Advanced Treatment Systems Research in the Tahoe Basin

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Outline

- Current projects at Lake Tahoe
  - What they are?
  - Who is involved?
- Approach
- Constituents of Concern (COCs)
- Discussion of Our Current Projects

AT Projects in the Tahoe Basin

Project	Goal	Organizations	Funders
Low Intensity Chemical Dosing (LICD) for P and Fine Particle Removal	Integrating wetlands/basin with chemical treatment to improve stormwater treatment	B&A, UCD CE, UCD TRG, USGS/CSUS	Caltrans/OWP, USDA FS, City of SLT
Enhancing P removal with Adsorptive Media	Investigating locally available adsorptive media for application in basins and wetlands	UCD TRG, B&A	USDA FS, Placer Co.
Apalachee Phase I Erosion Control Project	Investigate innovative BMPs for stormwater control	CSUS OWP; UCD TRG, CE & Ecotox; B&A	
Meyers Station Experimental Station	Investigate chemical dosing and adsorptive technologies for highway runoff treatment	CSUS OWP, Eco-logic	Caltrans
Caltrans Demonstration Projects	Demonstration system using filtration basins and different adsorptive media to improve stormwater quality	CSUS OWP	Caltrans

Involved Researchers (in no particular order)

Abbreviation	Organization	Principal[1]
B&A	Bachand & Associates	Philip Bachand, Ph.D.
UCD CE	UC Davis Civil and Env. Eng.	Professor Jeannie Darby
USGS	USGS Water Resources Dept, Sacramento	Roger Fujii, Ph.D *and Brian Bergamaschi, Ph.D.*
UCD TRG	UC Davis, Tahoe Research Group	John Reuter, Ph.D. and Alan Heyvaert, Ph.D
UCD LAWR	UC Davis, Land, Air and Water Resources	*Professor Will Horwath*
UCD Ecotox	UC Davis, Ecotoxicology	Michael Johnson, Ph.D.
CSUS OWP	California State Univ. of Sacramento, Office of Water Programs	Kevin Murphy, Dipen Patel, Ph.D. and John Johnston, Ph.D.
CSUS Chem	California State Univ. of Sacramento, Chemistry	Professor Susan Crawford
HF	Hydrofocus, Inc	*Steve Deverel, Ph.D.*

[1] Italics indicates principal not involved in Tahoe but related California projects.

Unifying Approach

- Applied research bridging theory and real-world applications
- Mechanistic approach focusing on COCs
  - transport and cycling
  - removal and sequestration
- Integrates small-scale laboratory and *in situ* studies with larger-scale field studies
- If possible work within constraints of existing infrastructure (i.e., basins, treatment wetlands, basins and drains, farm fields)
- Consider regulatory framework and goals

COCs at Lake Tahoe

- Primary – Fine particles, Phosphorus
- Secondary – Nitrogen

Enhancing Phosphorus and Fine Particle Removal Through Low Intensity Chemical Dosing and its Potential Application in the Tahoe Basin

P.A.M. Bachand of Bachand & Associates;
J. Trejo, J. Darby, A. Heyvaert and J. Reuter of UC Davis; R. Fujii of USGS and S. Crawford of CSU Sacramento

- Funded by Forest Service through Placer County and Caltrans
- In collaboration with CSUS Office of Water Programs

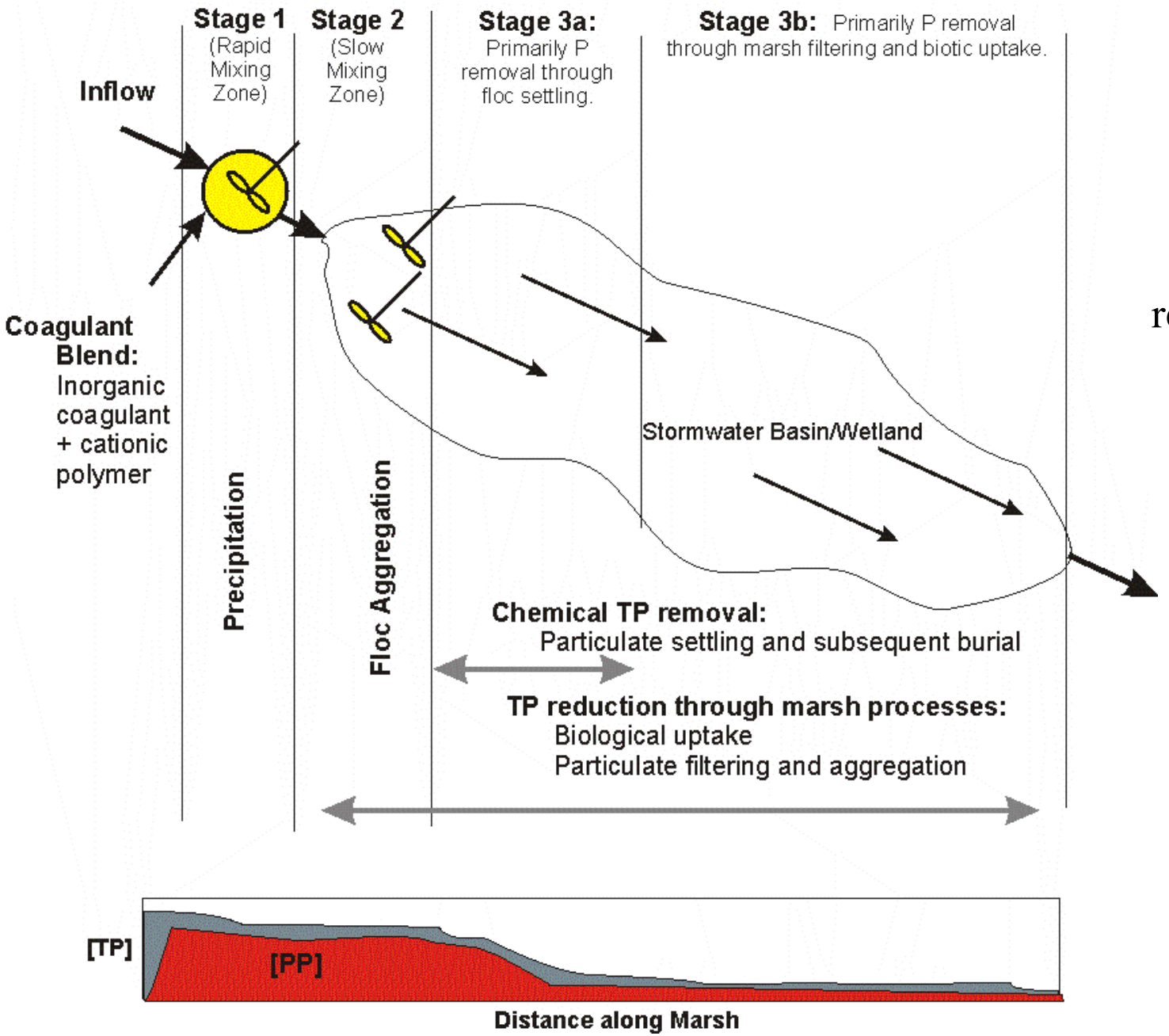
LICD Project's Goal

- Phase 1 study
  - Determine the feasibility (i.e., performance, environmental, logistical) of LICD for application in the Tahoe Basin.
  - Investigate its application to high nutrient/turbidity loaded sites for which agencies are enthusiastic

- Phase 2 (contingent upon Phase 1 results)
  - Test technology in larger-scale replicated pilot system.

Phase 1 Overview

- Feasibility
  - Laboratory & Settling Column
    - Performance
    - Flocculate stability and fate studies
  - Preliminary Eco-toxicity Assessment and EIR/EIS Issues Investigation
  - Site and Watershed Selection
  - Cost Analysis
- Pre-implementation
  - Site design
  - Experimental design



LICD Phosphorus removal model

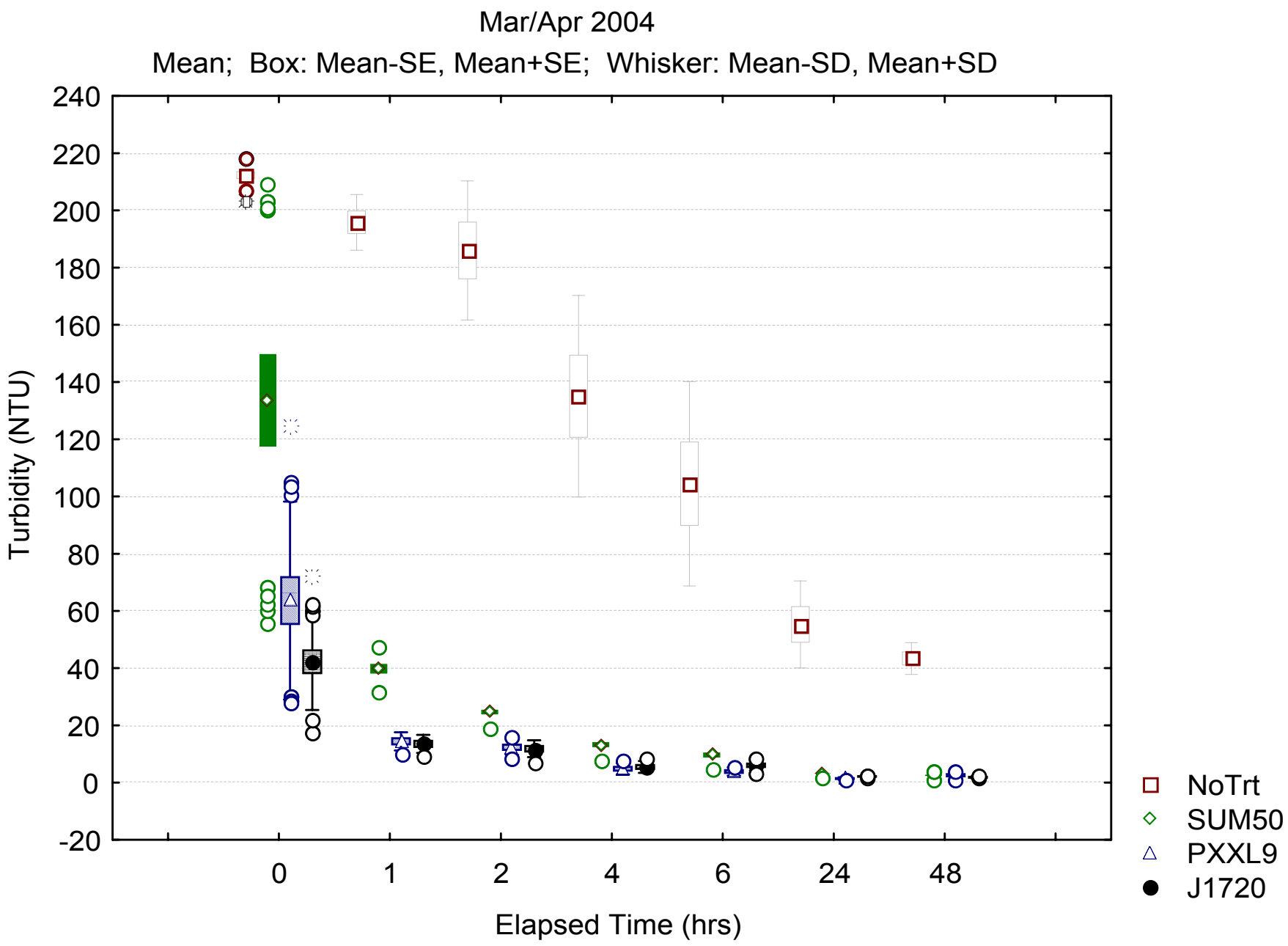
Summary of Water Quality Improvements using Coagulants, Phase 3 Studies, 2003

Dep. Var.	NoTrt		PASSC		PXXL9		SUM50		J1720	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Dose mg-me/L	NA	NA	7.1	1.1	6.0	0.8	2.7	1.7	1.3	0.8
Dose mg-coag/L	NA	NA	137	22	108	14	21	13	22	14
TP ppb	166	150	12	9	18	6	14	8	19	12
FTP ppb	19	9	5	2	6	2	7	3	7	3
Turbidity 5min	139	160	17	22	14	6	27	20	18	8
Turbidity 30 min	89	111	1	1	1	1	6	5	6	6

Turbidity Settling Column Tubidity at 24 hrs

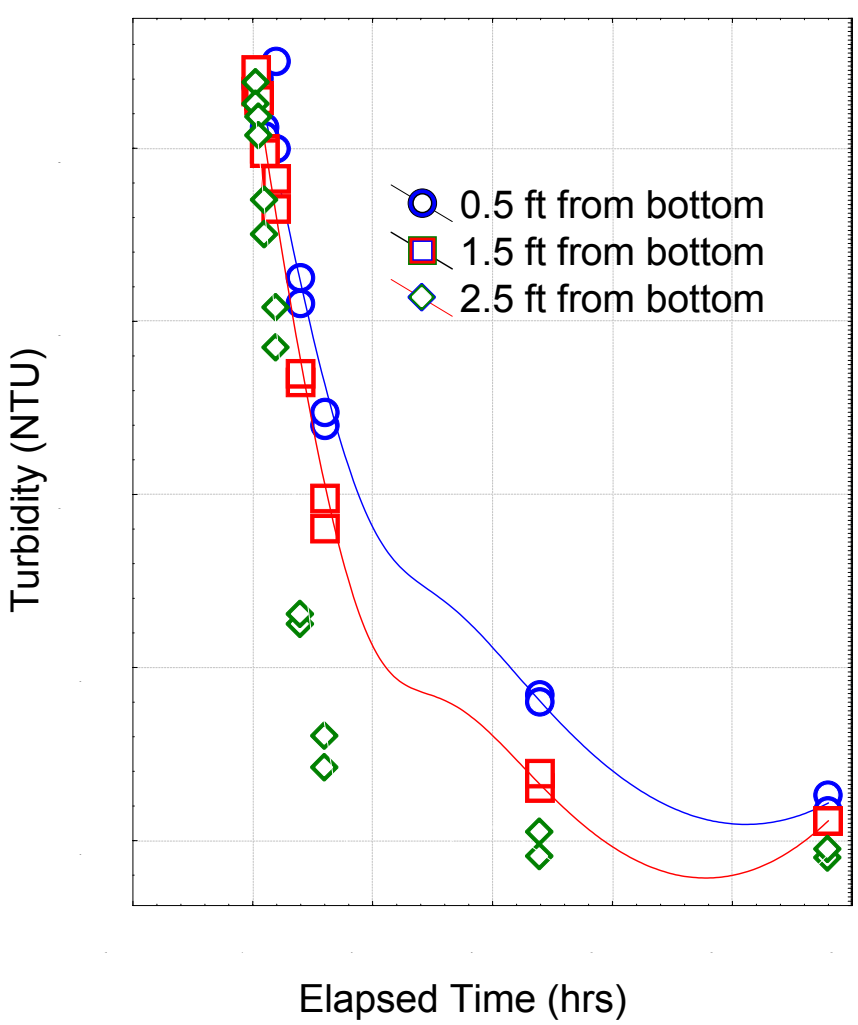
No Treatment

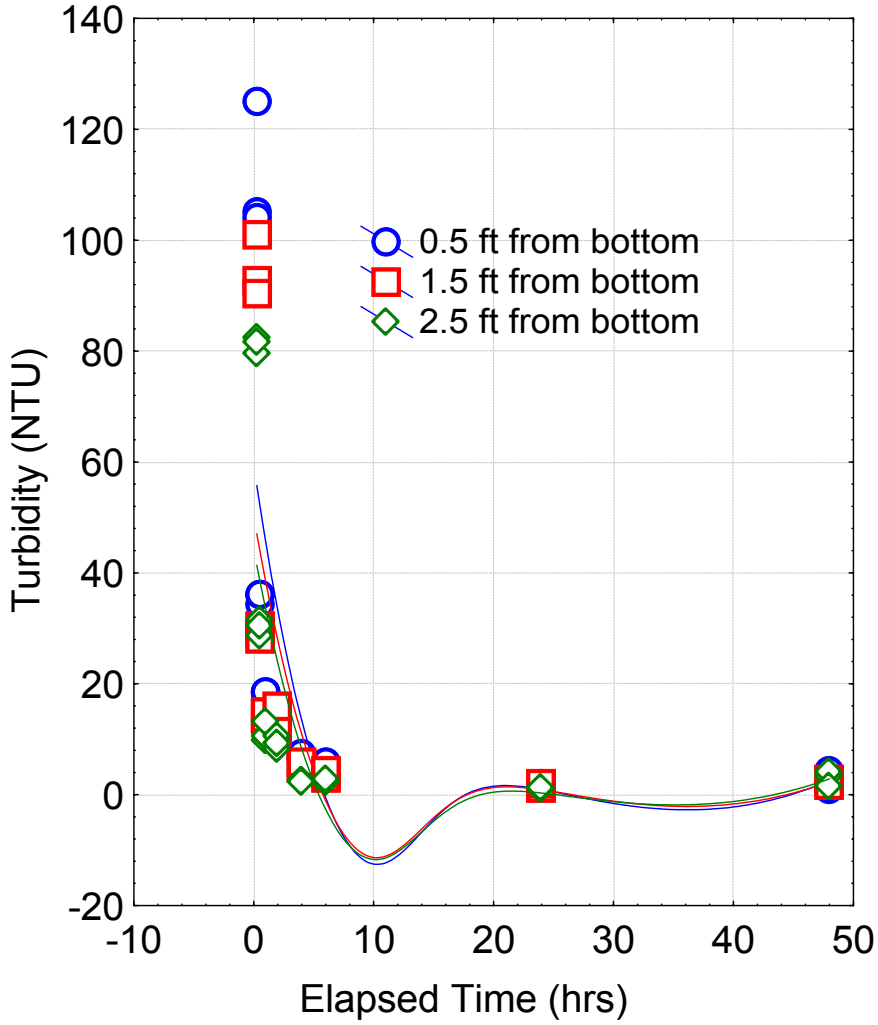
PAX XL9


Mar/Apr 2004
Mean; Box: Mean-SE, Mean+SE; Whisker: Mean-SD, Mean+SD
Turbidity (NTU)
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
0
1
2
4
6
24
48
Elapsed Time (hrs)
NoTrt
SUM50
PXXL9
J1720

Stratification in sampling

NoTrt = Distance Weighted Least Squares





Preliminary Floc Stability/ Ecotoxicity Results

- Preliminary Floc Stability Results
  - Clear crystalline structures
  - More stable structures than found in stormwater
  - Appears true chemical bond formation is creating stable aluminum compounds

- Very, Very Preliminary Ecotoxicity Results
  - Untreated and treated stormwater showing some toxicity

LICD Summary

Performance feasibility suggests ready for Phase 2 study

- Test application issues
- Test performance against temporally variable conditions
- Develop operational and design/retrofit recommendations

- Ecotoxicity & environmental effects studies need more study
- Broadened the dialog in the Tahoe Basin on this technology in a TMDL world
- Provided important data for other Tahoe AT projects
- Provided important data describing stormwater settling characteristics

Investigating Various Locally Available Media for Dissolved Phosphorus Removal through Adsorption

P.A.M. Bachand, Bachand & Associates
and
Alan Heyvaert, UC Davis Tahoe Research Group

- Funded by Forest Service through Placer County
- In collaboration with CSUS Office of Water Programs (Caltrans Research Team)

Adsorption Project's Goal:

- Test and describe adsorptive capacity of locally available soils and adsorptive media
- Predict performance for P removal
- Confirm performance with laboratory column studies and *in situ* experiments
- Develop recommendation for application in demonstration-scale project.

Factors affecting Performance of Different Media

Chemical –

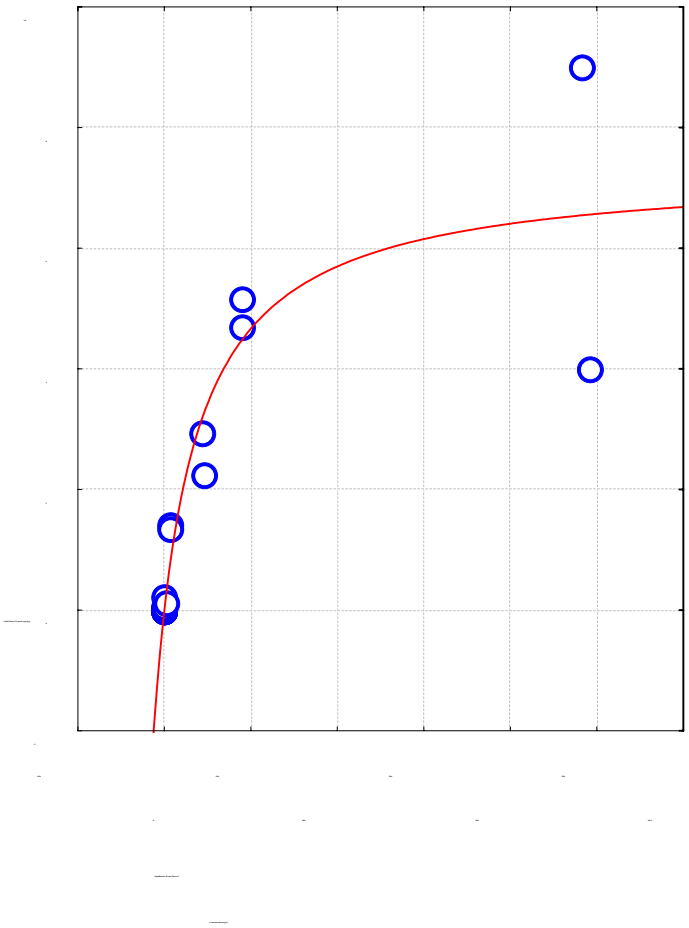
- Rich in Fe, Al or Ca

Physical -

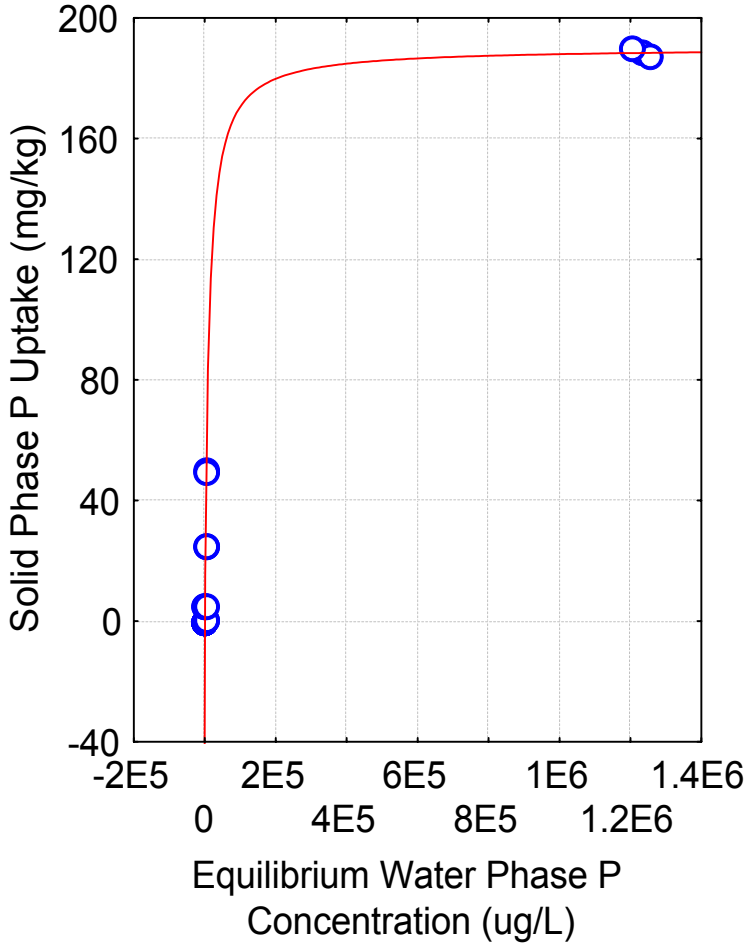
- Specific surface area (m^2/g)
  - Sand: 1.8 – 2.4 (Stevik et al. 1999)
  - LWA: 0.2 – 0.9 (Stevik et al. 1999)
  - DE: 2 – 90 (Eagle Picher)
  - AA: >300 (Alcoa)
- Grain size (Arias et al 2001) –
  - d_{10}: 0.3 – 2. Mm
  - d_{60}: 0.5 – 8.0 mm
  - $d_{60}/d_{10} < 4$

Langmuir Curves for Isotherm Data

Coon Street Basin Soil



Lanthanum coated MP79



Isotherm constants and retardation factors (R_d) for tested soils and substrates.

Soil/Media	Langmuir Constants			Linear Isotherms[a]		Retardation Factor R_d[c]
	a L/mg	b mg/kg	R^2	K_d ml/g	R^2	
20-mesh Dolomite	3.60E-02	7,976	0.8816	256.3	0.9561	1590
Coon St. Basin	1.76E-03	3,659	0.8820	12.9	0.7034	81
Round Hill Basin	6.62E-03	1,149	0.9452	3.8	0.3786	25
Eloise Basin	9.10E-03	796	0.6870	19.9	0.9371	125
Fine Truckee Sand[b]				3.6	0.9959	23
Course Truckee Sand[b]				0.8	0.5765	6

Notes

a. Based upon equilibrium phosphorus concentrations in the water of < 10 ppm.

b. From Martis Valley, Truckee, CA.

c. Assumed porosity of 30% and a dry bulk density of 1.86 g/cm^3 based upon dense mixed-grain sand (Terzaghi and Peck, 1967) or fine gravel and sand (Garde and Rau, 1987)

$$R \equiv 1 + \frac{\rho_b K_d}{n}$$

Adsorptive Project Summary to Date

- Local soils do not adsorb phosphorus as well as other locally available media
- Important to assess media in the context of P concentrations in the Tahoe Basin
- Realistic retardation coefficients can be developed from the isotherms an a physical assessment of the media.
- Data from project has been useful for larger-scale studies (i.e., Meyers, Caltrans Demonstration Projects)
- Results not only useful for assessing advanced treatment but also groundwater effects.

Related Projects in California

Project	Goal[1]	Organizations[2]	Funders[3]
Low Intensity Chemical Dosing (LICD) for DOC removal	Integrating wetlands/basin with chemical treatment to remove DOC and COCs from Ag Drains	B&A, UCD CE, USGS/CSUS, CCWD	CALFED, USGS
Hydrologic BMPs for Rice in the Delta	Developing hydrologic BMPs to minimize DOC and N export from Rice Fields	UCD LAWR, USGS, HF, B&A, DU	Board/CALFED
Watershed Effects on COCs and Recommended BMPs	Develop BMPs for different land uses to minimize watershed discharges of turbidity, DOC and other COCs	UCD CE & LAWR, HF, B&A, USGS, RCD	Board/CALFED, USGS
And Others ...			

1. DOC = Dissolved Organic Carbon; COC = Constituent of Concern

2. DU = Ducks Unlimited, CCWD = Contra Costa Water District, RCD = Yolo County Resource Conservation District

3. CALFED = California Bay Delta Authority; Board = State Water Quality Control Board