an overview of recent studies on

wabamun lake

Alberta
ENVIRONMENT

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In the spring of 2002, Alberta Environment initiated an investigation on Wabamun Lake in response to complaints about murky water in the lake near the TransAlta Utilities Wabamun Power Plant ash lagoon discharge. Water and sediment samples taken within 100 metres of the TransAlta Utilities settling pond exceeded Canadian guidelines for aluminium, chromium, arsenic and copper. Elevated concentrations of these metals were also found in sediment within the lagoon itself.

To learn more about sediment and water quality in Wabamun Lake and how it compares to other area lakes, Alberta Environment started several comprehensive studies of the lake in the summer of 2002, including assessments of differences in water quality across the lake, metals and trace organic contaminants in sediments, the significance of sediment quality to aquatic biota and the occurrence of disinfection by-products from the Wabamun Lake Water Treatment Plant. Additionally, a report summarizing the 20-year history of water quality of Wabamun Lake has been compiled to provide a historical perspective on water quality of the lake.

Overall Findings

> **Wabamun Lake ion concentrations have increased slightly, but the lake remains nutrient-rich.** A combination of reduced flushing due to dry conditions and the input of sulphate-rich water from the Wabamun Lake Water Treatment Plant have increased total dissolved solids and major ion concentrations in the lake over the last 20 years. Slight declines in phosphorus levels and chlorophyll-a concentrations are also believed to be the result of water input from the treatment plant.

> **Water quality across the lake is generally very similar.** Water temperature in the east basin is warmer because of the discharge of heated water from the TransAlta Utilities Wabamun Power Plant. As expected in a productive lake, particularly when weather is calm and very warm, measurements of dissolved oxygen, pH and temperature at the surface of the lake were different than measurements near the bottom of the lake.

> **Sediment from Wabamun Lake tends to have somewhat higher metal and polycyclic aromatic hydrocarbon (chemicals formed during the incomplete combustion of organic carbons) levels than other lakes tested.** These differences are likely the result of natural geology and human activities.

> **Initial testing shows no major impact on aquatic biota.** Laboratory testing showed that some test species (fish larvae and small crustaceans) had reduced survival, growth, or reproduction in some Wabamun Lake samples. Findings were similar for Pigeon, Wizard, Gull and Isle lakes. Benthic invertebrate communities in Wabamun Lake near the discharge of the ash lagoon and the Wabamun Lake Water Treatment Plant were generally similar to background sites.

> **A variety of disinfection by-products, a result of treating water, were detected in the water discharged from the Wabamun Lake Water Treatment Plant.** A number of these compounds were also found in the lake at lower concentrations. Little scientific information is available on the responses of aquatic biota to low levels or mixtures for several of these compounds.

The studies summarized in this report provide a great deal of scientific information on the current status of Wabamun Lake water and sediment chemistry, and some aspects of aquatic biota. They also identify areas where further study is needed to identify effective methods to distinguish between natural and man-made contributions of contaminants.

The influence of sediment quality and mixtures of naturally-occurring and man-made chemicals on aquatic ecosystem health needs to be better understood.

Overall, the results confirm that Alberta Environment's long-term monitoring program on the lake is suitable for tracking changes in overall lake water quality over time.

In addition to the Alberta Environment studies, TransAlta Utilities is conducting an Environmental Risk Assessment, at the request of Alberta Environment, to determine the extent of the metal concentrations, determine the past and present contributions of the power plant to the heavy metals concentrations and evaluate the risk to the lake ecosystem. This work is currently in progress.

wabamun lake and its watershed

Compared to other Alberta lakes, the Wabamun Lake watershed has a unique diversity of land uses and human activities. Coal mining, coal-fired power generation plants, farming, major transportation corridors, residential and recreational activities all influence Wabamun Lake and its watershed.

Drier than average conditions have prevailed in the Wabamun Lake area since the early 1990s and have resulted in a gradual decline in lake level. Activities of TransAlta Utilities in the watershed have also contributed to the decline in lake level.

In 1997, Alberta Environment directed TransAlta Utilities to replenish the water owed to the lake by constructing the Wabamun Lake Water Treatment Plant. The plant treats water from the Sundance cooling pond and discharges into the lake. The cooling pond is replenished with water diverted from the North Saskatchewan River, as well as wastewater from the Sundance Power Plant, local plant site runoff and runoff and wastewater from the Highvale mine.

trends in wabamun lake water quality (1982 to 2001)

Since the early 1980s, Alberta Environment has sampled Wabamun Lake monthly in open water periods (May to October) and at least once during the winter. Samples are taken at varying depths from three fixed sites (east basin, west basin and Sundance Bay). In addition, samples from the euphotic zone (from the lake surface down to a depth of water where there is enough light for photosynthesis) are collected from ten locations throughout the lake basin and combined to form a composite sample.

These samples are tested for a broad range of water quality measurements such as dissolved oxygen, pH, major ions, nutrients, chlorophyll-a, and in recent years metals, including mercury. Plankton is also sampled regularly and the species and abundance of algae and small animals living in the water are recorded.

Results show that over time some changes have occurred in the lake's water quality.

> Total dissolved solids and most major ion concentrations have increased over the last 20 years. In part, this is due to dry conditions that have resulted in reduced flushing of the lake. Similar increases of total dissolved solids were observed in two other nearby lakes with similar basin characteristics over the same period.

> There has been a further increase in total dissolved solids and sulphate in Wabamun Lake beginning in 1999 when the Wabamun Lake Water Treatment Plant started pumping large volumes of treated water into the lake. This is a result of higher levels of sulphate and total dissolved solids in the treated water.

> Nutrients and chlorophyll-a levels have remained fairly stable from 1982 to 2001, but a small decrease in phosphorus and chlorophyll-a was observed beginning in 1999. This may be related to the additional load of calcium entering the lake with water treated by the Wabamun Lake Water Treatment Plant.

Trends over time also show that many aspects of lake water quality have not changed.

> Wabamun Lake remains nutrient-rich. The small declines in phosphorus and chlorophyll-a have not altered the primary productivity of the lake.

> Plankton communities showed no major change from the early 1990s to 2001.

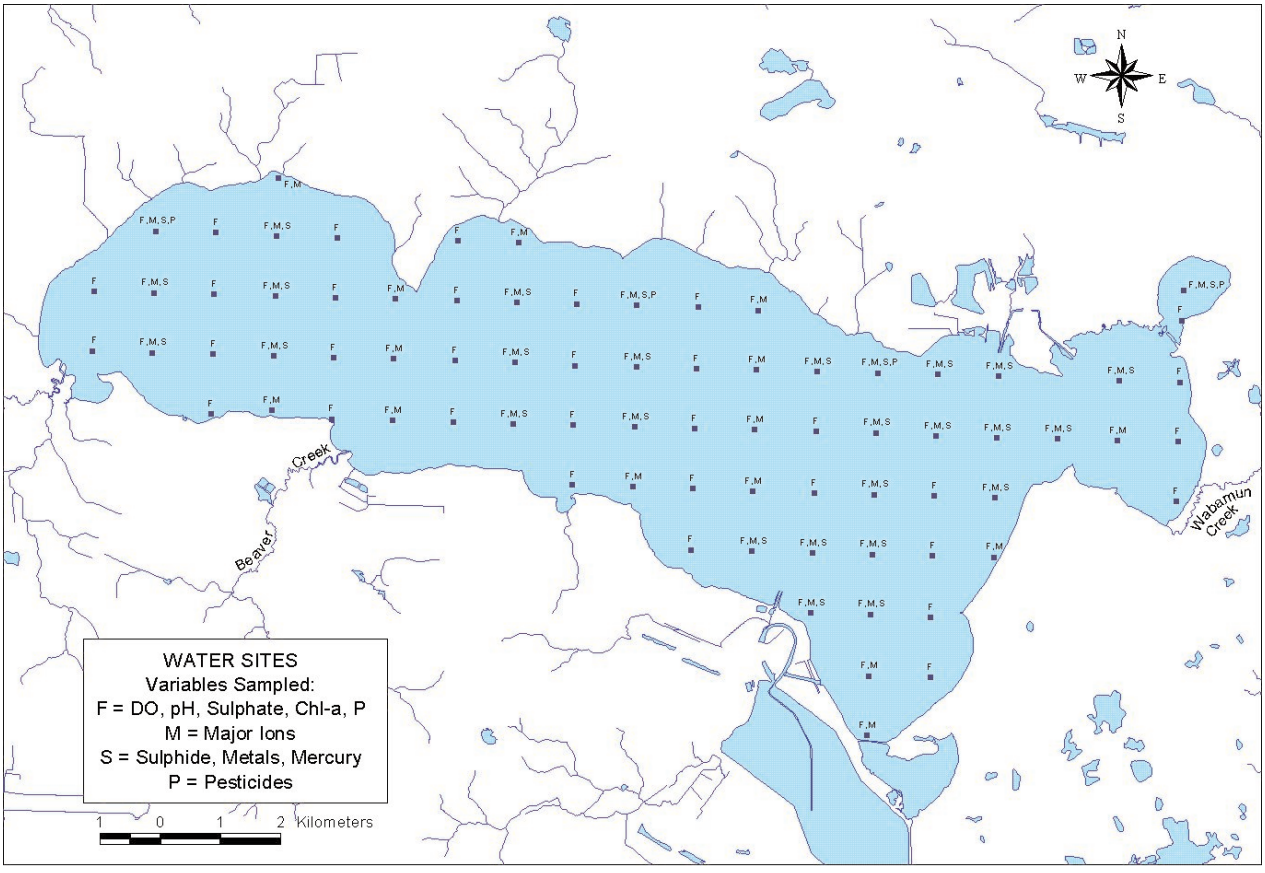
> Metals have consistently complied with Alberta Surface Water Quality Guidelines for the Protection of Aquatic Life since sampling began in 1999.

water quality across the lake

To provide a snapshot of water quality across the entire lake, samples were taken between July 22 and 24, 2002, at seventy-seven sites across Wabamun Lake, in various bays and along the shoreline (Figure 1). During these three days of sampling, the weather was dry, calm and very warm and the Wabamun Lake Water Treatment Plant was not operating at high volume.

Water quality measurements included field readings of pH, dissolved oxygen, temperature and conductivity near the surface, at mid-depth and near the bottom of the lake. Major ions, nutrients and chlorophyll-a measurements where sampled in the euphotic zone. Samples of sulphide and metals, including mercury, were taken near the bottom. In addition, samples from four sites were tested for 40 different pesticides.

Figure 1 Sampling locations and variables analysed in Wabamun Lake water samples, summer 2002



Key Findings

> Water chemistry was generally quite uniform across the lake. For most measures, the difference between the lowest and highest value recorded were very small.

> In some cases, measurements differed across the lake or at different depths:

- Temperature was a few degrees higher in Kapasiwin Bay than in the rest of the lake because of the warm water discharged from the Wabamun power plant.
- Dissolved oxygen was generally higher in samples taken near the surface compared to samples taken near the bottom of the lake. These differences are typical in nutrient-rich lakes and especially on calm, hot days.

> Alberta Surface Water Quality Guidelines for the Protection of Aquatic Life were met for most variables.

- Some measurements of dissolved oxygen and pH were outside the guideline range, a common occurrence in productive lakes.
- Some sulphide measurements taken in the deeper, oxygen-poor portion of the lake exceeded the guideline and a few measurements of the metals selenium and cadmium were just above the guideline.

> Two pesticides, MCPA and 2,4D, were detected in a sample taken on the north side of the lake, but at concentrations well below the guidelines. These two pesticides are commonly detected in Alberta surface waters. Atmospheric deposition and surface runoff are the two major pathways for their entry into surface waters.

It should be noted that this survey provides a snapshot of water quality in the lake. Water quality can be strongly influenced by the conditions at the time of sampling. Different water quality patterns may occur in deeper water under windy conditions, along the shoreline when inflow streams and the ash lagoon have greater discharge volume, or when the Wabamun Lake Water Treatment Plant discharges larger volumes of treated water to the lake.

Alberta Surface Water Quality Guidelines

Alberta Surface Water Quality Guidelines provide general guidance for evaluating surface water quality for the protection of aquatic life, agriculture use, recreation use and aesthetics. More information about the Alberta Surface Water Quality Guidelines is available online at www.gov.ab.ca/env/protenf/publications/surfwtrqual-nov99.pdf

metals and trace organics in sediments

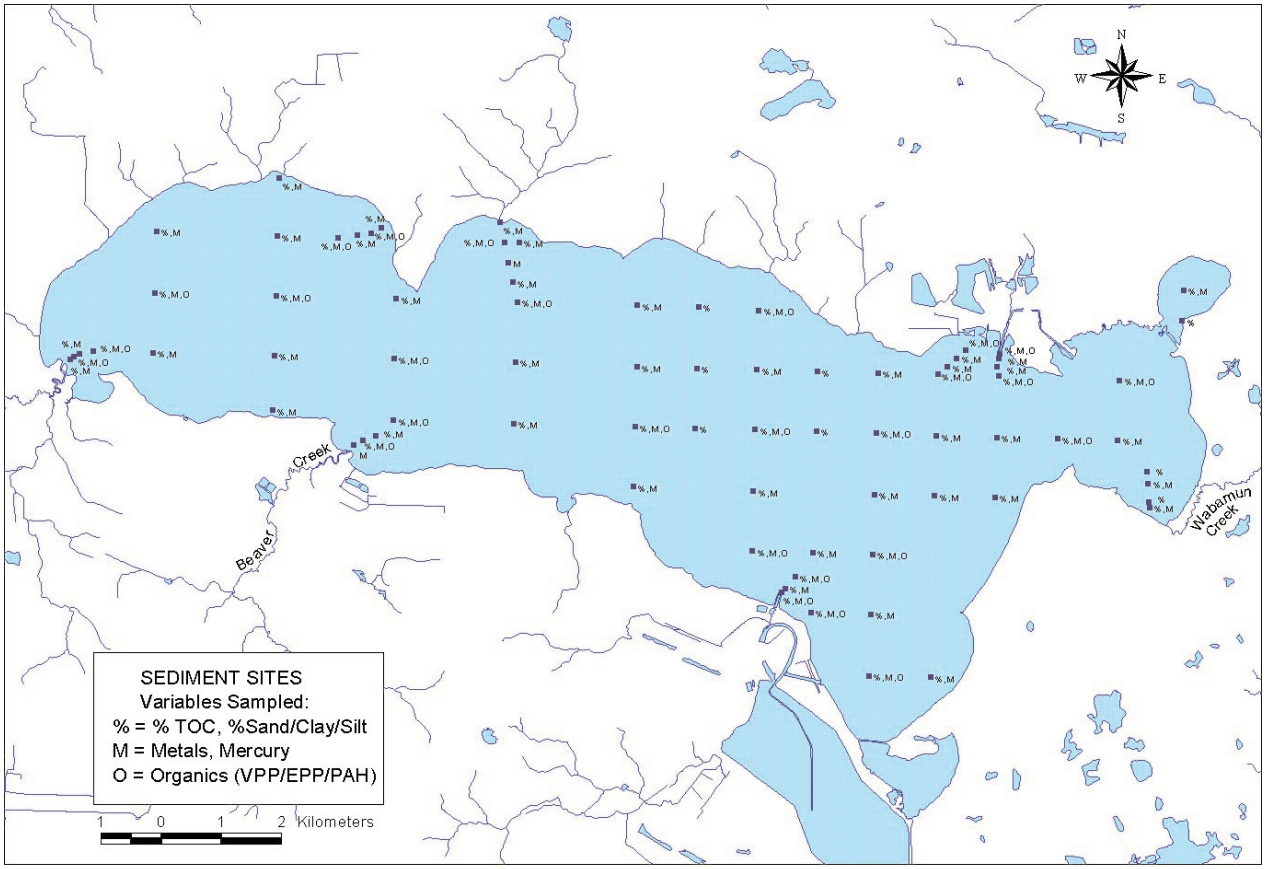
Sediments were sampled at sixty-nine sites across Wabamun Lake (Figure 2). Many locations correspond with the sites sampled for water quality. In addition, sediment samples were taken along the lake shoreline.

Samples of the top 5 centimetres were taken with an Ekman grab sampler. Samples were analysed for metals, including mercury, and for trace organic compounds including polycyclic aromatic hydrocarbons (chemicals formed during the incomplete combustion of organic carbons). Sediment texture and total organic content were also measured in all sediment samples.

Eight other lakes (Isle, Ste Anne, Pigeon, Sylvan, Gull, Wizard, Bonnie and Amisk) were also sampled in 2002 and analyzed for the same variables as Wabamun Lake. In addition, archived sediments from 29 lakes were analyzed for a selection of metals. Archived sediments were not suitable for analysis of volatile metals, such as mercury, or for trace organics.

Sample results were compared to Canadian Sediment Quality Guidelines to determine potential impacts on aquatic biota.

Figure 2 Sampling locations and variables analysed in Wabamun Lake sediment samples, summer 2002



Canadian Sediment Quality Guidelines

Canadian Sediment Quality Guidelines for the Protection of Aquatic Life provide scientific benchmarks, or reference points, for evaluating the potential for adverse biological effects in aquatic sediments. Depending on sensitivity of local fauna and other conditions, concentrations above guidelines are not necessarily harmful. However, the likelihood of effects increases with increasing concentrations above the guidelines. At present, only interim guidelines have been developed for metals because there is insufficient associated biological and chemical environmental data. More information about these guidelines, including concentration ranges, is available online at www.ccme.ca/publications/pub_updates.html

Key Findings

Metals

- All mercury samples complied with Canadian Sediment Quality Guidelines.
- Some samples taken at Wabamun and other lakes exceeded Canadian Sediment Quality Guidelines for arsenic, cadmium, chromium, copper and zinc.
- Levels of mercury, cadmium, copper, zinc and antimony occurred at higher concentrations in Wabamun Lake than in other lakes.
- Levels of nickel, bismuth, silver, lithium, cobalt, strontium and thallium were comparable among all lakes sampled.
- Metal concentrations in Wabamun Lake sediments tended to be higher in the deeper portions of the west basin where sediments were fine-grained and rich in organic carbon.
- Metal concentrations near the TransAlta Utilities Wabamun Power Plant ash lagoon outfall were somewhat higher than would be expected based on the nature of the sediments. This is consistent with findings from Alberta Environment's investigation in spring 2002 and suggests that the current or past operation of the ash lagoon has contributed elevated metals in the lake.

Sources of metals to the lake include both the natural geology and human activities in the watershed. The relative importance of these contributions is not known, although this study and others indicate that natural background levels for Wabamun Lake may be higher than for other nearby lakes.

Polycyclic Aromatic Hydrocarbons

- Polycyclic aromatic hydrocarbons (PAH) were found in Wabamun Lake and other lakes sampled in 2002. These compounds, which are toxic at high concentrations, occur naturally, but can also be contributed by human activities. Wabamun Lake had a greater variety and higher concentration of these compounds than other lakes sampled.
- Some measurements of PAH on the north and northeast side of the lake exceeded Canadian Sediment Quality Guidelines for the Protection of Aquatic Life.

Natural sources of Polycyclic Aromatic Hydrocarbons include exposed coal seams in and near the lake and forest fires. Man-made sources include coal mining and coal burning, creosote-treated wood structures in or near the lake (e.g., railway line, boat docks) and fossil fuel burning for the powering of boats, vehicles, trains, weed harvesters and heating of homes. The relative importance of these sources is not known.

significance of sediment quality on aquatic biota

The fact that some metals and polycyclic aromatic hydrocarbons exceed guidelines does not necessarily mean that aquatic life is negatively affected. However, these findings do identify the need for further work. Understanding the significance of metal and PAH levels for aquatic life is complex, as little is known about the dynamics, distribution and tolerance levels of benthic or bottom-dwelling lake species. Possible effects of sediment quality were tested on various aquatic species in the laboratory and in the lake.

SEDIMENT TOXICITY

Testing was done using sediment samples from the ash lagoon, which was expected to provide the worst-case situation. In addition, sediments from the lake east of the ash lagoon, the mouth of the inlet canal to the TransAlta Utilities Wabamun Power Plant near the outfall of the Wabamun Lake Water Treatment Plant and the west basin. Pigeon, Gull, Isle, and Wizard lakes were also tested.

Survival, growth and reproduction were measured in the test organisms, which included luminescent bacteria, algae, aquatic plants, small crustaceans, worms and fish larvae. A Toxicity Identification and Evaluation (TIE) was done to determine what substance, or substances, caused an adverse effect in test species. This involved exposing the test species to known chemical groups and testing the reactions.

Key Findings

- Results from sediment toxicity testing were similar for Wabamun Lake sediment and sediments from Isle, Pigeon, Gull and Wizard lakes.
- Some test species did not show any measurable response.
- Fish larvae and small crustaceans tested showed reduced survival, growth or reproduction when exposed to ash lagoon samples and some samples from Wabamun, Gull and Wizard Lake.
- Responses tended to be more pronounced and more consistent with ash lagoon samples.
- The Toxicity Identification and Evaluation (TIE), which was carried out on an ash lagoon sediment sample, was inconclusive because test species did not show toxicity in any of the chemical groups. Consequently, the substance, or substances, that caused responses in test organisms has not yet been identified.

BENTHIC INVERTEBRATE ASSESSMENT

Samples were collected in November 2002 to determine if the ash lagoon outfall and the Wabamun Lake Water Treatment Plant outfall were having an influence on benthic invertebrate species distribution and composition. Six sites were sampled near each outfall (test sites) and six sites were sampled in an area of the lake with similar depth and sediment appearance, but away from the influence of the outfalls (background sites).

Samples were also taken from the ash lagoon, the ash lagoon discharge canal and the outlet canal of the Wabamun Lake Water Treatment Plant. In total, 115 Ekman grabs were taken from 23 sites. Invertebrates were sorted to determine their abundance (numbers of invertebrates per unit area), richness (number of species per unit area) and biomass (weight per unit area).

Key Findings

> A total of 128 different invertebrates species were found in the sediment samples. These included various species of insects (mayfly nymphs, caddisfly larvae, fly larvae, midge larvae, beetles, water boatmen, aquatic moths, dragonfly and damselfly nymphs), water mites, crustaceans (water fleas, copepods, seed shrimps, scuds), aquatic earthworms, leeches, roundworms, snails, clams, flatworms, hydras and water bears.

> Overall, differences in the invertebrate community sampled from the ash lagoon test sites and control site were slight and do not indicate a toxic effect from the ash lagoon discharge, however, signs of mild enrichment were apparent.

> There were some significant differences in the invertebrate community from the Wabamun Lake Water Treatment Plant test site and background sites, but these differences appear to be due to differences in habitat and water quality rather than negative effects from the discharge from the treatment plant.

disinfection by-products in wabamun lake

The pumping of large volumes of treated water (equivalent to drinking water) directly into a lake rather than into a drinking water distribution system represents a unique situation.

Chlorination and ozonation, two treatment processes used in the Wabamun Lake Water Treatment Plant, are known to produce disinfection by-products (DBPs). DBPs include a wide range of chemicals such as various halogenated volatile organic compounds (trihalomethanes such as chloroform or THMs), haloacetic acids, haloacetonitriles, haloketones, chlorinated phenols, aldehydes, chloral hydrate, chloropicrin, bromate, chlorate and chlorite.

A study was undertaken to determine the occurrence of DBPs in the treated water and at various locations close to the treated water discharge and in the lake.

Key Findings

- Various DBPs were detected in the samples.
- Generally, the number of DBPs detected and their concentrations were higher in the treated water and declined with increasing distance from the treated water discharge.
- Aldehydes were the only DBPs found in the lake furthest away from the discharge. Although aldehydes may be by-products of the water treatment processes, some occur naturally in the environment and can be generated by forest fires and irradiation of dissolved organic carbon.
- The types and concentrations of DBPs in Wabamun Lake were similar over the three seasons sampled (summer, fall and winter).
- Chloroform levels were near or above the CCME Interim Water Quality Guideline for the Protection of Aquatic Life in the inlet canal and in two lake samples taken close to the mouth of the canal. Chloroform was not detected in the other lake samples.

Water Quality Guidelines for the Protection of Aquatic Life have been developed for only one DBP (chloroform) detected in this study. The significance of other compounds can only be assessed in the context of available toxicological information. Based on available data, the concentrations of haloacetic acids, aldehydes and chlorate in the lake were lower than the concentrations where effects occurred. No toxicity data was found for other DBPs detected nearest to the treated water discharge. Mixtures of DBPs were present at all sites during the study. Guidelines generally focus on single compounds, which made it not possible to evaluate the potential effect of DBP mixtures on aquatic biota.

next steps

Alberta Environment will continue to work with Alberta Sustainable Resource Development, Alberta Health and Wellness, the local Health Authority, Environment Canada, the Department of Fisheries and Oceans, the University of Alberta, TransAlta Utilities and other stakeholders to:

- Gain a better understanding of the contributions of natural and various man-made activities to the lake, now and historically.
- Further investigate potential impacts on aquatic biota as a result of changes in lake water and sediment quality.
- Evaluate human health implications, if any, which may arise from power plant activities in the watershed.

This knowledge will allow the department to make appropriate management decisions for the lake and its watershed. Alberta Environment will also continue monitoring lake water quality on an on-going basis.

Copies of all of the studies referenced in this summary report are available on the Alberta Environment Web site at www.gov.ab.ca/env or by calling (780) 427-6267.

notes

For additional copies of this summary or any of the Alberta Environment studies referenced, contact:
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