Another benefit is the potential value associated with fish habitat units. Canada's Fisheries Act requires that the Harmful Alteration, Disruption or Destruction of fish habitat (HADD) be offset in a 2:1 ratio; that is, two fish habitat units are required to offset each unit lost to a HADD. The BRP commissioned a literature review of the cost to develop an approved fish habitat unit that could be used as an offset (see sidebar for details). The number of potential offsets created by altering the operating conditions of the Pocaterra power plant (i.e., stabilizing Lower Kananaskis Lake and the Kananaskis River) is enormous. Provincially, there may be significant cost savings, fewer negative environmental impacts, reduced land impacts, and much higher success rates in increasing fish populations simply by creating a fish habitat "bank" of HADD offsets in Kananaskis Country. This would require removing any known regulatory interpretation barriers that may stand in the way of the "offset bank" concept.

Fisherman on the Bow River

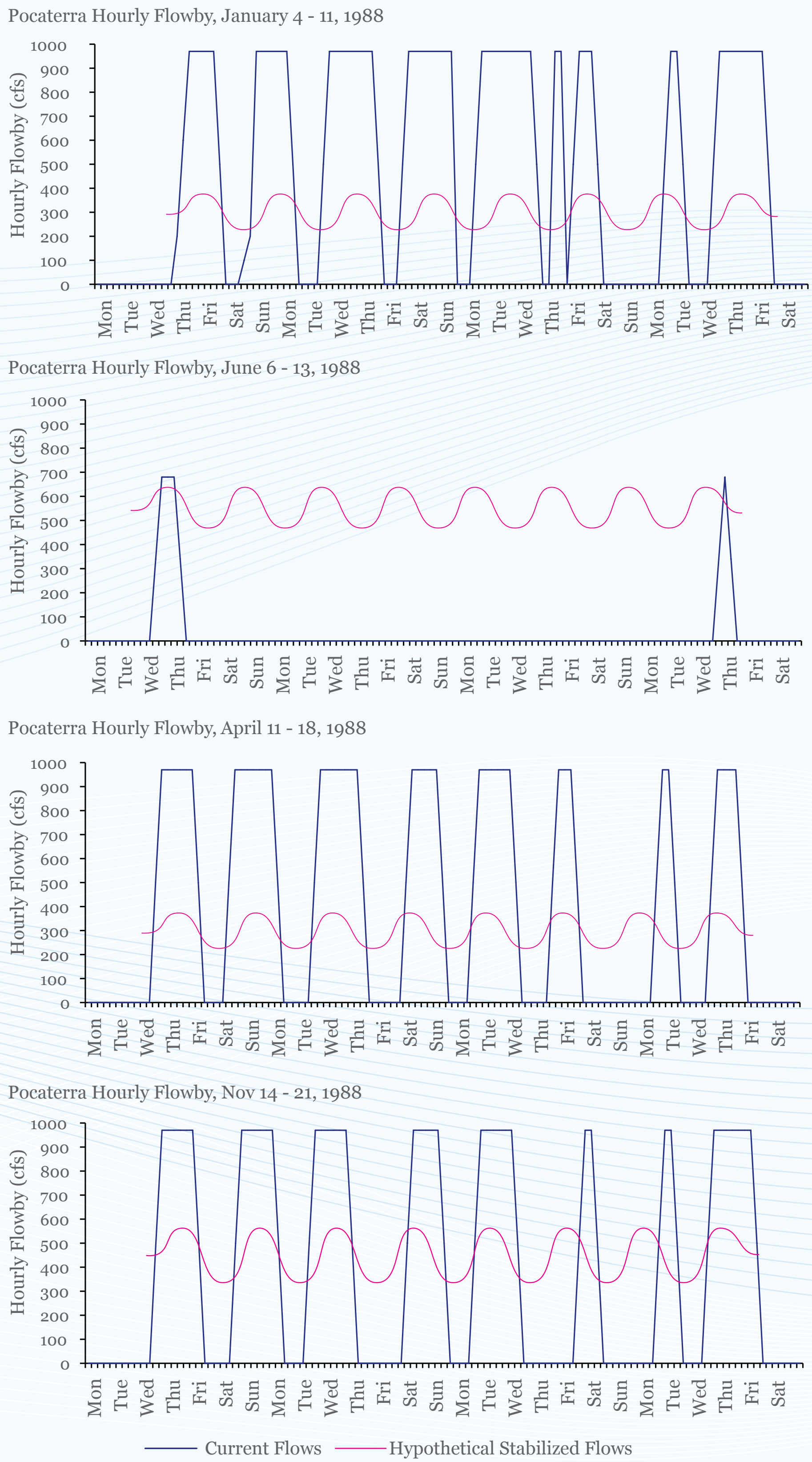
Economic Aspects of Improving Fish Habitat

The FREWG study (2001) concluded that the cost to TransAlta in terms of power generation and capital costs to alter the operating criteria at Pocaterra would be under $1-million per year, at that time. The BRP's modelling work showed these changes would have little effect on power production revenues. Capital costs may be different since the capital equipment has been partially rebuilt. The original wood-stave penstock is currently being replaced. As well, the turbine and generator equipment (15 megawatt capacity with about 30,000 MWhrs annual production) have been in place since 1955 and may be due for replacement. Whether replacement or overhauled equipment is optimized for original operating rules of peak price production or for stabilized flow to enhance biological and fish productivity may not have a large impact on capital cost.

With respect to the value of fish habitat units, a Canadian study has found that the cost of creating them varies from $0.24 to $1,074.00 per square metre (mean=$85.00, SE=$56.00) (Harper and Quigley, 2005). Based on these calculations, any new fish habitat in the Kananaskis River system could have an estimated value of about $85 per m^2. Establishing a market for offsetting at least some of the 2:1 ratio HADD requirement could, over the medium to long term, easily pay for all of the opportunity, capital, and maintenance costs needed to restore the fishery and biological productivity of this high-profile portion of Kananaskis Country.

The current and hypothetical stabilized flows for the Pocaterra facility are illustrated in Figure 17. The hypothetical stabilized flows are estimated flows that are not yet built into the model as more detailed analysis is needed to narrow the proposed operating rules.

FIGURE 17. Current and Hypothetical Stabilized Flows for TransAlta's Pocaterra Facility
{Source: 1988 data from TransAlta; Hypothetical stabilized flows are BRP estimates)



The water level in Lower Kananaskis Lake could be stabilized at the desired level without changing the turbine system in the Pocaterra power facility. As changes are anticipated to this facility anyway, decisions could be made within the next two years to design, engineer and replace the Pocaterra turbine with an efficient mid-range turbine and generator, which would enable flows to be stabilized in the Kananaskis River. Revenue from a stabilized operation will be lower than with the current peak power operation, but this could be partially offset by certifying this facility as generating "green power." This should be acceptable since its new purpose would be dedicated to improving environmental conditions in the Kananaskis River.

3.6.7 WATER QUALITY AND CONSERVATION

The changes proposed in the Preferred Scenario mean that:

- » Water Conservation Objective would be met more often downstream of Bassano during low flow in the spring and fall periods.
- » Water flow levels would be maintained through Calgary at a minimum of 35.4 cms (1250 cfs) year-round to ensure water quality standards continue to be met on an ongoing basis.
- » Water flow through Calgary and downstream would be maintained at a winter level intended to retain or improve the sport fishery between Calgary and the Carseland Dam.
- » Dissolved oxygen levels, temperature and flow rate would be monitored through Calgary to determine if water flow rates could be used to improve dissolved oxygen levels during critical periods.
- » Pending further investigation, overnight flow rates though Cochrane could be maintained or improved to maintain fisheries productivity and improve environmental amenities.

3.6.8 OTHER BENEFITS

Further work is needed, but other potential benefits could also result from implementing the Preferred Scenario, including:

- » Winter water flow through Calgary would be managed to minimize and mitigate ice dam formation.
- » Water flows through Cochrane would continue to be managed to prevent ice dams that create flood conditions.

3.7 POTENTIAL IMPLEMENTATION CONSIDERATIONS

The Consortium acknowledged that there are likely to be some economic impacts related to implementing the Preferred Scenario, which includes several components as noted above. Some of the costs are identified in section 4 but because there are gradients of implementation and each has its own potential costs and benefits, detailed analysis was not possible within the timeframe of this project.

These potential costs vary with the components and need to be refined further, as and when decisions are made to proceed toward implementation. For example, depending on TransAlta's schedule for major maintenance or replacement of equipment, replacing the turbine runner (essentially the water wheel that is powered by flowing water) and possibly the generator at Pocaterra may be an added cost to stabilize flow in the Kananaskis River. (Note: This is not needed to stabilize Lower Kananaskis Lake.) However, if replacement work is already planned for the next few years, the only added capital expense may be the difference between replacing a "peak power" turbine runner with a more "constant flow" turbine. There is likely little difference in cost, and the amount of total power generated should be nearly identical; the difference is whether the water is turned on and off as in current operations, or more regular hourly flows are permitted, similar to the flow from Bearspaw. Additional studies will be needed to ensure the spillway is adequate for the changed operations and other potential local impacts. Depending on the existing maintenance schedule, the actual operating and capital cost for stabilizing Lower Kananaskis Lake and Kananaskis River all the way to Barrier Lake may mostly comprise the lower intra-day power prices realized by a more stable operating rule curve and the different annual flow required by a relatively stable lake level.

Assuming the benefits outweigh the costs, and cost allocation agreements can be reached, a hypothetical sequence of events might be to stabilize Lower Kananaskis Lake in year one, while testing the water bank operating scenario and completing the rehabilitation of the BRID headworks so they can effectively take lower diversion rates during low-flow periods. Lost opportunity costs for TransAlta would include lost peak-power generation (but not total generation) from the small Pocaterra facility and a certain amount of lost peak-power prices for other generating stations on the Bow caused by using the water bank for environmental or other uses at different times than peak power prices are in place. TransAlta may still be able to capture a portion of the peak power prices due to time-of-travel planning when releasing water for downstream purposes.

Capital costs associated with the water bank involve improvements to the diversion canal at Carseland to allow 8.5 cms (300 cfs) diversions rather than the current minimum 14.1 cms (500 cfs), which are thought to be in the $1-million range. This change would allow for more flow downstream of Carseland and Bassano during critical low-flow periods while allowing upstream reservoirs to save the equivalent flow in storage for other purposes. Other costs could include such things as additional risk for testing different operating rules, additional maintenance if any, achieving an adequate rate of return for TransAlta, additional collaboration time for determining required flow rates for different reaches throughout the year, and others.

Implementing the water bank component may postpone the full stabilization of the Kananaskis River until the Pocaterra turbine replacement was scheduled or until the full suite of benefits was determined to be clearly positive. Other improvements could be evaluated and sequentially implemented, or not, as circumstances and careful analysis show significant added value. Further refinement and use of the BROM may uncover options not considered in the short timeframe of the BRP. Additional relatively small studies of potential threats such as flood and drought risk and potential costs, or possible climate change scenarios may either enhance the urgency for certain actions, or provide some assurance that things are being managed adequately and water managers have assessed and addressed the key risks.

3.8 USING THE BROM TO ASSESS ECONOMIC DEVELOPMENT

The BROM offers a flexible, data-driven analytical tool to model and understand the impact of potential new industrial, commercial and real estate developments in the Bow River Basin. Access to water continues to be a critical and costly consideration for population growth and many economic developments in southern Alberta. The ability to understand the true impact of such ventures is a valuable asset for decision makers tasked with planning or approving economic development in a responsible manner.

One example of such use of the model might be to assess the potential flow rate impact of significant water licence transfers. Moving a large diversion upstream or for a different purpose could be modelled for its effects on other users and the environment in the event of future dry years such as represented by the extreme low flows during the 1930s. This type of analysis can be done nearly in real time, saving the director or proponents valuable time and expense.

Perhaps more important, government and other stakeholders and water users can hypothesize various wet and dry years or decades, insert changes in the model to address longer-term climate or shorter-term changing weather patterns, and test whether human water use is protected. They can similarly test under what conditions risks to the water supply become unacceptable, whether for economic, environmental or human usage. Equally important, they can then test what changes to current conditions of conservation, technology, storage and release might be needed to reduce the risk to acceptable levels. Finally, if adequate costs and pricing are known, these can be built into the model to support decisions on least-cost or highest-return alternatives.

4. CONCLUSIONS

The results of this project clearly show that the Bow River System can and should be managed differently. The results of the Bow River Operational Model confirm that proposed changes to improve water management are realistic and doable. They will improve fish and riparian habitat and water flows downstream, enhance recreation opportunities, and potentially improve water quality through many parts of the river. And they can be implemented cost-effectively and in a way that does not significantly diminish economic returns from power generation.

The foundation for these proposed changes is a move to integrated adaptive management of the Bow River System from headwaters to confluence—an approach that considers all users as well as economic, environmental and social impacts. This opportunity represents a significant shift in thinking and action and reflects the approach that is emerging through Alberta's Land-use Framework to place-based management.

The BRP Research Consortium is convinced that if the Bow River and its controlled tributaries were managed as an integrated system, the benefits described in this report would be secured. In support of this conclusion, the Consortium has identified five opportunities for consideration by the Government of Alberta and others with a stake in the way the Bow River System is used and managed.

The key components of the Base Case and the Preferred Scenario are illustrated in Figures 18 and 19.

FIGURE 18. BRP Base Case Summary (Current Situation)

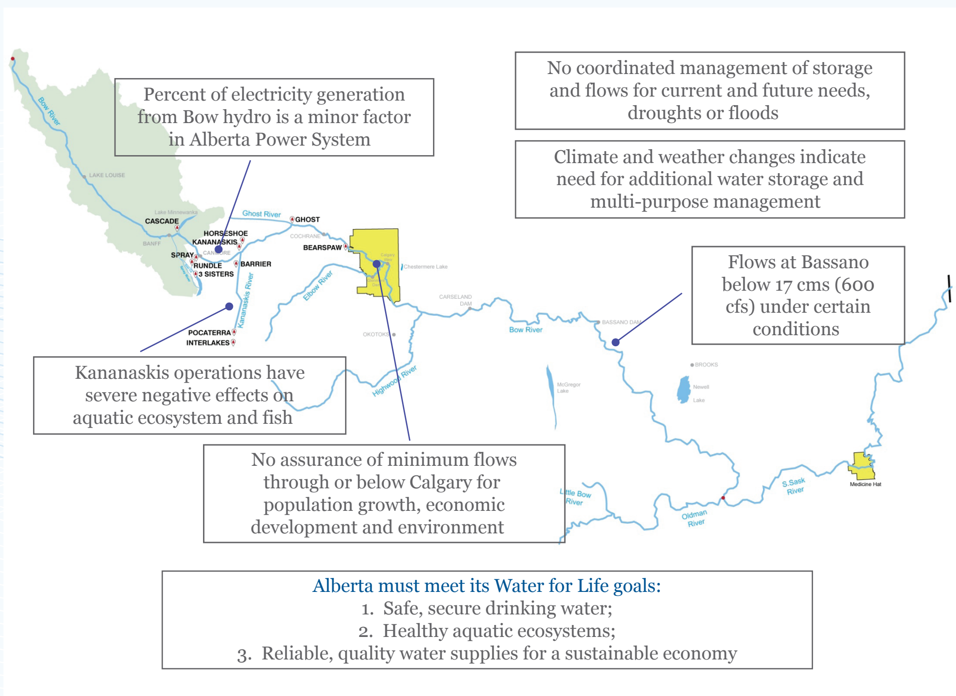
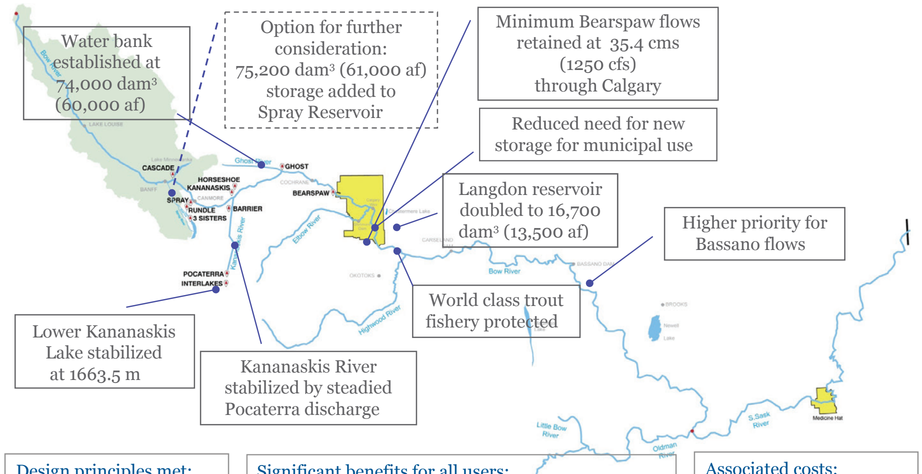


FIGURE 19. BRP Preferred Scenario Summary



Design principles met:

- Net benefit to environment
- Population, economic needs met
- Apportionment met
- Minimum flows met
- Known First Nations requirements met
- Priority water allocations respected
- TransAlta costs covered

Significant benefits for all users:

- Enhanced flows below Bassano & other reaches during low-flow periods
- Protected Calgary flow levels ensuring water quality standards, fisheries protection and reduced ice jams
- Aquatic health, fisheries and recreation improvements in Lower Kananaskis Lake & Kananaskis River
- Greater opportunities to support growing population demands
- Offers flood & drought mitigation options
- Improved alignment of irrigation needs, environmental values and upstream users

Associated costs:

- Compensation for lost TransAlta revenue
- Additional recreation facilities
- Possible capital for Pocaterra turbine
- Possible capital for Spray restoration

Spray Lakes Reservoir in Spray Valley above Canmore

Table 4 summarizes the benefits and costs of the Preferred Scenario compared with the Base Case.

TABLE 4. Benefits and Costs Comparison for the Preferred Scenario

BENEFITS of Preferred Scenario over Base Case	COSTS of Preferred Scenario over Base Case
DIRECT BENEFITS: » Greater achievement of WCOs below Bassano and along Bow River » Protected Calgary flow levels ensure water quality standards and protect fisheries » Aquatic health and fisheries improvements in Lower Kananaskis Lake and Kananaskis River » Opportunity to monetize significant fish habitat offsets in Kananaskis » Enhanced recreation and tourism, specifically in the Kananaskis region but also throughout the Bow Basin » Adequate, quality raw water supply for growing population demands in Calgary and region » Improved alignment of irrigation needs, environmental values and upstream users » Potential to explore and implement further flood and drought mitigation options AVOIDED COSTS: » Reduced infrastructure damage from ice dams in parks and municipalities » Reduced damage from flood events » Reduced damage from drought events » Reduced need for high cost new reservoirs	CAPITAL COSTS: » Replacement of Pocaterra turbine to accommodate steadied flows into Kananaskis River: preliminary estimate of $5-6-million based on 1998 estimate for Ghost Unit #1 replacement (FREWG) » Option for consideration: Restoration of Spray Lakes Reservoir to original FSL, adding 74,200 dam^3 (61,000 acre feet); preliminary estimates range from $20-100-million » Other costs may be identified OPERATING COSTS: » Compensation for lost TA revenue: preliminary estimate from BROM suggests lost revenue from power generation would be $2-2.5-million » Other costs may be identified

In summary, the Consortium believes there is potential for substantial economic, environmental and social benefits for relatively modest cost.

5. OPPORTUNITIES FOR INTEGRATED MANAGEMENT OF THE BOW RIVER SYSTEM

OPPORTUNITY 1: Manage the Bow River System in an integrated, adaptive, end-to-end manner, considering all users, interests and values

River systems are complex and present many challenges to those charged with their management. The Bow River System is particularly complex as it includes TransAlta's 11 on-stream hydro facilities, the Glenmore reservoir in the City of Calgary, numerous off-stream reservoirs throughout three large irrigation districts, and thousands of water diversion licences.

At present, many parties are involved in managing the Bow River System on a reach-by-reach basis for independent purposes. Upstream of Calgary, TransAlta has managed the system for nearly 100 years for the primary purpose of generating electricity. Downstream reservoirs are managed with a focus on meeting the needs of the large irrigation districts. Other parts of the river are managed to meet municipal needs such as drinking water and dilution of wastewater. Social and environmental considerations such as fisheries, aquatic and riparian habitat, and recreation are not always factored into these management decisions, although they can have important economic spin-offs too. Integrated management would optimize opportunities for licence holders, the environment and other users along the entire system.

OPPORTUNITY 2: Pursue and support discussions between the Government of Alberta and TransAlta

Although TransAlta's primary interest is managing the Bow River System to maximize power generation revenues, the company continues to work collaboratively with other water users. TransAlta is now facing significant capital upgrades to its operating system, which creates a rare window of opportunity to influence near- and long-term infrastructure investment choices and introduce a new management approach. The BRP Research Consortium sees a unique and timely opportunity for the Government of Alberta and TransAlta to discuss and negotiate the benefits, costs and opportunities related to integrated management of the Bow River System, specifically with regard to the storage reservoirs upstream of Calgary.

OPPORTUNITY 3: Identify and consolidate the functions required to enable integrated, adaptive management of the Bow River System

The opportunity to take a new direction, as proposed in this report, would mean re-managing the Bow River as an integrated system from source to confluence, with a new long-term management function. The Government of Alberta could continue to be ultimately accountable for administration of water and watershed management activities, but the success of these efforts in the Bow Basin depends on a shared approach to management involving the key water managers and users of the resource. The collaborative approach used in this project and the resulting tool—the Bow River Operational Model—exemplify the importance and value of knowledgeable stakeholders working together, with access to agreed-upon data.

A multi-stakeholder group comprising at least some of the members of the Bow River Project Research Consortium should be convened to design the potential roles, processes and authorities of a shared management function and should draw on the many successful examples from other jurisdictions.

OPPORTUNITY 4: Encourage and enable transparency and open data

Collaborative and transparent processes can successfully address complex, multi-faceted issues, yielding cost-effective, innovative approaches that would likely never have emerged without all the affected stakeholders at the table. The right information is a fundamental element for success and the Consortium worked hard with its partners to secure access to timely and reliable data on which to base its analysis. Often this valuable data and other information are held by the provincial government and it is not always easy to determine what is available and how to access it. The Consortium greatly appreciated the wealth of data provided to it, and encourages the Government of Alberta and stakeholders to explore ways and means of making these excellent resources more easily accessible to researchers and others engaged in similar initiatives. Ongoing open public access to the Bow River Basin data, the BROM, and the body of knowledge being built about river management is particularly desirable.

Pike fishing in the Bow River Basin

OPPORTUNITY 5: Continue working toward an improved and integrated Bow River Management System

The results reflected in this report have yielded important insights into opportunities for better managing the Bow River System. However, additional work is needed to:

a) ensure that all the goals identified for the project are met without unintended consequences, and

b) identify and assemble data to further enhance the Bow River Operational Model and contribute to efforts that may emerge from this project to model other river systems in Alberta.

Moving ahead with this work in 2011 would build on the momentum from this phase of the project and would provide timely support for discussions between the Government of Alberta and TransAlta. As well, other stakeholders may be in a position to take action in some of the six areas identified below where more work is needed.

ECONOMIC ANALYSIS

» Refine the estimated financial impact of potential alternative scenarios on TransAlta's power and ancillary businesses. While this project provided estimates of the financial impact, a more thorough and comprehensive assessment is needed to strengthen the precision of the economic analysis.

» Determine the capital and operating costs of needed infrastructure changes, such as changes to the Spray Lakes Reservoir and Pocaterra turbine, to support the integrated re-management of the Bow River System; for example, a geotechnical study on the Three Sisters Dam should be done to narrow the range of estimated cost.

- Assess new infrastructure-related requirements to support an enhanced recreation and tourism industry.

ECOLOGICAL AND ENVIRONMENTAL CONSIDERATIONS

- Assess the impacts on the Bow River System of a new WID reservoir for residential and irrigation purposes.

- Improving the canal from the Carseland diversion to McGregor reservoir to enable lower rates of off-take is another opportunity for enhancing environmental flow in the lower Bow River during the critical low-flow period in late summer. This would enable the associated large reservoirs to fill during high flows and later be able to divert much lower flow rates (8.5 vs. 14.1 cms, or 300 vs. 500 cfs) during low-flow periods later in the summer. Cost to alter the diversion and associated infrastructure is minimal and can provide measurable environmental benefits downstream of Carseland.

- Confirm the value, potential market and regulatory applicability of potential fish habitat offsets in the Kananaskis system. Removal of regulatory interpretation barriers to using this resource could essentially pay for all or most of the opportunities described in this report.

- Investigate opportunities to enhance riparian health downstream of Carseland and Bassano. Controlled, limited floods at appropriate times, perhaps to coincide with low-level natural flood periods, offer a substantial benefit. Pulsed flows, rather than continual high flows, have also demonstrated beneficial impacts. Research conducted on the Oldman and Red Deer rivers have indicated that riparian health can be improved significantly without a prolonged period of inundation and could thus be planned and managed for some critical areas as part of an overall adaptive management system.

MODELLING

- Further integrate water quality metrics into the Bow River Operational Model; some monitoring and assessment may require hourly data. Leverage the metrics, standards and tools already available for the Bow River System; examples include those developed and used by the Bow River Basin Council.

- Leverage existing climate change models to incorporate into BROM the potential impacts of climate change and adaptation to the extent that global circulation models show potential results even more extreme than the historic and pre-historic record. Precipitation falling as rain rather than snow in the early fall and spring at higher elevations could create conditions of severe flood followed by drought in the same year. Further modelling could enable a prudent consideration of risks, options, costs and benefits of alternative mitigation scenarios under such conditions. Future efforts using existing models can provide water managers with greater ability to respond to the potential effects of climate change on the river system.

- Further explore and refine the balancing of reservoir releases under the water bank philosophy to optimize the use of storage capacity, natural fill periods and offsetting flow patterns. In addition, consider using the available flow releases to meet the other downstream needs beyond the flows below Bassano (as currently modelled).

- Develop a suite of comprehensive environmental performance measures to reduce the uncertainty in projecting environmental outcomes.

INSTITUTIONAL ARRANGEMENTS

- Design a possible stored-water insurance arrangement between TransAlta, municipalities, environmental flow and other users. The feasibility of this action has been modelled in the water bank scenarios (Scenarios 2, 3 and 4 in section 3.2.2).

  It is understood that TransAlta prefers a single entity with which to negotiate this or any alternative arrangement to change the operational flow of the Bow River and its tributaries upstream of Calgary. The Consortium encourages the Government of Alberta to be that entity to sort out the specifics of any additional commercial arrangements that may be needed at a later date.

DROUGHT AND FLOOD MITIGATION

- Conduct a preliminary assessment of potential storage expansion of upstream reservoirs for long-term additions to storage, in the event that flood mitigation and/or precipitation capture is shown to be needed as adaptation mechanisms to a changing climate or long-term weather patterns. Likely candidates would be Minnewanka, Upper Kananaskis Lake and Ghost reservoir, although Barrier may also have some small capacity for additional storage if needed.

- Explore flood mitigation opportunities such as improved forecasting of snowpack, weather systems and precipitation. Although heavy rainfall during already high runoff periods is the usual cause of severe flooding, some climate change models forecast rain in place of snow, including possibly late fall or spring rain instead of snow. Both of these conditions may cause more frequent flood flows at different times of the year than has been the usual historic pattern. Coordinated reservoir draw-downs and fills, emergency-only Ghost reservoir storage, and emergency-only increases in Ghost diversion to Lake Minnewanka may be beneficial but have not been analyzed.

- Explore drought mitigation opportunities using integrated reservoir and flow management (e.g., reliable forecasts to support spring draw-down decisions, feasibility of storing water across seasons, Lower Kananaskis Lake storage as “last resort” emergency supply, continued fall filling of irrigation district reservoirs).

GREEN POWER

- Assess the option of green power certification for certain re-managed Bow River hydro facilities. Current criteria for green power hydro have numerous requirements that work for certain other situations in Canada but don’t apply well to some Alberta facilities (e.g., requirements for fish passage). In the Bow watershed, providing fish passage may lead to further upstream intrusion of non-native species that could be harmful to natural ecosystems. Furthermore, upstream fish passage may not have occurred prior to dam construction (e.g., there were falls just below Lower Kananaskis Lake).

  If TransAlta is planning to rebuild some of its facilities, the criterion that facilities need to be relatively new will fit the Bow situation. Green power premiums would not be enough to cover expected costs to TransAlta for a re-managed system, but would represent another source of revenue that could act as an incentive for environmental improvements.

Climate Change Forecasts

The BRP modelled the flow in the Bow River System for each year from 1928 to 1995—a period that included many extreme weather events as well as the prolonged drought known as the "dirty thirties." However, some believe that global climate factors may be changing such that even more extreme weather events or more subtle but highly significant changes could occur in the future. The time constraints of this project meant it was not possible to integrate Global Circulation Models of climate change forecasts into the base case or the modelled scenarios and stress tests. The Consortium did model extremely wet and dry periods but climate change-related weather changes could result in different precipitation patterns rather than simply more or less precipitation. Although climate change scenarios may only add to the urgency of making some of the changes described in this report, prudence indicates that further work is needed to test certain climate change weather patterns and their implications.

Most worrisome is not that the region receives more or less precipitation, but that the timing and nature of the precipitation changes. If weather patterns change such that precipitation occurs earlier in the winter and as rain rather than snow, there could be implications for water storage reservoirs. Snowpack provides approximately 80% of the total annual flow in the Bow River. Snowpack acts as, by far, the largest reservoir, storing vast amounts of water-equivalent during winter. In the spring, snowmelt is used to refill reservoirs all along the Bow. Gradually melting snowpack increases river flow in early spring, and creates high flow periods from May to July each year. If winter precipitation comes as rain, whether early or late in the winter, current reservoir capacity may be inadequate to continue managing the flow the same as in the past and in the manner modelled in the BRP.

Another rarely considered possibility is that the climate might change such that the glaciers on the east side of the Continental Divide begin growing rather than receding as they have done since at least the late 1800s. Although glacial melt contributes a relatively small amount to the total annual flow, during mid-summer its contribution is quite substantial in the upper Bow. Environmental consequences could be significant, especially for the pure strain west-slope cutthroat trout, the tourism attractiveness of the region and even the water supply in Banff. The BROM can model these and many alternative scenarios related to changed weather patterns throughout the basin, but particularly for the headwaters region, which affects the environmental, social, and economic bases of the entire watershed.

5.1 ADVANCING THE GOALS OF WATER FOR LIFE

The vision of the BRP is to improve environmental conditions in the Bow River System by more efficiently and productively using the available water for purposes in addition to power generation. This project, like all projects sponsored wholly or in part by the AWRI, takes the *Water for Life* goals as a starting point and as criteria for achievement; as described below, the BRP encompasses all three *Water for Life* goals in innovative and significant ways.