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!
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
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
Site Description

Reno-Sparks
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

July 2002
Municipal Well Contamination

Graph showing nitrate levels from 1979 to 2008 with a trend line indicating an increase over time. The graph includes data points for each year, showing fluctuations and an overall upward trend in nitrate levels.
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
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

Scale ~ 200 ft per Horizontal Unit

NO$_3^-$ Concentrations presented in ppm NO$_3^-$N
Source Identification

Nitrate-N (mg/L)

Inside: 23.2
Outside: 5.0
Source ID

- 3 Homes
- 1 Park
- 1 School
- 49 Lysimeters
- 10 Neutron Holes
- 6 Monitor Wells
- 4 Flux Meters
- 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 Identification: N and O Isotopes in Nitrate

Nitrate - $^{15}\text{N}$

Nitrate - $^{18}\text{O}$

- Shallow Wells
- Deep Wells

Nitrate in Precipitation

- NO$_3$ fertilizer
- NH$_4$ in fertilizer & rain
- Soil N
- Manure & Septic waste

(adapted from Kendall 2007)
NONO33Source ReSource Re--thinkthink

Septic Source?
Buried Swamp?
Soil cores refuted swamp
Recharge from a mining operation leaching
naturally-occurring nitrate from vadose
zone?
Plausible!
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
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
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
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

MW03

- base case
- septic to sewer
- manage wells
- remove or ditch

Nitrate Concentration (mg/l)

Date

2010 2020 2030 2040 2050
Questions?