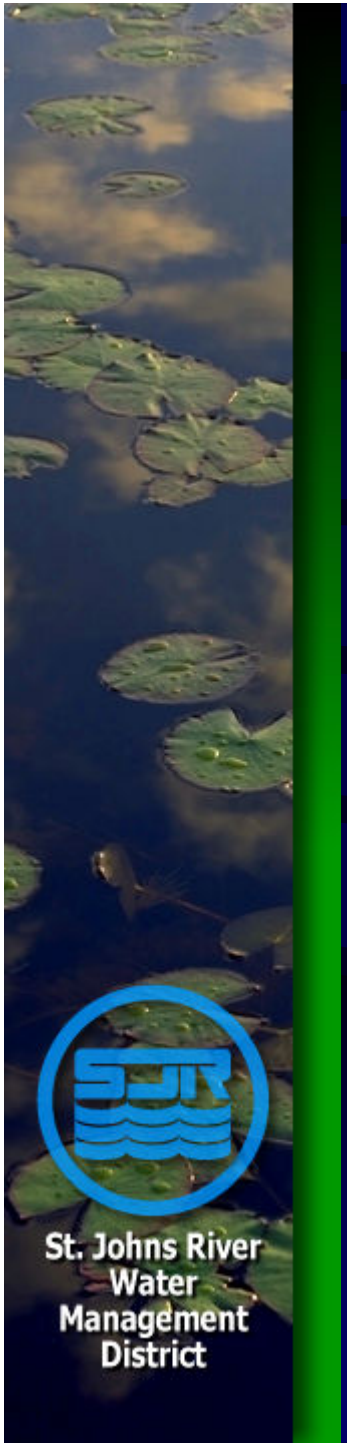

Scorecard for Chemical Treatments to Control Nutrients in Surface Water Restorations in Florida

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St. Johns River
Water Management District

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MACTEC Engineering and Consulting, Inc.

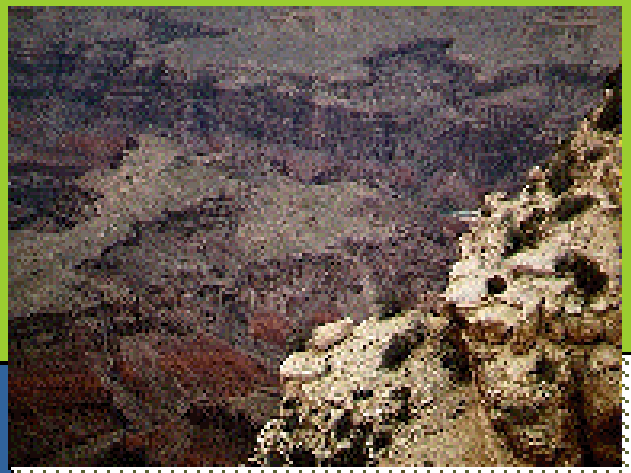
MACTEC

Natural Phosphate, PO_4^{-3}, Cycle

Erosion

Phosphate in plants

Bacterial decay



Water food chains → Bacterial decay → Phosphate dissolved in water

Phosphate in rocks, fossil bones, guano

uplifted

Shallow water sediments

Deep sea sediments

Chemical Treatments for Nutrient Control

- Metallic salts
- Water treatment residuals – WTR's
- Polymers

Metallic Salts for Nutrient Removal

- Aluminum sulfate (alum)
- Polyaluminum hydroxychlorides (PACl)
- Ferric sulfate
- Ferric chloride
- Sodium aluminate
- Lime

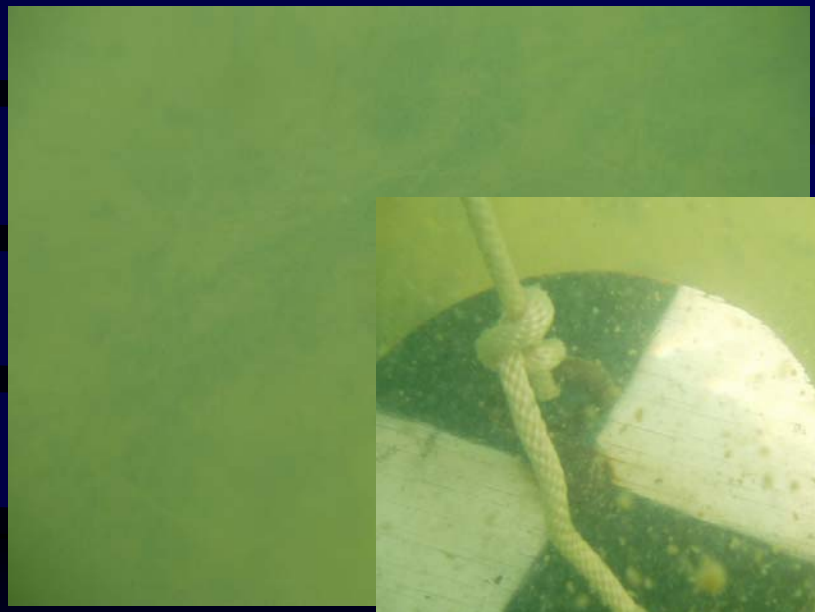
Typical Precipitation (Alum)

$$Al^{+3} + 3H_2O <-> Al(OH)_3 + 3H^+$$

$$Al_2(SO_4)_3 + 2H_3PO_4 <-> 2AlPO_4 + 3H_2SO_4$$

- If sufficient alkalinity is present, the acidity will be neutralized
- $AlPO_4$ precipitates
- Sorption of P onto the surface of Al hydroxide polymers (floc)
- Entrapment/sedimentation of particulate P by floc

Progressive Improvement – Nutrient Reduction and Water Clarity



Application Methods

- Barge
- Marsh Master
- Airboat
- Injection
- Land (via spreader)

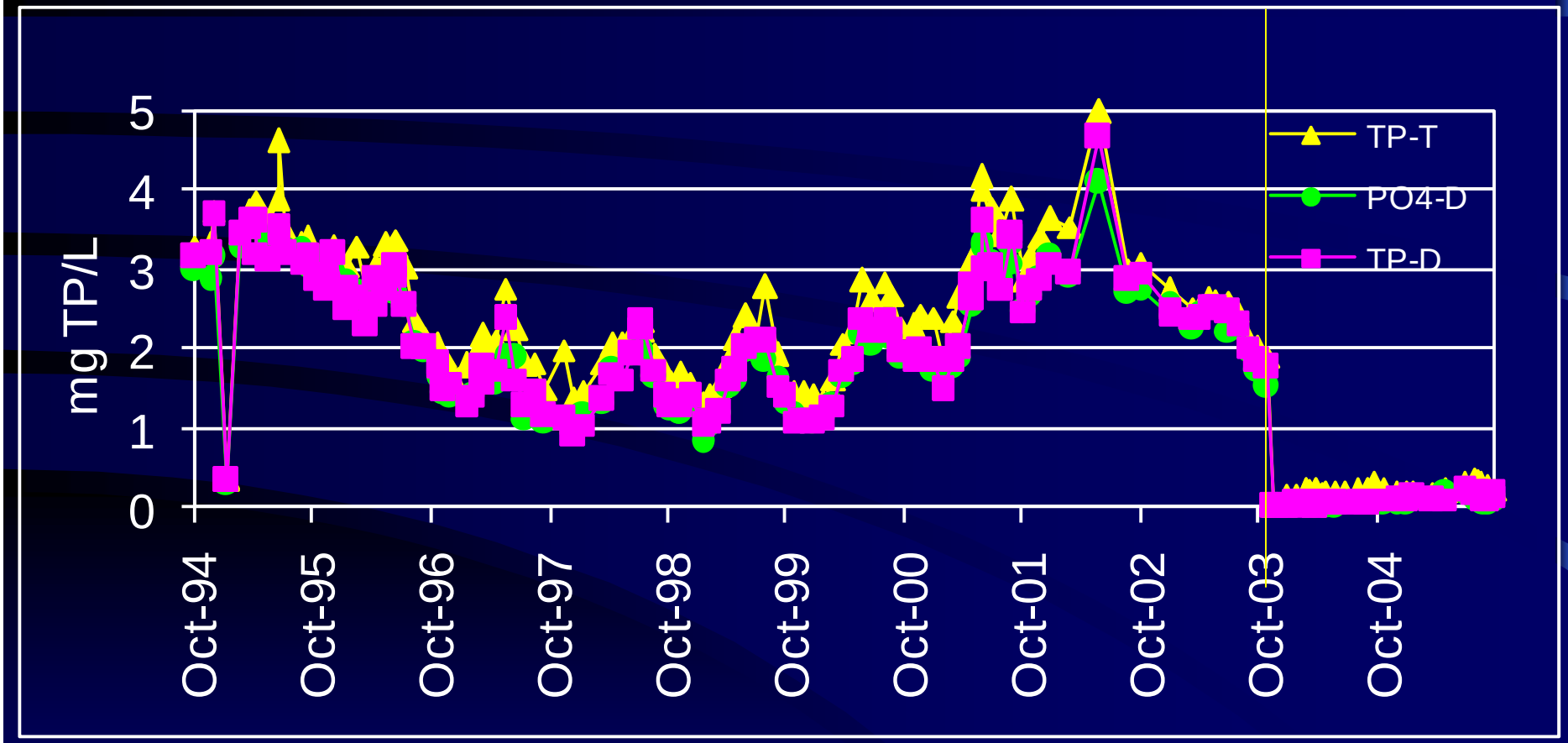
Logistical Challenges

Removal Efficiencies Among Selected BMPs

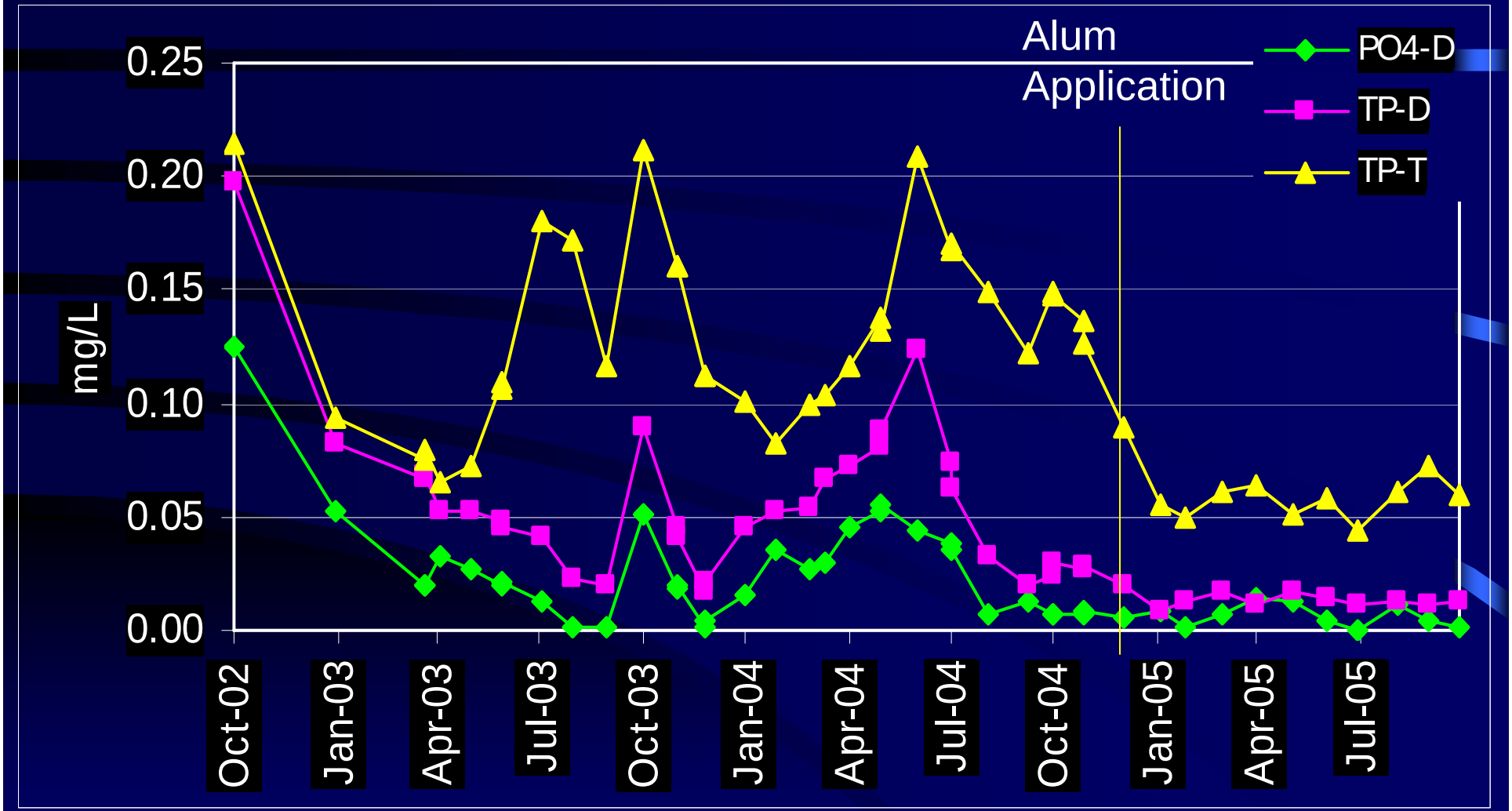
BMP Category (FDEP 2007)	# BMP Studies	Weighted Average Removal Efficiency (%)		
		TSS	TN	TP
Dry Detention	4	77	-2	22
Grassed Swales	10	33	-33	-270
Hydrodynamic Devices	9	2	2	0
Media Filter System	4	52	26	36
Periphyton Filters	1	35	12	17
Wetland Treatment	8	48	-8	31
Porous Pavement	2	-67	-16	18
Wet Detention	22	49	26	61
Hydrodynamic Devices (Alum Enhanced)	2	-78	16	38
Wet Detention with Alum	3	57	14	50
Alum Injection Systems (Harper 1990)	-	89	78	89

Eustis Muck Farm – P Species

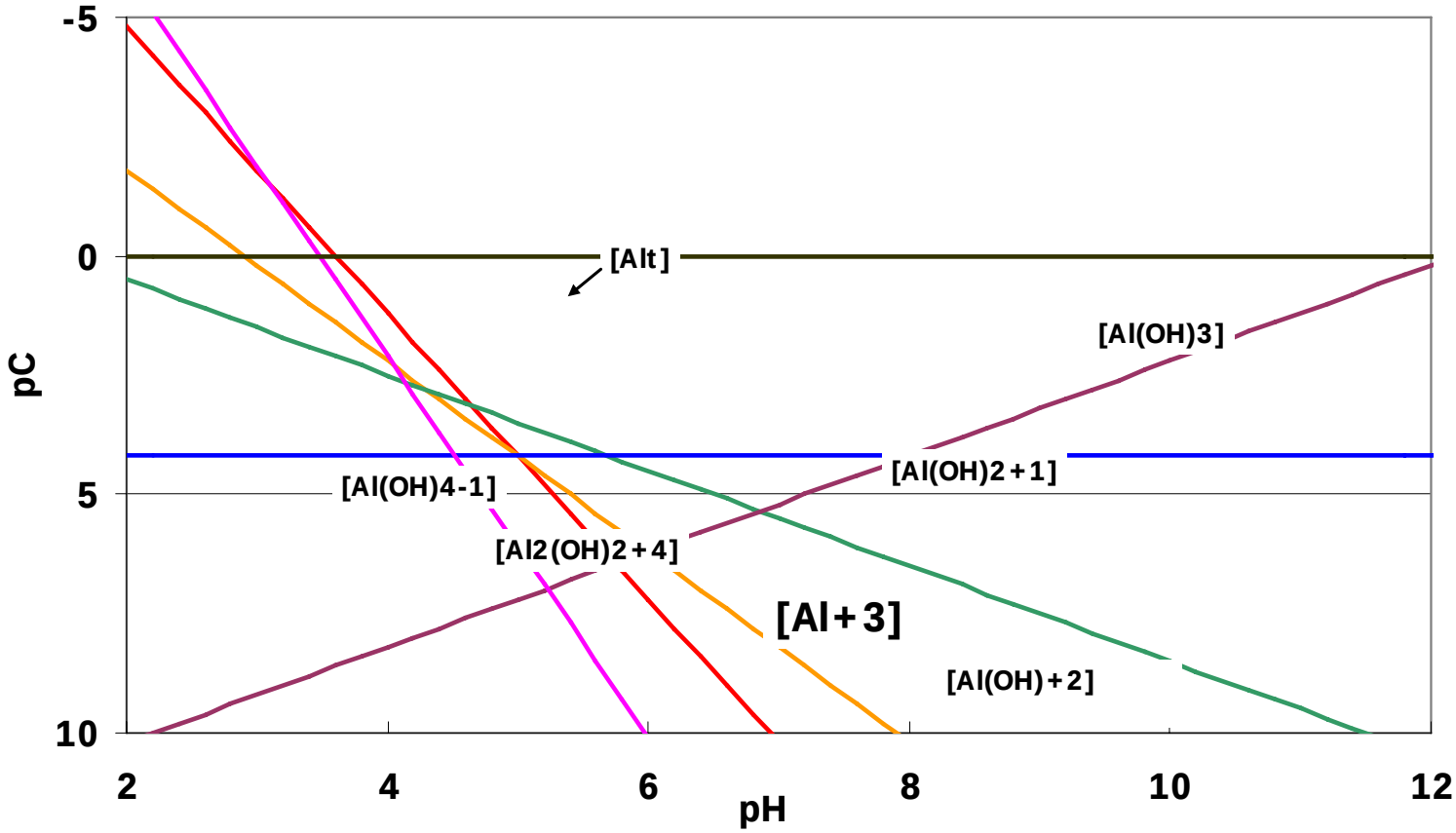
Alum / Sodium
Aluminate Application



S N Knight North – P Species



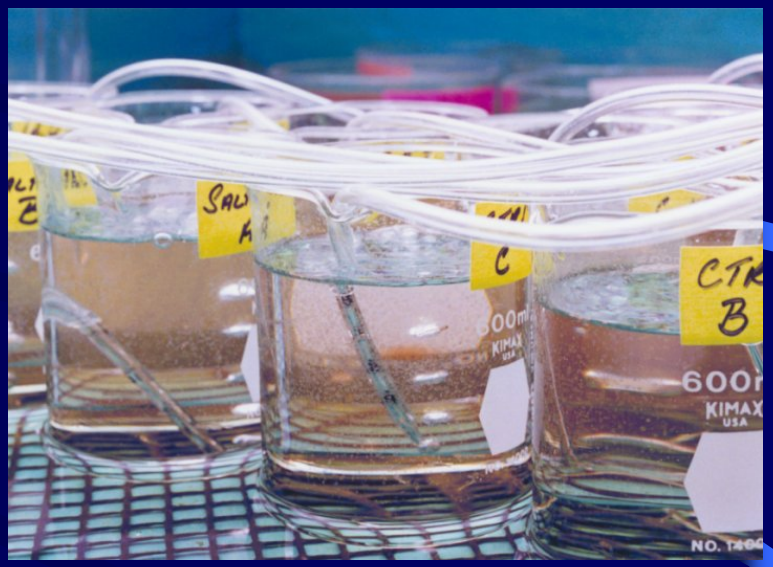
Solubility of Aluminum Species as Function of pH and Relationship to Toxicity



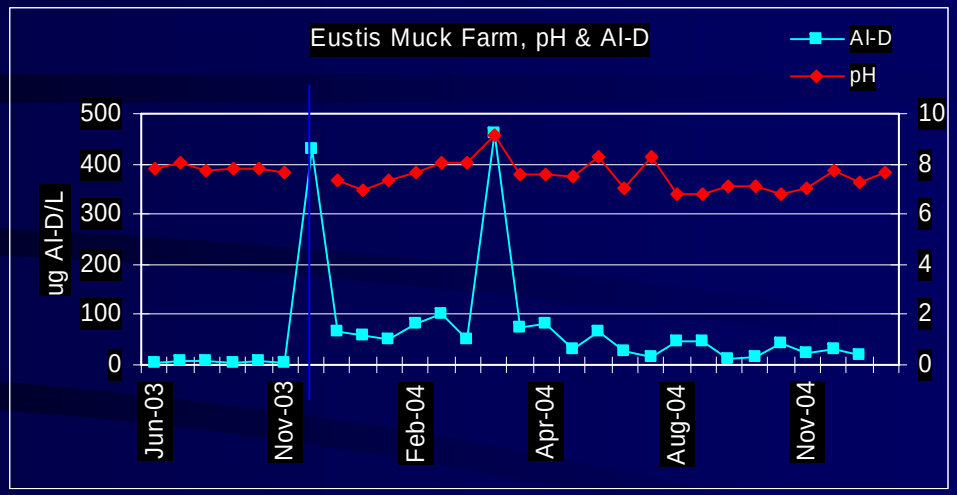
Reducing potential toxicity of aluminum

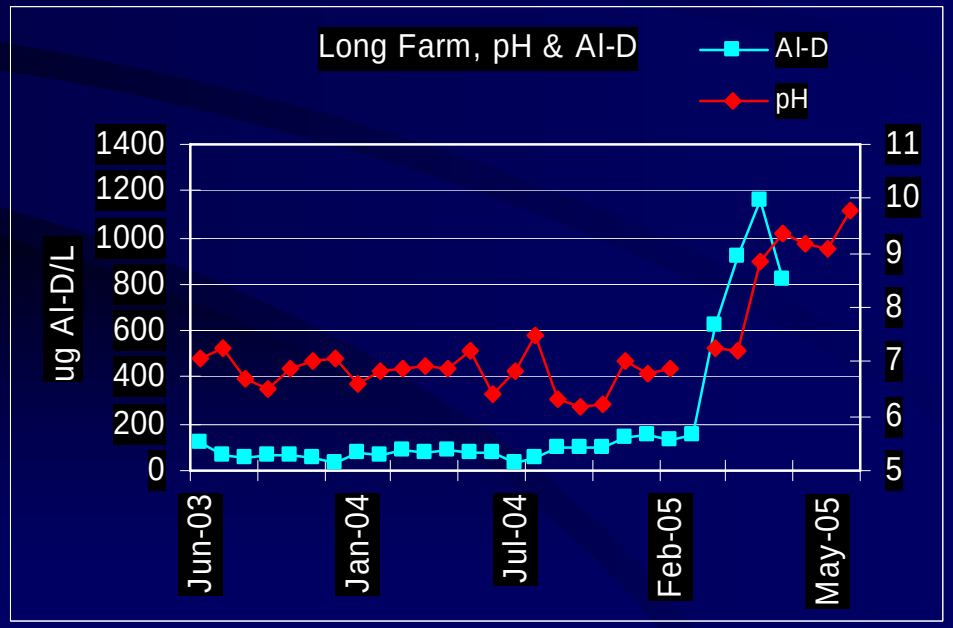
- Adaptive management of pH
- Bench scale testing of site water
- In small ponds, treat in stages to allow fish movement away from floc
- Molluscs may be sensitive
- Is bedding of floc an issue?

- Al toxicity to humans – fact or perception?



Dissolved Al and pH





Treatment Dosing Design

- Site-specific
- Benchscale testing
- Mesocosms or field trials

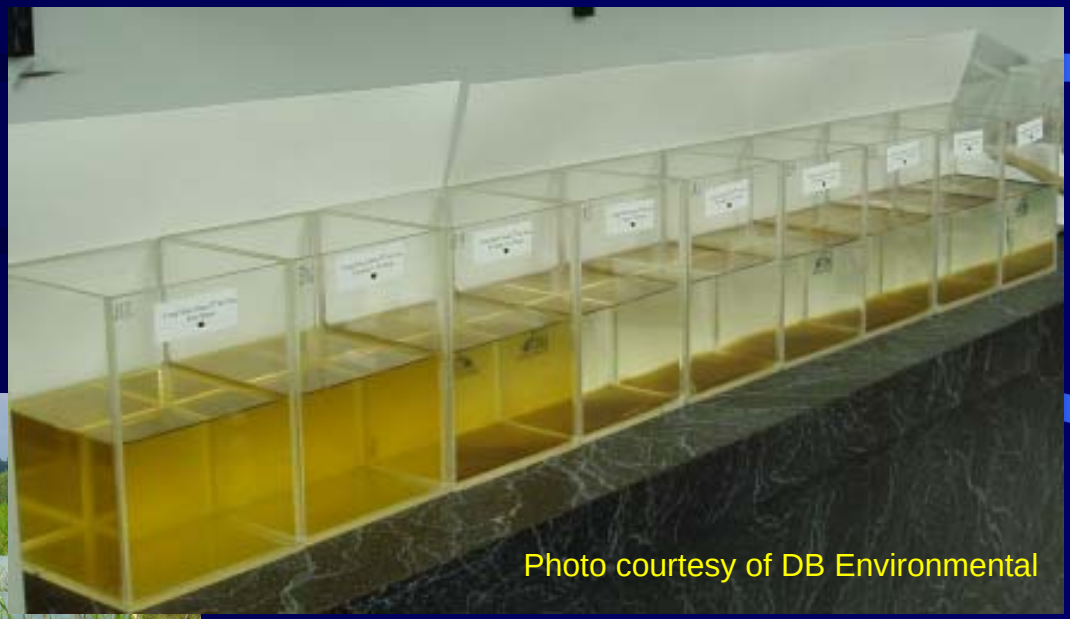
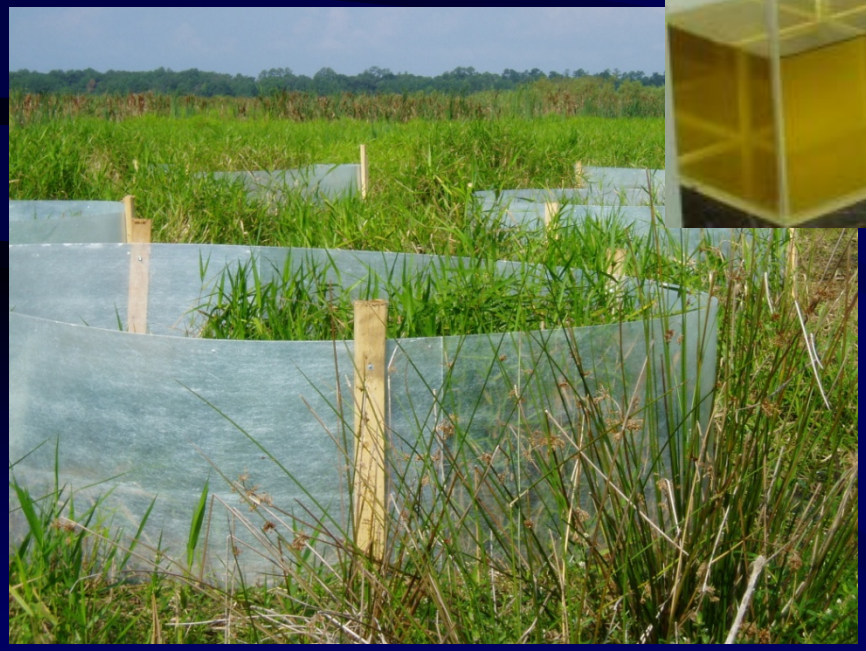


Photo courtesy of DB Environmental



Design – Information Requirements

- Background water quality
- Soil or sediment nutrient concentrations
- Water quality target
- Site accessibility
- Space availability
- Floc retention and disposal
- Vegetation and/or sediment disruption during application

Design Issues - Injectors

- Lengthy distribution lines
- Adequate area to incorporate a settling basin
- Automatic floc collection system
- Pump sizing and performance
- Effects of weather on design
- Permitting can take longer than expected

Permitting Constraints - FDEP

- pH maintained between 6 and 7
- Minimum one minute mixing time before floc reaches settling basin
- Floc must be disposed of properly
- No discharge of floc to waters of the State unless there is no other choice

- Whole waterbody applications vs. injections

Floc Fate – Proper Disposal or Reuse

- Sanitary sewer
- Collection systems
- Resource vs. waste

Floc Disposal (fate) Issues

- The FDEP always wants to have floc completely removed and not discharged into receiving water.
- However, some SJRWMD permits (typically older ones) did not have this as a requirement.
- Currently, all systems are required to collect and remove all floc, usually in a settling basin prior to discharge into the receiving water body, unless a feasibility study has demonstrated that this is not possible.

Floc Disposal Issues (cont.)

- If floc is to be discharged to the receiving water, then extensive monitoring (water quality, macroinvertebrates, etc.) must be carried out.
- At a predetermined level, the entire volume of settled floc must be removed from the lake.

Operation Issues

- Proper design – buffer required?
- Proper dosage
- Trained staff
- Access
- Chemical delivery and storage

O&M Issues: Alum Injection Stormwater Treatment Systems

- Range: $10,000 to $50,000 annually.
- Actual cost depends heavily on rainfall.
- Long lines can create more difficulty.
- Pumps for alum system are difficult to regulate

Typical Cost per Mass P Removed ($/kg)

Method	$/kg P removed
Alum injection	~ 200 - 500+
Barge application	~ 30
Alum residual	~ 60

Scorecard – Alum Injection

Item	++	+	0	-	--
Removal Efficiency	✓				
Toxicity			✓		
Ease: Design		✓			
Ease: Permitting					✓
Ease: Operation				✓	
Value (Cost)		✓	✓	✓	

Scorecard – Alum Application

Item	++	+	0	-	--
Removal Efficiency	✓				
Toxicity			✓		
Ease: Design		✓			
Ease: Permitting	✓				
Ease: Operation			✓		
Value (Cost)	✓				

Questions?

January 24, 2006
Before

January 27, 2006
After