Aluminum Removal: Field Trials at WVDEP Special Reclamation Sites

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Introduction

* This project was funded by the WVDEP/OSR
* The Special Reclamation Program is obliged to obtain NPDES permits for Al
* Add ons to existing AMD treatment systems
* NPDES permit limit for Al
  * Non-trout streams 0.750 mg/L
  * Trout streams 0.087 mg/L
* Most discharges vary with respect to flow and Al concentration
* Power and space very limited

Objectives

* To identify cost-effective and efficient treatment methods to reduce Al in the discharges from AML reclamation sites to a level that would meet anticipated NPDES permit requirements.

Treatment systems
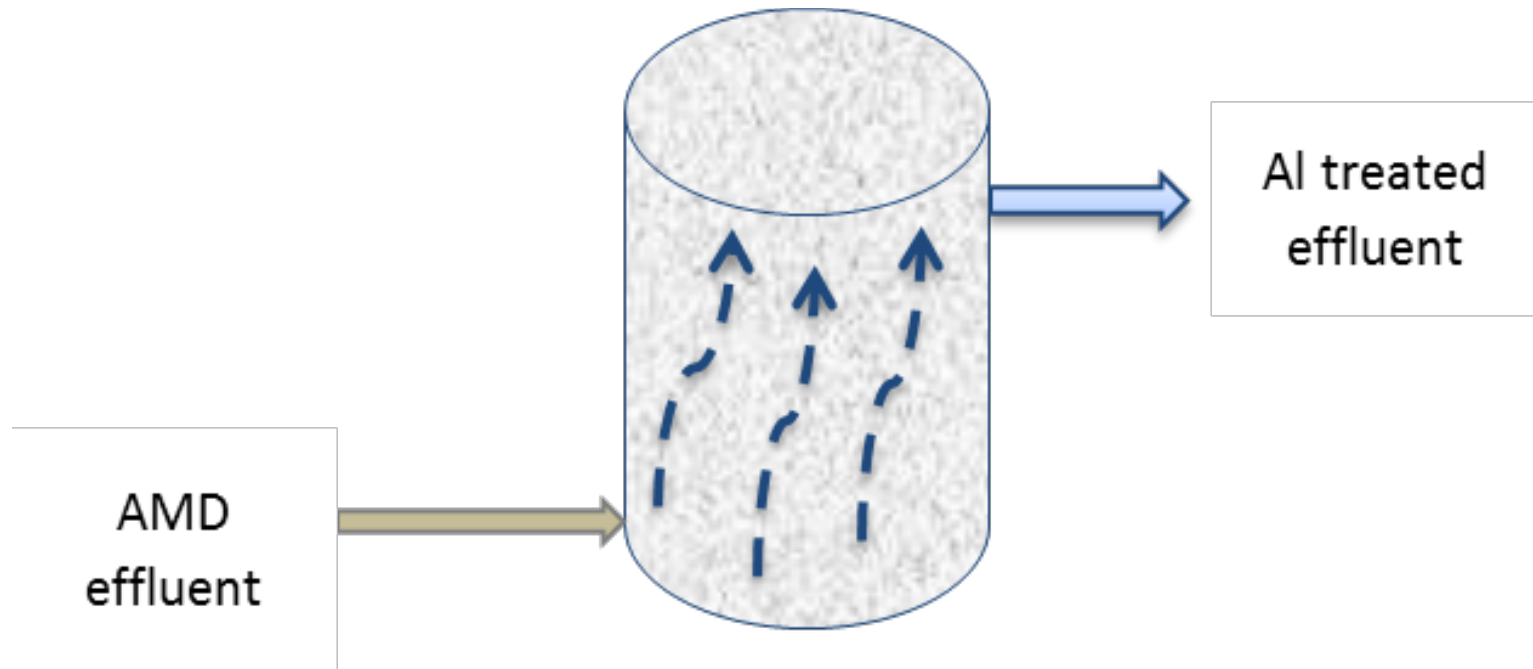
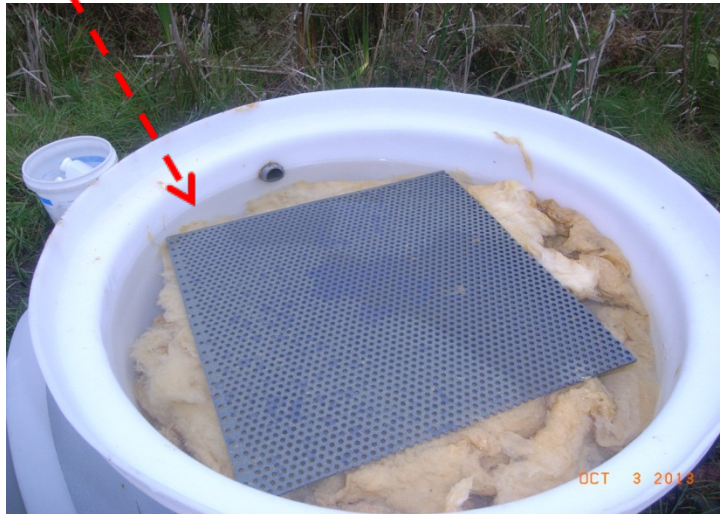# Stainless steel wool treatment

- Treatment tank volume 50 gallons

- Stainless steel wool in each tank 6.81 kg

- Residence time
  - Fast flow treatment: 5 min
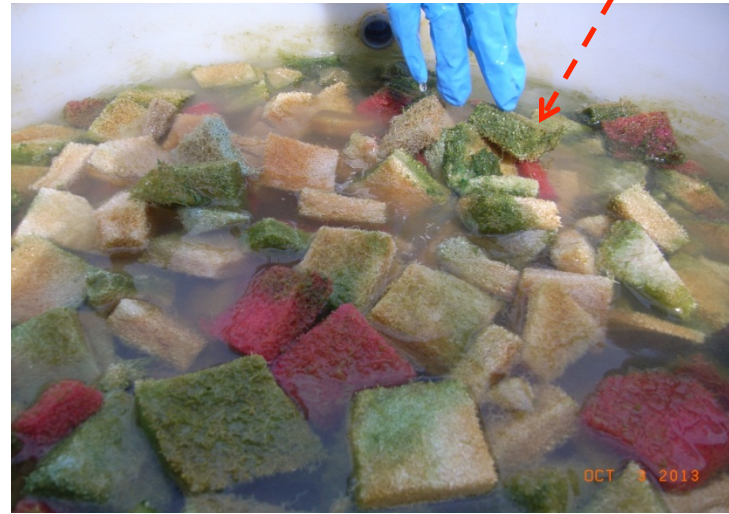 - Slow flow treatment: 25 min

Treatment media

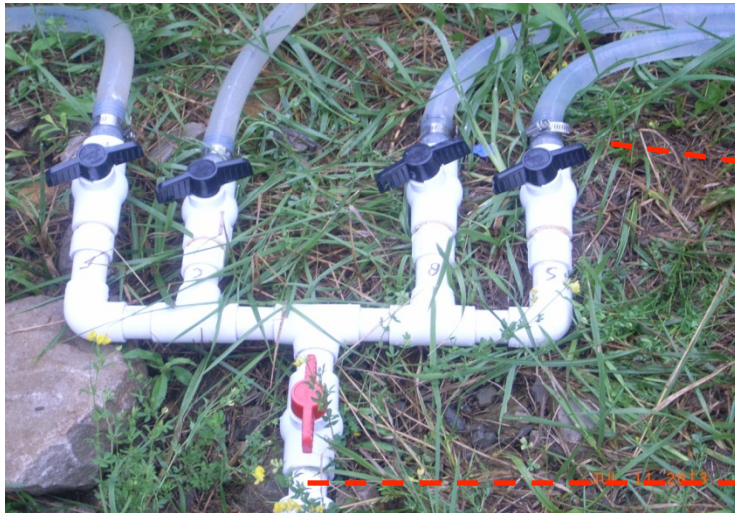Stainless steel wool

Fiberglass

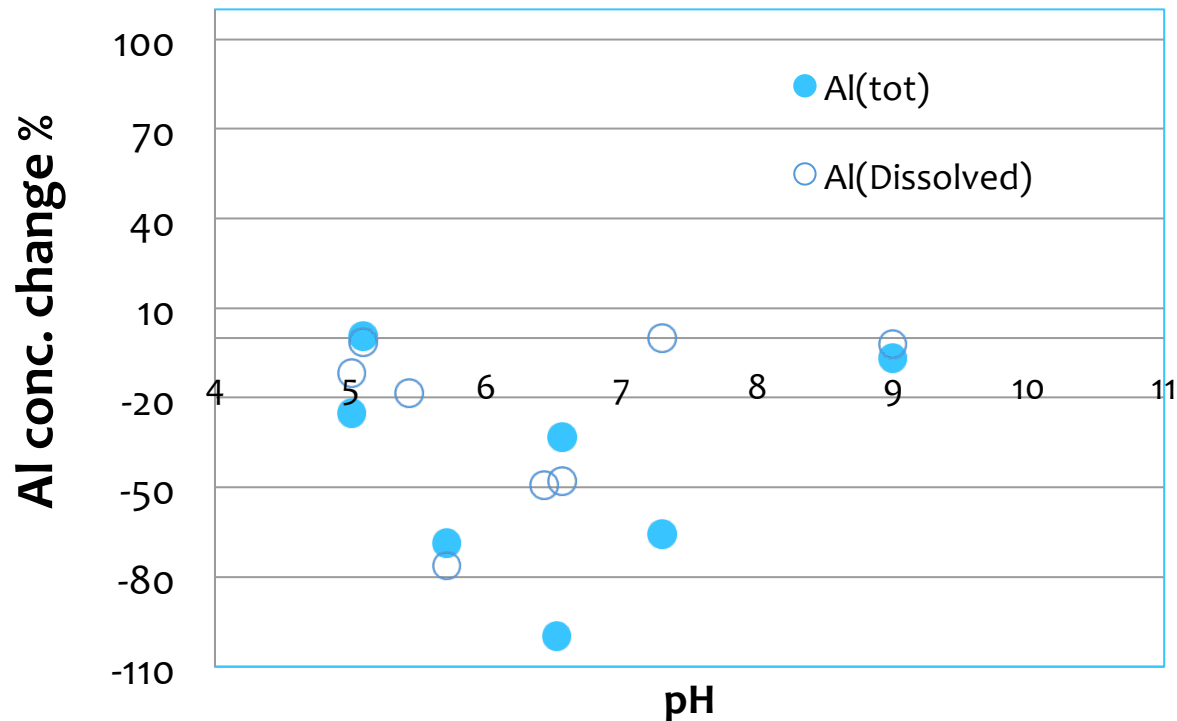Bioblox

Treatment Setup

Effluent

Treatment system Influent

Main line from AMD discharge

Treatment Results
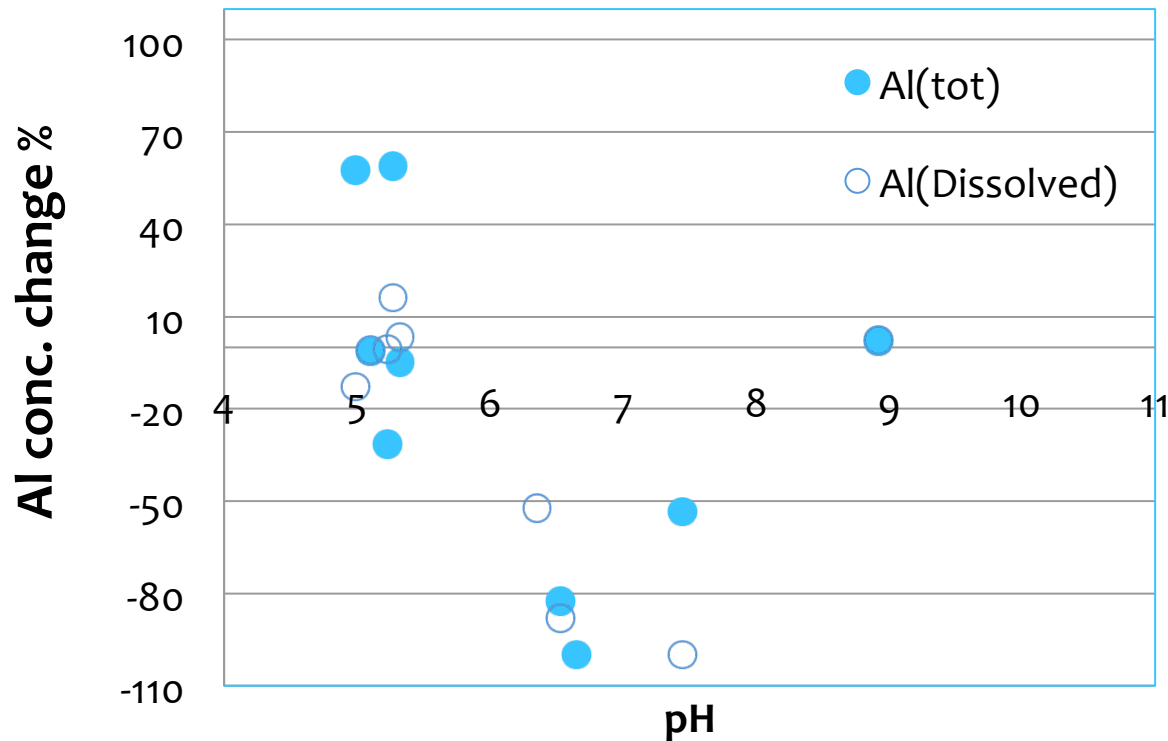## % change= $(Al_{out} - Al_{in})/Al_{in}$

Fiberglass
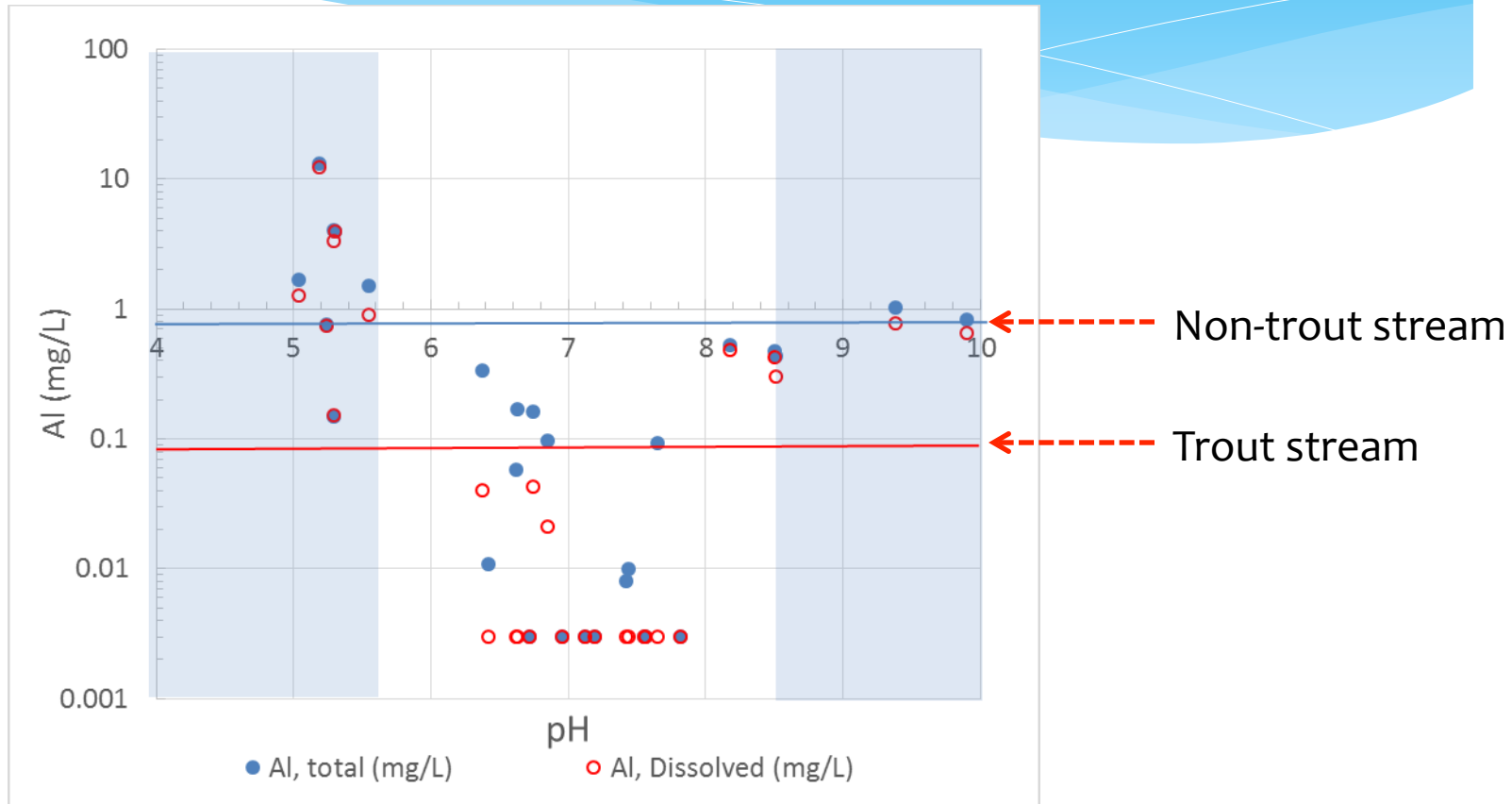
Treatment results (cont.)

Bio-Blox™

Good control within the pH range of 5.5 to 8.5 stainless steel wool

- Al concentrations in effluent samples after treatment with stainless steel wool.
- The unshaded area represents the pH ranges where treatment was effective.

Stainless Steel Treatment

| Al species	Al std	pH range		
		< 5.6	5.6-8.2	> 8.2
dissolved	<0.087	0%	100%	0%
total	<0.087	0%	69%	0%
		< 5.6	5.6-8.5	> 8.5
dissolved	<0.750	29%	100%	50%
total	<0.750	14%	100%	0%

- Percentage of effluent samples from stainless steel wool treatment that meet anticipated Al standards

Percent Al reduction using Stainless Steel wool

	pH range		
	< 5.6	5.6-8.5	> 8.5
Al dissolved	-25%	-74%	3%
Al total	-41%	-82%	-10%

- Percent reduction in Al within three pH ranges when treated with stainless steel wool

# pH effect on Al

pH effect on Al speciation
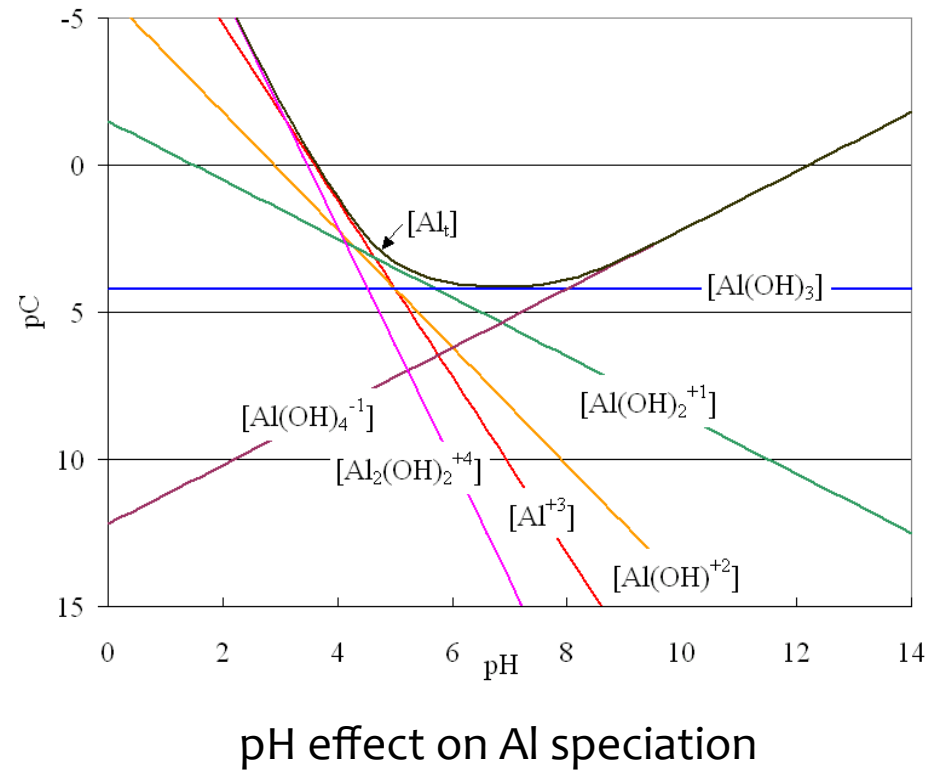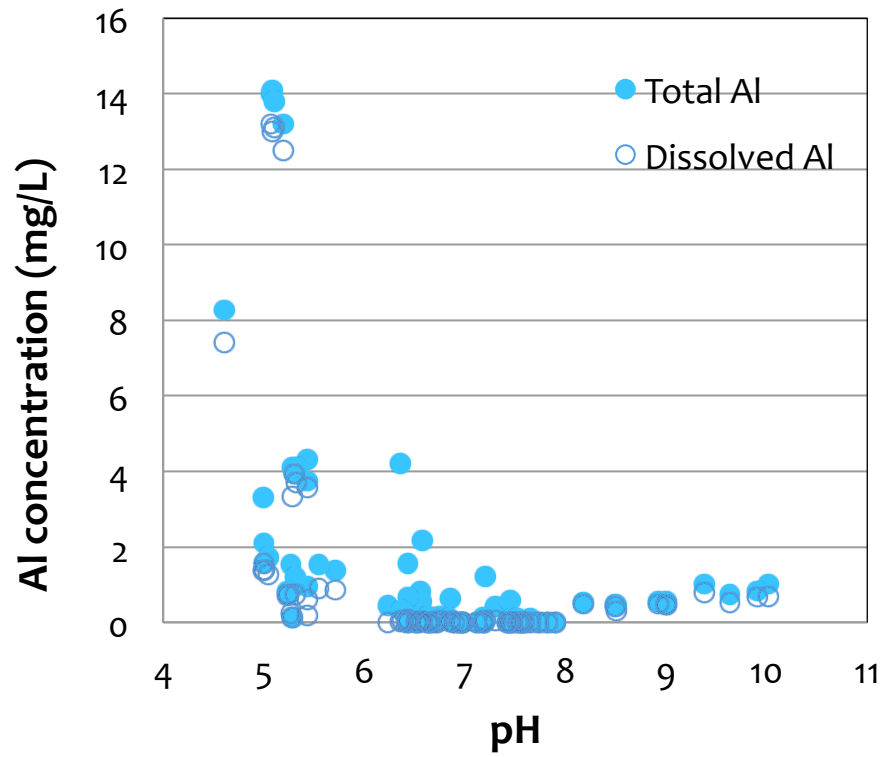
There should not be any Al in solution between pH ~ 5 and 8

Dissolved Al concentration based on gibbsite

pH	logC	C (mol L-1)	Al Conc (mg/L)
4	-4	0.0001	2.70
5	-6.6	2.51E-07	0.01
6	-7.8	1.58E-08	0.00
7	-7.5	3.16E-08	0.00
8	-6.5	3.16E-07	0.01
9	-5.5	3.16E-06	0.09

Flow rate had little effect on treatment efficiency

- High flow 10 gal/min, residence time ~5 min
- Low flow 2 gal/min, residence time ~25 min
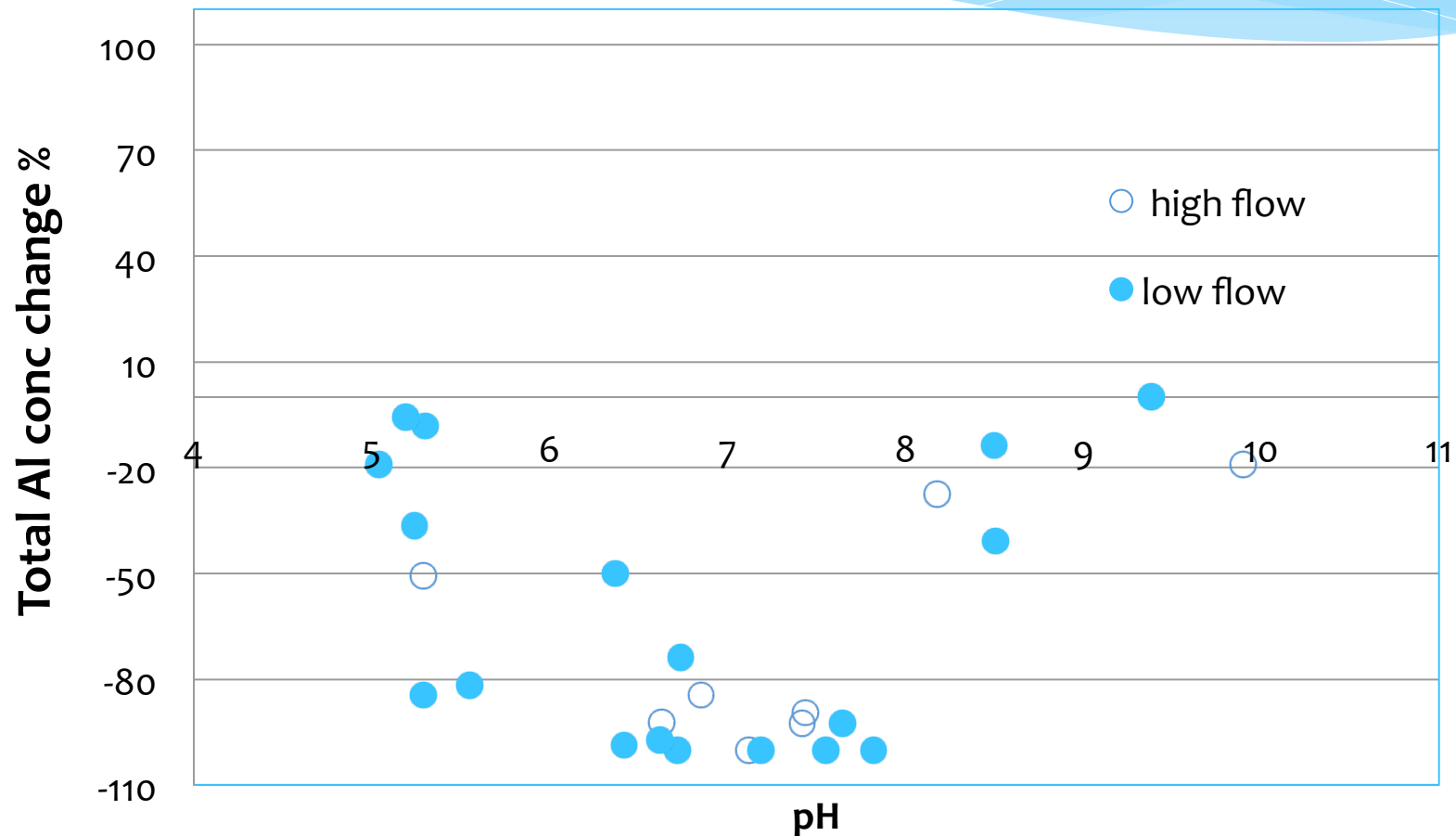
Fouling

Media fouling observed after 2 months

System maintenance

* Estimated suspended solids accumulation
    * *Total amount of suspended solids accumulation = Time (2 months) x flow rate (2 gpm) x removed suspended solids (influent TSS - effluent TSS)*

* Factors impact maintenance frequency
    * Time
    * Total suspended solids loading
    * System configuration

* Maintenance
    * For stainless steel wool, rinse with water

Conclusions

* The Bio-Blox™-a polymer sponge material and fiberglass insulation were moderately effective in removing Al.

* Stainless steel wool was most effective in Al removal.   It consistently removed Al to below the anticipated NPDES permit limit (0.75 mg/L) for non-trout waters.

* For all media, performance was strongly dependent on pH and within the optimal range of 5.6 to 8.5, 100% of observations were less than 0.750 mg/L while 69% of observations were less than 0.087 mg/L.

* Treatment media is not consumed during the treatment process, thus the only maintenance requirement would be to periodically remove/ flush accumulated sediment.

Recommendations

* The results indicate that stainless steel wool would be an effective end of system treatment for maintaining compliance at AML reclamation bond forfeiture sites.

* The treatment technology would be improved by scaling up to operational levels and fine tuning to identify optimal design and operating conditions.
    * Floating curtain
    * Media filled Gabion baskets

* The maintenance schedule depends on total suspended solids loading and treatment media configuration. It is likely to be site specific.

Focusing on tAl causes bias

- Only dissolved Al is toxic
- Total Al determination involves taking the unfiltered sample, digesting it in hot acid, then analyzing the resulting liquid
- This dissolves clay in the sample which releases Al
- This results in false positive values
- The Al translator is intended to account for this bias
- According to USEPA 823-B-96-007 the translator is the ratio dAl/tAl

By law, effluent standards are based on total analysis in theory, tAl predicts dAl-it does not
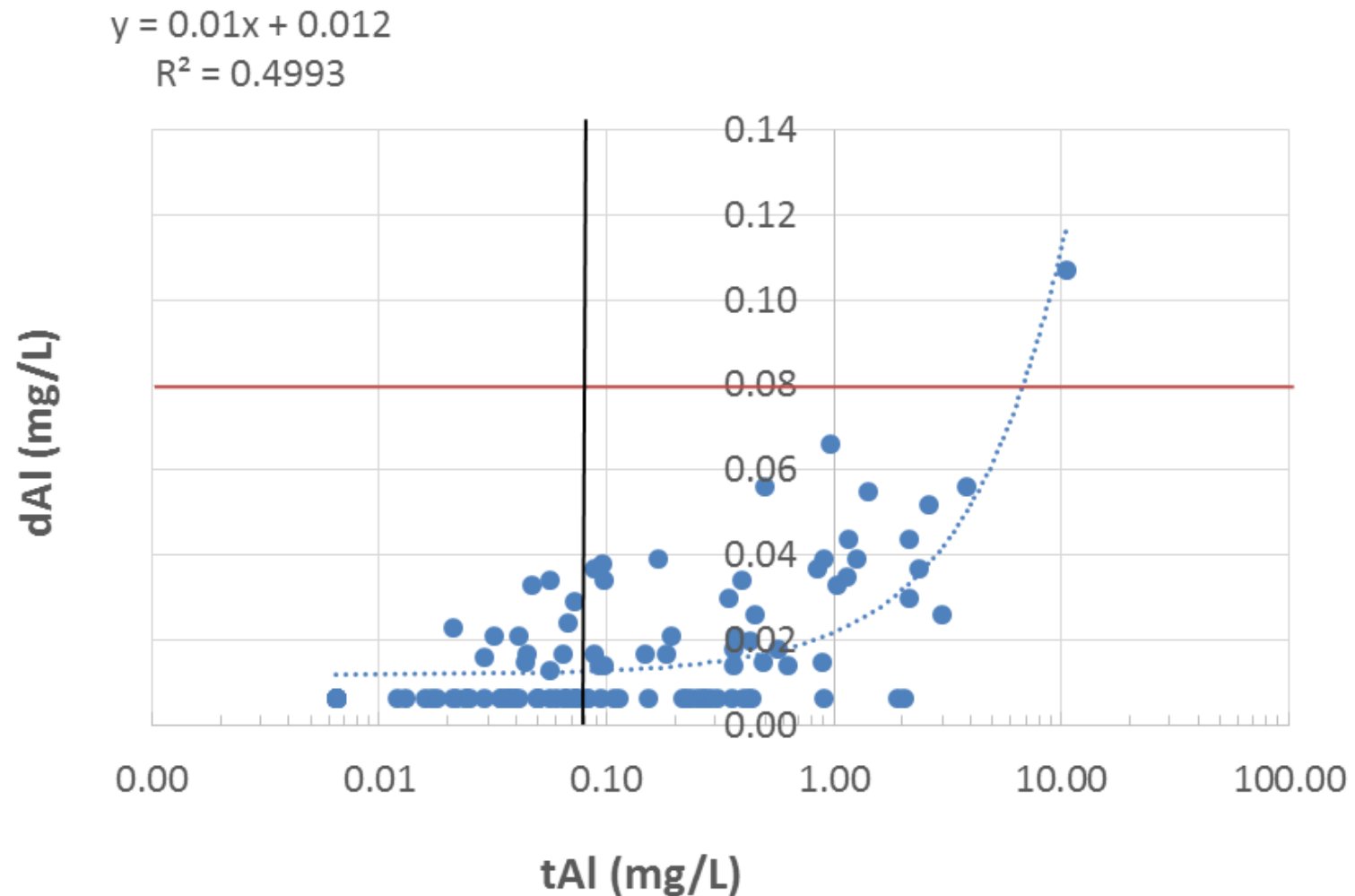
Your translator determines whether you are in compliance or not

* dAl = tAl * (dAl/tAl)

From USEPA: The translator may take one of three forms. (2) It may be developed directly as the ratio of dissolved to total recoverable metal
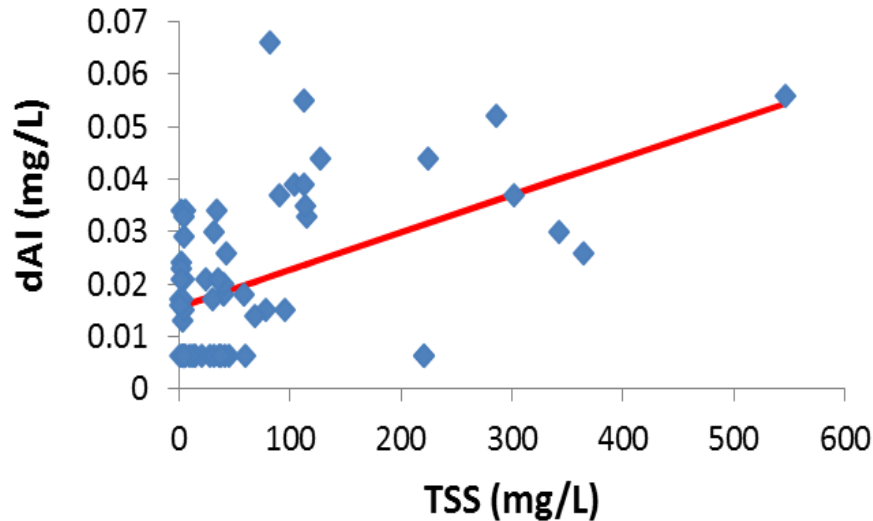
* For example:

tAl mg/L	Translator (dAl/tAl)	dAl mg/L
1.00	0.92	0.92
1.00	0.45	0.45
1.00	0.04	0.04

That's because the digestion procedure for total aluminum dissolves clay
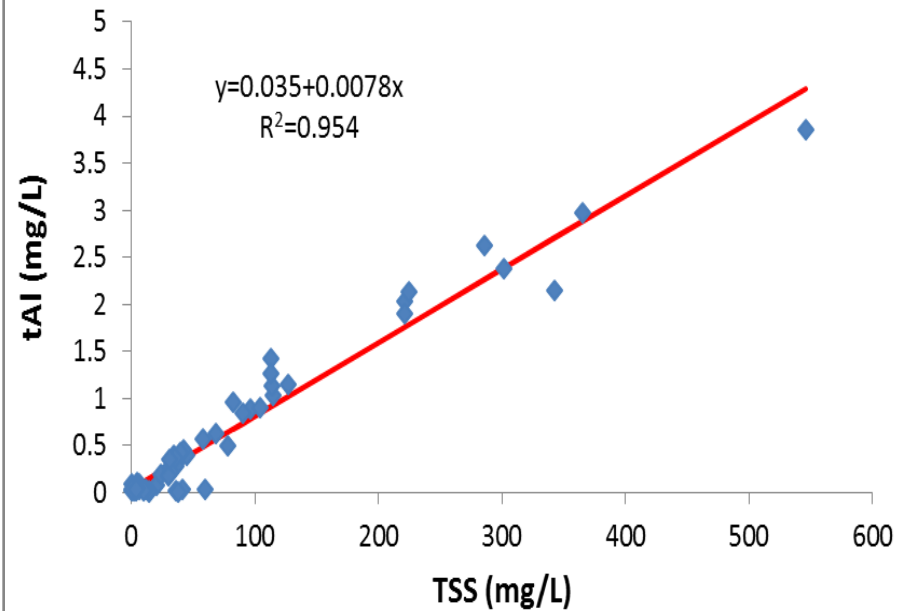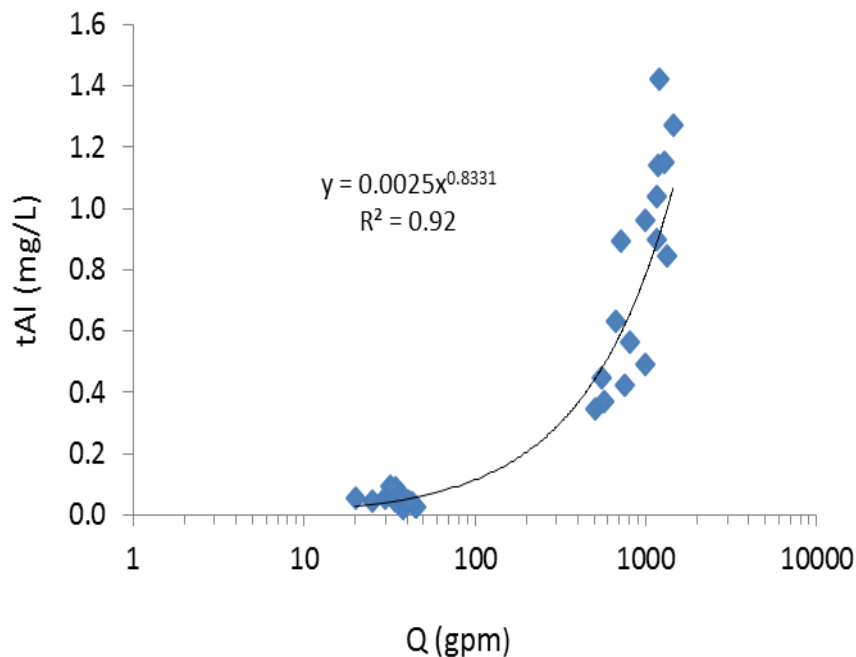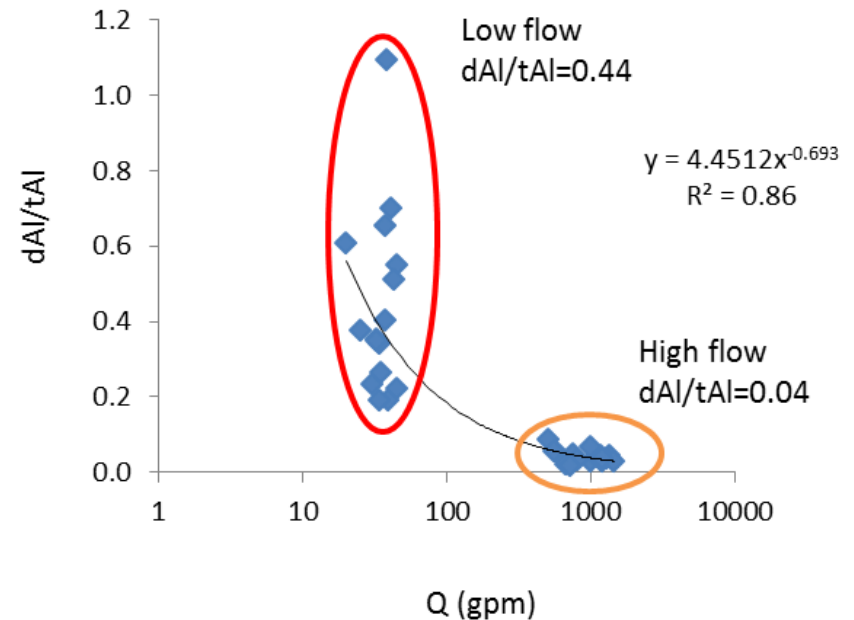
Total Al is controlled by TSS
dAl/tAl changes as a function of Q
(in theory, dAl/tAl should be the Aluminum translator)

tAl increases with flow

$y = 0.0025x^{0.8331}$
$R^2 = 0.92$

tAl (mg/L) vs Q (gpm)

Same outlets sampled during wet and dry weather

Low flow
dAl/tAl=0.44

$y = 4.4512x^{-0.693}$
$R^2 = 0.86$

High flow
dAl/tAl=0.04

dAl/tAl vs Q (gpm)

Most Al exceedances occurred during high flow but the translator is an average of high and low flow conditions and gives a high bias

If these three conditions are met then the translator (fd) is dAl/tAl Otherwise, an alternative, very high fd is imposed

1. Is the majority of data generated at or near the critical condition?

2. Is the dataset log-normally distributed?

3. Is fd (dAl/tAl) independent of TSS?

* It is unlikely that condition 3 is ever met

This is a serious problem

In Alpha's recent $27MM settlement about one third of the violations were for aluminum

Under current practice, anyone with aluminum in their NPDES permit will largely be treating clay particles even though EPA recognizes that dissolved, not total aluminum is toxic

Thank you and good luck