# A New Tool in the Toolbox for Wellhead Protection

Ryan Chapman, NDEE

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# A NEW TOOL FOR WELLHEAD PROTECTION

Project Vision
Groundwater Evaluation Toolbox
Wellhead Protection Scenario
Dynamic Reports
Use Case


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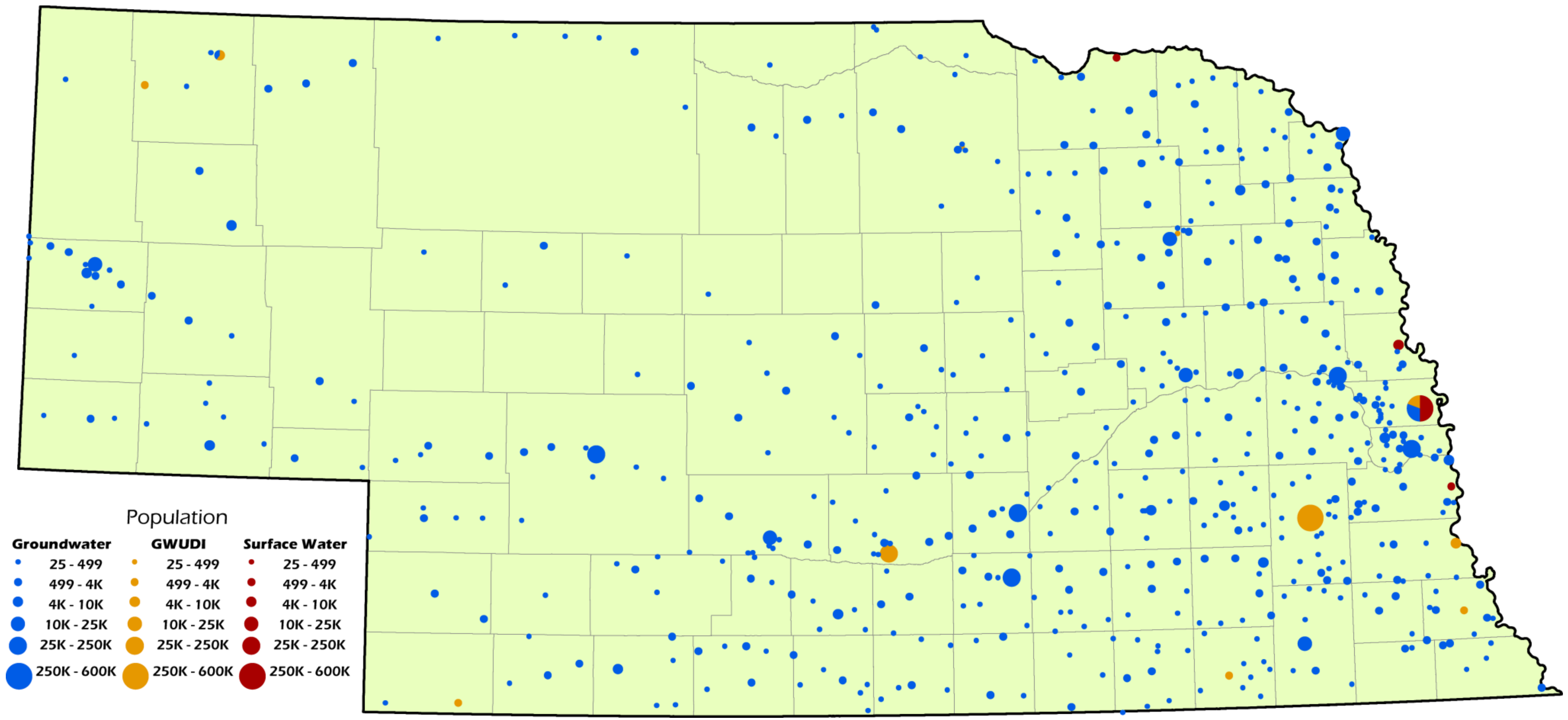
# Project Vision

# Community Public Water Systems

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# Groundwater Evaluation Toolbox

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# The Next Generation of Groundwater Management

Applications of the Groundwater Evaluation Toolbox

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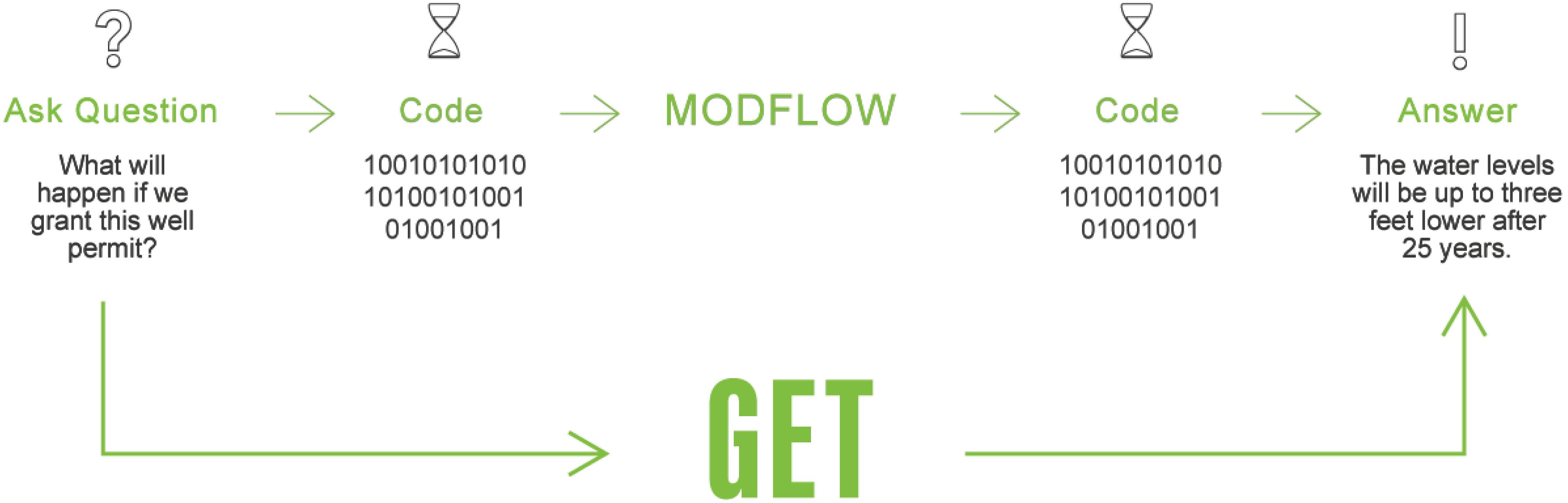
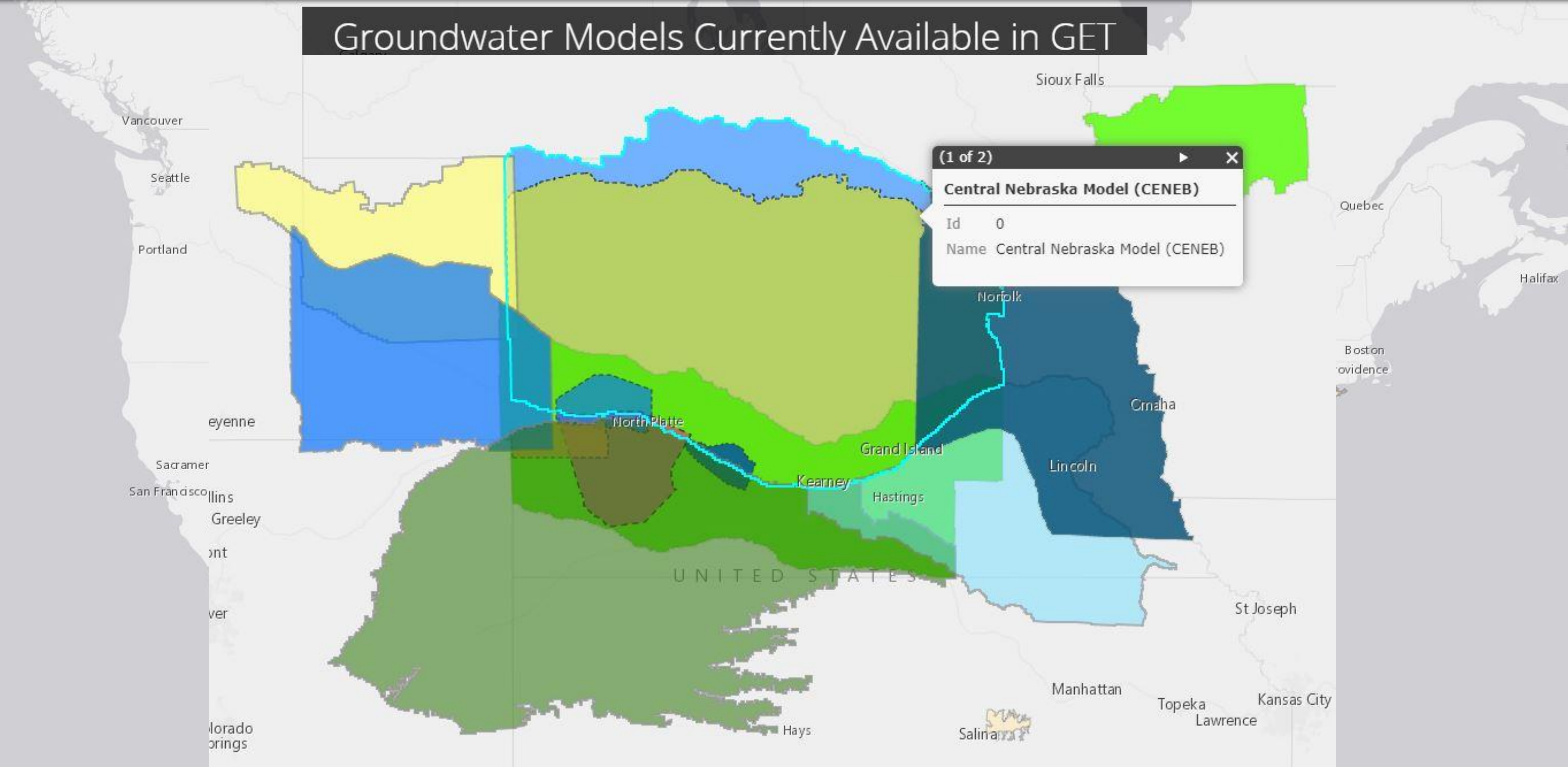
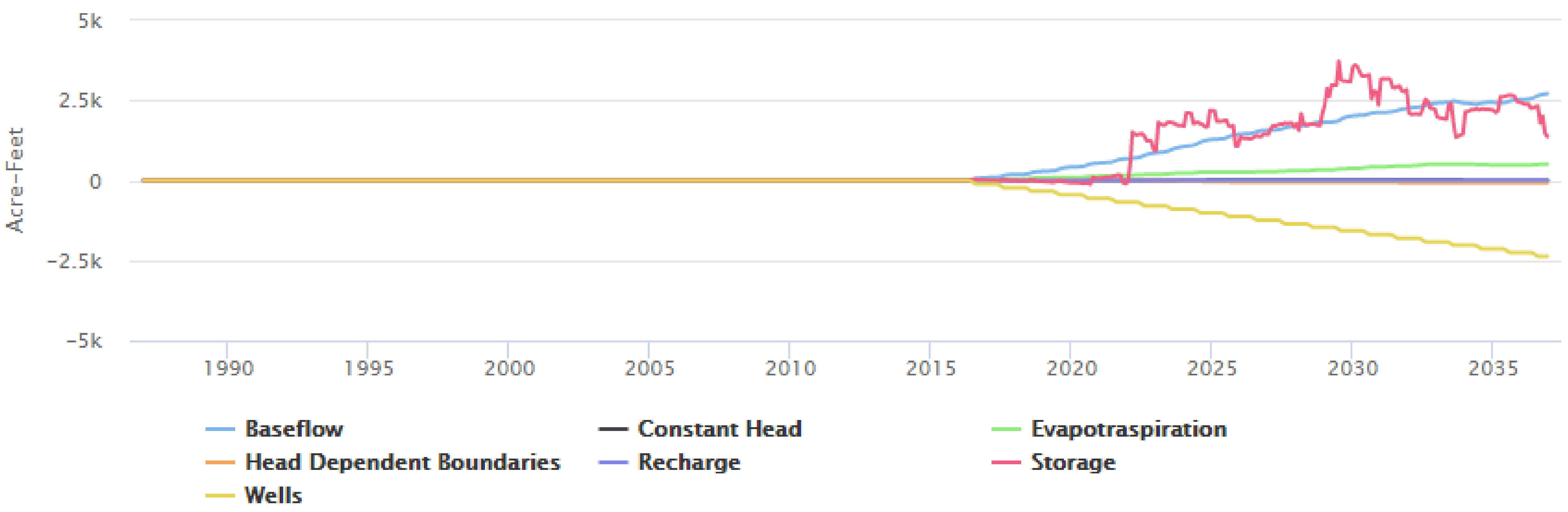

Ask Question
What will happen if we grant this well permit?
Code
10010101010
10100101001
01001001
MODFLOW
Code
10010101010
10100101001
01001001
Answer
The water levels will be up to three feet lower after 25 years.
GET

# Groundwater Models Currently Available in GET



# The Central Nebraska Model (CENEB)

## Cumulative





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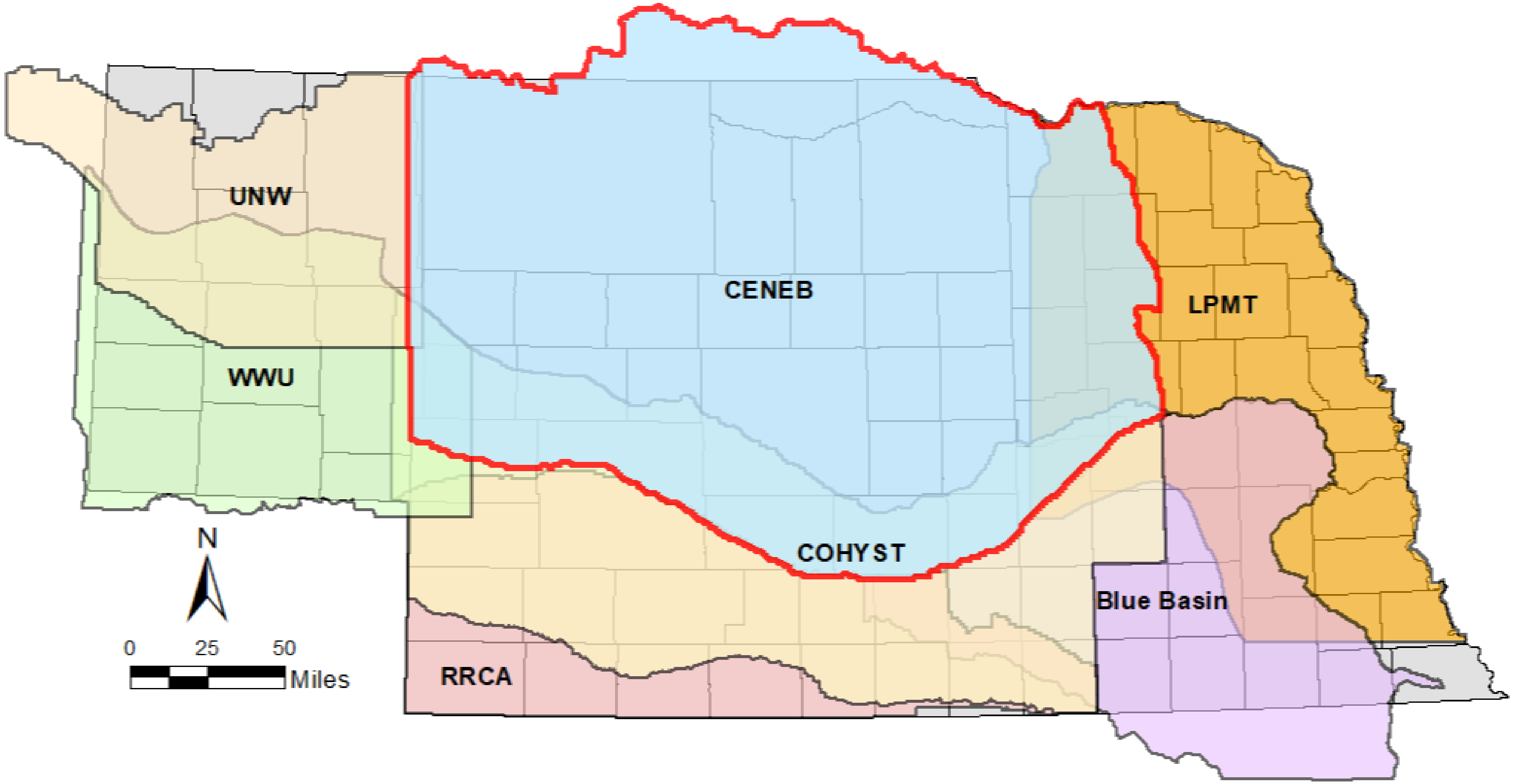
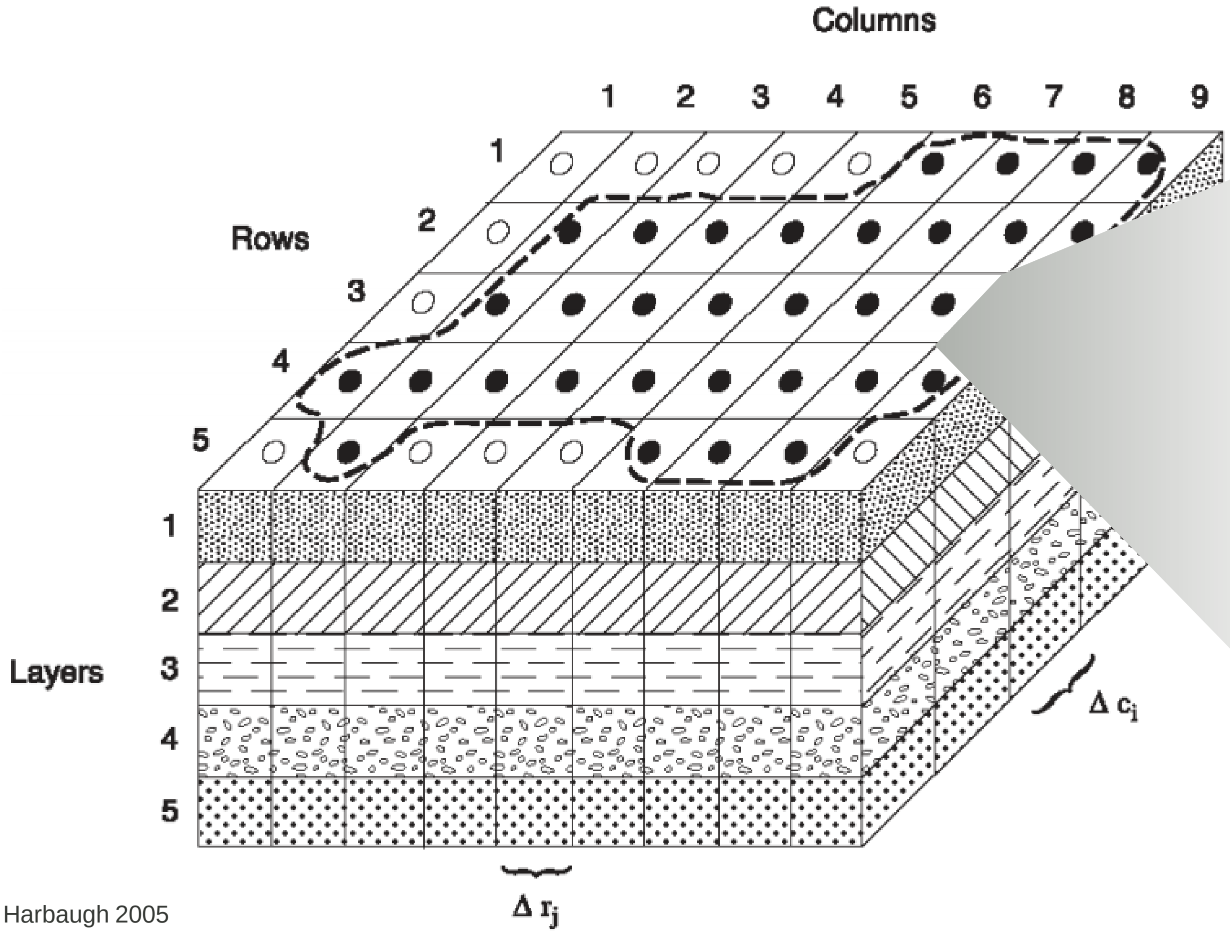
# Wellhead Protection Scenario

# Behind the Tool

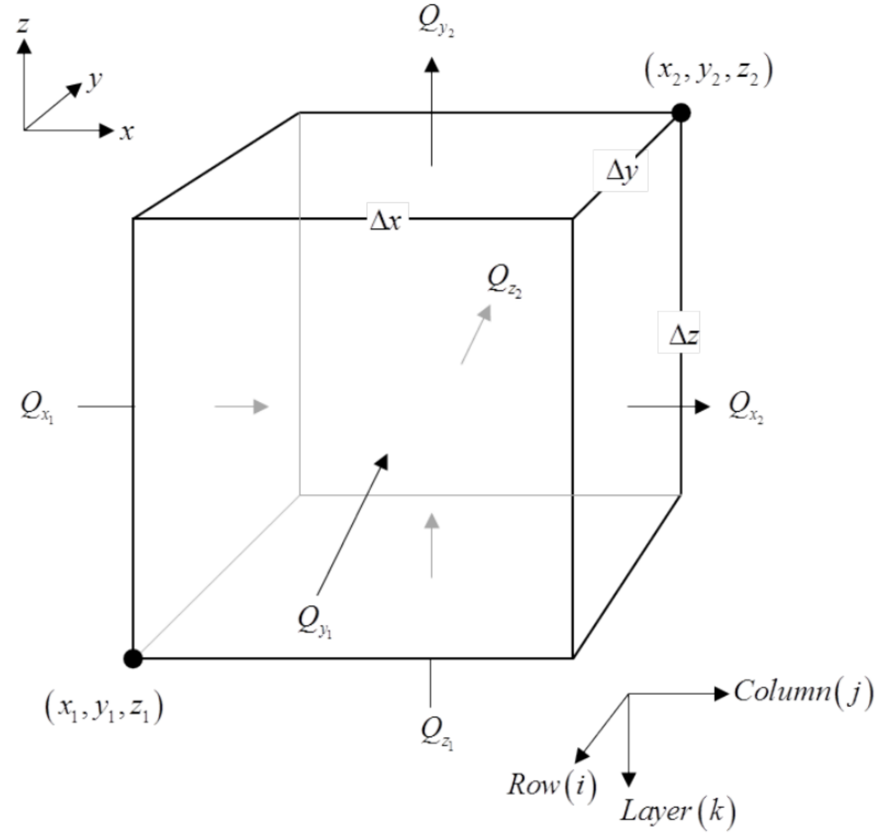
- MODFLOW
- MODPATH
- Numerical
- Data utilization
- Time and money



# MODFLOW Grid Cell Showing Volumetric Flow Components

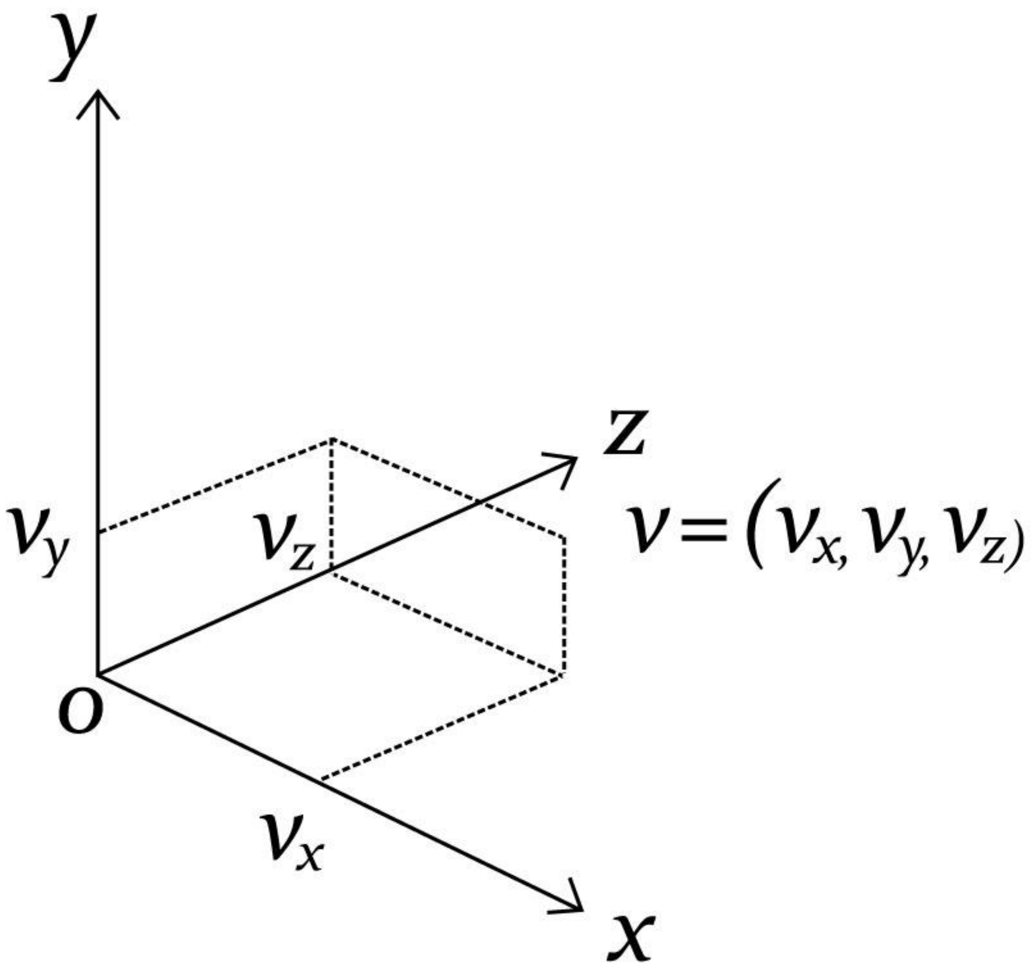



Harbaugh 2005



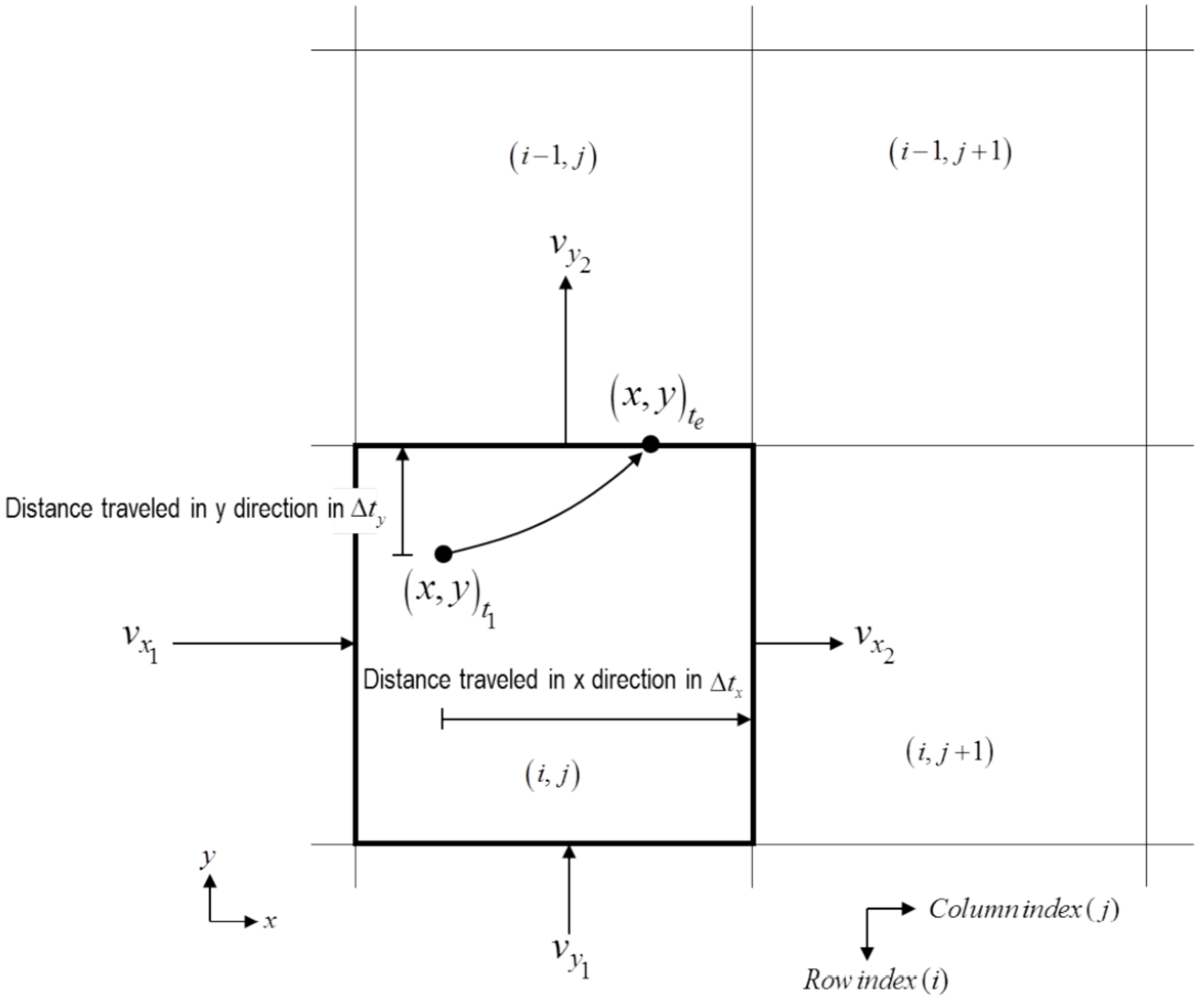

Pollock 2016

# Compute average linear velocity component




$$v_x = \frac{Q_x}{(n\Delta y\Delta z)} \qquad v_y = \frac{Q_y}{(n\Delta x\Delta z)} \qquad v_z = \frac{Q_z}{(n\Delta x\Delta y)}$$

# Compute a Particle's Location at Time t




$$\Delta t_x = \frac{1}{A_x} \ln \left[ \frac{v_{x_2}}{(v_x)_t} \right]$$

$$\Delta t_y = \frac{1}{A_y} \ln \left[ \frac{v_{y_2}}{(v_y)_{t_1}} \right] .$$

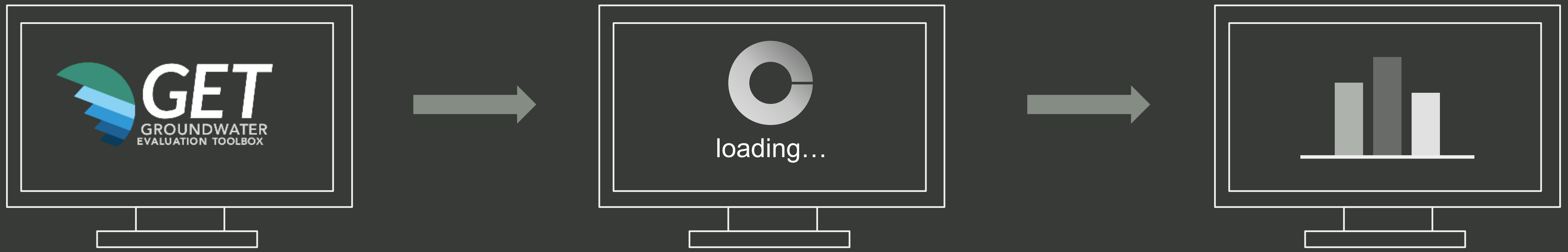
# Wellhead Protection Mapping with GET

**MINUTES TO COMPLETE**

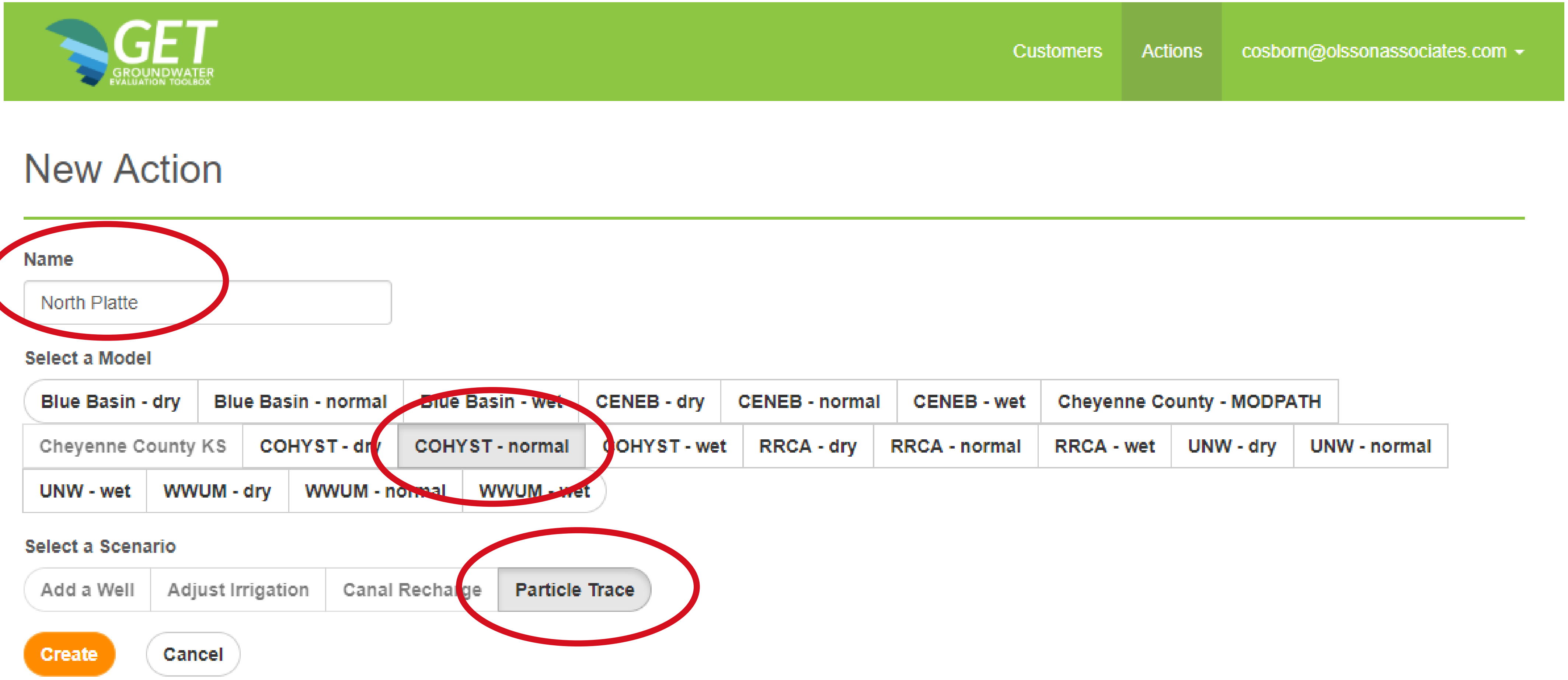
**Select water supply well locations**

**Program enters data and runs MODPATH**

**Results Displayed**



# Create a Run

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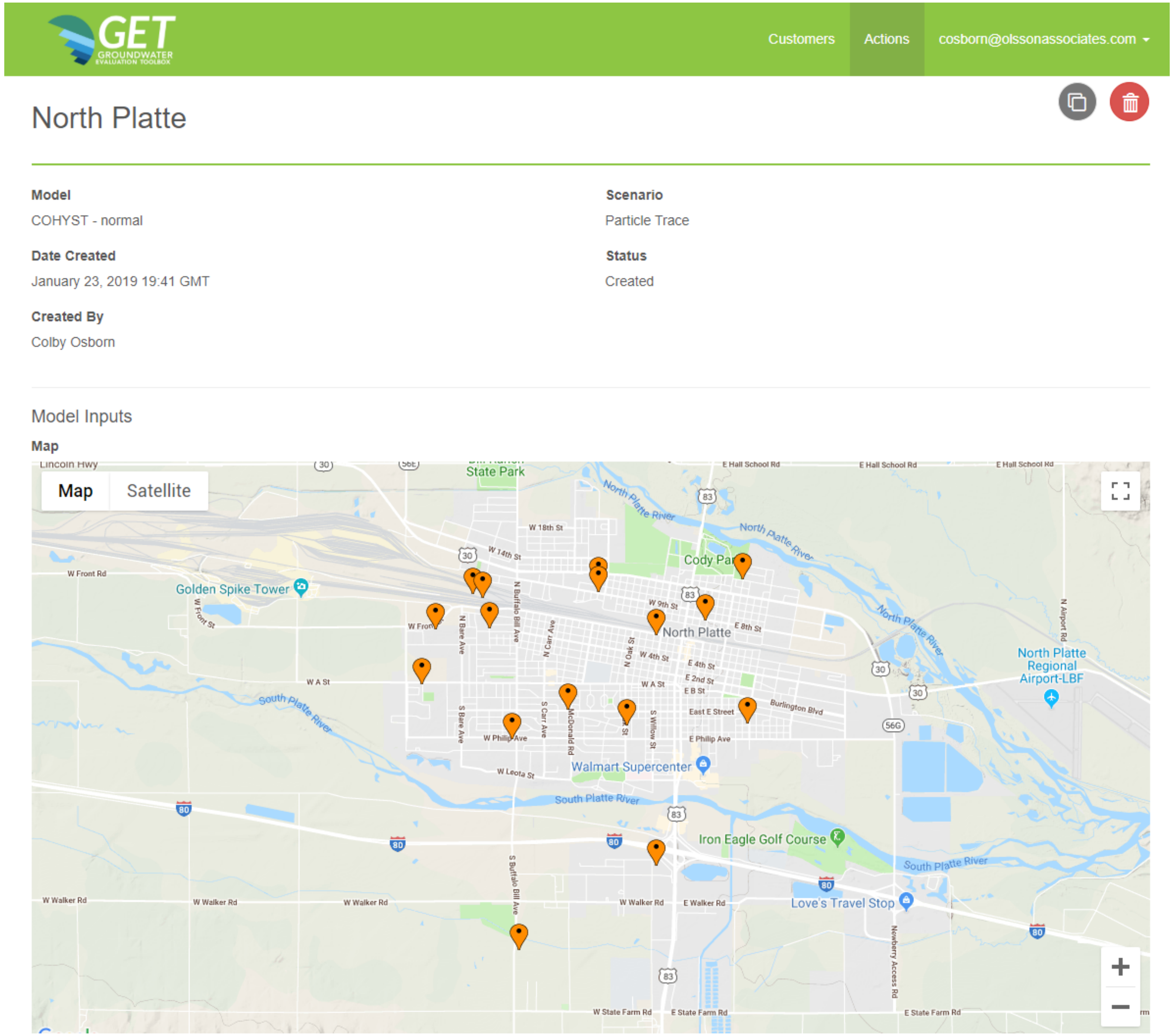
# Select Locations

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# Results

GET GROUNDWATER EVALUATION TOOLBOX

Customers | Actions | cosborn@olssonassociates.com

## North Platte

**Model**
COHYST - normal

**Scenario**
Particle Trace

**Date Created**
January 23, 2019 19:41 GMT

**Status**
Complete

**Created By**
Colby Osborn

### Model Inputs

View Model Input Data

### Model Summary

```
MODPATH Version 7.1.000    (September 26, 2016)


Run particle tracking simulation ...
Processing Time Step     2 Period   274.  Time =  2.65705E+04
Processing Time Step     1 Period   274.  Time =  1.74392E+04

Particle Summary:
         0 particles are pending release.
        88 particles remain active.
        40 particles terminated at boundary faces.
         0 particles terminated at weak sink cells.
         0 particles terminated at weak source cells.
         0 particles terminated at strong source/sink cells.
         0 particles terminated in cells with a specified zone number.
         0 particles were stranded in inactive or dry cells.
         0 particles were unreleased.
         0 particles have an unknown status.

Normal termination.
```

### Results

List File Output | KML File Output

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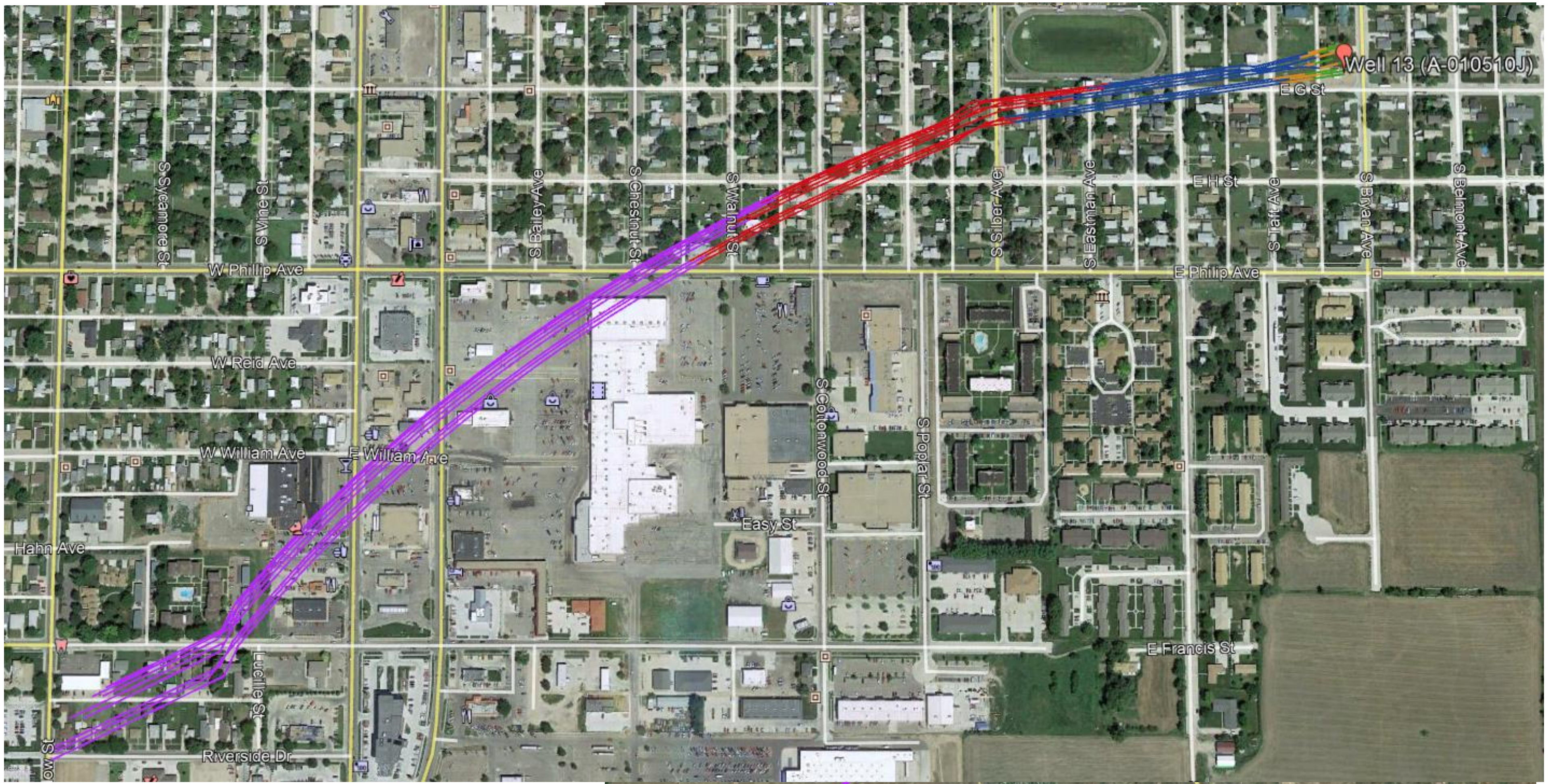
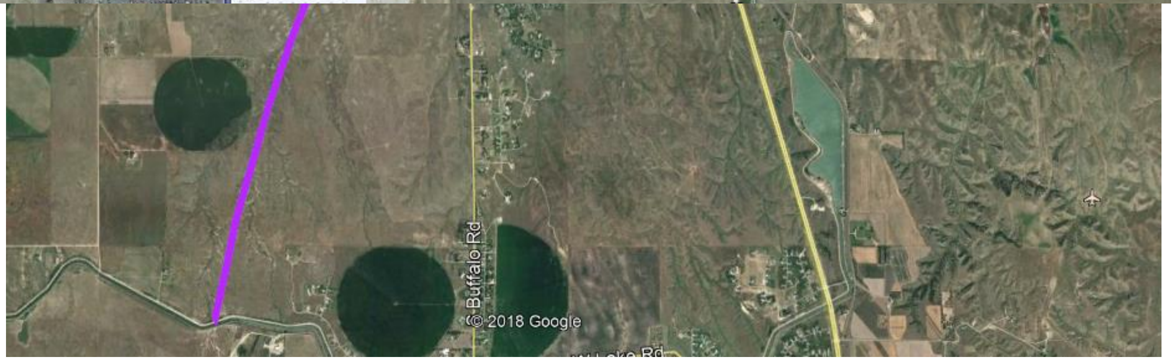
# KML




## Map Legend

- 0-1 year
- 1-2 years
- 2-10 years
- 10-20 years
- 20-50 years

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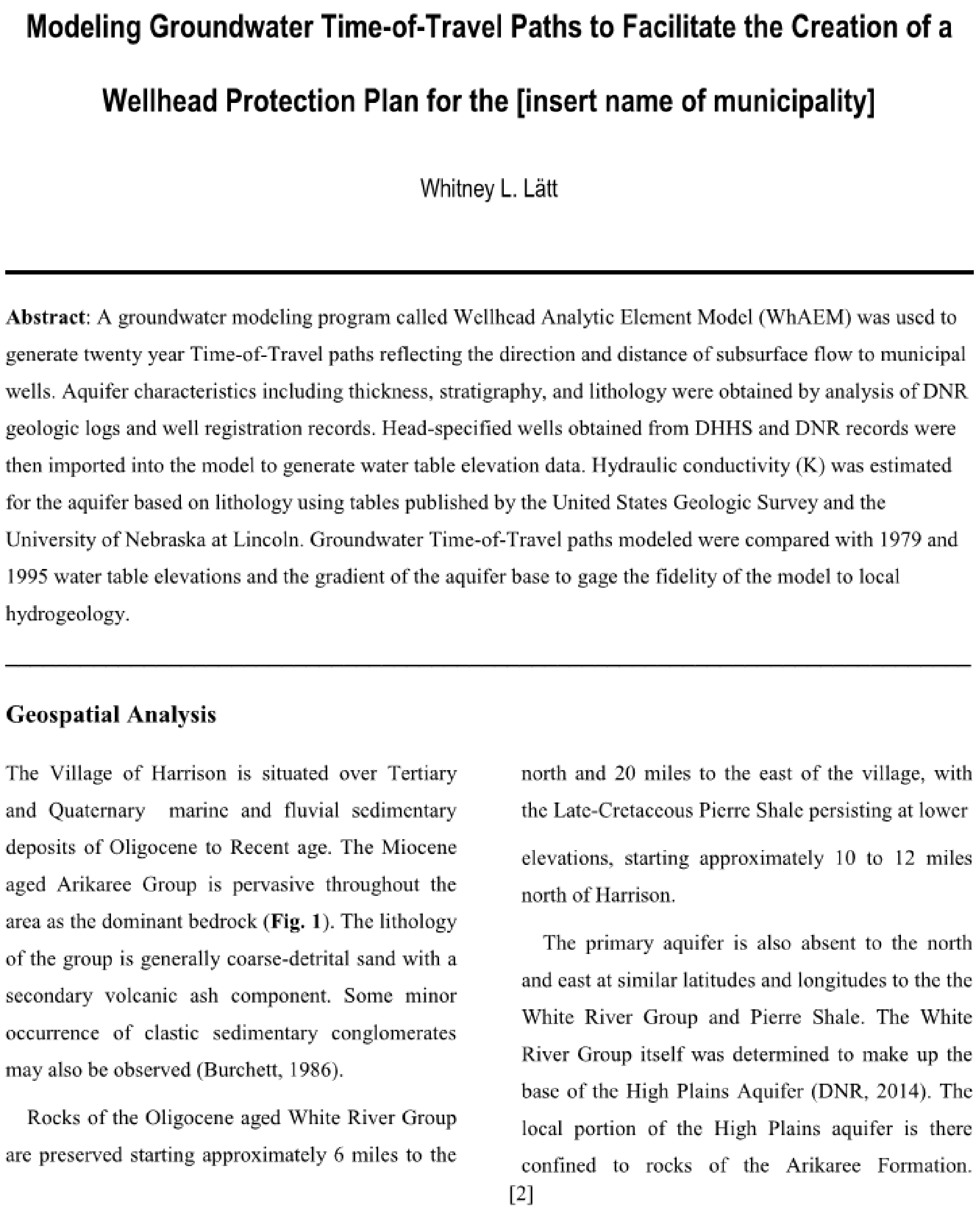
# DYNAMIC REPORTS

# Traditional Reports

- Typically completed by one person
- 1-4 weeks per report
- Investigation of local geology



**Modeling Groundwater Time-of-Travel Paths to Facilitate the Creation of a Wellhead Protection Plan for the [insert name of municipality]**

Whitney L. Lätt

**Abstract**: A groundwater modeling program called Wellhead Analytic Element Model (WhAEM) was used to generate twenty year Time-of-Travel paths reflecting the direction and distance of subsurface flow to municipal wells. Aquifer characteristics including thickness, stratigraphy, and lithology were obtained by analysis of DNR geologic logs and well registration records. Head-specified wells obtained from DHHS and DNR records were then imported into the model to generate water table elevation data. Hydraulic conductivity (K) was estimated for the aquifer based on lithology using tables published by the United States Geologic Survey and the University of Nebraska at Lincoln. Groundwater Time-of-Travel paths modeled were compared with 1979 and 1995 water table elevations and the gradient of the aquifer base to gage the fidelity of the model to local hydrogeology.

**Geospatial Analysis**

The Village of Harrison is situated over Tertiary and Quaternary marine and fluvial sedimentary deposits of Oligocene to Recent age. The Miocene aged Arikaree Group is pervasive throughout the area as the dominant bedrock (**Fig. 1**). The lithology of the group is generally coarse-detrital sand with a secondary volcanic ash component. Some minor occurrence of clastic sedimentary conglomerates may also be observed (Burchett, 1986).

Rocks of the Oligocene aged White River Group are preserved starting approximately 6 miles to the north and 20 miles to the east of the village, with the Late-Cretaceous Pierre Shale persisting at lower elevations, starting approximately 10 to 12 miles north of Harrison.

The primary aquifer is also absent to the north and east at similar latitudes and longitudes to the the White River Group and Pierre Shale. The White River Group itself was determined to make up the base of the High Plains Aquifer (DNR, 2014). The local portion of the High Plains aquifer is there confined to rocks of the Arikaree Formation.

[2]

# Dynamic Reports

- Report created using GET results
- 1-2 minutes per report
- Summarizes groundwater model information and GET results
- Dynamic variables

Particle Trace Documentation Report for the Community of York

Report Generated by Mallory Morton

at the Nebraska Department of Environmental Quality

12/31/2018

This report was generated using the

Groundwater Evaluation Toolbox®

Wellhead Protection Scenario developed for the

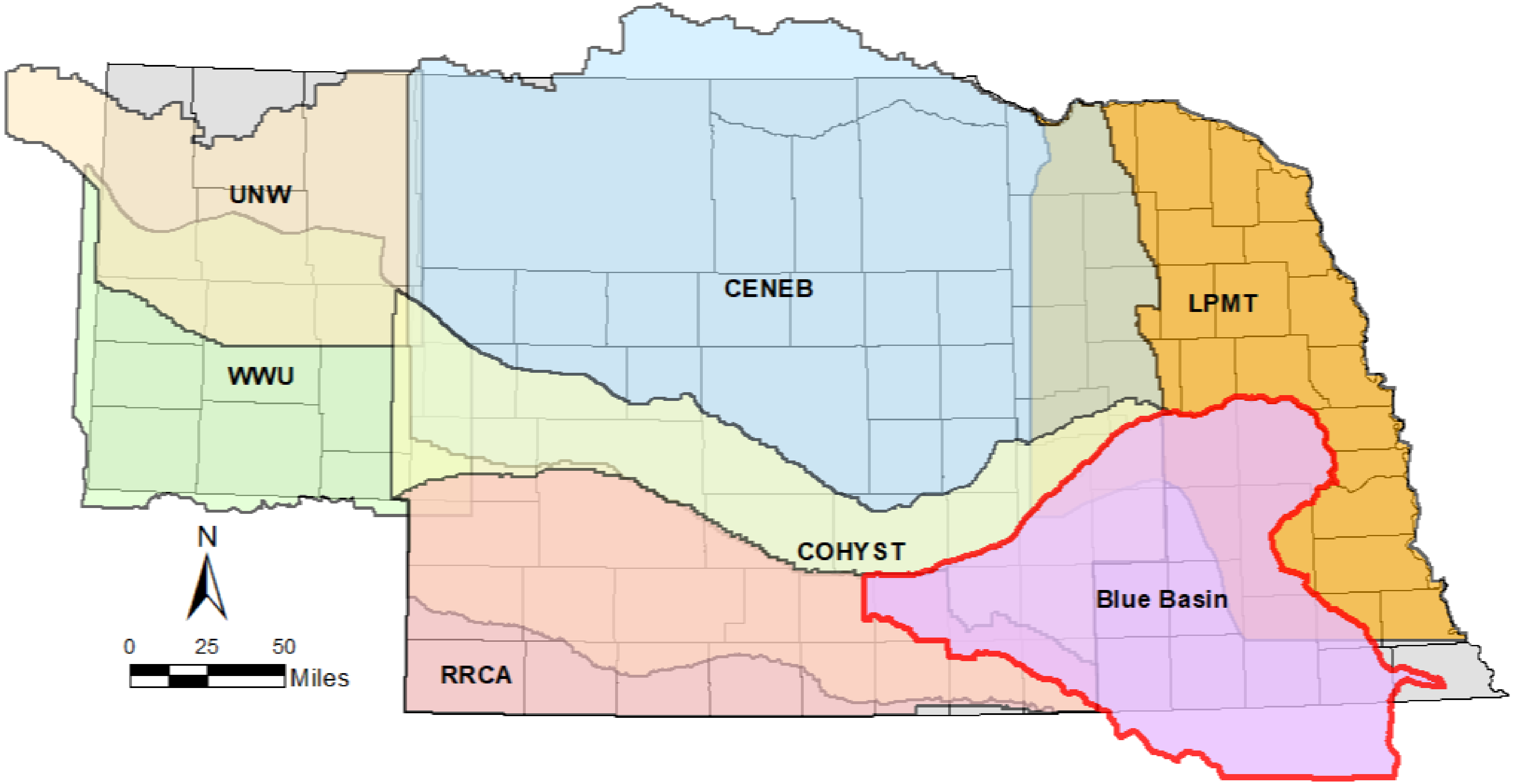
Nebraska Department of Environmental Quality

by Olsson

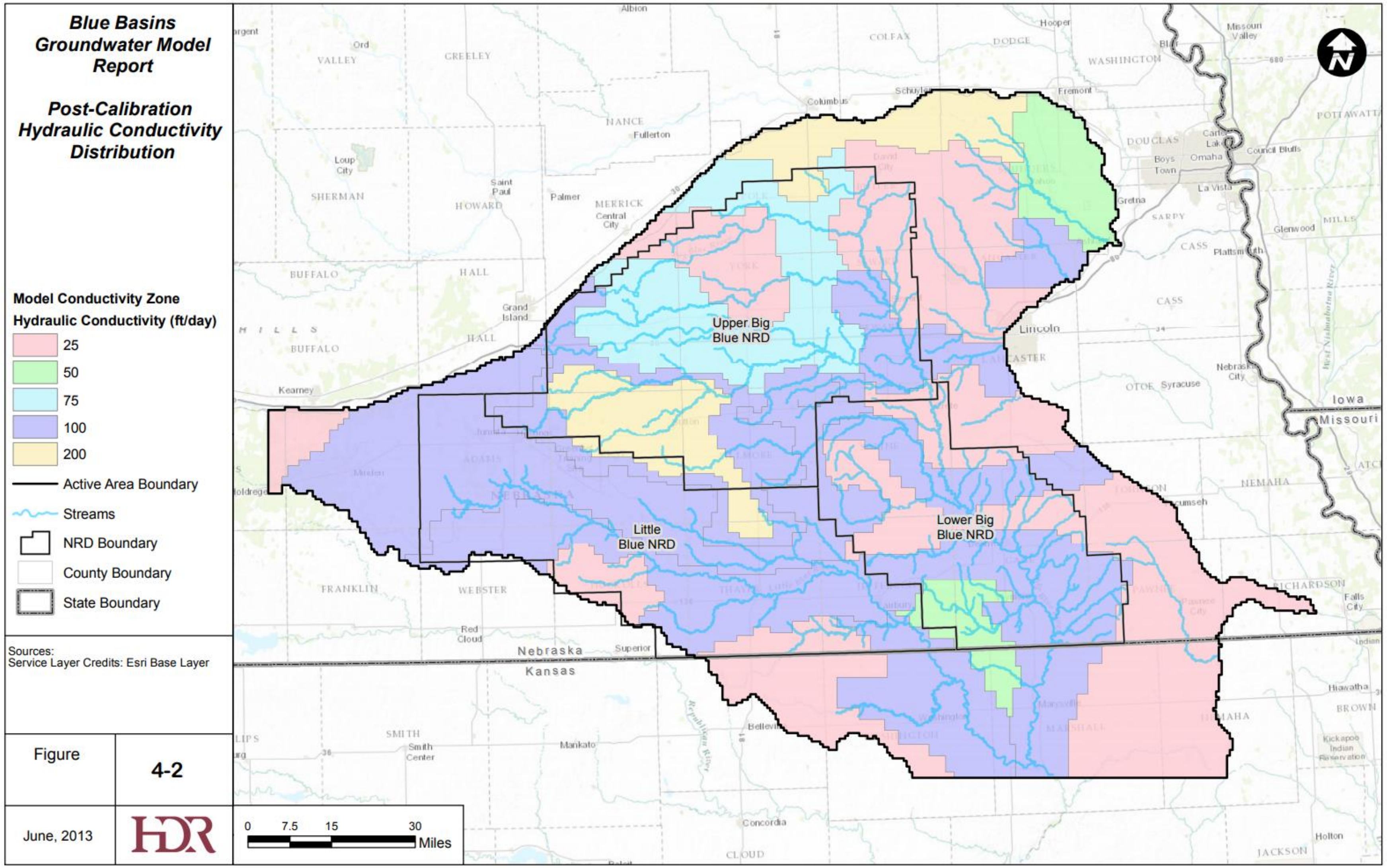
## Table of Contents

## Dynamic Report Sections

Location map of the model being used



2. Spatial Resolution
3. Temporal Resolution
4. Vertical Model Layers
5. Aquifer Properties
6. Pumping
7. Recharge
8. Evapotranspiration
9. Boundary Conditions



10. Particle Trace User Input

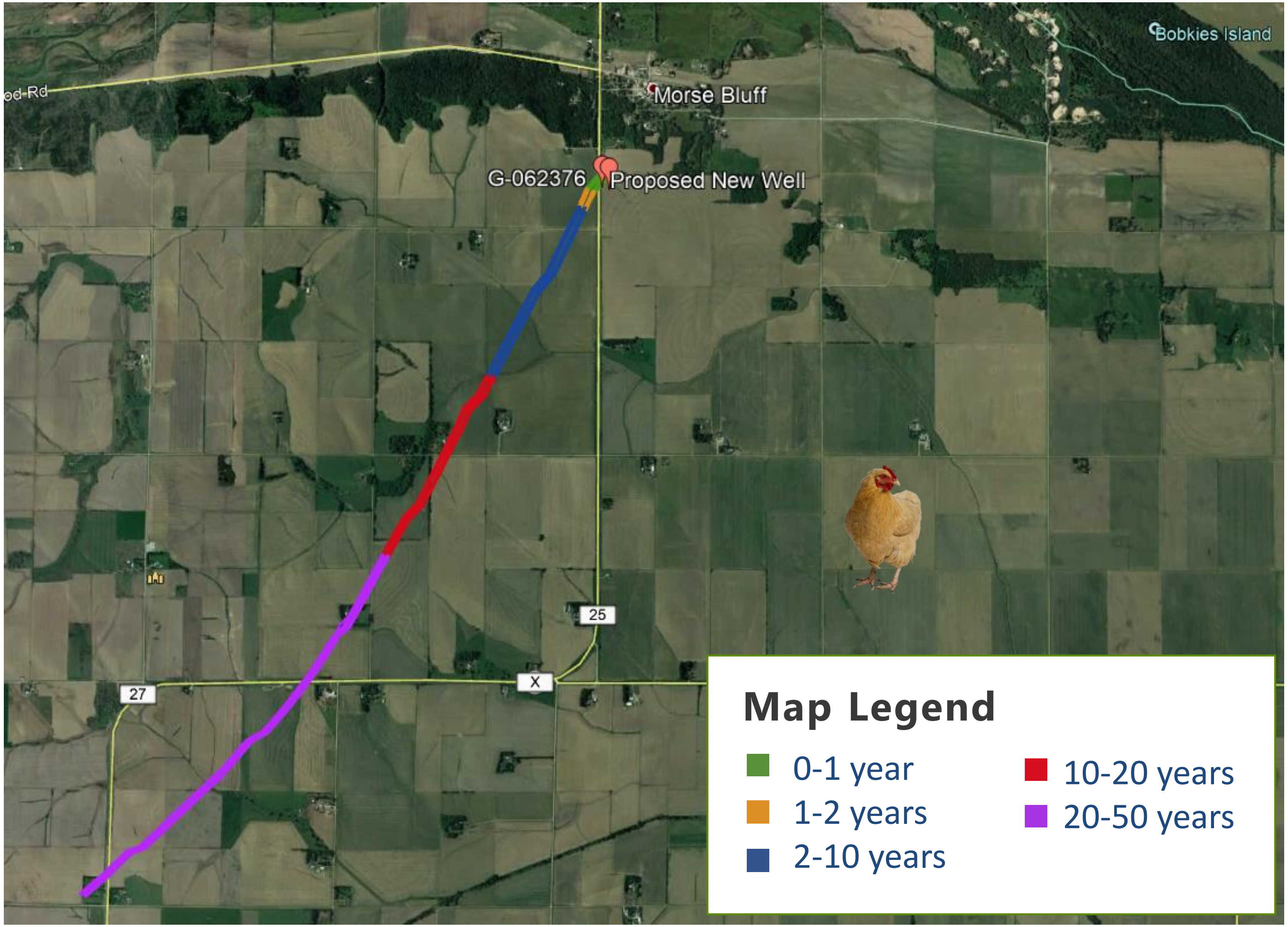
| Name | Latitude | Longitude | Particle Count |
|---|---|---|---|
| Well 1 | 40.86283 | -97.59681 | 8 |

11. Model Parameters

| Name | Aquifer Thickness (feet) | Horizontal Hydraulic Conductivity (feet per day) | Transmissivity (square feet per day) | Porosity (percent) |
|---|---|---|---|---|
| Well 1 | 313 | 25 | 7835 | 15 |

# Use Case

# Fast!


Bobkies Island
od Rd
Morse Bluff
G-062376
Proposed New Well
25
27
X
Map Legend
0-1 year
1-2 years
2-10 years
10-20 years
20-50 years

# QUESTIONS?

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