# Groundwater Study in the Salt Pond Region of Southern Rhode Island, With a Focus on Nitrate Pollution


**Jessica Donohue and Anne Veeger**

Department of Geosciences, University of Rhode Island, Kingston, RI



## Abstract:

A major issue that needs to be assessed in the groundwater system in Charlestown, Rhode Island is the pollution of the coastal salt ponds from anthropogenic sources of nitrate. This study focuses on the Quonochontaug headland of coastal Charlestown, RI, where groundwater concentrations of nitrate have been assessed in order to understand the contribution of nutrients from groundwater sources to the salt ponds. All drinking water in the study area comes from groundwater, mostly private wells with two small public supply companies drawing water from shallow wells. Water samples were collected from 46 private wells with a variety of depths, including shallow wells constructed in the stratified glacial material and deep wells drilled into the underlying fractured granitic bedrock. The variety of sampling locations allow for analysis of spatial and depth related trends in water chemistry. This is an area with many seasonal residents, resulting in greater stress on the groundwater system in the summer. In order to evaluate temporal changes samples were collected in three rounds; early summer, late summer, and fall. Nitrate concentrations were above background levels (0-1 mg/L NO3-N) in most samples collected, indicating an anthropogenic impact from sources of nitrate such as septic systems, cesspools and fertilizers. The overall distribution of nitrate remained consistent throughout the three sampling rounds, indicating no temporal trend. The range found was less than 1 mg/L to 11 mg/L NO3-N, with the mean being 3.5 mg/L NO3-N. Higher concentrations of nitrate tended to be in areas of higher housing density and smaller lot size. The correlation found between housing density and nitrate concentrations may be applied to the entire watershed of the nearby salt ponds in order to better constrain the amount of nitrate entering the ponds from groundwater sources.


## Objectives:

- Characterize the groundwater chemistry of the Quonochontaug area in Charlestown, RI.
- Evaluate the spatial and temporal distribution of nitrate in this groundwater system and assess the magnitude of groundwater derived nitrogen loading to the nearby salt ponds, along with determining areas of concern to target for management decisions.

## Nitrate Pollution in Coastal Groundwater:

- High nitrate loading to the nearby salt ponds can lead to many environmental issues:
  - Algal blooms/depleted oxygen
  - Eutrophication
  - Ecosystem disruption
- Natural background levels in groundwater are < 1 mg/L $NO_3$-N
- EPA drinking water standard is 10 mg/L $NO_3$-N
- 5 mg/L $NO_3$-N is an action level, where levels are of concern
- Anthropogenic sources of nitrate are:
  - Fertilizer
  - Pet Waste
  - Septic systems and cess pools

## Study Area:

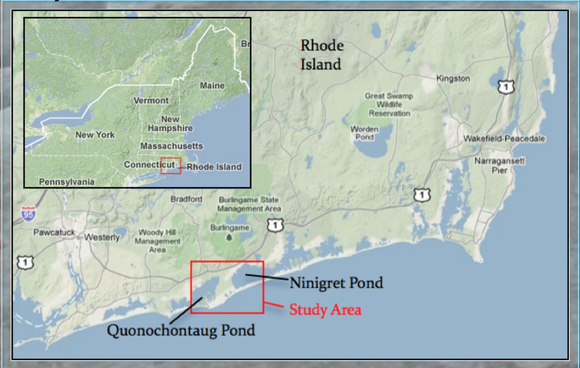


*Figure 1:* **Quonochontaug headland in Charlestown, RI.**

- Located between two salt ponds, Quonochontaug Pond to the west and Ninigret Pond to the east
- Many seasonal residents, therefore more stress on the groundwater system in the summer
- Facing increasing population and seasonal cottages converting to larger year-round homes
- Groundwater is the only source of drinking water, primarily from private wells
- Every residence uses Individual Sewage Disposal Systems (ISDS) for waste disposal
- Regulations in place for converting to denitrifying ISDS with new construction or failing systems, this can be very costly

## Geology and Hydrogeology:

- Low-relief area that is part of the South Coastal watershed (Friesz, 2010), to the north lies the Charlestown Moraine, which acts as a watershed divide.
- Unconsolidated stratified glacial outwash material (6-12 meters) overlying Permian age Narragansett Pier Granite (Hermes et al., 1994)
  - Shallow wells draw water from the aquifer in the unconsolidated material
  - Deep wells intersect water-bearing fractures in the granite

## Sample Locations:

*Figure 2:* The locations of the 46 sample wells are shown above.

- 46 samples sites were used for the duration of the study
- Home owners were asked to volunteer their private wells for sampling
- Both shallow wells in the overlying stratified glacial material and deeper bedrock wells were utilized
- 3 Rounds of sampling took place, to determine any temporal trends:
  - Early summer: 6/21/10 – 7/15/10
  - Late summer: 8/30/10 – 9/9/10
  - Fall: 10/7/10 – 11/7/10

## Methodology:

- Samples were collected from untreated outdoor faucets according to Standard Methods 1060. Field measurements of pH, electrical conductivity, temperature and dissolved oxygen were also taken.
- All samples were analyzed on a Dionex DX-120 Ion Chromatograph at the University of Rhode Island Dept. of Geosciences, following Standard Methods 4110 (APHA et al., 2005).

## Results:

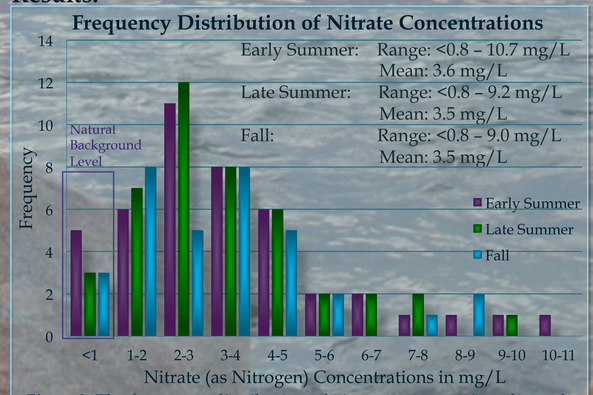


*Figure 3:* The frequency distribution of nitrate concentrations for each round of sampling, showing similar distributions for each.

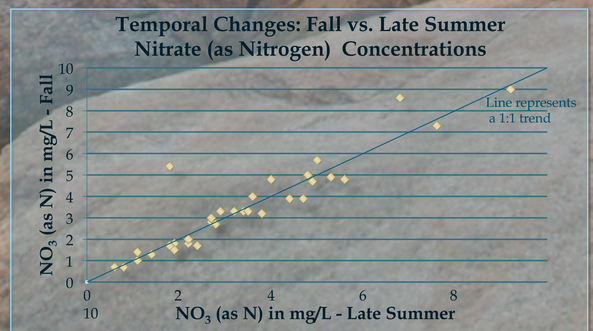


*Figure 4:* Graph showing nitrate concentrations in the fall versus the late summer, indicating a lack of an overall temporal trend.

## Distribution of Nitrate Concentrations and ISDS Locations

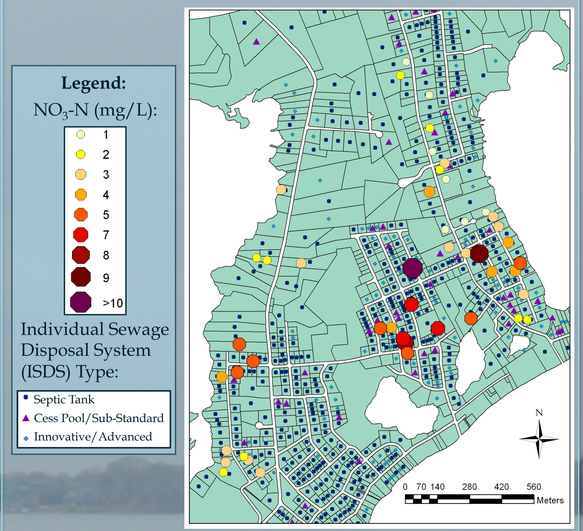


*Figure 4:* Map showing the spatial distribution of nitrate concentrations along with locations and types of ISDS.

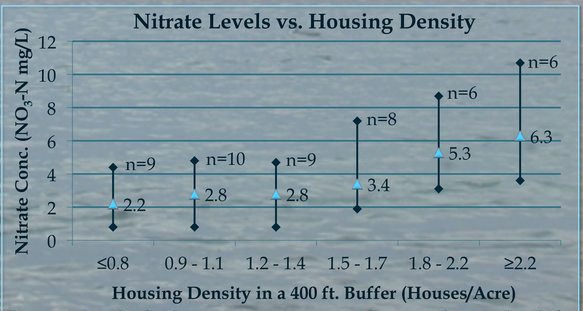


*Figure 5:* Graph of $NO_3$ concentrations versus housing density divided into bins, showing an increase in $NO_3$ with higher housing density. Error bars show range of concentrations found in each bin.

## Spatial Relationship of Housing Density and Nitrate Levels

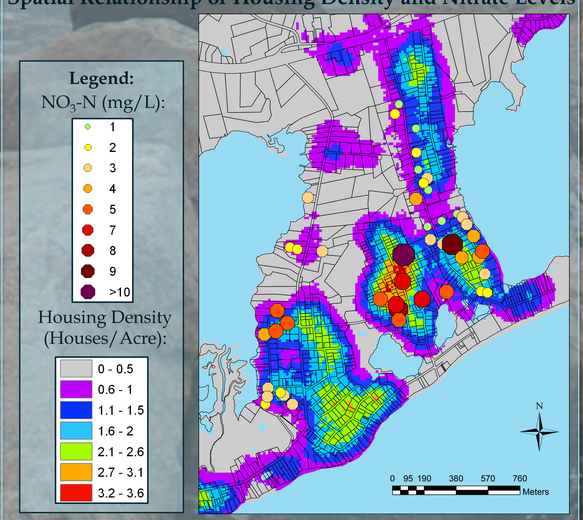


*Figure 6:* Map showing the spatial distribution of nitrate concentrations overlying housing density, indicating a spatial correlation.

## Model of Housing Density with Corresponding Nitrate Values: Charlestown, RI

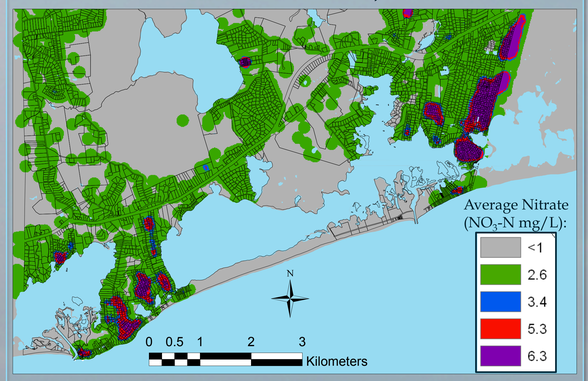


*Figure 7:* Map of all of Charlestown, RI with estimated average nitrate concentrations based on housing density using 400ft. buffers. Areas in red and purple are areas of concern based on this model.

## Discussion:

- The distribution of $NO_3$ levels stayed consistent throughout all three rounds of sampling, showing that there was not an increase in $NO_3$ with the increase in seasonal residents.
- Using the positive correlation between $NO_3$ and housing density, a model can be created and applied to a larger area of the salt pond region. This would indicate an expected average $NO_3$ concentration based on the housing density, shown in Fig. 7.
- Model of nitrate concentrations with housing density can be used for:
  - Better quantifying nutrient loading to the salt ponds from groundwater
  - Identifying areas of concern for remediation
  - Better management practices, identifying areas to target for management changes
- Limitations of model include:
  - Large variability in ranges found at each housing density
  - Depth variations of wells is also a factor
  - Groundwater flow patterns also have an impact on nitrate concentrations, this model looks at source concentrations
- Future tests in other areas of the salt pond region, of high and low housing density, would be useful to ground truth this model and build upon it.

## Conclusions:

- Majority of sites are above natural background levels, with 27% of sites reaching the action level of 5 mg/L $NO_3$ – N at least once
- Of well depths that are known there is variability in nitrate levels
- Some variability in temporal measurements but no overall trend
- Overall distribution of nitrate stays the same throughout the summer and fall rounds of sampling
- Trends of higher nitrate values with higher housing density are present, this can help determine areas of concern for better management practices and calculations of nitrate loading to the nearby salt ponds

## References:


American Public Health Association (APHA), American Water Works Association, Water Environment Federation, 2005, Standard Methods for Examination of Water & Wastewater: Washington D.C., 21st Edition.

Friesz, P. J., 2010, Delineation and Prediction Uncertainty of Areas Contributing Recharge to Selected Well Fields in Wetland and Coastal Settings, Southern Rhode Island: Prepared in cooperation with the Rhode Island Department of Health Scientific Investigations Report 2010–5060.

Hermes, O.D., Gromet, L.P., and Murray, D.P., 1994, Bedrock geologic map of Rhode Island: Rhode Island Map Series No. 1, University of Rhode Island, Kingston, scale 1:100,000.



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