

Nitrate Contamination: Tools, Insights, and Potential Solutions

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May 5, 2009



Recipe for Success

1. Apply for a large EPA Grant
2. Receive large EPA Grant
3. Hire the best scientists you can!



Presentation Outline

- Nitrate: What's the big deal?
- Nitrate contamination case study
- Characterization tools and insights
- Applying this information regionally
- Potential solutions



Background: Nitrate

- Nitrate-N MCL is 10 ppm
- Do not bind with soils & highly soluble
- Travels with groundwater
- Little or no retardation or degradation
- Conservative solute that tends to accumulate in ground water



Background: Nitrate

- One septic tank contaminates ~ 900 gallons of water per day to the MCL of 10 ppm NO_3
- 18,000+ septic systems in Washoe County
 - 1.3 Billion gallons of septic effluent to groundwater annually
 - ~ 5.7 Billion gallons of groundwater to the MCL of 10 ppm annually
 - ~ 17,500 AFY or enough to serve ~ 50,000 homes!
- Greatest potential for nitrate contamination of groundwater arises in areas of low rainfall recharge and high development density (Hantzsche and Finnemore, 1992)
- Septic tanks are the most frequently reported cause of groundwater contamination associated with disease outbreaks (Yates, 2006)



Background: Nitrate

- **Methemoglobinemia (blue-baby syndrome):**
blood lacks the ability to carry oxygen throughout the body - especially in infants
- **Others:** non-Hodgkin's lymphoma, gastric cancer, hypertension, thyroid disorder and birth defects.
- **Indicator contaminant:** bacterial, viral, and pharmaceutical contamination



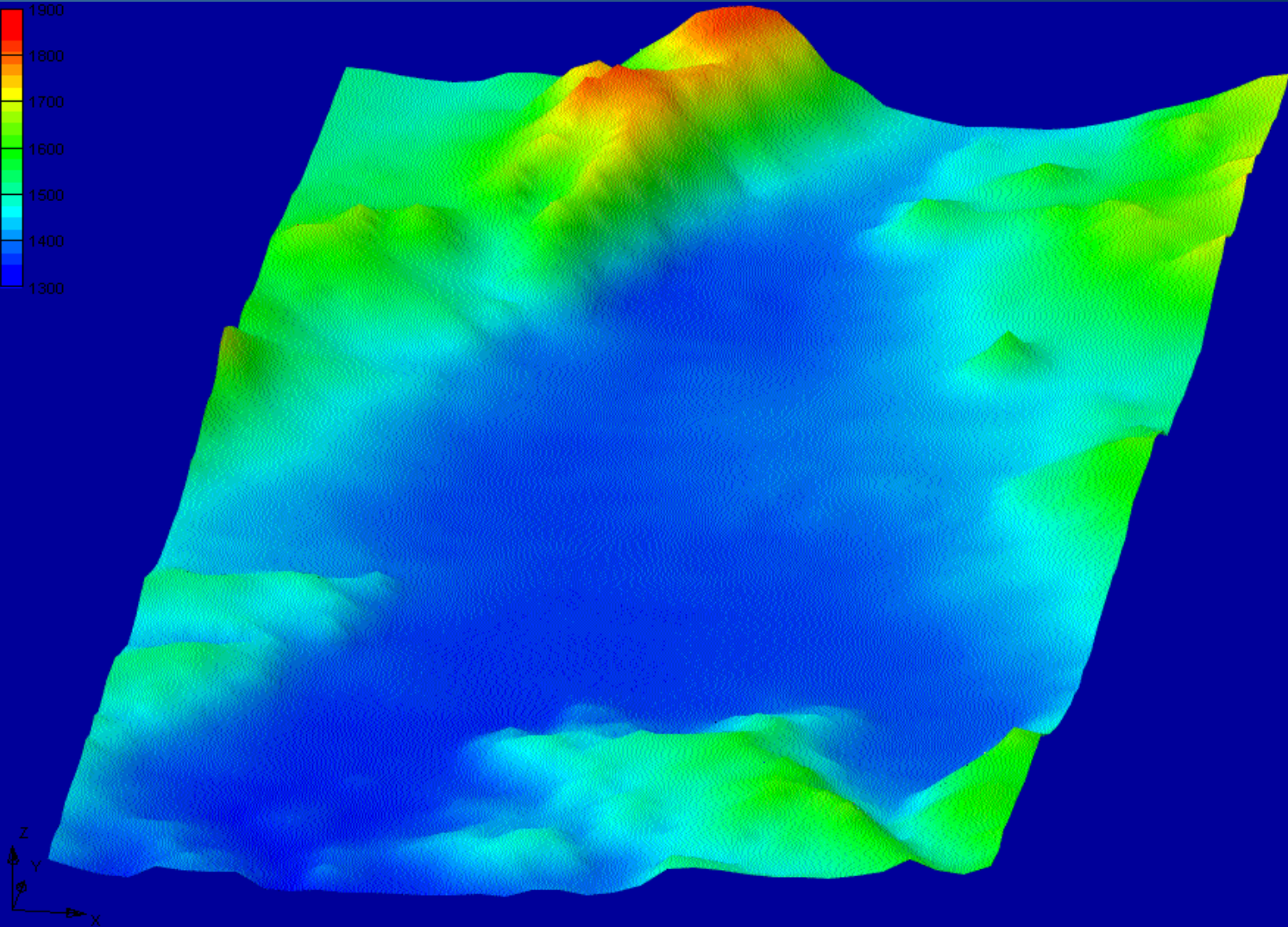
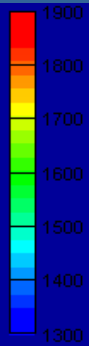
Location Map







Spanish Springs Valley

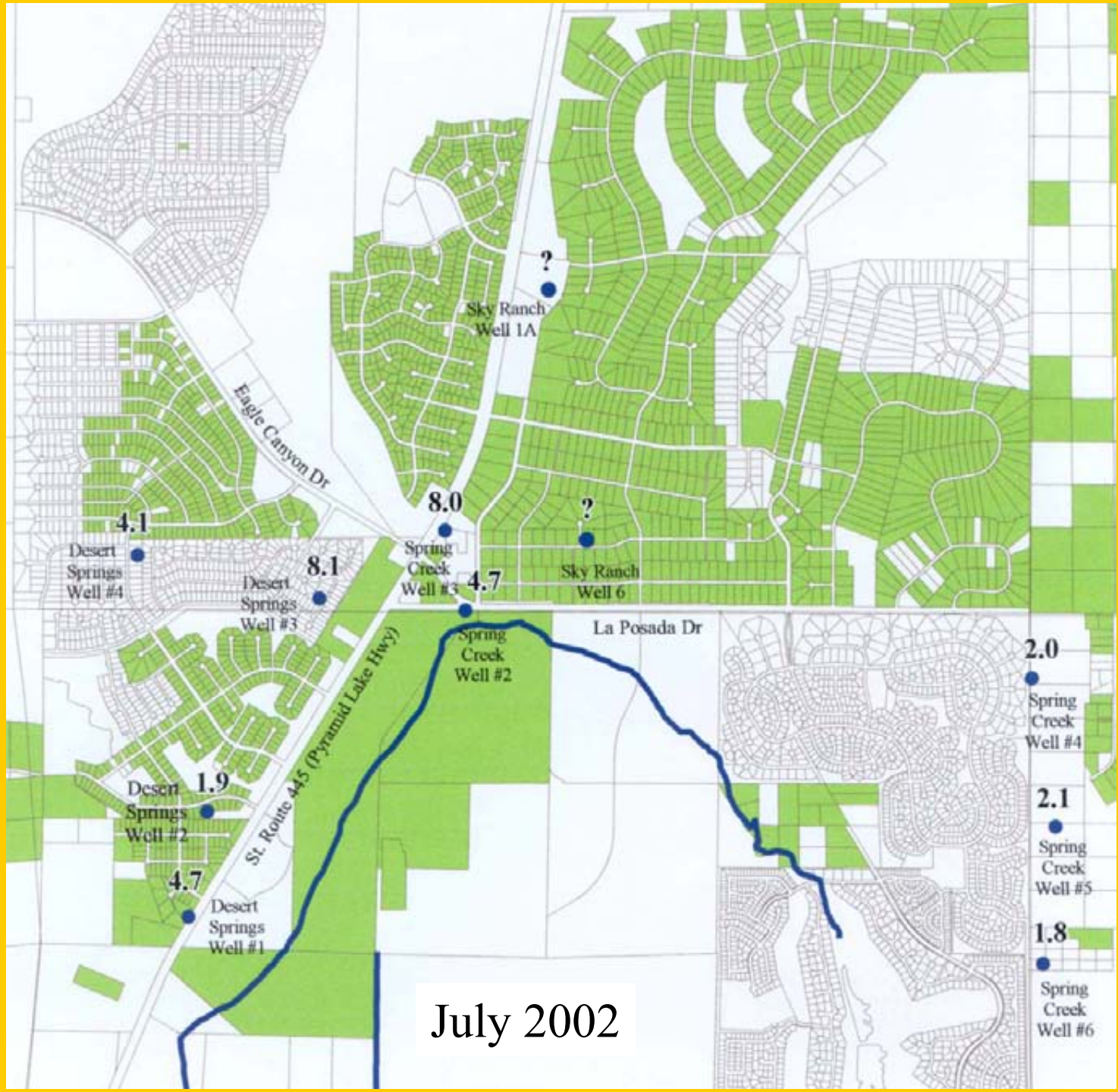




Recipe for Contamination

- 2,000+ homes on septic
- 1/2 within 2,000 ft of municipal wells
- Increasing nitrate concentrations
- Letter from the NDEP

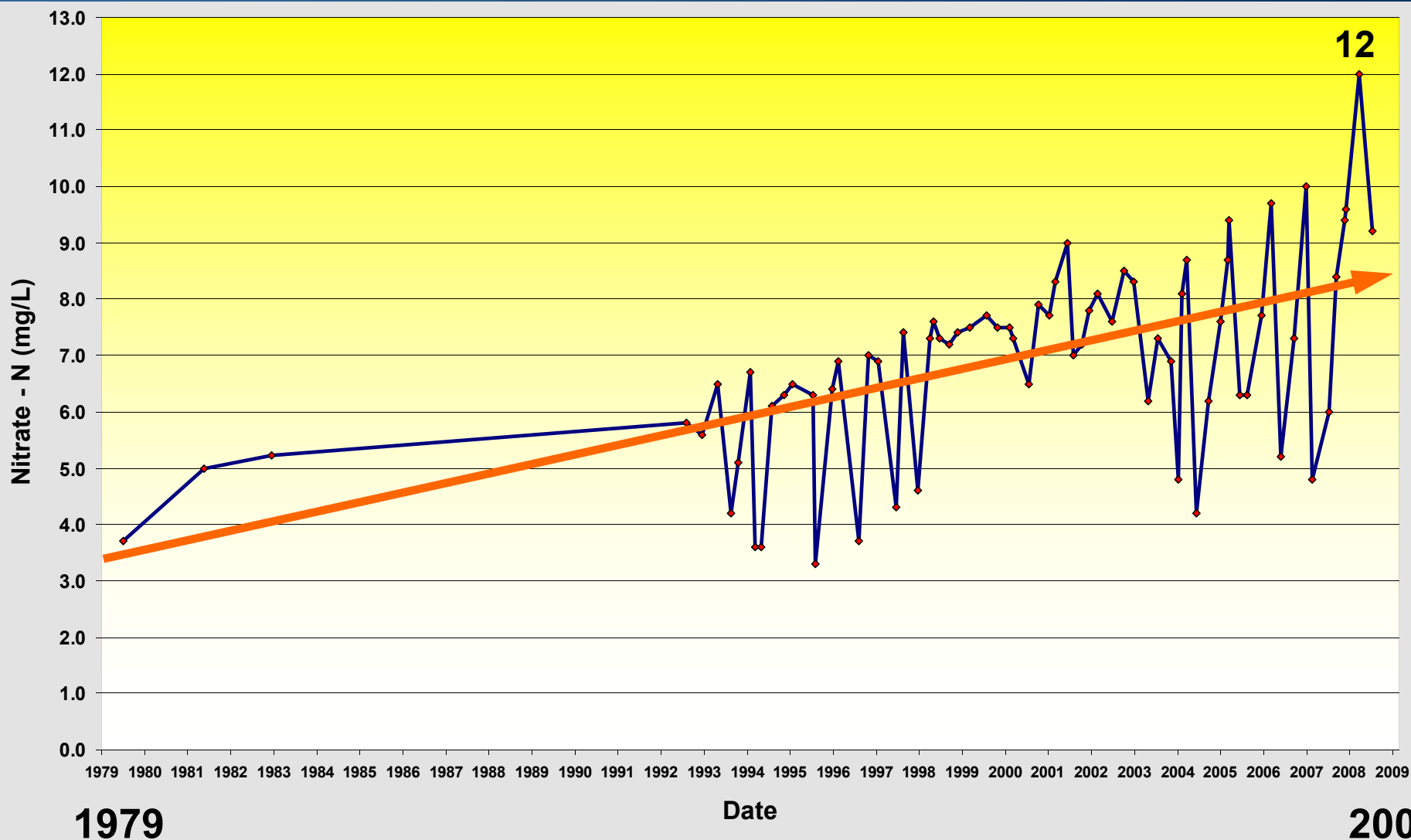
Previous Condition



July 2002



Municipal Well Contamination





Characterization Tool Kit

- Team
- Software
- Plan
- Conceptual model
- Rough mass balance from septic
- Initial characterization
- Follow-up characterization
- Municipal well Quality and Flow profiles
- Source identification
- Source magnitude
- Vadose zone assessment
- Groundwater flow & contaminant transport model



Team Members

- GIS analyst - County
- Modeler - DRI
- WQ specialist - County
- Geochemist – USGS/County
- Soil scientist – UNR
- Hydrogeologist – County
- Database specialist - County
- Grant writer!! – County
- Interns and graduate students!! – County and UNR

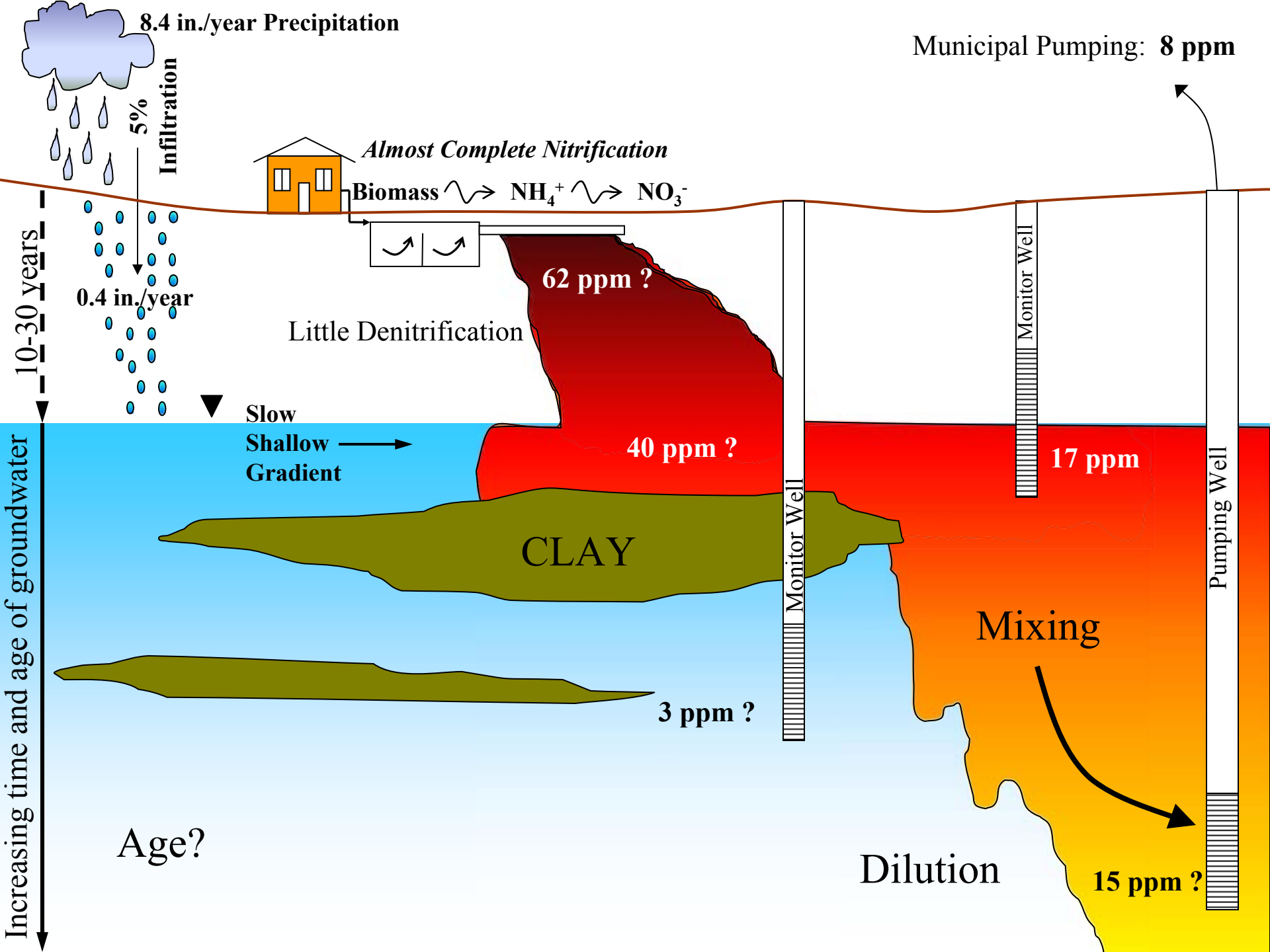


Software

- Access
- MS Office – Excel and PowerPoint!
- Surfer
- Grapher
- ArcGIS
- Aerial photos
- GMS – or any MODFLOW pre- & post-processor
- Statistical software – Excel, Origins, SAS

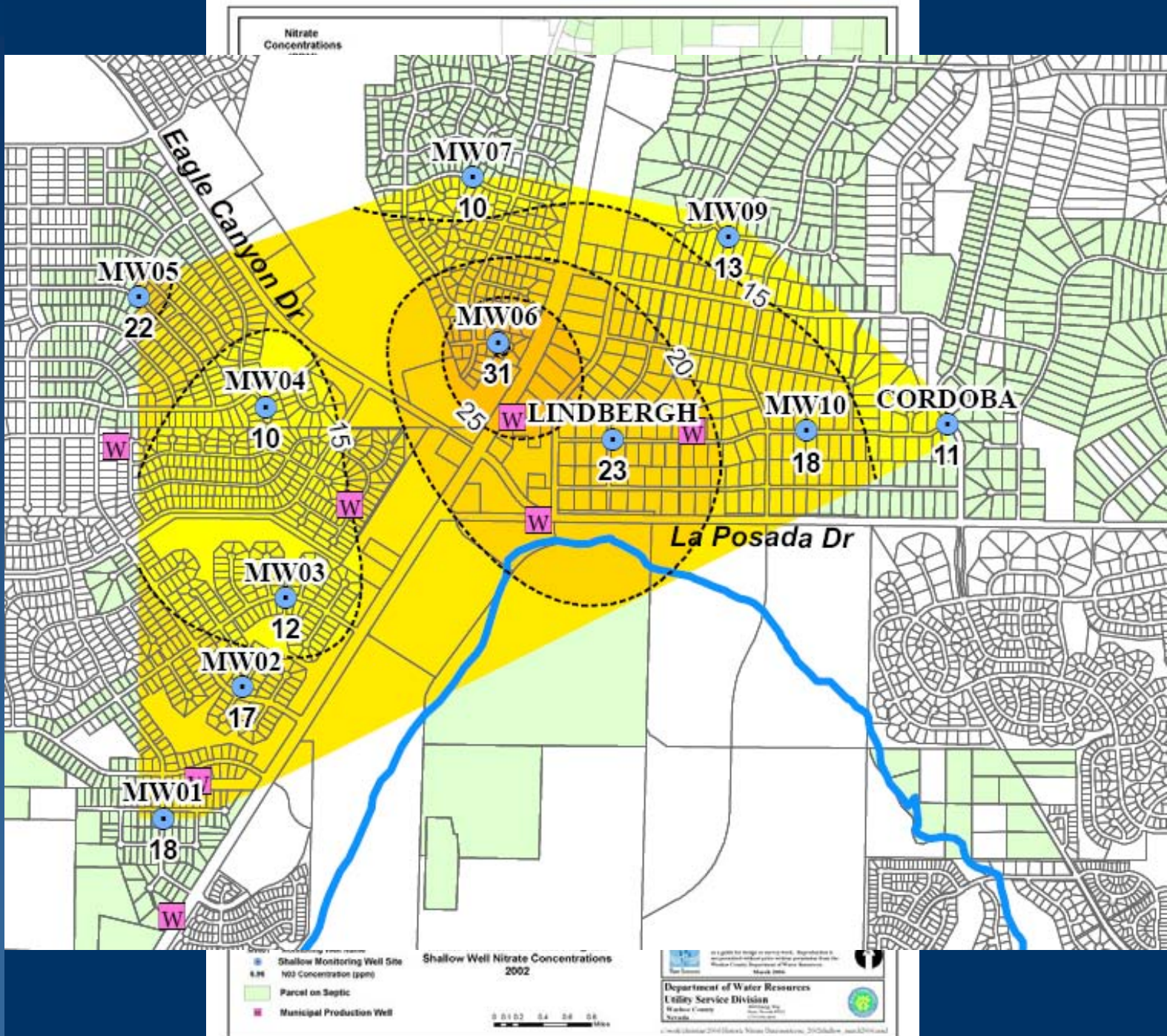


Conceptual Model



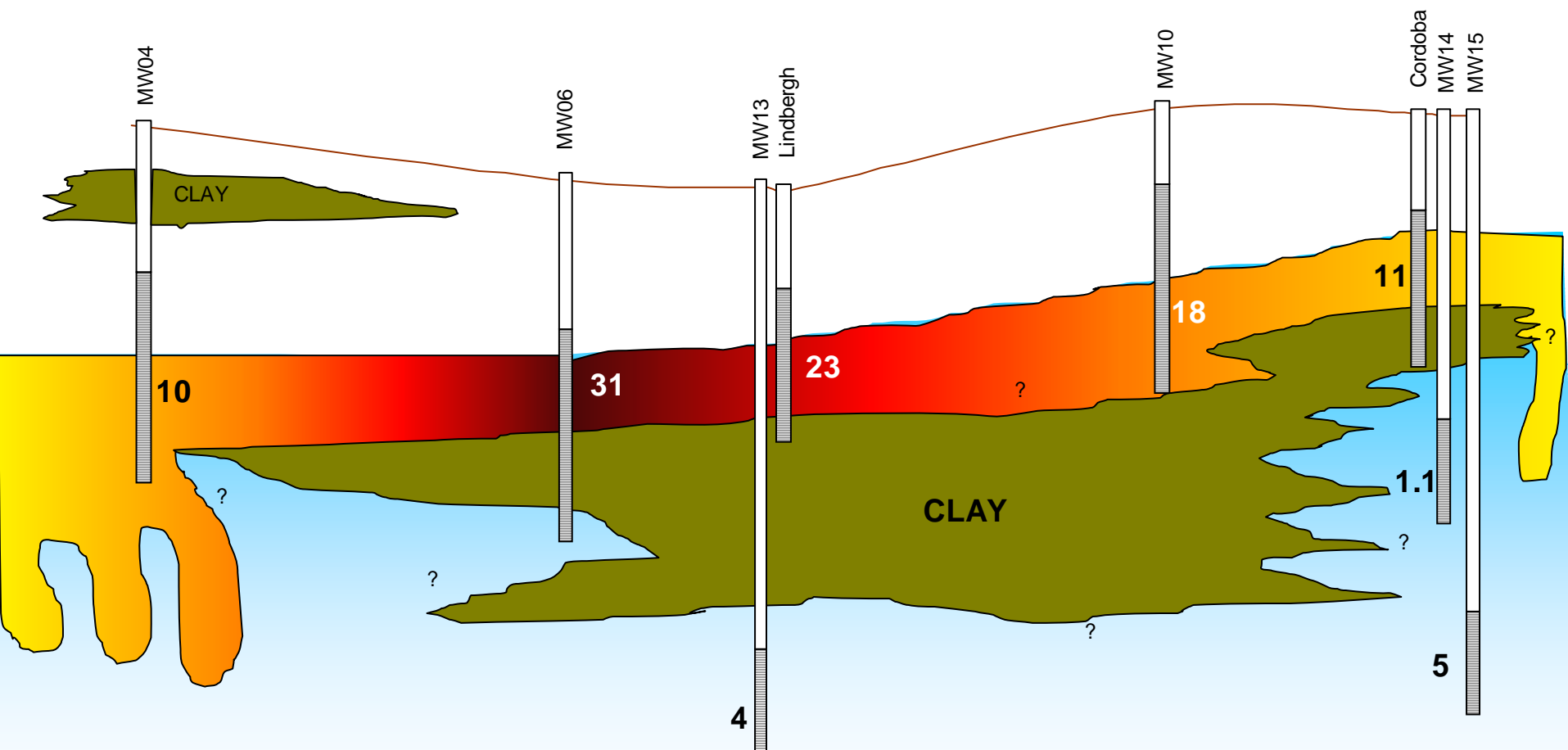


Initial Characterization



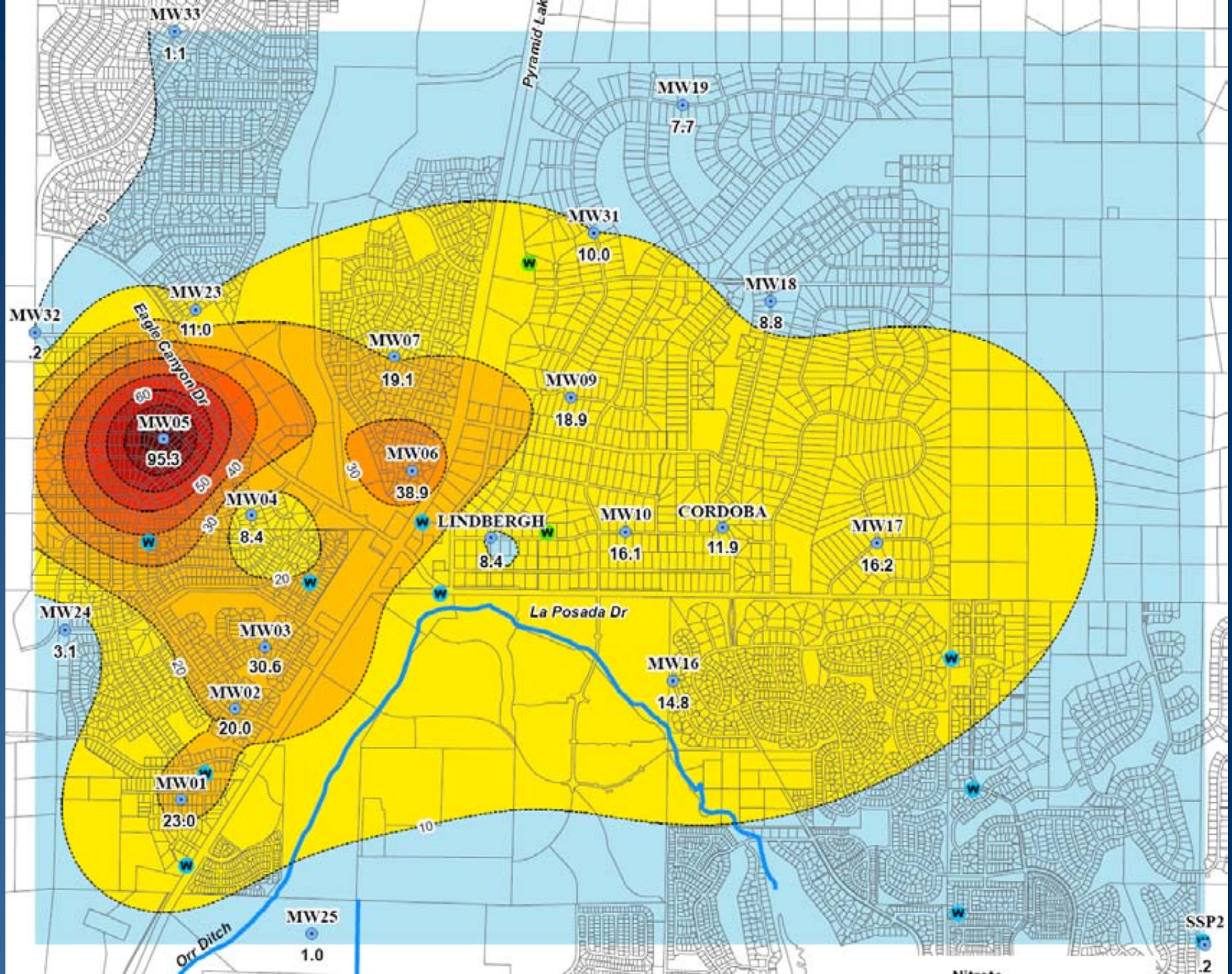
Reality Mimics Concept

E-W Cross Section Through Spanish Springs Valley



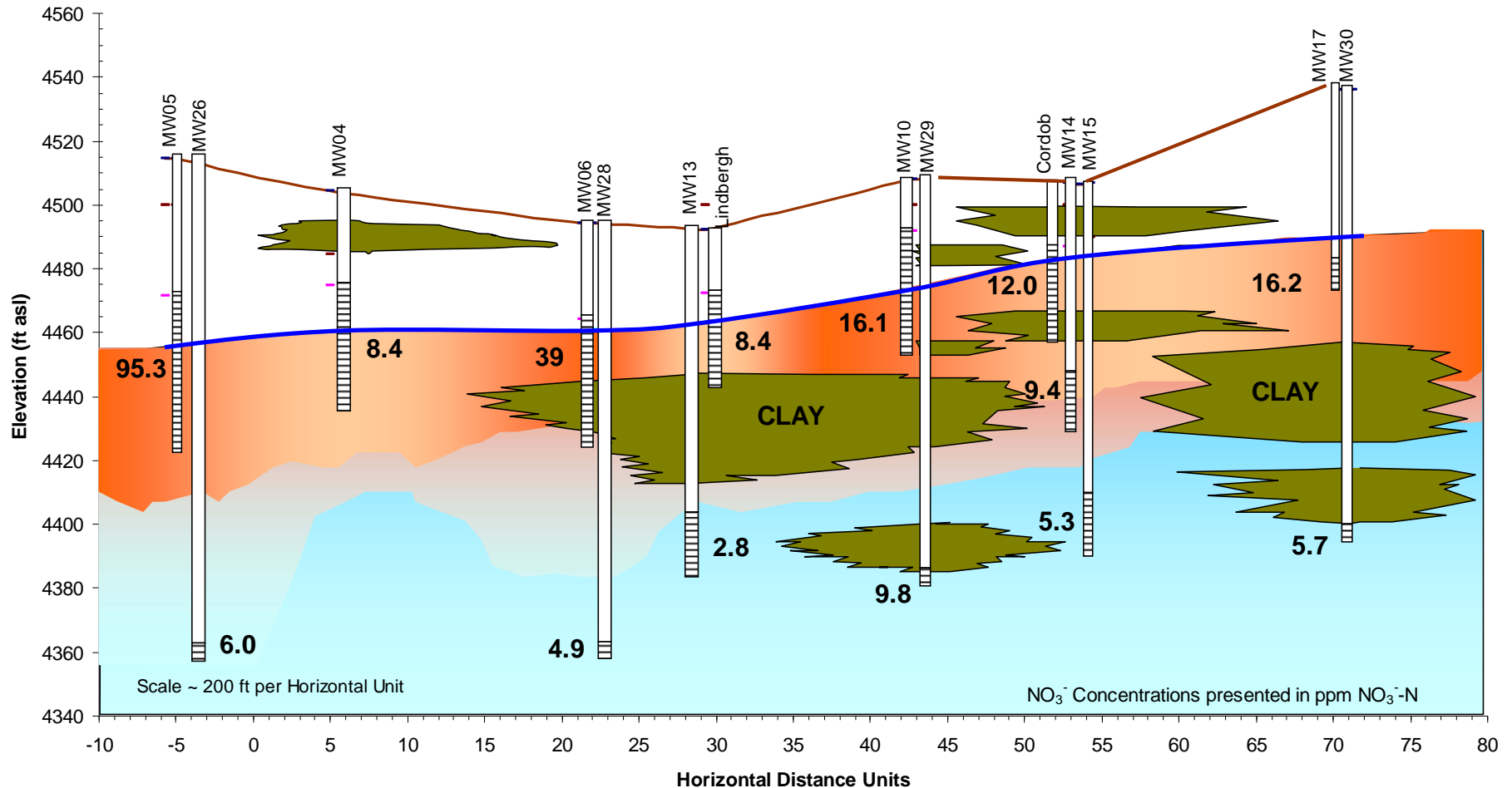
Scale ~ 170 ft per Horizontal Unit

NO₃⁻ Concentrations presented in ppm NO₃⁻-N



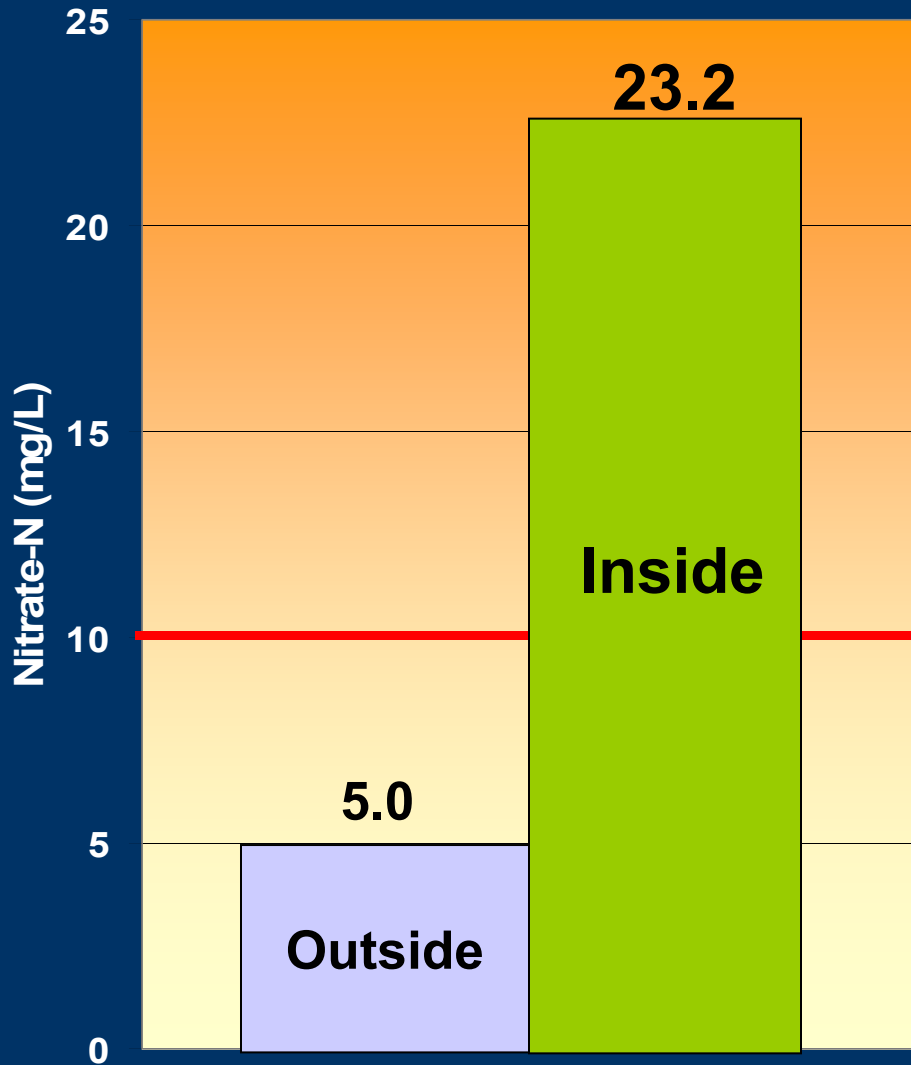
Reality Mimics Concept: Q3 2008

E-W Cross Section Through Spanish Springs Valley





Source Identification





Source ID

- 3 Homes
- 1 Park
- 1 School
- 49 Lysimeters
- 10 Neutron Holes
- 6 Monitor Wells
- 4 Flux Meters



Well ●
Lysimeter ■
Neutron ▲



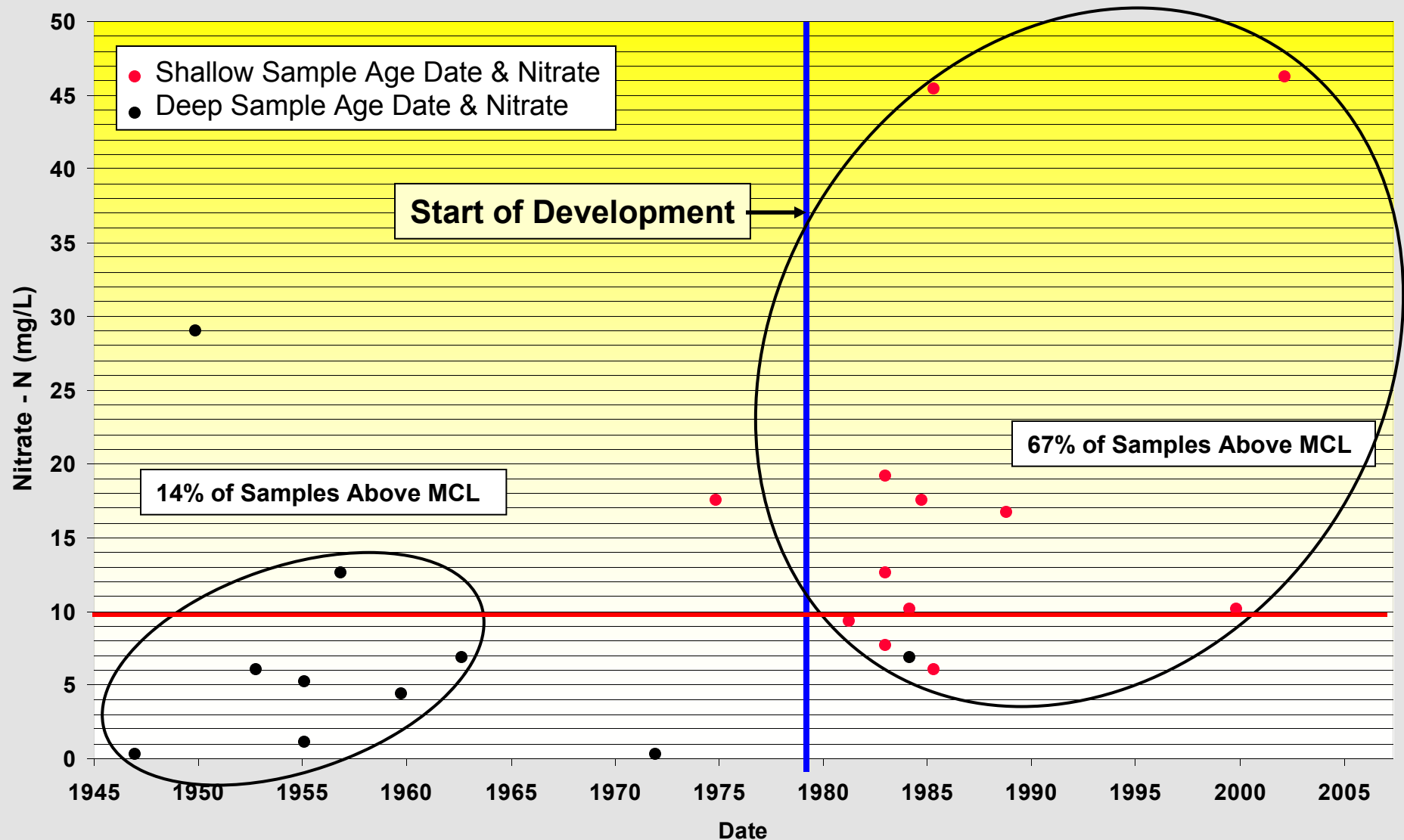
Nitrate Source Study



- Septic nitrate discharge from 1 to >500 mg/L as N
- Median value of 44 mg/L Nitrate-N similar to the range of published values for septic tanks
- Denitrification literature value of around 25% appears about right for Spanish Springs Valley septic tanks
- Approximately 30 tons of N per year is being conveyed to the aquifer from septic tanks

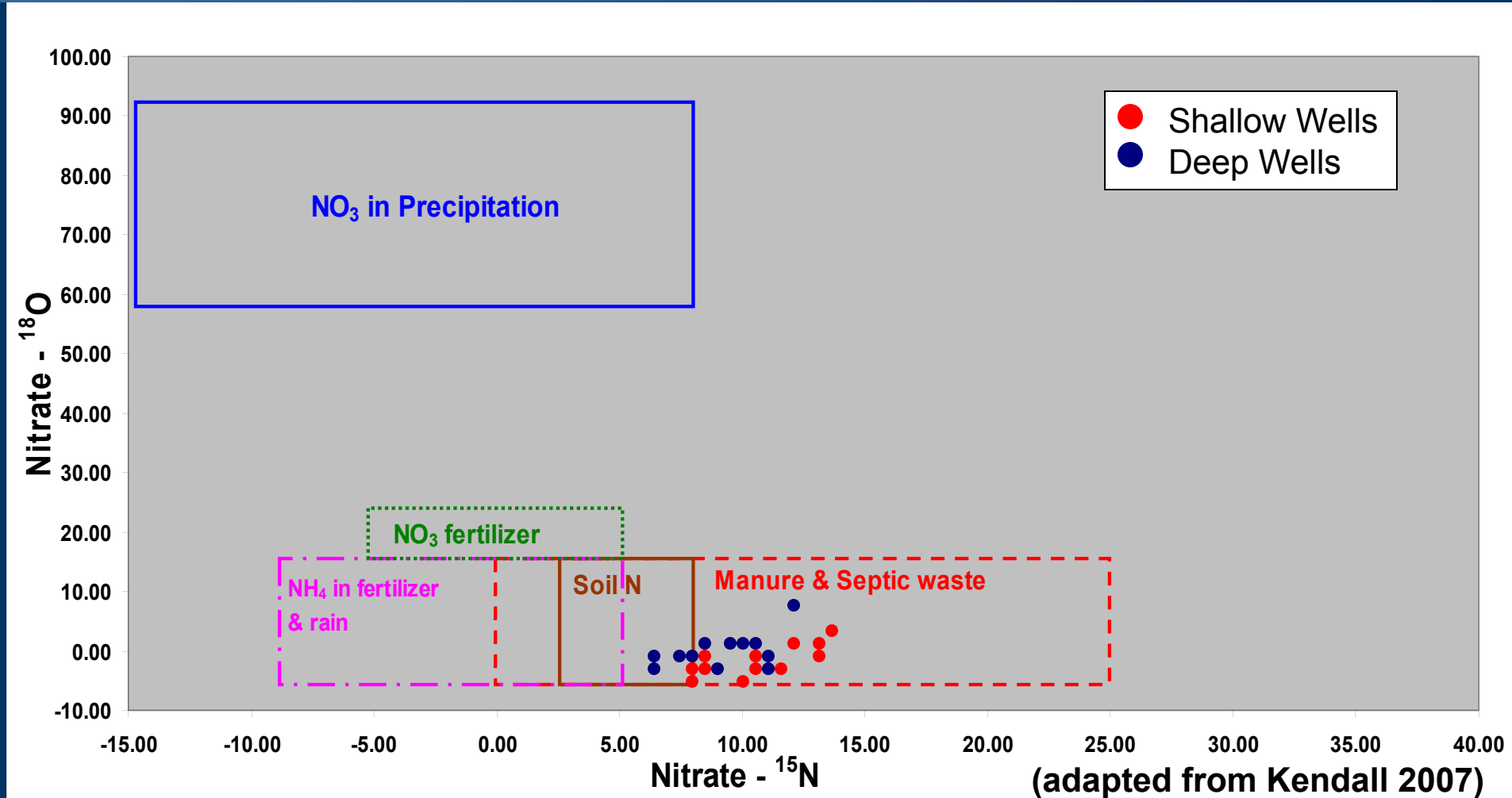


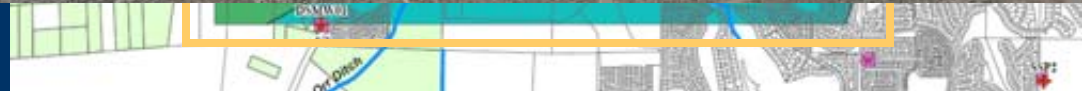
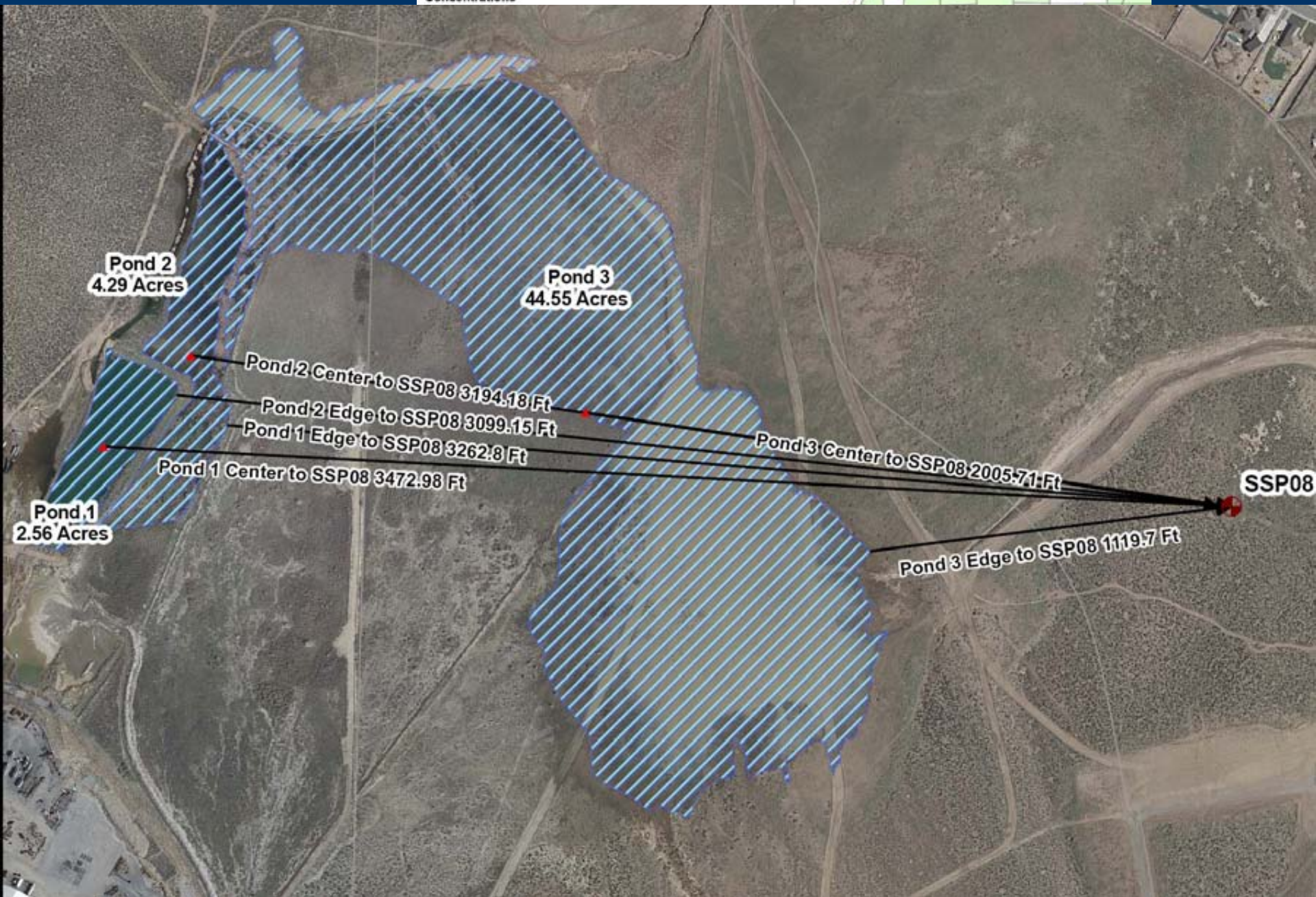
Source ID: NO₃ & GW Age Date





Source Identification: N and O Isotopes in Nitrate







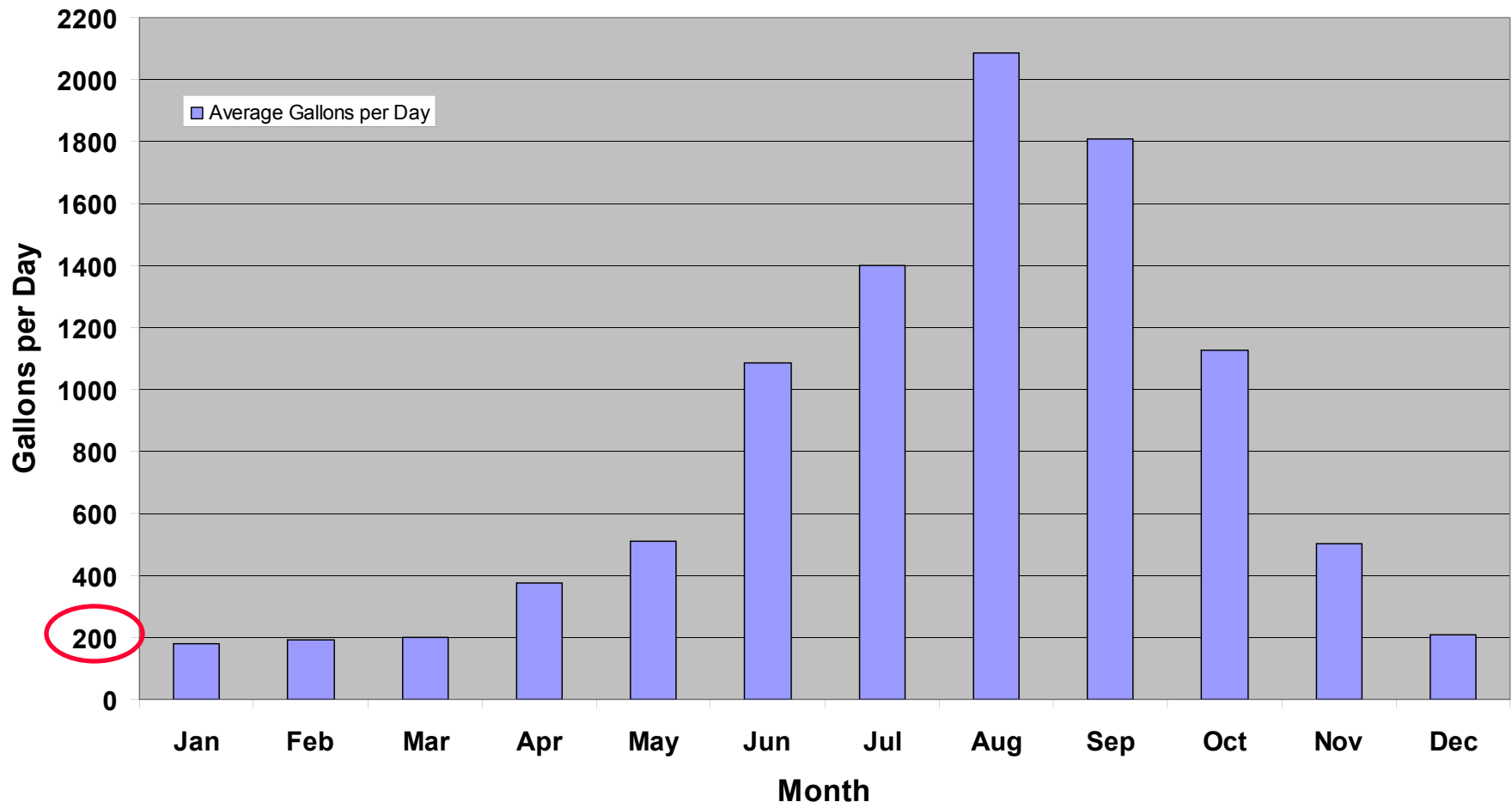
Source Magnitude

- 233 g/d/h from engineering estimate based on usage records
- 228 g/d/h from modeled estimate
- **INSIGHT!** Don't be afraid to recheck your data!
 - New data
 - New software
 - New processing ability



Source Magnitude: Recheck

SSV Septic Users Gallons per Day per House



Vadose Zone Nitrate Transport Models



SIMULATION

- Modeled from soil cores
- 230 gal/day/house
- 44 mg/L Nitrate-N applied
- Accounts for precipitation and soil moisture
- Accounts for naturally occurring Nitrate in subsurface

RESULTS

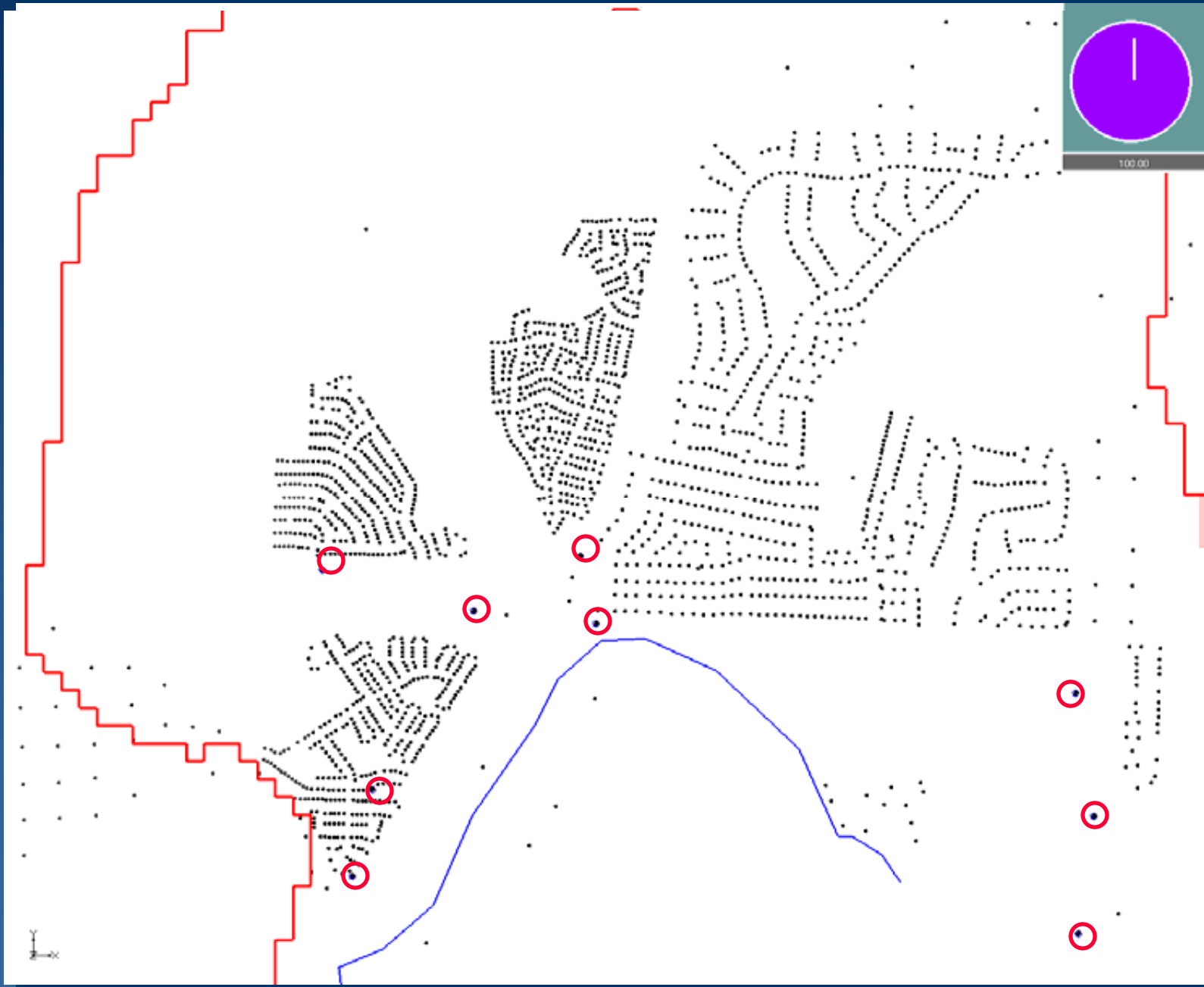
- 2-3 yrs for leading edge
- 6-10 yrs for max concentration

Nitrate - N (mg/L)





Groundwater Nitrate Transport Models





Expanding the Scope of Investigation County-Wide

- Septics
- Wells
 - Municipal, monitoring, domestic
- Depth to Water
- Geology
- Concentration (Nitrate and others)
- Precipitation

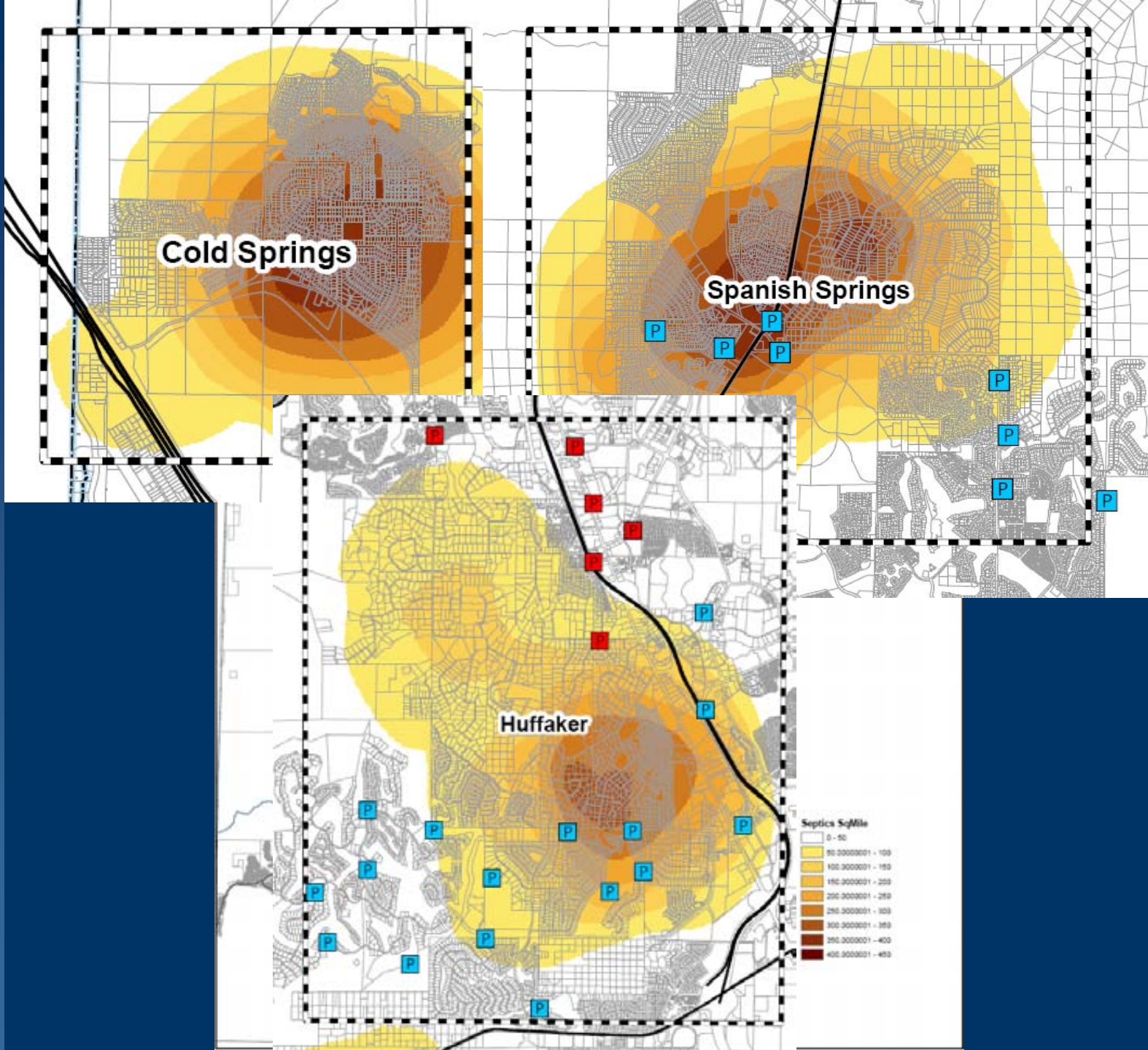
GIS-Based
Regional
Risk
Assessment



Regional Risk Assessment

- Literature review & compile data & data gaps
- ID potential areas of concern (Project Areas)
- Prioritize Project Areas for further study
- 79% - 95% of all septic systems in a basin were found in these individual Project Areas
- Densities ranged from 50 – 350 septics/mile²
- High Risk = High septic density, Shallow depth to water, Shortest distance to sensitive receptors

Septic Nitrate Project Areas



Methods: Septic Density



Basin Stats

Septics: 1,397

Area: 29.5 mi²

Density: 47/mi²

NV Limit: 92 /mi²

Project Area

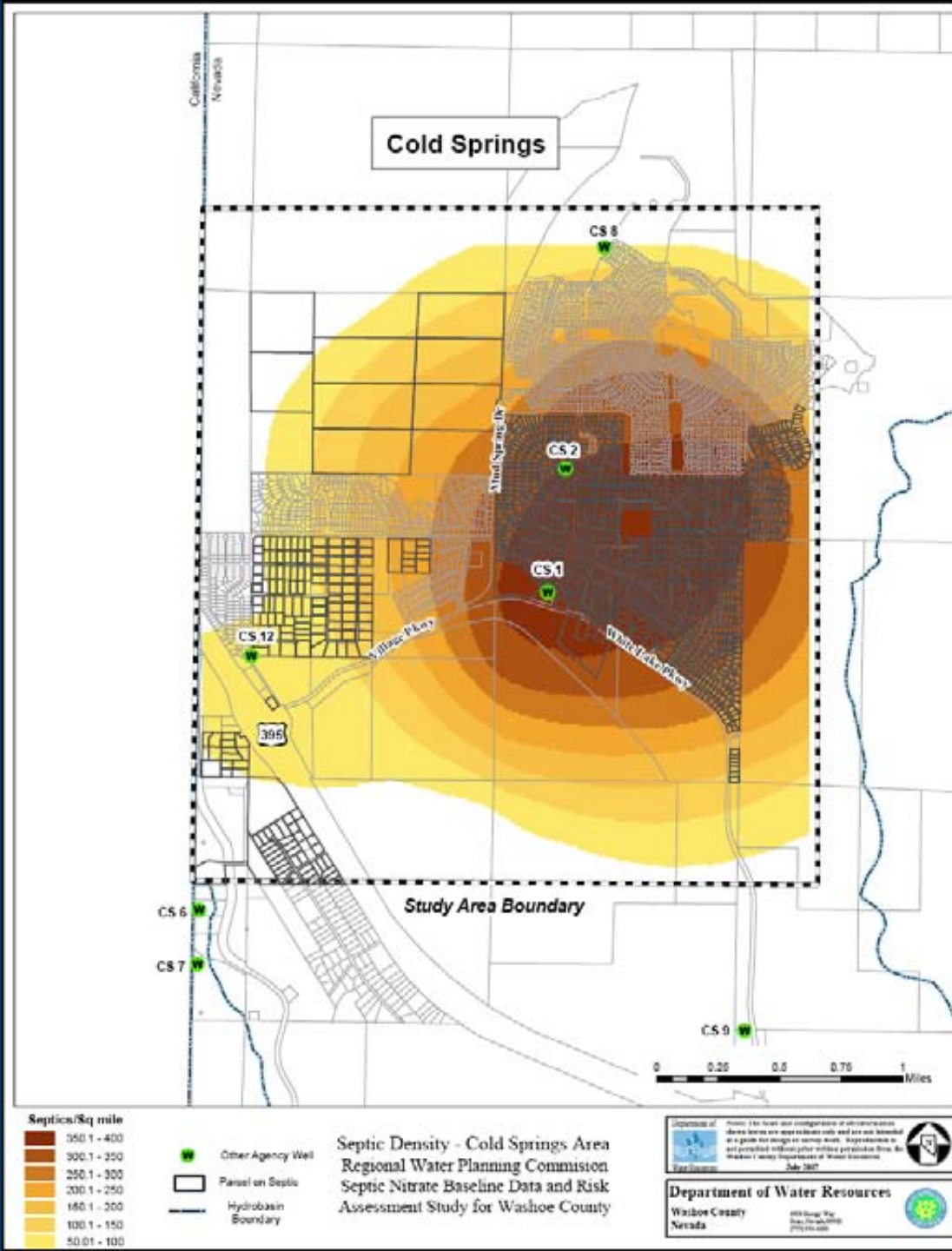
Septics: 1,325

Area: 7.5 mi²

Density: 177/mi²

Max D: 350 /mi²

NV Limit: 92 /mi²



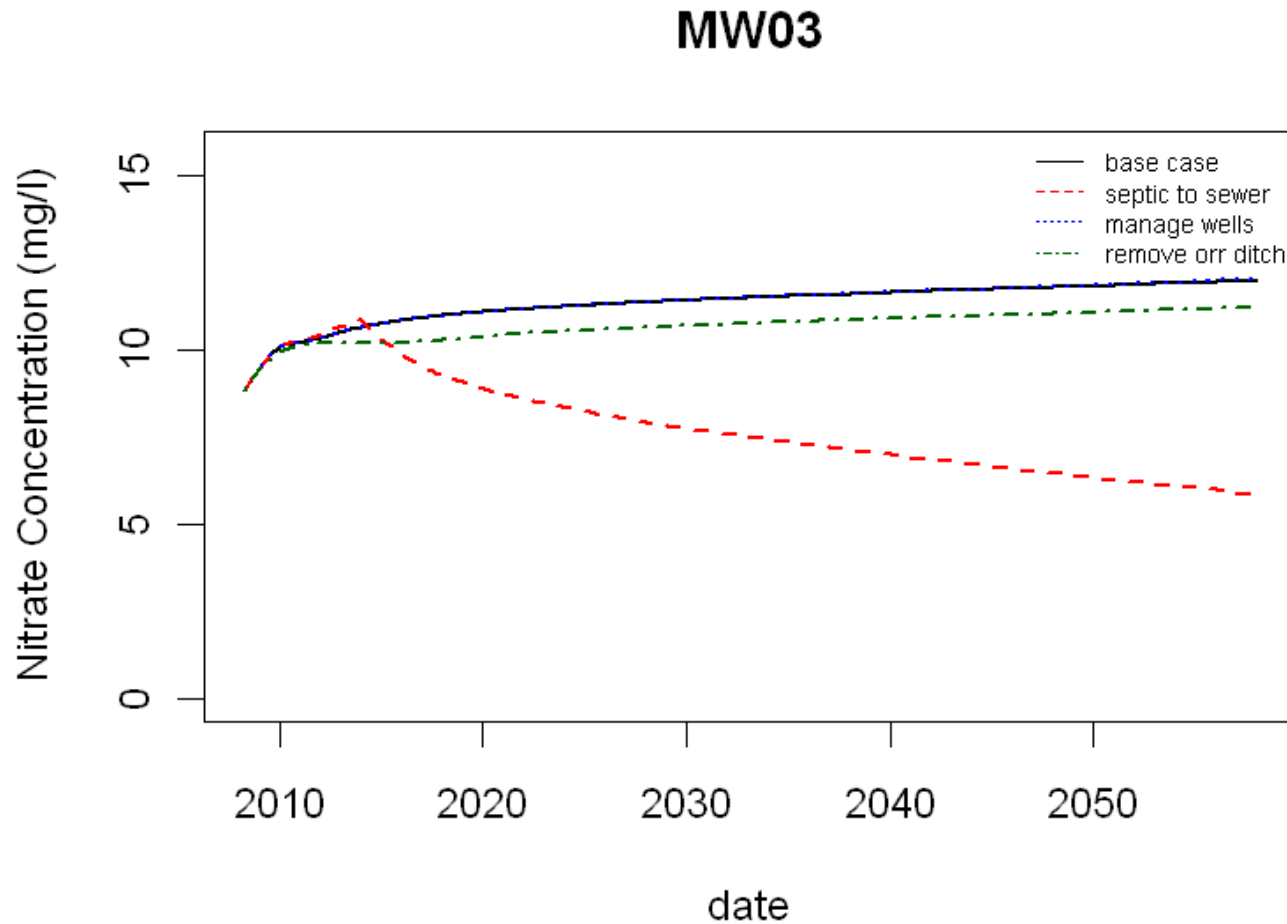


Potential Solutions

- Continue monitoring of past projects
- Baseline Dataset Creation
 - Fill data gaps, DTW, water quality (PPCP's)
- ASR or at least Recharge to dilute nitrate
- No more RIBs
- Watering restrictions / efficiency
- Phased sewers through remediation district
- NO MORE HIGH DENSITY SEPTICS!



Potential (THE!) Solution



Questions?

