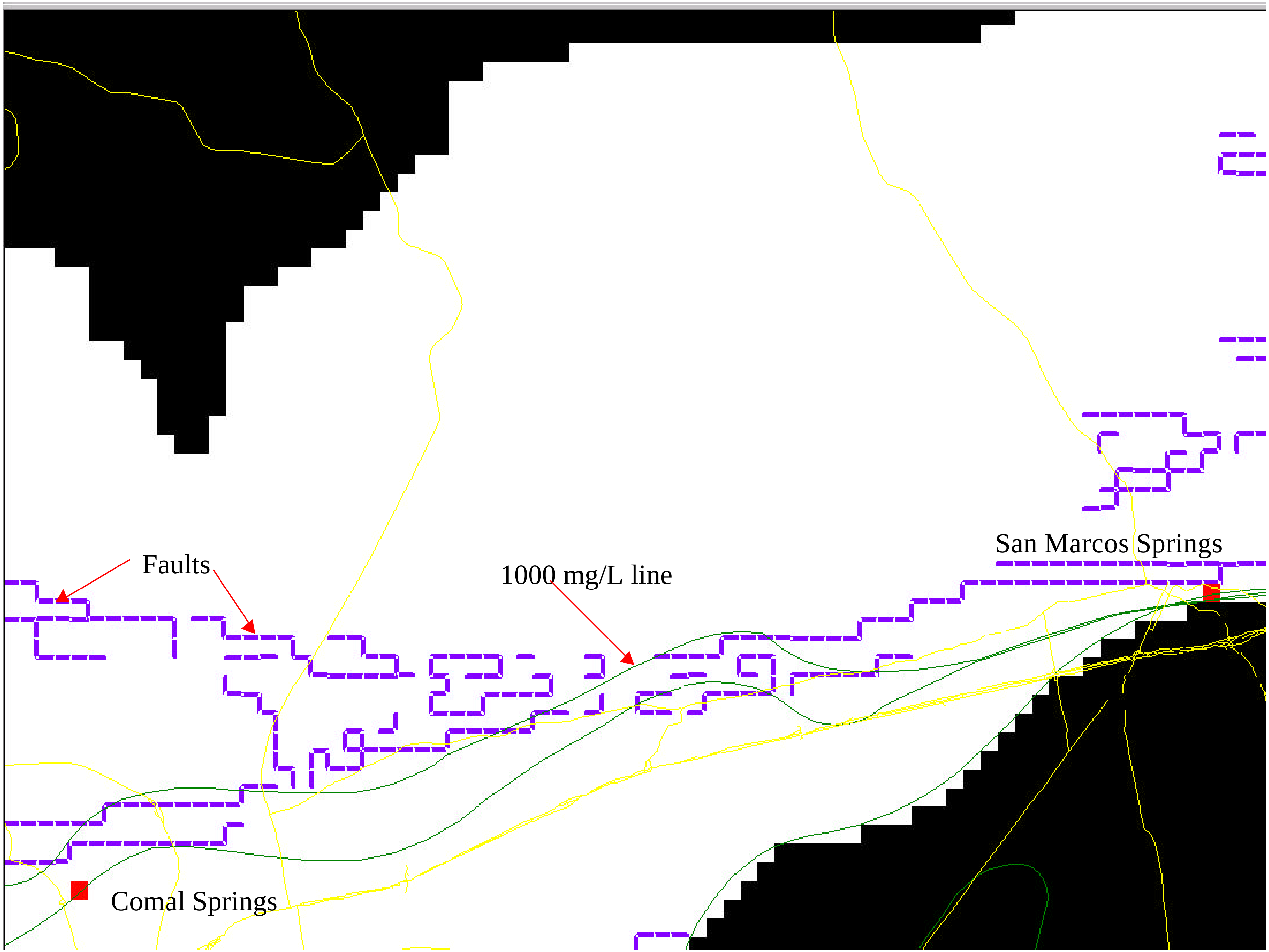
  Leona

REPRESENTATION OF SPRINGS

- Springs represented using MODFLOW Drain Package
- Model inputs

  (a) hydraulic conductance term (C)

  (b) drain elevation
- Parameters are poorly defined, difficult to measure
- C determined by model calibration

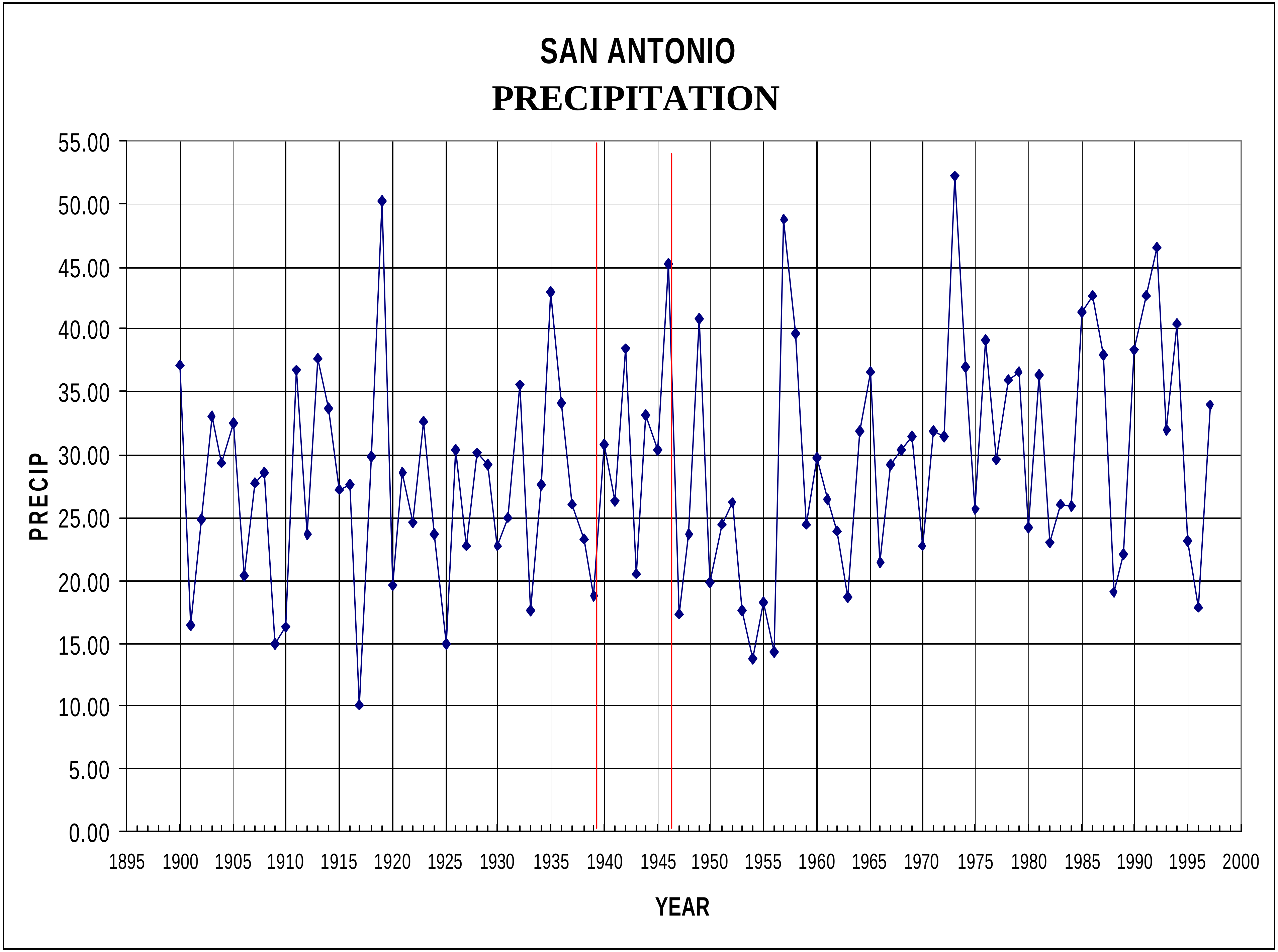

San Marcos Springs
Faults
1000 mg/L line
Comal Springs

STEADY-STATE CALIBRATION

- Calibration period: 1939 – 1946
- Pre-1950's drought, minimal irrigation development
- Near-normal precipitation
- San Antonio precipitation:

  normal (1961-90)   30.98 in/yr

  average 1939-46   30.47 in/yr



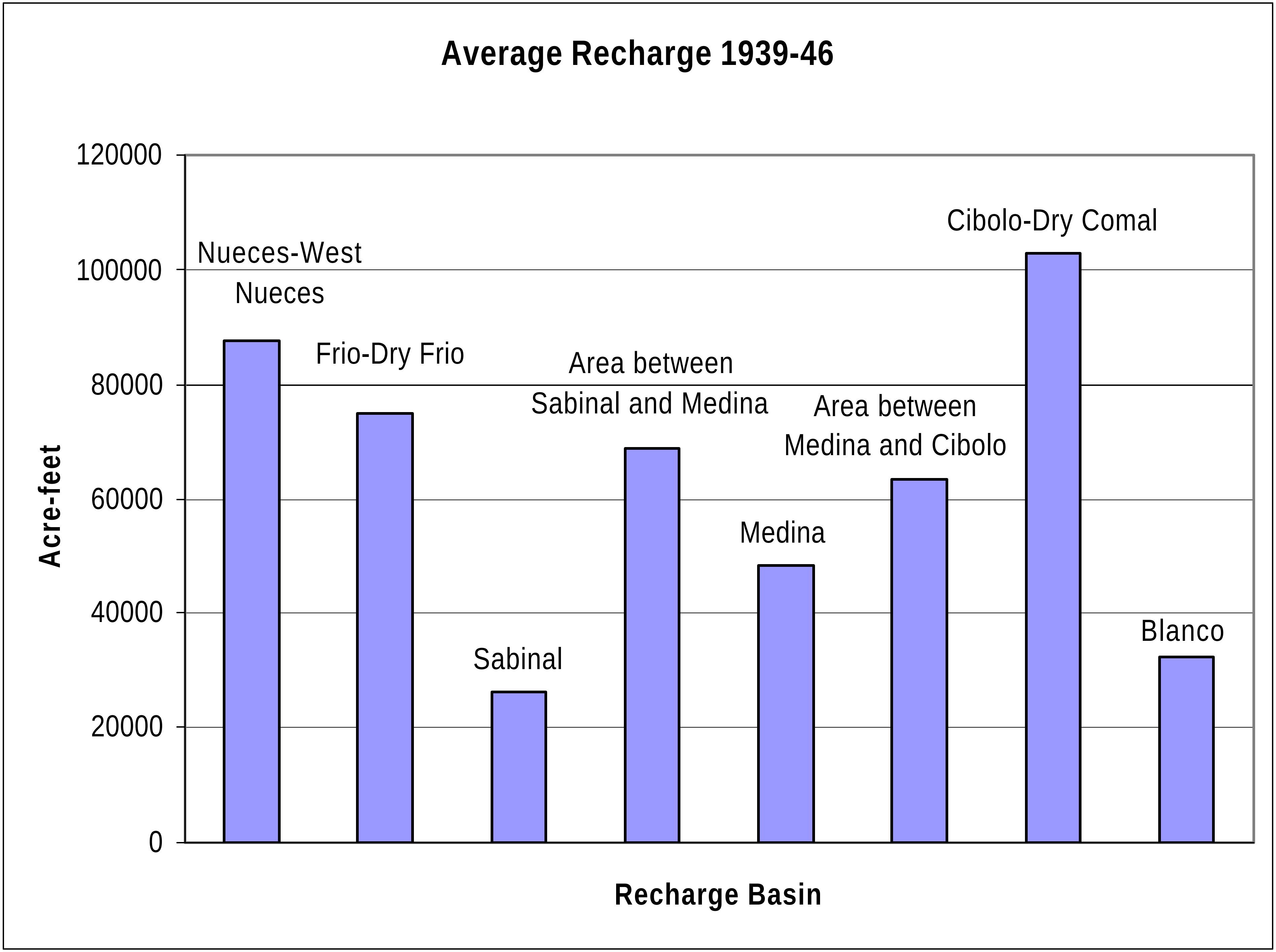
SAN ANTONIO
PRECIPITATION
PRECIP
55.00
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
1895
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
YEAR

STEADY-STATE CALIBRATION

- Average conditions 1939-46

- Recharge

- Discharge
  - Pumpage


Average Recharge 1939-46
120000
100000
80000
60000
40000
20000
0
Acre-feet
Nueces-West Nueces
Frio-Dry Frio
Sabinal
Area between Sabinal and Medina
Medina
Area between Medina and Cibolo
Cibolo-Dry Comal
Blanco
Recharge Basin

STEADY-STATE
CALIBRATION TARGETS

- Calibration targets

(1) Measured predevelopment water-levels

- Measured water levels for 1939-46

(2) Springflow

- 1939-46 averages

SPRINGS

- 5 springs simulated:

	1939-46 mean flows (cfs)
San Marcos	153
Comal	335
Leona	16
San Pedro	ND
San Antonio	ND

ND – no data; flow will be estimated

TRANSIENT
CALIBRATION TARGETS

- Calibration targets

(1) Long-term record wells

- County Index wells
- match hydrographs

(2) Selected time periods

- periods of above- and below-normal precipitation
- match measured water levels

TRANSIENT
CALIBRATION TARGETS

- Selected time periods

  (1) Below-normal precipitation

    (a) 1950-56

    (b) 1982-84

  (2) Above-normal precipitation

    (a) 1971-74

    (b) 1990-94

PROJECT SCHEDULE

• Develop conceptual model	June – Nov 2000
• Construct model	Dec 2000 – June 2001
• Steady-state calibration	July – Nov 2001
• Transient calibration and verification	Dec 2001 – June 2002
• Report preparation	July – Nov 2002
• Draft report due	Dec 2002
• Final report due	July 2003