Groundwater Modeling on the Cutting Edge (Trinity Hill Country Aquifer, TX)

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Introduction

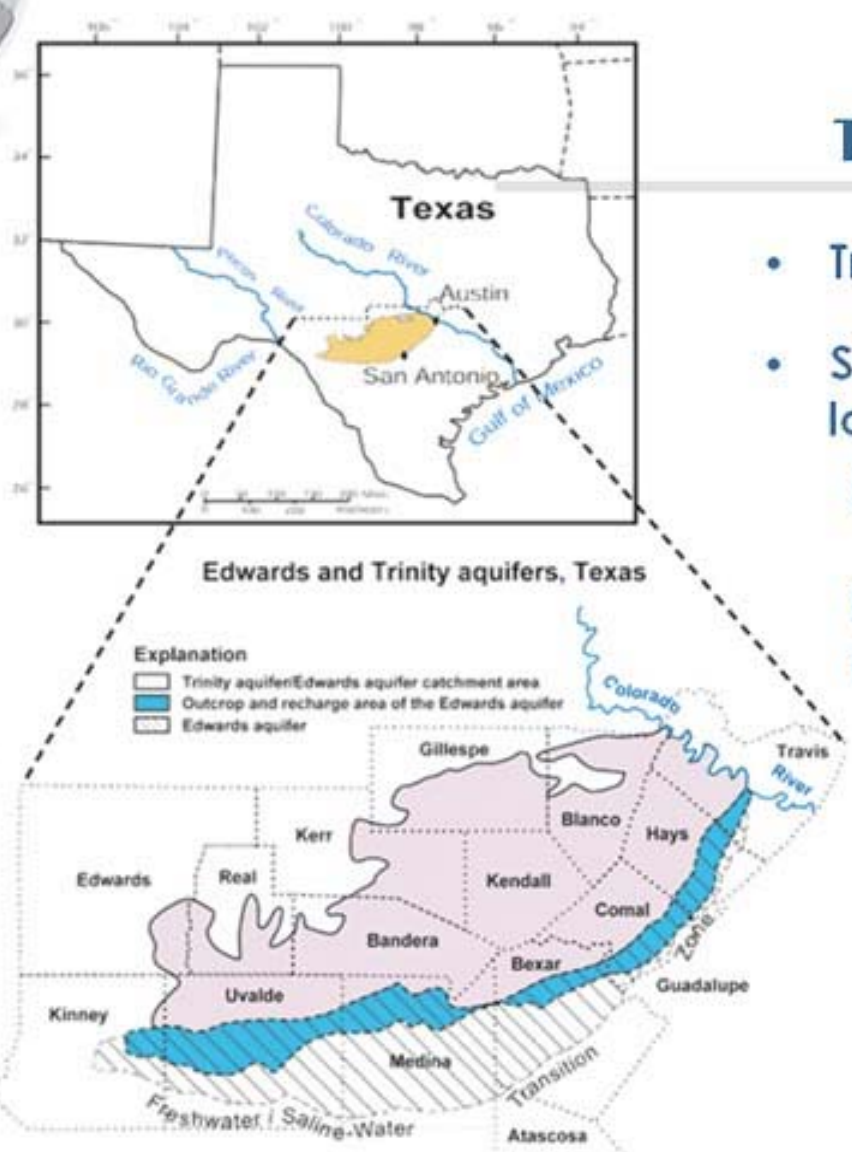
GIS Modeling

- A model is: "a simplification of reality created to better understand the system being created" - Booch *et al.*
- Using GIS to prepare and analyze data, and display results, bundled with modeling code
- Vector/raster data models to represent spatial features
- Component-based software architecture

Major Aquifers in Texas

Source: TWDB

Target Area



- Trinity-Hill Country Aquifer
- Study area includes three layers:
  - (1) Layer 1: Edwards group of the Edwards Trinity plateau
  - (2) Layer 2: Upper Trinity
  - (3) Layer 3: Middle Trinity

Source: USGS and TWDB

GIS Modeling Objectives

- Get GAM to talk to GIS (enhance Semantic Interoperability)
- Represent GAM results in 2-D & 3-D GIS models

This includes:

- Delineate and analyze the Trinity Hill Country aquifer
- Develop planning and decision making support system tools to easily test and model different pumping scenarios
- Evaluate the impacts of incremental increased pumping (10, 20, 30, 40, and 50%)
- Develop a better understanding of different future scenarios to easily and interactively visualize impacts
- Examine aquifer behavior in specific zones, based on political boundaries and zones of potential growth
- Make informed decisions pertinent to desired future conditions (in 2050)

How GAM Works

Modeling Components

Model consists of:

- Matrix of rows and columns (with mile x mile cell size)
- Point locations representing well coordinates and distribution.

Inputs:

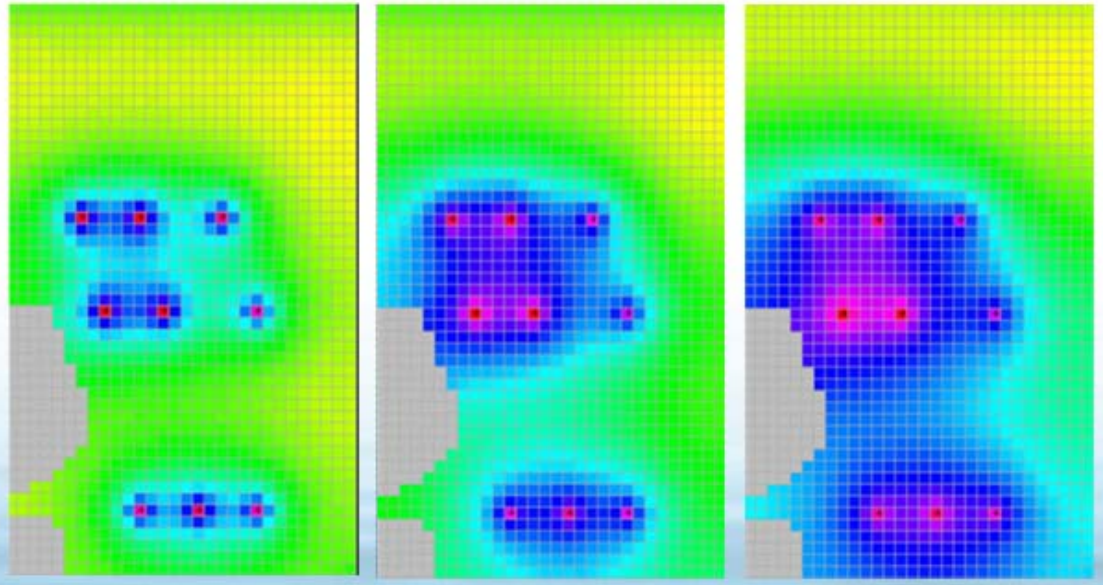
- Geology
- Recharge (based on rainfall)
- Surface water - Drains (rivers and springs)
- Pumping rate/discharge (wells)

Outputs:

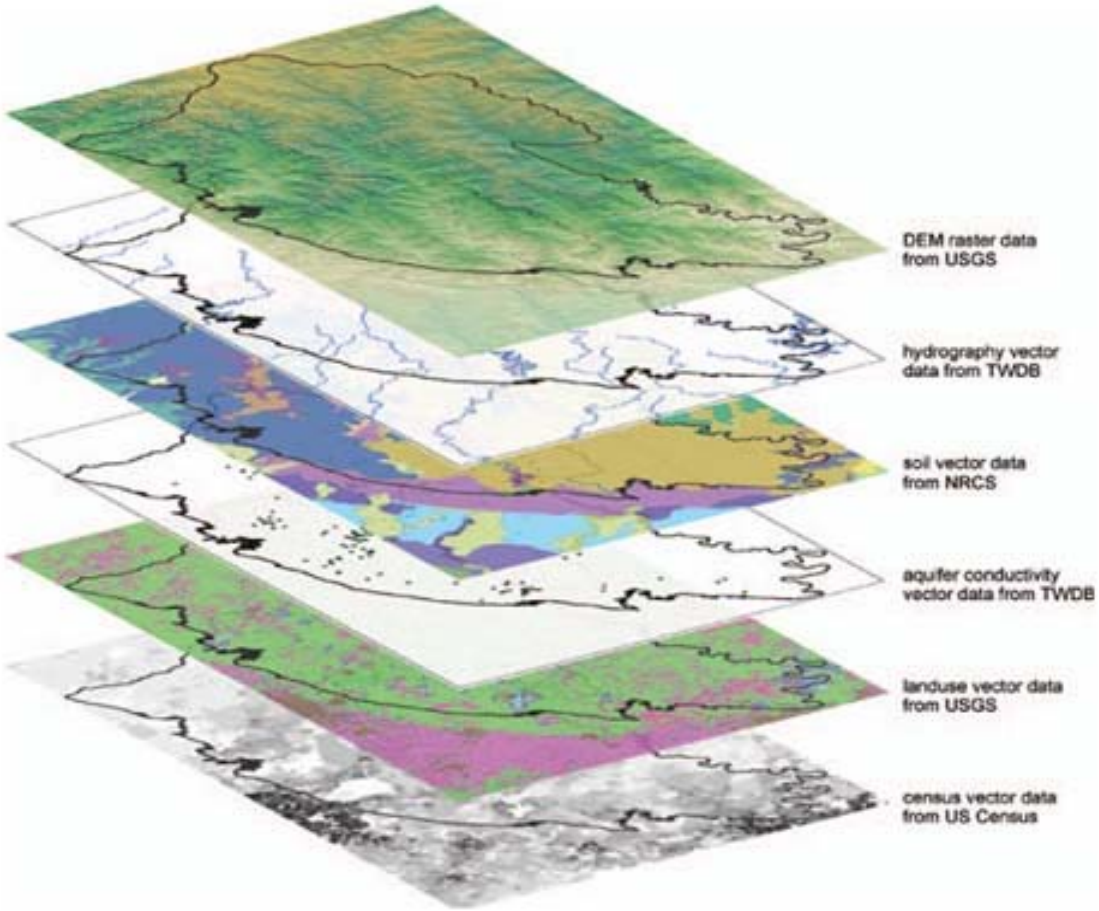
- Water levels (drawdown)
- Water budget data (changes in storage and discharge to rivers)

GIS Modeling Approach

- Grid and mesh generation
- Spatial and temporal diffusion: simulation and rendering of water extraction over time



GIS Thematic Layers



Source: TWDB

Trinity-Hill Country Aquifer

- 69 rows x 115 columns mile by mile cells
- Different cells have different hydraulic properties

Model Grid

- Define "Zones" based on:

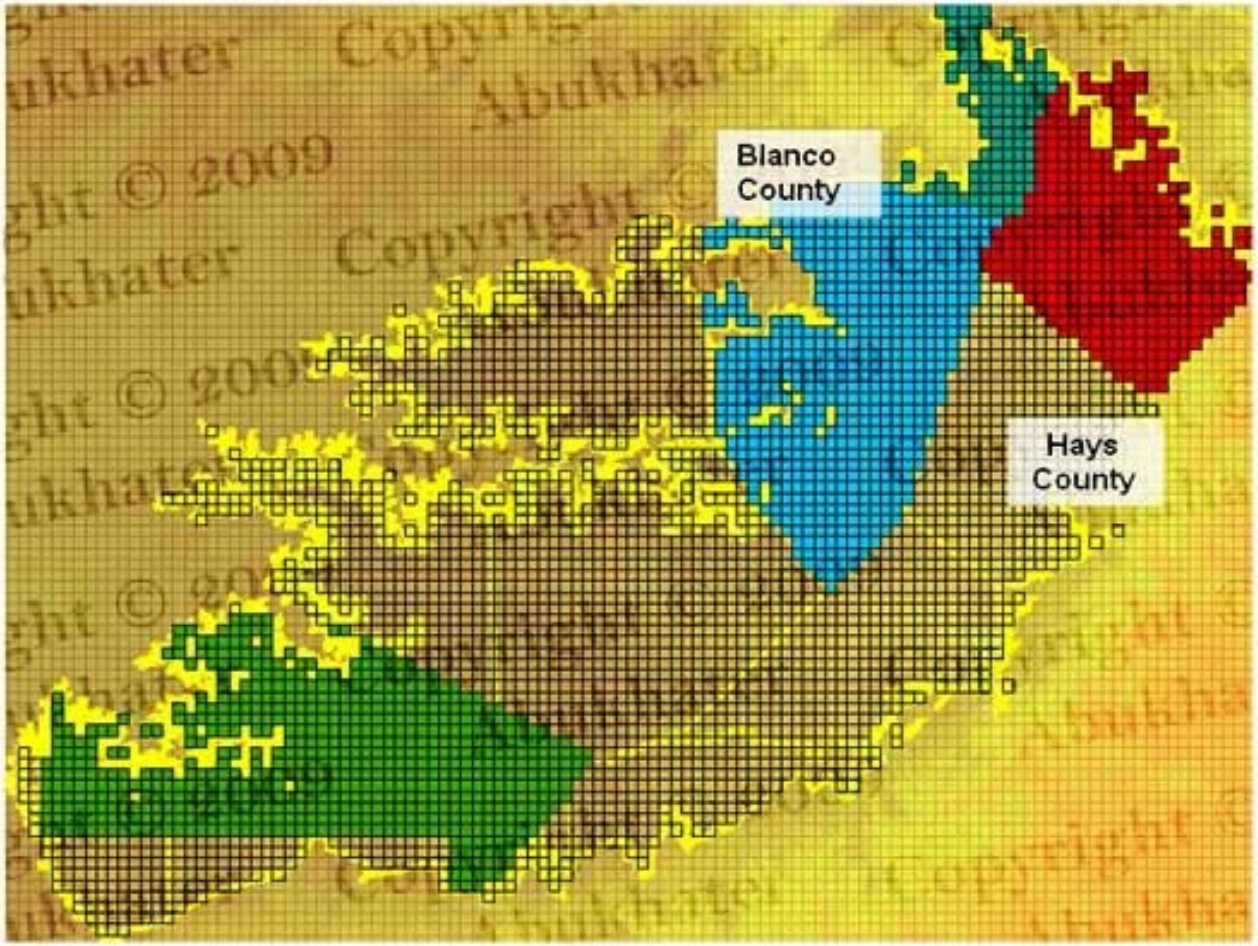
1- Expected growth corridors (Buffering):
  - Major roads (1 mile)
  - Municipal boundaries (1 mile)

2- Political boundaries (County lines)

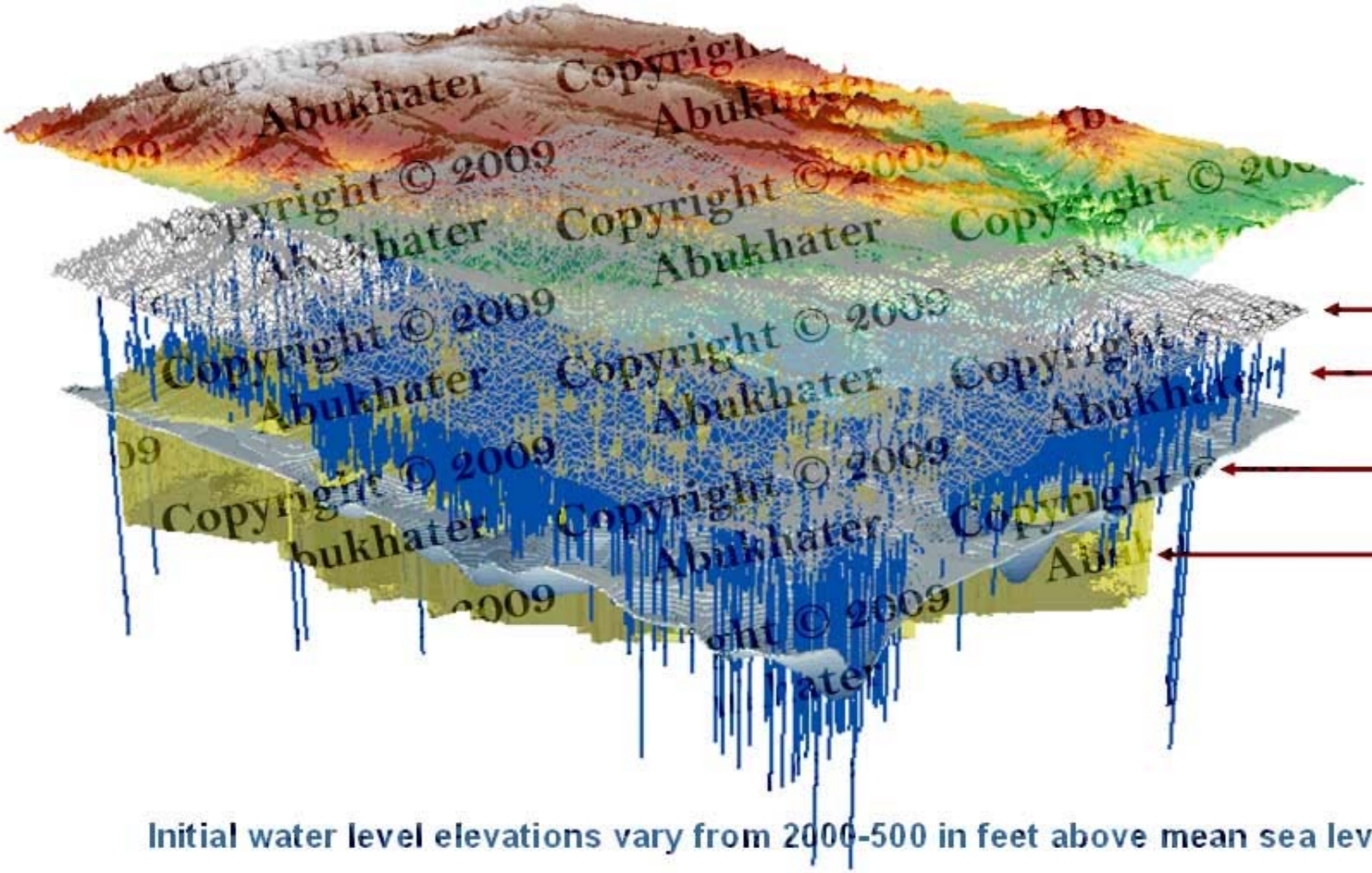
Expected Growth Corridors
(Major Roads)

Expected Growth Corridors (Municipal Boundaries)

Zones Based on County Lines



GIS System Architecture Design & Components



Initial water level elevations vary from 2000-500 in feet above mean sea level

GIS Modeling Methodology

Imported into

GAM Results

Values of water table drawdown from GAM

GIS

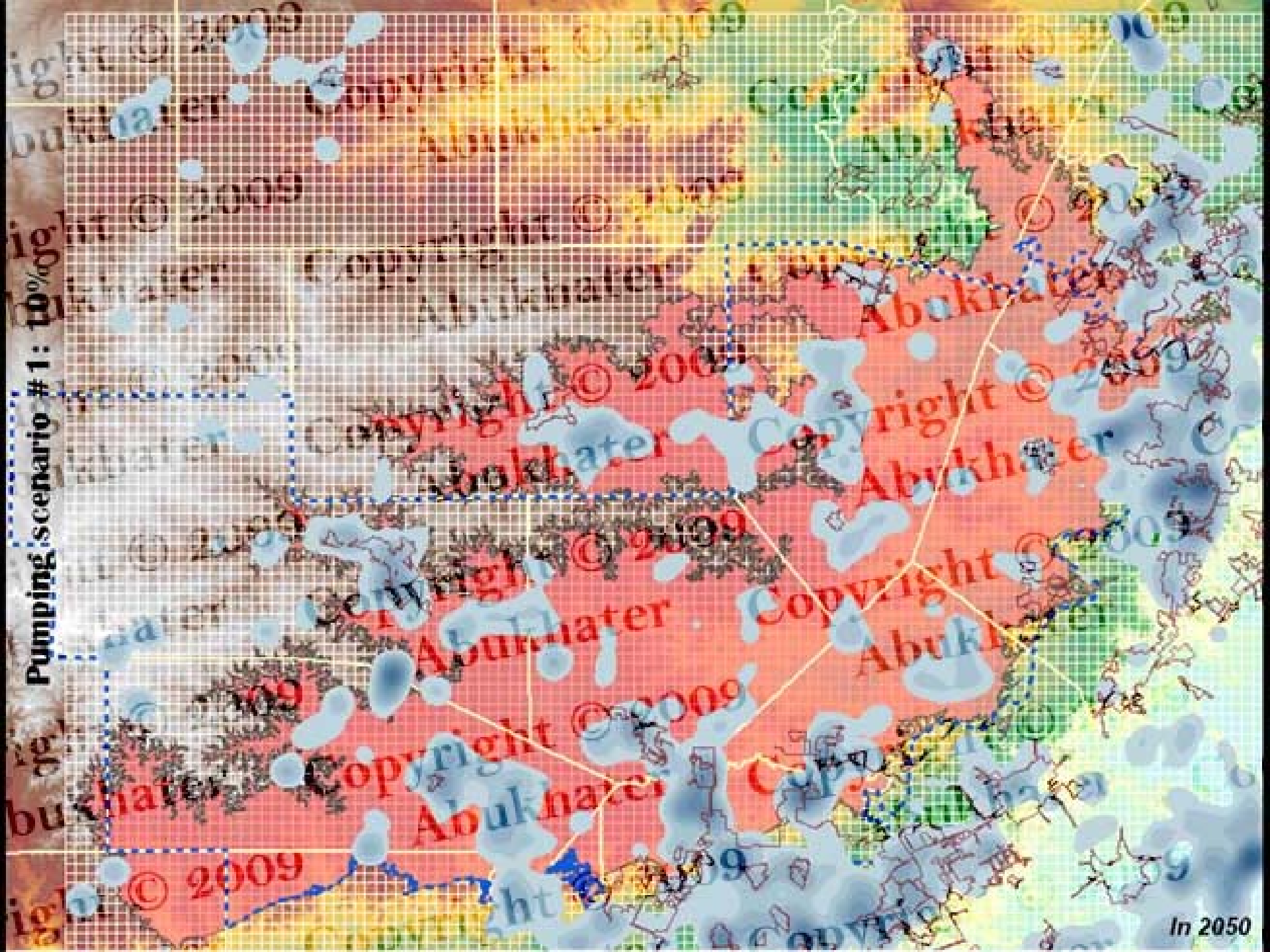
Values stored in cell centroids in GIS

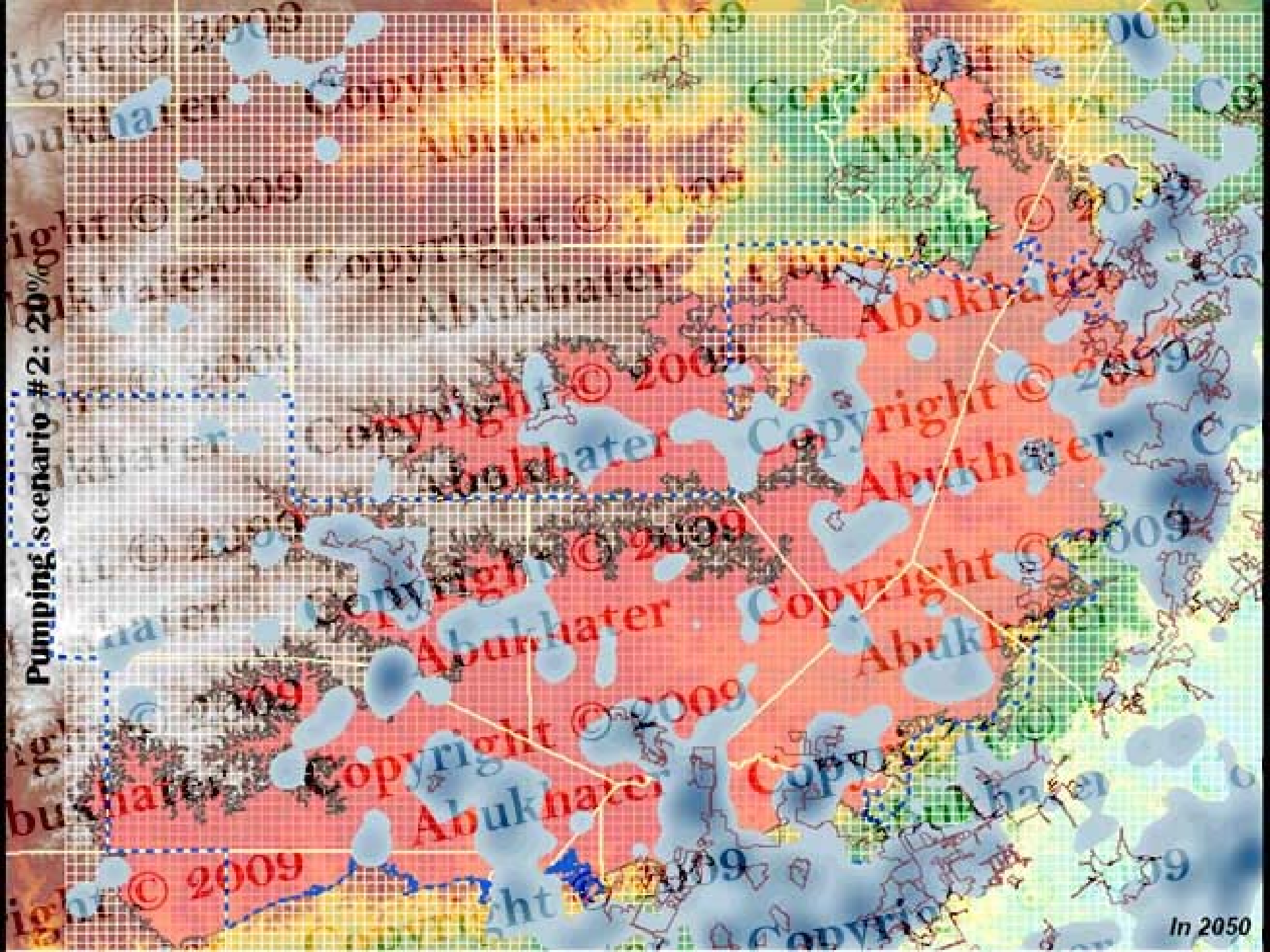
Changes in water level elevations; Water level decrease (drawdown)

GIS Modeling Methodology

- Different pumping scenarios (10%, 20, 30, 40, 50%)
- Three factors were considered in 3D modeling:
  - ♠ Depth of wells
  - ♠ Concentration of well distribution
  - ♠ Extraction rate intensity (from GAM)

- Extraction (withdrawal) values are assigned to each cell
- A continuous 3D surface (mesh) is generated and color-coded based on these values
- Density function is performed to create a continuous raster surface (2D)
- 2D results are transferred and incorporated into 3D model


Pumping scenario # 1 : 10%
In 2050


Pumping scenario #2: 20%
In 2050
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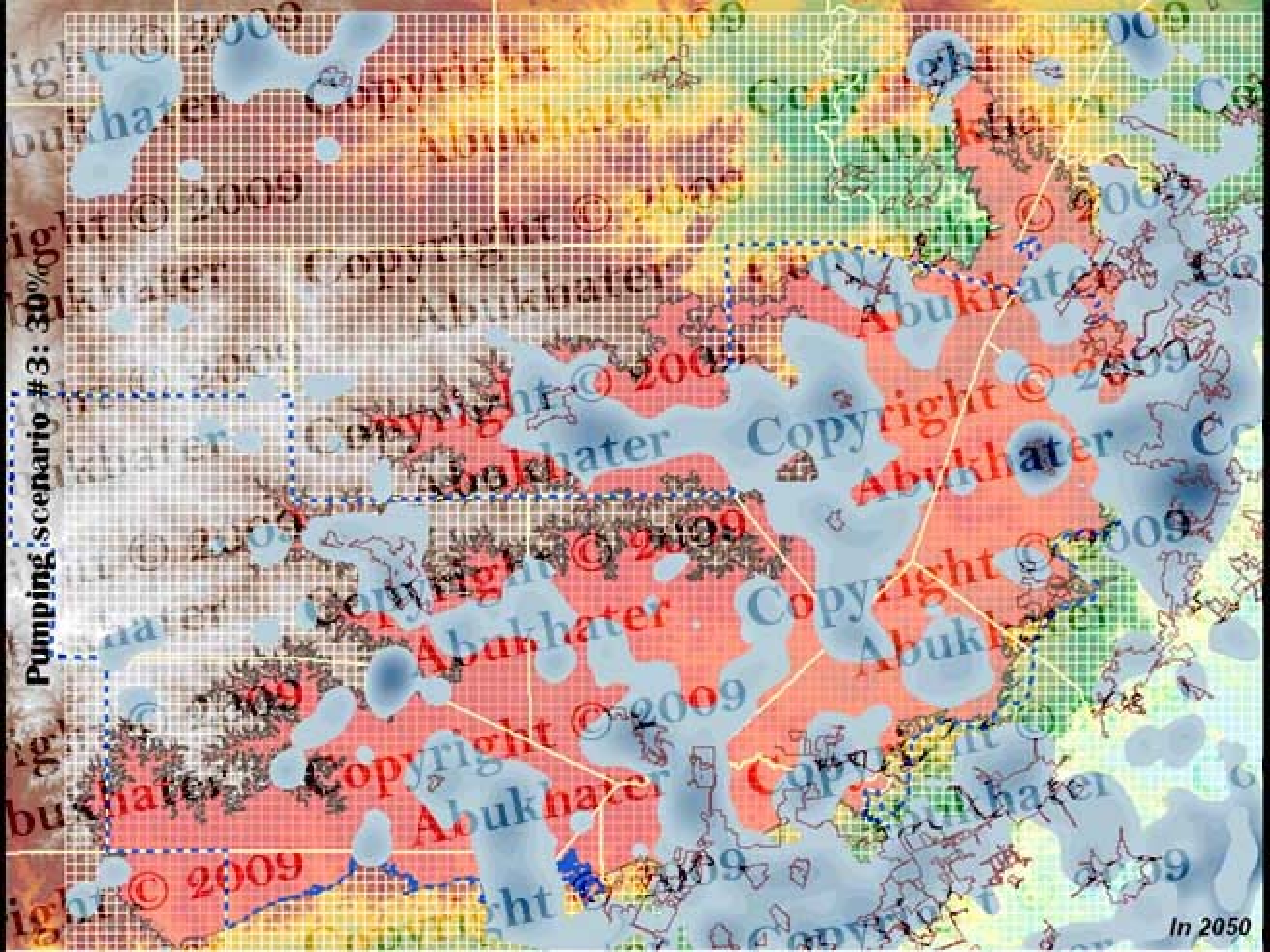
Pumping scenario #3: 30%
In 2050
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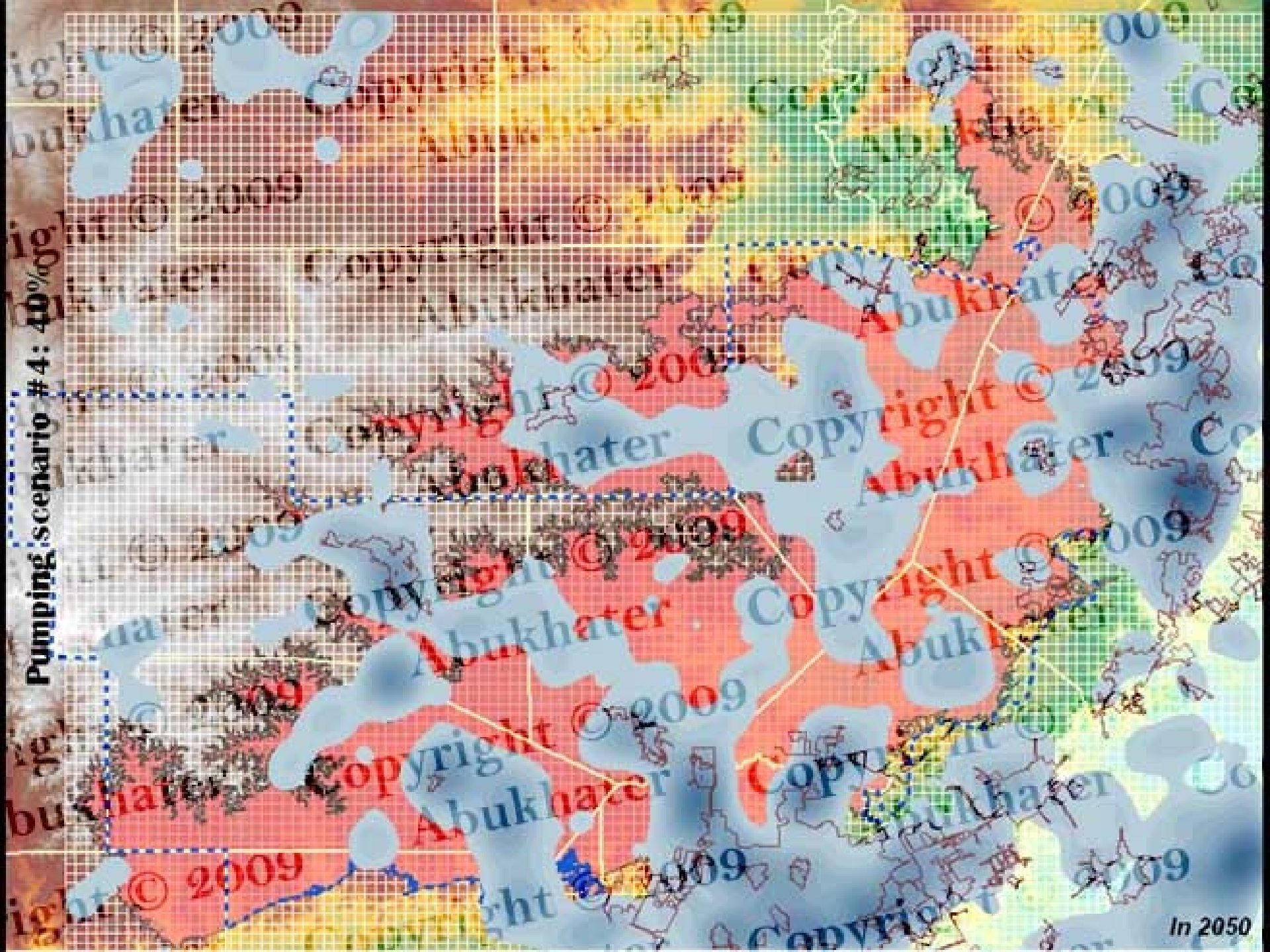
Pumping scenario # 4: 40%
In 2050
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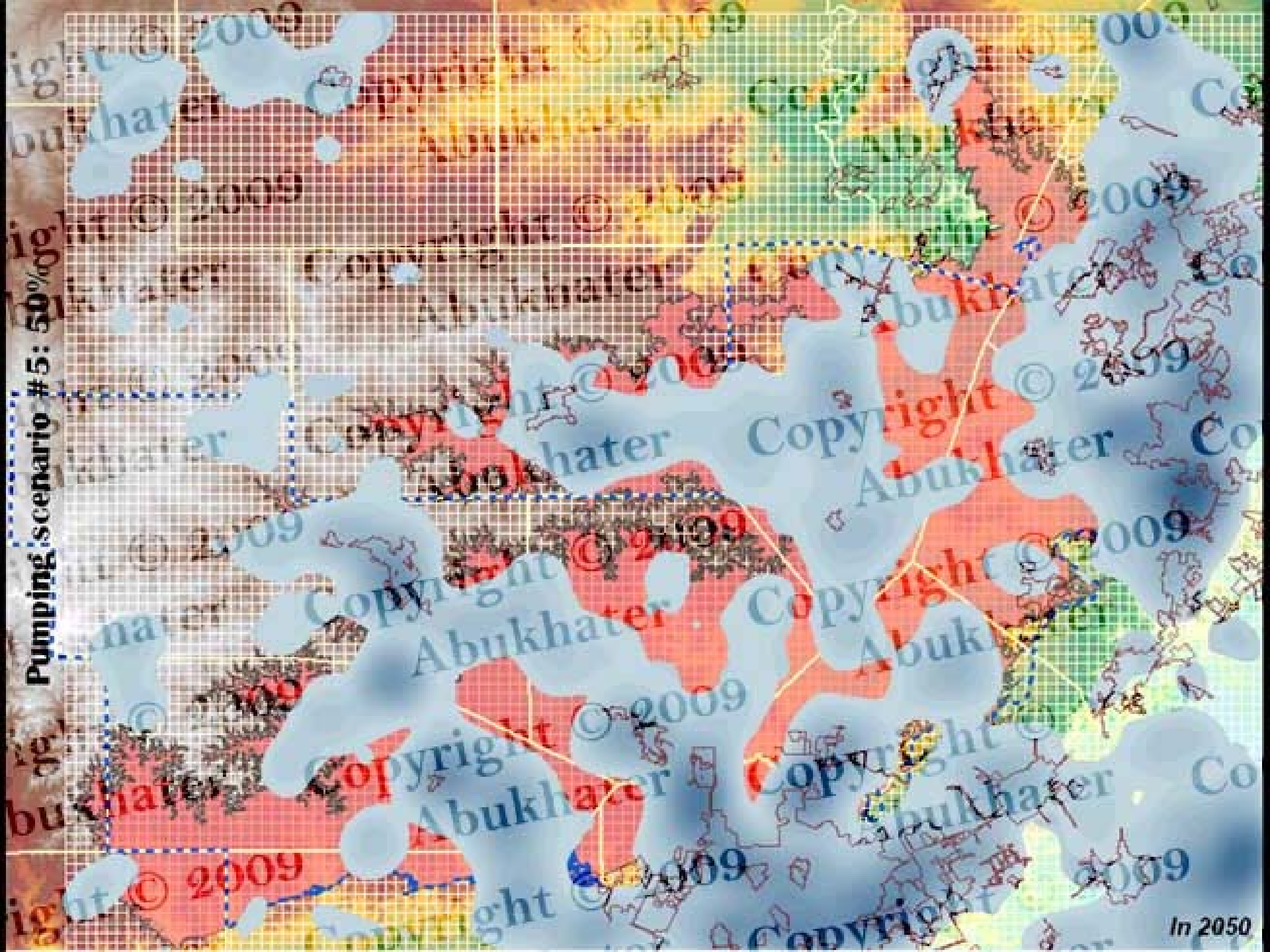
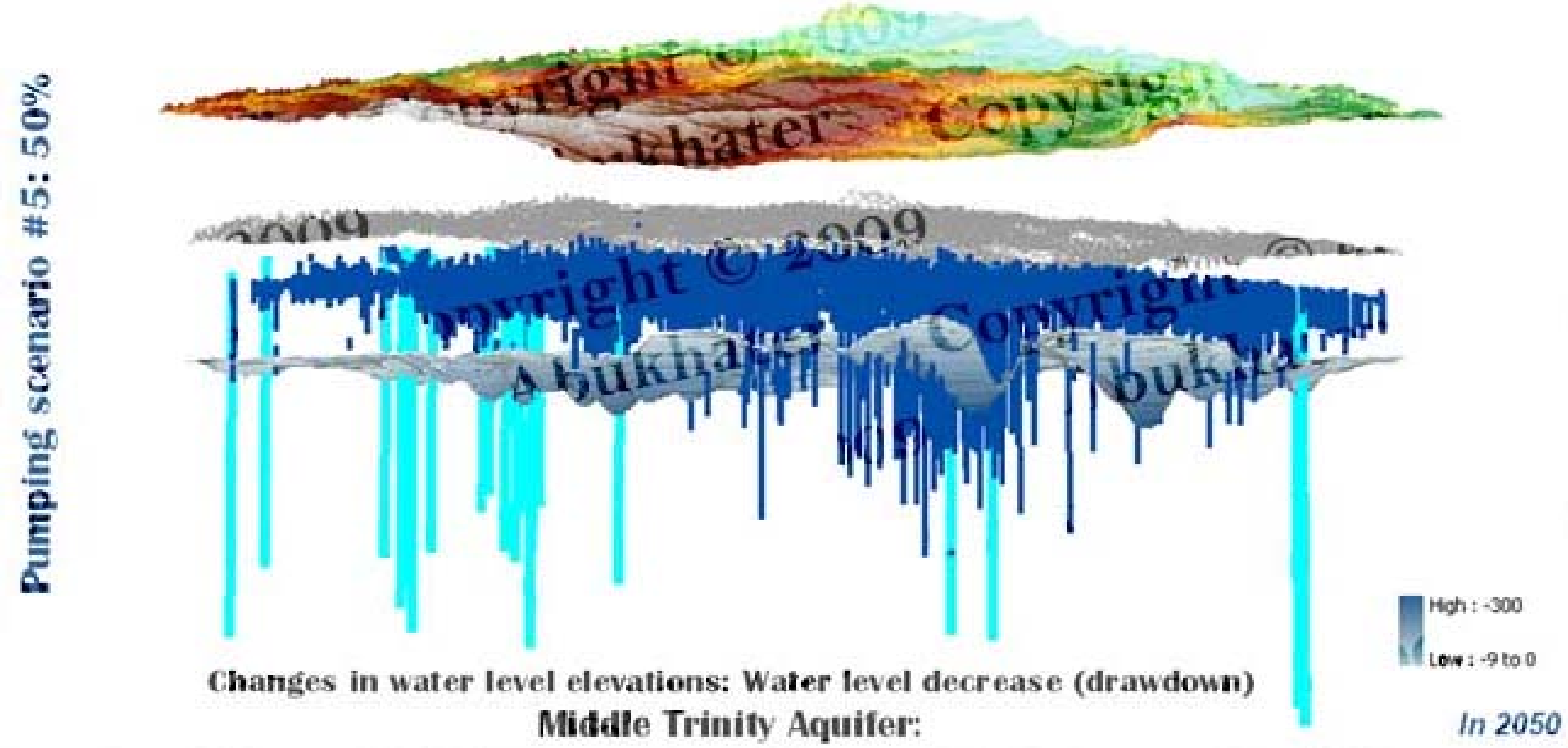

Pumping scenario #5: 50%
In 2050

GIS 3-D Modeling



Changes in water level elevations: Water level decrease (drawdown)
Middle Trinity Aquifer:

Intelligent PSS

Conclusions

Easy manipulation of inputs/outputs

Calculating and representing drawdown

Calibrated to match water level elevations

Integrating surface water and groundwater data

Facilitating groundwater simulation models with GIS

Providing estimates of regional trends and water availability

Studying the impact of increased pumping within each zone (cities & growth corridors)

Evaluation of Desired Future Conditions

Data acquisition, manipulation, organization, & integration

Efficient & Effective PSS

Questions?

Thank you…

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