A Simple and Effective Filtering System for Pesticide and Nutrient Removal from Surface Water

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Why P management?

- Phosphorus (P) is essential to all forms of life on earth – no known toxic effects
- Adequate P levels in soils are essential for production of agronomic crops
- In most fresh surface water bodies growth of algae or aquatic plants is limited by P availability

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P Impact on Plants

- Vigorous crop (Shoot/Root) growth
  - Improved resource utilization
    - water, nutrients
    - positive environmental implications
  - Better resistance to stress
    - disease, pest, moisture, temperature
  - Earlier maturity
    - good grain & fruit development
    - better crop quality, yield

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Introduction

- Problem: phosphorus (P) in surface waters
  - P is a limiting nutrient among surface waters
    - Excessive P concentrations leads to eutrophication
      - Fish kills, odors, problems with water treatment processes (drinking water) and recreation

P transport to surface waters

- Occurs primarily via surface flow
  - Dissolved P – 100% biologically available
  - Particulate P – carried on eroded particles, not immediately bio-available
- Leaching and lateral subsurface flow very important in golf greens
- If the soil becomes saturated with P the potential for P loss increases significantly

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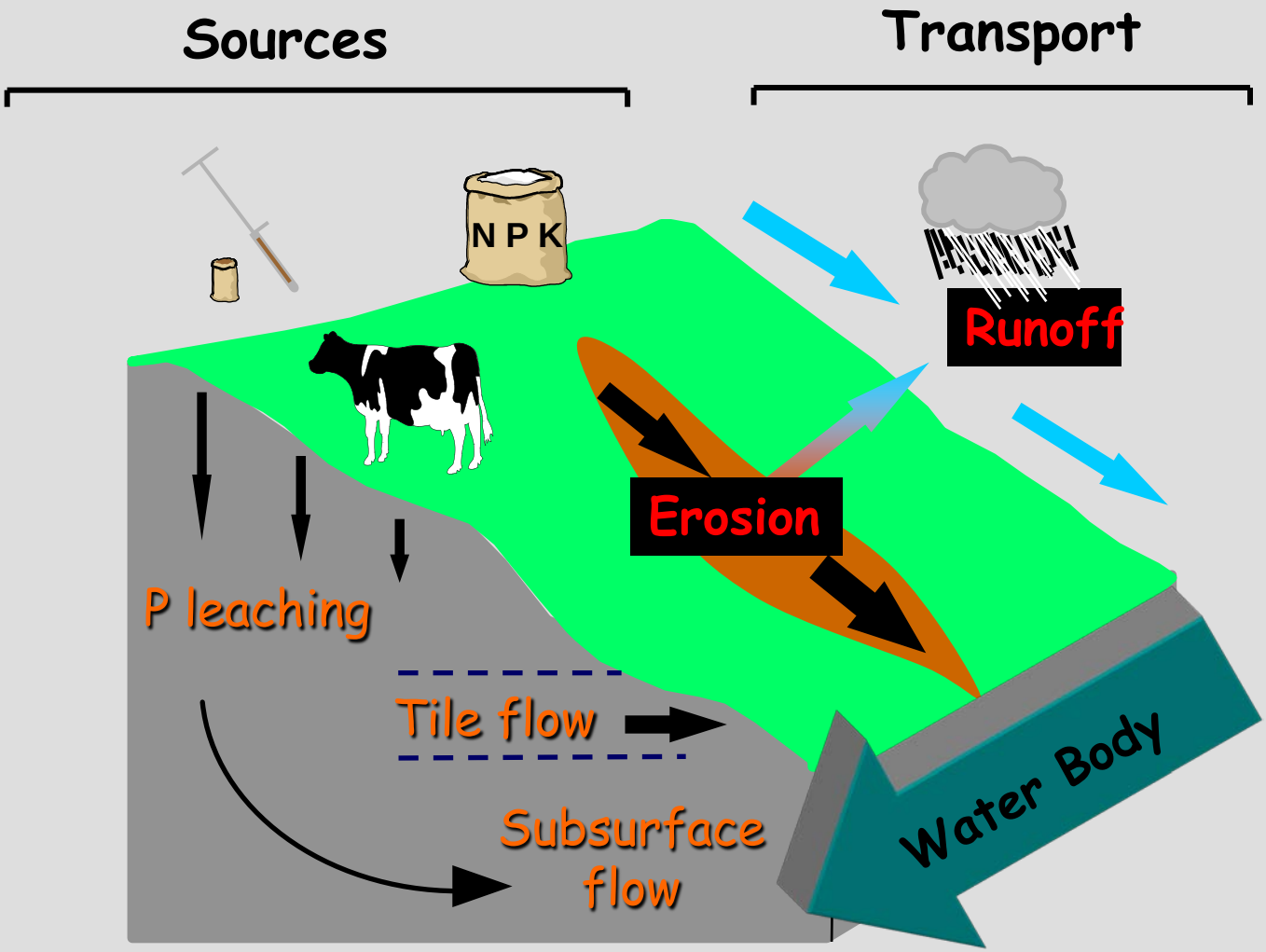
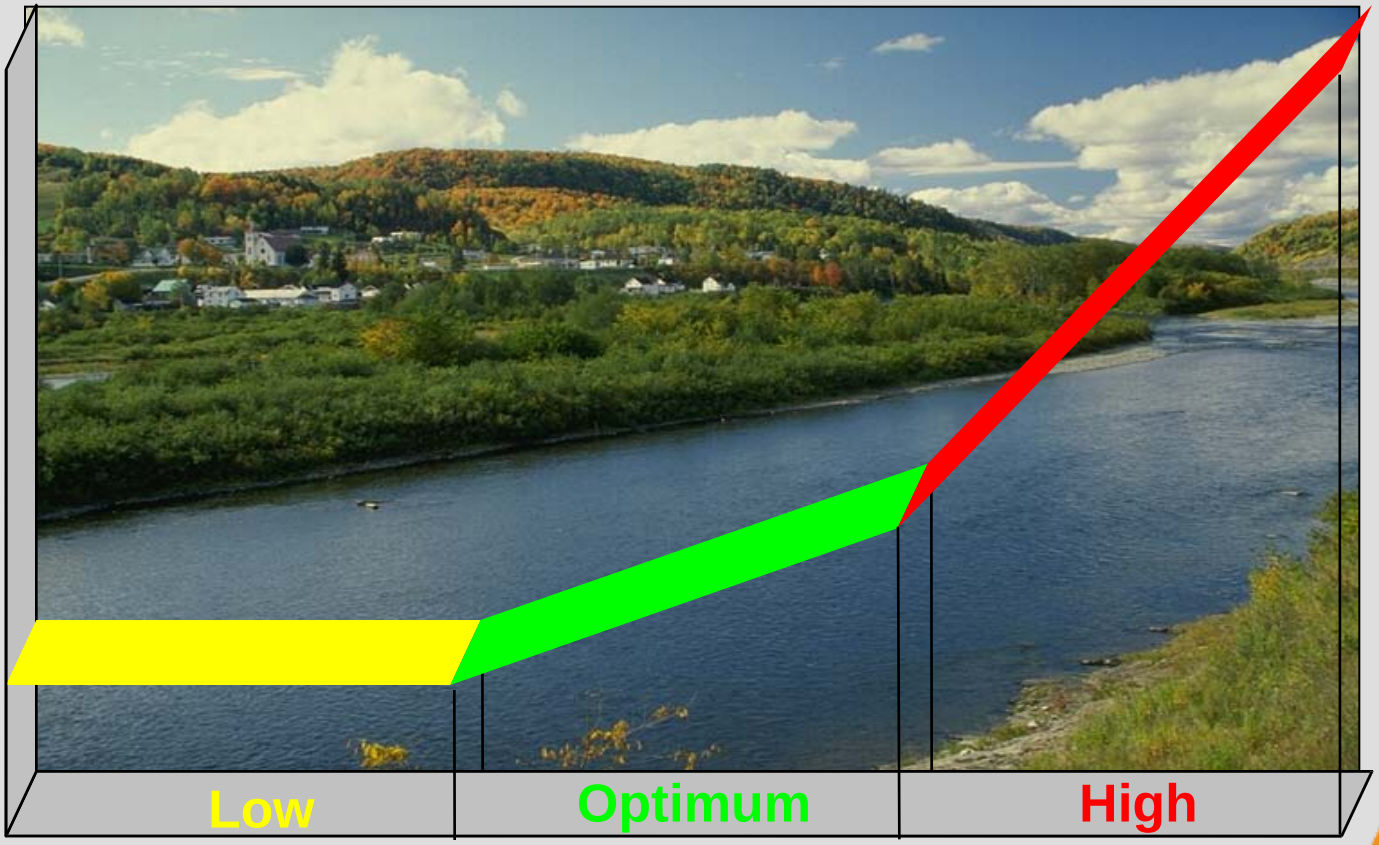
Phosphorus Losses: Source and Transport



P Losses to Surface Water

Risk Increases As Soil P Increases



P losses to surface waters

- Particulate P loss is easy to prevent
  - Erosion control
- Dissolved P loss is difficult to prevent from soils with high P levels or systems with little P retention capacity
  - Even if we stop applying P to high P soils, they will continue to produce dissolved P in runoff for many years

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Potential Solution for Dissolved P: P Sorbing Materials

- Chemical additions to soils, manures, and surface waters
  - Al, Fe, and Ca containing materials that chemically bind with P, reducing soluble P concentrations.
    - Al and Fe oxides/hydroxides: precipitation, ligand exchange, and electrostatic attraction
    - Ca: precipitation and electrostatic attraction
  - Many by-products contain potential P sorbing minerals

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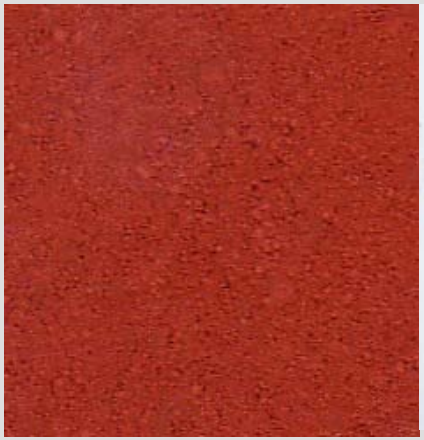
Examples of PSM's

Highly soluble Ca products (gypsum)

Highly soluble Al and Fe products (alum)



Natural or synthetic Al and Fe oxy/hydroxides (Fe oxides)

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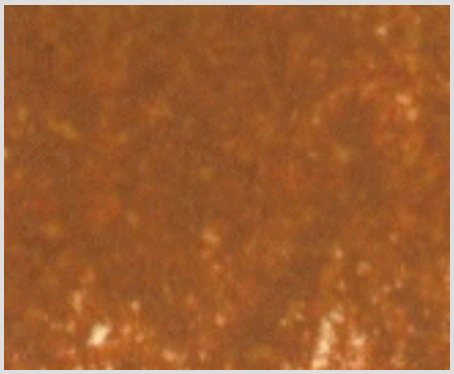
Example waste product PSM's

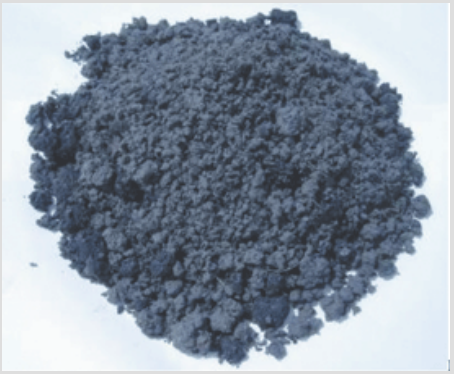


Acid mine drainage treatment residuals

Drinking water treatment residuals

Bauxite mining and production waste (red mud)

Fly ash



Paper mill waste

Steel slag waste

Waste recycled gypsum

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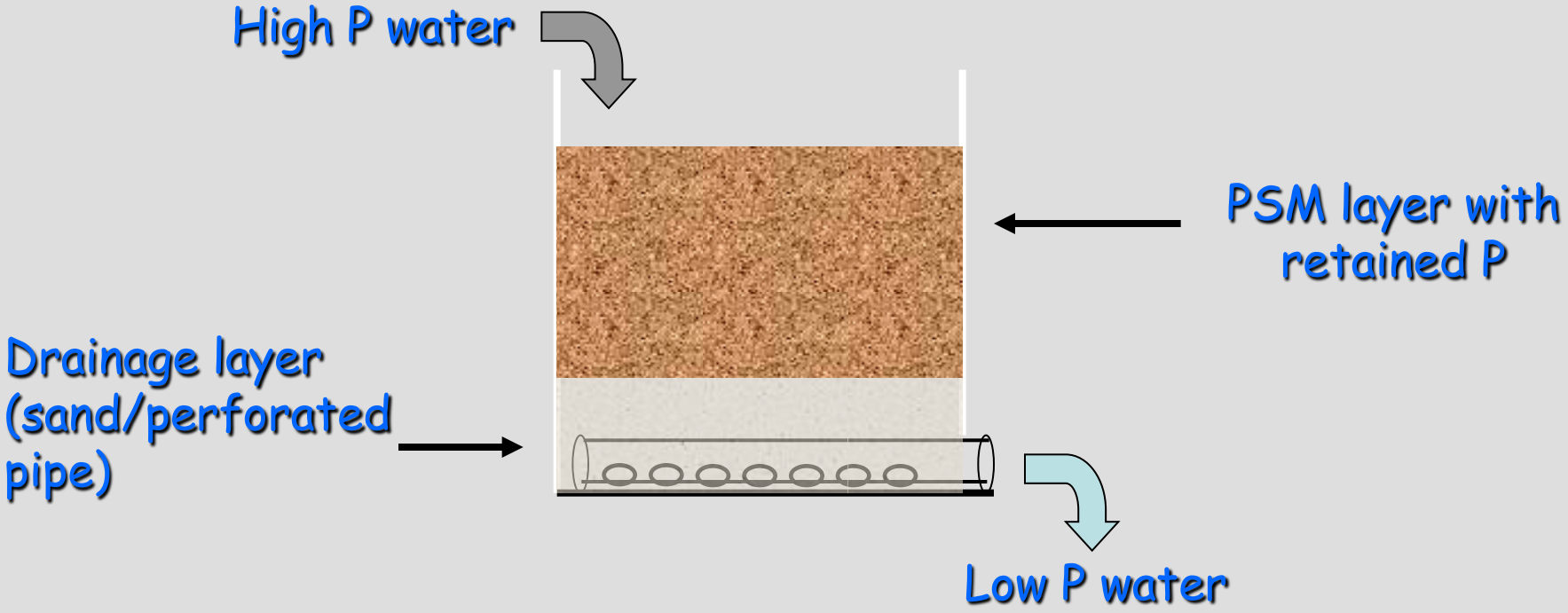
P Sorbing Materials: application to soils, manure, and surface water

- P is still present: simply converted into a less soluble form
- Therefore, one must consider the long term fate of P bound to PSM's

Solution: P removal structure theory



Advantages of P removal structures

- Ability to remove PSM after becoming saturated
  - P, various metals, and pesticides are removed from the system, preventing long term exposure.
  - spent P saturated material has fertilizer value
- Remove particulate P (PP) in addition to dissolved P (DP)

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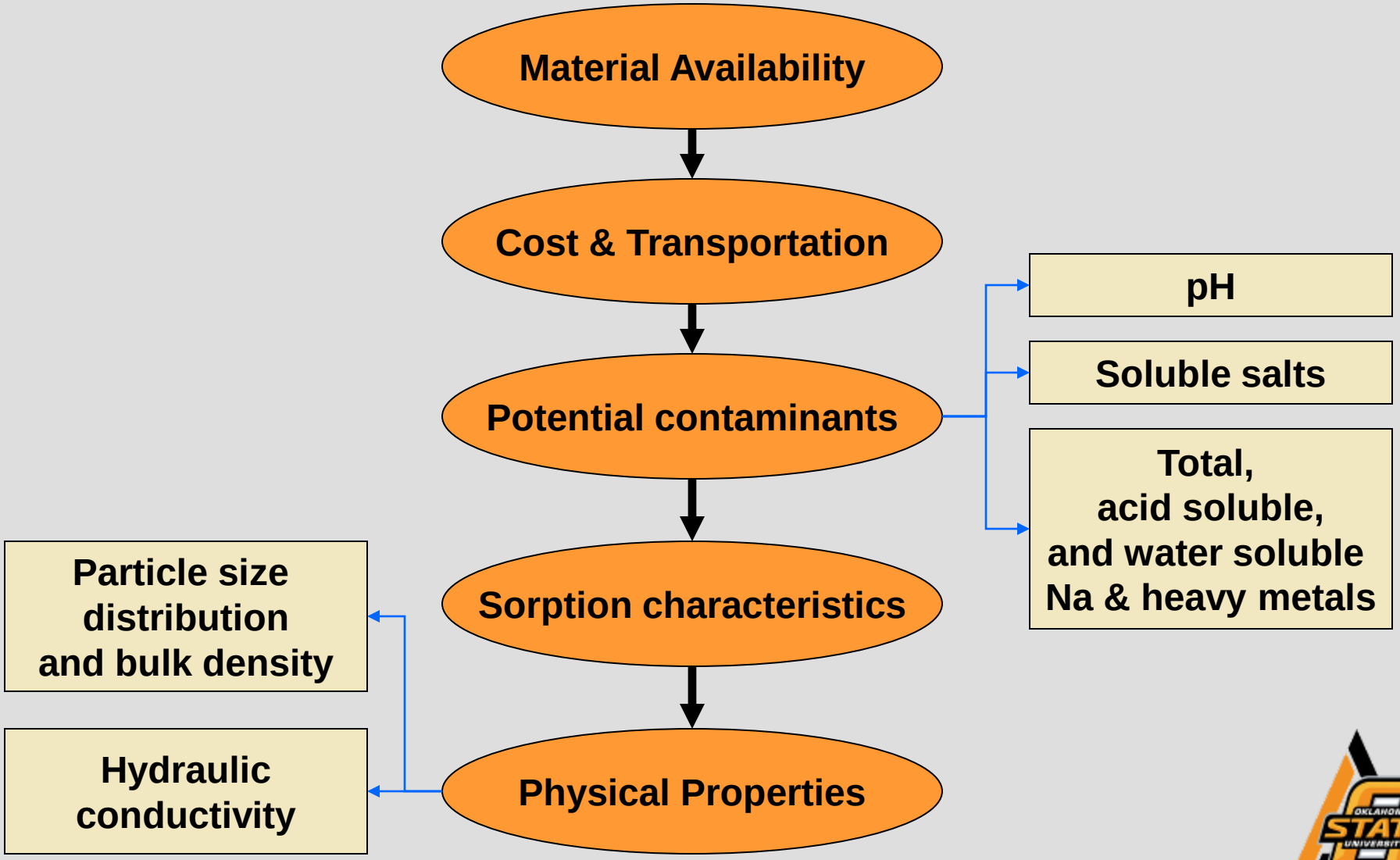
Selection Process for PSMs



Testing Grounds for Materials

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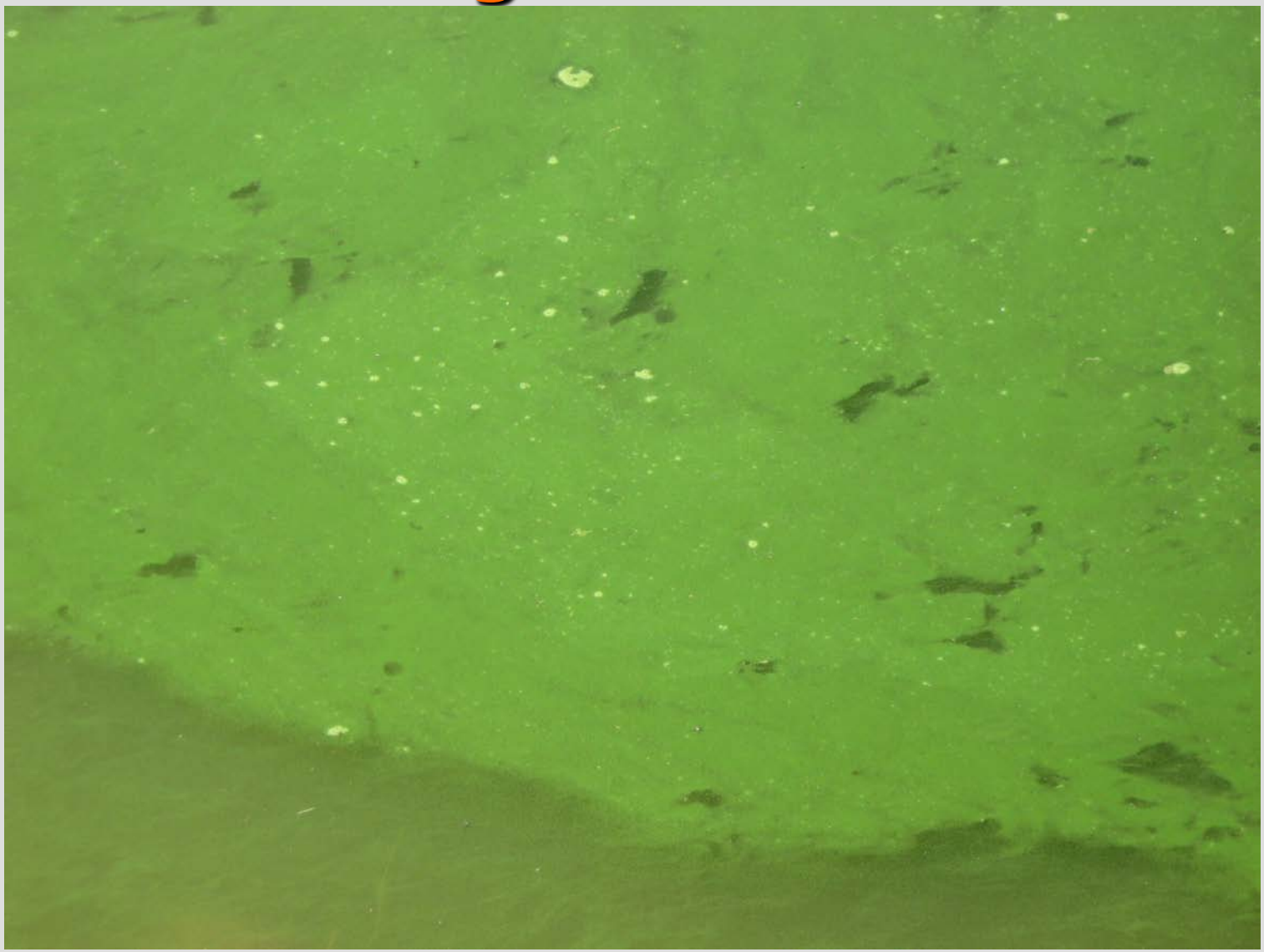
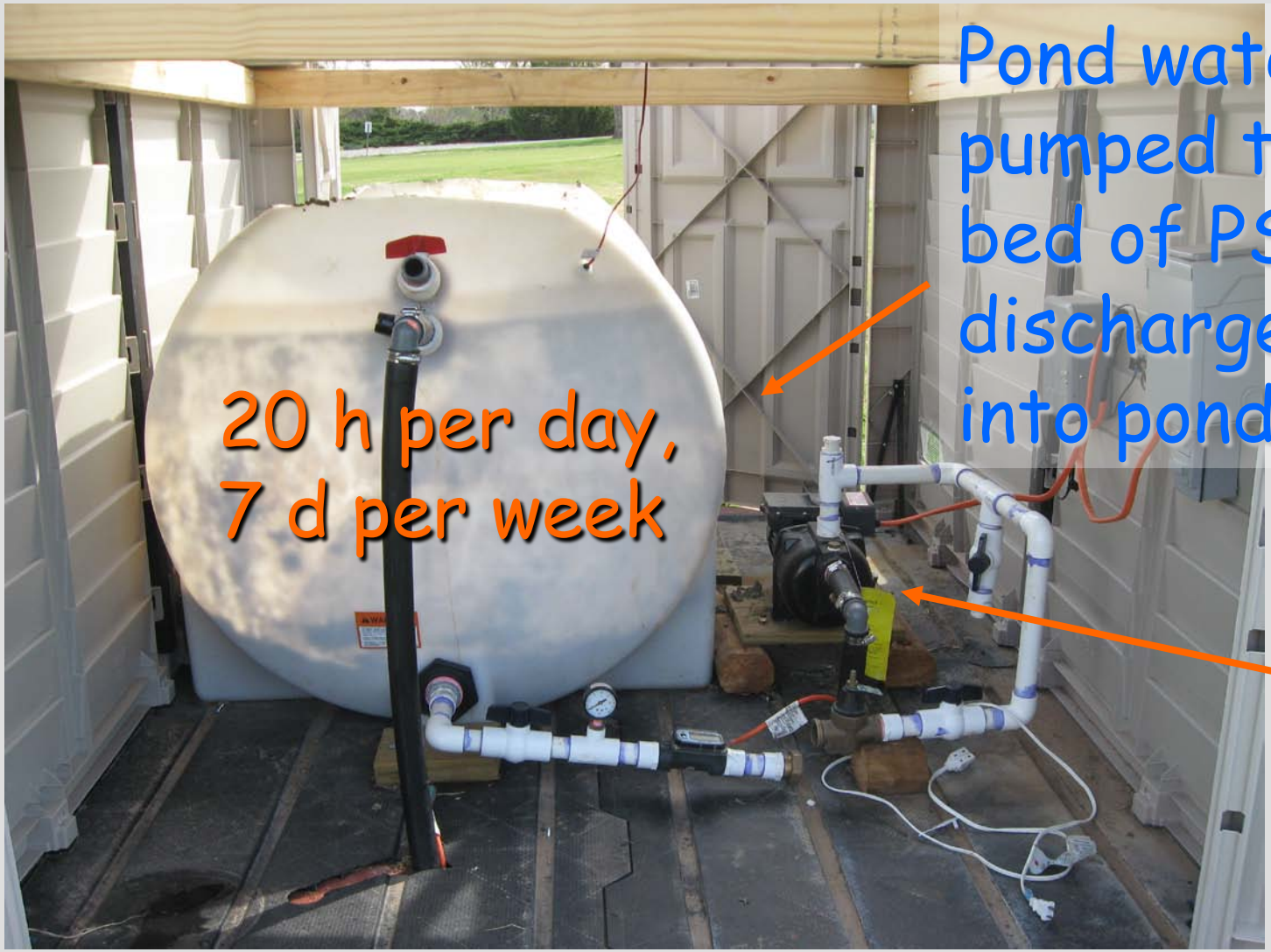
Algae Blooms



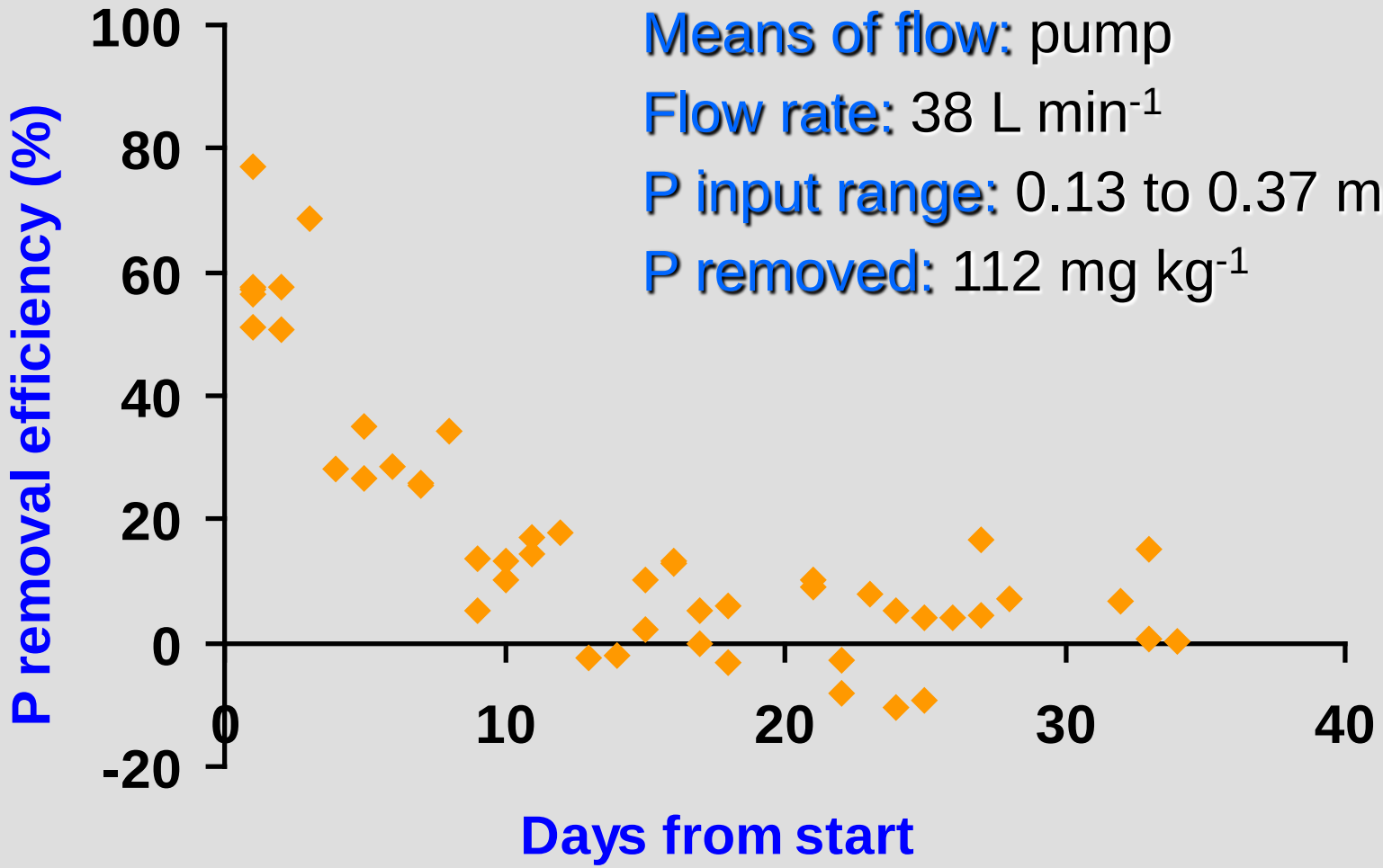
Objective

- Construct a P removal structure for the pond in order to test the P sorption capability of different materials under "real world" conditions
  - Drinking water treatment residuals (WTRs)
  - Fly-ash
  - Steel slag
- The goal was NOT to remediate the pond

Treatment Structure



P Removal: Tulsa WTRs



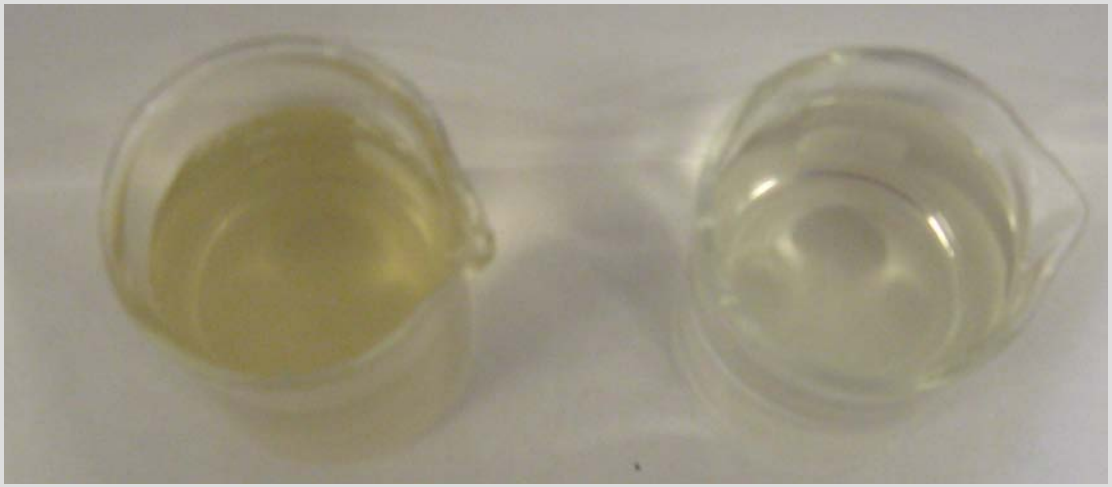
Means of flow: pump

Flow rate: 38 L min^{-1}

P input range: 0.13 to 0.37 mg L^{-1}

P removed: 112 mg kg^{-1}

Visible Removal of Green Color



Summary of materials tested in pond filter

Material	Flow rate (L/minute)	Flow method	Input P range (mg/L)	Time until spent (Days)	Total P removed (mg/kg)	P removal rate (mg/kg/day)
Stillwater WTRs+ 5% alum+ 5% sand	38	pump	0.10 - 0.33	17	79	4.65
AB-Jewel WTRs	38	pump	0.13 - 0.37	23	132	5.74
Fly ash (5%) with sand	0.3	gravity	0.17-0.43	na	23.7	2.37
Slag	1.5 - 8.5	gravity	0.31 - 0.46	na	18.7	2.67
> 1/4" slag	8.5	gravity	0.26-0.62	15	82.7	5.51

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Conclusions

- All materials tested were effective at removing P
  - Gravity-flow structures: hydraulic conductivity may be limiting factor
- More effective to filter drainage and runoff BEFORE it reaches a collection pond

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Success Stories: AMDR box filter

- Stainless steel box (1 x 2 m) installed in field drainage ditch (500 lbs AMDR).
- Results: removed **99% of P, Zn, Cu, and As** entering the box.

Success Stories: Gypsum Dam Filter

- 0.4 m thick bed of 90 tons *FGD gypsum;* 3 m wide by 1.5 m deep public drainage association (PDA) ditch.
- Results: removes about **67% of P** entering the ditch and is able to treat **more water** than the former system.

Structure in Progress: Stillwater Country Club

Future Research

- Pesticides
  - Many of the materials used to remove P will also have a strong affinity for organic compounds i.e. pesticides
- Nitrogen
  - More difficult: not held as strong
- Currently developing a simple model for designing structures
  - Based on easily measured characteristics

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