

# Effects of deicing chemicals on ground- and surface-water quality in glaciated parts of the United States- an update



# Objectives

- Describe concentrations of ions related to deicing chemicals (sodium, chloride, other ions) in urbanized shallow aquifers and in urban stream base flow
- Relate concentrations to regional application rates, land use, presence of septic systems, hydrogeology and climatic factors.
- Describe relations between sodium, chloride and other urban anthropogenic contaminants.
- Describe water-type and the potential changes to overall water chemistry due to input of sodium chloride.
- Determine if ground-water discharge to streams is a major contributor of road deicing chemicals relative to the annual load

# Tasks

[illegible]

# Staffing

- FY04

Mullaney (Connecticut) .24 FTE

Arntson (Minnesota) .24 FTE

- FY05

Mullaney (Connecticut) .16 FTE

Arntson (Minnesota) .16 FTE

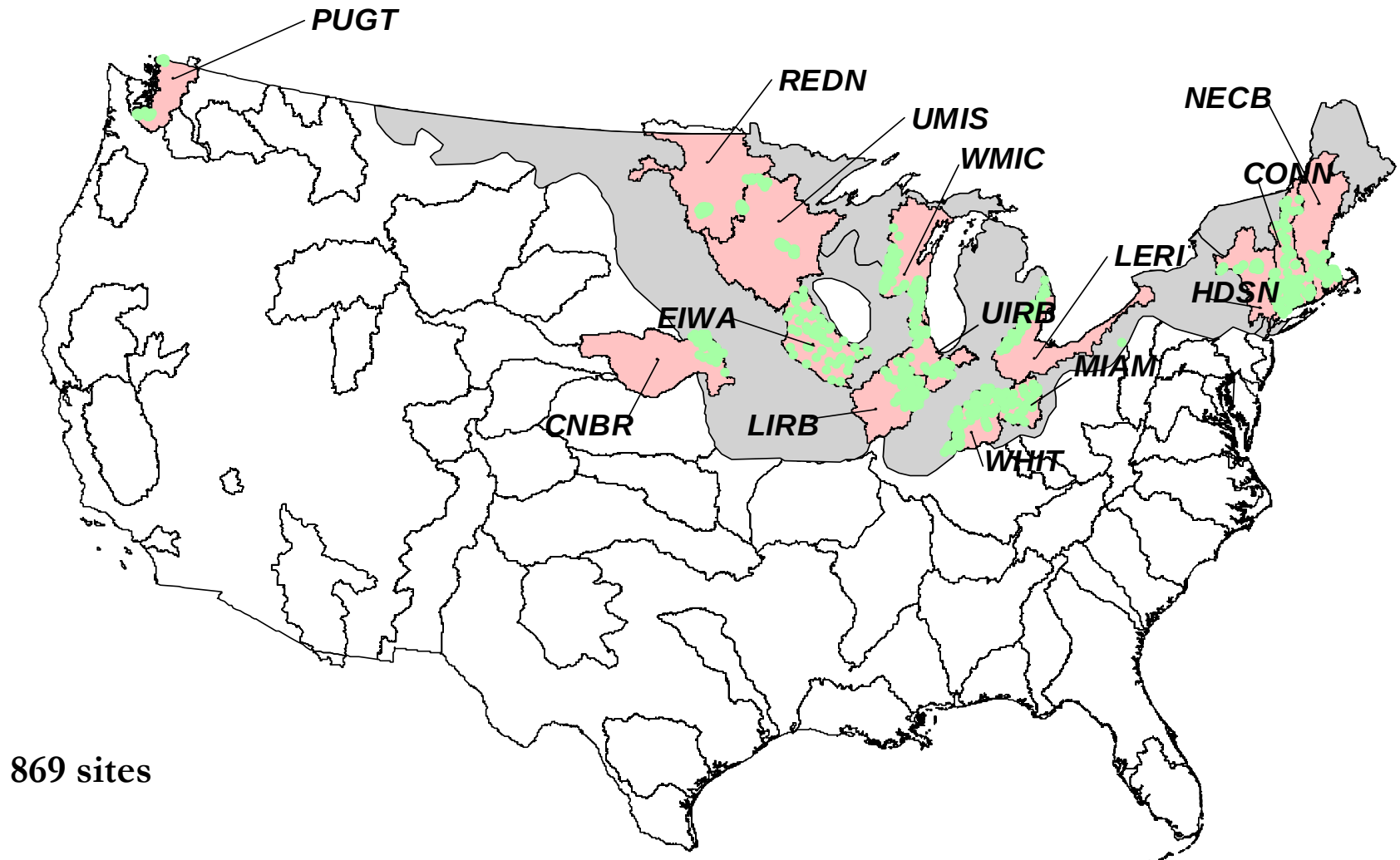
- FY06

Mullaney (Connecticut) .30 FTE

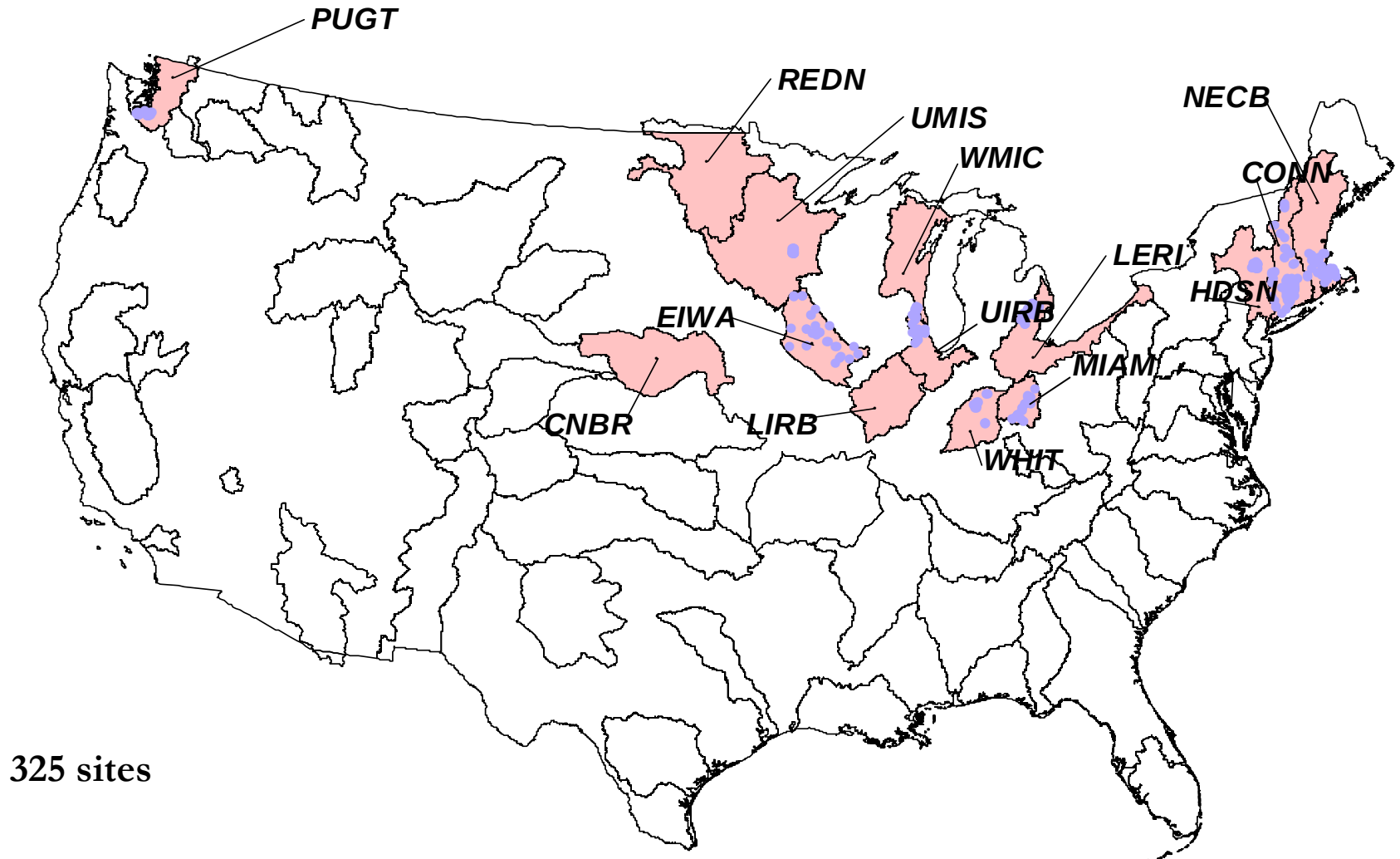
Arntson (Minnesota) .30 FTE

Editor and pubs .07 FTE

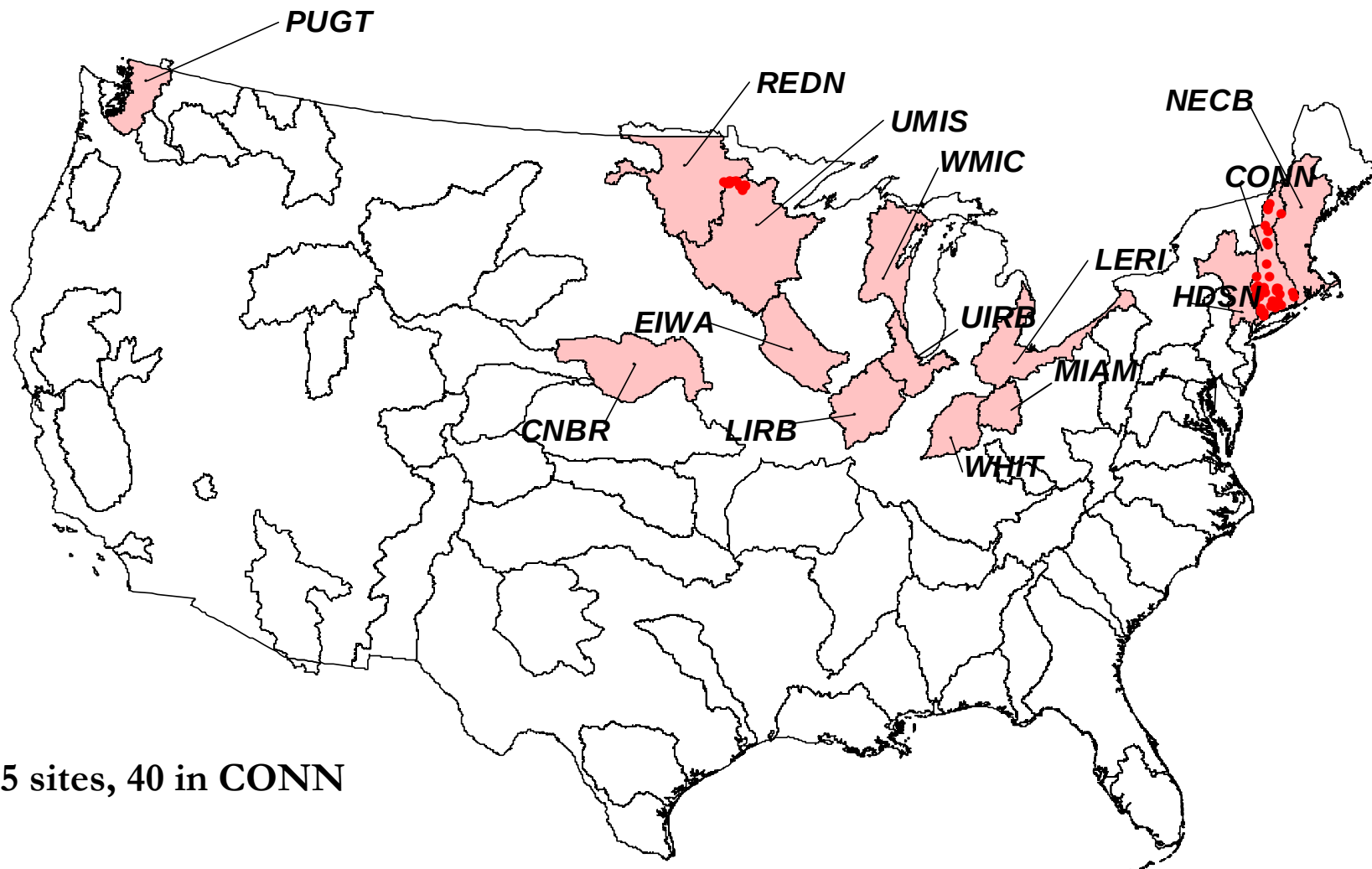
## Land Use Wells in Glacial Aquifer Area



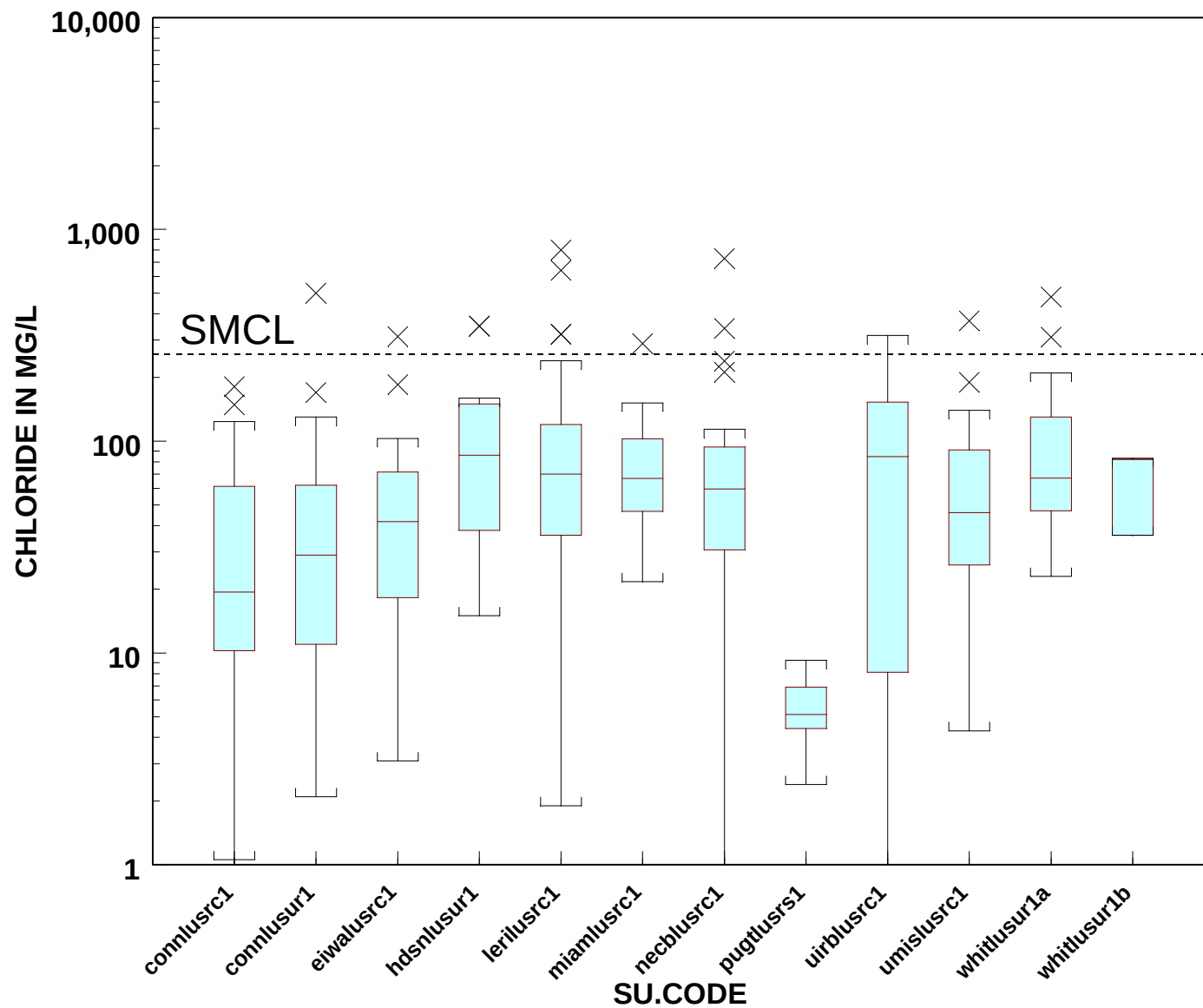
## Urban Land Use Wells in Glacial Aquifer Area



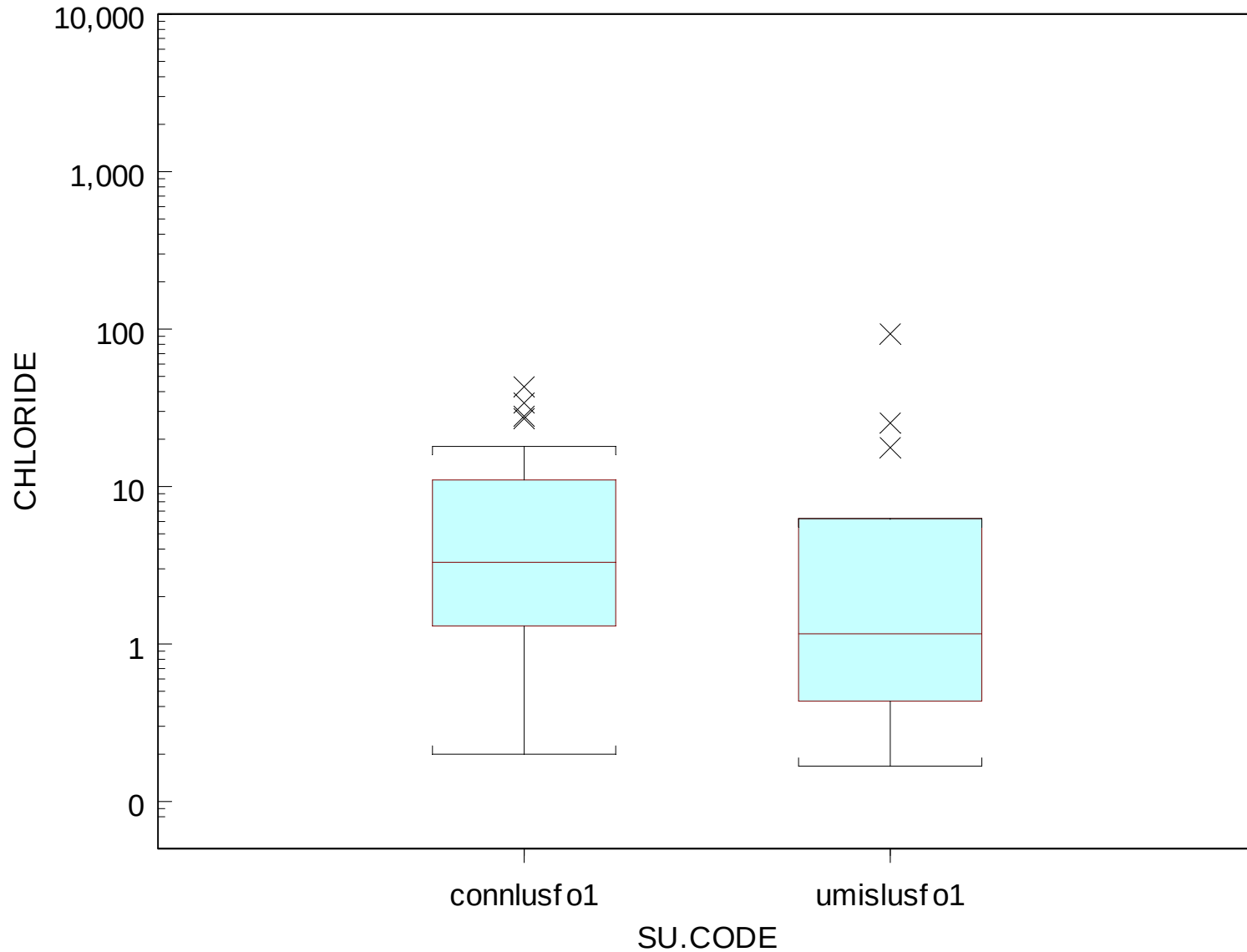
## Reference (or forested) Land Use Wells in Glacial Aquifer Area

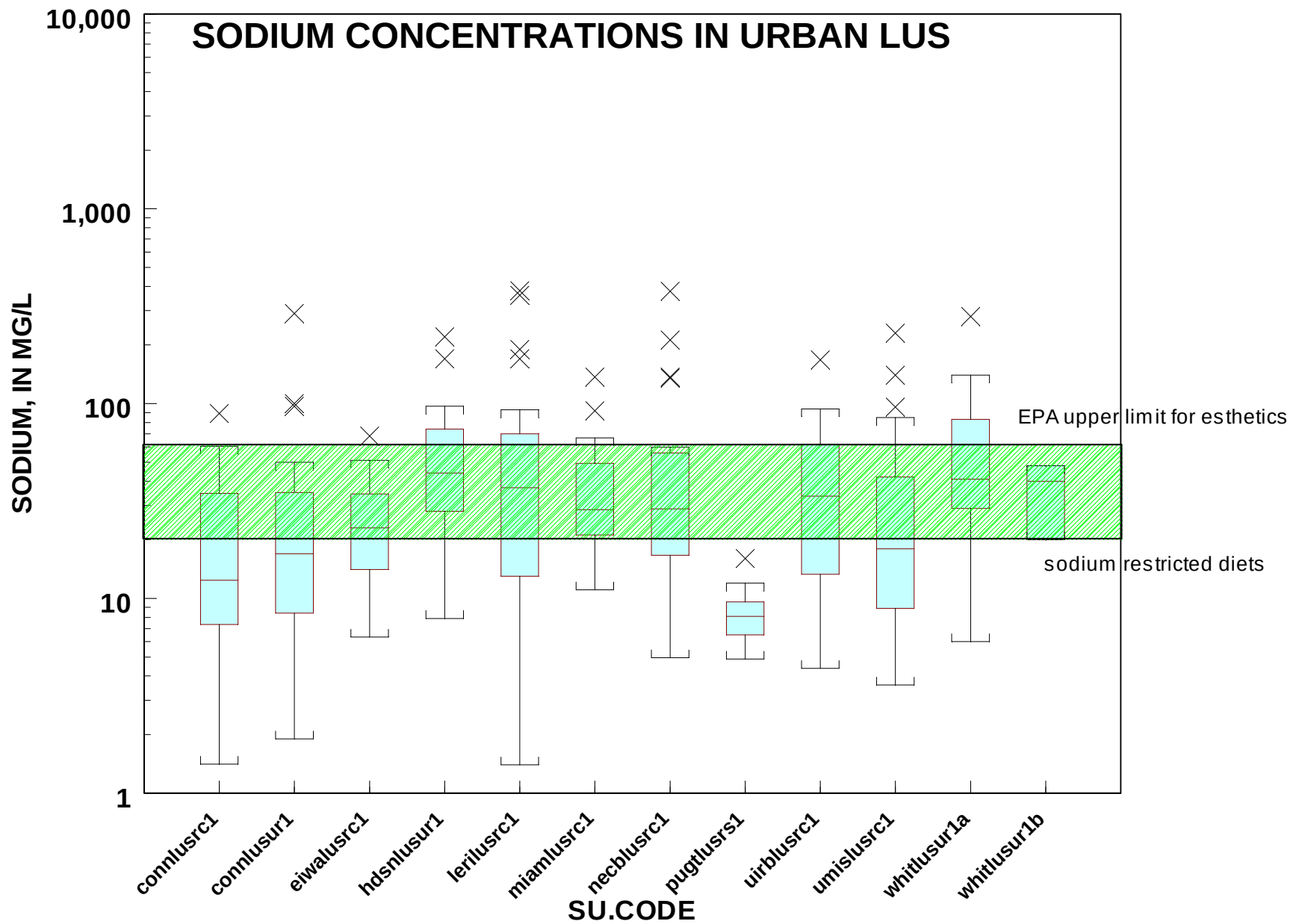


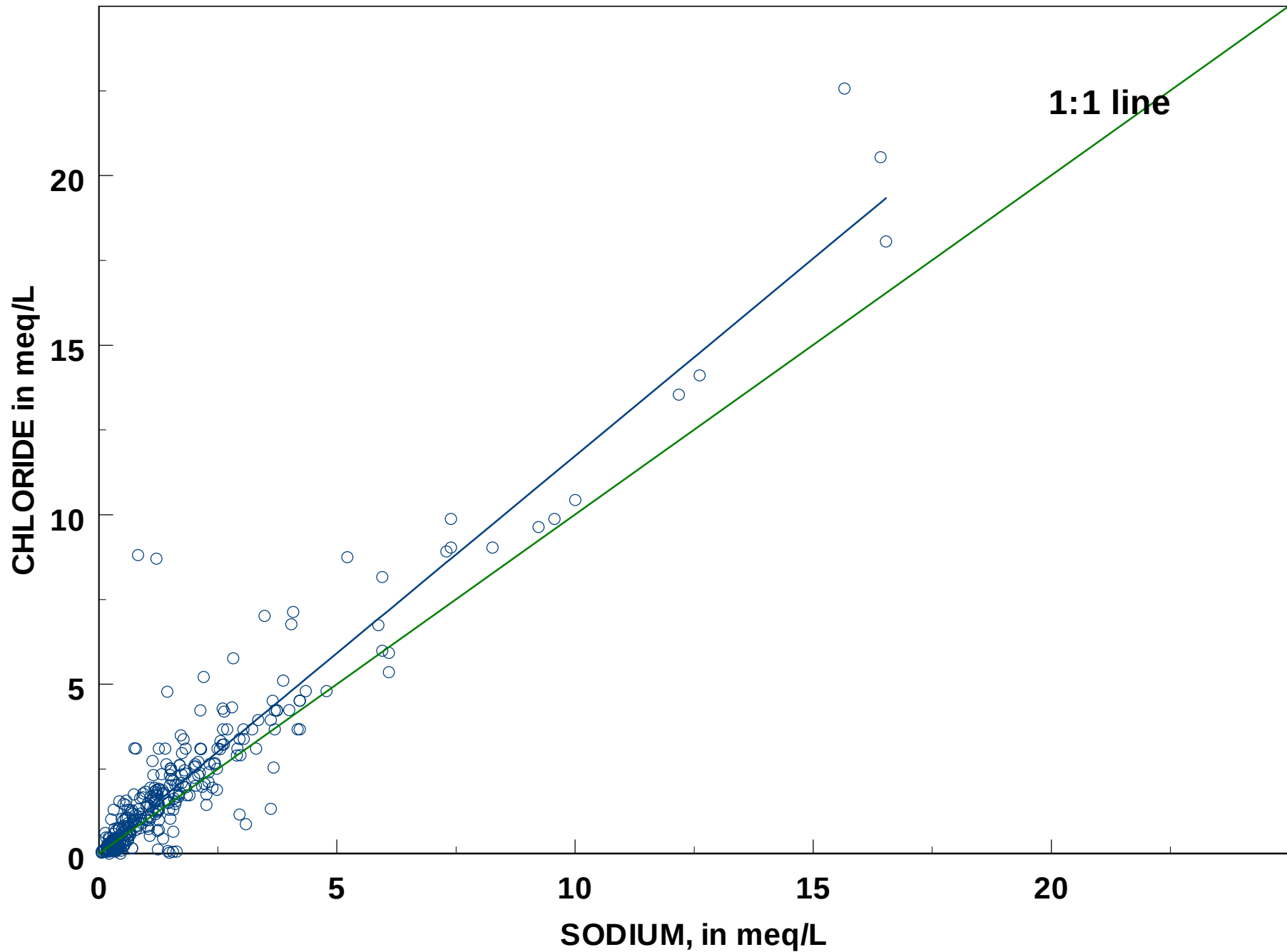
# CHLORIDE CONCENTRATIONS IN URBAN LUS

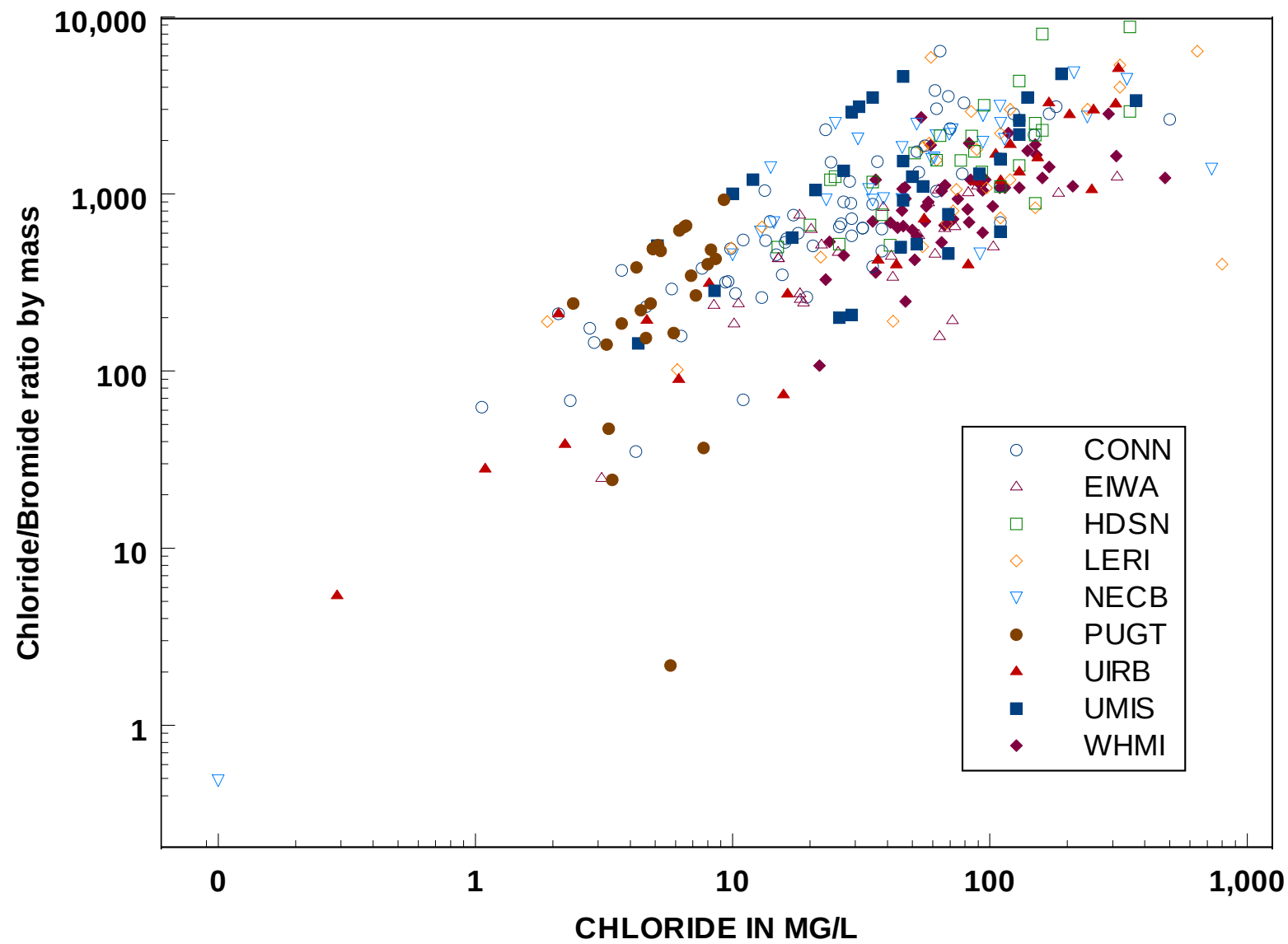


# CHLORIDE CONCENTRATIONS IN FORESTED LUS









# Preliminary Regression Analysis

- Factors tested include those previously summarized for 500 m buffer in ancillary data sets
- NLCD land use
- population density
- % of area with septic systems
- % of area with private wells
- Median year of housing

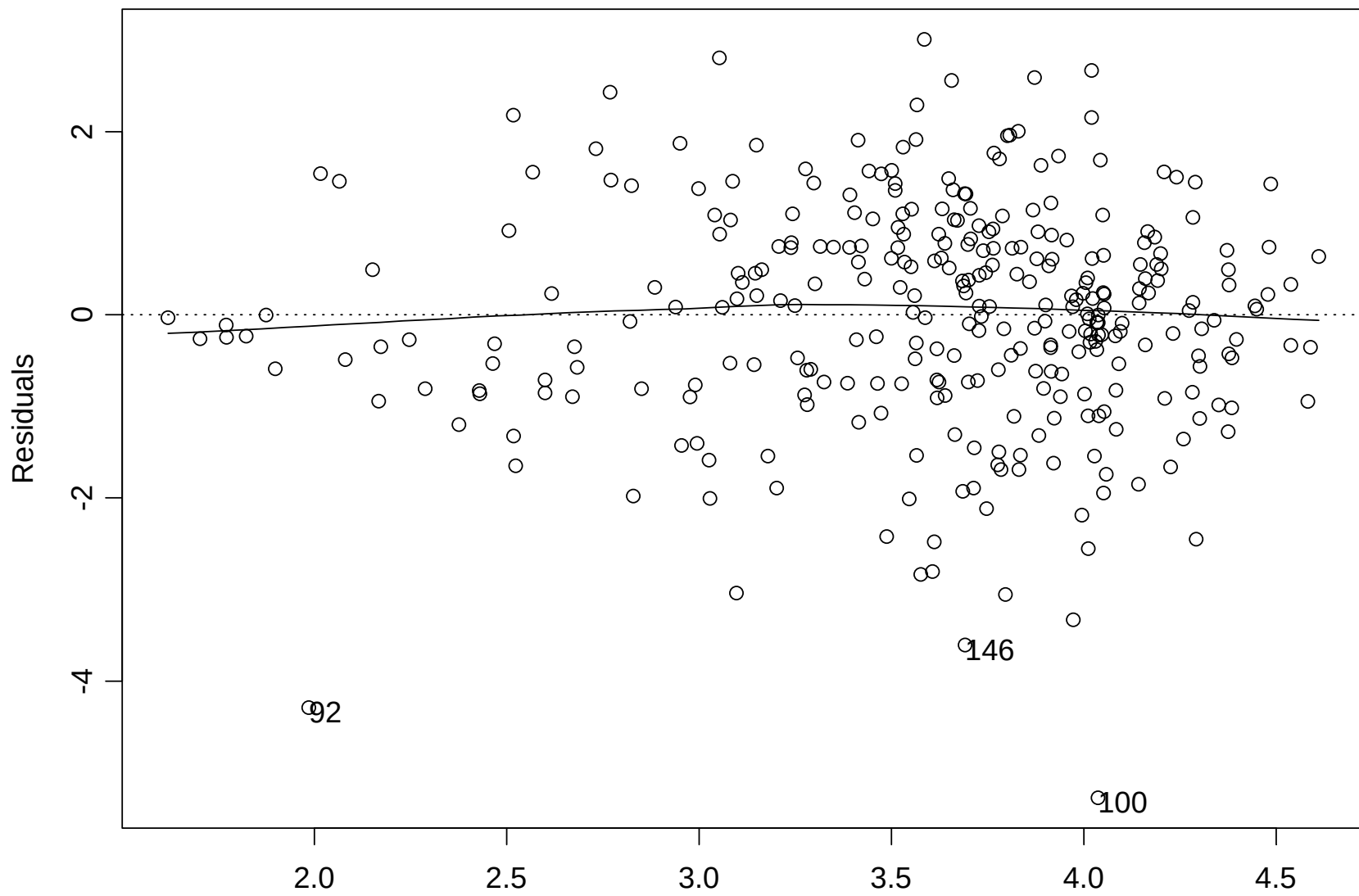
# Preliminary Regression Analysis

- Factors tested include those previously summarized for 500 m buffer in ancillary data sets
- Recharge rate
- Runoff
- Soil Permeability

## Exploratory Analysis of GIS variables (variables significant, but low R<sup>2</sup>)

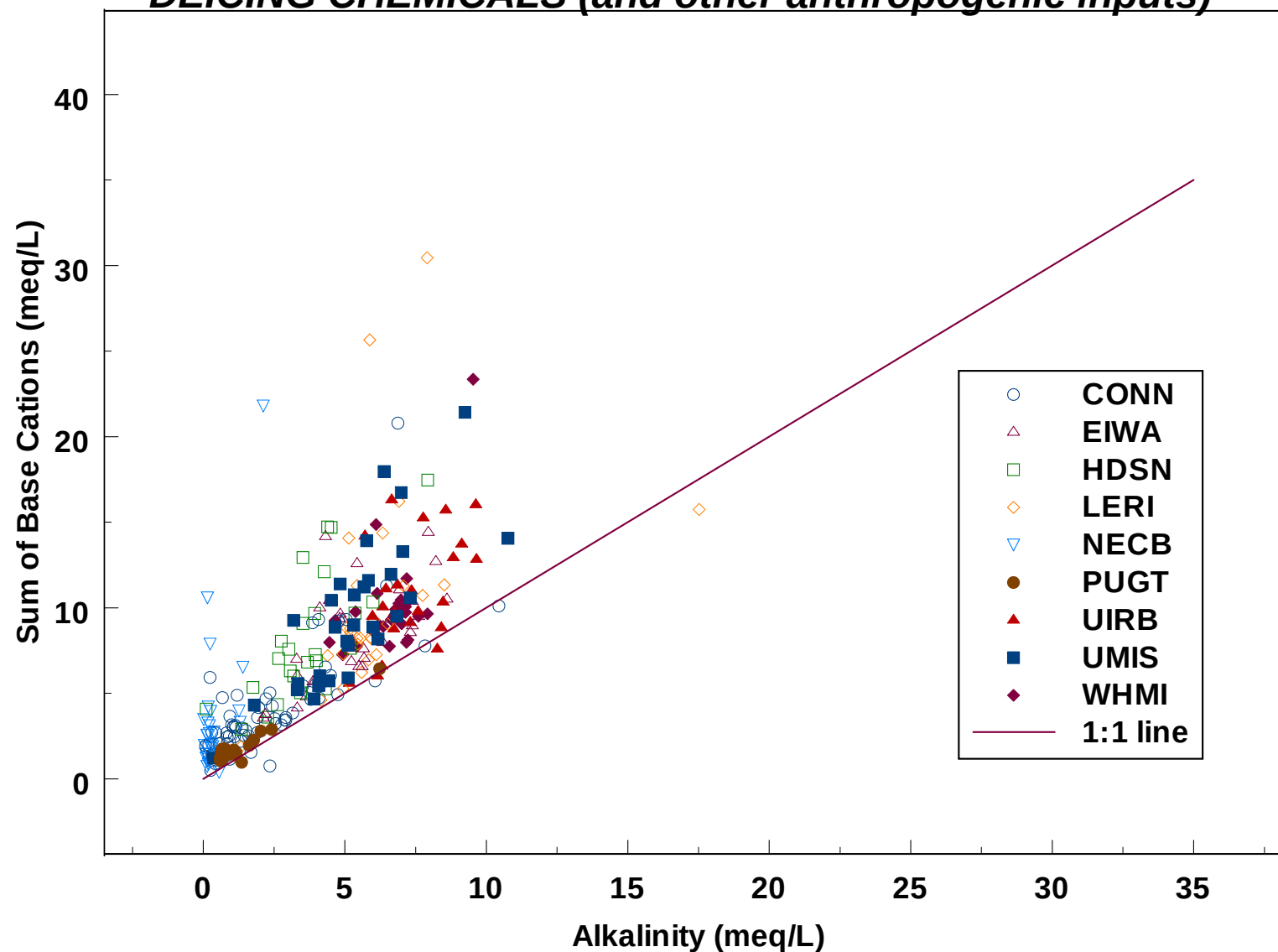
| <i>Variable</i>                                          | <i>Parameter estimate</i> | <i>Std. Error</i> | <i>t value</i> | <i>P value</i> |
|----------------------------------------------------------|---------------------------|-------------------|----------------|----------------|
| Intercept                                                | 41.7700                   | 11.1144           | 3.7582         | 0.0002         |
| Recharge Rate                                            | -0.0754                   | 0.0184            | -4.0870        | 0.0001         |
| 1990 Census median year of housing                       | -0.0197                   | 0.0057            | -3.4589        | 0.0006         |
| 1990 Census percent of buffer with private septic system | 0.0072                    | 0.0026            | 2.8366         | 0.0049         |
| ln(2000 Census population density)                       | 0.1349                    | 0.0743            | 1.8158         | 0.0704         |
| Soils--minimum value of permeability (inches per hour)   | -0.1114                   | 0.0371            | -3.0053        | 0.0029         |
| Soils-maximum value of permeability (inches per hour)    | 0.0579                    | 0.0189            | 3.0647         | 0.0024         |
| Evergreen Forest (NLCD)                                  | -0.0296                   | 0.0117            | -2.5364        | 0.0117         |

## Residuals



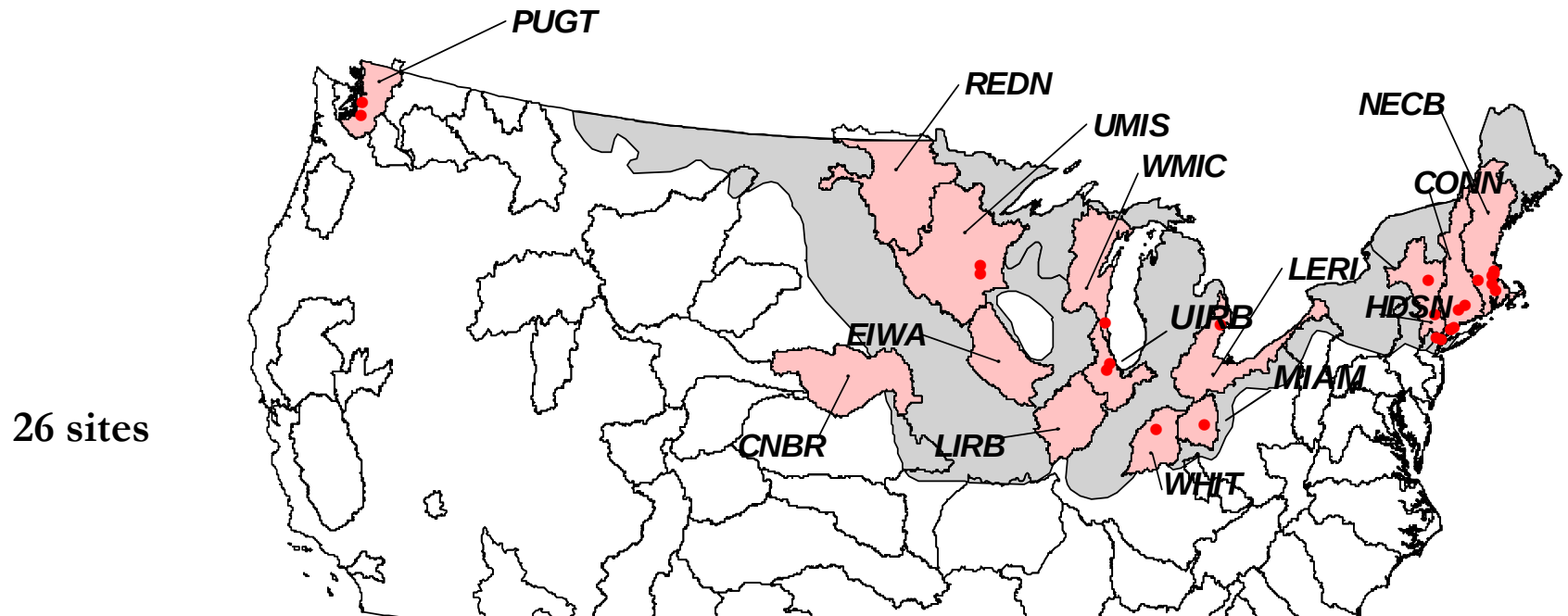
Fitted : RECHARGE<sub>BF</sub> + MEDYRBLT + SEWSEP + ln.popden00. + PERML + PERMH + NLCDE.42

***DEVIATION FROM 1:1 LINE MAY REPRESENT WATER  
CHANGES IN CATION COMPOSITION DUE TO INPUT OF  
DEICING CHEMICALS (and other anthropogenic inputs)***



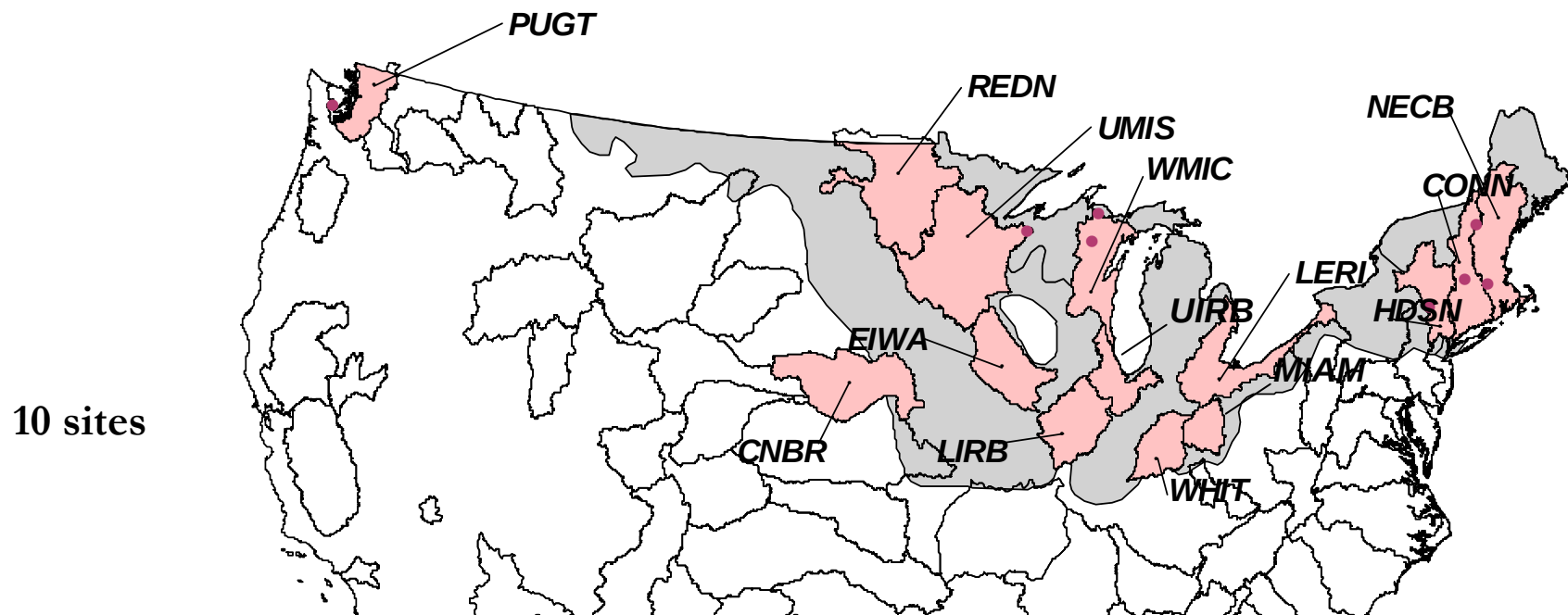
COOK

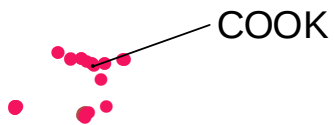
## Fixed Urban Indicator SW sites in Glacial Aquifer Area



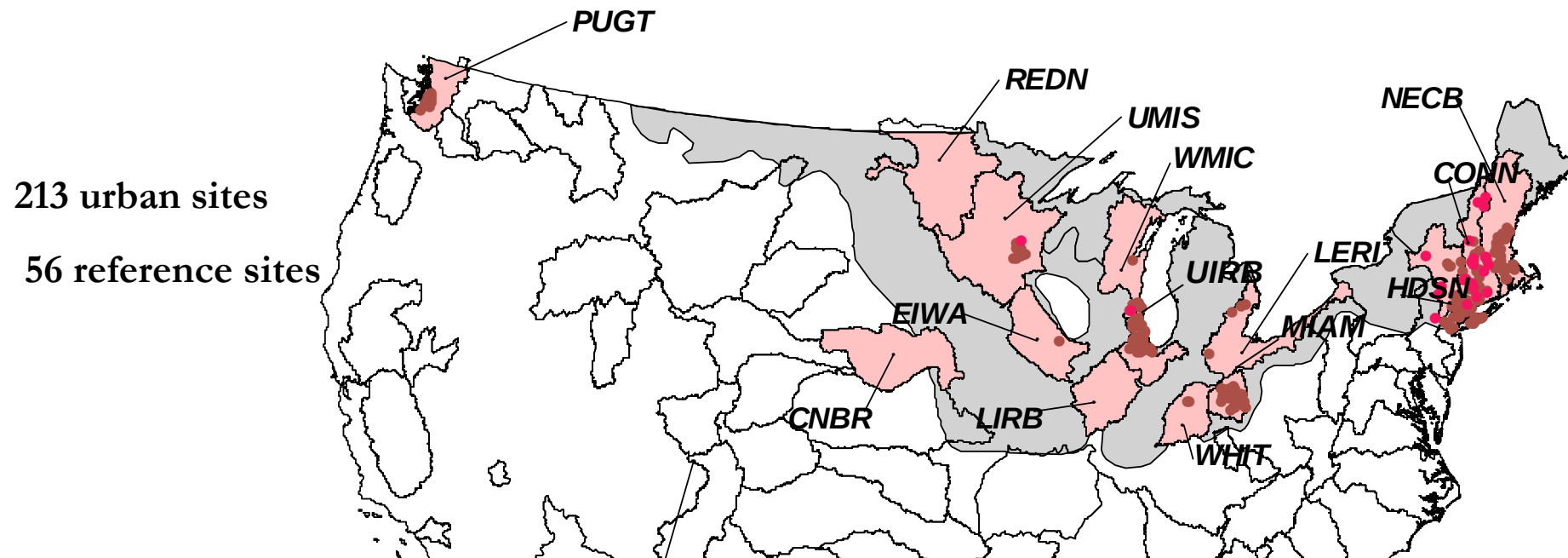
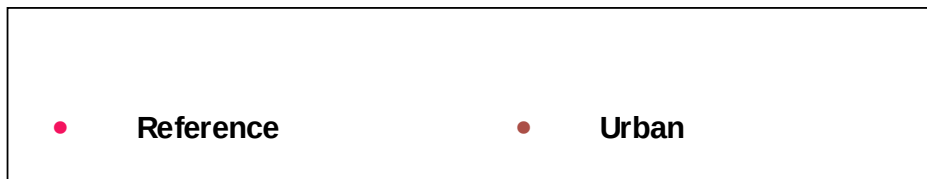
COOK

## Fixed Reference Indicator SW sites in Glacial Aquifer Area

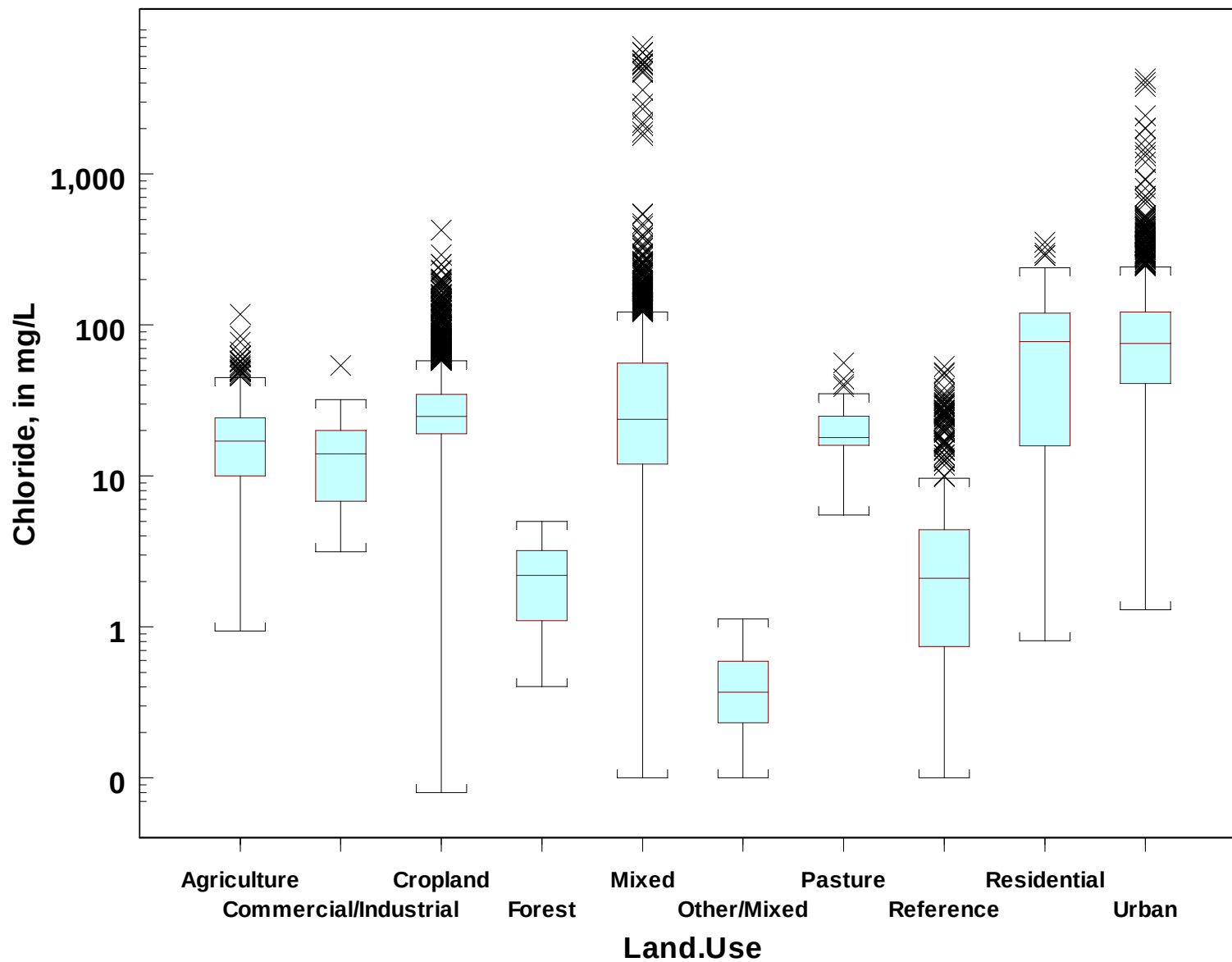




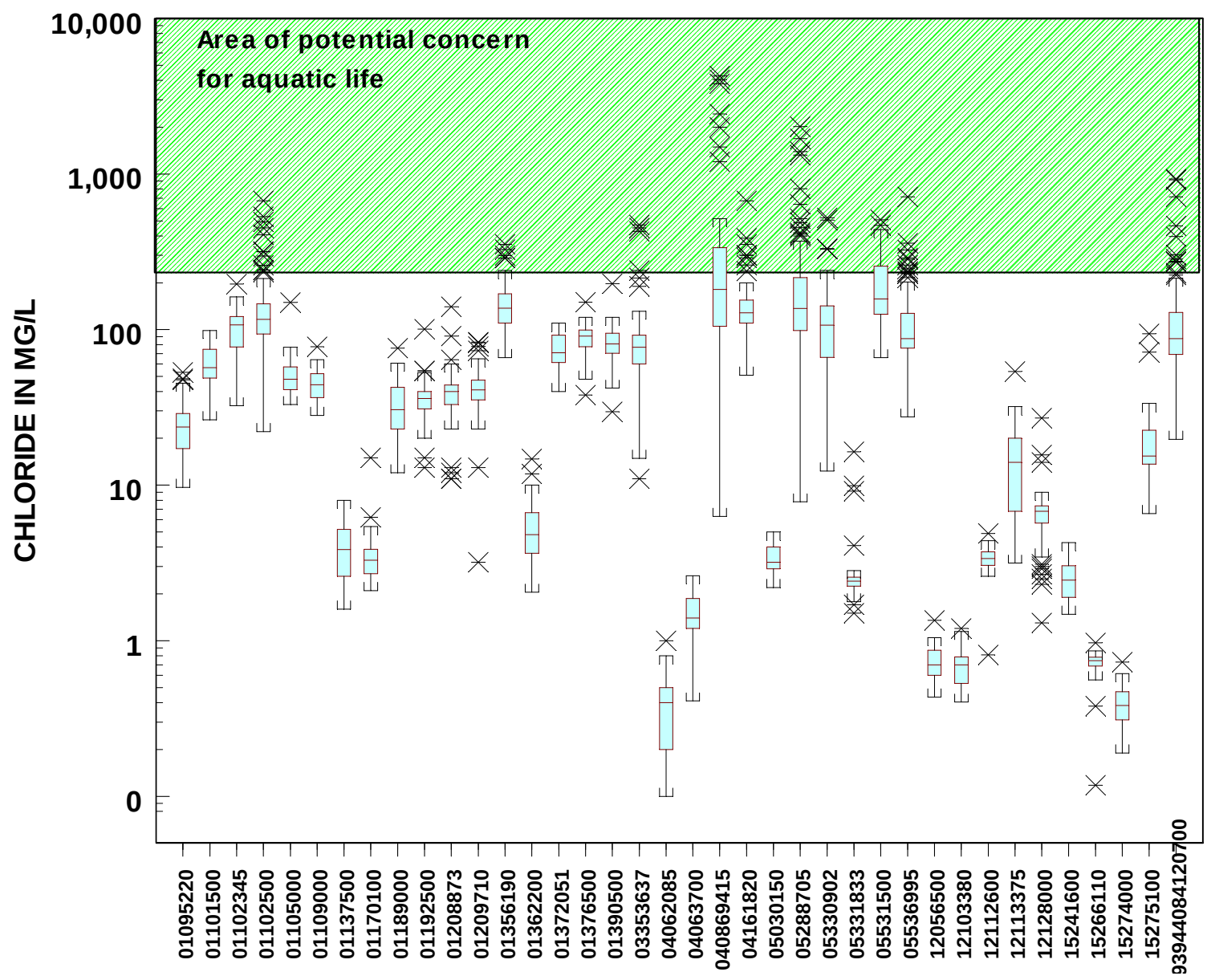
## Other NAWQA SW sites with some Chloride Data



## CHLORIDE CONCENTRATIONS IN SURFACE WATER BY LAND USE IN GLACIAL AQUIFER AREA



# CHLORIDE CONCENTRATIONS IN SURFACE WATER (URBAN AND REFERENCE SITES IN GLACIAL AQUIFER AREA)



# Load Estimates

- Comparison of Highly Urbanized Basins
  - 01208873 Rooster River near Fairfield Connecticut
    - DA= 10.6 mi<sup>2</sup>, Road Density- 9.9 km/km<sup>2</sup>, 2000 population density
  - 040869415 Lincoln Creek at 47th Street at Milwaukee, WI

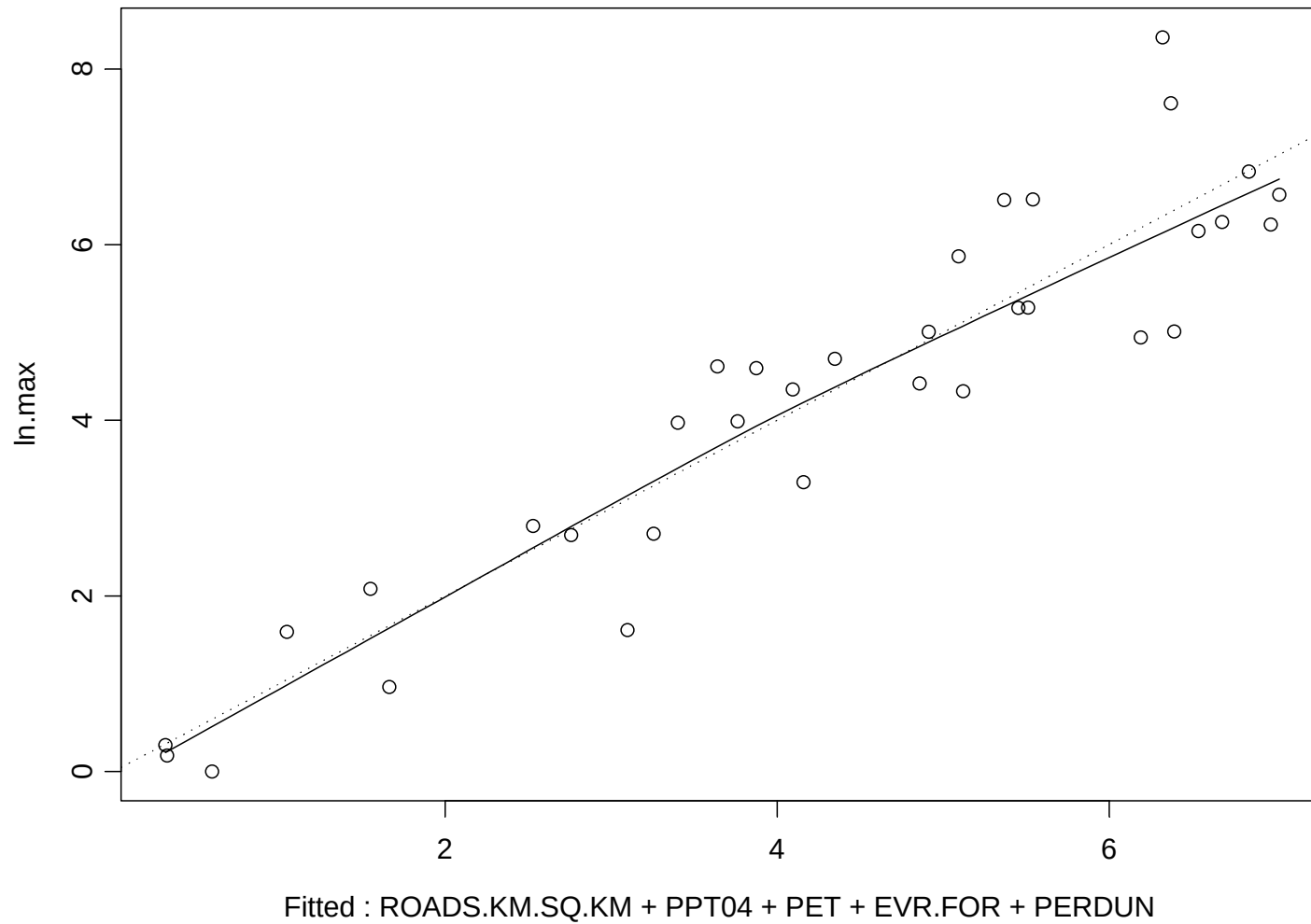
**Comparison of preliminary loads in different areas with  
potentially different application rates, and different hydrology**

| <b>Station</b>                                                   | <b>Drainage<br/>area<br/>in mi<sup>2</sup></b> | <b>Road<br/>Density<br/>km/km<sup>2</sup></b> | <b>Pop.<br/>Density<br/>2000<br/>People/<br/>mi<sup>2</sup></b> | <b>Annual<br/>Runoff<br/>inches</b> | <b>Water<br/>Year<br/>1994<br/>Load<br/><br/>(million Lbs.)</b> | <b>Yield/<br/>road mile<br/><br/>tons</b> |
|------------------------------------------------------------------|------------------------------------------------|-----------------------------------------------|-----------------------------------------------------------------|-------------------------------------|-----------------------------------------------------------------|-------------------------------------------|
| 01208873<br>Rooster River<br>nr.<br>Fairfield<br>Connecticut     | 10.6                                           | 9.9                                           | 1,960                                                           | 24.22                               | 1.53<br><br>(70 tons/mi <sup>2</sup> )                          | 4.6                                       |
| 040869415<br>Lincoln Creek at<br>47th Street at<br>Milwaukee, WI | 9.6                                            | 9.8                                           | 2,200                                                           | 8.04                                | 2.99<br><br>(155 tons/mi <sup>2</sup> )                         | 9.9                                       |

# Preliminary Regression Analysis On *ln*(max chloride) ( $R^2=0.87$ )

| <i>Variable</i>                 | <i>Parameter</i> |                   |                |                |
|---------------------------------|------------------|-------------------|----------------|----------------|
|                                 | <i>estimate</i>  | <i>Std. Error</i> | <i>t value</i> | <i>P value</i> |
| Intercept                       | -5.8837          | 2.5690            | -2.2903        | 0.0297         |
| Road Density km/km <sub>2</sub> | 0.2169           | 0.0750            | 2.8907         | 0.0073         |
| April Precipitation in cm.      | 0.0242           | 0.0080            | 3.0159         | 0.0054         |
| Potential Evapotranspiration    | 0.0154           | 0.0048            | 3.2355         | 0.0031         |
| Evergreen Forest in percent     | -0.0500          | 0.0174            | -2.8765        | 0.0076         |
| Percent Dunne Overland Flow     | -0.8762          | 0.1607            | -5.4522        | 0.0000         |

## Observations vs. predictions



# Plans FY04

- Complete preliminary outline for report
- Continue data acquisition and analysis
- Baseflow separation
- Load estimation
- Comparison of chloride with other constituents
- Availability of additional data from other networks

# Some potential problems

- No National Data Set available to point source wastewater discharges in fixed site basins.
  - Will probably have to interview the study unit staff
- Limited amount of data on trace metals
- Bromide not analyzed for surface water sites
- Limited number of samples to determine baseflow loads

# Some potential problems

May be best to limit data analyses to  
NAWQA stations because of pre-  
summarized ancillary data for these sites