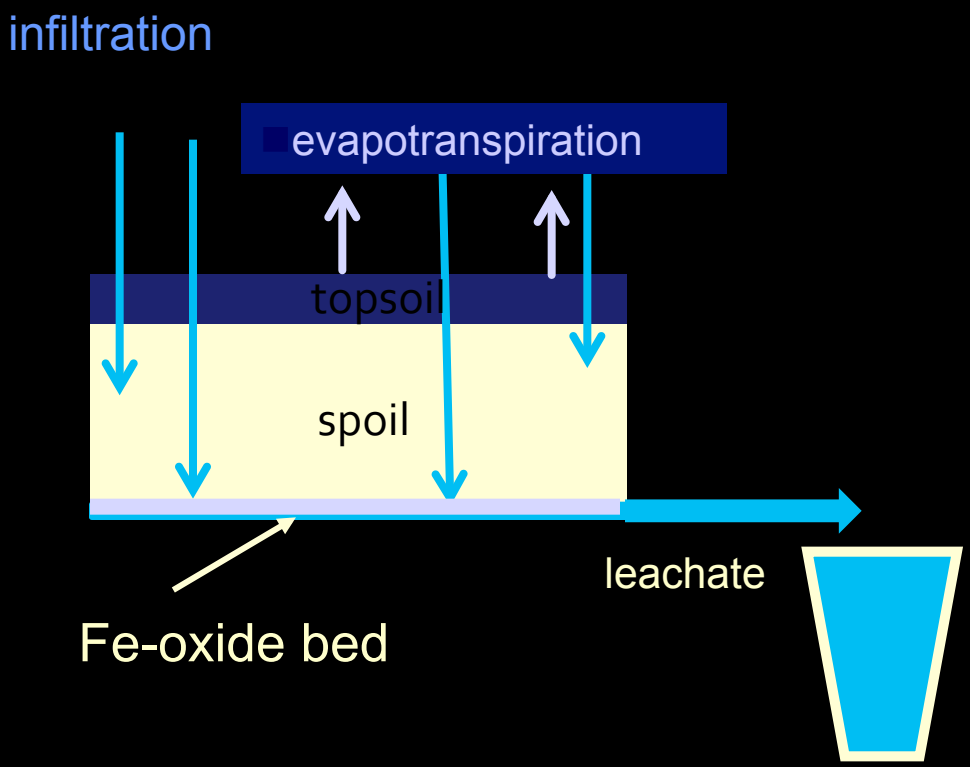
Selenium treatment with iron oxides at a surface mine in WV



Joe Donovan *
Paul Ziemkiewicz **

West Virginia University

* Department of Geology and Geography
** WV Water Research Institute

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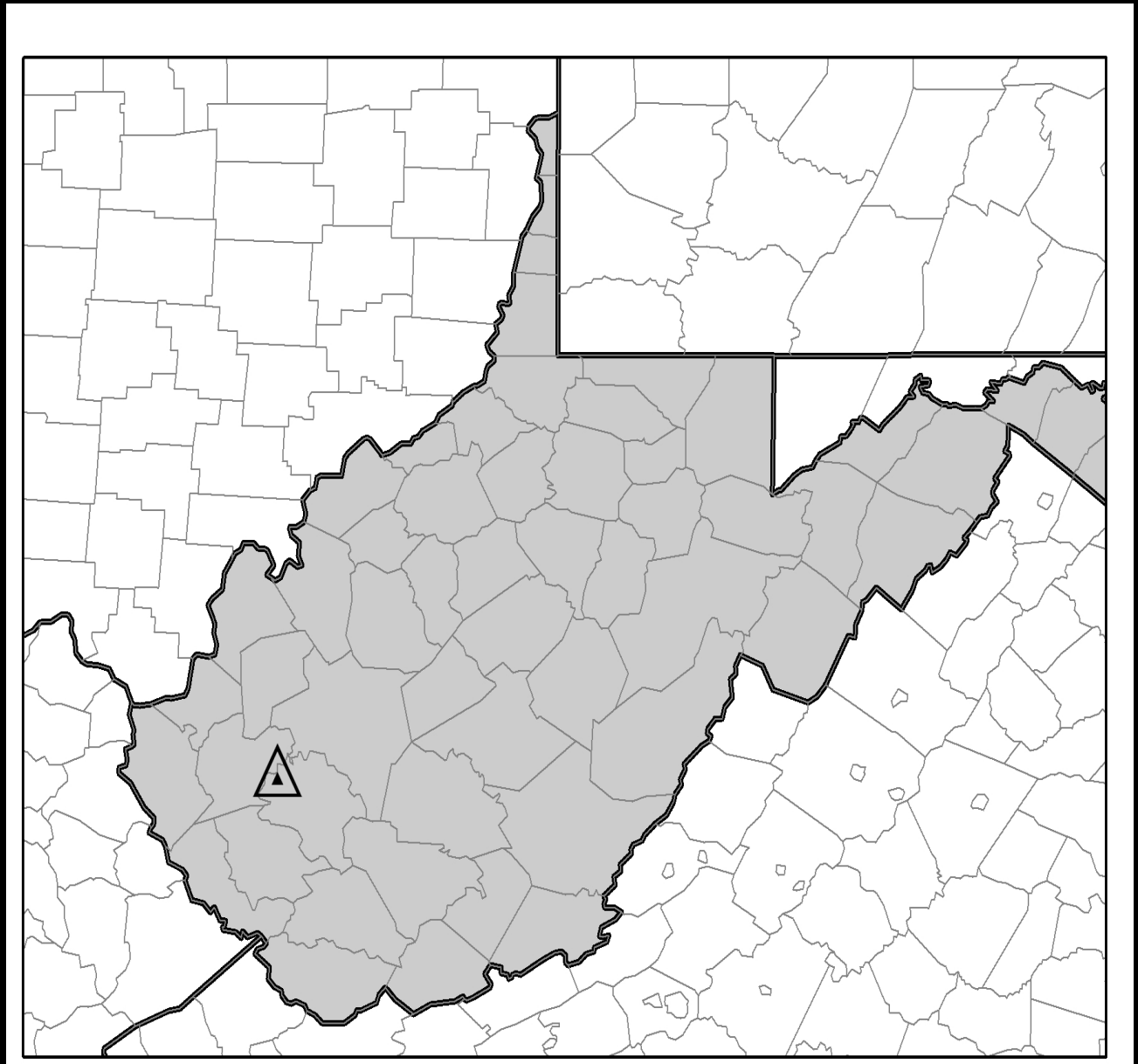
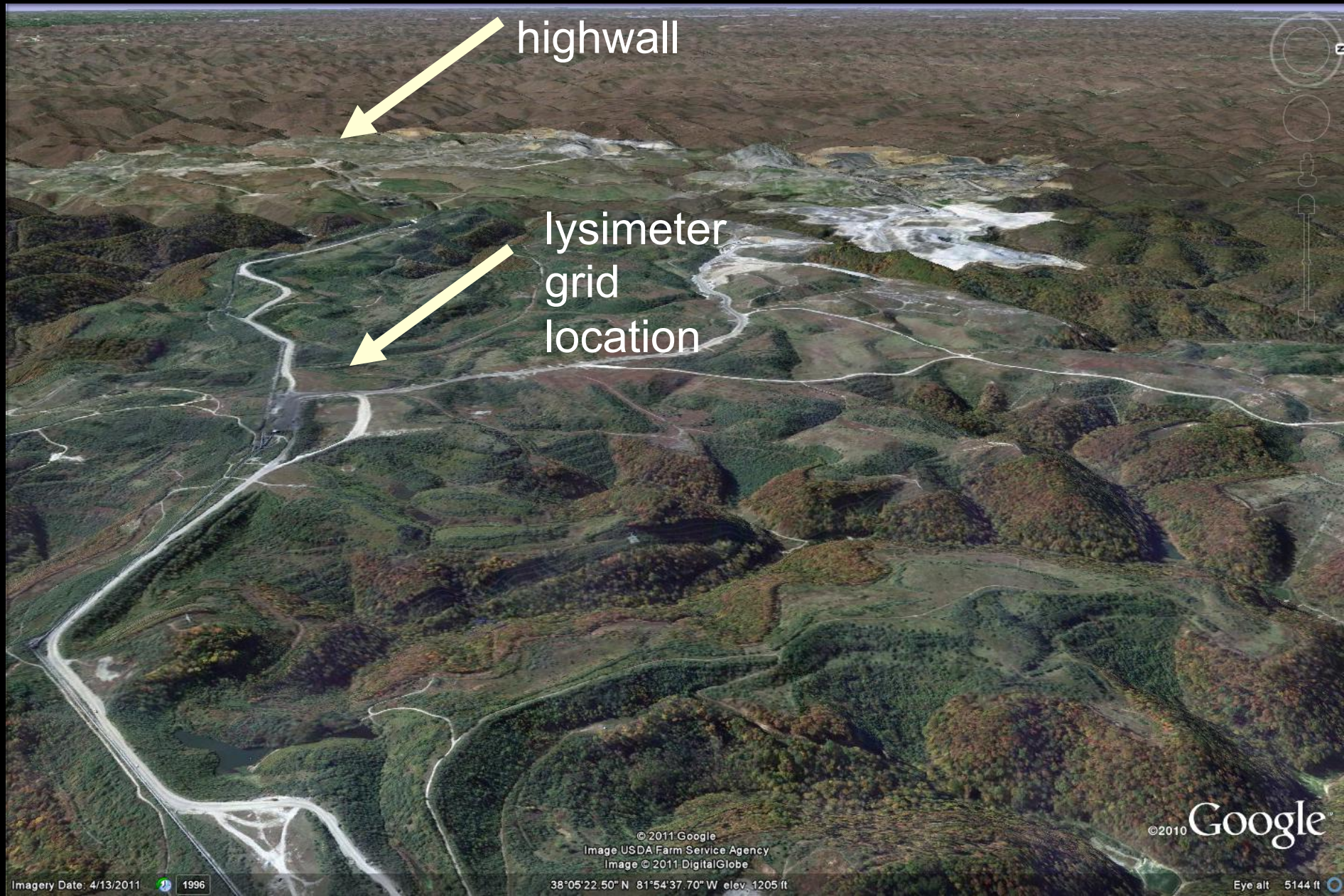
Louis McDonald, Liviu Magean

study area: Hobet mine, Lincoln Co.



mine layout


highwall
lysimeter
grid
location
© 2011 Google
Image USDA Farm Service Agency
Image © 2011 DigitalGlobe
©2010 Google
Imagery Date: 4/13/2011
1996
38°05'22.50" N 81°54'37.70" W elev. 1205 ft
Eye alt 5144 ft

the Hobet spoil experiment

- earlier research at Hobet shows that Se is leached from “hot” waste rock over 5-15 yr timeframe
- can this Se be sequestered by adsorption using Fe-oxide materials
- 30 identical “mesocosms” of overburden leaching
- varying thicknesses of basal Fe-oxide layers
- approximately biweekly sampling
- 6 replications per amendment
- installed 2010; still being sampled

materials

- pit-run carbonaceous shale from Stockton and Coalburg seams (Se-rich)
- thin topsoil layer (weathered brown sandstone)
- Fe-oxide from limestone-treated AMD wetland, New Stanton, PA
- lysimeters 5 x 7 m in size
- plumbed to collect leachate by gravity drainage in 350 gal tanks
- complete capture of leachate == interval sampling
- yields chemistry + flow rates but no speciation

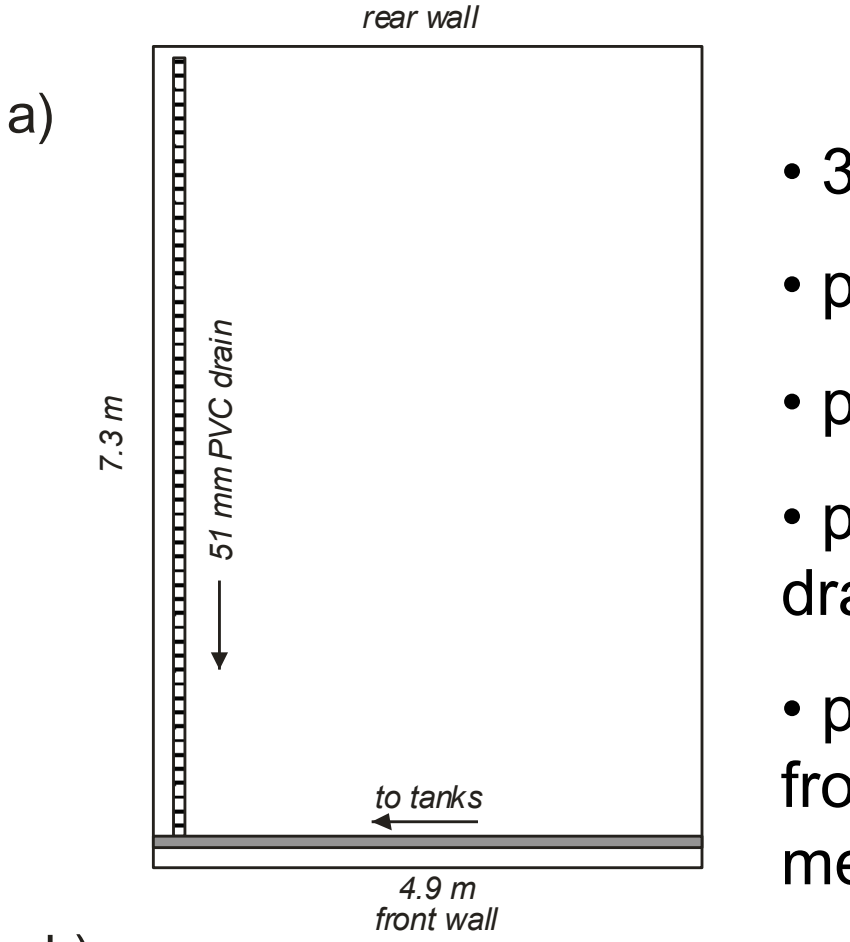
dataset

- bi-weekly flows and water chemistry == > monthly after 9/2012 === >1500 samples
- duration May 2010 to present
- freeze-up period in winter 2010-11 and 2014 (!) when samples were not collected

research questions

- will significant adsorption of Se occur? ☑
- what species of Se are present/dominant?
- what Fe-oxide application rates are needed? ☑
- application method (blending, layering) ☑
- will other ions compete for adsorption sites?

lysimeter construction

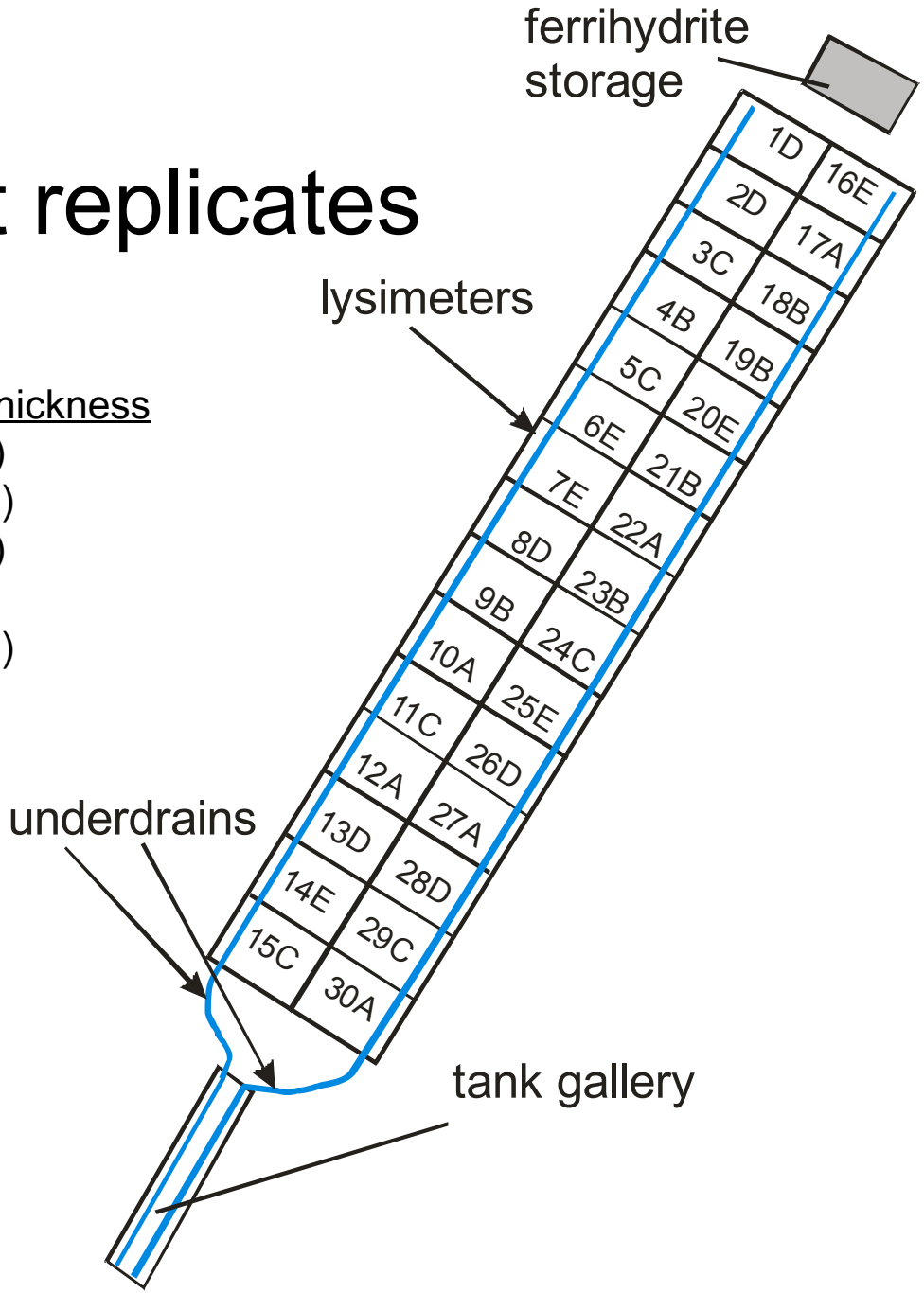


- 30 cells, 5 x 7 m x 1.3 m H
- plywood construction
- plastic-lined
- plumbed via ABS pipes to drain leachate to tank array
- periodic sampling of water from 350 gal tanks + volume measurement

lysimeter layout

treatment replicates

<u>ferrihydrite layer thickness</u>
A – zero (0% w/w)
B – 6.4 mm (0.2%)
C – 57 mm (1.5%)
D – 229 mm (6%)
E – 457 mm (12%)

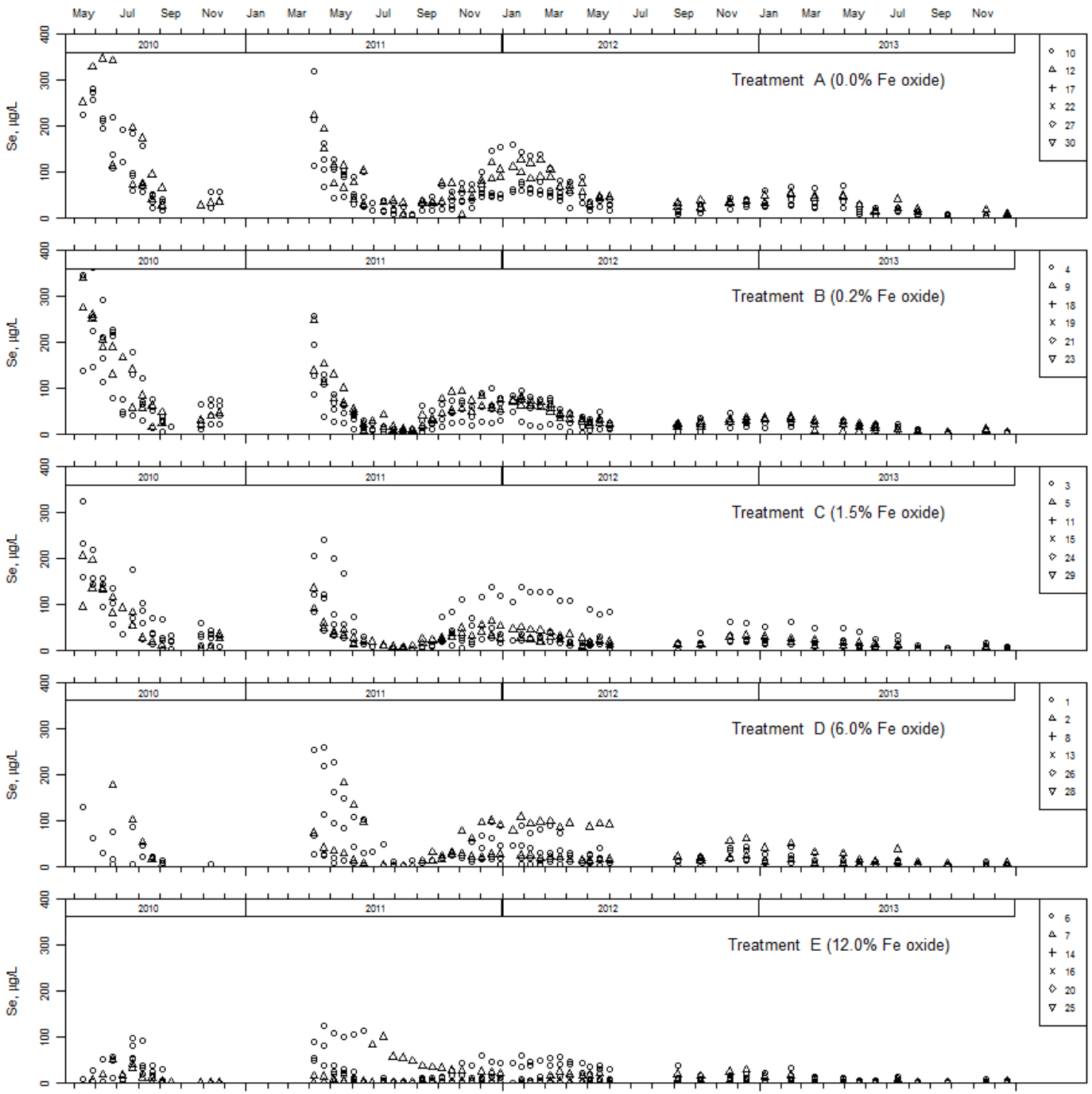


gravity-drainage sampling tanks

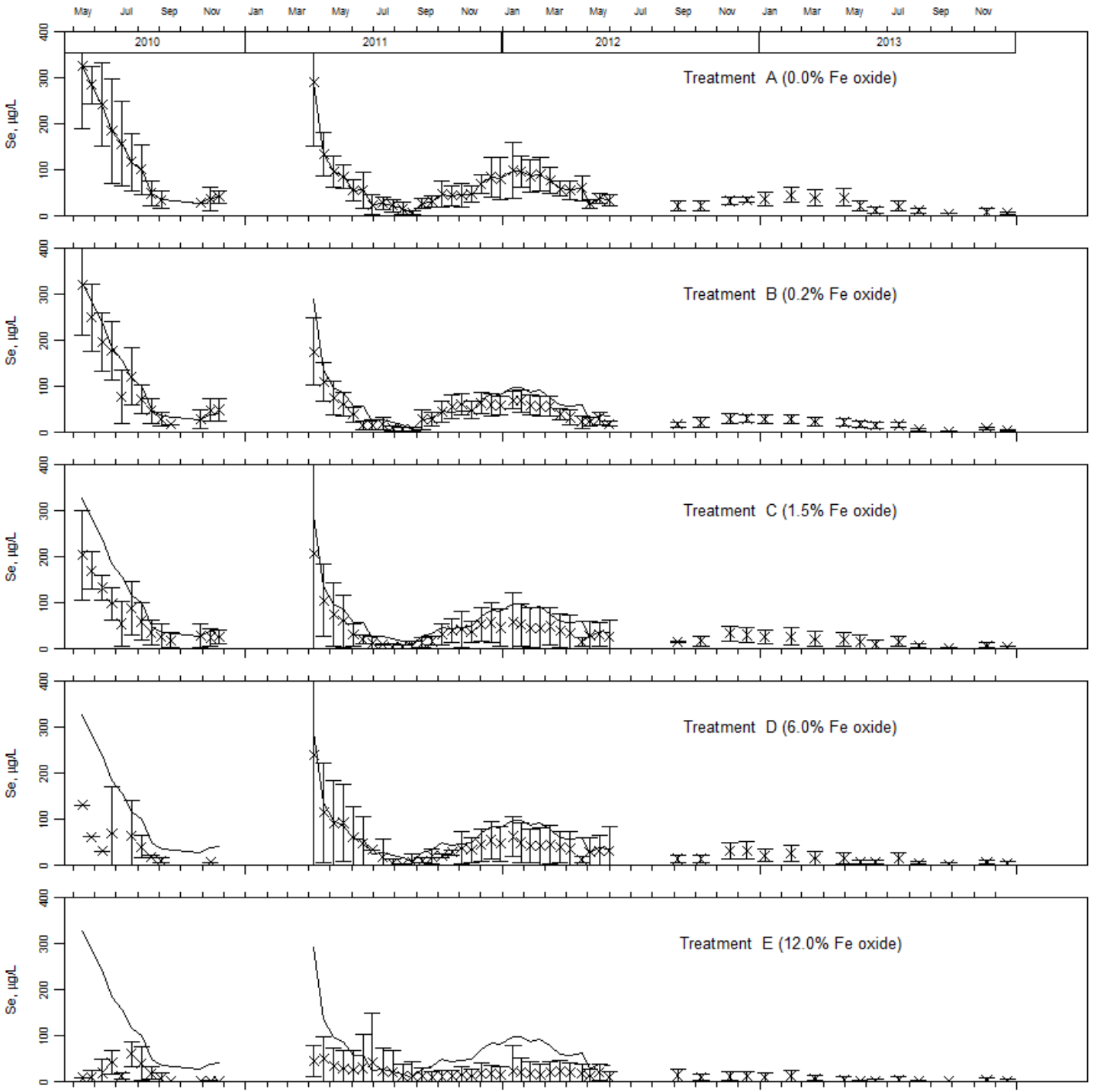
sampling/average flow measurement

2010-2013 Se and flow data

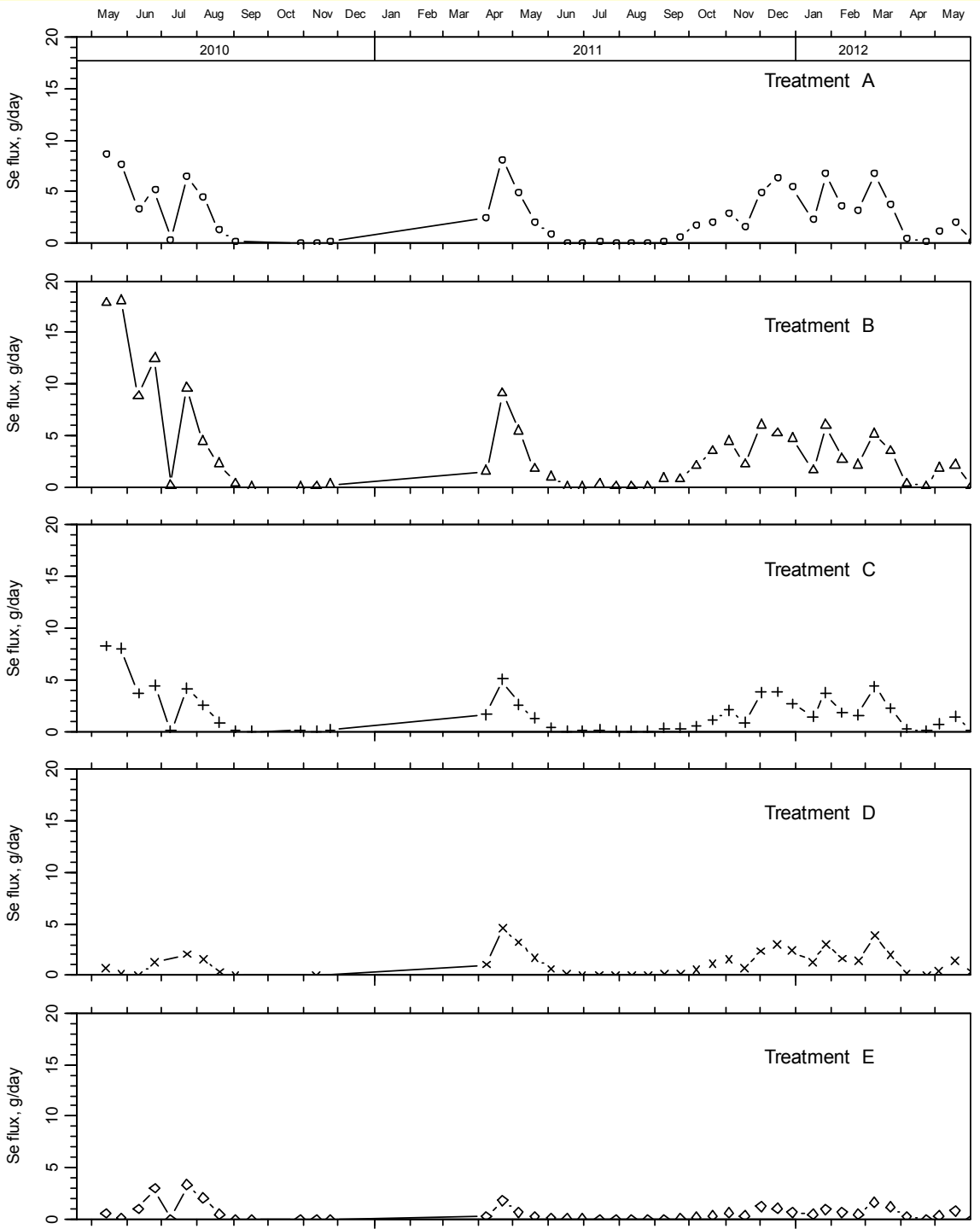
raw Se concentrations (μg/L) for replicates



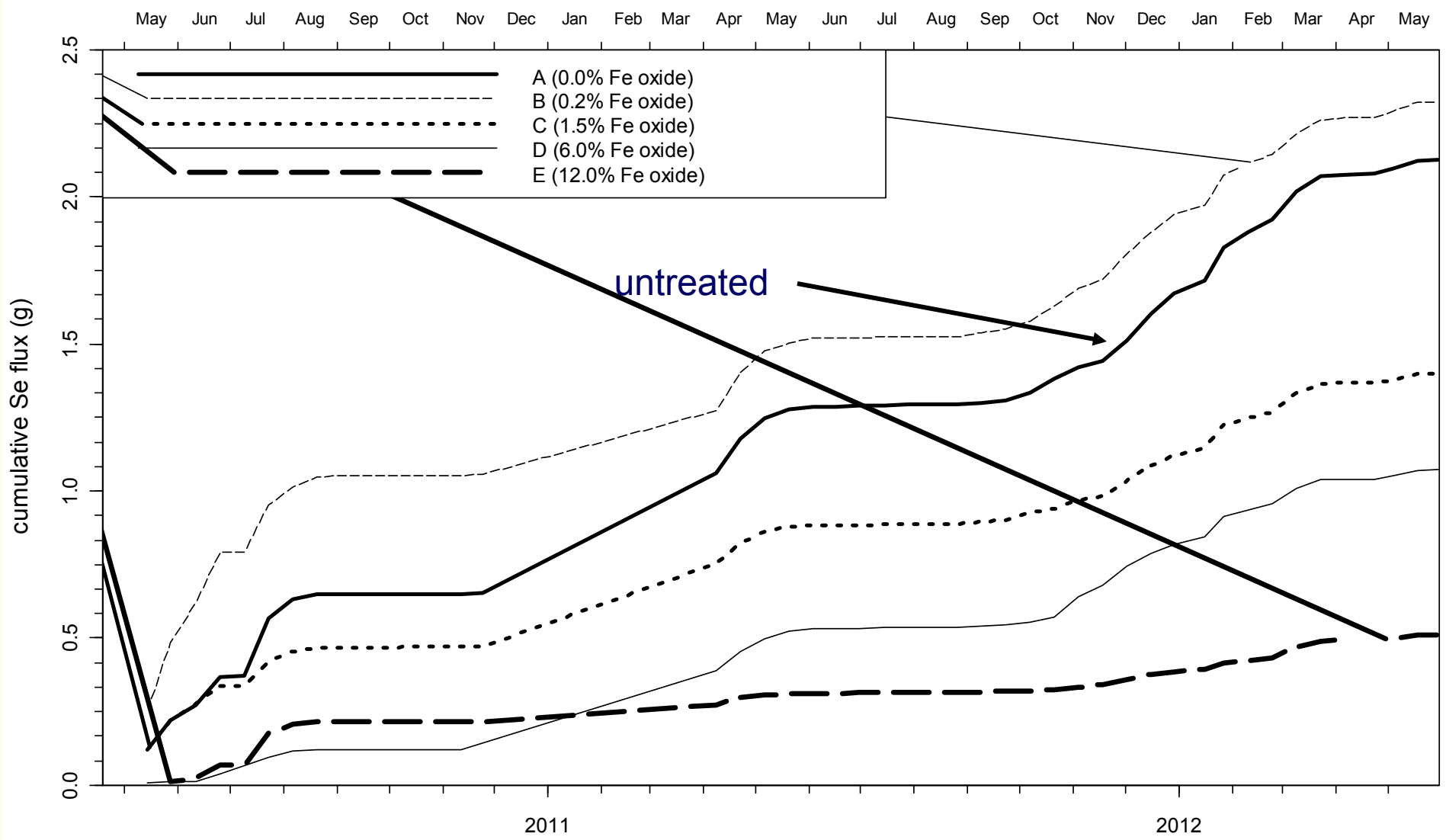
mean Se concentrations (μg/L) within replicate groups



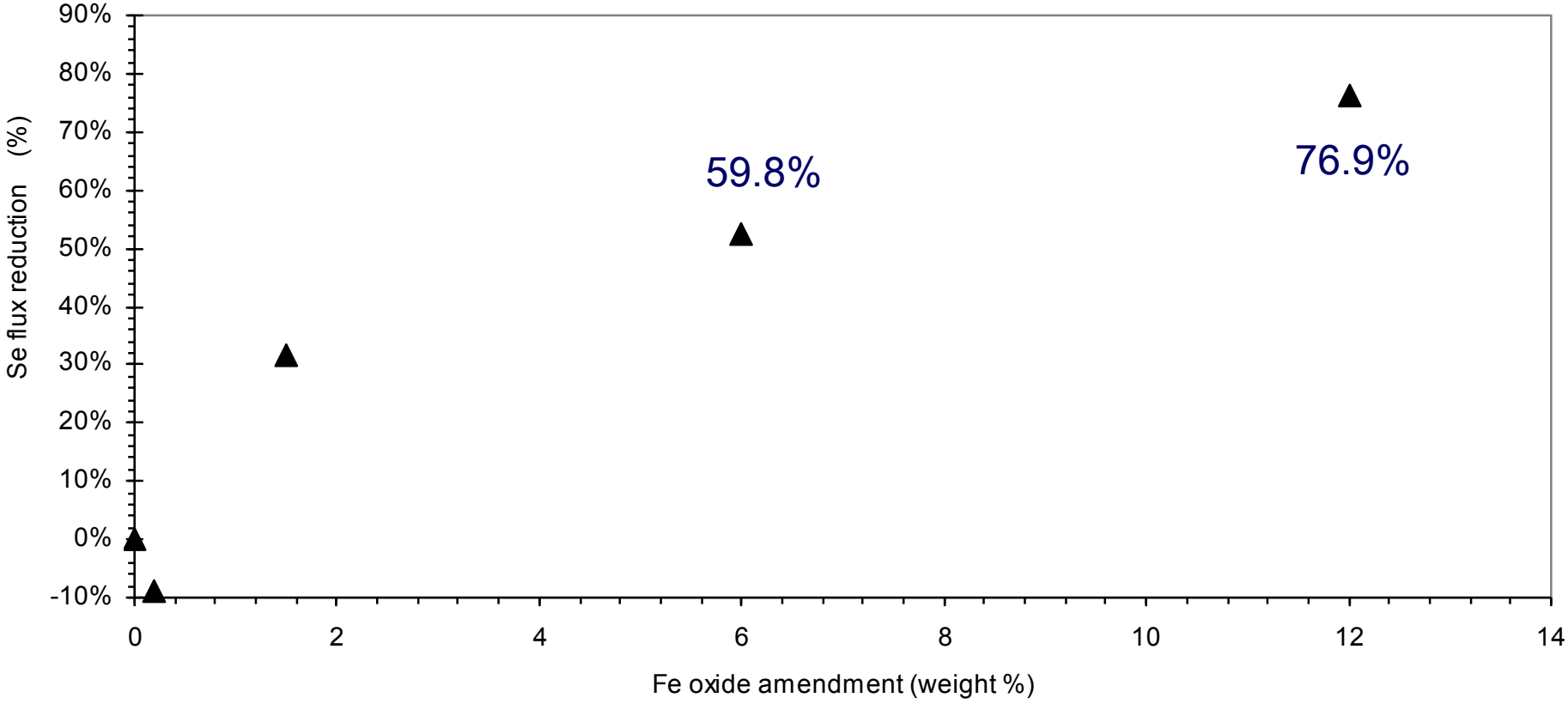
mean Se flux (mg/day) 2010-12



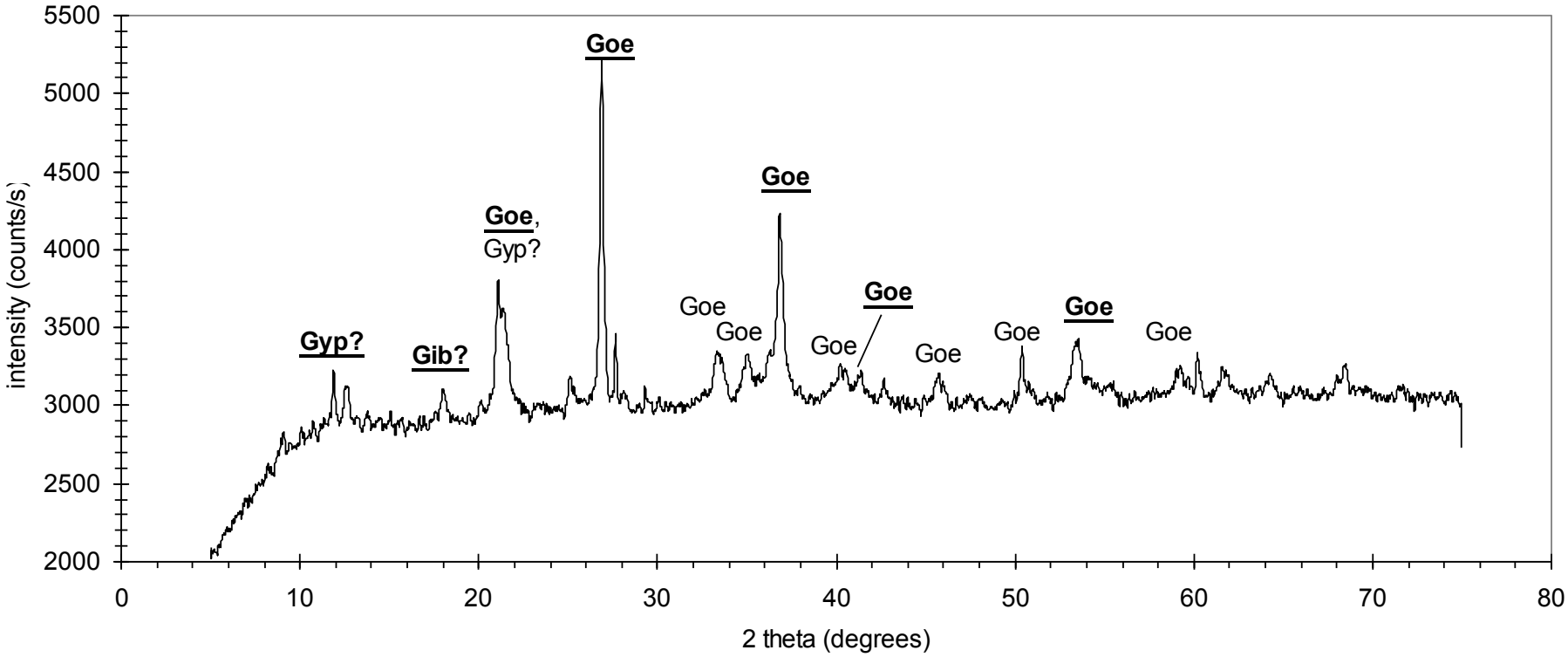
cumulative average Se flux (thru 2012)



Se flux reduction (2010 to June 2012)



iron oxide mineralogy (mainly goethite)



key results of Se time series

- unamended Se concentrations were up to 300-400 μg/L in years 1-2 – falls off to <50 μg/L in years 3-4
- in year 4, all but one Treatment D replicate was <10 μg/L (at most times <5 μg/L)
- Highest Se flux and flows in spring – "spring flush"
- thin Fe-oxide layers have little adsorption effect
- thick Fe-oxide treatments (D and E) were highly effective at reducing Se flux (through 2012: 59.8% and 76.9% cumulative reduction compared to untreated)
- replicates indicate results not an artifact of spoil heterogeneity or hydrology

practical implications of results

utility for Se control

- special handling cells for "hot" spoil could greatly reduce effluent Se concentrations from >300 to <10 ppb in first 2-3 years, and perhaps in compliance thereafter
- dealing with spring "flushes" could be accomplished by innovative water management (dilution/blending)

problems to work out

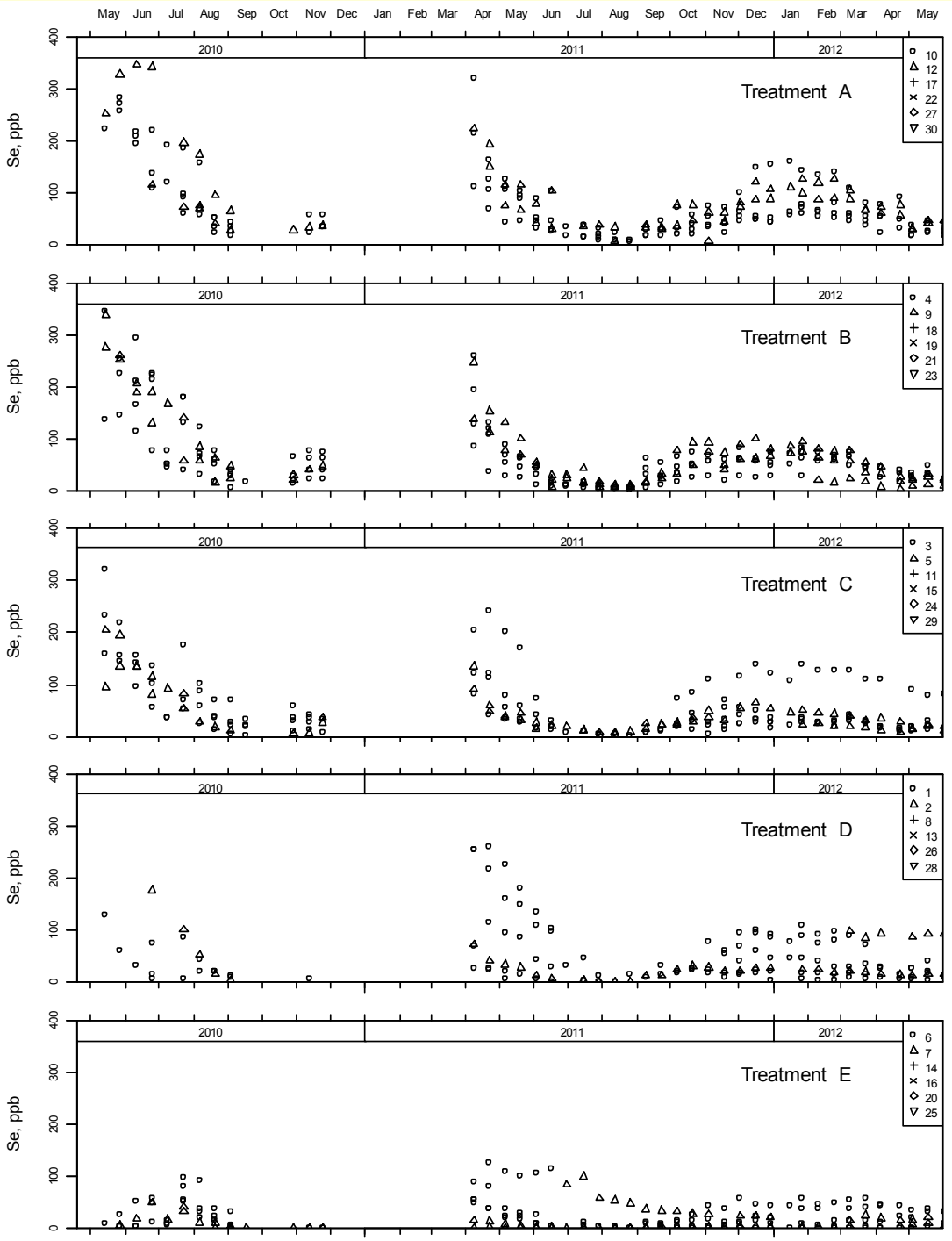
- minimum Fe-oxide needs/optimal layering strategies
- scale-up issues
- long-term stability of adsorbed Se
- Were test cells so oxic that timeframes were accelerated?

questions

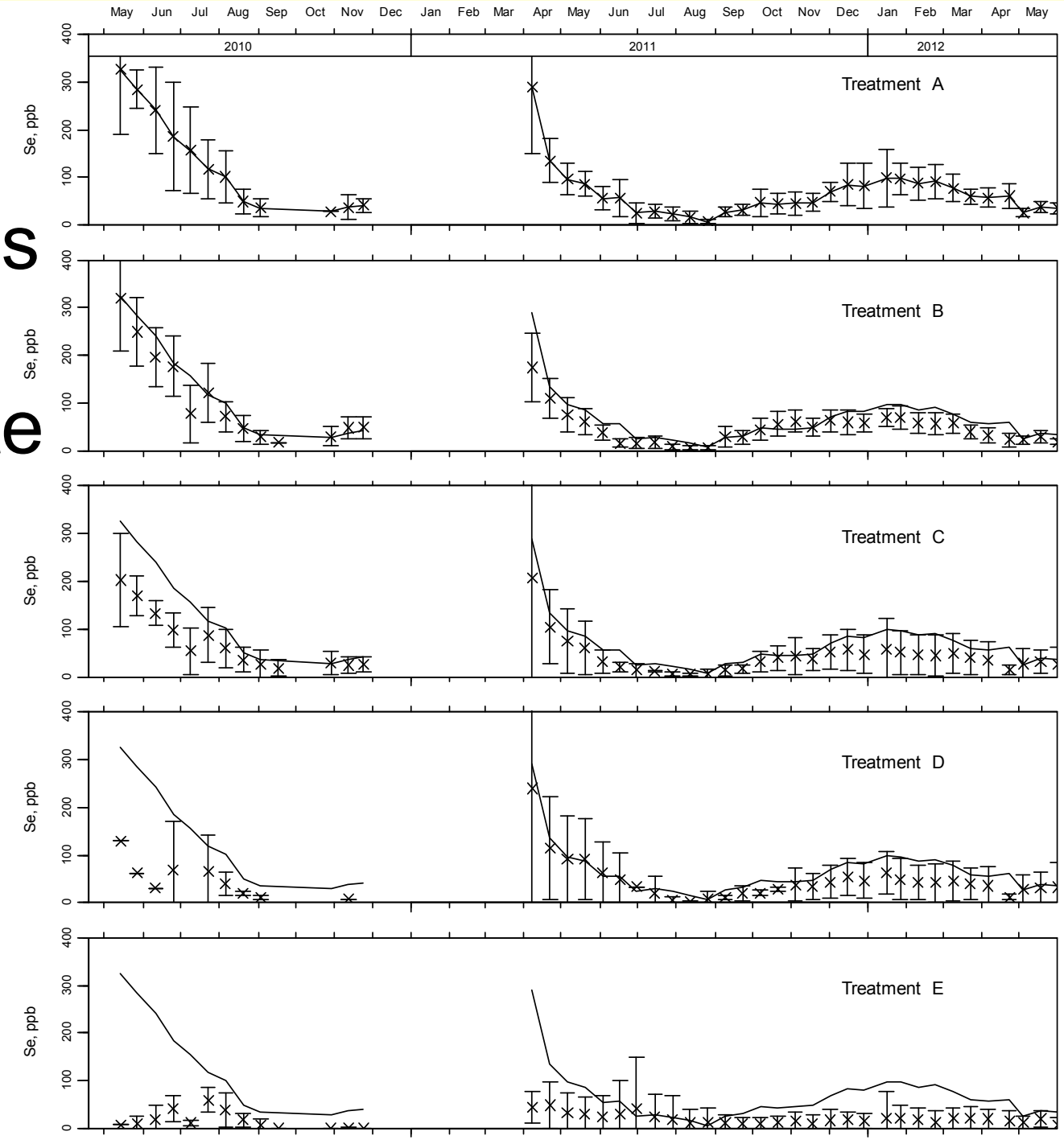
work in progress/pending

- continue long-term sampling
- harvest/characterize Fe-oxide beds from 2 cells
  - elemental chemistry/mineralogy
  - characterize adsorption sites
  - is Se adsorption reversible?
- scale up to large amendment piles
- test different layering strategies

raw Se concentrations (μg/L) for replicates



mean Se concentrations (μg/L) within replicate groups



mean Se flux (g/day)