ENVIRONMENTAL REVIEW OF ICE MANAGEMENT OPERATIONS ON THE RIDEAU RIVER IN OTTAWA

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ABSTRACT

Each year the residents in the low lying areas of the Cities of Ottawa and Vanier are faced with the risk of flooding caused by break-up ice jams on the Rideau River. In order to prevent or reduce the potential for ice induced flooding at more than 900 buildings located in the flood-prone area, there is an annual ice removal program traditionally involving ice cutting and explosives.

Despite the long-term success of the ice management component of the flood control program, its environmental implications had never been examined in a systematic manner. Prior to this study, however, there was limited documentation about aquatic environmental issues, and several noise and vibration monitoring surveys had been initiated, in part, in response to complaints from landowners or residents.

This study provided an opportunity to address the broad range of issues pertinent to evaluating the current ice management program. It was specifically designed to evaluate these issues and was undertaken in the context of the Class Environmental Assessment for Remedial Flood and Erosion Control Projects as it pertains to a riverine flooding situation.

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THE SETTING

The Rideau River is a north flowing river in Eastern Ontario (see Figure 1). The upper third of the River's 1400 square kilometre watershed is regulated by dams built in the early 1830's during construction of the Rideau Canal. Set in an area of Precambrian Shield topography, the Rideau Lakes district, upstream of the Town of Smiths Falls is cottage country. The remaining two thirds of the watershed has relatively little relief, being on limestone or clay plains. The urban area of Ottawa-Carleton lies at the northern, downstream end of the watershed. The River flows through older neighbourhoods of the Cities of Ottawa and Vanier to Rideau Falls, a 10 metre high drop into the Ottawa River.

Ice-jam induced flooding is of concern of the lowermost 11.5 kilometres of the river from Mooney's Bay to Rideau Falls (see Figure 2). In this reach, the river consists of an alternating series of relatively deep pools and shallow rapids. Ice jams are known to have occurred at break-up at five locations (typically at the downstream end of a steeper, shallow reach).

Ice formation typically begins on the river in late November or early December, continuing throughout the winter. Steeper, faster moving reaches will often remain open year round, except during the coldest winters. Frazil ice generation in the open water reaches is known to be a significant contributor to the total ice volume in the river at break-up. The average thickness of sheet ice at break-up is 40 to 50 cms (60-120 cm under bridges), and previous studies have estimated the average volumes of sheet ice and frazil ice in this reach of the river to be 120,000 m^3 and 110,000 m^3, respectively, at break-up (Fenco MacLaren, 1992).

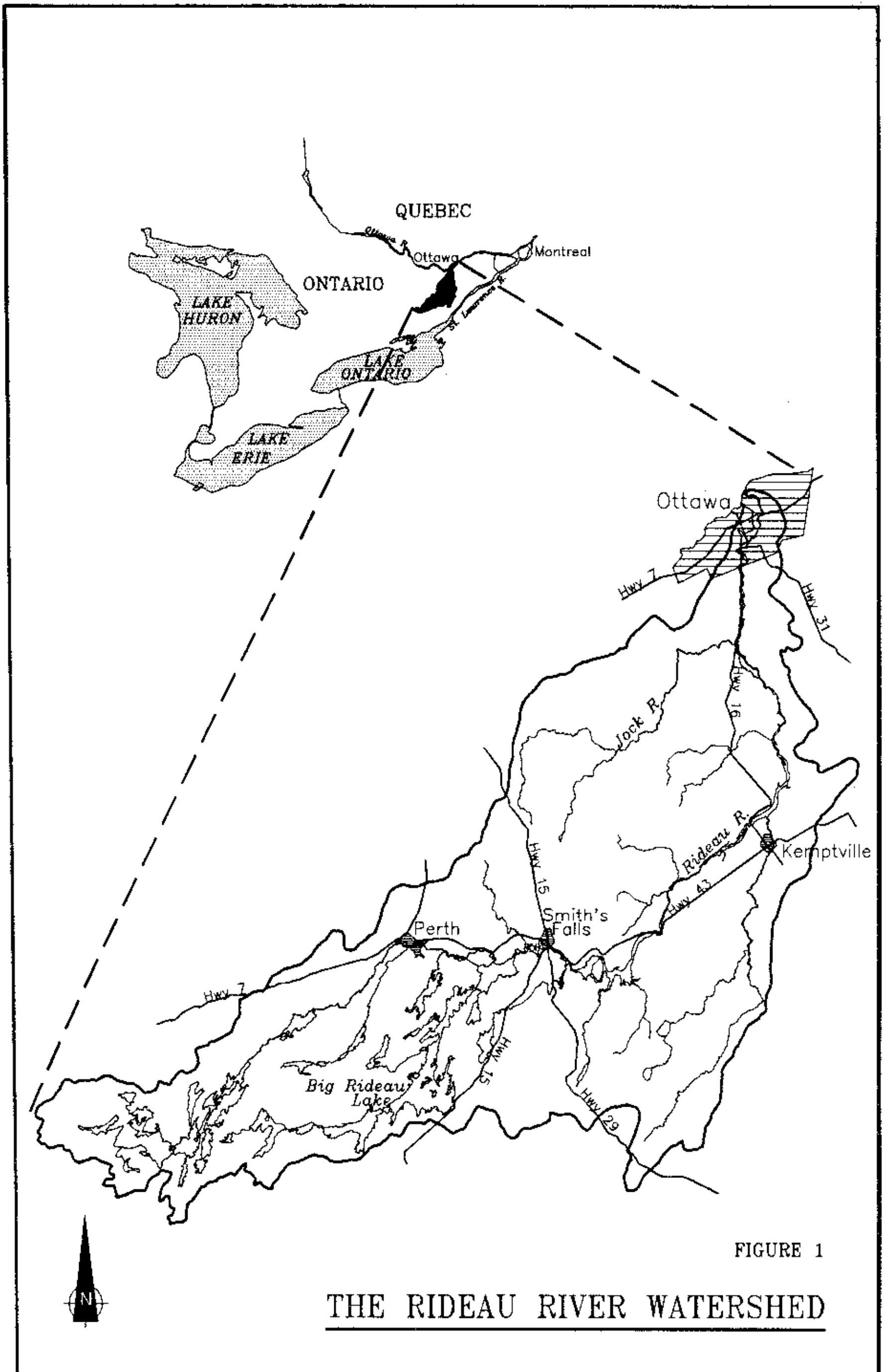
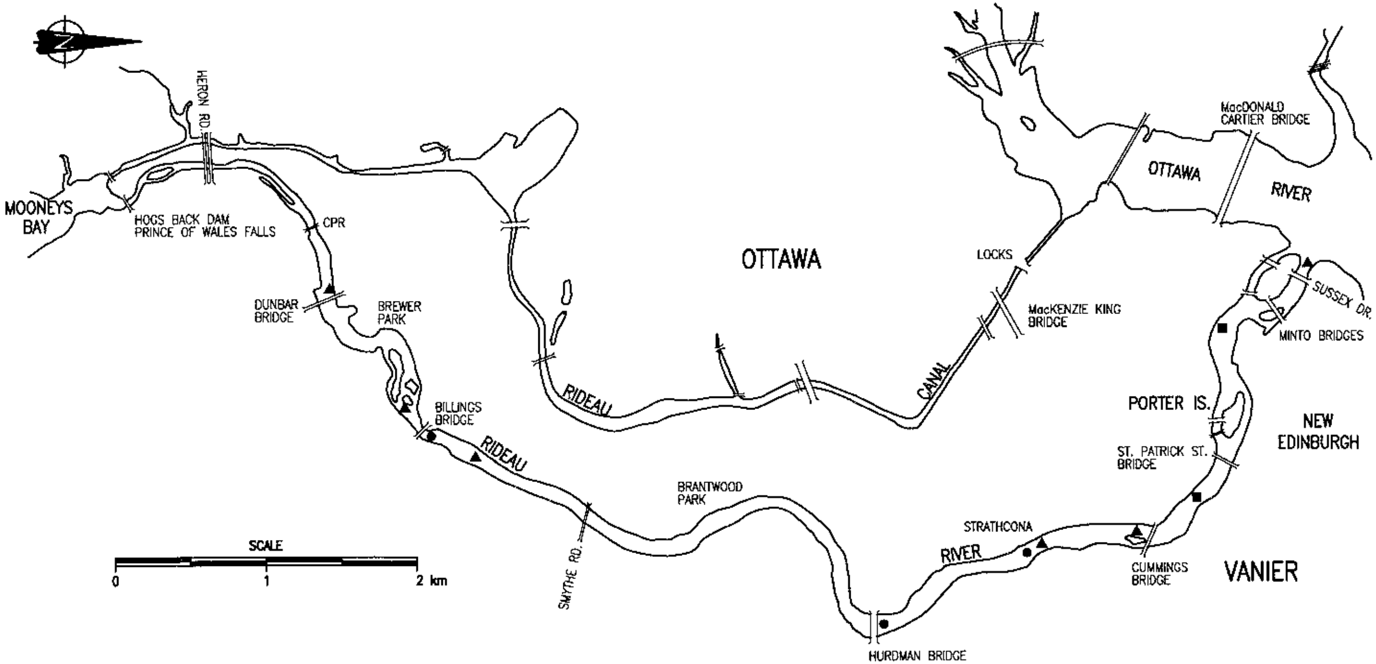


FIGURE 1

THE RIDEAU RIVER WATERSHED



LEGEND

▲ AREAS OF KNOWN ICE JAMMING

■ AREAS OF KNOWN FRAZIL DEPOSITION

● TYPICAL MID-WINTER OPEN WATER REACHES

FIGURE 2

HISTORICAL ICE JAM AND FRAZIL DEPOSITION REGIONS

FILENAME: RVCA-1.DWG

Natural break-up on the river normally occurs anytime between March 15th and April 15th, occasionally earlier. Accounts of ice-related flooding and the efforts of municipal officials and workers to alleviate the effects of ice-jams appear in newspapers from as early as the late 1870s. Efforts in the earliest years were reactive - aimed at dislodging ice jams after their formation. The annual program of *preventive* ice management which continues today began in the 1890s. The mean annual flood is approximately 400 cms and the 100-year flood is estimated at 654 cms (A.J. Robinson & Assoc., 1984). Flood risk mapping (100-year flood, ice-free conditions) has identified six flood-damage areas in the study area. In previous studies, the water surface elevation for the mean annual ice-related flood has been estimated to be as much as 2 metres higher than that of the 100 year open water flood at some locations. More than 900 buildings are located in the areas that are considered prone to ice-related flooding, and average annual flood damages (without preventive ice management and flood control operations) have been estimated to be as high as $2,000,000 (Cumming Cockburn Ltd., 1986).

ICE MANAGEMENT PROCEDURES

The risk of ice-jam induced flooding is reduced each year through a two stage process of eliminating ice from the river before natural break-up occurs. In early to mid-February, sled-mounted circular saws are used to cut "keys" in the sheet ice at utility crossings, bridges and locations where explosives cannot be used. A series of trenches about 30 cm wide, aligned in the direction of flow are cut through the full thickness of the ice sheet. This is followed in early March (typically) by systematically breaking up the ice cover using explosive charges, starting at the Rideau Falls outlet and working upstream. The broken ice cover is moved downstream onto the Ottawa River with the assistance of armoured open boats. Usually it is necessary to artificially augment the river's flow during the blasting phase (from normal winter flow of about 10 cms to at least 50 cms) using water released from the upstream reservoir lakes, but the volume of available storage is limited.

The key cutting and blasting procedure is carried out over 9 kilometres of the river, but it is considered essential that the lowermost three kilometres of ice removal be completed before the flow reaches 450 cms to avoid significant flood damages. Progress on the ice is hampered when frazil ice deposits have accumulated under the ice cover, thickening the ice sheet and forming hanging dams, and is accelerated when the natural river flow increases with melting temperatures. The blasting phase normally takes two to three weeks to complete. Flows can rise to the threshold at which natural break-up would occur relatively quickly in response to very warm temperatures, particularly when accompanied by rainfall, making it too risky to wait for natural increase in flows before beginning the ice clearing operation.

The cost of the ice removal program varies considerably from year to year, with the ice conditions and flow regime of the river, but is typically in the $200,000 to $400,000 range. In the last two years, trials have been conducted with amphibious excavation equipment (in lieu of blasting), but for very limited time periods. The whole process requires coordination amongst several organizations, each of which plays some role in the Rideau River flood control effort - from flow forecasting, to reservoir and dam operations, to the supply of manpower and materials to the physical task of cutting and breaking ice.

ENVIRONMENTAL IMPACTS OF CONCERN

The annual ice removal operation has been carried out for many years and come to be relied upon by many residents. It has become a part of the local "routine" and is a harbinger of spring in the Ottawa area. Concerns have been raised in recent years by nearby residents (mostly those whose properties are not at risk, or those who may not be aware of the flood risk) and local groups and government agencies regarding the ice blasting component of the work. The environmental impacts of concern relate to:

Harm to fish and fish habitat

Fish are known to have been killed during the ice blasting phase of operations, but fish mortality attributable to the work had never been quantified. The cumulative effects on the fish population or on the overall health of the river's aquatic habitat, after many years of operating in a more or less consistent fashion had not been assessed in any formal way. A second fisheries concern questioned the effect of using storage from the Rideau Lakes (to augment flows for the ice removal operation) on the viability of the important lake trout fishery in Big Rideau Lake.

Water and air quality degradation

The concentration and fate of chemical residues from the use of explosives, either in the water or the air, was in question.

Damage to nearby buildings and structures due to blast induced vibrations

The risk of structural and "cosmetic" damage to nearby structures had been a long standing concern to property owners near the river. The operation is self-insured, in the sense that damage claims are generally paid, if there is sufficient evidence that blasting was responsible for the damages. Vibration monitoring is carried out as part of the annual operation (to reduce exposure to liability for property damages), but the results had not been reported in the context of an overall review of the program (environmental or otherwise).

Noise

As with vibration effects, the noise implications of the annual operations had not been assessed in the context of an overall program review, but it was recognized as a an environmental impact.

STUDY OBJECTIVES

While environmental concerns were increasingly being raised in the media and by groups interested in the health of the aquatic ecosystem, submissions were being made by several researchers and contractors proposing alternative approaches to the ice management problem. To resolve the growing debate over the environmental appropriateness of current practices and at the same time provide some basis for the assessment of unsolicited proposals from the entrepreneurial sector, the study was initiated with two goals in mind:

Goal 1: *to review the potential environmental impacts of the current ice management component of the Rideau River Flood Control Program, against those of alternative approaches or techniques, and to make recommendations regarding the implementation of needed adjustments to mitigate undesirable impacts, and*

Goal 2: *to inform the public about flood risks along the Rideau River in the Cities of Ottawa and Vanier and the relative merits of methods available to reduce those risks to acceptable levels.*

STUDY METHODOLOGY

The study design was developed based on the planning and design process prescribed in the Class Environmental Assessment for Remedial Flood & Erosion Control Projects (ACAO, 1993), approved under the Ontario Environmental Assessment Act. There were four basic steps to the methodology:

Step 1: to describe the present environment and the problem that calls for intervention of a remedial (or preventive) nature

Step 2: to quantify the environmental impacts of current ice management procedures ("the undertaking"), through direct observation of the 1994 operations

Step 3: to assess and compare alternative means of preventing ice-related flooding (i.e. alternatives to ice removal)

Step 4: to assess and compare alternative ice removal techniques (after having selected ice removal as the preferred ice management option)

Public communication and participation was an important aspect of the study design, given the second goal that had been set for the project, and the need for public support of any proposed changes to the ice management operation. The study was publicized by advertisements on initiation and completion, and news-releases at study milestones. A "Community Liaison Committee" (CLC) was established, though it chose not to organize itself in any structured way, preferring to remain a large group of interested individuals. Three public "town-hall" type meetings of the CLC were held during the study, at the completion of steps 2, 3, and 4.

ENVIRONMENTAL EFFECTS OF THE CURRENT PRACTICE

Fish and Fish Habitat

As noted earlier, the environmental effects associated with the ice removal program involve a number of concerns including potential impacts on fish and fish habitat. Although each concern was examined in detail in the full RVCA study (Fenco MacLaren, 1995), the following focusses on the discussion of fish and fish habitat.

One of the more frequently noted concerns was related to the effects of explosives. Observations of fish mortalities have been reported annually from along the river margins during blasting operations and during the spring thaw. These concerns, as well as the application of the federal Fisheries Act and Department of Fisheries and Oceans' (DFO's) Policy for the Management of Fish Habitat by the provincial MNR, have contributed to the impetus behind the evaluation of alternatives to ice removal and alternative methods of ice removal.

In addition to the concerns about direct impact in the reaches of the Rideau River where blasting has historically been the only method for ice removal, consideration of associated impacts, through the manipulation and augmentation of river flows, had also to be recognized. This flow augmentation is achieved by releases from an upstream lake (Big Rideau Lake) during the ice clearing period. The potential impacts to lake trout populations in Big Rideau Lake (approximately 85 km upstream) were related to drawdown potentially exposing spawning shoals to the winter elements (ice and dryness).

Fisheries biologists monitored ice clearing operations in the winter of 1994 and subsequently conducted a fish habitat assessment of the lower reaches of the Rideau River in July 1994. The habitat assessment involved all components of the river including backbay areas and portions of the river channel in which ice removal (blasting) does not typically occur. Approximately 8 km of the river was assessed in total.

In addition, representatives of the MNR, Muskies Canada and a local river improvement group provided mapped documentation of specific fish species habitats throughout the study area, documented reports of observed fish mortalities at "ice out" or spring periods, and local information on fisheries resources within the Lower Rideau River reaches.

Observations of the March 1994 operations confirmed that the blasting operations were indeed impacting the Lower Rideau River fisheries. A number of common Rideau River fish species were observed to have succumbed to the blast concussion and were found floating on the surface of the water. These included, in order of decreasing abundance; rock bass, yellow perch, minnows, pumpkinseed, carp, and white suckers. Other species observed in fewer numbers (i.e., less than five) were walleye and northern pike. All dead fish were either collected or counted, and species and estimated year class were recorded, where possible. Table 1 presents the number of mortalities and length ranges of samples of each species.

TABLE 1: Summary of Composition, Abundance and Length Range of Fish Mortalities Collected During the 1994 Ice Removal Program on the Lower Rideau River, Ontario

Fish Species	Number of Mortalities	Range of Total Length (mm)[1]
Rock Bass	460	33 - 202 (35)
Yellow Perch	53	80 - 220 (16)
Cyprinids	18	75 - 120 (5)
Sunfish	16	120 - 160 (4)
Common Carp	7	659 - 738 (3)
White Sucker	7	281 - 472 (7)
Northern Pike	3	290 - 433 (3)
Walleye	2	165 - 311 (2)
Smallmouth Bass	2	72 - 196 (2)
River Redhorse	1	612 (1)
Total	569	

[1] Number of fish measures in parentheses

Although not considered very significant, there are impacts to the fishery, and it was concluded that mitigative measures should be taken to limit these impacts to the fullest extent possible without compromising the safety of the general public from potential flooding. It was, therefore, viewed important to implement an ice management strategy that considers alternatives to the use of explosives, specifically, and as a starting point, in locations along the reaches of river that contain fish habitat considered sensitive. The implementation of such a strategy would at least begin to minimize the direct impacts to known areas of concern and whould include a data collection component that would better quantify the impacts that may not presently be fully known.

On the basis of this study, 13 specific locations along the Lower Rideau River were identified as warranting immediate protection and/or consideration of alternative technologies to the existing ice removal practice (mapped as the example shown in Figure 3). These sensitive areas are considered to be those areas where fish communities are most likely to inhabit during late winter and early spring (periods of blasting).

Noise and Vibration

Although there were a number of concerns in addition to aquatic resources, it was issues relating to noise and vibration which appeared to hold the next level of interest to the residents. Monitoring investigations undertaken for this project served to confirm the general findings of previous noise and vibration studies commissioned by the City of Ottawa. These study investigations suggested that the vibration levels recorded during the 1994 ice removal program were below the criteria for architectural damage and were not believed to be capable of causing even cosmetic damage. At nearly every seismograph location, peak vibration levels were below the criteria set for structures of historic or architectural importance, or structures that are in a poor or deteriorated state of maintenance. Noise level measurements recorded at the three locations near the blasting site were below the MOEE daytime noise criteria (55 dB). Overpressure (noise) impacts recorded from the vibration surveys generally fell within the 120 dB cautionary limit of the criteria.

It should be noted that although the potential property damage attributable to blasting appears to be very low, it is recognized that there may be a nuisance or disruption impact to local residents; the most common disruption impacts being house rattling, fright (fear of damage or injury), and being startled. This impact may also have a

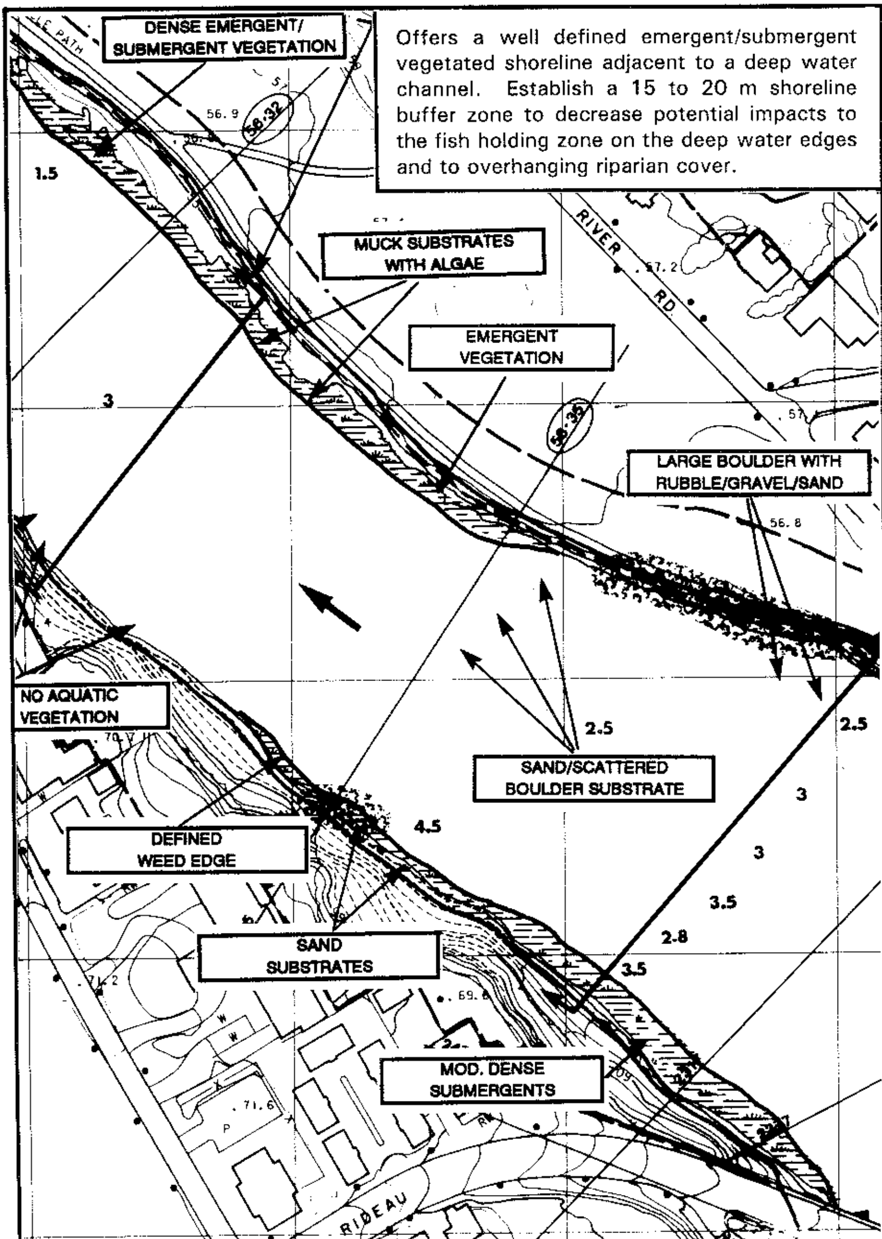


FIGURE 3

NORTHEAST AND SOUTHEAST SHORELINES – ST. PATRICK STREET TO CUMMINGS BRIDGE

greater effect on certain noise-sensitive segments of the population (such as young children, senior citizens, etc.) than on the general population.

To some extent, the concerns identified by the public with regard to noise and vibration impacts can be reduced through greater public awareness of the real vs. perceived effects of blasting and by making people more aware of the blasting schedule within specific neighbourhood areas.

EVALUATION OF ICE MANAGEMENT OPTIONS

The current program of ice removal had been compared against other ice management approaches in previous studies - during flood risk mapping exercises (M.M. Dillon, 1972 and A.J. Robinson, 1984), and in engineering studies more specifically designed to address problems associated with ice-jam induced flooding (Cumming Cockburn, 1986, MacLaren Plansearch, 1992). Aside from the latter study, however, the previous studies had not considered the environmental merits of the alternatives, as was required in this project. This step in the study process, was really an updating of the previous assessments of ice management options. The following alternative approaches were reviewed and included the "Do Nothing" alternative:

Options to Reduce Ice Volume:

- Reduce Winter Operating Level
- Flow Control in Upstream Reservoirs
- Flow Diversion through Rideau Canal

Options to Reduce Ice Volume:

- River Modifications - Weirs
- River Modifications - Channels

Creation of Ice Storage Zones

Dyking at Flood Prone Areas

Ice Removal

The analysis of these options was carried out in a qualitative screening exercise. The environmental screening criteria were as listed in Table 2. The pros and cons of the alternatives were considered by the Technical Advisory Committee and the Community Liaison Committee. It was confirmed that ice removal prior to freshet remains the preferred approach to reducing the risk of ice-related flooding on the lower Rideau River. The reliability of the flood control procedures after many years of practice and innovation, uncertainty about the effectiveness of other alternatives, and the observation that the Rideau River is in a relatively healthy state in spite of the annual ice removal operations were the main factors leading to this conclusion.

TABLE 2: List of Screening Criteria Used in The Evaluation of Alternative Ice Management Options

Technical Considerations

- technical design requirements
- architectural-landscape design requirements
- reliability and effectiveness
- effects on urban infrastructure(s) and municipal or private services and utilities
- need for back-up measures

Environmental Considerations

- impacts on visual landscape
- nuisance effects (noise, dust) from construction and/or operation of ice management
- impacts on ice regime
- effects on aquatic and terrestrial ecology
- effects on land uses and recreational activities
- public safety issues (flood risk, property damage, personal safety)

Economic Considerations

- cost of ice control option (where readily available)

Community support for this conclusion was strong - some expressing an opinion that this interim step in the study was not necessary since the conclusion was self-evident, regardless of the need look at all of the alternatives to the undertaking as stipulated in the Environmental Assessment Act.

EVALUATION OF ICE REMOVAL ALTERNATIVES

Having decided that ice removal by some technique would be recommended, and that there are environmental impacts associated with the current practice of key-cutting and blasting, the next phase of the study was to assess the merits of other ice removal techniques, which included:

Thermal Techniques

- Surface Treatment
- Thermal Discharge
- Flow Inducers

Mechanical Techniques

- Ice Cutting
- Mechanical removal (Excavation)
- Ice Breaking Vessels
  - tugs, hovercraft
  - amphibious excavators
- Blasting
  - explosives
  - electro-hydraulic
- Ice Volume Reduction using fringe/net booms

Again, a qualitative analysis of the alternatives was carried out. The evaluation criteria for this screening exercise were as shown in Table 3. The screening process recognized that alternative techniques could work in combination with one another, much as has been done in recent years with experimental use of different techniques, most notably hovercraft and amphibious excavation equipment (Watermaster).

TABLE 3: List of Screening Criteria Used in the Evaluation of Alternative Ice Management Options

Technical Considerations: • eliminate options which are not feasible or viable given the characteristics of the study area • eliminate options which have not been demonstrated to have successful application
Environmental Effects: • eliminate options with significant environmental effects which cannot be mitigated
Economic Considerations: • eliminate options which are not generally affordable without significant financial investments beyond costs normally incurred by the existing ice removal program

During the Community Liaison Committee discussion of the alternatives it became apparent that most of the interested public placed a great deal of faith in the municipal crews' experience with the established procedures, and were wary of any dramatic changes to the procedures. Significant modifications in procedures would have to be tested in the field before they would be considered reliable enough to win public support and, in the meantime, it would be necessary to be able to resort to the traditional methods. At the same time, most participants were in favour of adopting a common-sense strategy of gradually shifting away from the use of explosives in favour of less harmful means of removing the ice sheet, in particular the use of the amphibious excavation equipment, which at the present time has the disadvantage of being a relatively new technology having few machines available on a "for-hire" basis.

RECOMMENDATIONS

Recommendations emerged from the study and have been arranged into a four part strategy to steer the continued evolution and refinement of the Rideau River ice/flood control program in an environmentally responsible manner. This strategy is summarized as follows:

Essential Operational Elements of the Ice Management Program should include, but not necessarily be limited to, weather/flood forecasting procedures that can assist in scheduling the ice removal operations, key cutting using saws in environmentally sensitive areas and in proximity to bridges and utilities, ice removal with explosives (with controls to avoid or minimize environmentally sensitive habitats and to reduce the effects of noise and vibration impacts on nearby buildings and/or residents), and ice removal through the use of amphibious excavating equipment in environmentally sensitive areas.

Recommended Follow-up Research and Engineering should consider trial deployment of frazil ice fringe booms to assist in the reduction of frazil ice volumes, provision of field trial opportunities for new technologies, specialized environmental monitoring investigations to obtain environmental impact data relating to fish habitat, fish mortality, specific monitoring requirements, and noise and vibration levels.

Recommended Environmental Impact Mitigation Measures include increased key-cutting and use of amphibious excavating equipment in more sensitive areas, preparation of an Environmental Practices Guideline and Procedures document identifying blast-free buffer zones and setting out protocols to reduce fish mortality and excessive noise and overpressure impacts, and establishment of minimum environmental monitoring inspection and reporting requirements. Provision of environmental protocol training for ice crew staff to ensure environmentally sensitive features are considered and respected is recommended to enhance this step.

Recommended Actions for Improved Accountability and Public Awareness include enhanced public communications and distribution of information on the flood risks associated with ice jams, open water flooding and flood damage reduction; an environmental monitoring/audit appraisal over the next two or three years to assess benefits and/or negative impacts of particular elements of the operations, and preparation of an annual environmental summary statement documenting the ice program activities, the nature and extent of any difficulties encountered, and the extent of any environmental effects observed.

CONCLUSION

This study provided new directions for municipal workers to follow in the process of ice clearing while confirming, from an environmental point of view, many of the ice management practices that have been employed on the Lower Rideau River for many years. The study was conducted in an open, public forum, with participation from a wide range of public agencies, interested citizens and private sector businesses. By following the recommendations that emerged from the study, municipal officials and workers should continue to have the support of regulatory bodies and the public they serve, as they deliver these important flood control and ice management services.

ACKNOWLEDGEMENT

The authors would like to express their appreciation to members of the study Technical Advisory Committee which included representatives from the Ontario Ministry of Natural Resources, Rideau Valley Conservation Authority, City of Ottawa, City of Vanier, Rideau Canal Office-Canadian Parks Service, Department of Government Services, Public Works Canada, National Capital Commission, and Gananoque Light & Power Company.

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DISCUSSION

Susan Wilkins

Sigma Engineering:

What was the fisheries agency response to the observed fish mortality rates?

Reply:

At the end of the study process the Ministry of Natural Resources indicated that it was satisfied that the study had accomplished what it had set out to do; that is, to rationalize the annual ice management program and all of its costs and benefits, including those related to conservation of the natural environment. It should be noted that the study found the overall condition of the Rideau River sport fishery to be remarkably good given its downtown location and the many other stresses it is exposed to.

It is interesting to note that a question was raised during the study as to the applicability of the Federal Fisheries Act, given the history of the ice blasting ritual, pre-dating the Act or its enforcement. The Study Team chose to direct the study towards identifying reliable alternatives to the use of explosives, instead of dwelling on the legalities. Recommendations were made accordingly.

David Andres

Trillium Engineering and Hydrographic Inc.:

You indicated that the flood plain delineation is not based on ice related water levels. Do you recommend that such an analysis be undertaken, and if so do you have any thoughts on the procedures that would be used?

Reply:

On the Rideau, the 100 year open water flood discharge was determined from single station frequency analyses of streamflow and was used to delineate the flood plain. Further analysis to include the effects of ice jams in the determination of regulatory flood level (the one with a 1% chance of occurring each year) would require analysis of the joint probability of streamflows and ice conditions, if it can be accepted that the occurrence of ice jams and the occurrence of peak streamflows of any given magnitude are mutual exclusive events. This would be difficult on the Rideau , since there can be no historical record of the ice jams that would have occurred, had ice removal operations not been carried out. Instead, a synthetic record of ice jam occurrences could be constructed, and then used in a frequency analysis, if we could predict ice jam occurrence in a continuous simulation hydrologic model which could also account for ice growth and decay and ice hydraulics at break-up.

We have so far avoided the whole question on the Rideau, by accepting that in most years the risk of ice-related flooding is eliminated by means of the ice removal operations, and assuming that this will continue to be the case. There is, however, a quantifiable risk of failure associated with the ice management operations (when very early break-up occurs), yet the analysis to quantify the risk hasn't been completed.

Development restrictions only apply in the 100 open water flood plain; any buildings or structures permitted are required to incorporate a minimum 30 cm freeboard into the design for flood-proofing. In this area, designers should be advised to consider increasing the freeboard to account for the possibility of ice-related floods in excess of open water flood levels. For buildings outside the regulated area (but potentially affected by ice-related floods), designers are on their own.

Rick Carson
Acres International:

Was the Watermaster used only to break the ice? What was the maximum ice thickness that was broken successfully?

Reply:

In trials to date the Watermaster has been effective at breaking the ice sheet in considerably less time than blasting with explosives. However the 1994 trials occurred after the ice had softened somewhat, and 1995 trials were on thinner ice than normal. The Watermaster was used to break the ice cover into small enough floes that they could pass through bridge spans with no trouble. Moving the broken ice out of the river often limits the progress of the procedure, unless there is sufficient flow to carry it away. To my knowledge there has never been an attempt to break the ice throughout the critical reaches, and leave it in the channel to be carried away with naturally rising flows during the early stages of the spring freshet. One might be concerned about doing so for fear of generating a jam with the large volume of ice that would be available all at once.