Nitrate Contamination: Tools, Insights, and Potential Solutions

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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

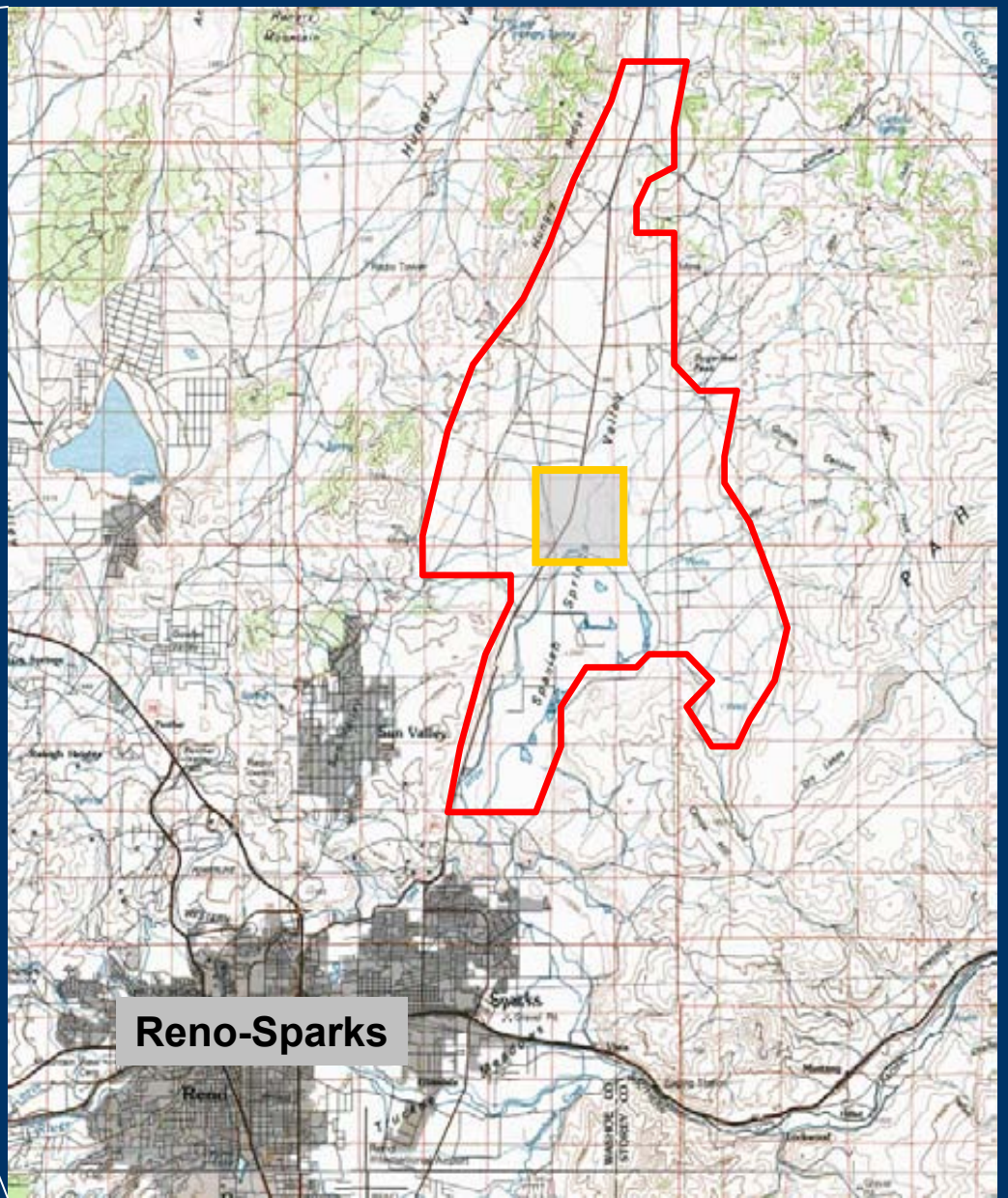
- Methemoglobinemia (blue-baby syndrome):
  blood lacks the ability to carry oxygen throughout the body - especially in infants

- Others: non-Hodgkin's lymphoma, gastric cancer, hypertension, thyroid disorder and birth defects.

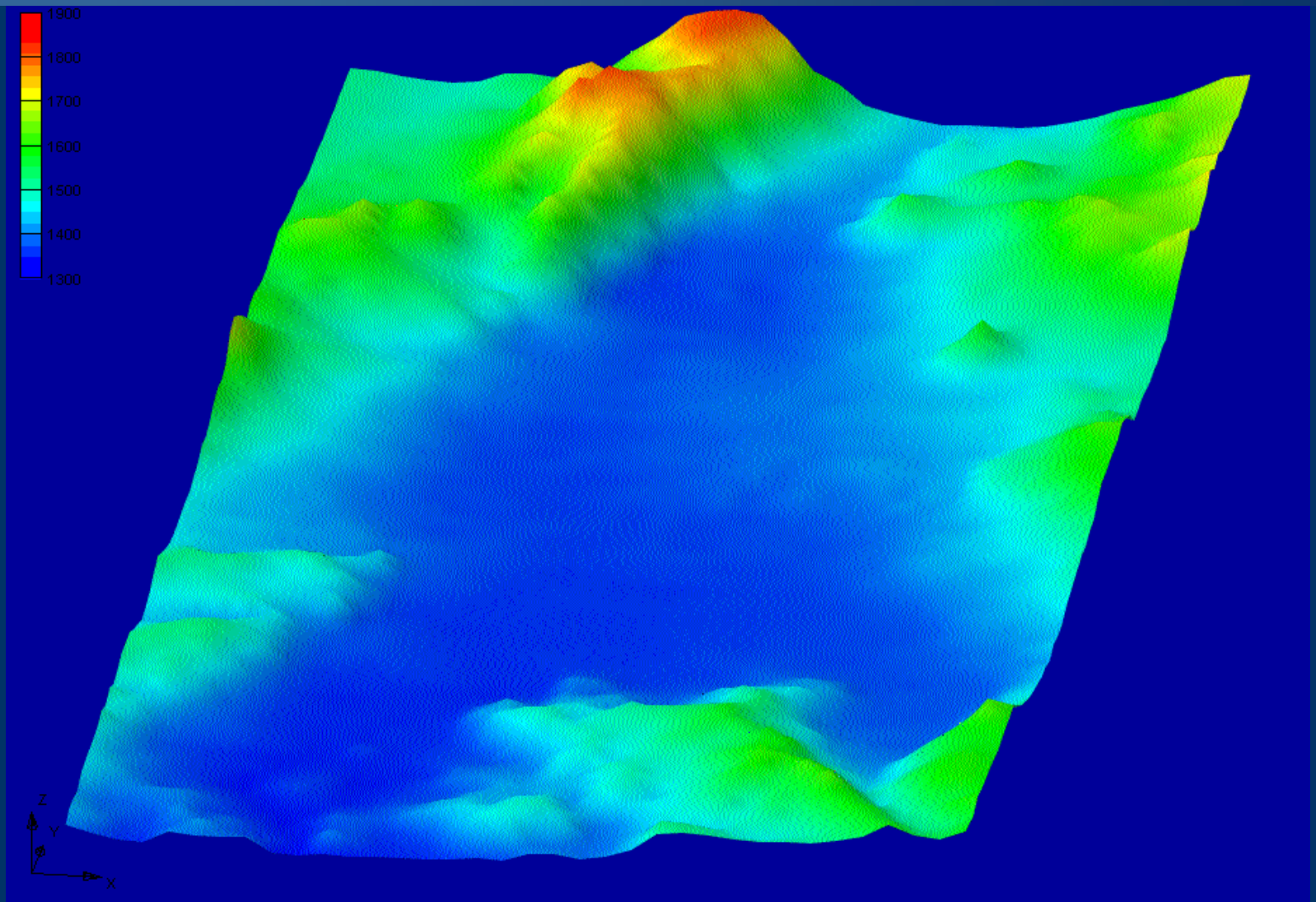
- Indicator contaminant: bacterial, viral, and pharmaceutical contamination

Location Map

Site Description



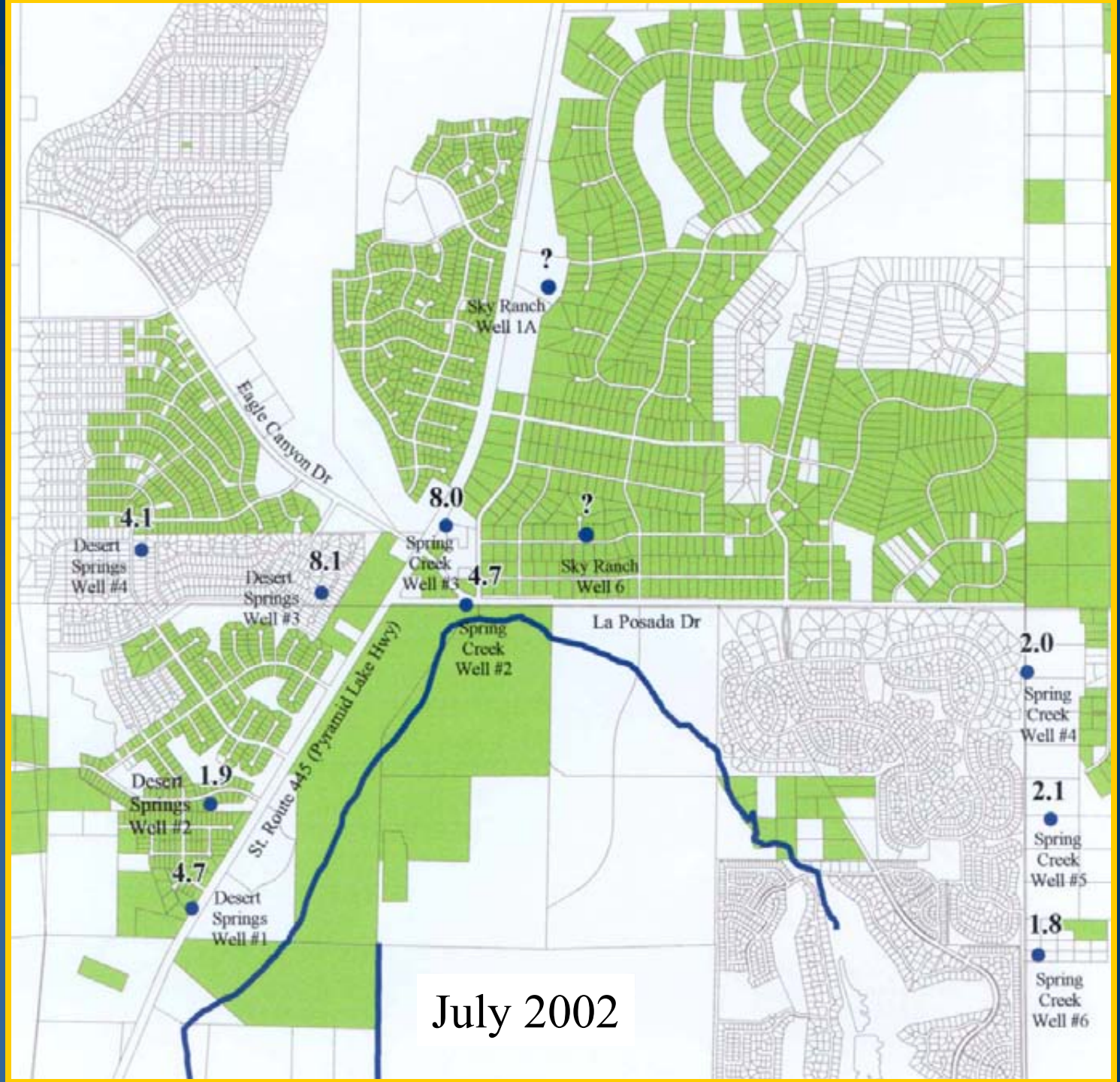
Spanish Springs Valley



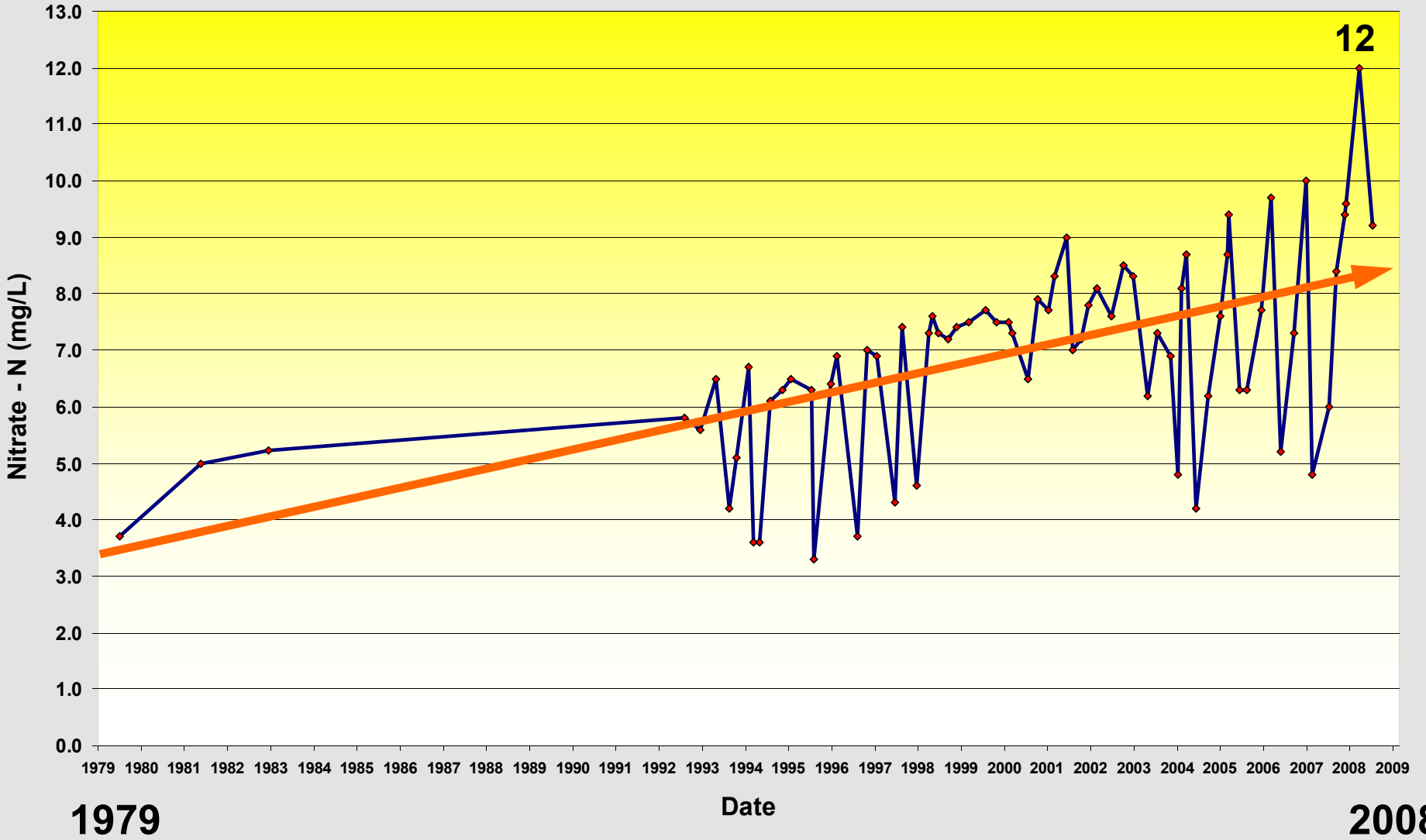
Recipe for Contamination

- 2,000+ homes on septic
- ½ within 2,000 ft of municipal wells
- Increasing nitrate concentrations
- Letter from the NDEP

Previous Condition



Municipal Well Contamination



Characterization Tool Kit

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

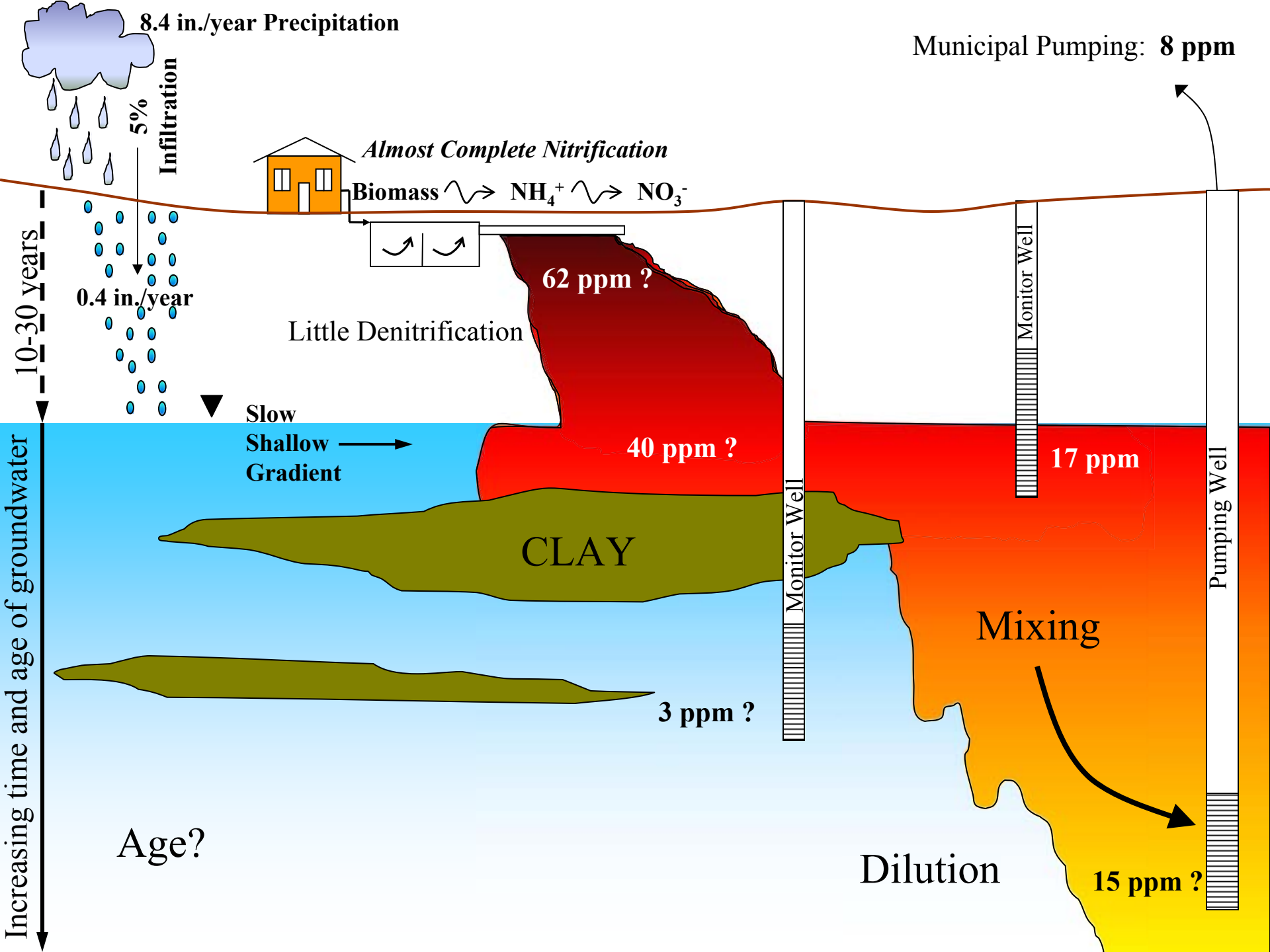
Team Members

- 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

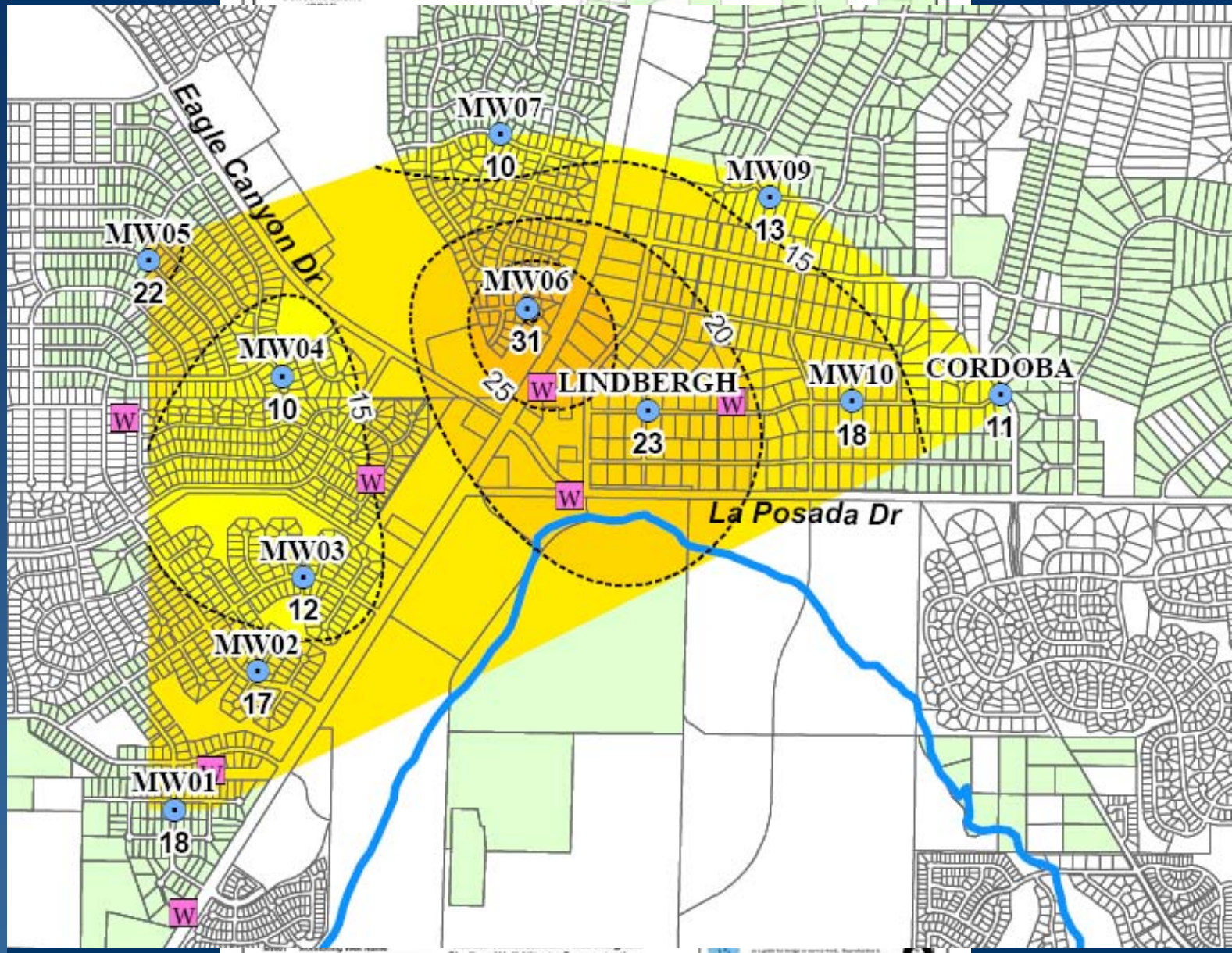
Software

- 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

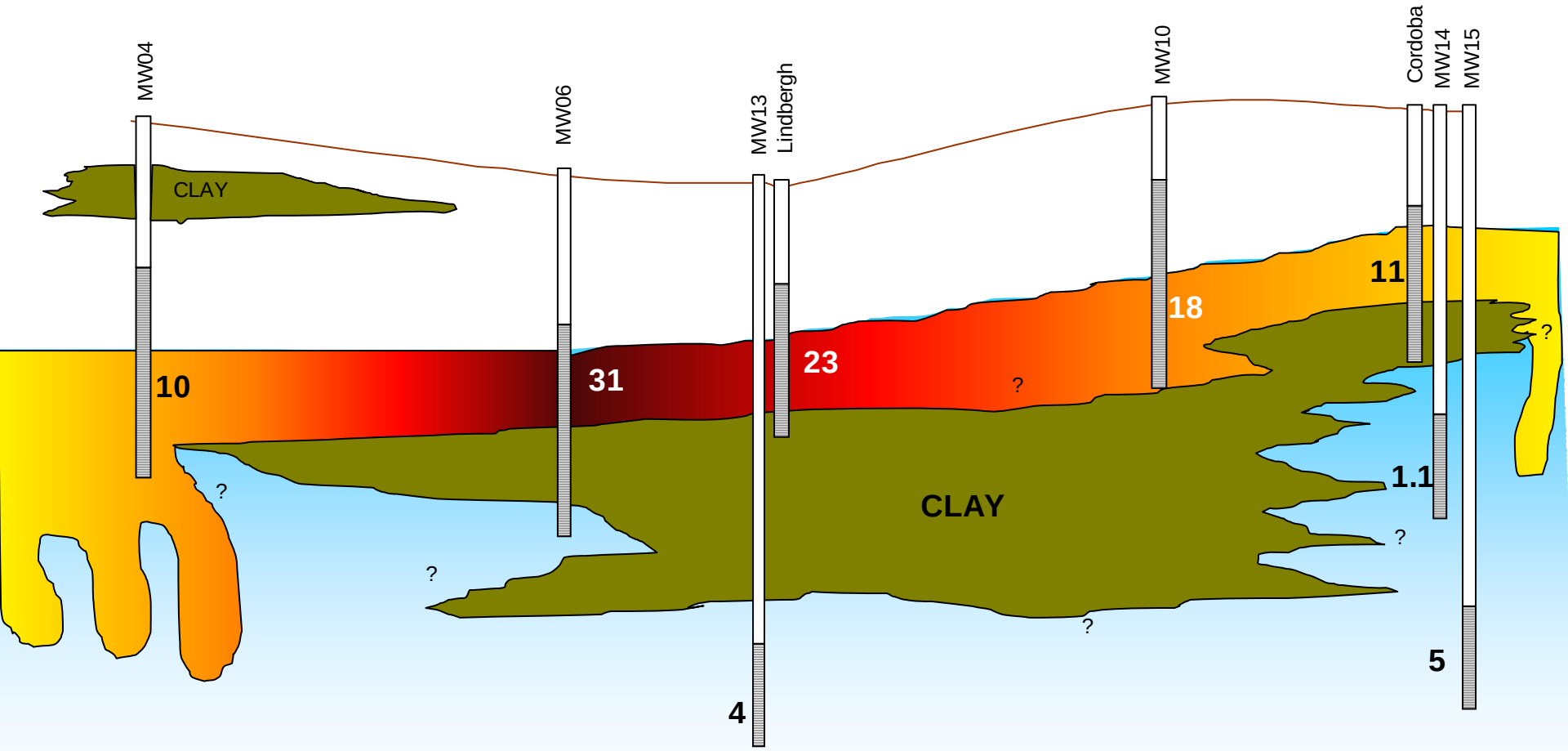

8.4 in./year Precipitation
5% Infiltration
0.4 in./year
10-30 years
Increasing time and age of groundwater
Municipal Pumping: 8 ppm
Almost Complete Nitrification
Biomass
NH_4^+
NO_3^-
Little Denitrification
62 ppm ?
Slow
Shallow
Gradient
40 ppm ?
17 ppm
CLAY
Monitor Well
Monitor Well
Pumping Well
Mixing
3 ppm ?
Age?
Dilution
15 ppm ?

Initial Characterization



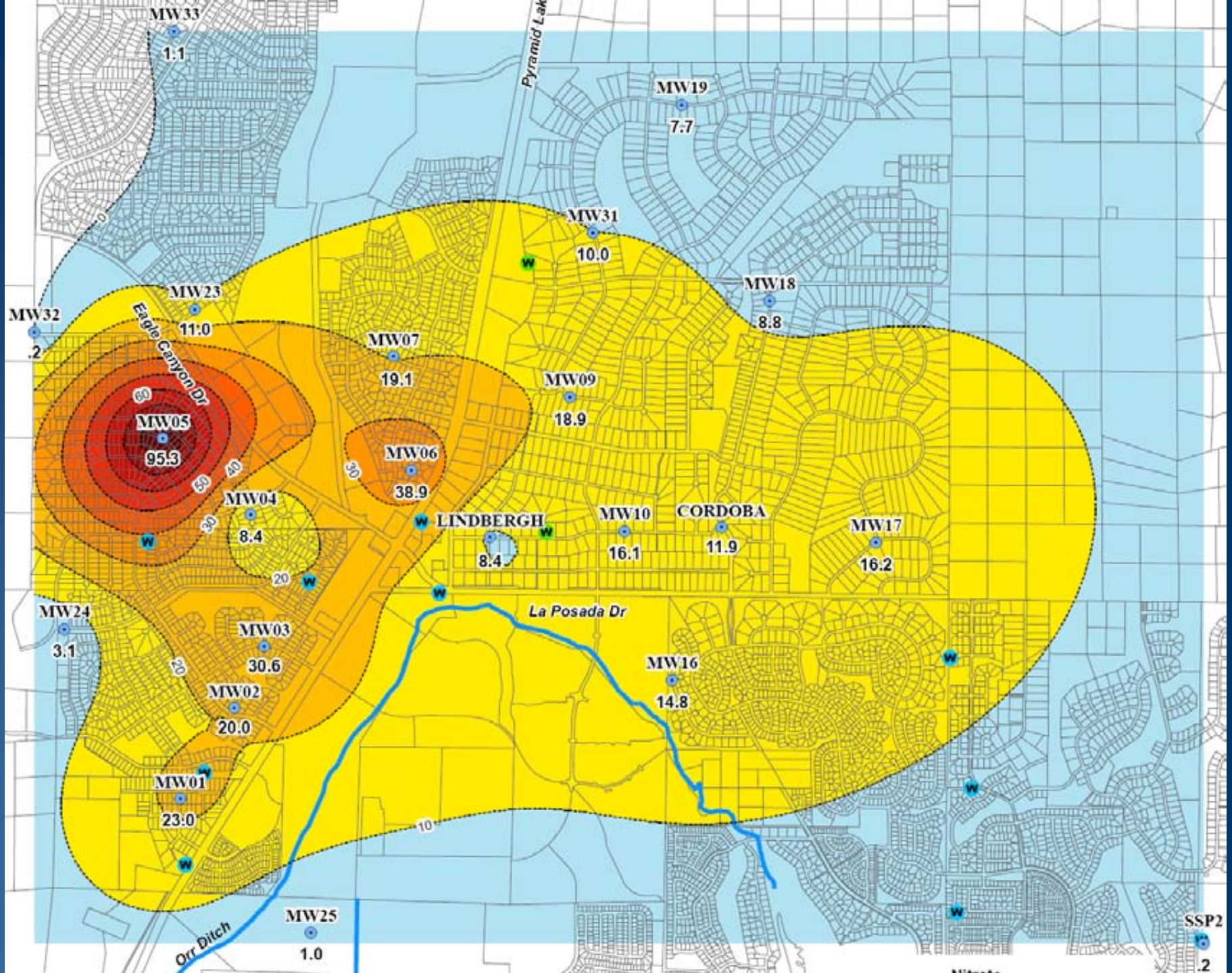
Reality Mimics Concept

E-W Cross Section Through Spanish Springs Valley



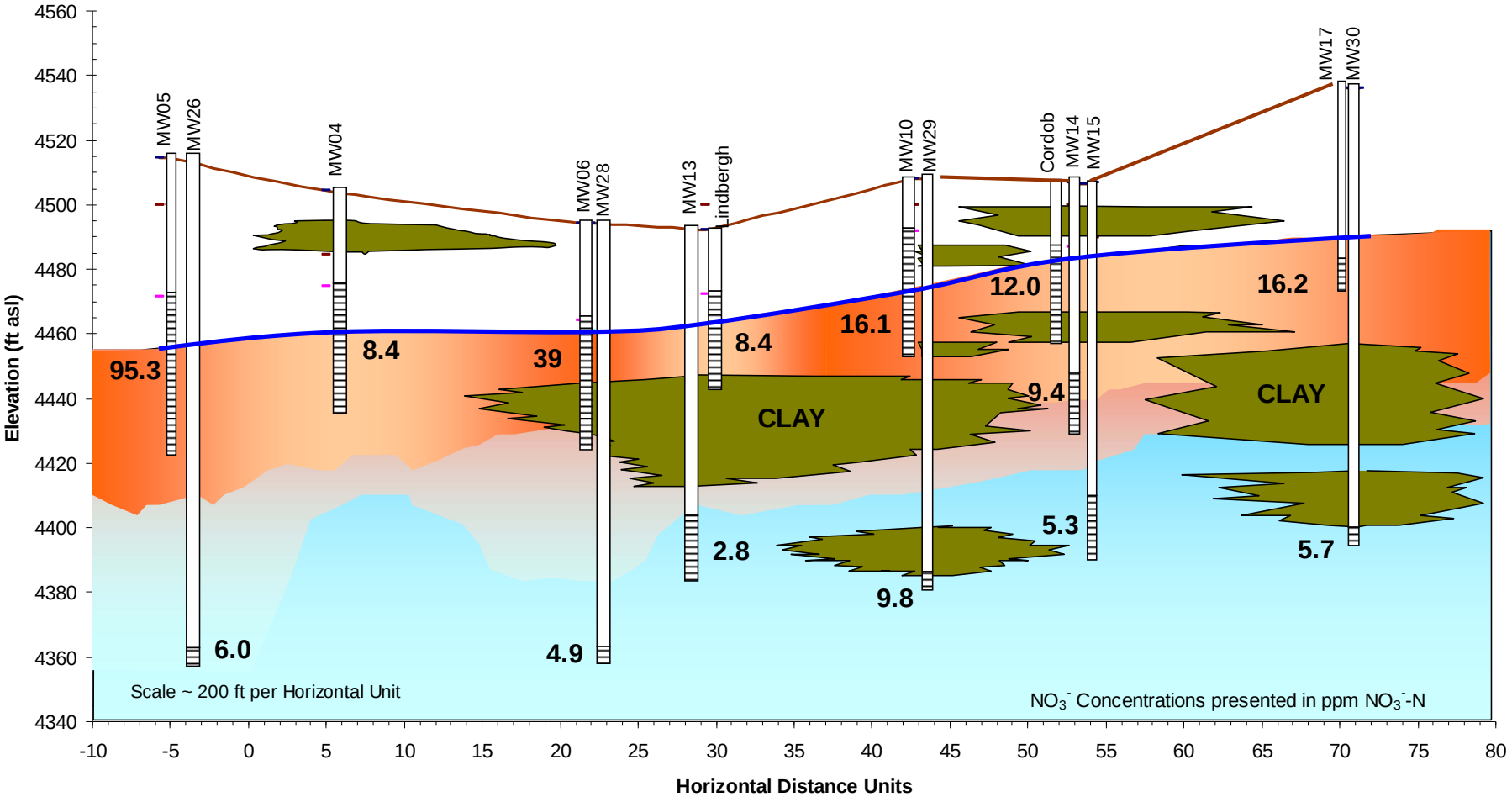
Scale ~ 170 ft per Horizontal Unit

NO_3^- Concentrations presented in ppm NO_3^--N

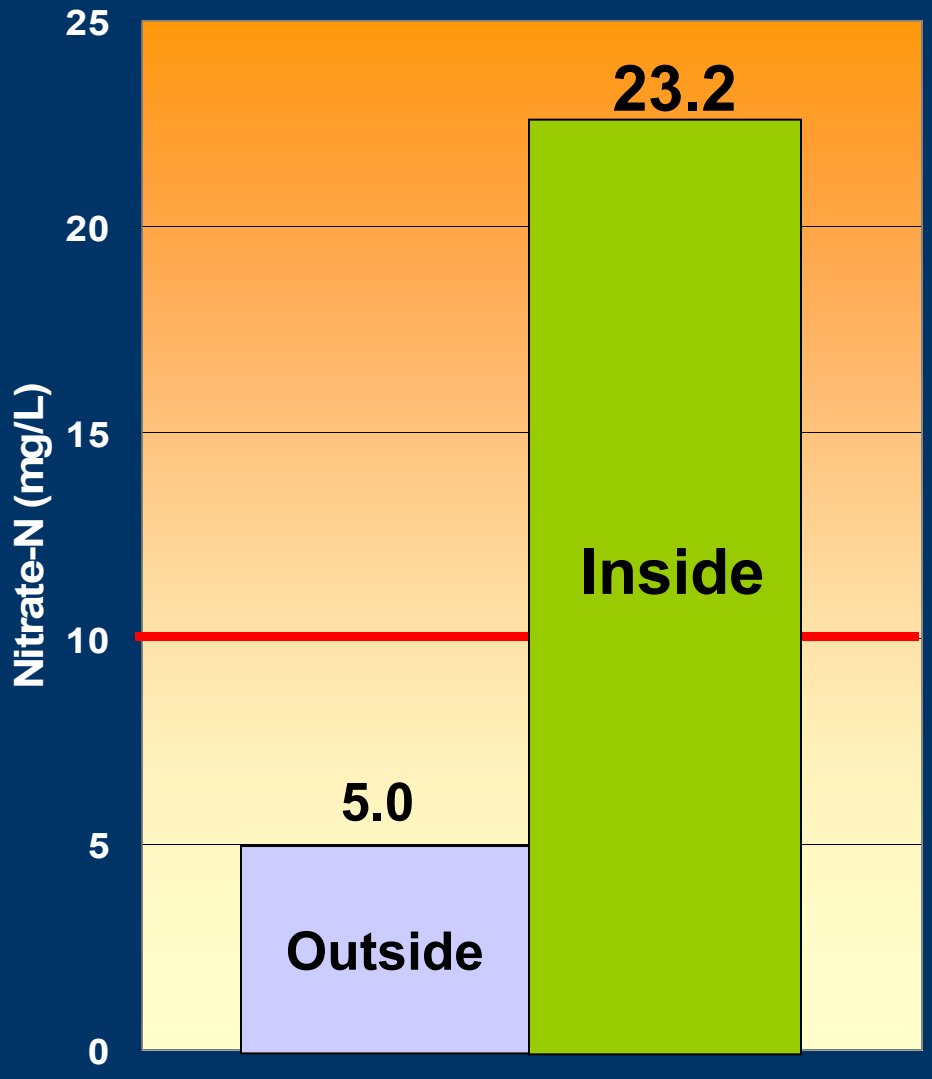

MW33
1.1
Pyramid Lake
MW19
7.7
MW31
10.0
MW18
8.8
MW32
.2
MW23
11.0
Eagle Canyon Dr
MW07
19.1
MW09
18.9
MW05
95.3
MW06
38.9
MW04
8.4
LINDBERGH
8.4
MW10
16.1
CORDOBA
11.9
MW17
16.2
La Posada Dr
MW24
3.1
MW03
30.6
MW16
14.8
MW02
20.0
MW01
23.0
MW25
1.0
Orr Ditch
SSP2
.2
60
50
40
30
20
90
10

Reality Mimics Concept: Q3 2008

E-W Cross Section Through Spanish Springs Valley



Source Identification



Source ID

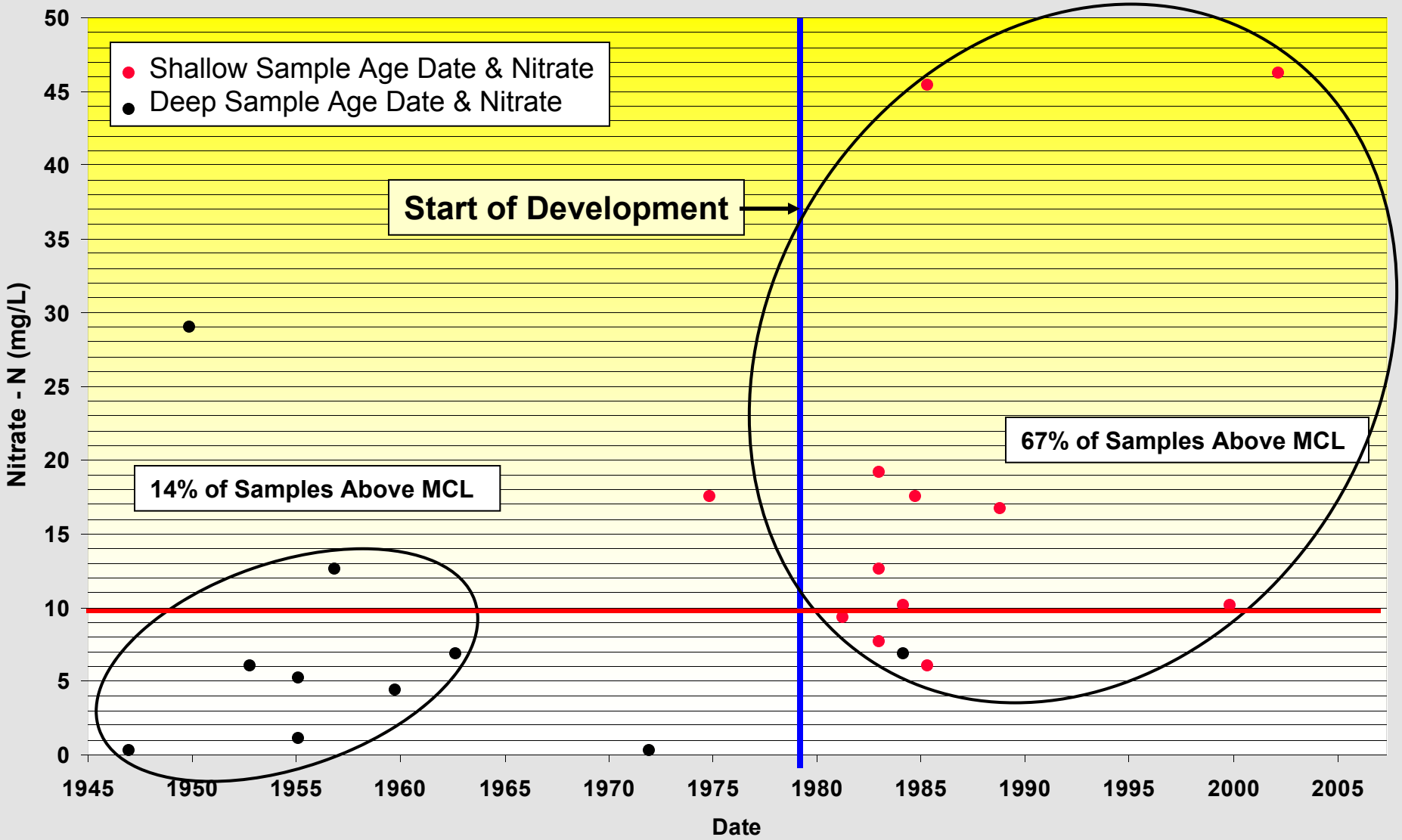
- 3 Homes
- 1 Park
- 1 School

- 49 Lysimeters
- 10 Neutron Holes
- 6 Monitor Wells
- 4 Flux Meters

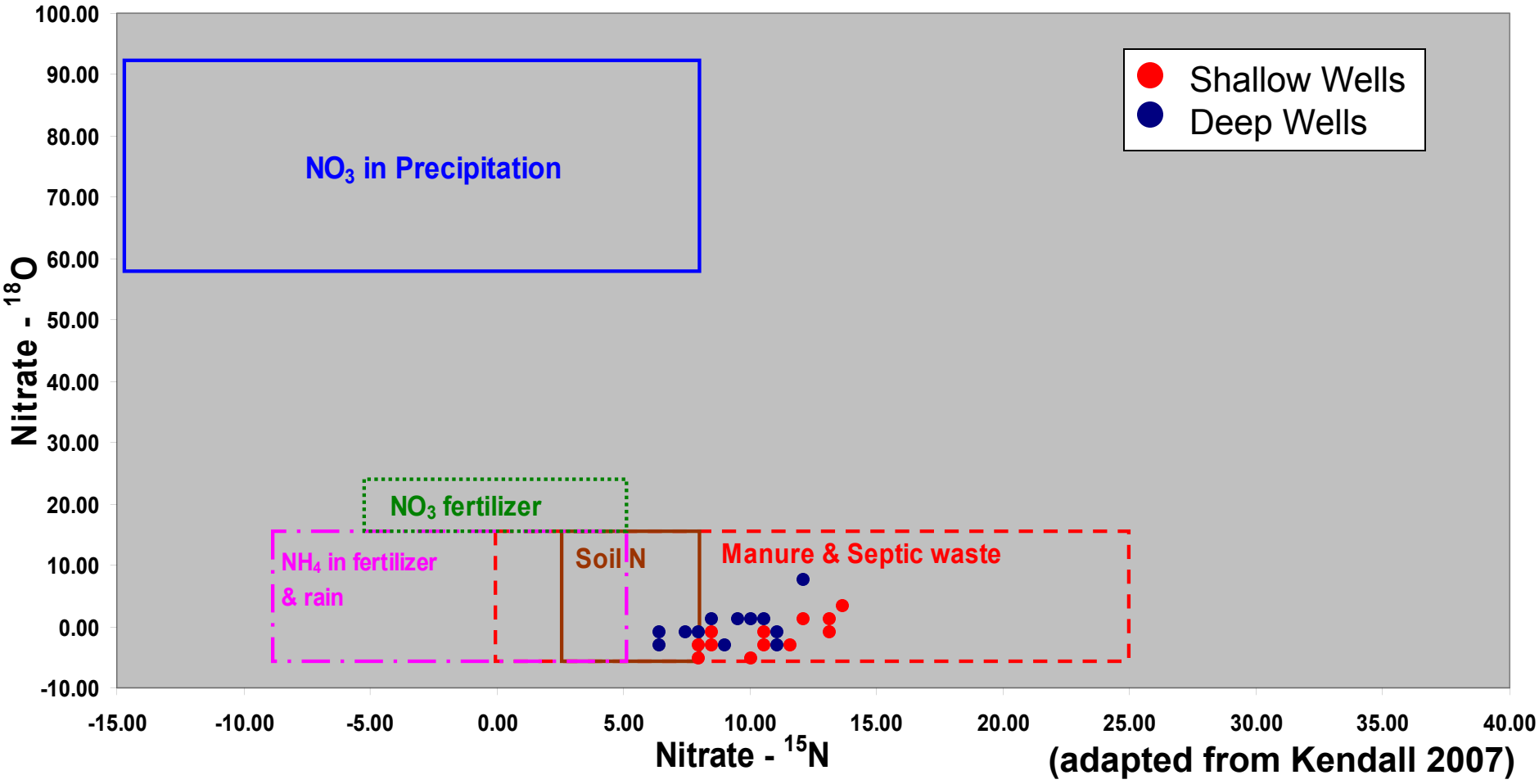
Nitrate Source Study

- 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: NO_3 & GW Age Date



Source Identification: N and O Isotopes in Nitrate



(adapted from Kendall 2007)

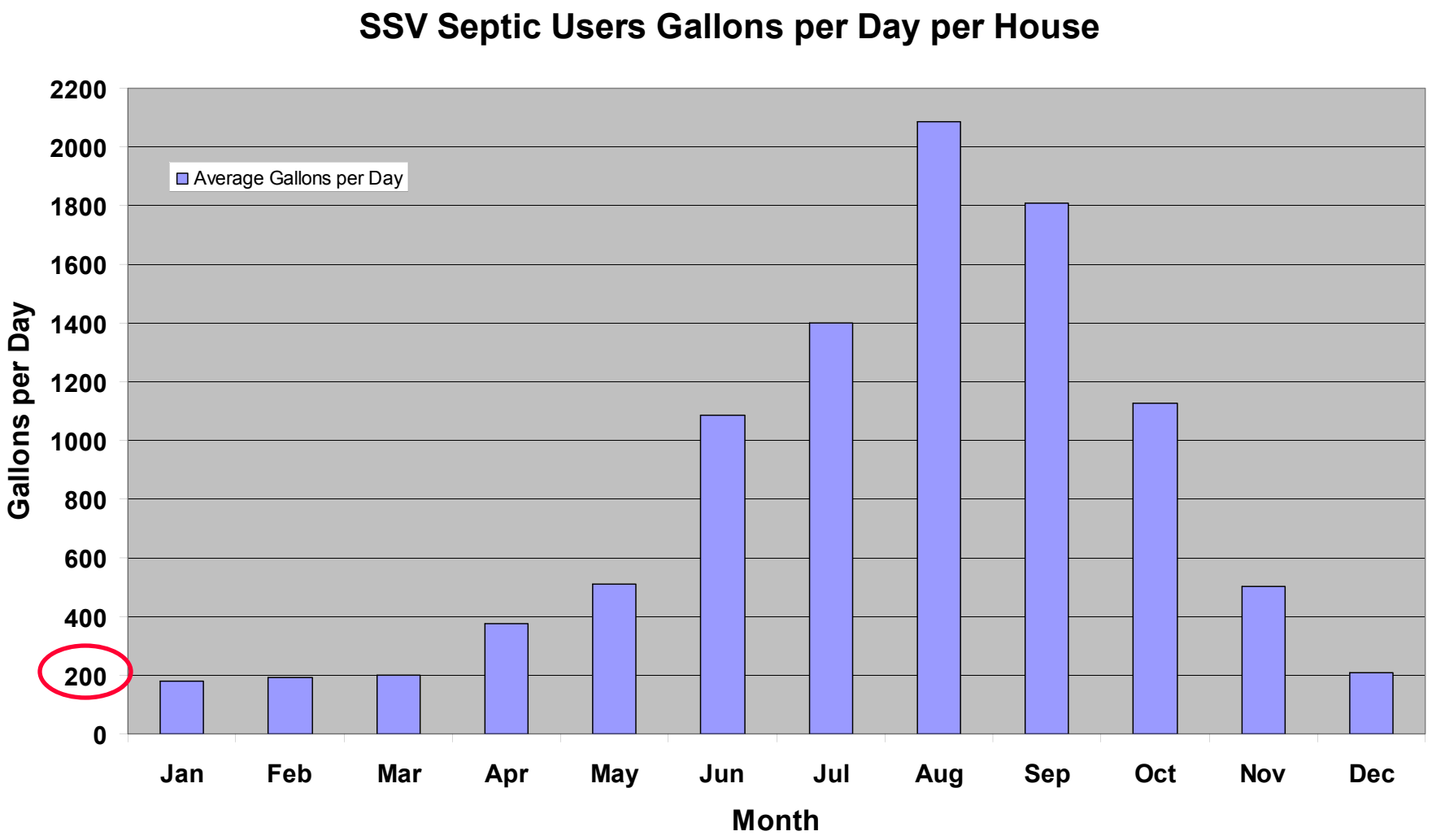

Nitrate
Concentrations
Pond 2
4.29 Acres
Pond 3
44.55 Acres
Pond 2 Center to SSP08 3194.18 Ft
Pond 2 Edge to SSP08 3099.15 Ft
Pond 1 Edge to SSP08 3262.8 Ft
Pond 1 Center to SSP08 3472.98 Ft
Pond 3 Center to SSP08 2005.71 Ft
Pond 3 Edge to SSP08 1119.7 Ft
SSP08
Pond 1
2.56 Acres

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



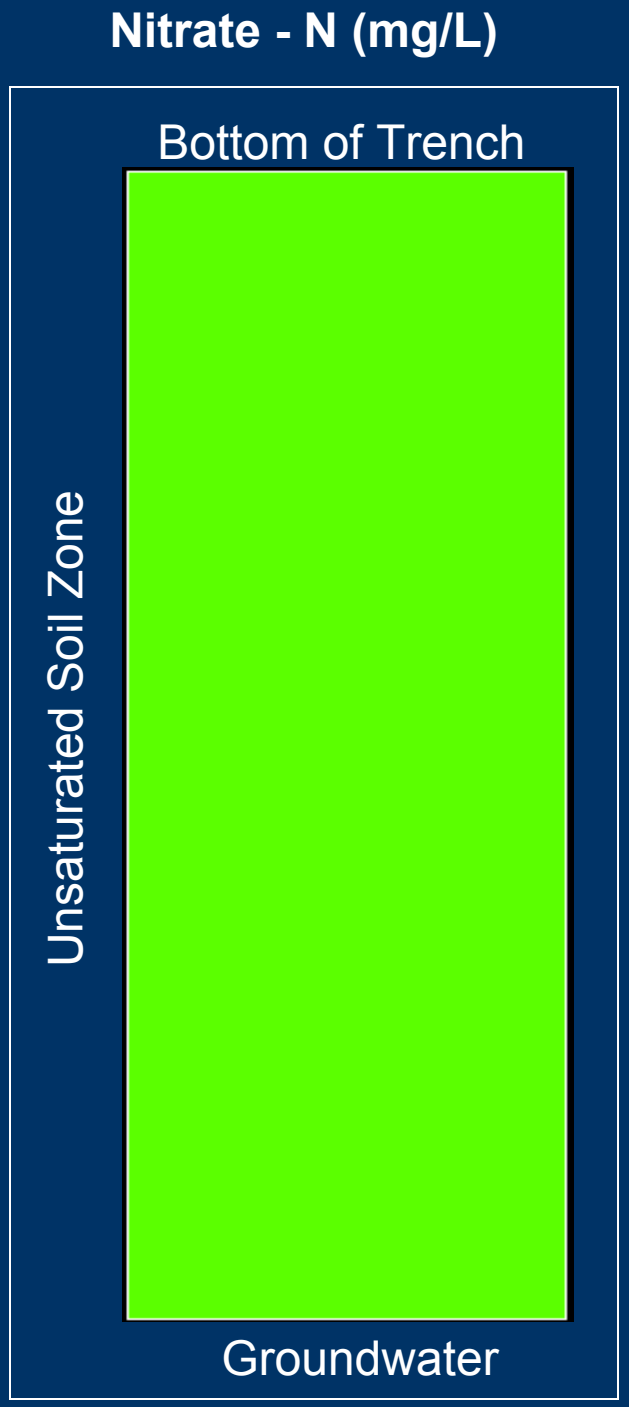
Vadose Zone Nitrate Transport Models

SIMULATION

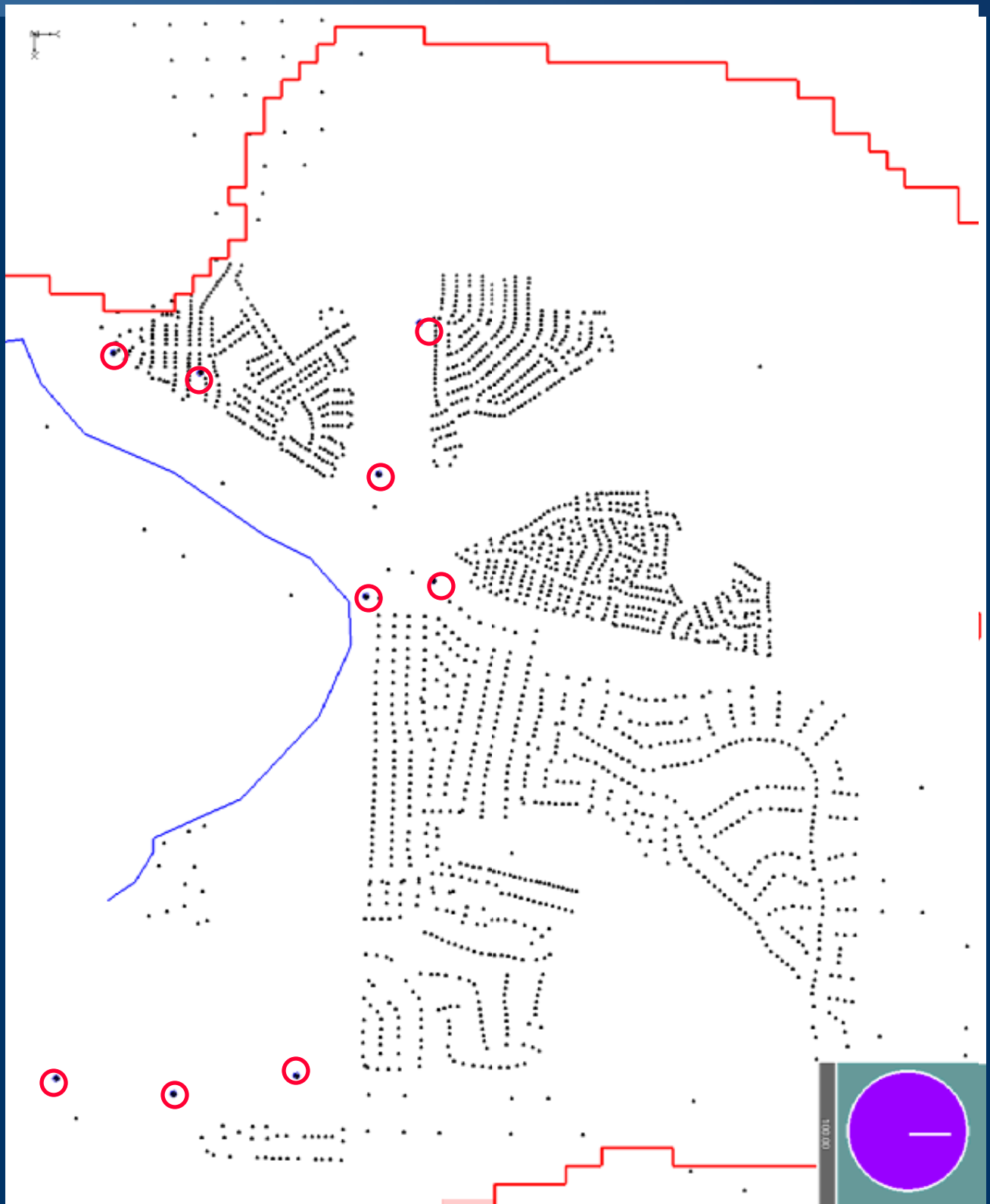
- Modeled from soil cores
- 230 gal/day/house
- 44 mg/L Nitrate-N applied
- Accounts for precipitation and soil moisture
- Accounts for naturally occurring Nitrate in subsurface

RESULTS

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



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

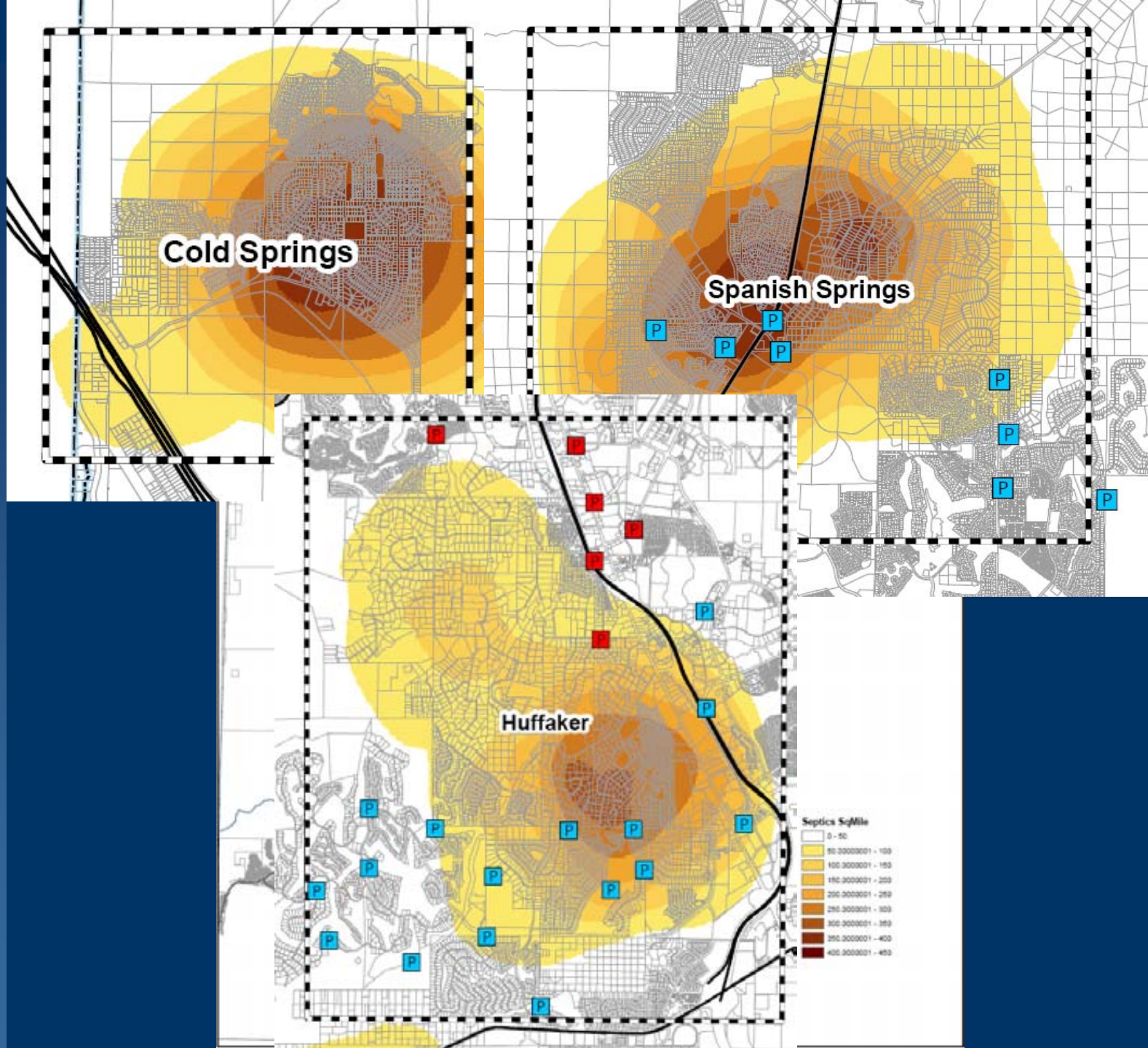
Regional Risk Assessment

- 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/mile^2

- 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

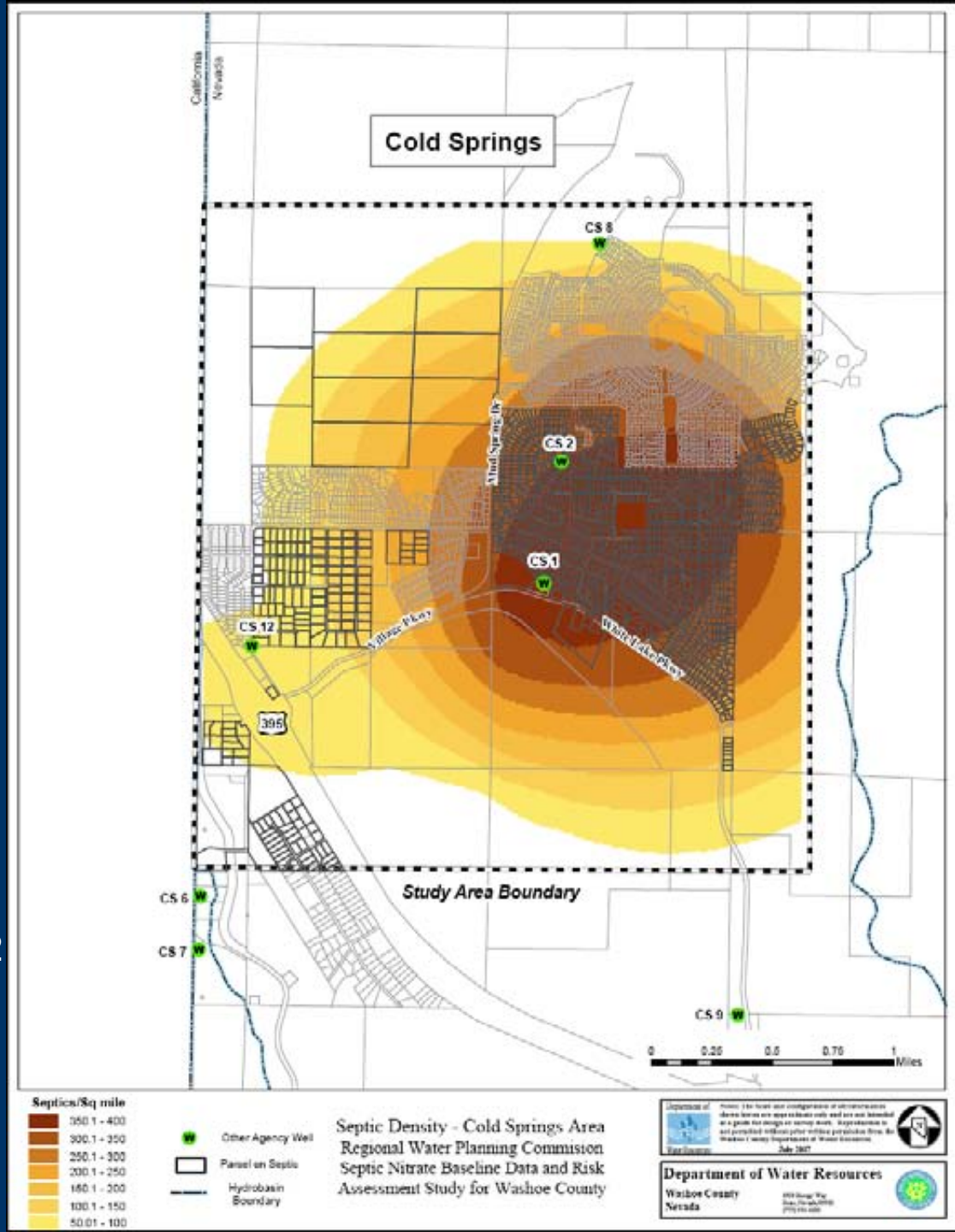
Septics: 1,325

Area: 7.5 mi²

Density: 177/mi²

Max D: 350 /mi²

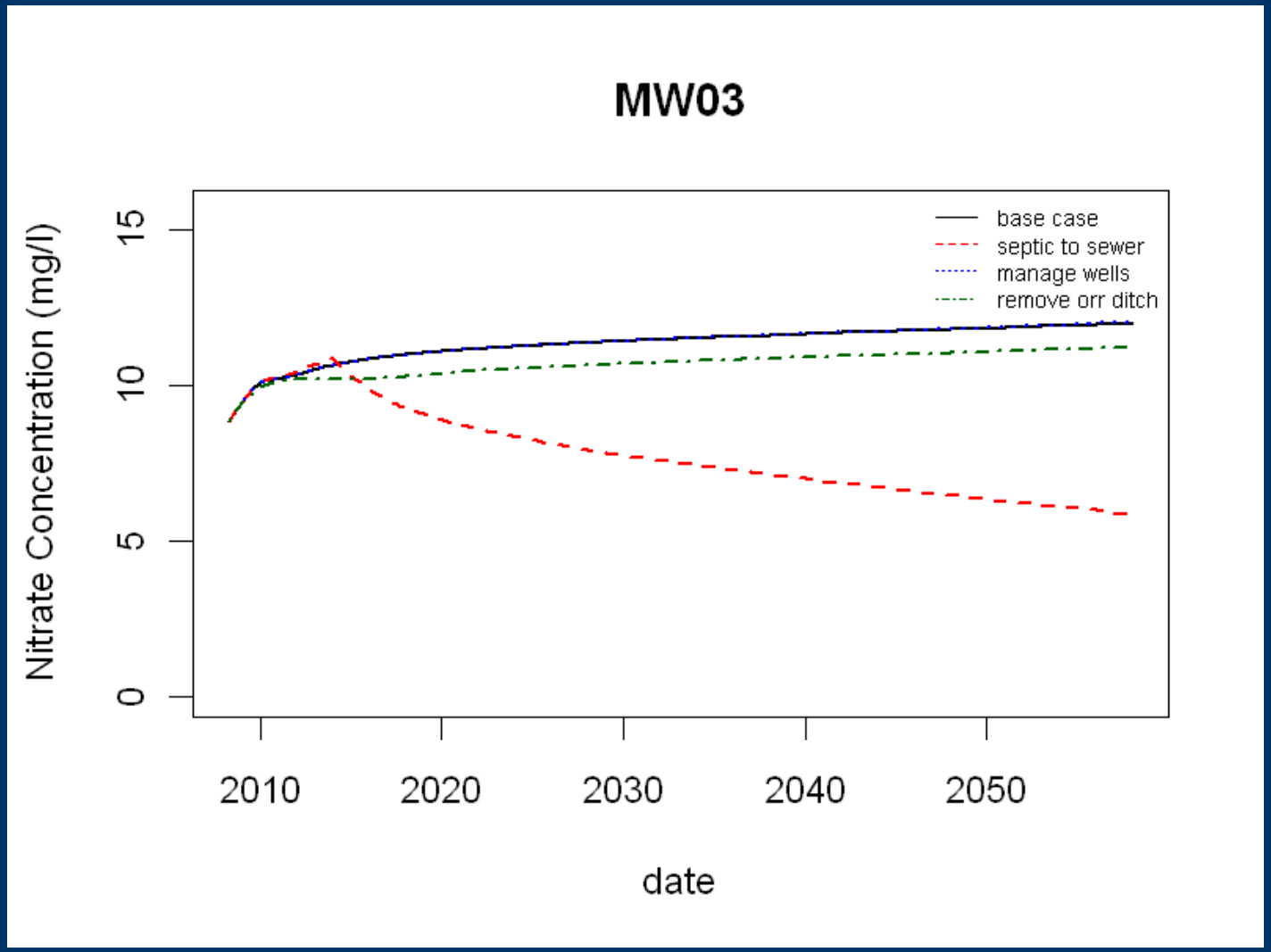
NV Limit: 92 /mi²



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?