April 25, 2005

Contextual Narrative
Coastal – Lower St. Lawrence River

1. General Socioeconomic Context

a. *Production value of the interest :*

The shorelines of the St. Lawrence River between Cornwall and Lac St-Pierre are a vital cultural, recreational, ecological and residential resource. Currently, there are 5767 single-family dwellings within the 100-year return floodplain of the lower St. Lawrence River between Cornwall and Trois-Rivières. There are also 615 other buildings, either commercial, industrial, farming, *etc.* present in the floodplain [1]. In 2003, the existing residential buildings had an approximate total value of 460 million dollars (CAD).

There is 388 km of eroding shoreline in this section of the St. Lawrence River, of which 27 km is heavily eroding (average recession rate of 1.1 m/yr). There are over 400 km of shore protection along the St. Lawrence River downstream of Cornwall representing an infrastructure investment of over $200 Million US. Erosion and shore protection design is influenced by the combined effects of waves, ship wakes and water levels. In most residential areas, waterfront property is the most desirable and therefore most valuable property.

b. *Number of stakeholders:*

There are approximately 42 000 individual land parcels and 20 000 residents living along the river's banks or within the 100-year return floodplain of the lower St. Lawrence River between Cornwall and Trois-Rivières. These shorelines constitute a major natural feature of dozens of communities including small towns and villages, First Nation communities and the City of Montreal (regional population 3.3 million). Furthermore, the river shoreline serves as a key cultural and historical focal point for the origins of the communities.

c. *Organizational characteristics:*

Urban land uses occupy 3% of the territory along the shores and within the floodplain of the St. Lawrence River [2]. Agricultural activities, natural environments and wetlands constitute the dominant land uses for this sector. Certain areas of the river reach between Cornwall and Trois-Rivières are heavily urbanized, with residential land occupancy reaching 90% (Montréal, Longueuil, Trois-Rivières, Repentigny and Sorel). Other areas are moderately urbanized and urban land uses account for approximately 50% of land use (St. Lawrence River banks between Montréal and Sorel, Lake Saint-Louis and Bécancour). Finally, in the less urbanized areas (Lake St. Francis, Lake Saint-Pierre and the Sorel Islands), urban land uses represent a low percentage of the land, generally less than 20%. Some of these areas, such as the Sorel Islands, have extensive seasonal residential development.

Generally speaking, densities and property values are higher in and near urban centers, such as Montréal, Longueuil and Trois-Rivières, with both density and property values decreasing into the rural communities. The average value of residences is $213K in the heavily urbanized areas, while the value in the moderately and less urbanized areas is $80K and $43K respectively. In most residential areas, waterfront property is the most desirable and therefore most valuable property.

d. *Values and perceptions of the interest:*

Ecologically, these shorelines are comprised of a complex mixture of wetlands, wooded and grassed areas comprising valuable habitat for a vast number of migratory waterfowl. Culturally, the river has been the source of food, transportation and provides an important connection to historical origins for both aboriginal and European peoples. The values and perceptions of the riparian owners are as wide and diversified as the study area itself.

e. *Significant statutory, regulatory and policy restrictions:*

Prior to about 1980, there were no laws or regulations controlling construction within the floodplain in Québec. Since then, several laws and regulations have been progressively implemented for the management of construction within the floodplain. These laws address land use, shore and floodplain protection, and environmental protection. In 1976, the Canada – Québec Convention concerning the mapping of floodplains was adopted. In 1987, the Shore, Coast and Floodplain Protection Policy was adopted, the main elements of which were integrated in the development plans of Québec's RCMs.

However, these laws and regulations seem to have failed in stopping construction within the floodplain. Several authors have shown that residential development in the floodplain has continued, and in certain cases has even increased, since the beginning of the 1980s, urban expansion seemingly unaffected by the designation of floodplains [3, 4, 5]. In the last 30 years in Québec, floodplain occupancy and its consequent economic value have generally increased.

Since 1998, the Government of Québec has implemented exception mechanisms to the prohibition to build within the floodplain. These mechanisms allow building within the floodplain under certain conditions (defence work, uplifted buildings, *etc*.). Despite the implementation of these derogation mechanisms, the laws and regulations applying to construction within the floodplain have become, over the years, increasingly restrictive. It is therefore likely that this trend will continue in coming years. However, it is difficult to assess the long-term impact of the overall regulations, as the regulations are applied in different manners in different areas, and certain RCMs or municipalities are more permissive regarding construction within the floodplain.

Erosion processes (and related shore protection works) are driven by the combined influences of ship traffic, wind waves, river currents and water levels. Recent trends toward larger container ships downstream of Montreal have been shown to increase shoreline erosion. This places an increased pressure on the riverine system and increases the need for careful management of the combined effects of river flows, water levels and ship traffic.

As a waterway, the river provides an essential link for one of the most safe and fuel-efficient transportation modes available. The port of Montreal and the St. Lawrence Seaway system are important socioeconomically in their own rights (see contextual narrative for navigation). Concerns about climate change and fuel costs and availability is increasing the economic imperative to use ships rather than rail or trucking to transport our goods. In light of this, the Canadian and U.S. governments are examining the feasibility of expanding the draft and vessel length capabilities of the present seaway system to accommodate much larger vessels and to accommodate container vessel traffic upstream of Montreal.

Over the next ten years, public concerns about the environmental degradation of the shorelines of the St. Lawrence due to the combined effects of water levels and ship traffic are going to increase – both because of increased pressures on the system (in particular due to navigation issues) and due to an increasing public concern over man's impact on the natural environment (climate change, urbanization, environmental degradation, etc.).

f. *History of the interest:*

For several centuries, the shores of the St. Lawrence have been privileged for human occupancy. The first houses were built mostly outside of the floodplain, residential development within the floodplain being a relatively recent phenomenon. Between 1930 and 1945, the socio-economic context (economic crisis, war) resulted in very few single-family dwellings being built in Québec, and consequently within the floodplain. From 1945 to 1964, in the context of an economic boom, several houses were built within the floodplain in Québec, the regulations being rather loose. Between 1964 and 1983, construction within the floodplain was also fairly important, as it also was during the period from 1983 to 1997 despite the implementation of regulatory mechanisms to control this type of development.

This interest suffered badly during the 1970s high water levels. Extensive flooding occurred in 1974 and 1976, while heavy erosion triggered strong public outcry and resulted in the construction of many kilometres of shore protection. The media often portray high water levels and downstream erosion as a consequence of dam operations designed to protect Lake Ontario riparians at the cost of those downstream.

g. *Trade flows and current market condition:*

The market for waterfront properties is still very active, even more so for houses located near major cities or in seasonal residence areas. At the same time, certain areas located within the floodplain, especially between Sorel and Trois-Rivières, are under pressure for development.

h. *Effect of last high or low water conditions:*

Residents around Lake Saint-Louis and the Sorel Islands suffered severe flood damages in 1974 and again in 1976. The most recent major flood event, which occurred in 1998, forced the evacuation of 1 000 residents in the Sorel Islands area. In the other extreme, when the river's water levels are low, flooding is not an issue for the riparian property owners.

Similarly, high water conditions in the past have increased shoreline erosion and triggered increased shore protection costs, while lower water levels have reduced erosion and reduced public concerns regarding shore protection. There is no established program to reimburse property owners for land lost due to erosion, nor for costs associated with construction or maintenance of shore protection structures. There is however a historical precedent of the Canadian federal government paying to build and maintain shore protection structures built within 1000 ft of the navigation channel in recognition of the impact of ship wakes and drawdown on bank erosion.

2. Performance Indicators

a. The performance indicators (PI) selected for the analysis are [6]:

- Cost ($) of the residential damages (structure and content)
- Number of flooded homes
- Number of properties that could be expropriated (based on provincial regulations)
- Total area (in hectares) of flooded lands quantified by land-use type
- Total length (in km) of flooded roads quantified by road type.
- Total area and value of land lost due to erosion
- Total cost for modification and maintenance of shore protection
- Total volume of fine sediment in river

Because we believed that economic performance indicators are not sufficient to fully describe the impacts of a flood and erosion on communities, we have established societal PIs to form the basis of the socio-economic impact assessment tools for flooding and erosion. As a result, some PIs translate the damage in terms of dollars while others account for societal aspects of the damage.

b. The estimated cost of possible flooding damages is based on fully comparable data that were provided by surveyed riparian property owners of the study area. The survey asked different questions related to the cost and nature of the damages from the last major flood event that hit the region of the Sorel Islands in the spring of 1998.

Flood-depth damage curves applicable to residential buildings of the study area were built for the purpose of the study.

Also, it should be noticed that, sometimes and for different reasons, the cost of the damage is fully assumed by the property owners affected by a flood as they don't automatically ask for a government indemnity. In other words, the cost of the flooding damage is not fully assumed by the community.

3. Potentially Significant Benefit Categories Not Addressed by the Current Performance Indicators (secondary impacts)

The Performance Indicators listed above reflect direct damages without regard to the metric involved. The key PI is the cost of the residential damages (structure and content) as 89% of the buildings within the 100-year floodplain limits of the lower river are residential [7]. However, it should be stressed that the damages are not limited to the residential sector. Significant damages also occur to businesses and public infrastructure, particularly in larger floods. Infrastructure damages include damages to telephone, electricity, roads, rail, flood structures and other public utilities.

At the same time, significant flood damages may arise from the disruptions to physical and economic activities such as the loss of sales, reduced productivity and the cost of alternative travel if road and rail links are broken. These are indirect damages that have not been included in the monetary assessment of flood damages. The costs for relocating evacuated people as well as for deployment of the contingency measures are other examples of indirect damages.

Intangible damages represent another category of damages. They arise from adverse social and environmental effects caused by flooding. There are a number of intangible costs of flooding to the community, including factors such as loss of life and limb, preparedness (cost of flood warning, planning, and community education), inconvenience, isolation/evacuation, stress and anxiety, disruption as well as other health issues. These intangible damages are not easily quantifiable and have not been included in the economic PIs.

Also, some secondary impacts can turn out to be very subtle and yet, significant. For example, the properties at high risk generally have a reduced tax list value and, for this reason, they constitute a significant fiscal shortfall, in terms of municipal and school taxes, for local authorities.

Finally, we developed PIs that would allow ranking of the plans based on the assessment of specific, possible flood damages (*e.g.* residential damages). It should be emphasized at this point that the key PI does not allow assessment of all possible flood damages whether they are direct, indirect or intangible. Thus, the ranking of the plans will be predicated upon absolute damages, but not exhaustive ones.

4. Key Baseline Conditions

The performance indicators used to estimate flood damages rest on two working hypothesis: the first one considers only the existing residences in the assessment of possible flood damages. In other words, the residential occupancy comprises 5 767 single-family dwellings recorded within the floodplain and the model considers that no new construction will be added to the housing inventory during the simulation. Also, the real estate values always remain constant, *i.e.* it is not indexed to the cost of living and does not follow the fluctuations of the real estate market. The economic damages are assessed in $US of 2003.

The second hypothesis assumes that no mitigation measure is given to houses affected by flood damages during the simulation. Upon request by the PFEG, the model allows that a house having suffered damages (structure or content) could suffer further damages during the next flood event, whether or not the owner has taken steps to mitigate the risks of future flooding.

The analysis has assumed that ship traffic and wind-wave conditions in the river are those observed over the last decade – any large scale changes to ship traffic such as deepening and expansion of the seaway beyond its current dimensions have not been considered in this analysis. Trends in increasing ship size downstream of the Port of Montreal have not been considered in this analysis.

5. Key Trends

Construction along river banks and within the floodplain will be more and more controlled given the increasing efforts of governments and municipal authorities to limit this type of development. A case in point, the construction rate within the floodplain has greatly decreased in the Lake Saint-Louis area and between Montréal and Sorel; and this trend is likely to continue. However, the regulatory mechanisms have a much more moderate impact in the Sorel Islands area, where the density of houses within the floodplain is increasing. On the other hand, the newly built houses in the floodplain are better protected against flood damages.

In the coming years, it is expected that residential development will occur mostly within areas determined by the development plans of the RCMs known as residential development priority zones. These zones are adjacent to existing urban perimeters, generally away from river banks and the floodplain. However, the potential development of some sectors of the floodplain of the St. Lawrence River is not completely excluded, due to the existence of mechanisms that permit construction in floodplains under certain conditions.

Areas of moderate urban density are experiencing growth through new residential construction, and it is likely that a small amount of this growth will be in the floodplain. Also, construction of cottages on vacant land is continuing to occur in areas with existing cottages, and it is expected that this trend will continue, especially in the Sorel – Trois-Rivières reach. Also, over the past thirty years, there has been a

trend towards conversion of seasonal cottages to permanent residential dwellings. Many cottages still remain in some areas, and it is likely that the trend will continue.

In heavily urbanized areas such as Montréal and Longueuil, most of the available land along the river has been developed and there is very limited potential for additional development in these areas. Although this cannot be qualified as a significant trend, it is not uncommon to tear down a modest cottage (or 2 or 3 cottages) and replace it with a large house worth several times what the cottage was.

Generally, the properties at high risk of being regularly flooded have a reduced tax list value and constitute a significant fiscal shortfall for local authorities (*cf.* Section 3). Although they are devalued, the market value of these properties has historically followed the overall real estate market fluctuations, some properties having seen their value grow five fold over the past decade [8].

The natural environment areas that are protected by virtue of a legal status (the protected sites) are not at risk of being affected by development in the future. There is a trend in some areas to an increase in the amount of protected natural areas.

Increasing ship traffic effects due to size of vessels (downstream of Montreal) and the effects of possible ship channel deepening could have a major effect on erosion processes and associated shore protection costs in the river. The intensity and extent of erosion and shore protection impacts is directly linked to the size, speed and number of ships using the waterway – changes in the waterway and the ships that use it can have direct consequences on the shorelines. Speed controls such as those presently in place downstream of Montreal are one of the key elements in reducing erosion due to ship traffic. The effects of ship wakes on erosion are inexorably linked to the water levels in the river: river banks are generally more susceptible to erosion during periods of high water levels.

6. Expected Consequences of Changes

It is unlikely that there will be any significant movement of residences out of the floodplain. Also, residential construction within the 20-year return floodplain will be almost nil, considering the control applied by government authorities. In the 100-year return floodplain, residential development is likely to continue although it will remain a rather limited phenomenon. Nevertheless, we estimate at 375 the number of new houses that could be built within the 100-year return floodplain in the next 15 years. However, these houses will be better protected against flood damages. Also, the existing houses are likely to become better protected over the years.

Obviously, all these phenomena will induce an increase in the economic value of the dwelling stock within the floodplain. The number of single-family homes within the floodplain is likely to grow above 6 000 units over the next 10 years.

The combination of increased erosional pressures (due to shipping) and increased public concern over environmental degradation could result in a change in the

manner in which this waterway is used. Navigation management will likely have to consider shoreline responses as a key component of channel design and traffic control. Mitigation measures related to any navigational changes will likely have the effect of increasing the amount of protected natural shoreline and wetland habitat – this may necessitate the construction of shore protection works to protect sensitive areas.

7. Adaptive Behaviors

In general, the major benefit of the construction of flood modification measures is a decreased cost of flood damage to properties protected by the measure. In spite of the fact that mitigation measures also allow a decreased emotional, social and psychological trauma experienced by residents in times of flooding, we learned through this study that riparian owners of the lower river do not automatically apply mitigation measures to their property after a flood event, regardless to the severity of the damages [7].

As an example, after the two major flood events of 1974 (recurrence at the Sorel hydrometric station: 1 in 18 years) and 1976 (1 in 300 years), significant damages have been reported after much less important floods. In order of importance, the following lists the dates of other minor floods for which damages have been recognized (but mostly in the Sorel Islands and around Lake St. Pierre):

March 31, ’98 (1 in 5.5 years)
February 23, ’81 (1 in 2.5 years)
May 10, ’83 (1 in 1.9 years)

The previous example illustrates that mitigation measures are not automatically applied by property owners. If mitigation measures would have been applied by all property owners who suffered severe flood damages during the flood of 1976, the following minor floods would have caused only minor damages, if any. However, we recognize that some property owners will want to eliminate all future hazards after a major flood event. For other property owners, it might be possible that they consider the indemnity paid by government authorities as some sort of insurance policy, which would explain why mitigation takes place gradually.

That being said, **none of the selected performance indicators described above involves adaptive behaviour of the riparian owners**. Again, this doesn’t mean that adaptive behaviours or application of mitigation measures by the shoreline property owners does not happen.

Finally, from a computational stand point, it must be said that the application of a mitigation factor is quite straightforward when using the building to building approach of the detailed models. However, a progressively applied mitigation factor might not be as simple to implement when in the form of an SVM equation that expresses the damages for a whole municipality.

8. Risk Assessment/Sensitivity Analysis

Some environmentally significant wetlands and habitats exist in the lower St. Lawrence that are sheltered by small islands close to the ship channel (e.g. the Contrecoeurs region). These small islands are presently eroding. Should these islands be completely eroded, large wetland areas would lose their sheltering and become exposed to wind waves, ship wakes and currents that could disrupt their ecosystem and result in significant habitat loss (due to changes in bed sediments and vegetation patterns).

There are many residential properties along the St. Lawrence River that have been only marginally affected by flooding in the past. For example, around 440 cottages are situated on the Sorel Islands. Most of them are on piles and are situated in the floodplain of the river. An increase in peak water levels/flows in these areas will cause extensive property damage and human dislocation.

In the same line of thought, many residential properties along the river are only slightly removed from the 100-year floodplain limits. The number of residences situated at the outer limits literally explodes: from less than 6 000 within the floodplain, the number of homes exceeds 60 000 near the perimeter of the floodplain (around a half kilometre above the floodplain limits). Obviously, the effects of water levels exceeding the actual 100-year mark would be dramatic in terms of property damage.

The stage-damage curves produced for the lower river are calibrated for the regulation plan actually in effect. The curves are representative of the risk that the property owners are willing to assume at the present time, considering the expected water level fluctuations. Should the IJC implement another regulation plan that would suddenly cause drastic changes in the water levels and, in turn, causing houses that were not usually at risk to be regularly flooded, then it is expected that the property owners would react differently. In these circumstances, it might be appropriate to adapt the flood damage assessment method by including the application of a mitigation factor.

Finally, it is important to notice that the damage functions cannot be used to assess the damage resulting from flooding due to the presence of an ice jam. Nevertheless, the ice jams remain a significant factor in flooding, especially during winter with heavy snowfall or severe cold. For instance, in 1993, some 39 450 people were displaced and assets worth an estimated $1.5 billion (not including municipal, industrial and agricultural producer losses) were damaged when an ice jam affected the St. Lawrence and its tributaries [9].

9. Sources

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10. Review Process

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Reviewed by: Ralph Moulton
Received TWG Support: April 25, 2005
External Review: PFEG and EAC