

Mapping Ground Water Vulnerability to Nitrate in Arizona

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ADEQ NITRATE DATA

- ✦ Excel Database File
- ✦ Nitrate Data and Other Data
- ✦ 7,657 Records
- ✦ 2,708 Different Wells
- ✦ All with ADEQ #s
- ✦ 2,198 with ADWR #s

JOIN

- ✦ Nitrate Locations
- ✦ ADEQ Nitrate Data for which we have well locations
- ✦ 2,701 Records

APPEND

FINAL DATASET

- ✦ All Nitrate
- ✦ Well Locations With Nitrate Data
- ✦ 6,802 Records

WELL LOCATION DATA

- ✦ adeqwell.shp
- ✦ 53,988 Well Locations
- ✦ All with ADEQ #s
- ✦ 17,672 with ADWR #s

APPEND

- ✦ dwwells.shp
- ✦ dwwells_intact.shp
- ✦ 182 Records
- ✦ No identifiers that match other well data or Nitrate data

APPEND

- ✦ dws_i.shp
- ✦ dws_i_intact.shp
- ✦ 5,760 Records
- ✦ Have ADWR #s

EXTRACT

- ✦ ADWR Wells
- ✦ 23,432 Unique Identifiers

DRINKING WATER DATA

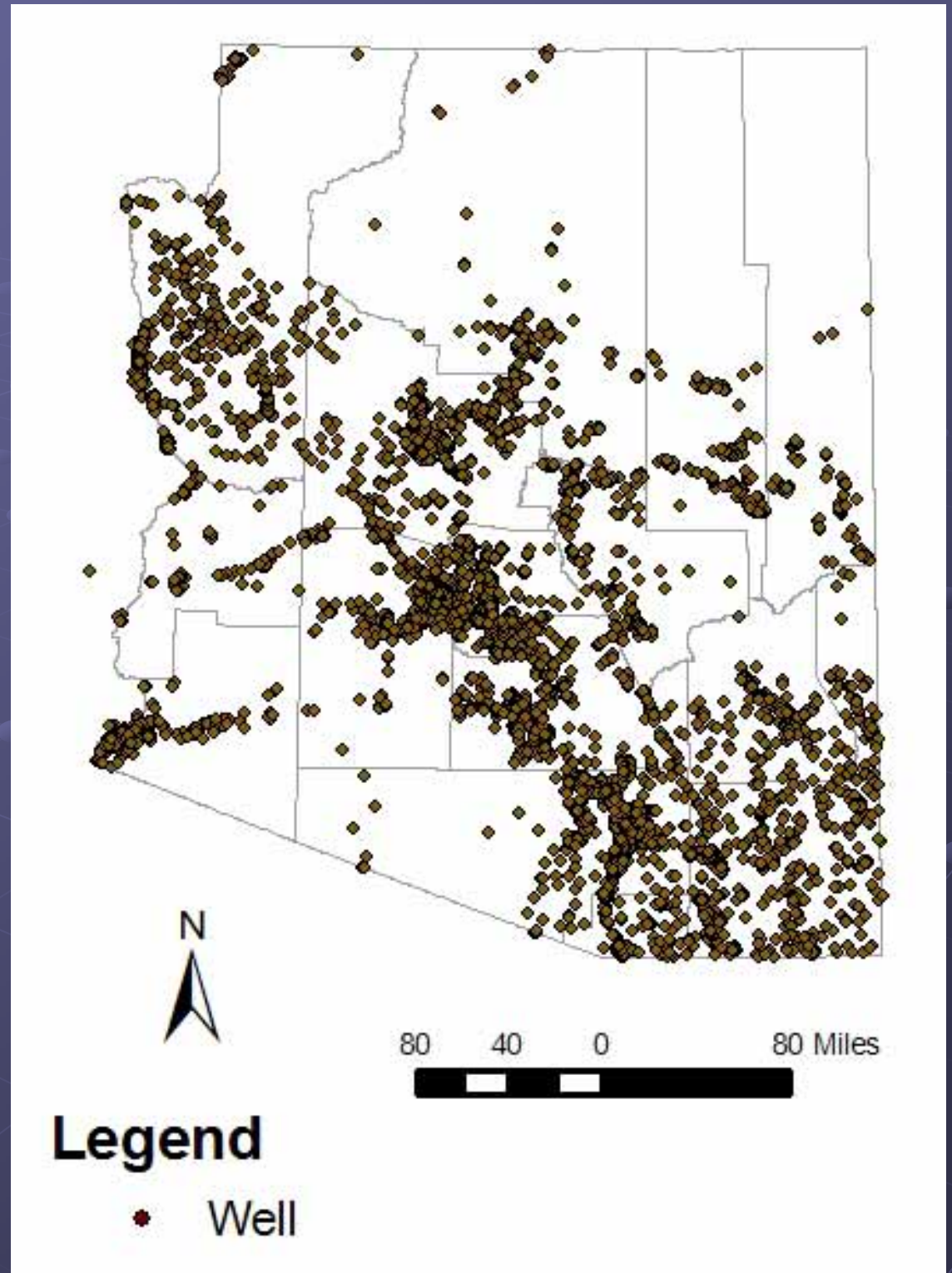
- ✦ ADEQ Drinking Water Data
- ✦ Solely Nitrate Data
- ✦ 15 Excel Files
- ✦ 640,816 Records
- ✦ 4,288 Unique ADWR #s

JOIN

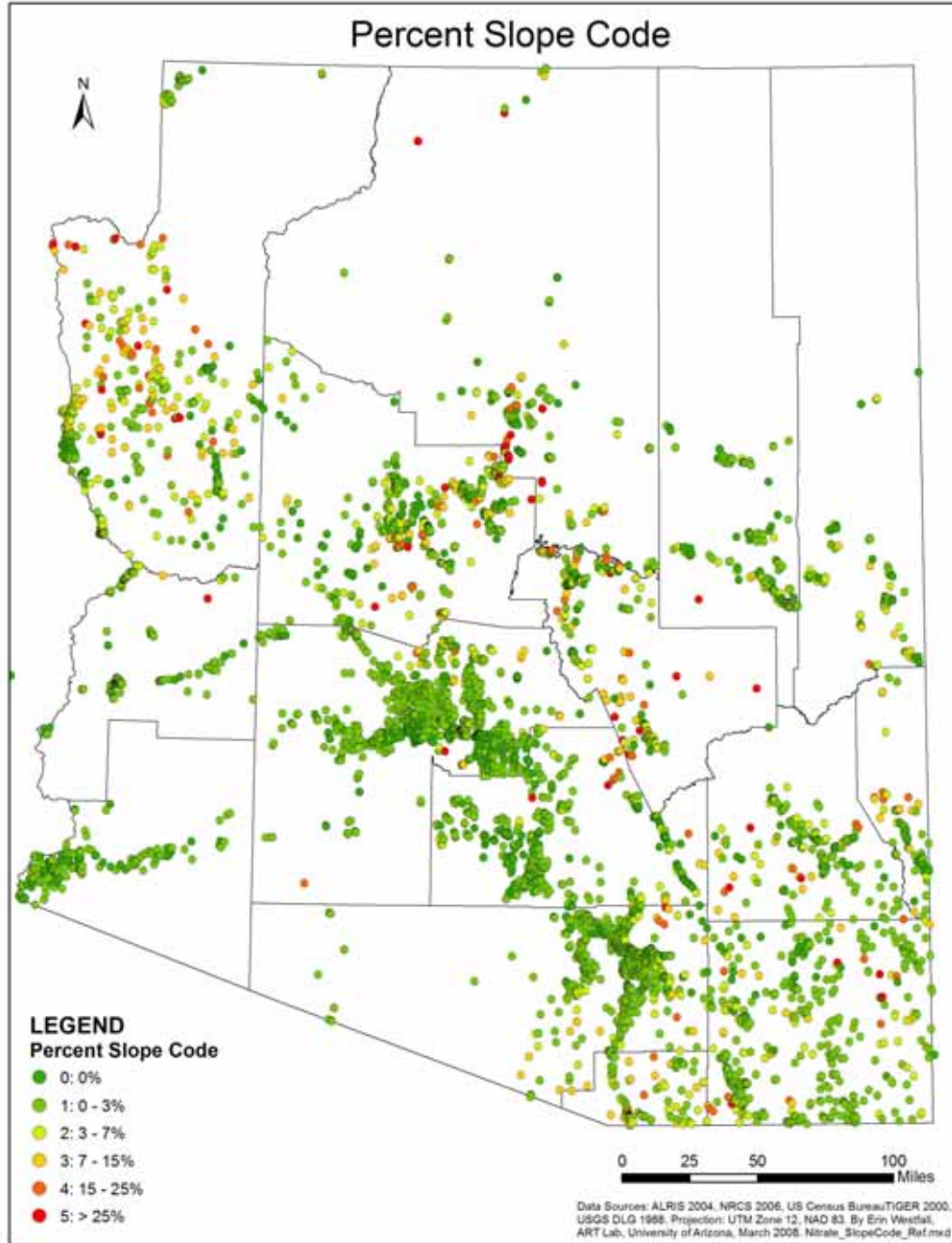
- ✦ DWData_ADWRs
- ✦ Drinking Water Data for which we have well locations
- ✦ 4,313 Records

7,014 wells
across the state

~ after data clean
up we had
6,802 wells
to work with.

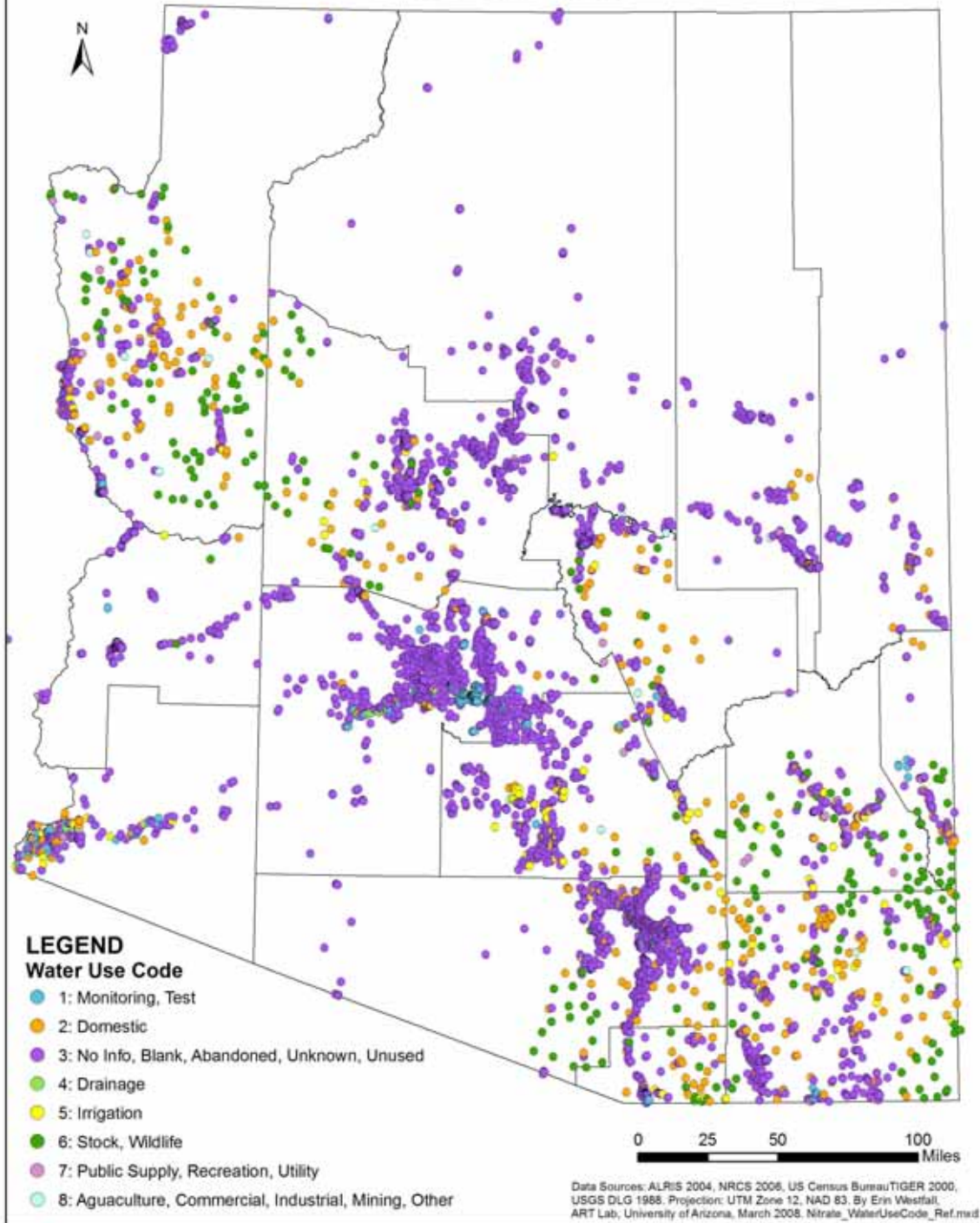


Slope at Well Location



- 0 - 0%
- 1 - >0% to 3%
- 2 - >3% to 7%
- 3 - >7% to 15%
- 4 - >15% to 25%
- 5 - >25%

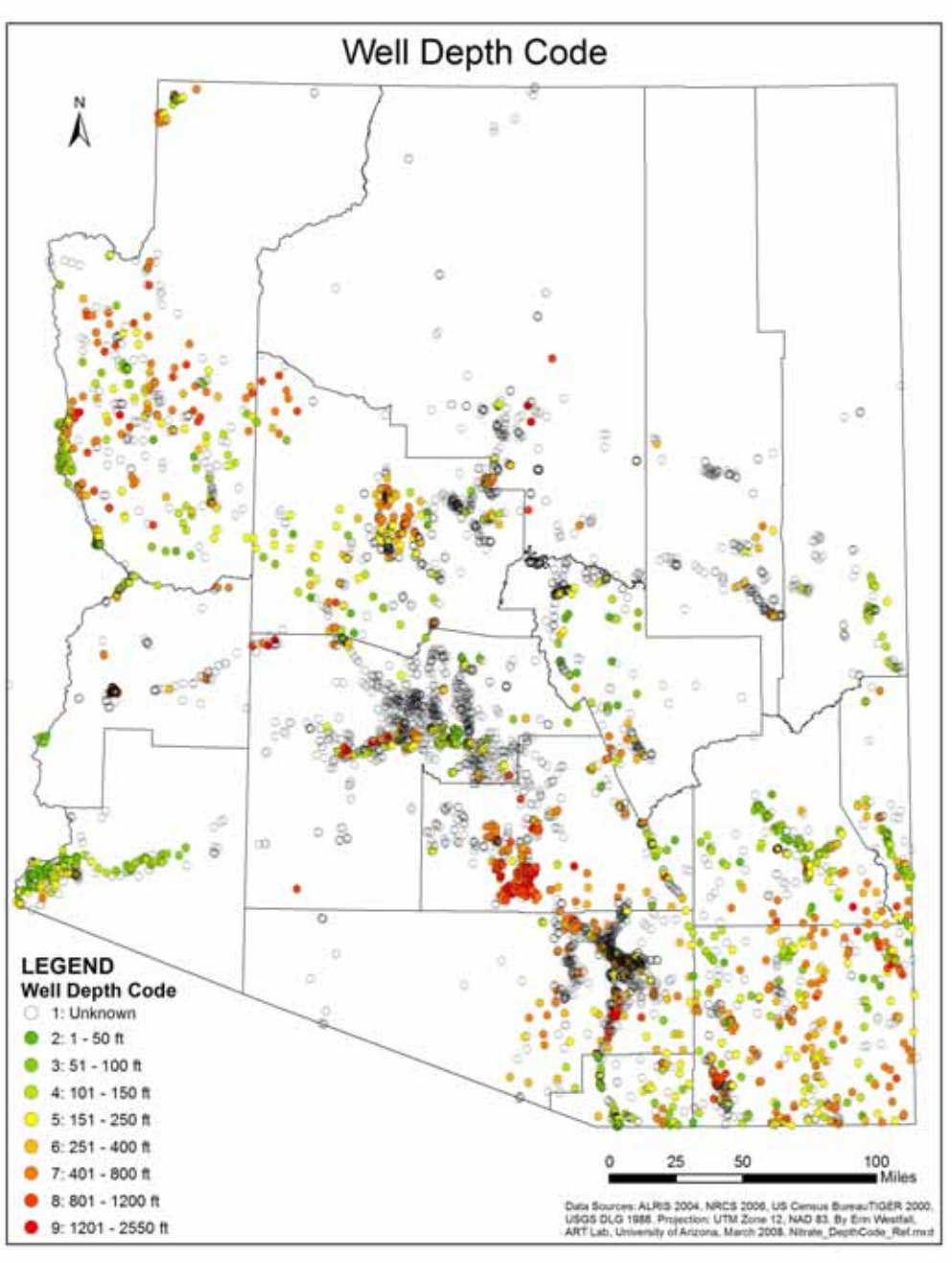
Water Use Code



Water Use
data provided by
ADEQ

Well Depth in Feet

No depth information
for 4,716 wells

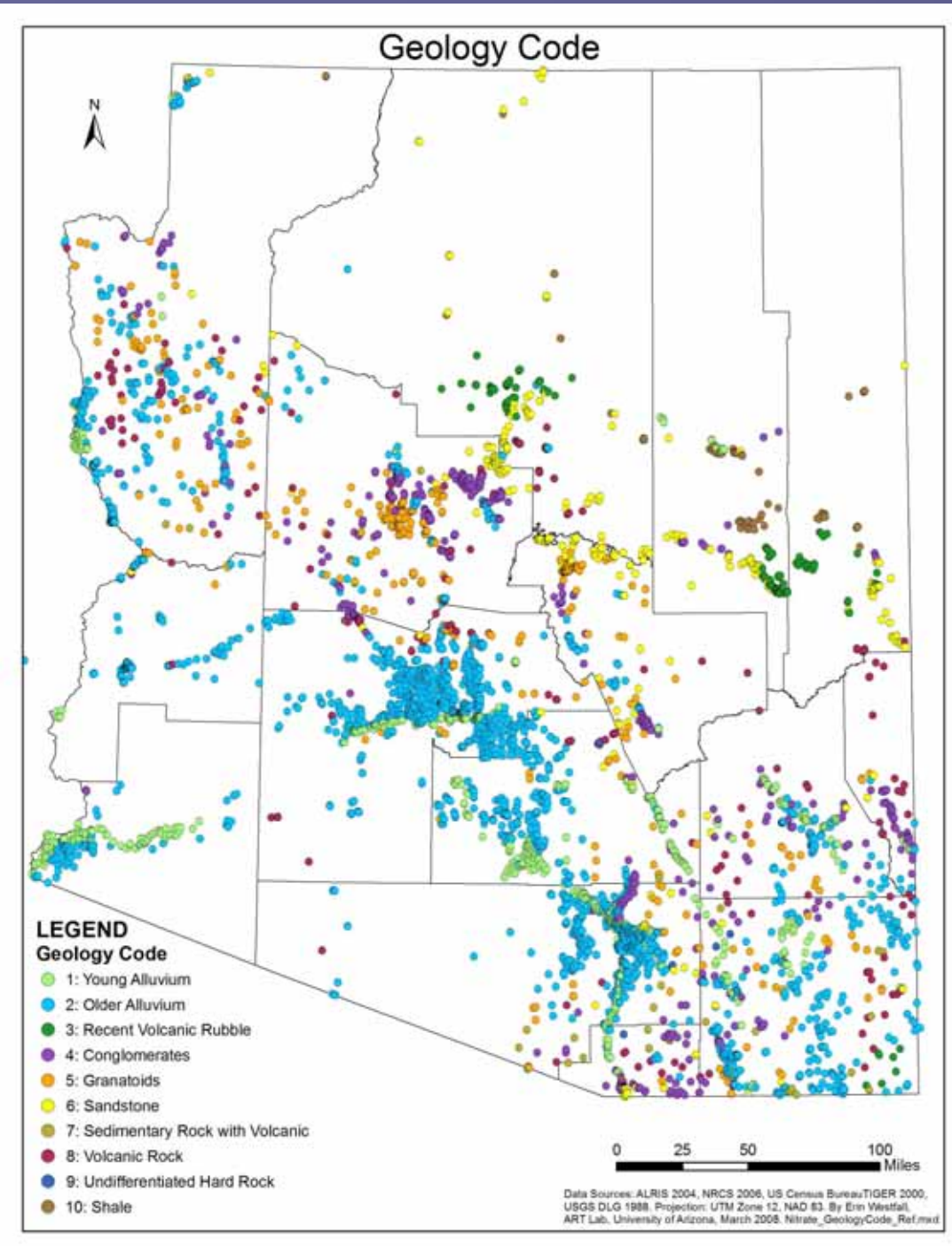


Geology

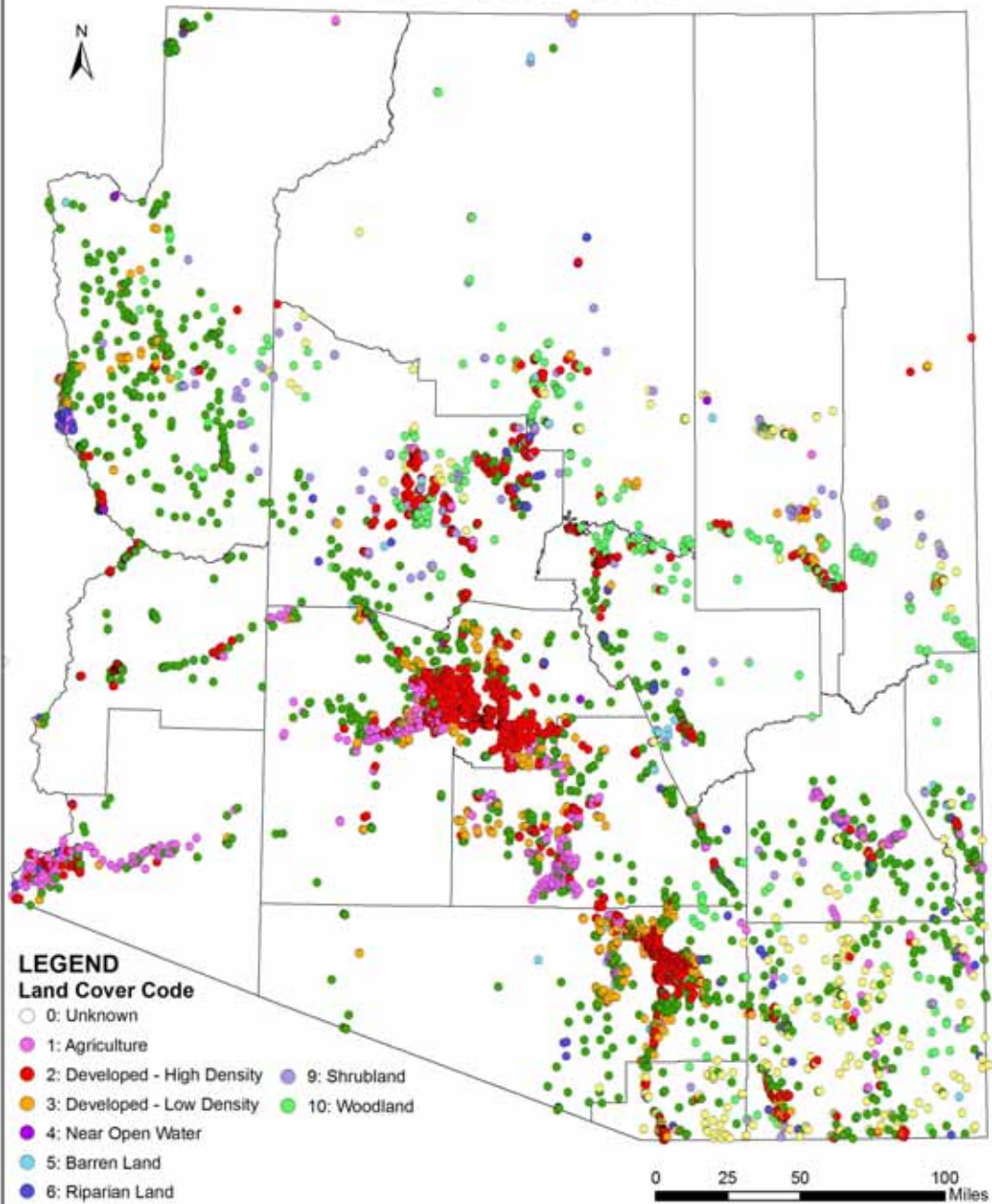
Ranked by aquifer characteristics

Code 2: Older Alluvium

Code 7: Sedimentary rock with Volcanics



Land Cover Code



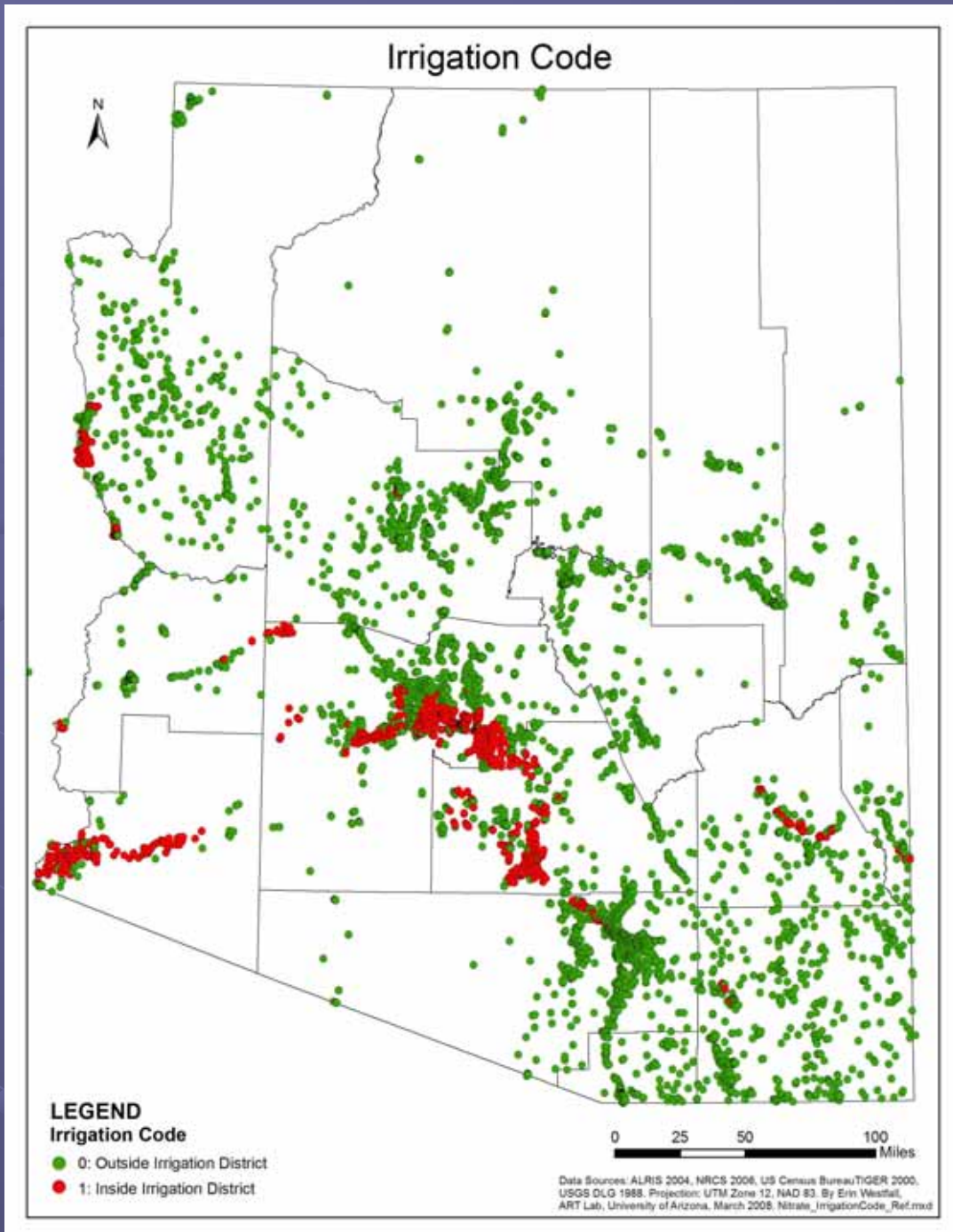
Data Sources: ALRIS 2004, NRCS 2006, US Census Bureau/TIGER 2000, USGS DLG 1988. Projection: UTM Zone 12, NAD 83. By Erin Westfall, ART Lab, University of Arizona, March 2008. Nitrate_LandCoverCode_Ref.mxd

Land Use

Captures agricultural land use, urban areas

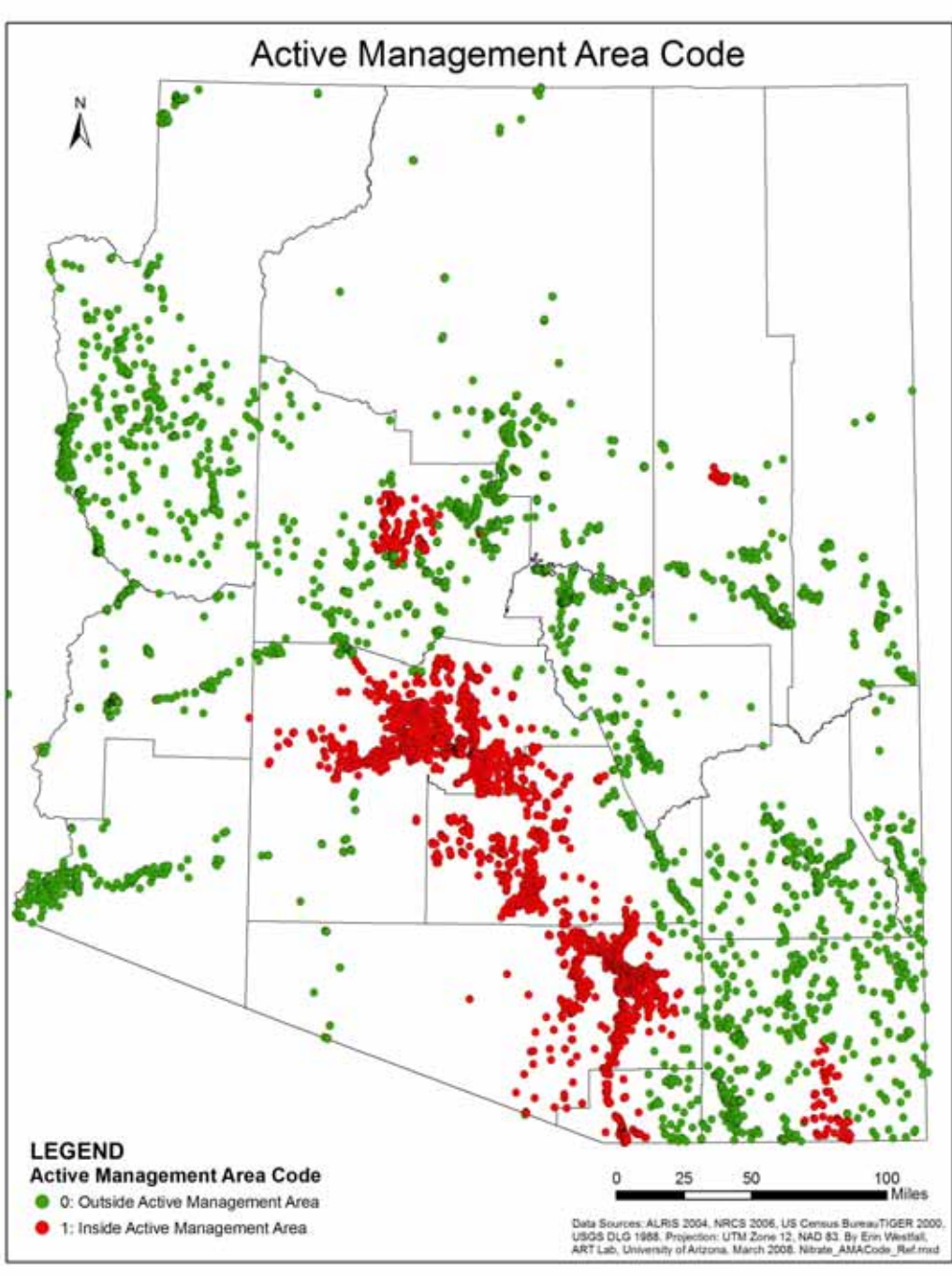
“agriculture” has the highest likelihood of exceeding the threshold value of 3 mg/L.

Irrigation District



Active Management Area - AMA

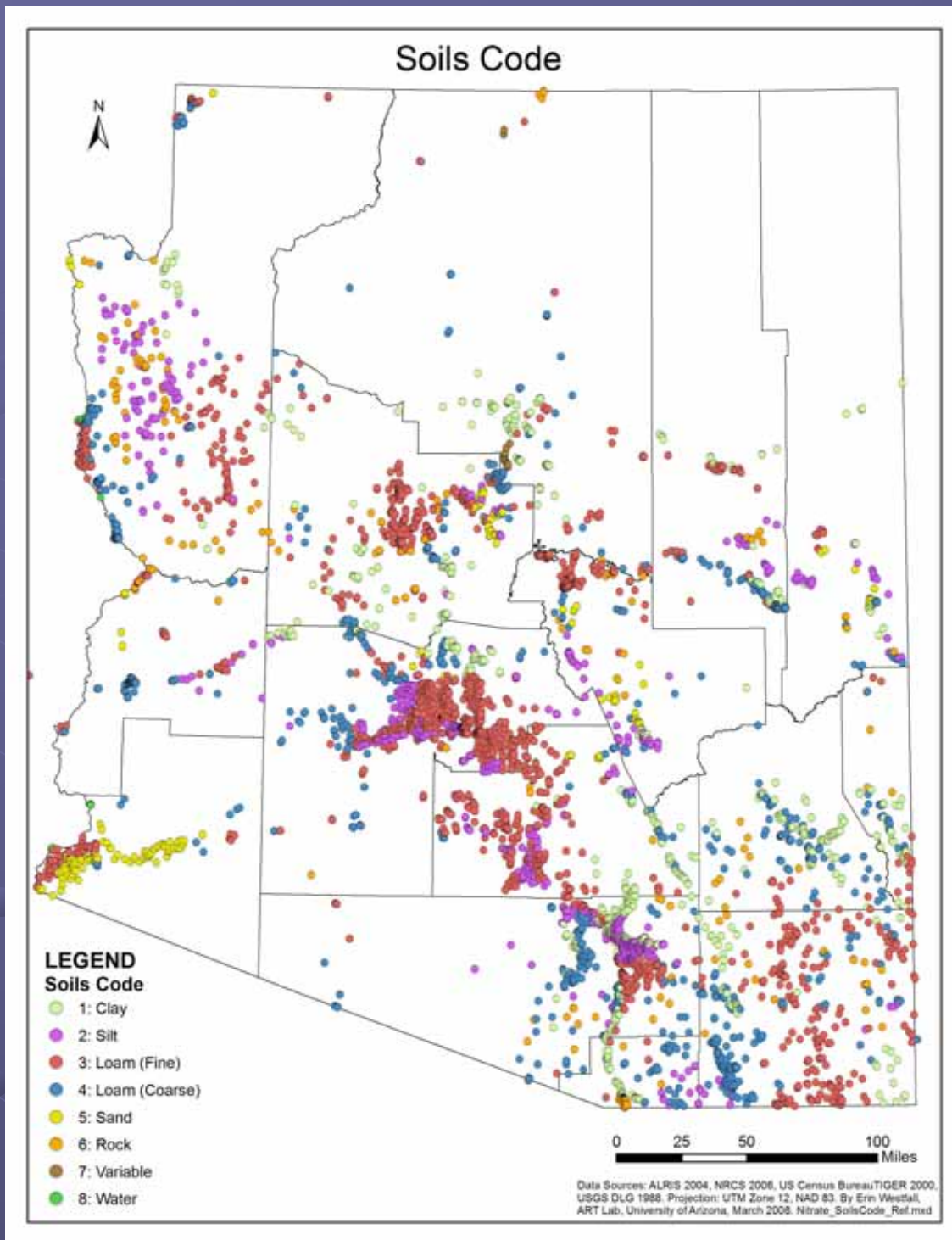
Irrigation non-expansion Area - INA



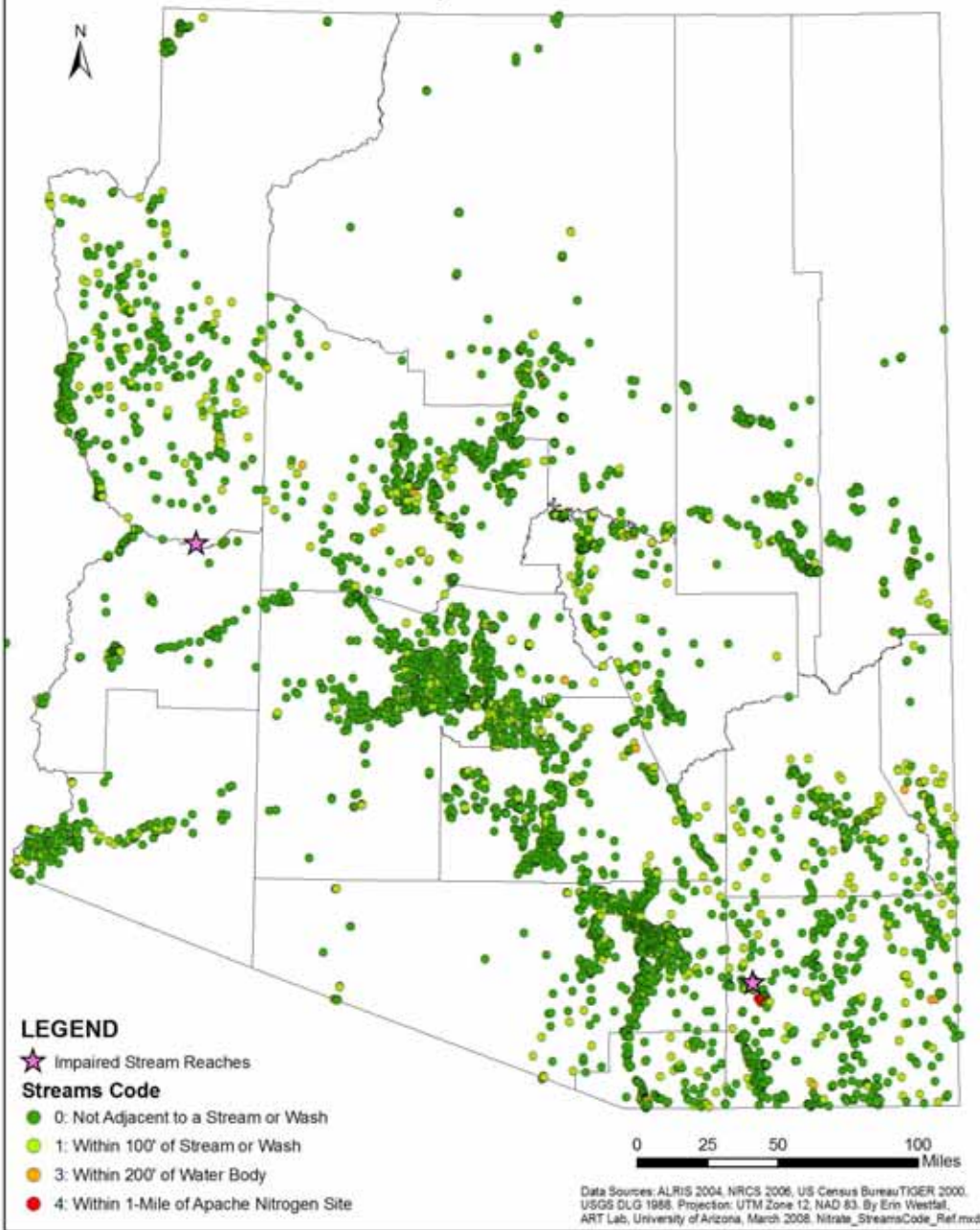
Soils

Drainage capacity

“rock” is more likely to exceed the threshold value of 3 mg/L



Proximity to Streams Code



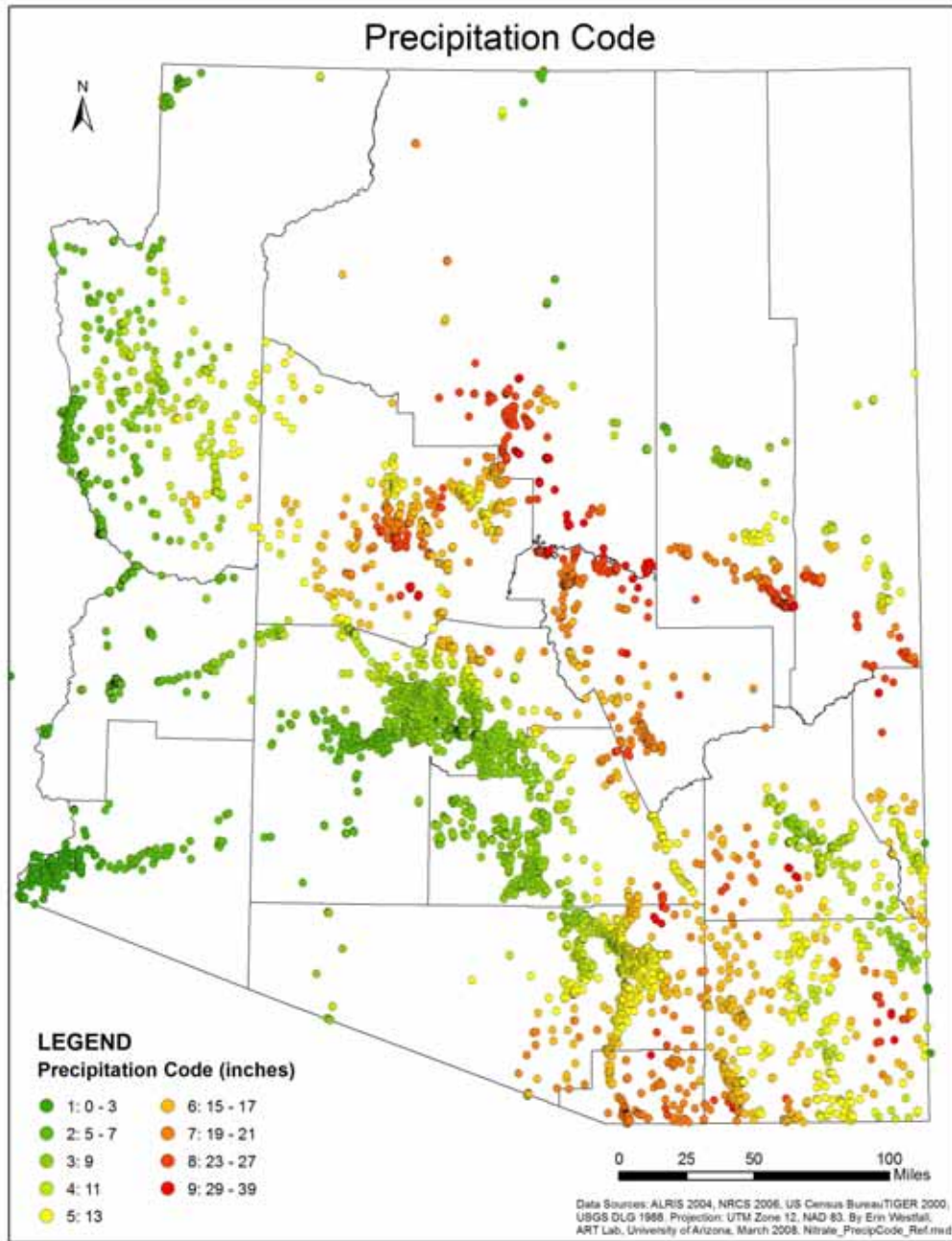
Wells within 200' of a Stream or Wash

Impaired Stream reaches:

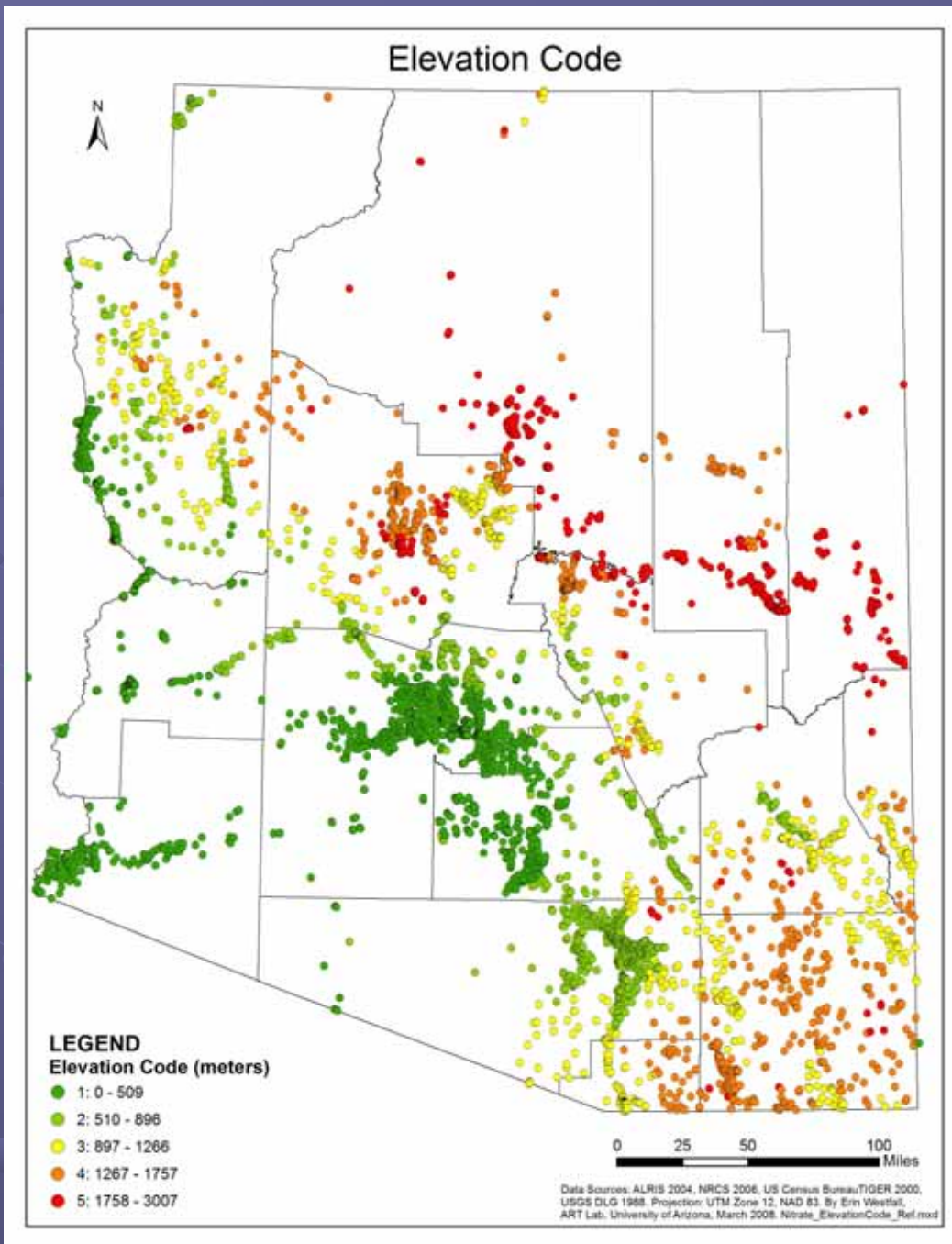
San Pedro (nitrate)

Bill Williams (ammonia)

Precipitation Values



Well Elevation



Septic Systems:

Two explanatory variables: the continuous ratio (*Septic/Sewer*); and, groupings of households served by private septic systems in each census block, ranked by natural breaks (*Septic*).

The continuous ratio was obtained by dividing the number of houses served by private septic systems by the number of households within the census block.

The ranked groupings (*Septic*) were based on the actual number of households served by a private septic system within the census block. The rankings are:

- None to 16,490;
- 16,491 to 57,450;
- 57,451 to 224,000;
- 224,001 to 470,000; or,
- Entire Census Block area on private septic systems, no wastewater treatment or sewer collection available.

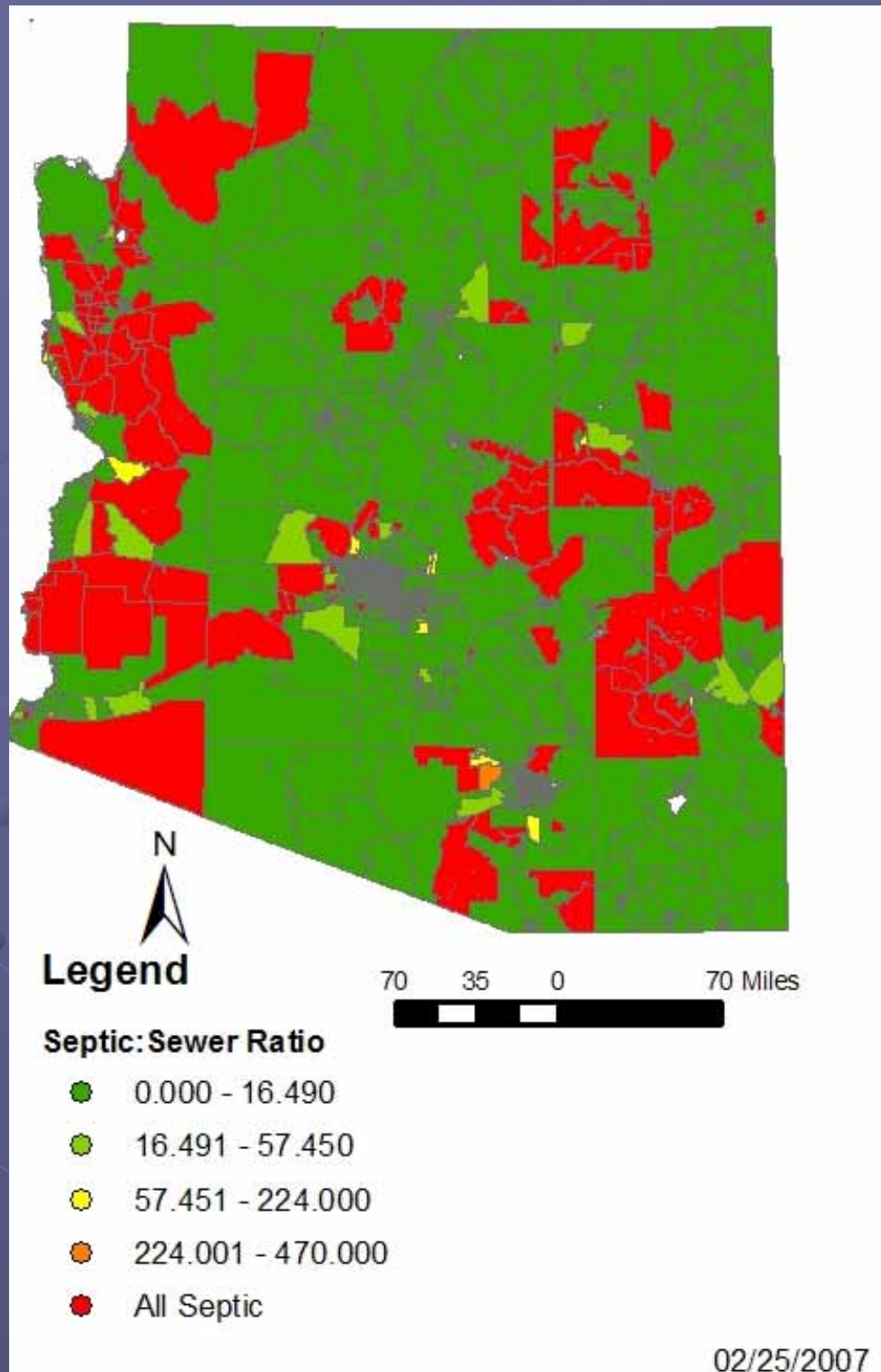
No figure was generated for the continuous variable data.

Septic/Sewer Data from 1990 Census

The continuous ratio (*Septic/Sewer*) was obtained by dividing the number of houses served by private septic systems by the households within the census block served – no figure generated.

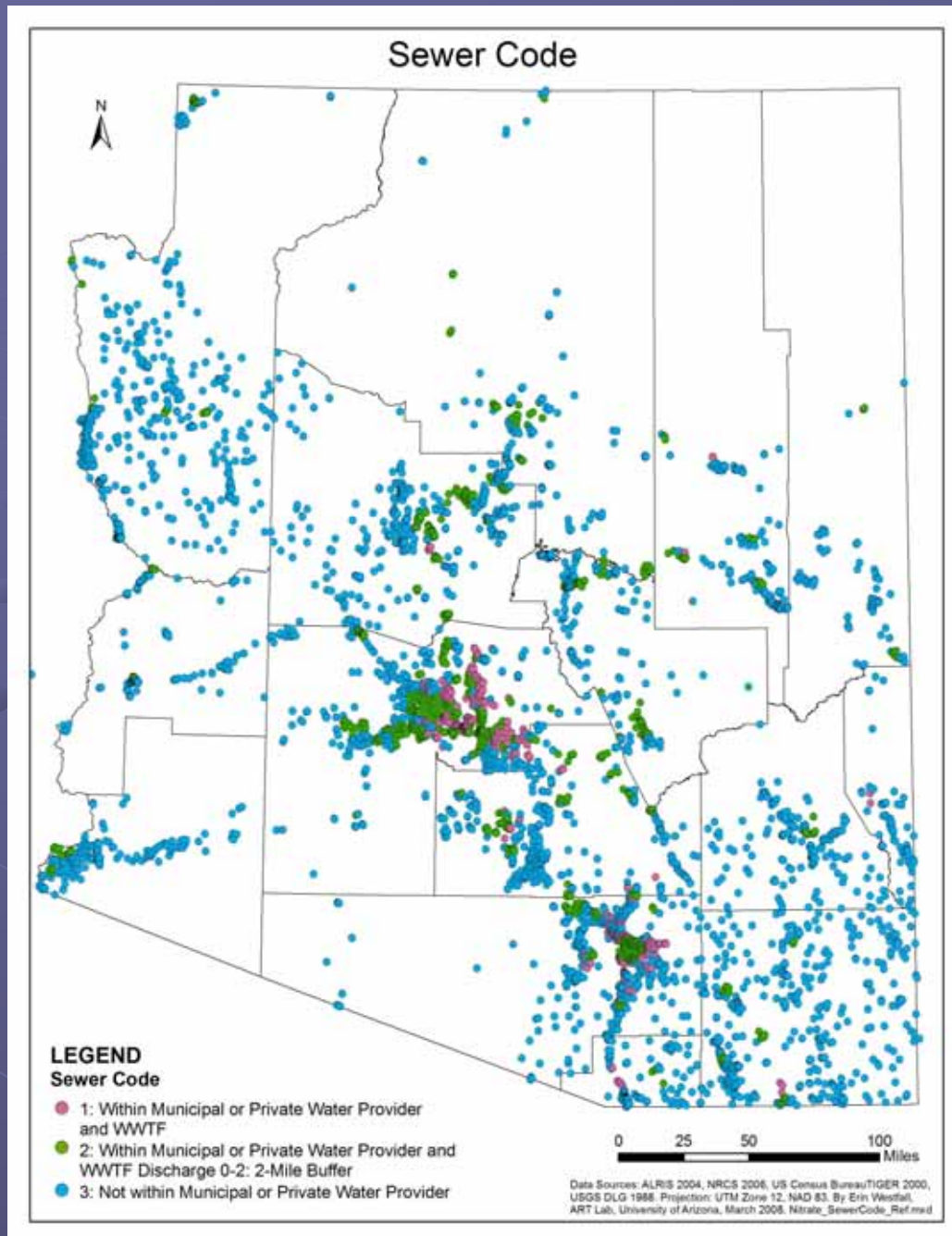
Confusion caused by 'other' category in data set.

Difficult data set to work with.



Sewer Code based on proximity to WWTP and Municipal Water Provider

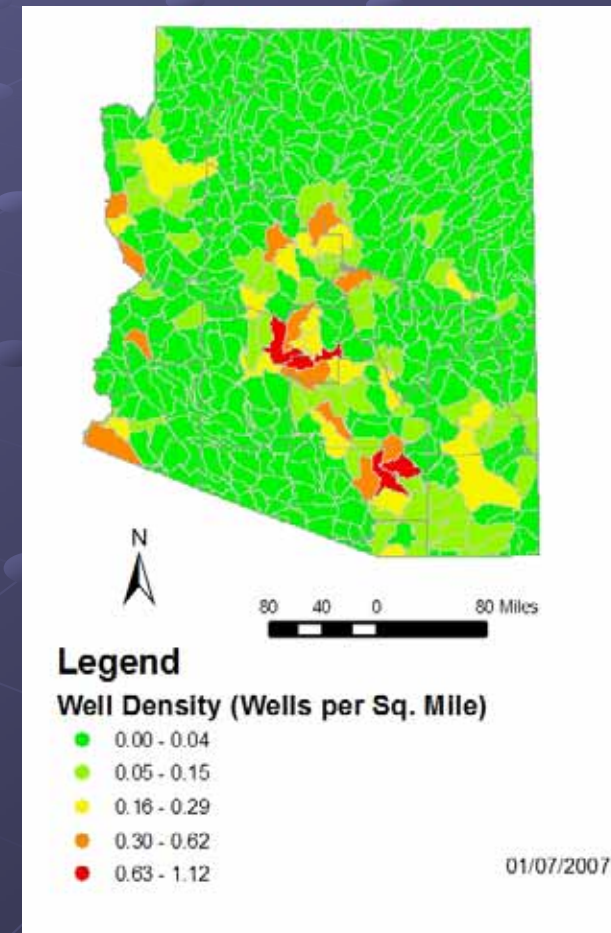
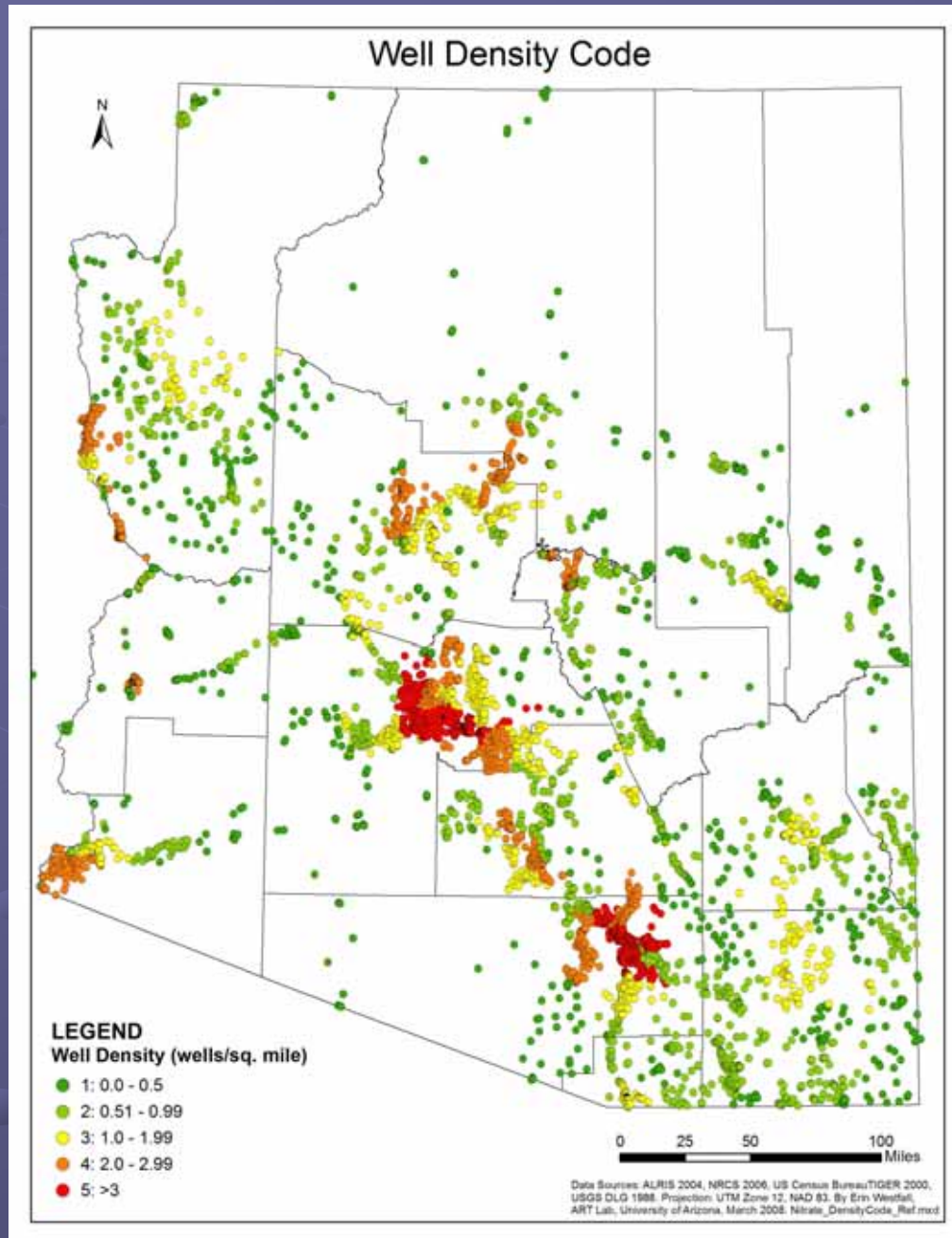
- ~ Area served by a Water Provider *and if* a WWTP is located within the water provider service area;
- ~ Area served by a Water Provider *and if* WWTP plant discharge volume is ≤ 2 MGD but within 2 miles of the border of service area **AND** *if* WWTP discharge volume is ≥ 2 MGD but within 5 miles of the border; or,
- ~ Not within an area served.



This approach worked!

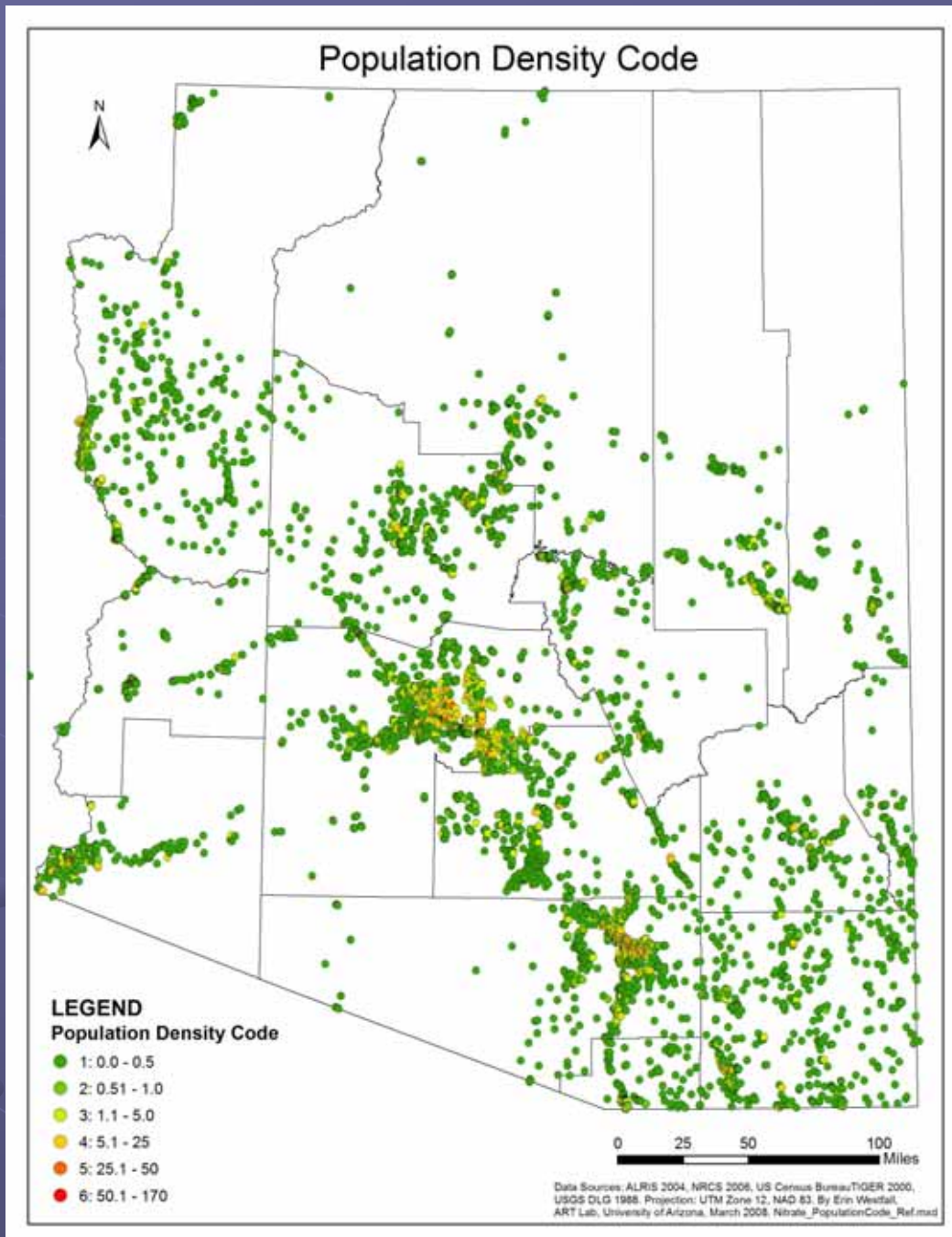
Well Density by 10Digit HUC

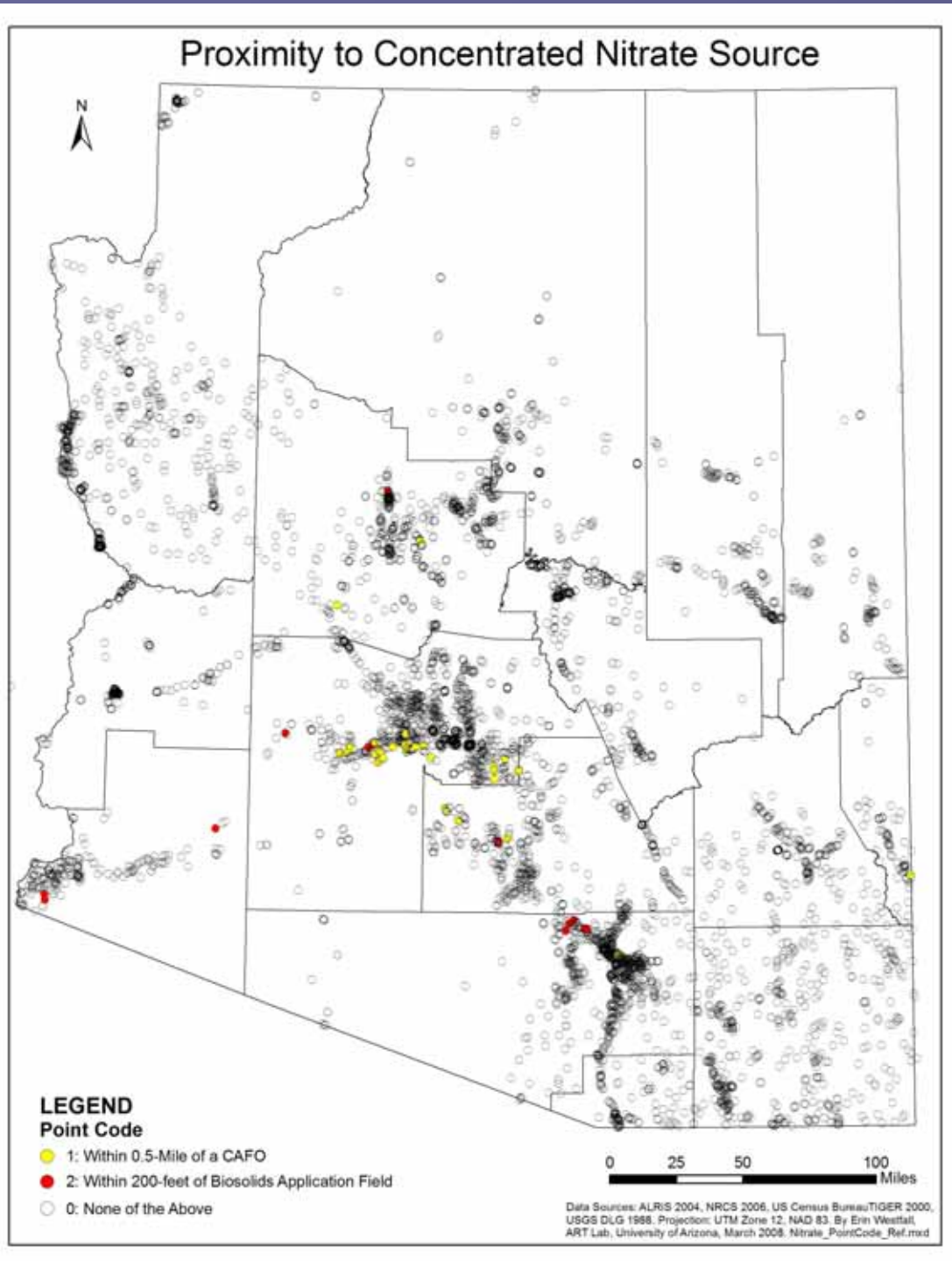
- Number of wells/HUC Area



Population Density

based on people per
acre, 2000 Census





Proximity to Concentrated Nitrate Source

- ~ CAFO
- ~ Biosolids Application Field

The Logit model is defined as:

$$p_i = P(Y = 1 | X_i) = \frac{e^{(\beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \dots + \beta_k x_{ik})}}{1 + e^{(\beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \dots + \beta_k x_{ik})}}$$

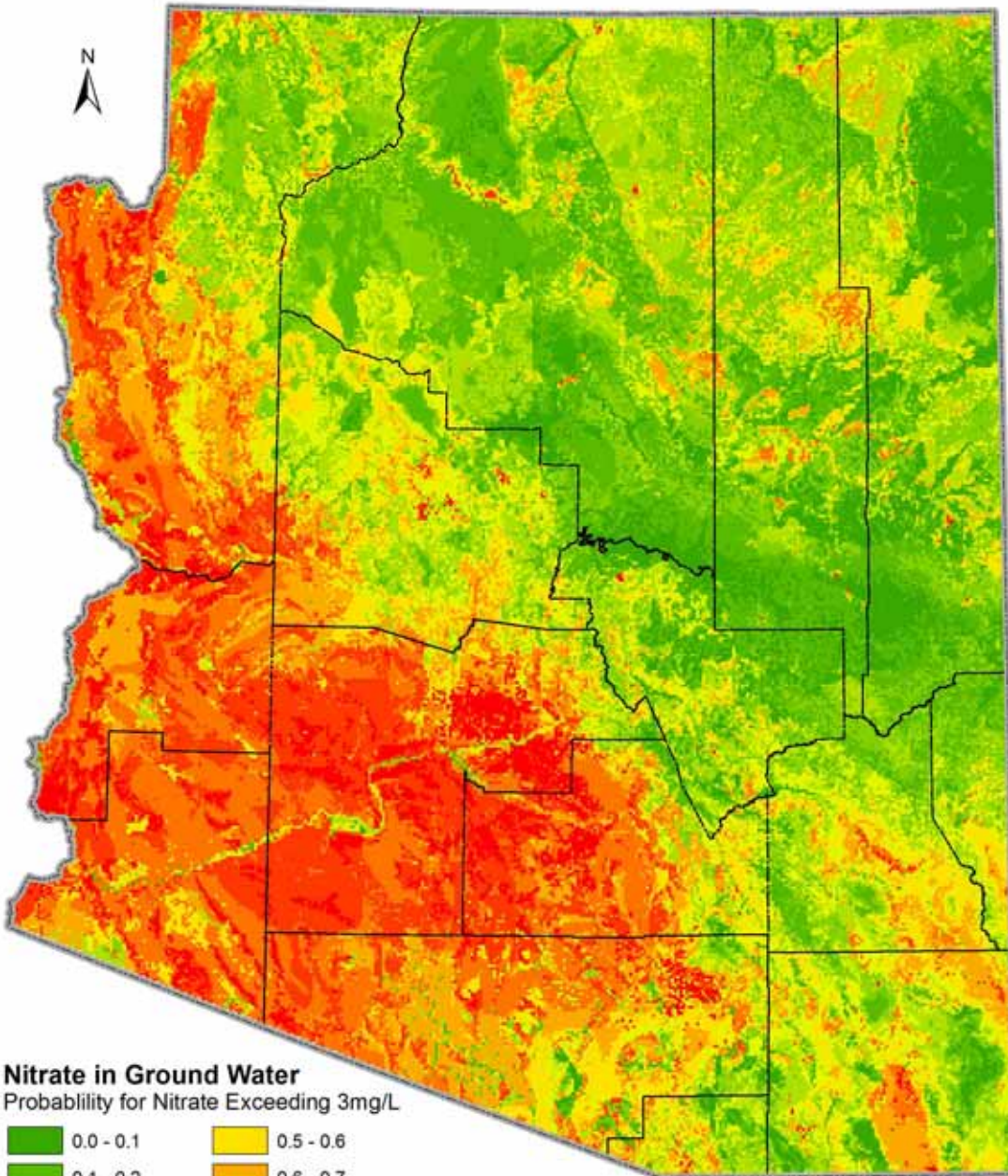
where, for each of n observations, there is a response Y_i that can take on values of 1 or 0, from corresponding independent explanatory variables $X_i, i=1,2,\dots,n$, where $X_i = (1, x_{i1}, x_{i2}, \dots, x_{ik})$.

β_k represents the regression coefficient corresponding to the k^{th} explanatory variable, with β_0 representing the intercept.

$$p_i = P(Y = 1 | X_i) = \frac{1}{1 + e^{(-\beta_0 - \beta_1 x_{i1} - \beta_2 x_{i2} - \dots - \beta_k x_{ik})}}$$

the probability of P_i will always be between 0 and 1.

Probability for Nitrate Levels That Exceed 3mg/L



Grid the state
at one point every
1,500 meters
(0.9 square mile)

Total of 274,945 grid points

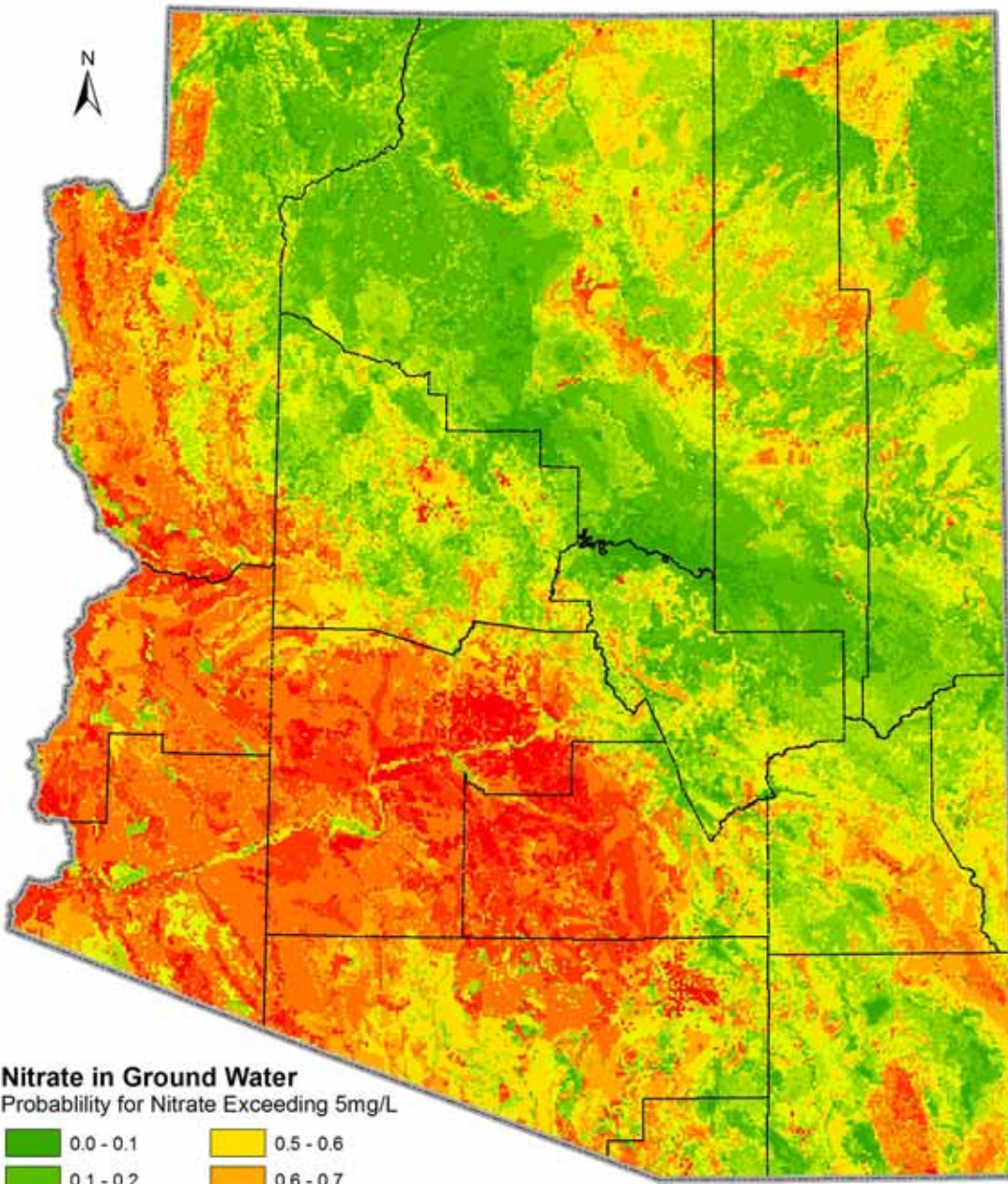
12.8% of the state,
or 16,682 square miles
has a probability >80%
of exceeding 3 mg/l

NITRATE-N

> 3 mg/l

- “Slope” and “population density” are statistically insignificant factors.
- If a well is located within an AMA it is more likely to exceed the threshold of 3 mg/L.
- Statistically significant variables were:
 - ~ water use “public supply”;
 - ~ land uses of “agriculture”, “desert-scrub”, “grassland”, and “woodland”;
 - ~ “precipitation”;
 - ~ “Irrigation District” and “AMA”;
 - ~ Soil type “rock” soil type;
 - ~ “well density”; and,
 - ~ proximity to a wastewater treatment facility (“sewer”).

Probability for Nitrate Levels That Exceed 5mg/L



NITRATE-N > 5mg/l

9.4% of the State,
or 12,199 square miles
has a probability >80%
of exceeding 5 mg/l

State = 130,360 Square miles

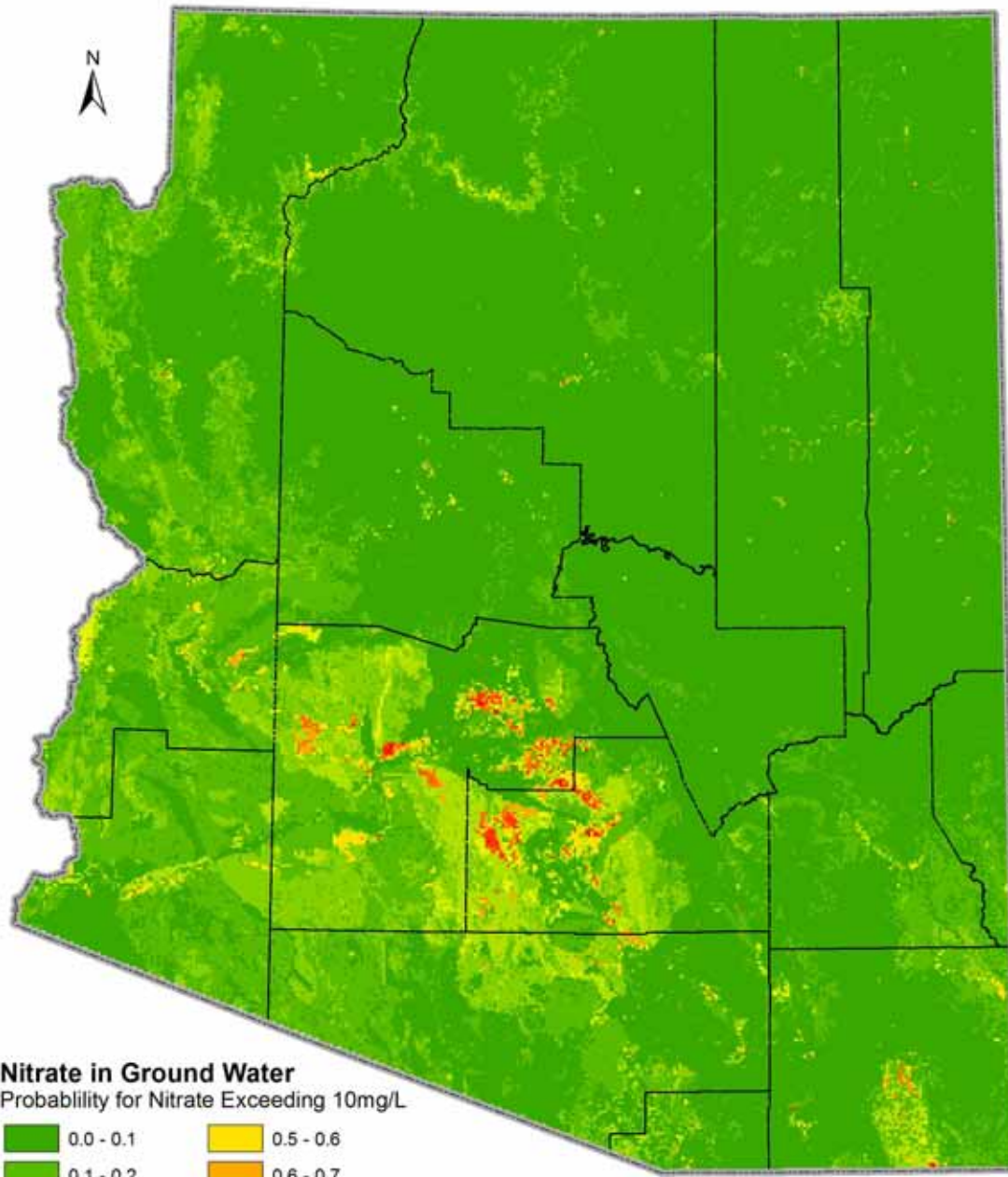
NITRATE-N > 5mg/l

- Well depth is statistically significant factor - with increasing well depth the probability of well exceeding nitrate of 5 mg/L, decreases. Shallower wells are more likely to exceed the nitrate threshold value, as compared to deeper wells.

The significant predictors were:

- ~ well depth;
- ~ geology type “Granitoids”;
- ~ land uses of “agriculture”, “high density”, and “low density”;
- ~ “Irrigation District” and “AMA”,
- ~ “well density”; and,
- ~ proximity to a wastewater treatment facility (“sewer”).

Probability for Nitrate Levels That Exceed 10mg/L



NITRATE-N > 10mg/l

0.17% of the state,
or 226 square miles
has a probability >80%
of exceeding 10 mg/l

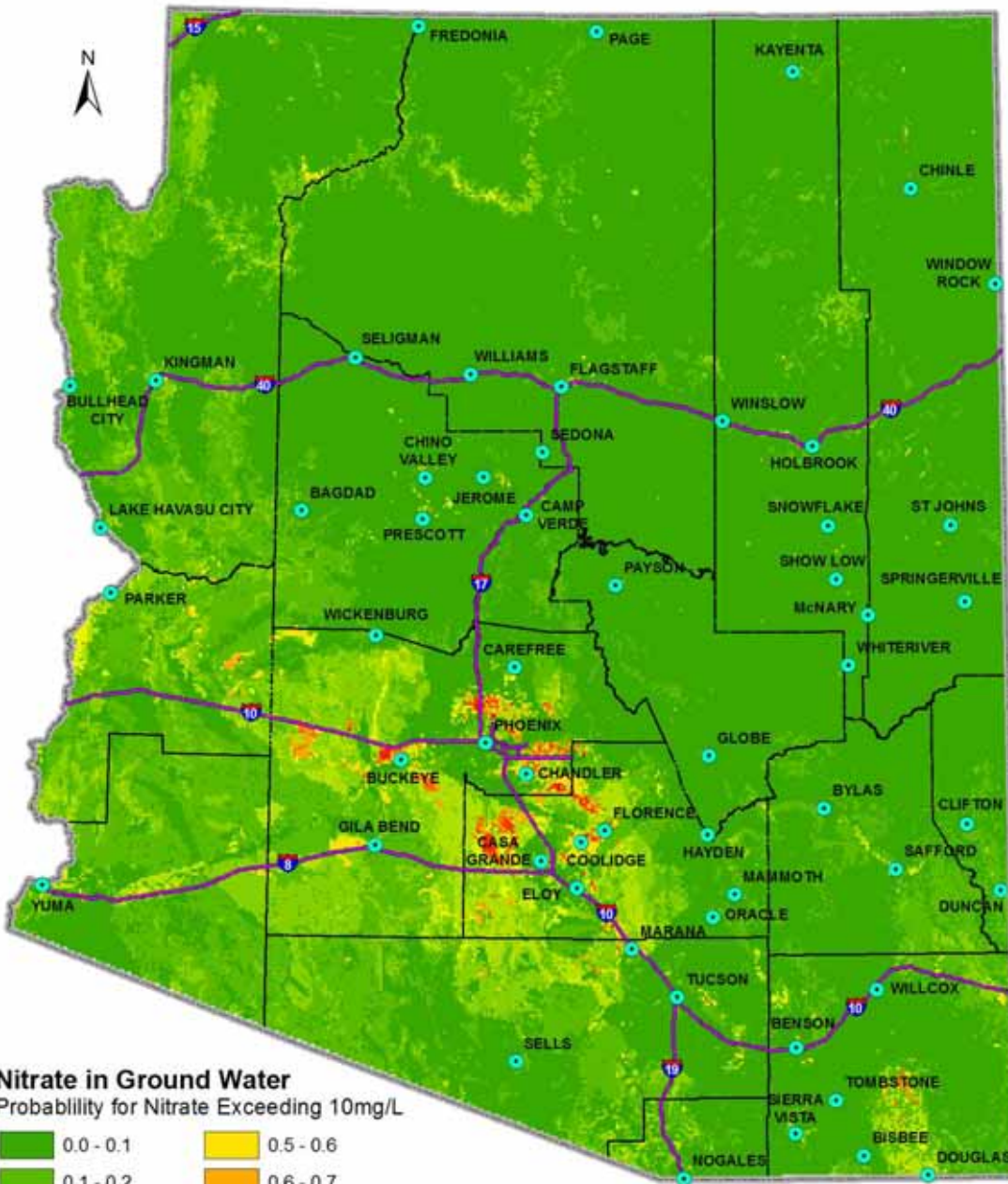
NITRATE-N > 10mg/l

- No well depth for 69% of the wells, but well depth was found to be a statistically **insignificant** factor in explaining the nitrate level of 10 mg/L.
- Also, we find that with increasing population density, the probability of well exceeding 10 mg/L of nitrate decreases.
- If a well is located within the AMA, it has higher probability of exceeding.
- Additionally, “elevation code”, and “well density” are statistically significant factors. That is, with increasing elevation, the probability decreases, and with increasing well density the probability of nitrate exceeding 10 mg/l decreases.

Other significant predictors were:

- ~ water uses “domestic”, “irrigation”, and “public supply”; and,
- ~ proximity to a wastewater treatment facility (“sewer”).

Probability for Nitrate Levels That Exceed 10mg/L



NITRATE-N > 10mg/l

Locations of interest:

Buckeye
Casa Grande
Chandler
Phoenix

Thank You!



ARIZONA COOPERATIVE
EXTENSION

