BIOCHEMICAL REACTOR/ANAEROBIC WETLAND DESIGN/STARTUP ISSUES

Ramblings, Random Thoughts, Lessons Learned and Audience Participation

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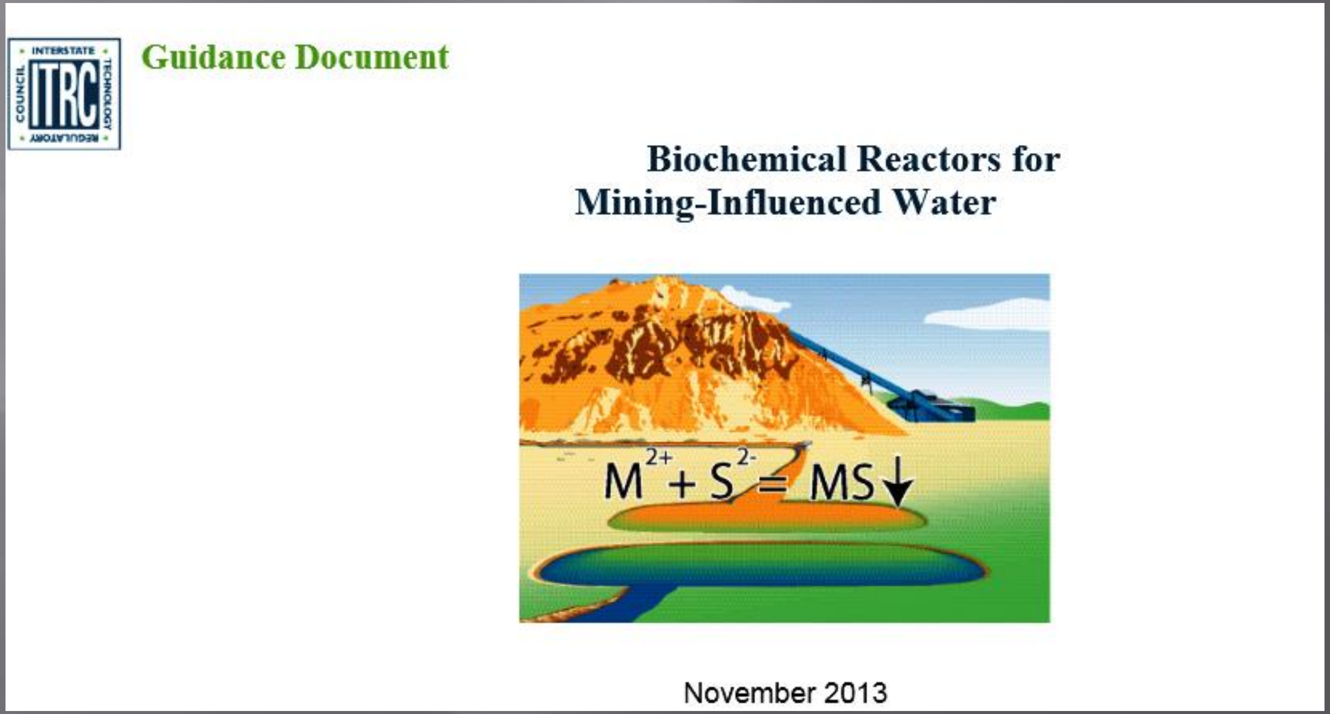
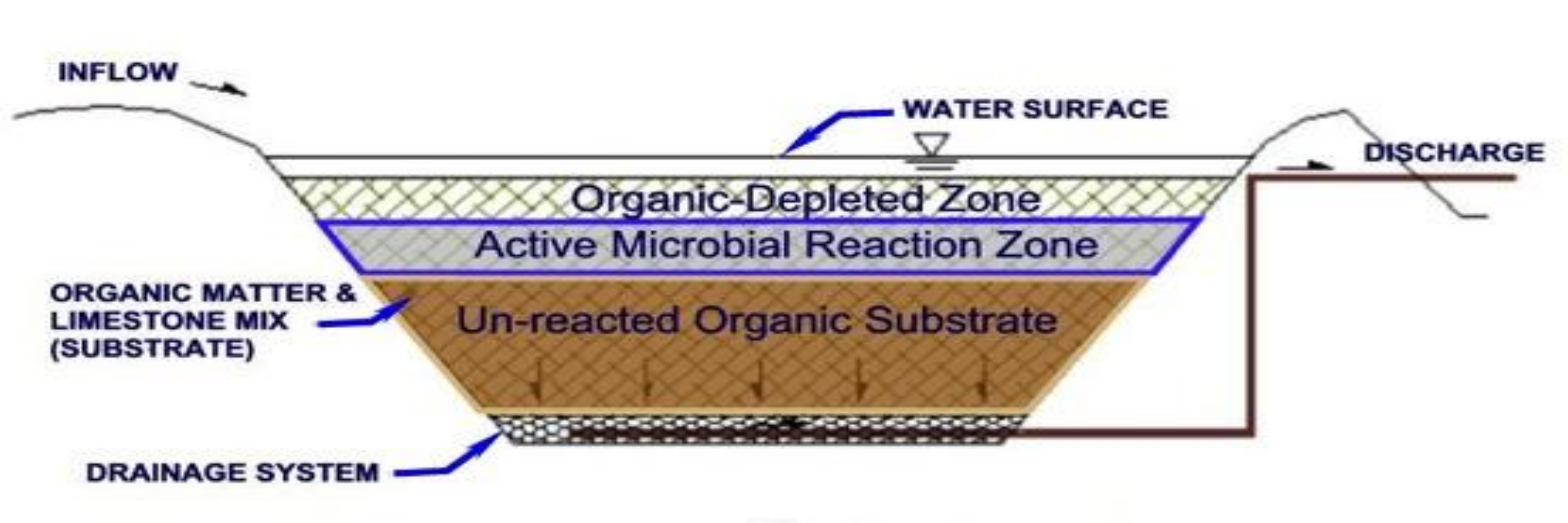
Objectives

- Share experiences related to start up and operation of BCRs
- Collect other examples of lessons learned
- Update ITRC Guidance Document (Eger et al, ASMR 2014)



Biochemical Reactors

- *Engineered treatment system that uses an organic substrate to drive microbial and chemical reactions to reduce concentration of metals, acidity, and sulfate in MIW (mining influenced water).*



What Does a BCR Do?

- Precipitate metals and metalloids
- Produce circumneutral waters

Iron precipitate in a BCR

Golinsky BCR, Lake Shasta, CA

How Does a BCR Do That?

- Sulfate reducing bacteria
  - Common bacteria
  - Present in soil
  - High concentrations in manure
- Remove sulfate by reducing it to sulfide
- Need oxygen free environment, sulfate, and an electron donor
  - Usually organic compound

Photo of sulfate reducing bacteria

Chemistry 101

- Sulfate reacts with organic carbon

$$SO_4^{-2} + 2\ CH_2O = H_2S + 2\ HCO^-_3$$

$$H_2S + M^{+2} = MS\ (solid) + 2H^+$$

- Limestone is often necessary

$$2H^+ + 2HCO_3^{-1} = 2\ H_2CO_3$$

$$2H^+ + CaCO_3(solid) = Ca^{+2} + 2HCO_3^{-1}$$

- If there is not enough M^{+2}
  - H_2S will be lost as a gas

Nuisance Parameters

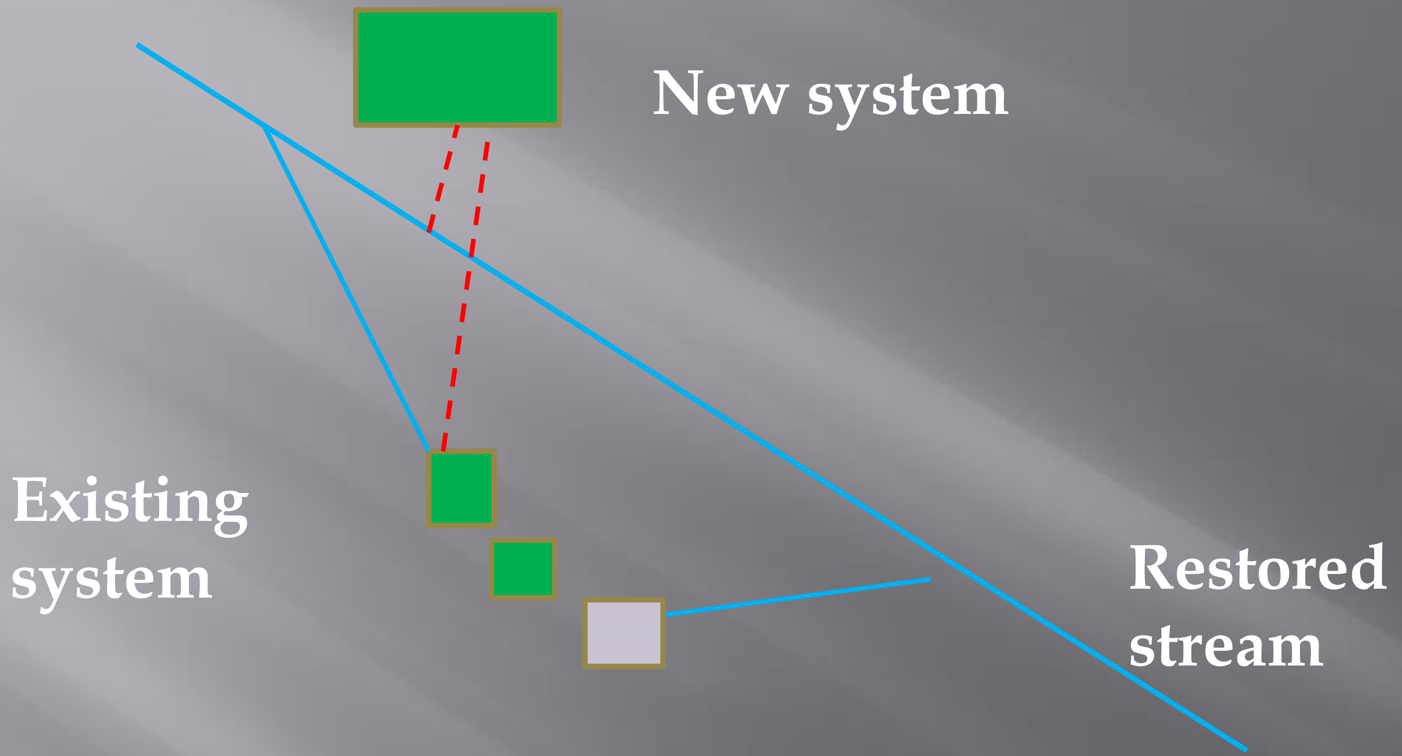
- Elevated concentrations of organic material and nutrients
  - Concentrations decrease with time
  - Typically 3- 6 months
- Concentrations are function of substrate and residence time
  - Increase with time and % manure
  - Older systems had higher manure
  - BOD range 500 – 16000 mg/l

Dealing with Nuisance Parameters

- Post treatment
  - Aeration
  - Constructed wetland
- Infiltration into groundwater
- Recycle use for treatment
- Pump to mine pit or shaft
- Source treatment

The Situation

- New wetland constructed
  - Additional sources
- Previous wetland existed on site
  - Stream was dead when system built
  - Now supported viable community
- Pump water to existing wetland
- Existing System
  - Anaerobic wetland
  - Aerobic wetland
  - Limestone bed



	Input	Output existing anaerobic wetland	Outflow from system
Manganese	1800	2200	3200
Copper	92	1.5	21
Zinc	420	7.3	410

Post treatment gone wild!

	Input	Output anaerobic	Output aerobic wetland	Output limestone bed
Manganese	1200	1100	610	55
Copper	136	5.6	3.7	2.2
Zinc	590	242	186	63

New wetland discharge added

	Input	Output anaerobic	Output aerobic wetland	Output limestone bed
Manganese	1675	2900	4500	4000
Copper	206	1.8	1	13
Zinc	424	8.9	6	300

Options

- Hindsight is 20/20
- Near by mine shaft would have been better option
- Source control or insitu treatment?

Treatment Example

Strongly Reducing Effluent from BCR removed selenium in the backfill

Summary

- BCRs are now used in areas where parameters other than just acid and metals are issues
- Requires careful handling of initial waters
- Initial water can be used for treatment, and potentially source control
- Sharing lessons learned are critical to the success of passive treatment
  - Source control test coming soon (summer 2015)

Other Lessons Learned

Challenges and Discoveries

- Controlling sediment load, attenuating flow to BCR
- Invasive plants
- Nitrates are everywhere (except in bioreactor outlets)

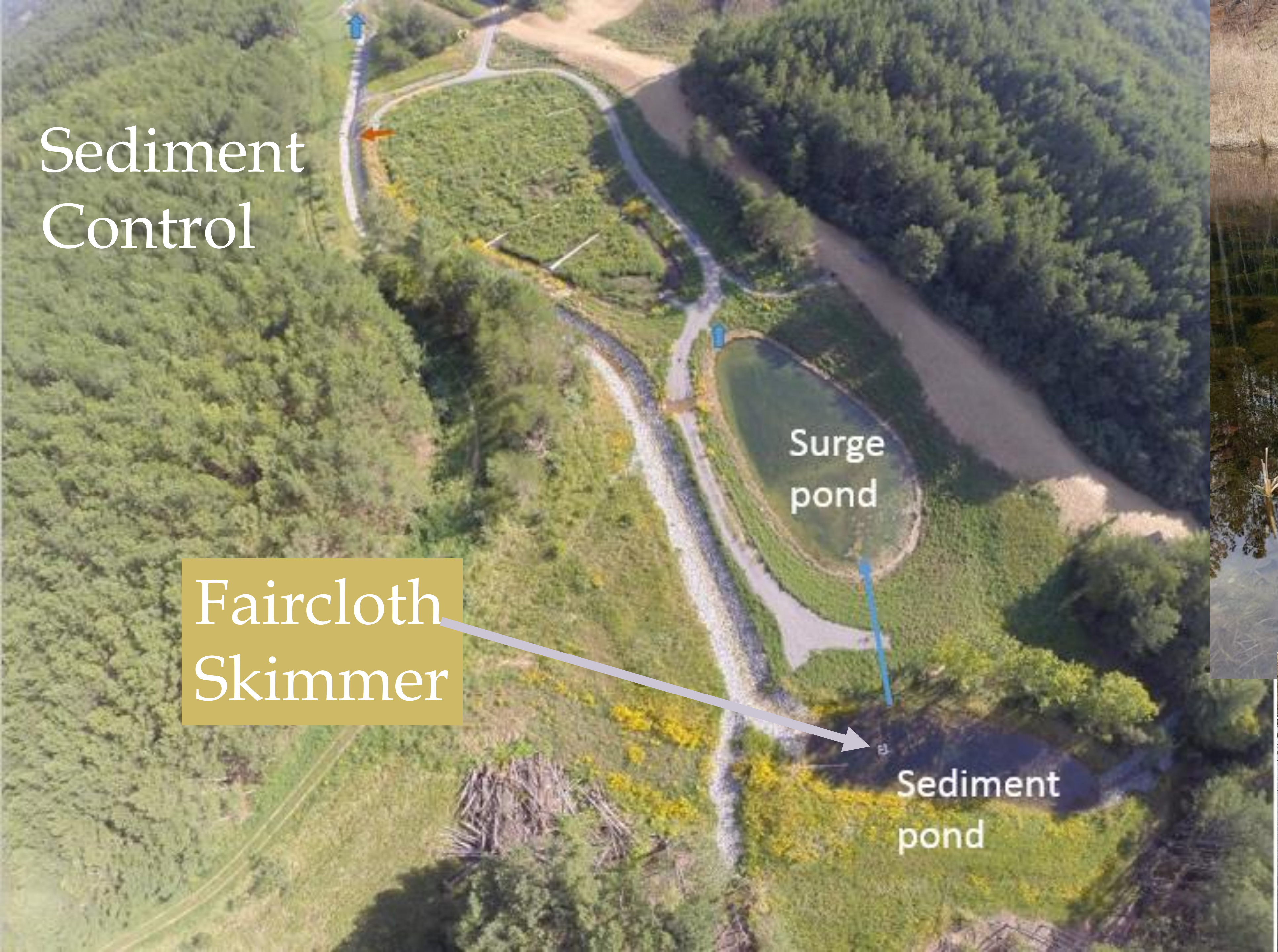
Controlling sediment load to BCR

- Silt is the enemy of bioreactors
- Locating the bioreactor outside the flood plain or providing sediment control/surge control to attenuate flow and reduce footprint.

Siting

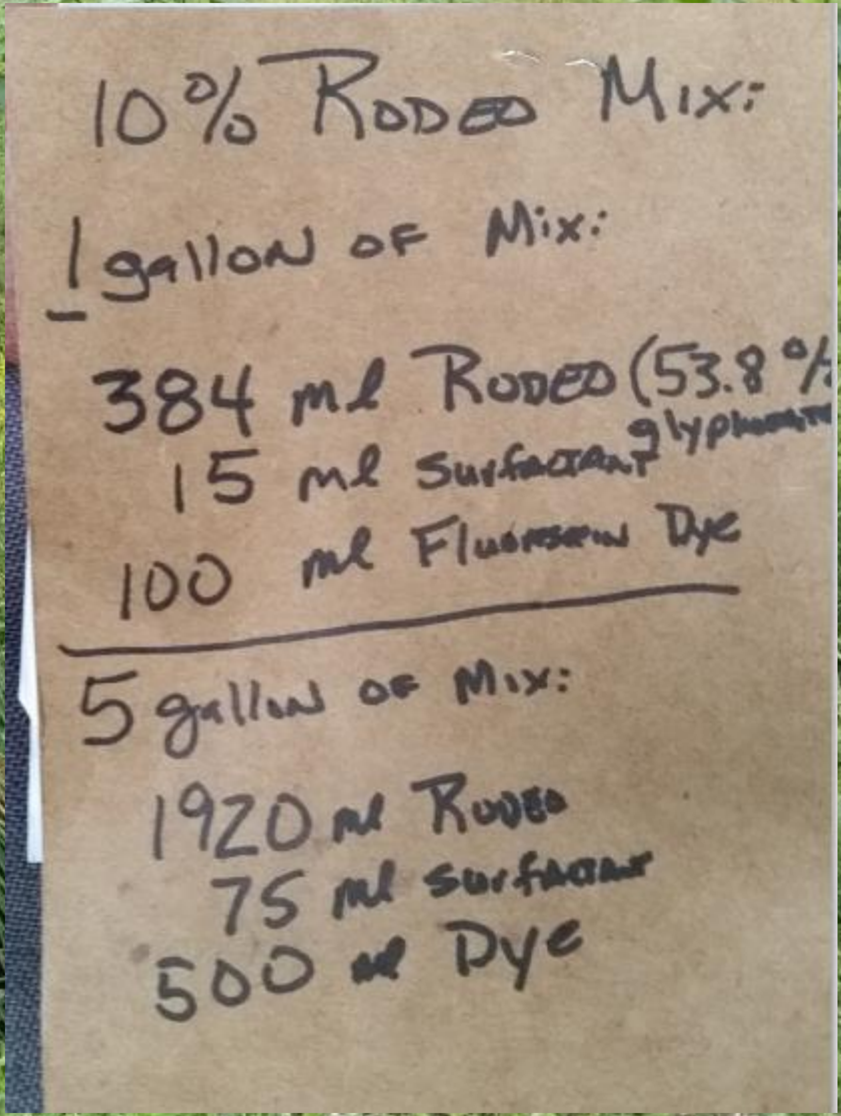
Passive Treatment Demonstration

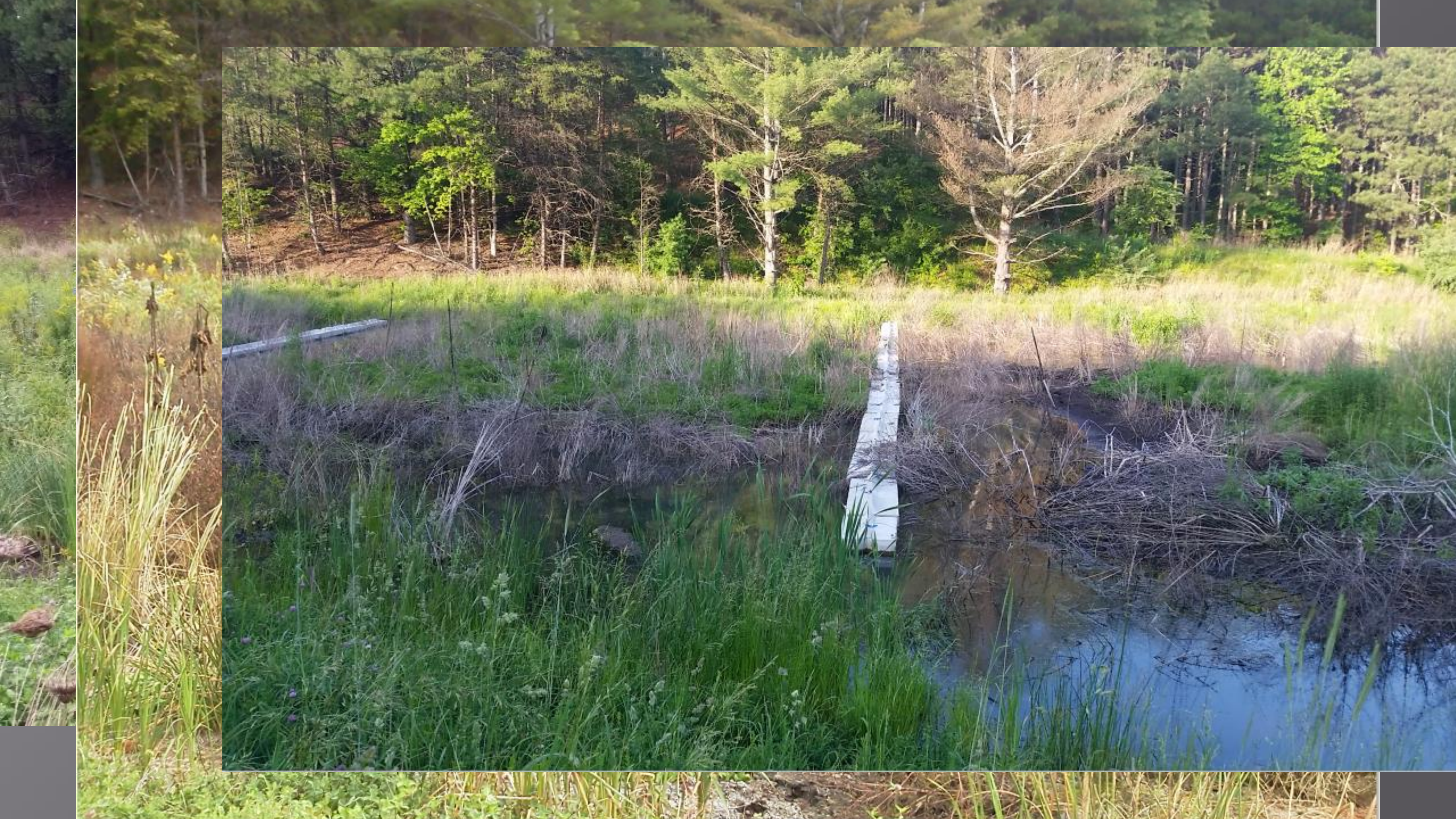
Sediment Control



Invasive Plants

- Volunteers from Hay or organic substrate layer
- Controlled higher water level
- Controlled by Herbicide
  - Cutting/painting stems and stumps (both will sprout)
  - Taking system off-line
- Restrictions on herbicides in water bodies


10% Rodeo Mix:
1 gallon of Mix:
384 ml Rodeo (53.8% glyphosate
15 ml Surfactant
100 ml Fluorescein Dye
5 gallon of Mix:
1920 ml Rodeo
75 ml Surfactant
500 ml Dye

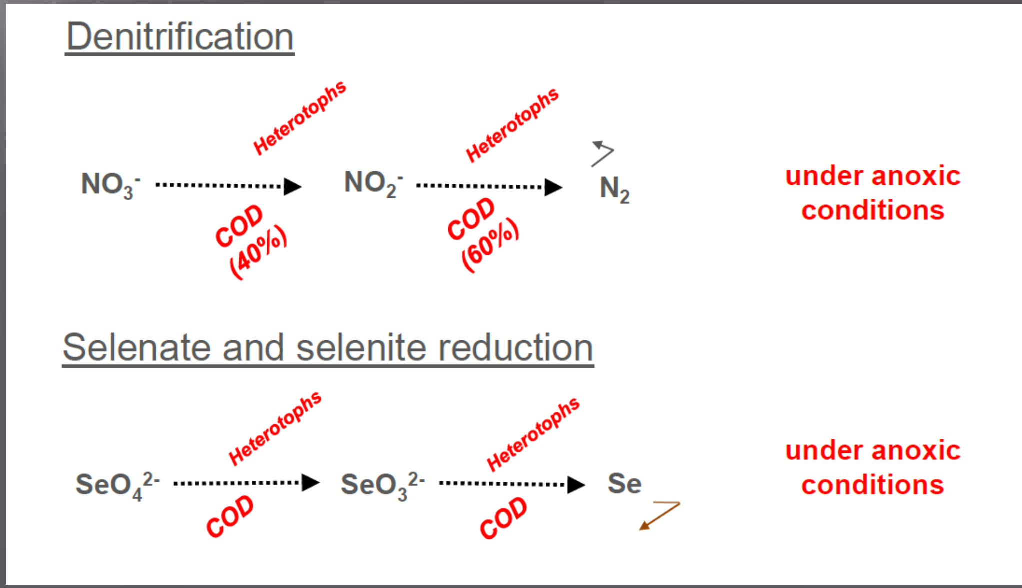


BCRs for Selenium Removal

- Similar to Passive Systems used for ameliorating metals in mine drainage.
- Likely used in watersheds with better quality streams where metals have not been an issue.
- Necessitates more care with BCR effluent. NPDES permits may limit:
  - $N\text{-}NO_3\text{-}NO_2$ <0.68 mg/L
  - BOD < 30 mg/L
  - DO >6 mg/L
  - COD < 120 mg/L
  - $NH_3 – N$ <4 mg/L

Sources of Nitrogen as nitrate–nitrite in drainage from (coal) surface mines

- Rock fractures during mining
- Residual nitrates from ammonium nitrate explosive agents
- Nitrogen fertilizers used in revegetation effort



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It's Your Turn!