

# **Report as of FY2009 for 2008ID129B: "Investigating Mechanisms by Which Long Distance Circulation (LDC) Enhances Surface Water Quality"**

## **Publications (also see end of this report)**

- Other Publications:

- ◆ Wilhelm, F. M., and Adams, C. J. 2009. Quarterly progress report #3 for Monitoring water quality in Willow Creek Reservoir in 2009 and obtaining in- and outflow samples to determine the nutrient mass balance . Submitted to US Army Corp of Engineers, Portland District. 4p.
- ◆ Adams, C. J., and Wilhelm, F. M. 2009. Quarterly progress report #2 for Monitoring water quality in Willow Creek Reservoir in 2009 and obtaining in- and outflow samples to determine the nutrient mass balance . Submitted to US Army Corp of Engineers, Portland District. 4p.

## **Report Follows**

## Project Summary

In 2009 we installed large-scale enclosures (Figure 1) to cordon off ‘untreated’ areas of the reservoir, because the entire reservoir was treated by the installation of eight large solar powered SolarBee circulators. SolarBee made the decision to treat the entire lake in early 2009. To examine the effect of this treatment on the water chemistry, and the phytoplankton and zooplankton communities in lake, we excluded a part of the lake from treatment, to determine potential differences between treated and untreated areas.

Enclosures were installed in early June 2009, and sampled every 2 weeks until early November when they were removed for the winter. Water chemistry in the enclosures showed the same patterns as in the lake, however, the concentration was slightly lower in the enclosures compared to the lake. This pattern remained consistent for the entire duration for which the enclosures were deployed, except for sampling date. An unexplained increase in TP occurred on or around July 20, resulting in a spike in the TP concentration in the lake. A concomitant rise in temperature was also recorded in the lake in the thermal profile as well as in a thermistor string deployed in the lake. Thus we believe this be related to a runoff event that occurred in the watershed. The spike was not noted in the enclosures as they were isolated from the lake. Because the enclosures were not sealed on the bottom, zooplankton, and fish could migrate upward into the enclosures, while phytoplankton settling out of the water column were not retained. We captured zooplankton on all dates, and small (10-14 ind) schools of fish were observed in enclosures on several occasions during the summer. After the lake was strongly stratified and hypolimnetic oxygen was lost, the bottom parts of the enclosures became anoxic and fish ceased to enter them. We also believe that zooplankton exchange with the lake ceased after anoxia. This was the intended design, as zooplankton would be restricted vertically in the lakes as well.

The TN:TP ratio in the lake and enclosures also showed the same patterns except for the above noted date. Overall, at the start of the experiments in June, the TN:TP ratio was 6.3 in the lake and 6.4 in the enclosures. This should have favored the cyanobacteria. At a mass ratio of  $< 10$  P is considered to be in excess and nitrogen limiting for phytoplankton growth. However, as the season progressed, the ratio increased to  $>10$  in both the lake and the enclosures indicating P limitation. Thus from a stoichiometric perspective, cyanobacteria should not have been favored in 2009.

Analysis of phytoplankton from the lake and enclosures showed that cyanobacteria were



Figure 1. 1Large-scale (3 m diam. 10 m deep) enclosures installed in Willow Creek Reservoir in 2009.

present in the lake during the entire summer. Incidentally, the lake suffered a severe cyanobacteria bloom in mid September, while the enclosures remained unaffected. We had predicted that the untreated enclosures would show bloom conditions while the lake would remain unencumbered from cyanobacteria blooms over the course of the year. Thus, it is unclear if long distance circulation can prevent the formation of cyanobacteria blooms in Willow Creek.

A confounding factor may have been the weather. In 2009, the average air temperature was lower compared to 2008, and the volume weighted average temperature of the epilimnion was approximately 1.5 °C lower. As well, water withdrawal for irrigation purposes caused the lake to drop more rapidly in 2009 compared to 2008. Thus, it is unclear if the lack of a summer-long bloom or delayed onset of a bloom in Willow Creek reservoir was related to the SolarBee circulators, or the cooler water temperature in the epilimnion. The bloom in September may have been induced by light limitation at the end of the growing season. Because cyanobacteria can regulate their buoyancy, they may have been able to reduce light deficiencies in early fall and thus generate a bloom.

Zooplankton data are being finalized in the next month, however, preliminary results indicate that large *Daphnia* (herbivores) were present in the enclosures as well as the lake. Thus, zooplankton may also have contributed to the onset of an early cyanobacteria bloom in Willow Creek Reservoir.

Firm conclusions regarding the efficacy of long distance circulators at preventing harmful blooms of cyanobacteria can not be reached at this time given the data on hand. However, overall water movement has been suggested as a method to mitigate against cyanobacteria. We hope to continue experiments this summer, to attempt to eliminate confounding factors and eliminate competing hypotheses.

We consider the deployment of the large-scale enclosures 2009 a success, and plan to continue investigations in 2009. Additional grant funding is being sought, two attempts at a federal earmark (collaboration between industry, university researchers, and federal entity - USACE) have been undertaken but not been successful to this point. A recent (June '10) USACE grant to Wilhelm to undertake additional monitoring on Willow Creek as well as examine fine-scale water movements around the circulators is a direct result of this grant. To date one (1) graduate student (MS) and three undergraduate students, as well as three undergraduate volunteer students have been involved with the research. An additional MS student will join the project this summer on the new grant.

## **Publications Resulting from the Project**

### ***Conference presentation and published abstracts:***

Adams, C. J., and Wilhelm, F. M. (Accepted) 2010. Implications of solar powered circulation of an epilimnion for cyanobacteria control on the zooplankton populations within Willow Creek Reservoir, Oregon. Annual joint meeting of the American Society for Limnology and Oceanography and the North American Benthological Society. Santa Fe, NM, June 6-11.

Adams, C. J., and Wilhelm, F. M. 2009. The vertical and horizontal distribution of zooplankton populations in response to a mechanical whole-lake management strategy. Annual meeting of the North American Lakes Management Society. Hartford, Connecticut,

USA. October 27-31.

***Reports:***

Wilhelm, F. M., and Adams, C. J. 2009. Quarterly progress report #3 for ““Monitoring water quality in Willow Creek Reservoir in 2009 and obtaining in- and outflow samples to determine the nutrient mass balance”. Submitted to US Army Corp of Engineers, Portland District. 4p.

Adams, C. J., and Wilhelm, F. M. 2009. Quarterly progress report #2 for ““Monitoring water quality in Willow Creek Reservoir in 2009 and obtaining in- and outflow samples to determine the nutrient mass balance”. Submitted to US Army Corp of Engineers, Portland District. 4p.

Wilhelm, F. M., and Adams, C. J. 2009. Willow Creek 2008 data review. Interim progress report prepared for SolarBee Inc. and US Army Corps of Engineers, Portland District. 4p.

**Undergraduate and Graduate Student Researchers supported on the project**

*Susan Bury* (REU) student. Working on undergraduate degree at Moorehad State University, MN. Currently studying abroad for last semester at Waikato University in New Zealand. Completed a side project to this grant that is currently being prepared for publication.

**Notable Achievements or Awards**