Business Case for Lake Purdy Solar Powered Mixing System

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with Birmingham Water Works Board

Lake Purdy is a source of water for the Shades Mountain Filter Plant, which provide water to over 40 percent of the customers of Birmingham Water Works Board (BWWB). ADEM has ranked Lake Purdy as hypereutrophic – Carlson's tropic state index (TSI) of 70 or greater (based on Secchi disk transparency, chlorophyll, and total phosphorus). In its hypereutrophic state, Lake Purdy has the highest content of algae growth of any of BWWB's source waters.

Popular methods of trying to control algae growth include copper sulfate addition, mechanical aeration systems, or solar powered mixing systems. Copper sulfate, an herbicide, is falling out of favor because of the environmental problems associated with it. Most mechanical aeration systems are power intensive and cost prohibitive. However, over the last few years other water utilities across the nation have been very successful at reducing algae growth in their source water with solar powered mixing systems. Information on these mixing systems and success stories can be found at http://solarbee.com/

BWWB has worked with SolarBee, Inc. to estimate how many solar powered mixing units would be required to make significant improvement in Lake Purdy's water quality – sixteen units will be required at an estimated cost of $903,000. This would include the installation costs. After installation, there would be no additional power costs for operation because of the clean power being provided with solar panels.

The algae in the Lake Purdy source water increases the demand for chlorine in the treatment process. Reduction of algae in the source water for Shades Mountain Filter Plant would reduce the amount of chlorine needed for treatment. The more chlorine that is added the more disinfection by-products that are formed. Therefore, reducing the amount of chlorine needed for treatment would also lower the potential formation of disinfection by-products in the distribution system. Lower disinfection by-products would help to meet the more stringent Stage 2 DBP Rule for which sampling begins in 2012. Therefore, installation of Lake Purdy Solar Powered Mixing System would help BWWB meet future ADEM/EPA regulations.

Attached are energy costs and carbon dioxide output calculations for Lake Purdy for (1) Solar Powered Mixing System, (2) Mixing System without Solar Power, and (3) a typical Aeration System. Savings with the Solar Powered Mixing System is substantial. Also, attached are unit specifications and an example of how the system works.

	Solar Powered Mixing System	Mixing System w/o Solar Power	Aeration System
kWh	0.24	0.240	0.966
Run time (hours)	**24**	**24**	**24**
Energy Cost/kWh (cents)	$0.00	$0.105	$0.105
kW/day	**0**	**5.8**	**23.2**
kW/year	0	2,102.4	8,462.2
kW/5 Years	**0**	**10,512.0**	**42,310.8**
kW/10 Years	0	21,024.0	84,621.6
kW/20 Years	**0**	**42,048.0**	**169,243.2**
kW/25 Years	0	52,560.0	211,554.0
Energy Cost/Day	**$0.00**	**$0.60**	**$2.43**
Energy Cost/Year	$0.00	$220.75	$888.53
Energy Cost/5 Years	**$0.00**	**$1,103.76**	**$4,442.63**
Energy Cost/10 Years	$0.00	$2,207.52	$8,885.27
Energy Cost/20 Years	**$0.00**	**$4,415.04**	**$17,770.54**
Energy Cost/25 Years	$0.00	$5,518.80	$22,213.17

	Solar Powered Mixing System	Mixing System w/o Solar Power	Aeration System
Quanity Required	**16**	**16**	**32**
Price/Day	$0.00	$9.68	$77.90
Energy Cost/Year	**$0.00**	**$3,532.03**	**$28,432.86**
Energy Cost/5 Years	$0.00	$17,660.16	$142,164.29
Energy Cost/10 Years	**$0.00**	**$35,320.32**	**$284,328.58**
Energy Cost/20 Years	$0.00	$70,640.64	$568,657.15
Energy Cost/25 Years	**$0.00**	**$88,300.80**	**$710,821.44**

CO_2 Output	Solar Powered Mixing System	Mixing System w/o Solar Power	Aeration System
lbs/kWh *	0	1.42	1.42
lbs/Hour	**0**	**0.34**	**1.37**
lbs/Day	0	8.18	32.92
lbs/Year	**0**	**124.39**	**12,016.27**
lbs/5 Years	0	621.96	60,081.34
lbs/10 Years	**0**	**1,243.92**	**120,162.67**
lbs/20 Years	0	2,487.84	240,325.34
lbs/25 Years	**0**	**3,109.80**	**300,406.68**

*** 1.42 lbs of CO2 /kWh from BlueSkyModel.org (Southern Company)**

Patent Pending

SolarBee®

Circulating the World's Water

SB10000HW v18 FEATURES

Technology Description:	Floating, solar powered, circulation equipment for wastewater treatment and freshwater applications. Day/night operation on solar only by utilizing a battery to store excess daytime energy for nighttime operation.
Flow Rates:	*Flow rates at full speed at 10 feet (3 meter) diameter.*
Direct Flow Rate - Day	3,000 gallons per minute, (12,000 Liters per minute).
Induced Flow Rate - Day	7,000 gallons per minute. (26,000 Liters per minute).
Combined Flow Rate - Day	10,000 gallons per minute. (38,000 Liters per minute).
Combined Flow Rate - Night	10,000 gallons per minute (38,000 Liters per minute).
Machine Size/Weight:	Assembled machine is 16 feet (5m) in diameter and weighs 850 pounds (380kg).
Materials of Construction:	316 stainless steel construction. Foam-filled high-density polyethylene (HDPE) floats. Thermoplastic rubber intake hose. Concrete mooring blocks are encapsulated in HDPE.
Drive System:	High torque, direct drive (no gearbox), low voltage brushless D.C. motor.
Power Supply/Control System:	*PV solar panels are protected from bird fouling with bird deterrent kit.*
PV Solar Panels	3 X 80-watt photovoltaic solar panels orientated in triangular pattern. On-board battery storage for day/night operation.
Electronic Controller	Digital solid-state controller, mounted in weather-tight (NEMA 4X) enclosure with externally fused disconnect. SCADA output through RS-232 serial communication (Modbus RTU), DB9 male connection point inside enclosure. Wireless options available, not included.
Wiring	Corrosion-resistant industrial cord with molded watertight connectors that are indexed to prevent improper wiring.
Rotating Assembly:	Removable assembly with easy access to motor and digital controller. Impeller handles 4-inch (10cm) spherical solids. Oil-filled (food grade) teflon freeze sleeve with o-rings, shaft. Rotational indicator on shaft.
Flotation System:	Three floats in triangular pattern each with an adjustable float arm for proper vertical positioning, total float buoyancy of 1,450 pounds (660kg).
Floats	Each float have independence to move freely about a central pivot point on the bottom side of the float which allows the forces due to waves be applied to the floats which does not transfer to other machine components.
Float Arms	316 stainless steel heavy walled tubing provides a robust connection of the machine to the bottom pivot point of the high wave float.
Fluid Intake Assembly:	*Hose system bolted to bottom of structural assembly.*
Hose System	10 to 100 feet (3 to 30.5 meters) available in 36 inch (91cm) diameter X 10, 15, or 20 feet (3, 4.5, 6 meter) sections.
Intake Type	Horizontal high wave plate valve with 12-inch (31cm) openings. Valve releases escaping water through bottom of hose during high wave events to minimize stress on machine.
Intake Depth Adjustment	15 feet (4.5 m) of field adjustment with three SS chains connected to hose coupling.
Anchoring:	Two mooring blocks tethered together with SS chain and attached to structural member on unit.
Ice Protection:	Freeze sleeve and positive pumping under distribution dish to maintain circulation.
Minimum Operating Depth:	48-inches (1.2 m) with optional leg extensions. No damage to machine or bottom of reservoir when run dry in shallow water.
Accessories Available:	(1) Marker Light Kit, and (2) Salt Water, Bio-fouling Kit.
Warranty:	Expect 25-year life, minimal maintenance. Limited 2-year parts and labor warranty. Limited 25 year photovoltaic module manufacturer performancy warranty and 10 year motor warranty.

Subject to change without notice.

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MEMORANDUM

To: Bob Smith, Director of International Business, CH-Trade

From: Christopher F. Knud-Hansen, Ph.D., CLM

Date: March 16, 2009

Re: Destratification in comparison to using SolarBees for lake management

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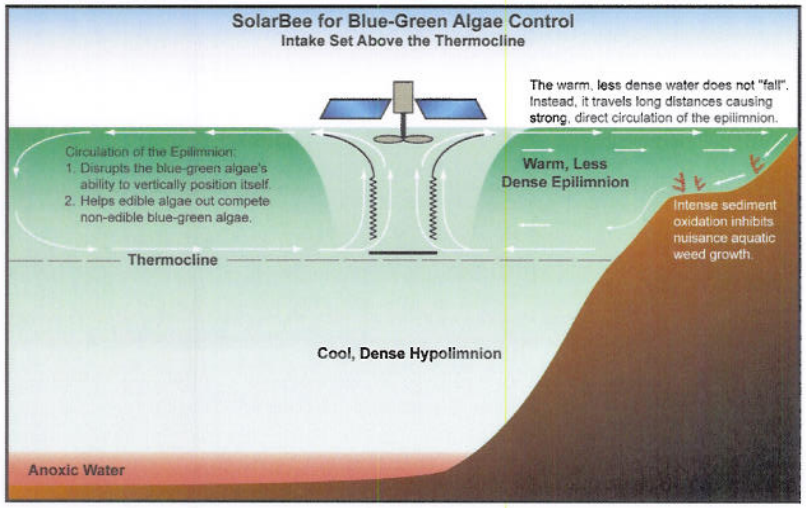
The following is a brief discussion on the relationship between SolarBee-induced circulation and destratification for lake management.

Background

It has been well established in the scientific literature for several decades that sufficient circulation inhibits cyanobacteria (blue-green algae) blooms. Since the 1920s, the most common way to circulate lake water has been through bubble plume aeration with the diffusers sitting on or just above lake sediments. The effectiveness of rising bubbles to mix waters is commonly demonstrated by isothermal (i.e., uniform temperature) vertical profiles indicating water column destratification above the aerators, but with limited horizontal range. As discussed below, however, it is not necessary (or necessarily beneficial) to destratify the entire water column to achieve either cyanobacteria bloom control or hypolimnetic oxygenation.

SolarBee circulation for cyanobacteria bloom control

The SolarBee is an up-flow circulation pump that can draw water up from any depth. The bottom of the intake hose has an induction plate fixed about 30 cm beneath the hose that forces water to enter the hose horizontally, not vertically. In order to achieve a greater area of influence, we keep the intake hose above the thermocline so only epilimnetic waters are circulated.

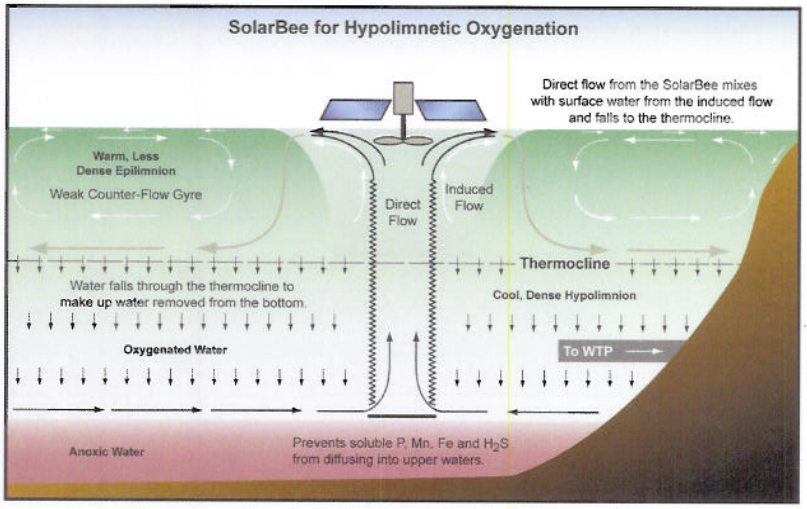


By circulating waters of similar density above the thermocline, there is both direct flow up the intake hose of about 11,400 lpm as well as induced flow of about 26,500 lpm, as illustrated in the above schematic drawing. Circulating only upper, epilimnetic waters where cyanobacteria grow has shown to be over 95% successful in controlling cyanobacteria blooms in the nearly 300 ponds, lakes and reservoirs (including about 120 municipal raw water storage reservoirs) where SolarBees are currently installed, some since 2000.

There are several advantages of circulating only epilimnetic waters for controlling cyanobacteria blooms. First, the density gradient due to any thermal stratification is minimized, facilitating the ability to extend horizontally (because of the horizontal pull to the intake hose) effective circulation up to 14 ha per machine. Second, significantly less energy is required to circulate waters of more similar densities, allowing the SolarBee to use a high-efficiency brushless motor capable of performing effectively only on solar energy. Third, there is no probability of bringing up anoxic, nutrient-rich hypolimnetic bottom waters from beneath the thermocline that can actually stimulate a cyanbacteria bloom in surface waters, particularly if there is insufficient water circulation throughout the entire epilimnion.

SolarBee circulation for hypolimnetic oxygenation

When the SolarBee intake hose is set in deep waters beneath the thermocline, only the direct flow of 11,400 lpm occurs. This deep, oxygen-poor water is brought up to the surface for natural re-aeration. Because colder bottom water is denser than warmer surface waters, this water will descend down to the thermocline. As this water falls, it pushes epilimnetic water deeper down in the water column.

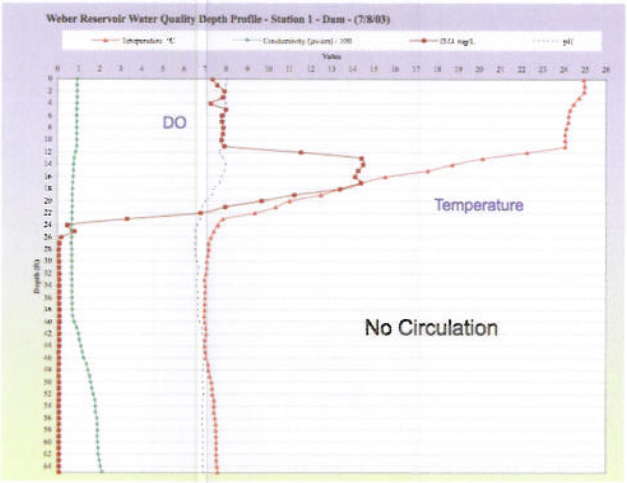


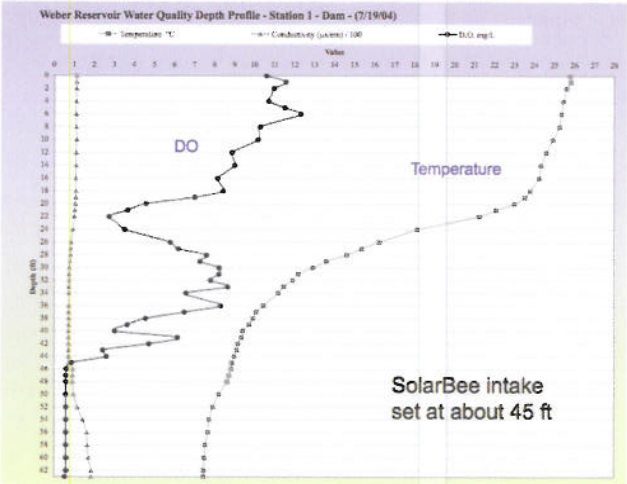
The net effect is that anoxic bottom waters are replaced with more oxygen-rich water moving through the thermocline. This approach of situating the SolarBee's adjustable intake hose just below the depth of the water treatment plant (WTP) intake pipe (as illustrated above) has been used successfully in numerous raw water storage reservoirs to prevent high concentrations soluble manganese, iron and hydrogen sulfide from entering the WTP facility.

This circulation does not destratify the water column, however, but it does smooth out the vertical thermal profile creating a much larger metalimnion. The two graphs below from Weber Reservoir

(California) illustrate this process. The first graph is from July 2003 before the SolarBee was installed and when anoxia extended from the reservoir bottom to just below the thermocline at 26 feet (7.9 m); the second graph is from July 2004 after installation. Notice that in 2004 waters between the thermocline and the bottom of the SolarBee intake hose at 45 feet (13.7 m) had dissolved oxygen concentrations as high as 8 mg/L where it had been anoxic the year before, while anoxia remained just below the level of the SolarBee intake hose down to the bottom.

Weber Reservoir, California





There are several advantages for using an adjustable up-flow pump like the SolarBee rather than bottom aeration to achieve hypolimnetic oxygenation. First, bottom sediments are not disturbed. Second, often the entire water column does not need to be oxygenated. If the reservoir outlet to the WTP is 20 m deep but the lake is 40 m deep, there is no need to oxygenate the entire 40 m water column to achieve good oxygenated water at 20 m. Oxygenating only the waters required for the treatment plant is more efficient and cost effective. Third, there are no hoses or other aeration devices on the lake bottom to install, maintain, repair or replace. And fourth, there are no grid-power energy requirements as the SolarBee is solar powered.

Conclusion

It is important to appreciate that destratification is <u>not</u> the goal, but simply a potential means for attaining the goals of cyanobacteria bloom control and/or hypolimnetic oxygenation. Destratification can be effective under proper conditions, but not a necessary requirement as demonstrated by nearly a decade of SolarBee successes without ever having to create water column destratification. Circulation has documented ecological benefits in lakes, and SolarBee's high-flow solar-powered circulation can more effectively, efficiently and consistently achieve desired lake management goals without risking any undesirable consequences associated with aeration (e.g., promoting cyanobacteria blooms by bubbling up nutrient-rich bottom waters).