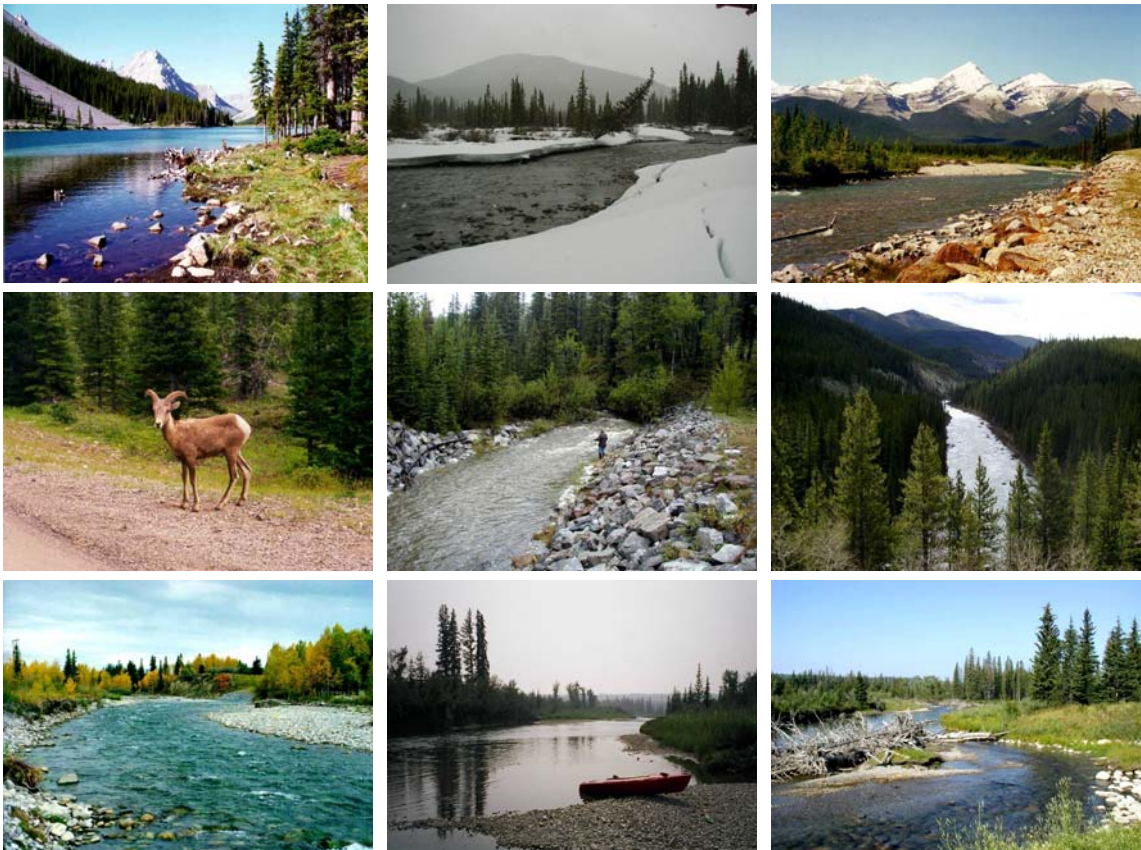


*Impacts on Water Quality in the*  
**UPPER ELBOW RIVER**



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## Executive Summary

Recent work has found evidence of significant increases in some key water quality indicators (dissolved phosphorus, coliforms, turbidity) in the Elbow River upstream from Calgary. Consequently, it is very important to identify the reasons for increases in these constituents and take remedial action to protect this drinking water supply.

Accordingly, the City of Calgary and Alberta Environment (AENV) conducted intensive basin-wide sampling of the upper Elbow River and its tributaries from 1999 to 2003, inclusive. The objectives of this sampling were to: (a) describe spatial and temporal trends in the concentration of key water quality indicators, and (b) identify factors that could be contributing to water quality deterioration in the Elbow River. This program included grab sampling of the Elbow River and its major tributaries near their mouths. To ensure all loadings to the river were accounted for in the sampling, daily composite samples for total phosphorus and suspended solids analysis were also collected at five Elbow River sites from above Bragg Creek to Weaselhead Bridge using automated samplers. To determine whether coliforms were from human sources or ungulates, samples were collected for bacterial DNA analysis at sites throughout the basin.

This report presents the results of intensive water quality sampling from 1999 to 2002, inclusive, and bacterial source tracking work in 2003, and compares these findings to previous studies. Included is a statistical analysis of spatial and temporal trends in concentration of key water quality indicators, and, where feasible, a mass flux analysis from Bragg Creek to Weaselhead. The analysis of spatial trends in suspended solids was supplemented by an aerial survey in November 2002, to identify erosion sites and other factors that could contribute to suspended solid concentrations in the Elbow River. Throughout this report, sources other than discrete tributary loadings are described as nonpoint sources. There are no approved point source discharges of wastewater to the Elbow River upstream from Glenmore Reservoir.

Phosphorus is an essential plant nutrient which in excess can cause an increase in the growth of aquatic plants. In turn, aquatic plants can result in low levels of dissolved oxygen through plant respiration at night, impede water flow and affect aesthetics. Results of this study suggest that sources near Calgary between Twin Bridges and Weaselhead Bridge generally contributed most of the total phosphorus (TP) mass entering the Elbow River. Small but significant increasing trends in total dissolved phosphorus (TDP) concentration and total ammonia suggest that sources in this reach are also contributing dissolved nutrients, which will be more biologically-available than TP to stimulate the growth of aquatic plants. Specific sources of phosphorus in this reach cannot be individually identified using the available data, but could include urban runoff from new and old residential developments, agriculture, groundwater, and other nonpoint sources. No evidence of trends in tributary concentration that could account for these increasing trends in TDP in the Elbow River was found. However, TP and TDP median concentrations were higher in tributary streams than in the Elbow River, sometimes well above guidelines and high enough in some streams to have the potential to cause nuisance periphyton growth. Lott Creek contributed the largest mass of TP from tributaries to the Elbow River during 1999 and 2000 when flows were low, and Bragg Creek contributed the greatest TP mass loading among tributaries in 2002, a higher flow year. Although concentrations in tributaries were often high, the mass of TP contributed by tributaries to the Elbow River was much lower than the mass contributed by nonpoint sources, because tributary flows were generally low. In contrast, Lott Creek contributed a greater mass of TDP than nonpoint sources to a lower reach of the Elbow River in 2000.

Nitrogen (N) is another essential nutrient for aquatic plants. Excessive nitrogen can lead to increased growth of aquatic plants; high levels of nitrate can impair drinking water quality, and high levels of ammonia and nitrite may be toxic to aquatic life. Appreciable mass loading of nitrate+nitrite-N occurred in 1999 and 2002 between Twin Bridges and Weaselhead from

nonpoint sources close to Calgary and loadings from Lott Creek. Nonpoint sources in this reach could include loadings from urban runoff contributed by storm sewers, atmospheric deposition, agriculture, and contributions from groundwater. A significant increasing trend in nitrate+nitrite concentration occurred at every Elbow River site from just upstream of Bragg Creek to the Weaselhead Bridge, and in several headwater tributaries including the near-pristine Little Elbow River. The reason for these increasing trends in nitrate+nitrite along the Elbow River cannot be determined from the available data. Tributaries between Highway 22 and the Glencoe Golf and Country Club (Glencoe GCC) were major sources of nitrate+nitrite, in particular Pirmez Creek, which contributed a greater mass of nitrate+nitrite each year than any other tributary. Nitrate concentrations were high enough to have the potential to cause nuisance growth of periphyton in Pirmez Creek in some years. However, nitrate+nitrite at all sites was well below Canadian water quality guidelines. Total nitrogen (TN) and total kjeldahl nitrogen (TKN) mass flux generally followed the same pattern as nitrate+nitrite, with a loss of mass along some reaches of the Elbow River during low flow years (1999 and 2000), and some evidence of loading from Lott Creek and from nonpoint sources close to Calgary in 1999. Tributaries contributed a greater mass of TKN and TN to the Elbow River than nonpoint sources during low flow years. Although TKN and TN median concentrations were generally highest in Millburn Creek, Lott Creek contributed the greatest mass of TKN in 1999 and 2000, and Bragg Creek was the greatest tributary source of both variables in 2002, when flows were higher.

Total suspended solids (TSS) is a measure of the total amount of suspended particles such as fine silt and clay, organic matter and small organisms in water. These particles can carry nutrients and toxic contaminants, interfere with water treatment, can be aesthetically undesirable, and kill aquatic life when they settle onto a stream bottom. Sources between Twin Bridges and Weaselhead Bridge contribute the bulk of the TSS in the Elbow River during low to average flows. Some possible sources include the re-suspension of bed material, bank erosion, and storm sewers that release urban runoff. TSS loadings from all Elbow River tributaries were

very small each year compared to nonpoint sources along the Elbow River, with only 0.3% of the total mass flux coming from tributaries in 2002. During the high flows in 2002, a large influx of TSS mass occurred between Bragg Creek and Highway 22, more than was contributed by nonpoint sources along any other reach of the Elbow River that year. Bank erosion at various sites and other potential TSS sources in that reach were identified during an aerial survey in November 2002. This large influx of TSS mass probably caused concentrations in 2002 to peak at the Glencoe GCC, and a significant increasing trend in TSS concentration over time was also detected at that site. The mass flux analysis suggests that the area of greatest deposition of TSS occurred just upstream of Twin Bridges in 2000, but more deposition occurred downstream between Twin Bridges and Sarcee Bridge during the higher flows in 2002. These findings suggest that the spatial pattern of TSS loading and deposition changed considerably from year to year depending on river flows and other factors.

Fecal coliforms are found in the intestinal tract of warm-blooded animals, and are a useful indicator of contamination from sewage or manure. *E. coli* is one species of fecal coliform bacteria, and is generally considered the preferred indicator for fecal contamination. The greatest change in *E. coli* counts in the Elbow River occurred each year between the Glencoe GCC and Weaselhead Bridge. *E. coli* counts declined from Highway 22 to the Glencoe GCC in 1999 and 2000, then increased significantly at sites further downstream. *E. coli* counts were generally significantly higher at Twin Bridges and Weaselhead Bridge than at most upstream sites, including the site at the Glencoe GCC. Fecal coliforms have increased significantly over time (1979-2002) at the Twin Bridges site alone. Except for Lott Creek, Elbow River tributaries had higher *E. coli* and fecal coliform counts than the mainstem sites in low to average flow years (1999 and 2000). Among tributary sites, both *E. coli* and fecal coliforms were consistently lowest in Lott Creek, and highest in either Pirmez or Millburn Creeks. Fecal coliform counts in Pirmez Creek and Millburn Creek often exceeded the guidelines for irrigation and contact recreation, indicating that water quality for these uses was impaired in both streams. Since no trend in fecal coliform counts was

found in the Elbow River at Glencoe GCC, immediately downstream from Pirmez, Millburn, and Springbank Creeks, no evidence was found that activities on those tributaries would account for the increasing trend in fecal coliform counts in the Elbow River at Twin Bridges. Similarly no evidence was found that human sewage could account for this trend. Nonpoint sources such as runoff from residential developments and agriculture, or contributions from groundwater could account for increasing fecal coliform counts in the Elbow River at Twin Bridges. As with other variables in this reach it is not possible to determine the relative importance of various potential sources of coliforms from results available to date.

these sites were only significantly different in 2000.

In the 2003 bacterial tracking study, DNA markers from ruminant animals were found in samples at each location in the Elbow River basin on at least one sampling date, except for sites on Lott Creek, the headwaters of Pirmez Creek, Weaselhead Bridge, and the headwaters of Millburn Creek. These results confirm that ruminant animals are present upstream from all sampling locations where such markers were found, even in the headwaters of the Elbow River at Cobble Flats. A wide range of wild and domesticated animals that occur in this basin are ruminants, including cattle, bison, sheep, elk, and deer. No human markers were found at any sampling site, although this marker was found in a raw sewage sample. This implies that there was little or no movement of bacteria from human sewage to these water bodies during the sampling period. Of the human pathogens for which samples were tested in the bacterial source tracking study, there was only one positive result for *Salmonella* at one site, on one date. Neither *E. coli* 0157:H7 nor *Campylobacter* were detected.

Results of this study did not provide consistent evidence of impacts on surface water quality in the Elbow River that might be attributed to sources in the Hamlet of Bragg Creek. In 1999 before the spring flood, nonpoint sources contributed 454 kg TP to the Elbow River between the Hamlet of Bragg Creek and Highway 22, however there was no increase in TP mass between these sites in 2000. *E. coli* counts increased each year between the Hamlet of Bragg Creek and Highway 22, but counts at

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