Groundwater Appropriations—Using Simple Groundwater Models to Inform the Decision in Areas of Sparse Data

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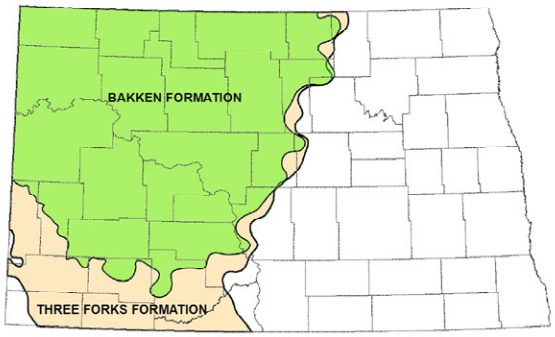
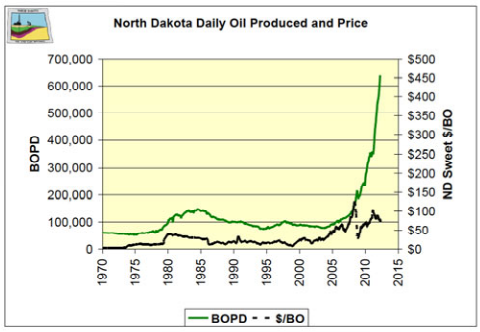
North Dakota State Water Commission

Water Demand in Western North Dakota

- Each well needs 2 to 3 million gallons of water for hydraulic fracturing and oil recovery
- Daily water demand of 20 to 30 million gallons (22,400 to 33,600 acre-feet per year)

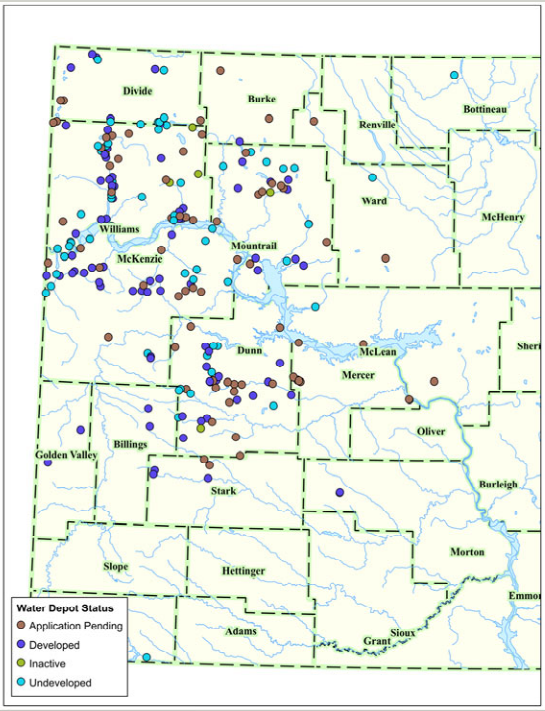
Figure source: North Dakota Department of Mineral Resources, Oil and Gas Division. Presentation to Chamber of Commerce, Bismarck, ND. August 1, 2012.



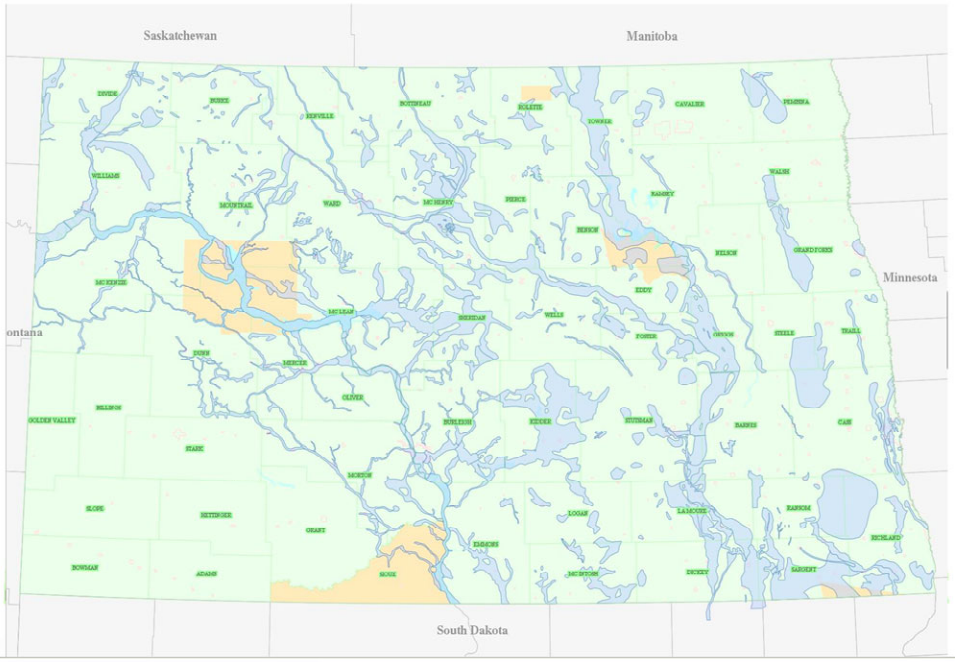


Meeting the Demand

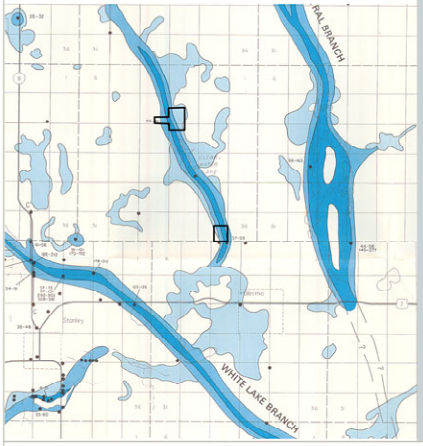
- Water Depots (Independent Groundwater Providers)

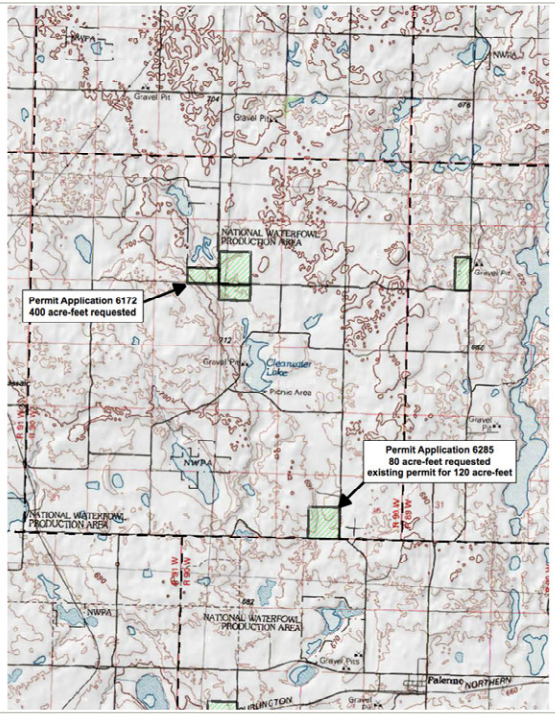


Glacial Aquifers of North Dakota



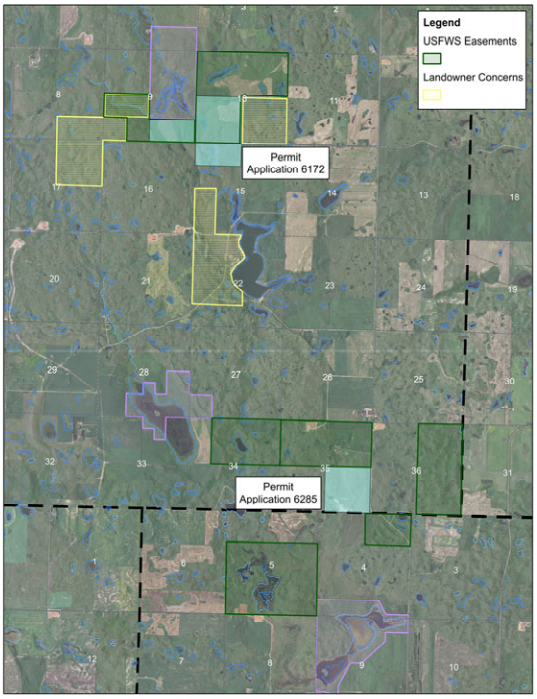
Case Studies: Two Permit Applications for Industrial Depots



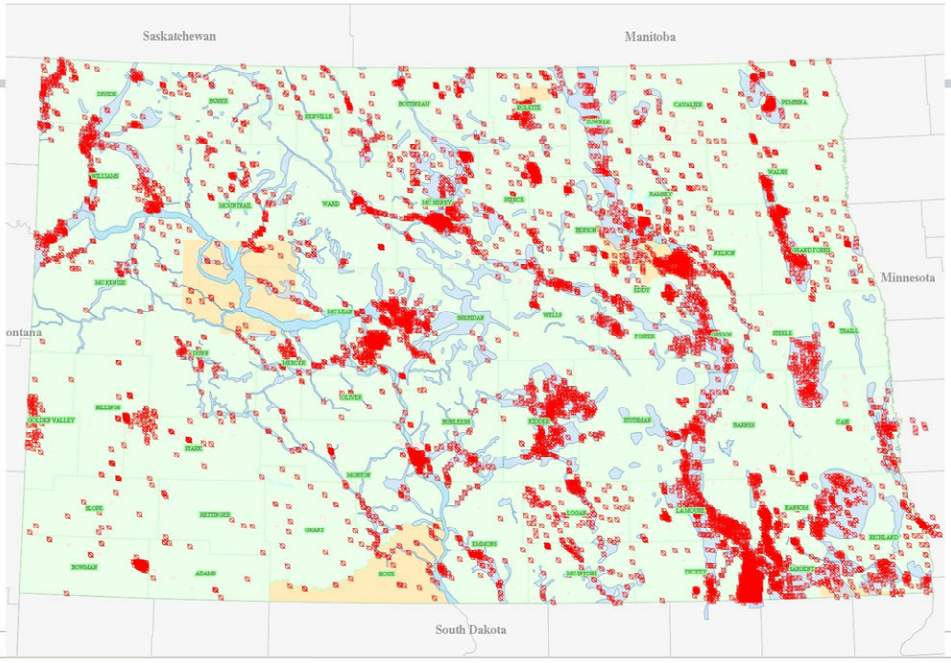


Concerns about the Applications

- Nearby groundwater appropriators
  - Individual wells owners
  - Nearby city
  - County water resource district
- Fish and wildlife easements and protection areas
- Recreational surface water users



Available Data - Groundwater Monitoring Network



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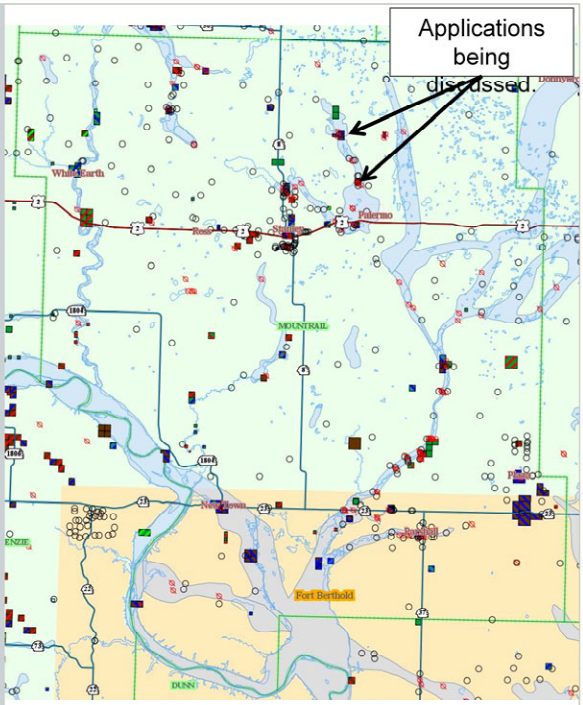
Sparse Data in Western North Dakota

- Frequently applications are not located near SWC test holes and observation wells.
- Observation wells installed for new applications lack historical data.

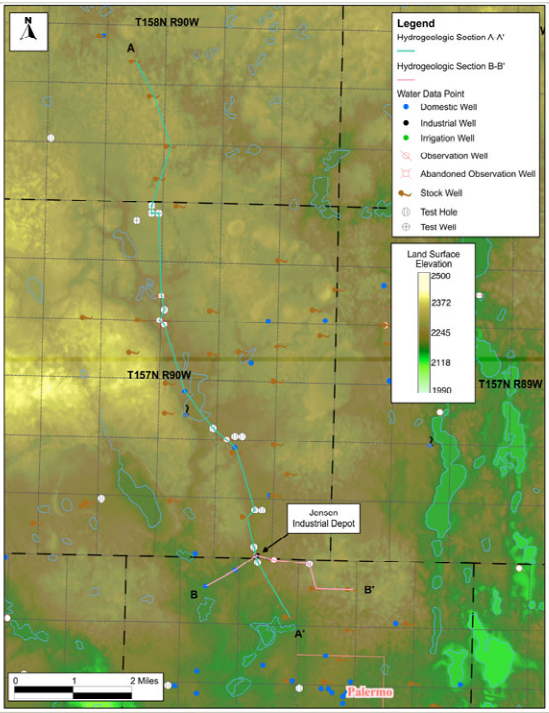


Slide 8

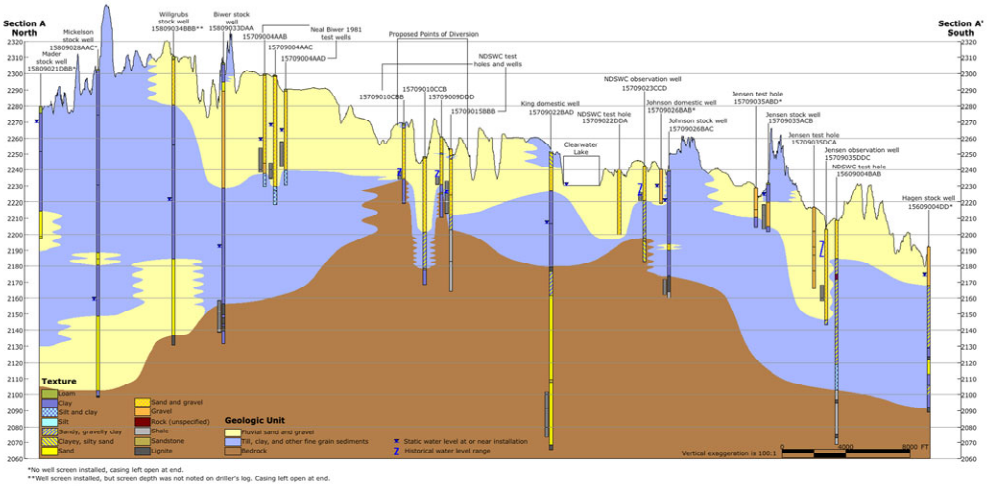
JM1 Update this figure once new aquifer layer has been updated in MapServices. Same with previous two slides.
Jennifer Morin, 9/11/2012

Available Hydrogeologic Data

- Six NDSWC test holes
- Seven NDSWC obs. wells (one installed in 1967, three in 2010, and three in 2012)
- One abandoned obs. well (water level data from 1966 to 1968)
- Data from 30 domestic and stock well reports.
- Surficial soils data (NRCS SSURGO database)



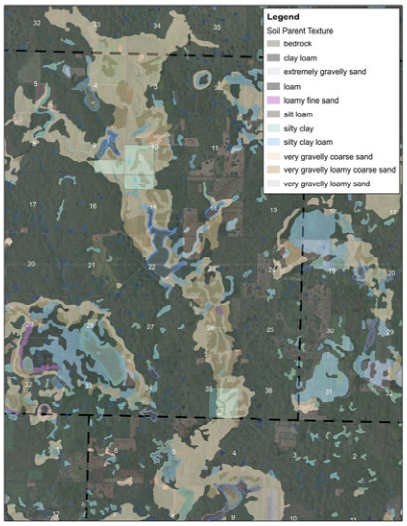
Hydrogeologic Setting

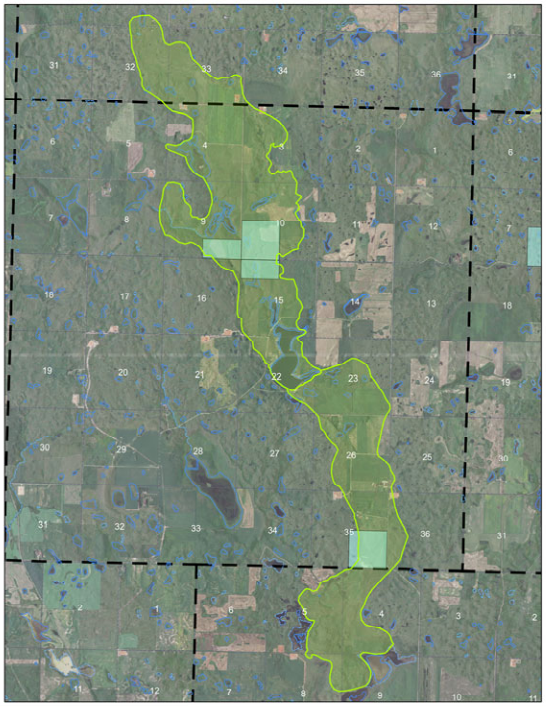


Choosing a Method to Evaluate Potential Impacts of the Applications on Prior Appropriators

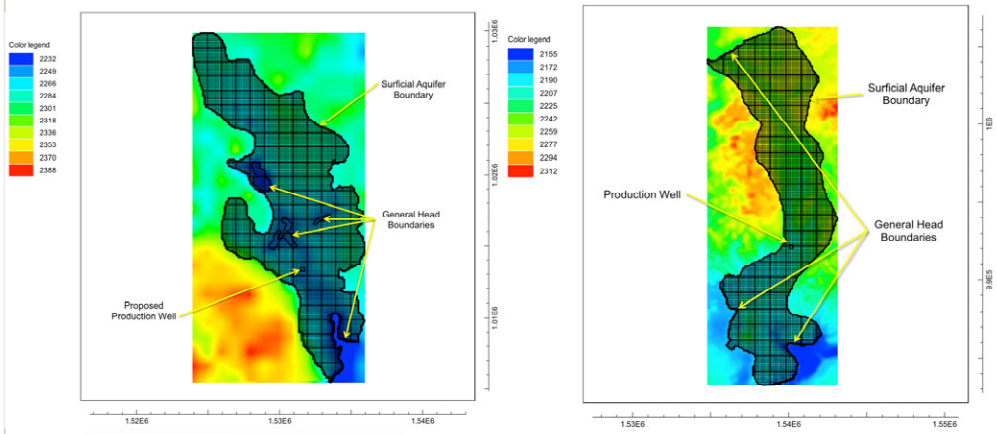
- Problems with using traditional analytical methods:
  - Cannot incorporate all boundaries
  - Difficult to assess variable pumping rates
- Problems with numerical models:
  - Lack of lithologic data for model development
  - Lack of observation data for model calibration
- Evaluation method choice:
  - One-layer, numerical model using MODFLOW-2005 based on conceptual model of the aquifer
  - ModelMuse 2.12.0.0 user interface

Developing a Model of Aquifer Response: Aquifer Extent

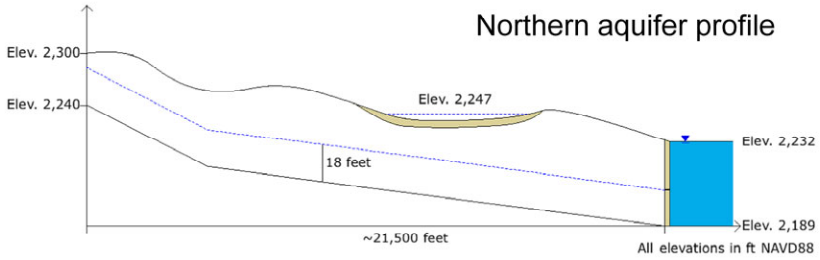




Developing a Model of Aquifer Response - Boundaries



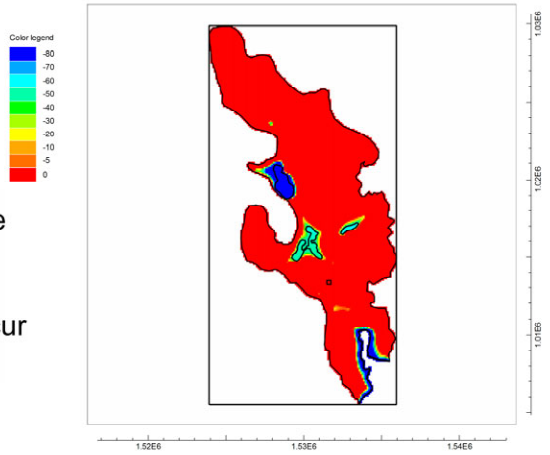
Developing a Model of Aquifer Response – Layer Thickness and Properties



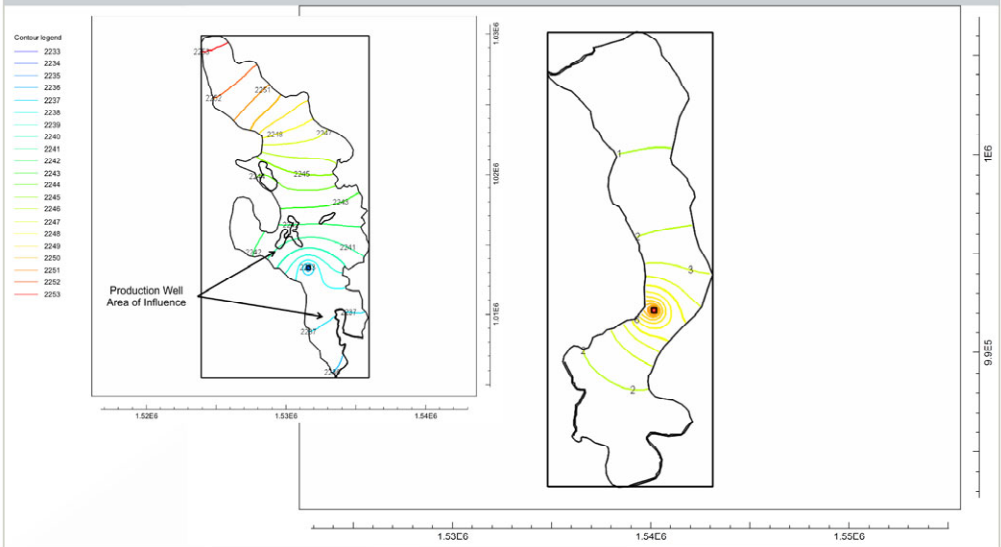
- Homogeneous and isotropic
- Hydraulic Conductivity (K) = 300 feet/day
- Specific yield = 0.2

Developing a Model of Aquifer Response - Climate

- Uniform recharge rate of 3 inches/year (RCH package)
- ET modeled using the EVT package
  - Max GW ET of 35 inches/year
  - ET surface at land surface
  - Extinction depth at 7 feet below land surface
- Groundwater ET does not occur over much of the aquifer because water table is below the extinction depth

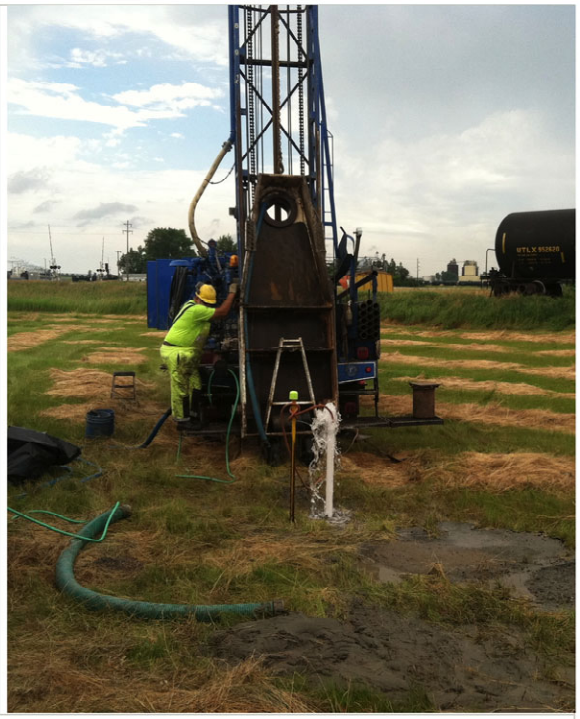


Model Calibration and Results



Permit Application Decisions

- Permit No. 6172 – Grant 50 acre-feet of the 400 acre-feet requested and hold the rest in abeyance
- Permit No. 6285 – Defer a decision to grant the permit until more hydrogeologic data can be collected
- Continue to add test holes and wells



Utility of Simple Numerical Models for Making Groundwater Management Decisions

- Useful for real-world challenges in groundwater appropriations:
  - Too complex for analytical methods (boundaries)
  - Not enough information to make a detailed numerical model
- A numerical model based on a conceptual model of the aquifer can give you additional insight into characteristics of the aquifer and it's response to development.
- Additional model complexity could be added (e.g. detailed climate information, lithologic data), but the simple model aids the primary goal of making a management decision with limited data in a short time frame.

Thank You

Questions?

North Dakota State Water Commission