Adapting to a Changing Climate in Nova Scotia: Vulnerability Assessment and Adaptation Options

FINAL

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NOVA SCOTIA

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Preface

The *Kyoto Protocol* established under the *United Nations Framework Convention on Climate Change* (UNFCCC) has set targets for reductions in greenhouse gas emissions by developed countries. Regardless whether these targets are met, the level of emissions will still be such that climate impacts are expected. Consequently there exists a need to understand how our climate is changing and potential adaptation measures. Changes in precipitation and temperature patterns, climate variability, sea level rise and extreme events all can result in significantly damaging effects.

Nova Scotia is vulnerable to climate change due to its coastal infrastructure and due to the significant role played in the economy by natural resource sectors such as agriculture, forestry, fishing, and aquaculture. Understanding these vulnerabilities in a manner that allows prioritization can allow action to be taken. Once the key vulnerabilities are understood, it is possible to develop action plans to either adapt to the changing climate, or to mitigate the effects. These adaptation measures can take many forms including management tools, design tools, infrastructure changes, changes in behavioral patterns, etc.

To date most research and study with respect to climate change has focussed on understanding the types of changes which can be expected, and mitigation measures to reduce greenhouse gas emissions. However very little work has been undertaken to understand how regions such as Nova Scotia might adapt to climate change. This is a critical missing piece to the Province's approach to climate change.

The Province of Nova Scotia is committed to developing a climate change impacts and adaptation action plan for government ("Towards a Sustainable Environment," p 20, June 2003). The Nova Scotia Department of Energy (NSE) is the lead agency for climate change issues in Province, while the Nova Scotia Department of Environment and Labour (NSEL) has played a supporting role, particularly in the area of adaptation.

The intent of this report is to identify Nova Scotia's vulnerabilities to climate change, and identify priority options for adapting to climate change impacts. The results of this initiative could ultimately be used by the Province to develop a climate change impacts and adaptation action plan. This initiative will also provide recommendations on the nature and scope of the action plan and where possible its format and structure. A stakeholder review was undertaken of the preliminary findings contained in this report involving a broad corss-section of provincial government departments (see List of Participants – Annex 1) and Summary of Consultant Meeting, Annex 2. The outcomes of these consultations have been included in the report will serve to identify opportunities for partnerships between all levels of government, industry and non-governmental organizations (NGOs) in dealing with adaptation.

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1.0 Provincial Context

1.1 Introduction

The Atlantic region is geographically unique in Canada and North America because of its proximity to the ocean. The four provinces are relatively small and with the exception of Labrador, are almost completely surrounded by the ocean. The region has a combined coastline of 40,000 km with an area of 538,000 square kilometers.[1] This means that many areas of the region are relatively close to the ocean shore.[2] Not surprisingly, climate in Atlantic Canada is highly influenced by ocean currents, sea ice and atmospheric circulation. Local weather patterns are additionally influenced by topography, air movements and distance to the sea, resulting in numerous micro-climates. The region's ecosystems exist in a delicate balance under the combined influences of air and ocean circulation patterns.

Nova Scotia is a transition point between the North American continent and the Atlantic Ocean, where southerly climatic and forest regions transition to the northerly boreal zone (refer to Figure 1-1). With its relatively small and elongated landmass, extensive and meandering coastline stretching 10,424 km, numerous coastal communities and an economy based substantially on natural resources, Nova Scotia is particularly vulnerable to climate change.

Landform is extremely varied within Nova Scotia's 55,000 km^2 of area. In addition to extensive coastal areas, there are highlands, uplands, valleys and lowlands within 60 km at least of one of three major water bodies – the Atlantic Ocean, the Northumberland Strait/Gulf of St. Lawrence, and the Bay of Fundy. It is also at the convergence of major ocean currents. The cold Labrador Current sweeps down from the north becoming the Nova Scotia Current, converging with the warm Gulf Stream as it pushes up from the equator. In addition, the climate along the north shore of Nova Scotia influenced by the warmer waters of the Gulf of St. Lawrence.[3]

The Province's climate, which is as diverse as its landscape, is heavily influenced by varying proximity to one or more of these three water bodies, elevation and its position between 43 and 47 degrees north latitude, which results in varied temperatures, wind exposure and precipitation. While Nova Scotia exhibits a continental climate, due to the predominantly eastward movement of winds across North America, surrounding waters modify the climate, making winters milder and summers cooler than in the center of Canada.

[1] National Atlas of Canada, data from the Canadian Hydrographic Service, Fisheries and Oceans Canada, accessed at http://atlas.gc.ca/site/english/facts/coastline.html#c4

[2] As a note of interest, the ratio of perimeter to area for the Atlantic region is 0.74, providing 1 km of shore for every 1.35 km^2 of land area.

[3] Environment Canada. 1997. Canada Country Study, Volume VI – Climate Change and Vulnerability in Atlantic Canada.

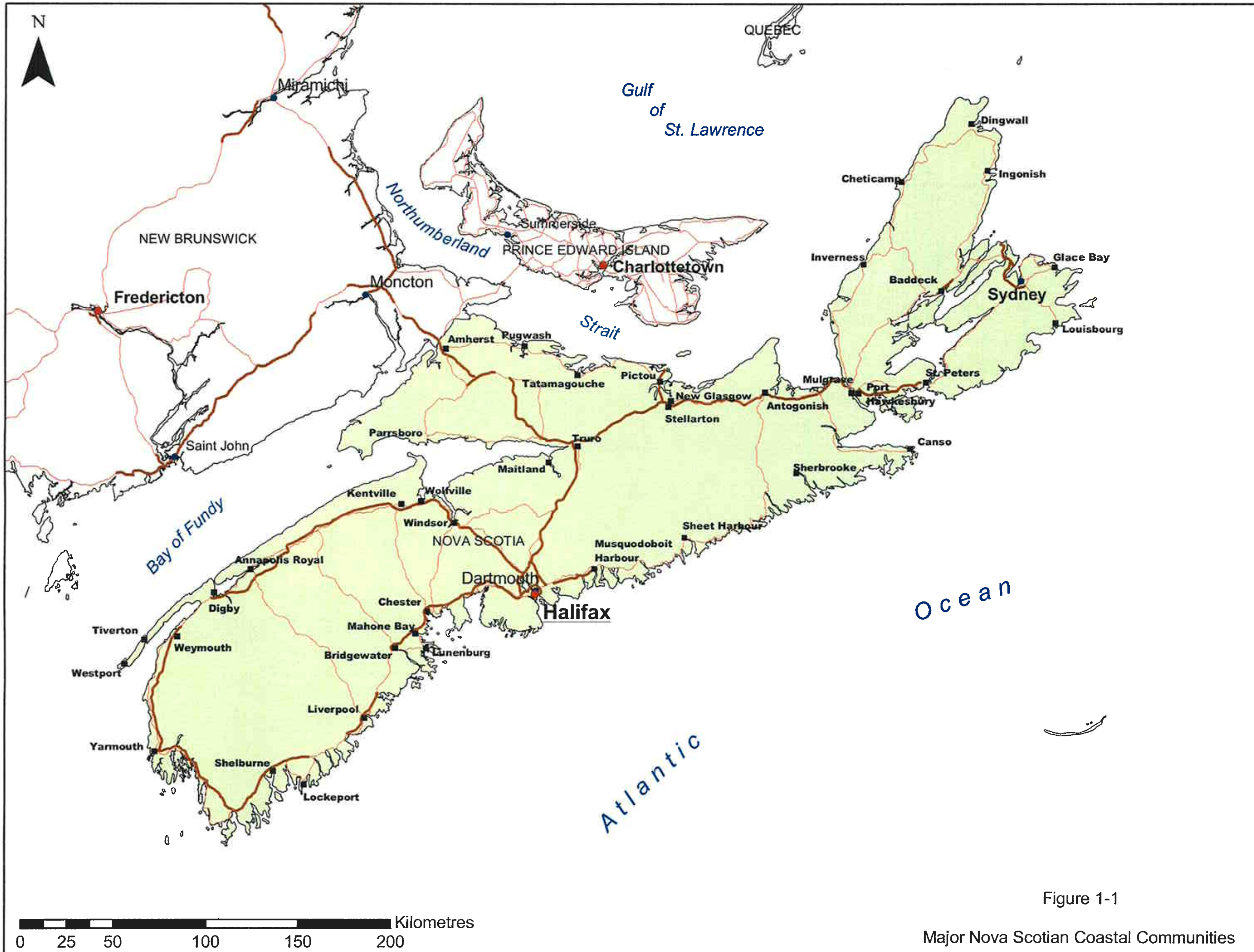


Figure 1-1

Major Nova Scotian Coastal Communities

Atmospheric currents from the south and northwest also converge over the Atlantic region, with a warm moist storm track from the south and cold dry air moving with the jet stream from the northwest. These atmospheric systems are more intense during winter months and produce a wide range of natural weather extremes, including heavy snowfalls and rainfalls, winter thaws and ice storms, gale to hurricane force winds, high waves and storm surges. In the recent past, hurricanes and extreme wave action have proven devastating to the region's ecosystems and human populations alike.[4] The significant influences of both air and ocean circulation make Nova Scotia highly variable in climate both throughout the region and over the course of years, months and days.

Historically, settlements by the Mi'kmaq as well as Europeans were centered in coastal areas, especially in sheltered bays and along estuaries, as water was the primary route for transportation and source of food. Present day communities, many continuing from historical settlements, including the Province's largest population centers, are located along each of three coastal areas, as well as along esturaries and river systems. The Province's capital city, Halifax, is located along Halifax Harbour on the Atlantic Coast. The Province's only other city - Sydney - is located in Sydney Harbour on the Gulf of St. Lawrence. Many other communities, including the Towns of Truro and Windsor, are located along major rivers discharging to the Bay of Fundy.

1.2 Physical Character

Landform and climate within Nova Scotia can be categorized within several distinct landforms, based on "theme regions" as described in the *Natural History of Nova Scotia*. For the purposes of this discussion, the theme regions have been amalgamated as Highland, Interior, Lowland and Coastal regions, as discussed below and shown on Figure 1-2.[5]

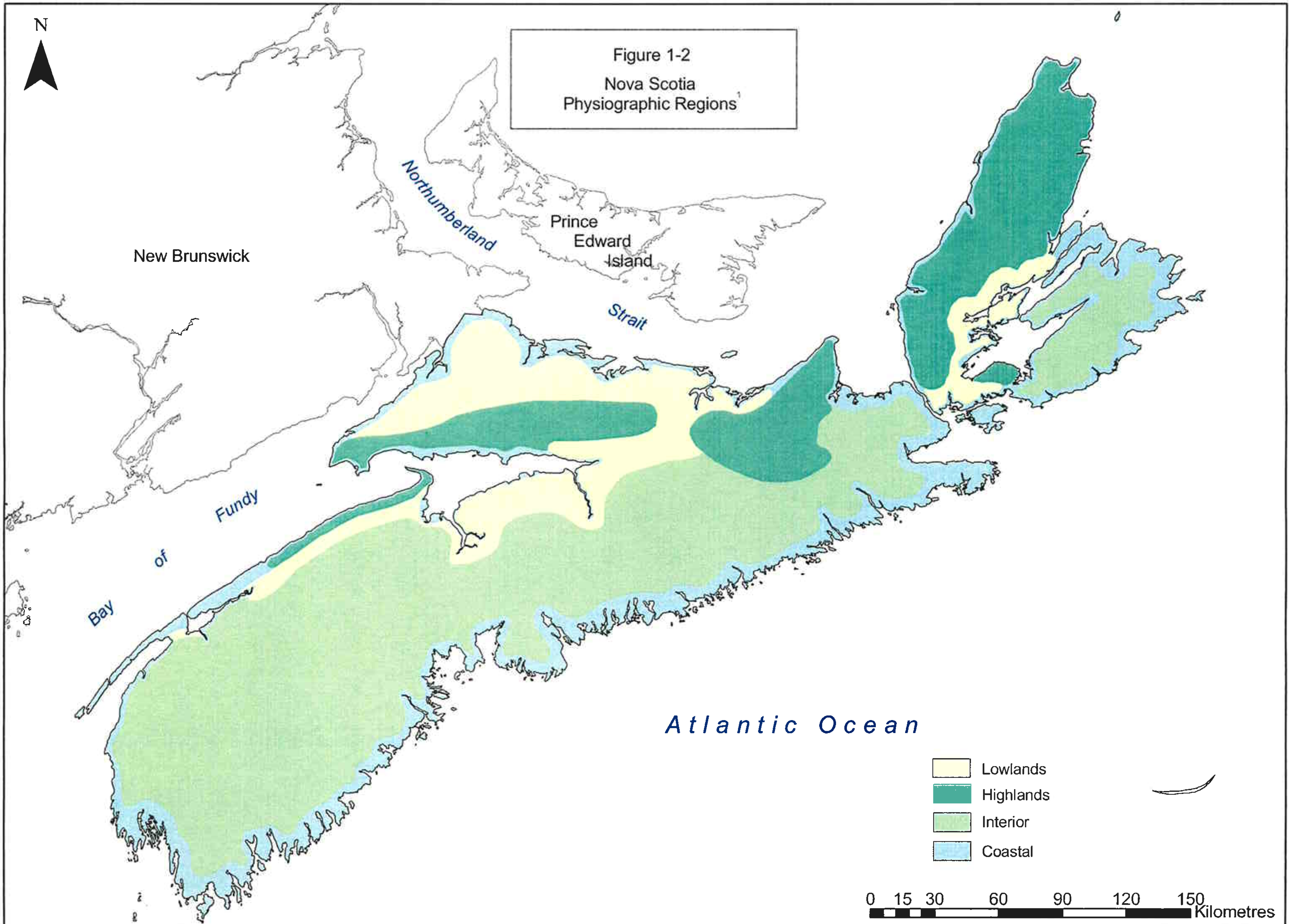
Coastal

As a peninsula, Nova Scotia is almost entirely surrounded by marine waters – the Atlantic Ocean to the south and east, the Bay of Fundy to the northwest, and the Northumberland Strait and the Gulf of St. Lawrence to the north and northeast. These water bodies form three distinct coastal areas.

These waters modify the Province's weather. Because the sea is much slower to warm up and cool down than the land, cold winds from coastal areas delay the arrival of spring, extend the fall season and delay the onset of winter. Additionally, daily temperatures in coastal areas and inland can differ by as much as 20°C due to the influence of sea breezes, particularly in late spring and

[4] Op.cit.

[5] Davis, D and Browne, S. (Eds.) 1996. The Natural History of Nova Scotia. Halifax. Nimbus and Nova Scotia Museum.



[1] After Davis and Browne (1996)

early summer. Conditions in the three coastal areas vary sufficiently to result in different climatic conditions.[6]

Atlantic Coast

The Atlantic Coast is an exposed, high wave energy environment, a mixture of resistant granite and Meguma group headlands interspersed with extensive sand or gravel beaches in protected areas and bays. Landforms include rocky headlands, large bays, small coves, and natural harbours. The coastal bedrock is low lying and elevations rarely exceed 100 m. Tidal range may reach over 2 m along the Atlantic Coast. Coastal areas are exposed to significant erosional forces from tidal action, storm surges and wind. While offshore winds do not have an erosive effect on the Atlantic coastline, storm events do produce onshore waves that rework exposed glacial deposits, with Atlantic coast drumlins being eroded at a mean rate of 1 m per year.[7]

In general, this is a cool water coast. The ocean moderates seasonal and daily temperatures, resulting in high precipitation and humidity, high winds, fog and salt spray. Winters are relatively mild and summers are short and cool. Mean winter temperatures are above -5°C and in some areas remain above 0°C. Spring starts early but is long and cool. Because of frequent fogs and the cooling influence of ocean waters, the mean summer temperature is 15-20°C compared to 20-25°C throughout the rest of the Province. The Atlantic Coast receives fairly high precipitation, usually between 1400 and 1600 mm. Only about 15% falls as snow because of mild winter temperatures, with most of the region receiving less than 200 cm of snow annually. Ice forms only locally in bays on the Atlantic Coast.

Fundy Coast

The Fundy Coast is a climatic transition zone. The central sections of the Bay are protected from the extreme climatic conditions of the Atlantic Coast. Landforms include basalt headlands with vertical cliffs and sandstone bays. Extensive salt marshes and tidal flats are characteristic of the shoreline. Winds and tides cause significant erosion of non-resistant rock and sediment in the Bay, measured at a mean rate of .5 m per year. Ice forms in the Bay of Fundy from December to April and provides protection to the shoreline from erosion during that time.

The Bay of Fundy and Minas Basin experience strong near shore tidal currents, with extremely large tidal ranges in the inner Bay of Fundy – among the largest tidal ranges in the world (from 6 to over 15 meters). As the strong tides enter the Bay, the water accumulates and deepens, forming a steep-fronted surge called a tidal bore. Six major river systems discharging to the Bay of Fundy experience tidal bores. Flooding of low-lying areas at the head of the Bay of Fundy is common when spring tides occur in concert with storm surges and heavy runoff into estuaries.

Extreme tidal-induced turbulence prevents coastal waters in the Bay of Fundy from freezing, and prevents warming of the surface layers in summer. By late summer, the surface coastal waters in

[6] Environment Canada website – The Climate of Nova Scotia http://www.atl.ec.gc.ca/climate/ns.html

[7] Geological Society of Canada CoastWeb Fact sheet. http://www.gsca.nrcan.gc.ca/coastweb/facts_e.php. 2002.

the Bay are cooler than any other surface water along the Province's coasts, and do not exceed 12°C. However, waters in shallow shore areas reach 20°C or greater after crossing sand and mud bars. Although temperatures are similar to the Atlantic Coast, there is less exposure to winds. In the Minas Basin, surface waters are considerably warmer and the coastal climate approximates that of the Annapolis Valley in terms of temperature and precipitation.

Northumberland Coast
The coast of the Northumberland Strait is characterized by eroding till and rock. The bedrock is primarily sedimentary and is much less resistant to the effects of waves. Sand beaches are common as are extensive salt marshes in the protected bays and inlets. The area is submergent with many long inlets and estuaries extending inland from sheltered harbours. Winter waves move sand and gravel from beaches to offshore locations and summer onshore winds return the material shoreward, rebuilding beaches and bars. The tidal range is only 1-2 m. This coastal region contains the warmest waters on the Nova Scotia coastline.

Sea ice occurs in the Gulf of St. Lawrence (Northumberland Strait), forming in December and breaking up in late March or April.

Highlands
The highest elevations in Nova Scotia are found within four distinct highland regions. Two are located along Province's coastline: the Highlands of western Cape Breton Island, which are bordered by the Northumberland Strait and the Gulf of St. Lawrence, and the North Mountain range, which makes up much of the mainland's northwest coastline along the Bay of Fundy. Two highland areas occur primarily inland: the Pictou - Antigonish Highlands, which extend inland from a relatively short length along the Northumberland Strait; and the Cobequid Highlands, which extend inland from the Minas Basin at the end of the Bay of Fundy.

The climate of the Highland areas of Nova Scotia is influenced by elevation (averaging 150 to greater than 300 meters above sea level) and the proximity of surrounding waters of the Atlantic Ocean, Gulf of St. Lawrence and the Bay of Fundy. Winters are longer than other regions of Nova Scotia and summers are short and cool. Precipitation ranges from over 1200 mm to 1600 mm.

Interior
The Interior of Nova Scotia encompasses nearly the entire southern and eastern inland portions of the province. The region is primarily a uniform plateau with some low ridges and shallow valleys. Elevations range from about 150 m to 275 meters above sea level.

Climate patterns in the Interior vary with proximity to the ocean and according to latitude. While there is considerable climatic variation, the Interior essentially has an inland, lowland climate sheltered from direct marine influences and characterized by cold winters and warm summers. Mean annual temperature ranges from 1 to 5°C and higher.

Rainfall in the Interior averages 1000 mm per year, whereas the average annual rainfall in regions near the coast exceeds 1600 mm. Snowfall averages 150 cm near the coast to 250 cm or more in higher areas and further inland.

Lowlands

The Lowlands of Nova Scotia include inland areas such as the Annapolis Valley as well as coastal areas bordering the Minas Basin/Bay of Fundy and the Northumberland Strait/Gulf of St. Lawrence. Climate varies considerably, although the region essentially has an inland lowland climate characterized by cold winters and warm summers. Climate is influenced by nearby high elevations, particularly in Cape Breton adjacent the highlands, and proximity to marine waters as well as Bras D'Or Lake.

Although winters are cold, they are not severe. Temperatures warm quickly in central and southern areas of Nova Scotia and remain cool in areas along the Gulf of St. Lawrence due to ice cover. Mean daily summer temperatures are over 17 degrees C.

The Annapolis Valley experiences the warmest temperatures in the Province as well as low precipitation. North and South Mountains provide a sheltering effect that does not allow for the waters of the Bay of Fundy to moderate summer or winter temperatures, although the western and eastern ends of the Valley are influenced by the Bay of Fundy and Minas Basin, respectively. The Valley generally experiences warm early springs, hot summers and cold but not severe winters.

The lowland area located east of the Cobequid Highlands and sloping to the Northumberland Strait is considered a coastal plain. The Northumberland coastal plain receives the least amount of precipitation in the province. Since the Northumberland Strait freezes in the winter, the winters tend to be colder than other coastal regions of Nova Scotia and long. The warmer waters of the Strait do not moderate summer temperatures.

Precipitation varies throughout the lowlands, being generally drier near the New Brunswick border (with less than 1000 mm) and wetter in Cape Breton (which receives 1200-1600 mm). Snowfall is heavy inland and in Cape Breton, moderate in the Annapolis Valley and lighter near the coast.

1.3 Special Natural Features, Factors and Processes

Land Emergence

Land emergence in Nova Scotia is a result of post-glacial rebound and tilting of the coastline. During glacial retreat at the end of the Wisconsin period, sea level rose and flooded the present day land areas. The land then underwent isostatic rebound and the sea levels receded, leaving evidence of marine habitat stranded above high water. Raised beaches and estuarine delta sediments several metres above high tide, wave cut platforms, and fossilized marine organisms above high tide are evidence of lower sea levels from 15,000 to 8,000 years ago.

Since the last recession of glacial ice, sea level has been rising worldwide - at a rapid rate until about 6,000 years ago, and at a much slower rate since then. Uplift had varying results in Nova Scotia: in the Bay of Fundy the coastline was raised several tens of meters above the present high tide mark; the south coastline around Yarmouth was left in the same position relative to the sea; while the southeast coastline, from Shelburne County to Guysbourough County, was drowned as the sea moved landwards across the continental shelf.[8]

Submergence

Once the glaciers retreated and the earth's crust rebounded, it began to subside. Evidence of past submergence of terrestrial habitats are shown in the remains of ancient forests exposed several metres below the present high tide level. An example of submergence is an area west of Church Point in Clare Municipality on St. Marys Bay. The remains of a 5,000 yr. old forest lies 5 m below the high tide mark.[9]

Tide records for the past century in Nova Scotia indicate an increase in sea level of more than 35 cm since 1896; however, Roland Gehrels, of the University of Plymouth, has recorded a rise in sea level at Chezzetcook of 60 cm since 1750 by reconstructing the deposition of salt marsh sediments.[10]

Part of the reason for the increase in sea levels can be attributed to subsidence of the crust following post-glacial rebound. According to Webster et. al, approximately 20 cm per century of sea level rise can be attributed to subsidence of the earth's crust; the remaining 10 to 12 cm (this number varies within the Maritime provinces) is considered to be due to sea level rise.[11] Environment Canada reports for Nova Scotia that "Increases in sea level will vary regionally but, on average, are estimated to be between 0.20 and 0.65 m by 2100."

The Geological Survey of Canada maintains 100 coastal monitoring sites in Nova Scotia to provide baseline information about long-term changes in shoreline position, morphology and the impacts of extreme storm events. Forty-one of those sites have provided data for 15 years. Recent monitoring of two beaches on the Eastern Shore of Nova Scotia has shown the variations of coastal change: one low beach has been retreating landward at a rate of eight metres a year, whereas a higher-crested beach a few kilometres away shows little retreat. In areas where the coastline is rocky the rate of retreat is barely noticeable over historical time. In other areas, where the coast is composed of loose sand, gravel and mud, the rate of retreat is much higher. In

[8] "Fundy Dykelands and Wildlife", Nova Scotia Department of Natural Resources publication.
[9] Natural Resources Canada, http://www.gsca.nrca.ga.ca/coastweb/facts_e.php#fast.
[10] Gehrels, Roland et al. (2001) High –resolution Reconstruction of Sea-Level Change During the Past 300 Years. Geological Society of America, November 2001.
[11] J. Shaw, R. B. Taylor, D. L. Forbes, M-H Rus and S. Solomon, 1998. Sensitivity of the Coast of Canada to Sea-Level Rise; Geological Survey of Canada Bulletin 505, 79 p. + map

Atlantic Canada, rates of erosion can reach up to 10 metres per year, but are generally less than one metre per year. Historical records show the loss of entire islands along the coast of Nova Scotia[12].

1.4 Regional/Local Climatology and Related Phenomena

Environment Canada reports "Average summertime temperatures in Atlantic Canada could increase by as much as 3-4°C over the next 80 years. These changes would have enormous impacts on the lives of the people of Atlantic Canada and the ecosystems that support them."

Variability in Rainfall and Temperature

The highlands of Cape Breton are currently the wettest area in Nova Scotia, receiving over 1600 mm of precipitation fall in an average year. The southern coast experiences almost as much, with totals of 1500 mm. By contrast, the north shore along the Northumberland Strait has less than 1000 mm a year.

Precipitation is slightly greater in the late fall and early winter because of the more frequent and intense storm activity. In most years there is an adequate supply of rain during the growing period. However, drought is not unknown in Nova Scotia. A dry month is considered to be one in which 25 mm or less of rain falls. In our current climate, dry months are not common anywhere in the Province, but are more likely to occur in the Annapolis Valley, Northumberland Shore and eastern Cape Breton.[13] A prolonged warm, dry, and sunny spring in 1986 contributed to the worst forest fire outbreak in the province's history. The previous summer, several months of below normal precipitation dried up wells and streams, and water levels did not begin to recover until Hurricane Gloria brought heavy rains in late September. The summer of 2001 was the third driest summer on record for the Atlantic Region.[14]

Most of Nova Scotia presently receives less than 15% of precipitation in the form of snow, with the exception of the Cape Breton Highlands, where more than 30% is normal. Higher elevations now receive in excess of 300 cm of snow per year in contrast with the southwestern region, which receives less than 150 cm. Heavy snowfall resulting from onshore winds over the Bay of Fundy and Northumberland Strait is common.

[12] Geological Society of Canada CoastWeb Fact sheet. http://www.gsca.nrcan.gc.ca/coastweb/facts_e.php. 2002.

[13] Nova Scotia Department of Natural Resources Education Modules – Forest Sustainability http://www.gov.ns.ca./natr/extension/education/sustain/intro1.html

[14] Nova Scotia Department of Agriculture and Fisheries Fact Sheet – What You Should Know About Irrigation Water Quality Safety.

The mean annual temperature across most of Nova Scotia currently ranges from 5 to 7°C, except in the Cape Breton Highlands and the Cobequid Hills, where it is cooler. The Northumberland Strait has the greatest range in annual temperature, with over 25°C difference between temperatures in the coldest and warmest months. This decreases to a range of 10°C along the southwestern Atlantic Coast. January and February are the coldest months while July and August are the warmest. Mean daily temperatures fall below freezing between mid November and mid March (April at higher elevations in the northern part of the Province). Winter conditions lasts from 80 days in southwestern Nova Scotia to 120 days in the Cobequid Hills and Cape Breton Highlands. The most significant aspect of winter is the marked day-to-day variation caused by the alternation of Arctic and maritime air.

Vulnerability to Storms, Hurricanes and Other High-Energy Events

According to Environment Canada, Nova Scotia (along with Newfoundland and Labrador) receives the most storms of any region in Canada due to its proximity to the Gulf Stream. This is attributed to nor'easters, which are most prominent during the winter and early spring. These storms can generate wave heights in excess of 14 metres and storm surges of more than one metre.

The coast of Nova Scotia is often subjected to high-energy wave action associated with hurricanes and other tropical storm systems. Typically tropical storms and hurricanes weaken as they approach the Province, once they pass over the cooler water north of the Gulf Stream. In the recent case of hurricane Juan in September 2003, the waters along the Atlantic coast of NS were 3°C warmer than normal, which allowed the storm to retain its strength as it made landfall.

Since 1970, 17 hurricanes and tropical storms have made landfall in Nova Scotia, a summary of these events is provided in Table 1-1.

Table 1-1
Hurricanes and Tropical Storms 1970-2003[15]

Year	Storm	Type	Landfall Location
1970	Beth	Hurricane	Copper Lake
1975	Blanche	Hurricane	Southwestern Nova Scotia
1988	Alberto	Tropical Storm	Digby
1988	Chris	Tropical Storm	Digby
1990	Bertha	Hurricane	Cape Breton Island
1991	Bob	Hurricane	Crossed New Brunswick
1991	Unnamed 'The Perfect Storm'	Tropical Storm	Halifax
1995	Allison	Extratropical Storm	Cape Breton Island
1995	Barry	Tropical Cyclone	Cape Breton Island
1996	Bertha	Extratropical Storm	Crossed New Brunswick
1996	Fran	Tropical Storm	Crossed New Brunswick
1996	Hortense	Hurricane	Eastern Shore

[15] Canadian Hurricane Center website

Year	Storm	Type	Landfall Location
1999	Floyd	Tropical Storm	Amherst
2000	Unnamed	Subtropical Storm	Cape Breton Island
2001	Karen	Tropical Storm	Southwest Nova Scotia
2002	Gustav	Hurricane	Cape Breton Island
2003	Juan	Hurricane	Halifax

1.5 Important Natural Features

Environment Canada reports "Much of the coast of Atlantic Canada is highly sensitive to the effects of sea-level rise. The most sensitive coasts are commonly low-lying, with salt marshes, barrier beaches, and lagoons. These areas will experience such effects as increased erosion, rapid migration of beaches, and flooding of coastal freshwater marshes. A higher sea level will affect wetlands and ecosystems at the edge of the ocean, disrupting the habitat and life cycle of marine life, birds and wildlife in those areas." Flooding and dyke breaching in the Bay of Fundy is a particular concern.

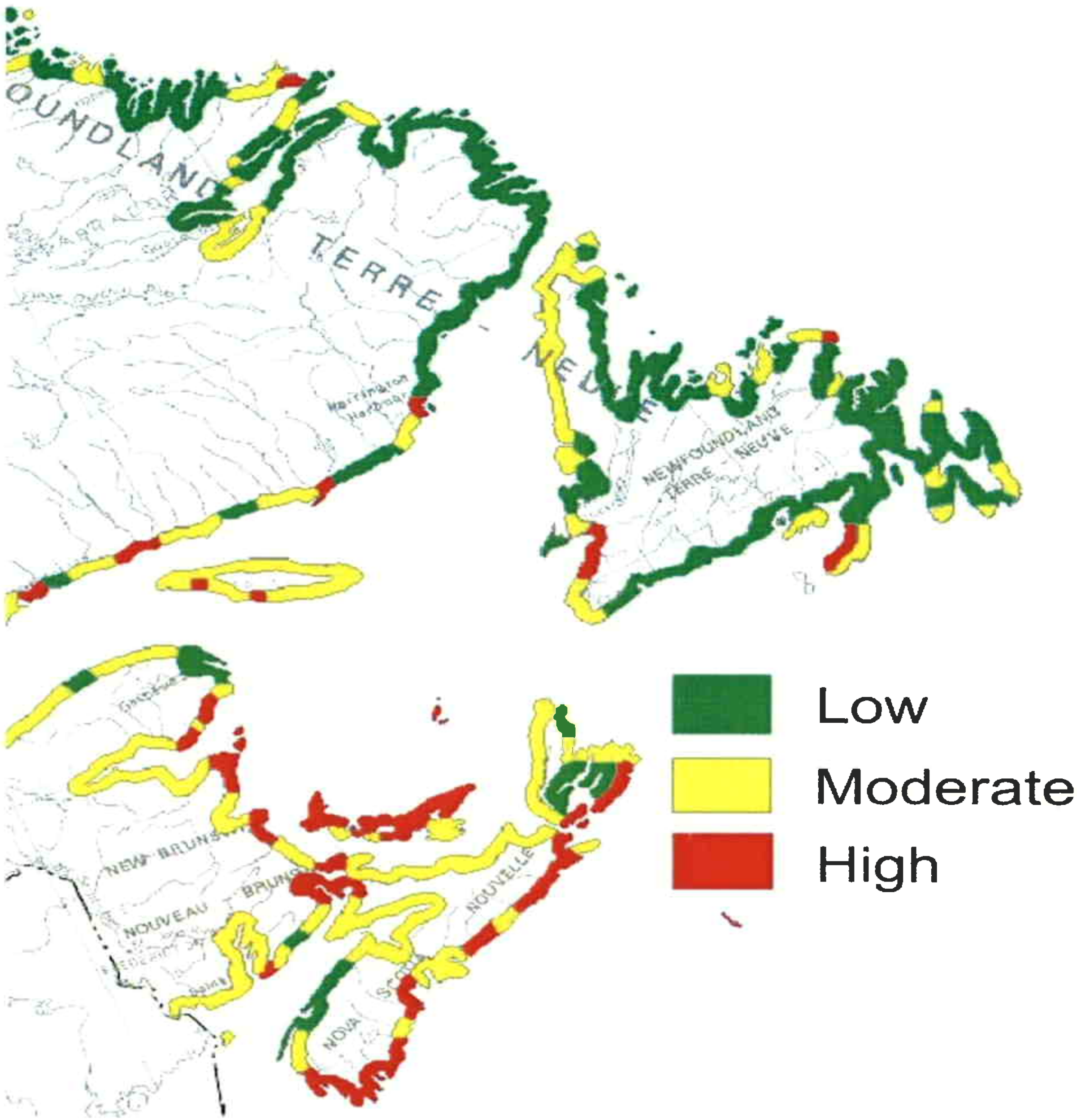


Figure 1-3 Sensitivity of Coastlines to Climate Change

Figure 1-3 depicts the sensitivity of coastlines in Atlantic Canada to an accelerated rise in sea level. All of the Atlantic Coastline of Nova Scotia is ranked as having either moderate or high sensitivity to sea level rise with approximately 80% being ranked as high. The Northumberland and Fundy coasts are ranked as low to moderate, as is Cape Breton. According to Natural Resources Canada, the sea level is likely to rise by 70 cm by the year 2100.

Wetlands

Nova Scotia has about 600,000 acres (242,816.7 ha) of freshwater and saltwater wetlands, which cover more than 15 per cent of the province. The majority of wetlands throughout the Province are classed as peatlands. Wetlands provide a natural system of filtration and storage of freshwater and serve to control flooding by absorbing surface water during periods of precipitation and releasing water during drier periods.

Salt Marshes

The most extensive salt marshes in Nova Scotia are present along the margins of the Bay of Fundy and Minas Basin. Sediments deposited by tidal action are colonized by vegetation. The vegetation stabilizes the sediment and, as deposition continues, the height of the salt marsh increases until it is less than a metre below the highest tide levels.

The salt marshes of the Atlantic Coast and Northumberland Strait area are smaller than those of the Bay of Fundy and develop primarily from sediments deposited from the land as opposed to tidal borne sediments.

Forests

Approximately 90% of Nova Scotia is forested (refer to Figure 1-4). Of the 5.5 million hectares of land area, 4.2 million is productive forest land. As with many other aspects of Nova Scotia's natural history, its forest type is a transition between two major vegetation regions. Nova Scotia is in the Acadian Forest Region with the Boreal Forest to the north and the Deciduous Region to the south. The location of the Province between the two zones and the influence of the Atlantic Ocean, which contributes to a higher humidity in the coastal areas, leads to a greater variety in vegetation than in the zones to the north and south. Dominant species in the Acadian Region include Red Spruce (Provincial Tree), Balsam Fir, Sugar Maple and Yellow Birch, as well as White and Red Pine and Hemlock. There are 15 coniferous and 30 deciduous tree species native to Nova Scotia.

Coastal forests in Nova Scotia are primarily dominated by Red and Black spruce and Balsam Fir. The vegetation found along the coast is heavily influenced by the moisture and fog resulting from the proximity to the ocean.

In addition to supplying the forest products industry (discussed later), Nova Scotia forests support a variety of important habitats for native and rare wildlife species. For example, forests provide important nesting habitats for several species of birds including Great Blue Heron, Osprey, Common Goldeneye and the Bald Eagle.

Further, according to Wilson and Colman (2001), "Nova Scotia forests are estimated to provide a minimum of $1.68 billion (1997$) worth of services annually in climate regulation, soil formation, waste treatment, biological control, food production, recreation and cultural benefits (Costanza et al. 1997). This estimate does not include other vital forest ecosystem services such as soil erosion control, water supply and watershed protection, nutrient cycling, gas regulation, pollination, habitat, disturbance regulation and genetic resource. Nova Scotia's forests store about 107 million tonnes of carbon, thereby avoiding an estimated $2.2 billion in climate change damage costs."

Water Resources

Nova Scotia has 6,700 lakes, 100 rivers and immeasurable groundwater resources (Figure 1-5). Water resources supply potable and industrial water, irrigate farmland, support freshwater aquaculture and generate hydro-electricity, as well as providing a foundation for the tourism industry and recreation for the Province's residents.

A major east-west divide separates the Province into three distinct hydrologic zones. Watercourses within these zones drain in the south to the Atlantic Ocean and in the north to either the Bay of Fundy or the Northumberland Strait. Most of Nova Scotia's watersheds are relatively small (74-2,614 km^2).

The Atlantic coast is considered to be one of the regions with the highest sensitivity of rivers to predicted climate change. This is a result of the shift to more intense rainstorms (rather than snowmelt) as the main flood generator. Small streams in urban areas may be particularly problematic. While the most direct effect of predicted climate change will be to increase flood and river erosion hazards, the impact will extend to the use and value of rivers for recreation, habitat, fisheries, water supply, and transportation.

Groundwaters and surface waters supply potable water to Nova Scotia's residents, businesses and industries. Approximately 54% of the Province's population relies on treated water from municipal water supply systems; approximately 46% rely on groundwater, supplied through private wells. There are 82 municipal water supply systems in Nova Scotia. Of those, 34% rely on groundwater, 54% draw surface water, and 12% are based on a combination of surface and groundwater. Groundwater supplies in lowland and coastal areas may be at risk of salt water intrusion.

Nova Scotia fruit and vegetable farmers rely on irrigation during periods of dry weather during the growing season as well as for frost protection. Most producers use surface water supplies rather than groundwater for irrigation due to operational costs, but also because groundwater is not available in sufficient quantities for irrigation in some regions. Some areas of the Province are currently facing water-supply issues related to climatic conditions. The Annapolis Valley in the Lowland region has the longest growing season in the Province and supports the most commercial agricultural use. However, low summer precipitation and coarse sandy soils in areas of the region lead to droughty conditions in some years. The effect on agricultural operations is exacerbated by increasingly tighter restrictions on the withdrawal of surface water for irrigation and increased degradation of river systems as a result of agricultural and residential uses.

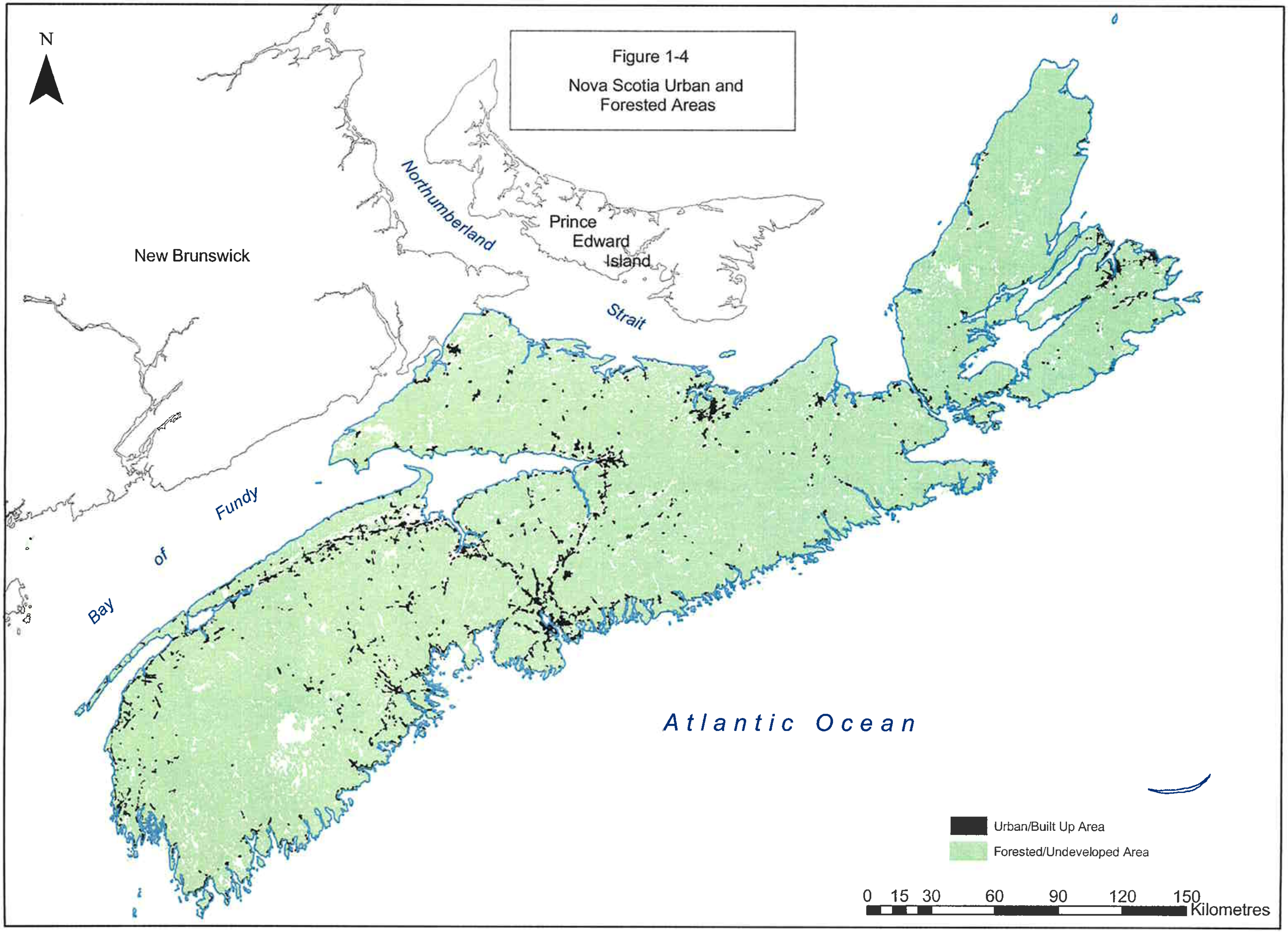


Figure 1-4
Nova Scotia Urban and Forested Areas
N
New Brunswick
Northumberland
Prince Edward Island
Strait
Bay of Fundy
Atlantic Ocean
Urban/Built Up Area
Forested/Undeveloped Area
0 15 30 60 90 120 150 Kilometres

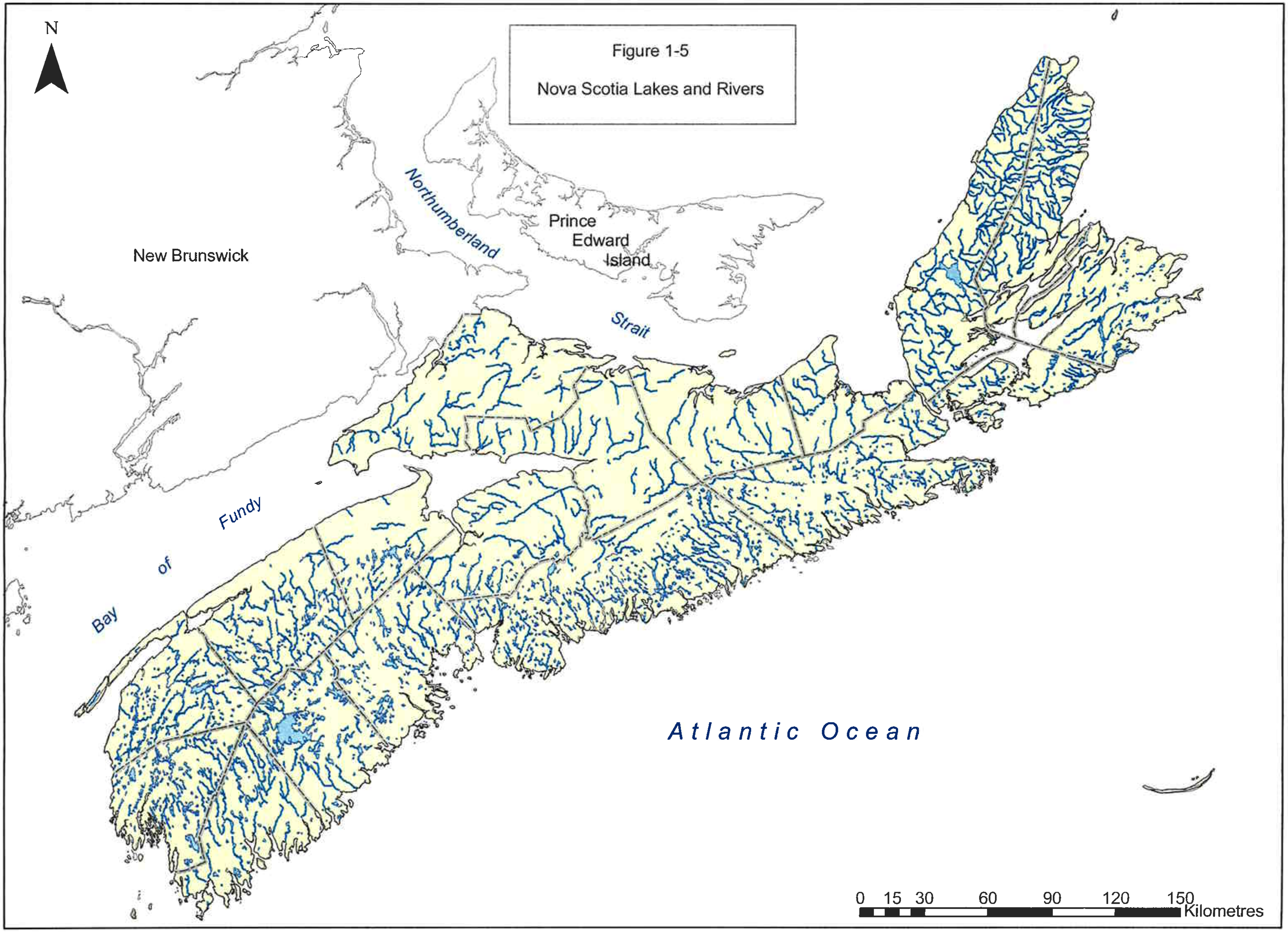


Figure 1-5
Nova Scotia Lakes and Rivers
N
New Brunswick
Prince Edward Island
Northumberland Strait
Bay of Fundy
Atlantic Ocean
0 15 30 60 90 120 150
Kilometres

Water resources also supply power. Almost 10% of Nova Scotia's electricity is generated from 33 hydroelectric plants and one tidal plant (the only saltwater generating station in North America), many located in the Southwestern part of the Province, where there is an abundance of natural lakes and waterways.

In January 1984, the Canadian Heritage Rivers System (CHRS) was established by the federal, provincial and territorial governments to give national recognition to the important rivers of Canada, to conserve and protect the best examples of Canada's river heritage. Two rivers in Nova Scotia have been designated as Heritage Rivers: the Shelburne River, the Province's most remote wilderness river, which discharges to Lake Rossignol; and the Margaree River in Cape Breton, which discharges to the Gulf of St. Lawrence. While the designation affords no official protection, it serves to represent the uniqueness or particular value of a river on a national scale.

1.6 Socio-Economic Profile

According to Statistics Canada, the population of Nova Scotia in the 2001 Census was 908,007. Approximately 70% of Nova Scotia's population, or 651,868 people, live in the coastal zone in more than 360 coastal communities, many of which have a population of less than 1000 people. The largest concentrations are in Greater Halifax (population of 360,000) and Cape Breton Regional Municipality (population 109,831). Other major communities in the coastal zone include: Yarmouth (7,600); Truro (21,000); urban Pictou County (25,000); and Amherst (9,500). The interior of the Province is relatively uninhabited compared to the coast.

Nova Scotia's economy is substantially based on several natural resources-based industries – fishing, forestry, farming and tourism. Exports related to the fishery and forestry industries total more than 40% of the total value of Nova Scotia's exports as shown in Table 1-2.

The financial budget for the Province of Nova Scotia includes a summary of net program expenses. For the 2004-2005 period, 70% is allocated to Health and Education departments, including universities; 5% is allocated for Transportation and Public Works; and approximately 2% is allocated for Agriculture, Fisheries and Natural Resources combined.

While directly responsible for its own expenditure programs, the Province of Nova Scotia also has an interest in the economic and social activity within its jurisdiction. The Nova Scotia Statistical Review for 2003 includes gross domestic product (GDP) figures for various sectors of the provincial economy. With respect to the total provincial GDP, the 2002 values presented in the document indicate 23% consists of the Health Care, Education and Public Administration sectors; 22% consists of the private sector Wholesale and Retail Trade; 21% consists of the Financial, Insurance, Real Estate and Rental sectors; and 3% consists of Agriculture, Fisheries, Forestry, and Support Activities. A separate table in the same document indicates Tourism may account for 3% of the total provincial GDP.

The First Nations People of Nova Scotia are known as the Mi'kmaq. At the time of first contact with European explorers in the 16th and 17th centuries, the Mi'kmaq lived in the region now known as the Maritime Provinces and the Gaspé Peninsula. Today, the Mi'kmaq Nation in Nova Scotia consists of a total of 13 Mi'kmaq Bands as well as Reserve lands set aside for use by band members. (Figure 1-6). There are approximately 11,000 Mi'kmaq in the Province.

Resource use by Mi'kmaq includes hunting, fishing and forestry as well as harvesting resources needed for use by traditional artisans such as basketry, carving, painting, and leatherwork. Another important aspect includes the preservation of traditional environmental resources for medicines and food. Fishing is the largest use of natural resources by First Nations people in Nova Scotia with several bands participating in the inshore fishing sectors traditionally dominated by non-native fishers, particularly the crab and lobster fishery.

Table 1-2
Nova Scotia Exports by Commodity Group

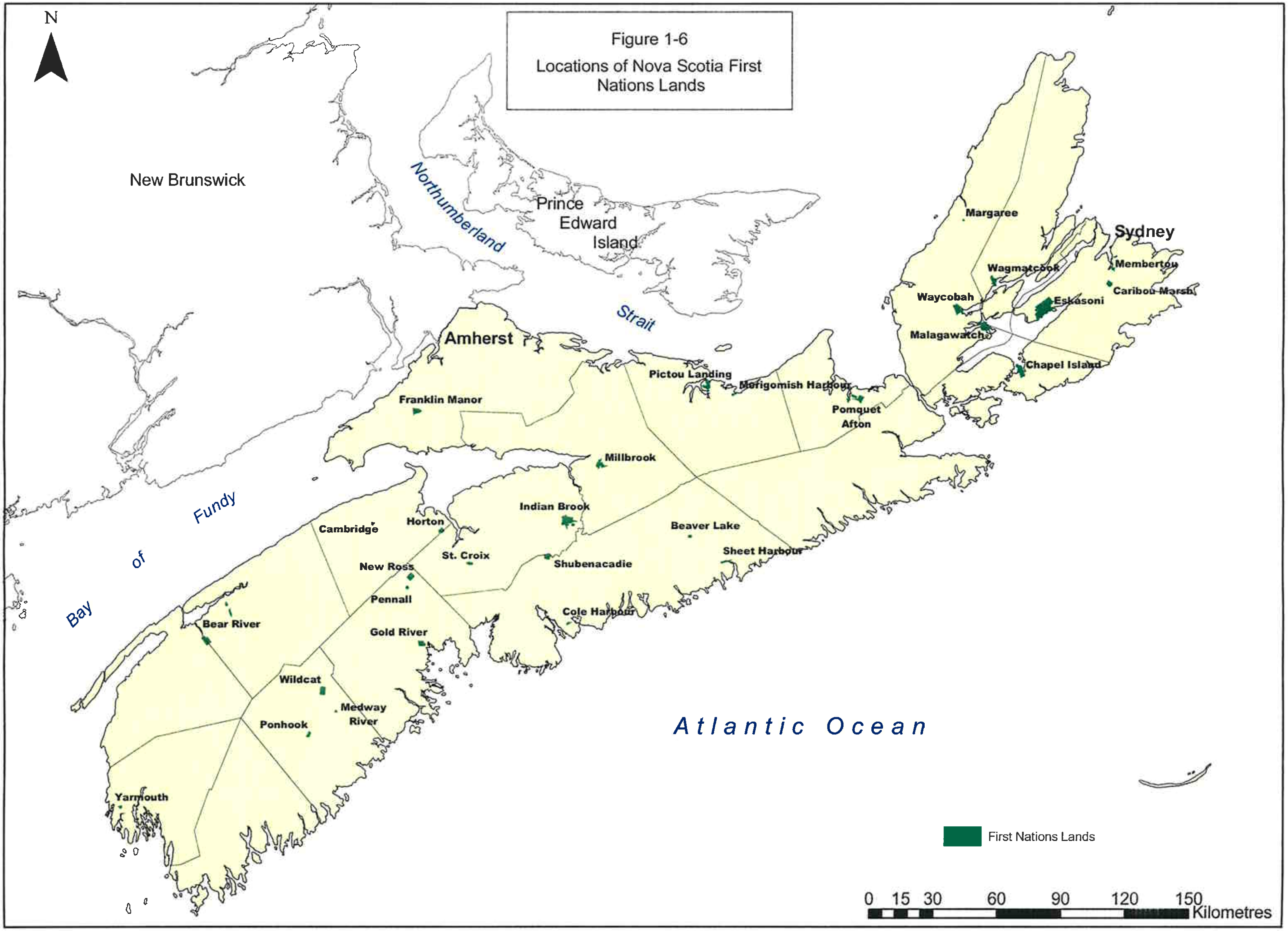
Commodity Group	$ Value (millions) in 1998	$ Value (millions) in 2002
Fish and Fish Preparations	908	1,236
Paper and Paperboard	390	541
Transportation Equipment	411	168
Wood Pulp and Similar Pulp	185	190
Non-Metallic Minerals, Mineral Fuels	219	972
Lumber	136	213
Other Commodity Groups	1,509	2,032
Total	**3,785**	**5,352**

Commercial Fisheries

According to Environment Canada "It is expected that as a result of warmer ocean temperatures, there will be shifts in the distribution of fish species and in their migration patterns. There are also expected to be changes in the ratio of deep sea to ground fish abundance. There may be lower overall sustainable harvests and estuarine fish populations for Atlantic marine fisheries."

According to the Nova Scotia Department of Agriculture and Fisheries' Business Plan 2002-03, the commercial fishery is a vital economic sector in the Province's Economic Growth Strategy. Agriculture, commercial and recreational fishing, and aquaculture drive the economy of our rural and coastal regions, employing over 28,000 Nova Scotians and contributing some $1.5 billion to the Provincial economy. Seafood continues to dominate Nova Scotia exports, posting a record over $1 billion in 2001.

Figure 1-6
Locations of Nova Scotia First Nations Lands



The website **Fishjobs.ca** states "Nova Scotia has the highest value fishery of all Canadian provinces and territories. It also has the most varied fishery, with a wide variety of commercially valuable species found in provincial waters."

Nova Scotia's fishery stretches from the waters of the open Atlantic Ocean, including lucrative offshore fishing banks such as Georges, Browns and Banqueral Banks, to the high tides of the Bay of Fundy and the diverse southern portion of the Gulf of St. Lawrence. The top commercially valuable species include shellfish such as lobster, scallops, crab, shrimp; groundfish such as cod, haddock, pollock, redfish, flatfish, hake, and cusk; and pelagic fish such as tuna, swordfish, herring, mackerel and shark.

Changes in water conditions, over-fishing and other factors have resulted in a decline in groundfishing, including moratoria on fishing in some areas. This has changed the picture of the Nova Scotia fishery so much that groundfish accounted for only 23 percent of all landings and 14 percent of the landed value in the 2000 fishery. This contrasts with 1984, when groundfish accounted for 68 percent of landings and was 43 percent of the landed value in Nova Scotia. However, the overall value of the fishery in Nova Scotia has continued to climb because the value of shellfish landings has increased even as groundfish quotas have been reduced and continue to stay at low levels.

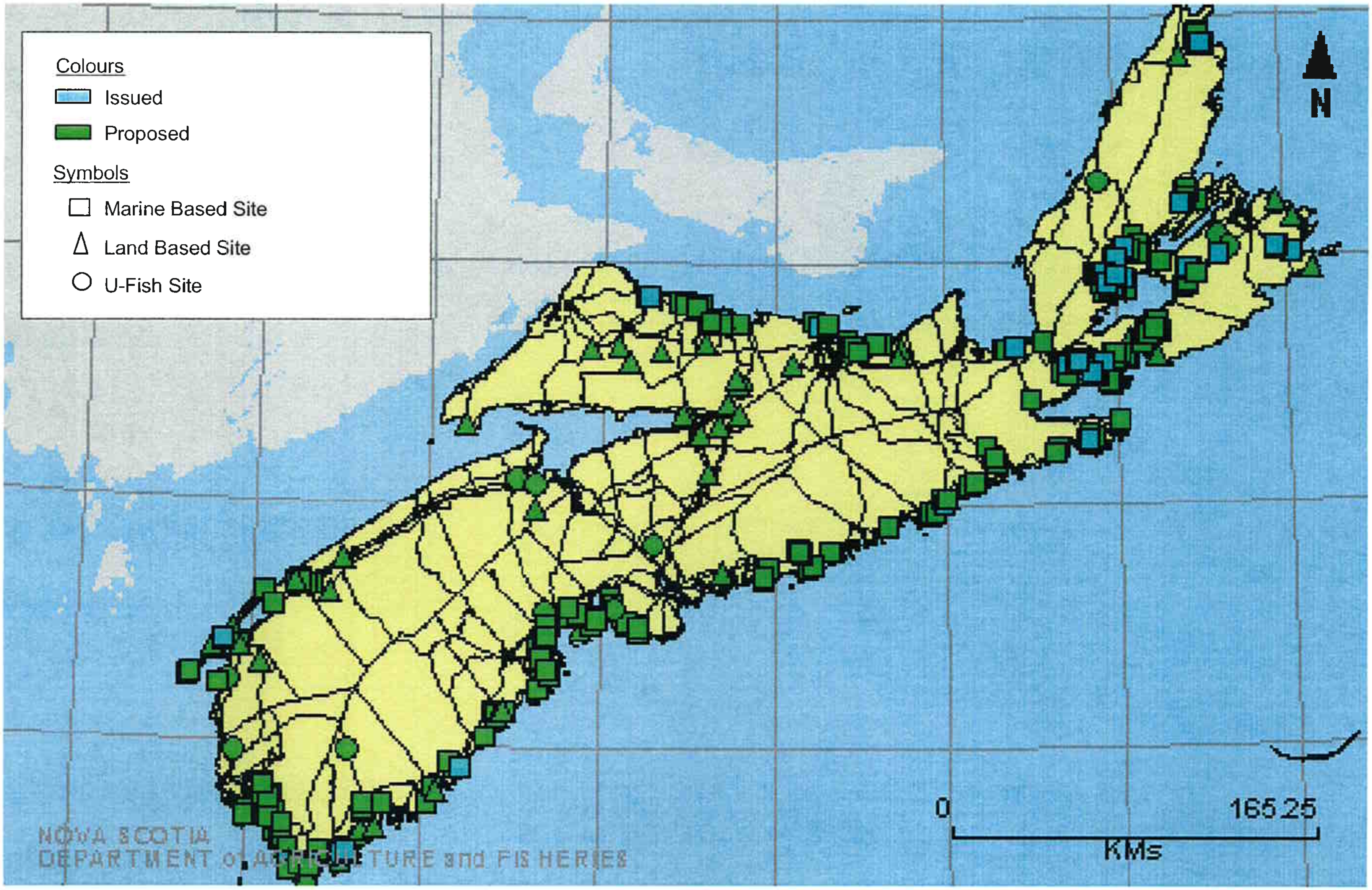
The fishing industry constitutes the economic backbone of many coastal communities. Nova Scotia's fishery operates from 165 "small craft harbours", which are associated with small fishing villages. Large, deep-water, ice-free harbours are also important to the Nova Scotia economy, providing berthing and offloading for fishing fleets as well as essential access to marine transportation for many of Nova Scotia's resource industries for products including pulp and paper, aggregates and gypsum. Nova Scotia's harbours in Halifax and Port Hawkesbury are among the largest deep-water ice-free harbours in the world.

The aquaculture industry is also significant for rural and coastal Nova Scotia communities, which have experienced economic challenges. The industry is maintaining strong growth trends, for a total value of $55.4 million in 2001. Mussels, American oysters, salmon, and trout have been farmed for a relatively long time; other species such as scallops, European oysters, halibut, sea urchins, arctic char, and tilapia are also being farmed successfully. Access to quality sites determines how much further the aquaculture industry will grow. Existing aquaculture sites are shown on Figure 1-7. Prime locations often have competing users.

Forestry

Forestry activity is an important part of the economy in Nova Scotia, and particularly for rural areas, where nearly 75% of the Province's primary forestry workers reside, making it the most rurally-based industry in Nova Scotia. Forestry products account for nearly 20% of provincial exports and were valued at over $1.1 billion in 2001. Forestry products include lumber, pulp and paper products, as well as Christmas trees and maple sugar.

Figure 1-7
Locations of Nova Scotia
Aquaculture Licenses



Environment Canada reports, "Climate change will increase the risks of forest fires and insect invasion to forests in the Atlantic provinces. Blowdown may increase with climate change as storms become more frequent and intense."

Agriculture
Nova Scotia has a highly specialized commercial agriculture sector. Dairy is the largest sector, followed by horticultural crops, poultry, eggs, beef cattle and hogs. Export commodities include blueberries, apples and processed fruits, vegetables and juices. Approximately 427,000 hectares of the Province is farmed (Figure 1-8). Close to 4,500 farms produced over $408 million in farm cash receipts in 2002. Twenty-seven percent of receipts came from crops; 14% beef cattle and hogs; 22% dairy farms; 14% poultry; and 6% eggs. The agriculture industry creates 16,000 jobs and contributes over $1 billion annually to the Provincial economy.

Land is farmed commercially throughout Nova Scotia, but soils are shallow and rocky in many places. Typically, farming is concentrated over the better quality soils found in fertile river valleys and flood plains, such as along the tidal Shubenacadie River, and mostly significantly in the Annapolis Valley.

Most agricultural areas in Nova Scotia experience a frost-free period of 120 to 130 days between late May and early October, which is the effective growing season for most crops. The Annapolis Valley has up to 140 frost-free days, but the higher highlands on Cape Breton Island have less than 100 days.

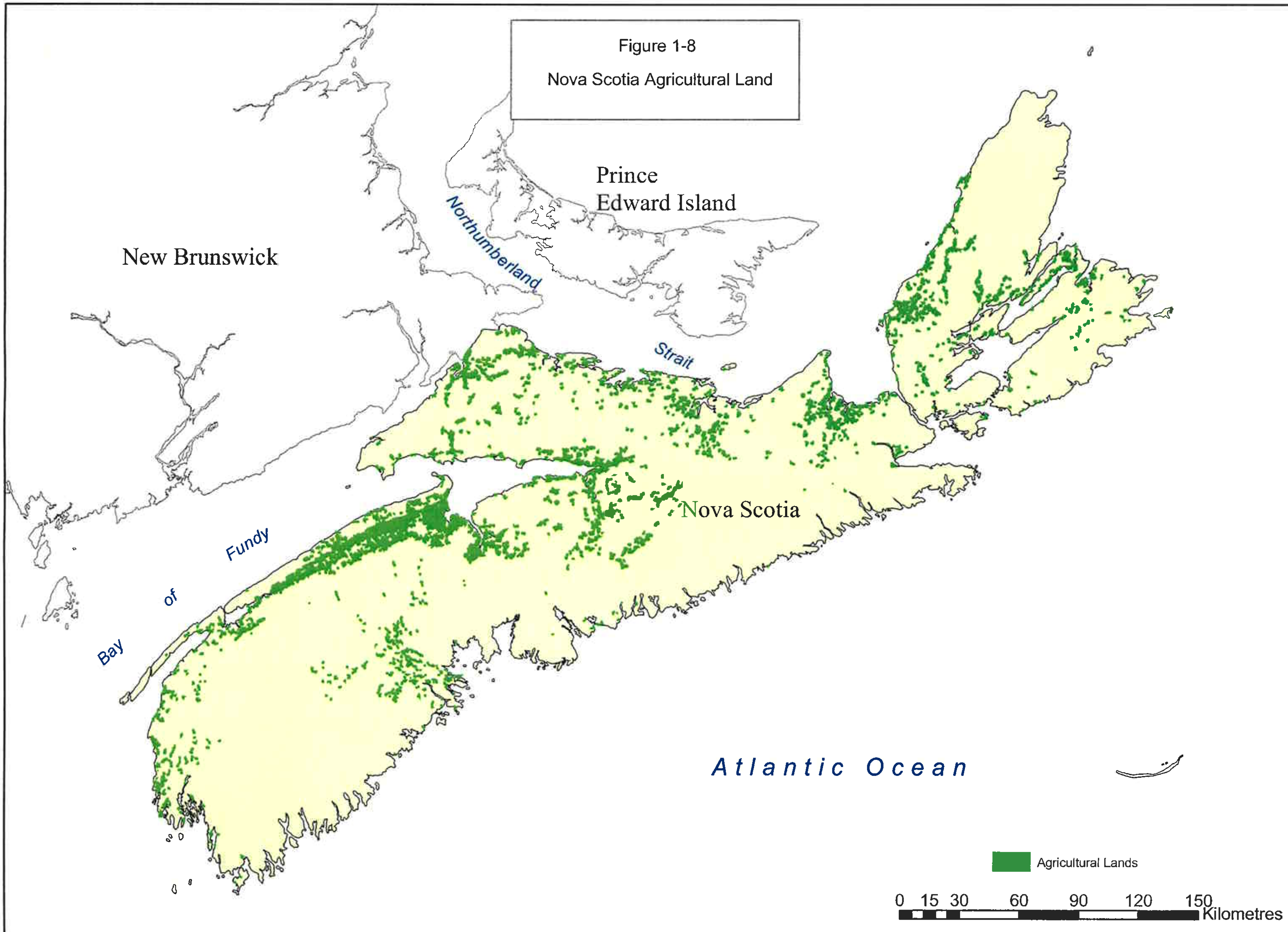
Farmland was also created or reclaimed in Nova Scotia from saltwater marshes through the construction of dykes by European settlers. Dykes protect large tracts of farmland in the Annapolis Valley region, the Cumberland Shore and near Truro, located along the Bay of Fundy and Minas Basin. Prominent examples of dykelands include the Queen Anne's Marsh near Port Royal on the Annapolis Basin, the Grand Pré marsh in King's County, and the Minudie Marsh in Cumberland County. The dykes along the Annapolis River protect over 1,740 ha of farmland in that system while the Grand Pre dyke protects over 1,220 ha of farmland. Today, the Nova Scotia Department of Agriculture and Marketing maintains 240 km of dykes that protect approximately 17,300 hectares of dykeland.

Dykelands today are used largely for the production of hay and pasture, corn and cereal crops, and sod. As they hold water late in the spring and are not well suited for fall ploughing, dykelands have a shorter season for cropping and maintenance compared to many other agricultural lands. Increasing sea levels and more frequent severe storms threaten the dykes and the cropland behind them.

Although their primary use is for agriculture production, dykelands and surrounding areas can be exeedingly important for wildlife, including small mammals, birds, raptors, deer, red foxes, and coyotes. Dykelands may provide roosting sites for migrating shorebirds at high tide. The Fundy dykelands are located on the traditional migration routes of a wide range of bird species. The

Figure 1-8

Nova Scotia Agricultural Land



extensive dykelands at Grand Pré are one of two known nesting sites in Nova Scotia for the Short-Eared Owl. The diversity of habitats in the vicinity of dykelands, including salt marshes, freshwater marshes, and tital flats, is important in maintaining a wide range of species and complex biological interactions.

Tourism
Nova Scotia's coastline and coastal waters also provide natural resources in support of the Province's tourism industry. The Province's sand beaches have an international reputation and many of the Province's formal tourist destinations are located along the coast. Activities such as sailing, boating, sea kayaking, windsurfing, surfing, deep-sea fishing, whale watching, scuba diving and fossil hunting form basic components for existing and new ventures in tourism and eco-tourism.

Wilson and Colman (2001) state " Nova Scotians spend $250 million a year on nature and wildlife-related pursuits... of which 70% is non-consumptive (e.g., hiking, bird watching, canoeing) and 27% is consumptive (mostly hunting and fishing). In addition, total tourism revenues rose to a record $1.26 billion in 1999, contributed $430 million to the provincial GDP, and generated $200 million in tax revenues (current dollars), with nature tourism the fastest-growing sector of the industry. The tourism industry directly employs more than 12,000 Nova Scotians, with direct and indirect tourism jobs increasing by 23.4% between 1997 and 1999."

Infrastructure
Large deep-water, ice-free harbours are important to the Nova Scotia economy providing essential access to marine transportation for many of Nova Scotia's resource industries. Nova Scotia's harbours in Halifax and Port Hawkesbury are among the largest deep-water ice free harbours in the world. Combined, the ports handle in excess of 14 millon tonnes of cargo annually. In addition, several hundred kilometres of the Province's highways and roads are located in vulnerable coastal areas.

1.7 Other Factors and Phenomenon

Natural Resources Canada has produced a map of Canada depicting the sensitivity of coastal areas to sea level rise (Figure 1-3). All of the Atlantic Coastline of Nova Scotia is ranked as having either moderate or high sensitivity to sea level rise with approximately 80% being ranked as high. The Northumberland and Fundy coasts are ranked as low to moderate, as is Cape Breton. According to Natural Resources Canada, the sea level could rise by 70 cm by the year 2100.

Those areas most likely to be affected include barrier beaches, salt marshes, lagoons and estuaries. These are important natural habitats, which could be lost along with the species, and ecosystems they support.

Changes in the climate are likely to also have impacts as weather patterns change to produce more frequent and severe storms. If the long-term trend is that of warmer waters around Nova Scotia or a shift of the Gulf Stream toward the coast, the likelihood of more severe storms affecting the province may be increased.

Industries, which depend heavily on the coastal zone such as fishing, shipping and tourism/recreation, will face impacts as the sea level rises and weather patterns change. The forestry sector may also face negative effects of climate change through infestations of new pests, and an increased risk of forest fires as temperatures increase.

As temperatures rise, sea ice will be less prevalent in coastal areas and on the shorelines. Currently, sea ice and the ice that forms on beaches and mud flats protect the shoreline from the effects of storms and other high-energy events. Pack and sea ice reduce wave energy and the shore ice acts as a shield, holding the sediment in place.

The sensitivity of the Province's ecosystems to climate change is not well understood as the research into ecosystem responses in general are in the early stages. The understanding of these responses will be important in implementing conservation plans and biodiversity strategies.

Lastly, the health system is a dominant component of Provincial spending. The responsiveness and capacity of the system to new issues brought about by climate changes such as potential for decrease in air quality; increase in vector borne disease; and the potential for increased water borne pathogens will require consideration in future system planning.

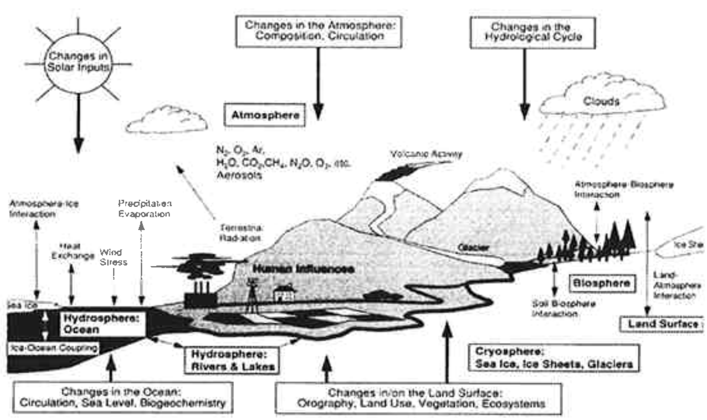
2.0 Key Issues with Respect to Climate Change

2.1 Climate Change

Climate is considered to be average weather measured over a period of time in a geographic area described in terms of the mean and statistical quantities. For example, you expect the tropics to have a tropical climate with a particular mean temperature and average yearly precipitation that's different from other geographical areas.

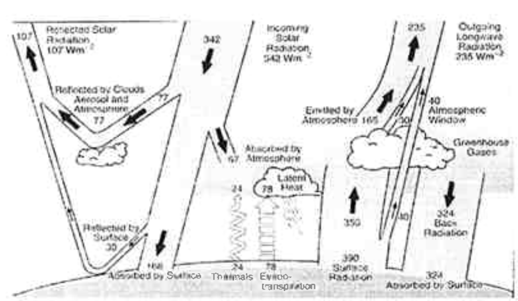
The internal components in the climate system include the atmosphere, the oceans, sea ice, the land and its features, including the vegetation, albedo (ratio of reflected to incident light), biomass, ecosystems, snow cover; land ice, and hydrology (Figure 2-1). The external components in the climate system are: the Sun and its output; the Earth's rotation; Sun-Earth geometry and the slowly changing orbit; the physical components of the Earth system such as the distribution of land and ocean, the geographic features of the land, the ocean bottom topography and basic configurations; and the mass and basic composition of the atmosphere and ocean.

Figure 2-1 Climate System Components



When solar energy enters and leaves Earth at the same rate, the climate system stays in balance and the average temperature remains relatively constant. If there is a change in the rate at which energy either enters or exits the system, or in how that energy is distributed, the balance is upset. Global temperature will change and other elements such as precipitation or wind patterns will adjust. Local and regional climates are affected by latitude, altitude, topography, proximity of large bodies of water and ocean currents.

Figure 2-2 Radiation Balance



The Earth's atmosphere contains naturally occurring "Greenhouse Gases" (GHGs) such as water vapour, carbon dioxide, ozone, methane and nitrous oxides as well as solely human-made (anthropogenic) greenhouse gases. These gases are relatively transparent to incoming short wave radiation but absorb the re-radiated long-wave energy and heat up Earth's atmosphere (Figure 2-2). This results in the greenhouse effect that insulates Earth from heat loss. Without this natural greenhouse effect, the average temperature of Earth's surface would be 33°C colder than the present 15°C. This is a naturally occurring phenomenon, in a delicate balance.

By releasing more greenhouse gas into the atmosphere through human activity, including burning fossil fuels and poor agricultural practices, that balance is disrupted. Both the oceans and the biomass on the land take up carbon dioxide in a natural cycle called the carbon cycle. At the moment so much extra carbon dioxide is being added to the cycle that both of those "carbon sinks" cannot handle the extra amount. The result is an accumulation of carbon and warming of the atmosphere from the increased carbon dioxide.

2.2 Historical Change

Climate Change refers to long-term (months, years, decades) changes in climate variables such as mean temperature, annual precipitation and related events such as storm frequency or intensity as a result of natural and/or anthropogenic (man-made) climate interference. Most natural changes are well understood; dust and ash from volcanic eruption can lower global mean temperature by several degrees over the span of 3-5 years while changes in Earth's orbit affect solar radiation, and hence global mean temperature on a scale of 10,000's of years.

Most recently scientists have discovered that the addition of ever-increasing GHGs to the atmosphere since the Industrial Revolution (approximately 150 years ago) has "warmed" the atmosphere by 0.5° to 1°C (Figure 2-3).

It is now believed that such a human impact on our climate, especially over the past 50 years, has resulted in dramatic melting of ice and permafrost in our Arctic Regions as well as accelerating the ongoing sea-level rise globally. Such impacts threaten both human and animal species world-wide and in our Province.

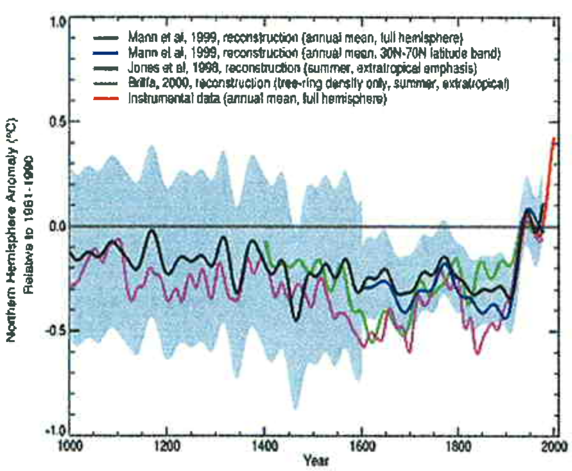


Figure 2-3 Northern Hemisphere Temperature Over The Last Millenium

2.3 Historical Change in Nova Scotia

For Nova Scotia, the long term trend in temperatures (from 1895-1998) show an increase of approximately 0.5°C (Figure 2-4).

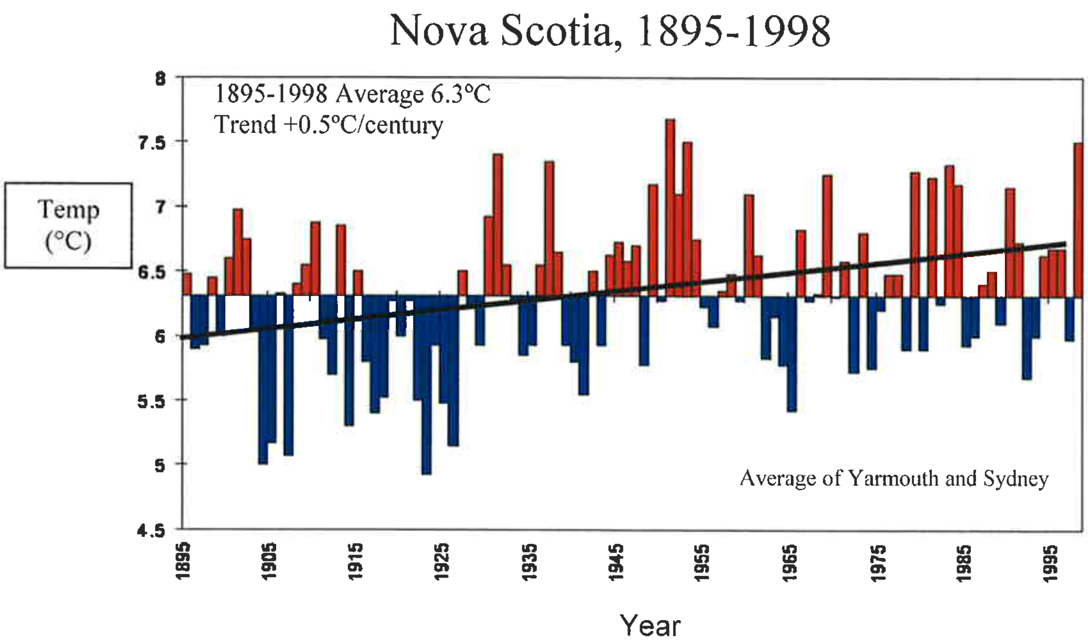


Figure 2-4 Long-Term Temperature Trend – Nova Scotia (Red above average/Blue below average)

For precipitation, the variability across the region, and between years, makes any trend to increased or decreased amounts more difficult to discern. Parts of Nova Scotia have experienced increase in total annual amounts of precipitation, but snow cover has been decreasing (Figure 2-5).

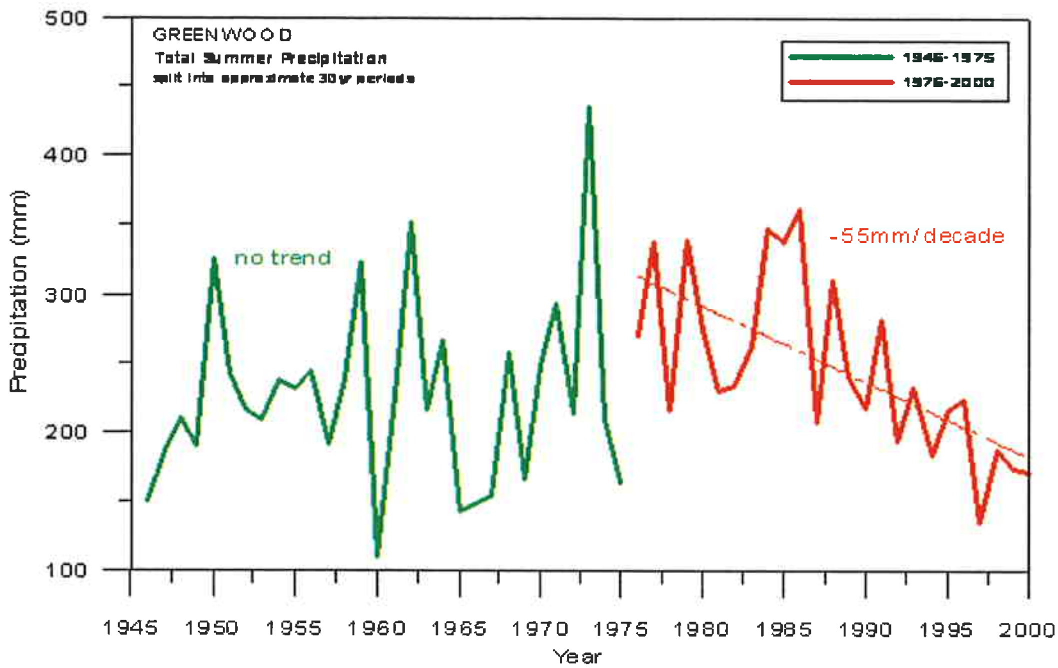
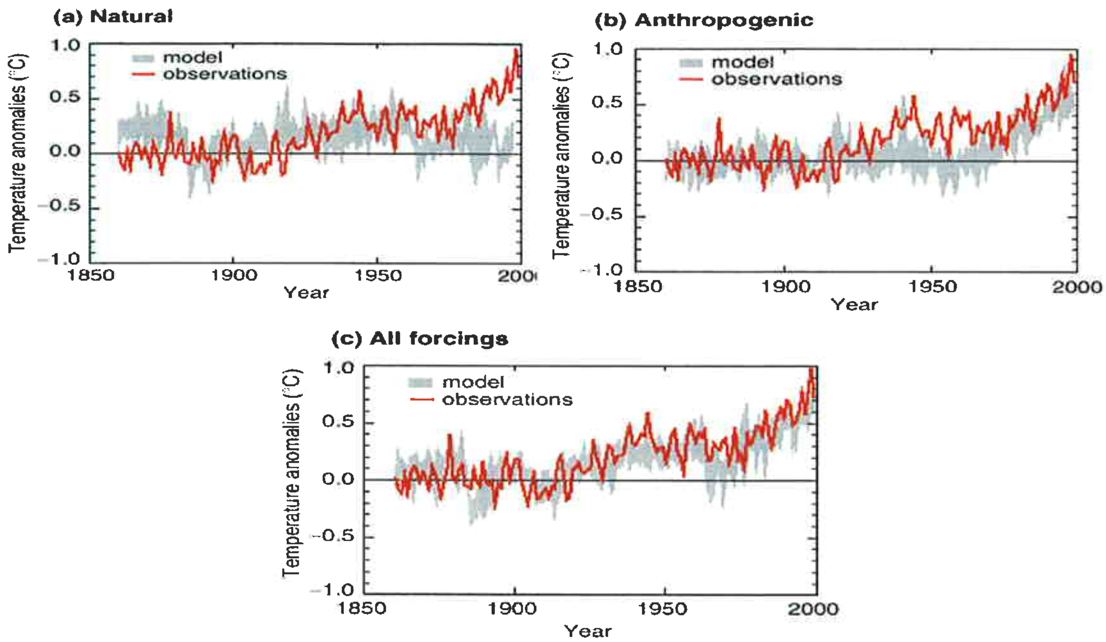


Figure 2-5 Total Summer Precipitation – Greenwood, Nova Scotia

2.4 Projections of Future Climate

Climate modelers use the most advanced physics and mathematics available today to develop complex climate models. Models are first tested against observed climates and climates of the past to ensure they can adequately simulate real climates. Once they have passed these and other tests, they are used to project future climates for various scenarios of future greenhouse gas and aerosol emissions. Modelers have become confident that they can provide useful indicators of how the climate will respond to continued human interference with the climate system. Figure 2-6 illustrates an experiment where natural and anthropogenic changes were applied to the climate model and compared to the historical record. Only when both the natural and anthropogenic influences on climate are considered, the climate model portrays the changes fairly accurately.

Figure 2-6 Comparison of Natural, Anthropogenic and Combined Temperature Models

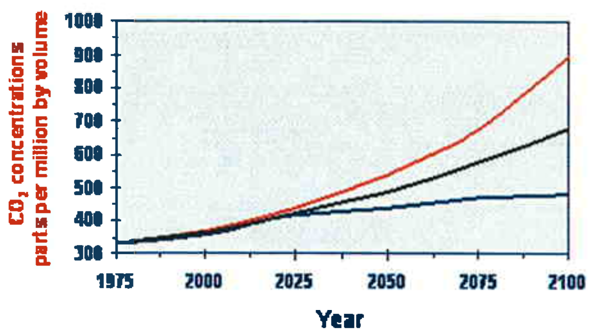


Comparison of observed changes in globally average surface temperatures (red line) with model simulations of different combinations of radiative forcing (grey lines): a) natural forcing due to solar and volcanic activity; b) forcing due to human activities only (greenhouse gases, aerosols, stratospheric ozone depletion; c) forcing due to both natural and human causes. IPCC TAR Synthesis Report Figure 2.4.

General Circulation Models (GCMs) are designed to best describe how the three main drivers of Earth's climate; the atmosphere, the oceans and the icecaps, work together to give us our planet's varied climates. Also, they are the only tool available to help us project the impact of changes on future climates. The most current Canadian model is the Canadian Coupled Climate Model Version 2 (CGCM2) (for specific model output refer to CCIS website). There are a number of other climate models of varying but relatively equal capability to project future climate. The most noteworthy are the HadCM2 from the Hadley Research Centre in the UK, the GFDL model from the US and the CSIRO Model from Australia.

2.5 Future Emission Scenarios

Future climate projections are made by modifying a GCM with changes in greenhouse gas emissions and aerosol concentrations over the next 100 years. These changes have been determined through the development of "emission scenarios", i.e. different future greenhouse gas and aerosol concentrations based on changing socio-economic conditions. The first series of emission scenarios were completed in 1995 and can be summarized by the three curves illustrated in Figure 2-7.



Based on an energy-intense (fossil fuel dependent) future, the red curve in Figure 2-7 indicates an almost tripled GHG concentration while a future where renewable energy technologies are adopted and developing countries follow energy conservation steps, the resultant change (blue line) is a more modest 50% increase.

Figure 2-7 Comparison of CO_2 Concentrations Under Different Scenarios

International scientists have agreed however that to study climate change and be able to compare results across more than one GCM model, a "standard" emission scenario is required. The black line, typically described as the "Business As Usual" scenario, is based on a GHG increase of 1% a year for 100 years, effectively doubling the concentration of GHGs by 2100 and was chosen as that "standard".

In 2001, scientists decided to expand the emission scenario possibilities and developed what has come to be called the "SRES" group of emission scenarios. Instead of three basic futures, the scenarios were expanded to over 40 possible emission futures. As shown in Figure 2-8, there still exists a "high" and "low" estimate and a "middle" or "business As Usual" one, noted as "A2". It is across this range of scenarios that the climate modelling community has developed their results for temperature and precipitation to 2100.

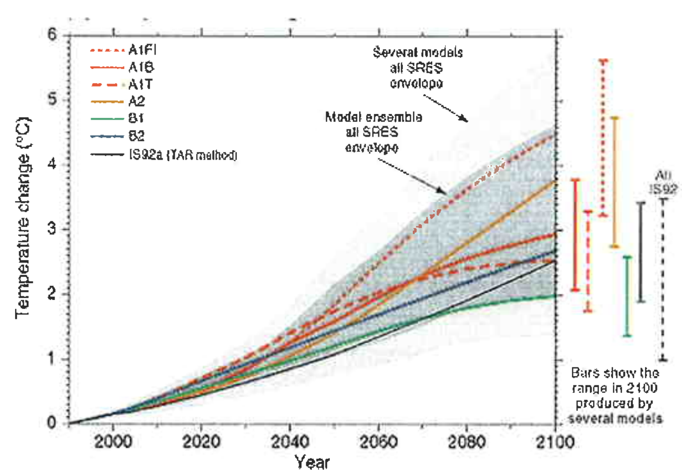


Figure 2-8 Results of "SRES" Group Emissions Scenarios

Refer to Annex 3 for technical specifics describing the development of SRES scenarios.

Projections of mean global temperature, based on the SRES scenarios, range from 1.4° to 5.8°C. For comparison of models scientists have agreed on the A2 scenario as the "standard" giving

3.2°C as an average projection to 2100. Precipitation amounts are projected to increase ranging from 10-30% over mid-northern latitudes. Also, projections point to more variability in climate, with the possibility of more frequent and more intense extreme events.

2.6 Understanding Future Climate Scenarios

In order to properly assess the impacts of a changing climate, relevant projections of that climate must be developed. This can be approached several ways, each way has advantages depending on the assessment approach you wish to take. The first choice that has to be made is to decide how to generate the future climate scenario.

It has been recommended by the IPCC that a scenario of future climate be developed based on a range of assumptions concerning the future of greenhouse gas emissions (socio-economic) and a range of climate models with varying skills and assumptions as to the behaviour of the climate system. By doing so, the assessor can acquire the full range of possibilities of plausible future climates and reduce the uncertainty inherent in making projections out to 100 years.

Climate scenarios should be built using either a range of models appropriate for the geographical region or several very specific models that represent the regional climate well. The scenario developer must then decide which GHG emission scenario that best applies socio-economically. A range of emission scenarios can be chosen but the combinations of models and scenarios can become quite complex and assessing their impact even more so.

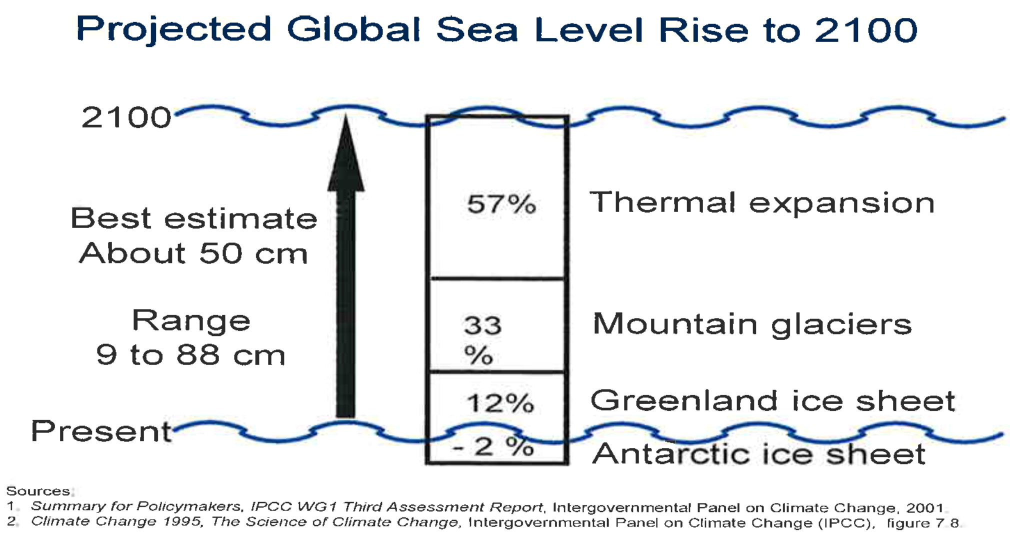
In the case of Atlantic Canada, projections of temperature and precipitation change are based on the Canadian Climate Model (CGCM1) and the GHG emission scenario equivalent to the IS92a, business-as-usual future. Since the Canadian model produces climate results, when compared with other global models, that are "middle-of-the-road" and the emission scenario is considered an average, doubled CO future, the resulting values for temperature and precipitation change can be assessed as "average" projections.

This means that there exists, when using other climate models, equally plausible but different climate futures. It also means that, if you used a more fossil-fuel intense emission scenario, you would get more dramatic (higher) results.

2.7 Sea Level Rise

Sea levels are rising along most coasts in Atlantic Canada, in part an effect of post-glacial subsidence and also global sea-level rise[16]. Much of Atlantic Canada's extensive shoreline, especially in the Maritime Provinces, is at moderate-to-high risk of impacts from rising sea levels[17]. Coastal areas will also be vulnerable to changes in sea ice, winter storms and storm surges.

Figure 2-9 Projected Global Sea Level Rise to 2100



Projected sea level rise is based on the theory that a warming atmosphere will transfer that heat to the oceans, expanding the oceans as they warm. As well, as shown in Figure 2-9, melt of mountain glaciers and the Greenland ice sheet will add to that sea level rise. The range provided (9 to 88 cm) is in response to the range of emission scenarios as described earlier. The "best estimate" of 50 cm rise comes from the "Business As Usual" scenario, the average change expected to 2100.

[16] National Atlas of Canada, Coastal Sensitivity to Sea Level Rise, from data from J. Shaw. 1998, accessed at http://atlas.gc.ca/site/english/maps/climatechange/potentialimpacts/coastalsensitivitysealevelrise

2.8 Projections for Nova Scotia

For Atlantic Canada, scenarios of temperature and precipitation change can be extracted from a well-designed website developed by the Canadian Climate Impacts Scenarios Project (CCIS) (www.cics.uvic.ca). These scenarios are based on results from a large suite of climate models and provide ranges for temperature and precipitation change. As an example, the models are projecting for Greenwood, Nova Scotia a mean temperature change range of 3° to 9°C by 2100 and a percent change in annual precipitation amounts of -5% to +22%.

Although such projections are useful they are based on a large geographical area that includes Greenwood as well as half of New Brunswick and are not reflective of the micro-climate influences at play at Greenwood or other sites in Nova Scotia. To refine these projections for Greenwood and three other sites in NS, their historical climate records are statistically combined with global climate model projections and used to calculate specific temperature and precipitation changes over the next 100 years. This technique is called downscaling and has been completed for four sites in Nova Scotia.

Table 2-1
Annual Projected Change Fields for Nova Scotia

	Maximum Temperature			**Minimum Temperature**			**Precipitation Amount[FN]**		
Tri-decade	**2020s**	**2050s**	**2080s**	**2020s**	**2050s**	**2080s**	**2020s**	**2050s**	**2080s**
	Δ°C	Δ°C	Δ°C	Δ°C	Δ°C	Δ°C	%	%	%
Greenwood	1.8	3.2	5.3	1.1	2.7	4.0	12	12	10
Kentville	1.8	3.2	5.3	1.0	2.1	3.8	15	11	15
Shearwater	1.7	2.8	4.7	1.2	2.2	3.9	7	7	2
Nappan	1.8	3.1	5.1	1.1	2.1	3.9	-6	-7	-9

FN - % change of precipitation amount is relative to base climate tri-decade (1961-1990). It is not cumulative or additive.

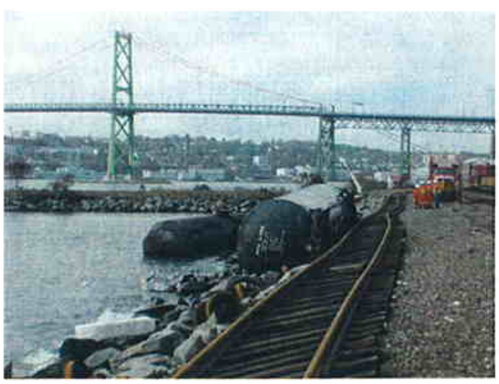
The detail provided by Table 2-1 is required before developing any type of adaptation plan since much of Nova Scotia is impacted by micro-climate elements that separate those areas significantly. For example, adaptation measures determined to work for the Annapolis Valley may not be applicable for Cape Breton, based on the projected changes. The precipitation amount change noted in Table 2-1 is a clear indication that both the large scale climate model projections as well as projections for individual sites on locations indicate a change is projected. Our current climate cannot be used as a proxy for the future and any decisions taken based on current climate run the risk of not being applicable in our future.

As seen in Table 2-1, changes to temperature and precipitation amounts can vary across the four sites currently available. However the precipitation amounts do not provide information about the characteristic of precipitation. For example, an increase of 15% in annual precipitation amount is not advantageous to agriculture if the precipitation falls in one or two events a year. Therefore it is just as important to understand the shift in precipitation pattern by season as it is to know the amount of annual precipitation change.

2.9 Extreme Events in Nova Scotia

Of greatest concern to all Nova Scotians is our vulnerability to extreme events. Two elements are important when determining that vulnerability: are extreme events increasing in frequency and intensity and are we now more vulnerable due to our infrastructure planning?

Extreme events such as heat waves, droughts, flash floods, are increasing world-wide. Climate models are projecting those events to continue to increase. For example, in Greenwood NS, downscaled projections of extreme precipitation events indicate that 100 year events will increase in frequency to become 50 year events by 2100.



Such extreme precipitation events would mean a larger fraction of water moving into lakes, streams and on into estuaries, affecting estuarine processes in the coastal zone. Similarly, freshwater resources and wetlands in the region could be seriously impacted by changes in precipitation. Heavy rainfall brings an increased erosion of exposed soils and localized flooding and increased risk of contamination of drinking water supplies by surface water. Heavy rainfall can also result in a smaller fraction of that water moving into groundwater recharge. Timing of precipitation is also critical to freshwater resources, as rain during a mid-winter thaw, when the ground is frozen could essentially be lost to the terrestrial hydrologic system[18].

Current projections indicate an increase in hurricane intensity over the next 100 years, suggesting stronger wind speeds in the hurricanes that we experience. However, it is yet to be determined whether more hurricanes will occur in the Atlantic Basin. Nor has it been determined whether Nova Scotia will get more landfall hurricanes. Research on these issues is currently underway.

A summary of projected climate change impacts for Nova Scotia for Tri-decadal Periods 2020, 2050, and 2080 is provided in Figure 2-10.

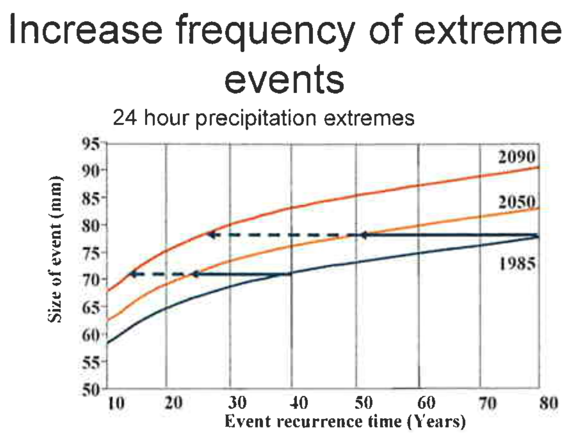


Figure 2-10 Projected Climate Change Impacts

[18] Environment Canada. 1997. Canada Country Study Volume VI - Climate Change and Climate Variability in Atlantic Canada.

Table 2-2 Summary of Projected Climate Change Impacts for Nova Scotia for Tri-decadal Periods 2020, 2050 and 2080

Climate Variable	Mean Change	Variability/Frequency	Extreme Value	Knowledge Gap
Periods	**2020s/2050s/2080s**	**2020s/2050s/2080s**	**2020s/2050s/2080s**	
Maximum Temperature	+1.8/+3.2/+5.3 (increase from 61-90 normals)	Hot days per year. (days above 30C) 23/34/48	Number of heat waves (days above 35C). 2.4/6/16.9	Duration of heat waves unknown.
Minimum Temperature	+1.1/+2.7/+4.0[1] (increase from 61-90 normals)	Cold days per year. (days below -10C) 11/8/5	Not Available.	Decrease in number and duration of cold waves unknown.
Season Length	Frost free season (days per year) 199.3/214.9/236.9	Surprises possible. (Late hard frost in spring, early hard frost in fall)	Not Applicable	Specific changes related to geographical differences need to be developed
Precipitation Amount	% change amount +12/+12/+10	100 year amount becoming 50 year amount	Potential Max Precipitation (PMP) increasing.	Return periods vary by location and need to be validated.[4]
Precipitation Intensity	Percent change in intensity (2080s) <2mm -36% 2-25mm +12% >25mm +20%	Max number consecutive dry days 10.7/10.6/11.8	Max 120-hr (5 day) precipitation (mm) 98.4/98.1/99.1	
Period	**By 2080s**	**By 2080s**	**By 2080s**	
Sea Level	50 cm rise globally	Not Available	88cm globally	Regional variations on mean and extreme amount unknown.
Synoptic Storms[2]	Not Applicable	Increase in intense storms. Decrease in weak storms. (North of 30N)	Not Applicable.	Specific number and intensity of future storms over NS unknown.
Tropical Cyclones[3]	Increase in peak wind speed	Unknown	Not Applicable.	Increase in frequency unknown.
Ozone (Smog)	Unknown	Increase in production of smog with increase in maximum temperature.	Not Available.	Projections of ozone production increase unavailable.
Cloud Cover	Values vary widely from model to model globally.	Unknown	Not Available.	Specifics of cloud cover change unknown.
Fog	Not Available.	Frequency of occurrence may increase with increased storm activity.	Not Available.	Specifics of frequency change over NS unknown.
Winds	See Tropical Cyclone above			

Climate Variable	Mean Change	Variability/Frequency	Extreme Value	Knowledge Gap
Waves	Increase in mean Significant Wave amount over North Atlantic (0.5-1.0M by 2080s).	Increase in Significant Wave occurrence (return period of 20year wave height reducing to 8-16yrs).	Not Available.	Need more specifics regionally.
Ice Storms (ZR)	Most recent work for Ontario and Quebec	Increase in frequency expected by 2050	Not Available.	Specifics of frequency change over NS unknown.

1. Numbers (+1.1/+2.7/+4.0) indicate amount that minimum temperature will increase in 2020s/2050s/2080s over the value we now have as the normal minimum temperature for 1961-90.
2. Synoptic Storm is most commonly a storm that forms in the mid latitudes (along Eastern Seaboard or from the center of North America) and spreads rain or snow across the region. It can last several hours or days.
3. Tropical cyclones are storms of tropical origin and can exist as "tropical depressions", "tropical storms" or "hurricanes" depending on their intensity.
4. Return period is a statistical reference to the amount of time during which extreme event may occur. For example, a 100-year event has a return period of 100 years – or more specifically is expected, statistically, to occur only once in 100 years.

3.0 Impact of Potential Changes

Given the provincial assets and characteristics including those presented in Section 1, and the anticipated climate changes presented in the Section 2, the purpose of this section is to present the most relevant potential impacts on the socio-economic sectors, that will then be evaluated in Section 4 of this document.

Sources for information on potential impacts have included the federal Canadian government, the Climate Change Impacts and Adaptation Research Network (C-CIARN) Atlantic Region, and Environment Canada's National Water Resources Institute (NWRI).

3.1 Socio-Economic Impacts of Climate Change in Nova Scotia

The following sections present the most relevant anticipated climate change impacts on the socio-economic sectors. It is recognized that detailed research on such impacts in Nova Scotia is limited. However, for the purpose of this report, a qualitative assessment (i.e. best professional judgment using available information) has been undertaken.

3.1.1 Human Health

Anticipated impacts of climate change on human health in Nova Scotia include the following:

a) Change in Use and Capacity of Public Health System from Increased Incidents of Extreme Events.
   Possible increased incidents of -
   - Local introduction of foreign diseases by migrating Canadians and visitors (i.e. families, students, business, employment, tourists), residents displaced by extreme events, and the arrival of people from overseas including immigrants and refugees;
   - Stress and over-loading of the adaptive capacity of public health infrastructure, from the cumulative effects of extreme events, introduction of foreign diseases, and break-down in essential services such as electrical power and communications.

b) Change in Incidence, Distribution and Severity of Vector and Flood Borne Disease from Combination of Changes in Temperature, Precipitation, and Extreme Events.
   - Possible increase in -
     - Incidents and distribution of vector-borne diseases (e.g. Lyme disease, eastern equine encephalitis, Malaria and dengue spread to Canada, West Nile virus). The number and location of local incidents involving West

Nile virus in birds is anticipated to spread with continuing climate variability;
- Incidents and distribution of temperature-, rainfall- and humidity-sensitive vector-borne and food-borne diseases;
- Incidents and distribution of water-borne diseases due to impact of water scarcity on sanitation systems.

c) <u>Change in Respiratory Disorders due to Increased Incidents of Air Pollution from Smog and Temperature Rise.</u>
Possible increased incidents and distribution of respiratory disorders associated with increases in temperature and air pollution. There is a strong connection between higher daily temperatures and the potential for smog formation, and correspondingly between smog and respiratory disease. Local air pollution is associated with long-range transport of pollutants from New England, the Midwest, and central Canada, and with that having local origins. The highest annual average value of ground-level ozone (an integral component of smog) in Atlantic Canada was measured at Aylesford in the Annapolis Valley.

d) <u>Change in Illness, Stress, Injury and Casualty Rates from Change in Hot and Cold Thermal Extremes.</u>
Possible increase in –
- health impact of thermal extremes (death and illness in vulnerable sectors of the community including the elderly, frail and ill). Several sites, especially in the Annapolis Valley, are projected to increase in daily maximum temperatures (increase in number of hot days);
- incidents of health impacts associated with extreme weather events and other natural hazards (deaths, injuries, infectious diseases, stress-related disorders, adverse health effects associated with social disruption, environmentally-forced migration). Extreme events such as heat waves are projected to be more numerous in Nova Scotia.

e) <u>Change in Eye and Skin Disorders from Change in Ultra Violet (UV) Radiation.</u>
Increased incidents of disruption to the immune system and increased incidents of skin cancer and cataracts in the eyes due to changes in levels of ultra-violet radiation.

f) <u>Change in General Public Health by Food-Borne Diseases Attributed to Changes in Temperature.</u>
Possible increased incidence of food poisoning and intestinal tract ailments associated with spoiled food in summer temperatures, and seafood affected by increased levels of pollution associated with run-off events of increased severity. Anticipated increased incidence in toxic algae blooms from change in sea level, temperature, and sediment in precipitation runoff.

3.1.2 Communities, Infrastructure and Transportation

Anticipated impacts of climate change on communities, infrastructure and transportation in Nova Scotia include the following:

a) Change in Ports Operations from Climate Variability and Changes in Sea Level.
Potential impact on commercial shipping due to changes in shipping traffic as a result of access by deeper draft vessels from increases in sea level in port areas. Sea level has been rising for thousands of years, mainly because the Earth's crust in Nova Scotia is sinking. This is illustrated in Figure 3-1 by the mooring rings at Fortress Louisbourg, Cape Breton Island. Figure 3-2 shows the tide gauge record of rising sea level at Halifax (36 cm/century) and the predicted rise by 2100 AD. Additional impacts on shipping traffic could be expected due to changes in ice patterns affecting viability of year-round Northwest Passage as a principal shipping route. Increased incidents of damage to ports infrastructure due to extreme events.

Figure 3-1 Mooring Rings, Fortress Louisbourg

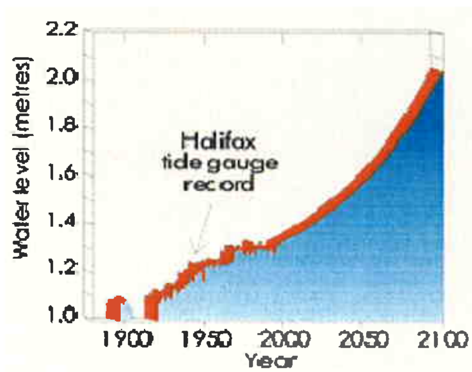


Figure 3-2 Tide Gauge Record for Halifax Harbour

b) Impact on Infrastructure from Extreme Events, Precipitation (Rain and Snow), Wind, Sea Level Rise and Storm Surge.

- Possible intensified damage and disruption to an increased range and distribution of coastal infrastructure, essential services, communications, safety and health, from extreme events, sea level rise, and storm surge flooding.
- Possible increased incidents of dykes, storm sewers and sanitary systems unable to deal with more frequent, high-intensity rainfall and storms.
- Changes in distribution and range of river and coastal ice, compounded by break-up and extreme events, will likely increase damage to river and coastal infrastructure.

- Buried municipal infrastructure at risk of being inundated or damaged by sea-level rise.
- Likely increased incidents of sewer failure in coastal as a result of rising sea levels and more intense storm events.
- Possible increased damage and disruption to vulnerable critical services, utilities and other infrastructure.

c) Impacts on Design, Development and Operation of Infrastructure from Wind and Precipitation (Rain and Snow), Temperature, and Extreme Events.
- Possible increased incidents of structural failures.
- Projected increased insurance costs associated with damage to vulnerable infrastructure.
- Anticipated increased costs for road maintenance related to pavement softening and traffic-related rutting, as well as the migration of liquid asphalt.
- Potential for increased cracking and deterioration of pavements related to low-temperature frost action and freeze-thaw cycles.

d) Impact on Land Use Planning from Changing Extent of 1/100 Year Flood and Storm Surge Events.
- Increased uncertainty in human settlement patterns and urban planning due to climate variability, sea level rise and impacts from extreme events. Much of the coast (from Yarmouth to Sydney) is highly sensitive to the effects of sea-level rise combined with extreme events.
- Indications are that communities such as Truro will be flooded more frequently and the floods will become more severe. Projections are for more intense precipitation events occurring over shorter time frames. The most recent flooding in Truro (March 2003) had the added element that the ground was either already saturated with water or still frozen. The precipitation that fell therefore could not be absorbed. Will more severe flooding mean that water levels will be higher over a shorter period of time? Or will it mean that these events will occur more often as "cumulative" events, where other factors make the event worse that it otherwise would be? The projections are unclear but it appears that both situations are possible.
- Anticipated increased economic and social 'costs' associated with adaptation by vulnerable coastal communities.

e) Impact on Transportation (Infrastructure, Operations and Maintenance) from Changing Sea Level, Precipitation, Season, Cloud, Fog, Wind, and Extreme Events (i.e. Flooding).
- Projected increase in the frequency and unpredictability of break up of ice on the river, and flooding with associated change in patterns of damage to property, highways, and bridges, and related impact on the management regimes of reservoirs.
- Anticipated increased costs for road construction and maintenance.

- Likely change to road maintenance costs.

f) Change in Recreational Activities (Especially Water Based Ones) from Change in Temperature, Precipitation, Season, and Sea Level.
  - Projected sea level rise highly likely to reduce or relocate existing recreational beaches.
  - Possible changes to timing, nature and scope of water-based recreational activities.
  - Potential direct and indirect effects on tourism through beach loss, impacted infrastructure, and ecosystem degradation.

g) Impact on Power Use from Change in Temperature, Precipitation, and Season.
  - Anticipated increase in air conditioning demand from changes in temperature and seasons.
  - Likely changes in demand for heating fuel.

3.1.3 Coastal Zones

Anticipated impacts of climate change on coastal zones in Nova Scotia include the following:

a) Change in Natural Erosion, Migration, and Deposition Patterns (incl. Beach Dunes) from Extreme Events, Precipitation, Wind, Sea Level and Storm Surge Events.
  - Rising sea level likely to expose coastlines to increase damage from wave action, and intensify rates of change (of erosion). More coastline will be exposed to wave action but the strength of the waves themselves could vary. Current projections are for wave heights (and thus wave-energy) to increase as a direct result of global warming.
  - With global climate change, sea ice likely to become thinner and less extensive. If there is less sea ice in the Gulf of St. Lawrence, beaches along that coast would be exposed to winter storm waves more often than today, increasing coastal erosion and storm damage to man-made structures.
  - Potential for increased variability in shoreline dynamics with potential changes in shoreline advance [accretion] or retreat [erosion], and resultant impact on distribution of beach sediment and sand budget.

b) Changes in Current Flooding Patterns from Extreme Events, Precipitation and Sea Level.
  - Sea level will rise in Atlantic Canada over the next century with the result that storm surges are likely to inundate areas never before flooded (i.e. Saxby Tide, which flooded the lowlands at the head of the Bay of Fundy on October 5, 1869).
  - Possible increased variability in shoreline dynamics with potential changes in shoreline advance [accretion] or retreat [erosion], and resultant impact on distribution of beach sediment and sand budget.
  - Sea-level rise and storm surge likely to result in the inundation of agricultural dyke lands.

- Potential increases in the extent and location of marine pollution associated with run-off.

c) Changes to Coastal Ecosystems and Biodiversity from Extreme Events, Precipitation, Wind, Sea Level and Storm Surge Events.

- The most sensitive coasts are commonly low-lying, with salt marshes, barrier beaches, and lagoons. These area are likely to experience such effects as increased erosion, rapid migration of beaches, and flooding of coastal freshwater marshes. The viability of sensitive coastal wetlands and associated ecosystems likely to be threatened.

3.1.4 Water Resources

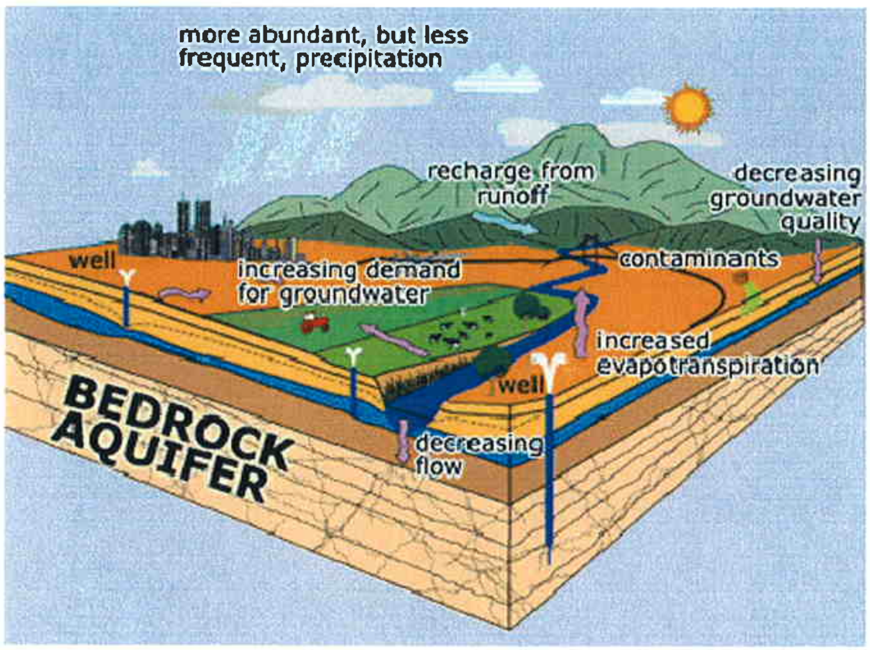


Figure 3-3 Impacts of Climate Change on Water Resources

Anticipated impacts of climate change on water resources in Nova Scotia include the following:

a) Change in Surface Water Supply and Quality for Communities' Health and Economy, from Precipitation (i.e. Seasonal Patterns and Run-off Rates).

- Potential for increased variability in the quality and quantity of regional water resources (including, but not limited to winter ice regimes, hydrogeology, water chemistry, and hydro generation).
- Possible increased variability in water supply, affecting energy production (hydropower), domestic supplies, industrial supplies, agriculture, exports, and pollution events and extent.

- Anticipated increases in both intense rain events and sea level rise places Nova Scotia at risk for reductions in surface and underground water quality from run-off, flooding, pollution, evaporation, decreased flow, and salt-water intrusion.
- Water resources in lakes and reservoirs are becoming increasingly vulnerable to a range of stresses, both natural and human-induced. For example, natural stresses include increased climate variability and extremes that can affect both the magnitude and seasonal cycles of water budget components that influence the availability of clean freshwater. Climate extremes (e.g., El Niño and large-scale weather systems with high winds and precipitation) have been shown to significantly affect lake heat storage, temperature and evaporation.
- Potential for increased consumptive use of water linked to regions with significant growth in population.

b) <u>Change in Ground Water Supply and Quality for Communities' Health and Economy, from Precipitation (i.e. Seasonal Patterns and Run-off Rates).</u>

- Potential for increased incidents and distribution of environmental and water contamination primarily related to agricultural management (i.e. manure) and water management (e.g. well-head and water quality management).
- Changes in temperature and precipitation likely to alter recharge to groundwater aquifers, causing shifts in water table levels in unconfined aquifers as a first response. With respect to aquifer character, shallow aquifers are affected by local climate changes, whereas water levels in deeper aquifers are affected by regional changes. Therefore, climate variability, being of relatively short term compared to climate change, will have greater impact on these shallow aquifer systems. In contrast, deep aquifers have an increased capacity to buffer the effects of climate variability, and are therefore able to preserve the longer-term trends associated with climate change.

c) <u>Change in Hydropower Capacity/Water Elevation from Precipitation (i.e. Seasonal Patterns and Run-off Rates).</u>

- The annual capacity of the small provincial hydroelectric power suppliers likely to be affected due to changes in rainfall patterns combined with heavy snow melt, with increases in the range and distribution of flooding incidents. Anticipated that water bypassing the turbines from flooding conditions, will not be available later in the summer for use in electricity generation, agricultural, domestic or other uses.

d) <u>Change in Surface and Groundwater Supply and Quality on Aquatic Life from Precipitation (i.e. Seasonal Patterns and Run-off Rates).</u>

- Anticipated that less water likely to be available for consumption, agriculture, and recreation and more conflicts over use. Associated impacts on aquatic ecosystems. Groundwater generally moves from higher to lower elevations. It feeds rivers and lakes and maintains flow when precipitation is light. Because it is cold, groundwater keeps rivers from becoming too hot for fish such as trout and salmon. If groundwater supplies dwindle, the health of rivers and the aquatic life they sustain will be threatened.

e) Change in Surface and Groundwater Supply and Quality on Agriculture from Precipitation (i.e. Seasonal Patterns and Run-off Rates).

- Projected climate change likely to alter snow and rainfall patterns, resulting in less frequent, but heavier, precipitation earlier than present (April rather than May), with summer flows less than present and earlier. Intense, heavy rainfall leads to significant runoff and therefore does less to recharge groundwater than a long-lasting, steady rainfall because the ground can only absorb a certain amount of water in a short period of time.
- Relatively modest changes in temperature and precipitation likely to have a marked effect on the volume and duration of spring runoff, as well as the intensity of flooding and drought.
- Longer and warmer summers likely to result in more drought and greater need for irrigation.
- Longer and warmer summers and droughts likely to increase the demand on groundwater and surface water resources to support agriculture.

f) Change in Water Quality through Salt-Water Intrusion from Sea Level Rise and Extreme Events.

- Possible increased incidents of salt-water intrusion in coastal aquifers affecting potable and agricultural groundwater supplies.
- Potential for increased incidents of aquatic pollution associated with runoff and flooding.

3.1.5 Agriculture

Anticipated impacts of climate change on the agriculture sector in Nova Scotia include the following:

a) Change in Long-term Fruit Crop Planting Decisions from Temperature, Precipitation and Season.

- Longer, warmer growing season likely to affect yields of warm weather crops (corn, soybeans, grapes), dependant on heat stress tolerance of crops, availability of water for irrigation and nature of seasonal change (i.e., surprise late hard frosts).

b) Change in Crop Heat Unit, Degree-Day, and Hardiness Zone Type Values from Temperature, Precipitation and Season.

- Possible changes to the diversity and types of crops able to be grown.
- Losses from winter kill of forage and fruit likely to be less and fall harvesting will be easier.

c) Change in Pest, Mold, Disease, Weeds, from Temperature, Precipitation and Season.

- Changes in seasonal weather patterns likely to affect the incidents and distribution of plant pests and diseases. Warmer weather in winter and growing season projected to allow more generations of pests to develop. More importantly, it may allow for the over-wintering of insect larvae normally killed by cold winter temperatures.
- Projected social and economic impacts associated with changing pest and disease regimes.

d) Change in Grass and Hay Potential For Animal Use from Temperature, Precipitation and Season

- Anticipated changes in fodder production patterns due to longer growing season and climate variability.

e) Change in Seasonal or Annual Crop Maintenance and Planting Selections from Temperature, Precipitation and Season

- Longer summers would lengthen the growing season; losses from winter kill of forage and fruit would be less; fall harvesting would be easier; and lead to higher yields of warm weather crops (corn, soybeans, grapes).
- Change in total acreage and erosion potential from variability in temperature, precipitation and season
- Anticipated changes in crop viability due to drought and changing precipitation patterns.
- Likely economic impact of water availability on crop production.

f) Change in Farm Insurance Payouts from Extreme Events, Sea Level and Storm Surge.

- Trend towards more extreme weather events (frequency and intensity), likely to result in damage to crop and livestock operations from storms, hail, floods, and droughts.
- Anticipated increased disruption for agricultural operations from increased disruption to hydro power generation and power lines on which farms rely.

3.1.6 Fisheries and Marine Resources

Anticipated impacts of climate change on fisheries and marine resources in Nova Scotia include the following:

a) Change in Marine Resources and Sustainable Harvest

- Change in habitat, salinity, and food web energy cycle, from change in sea level, temperature, and sediment in precipitation runoff likely to affect the commercial viability of certain fish stocks (crab, lobster, salmon, fresh water fin fish, other salt water fin fish, and other salt water shell fish).
- Changing temperatures likely to affect distribution and population abundance of some species. Population abundance will also depend on many other factors, such as food supply and predation. Because fish stocks are influenced by so many factors, including overfishing, a relationship between climate change and marine species cannot be easily determined. Warmer water temperatures are more favourable to crab reproduction and are more of a challenge for salmon and fin-fish.
- Potential for impacts on social and economic enterprises such as fisheries, tourism, oil and gas, marine transportation.
- Distribution and population abundance of fish species likely to be affected as coastal ecosystems change.
- Possible increased incidence of biotoxins associated with ocean warming and reduced resilience of natural ecosystems from pollution, with associated increase in contamination of fish and shellfish.
- Changes in temperature and reduced resilience of coastal ecosystems likely to affect the viability of aquiculture species being grown.
- Change in physical and chemical patterns in ocean currents from sea level, temperature, precipitation, and sediment in precipitation runoff likely to affect the resilience of marine ecosystems and associated commercial fisheries.

b) Change in Marine Water Quality on Aquatic Species and Habitat from Temperature, Sea Level, Sediment in Precipitation Run-off, and Extreme Events.

- Anticipated reduced resilience of aquatic ecosystems likely to impact associated commercial/recreational fishery.
- An increase in extreme events and shifts in wind patterns could affect the flushing of wastes and nutrients between farm sites and the ocean. Higher water temperatures likely to increase the risk of disease and compromise water quality.

c) Change in Fisheries and Marine Insurance Payouts from Extreme Events, Sea Level and Storm Surge.

- Anticipated increased insurance costs associated with damage to marine transport and fisheries infrastructure.

3.1.7 Forestry

Anticipated impacts of climate change on the forestry sector in Nova Scotia include the following:

a) Change in Long-Term Planting Selections and Harvests from Temperature, Precipitation, and Season.
   - Anticipated increase in incidents and location of dieback and decline of birches due to climate extremes.
   - Projected increased variation in harvesting processes (e.g. maple sugar).
   - Possible increased social disruption to forest dependent communities.

b) Change in Soil Erosion Potential from Temperature, Precipitation, and Wind.
   - Increased soil erosion and run-off likely to impact habitat, wildlife, sustainable harvests, and sediment in storm run-off.

c) Change in Forest Fire Potential from Temperature, Precipitation and Wind.
   - Anticipated increase incidents and range of forest fires due to changes in temperature and precipitation bringing about extended hot dry conditions.

d) Change in Sustainable Forest and Wildlife Habitat from Temperature, Precipitation, Season, and Sea Level.
   - Potential for increased variability in forest structure, composition, productivity, and regeneration. Warmer and more humid climate could increase the numbers of local and exotic forest pests.
   - Periods of midwinter thaw may become more frequent and extended. Such events are known to increase air bubble formation in the stems, which, if not removed, can affect tree health. Air bubbles are removed by spring time root pressure. However, if snow pack is removed by extended thaws, refreezing of the soil may damage roots. Air filled stems are thus not refilled with water, resulting in die back.

e) Change in Pest Populations from Extreme Events, Temperature and Precipitation.
   - Potential for increased variability in incidents and location of pest, and on the natural disturbance regime, pest cycle, and rate of infestation. For example, the Gypsy Moth has rarely caused more than trace defoliation in Atlantic Canada. However it likes hardwood foliage and is potentially a risk to these species. Winter temperature increase is a critical limitation to development and survival of this moth, as eggs are killed on prolonged exposure to temperatures at or below -9°C, and -23°C for even short periods is lethal.
   - Anticipated increased number of extreme climatic events likely to make ecosystems more vulnerable to a greater number of pests.
   - Possible increased risk of invasive species, especially as winter temperatures rise. Potential changes in range and distribution of invasive species. Changes in

precipitation and temperature significantly affect the impacts from invasive species.

f) Change in Forestry Insurance Payouts and Blow Downs from Extreme Events.

- "Blow down" (of forests into an increased fire hazard) may increase with storms that are more frequent and intense.
- Anticipated increased insurance costs associated with damage to forestry resources and infrastructure.

g) Change in Natural Abundance and Distribution of Forest Ecosystem Species from Temperature, Precipitation and Season.

- Warmer climate could push the tree line farther north, while gradually changing the abundance and distribution of species. (In Nova Scotia, from a boreal to temperate climate zone boundary for vegetation). Despite ongoing research, predicting the impact of climate change on the forest remains a difficult task.
- Possible change in diversity and range of forest eco-systems. Temperate forest zone could extend northwards. However, the resilience of forest eco-systems will be affected by changing soil conditions and life cycles that are affected by temperature and precipitation changes. In Nova Scotia, plant hardiness has been decreasing in certain areas.
- Birds and other wildlife dependent upon forest habitat likely to be affected. Some wildlife populations will be threatened and become extinct.

3.1.8 Environment

Anticipated impacts of climate change on the environment in Nova Scotia include the following:

a) Change in Abundance and Distribution of Wildlife Populations, including those associated with Hunting and Bird Watching, from Temperature, Precipitation, and Season.

- Possible changes in the distribution, range and number of birds and other wildlife depend on habitat affected by climate change. Up to a certain point, living organisms can adapt to natural stresses such as new climatic conditions. However, the capacity to adapt varies from species to species. More resistant species may survive, others will have to migrate if they can, whereas still others will disappear and be replaced by different species that are better adapted to the new conditions. Wildlife is sensitive to climate variations. The results of recent studies show that any change in summer climatic conditions would likely cause rapid advances or retreats of certain populations as their habitats shift or are disturbed. Mild winters will enhances the reproductive capacities of some species, leading to a gradual northward expansion of their populations.
- Anticipated changes in indigenous biodiversity.
- Projected increased stress on native species due to invasion/migration of alien species without natural controls

b) Change in Abundance and Distribution of Isolated Populations and Ecosystems from Temperature, Precipitation, Season, and Sea Level.

- Projected increased stress on isolated wildlife populations and ecosystems, such as protected areas that are ecosystems "islands", which will likely threaten the sustainability of the species or ecosystem.

c) Change in the Migration of Species (i.e. Coastal Waterfowl) from Temperature, Precipitation, Season, and Sea Level.

- Anticipated changes in river flow - earlier break-up, stronger spring freshet, and reduced summer flow - could impact the endangered coastal waterfowl.
- Anticipated alteration in the migration patterns of species, particularly waterfowl due to changes in coastal wetlands from temperature, precipitation, season, and sea level.
- Projected changes in river flow (early break up, stronger spring flows and reduced summer flow) could further threaten certain endangered species (for example ducks and aquatic species).

3.1.9 Aboriginal Communities Anticipated impacts of climate change on aboriginal communities in Nova Scotia include the following:

a) Anticipated change in use and harvesting of natural resources (i.e. hunting, fishing, and logging) while exercising treaty rights, from temperature, precipitation, sediment in precipitation runoff, and sea level. (Most importantly it must be understood that any change from what has been experienced by aboriginal peoples over the past 100 years will have dramatic impact on their role in the environment.

- Projected impacts on Aboriginal gathering rights.
- Likely impacts on treaty rights.
- Anticipated impacts on Aboriginal rights.

4.0 Identification Of Priorities

4.1 Objective

This section of the document is designed to integrate information presented in the forgoing three sections and using a risk-assessment-based process, categorize the vulnerability/risk of the impacts potentially associated with the issues defined in Section 3 as they relate to Nova Scotia.

4.2 Approach

The approach is based on two risk management-related CSA standards, namely: *CAN/CSA-Q634-M91 – Risk Analysis Requirements and Guidelines*, and *CAN/CSA-Q850-97 – Risk Management: Guidelines for Decision-Makers.* In these standards, risk is defined as "a measure of the probability and severity of an adverse effect to health, property, or the environment" and can be expressed mathematically as the product of *probability x consequence* or as a more general interpretation of risk based on non-numerical expression of probability and consequence in a non-product form. The latter of these two approaches is employed in this application as the aim is to qualitatively identify priority areas. The general structure of the approach is illustrated in Figure 4-1. For the purpose of identifying appropriate adaptation options, Steps 1 to 4 were completed in the development of this Issues Paper.

For each identified potential impact under each element identified in Section 3, **probability** (based on the estimated frequency of the event) has been allocated a category of Low, Medium, or High (**L, M, H**). The **consequence** (based on the estimated impact severity) on the other hand, has been assessment on the basis of two criteria, namely **socio-economic importance** and **environmental importance**. The chosen designations under the consequence column are as follows:

For socio-economic considerations: $\mathbf{L_S}$, $\mathbf{M_S}$, **or** $\mathbf{H_S}$ and

For environmental considerations: $\mathbf{L_E}$, $\mathbf{M_E}$, **or** $\mathbf{H_E}$.

In this way the integration of the probability and consequence are provided separately for the socio-economic importance and environmental importance (see column 4 - Table 4-1). This integration decision process was guided by the matrix shown in Figure 4-2.

Subsequently a single overall categorization based on integrating both considerations (i.e. social and environmental) was also provided using professional judgment as shown in column 5 of

Table 4-1. The integrated findings were then inputted into Section 6 to provide guidance in the derivation of a provincial adaptation strategy.

Limitation in the Categorization Process

It should be noted that the sub-headings presented in Table 4-1 were categorized only if specific research or published information could be accessed and assessed in the preparation of this document. A '-' is shown where sufficient data does not exist. The absence of any particular sub-heading or category should not be considered as negating the potential seriousness of the issue in question.

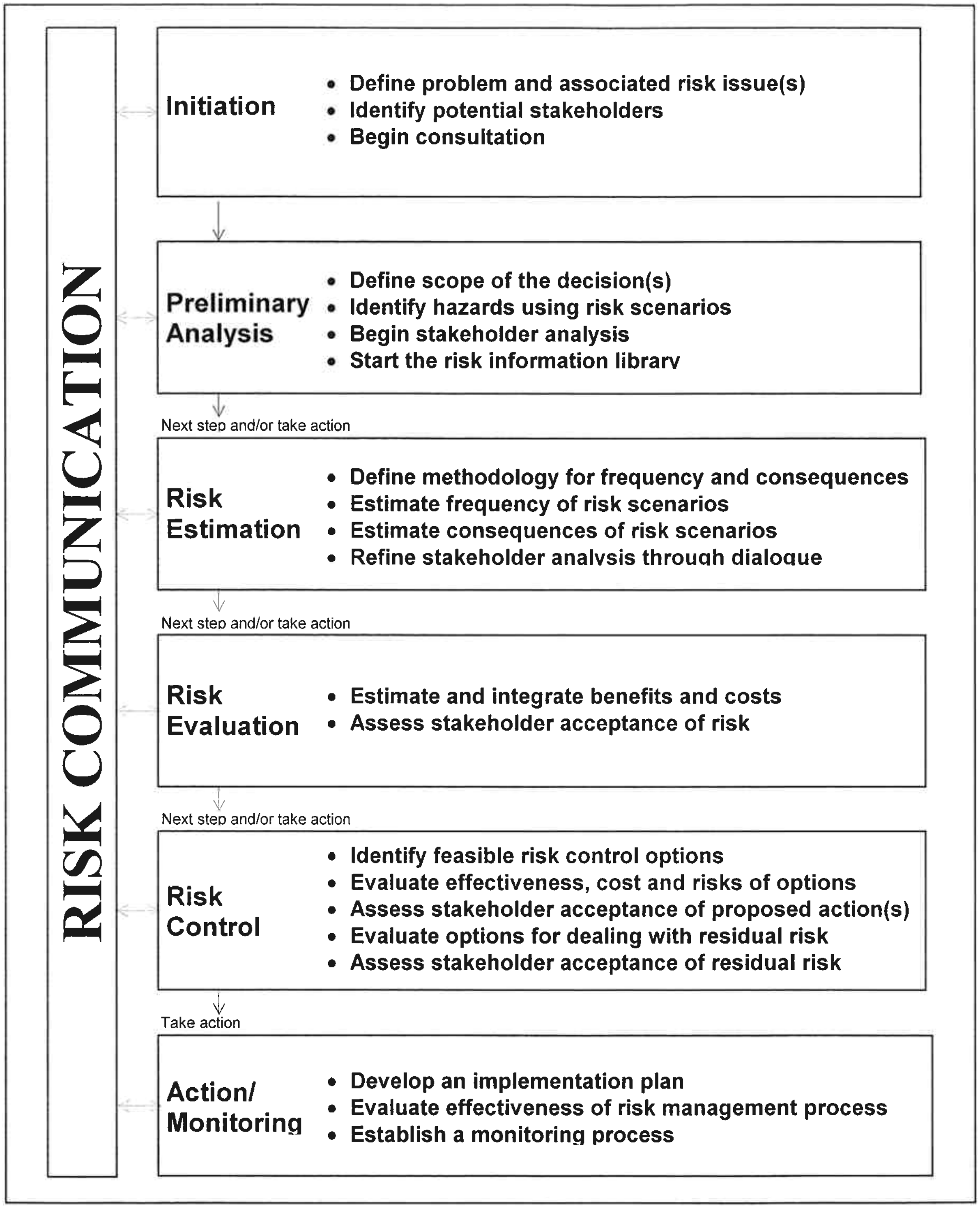


Figure 4-1 **Structure of a Risk-Based Process Adopted for Vulnerability Assessment**

Figure 4-2
Risk Assessment Matrix

		PROBABILITY		
IMPACT SEVERITY		LOW	MEDIUM	HIGH
	HIGH	M	H	H
	MEDIUM	L	M	H
	LOW	L	L	M

Table 4-1
Risk Evaluation Tabulation

Item	Probability (Frequency of event)	Consequence (Impact severity)	Segregated risk	Integ-rated risk
1. ENVIRONMENT				
a) Impacts on terrestrial & aquatic biodiversity • From temp & flow changes	H	L_S H_E	M_S H_E	H
b) Impacts on isolated populations & ecosystems •	M	L_S H_E	M_S H_E	M
c) Impacts on migration of species • break up & low summer flows	H	M_S H_E	M_S H_E	H
d) Impacts on native species due to invasion/migration of alien species without natural controls • hunting, bird watching & others	M	M_S M_E	M_S M_E	M
2. AGRICULTURE				
a) Impacts on crops due to drought & changing pptn. patterns • Storm/hail/drought damage	H	H_S L_E	H_S L_E	H
b) Impacts due to longer growing season • Higher yields	M	H_S L_E	H_S L_E	M
c) Impacts from changing pest & disease regimes • Increase in pests due to warmer winters	M	H_S L_E	H_S L_E	M
d) Impacts on diversity & types of crops able to be grown •	M	M_S M_E	M_S M_E	M
3. MARINE/FISHERIES ISSUES				
a) Impacts of changes to ocean currents • Gulf Stream • Labrador Current	- -			- -
b) Impacts on land-sea interactions • Habitats of migratory fish	H	H_S M_E	H_S M_E	H
c) Impacts on physical & chemical regime of oceans • Thermal • Currents • Salinity • chemical	- - - -			- - - -
d) Impacts on social & economic enterprises • Fisheries • Tourism • Oil & gas • Marine transportation • To human health	H - - L	H_S M_E L_S L_E	M_S M_E L_S L_E	H - - L

Item	Probability (Frequency of event)	Consequence (Impact severity)	Segregated risk	Integ-rated risk
4. HEALTH				
a) Impacts from extreme weather events				
• General	M	$H_S L_E$	$H_S L_E$	M
• Thermal extremes	M	$H_S L_E$	$H_S L_E$	M
• Higher UV levels	H	$M_S L_E$	$H_S M_E$	H
b) Impacts from vector-borne disease				
• West Nile virus	H	$H_S L_E$	$H_S L_E$	H
c) Impacts from air pollution with higher temperatures				
• g/l ozone increases	H	$H_S H_E$	$H_S H_E$	H
• overloading of public health system	M	$M_S L_E$	$M_S L_E$	M
d) Impacts from heat waves & vulnerability to drought				
• See item 4a	-			-
5. FORESTS				
a) Impacts on the natural disturbance regime, pest cycle, & rate of infestation				
• Midwinter thaws	M	$M_S L_E$	$M_S L_E$	M
• Forest fires	M	$M_S L_E$	$M_S L_E$	M
• Pest invasion	M	$M_S L_E$	$M_S L_E$	M
• Blowdown from Extreme Events	H	$M_S M_E$	$M_S M_E$	M
b) Impacts on harvesting processes				
•	M	$M_S L_E$	$M_S L_E$	M
c) Impacts on forest dependant communities				
• Dependant wildlife/birds	L	$L_S M_E$	$L_S L_E$	L
d) Impacts on forest structure, composition, productivity & regeneration				
• Ecosystem changes	L	$M_S L_E$	$M_S L_E$	L
6. COMMUNITIES/ INFRASTRUCTURE/TRANSPTATION				
a) Impacts from more frequent extreme weather events				
• Safety of population	-			-
• Flooding	M-	$H_S M_E$	$M_S M_E$	M
• Erosion	-			-
• Insurance & property values	H	$H_S M_E$	$H_S L_E$	H
b) Impacts on settlement patterns & land-use planning				
• Extreme events, sea level rise & surges	H	$H_S H_E$	$H_S H_E$	H
• Coastal ice damage	L	$L_S L_E$	$L_S L_E$	L
c) Impacts on transportation				
• infrastructures & patterns	M	$H_S L_E$	$H_S L_E$	M
• cost of maintenance (extreme events)	M	$M_S L_E$	$M_S L_E$	M
• port operations	H	$H_S L_E$	$H_S M_E$	H

Item	Probability (Frequency of event)	Consequence (Impact severity)	Segregated risk	Integ-rated risk
d) Impacts on buildings and building code criteria • Extreme events	H	H_S L_E	H_S L_E	H
7. WATER RESOURCES				
a) Impacts on the variability of quality & quantity of regional water resources				
• Winter ice regimes	-			-
• Hydrogeology	M	M_S M_E	M_S M_E	M
• Water chemistry	M	M_S H_E	M_S H_E	M
• Hydro generation	M	M_S L_E	M_S L_E	M
• Due to sea rise	M	M_S H_E	M_S H_E	M
b) Impacts on water supply				
• Energy/hydropower	M	M_S M_E	M_S M_E	M
• Domestic supplies	M	M_S M_E	M_S M_E	M
• Industrial supplies	M	M_S M_E	M_S M_E	M
• Agriculture	H	M_S M_E	H_S M_E	H
• Exports	-			-
• Pollution dilution	M	M_S M_E	M_S M_E	M
c) Impacts on communities due to decreased water quality • Health problems	M	M_S L_E	M_S L_E	L
d) Other water related impacts				
• On water based recreation activities	-			-
• On water related infrastructure	M	H_S L_E	H_S L_E	M
8. COASTAL ZONES				
a) Impacts on coastal wetlands/ecosystems • Sea level rise/surges	H	H_S H_E	H_S H_E	H
b) Impacts from erosion • Sea level rise/surges	H	H_S H_E	H_S H_E	H
c) Impacts from flooding • Sea level rise/surges	H	H_S H_E	H_S H_E	H
d) Impacts on human settlements & coastal infrastructure • Sea level rise/surges	H	H_S H_E	H_S H_E	H
9. ABORIGINAL ISSUES				
a) Impacts on Aboriginal gathering rights •	M	M_S L_E	M_S L_E	M
b) Impacts on treaty rights •	-			-
c) Impacts on Aboriginal use of natural resources •	-H	H_S M_E	H_S M_E	H

4.3 Summary of Findings

This risk assessment indicates that the following integrated risk categorizations of the issues defined in Section 3:

High risk category (18 items)

- Environment - temperature and flow changes resulting from impacts on terrestrial and aquatic biodiversity
- Environment - impacts on migrations of species
- Agriculture - impact due to drought and changing precipitation patterns
- Marine/fisheries issues - impacts on fish migration
- Marine/fisheries issues - impacts on the fishery aspects of social and economic enterprises
- Health - West Nile virus increase
- Health - ground-level ozone increases
- Communities/infrastructure/transportation - impacts on insurance and property values
- Communities/infrastructure/transportation - impacts on transportation infrastructure and patterns from extreme events
- Communities/infrastructure/transportation - extreme events, sea level rise and surges on settlement patterns
- Communities/infrastructure/transportation - transportation - port operations
- Communities/infrastructure/transportation - extreme events on buildings and building code criteria
- Water resources - impacts related to agriculture
- Coastal zones - sea level rise/surges on wetlands/ecosystems
- Coastal zones - sea level rise/surges on erosion
- Coastal zones - sea level rise/surges on flooding
- Coastal zones - sea level rise/surges on human settlement and coastal infrastructure.
- Aboriginal use of natural resources

Medium risk category (30 items)

- Environment - impacts on isolated populations and ecosystems
- Environment - impacts resulting from invasion/migration of alien species
- Agriculture - higher yields due to longer growing season
- Agriculture - impact due to an increase in pest and disease regimes
- Agriculture - impacts on diversity and types of crops grown
- Health - general impacts from extreme weather events
- Health - thermal event related impacts
- Health - overloading of the health system with respect to higher temperature effects

- Forests - impacts on natural disturbance regime, pest cycle and rate of infestation due to midwinter thaws
- Forests - impacts on natural disturbance regime, pest cycle and rate of infestation due to increased forest fires
- Forests - impacts on natural disturbance regime, pest cycle and rate of infestation due to pest infestations
- Forests - impacts on natural disturbance regime, pest cycle and rate of infestation due to blowdown from extreme events
- Forests - impacts on harvesting processes
- Communities/infrastructure/transportation - impacts on transportation infrastructure and patterns
- Communities/infrastructure/transportation - impacts of flooding resulting from extreme events
- Communities/infrastructure/transportation - impacts on transportation maintenance costs
- Water resources - impacts on variability of quality and quantity with respect to hydrogeology
- Water resources - impacts on variability of quality and quantity with respect to water chemistry
- Water resources - impacts on variability of quality and quantity with respect to hydro generation
- Water resources - impacts on variability of quality and quantity due to sea rise
- Water resources - impacts on water related infrastructure
- Water resources - impacts related to energy/hydropower
- Water resources - impacts related to domestic supplies
- Water resources - impacts related to industrial supplies
- Water resources - impacts related to pollution dilution
- Aboriginal issues - impacts on aboriginal gathering rights

Low risk category (5 items)

- Forests - impacts on forest dependant communities including wildlife and birds
- Forests - impacts ecosystem changes
- Communities/infrastructure/transportation - impacts settlement patterns and land-use planning due to coastal ice damage
- Water resources - health problems related to decreased water quality
- Communities/infrastructure/transportation – coastal ice damage on settlement patterns

The implications of these categorizations to the development of a provincial climate change adaptation strategy are discussed in Section 6.

5.0 Institutional and Legal Arrangements for Responding to Issues

5.1 Allocation of Responsibilities

General environmental and coastal management responsibilities are entrusted to a number of federal, provincial, municipal agencies. A summary of management functions and the agency or agencies responsible are provided in Table 5-1. In Nova Scotia, there is generally clear division between the levels of government and their responsibilities as shown in Tables 5-1 and 5-2. Where there is overlap, the agencies tend to complement each other. For example protection of water quality in inland waters falls within both federal e.g. Fisheries and Oceans Canada and provincial e.g. Nova Scotia Department of Environment and Labour agencies.

Table 5-1
Environmental and Coastal Management Responsibilities

Management Function	Agency Responsible
Agricultural Marshlands Conservation	NSDAF
Beaches	NSDNR
Crown Lands Management	NSDNR
Ditching and Watercourses	NSDNR, Municipalities
Municipal and Regional Planning	SNSMR, Municipalities
Endangered Species Protection	NSDNR, EC
Fisheries and Coastal Resources	NSDAF, DFO
Forest Management	NSDNR
Marine and Freshwater Habitat Protection	Fisheries and Oceans Canada (DFO)
Oceans Management	DFO
Pollution Abatement	NSDEL, DFO, Environment Canada (EC)
Protection of Migratory Birds	EC
Protection of Wildlife	NSDNR, EC
Water Quality Protection	NSDEL (Freshwater), DFO
Economic Development	ACOA, NSBI, NSDEL, NSDNR, Fisheries and Oceans Canada (DFO),
Aboriginal Issues	INAC, CIER, CMM, UNSI, Bands
Works in Coastal Areas	Municipalities, NSDNR
Infrastructure	NSTPW, Municipalities, PWGSC

From Table 5-1, it is clear that all three levels of government share responsibility and opportunity to address climate change as part of the management of resources or infrastructure.

Nova Scotia recognized in its *Green Plan* the potential for environmental and economic impacts from climate change given the concentration of the Province's economy and population in coastal areas. Of primary concern to the Province are the potential effects from sea-level rise and the potential increase in storm surge impacts. Climate change impacts and adaptation action planning are one of the Province's priorities under the *Green Plan.* As well, the Province has also participated in the development of the New England Governers and Eastern Canadian Premiers *Climate Change Action Plan.*

5.2 Legislation and Statutory Provisions

Table 5-2 below provides a summary of existing legislation relevant to environmental and coastal management.

From a review of the legislation, consideration of climate change is not specifically addressed in current federal or provincial legislation but since environmental and natural resource management legislation mandates protection, climate change issues can be addressed as it directly and indirectly can affect the resource protected or managed by legislation. Apart from the Nova Scotia Department of Environment and Labour and Energy, Environment Canada and Natural Resources Canada, the degree of awareness within the responsible departments has not been determined. However, it is likely that climate change factors are not being addressed in policies, plans and decisions made under provincial and in most cases, federal legislation.

Climate change is also increasingly being recognized as a factor in maintaining the sustainability of the Province's largest urban center, Halifax Regional Municipality. The municipality is currently undertaking a project related to the development of mitigation and adaptation risk management tool kits through the *Climate SMART* project. As well, regional planning staff are taking into consideration the effects of climate change on the coastal features and infrastructure as part of its regional planning initiative.

5.3 Other Relevant Institutional Considerations

Canada has committed through the *National Implementation Strategy on Climate Change* to implement strategies dealing with climate change, in part through joint federal/provincial efforts. As part of Phase One of the *Strategy* Canada is to invest in building knowledge related to climate change mitigation and adaptation capacity building.

Table 5-2
Summary of Relevant Legislation

Legislation	Agency	Description
Agricultural Marshland Conservation Act	NSDAF	Permits the construction and maintenance of works to develop marshlands for agricultural purposes.
Beaches Act and Regulations	NSDNR	Provides protection for beaches and associated dune systems. Regulates and enforces land use activities on beaches
Beaches and Foreshores Act	NSDNR	Allows the Minister to give a grant or enter into a lease of a flat, beach or foreshore.
Canadian Environmental Assessment Act	CEAA	Requires projects meeting certain criteria to undergo an environmental impact assessment.
Crown Lands Act	NSDNR	Minister is responsible for the administration, leasing and disposal of Crown lands in the Province.
Ditches and Watercourses Act	NSDNR/ Municipalities	Sets rules for the approval, construction, and maintenance of ditches.
Emergency Measures Act	NS Executive Council	Act addresses the organization of emergency response measures in the Province and describes the powers of the Emergency Measures Organization.
Endangered Species Act	NSDNR	Provides for protection, designation, and recovery of species at risk and their habitats.
Environment Act	NSDEL	Purpose of the Act is to support and promote the protection, enhancement and prudent use of the environment.
Environmental Assessment Regulations	NSDEL	The regulation defines the type of projects requiring environmental impact assessment in the Province and minimum requirements for impact assessments.
Fisheries Act	DFO	Concerns the protection of fish, fish habitat and management of commercial fisheries.
Fisheries and Coastal Resources Act	NSDAF	Promotion and implementation of programs to sustain and improve the recreational/sport fishery and aquaculture. Fosters community involvement in the management of coastal resources.
Forest Act	NSDNR	Act applies to many aspects of forest management including improvement of yield, improvement in management, enhancing habitat and recreational opportunities, and job creation.
Forest Enhancement Act	NSDNR	Act provides general guidance on the selected elements of the Forest Act.
Forest Sustainability Regulations	NSDNR	Requires buyers of primary forest products to prepare a plan on how it intends to maintain forest sustainability (e.g. through silvaculture or financial contributions).
Migratory Birds Convention Act	EC	Provides for the protection of migratory birds.

Legislation	Agency	Description
Oceans Act	DFO	The Act, in part, directs the Minister to develop and implement a national strategy and integrated management plans for the management of estuarine, coastal and marine ecosystems.
Species At Risk Act	EC	The purposes of this Act are to prevent wildlife species from being extirpated or becoming extinct, to provide for the recovery of wildlife species that are extirpated, endangered or threatened as a result of human activity and to manage species of special concern to prevent them from becoming endangered or threatened.
Wildlife Act	NSDNR	Develop and implement policy and programs to maintain diversity, integrate protective measures on Crown lands, regulate hunting and fishing, and provide continual renewal of the resource.

CEAA – Canadian Environmental Assessment Agency
CMM – Confederation of Mainland Mi'kmaq
DFO – Department of Fisheries and Oceans
EC – Environment Canada
NSBI – Nova Scotia Business Incorporated
NSDAF – Nova Scotia Department of Agriculture and Fisheries
NSDNR – Nova Scotia Department of Natural Resources
NSTPW – Nova Scotia Department of Transportation and Public Works
INAC – Indian and Northern Affairs
PWGSC – Public Works and Government Services Canada
UNSI – Union of Nova Scotia Indians

In addition, Nova Scotia is also party to the New England Governors and Eastern Canadian Premiers *Climate Change Action Plan,* which in addition to setting priorities for GHG reduction, also emphasizes the undertaking of adaptive measures recognizing that climate in the region, is changing now. One of the Guiding Principles of the *Action Plan* directs the Governors and Premiers to "explore ways to adapt to the already changing climate, to take advantage of any benefits that might come from these changes, and to adapt our infrastructure and natural resource base accordingly."

First Nations organizations and bands are active both nationally and locally in monitoring changes in the ecosystem and identifying strategies for adapting to climate change. The Assembly of First Nations is active in international initiatives to mitigate and adapt to climate change through CUSO and First Nations organizations and governing bodies in the United States.

Non-governmental organizations in the province such as Clean Nova Scotia, Sierra Club, and the Ecology Action Centre are actively working to promote a climate change agenda, but with a focus on mitigation and environmental protection. Adapting to climate change has not, to date, been a focal point for NGOs. Likewise, financial, insurance institutions and utilities have focused efforts on mitigating climate change through greenhouse gas reduction rather than planning for change by developing adaptation strategies.

The status of adaptation policies of crown corporations at both the provincial and federal level is unknown at this point.

Climate change considerations have a serious bearing on a number of corporately controlled issues, including:

- Protection of corporate property and assets vulnerable to climate change
- Incorporation of climate change considerations into ISO 14001 and other environmental management systems
- Inclusion of climate change considerations into the approval of mortgages and other long-term loans by financial institutions, and
- Consideration of climate change related liabilities associated with environmental impact assessments for new construction, property transactions and insurance risk assessment.

6.0 Formulation of Climate Change Adaptation Options for Nova Scotia

6.1 Introduction

This section serves to begin the process of enunciating *general* or *guiding principles* that could inform the selection, design and implementation of appropriate climate change adaptation options for Nova Scotia. These guiding principles logically emerge from the key provincial concerns identified in the preceding sections. While the main objective is to establish general principles, an attempt has been made to identify *specific adaptation options* that would lessen the anticipated ***high-risk*** impacts of climate change as identified in Section 4.

It is anticipated that discussions with key provincial stakeholders will begin to identify additional opportunities and constraints resulting from global climate change. More specifically, these discussions will assist in the identification of:

- **Specific Adaptation Options -** Specific adaptation options that might be considered for implementation, taking relevant local circumstances into account; and
- **Opportunities (if any) and constraints -** Local circumstances that support any particular adaptation option, or that may present a constraint to any appropriate adaptation option. For example, the diversification of the tourism product with a focus on non-coastal assets (which may be threatened by climate change) may be considered an 'opportunity'. On the other hand, the lack of trained coastal engineers and limited availability of capital might be definite 'constraints' to the implementation of certain coastal protection options.

The adaptation options identified through discussions with stakeholders will serve to identify the nature and scope of an appropriate climate change impacts and adaptation action plan for Nova Scotia, and where possible recommend its format and structure. It should also serve to identify opportunities for partnerships between all levels of government, industry and non-governmental organizations (NGOs) in dealing with adaptation. It is anticipated that the options identified in this document will ultimately be used by the Province to develop a climate change impacts and adaptation action plan.

6.2 High Risks for the Environment

The ***high risk*** factors associated with climate change include:

- Impacts on terrestrial and aquatic biodiversity from changes in temperature, precipitation and extreme events; and
- Impacts on migration of certain species from; (a) ice break up and low summer flows; and (b) loss of or changes to coastal wetlands due to sea-level rise, coastal flooding, and changes in salinity.

Appropriate adaptation responses could include:

- An improved understanding of –
  - The location and vulnerability of ecosystems and species at risk, and the "threshholds" which – if surpassed – will prevent natural adaptation responses by such ecosystems and species;
  - Natural adaptive capacity of vulnerable ecosystems and species, to identify measures that can be undertaken to enhance the resilience of vulnerable ecosystems.

- A determination of potential threats to forest resources in silviculture, harvesting and other forest management issues.
- The establishment of appropriate measures to provide for the maintenance of terrestrial and marine biodiversity affected by climate change and habitat reduction.
- An evaluation of the viability of systems that have been established for safeguarding isolated populations and ecosystems, such as in parks and other protected areas.
- The revision of habitat and wildlife management programs to address the threats of the northward migration of alien species as a consequence of climate change.
- The protection of important coastal wetlands to prevent coastal erosion and inundation from sea-level rise.

Entity Responsible:
Such adaptation responses should be a priority activity undertaken by the Nova Scotia Department of Natural Resources, Environment Canada, Canadian Wildlife Service, Parks Canada, regional and community wildlife conservation organizations and academia. Additionally, appropriate adaptation risk assessment and risk management measures should be incorporated into provincial conservation and parks management strategies, private conservancy programs, and Canada's Biodiversity Strategy.

6.3 High Risks for the Agricultural Sector

The ***high risk*** factors associated with climate change include:

- Impacts on crops due to increased incidents of extreme events (drought, hail, floods and storms), changing precipitation and temperature regimes, and changes in the distribution and incidents of pests.

Appropriate adaptation responses could include:

- An improved understanding of the location and vulnerability of specific crops at risk.
- Investigation of opportunities for crop diversification to identify varieties that are more resilient or less vulnerable to climate change impacts.
- The development of monitoring and appropriate adaptation measures to address new and changing pest and disease regimes in agriculture and forestry.

Entity Responsible:
Such adaptation responses should be a priority activity undertaken by the Nova Scotia Department of Agriculture and Fisheries, and community agricultural organizations and academic institutions. Additionally, appropriate adaptation risk assessment and risk management measures should be incorporated into provincial agricultural programs, farm subsidy programs, and agricultural insurance schemes. Where necessary, improved coverage should be provided under agricultural insurance programs to spread the risks associated with climate change, particularly those associated with the increased incidents of extreme events. Federal and Provincial Governments may need to investigate appropriate re-insurance schemes for the agricultural sector.

6.4 High Risks for the Marine/Fisheries Sector

The ***high risk*** factors associated with climate change include:

- Impacts on land-sea interactions including changes in the location and viability of sensitive habitats of marine species due to changes in marine ecosystems associated with changing water temperatures, and increased incidents of marine pollution associated with higher run-off, greater incidents of coastal erosion, and higher incidents of algae blooms associated with warming of ocean areas;
- Impacts on social and economic enterprises largely as a result of changes in migration patterns, fish size and availability that will be affected by changing water temperatures and higher incidents of contamination from increased incidents of marine pollution associated with higher run-off, greater incidents of coastal erosion, and higher incidents of algae blooms associated with warming of ocean areas.

***Appropriate adaptation responses* could include:**

- An improved understanding of the location and vulnerability of specific marine species and ecosystems at risk to establish a sound basis for commercial fisheries conservation and management programs to protect species or habitats that are vulnerable.
- Investigation of opportunities for diversifying the fishing industry to respond to the possible long term declines in different fish stocks and other marine resources.
- A study of the specific vulnerability of aquaculture operations to identify: (a) species that are more resilient or less vulnerable to climate change impacts; and (b) potential opportunities for diversification in the species farmed under aquaculture.

Entity Responsible:
Such adaptation responses should be a priority activity undertaken by the Nova Scotia Department of Agriculture and Fisheries, Fisheries and Oceans Canada, the aquaculture community, community coastal management organizations and academic institutions. Additionally, appropriate adaptation risk assessment and risk management measures should be incorporated into provincial aquaculture programs, aquaculture subsidy programs, and aquaculture insurance schemes. Where necessary, improved coverage should be provided under aquaculture insurance programs to spread the risks associated with climate change. Federal and Provincial Governments may need to investigate appropriate re-insurance schemes for the aquaculture sector.

6.5 High Risks for the Health Sector

The ***high risk*** factors associated with climate change include:
Increased likelihood of outbreaks of vector-borne diseases – particularly

- West Nile virus and other vector-borne diseases – due to changes in seasons (longer summers, higher incidents spring precipitation) which affect the range and incidents of disease-carrying insects;
- Increased incidents in respiratory ailments associated with ground-level ozone increases.

***Appropriate adaptation responses* could include:**

- An improved understanding of –
  - The climatic factors affecting the spread of vector-borne diseases;
  - The adaptive capacity of the health service in Nova Scotia to address increased outbreaks of diseases and illnesses associated with climate change.
- The establishment of public health education programs to provide information on appropriate preventative measures.
- Municipalities, local authorities, community groups and the general public taking a pro-active role in controlling the spread of disease-carrying insects through appropriate measures.

Entity Responsible:
Such adaptation responses should be a priority activity undertaken by the Nova Scotia Department of Health, Health Canada, municipalities and local authorities, and academic institutions. Appropriate adaptation risk assessment and risk management measures should be incorporated into provincial health programs.

6.6 High Risks for Communities/Infrastructure/ Transportation

The ***high risk*** factors associated with climate change include:

- Changes in settlement patterns due to increased incidents of extreme events, sea level rise and storm surges;
- Insurance and property values will be affected by extreme events, sea-level rise and storm surges;
- Port operations will be affected by impacts from sea-level rise, extreme events (storms), and changes in shipping patterns associated with changes in ice-patterns;
- Increased damage to buildings and coastal infrastructure due to cumulative effect of sea-level rise, and increased incidents of extreme events.

Appropriate adaptation responses could include:

- an inventory and vulnerability maps of communities, infrastructure and buildings at risk from climate change impacts.
- An evaluation of –
  - Opportunities to extend the winter shipping season and increase the access to shipping ports now closed seasonally due to sea-ice;
  - The vulnerability of port facilities and associated infrastructure due to changes in water level, increased wave activity, storm surges, flooding, and ice ride-up and pile-up;
  - The possibility of accommodating larger ocean vessels as ports deepen with sea level rise.
- Municipalities, local authorities, community groups and the general public take a pro-active role in identifying buildings, infrastructure and essential services that are vulnerable to climate change impacts, and establishing appropriate adaptation measures to reduce risks.

Entity Responsible:
Such adaptation responses should be a priority activity undertaken by the Nova Scotia Department of Municipal Affairs, municipalities and port authority/managers. Appropriate adaptation risk assessment and risk management measures should be incorporated into municipal and local authority physical planning processes. Federal, Provincial and Municipal Governments may need to investigate appropriate re-insurance schemes for vulnerable coastal communities and infrastructure.

6.7 High Risks for Water Resources

The ***high risk*** factors associated with climate change include:

- Impacts on water availability for agricultural sector from:
  - Extreme events, rise in temperature, increased evaporation, increased demand from other water users;
  - Natural stresses include increased climate variability and extremes that can affect both the magnitude and seasonal cycles of water budget components that influence the availability of clean freshwater;
  - Climate extremes (e.g., El Niño, and large-scale weather systems with high winds and precipitation) will significantly affect lake heat storage, temperature and evaporation;
  - Natural climate variability and climate change both affecting water levels in aquifers; and
  - Changes in temperature and precipitation altering recharge to water catchment areas and groundwater aquifers, causing shifts in water table levels in unconfined aquifers.

Appropriate adaptation responses could include:

- An improved understanding of –
  - Water use and availability in relation to the agricultural sector.
  - The social and economic factors underlying demands for water in the agricultural sector and the forces driving demand patterns and recirculation decisions that may be affected by changing precipitation patterns;
- The identification of crops that are vulnerable to changes in water availability.
- The establishment of targeted baseline monitoring and reliable inventories for –
  - Lake, river and groundwater resources and demand;
  - Usage parameters;
  - Effluent quality and aquatic impacts;
  - The condition and capacity of water distribution and treatment systems; and
  - Other important elements such as the number, size and location of agricultural operations where high water demand is expected.

- The incorporation of climate change vulnerability assessment and appropriate adaptation measures into irrigation and soil moisture management in agricultural regions facing water deficits.
- The development of integrated water resource management programs at the provincial and local levels to balance the needs of competing users when confronted with changes in water availability due to climate change.
- The evaluation of opportunities for crop diversification to identify varieties that are more resilient or less vulnerable to changes in water availability.

Entity Responsible:
Such adaptation responses should be a priority activity undertaken by the Nova Scotia Department of Agriculture and Fisheries, and community agricultural organizations and academic institutions. Appropriate adaptation risk assessment and risk management measures should be incorporated into provincial agricultural programs, farm subsidy programs, and agricultural insurance schemes. Where necessary, improved coverage should be provided under agricultural insurance programs to spread the risks associated with climate change, particularly those associated with the increased incidents of extreme events and changes in water availability. Federal and Provincial Governments may need to investigate appropriate re-insurance schemes for the agricultural sector.

6.8 High Risks for Coastal Zones

The ***high risk*** factors associated with climate change include:

- Impacts of sea level rise and extreme events (storm surges) on coastal wetlands and ecosystems;
- Increased incidents of coastal erosion and flooding from sea level rise and extreme events (storm surges);
- Increased damage to coastal settlements and infrastructure from sea level rise and extreme events (storm surges).

***Appropriate adaptation responses could include*:**

- An inventory and the development of vulnerability maps of coastal ecosystems, communities, infrastructure and buildings at risk from climate change impacts.
- The establishment of appropriate adaptation and risk reduction measures including protection, abandonment, compensation, marketing, and legal issues for coastal property and private residences facing increased erosion in the future needs to be addressed.
- The evaluation of the cost of converting privately owned coastal land back to public land in most vulnerable areas compared to the costs of fortification and/or compensation.
- The protection or relocation of coastal roads, particularly in low-lying areas or along shorelines that are vulnerable to rising sea level, erosion, storm surges or flooding;
- Municipalities, local authorities, community groups and the general public need to take a pro-active role in identifying ecosystems, buildings, infrastructure and essential services that are vulnerable to climate change impacts, and establish appropriate adaptation measures to reduce risks.
- Appropriate adaptation risk assessment and risk management measures could be incorporated into municipal and local authority physical planning processes.

Entity Responsible:
Such adaptation responses should be a priority activity undertaken by the Nova Scotia Departments of Municipal Affairs, Transportation and Public Works, and Natural Resources, municipalities and local authorities, and community groups. Federal, Provincial and Municipal Governments may need to investigate appropriate re-insurance schemes for vulnerable coastal communities and infrastructure.

6.9 High Risks for Aboriginal Communities

The ***high risk*** factors associated with climate change include:

- Change in use and harvesting of natural resources (i.e. hunting, fishing, logging) while exercising treaty rights, from temperature, precipitation, sediment in precipitation runoff, and sea level;
- Increased threats to economic survival and diversifying of the economy of communities that are:
  - Dependent on single resource industries (i.e. forestry and fisheries) as a consequence of climate change impacts on these resources;
  - Located in vulnerable coastal areas that may be affected by sea-level rise and extreme events.

Appropriate adaptation responses could include:

- The identification and protection of traditional resources used by aboriginal peoples that may be adversely affected by climate change.
- The introduction of climate change risk assessment - particularly the vulnerability to sea level rise, storm surges, increased winter wave action and winter flooding due to ice changes - into infrastructure life-cycle planning in communities, including the maintenance and improvements of dykes, sewer, and water systems, emergency planning systems, coastal roads, flood plain zoning, and property.

Entity Responsible Adaptation responses should be led by the Confederacy of Mainland Mik maq and the Union of Nova Scotia Indians supported by Indian and Northern Affairs Canada.

6.10 Data for Adaptation Decision-Making

For the Province of Nova Scotia, the following are the data gaps in local knowledge that, if reliable data was available, would be most useful in attempts to take climate change adaptation into account in local decision making.

1. Downscaling of climate change modelling to provide results on a finer scale than currently available. This would improve adaptation planning.

2. Measuring the overall multiplier effects of climate change on provincial economies in Atlantic Canada, in terms of gross domestic product, employment, and wages.

3. Targeted baseline monitoring and reliable inventories for lake, river and groundwater resources and demand, usage parameters, and effluent quality and aquatic impacts, the condition and capacity of water distribution and treatment systems, and other important elements such as the number, size and location of agricultural operations and other activities where high water demand is expected.

4. Improve the understanding of the social and economic factors underlying demands for water and the forces driving demand patterns and recirculation decisions.

5. Improve the near-real-time stream flow observations and access to historic data, including paleo-climate and paleo-flood records.

6. Improved understanding and modelling of hydrological processes and systems, including aspects such as: incorporating results of climate change modelling and hydrological modelling; effects of land use changes on floods; relationships among land management, soil water balance and partitioning of precipitation.

7. Improve and increase the collection of relevant Nova Scotia weather measurements to support regional and local climate monitoring, analyses and modelling.

8. Assess the significance of extreme weather events and weather variability in the design, cost, mobility and safety of infrastructure and transportation systems.

9. Improved understanding and predictability of shoreline response to changing climate and water levels, particularly for highly vulnerable coastlines at the local level.

10. Improve data availability and accessibility, including climate, water level and current data, as well as the capacity for future monitoring and data gathering.

11. Increased focus on the impacts of changes in the frequency of extreme events, rather than mean conditions, on both agricultural crops and livestock, and woodlands.

12. Improved availability and use of tools and guides to incorporate the role of adaptation into decision-making at the farm, fishery, forest planning, municipal planning, industry and governmental levels.

13. <u>Information on the long-term interactive effects of climate and other environmental changes on ecosystems in general, and forests in particular</u>. This would include efforts to improve the understanding of the impacts of active forest management on ecosystems, such as the effects of reintroducing species to disturbed ecosystems.

14. <u>Studies that derive realistic cost estimates</u> for different adaptation options.

7.0 Climate Change in Nova Scotia – The Way Forward

This final section of the document provides recommendations on key measures that are needed to address the anticipated risks to Nova Scotia associated with global climate change as has been provided in earlier sections.

7.1 Climate Change Adaptation Committee

The management of risks associated with climate change cannot be adequately addressed by any one government department or agency, or indeed by the public sector alone. Effective risk management requires that a formal and effective structure be established to "institutionalize" climate change risk management and the establishment of appropriate adaptation planning and management mechanisms within all sectors in Nova Scotia. Although individual adaptation risk management initiatives are being undertaken and supported with the Province (e.g. the "ClimAdapt" network supported by NSDEL and Environment Canada, and the "Climate SMART" initiative by HRM), the need to identify and act upon priority options within limited resource (human, technical, financial) constraints dictates that a vehicle be established to foster sound adaptation risk management. In this regard, ***it is strongly recommended that an inter-departmental climate change adaptation committee be established*** that will be tasked to follow-on from the inter-government consultations that were undertaken to develop this Issues Paper, and:

(a) Direct, through broad-based consultations, a *Climate Change Adaptation Strategy* for Nova Scotia (see section 7.2. below);

(b) Co-ordinate and support public sector adaptation planning and management and awareness building;

(c) Liaise with federal and municipal government on the identification and implementation of appropriate adaptation risk management strategies for the province of Nova Scotia in keeping with the ***National Climate Change Adaptation Framework***;

(d) Provide technical support for Provincial Deputy Minister's talks undertaken with Deputy Ministers of Environment Canada (EC) and Natural Resources Canada (NRCan) on adaptation issues and strategies;

(e) Support and foster broader public awareness and information on climate change risk management – particularly with key stakeholders (e.g., APENS, Nova Scotia Home Builders Association, insurance industry, etc.);

(f) Promote and encourage climate change risk management partnerships with the private sector, non-governmental organisations and communities;

(g) Guide and promote applied research into climate change adaptation risk management for decision-makers in the public and private sectors, and at the community level (see Section 7.3. below)

7.2 Climate Change Adaptation Strategy

It is clear from this Issues Paper that Nova Scotia (and other vulnerable regions in Canada) will need to establish a number of management mechanisms for integrated adaptation planning and management to become a reality. Clearly, each of these mechanisms cannot be established concurrently, and in almost all instances considerable resources (human, technical, financial) will be required to establish the policy, legal and institutional structures that are necessary to give effect to these mechanisms. There is a pressing need to prioritise and rationalize appropriate adaptation policy options, and ensure broad-based stakeholder support, buy-in and co-operation if such policy options are to be implemented. This can be achieved in the development, through a broad-based consultative process, of a *Climate Change Adaptation Strategy* for the Province of Nova Scotia. Such a Strategy should serve as a mechanism to facilitate integrated planning and management for cost-effective response to the impacts of global climate change, and should effect the formulation and implementation of appropriate adaptation management mechanisms for the public and private sectors and local communities.

The principal objective is the development, through a broad-based consultative process with affected stakeholders, of a *Climate Change Adaptation Strategy* for the Province of Nova Scotia that would:

a) Support Canada's obligations to implement commitments under Article 4 of the *United Nations Framework Convention on Climate Change;*

b) Support Nova Scotia's obligations to implement commitments under Action Item 7 of the *New England Governors/Eastern Canadian Premiers Climate Change Action Plan* (2001);

c) Establish a framework for discussion on adaptation risk management for Provincial Deputy Minister's negotiations with Deputy Ministers of Environment Canada (EC) and Natural Resources Canada (NRCan);

d) Ensure that the public and private sectors in Nova Scotia initiate the process to formulate appropriate climate change adaptation policy options in keeping with developments in British Columbia and other vulnerable Canadian provinces;

e) Support the development and implementation of appropriate policy options for adaptation planning and management thereby reducing anticipated impacts from climate change on vulnerable sectors in Nova Scotia in keeping with the *National Climate Change Adaptation Framework.*

Step 1 – Stakeholder Consultation on "Issues Paper"

In order to initiate appropriate 'buy-in' and 'ownership' at the provincial level, it is recommended that broad stakeholder consultations be undertaken on the Issues Paper, and subsequent draft of the Strategy document. This consultative process could be facilitated by the inter-departmental climate change adaptation committee (see Section 7.1.), and may include:

(a) Launch of Public Education and Awareness Program

A public education and awareness program will be launched in support of the development of the *Climate Change Adaptation Strategy.*

(b) Stakeholder Consultative Meetings

Presentations could be made to stakeholders in vulnerable sectors to obtain their input in the identification and development of appropriate adaptation policy options.

(c) Technical Meeting

Provincial workshops could be convened, facilitated by the inter-departmental climate change adaptation committee, with stakeholder from vulnerable sectors and communities, which will provide a form for -

(a) A critical review of the "Issues Paper" during which comment arising from the consultation process will be evaluated;

(b) The identification of appropriate intervention options to address identified issues.

The inter-departmental climate change adaptation committee could guide other stakeholders in the evaluation and identification of appropriate policy options and strategies for climate change adaptation planning and management.

Step 2 – Development of Draft Strategy

Taking the outputs from the consultative process, the inter-departmental climate change adaptation committee, could develop the first draft text of the *Climate Change Adaptation Strategy*. This first draft is intended to:

(i) Where possible, identify anticipated changes to local, provincial and regional climate patterns in the short, medium and long term;

(ii) Outline anticipated impacts from anticipated local, provincial and regional climate patterns;
(iii) Identify activities and areas that are vulnerable, or at risk or that may be affected by anticipated local, provincial and regional climate patterns (drawing from the "Issues Paper" and stakeholder consultations, and C-CIARN risk assessment program);
(iv) Outline appropriate adaptation planning and management policy options and strategies for addressing anticipated climate change impacts in the short, medium and long term (drawing from the technical meeting and the "Issues Paper");
(v) Define the implementation strategy to give effect to the appropriate adaptation planning and management strategies, including time frames for implementation (drawing from the technical meeting and the "Issues Paper");
(vi) Identify activities that should be undertaken at the regional and national levels to support and complement the provincial policy and implementation Strategy;
(vii) Identify mechanisms for integrating climate change adaptation into sectoral strategies, programs and policies;
(vii) Identify the legal, institutional and financial mechanism that could be established to:
- Give effect to the policy and implementation strategy (drawing from the technical review and the "Issues Paper"); and
- Coordinate provincial, regional and national adaptation activities;

(viii) Identify policy options/mechanisms to be implemented within the private sector and at the community level to reduce vulnerability to climate change impacts;
(ix) Outline the process whereby the *Climate Change Adaptation Strategy* could be kept under regular and periodic review (possibly every 5 to 10 years) in order to accommodate changing climate patterns and local circumstances.

Step 3 - Review of Draft Adaptation Strategy

The inter-departmental climate change adaptation committee could facilitate the review of the draft Strategy through a consultative process with affected stakeholders. With this in mind, the first draft text of the *Climate Change Adaptation Strategy* will be presented in a format suitable for use in the consultation process.

Step 4 - Preparation of Final Adaptation Strategy

To facilitate the presentation of the final policy document to Cabinet for approval, the inter-departmental climate change adaptation committee will undertake the following activities:
(a) Reviewing and revising the documents as necessary, and preparing the final text of the *Climate Change Adaptation Strategy*;
(b) Preparing any documents that may be required to facilitate the submission of the *Climate Change Adaptation Strategy* to Cabinet for consideration and eventual approval.

7.3 Data for Adaptation – Decision Making

For the Province of Nova Scotia, there exist considerable gaps in local knowledge that, if reliable data was available, would be most useful in attempts to take climate change adaptation into account in local decision making. It is recommended that the inter-departmental climate change adaptation committee guide and promote applied research into climate change adaptation risk management for decision-makers in the public and private sectors, and at the community level. Priority areas (in no particular order of priority) include:

1. Downscaling of climate change modelling to provide results on a finer scale than currently available. This would improve adaptation planning.

2. Measuring the overall multiplier effects of climate change on provincial economies in Atlantic Canada, in terms of gross domestic product, employment, and wages.

3. Targeted baseline monitoring and reliable inventories for lake, river and groundwater resources and demand, usage parameters, and effluent quality and aquatic impacts, the condition and capacity of water distribution and treatment systems, and other important elements such as the number, size and location of agricultural operations and other activities where high water demand is expected.

4. Improve the understanding of the social and economic factors underlying demands for water and the forces driving demand patterns and recirculation decisions.

5. Improve the near-real-time stream flow observations and access to historic data, including paleo-climate and paleo-flood records.

6. Improved understanding and modelling of hydrological processes and systems, including aspects such as: incorporating results of climate change modelling and hydrological modelling; effects of land use changes on floods; relationships among land management, soil water balance and partitioning of precipitation.

7. Improve and increase the collection of relevant Nova Scotia weather measurements to support regional and local climate monitoring, analyses and modelling.

8. Assess the significance of extreme weather events and weather variability in the design, cost, mobility and safety of infrastructure and transportation systems.

9. Improved understanding and predictability of shoreline response to changing climate and water levels, particularly for highly vulnerable coastlines at the local level.

10. Improve data availability and accessibility, including climate, water level and current data, as well as the capacity for future monitoring and data gathering.

11. Increased focus on the impacts of changes in the frequency of extreme events, rather than mean conditions, on both agricultural crops and livestock, and woodlands.

12. Improved availability and use of tools and guides to incorporate the role of adaptation into decision-making at the farm, fishery, forest planning, municipal planning, industry and governmental levels.

13. Information on the long-term interactive effects of climate and other environmental changes on ecosystems in general, and forests in particular. This would include efforts to improve the understanding of the impacts of active forest management on ecosystems, such as the effects of reintroducing species to disturbed ecosystems.

14. Studies that derive realistic cost estimates for different adaptation options.

Annex 1
List of Workshop Participants

Annex 1
List of Workshop Participants

March 10, 2005

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March 24, 2005

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Annex 2
Provincial Rount Table Workshop Summary Notes

Annex 2
Provincial Round Table Workshop
Summary Notes

On March 10, 2005 the Nova Scotia Department of Environment & Labour, and the Department of Energy co-hosted an Introductory Session on climate change in Nova Scotia. This Session was followed by a Provincial Round Table Workshop on March 24, 2005.

These two sessions were convened:

1. To provide Provincial Departments with background information and guidance concerning key climate change elements, and anticipated risk management outputs; and,
2. To facilitate discussion amongst Provincial Departments to determine what and how climate change impacts present a risk to Nova Scotia, such that the Province needs to initiate the development of a policy and strategy to respond to such risks. This discussion was framed in the context of anticipated Federal funding to support climate change impact and adaptation (i.e. risk management) initiatives by Provincial governments.

Contributions (by no means exhaustive) from Departmental participants are summarized by workshop section, as follows:

1.0 General Validation of Draft Issues Paper

1.1 Are there errors or omissions in the Draft Issues Paper (Document), especially Section 1?

1.2 What sections or data within the Document require clarification/greater emphasis?

- The document places more emphasis on natural resources over services (such as Finance)
- What is the relationship between climate change global models and anticipated impact on downscaled issues (i.e., natural resources; services)?
- How is the data arrived at? What is the overall methodology being used? Where is the data obtained from for aboriginal affairs?
- Why is the overall focus on moderate impacts? There is a distinct need for a section that addresses extreme scenarios for the Province to prepare and adapt.
- Fishery data needs to abide by the NAICS (N. American Industrial Classification System)/Stats Canada codification. (Information can be provided from Finance)
- Severe climate impacts are anticipated on the trout fishery (Information from Inland Fishery)
- The document requires further emphasis on:
  - Decreasing biodiversity fro climate change; and,
  - Simplified ecosystems and ecosystem integrity (NSDEL)
- Climate change extreme impact is expected on the 400 treatment plants (NSEL)
- The document needs sections on:
  - Direct physical impact of climate change
  - Socio-economic impacts (people, built & natural environment, natural resources) from climate change
- Improve and add to the section on socio-economic issues/impacts (the information is dated) (information from OAA or Finance?)

- Add to section 5: aboriginal governance, regulations, climate impact. The legal and social framework for aboriginal affairs is very different from mainstream society (info from OAA)
- Important data sources need to be clearly indicated

2.0 What are the Provinces Risk Management Issues?

2.1 Discuss the Provinces climate change impacts (sectors/geography/socio-economic) in section 3. Are there any anticipated climate change impact areas that are not highlighted?

A. What sectors (i.e., human health, infrastructure, water, agriculture, fisheries, forestry), geographical areas (i.e., physiographic regions, urban/rural, forests, lakes & rivers), or socio-economic issues, potentially impacted by climate change have not been adequately covered in the Document?

B. Process: Comment on the Documents' process to evaluate and prioritize climate change impacts to the Province

C. Sectors: Prioritize impacted sectors/geographical areas

- Reference the goods and services producing industries and potential climate impacts. Make reference to ferry services in the section on transportation (Info. From Finance DDC)
- Integrated pest control management regimes need a more collective (perhaps a transborder) approach (Info from Department Agriculture & Fisheries). What about organic farming options as adaptive approach. (OAA)
- What about climate impact on externalities, such as foreign goods, and the potential impact on Nova Scotia's economy, and its food security (OAA)
- Water management (quality & distribution) and drought & flood impacts and risks are of concern. Also climate impacts to surface and ground water hydrology (Information from Department of Agriculture & Fisheries)
- We need a climate change integrated water sources Management Plan for agriculture. The Provincial Water Strategy is not climate adaptive!
- A big question whether the existing tripartite negotiations for aboriginal communities are adequate to deal with climate change impact/vulnerability, and the anticipated scarcity or potential collapse of fish stocks (including groundfish and shellfish). Also, there is a need for a climate change oriented management strategy for the Fishery and fishers. What will the temperature impact on the fishery be?
- Mining infrastructure is vulnerable (Natural Resources)
- There is a need to balance the assessed value of forestry (i.e., between biodiversity, recreation, watershed, water quality). Reference climate change and adverse impact on reforestation. Reference forest as a carbon sink (DNR)
- Need to make a distinction between municipal utilities and differential impacts (?) (SMSNR)

3.0 Departmental Prioritization

3.1 Comments concerning your Department's prioritization of issues in Section 4? What might your Department's risk management priorities be at the programme, or operational level?

For NSEL

- Priorities include: water management; water quality/monitoring; protection of clean water supply
- Improve water monitoring strategy, and climate-proof it to manage risk (i.e., storm water & flash floods)
- Protected Areas: Loss of species & ecosystem integrity due to climate change
- Climate impact on the integrity of unprotected areas & the cumulative impact of climate change on biodiversity
- Impact of climate change on wildlife corridors
- How to protect developed and natural environment under changing climate regimes
- Need a climate change GIS database
- Sanitation & storm drain overflows are of increasing concern

For NSDOE

- Energy reliability and demand (will these increase or decrease?)
- Need to capitalize on wind resource potential, and integrate into electricity grid to help reduce vulnerability, and to adapt to electric utility risks

For Dpt. Agriculture & Fishery

- Adapting cropping system to climate variability/extremes
- Water management and access are priorities
- Prioritize climate variability and impact on agricultural production/productivity
- Extreme impact on agri-infrastructure is a concern

For Health

- Water & airborne vectors and human pathology (brown water infiltration into municipal water supply)
- Protection of watersheds (wells and surface water) against dysentery (giardia, cryptosporidium).
- Climate change-oriented population health surveillance is needed
- Morbidity and mortality rates from thermal stressors (especially extremes) are of concern
- Air quality & pulmonary morbidity from PM (particulate matter) and GHGs needs to be assessed
- What is the climate change resilience of human health

For DNR

- Prioritize the synergies between wildlife (species at risk), parklands, and forest regime
- Also, ecological restoration and resilience (adaptive & mitigative) of Acadian forests as carbon sinks
- Travel bans from climate extreme events and infestations will decrease harvesting opportunities
- Managed forests are generally less adaptive to climate change than mixed/natural forest stands
- The mining sector is also vulnerable: flash floods impacting low-lying mines; floods and droughts will have impact on tailings seepage & tailing treatment plants requiring large water supplies

For Sport Fishery

- Habitat loss enhancement is an issue
- Identify changes in species composition due to climate change

For Finance

- What are the anticipated impacts from climate change on Provincial equalization & bond rating
- Climate impact on the Province's economic competitiveness & bottom-line; Cost of extreme events on economy and sectoral service delivery
- Water, utility & transportation infrastructure vulnerability is of concern
- Impact on, and sustainability of forestry and related industries (i.e. construction)
- Corporate integrity - the impact on tax and revenue base – is in question, especially with resource industries (agriculture, fishery, forestry) and service industries (tourism, etc.)

For Justice

- Aboriginal rights would be respected how, under changing climatic conditions and in context of the tripartite framework?
- Need to develop legislative regimes, in a climate change context, with appropriate enforcement measures. The existing legal framework may not compensate for climate changes

For OAA

- How would land claims (especially coastal) evolve, as the value and composition of on-reserve and crown lands are altered from climate change (erosion, species migration, shifts in water resources). Thus, climate change would affect aboriginal resource development and resource management
- How EMO Plans would be tailored to target communities (especially rural). Health access/services may be impacted as available public resources are stressed
- Impact of a changing biodiversity and the natural resource base (fisheries, hunting, etc)

For Economic Development

- Inadequate government response could compromise the Province's economic integrity
- What is the resilience of existing market mechanisms?
- Transportation infrastructure is at risk. What about access issues?

For Service Nova Scotia & Municipal Relations

- Municipal revenues may be at risk, with changing property values and increased burden on municipal budgets (snow removal/salting, facility heating/air conditioning) from extreme events
- How to protect municipal investments and infrastructure
- There is a need to base-map potential risks (hazard map). Coastal zone mapping is not climate-oriented

For Transportation & Public Works

- Impact on this infrastructure is undetermined
- Change (climate-proof) Environmental Assessment (EA) protocols

- Climate-orient our communications systems
- Insurance liabilities on government buildings are a concern

4.0 Institutional & Legal Arrangements (this section to be covered outside of this session)

4.1 Are there any suggested additions relating to institutional arrangements (legislative, regulatory, NEG-ECP), in Section 5?

- For Justice and aboriginal Affairs, there is a need to develop legislative regimes in a climate change context, and develop appropriate enforcement protocols
- The big question is whether the tripartite negotiations are adequate to deal with climate change impact and vulnerability issues, and anticipated scarcity or the collapse of fish stocks (including ground fish and shellfish) for aboriginal communities
- Emergency management office (EMO) municipal adaptability to extremes is in question

5.0 What Risk Management Strategic Options & Approaches can the Province consider?

Identify and explain risk management options for your Department.

- Possible policy options
- Possible operational options
- Resource (human, technical, financial) implications

For NSEL

- Strengthen air quality and air-shed monitoring (incorporate variable temperature regimes, PM, ozone & N_2O into monitoring) with climate change considerations
- Encourage Fed-Prov-Municipal investment in climate-designed sewage infrastructure with municipalities
- Flood protection measures: change timeline (50-year storm) for flood protocol
- Better systems monitoring is needed. There is also a need to decrease vulnerable on-site sewer systems
- Low-tech lagoon and low tech infrastructure needs assessments are required, as current infrastructure is highly reliant on mechanical systems that are vulnerable to climate-induced disruption of power and flooding, etc.

For Energy

- Utility infrastructure (oil & gas, power, water) is vulnerable. We need to make the regulatory process resilient to climate change impacts
- Institutional responsiveness needs to be assessed

For Agriculture & Fishery

- Agricultural performance issues such as crop reporting, moisture status, land-use, nutrient management are unprepared for changing climate regimes. The ability of cropping strategy and methods are ill-prepared
- Current extensionist services are unable to accommodate and adapt to climate change

- Crop insurance/reinsurers need to consider covering the risk portfolio. As well, there is also a need for risk coverage
- There is a need for a Regional Climate Change Management Strategy

For Health
- Track climate-induced morbidity (i.e., vector-borne disease i.e. West Nile, Lyme disease, cryptosporidium, giardia)
- Identify groups vulnerable to temperature stressors (both extreme heat and cold)
- The health sector's inability to institutionally respond to climate extremes is of great concern

For DNR
- Ecosystem land management and integrated land management methods are not climate-derived
- Increasing deer populations, and a subsequent increase in car insurance claims and premiums is an issue
- Incorporate climate change in Management Strategies/Plans for: Parks; Forestry; Fishery; Wildlife; Wetlands; Agricultural Landscape, & Biodiversity

For Inland Fishery
- The cold-water fishery is vulnerable, therefore there is a need to diversify species and classify cold water habitats toward a climate & species management strategy
- The inland fishery has little ability to adequately respond to temperature increase, but the industry could minimize or manage climate changes through adaptive measures such as sediment controls, forestry shading practices, river bank and water shed enrichment, watershed stabilization efforts, river defence, etc.

For Finance
- Educate the bond-rating agencies about the Province's low risk economy in the context of a risk management (adaptation) strategy
- The Province's fiscal integrity is challenged by climate change, therefore there is a need for a review of the taxation policy regime (forgiveness, negotiate tax rates, renegotiate Fed-Prov. tax burden regime)
- Negotiate/renegotiate the Province's risk burden with re-insurers

For Natural Resources (Peter)
- A sample of agricultural plots data can be used for climate change assessments
- Aerial (helicopter) monitoring of post-disaster events would be useful
- The code of forest practices (Plan) is mandatory for crown stands, and voluntary for private lots. The Province needs a climate change lens to make the Forestry Plan and forest stands resilient to climate variability and extremes

For NSEL
- Increase the research and monitoring capacity of vulnerable species in the province, and identify existing and potential climate stressors
- Assess the connectivity between crown and private landowners regarding changes in species migrations, and species composition from climate change

For Justice

- Increase the emphasis on environmental legislative and regulatory measures (legal framework) to address climate change impacts
- Increase the exchange of information between stakeholders on the risks of climate change, and review the consultative mechanisms to minimize these risks

For OAA

- Distinguish the 13 target communities' needs in relation to environmental changes attributed to climate change
- Conduct community-based vulnerability/risk assessments
- Ensure the incorporation of traditional environmental knowledge (TEK)/traditional adaptive practices in Adaptation Plans and initiatives

For NSEL Water Resources

- Run climate scenarios in relation to the Water Strategy (inter-departmental water committee)
- There is a need for flood-control resistant dams, and extreme hydrometric gauging
- Engage Public Service Commission (PSC) and the Department of Transport to incorporate climate change expertise in the Departments, and avoid burden on Human Resources having to manage climate extremes without adequate planning and support resources, etc.
- There is a need for academic and research capacity to understand anticipated and existing climate impacts, and to strategically disseminate information, and operationalize adaptive actions and recommendations

For Economic Development

- Numerous commercial vulnerabilities exist. Thus, a climate-oriented incentives system (R&D, credits) should be considered
- There is potential for positive outcomes from climate change. Opportunities exist to develop a Prosperity Strategy: To increase qualified professionals with sectoral expertise in climate change; Increased agricultural production and productivity.

For SNS & MR

- A hazard assessment is needed for coastal infrastructure
- We need a statement of Provincial & Municipal interest in climate change risk management issues
- Climate change best practices for community planning and infrastructure would be beneficial
- Integrated Sustainability Plans (Fed-Prov-Mun) require a climate change approach
- Amend flood-mapping and flood plain development with climate change considerations
- Reassess property tax and municipal grants in the context of climate change

For Inter-Governmental Affairs (IGA)

- Assess the Federal Government's direction re extreme gauging program and water issues in relation to climate change

For Transportation & Public Works

- Review EAs and building codes, and coastal highway design protocols
- Road weather information needs improved sharing amongst stakeholders

6.0 Strategic Options

Identify & discuss key strategies to advance Provincial Risk Management options, such as:

A. Development of Provincial Adaptation Policy frameworks, supported by Departmental Plans
B. Decision-making framework options
C. Operational (tools, programmes) options
D. Engaging Federal & Municipal counterparts (partnership, resources, policy support)
E. Engaging civil society stakeholders (commercial, community and business associations, universities, residents).

- We need a Climate-Adaptation Provincial Plan developed on the basis of Departmental prioritization, and Departmental buy-in (i.e., at the level of Deputies/Directors & municipal authorities)
- We need a Fed-Prov bilateral Climate Change Strategy, in cooperation with other Province's and Municipalities
- Engage and inform APENS and the Home Builder's Association, etc. of expected design risks, and adaptive climate change options
- Develop a Provincial awareness piece simultaneously with all Line Ministry actions
- Amend Provincial EA guidelines
- Target line Ministry and Departmental policy groups
- A transparent consultative process would be beneficial, with a credible and highly determined taskmaster
- Identify appropriate Provincial, private sector, and community resource partners
- Strengthen the province's coordinating strategy to effectively respond to the challenges of climate change
- Identify knowledge gaps in climate change awareness, and develop practical data sources

7.0 Mainstreaming Adaptation

7.1 Identify civil society stakeholders (utilities, private sector, community associations, aboriginal groups, NGOs, etc), and their issues. What strategies would successfully engage stakeholders to partner in risk management (adaptation) practices. Would this be via policy forums, government consultative workshops, public education & outreach, projects?

To be determined

8.0 What are the key Recommendations for Next Steps?

To be determined

Departmental Actions/Commitments (Departmental information is referenced only where it was offered)

- Fishery data needs to abide by the NAICS (N. American Industrial Classification System)/Stats Canada codification. (Information can be provided from Finance)
- Severe climate impacts are anticipated on the trout fishery (information from Inland Fishery)
- Simplified ecosystems & ecosystem integrity (info. from NSEL)
- Impact expected on the 400 treatment plants (info. from NSEL)
- Improve and add to socio-economic section (information is dated) (information from OAA or Finance?)
- Add to section 5: aboriginal governance, regulations, climate impact, legal and social framework very different (info from OAA)
- See goods & services producing industries. Make reference to ferries in transportation section (Info. From Finance DDC)
- Integrated pest control management regimes needs a more collective (perhaps a transborder) approach (Info from Department Agriculture & Fisheries). What about organic farming options? (OAA)
- Mining infrastructure is vulnerable (Info. From Natural Resources)
- Reference forest as a carbon sink (DNR)
- Distinction between municipal utilities … differential impacts

Annex 3
Emission Scenarios

Annex 3
Emission Scenarios
(taken from CCIS Website)

In order to determine how climate may change in the future we need to know how the concentrations of those atmospheric components which affect the Earth's energy balance may change. Gases such as water vapour, carbon dioxide, methane and nitrous oxide (the greenhouse gases) absorb long-wave (heat) radiation emitted from the Earth's surface and re-emit this energy, ultimately resulting in raised surface temperatures. Whilst these greenhouse gases occur naturally, human activities since the beginning of the industrial revolution have resulted in large increases in the atmospheric concentrations of these gases and it is now widely accepted that this has affected global climate.

Trying to determine how atmospheric composition may change in the future is fraught with uncertainty since it is necessary to make assumptions about how both the natural and anthropogenic emissions of these greenhouse gases will change which, in turn, is dependent on assumptions regarding population growth, economic activity, energy use, land use change, etc.

For the IPCC Third Assessment Report (IPCC, 2001), a new set of emissions scenarios was commissioned to replace the six IS92 emissions scenarios (Leggett *et al.*, 1992) detailed in the 1992 Supplement (IPCC, 1992) to the IPCC First Assessment Report (IPCC, 1990). Until recently, the IS92a scenario, a 'business-as-usual' type scenario, had been in wide use by the climate modelling and vulnerability, impacts and adaptation communities.

The IPCC Special Report on Emissions Scenarios (SRES; Nakicenovic *et al.*, 2000) details 4 storylines, narratives of qualitative (e.g., political, social, cultural and educational conditions) emissions drivers. The SRES emissions scenarios are the quantitative interpretations of these qualitative storylines. Six international modelling teams (see Table 1) were involved in quantifying the SRES storylines, which resulted in the formulation of 40 alternative SRES scenarios, of which no single scenario is treated as more or less probable than others belonging to the same scenario family. In order to reduce the number of scenarios to be used in climate change studies, six marker, or illustrative, scenarios have been selected based on the consensus opinion of the modelling teams. These are A1FI, A1T and A1B from the A1 family, and A2, B1 and B2.

Table 1: Modelling Teams Involved in Quantifying the SRES Storylines

Acronym	Model Name	Institutes	References
AIM	Asian Pacific Integrated Model	National Institute for Environmental Studies (NIES), Japan	Morita *et al.* (1994)
ASF	Atmospheric Stabilisation Framework Model	ICF Consulting, USA	Lashof & Tirpak (1990); Pepper *et al.* (1998); Sankovski *et al.* (2000)
IMAGE	Integrated Model to Assess the Greenhouse Effect (used in connection with the Central Planning Bureau (CPB) WorldScan model)	National Institute for Public Health (RIVM), The Netherlands	Alcamo *et al.* (1998); de Vries *et al.* (1994, 1999, 2000); de Jong & Zalm (1991)

Acronym	Model Name	Institutes	References
MARIA	Multiregional Approach for Resource and Industry Allocation	Science University of Tokyo, Japan	Mori & Takahashi (1999); Mori (2000)
MESSAGE	Model for Energy Supply Strategy Alternatives and their General Environmental Impact	International Institute for Applied Systems Analysis (IIASA), Austria	Messner & Strubegger (1995); Riahi & Roehrl (2000)
MiniCAM	The Mini Climate Assessment Model	Pacific Northwest National Laboratory (PNNL), USA	Edmonds *et al.* (1994, 1996a,b)

The Six SRES Marker Scenarios

Only a brief introduction to the SRES emissions scenarios is given here. Full details can be found in the Special Report on Emissions Scenarios (Nakicenovic *et al.*, 2000). (Full text for other IPCC Special Reports and also the Third Assessment Report can be found on the IPCC web site.)

A very simplistic representation of the six SRES Marker Scenarios is given in Figure 1.

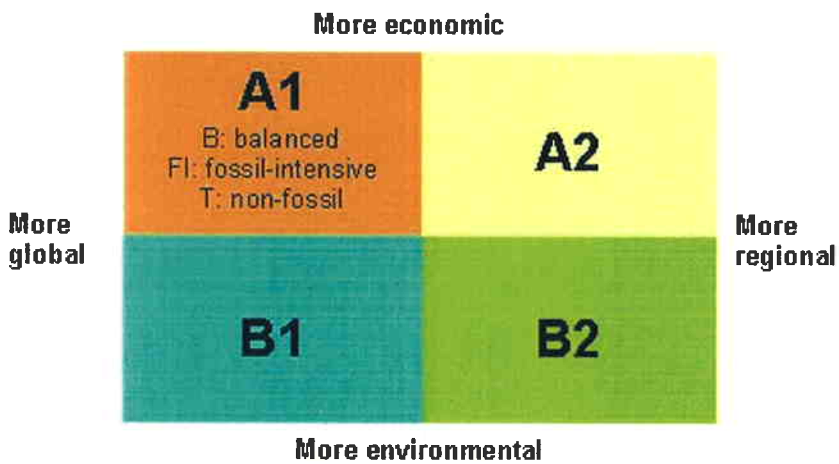

Figure 1: A schematic representation of the SRES scenario family. The A1 and A2 families have a more economic focus than B1 and B2, which are more environmental, whilst the focus of A1 and B1 is more global compared to the more regional A2 and B2.

The quantitative inputs for each scenario are, for example, regionalised measures of population, economic development and energy efficiency, the availability of various forms of energy, agricultural production and local pollution controls. Explicit policies to limit greenhouse gas emissions or to adapt to the expected global climate change are NOT included. Details of these inputs (population, energy use etc.) for each scenario can be found in Appendix VII: Data Tables of the SRES.

A1FI, A1T and A1B

The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity-building, and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil intensive (A1FI), non-fossil energy sources (A1T), or a balance across all sources (A1B; where balanced is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end use technologies).

A2

The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is primarily regionally oriented and per capita economic growth and technological change more fragmented and slower than other storylines.

B1

The B1 storyline and scenario family describes a convergent world with the same global population that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives.

B2

The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing global population, at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented towards environmental protection and social equity, it focuses on local and regional levels.

Changes in global-mean temperature associated with each of the six marker scenarios are illustrated in Figure 2. The response of global-mean temperature to the different emissions scenarios can be determined by using a relatively simple upwelling diffusion energy balance (UD/EB) climate model, such as the one developed by Wigley and Raper (1992). This model distinguishes between land and ocean and between the hemispheres, but simulates only the underlying signal in response to external forcing and not the variability.

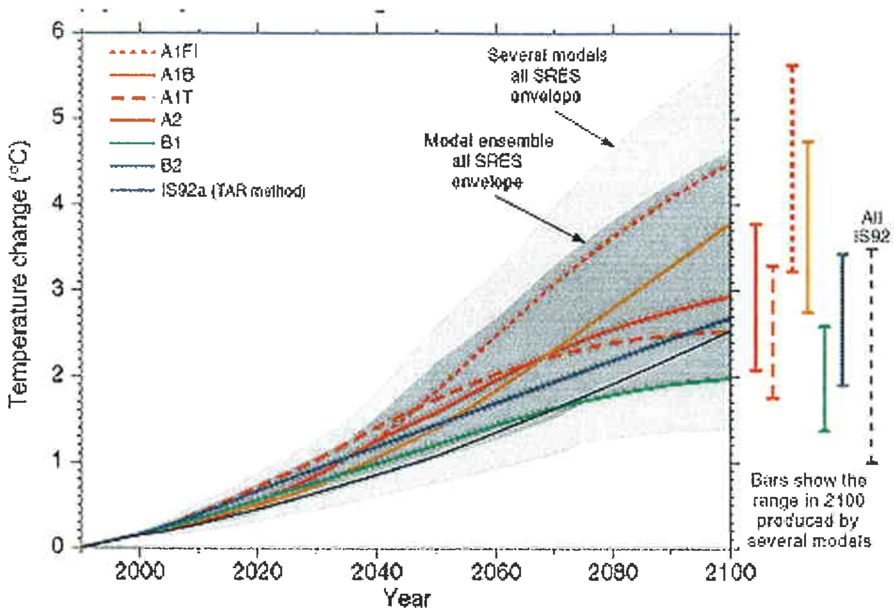

Figure 2: Global-mean temperature change (°C) associated with the six SRES marker scenarios, A1FI, A1T, A1B, A2, B1 and B2. These figures have been derived using a simple climate model. The 'several models all SRES envelope' shows the temperature projections for the simple model when tuned to a number of complex models with a range of climate sensitivities. [Source: IPCC WGI Summary for Policymakers]

IS92 Emissions Scenarios

In the 1992 Supplement (IPCC, 1992) to the IPCC First Assessment Report (IPCC, 1990), Leggett *et al.* (1992) proposed six emissions scenarios, the IS92 scenarios, which reflected the large uncertainty associated with, for example, the evolution of population and economic growth, technological advances, technology transfer and responses to environmental, economic or institutional constraints.

IS92a: a middle of the range scenario in which population rises to 11.3 billion by 2100, economic growth averages 2.3% year $^{-1}$ between 1990 and 2100 and a mix of conventional and renewable energy sources are used. Only those emissions controls internationally agreed upon and national policies enacted into law, e.g., London Amendments to the Montreal Protocol, are included.

IS92b: population rises to 11.3 billion by 2100 and the current emissions control policies are enlarged to include stated policies beyond those legally adopted, e.g., all CO_2 commitments of OECD member countries are included along with an assumption of world-wide ratification and compliance with the amended Montreal Protocol.

IS92c: economic growth averages 1.2% year^{-1} between 1990 and 2100 and population is forecast to be 6.4 billion by 2100, with population decreasing in the 21st century. As well as assuming lower growth in GNP per capita than IS92a and IS92b, low oil and gas resource availability results in higher prices which promote the expansion of nuclear and renewable energy. Lower population growth results in slower deforestation rates.

IS92d: another low scenario, but more optimistic than IS92c. The trend is towards increasing environmental protection but only actions that could be taken due to concerns about local or regional air pollution and waste disposal are included. Population is forecast to be 6.4 billion by 2100 and would be associated with lower natality, falling below the replacement rate late in the 21st century, due, for example, to improvements in per capita income or increased family planning. Low fossil fuel resource availability means that there is greater market penetration of renewable energy and safe nuclear power. A 30% environmental surcharge on fossil energy use is levied to meet the costs of more stringent local pollution controls. Greater well-being is assumed to lead to voluntary actions to halt deforestation, to adopt CFC substitutes with no radiative or other adverse effects and to recover and efficiently use the methane from coal mines and land fills.

IS92e: results in the highest CO_2 emissions. Economic growth averages 3% $year^{-1}$, between 1990 and 2100 and the population is forecast to reach 11.3 billion by 2100. Fossil resources are plentiful but, due to assumed improvements in living standards, environmental surcharges are imposed on their use. Nuclear energy is phased out by 2075 and, although CFC substitute assumptions are the same as those of IS92d, the plentiful fossil fuel resources discourage the additional used of coal mine methane for energy supply. Deforestation proceeds at the same pace as IS92a.

IS92f: falls below IS92e, has high population growth (17.6 billion by 2100), but lower assumptions of improvements in GNP per capita than IS92a. Other assumptions are high fossil fuel resource availability, increasing costs of nuclear power and less improvement in renewable energy technologies and costs.

These six emissions scenarios were considered to be equally likely.

Figure 3 illustrates the global-mean temperature change associated with the six IS92 scenarios.

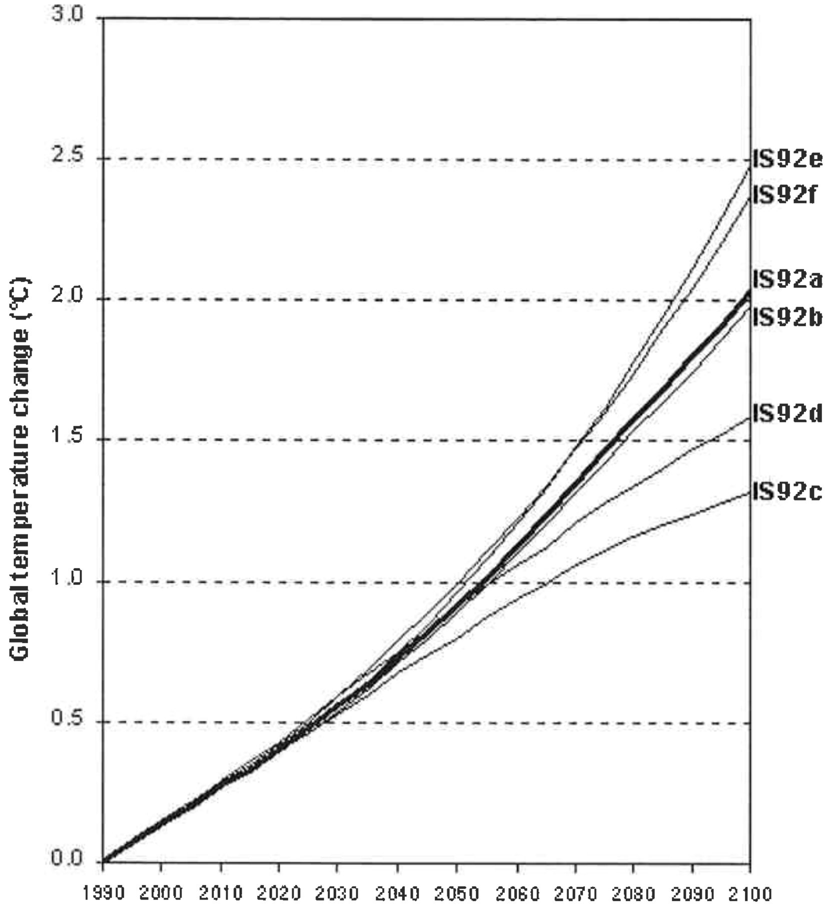

Figure 3: Global-mean temperature change (°C) associated with the IS92 emissions scenarios. IS92a is shown in bold.