



Bow River Basin Council

# **Bow Basin Watershed Management Plan 2012 Technical Reference Guide**

Land Use, Headwaters,  
Wetlands, Riparian Lands, Water Quality

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## CONTACT US

To learn more about the Bow Basin Watershed Management Plan 2012, please contact Mark Bennett, BRBC Executive Director at (403) 268-4596 or via e-mail at [Mark.Bennett@calgary.ca](mailto:Mark.Bennett@calgary.ca).



# Glossary

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Because there are many acronyms and technical terms in this report, it is recommended that the reader review the glossary prior to reading the document.

**AARD:** Alberta Agriculture and Rural Development.

**AE:** Alberta Energy.

**AEPA:** Agri-Environmental Partnership of Alberta.

**AEW:** Alberta Environment and Water.

**ALIDP:** Alberta Low Impact Development Partnership.

**AWC:** Alberta Water Council.

**Aquifer:** Refers to a sub-surface layer or layers of porous rock which hold water within the spaces between the rocks (interstitial spaces).

**Alluvial aquifer:** A non-confined aquifer comprised of groundwater that is under the influence of surface water.

**ASRD:** Alberta Sustainable Resource Development.

**ATPR:** Alberta Tourism, Parks and Recreation.

**BBWMP:** *Bow Basin Watershed Management Plan.*

**Bed and Shore:** The land covered so long by water as to wrest it from vegetation or as to mark a distinct character on the vegetation where it extends into the water or on the soil itself. In Alberta, the province owns most of the beds and shores of all naturally occurring lakes, rivers and streams.

**Bow Basin First Nations:** Refers to First Nations in the Bow Basin including the Tsuu T'ina Nation, Stoney Nations (Bears paw, Chiniki and Wesley) and Siksika Nation.

**Bow Basin Municipalities:** Includes Improvement Districts, Counties, Municipalities, Cities, Towns, Villages and Hamlets.

**BRBC:** Bow River Basin Council.

**Buffer:** A buffer is a strip of land placed in the landscape and managed in such a way so as to maintain desired ecological processes and provide economic and societal benefits.

**Conservation:** The responsible preservation, management and care of our land and or our natural and cultural resources.<sup>2</sup>

**Cows and Fish:** Alberta Riparian Habitat Management Society.

**Cumulative Effects:** Refers to the combined effects of past, present and reasonably foreseeable future land-use activities over time on economic, social and environmental values.

**DFO:** Federal Department of Fisheries and Oceans.

**DUC:** Ducks Unlimited Canada.

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<sup>2</sup> South Saskatchewan Regional Advisory Council Advice to the Government of Alberta for the South Saskatchewan Region Plan, Government of Alberta. 2010.

**Ecological Boundary:** The ecological boundary of a water body is the farthest landward extent of the feature directly influenced by and ecologically part of the water body. It is defined by a distinct change in soils and/or vegetation as compared to adjacent upland vegetation.<sup>3</sup>

**Ecosystem Services:** Ecosystem services are the benefits that nature provides to people. Examples include the ability of forest to regulate carbon and mitigate climate change, or the filtration and purification of water by wetlands. Ecosystem services are crucial to long-term, human well-being and economic success.<sup>4</sup>

**Ephemeral Wetland:** An area that is periodically covered by standing or slow moving water and that has a basin typically dominated by vegetation of the low prairie zone, similar to the surrounding lands. Because of the porous condition of the soils, the rate of water seepage from these areas is very rapid, and surface water may only be retained for a brief period in early spring.<sup>5</sup>

**ERCB:** Energy Resources Conservation Board.

**Floodplain:** An area adjoining a body of water that has been or may be covered by flood water.<sup>6</sup>

**GOA:** Government of Alberta (Departments, Agencies and Boards).

**Green Zone (Green Area):** Where forestry is the dominant land use activity.<sup>7</sup>

**GWAS:** Ghost Watershed Alliance Society.

**Headwaters:** Headwaters are the upland areas that contribute the greatest portion of flow – somewhere in the range of 80 percent of total volume of the Bow River Basin. Headwaters are characterized by accumulation, storage, purification and gradual release of surface and groundwater flows.<sup>8</sup>

**Hydrologically Significant Areas:** Critical source areas, alluvial aquifers, recharge zones, wetland meadows, groundwater zones susceptible to contamination, wetland complexes, and riparian lands.<sup>9</sup>

**Hyporheic Zone:** The zone beneath and lateral to a stream bed, where there is mixing of shallow groundwater and surface water.<sup>10</sup>

**Implementer:** The individual, agency or jurisdiction proposed to carry out or accomplish a given task.<sup>11</sup>

**Indicators:** Indicators are specific physical, chemical, and biological attributes or components of the environment that play an important role in affecting environmental outcomes. Indicators are always part of the cause-and-effect relationship between human activities on the landscape and the environmental response to those activities. When selecting environmental indicators, both condition and pressure indicators should be considered. Condition indicators measure biotic or abiotic characteristics in the environment such as soil erosion rates, the concentrations to total suspended solids in the water body, etc. Pressure indicators measure human activities like human land cover types, pesticide application rates, etc.<sup>12</sup>

**Invasive plants:** Refers to non-native species that displace native habitat. Invasive plants typically spread rapidly and are difficult to control.

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<sup>3</sup> ERCB Draft Directive - Oil and Gas Development Within or Adjacent to Water.

<sup>4</sup> Bow River Basin Council Definition.

<sup>5</sup> *Glossary of Terms Related to Water and Watershed Management in Alberta*, Alberta Environment, 2008.

<sup>6</sup> *Glossary of Terms Related to Water and Watershed Management in Alberta*, Alberta Environment, 2008.

<sup>7</sup> Alberta Sustainable Resource Development.

<sup>8</sup> *Bow River Basin Council Bow Basin Watershed Management Plan Terms of Reference*, 2010.

<sup>9</sup> Bow River Basin Council Definition.

<sup>10</sup> White, D.S., *Perspectives on Defining and Delineating Hyporheic Zones*. *Journal of North American Benthological Society* 12:61-69. Cross Ref. CSA. 1993.

<sup>11</sup> Bow River Basin Council Definition.

<sup>12</sup> *Indicators for Assessing Environmental Performance in the Watersheds of Southern Alberta*, Alberta Environment, 2008.

**Landscapes:** Refers to all the natural features such as fields, hills, forests, water, etc., which distinguish one part of the earth's surface from another part.

**Land Use:** The occupation or use of land or water area for any human activity or any purpose; a description of how land is occupied or utilized; the development that has occurred on the land, the development that is proposed by a developer on the land, or the use that is permitted or permissible on the land under an adopted.<sup>13</sup>

**Land Use District:** Under the *Alberta Municipal Government Act*, a municipality must be divided into land use districts prescribing permitted and discretionary uses for land, buildings, and development standards.<sup>14</sup>

**Limit:** Limits represent levels at which the risk of adverse effects on environmental quality is becoming unacceptable. Limits consider current science, and are meaningful and future-focused.<sup>15</sup>

**Linear Disturbance:** Features that disrupt the structure of a population, community or ecosystem, change the availability of the resources in the physical environment, and form a more or less straight line pattern in the landscape.<sup>16</sup> Examples include roads, pipelines, and seismic lines amongst others.

**NCWP:** Nose Creek Watershed Partnership.

**NRCB:** Natural Resource Conservation Board.

**Objective:** The desired end result or goal in well-defined, measurable terms achievable within a certain timeframe. Objectives translate the broad outcomes into more specific quantifiable statements and guide content and direction of policy.<sup>17</sup>

**OHV:** Off-Highway Vehicle.

**Outcomes:** For planning purposes, outcomes are the desired future conditions that guide the development and implementation of related programs. Outcomes can be broad and long-term in nature or focused. They are used in both direction setting and performance measurement.<sup>18</sup>

**Riparian Land:** Riparian lands are transition zones between the land and water. Riparian lands include any land that is directly influenced by a water body, floodplains and/or alluvial aquifers.<sup>19</sup>

**Setback:** For the purposes of this document, a setback is a minimum distance that must be maintained between a land use or development and a water body. The distance is measured from the legal bank of the water body to the boundary line of the adjacent development.

**Source Water:** Raw/untreated water received for treatment to provide potable water to municipal, industrial or private users. Sources may include high quality groundwater, groundwater under the influence of surface water and surface water from a lake, stream, river or watercourse.<sup>20</sup>

**Target:** An indicator value that reflects a desirable environmental outcome.<sup>21</sup>

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<sup>13</sup> American Planning Association.

<sup>14</sup> Association of Summer Villages of Alberta – Lake Stewardship Reference Guide, 2006.

<sup>15</sup> *Environmental Management Frameworks and the Lower Athabasca Regional Plan, Facts at Your Fingertips*, Government of Alberta, 2011.

<sup>16</sup> Manitoba Wildlands. <http://manitobawildlands.org/forests.htm>

<sup>17</sup> Bow River Basin Council Definition.

<sup>18</sup> *Modified from Glossary of Terms Related to Water and Watershed Management in Alberta*, Alberta Environment, 2008. The term “endpoints” was switched to “future conditions.”

<sup>19</sup> Bow River Basin Council Definition.

<sup>20</sup> *South Saskatchewan Regional Advisory Council Advice to the Government of Alberta for the South Saskatchewan Region Plan*, Government of Alberta 2010.

<sup>21</sup> *Indicators for Assessing Environmental Performance in the Watersheds of Southern Alberta*, Alberta Environment, 2008.

**Trigger:** Triggers are set in advance of limits as early warning signals. Limits and triggers consider current science, and are meaningful and future-focused.<sup>22</sup>

**Threshold:** Threshold has the meaning given to it in a regional plan and may include a limit, target, trigger, range, measure, index or unit of measurement.<sup>23</sup>

**UDI:** Urban Development Institute.

**Upland Area:** All land areas that are not riparian areas or waterbodies.<sup>24</sup>

**Water Body:** Means any location where water flows or is present, whether or not the flow or the presence of water is continuous, intermittent or occurs only during a flood, and includes but is not limited to wetlands and aquifers.<sup>25</sup>

**Water Management Plan:** A document developed under the Water Act that provides broad guidance regarding water conservation and management, sets clear and strategic directions regarding how water should be managed, or results in specified actions. *Alberta's Framework for Water Management Planning* outlines the process for water management planning and the components required for water management plans. The process applies to all water bodies in Alberta, including streams, rivers, lakes, aquifers, and wetlands. The plans may be considered by a Director when making licence and approval decisions. An Approved Water Management Plan must be considered by a Director when making licence and approval decisions.<sup>26</sup>

**Watershed Management Plan:** A comprehensive document that addresses many issues in a watershed including water quantity, water quality, point and non-point-source pollution, and source water protection. It may or may not include a Water Management Plan. It may also examine ways to better integrate land and resource management within a watershed.<sup>27</sup>

**Watershed:** An area of land that catches precipitation and drains it to a specific point such as a marsh, lake, stream or river. A watershed can be made up of a number of sub-watersheds that contribute to the overall drainage of the watershed.<sup>28</sup>

**Wetland:** Land that is saturated with water long enough to promote wetland or aquatic processes as indicated by poorly drained soils, water-loving or tolerant vegetation, and various kinds of biological activity which are adapted to a wet environment.<sup>29</sup>

**White Zone (White Area):** Where agriculture is the dominant land use activity.<sup>30</sup>

**WSG:** Watershed Stewardship Groups are community-based groups made up of volunteer citizens, often supported by local businesses and industries, who have taken the initiative to protect their local creek, stream, stretch of river or lake. These proactive groups develop on-the-ground solutions to ensure the protection of their specific watersheds.<sup>31</sup>

**WSSC:** The Watershed Stewardship Coordinating Committee is a BRBC Committee that provides opportunities for watershed stewards to communicate with each other and collaborate on stewardship initiatives that improve the effectiveness of watershed management in the Bow River basin.

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<sup>22</sup> Environmental Management Frameworks and the Lower Athabasca Regional Plan, Facts at Your Fingertips, Government of Alberta, 2011.

<sup>23</sup> Alberta Land Stewardship Act, Statutes of Alberta, 2009.

<sup>24</sup> Bow River Basin Council Definition.

<sup>25</sup> Alberta Water Act.

<sup>26, 27</sup> Glossary of Terms Related to Water and Watershed Management in Alberta, Alberta Environment, 2008.

<sup>28</sup> South Saskatchewan River Basin Water Management Plan.

<sup>29</sup> Bow River Basin Council Definition based on version in Glossary of Terms Related to Water and Watershed Management in Alberta, Alberta Environment, 2008.

<sup>30</sup> Alberta Sustainable Resource Development.

<sup>31</sup> Glossary of Terms Related to Water and Watershed Management in Alberta, Alberta Environment, 2008.

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## 1.0 SECTION ONE: OUTCOMES

### 1.1 OUTCOMES FOR BBWMP 2012

<b>BOW BASIN SCALE OUTCOMES – Bow Basin Watershed Management Plan<sup>32</sup></b>	
General	<ul style="list-style-type: none"> <li>• A better understanding of the value, importance and functions of the Bow River Watershed.</li> <li>• A healthy resilient watershed where people, wildlife and habitat thrive.</li> <li>• Responsible tourism and recreational opportunities.</li> <li>• Recognition that a healthy economy depends on a healthy watershed.</li> <li>• Recognition that the Bow River Watershed is an area of naturally occurring extremes and that droughts, wet periods and flood events will occur. Climate variability needs to be acknowledged.</li> <li>• Recognition that there is a finite carrying capacity for the Bow River Watershed to accommodate anticipated population growth, higher intensity agriculture, and expanded activities in the area of recreation, tourism, oil &amp; gas, and forestry in the future.</li> <li>• A better understanding of the concept of ecosystem services, and the value they provide to a healthy watershed and its residents.</li> <li>• Enhanced understanding of water, land, air, and biodiversity interactions for all stakeholders.</li> </ul>
Groundwater	<ul style="list-style-type: none"> <li>• Enhanced knowledge and understanding of the interaction between surface and groundwater, including alluvial aquifers.</li> <li>• Enhanced knowledge and understanding of the quantity, quality and locations of groundwater for all stakeholders.</li> <li>• Groundwater supports base flow in surface water bodies and riparian lands, resulting in healthy aquatic ecosystems;</li> <li>• Groundwater quality is better understood, improved and supports designated and desired uses.</li> </ul>
Water Quality	<ul style="list-style-type: none"> <li>• Surface water quality is improved.               <ul style="list-style-type: none"> <li>– Maintain or enhance surface water quality (and linked alluvial aquifers) for human consumption.</li> <li>– Surface water quality that is appropriate for irrigation of crops.</li> <li>– Surface water quality that is appropriate for livestock watering.</li> <li>– Surface water quality that protects water withdrawal systems from high levels of algae and/or macrophytes.</li> <li>– Surface water quality that maintains the existing cold-water and/or cool-water aquatic functionality.</li> <li>– Surface water quality where body contact recreation is safe.</li> </ul> </li> <li>• Rivers and streams are free of “nuisance” growth of aquatic vegetation.</li> </ul>
Water Quantity	<ul style="list-style-type: none"> <li>• Recognition that high and low flow periods are essential to aquatic and riparian ecosystems.</li> <li>• Significant groundwater recharge and discharge areas are identified and protected to sustain surface and groundwater supply.</li> <li>• Alluvial aquifers and floodplains are identified and protected as shallow water reservoirs for sustaining instream flows during low flow periods.</li> <li>• Efficient water use through improved urban, rural residential, agricultural, and industrial conservation practices.</li> <li>• Appropriate instream flow needs year-round to enhance a functioning ecosystem.</li> <li>• As opportunities present, enhanced flows for recreational opportunities.</li> </ul>
Land Use	<ul style="list-style-type: none"> <li>• Lands are managed with source water protection as a high priority.</li> <li>• Hydrologically significant lands are identified, conserved and managed in order to sustain their functionality.</li> <li>• Cumulative effects management principles are applied to all land management decisions.</li> <li>• Integrated landscape management principles are applied to all land management decisions.</li> <li>• Landscapes support healthy ecosystems with an abundance of economic, aesthetic and recreational opportunities.</li> <li>• Land conserved and/or managed for multiple uses with minimal impact on water-related natural, cultural and historical assets in order to protect the ecological integrity of the area.</li> <li>• Invasive plant species are reduced, especially in riparian lands adjacent to watercourses and water bodies.</li> <li>• Restoration of indigenous upland plant communities where opportunities exist.</li> <li>• Enhanced knowledge and understanding of:               <ul style="list-style-type: none"> <li>– the spatial connectivity of structural and functional terrestrial and aquatic landscape features, inter-relationships and processes that produce ecosystem services at a regional scale;</li> <li>– ecosystem services provided by soils, vegetation and landscapes and methods to quantify the value of these ecosystems services;</li> <li>– how uplands can have direct and indirect influences on water quality and quantity.</li> </ul> </li> </ul>

<sup>32</sup> These outcomes are a combination on existing and revised outcomes from Phase One and new outcomes developed specifically for Phase Two.



## BOW BASIN SCALE OUTCOMES – Bow Basin Watershed Management Plan<sup>33</sup>

Riparian Lands	<ul style="list-style-type: none"> <li>• Existing riparian land including associated upland areas are kept intact or restored, ecologically functional, appreciated and valued.</li> <li>• Core ecological functions of healthy riparian lands are maintained (e.g., water quality protection, water storage and flood conveyance, bank stability, biodiversity, soil health, etc.).</li> <li>• Invasive plant species are reduced, especially in riparian lands adjacent to watercourses and water bodies.</li> <li>• Enhanced knowledge and understanding of:             <ul style="list-style-type: none"> <li>– the importance of the composition, structure and health of the upland area to the health of riparian lands; and,</li> <li>– the functions provided by riparian land and how to conserve and manage for those functions.</li> </ul> </li> </ul>
Wetlands	<ul style="list-style-type: none"> <li>• Impacts to existing wetlands should be avoided wherever possible.</li> <li>• Existing wetland complexes including associated upland areas and ephemeral wetlands are kept intact or restored, ecologically functional, appreciated and valued.</li> <li>• Core ecological functions of healthy wetlands are maintained (e.g., water quality protection, water storage and flood protection, biodiversity, habitat, etc.).</li> <li>• Invasive plant species are reduced, especially in riparian lands adjacent to watercourses and water bodies.</li> <li>• Enhanced knowledge and understanding of:             <ul style="list-style-type: none"> <li>– the role wetlands play in supporting healthy watersheds through water capture and storage, groundwater recharge and/or discharge, and water purification;</li> <li>– the importance of connectivity of wetlands to the continued functionality of wetlands.</li> </ul> </li> </ul>
Headwaters and Other Hydrologically Significant Areas	<ul style="list-style-type: none"> <li>• Headwaters are managed with source water protection as the highest priority.</li> <li>• Headwaters are managed to provide a continuous supply of clean water to meet the needs of the environment, and the residents of the Bow Basin and those who depend on its water, now and in the future.</li> <li>• Enhanced knowledge and understanding of the key ecosystem services provided by headwaters.</li> </ul>

<sup>32</sup> These outcomes are a combination on existing and revised outcomes from Phase One and new outcomes developed specifically for Phase Two.

## 2.0 SECTION TWO: LAND USE

### 2.1 LAND USE INDICATORS AND THRESHOLDS

INDICATOR	TRIGGERS, LIMITS AND TARGETS <sup>34</sup>	PRIORITY & TIMELINE
Percentage of Bow Basin Municipalities that have taken steps to minimize the development and redevelopment footprint	Target: 100% of Bow Basin Municipalities with guidelines, policies and/or bylaws to help ensure that the development and redevelopment footprint is minimized to the greatest extent possible.	Medium-Term by End 2015
Percentage of Bow Basin Municipalities with erosion and sediment controls for new residential and industrial construction both during and post-construction. Municipal and urban focus.	Target: 100% of Bow Basin Municipalities with erosion and sediment controls (ESC) for new residential and industrial construction. Furthermore, these agencies require erosion and sediment control training and designation for erosion and sediment control designers and inspectors.	Short-Term by End 2013
Percentage of land use decisions made by ERCB, NRCB and provincial government departments involved with land use decisions that have taken steps (where applicable) to incorporate: 1) industrial erosion and sediment controls prior to any construction of facilities; 2) low impact development strategies and methodologies; 3) performance management principles as part of the land use decision making process; and, 4) integrated land management principles.	Target: 100% of land use decisions made by ERCB, NRCB and provincial government departments involved with land use decisions that have taken steps (where applicable) to incorporate: 1) industrial erosion and sediment controls prior to any construction of facilities; 2) low impact development strategies and methodologies; 3) performance management principles as part of the land use decision making process; and, 4) integrated land management principles.	Short-Term by End 2013
Percentage of Bow Basin Municipalities with guidelines, policies and/or bylaws to limit landscape fragmentation.	Target: 100% of Bow Basin Municipalities with guidelines, policies and/or bylaws to limit landscape fragmentation through the application of access management and integrated land management principles.	Medium-Term by End 2015
Percentage of Bow Basin Municipalities using performance management principles.	Target: 100% of Bow Basin Municipalities using performance management principles (e.g., inventories, indicators, targets and thresholds) to manage the landscape and evaluate progress.	Medium-Term by End 2015
Maximum Soil Erosion Target per Year	Target: Erosion and sediment control (ESC) plans should be designed with a soil loss tolerance level of: <ul style="list-style-type: none"> <li>• 6 tonnes/hectare/year for topsoil in good condition, high organic matter, well-structured. Subsoil permeability within 60 cm of the surface is limited.</li> <li>• 2 tonnes/hectare/year for all soils contributing runoff and sediments to stream or surface water supplies; shallow soils (&lt;10 cm) over bedrock.<sup>35</sup></li> </ul> The use of low impact development strategies and technologies may further reduce the amount of sediment-laden runoff.	Short-Term by End 2013
Sediment Transported to Water Bodies	Target: A reduction in sediment being transported to waterbodies by 2017 based on 2010 baseline levels (with the understanding that this comparison would only be applicable during relatively normal years (i.e., no significant floods or droughts during the defined year)). The reduction would be based on the best available data for the lower Bow River Basin from Calgary to the mouth. More modeling to confirm a reasonable and achievable percentage to be identified by future modeling efforts. All modeling must be suitably "ground-truthed" or calibrated with monitoring data.	Long-Term by End 2017
Runoff Rate and Volume Targets	Target: 100% of Bow Basin Municipalities should develop runoff rate and volume targets for all developments based on the overall goal of trying to achieve pre-development rates and volumes entering the streams or rivers. Targets shall apply to both new development and areas subject to re-development, and may reflect staged implementation.	Medium-Term by End 2015

<sup>34</sup> Limits represent levels at which the risk of adverse effects on environmental quality is becoming unacceptable. Triggers are set in advance of limits as early warning signals. Limits and triggers consider current science, and are meaningful and future-focused. Targets are an indicator value that reflects a desirable environmental outcome.

<sup>35</sup> Wall, G.J., D.R. Coote, E.A., Pringle and I.J. Shelton (editors). 2002. *RUSLEFAC – Revised Universal Soil Loss Equation for Application in Canada. A Handbook for Estimating Soil Loss from Water Erosion in Canada*. Research Branch, Agriculture and Agri-Food Canada. Ottawa. Contribution No. AAFC/AAC2244E. 117 pp.

## 2.2 LAND USE STRATEGIES AND ACTIONS\*\*

NO.	TOPIC	RECOMMENDATION	PROPOSED IMPLEMENTERS	PRIORITY & TIMELINE
<b>LAND USE - PERFORMANCE MANAGEMENT</b>				
2.1	BBWMP Phase Two Implementation Committee	Formation of an implementation committee to provide assistance and advice to all proposed implementers. This will include: <ul style="list-style-type: none"> <li>• presentations on materials contained within the BBWMP (as requested);</li> <li>• providing contact names of local experts for specific topics (where available);</li> <li>• encouraging and tracking implementation progress;</li> <li>• identifying opportunities for shared responsibility and coordination of efforts;</li> <li>• providing further examples of templates and municipal land bylaw provisions on the BRBC website to assist with implementation;</li> <li>• providing incentives for good stewards (recognition, awards, etc.)</li> <li>• encouraging the development of intermunicipal bodies and intermunicipal development plans to help conserve and manage hydrologically significant areas;</li> <li>• providing an annual summary report (contingent on the level of stakeholder implementation) activities highlighting progress to date, lessons learned and next steps.</li> </ul>	BRBC	Short-Term by End 2013
2.2	Use of Performance Management Principles within Municipalities and First Nations	Develop a performance management system (e.g., inventories, indicators, targets and thresholds) to manage the landscape and evaluate progress	Bow Basin Municipalities, Bow Basin First Nations	Medium-Term by End 2015
<b>LAND USE - POLICY AND/OR BYLAWS</b>				
2.3 (Link 1.50)	Erosion and Sediment Policies and/or Bylaws – Municipal and Urban Focus	Develop erosion control and sediment management policies and/or bylaws for all new developments, and develop strategies and tools for implementing policies and bylaws. Require erosion control and training and designation for erosion and sediment control designers and inspectors.	Bow Basin Municipalities, Bow Basin First Nations	Short-Term by End 2013
2.4	Integrated Land Management Guidelines, Policies and/or Bylaws	Develop guidelines, policies and/or bylaws to limit landscape fragmentation and minimize the development and redevelopment footprint through the application of integrated land management principles. The corresponding reduction in footprint will result in benefits to wetlands, riparian areas, waterbodies and other hydrologically significant areas.	Bow Basin Municipalities, Bow Basin First Nations, GOA (ASRD)	Medium-Term by End 2015
2.5	Review of Current Land Use Bylaws	Review current land use bylaw provisions for opportunities to enhance the management of the following topics: <ul style="list-style-type: none"> <li>• Public access management and appropriate land uses for environmental reserves, natural areas, wetlands, water bodies and watercourses;</li> <li>• Use of alluvial aquifers for gravel extraction (to reduce or eliminate use of alluvial aquifers for this purpose);</li> <li>• Use of municipal lands for ATV or OHV recreational use (to minimize sedimentation and negative impacts to waterbodies);</li> <li>• Storm drainage treatment facilities (to minimize contaminants and sediments from entering waterbodies).</li> </ul>	Bow Basin Municipalities, Bow Basin First Nations	Short-Term by End 2013
2.6	Gravel Extraction	Recommend and support implementation of the new aggregate policies. The loss of ecosystem services that occurs when alluvial structures are mined for their gravel and sand, then replaced or built up with disturbed overburden or fill results in significant long-term negative impacts that must be addressed.	GOA (AEW*, ASRD)	Short-Term by End 2013

\*\*It is the expectation that if these strategies and actions are implemented, the majority of the desired outcomes will be achieved over time.

**TABLE NOTES:** The highest priority recommendations are highlighted in blue under topic. Where applicable, the lead agency or jurisdiction is highlighted in blue under proposed implementers. Topics with asterisk are projects that are either in progress or are planned subject to budgetary approval. Topics that have been italicized are topics that have been carried over from Phase One.

NO.	TOPIC	RECOMMENDATION	PROPOSED IMPLEMENTERS	PRIORITY & TIMELINE
<b>LAND USE - PLANNING</b>				
2.7	Coordinated Land Use Decision Making	Enhance the process of coordinating land use decisions to better reflect shared local community values as expressed in municipal development plans and land use bylaws. Intermunicipal development plans should be considered for transboundary issues such as wetland complexes and riparian lands.	Bow Basin Municipalities, Bow Basin First Nations, GOA (ERCB, NRCB)	Short-Term by End 2013
2.8	Support to Watershed Stewardship Groups	Provide ongoing support to local Watershed Stewardship Groups through programs, funding, in-kind and technical support, policy development, etc. This will be instrumental towards implementing BBWMP recommendations and achieving desired outcomes.	GOA, BRBC, Cows and Fish, Bow Basin Municipalities, Bow Basin First Nations	Medium-Term by End 2015
2.9	Water Stewardship Group Initiatives	<ul style="list-style-type: none"> <li>Identify and better manage (for the health and function of the watershed) wetland and riparian lands</li> <li>Identify and restore degraded wetland and riparian land complexes;</li> <li>Educate membership and others of the importance of headwaters, wetlands and riparian lands, aquifers, springs and seeps</li> <li>Host workshops and projects, pilot programs for low impact development, bioengineering, natureescaping, etc.;</li> <li>Share created or combined research and/or knowledge with WPACs, municipalities, First Nations, other WSGs and AWC;</li> <li>Regularly update their respective websites and materials to demonstrate state of the art technology or advice for release to members and others.</li> </ul>	WSG	Medium-Term by End 2015
2.10	Use of Off-Highway Recreational Vehicles Outside of Designated Trails <sup>36</sup>	Work with land managers (GOA in Green Zone and Municipal Governments in White Zone), to continue dialogue with OHV User Associations regarding water-related negative impacts from OHV use outside of designated trails, to develop a series of next steps.	GOA (ASRD, ATPR), Bow Basin Municipalities, BRBC, OHV User Associations	Short-Term by End 2013
2.11	Formalized Off-Highway Vehicle Trail Systems	Develop more formalized, sustainable off-highway vehicle trail systems within the Ghost and McLean areas with proper water crossings, staging and camping facilities (while limiting negative impacts on the landscape and water quality).	GOA (ATPR*, ASRD*)	Long-Term by End 2017
2.12	Review of Municipal Development Plans and Areas Structure Plans	Ensure SRD's process and timelines for reviewing Municipal Development Plans and Area Structure Plans that contain significant wetland complexes, headwaters, alluvia aquifers, etc. are known to those that are submitting the plans.	GOA (ASRD)	Short-Term by End 2013
2.13	Process for Claiming Bed and Shore	Communicate SRD processes for claiming the bed and shores of permanent and naturally occurring wetlands, subject to the Public Lands Act.	GOA (ASRD), Bow Basin Municipalities	Short-Term by End 2013
2.14	Flood Hazard Management	Incorporate AEW approved Flood Hazard Mapping into municipal land use bylaws to limit development in flood prone areas. The addition of additional land to enable meander belts to move over the landscapes over time should be considered.	Bow Basin Municipalities, Bow Basin First Nations	Medium-Term by End 2015
2.15	Land Trusts and the BRBC	Establish a formal working partnership between land trusts operating in the Bow Basin and the BRBC. This should help clarify roles and relationships, and identify opportunities for mutual cooperation and sharing of information.	Western Sky Land Trust, BRBC, Southern Alberta Land Trust Society, Foothills Land Trust, Nature Conservancy of Canada	Short-Term by End 2013
<b>LAND USE - BEST MANAGEMENT PRACTICES</b>				
2.16 (Link 1.48)	<i>Low Impact Development Best Management Practices</i>	Incorporate low impact development best management practices and performance monitoring into the design of new residential, commercial and industrial developments. The goal is to achieve pre-development flow rates and volume, and to help meet water quality objectives. Pilot projects should be encouraged.	Bow Basin Municipalities, Bow Basin First Nations, Landowners, ALIDP, GOA (ERCB, NRCB)	Medium-Term by 2013
2.17 (Link 1.54)	<i>Soil Erosion Along Trails and Recreation Sites</i>	Continue efforts to reduce erosion from trails, recreation sites or other activities. Erosion and sediment control plans should be developed and implemented for construction sites with any connection to surface water.	GOA (ATPR*, ASRD), GWAS	Short-Term by End 2013

<sup>36</sup> This recommendation is also included in the riparian land section.

NO.	TOPIC	RECOMMENDATION	PROPOSED IMPLEMENTERS	PRIORITY & TIMELINE
<b>LAND USE - KNOWLEDGE</b>				
2.18	<a href="#">Bow Basin Sample Guidelines, Policies, Bylaws Warehouse</a>	Provide and maintain a warehouse of sample guidelines, policies and bylaws and maps related to the improvement of watershed health. The site should be located on the BRBC website with access to all BRBC members.	Bow Basin Municipalities, Bow Basin First Nations, GOA (AEW, ASRD, ATPR, AARD), WSG, (GOC) DFO, BRBC, Alberta Water Portal	Short-Term by End 2013
2.19 (Link 1.52)	<a href="#">Runoff and Soil Erosion in Forested Areas</a>	Continue to apply forestry legislation, policies and operating ground rules in the prevention of erosion and sediment entering watercourses and waterbodies resulting from logging, reforestation and reclamation operations. The Spray Lake Sawmills/C5 FMU Operating Ground Rules are reviewed annually for possible changes supported by new legislation and policies, best management practices or recommendations from applied research.	GOA (ASRD)	Ongoing
2.20 (Link 1.51)	<a href="#">Run-off Rates and Volumes</a>	Develop runoff rate and volume targets for all developments based on the overall goal of trying to achieve pre-development rates and volumes entering the streams or rivers.	Bow Basin Municipalities, Bow Basin First Nations	Short-Term by End 2013
2.21	<a href="#">Septic Sludge Management</a>	Further research is required to determine the impacts from land spreading of septic waste sludge.	Research Institutions	Medium-Term by End 2015
2.22	<a href="#">Model-predicted Soil Erosion Rates</a>	Identify areas with high erosion rates to determine where existing or proposed land use will likely impact water quality and quantity.	GOA (AEW, ASRD, AARD, ATPR), GWAS	Medium-Term by End 2015
<b>LAND USE - EDUCATION</b>				
2.23	<a href="#">Land Use Tools and Concepts</a>	Host a workshop or series of workshops (subject to available funds) to share information and educate municipalities on key land use tools and concepts including 1) erosion and sediment control, 2) performance management principles 3) integrated land management principles and 4) low impact development principles.	BRBC, Bow Basin Municipalities, Bow Basin First Nations, GOA (AEW, ASRD, ATPR, AARD)	Short-Term by End 2013
2.24	<a href="#">BBWMP Phase Two Implementation Committee</a>	Develop specific education and awareness programs and/or host educational workshops that are linked to the four themes contained in this BBWMP (i.e., land use, headwaters, wetlands and riparian lands). Priority topics include: <ul style="list-style-type: none"> <li>Alluvial Aquifers</li> <li>Ecosystem Services</li> <li>Best Management Practices (Cattle and Riparian Lands; Improvements in Off-Site Watering Technology)</li> <li>Importance of Headwaters, Riparian Lands, Wetlands and Other Hydrologically Significant Areas</li> <li>Market Based Tools and Public Education Media Tools</li> <li>Effects of Recreational Activities on Water Quality and Quantity</li> <li>Municipal and Industrial Methods for Protection of Wetland Complexes and Riparian Lands</li> </ul>	WSG, Cows and Fish, DUC, BRBC, Industry, Water Matters, GOA (AARD, AEW, ASRD, ATPR), Western Sky Land Trust, Southern Alberta Land Trust Society, Foothills Land Trust, Nature Conservancy of Canada, GOC (DFO)	Short-Term to 2013
2.25 (Link 1.48)	<a href="#">Low Impact Development</a>	Take a lead role in helping educate municipalities and developers on the basic principles of low impact development and encourage developers to utilize these practices in the overall design.	ALIDP, Bow Basin Municipalities, Bow Basin First Nations, UDI	Short-Term by End 2013
2.26 (Link 1.46)	<a href="#">Manure Applications and Setbacks</a>	Continue to educate producers on manure application and setback distances with respect to water bodies as outlined by the Agriculture Operations Practices Act.	GOA (AARD*, NRCB), Bow Basin Municipalities, Cows and Fish, AEPA	Ongoing
<b>LAND USE - RESEARCH</b>				
2.27	<a href="#">Linear Disturbance Thresholds</a>	Further research is required to determine linear disturbance thresholds for all sub-basins within the Bow Basin. This would be particularly effective if done at the sub-basin watershed scale. This research should identify the sub-basins and/or municipalities for priority implementation. The width of buffers along the linear disturbance should be clearly defined as part of this research.	Research Institutions, WSG, GWAS, GOA (ASRD)	Long-Term by End 2017
2.28	<a href="#">Manure Applications and Setbacks</a>	Research the effectiveness of different application techniques and manure management strategies to reduce runoff of nutrients and bacteria into receiving water bodies.	GOA (AARD*), Bow Basin Municipalities, Research Institutions, Cows and Fish, NRCB, AEPA	Ongoing

### 3.0 SECTION THREE: RIPARIAN LANDS

#### 3.1 RIPARIAN LANDS INDICATORS AND THRESHOLDS

INDICATOR	TRIGGERS, LIMITS AND TARGETS <sup>37</sup>	PRIORITY & TIMELINE
Area of functioning riparian lands	Target: No net loss of area of functioning riparian lands. This target “may” be achieved through 1) avoidance of negative impacts, 2) the development of new policies and bylaws, 3) the application of best management practices (e.g., fencing and off-stream watering allowing some riparian areas to recover), and 4) through restoration of degraded riparian lands (with the understanding that restored riparian lands will take substantial time to recover their original function) and 5) changes to river management (i.e., flow changes). Other tools may also be used.	Long-Term by End 2017
Restoration of riparian lands identified as degraded as a result of human activity	Target: Riparian lands identified as degraded have a plan in place to address the recovery or restoration of riparian function. This target for restoration can be captured by the indicators immediately above and below.	Medium-Term by End 2015
Condition of riparian land health as indicated using the <i>Cows and Fish Riparian Health Inventory Rating System</i> or alternative methodologies	Target: Riparian land health is 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”. See table below. Alternative methodologies could include aerial surveys, float evaluations, etc.). The chosen method of evaluation should be carefully considered depending on the location and characteristics of the area (e.g., rural versus urban).	Very Long-Term by 2030
Percentage of Bow Basin Municipalities with riparian conservation and setback guidelines and/or policies for future development and redevelopment	Target: 100% of Bow Basin Municipalities with riparian conservation, restoration and management guidelines, policies and/or bylaws for future development and redevelopment based on no further loss or impairment of riparian lands.	Short-Term by End 2013

#### THEORETICAL EXAMPLE OF RIPARIAN HEALTH STATUS OF SAMPLED SITES DURING IDENTIFIED TIME PERIODS

RIPARIAN HEALTH CATEGORY	2001-2005	2006-2010	2011-2015
Healthy	36% (4/11)	36% (5/14)	38% (5/13)
Healthy with Problems	36% (4/11)	43% (6/14)	46% (6/13)
Unhealthy	27% (3/11)	21% (3/14)	15% (2/13)

<sup>37</sup> Limits represent levels at which the risk of adverse effects on environmental quality is becoming unacceptable. Triggers are set in advance of limits as early warning signals. Limits and triggers consider current science, and are meaningful and future-focused. Targets are an indicator value that reflects a desirable environmental outcome.

### 3.2 RIPARIAN LANDS STRATEGIES AND ACTIONS\*\*

NO.	TOPIC	RECOMMENDATION	PROPOSED IMPLEMENTERS	PRIORITY & TIMELINE
<b>RIPARIAN LANDS - POLICY AND/OR BYLAWS</b>				
2.29	Healthy Riparian Lands for Municipal and Urban Areas	Develop riparian conservation and management policies and/or bylaws based on no further loss of area of functioning riparian lands, and develop strategies and tools for measuring and implementing no net loss within municipal boundaries. These tools should address access to riparian lands and management of inappropriate uses (e.g., zoning could be considered). Municipal and urban examples provided.	Bow Basin Municipalities, Bow Basin First Nations	Short-Term by End 2013
2.30	Healthy Riparian Lands for Agricultural Areas	In consultation with landowners, develop riparian conservation, restoration and management strategies, tools, guidelines, policies and/or bylaws based on no further loss of area of functioning riparian lands or functional impairment of riparian lands. Agricultural areas examples provided.	Bow Basin Municipalities, Bow Basin First Nations	Medium-Term by End-2015
2.31	Healthy Riparian Lands for Recreational Use	Develop riparian conservation and management guidelines and/or policies for recreational use in riparian areas.	Bow Basin Municipalities, Bow Basin First Nations, GOA (ASRD), Cows and Fish, WSG	Short-Term by End 2013
2.32	"Stepping Back from the Water" Document	Release the publication. This will assist municipalities in developing riparian conservation and management guidelines, policies and/or bylaws with an emphasis on determining development setbacks.	GOA (AEW)	Short-Term by End 2012
2.33	Provincial Riparian Policy Options and Tools	Develop various policy options and tools (e.g., standardized provincial riparian conservation and setback guideline and/or policies) as part of the Riparian Lands Conservation and Management Project.	Alberta Water Council	Short-Term by End 2012
<b>RIPARIAN LANDS - PLANNING</b>				
2.34	Use of Off-Highway Recreational Vehicles Outside of Designated Trails <sup>38</sup>	Working with land managers (SRD on public land in the Green and White Zones, and Municipal Government on other lands in the White Zone) BRBC will help initiate dialogue with OHV User Associations in the Bow Basin regarding water-related negative impacts as a result of OHV use outside of designated trails. This initial dialogue should result in a series of next steps.	GOA (ASRD, ATPR), Bow Basin Municipalities BRBC, OHV User Associations, Western Sky Land Trust, Southern Alberta Land Trust Society, Foothills Land Trust,	Short-Term by End 2013
2.35	Land Trusts and Riparian Conservation	Land trusts should continue to work with the BRBC, landowners and other key stakeholders to help conserve and protect significant riparian and wetland areas.	Nature Conservancy of Canada	Short-Term by End 2013
<b>RIPARIAN LANDS - BEST MANAGEMENT PRACTICES</b>				
2.36	Wetland and Riparian Lands Best Management Practices <sup>39</sup>	Apply best management practices for all wetlands and riparian lands (e.g., targeted access points, alternative grazing management systems such as rotational grazing, apply buffers around wetlands and riparian areas, etc.).	Bow Basin Municipalities, Bow Basin First Nations, Landowners, Industry	Short-Term by End 2013

\*\*It is the expectation that if these strategies and actions are implemented, the majority of the desired outcomes will be achieved over time.  
**TABLE NOTES:** The highest priority recommendations are highlighted in blue under topic. Where applicable, the lead agency or jurisdiction is highlighted in blue under proposed implementers. Topics with asterisk are projects that are either in progress or are planned subject to budgetary approval. Topics that have been italicized are topics that have been carried over from Phase One.

<sup>38</sup> This recommendation is also included in the land use section.

<sup>39</sup> This recommendation is also included in the wetlands section.

NO.	TOPIC	RECOMMENDATION	PROPOSED IMPLEMENTERS	PRIORITY & TIMELINE
<b>RIPARIAN LANDS - KNOWLEDGE</b>				
2.37	Cow and Fish Riparian Health Inventory Results for the Bow Basin	Prepare a summary of all available public Cows and Fish data for the Bow Basin. This summary should be completed in advance of the workshop below. This summary should be updated on a regular basis.	BRBC, Cows and Fish	Short-Term by End 2013
2.38	Priority Wetland and Riparian Areas in the Bow Basin Workshops <sup>40</sup>	<p>Host a workshop (or workshops) of experts and key stakeholders to:</p> <ul style="list-style-type: none"> <li>• identify high priority areas for future wetland and riparian inventories in the Bow Basin;</li> <li>• with the information available, develop a strategy to identify all “significant wetland and riparian lands and/or complexes” in the Bow Basin.</li> <li>• determine if further management actions are required (in addition to those contained herein).</li> </ul> <p>This information should be made available on the BRBC website for municipalities and other decision makers as an information and decision support tool. A list of clearly defined action items and next steps should result from these workshops. The inventory should be kept up-to-date as new information become available.</p>	BRBC, GOA (ASRD, AEW, AARD), Bow Basin Municipalities, Bow Basin First Nations, DUC, Cows and Fish, WSG	Short-Term by End 2013, Medium-Term by End 2015 to Complete
2.39	Scientific Tools for Delineating Riparian Areas	Develop scientifically established tools to help delineate extent of riparian lands adjacent to watercourses and water bodies, including wetlands and alluvial aquifers, to sustain water quantity and water quality.	AWRI*	Short-Term by End 2013
<b>RIPARIAN LANDS - EDUCATION</b>				
2.40	Wetland and Riparian Management Tools Workshop <sup>41</sup>	Host a workshop of experts and key stakeholders to raise awareness of existing wetland and riparian conservation and management tools (e.g., existing policies, tradable credits, incentives, disincentives, direct methods, indirect methods, financial methods, social methods, guidelines, policies, bylaws, zoning regulations, land use overlays, etc.). A list of clearly defined action items and next steps should result from this workshop.	GOA (ASRD, AEW, AARD), Bow Basin Municipalities, Bow Basin First Nations, BRBC, Cows and Fish, DUC, WSG	Medium-Term by End 2015
2.41 (Link 1.47)	<i>Livestock Management in Floodplains and Riparian Lands</i>	Encourage landowners to implement grazing strategies (e.g., fencing, off-site watering, rotational grazing to avoid seasonal wet areas) to reduce the degree and impact of livestock grazing on riparian habitat and flood plains along rivers and creeks (for grasslands, forested areas and protected areas). Wintering site management strategies should be developed as part of this overall strategy.	Cows and Fish, Landowners, GOA (ASRD, AARD) Alberta Environmental Farm Plan Company, Bow Basin Municipalities, WSG, Bow Basin First Nations, AEPA	Ongoing
2.42	Wetlands and Riparian Areas Educational Programming and Information	Enhance the riparian area component of the wetlands school curriculum and public programming Also provide a range of opportunities for the general public to learn about the value of and stresses to riparian areas through various information sources (e.g. signage) and social media.	BRBC, Cows and Fish, Bow Basin Municipalities, Bow Basin First Nations, GOA, WSG, DUC	Short-Term by End 2013

<sup>40</sup> This recommendation is also included in the wetlands section.

<sup>41</sup> This recommendation is also included in the wetlands section.



## 4.0 SECTION FOUR: WETLANDS

### 4.1 WETLANDS INDICATORS AND THRESHOLDS

INDICATOR	TRIGGERS, LIMITS AND TARGETS <sup>42</sup>	PRIORITY & TIMELINE
Net loss of wetland area.	Limit: No further net loss of wetland area. This can be achieved using existing tools (e.g., avoidance of negative impacts, guidelines, policies, best management practices, compensation through restoration of wetlands, etc.).	Short-Term by End 2013
Net loss of wetland number and diversity.	Target: No net loss of wetland number and diversity. Cumulatively, multiple wetlands on the landscape provide greater benefit and function than fewer, larger wetlands. The diversity of wetland types also need to be maintained.	Short-Term by End 2013
Percentage of Bow Basin Municipalities with wetland conservation, restoration and management guidelines, policies and/or bylaws based on no further loss of wetland areas.	Target: 100% of Bow Basin Municipalities with wetland conservation, restoration and management guidelines, policies and/or bylaws based on no further loss of wetland areas.	Short-Term by End 2013

### 4.2 WETLANDS STRATEGIES AND ACTIONS\*\*

NO.	TOPIC	RECOMMENDATION	PROPOSED IMPLEMENTERS	PRIORITY & TIMELINE
<b>WETLANDS - POLICY AND/OR BYLAWS</b>				
2.43	Wetland Conservation Guidelines for Municipal and Urban Areas	Develop wetland conservation and management policies and/or bylaws based on no further loss of wetland areas, and develop strategies and tools for measuring and implementing no net loss within municipal boundaries. <sup>43</sup> Municipal examples provided.	Bow Basin Municipalities, Bow Basin First Nations	Medium to Long-Term by 2015 or beyond
2.44	Wetland Conservation and Management Guidelines for Agricultural Areas	In consultation with landowners, develop wetland conservation, restoration and management guidelines, policies and/or bylaws based on no further loss of wetland areas, and develop strategies and tools for measuring and implementing no net loss within agricultural areas.	Bow Basin Municipalities, Bow Basin First Nations	Medium-Term by End 2015
2.45	Provincial Wetland Policy	Finalize and release a provincial wetland policy. For the Bow Basin, the BRBC recommends that this policy should be based on the concept of no net loss of wetland area.	GOA	Short-Term by End 2013

<sup>42</sup> Limits represent levels at which the risk of adverse effects on environmental quality is becoming unacceptable. Triggers are set in advance of limits as early warning signals. Limits and triggers consider current science, and are meaningful and future-focused. Targets are an indicator value that reflects a desirable environmental outcome.

\*\*It is the expectation that if these strategies and actions are implemented, the majority of the desired outcomes will be achieved over time. **STRATEGIES AND ACTIONS TABLE NOTES:** The highest priority recommendations are highlighted in blue under topic. Where applicable, the lead agency or jurisdiction is highlighted in blue under proposed implementers. Topics with asterisk are projects that are either in progress or are planned subject to budgetary approval. Topics that have been italicized are topics that have been carried over from Phase One.

<sup>43</sup> In Alberta, the Wetland Management in the Settled Area of Alberta: An Interim Policy (1993) and the Provincial Wetland Restoration / Compensation Guide (2007) remain current.

NO.	TOPIC	RECOMMENDATION	PROPOSED IMPLEMENTERS	PRIORITY & TIMELINE
<b>WETLANDS - PLANNING</b>				
2.46	Priority Wetland and Riparian Areas in the Bow Basin Workshops <sup>44</sup>	Host a workshop (or workshops) of experts and key stakeholders to: <ul style="list-style-type: none"> <li>• identify high priority areas for future wetland and riparian inventories in the Bow Basin;</li> <li>• with the information available, develop a strategy to identify all “significant wetland and riparian lands and/or complexes” in the Bow Basin.</li> <li>• determine if further management actions are required (in addition to those contained herein).</li> </ul> This information should be made available on the BRBC website for municipalities and other decision makers as an information and decision support tool. A list of clearly defined action items and next steps should result from these workshops. The inventory should be kept up-to-date as new information become available.	BRBC, DUC, Cows and Fish, GOA ( ASRD, AEW, AARD), Bow Basin Municipalities, Bow Basin First Nations, WSG	Short-Term by End 2013, Medium-Term by End 2015 to Complete
2.47	Wetland Restoration	Continue with efforts to restore and/or reclaim lost and/or degraded wetlands.	DUC, GOA (AEW) Western Sky Land Trust, Southern Alberta Land Trust Society, Foothills Land Trust	Short-Term by End 2013
2.48	Land Trusts and Wetlands Conservation	Land trusts should continue to work with landowners and other key stakeholders to help conserve and protect significant riparian and wetland areas.	Nature Conservancy of Canada	Short-Term by End 2013
<b>WETLANDS - BEST MANAGEMENT PRACTICES</b>				
2.49	Wetland and Riparian Lands Best Management Practices <sup>45</sup>	Apply best management practices for all wetlands and riparian lands (e.g., targeted access points, alternative grazing management systems such as rotational grazing, apply buffers around wetlands and riparian areas, etc.).	Bow Basin Municipalities, Bow Basin First Nations, Landowners, Industry, AEPA	Short-Term by End 2013
<b>WETLANDS - KNOWLEDGE</b>				
2.50	Alberta Wetland Classification System	Finalize and release a single wetland classification system to be used throughout Alberta.	GOA	Short-Term by End 2013
<b>WETLANDS - EDUCATION</b>				
2.51	Wetland and Riparian Management Tools Workshop <sup>46</sup>	Host a workshop of experts and key stakeholders to raise awareness of existing wetland and riparian conservation and management tools (e.g., existing policies, tradable credits, incentives, disincentives, direct methods, indirect methods, financial methods, social methods, guidelines, policies, bylaws, zoning regulations, land use overlays, etc.). A list of clearly defined action items and next steps should result from this workshop.	BRBC, Cows and Fish, DUC, GOA, Bow Basin Municipalities, Bow Basin First Nations, WSG	Short-Term by End 2013 Short-Term by End 2013
2.52	Wetland Education	Develop an education strategy to specifically target the loss of wetlands in agricultural areas.	DUC, BRBC, GOA	
<b>WETLANDS - KNOWLEDGE</b>				
2.53 (Link 1.61)	Wetland Function Research	Further research into wetland function including investigating groundwater recharge and surface water quantity relationships in wetland function.	DUC*, AEW, University of Calgary	Medium-Term by End 2015

<sup>44</sup> This recommendation is also included in the riparian lands section.

<sup>45</sup> This recommendation is also included in the riparian lands section.

<sup>46</sup> This recommendation is also included in the riparian lands section.

## 5.0 SECTION FIVE: HEADWATERS AND OTHER HYDROLOGICALLY SIGNIFICANT AREAS

### 5.1 HEADWATERS AND OTHER HYDROLOGICALLY SIGNIFICANT AREAS INDICATORS AND THRESHOLDS

INDICATOR	TRIGGERS, LIMITS AND TARGETS <sup>47</sup>	PRIORITY & TIMELINE
Percentage of Bow Basin Municipalities that have prepared an inventory of all hydrologically significant areas and areas of high biodiversity / species intactness within the organization's jurisdiction	Target: 100% of Bow Basin Municipalities have prepared an inventory of all hydrologically significant areas (e.g., critical recharge areas, alluvial aquifers, riparian lands, floodplains, wetlands, groundwater resources, etc.) and areas of high biodiversity / species intactness within the organization's jurisdiction.	Medium-Term by End 2015
Percentage of Bow Basin Municipalities that have taken steps to avoid hydrologically significant areas and areas of high biodiversity / species intactness.	Target: 100% of Bow Basin Municipalities with guidelines, policies or bylaws to help ensure that identified hydrologically significant areas and areas of high biodiversity are avoided during development and redevelopment.	Medium-Term by End 2015

### 5.2 HEADWATERS AND OTHER HYDROLOGICALLY SIGNIFICANT AREAS STRATEGIES AND ACTIONS\*\*

NO.	TOPIC	RECOMMENDATION	PROPOSED IMPLEMENTERS	PRIORITY & TIMELINE
<b>HEADWATERS AND OTHER HYDROLOGICALLY SIGNIFICANT AREAS - POLICY AND/OR BYLAWS</b>				
2.54	Conservation of Hydrologically Significant Areas and Areas of High Biodiversity	Develop a process to identify and better manage (for the health and function of the watershed) all hydrologically significant areas (e.g., critical recharge areas, alluvial aquifers, etc.) and areas of high biodiversity within the organization's jurisdiction. Potential methods include 1) avoidance of areas through regional planning and/or zoning and 2) clarifying appropriate land uses within hydrologically significant areas.	GOA, GOC (Parks Canada), Bow Basin Municipalities, Bow Basin First Nations, Bow Basin	Medium-Term by End 2015
2.55	Land Use Districts	Create land use districts and accompanying land use bylaws to manage permitted uses within hydrologically significant areas.	Municipalities, Bow Basin First Nations	Medium-Term by End 2015
<b>HEADWATERS AND OTHER HYDROLOGICALLY SIGNIFICANT AREAS - PLANNING</b>				
2.56	Water Stewardship Group Initiatives	Identification of strategies to help identify and better manage (for the health and function of the watershed) hydrologically significant areas that are particularly vulnerable to land-use impacts (e.g., alluvial aquifers, recharge zones, groundwater zones susceptible to contamination, wetland complexes, riparian lands).	WSG, Bow Basin Municipalities, Bow Basin First Nations	Short-Term by End 2013

<sup>47</sup> Limits represent levels at which the risk of adverse effects on environmental quality is becoming unacceptable. Triggers are set in advance of limits as early warning signals. Limits and triggers consider current science, and are meaningful and future-focused. Targets are an indicator value that reflects a desirable environmental outcome.

\*\*It is the expectation that if these strategies and actions are implemented, the majority of the desired outcomes will be achieved over time. **STRATEGIES AND ACTIONS TABLE NOTES:** The highest priority recommendations are highlighted in blue under topic. Where applicable, the lead agency or jurisdiction is highlighted in blue under proposed implementers. Topics with asterisk are projects that are either in progress or are planned subject to budgetary approval. Topics that have been italicized are topics that have been carried over from Phase One.

NO.	TOPIC	RECOMMENDATION	PROPOSED IMPLEMENTERS	PRIORITY & TIMELINE
<b>HEADWATERS AND OTHER HYDROLOGICALLY SIGNIFICANT AREAS - KNOWLEDGE</b>				
2.57	Inventory of Hydrologically Significant Areas and Areas of High Biodiversity	Establish criteria for defining hydrologically significant areas, and help achieve a constant approach in the inventory process. Prepare a publicly accessible inventory (database and maps) of all hydrologically significant areas (e.g., critical recharge areas, alluvial aquifers, riparian lands, floodplains, wetlands, groundwater resources, etc.) and areas of high biodiversity within the organization's jurisdiction. This inventory should clearly highlight areas that are priority areas for conservation or enhanced management due to their functional significance.	GOA (AEW*, ASRD, AARD, ATPR), Bow Basin Municipalities, Bow Basin First Nations	Short-Term by End 2013
2.58	Provincial Aquatic Environmentally Significant Areas	Continue the development of a provincial aquatic environmentally significant areas map based on criteria provided by the Alberta Water Council. Detailed basin-specific maps should be provided to all WPACs.	GOA (AEW*, ASRD, AARD, ATPR)	Short-Term by End 2013
2.59 (Link 1.56)	<i>Alluvial Aquifers</i>	Land use (e.g., development) on alluvial aquifers has the potential to affect both groundwater and surface water quality and quantity. River connected alluvial aquifers should be mapped and included on maps as areas where groundwater protection should be considered. Ideally, alluvial aquifers should be zoned as groundwater protection areas, and limited to land uses that are protective of groundwater (and hence surface water) quality.	GOA, GOC (Parks Canada), Bow Basin Municipalities, Bow Basin First Nations,	Short-Term by End 2013
2.60 (Link 1.25)	<i>Headwater Runoff Modeling</i>	Evaluate the potential landcover scenarios in the headwaters of the Bow Basin using existing runoff models in response to different levels of forest disturbance (e.g. forestry, fire and mountain pine beetle). Investigate the relative risks using more extreme flow events, changes in annual water supplies, and changes to erosion and sediment loading.	GOA (ASRD*, AEW), Alberta Water Research Institute, Research Institutes, GOC (Parks Canada)	Medium-Term by End 2015
2.61	Sedimentation from Road Construction	Continue to investigate enhanced strategies to control sedimentation from road construction.	GOA (ASRD), Spray Lakes Sawmills, Off Highway Vehicle User Groups, GWAS, GOC (Parks Canada)	Ongoing
2.62	Sedimentation from Off Highway Vehicle Use	Continue to investigate enhanced strategies to control sedimentation from off road vehicle use.	GOA (ASRD), Off Highway Vehicle User Groups, GWAS	Ongoing
2.63	Wet Areas Mapping	Complete and release the LIDAR-based wet areas mapping project results.	GOA (ASRD*)	Short-Term by End 2013
<b>HEADWATERS AND OTHER HYDROLOGICALLY SIGNIFICANT AREAS - RESEARCH</b>				
2.64	Ecosystem Services	Further research on ecosystem services for headwaters and other hydrologically significant areas is required.	Research Institutes	Long-Term by End 2017
2.65	Market-Based Tools	Further research on market based tools (e.g., tradable credits, incentives, disincentives, etc.) for headwaters and hydrologically significant areas is required.	Research Institutes	Medium-Term by End 2015
2.66	Social Science Research on Recreational Trends in the Bow Basin	Further research on anticipated recreational trends in the Bow Basin is required.	Research Institutes	Medium-Term by End 2015



Bow River Basin Council  
Calgary Water Centre  
Mail Code #414  
P.O. Box 2100 Station M  
Calgary, AB Canada T2P 2M5  
Street Address: 625 - 25<sup>th</sup> Ave S.E.

Mark Bennett, B.Sc., MPA  
Executive Director  
tel: 403.268.4596  
fax: 403.268.6906  
email: [mark.bennett@calgary.ca](mailto:mark.bennett@calgary.ca)

Mike Murray, B.Sc.  
Program Manager  
tel: 403.268.4597  
fax: 403.268.6906  
email: [mike.murray@calgary.ca](mailto:mike.murray@calgary.ca)

[www.brbc.ab.ca](http://www.brbc.ab.ca)

## SECTION 6.0: UP-DATED PHASE ONE WATER QUALITY OBJECTIVES AND INDICATORS\*\*

PROPOSED INDICATOR OR TOPIC AREA	REACH OR RIVER	WQOS, WARNING LEVELS AND TARGETS (INDICATORS WITH ONLY TARGETS ARE GREYED)	BASELINE WATER QUALITY (MEDIAN, PERCENTILES), MG/L UNLESS OTHERWISE NOTED	RATIONALE	RELATED RECOMMENDATION NUMBER IN TABLE 2, BBWMP
Attached Algae (Periphyton) Biomass – defined as chlor a	Bow River Above Park Boundary	WQO: 47 mg/m <sup>2</sup> maximum value during open water season.	Harvie Heights Fall measurements (Sept – Oct) 1999-2006      2002-2006 30                      9 (243) <sup>max</sup> (44) <sup>max</sup> (197.6) <sup>90</sup> -              (32.9) <sup>90</sup> includes data prior to treatment plant upgrades	<ul style="list-style-type: none"> <li>Objective supports the Park Canada mandate to maintain near pristine conditions in park areas.</li> <li>Objective is an experimentally derived value based on data from 1998-2006 upstream of the Banff town site (Bowman 2006). This is the value that represents the transition from good to fair rankings according to Parks Canada (Bowman 2003).</li> <li>Decline in algal growth with recent wastewater treatment upgrades.</li> <li>Objective may not be met in some locations due to recent occurrence of invasive strain of <i>Didymosphenia geminata</i>. Research recommended on reasons for its recent occurrence and growth.</li> </ul>	14, 15
Dissolved Oxygen	Bow River Above Park Boundary	WQO: CCME with protection of spawning and incubation. (CCME 1999) <ul style="list-style-type: none"> <li>9.5 mg/L for spawning and incubation</li> <li>6.5 mg/L for acute daily minimum.</li> </ul>	Year round Upstream Lake Louise 1973-2002 Monthly : 11.5 (9.5) <sup>10</sup>	<ul style="list-style-type: none"> <li>CCME provides a high-level of protection for saturated conditions.</li> </ul>	2
Macrophytes	Bow River Above Park Boundary	WQO: No macrophyte biomass that adversely affects users.	Insufficient data, rare or absent	<ul style="list-style-type: none"> <li>Numerical relationships between biomass and DO are poorly understood and need to be established. For example, higher macrophytes biomass may naturally occur in standing or slower moving water.</li> </ul>	14
Nitrate (nitrate + nitrite (as N))	Bow River Above Park Boundary	WQO: 0.13 mg/L during growing season.	Year round Harvie Heights 73-02 monthly 0.08 (0.13) <sup>90</sup>	<ul style="list-style-type: none"> <li>0.13 is based on 90<sup>th</sup> percentile from the 1983 to 2002 at the downstream monitoring station.</li> <li>Trying to maintain this reach at its current trophic state.</li> </ul>	27, 35
<i>Pathogens as indicated by E. coli</i>	<i>Bow River Above Park Boundary</i>	<i>WQO: Meet recreational guideline – no single value to exceed 400 E.coli/100 mL or &lt; 200 E. coli/100 mL (geometric mean 5 samples/30 d).</i>	<i>Insufficient data</i>	<ul style="list-style-type: none"> <li><i>E. coli objectives were not originally provided in some cases in Phase One. Where this occurred, the agreement was to use CCME Guidelines.</i></li> </ul>	5, 28
Pathogens as indicated by Total Coliforms	Bow River Above Park Boundary	WQO: Should not exceed 20,000 counts (total coliforms) per 100 mL at intake for drinking water treatment plant.	Year Round Coliforms/100 mL Harvie Heights 73-02 monthly 13 per 100 mL (310) <sup>90</sup>	<ul style="list-style-type: none"> <li>The instantaneous objective of &lt; 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).</li> <li>Protects human health by ensuring that municipal water treatment plants can remove pathogens (e.g., bacteria, protozoa, and viruses) from raw water.</li> </ul>	28

\*\*NOTE TO USER: Italicized sections indicate updates added during Phase Two.

PROPOSED INDICATOR OR TOPIC AREA	REACH OR RIVER	WQOS, WARNING LEVELS AND TARGETS (INDICATORS WITH ONLY TARGETS ARE GREYED)	BASELINE WATER QUALITY (MEDIAN, PERCENTILES), MG/L UNLESS OTHERWISE NOTED	RATIONALE	RELATED RECOMMENDATION NUMBER IN TABLE 2, BBWMP
Pathogens – Giardia	Bow River Above Park Boundary	WQO: Not set for this reach. However, Giardia is an important issue, and agencies should continue to monitor for Giardia and attempt to identify sources.	Insufficient data	<ul style="list-style-type: none"> <li>Insufficient data to make an objective, as it is not currently monitored.</li> <li>Groundwater is currently being used as the drinking water source for this reach.</li> <li>Wildlife are the prime vectors of Giardia transmission in this reach.</li> </ul>	3
Pesticides and Degradation Products	Bow River Above Park Boundary	WQO: Should not exceed the lower of: <ul style="list-style-type: none"> <li>&lt; 1/10 of federal drinking water guidelines or</li> <li>&lt; CCME guidelines for aquatic life in the river (provisional objective) (CCME 1999).</li> </ul>	Insufficient data	<ul style="list-style-type: none"> <li>Provisional objective was set as there is currently no ongoing monitoring available at this time to set an objective.</li> <li>No current use of surface water for municipal water supplies however drinking objective included to consider to protect downstream users.</li> </ul>	37, 38, 39, 41, 42
Total Ammonia	Bow River Above Park Boundary	WQO: Should not exceed CCME guideline for protection of aquatic life (CCME 1999). To apply outside mixing zone (AENV 1995).	Year Round Harvie Heights 87-02 monthly 0.011 (0.044) <sup>90</sup>	<ul style="list-style-type: none"> <li>Designed to protect aquatic life and considers the influence of both temperature and pH on the toxicity of ammonia.</li> </ul>	27, 28
Total Dissolved Phosphorus	Bow River Above Park Boundary	WQO: 0.005 mg/L TDP.	Year round Harvie Heights 73-02 monthly 0.006 (0.016) <sup>90</sup>	<ul style="list-style-type: none"> <li>Based on trying to maintain or improve the existing water quality.</li> <li>Recent (2002 – 2003) water treatment improvements have decreased TDP concentrations at Harvie Height's site to below 0.005 mg/L (Humphries pers. comm.).</li> <li>It is expected that recent treatment plant upgrades will allow this water quality objective to be met.</li> </ul>	27, 28
Total Organic Carbon	Bow River Above Park Boundary	WQO: Should not exceed 3.0 mg/L (instantaneous).	Year Round Cochrane 00-06 Monthly 0.82 (1.51) <sup>90</sup>	<ul style="list-style-type: none"> <li>Value excludes periods of snowmelt runoff, mountain runoff, and significant precipitation events.</li> <li>TOC is generally lower in these upper reaches.</li> <li>Increasing TOC levels in the source water has affected the treatment process of water at many surface water treatment plants. TOC &gt; 3 mg/L result in increased coagulant and chlorine demands, and gets worse as TOC levels get higher. (UEWG 1999).</li> <li>Total Organic Carbon objectives were not originally provided in Phase One. For the Bow River above Park Boundary, the agreement was to use the same value for Bow River below Park Boundary.</li> </ul>	
Total Phosphorus	Bow River Above Park Boundary	WQO: 0.012 mg/L TP.	Year round Harvie Heights 73-02 monthly 0.012 (0.025) <sup>90</sup>	<ul style="list-style-type: none"> <li>Based on trying to maintain or improve the existing water quality in the mountain parks to a natural state, protected under federal legislation.</li> <li>Values may be exceeded during freshet conditions.</li> <li>Recent upgrades to the WWTPs (post 2002) have improved receiving water quality.</li> </ul>	27, 28
Total Suspended Solids	Bow River Above Park Boundary	WQO: CCME (CCME 1999).	Year Round Harvie Heights 73-02 monthly 2.0 (11.2) <sup>90</sup>	<ul style="list-style-type: none"> <li>To maintain existing water quality for aquatic life.</li> </ul>	27, 52, 54

PROPOSED INDICATOR OR TOPIC AREA	REACH OR RIVER	WQO, WARNING LEVELS AND TARGETS (INDICATORS WITH ONLY TARGETS ARE GREYED)	BASELINE WATER QUALITY (MEDIAN, PERCENTILES), MG/L UNLESS OTHERWISE NOTED	RATIONALE	RELATED RECOMMENDATION NUMBER IN TABLE 2, BBWMP
Water Temperature	Bow River Above Park Boundary	WQO: Should not exceed 18°C at any time or a 7-day mean of 15°C (added)	Year Round, °C Harvie Heights 73-02 monthly 5.0 (11.0) <sup>90</sup> (16.3) <sup>max</sup>	<ul style="list-style-type: none"> <li>To protect most sensitive native fish, namely bull trout</li> <li>7-day mean based on Taylor &amp; Barton 1992.</li> </ul>	2, 27
Riparian Condition <sup>48</sup>	Bow River Above Park Boundary	TARGET: maintaining a “healthy” rating using Cows and Fish rating system.		<ul style="list-style-type: none"> <li>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”.</li> </ul>	45, 47, 49, 57, 59
Soil Erosion <sup>49</sup>	Bow River Above Park Boundary	TARGET: The 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).		<ul style="list-style-type: none"> <li>For new developments permitted within the defined boundaries, Operating Ground Rules are in place to minimize erosion and sedimentation (ASRD).</li> <li>An erosion and sediment control plan (ESC) must be developed, implemented and monitored for construction sites with any direct connection to surface water.</li> <li>An ESC plan should be prepared by a qualified professional (a professional certification that includes erosion and sediment control as a field of expertise).</li> <li>Based on methods described in Wall et al 2002.</li> </ul>	49, 50, 51
Attached Algae (Periphyton) Biomass – defined as chlor a	Bow River Below Park Boundary	WQO: 150 mg/m <sup>2</sup> maximum value during open water season	Open Water Cochrane monthly 1995-2006 21 (83) <sup>90</sup> (154.3) <sup>max</sup>	<ul style="list-style-type: none"> <li>A literature review over many regions determined that periphyton concentrations above 150 mg/m<sup>2</sup> are associated with adverse impacts on users (Welch et al 1998).</li> </ul>	15
Dissolved Oxygen	Bow River Below Park Boundary	WQO: CCME with protection of spawning and incubation (CCME 1999). <ul style="list-style-type: none"> <li>9.5 mg/L for spawning and incubation</li> <li>6.5 mg/L for acute daily minimum.</li> </ul>	Open Water Cochrane, 87-06 Monthly: 10.2 (8.9510) (7.61) <sup>min</sup>	<ul style="list-style-type: none"> <li>CCME provides a high-level of protection for saturated conditions.</li> </ul>	2, 27, 28
Macrophytes	Bow River Below Park Boundary	WQO: No macrophyte biomass that adversely affects users.	Insufficient data	<ul style="list-style-type: none"> <li>Numerical relationships between biomass and DO are poorly understood and need to be established. For example, higher macrophytes biomass may naturally occur in standing or slower moving water.</li> </ul>	14

<sup>48</sup> Healthy riparian condition filters nutrients and minimizes the runoff of sediments into receiving water bodies.

<sup>49</sup> 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.



PROPOSED INDICATOR OR TOPIC AREA	REACH OR RIVER	WQOS, WARNING LEVELS AND TARGETS (INDICATORS WITH ONLY TARGETS ARE GREYED)	BASELINE WATER QUALITY (MEDIAN, PERCENTILES), MG/L UNLESS OTHERWISE NOTED	RATIONALE	RELATED RECOMMENDATION NUMBER IN TABLE 2, BBWMP
Nitrate (nitrate + nitrite (as N))	Bow River Below Park Boundary	<ul style="list-style-type: none"> <li>WQO: 0.267 mg/L</li> <li>WARNING LEVEL: 0.163 mg/L</li> <li>WQOs, warning levels and targets for nitrate apply during the growing / open water season.</li> </ul>	Open water Cochrane 87-06 monthly 0.067 (0.112) <sup>90</sup>	<ul style="list-style-type: none"> <li>The value of 0.267 mg/L was obtained from Sosiak 2004 as the nitrate + nitrite level that corresponds to nuisance growth of periphyton in the Bow River basin.</li> <li>The warning level was developed based on the 90th percentile level for the period 1987 – 2006.</li> </ul>	27, 28
Pathogens as indicated by E. coli	Bow River Below Park Boundary	WQO: Meet recreational guideline – no single value to exceed 400 E.coli/100 mL or < 200 E. coli/100 mL (geometric mean 5 samples/30 d).	Year Round coliforms/100 mL Cochrane 94-06 monthly 1 per 100 mL (14) <sup>90</sup>	<ul style="list-style-type: none"> <li>400 E. coli/100 mL is the CCME re-sampling guideline. (CCME 1999)</li> </ul>	28
Pathogens as indicated by fecal coliforms	Bow River Below Park Boundary	WQO: Meet 100 fecal coliforms/100 mL (no single value to exceed objective) at the point of withdrawal.	Year Round Coliforms/100 mL Cochrane 91-05 monthly 2 per 100 mL (20) <sup>90</sup>	<ul style="list-style-type: none"> <li>Irrigation guidelines set by CCME. (CCME 1999)</li> <li>It is recognized, that the WQO values may be briefly exceeded for short periods of time during storm events.</li> <li>The intention though, is to maintain in-stream concentrations at or below current levels.</li> </ul>	28
Pathogens as indicated by Total Coliforms	Bow River Below Park Boundary	WQO: Should not exceed 20,000 counts (total coliforms) per 100 mL at intake for drinking water treatment plant.	Year Round Cochrane 00-06 monthly 66 per 100 mL (435) <sup>90</sup>	<ul style="list-style-type: none"> <li>The instantaneous objective of &lt; 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).</li> <li>Protects human health by ensuring that municipal water treatment plants can remove pathogens (e.g., bacteria, protozoa, and viruses) from raw water.</li> </ul>	28
Pathogens – Giardia	Bow River Below Park Boundary	WQO: Should not exceed 100 cysts per 100L (instantaneous) for the Bears paw Water Treatment Plant.	Insufficient data	<ul style="list-style-type: none"> <li>This is the level above which will require in excess of 5-log reduction at the Bears paw Water Treatment Plant (AENV 2006b).</li> <li>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.</li> </ul>	3
Pesticides and Degradation Products	Bow River Below Park Boundary	WQO: Should not exceed the lower of: <ul style="list-style-type: none"> <li>&lt; 1/10 of federal drinking water guidelines or</li> <li>&lt; CCME guidelines for aquatic life in the river (CCME 1999).</li> </ul>	Data not readily available	<ul style="list-style-type: none"> <li>Provisional objective as there is currently no ongoing monitoring available at this time to set an objective.</li> <li>Protects drinking water and aquatic ecosystems.</li> <li>&lt; 1/10 of federal drinking water guidelines used to provide a safety margin to protect against compounds for which there is no treatment.</li> </ul>	37, 38, 39, 41, 42
Total Ammonia	Bow River Below Park Boundary	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 (CCME 1999). To apply outside mixing zone (AENV 1995).	Open water Cochrane 87-06 monthly 0.010 (0.020) <sup>90</sup>	<ul style="list-style-type: none"> <li>Protects municipal water supply from unacceptable chlorine demand.</li> <li>Based on experience at Glenmore Water Treatment Plant.</li> <li>This is more restrictive than the current CCME guideline.</li> <li>Designed to protect aquatic life and takes into account the influence of both temperature and pH on the toxicity of ammonia.</li> </ul>	27, 28

PROPOSED INDICATOR OR TOPIC AREA	REACH OR RIVER	WQOS, WARNING LEVELS AND TARGETS (INDICATORS WITH ONLY TARGETS ARE GREYED)	BASELINE WATER QUALITY (MEDIAN, PERCENTILES), MG/L UNLESS OTHERWISE NOTED	RATIONALE	RELATED RECOMMENDATION NUMBER IN TABLE 2, BBWMP
Total Dissolved Phosphorus	Bow River Below Park Boundary	WQO: 0.005 mg/L TDP during the growing season for aquatic plant	Open Water Cochrane 87-06 monthly 0.002 (0.005) <sup>90</sup>	<ul style="list-style-type: none"> <li>Based on trying to maintain or improve the existing water quality.</li> <li>Objective is the 90<sup>th</sup> percentile (1987-2006) open water concentrations in the Bow River at Cochrane.</li> </ul>	27, 28
Total Organic Carbon	Bow River Below Park Boundary	WQO: Should not exceed 3.0 mg/L (instantaneous).	Year Round Cochrane 00-06 Monthly 0.82 (1.51) <sup>90</sup>	<ul style="list-style-type: none"> <li>Value excludes periods of snowmelt runoff, mountain runoff, and significant precipitation events.</li> <li>TOC is generally lower in these upper reaches.</li> <li>Increasing TOC levels in the source water has affected the treatment process of water at many surface water treatment plants. TOC &gt; 3 mg/L result in increased coagulant and chlorine demands, and gets worse as TOC levels get higher. (UEWG 1999)</li> </ul>	
Total Phosphorus	Bow River Below Park Boundary	WQO: 0.014 mg/L TP.	Open Water Cochrane 87-06 Monthly 0.004 (0.014) <sup>90</sup>	<ul style="list-style-type: none"> <li>Based on trying to maintain or improve the existing water quality.</li> <li>Objective is the 90<sup>th</sup> percentile (1987-2006) open water concentrations in the Bow River at Cochrane.</li> </ul>	27, 28
Total Suspended Solids	Bow River Below Park Boundary	WQO: CCME (CCME 1999).	Year Round Cochrane 87-06 monthly 1.0 (6.0) <sup>90</sup>	<ul style="list-style-type: none"> <li>To maintain existing water quality for aquatic life.</li> </ul>	27, 50, 52, 54
Water Temperature	Bow River Below Park Boundary	WQO: Should not exceed 22°C at any time or a 7-day mean of 18°C.	Open Water Cochrane 87-06 monthly 10.4 (15.07) <sup>90</sup> (18.02) <sup>max</sup>	<ul style="list-style-type: none"> <li>To protect most sensitive native fish, namely mountain whitefish.</li> <li>Maximum values are based on Taylor &amp; Barton 1992.</li> </ul>	2, 16, 27
Riparian Condition	Bow River Below Park Boundary	TARGET: Maintaining a “healthy” rating using Cows and Fish rating system.		<ul style="list-style-type: none"> <li>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”.</li> </ul>	45, 47, 49, 57, 59
Soil Erosion	Bow River Below Park Boundary	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).		<ul style="list-style-type: none"> <li>For new developments that are permitted within the defined boundaries, Operating Ground Rules are in place to minimize erosion and sedimentation (ASRD).</li> <li>An erosion and sediment control plan (ESC) must be developed, implemented and monitored for construction sites with any direct connection to surface water.</li> <li>An ESC plan should be prepared by a qualified professional (a professional certification that includes erosion and sediment control as a field of expertise).</li> <li>Based on methods described in Wall et al 2002.</li> </ul>	45, 48, 50, 51, 52

PROPOSED INDICATOR OR TOPIC AREA	REACH OR RIVER	WQOS, WARNING LEVELS AND TARGETS (INDICATORS WITH ONLY TARGETS ARE GREYED)	BASELINE WATER QUALITY (MEDIAN, PERCENTILES), MG/L UNLESS OTHERWISE NOTED	RATIONALE	RELATED RECOMMENDATION NUMBER IN TABLE 2, BBWMP	
Attached Algae (Periphyton) Biomass-defined as chlor a	Bow River Central	<ul style="list-style-type: none"> <li>WQO: No periphytic algal biomass that adversely affects users.</li> <li>Target: 150 mg/m<sup>2</sup> maximum value during open water season</li> </ul>	Open Water Carseland 87-98 monthly (469) <sup>90</sup> (682) <sup>max</sup>	99-06 monthly 121 (242) <sup>90</sup> (432) <sup>max</sup>	<ul style="list-style-type: none"> <li>A literature review over many regions determined that periphyton concentrations above 150 mg/m<sup>2</sup> are associated with adverse impacts on users (Welch et al 1998).</li> <li>Currently exceeded around Stier's ranch.</li> <li>Last 6 years there have been declines in periphyton biomass therefore this target was considered appropriate.</li> </ul>	14
Dissolved Oxygen	Bow River Central	<ul style="list-style-type: none"> <li>WQO: 5.0 mg/L (acute daily minimum), 6.5 chronic (7 day running average)</li> <li>WARNING LEVEL: 5.5 mg/L (acute daily minimum)</li> <li>TARGET: 6.0 mg/L (acute daily minimum), 8.0 mg/L<sup>50</sup> (acute daily minimum) for spawning and incubation from October to end of May from WID Weir to Hwy 22, 9.5 mg/L upstream of WID Weir from Oct. to end of June.</li> </ul>	Open Water Monthly Carseland 87-05: 10.1 (9.0) <sup>10</sup> (7.7) <sup>min</sup>	Hourly Above Highwood 2006: 8.49 (5.53) <sup>10</sup> (4.08) <sup>min</sup>	<ul style="list-style-type: none"> <li>5.0 mg/L is the Alberta guideline, which provides a threshold for aquatic effects and a margin of safety.</li> <li>5.5 mg/L is the warning level used for the Highwood River.</li> <li>The Calgary Total Loading Management Plan adopted a trigger value of 340 kg/day for total phosphorus (CoC 2005). It is based on maintaining the surface water quality guideline of 5.0 mg/L dissolved oxygen as a cross-sectional average across the Bow River just upstream of the confluence of the Highwood River at a frequency of compliance of 99.91%.</li> <li>8.0 mg/L is to protect brown trout spawning in this reach [5 mg/L + 3 mg/L (safety margin (CCME 1999))]</li> <li>9.5 mg/L to protect rainbow trout spawning in this reach.</li> <li>During spawning periods, there is a recognized need to have a higher level of DO in the water column to ensure 5.0 mg/L within gravel for eggs and incubation.</li> </ul>	2, 6, 7, 17, 24, 27, 28
Macrophytes	Bow River Central	WQO: No macrophyte biomass that adversely affects users.	AENV Macrophyte sites, M1-M8, g/m <sup>2</sup> 1979-1996: Median: 503 Range: 0-3897 2006: Median: 71.0 Range: 0-1273	<ul style="list-style-type: none"> <li>Numerical relationships between biomass and DO are poorly understood and need to be established. For example, higher macrophytes biomass may naturally occur in standing or slower moving water.</li> <li>Trying to relate measured macrophyte biomass in this reach to problems in irrigation district canals.</li> </ul>	14	
Nitrate (nitrate + nitrite (as N))	Bow River Central	<ul style="list-style-type: none"> <li>WQO: 1.5 mg/L</li> <li>WARNING LEVEL: Need to better understand the limiting factor for macrophytes and periphyton growth before assigning a warning limit.</li> <li>TARGET: Eliminate levels that cause nuisance aquatic plant growth.</li> <li>WQOs, warning levels and targets for nitrate apply during the growing / open water season.</li> </ul>	Open Water Carseland 87-05 monthly 0.622 (1.146) <sup>90</sup>	<ul style="list-style-type: none"> <li>WQO of 1.5 mg/L nitrate was the concentration in the City of Calgary Total Loading Management model (Golder 2007) that corresponded to 5 mg/L DO for the period April to September 30.</li> <li>Nitrate + nitrite levels will be typically well below this objective except for occasional outliers during the open water season and levels may be exceeded during the winter.</li> <li>The model assumes that some form of nitrification is occurring at the Fish Creek WWTP. This objective may need to be revisited as improvements around the WWTP occur over time and as findings from related research recommendations become available.</li> </ul>	6, 7, 24, 27, 28, 29, 31	

<sup>m</sup> Healthy riparian condition filters nutrients and minimizes the runoff of sediments into receiving water bodies.

<sup>n</sup> Erosion is caused when soil particles are dislodged by water falling on or running across bare soil or vegetated areas that are unable to handle the force of the flowing water. Receiving water bodies adjacent to eroded stream banks tend to have poor water quality after storm events.

<sup>50</sup> Based on brown trout population.

PROPOSED INDICATOR OR TOPIC AREA	REACH OR RIVER	WQOS, WARNING LEVELS AND TARGETS (INDICATORS WITH ONLY TARGETS ARE GREYED)	BASELINE WATER QUALITY (MEDIAN, PERCENTILES), MG/L UNLESS OTHERWISE NOTED	RATIONALE	RELATED RECOMMENDATION NUMBER IN TABLE 2, BBWMP
Pathogens as indicated by E. coli	Bow River Central	<ul style="list-style-type: none"> <li>WQO: Meet recreational guideline – no single value to exceed 400 E.coli per 100 mL or &lt; 200 E. coli per 100 mL (geometric mean 5 samples/30 d).</li> <li>TARGET: Meet recreational guideline of &lt; 200 E. coli per 100 mL (geometric mean 5 samples/30 d).</li> </ul>	Year Round Carseland 94-05 monthly 23 per 100 mL (205) <sup>90</sup>	<ul style="list-style-type: none"> <li>Pathogen indicator loads are significant.</li> <li>It is recognized that E. coli in the Bow Central can be above recreational guidelines following storm events.</li> <li>Further research required to establish warning level.</li> <li>E. coli objectives were not originally provided in some cases in Phase One. Where this occurred, the agreement was to use CCME Guidelines.</li> </ul>	8, 28, 32
Pathogens as indicated by fecal coliforms	Bow River Central	WQO: Meet 100 fecal coliforms per 100 mL (no single value to exceed objective) at the point of withdrawal	Year Round Carseland 87-05 monthly 91 per 100 mL (590) <sup>90</sup>	<ul style="list-style-type: none"> <li>Irrigation guidelines set by CCME (CCME 1999).</li> <li>The WQO values can be briefly exceeded for short periods of time during storm events.</li> <li>Fecal coliforms at this site have declined greatly (medians &lt; 62) since disinfection installed at both Calgary wastewater treatment plants in 1997.</li> </ul>	8, 28
Pathogens as indicated by Total Coliforms	Bow River Central	WQO: Should not exceed 20,000 counts (total coliforms) per 100 mL at intake for drinking water treatment plant.	Year Round Carseland 87-94 monthly 870 per 100 mL (2900) <sup>90</sup>	<ul style="list-style-type: none"> <li>The instantaneous objective of &lt; 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).</li> <li>Protects human health by ensuring that municipal water treatment plants can remove pathogens (e.g., bacteria, protozoa, and viruses) from raw water.</li> <li>Total coliforms are not typically monitored here.</li> </ul>	8, 28
Pathogens – Giardia	Bow River Central	WQO: Should not exceed 100 cysts per 100L (instantaneous) for the Bearspaw Water Treatment Plant.	Insufficient data	<ul style="list-style-type: none"> <li>This is the level above which will require in excess of 5-log reduction at the Bearspaw Water Treatment Plant (AENV 2006b).</li> <li>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.</li> </ul>	3, 8, 28
Pesticides and Degradation Products	Bow River Central	WQO: Should not exceed the lower of: <ul style="list-style-type: none"> <li>&lt; 1/10 of federal drinking water guidelines or</li> <li>&lt; CCME guidelines for aquatic life in the river (CCME 1999).</li> </ul>	Breakdown of data by reach not available (Anderson 2005) <sup>51</sup>	<ul style="list-style-type: none"> <li>Protects drinking water and aquatic ecosystems.</li> <li>&lt; 1/10 of federal drinking water guidelines used to provide a safety margin to protect against compounds for which there is no treatment.</li> </ul>	31, 37, 38, 39, 41, 43, 44
Total Ammonia	Bow River Central	<ul style="list-style-type: none"> <li>WQO: The lower of US EPA or 0.2 mg/L ammonia during the growing season for growth of aquatic vegetation. To apply outside mixing zone (AENV 1995).</li> <li>TARGET: CCME (CCME 1999)</li> </ul>	Open Water Carseland 87-05 monthly 0.040 (0.160) <sup>90</sup>	<ul style="list-style-type: none"> <li>0.2 mg/L total ammonia was a fully-mixed concentration in the City of Calgary Management model (Golder 2007) that corresponded to 5 mg/L DO.</li> <li>The model assumes that some form of nitrification is occurring at the Fish Creek WWTP. This objective may need to be revisited as improvements around the WWTP occur over time and as findings from related research recommendations become available.</li> <li>Objectives are based on toxicity thresholds and aquatic plant growth.</li> </ul>	7, 24, 27, 28, 31

<sup>51</sup> Over entire Bow basin, (Anderson 2005; Table 4c) found 180 of 406 samples exceeded irrigation guidelines (mainly Dicamba and MCPA), 12 of 406 samples (mainly, 2,4-D and chlorpyrifos-ethyl exceeded aquatic life guidelines, and no exceedences of guidelines for drinking water or livestock watering.

PROPOSED INDICATOR OR TOPIC AREA	REACH OR RIVER	WQO, WARNING LEVELS AND TARGETS (INDICATORS WITH ONLY TARGETS ARE GREYED)	BASELINE WATER QUALITY (MEDIAN, PERCENTILES), MG/L UNLESS OTHERWISE NOTED	RATIONALE	RELATED RECOMMENDATION NUMBER IN TABLE 2, BBWMP
Total Dissolved Phosphorus	Bow River Central	<ul style="list-style-type: none"> <li>WQO: 0.015 mg/L TDP during the growing season for aquatic plants</li> <li>Provisional objective: 0.054 mg/L for winter season</li> </ul>	<p>Open Water Carseland 83-05 monthly 0.016 mg/L (0.037)<sup>90</sup></p> <p>With Enhanced P Removal monthly 2004: 0.008 2005: 0.006</p> <p>Winter season 84-06 0.032 (0.054)<sup>90</sup></p>	<ul style="list-style-type: none"> <li>Objective based on protecting DO and nuisance aquatic plants.</li> <li>Cross-sectional average TDP concentration that maintained DO levels above 5.0 mg/L in City of Calgary Total Loading Management model (Golder 2007) using data from the April to Sept time period.</li> <li>Provisional objective is the 90<sup>th</sup> percentile based on historical data.</li> <li>Lower [TDP] have been observed with recent wastewater treatment upgrades.</li> </ul>	7, 24, 27, 28, 31
Total Organic Carbon	Bow River Central	<ul style="list-style-type: none"> <li>WQO: Should not exceed 5.0 mg/L (instantaneous)</li> <li>TARGET: Should not exceed 3.0 mg/L (instantaneous).</li> </ul>	<p>Year Round Carseland 87-05 monthly 1.90 (3.11)<sup>90</sup></p>	<ul style="list-style-type: none"> <li>Increasing TOC levels in the source water has affected the treatment process of water at many surface water treatment plans. TOC &gt; 3 mg/L result in increased coagulant and chlorine demands, and gets worse as TOC levels get higher (UEWG 1999).</li> <li>Values exclude periods of snowmelt runoff, mountain runoff, and significant precipitation events.</li> </ul>	9
Total Phosphorus	Bow River Central	<ul style="list-style-type: none"> <li>WQO: 0.028 mg/L</li> <li>TARGET: Eliminate levels that cause nuisance aquatic plant growth.</li> <li>Provisional WQO: 0.075 mg/L during winter season</li> </ul>	<p>Open Water Carseland 83-05 monthly 0.038 (0.095)<sup>90</sup></p> <p><i>Open Water Carseland 99-10 Monthly median, open water season 0.028<sup>52</sup></i></p> <p>With Enhanced P Removal monthly 2004: 0.023 2005: 0.021</p> <p>Winter season Carseland 84-06 0.052 (0.075)<sup>90</sup></p>	<ul style="list-style-type: none"> <li>Objective is based on protecting DO and the target relates to controlling the growth of aquatic plant growth. The TP objective was inferred from the TDP objective using observed TP:TDP ratios.</li> <li>Based on TLM model (Golder 2007) using an average TDP concentration during Apr. to Sept. that maintained DO above 5.0 mg/L and a TDP:TP ratio of approx. 55%.</li> <li>Although there is currently no CCME guideline for phosphorus, the Bow River water quality objective is in the middle of the “trigger range” of TP concentration (0.020-0.035 mg/L) that CCME 2004 recommends for mesotrophic rivers (those with moderate levels of productivity), above which management action and investigation is required. It is also within the range of TP levels (0.018 – 0.030 mg/L) that corresponded to nuisance growth of periphyton in studies reviewed in Sosiak 2004.</li> <li>The WQO may be exceeded during storm events due to particulate phosphorus.</li> <li>With the addition of alum treatment, concentrations have declined in the last couple of years.</li> <li>Provisional objective is the 90<sup>th</sup> percentile based on historical data</li> </ul>	7, 24, 27, 28, 31

<sup>52</sup> Wendell Koning, Personal Communication, May 10, 2011.

PROPOSED INDICATOR OR TOPIC AREA	REACH OR RIVER	WQOS, WARNING LEVELS AND TARGETS (INDICATORS WITH ONLY TARGETS ARE GREYED)	BASELINE WATER QUALITY (MEDIAN, PERCENTILES), MG/L UNLESS OTHERWISE NOTED	RATIONALE	RELATED RECOMMENDATION NUMBER IN TABLE 2, BBWMP
Total Suspended Solids	Bow River Central	<ul style="list-style-type: none"> <li>WQO: If the background<sup>53</sup> concentration is:               <ul style="list-style-type: none"> <li>&lt; 25 mg/L conditions must not exceed an SEV value of 6</li> <li>&gt; 25 mg/L conditions must not exceed an SEV value of 7- (CCME 2002, Caux et al 1997)</li> <li>&gt; 250 mg/L (CCME 2002) applies (conditions should not increase more than 10% above background levels when background is &gt; 250 mg/L)</li> </ul> </li> <li>Calculation of the SEV value must be taken from fully mixed zone.</li> <li>WARNING LEVEL: Visible plume entering river during base river flow.</li> <li>TARGET: CCME (CCME 1999), increase compliance frequency with objectives.</li> </ul>	Year Round Carseland 87-05 monthly 5.0 (26.9) <sup>90</sup>	<ul style="list-style-type: none"> <li>There are different objectives to consider natural and anthropogenic TSS variation along the river.</li> <li>When the background is less than &lt; 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.</li> <li>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.</li> <li>It is recognized that the objectives may be temporarily exceeded during spring freshet and storm events.</li> <li>Warning narrative similar to what is used by the City of Calgary.</li> </ul>	18, 27, 28, 30, 31, 33, 50, 52, 53
Water Temperature	Bow River Central	<ul style="list-style-type: none"> <li>WQO: Should not exceed 22°C at any time or 7 day mean &gt; 18°C at frequencies greater than natural exceedences.</li> <li>TARGET: See footnote at bottom of page.<sup>54</sup></li> </ul>	Open Water Carseland  87-05: Monthly 12.4 (17.1) <sup>90</sup> (20.2) <sup>max</sup>  Above Highwood  2006: hourly 17.37 (19.81) <sup>90</sup> 22.49 <sup>max</sup>	<ul style="list-style-type: none"> <li>Bow River (and tributaries) in this area contain Rainbow Trout, Mountain Whitefish, Brown Trout, Bull Trout (not common) and Cutthroat Trout (not common). Acute temperatures for Bull Trout, Cutthroat Trout and Mountain Whitefish are all 22°C, as described in Taylor and Barton, 1992. The 24°C value used from the Highwood Management plan is not suitable for widespread application in Bow River Central area.</li> <li>Temperatures above 26°C can be lethal to rainbow trout (Hokanson et al 1977).</li> <li>Need to also consider the interplay between oxygen &amp; temperature.</li> </ul>	2, 7, 17, 24, 27

<sup>53</sup> Two general approaches are considered acceptable to define background concentrations of water quality variables which involve (CCME 2002 pg20, Site-specific guidance): i) utilization of historically-collected water quality data for site (i.e., prior to the commencement of activities that could have substantially altered water quality conditions); or ii) monitoring contemporary water quality conditions at one or more stations located upstream of contaminant sources.

<sup>54</sup> Changes to the Bow Central Water Temperature Targets (see table below). Optimum Temperature Ranges (°C from Literature).

CHANGES TO THE BOW CENTRAL WATER TEMPERATURE TARGETS							
Species	Egg Incubation	Egg Incubation Timing	Fry	Juvenile	Adult	Spawning Migration	Spawning Timing
Rainbow Trout	7-12	Apr 1-Jun 15	7-12	15-20	12-18	2-16	Apr 1-Jun 15
Brown Trout	2-10	Sept 15-Mar 31	7-15	7-19	12-19	<9 (to initiate)	Sept 15-Nov 15
Mountain Whitefish	~4	Sept 15-Mar 31	~12	~12	Unavailable	~3 (<6 to initiate)	Sept 15-Nov 15

PROPOSED INDICATOR OR TOPIC AREA	REACH OR RIVER	WQOS, WARNING LEVELS AND TARGETS (INDICATORS WITH ONLY TARGETS ARE GREYED)	BASELINE WATER QUALITY (MEDIAN, PERCENTILES), MG/L UNLESS OTHERWISE NOTED	RATIONALE	RELATED RECOMMENDATION NUMBER IN TABLE 2, BBWMP
Riparian Condition	Bow River Central	TARGET: a "healthy" rating using Cows and Fish rating system		<ul style="list-style-type: none"> <li>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".</li> </ul>	45, 47, 49, 57, 59
Soil Erosion	Bow 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).		<ul style="list-style-type: none"> <li>An erosion and sediment control plan (ESC) must be developed, implemented and monitored for construction sites with any direct connection to surface water.</li> <li>An ESC plan should be prepared by a qualified professional (a professional certification that includes erosion and sediment control as a field of expertise).</li> <li>Based on methods described in Wall et al 2002.</li> </ul>	30, 31, 45, 47, 50, 51, 52
Attached Algae (Periphyton) Biomass-defined as chlor a	Bow River Lower	<ul style="list-style-type: none"> <li>WQO: No periphytic algal biomass that adversely affects users.</li> <li>Target: 150 mg/m<sup>2</sup> maximum value during open water season</li> </ul>	Open Water Ronalane 87-05 monthly 53 (109) <sup>90</sup> (493) <sup>max</sup> last exceeded 150 mg/m <sup>2</sup> in 1987	<ul style="list-style-type: none"> <li>A literature review over many regions determined that periphyton concentrations above 150 mg/m<sup>2</sup> are associated with adverse impacts on users (Welch et al 1998).</li> </ul>	14
Dissolved Oxygen	Bow River Lower	WQO 5.0 mg/L (acute daily minimum), 6.5 chronic (7 day running average)	Open Water Ronalane 87-05 monthly 10.1 (8.0) <sup>10</sup> (3.7) <sup>min</sup> 2000 hourly 8.79 (6.93) <sup>10</sup> (5.75) <sup>min</sup>	<ul style="list-style-type: none"> <li>These values support the species of concern (e.g., sturgeon) and the main sport fish (e.g. Walleye, Northern pike).</li> </ul>	2, 24, 27, 28
Macrophytes	Bow River Lower	WQO: No macrophyte biomass that adversely affects users.	Peak macrophyte biomass of 105 g/m <sup>2</sup> below Bassano Dam during 1994-97 synoptic surveys (WRS 2004)	<ul style="list-style-type: none"> <li>Numerical relationships between biomass and DO are poorly understood and need to be established. For example, higher macrophytes biomass may naturally occur in standing or slower moving water.</li> <li>Trying to relate measured macrophyte biomass in this reach to problems in irrigation district canals.</li> </ul>	14
Nitrate (nitrate + nitrite (as N))	Bow River Lower	<ul style="list-style-type: none"> <li>WQO: 1.5 mg/L</li> <li>WARNING LEVEL: Need to better understand the limiting factor for macrophytes and periphyton growth before assigning a warning limit.</li> <li>TARGET: Eliminate levels that cause nuisance aquatic plant growth.</li> <li>WQOs, warning levels and targets for nitrate apply during the growing / open water season.</li> </ul>	Open Water Ronalane 87-05 monthly 0.166 (0.596) <sup>90</sup>	<ul style="list-style-type: none"> <li>WQO of 1.5 mg/L nitrate was the concentration in the City of Calgary Total Loading Management model (Golder 2007) that corresponded to 5 mg/L DO for the period April to September 30.</li> <li>Although the City of Calgary model was not designed for this reach, it is assumed that the model's predicted limit is appropriate and it has been applied to this reach as well.</li> <li>Nitrate + nitrite levels will be typically well below this objective except for occasional outliers during the open water season and levels may be exceeded during the winter.</li> <li>The model assumes that some form of nitrification is occurring at the Fish Creek WWTP. This objective may need to be revisited as improvements around the WWTP occur over time and as findings from related research recommendations become available.</li> </ul>	24, 27, 28

PROPOSED INDICATOR OR TOPIC AREA	REACH OR RIVER	WQOS, WARNING LEVELS AND TARGETS (INDICATORS WITH ONLY TARGETS ARE GREYED)	BASELINE WATER QUALITY (MEDIAN, PERCENTILES), MG/L UNLESS OTHERWISE NOTED	RATIONALE	RELATED RECOMMENDATION NUMBER IN TABLE 2, BBWMP
Pathogens as indicated by E. coli	Bow River Lower	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 Ronlance 94-05 monthly 6 per 100 mL (43) <sup>90</sup>	<ul style="list-style-type: none"> <li>400 E. coli per 100 mL is the re-sampling guideline (CCME 1999).</li> </ul>	28
Pathogens as indicated by fecal coliforms	Bow River Lower	WQO: Meet 100 fecal coliforms per 100 mL (no single value to exceed objective) at the point of withdrawal.	Year Round Ronlance 87-05 monthly 10 per 100 mL (109) <sup>90</sup>	<ul style="list-style-type: none"> <li>Irrigation guidelines set by CCME (CCME 1999).</li> <li>The WQO values can be briefly exceeded for short periods of time during storm events.</li> </ul>	28
Pathogens as indicated by Total Coliforms	Bow River Lower	WQO: Should not exceed 20,000 counts (total coliforms) per 100 mL at intake for drinking water treatment plant.	Year Round Ronlance 87-94 monthly 66 per 100 mL (580) <sup>90</sup>	<ul style="list-style-type: none"> <li>The instantaneous objective of &lt; 20,000 counts per 100 mL is based on conventional water treatment plant's ability to remove contaminants if pre-disinfection is present (US EPA 1991).</li> <li>Protects human health by ensuring that municipal water treatment plants can remove pathogens (e.g., bacteria, protozoa, and viruses) from raw water.</li> <li>Total coliforms are not typically monitored here.</li> </ul>	28
Pathogens – Giardia	Bow River Lower	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	<ul style="list-style-type: none"> <li>Insufficient data to make recommendation. We need to first determine Giardia counts in surface water reaches that can be effectively treated by different methods.</li> <li>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.</li> </ul>	3
Pesticides and Degradation Products	Bow River Lower	WQO: Should not exceed the lower of: <ul style="list-style-type: none"> <li>&lt; 1/10 of federal drinking water guidelines or</li> <li>&lt; CCME guidelines for aquatic life in the river (CCME 1999).</li> </ul>	Breakdown of data by reach not available (Anderson 2005) <sup>55</sup>	<ul style="list-style-type: none"> <li>Protects drinking water and aquatic ecosystems.</li> <li>&lt; 1/10 of federal drinking water guidelines used to provide a safety margin to protect against compounds for which there is no treatment.</li> </ul>	37, 38, 39, 41, 42
Total Ammonia	Bow River Lower	<ul style="list-style-type: none"> <li>WQO: The lower of US EPA or 0.2 mg/L ammonia during the growing season for growth of aquatic vegetation. To apply outside mixing zones (AENV 1995).</li> <li>TARGET: CCME (CCME 1999)</li> </ul>	Open Water Ronlance 87-05 monthly 0.010 (0.072) <sup>90</sup>	<ul style="list-style-type: none"> <li>0.2 mg/L total ammonia was a fully-mixed concentration in the City of Calgary Total Loading Management model (Golder 2007) that corresponded to 5 mg/L DO.</li> <li>Although the City of Calgary model was not designed for this reach, the model predicted limit is appropriate and has been applied to this reach as well.</li> <li>The model assumes that some form of nitrification is occurring at the Fish Creek WWTP. This objective may need to be revisited as improvements around the WWTP occur over time and as findings from related research recommendations become available.</li> <li>Objectives are based on toxicity thresholds and aquatic plant growth.</li> </ul>	24, 27, 28

<sup>55</sup> Over entire Bow basin, (Anderson 2005; Table 4c) found 180 of 406 samples exceeded irrigation guidelines (mainly Dicamba and MCPA), 12 of 406 samples (mainly 2,4-D and chlorpyrifos-ethyl) exceeded aquatic life guidelines, and no exceedences of guidelines for drinking water or livestock watering.



PROPOSED INDICATOR OR TOPIC AREA	REACH OR RIVER	WQOS, WARNING LEVELS AND TARGETS (INDICATORS WITH ONLY TARGETS ARE GREYED)	BASELINE WATER QUALITY (MEDIAN, PERCENTILES), MG/L UNLESS OTHERWISE NOTED	RATIONALE	RELATED RECOMMENDATION NUMBER IN TABLE 2, BBWMP
Total Dissolved Phosphorus	Bow River Lower	<ul style="list-style-type: none"> <li>WQO: 0.015 mg/L TDP during the growing season for aquatic plants</li> <li>Provisional objective: 0.025 mg/L for winter season</li> </ul>	Open Water Ronalane 83-05 monthly 0.007 mg/L (0.017) <sup>90</sup> Winter season 84-05 0.007 (0.025) <sup>90</sup>	<ul style="list-style-type: none"> <li>Objective based on protecting DO and reducing nuisance aquatic plant growth.</li> <li>Although the City of Calgary model (Golder 2007) was not designed for this reach, the model's predicted limit is appropriate and has been applied to this reach as well using avg. conc. During Apr. to Sept.</li> <li>Based on TLM model (Golder 2007) using average TDP concentration during Apr. to Sept. that maintained DO above 5.0 mg/L and TDP:TP ratio of approx. 55%.</li> <li>Provisional objective is the 90<sup>th</sup> percentile based on historical data.</li> </ul>	24, 27, 28
Total Organic Carbon	Bow River Lower	<ul style="list-style-type: none"> <li>WQO: Should not exceed 5.0 mg/L (instantaneous)</li> <li>TARGET: Should not exceed 3.0 mg/L (instantaneous).</li> </ul>	Year Round Ronalane 87-05 monthly 2.55 (4.20) <sup>90</sup>	<ul style="list-style-type: none"> <li>Increasing TOC levels in the source water has affected the treatment process of water at many surface water treatment plans. TOC &gt;3 mg/L result in increased coagulant and chlorine demands, and gets worse as TOC levels get higher. (UEWG 1999)</li> <li>Values exclude periods of snowmelt runoff, mountain runoff, and significant precipitation events.</li> </ul>	
Total Phosphorus	Bow River Lower	WQO: 0.05 mg/L TARGET: Eliminate levels that cause nuisance aquatic plant growth.		<ul style="list-style-type: none"> <li>Total Phosphorus objectives were not originally provided in Phase One. Where this occurred, the agreement was to use Alberta Surface Water Quality Guidelines.</li> </ul>	
Total Phosphorus	Bow River Lower	<ul style="list-style-type: none"> <li>WQO: No recommendation for TP. TDP is believed to be the better WQO for this reach.</li> <li>TARGET: Eliminate levels that cause nuisance aquatic plant growth.</li> </ul>	Open Water Ronalane 83-05 monthly 0.027 (0.095) <sup>90</sup> Winter season 1984-2006 0.020 (0.041) <sup>90</sup> With Enhanced P Removal monthly 2004: 0.031 2005: 0.019	<ul style="list-style-type: none"> <li>Total phosphorus in this reach is predominantly particulate phosphorus which can increase above this level with concurrent algae production. For this reason, total dissolved phosphorus is the better indicator for this reach.</li> </ul>	24, 27, 28
Total Suspended Solids	Bow River Lower	<ul style="list-style-type: none"> <li>WQO: If background<sup>56</sup> concentration is:               <ul style="list-style-type: none"> <li>&lt; 25 mg/L conditions must not exceed an SEV value of 6</li> <li>&gt; 25 mg/L conditions must not exceed an SEV value of 7- (CCME 2002, et al 1997)</li> <li>&gt; 250 mg/L (CCME 2002) applies (conditions should not increase more than 10% above background levels when background is &gt; 250 mg/L)</li> </ul> </li> <li>Calculation of the SEV value must be taken from fully mixed zone.</li> <li>WARNING LEVEL: Visible plume entering river during base river flow.</li> <li>TARGET: CCME (CCME 1999), increase compliance frequency with objectives</li> </ul>	Year Round Ronalane 87-05 monthly 9.6 (80.0) <sup>90</sup>	<ul style="list-style-type: none"> <li>There are different objectives to consider natural and anthropogenic TSS variation along the river.</li> <li>When the background is less than &lt; 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.</li> <li>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.</li> <li>It is recognized that the objectives may be temporarily exceeded during spring freshet and storm events.</li> <li>Warning narrative similar to what is used by the City of Calgary.</li> </ul>	27, 50

<sup>56</sup> Two general approaches are considered acceptable to define background concentrations of water quality variables which involve (CCME 2002 pg20, Site-specific guidance):

i) Utilization of historically- collected water quality data for site (i.e., prior to the commencement of activities that could have substantially altered water quality conditions); or ii) Monitoring contemporary water quality conditions at one or more stations located upstream of contaminant sources.

PROPOSED INDICATOR OR TOPIC AREA	REACH OR RIVER	WQO, WARNING LEVELS AND TARGETS (INDICATORS WITH ONLY TARGETS ARE GREYED)	BASELINE WATER QUALITY (MEDIAN, PERCENTILES), MG/L UNLESS OTHERWISE NOTED	RATIONALE	RELATED RECOMMENDATION NUMBER IN TABLE 2, BBWMP
Water Temperature	Bow River Lower	<p>WQO:</p> <p>1) Should not a) exceed 22°C at any time; or b) exceed a 7 day mean &gt; 18°C for the Bow River between Carseland Weir and Bassano Dam at frequencies greater than natural exceedences.</p> <p>2) Should not exceed 29°C at any time or a 7-day mean &gt; 24°C for the Bow River between Bassano Dam and the South Saskatchewan River confluence at frequencies greater than natural exceedences.</p> <ul style="list-style-type: none"> <li>WARNING LEVEL: ABOVE BASSANO DAM: A warning level of 24°C should be used as a signal to stop all angling until such time as temperatures fall below 24°C for a period of 2 consecutive days.</li> </ul>	<p>Open Water</p> <p>Ronalane 87-05 Monthly 15.7 (20.9)<sup>90</sup> (25.9)<sup>max</sup></p> <p>Bow City 1998 Hourly 20.38 (23.97)<sup>90</sup> (28.8)<sup>max</sup></p>	<ul style="list-style-type: none"> <li>Lake Sturgeon occur in this reach and are considered a species of concern in Alberta.</li> <li>The original WQO acute water temperature values of 29°C suggested in Phase One are based on Walleye. Walleye are not present in the reach between Carseland Weir and Bassano Dam. This section is actively managed for Rainbow Trout, Brown Trout and Mountain Whitefish, for which appropriate values have been provided. It is recognized that there are currently exceedences of 22°C and a 7 day mean of &gt;18°C; the intent is to ensure no additional frequency of exceedences.</li> </ul>	2, 24, 27
Riparian Condition	Bow River Lower	<ul style="list-style-type: none"> <li>TARGET ABOVE BASSANO DAM: a "healthy" rating using the Cows and Fish rating system</li> <li>TARGET BELOW BASSANO DAM: a "healthy with problems" rating using the Cows and Fish rating system</li> </ul>		<ul style="list-style-type: none"> <li>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".</li> </ul>	45, 47, 49, 57, 59
Soil Erosion	Bow River Lower	<p>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).</p>		<ul style="list-style-type: none"> <li>An erosion and sediment control plan (ESC) must be developed, implemented and monitored for construction sites with any direct connection to surface water.</li> <li>An ESC plan should be prepared by a qualified professional (a professional certification that includes erosion and sediment control as a field of expertise).</li> <li>Based on methods described in Wall et al 2002.</li> </ul>	45, 48, 50, 51
Attached Algae (Periphyton) Biomass - defined as chlor a	Elbow River Central	<p>WQO: 150 mg/m<sup>2</sup> maximum value during open water season</p>	<p>Open Water Sarcee Bridge 88-89 monthly 105.1 (143.1)<sup>75</sup> (174.4)<sup>max</sup></p> <p>Not currently monitored</p>	<ul style="list-style-type: none"> <li>A literature review over many regions determined that periphyton concentrations above 150 mg/m<sup>2</sup> are associated with adverse impacts on users (Welch et al 1998).</li> </ul>	14
Dissolved Oxygen	Elbow River Central	<p>WQO: CCME (CCME 1999) with protection of spawning and incubation.</p> <ul style="list-style-type: none"> <li>9.5 mg/L for spawning and incubation</li> <li>6.5 mg/L for acute daily minimum.</li> </ul>	<p>Open Water Weaselhead 00-06 monthly 9.7 (8.5)<sup>10</sup> (7.0)<sup>min</sup></p>	<ul style="list-style-type: none"> <li>CCME minimum for adult and juvenile cold-water fish</li> <li>Requires fishery inventory to determine spawning areas.</li> </ul>	2, 28

PROPOSED INDICATOR OR TOPIC AREA	REACH OR RIVER	WQOS, WARNING LEVELS AND TARGETS (INDICATORS WITH ONLY TARGETS ARE GREYED)	BASELINE WATER QUALITY (MEDIAN, PERCENTILES), MG/L UNLESS OTHERWISE NOTED	RATIONALE	RELATED RECOMMENDATION NUMBER IN TABLE 2, BBWMP
Nitrate (nitrate + nitrite (as N))	Elbow River Central	<ul style="list-style-type: none"> <li>WQO: 0.267 mg/L</li> <li>WARNING LEVEL: 0.132 mg/L</li> <li>WQOs, warning levels and targets for nitrate apply during the growing / open water season.</li> </ul>	Open Water Weaselhead 97-06 monthly 0.065 (0.129) <sup>90</sup>	<ul style="list-style-type: none"> <li>Protects against stimulation of excessive algal growth to protect municipal water supplies.</li> <li>Nitrogen may be entering the reach as a result of long-range transport.</li> <li>The value of 0.267 mg/L was obtained from Sosiak 2004 as the nitrate + nitrite level that corresponds to nuisance growth of periphyton.</li> <li>The warning level was developed based on the 90th percentile level for the period 1992 – 2006.</li> </ul>	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 <sup>57</sup> Weaselhead 94-06 monthly 28 per 100 mL (167) <sup>90</sup>	<ul style="list-style-type: none"> <li>400 E. coli per 100 mL is the CCME re-sampling guideline (CCME 1999).</li> </ul>	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	<ul style="list-style-type: none"> <li>Irrigation guidelines set by CCME (CCME 1999).</li> <li>The WQO values can be briefly exceeded for short periods of time during storm events.</li> </ul>	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 <sup>58</sup> Weaselhead 93-06 monthly 444 per 100 mL (2420) <sup>90</sup>	<ul style="list-style-type: none"> <li>The instantaneous objective of &lt;20,000 counts per 100 mL is based on conventional water treatment plant's ability to remove contaminants if pre-disinfection is present (US EPA 1991).</li> <li>Protects human health by ensuring that municipal water treatment plants can remove pathogens (e.g., bacteria, protozoa, and viruses) from raw water.</li> </ul>	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 cysts/100 L Weaselhead 97-05 24 (172) <sup>90</sup>	<ul style="list-style-type: none"> <li>This is the level above which will require in excess of 5-log reduction at the Glenmore Water Treatment Plant (AENV 2006b).</li> <li>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.</li> <li>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.</li> </ul>	3, 28
Pesticides and Degradation Products	Elbow River Central	WQO: Should not exceed the lower of: <ul style="list-style-type: none"> <li>&lt; 1/10 of federal drinking water guidelines or</li> <li>&lt; CCME guidelines for aquatic life in the river (CCME 1999).</li> </ul>	Insufficient data	<ul style="list-style-type: none"> <li>Provisional objective as there is currently no ongoing monitoring available at this time to set an objective.</li> <li>Protects drinking water and aquatic ecosystems.</li> <li>&lt; 1/10 of federal drinking water guidelines used to provide a safety margin to protect against compounds for which there is no treatment.</li> </ul>	31, 37, 38, 39, 41, 42, 44
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 (CCME 1999). To apply outside mixing zones.	Open Water Weaselhead 97-06 monthly 0.010 (0.020) <sup>90</sup>	<ul style="list-style-type: none"> <li>Protects municipal water supply from unacceptable chlorine demand.</li> <li>Based on experience at Glenmore Water Treatment Plant.</li> <li>This is more restrictive than the current CCME guideline.</li> <li>Designed to protect aquatic life and takes into account the influence of both temperature and pH on the toxicity of ammonia.</li> <li>This objective does not represent a value to protect the river against excessive growth of aquatic plants.</li> </ul>	27, 28

<sup>57</sup> Most available data from Apr.-Sep., although some years include Mar., Oct. and Nov. data

<sup>58</sup> Mostly Apr.-Sep., although some years include Mar., Oct. and Nov. data

PROPOSED INDICATOR OR TOPIC AREA	REACH OR RIVER	WQOS, WARNING LEVELS AND TARGETS (INDICATORS WITH ONLY TARGETS ARE GREYED)	BASELINE WATER QUALITY (MEDIAN, PERCENTILES), MG/L UNLESS OTHERWISE NOTED	RATIONALE	RELATED RECOMMENDATION NUMBER IN TABLE 2, BBWMP
Total Dissolved Phosphorus	Elbow River Central	<ul style="list-style-type: none"> <li>WQO: 0.009 mg/L TDP</li> <li>TARGET: Eliminate levels that cause nuisance aquatic plant growth.</li> </ul>	Open Water Weaselhead 93-06 monthly 0.002 (0.009) <sup>90</sup>	<ul style="list-style-type: none"> <li>Based on 90th percentile (1993-2006) for all available data from Mar. to Nov. at the Elbow River at Weaselhead.</li> </ul>	27, 28
Total Organic Carbon	Elbow River Central	<ul style="list-style-type: none"> <li>WQO: Should not exceed 5.0 mg/L (instantaneous).</li> <li>TARGET: Should not exceed 3.0 mg/L (instantaneous).</li> </ul>	Open Water <sup>59</sup> Weaselhead 93-06 monthly 1.41 (3.97) <sup>90</sup>	<ul style="list-style-type: none"> <li>Values exclude periods of snowmelt runoff, mountain runoff, and significant precipitation events.</li> </ul>	9
Total Phosphorus	Elbow River Central	WQO: 0.05 mg/L TARGET: Eliminate levels that cause nuisance aquatic plant growth.		<ul style="list-style-type: none"> <li>Total Phosphorus objectives were not originally provided in Phase One. Where this occurred, the agreement was to use Alberta Surface Water Quality Guidelines.</li> </ul>	27, 28
Total Phosphorus	Elbow River Central	<ul style="list-style-type: none"> <li>WQO: No recommendation for TP. TDP is believed to be the better WQO for this reach.</li> <li>TARGET: Eliminate levels that cause nuisance aquatic plant growth.</li> </ul>	Open Water Weaselhead 93-06 monthly 0.011 (0.089) <sup>90</sup>	<ul style="list-style-type: none"> <li>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.</li> </ul>	
Total Suspended Solids	Elbow River Central	<ul style="list-style-type: none"> <li>WQO: If the background<sup>60</sup> concentration is: <ul style="list-style-type: none"> <li>&lt; 25 mg/L conditions must not exceed an SEV value of 6</li> <li>&gt; 25 mg/L conditions must not exceed an SEV value of 7- (CCME 2002, Caux et al 1997)</li> <li>&gt; 250 mg/L (CCME 2002) applies (conditions should not increase more than 10% above background levels when background is &gt;250 mg/L)</li> </ul> </li> <li>Calculation of the SEV value must be taken from fully mixed zone.</li> <li>WARNING LEVEL: Visible plume entering river during base river flow.</li> <li>TARGET: CCME (CCME 1999), increase compliance frequency with objectives</li> </ul>	Open water <sup>61</sup> Weaselhead 98-06 monthly 8.1 (62.0) <sup>90</sup>	<ul style="list-style-type: none"> <li>Trend analysis has indicated that levels of suspended solids are increasing.</li> <li>There are different objectives to consider natural and anthropogenic TSS variation along the river.</li> <li>When the background is less than &lt; 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.</li> <li>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.</li> <li>It is recognized that the objectives may be temporarily exceeded during spring freshet and storm events.</li> </ul>	27, 28, 31, 33, 50, 53

<sup>59</sup> Include some Mar. and Nov. data

<sup>60</sup> Two general approaches are considered acceptable to define background concentrations of water quality variables which involve (CCME 2002 pg20, Site-specific guidance):

i) Utilization of historically-collected water quality data for site (i.e., prior to the commencement of activities that could have substantially altered water quality conditions); or

ii) Monitoring contemporary water quality conditions at one or more stations located upstream of contaminant sources.

<sup>61</sup> Available data is mostly from Apr.-Sep., although some years include Mar., Oct. and Nov. dates

PROPOSED INDICATOR OR TOPIC AREA	REACH OR RIVER	WQO, WARNING LEVELS AND TARGETS (INDICATORS WITH ONLY TARGETS ARE GREYED)	BASELINE WATER QUALITY (MEDIAN, PERCENTILES), MG/L UNLESS OTHERWISE NOTED	RATIONALE	RELATED RECOMMENDATION NUMBER IN TABLE 2, BBWMP
Water Temperature	Elbow River Central	WQO: Should not exceed 18°C at any time or a 7-day mean of 18°C.	Open Water Weaselhead 98-06 monthly 9.9 (14.5) <sup>90</sup> (17.2) <sup>max</sup>	<ul style="list-style-type: none"> <li>18°C is above the recorded maximum</li> <li>To protect most sensitive native fish, namely white fish.</li> <li>Chronic maximum based on Taylor &amp; Barton 1992.</li> </ul>	2, 27
Riparian Condition	Elbow River Central	TARGET: maintaining a “healthy” rating using Cows and Fish rating system.		<ul style="list-style-type: none"> <li>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”.</li> </ul>	45, 47, 49, 56, 57, 59
Soil Erosion	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 a direct connection to a water body (no buffer, no interception). This applies to all construction sites and endures for the life of project (during and post construction phases).		<ul style="list-style-type: none"> <li>An erosion and sediment control plan (ESC) must be developed, implemented and monitored for construction sites with any direct connection to surface water.</li> <li>An ESC plan should be prepared by a qualified professional (a professional certification that includes erosion and sediment control as a field of expertise).</li> <li>Based on methods described in Wall et al 2002.</li> </ul>	27, 28, 29, 45, 48, 50, 51
Attached Algae (Periphyton) Biomass - defined as chlor a	Elbow River Upper	<ul style="list-style-type: none"> <li>WQO: 150 mg/m<sup>2</sup> maximum value during open water season</li> <li>TARGET: 47 mg/m<sup>2</sup> maximum</li> </ul>	Open Water Downstream Bragg Creek 88-89 monthly 14.8 (21.5) <sup>75</sup> (61.1) <sup>max</sup>	<ul style="list-style-type: none"> <li>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.</li> <li>A literature review over many regions determined that periphyton concentrations above 150 mg/m<sup>2</sup> are associated with adverse impacts on users (Welch et al 1998).</li> <li>Not currently monitored and no historic data in this reach, very sparse.</li> </ul>	14
Dissolved Oxygen	Elbow River Upper	WQO: CCME (CCME 1999) with protection of spawning and incubation. <ul style="list-style-type: none"> <li>9.5 mg/L for spawning and incubation</li> <li>6.5 mg/L for acute daily minimum.</li> </ul>	Open Water Above Bragg Creek 00-06 monthly 10.6 (9.4) <sup>10</sup> (8.1) <sup>min</sup>	<ul style="list-style-type: none"> <li>CCME provides a high-level of protection for saturated conditions.</li> </ul>	2
Nitrate (nitrate + nitrite (as N))	Elbow River Upper	WQO: 0.13 mg/L during the open water season	Open Water Above Bragg Creek 99-06 monthly 0.083 (0.118) <sup>90</sup>	<ul style="list-style-type: none"> <li>Trying to maintain this reach at its current trophic state.</li> <li>90<sup>th</sup> percentile for Elbow River above Bragg Creek = 0.125 mg/L (1999 - 2006).</li> </ul>	27, 35

PROPOSED INDICATOR OR TOPIC AREA	REACH OR RIVER	WQOS, WARNING LEVELS AND TARGETS (INDICATORS WITH ONLY TARGETS ARE GREYED)	BASELINE WATER QUALITY (MEDIAN, PERCENTILES), MG/L UNLESS OTHERWISE NOTED	RATIONALE	RELATED RECOMMENDATION NUMBER IN TABLE 2, BBWMP
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 <sup>62</sup> Above Bragg Creek 98-06 monthly 4 per 100 mL (22) <sup>90</sup>	<ul style="list-style-type: none"> <li>400 E. coli per 100 mL is the CCME re-sampling guideline (CCME 1999).</li> </ul>	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 <sup>63</sup> Above Bragg Creek 98-06 monthly 68 per 100 mL (249) <sup>90</sup>	<ul style="list-style-type: none"> <li>The instantaneous objective of &lt;20,000 counts per 100 mL is based on conventional water treatment plant's ability to remove contaminants if pre-disinfection is present (US EPA 1991).</li> <li>Protects human health by ensuring that municipal water treatment plants can remove pathogens (e.g., bacteria, protozoa, and viruses) from raw water.</li> </ul>	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	<ul style="list-style-type: none"> <li>Insufficient data to make recommendation. We need to first determine Giardia counts in surface water reaches that can be effectively treated by different methods.</li> <li>Wildlife are the prime vectors of Giardia transmission in this reach.</li> </ul>	3
Pesticides and Degradation Products	Elbow River Upper	WQO: Should not exceed the lower of: <ul style="list-style-type: none"> <li>&lt; 1/10 of federal drinking water guidelines or</li> <li>&lt; CCME guidelines for aquatic life in the river (CCME 1999). (provisional objective)</li> </ul>	Insufficient data	<ul style="list-style-type: none"> <li>Provisional objective as there is currently no ongoing monitoring available at this time to set an objective.</li> <li>&lt;1/10 of federal drinking water guidelines used to provide a safety margin to protect against compounds for which there is no treatment.</li> <li>Protects drinking water and aquatic ecosystems.</li> </ul>	37, 38, 39, 41, 42
Total Ammonia	Elbow River Upper	WQO: Should not exceed CCME guideline for protection of aquatic life (CCME 1999). To apply outside mixing zone (AENV 1995).	Open Water Above Bragg Creek 00-06 monthly 0.010 (0.020) <sup>90</sup>	<ul style="list-style-type: none"> <li>Designed to protect aquatic life and takes into account the influence of both temperature and pH on the toxicity of ammonia.</li> <li>Historical total ammonia values have not exceeded 0.02 mg/L in 7 years of data.</li> </ul>	27, 28
Total Dissolved Phosphorus	Elbow River Upper	WQO:0.006 mg/L TDP	Open Water Above Bragg Creek 00-06 monthly 0.001 (0.006) <sup>90</sup>	<ul style="list-style-type: none"> <li>Based on year-round historical data at Elbow River above Bragg Creek using 90th percentile (2000-2006).</li> </ul>	28
Total Organic Carbon	Elbow River Upper	<ul style="list-style-type: none"> <li>WQO: Should not exceed 5.0 mg/L (instantaneous).</li> <li>TARGET: Should not exceed 3.0 mg/L (instantaneous).</li> </ul>	Open Water <sup>64</sup> Above Bragg Creek 00-06 monthly 0.960 (3.76) <sup>90</sup>	<ul style="list-style-type: none"> <li>Values exclude periods of snowmelt runoff, mountain runoff, and significant precipitation events.</li> </ul>	28

<sup>62</sup> Not entirely year round historical data, year round data for 2004-2006

<sup>63</sup> Not entirely year round for all years in the period of record (2004-2006)

<sup>64</sup> Healthy riparian condition filters nutrients and minimizes the runoff of sediments into receiving water bodies.

<sup>90</sup> Include some March and November data

PROPOSED INDICATOR OR TOPIC AREA	REACH OR RIVER	WQOS, WARNING LEVELS AND TARGETS (INDICATORS WITH ONLY TARGETS ARE GREYED)	BASELINE WATER QUALITY (MEDIAN, PERCENTILES), MG/L UNLESS OTHERWISE NOTED	RATIONALE	RELATED RECOMMENDATION NUMBER IN TABLE 2, BBWMP
Total Phosphorus	Elbow River Upper	WQO: 0.019 mg/L TP	Open Water Above Bragg Creek 99-06 monthly 0.003 (0.019) <sup>90</sup>	<ul style="list-style-type: none"> <li>Based on historical data at Elbow River above Bragg Creek using 90<sup>th</sup> percentile.</li> </ul>	28
Total Suspended Solids	Elbow River Upper	WQO: CCME (CCME 1999).	Year Round <sup>65</sup> Above Bragg Creek 01-06 monthly 1.0 (16.7) <sup>90</sup>	<ul style="list-style-type: none"> <li>To maintain existing water quality for the protection of aquatic life.</li> </ul>	27, 50, 52, 54
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 Creek 98-06 monthly 8.8 (11.3) <sup>90</sup> (14.0) <sup>max</sup>	<ul style="list-style-type: none"> <li>14°C is the recorded maximum in the Elbow River above Bragg Creek.</li> <li>To protect most sensitive native fish, namely bull trout</li> <li>Chronic maximum based on Taylor &amp; Barton 1992.</li> </ul>	2, 27
Riparian Condition	Elbow River Upper	TARGET: maintaining a “healthy” rating using Cows and Fish rating system.		<ul style="list-style-type: none"> <li>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”.</li> </ul>	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).		<ul style="list-style-type: none"> <li>For new developments that are permitted within the defined boundaries, Operating Ground Rules are in place to minimize erosion and sedimentation (ASRD).</li> <li>An erosion and sediment control plan (ESC) must be developed, implemented and monitored for construction sites with any direct connection to surface water.</li> <li>An ESC plan should be prepared by a qualified professional (a professional certification that includes erosion and sediment control as a field of expertise).</li> <li>Based on methods described in Wall et al 2002.</li> </ul>	45, 50, 51, 52, 54
Attached Algae (Periphyton) Biomass - defined as chlor a	Nose Creek	<ul style="list-style-type: none"> <li>WQO: No periphytic algal biomass that adversely affects users.</li> <li>Target: 150 mg/m<sup>2</sup> maximum value during open water season</li> </ul>	Open Water Downstream Airdrie 99-01 monthly 48 (136) <sup>90</sup> (257.2) <sup>max</sup>	<ul style="list-style-type: none"> <li>Creeks may be light-limited so the amount of periphyton is highly variable depending on location.</li> <li>A literature review over many regions determined that periphyton concentrations above 150 mg/m<sup>2</sup> are associated with adverse impacts on users (Welch et al 1998).</li> <li>Not currently monitored.</li> </ul>	19

<sup>65</sup> Data record is not entirely year round for all years in the period of record (2004-2006.)

PROPOSED INDICATOR OR TOPIC AREA	REACH OR RIVER	WQOS, WARNING LEVELS AND TARGETS (INDICATORS WITH ONLY TARGETS ARE GREYED)	BASELINE WATER QUALITY (MEDIAN, PERCENTILES), MG/L UNLESS OTHERWISE NOTED	RATIONALE	RELATED RECOMMENDATION NUMBER IN TABLE 2, BBWMP	
Dissolved Oxygen	Nose Creek	<ul style="list-style-type: none"> <li>WQO: Not recommended at this time.</li> <li>TARGET: 5.0 mg/L (acute daily minimum), 6.5 chronic (7-day running average).</li> </ul>	Open Water At Mouth 95-06 7.1 (4.8) <sup>10</sup> (2.3) <sup>min</sup>	Open Water At Mouth 2004 6.6 (4.52) <sup>10</sup> (2.21) <sup>min</sup>	<ul style="list-style-type: none"> <li>Action and more research is required before setting a WQO.</li> <li>DO is currently going well below 5.0, at both the mouth and the City of Calgary limit (can go as low as 3.0 mg/L).</li> </ul>	2, 11, 27, 28
Nitrate (nitrate + nitrite (as N))	Nose Creek	<ul style="list-style-type: none"> <li>WQO: 1.5 mg/L</li> <li>TARGET: Eliminate levels that cause nuisance aquatic plant growth.</li> <li>WARNING LEVEL: Need to better understand the limiting factor for macrophytes and periphyton growth before assigning a warning level.</li> <li>All apply during the growing season.</li> </ul>	Open water At the Mouth 95-06 monthly 0.500 as nitrate (1.408) <sup>90</sup> as nitrate	<ul style="list-style-type: none"> <li>Although exceeded at times, the WQO is reasonable and will be a catalyst for action.</li> <li>WQO of 1.5 mg/L nitrate was the concentration in the City of Calgary Total Loading Management that corresponded to 5 mg/L DO for the period April to Sept 30 (Golder 2007).</li> <li>Although the City of Calgary model was not designed for Nose Creek, the model's predicted limit is appropriate and has been applied to this reach as well.</li> </ul>	27, 28	
Pathogens as indicated by E. coli	Nose Creek	Provisional 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).		<ul style="list-style-type: none"> <li>E. coli objectives were not originally provided in some cases in Phase One. Where this occurred, the agreement was to use CCME Guidelines. A provisional WQO indicates that further research is required.</li> </ul>		
Pathogens as indicated by fecal coliforms	Nose Creek	TARGET: Meet 100 fecal coliforms per 100 mL (no single value to exceed objective) at the point of withdrawal	Year Round At the Mouth 95-06 monthly 350 per 100 mL (2540) <sup>90</sup>	<ul style="list-style-type: none"> <li>Irrigation guidelines set by CCME (CCME 1999).</li> <li>The WQO values can be briefly exceeded for short periods of time during storm events.</li> <li>The challenge for Nose Creek is to determine what pathogen levels will be indicative of negative impacts to human health, stock health and pet health.</li> </ul>	28	
Pesticides and Degradation Products	Nose Creek	<ul style="list-style-type: none"> <li>WQO: Not recommended at this time.</li> <li>TARGET: Should not exceed CCME guidelines for aquatic life in the river (CCME 1999).</li> </ul>	1999-2001 (Cross 2002): samples exceeding CCME irrigation MCPA: 35% Dicamba: 59% (sensitive crops)	<ul style="list-style-type: none"> <li>Guidelines are currently being exceeded.</li> </ul>	37, 38, 39, 41, 42, 44	
Total Ammonia	Nose Creek	<ul style="list-style-type: none"> <li>WQO: US EPA during the growing season for growth of aquatic vegetation. To apply outside mixing zone (AENV 1995).</li> <li>TARGET: CCME (CCME 1999)</li> </ul>	Open Water At the Mouth 95-06 monthly 0.250 (0.500) <sup>90</sup>	<ul style="list-style-type: none"> <li>Currently both the WQO and target are exceeded at times.</li> <li>Ammonia can be toxic to fish and other aquatic species.</li> </ul>	27, 28	
Total Dissolved Oxygen	Nose Creek	Provisional WQO 5.0 mg/L (acute daily minimum), 6.5 chronic (7 day running average)		<ul style="list-style-type: none"> <li>Dissolved Oxygen objectives were not originally provided in Phase One for Nose Creek. Where this occurred, the agreement was to use CCME Guidelines. A provisional WQO indicates that further research is required.</li> </ul>		
Total Dissolved Phosphorus	Nose Creek	Provisional WQO: 0.02 mg/L TARGET: Eliminate levels that cause nuisance aquatic plant growth.	Open Water At the Mouth 99-06 (as DRP) monthly 0.020 (0.070) <sup>90</sup>	<ul style="list-style-type: none"> <li>Values fluctuate widely throughout the basin.</li> <li>Sources likely urban storm water and agricultural runoff adjacent to stream.</li> <li>Total Dissolved Phosphorus objectives were not originally provided in Phase One for Nose Creek. The TDP objective for Nose Creek was calculated based on the average/median TDP/TP values calculated for Nose Creek at the Mouth (average=0.35, median=0.35, N=135), and then applied the ratio to the provisional TP WQO of 0.05 mg/L, i.e., WQO = (0.05 mg/L * 0.35) = 0.02 mg/L. A provisional WQO indicates that further research is required.</li> </ul>	27, 28, 36	



PROPOSED INDICATOR OR TOPIC AREA	REACH OR RIVER	WQOS, WARNING LEVELS AND TARGETS (INDICATORS WITH ONLY TARGETS ARE GREYED)	BASELINE WATER QUALITY (MEDIAN, PERCENTILES), MG/L UNLESS OTHERWISE NOTED	RATIONALE	RELATED RECOMMENDATION NUMBER IN TABLE 2, BBWMP
Total Phosphorus	Nose Creek	<ul style="list-style-type: none"> <li>Provisional WQO: 0.05 mg/L TARGET: Eliminate levels that cause nuisance aquatic plant growth.</li> <li>TARGET: Reduction in number of exceedences of the SWQG.</li> </ul>	Open water At the Mouth 95-06 monthly 0.170 (0.500) <sup>90</sup>	<ul style="list-style-type: none"> <li>The provincial guideline is frequently exceeded, with values fluctuating widely throughout the basin.</li> <li>West Nose is in better condition but is still two times higher than the SWQG.</li> <li>Sources are urban storm water and agricultural runoff adjacent to stream.</li> <li>Total Phosphorus objectives were not originally provided in Phase One. Where this occurred, the agreement was to use Alberta Surface Water Quality Guidelines. A provisional WQO indicates further research is required.</li> </ul>	27, 28, 36
Total Suspended Solids	Nose Creek	<ul style="list-style-type: none"> <li>WQO: Provisional WQO: If the background concentration is: <ul style="list-style-type: none"> <li>&lt; 25 mg/L conditions must not exceed severity of ill-effect (SEV) value of 6</li> <li>&gt; 25 mg/L conditions must not exceed an SEV value of 7- (CCME 2002, Caux et al 1997)</li> <li>&gt; 250 mg/L (CCME 2002) applies (conditions should not increase more than 10% above background levels when background is &gt; 250 mg/L)</li> </ul> </li> <li>Calculation of the SEV value must be taken from fully mixed zone. WARNING LEVEL: Visible plume entering river during base river flow. TARGET: CCME (CCME 1999), increase compliance frequency with objectives</li> <li>TARGET: Maintain and then reduce TSS loadings from current levels.</li> </ul>	Year Round At the Mouth 95-06 monthly 19.0 (62.1) <sup>90</sup>	<ul style="list-style-type: none"> <li>Highest levels are at the mouth and downstream of Airdrie probably resulting from urban runoff and urban flow alteration (higher flows).</li> <li>Nose Creek is a very turbid system with a mixture of natural sediments and those that result from human activities.</li> <li>Total Suspended Solids objectives were not originally provided in Phase One for Nose Creek. Where this occurred, the agreement was to use CCME Guidelines. A provisional WQO indicates that further research is required.</li> </ul>	10, 27, 50, 55
Water Temperature	Nose Creek	WQO: Should not exceed 29°C at any time or a 7-day mean of 24°C.	Open Water At Mouth 95-06 Monthly 13.10 (18.91) <sup>90</sup> (20.50) <sup>max</sup>  At Mouth 2004 hourly 16.57 (20.94) <sup>90</sup> (26.2) <sup>max</sup>	<ul style="list-style-type: none"> <li>Objective is derived from Taylor and Barton 1992.</li> </ul>	2, 11, 27
Riparian Condition	Nose Creek	<ul style="list-style-type: none"> <li>TARGET FOR WEST NOSE CREEK: a “healthy” rating using the Cows and Fish rating system.</li> <li>TARGET FOR NOSE CREEK: a “healthy with problems” rating using the Cows and Fish rating system.</li> </ul>		<ul style="list-style-type: none"> <li>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”.</li> <li>Also to follow riparian protection recommendations outlined in the Nose Creek Watershed Management Plan (NCWP 2006). The Nose Creek Watershed Partnership website is located at <a href="http://www.nosecreekpartnership.com">www.nosecreekpartnership.com</a>.</li> </ul>	45, 47, 49, 57, 59
Runoff, soil erosion and impervious areas	Nose Creek	TARGET: Impervious and runoff recommendations as detailed in the Nose Creek Watershed Water Management Plan.		<ul style="list-style-type: none"> <li>To preserve the natural hydrological runoff volume to pre-development conditions (i.e., natural conditions).</li> <li>Based on the overall goal of trying to achieve pre-development rates and volumes entering the streams or rivers.</li> <li>Erosion and sediment control plan required (encourage retrofitting where possible).</li> <li>Erosion control plan applies to any new development or construction site during and post construction.</li> </ul>	10, 26, 40, 45, 48, 50, 51, 55

## SECTION 7.0: WATER QUALITY RECOMMENDATIONS FROM PHASE ONE

#	THEME	ACTIVITY	PROPOSED INDICATOR OR TOPIC AREA	RIVER OR REACH	RECOMMENDATIONS	DECISION-MAKERS	IMPLEMENTATION TIMELINES
<p>The recommendation numbers in the leftmost column are referenced in Appendix A for each water quality objective.</p> <p>*Asterisked Recommendations: Projects that are either in progress or are planned subject to budgetary approval.</p> <p><b>Blue Recommendations:</b> Identified by the Technical Committee as being the highest priority based on science for short-term implementation.</p>							
1.1	1a water quality performance indicators	Monitoring and evaluation	Coordinated Monitoring	Overall Bow Basin	<a href="#">Coordinate a workshop to develop strategies for enhanced coordination of monitoring programs within the Bow Basin.</a>	BRBC	Short-Term (2008-2010)
1.2	1a water quality performance indicators	Reporting	Real-Time Monitoring	Overall Bow Basin	Expand real-time monitoring for both flow and water quality and make data "publicly accessible".	Calgary*, AENV, EC, BRBC	Medium-Term (2011-2012)
1.3	1a water quality performance indicators	Research	Giardia	Overall Bow Basin	Further research and monitoring to develop a long-term target for Giardia, and to determine natural and anthropogenic sources.	Research communities	Long-Term (2012-2013)
1.4	1a water quality performance indicators	Indicator development	Cryptosporidium	Overall Bow Basin	Develop a report to review Cryptosporidium data and monitoring methodologies.	Research communities, Calgary, U of C, CHR, AENV and EC	Medium-Term (2011-2012)
1.5	1a water quality performance indicators	Monitoring and target development	Pathogens E.coli	Bow above park boundary	Include E. coli in surface water quality monitoring to determine an appropriate target.	PC and EC	Medium-Term (2011-2012)
1.6	1a water quality performance indicators	Monitoring and evaluation	Spawning and Dissolved Oxygen Levels	Bow River Central	Evaluate wastewater treatment methods and/or other options to improve river DO levels particularly during trout spawning and incubation.	Calgary	Medium-Term (2011-2012)
1.7	1a water quality performance indicators	Research and monitoring	Research and Monitoring on Dissolved Oxygen	Bow River Central	<a href="#">Further research on dissolved oxygen to determine the following:</a> <ul style="list-style-type: none"> <li><a href="#">cause of low nocturnal dissolved oxygen levels in the Bow River downstream from Calgary in the spring and summer;</a></li> <li><a href="#">whether N and/or P is the limiting nutrient for aquatic plant growth which contributes to low dissolved oxygen levels;</a></li> <li><a href="#">additional monitoring, model refinement and research to ensure that 0.015 mg/L TDP is sufficient to prevent DO from falling below 5 mg/L</a></li> <li><a href="#">spawning success in relation to interstitial oxygen levels.</a></li> </ul>	Research communities, Calgary, AENV, ASRD	Short-Term (2008-2010)
1.8	1a water quality performance indicators	Education	Pathogens (E. coli) and Education	Bow River Central	Increase education programs about the risks associated with body contact recreation.	Calgary*, CHR, Bow River Central Municipalities, AENV	Short-Term (2008-2010)
1.9	1a water quality performance indicators	Research	Total Organic Carbon Thresholds and Exceedences Options	Bow River Central and Elbow River Central	Further research to better define thresholds for total organic carbon to set treatment and source control options if necessary.	Calgary, U of C, AENV and EC	Medium-Term (2011-2012)
1.10	1a water quality performance indicators	Indicator development and research	Total Suspended Solids WQO and Research	Nose Creek	Develop a total suspended solids WQO and conduct research to identify the anthropogenic causes of total suspended solids relative to natural sources.	NCWP	Long-term (2012-2013)

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1.11	1a water quality performance indicators	Monitoring and evaluation	Dissolved Oxygen Monitoring	Nose Creek	Enhance monitoring of DO to better characterize and understand low nocturnal DO concentrations.	AENV, Calgary, NCWP	Short-Term (2008-2010)
1.12	1b. Aquatic ecosystem performance indicators	Indicator development	Benthic Invertebrate Research and Index of Biotic Integrity	Overall Bow Basin	Complete benthic invertebrate study for sites upstream and downstream of Calgary. Develop an index to assess benthic invertebrate response to water quality and assess overall aquatic ecosystem health.	Calgary*, EC, AENV, ASRD, ACA, PC, Research communities	Medium – Term (2011- 2012)
1.13	1b. Aquatic ecosystem performance indicators	Indicator development	Fish community Index	Overall Bow Basin	Fisheries Management will continue to refine the fish IBI (Index of biotic integrity) for use as an index to assess fish community response to water quality.	ASRD*	Medium-Term (2011-2012)
1.14	1b. Aquatic ecosystem performance indicators	Research	Macrophyte, Periphyton and Fish Research	Overall Bow Basin	Further research is required to link adverse human use impacts to macrophyte growth. Research is needed to determine acceptable periphyton levels with respect to water quality and still provide benefits for fish growth.	Research communities	Medium-Term (2011-2012)
1.15	1b. Aquatic ecosystem performance indicators	Research	Didymosphenia Research	Bow River Above Park Boundary, Bow River Below Park Boundary	Research is required to determine how Didymosphenia geminata is proliferating and what can be done to contain its growth.	Research communities, EC	Short-Term (2008-2010)
1.16	1b. Aquatic ecosystem performance indicators	Research	Water Temperature & Cutthroat Trout	Bow River Below Park Boundary	Research to help determine if water temperatures are sufficiently warm for cutthroat trout spawning in the spring.	PC, ASRD, Trout Unlimited	Short-Term (2008-2010)
1.17	1b. Aquatic ecosystem performance indicators	Monitoring and evaluation	Water Temperature and Dissolved Oxygen &	Bow River Central	Establish thresholds for acute and chronic temperature and dissolved oxygen effects on mountain whitefish.	Research communities, ASRD	Short-Term (2008-2010)
1.18	1b. Aquatic ecosystem performance indicators	Research	Mountain Whitefish	Bow River Central	Further research on the effects of smaller particle sizes (e.g., in storm water) on fish health and spawning.	Research communities, other academic agencies	Long-Term (2013-2014)
1.19	1b. Aquatic ecosystem performance indicators	Monitoring and evaluation	Total Suspended Solids – Particle Size & Fish	Nose Creek	Future water quality monitoring should include the collection of periphyton biomass (as chlorophyll a).	AENV	Short-Term (2008-2010)
1.20	2a. Water quantity management in relation to water quality	Modelling and research	Periphyton Biomass Water Balance Schematics	Overall Bow Basin	Develop water balance schematics, including groundwater, for the basin and all key reaches defined in this document.	AENV, ASRD	Medium-Term (2011-2012)

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1.21	2a. Water quantity management in relation to water quality	Indicator development	Flow Deviations	Overall Bow Basin	Further work is needed to develop an appropriate method to evaluate the deviation of recorded flows from naturalized flow regimes and three flow regime benchmarks <sup>66</sup> (AENV 2006a, Clipperton et al 2003) that have been set in the Bow Basin to meet the needs of the aquatic environment and consumptive water users.	AENV, ASRD, EC*	Short-term (2008-2010)
1.22	2a. Water quantity management in relation to water quality	Indicator development	Water Conservation	Overall Bow Basin	<b>Develop water conservation, efficiency, productivity targets and programs to meet targets for all municipalities and irrigation districts within the Bow Basin.</b>	Bow Municipalities	Short-Term (2008-2010)
1.23	2a. Water quantity management in relation to water quality	Reporting	Water Use Data	Overall Bow Basin	Provide readily, accessible water use data for all major licensed water users in the Bow Basin (i.e. IDs, municipalities, and industry) and strive for enhanced recording of use for all other licence users.	AENV	Medium-Term (2011-2012)
1.24	2a. Water quantity management in relation to water quality	Modelling	Coupled-water quantity and quality modelling	Bow River Central, Bow River Lower	Modelling work is required to understand the effects of flow alterations (i.e. upstream hydroelectric dams and irrigation diversions) on the assimilation capacity of the river to wastewater loadings and on ambient water quality.	Research communities, hydroelectric and irrigation groups	Medium-Term (2011-2012)
1.25	2a. Water quantity management in relation to water quality	Modelling	Headwater runoff modelling	Bow River Upper, Bow River Below Park Boundary, Elbow River Upper	Evaluate the potential landcover scenarios in the headwaters of the Bow Basin using existing runoff models in response to different levels of forest disturbance (e.g. forestry, fire and mountain pine beetle). Investigate the relative risks using more extreme flow events, changes in annual water supplies, and changes to erosion and sediment loading.	ASRD, U of A	Medium-Term (2011-2012)
1.26	2a. Water quantity management in relation to water quality	Research	Peak and Base Flows	Nose Creek	Further research is needed to compare the frequency and magnitude of base and peak flows. Storm events should remain within the range of pre-developments conditions (pre-1970).	NCWP	Short-Term (2008-2010)
1.27	2b. Storm water and wastewater management	Modelling	Water Quality Modelling	Overall Bow Basin	Expanded water quality modelling for both NPS and PS pollution entering the Bow River and key tributaries.	Calgary, Research communities, AA&RD, & AENV*	Medium-Term (2011-2012)
1.28	2b. Storm water and wastewater management	Monitoring and reporting	Wastewater Monitoring and Reporting	Overall Bow Basin	<b>Wastewater loadings from all licensed municipal and industrial sources throughout the Bow Basin should be monitored and reported for the various sub-basins.</b>	AENV, Bow Municipalities and industries with discharges to the river	Medium-Term (2011-2012)

<sup>66</sup> The three flow benchmarks that have been set for the Bow Basin are: i) the Instream Flow Need values determined using the Instream Flow Incremental Methodology, ii) the Water Conservation Objectives established under the approved Water Management Plan for the South Saskatchewan River, and (iii) the Instream Objectives established under the Water Act and used as regulatory restrictions on existing water licences for dams and diversions.

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1.29	2b. Storm water and wastewater management	BMP implementation	Wastewater and Stormwater Treatment	Overall Bow Basin	Municipalities must evaluate and implement the best treatment wastewater and stormwater options or technologies to protect the river water quality.	Bow Municipalities, AENV (lead), AT	Medium- Term (2011-2012)
1.30	2b. Storm water and wastewater management	BMP implementation	Total Suspended Solids and Source Control Practices	Bow River Central	Develop design guidelines for source control practices (i.e., BMPs).	Calgary*	Medium-Term (2011-2012)
1.31	2b. Storm water and wastewater management	Monitoring and modelling	Storm water Monitoring	Bow River Central, Elbow River Central	Continue to conduct the water quality monitoring program for the representative storm water outfalls in Calgary in support of the Total Loading Management Plan (CoC 2005). Work on verifying and improving the storm water total suspended solid loading estimates. Expand the model to estimate loadings from the pertinent storm outfalls in the Elbow Central reach (both Elbow and Glenmore outfalls).	Calgary*	Short-Term (2008-2010)
1.32	2b. Storm water and wastewater management	Objective development	Pathogen (E. coli) Source Tracking	Bow River Central, Elbow River Central	Further source tracking within the City of Calgary (including evaluation of risks) is required prior to setting WQOs and warning levels.	Calgary, U of C, CHR, AENV and EC	Medium Term (2011-2012)
1.33	2b. Storm water and wastewater management	BMP implementation	Stormwater Improvements	Bow River Central, Elbow River Central	Implement significant stormwater quality upgrades / improvements within Calgary.	City of Calgary*	Short to Long-Term (2008-2014)
1.34	2b. Storm water and wastewater management	Research	Pathogenic Speciation and WQOs (Total Coliforms)	Elbow River Central	Need to determine the species composition of pathogens and other organisms when counts exceed 20,000 coliforms/100 mL at the intake for Glenmore Water Treatment Plant. Once the pathogenic speciation work has been completed, further work will be required to refine the WQO.	Calgary, BRBC, CHR, AENV, EC and U of C	Medium-Term (2011-2012)
1.35	2b. Storm water and wastewater management	Research	Nitrate Research	Elbow River Central, Elbow River Upper, Bow River Above Park Boundary	Further research to determine if increased nitrate in the headwaters and foothills is from natural sources, local anthropogenic changes or long-range transport.	Research communities, other academic agencies	Medium-Term (2011-2012)
1.36	2b. Storm water and wastewater management	Research	Total Phosphorus Reductions	Nose Creek	Conduct research into the primary productivity of Nose Creek with the intent to reduce total phosphorus and total dissolved phosphorus.	NCWP (lead), Research communities	Medium-Term (2011-2012)
1.37	2c. Pesticide management	Education	Pesticide Use and Education	Overall Bow Basin	Develop education programs to encourage a reduction in urban pesticide applications.	Bow Municipalities	Medium-Term (2011-2012)
1.38	2c. Pesticide management	Indicator development	Pesticide Index	Overall Bow Basin	Once completed, the new 1) Alberta pesticide index (based on thresholds of observable effects limits developed by A-M. Anderson, AENV) and the new 2) European Union Water Framework Directive pesticide index be reviewed as alternatives to the existing recommended WQO.	BRBC's Knowledge Data and Research team	Short-Term (2008-2010)

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1.39	2c. Pesticide management	Monitoring and evaluation	Pesticide Monitoring	Overall Bow Basin	Agencies monitor pesticide concentrations in long-term monitoring programs. Parks Canada will consider adding pesticide monitoring to their existing agreement with Environment Canada. The monitoring programs should be coordinated and consistent with the sampling methodologies utilized by AENV (e.g., frequency, variables tested, etc.)	AENV*, Calgary, EC, PC	Long-Term (2013-2014)
1.40	2c. Pesticide management	BMP implementation	Topsoil Thickness in New Developments	Overall Bow Basin	Require developers to provide thicker topsoil layers for all landscaped areas within new developments, to minimize the use and resulting impacts of urban pesticide applications and will increase water retention.	Bow Municipalities	Medium-Term (2011-2012)
1.41	2c. Pesticide management	BMP implementation	Pesticide Use	Overall Bow Basin	Municipalities to uphold the principle of minimizing the quantity and/or toxicity of active ingredients when applying pesticides on the land they manage. It is recognized that the management of invasive species may require aggressive control measures.	Bow Municipalities, landowners	Short-Term (2008-2010)
1.42	2c. Pesticide management	Reporting and evaluation	Pesticide Surveys for Bow Basin	Overall Bow Basin	Continue to survey pesticide sales every five years and break information down by major river basins including the Bow Basin. Data on pesticide sales can contribute important information for a variety of monitoring and research needs, such as the relationship between pesticide use and their persistence in the environment.	AENV*	Short-Term (2008-2010)
1.43	2c. Pesticide management	Education	Pesticide Applications and Buffer Areas	Bow River Central & Elbow River Central	Continue to support pesticide use education programs and BMP 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, the provisions contained in the fact sheet "Pesticide Use In or Near Water" should be followed. <a href="http://environment.gov.ab.ca/info/library/7459.pdf">http://environment.gov.ab.ca/info/library/7459.pdf</a>	AA&RD, BRBC Legislation & Policy Committee, Bow Municipalities	Short-Term (2008-2010)
1.44	2c. Pesticide management	Reporting	Pesticide Use and Sales in Calgary	Bow River Central & Elbow River Central, Nose Creek	Continue to prepare annual surveys of urban domestic pesticide sales and actual use by golf course and landscape companies beyond 2008.	Calgary*	Short-Term (2008-2010)
1.45	2d. Land use management in relation to water quality	Education	Low Impact Development Education	Overall Bow Basin	<a href="#">Take a lead role in helping to educate municipalities and developers on the basic principles of low impact development and encourage developers to utilize these practices in the overall design.</a>	ALIDP, Bow Municipalities	Short-Term (2008-2010)
1.46	2d. Land use management in relation to water quality	Education	Manure Application & Setbacks	Overall Bow Basin	<a href="#">Continue to educate producers on manure application and setback distances with respect to water bodies as outlined by the Agriculture Operations Practices Act. Research the effectiveness of different application techniques to reduce runoff of manure into receiving water bodies.</a>	AA&RD*, NRCB* Bow Municipalities	Short-Term (2008-2010)
1.47	2d. Land use management in relation to water quality	BMP implementation	Cattle Grazing in Riparian Areas	Overall Bow Basin	Encourage landowners to implement grazing strategies to reduce the degree and impact of cattle grazing on riparian habitat along rivers and creeks (for grasslands, forested areas and protected areas).	Cows & Fish*, ASRD, Alberta Environmental Farm Plan Company, AA&RD, Bow Municipalities	Short-Term (2008-2010)

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1.48	2d. Land use management in relation to water quality	BMP implementation	Low Impact Development and Municipal Approvals	Overall Bow Basin	Incorporate elements of low impact development Best Management Practices and performance monitoring into the overall development design of new residential and commercial developments.	Bow Municipalities, landowners	Short-Term (2008-2010)
1.49	2d. Land use management in relation to water quality	BMP implementation	Riparian Buffer Zone Protection	Overall Bow Basin	Adopt riparian setbacks (e.g. City of Calgary setback policy (COC 2007); Nose Creek Watershed Management Plan (NCWP 2006) in all new developments.	Bow Municipalities	Short-Term (2008-2010)
1.50	2d. Land use management in relation to water quality	BMP implementation	Soil Erosion	Overall Bow Basin	<b>Include erosion and sediment control measures for construction sites in all development plans submitted to municipalities or management agencies (e.g. Alberta Transportation) e.g. The City of Calgary's erosion and sediment control manuals. A requirement for an inspection of the development site by a professional should be included.</b>	Bow Municipalities	Short-Term (2008-2010)
1.51	2d. Land use management in relation to water quality	Target development	Runoff, Erosion and Effective Impervious Areas	Overall Bow Basin	Review the 1) effective impervious area targets, 2) reach-specific runoff volume targets, and 3) erosion control targets for all new developments; to meet water quality objectives.	Bow Municipalities, AENV	Medium-Term (2011-2012)
1.52	2d. Land use management in relation to water quality	Target development	Runoff and Soil Erosion	Bow River Upper, Bow River Below Park Boundary and Elbow River Upper	Review the effectiveness of existing forestry guidelines (e.g., stream crossings, riparian protection, road maintenance) on water quality. Erosion control targets should be developed and implemented for reaches without a target.	ASRD	Short-Term (2008-2010)
1.53	2d. Land use management in relation to water quality	Indicator development	Effective Impervious Areas	Bow River Central & Elbow River Central	Develop effective impervious area targets for all new developments based on the overall goal of trying to achieve pre-development rates & volumes entering the streams or rivers.	Calgary, M.D. of Rocky View, Airdrie, Strathmore, AENV, other municipalities in the reaches	Short-Term (2008-2010)
1.54	2d. Land use management in relation to water quality	BMP implementation	Soil Erosion	Elbow River Upper, Bow River Upper	Continue efforts to reduce erosion from trails, recreation sites or other activities. Erosion and sediment control plans must be developed and implemented for construction sites with any connection to surface water. A requirement for environmental inspection of the development site during (and following) construction (by a qualified professional) should be included.	ASRD*; Alberta Tourism, Parks & Recreation*	Short-Term (2008-2010)
1.55	2d. Land use management in relation to water quality	Target development	Runoff and Effective Impervious Areas	Nose Creek	Enhanced stream and storm water flow monitoring at various points throughout the system is needed to assist in the identification of the impervious and runoff targets.	Calgary, NCWP, AENV	Short-Term (2008-2010)
1.56	2e. Source water protection	Planning	Alluvial Aquifer	Elbow River Central	<b>Land use on alluvial aquifer lands overlying groundwater under the direct influence of surface water (GUDI) has the potential to affect both groundwater and surface water quality. Carefully consider land use in the context of downstream river water uses with appropriate groundwater assessments done prior to development, if any. Groundwater assessments may lead to some additional monitoring.</b>	MD of Rocky View, Tsuu T'ina, City of Calgary	Short-Term (2008-2010)

#	THEME	ACTIVITY	PROPOSED INDICATOR OR TOPIC AREA	RIVER OR REACH	RECOMMENDATIONS	DECISION-MAKERS	IMPLEMENTATION TIMELINES
<p>The recommendation numbers in the leftmost column are referenced in Appendix A for each water quality objective.            *Asterisked Recommendations: Projects that are either in progress or are planned subject to budgetary approval.  <b>Blue Recommendations:</b> Identified by the Technical Committee as being the highest priority based on science for short-term implementation.</p>							
1.57	2f. Wetland and riparian characterization and protection	Objective and indicator development	Wetland and Riparian Health Inventory and Classification	Overall Bow Basin	<b>A comprehensive wetland and riparian inventory which includes drained and altered wetland and developed and degraded riparian areas is critical for source water protection. The inventories to classify wetland and riparian areas at appropriate resolution/scale and according to their existing vegetation, the vegetation potential and the type and intensity of land use occurring within them. Priorization by geographic area (e.g., White/Settled area vs. Green/Forested area, heavily populated versus lightly populated areas). Reassess objectives and indicators of wetland and riparian health that relate to water quality when this is complete.</b>	AENV, DUC, ASRD Cows and Fish*	Short-Term (2008-2010)
1.58	2f. Wetland and riparian characterization and protection	Objective and Indicator development	Wetland Coverage	Overall Bow Basin	The comprehensive wetland inventory capturing historic wetland loss and alteration should be used as an indicator for future state of watershed reporting and planning and the setting of wetland conservation and restoration goals.	BRBC	Short-Term (2008-2010)
1.59	2f. Wetland and riparian characterization and protection	Planning	Wetland and Riparian Restoration and Planning	Overall Bow Basin	Develop a wetland management plan and riparian management plan, based on comprehensive wetland and riparian inventories.	AENV, DUC	Medium-Term (2011-2012)
1.60	2f. Wetland and riparian characterization and protection	Research	Wetlands and Storm water	Overall Bow Basin	Further research to determine the practicality of using existing undisturbed wetlands for storm water treatment purposes.	DUC, AENV, Bow Municipalities, BRBC, ASRD U of C*	Long-Term (2013-2014)
1.61	2f. Wetland and riparian characterization and protection	Research	Wetlands and Water Quality	Overall Bow Basin	Further research into wetland function and which include investigating groundwater recharge and surface water quantity relationships in wetland function.	DUC*, AENV	Medium-Term (2011-2012)