CRP Regional Servicing Study: Review of Water Management Initiatives within the Calgary Region

PREPARED FOR: Calgary Regional Partnership

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Executive Summary

Phase Two of the Calgary Regional Partnership (CRP) Study on Water and Wastewater Servicing in the Calgary Region involves reviewing existing information on water and wastewater management within the region to determine how it may affect the solutions developed in this study.

Several Water Management Plans are being developed based on Alberta Environment's *Framework for Water Management Planning*. These plans will have a significant impact on water management. Once they are approved, they must be considered when decisions are being made on any new water licenses or approvals.

The document review identified several key issues that will affect the CRP Regional Servicing Study, including the following items:

- The *Water Management Plan for the South Saskatchewan River Basin in Alberta* (Alberta Enviroment, October 2005) recommends that Alberta Enviroment (AENV) stop accepting applications for new water allocations. However, a regulatory framework is in place to allow the transfer of existing water licenses from license holders to others, or to sell water to others.
- In 2005, approximately 46 percent of the average annual natural flows of the Bow River were either diverted or consumed, and many of the existing licenses were being underused. At the lowest reaches of the river, 68 percent of the average flows had been allocated for withdrawals. During low flow years, these allocations can be as high as 80 percent.
- Irrigation is the largest user of water in the basin, accounting for over 76 percent of the total allocations. As irrigation demands increase, it is likely that irrigation practices will become more efficient (i.e. more of the diverted water will be used rather than returned as drain water) and return flows to the river will decrease. This will cause further degradation to the aquatic environment as a result of less water being available in-stream.

- The flow is insufficient to meet the instream flow needs (IFNs) in the Bow River downstream of the major water withdrawals. With the existing allocations, restoring the flows in these reaches will be difficult.
- Hydroelectric facilities, water withdrawals, diversions, and wastewater discharges have altered the natural flows in the Bow River. Current summer flows are lower than historical, natural summer flows, which has a negative impact on fish and riparian habitat. Current winter flows are higher than historical, natural winter flows, which can be beneficial to the habitat.
- Total pollutant loadings from both stormwater and wastewater effluents are approaching the provincially-regulated limits and the assimilative capacity of the Bow River during storm events.
- Key indicators increasingly suggest that the water quality in the Elbow River upstream of Calgary is deteriorating.

An overview of water allocations and management of licenses is provided in Appendix A, and a summary of the groundwater resources in the region are provided in Appendix B.

Introduction

Phase Two of the CRP Study on Water and Wastewater Servicing in the Calgary Region involves reviewing existing information on water and wastewater management within the region to determine how it may affect the solutions developed in this study.

In addition to reviewing the existing documents described below, CH2M HILL contracted Hart Water Management and Westwater Environmental Ltd. to prepare two reports, which are included in the appendices. Appendix A contains additional information on water allocations and the water management in the region, and Appendix B contains an overview of the groundwater resources within the CRP region.

During this phase, the review included the following documents:

- *Approved Water Management Plan for the South Saskatchewn River Basin in Alberta* (AENV, 2005)
- *Nature, Renew, Protect: A Report on the State of the Bow River* (Bow River Basin Council, 2005)
- *Preserving our Lifeline: A Report on the State of the Bow River 1994* (Bow River Water Quaility Council, 1994)
- *The Calgary Total Loading Management Plan* (v1.0) (The City of Calgary, 2005)
- *Hydrogeology of the Canmore Corridor and Northwestern Kananaskis Country, Alberta* (AENV 2002)
- *Instream Flow Needs Determination for the South Saskatchewan River Basin*, (AENV 2003)
- *Impacts on Water Quality in the Upper Elbow River* (AENV and The City of Calgary, 2004)
- *Draft Elbow River Water Management Plan Phase 1 Terms of Reference* (2005)
- *Draft Water Management Plan for the Nose Creek Watershed* (Palliser Environmental Services Ltd., 2007)
- *Environmental Sensitivity Analysis: A Regional Examination in Alberta Canada* (Hodge, Kim and Gilson, Neil, date unknown)
- *Town of Okotoks Water Management Plan* (Town of Okotoks, 2004)
- Urban Stormwater Bow Basin: Urban Stormwater Basics website

The information extracted from these documents and summarized in this memo focuses on water and wastewater servicing in the Calgary Region and the participating members of the CRP (see Figure 1). Information that is outside the scope of this project is not included in this memo.

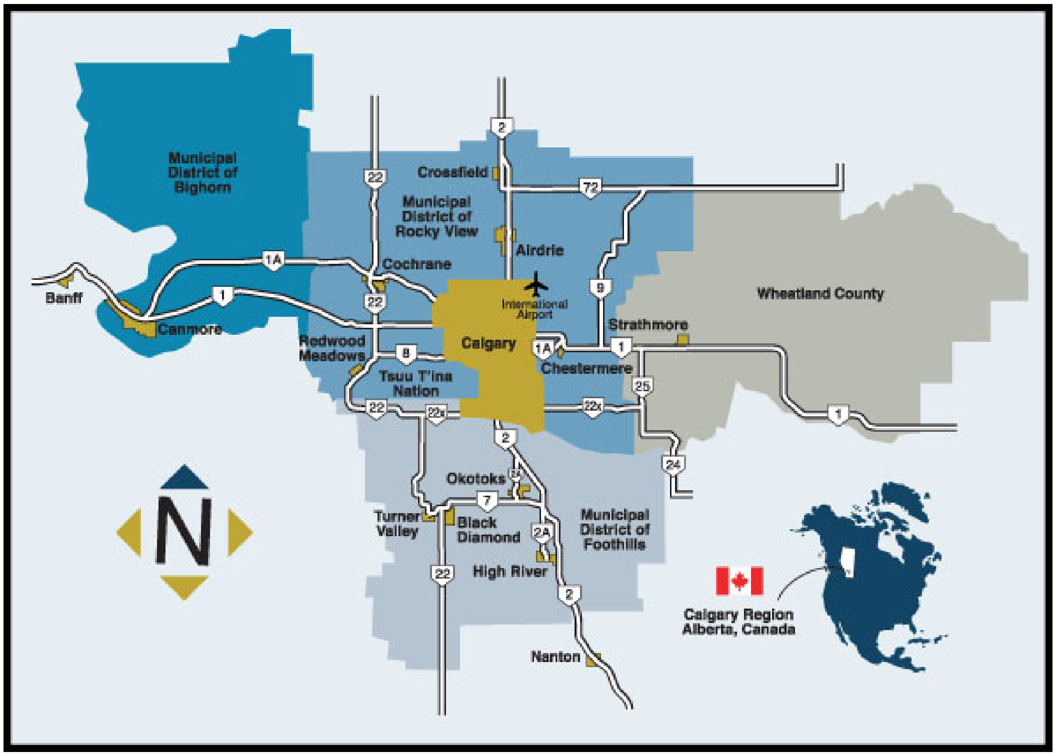

Figure 1. Map of Participating Members of the CRP (www.calgaryregion.ca)

Overview of Water Licensing and Management in Alberta

The 1999 *Water Act* guides the work of AENV, which is responsible for water policy in the Province. Whereas the previous *Act*, the *Water Resources Act*, focused on allocating water, the *Water Act* is also concerned with water conservation and management.

Approvals and Licenses

The *Water Act* defines both approvals and licenses. Approvals govern the construction of works, or the undertaking of an activity within a water body, such as the operation of a water or wastewater treatment plant (WWTP). Approvals are issued for a finite period of time and must be renewed periodically. The conditions of an approval are subject to change as public health or environmental policies change.

Licenses govern the diversion and use of surface water or groundwater. Licenses are given a priority number based on the date that the complete application was received by AENV. Because many licenses were in place prior to when the new *Act* was adopted in 1999, pre-existing licenses were brought forward and made subject to the new *Act*, but they maintained the priority number they had under their original license. Those licenses with a lower priority number are entitled to divert the whole allocation (or their maximum rate of diversion) of water specified under the license before a licensee with a higher priority number has any right to divert water pursuant to their license: first in time, first in right.

The licensed amounts for water diversion may be reduced for the following reasons:

- License not in good standing
  - Breach of the *Water Act*
  - Subject to an investigation under the *Water Act*
  - Subject to an enforcement tool or prosecution
  - Breach of terms and conditions of the license
  - Non-compliance with the terms and conditions
- Non-use of water allocated by a licence
- Seasonal changes in stream flow or environmental needs (i.e. in stream flow needs or water conservation objectives)
- Ministerial over-ruling of priority system

Some senior licenses are not subject to all of these restrictions.

Licenses to divert water are not required for statutory household use or traditional agriculture use. To qualify as a household user or a traditional agriculture user, a person must own or occupy land that adjoins a natural water body or under which groundwater exists. Statutory household users do not have a priority ranking with respect to other household users. Traditional agricultural users can register voluntarily, and the priority is based on when the water use first started. Statutory household users have top priority over all water users. Licenses and traditional agricultural users have priority amongst themselves according to the priority number that has been assigned to their license or registration.

Framework for Water Management Planning

The *Water Act* also required that, in addition to licensing, a framework for water management planning be established, which must include a strategy for the protection of the aquatic environment. AENV's publication *The Framework for Water Management Planning* outlines the process for water management planning and identifies the components required for water management plans. As required, it includes a strategy that addresses the aquatic environment, which can include water quality, water quantity, and aquatic habitat and species. The scope of the planning is typically defined by geographic limits, normally watershed boundaries. The criteria that determine which planning initiatives to undertake and their priority include:

- Pressure on the resource
- Public concern
- Relationship with other resources and initiatives

The water management planning process can result in a Water Management Plan, an Approved Water Management Plan, or a Water Conservation Objective. The Framework requires that a Water Management Plan include:

- A summary of the issues considered
- A description of the area in which the plan applies
- A summary of the information assembled as part of the planning process
- The relationship of the plan to regional strategies or other planning initiatives
- The recommended options and strategies to address the issues

- A list of performance monitoring requirements

To become an Approved Water Management Plan approval by the Lieutenant Governor is required and then the plan must be considered when making decisions on applications for water licenses and approvals. In addition to the information required for a Water Management Plan, an Approved Water Management Plan must also include the following items:

- A summary of issues considered in the plan
- A description of the area to which the plan applies
- A summary of the recommendations
- The matters and factors that must be considered

A Water Conservation Objective (WCO) refers to the amount and quality of water that is necessary for the following action:

- Protecting a natural water body or its aquatic environment, or any part of them
- Protecting tourism, recreational, transportation, and waste assimilation uses of water
- Managing fish or wildlife

WCOs may be established either as part of a Water Management Plan or outside a plan.

Water for Life: Alberta's Strategy for Sustainability

Increasing demand on water supplies and the risk to human health, economy, and aquatic ecosystems requires changing the approach to managing the water supplies. AENV outlines a new water management approach in *Water for Life: Alberta's Strategy for Sustainability*, which is based on the following commitments:

- Safe, secure drinking water supply
- Healthy aquatic ecosystems
- Reliable, quality water supplies for a sustainable economy

The strategy identifies short, medium, and long-term actions to achieve the goals associated with the above commitments. The actions focus on three key areas:

- Knowledge and research
- Partnerships for watershed management and stewardship
- Water conservation

Implemented in 2004-2005, the strategy contains objectives and actions for the next 10-12 years. Key initiatives undertaken in 2004-2005 include the following:

- Forming the Alberta Water Council and Watershed Planning and Advisory Councils, which will make recommendations regarding water management
- Assessing drinking water facilities
- Enhancing water monitoring programs
- Reviewing water storage sites
- Examining protocols to reduce the amount of fresh water used in oilfield injection

- Developing the Alberta Water Information Centre
- Developing an electronic water use reporting system

Additional information on water allocations and management is included in Appendix A.

Overview of Groundwater Resources in the CRP Region

This section includes a review and summary of the geology and hydrogeology (groundwater quantity and quality) in the CRP study area. The complete hydrogeology report is included in Appendix B**.** The information was compiled from regional hydrogeology reports conducted by the Alberta Research Council and from other site specific hydrogeology assessments (HCL, 2002 and 2003) undertaken by the MD of Bighorn, MD of Rocky View, MD of Foothills and Wheatland County.

The geology provides the framework for the various aquifers (water – bearing units) and includes both bedrock and overlying sediments that consist of sand and gravel (pre-glacial, glacial, or post-glacial activity). The bedrock aquifers are predominately sandstone formations since shale and other finer-grained formations are generally not productive aquifers. The sandstones of the Paskapoo and Scollard Formations are important aquifers for domestic water supplies, but are limited in overall water production capacity. Due to their limited capacity, bedrock aquifers are not considered to be larger-scale water sources.

The sand and gravel aquifers adjacent to present-day river valleys such as the Bow and Elbow Rivers are important sources of groundwater. Larger volumes of groundwater are generally possible in these aquifers; prominent examples of large volume municipal groundwater use include Banff and Canmore. The coarser-grained sediments associated with buried bedrock valleys (see Appendix B, Figure 2-1) provide smaller volumes of groundwater and are important water sources for smaller communities, industry, or agriculture.

The CRP is located within three physiographic regions, the Rocky Mountains, Rocky Mountain Foothills, and the Western Alberta Plains. The majority of the CRP is within the Plains area and has been modified by intensive glacial activity. The climate is essentially semi-arid where the rate of evapotranspiration is greater than the amount of precipitation; this results in an overall moisture deficiency within the CRP area.

Groundwater is recharged by precipitation that infiltrates into the soil and rocks. The rate of recharge is dependent upon a number of factors, including the coarseness of the soil, permeability, porosity, degree of fracturing etc. Therefore, the amount of pumping the aquifer can sustain is dependent on the recharge it receives. Aquifers, such as those along the Bow or Elbow Rivers, may receive a high degree of recharge, as would many other coarse-grained aquifers associated with buried bedrock valleys. Groundwater also contributes a significant amount of flow to rivers and streams and helps to maintain river flows in the drier periods of the year.

Groundwater quality is site specific and groundwater quality reports are available for individual wells and also from particular aquifers in the area. The groundwater quality is generally potable with most chemical constituents' concentrations less than maximum acceptable concentrations and/or aesthetic objectives of the Guidelines for Canadian Drinking Water Quality.

Adequate quality groundwater can be found throughout the CRP. However, groundwater volumes exceeding approximately 3000 m^3/d/well are only expected to be associated with aquifers adjacent to the present day rivers; lesser volumes may be associated with buried bedrock valleys, if present. Using the average per capita water usage rate of 450 L/c/d within the CRP, a groundwater supply of 3000 m^3/d could support a population of approximately 6,600 people. The eastern CRP area must rely on the bedrock formations to provide groundwater through individual domestic wells. Therefore, groundwater is not expected to be a viable sole water source for most of the larger communities in the CRP, especially on a regional basis. Groundwater will, however, continue to be viable for smaller communities, and those communities where aquifers are associated with present day rivers and buried bedrock valleys.

Approved Water Management Plan for the SSRB in Alberta [1]

Once approved by the Lieutenant Governor, the *Water Act* requires that the information and recommendations in the SSRB Water Management Plan be considered in decisions made on all applications for licenses and/or approvals within the SSRB.

To develop the plan, a series of reports were completed that identified the status of water allocations in the SSRB; determined the current status of the aquatic environment and the flow required to protect them; estimated future human demands for water, and determined the sub-basin flow contributions to the Master Agreement on Apportionment. The key findings of the SSRB Water Management Plan, as they relate to this study, are summarized below:

- The report recommends that no new water license applications be accepted for allocations in the Bow, Oldman, and South Saskatchewan sub-basins.
- With the exception of the Red Deer River, the rivers in the SSRB are highly allocated.
- There is a significant risk that new licenses issued in the Bow River Basin would not get water in drier years.
- Improved efficiency (using more of the allocated water, and reducing return flows) with existing licenses will increase the risks to existing junior licenses and reduce the instream flows.
- Population growth and economic development continue, increasing water demands.
- There is insufficient flow to meet the IFN in the Bow River downstream of the major water withdrawals. With the existing allocations, restoring the flow in these reaches will be difficult.
- The health of the aquatic environment is believed to be declining downstream of the major water withdrawals.

The recommendations made in the report will influence how future water allocations are managed, as well as limit the water available for diversion in the SSRB.

Report Overview

This plan reflects a balance between protecting the aquatic environment and water allocation of rivers in the SSRB. Albertans were asked for their views on the direction water management should take in the SSRB, and their comments and concerns were carefully considered while preparing this document.

The plan provides guidance to decision makers and acts as a foundation for future watershed management planning for the SSRB by Watershed Planning and Advisory Councils, as well as stewardship groups. It recognizes and accepts that limits for water allocations have been reached or exceeded in the Bow, Oldman, and South Saskatchewan River Sub-basins. The plan also recognizes that the limit of the water resource will be reached in the Red Deer River Sub-basin.

This plan includes the following principal recommendations:

- AENV no longer accept applications for new water allocations in the Bow, Oldman, and South Saskatchewan River Sub-basins except for purposes specified in a Crown Reservation of water to be established by the Minister of Environment for these sub-basins.
- That water be allocated from the Crown Reservation for the following activities:
  - First Nations requirements
  - Water conservation objectives
  - Storage of peak flows to mitigate impacts on the aquatic environment and to support existing licenses. (AENV will assist the Watershed Planning and Advisory Councils in evaluations of the potential for on-stream and off-stream storage.)
  - Licenses that may be issued for applications and registrations pending at the date of the Crown Reservation. (This does not necessarily imply approval; but the pending applications and registrations will be reviewed.)
- A thorough review be conducted to identify the maximum allocation limit once the allocations in the Red Deer River Sub-basin reach 550,000 dm^3.

Other recommendations and provisions included are:

- A committee be formed to provide water management coordination recommendations across the SSRB. The membership could include representation from the Watershed Planning and Advisory Councils in the Bow, Oldman, and Red Deer Sub-basins, and the South Saskatchewan River Sub-basin.
- AENV continue managing the SSRB as a whole, to meet the *Master Agreement on Apportionment* requirements. It is recommended that the aforementioned committee prepare an apportionment operations plan for consideration by the Director under the *Water Act*.

The WCO should be 45 percent of the natural rate of flow, or the existing instream objective plus 10 percent, whichever is greater at any point in time, with the following exceptions:

- The WCO for licenses under the Crown Reservation will be the existing instream objective plus 10 percent.
- The existing instream objective or WCO will continue to be a condition on existing licenses when off-stream storage is constructed to increase the use of existing allocations.

- AENV to establish WCOs for the Red Deer River Sub-basin. Any licenses issued for applications received after May 1, 2005 will be subject to the following WCOs:

  Upstream of the confluence with the Blindman River, to Dickson Dam:

  - For new licenses or existing licenses with a retrofit provision, a rate of flow that is 45 percent of the natural rate of flow, or 16 m^3/s, whichever is greater at any point in time.

  Downstream of the confluence with the Blindman River:

  - For future licenses that withdraw from November to March inclusive, a rate of flow that is 45 percent of the natural rate of flow, or 16 m^3/s, whichever is greater at any point in time.
  - For future licenses that withdraw from April to October inclusive, a rate of flow that is 45 percent of the natual rate of flow, or 10 m^3/s, whichever is greater at any point in time.
  - For existing licenses with a retrofit provision, a rate of flow that is 45 percent of the natural rate of flow, or 10 m^3/s, whichever is greater at any point in time.

- *The South Saskatchewan Basin Water Allocation Regulation (1991)* be repealed.
- The Director is authorized to consider applications for transfers of water allocations.
- The Director is authorized to withhold up to 10 percent of the volume of water being transferred, if it is considered to be in the public interest to protect the aquatic environment or to implement a WCO.
- The Director to consider the Matters and Factors provided in this plan in making decisions on applications for licenses, preliminary certificates, approvals, or transfers of an allocation of water.
- To improve the efficiency, effectiveness and productivity of water use in the Bow, Oldman, and South Saskatchewan River Sub-basins, three broad avenues be followed by AENV and water users.
  - Continue to improve water management and administration of water allocations.
  - Develop water markets and transfers.
  - Encourage improvements in water conservation by water users.

- Watershed Planning and Advisory Councils (WPACs) are encouraged to consider the planning priorities in their watersheds and undertake future watershed management planning with this water management plan as a foundation.

Nurture, Renew, Protect: A Report on the State of the Bow River Basin [2]

In 2004, the Alberta Government formally recognized the Bow River Basin Council (BRBC) as the Watershed Planning and Advisory Council for the Bow River Basin. The 2005 Report on the current State of the Bow River provides a comprehensive study that will improve public understanding of the basin and facilitate responsible decision-making regarding water quality issues by both the general public and water resource managers. While it may be too early for the information and recommendations in the report to have been turned into formal policies, it is important that the CRP Water and Wastewater Servicing Study use this information in developing recommendations. The information is used by water resource managers and policy-makers and will have an impact future water allocations and water quality guidelines.

Report Overview

The purpose of the Report was to provide up-to-date information on the water quantity, quality, and natural ecosystems of the Bow River Basin. The 2005 Report covers a broader mandate than the 1994 Report, as it includes an assessment of the vegetation, and wildlife and human use of the land. Since the 1994 Report, the Bow River Basin has included the following major accomplishments:

- Upgrades to several water and wastewater treatment plants
- Implementation of water conservation measures, including water metering and low flow fixtures
- Increase in the number of local stewardship groups
- Designation of the BRBC as the official Watershed Planning and Advisory Council for the basin
- Initiation of volunteer water quality monitoring programs
- Increase in public awareness and education

The state of the Bow River is determined by evaluating the following criteria:

- Water quantity (hydrology)
- Water quality
- Natural ecosystems
- Stewardship

The Report divides the Bow River Basin into the following eight reaches:

- Bow Lake to Lake Louise

- Lake Louise to Banff National Park Boundary
- Banff National Park Boundary to Upstream of Bearspaw Dam
- Bearspaw Dam to Western Irrigation District Weir
- Western Irrigation District Weir to Upstream of Highwood River Confluence
- Highwood River Confluence to Upstream of Carseland Weir
- Carseland Weir to Upstream of Bassano Dam
- Bassano Dam to Confluence with Oldman River

Of the eight reaches, six reaches (Reaches 2 through 7) are within the CRP area.

The Bow River Basin makes up 23 percent of the drainage area for the South Saskatchewan River. It is the largest tributary to that river, contributing 43 percent of the average annual combined flows of the South Saskatchewan. The majority of the flows in the Bow River are supplied by precipitation in the Rocky Mountains; there are also groundwater contributions, which are important during low flow periods. Peak flows generally occur during the spring and summer, when snow packs are melting, and decline throughout the fall and winter. While streamflows in the two reaches upstream of Banff have remained relatively unchanged, the downstream flows have been significantly altered from the natural flows. The summer flows are much lower, and the winter flows are higher than natural flows. Hydroelectric facilities, water withdrawals, diversion, and wastewater discharges have all contributed to these changes.

Eleven hydroelectric facilities are operated by TransAlta Utilities on the Bow River upstream of Calgary. Although not considered as a consumptive use of the river, these facilities can modify the flow patterns in the river. Six are dams, creating reservoirs that store water during the spring melt and gradually release it over the year to maintain a reliable electricity source. The total storage available in the reservoirs is approximately 25 percent of the average annual runoff of the Bow River at Calgary. Other facilities are run-of-river developments which do not have reservoirs and have little impact on the seasonal flows.

The reduction in spring and summer flows as a result of the hydroelectric facilities negatively impacts fish habitat and riparian habitat by reducing the flooding they require to regenerate; however, the increased flows in the river during the winter may benefit the habitat. The fluctuation in water levels also has a negative impact on the littoral zone of the reservoirs and increases erosion and sedimentation, which reduces habitat and food available to fish. The hydroelectric facilities do consider recreational users when releasing from the reservoir, and the increased winter flows provide additional dilution to municipal and industrial effluents.

At the time of the Report, approximately 46 percent of the average annual natural flows of the Bow River was either diverted or consumed, and many of the existing licenses were being underused. At the lowest reaches of the river, 68 percent of the average flows had been allocated for withdrawals. During low flow years, these allocations can be as high as 80 percent. If the water supply in the Bow River is insufficient to meet all the license requirements, then AENV uses the principle of “first in time, first in right” to manage water, with more senior license holders being entitled to their full allocation before the more junior licenses receive any water.

The Government of Alberta regulates the water licensing and allocation for the Bow River Basin outside Banff National Park. Within the park, licenses for diversion are issued by the Federal Government. Water use within the Bow River Basin includes irrigation, non irrigation agriculture, municipal, and industrial. Irrigation is the largest user of water in the basin, accounting for over 76 percent of the total allocations. As irrigation practices become more efficient, the return flows to the river will decrease.

Many municipalities in the basin have water licenses, the largest being The City of Calgary. It is expected that new conservation initiatives being implemented will decrease consumption by municipal users in the immediate future. Overall, return flows in the basin from municipalities are about 94 percent of consumption. The municipalities can actually contribute more water to the river than they withdraw because of storm sewer systems that can quickly transport precipitation or snowmelt from within the basin to the river. However, municipal stormwater and wastewater return flows can contain a number of pollutants. Wastewater contains a number of chemical and biological contaminants, and stormwater can contain road salts, metals, hydrocarbons, etc. The WWTP effluents are also a higher temperature than natural flows. Lake Louise, Banff, Canmore, and Calgary all use tertiary treatment and have improved the quality off their wastewater effluent.

Industrial uses of water in the basin include aggregate washing, cement production, oilfield injection, gas plant/petrochemical production, greenhouses, feedlots, industrial processing, etc.

The current state of the Bow River can be summarized in the following terms:

- Compared to the downstream reaches, the upper reaches of the Bow River are generally considered to be healthy.
- Streamflows in the majority of the Bow River reaches are highly altered from the natural flows. Approximately 40 percent of the total annual natural flows in the basin are altered. Hydroelectric facilities have the largest impact on flows in the upper reaches, whereas withdrawals and diversions impact flows in the lower reaches.
- Water quality decreases as you move downstream. The City of Calgary WWTPs and stormwater runoff have a significant impact on water quality in the lower reaches. Upgrades to the WWTPs are improving the water quality, but growth in the area is going to offset the improvements.

The report contains the following six major recommendations:

1. The Bow River Integrated Watershed Management Plan development – Enhanced coordination and communication between different organizations and departments responsible for planning and policies is required.
2. Appropriate use and technology sharing
3. Preparation of a Water Balance Sheet – A simple application that can be used during public consultations is required. It should include a full accounting of the available water, the inputs, the outputs, and storage within the Bow River Basin.

4. Continued research and monitoring – Research and monitoring should continue to focus on water quality and quantity, but additional information is also required on the groundwater within the basin, land use, impacts of non-point sources of pollutants, management of camping facilities and off-highway vehicles on public lands, and wetlands.
5. Public consultation and engagement – Many of the programs developed for watershed management often must be implemented by the public to be effective, so the public must be well informed of its role and the impact they can have.
6. Pro-active contingency planning – Water management planning and future water allocations should consider the future impacts of global warming, drought, glacier shrinkage, and potential disasters.

Preserving our Lifeline: A Report on the State of the Bow River [3]

The 1994 Report on the State of the Bow River was the first state-of-the-river reports developed by the BRBC. Similar to the 2005 Report, the 1994 Report assesses the state of the entire Bow River, but it does not include as comprehensive a look at the vegetation, wildlife, and human use of the land within the watershed.

Report Overview

This Report evaluates the state of the Bow River ecosystem – considering water quantity, water quality, and riparian and aquatic habitat – and looks at opportunities for improving the management of the river for human uses. The purpose of the Report is to provide information that will help to improve the overall understanding of the Bow River, improve decision-making regarding the water quality, provide a baseline for future monitoring, and engage stakeholders and managers in public discussion.

In 1991, the population within the Bow River Basin was 836,000, with the City of Calgary accounting for 87 percent of that number. Municipal and domestic water withdrawals in the region accounted for 19.4 percent of the total water licensed for withdrawal from the Bow River. In 1991, there were 74 licenses for direct withdrawals for domestic or municipal withdrawals, and 25 for indirect withdrawals from irrigation systems. Actual withdrawals for municipal and domestic use were only around 11 percent of the total withdrawals, with returns of approximately 94 percent back to the river through the WWTPs. Irrigation was the largest user of water from the Bow River, accounting for 75 percent of the total water licensed for withdrawals. In 1991, there were 200 licenses for irrigation withdrawals, and approximately 96 percent of the water actually consumed (withdrawals less the amounts returned to the river) was for irrigation uses. Three major irrigation districts in the region accounted for 98 percent of the irrigation withdrawals: Bow River Irrigation District, Western Irrigation District, and Eastern Irrigation District. There were also 572 withdrawal licenses for agricultural uses other than irrigation, which accounted for about 0.4 percent of the volume of water licensed for diversion, and 68 licenses for industrial uses, which accounted for 1.2 percent of the total consumption of water from the Bow River. Several hydroelectric facilities in the upper reaches of the Bow River were considered non-consumptive users but had a significant impact on the flows in the river.

At the time of the 1994 Report, the general state of the Bow River could be summarized as follows:

- Water quality in the Bow River ranged from unaffected by human activity in the upper reaches to highly impacted in the lower reaches.
- Flows in the river had been reduced to 91 percent of the long-term average flow. Upper reaches had been altered by the operation of the hydroelectric facilities, and withdrawals and diversions had impacted flows in the lower reaches.
- Abandoned industrial sites and the City of Calgary WWTPs were reducing the quality of the water downstream, and it was not meeting the water quality quidelines for several different user types.

The Report identified the following opportunities to improve the river, particularly to water quality and riparian habitat:

- Assessment and Accountability
  - Prepare detailed status reports on the major water uses affecting water quality
  - Prepare a self-assessment tool for riparian landowners to measure the environmental impacts and liabilities of activities or developments on the Bow River
  - Develop objective goals and effective indicators of all aspects of the river's health
- State of River Measurement and Monitoring
  - Monitor the state of the river indicators for all aspects of the river
  - Review the water quality guidelines used in the report
  - Conduct regular visual assessments of the river
  - Establish a volunteer water quality monitoring program
  - Prepare water quality models for the river
- Water Quality and Ecosystem Investigations
  - Investigate the water quality trends presented in the State of the Bow River Report
  - Determine the effects of water quality limitations on fish and other aquatic life in reaches 6, 7, and 8 of the Bow River
  - Determine the relative contributions of wastewater effluents, stormwater, and agriculture runoff to changes in water quality in the river
  - Measure the improvements in water quality resulting from new or improved WWTPs in Calgary, Canmore, Cochrane, and Lake Louise

  - Research the extent and location of threats to the riparian cottonwood forests along the Bow River
  - Gather fisheries information to assist in updating and improving the provincial government's strategies for managing the Bow River fisheries

- Planning Considerations
  - Establish a "River Management Zone"
- Community Stewardship
  - Adopt segments of the Bow River and tributaries
  - Develop stormwater control measures in communities
  - Set-up and promote "Model Intensive Livestock Operations"
  - Clean-up litter along the riverbanks
  - Promote individuals taking personal action
  - Improve Fish Creek and Nose Creek

The Calgary Total Loading Management Plan[4]

The Calgary Total Loading Management Plan developed by The City of Calgary deals with the management of pollutant loads from both stormwater and wastewater effluents. During storm events, stormwater discharge loads for some pollutants within The City of Calgary are approaching the provincially-regulated limits, and the assimilative capacity of the Bow River, and the total suspended solids are exceeding Federal guidelines. If the treatment of these pollutants is not improved, the resulting water quality issues may have an impact on growth and development within Calgary. The City recognizes that, as the largest municipality in the Bow River Basin and one of the largest sources of pollution, it has a responsibility to other stakeholders to minimize its impact on the river. Any recommendations made in the CRP Water and Wastewater Study regarding regional servicing and/or upgrades to The City's infrastructure must take into account the thresholds, targets, and triggers identified in the total loading management plan.

Report Overview

As part of their approval from AENV, The City of Calgary is required to submit recommendations for managing total loadings from both stormwater and wastewater effluents for total suspended solids (TSS), carbonaceous biochemical oxygen demand (CBOD), phosphorus, and nitrogen. This plan represents The City's proposal for managing total loading, and they have requested that AENV reference this plan when they issue the revised approval.

The instream thresholds for the above parameters were determined from the Bow River Water Quality Model (BRWQM). When there was information available on the instream effects of loading substances, the thresholds were developed for parameters reflecting these effects, rather than developing thresholds for the parameters themselves. For example, the threshold for Dissolved Oxygen is used to determine the loading values for phosphorus and nitrogen nutrient compounds. The thresholds are then converted to average loading targets that would allow the thresholds to be met under the most limiting conditions for that parameter. The City than used the targets to establish planning triggers and develop management plans for each parameter. The total loading management plan looks at these triggers and parameter management plans, as well as addressing the ongoing management process.

Dissolved Oxygen (DO), which is essential for respiration in aquatic animals, is the primary concern in the Bow River. When climatic conditions have been extreme, recent monitoring has shown levels to be below the Alberta guidelines for surface water quality, negatively impacting aquatic populations and limiting the assimilative capacity of the river.

There are two primary factors for low DO levels:

- The biodegradation of organic material in WWTP effluents and stormwater, referred to as carbonaceous biochemical oxygen demand (CBOD) – CBOD has been shown to have minimal effects on the Bow River. The processes at the WWTPs have treated any rapidly biodegrading materials prior to discharging, and while stormwater CBOD may have more rapidly biodegradable materials, there impact is minimal.
- Night time respiration of aquatic plants. – The effects of nighttime respiration are having the largest impact on DO levels. The respiration cycle results in large fluctuations in DO levels over a short period, and monitoring has shown that the short term DO minimums can reach the water quality guidelines in late summer when aquatic plants are abundant. Macrophytes have been shown to have the largest impact on DO levels, and there growth is largely effected by phosphorus levels in the river.

There are also emerging issues surrounding the impacts of climate change and water conservation. Climate variability is important with respect to dissolved oxygen because lower flows and higher temperatures can increase the DO demand and reduce the assimilative capacity of the river. Future water conservation is going to be necessary to ensure adequate water supplies for all users. The City of Calgary is targeting a 30 percent reduction in per capita water usage over the next 30 years, but loading at the WWTP will increase, and it is unclear how the higher influent concentrations will impact loadings on the river.

The levels of the parameters were compared to the *Surface Water Quality Guidelines for Use in Alberta* (AENV, 1999) to determine the present and emerging issues. In future plans, the impacts on downstream users will also be considered. The total loading is defined as "the annual weigh of …", so the daily values expressed in the plan are equal to the annual loadings divided by the number of days in the year. The daily loading values are not such that if exceeded slightly will cause significant negative effects on the river's aquatic ecosystem. The parameter-specific management plans can be summarized as follows:

- Phosphorus – Phosphorus levels in the river impact aquatic plant growth, particularly macrophytes. Increased aquatic plant growth can interfere with mechanical devices and recreational users, but it also affects the DO levels in the river and causes diurnal DO depletion. The City's approval limits the levels of Total Phosphorus, so the trigger adopted for this is 340 kg/day. Currently the City exceeds this trigger, but there are seasonal emergency actions in place until permanent processes can be put in place to maintain the levels. Eighty-two percent of the phosphorus loadings from the City is from treated wastewater, so improvements at the WWTPs are being implemented to increase phosphorus removal.

- Nitrogen – The management of nitrogen compounds focuses on ammonia because of toxicity concerns. The present end-of pipe limits are effective at addressing toxicity issues so no triggers have been established for ammonia. Because nitrogen nutrients are not limiting with regard to plant growth, no triggers have been adopted for them. Ninety-one percent of the City's nitrogen nutrient loading is from WWTP effluents, with the primary source being human waste. Improvements at the WWTPs are expected to reduce nitrogen nutrient loading.
- Total Suspended Solids (TSS) – TSS is a measure of the solids suspended in water that can be retained by a defined filter. Solids have a negative impact on aquatic ecosystems, including sedimentation of spawning beds, reduced visibility, and reduced penetration of sunlight required for plant growth. The trigger value adopted for TSS is an average value of 52,920 kg/day. This value is based on the 10 month "clear flow period" from August 01 through May 21 annually, so it is not an annual average. Stormwater is the largest contributor of TSS, with almost nine times the loading of the WWTPs in 2002. The City has implemented an erosion and sedimentation control program, and requires that all new subdivision developments include retention facilities that remove at least 80 percent (increased to 85 percent in 2006) of the solid particles 75 microns and larger. They are also looking at retrofitting older areas with Best Practicable Technology (BPTs).
- Carbonaceous Biochemical Oxygen Demand (CBOD) – CBOD has minimal affect on the DO levels in the Bow River, so no trigger has been adopted for them. CBOD loadings are split relatively evenly between stormwater and wastewater effluent.

The Calgary Total Loading Management Plan expands on the master plans currently developed for the WWTPs. This plan also considers loading from stormwater effluent, background loadings, and tributaries. In the future, the thresholds, targets, and triggers will be updated as required based on new information from modeling, changing legal requirements, and new scientific information. The plans will be updated and published every five years.

Hydrogeology of the Canmore Corridor and Northwestern Kananaskis Country, Alberta [5]

The majority of water use in the Calgary region is from surface water, although some communities rely on groundwater for their water source. This Report focuses on the Canmore corridor. The CRP Regional Servicing Study will use the information to determine the impact that the groundwater supply will have on growth in the area. It will also assess the impact that groundwater availability and quality will have on how the communities in the area can be serviced.

Report Overview

The objective of this Report, which was started in 1999 by the Hydrogeology Section of AENV, was to provide an assessment of groundwater capabilities, including availability, quality, movement, and interaction with the natural environment. A field component was completed to identify, describe, locate, and catalogue the known wells and test holes. This information was then supplemented with information from exploratory drilling, review of aerial photos, and water sampling. A total of 670 groundwater data locations were spread throughout the study area.

The study area includes the Canmore Corridor, which is the area in the Bow River Valley running from the Banff National Park Boundary to the Stoney Indian Reserve, and includes the communities of Canmore, Dead Man's Flats, Lac des Arcs, Exshaw, and Seebe, and the northwest portion of Kananaskis Country, which is bounded by Banff National Park, Peter Lougheed Provincial Park, and Elbow Sheep Wildland Provincial Park.

Several hydroelectric facilities operated by TransAlta Utilities within the study area have an impact on river flows in the area. The facilities on the Kananaskis River control the flow with dams at Kananaskis Lake and Barrier Lake. Just south of Canmore, there is an extensive hydroelectric complex consisting of the Spray Lakes Reservoir, Goat Pond Reservoir, and a canal system that diverts flows to the Bow River. At the Town of Banff, the long-term mean monthly discharge in the Bow River varies from 7.6 m^3/s in March to 127 m^3/s in June, with an average of 40 m^3/s over the year. Downstream at Seebee, the flows in the Bow River range from 19.6 m^3/s in March to 245 m^3/s in June, averaging 79.9 m^3/s over the year. The Kananaskis River joins the Bow River at Seebe, and the long-term mean monthly discharge in this river ranges from 3.4 m^3/s in January/February to 49.2 m^3/s in June, with an average flow for the year of 15.7 m^3/s. The flow in the Kananaskis River is controlled by the dams that form the Kananaskis Lakes and Barrier Lake. The Spray Lakes Reservoir has changed the natural drainage in the Spray Lakes Valley. Historically, the natural drainage at the north end was through Goat Creek to Banff. At the south end, drainage was through the Spray River to the Bow River at Banff. With the construction of the reservoir, the drainage is now through the Spray River, which flows from the Canyon Dam at the south end of the reservoir, or it is diverted by the Three Sisters Dam at the north end into a canal system, which ultimately flows to the Bow River. The Spray Lakes Valley has the lowest flow rates of the three in the study area, with long-term monthly discharges from the diversion varying from 7.35 m^3/s in October to 15.4 m^3/s in January, with a yearly average of 11.3 m^3/s.

The primary source of potable water in the study area is groundwater, which comes mainly from surficial sand and gravel aquifers. Surficial aquifers are those found in surficial deposits laid by glaciers; they may be found very deep if subsequent deposits overlie them. Bedrock aquifers are usually only used in upland areas when sufficient water from surficial deposits is unavailable. The Town of Canmore relies on a combination of surface water and groundwater, but they are looking at transitioning entirely to groundwater. Seebe uses surface water, because of limited availability of groundwater sources in the immediate area. The main aquifers in the region are Benchlands, Outwash Plain, Alluvial Fan and Valley, Calgary Buried Valley, and Bedrock.

The Benchlands Aquifers run along either side of the western end of the Bow River Valley near Canmore. The Hamlet of Harvie Heights, Alpine Resort Haven, and Dead Man's Flats, the subdivisions of Silver Tip and Three Sisters, and several quarries along Hwy 1A are all located along the benchlands. The material found along the south facing benchlands is coarse and permeable, which has caused the water table to lower in many places. The north-facing benchlands are better at retaining water, but the aquifers are thin and have poor yields. The Hamlet of Harvie Heights is one of the only communities that accesses groundwater from this aquifer in any significant capacity. Two zones within the aquifer are separated by a clay layer. Most of the residents in the upper hamlet access the shallower of the two zones, which experiences seasonal fluctuations in water levels. The deeper zone accessed by some residents and businesses is more reliable, with a hydraulic head close to that of the Bow River, and yields close to 150 m^3/day.

The Outwash Plain Aquifer extends over the Seebe district, including Bow Valley Provincial Park and Yamnuska Natural Area. The yields in this area can vary from dry to 560 m^3/day depending on the thickness of the aquifer, and its distance from the Bow River and Kananaskis River. The aquifer is unconfined and relatively thin and shallow, which makes it susceptible to contamination.

There are three Alluvial Fan and Valley Aquifers within the region: the Bow River Aquifer, Kananaskis Valley Aquifer, and the Spray Lakes Valley Aquifer. The Bow River Aquifer is found in the floodplains of the Bow River. The aquifer is unconfined and extends between 40 m, at the west end near Exshaw, and to at least 110 m deep at Canmore. The water table in this aquifer is typically near the surface and may fluctuate with the river levels, and the network of streams in the flood plain suggests that the Bow River both contributes to and receives water from the channels through groundwater flow. Yields in this aquifer can reach higher than 3300 m^3/day. Because of the high yields and high water table, any wells are usually shallow. Several alluvial fans encroach on the Bow River Aquifer, but because of their higher elevations, the depth to the water table in these locations is greater. The yields in the alluvial fans are lower than along the floodway (between 100 m^3/day to 750 m^3/day), and the type is influenced by the source and the alluvial material. The Kananaskis Valley Aquifer provides water to facilities at Kananaskis near the Kananaskis Golf Course. The wells within the Kananaskis River floodplain are shallow and have yields ranging from 200 m^3/day to 3300 m^3/day. The Spray Lakes Valley Aquifer is closely linked to water levels in the Spray Lakes Reservoir. While yields are typically around 200 m^3/day, draining the reservoir will result in draining the aquifer.

The Calgary Buried Valley Aquifer extends from the Saskatchewan border and travels west to Calgary. Drilling at the gate to Banff National Park, the Lafarge property in Exshaw, the Graymont Lime property in Kananaskis and Many Springs suggests that the aquifer continues up the Bow Valley from Calgary. The water level in the aquifer rises close to the surface at Canmore, Dead Man's Flats, and Exshaw, and is flowing at Many Springs.

Bedrock aquifers are typically only used where surficial aquifers are not available or yields are insufficient. A few areas that lack surficial or bedrock aquifers use surface water supplies. Wells at Seebe would have to be deep, as the river runs through deep canyons, and would drain the wells if too shallow. The northern few blocks of Exshaw use water from Exshaw Creek, since well yields are less than 25 m^3/day in that area. On the opposite side of the valley from Exshaw, a well at Heart Creek produces over 130 m^3/day from fractured limestone.

Of the more than 330 samples used, the Total Dissolved Solids (TDS) concentration mean over the region was 290 mg/L, with the maximum of 1240 mg/L found at Dead Man's Flat and minimum of 70 mg/L at Canmore. By comparison, the TDS concentration in the Bow River at Canmore was found to range between 140 mg/L to 205 mg/L. Aquifers closer to the recharge areas, Spray Lakes and Upper Kananaskis Valley, tend to have lower concentrations of TDS. The composition and type of groundwater varies depending on the geologic origin and contact time. Most of the groundwater in the region is similar in composition to the Bow River, but is usually more concentrated. The water quality in the region is considered good. All cations and anions were within the *Guidelines for Canadian Drinking Water Quality* (2000) maximum allowable concentrations (MAC) and aesthetic objectives (AO). Some results in the Dead Man's Flats area showed TDS concentrations exceeding the AO of 500 mg/L. Iron concentrations also exceeded the AO in some areas and were usually associated with wells with iron casings that were only used sporadically or where iron-reducing bacteria were present.

There are several significant springs, which are areas of concentrated groundwater discharge, located throughout the region. The flows from a spring are dependent on the permeability of the source material, the hydraulic gradient, and the amount of water available from recharge. In the Bow Valley – Kananaskis area, the flows may vary from small seepages to those found at Many Springs, which are in excess of 9000 L/min. A few communities in the region, including Harvie Heights, Canmore, and the community of Kananaskis, have tapped into springs for their domestic supply. The Kananaskis Guest Ranch and the University of Calgary Kananaskis Field Station use springs for their domestic water supply. The TDS measured in the springs throughout the region averaged 325 mg/L.

Instream Flow Needs Determinations for the South Saskatchewan River Basin, Alberta, Canada [6]

The Instream Flow Needs (IFN) Determinations was one of the reports initiated to collect information that would be used in the SSRB Water Management Plan. The report provides recommendations on the IFN required to maintain a healthy aquatic ecosystem. Any decisions on new applications for water allocations will take into account the IFN through the recommendations in the approved SSRB Water Management Plan. Under the existing policy framework, some senior licenses are not affected by IFNs.

IFNs are determined seasonally for individual river reaches, and are based on a complex formula that accounts for protection of fish habitat, water quality considerations, protection of riparian ecosystems, and channel maintenance considerations.

Report Overview

The goal of the study team and purpose of the report was to define the IFN requirements for each reach on a weekly time step. The areas studied include reaches of the Red Deer River, the Bow River, the Oldman River, the St. Mary River, the Belly River, the Waterton River, and the entire extent of the South Saskatchewan River to the Alberta Saskatchewan border.

The flows should follow the natural flow hydrograph and take into consideration the variations in intra-annual and inter-annual flows. The IFN requirements are determined for four ecosystem components; water quality, fish habitat, riparian vegetation, and channel maintenance, and then integrated into a single IFN determination.

Fish Habitat

Determination of the IFN for fish habitat was based on fish habitat modeling using available field data. The process consists of five basic steps:

1. Create a series of constant-percent flow reductions from the natural flow in 5 percent increments. Using a constant-percent flow reduction ensures that the integrity of the natural flow regime is preserved.
2. Calculate the Ecosystem Base Flow (EBF), using hydrological flow statistics where site-specific fish habitat data does not exist and in reaches where the data is available, select the greater of the 95 percent exceedence flow or the 80 percent habitat retention flow.
3. Identify the flow range for conducting the habitat time series analysis, by using an evaluation of site-specific Weighted Usable Area (WUA) curves.
4. Conduct a habitat time series analysis for the natural flow and the constant-percent flow reductions using several thresholds:
   - A 10 percent loss in total average habitat
   - A 15 percent maximum weekly loss of average habitat
   - A 25 percent maximum instantaneous habitat loss
5. Check the series of flow reductions to see if they meet or exceed the above thresholds; the greatest flow reduction that did not exceed any of the thresholds is chosen as the flow recommendation.

The IFN results for each are expressed as a percent reduction from natural flows, with an associated EBF. There are two components to the fish habitat IFN: the EBF, which protects naturally limiting habitat for a range of flow conditions, and the constant-percent flow reduction, which protects a range of habitat conditions that vary within and between years. The majority of the reductions are between 15 percent and 30 percent, but there are reaches on the Bow River with larger flow reductions.

Water Quality

Water quality IFN determinations focus on water temperature and concentration of dissolved oxygen (DO) and ammonia. These parameters can be managed through flow reduction and are important for fisheries protection. Temperatures that exceed guidelines can have a negative effect on fish metabolism and can result in mortality. The instream flows were determined to prevent exceeding chronic and acute temperature limits. As stream temperatures increase, there is a reduction in DO. The guideline for DO for fish protection is 5 mg/L for acute occurrences, and 6.5 mg/L seven-day average for chronic occurrences. The instream flows were determined to prevent these occurrences.

Assimilation flows are instream flows that dilute waste and allow for biological breakdown of organic wastes. They are intended to ensure that DO and ammonia concentrations do not exceed guidelines. Assimilation flows are considered a consumptive use of water and prevent other allocations of the water.

Flushing or scouring flows are high flows, usually due to snow melt in late spring/early summer, that dislodge sediments built up along the riverbed. These flows are important for spawning fish and limiting the growth of aquatic plants. Where possible, IFN values for water quality were determined for all four seasons, and the IFN determination is presented as a series of weekly exceedence curves.

Riparian Ecosystem

The instream flow recommendations for riparian ecosystems are established to ensure that the natural extent and character of the riparian forests are maintained and restored. The stream flow requirements can be categorized into flows for tree survival (minimum flows), tree growth (moderate flows), seedbed preparation (peak flows), and seedling and sapling survival (flow ramping and extended moderate flows).

The determination of the poplar instream flows must consider the variation in flows required to meet poplar moisture requirements. The calculation of the 'Poplar Rating Curve' can be simplified into four rules that dictate:

- There be no reduction to flows with natural exceedences of 90 percent or greater.
- Flows may not be reduced below the 90 percent exceedence level.
- Naturalized flows may be reduced up to 25 percent, provided that the resulting RI shift is not greater than 50 percent.
- The maximum flow required is 125 percent of bankfull.

The IFN recommendation for riparian ecosystems therefore comprises a series of natural weekly exceedence curves to which the above criteria are applied.

Channel Maintenance

Channel Maintenance Flows (CMF) define the flow regime needed to maintain the physical characteristics of the river channel, and consist of flushing flows, bed mitigation flows, channel structure flows, and channel forming flows.

Because no new data was collected for this study, sufficient information was not available to determine IFN requirements using existing methods. The method used produced flow magnitudes, and it was not possible to generate values in a duration curve format that could be integrated with the other IFN determinations for riparian vegetation, water quality, and fish habitat. Therefore, the other three components were combined, and a comparative analysis was completed to ensure that channel maintenance flows were being met. When there is insufficient data available to calculate the CMF, the five-year return flow should be used.

There is no widely accepted method for integrating the IFN determinations for different ecosystem components into one flow recommendation. This study presents a flow duration curve using a weekly time step.

Impacts on Water Quality in the Upper Elbow River [7]

This report was undertaken as a result of significant increases in water quality indicators upstream of the City of Calgary. As growth continues along the Elbow River upstream of Calgary, it will be important to consider the impact on water quality and how potential servicing options can minimize any negative impacts.

Report Overview

This report presents the results of a study completed by the City of Calgary and AENV from 1999 to 2003 inclusive. The study involved extensive sampling throughout the basin of the upper Elbow River and its tributaries to determine the spatial and temporal trends in the concentration of key water quality indicators, and to identify factors that may be impacting the water quality in the Elbow River.

Several studies that examine the water quality in the upper Elbow River and the Glenmore Reservoir have identified potential. The main issues identified related to water quality were taste and odour, which can be a result of algal blooms, disinfection by-products from the Water Treatment Plant, microbial pathogens, and turbidity. While the treated water from the Glenmore Water Treatment Plant has met the Canadian Drinking Water Quality Guidelines, aside from odour aesthetic guidelines, there have been increasing trends in key indicators that suggest the water quality upstream is deteriorating.

The testing for phosphorus suggested that most of the Total Phosphorus entering the Elbow River was from sources near Calgary upstream of the Weaselhead Bridge. There was also a small increasing trend in Total Dissolved Phosphorus (TDP) concentrations that suggest these sources are also contributing dissolved nutrients, which are more biologically available to stimulate the growth of aquatic plants. The nonpoint sources could include runoff from residential developments, agricultural activities, groundwater, and direct atmospheric deposition. While there were not similar increasing Trends of TDP in the tributary streams, the median concentrations of TP and TDP were higher than in the Bow River, and were sometimes above guidelines.

There was a noticeable mass loading of nitrate+nitrite in the river near Calgary, just upstream of Weaselhead in 1999 and 2002 from nonpoint sources such as urban runoff from storm sewers, atmospheric deposition, agriculture, and groundwater, and from loadings from Lott Creek. There was a significant increasing trend in nitrate+nitrite concentrations along the Elbow River from Bragg Creek to Calgary, similar to the trend found in the upper Bow River. The tributaries between Highway 22X and the Glencoe Golf and Country Club were major sources of nitrate+nitrite, particularly Pirmez Creek.

The testing suggests that river flows from year to year have a considerable impact on the spatial pattern of Total Suspended Solids (TSS) loading and deposition. During low flow years, the greatest contributions were from sources just upstream of the Weaselhead bridge, possibly from re-suspension of bed material, bank erosion, and stormwater effluent. During high flow years, the largest contribution of TSS mass occurred between Bragg Creek and Highway 22.

The greatest loading of E. Coli occurred directly upstream of Calgary, between the Glencoe Golf and Country Club and the Weaselhead bridge. There was also a significant increase in fecal coliforms within this section of river between 1979 and 2002. The majority of the tributaries had higher E. Coli and fecal coliform counts than the Bow River during years with low to average flows. Since there was no trend in fecal coliform at the Glencoe Golf and Country Club directly downstream of some of these tributaries, there is no evidence to suggest that those tributaries can account for the increasing trend in coliforms in the Elbow River. As well, there was no evidence to suggest that human sewage could account for the trend. Possible sources include runoff from residential developments, agriculture, and groundwater.

Recommendations to improve the quality of the water in the Elbow River include:

- Improve erosion protection through development restrictions within the flood plain and flood fringe
- Enhance existing efforts to improve agricultural practices on tributary streams
- Assess contributions of current and future storm sewer systems, and improve where feasible and cost-effective, and adopt Best Management Practices
- Repeat the Bacterial Source Tracking and Protozoan Sampling that was conducted in 2003 during a wetter year when there could be more movement of septic leachate into receiving streams

Draft Elbow River Water Management Plan Phase 1 Terms of Reference. [8]

The draft version of this document was reviewed, so the information may change as the document progresses. The development of the Elbow River Water Management Plan will be guided by the provincial *Framework for Water Management Planning*. Once the Plan is approved, its recommendations must be considered when decisions are made on any new applications for water licenses or approvals.

Report Overview

Realizing the need for collaboration between all stakeholders to manage the Elbow River watershed, the Elbow River Watershed Partnership developed the terms of reference for development of the Elbow River Water Management Plan. The objective of the plan is to provide recommendations relating to the protection, restoration, and maintenance of the Elbow River watershed.

Sixty-three percent of the Elbow River watershed is located within the Kananaskis Improvement District, and the remaining percentage is divided among the M.D. of Rocky View, the Tsuu Tina Nation, and the City of Calgary. There are currently 133 water allocation licenses within the watershed, of which 77 are surface water withdrawals, and 137 registrations, of which 64 are surface water withdrawals. The recommendations made from the plan must respect all existing licenses and registrations.

There are several key issues that the have been identified that range from water quantity, land use, water quality, and health of the aquatic ecosystems. Phase One of the water management plan will focus on water quality, both in surface water, and groundwater that is hydraulically connected to surface water. The plan will recommend Water Conservation Objectives based on the Elbow River Instream Flow Needs Study (2005) that can be used by authorities when reviewing applications for water licenses. The objective of the plan is to recommend WCOs for the Elbow River upstream of the Glenmore Dam, and to recommend Elbow River specific matters and factors that AENV can consider when implementing the SSRB Water Management Plan.

A key component in the planning process is public consultation. The objective of public involvement is to ensure that all stakeholders have as much input as possible in developing the plan and recommendations. The Elbow River Technical Committee will be responsible for leading the Water Management Plan initiative, and the Elbow River Watershed Partnership Steering Committee will provide direction and feedback at key milestones. AENV will provide planning and technical support throughout Phase One of the plan.

Final Draft Water Management Plan for the Nose Creek Watershed [9]

The Water Management Plan for the Nose Creek Watershed was also developed under AENV's *Framework of Water Management Planning*. The final draft (January 2007) was reviewed and the overview of this version is provided below. This final draft has not been authorized at the time of this review, but if the report is authorized by the Director responsible for water management, any recommendations should be considered when decisions are made on any new applications for water licenses or approvals.

Report Overview

The Nose Creek Watershed Partnership consists of the M.D. of Rocky View, the City of Calgary, the City of Airdrie, the Town of Crossfield, the Calgary Airport Authority, and the BRBC. In 2003 the Terms of Reference for the Water Management Plan were issued after consultation between the Nose Creek Watershed Partnership and AENV. The Water Management Plan includes the following:

- Recommends water conservation objectives (WCOs) for Nose Creek and West Nose Creek
- Specifies the matters and factors that AENV should consider when reviewing water license applications or transfer applications
- Builds upon and refines the requirements specified in broad-scale planning documents

The recommendations in the Nose Creek Watershed Water Management Plan are summarized as follows:

- General Implementation Actions for the Nose Creek Watershed Partnership.
  - Adopt and administer the key policy recommendations
  - Conduct annual review of the Water Management Plan
  - Reinstate the NCWP Communication Team and regular meetings with representatives from each jurisdiction
  - develop education and outreach programs
  - Monitor and evaluate performance.
  - Increase and review the enforcement capacity
- Water Conservation Objectives
  - The water management plan recommends that the water conservation objective should be 45 percent of the natural flow, or the existing instream objective plus 10 percent, whichever is greater at any one point in time. This is consistent with the WCO recommended for tributaries in the Bow River sub-basin by the SSRB Water Management Plan. Based on the current instream objectives in the Nose Creek watershed, the WCO for Nose Creek should be 0.094 cms (3.3 cfs) and 0.062 cms (2.2 cfs) for West Nose Creek and McPherson Coulee or 45 percent of the natural flow, whichever is greater at any one point in time.
- Integrated Stormwater Management
  - To achieve intermediate and high flow instream objectives, the water management plan recommends that the current Maximum Allowable Release Rate of 2.6 L/s/ha for the 1:100 year return period be reduced to 0.99 L/s/ha on West Nose Creek and 1.257 L/s/ha on Nose Creek for the period of April through October.
  - Interim Runoff Volume Control Targets of 90 mm on the Nose Creek main stem and 90 mm on West Nose Creek should be implemented in 2007, and reduced in following years for typical residential, industrial, commercial and institutional developments. For country residential developments and low density industrial, commercial, and institutional developments, a target of 50 mm should be established.
  - Because of the importance of internal drainage in this area, the plan recommends that direct drainage not be permitted to West Nose Creek, Nose Creek, or an associated tributary, and that these areas remain isolated from the effective watershed area.
  - Low impact development practices are recommended where feasible to meet the Runoff Volume Control Targets.
- Natural Features Protection
  - The natural topography and hydrology of the area should be preserved by minimizing cutting and filling and using natural drainage swales to convey runoff.
  - The plan recommends that escarpments equal to or greater than a 15 percent slope should be designated as Environmental Reserve, and development around escarpments should be limited.
  - Wetlands should be retained with a 30 m setback that may be revised after further evaluation.

  - The water management plan recommends that sediment and erosion control measures should be implemented, monitored, and maintained according to the City of Calgary's Sediment and Erosion Control Manual.
- Riparian Protection
  - The water management plan recommends that riparian setback widths should be determined on a site by site basis based on three criteria: the 1:100yr floodplain width, the meander belt width, and the width of escarpments.
  - Activities should be restricted within the setback area.
- Water Quality Protection
  - The plan recommends that Nose Creek and West Nose Creek be reclassified from a Class D to a Class C water body, which would place timing restrictions on activities scheduled for the creek.
- Source Water Protection
  - A source water protection plan should be developed to identify the protection and management strategies for source water in the Nose Creek watershed.
  - Source water protection education and awareness should be improved .
- Channelization
  - To prevent further loss of channel length and ecological function, the plan recommends that there should be no approval for development in Nose Creek and West Nose Creek unless it can be demonstrated that there will be no net loss of channel length, no degradation of aquatic habitat or riparian areas, and no net loss associated with upgrades for major infrastructure.
- Cumulative Effects
  - The cumulative effects of any project within the Nose Creek watershed should be identified on a regional area.

Environmental Sensitivity Analysis: A Regional Examination in Alberta Canada [10]

The report outlined the development of a tool to provide the M.D. with information that can provide planning assistance. The tool produces an overall environmental sensitivity analysis that provides the M.D. with a way to compare the relative sensitivity of the lands within the M.D.

Report Overview

The purpose of this study was to develop a tool that the Municipal District (M.D.) of Foothills could use in planning development in the region. The GIS based tool would evaluate environmentally sensitive areas within the region to determine there sensitivity to proposed development. There has been some work done at the provincial level to identify environmentally significant areas. Designations made at a provincial level are of limited use to the M.D. in there local planning, so this project will expand on the processes used at the provincial level to develop a process that the M.D. can use.

For the purpose of this study, environmentally sensitive areas (ESAs) include key components of the ecosystems that are vulnerable to the impact of land use, development, and certain management activities, and may be impacted either directly or indirectly. The relative sensitivity of any given location within the M.D. is determined by ranking features based on several variables, including aquifer vulnerability, BSOD, landcover, roadless lands, parks and protected areas, and riparian sensitive zones, and then overlaying the features using GIS. The relative sensitivity is then determined by calculating the sum of the overlapping features in that area. The higher the value, the greater the potential for sensitivity to changes.

The groundwater sensitivity analysis for this project focused on an area's potential vulnerability to contamination resulting from changes in land use. The vulnerability to contamination was estimated using surficial geology data. Those areas with more permeable, coarser texture material, have a higher potential for contamination, where as those areas with thick lacustrine clays, which are relatively impermeable, have less potential for contamination. The areas were ranked according to four risk categories, based on permeability, which were assigned an environmental sensitivity value and then included in the overall calculation.

The surface water sensitivity analysis focused on the relative health of the riparian zones, and they were evaluated and ranked according to ecological and distance criteria. The approach relies on specified fixed-width setback distances (30 and 100 m buffers for minor watercourses, and 30, 100, and 200 m buffers for larger, permanent streams and lakes), and on evaluating site-specific ecological criteria.

The terrestrial environment sensitivity analysis used existing information in the Biodiversity Species Observation Database (BSOD), the Alberta Natural History Information Centre (ANHIC) Rare Plants Database, the Classified Landcover database, as well as information in past studies conducted in the area. Any parks or protected areas that are managed by Alberta Sustainable Resource Development, Alberta Community Development, Heritage Canada, or non-government organizations were mapped as sensitive areas, and roadless lands were classified by there distance to a road and were mapped based on 1:20000 transportation data. Slope maps were created based on three slope intervals: 1-7 percent, >7-15 percent, >15 percent.

The maps and rankings from the sensitivity analysis for each variable were combined to produce an overall environmental sensitivity analysis that provides the M.D. with a way to compare the relative sensitivity of the lands within the M.D. The outputs from the project provide the M.D. with information that can assist them in there planning, as well as guide further studies.

Town of Okotoks Water Management Plan [11]

The Town of Okotoks has developed a Water Management Plan that identifies the challenges they face and the goals they have developed to ensure they meet the water supply needs of the community.

Project Overview

The Town of Okotoks has established its build-out population will be 30,000; therefore, the goal of the Water Management Plan is to ensure quality potable water is available to service this population. There are three key challenges to meeting this goal.

- Environmental Conditions – Recently-reduced flows in the Sheep River
- Instream Objectives – Licensed withdrawals approved after 1995 have conditions that must be met during low flow periods
- *Water Act* Legislation –Various regulations under the *Water Act* affect how withdrawals are managed

The management plan identifies the following eight goals that the Town of Okotoks is working towards:

- Goal 1: Ensuring the delivery of a reliable water supply using existing infrastructure and scheduling future expansion by developing additional wellfields and securing their rights, rehabilitating existing wells, and looking at future water supply alternatives.
- Goal 2: Operate an effective and efficient waterworks utility by managing daily and peak flow demands, providing automated water consumption monitoring, collecting baseline data, scheduling water use, and conducting leak detection.
- Goal 3: Develop a life cycle maintenance and recapitalization strategy that looks at the long range planning of infrastructure maintenance, replacement, expansion, and upgrade and the framework for operations.
- Goal 4: Develop a utility rate restructuring strategy that is based on a demand structure to promote reduced water consumption, and stabilize utility revenues over the long-term.
- Goal 5: Revise municipal bylaws to reflect water conservation objectives and promote the wise use of water resources to ensure effective and efficient use of the water supply by all users.
- Goal 6: Provide proactive input and response to Provincial *Water Act* issues that affect the municipal use of water, by complying with the *Act* and working or partnering with other water users to develop water management strategies.
- Goal 7: Provide public information and education programs that will engage residents in decision-making processes and keep them informed of the best water conservation strategies.
- Goal 8: Continue evaluation of the goals and activities in the Water Management Plan to ensure continued improvement.

Urban Stormwater Bow Basin: Urban Stormwater Basics [12]

This document outlines best management practices for stormwater management that are recommended for implementation in the Bow River Basin.

Report Overview

In the past, the objective of urban stormwater systems was to divert stormwater off the streets. It has become evident that urban stormwater has a large impact on the quality of the water in our rivers and streams, and management approaches must change. The increase in impervious areas and decrease in green space results in higher amounts of runoff and less groundwater recharge. This has modified the natural flows in the river, increasing the high flows and reducing the low flows. Water quality is also impacted by increased Total Suspended Solids, high phosphorus levels, increased coliform bacteria levels, increased nitrogen levels, and higher concentrations of Total Dissolved Solids that result from stormwater runoff.

A watershed approach to stormwater management considers management of the watershed as a whole, rather than managing individual wastewater discharges. The watershed approach considers that anything that affects the water quality, quantity or rate at one location has the potential to change the downstream characteristics of the watershed. The watershed planning approach includes the following activities:

- Looking at the natural characteristics of the watershed
- Taking into account existing and future land use
- Considering all of the uses of water
- Working to ensure that stormwater discharge causes the least impact possible
- Preventing problems before they occur
- Taking an active stewardship role with long term responsibility of the health of the watershed

Best Management Practices (BMPs) are generally accepted methods for improving stormwater quality. BMPs can be categorized as non-structural BMPs, which are "soft" techniques like establishing policies and regulations, or structural BMPs, which are designed facilities that make predictable improvements. There are often specific practices that are required or recommended by regulating authorities and are documented in stormwater management standards and guidelines.

Often there are incentives that promote using stormwater management practices, like delays in development approvals, user fees, or credits. There may also be funding for specific projects or when the broader watershed approach is used. Pollution trading and mitigation banking can be used to implement projects that are outside of the actual development. Pollution trading allows developers to invest in improvements in areas outside of their development to avoid costly retrofits. Mitigation banking creates a fund that can be used to compensate for losses in one project, by conserving, reclaiming, or creating habitats in other locations. Many of the these incentives and funding programs require a suitable agency to administer them, like existing public works departments, or sub-basin or river basin agencies.

There is limited information available for the Bow River Basin on how effective BMP's are for urban stormwater, and more research is needed to determine the impact of urban stormwater on water quality. Watershed studies should be conducted over the next five to ten years to determine the impacts that non-point sources are having on the water quality and compare stormwater loadings to those of agriculture and industry. In addition, watershed monitoring programs should be evaluated to determine if they are effective.

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Appendix A
Overview of Water Allocation and Management

Appendix B
Overview of Groundwater