Sea Level Rise Primer Summary Guide

Why a Sea Level Rise Adaptation Primer?

Sea level rise is a new challenge facing coastal communities in Canada. Uncertainty around how much sea levels will rise, when and what impacts this will have on any given community also make adaptation a challenge. However the mandate of local government to protect people and property requires coastal managers to respond to this new challenge by pursuing adaptation and building resilience. Fortunately local governments have a wide variety of regulatory tools to enable adaptation – the Primer identifies 21 such tools and a broad array of applications.

Who should read this Primer?

Any level of local government with responsibility for coastal management, including professional and consulting staff. The Primer may also be of interest to other authorities and organizations with an interest in coastal zone management.

How is the Primer Organized?

Background
This section of the Primer briefly explores some of the historical changes in sea level rise globally and along Canada’s southern coasts. Projected increases in SLR are discussed globally and at the provincial level. In addition, some of the more destructive coastal hazards associated with SLR (storm surge and wave action) are briefly discussed. The background section also outlines the difference between adaptation and mitigation and identifies why the Primer focus is on adaptation rather than mitigation.

Study Area
In terms of geography, the Primer addresses Canada’s southern coasts, more specifically the coastlines of British Columbia, Quebec, and the Atlantic provinces of New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland and Labrador. This section of the Primer provides a context summary and introduces how SLR is being approached by each coastal province. A general description of the physical features of each provincial coastline is given and an indication of the population living on or near the coast. Specific areas at risk within provinces are identified and the general management approach of coastal areas is also described. In addition, the SLR estimates used by policy makers in each province are provided.

Framework for Decision Making
This section discusses four strategies for adaptation to SLR: Protect, Accommodate, Retreat and Avoid. In addition a Sea Level Rise Adaptation Framework is introduced consisting of four interactive elements: Information Gathering, Public Education and Community Engagement, Adaptation Tools, and Monitoring and Evaluation. The adaptation tools explored in the Primer are not stand alone solutions to coastal hazards associated with SLR. The tools fit within an overall strategy as well as an adaptation framework as discussed in this section.

Throughout the Primer, examples of how adaptation tools have been applied are provided in boxes embedded in the text. These are intended to provide guidance and insight into approaches that have worked (or not) as well as lessons learned.

Every coastal context is different and faces different challenges with respect to SLR. Information Gathering explores some of the initial questions that should be asked, provides some suggestions as to the kinds of data that should be gathered and examples of information resources available.
Public Education and Community Engagement explores options for enabling communities to be involved in the adaptation process and provides some examples of successful engagement. As with any process, a feedback element (Monitoring and Evaluation) is imperative to ensure long-term success and is identified as the 4th element of the decision-making framework.

Adaptation Tools
The main focus of the Primer is the 21 adaptation tools. They are organized into Planning, Regulatory, Land Use Change or Restriction, Structural and Non-Structural tools. For each of the tools, a description, an outline of its application and discussion of enabling legislation (where applicable) are provided. The advantages and disadvantages of each tool are summarized in table form and evaluation and governance considerations consisting of economic, environmental and social elements are identified. Each tool includes a discussion of implementation measures and challenges along with illustrative examples. Concluding this section is a discussion of hybrid techniques (such as living shorelines) in which one or more tools can be used in combination. A matrix indicating the compatibility of each tool with the four adaptation strategies is also provided.

Other Adaptation (Non-Local Government) Responses
Recognizing local government are not the only players involved in adaptation to SLR, the Primer explores insurance as a potential adaptation option. This section features a discussion of how flood insurance functions in the US, Germany, and the UK. In addition provincial and federal responsibilities for emergency management and disaster financial assistance are also discussed.

The Costs of SLR and Adaptation
Finally, the Primer includes a discussion of the costs associated with adaptation or not implementing adaptation measures. This section also includes some provincial approaches to funding SLR adaptation and identification of funding programs in other countries.

Additional Features
The Primer includes the following information resources with respect to adaptation to SLR:
- Glossary with common SLR adaptation terms identified and described
- Summary table of the adaptation tools
- Table of SLR adaptation legislation by province
- Examples of bylaws addressing SLR from Quebec and Atlantic Canada
- Annotated bibliography with a summary of some of the key references used in the Primer
- Links to online versions of the materials sourced
- Complete bibliography of the reference sources used in the Primer
Historical Changes in Global SLR

In the latter part of the 19th century and during the 20th century, the global mean sea level rose at a rate of about 1.7 mm/year (17 cm/century). Since 1993, the rate of global sea level rise has increased to around 3 mm/year. Figure 1 - Global Mean Sea Level 1870-2003 shows the global trend.

Factors contributing to global SLR:
- expansion of ocean volume due to warming of ocean water
- melting of glaciers and ice caps,
- melting of the Greenland ice sheet and melting of the Antarctic ice sheet.

Projected Increases in SLR

How will sea level change in the future? Predictions of exactly how much SLR will occur and when are subject to uncertainty. The longer the time frame, the greater the degree of uncertainty. The Intergovernmental Panel on Climate Change (IPCC) estimates rise in global sea level to the end of this century (i.e., 2100) will vary from 0.47 to 1.90m.

Both BC and Atlantic Canada project a SLR of 1m by the year 2100.
Storm Surge & Wave Action

Storm surge is one of the more common coastal hazards associated with SLR and a significant contributor to coastal flooding. It refers to a temporary increase in the height of the sea due to extreme weather conditions such as low atmospheric pressure and/or strong winds. Higher water levels will result in water advancing further inland and increased overland flooding. Although independent of high tide, the risk of flooding increases when a storm surge coincides with high tide producing an extreme high water level.

A storm surge temporarily raises relative sea level, and may be combined with tidal, wave and wind action in a storm to increase their destructive potential. The potential impacts of wave action (intensity and frequency) will be influenced by shoreline type and exposure to open water and can include erosion and overtopping of flood barriers.

Adaptation vs. Mitigation

Mitigation: In the context of climate change, mitigation means implementing policies to reduce greenhouse gas (GHG) emissions.

Adaptation: means an adjustment in natural or human systems to a new or changing environment. With respect to SLR, adaptation refers to action taken to prepare for its occurrence.

Mitigation and adaptation work hand in hand. Mitigation aims to limit the impacts of climate change while adaptation will help us cope with the impacts we can’t avoid. Adaptation should ideally aim at creating resilient communities through a triple bottom line approach to:
In terms of geography, the Primer addresses Canada’s southern coasts, more specifically the coastlines of:

- British Columbia,
- Quebec,
- New Brunswick,
- Nova Scotia,
- Prince Edward Island, &
- Newfoundland and Labrador.

**British Columbia**
Population: 4,400,057 (2011 Census)
Total Coastline: 29,000 km
Coastal Population: 80%+ lives within 5km of the coast.
Areas Vulnerable to SLR: Most settled areas on the coast, especially the Lower Mainland, Vancouver Island low lying coastal communities, Haida Gwaii and Prince Rupert.

**Quebec**
Population: 7,903,001 (2011 Census)
Total Coastline: 6,825 km
Coastal Population: 400,000 live in coastal municipalities at risk of SLR.
Areas Vulnerable to SLR: Municipality of Sept-Îles, Côte-Nord region, parts of the Bas-Saint-Laurent region and Chaleur Bay (Baie des Chaleurs).

**New Brunswick**
Total Coastline: 5,500 km
Coastal Population: Nearly 60% live within 50km of the coast.
Areas Vulnerable to SLR: The Gulf of St. Lawrence coast.

**Nova Scotia**
Total Coastline: 13,300 km
Coastal Population: 70% live on or near coastline.
Areas Vulnerable to SLR: Much of Nova Scotia is considered highly sensitive to SLR, particularly the south coast and eastern shores.
Throughout the Primer, examples of how adaptation tools have been applied are provided. These are intended to provide guidance and insight into approaches that have worked (or not) as well as lessons learned.

Prince Edward Island (P.E.I.)
Population: 104,204 (2011 Census)
Total Coastline: 3,200 km
Coastal Population: Most live on or near the coastline.
Areas Vulnerable to SLR: Entire coast of P.E.I. identified as highly sensitive to sea-level rise.

Newfoundland and Labrador
Population: 514,536 (2011 Census)
Total Coastline: 29,000 km
Coastal Population: Over 90% of the population live in coastal communities.
Areas Vulnerable to SLR: The Burin Peninsula and St. George’s Bay as well as communities such as Placentia.

Provincial SLR Projections
Each of the different Provinces has established SLR scenario estimates which are being used to guide decision-making for adaptation policy and approaches.

<table>
<thead>
<tr>
<th>Province</th>
<th>SLR Planning Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.C.</td>
<td>50cm by 2050 1.0m by 2100 2.0m by 2200</td>
</tr>
<tr>
<td>Quebec</td>
<td>Focus on creating precise local estimates rather than general estimate for entire province</td>
</tr>
<tr>
<td>New Brunswick</td>
<td>0.9 to 1.05m over the next century</td>
</tr>
<tr>
<td>Nova Scotia</td>
<td>0.7 to 1.4m over the next century</td>
</tr>
<tr>
<td>P.E.I</td>
<td>1.0 to 1.08m by 2100 (± 0.48m)</td>
</tr>
<tr>
<td>Newfoundland and Labrador</td>
<td>0.8 to 1.0m+ by 2099 0.8m by 2099 (east coast of Labrador)</td>
</tr>
</tbody>
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CASE STUDY
Throughout the Primer, examples of how adaptation tools have been applied are provided. These are intended to provide guidance and insight into approaches that have worked (or not) as well as lessons learned.
This section discusses four strategies for adaptation to SLR: Protect, Accommodate, Retreat and Avoid.

**Protect** - A reactive strategy to protect people, property and infrastructure from sea level rise. Structural flood protection has been widely used in Canada e.g. dikes.

**Accommodate** - An adaptive strategy that allows continued occupation of coastal areas through changes made to human activities and/or buildings and infrastructure to improve resilience to occasional flooding. May be used as an interim measure.

**Retreat** - An adaptive strategy designed to limit the use of structural protection, discourage development in areas subject to sea level rise, and plan for the eventual relocation of buildings and infrastructure to areas with no risk or a lesser risk. A retreat strategy includes withdrawal, relocation or abandonment of private or public assets at risk due to coastal hazards.

**Avoid** - Planning so that development does not take place in areas subject to coastal hazards associated with sea level rise or where the risk is low at present but will increase over time. This may involve identifying future “no build” areas within local government planning.

**SLR Adaptation Framework**


Every coastal community is different and faces different challenges with respect to SLR. Information Gathering is identified as an imperative first step in the process of adaptation.
Some initial questions to be asked and to guide data gathering:
• What areas of our community are at risk?
• What is the nature and magnitude of the risk?
• What is the value of property, buildings and infrastructure at risk?
• What is the overall community vulnerability?

Information gathering provides an important baseline of information which can then be disseminated to the wider community through Public Education and Community Engagement. These processes can take a long time but the investment, in most cases, will be well spent providing community support and empowerment when it comes to adaptation.

Information Gathering Resource Examples:
• BC Ministry of Environment online resources
• Pacific Climate Impacts Consortium (PCIC) Plan2Adapt tool

Public Education and Community Engagement Examples:
• Community visualization (3D)
• Scenario based planning

Adaptation is a process and implementation of the tools is only one component; monitoring and evaluation are necessary to ensure successful long-term adaptation. This provides feedback into the adaptation process and allows adjustments to be made in response to changing circumstances or priorities.

Adaptation Framework:
The main focus of the Primer is on 21 adaptation tools. For the most part, the tools reviewed are already used by local government. They are organized into Planning, Regulatory, Land Use Change or Restriction, Structural and Non-Structural tools and this section of the Primer describes how they can be applied in a SLR adaptation strategy.

For each of the tools, a description, an outline of its application and discussion of enabling legislation (where applicable) are provided. The advantages and disadvantages of each tool are summarized in table form. Evaluation and governance considerations consisting of economic, environmental and social elements are identified. The discussion of each tool concludes with implementation measures and challenges along with illustrative examples.
Hybrid Techniques

The integration of structural and non-structural protection methods is sometimes referred to as hybrid shoreline protection systems. At first glance, structural and non-structural adaptation tools may appear to represent polar opposites; however, they are often used in combination. Non-structural tools, sometimes referred to as soft armouring or soft engineering, offer flexibility and can reduce the cost of construction compared to structural tools alone. In addition to cost-effective adaptation, hybrid shoreline protection can be used to offset negative environmental effects resulting from hard protection measures. One approach to shoreline protection using hybrid techniques in BC is Green Shores. Using the living shorelines model pioneered in the USA, Green Shores promotes the sustainable use of coastal ecosystems through planning and design that recognizes their ecological features and functions.

Photos
The cost of adaptation is considered to be the sum of all investments (and maintenance costs) necessary to protect coastline and human settlements located in at-risk areas.

**National Round Table on the Environment and the Economy “Paying the Price: The Economic Costs of Climate Change for Canada” (Sept. 2011).**

The report addressed coastal lands that would be risk without SLR (baseline case) and additional lands at risk due to climate change. By the 2050s, climate change will expand the land area at risk of coastal flooding by 6% to 18%. The report evaluated two adaptation strategies for coastal areas: climate related development planning and strategic retreat.

The first strategy would prohibit future construction in areas expected to be at risk of flooding by 2050 in a high climate change scenario. No additional growth would be permitted, but existing dwellings could be rebuilt following a storm surge. The second strategy would involve a gradual abandonment of newly flooded areas.

The National Round Table report found that both strategies would reduce the overall cost of climate change, but strategic retreat produced benefits one order of magnitude higher than climate-wise development planning. The report estimates climate change costs could escalate from roughly $5 Billion per year in 2020 - to between $21 billion and $43 billion per year by the 2050’s. When pursued in combination, the two strategies could lower the cumulative cost of climate change by $1 to $6 billion over the next century.

There is no national program for funding shoreline protection or for combating the impacts of sea level rise along the 243,000 kilometres of coastline in Canada. Shoreline protection projects have been funded through a number of programs including: the Building Canada Fund, Gas Tax Fund, Disaster Financial Assistance Program, Small Crafts Harbour Program, Infrastructure projects, Highway funding programs, Green Municipal Fund and other federal initiatives.

Example of effects of SLR, Cottage at Pugwash, N.S. Photo Credit: T. Webster
DIKE UPGRADE COSTING STUDY, METRO VANCOUVER, BRITISH COLUMBIA

In 2011 the Province of BC published Climate Change Adaption Guidelines for Sea Dikes and Coastal Flood Hazard Land Use (Ausenco Sandwell, 2011), which defines sea level rise planning levels and flood protection requirements to accommodate SLR.

The BC Ministry of Forests, Lands and Natural Resource Operations commissioned a study to estimate the cost to adapt flood protection to meet the rise in sea level predicted by 2100. The study covered the Metro Vancouver coastal shoreline and the Fraser River shoreline as far east as the Port Mann Bridge, some 250 km of shoreline and dikes in total. Within this area both diked shorelines and low-lying areas that may require protection as sea level rises were considered.

The report calculated the full costs of establishing flood protection for seismic stabilization of the diking system and year 2100 sea level rise including land acquisition, engineering, environmental design, relocation of utilities, and upgrading of pump stations and other appurtenant works. The total estimated cost was $9,470 million, including a 50% contingency factor. The estimated cost for sea level rise alone, including associated infrastructure and property acquisition was $2,810 million.

Funding may be available from Environment Canada, Environmental Damages Fund for the protection of and restoration of wildlife habitats in coastal areas. Natural Resources Canada has also made funding available to help assess the impacts of climate change and how to mitigate and adapt to them. The Regional Adaptation Collaborative program has contributed valuable funding to help provinces, local governments and individuals improve their decision-making in regard to adapting to sea level rise, storm surges, heavy to intense precipitation events, flooding and other events related to climate change.

Additional Features!
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