Lake Kampeska Phosphorus Removal Demonstration Project

Upper Big Sioux River Watershed Project

2014 Excellence in Environmental Engineering & Science

National Press Club Washington, DC

April 24, 2014

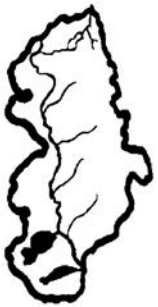
Project Team

South Dakota Department of Environment & Natural Resources
Protecting South Dakota's tomorrow...today!

HDR

WATERTOWN, SD

MUNICIPAL UTILITIES
WATER ELECTRIC GAS
WATERTOWN, SD



Upper Big Sioux River Watershed Project

Lake Kampeska Water Project District

Miller Electric, Inc.

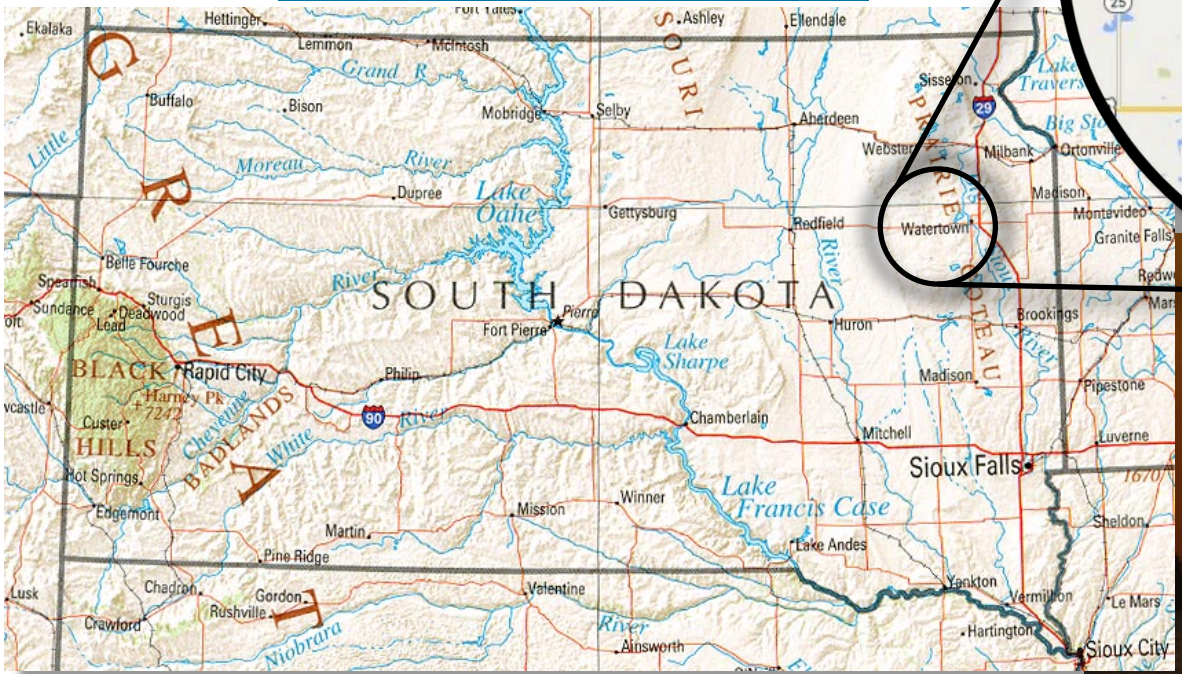
Upper Big Sioux River Watershed Project

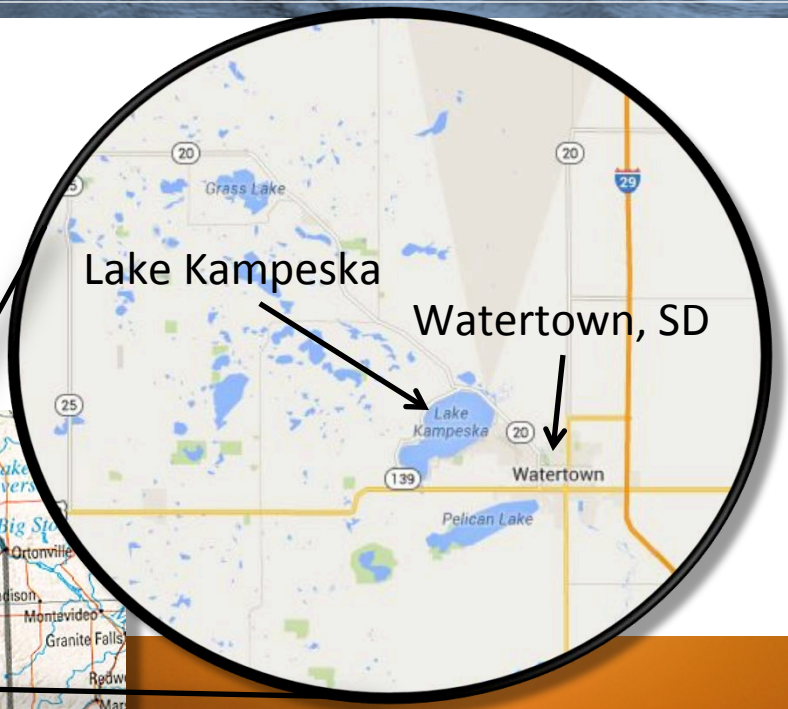
an EPA 319 program

- Put in place by the Clean Water Act 1972
- Targets Nonpoint Source Pollution
- Funding is 60/40, EPA / Local
- Upper Big Sioux Project Started about 20 years ago as the Lake Kampeska Watershed Project
- Was initiated by the Kampeska chapter of the Isaac Walton League
- Providing incentives and technical advise to install clean water practices

Lake Kampeska

Lake Kampeska
Phosphorus Removal
Demonstration Project





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The Swirls of Algae

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Basic Concepts

- Lake is nutrient rich
- Phosphorus feeds wild algae which degrades lake
- Algae eat nutrients
- Algae are easy to grow
- Basic growth requirements are light, nutrients, CO2
- The existing plant has the tanks, pumps, plumbing and control system to make the whole process possible

The Big Questions

- Can the treatment plant be efficient enough to counter spring loadings and make headway to reduce overall lake P levels?
- What will be the annual operating cost once we reach maximum efficiency?
- As the overall concentration of P decreases in the lake, will there be a decrease in sediment-based P releases due to fewer low oxygen events?
- Will we still be able to fish for walleye off the sea wall?

Project Approach

Lake Kampeska Filtration Plant

Conventional Surface Water Treatment Plant

- **Originally designed for chemical/ physical potable water treatment processes**
- **Out of service for several years**
- **Generally in good working order**

CONVERTING A DRINKING WATER TREATMENT PLANT TO GROW ALGAE

Project Approach

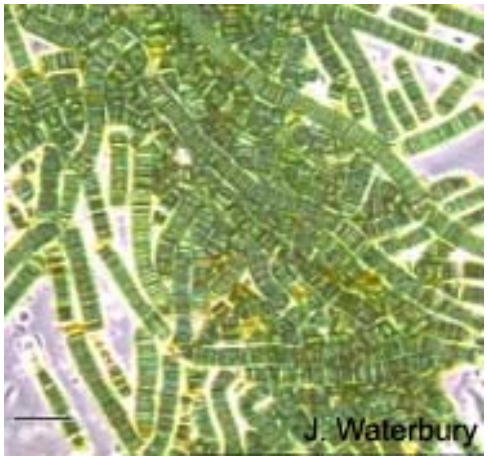
Comparison with Conventional Algae Biofuel Systems

Algae Biofuel Systems	Lake Kampeska Plant
• Large Surface Area to Volume Ratio	• Small Surface Area to Volume Ratio
• Use natural sunlight	• Artificial Light
• Cultivating specific algal species for maximum fuel production	• Cultivate native algal species for maximum phosphorus removal

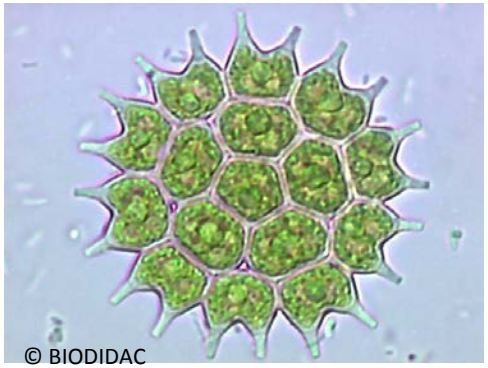
Most Significant Design Issue For Lake Kampeska Filtration Plant

Project Approach

- Encourage native algae populations
- Encourage an algae species that settles, such as Pediastrum sp.
  - Easier to separate and harvest



Blue Green Algae

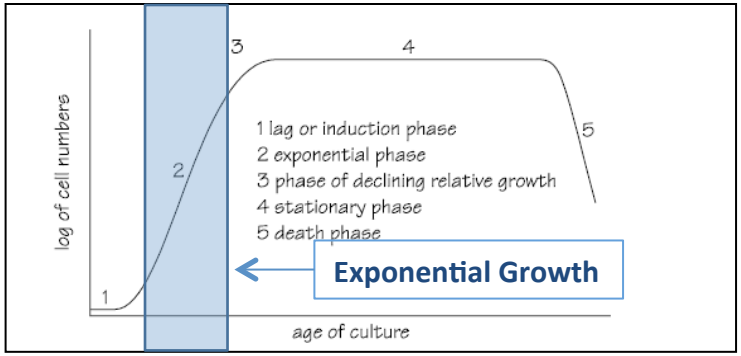


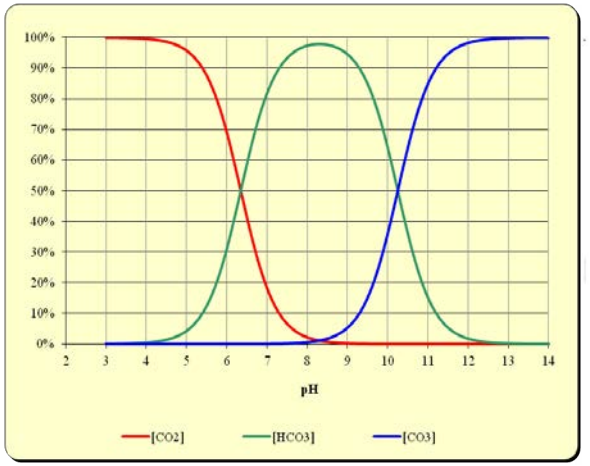
Pediastrum borianum

Project Approach

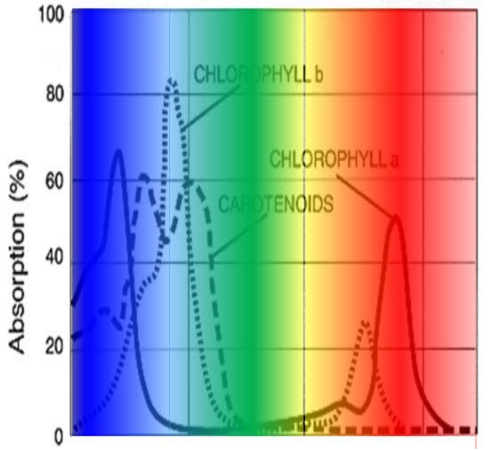
Key Technical Issues for Algal Growth

- Algal growth rate
- Algal decay rate
- Carbon Dioxide
- Temperature Effects
- Light Intensity and Distribution
- Optimum Mixing





Relationship between CO_2, HCO_3 and CO_3

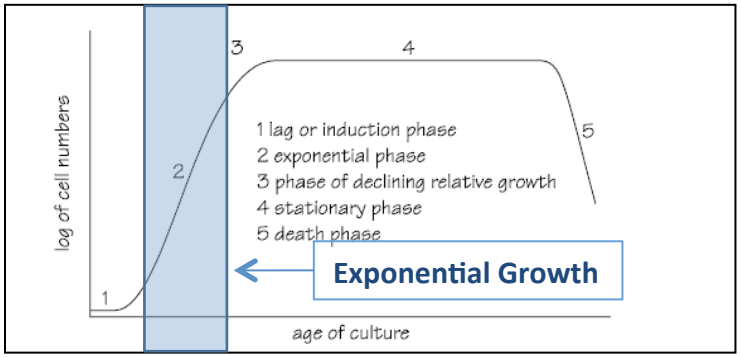


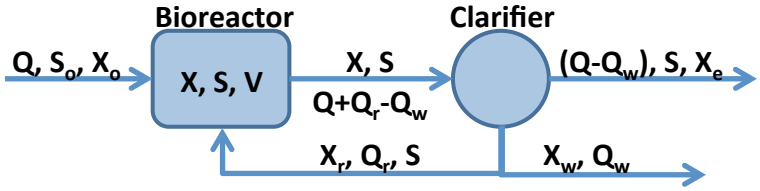
Wavelength (nm)

Project Approach

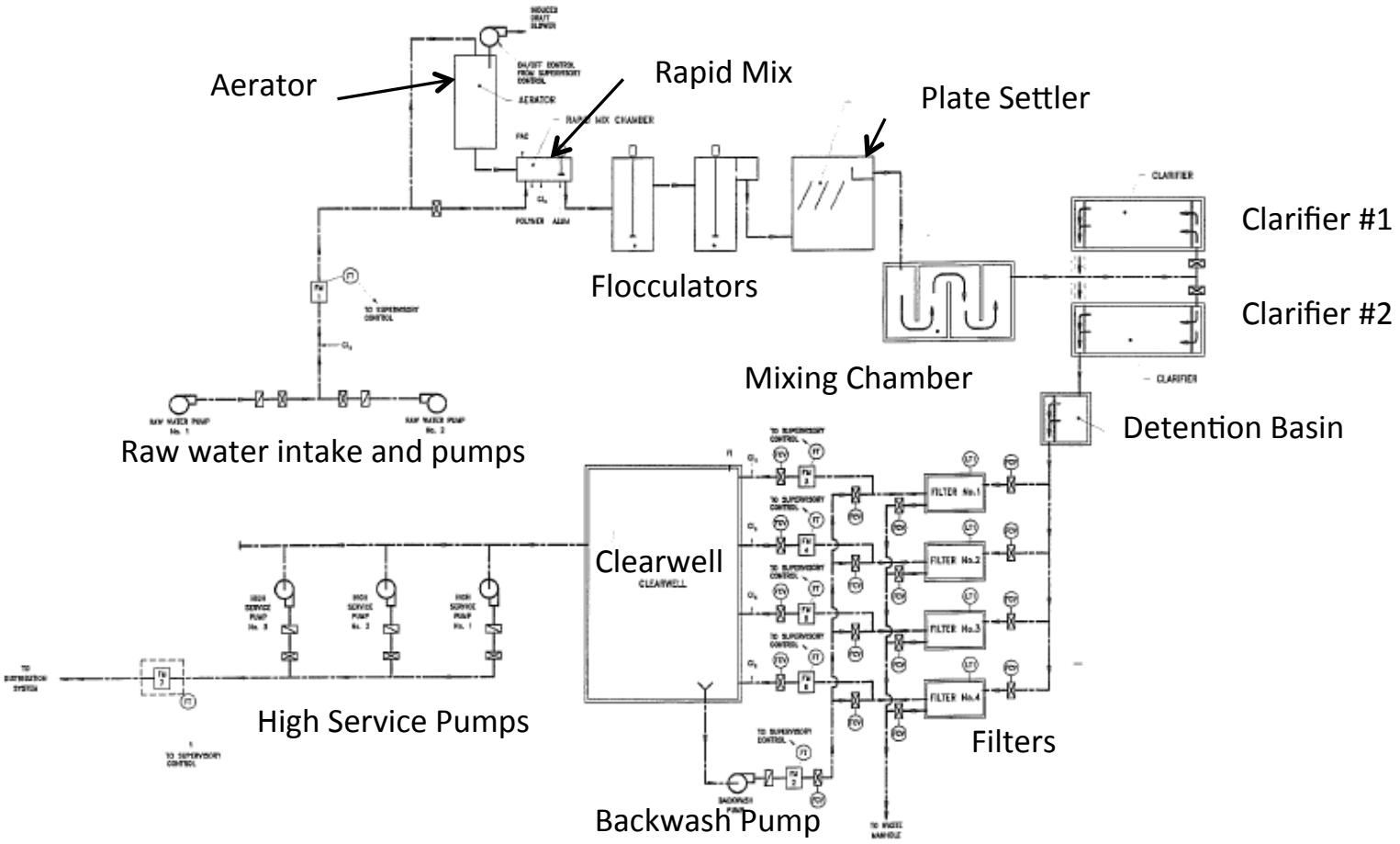
Comparison with Activated Sludge Process

Design Parameter	Algae Cultivation	Activated Sludge
S (Substrate)	Light	Organic Carbon
X (microorganisms)	Algae	Bacteria
Nutrients	P, N, CO_2	P, N, O_2
Hydraulic Retention Time (HRT = V/Q)	≈4 days	4 – 8 hours
Mean Cell Residence Time ($MCRT = VX/Q_wX_w$)	≈4 days (warm water) ≈10.5 days (cold water)	10 days





Project Approach



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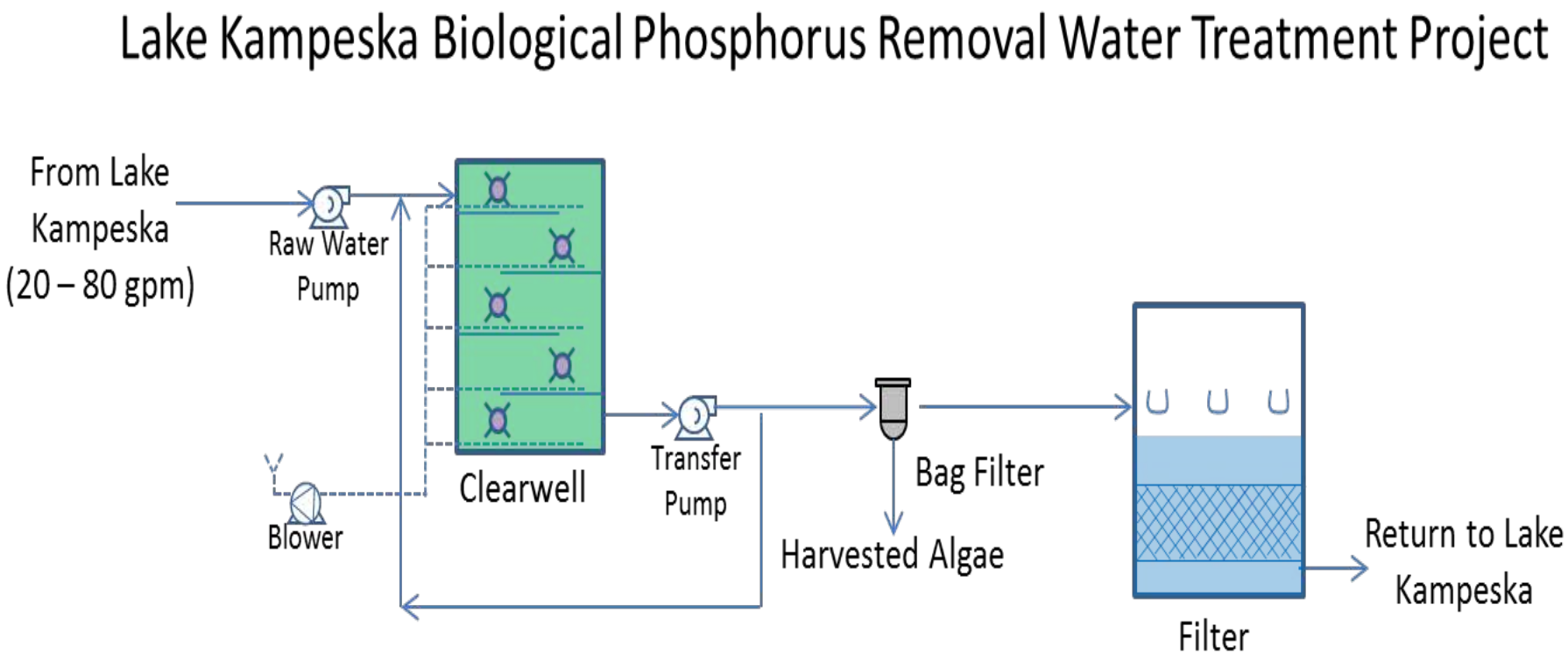

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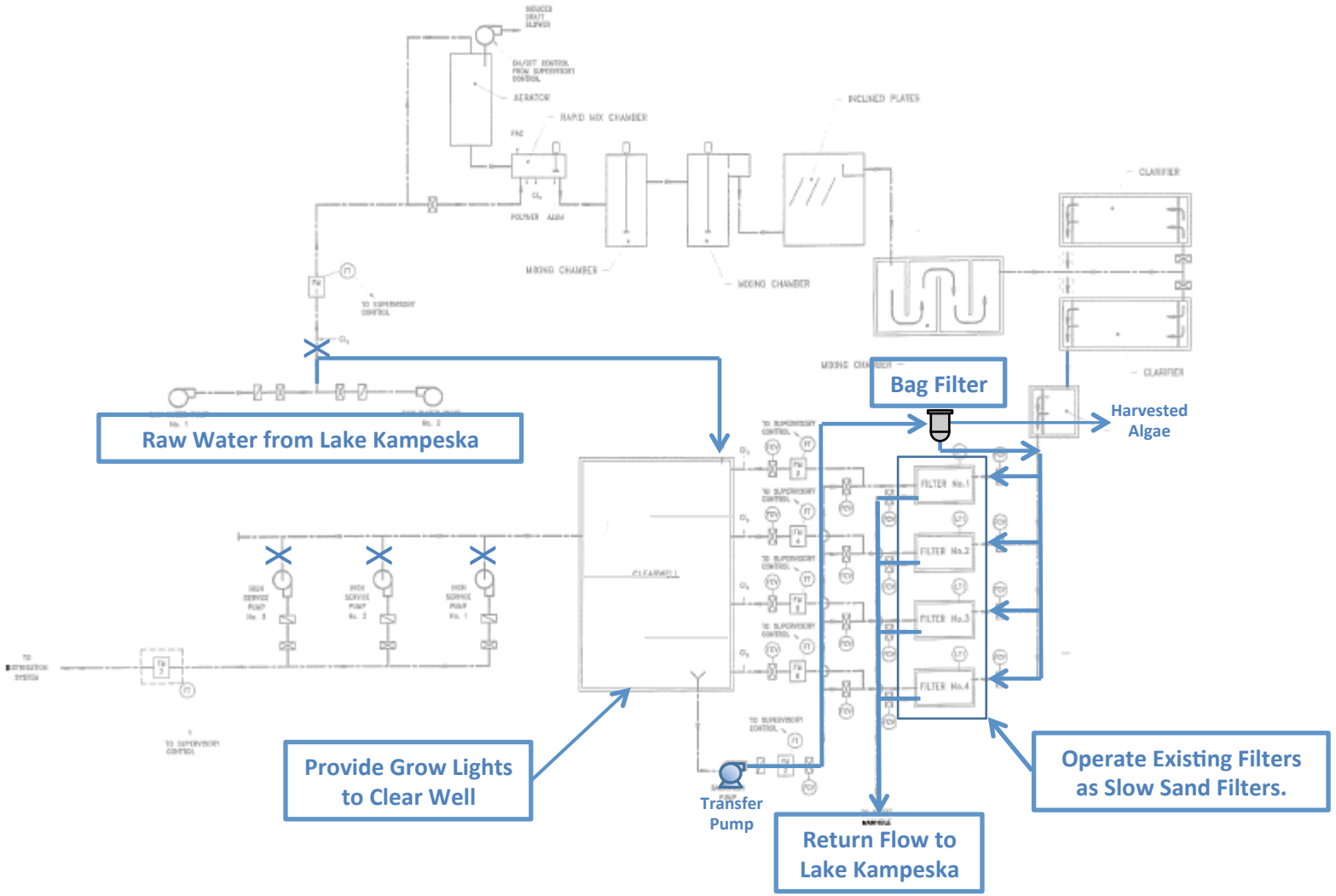
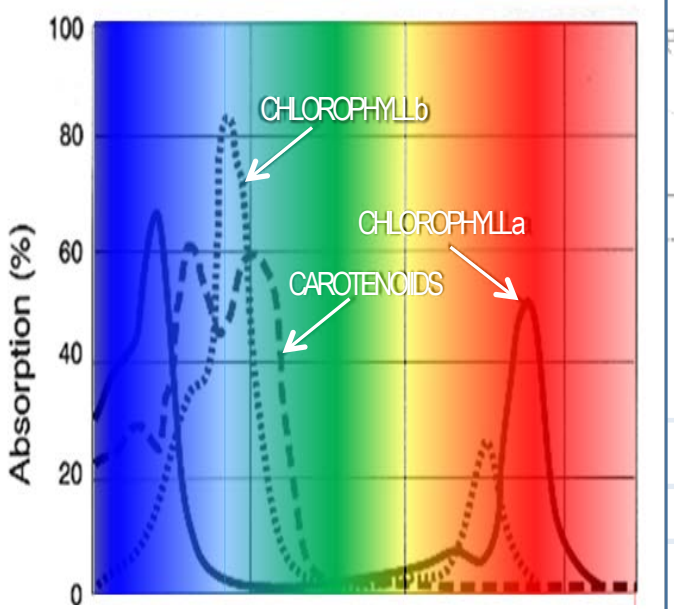


Project Approach



Algae adsorbs light in the red and blue spectra

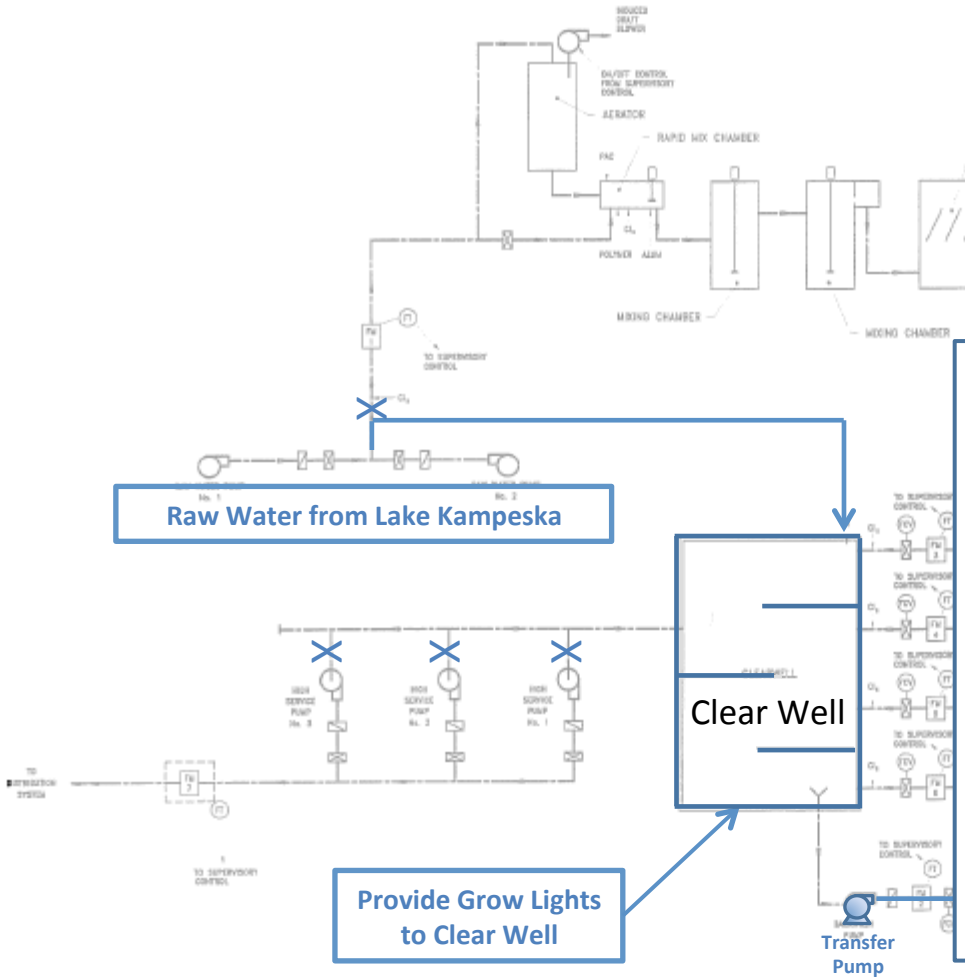
Clarifier #1

Clear Well

Provide Grow Lights to Clear Well

Lighting in Clear Well during startup illustrating the Purple Haze

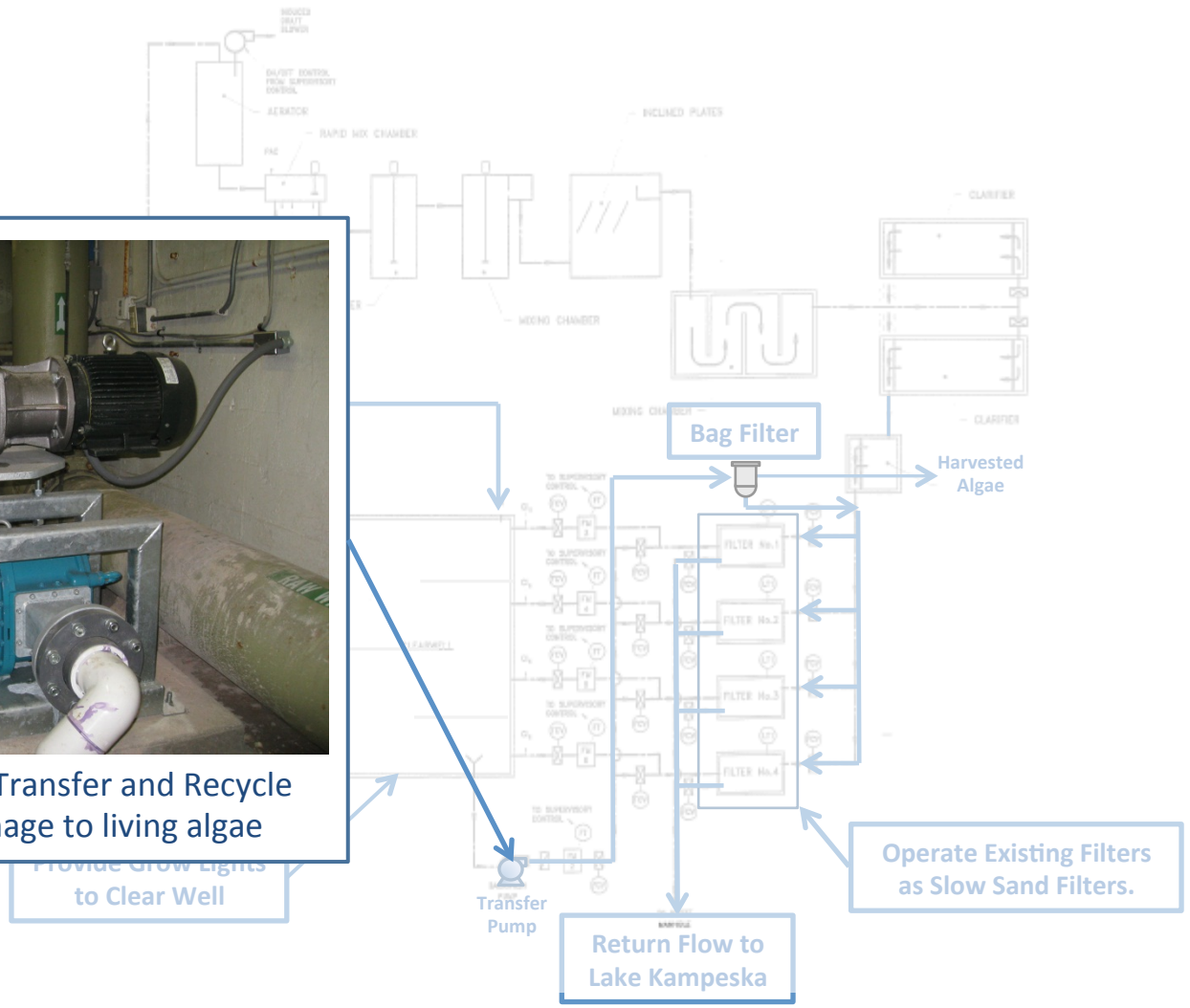
Project Approach



View through access hatch showing air bubbles and circulating the water.

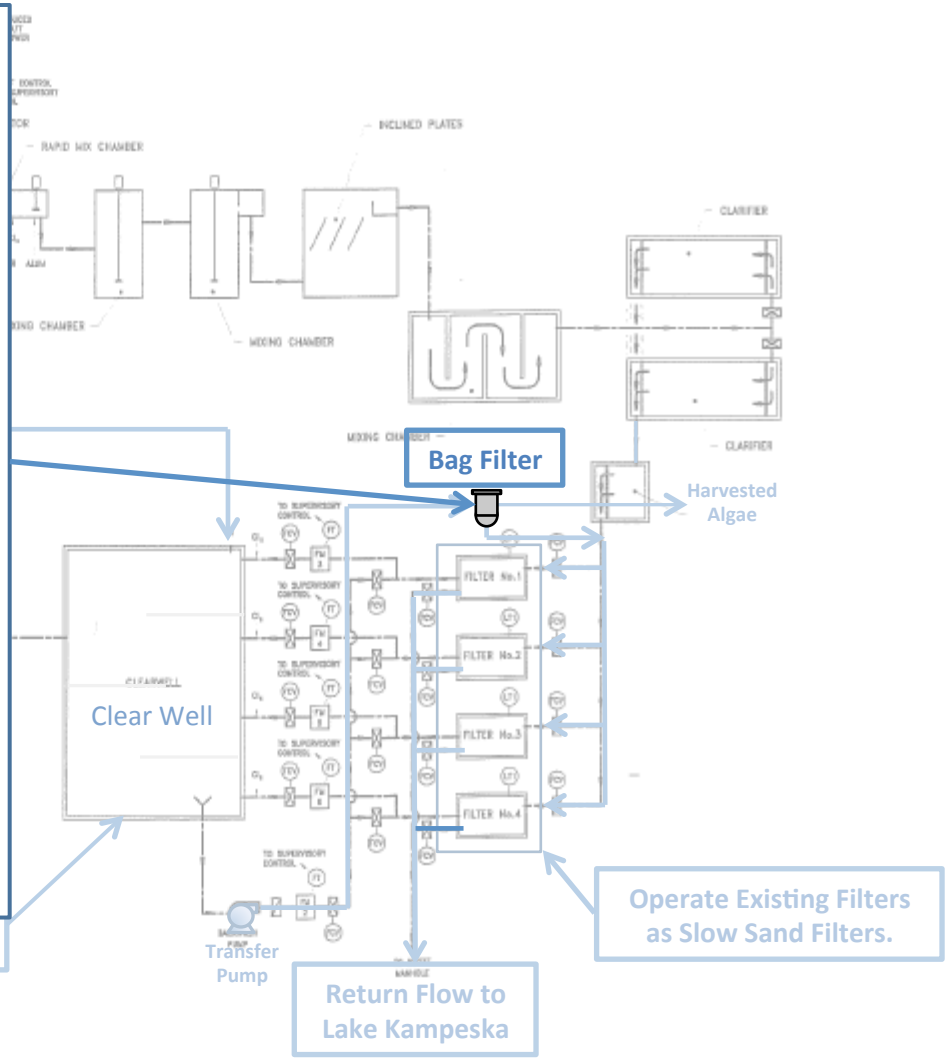
Project Approach

Rotary pumps used for Transfer and Recycle Pumps to minimize damage to living algae



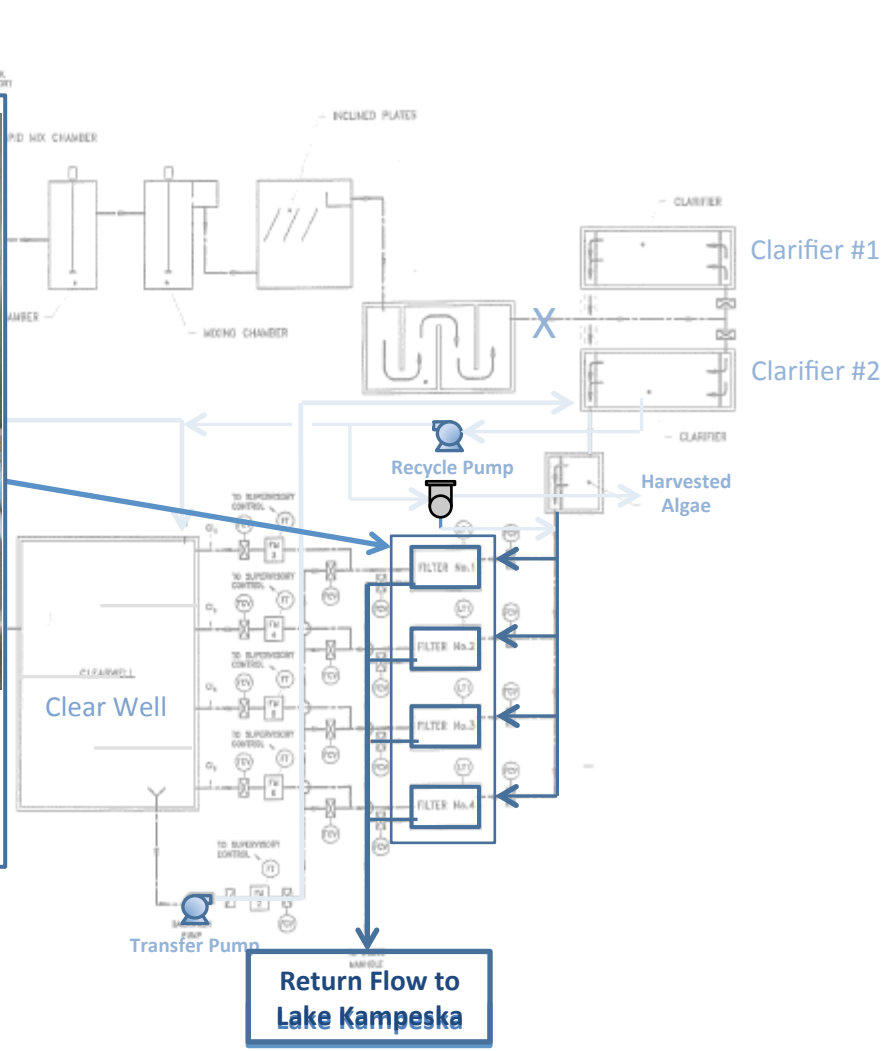
Project Approach

Bag filter allows for harvesting algae for investigating alternative uses



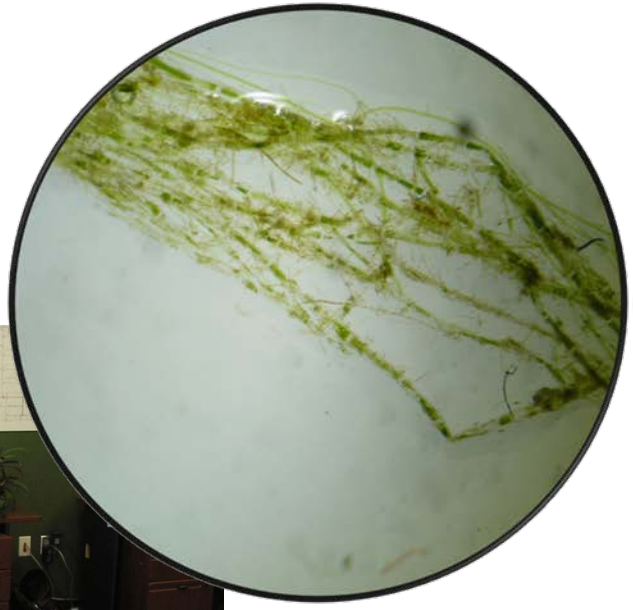
Project Approach

Existing filters are used as slow sand filters removing suspended solids before returning treated water to Lake Kampeska



HOW IS THE SYSTEM WORKING?

Algae Species



Microscopic view of algal species, Chaetophora (left) and Spirogyra (right), growing in cold (38 degree F) water

Results

July Phosphorus - 10% reduction

August Phosphorus – 5% increase

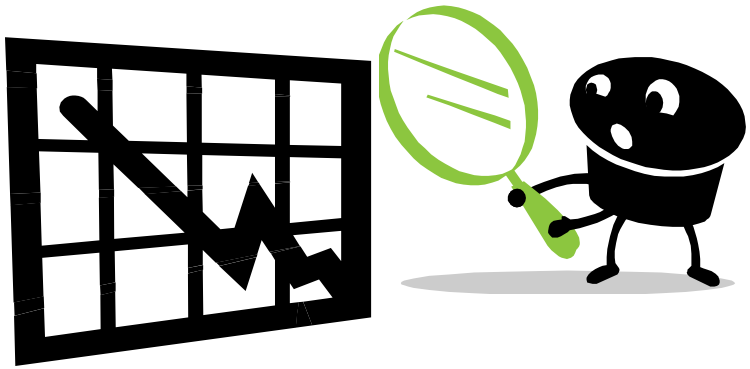
September Phosphorus – 4% reduction

October Phosphorus - 8% reduction

November Phosphorus – 2% reduction

December Phosphorus – 5% reduction

January Phosphorus – 30% reduction



Identified Algae Species

- Chaetophora
- Spirogyra

Pump Motor Failed is in for Warranty Repair/Replacement

Student Tours

Watertown High School science class facilities tour

Conclusions

- There are a large number of variables
  - Little literature is available to help make operational decisions
  - Long time to determine what changes improved or harmed the performance

- We can grow algae to reduce the phosphorus concentrations before returning it to the lake
  - It works, but the process continues needing optimization

Lessons Learned to date….

- Algae do not read the studies or behave accordingly.
- There are never enough valves or connections in a pilot/demonstration project.
- Clarifier detention time too long and algae die and release phosphorus into the water
- We also grow lots of water fleas.

Next Steps

- Vary detention time in clear well (change flow rate)
- Continue to identify and track algal species as they become dominant in the clear well
- Compare to summer warm water operations
- SDSU environmental engineering and biology students to assist with optimization and operation of the facility

Questions

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