



USING ACID MINE DRAINAGE SLUDGE TO REMOVE PHOSPHORUS AND OTHER METAL OXYANIONS FROM WASTE WATER

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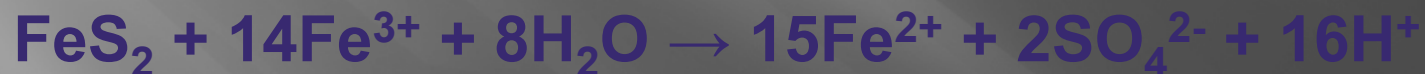
USGS Leetown Science Center, Kearneysville, WV 25430

U.S. Department of the Interior
U.S. Geological Survey



Problem #1 – Acid Mine Drainage

Pyrite + Air + Water → AMD



St Georges River,
Western Maryland



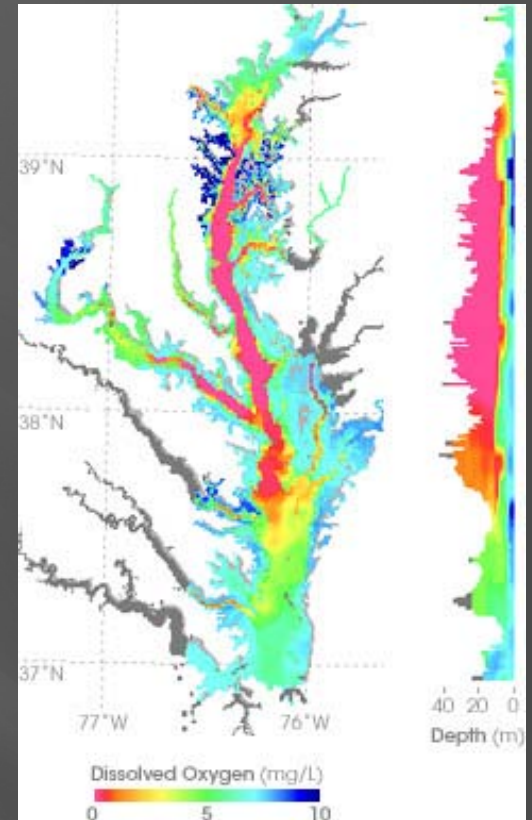
Problem #2 – Excess Nutrients



Animal feeding operations

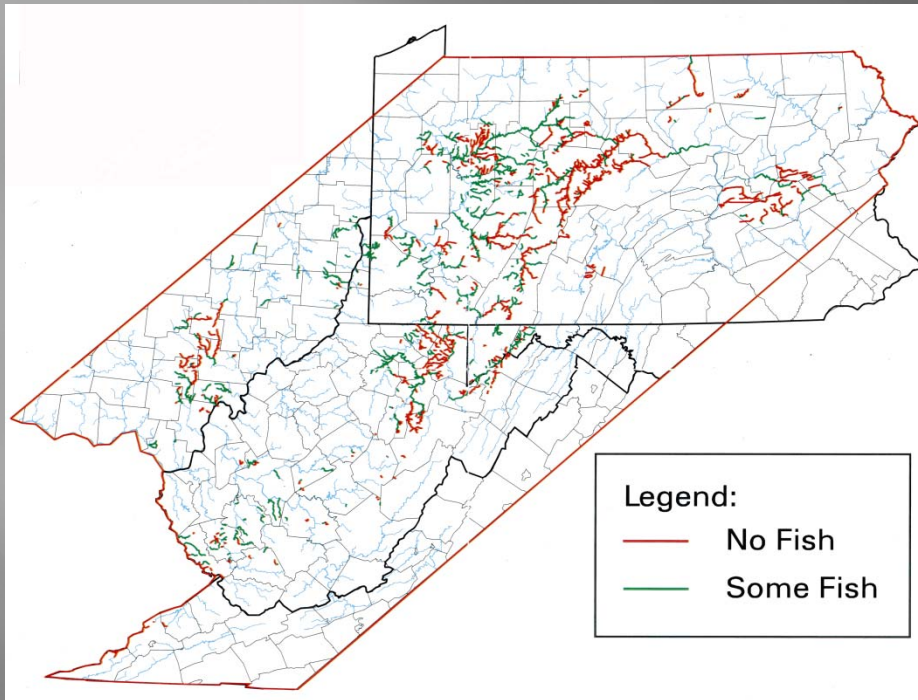


Eutrophication



Anoxic dead zones

AMD and P Sources Overlap Geographically

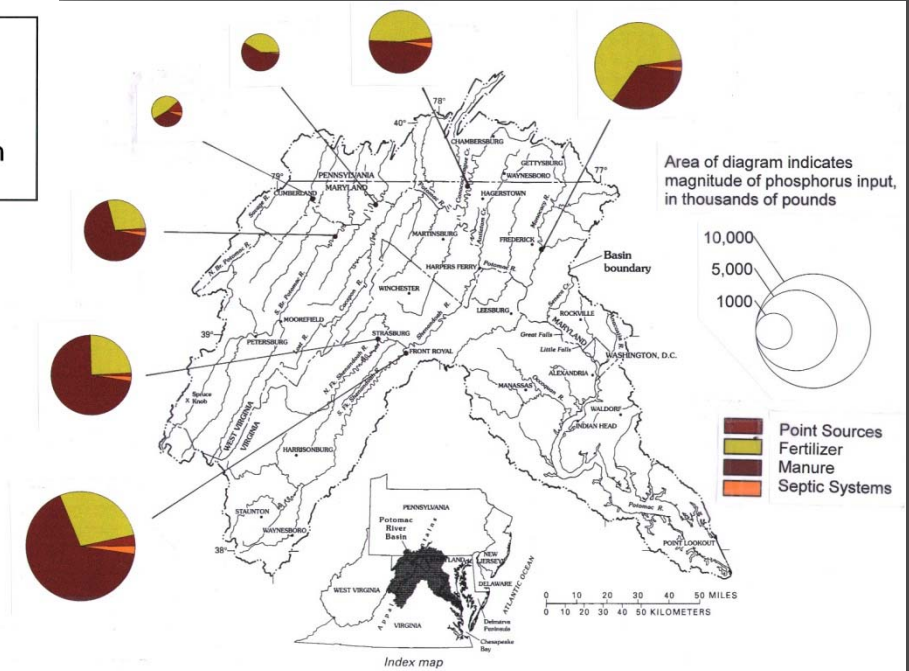


Legend:
 — No Fish
 — Some Fish

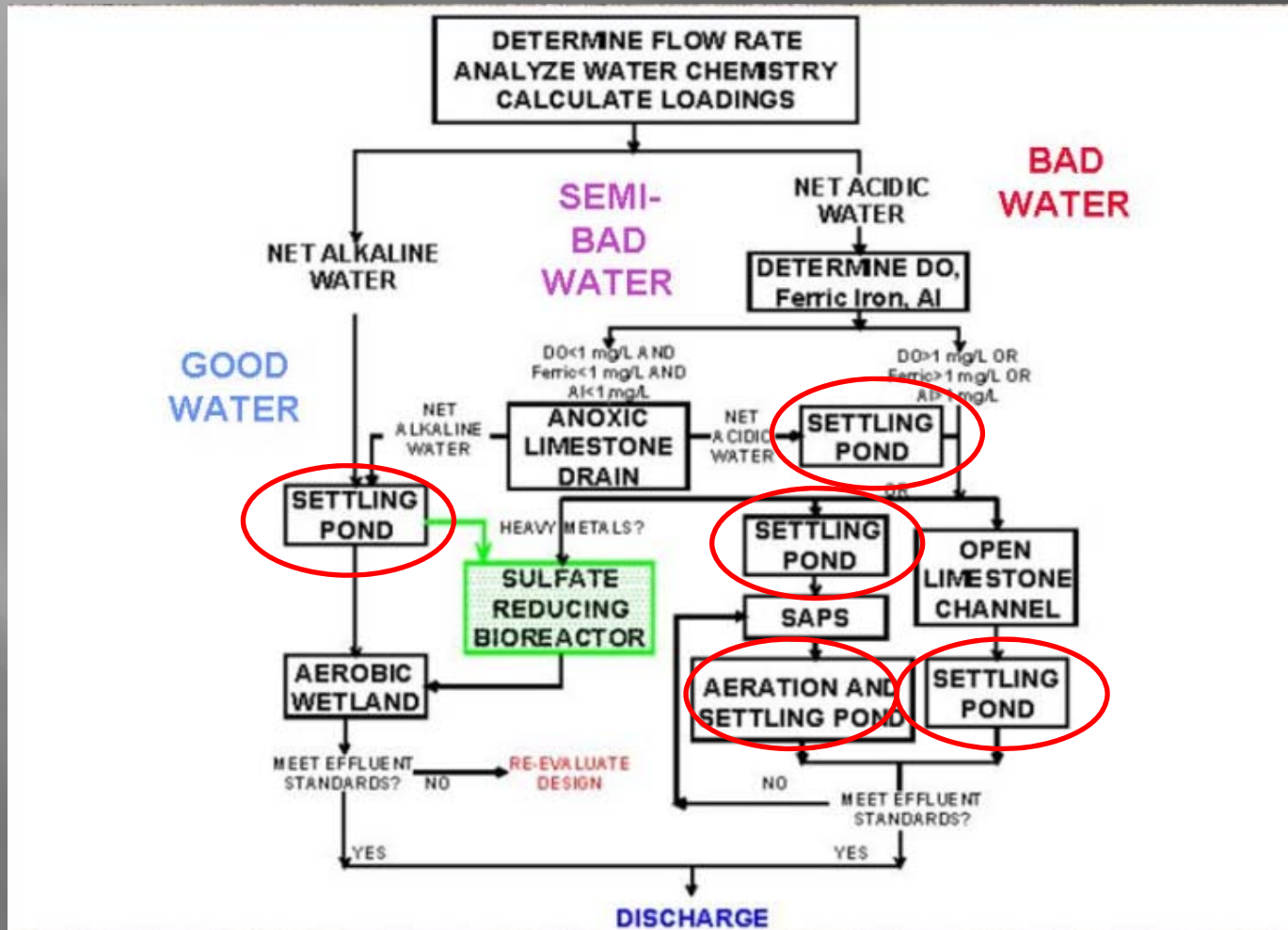
Over 5000 stream miles Impacted by AMD in the Appalachian region alone (From AMD: A Citizen's Introduction. 1995. U.S. EPA and the Pennsylvania Organization for Watersheds and Rivers.)



Over 1000 tons of P input to Chesapeake per year from Potomac watershed (From Water-Quality Assessment of the Potomac River Basin. 1996. USGS Water Resources Investigations Report 95-4221.)



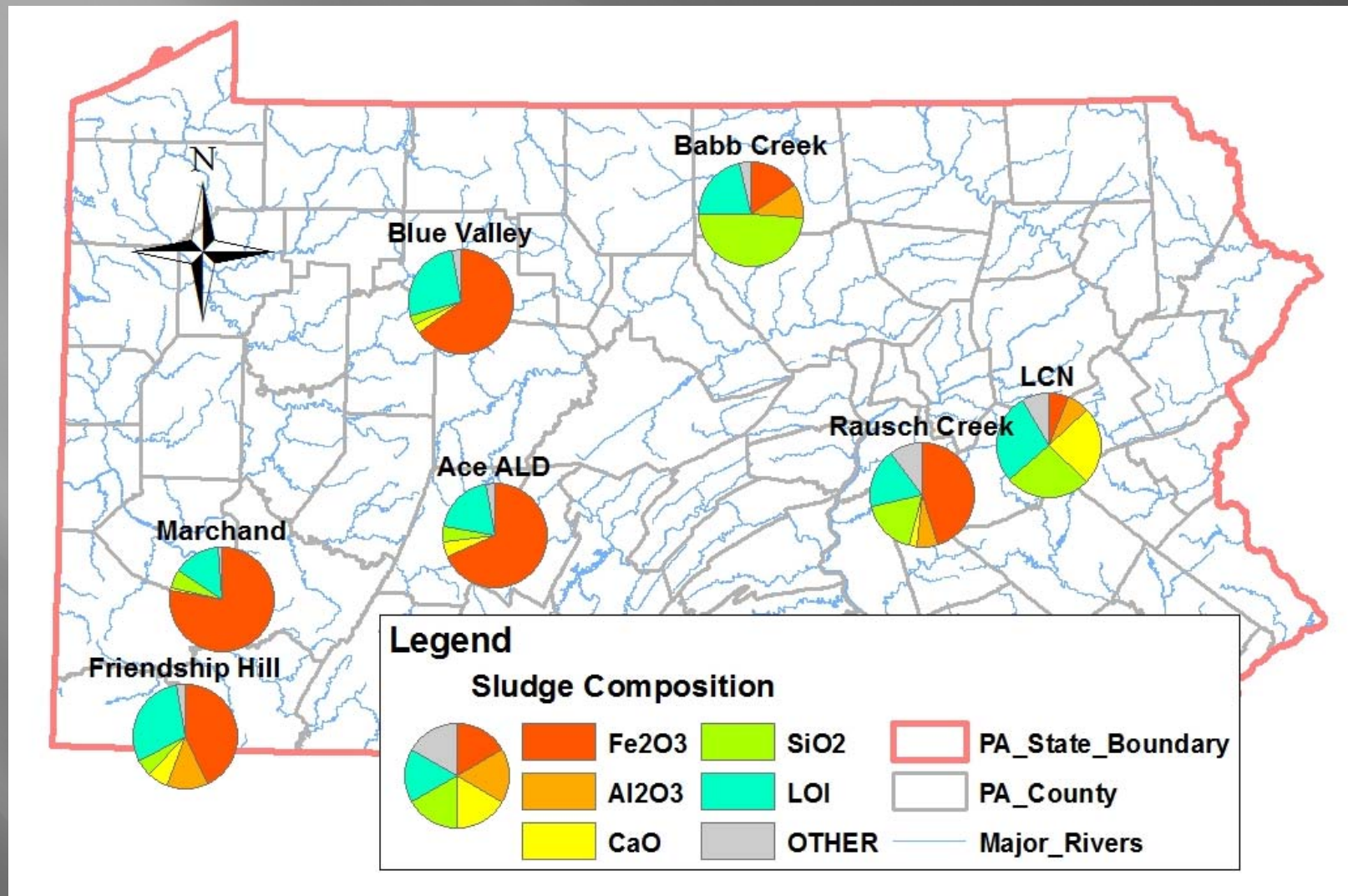
Treating AMD: You Always Get Sludge...



... And There's Lots of it Out There



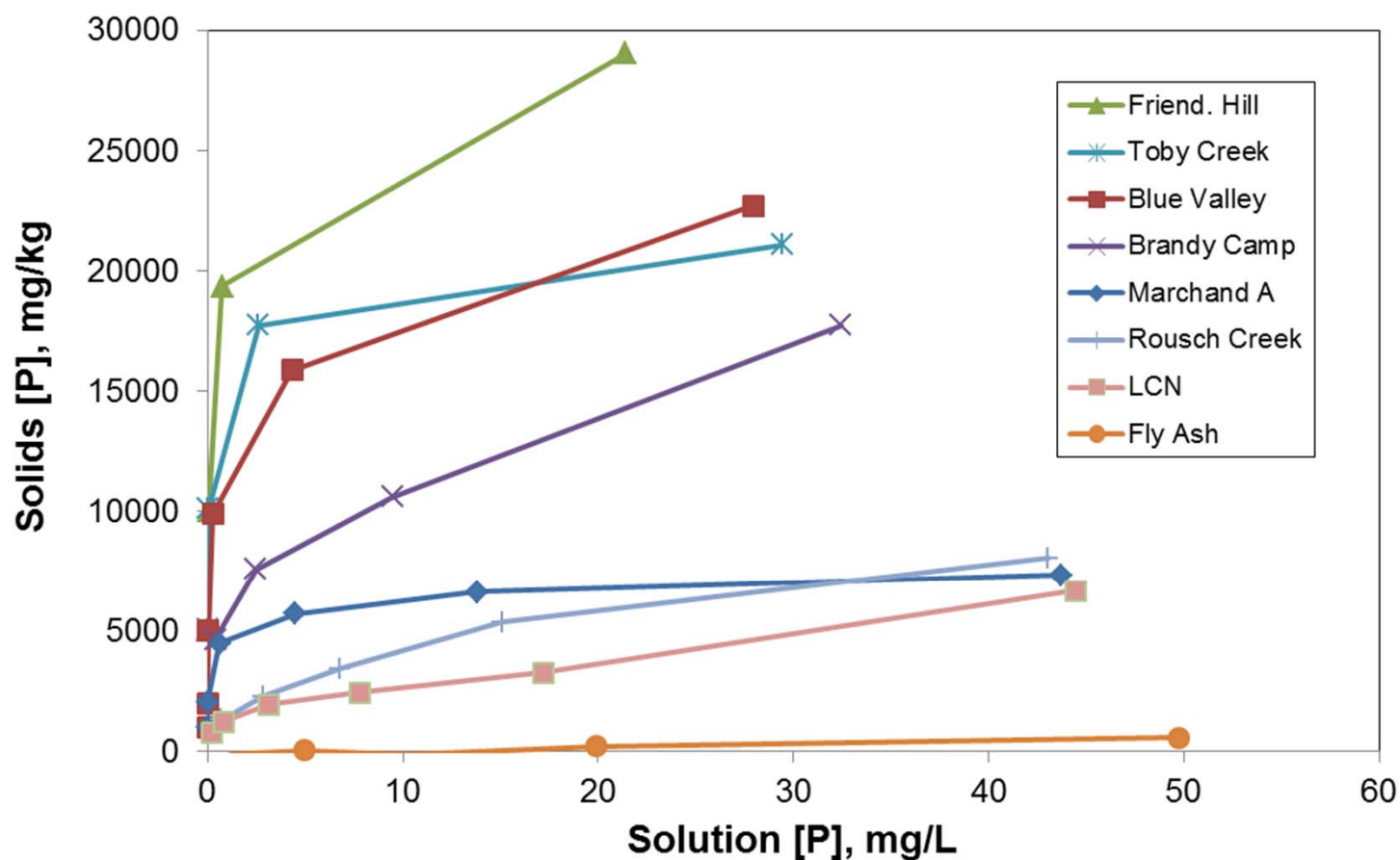
What's in the sludge?



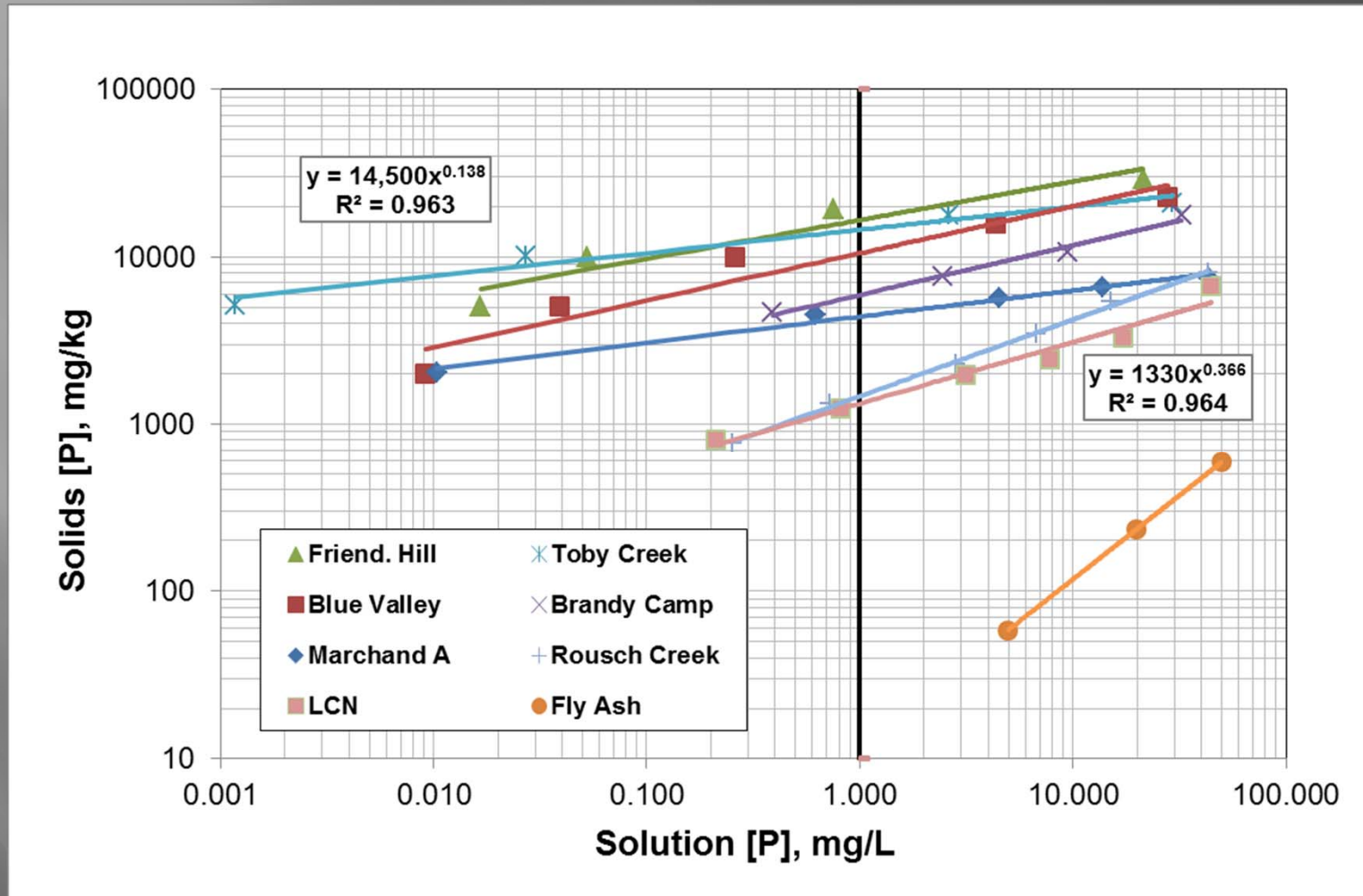
Sludge Trace Elements

Site	As	Cd	Cu	Hg	Ni	Pb	Se	Zn
Friendship Hill	46.1	0.73	32	0.023	2.5	5	4.1	191
Ace ALD	2.1	0.58	7	0.062	14	2.5	0.9	1400
Babb Creek	10.5	0.04	31	0.203	13	17	2.3	61
Rausch Creek	48.1	4.7	119	0.039	1895	41	2.6	4390
LCN	6.7	0.6	27	0.05	174	15	1.8	994
Blue Valley	40.6	0.09	2.5	0.02	2.5	2.5	2.2	251
Marchand	23	2.1	1	0.012	13	13	1.5	24
EPA 503 Table III	41	39	1500	17	420	300	100	2800
EPA 503 Table I	75	85	4300	57	420	840	100	7500

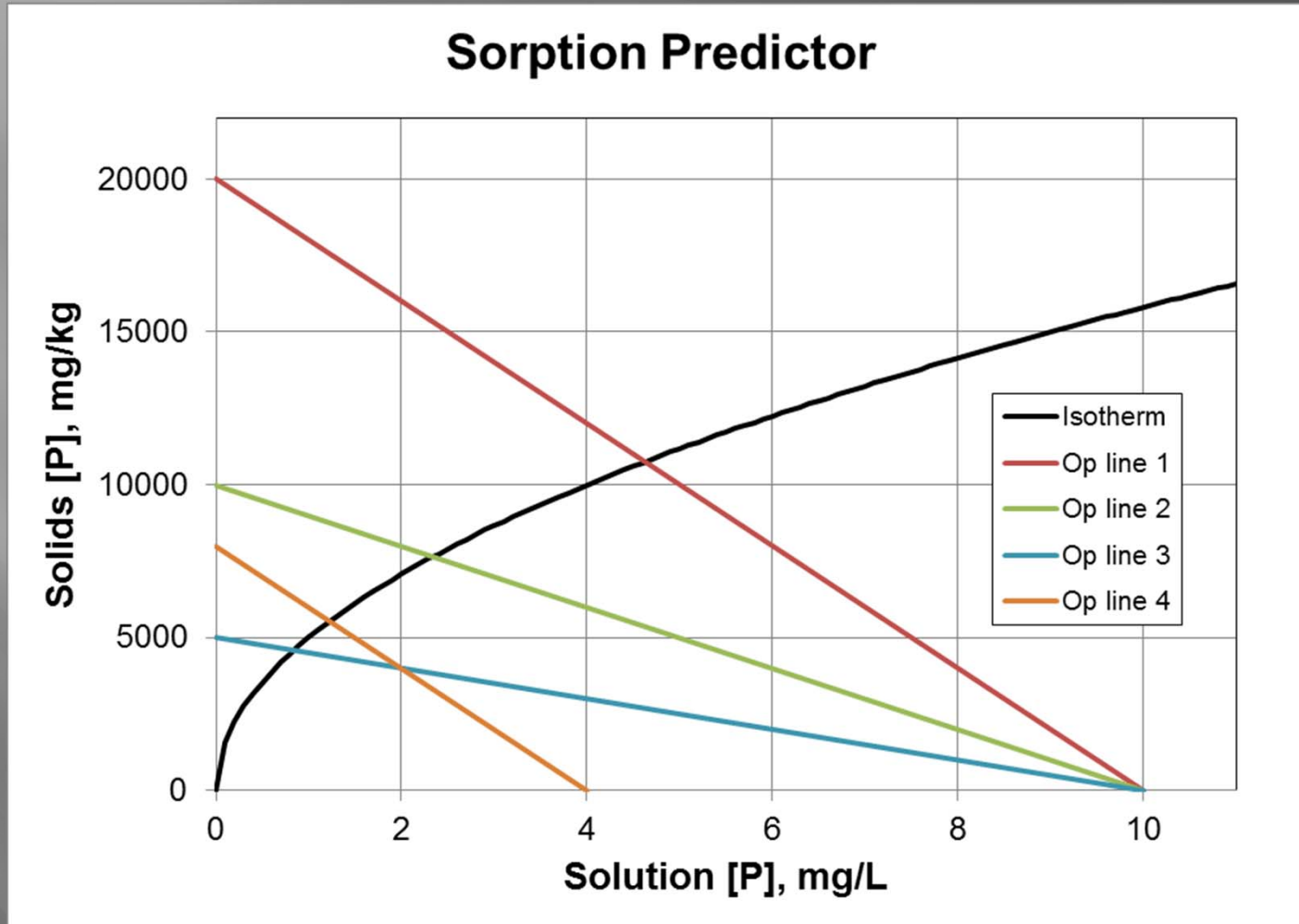
AMD Sludges Adsorb P to Varying Degrees



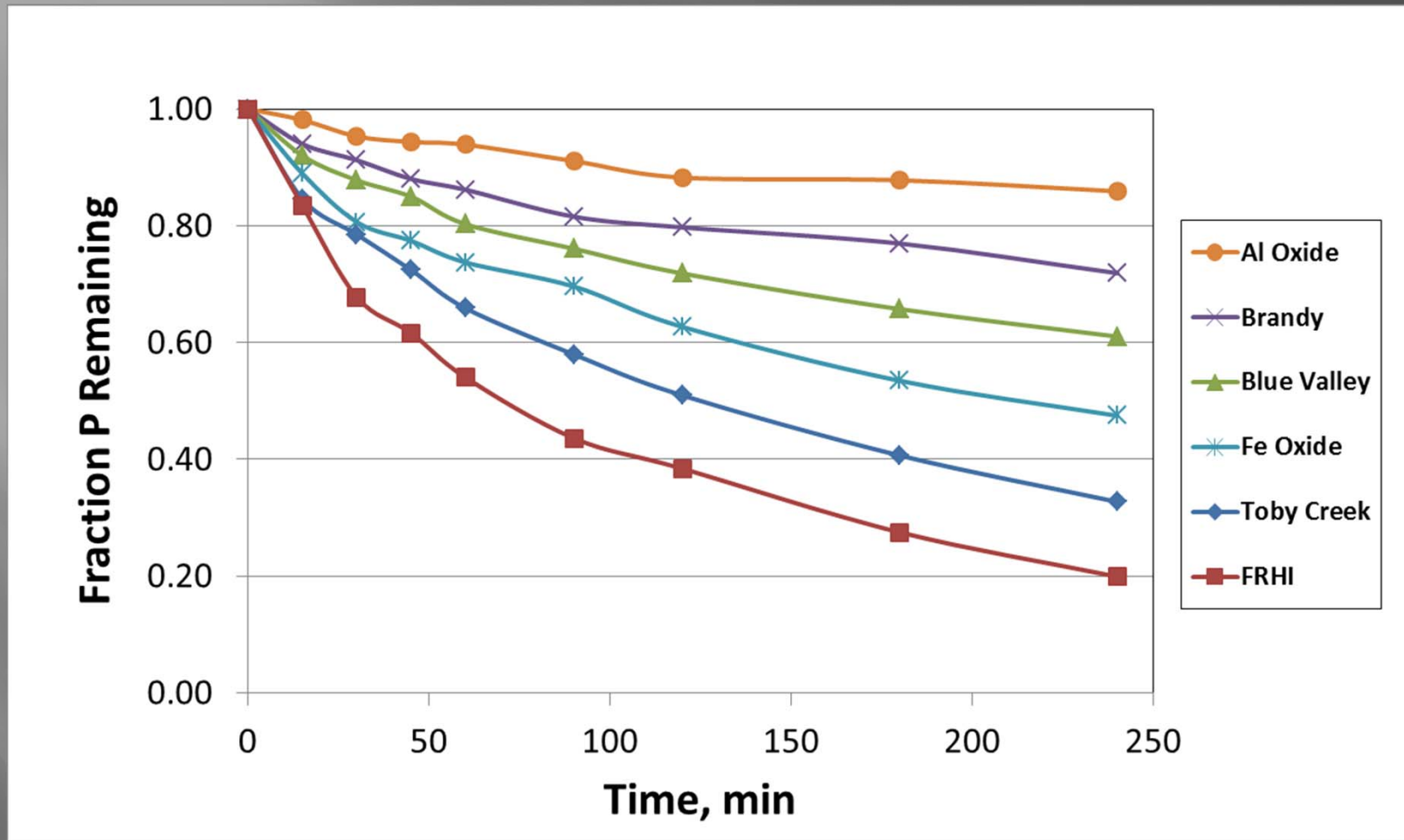
Sorption Isotherms – Log Scale



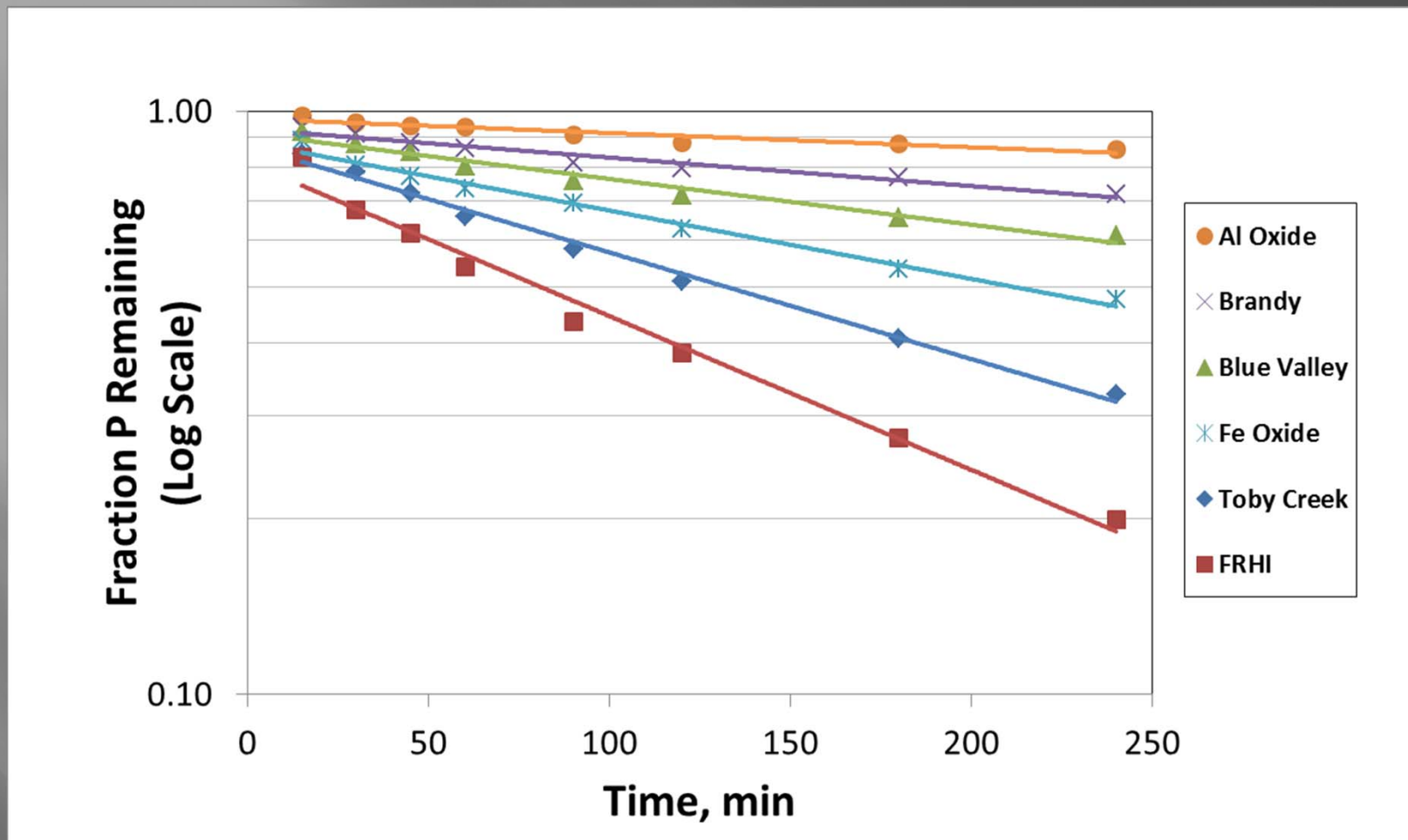
How is the Isotherm Useful?



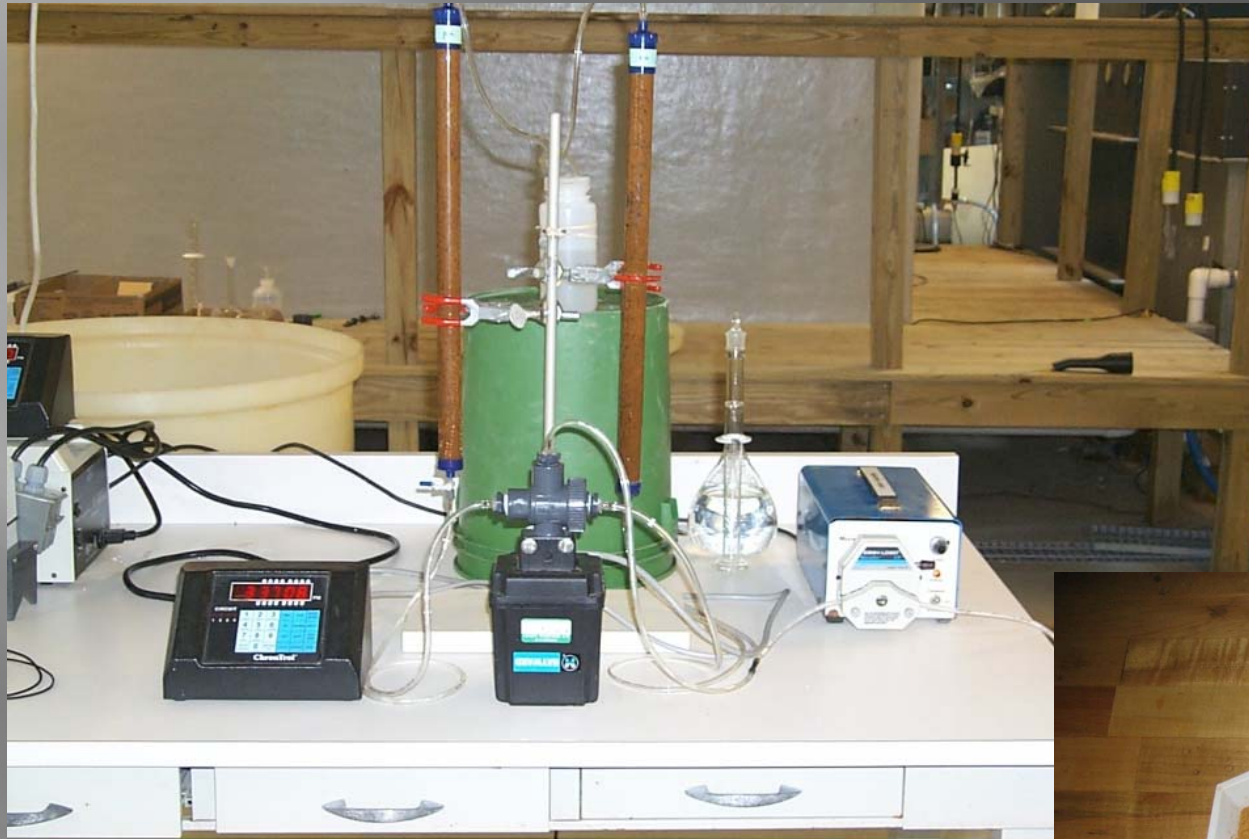
The Rate of P Removal from Water is Important, too.



First Order Kinetics Plots



Water Treatment Method- Fixed Bed Sorption of P



Understanding the Break-through Curve

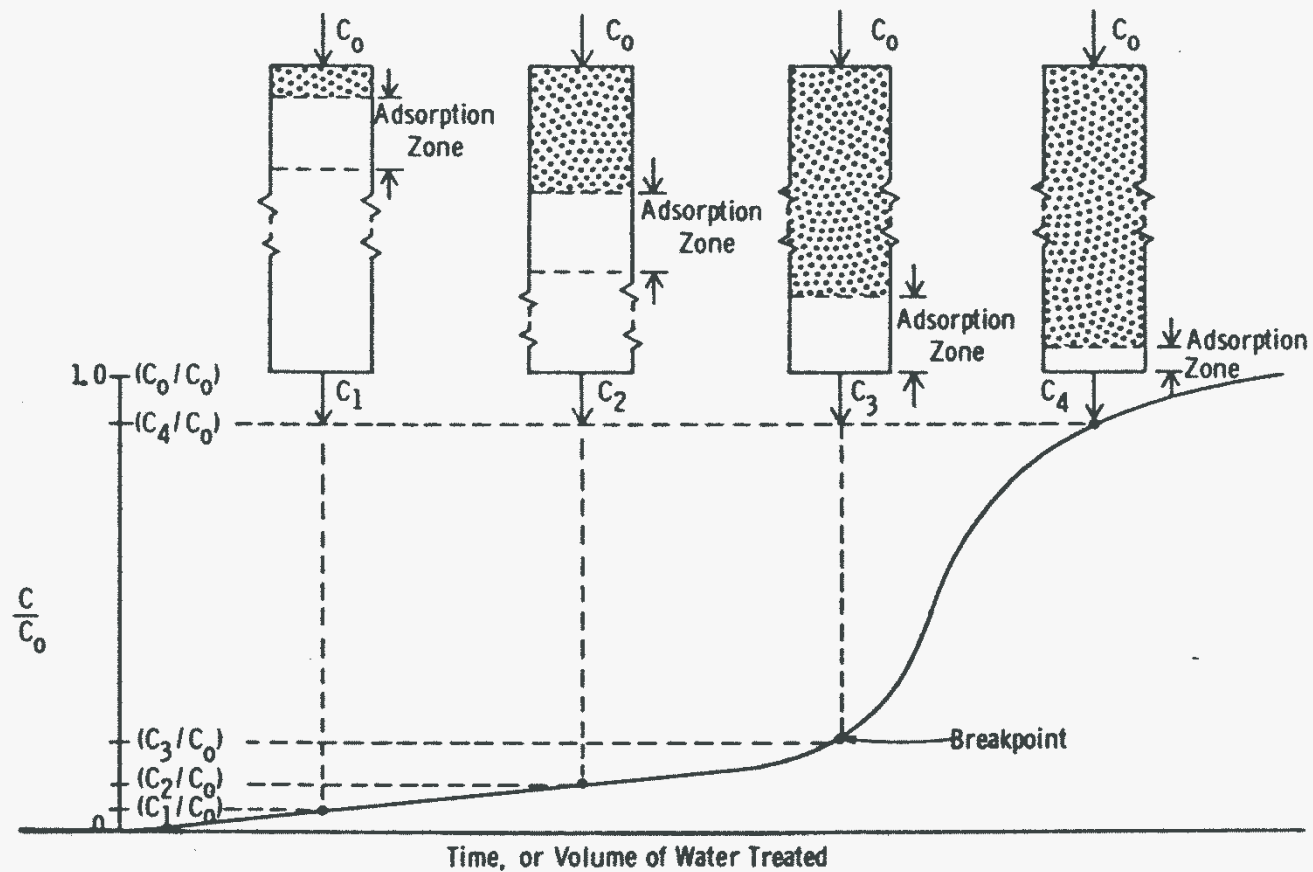
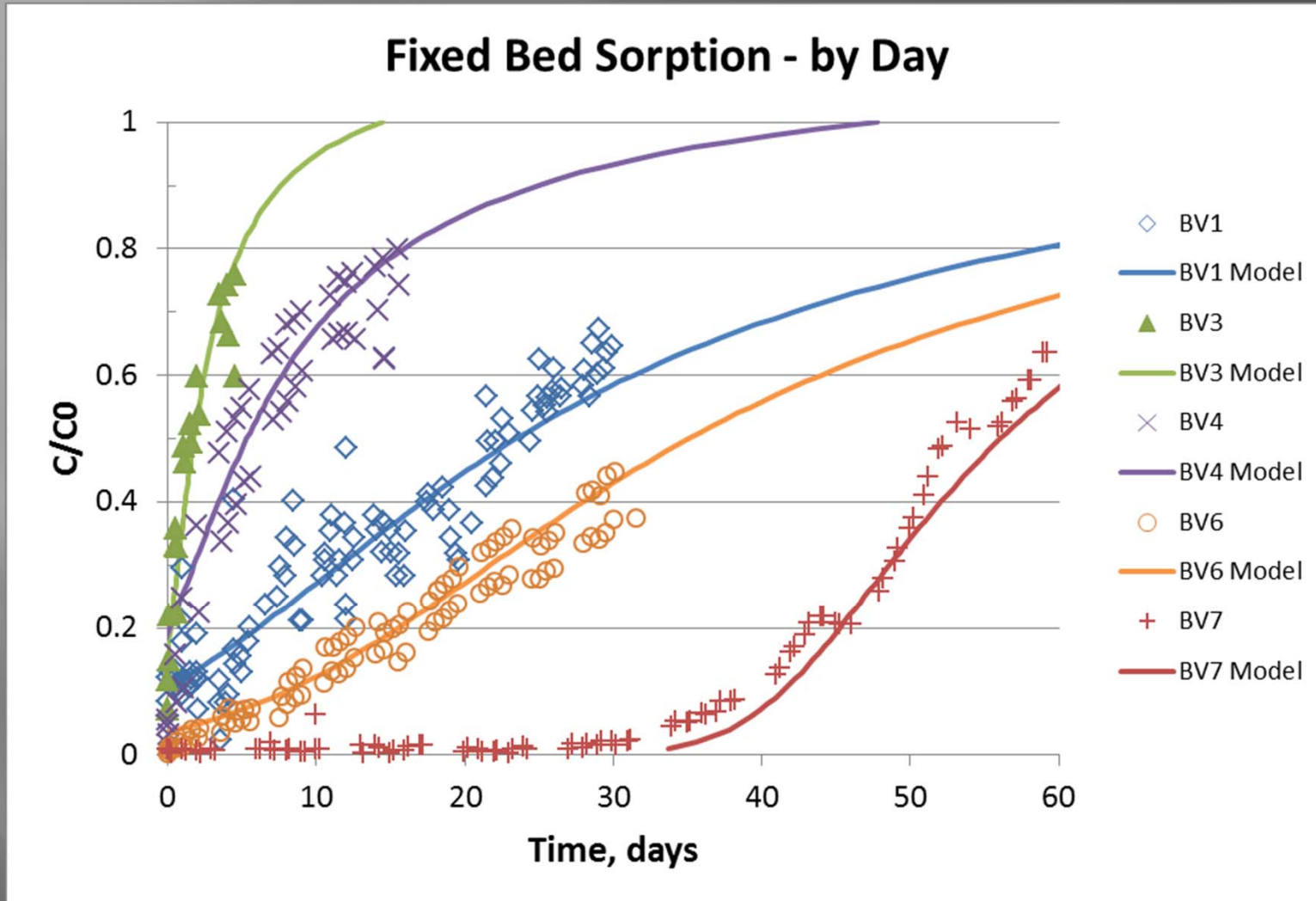
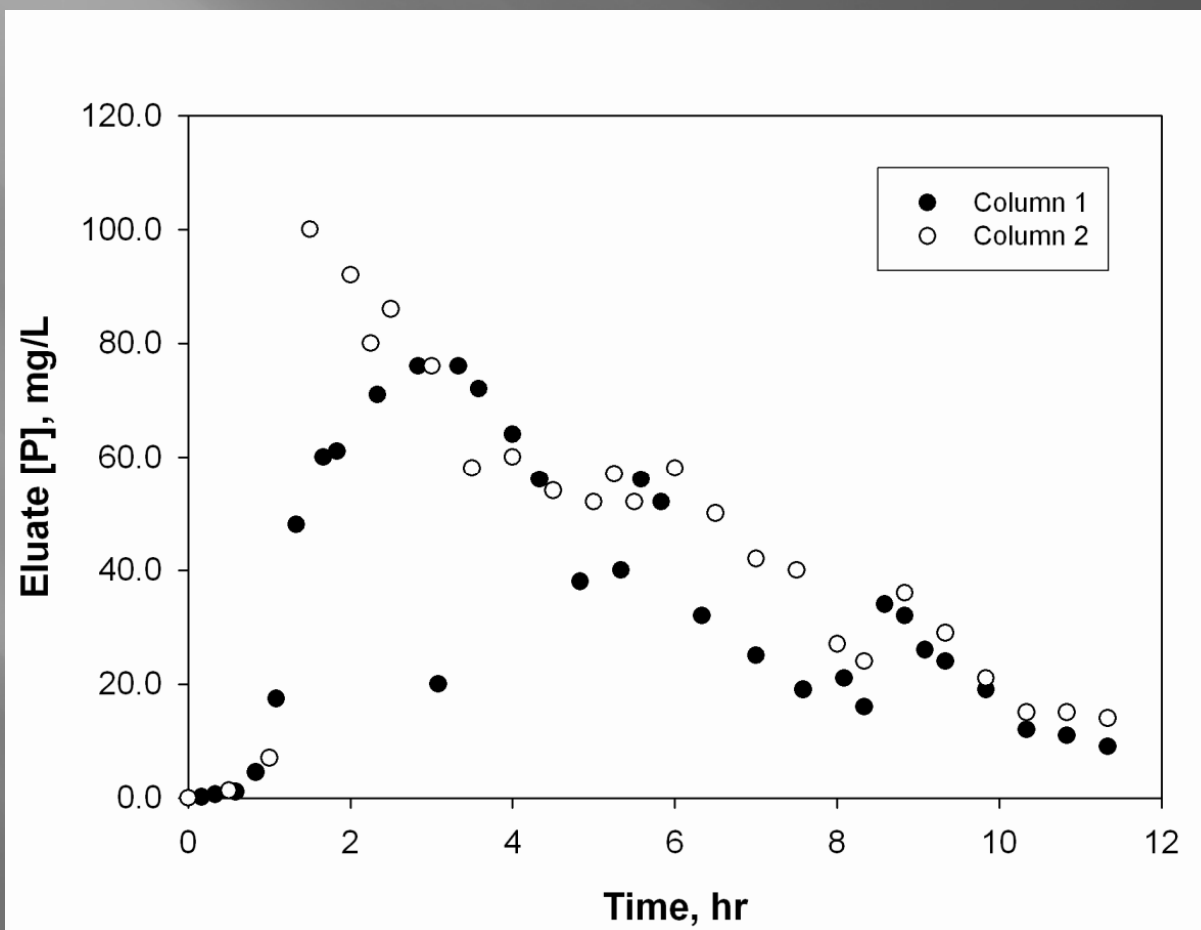


Figure 5-12 Schematic representation of the movement of the adsorption zone and the resulting breakthrough curve.

Modeling the Break-through Curve

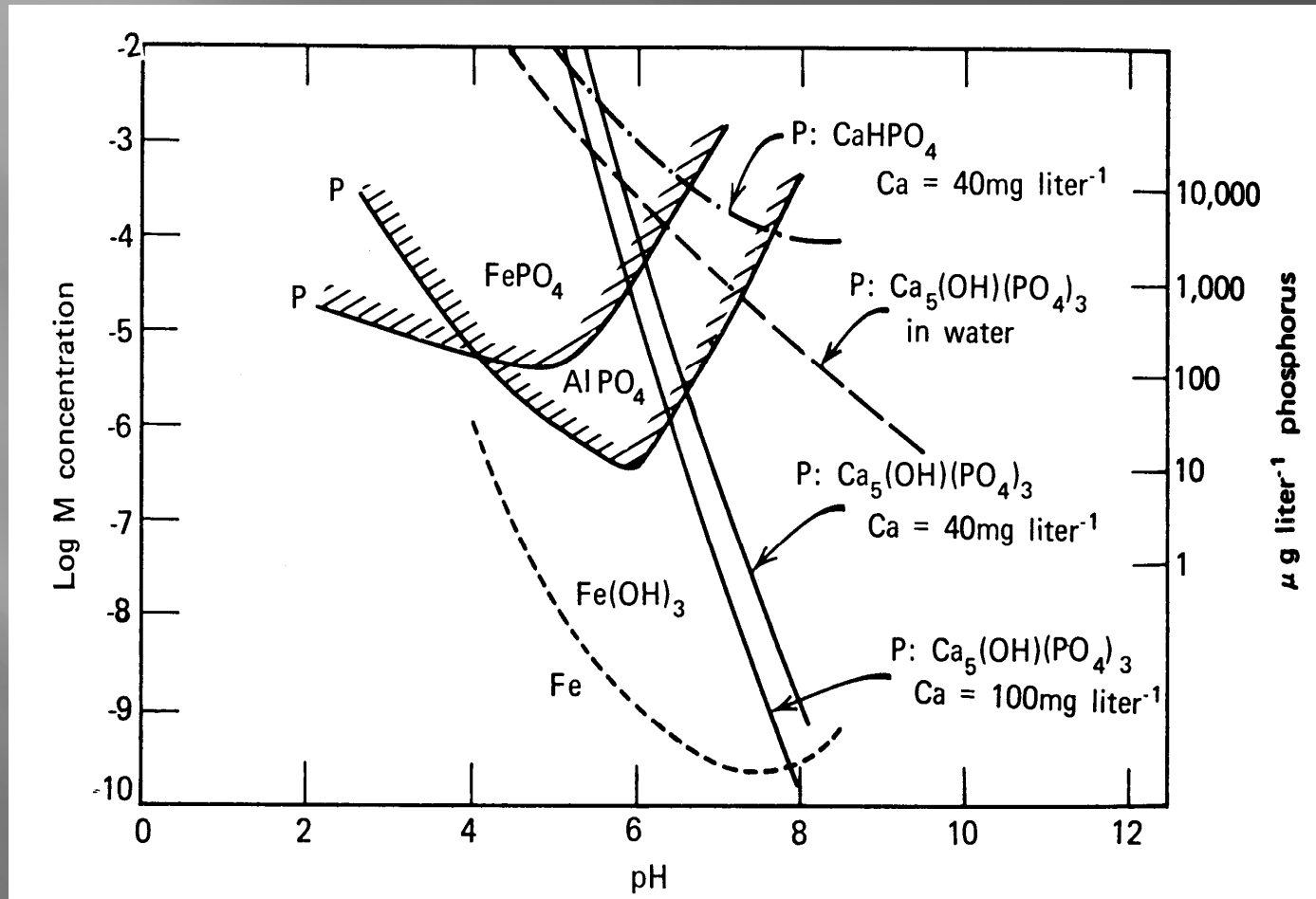


The Media Can Be Stripped and Reused...



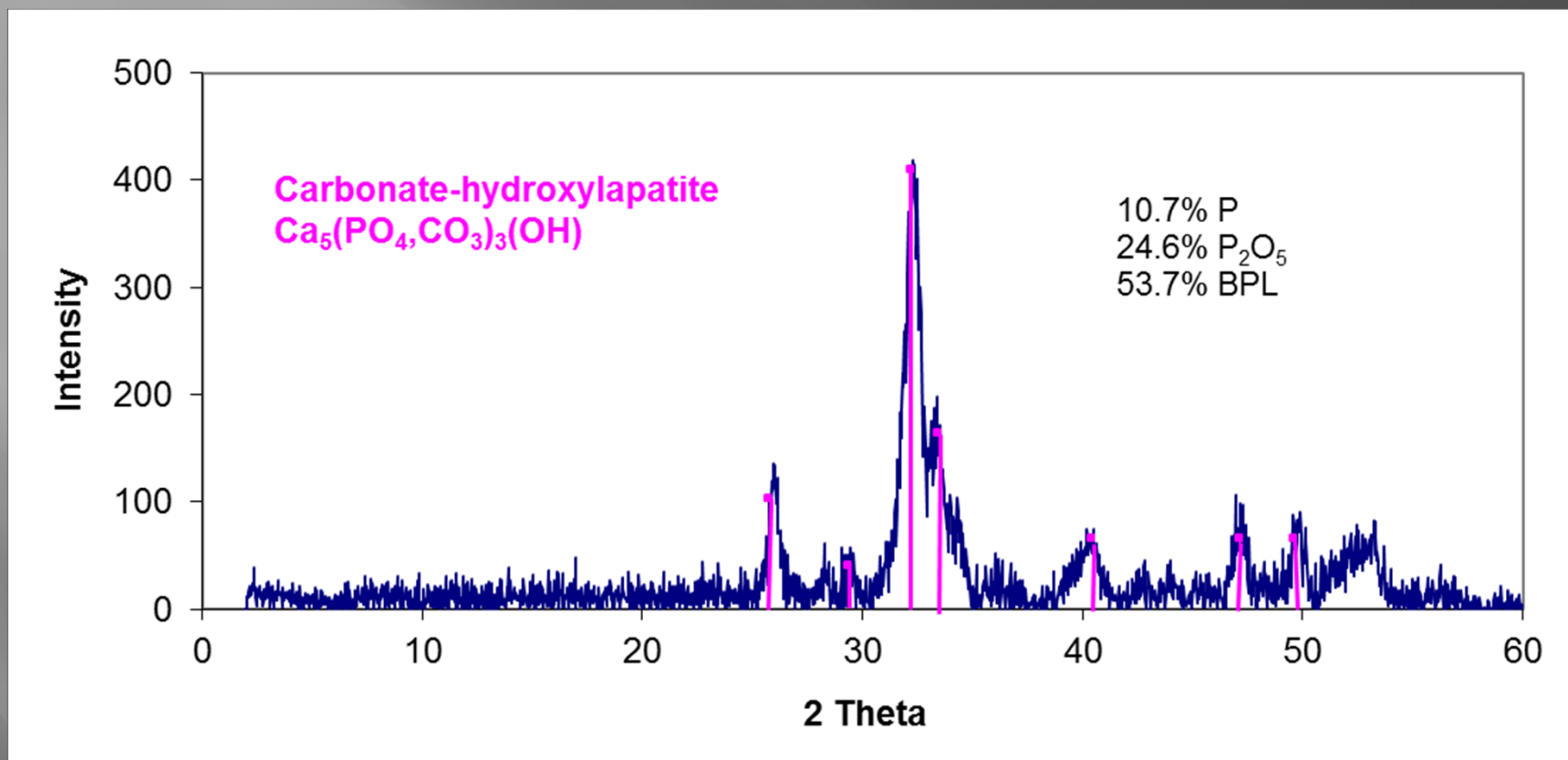
Strip solution removed 76% of P, and concentrated it up to 1000-fold

...P can be Precipitated...



Stumm and Morgan, Aquatic Chemistry, 3rd. Ed, 1996.

...and the P Recycle Loop can be Closed

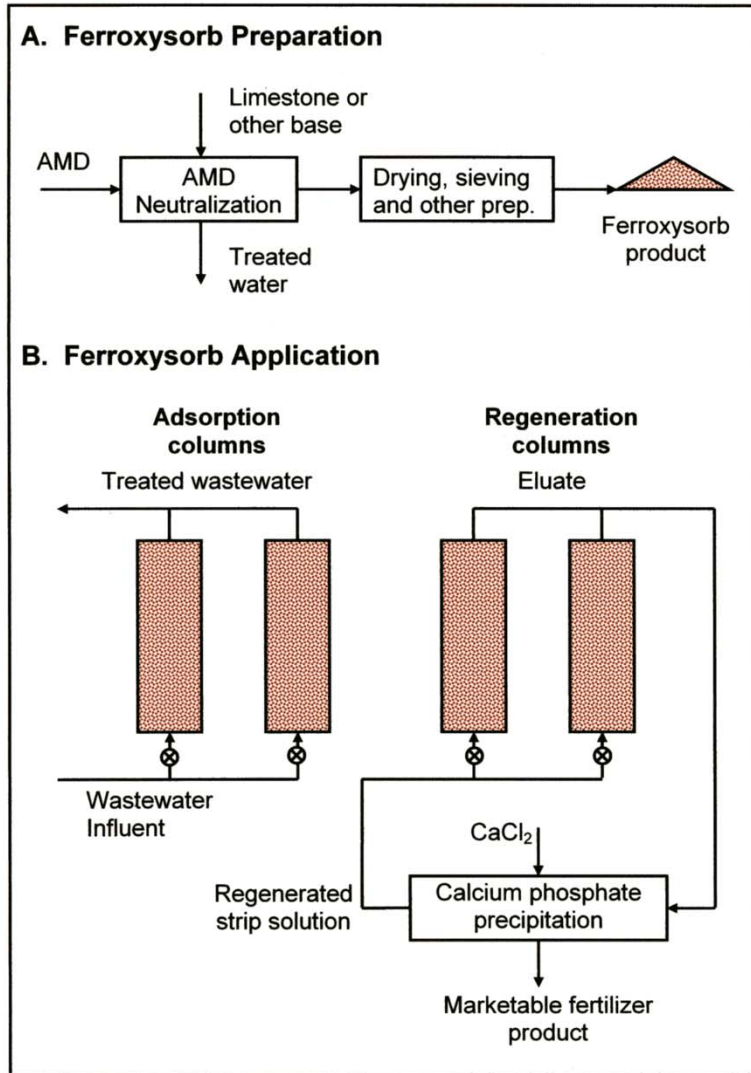


What About Water Contamination?

Sludge Source	Al mg/L	Ca mg/L	Fe mg/L	K mg/L	Mg mg/L	Mn mg/L	Na mg/L
Friendship Hill	<1	51.1	<1	<5	1.48	<0.01	<1
Toby Creek	<1	9.7	<1	<5	0.74	0.01	<1
Brandy Camp	<1	9.7	<1	<5	4.06	<0.01	<1
Glen White	<1	1.8	<1	<5	0.19	0.07	<1
Ace ALD	<1	10.3	<1	<5	<0.05	<0.01	<1
Babb Creek	<1	0.6	<1	<5	<0.05	0.03	<1
MDL	1	0.5	1	5	0.05	0.01	1

Sludge Source	As mg/L	Cd mg/L	Co mg/L	Cu mg/L	Ni mg/L	Pb mg/L	Zn mg/L
Friendship Hill	<0.05	0.002	0.02	<0.01	0.02	<0.05	0.06
Toby Creek	<0.05	<0.001	<0.02	<0.01	<0.01	<0.05	0.08
Brandy Camp	<0.05	<0.001	0.04	<0.01	0.01	<0.05	0.06
Glen White	<0.05	<0.001	0.02	0.01	0.02	<0.05	0.14
Ace ALD	<0.05	<0.001	<0.02	<0.01	<0.01	<0.05	<0.01
Babb Creek	<0.05	<0.001	<0.02	<0.01	0.02	<0.05	0.16
MDL	0.05	0.001	0.02	0.01	0.01	0.05	0.01

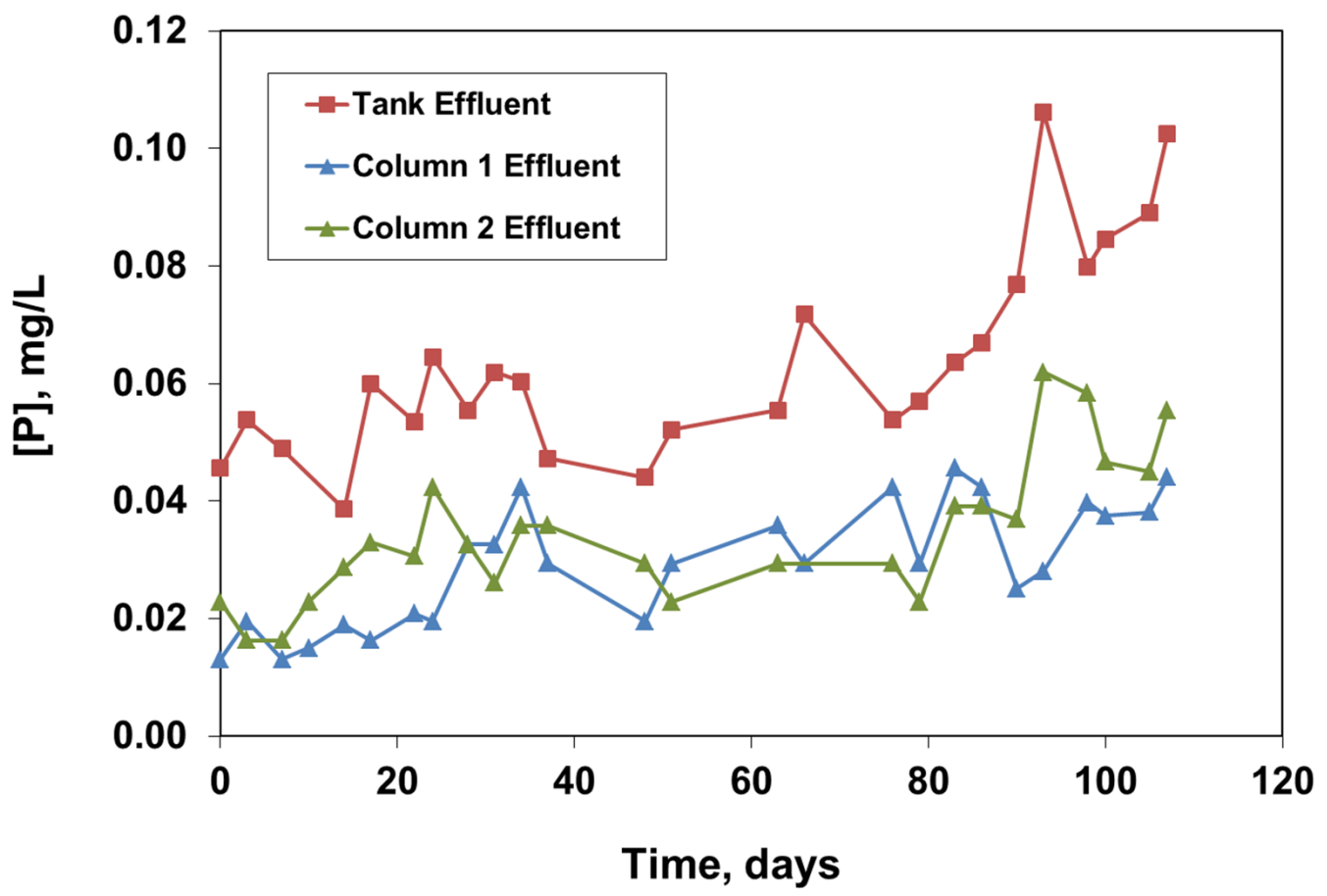
Schematic Flowsheet for the Production and Use of Feroxysorb P Sorption Media



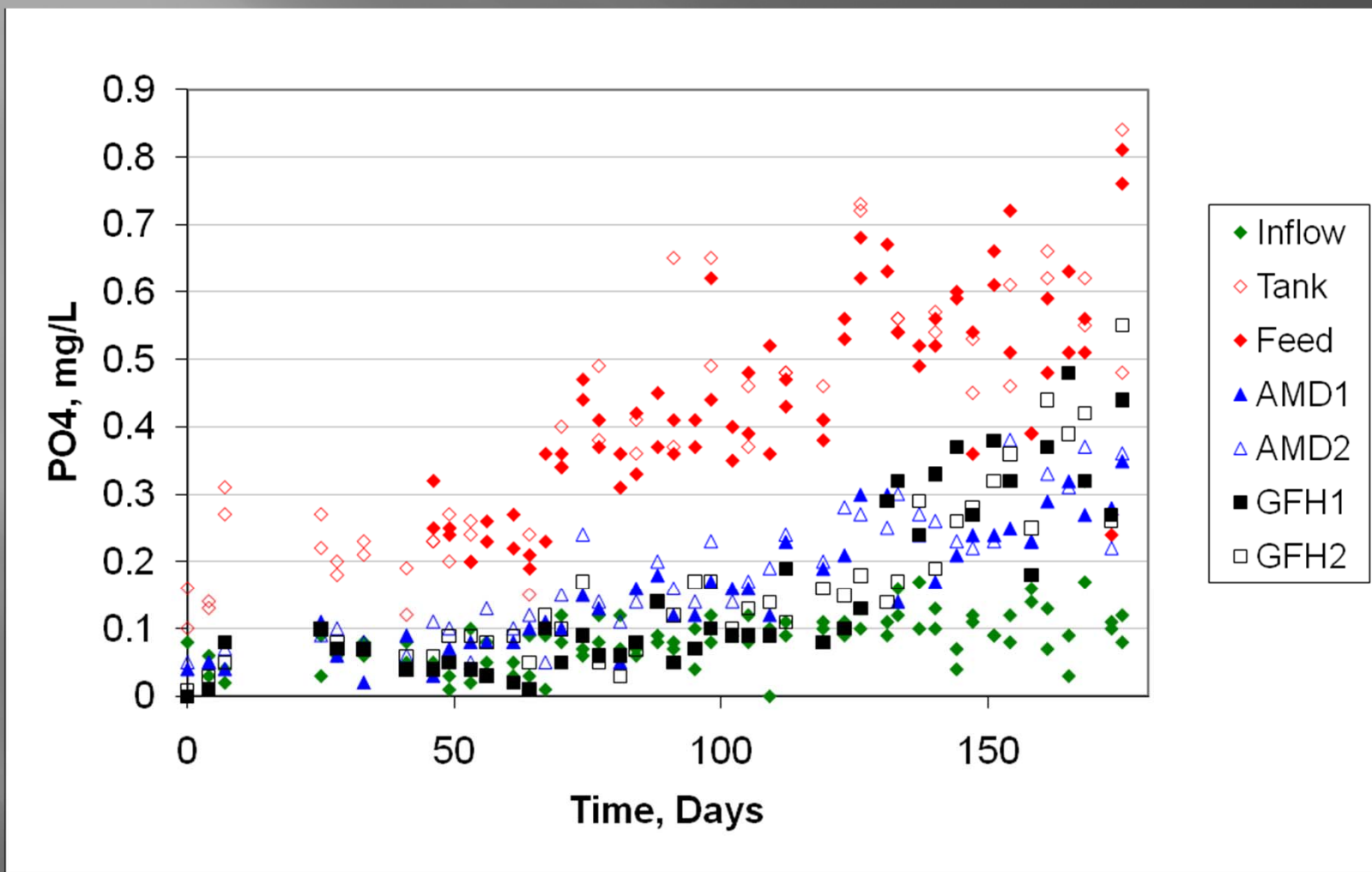
Field Trial at USFWS Northeast Fishery Center, Lamar, PA



Field Trial, Phase I



Field Trial, Phase II

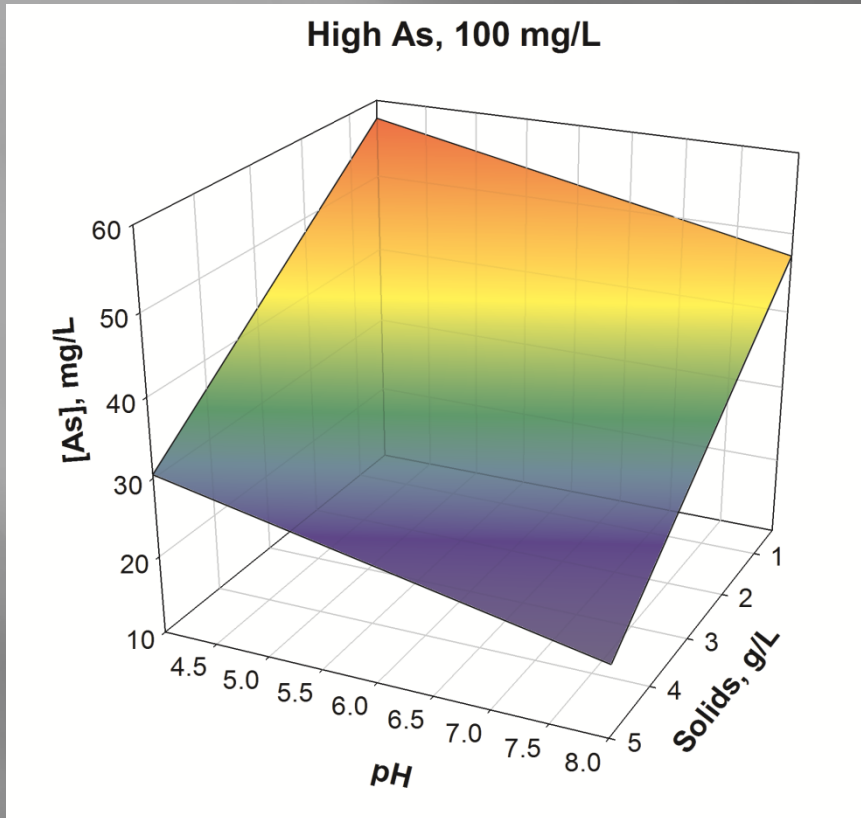


What About Other Species Besides P?

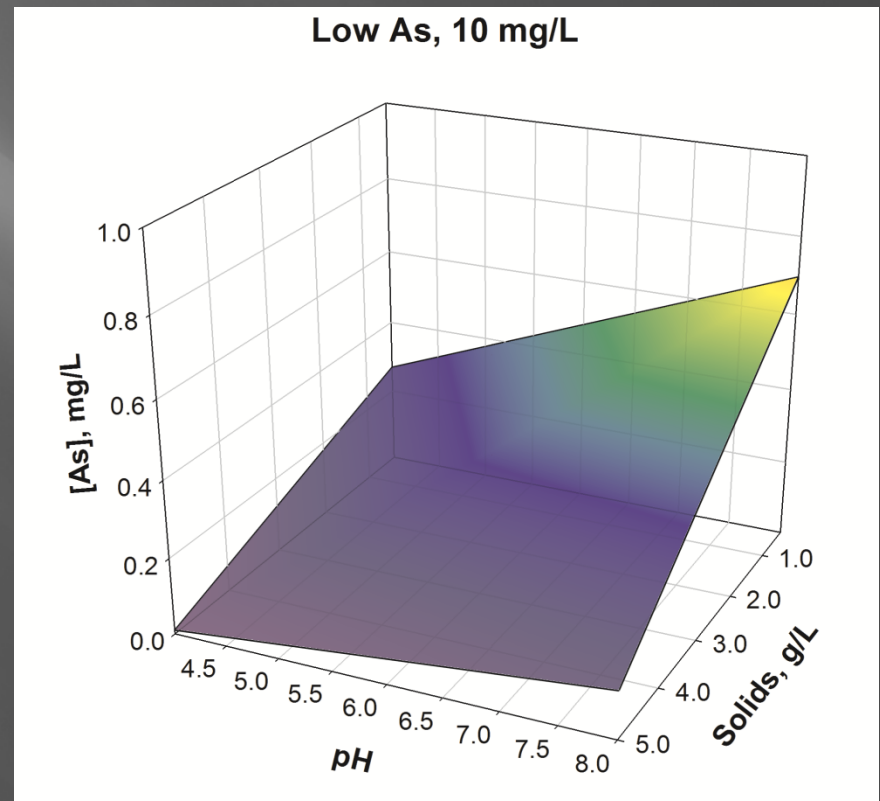
As feed (mg/L)	Solids (g/L)	pH	Effluent As (mg/L)	As Removal (%)
10	0.4	4.0	0.270	97.30
10	0.4	8.0	0.697	93.03
10	5.0	4.0	0.010	99.90
10	5.0	8.0	0.124	98.76
55	2.7	6.0	8.430	84.67
55	2.7	6.0	14.820	73.05
100	0.4	4.0	57.660	42.34
100	0.4	8.0	47.180	52.82
100	5.0	4.0	30.480	69.52
100	5.0	8.0	19.220	80.78

Visualizing As Sorption

High As, 100 mg/L



Low As, 10 mg/L



Bottom Line

Laboratory and field test results have demonstrated that solid Fe/Al oxide media prepared from mine drainage residuals can be used as an effective and economical sorbent for the removal of P and As from wastewaters.

