resourceful. naturally.
engineering and environmental consultants

BARR

# Technical Memorandum

**To:** RWMWD Board of Managers
**From:** Barr Engineering Company (Meg Rattei)
**Subject:** Potential Impacts of Whole Lake Alum Treatments on Invertebrates
**Date:** October 28, 2010
**Project:** 23620982.01 091 005
**c:** Cliff Aichinger, Brad Lindaman

Jack Frost recently heard a presentation by Dr. Nancy Simon, a research chemist for USGS. While answering questions following the presentation, Dr. Simon said she had issues with potential harmful impacts of whole lake alum treatments to the small animals living on or in lake sediments (invertebrates). Jack directed Barr Engineering Company to (1) complete a literature search on the topic to determine whether studies have documented any harmful impacts to invertebrates following whole lake alum treatments, (2) Contact Dr. Simon and request information regarding the basis of her concerns including literature citations, and (3) prepare a memorandum to the managers summarizing Barr's findings. This memorandum summarizes Barr's findings.

## Overview of Findings

During our review of the literature, we found there were few studies of impacts of whole lake alum treatments on the small animals (invertebrates) that live on or in lake sediments. We also found there were no recent studies. Available studies had been completed during the period 1981 through 1999. Study results indicate that whole lake alum treatments have not caused long-term harm to invertebrates, although a short-term decline in numbers was observed in one study. Laboratory studies of common animals found on or in lake sediments concluded it is unlikely that alum treatments would cause long-term harm to them. They did note some short-term challenges could occur due to animals having difficulty moving through floc. However, they noted that alum treatments generally occur during periods when animals are dormant and that the floc would be expected to settle before animal activity resumed. A literature review concluded that aquatic invertebrates are not very sensitive to aluminum. The following paragraphs discuss the findings in detail.

## Study of Wisconsin Lakes

A study of five Wisconsin Lakes treated with alum found that the numbers and kinds of animals living on or in lake sediment either increased or remained the same following alum treatment. The study concluded "There was no discernible toxic effect in lakes from the use of aluminum salts."[1]

## Study of a Vermont Lake

A study of Lake Morey, located in Vermont, found the numbers of animals on or in lake sediment was reduced during the first year after treatment, but a rapid recovery occurred during the second year. The results of a long-term study suggest that the alum treatment actually improved the community. During the 13 year study, more animals as well as more types of animals were consistently found because better oxygen conditions occurred at the lake bottom following the alum treatment.[2]

## Study of a Washington Lake

A study of a Newman Lake, located in Washington, found the alum treatment did not cause any harmful impacts to the animals living on or in the lake's sediment. Invertebrate samples collected one month after treatment indicated no change in the types or numbers of invertebrates. However, other lake management efforts that were later implemented caused changes in the number of animals. When fewer trout were stocked in the lake, fish predation on the animals declined resulting in an increase in the number of animals living on or slightly above the sediments. When larger numbers of trout were stocked, the opposite effect occurred and fewer animals were found. Installation of an aerator improved oxygen

---

[1] Narf, Richard P. 1990. Interactions of Chironomidae and Chaoboridae (Diptera) with Aluminum Sulfate Treated Lake Sediments. Lake and Reservoir Management 6 (1): 33-42.

[2] Smeltzer, Eric, Richard A. Kirn, and Steven Fiske. 1999. Long-Term Water Quality and Biological Effects of Alum Treatment of Lake Morey, Vermont. Journal of Lake and Reservoir Management 15 (3): 173-184.

conditions and higher numbers of animals were observed. The study concluded that alum did not impact the lake's invertebrate community.[3]

## Biological Impacts of Aluminum on Aquatic Invertebrates

A literature review of harmful impacts of aluminum on aquatic invertebrates found that aquatic invertebrates are not very sensitive to aluminum.[4] Laboratory experiments to determine impacts of aluminum on the common animals living in on or in lake sediment confirmed that these animals are not very sensitive to aluminum. The laboratory studies used aluminum concentrations that fall within the range of alum doses used in whole lake treatments and tested the response of three common species to aluminum. A study of a chaoborid species (*Chaoborus punctipennis*) and a chironomid species (*Chironomus anthrocinus*) found both to be tolerant of aluminum.[5] A laboratory study of a chironomid (*Tanytarsus dissimilis*) found it unaffected acutely by alum doses between 80 and 960 mg/L, but subtle chronic effects were found.[6] The animals had a hard time moving through the floc. In addition, larvae failed to develop because they were unable to move through the floc layer. The study noted that alum treatments generally occur when invertebrates are dormant rather than during developmental stages. They further concluded that the floc layer would likely settle before the dormant period ended and the animals again became active. Hence, the study concluded that it seems unlikely that a well planned alum treatment would result in significant mortality in benthic insect populations.

---

[3] Doke, Jeffrey L., William H. Funk, Steve T.J. Juul, and Barry C. Moore. 1995. Habitat Availability and Benthic Invertebrate Population Changes Following Alum Treatment and Hypolimnetic Oxygenation in Newman Lake, Washington. Journal of Freshwater Ecology 10 (2): 87-102.

[4] Gensemer, Robert W. and Richard C. Playle. 1999. The Bioavailability and Toxicity of Aluminum in Aquatic Environments. Critical Reviews in Environmental Science and Technology 29(4):315-450.

[5] Havas, M. and G.E. Likens. 1984. Toxicity of Aluminum and Hydrogen Ions to *Daphnia Catawba*, *Holopedium gibberum*, *Chaoborus punctipennis*, and *Chironomus anthrocinus*. Can. J. Zool. 63:1114-1119.

[6] Lamb, D.S. and G.C. Bailey. 1981. Acute and Chronic Effects of Alum to Midge Larva (Diptera: Chironomidae). Bull. Environ. Contam. Toxicol. 27:59-67.

A recent examination of sediment cores collected from Kohlman Lake to assess the spring alum treatment confirms the conclusions from the laboratory study. No visible floc layer was observed on Kohlman sediment. All of the aluminum applied to Kohlman Lake had mixed into the sediment and was no longer discernible from the sediment. This examination of Kohlman sediment confirms the conclusion of the laboratory study that the floc settles before animals become active and, hence, the animals do not experience the negative effects observed in the laboratory – animals having a hard time moving through the floc.

## Citations from Nancy Simon

I contacted Nancy Simon and requested citations to the materials that formed the basis of the concerns. She sent electronic files of four journal articles about alum treatment and links to a couple of books that mentioned impacts of alum treatments on invertebrates.

Brian Huser (Barr) reviewed the four alum treatment journal articles and indicated the articles are outdated (i.e., 1996 through 2002) and do not reflect the more recent advances in alum treatment approaches and techniques. He did not consider the contents of the articles to be applicable to current practices. The four alum treatment articles did not mention impacts of alum treatment on invertebrates.

I reviewed the pertinent sections of the two books and found the following discussions regarding impacts to invertebrates. Cooke et al (2005)[7] discussed the Lake Vermont [2] and Wisconsin Lake[1] studies detailed above as well as the Lamb et al[6] laboratory study. The discussions of the Wisconsin Lake studies and the Lamb et al laboratory experiments did not provide any new information relative to the above discussion of these studies. However, in discussing the Vermont study, Cooke detailed some additional information regarding the alum treatment of Lake Morey. A higher than intended aluminum dose accidentally occurred during the application process. Cooke et al[7] mentioned the reduction in numbers of bottom dwelling invertebrates during the first year after treatment and also mentioned that the sediments had been inadvertently exposed to an unusually high dose of aluminum. Cooke et al[7] then mentioned that the

---

[7] Cooke, G. Dennis, Eugene B. Welch, and Stanley Nichols. 2005. Restoration and Management of Lakes and Reservoirs, Third Edition. Taylor and Francis Group. New York. 591 pages.

invertebrates had recovered by the second summer and that two additional species colonized the lake. They concur that the long-term result was benefit to the invertebrates.

The second citation, Pfafflin et al[8], concluded "To date, alum treatments have not resulted in adverse effects on fish and have not damaged invertebrate populations in well-buffered lakes." [8] The Lake Morey study (Vermont) was mentioned as having a short-term adverse effect following alum treatment.

## Conclusion

Literature findings were consistent and indicated whole lake alum treatments do not cause a long-term harmful impact on aquatic invertebrates. The short term impact in Lake Morey may be explained by an inadvertent exposure to high aluminum concentrations. A laboratory study found that subtle chronic effects could occur, but indicated harm to invertebrates during alum treatment is unlikely since they are dormant at the time of application. Alum floc is expected to settle before invertebrates again become active. Examination of Kohlman Lake sediment cores confirms that floc settles and becomes incorporated into the sediment following treatment. Citations provided by Nancy Simon included outdated journal articles regarding alum treatment that do not reflect current practices. Citations that provided the basis of her concern for invertebrates were two books that discussed the same journal articles that I have discussed in this technical memorandum. Hence, her basis of concern to invertebrates seems to be the first year decline in invertebrates in Lake Morey (Vermont) and the Lamb et al[6] laboratory study that indicated some subtle chronic effects could occur. The Lake Morey study concluded that alum treatment resulted in a long-term benefit to the invertebrate community. The Lamb et al[6] laboratory study concluded that it seems unlikely that a well planned alum treatment would result in significant mortality in benthic insect populations.

---

[8] Pfafflin, James R. and Edward N. Ziegler. 2006. Encyclopedia of Environmental Science and Engineering, Fifth Edition, Volume 1. Gordon and Breach Science Publishers, Philadelphia, PA. 650 pages.