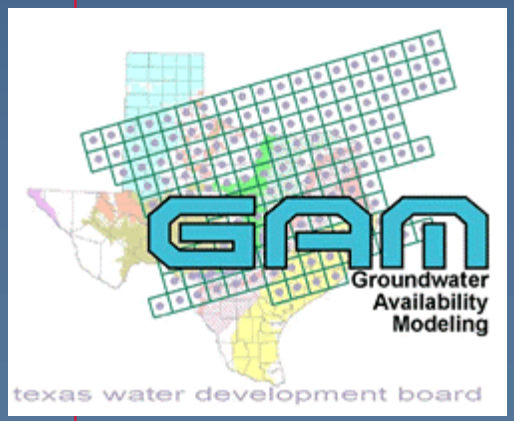
Stakeholder Advisory Forum - 4

Groundwater Availability Modeling (GAM) for the Northern Carrizo-Wilcox Aquifer



Northeast Texas Municipal Water District (NETMWD)

Hughes Springs, Texas

February 28, 2002

INTERA

PARSONS

WATERSTONE
Environmental Hydrology and Engineering, Inc.

Presentation Outline

- The INTERA – DE&S Connection
- GAM Review
- Approach to Groundwater Pumping Allocation in the GAM
- Water Quality Evaluations
- Modeling Approach and Progress
- Topics Planned for Next SAF

INTERA Inc.

- 1974 - Founded as INTERA Technologies
- 1995 - Acquisition by DE&S
- 1/2002 - Employee buy-out and formation of INTERA

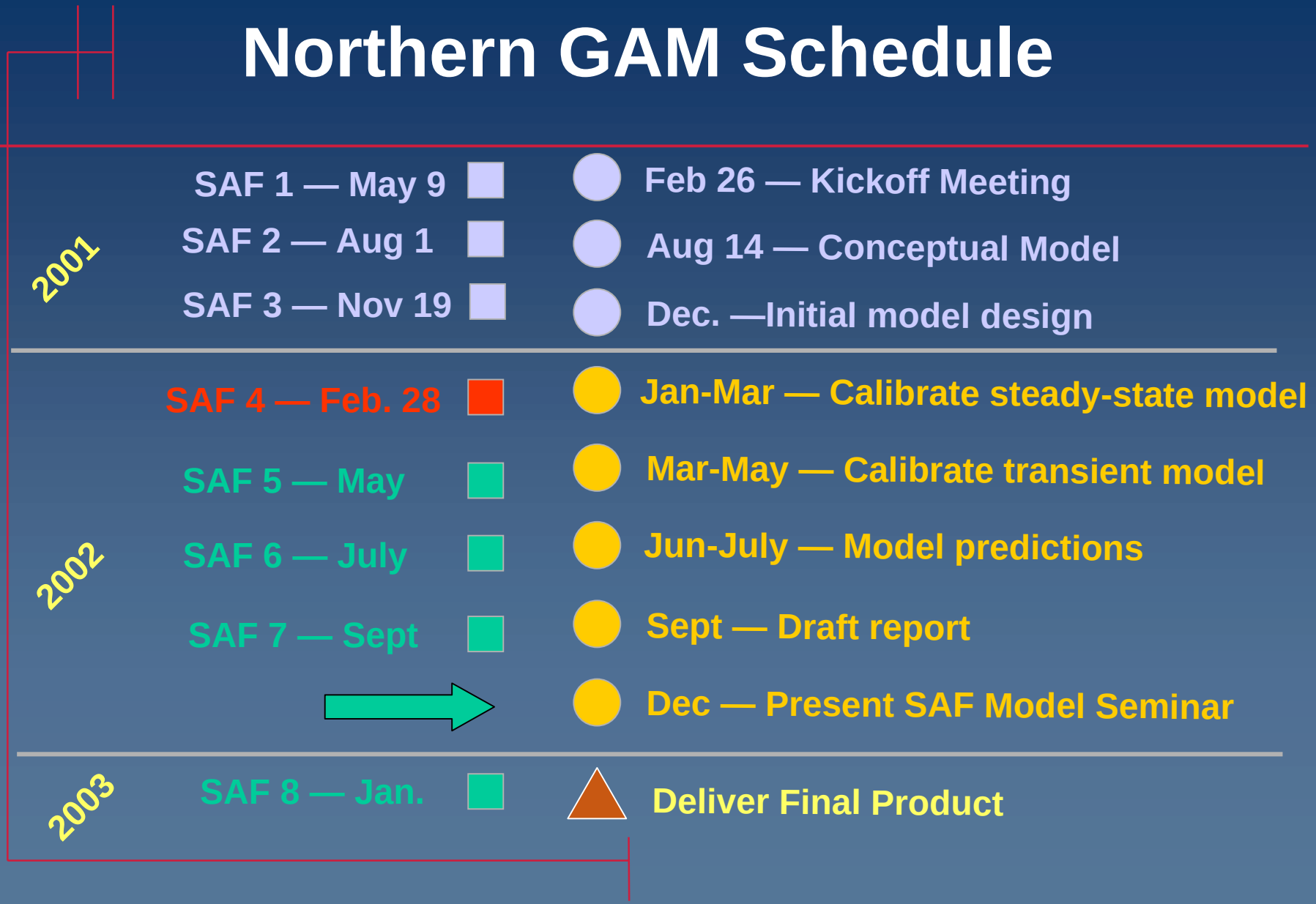
INTERA Inc.

- 70 professionals specialized in groundwater and the earth sciences
- Based in Austin, Texas
- 28 – year track record in the field of groundwater modeling
- Represents continuity of all GAM technical staff

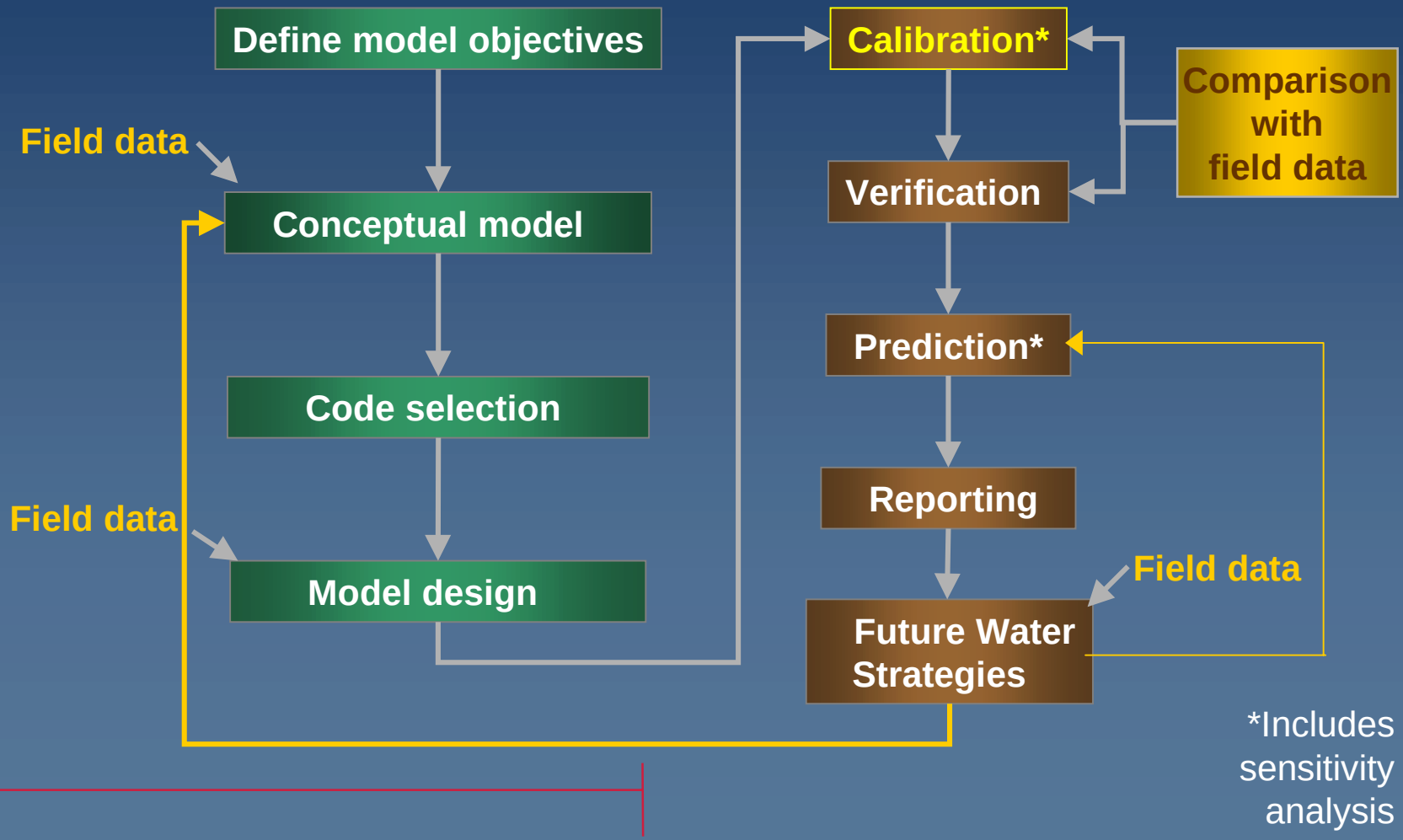
GAM Objectives

- 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 GWCD, RWPGs, and individuals assess groundwater availability
- Stakeholder participation is important to ensure that the model is accepted as a valid model of the aquifer

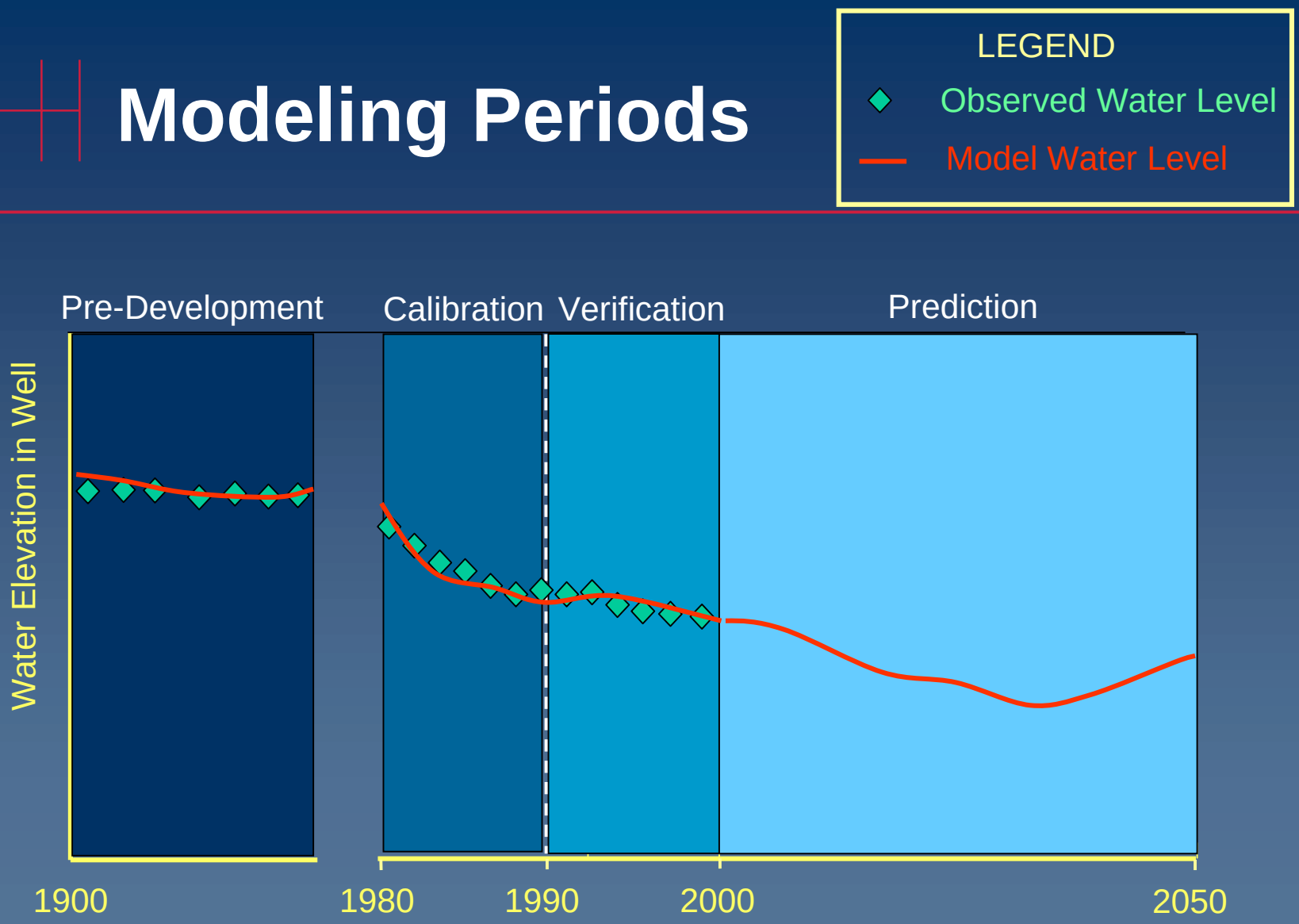
Northern GAM Schedule



Modeling Protocol



Modeling Periods



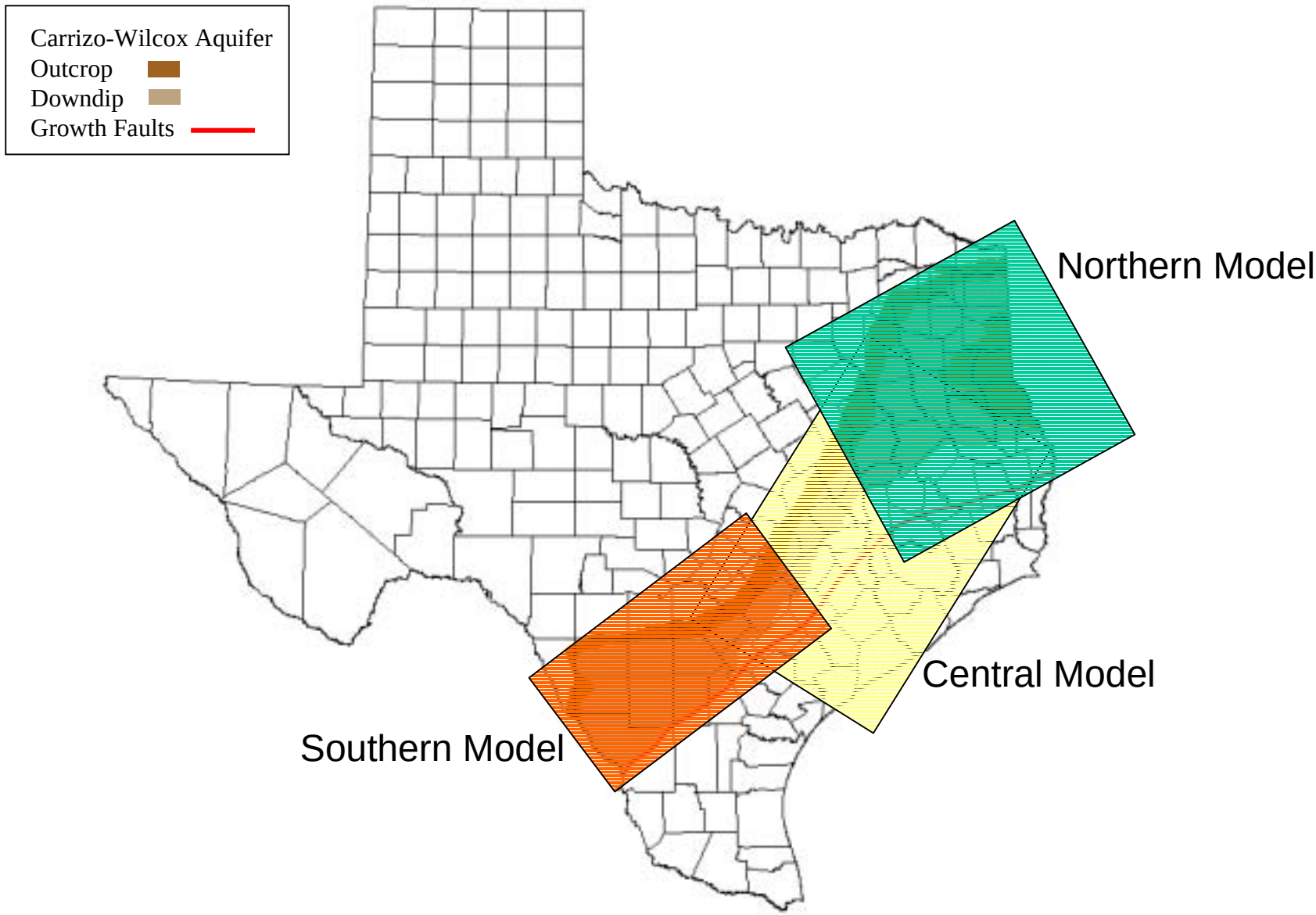
Presentation Outline

- The INTERA – DE&S Connection
- Review of GAM Objectives
- **Approach to Groundwater Pumping Allocation in the GAM**
- **Water Quality Evaluations**
- Modeling Approach and Progress
- Topics Planned for Next SAF

Presentation Outline

- The INTERA – DE&S Connection
- GAM Review
- Approach to Groundwater Pumping Allocation in the GAM
- Water Quality Evaluations
- **Modeling Approach and Progress**
- Topics Planned for Next SAF

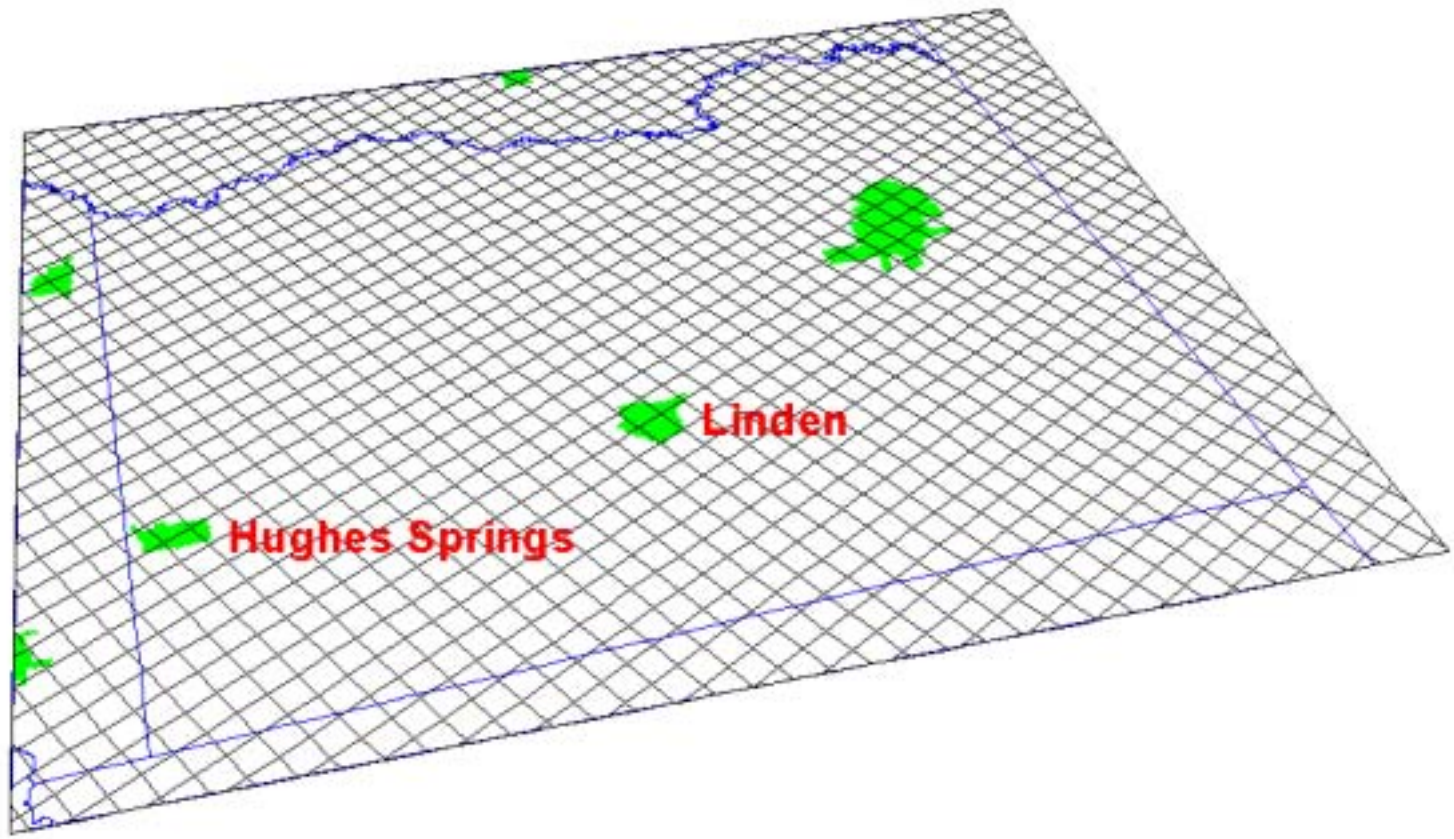
Carrizo-Wilcox GAM Model Domains



Model Specifications

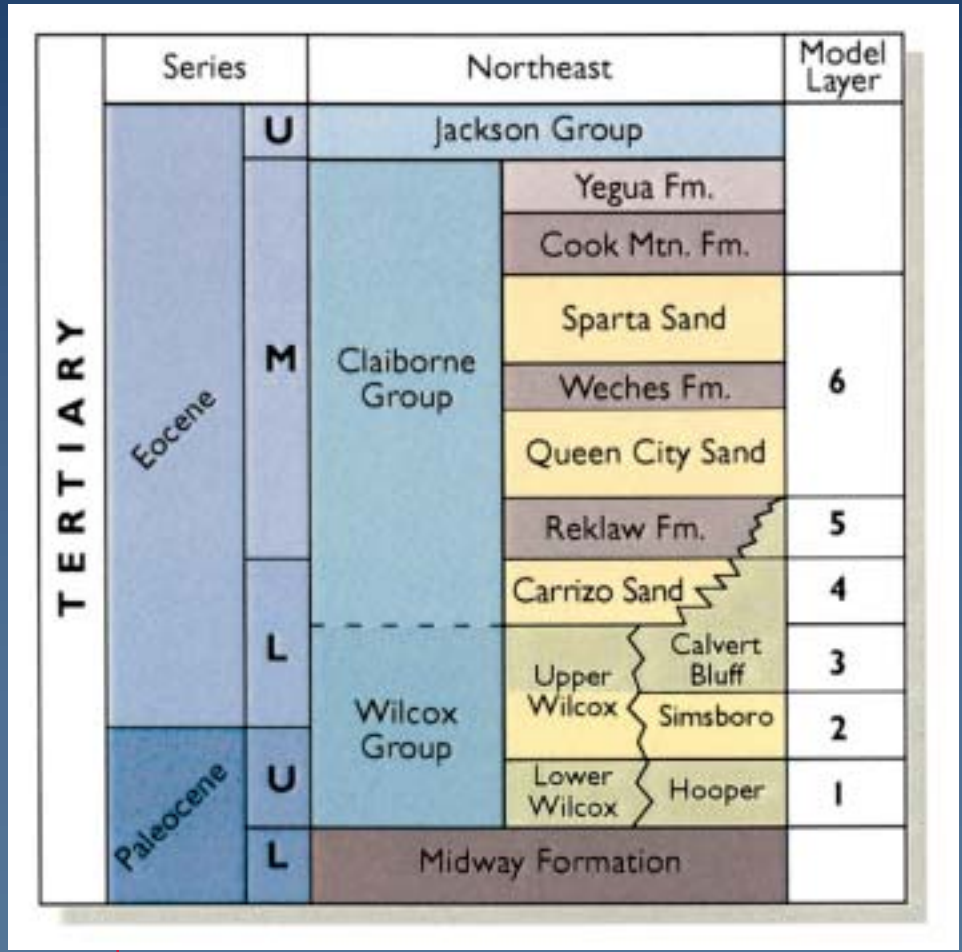
- Three dimensional (MODFLOW-96)
- Regional scale (100’s of mi2)
- Grid spacing of 1 square mile
- Include Groundwater/surface water interaction (Stream routing, Prudic 1988)
- Properly implement recharge
- Stress periods as small as 1 month
- Calibration to within 10% of head drop

Model Grid Scale

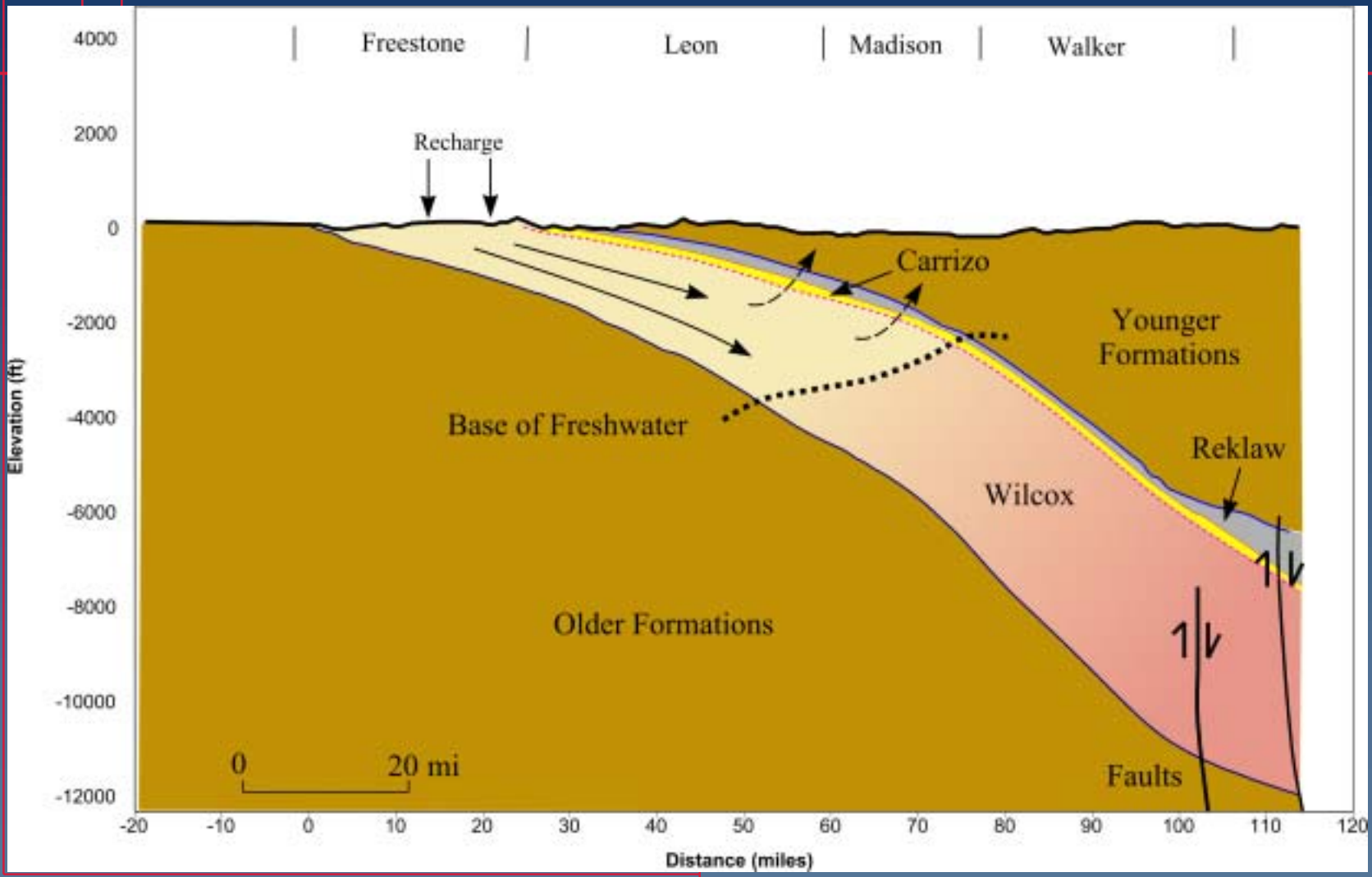


Model Layers

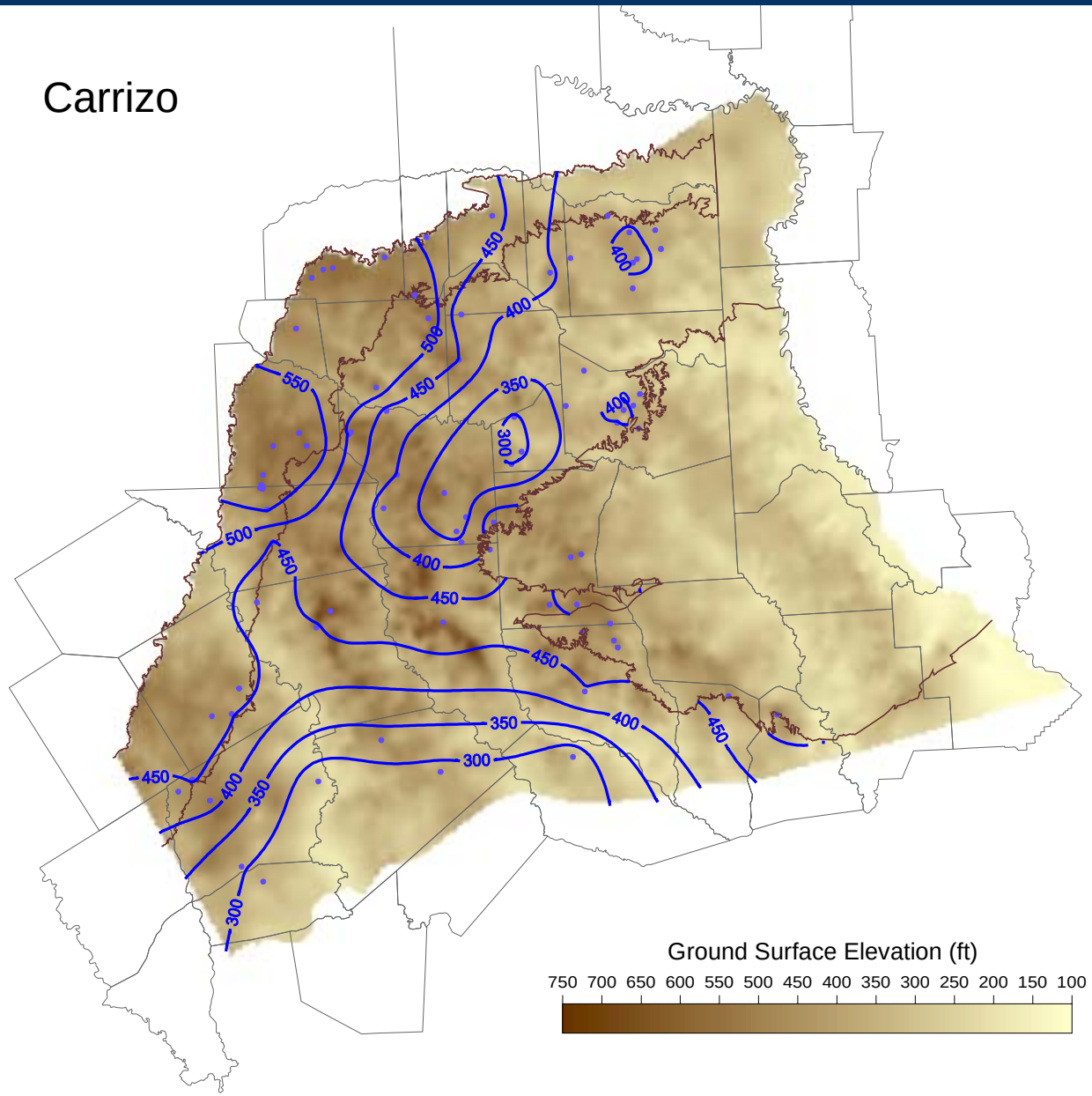
- Total of six layers
  - Lower Wilcox (Hooper)
  - Middle Wilcox (Simsboro)
  - Upper Wilcox (Calvert Bluff)
  - Carrizo Sand
  - Reklaw Fm
  - Shallow aquifers
    - (QC, W, S)

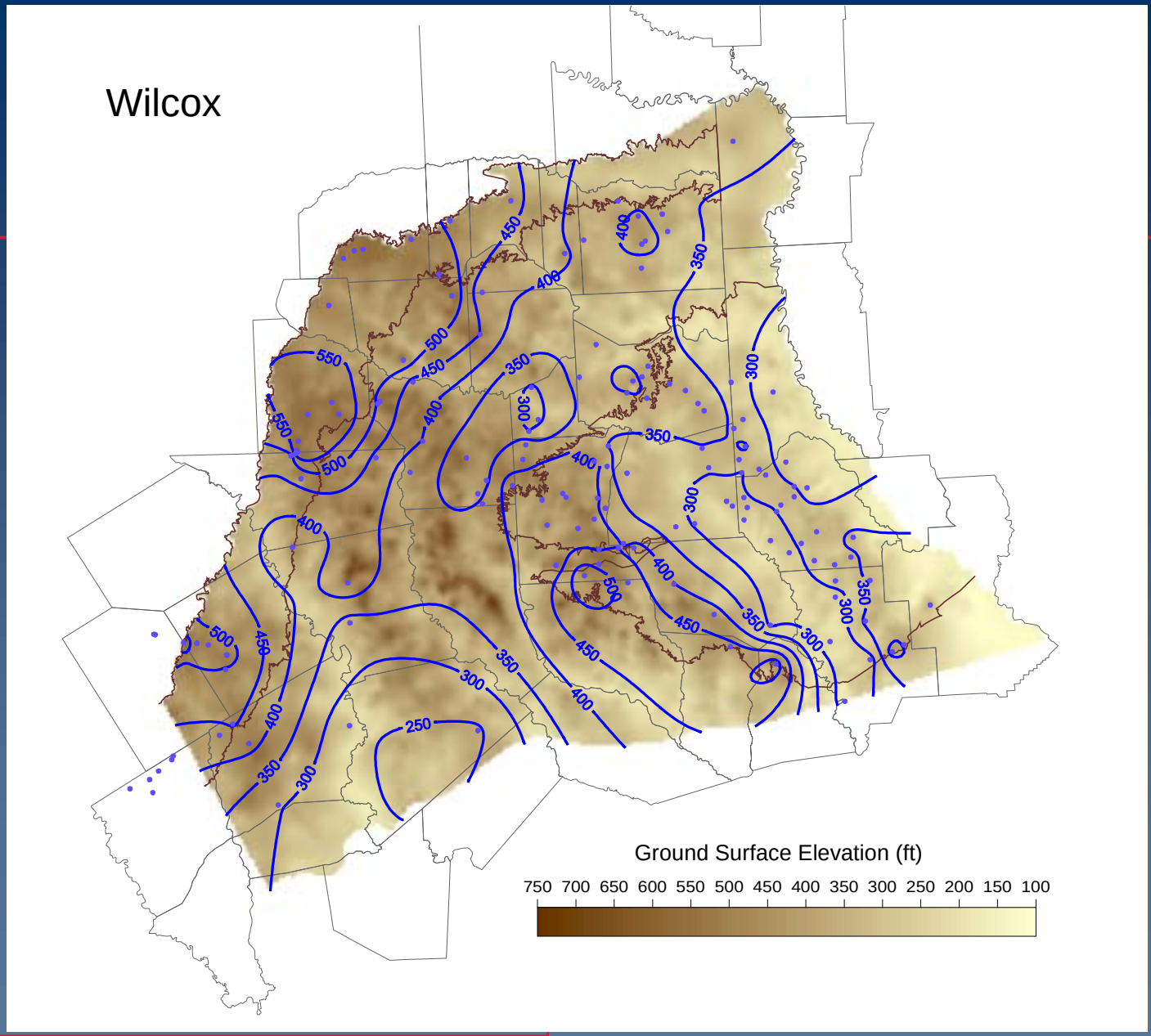


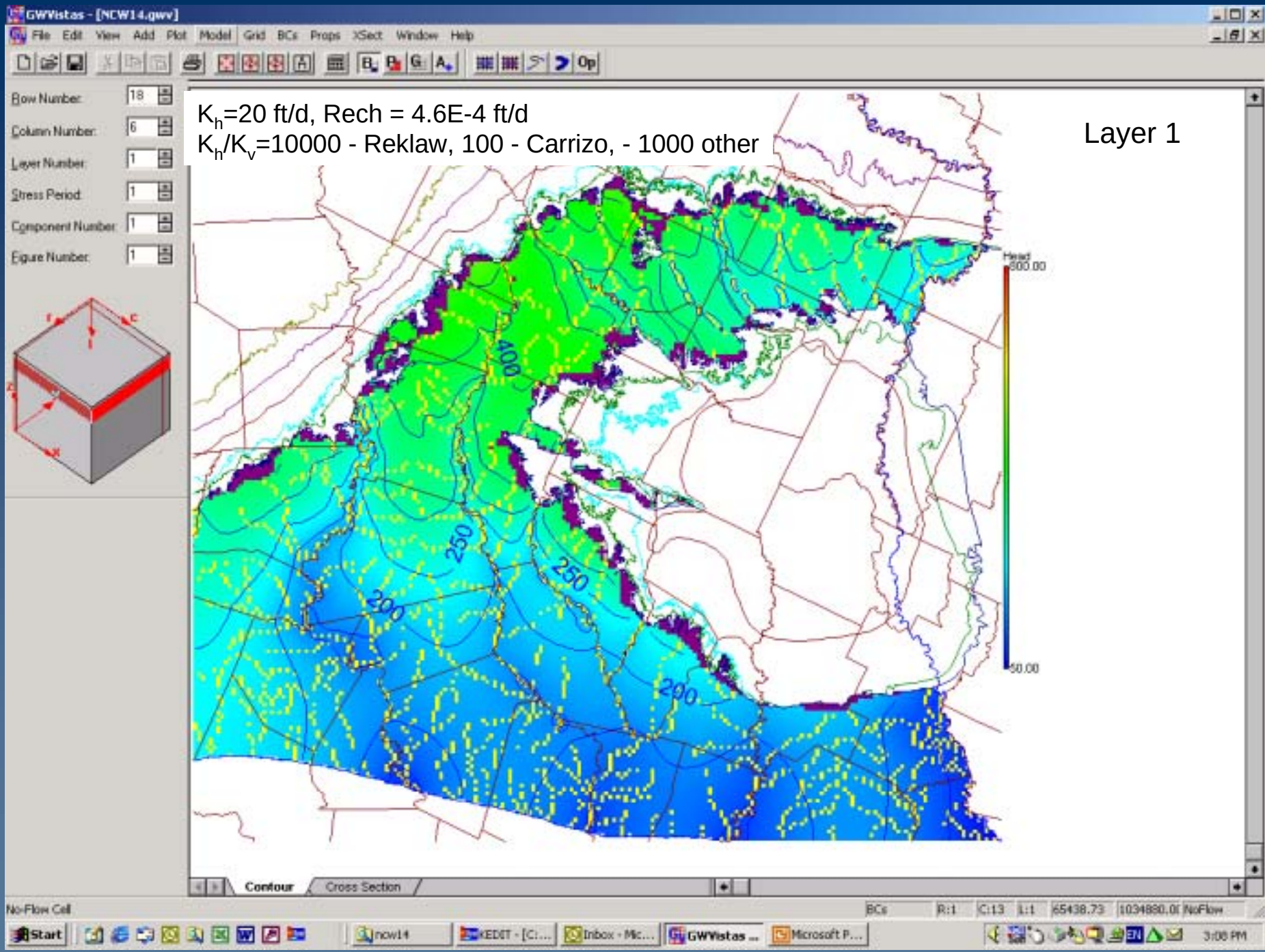
Geologic Framework: X-Section

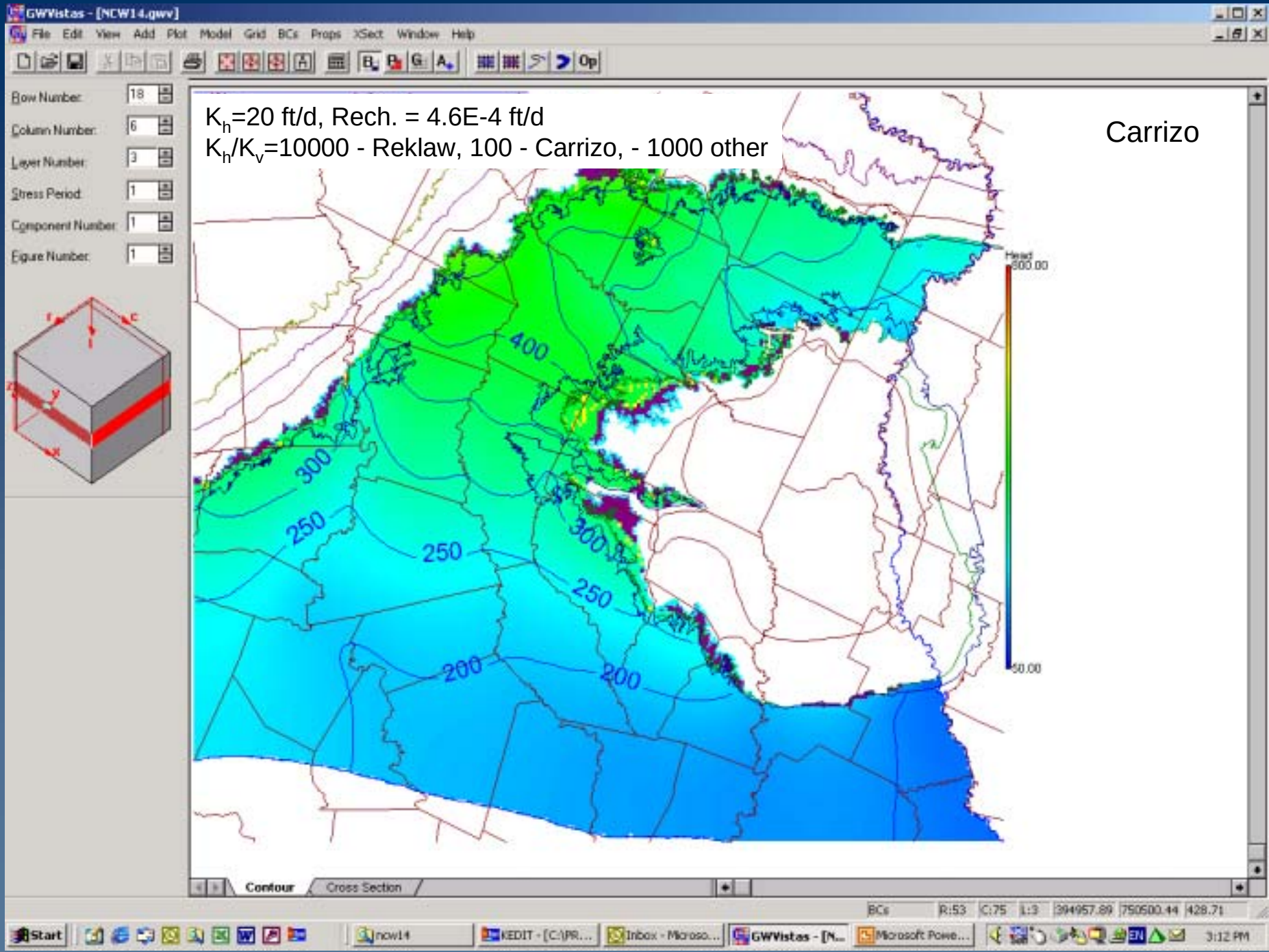


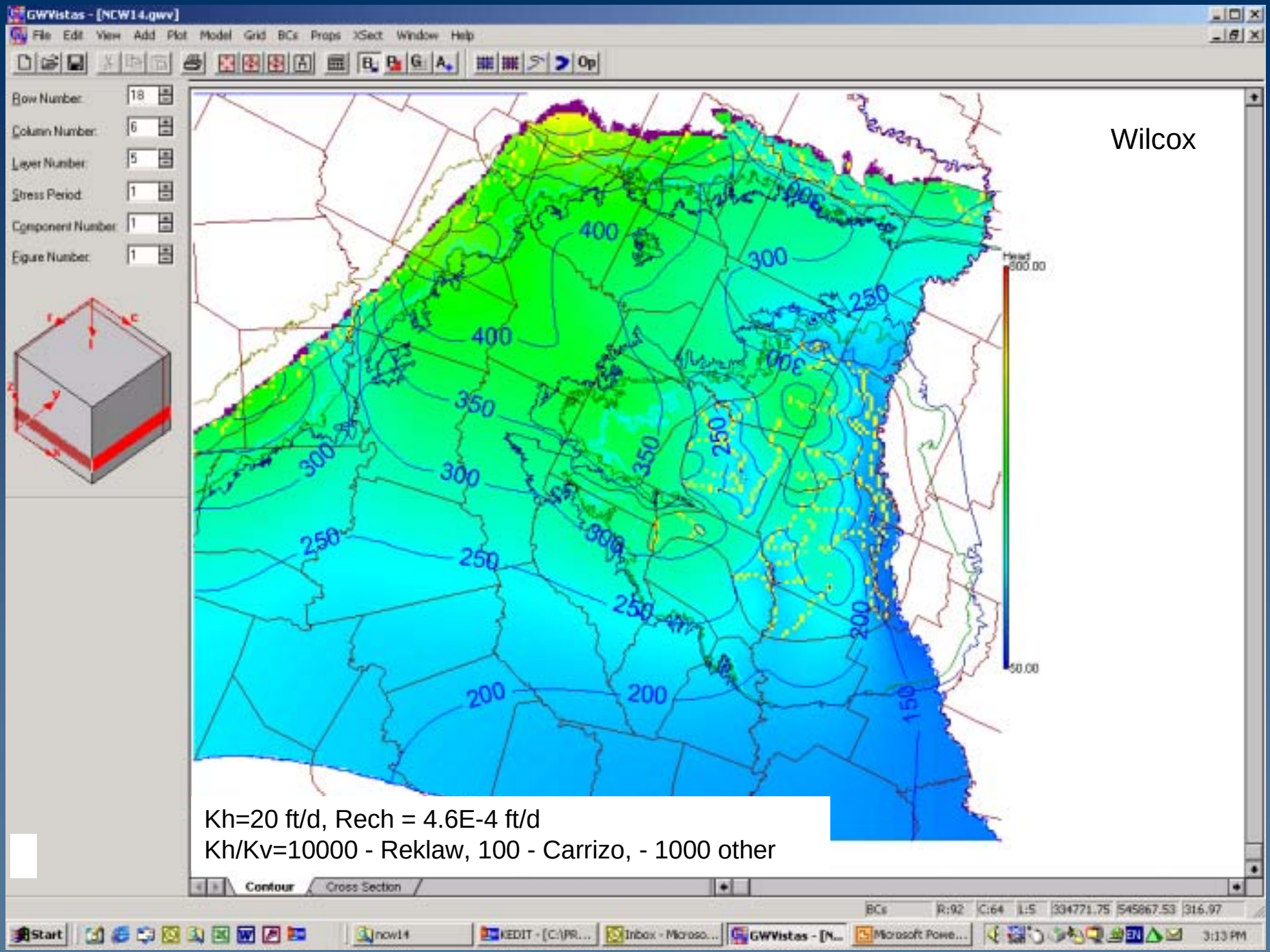
Carrizo


550
500
450
400
350
300
Ground Surface Elevation (ft)
750 700 650 600 550 500 450 400 350 300 250 200 150 100


Wilcox
Ground Surface Elevation (ft)
750 700 650 600 550 500 450 400 350 300 250 200 150 100


GWVistas - [NCW14.gwv]
File Edit View Add Plot Model Grid BCs Props XSect Window Help
Row Number: 18
Column Number: 6
Layer Number: 1
Stress Period: 1
Component Number: 1
Figure Number: 1
K_h=20 ft/d, Rech = 4.6E-4 ft/d
K_h/K_v=10000 - Reklaw, 100 - Carrizo, - 1000 other
Layer 1
Head
800.00
50.00
400
250
250
200
200
Contour
Cross Section
No-Flow Cell
BCs
R:1
C:13
L:1
65438.73
1034880.0
NoFlow
Start
ncw14
KEDIT - [C:...
Inbox - Mic...
GWVistas ...
Microsoft P...
3:08 PM

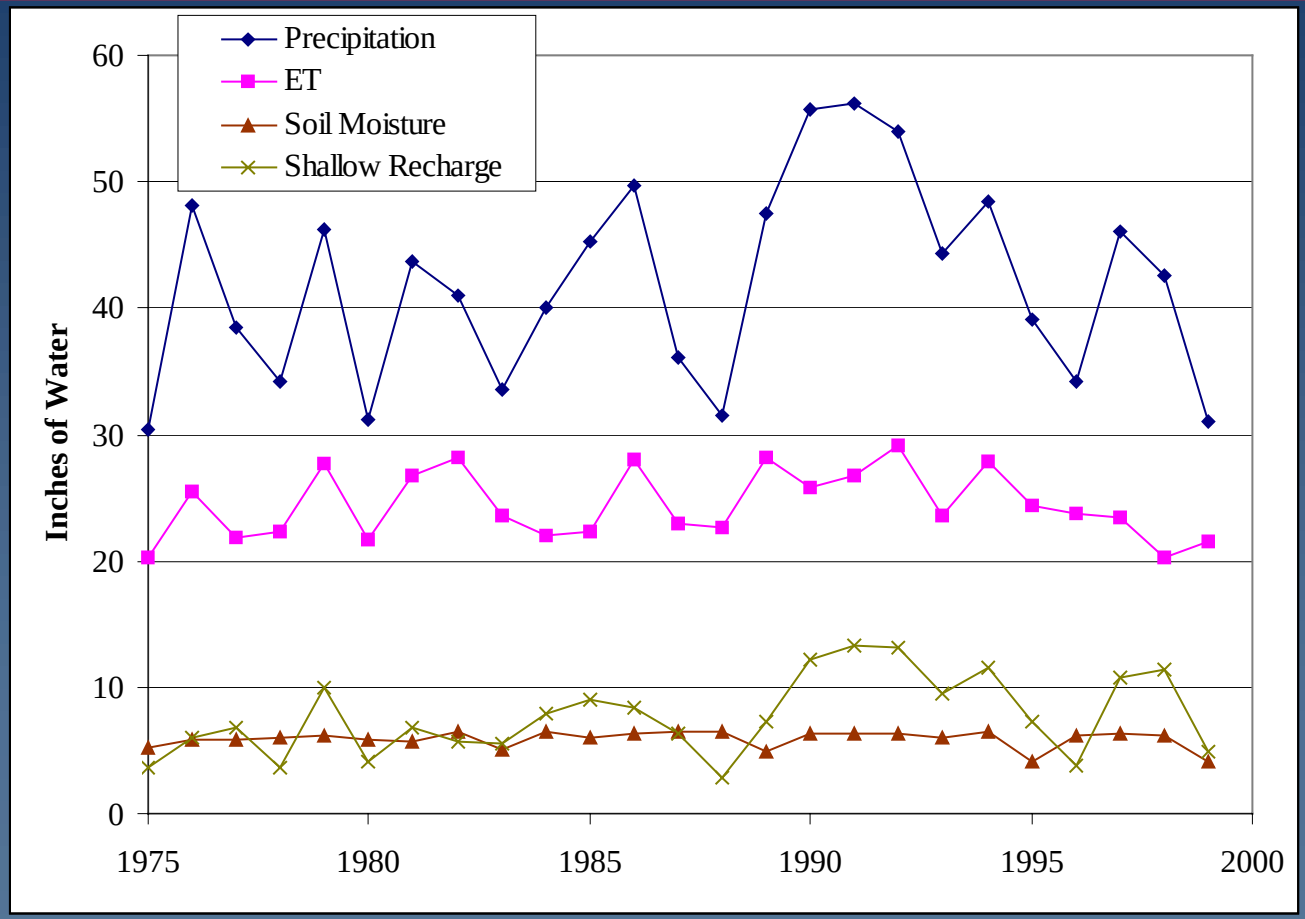

GWVistas - [NCW14.gwv]
File Edit View Add Plot Model Grid BCs Props XSect Window Help
Row Number: 18
Column Number: 6
Layer Number: 3
Stress Period: 1
Component Number: 1
Figure Number: 1
K_h=20 ft/d, Rech. = 4.6E-4 ft/d
K_h/K_v=10000 - Reklaw, 100 - Carrizo, - 1000 other
Carrizo
Head
800.00
50.00
400
300
250
250
300
250
200
200
Contour
Cross Section
BCs R:53 C:75 L:3 394957.89 750500.44 428.71
Start
now14
KEDIT - [C:\PR...
Inbox - Microso...
GWVistas - [N...
Microsoft Powe...
3:12 PM


GWVistas - [NCW14.gwv]
File Edit View Add Plot Model Grid BCs Props XSect Window Help
Row Number 18
Column Number 6
Layer Number 5
Stress Period 1
Component Number 1
Figure Number 1
Wilcox
Head
500.00
50.00
400
300
250
350
200
150
Contour
Cross Section
Kh=20 ft/d, Rech = 4.6E-4 ft/d
Kh/Kv=10000 - Reklaw, 100 - Carrizo, - 1000 other
BCs R:92 C:64 L:5 334771.75 545867.53 316.97
Start
now14
KEDIT - [C:\PR...
Inbox - Microso...
GWVistas - [N...
Microsoft Powe...
3:13 PM

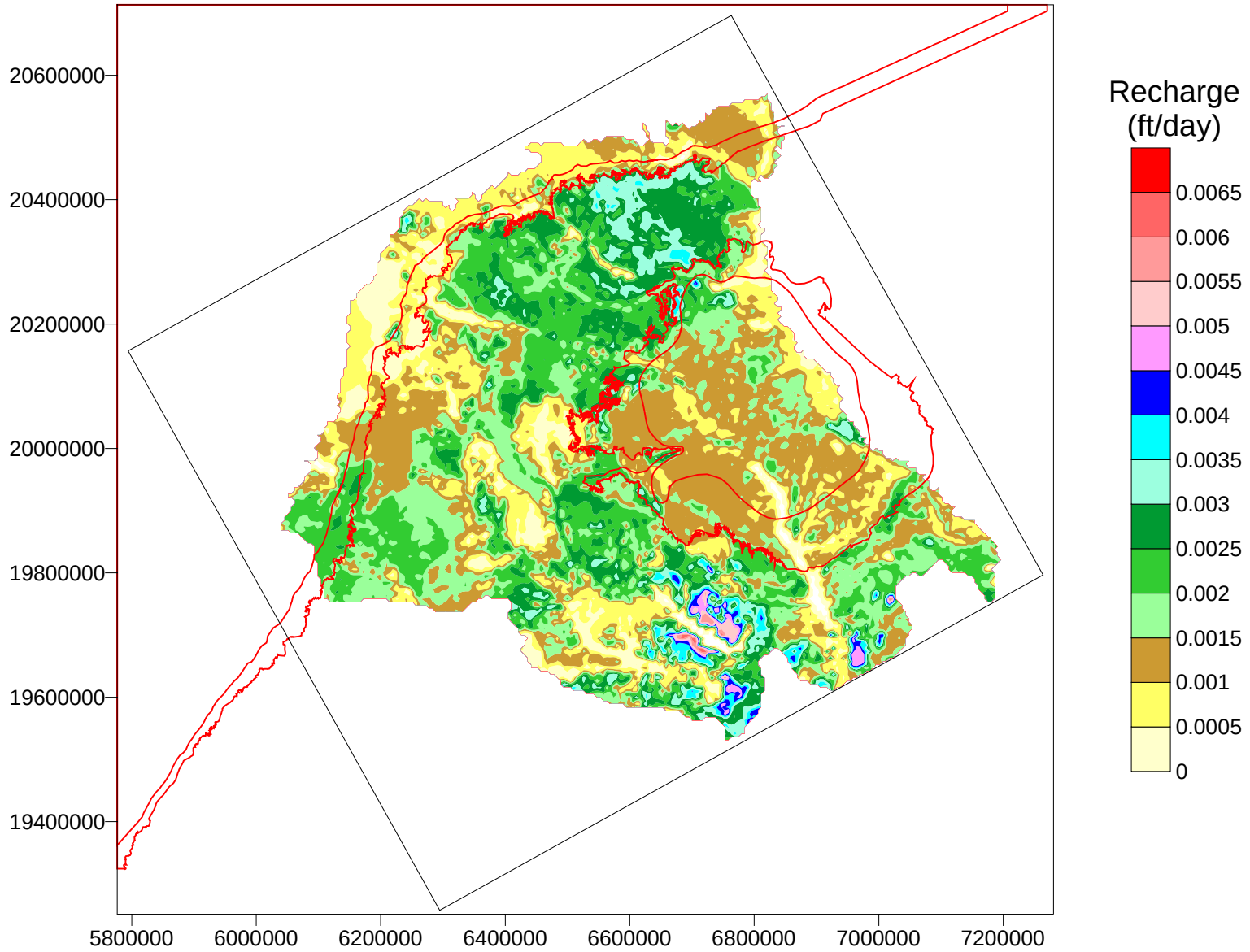
Soil and Water Assessment Tool

- SWAT (Blacklands Research Center)
- Physically based (primarily) watershed scale model
- Infiltration/runoff based on SCS Curve Number method (daily timestep)
  - Land use
  - Soil type
  - Antecedent soil condition
- Recharge = Infiltration - Evapotranspiration

SWAT - Example Results

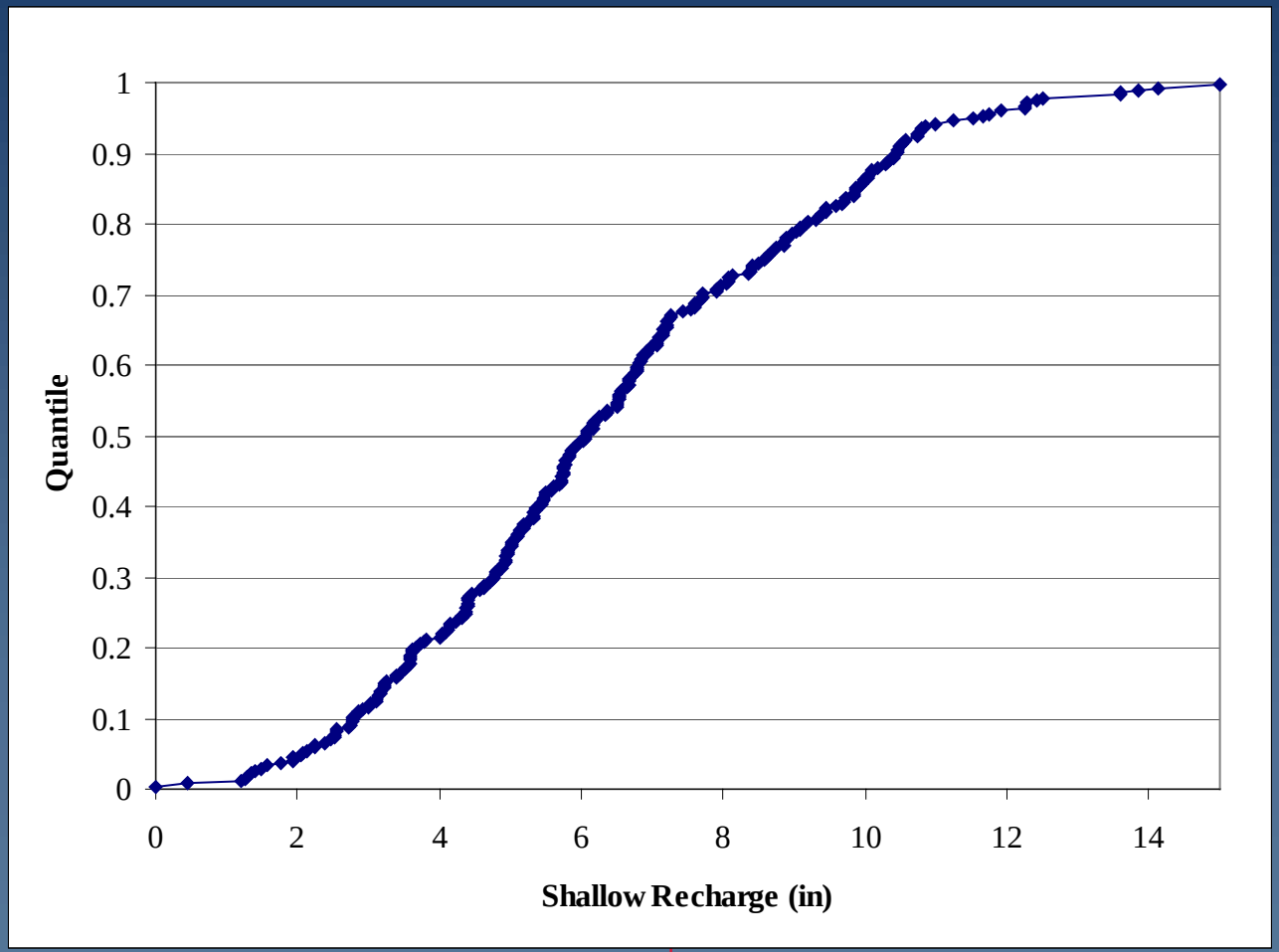


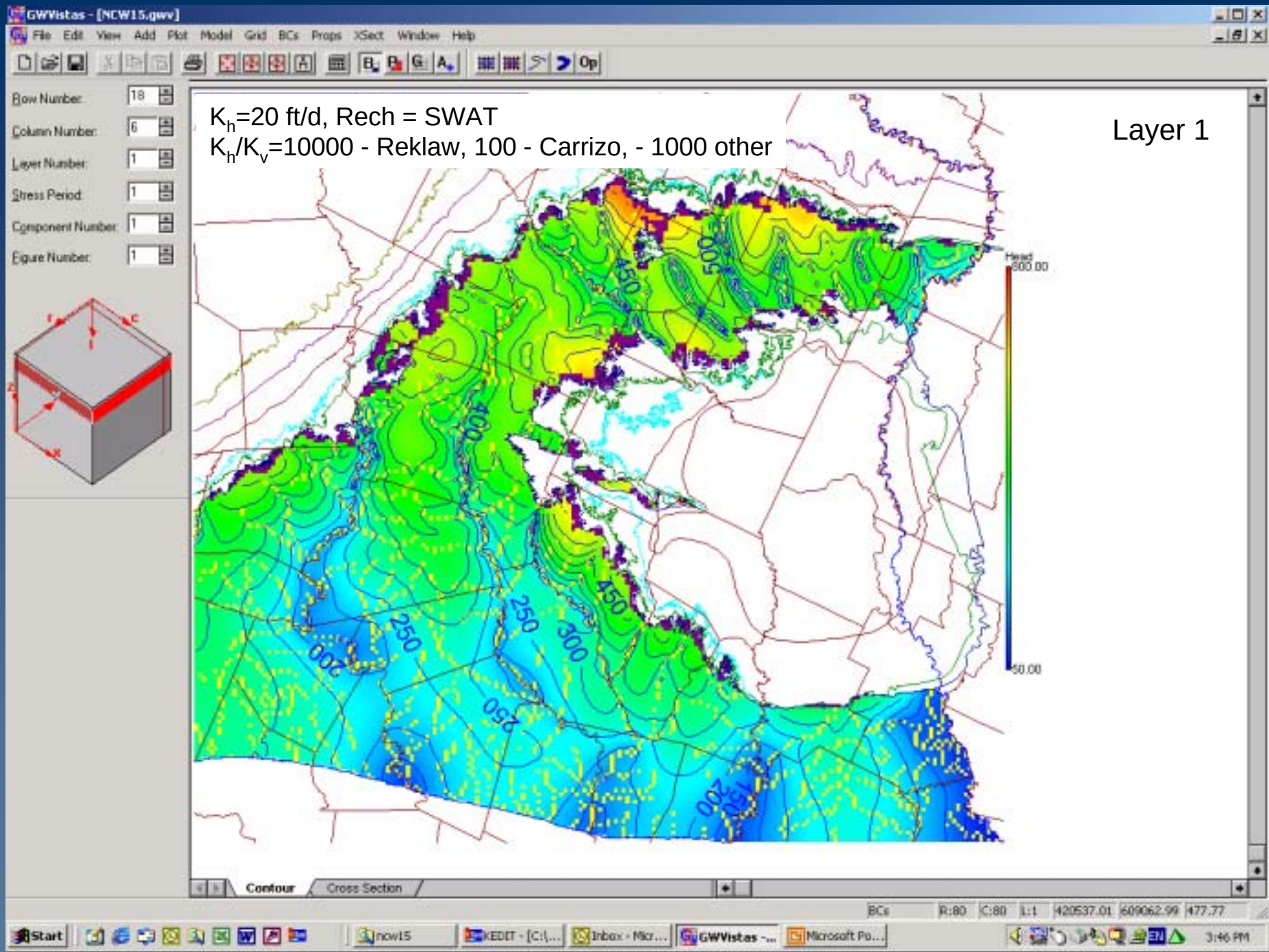
SWAT Recharge Estimates

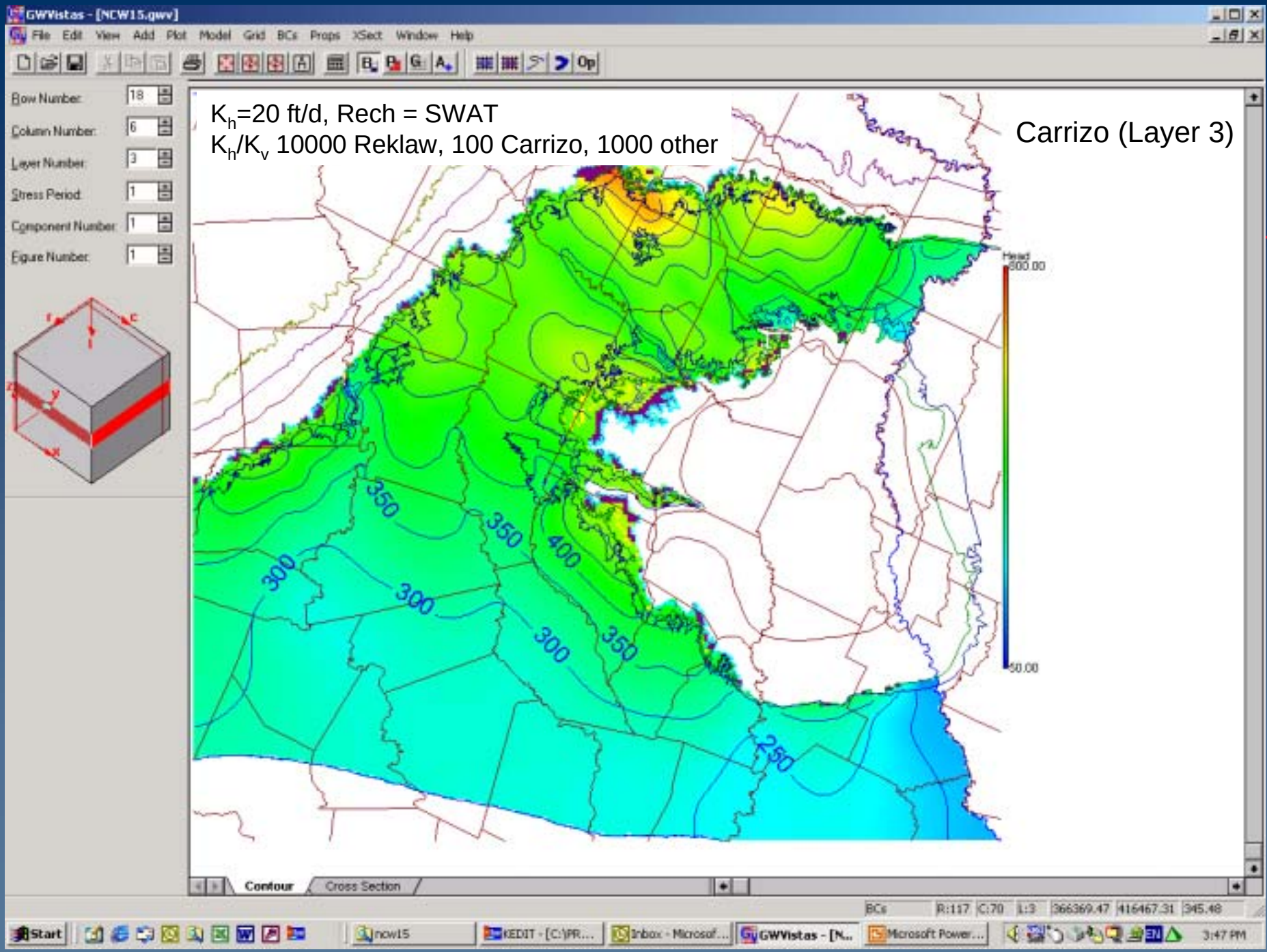


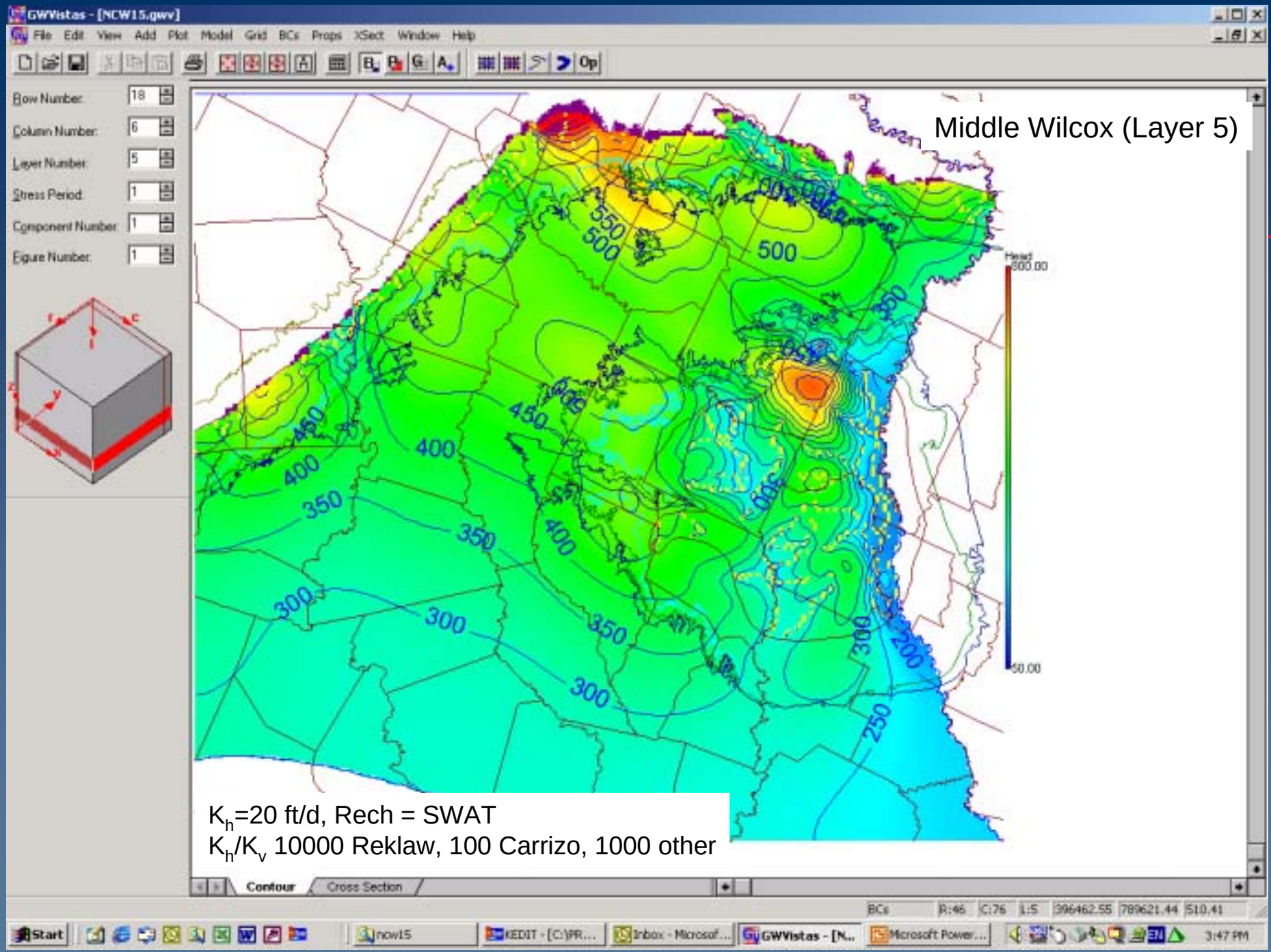
SWAT - Example Results

20-year average annual *shallow* recharge




GWVistas - [NCW15.gwv]
File Edit View Add Plot Model Grid BCs Props XSect Window Help
Row Number 18
Column Number 6
Layer Number 1
Stress Period 1
Component Number 1
Figure Number 1
K_h=20 ft/d, Rech = SWAT
K_h/K_v=10000 - Reklaw, 100 - Carrizo, - 1000 other
Layer 1
Head
500.00
50.00
500
450
400
300
250
200
150
Contour
Cross Section
BCs R:80 C:80 L:1 420537.01 609062.99 477.77
Start
ncw15
KEDIT - [C:\...
Inbox - Micr...
GWVistas -...
Microsoft Po...
3:46 PM

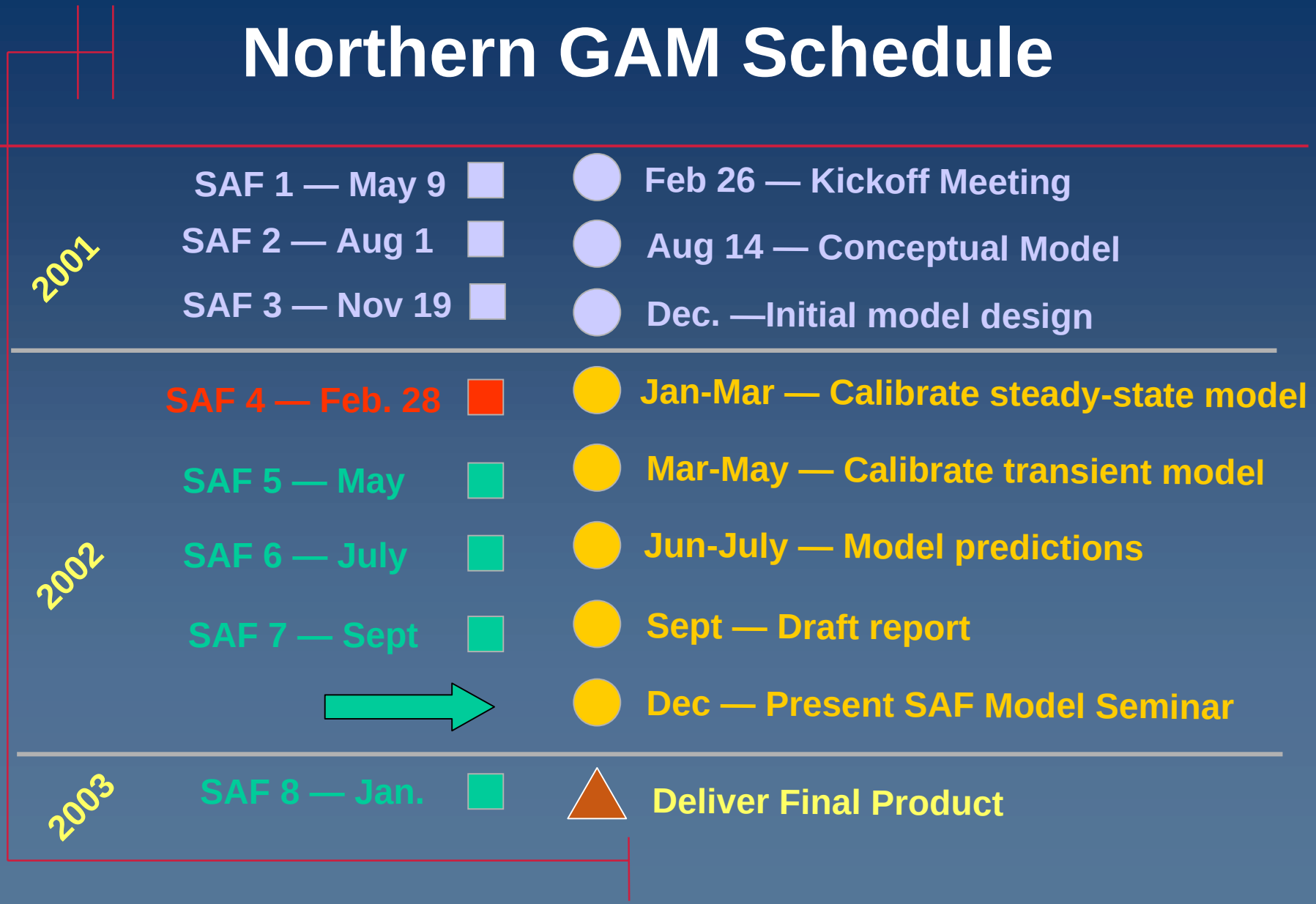

GWVistas - [NCW15.gwv]
File Edit View Add Plot Model Grid BCs Props XSect Window Help
Row Number: 18
Column Number: 6
Layer Number: 3
Stress Period: 1
Component Number: 1
Figure Number: 1
K_h=20 ft/d, Rech = SWAT
K_h/K_v 10000 Reklaw, 100 Carrizo, 1000 other
Carrizo (Layer 3)
Head
500.00
50.00
350
350
400
300
300
300
350
250
Contour
Cross Section
BCs R:117 C:70 L:3 366369.47 416467.31 345.48
Start
now15
KEDIT - [C:\PR...
Inbox - Microsof...
GWVistas - [N...
Microsoft Power...
3:47 PM


GWVistas - [NCW15.gwv]
File Edit View Add Plot Model Grid BCs Props XSect Window Help
Row Number 18
Column Number 6
Layer Number 5
Stress Period 1
Component Number 1
Figure Number 1
Middle Wilcox (Layer 5)
Head
500.00
50.00
550
500
500
450
450
400
400
350
350
300
300
300
350
400
350
300
300
250
Contour
Cross Section
K_h=20 ft/d, Rech = SWAT
K_h/K_v 10000 Reklaw, 100 Carrizo, 1000 other

Expected SAF-5 Discussion

- Steady-state model calibration
- Transient model parameterization
- Preliminary transient model calibration
- Stream flow routing

Northern GAM Schedule



Northern Carrizo-Wilcox Groundwater Availability Model (GAM)

Evaluation of Historic Pumping Demand

- Standard Operating Procedures
- Processing Historical (1980-1999) Pumpage Data

INTERA

PARSONS

Data Sources for Groundwater Use Provided by the TWDB (1980-1999)

- Annual Water Use summary by major aquifer
- Annual Water Use summary by individual county and river basin

3. Monthly Water Use summary for municipal users

- Monthly Water Use summary for manufacturing users (includes manufacturing, power generation, and mining)

Categories of Groundwater Use

Point Source Data

- Municipal
- Manufacturing
- Power
- Mining

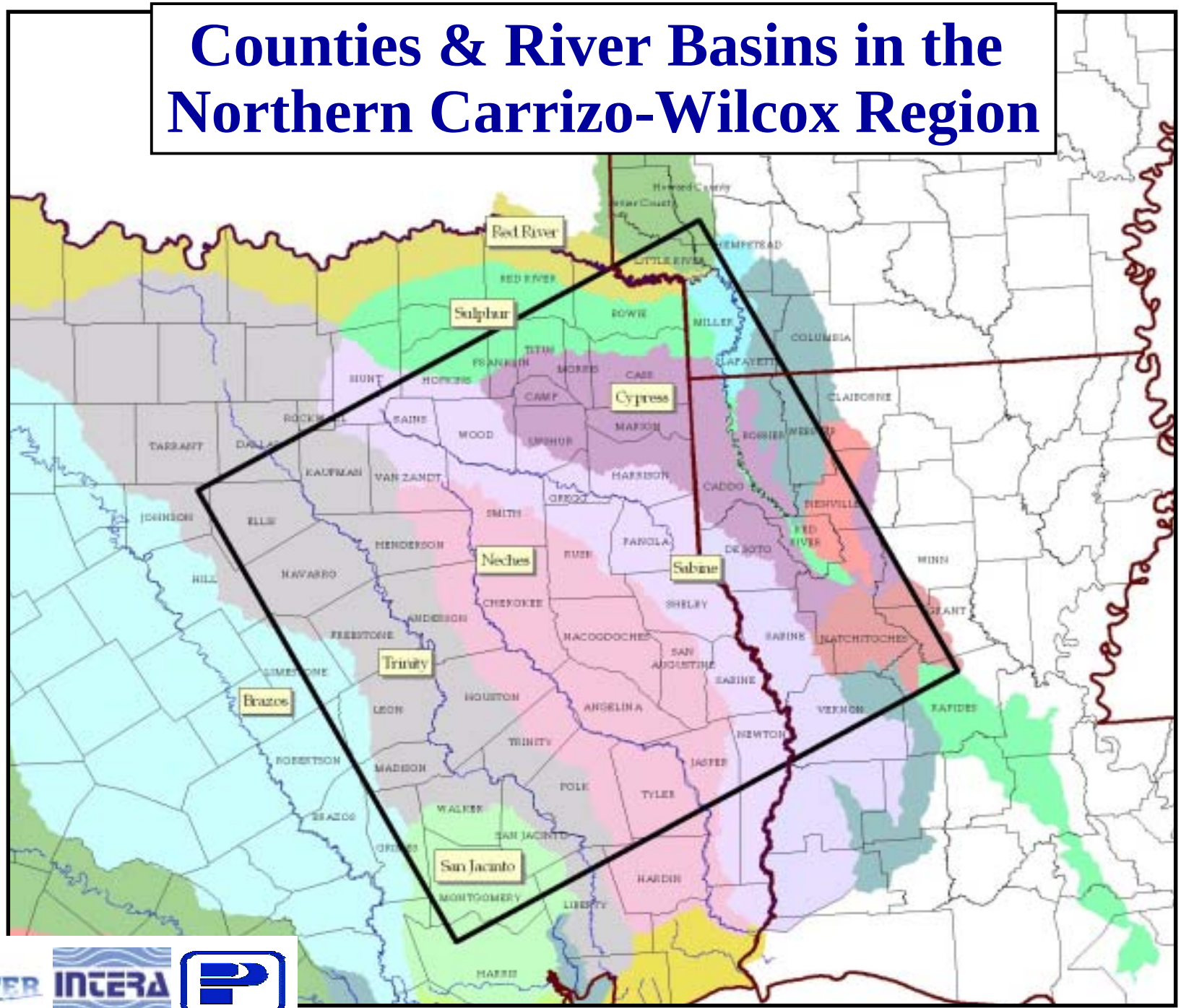
Non-Point Source Data

- Irrigation
- Livestock
- Rural Domestic

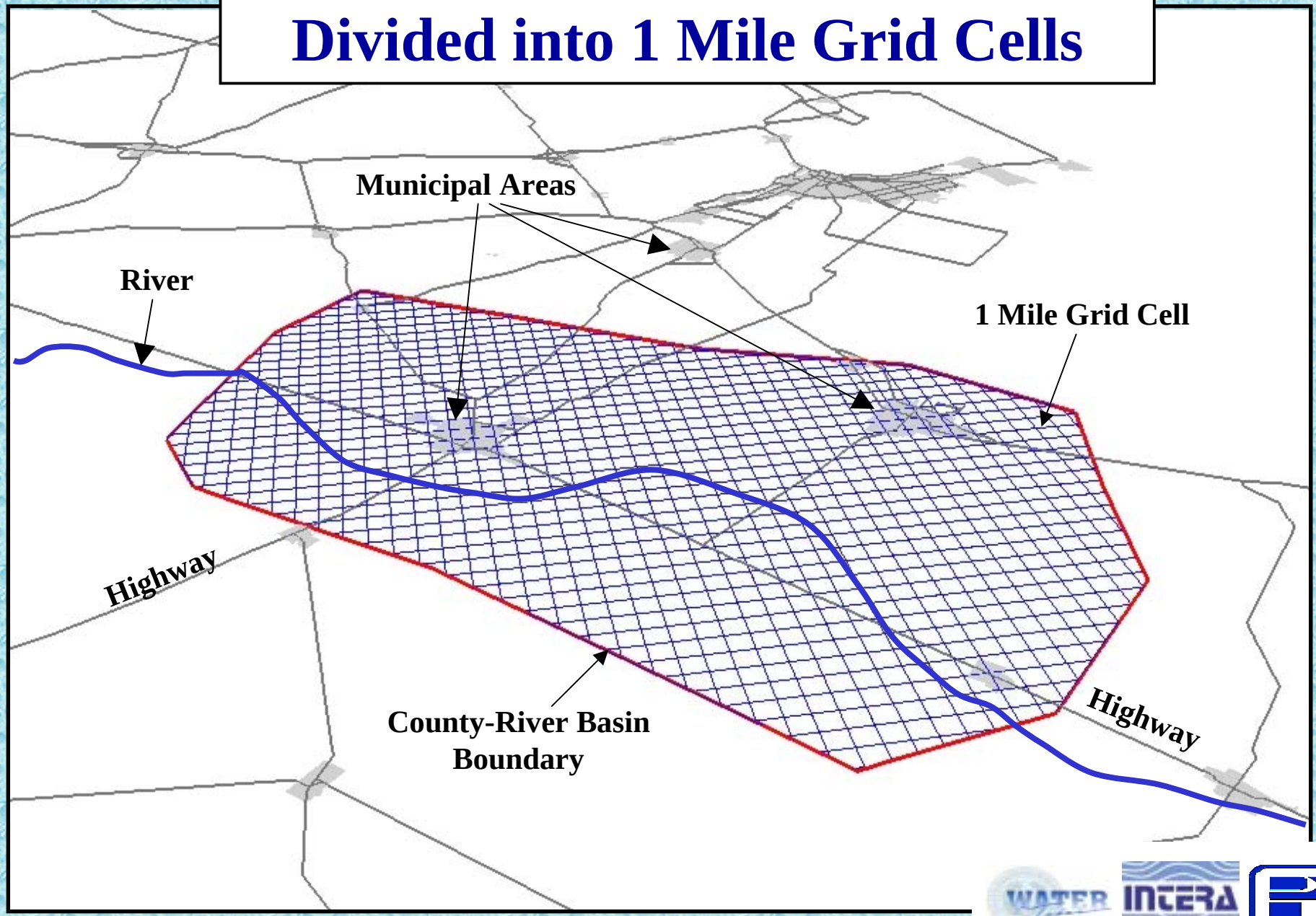
Database Processing

- Utilize TWDB Technical Memorandums
- Prepare 1 mile by 1 mile grid cells using GIS (Geographic Information Systems) computer programs
- Separate point source municipal wells from non-point source rural domestic wells
- Distribute monthly pumpage for each of the 7 groundwater uses across each grid cell

Counties & River Basins in the Northern Carrizo-Wilcox Region



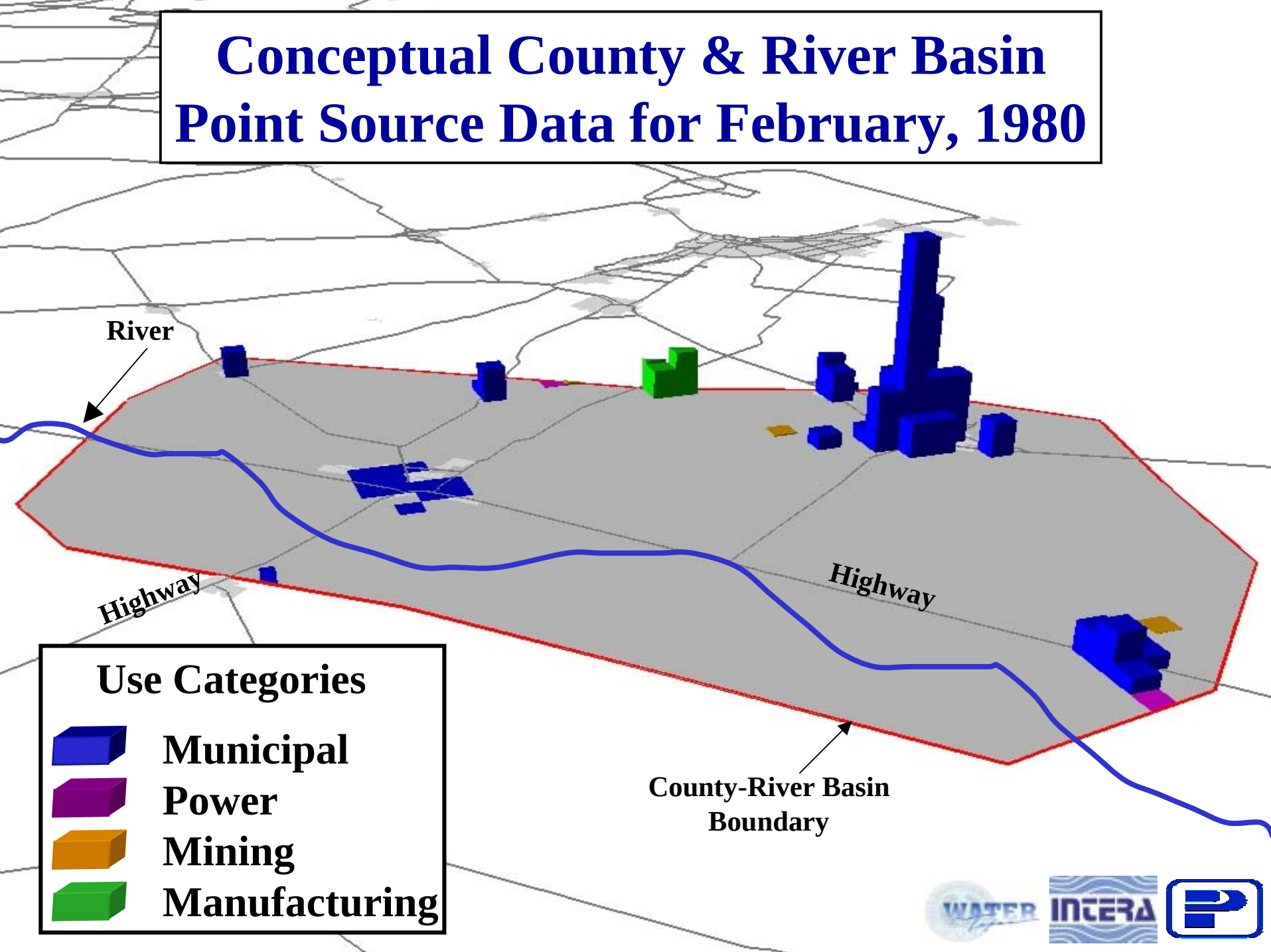
Conceptual County & River Basin Divided into 1 Mile Grid Cells



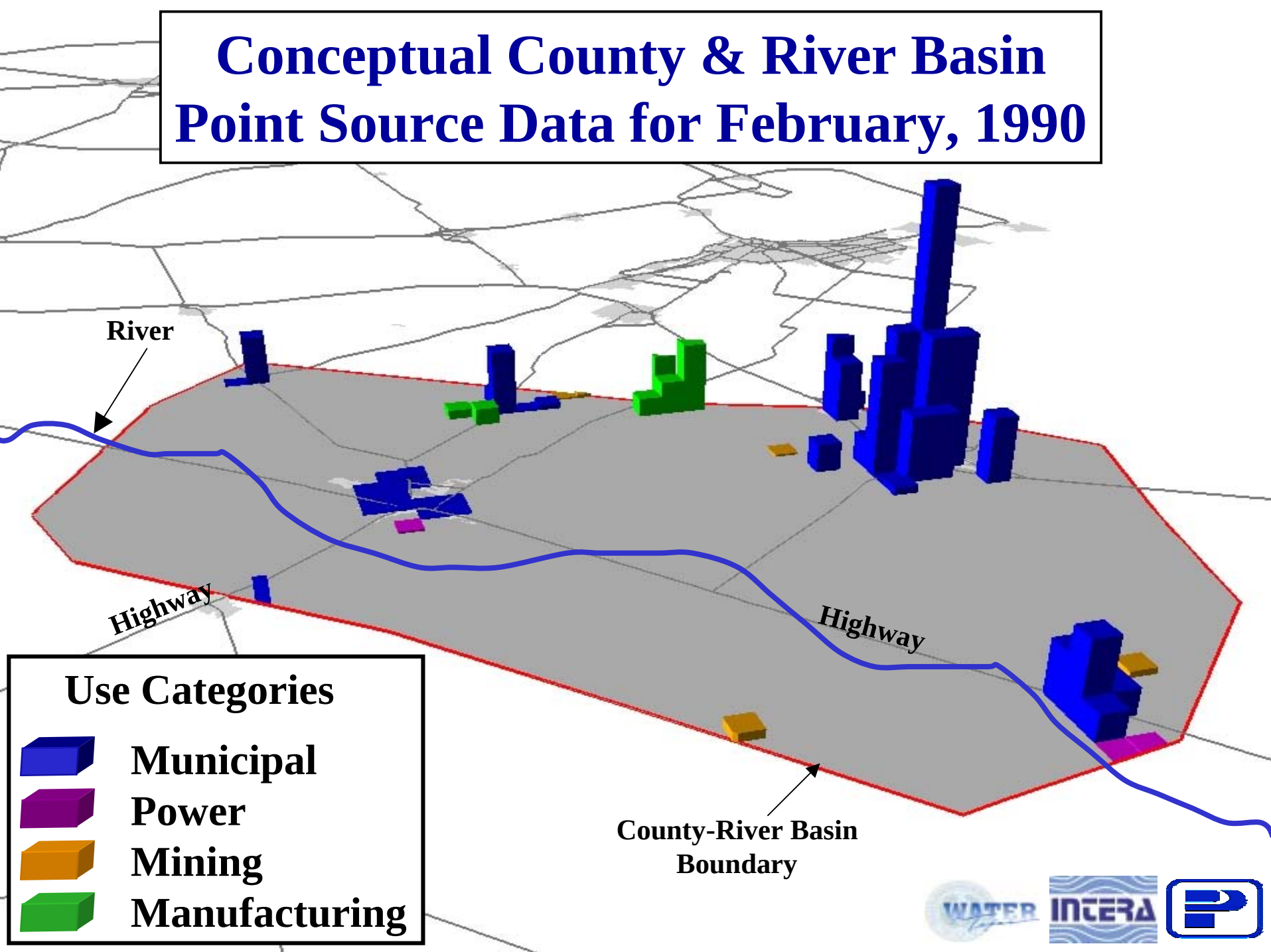
Locate Pumpage Using Point Source Data

- Applicable for municipal, manufacturing, power and mining uses
- Utilize TWDB water use survey and TWDB well database
- Assign well screened intervals (top and bottom) to specific groundwater flow layers within the model
- Label each pumping record with the appropriate grid cell identifier

Conceptual County & River Basin Point Source Data for February, 1980



Conceptual County & River Basin Point Source Data for February, 1990



Locate Pumpage Using Non-Point Source Data

1. Irrigation

- Locate irrigated areas based on land use and land cover records
- Assign monthly pumpage amounts based on rainfall, temperature, and crop demand data
- Well depths assigned from nearby wells in state well database

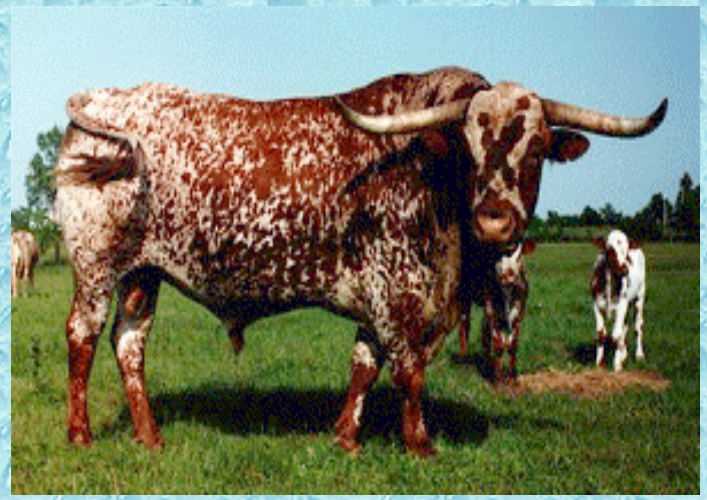
Locate Pumpage Using Non-Point Source Data

- **Rural Domestic Pumpage**

- **Distribute pumpage data based on population density, excluding municipalities with a Public Water Supply**
- **Distribute annual pumpage into monthly increments in proportion to nearby larger municipalities**
- **Well depths assigned from nearby wells in TWDB well database**

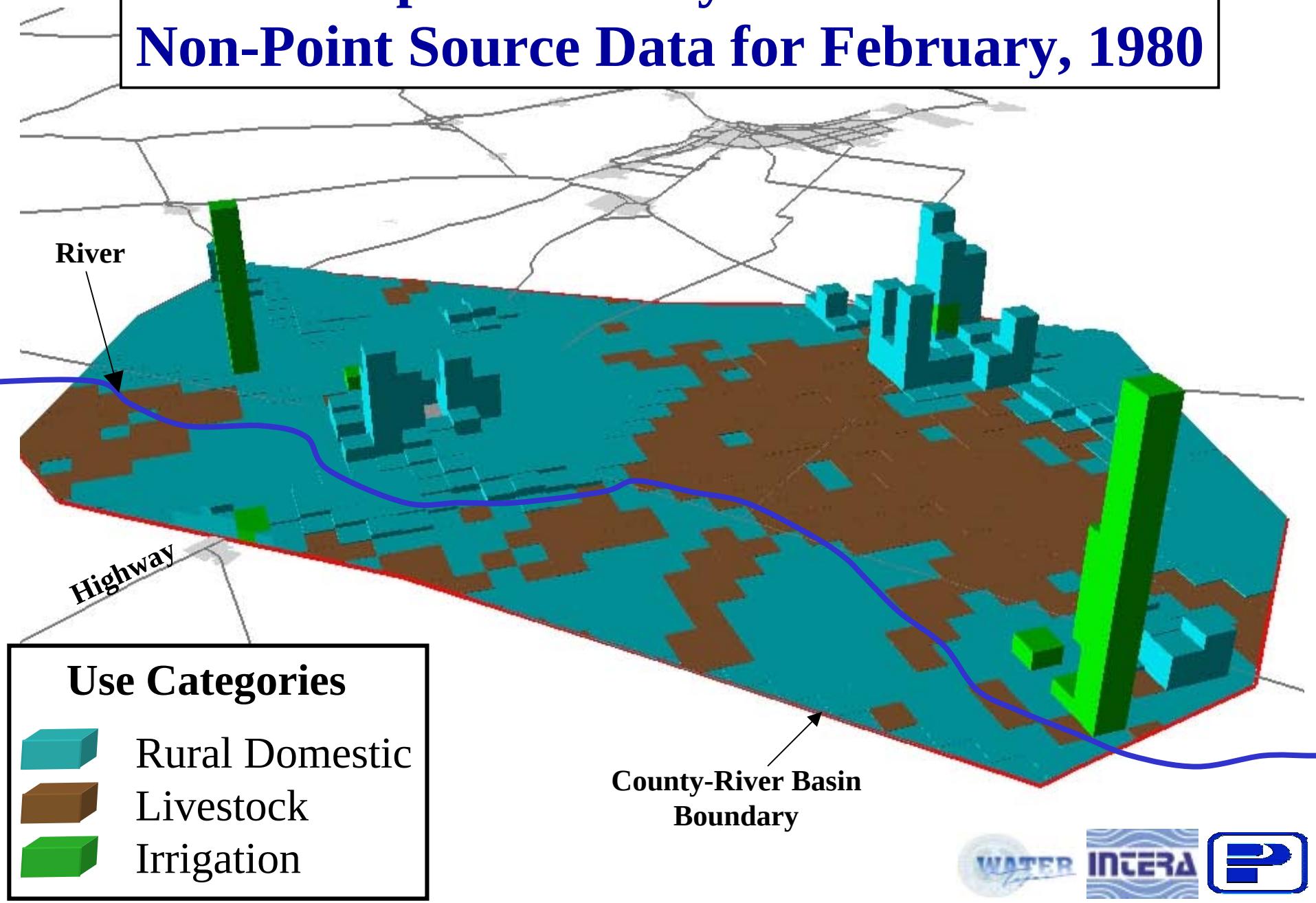
Locate Pumpage Using Non-Point Source Data

3. Livestock Pumpage

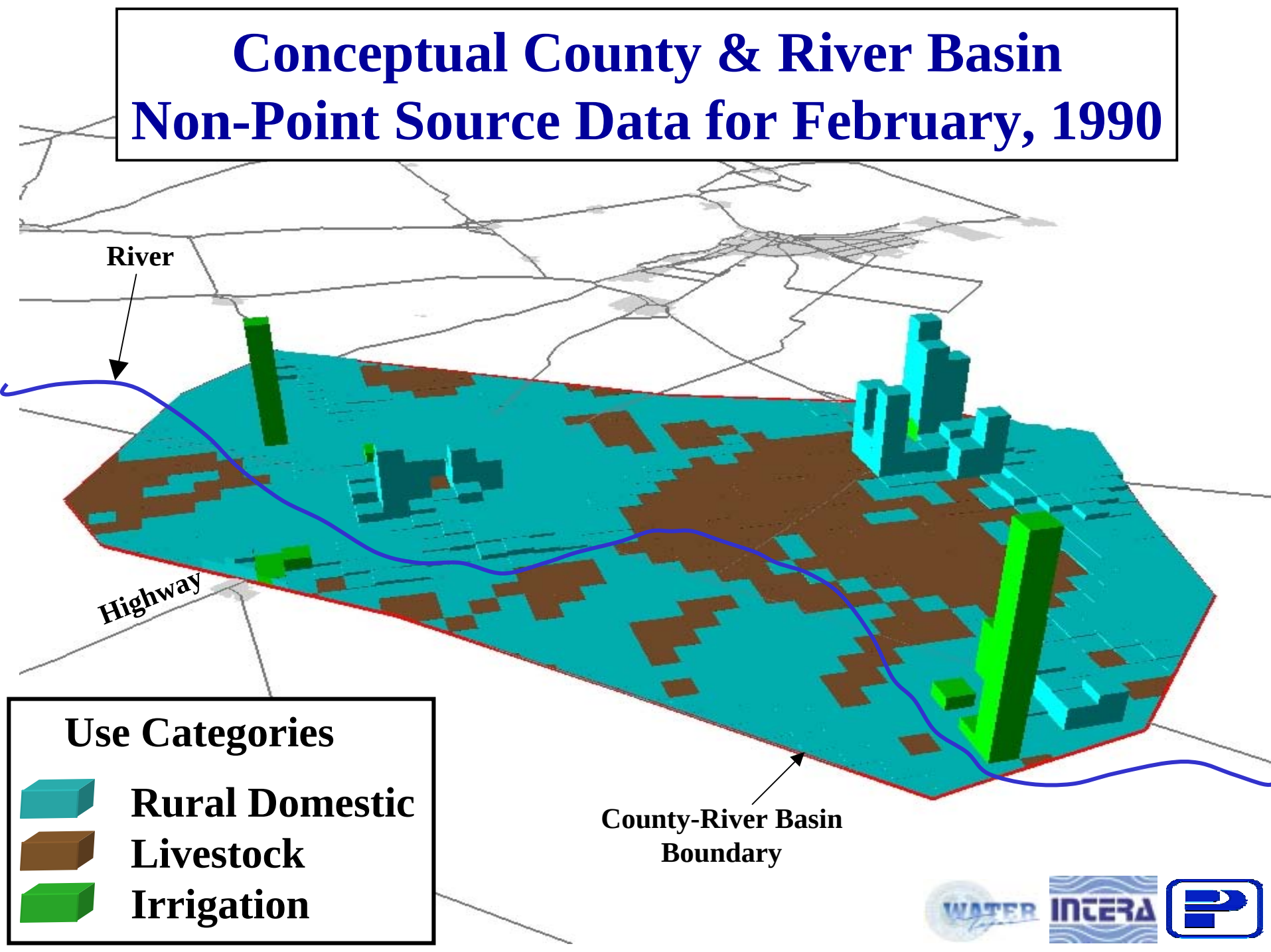


- Locate livestock areas based on land use and land cover records (rangeland and pasture)
- Assign monthly pumpage based on 1/12 of reported annual use
- Well depths assigned to upper-most water bearing unit

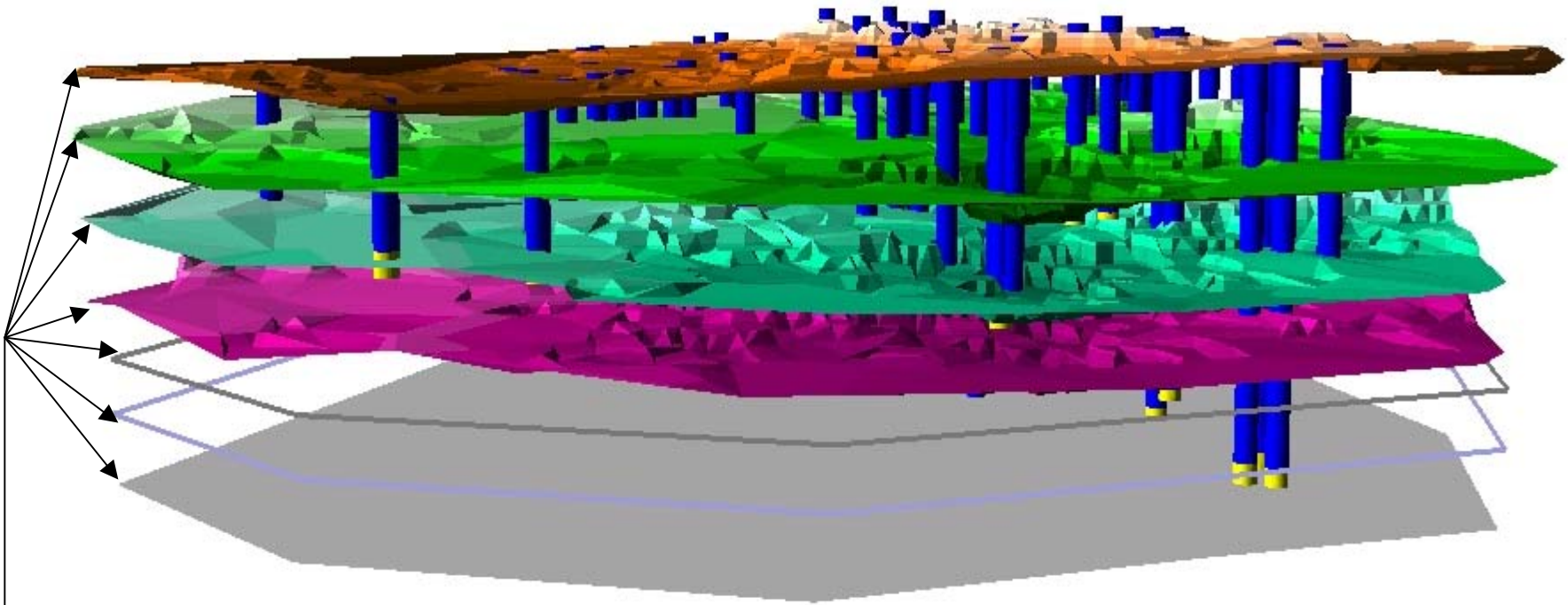
Conceptual County & River Basin Non-Point Source Data for February, 1980



Conceptual County & River Basin Non-Point Source Data for February, 1990



Conceptual County & River Basin Wells with Various Depths in Multiple Aquifer Layers



Top/Bottom of Aquifer Layers

Well Screen
Well Casing

Northern Carrizo-Wilcox Groundwater Availability Model (GAM)

Water Quality in the Northern Carrizo-Wilcox Aquifer

INTERA

PARSONS

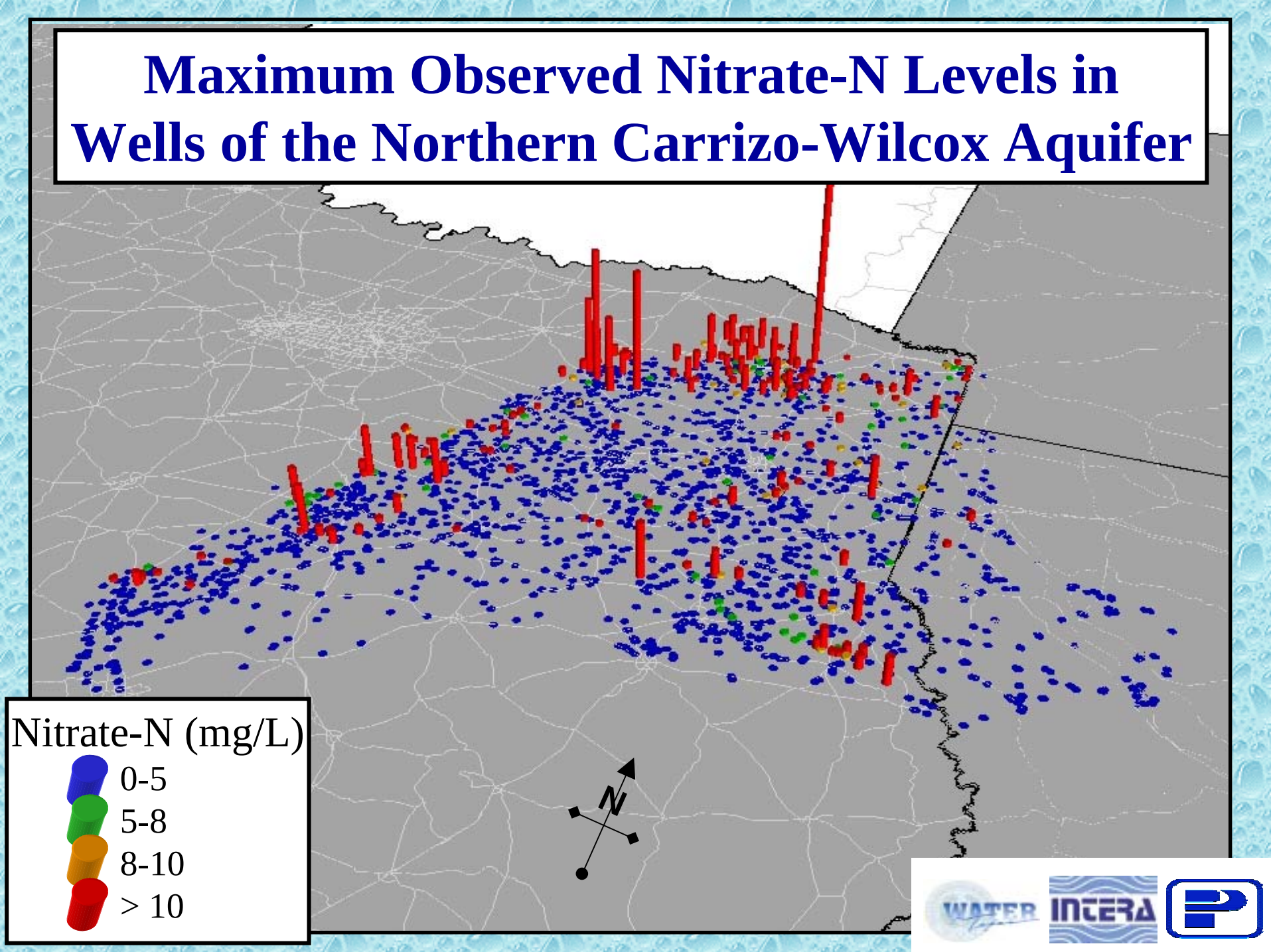
GOOD OR BAD?
Water Quality Screening Levels

- National Primary Drinking Water Regulations – legally enforceable standards to protect human health from contaminants in drinking water
- National Secondary Drinking Water Regulations – guidelines to prevent aesthetic effects (taste, odor, color), cosmetic effects (staining) in drinking water, and technical effects (corrosion, expense of treatment)
- Irrigation Water Supply
- Industrial Water Supply

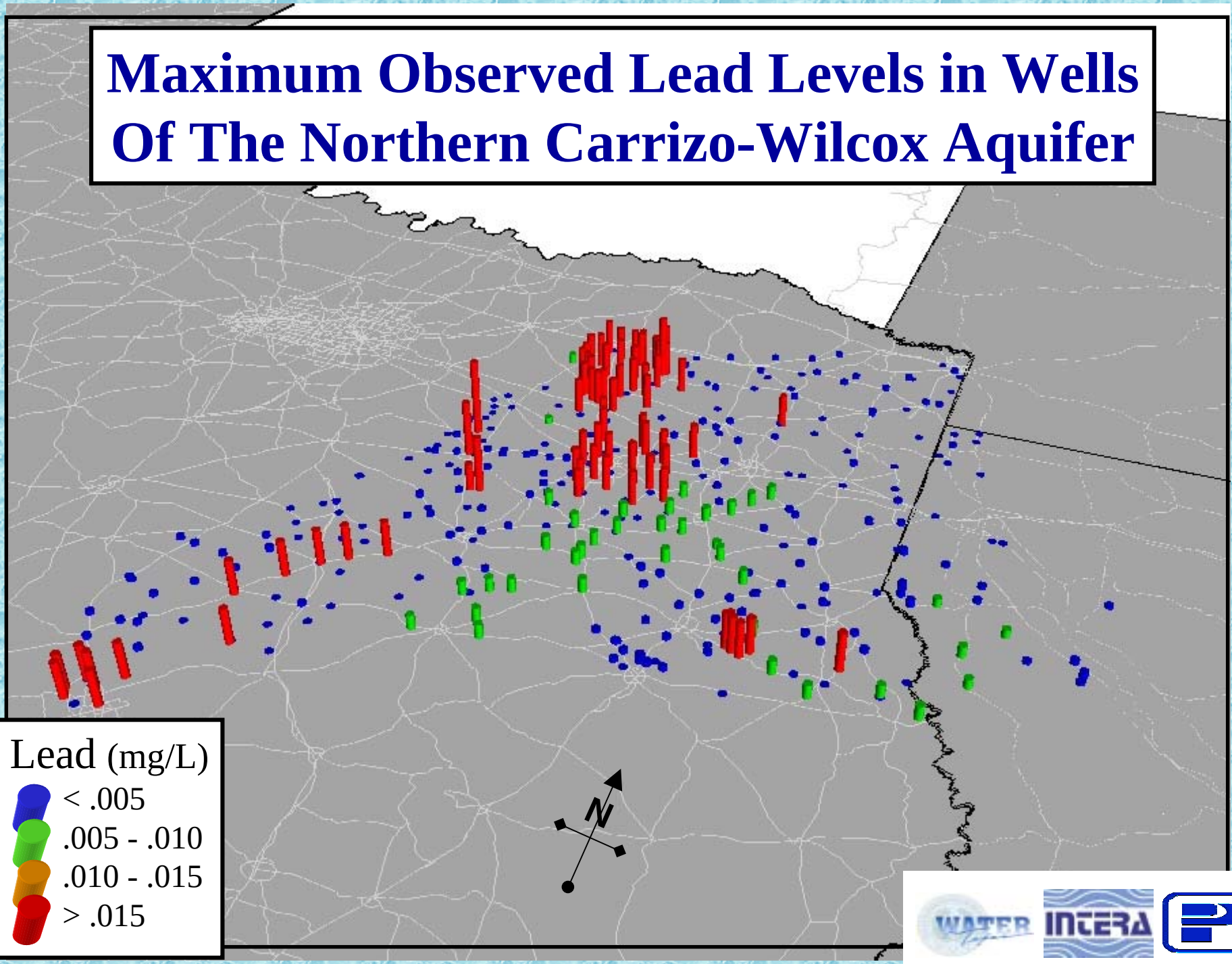
Selected Primary MCLs in the Northern Carrizo-Wilcox GAM Area

Water Quality Constituent	Wells Monitored	Screening Level	Wells > S.L.
Nitrate Nitrogen	2502	10 mg/L	6.2%
Lead	388	.015 mg/L	2.1%
Alpha Activity	245	15 pCi/L	0.8%
Beryllium	255	.004 mg/L	0.8%
Cadmium	385	.005 mg/L	0.8%
Fluoride	2681	4 mg/L	0.3%

Maximum Observed Nitrate-N Levels in Wells of the Northern Carrizo-Wilcox Aquifer



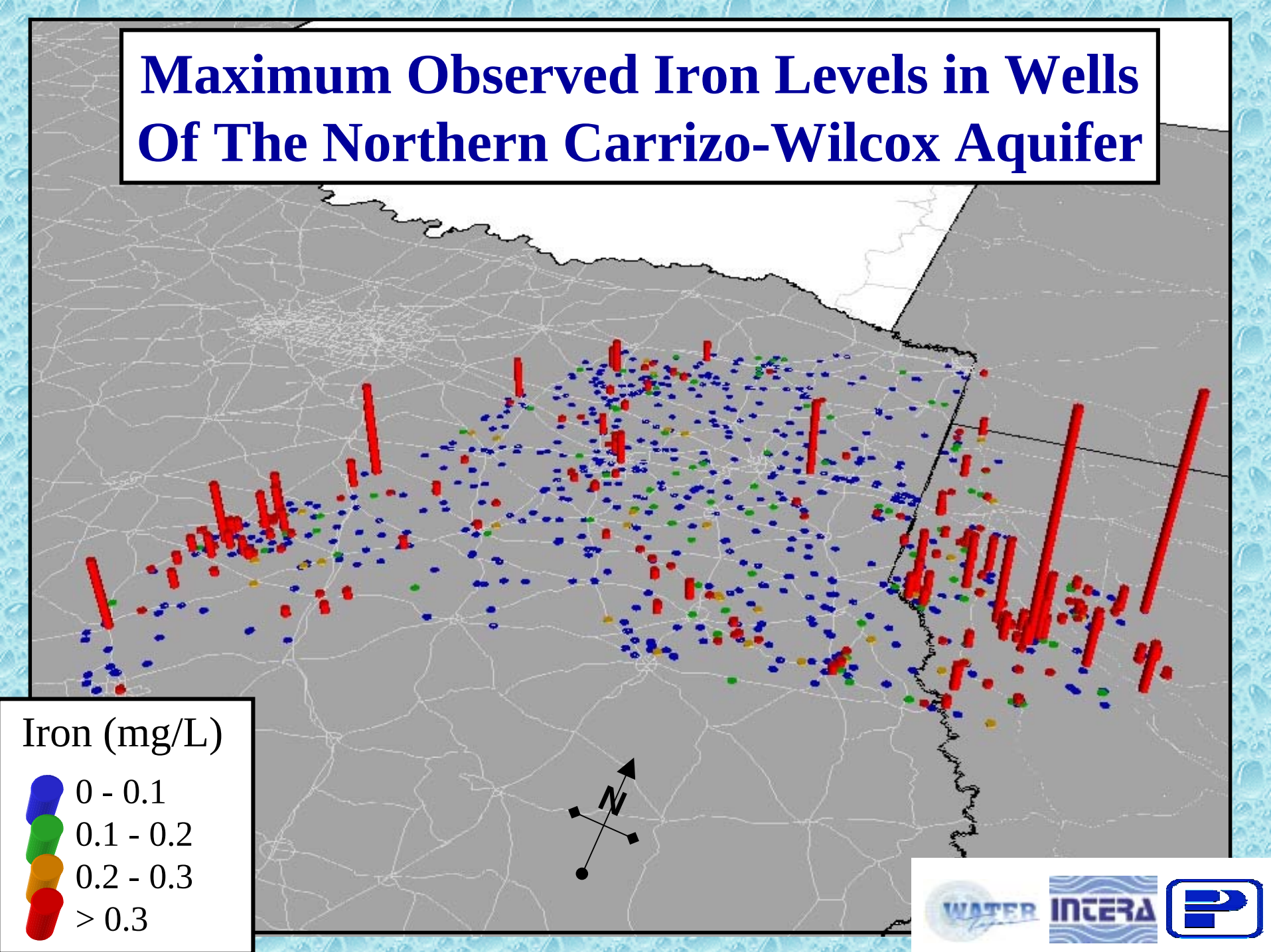
Maximum Observed Lead Levels in Wells Of The Northern Carrizo-Wilcox Aquifer



Selected Secondary MCLs

Water Quality Constituent	Wells Monitored	Screening Level	Wells > S.L.
Total Dissolved Solids	2977	500 mg/L	29%
		1000 mg/L	7.4%
Iron	961	0.3 mg/L	19%
Manganese	575	0.05 mg/L	18%
Chloride	3225	250 mg/L	8.5%
Fluoride	2681	2 mg/L	2.6%
Aluminum	286	0.2 mg/L	2.4%
Sulfate	3065	250 mg/L	2.4%

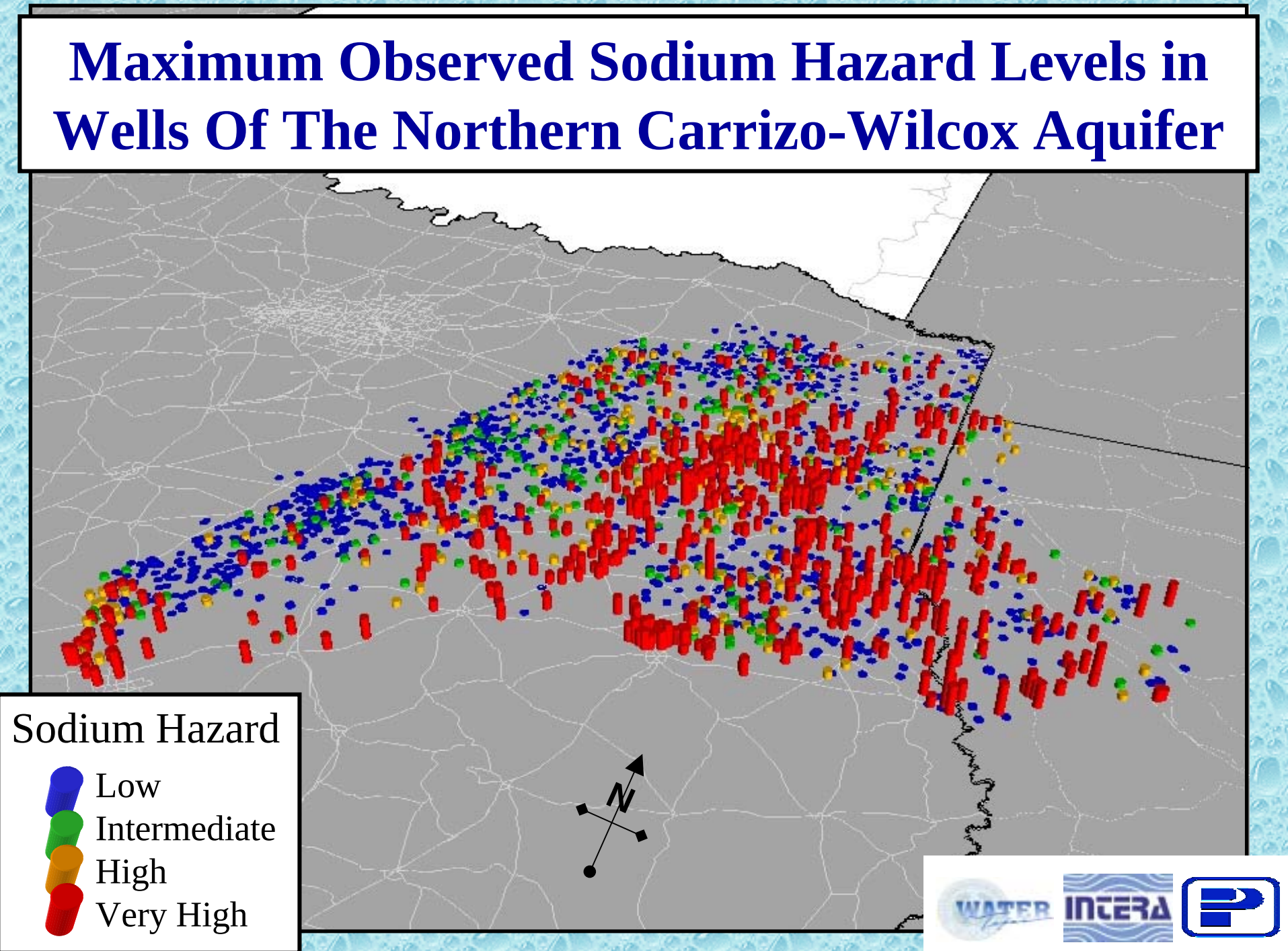
Maximum Observed Iron Levels in Wells Of The Northern Carrizo-Wilcox Aquifer



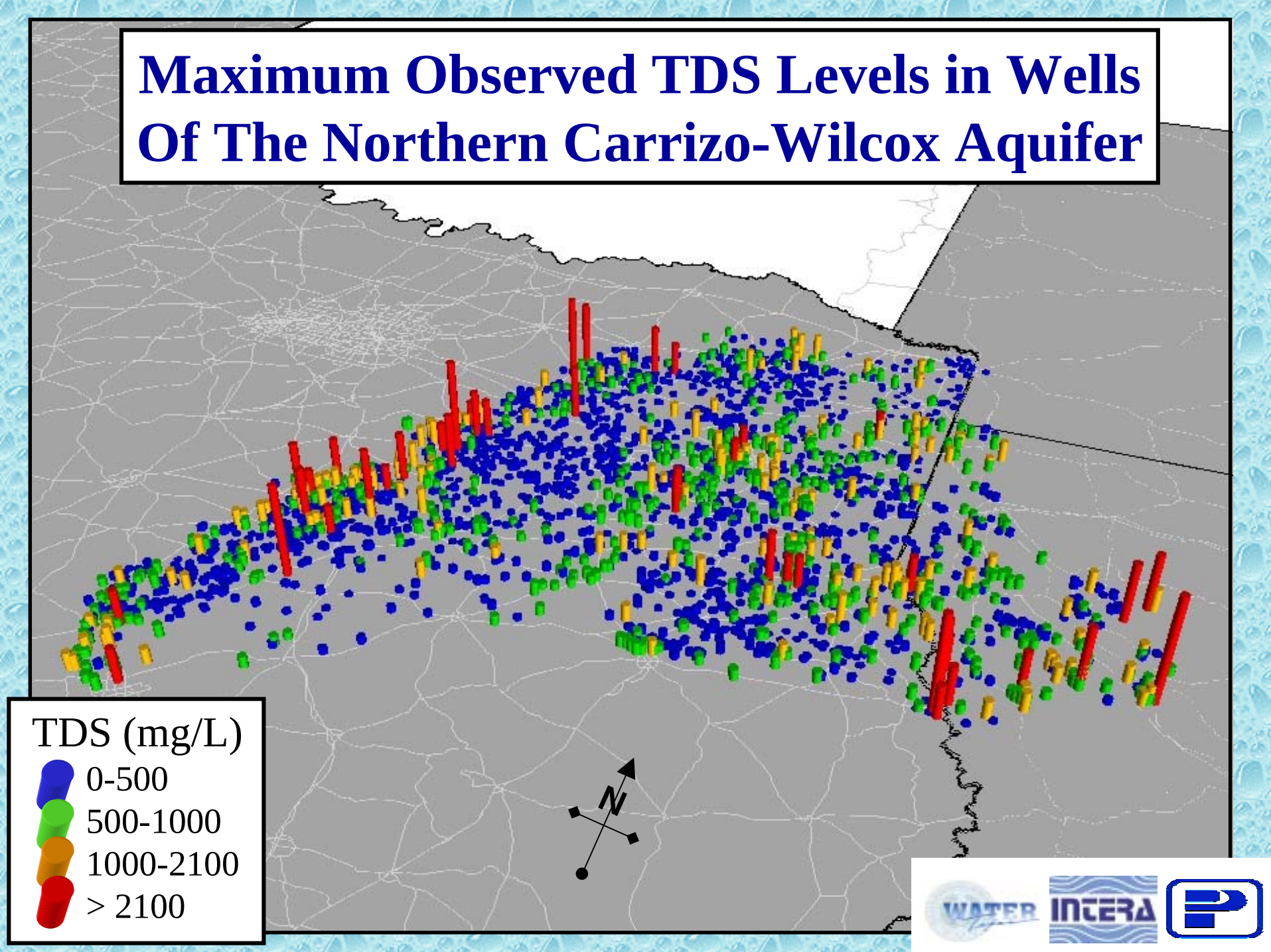
Northern Carrizo-Wilcox Irrigation Water Supply

Water Quality Constituent	Wells Monitored	Screening Level	Wells > S.L.
Salinity Hazard	2464	High	35%
		Very High	3.2%
Sodium Hazard	2858	High	33%
		Very High	24%
Boron	425	2 mg/L	1.9%
Total Dissolved Solids	2977	2100 mg/L	1.4%
Chloride	3225	1000 mg/L	1.0%

Maximum Observed Sodium Hazard Levels in Wells Of The Northern Carrizo-Wilcox Aquifer



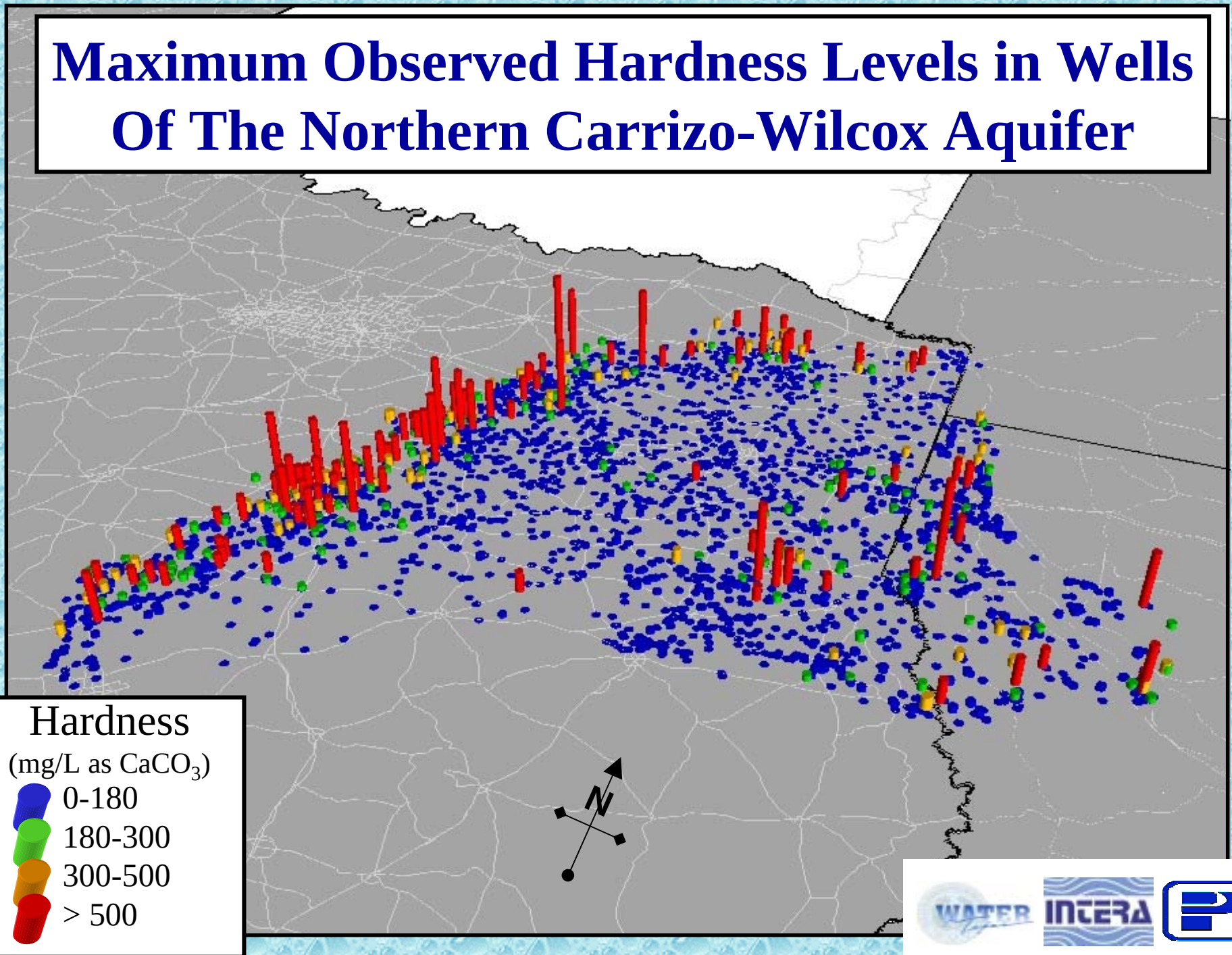
Maximum Observed TDS Levels in Wells Of The Northern Carrizo-Wilcox Aquifer



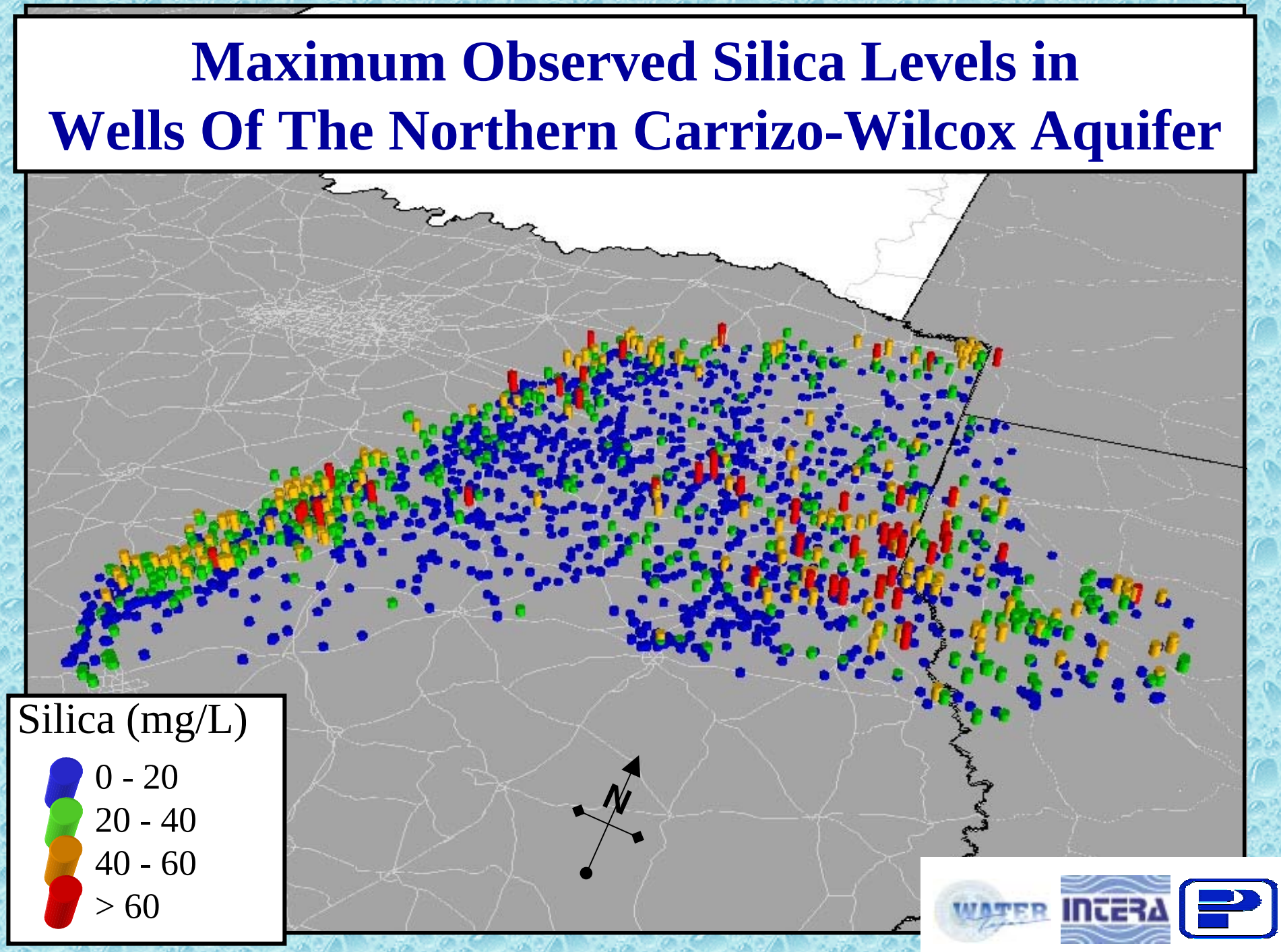
Northern Carrizo-Wilcox Industrial Water Supply

Water Quality Constituent	Wells Monitored	Screening Level	Wells > S.L.
pH	2512	<6.5, >8.5	30%
Hardness (as $CaCO_3$)	3312	180 mg/L	11%
Silica	2241	40 mg/L	10%

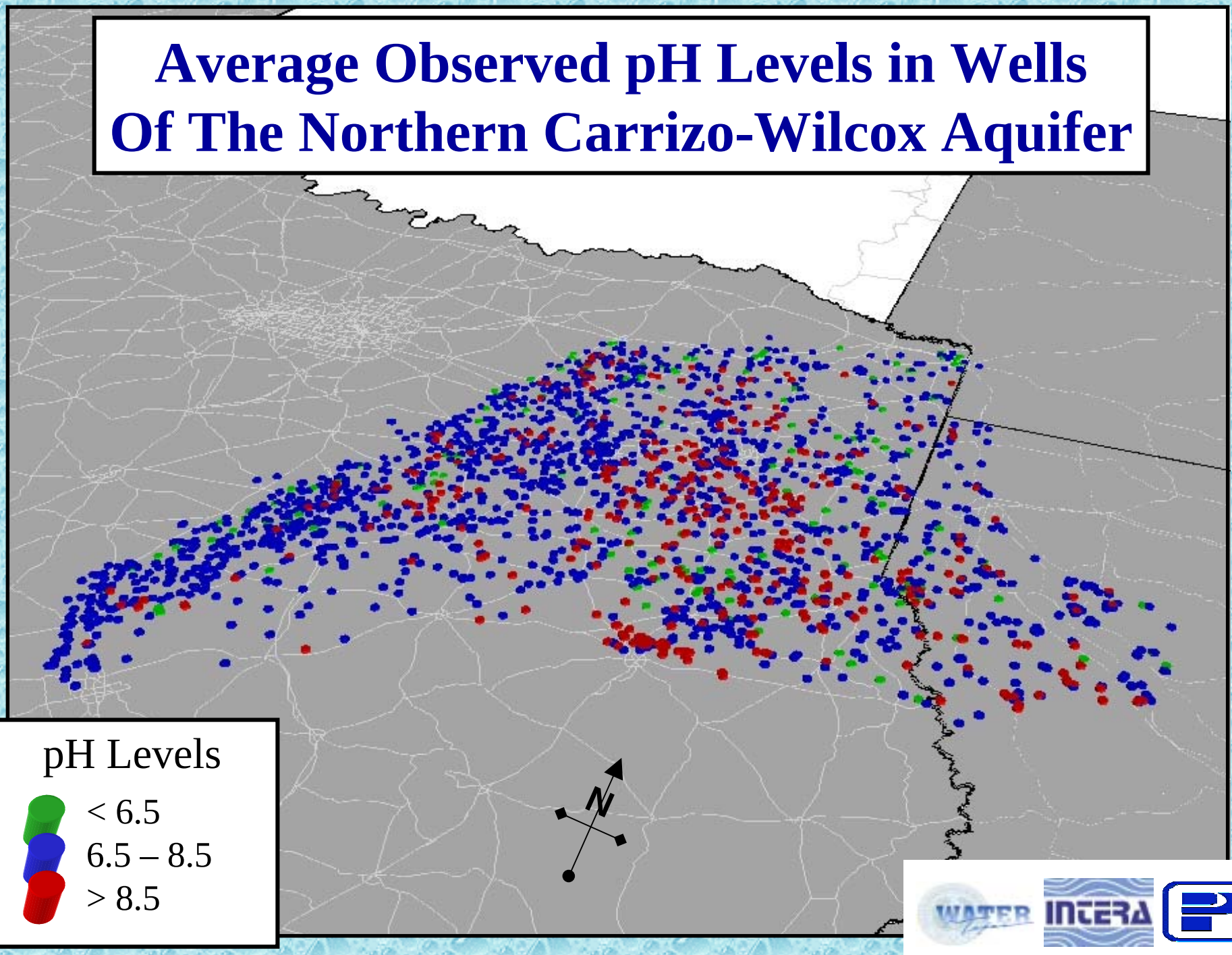
Maximum Observed Hardness Levels in Wells Of The Northern Carrizo-Wilcox Aquifer



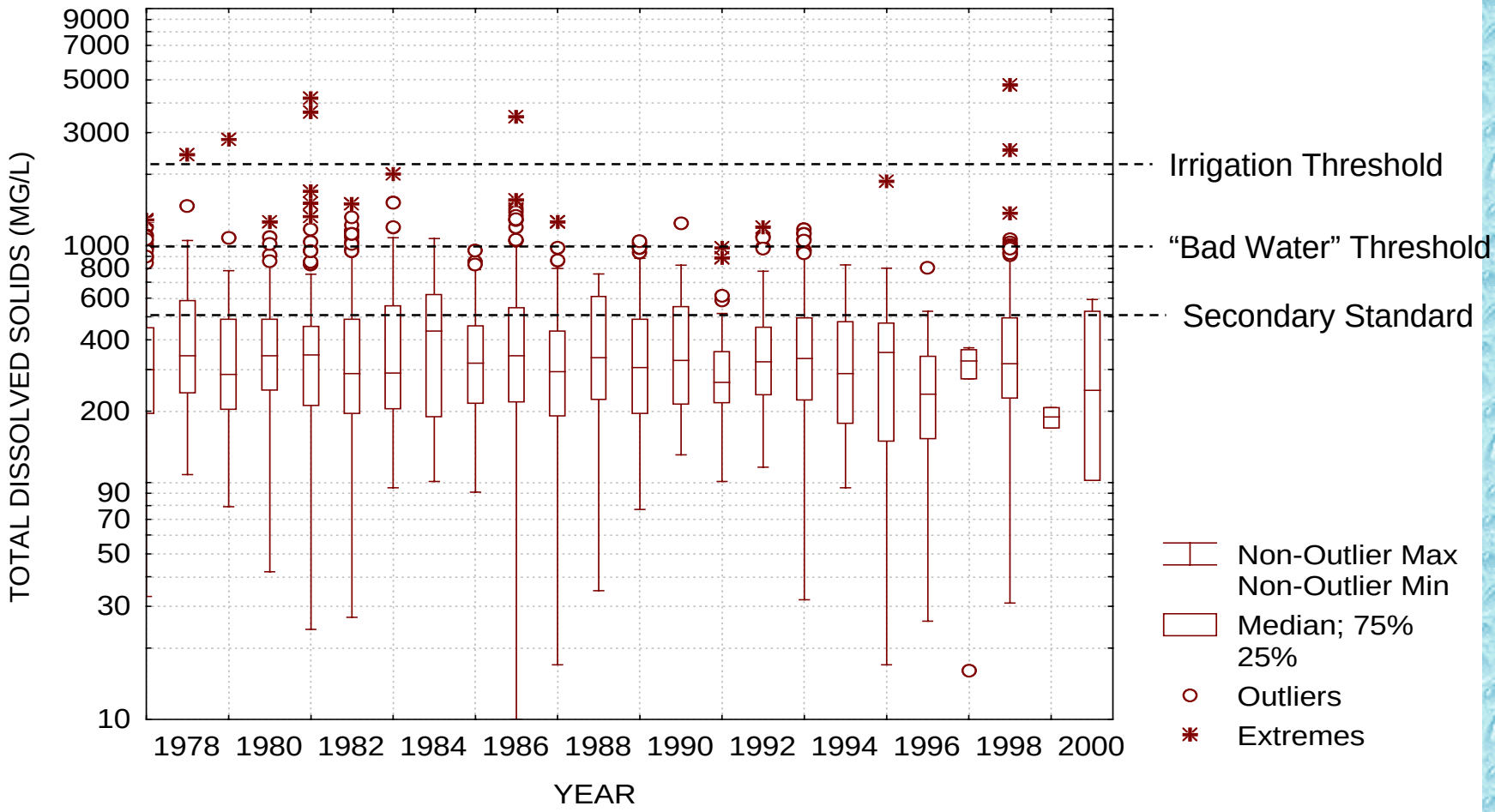
Maximum Observed Silica Levels in Wells Of The Northern Carrizo-Wilcox Aquifer



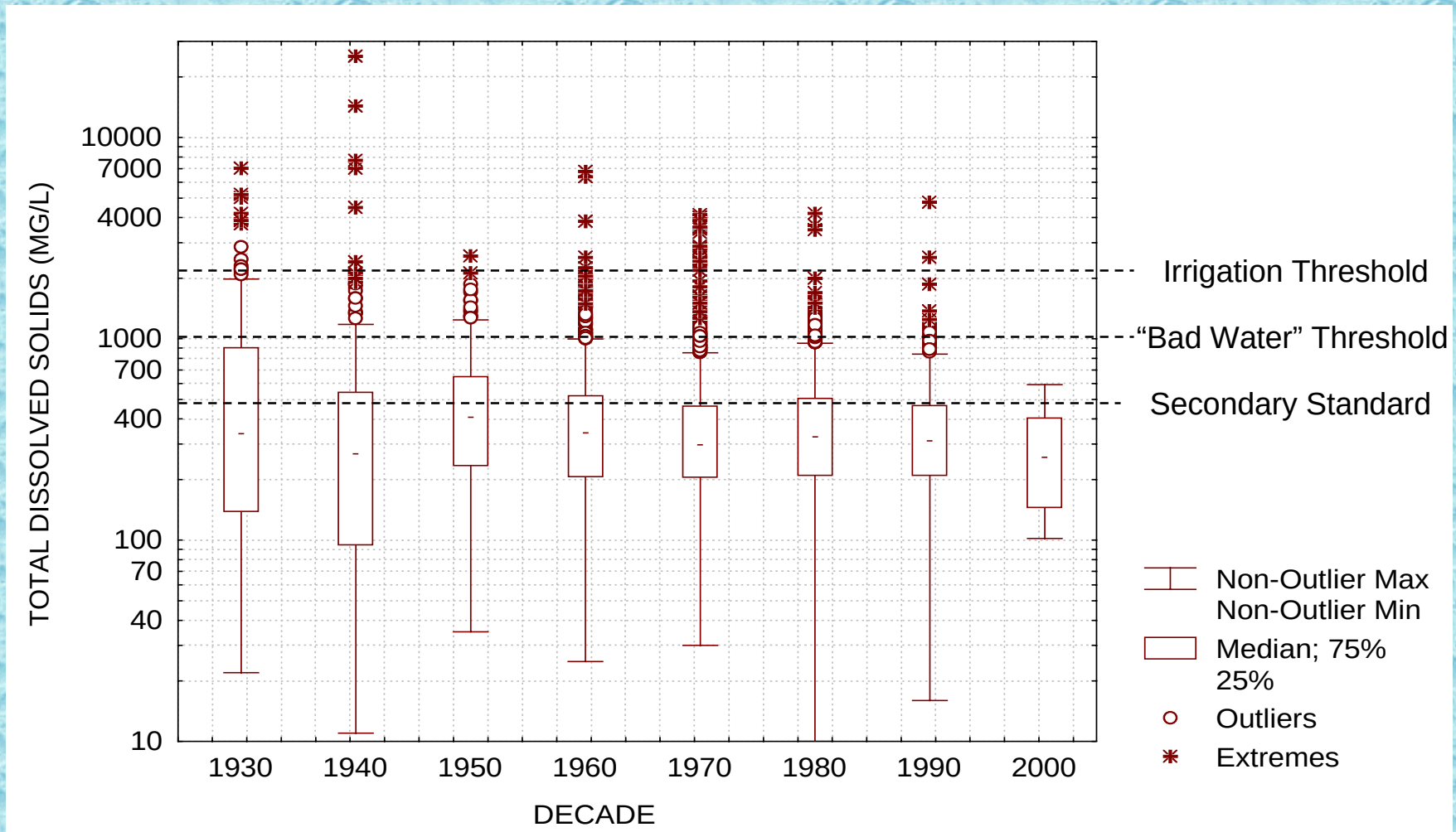
Average Observed pH Levels in Wells Of The Northern Carrizo-Wilcox Aquifer



Recent Trends in TDS Levels in the Northern Carrizo-Wilcox Aquifer



Long-Term Trends in TDS Levels in the Northern Carrizo-Wilcox Aquifer



LIST OF ATTENDEES

NORTHERN CARRIZO-WILCOX AQUIFER GAM MEETING

February 28, 2002
Hughes Springs, Texas

Name	Affiliation
Burgess Stengl	Schaumburg & Polk, Inc.
Malcolm Murray	Western Cass WSC
Maxie Chester	City of Emory
Richard Zachary	Cypress Springs WSC
Melvin Reynolds	Director, SOSONET
Terry Winn	KSA Engineers, Inc.
Tommy Spruill	TCFWSD
Bobby Pyner	Bi-County WSC
Harlton Taylor	Bi-County WSC
Kelly Mills	TNRCC
Sanjeev Kalaswad	TWDB
Walt Sears	NETMWD
Stan Hayes	NRS
Ronald Robertson	Fouke WSC
Kathy Cameron	Fouke WSC
Rainer Senger	Intera, Inc.

Fourth Northern Carrizo-Wilcox Groundwater Availability Model (GAM) Stakeholder Advisory Forum (SAF)

February 28, 2002

Northeast Texas Municipal Water District (NETMWD) Office

Hughes Spring, Texas

The fourth Stakeholder Advisory Forum (SAF) for the Northern Carrizo-Wilcox Groundwater Availability Model (GAM) was held on February 28th from 10:00 am until 12:30 pm at the Northeast Texas Municipal Water District (NETMWD) Office, Hughes Springs, Texas.

The purpose of the fourth SAF was to present the first results of the groundwater flow model for the northern Carrizo-Wilcox aquifer, describe the approaches for pumpage allocation in the model, and discuss water quality issues. The presentation material is available at the TWDB's GAM website (www.twdb.state.tx.us/gam).

Meeting Introduction: Dr. Sanjeev Kalaswad, TWDB.

The meeting was opened by Dr. Sanjeev Kalaswad of the Texas Water Development Board (TWDB), who introduced the North Carrizo-Wilcox GAM team personnel giving the presentation.

SAF Presentation: Dr. Rainer Senger (INTERA Inc.), Mr. Arthur Whallon and Mr. Kirk Dean (Parsons Engineering).

After the introduction by Mr. Kalaswad, Dr. Rainer Senger gave a review of the GAM project, which was followed by Mr. Whallon describing the approach for pumpage allocation in the model. Mr. Dean presented the water quality evaluation for the aquifer. Dr. Senger then reviewed the modeling approach and presented preliminary results from the steady-state model calibration.

During and following the presentation, questions were asked by the stakeholders, which are summarized below.

Questions and Answers: Open Forum:

1. Pumpage Assessment:

Q: Are private wells considered?

A: Yes, they are included in rural domestic wells as non-point source data.

Q: Are small municipal wells considered as point-source wells or is there are lower cutoff limit?

A: Any municipal well for which a permit was submitted is considered a point-source well; this also includes wells from private water corporations.

Q: Pumping from municipal wells is assigned to different model layers depending on the screen depth; what about those wells for which no information is available?

A: Wells without depth or screen information are assigned to the different layers based on typical depth assignments of similar wells nearby.

Q: How do you estimate rural population for water usage purposes?

A: This is based on the total population minus the population using municipal water.

Q: Irrigation well allocation according to land use: Is land use for nurseries distinguished, since there are a number of large nurseries in the area?

A: No; will examine for this specific area. Information about nurseries in the area can be obtained from the Nursery Association and its web site.

Q: Do you use land-use coverage for livestock water usage?

A: Yes

Q: How is water consumption for livestock estimated?

A: Estimate is provided by the TWDB.

Q: Is the goal of the GAM to predict how much water can be pumped from a specific location?

A: No, the model is regional in nature based on 1 by 1-mile grid cells to provide regional groundwater availability, whereby groundwater availability or sustainable yield is defined by the RWPGs or GCDs.

2. Water Quality Issues:

Q: What time period is considered in the water quality data evaluations?

A: From 1930 through present; overall there are no trends apparent through time.

Q: Wells that were drilled and show non-potable water will be typically plugged and that information is typically not provided to the TWDB; how representative, then, is the water quality assessment for the aquifer?

A: This is a problem; apparently only limited information shows up in the data base from wells that are plugged. TWDB has a state-wide water quality monitoring program which provides some information regardless of water quality.

Q: Can contamination in one layer move to another layer within the model area?

A: Yes, it can, but it is not explicitly simulated in the model; it only can be inferred from the flow rates.

3. General Issues:

Q: How was a determination made regarding the assignment of a well to a particular layer in the model?

A: This was done based on the well depth and well screen information; if this information was not available, it was assigned based on information from nearby wells.

Q: Does water in one cell of the model move to another cell, or is it restricted to the cell?

A: Yes, the model simulates water flow between cells.

Q: Will the model be capable of producing sustainable yield numbers?

A: The model can be used to estimate sustainable yield, which depends on the way one defines sustainable yield.

Q: How fast does water move within the different layers in the model area?

A: This depends on the overall hydraulic conductivity and porosity of the sands in the layer and interconnectedness of the sand channels. In the confined section, age-dating of groundwater indicates relatively "old" water (thousands of years) suggesting overall slow velocities, whereas in the outcrop, flow velocities could be relatively fast (several days to years).

Q: Will groundwater conservation districts (GCDs) within the model area be able to provide information to the TWDB to refine the model?

A: Yes, GCDs can provide information to the TWDB that can be used to improve the model and possibly refine the model for more local-scale application.

Comments:

- It would be helpful to combine the different MCL exceedances to identify how many of the wells have constituents that exceed their MCL's, in addition to having the well exceedance for different water users.

- Quantity of groundwater available may not be representative of "good" quality of groundwater. In terms of water availability, it is also important to identify the amount of potable water. Stakeholders' experience indicates lots of wells drilled that either don't yield significant amounts of water, or that they yield poor quality water.

- Most stakeholders at the meeting are interested in using the results of the modeling to obtain site-specific information rather than for regional purposes.