9 Option Development Process

9 Option Development Process

The process undertaken to develop a new operational strategy for the Muskoka River system (lakes and river reaches) is described in detail in the *Options Report Muskoka River Water Management Plan* (Acres 2004a). The process is summarized in Figure 9.1.

The option development process was initiated by the Planning Team during a series of 'brain storming' sessions (beginning with a 2-day meeting May 13 and 14, 2003) that examined the background information available for the Muskoka River system, the issues and concerns previously identified, and the data gaps and results of the recently completed data collection investigation (see Section 8). In addition, most Planning Team members worked and/or lived within the Muskoka River watershed, and were able to bring local knowledge and expertise to the table. The process continued through a series of Planning Team, Public Advisory Committee (PAC) and Steering Committee[*] meetings and discussions until a preliminary preferred option was developed.

The discussions resulted in the identification of a number of key features of the Muskoka River watershed that were given primary consideration in the development of goals and objectives for the Water Management Planning process. A number of the most important, relevant features are as follows:

- Many of the larger lakes and associated river reaches within the watershed are extensively developed for recreational use, with well established, long-term, high value infrastructure (cottages, boathouses, resorts, camps, etc).
- Recreational boating occurs to varying degrees on almost all watershed lakes, with commercial navigation (tour/sight-seeing boats) an important commercial activity on the larger lakes.
- Ecological conditions within the watershed are generally good, although the potential for improvement in specific areas had been identified (A&A, 2003a).
- The existing operational plan (as documented in the Muskoka River Dam Operation Manual, MNR, 1997) provided specific amounts of base flow

[*] Steering Committee, Planning Team, and Public Advisory Committee members are listed in Appendix A.

below individual dams throughout the watershed. While these flow targets were often met in lower portions of the watershed, the provision of base flow in upper watershed river reaches and the specific contribution from individual lakes/reaches was less well defined.

- The dams have increasingly less ability to control lake levels and river flows and levels as inputs (i.e., rainfall, snow melt) to the system increase. During high input periods, such as the spring freshet and other large seasonal storm events, no control is exerted and dams are intentionally opened to allow the flow to pass unhindered through the system.

- The waterpower sites within the watershed are all located on riverine portions of the watershed, and are 'run-of-river' operations. Management of the dams at the outlet of upstream lakes provides the flow required for the operation of these facilities.

- Existing structures have specific limits in terms of flow passage and water retention capability. Only water level and flow changes that could be accommodated within the operational constraints of the present structures should be considered.

These and other characteristics of the watershed were used to develop a series of goals and objectives for the water management planning process for the Muskoka River watershed, which have been grouped into three categories, being ecological, social and economic objectives. Subsequently specific features, issues and considerations were identified and documented for the various water bodies and river reaches. The results of additional studies or investigations were incorporated to provide a complete listing of watershed characteristics and issues.

9.1 General Watershed-Wide Objectives

9.1.1 Ecological Objectives

As noted in the Aquatic Ecosystem Guidelines (MNR, 2003), "The dynamic variability of a river's flow organizes and defines river ecosystems and their biodiversity, production, and sustainability. Native biota and riverine communities have evolved with, and adapted to, the natural flow regime of a river system, including the seasonal and inter-annual variability that is an ecologically important part of this natural cycle. A range of flows is necessary to scour and revitalize gravel beds, to import wood and organic matter from the floodplain, and to provide access to productive riparian wetlands. The natural flow regime of a river plays a critical role in sustaining a river's native biodiversity and protection ecological integrity through its influence on geomorphic and ecological processes and its control over the distribution and abundance of riverine species."

Ecological principles acknowledge that variability is an integral component of any normal ecosystem, and contributes to the diversity of its flora and fauna. Under natural conditions, lake levels and river flows fluctuate around some median level. Too little or too much fluctuation (as a result of imposed controls) can result in reduced diversity of both habitats and species. Accordingly, a number of ecological objectives were developed for the watershed as potential goals for the future operation of watershed lakes and rivers. Information from applicable guidance documents and the scientific literature was utilized in the development of these objectives.

1. Allow a reasonable amount of annual and inter-annual variability of lake levels. Based on information derived from the literature (A&A, 2003b, see also Section 8.2.4), the annual variability of lake levels (spring peak to late summer/fall minimum) could be up to 1.0 m (depending on lake size and inputs). On an inter-annual basis, this difference could approach 1.5 m once every 5 years.

2. Spring lake levels should be allowed to rise 30 to 50 cm above the level of established shoreline vegetation (30 to 50 cm increase not unusual in natural systems). Benefits arising from this objective include:

    - recharging of groundwater supplies
    - inundation of wetlands and shoreline vegetation and associated transfer of flood water nutrients to these areas
    - provision of access to spawning grounds and flooded shoreline vegetation for spring spawning species.

3. The duration of higher spring levels should be in the order of 45 days to allow offspring (fry) arising from spring spawning species that utilize the floodplain to return to the lake or river environment.

4. Lake levels should be allowed to fall during the summer (minimum 20 to 30 cm). Receding water levels provide new habitats for the development

of shoreline species, which will increase the overall diversity of the plant and animal communities of the water/land interface in the long term.

5. In the absence of detailed information on the location and depth of lake trout spawning shoals, the late winter/early spring water level in lake trout lakes should not be lower than the fall water level during lake trout spawning (approximately mid-late October). Where the depth of lake trout spawning shoals is known, the fall water level should strive to maintain a minimum water depth of 20 cm over the top of the spawning shoal.

6. Base flow should be maintained in all river reaches during normal hydrological conditions. During drought conditions, a minimum flow should be maintained to preserve ecological integrity of the river system.

9.1.2 Social Objectives

The following outlines the basic social objectives for the planning process.

1. Many of the large lakes within the Muskoka River system have well established, high-value shoreline infrastructure (cottages, boathouses, docks, and associated systems). Much of the infrastructure has been built around the present operational regime. Major changes to water levels or river flows that will significantly impact infrastructure will be avoided, unless they are being proposed to address significant other concerns. As a starting point, proposed changes will remain within the existing NOZ on those lakes where there is significant infrastructure.

2. The frequency and magnitude of flow changes within river reaches had been identified as a concern during the Phase I study. Daily flows should be compared to the maximum daily flow criteria outlined in the Dam Operation Manual (MNR, 1997) in river reaches with significant infrastructure. Equal consideration should be given to river flows/water levels as lake levels.

3. River system flows must provide adequate supplies for any water taking purposes (e.g., irrigation, domestic water supplies, and municipal requirements) as well as waste assimilation.

4. Recreational boating (primarily during the summer months) and commercial navigation on Lake Muskoka, Lakes Rosseau/Joseph and the Huntsville lakes from May to October are important traditional features of the Muskoka watershed. River reaches provide access between lakes (i.e., North Muskoka between Huntsville lakes and Mary Lake, Indian River between Lake Muskoka and Lakes Joseph and Rosseau) as well as other recreational opportunities (canoeing, kayaking, etc).

5. Winter sporting activities (snowmobiling, ice fishing, etc) that utilize or cross over frozen water bodies require stable lake levels and/or river flows to maintain ice integrity.

6. The beneficial aspects of waterpower generation, as a renewable energy resource, will be taken into account. Recent government renewable energy initiatives recognize waterpower has important social benefits, including: displacement of greenhouse gases, decreasing respiratory illness and disease, reduction of smog and load following ability (i.e., the ability of waterpower to make quick changes in generation output to meet consumer needs). Waterpower, as a form of "green" power, achieves these objectives by reducing smog and greenhouse gases and associated health and ecosystem effects.

To clarify water level constraints related to infrastructure, studies were undertaken in 2002 and 2003 to determine the elevation of existing infrastructure (boathouses and docks) in relation to water levels (A&A, 2002; Acres, 2003a and 2004c). The surveys were undertaken on Lake Muskoka, Lakes Rosseau and Joseph, Lake of Bays, Kawagama Lake, Matthias reservoir, Mary Lake (including the North Muskoka River south of Huntsville), Lake Vernon, Peninsula Lake, Fairy Lake, Tasso Lake and Camp Lake. Information from these studies was utilized by the Planning Team in the development and evaluation of alternative operating strategies.

9.1.3 Economic Objectives

The following economic objectives were used to guide the planning process.

1. Waterpower production should be maintained at its present level and/or enhanced if possible.

2. Opportunities to reduce the operation of MNR owned/operated control structures should be investigated/implemented as possible.

3. Existing commercial activities (e.g., marinas, boat tour operations, campgrounds, etc) should not be negatively impacted.

4. Practical solutions to water management should be sought which can be implemented within current budgetary constraints.

9.2 Subwatershed Issues and Considerations

While the above-noted general objectives applied broadly to most river reaches and lakes across the watershed, there were also a number of unique features of each subwatershed that needed to be taken into consideration in the development of any alternative water management strategy. Table 9.1 provides a summary of the issues considered by subwatershed and lake in the options development. This information is presented in full in Section 3 of the Options Report (Acres, 2004a).

9.3 Base Case Model

A computer model of the Muskoka River system was set up as part of the Phase I study and is fully described in the Background Information Report (A&A 2003a). ARSP was used to model the operation of the physical structures (dams and waterpower facilities) which store and release water throughout the river system. A Base Case model was set up to simulate the period from 1970 to 2000 (31 years of data) which represents the Muskoka River system as it is currently operated, and coincides with the period of time that the most recent version of the Hackner-Holden Agreement has been in effect.

The ARSP computer model is most easily thought of as a network of nodes and channels, where each node represents either a junction point or a storage location in the system (such as a lake or reservoir), and each channel represents a potential path for water to move through the basin. These channel types include river reaches, powerhouse turbines, dam spillways, locks and local inflows. Each channel originating at a lake or reservoir contains a structure that defines the maximum discharge limits through its outlet gates, spillwalls or valves into the downstream river reach. The schematic of the Muskoka River ARSP model, illustrating river reaches, junctions, lakes and structures, is shown in Figure 9.2. Other model input parameters that are required for accurate simulation of the watershed include the discharge rating curves for the dams and weirs, reservoir storage curves, evaporation losses, reservoir operating plans and criteria, and minimum and maximum flow constraints for various channel sections/river reaches.

As illustrated in Figure 5.3, the operation of the dams follows an established operating regime that targets a defined range of water levels during specific season intervals. The annual operating range for a managed lake typically includes a fall and/or winter drawdown, a rapid rise in lake level during the spring as the snowmelt and spring rains fill the lake, and a relatively stable summer water level. The exact timing and the magnitude of the drawdown and/or seasonal peak varies from lake to lake within the system, and depends on the contributions of the upstream drainage area, the operational characteristics of the structure, and various ecological, social and navigational constraints. The operating plans include a TOL around which water levels normally fluctuate. This NOZ is the typical variability around the target level. The frequency of dam operation varies throughout the watershed, with some of the more remote headwater dams, which are not readily accessible, operated on a seasonal basis, while other more accessible structures, may be operated on a daily or weekly basis in response to rainfall or snowmelt events.

In setting up the ARSP model, these operating regimes are entered into the model for each lake or reservoir. The water levels bounding the different operating zones are linked in the model with a penalty structure, which is used to describe the operating policy for each dam and associated lake. The NOZ is associated with a lower penalty than water levels within the higher or lower zones. The magnitude of the penalty increases as the water level moves away from the TOL, that typically has a penalty of zero. Likewise, flow constraints in river reaches are modeled in ARSP as flow ranges associated with penalties. A preferred flow range will have a low penalty and flows below minimum ecological requirements will have higher penalties, as will high flood flows. The model simulates the movement of water through the elements of the river system by allocating priorities to storage or release of water from the lakes and through river reaches, such that it minimizes the sum of all penalties incurred throughout the river and lake network. Appropriate model setup requires considerable expertise and is labor intensive as it is often a 'trial and error' process to establish the correct penalty structure that reflects actual system conditions.

The physical model is driven by inflow hydrology (flows that would result from rainfall events within the watershed) which represents flow entering the system at each sub-basin. These local inflows are indicated as inflow channels or arrows in the model schematic shown in Figure 9.2. The time series flow data used in model setup was derived from WSC gauges with long periods of record, being: the Black River WSC gauge number 02EC002 and the North Magnetawan River WSC gauge 02EA005, located in close proximity and in a similar hydrologic region to the Muskoka basin, and the Big East River WSC gauge number 02EB013, which is located in the study basin. These daily flows were pro-rated on a drainage area basis for each sub-basin in the system. In response to these inflows and the starting water levels for each lake, the model makes a decision for each simulation time step on whether to store or release and route water. During simulation runs, the model attempts to minimize the total penalty "cost" during the specified simulation period.

Incorporation of Historic Fluctuations

The Phase I Base Case model was calibrated and verified through a series of iterative model runs until the simulation results closely matched actual water level and flow data from the Muskoka River system. At the start of next phase of the WMP process, a modification to the model was initiated to make it more representative of natural conditions within the watershed, by incorporating the range of historic water level fluctuations into the base case model. While it was recognized that water level fluctuations are a direct result of rainfall and/or snowmelt events or periods of drought, those events are often moderated by operational changes at the dams in order to remain within the established operating zone. However, strict adherence to the TOL is unrealistic/not possible due to the excessive number of dam operations that would be required (micro-management) and the associated costs (time and manpower to operate the dams) that would be incurred.

Historic water level and flow data were obtained for Huntsville lakes, Mary Lake, Kawagama Lake, Lake of Bays, and Lake Muskoka for the period from 1980 to 1998, while only water level data was available for Lakes Joseph and Rosseau and Go Home Lake. An example of the historic water level and river flow data (for

Lake of Bays and Baysville dam outflow) is presented in Figure 9.3. Daily water level information is presented as a frequency distribution superimposed on the lake operating zone. The statistics summarize the range of levels recorded on each day over the period of record (1980 to 1998 for most lakes), and provide the mean and median daily water level, the daily minimum and maximum water level, and the 80% range (i.e., range within which daily water levels occur 80% of the time). Flows are summarized on a weekly basis. The plots indicate that historic water levels were within the NOZ most of the time, and that fluctuating lake level/river flows are a normal occurrence (i.e., it is very difficult to operate a dam so as to maintain lake level or river flow to a specific target level). Water levels occasionally move into the upper and lower operating zones, and less frequently into the high and low water zones (only during significant flood and/or drought events).

In order for the Base Case model to more closely reflect the historical water level variability, the ARSP penalty structure was “relaxed” to allow water levels to fluctuate within the NOZ. This often required successive iterations until a similar level of variability as was present within the historical data sets could be achieved in the model simulation. Relaxing the penalty structure eliminated the model’s tendency to maintain water levels at one preferred elevation (i.e., the TOL). As noted previously, the first phase model set-up simulated the 31-yr period (1970 to 2000) which corresponds to the implementation of the current Hackner-Holden Agreement. In addition, as the new WMP would replace the old agreement, it was deemed that an extended period of record (i.e., 50 years of hydrology data) would provide a better representation of the variability of the river system flows. The hydrology was therefore updated to include more information for subsequent modeling of the river basin. Available hydrologic data within the basin that best represents natural runoff is the Big East River - WSC Gauge 02EB013. Although there are a number of small control dams upstream of this gauge, the storage volume of those dams is small compared to the annual runoff, and the flow in the Big East River is very close to natural. To develop the 50 years of hydrology, the recorded flows for the Big East gauge were extended, by performing a regression analysis to develop equations that would transform known natural flows at North Magnetawan River near Burk’s Falls (WSC 02EA005), North Magnetawan River above Pickerel Lake (WSC 02EA010), and the Black River (WSC 02EC002) into estimated natural flows in the Big East River. These equations were used to develop flows from January 1939 to June 1973. Recorded flows in the Big East

River from July 1973 to December 2000 were used 'as is' to complete the 50-yr period of record.

The result of the final simulation runs of the existing operating regimes with the revised penalty structure and updated hydrology was termed Base Case 2. This model run was used as the basis for comparison with all alternate operating strategies developed during the remainder of the planning process.

9.4 Case One

A river system like the Muskoka is a complex series of interactions between lake levels and river flows and levels as water moves through the system. Changes to levels or flows within one lake or river section could result in changes to levels and flows within other parts of the system (particularly downstream) that may have adverse or cumulative effects. The Case One option was developed as a "first cut" that addressed primarily individual lake or river reach issues without prior knowledge of the potential adverse or cumulative effects which could arise at other locations within the river system if the proposed changes were implemented. The proposed modifications to the lake operating regimes were entered into the ARSP model, and a run was carried out to assess the effects (on a river system wide basis) of the proposed changes. The goals/expectations arising from the Case One model run were as follows:

- determine the effect of the proposed operating changes on spring flood levels
- determine the effect of the proposed operating changes on waterpower production
- identify any adverse or potentially 'cumulative' effects (i.e., a series of small changes in a number of upstream lakes could result in a large change in a downstream lake or river reach)
- assess the magnitude of any resultant changes.

The Case One model run was intended to evaluate the feasibility of the overall management strategy, and provide a starting point for subsequent "fine tuning" (i.e., development of a preferred option). No attempt was made to develop or refine the NOZ around the TOL at this early point in the planning process.

The results of the Case One model run were presented to the Planning Team and PAC on August 6, 2003 for review and discussion. Upon completion of the review and subsequent evaluation of the proposed changes, it became apparent that the overall strategy was workable, but additional “fine tuning” would be required to balance the various interests and issues identified within various lakes and river reaches, and integrate them into an operating plan that was functional on a watershed basis. An example of the Case One Option and model output for Lake of Bays is provided in Figure 9.4, while a complete description of the Case One Option for other managed lakes is provided in the Options Report (Acres, 2004a).

9.5 Case Two Option

The Case Two Option was developed as an iterative process in which successive changes were made to the operating regime of individual lakes (in some cases four or five different flow/water level options were postulated and assessed) to address identified concerns in those lake and/or associated downstream river reach (as identified at the completion of the Case One option evaluation) while resulting changes were monitored/evaluated on a river system wide basis. For example, spring water levels that were too high on an individual lake could be addressed by lowering the winter drawdown level in the affected lake (to increase lake storage volume and the ability to manage the spring freshet), or by altering the inflow to the lake by adjusting the operation of upstream lakes/river sections (if possible). Alternately, the effect of a change to the fall water level could be examined in terms of its impact on lake storage and spring water levels. The model allowed alternate operating strategies to be evaluated, and lead to the selection of a ‘best or preferred’ means of addressing particular issues while maintaining a system wide perspective.

In developing the Case Two Option, closer attention was paid to flows within individual river reaches (and specific flow constraints within those reaches) and the development of operational strategies that would respond to identified concerns. The main river reach concerns that were addressed were the day-to-day variability of flows and minimum flows. Under the Case Two Option, the available storage within the NOZ zone on the large lakes would be utilized to modulate the discharges from the dams to provide more gradual changes in river flows and provide minimum flows in the stream reaches. This would result in more frequent fluctuation in lake levels than with the Base Case, but these level changes would be gradual during average conditions and would be significantly less than the average fluctuations in river water levels. This also provides more consistent flows for hydropower, which would potentially increase generation of energy. The criteria used to compare/evaluate the Case 2 Option against the present operating regime (Base Case 2) are described in the following section.

Table 9.1

Issues and Considerations* Related to Water Levels and Flows (by Subwatershed and Lake)

	Environmental								Social										Economic/Engineering	
	Fish Habitat																			
	Lake Trout Lake	Brook Trout	Walleye Spawning	Cold Water Fishery	Warm Water Fishery	Downstream Base Flow	Littoral and Riparian Habitat	Shoreline Erosion	Recreational Lake	Infrastructure Requirements	Flooding	Navigation	Rapidly Fluctuating Water Levels	Ice Damage	Low Winter Water Levels	Water Quality	Drought – Low Water Levels	Aesthetics	Flow for Water Power (Hackner-Holden Agreement)	Difficult Operation
North Branch																				
McCraney Lake	✓	✓		✓		✓	✓		✓			✓							✓	✓
Camp Lake	✓	✓		✓		✓			✓	✓									✓	✓
Tasso Lake	✓	✓		✓		✓			✓	✓	✓	✓							✓	
Buck Lake					✓			✓												✓
Fox Lake			✓		✓			✓	✓											✓
Big East River		✓		✓					✓		✓									
Huntsville Lakes	✓			✓	✓	✓	✓		✓	✓	✓	✓		✓					✓	
Mary Lake	✓			✓	✓	✓			✓	✓	✓	✓				✓	✓		✓	
High Falls					✓	✓							✓			✓				
Wilson Falls					✓	✓							✓							
Bracebridge Falls			✓			✓														
South Branch																				
Burnt Island Lake	✓			✓					✓										✓	✓
Joe Lake	✓			✓					✓										✓	
Ragged Lake	✓			✓					✓										✓	
Canoe/Tea/Smoke Lakes	✓			✓		✓			✓	✓									✓	
Oxtongue River		✓		✓		✓			✓											
Kawagama Lake	✓			✓	✓	✓	✓	✓	✓	✓		✓		✓	✓				✓	
Lake of Bays	✓			✓	✓	✓			✓	✓				✓	✓				✓	
Wood Lake					✓				✓											
Baysville to Matthias Head Pond					✓	✓		✓				✓	✓			✓	✓	✓		
Matthias Head Pond					✓	✓						✓	✓							
Trethewey					✓	✓						✓	✓							
Hanna					✓	✓														
South Falls			✓		✓	✓														
Lower Subwatershed																				
Skeleton Lake	✓			✓	✓						✓	✓					✓			
Lakes Rousseau/ Joseph	✓			✓	✓	✓			✓	✓				✓	✓				✓	
Lake Muskoka	✓		✓	✓	✓	✓			✓	✓	✓	✓		✓	✓				✓	
Bala Reach			✓		✓	✓				✓	✓	✓	✓							
Ragged Rapids GS					✓															
Moon Dam			✓		✓	✓					✓		✓							
Big Eddy					✓								✓							✓
Go Home			✓		✓				✓	✓		✓	✓	✓	✓					✓

*Refer to Appendix D for a complete description of public comments and concerns.
✓indicates concern was raised, but provides no magnitude.

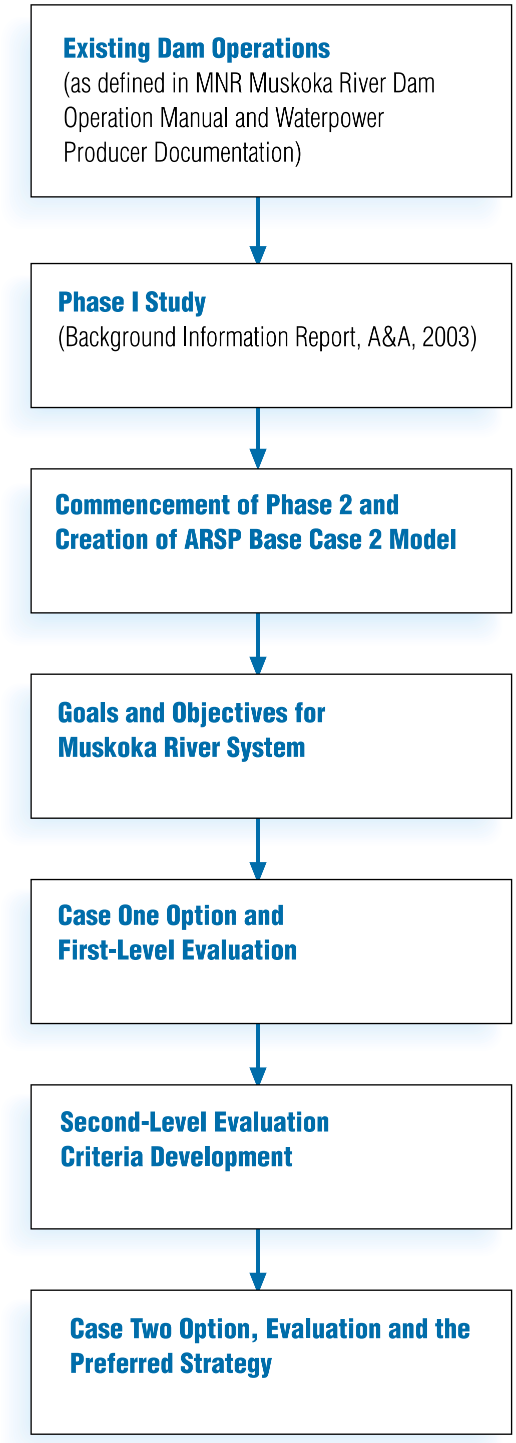


Figure 9.1
Muskoka River Water Management Plan
Option Development and Evaluation Process

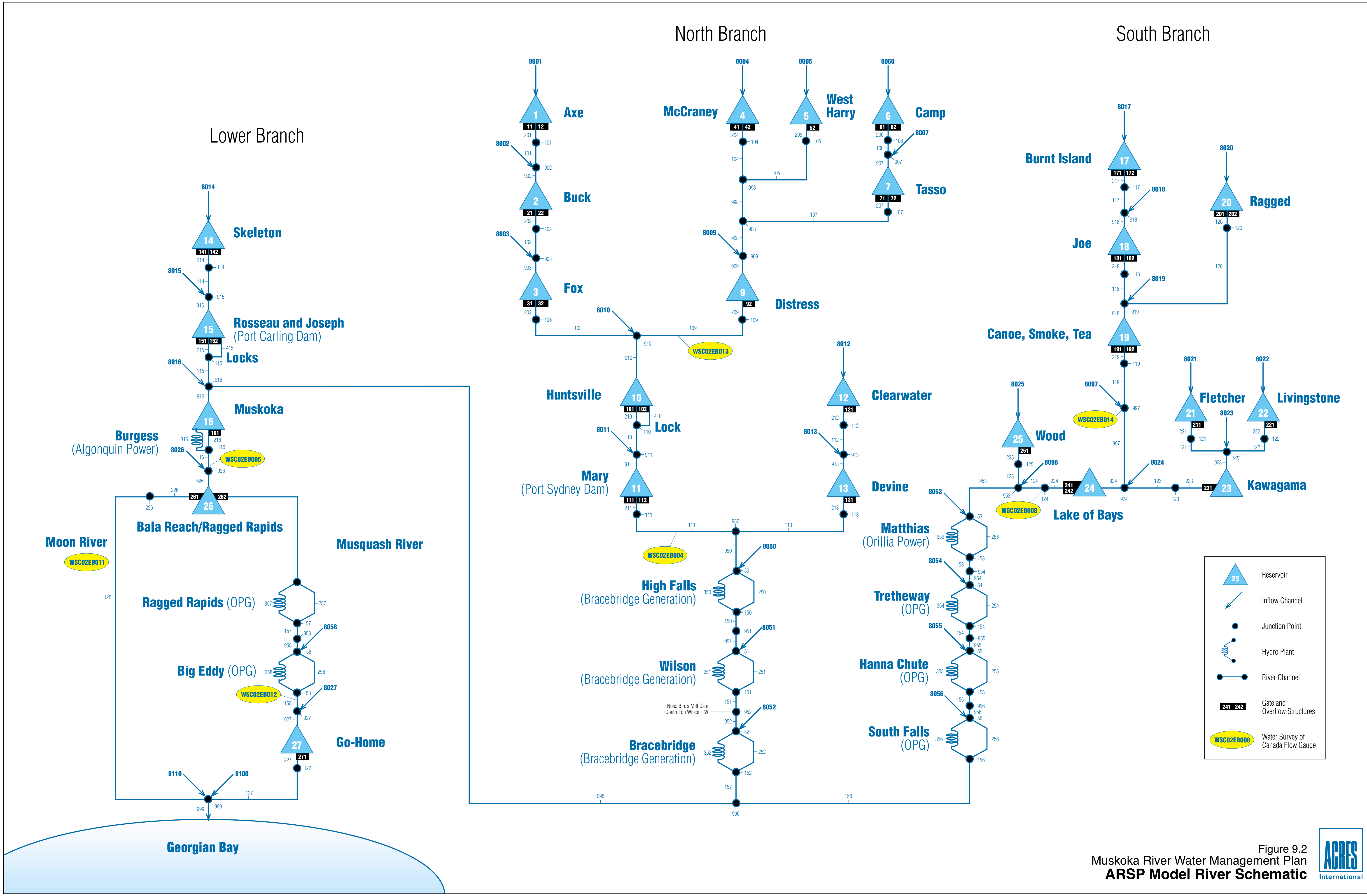
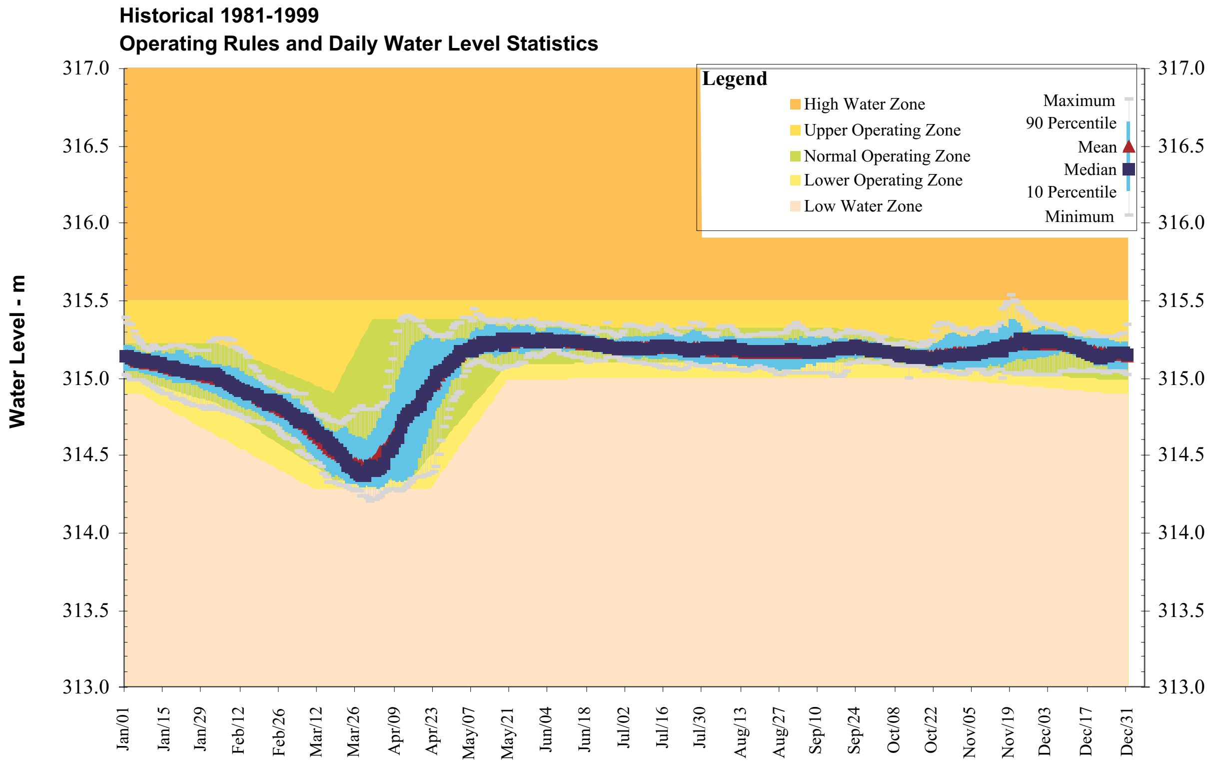


Figure 9.2
Muskoka River Water Management Plan
ARSP Model River Schematic



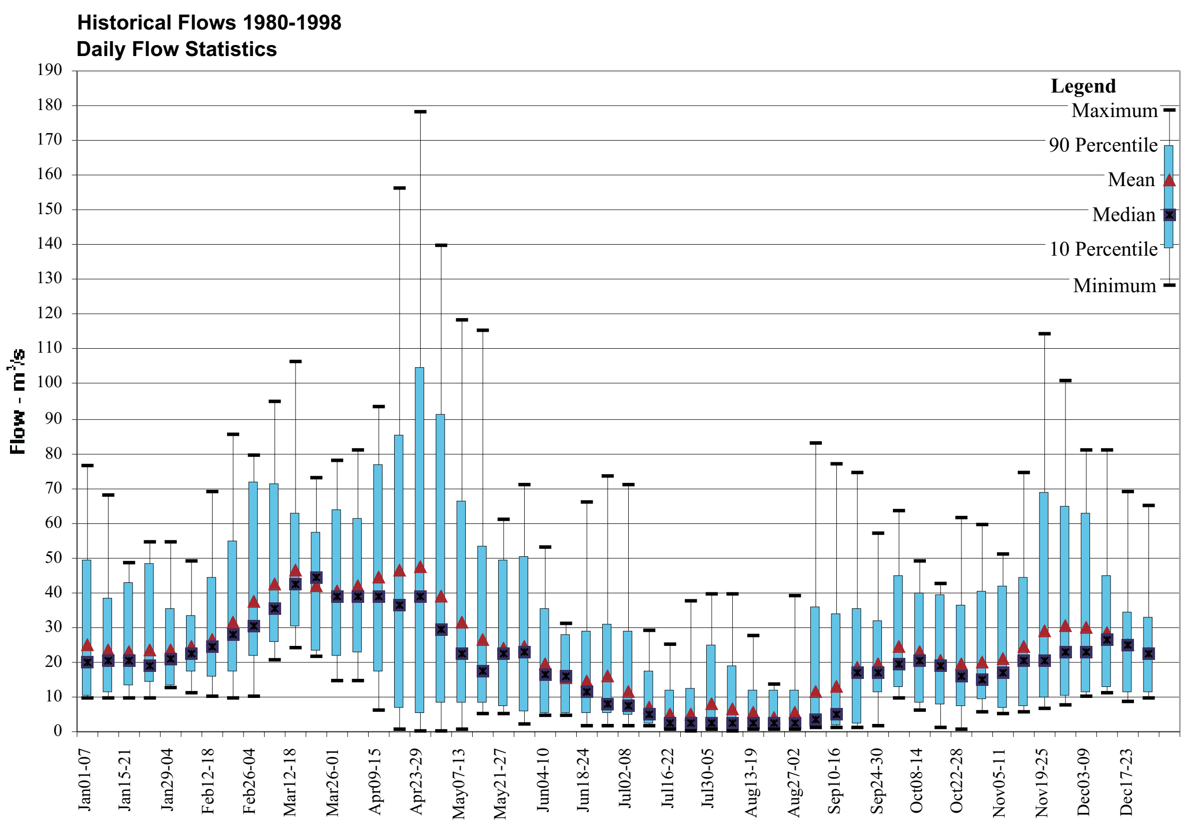
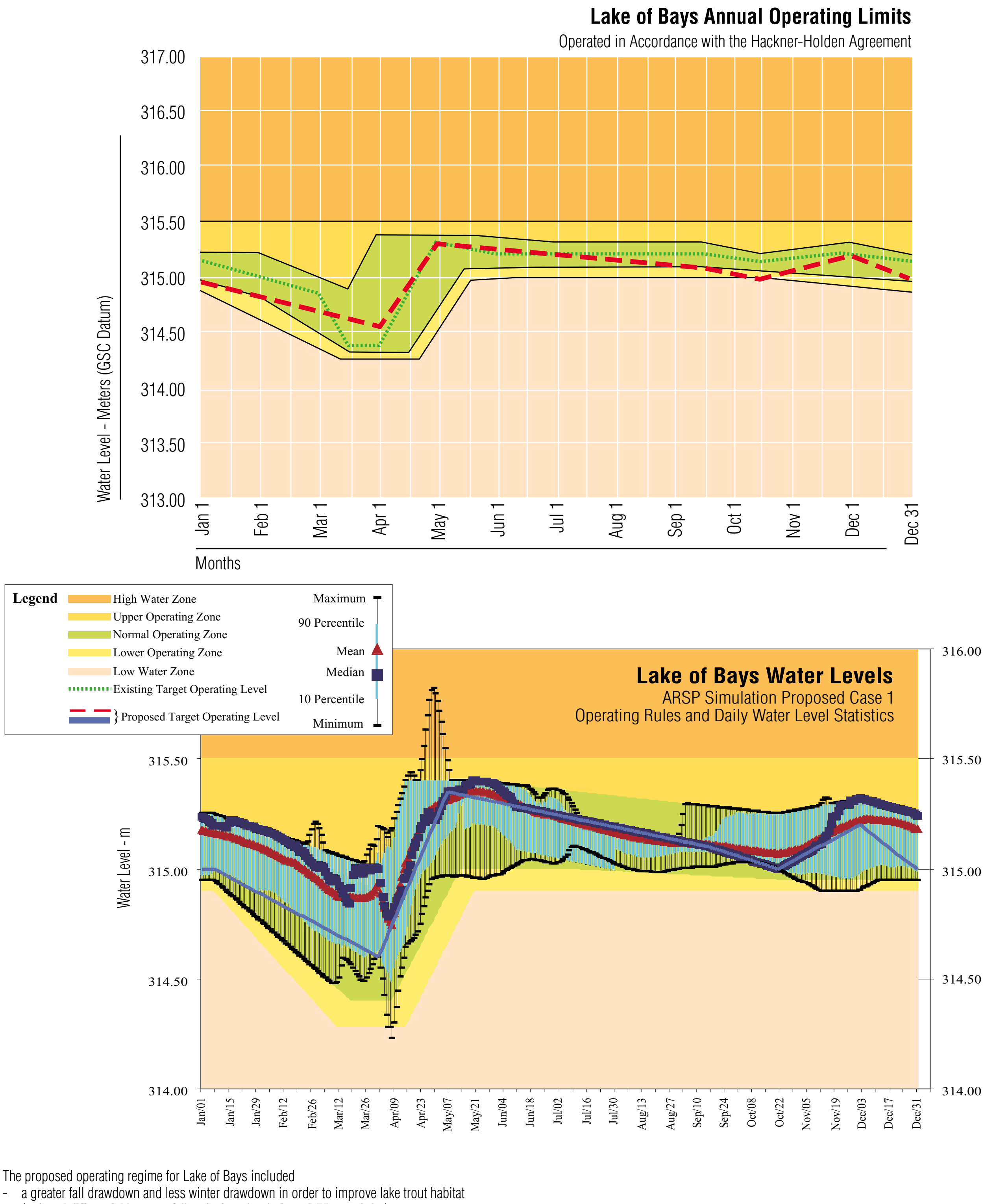


Figure 9.3
Muskoka River Water Management Plan
Historic Water Level and River Flow - Lake of Bays

ACRES International



The proposed operating regime for Lake of Bays included
- a greater fall drawdown and less winter drawdown in order to improve lake trout habitat (reduced differential between fall and winter levels from 0.75 m to 0.4m).
- no change is proposed to the spring peak as ice damage during high water in the spring is a significant concern along the south shore of the lake.
- a gradual water level decline from spring to late summer is proposed (to provide base flow for ecological benefits and waterpower production).
- an additional decline to reach the proposed fall elevation.

The results of the ARSP model run indicated:
- the reduced winter drawdown level would exceed the high water zone (HWZ) elevation at least 10% of the time. This was a considerable negative effect compared to the base case that normally did not exceed the NOZ range.

Figure 9.4
Muskoka River Water Management Plan
Option 1 Operating Plan and ARSP Simulation Run

ACRES International