Comparison of Kriging Methods for Polk County, Florida

Barnali Dixon Ph.D.
Robert Stetson
Nivedita Candade
Geo-Spatial Analytics Lab
University of South Florida St. Petersburg

Barnali Dixon: bdixon@stpt.usf.edu

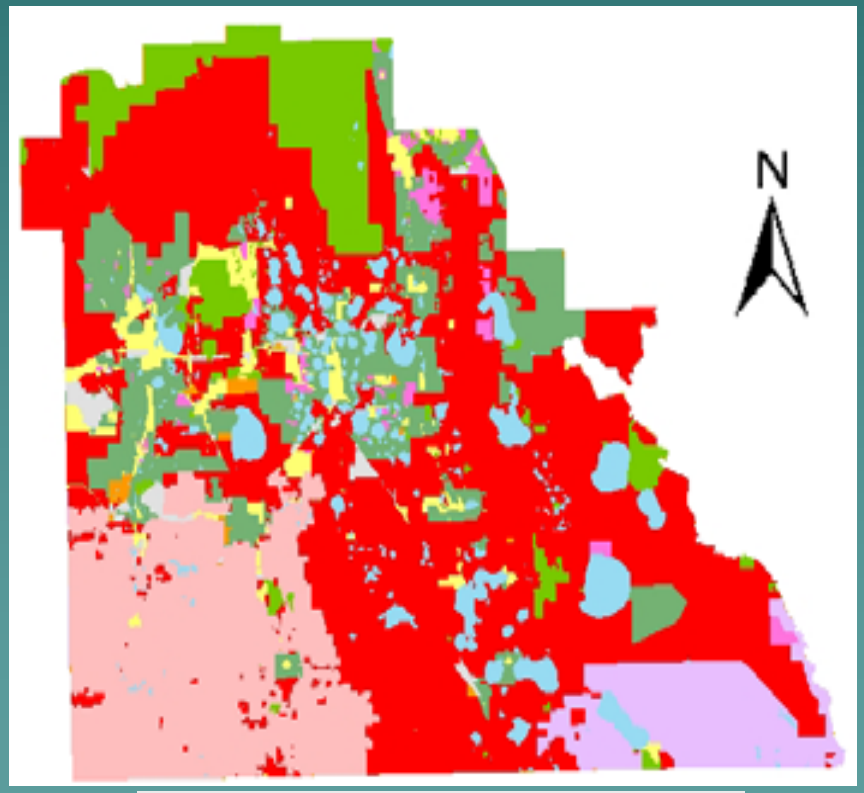
Introduction

- Groundwater provides drinking water for more than half of the population in United States and is the only source of drinking water for many in rural areas and some cities (Solley et. al. 1993)
- Contamination of groundwater is a serious environmental problem.
- Obtaining a comprehensive understanding of spatially explicit contamination potential is imperative for long-term monitoring and protection of this valuable water resource.

Objectives

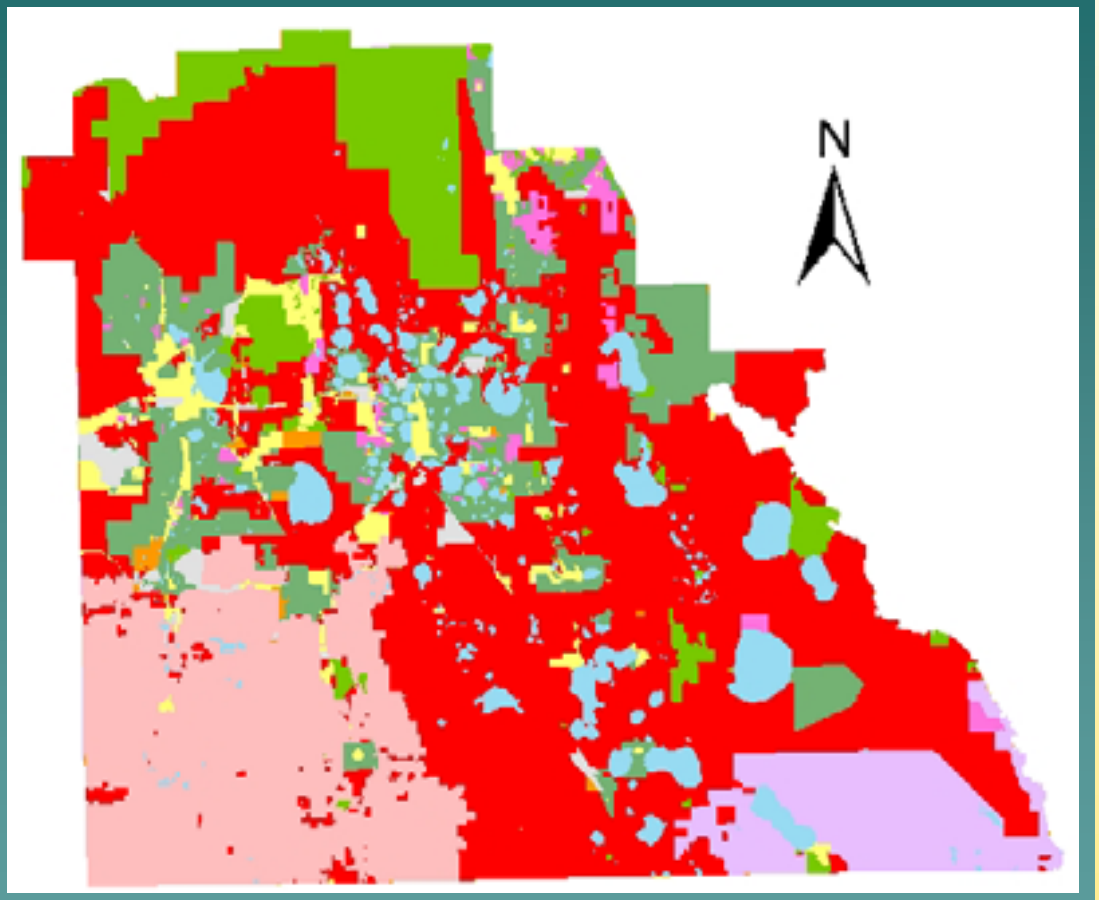
- The over all goal of this project is to predict contamination wells using two different kriging methods to determine which method is optimal in predicting contamination of wells.
  - Ordinary
  - Universal
- Each of the kriging method's performance was assessed by calculating the numbers of wells that coincided with respective concentration levels
  - For example, wells with high concentration coincided with the high concentration areas and areas of low concentration coincide with wells of low concentration.

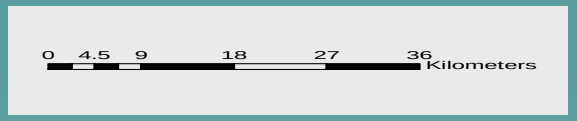
Study Area



- Polk county is located in central Florida, equidistant between the east and west coasts.
- Polk lies on the Interstate-4 corridor, 25 miles east of Tampa and 35 miles southwest of Orlando, it is the geographical center of Florida.
- It is estimated that more than 7.5 million people live within a 100-mile radius of the county.

Study Area Landuse





Land Use Classes

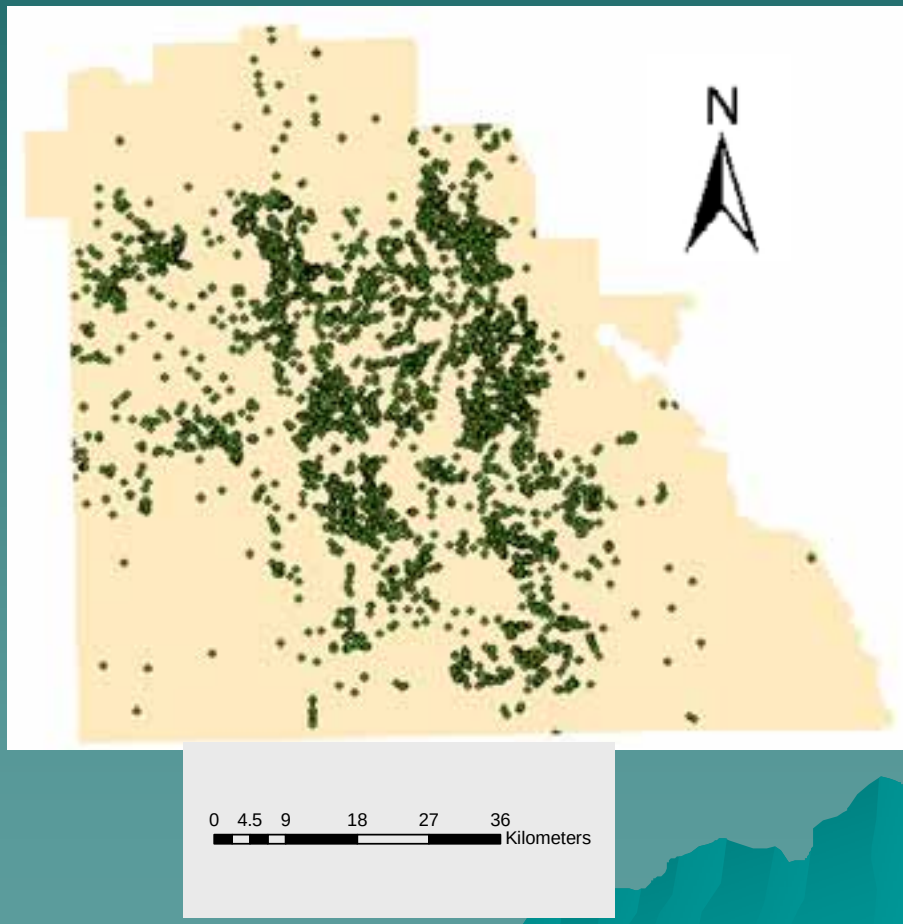
- AGRICULTURE
- COMMERCIAL
- **Urban**
- INDUSTRIAL
- MILITARY
- MINING
- MULTI-FAMILY
- PRESERVE
- SINGLE FAMILY
- UNDEFINED
- WATER BODIES

Methods

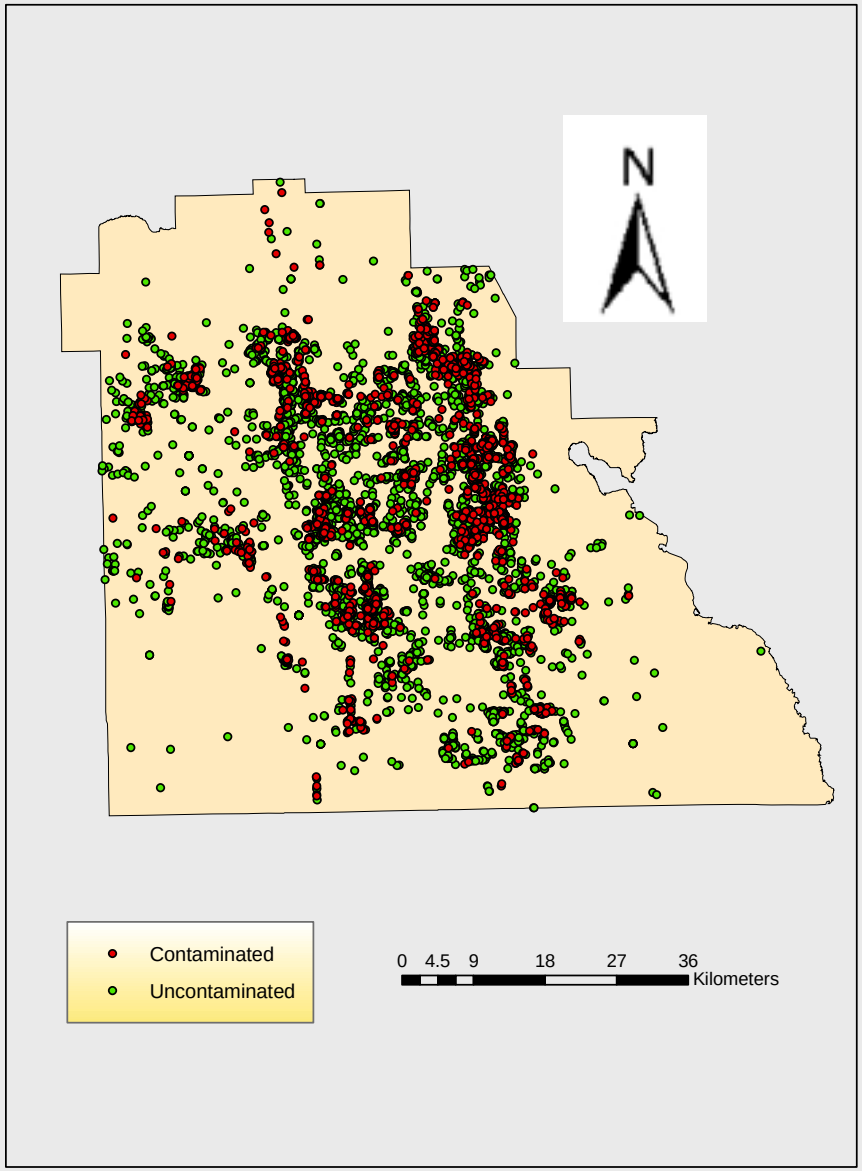
- Kriging Maps were created using ArcGIS and the Geostatistical Analyst Extension.
- Coincidence analysis was conducted between the resultant interpolated surface maps and well contamination data to determine which method predicted better
  - if areas of high concentration coincided with wells having high concentration
  - and low concentration areas coincided with wells having low concentration

Data

- Data for this study was taken from the Florida Department of Environmental Protection (FDEP) in conjunction with the Florida Department of Health (FDOH) well monitoring program : Water Supply Restoration Program (WSRP)
- The total number of 7,336 wells was sampled during 200 – 2003 for the study area.
- The method of sampling for Nitrate was the EPA Method 353.2 (Colorimetric, Automated, Cadmium Reduction).
- Data was obtained from the FDEP website.

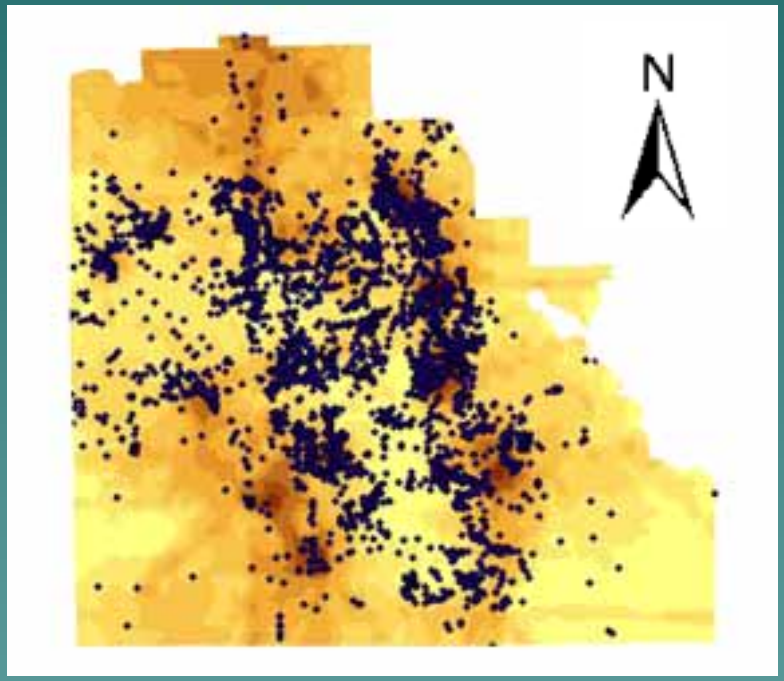


Location of Wells



Kriging

- Kriging is a statistical technique that uses semi-variograms to produce a continuous surface from point data and provide an estimate for unsampled locations.



Ordinary Kriging Equation

$$Z_r(s) = \mu(s) + Y(s) + \eta(s) + \varepsilon_r(s)$$

Where Zr(s) is denotes the *t*th relation at location **s**, and *ni* is the number of measurements at location **s***i.* Assume that m(**s**) = m is the unknown deterministic mean value and *Y*(**s**) is a smooth second order stationary process, η is a second order stationary process whose variogram range is close to 0. ε is a white noise process composed of measurement errors (Krivoruchko 2001).

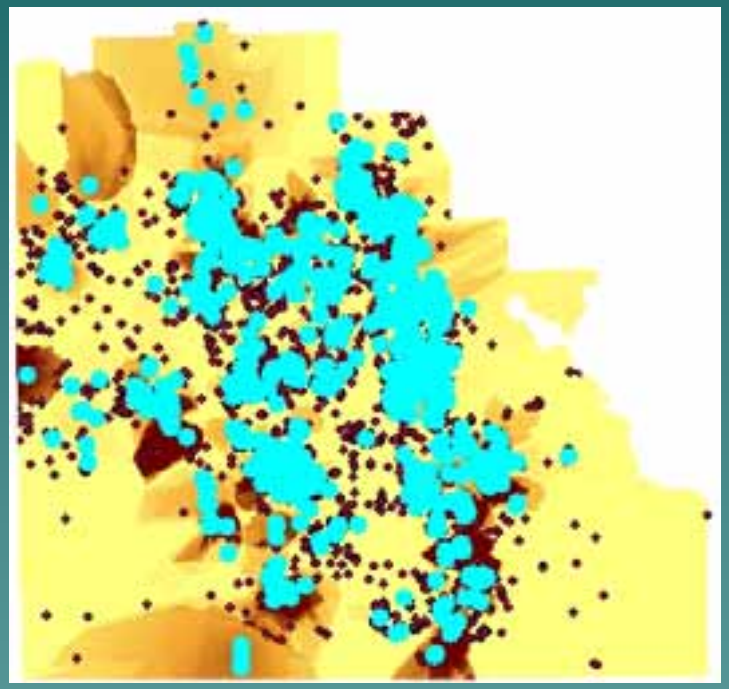
Universal Kriging Equation

$$Z(x) = Y(x) + \beta^t f(s)$$

- Where Z(x) is a random field, and x is the location of observations in the random field. Y(x) is a second orders stationary random field and β is a deterministic trend with a known function (van den Boogart and Brennen 2001).

Results and Discussion

Distribution of Wells using Nitrate Concentration

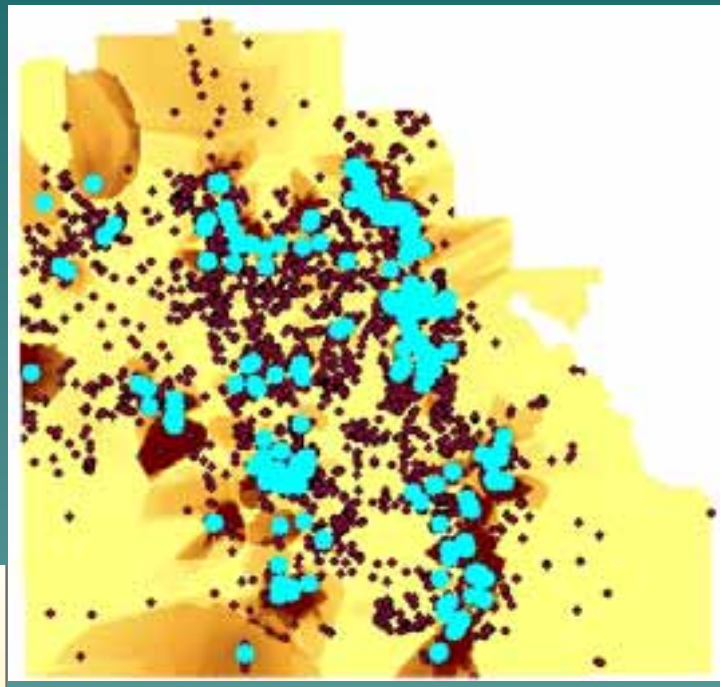


Wells Contaminated with Nitrate

Selected Wells

mg/L

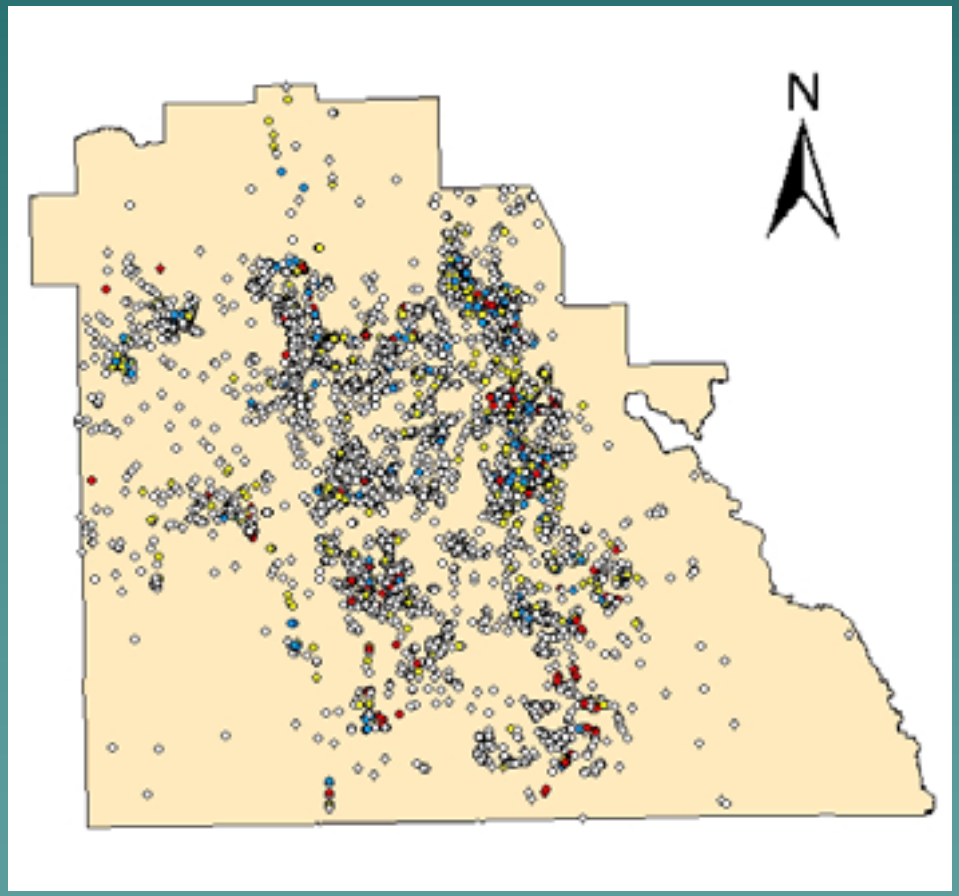
- 0 - 0.014
- 0 - 0.045
- 0.045 - 0.12
- 0.12 - 0.28
- 0.28 - 0.66
- 0.66 - 1.53
- 1.53 - 3.54
- 3.54 - 8.14
- 8.14 - 18.7
- 18.7 - 43



Wells above MCL for Nitrate.

0 4.5 9 18 27 36 Kilometers

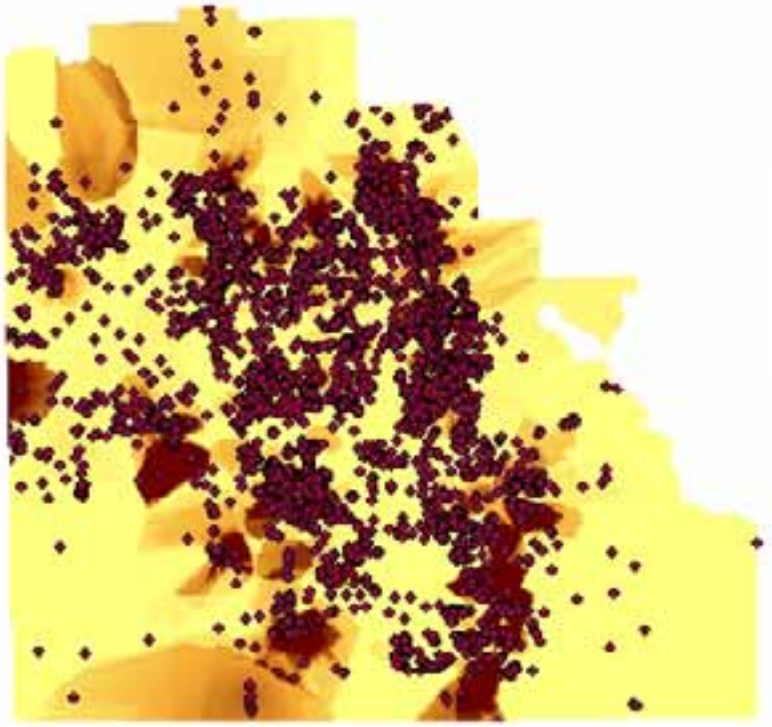
Distribution of Wells with Different Concentration

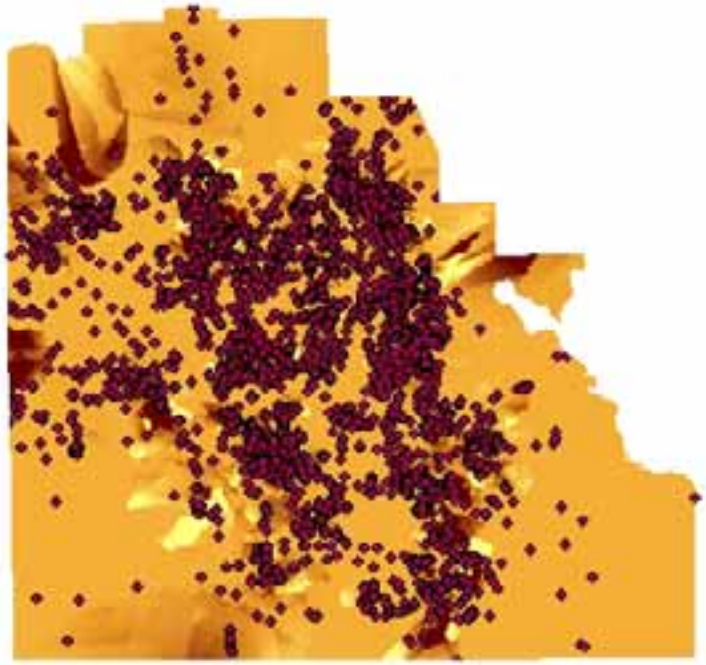


mg/L NO_3

- 0
- 0.1 - 3
- 3 - 10
- > 10

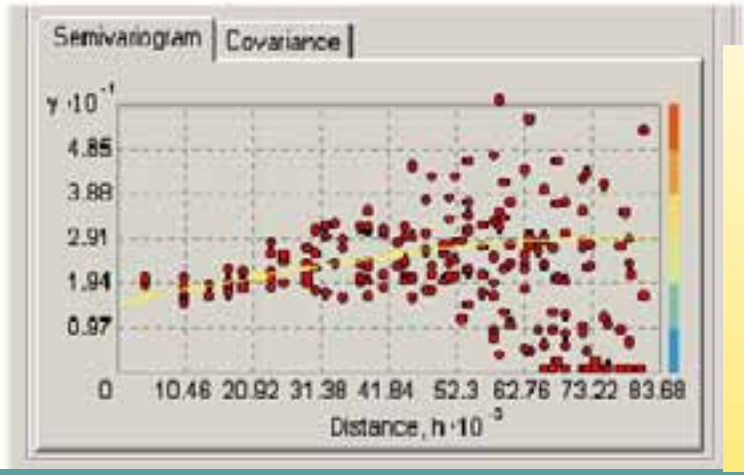
0 4.5 9 18 27 36 Kilometers



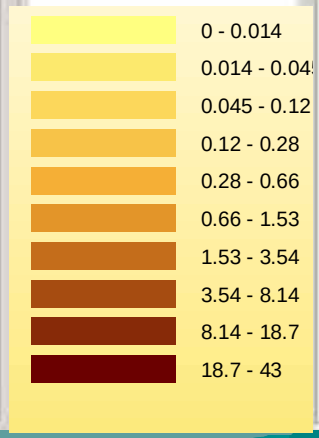


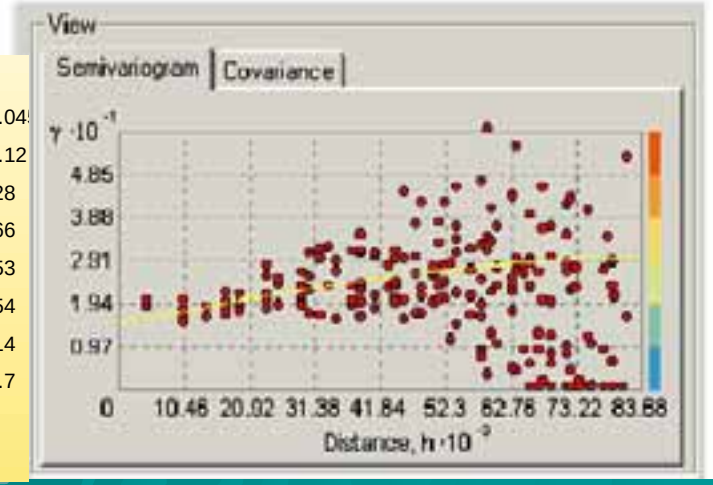
Ordinary Kriging for Nitrate

Universal Kriging for Nitrate

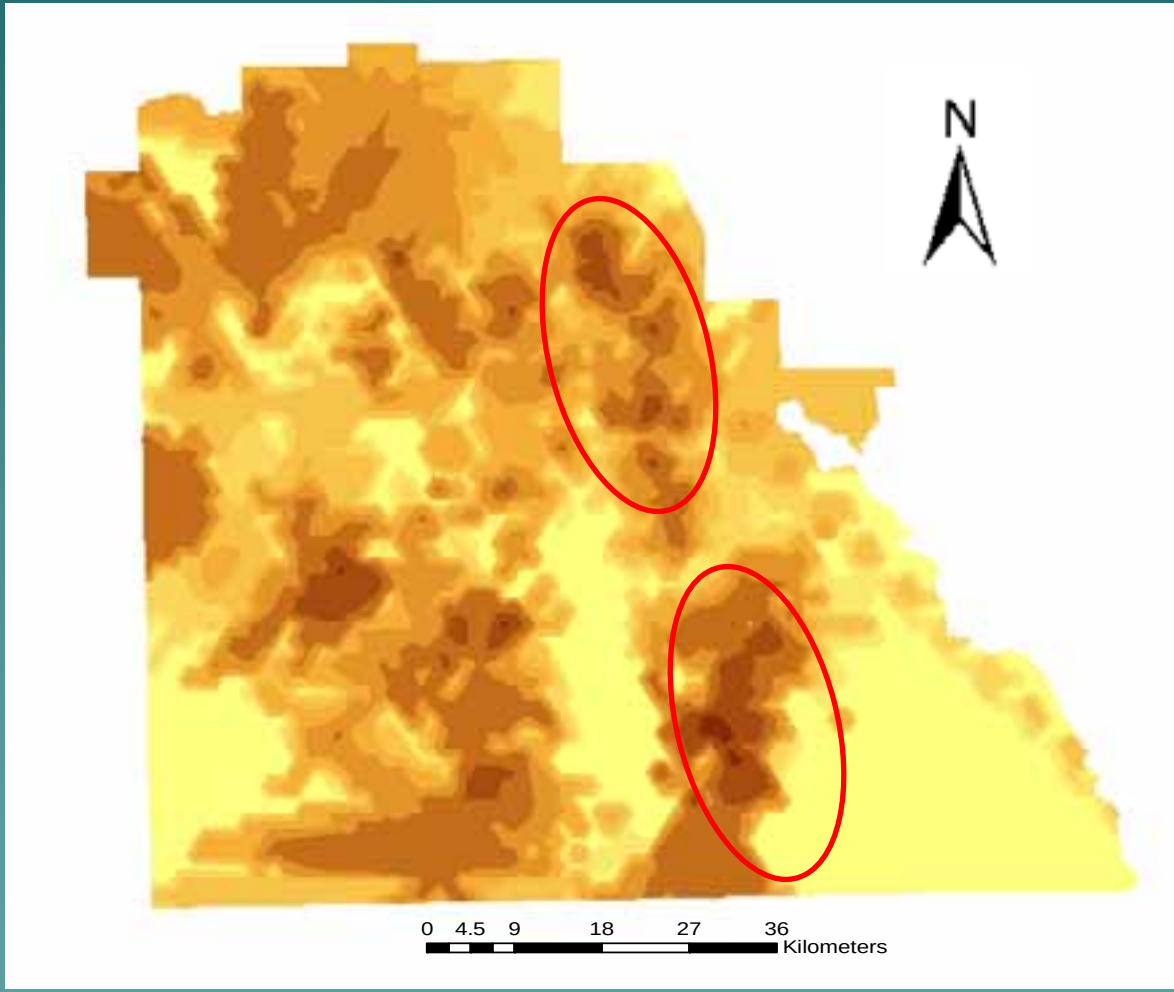


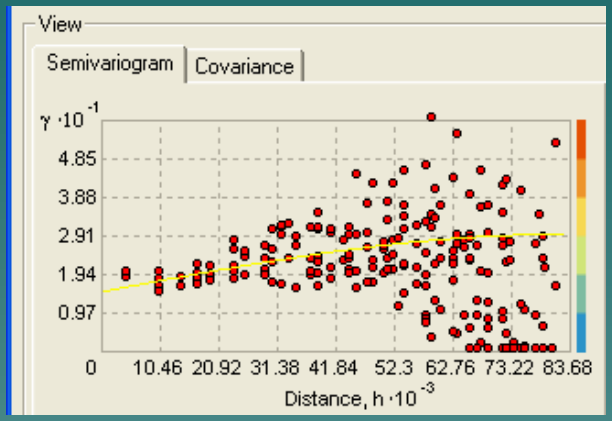
mg/L





Ordinary Kriging





Ordinary Kriging

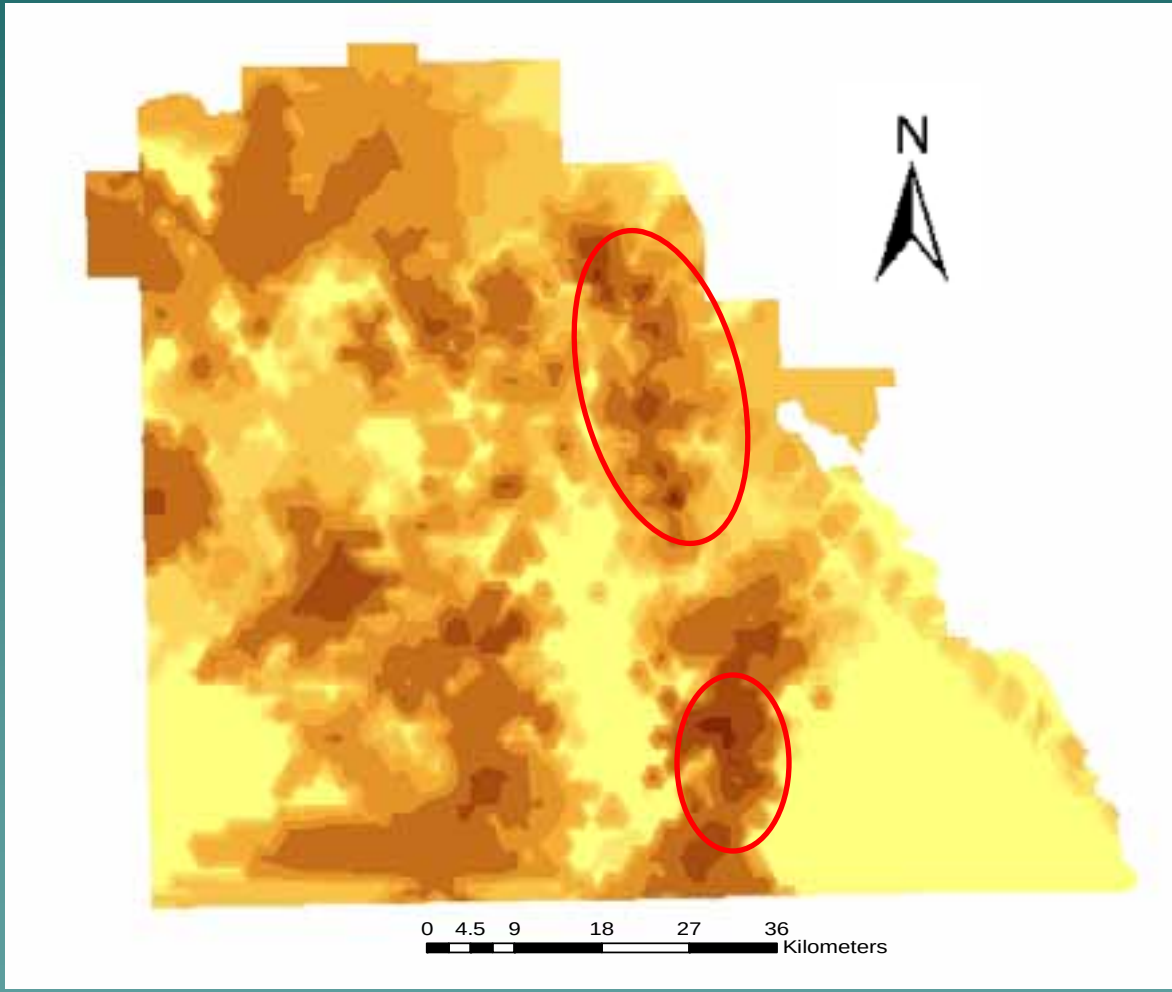
Prediction Map

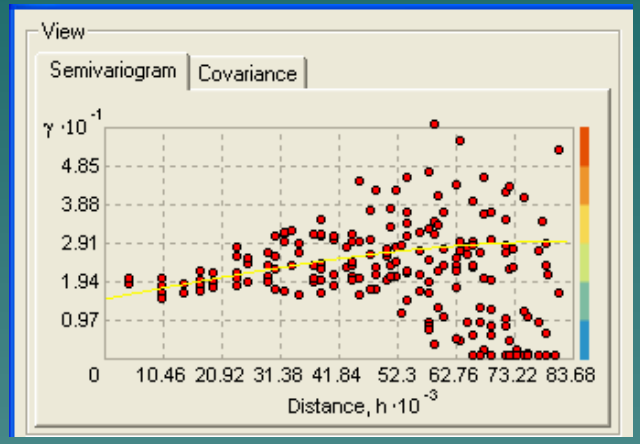
Nitrate (NO3)

Filled Contours

- 0 - 0.014
- 0.014 - 0.045
- 0.045 - 0.12
- 0.12 - 0.28
- 0.28 - 0.66
- 0.66 - 1.53
- 1.53 - 3.54
- 3.54 - 8.14
- 8.14 - 18.7
- 18.7 - 43

Universal Kriging





Universal Kriging

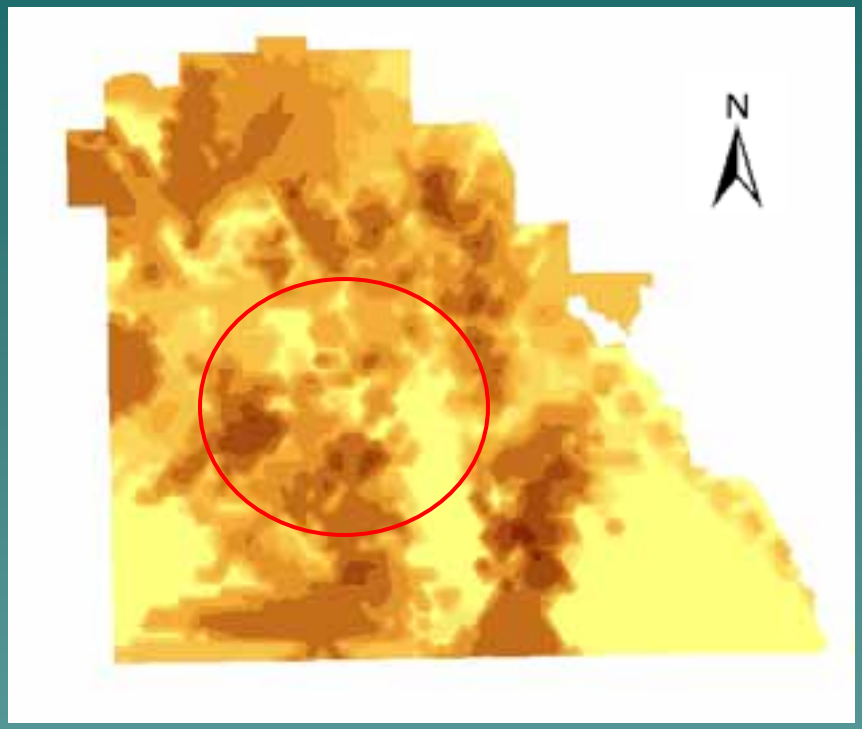
Prediction Map

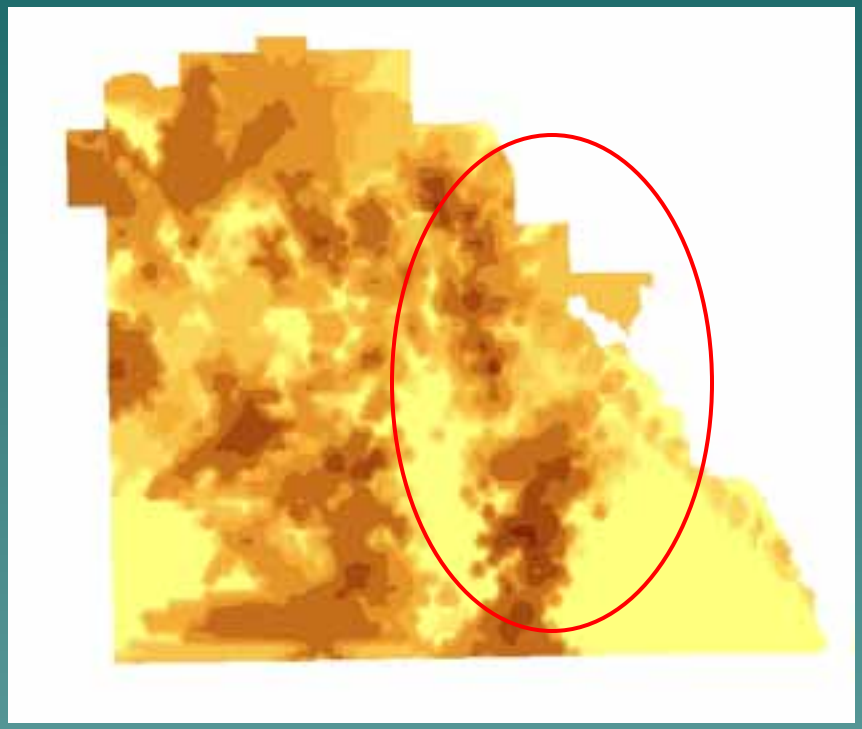
Nitrate (NO3)

Filled Contours

- 0 - 0.014
- 0.014 - 0.045
- 0.045 - 0.12
- 0.12 - 0.28
- 0.28 - 0.66
- 0.66 - 1.53
- 1.53 - 3.54
- 3.54 - 8.14
- 8.14 - 18.7
- 18.7 - 43

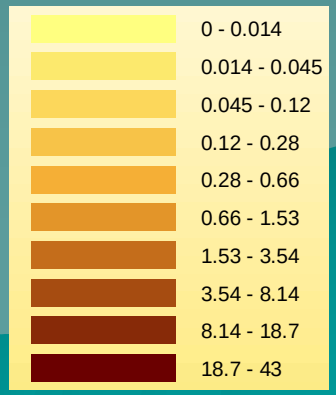
Comparison NO_3



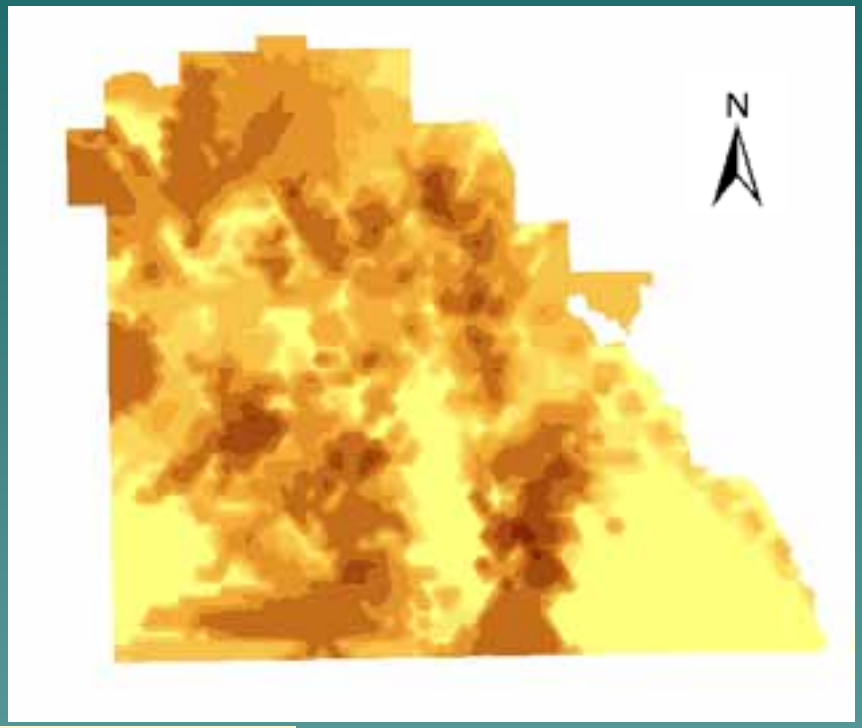


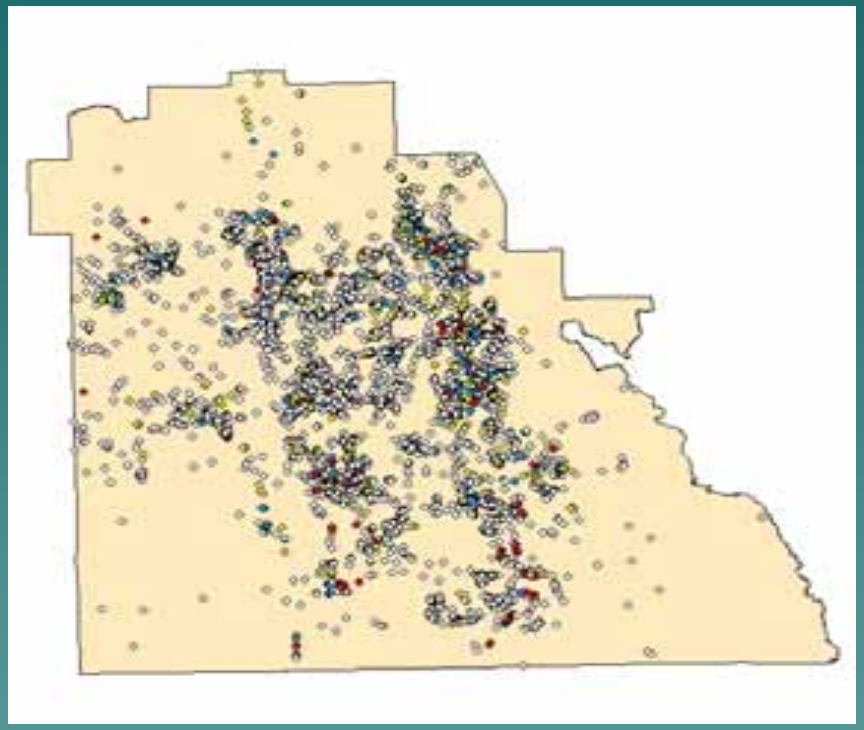
Ordinary

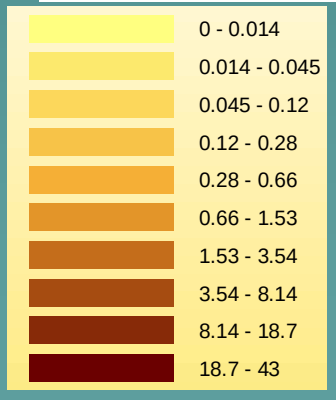
Universal

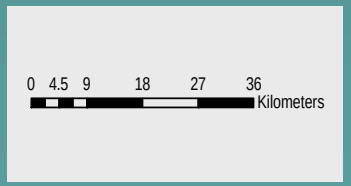


Ordinary Kriging and NO_3

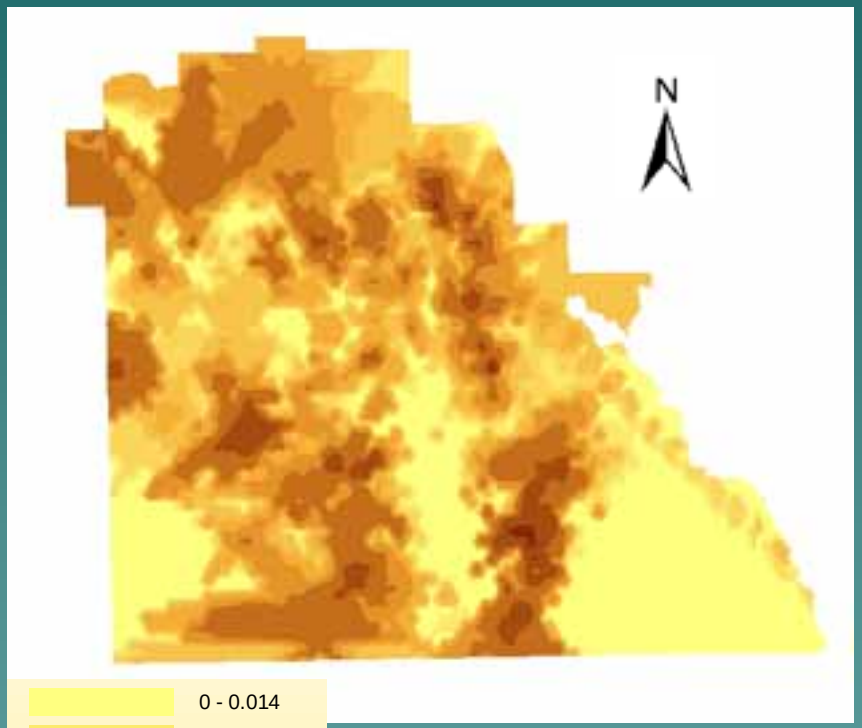


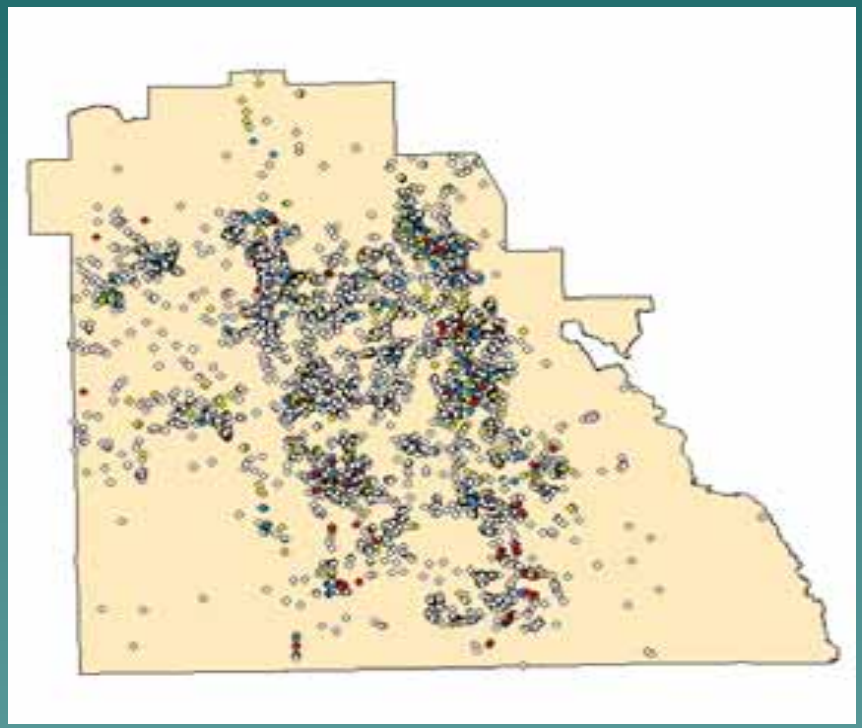


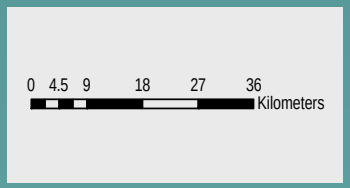




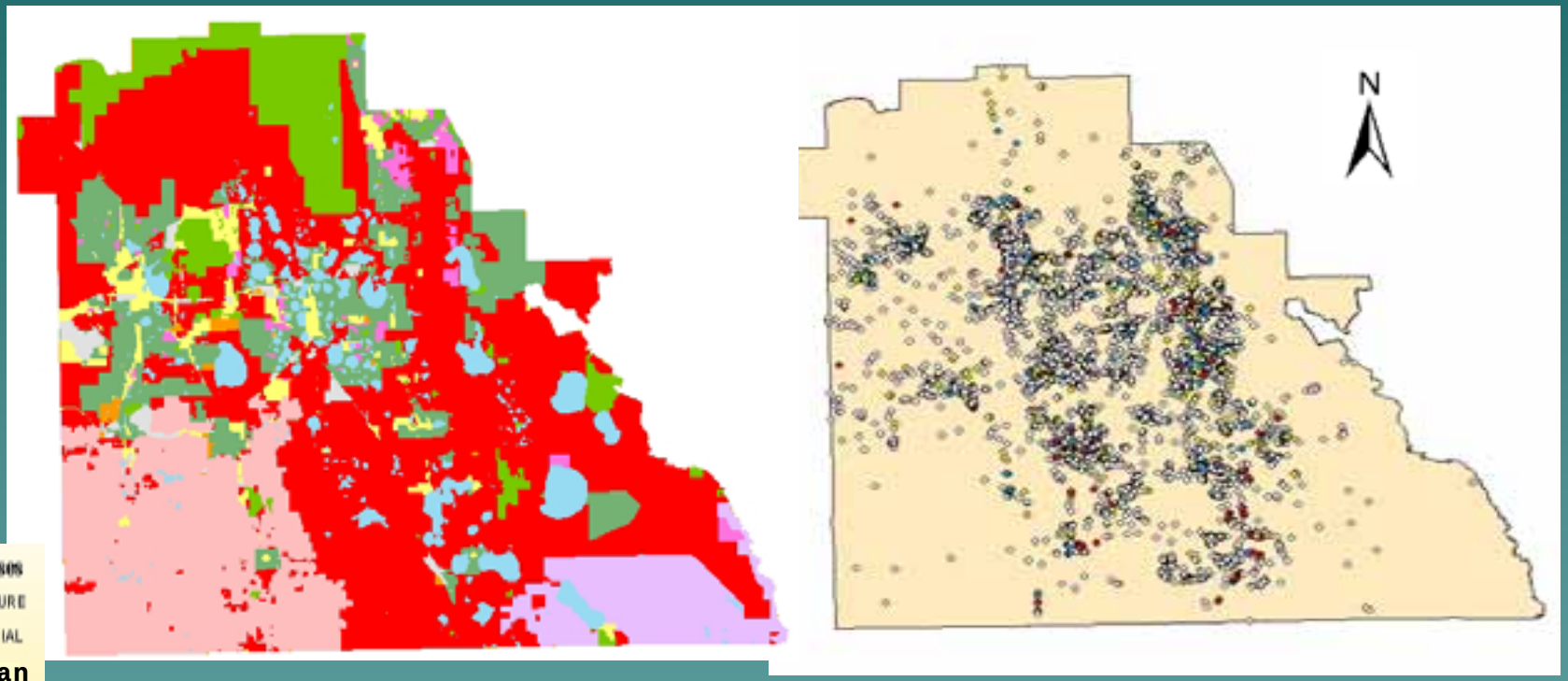
Universal Kriging and NO_3



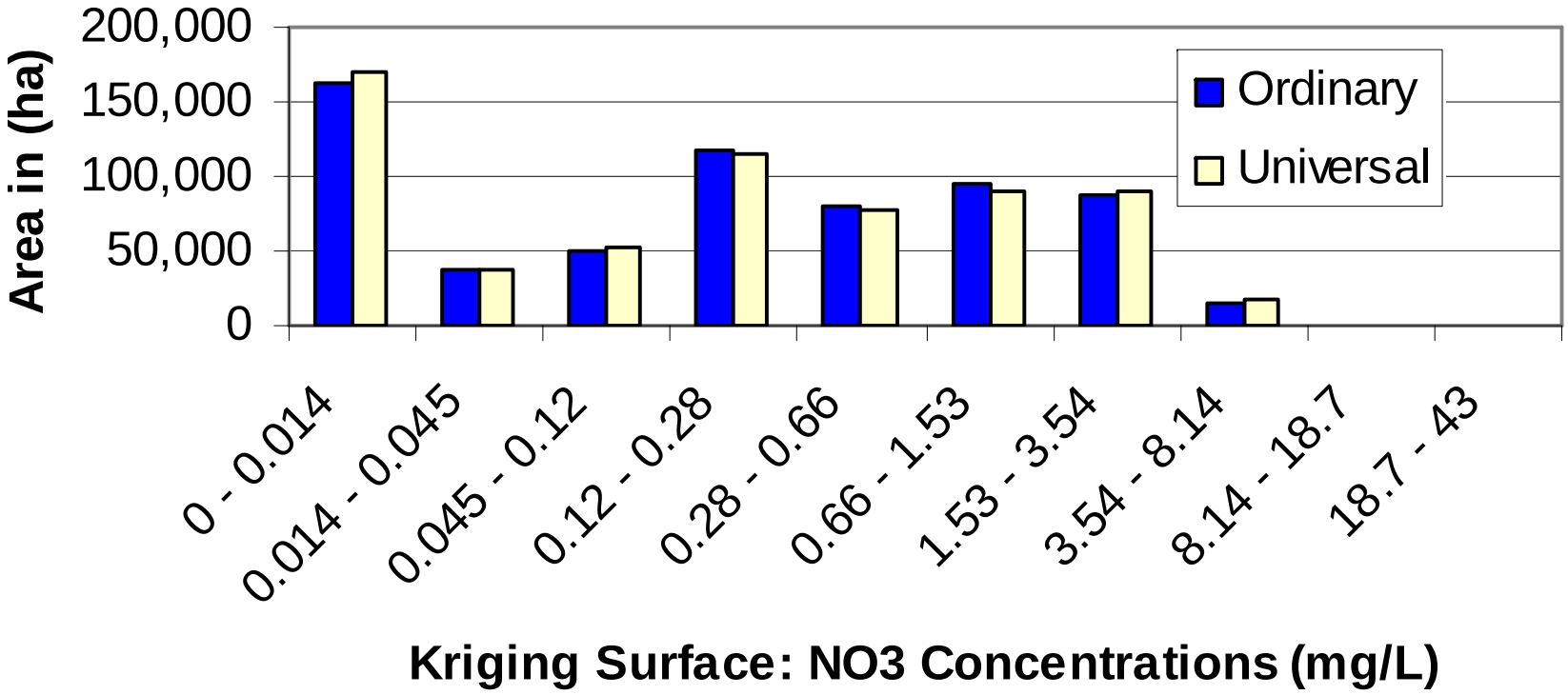




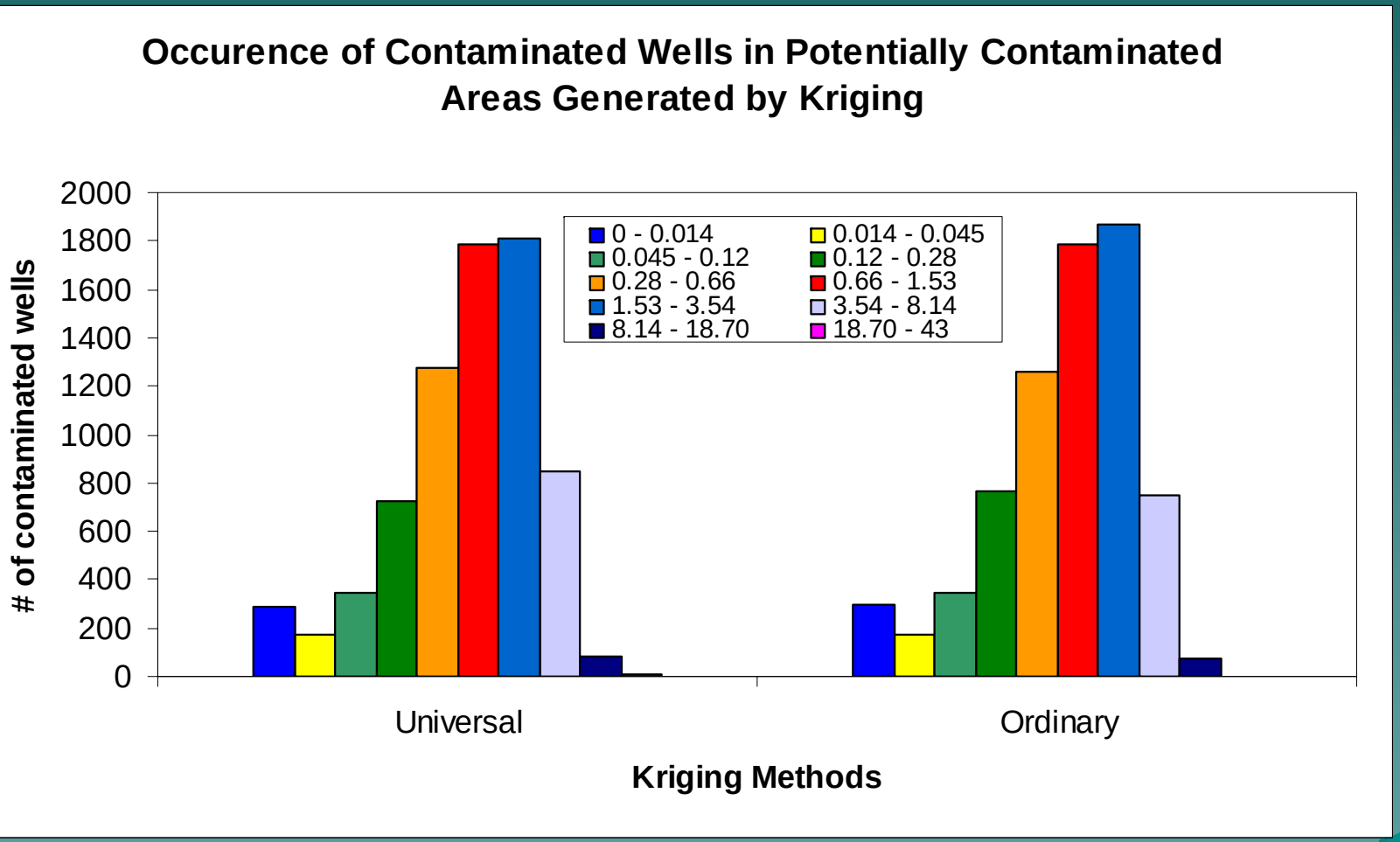
LULC and Kriged NO_3 concentration



Comparison of Area Coverage for the Two Kriging Methods

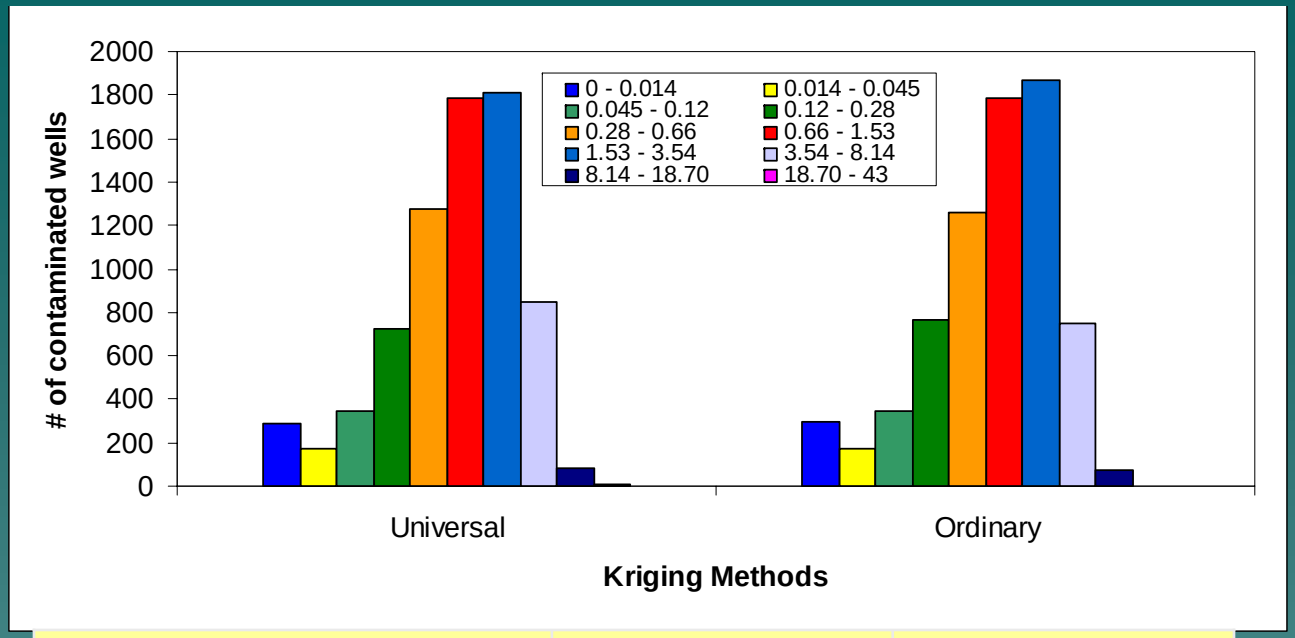


Mutual Occurrence



Kriging concentration NO_3 mg/L

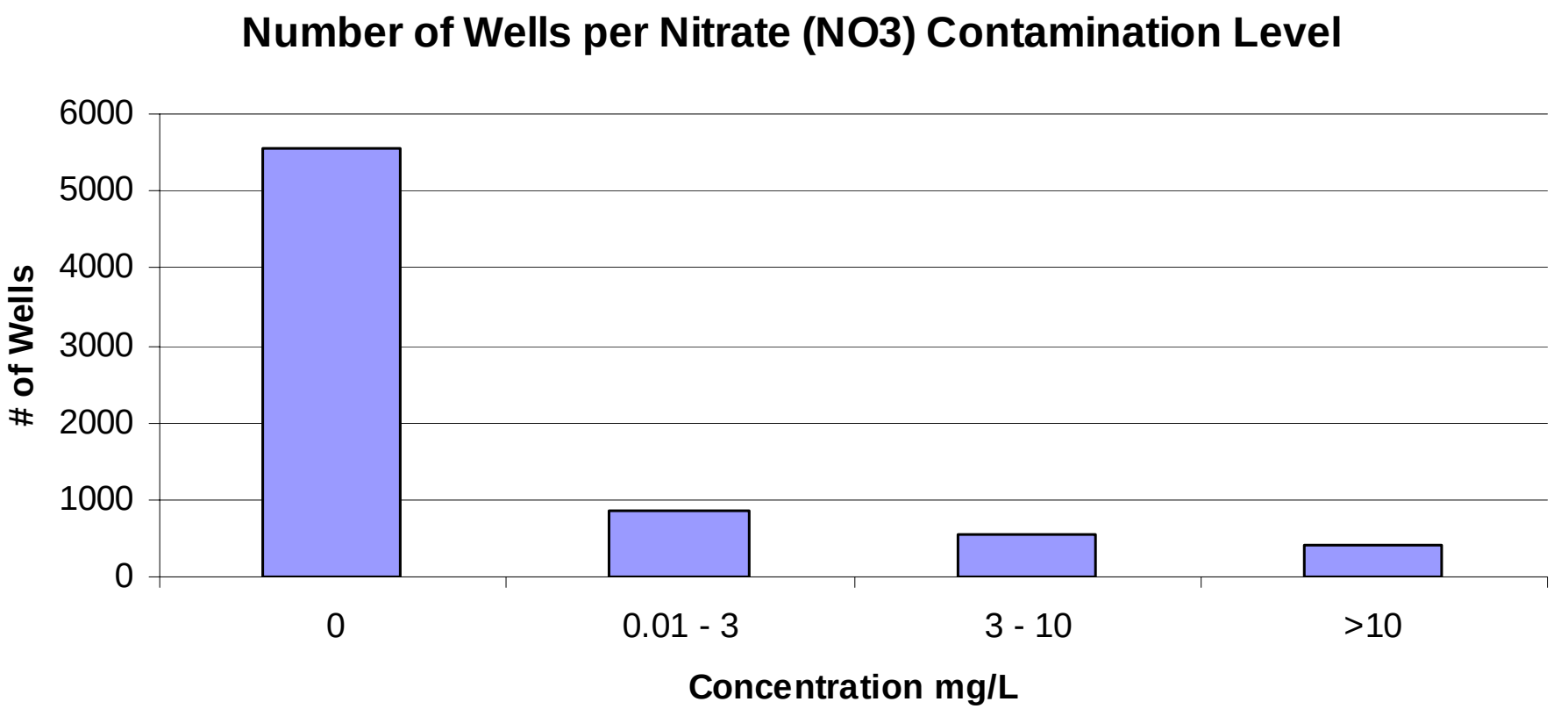
Occurrence Of Contaminated Wells in Potentially Contaminated Areas Derived from Kriging



Kriging Values	Universal	Ordinary
0 - 0.014	292	300
0.014 - 0.045	173	171
0.045 - 0.12	344	348
0.12 - 0.28	721	767
0.28 - 0.66	1274	1262
0.66 - 1.53	1782	1787
1.53 - 3.54	1811	1870
3.54 - 8.14	851	752
8.14 - 18.70	80	78
18.70 - 43	8	1
Total	7336	7336

Kriging concentration NO_3 mg/L

Concentration of Wells



Summary

- About 396 sampled wells in the study area had concentration greater than 10mg/L where as 537 wells had concentration of 3 – 10 mg/L
- About 855 sampled wells showed NO3 concentration between 0.1 – 3 mg/L
- About 5548 sampled wells had no contamination with NO_3

Summary cont.

- Universal kriging and Ordinary kriging showed comparable results.
- Results showed that Universal kriging predicted more contaminated wells in the higher category (939 wells) than ordinary kriging (831 wells).
- Krigged Maps in general showed more wells with concentration range between 0.66 – 3.54 mg/L