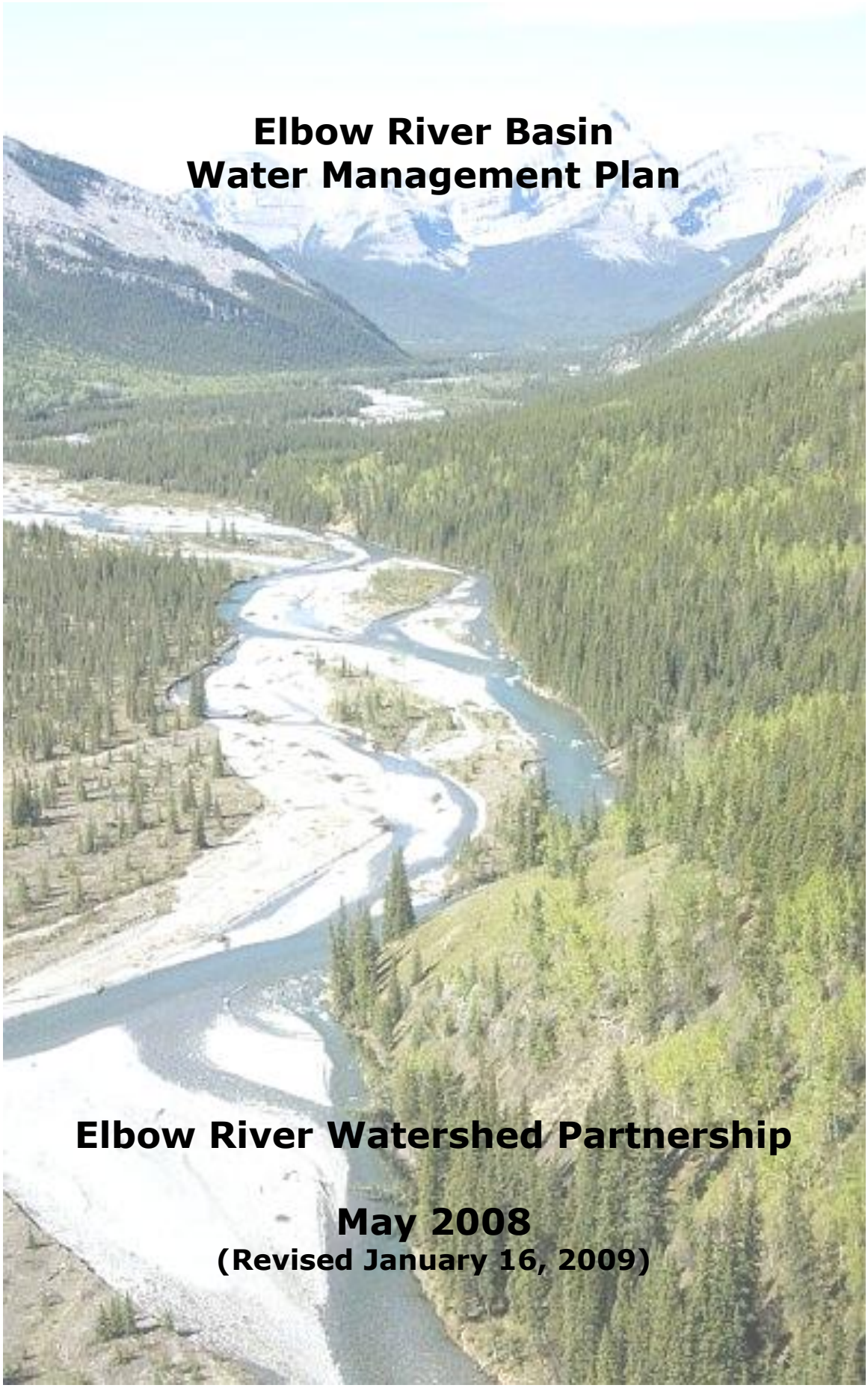
# Elbow River Basin
# Water Management Plan



## Elbow River Watershed Partnership

## May 2008
**(Revised January 16, 2009)**

# Elbow River Basin Water Management Plan:

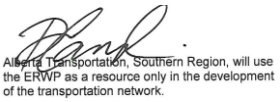
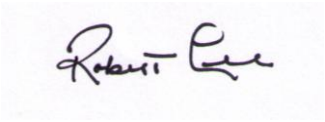
# A Decision Support Tool for the Protection of Water Quality in the Elbow River Basin

## Vision

**Ample clean water for the benefit of all, while maintaining the integrity of the aquatic environment.**

## SIGNATORIES DOCUMENT

The following organizations agree to use this document as a decision support tool and work with the Elbow River Watershed Partnership by developing implementation strategies toward realizing the outcomes of the Elbow River Basin Water Management Plan.

| Organizations | Signature and/or Comments |
|---|---|
| **Alberta Environment**<br>❑ Jay Litke, Director | Signed endorsement letter, dated November 17, 2008, was received by the ERWP. |
| **Alberta Health Services - Calgary Health Region**<br>❑ Robert W. Bradbury, Director<br>(October 17, 2008) |  |
| **Alberta Sustainable Resource Development**<br>❑ Rick Blackwood<br>(February 25, 2009) |  |
| **Alberta Tourism, Parks and Recreation**<br>❑ Dave Nielsen<br>(March 5, 2009) |  |
| **Alberta Transportation**<br>❑ Darrell Camplin<br>(June 8, 2009) |  <br>Alberta Transportation, Southern Region, will use the ERWP as a resource only in the development of the transportation network. |
| **Bow River Basin Council**<br>❑ Bill Berzins, Chair<br>(June 8, 2008) |  |
| **City of Calgary**<br>❑ City Council | On September 8, 2008, City Council approved the plan as a guidance document and planning tool. |
| **Elbow River Watershed Partnership**<br>❑ Robert Lee, Chair<br>(September 18, 2008) |  |
| **Municipal District of Rocky View**<br>❑ MD Council | On January 13, 2009, MD Council endorsed the document as a guidance document and planning tool. |
| **Townsite of Redwood Meadows**<br>❑ Council | On February 17, 2010, Tim Anderson moved and John Welsh seconded that Council approve the Elbow River Basin Water Management Plan as a guidance document and planning tool, subject to Tsuu T'ina leasehold restrictions. |
| **Tsuu T'ina Nation** | Legal issues prevent Tsuu T'ina Nation from considering adoption of this plan. |

## ACKNOWLEDGEMENTS

It took the work of a number of dedicated individuals to produce this water management plan. Foremost among them are the following:

**Gloria Wilkinson**, Volunteer Chair, Elbow River Basin Water Management Plan Steering Committee, who championed the creation of this plan right from the start and steered its course every step of the way (even when it appeared that some of us were paddling in circles). Without her capable guidance and the hundreds of volunteer hours she provided, this plan would never have come to fruition.

**Elbow River Water Management Plan Steering Committee**,which spent countless hours developing the plan, debating the plan, revising the plan, then debating the plan and revising it yet again. The committee members, all of whom generously provided their time, were

| | |
|---|---|
| Bryce Starlight | Tsuu T'ina Nation |
| David Crowe | Calgary Health Region |
| Don Cockerton | Alberta Tourism, Parks, Recreation |
| Doug Balsden (facilitator) | Alberta Municipal Affairs |
| Jean Lussier and Axel Anderson | Alberta Sustainable Resource Development |
| John Jagorinec | City of Calgary |
| Mike Murray | Bow River Basin Council |
| Monique Dietrich | Alberta Environment |
| Paul vonShoenberg | Calgary Health Region |
| Sarah Hamza | Elbow River Watershed Partnership |
| Sheena Majewski | Fisheries and Oceans Canada |
| Sheikh Javed Ahmed | Municipal District of Rocky View |

**Bow Basin Water Management Plan Technical Committee Members** (see www.brbc.ab.ca), who volunteered their technical expertise to develop the water quality objectives, and in particular the committee chair **Al Sosiak**.

**Angela Braun, Margaret Bradley and Steve Gaylor**, Alberta Sustainable Resource Development, who prepared the watershed maps.

**Jamie Dixon**, City of Calgary Water Resources, who provided the Elbow River water quality and water quantity data.

**Robert Lee**, photographer extraordinaire, who provided the stunning cover photo, which captures the Elbow River's meandering nature.

**Alberta Environment, City of Calgary, and MD of Rocky View**, which provided funding for this plan.

The ERWP sincerely thanks the people and organizations mentioned above, as well as all those of you who took the time to provide feedback.

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## EXECUTIVE SUMMARY

Water quality in the upper Elbow River watershed is excellent. However, there is documented water quality deterioration in the central and lower reaches, that is, the more developed reaches of the watershed. There is evidence that activities on the alluvial aquifer, adjacent to the Elbow River, are contributing to the observed downward trend in water quality. Increasing urban and rural developments are having significant impacts on the watershed, with urban runoff a known source of river pollutants.

To address the water quality degradation trend in the Elbow River and to ensure sustainability of long-term water resources, the Elbow River Watershed Partnership (ERWP) recommends all stakeholders and jurisdictions in the watershed implement watershed management practices. A multi-stakeholder steering committee, which derived its authority in signed terms of reference, has provided key recommendations and implementation actions to maintain or improve water quality in the Elbow River watershed.

The two main objectives of the Elbow River Basin Water Management Plan are to establish reach-specific guidelines for water quality and to provide decision-making advice to federal, provincial and municipal authorities. The plan recommendations include protecting the Elbow River's natural functions, limiting land-use on the alluvial aquifer, implementing low impact development practices, increasing education and awareness initiatives and monitoring and evaluating the actions required to meet the desired outcomes. The plan also aims to encourage a stewardship ethic for resource management in the Elbow River watershed.

The ERWP Steering Committee presents this final draft of the water management plan, which incorporates a broad range of stakeholder and public input. It is anticipated that a final water management plan will be adopted by all jurisdictions by late 2008. It is recommended that the ERWP strike a new committee to develop an implementation plan to achieve the plan recommendations. An annual review by the ERWP with adaptive management strategies applied as needed will ensure steady progress of the evolving implementation plan.

## GLOSSARY

| | |
|---|---|
| **Agriculture** | The raising of crops or the rearing of livestock, either separately or in conjunction with one another, and includes buildings and other structures incidental to the operation. |
| **Alluvial Aquifer** | Subsurface geological unit along a river or stream that is hydraulically connected to the surface water. This is an unconfined aquifer but not all unconfined aquifers are in alluvial deposits. |
| **Aquaculture** | The culturing of animals or plants in an aquatic setting. |
| **Basin/Watershed** | The land area that drains into a water body, such as a lake, river or wetland. These terms are used interchangeably. |
| **Instream Flow Needs (IFN)** | The amount of water flowing through a natural stream course that is needed to sustain, rehabilitate, or restore the ecological functions of a stream in terms of hydrology, geomorphology, biology, water quality, and connectivity at a particular level. |
| **Development** | Alteration or change to the land as a result of human activity that impacts on groundwater or surface water quality. |
| **Green Area and White Area** | These two major land designations in Alberta were created in 1948 to guide development of the province and to deal, in part, with the failure of homesteads on lands unsuitable for agriculture. The White Area was set aside as land primarily suited for agriculture and settlement. The Green Area included forested land for forest management planning and protection of important watershed areas (Alberta Government).[1] |
| **Groundwater** | The water that is found under the ground surface, in the spaces between rocks, soils and overburden (pore space). The upper limit of the saturated zone is defined by the water table, while the lower limit of groundwater is less well-defined. |
| **Groundwater under the direct influence (GWUDI)** | Groundwater that is found below the ground surface and is in direct contact with surface water. |
| **Low Impact Development** | A comprehensive landscape-based approach to sustainable urban-style development encompassing strategies to maintain existing hydrology and ecology. |
| **Outcome** | A desired state; an achievable result. |
| **Precautionary Principle / Approach** | Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. Conversely, the precautionary principle should not be used as a reason not to proceed with development in the face of uncertainty, which always exists to some degree. It is a reason to proceed with appropriate precautions and risk management plans in place or to actively investigate the uncertainty. The fundamental elements of risk analysis are essential when applying the precautionary principle: |

[1] Alberta's Land Use Framework can be viewed at www.landuse.gov.ab.ca.

| | |
|---|---|
| | • Is the activity or the environment vulnerable/ hazardous;<br>• What is the risk scenario and the probability of an adverse sequence or outcome and;<br>• What is the consequence or importance if an adverse event occurs? |
| **Pesticide** | A substance used to destroy pests. A pest can be in the form of a plants, insects, animals or fungi. Pesticide includes fungicides, herbicides and insecticides. |
| **Riparian Areas** | Transitional zones between upland and aquatic habitat. They provide important ecological functions, contain a diverse assemblage of plan and animal species, provide essential habitat for wildlife and are influenced by seasonal water levels. |
| **Stakeholder or Shareholder** | Individual, organization or government with an interest in or engaged in resource and environmental management or are affected by a management decision and have an interest in its outcome. |
| **Stewardship** | A means by which citizens participate in the careful and responsible management of air, water, land and natural resources to sustain the natural processes on which life depends. |
| **Stormwater** | Precipitation that runs off of the land rather than soaking into the ground. |
| **Water Conservation Objective (WCO)** | Pertains to the amount and quality of water established by the Director (designated under the *Water Act*) to be necessary for the:<br>• protection of a natural water body or its aquatic environment, or any part of them;<br>• protection of tourism, recreational, transportation or waste assimilation uses of water; or<br>• management of fish or wildlife; and<br>• may include water necessary for the rate of flow of water or water level requirements.<br>*Water Act*, Interpretation 1(1)(iii) |
| **Water Quality Objective (WQO)** | A site- or reach-specific water quality guideline. |
| **Water Source Area** | That portion of a watershed where soils are water-saturated and/or surface flow occurs and contributes directly to streamflow. The area of saturated interflow associated with a stream. |
| **Wetlands** | Lands that have water near or above the land surface or that is saturated with water long enough to promote aquatic processes as indicated by poorly drained (hydric) soils, hydrophytic vegetation and other activities adapted to a wet environment. |

# PART 1: INTRODUCTION

The Elbow River is an important multi-use tributary river in the Bow River basin supporting many uses, including raw water supply for drinking water, irrigation for crops and golf courses, stock watering, resource extraction, and various kinds of recreation. The Elbow River watershed, which includes many tributaries and occupies an area of 1235 km$^2$, is currently experiencing rapid development and increasing activities in both rural and urban areas.

Water quality in the upper watershed is of excellent quality while in the lower developed portions water quality has deteriorated. Increasing trends in the concentrations of phosphorus, nitrogen, total suspended solids and coliform bacteria have been observed over the past decade in the Elbow River, especially in the area of Twin Bridges and Weaselhead Bridge in the City of Calgary (Sosiak 1999, Sosiak and Dixon 2004). A bacterial source tracking study in 2004 showed ruminant sources of bacteria at sampling locations throughout the watershed (Sosiak and Dixon 2004). In 2005, a year of very high precipitation, Alberta Environment recorded human sources and ruminant sources of bacteria at sampling sites in the main stem of the river and various tributaries.[2]

The jurisdictions responsible for managing activities in the watershed include the Government of Alberta, Kananaskis Improvement District, Municipal District of Rocky View, Tsuu T'ina Nation, and The City of Calgary (Figure 1).

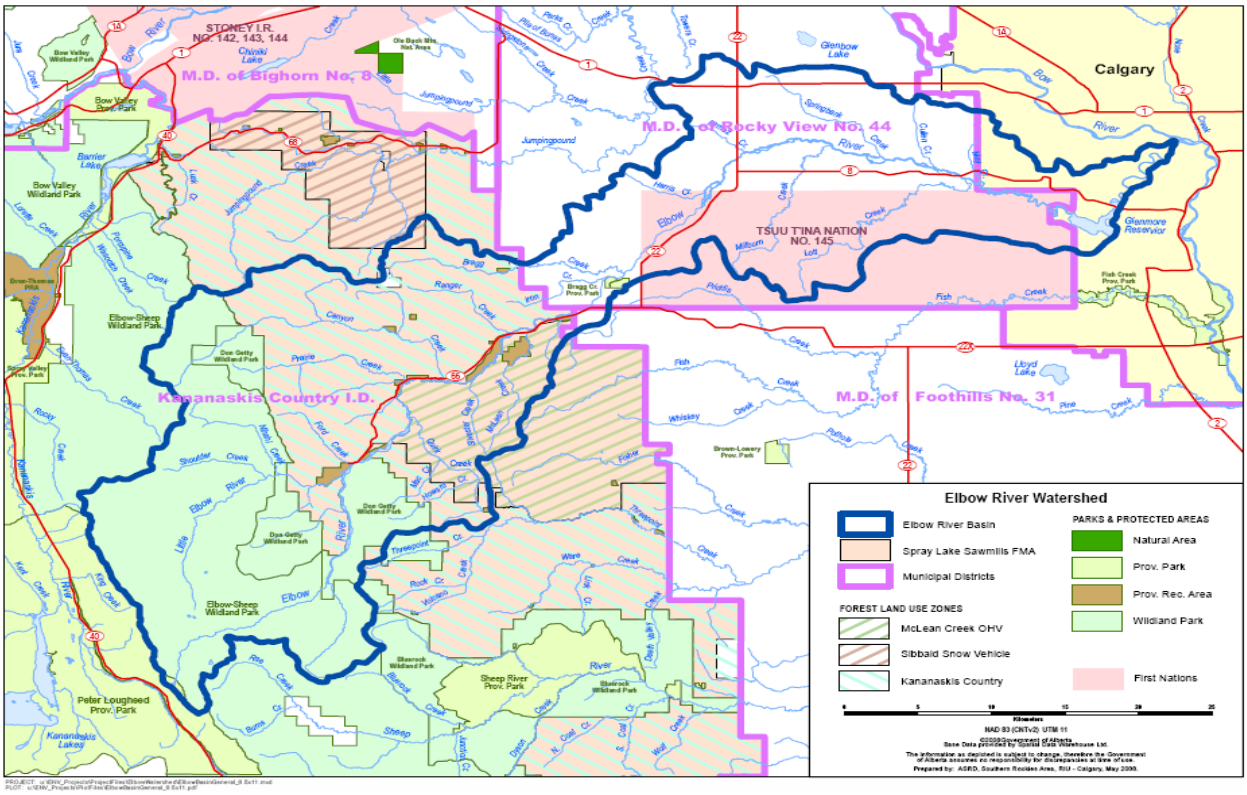


**Figure 1: Jurisdictional map of the Elbow River watershed**

[2] March 8, 2007 – Presentation to ERWP of scientifically verified but unpublished data by A. Sosiak, Alberta Environment.

The Elbow River Basin Water Management Plan (ERBWMP) is a unique plan, collaboratively developed by and for the stakeholders of the Elbow River watershed and Tsuu T'ina Nation, as Chief and Council allowed. The purpose of this water management plan is to provide guidance for decision-makers when their decisions could impact the protection, restoration and/or maintenance of water quality in the Elbow River and its tributaries**.**

(Note: Water quantity was not assigned to the ERBWMP Steering Committee because the South Saskatchewan River Basin Water Management Plan, which addresses water quantity, was awaiting approval at the time. The South Saskatchewan River Basin Plan has since been approved with the decision by Cabinet to close the Basin, which includes the Elbow River basin, to any new surface water license allocations.)

## 1.1 Authority

The Government of Alberta's *Water for Life* strategy (www.waterforlife.alberta.ca/) identified the need to engage all Albertans in managing our watersheds. It is through the volunteer work of collaborative partnerships such as the Elbow River Watershed Partnership and the Bow River Basin Council that the desired outcomes of the *Water for Life* strategy are being realized.

In the province of Alberta, the authority to develop and implement a water management plan comes from the *Water Act* allowing anyone to develop a water management plan. The process is guided by the *Framework for Water Management Planning,* which is currently being revised to include a watershed approach to managing water under a shared governance model. With this framework being currently under revision, the ERBWMP Steering Committee took a watershed approach when developing water quality management recommendations.

The following organizations have endorsed the Elbow River Water Management Plan Terms of Reference, dated 18 August 2006, showing their support to participate in the development and implementation of recommendations (documentation of signatory process available upon request).

- Alberta Community Development (now, Alberta Tourism, Parks and Recreation)
- Alberta Environment
- Alberta Sustainable Resource Development
- Bow River Basin Council
- Calgary Health Region
- The City of Calgary
- Elbow River Watershed Partnership
- Fisheries and Oceans Canada
- Municipal District of Rocky View
- River Valleys Committee
- Kananaskis Improvement District

Tsuu T'ina Nation has determined that since the South Saskatchewan River Basin Water Management Plan has now become legislation, they will be unable to endorse the ERBWMP until their issues with the South Saskatchewan River Basin process are resolved.

## 1.2 Roles and Responsibilities

The Elbow River Watershed Partnership (ERWP) assigned the development of a water management plan to a steering committee to address the trend of water quality degradation reported in Sosiak and Dixon (2004). Through the commitment of stakeholders and decision makers in the watershed, the recommendations within this plan are suggested as a means to reverse the existing trend of water quality degradation in the Elbow River. Additionally, the actions of the ERWP focus on the protection of the Elbow River and its tributaries as noted in its annual operational plan.

The role of the ERBWMP Steering Committee was to review the current state of water quality in the Elbow River and consider the available science to develop recommendations for long-term protection of water quality in the Elbow River and its tributaries. For a full description of the roles and responsibilities of the committees involved in this process, please see the Terms of Reference (www.erwp.org/watermgtplan.html). A technical committee was assigned the task to determine site-specific requirements for water quality.

It is expected that all decision-makers in the Elbow River watershed will use the recommendations put forth in this plan to develop innovative solutions and policies to achieve the water quality objectives and outcomes. The Steering Committee recommends a risk-based precautionary approach to decision-making.

### 1.2.1 Existing Jurisdictions

**Provincial Crown Lands**

*Protected Areas*
In 1998 the Government of Alberta established the Elbow-Sheep Wildland Provincial Park in the headwaters portion of the Elbow watershed to provide a high degree of protection to the lands and water. Land use activities in Wildland Parks are limited to non-motorized recreation and development is restricted to trails and back country campgrounds. Alberta Tourism, Parks and Recreation is responsible for managing the Protected Areas.

*Forest Reserve*
In 1906 the Government of Canada passed the Dominion Forest Reserves Act, authorizing forest reserves to be set up "for the maintenance and protection of the timber growing or which may hereafter grow thereupon, for the protection of the animals and birds therein, and the fish in the waters therein, and for the maintenance of conditions favourable for a continuous water supply." The Bow River Forest Reserve was established by Order in Council in 1911 as part of the Rocky Mountains Forest Reserve. It was established for the purpose of conserving the headwaters of the North and South Saskatchewan River basins to ensure optimum flow of water in both river systems to meet the needs of Alberta, Saskatchewan and Manitoba. The Rocky Mountains Forest Reserve was formally re-established in 1964 under Alberta's *Forest Reserves Act* and revised in 2004. In describing the purpose of forest reserves, the current Act states the following: "All forest reserves within Alberta are set apart and established for the conservation of the forests and other vegetation in the forests and for the maintenance of conditions favourable to an optimum water supply." (Alberta Sustainable Resource Development 2006). Alberta Sustainable Resource Development is responsible for managing the Rocky Mountains Forest Reserve.

### Municipalities

The Municipal District of Rocky View #44 and The City of Calgary are development control authorities within their respective boundaries under the *Municipal Government Act*.

### First Nations

Tsuu T'ina Nation is the land manager and development control authority within their boundary under federal legislation.

## 1.3 Water Management Plan Context

The Elbow River is a tributary of the Bow River. The Bow River contributes flow to the South Saskatchewan River, as shown in Figure 2. Water management plans exist, or are being developed, for the Bow and Elbow Rivers and each plan must fit together with the other, just like rivers flowing one into the other. Under the *Water for Life* strategy, water management planning is encouraged at all scales to help address the integration of land-use management.

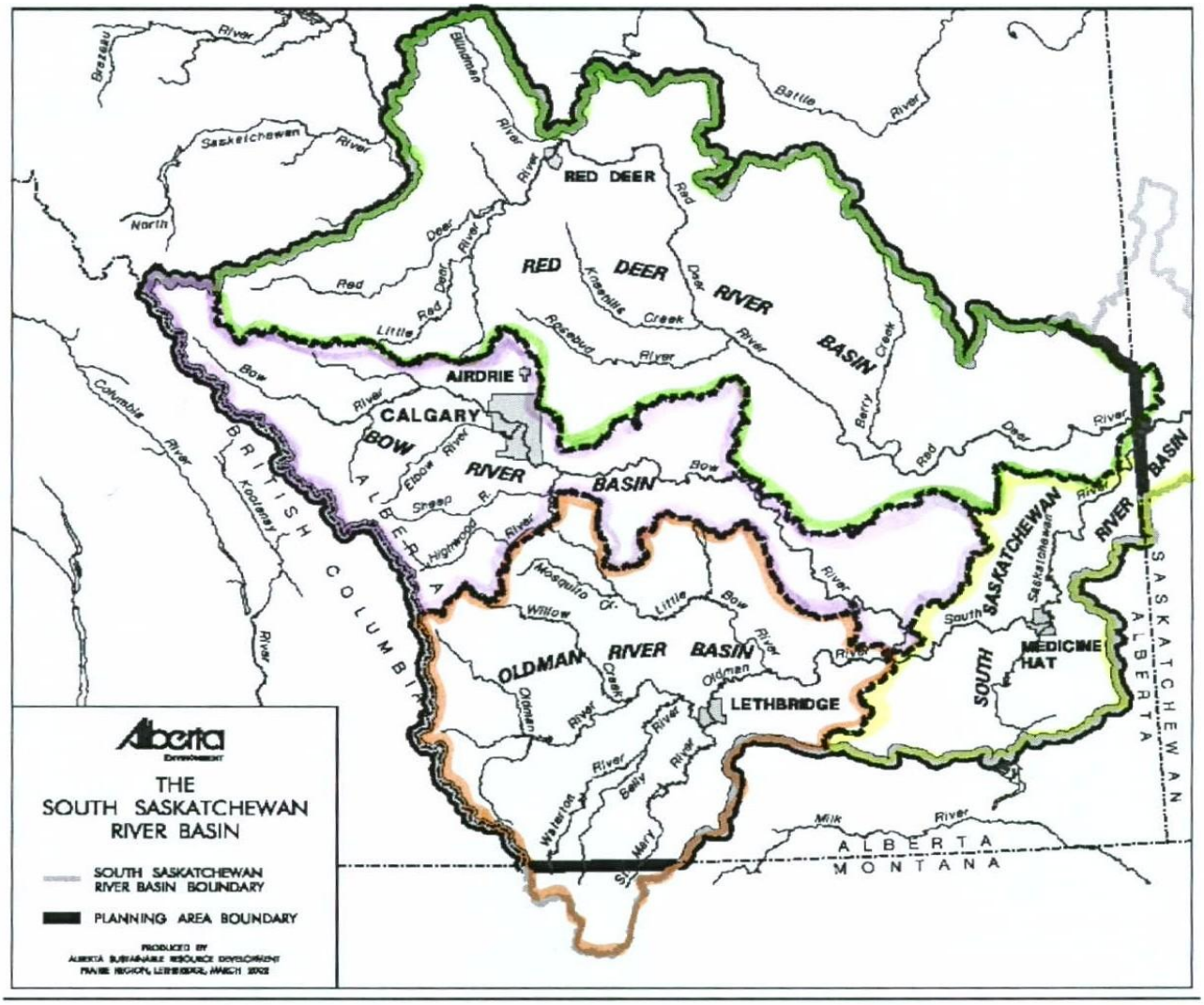


**Figure 2: South Saskatchewan River Basin**

## 1.4 Outcomes and Objectives

### 1.4.1 Outcomes

The ERBWMP Steering Committee identified four outcomes, or desired states, to be achieved with the implementation of the Elbow Plan. The first three outcomes are aligned with Alberta's *Water for Life Strategy*, while the fourth addresses the importance of local stewardship. The four desired outcomes are as follows:

1. Safe, secure drinking water supply
2. Healthy aquatic ecosystems
3. Reliable, quality water supplies for a sustainable economy
4. Inclusive, integrated and committed stewardship of the river and watershed

Water quality objectives and related indicators were determined by the Bow Basin Watershed Management Plan Technical Committee using the best available scientific studies and were based on reach-specific outcomes for the protection of surface water quality for the purposes of:

- raw water supply for human consumption
- irrigation of crops
- livestock watering
- water withdrawal systems protected from high levels of algae and/or macrophyte growth
- maintaining the existing cold water aquatic ecosystem fauna structure and abundance
- safe contact recreation

### 1.4.2 Objectives

Based on the desired outcomes, the objectives of the Elbow River Basin Water Management Plan are as follows[3]:

**Objective 1:** Recommend water quality objectives.

***Rationale:*** Water quality in the Elbow River has deteriorated in recent years, with concentrations of phosphorus, nitrogen, turbidity, total suspended solids and coliform bacteria all increasing (Sosiak and Dixon 2004). Both point and non-point contaminant sources can affect water quality in the Elbow River, which is a drinking water source for rural residents, public facilities and the City of Calgary.

Establishing water quality objectives allows stakeholders to work out mutually acceptable targets for the protection, restoration, and/or maintenance of the Elbow River watershed. Regulators can be confident that the objectives are achievable since they are based on consensus among stakeholders developed through an open process using credible scientific information.

**Objective 2:** Provide decision-making advice within the Elbow River watershed for federal, provincial and municipal authorities.

***Rationale:*** The ERBWMP is a local level planning initiative that provides decision-makers with relevant, Elbow-specific considerations and information essential for effective protection, restoration, and/or maintenance of the Elbow River watershed.

[3] From Elbow River Water Management Plan Terms of Reference (www.erwp.org/watermgtplan.html).

# PART 2: DESCRIPTION OF THE ELBOW WATERSHED

## 2.1 Geography and Geology

The Elbow River watershed originates in Alberta's eastern slopes of the Rocky Mountains at Elbow Lake and flows approximately 120 kilometres through mountainous terrain and foothills then through prairie grasslands where it empties into the Bow River at the City of Calgary. The river is considered short and steep with an average slope of 1%; it drops 1000 metres from source to mouth (Dixon 2006).

The entire watershed is approximately 1235 $km^2$ in area. The majority of it, or 780 $km^2$ (63%), lies within Kananaskis Country, which is in the Green Area, principally zoned Forest Reserve. The rest of the watershed is in the White Area. Approximately 264 $km^2$ (22%) of the watershed is within the Municipal District of Rocky View #44. At the time of their study, Sosiak and Dixon (2004) found that land uses in 80% of this part of the watershed is low-intensity agriculture and approximately 16% is residential. Tsuu T'ina Nation covers 160 $km^2$, or 13% of the watershed, and the remaining 2% is within the City of Calgary which is fully urbanized. Agriculture consists mostly of cattle ranching operations on large, open tracts of land, rather than crop production. Most of the residential development in the watershed is on large lots (> 2 acres) upstream of the Glenmore Reservoir, but the number of smaller-lot, cluster-type subdivisions has increased in recent years (Elbow River Water Quality Steering Committee and Task Force 1993).

### 2.1.1 River Reaches

This water management plan covers the area that drains into the Elbow River from the headwaters to the Glenmore Reservoir (Figure 3). The area downstream of the reservoir is controlled by the drinking water operations of the City of Calgary and is to be addressed in the Bow Basin Watershed Management Plan (BBWMP).

For water management planning, the Elbow River watershed is divided into distinct reaches, which follow jurisdictional boundaries as described below. Each reach is subject to local land-use decisions by the presiding jurisdiction and therefore decision-making may be different in each reach.

1. The **upper reach** is the area within the Kananaskis Improvement District and includes land uses such as tourism and recreation, including off-highway vehicle trails, cattle grazing, timber harvesting and oil and gas operations. It is entirely within the Green Area.
2. The **central rural reach** includes the portion of the watershed in the Municipal District of Rocky View and Tsuu T'ina Nation lands and a very small portion in the Municipal District of Foothills. Land uses are primarily agriculture, recreation and rural residential, including the Hamlet of Bragg Creek.
3. The **central urban reach** is the area within the Calgary municipal boundary upstream of the Glenmore Dam and includes land uses related to urban residential, commercial and recreation.

The **lower Elbow River**, although not included in this plan, refers to the area downstream of the Glenmore Dam, the only flow control structure on the Elbow River. This reach is fully developed with a mixture of commercial, residential, urban park areas and golf courses. Areas that are undergoing redevelopment will benefit from the recommendations in this plan and those in the BBWMP.

### 2.1.2 Geomorphology and Hydrology

The Elbow River is a naturally braided river, which means the river is divided into a number of channels by relatively transitory gravel bars or islands (Kellerhals, Neill and Bray 1972). Braided rivers are subject to rapid and unpredictable abandonment of a channel segment and creation of another channel some distance away (Dunne and Leopold 1978). The Elbow River displays this characteristic on a regular basis and changes in channel morphology are often evident following times of high flow.

The flow pattern, or discharge pattern, of the Elbow River is routinely measured and has been documented in the City of Calgary watershed report as highly variable throughout the year, with the average flow ranging from 4 cubic meters per second ($m^3/s$) in winter months to 31 $m^3/s$ during spring runoff (City of Calgary 2004). The 2005 spring runoff was a year of significant flooding when the instantaneous peak flow rate was 525 $m^3/s$. For comparison, the instantaneous peak flow rate for the 1932 flood was estimated at 726 $m^3/s$ (pers. comm. Jamie Dixon). Flooding is a natural part of the Elbow River system and important for recharging the alluvial aquifer, improving riparian function through the deposition of sediment, flushing of sediments and plant material from the river channel, creating new channels and undercut banks, and for contributing large woody debris to the river for fish habitat (ERWP 2005).

In a changing climate, the streams in the South Saskatchewan River Basin are highly vulnerable and may face increasing temperatures, accelerated evaporation and a more active precipitation cycle. Regionally, the potential impacts from climate change are anticipated to include changes in annual stream flow with potentially large declines in summer flow and changes in water availability (Martz, Bruneau and Rolfe 2007).

### 2.1.3 Alluvial Aquifer

The Elbow River alluvial aquifer refers to the shallow, unconfined gravel and sand unit deposited by current and historic river processes (Manwell 2005). It was formed by alluvial (river) deposition and is very permeable and highly hydraulically connected to the Elbow River. The upper surface of the unconfined aquifer is the water table and the other surfaces are bound by less permeable sandstones and shales (Manwell and Ryan 2006). Groundwater from the alluvial aquifer flows into the river during periods of low river flow and river water flows into the aquifer during times of high river flow. Water withdrawal from groundwater in the alluvial aquifer is considered to be surface water and is licensed as such by Alberta Environment under the *Water Act*. The aquifer is located on both sides of the Elbow River at varying widths and is mapped in the central reach (Figure 4). It represents approximately 5% of the land area or 58 $km^2$ of the watershed. To accompany the recommendations in this plan, the alluvial aquifer has been mapped using surficial geology documented by the Alberta Geological Society (Moran 1986) and elevation information as provided by Alberta Sustainable Resource Development. The map will be updated as information becomes available.

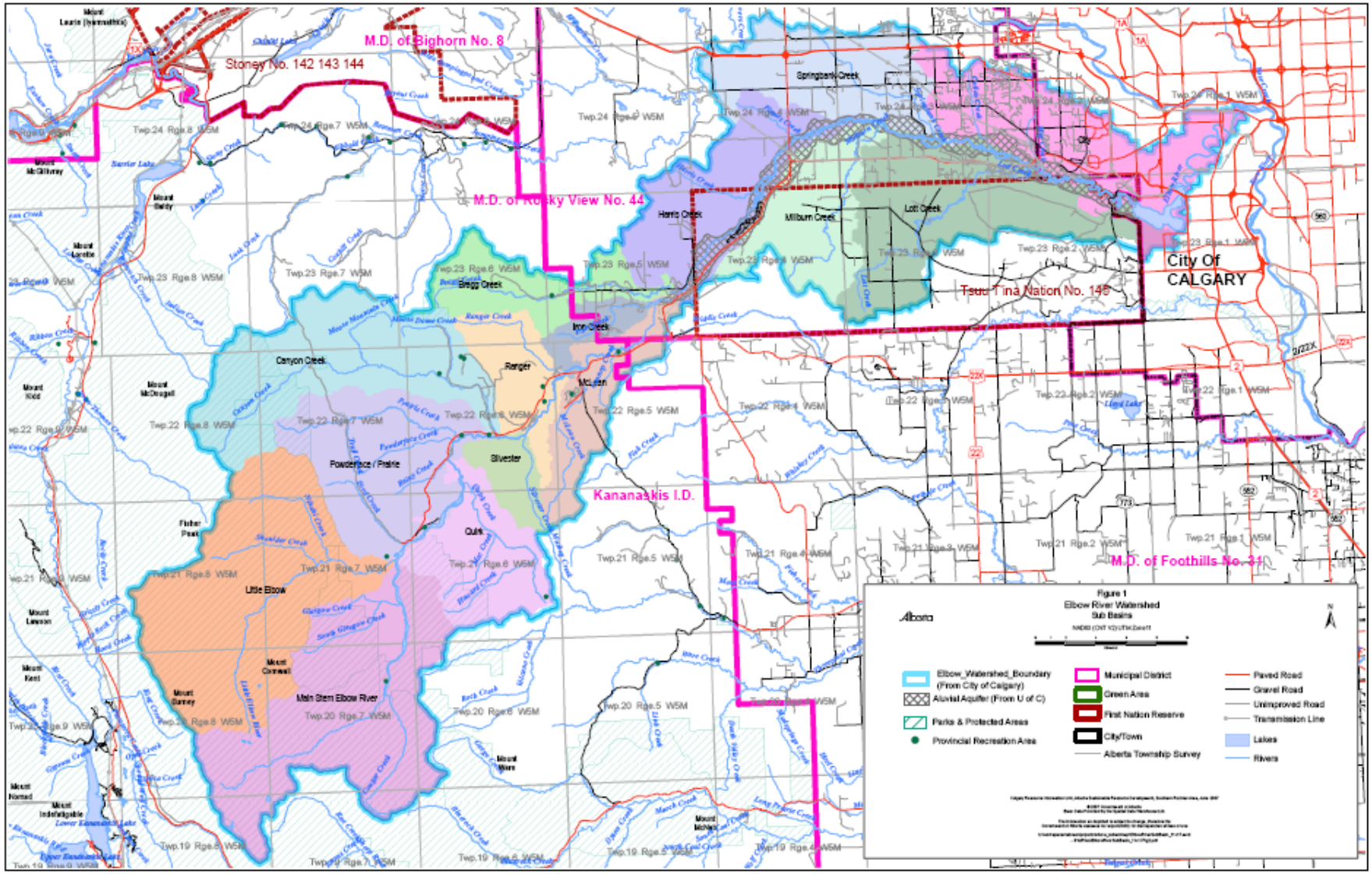


**Figure 3: Elbow River watershed with sub-basins delineated by colour**

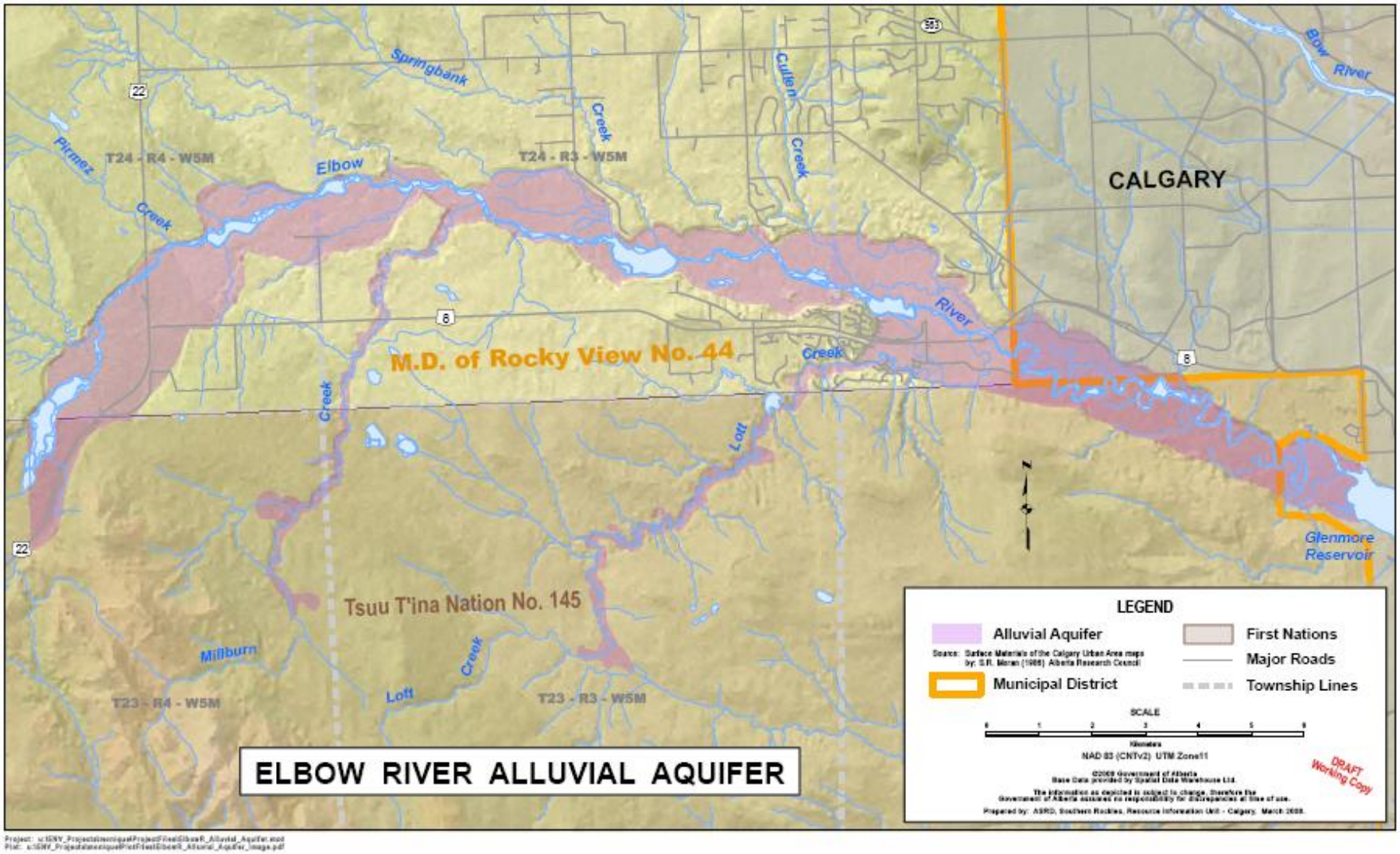


**Figure 4: A portion of the Elbow River alluvial aquifer**

### 2.1.4 Riparian Areas

Riparian areas are an integral part of the river system and are maintained in part by river flows and flooding (Annear *et al.* 2004). Their functions and values are important to water quality, riverbank stability, aquatic and terrestrial wildlife habitat, flood control and aesthetics. In addition to providing environmental functions, healthy riparian areas provide important economic benefits including adding fertility to floodplain soils, food, shelter and shade for fish and wildlife, as well as a high quality water source for livestock (Alberta Government 2007).

## 2.2 Demands on the Watershed

### 2.2.1 Discharges to the River

Stormwater from urbanized land areas is discharged directly to the Elbow River or, in some cases, after pretreatment in stormwater retention ponds. There are 9 stormwater ponds located in the central urban reach upstream of the Glenmore Dam and a total of 5 stormwater outfalls. Two of these outfalls are discharged directly into the Elbow River and three are discharged into stormwater retention ponds.

There are no authorized direct discharges of wastewater (from sewage) to the Elbow River upstream of Glenmore Dam (Sosiak and Dixon 2004). Such operations would be authorized and regulated by Alberta Environment under the *Environmental Protection and Enhancement Act* (*EPEA*).

### 2.2.2 Industry

#### Agriculture

Agricultural operations are governed under various provincial agencies including Alberta Agriculture and Rural Development, Alberta Environment, Alberta Sustainable Resource Development and the Natural Resources Conservation Board. Current livestock operations in the Elbow River watershed are considered to be low intensity, with declining numbers of operations due to land-speculation purchases in the White Area.

Grazing allotments are granted to cattle managers that meet specific criteria to allow temporary access to specified grazing areas in the Forest Reserve. Managers are required to follow a rotational grazing system. The Elbow allotment area allows 990 animal unit months (AUM) per year (1.18 AUM is the amount of forage required by one cow weighing 1250 pounds (or a cow-calf pair) per month; bulls require 1.7 AUM, and yearlings (steers and heifers) require 0.78 AUM. Allotments are administered and regulated under the *Forest Reserves Act* and most are only active from June to October.

#### Aquaculture

Aquacultural operations exist in the Elbow watershed for commercial fish growing. They are licensed through Alberta Agriculture and Rural Development under the provincial *Fisheries Act* and governed by Alberta Sustainable Resource Development, Fish and Wildlife Branch. Water quality guidelines developed by Alberta Environment (for biological oxygen demand, total suspended solids, phosphorus and ammonia nitrogen), must be met for wastewater effluent, if any, from these operations.

#### Golf Courses

There are eight golf courses operating in the Elbow River watershed. All are authorized municipal land uses located adjacent to the main stem Elbow River. Water for irrigation

is licensed under the *Water Act*. Some of the current tools used in a complex golf course maintenance program include irrigation systems, fertilizers and pesticides to ensure optimum turf for golfing. An Audubon Cooperative Sanctuary Program for Golf Courses helps golf courses protect the environment by helping golf managers enhance the natural areas and wildlife habitats that golf courses can provide, improve efficiency, and minimize potentially harmful impacts of golf operations.[4]

**Oil and Gas**

In Alberta, public land and natural resources are under the jurisdiction of the Government of Alberta. Access to and use of public land and its resources are authorized through a variety of separate authorities, which grant leases, licenses, permits, agreements, or other types of approvals. Private land operations are subject to federal approvals under Indian Oil and Gas and municipal approvals.

Industrial activities such as geophysical exploration, well sites, access roads and pipelines may increase the potential for stream bank or riparian erosion, which results in increased sedimentation. Exploration programs on Crown Lands are approved under the authority of the *Mines and Minerals Act* and industrial dispositions such as well sites, access roads or pipelines under the *Public Lands Act.* Current activities occur mainly in the Forest Reserve.

**Timber Harvesting**

Timber harvesting rights are granted through a timber disposition, which can take the form of a forest management agreement, a timber license or a timber permit. A timber disposition contains a list of conditions, a timber harvest plan with operating ground rules, which the harvester must follow. A timber disposition is a legal document subject to provincial legislation, including the *Forest Act*, *Forest Reserves Act*, *Public Lands Act*, *Forest Prairie and Protection Act*, *Environmental Protection and Enhancement Act* and associated provincial regulations, such as the Timber Management Regulation, as well as federal legislation, such the *Fisheries Act* and *Navigable Waters Protection Act*. All timber and public lands dispositions have approval conditions that involve protection of waterbodies, watercourses, and water source areas, as well as road construction and reclamation, to minimize any impacts on fisheries, fish habitat and water quality.

### 2.2.3 Recreation

The upper watershed, which is located within Kananaskis Improvement District, provides a wide range of public outdoor recreation opportunities. The surrounding population of over 1,000,000 people is within a 45-minute drive of these public recreation facilities. The main activities provided for include off-highway vehicle use in the McLean Creek Forest Land Use Zone, camping, picnicking, fishing, hiking, biking, and horse riding. Canoeing or kayaking occurs on portions of the Elbow River during high flow periods, usually in spring.

Potential impacts to water quality can be mitigated or eliminated by careful consideration of facility location and design. For example, where feasible, facility development close to the river is minimized and often limited to pathways, viewpoints or picnic sites. Vegetative buffers are left where possible or rapid re-establishment of effective vegetative buffers is done during facility upgrading. Measures such as rerouting, bio-engineering for soil stabilization and bridge construction on watercourse crossings continue to be used as designated trail networks are upgraded. Stewardship

[4] http://www.audubonintl.org/programs/acss/golf.htm

and responsible recreation is promoted through Alberta Sustainable Resource Development's *Respect-the-Land* Program.

The central rural portion of the Elbow River watershed (downstream from the Kananaskis Improvement District boundary) is used less intensively for recreation for activities such as golf courses, informal walking and equine riding and access for fishing and light boat paddling.

### 2.2.4 Residential and Commercial

The Elbow River watershed has a mix of high to low density residential areas. Rural is typically low density clusters of homes on two acre or larger parcels of land served by a common road and a common water supply. Based on Alberta Labour Codes, each developed parcel of land has a septic tank and tile field for wastewater.

Drinking water is supplied by water co-ops, private systems, groundwater wells or a municipal drinking water supply. The Elbow River is the direct source of drinking water to approximately 1 in 6 Albertans (Sosiak and Dixon 2004). It is a significant raw water source for the City of Calgary, Redwood Meadows and some rural residential communities in Springbank. Some drinking water wells within Bragg Creek are located in the alluvial aquifer and are therefore considered to be surface water directly connected to the Elbow River. The Hamlet of Bragg Creek remains under an active boil water advisory due to confirmed aquifer contamination, with high numbers of wells throughout the community showing the presence of coliforms.

# PART 3: MEASURABLE IMPACTS ON WATER QUALITY

In determining recommendations for long-term water quality protection, the Steering Committee considered the known impacts to water quality in the Elbow River watershed as detailed in published studies and presented to the Committee by scientific experts. These impacts are described below.

## 3.1 Natural Disturbance

Stream bank erosion, avalanche, landslide and nutrient cycling are normal ecosystem processes that influence water quality. The Elbow River requires inputs of sediments to maintain geomorphic structure. Inputs of nutrients are important for stream productivity. Flooding, fire and large-scale insect damage are natural processes that affect the transport of sediments and nutrients from hill slopes to streams and also redistribute sediments and nutrients downstream. In the Elbow River watershed, decades of fire suppression have created a landscape with a large component of old growth forest that is at high risk for severe large-scale fire and insect damage. This risk to water quality and flow regimes (amount and timing of stream flow) has to be recognized and should be managed accordingly.

## 3.2 Turbidity and Sedimentation

Although large-scale disturbances can be natural processes and a stream would naturally recover from them with time, disturbances can cause catastrophic changes to water quality and geomorphic structure of the stream. These changes may no longer be acceptable given the current human uses and reliance on the water. Increased sediment and turbidity causes problems for drinking water treatment plants and for aquatic life.

The construction of logging roads and watercourse crossings, the creation of bare areas and the removal of forest vegetation may lead to increased erosion and sedimentation, resulting in reduced water quality for a certain period of time. The flow regime can also be impacted by the removal of forest vegetation and the development of road networks. The degree of change to the flow regime depends on the scale and location of harvest operations and road development, watershed topography, season of activities, climate and forest composition.

At times of high flow in the Elbow watershed, river bank erosion contributes a large amount of suspended sediment to the Elbow River, as measured by Sosiak and Dixon in the year of 2002. During years of low to average flow, Sosiak and Dixon (2004) found that most of the suspended sediment was measured in the lower reaches, citing urban stormwater conveyance systems as a source.

## 3.3 Alluvial Aquifer Pollutant Loading

Considerable groundwater-surface water interaction occurs along the Elbow River (in the alluvial aquifer). Land uses on the alluvial aquifer, such as pesticide application, road salting, lawn and field fertilizer applications and manure deposition, can enter the ground through percolation and directly affect river water quality as demonstrated in a pollutant tracking study of septic effluent plumes in the Hamlet of Bragg Creek (Manwell 2005). Activities on the alluvial aquifer have the potential to emit pollutants into the Elbow River because of the aquifer's direct connection to the river. The floodplain and riparian areas of the Elbow River are within the alluvial aquifer and many types of land

uses currently take place on and within it, including intensive urban development, rural residential development, private septic systems and agricultural operations.

## 3.4 Loss of Riparian Functions

Riparian area changes such as excessive use, clearing for development and hard armouring with concrete or rock can reduce the amount of large woody debris that enters the river, causing a transfer of energy and subsequent erosion downstream that results in an increase in suspended solids. Suspended solids can negatively impact the aquatic environment, impair drinking water quality and add to treatment costs (ERWP 2005).

Erosion of stream banks and sedimentation in the streambed increases in areas with excessive removal of riparian vegetation, the causes of which can be foraging or trampling by ungulates and vehicles crossing at fords.

## 3.5 Nutrient Loading

Phosphorus and nitrogen that are present in large amounts have a detrimental effect on aquatic ecosystems and drinking water taste. Phosphorus, in particular, when present in excess, can lead to eutrophication, which stimulates the growth of algae, lowers oxygen levels, and may create taste and odour problems (Sosiak and Dixon 2004). According to Sosiak and Dixon (2004), both phosphorus and nitrogen have been found in increasing quantities in the central urban reach of the watershed, which suggests that the nutrients are not from natural sources. Although the local sources have not been identified, typical anthropogenic sources of phosphorus are fertilizers and detergents. Nitrogen sources include plant matter, atmospheric deposition, human and animal waste and fertilizers entering the streams through precipitation runoff and stormwater conveyance systems.

## 3.6 Impervious Surfaces

Development of land for urban or rural residential uses means the construction of roads, parking lots and dwellings resulting in an increase in impervious surfaces. As a watershed becomes more urbanized with an increase in hard surfaces, its hydrologic cycle experiences significant changes such as larger and more frequent floods, greater total surface runoff, decreased time to produce runoff, reduced infiltration and groundwater recharge and higher peak flows (Finkenbine *et al.* 2000, Shuster *et al*. 2005).

Sosiak and Dixon (2004) identified surface runoff from Calgary storm outfalls as a potentially significant source of pollutants to the Elbow River. Newly graded subdivisions contribute significantly more total suspended solids than established subdivisions (pers. comm. Liliana Bozic, City of Calgary and documented in City of Calgary 2003).

## 3.7 Water Demand

Water demand in southern Alberta is high and is rapidly increasing due to the region's population growth. Currently, eighty percent of the provincial population lives where only 20% of the water is located. As a result, the Alberta Government considers southern Alberta to be a water scarce region (Alberta Government 2007).

# PART 4: KEY RECOMMENDATIONS

## 4.1 To Achieve Objective 1

All jurisdictions and stakeholders adopt the water quality objectives and associated indicators for the Elbow River and its tributaries as outlined in the Bow Basin Watershed Water Quality Objectives & Indicators report. (See Appendix B for Elbow-specific objectives or go to www.brbc.ab.ca for the full report). All stakeholders, land users and water users practise watershed stewardship to help achieve these water quality objectives and related indicators.

## 4.2 To Achieve Objective 2

Decision-makers follow the recommendations for water quality protection provided below and agree to participate in the development of an implementation plan. These recommendations are based on the best available and most current science and they will be reviewed as new information becomes available.

These recommendations are presented by category and have not been prioritized. See Appendix A for actions to implement the recommendations listed below, as well as the logical jurisdictions and/or agencies.

**Category 1: Land Use and Stewardship**

1. Manage water source areas to maintain or improve water quality in the Elbow River and its tributaries.
2. Manage riparian areas and wetlands to maintain or improve water quality.
3. Limit new development on the alluvial aquifer to those that improve water quality in the central urban and central rural reaches and those that maintain or improve water quality in the upper reach.
4. Modify existing developments on or within the alluvial aquifer to ensure water quality objectives are met (e.g. improvements to wastewater and stormwater systems).
5. No new direct stormwater discharge to the river.
6. Retrofit old stormwater outfalls to meet or exceed current industry standards to improve stormwater quality.
7. Reduce the risk of spills and potential contamination in the design, construction, operation and maintenance of stream/river crossings so that water quality is not adversely affected.
8. Implement best management practices (e.g. low impact development practices[5], Environmental Farm Plans[6]).
9. Restrict pesticide use. Manage only the weeds designated in the *Alberta Weed Control Act* (i.e. restricted, noxious and nuisance weeds).

**Category 2: Education**

10. Continue educational initiatives for decision-makers to increase awareness and understanding of water quality issues and the impacts of decisions on water quality.

[5] Alberta Low Impact Development Partnership provides detailed information on appropriate practices (www.alidp.org)
[6] Alberta Environmental Farm Plan Company (www.albertaefp.com).

11. Continue youth and adult educational initiatives for all sectors including industrial, residential, agricultural and recreational to increase awareness and understanding of best management practices to protect water quality.
12. Ensure local stewardship groups have resources to remain active to effectively facilitate the transfer of knowledge of watershed stewardship practices.

**Category 3: Monitoring and Reporting**

13. Monitor water quality in the alluvial aquifer.
14. Continue to monitor surface water quality for phosphorus, nitrogen, total suspended solids and coliform bacteria.[7]
15. Report on trends and emerging water quality concerns.
16. Monitor and report on the effectiveness of erosion and sediment control plans.

**Category 4: Regulation and Compliance**

17. Encourage decision-makers to make changes to legislation and policies to achieve the water quality objectives and targets.
18. Encourage decision-makers to make adequate enforcement resources available to help achieve the water quality objectives and targets.

**Category 5: Research and Information**

19. Increase awareness through better access to information on human and natural resource activity in the Elbow River watershed.
20. Continue to improve water management by supporting research to fill knowledge gaps.
21. Apply adaptive management principles.

[7] These four parameters are increasing (Sosiak and Dixon 2004).

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# Appendix A: RECOMMENDATIONS FOR IMPLEMENTATION

The following is an implementation plan devised by the Steering Committee. It contains suggested actions for implementing the recommendations in Part 4. Each jurisdiction or agency is encouraged to refine this implementation plan with its own actions, timelines, and performance indicators.

**Abbreviations used:** **AENV**–Alberta Environment; **AT**-Alberta Transportation; **ASRD**– Alberta Sustainable Resource Development; **BRBC**-Bow River Basin Council; **ERWP**–Elbow River Watershed Partnership; **KCICC**-Kananaskis Country Interdepartmental Consultative Committee, **KID**–Kananaskis Improvement District; **MDRV**–Municipal District of Rocky View; **TPR**–Alberta Tourism, Parks and Recreation

## Category 1: Land Use and Stewardship

| | Theme | Action Required for River Stewardship | Jurisdictions or Agencies | Timeline | Implementation Indicator | Environmental Indicator |
|---|---|---|---|---|---|---|
| 1 | **Source Water Protection** | Adopt the Elbow-specific water quality objectives recommended by the Bow Basin Watershed Management Plan Technical Committee and incorporate them into plans and policies. | AENV, City of Calgary, KID, MDRV, ASRD, Tsuu T'ina, KCICC | Short Term 2008-2009 | Formal adoption of BBWMP | Targets are being met |
| 2 | **Source Water Protection** | Develop policies to manage the Elbow River alluvial aquifer as an important recharge area for the Elbow River. | AENV, Municipalities | Short Term 2008-2009 | Policy drafted | |
| 3 | **Source Water Protection** | Cap and decommission unused groundwater wells. Upgrade wells located in pits. | Municipalities, AENV | Medium Term 2010-2011 | | |
| 4 | **Source Water Protection** | Resolve problems that are identified in a private septic treatment system inspection program. | Landowners | Short Term 2008-2009 | | |
| 5 | **Alluvial Aquifer** | Secure the necessary funding to implement a solution to Bragg Creek septic systems in the alluvial aquifer. | Government of Alberta, MDRV, City of Calgary | Short Term 2008-2009 | | |
| 6 | **Alluvial Aquifer and Economics** | Facilitate or encourage a study to investigate the economic value of protection as a land use on the alluvial aquifer. | MDRV with partners | Medium Term 2010-2011 | | |
| 7 | **Riparian Protection** | Create an inventory of riparian areas, assess the need for mitigation and develop a program for protection and restoration. | ERWP with Cows and Fish and land owners | Short Term 2008-2009 | Riparian Health Inventories completed and Elbow Riparian Strategy in place | Assessment of riparian areas using accepted protocol (Cows & Fish) |
| 8 | **Riparian Restoration** | Restore damaged riparian areas along tributary streams using ecological restoration techniques to restore natural functions. | TPR, ASRD, AT, ERWP | Ongoing | Bioengineering and stream-crossing protection projects | # of hectares adequately restored |
| 9 | **Riparian Setback** Adapted from Bow Plan | Adopt provincial setback protocol (under development) for riparian setbacks in developing areas. More protective setbacks are encouraged in areas where water quality needs improvement. | Municipalities | Short Term 2008-2009 | | |
| 10 | **Riparian and Wetland Plans** Overall Bow Basin | Develop and implement wetland and riparian management plans as part of the BBWMP planning process based on the findings of the comprehensive riparian and wetland inventories. | Ducks Unlimited, AENV, Bow Municipalities, BRBC, ASRD | Medium-Term 2009-2011 | | |

(continued)

| | Theme | Action Required for River Stewardship | Jurisdictions or Agencies | Timeline | Implementation Indicator | Environmental Indicator |
|---|---|---|---|---|---|---|
| 11 | **Agricultural Stewardship** | Expand the scope of FEW[1] Cattle Setback Program, which provides funding for riparian restoration activities. | ERWP with ASRD, land owners and grazing lease holders | Short Term 2008-2009 | #of ranchers participating in the program & # of hectares of riparian area restored | No cattle DNA markers found |
| 12 | **Agricultural Stewardship**<br><br>Adapted from Bow Plan | Support and implement grazing strategies to eventually eliminate cattle grazing in riparian habitat along rivers and creeks (for grasslands, forested areas and protected areas). | Municipalities, ASRD, Alberta Environmental Farm Plan Company, Alberta Agriculture & Rural Development, Cows & Fish, land owners, lease holders | Short Term 2008-2009 | | |
| 13 | **Stormwater** Overall Bow Basin | Implement significant stormwater quality upgrades within Calgary. | City of Calgary | Short- to Long Term 2008-2013 | | |
| 14 | **Stream Crossings** | Replace fords with bridges in McLean Creek Forest Land Use Zone. | SRD with partners | Short Term 2008-2009 | | |
| 15 | **Low Impact Development** Overall Bow Basin | All new residential and commercial developments incorporate elements of low impact development into overall design. Whenever possible, monitor and assess the practices for effectiveness (performance monitoring). | Municipalities, Urban Development Institute Calgary | Short Term 2008-2009 | | |
| 16 | **Low Impact Development** | Assess and upgrade existing recreation facilities and trails where necessary to minimize or eliminate erosion and sedimentation into streams/river and to eliminate direct flow of stormwater into streams using vegetative buffers or by creating settling pond areas. | TPR, KID, ASRD | Short Term 2008-2009 | | |
| 17 | **Low Impact Development** Overall Bow Basin | Ensure timely responses to approval requests from developers wishing to incorporate low impact development practices. | Municipalities, AENV | Short Term 2008-2009 | | |
| 18 | **Low Impact Development** | Ensure erosion and sediment control plans are in place and followed at new construction sites. | AENV, Municipalities | Short Term 2008-2009 | | |
| 19 | **Low Impact Development** Adapted from Bow Plan | Require developers to rip subsoil and provide thicker topsoil layers for all landscaped areas within new developments to minimize the need for pesticides and the resulting impacts of urbanization and to increase water retention. | Municipalities, Urban Development Institute Calgary | Short- to Long Term 2008-2013 | | |
| 20 | **Pesticide Applications** Overall Bow Basin | Municipalities uphold the principle of minimizing the quantity and/or toxicity of active ingredients when applying pesticides on the land they manage. | Municipalities | Short Term 2008-2009 | | |

[1] Farmers of the Elbow Watershed (FEW), a local stewardship group made up of area ranchers, was disbanded in 2005; the ERWP has since adopted this program.

## Category 2: Education

| | Theme | Action Required for Education | Jurisdictions or Agencies | Timeline | Implementation Indicator | Environmental Indicator |
|---|---|---|---|---|---|---|
| 21 | **Alluvial Aquifer** | Develop an education program about the connection between land use and water quality and deliver to land users/owners on the aquifer and the general public. | ERWP with partners | Short Term 2008-2009 | Educational materials produced and distributed | |
| 22 | **Residential Yard Care** | Develop and/or expand a residential alternative outdoor care education program to discourage use of phosphate fertilizers. | Municipalities, AENV | Short Term 2008-2009 | | |
| 23 | **Pesticides** Overall Bow Basin | Develop enhanced education programs to encourage a reduction in urban pesticide applications. | Bow Municipalities | Medium Term 2010-2011 | | |
| 24 | **Pesticides** Overall Bow Basin | Continue to support education programs for careful pesticide use and prepare best management practices extension materials. Producers and commercial applicators must continue to follow product label application specifications if spraying on cultivated land. If no specifications are provided on the label, follow the provisions contained in the fact sheet "Pesticide Use In or Near Water". (http://environment.gov.ab.ca/info/library/7459.pdf | Alberta Agriculture and Rural Development, BRBC Legislation & Policy Committee, Bow Municipalities | Short-Term 2008-2009 | | |
| 25 | **Water Conservation** | Introduce or expand efficiency programs to eliminate leakage from water withdrawal systems. | Municipalities, AENV | Short Term 2008-2009 | | |
| 26 | **Low Impact Development** Overall Bow Basin | Deliver the basic principles of low impact development to municipalities and developers to encourage them to incorporate such practices in overall designs. | Urban Development Institute Calgary, Alberta Low Impact Development Partnership | Short Term 2008-2009 | | |
| 27 | **Agricultural Practices** Overall Bow Basin | Continue to educate producers on manure application and setbacks distances with respect to water bodies as outlined in the *Agriculture Operations Practices Act*.<br>Research the effectiveness of different application techniques to reduce runoff of manure into receiving water bodies. | Alberta Agriculture & Rural Development, Natural Resource Conservation Board | Short-Term 2008-2009 | | |

## Category 3: Monitoring and Reporting

| | Concept or Theme | Action Required for Monitoring | Jurisdictions or Agencies | Timeline | Implementation Indicator | Environmental Indicator |
|---|---|---|---|---|---|---|
| 28 | **Groundwater under the influence of surface water** | Monitor water quality in the alluvial aquifer to ensure water quality objectives are met. | AENV and City of Calgary | Medium Term 2010-2011 | Annual program in place | Maintained or enhanced water quality |
| 29 | **Water Quality** | Continue to monitor drinking water at recreation sites to ensure no leakage, spills or contamination. Treatment standards must meet or exceed provincial standards. | KID, TPR | | | |
| 30 | **Water Quality** | Monitor for sewage leakage from holding tanks and repair as soon as detected. | TPR, KID | | | |
| 31 | **Water Quality** | Monitor for *E. coli* on major tributaries. | AENV, City of Calgary | Short Term 2008-2009 | Results are shared with ERWP | |
| 32 | **Stream Flow** | Monitor flows for trends in seasonal changes and ensure current flow gauging stations are sufficient for year-round real-time data. | AENV and others? | | Results are shared with ERWP | |

(continued)

| | Concept or Theme | Action Required for Monitoring | Jurisdictions or Agencies | Timeline | Implementation Indicator | Environmental Indicator |
|---|---|---|---|---|---|---|
| 33 | **Stormwater** Overall Bow Basin | Continue water quality monitoring for representative stormwater outfalls in Calgary in support of the Total Loading Management Plan. Work on verifying and improving total suspended solid loading estimates. Expand the plan to estimate loadings from pertinent outfalls in the Elbow Central reach. | City of Calgary | Short Term 2008-2009 | | |
| 34 | **Pesticides** | Monitor for the presence of and for trends in pesticides in surface water and the alluvial aquifer. | AENV, City of Calgary | | Results are shared with ERWP | |
| 35 | **Monitoring Pesticides** Overall Bow Basin | Include pesticide monitoring in all long-term monitoring programs and ensure consistency with sampling methodologies used by AENV (e.g. frequency, variables tested, etc.) | All monitoring agencies: AENV, City of Calgary, Environment Canada, Parks Canada | Long Term | | |
| 36 | **Water Quality Reporting** | Provide water quality information to ERWP annually. Report on trends in water quality when possible, especially parameters reported as degraded (nutrients, TSS, bacteria). | City of Calgary | Short Term 2008-2009 | Results are shared with ERWP | |
| 37 | **Reporting** Overall Bow Basin | Continue to prepare annual surveys of urban domestic pesticide sales and actual use by golf course and landscape companies beyond 2008. | City of Calgary | Short Term 2008-2009 | | |
| 38 | **Reporting** Overall Bow Basin | Continue to survey pesticide sales every five years and break information down by major river basins (including the Bow Basin) to help with monitoring and research needs, such as the relationship between pesticide use and their persistence in the environment. | AENV | Short Term 2008-2009 | | |
| 39 | **Alluvial Aquifer** | Conduct groundwater assessments prior to development of lands located near the alluvial aquifer. Groundwater assessments may lead to some additional monitoring. | MDRV, Tsuu T'ina, City of Calgary | Short Term 2008-2009 | | |
| 40 | **Water Management Plan Performance** | Convene a committee to help implement and annually review the ERBWMP and recommend adaptive management strategies as necessary. | ERWP | Short Term 2008-2009 | Annual progress report | |

## Category 4: Regulation and Compliance

| | Theme | Action Required for Compliance | Jurisdictions or Agencies | Timeline | Implementation Indicator | Environmental Indicator |
|---|---|---|---|---|---|---|
| 41 | **Alluvial Aquifer** | Investigate the use of tools, such as transfers of development rights, to compensate current land owners on the alluvial aquifer. | Government of Alberta, MDRV | Short Term 2008-2009 | | |
| 42 | **Legislation, Policy and Bylaws** | Amend land use bylaws and accompanying procedures to protect the functions of riparian areas, wetlands and the alluvial aquifer. Example: City of Calgary ER Setback Policy[2] | City of Calgary, KID, MDRV, ASRD, Tsuu T'ina | Short Term 2008-2009 | Bylaw introduced, passed and enforced | |
| 43 | **Legislation, Policy and Bylaws** | Investigate the use of tools and programs to minimize or eliminate the use of pesticides. | Municipalities Agricultural Service Boards with CHR, AENV | | | |

(continued)

[2] Environmental Reserves Setback Guidelines were adopted by the City of Calgary Council on May 7, 2007 http://www.erwp.org/education.html.

| | Theme | Action Required for Compliance | Jurisdictions or Agencies | Timeline | Implementation Indicator | Environmental Indicator |
|---|---|---|---|---|---|---|
| 44 | **Legislation, Policy and Bylaws** | Review timber setback guidelines on a site-specific basis with watershed approach. | ASRD | Done | ASRD has effective timber harvest regulations and ground rules. | Functioning and healthy riparian areas and wetlands. |
| 45 | **Enforcement** | Enforce the use of crossings and designated trails in McLean Creek Forest Land Use Zone | ASRD | Short Term 2008-2009 | | |
| 46 | **Groundwater Protection** | Introduce an inspection program for private septic treatment systems (PSTS) to ensure proper operation in each geotechnical situation. | AENV, MDRV, Tsuu T'ina, PSTS owners | Short Term 2008-2009 | MDRV staff has been trained # of sites inspected/year | |

## Category 5: Research and Information

| | Concept or Theme | Action Required for Research | Jurisdictions or Agencies | Timeline | Implementation Indicator | Environmental Indicator |
|---|---|---|---|---|---|---|
| 48 | **Source Water** | Increase our understanding of and identify areas of resource sensitivity, such as unconfined aquifers, in the Elbow watershed. | University of Calgary, City of Calgary, AENV, ASRD | Short Term 2008-2009 | | |
| 49 | **Mapping** | Expand alluvial aquifer map upstream of Bragg Creek and superimpose entire aquifer onto current MDRV land ownership map. | ERWP, AENV, with University of Calgary ASRD and MDRV | Short Term 2008-2009 | Alluvial Aquifer Map available to land owners, developers. | |
| 50 | **Mapping** | Map groundwater aquifers showing recharge areas and connectivity. | AENV | Medium-Term 2010-2011 | | |
| 51 | **Water Allocation** | Provide a list of surface water and ground water under the influence license allocations. | AENV | Short Term 2008-2009 | | |
| 52 | **Indicators** Overall Bow Basin | Conduct further research to better define thresholds for total organic carbon. If WQOs are exceeded, treatment and source control options need to be investigated. | City of Calgary | Medium Term 2010-2011 | | |
| 53 | **Indicators** Overall Bow Basin | Conduct further research and monitoring to develop a long-term target for *Giardia*, and to determine natural and anthropogenic sources. | University of Calgary | Long Term 2012-2013 | | |
| 54 | **Indicators** Overall Bow Basin | Conduct further source tracking (including evaluation of risks) prior to setting WQOs and warning levels within the City of Calgary. | City of Calgary | Medium Term 2010-2011 | | |
| 55 | **Indicators** Overall Bow Basin | Conduct further research to determine if increased nitrate in the headwaters and foothills is from natural sources, or the result of local anthropogenic changes or long-range transport. | University of Calgary, other academic agencies | Medium Term 2010-2011 | | |
| 56 | **Indicators** Overall Bow Basin | Determine the species composition of pathogens and other organisms if counts are seen above 20,000 coliforms/100 mL at the Glenmore Water Treatment Plant intake. Once the pathogenic speciation work has been completed, further work will be required to refine the WQO. | City of Calgary, BRBC | Medium Term 2010-2011 | | |
| 57 | **Indicators** Overall Bow Basin | Once completed, the new 1) Alberta pesticide index (based on thresholds of observable effects limits developed by Anne-Marie Anderson, AENV) and the new 2) European Union Water Framework Directive pesticide index should be reviewed as alternatives to the existing recommended WQO. | BRBC Knowledge Data and Research team | Short Term 2008-2009 | | |
| 58 | **Indicators** Overall Bow Basin | Develop effective impervious area targets for all new developments based on the overall goal of achieving pre-development runoff rates & volumes | City of Calgary and Municipal District of Rocky View, City of Airdrie, Town of Strathmore | Short Term 2008-2009 | | |

(continued)

| | Concept or Theme | Action Required for Research | Jurisdictions or Agencies | Timeline | Implementation Indicator | Environmental Indicator |
|---|---|---|---|---|---|---|
| 59 | **Indicators** Overall Bow Basin | Review the effectiveness of existing forestry guidelines (e.g., stream crossings, riparian protection, road maintenance) on water quality. Erosion control targets should be set and implemented. | AASRD | Short Term 2008-2009 | | |
| 60 | **Indicators** Overall Bow Basin | Enhance stream and stormwater flow monitoring at various points throughout the system is needed to assist in the identification of the impervious and runoff targets. | City of Calgary | Short Term 2008-2009 | | |
| 61 | **Indicators** Overall Bow Basin | Review the City of Calgary's and MD of Rocky View's 1) effective impervious area targets, 2) reach-specific runoff volume targets, and 3) erosion control targets for all new developments with the potential adoption of these targets (or modified version of the targets to reflect sub-regional differences) for all new developments within the respective municipality. | Bow Municipalities | Medium Term 2010-2011 | | |
| 62 | **Indicators** Overall Bow Basin | Create an inventory of wetland and riparian areas including drained and altered wetlands and developed and degraded riparian areas. Classify according to existing vegetation, vegetation potential and intensity of land-use. Re-assess the related objectives and indicators when inventory is complete. | AENV, Ducks Unlimited, ASRD Cows and Fish | Short Term 2008-2009 | | |
| 63 | **Indicators** Overall Bow Basin | Conduct further research to determine the practicality of using existing undisturbed wetlands for stormwater treatment purposes is required. | University of Calgary | Long Term 2012-2013 | | |
| 64 | **Indicators** Overall Bow Basin | Conduct further research into wetland restoration and its relationship with water quality is required. | Ducks Unlimited | Medium Term 2009-2011 | | |

## Appendix B: Water Quality Objectives and Indicators

The following table is an excerpt from Table 3 of the *Water Quality Objectives & Indicators* report prepared by the Bow Basin Watershed Management Plan Technical Committee.

The figure below explains how to read the values in the Baseline Water Quality column.

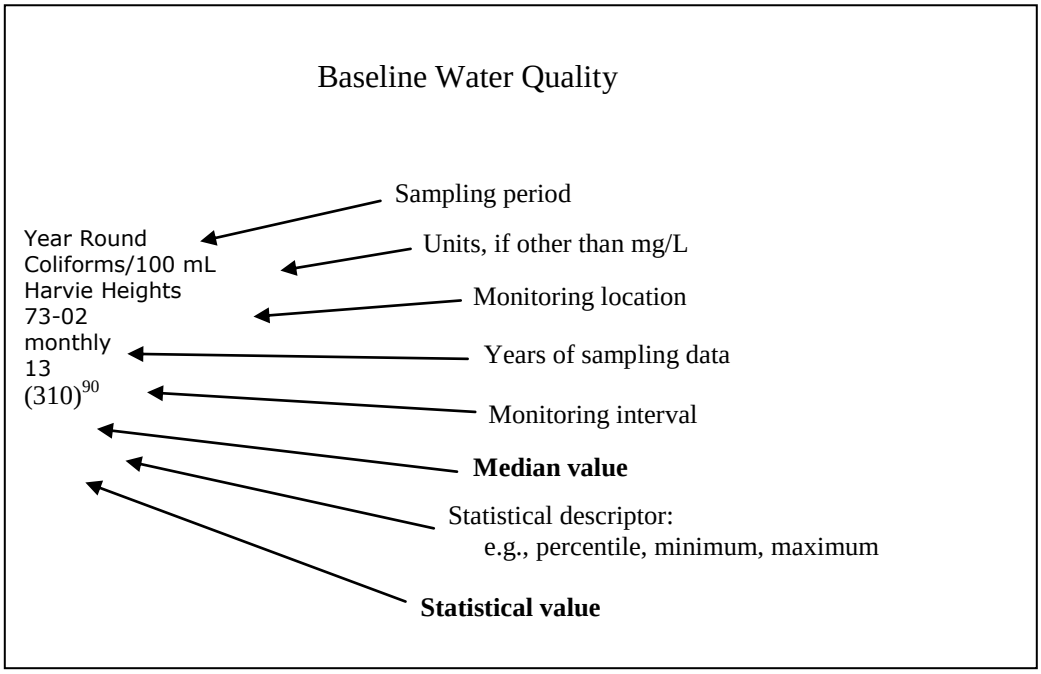


Figure A1. Definition of cell values for reach estimates of baseline Water Quality (column 4) in Table 3.

| Proposed Indicator or Topic Area | Reach or River | WQOs, Warning Levels and Targets | Baseline Water Quality (median, percentiles)[a] | Rationale | Related Recommendation Number in Table 4 |
|---|---|---|---|---|---|
| Attached Algae (Periphyton) Biomass-defined as chlor *a* | Elbow River Central | ❑ WQO: 150 mg/m$^2$ maximum value during open water season | Open Water<br>Sarcee Bridge<br>88-89<br>monthly<br>105.1<br>(143.1)$^{75}$<br>(174.4)$^{max}$<br>Not currently monitored | ❑ A literature review over many regions determined that periphyton concentrations above 150 mg/m$^2$ are associated with adverse impacts on users (Welch et al 1998). | 14 |
| Dissolved Oxygen | Elbow River Central | ❑ WQO: CCME with protection of spawning and incubation.<br>○ 9.5 mg/L for spawning and incubation<br>○ 6.5 mg/L for acute daily minimum. | Open Water<br>Weaselhead<br>00-06<br>monthly<br>9.7<br>(8.5)$^{10}$<br>7.0$^{min}$ | ❑ CCME minimum for adult and juvenile cold-water fish<br>❑ Requires fishery inventory to determine spawning areas. | 2, 28 |

[a] Units are mg/L unless otherwise noted.

| | | | | | |
|---|---|---|---|---|---|
| Nitrate (nitrate + nitrite (as N)) | Elbow River Central | ❑ WQO: 0.267 mg/L<br>❑ WARNING LEVEL: 0.132 mg/L<br>❑ WQOs, warning levels and targets for nitrate apply during the growing / open water season. | Open Water<br>Weaselhead<br>97-06<br>monthly<br>0.065<br>(0.129)[90] | ❑ Protects against stimulation of excessive algal growth to protect municipal water supplies.<br>❑ Nitrogen may be entering the reach as a result of long-range transport.<br>❑ The value of 0.267 mg/L was obtained from Sosiak (2004) as the nitrate + nitrite level that corresponds to nuisance growth of periphyton.<br>❑ The warning level was developed based on the 90th percentile level for the period 1992 – 2006. | 27, 28, 35 |
| Pathogens as indicated by *E. coli* | Elbow River Central | ❑ WQO: Meet recreational guideline - no single value to exceed 400 *E.coli* per 100 mL or (<200 *E. coli* per 100 mL (geometric mean 5 samples /30 d). | Open water[b]<br>Weaselhead<br>94-06<br>monthly<br>28 per 100 mL<br>(167)[90] | ❑ 400 *E. coli*/100 mL is the CCME re-sampling guideline. | 28, 32 |
| Pathogens as indicated by fecal coliforms | Elbow River Central | ❑ WQO: Meet 100 fecal coliforms per 100 mL (no single value to exceed objective) at the point of withdrawal. | No baseline data currently available | ❑ Irrigation guidelines set by CCME.<br>❑ The WQO values can be briefly exceeded for short periods of time during storm events. | 28 |
| Pathogens as indicated by Total Coliforms | Elbow River Central | ❑ WQO: Should not exceed 20,000 counts (total coliforms) per 100 mL at intake for drinking water treatment plant. | Open water[c]<br>Weaselhead<br>93-06<br>monthly<br>444 per 100 mL<br>(2420)[90] | ❑ The instantaneous objective of <20,000 counts/100 mL is based on conventional water treatment plant's ability to remove contaminants if pre-disinfection is present (US EPA 1991).<br>❑ Protects human health by ensuring that municipal water treatment plants can remove pathogens (e.g., bacteria, protozoa, and viruses) from raw water. | 28, 34 |
| Pathogens - *Giardia* | Elbow River Central | ❑ WQO: Should not exceed 100 cysts per 100 L (instantaneous) at the intake for Glenmore Water Treatment Plant. | Year Round<br>cysts/100 L<br><br>Weaselhead<br>97-05<br>24<br>(172)[90] | ❑ This is the level above which will require in excess of 5-log reduction at the Glenmore Water Treatment Plant (AENV, 2006).<br>❑ *Giardia* is more of a concern on the Elbow than the Bow, as levels are typically higher on the Elbow River. For this reason, the treatment facility has a clearwell to increase the chlorine contact time.<br>❑ Higher levels of *Giardia* require new water treatment processes for small water supply systems in the Basin. Over time, as approvals come up for renewal, small water supply systems may be required to upgrade to treat higher levels of *Giardia*. | 3, 28 |
| Pesticides and Degradation Products | Elbow River Central | ❑ WQO: Should not exceed the lower of:<br>○ < 1/10 of federal drinking water guidelines or<br>○ < CCME guidelines for aquatic life in the river. | Insufficient data | ❑ Provisional objective as there is currently no ongoing monitoring available at this time to set an objective.<br>❑ Protects drinking water and aquatic ecosystems.<br>❑ <1/10 of federal drinking water guidelines used to provide a safety margin to protect against compounds for which there is no treatment. | 31, 37, 38, 39, 41, 42, 44 |

[b] Most available data from April-September, although some years include March, October and November data
[c] Mostly April-September, although some years include March, October and November dates

| | | | | | |
|---|---|---|---|---|---|
| Total Ammonia | Elbow River Central | ❑ WQO: Should not exceed 0.04 mg/L in the river for municipal water supply, and should not exceed CCME guideline for protection of aquatic life. To apply outside mixing zones. | Open Water Weaselhead 97-06 monthly 0.010 $(0.020)^{90}$ | ❑ Protects municipal water supply from unacceptable chlorine demand.<br>❑ Based on experience at Glenmore Water Treatment Plant.<br>❑ This is more restrictive than the current CCME guideline.<br>❑ Designed to protect aquatic life and takes into account the influence of both temperature and pH on the toxicity of ammonia.<br>❑ This objective does not represent a value to protect the river against excessive growth of aquatic plants. | 27, 28 |
| Total Dissolved Phosphorus | Elbow River Central | ❑ WQO: 0.009 mg/L TDP<br>❑ TARGET: Eliminate levels that cause nuisance aquatic plant growth. | Open Water Weaselhead 93-06 monthly 0.002 $(0.009)^{90}$ | ❑ Based on 90th percentile (1993-2006) for all available data from March to November at the Elbow River at Weaselhead. | 27, 28 |
| Total Organic Carbon | Elbow River Central | ❑ WQO: Should not exceed 5.0 mg/L (instantaneous).<br>❑ TARGET: Should not exceed 3.0 mg/L (instantaneous). | Open Water[d] Weaselhead 93-06 monthly 1.41 $(3.97)^{90}$ | ❑ Values exclude periods of snowmelt runoff, mountain runoff, and significant precipitation events. | 9 |
| Total Phosphorus | Elbow River Central | ❑ WQO: No recommendation for TP. TDP is believed to be the better WQO for this reach.<br>❑ TARGET: Eliminate levels that cause nuisance aquatic plant growth. | Open Water Weaselhead 93-06 monthly 0.011 $(0.089)^{90}$ | ❑ Total phosphorus in this reach is predominantly particulate phosphorus which can increase above this level without concurrent algae production. For this reason, total dissolved phosphorus is the better indicator for this reach. | 27, 28 |
| Total Suspended Solids | Elbow River Central | WQO: If the background[e] concentration is:<br>< 25 mg/L conditions must not exceed an SEV value of 6<br>> 25 mg/L conditions must not exceed an SEV value of 7- (CCME 2002, Caux et al. 1997)<br>>250 mg/L CCME (2002) applies (conditions should not increase more than 10% above background levels when background is >250 mg/L)<br><br>❑ Calculation of the SEV value must be taken from fully mixed zone.<br>❑ WARNING LEVEL: Visible plume entering river during base river flow.<br>❑ TARGET: CCME, increase compliance frequency with objectives | Open water[f] Weaselhead 98-06 monthly 8.1 $(62.0)^{90}$ | ❑ Trend analysis has indicated that levels of suspended solids are increasing.<br>❑ There are different objectives to consider natural and anthropogenic TSS variation along the river.<br>❑ When the background is less than <250 mg/L, the objectives are based on SEV values derived from Newcombe and Jensen (1996). The approach relates the biological fish response to duration of exposure and suspended sediment concentration. The SEV values selected ensures that only a moderate level of physiological stress is endured by fish in this reach during 1 and 7 day exposure periods.<br>❑ SEV objectives are based on ASRD and DFOs' mandates which strive to ensure that fish and their habitats support success in all life stages. SEV exposure periods for 1 and 7 days were used to protect fish during storm events.<br>❑ It is recognized that the objectives may be temporarily exceeded during spring freshet and storm events. | 27, 28, 31, 33, 53, 50 |

[d] Includes some March and November data

[e] Two general approaches are considered acceptable to define background concentrations of water quality variables which involve (CCME 2002 pg20- Site-specific guidance):
-Utilization of historically-collected water quality data for site (i.e., prior to the commencement of activities that coud have substantially altered water quality conditions); or -Monitoring contemporary water quality conditions at one or more stations located upstream of contaminant sources.

[f] Available data is mostly from April-Sept, although some years include March, October and November dates.

| | | | | | |
|---|---|---|---|---|---|
| Water Temperature | Elbow River Central | ❑ WQO: Should not exceed 18°C at any time or a 7-day mean of 18°C. | Open Water<br>Weaselhead<br>98-06<br>monthly<br>9.9<br>$(14.5)^{90}$<br>$(17.2)^{max}$ | ❑ 18°C is above the recorded maximum<br>❑ To protect most sensitive native fish, namely white fish.<br>❑ Chronic maximum based on Taylor & Barton. | 2, 27 |
| Riparian Condition[g] | Elbow River Central | ❑ TARGET: maintaining a "healthy" rating using Cows and Fish rating system. | ❑ | ❑ Based on the best available data, targets were set at one level higher than initial conditions measured using the Cows and Fish Riparian Health Inventory rating system (Fitch and Ambrose 2003) (e.g., "unhealthy" ➔ "healthy with problems" ➔ "healthy"). If the river and/or reach previously rated as "healthy", the target remained as "healthy". In all cases, the long-term goal is "healthy". | 45, 47, 49, 56, 57, 59 |
| Soil Erosion[h] | Elbow River Central | ❑ TARGET: An erosion and sediment control (ESC) plan should be designed with a T-value or maximum soil erosion rate target of 2t/ha/yr where disturbed land has direct connection to a water body (no buffer, no interception). Applies to all construction sites and endures for the life of the project (during and post construction phases). | ❑ | ❑ An erosion and sediment control plan (ESC) must be developed, implemented and monitored for construction sites with any direct connection to surface water.<br>❑ An ESC plan should be prepared by a qualified professional (a professional certification that includes erosion and sediment control as a field of expertise).<br>❑ Based on methods described in Wall et al. (2002). | 27, 28, 29, 45, 48, 50, 51 |
| Attached Algae (Periphyton) Biomass-defined as chlor *a* | Elbow River Upper | ❑ WQO: 150 mg/m$^2$ maximum value during open water season<br>❑ Target: 47 mg/m$^2$ maximum | Open Water<br>Downstream Bragg Creek<br>88-89<br>monthly<br>14.8<br>$(21.5)^{75}$<br>$(61.1)^{max}$ | ❑ Target is an experimentally derived value based on 10 years of monitoring data for the Bow River near the Town of Banff. It is the value that represents the transition from good to fair rankings. In the absence of reach specific data for the Elbow, the upper Bow objective was considered a reasonable target.<br>❑ A literature review over many regions determined that periphyton concentrations above 150 mg/m$^2$ are associated with adverse impacts on users (Welch et al 1998).<br>❑ Not currently monitored and no historic data in this reach, very sparse. | 14 |
| Dissolved Oxygen | Elbow River Upper | ❑ WQO: CCME with protection of spawning and incubation.<br>o 9.5 mg/L for spawning and incubation<br>o 6.5 mg/L for acute daily minimum. | Open Water<br>Above Bragg Ck.<br>00-06<br>monthly<br>10.6<br>$(9.4)^{10}$<br>$8.1^{min}$ | ❑ CCME provides a high-level of protection for saturated conditions. | 2 |
| Nitrate (nitrate + nitrite (as N)) | Elbow River Upper | ❑ WQO: 0.13 mg/L during the open water season | Open Water<br>Above Bragg Ck<br>99-06<br>monthly<br>0.083<br>$(0.118)^{90}$ | ❑ Trying to maintain this reach at its current trophic state.<br>❑ 90$^{th}$ percentile for Elbow River above Bragg Creek = 0.125 mg/L (1999 -2006). | 27, 35 |

[g] Healthy riparian condition filters nutrients and minimizes the runoff of sediments into receiving water bodies.

[h] Erosion is caused when soil particles are dislodged and transported by water falling on or running across bare soil or vegetated areas that are unable to resist the force of the flowing and falling water. If eroded material is transported to water bodies sedimentation occurs which reduces water quality after and during storm events.

| | | | | | |
|---|---|---|---|---|---|
| Pathogens as indicated by *E. coli* | Elbow River Upper | ❑ WQO: Meet recreational guideline - no single value to exceed 400 *E.coli* per 100 mL or (<200 *E. coli* per 100 mL (geometric mean 5 samples /30 d). | Year Round[i] Above Bragg Ck. 98-06 monthly 4 per 100 mL (22)[90] | ❑ 400 *E. coli*/100 mL is the CCME re-sampling guideline. | 28 |
| Pathogens as indicated by Total Coliforms | Elbow River Upper | ❑ WQO: Should not exceed 20,000 total coliforms per 100 mL at intake for drinking water treatment plant. | Year Round[j] Above Bragg Ck. 98-06 monthly 68 per 100 mL (249)[90] | ❑ The instantaneous objective of <20,000 counts/100 mL is based on conventional water treatment plant's ability to remove contaminants if pre-disinfection is present (US EPA 1991).<br>❑ Protects human health by ensuring that municipal water treatment plants can remove pathogens (e.g., bacteria, protozoa, and viruses) from raw water. | 28, 34 |
| Pathogens - *Giardia* | Elbow River Upper | ❑ WQO: Not set for this reach. However, *Giardia* is an important issue, and agencies should continue to monitor for *Giardia* and attempt to identify and reduce sources. | Insufficient data | ❑ Insufficient data to make recommendation. We need to first determine *Giardia* counts in surface water reaches that can be effectively treated by different methods.<br>❑ Wildlife are the prime vectors of *Giardia* transmission in this reach. | 3 |
| Pesticides and Degradation Products | Elbow River Upper | ❑ WQO: Should not exceed the lower of:<br>o < 1/10 of federal drinking water guidelines or<br>o < CCME guidelines for aquatic life in the river. (provisional objective) | Insufficient data | ❑ Provisional objective as there is currently no ongoing monitoring available at this time to set an objective.<br>❑ <1/10 of federal drinking water guidelines used to provide a safety margin to protect against compounds for which there is no treatment.<br>❑ Protects drinking water and aquatic ecosystems. | 37, 38, 39, 41, 42 |
| Total Ammonia | Elbow River Upper | ❑ WQO: Should not exceed CCME guideline for protection of aquatic life. To apply outside mixing zone (AENV 1995). | Open Water Above Bragg Ck. 00-06 monthly 0.010 (0.020)[90] | ❑ Designed to protect aquatic life and takes into account the influence of both temperature and pH on the toxicity of ammonia.<br>❑ Historical total ammonia values have not exceeded 0.02 mg/L in 7 years of data. | 27, 28 |
| Total Dissolved Phosphorus | Elbow River Upper | ❑ WQO:0.006 mg/L TDP | Open Water Above Bragg Ck. 00-06 monthly 0.001 (0.006)[90] | ❑ Based on year-round historical data at Elbow River above Bragg Creek using 90th percentile (2000-2006). | 28 |
| Total Organic Carbon | Elbow River Upper | ❑ WQO: Should not exceed 5.0 mg/L (instantaneous).<br>❑ TARGET: Should not exceed 3.0 mg/L (instantaneous). | Open Water[k] Above Bragg Ck. 00-06 monthly 0.960 (3.76)[90] | ❑ Values exclude periods of snowmelt runoff, mountain runoff, and significant precipitation events. | |
| Total Phosphorus | Elbow River Upper | ❑ WQO: 0.019 mg/L TP | Open Water Above Bragg Ck. 99-06 monthly 0.003 (0.019)[90] | ❑ Based on historical data at Elbow River above Bragg Creek using 90th percentile. | 28 |
| Total Suspended Solids | Elbow River Upper | ❑ WQO: CCME | Year Round[l] Above Bragg Ck. 01-06 monthly 1.0 (16.7)[90] | ❑ To maintain existing water quality for the protection of aquatic life. | 27, 50, 52, 54 |

[i] Not entirely year round historical data, year round data for 2004-2006
[j] Not entirely year round for all years in the period of record (2004-2006)
[k] Include some March and November data

| | | | | | |
|---|---|---|---|---|---|
| Water Temperature | Elbow River Upper | ❑ WQO: Should not exceed 18°C at any time or a 7-day mean of 15°C. | Open Water Above Bragg Ck 98-06 monthly 8.8 $(11.3)^{90}$ $(14.0)^{max}$ | ❑ 14°C is the recorded maximum in the Elbow River above Bragg Creek.<br>❑ To protect most sensitive native fish, namely bull trout<br>❑ Chronic maximum based on Taylor & Barton (1992). | 2, 27 |
| Riparian Condition | Elbow River Upper | ❑ TARGET: maintaining a "healthy" rating using Cows and Fish rating system. | | ❑ Based on the best available data, targets were set at one level higher than initial conditions measured using the Cows and Fish Riparian Health Inventory rating system (Fitch and Ambrose 2003) (e.g., "unhealthy" ➔ "healthy with problems" ➔ "healthy"). If the river and/or reach previously rated as "healthy", the target remained as "healthy". In all cases, the long-term goal is "healthy". | 45, 47, 49, 57, 59 |
| Soil Erosion | Elbow River Upper | ❑ TARGET: An erosion and sediment control (ESC) plan should be designed with a T-value or maximum soil erosion rate target of 2t/ha/yr where disturbed land has direct connection to a water body (no buffer, no interception). Applies to all construction sites and endures for the life of the project (during and post construction phases). | | ❑ For new developments that are permitted within the defined boundaries, Operating Ground Rules are in place to minimize erosion and sedimentation (ASRD).<br>❑ An erosion and sediment control plan (ESC) must be developed, implemented and monitored for construction sites with any direct connection to surface water.<br>❑ An ESC plan should be prepared by a qualified professional (a professional certification that includes erosion and sediment control as a field of expertise).<br>❑ Based on methods described in Wall et al. (2002). | 45, 50, 51, 52, 54 |

[l] Data record is not entirely year round for all years is for 2004-2006 data