Groundwater Modeling Analyses to Inform Aquifer Management Decisions in the Nebraska Panhandle

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Adaptive Resources, Inc.

Scottsbluff, NE

Special Thanks to:

South Platte Natural Resources District

North Platte Natural Resources District

Upper Niobrara White Natural Resources District

Natural Resources Districts in Nebraska

- Local multi-purpose unit of government established to conserve, protect, develop, and manage natural resources in Nebraska
  - Includes Ground Water Quantity Management
    - Examples: Allocations, transfers of acres, retirement of consumptive use, etc.

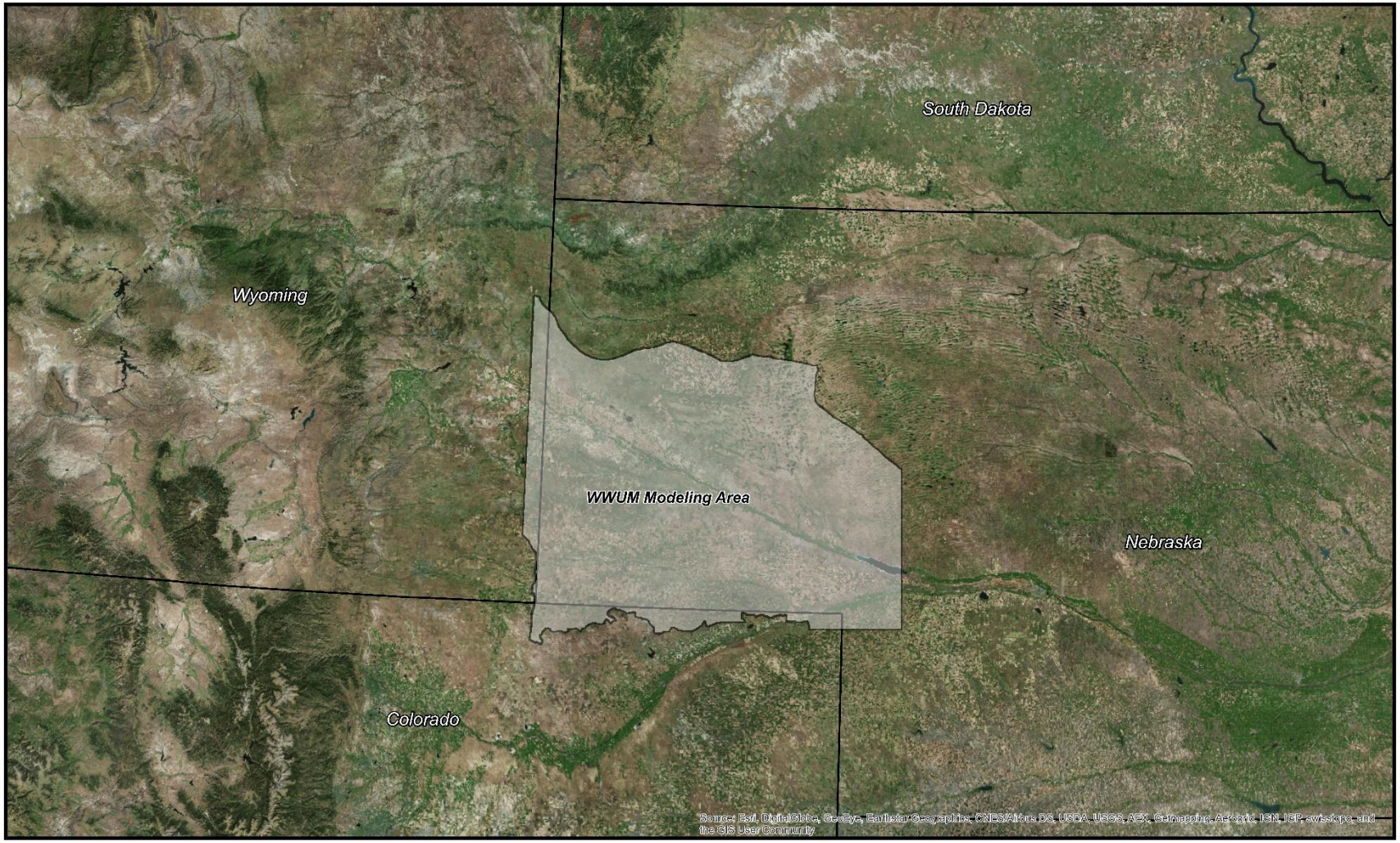
- Governed by locally-elected Board of Directors
  - In rural areas it is usually farmers and ranchers of the community

- Each NRD area is typically made up of multiple counties and based on watersheds

What type of modeling is completed in the Nebraska Panhandle?

- Three models are used to simulate the water system:
  - Surface Water Operations Model
    - Simulates the surface water system and diversions that occur under a prior appropriations surface water administration system (first in time and first in right)
  - Regionalized Soil Water Balance Model
    - Simulates the soil water balance of crops and pastures to determine pumping and recharge estimates
  - Ground Water Model (MODFLOW)
    - Provides timing and movement of water through the aquifer and discharge to surface water systems
- **Purpose:** Models are utilized as decision support to aid local Natural Resources Districts with ground water quantity management decisions.

WWUM Modeling Area



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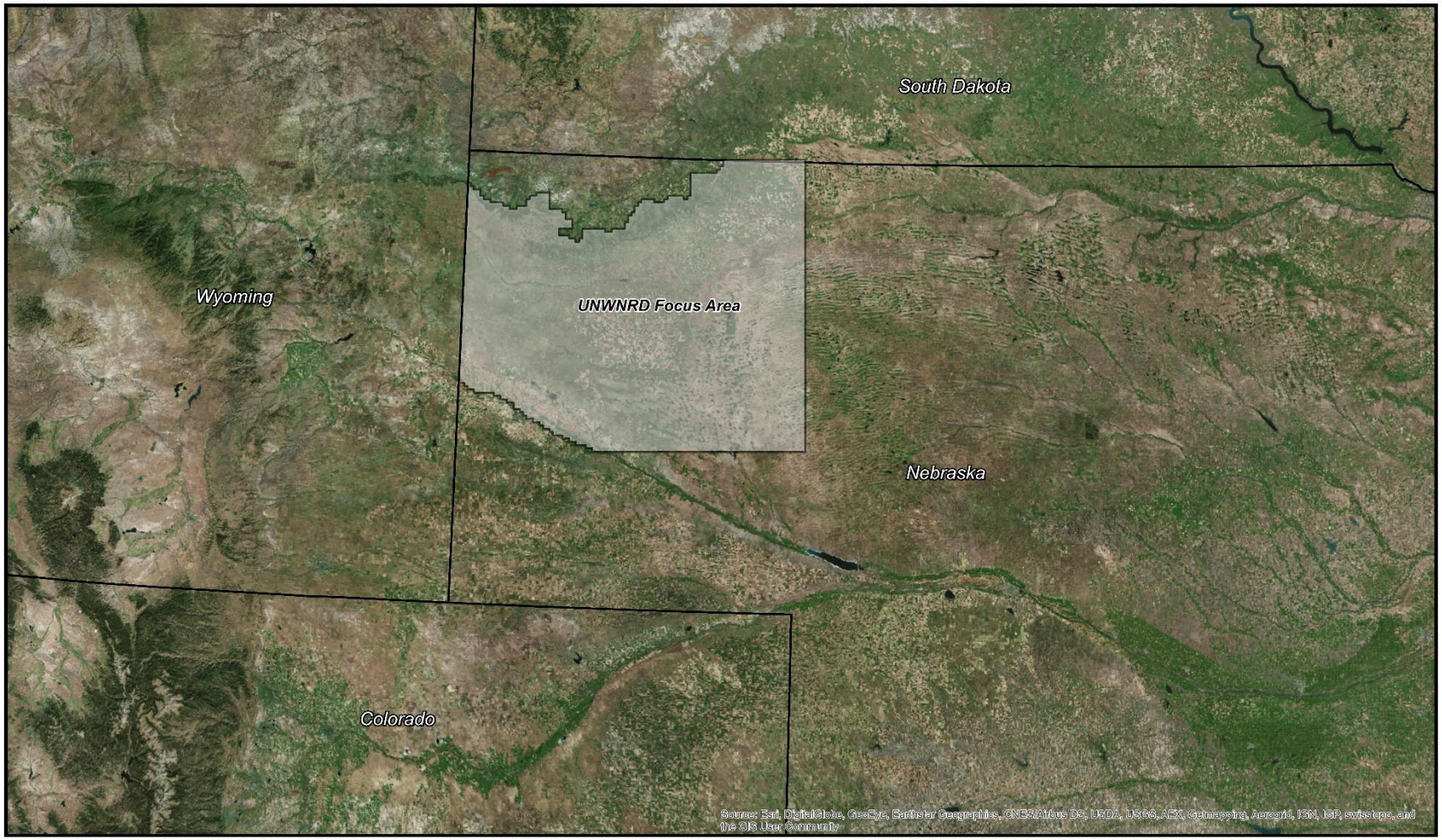
NORTH PLATTE
Natural Resources District

SOUTH PLATTE
NATURAL RESOURCES DISTRICT

0 30 60 90 Miles

N

UNWNRD Modeling Area - Aquifer Life Analysis Study Area



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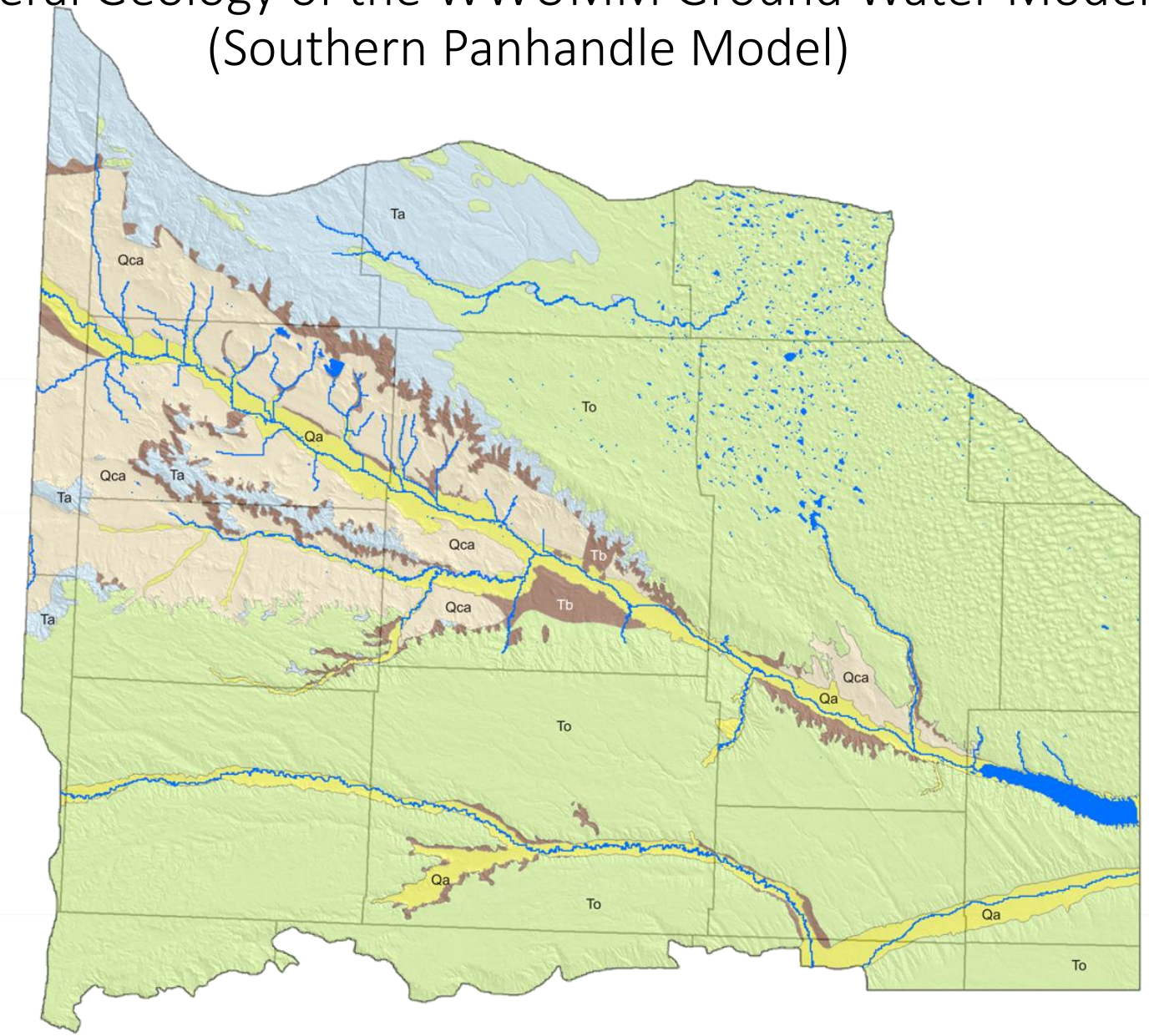
Review of Modeling

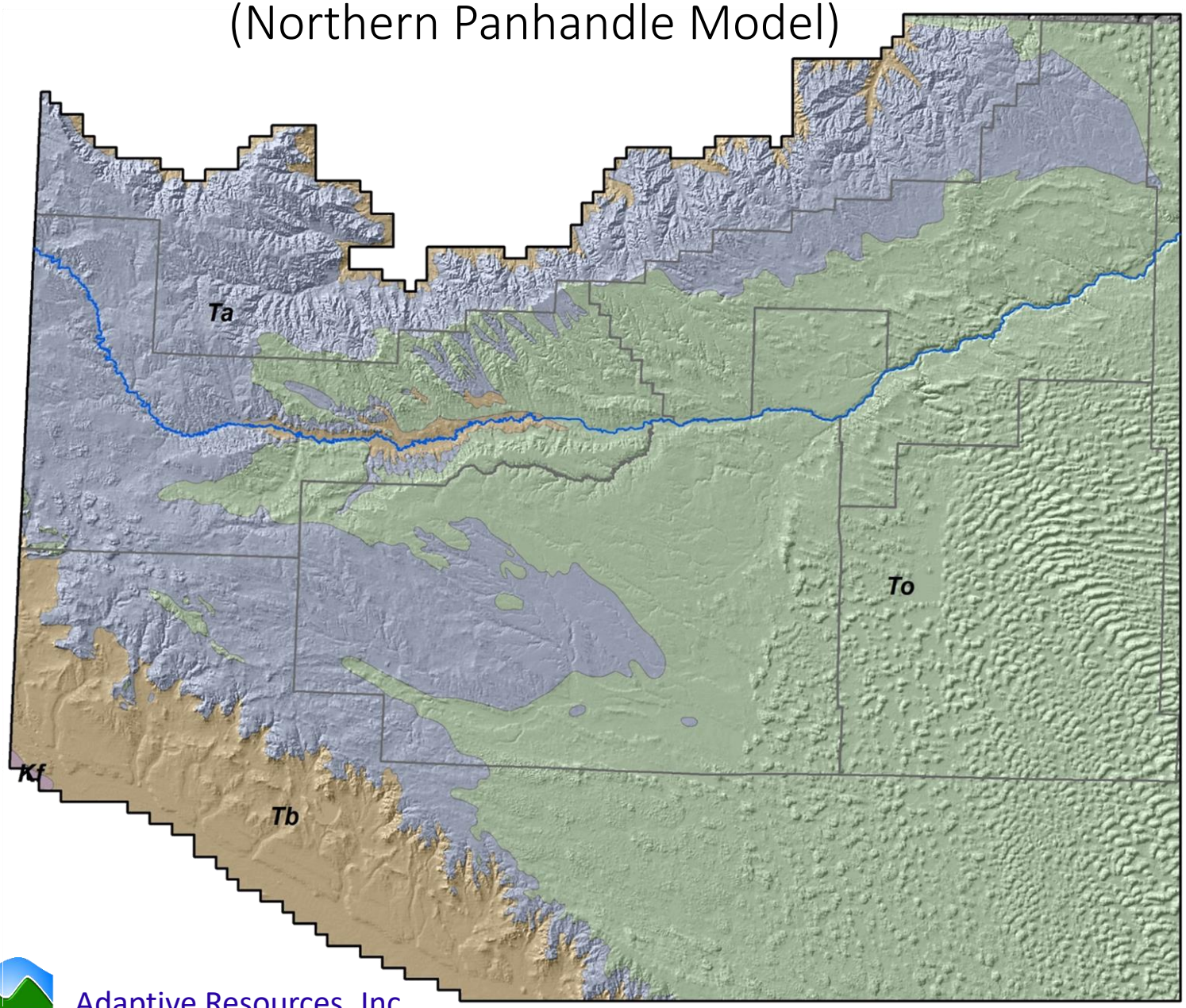
- Model Time Period: WWUMM - May 1953 through April 2014, UNW Model – January 1950 through December 2015
- Monthly Time Steps
- Extensive Datasets Include:
  - Land Use
  - Geology
  - Hydrology
  - Diversions
  - Ground Water Levels
  - Among Many Others!
- Partially Integrated Modeling (Shared Datasets)

General Geology of the Model Areas

General Geology of the WWUMM Ground Water Model (Southern Panhandle Model)



General Geology of the UNW Ground Water Model (Northern Panhandle Model)



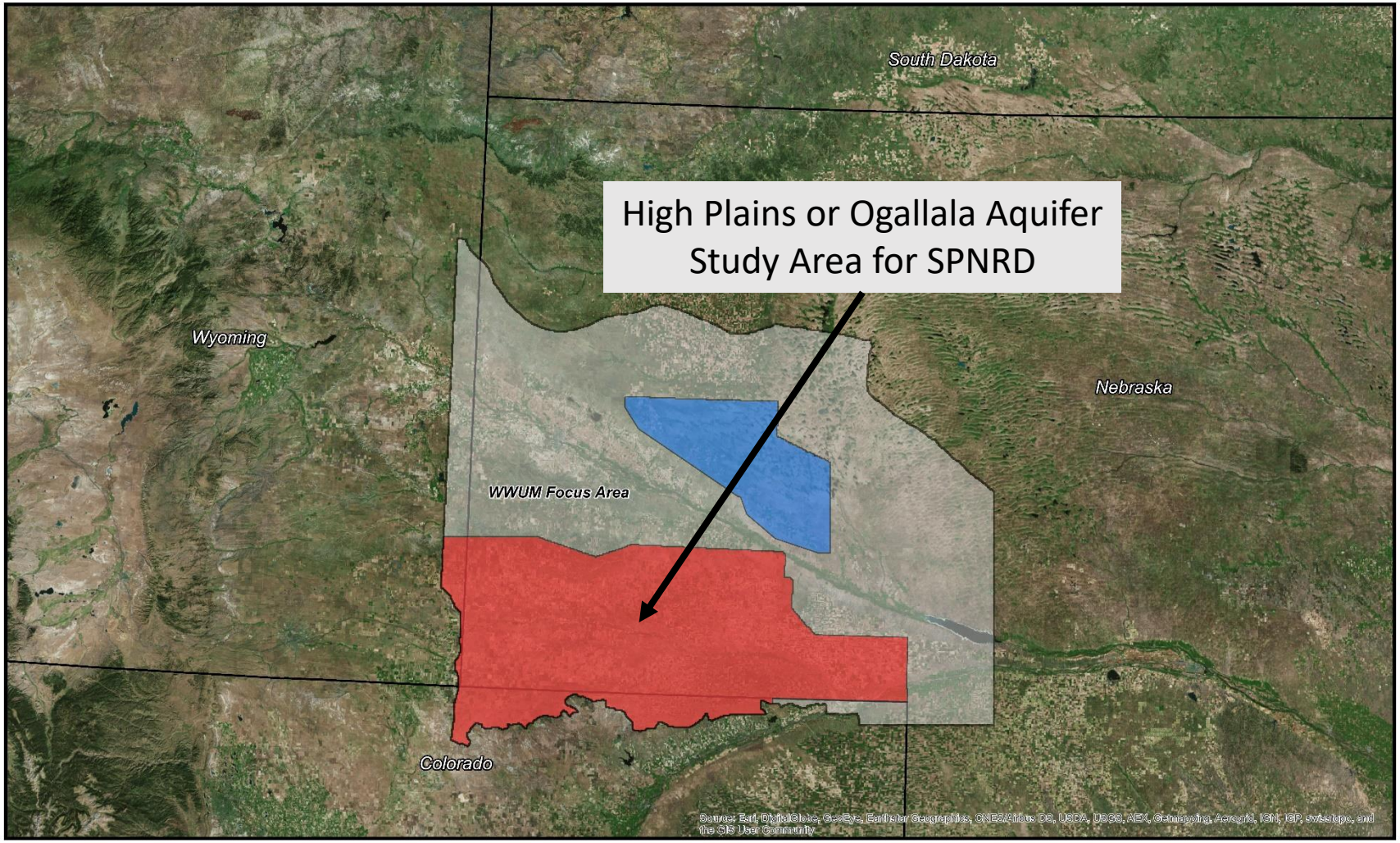
Aquifer Life Analysis

Aquifer Life Analysis

- Primary Objective: **Provide the NRDs with information on possible future drawdown and saturated thickness of deep aquifers.**

- Secondary Objective: **Facilitate Discussion about Aquifer Management among the Boards and Public**

WWUM Modeling Area - Aquifer Life Analysis Study Areas



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Explanation

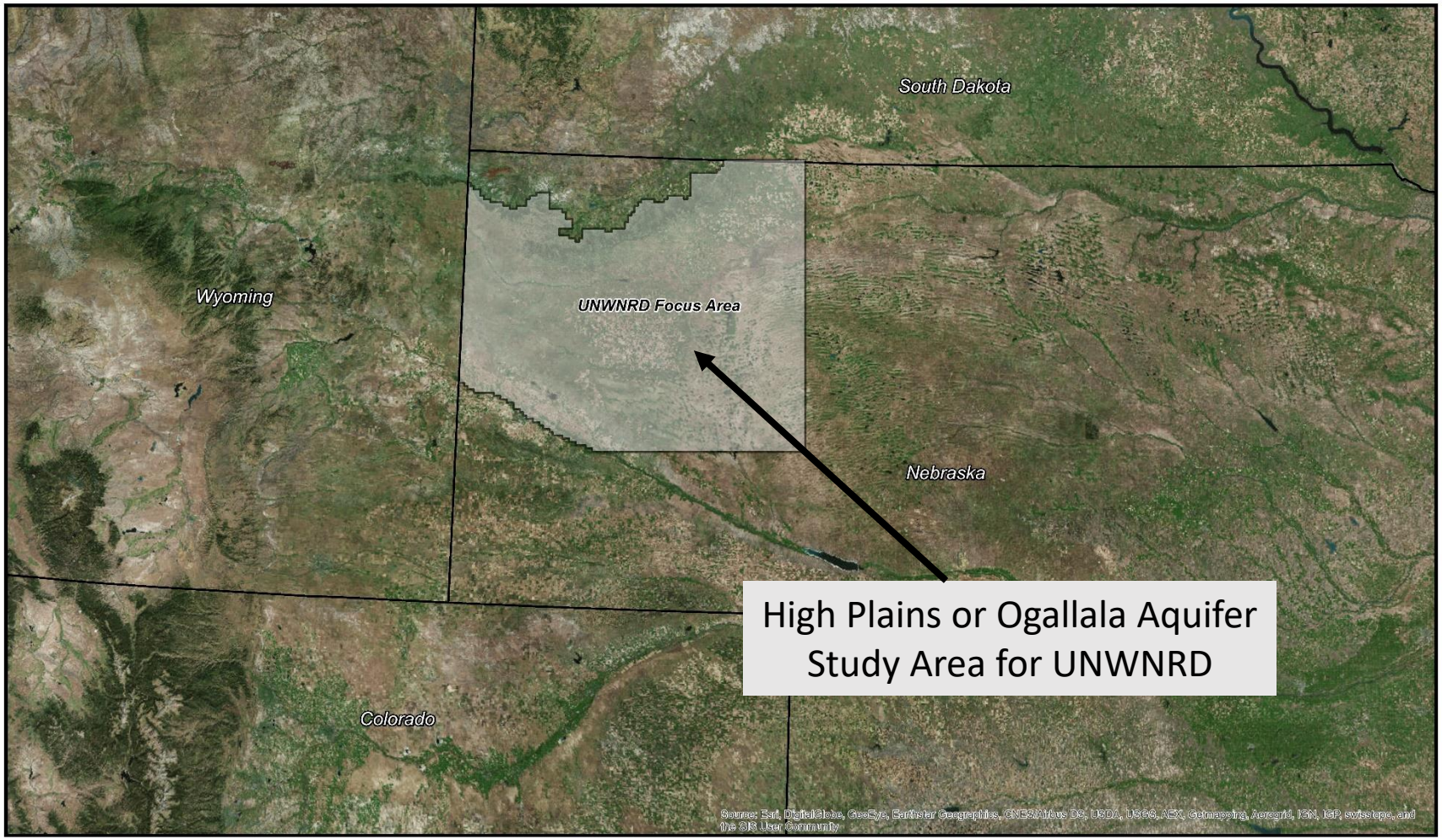
North Platte Focus Area

South Platte Focus Area

0 20 40 60 Miles

N

UNWNRD Modeling Area - Aquifer Life Analysis Study Area



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0 25 50 75 100 Miles

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Aquifer Life Analysis

- Thoughts I conveyed to the boards and the public:
  - Recharge from precipitation in these areas are minimal
    - (~0.25 inch/year)
  - Pumping from these aquifers is best described as a mining situation
  - There is no such thing as sustainable pumping without ground water declines
  - In the future, portions of these aquifers may not be able to sustain high capacity (irrigation) and possibly low capacity (domestic or range livestock) pumping

Aquifer Life Analysis

- Thoughts I conveyed to the boards and the public:
  - Rule of thumb: Once 2/3^{rds} of the saturated thickness is depleted, deeper wells will need to be drilled or new pump equipment will need to be installed to maintain some level of pumping
  - The deepest wells will be able to produce the longest
  - Best to frame management decisions toward sustainable ground water level declines under a pumping structure

Aquifer Life Analysis

- Used ground water model's initial heads from last stress period of historical simulation
- 500+ Year Model
- Annual Stress Periods
- Repeated the last 5 years of pumping and recharge from the historical model through the entire simulation
  - Timeframe had metered data and was a good mix of wet, dry, and average precipitation

- Results:
  - Drawdown
  - Saturated Thickness
  - **% Saturated Thickness Used**

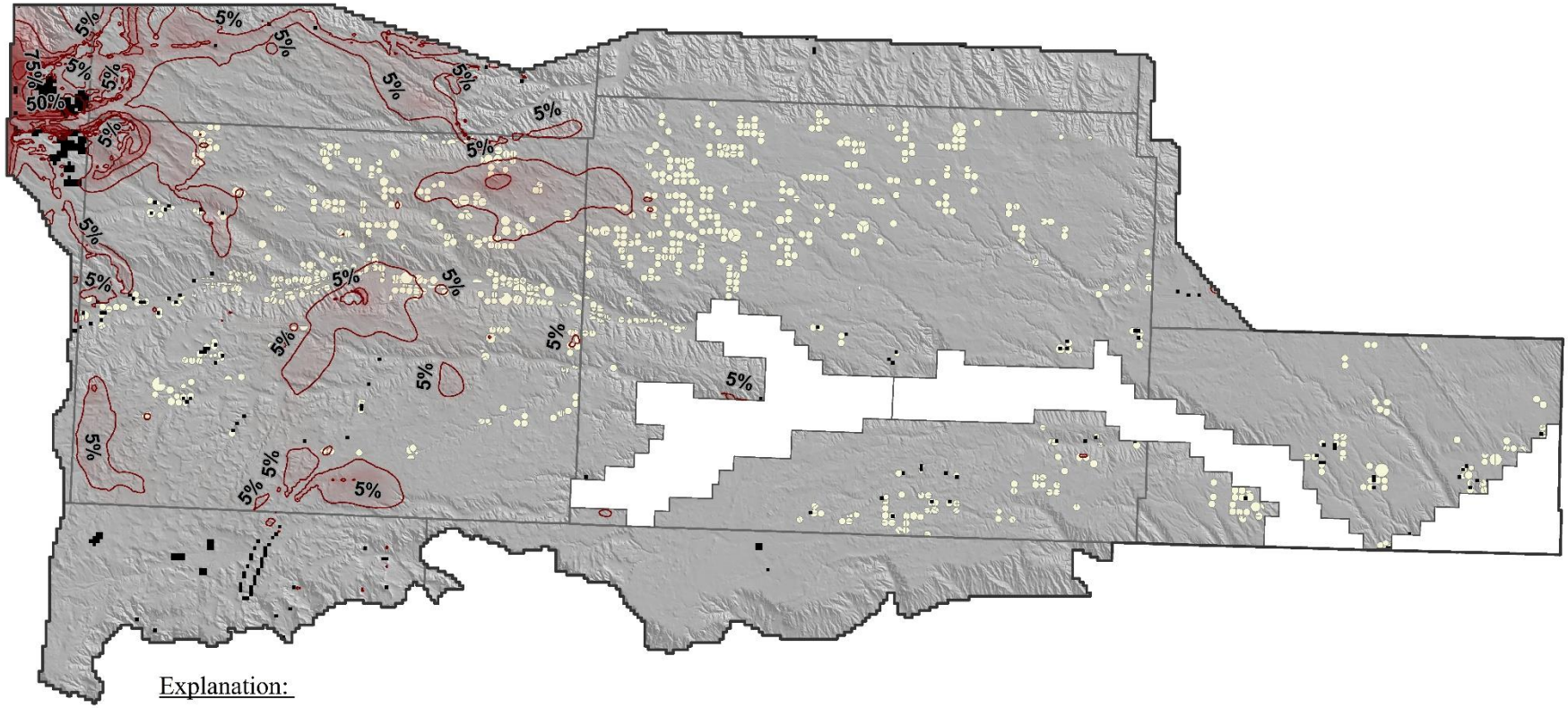
Why % Saturated Thickness Used?

- Describes in one map the relationship between:
  - Drawdown
  - Saturated Thickness
- One dataset is easier for the boards and public to absorb and understand
- Easily identifies the locations of problem areas

SPNRD Aquifer Life Analysis Results

% Saturated Thickness Used

Preliminary Aquifer Life Analysis:
Percent Saturated Thickness Used at 10 Years



Explanation:

Repeated Historic Pumping and Recharge 2009-2013
Red contours and shaded areas represent percent of initial saturated thickness used
Yellow areas represent certified irrigated acreage
Black areas represent dry cells

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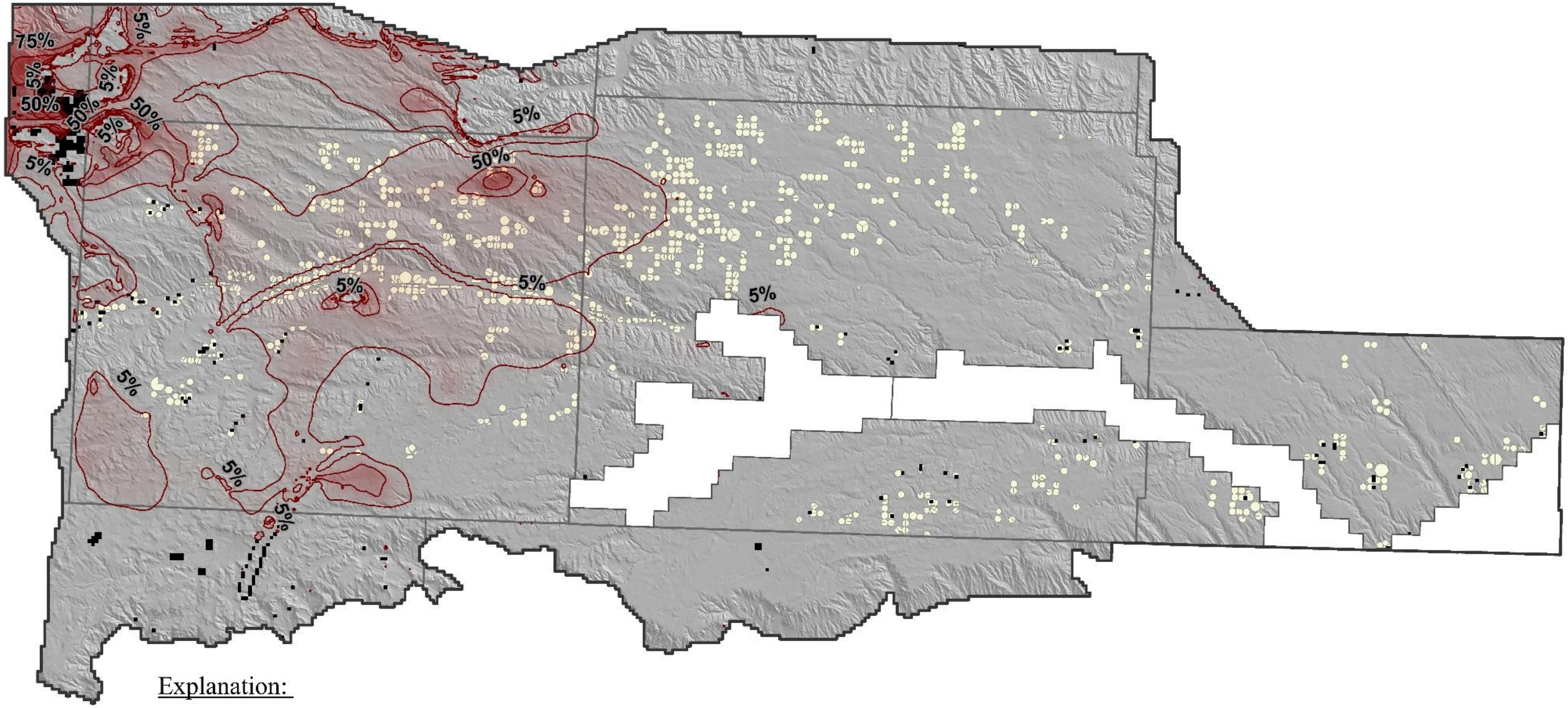
0 7.5 15 22.5 30 Miles

N

Preliminary Aquifer Life Analysis: Percent Saturated Thickness Used at 25 Years



Explanation:

Repeated Historic Pumping and Recharge 2009-2013
Red contours and shaded areas represent percent of initial saturated thickness used
Yellow areas represent certified irrigated acreage
Black areas represent dry cells

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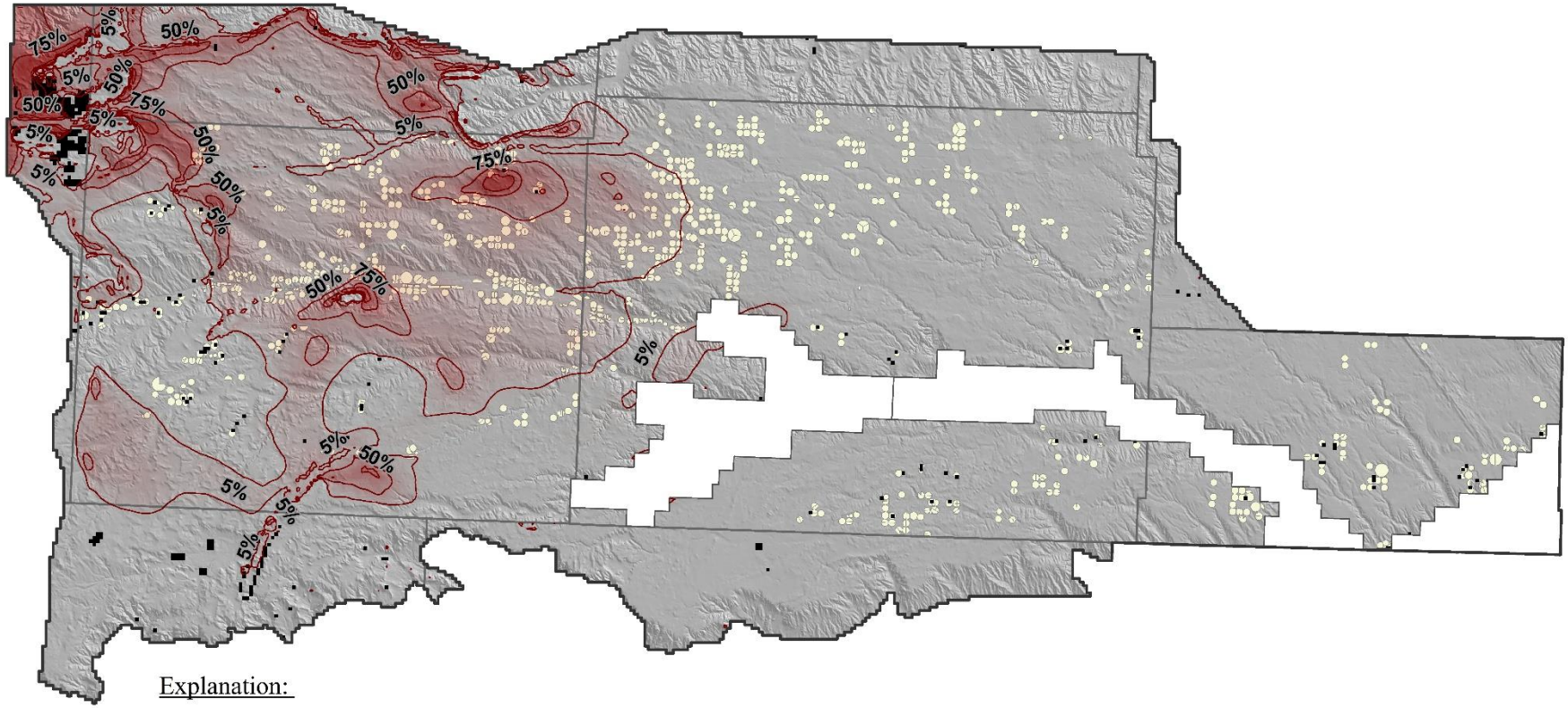
Preliminary Aquifer Life Analysis:
Percent Saturated Thickness Used at 50 Years



Explanation:

Repeated Historic Pumping and Recharge 2009-2013
Red contours and shaded areas represent percent of initial saturated thickness used
Yellow areas represent certified irrigated acreage
Black areas represent dry cells

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0 7.5 15 22.5 30 Miles

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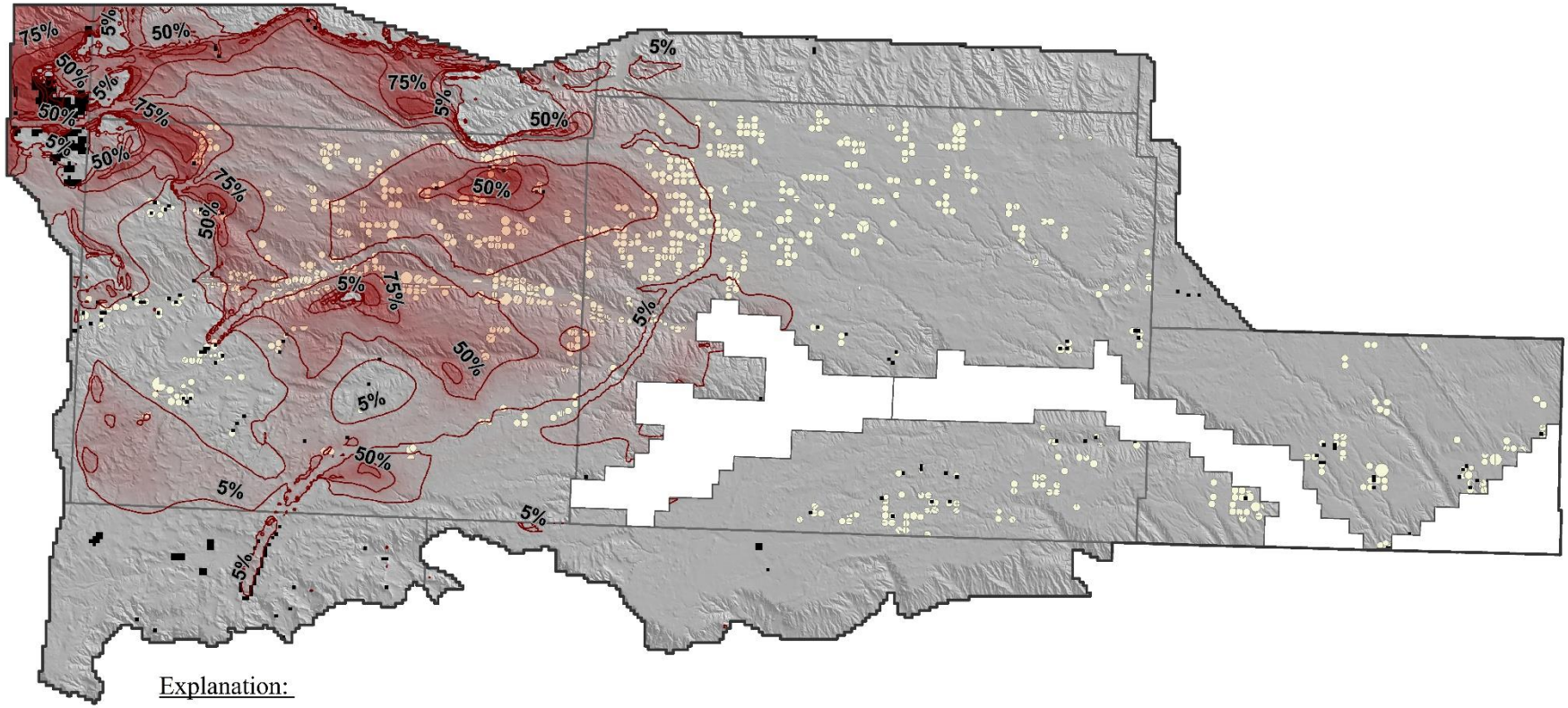
Preliminary Aquifer Life Analysis:
Percent Saturated Thickness Used at 100 Years



Explanation:

Repeated Historic Pumping and Recharge 2009-2013
Red contours and shaded areas represent percent of initial saturated thickness used
Yellow areas represent certified irrigated acreage
Black areas represent dry cells

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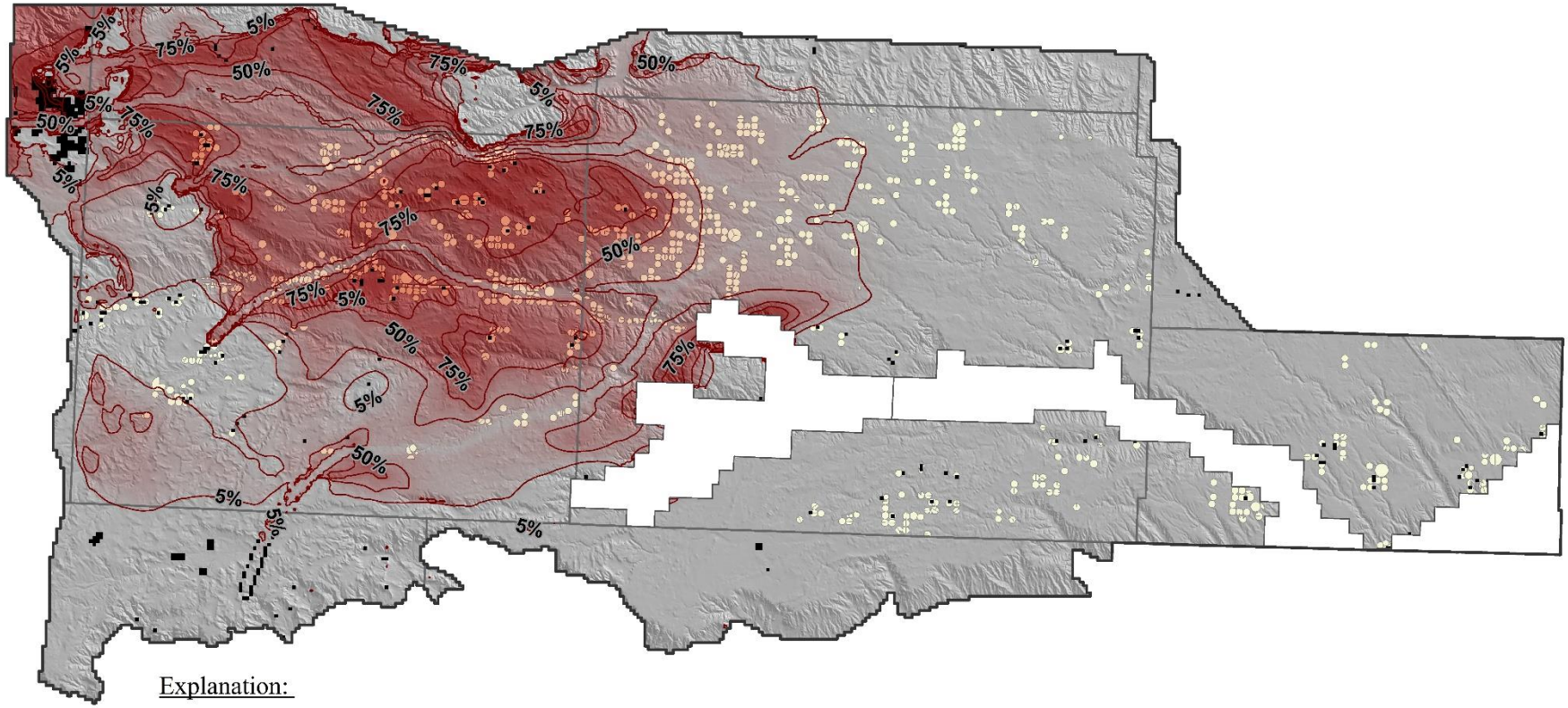
0 7.5 15 22.5 30 Miles

N

Preliminary Aquifer Life Analysis:
Percent Saturated Thickness Used at 500 Years



Explanation:

Repeated Historic Pumping and Recharge 2009-2013
Red contours and shaded areas represent percent of initial saturated thickness used
Yellow areas represent certified irrigated acreage
Black areas represent dry cells

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0 7.5 15 22.5 30 Miles

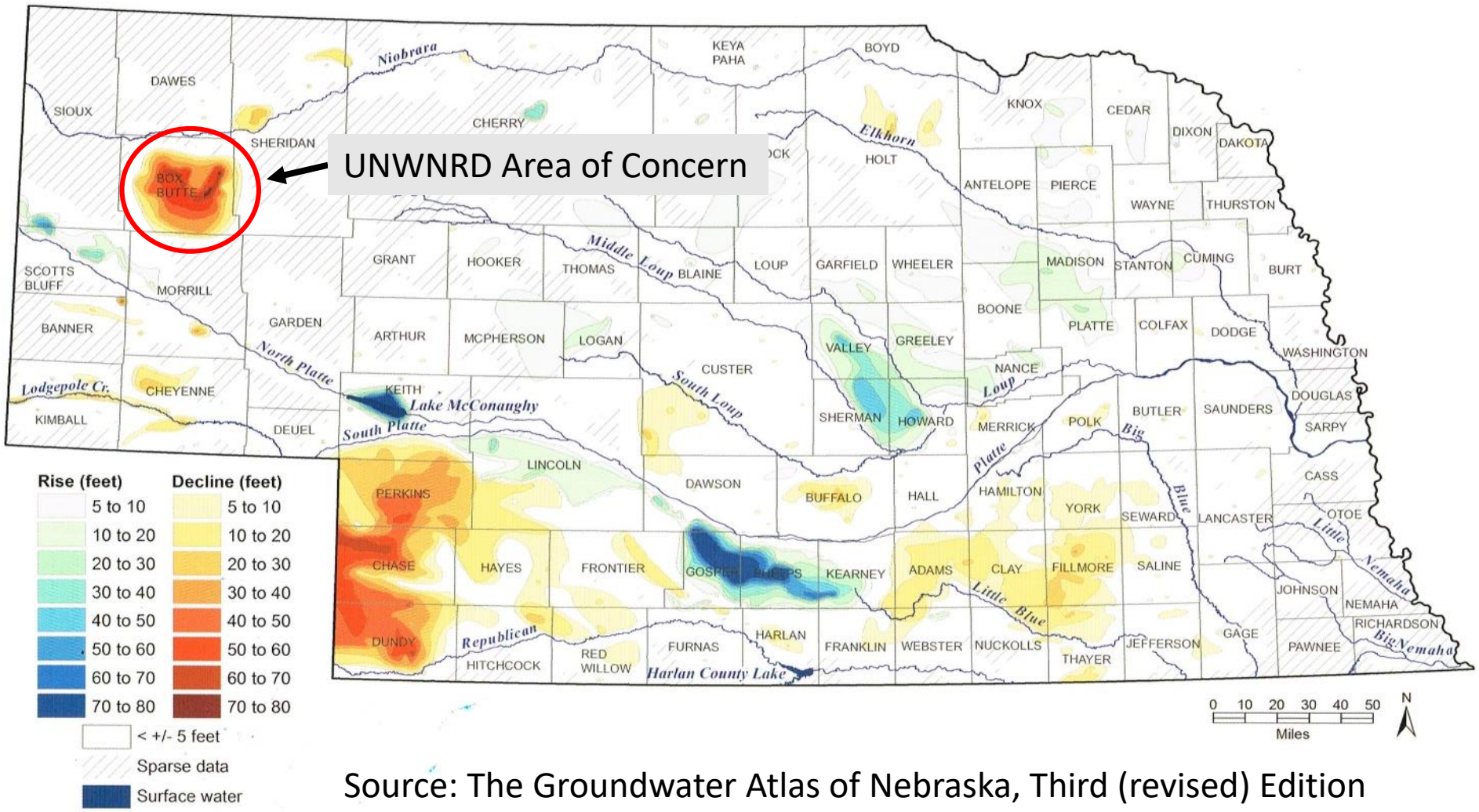
N

SPNRD Aquifer Life Analysis

- Additional Analyses Completed:
  - Climate Scenarios
    - Average, Above Average, and Below Average Precipitation
  - In Combination with:
  - Pumping Allocation Scenarios (acre-inches/acre)
    - 10, 12, 14, and no allocation

UNWNRD Analysis Catalyst

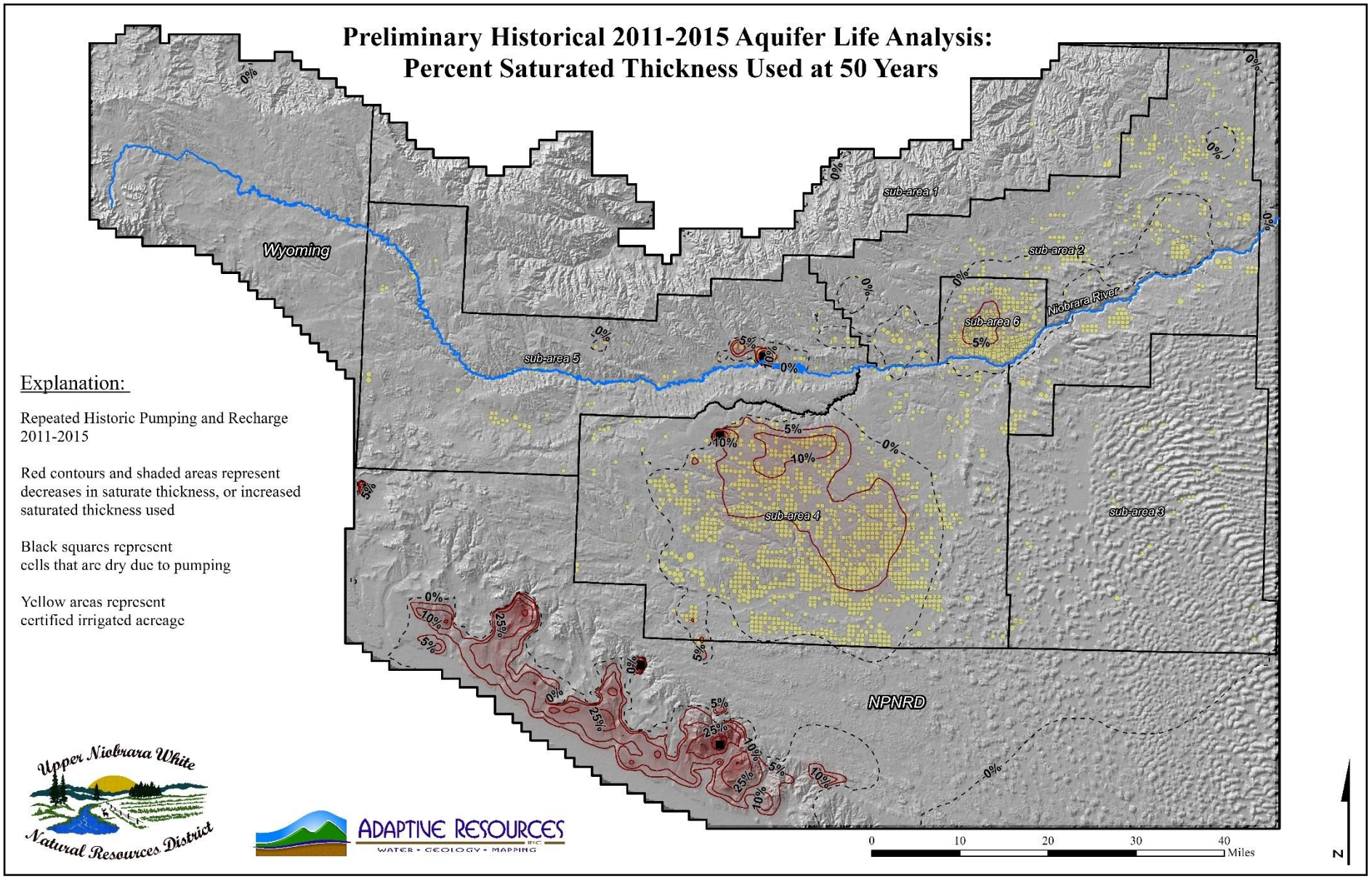
Drawdown from Predevelopment to 2012



Source: The Groundwater Atlas of Nebraska, Third (revised) Edition
By Conservation Survey Division, University of Lincoln-Nebraska

UNWNRD Aquifer Life Analysis Results

% Saturated Thickness Used


Preliminary Historical 2011-2015 Aquifer Life Analysis:
Percent Saturated Thickness Used at 50 Years
Explanation:
Repeated Historic Pumping and Recharge 2011-2015
Red contours and shaded areas represent decreases in saturate thickness, or increased saturated thickness used
Black squares represent cells that are dry due to pumping
Yellow areas represent certified irrigated acreage
Wyoming
sub-area 1
sub-area 2
sub-area 3
sub-area 4
sub-area 5
sub-area 6
Niobrara River
NPNRD
Upper Niobrara White Natural Resources District
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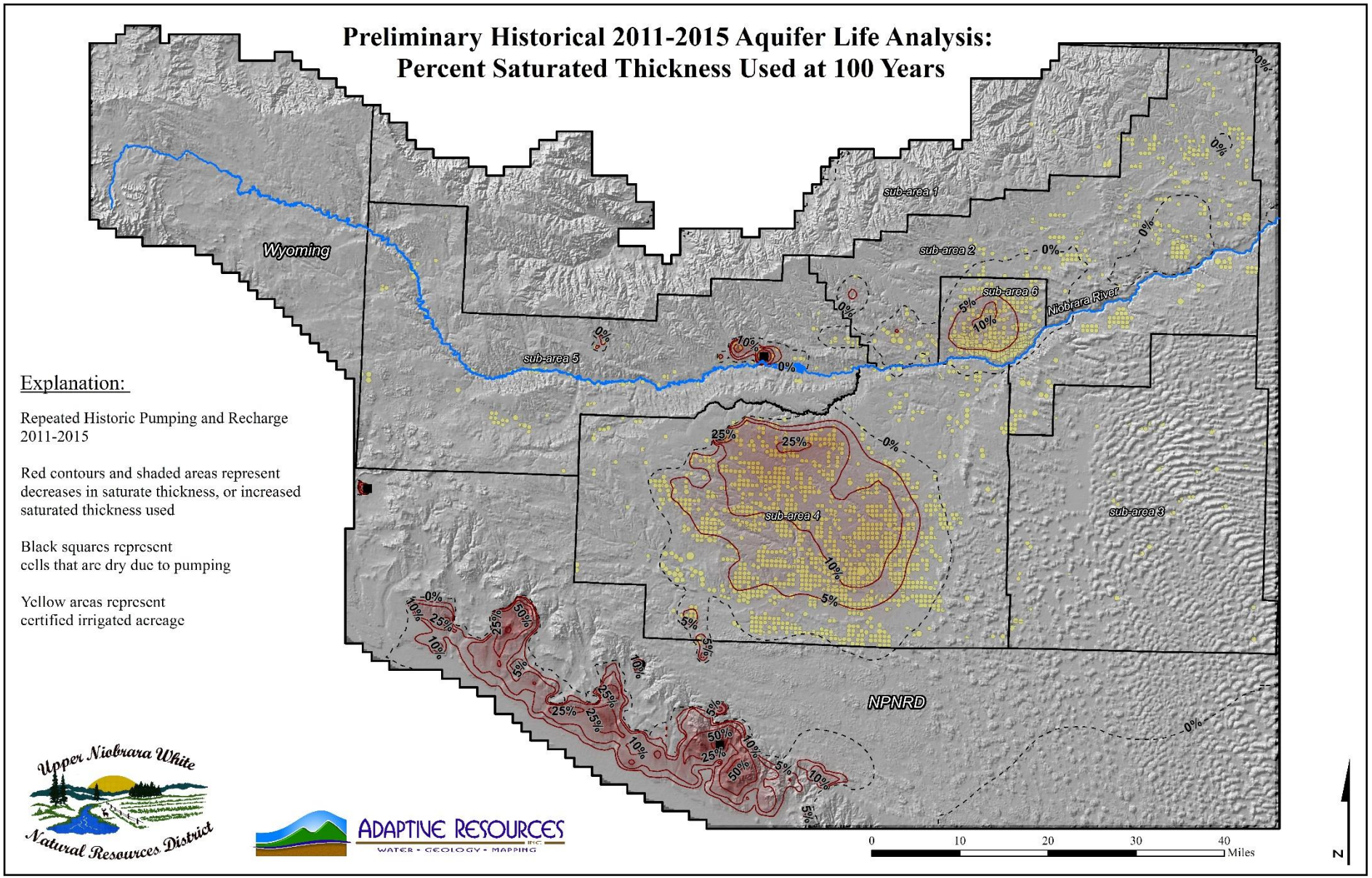
0
10
20
30
40
Miles
N


Preliminary Historical 2011-2015 Aquifer Life Analysis:
Percent Saturated Thickness Used at 100 Years
Explanation:
Repeated Historic Pumping and Recharge 2011-2015
Red contours and shaded areas represent decreases in saturate thickness, or increased saturated thickness used
Black squares represent cells that are dry due to pumping
Yellow areas represent certified irrigated acreage
Wyoming
sub-area 1
sub-area 2
sub-area 3
sub-area 4
sub-area 5
sub-area 6
Niobrara River
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0
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40
Miles
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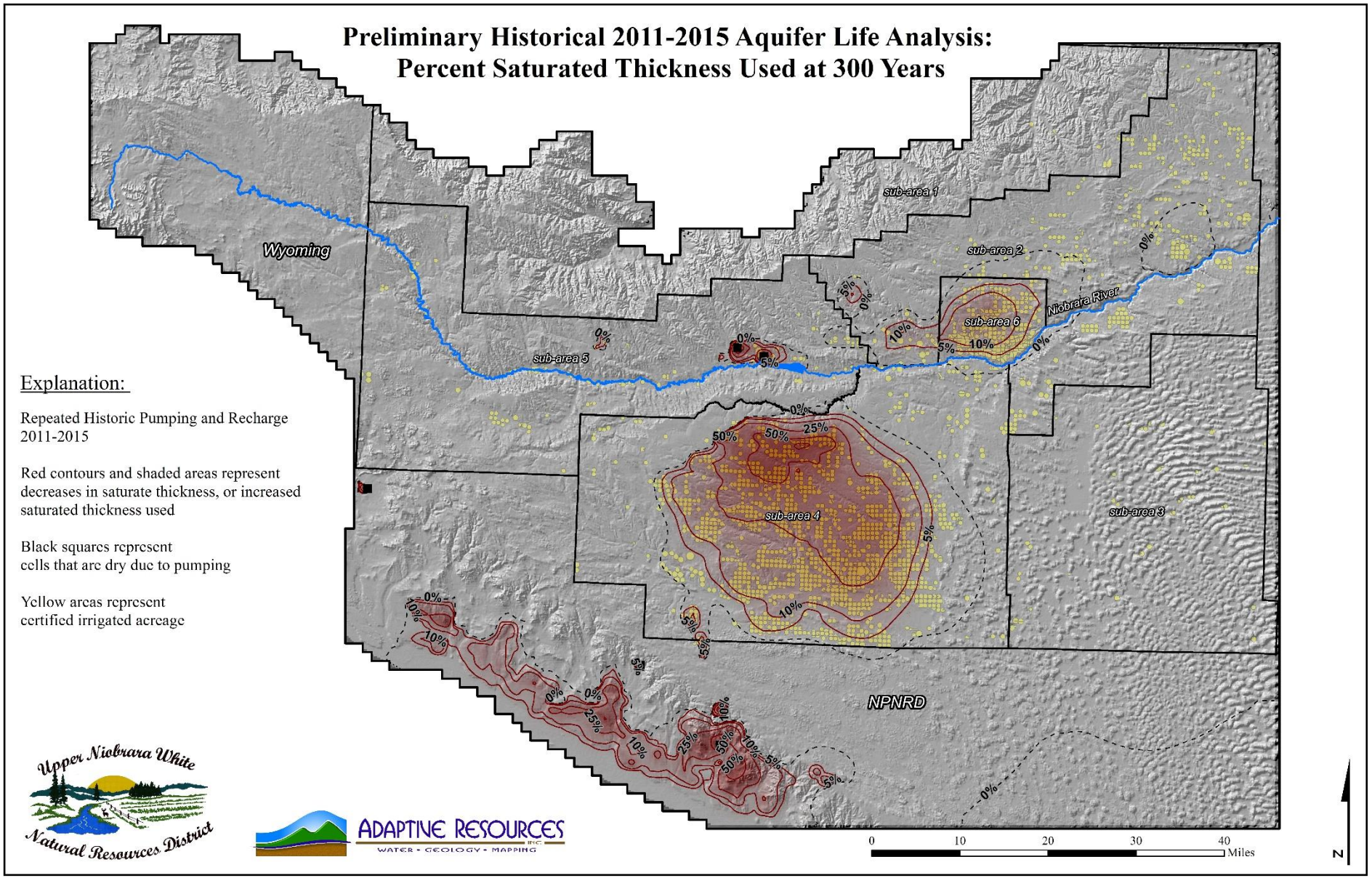
Preliminary Historical 2011-2015 Aquifer Life Analysis:
Percent Saturated Thickness Used at 300 Years
Explanation:
Repeated Historic Pumping and Recharge 2011-2015
Red contours and shaded areas represent decreases in saturate thickness, or increased saturated thickness used
Black squares represent cells that are dry due to pumping
Yellow areas represent certified irrigated acreage
Wyoming
sub-area 1
sub-area 2
sub-area 3
sub-area 4
sub-area 5
sub-area 6
Niobrara River
NPNRD
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WATER • GEOLOGY • MAPPING
0
10
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Miles
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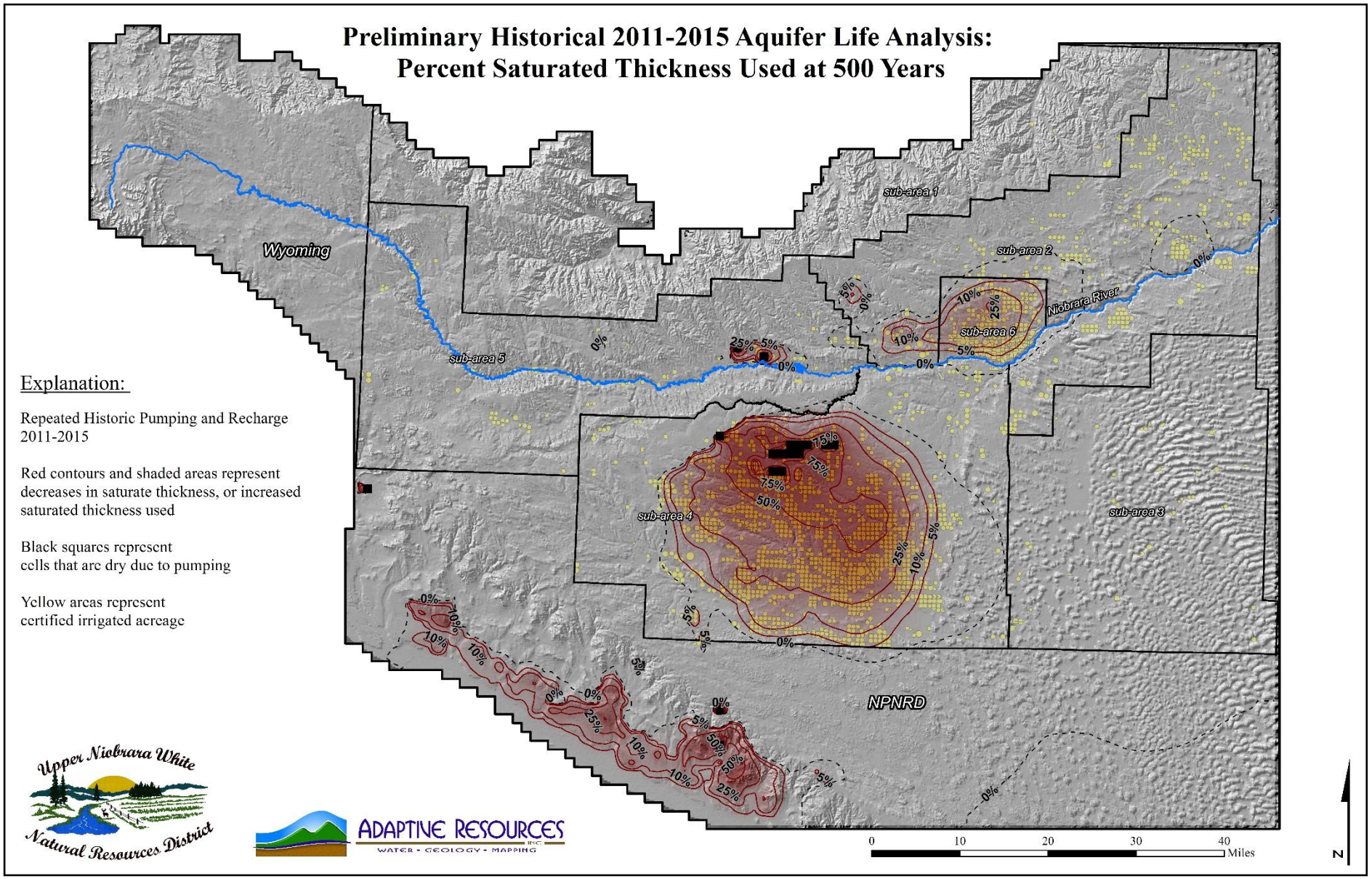
Preliminary Historical 2011-2015 Aquifer Life Analysis:
Percent Saturated Thickness Used at 500 Years
Explanation:
Repeated Historic Pumping and Recharge 2011-2015
Red contours and shaded areas represent decreases in saturate thickness, or increased saturated thickness used
Black squares represent cells that are dry due to pumping
Yellow areas represent certified irrigated acreage
Wyoming
sub-area 1
sub-area 2
sub-area 3
sub-area 4
sub-area 5
sub-area 6
Niobrara River
NPNRD
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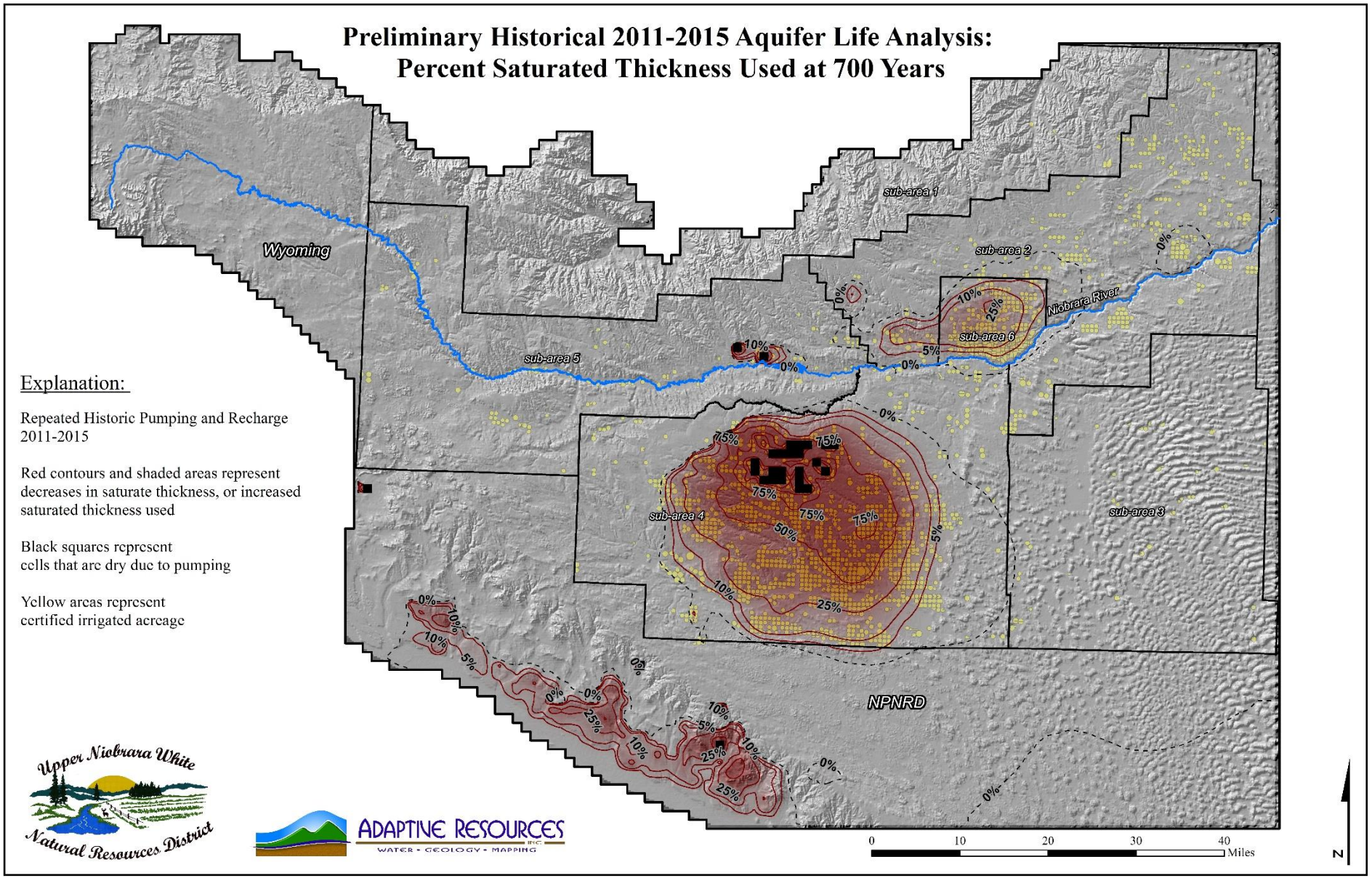
0 10 20 30 40 Miles
N


Preliminary Historical 2011-2015 Aquifer Life Analysis:
Percent Saturated Thickness Used at 700 Years
Explanation:
Repeated Historic Pumping and Recharge 2011-2015
Red contours and shaded areas represent decreases in saturate thickness, or increased saturated thickness used
Black squares represent cells that are dry due to pumping
Yellow areas represent certified irrigated acreage
Wyoming
sub-area 1
sub-area 2
sub-area 3
sub-area 4
sub-area 5
sub-area 6
Niobrara River
NPNRD
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0 10 20 30 40 Miles
N

UNWNRD Aquifer Life Analysis

- Additional Analyses Completed:
  - Full crop consumptive use analysis
    - Showed much greater declines as compared to actual metered pumping

Questions I Posed to the Boards and Public

- In your opinion, how far into the future would you like to plan for ground water level declines?
  - 10 Years?
  - 25 Years?
  - 50 Years?
  - 100 Years?
  - More?

Questions I Posed to the Boards and Public

- In your opinion, what would be a acceptable reduction in saturated thickness in that time period?
  - None?
  - 5%?
  - 10%?
  - 25%?
  - 50%?
  - 75%?
  - 100%?

SPNRD's Management

- In 2015, the SPNRD board was evaluating their pumping allocations for possible changes
  - As a result of this analysis, I recommended that the SPNRD Board:
    - Maintain their current allocation of 14 acre-inches/acre
    - Develop a plan to determine a management timeframe and decline goal
    - Then re-evaluate their allocations for possible changes

- The Board decided that there is too much exposure of the ground water to declines and reduced the allocation to 13 acre-inches/acre
  - This was completed during Board Member negotiations

UNWNRD Reaction

- They were shocked that their aquifer isn't going to go dry in the near future
  - I attribute this to not understanding the relationship between drawdown and saturated thickness of their area

- They are working with local water users to determine a ground water management plan of acceptable timeframe and decline goals
  - Additional aquifer life analyses will be part of this effort

SPNRD's Continued Discussion

- Currently, the SPNRD board is continuing the process of determining their management goals

- I find, when I ask the Board or Public for their ideas of aquifer management timeframe and level of acceptable water level declines, the room goes silent
  - This is not surprising but makes it challenging to help them come up with a management scheme

SPNRD's Continued Discussion

- To get the conversation started I proposed the following:
  - Use a 75 year management timeframe
  - Allow a maximum of 15% of the saturated thickness to be used within that timeframe
    - Knowing that some areas have very limited saturated thickness
    - Allow 3% to 5% of the total land area to completely deplete their available aquifer supplies
      - Allow the users in this area to sell their allocation to other users
  - Evaluate this proposal to determine the appropriate allocation
  - To not lose sight of the long term consequences of this management, I would analyze how this management scheme affects the aquifer in 250 years under various climate scenarios

SPNRD's Continued Discussion

- Another management aspect the Board would like to study:
  - Determine if pumping can be optimized by creating subareas to allow for multiple allocations
  - Examples:
    - Areas with less saturated thickness may get lower allocations
    - Areas with higher saturated thickness can get higher allocations

Thanks!

- Questions?
- Comments?