Use of Wetlands for Colloid Destabilization

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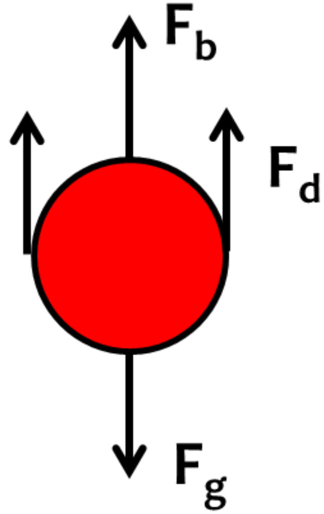
What we'll discuss

* Offer a low-cost, but highly effective, solution to settleability issues;
* But first, we'll review:
  * Physical Properties of suspended particles and fluids that affect settling;
  * Electrochemical Properties of suspended particles that affect settling;
  * Discuss how some of these properties prevent settling in ponds;
  * Discuss how these same properties can be used to promote suspended particle removal in wetlands

Use of Wetlands in treatment

* Researchers at Wright State University and WVU noticed wetlands improved mine drainage water quality (Huntsman et al. 1978, Wieder and Lang, 1982)
* Most of the early work focused on using wetlands to remove dissolved metals and acidity.
* The majority of NPDES violations is due to suspended solids
* We are going to discuss using wetlands for removing suspended metal precipitates

Physical Properties of fluid and particle that affects settling



ρ_d = Particle Density (lbs/ft)

μ = Viscosity of water

g = gravitational acceleration (ft/sec^2)

ρ= Density of water (lbs/ft^3)

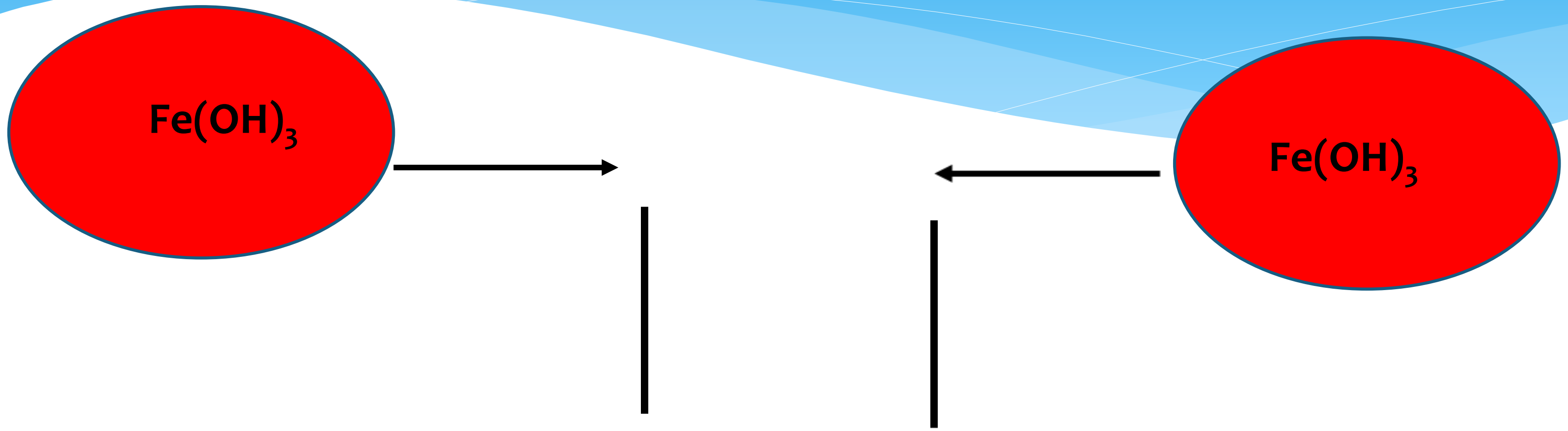
D = diameter of particles

$$Settling\ Velocity = \left(\frac{g * (\rho_d - \rho) * d^2}{18\mu}\right)$$

- Settling velocity of a sph proportional to its diame
  - large particles settle much f (assuming density is equal)

	Diameter (mm)	Settling Velocity (m/s)	Time to settle 1 meter
Fine sand	.05	2.25 x10^{-3}	7.4 mins
Silt	.005	2.25 x10^{-5}	12 hours
Clay	.0005	2.25 x10^{-7}	51 days

Electrochemical Properties of particle that affect Agglomeration



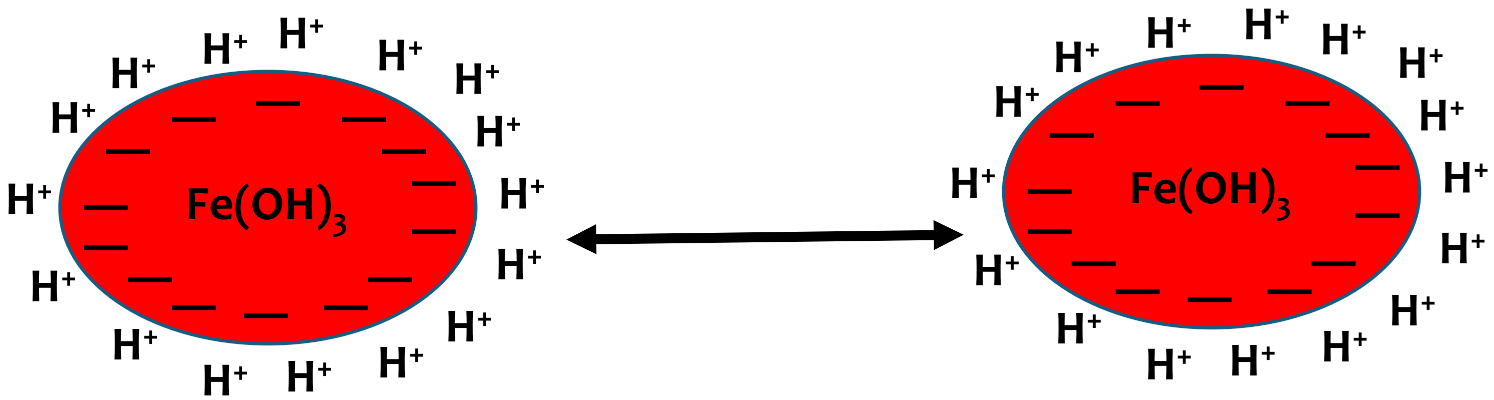
Van der Waals
Attractive forces
between particles

- Van der Waals is a universal attractive force which acts to bind particles together

Most metals suspended in water carry a negative "primary" surface charge due to hydroxide

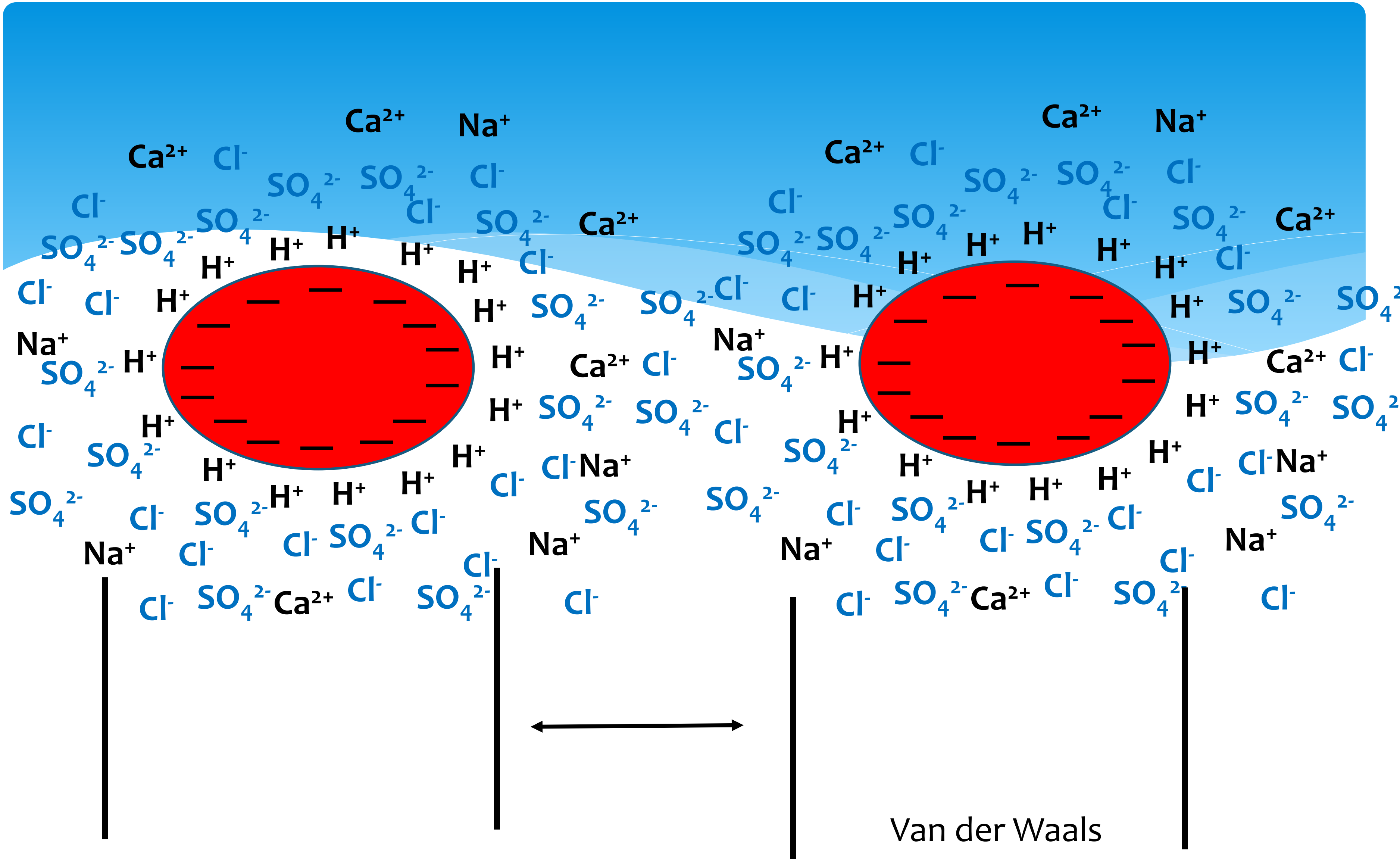
- Assume metal oxide particles have an excess of negative ions at its outer surface

Negative surface charge attracts positive ions on the surface



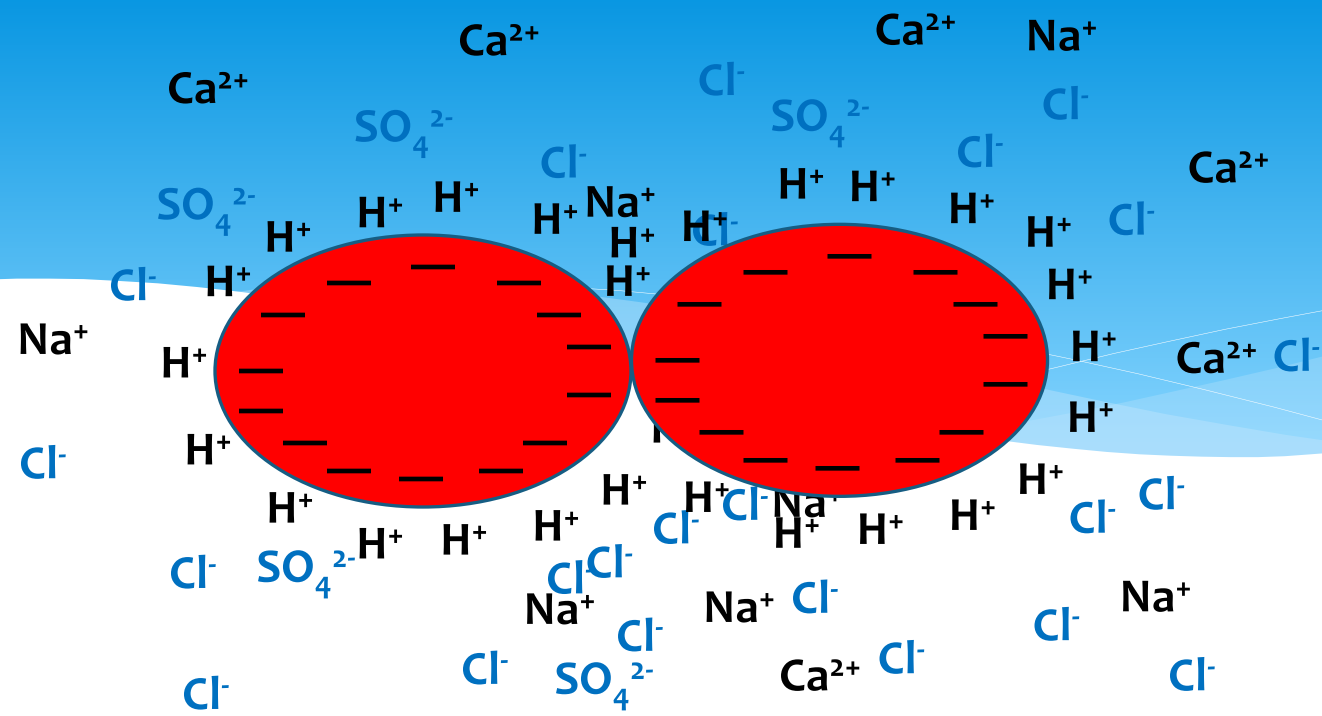
Repulsive Force

$$Fe\text{-}OH + H^+ \rightarrow Fe\text{-}OH_2^+$$



Van der Waals Attractive forces between particles

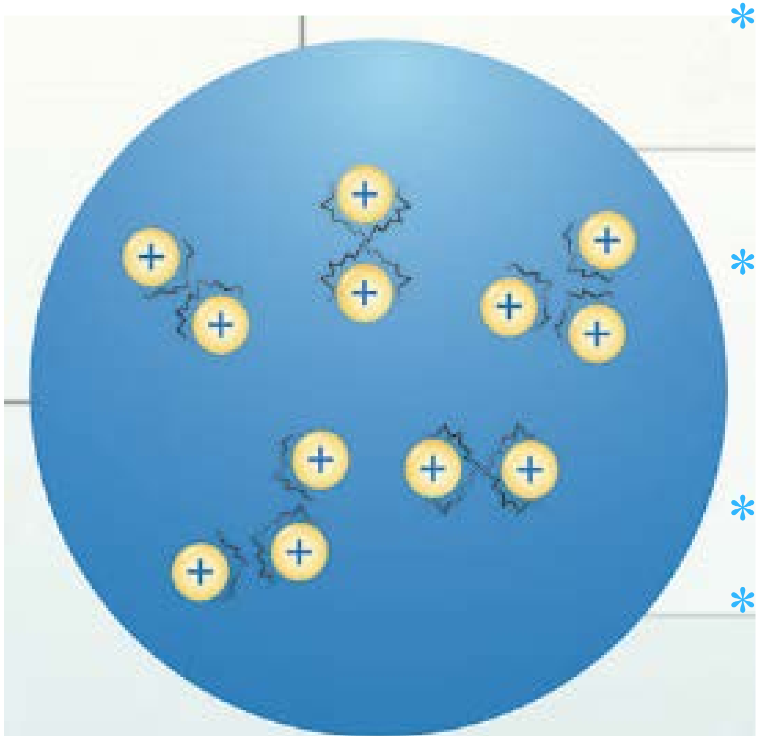
"Cloud" of counter ions causing repulsion of particles, thus preventing agglomeration



- Agglomeration occurs of Attractive forces >> Repulsive forces

- How can we decrease the repulsive forces to promote flocculation and grow the particle diameter to induce gravitational settling?

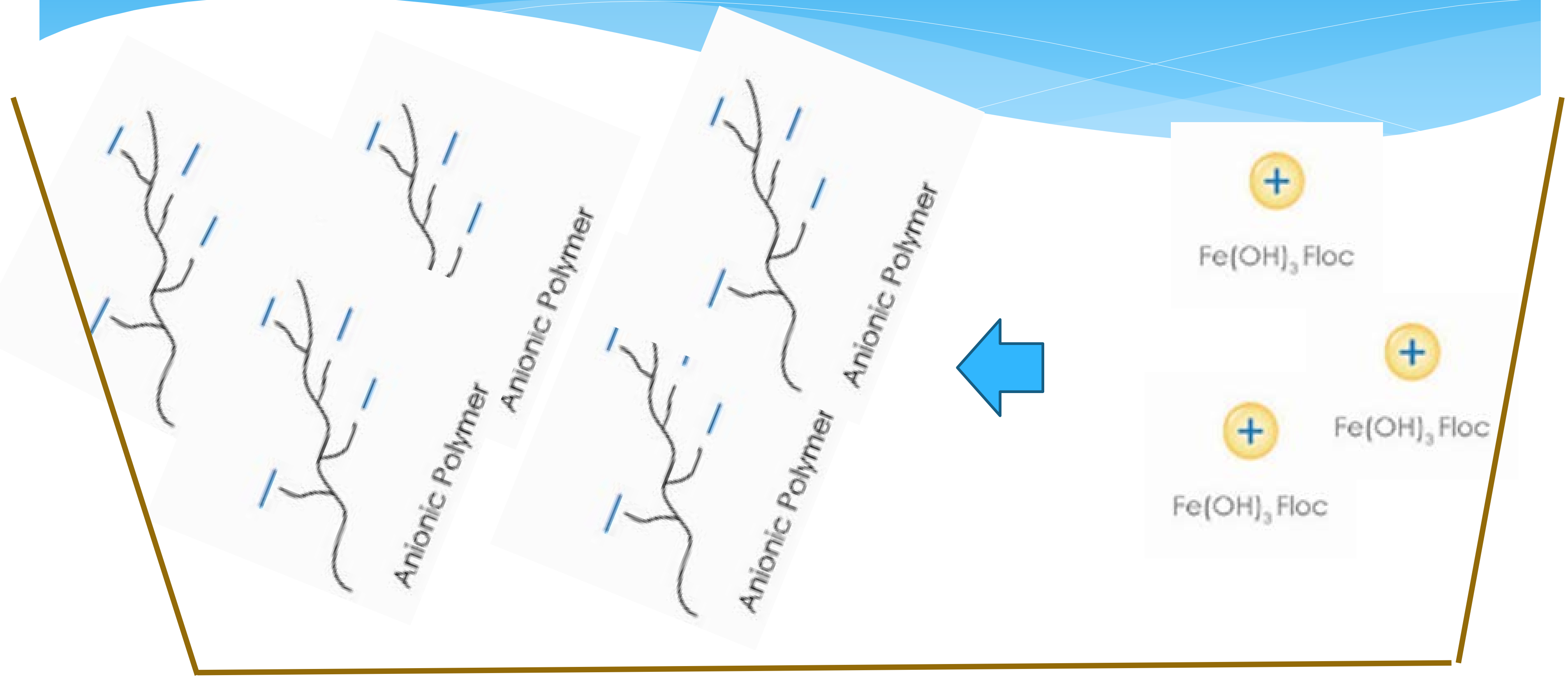
Add Flocculent to increase Diameter



- In most "Conventional" treatment we manipulate the diameter by adding a polymer
- Polymer will "bridge" numerous small diameter discrete particles into a single floc with a large diameter
- Polymer is effective, but costly.
- We need another settling mechanism for unsettled particles

* 7 acres of settling @ ~ 9.5 days of RT
* Effluent T Fe ~ 3 to 10 mg/L

Can we design a settling mechanism based on charge imbalance (adsorption)



Don’t fight chemistry, work with it!

- Wetland = 1.2 Acres
- Design Criteria of 10 g $Fe/m^2/day$



Date Sampled	Lab pH	Alkalinity mg/l	Acidity mg/l	Iron mg/l	Suspended Solids
4/29/2014	8.05	116	-134	**0.24**	7
6/20/2014	7.8	166	-36	**0.45**	6
7/11/2014	7.7	156	-124	**0.24**	7
7/24/2014	7.72	166	-86	**0.56**	8
8/4/2014	7.52	162	-94	**0.18**	6
9/3/2014	7.62	164	-74	**0.22**	11
10/10/2014	7.66	160	-144	**0.24**	7
10/21/2014	7.46	150	-130	**0.3**	8
11/12/2014	7.69	158	-140	**0.33**	4
11/20/2014	7.87	168	-110	**0.36**	4
12/3/2014	7.83	160	-100	**0.57**	6
12/15/2014	7.75	158	-38	**0.5**	9
2/9/2015	7.7	156	-100	**1.33**	6
2/16/2015	7.66	164	-80	**0.665**	9
3/16/2015	7.6	142	-108	**0.384**	6
3/23/2015	7.74	1646	-30	**0.29**	6
4/2/2015	7.86	172	-98	**0.43**	6
4/17/2015	7.78	190	-156	**0.788**	4
5/1/2015	7.53	160	-124	**0.441**	9
5/26/2015	7.4	140	-114	**<.1**	9
6/5/2015	7.61	138	-112	**<.1**	4
6/29/2015	7.57	122	-12	**<.1**	3
7/1/2015	7.87	170	-128	**0.121**	3
7/15/2015	7.37	168	-90	**0.319**	8
8/3/2015	7.56	164	-108	**0.123**	8
8/20/2015	7.62	148	-132	**0.128**	4
9/7/2015	7.7	144	-37	**<0.10**	5
9/20/2015	8.1	162	-124	**0.908**	7


Sykesville Wetland
1.5 Acres
Cost = ~$100,000
Design Criteria = 9 g Fe/m²/d

Wetland Vegetation Planted

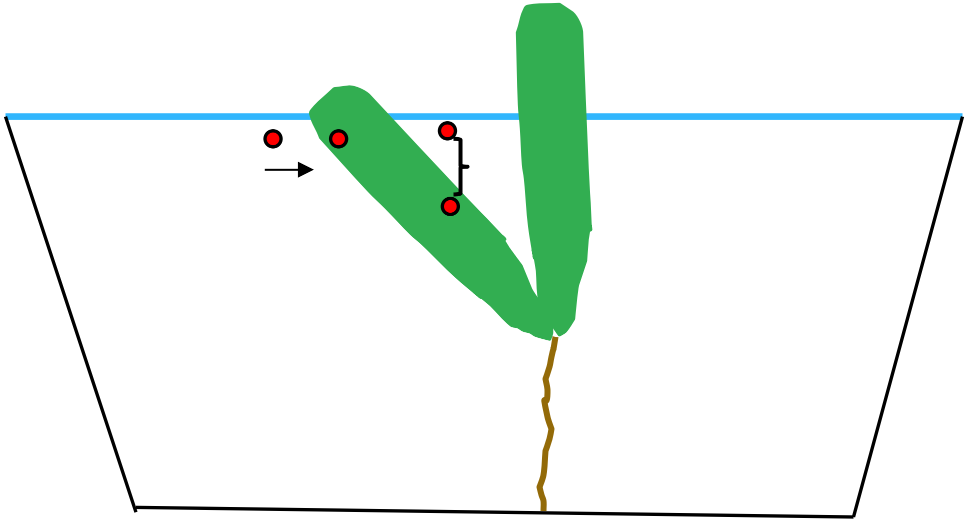
* Juncus canadensis (Canadian Rush) – deer and goose resistant
* Scripus cyperinus (Woolgrass) – prolific seeder
* Scripus atrovirens (Green Bulrush)
* Peltandra virginica (Green Arrow Arum) – prolific seeder
* Sagittaria latifolia (Broadleaf Arrowhead/duck potato) – vigorous by both sees and rhizomes – muskrat food
* Scripus validus (Soft-stemmed Bulrush)
* Sparganium eurycarpum (Broadfruit bur-reed)

Other Possible Wetland Colloidal Removal Mechanism's

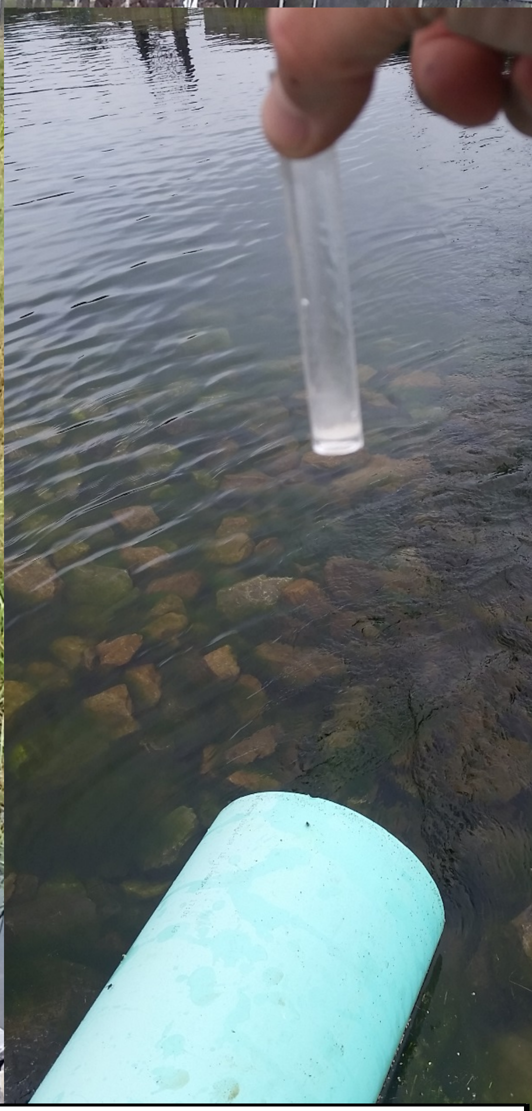
* Decreased settling distance, increased surface area

* Broadleaf arrowhead

* Release of Natural Organic Matter (NOM), like humic substances (-charge), that promote colloid destabalization

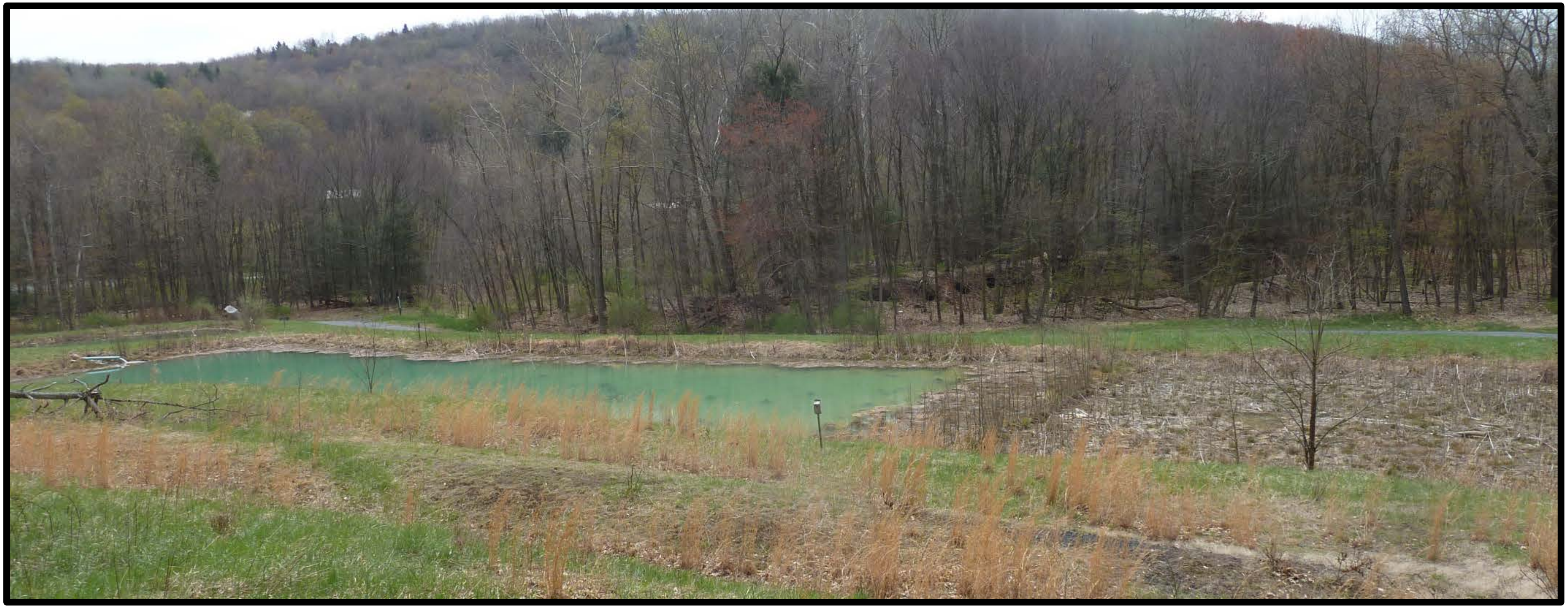


* Woolgrass (density/surface area > cattails)

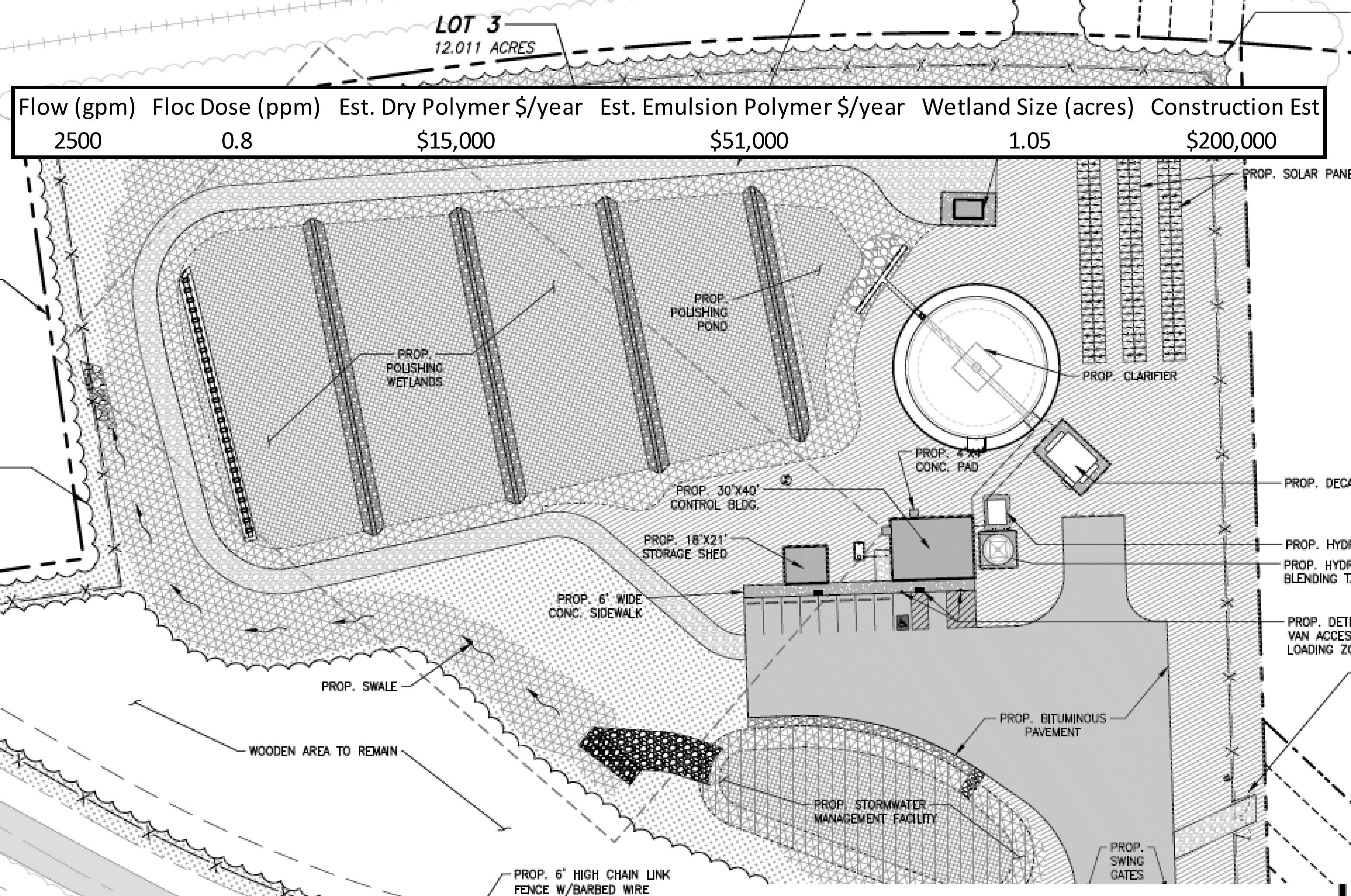


Sample Location	Date	Calculated Flow (gpm)	pH	Temp	Alkalinity	T_Fe	D_Fe
Pond 3 Effluent/Wetland influent	7/20/2016	916	7.06	14.7	133	4.5	4.5
Wetland Effluent pipe	7/20/2016		7.36	17.4	140	0.2	ND

Settling Pond transitioning to a wetland for Aluminum Hydroxide Sequestration



Flow (gpm)	Floc Dose (ppm)	Est. Dry Polymer $/year	Est. Emulsion Polymer $/year	Wetland Size (acres)	Construction Est
2500	0.8	$15,000	$51,000	1.05	$200,000



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ACID MINE DRAINAGE ABATEMENT PROJECT

CRESSON ACID MINE DRAINAGE TREATMENT PLANT

CRESSON BOROUGH — CAMBRIA AND BLAIR COUNTIES

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