Field-Scale in situ Measurements of Vadose Zone Transport Using Multiple Tracers at INEEL Vadose Zone Research Park

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Environmental Issues

- At INEEL, organic, inorganic, and radioactive contaminants have entered the environment and are present in the vadose zone, for example:
  - Idaho Nuclear Technology and Engineering Center (INTEC) – ^{90}Sr
  - Radioactive Waste Management Complex (RWMC) – U, Pu, solvents

Project Goals

- Improve conceptual models of contaminant migration through a thick, layered and fractured vadose zone
- Provide site-specific field-scale parameters for INEEL to better predict contaminant migration through the vadose zone

Results will have important applications at INEEL in assessing remedial actions and long-term stewardship and for understanding vadose zone flow and transport in general

Main Participants

- LANL: R. Roback – PI, P. Reimus and J. Sullivan, (field and lab tests), C. Jones (Dissertation project under R. Bowman NMT)
- INEEL: L. Hull – PI, T. McLing (field and lab tests) and collaborations with: C. Baker (hydrology), G. Heath (geophysics), L. Street (EM), S. Magnuson (EM) and many others
- UNM: Y. Asmerom – PI, E. Nichols (MS thesis under Asmerom)

In-Kind Support and Collaborations

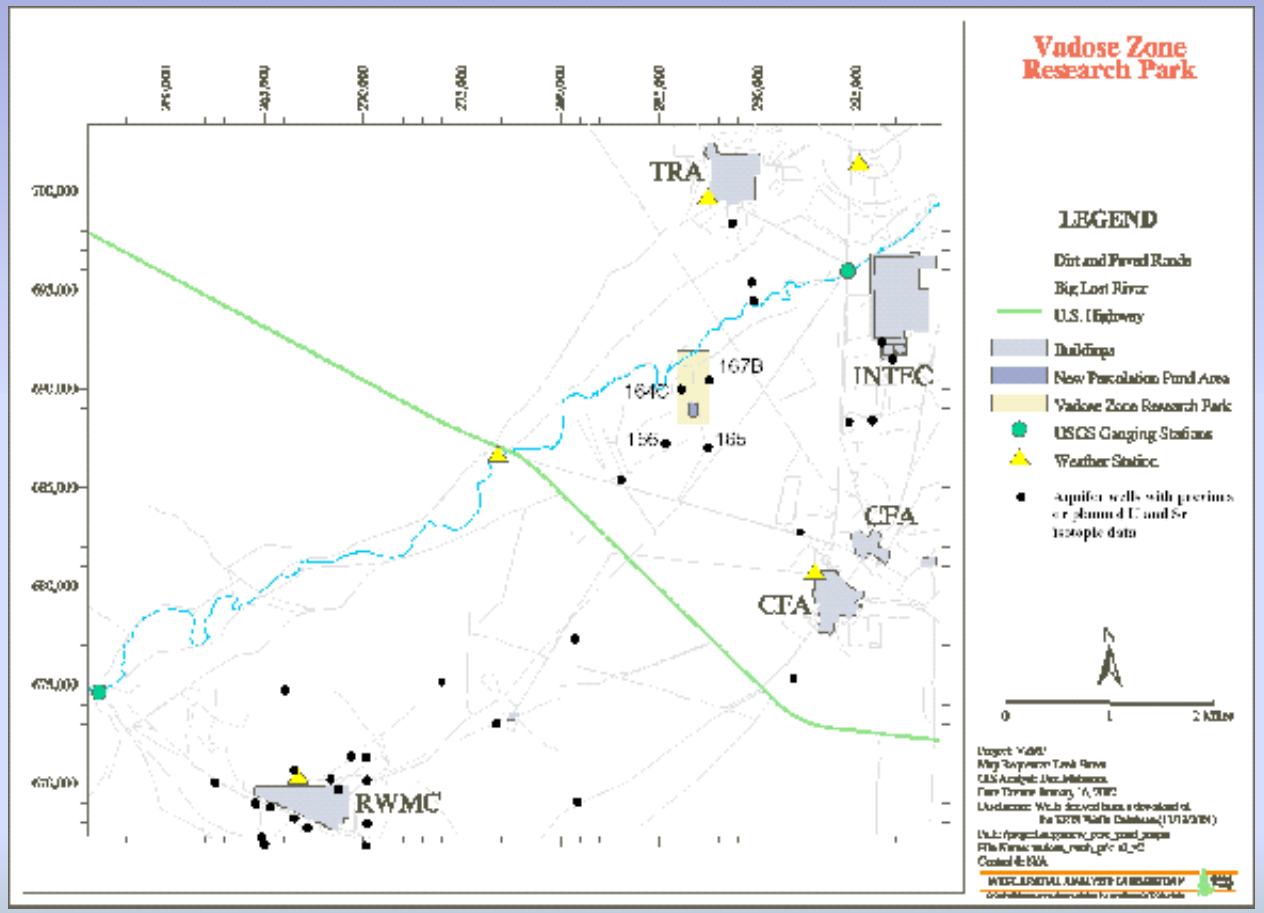
- Major investment by INEEL to install sampling and monitoring equipment
- Support from INEEL EM program through sampling and maintenance
- Collaborative studies:
  - geophysics (ERT array) through INEEL LDRD
  - monitoring and interpretation of hydraulic parameters through INEEL
  - cooperation with INTEC personnel who control discharge

Research Site:

INEEL – Vadose Zone Research Park

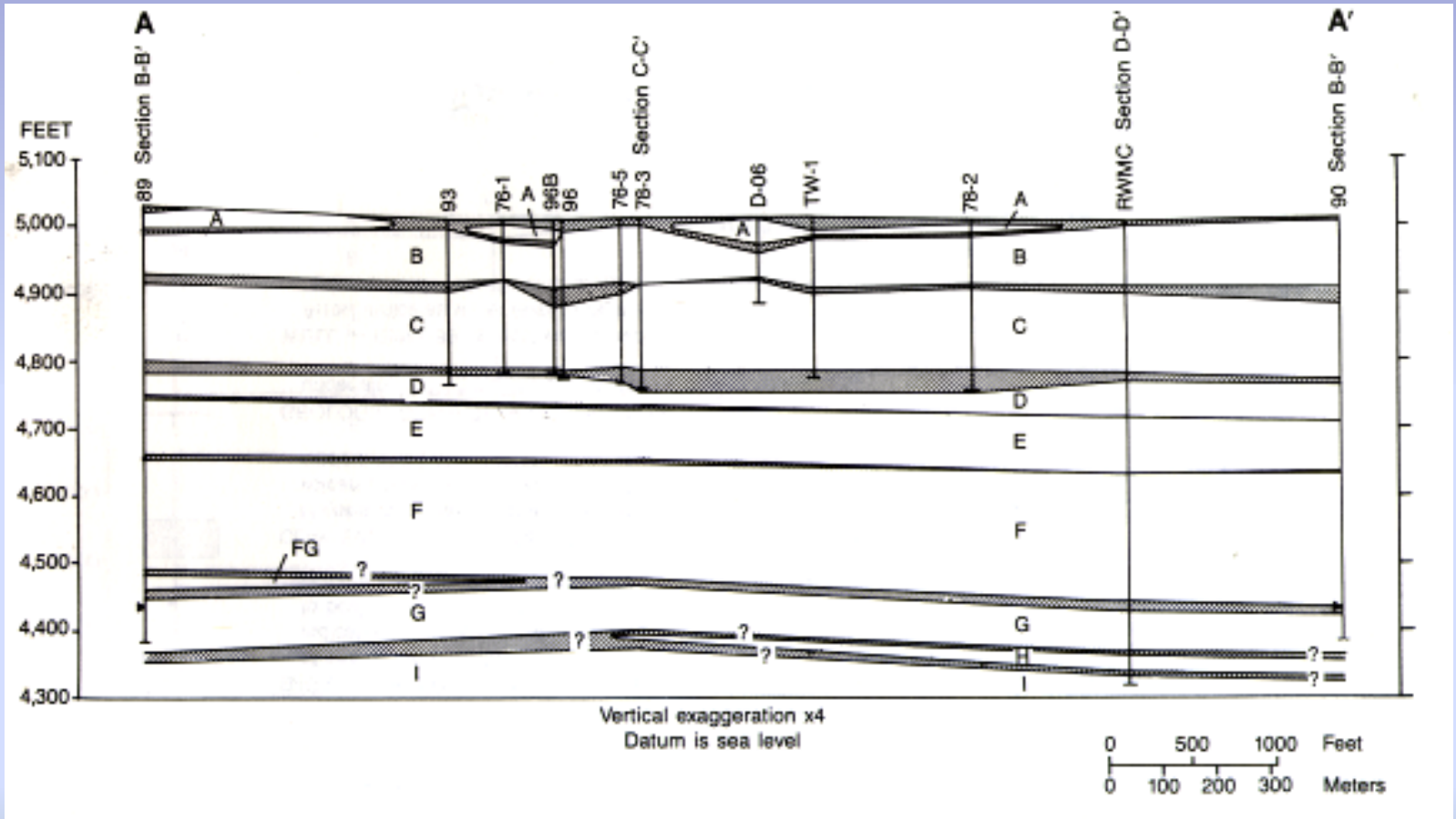
- Constructed to receive process water from INTEC operations
- Provides instrumentation and facilities to address vadose zone flow and transport
- Uncontaminated site with subsurface geology and hydrology very similar to those beneath INTEC and SDA

THE VZRP



- Located near major facilities and sites with most pressing environmental management issues
- Similar subsurface geology and hydrology
- Proximal to Big Lost River

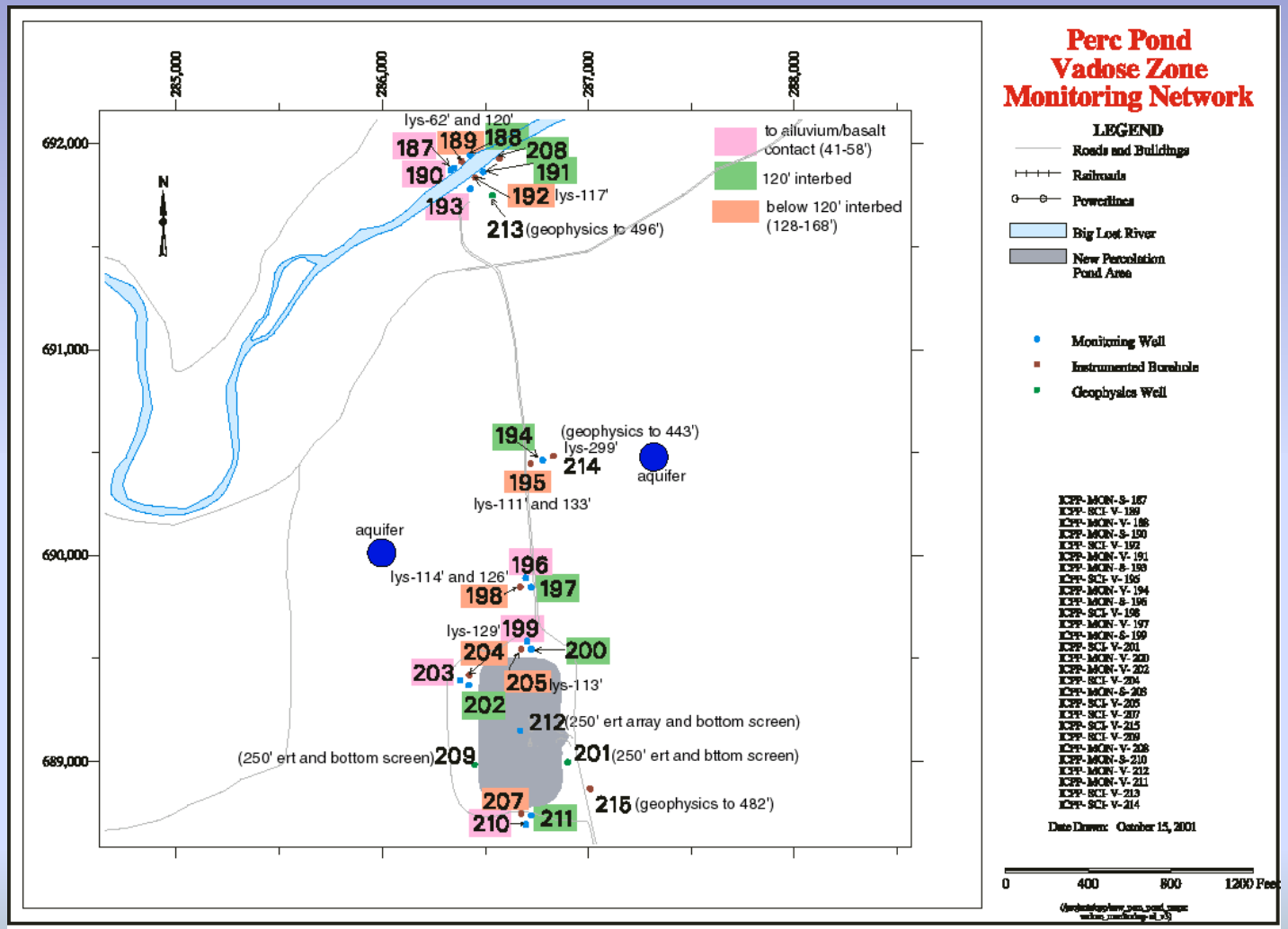
Subsurface Geology



VZRP Arial View

Wells Along the Big Lost River

The VZRP (cont.)



VZRP Instrumentation

- Monitoring Wells at infiltration ponds and BLR
  - 5 in aquifer (525’)
  - 7 at alluvium/basalt contact (45’-50’)
  - 9 at top of sedimentary interbed (125’-130’)
  - 4 to depth of 250’
- Instrumented boreholes
  - Lysimeters
  - Gas sampling ports
  - Water content sensors, thermocouples, tensiometers
- ERT arrays- down hole and along surface

Instrumentation

Wells are completed with stainless steel wellboxes. At instrumented boreholes, data are collected automatically and communicated with INEEL computer network over radio link.

Gas and water sampling ports are equipped with quick connects to facilitate sampling.

Project Objectives

Simultaneously inject multiple tracers to investigate:

- Spatial and temporal transport of reactive and conservative tracers through vadose zone
- Migration of colloids through the vadose zone
- Influence of degree of saturation, flow rate, flow transients, and water chemistry on these processes
- Interactions between vadose zone and saturated zone

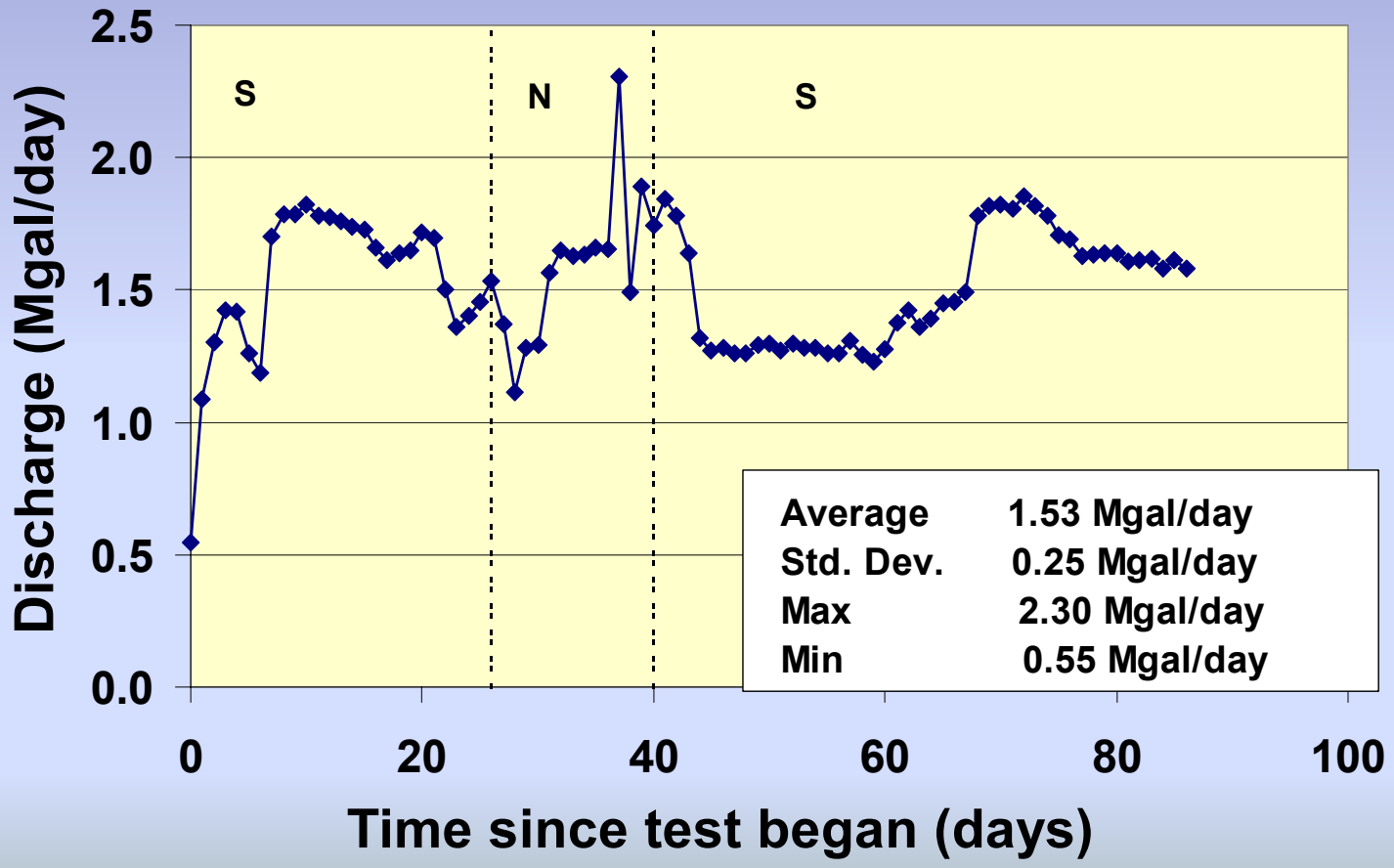
Methods

- Examine tracer recovery for conservative, reactive and colloid tracers
  - Use isotopically-tagged natural colloids?
- Examine natural U and Sr concentration and isotopics to provide element-specific transport parameters to contaminants of concern
- Evaluate spatial and temporal patterns in tracer recovery; compare these to hydraulic data from tensiometers, water levels, and geophysics
- Laboratory tests to provide transport parameters and comparison to field results
- Modeling of data

Some History

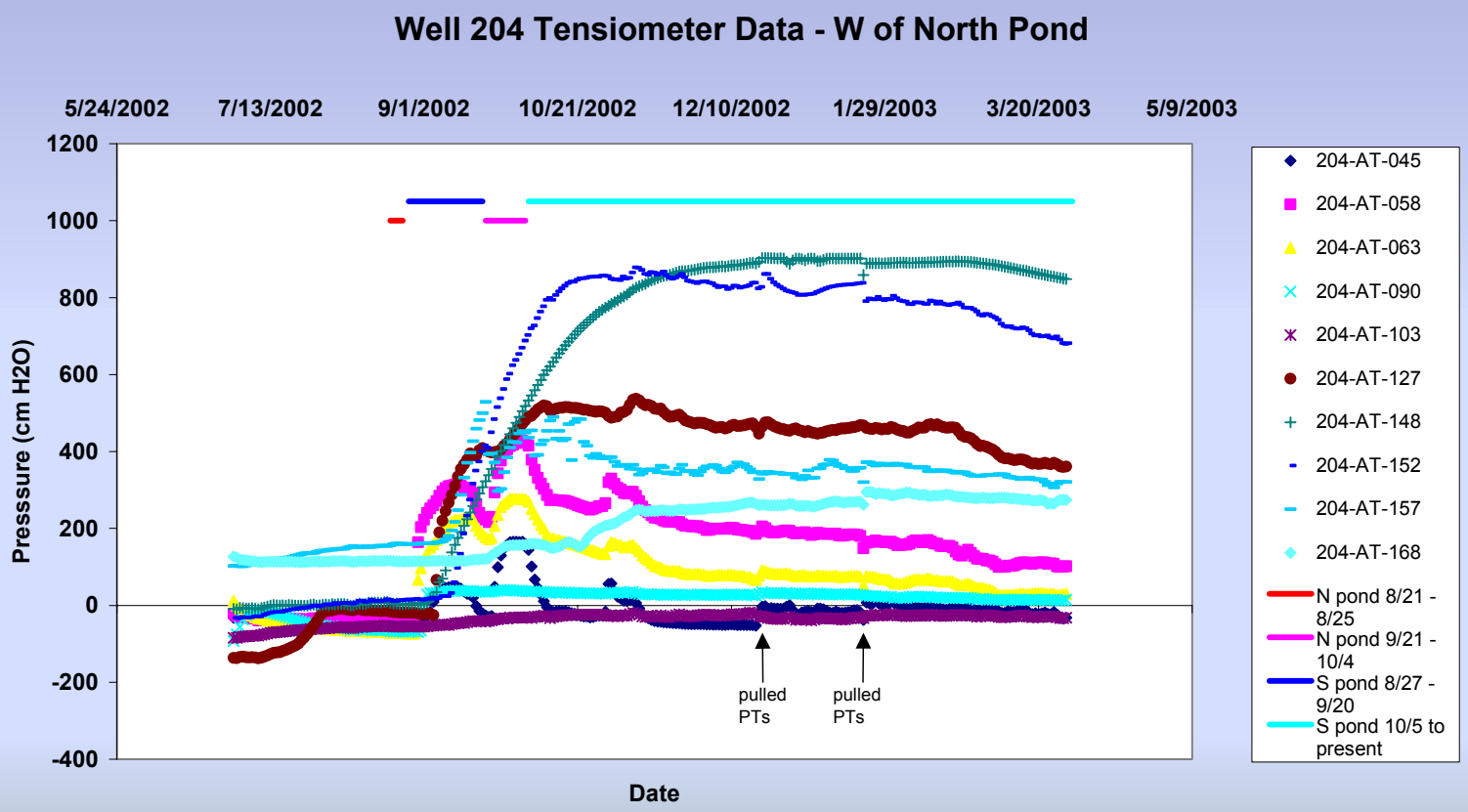
- Discharge to ponds was way ahead of schedule with steady inflow by August
- Sampling of first waters though INEEL EM; sampling at daily, then weekly, and now monthly intervals. Over 200 samples collected and most analyzed for anions, cation; subsets for δO^{18} and δD. Geophysical and hydraulic data collected and is being analyzed
- C. Jones joined project in August at NMT (Ph.D.); E. Nichols to begin in June at LANL then UNM (M.S.)

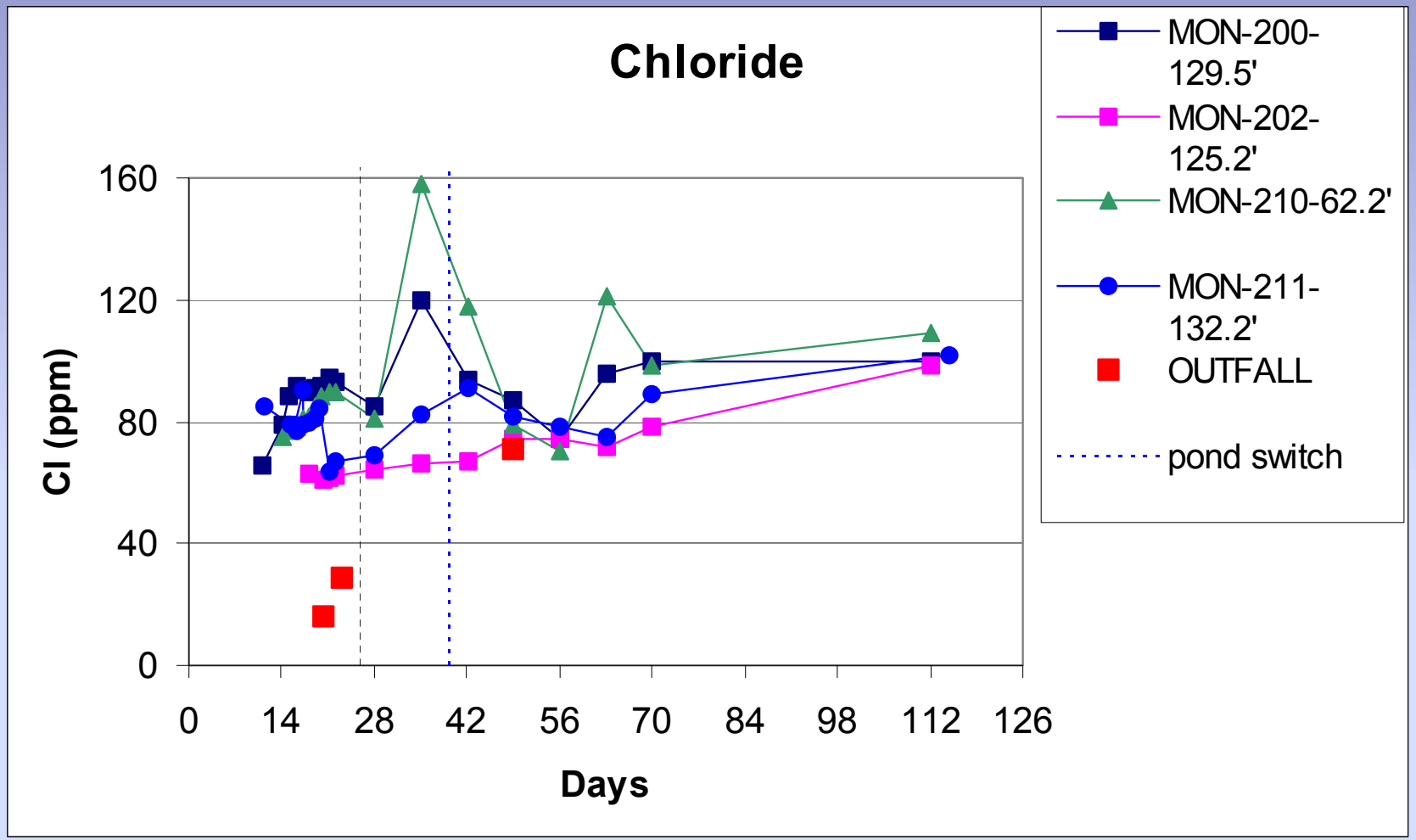
Discharge from INTEC

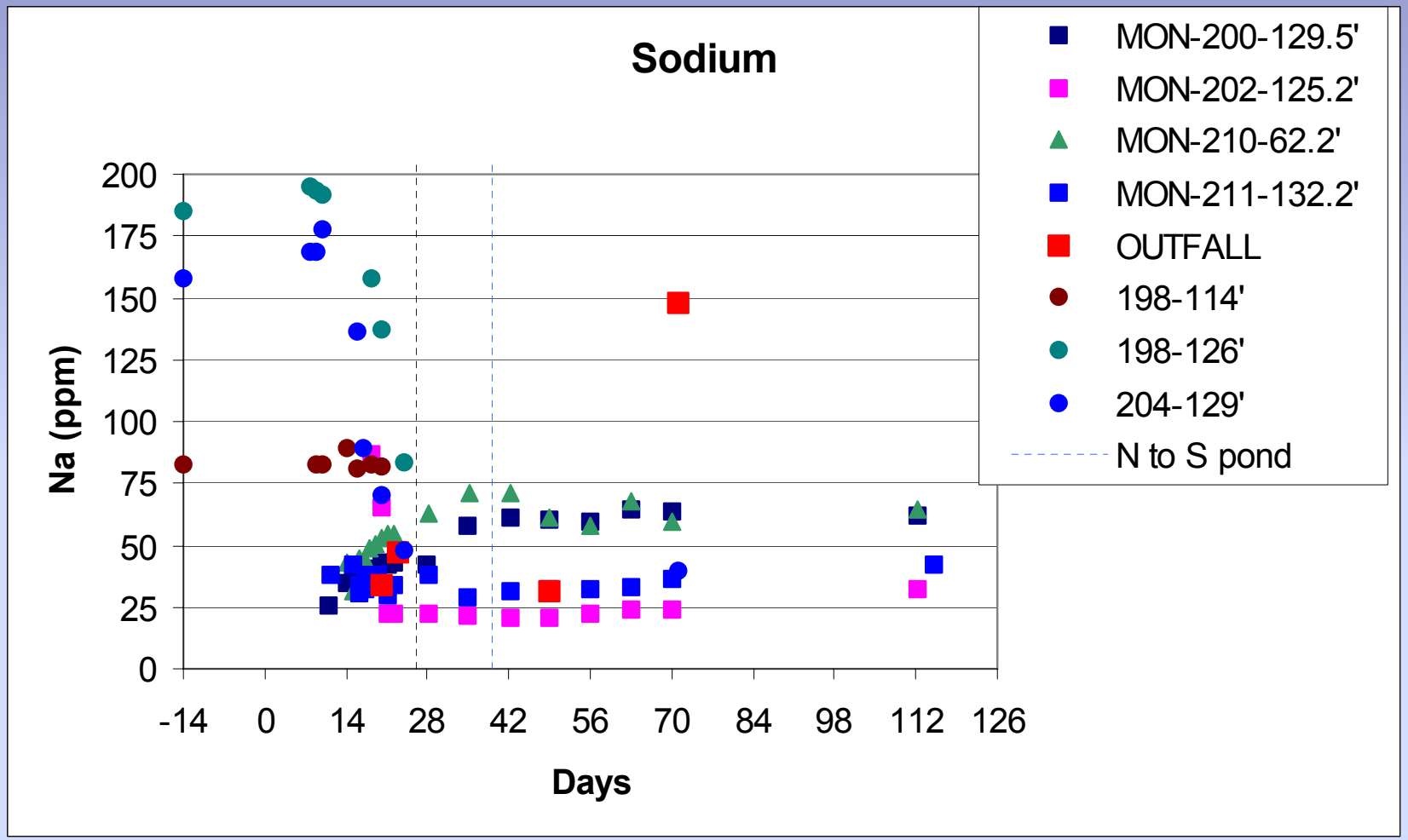


EMSP Workshop, 2003

Continuous Logging of Tensiometer Data




Chloride
Cl (ppm)
160
120
80
40
0
0
14
28
42
56
70
84
98
112
126
Days
MON-200-129.5'
MON-202-125.2'
MON-210-62.2'
MON-211-132.2'
OUTFALL
pond switch


Sodium
Na (ppm)
200
175
150
125
100
75
50
25
0
-14
0
14
28
42
56
70
84
98
112
126
Days
MON-200-129.5'
MON-202-125.2'
MON-210-62.2'
MON-211-132.2'
OUTFALL
198-114'
198-126'
204-129'
N to S pond

Preliminary Findings

- Discharge pulse defined
- Wells with differing response to conservative tracer identified
- Refinement of conceptual model
  - Lateral flow along lithologic contacts
  - Perched saturated zones, unsaturated zones
  - Flow velocities

Information critical to plan upcoming tracer tests

Future Plans

- Summer and Fall 2003
  - One to two tracer tests with conservative and reactive tracers to better understand system
  - Sample core from VZRP boreholes for laboratory experiments
  - Evaluate hydraulic and chemical data
- Future work
  - Additional tracer tests with different tracers and colloids, potentially under induced gradients, and outside of ponds
  - Tracer tests in BLR when (if) it flows
  - Laboratory experiments as dictated by initial tracer tests