Atlantic Climate Adaptation Solutions Association
Solutions d'adaptation aux changements climatiques pour l'Atlantique

SCENARIOS AND GUIDANCE FOR ADAPTATION TO CLIMATE CHANGE AND SEA LEVEL RISE – NS AND PEI MUNICIPALITIES

August 2011

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Natural Resources Canada
Ressources naturelles Canada

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1 Introduction

There is now widespread scientific consensus that accelerated climate change is happening and that human activities are the principal cause. However, measures to reduce emissions are only part of the climate change challenge. Even if significant reductions in emissions were put in place tomorrow, the lag in the climate system means that past emissions will continue to affect the climate for several decades to come. Climate change will have impacts on places where citizens live. Proactively adapting to climate change is therefore an essential part of ensuring our communities remain safe and sustainable.

Before deciding on how to best adapt to climate change, decision-makers and planners at the local level are faced with the problem of elucidating the changes in characteristics (social, economic, physical, ecological) of the environment which they have to manage. Scenario planning is considered to be a valuable strategic planning method that is used to assist with long-term planning and decision making, and is based on the understanding that many factors combine to create the future. The approach has been used internationally, and in Canada, to provide a description of possible future climate based on future population levels, economic activity, sea-level rise and greenhouse gas emissions (IPCC-TGICA, 2007). Although scenario analysis has gained much support as a tool for decision-making and in planning and policy setting, there are several challenges.

Developing adaptation plans at the community level requires scenarios for future conditions of climate and sea level and guidance on how to interpret and use them. Although climate scenario information is publically available, a barrier to using it is that the information often exists in a variety of formats and choices and has been derived using valid, but alternative, methods. The non-climate specialist whose intention is to develop plans, policies etc. requires information in simplified form tailored to their location. Furthermore, from a provincial or regional perspective, there is a need to have a consistent set of scenarios so that each municipality doesn’t have to start by deriving their own climate and sea level scenarios from the myriad of sources available from the specialist literature.

The Atlantic Climate Adaptation Solutions Association (ACASA), acting on behalf of Atlantic Canada governments and stakeholders is undertaking a series of projects that will assess coastal and inland vulnerability to climate impacts. This project provides background information on likely climate change and sea-level rise scenarios, as well as guidelines on how this information can be used in vulnerability assessments and adaptation planning.

2 Objectives and Deliverables

The purpose of this report is to provide information that will assist municipalities in the Provinces of Nova Scotia and Prince Edward Island to develop Climate Change Adaptation Plans.

2.1 Objectives

- Provide background on the key technical issues involved in developing local level climate scenarios (e.g. emission scenarios, models, downscaling, indices, sea level changes, data),

- Recommend an appropriate approach for climate scenario development in Nova Scotia and Prince Edward Island and follow through with a suite of climate scenarios for use in community vulnerability assessments, and
- Provide guidance for parties interested in developing climate scenarios to support provincial and local adaptation planning and decision-making in Nova Scotia and Prince Edward Island.

2.2 Deliverables

- Recommendations on an approach for climate scenario development appropriate for Nova Scotia and Prince Edward Island,
- A suite of climate scenarios, including both atmospheric and sea-level rise considerations, for use in Nova Scotia and Prince Edward Island vulnerability assessments, and
- Guidance on how to interpret and apply the scenarios in practice.

The recommendations and guidance are contained in the main report. The climate and sea level scenarios are in the Appendices.

2.3 Municipalities and Data Locations

The procedure we used for climate data requires historical climate data to bridge between historical and future periods. The choice of best representative climate station was based on length and quality of historical data, best representation of local climate and proximity to the municipality. Sea-level rise parameters are keyed to Canadian Hydrographic Service (CHS) tide prediction sites. The municipalities for which scenarios have been developed; representative climate stations and CHS sites are listed in Table 1 and Table 2.

Table 1: Municipalities and representative climate stations and CHS sites, Prince Edward Island

Municipality or Area	Climate Station	CHS Representative Site
Northwest PEI	Alberton	Alberton
Southwest PEI	O'Leary	West Point
Summerside	Summerside A	Summerside
North shore - Cavendish	Long River	Rustico
Charlottetown	Charlottetown A	Charlottetown
Morell, Mt. Stewart, St. Peter's	Bangor	St Peter's Bay
Northeast tip	East Baltic	North Lake Harbour
North Shore	Monticello	Naufrage
Southeast (Montague/Georgetown)	Alliston	Georgetown

Table 2: Municipalities and representative climate stations and CHS sites, Nova Scotia

Municipality or Area	Climate Station	CHS Representative Site
Amherst	Nappan CDA	Burncoat Head
Truro	Truro	Joggins
Pictou/Antigonish	Collegeville	Pictou
Cape Breton West	Cheticamp	Cheticamp
Sydney	Sydney A	Sydney
Guysborough	Deming	Canso Harbour

HRM	Shearwater A	Halifax
Lunenburg	Bridgewater	Lunenburg
Liverpool	Liverpool Milton	Liverpool
Yarmouth	Yarmouth A	Yarmouth
Annapolis	Weymouth	Digby
Annapolis Valley	Greenwood A	N/A
Kentville	Kentville CDA	Hantsport

3 Overview of Scenarios

An important element in the development of a successful adaptation strategy is to have climate scenarios at hand. Climate scenarios can provide guidance for decision makers as to the magnitude or significance of change to a climate element. That, combined with the impact of the projected change, can factor into the decision-making process.

A climate scenario can be defined as “a coherent, internally consistent and plausible description of a possible future state of the world…” (Parry, 2002). They are “plausible representations of the future that are consistent with assumptions about future emissions of greenhouse gases and other pollutants and with our understanding of the effect of increased atmospheric concentrations of these gases on global climate” (IPCC-TGICA, 2007). Climate scenarios are not predictions of future climate. They are typically used to assess impacts of climate change, address vulnerability to change and to develop adaptation strategies or actions.

Given that climate scenarios are dependent on emission assumptions and the effect these might have on climate we will first discuss emission scenarios and then the methods of translating these emissions into climate indices.

3.1 Greenhouse Gas Emission Scenarios

3.1.1 Emission Scenarios

It is well known that the concentration of greenhouse gases in the atmosphere has changed and that change is due to human influence. Figure 1 shows the “Keeling Curve” of atmospheric concentrations of carbon dioxide as measured at the Mauna Loa Observatory in Hawaii. CO_2 concentrations were 315 ppm when the direct measurement program began in 1958. In 2011 they are around 390 ppm and growing at about 2 ppm per year (Tans, 2011).

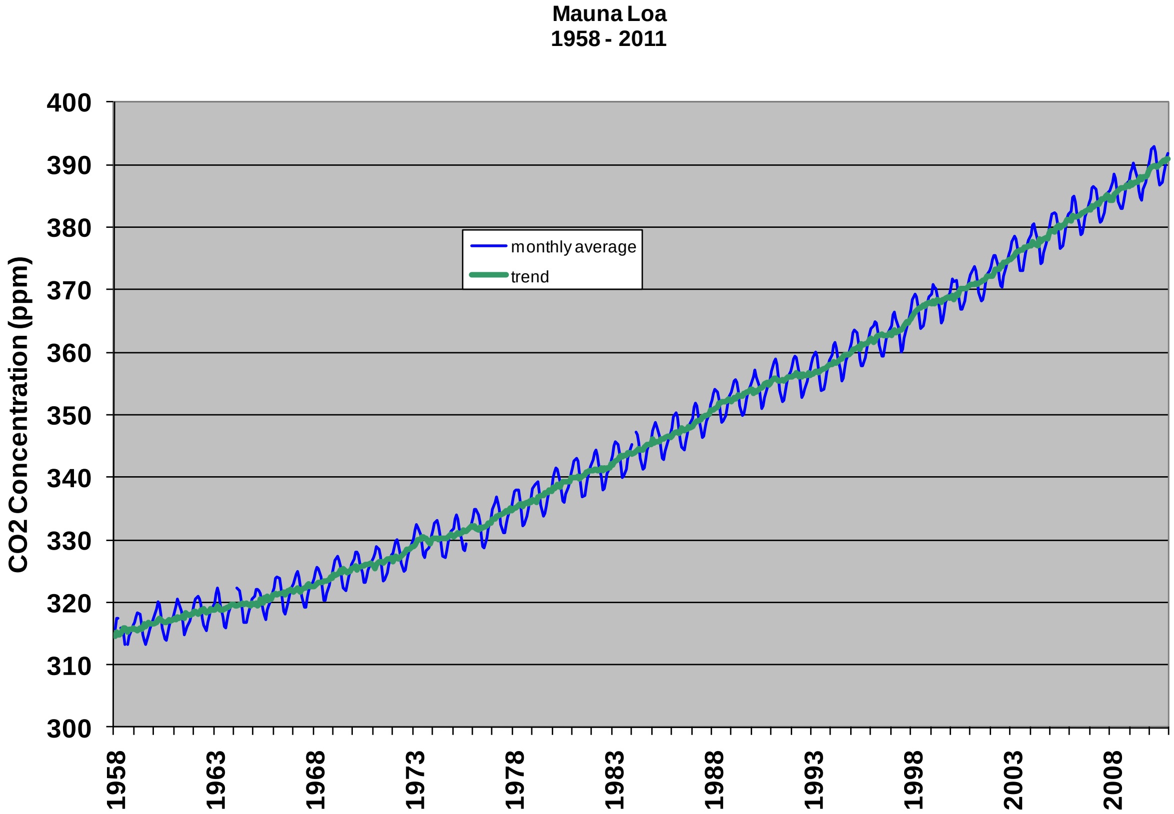

Figure 1: Atmospheric CO_2 concentration from Mauna Loa, Hawaii Observatory. Data from Tans (2011)

Anthropogenic climate change is driven, in part, by changes in atmospheric concentration of greenhouse gases and aerosols. In order to simulate future conditions, climate models require assumptions about the future concentrations of greenhouse gases and aerosols in the atmosphere. This is dependent on several socio-economic drivers such as population growth, economic growth and technological change.

The Intergovernmental Panel on Climate Change (IPCC) published a set of emissions scenarios in 2000 for use in climate change studies (Special Report on Emissions Scenarios – SRES (Nakicenovic, et al., 2000)). The SRES team developed storylines to describe future evolution of demographic, social, economic, technological, and environmental developments. Forty scenarios were developed which were reduced to six marker scenarios termed A1FI, A1B, A1T, A2, B1 and B2. Table 3 provides more information on these six marker scenarios. These emission scenarios for the 1990 – 2010 period are illustrated in Figure 3.

Table 3: The six SRES illustrative scenarios and the stabilization scenarios (Parts per Million CO2) they most resemble

SRES illustrative scenario	Description of emissions	Surrogate stabilisation scenario
A1FI	High end of SRES range	Does not stabilise
A1B	Intermediate case	750 ppm
A1T	Intermediate/low case	650 ppm
A2	High case	Does not stabilise
B1	Low end of SRES range	550 ppm
B2	Intermediate/low case	650 ppm

Table from (IPCC-TGICA, 2007) p 11

Modelling groups have focussed on three of these scenarios (B1, A1B and A2). Generally these three scenarios are the ones for which climate model data are available. They are often referred to as the low (B1), intermediate (A1B) and high (A2) scenarios.

3.1.2 Actual Emissions

Boden, Marland, & Andres (2010) of The Carbon Dioxide Information Analysis Centre regularly publish updates of Global CO2 Emissions from Fossil-Fuel Burning, Cement Manufacture, and Gas Flaring. The data from 1791 to 2007 are illustrated in Figure 2. Despite international protocols on greenhouse gases, global carbon emissions have continued to increase and may even be accelerating.

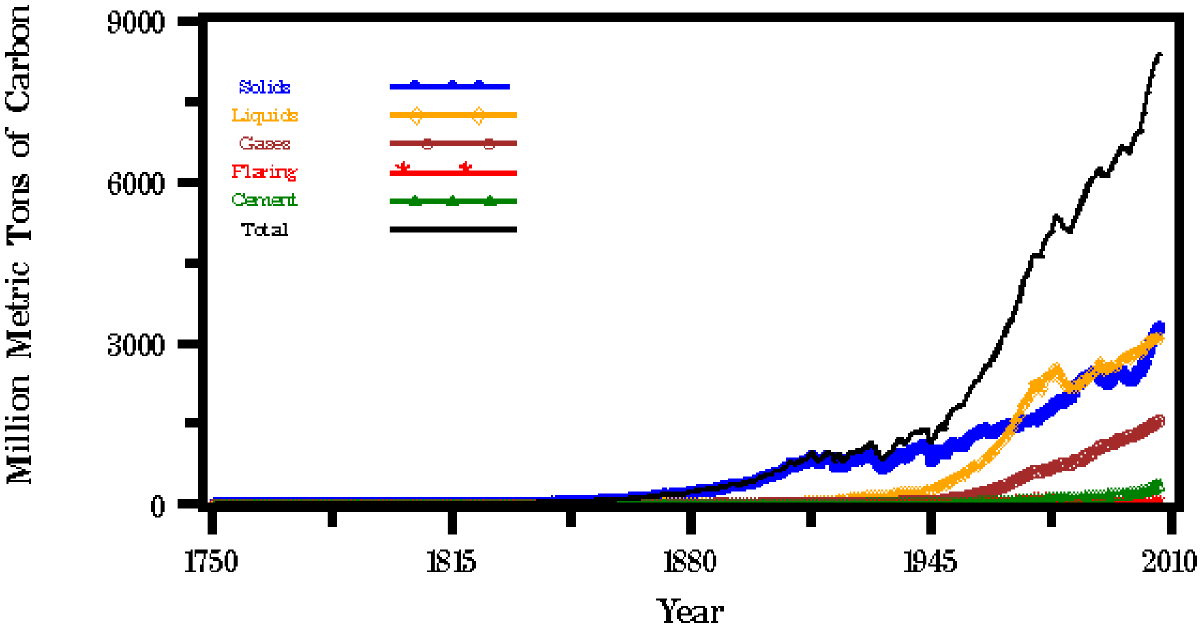

Figure 2: Global fossil-fuel carbon emissions 1791 - 2007 (Boden, Marland, & Andres, 2010)

How do the carbon emission rates compare to the assumptions of the SRES scenarios? Raupach, et al. (2007) (Figure 3) illustrated that actual emissions are on a trajectory which exceeds even the high end of the SRES range - the A1FI scenario. We have extended Raupach's curve by adding 2006 and 2007 points to Figure 3. The Raupach, et al. (2007) paper has been widely cited. In a 2010 interview Raupach commented[1] "CO_2 emissions are rising, faster than most estimates from a few years ago. Every region is contributing to this. Relative emissions growth in developing regions is faster than in developed (rich) regions, but both energy use and CO_2 emissions per person in developing regions are much less than in developed regions.

There are close relationships between wealth, energy use, and CO_2 emissions, which are showing no signs of changing, also changes in these relationships (particularly the amount of CO_2 emitted per dollar of wealth generated) are essential if global wealth generation is to continue while emissions are reduced to reduce the risks of adverse impacts from climate change."

Considering the disappointing results of international agreements to limit greenhouse gases e.g. Kyoto, more talk than action resulting from Copenhagen and Cancun meetings and the continued evidence of increasing emissions (Boden, Marland, & Andres, 2010) and concentrations (Tans, 2011) we recommend that the higher cases of SRES scenarios i.e. the A2 and A1B, should be the focus of scenarios for adaptation.

Therefore the climate scenarios in this document are based on the A2 and A1B emission scenarios.

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[1] Michael R. Raupach, 2010, Sciencewatch, (http://sciencewatch.com/dr/erf/2010/10feberf/10feberfRaup).

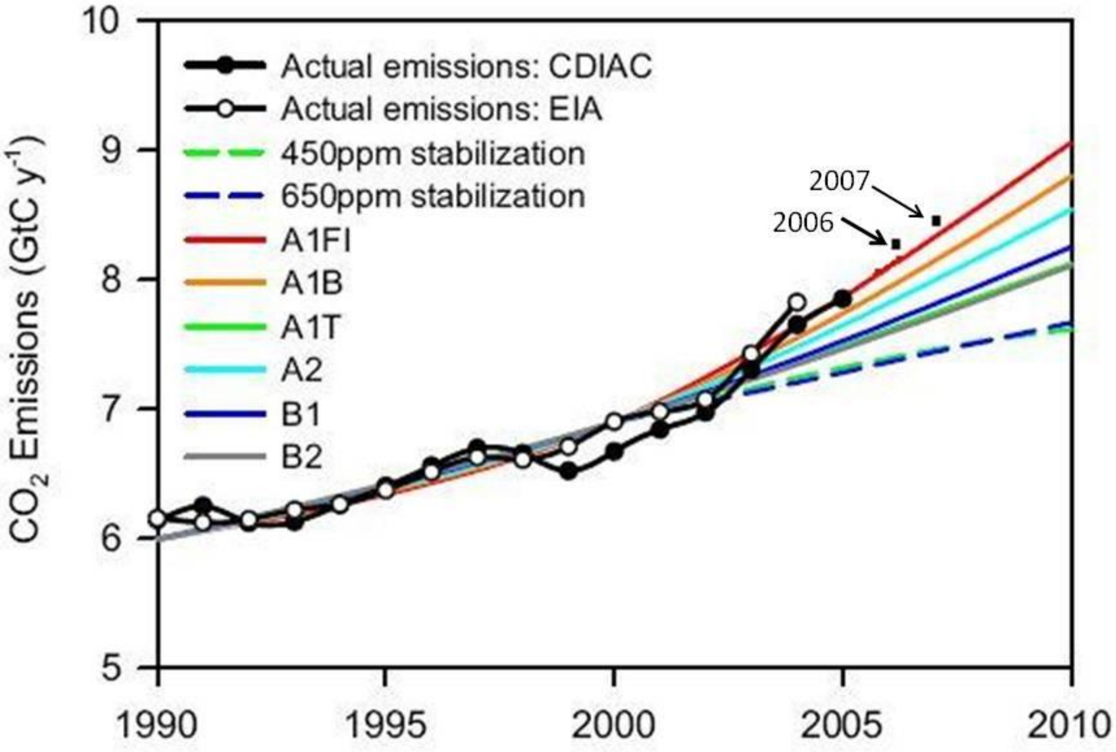

Figure 3: Observed global CO2 emissions compared with emissions scenarios and stabilization trajectories

From Raupach et al (2007). 2006 and 2007 points added using data from CDIAC (2011)

3.2 Climate Scenarios

As stated earlier climate scenarios are “a coherent, internally consistent and plausible description of a possible future state of the world…” (Parry, 2002). There are many ways of developing scenarios such as adopting a past event (analogue technique), increasing or decreasing climate parameters by arbitrary amounts (synthetic technique), global climate models (GCMs) and methods derived from GCMs like statistical downscaling and regional climate models. All of these techniques have been used as the basis for Vulnerability, Impact and Adaptation (VIA) studies.

3.2.1 Distinction between Climate Scenario and Climate Change Scenario

We should clarify the terminology between “climate scenario” and “climate change scenario”. A *climate change scenario* refers to the difference between some plausible future climate and the current climate. The climate change scenario can be derived through a variety of methods discussed below. A climate scenario is the combination of the climate change scenario and the description of the current climate as represented by climate observations.

CLIMATE SCENARIO = CURRENT (or Baseline) CLIMATE + CLIMATE CHANGE SCENARIO

3.2.2 Baseline Scenario Period

By international agreement, climatologists express climate Normals or averages and extremes based on thirty-year time periods. The current World Meteorological Organization (WMO) normal period is 1961-1990. The latest tri-decade for which Canadian Normals have been published is 1971 – 2000. Given that Canada has the most comprehensive source of climate data from this 1971-00 period, VIA studies in Canada usually use it as the Baseline Period. The 1971 – 2000 period is referred to as the 1980s in this report. The 1980s are the middle decade of the 30-year period.

3.2.3 Future Scenario Periods

For future scenarios based on a series of simulated data, thirty year time periods have also been adopted by common practice. The future periods used in this report are the 2020s (2011 – 2040), 2050s (2041 – 2070), and the 2080s (2071 – 2100). In the context of sea level parameters we adopt the mid-point of the three future periods (2025, 2055 and 2085) as the representative year for each scenario period.

3.2.4 Types of Climate Scenarios

3.2.4.1 Analogue Scenarios

Analogue scenarios are constructed by identifying recorded climate regimes which may resemble the future climate in a given region (IPCC-TGICA, 2007). There are two types of analogues - temporal and spatial.

Temporal analogues are usually taken from the same location but from a historical time period when the past example may resemble a future state. For example Richards & Russell (1995) examined the warm winter of 1952-53 in New Brunswick to identify impacts resulting from such an event. Temporal analogues can also be identified and described through paloeclimatic data like lake sediments or tree rings.

Spatial analogues usually involve transposition of the climate from one area to another. For example transposition of the New England climate to the Maritimes is sometimes used to generate scenarios for Canadian climates.

Analogue scenarios have limitations in that drivers for the climate during historical periods or other places are not usually transportable. For example, while one can shift a climate northward to simulate warming, other factors important to climate such as daylight and seasonality will not change.

3.2.4.2 Synthetic Scenarios

Synthetic scenarios refer to techniques where climate elements are changed by an arbitrary amount. The adjustment is applied to baseline data. For example, adjustments of baseline temperatures by +2°C and precipitation by +10% per cent could represent a scenario. Often climate model outputs are used as guidance to ensure that such arbitrary adjustments are realistic.

Synthetic scenarios are simple, transparent and easily interpreted by non-scientists. They offer a wide range of possibilities. However they suffer from the assumption of being uniform over time and space and possible inconsistency among variables.

3.2.4.3 Global Climate Models

Global climate models (GCMs) are complex computer programs which simulate the earth's climate system using the laws of physics. Because of their complexity and the significant resources required to manage them, there are a limited number of global climate modeling groups around the world. The Canadian Centre for Climate Modeling and Analysis (Environment Canada - CCCma, 2010) is one of the recognized centers of climate modeling expertise. Using climate models, numerical experiments can be performed which indicate the impact of changes to the climate system due to modifications to the atmospheric greenhouse gas and aerosol composition. GCMs have been around for decades. There have been steady improvements in capability and resolution of these models. GCMs depict the climate using a three dimensional grid over the globe, typically having a horizontal resolution of about 250 km, 10 to 20 vertical layers in the atmosphere and sometimes as many as 30 layers in the oceans. GCMs are the most advanced tools currently available for simulating the response of the global climate system to increasing greenhouse gas concentrations (IPCC-TGICA, 2007). Still the GCM's operate on a typical spatial resolution of 250 Km. GCM output underpins the results of the fourth IPCC assessment reports released in 2007. The most recent model results are the so-called AR4 runs which supported the IPCC 4th assessment (IPCC, 2007). Given the steady improvement to models we used the most recent results, i.e. the AR4 model results.

3.2.4.4 Downscaling GCM data

Using GCM output for local adaptation studies is limited by the coarse horizontal scale. The area of one gridbox of the Canadian GCM is approximately the same as New Brunswick or Nova Scotia. Thus several techniques for downscaling these data have been developed.

3.2.4.4.1 Interpolating grid box outputs

This is a simple way to get local estimates from large gridbox data. Change fields are often mapped e.g. (Environment Canada - AIRS, 2010) which allows one to interpolate to a particular location.

3.2.4.4.2 Statistical downscaling

Statistical downscaling techniques can be used to calculate sub-grid scale changes based on statistical correlations developed between large scale circulation and local observed climate. Other types of statistical downscaling relate surface weather types (e.g. freezing rain) to larger-scale circulation patterns. A key assumption is that these statistical correlations will hold under future conditions. This may or not be the case, especially in locations where the local climate may be heavily influenced by local conditions like water bodies, sea ice or topography.

3.2.4.4.3 Dynamical Downscaling - Regional Climate Models

Regional climate models (RCMs) use the same basic physical principles as GCM's but are designed to provide more detail over a limited area with typical finer resolution of approximately 50 km × 50 km. RCM's are "nested" within and get boundary conditions from a GCM. RCMs are also computationally demanding and results from them are starting to emerge. Usually the results are limited to narrow selection of scenarios and periods. RCMs may contain biases which need to be accounted for in applying their results (Richards & Daigle, 2010).

3.2.4.4.4 Hybrid Approach

Environment Canada (Environment Canada - AIRS, 2010) has made a facility available for a simpler approach to obtain estimates of climate change at the local level. This is not strictly a statistical downscaling technique. Nor is it a technique which uses GCM model output directly. This is a so-called "hybrid" technique where historical baseline data is used to adjust for model biases and tune the model output for use at a specific location. For the three future time periods the web tool has been configured to use the nearest model gridbox for the climate anomaly (either temperature or precipitation). The monthly anomalies from the climate model grid point are smoothed to daily anomalies and the daily anomalies are added to the historical data (Comer, pers. comm., 2009). Daily data are then fed to a bioclimate routine which calculates climate indices for future time periods.

The advantage of this technique is that, with modest effort, estimates can be prepared from a large number of GCM and RCM outputs which enables one to estimate confidence intervals as well as means.

This approach has been used successfully to create climate scenarios for New Brunswick municipalities (Dalton, Riley, Richards, & Daigle, 2010).

3.3 Sea-Level Rise Scenarios

3.3.1 Recent Research

The IPCC Fourth Assessment Report (AR4) cites updated information on global sea-level rise over the past 50-100 years and provides estimates of potential rise in mean sea level over the coming 100 years. For the global ocean as a whole, the latest literature assessed in AR4 indicates that sea level rose 0.17±0.05 m during the 20th century, an increase over the rate in the 19th century, and slightly less than the mean rate of 1.8±0.5 mm/year observed from 1961 to 2003. Climate model projections (Table 4) of global mean sea-level rise (mean for 2090-2099 relative to 1980-1999) are shown for a range of scenarios range from 0.18-0.26 m for the B1 scenario (lowest greenhouse gas emissions) to 0.26-0.59 m (central value of 0.43 m) for A1FI ("fossil intensive").

Table 4. Sea-level rise projections from AR4. (IPCC, 2007)

Scenario	**Temperature change (°C at 2090-2099 relative to 1980-1999)**		**Sea-level rise (m at 2090-2099 relative to 1980-1999)**
	Best estimate	Likely range	Model-based range Excluding future rapid dynamic changes in ice flow
Constant year 2000 concentrations	0.6	0.3 – 0.9	Not available
B1 scenario	1.8	1.1 – 2.9	0.18 – 0.38
A1T scenario	2.4	1.4 – 2.9	0.20 – 0.45
B2 scenario	2.4	1.4 – 3.8	0.20 – 0.43
A1B scenario	2.8	1.7 – 4.4	0.21 – 0.48
A2 scenario	3.4	2.0 – 5.4	0.23 – 0.51
A1FI	4.0	2.4 – 6.4	0.26 – 0.59

At the low end, this is equivalent to (or possibly less than) the present rate of rise. At the high end, it is less than projected in the 2001 IPCC Third Assessment (range up to 0.88 m), but still represents more than three times the rise observed during the 20th century. Furthermore, these estimates exclude the effects of any future acceleration in the flow rates of glaciers draining the Greenland and Antarctic ice sheets. For Atlantic Canada, AR4 indicates that the regional sea-level rise related to thermal expansion (the increase due to the warming of the oceans) may be very close to the global mean.

There has been much discussion since the release of AR4 by the scientific community regarding the effects of a potential acceleration in the flow rates of glaciers, particularly with regards to the Greenland Ice Sheet, which if entirely melted, would result in a global sea-level rise of the order of seven metres. The rise in sea levels would however not be uniform around the globe due the changes in the gravitational field associated with the changing mass distribution on the earth.

This heightened concern for the additional contribution of meltwater from Greenland relates to the fact that Arctic air temperatures have risen at almost twice the rate of the global average rise over the past few decades and this trend is predicted to continue. This has resulted in a more rapid loss of ice than projected by computer models from the Greenland Ice Sheet. The faster flow of glaciers to the sea appears to be responsible for much of the increase in mass loss.

The contribution of Antarctica to global sea-level rise which had been previously estimated to be negligible, has also been the topic of new research and there is now widespread concern that the West Antarctica Ice Sheet (WAIS) may collapse entirely due to climate change (Bamber, Riva, Vermeersen, & LeBrocq, 2009). The contribution to global sea-level rise from WAIS would be approximately five metres, but the rise in sea levels would however not be uniform around the globe (Mitrovica, Gomez, & Clark, 2009) due to changes in the gravitational field associated with the changing mass distribution on the earth (referred to as sea-level fingerprinting), and would in fact be more pronounced over the northern hemisphere. Conversely, contributions to sea-level rise from the Greenland Ice Sheet would be more pronounced over the southern hemisphere. The net balance from these changes in gravitational fields will however depend on the melting rates of the respective glaciers and noticeable impacts would not likely be evident within the next century. **The sea-level rise estimates in this report will not reflect any finger-printing considerations.**

A reputed sea-level rise expert and contributor to the IPCC process, Professor Stefan Rahmstorf of Potsdam University, Germany, has developed a simple semi-empirical correlation between mean globally averaged surface air temperature and global sea-level rise trends. He has then applied this correlation to predicted climate change warming over the next century to come up with new estimates of sea-level rise in the range of approximately 50-130 cm with a median value of 90 cm (Rahmstorf, 2007). The global sea-level rise estimates for this report were derived from the Professor Rahmstorf median A2 projections (red dashed line) as depicted in Figure 4. The yellow line is representative of a B1 scenario and the light blue represents the A1FI scenario.

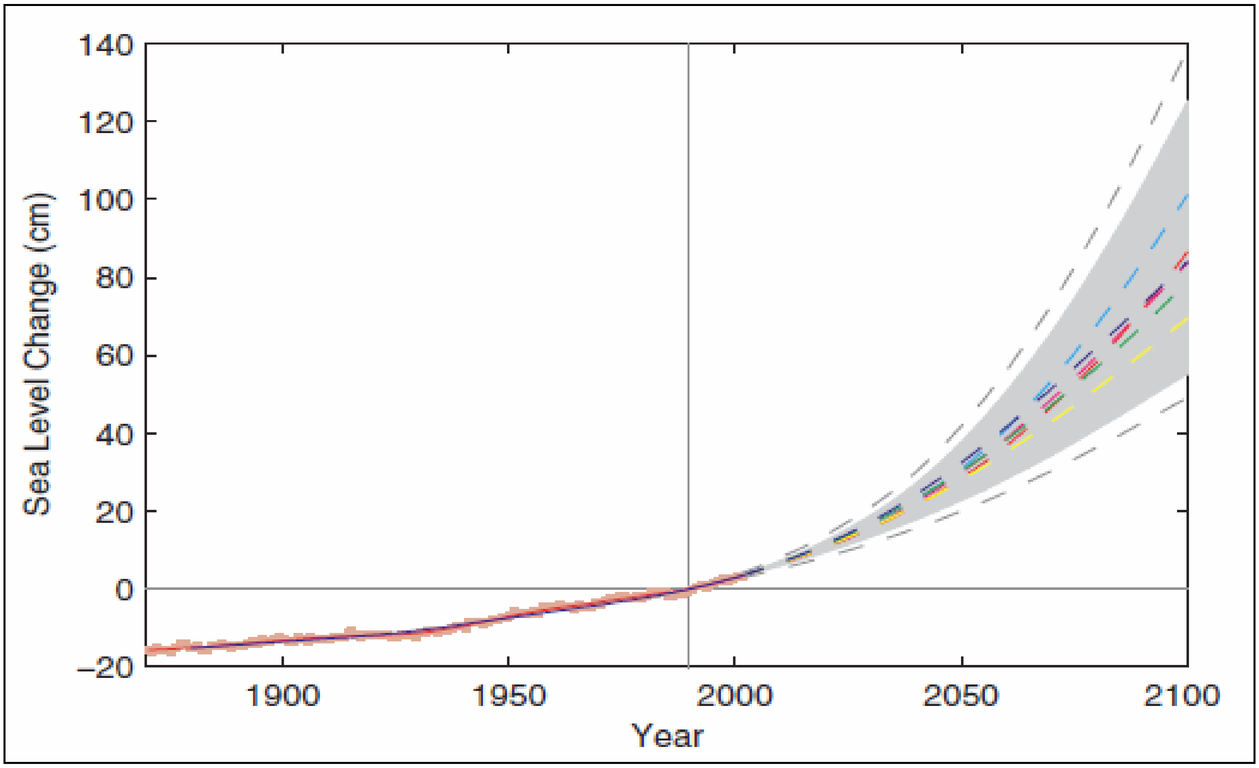

Figure 4: Sea-level rise based on simple relationship between rate of sea-level rise and global average temperature. (Rahmstorf, 2007).

4 Methodology

4.1 Climate Scenarios

4.1.1 Canadian Climate Change Scenario Network

The Adaptation and Impacts Research Section (AIRS) of Environment Canada has invested heavily in making climate scenario data from GCM experiments carried out by international climate modeling groups easily available. The site provides relatively easy access to scenarios derived from GCM simulations, tools such as statistical downscaling software, bioclimate profiles for Canada and visualization. These data and information are publicly available on the Canadian Climate Change Scenarios Network (CCCSN) website at www.cccsn.ca (Environment Canada - AIRS, 2010).

4.1.2 Bioclimate Profiles

The bioclimate routines available on the CCCSN website are based on previously published work of (MacIver & Isaac, 1989) and (Johnstone & Louie, 1983). For the present conditions we use the time period 1971 – 2000, which is the currently used thirty-year Normals period in Canada. The bioclimate indices for this period are based on actual data.

For the three future time periods the bioclimate tool has been configured to use the nearest model gridbox for the climate anomaly (either temperature or precipitation). The monthly anomalies from the climate model grid point are smoothed to daily anomalies and the daily anomalies are added to the historical data. Climate indices are then calculated using the future scenario data. This process can be repeated for each model under each emission scenario for the present and each of the three future time periods. We used the ensemble of the outputs for all the AR4 models available for the A1B and A2 runs and combined them as documented below.

4.1.3 Ensemble Approach

The ensemble approach is an increasing popular way to integrate the guidance of weather prediction and climate models. Studies have shown that a multi-model average often out-performs any individual model compared to observations (Knutti, et al., 2010).

A facility for producing ensemble outputs from a group of GCMs has recently been implemented on the Canadian Climate Change Scenarios Network (CCCSN) website (Environment Canada - AIRS, 2010). A more recent development is the ability to produce digital ensemble output from the bioclimate routines on CCCSN (Comer, 2011). For the climate projections in this report we have extracted and then combined projections for the A1B and A2 scenarios.

4.1.3.1 Combining Ensembles

For the climate indices, the A1B and A2 projections were simply averaged. Combining the uncertainties in the averages is more complex. The standard deviations were combined using the relationship:

$$\sigma_{combined} = \sqrt{\frac{\sigma_x^2 + \sigma_y^2}{2} + \frac{1}{4}(\mu_x - \mu_y)^2}$$

Where σ_x, σ_y are the standard deviations of the A1B and A2 scenarios, and
μ_x, μ_y are the means of the A1B and A2 scenarios.

4.1.4 Model Selection and Verification

It is recommended that one use multiple climate scenarios (IPCC, 2011) in order to provide an estimate of the mean and uncertainty. Climate scenarios come from model results and models were selected based on a) availability of all bioclimate parameters, b) availability of A1B and A2 scenarios and c) model performance for temperature and precipitation (Figure 5, Figure 6). Model performance was judged by constructing scatterplots of temperature and precipitation and inspecting the results visually for consistency. Information on the models is shown in Table 5.

Table 5: List of AR4 global climate models (GCM), modelling centres and country of origin

Model	Modelling Centre	Country
BCM2.0	Bjerknes Centre for Climate	Norway
CGCM3T47	Canadian Center for Climate Modelling and Analysis (CCCma)	Canada
CGCM3T63	Canadian Center for Climate Modelling and Analysis (CCCma)	Canada
CNRMCM3	Centre National de Recherches Meteorologiques	France
CSIROMk3.0	Commonwealth Scientific and Industrial Research Organisation (CSIRO)	Australia
CSIROMk3.5	Commonwealth Scientific and Industrial Research Organisation	Australia

	(CSIRO)	
ECHAM5OM	Max Planck Institute für Meteorologie	Germany
ECHO-G	University of Bonn Meteorological Research Institute	Germany
GFDLCM2.0	Geophysical Fluid Dynamics Laboratory (GFDL)	USA
GFDLCM2.1	Geophysical Fluid Dynamics Laboratory (GFDL)	USA
GISS-ER	NASA, Goddard Institute for Space Studies	USA
HADCM3	UK Met Office	UK
HADGEM1	UK Met Office	UK
INGV-SXG	Istituto Nazionale di Geofisica e Vulcanologia	Italy
INMCM3.0	Institute for Numerical Mathematics	Russia
IPSLCM4	Institut Pierre Simon Laplace (IPSL)	France
MIROC3.2 medres	National Institute for Environmental Studies	Japan
MRI CGCM2.3.2a	Meteorological Research Institute, Japan Meteorological Agency	Japan
NCARCCSM3	National Center for Atmospheric Research (NCAR)	USA
NCARPCM	National Center for Atmospheric Research (NCAR)	USA

This gave a list of 20 models times 2 scenarios times 3 time periods for a maximum of 120 estimates of climate indices per location, depending on availability of all required data. This is in addition to the baseline data which is calculated from observed data.

4.1.4.1 Scatterplots

The validity of the individual models in the ensemble was assessed by constructing scatterplots of annual temperature versus precipitation for two locations – Charlottetown, Prince Edward Island and Halifax, Nova Scotia. We constructed scatterplots for the A2, A1B and B1 scenarios. The results for the A2 scenario are illustrated in Figure 5 and Figure 6.

The scatterplots illustrate a few key facts about future climate scenarios. They illustrate *climate change scenarios* because the baseline has been removed. The baseline is illustrated by the (0,0) point at the centre of the plot. Each marker represents an individual model's result for the period indicated by its colour. Departures from the baseline are indicated either on the horizontal (temperature) axis or the vertical (precipitation) axis.

Some observations:

- All models indicate an increase in temperature.
- The magnitude of the temperature increase increases with time.
- Most, but not all, models indicate and increase in precipitation.
- The scatter in the cloud of points increases with time.
- The model consensus implies a warmer and wetter future climate.
- None of the results are extreme outliers justifying their removal from the ensemble.

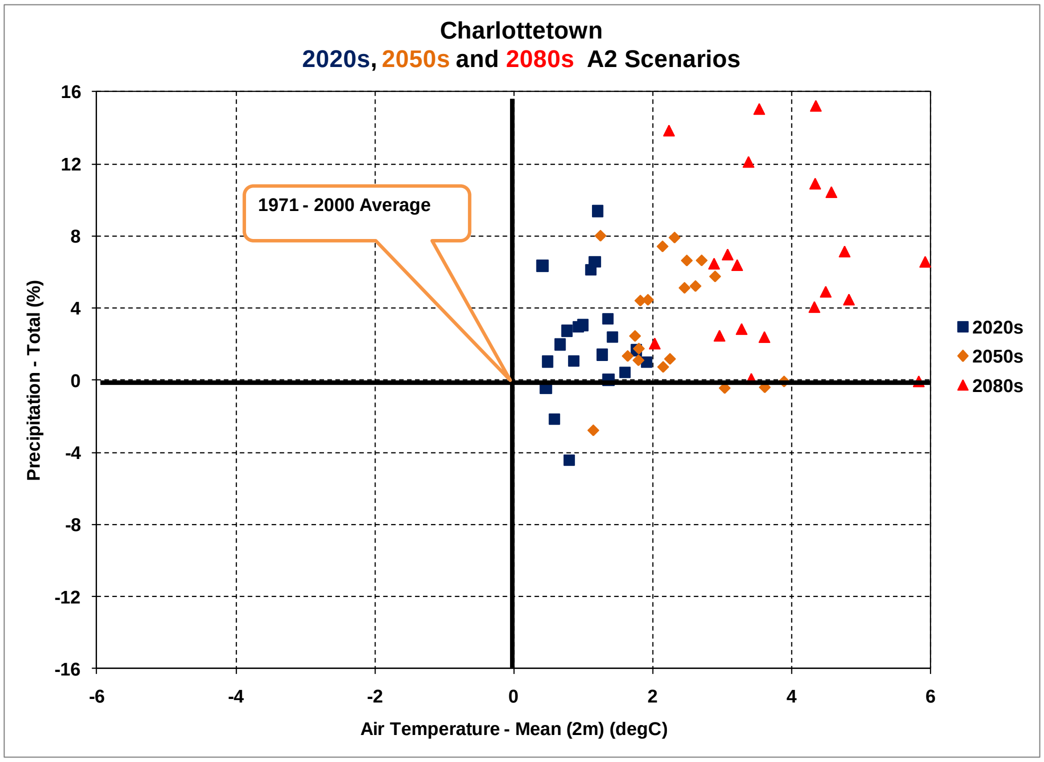

Figure 5: Scatterplot of annual temperature and precipitation scenarios - Charlottetown

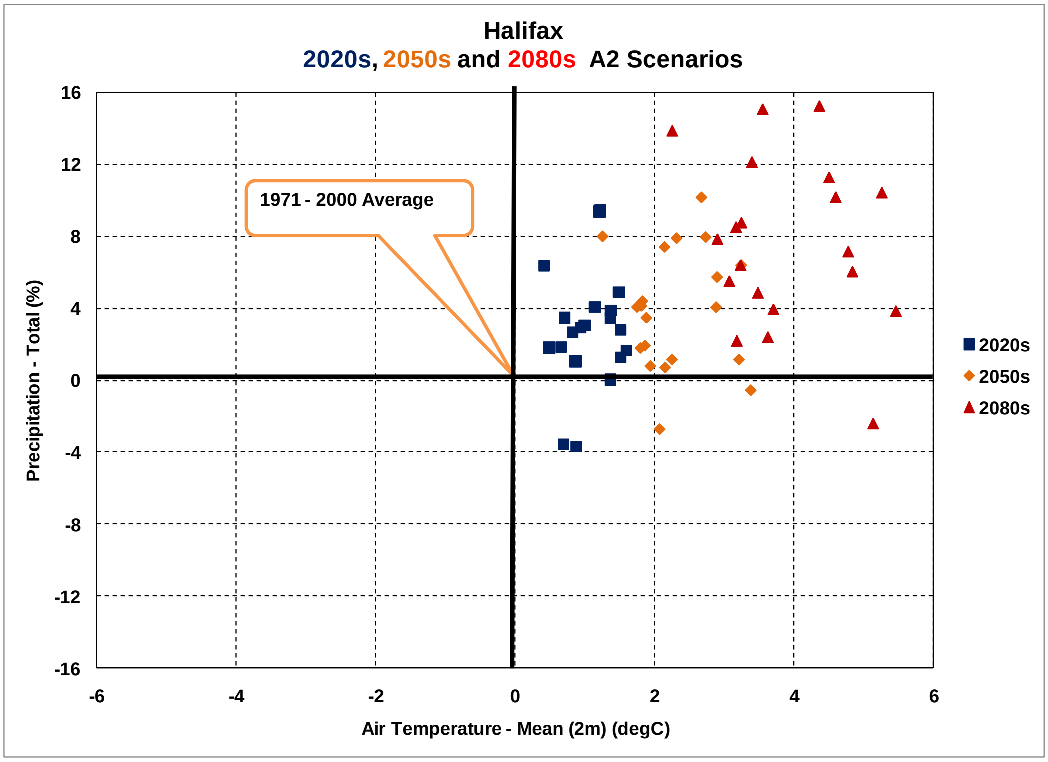

Figure 6: Scatterplot of annual temperature and precipitation scenarios - Halifax

4.1.5 Climate Indices

Changes to raw climate elements are often used to express climate change scenarios. Typical climate elements are temperature, precipitation amount, pressure, and wind etc., i.e. things that are measured directly. Climate indices add value to these basic elements by transforming them to an indicator that has a practical application or means something to a user. In applied climate practice indices derived from daily temperature and/or precipitation are commonly used. For example, the “heating degree days” index is related to energy consumption for space heating. Indices of extreme events such as average number of “very hot days” or “very cold days” place a value on the severity of climate. Growing degree days are related to crop growth. Some indices, e.g. water surplus, are derived from a combination of temperature and precipitation. In addition to raw elements we express climate change as changes to these indices. This will make it easier for practitioners to develop adaptation actions. Table 6 shows a list of climate and sea level indices and their definitions.

4.1.5.1 Degree Days

Some temperature sensitive indices are expressed in Degree Days where Degree Days are based on the formula:

$$\text{Degree Days} = \Sigma(\text{Tmean}_i - \text{Tbase})$$

where

T_{mean} is the mean daily temperature

T_{base} is a base temperature threshold which depends on application

Note: Negative values are ignored in this summation.

Table 6: Climate indices and definitions

Climate Index	Definition
Heating Degree Days	Base temperatures are +18C for heating degree days
Cooling Degree Days	Base temperatures are +18C for cooling degree days
Hot Days	Days when the maximum daily temperature exceeds 30ºC
Very Hot Days	Days when the maximum daily temperature exceeds 35ºC
Cold Days	Days when the maximum daily temperature is less than -10ºC
Very Cold Days	Days when the maximum daily temperature is less than -20ºC
Growing Degree Days > 5	Base temperatures are +5C for growing degree days > 5
Growing Degree Days > 10	Base temperatures are +10C for growing degree days > 10.
Growing Season Length	The number of days between the dates when the mean daily temperature exceeds 5ºC
Corn Heat Units	An index similar to growing degree days but tuned to corn growth as defined by (Brown, 1979)
Corn Heat Unit Season Length	The number of days between the start (mean daily temperature >12.8°C for 3 consecutive days during the period May 11 to July 31) and end (first occurrence when minimum daily temperature is < -2°C during the period August 1 to October 15) of the corn growing season
Freeze Free Season	The number of days during the year when the daily mean temperature is greater than 0°C
Days With Rain	The number of days of rain on a monthly basis, with the values averaged over the 30-year period

Days With Snow	The number of days of snow on a monthly basis, with the values averaged over the 30-year period
Freeze-Thaw Cycles	Freeze-thaw cycles represent the average number of days per period indicated when the daily maximum temperature equals or exceeds 0°C AND the daily minimum temperature is less than 0°C. The freeze-thaw cycle and its associated effects on water/ice formation can have significant effects on built environment deterioration
Water Surplus	The excess moisture remaining after the evaporation needs of the soil have been met (i.e. when actual evapotranspiration equals potential evapotranspiration) and soil storage has been returned to the water holding capacity level
Water Deficit	The amount by which the available moisture fails to meet the demand for water and is computed by subtracting the potential evapotranspiration from the actual evapotranspiration for the period in question
Change in High Intensity Short Period Rainfall	Percentage change in the 20 year return value of the 24 hour precipitation currently used in building design
Net Sea-Level Change	Estimated Rise in Sea Level
Change in Extreme High Coastal Water Levels	Estimated extreme high water elevation for 10, 25, 50 and 100 year return period.

4.1.5.2 Change in Intensity of Short Period Rainfall

Changes in intensity of extreme precipitation are difficult to predict. The consensus is that warmer climates are likely to experience an increase in precipitation intensity due to the relationship between saturated water vapour pressure and temperature. GCM simulations show that especially in areas where the mean precipitation is likely to increase, so is the probability of intense precipitation. Canada, and particularly eastern Canada, is in a zone of increasing annual precipitation. We adopted the results of Kharin et al (2007) to derive estimates of the percentage increase in the 20-year return period value of 24 hour precipitation for three time periods. Figure 7, taken from Kharin et al (2007) shows an average increase of 16±5% for the A1B and A2 scenarios for the North American land area in 2081-2100. Values interpolated from Kharin et al (2007) were adopted in the tables in appendices for all locations.

It should be noted that estimation of changes to the frequency of extreme precipitation is a difficult and uncertain science at this point in time. These values are considered to be the best estimate from the published literature and may well be adjusted in the future as more information becomes available.

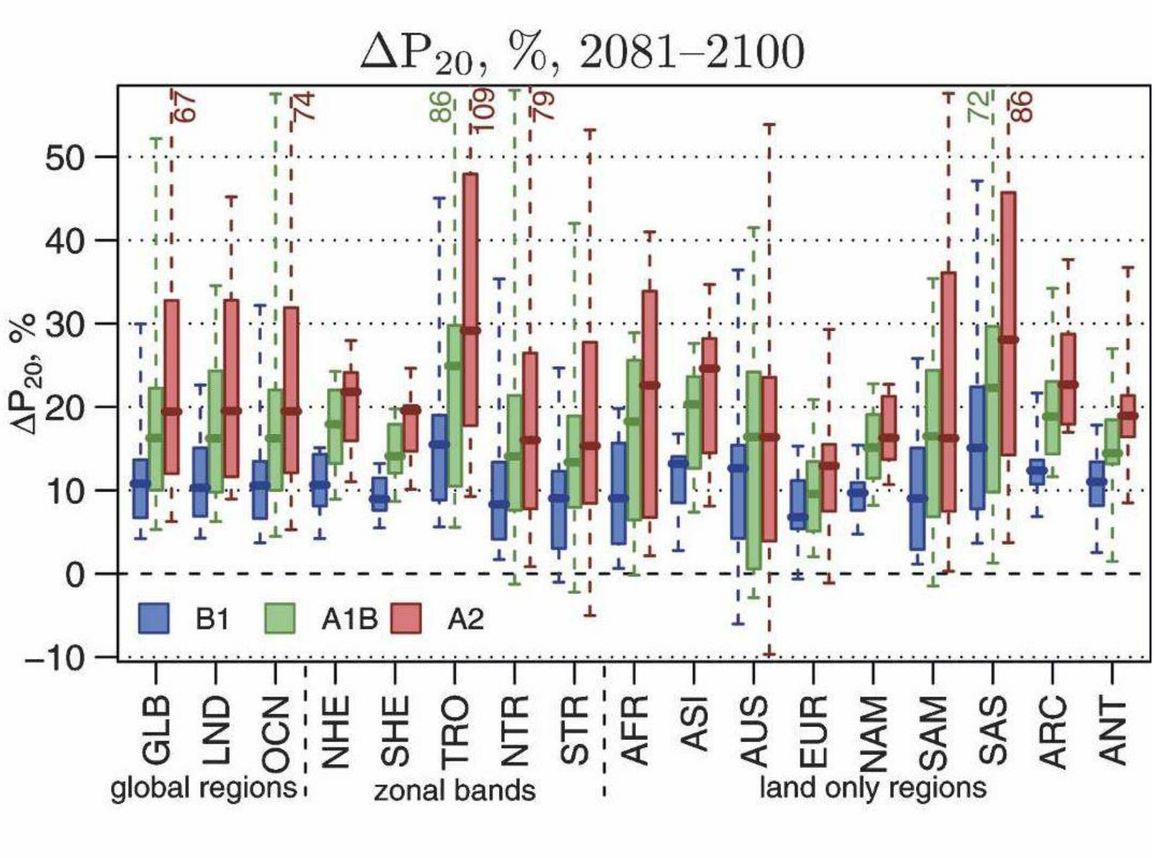

Figure 7: Box plots of the relative changes in 20-yr return values of annual extremes of 24-h precipitation rates (from Kharin et al, 2007)

4.2 Sea-Level Rise Scenarios

4.2.1 Sea-Level Rise Estimates

Estimates of global sea-level rise values were extracted directly from Rahmstorf (2007) (Figure 8). Specifically, values for years 1990, 2050, 2075 and 2100 for each of the upper and lower limits were "mined" from the Rahmstorf graph. The median value for each of the years was then calculated as the average of the upper and lower values. These values (upper, median and lower) were then plotted in Excel and a polynomial regression line was used to derive the sea-level rise estimates for each of the years 2025, 2055 and 2085. The values were adjusted for period 2000-2100 by subtracting the rise from 1990 to 2000.

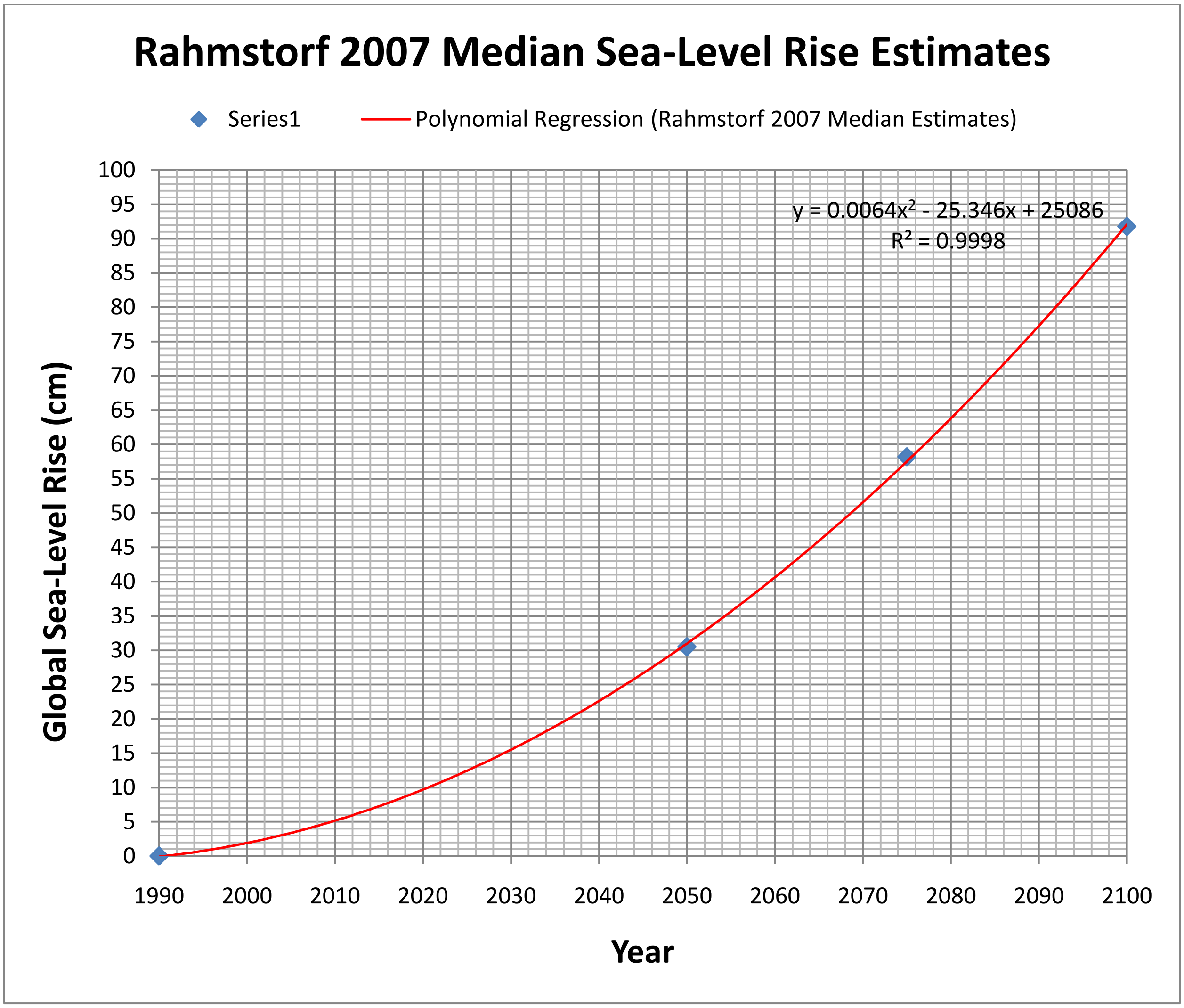

Figure 8: Sea-level rise estimates fitted to polynomial regression curve.

Figure 8 shows an example of the median estimates whereby extracted data points from Figure 5 for years 1990, 2050, 2075 and 2100 fitted with polynomial regression line used to calculate the median estimates for years 2025, 2055 and 2085. Similar graphs were produced for the upper and lower estimates. These values were further adjusted based on local crustal subsidence (vertical motion) using previously published results as guidance (Koohzare, Vanicek, & Santos, 2005), (Daigle, 2006), (Henton, Craymer, Ferland, Dragert, Mazzotti, & Forbes, 2006) and (Koohzare, Vanicek, & Santos, 2007). Crustal subsidence estimates for Halifax, Lunenburg and Liverpool were taken directly from (Forbes, 2009).

4.2.2 Local Crustal Subsidence

In addition to sea level rise due to a) thermal expansion of the oceans , b) melting of nonpolar glaciers and c) changes in the volume of the ice sheets of West Antarctica and Greenland, sea levels along most coasts of Atlantic Canada are rising due to the fact that these coastlines are very slowly subsiding (up to a few tenths of meters per century). This factor relates to a post-glacial rebound of the earth's crust. The rebound (maximum in the Hudson Bay area) and a corresponding subsidence along coastlines is in response to a depression of the earth's crust caused by the immense weight of continental ice sheets during the last Ice Age (Henton, Craymer, Ferland, Dragert, Mazzotti, & Forbes, 2006). Figure 9 (left) shows a schematic drawing of crustal motion both during a glacial maximum and after glaciations (the present scenario). Figure 9 (right) shows preliminary results of the earth's crust vertical motion in mm/year obtained from Natural Resources Canada's network of the Canadian Base Network (CBN) (Henton, Craymer, Ferland, Dragert, Mazzotti, & Forbes, 2006). These results are in agreement with north-south slopes calculated in Daigle (2006) and derived partially from previous research (Koohzare, Vanicek, & Santos, 2005) as depicted in Figure 10. A detailed analysis of tide gauge data from Charlottetown, Shediac (Pointe-du-Chêne) and Escuminac (Daigle, 2006) led to the conclusion that the zero-line as depicted in Figure 10 would be displaced further north towards the Gaspé peninsula.

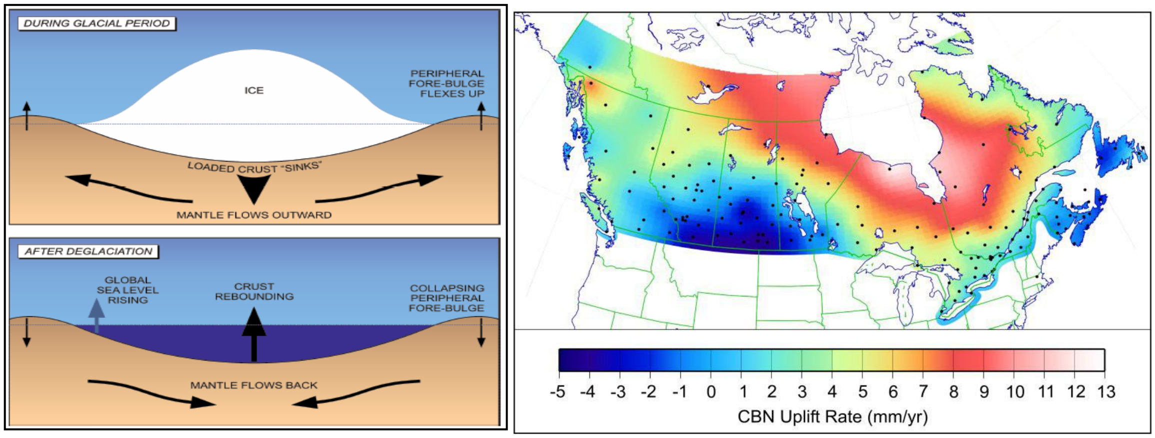

Figure 9: Crustal motion due to ice sheet loadings

Schematic drawing at left illustrates how the earth's crust reacts to changes in ice sheet loadings. Map at right depicts preliminary results of the earth's crust vertical motion in mm/year obtained from Natural Resources Canada's network of the CBN. Source: (Henton, Craymer, Ferland, Dragert, Mazzotti, & Forbes, 2006)

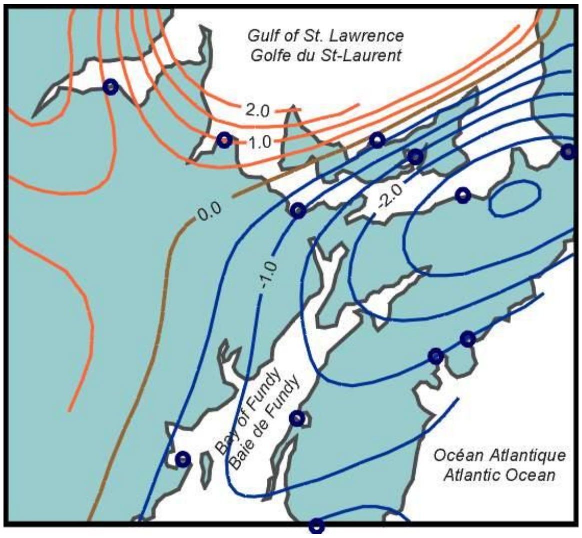

Figure 10: Vertical crustal motion in the Maritime Provinces (mm/yr) from published research (Koohzare, Vanicek, & Santos, 2005)

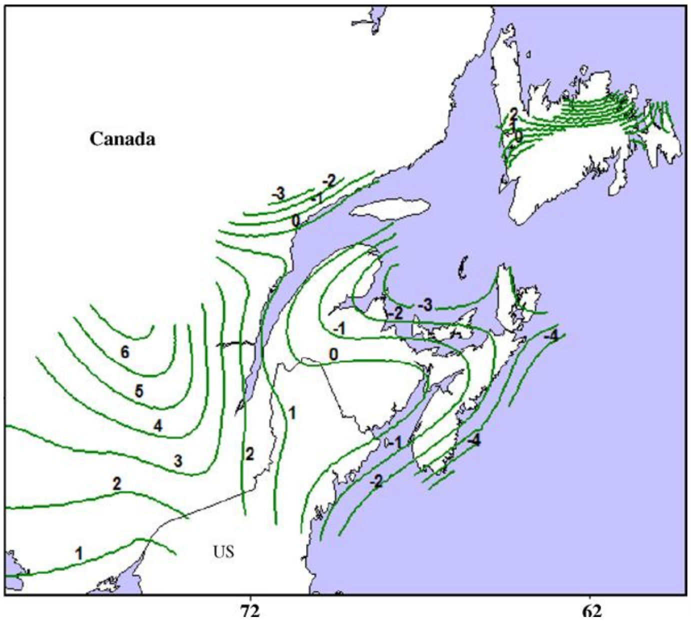

Figure 11: More recent research results on vertical crustal movement from (Koohzare, Vanicek, & Santos, 2007)

Some more recent research results (Koohzare, Vanicek, & Santos, 2007) with results depicted in mm/year in Figure 11 show a significant shift of the zero-line northward over the Gaspé peninsula, in agreement with findings in (Daigle, 2006). These results also show some similarities with the CBN data as depicted in Figure 9, but also a significant departure from earlier work in Daigle (2006) over New Brunswick.

The “take-home message” from the preceding is that are some significant gaps with regards to a clear understanding of the vertical crustal movement field over eastern Canada other than at Halifax and Charlottetown (Pers. Comm., D. Forbes, NRCan) where estimates are correlated with precise GPS determinations of vertical motion and water level measurements from tide gauges. It is expected that within the next few years (Pers. Comm., D. Forbes, NRCan), similar vertical crustal movement assessments will be conducted at all continuous tide gauges in the region using a Precision Point Positioning (PPP) technique.

Estimates of crustal subsidence for the Nova Scotia and Prince Edward Island municipalities and areas being considered in this report have been estimated using the best understanding of the data available at this time, and are listed in Table 8. These estimates will need to be refined pending the availability of more up-to-date information.

4.2.3 Storm-Surge Flooding Return Periods

A storm surge can be defined at the coast as the difference between the observed water level and the predicted astronomical tide. Tides result from the rise and fall of sea levels caused by the combined effects of the gravitational forces exerted by the moon and the sun and the rotation of the Earth. In reality, observed tide levels are rarely as predicted for the simple fact that their predicted levels are based on standard atmospheric pressure conditions, that being a mean sea level pressure of 101.33 kilopascals (1013.3 millibars). When the atmospheric pressure is lower than the standard, observed tides are higher than predicted and the opposite is true for higher atmospheric pressure. Additionally, onshore and offshore winds will respectively increase and diminish the sea level.

Storm surges can be positive or negative and may therefore raise or lower sea level from its predicted value. Storm surges occur everywhere along our coastlines and can occur anywhere in the tidal cycle or may last over several tidal cycles. Large positive storm surges at times of high tide are events that lead to coastal flooding, whereas when they coincide with low tides, flooding problems are averted. Elevated sea levels also enhance wave attack and coastal erosion and in the presence of ice and ice pressure can lead to ice ride-up and pile-up.

The magnitude of storm surges depends on the nature of the meteorological event responsible for the reduced atmospheric pressure and the strength of the winds associated with a particular event. Atlantic Canada has seen extreme cases of coastal flooding, and the frequency of these events seems to have been increasing over the past ten years. The most common devastating storms are the synoptic scale (meaning a horizontal scale of the order of 1000 km) events that typically intensify or re-form off the US east coast. The centre of these storms typically crosses Nova Scotia and tracks through the Gulf of Saint Lawrence.

Estimates of extreme total sea levels and associated levels of risk for this report were extracted from published results (Bernier, 2005), as displayed on the Environment Canada Atmospheric Hazards Web Site – Atlantic at the following link: http://atlantic.hazards.ca/search/search-e.html?user=H&who=A&class[]=427.

Figure 12, extracted from this website, shows the statistically derived total sea levels and storm surge residuals from the Halifax tide gauge database (Bernier, 2005). The storm surge residual is defined as the difference between the predicted astronomical tide and the actual water level as measured, in this case, by a tide gauge.

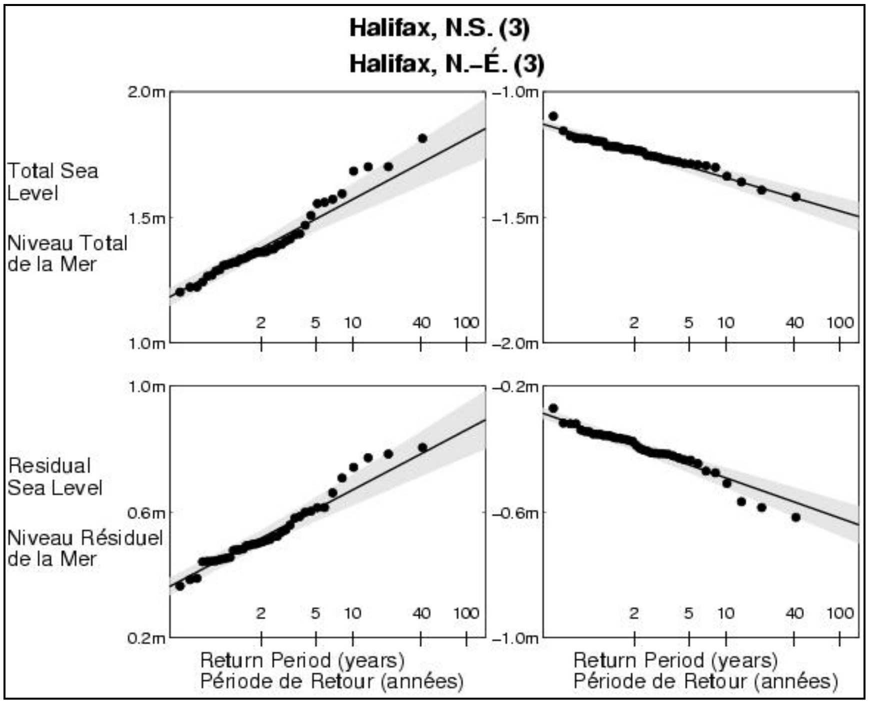

Figure 12: Total sea levels (upper left) and storm surge residual plots (lower left) for Halifax from Bernier, N.B. (2005).

Plots at right show negative surges**.**

A return period represents the average time between occurrences of an event exceeding a given level. Another way of interpreting a level with a given return period (T) is that in any year there is a 1/T chance that the return level will be exceeded. For example, in any given year there is a 10% chance that 10 year return period value will be exceeded. Similarly, in any given year there is a 1% chance that a 100 year return period will be exceeded. An example of a 100-year storm surge return period map can be seen in Figure 13.

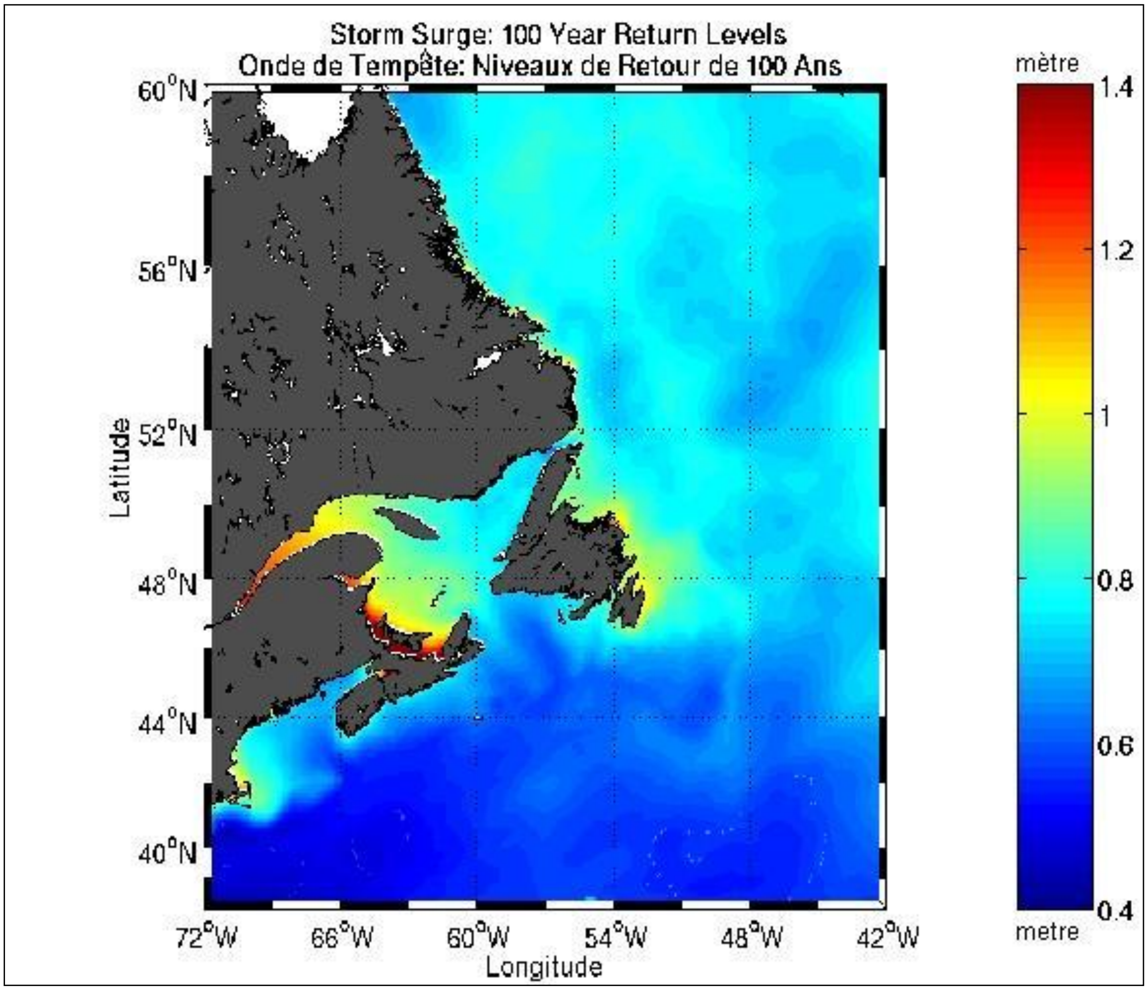

Figure 13: Storm surge 100-year return period map. (Bernier, 2005)

Close inspection of the published residual graphs (difference between the observed sea level and the anticipated tides) reveals that a significant number of recorded extreme storm surge events fall within range of the upper 95% confidence limit. The data used to estimate the extreme total sea-level return periods was hence extracted from the upper boundary of the shaded area on the representative graphs. The procedure used was as follows:

Residual sea-level values for the 2-, 10-, 40- and 100-year return periods, mined from the published semi-logarithmic graphs, were subsequently plotted on a linear graph and fitted to a natural logarithm (LN) regression curve; values were then calculated from the regression equation for the 10-, 25-, 50- and 100-year return periods. See Figure 14 and Figure 15 for Charlottetown example. Total estimated return-period sea levels (storm surge + tide levels) for the years 2025, 2055, 2085 and 2100 were then calculated as the sum of the relevant incremental values (estimated sea-level rise + storm surge) and the current Higher High Water at Large Tide (HHWLT) values (Table 7) as published by the Canadian Hydrographic Service (CHS) of Fisheries and Oceans Canada (Pers. Comm.,P. MacAuley, CHS). The HHWLT value is calculated over a 19 year cycle and represents the average of the highest annual high water, one for each of the 19 years of prediction. It is to be noted that HHWLT and Extreme Total Sea

Levels presented in this report are referenced to Chart Datum (CD), a datum level used on navigation charts, defined to be close to lower low-water at large tides. In reality, this level is rarely uncovered. For land planning purposes, GIS applications make use of a geodetic reference level (i.e. CGVD28), requiring a conversion between CD and CGVD28 that is specific to each location.

In more practical terms, the HHWLT value is representative of the highest astronomical tide possible for a given location; the CD-zero value is representative of the lowest possible tide for a given location; the Mean Water Level (MWL) value is representative of the average of HHWLT and CD-zero; and the CGVD28-zero value represents approximately the MWL value, but there are varying differences depending on the location (normally within 10-25 cm).

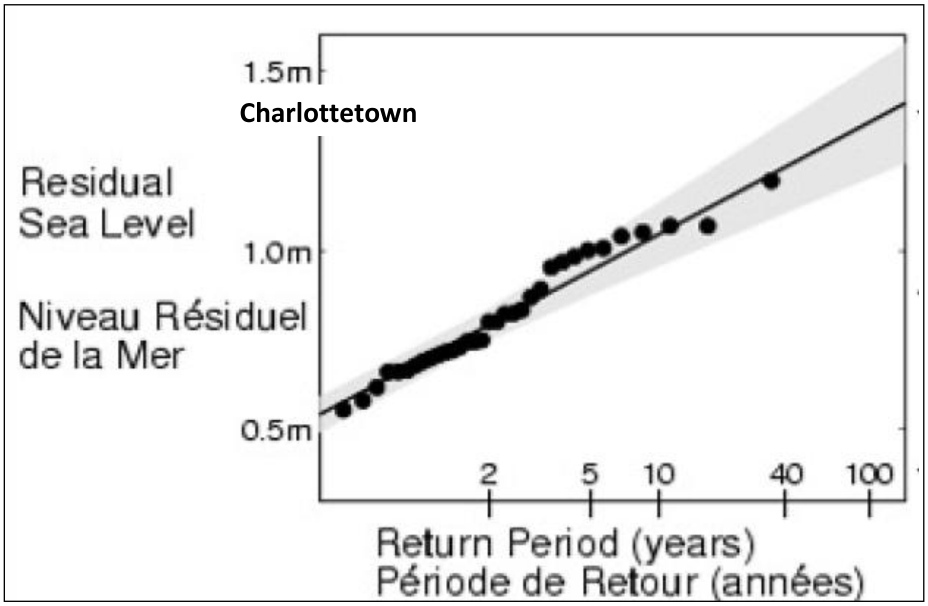

Figure 14: Residual sea levels (with 95% confidence levels in grey) and associated return periods for Charlottetown, with x-axis values on logarithmic scale (Bernier, 2005).

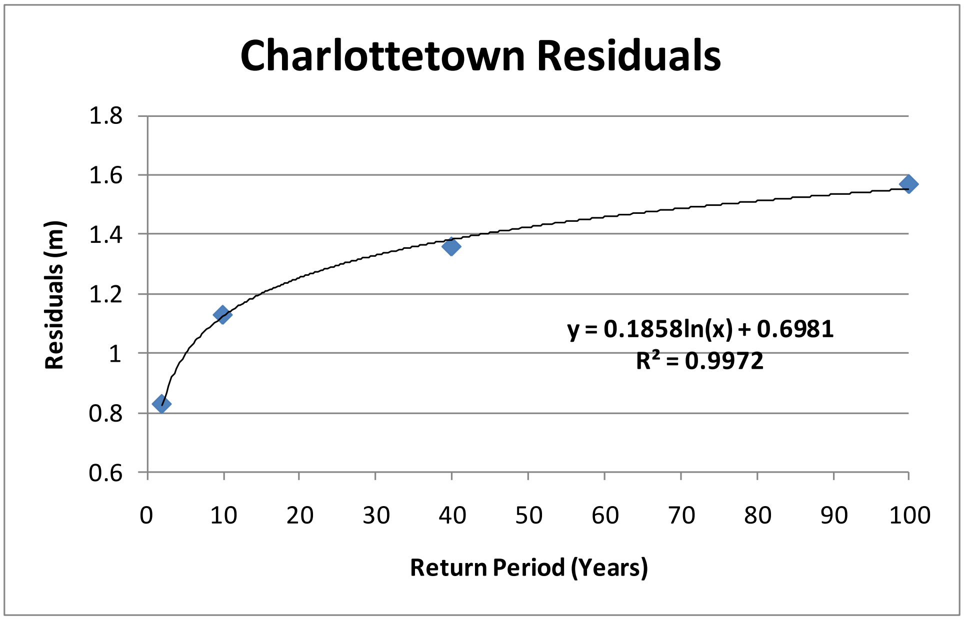

Figure 15: Charlottetown residuals

Figure 15 shows the same data as in Figure 14, but with x-axis values on a linear scale and the associated regression equation used to calculate residual values for 10-, 25-, 50- and 100-year return periods.

Storm-surge residual values for locations without tide gauge statistics were estimated from the Bernier (2005) color-coded return-period maps (Figure 13 shows 100-year return period map) and from the author's understanding of the behaviour of synoptic storms in the region.

Specific details about the representative CHS tide prediction sites for each municipality are listed in Table 7 below.

Table 8 provides estimates of the anticipated changes in Total Sea Levels for the future times frames of 2025, 2055, 2085 and 2100. The Total Sea Levels (presented in Appendices A and B) are meant to represent the worst case flooding scenario resulting from the simultaneous occurrence of a significant storm-surge event for the respective return-periods and the highest astronomical tide possible at a given location (the HHWLT).

It should be noted that the above-mentioned Total Sea Levels do not include the possibility of an extremely rare historical event such as the Saxby Gale (1869), the Groundhog Day Storm (1976) or of a direct hit by a hurricane (i.e. Hurricane Juan 2003). From a precautionary principle approach to risk management it is advisable to consider the impacts of a plausible upper bound water level that would combine the upper limits of global sea-level rise, local crustal subsidence and the highest storm-surge factor previously recorded by a tide gauge, or where available, some high precision measurements of identified high water marks. Estimates of plausible upper bound water levels are presented in Appendix B.

Table 7: Details and coordinates of representative tide prediction sites as documented by CHS.

Municipality or Area	CHS Representative Site	CHS Station Number	CHS HHWLT m (CD)
Nova Scotia			
Truro	Burncoat Head	270	16.50
Amherst	Joggins	215	13.40
Pictou/Antigonish	Pictou	1630	2.05
Cape Breton West	Cheticamp	1539	1.37
Sydney	Sydney	610	1.32
Guysborough	Canso Harbour	555	1.85
HRM	Halifax	490	2.16
Lunenburg	Lunenburg	455	2.43
Liverpool	Liverpool	440	2.30
Yarmouth	Yarmouth	365	5.16
Annapolis	Digby	325	9.13
Kentville	Hantsport	282	15.26
Prince Edward Island			
Northwest PEI	Alberton	1885	1.16
Southwest PEI	West Point	1845	1.51
Summerside	Summerside	1735	2.18
North Shore - Cavendish	Rustico	1915	1.23
Charlottetown	Charlottetown	1700	3.01
Morell, Mt. Stewart, St. Peter’s	St Peter's Bay	1935	1.05
Northeast Tip	North Lake Harbour	1955	1.45
North Shore	Naufrage	1945	1.25
Southeast (Montague/Georgetown)	Georgetown	1660	1.90

Table 8: Estimates of anticipated changes in total sea level for the years 2025, 2055, 2085 and 2100

Municipality or Area	Global Sea-Level Rise (2100) (Note 1)	Crustal Subsidence (2100)	Total Change (2025) (Note2)	Total Change (2055) (Note 3)	Total Change (2085) (Note 4)	Total Change (2100)
Nova Scotia						
Burncoat Head	0.90 ± 0.43	0.15 ± 0.05	0.15 ± 0.03	0.42 ± 0.15	0.82 ± 0.36	1.05 ± 0.48
Joggins	0.90 ± 0.43	0.15 ± 0.05	0.15 ± 0.03	0.42 ± 0.15	0.82 ± 0.36	1.05 ± 0.48
Pictou	0.90 ± 0.43	0.15 ± 0.05	0.15 ± 0.03	0.42 ± 0.15	0.82 ± 0.36	1.05 ± 0.48
Cheticamp	0.90 ± 0.43	0.20 ± 0.05	0.16 ± 0.03	0.45 ± 0.15	0.86 ± 0.36	1.10 ± 0.48
Sydney	0.90 ± 0.43	0.20 ± 0.05	0.16 ± 0.03	0.45 ± 0.15	0.86 ± 0.36	1.10 ± 0.48
Canso Harbour	0.90 ± 0.43	0.20 ± 0.05	0.16 ± 0.03	0.45 ± 0.15	0.86 ± 0.36	1.10 ± 0.48
Halifax	0.90 ± 0.43	0.16± 0.05	0.15 ± 0.03	0.43 ± 0.15	0.83 ± 0.36	1.06 ± 0.48
Lunenburg	0.90 ± 0.43	0.16 ± 0.05	0.15 ± 0.03	0.43 ± 0.15	0.83 ± 0.36	1.06 ± 0.48
Liverpool	0.90 ± 0.43	0.16± 0.05	0.15 ± 0.03	0.43 ± 0.15	0.83 ± 0.36	1.06 ± 0.48
Yarmouth	0.90 ± 0.43	0.16 ± 0.05	0.15 ± 0.03	0.43 ± 0.15	0.83 ± 0.36	1.06 ± 0.48
Digby	0.90 ± 0.43	0.15± 0.05	0.15 ± 0.03	0.42 ± 0.15	0.82 ± 0.36	1.05 ± 0.48
Hantsport	0.90 ± 0.43	0.20± 0.05	0.16 ± 0.03	0.45 ± 0.15	0.86 ± 0.36	1.10 ± 0.48
Prince Edward Island						
Alberton	0.90 ± 0.43	0.18± 0.05	0.16 ± 0.03	0.44 ± 0.15	0.84 ± 0.36	1.08 ± 0.48
West Point	0.90 ± 0.43	0.10 ± 0.05	0.14 ± 0.03	0.40 ± 0.15	0.78 ± 0.36	1.00 ± 0.48
Summerside	0.90 ± 0.43	0.10± 0.05	0.14 ± 0.03	0.40 ± 0.15	0.78 ± 0.36	1.00 ± 0.48
Rustico	0.90 ± 0.43	0.18 ± 0.05	0.16 ± 0.03	0.44 ± 0.15	0.84 ± 0.36	1.08 ± 0.48
Charlottetown	0.90 ± 0.43	0.16± 0.05	0.15 ± 0.03	0.43 ± 0.15	0.83 ± 0.36	1.06 ± 0.48
St Peter's Bay	0.90 ± 0.43	0.15 ± 0.05	0.15 ± 0.03	0.42 ± 0.15	0.82 ± 0.36	1.05 ± 0.48
North Lake Harbour	0.90 ± 0.43	0.20 ± 0.05	0.16 ± 0.03	0.45 ± 0.15	0.86 ± 0.36	1.10 ± 0.48
Naufrage	0.90 ± 0.43	0.20± 0.05	0.16 ± 0.03	0.45 ± 0.15	0.86 ± 0.36	1.10 ± 0.48
Georgetown	0.90 ± 0.43	0.20± 0.05	0.16 ± 0.03	0.45 ± 0.15	0.86 ± 0.36	1.10 ± 0.48

Note 1. The value of 90 cm is the central value from Rahmstorf (2007) year 2100 estimates and the ±43 cm error bar represents the associated range

Note 2. Total includes linear increase of crustal subsidence (25%) + prorated non-linear (polynomial) increase of 100-year global sea-level rise

Note 3. Total includes linear increase of crustal subsidence (55%) + prorated non-linear (polynomial) increase of 100-year global sea-level rise

Note 4. Total includes linear increase of crustal subsidence (85%) + prorated non-linear (polynomial) increase of 100-year global sea-level rise

5 Guidance on Use of Scenarios

The authors realize that the information needs and vulnerabilities of each municipality will be different. Therefore it is important to conduct a Vulnerability, Impact and Adaptation (VIA) assessment to prioritize adaptation actions.

In this section we present information to help those involved in VIA to properly use the scenario data presented in this report. The information is derived from literature and also our experience.

5.1 Climate Scenario Guidelines

In this section we refer to the climate indices that are listed and briefly described in Table 6. The actual values by municipality are in Appendix A. The Prince Edward Island and Nova Scotia Summary Tables (Table A 10 and Table A 24) are averages of the values in all the respective provincial stations.

5.1.1 Temperature and Precipitation

These categories of the scenarios show the present values and future scenarios for average temperature and precipitation. All values refer to a 30 year period with the label referring to the middle decade. The seasons are broken down as follows: Winter (December, January, February), Spring (March, April, May), Summer (June, July, August) and Autumn (September, October, November).

It is not straight forward to use changes in average values. How can they be made meaningful? One way that has been employed is to apply the spatial (or temporal) analogue technique (see Analogue Scenarios). For example Figure 2 of Wuebbles (2007) illustrates how US Northeast state climates may migrate.

Some things to note:

- While temperature and precipitation values are likely to increase in future, the tables show that the greatest increase is in the winter values.
- Higher precipitation does not necessarily translate to wetter soil conditions. More evaporation due to warmer temperatures can consume water and produce larger water deficits in warm seasons. See paragraph below on water surpluses and deficits.
- The scatterplots (Figure 5 and Figure 6) as well as the Standard Deviations (SD) in the Tables in Appendix A indicate increasing ranges of uncertainty in future scenarios. This could be due to two factors – increasing variability of future climate conditions or increasing uncertainty in the climate model projections. In either case future adaptation choices should consider the possible ranges of uncertainty. Like the uncertainty in crustal movement this is an area of active research which will be resolved over time.

5.1.2 Heating Degree Days (HDD)

This parameter is directly related to space heating demands. If present energy consumption for space heating is 1000 KwH/yr and HDD decreases by 20% then, all other factors being equal, the space heating requirement will decrease by 20% also. Warmer winter and shoulder season temperatures are likely to reduce the requirement for heating in the Maritimes.

5.1.3 Cooling Degree Days (CDD)

CDD's is a similar index but is directly related to the energy required for air conditioning. Warmer summer temperatures are likely to increase cooling demand, but the effect will vary by municipality. Coastal locations like Yarmouth will still have that huge oceanic air conditioner next door, while inland locations like Greenwood will be more affected.

5.1.4 Hot Days and Very Hot Days

Hot Days, i.e. days when the maximum temperature exceeds 30°C, are relatively rare in Nova Scotia and Prince Edward Island in the present climate. They are approximately 10 times more frequent in Windsor, ON where they occur on an average of 20 days per year. Very Hot Days (Maximum > 35°C) are almost unknown to Maritimers. To deal with extreme heat episodes other cities in Canada have implemented heat health alert systems and responses like air conditioned public cooling centers, heat alerts and vulnerable population monitoring. Maritime municipalities should look at adaptive strategies that have been implemented elsewhere.

5.1.5 Cold Days and Very Cold Days

People should already be adapted to dealing with cold days as they are endemic to living in Canada. Fewer cold and very cold days are anticipated across the board in future.

5.1.6 Growing Degree Days

Growing degree days are a parameter related to plant growth. The lower threshold temperature (5°C) usually applies to forage crops like hay. The higher threshold (10°C) applies to heat loving crops like beans or tomatoes. Varieties of agricultural crops, ornamentals, and trees often have GDD ratings associated with them. These ratings can be used along with other eco-parameters to choose varieties which will grow best under the applicable climate conditions. For immediate choices it is probably more important to consider climate ratings for plants with long lifetimes rather than annual flowers, for example. Long lived plants (trees) will experience changing conditions over their lifetimes. For example, NRCan have published information on the website http://planthardiness.gc.ca/ph_futurehabitat.pl?lang=en. Maps of 1951-80 GDDs for Atlantic Canada can be found in (Dzikowski, Kirby, Read, & Richards, 1984). The scenarios indicate substantial changes to the GDD climate in Nova Scotia and Prince Edward Island.

5.1.7 Growing Season Length, Freeze Free Season

These parameters are relatively obvious to interpret. Consideration for their application in adaptation actions could be:

- Agricultural or horticultural facilities
- Maintenance of parks, playing fields and other outdoor recreation facilities.

Both parameters are related to the summer season and indications are that they will increase by 1 to 2 months by the end of the century.

5.1.8 Corn Heat Units (CHU) and Corn Season Length (days)

These corn heat parameters should be used with expert agronomic guidance. They are related to agricultural crops that are presently grown in the Maritimes but are more common in areas with warmer climates. Substantial increases in CHUs and the corn growing season raise the possibility of changing agricultural crops.

5.1.9 Days with Rain and Days with Snow

The climate scenarios indicate a general increase in the number of days with rain and a decline in the number of days with snowfall. This makes sense when combined with the information about warmer winters as snow days would be converted to rain days. Fewer snow days would have positive impacts on snow clearing budgets but negative impacts on winter recreation activities.

5.1.10 Freeze-Thaw Cycles

Freeze thaw cycles are the number of days per year when the temperature passes through the melting point. They are generally related to stress on the built environment (concrete deterioration, potholes) but also important in winter survival of some plants like strawberries. It should be noted that while the number of annual freeze-thaw cycles decreases over time due to a warmer climate, the number of freeze-thaw cycles in winter stays nearly the same or increases. This factor should be considered as a freeze-thaw cycle during the time when soils etc are normally frozen will have more impact than a freeze-thaw cycle at other times of the year.

5.1.11 Water Surplus and Water Deficit (mm)

These numbers are derived by using a water balance model. The surplus can be thought of as excess runoff. The deficit is water that could evaporate if it were available to do so. Water deficit is a drought indicator.

It is interesting to note that even though precipitation is projected to increase in the future at all sites, the water surpluses are mostly projected to decrease and water deficits to increase. These indicators, especially increased summer water deficits, should be considered when assessing fresh water supplies. Many municipalities have undertaken water management reviews to identify, protect and enhance fresh water resources. Protection methods include metering, restrictions to lawn watering & washing cars. Diminished fresh water availability during the growing season could increase the need for crop irrigation.

5.1.12 Change in Intensity of Short Period Rainfall (%)

Short period (≤ 24 hours) rainfall intensities are used by hydrologists and engineers in the design of public infrastructure that requires water handling capacity. Rainfall-runoff affects storm sewers, culverts, detention ponds, drainage pump stations, roads, wastewater management infrastructure, and private structures like roof drainage systems. Short period rainfall values based on historical data are published by Environment Canada for 549 locations across Canada (Environment Canada, 2011). Information on the impact of climate change on short period rainfall rates is inconclusive at this point in time as there is no standard or accepted research methodology to determine how future sub-daily extreme rainfall could change in intensity and frequency at point locations or over a small area in the future climate (Canadian Standards Association, 2010). Global and regional climate models operate at spatial and temporal scales which do not capture the small scale storms that are responsible for extreme short period rainfalls.

In spite of these caveats, enough evidence, based on theory and studies of trends has been assembled to make recommendations as shown in the Appendix A tables.

Many hydrotechnical engineers are already incorporating these adjustments in to their designs. Until such time as official standards are updated, municipalities have the latitude to specify that their infrastructure be designed for future climate conditions. For a detailed discussion of rainfall extremes and their application in Canada the document Canadian Standards Association (2010) is recommended.

5.2 Coastal Flooding Scenarios Guidelines

5.2.1 HHWLT Values

The HHWLT values and the associated sea-level rise and storm-surge component scenarios provided in this report are linked to specific CHS tide prediction sites and are true only at those locations. The resulting Extreme Total Sea Levels can however be applied to appropriate sections of coastlines once the CD to geodetic (CGVD28) conversions have been applied to the point source data. The provision of these conversions are beyond the scope of this project and users of the flooding scenarios will need to obtain these conversions from official sources such as the Canadian Hydrographic Service.

5.2.2 Extreme Total Sea Level

It is recommended that the median value of the Extreme Total Sea Levels be used as a tool for sea-level rise adaptation planning and that contingencies be included to account for the potential impact of the upper limits, a sea-level scenario that would potentially result should greenhouse gas emissions continue to increase at the present rate. Planners should also keep in mind that sea levels will continue to increase past the year 2100. It should be noted that, with a 1-metre sea level rise scenario, the flooding levels reached at the height of the January 21, 2000 record storm-surge event (then near a 100-year return period event) could statistically occur every 3 years.

5.2.3 Plausible Upper Bound Water Levels

It is to be noted that the above-mentioned Total Sea Levels do not include the impact of an extremely rare historical event such as the Saxby Gale (1869), the Groundhog Day Storm (1976) or of a direct-hit by a hurricane (i.e. Hurricane Juan 2003). From a precautionary principle approach to risk management it is advisable to consider the impacts of a plausible upper bound water level that would combine the upper limits of global sea-level rise, local crustal subsidence and the highest storm surge factor that has previously occurred or could re-occur in the future due to extremely rare but plausible extreme meteorological events. Estimates of plausible upper bound water levels are presented in Appendix B.

5.2.4 Experience with other Municipalities

The availability of LiDAR mapping capabilities in conjunction with appropriate return-period flooding statistics, as presented in this report, have been used in other projects to develop effective tools to better manage land use planning with regard to existing and future developments. The point source flooding estimates presented in Appendix B (Tables B1 to B21) and duplicated in Appendix A, when applied to a regional LiDAR-derived Digital Elevation Model (DEM) can then provide contoured water level extents over much larger geographical areas. The approach requires that GIS-derived water level layers be prepared at nominal intervals (such as 0.1 m interval ESRI shapefiles) for the entire domain of the water levels under consideration for a particular region.

5.2.4.1 Pointe-du-Chêne, NB

Figure 16 provides an example of how a LiDAR-derived map was used to show the extent of the December 21, 2010 flood in the Shediac area. It should be noted that the elevations are as surveyed by LiDAR in May 2003 and that the orthophoto map (courtesy of Service New Brunswick) was taken in 2000. As part of a climate change adaptation strategy, the bridge on the main road into Pointe-du-Chêne has now been re-built and raised and was not flooded during this storm, though still being seen as under water on this map. The light blue shaded area is indicative of the maximum water level reached (3.3 m (CD)/2.4 m (CGVD28).

Figure 16: Map showing flooding zones at the worst of the December 21, 2010 storm in the Shediac area. Map source: R.J. Daigle Enviro

5.2.4.2 New Brunswick Mi'gmag First Nations Climate Change Adaptation

This project, led by the North Shore MicMac District Council Inc., being run in parallel with the New Brunswick component of Atlantic Climate Adaptation Strategy, has as a main focus an evaluation of climate change and storm-surge flooding impacts on New Brunswick Mi'gmag First Nations reserves for a planning window through the end of the current century. The work involves the development of a

LiDAR geodatabase and flooding scenarios from which adaptation strategies and emergency response plans will be derived. An interactive secure web mapping interface (third party) is being provided to provide communication to the communities. Figure 17 shows an example of a LiDAR DEM representation of water levels at the Indian Island First Nations Community. This map provides a visual example of how flood extents can be used to display the evolution of storm-surge flooding scenarios as sea levels rises through the century. In this case, DEM-derived elevation lines representing flooding levels are draped over an aerial photo.

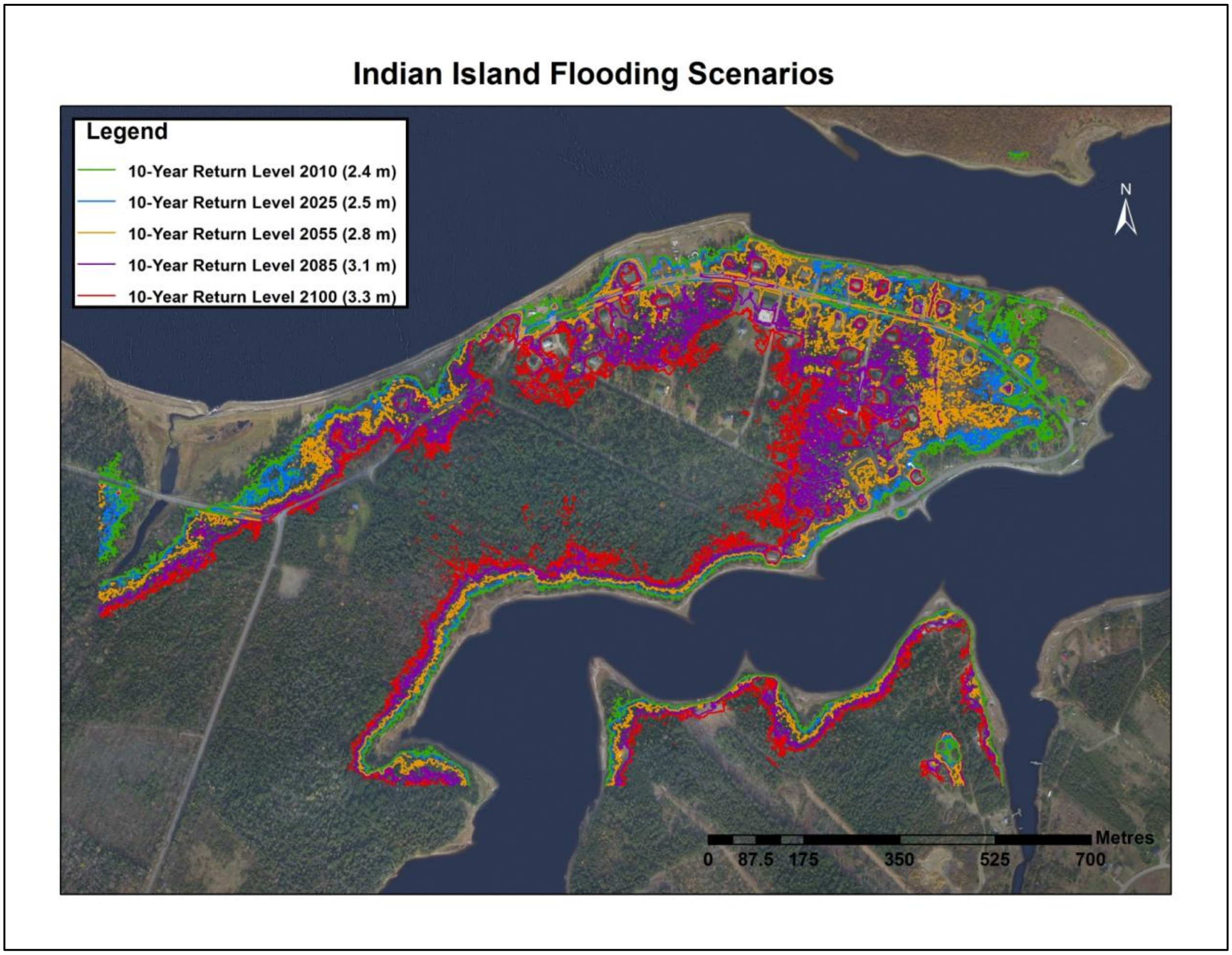

Figure 17: 10-year return-period flooding scenarios at Indian Island, NB. Map source: R.J. Daigle Enviro.

5.2.4.3 Communauté Rurale Beaubassin-Est Rural Community

The Council of the Communauté Rurale Beaubassin-est Rural Community has adopted a by-law to better regulate construction along coastal areas. The municipality is the first in New-Brunswick to adopt such a by-law to be integrated in the Rural Plan. The modifications to the existing by-law include the addition of a new zone regarding the elevation of the sea (4.3 m CGVD28) which is identified in the zoning map as well as a by-law that specifies guidelines for new constructions in the regions.

http://www.beaubassinest.ca/index_en.cfm

5.2.4.4 Planning for Sea-level Rise in Halifax Harbour

In August 2006, the Halifax Regional Municipality Council adopted the Regional Municipal Planning Strategy, an integrated land use planning guide for future development. The Strategy explicitly includes policies to address climate change impacts and recognizes the need to gather scientific data on sea-level rise, storm surges and vulnerability to inform development of an area-specific land use plan for Halifax Harbour. See http://adaptation.nrcan.gc.ca/mun/halifax_e.php

5.3 Summary and Suggested Additional Resources

In this document we have provided the numbers for climate and sea level rise scenarios relevant to Nova Scotia and Prince Edward Island communities along with guidance as to how to use them correctly.

The complete process of developing and implementing adaptation plans is another field of study. A number of publications exist both nationally and internationally to assist communities in preparing for climate change. Following is a partial listing of these references.

- Bizikova, L., Neale, T., & Burton, I. (2008). *Canadian communities' guidebook for adaptation to climate change*. Including an approach to generate mitigation co-benefits in the context of sustainable development. Vancouver: Environment Canada and University of British Columbia.
- Land Use Consultants, Oxford Brookes University, CAG Consultants, Gardiner & Theobald Consultants. (2006). *Adapting to Climate Change Impacts: A Good Practice Guide for Sustainable Communities*. London: Southeast Climate Change Partnership, Sustainable Development Roundtable for the East of England, London Climate Change Partnership.
- Ligeti, E. (2007). *Cities Preparing for Climate Change: A Study of Six Urban Regions*. Toronto, ON: Clean Air Partnership.
- Richardson, G. R. (2010). *Adapting to Climate Change: An Introduction for Canadian Municipalities*. Ottawa, Ont.: Natural Resources Canada
- Snover, A., Whitley Binder, L., Lopez, J., Willmott, E., Kay, J., Howell, D., et al. (2007). *Preparing for Climate Change: A guidebook for Local, Regional, and State Governments*. The Climate Impacts Group, Kings County, Washington. Oakland, Ca: In Association with and published by ICLEI - Local Government for Sustainability.

6 Conclusion and Recommendations

In this report we have provided a summary of key background information regarding climate scenarios and their application to the local level. We examined the literature and chose appropriate and up to date techniques for deriving future climate state and coastal flooding risks. We compiled data for future climate and coastal water levels to the end of this century and published it as a separate table for each of the twenty-two target municipalities in Nova Scotia and Prince Edward Island. Guidelines were prepared to help the user correctly interpret and apply the information.

These data should be useful for municipalities as they evaluate their risks and vulnerabilities and develop plans and actions to deal with them.

In spite of our efforts to provide the best and most appropriate information available at this time, it should be recognized that climate and sea level science will advance with time. Users will require updated information as more and better global climate models provide additional data. These scenarios will need to be updated periodically as new information becomes available.

In addition to updating the suite of parameters in this report there will no doubt be a demand for information not included here. Additional parameters such as multiday events, extreme convective weather, storminess, winter extremes (e.g. ice storms, blizzards), sea ice cover and hurricanes could be addressed.

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Appendix A: Climate Change and Sea-Level Rise Scenario Data by Municipality

Explanation

On the following pages are listed the climate and sea level scenario data for individual municipalities.

The table captions contain a name for the general area, the name and ID of the representative climate station and the name of the Canadian Hydrographic Service (CHS) Representative Site (Table 1). The values have been derived as specified in the accompanying report. Users should read the report to understand the source of the data and any inherent assumptions.

All temperature values are in °C. All precipitation values are in millimeters (mm).

Sea level values like sea-level rise and Extreme Total Sea Level (TSL) are in metres . The TSL values are referred to Chart Datum.

Table A 1: Northwest PEI, Climate Station Alberton (id: 8300080) @ 46.85N 64.02W, CHS Site Alberton

Parameter	1980s	2020s		2050s		2080s	
	Value	Value	SD	Value	SD	Value	SD
Temperature - Annual	5.1	6.3	0.5	7.6	0.7	9.0	1.1
Winter	-6.9	-5.5	0.7	-3.8	1.0	-2.2	1.4
Spring	2.4	3.5	0.5	4.6	0.8	5.9	1.2
Summer	17.1	18.1	0.5	19.3	0.8	20.5	1.1
Autumn	7.9	9.1	0.4	10.2	0.7	11.6	1.0
Precipitation - Annual	1068.7	1100.8	25.0	1121.3	31.5	1157.0	46.0
Winter	279.7	295.0	10.7	307.1	16.7	323.6	24.4
Spring	249.9	259.2	10.0	265.7	14.2	279.4	18.7
Summer	249.2	254.6	10.4	255.2	15.6	254.0	23.5
Autumn	289.9	293.1	11.9	295.7	13.9	304.7	20.1

	1980s	2020s	2050s	2080s
Heating Degree Days	4786.0	4415.5	4019.6	3620.1
Cooling Degree Days	110.8	164.3	244.2	343.1
Hot Days (Tmax > 30)	1.8	4.6	9.1	15.4
Very Hot Days (Tmax > 35)	0.0	0.0	0.2	0.8
Cold Days (Tmax < -10)	11.3	8.8	5.5	3.3
Very Cold Days (Tmax < -20)	0.2	0.0	0.0	0.0
Growing Degree Days > 5	1628.8	1827.3	2069.3	2347.1
Growing Degree Days > 10	837.7	981.8	1160.0	1359.7
Growing Season Length (days)	162.6	173.6	191.0	206.8
Corn Heat Units (CHU)	2376.4	2682.3	3043.6	3474.3
Corn Season Length (days)	132.4	143.6	158.5	174.4
Freeze Free Season (days)	194.6	221.1	242.7	262.2
Days With Rain	112.9	128.9	134.9	140.3
Days With Snow	44.2	53.5	45.3	37.9
Freeze-Thaw Cycles - Annual	87.5	82.9	72.9	65.4
Winter	28.7	31.5	34.1	36.2
Spring	38.1	34.0	25.8	20.5
Summer	0.4	0.2	0.0	0.0
Autumn	20.3	17.2	13.1	8.8
Water Surplus (mm)	602.9	595.0	595.5	609.6
Water Deficit (mm)	46.1	49.1	59.3	72.0
Δ Intensity Short Period Rainfall (%)	0	5	9	16

	2000	2025	2055	2085	2100
Total Sea Level Rise (m)		0.16 ± 0.03	0.44 ± 0.15	0.84 ± 0.36	1.08 ± 0.48
Extreme TSL - 10 Yr Ret Period	2.23 ± 0.20	2.39 ± 0.23	2.67 ± 0.35	3.07 ± 0.56	3.31 ± 0.68
Extreme TSL - 25 Yr Ret Period	2.38 ± 0.20	2.54 ± 0.23	2.82 ± 0.35	3.22 ± 0.56	3.46 ± 0.68
Extreme TSL - 50 Yr Ret Period	2.49 ± 0.20	2.65 ± 0.23	2.93 ± 0.35	3.33 ± 0.56	3.57 ± 0.68
Extreme TSL - 100 Yr Ret Period	2.61 ± 0.20	2.76 ± 0.23	3.05 ± 0.35	3.45 ± 0.56	3.69 ± 0.68

Table A 2: Southwest PEI, Climate Station OLeary (id: 8300525) @ 46.70N 64.26W, CHS site West Point

Parameter	1980s	2020s		2050s		2080s	
	Value	**Value**	**SD**	**Value**	**SD**	**Value**	**SD**
Temperature - Annual	5.2	6.4	0.5	7.7	0.7	9.1	1.1
Winter	-7.0	-5.6	0.7	-3.9	1.0	-2.3	1.4
Spring	2.9	4.0	0.5	5.2	0.8	6.4	1.2
Summer	17.2	18.2	0.5	19.4	0.8	20.6	1.1
Autumn	7.9	9.0	0.4	10.2	0.7	11.5	1.0
Precipitation - Annual	1139.4	1173.7	26.7	1195.4	33.5	1233.6	49.0
Winter	283.8	299.3	10.8	311.6	16.9	328.4	24.8
Spring	270.3	280.4	10.9	287.3	15.4	302.2	20.2
Summer	267.6	273.5	11.2	274.1	16.8	272.8	25.2
Autumn	317.7	321.2	13.0	324.0	15.2	333.9	22.0

	1980s	**2020s**	**2050s**	**2080s**
Heating Degree Days	4734.2	4364.6	3970.0	3573.4
Cooling Degree Days	98.6	152.9	234.2	336.0
Hot Days (Tmax > 30)	1.0	3.1	6.9	13.1
Very Hot Days (Tmax > 35)	0.0	0.0	0.0	0.4
Cold Days (Tmax < -10)	12.5	9.7	7.0	3.8
Very Cold Days (Tmax < -20)	0.2	0.1	0.0	0.0
Growing Degree Days > 5	1663.0	1865.6	2111.8	2392.9
Growing Degree Days > 10	848.9	997.0	1180.2	1385.9
Growing Season Length (days)	181.5	195.1	204.6	221.4
Corn Heat Units (CHU)	2489.1	2796.6	3143.4	3541.9
Corn Season Length (days)	151.2	161.5	171.2	182.4
Freeze Free Season (days)	198.7	224.5	244.8	263.1
Days With Rain	112.3	124.9	129.7	134.3
Days With Snow	41.3	48.7	40.6	33.8
Freeze-Thaw Cycles - Annual	78.3	75.0	66.6	61.2
Winter	26.7	29.7	31.7	35.1
Spring	35.3	32.0	24.7	18.9
Summer	0.0	0.0	0.0	0.0
Autumn	16.3	13.4	10.2	7.3
Water Surplus (mm)	658.5	645.3	659.1	666.7
Water Deficit (mm)	38.4	42.4	50.7	61.4
Δ Intensity Short Period Rainfall (%)	0	5	9	16

	2000	**2025**	**2055**	**2085**	**2100**
Total Sea Level Rise (m)		0.14 ± 0.03	0.40 ± 0.15	0.78 ± 0.36	1.00 ± 0.48
Extreme TSL - 10 Yr Ret Period	2.86 ± 0.20	3.00 ± 0.23	3.26 ± 0.35	3.64 ± 0.56	3.86 ± 0.68
Extreme TSL - 25 Yr Ret Period	3.09 ± 0.20	3.23 ± 0.23	3.49 ± 0.35	3.87 ± 0.56	4.09 ± 0.68
Extreme TSL - 50 Yr Ret Period	3.27 ± 0.20	3.41 ± 0.23	3.67 ± 0.35	4.05 ± 0.56	4.27 ± 0.68
Extreme TSL - 100 Yr Ret Period	3.44 ± 0.20	3.58 ± 0.23	3.84 ± 0.35	4.22 ± 0.56	4.44 ± 0.68

Table A 3: Summerside, Climate Station Summerside A (id: 8300700) @ 46.44N 63.83W, CHS site Summerside

Parameter	1980s	2020s		2050s		2080s	
	Value	**Value**	**SD**	**Value**	**SD**	**Value**	**SD**
Temperature - Annual	5.6	6.8	0.5	8.1	0.7	9.4	1.1
Winter	-6.4	-5.0	0.7	-3.3	1.0	-1.7	1.4
Spring	3.1	4.2	0.5	5.4	0.8	6.6	1.2
Summer	17.5	18.6	0.5	19.8	0.8	21.0	1.1
Autumn	8.1	9.3	0.4	10.4	0.7	11.8	1.0
Precipitation - Annual	1078.2	1110.6	25.3	1131.2	31.7	1167.3	46.4
Winter	280.4	295.7	10.7	307.9	16.7	324.4	24.5
Spring	257.5	267.1	10.3	273.8	14.6	287.9	19.3
Summer	257.4	263.0	10.8	263.6	16.2	262.5	24.3
Autumn	282.9	286.0	11.6	288.5	13.6	297.4	19.6

	1980s	**2020s**	**2050s**	**2080s**
Heating Degree Days	4620.8	4255.3	3864.6	3471.5
Cooling Degree Days	111.2	169.7	254.8	360.1
Hot Days (Tmax > 30)	1.0	2.6	6.2	12.7
Very Hot Days (Tmax > 35)	0.0	0.0	0.1	0.3
Cold Days (Tmax < -10)	10.1	7.5	4.4	2.6
Very Cold Days (Tmax < -20)	0.1	0.0	0.0	0.0
Growing Degree Days > 5	1717.8	1923.3	2172.3	2456.8
Growing Degree Days > 10	889.1	1040.9	1228.3	1437.9
Growing Season Length (days)	184.0	195.6	204.9	225.2
Corn Heat Units (CHU)	2186.0	2441.3	2727.7	3066.3
Corn Season Length (days)	159.0	168.5	176.4	191.1
Freeze Free Season (days)	171.4	189.2	206.6	222.1
Days With Rain	131.3	145.0	152.3	159.5
Days With Snow	64.3	60.2	50.4	42.5
Freeze-Thaw Cycles - Annual	86.1	81.6	72.6	66.6
Winter	31.7	34.5	36.5	39.4
Spring	36.4	33.1	26.1	20.3
Summer	0.0	0.0	0.0	0.0
Autumn	17.9	14.1	10.1	7.0
Water Surplus (mm)	612.8	622.6	622.2	639.3
Water Deficit (mm)	40.6	45.2	54.5	66.5
Δ Intensity Short Period Rainfall (%)	0	5	9	16

	2000	**2025**	**2055**	**2085**	**2100**
Total Sea Level Rise (m)		0.14 ± 0.03	0.40 ± 0.15	0.78 ± 0.36	1.00 ± 0.48
Extreme TSL - 10 Yr Ret Period	3.31 ± 0.20	3.45 ± 0.23	3.71 ± 0.35	4.09 ± 0.56	4.31 ± 0.68
Extreme TSL - 25 Yr Ret Period	3.48 ± 0.20	3.62 ± 0.23	3.88 ± 0.35	4.26 ± 0.56	4.48 ± 0.68
Extreme TSL - 50 Yr Ret Period	3.60 ± 0.20	3.74 ± 0.23	4.00 ± 0.35	4.38 ± 0.56	4.60 ± 0.68
Extreme TSL - 100 Yr Ret Period	3.73 ± 0.20	3.87 ± 0.23	4.13 ± 0.35	4.51 ± 0.56	4.73 ± 0.68

Table A 4: North Shore – Cavendish, Climate Station Long River (id: 8300500) @ 46.50N 63.55W, CHS site Rustico

Parameter	1980s	2020s		2050s		2080s	
	Value	**Value**	**SD**	**Value**	**SD**	**Value**	**SD**
Temperature - Annual	5.4	6.5	0.5	7.7	0.8	9.0	1.1
Winter	-6.6	-5.3	0.7	-3.8	1.0	-2.4	1.4
Spring	3.1	4.1	0.5	5.2	0.9	6.4	1.3
Summer	17.0	18.0	0.5	19.2	0.7	20.3	1.1
Autumn	8.1	9.1	0.4	10.2	0.7	11.5	1.1
Precipitation - Annual	1041.4	1069.7	28.8	1083.7	35.3	1115.2	53.0
Winter	241.2	251.7	9.2	259.6	13.0	271.4	18.7
Spring	234.5	243.3	9.6	248.7	13.2	261.1	17.7
Summer	263.9	268.3	14.3	266.3	17.7	264.8	26.7
Autumn	301.7	304.8	12.1	306.3	14.9	313.6	23.3

	1980s	**2020s**	**2050s**	**2080s**
Heating Degree Days	4675.3	4331.7	3964.8	3596.7
Cooling Degree Days	100.1	150.6	225.8	321.0
Hot Days (Tmax > 30)	0.8	2.8	6.8	13.2
Very Hot Days (Tmax > 35)	0.0	0.0	0.1	0.4
Cold Days (Tmax < -10)	11.5	9.1	6.6	4.5
Very Cold Days (Tmax < -20)	0.2	0.1	0.0	0.0
Growing Degree Days > 5	1666.9	1859.9	2095.0	2362.2
Growing Degree Days > 10	848.2	989.6	1163.4	1360.1
Growing Season Length (days)	166.8	176.6	189.2	208.9
Corn Heat Units (CHU)	2449.7	2738.4	3077.0	3464.1
Corn Season Length (days)	138.2	147.8	158.4	171.5
Freeze Free Season (days)	197.6	218.8	242.0	259.2
Days With Rain	106.4	118.7	123.6	127.4
Days With Snow	37.5	46.1	39.3	33.5
Freeze-Thaw Cycles - Annual	86.7	84.6	72.8	65.4
Winter	29.3	31.5	33.6	35.1
Spring	37.2	35.5	26.4	20.8
Summer	0.2	0.1	0.0	0.0
Autumn	19.9	17.5	12.8	9.5
Water Surplus (mm)	573.1	558.1	548.8	554.6
Water Deficit (mm)	40.4	42.4	51.5	61.9
Δ Intensity Short Period Rainfall (%)	0	5	9	16

	2000	**2025**	**2055**	**2085**	**2100**
Total Sea Level Rise (m)		0.16 ± 0.03	0.44 ± 0.15	0.84 ± 0.36	1.08 ± 0.48
Extreme TSL - 10 Yr Ret Period	2.30 ± 0.10	2.46 ± 0.13	2.74 ± 0.25	3.14 ± 0.46	3.38 ± 0.58
Extreme TSL - 25 Yr Ret Period	2.45 ± 0.10	2.61 ± 0.13	2.89 ± 0.25	3.29 ± 0.46	3.53 ± 0.58
Extreme TSL - 50 Yr Ret Period	2.56 ± 0.10	2.72 ± 0.13	3.00 ± 0.25	3.40 ± 0.46	3.64 ± 0.58
Extreme TSL - 100 Yr Ret Period	2.68 ± 0.10	2.84 ± 0.13	3.12 ± 0.25	3.52 ± 0.46	3.76 ± 0.58

Table A 5: Charlottetown, Climate Station Charlottetown A (id: 8300300) @ 46.29N 63.13W, CHS site Charlottetown

Parameter	1980s	2020s		2050s		2080s	
	Value	**Value**	**SD**	**Value**	**SD**	**Value**	**SD**
Temperature - Annual	5.3	6.4	0.5	7.6	0.8	8.9	1.1
Winter	-6.6	-5.3	0.7	-3.9	1.0	-2.4	1.4
Spring	2.9	3.9	0.5	5.0	0.9	6.2	1.3
Summer	17.0	18.0	0.5	19.2	0.7	20.3	1.1
Autumn	7.9	9.0	0.4	10.1	0.7	11.4	1.1
Precipitation - Annual	1167.7	1199.4	32.3	1215.1	39.6	1250.3	59.4
Winter	313.8	327.6	11.9	337.7	16.9	353.1	24.3
Spring	277.3	287.6	11.4	294.0	15.6	308.6	20.9
Summer	263.0	267.4	14.3	265.4	17.7	263.9	26.6
Autumn	313.6	316.9	12.5	318.3	15.5	325.9	24.2

	1980s	**2020s**	**2050s**	**2080s**
Heating Degree Days	4709.4	4364.6	3996.2	3625.9
Cooling Degree Days	100.0	149.4	223.1	316.0
Hot Days (Tmax > 30)	0.7	2.2	5.3	12.3
Very Hot Days (Tmax > 35)	0.0	0.0	0.0	0.2
Cold Days (Tmax < -10)	11.6	9.1	6.0	4.1
Very Cold Days (Tmax < -20)	0.1	0.0	0.0	0.0
Growing Degree Days > 5	1653.8	1845.3	2079.6	2346.7
Growing Degree Days > 10	838.8	979.1	1152.6	1348.3
Growing Season Length (days)	180.5	190.6	204.7	219.9
Corn Heat Units (CHU)	2506.6	2773.3	3126.3	3520.7
Corn Season Length (days)	154.5	160.7	172.7	183.9
Freeze Free Season (days)	199.0	217.5	237.3	255.1
Days With Rain	130.3	144.0	150.2	157.5
Days With Snow	75.5	71.7	61.8	53.6
Freeze-Thaw Cycles - Annual	89.2	85.6	76.6	68.4
Winter	30.6	34.1	36.0	38.0
Spring	38.9	35.1	28.7	22.4
Summer	0.1	0.0	0.0	0.0
Autumn	19.6	16.4	12.0	8.0
Water Surplus (mm)	707.1	704.0	704.5	722.1
Water Deficit (mm)	44.1	48.6	58.4	69.7
Δ Intensity Short Period Rainfall (%)	0	5	9	16

	2000	**2025**	**2055**	**2085**	**2100**
Total Sea Level Rise (m)		0.15 ± 0.03	0.43 ± 0.15	0.83 ± 0.36	1.06 ± 0.48
Extreme TSL - 10 Yr Ret Period	4.14 ± 0.10	4.29 ± 0.13	4.57 ± 0.25	4.97 ± 0.58	5.20 ± 0.58
Extreme TSL - 25 Yr Ret Period	4.31 ± 0.10	4.46 ± 0.13	4.74 ± 0.25	5.14 ± 0.58	5.37 ± 0.58
Extreme TSL - 50 Yr Ret Period	4.43 ± 0.10	4.58 ± 0.13	4.86 ± 0.25	5.26 ± 0.58	5.49 ± 0.58
Extreme TSL - 100 Yr Ret Period	4.56 ± 0.10	4.71 ± 0.13	4.99 ± 0.25	5.39 ± 0.58	5.62 ± 0.58

Table A 6: Morell Mt. Stewart St. Peter's, Climate Station Bangor (id: 8300128) @ 46.35N 62.68W, CHS site St. Peter's Bay

Parameter	1980s	2020s		2050s		2080s	
	Value	**Value**	**SD**	**Value**	**SD**	**Value**	**SD**
Temperature - Annual	5.3	6.4	0.5	7.6	0.8	8.9	1.1
Winter	-6.4	-5.1	0.7	-3.6	1.0	-2.2	1.4
Spring	2.8	3.9	0.5	5.0	0.9	6.1	1.3
Summer	16.8	17.8	0.5	19.0	0.7	20.1	1.1
Autumn	7.9	9.0	0.4	10.1	0.7	11.4	1.1
Precipitation - Annual	1242.4	1276.1	34.4	1292.8	42.1	1330.4	63.1
Winter	334.1	348.7	12.7	359.5	18.0	375.9	25.9
Spring	276.7	287.0	11.4	293.4	15.5	308.0	20.9
Summer	265.7	270.1	14.4	268.1	17.9	266.6	26.9
Autumn	365.9	369.7	14.6	371.4	18.1	380.3	28.2

	1980s	**2020s**	**2050s**	**2080s**
Heating Degree Days	4711.6	4364.5	3992.0	3618.1
Cooling Degree Days	100.7	147.8	217.4	306.7
Hot Days (Tmax > 30)	1.1	3.8	7.5	14.3
Very Hot Days (Tmax > 35)	0.0	0.0	0.1	0.3
Cold Days (Tmax < -10)	10.9	8.9	5.6	3.7
Very Cold Days (Tmax < -20)	0.1	0.1	0.0	0.0
Growing Degree Days > 5	1625.9	1818.7	2053.9	2324.1
Growing Degree Days > 10	817.1	955.6	1126.7	1321.4
Growing Season Length (days)	165.6	180.8	196.9	211.3
Corn Heat Units (CHU)	2288.3	2569.9	2927.1	3282.5
Corn Season Length (days)	139.2	149.6	164.0	174.0
Freeze Free Season (days)	186.5	207.4	230.6	248.1
Days With Rain	126.0	138.1	143.9	148.8
Days With Snow	54.0	62.1	53.4	46.5
Freeze-Thaw Cycles - Annual	92.5	89.1	76.3	67.2
Winter	32.1	34.4	36.3	37.7
Spring	38.8	36.8	27.8	21.7
Summer	0.7	0.5	0.1	0.0
Autumn	20.9	17.4	12.2	7.9
Water Surplus (mm)	775.0	773.6	771.9	771.2
Water Deficit (mm)	38.1	40.6	49.1	59.2
Δ Intensity Short Period Rainfall (%)	0	5	9	16

	2000	**2025**	**2055**	**2085**	**2100**
Total Sea Level Rise (m)		0.15 ± 0.03	0.42 ± 0.15	0.82 ± 0.36	1.05 ± 0.48
Extreme TSL - 10 Yr Ret Period	2.12 ± 0.20	2.27 ± 0.23	2.54 ± 0.35	2.94 ± 0.56	3.17 ± 0.68
Extreme TSL - 25 Yr Ret Period	2.27 ± 0.20	2.42 ± 0.23	2.69 ± 0.35	3.09 ± 0.56	3.32 ± 0.68
Extreme TSL - 50 Yr Ret Period	2.38 ± 0.20	2.53 ± 0.23	2.80 ± 0.35	3.20 ± 0.56	3.43 ± 0.68
Extreme TSL - 100 Yr Ret Period	2.50 ± 0.20	2.65 ± 0.23	2.92 ± 0.35	3.32 ± 0.56	3.55 ± 0.68

Table A 7: Northeast Tip, Climate Station East Baltic (id: 8300416) @ 46.43N 62.17W, CHS site North Lake Harbour

Parameter	1980s	2020s		2050s		2080s	
	Value	**Value**	**SD**	**Value**	**SD**	**Value**	**SD**
Temperature - Annual	5.4	6.6	0.5	7.8	0.8	9.0	1.1
Winter	-5.6	-4.3	0.7	-2.8	1.0	-1.4	1.4
Spring	2.4	3.4	0.5	4.5	0.9	5.7	1.3
Summer	16.6	17.6	0.5	18.7	0.7	19.9	1.1
Autumn	8.3	9.4	0.4	10.5	0.7	11.8	1.1
Precipitation - Annual	1225.2	1258.4	33.8	1274.9	41.5	1311.9	62.3
Winter	315.5	329.3	12.0	339.5	17.0	354.9	24.5
Spring	262.1	271.9	10.8	278.0	14.7	291.7	19.8
Summer	274.9	279.5	14.9	277.4	18.5	275.9	27.8
Autumn	372.7	376.6	14.9	378.3	18.4	387.4	28.7

	1980s	**2020s**	**2050s**	**2080s**
Heating Degree Days	4650.1	4300.7	3926.9	3551.9
Cooling Degree Days	90.3	135.1	203.3	291.7
Hot Days (Tmax > 30)	1.0	2.4	5.4	10.1
Very Hot Days (Tmax > 35)	0.0	0.0	0.2	0.2
Cold Days (Tmax < -10)	9.2	7.5	4.8	3.4
Very Cold Days (Tmax < -20)	0.1	0.0	0.0	0.0
Growing Degree Days > 5	1596.2	1786.9	2019.9	2287.9
Growing Degree Days > 10	793.7	931.3	1101.7	1294.8
Growing Season Length (days)	181.2	192.9	213.0	228.1
Corn Heat Units (CHU)	2235.8	2501.1	2856.4	3219.4
Corn Season Length (days)	153.4	163.3	180.7	190.6
Freeze Free Season (days)	191.3	213.0	236.5	252.8
Days With Rain	136.3	148.0	153.8	159.5
Days With Snow	51.9	60.1	50.7	43.3
Freeze-Thaw Cycles - Annual	79.4	76.1	63.3	56.1
Winter	30.6	32.4	33.1	33.5
Spring	34.6	33.5	23.4	18.6
Summer	0.0	0.0	0.0	0.0
Autumn	14.1	10.3	6.8	4.0
Water Surplus (mm)	764.6	767.7	749.2	745.2
Water Deficit (mm)	35.8	39.4	46.9	55.3
Δ Intensity Short Period Rainfall (%)	0	5	9	16

	2000	**2025**	**2055**	**2085**	**2100**
Total Sea Level Rise (m)		0.16 ± 0.03	0.45 ± 0.15	0.86 ± 0.36	1.10 ± 0.48
Extreme TSL - 10 Yr Ret Period	1.52 ± 0.20	1.68 ± 0.23	1.97 ± 0.35	2.38 ± 0.56	2.62 ± 0.68
Extreme TSL - 25 Yr Ret Period	1.67 ± 0.20	1.83 ± 0.23	2.12 ± 0.35	2.53 ± 0.56	2.77 ± 0.68
Extreme TSL - 50 Yr Ret Period	1.78 ± 0.20	1.94 ± 0.23	2.23 ± 0.35	2.64 ± 0.56	2.88 ± 0.68
Extreme TSL - 100 Yr Ret Period	1.90 ± 0.20	2.06 ± 0.23	2.35 ± 0.35	2.76 ± 0.56	3.00 ± 0.68

Table A 8: North Shore, Climate Station Monticello (id: 8300447) @ 46.47N 62.47W, CHS site Naufrage

Parameter	1980s	2020s		2050s		2080s	
	Value	**Value**	**SD**	**Value**	**SD**	**Value**	**SD**
Temperature - Annual	5.5	6.6	0.5	7.8	0.8	9.1	1.1
Winter	-5.8	-4.5	0.7	-3.0	1.0	-1.6	1.4
Spring	2.6	3.6	0.5	4.7	0.9	5.9	1.3
Summer	16.8	17.8	0.5	19.0	0.7	20.1	1.1
Autumn	8.4	9.4	0.4	10.5	0.7	11.8	1.1
Precipitation - Annual	1163.7	1195.3	32.2	1211.0	39.4	1246.1	59.2
Winter	308.7	322.2	11.7	332.2	16.6	347.3	23.9
Spring	254.0	263.5	10.5	269.3	14.2	282.7	19.1
Summer	258.8	263.1	14.1	261.1	17.4	259.7	26.2
Autumn	342.3	345.8	13.7	347.4	17.0	355.7	26.4

	1980s	**2020s**	**2050s**	**2080s**
Heating Degree Days	4643.9	4298.0	3926.7	3554.9
Cooling Degree Days	109.6	157.8	228.7	320.1
Hot Days (Tmax > 30)	1.0	3.7	8.4	14.1
Very Hot Days (Tmax > 35)	0.0	0.0	0.1	0.4
Cold Days (Tmax < -10)	9.0	7.3	4.9	3.2
Very Cold Days (Tmax < -20)	0.0	0.0	0.0	0.0
Growing Degree Days > 5	1633.9	1826.6	2062.1	2332.6
Growing Degree Days > 10	828.8	966.6	1137.2	1331.5
Growing Season Length (days)	168.2	179.1	201.4	221.5
Corn Heat Units (CHU)	2325.7	2562.9	2884.7	3244.1
Corn Season Length (days)	143.6	157.7	171.9	185.5
Freeze Free Season (days)	191.5	213.8	237.3	254.8
Days With Rain	119.9	134.4	138.7	142.7
Days With Snow	39.7	50.4	42.6	36.2
Freeze-Thaw Cycles - Annual	88.6	84.8	71.6	64.4
Winter	31.8	33.0	35.1	36.9
Spring	39.2	37.9	27.4	21.9
Summer	0.4	0.3	0.0	0.0
Autumn	17.1	13.6	9.1	5.6
Water Surplus (mm)	694.8	689.9	676.2	679.2
Water Deficit (mm)	43.2	47.5	56.6	67.3
Δ Intensity Short Period Rainfall (%)	0	5	9	16

	2000	**2025**	**2055**	**2085**	**2100**
Total Sea Level Rise (m)		0.16 ± 0.03	0.45 ± 0.15	0.86 ± 0.36	1.10 ± 0.48
Extreme TSL - 10 Yr Ret Period	2.32 ± 0.20	2.48 ± 0.23	2.77 ± 0.35	3.18 ± 0.56	3.42 ± 0.68
Extreme TSL - 25 Yr Ret Period	2.47 ± 0.20	2.63 ± 0.23	2.92 ± 0.35	3.33 ± 0.56	3.57 ± 0.68
Extreme TSL - 50 Yr Ret Period	2.58 ± 0.20	2.74 ± 0.23	3.03 ± 0.35	3.44 ± 0.56	3.68 ± 0.68
Extreme TSL - 100 Yr Ret Period	2.70 ± 0.20	2.86 ± 0.23	3.15 ± 0.35	3.56 ± 0.56	3.80 ± 0.68

Table A 9: Southeast, Climate Station Alliston (id: 8300100) @ 46.07N 62.60W, CHS site Georgetown

Parameter	1980s	2020s		2050s		2080s	
	Value	**Value**	**SD**	**Value**	**SD**	**Value**	**SD**
Temperature - Annual	5.8	6.9	0.4	8.0	0.6	9.2	1.0
Winter	-6.0	-4.8	0.6	-3.5	0.8	-2.2	1.2
Spring	3.3	4.3	0.5	5.4	0.8	6.5	1.2
Summer	17.4	18.4	0.4	19.5	0.6	20.6	1.0
Autumn	8.4	9.5	0.4	10.6	0.6	11.8	1.0
Precipitation - Annual	1196.7	1224.9	34.2	1231.6	38.7	1265.3	52.7
Winter	312.5	324.7	11.3	330.9	15.4	347.3	18.6
Spring	260.8	268.8	11.0	273.0	14.2	283.0	19.0
Summer	276.2	281.0	16.4	278.6	20.3	279.1	34.2
Autumn	347.3	350.1	15.6	347.8	17.1	353.7	28.3

	1980s	**2020s**	**2050s**	**2080s**
Heating Degree Days	4544.2	4220.9	3873.5	3537.5
Cooling Degree Days	117.1	172.5	251.4	344.7
Hot Days (Tmax > 30)	1.5	4.3	8.9	14.7
Very Hot Days (Tmax > 35)	0.0	0.0	0.1	0.3
Cold Days (Tmax < -10)	9.0	7.7	5.4	3.9
Very Cold Days (Tmax < -20)	0.2	0.1	0.0	0.0
Growing Degree Days > 5	1726.2	1924.4	2163.1	2421.8
Growing Degree Days > 10	888.1	1033.7	1211.0	1402.2
Growing Season Length (days)	184.6	193.2	204.1	223.7
Corn Heat Units (CHU)	2323.4	2563.8	2781.3	3085.8
Corn Season Length (days)	156.0	162.5	173.8	185.1
Freeze Free Season (days)	180.5	197.9	216.1	230.6
Days With Rain	130.4	142.4	146.2	150.3
Days With Snow	42.7	55.5	47.3	40.4
Freeze-Thaw Cycles - Annual	91.9	89.4	79.9	72.8
Winter	35.3	36.9	39.3	40.9
Spring	38.4	36.9	30.0	24.2
Summer	0.1	0.1	0.0	0.0
Autumn	18.0	15.6	10.6	7.7
Water Surplus (mm)	687.2	659.7	662.7	674.6
Water Deficit (mm)	46.1	51.1	61.1	71.4
Δ Intensity Short Period Rainfall (%)	0	5	9	16

	2000	**2025**	**2055**	**2085**	**2100**
Total Sea Level Rise (m)		0.16 ± 0.03	0.45 ± 0.15	0.86 ± 0.36	1.10 ± 0.48
Extreme TSL - 10 Yr Ret Period	3.08 ± 0.20	3.24 ± 0.23	3.53 ± 0.35	3.94 ± 0.56	4.18 ± 0.68
Extreme TSL - 25 Yr Ret Period	3.22 ± 0.20	3.38 ± 0.23	3.67 ± 0.35	4.08 ± 0.56	4.32 ± 0.68
Extreme TSL - 50 Yr Ret Period	3.36 ± 0.20	3.52 ± 0.23	3.81 ± 0.35	4.22 ± 0.56	4.46 ± 0.68
Extreme TSL - 100 Yr Ret Period	3.50 ± 0.20	3.66 ± 0.23	3.95 ± 0.35	4.36 ± 0.56	4.60 ± 0.68

Table A 10: Prince Edward Island Summary

Parameter	1980s	2020s	2050s	2080s
Temperature - Annual	5.4	6.5	7.8	9.0
Winter	-6.4	-5.0	-3.5	-2.0
Spring	2.8	3.8	5.0	6.2
Summer	17.0	18.0	19.2	20.4
Autumn	8.1	9.2	10.3	11.6
Precipitation - Annual	1147.0	1178.8	1195.2	1230.8
Winter	296.6	310.4	320.6	336.2
Spring	260.3	269.8	275.9	289.4
Summer	264.1	268.9	267.7	266.6
Autumn	326.0	329.3	330.8	339.2
Heating Degree Days	4675.1	4324.0	3948.2	3572.2
Cooling Degree Days	104.3	155.5	231.4	326.6
Hot Days (Tmax > 30)	1.1	3.3	7.2	13.3
Very Hot Days (Tmax > 35)	0.0	0.0	0.1	0.4
Cold Days (Tmax < -10)	10.6	8.4	5.6	3.6
Very Cold Days (Tmax < -20)	0.1	0.0	0.0	0.0
Growing Degree Days > 5	1656.9	1853.1	2091.9	2363.5
Growing Degree Days > 10	843.4	986.2	1162.3	1360.2
Growing Season Length (days)	175.0	186.4	201.1	218.5
Corn Heat Units (CHU)	2353.4	2625.5	2951.9	3322.1
Corn Season Length (days)	147.5	157.2	169.7	182.0
Freeze Free Season (days)	190.1	211.4	232.6	249.7
Days With Rain	122.9	136.0	141.5	146.7
Days With Snow	50.1	56.5	47.9	40.8
Freeze-Thaw Cycles - Annual	86.7	83.2	72.5	65.3
Winter	30.8	33.1	35.1	37.0
Spring	37.4	35.0	26.7	21.0
Summer	0.2	0.1	0.0	0.0
Autumn	18.2	15.0	10.7	7.3
Water Surplus (mm)	675.1	668.4	665.5	673.6
Water Deficit (mm)	41.4	45.1	54.2	64.9
Δ Intensity Short Period Rainfall (%)	0	5	9	16

Table A 11: Amherst, Climate Station Nappan Cda (id: 8203700) @ 45.77N 64.25W, CHS site Burncoat Head

Parameter	1980s	2020s		2050s		2080s	
	Value	**Value**	**SD**	**Value**	**SD**	**Value**	**SD**
Temperature - Annual	5.8	6.9	0.4	8.2	0.6	9.4	1.0
Winter	-6.0	-4.7	0.6	-3.3	0.8	-1.9	1.1
Spring	3.9	5.0	0.4	6.1	0.7	7.2	1.1
Summer	17.1	18.2	0.4	19.3	0.7	20.5	1.0
Autumn	8.2	9.3	0.4	10.5	0.6	11.8	0.9
Precipitation - Annual	1174.8	1207.1	28.8	1217.1	33.4	1253.2	43.7
Winter	319.6	335.2	12.7	343.2	16.4	361.9	21.0
Spring	285.0	294.4	12.1	298.7	16.2	310.4	21.3
Summer	262.5	266.9	15.5	266.0	20.6	266.4	34.2
Autumn	307.7	311.4	14.0	311.0	14.8	318.0	22.8

	1980s	**2020s**	**2050s**	**2080s**
Heating Degree Days	4516.7	4167.2	3797.1	3439.6
Cooling Degree Days	85.7	140.8	222.6	322.9
Hot Days (Tmax > 30)	0.6	2.7	6.8	14.6
Very Hot Days (Tmax > 35)	0.0	0.0	0.0	0.1
Cold Days (Tmax < -10)	8.4	7.0	4.9	2.9
Very Cold Days (Tmax < -20)	0.1	0.1	0.0	0.0
Growing Degree Days > 5	1713.5	1929.5	2187.7	2471.0
Growing Degree Days > 10	860.1	1017.0	1206.9	1414.3
Growing Season Length (days)	166.7	176.6	194.2	211.2
Corn Heat Units (CHU)	2468.5	2775.2	3140.5	3501.0
Corn Season Length (days)	136.9	146.0	159.1	170.2
Freeze Free Season (days)	197.3	221.7	241.5	257.0
Days With Rain	124.4	136.3	140.3	144.4
Days With Snow	41.3	50.6	42.7	36.9
Freeze-Thaw Cycles - Annual	95.5	89.1	79.7	72.6
Winter	33.8	35.2	37.6	38.7
Spring	38.3	34.1	26.8	21.6
Summer	0.4	0.3	0.1	0.0
Autumn	23.0	19.6	15.3	12.2
Water Surplus (mm)	708.3	689.3	688.7	694.9
Water Deficit (mm)	43.0	47.9	57.6	68.1
Δ Intensity Short Period Rainfall (%)	0	5	9	16

	2000	**2025**	**2055**	**2085**	**2100**
Total Sea Level Rise (m)		0.15 ± 0.03	0.42 ± 0.15	0.82 ± 0.36	1.05 ± 0.48
Extreme TSL - 10 Yr Ret Period	14.25 ± 0.20	14.40 ± 0.23	14.67 ± 0.35	15.07 ± 0.56	15.30 ± 0.68
Extreme TSL - 25 Yr Ret Period	14.36 ± 0.20	14.51 ± 0.23	14.78 ± 0.35	15.18 ± 0.56	15.41 ± 0.68
Extreme TSL - 50 Yr Ret Period	14.44 ± 0.20	14.59 ± 0.23	14.86 ± 0.35	15.26 ± 0.56	15.49 ± 0.68
Extreme TSL - 100 Yr Ret Period	14.53 ± 0.20	14.68 ± 0.23	14.95 ± 0.35	15.35 ± 0.56	15.58 ± 0.68

Table A 12: Truro, Climate Station Truro (id: 8205990) @ 45.37N 63.27W, CHS site Joggins

Parameter	1980s	2020s		2050s		2080s	
	Value	**Value**	**SD**	**Value**	**SD**	**Value**	**SD**
Temperature - Annual	5.8	6.9	0.4	8.0	0.6	9.2	1.0
Winter	-5.6	-4.5	0.6	-3.2	0.8	-1.9	1.2
Spring	3.9	4.9	0.5	6.0	0.8	7.1	1.2
Summer	16.9	17.9	0.4	19.1	0.6	20.2	1.0
Autumn	7.9	9.0	0.4	10.1	0.6	11.3	1.0
Precipitation - Annual	1204.0	1232.3	34.4	1239.0	38.9	1272.9	53.0
Winter	333.4	346.5	12.1	353.1	16.5	370.5	19.9
Spring	285.2	293.9	12.0	298.5	15.5	309.5	20.7
Summer	261.5	266.1	15.5	263.8	19.2	264.3	32.3
Autumn	323.8	326.4	14.6	324.3	15.9	329.8	26.4

	1980s	**2020s**	**2050s**	**2080s**
Heating Degree Days	4524.1	4194.0	3839.4	3496.7
Cooling Degree Days	89.9	138.5	210.2	297.0
Hot Days (Tmax > 30)	1.3	3.2	7.7	13.9
Very Hot Days (Tmax > 35)	0.0	0.0	0.1	0.3
Cold Days (Tmax < -10)	6.8	5.4	3.3	2.4
Very Cold Days (Tmax < -20)	0.0	0.0	0.0	0.0
Growing Degree Days > 5	1670.8	1873.4	2118.4	2384.7
Growing Degree Days > 10	828.3	972.0	1148.2	1340.7
Growing Season Length (days)	169.0	182.5	201.5	216.4
Corn Heat Units (CHU)	2420.5	2697.4	3052.0	3384.9
Corn Season Length (days)	137.8	147.0	160.9	171.0
Freeze Free Season (days)	188.7	210.4	230.8	247.9
Days With Rain	137.7	150.7	153.9	157.4
Days With Snow	50.1	57.7	50.2	43.7
Freeze-Thaw Cycles - Annual	108.3	101.3	89.9	80.1
Winter	38.1	40.0	41.8	42.9
Spring	41.5	38.4	31.1	24.7
Summer	0.3	0.2	0.0	0.0
Autumn	28.4	22.7	17.0	12.6
Water Surplus (mm)	813.1	761.8	744.9	768.1
Water Deficit (mm)	41.7	45.8	55.2	64.9
Δ Intensity Short Period Rainfall (%)	0	5	9	16

	2000	**2025**	**2055**	**2085**	**2100**
Total Sea Level Rise (m)		0.15 ± 0.03	0.42 ± 0.15	0.82 ± 0.36	1.05 ± 0.48
Extreme TSL - 10 Yr Ret Period	17.42 ± 0.20	17.57 ± 0.23	17.84 ± 0.35	18.24 ± 0.56	18.47 ± 0.68
Extreme TSL - 25 Yr Ret Period	17.54 ± 0.20	17.69 ± 0.23	17.96 ± 0.35	18.36 ± 0.56	18.59 ± 0.68
Extreme TSL - 50 Yr Ret Period	17.63 ± 0.20	17.78 ± 0.23	18.05 ± 0.35	18.45 ± 0.56	18.68 ± 0.68
Extreme TSL - 100 Yr Ret Period	17.73 ± 0.20	17.88 ± 0.23	18.15 ± 0.35	18.55 ± 0.56	18.78 ± 0.68

Table A 13: Pictou/Antigonish, Climate Station Collegeville (id: 8201000) @ 45.48N 62.02W, CHS site Pictou

Parameter	1980s	2020s		2050s		2080s	
	Value	**Value**	**SD**	**Value**	**SD**	**Value**	**SD**
Temperature - Annual	5.7	6.8	0.4	8.0	0.6	9.2	1.0
Winter	-5.4	-4.3	0.6	-3.0	0.8	-1.7	1.2
Spring	3.5	4.4	0.5	5.5	0.8	6.6	1.2
Summer	16.8	17.8	0.4	19.0	0.6	20.1	1.0
Autumn	8.1	9.2	0.4	10.3	0.6	11.5	1.0
Precipitation - Annual	1383.3	1415.8	39.5	1423.6	44.7	1462.5	60.9
Winter	363.6	377.8	13.2	385.1	17.9	404.0	21.8
Spring	324.3	334.3	13.7	339.5	17.6	352.0	23.6
Summer	291.5	296.6	17.3	294.1	21.4	294.7	36.0
Autumn	403.9	407.1	18.1	404.4	19.9	411.3	32.9

	1980s	**2020s**	**2050s**	**2080s**
Heating Degree Days	4556.0	4226.0	3869.7	3525.0
Cooling Degree Days	104.4	153.1	223.0	307.7
Hot Days (Tmax > 30)	3.1	6.3	11.6	18.6
Very Hot Days (Tmax > 35)	0.0	0.1	0.5	1.1
Cold Days (Tmax < -10)	6.9	5.9	4.5	3.2
Very Cold Days (Tmax < -20)	0.0	0.0	0.0	0.0
Growing Degree Days > 5	1652.7	1852.4	2094.2	2357.5
Growing Degree Days > 10	824.9	966.8	1141.0	1331.1
Growing Season Length (days)	161.0	173.1	190.9	208.6
Corn Heat Units (CHU)	2342.1	2632.3	2972.6	3333.5
Corn Season Length (days)	131.6	143.7	155.6	169.5
Freeze Free Season (days)	188.7	214.1	235.6	253.4
Days With Rain	108.2	120.7	124.2	127.1
Days With Snow	35.0	51.7	45.2	38.8
Freeze-Thaw Cycles - Annual	105.7	99.1	87.3	77.4
Winter	37.3	37.6	40.1	40.8
Spring	41.5	39.6	32.1	25.5
Summer	1.1	0.8	0.3	0.1
Autumn	25.8	21.1	14.8	11.0
Water Surplus (mm)	968.3	886.8	877.4	881.5
Water Deficit (mm)	28.0	31.4	39.0	46.6
Δ Intensity Short Period Rainfall (%)	0	5	9	16

	2000	**2025**	**2055**	**2085**	**2100**
Total Sea Level Rise (m)		0.15 ± 0.03	0.42 ± 0.15	0.82 ± 0.36	1.05 ± 0.48
Extreme TSL - 10 Yr Ret Period	3.17 ± 0.10	3.32 ± 0.13	3.59 ± 0.25	3.99 ± 0.46	4.22 ± 0.58
Extreme TSL - 25 Yr Ret Period	3.32 ± 0.10	3.47 ± 0.13	3.74 ± 0.25	4.14 ± 0.46	4.37 ± 0.58
Extreme TSL - 50 Yr Ret Period	3.43 ± 0.10	3.58 ± 0.13	3.85 ± 0.25	4.25 ± 0.46	4.48 ± 0.58
Extreme TSL - 100 Yr Ret Period	3.54 ± 0.10	3.69 ± 0.13	3.96 ± 0.25	4.36 ± 0.46	4.59 ± 0.58

Table A 14: Cape Breton West, Climate Station Cheticamp (id: 8200825) @ 46.65N 60.95W, CHS site Cheticamp

Parameter	1980s	2020s		2050s		2080s	
	Value	**Value**	**SD**	**Value**	**SD**	**Value**	**SD**
Temperature - Annual	6.2	7.2	0.5	8.3	0.8	9.6	1.2
Winter	-4.2	-3.0	0.7	-1.7	1.1	-0.4	1.5
Spring	3.3	4.2	0.5	5.3	0.9	6.4	1.4
Summer	16.8	17.8	0.5	18.9	0.7	20.0	1.2
Autumn	8.8	9.8	0.4	10.9	0.7	12.1	1.1
Precipitation - Annual	1388.7	1419.8	39.8	1441.2	50.1	1480.6	77.1
Winter	417.6	432.1	16.1	446.8	20.6	465.0	30.6
Spring	275.4	285.2	12.5	292.0	15.8	305.7	21.2
Summer	287.3	291.0	13.2	288.8	16.4	288.0	27.2
Autumn	408.5	411.0	16.9	413.0	22.2	422.1	33.8

	1980s	**2020s**	**2050s**	**2080s**
Heating Degree Days	4389.5	4073.9	3724.5	3376.0
Cooling Degree Days	107.5	153.1	220.1	306.4
Hot Days (Tmax > 30)	0.9	2.0	4.8	9.2
Very Hot Days (Tmax > 35)	0.0	0.0	0.0	0.1
Cold Days (Tmax < -10)	6.1	5.6	3.8	2.5
Very Cold Days (Tmax < -20)	0.0	0.0	0.0	0.0
Growing Degree Days > 5	1698.8	1890.0	2126.8	2394.0
Growing Degree Days > 10	846.3	984.1	1157.3	1353.3
Growing Season Length (days)	193.1	199.3	219.4	231.3
Corn Heat Units (CHU)	2277.5	2538.9	2852.0	3180.0
Corn Season Length (days)	162.5	170.9	183.6	192.5
Freeze Free Season (days)	190.6	210.4	227.5	242.2
Days With Rain	142.7	161.0	166.5	172.1
Days With Snow	62.2	67.9	59.8	51.8
Freeze-Thaw Cycles - Annual	83.7	78.2	70.4	63.2
Winter	36.2	35.5	38.2	38.0
Spring	35.1	32.7	27.1	22.1
Summer	0.1	0.0	0.0	0.0
Autumn	12.3	10.0	5.2	3.1
Water Surplus (mm)	880.0	887.4	861.5	850.6
Water Deficit (mm)	30.0	33.6	40.8	48.7
Δ Intensity Short Period Rainfall (%)	0	5	9	16

	2000	**2025**	**2055**	**2085**	**2100**
Total Sea Level Rise (m)		0.16 ± 0.03	0.45 ± 0.15	0.86 ± 0.36	1.10 ± 0.48
Extreme TSL - 10 Yr Ret Period	2.33 ± 0.20	2.49 ± 0.23	2.78 ± 0.35	3.19 ± 0.56	3.43 ± 0.68
Extreme TSL - 25 Yr Ret Period	2.47 ± 0.20	2.63 ± 0.23	2.92 ± 0.35	3.33 ± 0.56	3.57 ± 0.68
Extreme TSL - 50 Yr Ret Period	2.57 ± 0.20	2.73 ± 0.23	3.02 ± 0.35	3.43 ± 0.56	3.67 ± 0.68
Extreme TSL - 100 Yr Ret Period	2.68 ± 0.20	2.84 ± 0.23	3.13 ± 0.35	3.54 ± 0.56	3.78 ± 0.68

Table A 15: Sydney, Climate Station Sydney A (id: 8205700) @ 46.17N 60.05W, CHS site Sydney

Parameter	1980s	2020s		2050s		2080s	
	Value	**Value**	**SD**	**Value**	**SD**	**Value**	**SD**
Temperature - Annual	5.5	6.5	0.4	7.6	0.7	8.7	1.1
Winter	-4.8	-3.8	0.6	-2.6	0.9	-1.4	1.3
Spring	2.4	3.3	0.5	4.3	0.8	5.4	1.2
Summer	16.2	17.2	0.5	18.2	0.6	19.3	1.1
Autumn	8.2	9.2	0.4	10.3	0.6	11.5	1.1
Precipitation - Annual	1502.2	1530.6	45.8	1539.7	56.9	1577.6	76.3
Winter	447.3	461.6	16.0	471.5	22.0	491.4	27.1
Spring	372.2	382.4	16.2	389.0	20.3	403.1	27.4
Summer	272.5	277.0	15.7	273.0	18.9	273.4	31.3
Autumn	410.2	410.2	19.2	407.6	22.6	413.0	35.5

	1980s	**2020s**	**2050s**	**2080s**
Heating Degree Days	4615.1	4309.0	3965.3	3633.0
Cooling Degree Days	83.5	122.2	180.9	255.0
Hot Days (Tmax > 30)	2.4	4.1	7.6	12.8
Very Hot Days (Tmax > 35)	0.0	0.0	0.2	0.5
Cold Days (Tmax < -10)	5.3	4.3	2.9	2.0
Very Cold Days (Tmax < -20)	0.0	0.0	0.0	0.0
Growing Degree Days > 5	1535.9	1714.4	1936.4	2179.1
Growing Degree Days > 10	745.7	872.1	1030.6	1204.4
Growing Season Length (days)	173.7	185.7	199.5	216.6
Corn Heat Units (CHU)	2262.5	2506.0	2839.9	3203.4
Corn Season Length (days)	144.2	153.6	165.4	181.9
Freeze Free Season (days)	196.1	213.5	235.8	254.1
Days With Rain	143.2	151.3	156.7	163.5
Days With Snow	70.4	72.3	61.7	53.2
Freeze-Thaw Cycles - Annual	103.9	98.4	87.1	77.2
Winter	37.4	39.0	42.1	43.1
Spring	45.6	42.9	34.1	27.5
Summer	0.3	0.1	0.0	0.0
Autumn	20.5	16.5	10.9	6.7
Water Surplus (mm)	1099.6	1058.8	1046.9	1060.0
Water Deficit (mm)	34.0	37.9	46.7	55.1
Δ Intensity Short Period Rainfall (%)	0	5	9	16

	2000	**2025**	**2055**	**2085**	**2100**
Total Sea Level Rise (m)		0.16 ± 0.03	0.45 ± 0.15	0.86 ± 0.36	1.10 ± 0.48
Extreme TSL - 10 Yr Ret Period	1.95 ± 0.10	2.11 ± 0.13	2.40 ± 0.25	2.81 ± 0.46	3.05 ± 0.58
Extreme TSL - 25 Yr Ret Period	2.04 ± 0.10	2.20 ± 0.13	2.49 ± 0.25	2.90 ± 0.46	3.14 ± 0.58
Extreme TSL - 50 Yr Ret Period	2.10 ± 0.10	2.26 ± 0.13	2.55 ± 0.25	2.96 ± 0.46	3.20 ± 0.58
Extreme TSL - 100 Yr Ret Period	2.17 ± 0.10	2.33 ± 0.13	2.62 ± 0.25	3.03 ± 0.46	3.27 ± 0.58

Table A 16: Guysborough, Climate Station Deming (id: 8201410) @ 45.22N 61.18W, CHS site Canso Harbour

Parameter	1980s	2020s		2050s		2080s	
	Value	**Value**	**SD**	**Value**	**SD**	**Value**	**SD**
Temperature - Annual	5.8	6.7	0.4	7.8	0.7	8.9	1.1
Winter	-3.2	-2.2	0.6	-1.0	0.9	0.3	1.3
Spring	2.4	3.4	0.5	4.4	0.8	5.4	1.2
Summer	14.1	15.1	0.5	16.2	0.6	17.2	1.1
Autumn	9.6	10.6	0.4	11.7	0.6	12.9	1.1
Precipitation - Annual	1425.8	1452.8	43.5	1461.3	54.0	1497.4	72.4
Winter	352.6	363.9	12.6	371.7	17.4	387.4	21.4
Spring	359.7	369.5	15.7	375.9	19.7	389.5	26.5
Summer	307.5	312.6	17.7	308.1	21.3	308.6	35.3
Autumn	405.9	405.9	19.0	403.3	22.4	408.6	35.2

	1980s	**2020s**	**2050s**	**2080s**
Heating Degree Days	4460.3	4134.9	3771.4	3425.2
Cooling Degree Days	14.0	33.5	72.4	132.5
Hot Days (Tmax > 30)	0.0	0.1	0.1	0.2
Very Hot Days (Tmax > 35)	0.0	0.0	0.0	0.0
Cold Days (Tmax < -10)	3.1	2.9	1.7	1.1
Very Cold Days (Tmax < -20)	0.0	0.0	0.0	0.0
Growing Degree Days > 5	1378.4	1563.2	1794.8	2051.4
Growing Degree Days > 10	582.3	706.4	865.4	1041.4
Growing Season Length (days)	192.2	196.1	214.3	231.4
Corn Heat Units (CHU)	1892.7	2234.1	2618.2	2992.7
Corn Season Length (days)	141.2	147.8	161.5	172.8
Freeze Free Season (days)	224.3	244.5	264.2	280.2
Days With Rain	137.1	143.9	147.4	149.8
Days With Snow	24.5	42.6	34.2	28.4
Freeze-Thaw Cycles - Annual	82.5	78.6	69.7	60.6
Winter	40.6	40.3	41.2	40.5
Spring	33.2	30.6	24.1	17.0
Summer	0.0	0.0	0.0	0.0
Autumn	8.7	7.8	4.5	3.1
Water Surplus (mm)	1148.3	971.0	964.0	942.9
Water Deficit (mm)	13.8	15.9	20.2	24.4
Δ Intensity Short Period Rainfall (%)	0	5	9	16

	2000	**2025**	**2055**	**2085**	**2100**
Total Sea Level Rise (m)		0.16 ± 0.03	0.45 ± 0.15	0.86 ± 0.36	1.10 ± 0.48
Extreme TSL - 10 Yr Ret Period	2.56 ± 0.20	2.72 ± 0.23	3.01 ± 0.35	3.42 ± 0.56	3.66 ± 0.68
Extreme TSL - 25 Yr Ret Period	2.66 ± 0.20	2.82 ± 0.23	3.11 ± 0.35	3.52 ± 0.56	3.76 ± 0.68
Extreme TSL - 50 Yr Ret Period	2.73 ± 0.20	2.89 ± 0.23	3.18 ± 0.35	3.59 ± 0.56	3.83 ± 0.68
Extreme TSL - 100 Yr Ret Period	2.80 ± 0.20	2.96 ± 0.23	3.25 ± 0.35	3.66 ± 0.56	3.90 ± 0.68

Table A 17: HRM, Climate Station Shearwater A (id: 8205090) @ 44.63N 63.50W, Halifax

Parameter	1980s	2020s		2050s		2080s	
	Value	**Value**	**SD**	**Value**	**SD**	**Value**	**SD**
Temperature - Annual	6.7	7.7	0.4	8.9	0.6	10.1	1.0
Winter	-3.6	-2.4	0.6	-1.1	0.8	0.3	1.2
Spring	4.2	5.2	0.5	6.2	0.8	7.3	1.2
Summer	16.7	17.7	0.4	18.9	0.6	20.0	1.0
Autumn	9.3	10.4	0.4	11.5	0.6	12.7	1.0
Precipitation - Annual	1419.4	1452.8	40.6	1460.7	45.8	1500.7	62.5
Winter	388.4	403.6	14.1	411.3	19.2	431.6	23.2
Spring	355.0	365.9	15.0	371.6	19.3	385.3	25.9
Summer	312.1	317.6	18.5	314.9	22.9	315.5	38.6
Autumn	363.8	366.7	16.3	364.3	17.9	370.6	29.6

	1980s	**2020s**	**2050s**	**2080s**
Heating Degree Days	4191.4	3859.3	3506.5	3169.3
Cooling Degree Days	71.8	118.4	191.9	284.1
Hot Days (Tmax > 30)	0.9	1.7	3.9	7.0
Very Hot Days (Tmax > 35)	0.0	0.0	0.0	0.2
Cold Days (Tmax < -10)	3.4	2.3	1.3	0.7
Very Cold Days (Tmax < -20)	0.0	0.0	0.0	0.0
Growing Degree Days > 5	1711.0	1923.0	2180.2	2462.2
Growing Degree Days > 10	831.3	981.8	1166.4	1367.3
Growing Season Length (days)	198.2	208.9	222.9	240.4
Corn Heat Units (CHU)	2543.4	2866.4	3217.2	3612.9
Corn Season Length (days)	157.2	167.2	176.7	189.1
Freeze Free Season (days)	223.5	243.0	262.7	276.9
Days With Rain	138.5	146.1	148.8	152.8
Days With Snow	45.8	46.7	39.0	32.9
Freeze-Thaw Cycles - Annual	92.6	84.9	73.8	66.3
Winter	43.0	43.3	44.0	43.8
Spring	34.3	29.7	21.7	16.8
Summer	0.0	0.0	0.0	0.0
Autumn	15.4	11.9	8.1	5.7
Water Surplus (mm)	1054.9	986.0	953.5	925.3
Water Deficit (mm)	27.8	31.2	38.5	45.7
Δ Intensity Short Period Rainfall (%)	0	5	9	16

	2000	**2025**	**2055**	**2085**	**2100**
Total Sea Level Rise (m)		0.15 ± 0.03	0.43 ± 0.15	0.83 ± 0.36	1.06 ± 0.48
Extreme TSL - 10 Yr Ret Period	2.87 ± 0.10	3.02 ± 0.13	3.30 ± 0.25	3.70 ± 0.46	3.93 ± 0.58
Extreme TSL - 25 Yr Ret Period	2.97 ± 0.10	3.12 ± 0.13	3.40 ± 0.25	3.80 ± 0.46	4.03 ± 0.58
Extreme TSL - 50 Yr Ret Period	3.04 ± 0.10	3.19 ± 0.13	3.47 ± 0.25	3.87 ± 0.46	4.10 ± 0.58
Extreme TSL - 100 Yr Ret Period	3.11 ± 0.10	3.26 ± 0.13	3.54 ± 0.25	3.94 ± 0.46	4.17 ± 0.58

Table A 18: Lunenburg, Climate Station Bridgewater (id: 8200600) @ 44.40N 64.55W, CHS site Lunenburg

Parameter	1980s	2020s		2050s		2080s	
	Value	**Value**	**SD**	**Value**	**SD**	**Value**	**SD**
Temperature - Annual	6.8	8.0	0.4	9.2	0.6	10.5	1.0
Winter	-4.0	-2.7	0.6	-1.3	0.8	0.2	1.1
Spring	4.9	6.0	0.4	7.1	0.7	8.2	1.1
Summer	17.6	18.7	0.4	19.9	0.7	21.1	1.0
Autumn	8.7	9.9	0.4	11.0	0.6	12.3	0.9
Precipitation - Annual	1522.5	1564.2	37.4	1577.2	43.3	1624.0	56.6
Winter	436.2	457.5	17.3	468.4	22.3	493.9	28.6
Spring	392.4	405.4	16.5	411.2	22.3	427.3	29.3
Summer	294.4	299.3	17.4	298.4	23.2	298.8	38.3
Autumn	399.5	404.3	18.2	403.8	19.1	412.8	29.6

	1980s	**2020s**	**2050s**	**2080s**
Heating Degree Days	4190.5	3847.0	3480.8	3127.0
Cooling Degree Days	136.9	197.9	283.6	387.6
Hot Days (Tmax > 30)	5.8	12.6	21.6	31.4
Very Hot Days (Tmax > 35)	0.0	0.5	1.2	2.6
Cold Days (Tmax < -10)	3.1	2.3	1.0	0.5
Very Cold Days (Tmax < -20)	0.0	0.0	0.0	0.0
Growing Degree Days > 5	1828.8	2055.8	2327.1	2628.8
Growing Degree Days > 10	940.7	1102.9	1299.5	1515.9
Growing Season Length (days)	160.3	174.5	191.9	213.5
Corn Heat Units (CHU)	2518.5	2809.7	3144.2	3495.3
Corn Season Length (days)	133.8	142.5	153.4	164.9
Freeze Free Season (days)	195.6	222.5	243.8	263.1
Days With Rain	138.1	147.1	150.9	154.0
Days With Snow	36.1	51.7	43.9	37.1
Freeze-Thaw Cycles - Annual	117.6	108.7	95.6	82.7
Winter	45.5	45.9	46.2	44.9
Spring	42.2	37.8	30.6	24.3
Summer	0.6	0.4	0.0	0.0
Autumn	29.3	24.6	18.8	13.7
Water Surplus (mm)	1157.1	1004.5	978.1	982.7
Water Deficit (mm)	31.5	35.8	44.0	53.1
Δ Intensity Short Period Rainfall (%)	0	5	9	16

	2000	**2025**	**2055**	**2085**	**2100**
Total Sea Level Rise (m)		0.15 ± 0.03	0.43 ± 0.15	0.83 ± 0.36	1.06 ± 0.48
Extreme TSL - 10 Yr Ret Period	3.14 ± 0.20	3.29 ± 0.23	3.57 ± 0.35	3.97 ± 0.56	4.20 ± 0.68
Extreme TSL - 25 Yr Ret Period	3.24 ± 0.20	3.39 ± 0.23	3.67 ± 0.35	4.07 ± 0.56	4.30 ± 0.68
Extreme TSL - 50 Yr Ret Period	3.31 ± 0.20	3.46 ± 0.23	3.73 ± 0.35	4.14 ± 0.56	4.37 ± 0.68
Extreme TSL - 100 Yr Ret Period	3.38 ± 0.20	3.53 ± 0.23	3.80 ± 0.35	4.21 ± 0.56	4.44 ± 0.68

Table A 19: Liverpool, Climate Station Liverpool Milton (id: 8203120) @ 44.08N 64.77W, CHS site Liverpool

Parameter	1980s	2020s		2050s		2080s	
	Value	**Value**	**SD**	**Value**	**SD**	**Value**	**SD**
Temperature - Annual	7.4	8.5	0.4	9.8	0.6	11.0	1.0
Winter	-3.2	-1.9	0.6	-0.5	0.8	1.0	1.1
Spring	5.3	6.4	0.4	7.5	0.7	8.6	1.1
Summer	18.0	19.1	0.4	20.3	0.7	21.4	1.0
Autumn	9.4	10.5	0.4	11.7	0.6	13.0	0.9
Precipitation - Annual	1646.7	1691.9	40.4	1705.9	46.8	1756.5	61.2
Winter	502.3	526.7	20.0	539.3	25.7	568.7	32.9
Spring	424.1	438.2	18.0	444.5	24.1	461.9	31.7
Summer	287.2	292.0	17.0	291.1	22.6	291.5	37.4
Autumn	433.0	438.3	19.7	437.6	20.8	447.5	32.1

	1980s	**2020s**	**2050s**	**2080s**
Heating Degree Days	4017.2	3679.6	3321.7	2975.0
Cooling Degree Days	153.0	220.0	313.9	425.1
Hot Days (Tmax > 30)	6.2	11.8	20.4	29.9
Very Hot Days (Tmax > 35)	0.0	0.5	1.1	2.6
Cold Days (Tmax < -10)	2.5	1.5	0.7	0.2
Very Cold Days (Tmax < -20)	0.0	0.0	0.0	0.0
Growing Degree Days > 5	1915.9	2150.8	2432.0	2743.8
Growing Degree Days > 10	1001.6	1169.0	1371.6	1594.6
Growing Season Length (days)	182.4	196.8	213.6	229.1
Corn Heat Units (CHU)	2610.0	2904.6	3257.0	3586.6
Corn Season Length (days)	148.7	158.8	171.3	179.0
Freeze Free Season (days)	184.8	211.7	231.9	249.4
Days With Rain	139.0	148.1	151.4	153.7
Days With Snow	25.0	45.9	37.9	30.9
Freeze-Thaw Cycles - Annual	109.8	99.2	83.8	70.2
Winter	48.8	48.7	46.5	43.9
Spring	37.3	32.3	24.4	18.1
Summer	0.1	0.1	0.0	0.0
Autumn	23.6	18.1	13.0	8.3
Water Surplus (mm)	1356.2	1132.6	1098.0	1112.9
Water Deficit (mm)	39.0	46.8	56.0	66.3
Δ Intensity Short Period Rainfall (%)	0	5	9	16

	2000	**2025**	**2055**	**2085**	**2100**
Total Sea Level Rise (m)		0.15 ± 0.03	0.43 ± 0.15	0.83 ± 0.36	1.06 ± 0.48
Extreme TSL - 10 Yr Ret Period	3.01 ± 0.20	3.16 ± 0.23	3.44 ± 0.35	3.84 ± 0.56	4.07 ± 0.68
Extreme TSL - 25 Yr Ret Period	3.11 ± 0.20	3.26 ± 0.23	3.54 ± 0.35	3.94 ± 0.56	4.17 ± 0.68
Extreme TSL - 50 Yr Ret Period	3.18 ± 0.20	3.33 ± 0.23	3.61 ± 0.35	4.01 ± 0.56	4.24 ± 0.68
Extreme TSL - 100 Yr Ret Period	3.25 ± 0.20	3.40 ± 0.23	3.68 ± 0.35	4.08 ± 0.56	4.31 ± 0.68

Table A 20: Yarmouth, Climate Station Yarmouth A (id: 8206500) @ 43.83N 66.09W, CHS site Yarmouth

Parameter	1980s	2020s		2050s		2080s	
	Value	**Value**	**SD**	**Value**	**SD**	**Value**	**SD**
Temperature - Annual	6.9	8.1	0.4	9.3	0.6	10.6	1.0
Winter	-2.1	-0.8	0.6	0.7	0.8	2.1	1.1
Spring	5.0	6.0	0.4	7.1	0.7	8.3	1.1
Summer	15.7	16.7	0.4	17.9	0.7	19.1	1.0
Autumn	9.3	10.4	0.4	11.5	0.6	12.8	0.9
Precipitation - Annual	1275.1	1310.1	31.3	1320.9	36.3	1360.1	47.4
Winter	370.5	388.5	14.7	397.8	19.0	419.5	24.3
Spring	310.9	321.2	13.2	325.8	17.6	338.6	23.2
Summer	255.9	260.2	15.2	259.4	20.1	259.7	33.3
Autumn	337.8	341.9	15.4	341.5	16.2	349.1	25.1

	1980s	**2020s**	**2050s**	**2080s**
Heating Degree Days	4038.7	3663.0	3267.4	2892.9
Cooling Degree Days	21.0	49.8	106.0	189.4
Hot Days (Tmax > 30)	0.0	0.1	0.2	0.9
Very Hot Days (Tmax > 35)	0.0	0.0	0.0	0.0
Cold Days (Tmax < -10)	1.5	0.6	0.1	0.1
Very Cold Days (Tmax < -20)	0.0	0.0	0.0	0.0
Growing Degree Days > 5	1619.5	1858.6	2146.7	2466.8
Growing Degree Days > 10	707.2	869.6	1070.2	1294.2
Growing Season Length (days)	201.0	219.4	235.1	250.9
Corn Heat Units (CHU)	2329.3	2725.8	3144.8	3586.4
Corn Season Length (days)	153.9	169.7	183.6	196.4
Freeze Free Season (days)	234.6	255.9	276.5	294.4
Days With Rain	129.3	141.0	145.4	149.2
Days With Snow	50.3	50.3	41.8	34.3
Freeze-Thaw Cycles - Annual	88.7	78.9	65.5	53.5
Winter	45.7	45.3	41.9	38.3
Spring	29.0	23.2	17.1	11.6
Summer	0.0	0.0	0.0	0.0
Autumn	14.0	10.5	6.6	3.6
Water Surplus (mm)	846.9	770.9	739.0	718.6
Water Deficit (mm)	36.3	40.0	47.8	56.0
Δ Intensity Short Period Rainfall (%)	0	5	9	16

	2000	**2025**	**2055**	**2085**	**2100**
Total Sea Level Rise (m)		0.15 ± 0.03	0.43 ± 0.15	0.83 ± 0.36	1.06 ± 0.48
Extreme TSL - 10 Yr Ret Period	5.84 ± 0.10	5.99 ± 0.13	6.27 ± 0.25	6.67 ± 0.46	6.90 ± 0.58
Extreme TSL - 25 Yr Ret Period	5.91 ± 0.10	6.06 ± 0.13	6.34 ± 0.25	6.74 ± 0.46	6.97 ± 0.58
Extreme TSL - 50 Yr Ret Period	5.96 ± 0.10	6.12 ± 0.13	6.40 ± 0.25	6.80 ± 0.46	7.03 ± 0.58
Extreme TSL - 100 Yr Ret Period	6.02 ± 0.10	6.18 ± 0.13	6.46 ± 0.25	6.86 ± 0.46	7.09 ± 0.58

Table A 21: Annapolis, Climate Station Weymouth Falls (id: 8206275) @ 44.40N 65.95W, CHS site Digby

Parameter	1980s	2020s		2050s		2080s	
	Value	**Value**	**SD**	**Value**	**SD**	**Value**	**SD**
Temperature - Annual	7.3	8.5	0.4	9.7	0.6	11.0	1.0
Winter	-2.6	-1.4	0.6	0.1	0.8	1.5	1.1
Spring	5.4	6.5	0.4	7.6	0.7	8.8	1.1
Summer	17.2	18.3	0.4	19.5	0.7	20.7	1.0
Autumn	9.2	10.4	0.4	11.5	0.6	12.8	0.9
Precipitation - Annual	1291.9	1327.4	31.7	1338.4	36.8	1378.1	48.0
Winter	367.4	385.3	14.6	394.5	18.8	416.0	24.1
Spring	313.9	324.3	13.3	329.0	17.8	341.9	23.4
Summer	268.6	273.2	15.9	272.3	21.1	272.7	35.0
Autumn	342.0	346.1	15.5	345.6	16.4	353.4	25.4

	1980s	**2020s**	**2050s**	**2080s**
Heating Degree Days	3975.4	3628.2	3260.4	2906.6
Cooling Degree Days	95.0	152.3	236.3	340.4
Hot Days (Tmax > 30)	1.0	3.0	7.3	13.8
Very Hot Days (Tmax > 35)	0.0	0.0	0.1	0.4
Cold Days (Tmax < -10)	2.4	1.5	0.7	0.3
Very Cold Days (Tmax < -20)	0.0	0.0	0.0	0.0
Growing Degree Days > 5	1833.2	2072.1	2358.2	2674.6
Growing Degree Days > 10	908.5	1076.9	1281.0	1507.1
Growing Season Length (days)	182.8	198.3	213.8	233.4
Corn Heat Units (CHU)	2271.5	2548.9	2778.2	3104.9
Corn Season Length (days)	147.2	159.3	172.1	184.6
Freeze Free Season (days)	192.9	215.4	234.8	251.0
Days With Rain	114.2	122.5	125.6	127.6
Days With Snow	26.0	41.2	34.3	27.9
Freeze-Thaw Cycles - Annual	92.9	85.4	71.1	58.8
Winter	40.2	41.0	39.2	36.4
Spring	33.7	29.7	22.0	16.5
Summer	0.0	0.0	0.0	0.0
Autumn	18.9	14.7	10.0	6.0
Water Surplus (mm)	875.1	807.0	790.5	784.5
Water Deficit (mm)	32.3	30.8	38.1	45.8
Δ Intensity Short Period Rainfall (%)	0	5	9	16

	2000	**2025**	**2055**	**2085**	**2100**
Total Sea Level Rise (m)		0.15 ± 0.03	0.42 ± 0.15	0.82 ± 0.36	1.05 ± 0.48
Extreme TSL - 10 Yr Ret Period	9.81 ± 0.20	9.96 ± 0.23	10.23 ± 0.35	10.63 ± 0.56	10.86 ± 0.68
Extreme TSL - 25 Yr Ret Period	9.88 ± 0.20	10.03 ± 0.23	10.30 ± 0.35	10.70 ± 0.56	10.93 ± 0.68
Extreme TSL - 50 Yr Ret Period	9.94 ± 0.20	10.09 ± 0.23	10.36 ± 0.35	10.76 ± 0.56	10.99 ± 0.68
Extreme TSL - 100 Yr Ret Period	10.00 ± 0.20	10.15 ± 0.23	10.42 ± 0.35	10.82 ± 0.56	11.05 ± 0.68

Table A 22: Annapolis Valley, Climate Station Greenwood A (id: 8202000) @ 44.98N, CHS site N/A

Parameter	1980s	2020s		2050s		2080s	
	Value	**Value**	**SD**	**Value**	**SD**	**Value**	**SD**
Temperature - Annual	6.8	7.9	0.4	9.1	0.6	10.4	1.0
Winter	-4.4	-3.2	0.6	-1.7	0.8	-0.3	1.1
Spring	5.0	6.1	0.4	7.2	0.7	8.4	1.1
Summer	17.9	19.0	0.4	20.2	0.7	21.4	1.0
Autumn	8.5	9.6	0.4	10.8	0.6	12.1	0.9
Precipitation - Annual	1126.7	1157.6	27.6	1167.2	32.1	1201.8	41.9
Winter	310.3	325.3	12.3	333.1	15.9	351.3	20.4
Spring	259.8	268.4	11.0	272.3	14.8	282.9	19.4
Summer	250.4	254.6	14.8	253.8	19.7	254.1	32.6
Autumn	306.3	310.0	13.9	309.6	14.7	316.5	22.7

	1980s	**2020s**	**2050s**	**2080s**
Heating Degree Days	4215.6	3874.9	3513.7	3164.4
Cooling Degree Days	138.6	202.4	293.0	401.6
Hot Days (Tmax > 30)	6.0	11.3	19.0	32.7
Very Hot Days (Tmax > 35)	0.0	0.2	0.7	2.2
Cold Days (Tmax < -10)	4.3	2.9	1.5	0.5
Very Cold Days (Tmax < -20)	0.0	0.0	0.0	0.0
Growing Degree Days > 5	1859.9	2075.4	2338.6	2716.2
Growing Degree Days > 10	967.2	1122.4	1314.3	1592.8
Growing Season Length (days)	173.6	186.8	208.4	224.1
Corn Heat Units (CHU)	2619.1	2919.7	3294.0	3621.4
Corn Season Length (days)	140.6	151.3	167.0	177.3
Freeze Free Season (days)	204.9	224.8	246.3	265.1
Days With Rain	132.9	144.7	150.7	155.9
Days With Snow	65.6	59.9	51.1	44.3
Freeze-Thaw Cycles - Annual	106.8	98.8	86.1	75.6
Winter	41.3	42.8	43.3	44.4
Spring	38.6	33.9	26.9	20.5
Summer	0.1	0.0	0.0	0.0
Autumn	26.9	22.2	15.9	10.8
Water Surplus (mm)	684.3	643.5	630.0	620.9
Water Deficit (mm)	54.2	60.3	73.6	87.6
Δ Intensity Short Period Rainfall (%)	0	5	9	16

Table A 23: Kentville, Climate Station Kentville Cda (id: 8202800) @ 45.07N 64.48W, CHS site Hantsport

Parameter	1980s	2020s		2050s		2080s	
	Value	**Value**	**SD**	**Value**	**SD**	**Value**	**SD**
Temperature - Annual	6.9	8.1	0.4	9.3	0.6	10.6	1.0
Winter	-4.4	-3.1	0.6	-1.7	0.8	-0.3	1.1
Spring	5.0	6.0	0.4	7.1	0.7	8.3	1.1
Summer	18.1	19.2	0.4	20.4	0.7	21.5	1.0
Autumn	9.0	10.2	0.4	11.3	0.6	12.6	0.9
Precipitation - Annual	1212.5	1245.8	29.7	1256.1	34.5	1293.4	45.1
Winter	357.8	375.1	14.2	384.2	18.3	405.0	23.4
Spring	298.2	308.1	12.6	312.5	17.0	324.7	22.3
Summer	254.5	258.8	15.1	258.0	20.0	258.4	33.1
Autumn	302.0	305.7	13.8	305.3	14.5	312.1	22.4

	1980s	**2020s**	**2050s**	**2080s**
Heating Degree Days	4163.1	3825.3	3466.7	3120.5
Cooling Degree Days	146.9	213.6	307.0	418.5
Hot Days (Tmax > 30)	3.5	8.4	15.4	24.9
Very Hot Days (Tmax > 35)	0.0	0.1	0.4	1.2
Cold Days (Tmax < -10)	6.2	4.5	2.6	1.3
Very Cold Days (Tmax < -20)	0.0	0.0	0.0	0.0
Growing Degree Days > 5	1906.3	2134.8	2406.8	2704.1
Growing Degree Days > 10	1001.9	1169.3	1370.2	1589.7
Growing Season Length (days)	184.4	200.9	214.2	233.1
Corn Heat Units (CHU)	2318.9	2583.2	2878.8	3189.3
Corn Season Length (days)	152.9	165.0	173.9	188.2
Freeze Free Season (days)	180.6	201.5	217.9	233.0
Days With Rain	124.8	137.9	142.4	146.9
Days With Snow	49.6	55.4	46.9	40.0
Freeze-Thaw Cycles - Annual	87.8	80.6	70.3	61.7
Winter	36.7	37.9	37.8	37.7
Spring	33.2	29.1	22.6	17.2
Summer	0.0	0.0	0.0	0.0
Autumn	18.0	13.7	10.0	6.8
Water Surplus (mm)	728.0	714.7	697.3	708.3
Water Deficit (mm)	56.0	62.8	76.7	91.2
Δ Intensity Short Period Rainfall (%)	0	5	9	16

	2000	**2025**	**2055**	**2085**	**2100**
Total Sea Level Rise (m)		0.16 ± 0.03	0.45 ± 0.15	0.86 ± 0.36	1.10 ± 0.48
Extreme TSL - 10 Yr Ret Period	16.11 ± 0.20	16.27 ± 0.23	16.56 ± 0.35	16.97 ± 0.56	17.21 ± 0.68
Extreme TSL - 25 Yr Ret Period	16.22 ± 0.20	16.38 ± 0.23	16.67 ± 0.35	17.08 ± 0.56	17.32 ± 0.68
Extreme TSL - 50 Yr Ret Period	16.30 ± 0.20	16.46 ± 0.23	16.75 ± 0.35	17.16 ± 0.56	17.40 ± 0.68
Extreme TSL - 100 Yr Ret Period	16.39 ± 0.20	16.55 ± 0.23	16.84 ± 0.35	17.25 ± 0.56	17.49 ± 0.68

Table A 24: Nova Scotia Summary

Parameter	1980s	2020s	2050s	2080s
Temperature - Annual	6.4	7.5	8.7	9.9
Winter	-4.1	-2.9	-1.5	-0.2
Spring	4.2	5.1	6.2	7.4
Summer	16.9	17.9	19.0	20.1
Autumn	8.8	9.8	11.0	12.2
Precipitation - Annual	1351.8	1385.2	1396.0	1435.3
Winter	382.1	398.4	407.7	428.1
Spring	327.4	337.8	343.1	356.3
Summer	277.4	282.0	280.1	280.4
Autumn	365.0	368.1	367.0	374.2
Heating Degree Days	4296.4	3960.2	3598.8	3250.1
Cooling Degree Days	96.0	145.8	220.0	312.9
Hot Days (Tmax > 30)	2.4	5.2	9.7	16.1
Very Hot Days (Tmax > 35)	0.0	0.1	0.3	0.9
Cold Days (Tmax < -10)	4.6	3.6	2.2	1.4
Very Cold Days (Tmax < -20)	0.0	0.0	0.0	0.0
Growing Degree Days > 5	1717.3	1930.2	2188.3	2479.5
Growing Degree Days > 10	849.7	1000.8	1186.3	1395.9
Growing Season Length (days)	179.9	192.2	209.2	226.1
Corn Heat Units (CHU)	2375.0	2672.5	3014.6	3368.6
Corn Season Length (days)	145.3	155.6	168.0	179.8
Freeze Free Season (days)	200.2	222.2	242.2	259.0
Days With Rain	131.6	142.4	146.5	150.3
Days With Snow	44.8	53.4	45.3	38.5
Freeze-Thaw Cycles - Annual	98.1	90.8	79.2	69.2
Winter	40.4	40.9	41.5	41.0
Spring	37.2	33.4	26.2	20.2
Summer	0.2	0.1	0.0	0.0
Autumn	20.4	16.4	11.5	7.9
Water Surplus (mm)	947.7	870.3	851.5	850.1
Water Deficit (mm)	36.0	40.0	48.8	57.9
Δ Intensity Short Period Rainfall (%)	0	5	9	16

Appendix B – Coastal Water Levels

Estimated Extreme Total Sea Levels (HHWLT + Sea-Level Rise + Storm Surge) for Return Periods of 10, 25, 50 and 100 years for Years 2000, 2025, 2050, 2085 and 2100

Table B 1: Burncoat Head, HHWLT, 16.53 m (CD), Return Period levels estimated as per Saint John plus 25%.

Extreme Total Sea Level (metres CD) – Burncoat Head (Truro)

Return Period	Residual	Level 2000	Level 2025	Level 2055	Level 2085	Level 2100
10-Year	0.89 ± 0.20	17.42 ± 0.20	17.57 ± 0.23	17.84 ± 0.35	18.24 ± 0.56	18.47 ± 0.68
25-Year	1.01 ± 0.20	17.54 ± 0.20	17.69 ± 0.23	17.96 ± 0.35	18.36 ± 0.56	18.59 ± 0.68
50-Year	1.10 ± 0.20	17.63 ± 0.20	17.78 ± 0.23	18.05 ± 0.35	18.45 ± 0.56	18.68 ± 0.68
100-Year	1.20 ± 0.20	17.73 ± 0.20	17.88 ± 0.23	18.15 ± 0.35	18.55 ± 0.56	18.78 ± 0.68

Table B 2: Joggins, HHWLT, 13.40 m (CD), Return Period levels estimated as per Saint John tide gauge plus 20%.

Extreme Total Sea Level (metres CD) – Joggins (Amherst)

Return Period	Residual	Level 2000	Level 2025	Level 2055	Level 2085	Level 2100
10-Year	0.85 ± 0.20	14.25 ± 0.20	14.40 ± 0.23	14.67 ± 0.35	15.07 ± 0.56	15.30 ± 0.68
25-Year	0.96 ± 0.20	14.36 ± 0.20	14.51 ± 0.23	14.78 ± 0.35	15.18 ± 0.56	15.41 ± 0.68
50-Year	1.04 ± 0.20	14.44 ± 0.20	14.59 ± 0.23	14.86 ± 0.35	15.26 ± 0.56	15.49 ± 0.68
100-Year	1.13 ± 0.20	14.53 ± 0.20	14.68 ± 0.23	14.95 ± 0.35	15.35 ± 0.56	15.58 ± 0.68

Table B 3: Pictou, HHWLT 2.05m (CD), Return Period levels taken directly from Pictou tide gauge.

Extreme Total Sea Level (metres CD) – Pictou

Return Period	Residual	Level 2000	Level 2025	Level 2055	Level 2085	Level 2100
10-Year	1.12 ± 0.10	3.17 ± 0.10	3.32 ± 0.13	3.59 ± 0.25	3.99 ± 0.46	4.22 ± 0.58
25-Year	1.27 ± 0.10	3.32 ± 0.10	3.47 ± 0.13	3.74 ± 0.25	4.14 ± 0.46	4.37 ± 0.58
50-Year	1.38 ± 0.10	3.43 ± 0.10	3.58 ± 0.13	3.85 ± 0.25	4.25 ± 0.46	4.48 ± 0.58
100-Year	1.49 ± 0.10	3.54 ± 0.10	3.69 ± 0.13	3.96 ± 0.25	4.36 ± 0.46	4.59 ± 0.58

Table B 4: Cheticamp, HHWLT 1.37 m (CD), Return Period levels estimated as per Rustico tide gauge minus 10%.

Extreme Total Sea Level (metres CD) – Cheticamp (Cape Breton West)

Return Period	Residual	Level 2000	Level 2025	Level 2055	Level 2085	Level 2100
10-Year	0.96 ± 0.20	2.33 ± 0.20	2.49 ± 0.23	2.78 ± 0.35	3.19 ± 0.56	3.43 ± 0.68
25-Year	1.10 ± 0.20	2.47 ± 0.20	2.63 ± 0.23	2.92 ± 0.35	3.33 ± 0.56	3.57 ± 0.68
50-Year	1.20 ± 0.20	2.57 ± 0.20	2.73 ± 0.23	3.02 ± 0.35	3.43 ± 0.56	3.67 ± 0.68
100-Year	1.31 ± 0.20	2.68 ± 0.20	2.84 ± 0.23	3.13 ± 0.35	3.54 ± 0.56	3.78 ± 0.68

Table B 5: Sydney, HHWLT 1.32 m (CD), Return Period levels taken directly from North Sydney tide gauge

Extreme Total Sea Level (metres CD) – Sydney

Return Period	Residual	Level 2000	Level 2025	Level 2055	Level 2085	Level 2100
10-Year	0.63 ± 0.10	1.95 ± 0.10	2.11 ± 0.13	2.40 ± 0.25	2.81 ± 0.46	3.05 ± 0.58
25-Year	0.72 ± 0.10	2.04 ± 0.10	2.20 ± 0.13	2.49 ± 0.25	2.90 ± 0.46	3.14 ± 0.58
50-Year	0.78 ± 0.10	2.10 ± 0.10	2.26 ± 0.13	2.55 ± 0.25	2.96 ± 0.46	3.20 ± 0.58
100-Year	0.85 ± 0.10	2.17 ± 0.10	2.33 ± 0.13	2.62 ± 0.25	3.03 ± 0.46	3.27 ± 0.58

Table B 6: Canso Harbour, HHWLT 1.85 m (CD), Return Period levels estimated as per Halifax tide gauge.

Extreme Total Sea Level (metres CD) – Canso Harbour (Guysborough)

Return Period	Residual	Level 2000	Level 2025	Level 2055	Level 2085	Level 2100
10-Year	0.71 ± 0.20	2.56 ± 0.20	2.72 ± 0.23	3.01 ± 0.35	3.42 ± 0.56	3.66 ± 0.68
25-Year	0.81 ± 0.20	2.66 ± 0.20	2.82 ± 0.23	3.11 ± 0.35	3.52 ± 0.56	3.76 ± 0.68
50-Year	0.88 ± 0.20	2.73 ± 0.20	2.89 ± 0.23	3.18 ± 0.35	3.59 ± 0.56	3.83 ± 0.68
100-Year	0.95 ± 0.20	2.80 ± 0.20	2.96 ± 0.23	3.25 ± 0.35	3.66 ± 0.56	3.90 ± 0.68

Table B 7: Halifax, HHWLT 2.16 m (CD), Return Period levels taken directly from Halifax tide gauge.

Extreme Total Sea Level (metres CD) – Halifax (HRM)

Return Period	Residual	Level 2000	Level 2025	Level 2055	Level 2085	Level 2100
10-Year	0.71 ± 0.10	2.87 ± 0.10	3.02 ± 0.13	3.30 ± 0.25	3.70 ± 0.46	3.93 ± 0.58
25-Year	0.81 ± 0.10	2.97 ± 0.10	3.12 ± 0.13	3.40 ± 0.25	3.80 ± 0.46	4.03 ± 0.58
50-Year	0.88 ± 0.10	3.04 ± 0.10	3.19 ± 0.13	3.47 ± 0.25	3.87 ± 0.46	4.10 ± 0.58
100-Year	0.95 ± 0.10	3.11 ± 0.10	3.26 ± 0.13	3.54 ± 0.25	3.94 ± 0.46	4.17 ± 0.58

Table B 8: Lunenburg, HHWLT 2.43 m (CD), Return Period levels estimated as per Halifax tide gauge.

Extreme Total Sea Level (metres CD) – Lunenburg

Return Period	Residual	Level 2000	Level 2025	Level 2055	Level 2085	Level 2100
10-Year	0.71 ± 0.20	3.14 ± 0.20	3.29 ± 0.23	3.57 ± 0.35	3.97 ± 0.56	4.20 ± 0.68
25-Year	0.81 ± 0.20	3.24 ± 0.20	3.39 ± 0.23	3.67 ± 0.35	4.07 ± 0.56	4.30 ± 0.68
50-Year	0.88 ± 0.20	3.31 ± 0.20	3.46 ± 0.23	3.73 ± 0.35	4.14 ± 0.56	4.37 ± 0.68
100-Year	0.95 ± 0.20	3.38 ± 0.20	3.53 ± 0.23	3.80 ± 0.35	4.21 ± 0.56	4.44 ± 0.68

Table B 9: Liverpool, HHWLT 2.30 m (CD), Return Period levels estimated as per Halifax tide gauge.

Extreme Total Sea Level (metres CD) – Liverpool

Return Period	Residual	Level 2000	Level 2025	Level 2055	Level 2085	Level 2100
10-Year	0.71 ± 0.20	3.01 ± 0.20	3.16 ± 0.23	3.44 ± 0.35	3.84 ± 0.56	4.07 ± 0.68
25-Year	0.81 ± 0.20	3.11 ± 0.20	3.26 ± 0.23	3.54 ± 0.35	3.94 ± 0.56	4.17 ± 0.68
50-Year	0.88 ± 0.20	3.18 ± 0.20	3.33 ± 0.23	3.61 ± 0.35	4.01 ± 0.56	4.24 ± 0.68
100-Year	0.95 ± 0.20	3.25 ± 0.20	3.40 ± 0.23	3.68 ± 0.35	4.08 ± 0.56	4.31 ± 0.68

Table B 10: Yarmouth, HHWLT 5.16 m (CD), Return Period levels taken directly from Yarmouth tide gauge.

Extreme Total Sea Level (metres CD) – Yarmouth

Return Period	Residual	Level 2000	Level 2025	Level 2055	Level 2085	Level 2100
10-Year	0.68 ± 0.10	5.84 ± 0.10	5.99 ± 0.13	6.27 ± 0.25	6.67 ± 0.46	6.90 ± 0.58
25-Year	0.75 ± 0.10	5.91 ± 0.10	6.06 ± 0.13	6.34 ± 0.25	6.74 ± 0.46	6.97 ± 0.58
50-Year	0.81 ± 0.10	5.96 ± 0.10	6.12 ± 0.13	6.40 ± 0.25	6.80 ± 0.46	7.03 ± 0.58
100-Year	0.87 ± 0.10	6.02 ± 0.10	6.18 ± 0.13	6.46 ± 0.25	6.86 ± 0.46	7.09 ± 0.58

Table B 11: Digby, HHWLT 9.13 m (CD), Return Period estimated as per Yarmouth tide gauge.

Extreme Total Sea Level (metres CD) – Digby (Annapolis)

Return Period	Residual	Level 2000	Level 2025	Level 2055	Level 2085	Level 2100
10-Year	0.68 ± 0.20	9.81 ± 0.20	9.96 ± 0.23	10.23 ± 0.35	10.63 ± 0.56	10.86 ± 0.68
25-Year	0.75 ± 0.20	9.88 ± 0.20	10.03 ± 0.23	10.30 ± 0.35	10.70 ± 0.56	10.93 ± 0.68
50-Year	0.81 ± 0.20	9.94 ± 0.20	10.09 ± 0.23	10.36 ± 0.35	10.76 ± 0.56	10.99 ± 0.68
100-Year	0.87 ± 0.20	10.00 ± 0.20	10.15 ± 0.23	10.42 ± 0.35	10.82 ± 0.56	11.05 ± 0.68

Table B 12: Hantsport, HHWLT 15.26 m (CD), Return Period levels estimated as per Saint John tide gauge plus 20%.

Extreme Total Sea Level (metres CD) – Hantsport (Kentville)

Return Period	Residual	Level 2000	Level 2025	Level 2055	Level 2085	Level 2100
10-Year	0.85 ± 0.20	16.11 ± 0.20	16.27 ± 0.23	16.56 ± 0.35	16.97 ± 0.56	17.21 ± 0.68
25-Year	0.96 ± 0.20	16.22 ± 0.20	16.38 ± 0.23	16.67 ± 0.35	17.08 ± 0.56	17.32 ± 0.68
50-Year	1.04 ± 0.20	16.30 ± 0.20	16.46 ± 0.23	16.75 ± 0.35	17.16 ± 0.56	17.40 ± 0.68
100-Year	1.13 ± 0.20	16.39 ± 0.20	16.55 ± 0.23	16.84 ± 0.35	17.25 ± 0.56	17.49 ± 0.68

Table B 13: Alberton, HHWLT 1.16 m (CD), Return Period levels estimated as per Rustico tide gauge.

Extreme Total Sea Level (metres CD) – Alberton (Northwest PEI)

Return Period	Residual	Level 2000	Level 2025	Level 2055	Level 2085	Level 2100
10-Year	1.07 ± 0.20	2.23 ± 0.20	2.39 ± 0.23	2.67 ± 0.35	3.07 ± 0.56	3.31 ± 0.68
25-Year	1.22 ± 0.20	2.38 ± 0.20	2.54 ± 0.23	2.82 ± 0.35	3.22 ± 0.56	3.46 ± 0.68
50-Year	1.33 ± 0.20	2.49 ± 0.20	2.65 ± 0.23	2.93 ± 0.35	3.33 ± 0.56	3.57 ± 0.68
100-Year	1.45 ± 0.20	2.61 ± 0.20	2.76 ± 0.23	3.05 ± 0.35	3.45 ± 0.56	3.69 ± 0.68

Table B 14: West Point, HHWLT 1.51 m (CD), Return Period levels estimated as an average of the Escuminac and Shediac tide gauges.

Extreme Total Sea Level (metres CD) – West Point (Southwest PEI)

Return Period	Residual	Level 2000	Level 2025	Level 2055	Level 2085	Level 2100
10-Year	1.35 ± 0.20	2.86 ± 0.20	3.00 ± 0.23	3.26 ± 0.35	3.64 ± 0.56	3.86 ± 0.68
25-Year	1.58 ± 0.20	3.09 ± 0.20	3.23 ± 0.23	3.49 ± 0.35	3.87 ± 0.56	4.09 ± 0.68
50-Year	1.76 ± 0.20	3.27 ± 0.20	3.41 ± 0.23	3.67 ± 0.35	4.05 ± 0.56	4.27 ± 0.68
100-Year	1.93 ± 0.20	3.44 ± 0.20	3.58 ± 0.23	3.84 ± 0.35	4.22 ± 0.56	4.44 ± 0.68

Table B 15: Summerside, HHWLT 2.18 m (CD), Return Period levels estimated as per Charlottetown tide gauge.

Extreme Total Sea Level (metres CD) – Summerside

Return Period	Residual	Level 2000	Level 2025	Level 2055	Level 2085	Level 2100
10-Year	1.13 ± 0.20	3.31 ± 0.20	3.45 ± 0.23	3.71 ± 0.35	4.09 ± 0.56	4.31 ± 0.68
25-Year	1.30 ± 0.20	3.48 ± 0.20	3.62 ± 0.23	3.88 ± 0.35	4.26 ± 0.56	4.48 ± 0.68
50-Year	1.42 ± 0.20	3.60 ± 0.20	3.74 ± 0.23	4.00 ± 0.35	4.38 ± 0.56	4.60 ± 0.68
100-Year	1.55 ± 0.20	3.73 ± 0.20	3.87 ± 0.23	4.13 ± 0.35	4.51 ± 0.56	4.73 ± 0.68

Table B 16: Rustico, HHWLT 1.23 m (CD), Return Periods taken directly from Rustico tide gauge.

Extreme Total Sea Level (metres CD) – Rustico (North Shore – Cavendish)

Return Period	Residual	Level 2000	Level 2025	Level 2055	Level 2085	Level 2100
10-Year	1.07 ± 0.10	2.30 ± 0.10	2.46 ± 0.13	2.74 ± 0.25	3.14 ± 0.46	3.38 ± 0.58
25-Year	1.22 ± 0.10	2.45 ± 0.10	2.61 ± 0.13	2.89 ± 0.25	3.29 ± 0.46	3.53 ± 0.58
50-Year	1.33 ± 0.10	2.56 ± 0.10	2.72 ± 0.13	3.00 ± 0.25	3.40 ± 0.46	3.64 ± 0.58
100-Year	1.45 ± 0.10	2.68 ± 0.10	2.84 ± 0.13	3.12 ± 0.25	3.52 ± 0.46	3.76 ± 0.58

Table B 17: Charlottetown, HHWLT 3.01 m (CD), Return Periods taken directly from Charlottetown tide gauge.

Extreme Total Sea Level (metres CD) – Charlottetown

Return Period	Residual	Level 2000	Level 2025	Level 2055	Level 2085	Level 2100
10-Year	1.13 ± 0.10	4.14 ± 0.10	4.29 ± 0.13	4.57 ± 0.25	4.97 ± 0.58	5.20 ± 0.58
25-Year	1.30 ± 0.10	4.31 ± 0.10	4.46 ± 0.13	4.74 ± 0.25	5.14 ± 0.58	5.37 ± 0.58
50-Year	1.42 ± 0.10	4.43 ± 0.10	4.58 ± 0.13	4.86 ± 0.25	5.26 ± 0.58	5.49 ± 0.58
100-Year	1.55 ± 0.10	4.56 ± 0.10	4.71 ± 0.13	4.99 ± 0.25	5.39 ± 0.58	5.62 ± 0.58

Table B 18: St Peter’s Bay, HHWLT 1.05 m (CD), Return Periods estimated as per Rustico tide gauge.

Extreme Total Sea Level (metres CD) – St Peter’s Bay (Morell, Mt. Stewart, St. Peter’s)

Return Period	Residual	Level 2000	Level 2025	Level 2055	Level 2085	Level 2100
10-Year	1.07 ± 0.20	2.12 ± 0.20	2.27 ± 0.23	2.54 ± 0.35	2.94 ± 0.56	3.17 ± 0.68
25-Year	1.22 ± 0.20	2.27 ± 0.20	2.42 ± 0.23	2.69 ± 0.35	3.09 ± 0.56	3.32 ± 0.68
50-Year	1.33 ± 0.20	2.38 ± 0.20	2.53 ± 0.23	2.80 ± 0.35	3.20 ± 0.56	3.43 ± 0.68
100-Year	1.45 ± 0.20	2.50 ± 0.20	2.65 ± 0.23	2.92 ± 0.35	3.32 ± 0.56	3.55 ± 0.68

Table B 19: North Lake Harbour, HHWLT 1.45 m (CD), Return Periods estimated as per Rustico tide gauge.

Extreme Total Sea Level (metres CD) – North Lake Harbour (Northeast Tip)

Return Period	Residual	Level 2000	Level 2025	Level 2055	Level 2085	Level 2100
10-Year	1.07 ± 0.20	1.52 ± 0.20	1.68 ± 0.23	1.97 ± 0.35	2.38 ± 0.56	2.62 ± 0.68
25-Year	1.22 ± 0.20	1.67 ± 0.20	1.83 ± 0.23	2.12 ± 0.35	2.53 ± 0.56	2.77 ± 0.68
50-Year	1.33 ± 0.20	1.78 ± 0.20	1.94 ± 0.23	2.23 ± 0.35	2.64 ± 0.56	2.88 ± 0.68
100-Year	1.45 ± 0.20	1.90 ± 0.20	2.06 ± 0.23	2.35 ± 0.35	2.76 ± 0.56	3.00 ± 0.68

Table B 20: Naufrage, HHWLT 1.25 m (CD), Return Periods estimated as per Rustico tide gauge.

Extreme Total Sea Level (metres CD) – Naufrage (North Shore)

Return Period	Residual	Level 2000	Level 2025	Level 2055	Level 2085	Level 2100
10-Year	1.07 ± 0.20	2.32 ± 0.20	2.48 ± 0.23	2.77 ± 0.35	3.18 ± 0.56	3.42 ± 0.68
25-Year	1.22 ± 0.20	2.47 ± 0.20	2.63 ± 0.23	2.92 ± 0.35	3.33 ± 0.56	3.57 ± 0.68
50-Year	1.33 ± 0.20	2.58 ± 0.20	2.74 ± 0.23	3.03 ± 0.35	3.44 ± 0.56	3.68 ± 0.68
100-Year	1.45 ± 0.20	2.70 ± 0.20	2.86 ± 0.23	3.15 ± 0.35	3.56 ± 0.56	3.80 ± 0.68

Table B 21: Georgetown, HHWLT 1.90 m (CD), Return Periods estimated as per Rustico tide gauge plus 10%.

Extreme Total Sea Level (metres CD) – Georgetown (Southeast/Montague/Georgetown)

Return Period	Residual	Level 2000	Level 2025	Level 2055	Level 2085	Level 2100
10-Year	1.18 ± 0.20	3.08 ± 0.20	3.24 ± 0.23	3.53 ± 0.35	3.94 ± 0.56	4.18 ± 0.68
25-Year	1.32 ± 0.20	3.22 ± 0.20	3.38 ± 0.23	3.67 ± 0.35	4.08 ± 0.56	4.32 ± 0.68
50-Year	1.46 ± 0.20	3.36 ± 0.20	3.52 ± 0.23	3.81 ± 0.35	4.22 ± 0.56	4.46 ± 0.68
100-Year	1.60 ± 0.20	3.50 ± 0.20	3.66 ± 0.23	3.95 ± 0.35	4.36 ± 0.56	4.60 ± 0.68

Note 1. It should be noted that the Residual Values listed in Tables B1 to B21 exclude the incremental value of any wave run-up that could potentially accompany a storm surge event. The Residual Values also exclude the impacts from an extremely rare event such as a hurricane direct hit, as was the case with Hurricane Juan in September 2003, which produced a measured residual of 1.63 m in Halifax Harbour.

Note 2. Residual error bar of 0.1 m is from Storm Surge Extremal Analysis (Bernier, 2005). In the cases where Return Periods are estimated from non-local tide gauge data, the error bar has been arbitrarily increased to 0.2 m.

Plausible Upper Bound Water Levels

The estimated extreme total sea levels in Appendix A (also Tables B1 to B21), were calculated as the sum of the 10-, 25-, 50- and 100-Year return period residuals (from the Bernier method) and the HHWLT values for the future time frames of 2025, 2055, 2085 and 2100. These estimates do not include the impact of an extreme historical event such as the Saxby Gale (1869), the Groundhog Day Storm (1976), a direct-hit by a hurricane (i.e. Hurricane Juan 2003) or similar extreme past or future meteorological events. From a precautionary principle approach to risk management it is advisable to consider the impacts of a plausible upper bound water level that would combine the upper limits of global sea-level rise, local crustal subsidence and the highest storm surge factor previously recorded by a tide gauge, or where available, some high precision measurements of identified high water marks. Estimates of plausible upper bound water levels are presented in Table B22. The storm surge factors for these estimates were taken from the CHS tide gauge records with details for each tide gauge site as follows:

Yarmouth

The Yarmouth tide gauge recorded its highest water level (5.67 m CD) at 12:00 local time on Feb 2, 1976 (according to CHS records), when the predicted tide (according to JTides) would have been 4.38 m, hence a storm surge residual value of 1.29 m. A maximum storm surge residual of 1.49 m would have occurred at 14:00 local time with a measured water level of 5.0 m and a subsiding predicted tide of 3.54 m (according to JTides). If the timing of the Groundhog Day Storm had coincided with a tide phase at HHWLT, the water level could have reached 6.55 m (CD) with that storm.

Halifax

The maximum storm surge recorded at the Halifax tide gauge (Forbes et al., 2009, HRM Report) was 1.63 m on29 September 2003 during the passage of Hurricane Juan.

North Sydney

The North Sydney tide gauge recorded its highest water level (2.32 m CD, according to CHS records) at 19:00 local time on Feb 5, 1974, when the predicted tide (according to JTides) would have been 1.35 m (highest for that date), hence a storm surge residual value of 0.97 m.

Pictou

The Pictou tide gauge recorded its highest water level (3.17 m CD) at 21:00 local time on Dec 30, 1993 (according to CHS records), when the predicted tide (according to JTides) would have been 1.79 m, hence a storm surge residual value of 1.38 m. A maximum storm surge residual of 1.49 m would have occurred at 20:00 local time with a measured water level of 3.13 m (CD) and a rising predicted tide of 1.64 m (according to JTides).

Shediac

The maximum water level recorded at the Shediac tide gauge (Pointe-du-Chêne location) was 3.62 m (CD) on 21 January 2000, resulting in a record storm surge of 2.0 m. The tide gauge had been rendered unserviceable during that storm but a well documented high water mark was subsequently surveyed using high precision GPS.

Escuminac

The maximum water level recorded at the Escuminac tide gauge was 2.72 m (CD) on 21 December 2010 (a new record for Escuminac) at 15:45 local time (according to CHS records), resulting in a storm surge of 1.1 m. The maximum storm surge ever recorded at Escuminac was however 1.53 m, on 17 March 1976 (Daigle, 2006).

Charlottetown

The maximum water level recorded at the Charlottetown tide gauge was 4.22 m (CD) on 21 January 2000, resulting in a storm surge of 1.37 m (Daigle, 2006). The maximum storm surge measured by the Charlottetown tide gauge was however 1.53 m on 17 January 2004 (Daigle, 2006).

Rustico

The maximum water level recorded at the Rustico tide gauge was 2.11 m (CD) on 21 November 1988 at 16:00 local time (according to CHS records), resulting in a storm surge of 1.18 m at high tide on that date (0.93 m CD). The maximum storm surge on that date was however 1.38 m at 21:00 local time when the tide would have been 0.33 m CD (according to JTides).

Saint John

The maximum water level recorded at the Saint John tide gauge was 9.14 m (CD) on 2 February 1976 (Groundhog Day Storm)at 13:00 local time (according to CHS records), resulting in a storm surge of 1.28 m at 13:00 local time (high tide, according to JTides)

Table B 22: Plausible Upper Bound water levels for year 2100 calculated as the sum of: current HHWLT, predicted sea-level rise plus error bar, and the maximum storm surge recorded to date.

CHS Representative site	HHWLT m (CD)	Sea-Level Rise (2100) + Error Bar (m)	Maximum Storm Surge to Date (m) (See Note 1)	Plausible Upper Bound Water Level (m) (CD) by Year 2100 (see Note 2)
Nova Scotia				
Burncoat Head	16.50	1.53	1.28	19.31
Joggins	13.40	1.53	1.28	16.21
Pictou	2.05	1.53	1.49	5.07
Cheticamp	1.37	1.58	1.38	4.33
Sydney	1.32	1.58	0.97	3.87
Canso Harbour	1.85	1.58	1.63	5.06
Halifax	2.16	1.54	1.63	5.33
Lunenburg	2.43	1.54	1.63	5.60
Liverpool	2.30	1.54	1.63	5.47
Yarmouth	5.16	1.54	1.49	8.19
Digby	9.13	1.53	1.49	12.15
Hantsport	15.26	1.48	1.28	18.02
Prince Edward Island				
Alberton	1.16	1.56	1.38	4.10
West Point	1.51	1.48	1.77	4.76
Summerside	2.18	1.48	1.53	5.19
Rustico	1.23	1.56	1.38	4.17
Charlottetown	3.01	1.54	1.53	6.08
St Peter's Bay	1.05	1.53	1.38	3.96
North Lake Harbour	1.45	1.58	1.38	4.41
Naufrage	1.25	1.58	1.38	4.21
Georgetown	1.90	1.58	1.38	4.86

Note 1. Storm surge values taken from tide gauge to site relationship as in Tables B 3 to B 23 (without % adjustments) with maximum surge values known for the respective CHS tide gauge data.

Note 2. The storm surge estimates do not include any increases from the current historical values due to future changes, such as potentially an increase in strength of storms.