GEOCHEMICAL PROCESSES AFFECTING ARSENIC IN PRIVATE WELLS OF THE NORTH CAROLINA PIEDMONT

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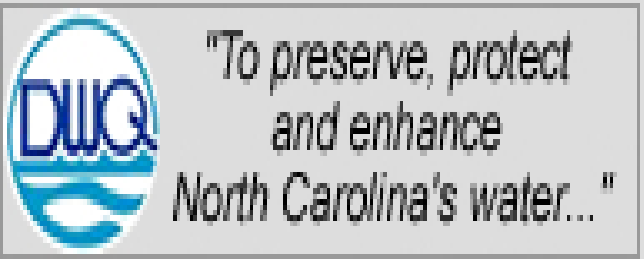


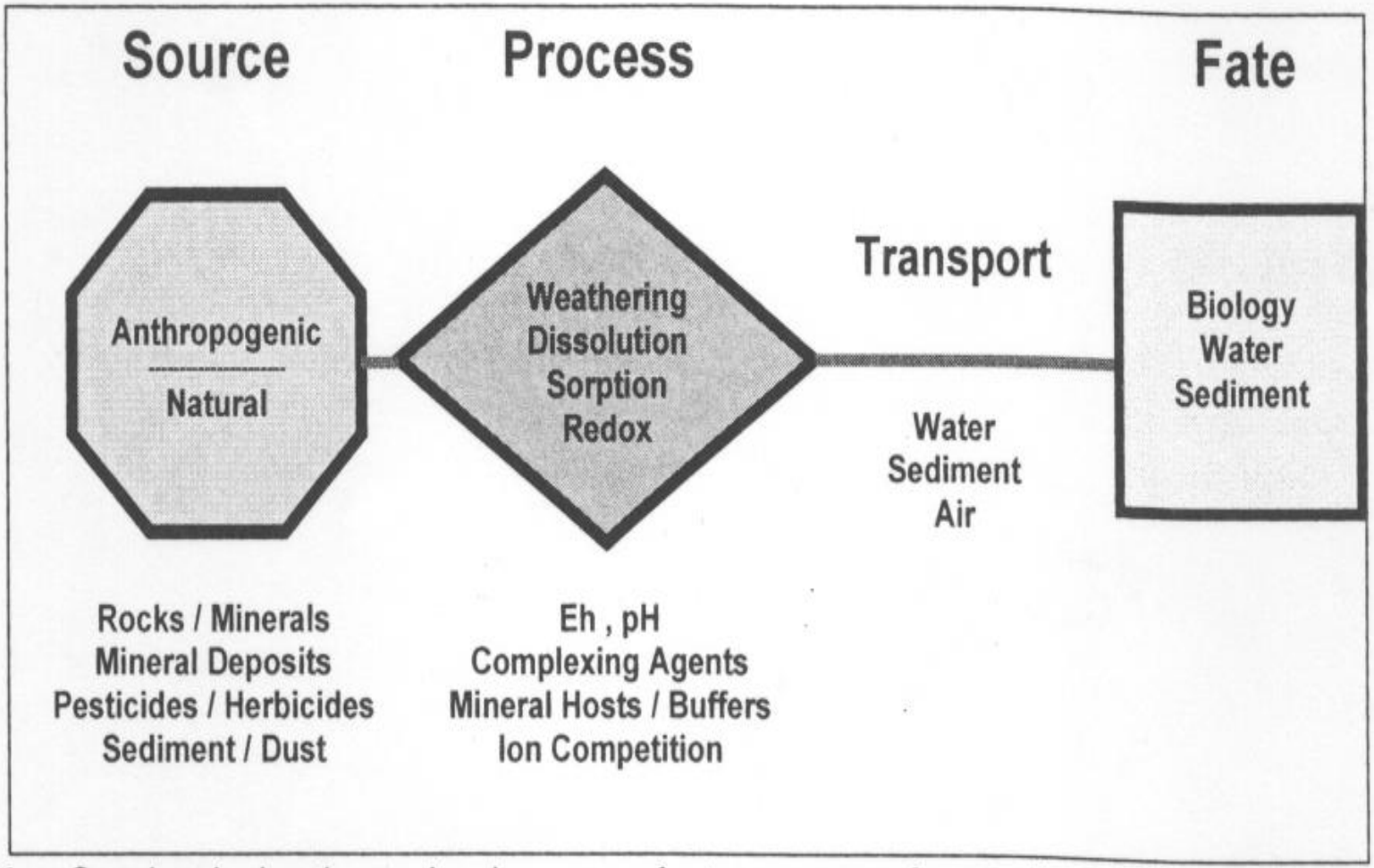


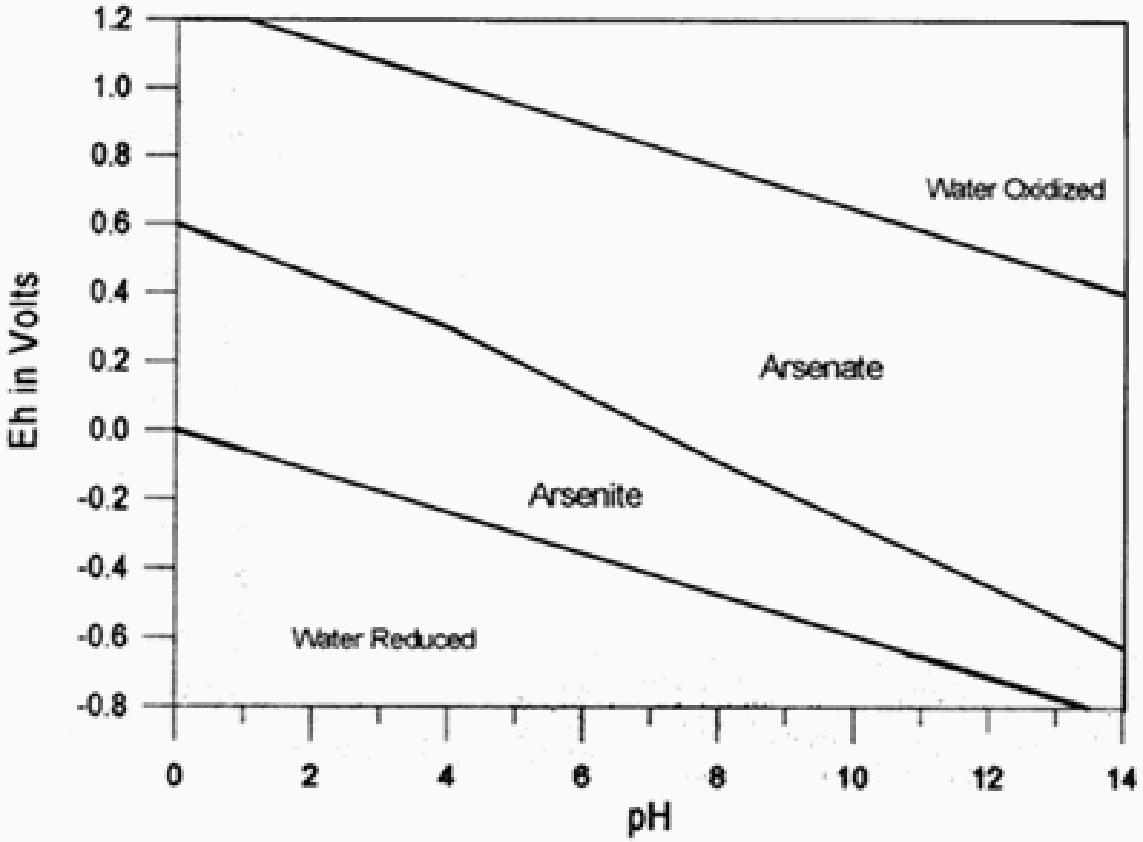
Figure 1. Geochemical pathways involve source factors, process factors that act on sources, and transport factors that collectively influence chemical concentrations in sediment, water, and biological receptors.

(Robinson and Ayotte, 2007)

Arsenic: Abundance & Speciation

(summarized from Smedley and Kinniburg, 2002)

	Baseline Conc. (ug/L)	Arsenic Species
Rain water (rural areas)	<0.03	-
Sea water - oxic	1.5	As(V) dominant
Sea water - anoxic	-	As(III) dominant
Estuarine water	0.7 - 2.5	As(V) dominant
Estuarine water - anthropogenic		As(III) dominant
Stream water - natural	0.83	As(V) dominant
Stream water - anthropogenic	-	As(III) dominant
Groundwater	< 10	variable
Groundwater - strongly reducing	-	As(III) dominant



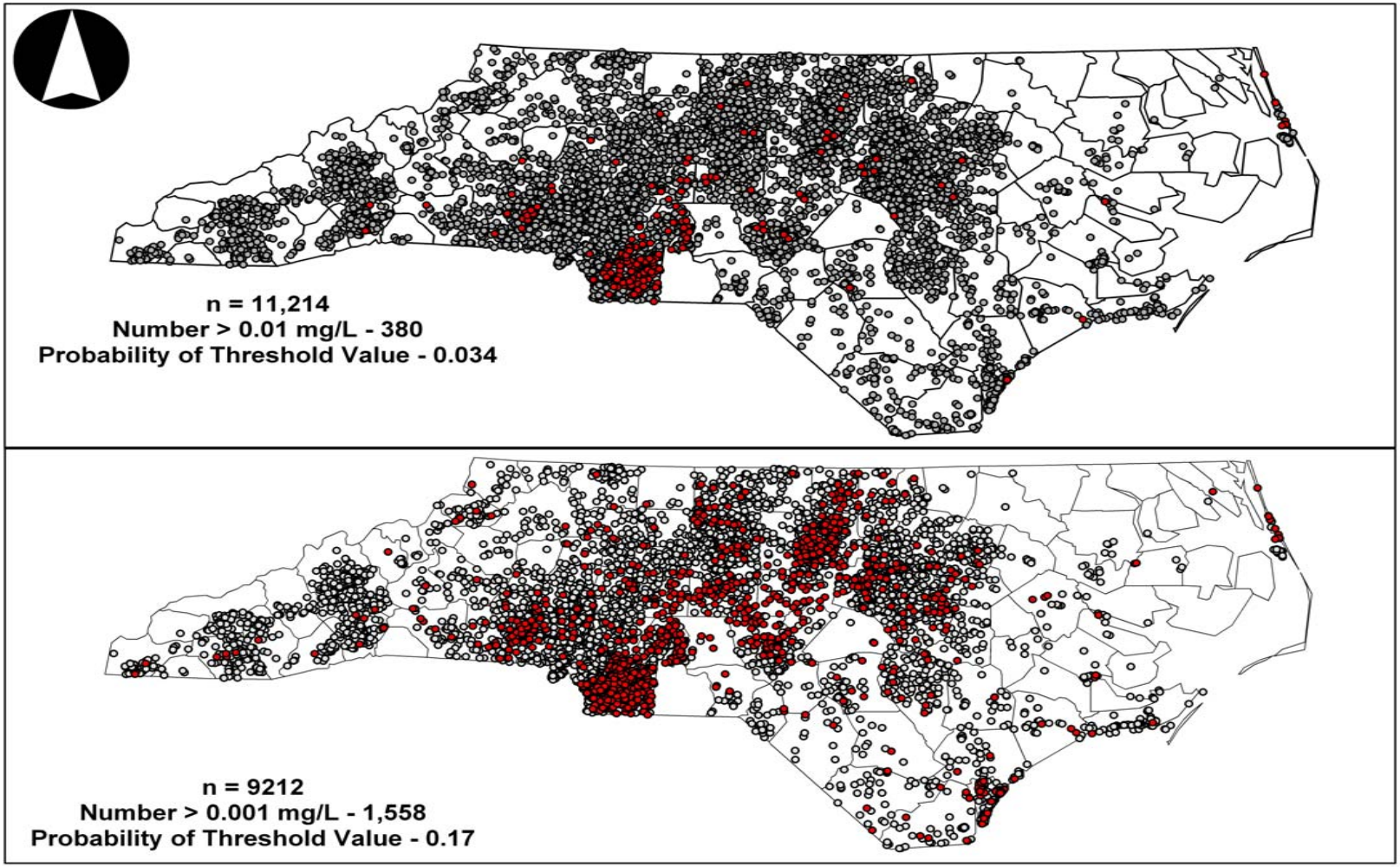
Stability fields for arsenate and arsenite

Arsenic adsorbtion to iron oxyhydroxides is strongly influenced by pH, redox potential, and presence of competing anions.

A number of factors are involved in the adsorption-desorbtion reactions. These include changes in redox potential and microbial-mediated reductive dissolution of iron hydroxides.

Previous Work in NC Piedmont

(Pippin and others 2002 – 2007)



Hypothetical Groundwater Transport Model for Piedmont Aquifer System

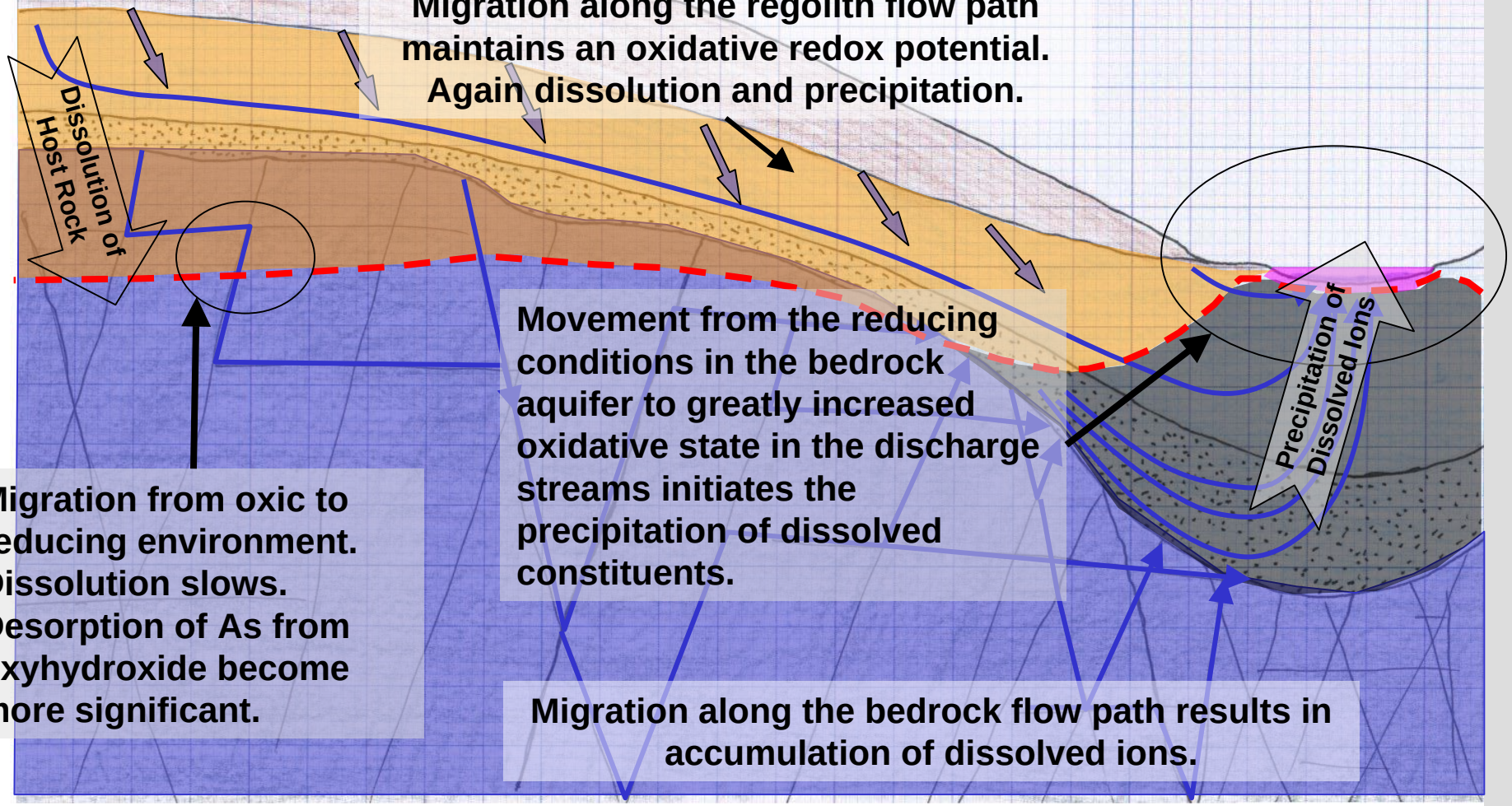
Highly Oxidative

Moderately Oxidative

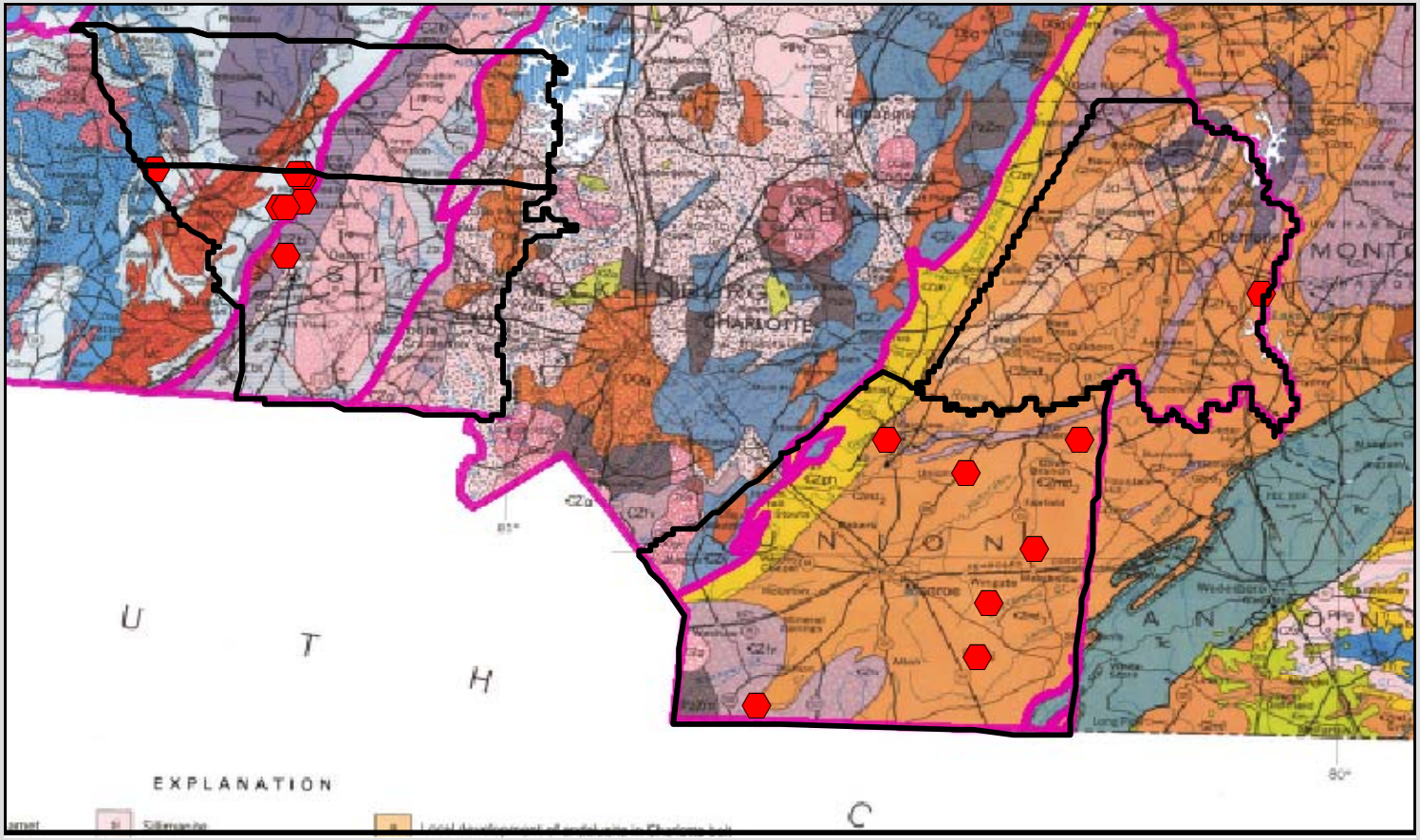
Mixing Zone Between Oxic and Reducing Waters

Reducing

Infiltration of O_2 rich water to groundwater surface. Dissolution of host materials and precipitation of dissolved ions.



STUDY AREA: GEOLOGIC MAP & SAMPLE LOCATIONS



N

Legend

arsenic2007_locat Events

DOT County Boundary

METHODS

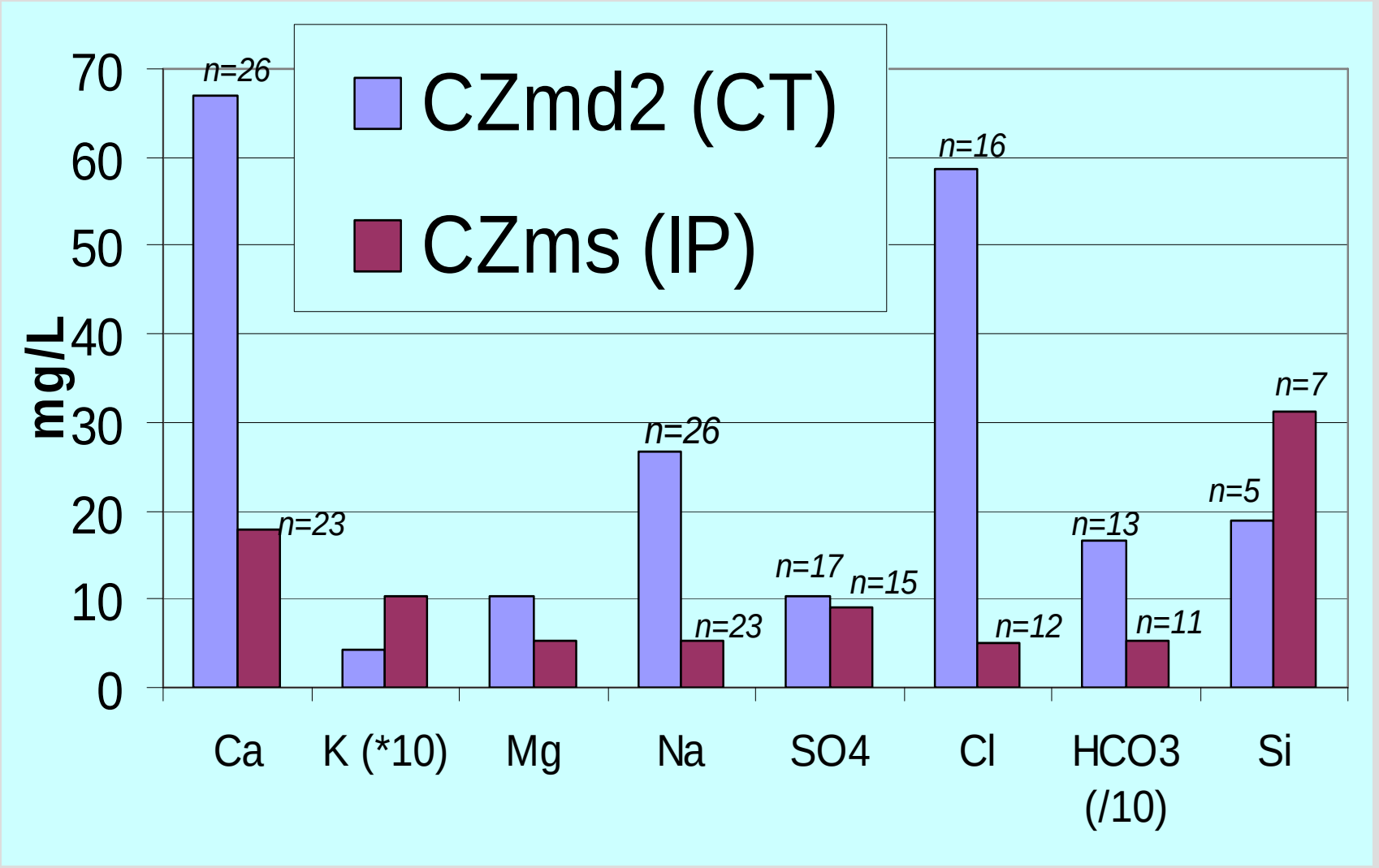
- Sample Collection
  - 3 to 5 samples from 16 locations
- Field measurements
  - pH, ORP, DO, Temp, Specific conductance
- Laboratory measurements
  - Al, Ca, Mg, Fe, K, Na
  - As, Ba, Cd, Cr, Cu, Mn, Pb, Se, Zn; Cl^-, $SO4^-$, $HCO3^-$
  - Arsenic analyzed by EPA method 200.8.
    - Detection limit for As = 5 ug/L

Field Speciation of Arsenic

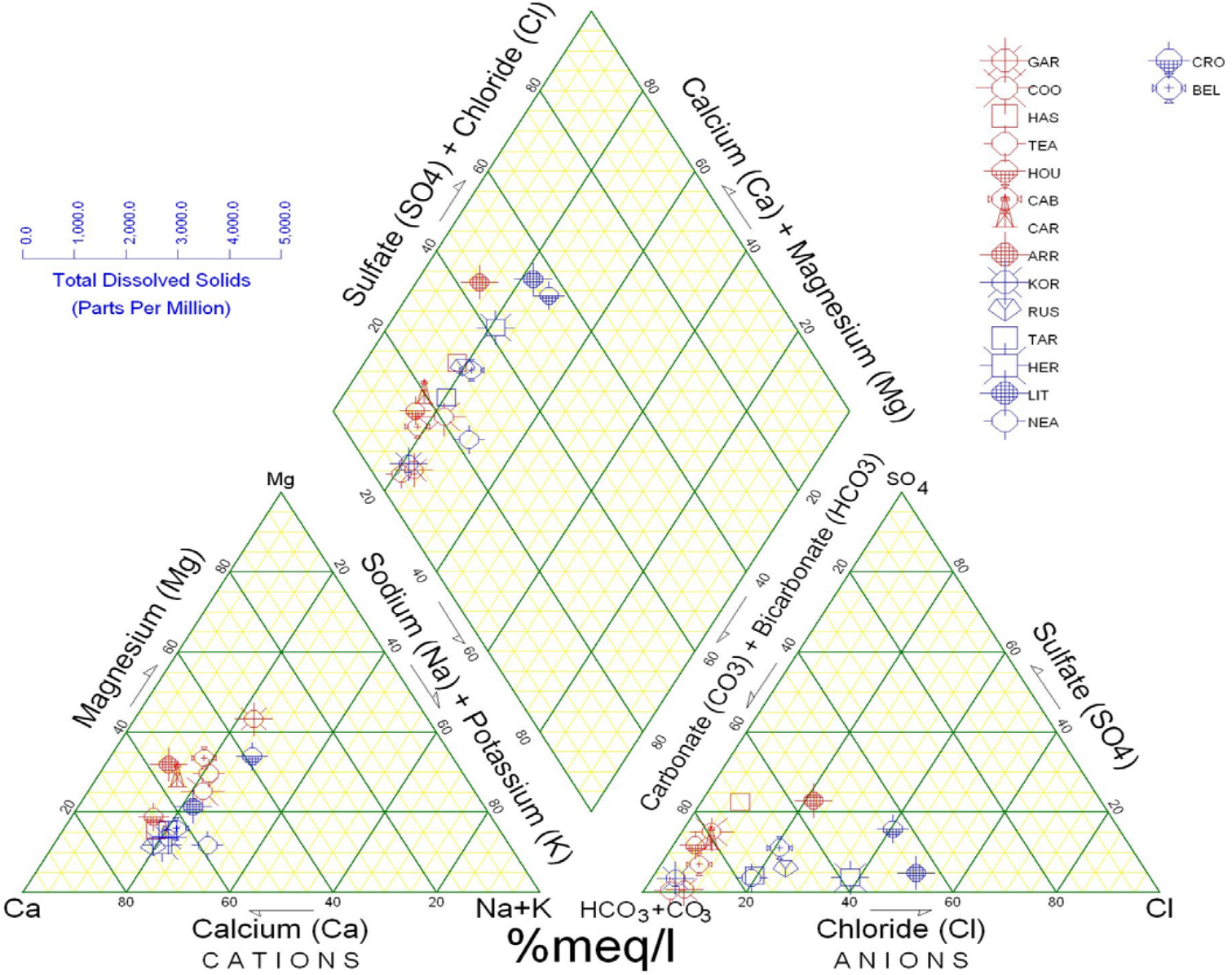
– The adsorbent in the cartridge removes arsenate [As(V)] but does not adsorb arsenite [As(III)]

RESULTS

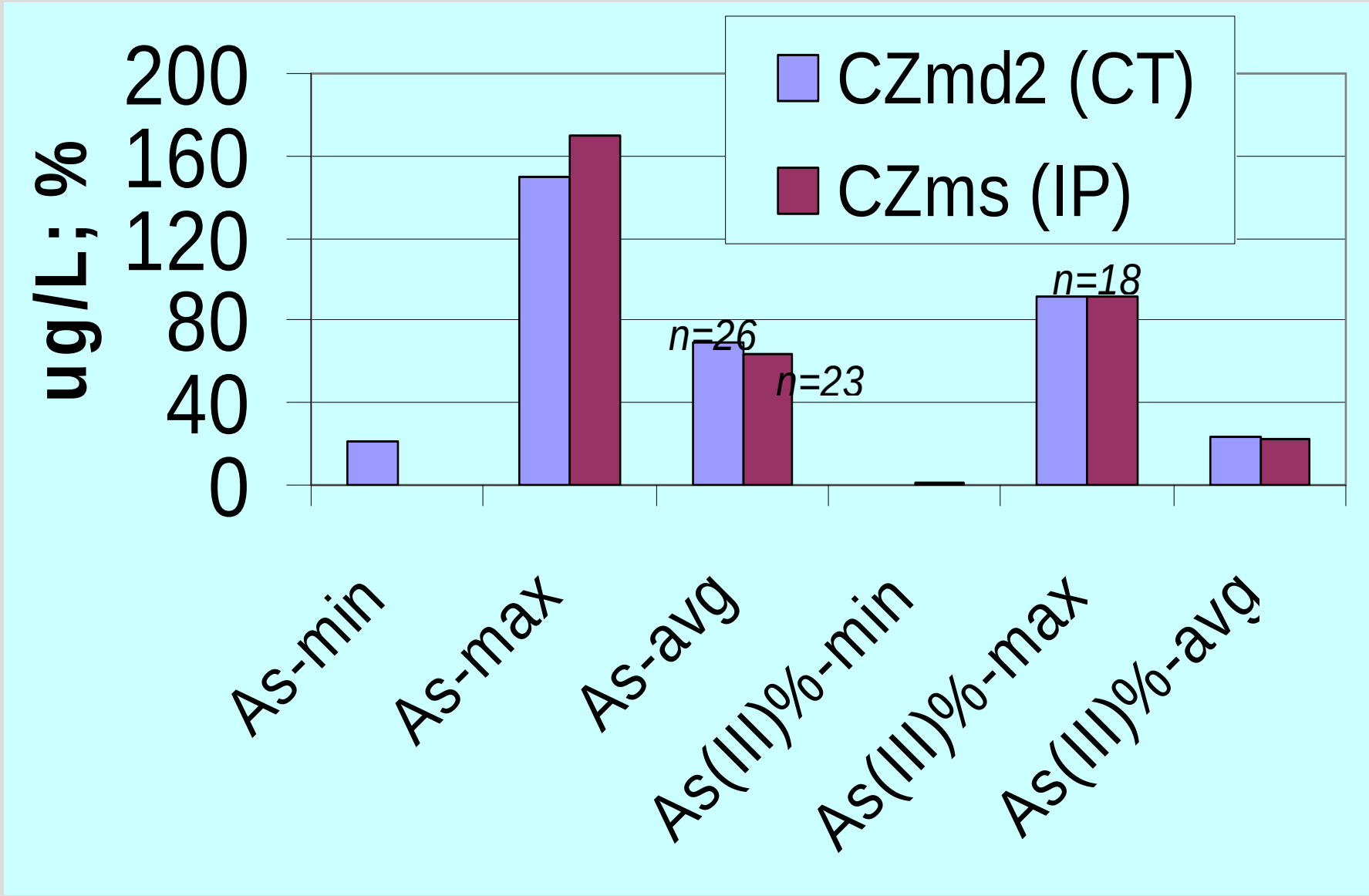
Major Ion (average) Concentrations



Piper Diagram - Carolina Terrane and Inner Piedmont

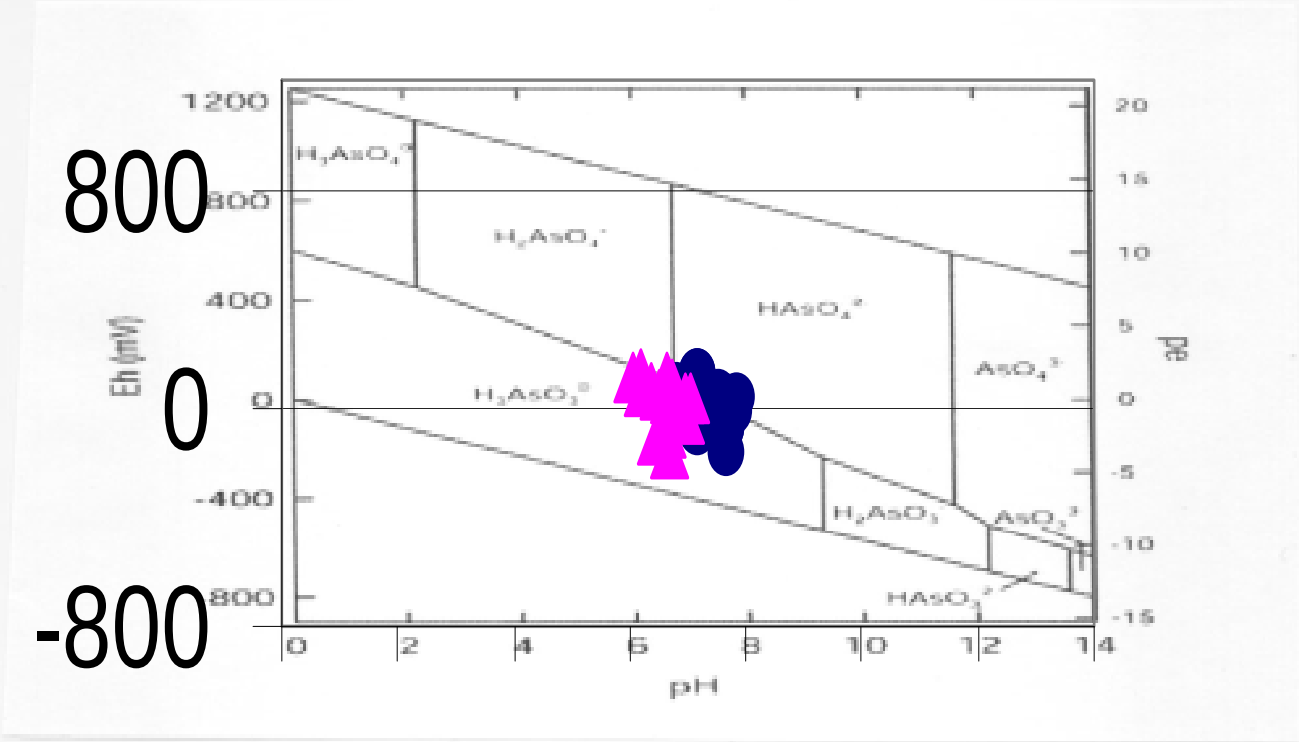


As concentration and speciation

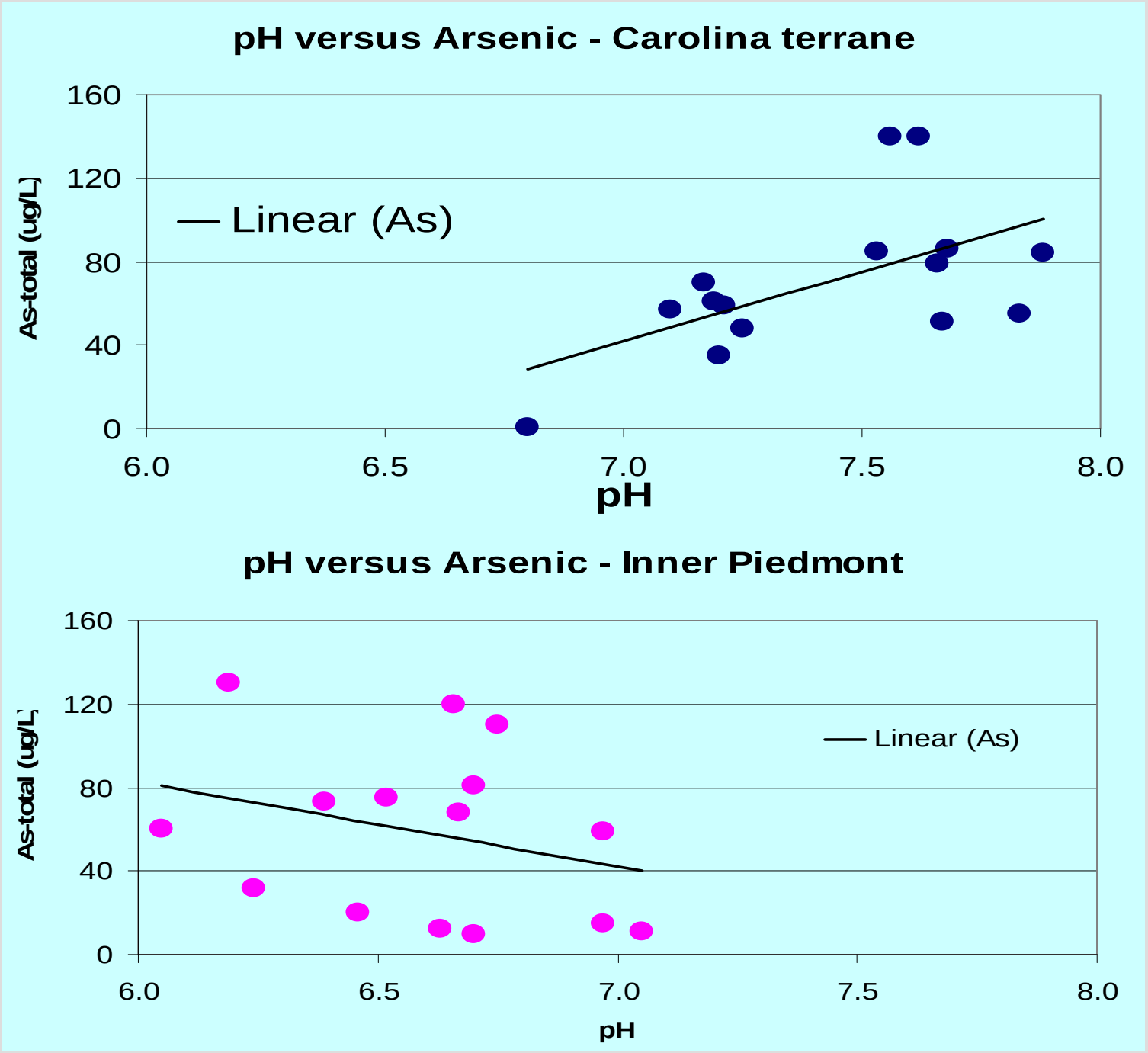


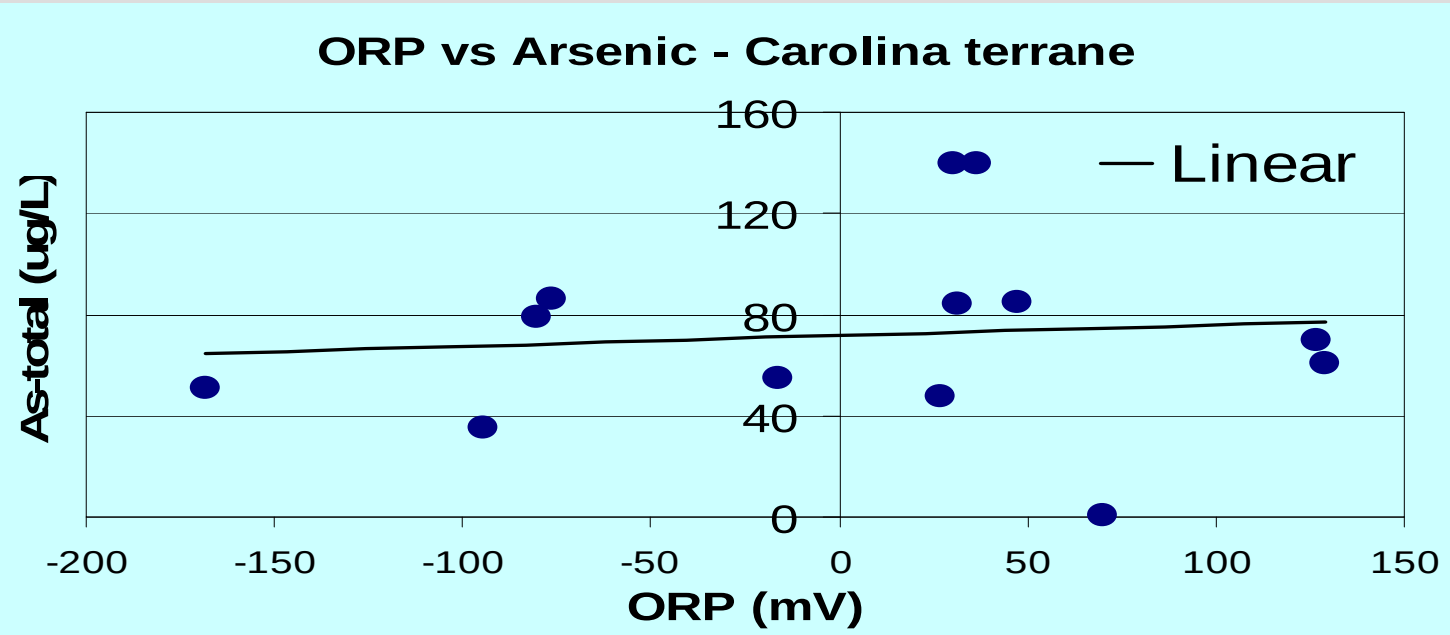
pH-ORP

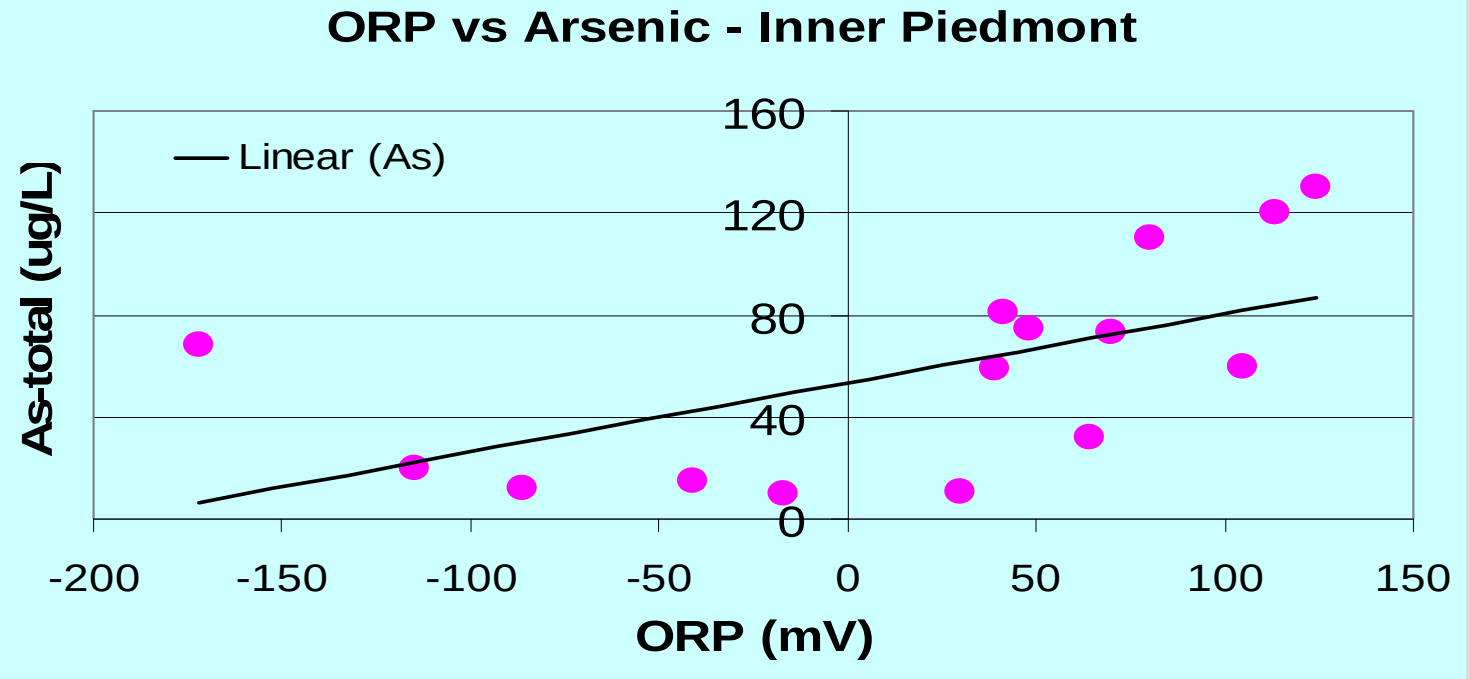
● CT ▲ IP

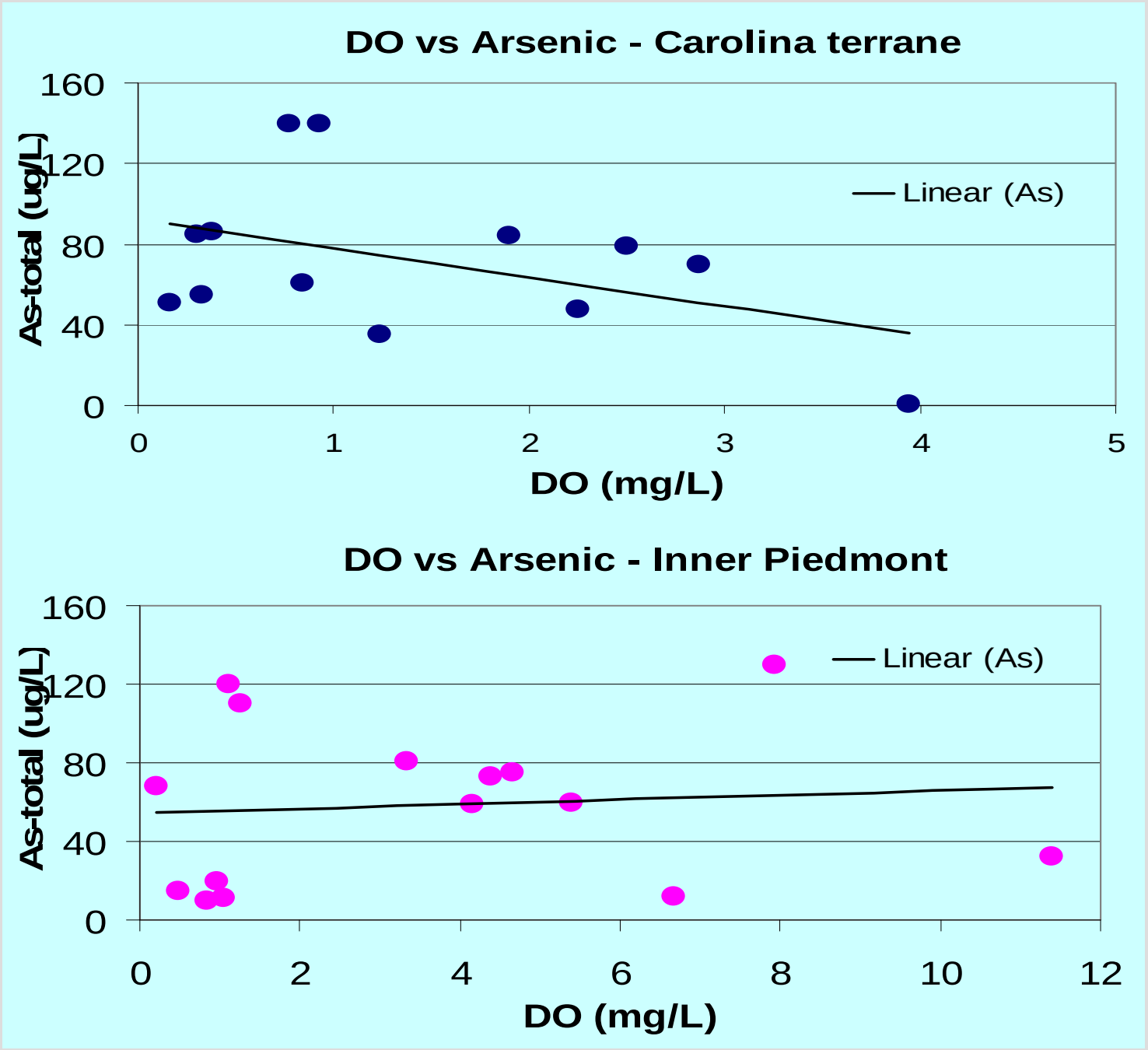


0 2 4 6 8 10 12 14

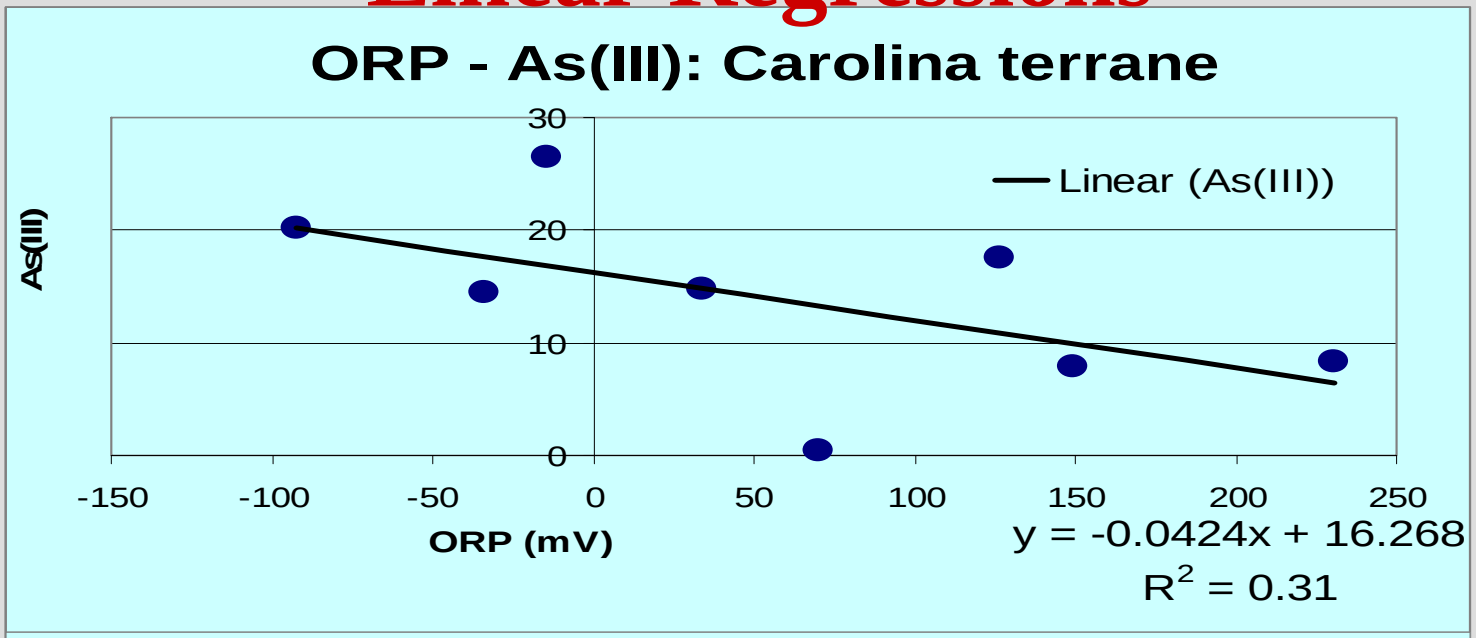

pH versus Arsenic - Carolina terrane
160
120
80
40
0
As-total (ug/L)
Linear (As)
6.0
6.5
7.0
7.5
8.0
pH
pH versus Arsenic - Inner Piedmont
160
120
80
40
0
As-total (ug/L)
Linear (As)
6.0
6.5
7.0
7.5
8.0
pH

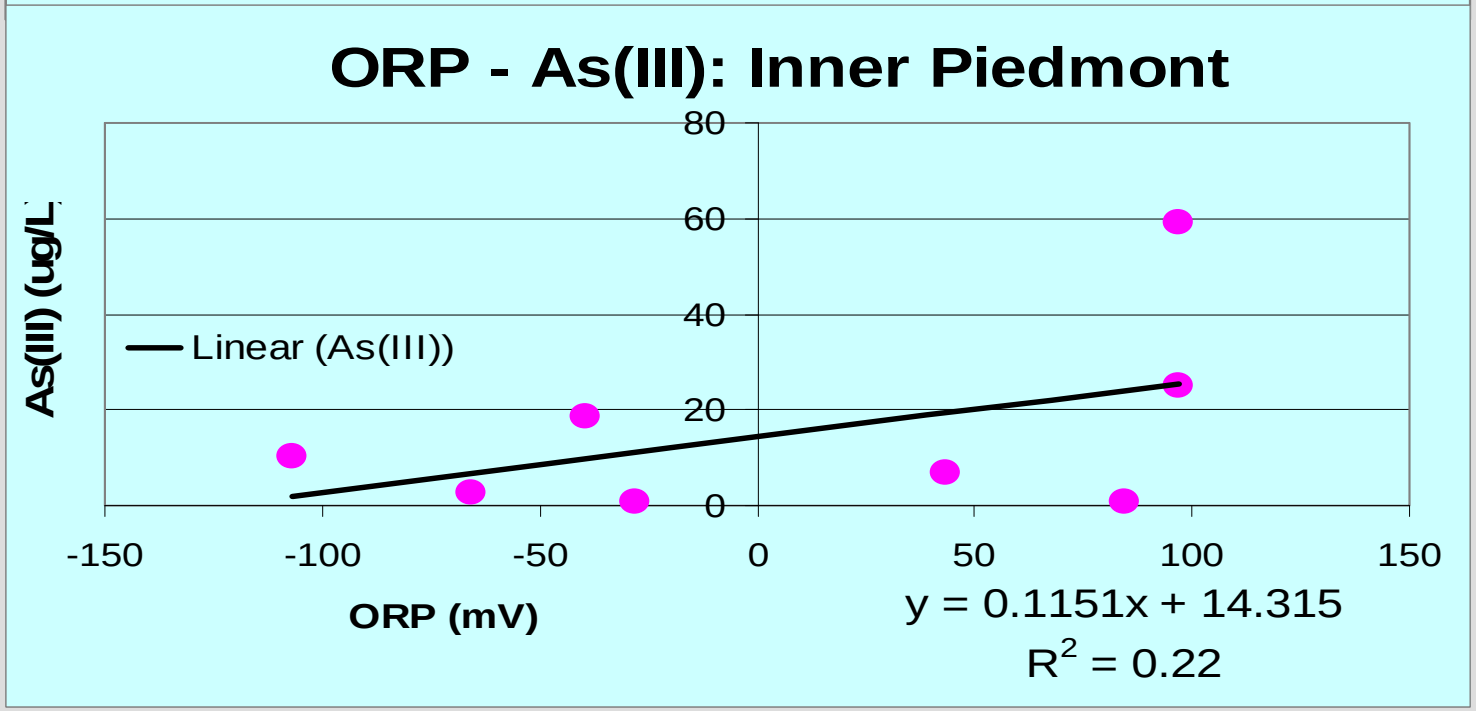

ORP vs Arsenic - Carolina terrane
As-total (ug/L)
160
120
80
40
0
-200
-150
-100
-50
0
50
100
150
ORP (mV)
Linear


ORP vs Arsenic - Inner Piedmont
As-total (ug/L)
160
120
80
40
0
-200
-150
-100
-50
0
50
100
150
ORP (mV)
Linear (As)

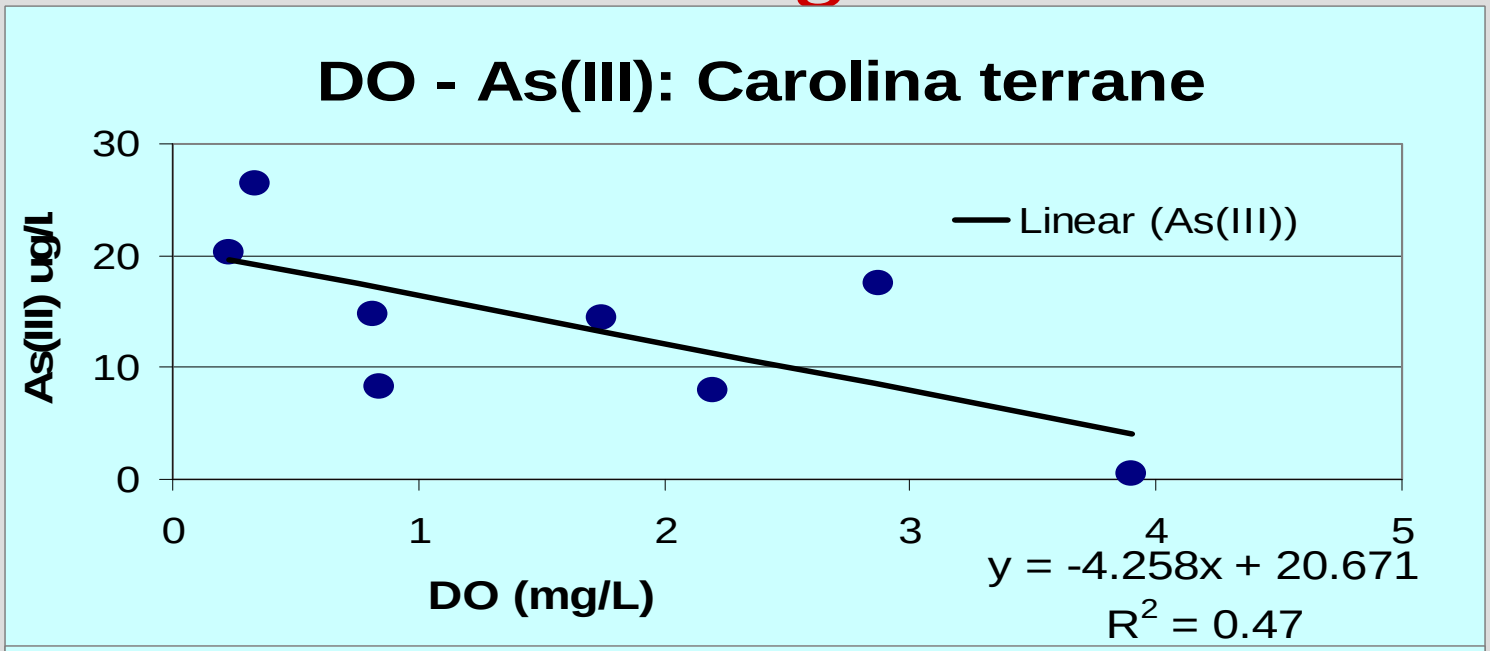

DO vs Arsenic - Carolina terrane
As-total (ug/L)
160
120
80
40
0
0
1
2
3
4
5
DO (mg/L)
Linear (As)
DO vs Arsenic - Inner Piedmont
As-total (ug/L)
160
120
80
40
0
0
2
4
6
8
10
12
DO (mg/L)
Linear (As)

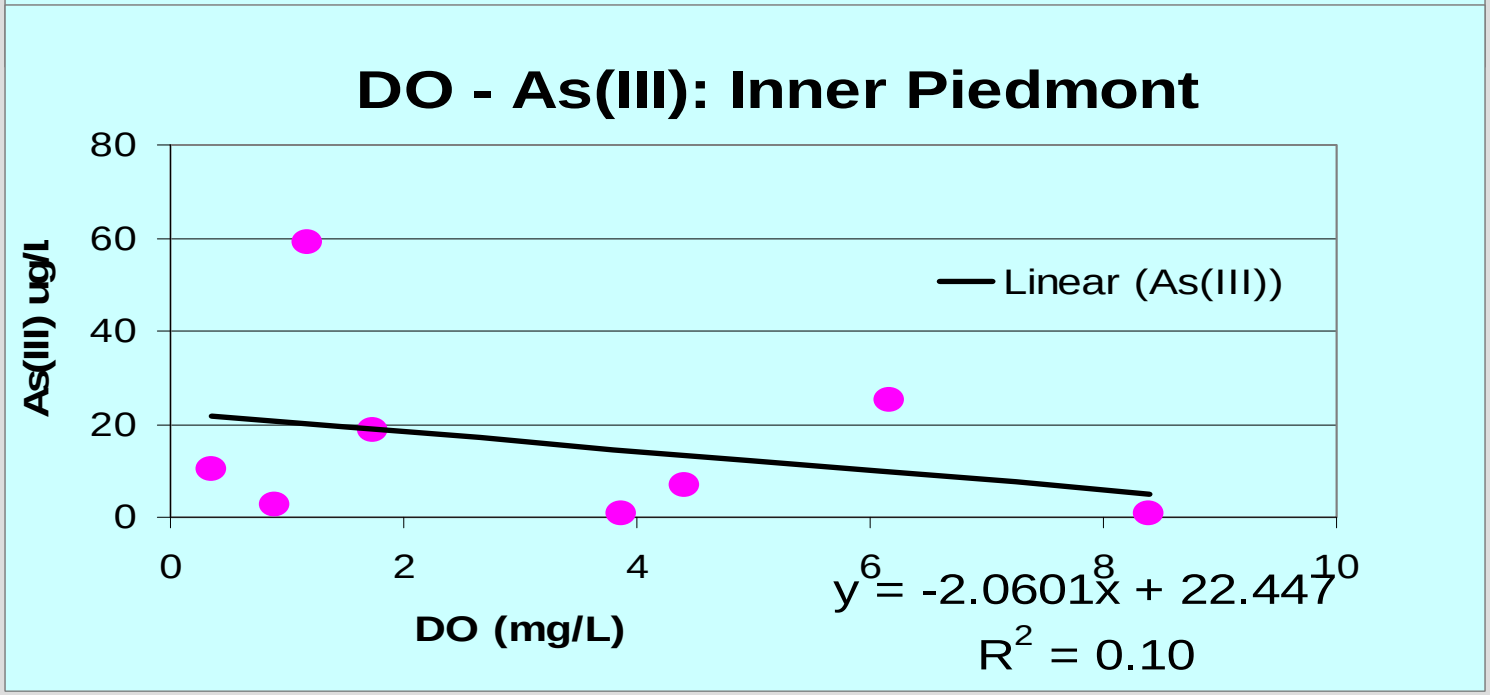
Linear Regressions

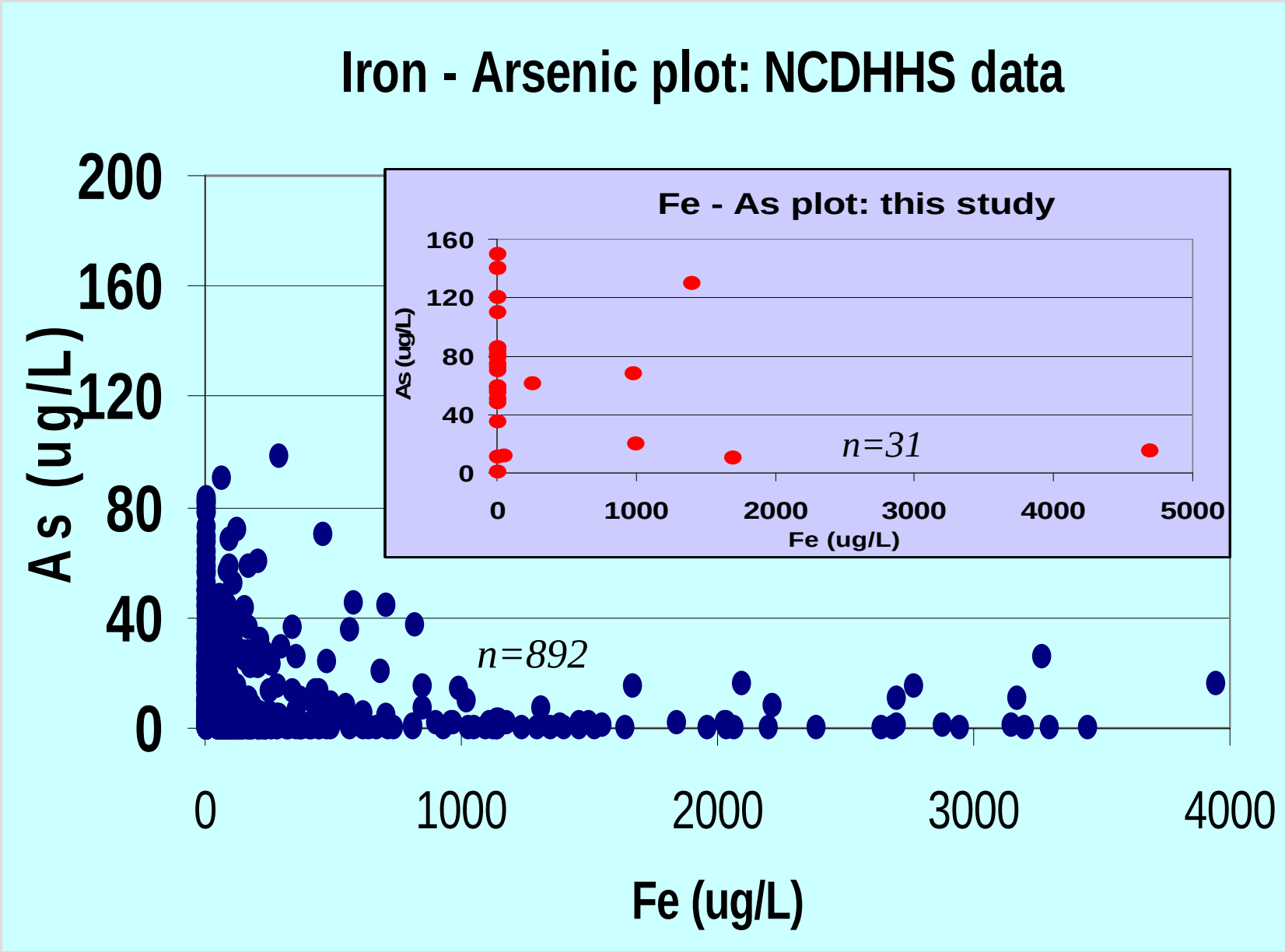




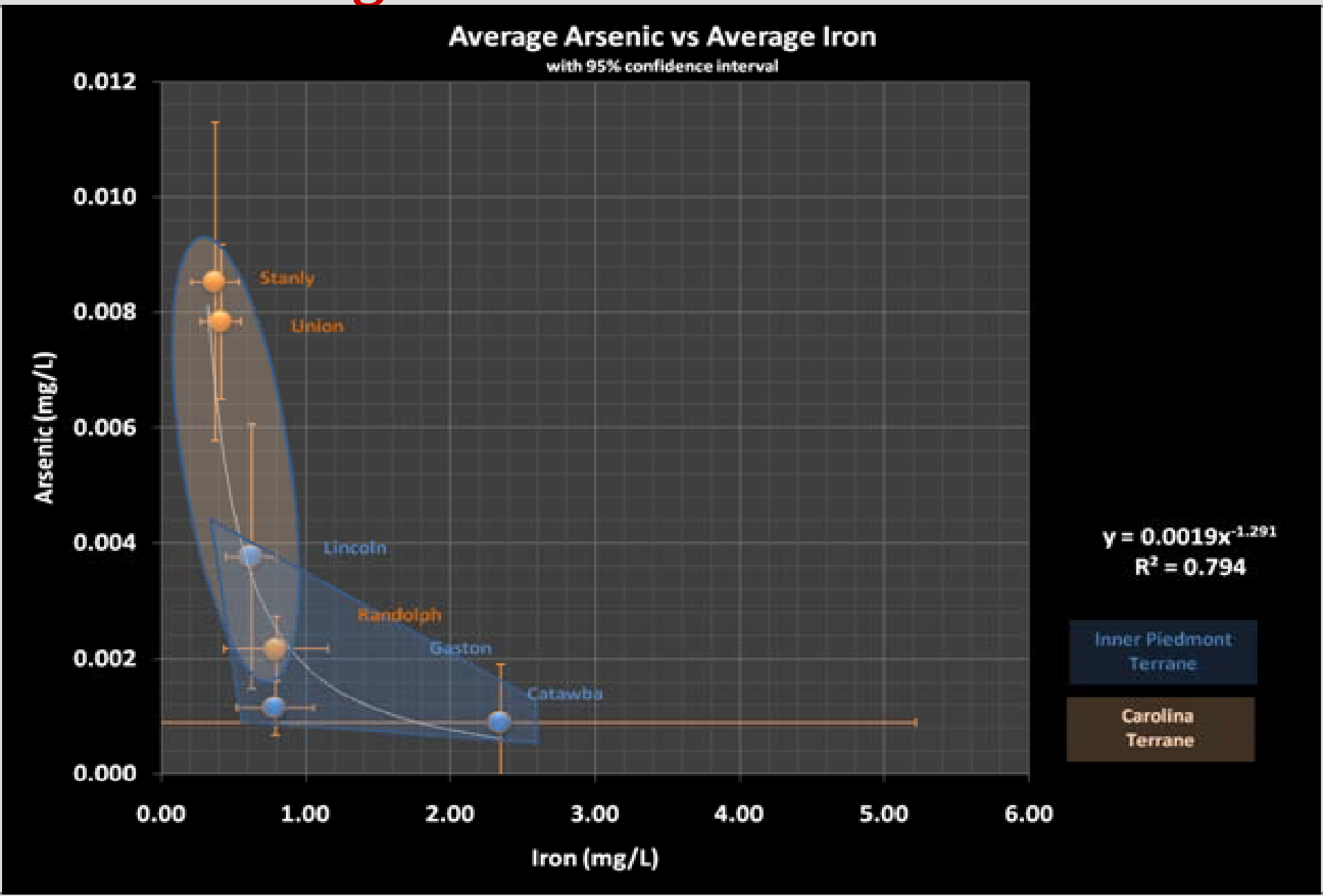
Linear Regressions



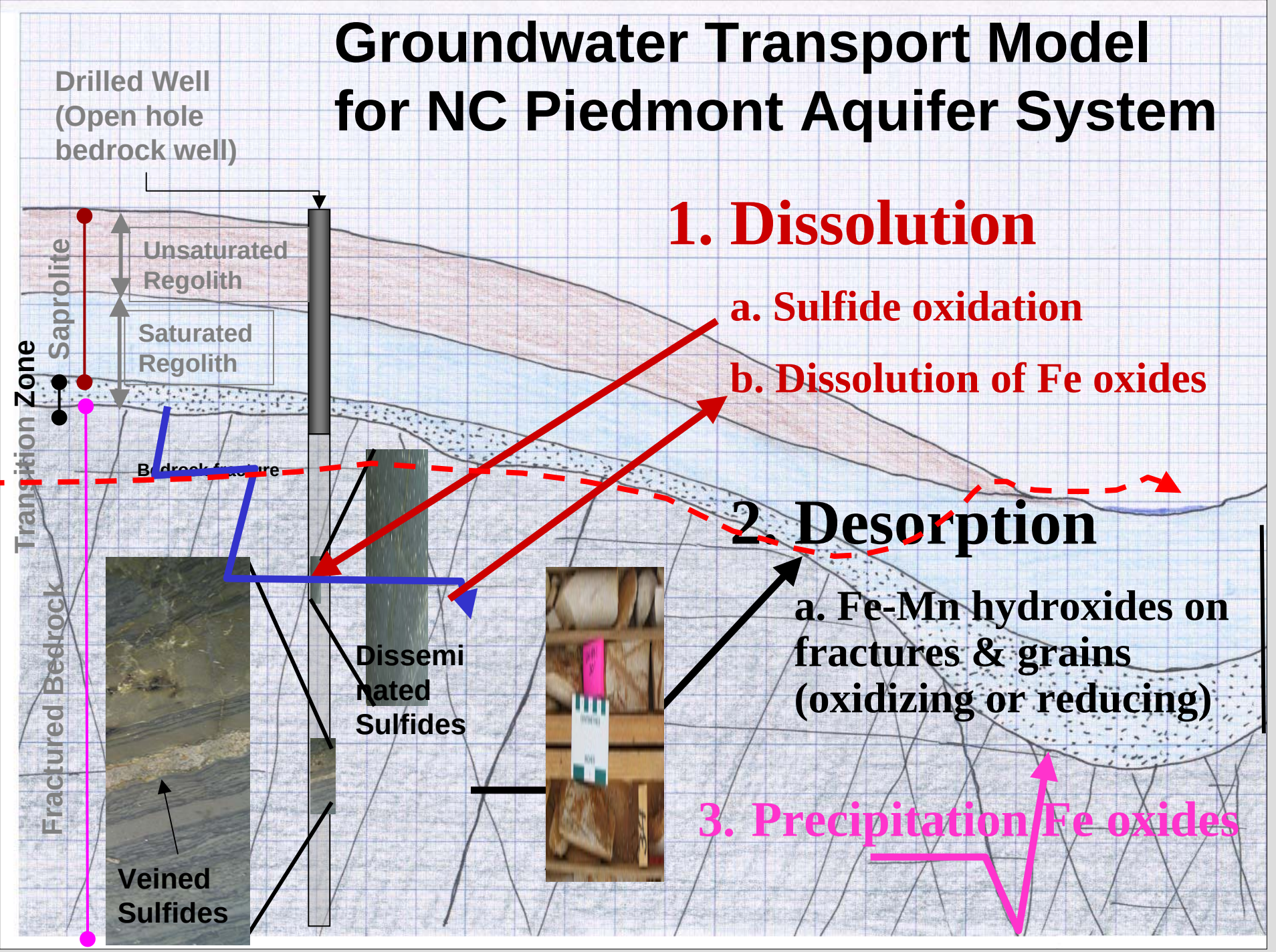



Iron - Arsenic plot: NCDHHS data
As (ug/L)
200
160
120
80
40
0
n=892
0
1000
2000
3000
4000
Fe (ug/L)
Fe - As plot: this study
As (ug/L)
160
120
80
40
0
n=31
0
1000
2000
3000
4000
5000
Fe (ug/L)

Regional Fe – As Relation



Groundwater Transport Model for NC Piedmont Aquifer System



SUMMARY

- There exists a relationship between ORP, pH, Fe and As concentrations.
- Higher Fe levels present naturally in the IP groundwater appear to regulate As levels through adsorption or precipitation onto Fe hydroxides.
- Reductive dissolution of As or desorption of As from Fe oxyhydroxides appear to control As levels in the CT.

SUMMARY

- This study:
  - Provides new data on As concentration and speciation in private wells.
  - Developed gross relationships between redox parameters and As levels in the region.
  - Supports the hypothetical model on groundwater As transport in the NC Piedmont.
- Further investigations are needed to:
  - Test and verify the groundwater transport model