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Final Report

Intensity-Duration-Frequency Curve Update for Newfoundland and Labrador

Prepared for: The Office of Climate Change and Energy Efficiency, Government of Newfoundland and Labrador

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Gerald Crane
The Office of Climate Change and Energy Efficiency
Government of Newfoundland and Labrador
P.O. Box 8700
St. John's, NL A1B 4J6

Dear Mr. Crane:

Re: Intensity-Duration-Frequency Curve Update Final Report

Conestoga-Rovers & Associates (CRA) is pleased to provide the Office of Climate Change and Energy Efficiency (CCEE), Government of Newfoundland and Labrador with the attached Final Report for the Intensity-Duration-Frequency (IDF) Curve Update.

This report presents the results of the IDF curve update for each of the 13 IDF curves included in the scope of work of the project. In addition, the future IDF curves are presented for all 19 IDF curves in the Province.

All of which is respectfully submitted,

CONESTOGA-ROVERS & ASSOCIATES

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Executive Summary

This report presents the results of an Intensity-Duration-Frequency (IDF) curve update study performed for the Province of Newfoundland and Labrador. The report was prepared for the Government of Newfoundland and Labrador, Office of Climate Change and Energy Efficiency (CCEE).

The Government of Newfoundland and Labrador recognized in its 2011 Climate Change Action Plan that climate change is a long-term challenge for the Province, with significant environmental, economic, and social impacts. One of the anticipated impacts of climate change in the Province is increased precipitation. Increased precipitation amounts and intensities will have a significant impact on infrastructure, which is designed with consideration of rainfall Intensity-Duration-Frequency (IDF) curves. IDF curves characterize the relationship between the intensity of precipitation occurring over a specified period of time and its frequency of occurrence. Accurate, up-to-date IDF curves are essential for ensuring that the Province can adapt and increase resiliency to the effects of climate change.

Currently, there are 19 IDF stations in Newfoundland and Labrador. The most recent set of IDF curves produced by Environment Canada (EC) were released in 2015 (V2.3). However, 13 of the stations are inactive and are no longer recording precipitation. IDF curves generated from inactive stations may become out-of-date if precipitation patterns change over time. The purpose of this project was to investigate what types of data are available to update the inactive IDF curves and then produce new, updated IDF curves. It is important to note that EC's IDF curve methodology was followed so that a consistent set of IDF curves would be produced.

The precipitation monitoring network in Newfoundland and Labrador is sparse. There are relatively few precipitation stations near each inactive IDF station, and there are areas of the Province with only 6-hr and/or 1-hr precipitation monitoring. The use of these data for updating the IDF curves was not optimal; the data had error due to the use of fixed time periods and only some durations could be updated. The durations that could not be updated were left unchanged. All durations are presented in the IDF curve update figures and tables. The figures and tables clearly indicate the durations that were updated/not updated. A new IDF curve was generated for the southwestern portion of St. John's (Ruby Line).

The updated IDF curves were generated by augmenting the EC data with the newer data. The method of moments was used to fit the Gumbel distribution to the augmented data set, using the EC methodology. This method can result in updated IDF curves that are lower than the previous IDF curves (EC IDF V2.3) for some, or all, combinations of durations and return periods. A longer observation record results in a more accurate estimation of the IDF curves. However, precipitation is expected to increase in the future due to climate change. Therefore, decreased

IDF curves may be an issue for engineering safety. This report presents the updated IDF curves, but where decreases from the previous EC IDF curves were identified, the changes are clearly marked and users are cautioned to use the updated curves with care or to use the EC IDF curves.

The differences in precipitation amounts between the EC IDF curves and the new, updated IDF curves were calculated and examined for all stations. A regional pattern was observed in the changes in precipitation amounts from the EC IDF curves to the updated IDF curves. During the update, the IDF curves for the durations of 1-hr and longer increased for the stations in Labrador. The stations in the northeast of Newfoundland also increased for the durations of 1-hr and longer, while the stations in the southwest of Newfoundland decreased. In the past decade, there have been several major storms that strongly affected the eastern part of Newfoundland. These were extra-tropical storms (moving in from the Atlantic), with large precipitation amounts for the durations of 1-hr and longer. Therefore, it was expected to find increases in precipitation at the eastern stations.

A long-term trend analysis was performed for each station using the EC trend test method. This method is used by EC to determine if the extreme precipitation data show consistent trends (increases or decreases) through time (e.g., due to climate change). The trend was calculated using the updated IDF curve data sets (combined EC data and updated data). By including the updated data in the trend analysis, it was possible to determine if the addition of the recent data revealed a trend in the entire time period (up to 2014). The trend analysis of the updated IDF rainfall amounts did not reveal any regions in the Province where all of the stations show statistically significant trends at some, or all, durations. Some of the northeast stations in Newfoundland showed positive trends in precipitation amounts for durations of 1-hr and longer, but only some of them were statistically significant. The other regions of the Province did not show a consistent pattern. Therefore, the historical data do not currently show an unequivocal and consistent climate change signal. These results are similar to the results found by other authors: there is a significant increase in the number of days with precipitation; there are more stations with increasing trends than decreasing trends; and most trends (positive and negative) are not statistically significant.

There are three possible reasons for the lack of consistent evidence of climate change in the trend results. Firstly, the trend analysis used by EC is performed on the annual maxima only, and does not include the case where multiple extreme precipitation events occur during the same year (partial duration series analysis). Secondly, the record length for IDF curves is often only 10 to 20 years long, which may not be long enough for trend analysis (it is recommended that at least 30 years of data be used). Lastly, the Canadian Standards Association (CSA) has suggested that the lack of density in EC's precipitation network may be another reason for non-consistent, non-significant trends in daily precipitation extremes across the country.

Although there was no conclusive evidence of climate change in the data according to the trend analysis, the changes in precipitation amount between the EC IDF and the updated IDF curves were greater than 5 percent for several stations in the Province. Natural variability in precipitation can cause large changes in the IDF curve estimates over time. Therefore, it is important to perform IDF curve updates regularly in order to capture variability and trends in precipitation, find and utilize a longer climatic dataset so that a more accurate estimation of the IDF curves is obtained.

Future climate IDF curves were generated with the Intensity-Duration-Frequency under a Changing Climate (IDF_CC) tool. The Representative Concentration Pathway (RCP) 4.5 scenario developed by the Intergovernmental Panel on Climate Change Assessment Report 5 (IPCC AR5) was used to develop projections of future climate IDF curves for three time horizons (2011-2040, 2041-2070, and 2071-2100). For the three time horizons, there was projected to be an overall provincial average increase in precipitation amounts of 12 percent (2011-2040), 20 percent (2041-2070) and 24 percent (2071-2100).

There were no regional patterns/differences identified in the projected precipitation increase in the Province as all stations increased by similar amounts. Generally, the shorter duration portions of the IDF curves were projected to increase more than the longer durations. Also, the smaller return periods were projected to increase more than the longer return periods. For most stations, the 100-year return period precipitation amount was projected to become the 50-year return period precipitation amount by mid-century, and become the 25-year return period precipitation amount by the end of the century.

The projected increases in precipitation found using the IDF_CC tool were in a similar range as those reported by other authors. Differences in reported projections can be attributed to a number of factors such as data sets used in the analysis, downscaling of Global Circulation Model (GCM) projections, types of GCMs, methodology for deriving future climate IDFs, and emission scenarios. However, the future climate IDF projections derived in this report have several advantages over previous studies. This analysis produced IDF projections for all rainfall durations from 5-min to 24-hr, for three future time horizons. The most up-to-date methodology for future climate change predictions was used (RCP 4.5 emission scenario from the IPCC AR5). This analysis used the recommended ensemble modeling approach, with projections from 22 GCMs. Finally, the methodology used in this analysis (the IDF_CC tool) was developed specifically for deriving future climate IDFs in Canada.

The Province is underserviced in the area of precipitation monitoring. It is recommended that the precipitation monitoring network be increased in spatial density in the Province, as there are areas with no precipitation monitoring and areas with only 6-hr precipitation monitoring.

Performing an IDF curve update with 6-hr data is not optimal as only three durations may be updated (6-, 12-, and 24-hr). There are tipping bucket stations in the Province (operated by the Department of Environment and Conservation (ENVC) and Hydro) that are archived hourly. However, since the data are collected using tipping buckets, it may be possible to archive the data every 5-min or 15-min. Increasing the archiving frequency would ensure that these data can be used to update/produce IDF curves at more durations in the future. The IDF curve database also warrants improvement in the Province, as there are weather forecast regions with no IDF curve associated with them.

Many GCMs predict increased winter precipitation in the Province, and this may have adverse impacts on infrastructure. Due to the air temperature increase, the winter precipitation may fall as rain instead of snow which can melt snow and/or generate significant runoff potential. If the precipitation falls as snow, the snow accumulation may result in significant runoff potential as the snow melts. Therefore, it is recommended that the Province investigate the potential adverse impacts of increased winter precipitation.

It is recommended that the Province perform an analysis using the Partial Duration Series (PDS) of precipitation for the next step in trend analysis of extreme precipitation in the Province. PDS analysis would capture the case where two or more extreme precipitation events occur in the same year by selecting all events with precipitation greater than a certain threshold. Trend analysis performed using the PDS may result in more consistent evidence of climate change than a trend analysis performed using only the annual maxima.

It is recommended that the Province's flood risk mapping inventory be updated with the updated IDF curves and with the future climate IDF curves. This would enhance public safety by providing both up-to-date flood risk areas and a tool for long-term development planning.

Finally, it is recommended that the IDF curve update be regularly repeated every 3-5 years. Currently, a five-year period is acceptable as there were no consistent statistically significant trends found in the Province. However, if statistically significant trends are identified in the Province, it may be necessary to increase the frequency of IDF updates to three years.

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Section 1.0 Introduction

1.1 Background

The Government of Newfoundland and Labrador recognized in its 2011 Climate Change Action Plan (Newfoundland and Labrador, 2011) that climate change is a long-term challenge for the Province, with significant environmental, economic, and social impacts. Climate change is expected to affect the Province in multiple ways, including increasing intensity and frequency of storms and cyclones, permafrost thawing, decreasing snow cover, earlier and more frequent snowmelt, changes in the hydrological regime and water cycle, increasing frequency and magnitude of floods and storm surges, sea level rise, coastal flooding and erosion, saltwater intrusion, range shifts in flora and fauna, ecosystem changes, and increasing risk of forest fires. Projections of future climate as estimated by Global Circulation Models (GCMs) indicate that air temperatures and precipitation (amounts and intensity) will increase in the Province throughout the 21st century (Lines et al., 2009; Finnis, 2013). There are wide variations predicted locally in the projected air temperature and precipitation increases. The precipitation increases also vary according to season with the largest predicted increases in precipitation amount occurring during the winter months where it may fall more as rain instead of snow due to the air temperature increase.

Increased precipitation will have a significant impact on infrastructure. Engineers, planners, and policy makers utilize rainfall Intensity-Duration-Frequency (IDF) curves in municipal planning and infrastructure design. IDF curves characterize the relationship between the intensity of precipitation occurring over a specified period the time and its frequency of occurrence. They are based on historical observations of precipitation. IDF curves are a better estimate of the current precipitation regime when they are based on time series data that include up-to-date precipitation data. Accurate, up-to-date IDF curves are required to ensure that the Province will adapt and be positioned to be resilient to climate change impacts.

A number of studies have examined the IDF curves in Atlantic Canada. The studies have identified increases in historical precipitation as well as significant increases in projected future precipitation estimates. Khan and Colbert (2012) found that the 12-hr, 100-year precipitation event for Stephenville on the west coast of Newfoundland increased by 19 percent between the 1990 IDF curve and the 2007 IDF curve. CBCL Limited (2012) produced an updated IDF curve for the St. John's A station by combining it with the Windsor Lake station, and found small decreases for short duration and significant increases for long duration rainfall amounts. Atlantic Climate Adaptation Solutions Associations (ACASA, 2011) performed precipitation projections for the Greater Moncton Area using GCMs, and found increases of up to 8 percent for the 2080s horizon. Lines et al. (2009) also utilized GCMs, and found increases in precipitation of up to 31 percent for Newfoundland and Labrador for the 2050s horizon.

In order to understand, prepare for, and enable adaptation to the impacts of climate change, the Office of Climate Change and Energy Efficiency (CCEE) commissioned a study of the climate monitoring capabilities of the Province of Newfoundland and Labrador (AMEC, 2012). The report performed an inventory of the climate monitoring stations in the Province, and included several climatic variables: air temperature, precipitation, snow, wind, sea level, and oceanography. In addition, the report also inventoried several derived climate information products: IDF curves, flood risk maps, climate normals, and climate predictions. The report concluded that the IDF curves for many regions of the Province were out-of-date, and recommended that the IDF curves be updated with recent data.

Shephard (2011) reviewed the short-duration precipitation data available in the Atlantic Provinces, and was able to combine some precipitation stations to allow updating of the IDF curves. This work has been incorporated into the Environment Canada (EC) IDF curves. The most recent release of IDF curves (V2.3) was published in 2015. However, 13 of the 19 IDF curves in Newfoundland and Labrador are generated from inactive stations. The stations became inactive from 1983 to 2009. The inactive stations may not be representative of the current precipitation regime in the Province.

The purpose of this project was to update the 13 IDF curves that come from inactive stations. The IDF curves were updated using the most recent and up-to-date precipitation data near each IDF curve station. The project consisted of three stages:

- Phase I: Scoping/Inventory
- Phase II: IDF Curve Update
- Phase III: Future Climate IDF Curves

The objective of Phase I was to perform an inventory of precipitation monitoring stations and select suitable donor stations for each of the 13 IDF curves that do not have recent data. The inventory included precipitation data collected by EC and a number of other agencies in the Province. Potential donor stations were identified as nearby each of the 13 IDF curve stations to be updated. The methods used to collect the data, the durations used in the data collection, and the years of data available were identified for each potential donor station. Statistical tests were applied to the data at each of the data duration periods to determine the suitability of the donor station to be used to update the IDF curve.

The objective of Phase II was to prepare the updated IDF curves, inclusive of analysis for trends and outliers in the data and the appropriate probability distribution to use in generating the IDF curves. The tables and figures produced by EC were reproduced with the additional data. The

EC methodology was used so that the resulting IDF curves would be consistent with the six IDF curves already updated by EC.

The objective of Phase III was to produce estimates of the future climate IDF curves using the Intensity-Duration-Frequency under a Changing Climate (IDF_CC) tool (Srivastav et al., 2015), utilizing the latest Representative Concentration Pathway (RCP) scenarios described in the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (IPCC, 2013).

1.2 Report Organization

This report is organized as follows:

- Section 2 describes the data inventory, detailing the various sources of precipitation data in the Province and the IDF curve database. Comments are provided regarding the impacts of combining different sources of precipitation monitoring on the quality of the IDF curves.
- Section 3 describes the approach taken for the updating of the IDF curves, including the methodology for the selection of potential donor stations, the various updating strategies, the Quality Assurance/Quality Control (QA/QC) applied to the data, the statistical tests used to determine the suitability of the data, the goodness-of-fit tests used to determine which probability distributions can be used, and the IDF curve fitting technique.
- Section 4 describes the update process utilized for each of the 13 IDF curves, including the data source and updating strategy used, data QA/QC, and changes from the last EC IDF curve update.
- Section 5 describes the future IDF curves produced using the IDF_CC tool, including a detailed description of the method chosen to produce the future IDF curves and the results.
- Sections 6 and 7 describe the conclusions and recommendations, including a summary of the regional changes and trends in precipitation in the Province, and recommendations for future studies.

Section 2.0 Data Inventory

2.1 Precipitation Monitoring in Newfoundland and Labrador

Precipitation monitoring has been performed by a number of agencies in Newfoundland and Labrador. This section describes the different monitoring programs and types of data available.

2.1.1 Environment Canada

Environment Canada (EC) is the main government agency responsible for precipitation monitoring in Canada. EC has collected precipitation data at 312 locations in Newfoundland and Labrador. There are several monitoring programs operated by EC: tipping bucket rain gauges, precipitation weighing gauges, and 24-hr manual measurements.

EC has collected tipping bucket rain gauge (TBRG) data at 41 stations in the Province. When there are at least 10 years of valid data at a station, EC uses the data to produce an IDF curve for that station. Historically, EC used the Meteorological Service of Canada (MSC) TBRG. These gauges were used to calculate precipitation intensity data at a number of durations from 5 minutes to 24 hours. The MSC TBRGs were known to underestimate high intensity precipitation events (Hogg et al., 1989), and EC corrected the data using co-located precipitation measurements taken with MSC Type A (prior to the 1970s) and MSC Type B (1970s to present) standard gauges (manual gauges). Since 2000, EC has been replacing the MSC TBRG with TB3 tipping buckets, which do not underestimate high intensity precipitation events to the same extent (Canadian Standards Association (CSA), 2012) and do not need to be adjusted by a co-located rain gauge. EC TBRGs only operate when the air temperature is above 0°C and hence only record rainfall (they are not heated). EC performs thorough QA/QC on the TBRG data, in conformance with World Meteorological Organization (WMO) standards.

EC has also collected data at 77 stations in the Province using various precipitation weighing gauges, including: Fischer-Porter, Geonor, and Pluvio gauges. These gauges are all-weather precipitation gauges, recording both liquid and solid precipitation. These gauges record precipitation data at a number of durations, including: 15-min, 1-hr, and 6-hr, depending on the station. When these stations are co-located with a TBRG, they can be used for additional QA/QC on the TBRG data. The 15-min and 1-hr data are archived by EC, with no QA/QC performed on the data. There are numerous spurious outliers in the data (e.g., more than 100 mm of precipitation occurring in 15 minutes). The 6-hr data do undergo a QA/QC process. EC produces two 6-hr time series: the data that pass the QA/QC process and the "raw" data that fail the QA/QC process. For this project, the QA/QC 6-hr data were preferred over the raw 6-hr data with the raw data only being used if the QA/QC data were unavailable at that date/time. If a raw data point was the annual maximum for a year, it was flagged for further QA/QC and verification before being used in the IDF curve update. If it could not be verified with other data, it was not used for generating the IDF curve. In addition, the QA/QC'd 6-hr data were used to verify the 15-min and 1-hr data. Spurious outliers were checked against the 6-hr data, and then the data points were marked as "missing". The 6-, 12-, and 24-hr annual maxima from the 15-min and 1-hr data were also checked against the annual maxima from the 6-hr data to ensure that the total depths of rainfall for the two time series were in agreement, and that the annual maxima occurred on the same date for each duration.

EC has also collected 24-hr precipitation at 291 stations in the Province. Some of the 24-hr stations use high quality precipitation measurement gauges, such as the MSC Type B standard rain gauge; these are generally located at airports and other key locations. They operate on a standard "climate day" of 0600 UTC to 0600 UTC. As such, they can be used to correct/validate TBRG data. Other 24-hr stations are run by volunteers/other agencies, who report the data to EC. The type of measurement gauge and hours of measurement for volunteer stations vary from station to station. EC does not perform QA/QC on the volunteer data, but only adds the data to the archive.

Although there are a total of 312 EC stations distributed throughout the Province, a large number of these stations are inactive. Also, a station that recorded TBRG data in the past may only record 6-hr data at present. Table 2.1 lists the number of active and inactive stations for each type of data. Note that where more than one type of measurement is being or has been recorded at a station that the station is included in more than one of the categories. For instance, a station that recorded 5-min TBRG data in the past but records only 6-hr weighing gauge data at present would be included as inactive in the 5-min data category and active in the 6-hr data category. A full listing of the stations for each category is included in Appendix A.

Table 2.1 Summary of Environment Canada Stations

Type of Data[1]	*Active Stations*				*Inactive Stations*			
	Number	*Maximum Length [years][2]*	*Minimum Length [years][2]*	*Mean Length [years][2]*	*Number*	*Maximum Length [years][2]*	*Minimum Length [years][2]*	*Mean Length [years][2]*
5-min Data	14[3]	53	4	13.6	27	49	1	17.6
15-min Data	16	10	2	6.4	0	0	0	0.0
1-hr Data	26	13	2	8.0	3	3	3	3.0
6-hr Data	33	69	2	18.3	44	68	1	20.6
24-hr Data	13	98	20	45.8	278	87	1	18.3

Notes:
1. Precipitation data are often measured with more than one technique (e.g., tipping bucket and weighing gauge) and/or archived at multiple durations at a station. When this occurs, the station is included in more than one category in this table.
2. A part year is counted as a full year.
3. Tipping bucket data were only available to the end of 2013. These stations recorded data in 2013 and are assumed to still be active.

2.1.2 Department of Environment and Conservation: Provincial Real-Time Water Resources Data

The Department of Environment and Conservation in Newfoundland and Labrador operates a provincial water resources network that began recording precipitation in 2009. The network uses TBRGs that report precipitation at an hourly time step. The gauges are unheated but operate year-round. There are six stations in the Province, but the data could not be used as the stations were all too distant from the IDF curve stations to be used. However, they may be useful for generation of IDF curves in the future. The Department of Environment and Conservation does not perform any QA/QC on the data. Table 2.2 summarizes the precipitation stations maintained by the Department of Environment and Conservation. A full listing of these stations is included in Appendix A.

Table 2.2 Summary of Provincial Real-Time Water Resources Stations

Type of Data	*Active Stations*			
	Number	*Maximum Length [years][1]*	*Minimum Length [years][1]*	*Mean Length [years][1]*
1-hr Data	6	8	2	6.2

Notes:
1. A part year is counted as a full year.

2.1.3 Department of Natural Resources: Forestry Services Weather Observation Program

The Forestry Services Weather Observation Program is a seasonal program that collects precipitation data for the purpose of predicting the level of forest fire risk. The data are manually collected every 24 hours, usually at 1:00 PM local time. However, the data were not used for this project because the program only operates during June, July and August (the fire season). The annual maximum rainfall is required for IDF curve analysis, which may occur at any time during the warm (above freezing) part of the year.

The Forestry Services Weather Observation Program is planning to install 10 automatic weather stations around the Province in the near future. These may be a suitable source of data for future IDF updates, especially if the weather stations include TBRG.

2.1.4 Department of Transportation and Works: Road Weather Information Systems

The Department of Transportation and Works in Newfoundland and Labrador operates a Road Weather Information System (RWIS) that collects precipitation data. However, the data were not used for this project for the following reasons:

- The RWIS only collects data during the winter season
- The RWIS does not record precipitation amounts, only instantaneous precipitation as a logical (true/false) flag

2.1.5 City of St. John's Rainfall Network

The City of St. John's commenced monitoring precipitation using Met One TBRGs just after the TBRG was removed from the St. John's Airport station (1996). The Met One gauges have a sensitivity of 0.1 mm and data are archived every 5 minutes. The gauges are heated and operate year-round. They are checked periodically with a MSC Type B standard rain gauge to verify daily totals. There are three stations in the network, two of which were used in this study. The City of St. John's performs QA/QC on the data. Table 2.3 summarizes the precipitation stations maintained by the City of St. John's. A full listing of these stations is also included in Appendix A.

Table 2.3 Summary of City of St. John's Rainfall Network Stations

Type of Data	*Active Stations*			
	Number	*Maximum Length [years][1]*	*Minimum Length [years][1]*	*Mean Length [years][1]*
5-min Data	3	18	15	17.3
Notes: 1. A part year is counted as a full year.				

2.1.6 Newfoundland and Labrador Hydro

Newfoundland and Labrador Hydro (Hydro) monitors precipitation at a number of locations in the Province. The data are used to assist Hydro with hydro-power operation and planning. Hydro uses unheated TBRG to record the precipitation, and archives the data hourly. The gauges are known to underestimate precipitation. Hydro performs minimal QA/QC on the data, aimed at preparing the data for use in operation and planning. The QA/QC is not sufficient for use in this application, and the data must be compared to nearby gauges for verification. One of the stations was sufficiently close to one of the IDF curve stations to transfer the longer duration data. The other stations may be useful for generation of IDF curves in the future. Table 2.4 summarizes the precipitation stations maintained by Hydro. A full listing of these stations is included in Appendix A.

Table 2.4 Summary of Hydro Stations

Type of Data	*Active Stations*			
	Number	***Maximum Length [years]***[1]	***Minimum Length [years]***[1]	***Mean Length [years]***[1]
1-hr Data	6	8	6	7.2

Notes:
1. A part year is counted as a full year.

The locations of all the precipitation stations described in the previous sub-sections are shown on Figures 2.1 (Newfoundland) and 2.2 (Labrador). The stations are colour-coded by agency and type of measurement. Where more than a single type of precipitation measurement is/was performed at a particular station, the station is colour-coded according to the shortest duration measurement (e.g., where a 5-min TBRG is/was co-located with a 6-hr weighing gauge, the station is colour-coded as a 5-min station). The provincial weather forecast regions are also included in the Figures. The weather forecast regions were used during the selection process for potential donor stations.

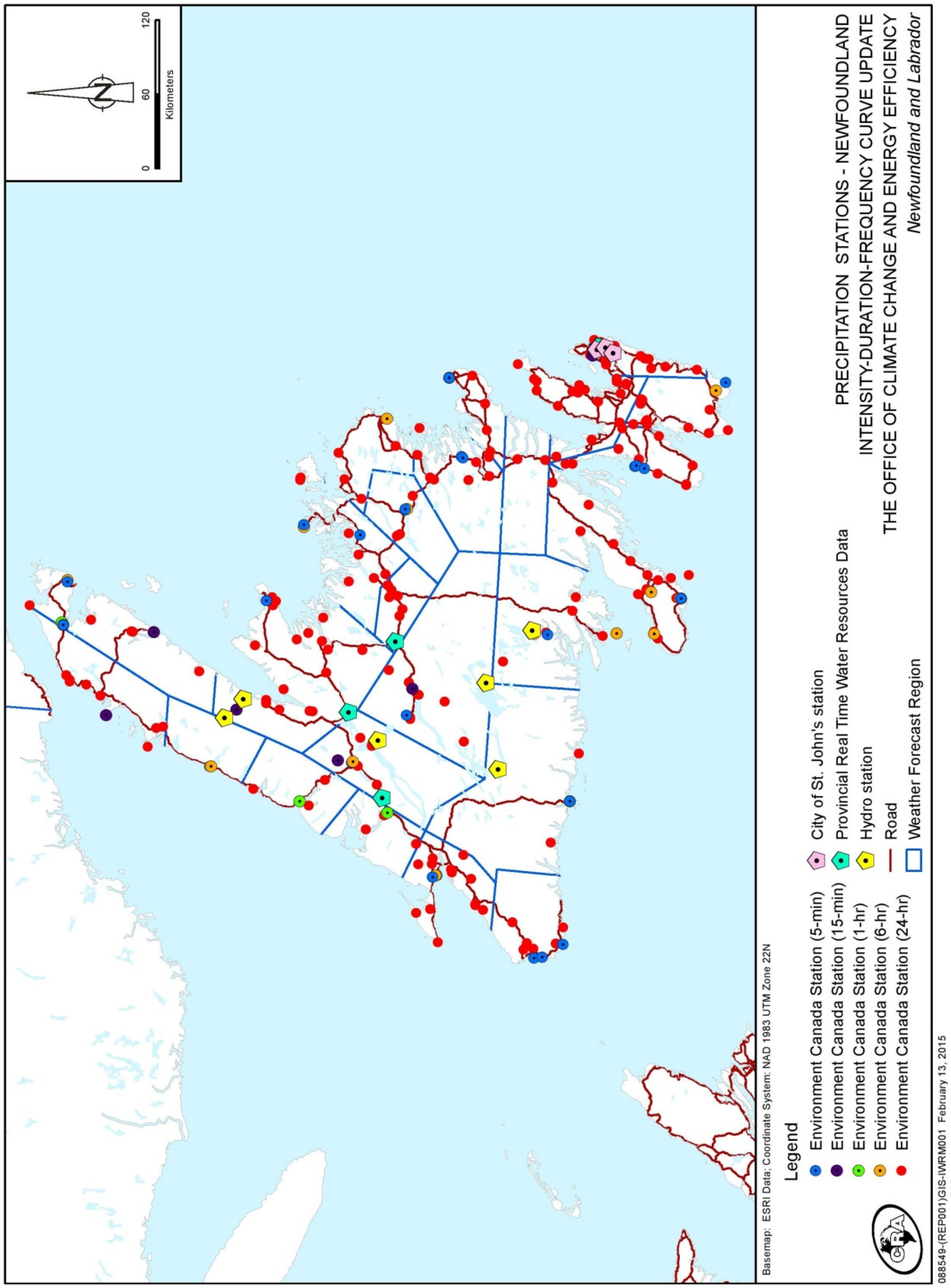

Figure 2.1 Precipitation Stations – Newfoundland

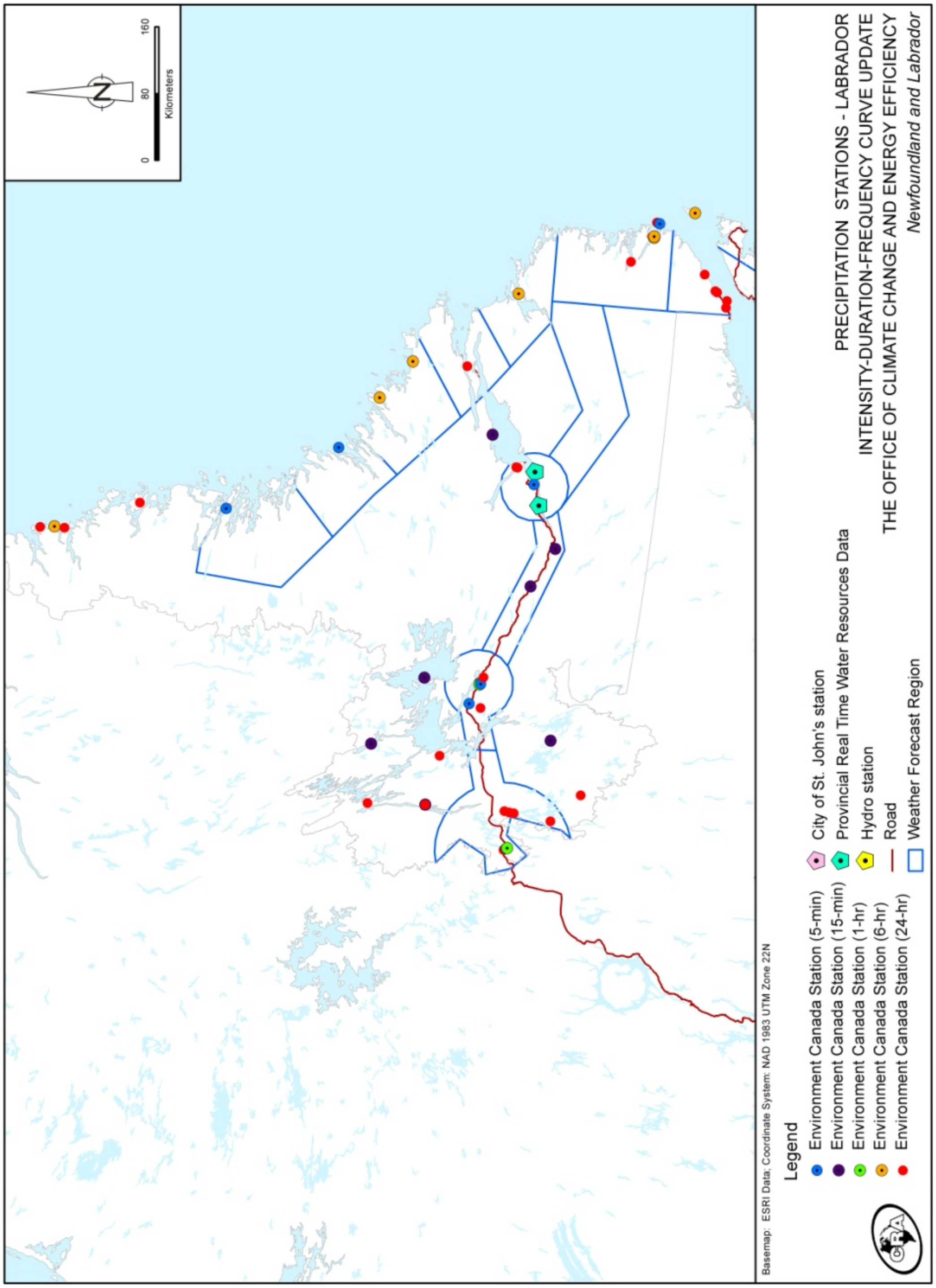

Figure 2.2 Precipitation Stations – Labrador

The Province is underserviced in the area of precipitation monitoring. Many of the EC stations have become inactive, leading to a sparse monitoring network. In addition, there are relatively few stations that record short-duration precipitation at a 5-min, 15-min, or 1-hr time step. There are some weather forecast regions with only 6-hr or 24-hr precipitation monitoring, and some weather forecast regions with no active precipitation monitoring. This leads to a sub-optimal monitoring network which may not capture/detect precipitation accurately, potentially leading to underestimation of IDF curves (rainfall events missed or under-represented).

2.2 Intensity-Duration-Frequency Curves

EC is the agency responsible for the production of Intensity-Duration-Frequency (IDF) curves in Canada. EC uses TBRG data to produce the IDF curves, and produces new IDF curves every three years. The most recent IDF curves (V2.3) were released in January, 2015, and included data up to the end of 2013.

There are 19 IDF curves in the Province of Newfoundland and Labrador. The stations are distributed as follows: 13 in Newfoundland and 6 in Labrador. The stations are widely spaced, and there are weather forecast regions that do not have an associated IDF curve. In addition, only six of the IDF curves are calculated from an active station. There are four active stations in Newfoundland, and two active stations in Labrador. The stations are listed in Table 2.5 and shown on Figure 2.3. The inactive stations became inactive from 1983 to 2009. The utilization of inactive IDF curves for municipal planning purposes is problematic, as recent data are not captured in the IDF curves. IDF curves produced from the stations without current precipitation data will not include the recent effects of climate change and/or may under-represent the natural climatic variability at a location. Therefore, the Province is underserviced in the area of IDF curves as the network is both sparse and out-of-date.

Table 2.5 Summary of Environment Canada IDF Curves

Station Name	*Station ID*	*Duration of Data in IDF Curve*	*Number of Years of Data*	*Status of Station*
Argentia (AUT)	8400104	1980 – 2013	15	Active
Burgeo	8400801	1967 – 2012	31	Active
Comfort Cove	8401259	1967 – 1995	27	Inactive
Daniels Harbour	8401400	1969 – 1995	26	Inactive
Deer Lake A	8401501	1966 – 2002	36	Inactive
Gander Airport CS	8401705	1939 – 2009	65	Inactive
La Scie	8402520	1984 – 1995	11	Inactive
Port Aux Basques	8402975	1975 – 1996	19	Inactive
St. Albans	8403290	1969 – 1983	14	Inactive
St. Anthony	8403401	1971 – 1995	23	Inactive
St. John's A	8403506	1949 – 1996	35	Inactive
St. Lawrence	8403619	1969 – 2013	33	Active
Stephenville A	8403800	1967 – 2012	43	Active
Battle Harbour LOR	8500398	1972 – 1983	11	Inactive
Churchill Falls A	8501132	1969 – 1992	23	Inactive
Goose A	8501900	1961 – 2013	50	Active
Mary's Harbour A	8502591	1983 – 1995	12	Inactive
Nain	8502799	1993 – 2013	17	Active
Wabush Lake A	8504175	1974 – 2003	25	Inactive

088549-(REP001)GIS-IWRM016 February 17, 2015

Figure 2.3 Active and Inactive IDF Stations

2.3 Implications of Updating IDF Curves with Other Precipitation Data Sources

The purpose of this project is to update the 13 inactive IDF curves in the Province of Newfoundland and Labrador. However, the precipitation monitoring network is sparse, particularly for the 5-min, 15-min, and 1-hr recording intervals. In some locations, only 6-hr data were available to use for updating the IDF curves. The use of other precipitation monitoring techniques to update the IDF curves has implications for the accuracy of the IDF curves.

EC IDF curves are generated with TBRG data, which report precipitation at 5-min intervals. TBRGs are the preferred precipitation monitoring method for IDF curve generation. EC has established procedures for QA/QC of TBRG data. In many locations, the data used for the IDF curve update came from precipitation weighing gauges. Precipitation weighing gauges are the other main method for automated precipitation monitoring. Precipitation weighing gauges are very accurate at both low and high rates of precipitation (as long as the bucket does not overflow) and are considerably better than TBRGs at measuring solid precipitation.

The main effect of using other types of data for IDF curve generation is due to the use of fixed reporting periods. The 24-hr data are generally recorded for the 24 hours ending at 0600 UTC (or another time for a volunteer station), but the TBRG 24-hr data are based on running totals of the hourly precipitation and do not contain any artificial day boundaries. For instance, if a 24-hr rain event began at 1800 UTC one day and continued until 1800 UTC the next day, the rain would be recorded on two separate days in the 24-hr station data. However, the total precipitation would be recorded in the TBRG 24-hr data. Shephard et al. (2014) stated that this results in the TBRG 24-hr data being on average 1.13 times larger than the 24-hr data at the daily stations. This problem also exists for the 15-min, 1-hr, and 6-hr data, which are also based on fixed reporting periods. However, the problem is less severe for the shorter durations. To overcome this problem, Shephard (2011) recommended that the shortest duration that can be updated is the duration that is double the observation period. The ability to use the duration of the observation period for generation of the IDF curve was explored by correlation and statistical tests in this study. It is possible, however, that some underestimation of the true precipitation remains, particularly when 6-hr weighing gauge data were used for the update.

A second effect of using other data sources for IDF curve updating is due to the fact that precipitation weighing gauges operate year-round, collecting both snow and rain. It was therefore necessary to determine whether precipitation events were snow or rain for generation of the IDF curves, and to remove the snow events from the annual maximum time series.

A third effect of using other data sources for IDF curve updating is the introduction of heterogeneity into the historical time series. The updated data were often measured using another technique (precipitation weighing gauge instead of TBRG), may have come from a different location, and were subjected to different QA/QC practices. The heterogeneity can affect whether or not trends appear in the time series and/or affect the IDF curve itself. This problem was addressed with the use of statistical homogeneity tests.

Section 3.0 Approach

3.1 IDF Curve Background

IDF curves reflect a number of different processes (Figure 3.1). The IDF curve is created from the time series of annual maximum precipitation intensities derived for a number of durations ranging from 5-min to 24-hr.

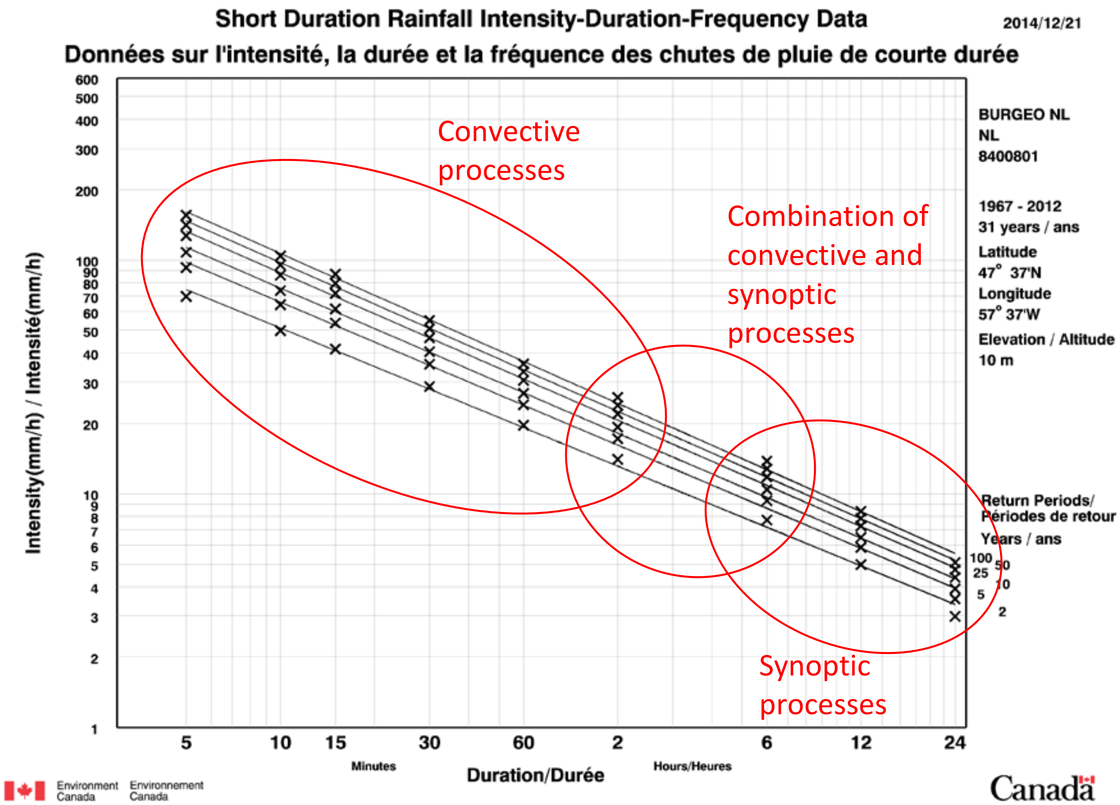

Figure 3.1 IDF Curve Showing Types of Precipitation Events for Each Duration

(Image source: EC IDF Curve V2.3 for Burgeo, NL)

Short duration annual maximum intensities are typically generated by convective precipitation events (e.g., a thunderstorm). Convective events have typically small horizontal (10-100 km) and temporal (minutes to hours) scales. They are generally very localized and precipitation amounts/intensities can vary greatly from location to location and during the course of the event.

Long duration intensities, on the other hand, are typically generated by large synoptic events (e.g., a frontal system or extra-tropical storm). Synoptic events have large horizontal (100-1000 km) and temporal (hours to days) scales. They cover large areas and precipitation amounts/intensities are more uniformly distributed throughout the duration of the event.

Newfoundland and Labrador's unique topography and location strongly influence the precipitation characteristics in the Province. The topography of Labrador ranges from sea level on the coast to 1600 m in the interior. The topography of Newfoundland ranges from sea level to 800 m in the Long Range Mountains on the west side of the island. The topographical influences cause significant changes in precipitation characteristics (enhanced rainfall and rainfall shadows). The Province is located near the ocean and the Labrador Current and the Gulf Stream both affect the weather in the Province. The coastal areas of Labrador and the entire island of Newfoundland have maritime weather. The Labrador Current and the Gulf Stream intersect just off the east coast of Newfoundland, and these can contribute to significant precipitation events. The Province is also close to a number of major storm tracks as most precipitation events come from the south (maritime) and west (continental). Extra-tropical storms and hurricanes occur frequently in the summer/fall, bringing large precipitation amounts. Most of the extra-tropical storms and hurricanes come from the Atlantic Ocean.

The IDF curve update process in Newfoundland and Labrador must consider the specific weather characteristics in the Province. Donor stations used to update the IDF curves must be physically close to the IDF curve station, with little elevation change between the two locations. An overlap between the two locations and/or precipitation monitoring methods was preferred so that the two data sources could be compared. Homogeneity testing must be used to ensure that the donor data are suitable for use to extend the IDF curve data. IDF curves are generated with a minimum of 10 years of data, so new IDF locations must be chosen accordingly.

The QA/QC process must account for the use of different precipitation monitoring programs (TBRG and weighing gauges) and different levels of data quality (e.g., 6-hr data instead of 5-min data).

3.2 Selection of Potential Donor Stations

Potential donor stations were selected by the following criteria (all three criteria were requirements for selection).

- The distance between the potential donor station(s) and the IDF curve station was less than 50 km. This was a very conservative distance for transference of precipitation data.
- The potential donor station(s) were within the same provincial weather forecast region as the IDF curve station.
- There should be no significant elevation changes between the potential donor station(s) and the IDF curve station.

The provincial weather forecast regions provided a guide to delineate the types of weather that occur in each region of the Province. Stations that were in different weather forecast regions were assumed to have different precipitation regimes and were not selected as potential donor stations.

For some stations, precipitation monitoring continued at the location after the TBRG was removed. This was considered to be preferable to data at any other location, and therefore data were not transferred from other locations in this case. However, if additional durations could be obtained from a nearby station (e.g., the IDF station recorded 6-hr data, but a nearby station recorded 1-hr data), then the nearby station was considered as a donor so that the shorter durations could also be updated.

3.3 Record Extension Cases

The IDF curve datasets were extended using recent observed precipitation data. There were four different extension cases, depending on the availability of precipitation data:

- Case 1: Monitoring Continued
- Case 2: Nearby Precipitation Stations
- Case 3: Distant Precipitation Stations
- Case 4: New IDF Location

3.3.1 Case 1: Monitoring Continued

In this record extension case, precipitation monitoring continued at the station, but no longer as a TBRG. The precipitation data were measured with a precipitation weighing gauge at 6-hr, 1-hr, or 15-min duration.

Heterogeneity can develop due to the change in precipitation monitoring technique (Figure 3.2). If there was an overlap between the second method of precipitation and the IDF curve, the level of homogeneity was assessed between the two overlapping data sets. If there was no overlap between the second method of precipitation and the IDF curve, the level of homogeneity for the newer, non-overlapping period was tested. If heterogeneity was found, however, further testing was performed to find the source of heterogeneity (e.g., due to change in measurement technique or due to climatic variation in the different time periods).

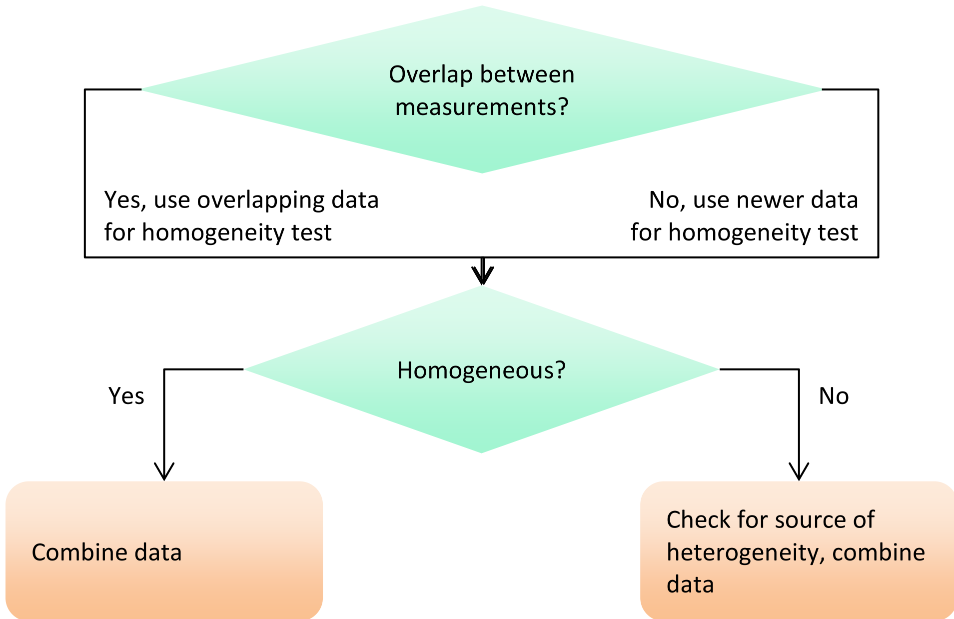

Figure 3.2 Methodology for Case 1: Monitoring Continued

3.3.2 Case 2: Nearby Precipitation Stations

In this record extension case, precipitation monitoring was discontinued at the station, but precipitation data were available nearby (within 3 km). A 3 km radius was used because Berndtsson and Niemczynowicz (1986) found that the correlation coefficient for daily precipitation is between 0.8 and 0.9 for stations that are less than 1 km apart, and the correlation remains high up to a distance of between 2 and 3 km apart. Precipitation stations may have moved location at any point in time within the time series (immediately after the TBRG was removed or at a later date).

In this record extension case, heterogeneity may develop due to the change in location as well as due to the change in precipitation monitoring technique (Figure 3.3). EC combines stations when the distance between the stations is less than approximately 1 km. EC does not perform homogeneity testing before combining such stations; the stations are automatically combined. Therefore, if the stations were less than 1 km apart, it was assumed that the two records would be homogeneous, and the data from the different stations were combined automatically. If the stations were between 1 and 3 km apart, the statistical homogeneity tests were performed. If any heterogeneity was found between the donor data and the IDF curve data, the heterogeneity was investigated further to determine if it was due to climatic variation/changes or due to the change in measurement technique and/or location.

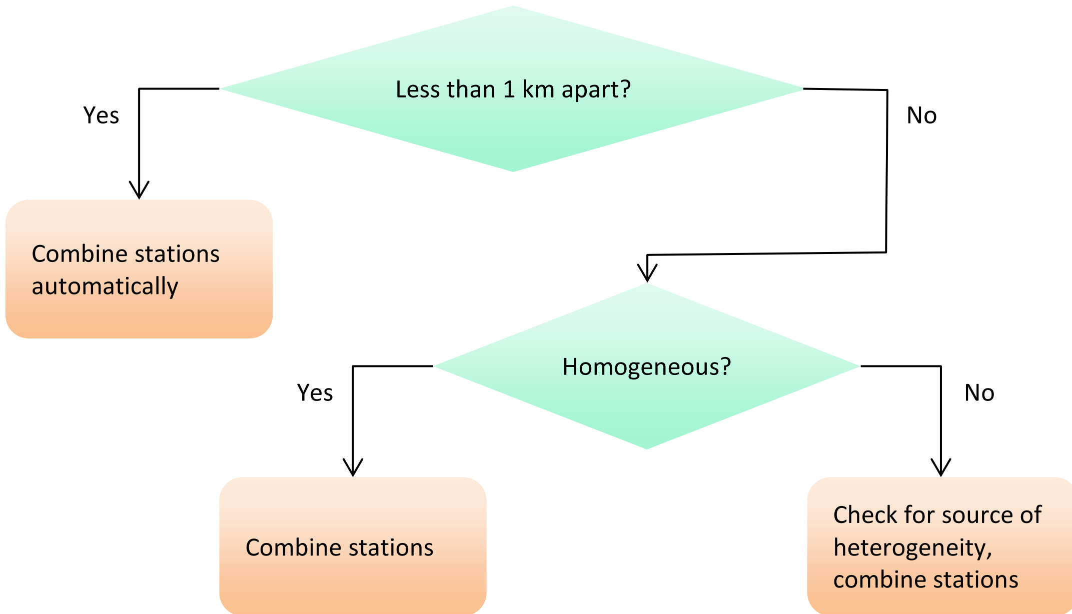

Figure 3.3 Methodology for Case 2: Nearby Precipitation Stations

3.3.3 Case 3: Distant Precipitation Stations

In this record extension case, precipitation monitoring was discontinued at the station, and the nearest precipitation data were more than 3 km away. Transferring sub-daily precipitation between distant stations is problematic because it may not be representative of or homogeneous with the precipitation at the IDF curve station. In addition, the type of precipitation event that generates the annual maximum event varies according to the duration (see Figure 3.1). For short durations, the annual maximum events are generally due to small-scale (convective) precipitation events, and the precipitation can vary widely from location to location, even when they are close together. Annual maximum events for the long durations are generally due to large-scale (synoptic) precipitation events. Due to this variation in type of precipitation event, it was decided that only the 6-, 12-, and 24-hr durations would be transferred from distant precipitation stations as these annual maxima are due to large-scale, synoptic precipitation events that could reasonably be expected to have similarly impacted both stations.

For transfer of 6-, 12-, and 24-hr precipitation amounts, a two-step process was used (Figure 3.4). The first step examined the relative locations of the two stations with respect to topography. For instance, if a station is located at a different elevation or in a different valley from the IDF station, it would be excluded. The correlation and statistical tests were then performed on the two annual maxima time series to determine the suitability for data transfer.

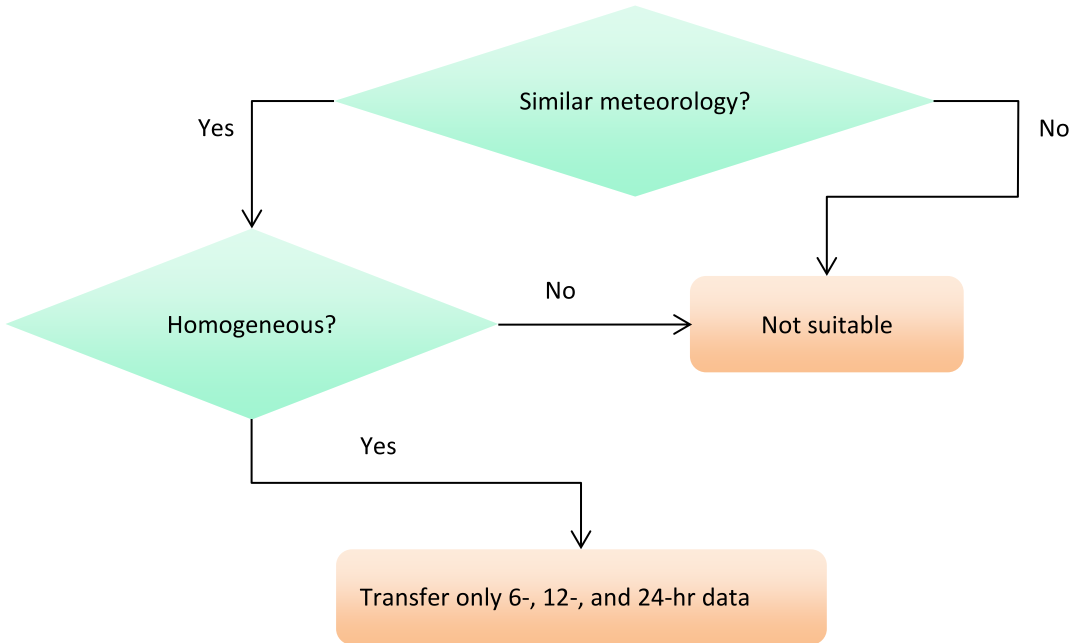

Figure 3.4 Methodology for Case 3: Distant Precipitation Stations

3.3.4 Case 4: New IDF Location

In this record extension case, precipitation monitoring was discontinued at the station, and there were no precipitation data available nearby. However, for these stations, the precipitation monitoring focus for the region was moved to another location that will likely become an IDF curve in the future. In addition, enough data (at least 10 years) have been measured at the other location (or nearby) to allow an IDF curve to be constructed for durations of 1-, 2-, 6-, 12-, and 24-hr. Homogeneity tests were performed to ensure that the data from the different measurement techniques used at the station or at nearby stations could be combined to produce an IDF curve (Figure 3.5).

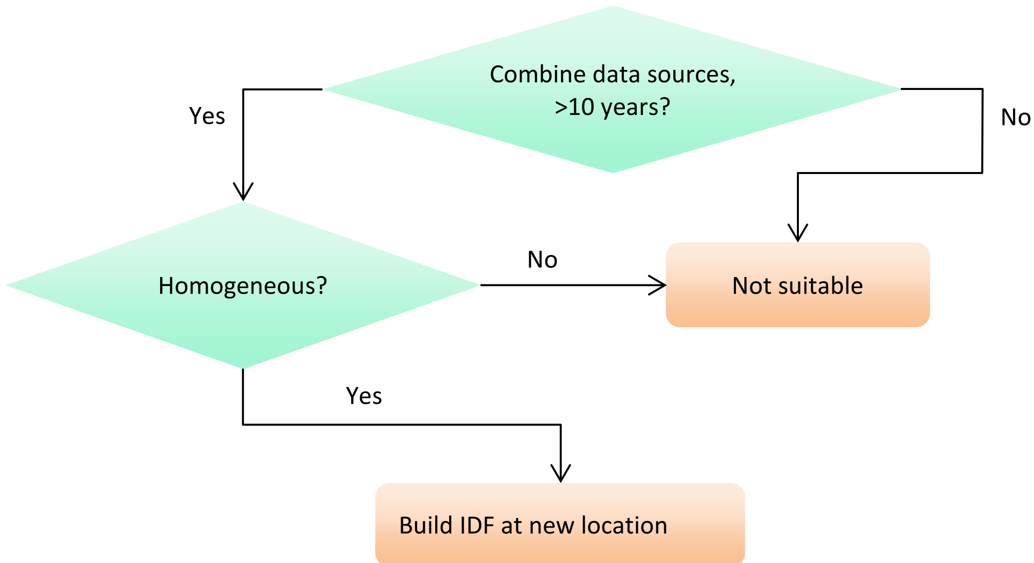

Figure 3.5 Methodology for Case 4: New IDF Location

3.4 Data QA/QC

Prior to performing the statistical tests, the data underwent a thorough and systematic QA/QC process. The time series data were obtained from the various agencies. EC performed automatic QA/QC on the 6-hr data. The EC 1-hr and 15-min data did not undergo QA/QC, but the six hour totals were checked against the 6-hr QA/QC data. The City of St. John's stations underwent QA/QC by the City of St. John's. Hydro performed minimal QA/QC on the Hydro data, and hence the Hydro data were only used when the data could be verified with a nearby EC station. The QA/QC described in this section focused on the ability to use the data to update the IDF curve.

The annual maximum amount was found for each year for each duration of storm. EC's method for deriving the annual maxima from the TBRG data was used. For the precipitation weighing gauge data, the data were accumulated to produce annual maxima for all durations longer than the observation period (e.g., 6-hr data were used to produce a 6-hr annual maximum using one 6-hr amount, a 12-hr annual maximum using two consecutive 6-hr amounts, and a 24-hr annual maximum using four consecutive 6-hr amounts). Several QA/QC tests were performed on the annual maxima. The QA/QC procedures outlined in CSA (2012) were followed and also expanded with some other QA/QC procedures specific to this project (e.g., checking for snow events, which are inapplicable for TBRG data). The full list of QA/QC procedures included the following.

- If the data were EC 15-min or 1-hr data, the data were compared to the QA/QC'd 6-hr data. If the data did not approximately match the 6-hr data, the data were marked missing.

Spurious outliers in the 1-hr and 15-min data were also removed by comparing the data with the 6-hr data.

- If the data were from a TBRG, the annual maxima were compared to the other data at the station (or nearby) to verify that the true annual maxima were identified. The dates of the annual maxima and the total depth of rainfall were both compared.
- Wherever different durations of data (e.g., 1-hr data and 6-hr data) were available at a location, the dates of the annual maxima and the total precipitation amounts for each duration were checked to ensure that the same events were identified.
- If the 'annual maximum for a duration' occurred on a date when the 6-hr data were marked as raw, other precipitation records were checked for that location or nearby locations to determine if the data could be verified (either that it was accurate or that it was deleted). If the data could not be verified, the annual maximum was marked as missing for that duration.
- If the annual maximum occurred during the cold part of the year (November to March), the 24-hr precipitation data and the air temperature data were checked. The 24-hr precipitation data are recorded separately as rain or snow for many stations. If the 24-hr data were available and indicated that the event was mainly or fully snow, the event was ignored. If these data were not available, the maximum, minimum, and mean air temperatures for that date were determined. If the mean and minimum air temperatures were below 0°C, it was assumed that the event was mainly or fully snow, and the event was ignored. The next largest event was taken as the annual maximum for that year, and the QA/QC repeated for that event.
- The annual maxima for each duration were compared to the annual maxima of the IDF curve to ensure that they were physically reasonable for the location. Values that were lower or higher than the observed range were flagged for additional verification.
- Various consistency checks were also performed. These included: ensuring that the 24-hr annual maximum was calculated from four valid 6-hr observations and that there were no missing/raw data on that date; ensuring that the 24-hr annual maximum was less than or equal to four times the 6-hr annual maximum; and other similar consistency checks for the other durations.
- The dates of the annual maxima were checked against the historical record of extreme precipitation events to affect Newfoundland and Labrador (i.e., hurricanes and extra-tropical storms). If the hurricanes were not identified as the annual maxima in a particular year, the data for that date were examined to confirm if precipitation was recorded or whether there were any missing data.
- If there were a large number of missing days of data in the year (as defined below), it was assumed that the annual maximum might have been missed and the year was not used in the IDF update. CSA (2012) suggested a minimum of 180 days between April and October

(with some variation according to location), but also states that a year may be included if the analyst is confident that the annual maximum was recorded. Therefore, other data sources at the station and nearby were compared to determine if the annual maximum could be verified when there were a large number of missing data. For instance, if the annual maximum occurred on the date of a hurricane, it was assumed that the true annual maximum was captured for that year, even if the year was otherwise incomplete. If the annual maximum could not be verified, the year was declared incomplete and not used in the IDF update.

As shorter duration data have less error from the use of fixed reporting periods, it was decided to use accumulated totals from the shorter duration data wherever possible, instead of the longer duration amounts. The following priority ordering was used for selecting the data to use for the IDF update: 5-min data, 15-min data, 1-hr data, 6-hr data, and 24-hr data. For instance, if a TBRG with 5-min data existed at a station for a particular year and passed the QA/QC described above, its data were used at all durations for the update, even if there were 1-hr or 6-hr data available at the station. Similarly, where both 1-hr and 6-hr data were available, the 1-hr accumulated totals were used for all durations of 1-hr and longer (if the 1-hr data passed the QA/QC described above).

3.5 Statistical Analysis for Donor Suitability

Statistical analysis was used to determine the suitability of the donor data to be used to augment the data in the IDF curve. Figure 3.6 provides the flow chart for the statistical analysis for donor suitability. There are two parts to the flow chart. The first part was performed for all cases. The second part was added for the cases when stations were between 1 and 3 km apart and there was short duration data.

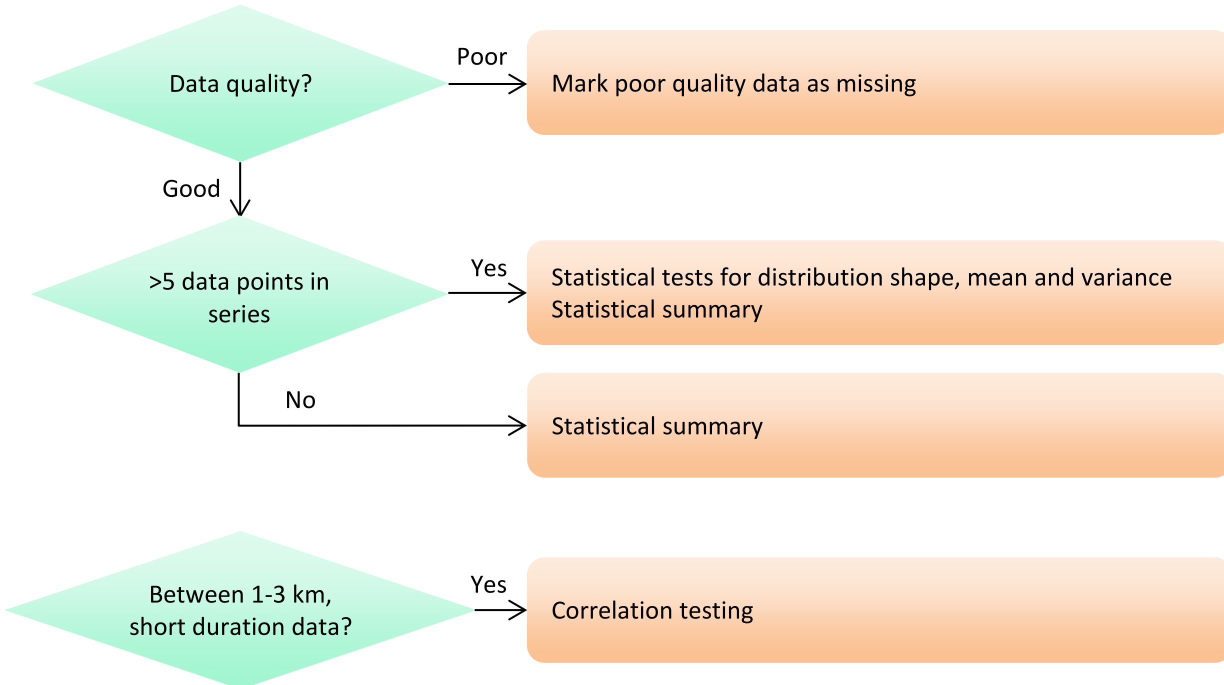

Figure 3.6 Methodology for Homogeneity Testing

The first step was to perform the QA/QC on the data and remove the poor quality data from the data set. Poor quality data were marked as missing and not used in the analysis. The data QA/QC was described in Section 3.4.

If there were at least five data points (years) in the series, statistical homogeneity tests were used to test for donor suitability. The Gumbel distribution used by EC is a two parameter distribution. Therefore, the mean and variance were both tested for similarity. In addition, the distribution shape was also tested for similarity. The Kolmogorov-Smirnov test was chosen as the test for distribution similarity, the Mann-Whitney test was chosen as the test for the mean of the distribution, and the Brown-Forsythe test was chosen as the test for the variance of the distribution. Three sets of data were tested for all stations: the overlapping data (if any), the newer data (non-overlapping), and the entire time series. Performing all three sets of homogeneity tests for all stations allowed for a more complete understanding of the level of homogeneity between the different data sets. The statistical tests are described in detail in Appendix B. In addition, a statistical summary of the data was produced. The statistical summary compared the mean, the standard deviation, and the ranges of the two data sets.

If there were less than five data points in the time series, the statistical tests were not performed. The statistical summary of the mean, variance, and range was produced. The data were checked to ensure that they were reasonable.

An additional test was used when the two stations were between 1 and 3 km apart to justify the transfer of the data for the durations of 2-hr and less. The annual maxima for these durations are often convective precipitation events (see Figure 3.1) and can be highly variable from location to location. To transfer these data to another location, the two stations must have very similar precipitation characteristics. Wadden (2002) used the correlation coefficient for daily precipitation totals. If the two stations are highly correlated, it is likely that the sub-daily precipitation data are also similar. Wadden (2002) included only dates with precipitation greater than 20 mm. This analysis also examined the correlations for dates with precipitation greater than 10 mm, and for all dates. A minimum correlation coefficient of 0.8 was used (Berndtsson and Niemczynowicz, 1986).

3.6 IDF Curve Fitting

The donor data were added to the IDF data, and used to estimate the updated IDF curves. As EC produces IDF curves using the Gumbel distribution, it was chosen as the preferred distribution for the updated IDF curves. Two statistical goodness-of-fit tests were used to ensure that the Gumbel distribution could be used for each station: the Kolmogorov-Smirnov test and the Chi-Square test. The tests are described in detail in Appendix B.

When EC performs an IDF update, EC collects the newer data, performs the QA/QC, and then adds the data to the existing IDF curve. The Gumbel distribution is then fitted to the augmented data set using the method of moments. The methodology is described in detail in the Canadian Standards Association (CSA) technical guide (2012). Frequently, this method results in updated IDF curves that are lower than the previous IDF curves (for some, or all, combinations of durations and return periods). The supporting argument for this methodology is that a more accurate estimation of the IDF curves is obtained from longer observation records. The estimates for the parameters of the Gumbel distribution become more accurate with a larger number of data points.

Another approach would be to not update a duration if it is decreasing. The supporting argument for this approach is that precipitation is expected to increase in the future climate and, as such, from an engineering safety perspective, IDF curves are not expected to decrease during an update.

For this project, EC's methodology was followed. Some of the updated IDF curves decreased from the previous EC IDF curves. However, in view of the expectation of increases in precipitation in the future climate, the changes from the previous EC IDF curves are clearly documented. When the updated IDF curve was much lower than the EC IDF curve, users are cautioned to use the updated IDF curve with care, or to use the EC IDF curve.

For this update, the three tables and four figures were reproduced to be similar to those produced by EC for each IDF curve. However, as various data sources were used to perform the update (e.g., 6-hr weighing gauge data for some stations, TBRG data for other stations), it was not always possible to update all durations at a station. In order to make it clear which durations were updated and which durations were not updated, the standard format used by EC for the tables and figures was modified. The durations that were not updated are still presented, but are equal to the existing EC IDF curve (V2.3, 2015). The updated durations are presented with different symbols. The methodology and changes to the EC templates are described in detail in Appendix C.

Section 4.0 IDF Curve Update Results

This section presents a station-by-station description of the results of the IDF curve update for each IDF curve station. The stations are organized by record extension case and alphabetically within each case. There are five Case 1 stations, one combined Case 1 and Case 2 station, three Case 2 stations, one Case 3 station, two Case 4 stations, and one station that was not updated.

4.1 Case 1 Stations

4.1.1 Daniels Harbour

Daniels Harbour is located on the west side of the island of Newfoundland, near the south end of the Great Northern Peninsula. The Long Range Mountains, with elevations up to 800 m, are located just to the east of Daniels Harbour. Daniels Harbour is located on route 430 (the "Great Northern Peninsula Highway"), which is the main access route to the Labrador ferry in St. Barbe. This station is therefore located in a key region for the Province. It has a subarctic climate that has severe winters, no dry season, cool and short summers, and a strong seasonality (Köppen-Geiger classification: Dfc). Average total annual precipitation is approximately 1,100 mm.

The EC IDF curve for Daniels Harbour includes data from 1969 to 1995. A co-located 6-hr precipitation weighing gauge was used to check and adjust the data. When the TBRG was removed (1995), the 6-hr data continued to be recorded at the station. There were no other hourly/sub-hourly stations in the area near Daniels Harbour. The stations are listed in Table 4.1 and shown on Figure 4.1.

Table 4.1 Daniels Harbour Station Listing

Station Name	*ID*	*Latitude*	*Longitude*	*Elevation [m]*	*Distance to IDF [km]*	*Type of Data*	*Years*
Daniels Harbour (IDF)	8401400	50°14'11" N	57°34'52" W	19.0	0.00	5-min	1969-1995
Daniels Harbour	8401400	50°14'11" N	57°34'52" W	19.0	0.00	6-hr	1969-current

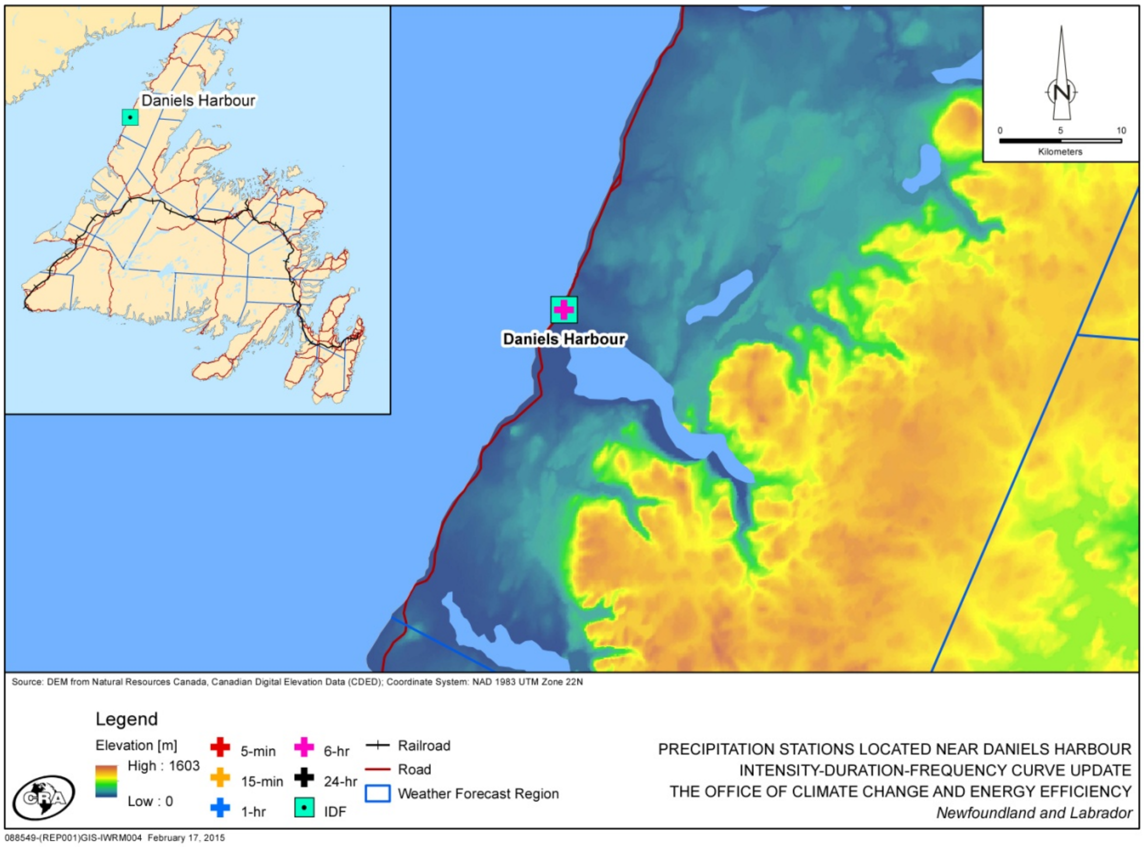

Figure 4.1 Precipitation Stations Located Near Daniels Harbour

Daniels Harbour was updated as a Case 1 station, using the 6-hr data located at the same location. Some years of the 6-hr data were incomplete and were therefore marked missing. Figure 4.2 shows the years of data available for each duration. However, only the 6-hr, 12-hr, and 24-hr durations were updated.

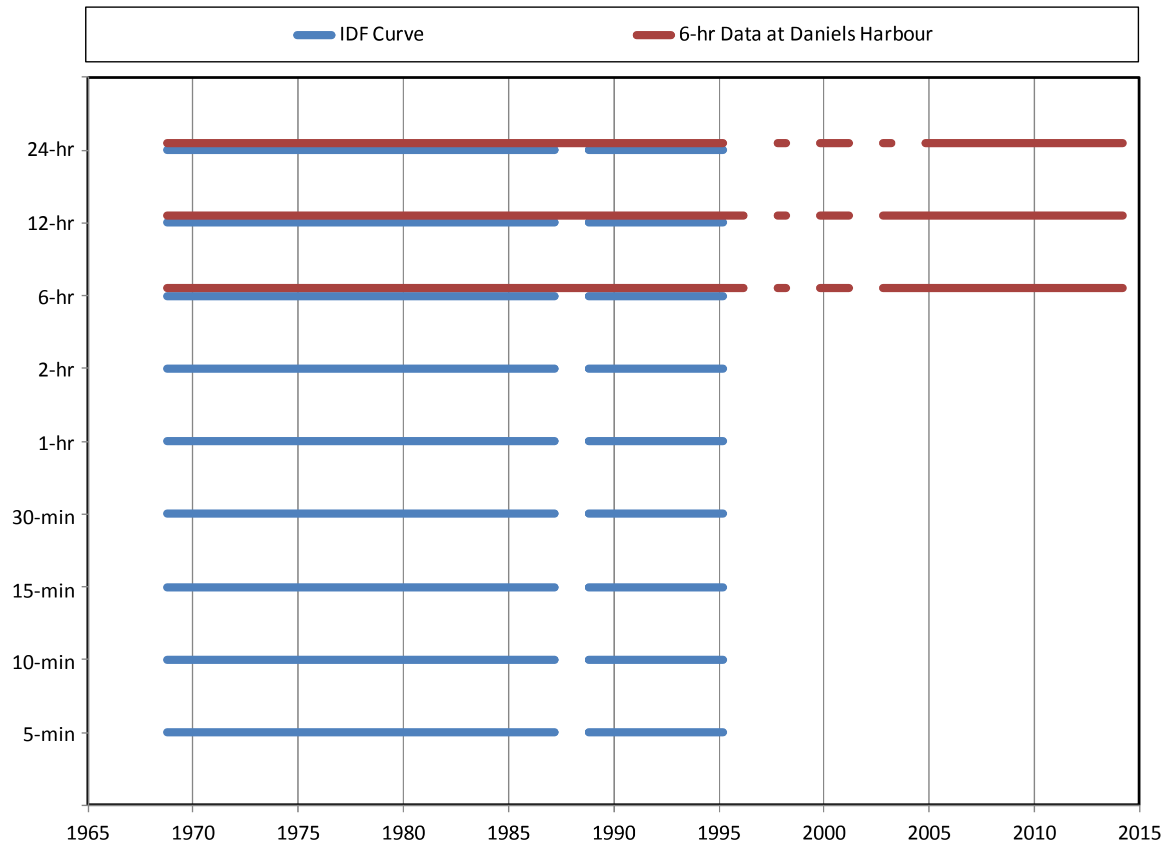

Figure 4.2 Daniels Harbour Data Availability by Year

The annual maxima for the 6-, 12-, and 24-hr durations were generated from the 6-hr weighing gauge data for the period 1969 to 2014, and tested with statistical analysis. The results of the statistical analysis are included in Appendix B. The 6-hr weighing gauge data were homogeneous with the IDF curve data for the 12- and 24-hr durations, but not homogeneous for the 6-hr duration for the overlapping time period. The 6-hr weighing gauge data generally underestimated the precipitation during the overlapping time period. However, the newer time period of 6-hr weighing gauge data were homogeneous with the IDF curve data for all three durations. The means and standard deviations of the newer 6-hr weighing gauge data were lower than the means and standard deviations for the IDF curve data, but the differences were not statistically significant. Therefore, the data could be combined to generate an IDF curve. Goodness-of-fit tests were performed to ensure that the Gumbel distribution could be used to fit the combined data from the Daniels Harbour station. The tests showed that the data could be modelled with the Gumbel distribution for all durations except for the 12-hr duration. For the 12-hr duration, one of the tests showed that the data did not fit with the Gumbel distribution, but the other test showed that the data did fit with the Gumbel distribution. Since only one of the tests indicated that the 12-hr data did not fit with the Gumbel distribution, and all of the rest of the durations fit the Gumbel distribution, the Gumbel distribution was used for this station.

The IDF curve was generated using the Gumbel distribution and the tables and figures are included in Appendix C. The quantile-quantile and return level plots indicated that the data were a good fit with the Gumbel distribution. There was one point that fell outside of the 95 percent confidence limits at the 5-min duration. This was an EC IDF data point, and was not part of the update. It was therefore not analyzed further. The trend plot showed that there were no significant trends at any of the durations. The updated data caused the trends to decrease at the 6-, 12-, and 24-hr durations.

The updated IDF curve was compared to the EC IDF curve (V2.3, 2015) in Table 4.2. The precipitation decreased for all durations. The decreases were larger than 5 percent for most return periods for all three durations. Therefore, users should exercise caution when using the updated IDF curve, or use the EC IDF curve instead.

Table 4.2 Daniels Harbour Summary of Changes

Return Period [years]	*Percent Change in Precipitation Amount [percent] (Change in Precipitation Amount [mm])*								
	5-min	*10-min*	*15-min*	*30-min*	*1-hr*	*2-hr*	*6-hr*	*12-hr*	*24-hr*
2	N/A	N/A	N/A	N/A	N/A	N/A	-4.5 (-1.5)	-2.2 (-0.9)	0.5 (0.3)
5	N/A	N/A	N/A	N/A	N/A	N/A	**-5.1 (-2.1)**	**-5.8 (-3.3)**	-4.2 (-3.2)
10	N/A	N/A	N/A	N/A	N/A	N/A	**-5.3 (-2.6)**	**-7.3 (-4.9)**	**-6.1 (-5.6)**
25	N/A	N/A	N/A	N/A	N/A	N/A	**-5.6 (-3.1)**	**-8.7 (-6.8)**	**-7.7 (-8.5)**
50	N/A	N/A	N/A	N/A	N/A	N/A	**-5.7 (-3.5)**	**-9.5 (-8.3)**	**-8.6 (-10.7)**
100	N/A	N/A	N/A	N/A	N/A	N/A	**-5.8 (-3.9)**	**-10.1 (-9.8)**	**-9.3 (-12.9)**

Notes:
Percent change is calculated between the EC IDF curve (V2.3, 2015) and the updated IDF curve using 6-hr precipitation weighing data at Daniels Harbour.
Red numbers indicate that the precipitation estimate decreased due to the updated data.
Bold numbers indicate a change of more than 5 percent.
N/A indicates that this duration was not updated at this station.

4.1.2 Gander Airport CS

Gander is located in the northeastern part of the island of Newfoundland, about 40 km south of Gander Bay. It was chosen as the site for Gander International Airport in 1935, and is an important stopping point for transatlantic aircraft that need to land in emergency situations. It has a humid continental climate with severe winters, no dry season, warm summers and strong seasonality (Köppen-Geiger classification: Dfb). Average total annual precipitation is approximately 1,200 mm.

The EC IDF curve for Gander Airport CS includes data from 1939 to 2009. This is the longest record for an IDF curve in Newfoundland and Labrador, and it was formed by combining different measurement types and stations. For the period of 1939-2004, the data came from the Gander Int'l A (8401700) station, with data recorded on strip charts (1939 to 1959) and with an MSC TBRG(1960 to 2004). For the period of 2005 to 2009, the data have come from the Gander Airport CS station, using an automatic TB3 TBRG. The TB3 TBRG record at Gander Airport CS continues to the end of 2012. These data were not included in EC's IDF update, however. The data did not pass the automatic QA/QC process because the precipitation weighing gauges recorded higher precipitation. Additional QA/QC was performed on these data to determine if they were suitable for use in the IDF curve update. In addition to the TBRG record, 15-min, 1-hr, and 6-hr precipitation data were available, recorded by precipitation weighing gauge(s). The stations are listed in Table 4.3 and shown on Figure 4.3.

Table 4.3 Gander Airport CS Station Listing

Station Name	*ID*	*Latitude*	*Longitude*	*Elevation [m]*	*Distance to IDF [km]*	*Type of Data*	*Years*
Gander Airport CS (IDF)	8401705	48°56'46" N	54°34'01" W	151.0	0.00	5-min	1939-2009
Gander Airport CS	8401705	48°56'46" N	54°34'01" W	151.0	0.00	5-min	2010-2012
Gander Airport CS	8401705	48°56'46" N	54°34'01" W	151.0	0.00	15-min	2013-current
Gander Airport CS	8401705	48°56'46" N	54°34'01" W	151.0	0.00	1-hr	2005-current
Gander Airport CS	8401705	48°56'46" N	54°34'01" W	151.0	0.00	6-hr	2005-current

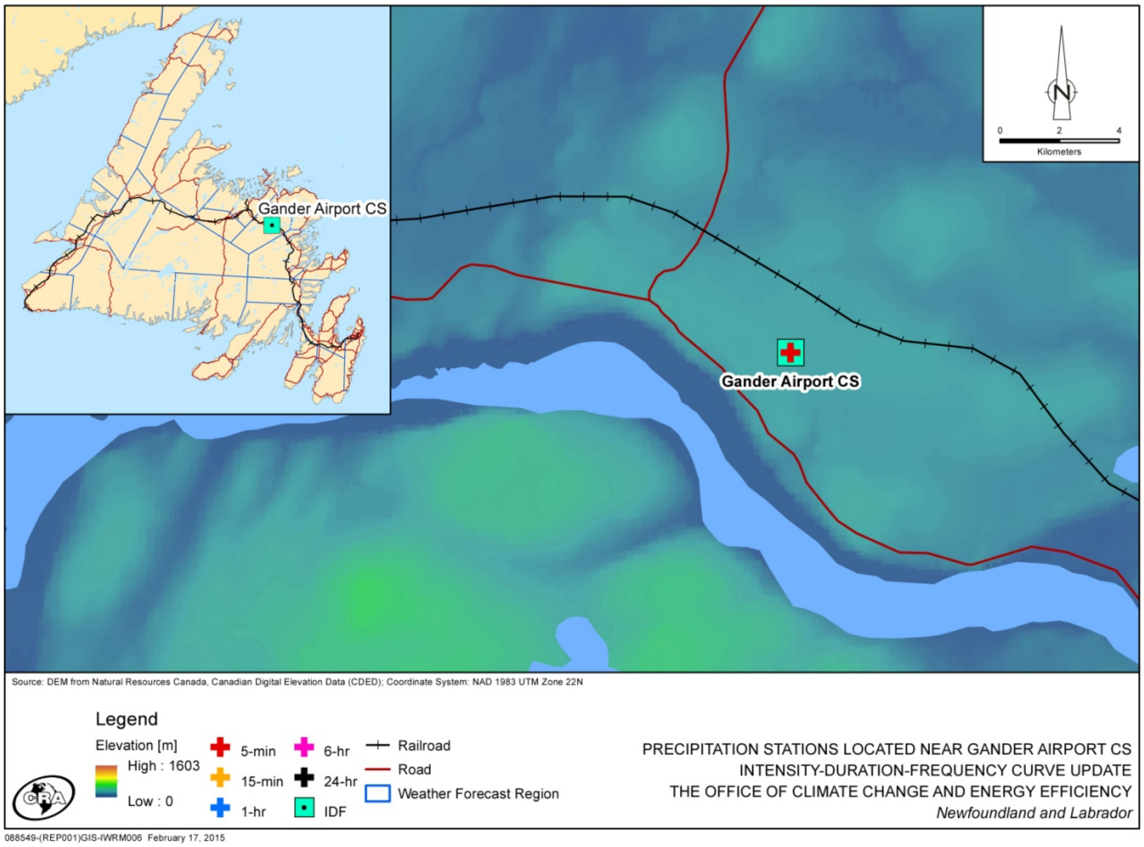

Figure 4.3 Precipitation Stations Located Near Gander Airport CS

Gander Airport CS was updated as a Case 1 station, using the precipitation data recorded at the same location. The QA/QC process examined each data source for the period 2010 to 2014. The annual maximum for each duration for 2010 was found to occur on the same dates for all three recording methods (TBRG, 1-hr, and 6-hr). The annual maximum for the long durations was due to Hurricane Igor. The TBRG under-recorded the precipitation for Hurricane Igor and could not be used in the update. However, the durations from 5-min to 30-min were included as these maxima were not caused by Hurricane Igor. For the durations of 1-hr and longer, the 1-hr data were used instead. For 2011, the three recording methods reported that the annual maxima occurred on different dates. Therefore, the 2011 data were not used for the IDF update, as the annual maximum for each duration could not be verified with the different recording methods. For 2012, the date of maximum precipitation in the 1-hr and 6-hr data was November 11, but the TBRG was not operating on November 11. The air temperature record on November 11 indicated that this event was likely a rain event that was missed by the TBRG. Therefore, the 1-hr data were used instead of the TBRG data for 2012. Fifteen minute data were available for 2013 and were compared to the 6-hr QA/QC'd data to ensure that they were reasonable and that the annual maximum event was captured. The year 2014 was incomplete and excluded from the update. Figure 4.4 shows the years of data available for each duration. Durations from 5 minutes to 24 hours were updated.

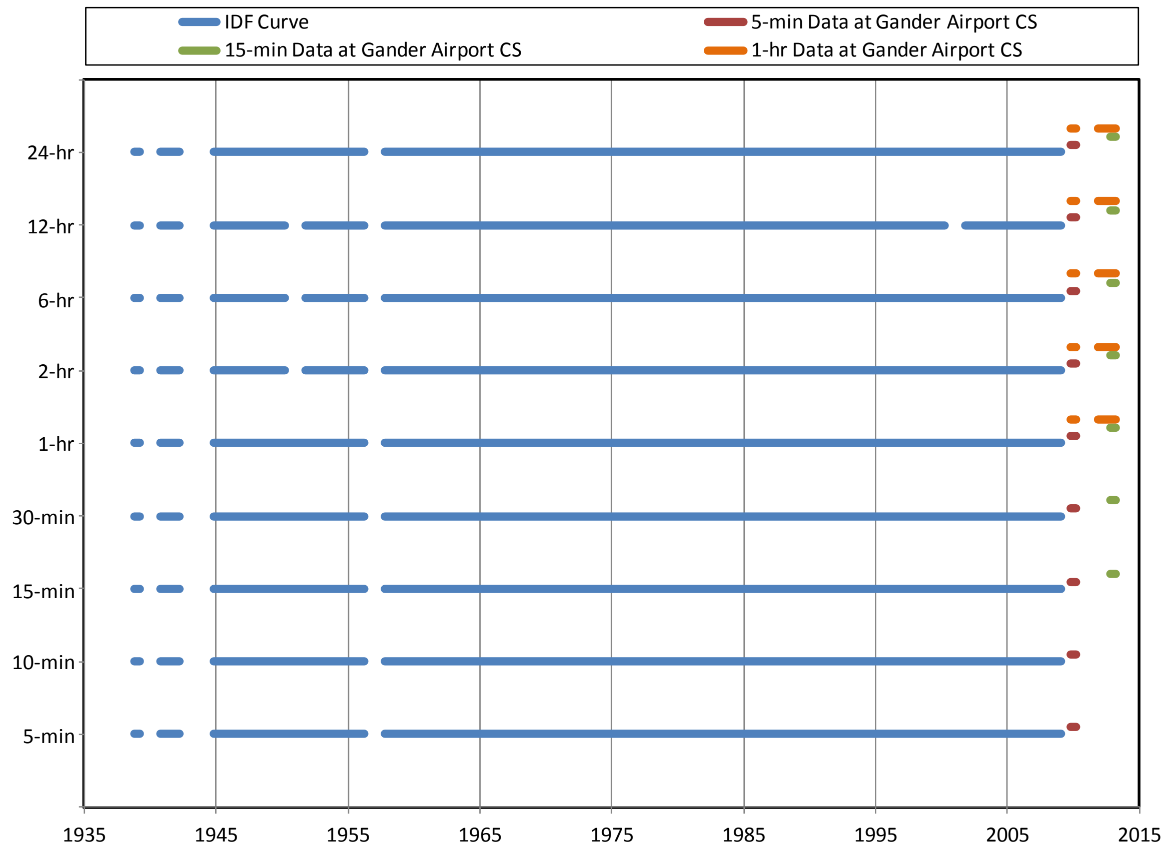

Figure 4.4 Gander Airport CS Data Availability by Year

The annual maxima for the 5-min, 15-min, and 1-hr data for each duration were generated, and tested with statistical analysis. The results of the statistical analysis are included in Appendix B. The 1-hr data were homogeneous with the IDF curve data for all durations. The newer 1-hr and 15-min data had higher means and standard deviations than the IDF curve data for most durations, indicating the effect of severe precipitation events in the most recent years (2010-2013). The differences were not statistically significant. Therefore, the data could be combined to generate an IDF curve. Goodness-of-fit tests were performed to ensure that the Gumbel distribution could be used to fit the combined data from the Gander Airport CS station. The tests showed that the data could be modelled with the Gumbel distribution.

The IDF curve was generated using the Gumbel distribution and the tables and figures are included in Appendix C. The quantile-quantile and return level plots indicated that the data were a good fit with the Gumbel distribution. There was one data point outside of the

95 percent confidence limits for the 24-hr duration. This was one of the update points: the large precipitation event on August 31, 2013. This value was a statistical outlier but matched with the 6-hr QA/QC'd precipitation data for that event. Therefore, it was left in the dataset. For all durations, the slopes of the trends increased with the addition of the newer data. There were significant positive trends at the 6-, 12-, and 24-hr durations.

The updated IDF curve was compared to the EC IDF curve (V2.3, 2015) in Table 4.4. The precipitation increased for all durations. The increases were less than 5 percent for the short durations, but larger than 5 percent for the durations of 2-hr and longer. These results show the effect of the large precipitation events that have occurred in recent years at this location.

Table 4.4 Gander Airport CS Summary of Changes

Return Period [years]	*Percent Change in Precipitation Amount [percent] (Change in Precipitation Amount [mm])*								
	5-min	*10-min*	*15-min*	*30-min*	*1-hr*	*2-hr*	*6-hr*	*12-hr*	*24-hr*
2	0.7 (0.0)	1.3 (0.1)	1.9 (0.1)	1.6 (0.2)	2.5 (0.3)	2.7 (0.5)	3.2 (0.9)	3.6 (1.4)	4.7 (2.2)
5	0.5 (0.0)	1.6 (0.1)	2.3 (0.3)	1.3 (0.2)	2.6 (0.5)	4.1 (1.0)	**6.2 (2.4)**	**8.8 (4.3)**	**12.3 (7.4)**
10	0.4 (0.0)	1.7 (0.2)	2.4 (0.3)	1.2 (0.2)	2.7 (0.6)	4.8 (1.3)	**7.6 (3.3)**	**11.2 (6.2)**	**15.7 (10.9)**
25	0.3 (0.0)	1.8 (0.2)	2.5 (0.4)	1.1 (0.2)	2.7 (0.7)	**5.4 (1.7)**	**8.9 (4.5)**	**13.6 (8.6)**	**18.9 (15.3)**
50	0.3 (0.0)	1.9 (0.3)	2.6 (0.5)	1.0 (0.3)	2.7 (0.8)	**5.7 (2.0)**	**9.7 (5.4)**	**14.9 (10.4)**	**20.7 (18.5)**
100	0.3 (0.0)	1.9 (0.3)	2.7 (0.5)	1.0 (0.3)	2.8 (0.9)	**6.0 (2.4)**	**10.4 (6.2)**	**16.1 (12.2)**	**22.2 (21.7)**

Notes:
Percent change is calculated between the EC IDF curve (V2.3, 2015) and the updated IDF curve using TBRG, 15-min, and 1-hr precipitation data at Gander Airport CS.
Bold numbers indicate a change of more than 5 percent.

4.1.3 La Scie

La Scie is located on the north side of the island of Newfoundland, at the head of the Baie Verte Peninsula between White Bay and Notre Dame Bay. The topography of the area is rugged with the site upon a ridge central to the peninsula; well exposed in all directions. It has a humid continental climate with severe winters, no dry season, warm summers and strong seasonality (Köppen-Geiger classification: Dfb). Average total annual precipitation is approximately 1,100 mm.

The EC IDF curve for La Scie includes data from 1984 to 1995. A co-located 6-hr precipitation weighing gauge was used to check and adjust the data. Precipitation monitoring ended when the TBRG was removed (1995). However, precipitation monitoring was then resumed at the same site for the period of 2003 to 2006, and again in 2014, using a precipitation weighing gauge. The stations are listed in Table 4.5 and shown on Figure 4.5.

Table 4.5 La Scie Station Listing

Station Name	ID	Latitude	Longitude	Elevation [m]	Distance to IDF [km]	Type of Data	Years
La Scie (IDF)	8402520	49°55'00" N	55°40'00" W	194.0	0.00	5-min	1984-1995
La Scie	8402520	49°55'00" N	55°40'00" W	194.0	0.00	6-hr	2003-2006 2014-current
La Scie	8402520	49°55'00" N	55°40'00" W	194.0	0.00	1-hr	2004-2006 2014-current

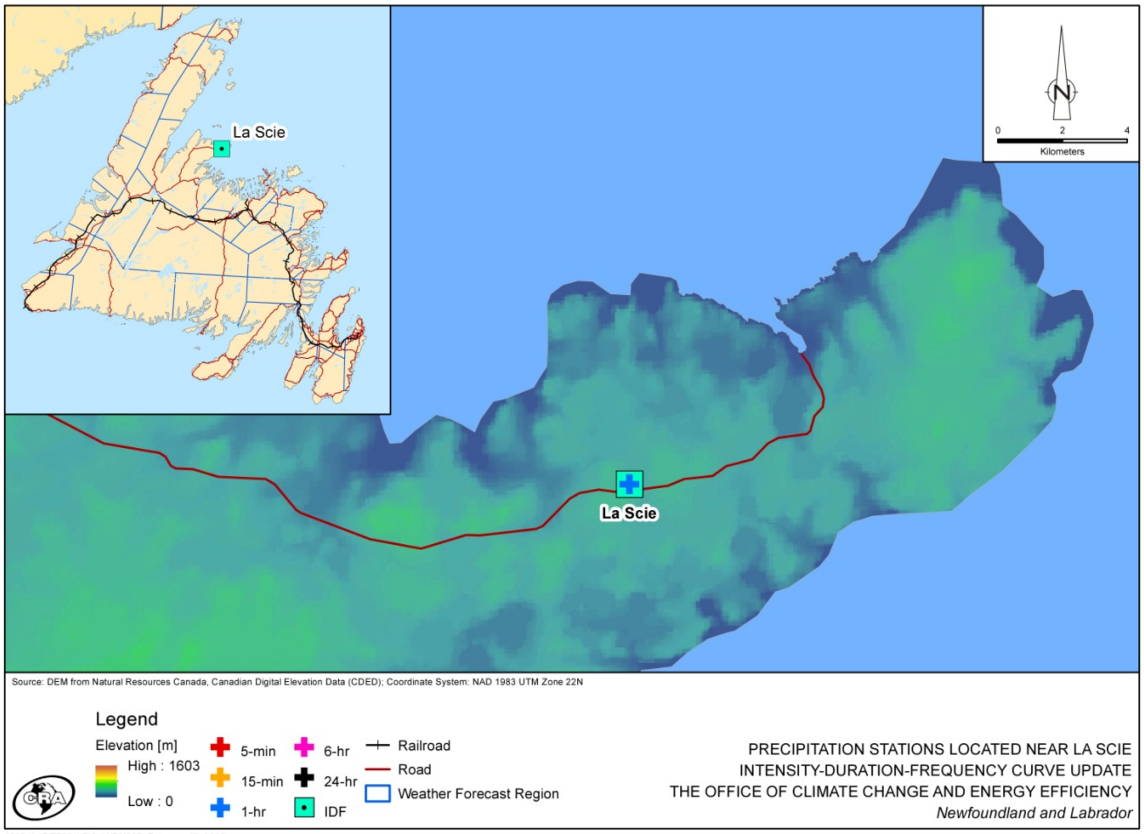

Figure 4.5 Precipitation Stations Located Near La Scie

La Scie was updated as a Case 1 station, using the 1-hr and 6-hr data measured at the same location. 2005 and 2014 were removed from the analysis because they had too much missing data and were therefore incomplete. Only three years of data were complete: 2003, 2004, and 2006. Figure 4.6 shows the years of data available for each duration. Durations from 1-hr to 24-hr were updated.

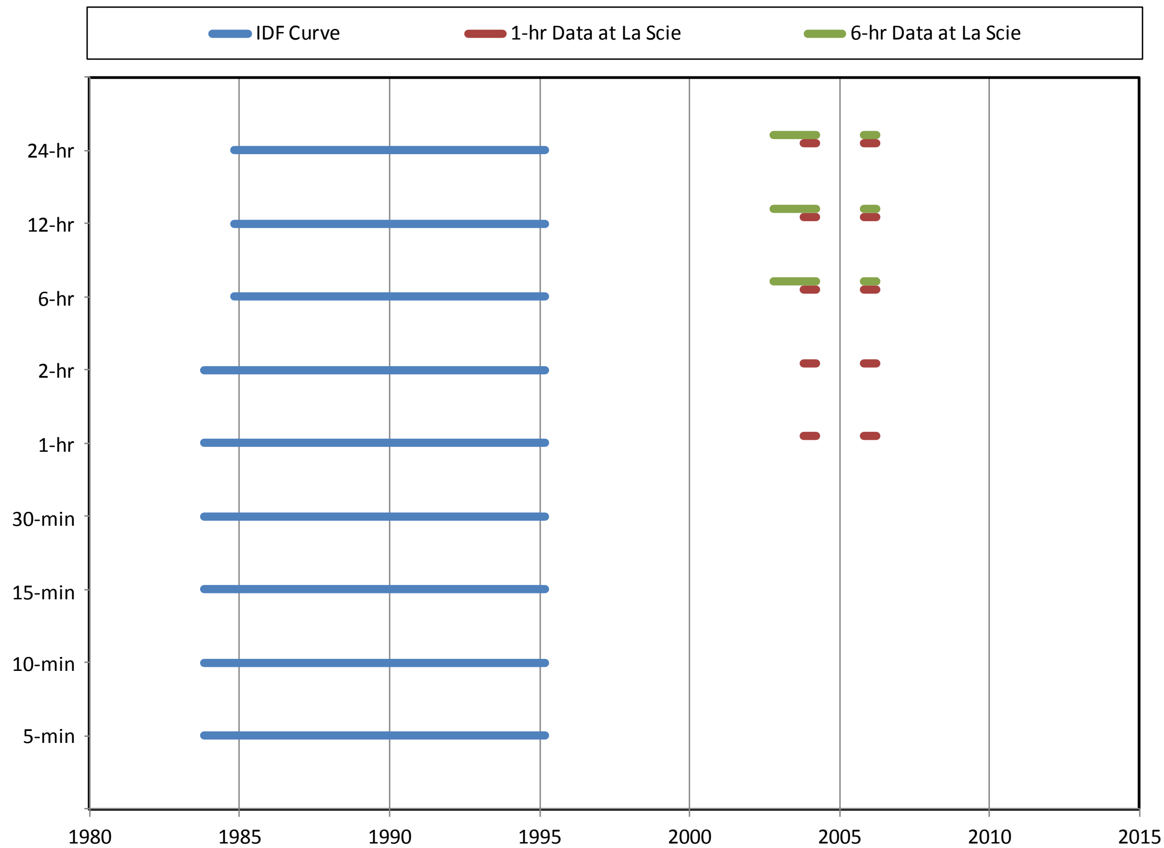

Figure 4.6 La Scie Data Availability by Year

The 1-hr and 6-hr data were used to generate 1-, 2-, 6-, 12-, and 24-hr annual maxima for the period 1983 to 2006. The annual maxima were examined with statistical analysis. The results of the statistical analysis are included in Appendix B. The 6-, 12-, and 24-hr were homogeneous with the IDF curve data. The newer data at La Scie had lower means and standard deviations than the IDF curve data for all durations except for the 24-hr duration. The differences were not statistically significant. Therefore, the data could be combined to generate an IDF curve. Goodness-of-fit tests were performed to ensure that the Gumbel distribution could be used to fit the combined data from the La Scie station. The tests showed that the data could be modelled with the Gumbel distribution.

The IDF curve was generated using the Gumbel distribution and the tables and figures are included in Appendix C. The quantile-quantile and return level plots indicated that the data were a good fit with the Gumbel distribution. There were no data falling outside of the 95 percent confidence limits. The trend plot showed that there were no significant trends at any of the durations. With the addition of the newer data, the slopes were closer to zero than the EC IDF (V2.3) slopes (if the slope was positive it decreased, if the slope was negative it increased).

The updated IDF curve was compared to the EC IDF curve (V2.3, 2015) in Table 4.6. The precipitation increased for the 24-hr duration and decreased for the other durations. The increases and decreases were less than 5 percent. However, there were only two or three newer data points to add at this station and therefore whether precipitation has generally been increasing or decreasing relative to the EC IDF curve cannot be inferred.

Table 4.6 La Scie Summary of Changes

Return Period [years]	*Percent Change in Precipitation Amount [percent] (Change in Precipitation Amount [mm])*								
	5-min	*10-min*	*15-min*	*30-min*	*1-hr*	*2-hr*	*6-hr*	*12-hr*	*24-hr*
2	N/A	N/A	N/A	N/A	0.0 (0.0)	0.0 (0.0)	-0.4 (-0.1)	-2.4 (-1.0)	1.1 (0.5)
5	N/A	N/A	N/A	N/A	-1.8 (-0.3)	-1.4 (-0.3)	-1.7 (-0.6)	-3.2 (-1.7)	1.4 (0.9)
10	N/A	N/A	N/A	N/A	-2.6 (-0.4)	-2.1 (-0.5)	-2.2 (-0.9)	-3.6 (-2.1)	1.5 (1.1)
25	N/A	N/A	N/A	N/A	-3.3 (-0.6)	-2.7 (-0.7)	-2.7 (-1.3)	-3.9 (-2.7)	1.7 (1.4)
50	N/A	N/A	N/A	N/A	-3.8 (-0.8)	-3.0 (-0.9)	-3.0 (-1.6)	-4.1 (-3.2)	1.8 (1.6)
100	N/A	N/A	N/A	N/A	-4.1 (-1.0)	-3.3 (-1.1)	-3.3 (-1.9)	-4.2 (-3.6)	1.9 (1.8)

Notes:
Percent change is calculated between the EC IDF curve (V2.3, 2015) and the updated IDF curve using 6-hr and 1-hr precipitation weighing data at La Scie.
Red numbers indicate that the precipitation estimate decreased due to the updated data.
N/A indicates that this duration was not updated at this station.

4.1.4 Port Aux Basques

Port Aux Basques is located in the southwestern coastal region of the island of Newfoundland, south of the Long Range Mountains. The year-round ferry from North Sydney, Nova Scotia, docks at Port Aux Basques, Newfoundland. It is also located on the Trans-Canada Highway (Highway 1). It has a subarctic climate that has severe winters, no dry season, cool and short summers, and strong seasonality (Köppen-Geiger classification: Dfc). Average total annual precipitation is approximately 1,500 mm.

The EC IDF curve for Port Aux Basques includes data from 1975 to 1996. A co-located 6-hr precipitation weighing gauge was installed in late 1992, but there were many missing data from 1992 to 1998. When the TBRG was removed (1996), the 6-hr data continued to be recorded at the station. As only 6-hr data were available at the Port Aux Basques station, other hourly/sub-hourly data sources were also considered to allow the shorter durations to be updated. The closest hourly/sub-hourly station is located at Wreckhouse, almost 20 km away from Port Aux Basques. Wreckhouse is more exposed to the west, while Port Aux Basques is exposed to the south, and therefore the two stations experience different precipitation regimes. The stations are listed in Table 4.7 and shown on Figure 4.7.

Table 4.7 Port Aux Basques Station Listing

Station Name	***ID***	***Latitude***	***Longitude***	***Elevation [m]***	***Distance to IDF [km]***	***Type of Data***	***Years***
Port Aux Basques (IDF)	8402975	47°34'26" N	59°09'17" W	39.7	0.00	5-min	1975-1996
Port Aux Basques	8402975	47°34'26" N	59°09'17" W	39.7	0.00	6-hr	1992-current
Wreckhouse	8404343	47°42'42" N	59°18'30" W	31.7	19.87	15-min	2006-current

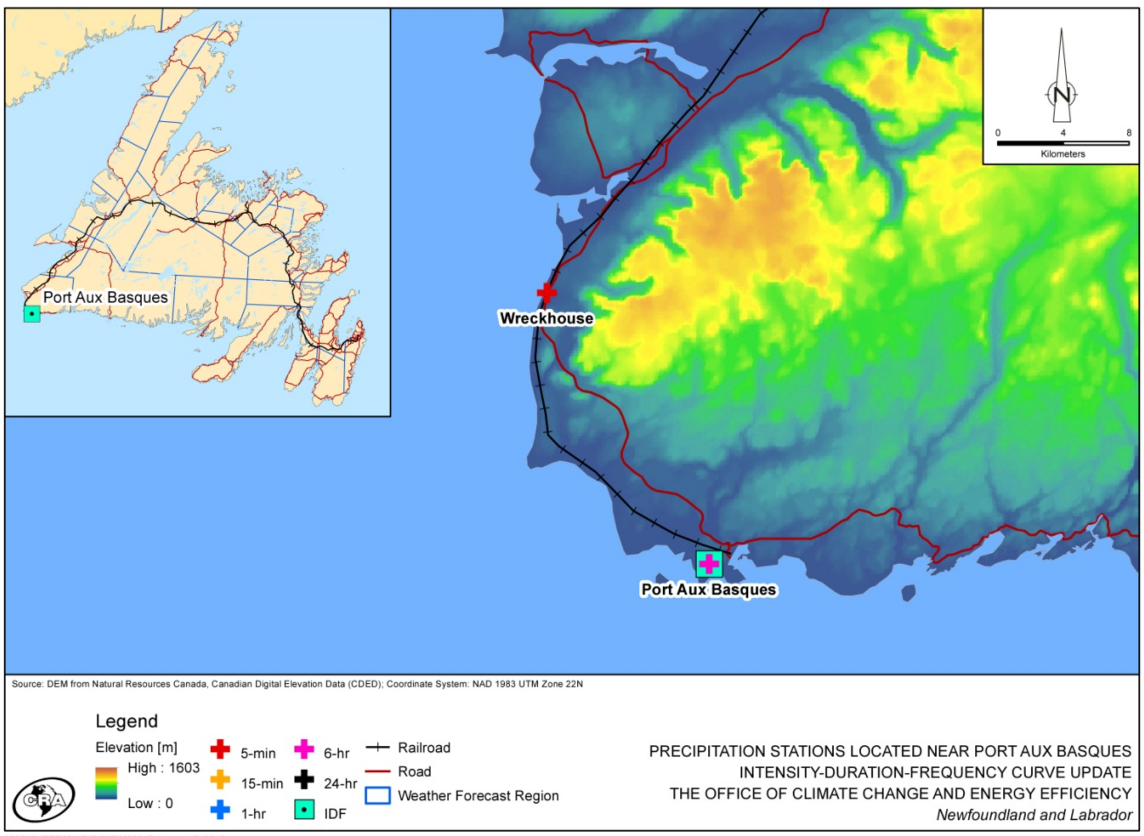

Figure 4.7 Precipitation Stations Located Near Port Aux Basques

Port Aux Basques was updated as a Case 1 station, using the 6-hr data located at the same location. Some years were removed from the analysis due to missing data. Wreckhouse is located more than 3 km away from the Port Aux Basques station (Case 3). Therefore, it could not be used to update durations shorter than 6-hr. However, there were 6-hr data at Port Aux Basques, and so Wreckhouse was not considered for updating the IDF at Port Aux Basques.

However, when enough data have been collected, it may be worthwhile to consider generating a new IDF curve using the Wreckhouse data. Figure 4.8 shows the years of data available for each duration.

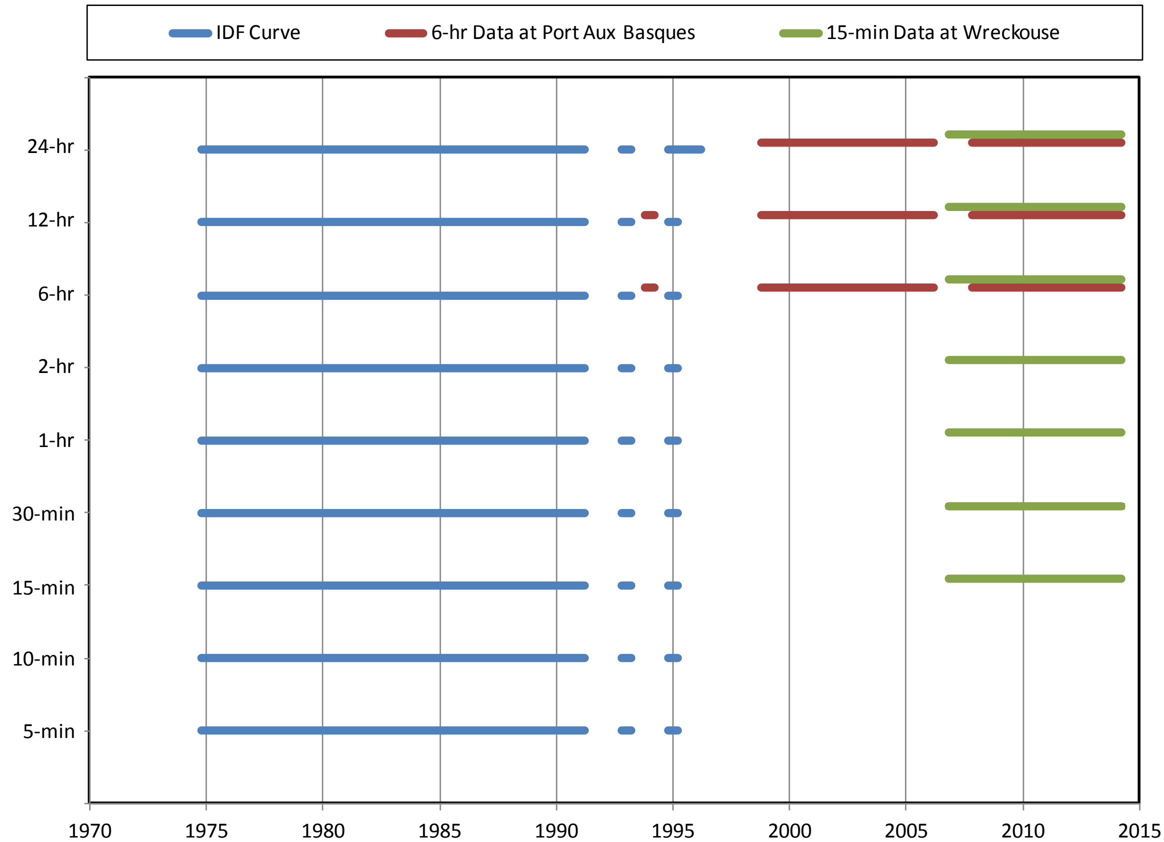

Figure 4.8 Port Aux Basques Data Availability by Year

The 6-, 12-, and 24-hr annual maxima were generated for the Port Aux Basques station for the period of 1994 to 2014 and the annual maxima were examined with statistical analysis. The results of the statistical analysis are included in Appendix B. The 12-, and 24-hr data were homogeneous with the IDF curve data, but the 6-hr duration was not. The newer data at Port Aux Basques had lower means and standard deviations than the IDF curve data for all three durations. The lower standard deviation for the 6-hr duration was statistically significant, but the other differences were not statistically significant. Therefore, the data could be combined to generate an IDF curve as most of the durations were homogeneous with the IDF curve data. Goodness-of-fit tests were performed to ensure that the Gumbel distribution could be used to fit the combined data from the Port Aux Basques station. The tests showed that the data could be modelled with the Gumbel distribution.

The IDF curve was generated using the Gumbel distribution and the tables and figures are included in Appendix C. The quantile-quantile and return level plots indicated that the data were a good fit with the Gumbel distribution. There were no data falling outside of the 95 percent confidence limits. The trend plot showed that there were no significant trends at any of the durations. The EC IDF (V2.3) trends were negative for the 6-, 12-, and 24-hr durations. With the newer data, the trends were higher (i.e., closer to zero), but still negative.

The updated IDF curve was compared to the EC IDF curve (V2.3, 2015) in Table 4.8. The precipitation decreased for all three durations, and the decreases were larger than 5 percent. Precipitation has been decreasing relative to the EC IDF curve. Therefore, users should exercise caution when using the updated IDF curve, or use the EC IDF curve instead.

Table 4.8 Port Aux Basques Summary of Changes

Return Period [years]	***Percent Change in Precipitation Amount [percent] (Change in Precipitation Amount [mm])***								
	5-min	***10-min***	***15-min***	***30-min***	***1-hr***	***2-hr***	***6-hr***	***12-hr***	***24-hr***
2	N/A	N/A	N/A	N/A	N/A	N/A	**-7.3 (-3.3)**	**-6.0 (-3.5)**	**-6.0 (-4.3)**
5	N/A	N/A	N/A	N/A	N/A	N/A	**-8.8 (-5.2)**	**-7.5 (-5.5)**	**-7.4 (-6.7)**
10	N/A	N/A	N/A	N/A	N/A	N/A	**-9.4 (-6.4)**	**-8.2 (-6.9)**	**-8.0 (-8.4)**
25	N/A	N/A	N/A	N/A	N/A	N/A	**-10.0 (-8.0)**	**-8.9 (-8.6)**	**-8.7 (-10.4)**
50	N/A	N/A	N/A	N/A	N/A	N/A	**-10.4 (-9.1)**	**-9.3 (-9.8)**	**-9.0 (-12.0)**
100	N/A	N/A	N/A	N/A	N/A	N/A	**-10.7 (-10.3)**	**-9.6 (-11.1)**	**-9.3 (-13.5)**

Notes:
Percent change is calculated between the EC IDF curve (V2.3, 2015) and the updated IDF curve using 6-hr precipitation weighing data at Port Aux Basques.
Red numbers indicate that the precipitation estimate decreased due to the updated data.
Bold numbers indicate a change of more than 5 percent.
N/A indicates that this duration was not updated at this station.

4.1.5 Wabush Lake A

Wabush Lake is located at the western edge of Labrador and is a twin community with Labrador City. It is located along the Trans-Labrador Highway (route 500), 23 km from the Quebec-Labrador border. It has a subarctic climate that has severe winters, no dry season, cool and short summers, and strong seasonality (Köppen-Geiger classification: Dfc). Annual total precipitation is approximately 880 mm.

The EC IDF curve for Wabush Lake A includes data from 1974 to 2003. A co-located 6-hr precipitation weighing gauge was used to check and adjust the data. When the TBRG was removed (2003), precipitation monitoring continued with the weighing gauge at the location until 2012. The station was moved in early 2013 to a location 0.98 km away, but ceased monitoring part way through 2014. The stations are listed in Table 4.9 and shown on Figure 4.9. A 1-hr precipitation weighing gauge was installed in late 2014. In the future, the data from the 1-hr gauge can be used to update the Wabush Lake A station for durations from 1-hr to 24-hr.

Table 4.9 Wabush Lake A Station Listing

Station Name	ID	Latitude	Longitude	Elevation [m]	Distance to IDF [km]	Type of Data	Years
Wabush Lake A (IDF)	8504175	52°55'38" N	66°52'27" W	551.4	0.00	5-min	1974-2003
Wabush Lake A	8504175	52°55'38" N	66°52'27" W	551.4	0.00	6-hr	1974-2012
Wabush A	8504176	52°55'22" N	66°51'53" W	551.4	0.98	6-hr	2013-2014
Wabush A	8504177	52°55'22" N	66°51'53" W	551.4	0.98	1-hr	2014-current

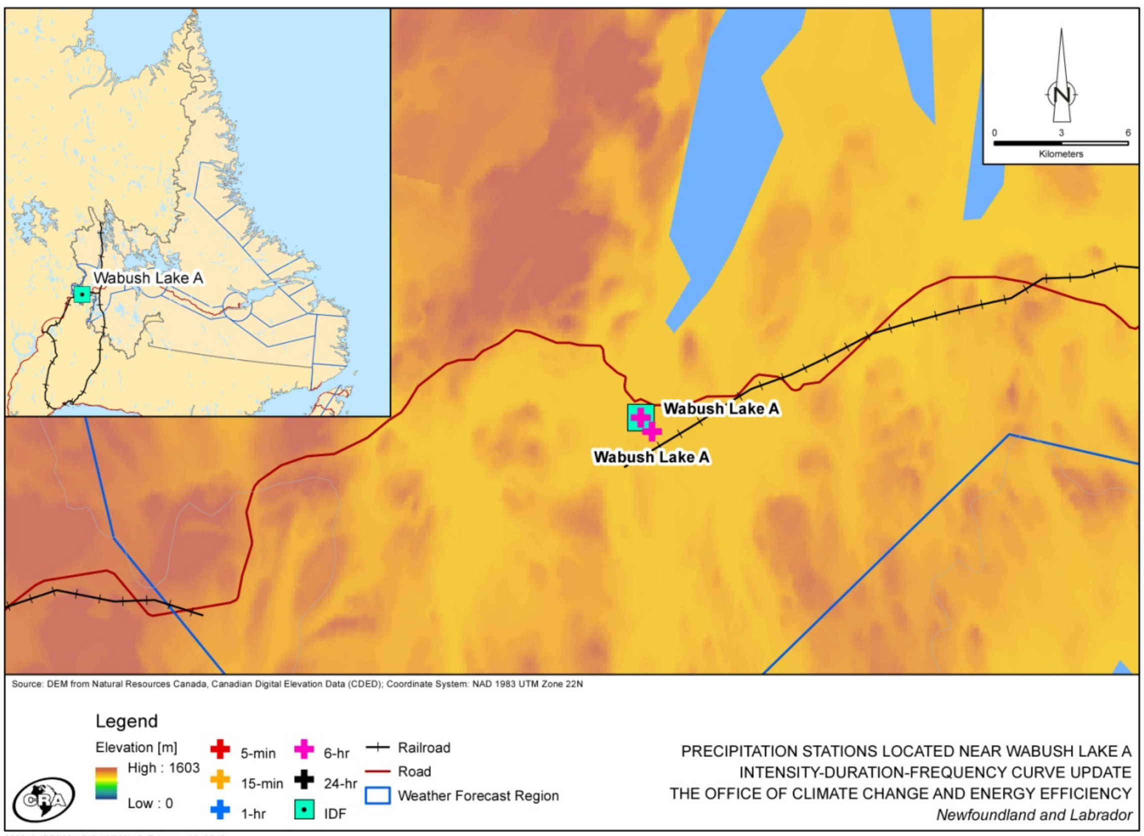

Figure 4.9 Precipitation Stations Located Near Wabush Lake A

Wabush Lake A was updated as a Case 1 station, using the 6-hr data recorded at the same location. The data from Wabush A (8504176) were not used in the update because the 2013 annual maximum events for the 6-, 12-, and 24-hr durations were marked as raw data (they did not pass the QA/QC performed by EC). 2014 was an incomplete year, due to the change in the precipitation gauge part way through the year. Figure 4.10 shows the years of data available for each duration. Durations from 6 hours to 24 hours were updated.

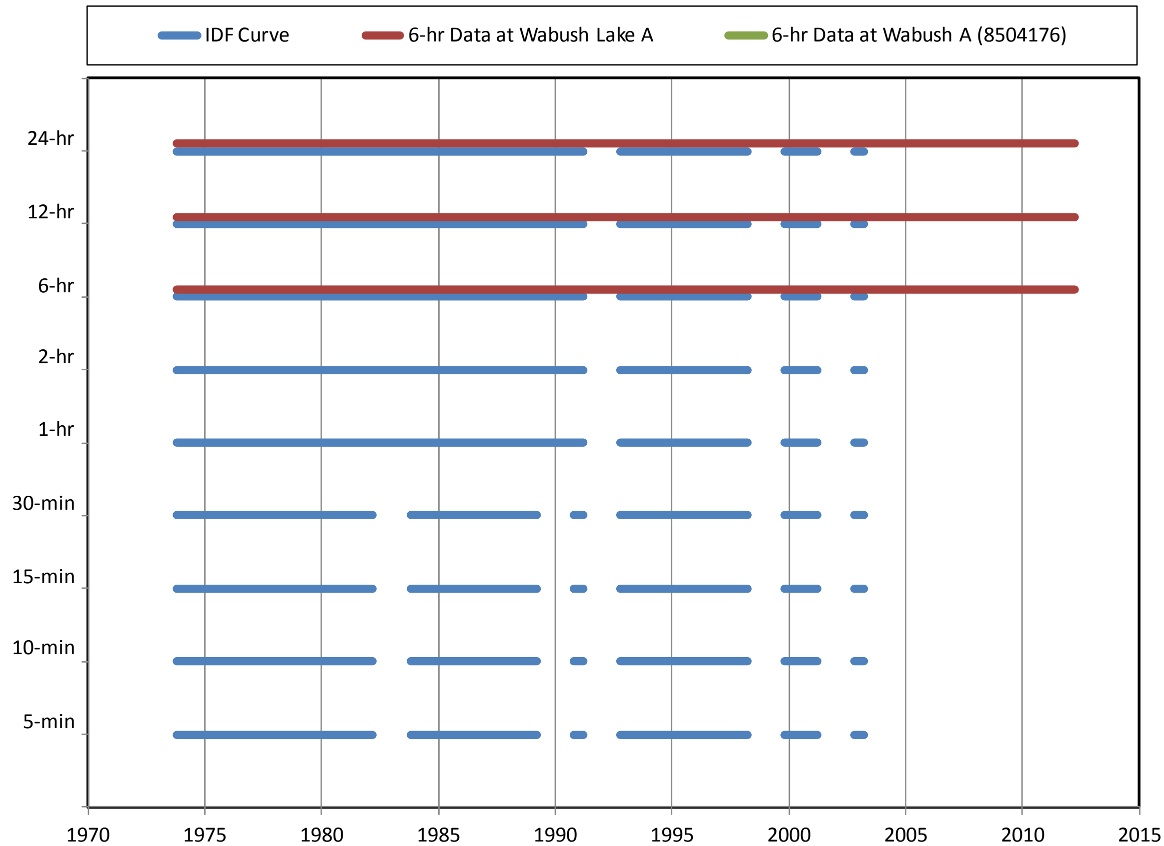

Figure 4.10 Wabush Lake A Data Availability by Year

The 6-hr precipitation weighing data at Wabush Lake A were used to calculate 6-, 12-, and 24-hr annual maxima for each year from 1974 to 2012. The annual maxima were compared to the 6-, 12-, and 24-hr annual maxima from the IDF curve. The results of the statistical analysis are included in Appendix B. The 6-, 12-, and 24-hr annual maxima time series were homogeneous with the IDF curve data, and hence could be used to augment the IDF data. The mean and standard deviation of the newer data (2004 to 2012) were generally higher than the mean and standard deviation of the IDF curve data. The differences were not statistically significant. This indicated that the precipitation has been increasing slightly at this station relative to the EC IDF curve. Goodness-of-fit tests were performed to ensure that the Gumbel distribution could be used to fit the augmented data set. The tests showed that the augmented 6-, 12-, and 24-hr data could be modelled with the Gumbel distribution.

The IDF curve was generated using the Gumbel distribution and the tables and figures are included in Appendix C. The quantile-quantile and return level plots indicated that the data were a good fit with the Gumbel distribution. There were no data outside of the 95 percent confidence limits. The trend plot showed that there were no significant trends at the 6-, 12-, or 24-hr durations. The EC trend plots (V2.3, 2015) showed non-significant decreasing trends at these durations. With the updated data, the slope was higher, but still negative.

The updated IDF curve has increased as compared to the EC IDF curve (V2.3, 2015) as shown in Table 4.10. The 6-hr, 100-year return period decreased slightly. There were no increases or decreases larger than 5 percent. Precipitation has been increasing slightly relative to the EC IDF curve.

Table 4.10 Wabush Lake A Summary of Changes

Return Period [years]	*Percent Change in Precipitation Amount [percent] (Change in Precipitation Amount [mm])*								
	5-min	*10-min*	*15-min*	*30-min*	*1-hr*	*2-hr*	*6-hr*	*12-hr*	*24-hr*
2	N/A	N/A	N/A	N/A	N/A	N/A	2.1 (0.4)	2.3 (0.6)	2.6 (0.9)
5	N/A	N/A	N/A	N/A	N/A	N/A	1.2 (0.3)	3.2 (1.1)	2.5 (1.1)
10	N/A	N/A	N/A	N/A	N/A	N/A	0.7 (0.2)	3.7 (1.4)	2.5 (1.2)
25	N/A	N/A	N/A	N/A	N/A	N/A	0.3 (0.1)	4.1 (1.8)	2.5 (1.4)
50	N/A	N/A	N/A	N/A	N/A	N/A	0.1 (0.0)	4.4 (2.1)	2.5 (1.5)
100	N/A	N/A	N/A	N/A	N/A	N/A	-0.1 (-0.1)	4.6 (2.4)	2.5 (1.7)

Notes:
Percent change is calculated between the EC IDF curve (V2.3, 2015) and the updated IDF curve using 6-hr precipitation weighing data at Wabush Lake A.
Red numbers indicate that the precipitation estimate decreased due to the updated data.
N/A indicates that this duration was not updated at this station.

4.2 Case 1 and Case 2 Stations

4.2.1 Deer Lake A

Deer Lake A is located on the west side of the island of Newfoundland, in the middle of the Long Range Mountains. Deer Lake A is located in a valley, and there are significant topographical differences to the west and east of the station. Deer Lake A is located where Route 430 meets the Trans-Canada Highway (Highway 1). It has a humid continental climate with severe winters, no dry season, warm summers and strong seasonality (Köppen-Geiger classification: Dfb). Average total annual precipitation is approximately 1,000 mm.

The EC IDF curve for Deer Lake A includes data from 1966 to 2002. A co-located 6-hr precipitation weighing gauge was used to check and adjust the data. When the TBRG was removed (2002), the 6-hr data continued to be recorded at the station. In early 2012, the 6-hr precipitation weighing gauge was moved to a new location 0.96 km away. As only 6-hr data were available at the Deer Lake A station, other hourly/sub-hourly data sources were also considered to allow the shorter durations to be updated. The only hourly/sub-hourly stations are located more than 3 km away from Deer Lake A and are at higher elevations. The stations are listed in Table 4.11 and shown on Figure 4.11.

Table 4.11 Deer Lake A Station Listing

Station Name	***ID***	***Latitude***	***Longitude***	***Elevation [m]***	***Distance to IDF [km]***	***Type of Data***	***Years***
Deer Lake A (IDF)	8401501	49°13'00" N	57°24'00" W	21.9	0.00	5-min	1966-2002
Deer Lake A	8401501	49°13'00" N	57°24'00" W	21.9	0.00	6-hr	1966-2011
Deer Lake A	8401502	49°12'33" N	57°23'40" W	21.9	0.96	6-hr	2012-current
Cormack RCS	8401295	49°19'19" N	57°23'36" W	165.8	11.72	15-min	2013-current
Hinds Lake Control	NLHydro	49°02'48" N	57°08'03" W	299.0	27.26	1-hr	2010-current
Humber River at Humber Village Bridge	NLENCL0003	48°58'48" N	57°45'35" W	65.0	37.68	1-hr	2010-current

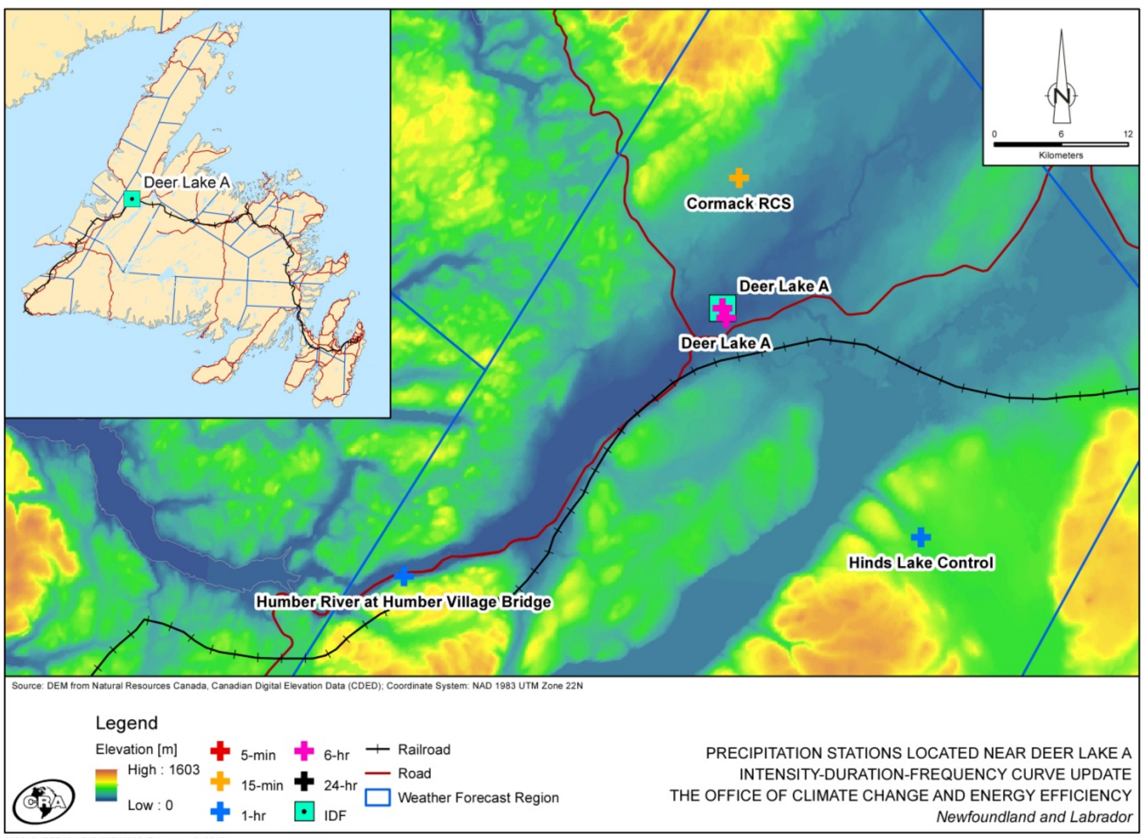

Figure 4.11 Precipitation Stations Located Near Deer Lake A

Deer Lake A was updated as a combined Case 1 and Case 2 station, using the 6-hr data located at the same location (Case 1) and nearby location (Case 2). The hourly/sub-hourly stations were located more than 3 km away from the Deer Lake A station (Case 3). Therefore, they could not be used to update durations shorter than 6-hr. However, the 6-hr data collected at Deer Lake A were preferable to more distant locations. When enough data have been collected at these stations, it may be worthwhile to consider using these stations to generate a new IDF curve for this region. Figure 4.12 shows the years of data available for each duration.

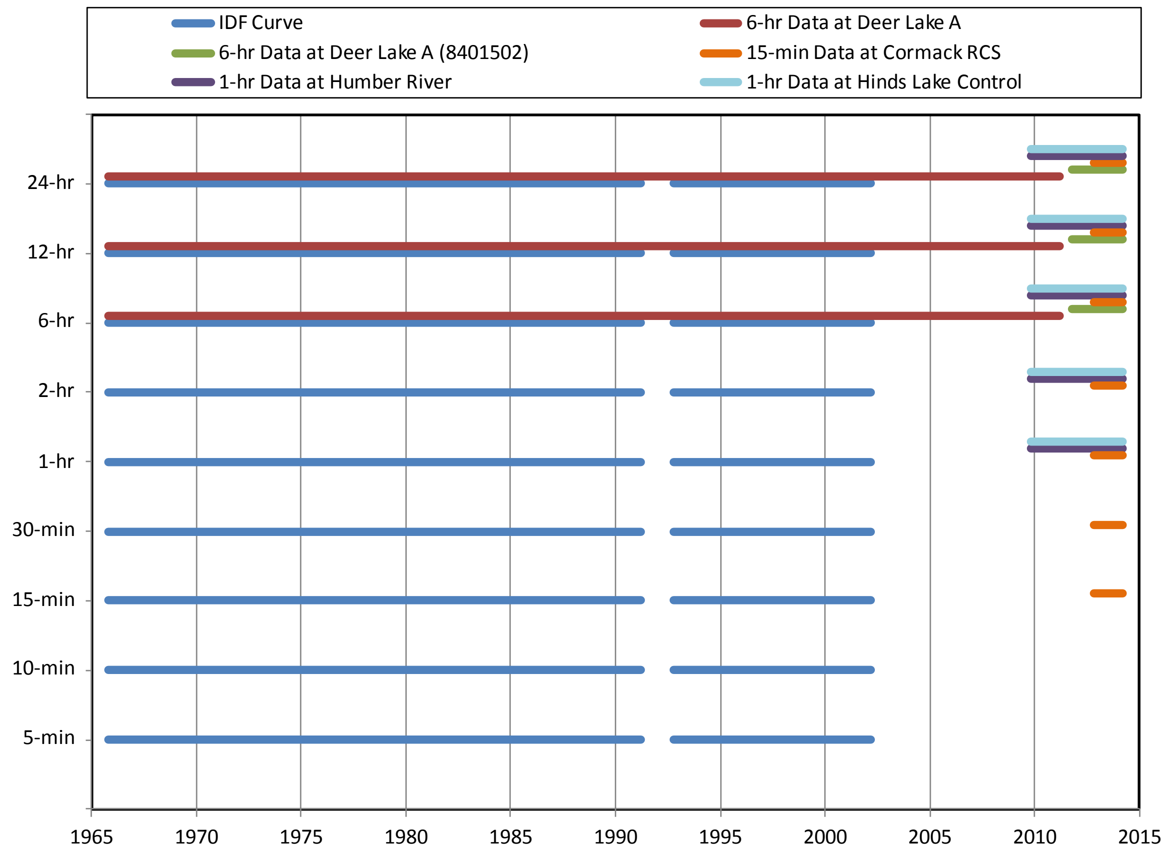

Figure 4.12 Deer Lake A Data Availability by Year

The 6-, 12-, and 24-hr annual maxima were generated for the two Deer Lake A stations for the period of 1966 to 2014 and the annual maxima were examined with statistical analysis. The results of the statistical analysis are included in Appendix B. The 6-, 12-, and 24-hr data were homogeneous with the IDF curve data for the overlapping period, and the newer data were homogeneous for most durations with the IDF curve data. The newer data at Deer Lake A (8401501) had a lower mean for the 6-hr duration and higher means for the 12- and 24-hr durations. The standard deviations were larger than the standard deviations of the IDF curve data. The newer data at Deer Lake A (8401502) had lower means than the IDF curve data. However, the differences were not statistically significant. Therefore, the data could be combined to generate an IDF curve. Goodness-of-fit tests were performed to ensure that the Gumbel distribution could be used to fit the combined data from the Deer Lake A stations (the IDF curve data and the newer 6-hr weighing data). The tests showed that the data could be modelled with the Gumbel distribution.

The IDF curve was generated using the Gumbel distribution and the tables and figures are included in Appendix C. The quantile-quantile and return level plots indicated that the data were a good fit with the Gumbel distribution. There were no data outside of the 95 percent confidence limits. The trend plot showed that there were no significant trends at any of the durations. The trends remained the same or increased after adding the newer data.

The updated IDF curve was compared to the EC IDF curve (V2.3, 2015) in Table 4.12. The precipitation decreased for the 6-hr duration and increased for the 12- and 24-hr duration. The increases and decreases were smaller than 5 percent for the 6- and 12-hr durations. The increases for the 24-hr duration were larger than 5 percent. Precipitation has generally been increasing relative to the EC IDF curve.

Table 4.12 Deer Lake A Summary of Changes

Return Period [years]	*Percent Change in Precipitation Amount [percent] (Change in Precipitation Amount [mm])*								
	5-min	*10-min*	*15-min*	*30-min*	*1-hr*	*2-hr*	*6-hr*	*12-hr*	*24-hr*
2	N/A	N/A	N/A	N/A	N/A	N/A	-2.3 (-0.7)	2.4 (0.9)	4.9 (2.1)
5	N/A	N/A	N/A	N/A	N/A	N/A	-1.6 (-0.6)	3.0 (1.3)	**8.3 (4.3)**
10	N/A	N/A	N/A	N/A	N/A	N/A	-1.3 (-0.5)	3.2 (1.6)	**10.0 (5.8)**
25	N/A	N/A	N/A	N/A	N/A	N/A	-1.0 (-0.5)	3.5 (2.0)	**11.7 (7.7)**
50	N/A	N/A	N/A	N/A	N/A	N/A	-0.8 (-0.4)	3.7 (2.3)	**12.8 (9.0)**
100	N/A	N/A	N/A	N/A	N/A	N/A	-0.6 (-0.3)	3.8 (2.5)	**13.6 (10.4)**

Notes:
Percent change is calculated between the EC IDF curve (V2.3, 2015) and the updated IDF curve using 6-hr precipitation weighing data at Deer Lake A (8401501) and Deer Lake A (8401502).
Red numbers indicate that the precipitation estimate decreased due to the updated data.
Bold numbers indicate a change of more than 5 percent.
N/A indicates that this duration was not updated at this station.

4.3 Case 2 Stations

4.3.1 Churchill Falls A

Churchill Falls is located in the southwestern part of Labrador, on the Churchill River. It is located along the Trans-Labrador Highway (route 500), 245 km east of Labrador City. It has a subarctic climate that has severe winters, no dry season, cool and short summers, and strong seasonality (Köppen-Geiger classification: Dfc). Average total annual precipitation is approximately 950 mm.

The EC IDF curve for Churchill Falls A includes data from 1969 to 1992. A co-located 6-hr precipitation weighing gauge was used to check and adjust the data, but monitoring was discontinued when the TBRG was removed (1992). A station 1.02 km away monitored precipitation from 1993 to 2011, and it was moved in late 2011 to a location 1.21 km away (1.45 km from the IDF curve station). A 1-hr precipitation weighing gauge was installed half-way through 2014. In the future the 1-hr data could be used to update the durations of 1-hr and longer. The stations are listed in Table 4.13 and shown on Figure 4.13.

Table 4.13 Churchill Falls A Station Listing

Station Name	*ID*	*Latitude*	*Longitude*	*Elevation [m]*	*Distance to IDF [km]*	*Type of Data*	*Years*
Churchill Falls A (IDF)	8501132	53°33'00" N	64°06'00" W	439.5	0.00	5-min	1969-1992
Churchill Falls	8501130	53°33'28" N	64°05'38" W	439.5	1.02	6-hr	1993-2011
Churchill Falls A	8501131	53°33'43" N	64°06'23" W	439.5	1.45	6-hr	2012-current
Churchill Falls A	8501131	53°33'43" N	64°06'23" W	439.5	1.45	1-hr	2014-current

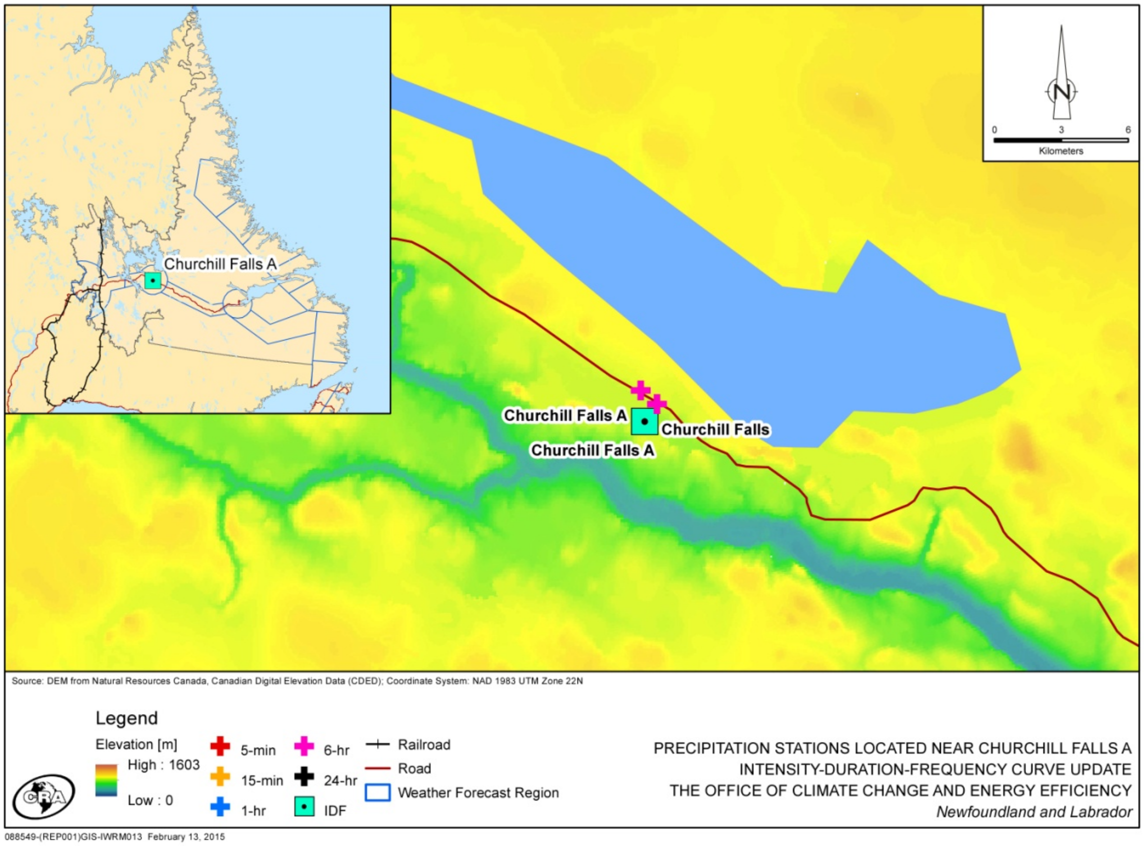

Figure 4.13 Precipitation Stations Located Near Churchill Falls A

Churchill Falls A was updated as a Case 2 station, using the 6-hr data recorded at the nearby stations. Some years were removed from the update because they were incomplete, and some annual maxima were removed because they were marked as raw data by EC (they did not pass the QA/QC performed by EC). The raw data could not be verified by other precipitation measurements and were therefore not considered for use in updating the IDF curve.
Figure 4.14 shows the years of data available for each duration. Durations from 6 hours to 24 hours were updated.

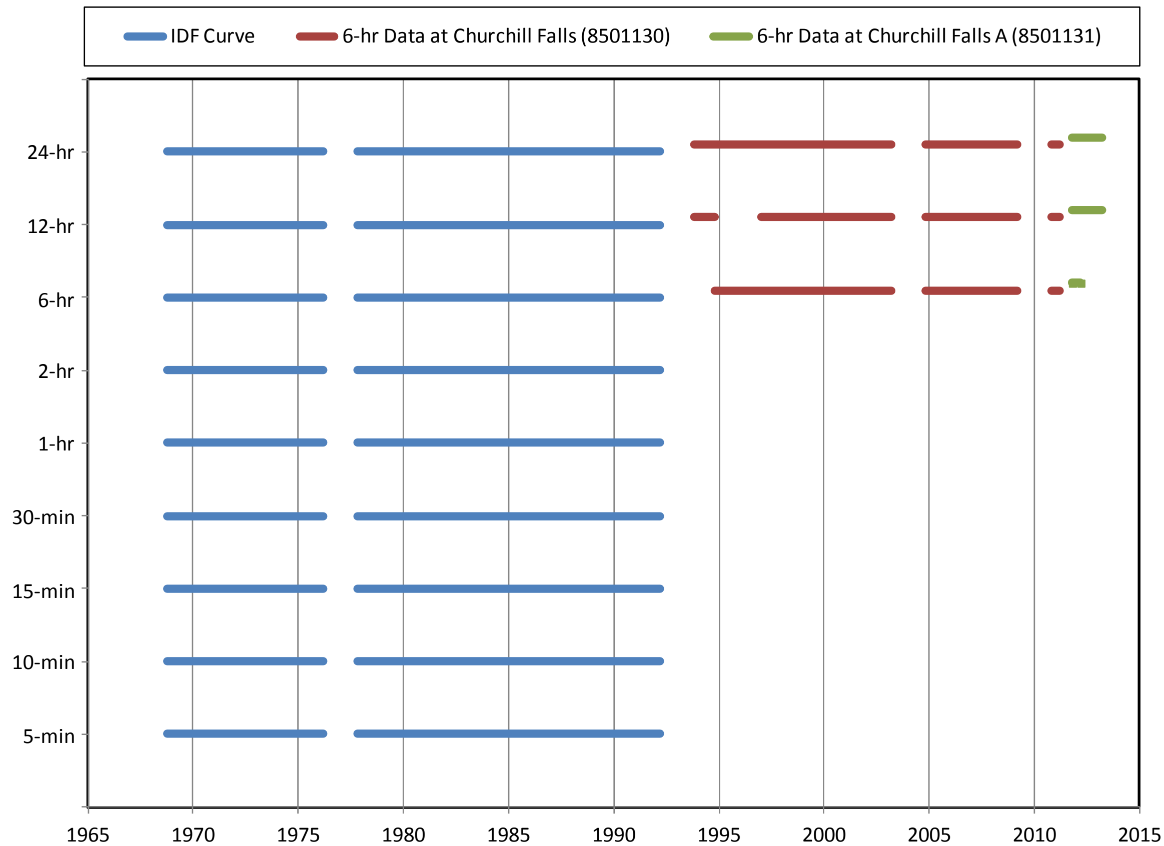

Figure 4.14 Churchill Falls A Data Availability by Year

The 6-, 12-, and 24-hr annual maxima were generated for the two newer Churchill Falls stations for the period of 1994 to 2014 and the annual maxima were examined with statistical analysis. The results of the statistical analysis are included in Appendix B. It was found that the newer data were homogeneous with the IDF curve data. The comparison of means showed that the newer data at Churchill Falls (8501130) and Churchill Falls A (8501131) were generally higher than the IDF curve data. The standard deviation for the 12-hr duration was lower than the standard deviation for the IDF curve data. However, the differences were not statistically significant. Therefore, the three stations could be combined to generate an IDF curve. Goodness-of-fit tests were performed to ensure that the Gumbel distribution could be used to fit the combined data from all three Churchill Falls stations (the IDF station and the two newer stations). The tests showed that the data could be modelled with the Gumbel distribution.

The IDF curve was generated using the Gumbel distribution and the tables and figures are included in Appendix C. The quantile-quantile and return level plots indicated that the data were a good fit with the Gumbel distribution. There were no data outside of the 95 percent confidence limits. The trend plot showed that there were no significant trends at any of the durations. The EC IDF (V2.3) trends were negative for the 6-, 12-, and 24-hr durations. After the update, the slopes increased: closer to zero for the 6-hr duration, and positive for the 12- and 24-hr durations.

The updated IDF curve was compared to the EC IDF curve (V2.3, 2015) in Table 4.14. The precipitation increased for most durations and return periods, but there was a slight decrease for the 12-hr duration for the 50- and 100-year return periods. Most of the increases and decreases were smaller than 5 percent, except for the 6-hr duration.

Table 4.14 Churchill Falls A Summary of Changes

Return Period [years]	*Percent Change in Precipitation Amount [percent] (Change in Precipitation Amount [mm])*								
	5-min	***10-min***	***15-min***	***30-min***	***1-hr***	***2-hr***	***6-hr***	***12-hr***	***24-hr***
2	N/A	N/A	N/A	N/A	N/A	N/A	2.1 (0.4)	4.3 (1.2)	3.1 (1.1)
5	N/A	N/A	N/A	N/A	N/A	N/A	4.2 (1.1)	2.1 (0.7)	2.6 (1.1)
10	N/A	N/A	N/A	N/A	N/A	N/A	**5.2 (1.5)**	1.1 (0.4)	2.4 (1.2)
25	N/A	N/A	N/A	N/A	N/A	N/A	**6.1 (2.1)**	0.1 (0.0)	2.2 (1.2)
50	N/A	N/A	N/A	N/A	N/A	N/A	**6.6 (2.5)**	-0.5 (-0.3)	2.1 (1.2)
100	N/A	N/A	N/A	N/A	N/A	N/A	**7.0 (2.9)**	-1.0 (-0.5)	2.0 (1.3)

Notes:
Percent change is calculated between the EC IDF curve (V2.3, 2015) and the updated IDF curve using 6-hr precipitation weighing data at Churchill Falls (8501130) and Churchill Falls A (8501131).
Red numbers indicate that the precipitation estimate decreased due to the updated data.
Bold numbers indicate a change of more than 5 percent.
N/A indicates that this duration was not updated at this station.

4.3.2 Mary's Harbour A

Mary's Harbour is located in the southern coastal region of Labrador, along the Trans-Labrador Highway (route 510). It has a subarctic climate that has severe winters, no dry season, cool and short summers, and strong seasonality (Köppen-Geiger classification: Dfc). Average total annual precipitation is approximately 950 mm.

The EC IDF curve for Mary's Harbour A includes data from 1983 to 1995. A co-located 6-hr precipitation weighing gauge was used to check and adjust the data. When the TBRG was removed (1995), precipitation monitoring was discontinued. However, monitoring continued at a location just 0.1 km away until 2013. The station was moved again in early 2014, and both 6-hr and 1-hr data were collected. The stations are listed in Table 4.15 and shown on Figure 4.15.

Table 4.15 Mary's Harbour A Station Listing

Station Name	ID	Latitude	Longitude	Elevation [m]	Distance to IDF [km]	Type of Data	Years
Mary's Harbour A (IDF)	8502591	52°18'13" N	55°50'01" W	10.6	0.00	5-min	1983-1995
Mary's Harbour	850B5R1	52°18'13" N	55°49'57" W	11.6	0.10	6-hr	1995-2013
Mary's Harbour A	8502592	52°18'10" N	55°50'52" W	10.6	1.25	6-hr	2014-current
Mary's Harbour A	8502592	52°18'10" N	55°50'52" W	10.6	1.25	1-hr	2014-current

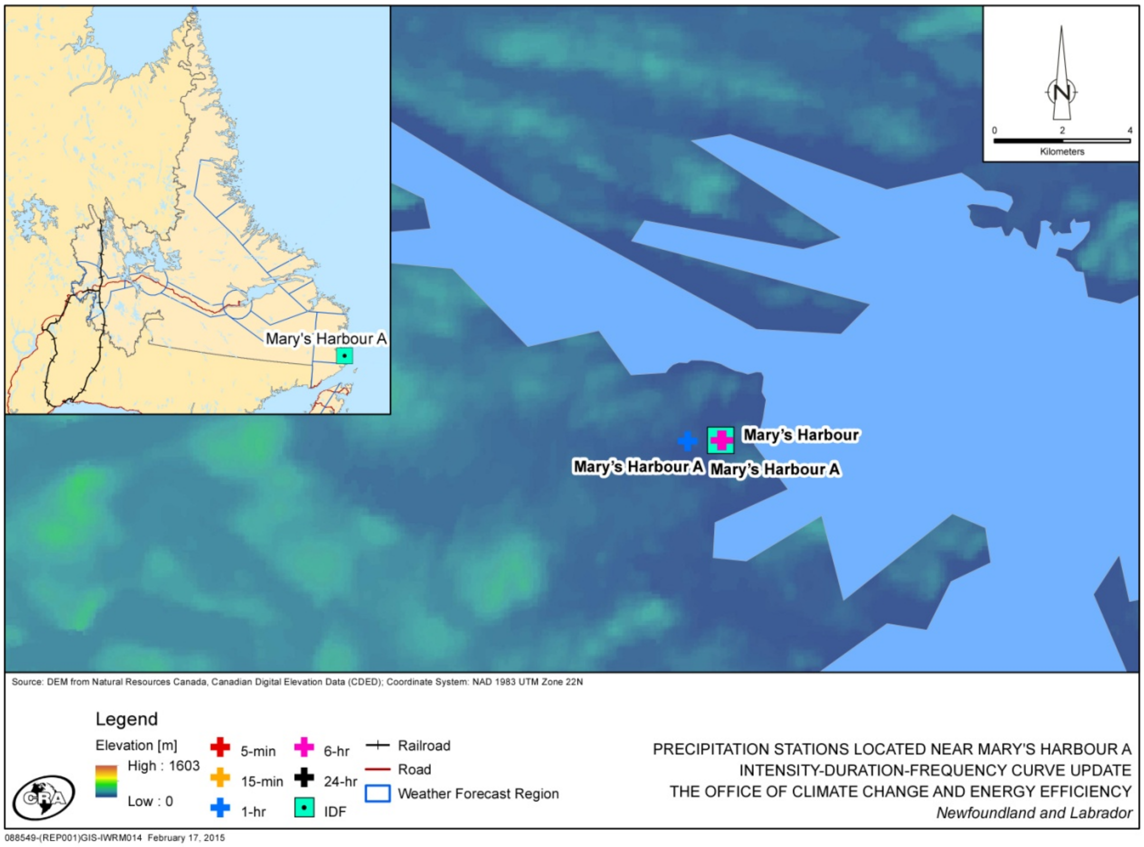

Figure 4.15 Precipitation Stations Located Near Mary's Harbour A

Mary's Harbour A was updated as a Case 2 station, using the 6-hr and 1-hr data recorded at the two nearby locations. Some years were removed from the update because they were incomplete. Figure 4.16 shows the years of data available for each duration. Durations from 6 hours to 24 hours were updated.

Figure 4.16 Mary's Harbour A Data Availability by Year

The 1-, 2-, 6-, 12-, and 24-hr annual maxima were generated for the three Mary's Harbour stations for the period of 1983 to 2014 and the annual maxima were examined with statistical analysis. The results of the statistical analysis are included in Appendix B. It was found that the newer stations were homogeneous with the IDF curve data (Mary's Harbour A 8502591). The comparison of means showed that the newer data at Mary's Harbour (850B5R1) and Mary's Harbour A (8502592) were generally higher than the IDF curve data. The 24-hr duration had a lower standard deviation than the IDF curve data. However, the differences were not statistically significant. Therefore, the three stations could be combined to generate an IDF curve. Goodness-of-fit tests were performed to ensure that the Gumbel distribution could be used to fit the combined data from all three stations. The tests showed that the data could be modelled with the Gumbel distribution.

The IDF curve was generated using the Gumbel distribution and the tables and figures are included in Appendix C. The quantile-quantile and return level plots indicated that the data were a good fit with the Gumbel distribution. There were no data outside of the 95 percent confidence limits. Prior to the update, there were significant positive trends for the 2-hr and

12-hr durations. After the update, only the 2-hr trend was significant. For all durations, the slopes of the trends decreased.

The updated IDF curve was compared to the EC IDF curve (V2.3, 2015) in Table 4.16. The precipitation increased for most durations. The 24-hr duration decreased, mainly due to the lower standard deviation of the newer data. Most of the increases and decreases were smaller than 5 percent, except for the 12-hr duration.

Table 4.16 Mary's Harbour A Summary of Changes

Return Period [years]	*Percent Change in Precipitation Amount [percent] (Change in Precipitation Amount [mm])*								
	5-min	*10-min*	*15-min*	*30-min*	*1-hr*	*2-hr*	*6-hr*	*12-hr*	*24-hr*
2	N/A	N/A	N/A	N/A	1.2 (0.1)	2.3 (0.3)	-2.6 (-0.7)	4.1 (1.3)	3.0 (1.2)
5	N/A	N/A	N/A	N/A	0.8 (0.1)	2.2 (0.4)	0.6 (0.2)	**7.5 (3.0)**	-0.3 (-0.2)
10	N/A	N/A	N/A	N/A	0.5 (0.1)	2.2 (0.4)	2.1 (0.7)	**9.0 (4.2)**	-1.7 (-1.0)
25	N/A	N/A	N/A	N/A	0.3 (0.0)	2.2 (0.4)	3.7 (1.4)	**10.5 (5.6)**	-2.9 (-2.2)
50	N/A	N/A	N/A	N/A	0.1 (0.0)	2.2 (0.5)	4.7 (1.9)	**11.4 (6.6)**	-3.6 (-3.0)
100	N/A	N/A	N/A	N/A	0.0 (0.0)	2.2 (0.5)	**5.5 (2.4)**	**12.1 (7.7)**	-4.2 (-3.8)

Notes:
Percent change is calculated between the EC IDF curve (V2.3, 2015) and the updated IDF curve using 6-hr and 1-hr precipitation weighing data at Mary's Harbour (850B5R1) and Mary's Harbour A (8502592).
Red numbers indicate that the precipitation estimate decreased due to the updated data.
Bold numbers indicate a change of more than 5 percent.
N/A indicates that this duration was not updated at this station.

4.3.3 St. John's A

St. John's is located on the east side of the island of Newfoundland, on the Avalon Peninsula. It is the capital and largest city of Newfoundland and Labrador. It has a humid continental climate with severe winters, no dry season, warm summers and strong seasonality (Köppen-Geiger classification: Dfb). Annual total precipitation is approximately 1,500 mm.

The EC IDF curve for St. John's A includes data from 1949 to 1996. A co-located 6-hr precipitation weighing gauge was used to check and adjust the data. The 6-hr precipitation monitoring continued when the TBRG was removed (1996). The station moved in early 2012 to a location 0.9 km away and 6-hr monitoring continued. One of the City of St. John's stations, Windsor Lake, is close enough (1.7 km) to be combined with the St. John's A data, and has been used with the St. John's A IDF curve data by other authors (Wadden, 2002; CBCL, 2012). More recently, EC established two TBRG monitoring locations in the southwestern part of St. John's. One of the City of St. John's stations, Ruby Line, is potentially close enough (2.8 km) to be combined with the southwestern St. John's data. The stations are listed in Table 4.17 and shown on Figure 4.17. The analysis for the St. John's A and Windsor Lake data will be presented first, followed by the analysis for the St. John's West and Ruby Line data.

Table 4.17 St. John's A Station Listing

Station Name	*ID*	*Latitude*	*Longitude*	*Elevation [m]*	*Distance to IDF [km]*	*Type of Data*	*Years*
St. John's A (IDF)	8403506	47°37'20" N	52°44'34" W	140.5	0.00	5-min	1949-1996
St. John's A	8403506	47°37'20" N	52°44'34" W	140.5	0.00	6-hr	1949-2011
St. John's Intl A	8403505	47°37'07" N	52°45'09" W	140.5	0.90	6-hr	2012-2014
Windsor Lake	St. John's	47°36'26" N	52°45'59" W	156.0	1.70	5-min	1999-2014
St. John's West CDA CS	8403605	47°30'56" N	52°47'05" W	114.0	12.35	5-min	1991-1995
St. John's West CDA CS	8403605	47°30'56" N	52°47'05" W	114.0	12.35	6-hr	2000-2005
St. John's West Climate	8403603	47°30'48" N	52°47'00" W	110.0	12.56	5-min	2011-2013
St. John's West Climate	8403603	47°30'48" N	52°47'00" W	110.0	12.56	6-hr	2010-2014
Ruby Line	St. John's	47°29'24" N	52°47'46" W	151.0	15.10	5-min	1997-2014

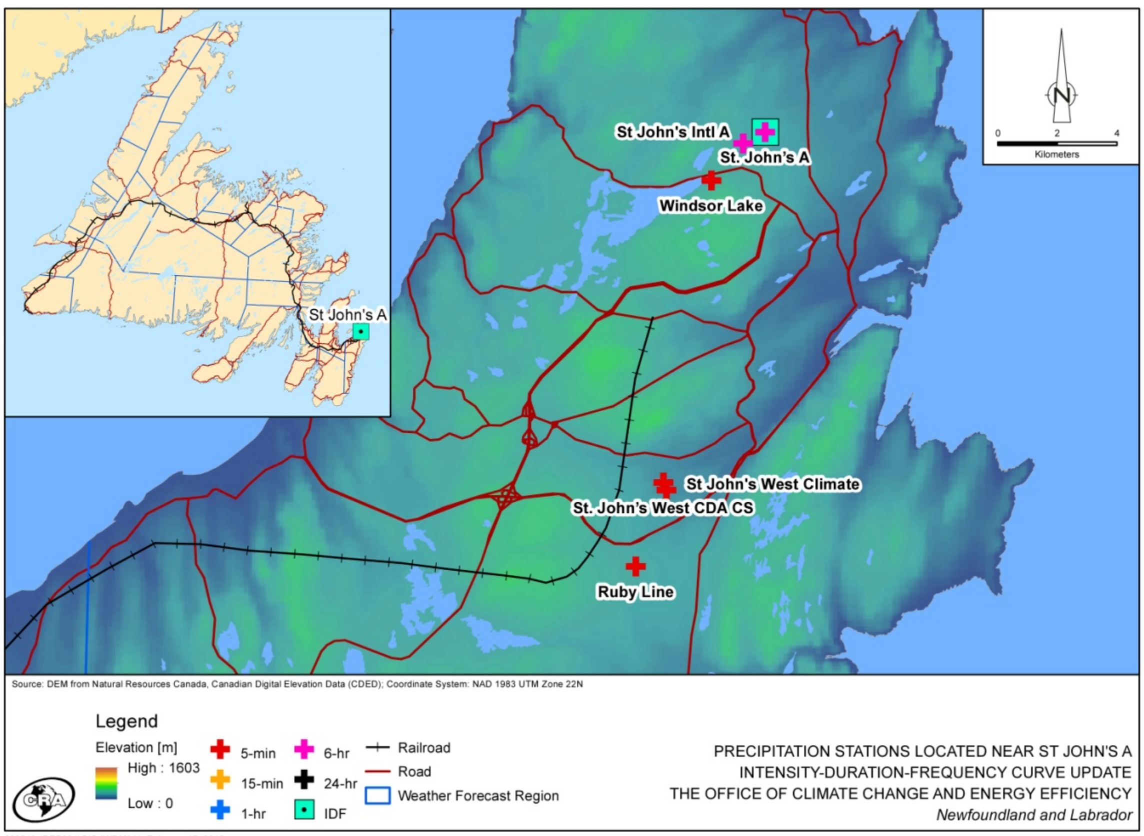

Figure 4.17 Precipitation Stations Located Near St. John's A

4.3.3.1 St. John's A and Windsor Lake

St. John's A was updated as a Case 2 station, using the 5-min data measured at the Windsor Lake location. Prior to using the Windsor Lake data, they were compared to the 6-hr data at St. John's A. The dates of the maximum events were checked and found to be the same for both locations. Three years of data were removed from the Windsor Lake data because the Windsor Lake station missed or recorded less precipitation than the maximum event at the St. John's A station. Figure 4.18 shows the years of data available for each duration for the St. John's A IDF curve station. All durations were updated.

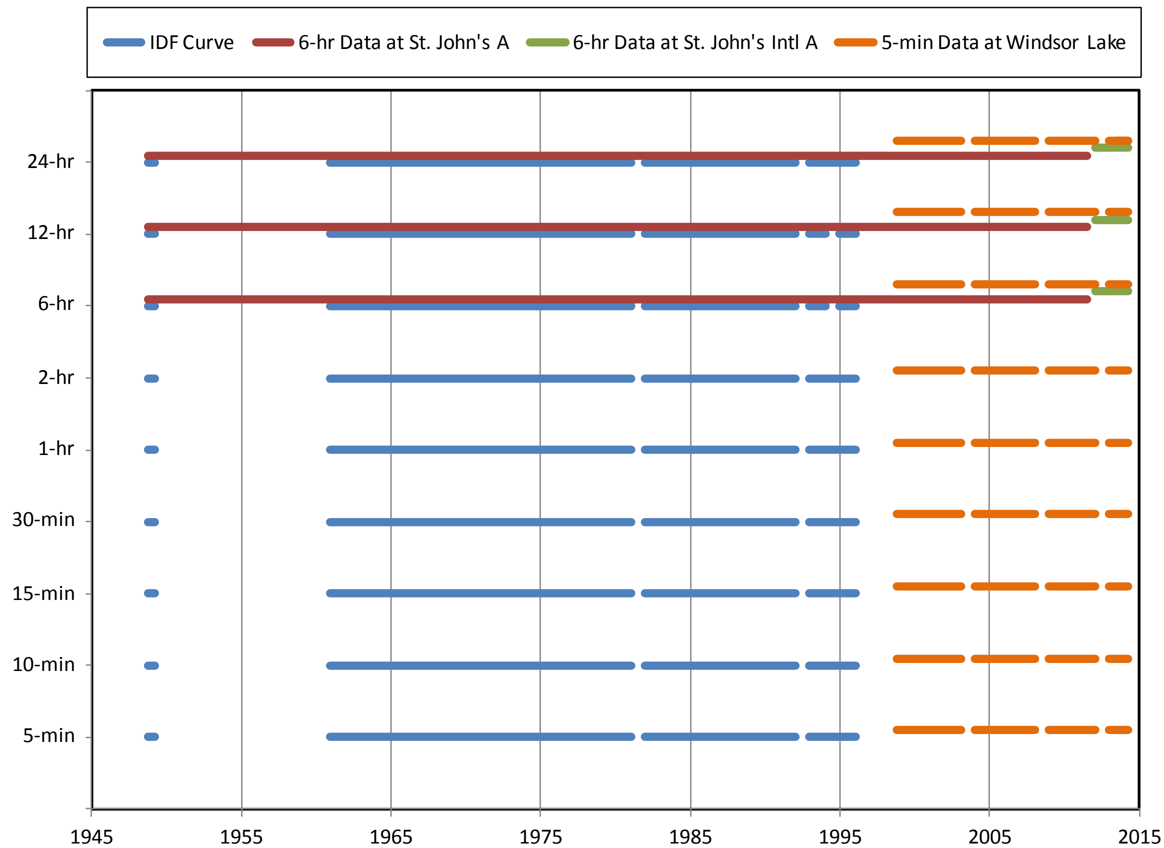

Figure 4.18 St. John's A Data Availability by Year

The St. John's A and Windsor Lake stations were examined with statistical analysis. The results of the statistical analysis are included in Appendix B. It was found that the annual maxima were not homogeneous for durations of 1-hr and longer, however there were no years of overlap in the data set. Therefore, the heterogeneity may be due to climatic change/variation instead of the change in measurement technique and location. The correlation analysis was performed using the daily precipitation data from St. John's A and Windsor Lake. The correlation analysis showed that the St. John's A and Windsor Lake stations receive similar daily precipitation.

Therefore, the two stations could be combined to generate an IDF curve, even though the annual maxima were not homogeneous. Goodness-of-fit tests were performed to ensure that the Gumbel distribution could be used to fit the St John's A/Windsor Lake data. The tests showed that the data could be modelled with the Gumbel distribution.

The IDF curve was generated using the Gumbel distribution and the tables and figures are included in Appendix C. The quantile-quantile and return level plots indicated that the data were a good fit with the Gumbel distribution. There was one data point outside of the 95 percent confidence limits for the 12-hr duration. The outlier corresponds to the precipitation from Hurricane Gabrielle in 2001. CBCL Limited (2012) also noted that this event was a statistical outlier. It is the largest event in the data, however, and it was left in the update as it was a significant rainfall event. Prior to the update, there were no significant trends in the data. After the update, there were statistically significant positive trends for the 1-hr, 2-hr, and 6-hr durations. The trends were also calculated without the data for the Hurricane Gabrielle outlier in 2001. The trends were lower but still positive without Hurricane Gabrielle, and the trends for the 1-hr, 2-hr, and 6-hr durations were still statistically significant. Therefore, the inclusion of Hurricane Gabrielle did not impact the trend analysis. Most trend slopes increased after the update.

The updated IDF curve was compared to the EC IDF curve (V2.3, 2015) in Table 4.18. The precipitation decreased for the 5- to 15-min durations and increased for the other durations. This pattern was also observed by CBCL (2012). The decreases for the 5-min duration were larger than 5 percent, but smaller than 5 percent for the 10-min and 15-min durations. Therefore, users should exercise caution when using the updated IDF curve for the 5-min duration, or use the EC IDF curve instead. Most of the increases were larger than 5 percent. There were six severe precipitation events with 24-hr totals of greater than 90 mm in the Windsor Lake data. The largest 24-hr precipitation total in the EC IDF curve data for St. John's A was only 89.2 mm. Therefore, precipitation has been increasing at this location for the long durations, relative to the EC IDF curve.

Table 4.18 St. John's A Summary of Changes

Return Period [years]	*Percent Change in Precipitation Amount [percent] (Change in Precipitation Amount [mm])*								
	5-min	*10-min*	*15-min*	*30-min*	*1-hr*	*2-hr*	*6-hr*	*12-hr*	*24-hr*
2	-1.7 (-0.1)	1.0 (0.1)	2.6 (0.2)	**5.0 (0.6)**	**7.8 (1.4)**	**9.1 (2.2)**	**7.7 (3.1)**	**7.5 (3.9)**	**8.1 (5.1)**
5	-4.3 (-0.3)	-1.7 (-0.2)	0.1 (0.0)	**5.0 (0.8)**	**11.0 (2.5)**	**10.9 (3.4)**	**12.5 (6.4)**	**15.5 (9.9)**	**13.9 (10.5)**
10	**-5.3 (-0.4)**	-2.8 (-0.3)	-1.0 (-0.1)	**5.0 (1.0)**	**12.5 (3.2)**	**11.6 (4.3)**	**14.8 (8.5)**	**19.4 (13.8)**	**16.8 (14.0)**
25	**-6.2 (-0.6)**	-3.8 (-0.5)	-2.0 (-0.3)	**5.0 (1.1)**	**13.8 (4.1)**	**12.3 (5.3)**	**17.0 (11.3)**	**23.3 (18.8)**	**19.6 (18.6)**
50	**-6.8 (-0.7)**	-4.4 (-0.6)	-2.5 (-0.5)	**5.1 (1.3)**	**14.6 (4.8)**	**12.7 (6.1)**	**18.4 (13.3)**	**25.7 (22.5)**	**21.4 (21.9)**
100	**-7.2 (-0.8)**	-4.9 (-0.8)	-2.9 (-0.6)	**5.1 (1.4)**	**15.3 (5.4)**	**13.0 (6.9)**	**19.5 (15.3)**	**27.7 (26.2)**	**22.8 (25.3)**

Notes:
Percent change is calculated between the EC IDF curve (V2.3, 2015) and the updated IDF curve using TBRG data at Windsor Lake.
Red numbers indicate that the precipitation estimate decreased due to the updated data.
Bold numbers indicate a change of more than 5 percent.

4.3.3.2 St. John's West and Ruby Line

St. John's West/Ruby Line was developed as a Case 2 station, using the 5-min data measured at the two St. John's West stations and the Ruby Line station. The Ruby Line station was not operating for most of 2003. The St. John's West Climate and Ruby Line stations both missed the precipitation for Hurricane Leslie in 2012. Therefore, these years were removed from the analysis. The St. John's West CDA and Ruby Line stations were year-round stations. Therefore, snow events were removed from the data record using the air temperature data from the closest station with data for that year: St. John's A (1997-2003, 2006-2010), St. John's West CDA CS (2004-2005), and St. John's West Climate (2011-2014). Figure 4.19 shows the years of data available for each duration for the St. John's West and Ruby Line stations. All durations were created.

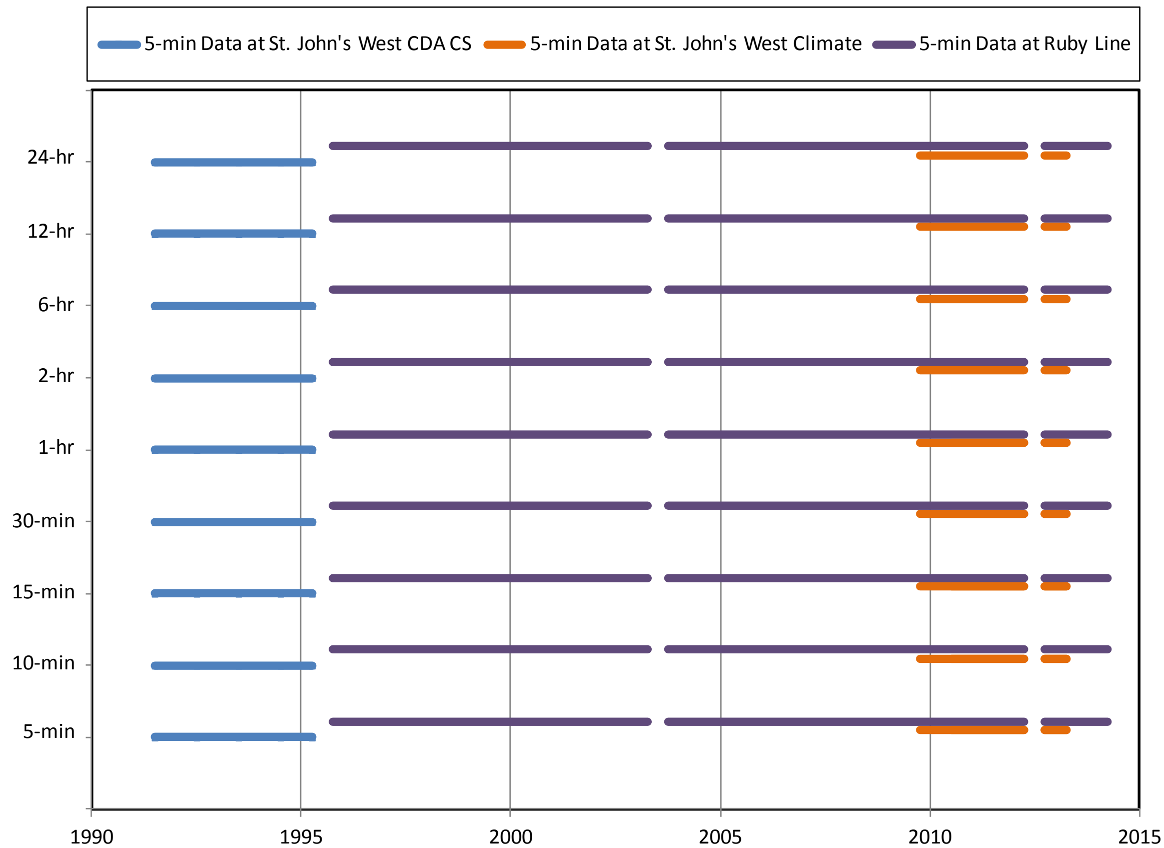

Figure 4.19 St. John's West/Ruby Line Data Availability by Year

The St. John's West and Ruby Line stations were examined with statistical analysis. The results of the statistical analysis are included in Appendix B. It was found that the annual maxima were homogeneous for most durations, but the correlation analysis showed that the St. John's West and Ruby Line stations are too far apart to receive similar precipitation. Therefore, it was decided to generate an IDF curve using only the data from Ruby Line. Goodness-of-fit tests were performed to ensure that the Gumbel distribution could be used to fit the Ruby Line data set. The tests showed that the Ruby Line data could be modelled with the Gumbel distribution.

The IDF curve was generated using the Gumbel distribution and the tables and figures are included in Appendix C. The quantile-quantile and return level plots indicated that the data were a good fit with the Gumbel distribution. There were no data outside of the 95 percent confidence limits. The trend plot showed that there were no significant trends at any of the durations.

The newer IDF curve for Ruby Line was compared to the St. John's A IDF curve (V2.3, 2015) in Table 4.19. The pattern was similar to the changes observed for the combined St. John's A and

Windsor Lake IDF curve; the 5- to 30-min durations decreased and the other durations increased. The decreases and increases were generally larger for the Ruby Line station; this is likely due to the fact that the changes for the combined St. John's A and Windsor Lake IDF curve were tempered by the inclusion of the earlier St. John's A data. Therefore, users should exercise caution when using the updated IDF curve for the 5-, 10-, and 15-min durations, or use the EC IDF curve instead.

Table 4.19 Ruby Line Summary of Changes

Return Period [years]	*Percent Change in Precipitation Amount [percent] (Change in Precipitation Amount [mm])*								
	5-min	*10-min*	*15-min*	*30-min*	*1-hr*	*2-hr*	*6-hr*	*12-hr*	*24-hr*
2	**-11.3 (-0.5)**	**-5.4 (-0.4)**	**-5.2 (-0.5)**	-3.4 (-0.4)	**6.8 (1.2)**	**22.0 (5.2)**	**15.6 (6.4)**	**15.7 (8.2)**	**17.3 (10.8)**
5	**-20.7 (-1.3)**	**-14.7 (-1.4)**	**-12.6 (-1.5)**	-1.8 (-0.3)	**14.6 (3.2)**	**23.0 (7.3)**	**20.2 (10.3)**	**26.4 (16.8)**	**24.2 (18.2)**
10	**-24.6 (-1.9)**	**-18.7 (-2.0)**	**-15.7 (-2.2)**	-1.1 (-0.2)	**18.1 (4.6)**	**23.4 (8.6)**	**22.3 (12.9)**	**31.5 (22.4)**	**27.6 (23.1)**
25	**-28.1 (-2.5)**	**-22.3 (-2.9)**	**-18.5 (-3.0)**	-0.4 (-0.1)	**21.5 (6.3)**	**23.8 (10.3)**	**24.4 (16.1)**	**36.7 (29.5)**	**31.0 (29.3)**
50	**-30.0 (-3.0)**	**-24.4 (-3.5)**	**-20.1 (-3.6)**	0.0 (0.0)	**23.4 (7.6)**	**24.0 (11.6)**	**25.7 (18.5)**	**39.8 (34.8)**	**33.1 (33.9)**
100	**-31.6 (-3.5)**	**-26.0 (-4.1)**	**-21.4 (-4.3)**	0.3 (0.1)	**25.0 (8.9)**	**24.2 (12.8)**	**26.7 (20.9)**	**42.4 (40.1)**	**34.8 (38.5)**

Notes:
Percent change is calculated between the EC IDF curve (V2.3, 2015) for St. John's A and the IDF curve generated using TBRG data at Ruby Line.
Red numbers indicate that the precipitation estimate decreased due to the updated data.
Bold numbers indicate a change of more than 5 percent.

4.4 Case 3 Stations

4.4.1 St. Albans

St. Albans is located in the south-central part of the island of Newfoundland along the Bay D'Espoir, an inland part of the Coast of Bays region. The topography of the area is rugged and complex with many bays and inlets. It has a subarctic climate that has severe winters, no dry season, cool and short summers, and strong seasonality (Köppen-Geiger classification: Dfc). Average total annual precipitation is approximately 1,700 mm.

The EC IDF curve for St. Albans includes data from 1969 to 1983. When the TBRG was removed (1983), precipitation monitoring was discontinued at this location. St. Albans is located in a data-poor region of the Province. The EC stations that are in the same weather forecast region are daily stations, and only two of them are active up to the end of 2014: Bay D'Espoir Gen Stn and Harbour Breton. The Bay D'Espoir Gen Stn is located north of the St. Albans station, along the Bay D'Espoir. As storms travel up the Bay D'Espoir they will likely impact both stations although orographic uplift may affect the precipitation: both enhanced rainfall and rain shadows may affect the precipitation amounts. However, if storms are coming from another direction, they may affect one station but not the other. The Harbour Breton station is located south of St. Albans, along the coast. This station is further away from St. Albans and may receive different precipitation due to its location along the coast with a much more maritime exposure. Hydro measures precipitation on an hourly basis using a TBRG at the Long Pond Intake, approximately 1.4 km from the Bay D'Espoir Gen Stn, however, little QA/QC is performed on the data. The Long Pond Intake station is at a higher elevation than the St. Albans station, but is located along the Bay D'Espoir and likely receives similar precipitation to the Bay D'Espoir Gen Stn. The stations are listed in Table 4.20 and shown on Figure 4.20.

Table 4.20 St. Albans Station Listing

Station Name	*ID*	*Latitude*	*Longitude*	*Elevation (m)*	*Distance to IDF (km)*	*Type of Data*	*Years*
St. Albans (IDF)	8403290	47°52'00" N	55°51'00" W	13.4	0.00	5-min	1969-1983
Bay D'Espoir Gen Stn	8400413	47°59'00" N	55°48'00" W	22.9	13.62	24-hr	1968-current
Long Pond Intake	NLHydro	47°59'21" N	55°49'00" W	162.0	13.88	1-hr	2009-current
Harbour Breton	8402071	47°28'00" N	55°50'00" W	30.0	44.50	24-hr	1984-2014

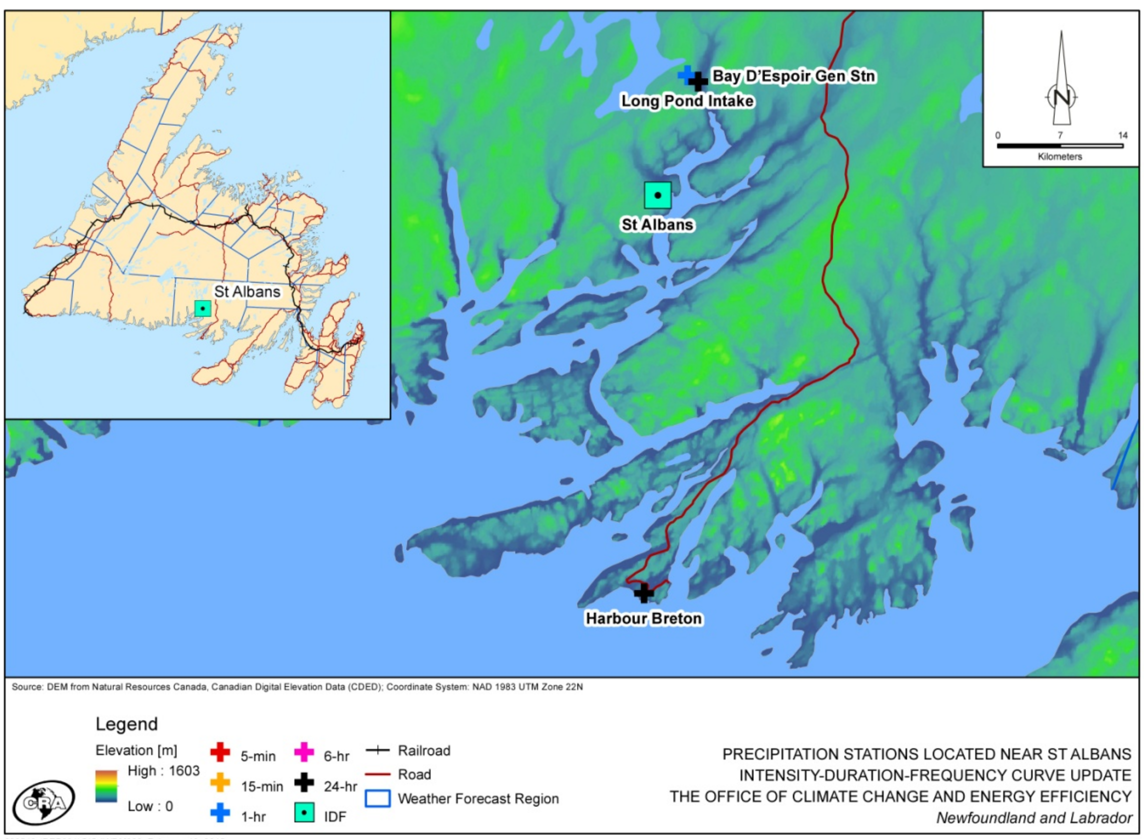

Figure 4.20 Precipitation Stations Located Near St. Albans

St. Albans was updated as a Case 3 station, using the 24-hr and 1-hr data from the distant donor stations. There were many periods of missing data in the latter part of the Bay D'Espoir Gen Stn dataset, requiring several years of data to be marked as missing, since the maximum event may have been missed. Since the 1-hr station was more than 3 km away from the IDF station, its data were only used to update the 6-, 12-, and 24-hr durations. As little QA/QC was performed on the Hydro data, these data were only used if they could be verified against the Bay D'Espoir Gen Stn or Harbour Breton data. Only four years of Long Pond Intake data could be verified. The data availability is shown on Figure 4.21.

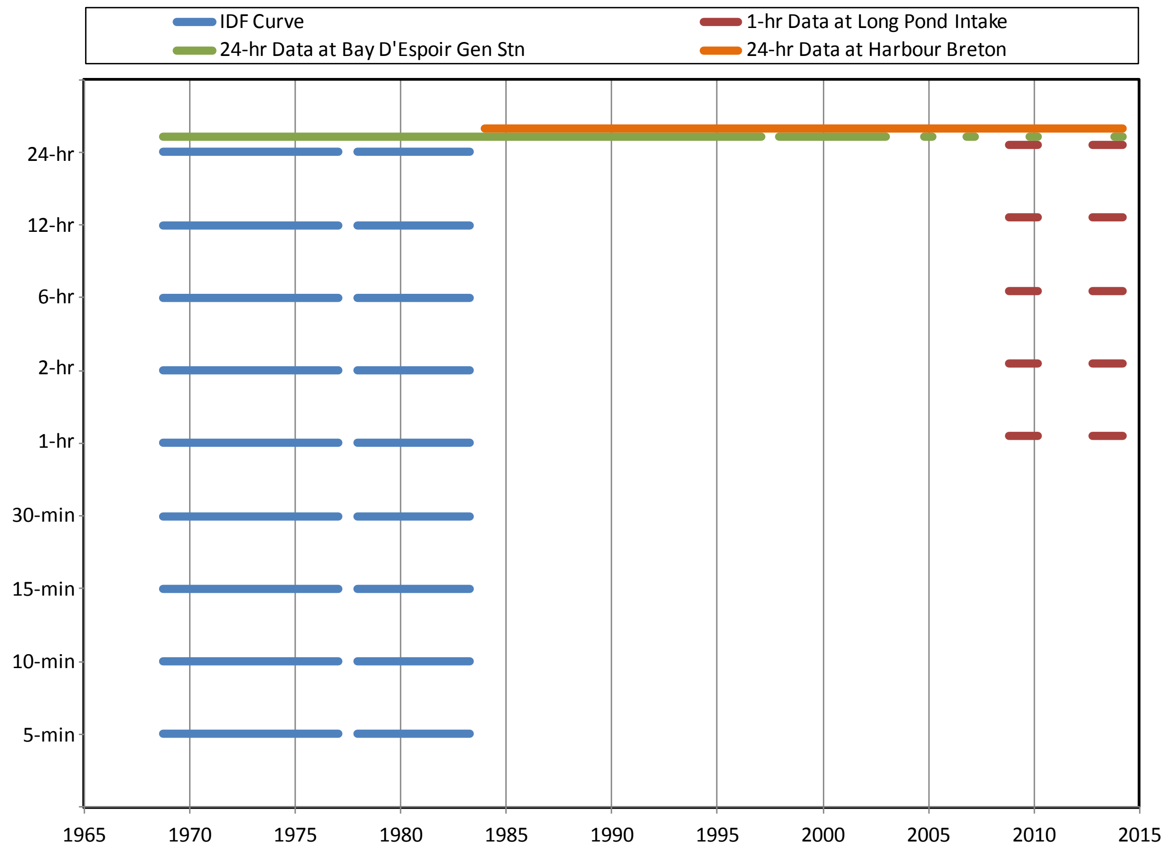

Figure 4.21 St. Albans Data Availability by Year

The donor station data were compared to the IDF curve data with statistical analysis. The results of the statistical analysis are included in Appendix B. The Bay D'Espoir Gen Stn data were homogeneous with the IDF curve data for the overlapping period but not for the newer data period. The newer Harbour Breton data were also not homogeneous with the IDF curve data. When the means and standard deviations of the three potential donor stations were compared with the IDF curve data, it was found that the newer data from Bay D'Espoir Gen Stn and Harbour Breton were much lower than the IDF curve data, with lower means and standard deviations. The Long Pond Intake data were also lower than the IDF curve data, but were higher than the Bay D'Espoir Gen Stn and Harbour Breton data. Therefore, it was decided to update the St. Albans IDF curve with the four years of Long Pond Intake data. Goodness-of-fit tests were performed to ensure that the Gumbel distribution could be used to fit the augmented data set. The tests showed that the St Albans IDF curve with the four newer years of Long Pond Intake added could be modelled with the Gumbel distribution.

The IDF curve was generated using the Gumbel distribution and the tables and figures are included in Appendix C. The quantile-quantile and return level plots indicated that the data were a good fit with the Gumbel distribution. There were no data outside of the 95 percent confidence limits. The slopes of the trends decreased after the update for the 6-, 12-, and 24-hr durations. There were no significant trends at this location.

The updated IDF curve has decreased as compared to the EC IDF curve for St Albans (V2.3, 2015) in Table 4.21. A decrease was expected, as all three donor stations had lower precipitation amounts than the EC IDF data. Most decreases were smaller than 5 percent, except for the decreases at the 24-hr duration. Therefore, users should exercise caution when using the updated IDF curve for the 24-hr duration, or use the EC IDF curve instead.

Table 4.21 St. Albans Summary of Changes

Return Period [years]	***Percent Change in Precipitation Amount [percent] (Change in Precipitation Amount [mm])***								
	5-min	***10-min***	***15-min***	***30-min***	***1-hr***	***2-hr***	***6-hr***	***12-hr***	***24-hr***
2	N/A	N/A	N/A	N/A	N/A	N/A	-0.9 (-0.4)	-2.0 (-1.3)	-3.4 (-2.9)
5	N/A	N/A	N/A	N/A	N/A	N/A	-1.2 (-0.6)	-2.8 (-2.2)	-4.3 (-4.8)
10	N/A	N/A	N/A	N/A	N/A	N/A	-1.3 (-0.8)	-3.1 (-2.7)	-4.7 (-6.0)
25	N/A	N/A	N/A	N/A	N/A	N/A	-1.5 (-0.9)	-3.5 (-3.4)	**-5.1 (-7.6)**
50	N/A	N/A	N/A	N/A	N/A	N/A	-1.6 (-1.1)	-3.7 (-4.0)	**-5.3 (-8.8)**
100	N/A	N/A	N/A	N/A	N/A	N/A	-1.7 (-1.2)	-3.9 (-4.5)	**-5.4 (-9.9)**

Notes:
Percent change is calculated between the EC IDF curve (V2.3, 2015) and the updated IDF curve using 1-hr precipitation data at Long Pond Intake.
Red numbers indicate that the precipitation estimate decreased due to the updated data.
Bold numbers indicate a change of more than 5 percent.
N/A indicates that this duration was not updated at this station.

4.5 Case 4 Stations

4.5.1 Comfort Cove

Comfort Cove is located on the north side of the island of Newfoundland, on a small peninsula in the Bay of Exploits. The Comfort Cove climate station was located at the south end of the peninsula. Comfort Cove has a humid continental climate with severe winters, no dry season, warm summers and strong seasonality (Köppen-Geiger classification: Dfb). Average total annual precipitation is approximately 1,150 mm.

The EC IDF curve for Comfort Cove includes data from 1967 to 1995. A co-located 6-hr precipitation weighing gauge was used to check and adjust the data. Precipitation monitoring ended when the TBRG was removed (1995). The precipitation monitoring focus for this region of Newfoundland was moved to Twillingate (AUT), located on an island where Bay of Exploits empties into Notre Dame Bay (47 km away). Twillingate (AUT) is in the same weather forecast region as Comfort Cove. The data from Twillingate (AUT) cannot be combined with Comfort Cove due to the distance and due to the change in climate (Twillingate is on an island and exposed to oceanic influences while Comfort Cove is more inland and more protected from the ocean). Precipitation data were recorded at Twillingate (AUT) at a 6-hr duration starting in 1994. Hourly precipitation data were recorded beginning in early 2004 and a TBRG was installed in late 2004. Twillingate (AUT) will soon become an IDF station, when enough TBRG data have been collected. An older station also recorded 6-hr precipitation at Twillingate, but this station was not used because its elevation was only 4.9 m, compared to 92.3 m for Twillingate (AUT). The stations are listed in Table 4.22 and shown on Figure 4.22.

Table 4.22 Comfort Cove Station Listing

Station Name	*ID*	*Latitude*	*Longitude*	*Elevation [m]*	*Distance to IDF [km]*	*Type of Data*	*Years*
Comfort Cove (IDF)	8401259	49°16'00" N	54°53'00" W	99.4	0.00	5-min	1967-1995
Twillingate (AUT)	8404025	49°41'00" N	54°48'00" W	92.3	46.69	6-hr	1995-2006, 2012-2014
Twillingate (AUT)	8404025	49°41'00" N	54°48'00" W	92.3	46.69	1-hr	2004-2006, 2013-2014
Twillingate (AUT)	8404025	49°41'00" N	54°48'00" W	92.3	46.69	5-min	2005-2013

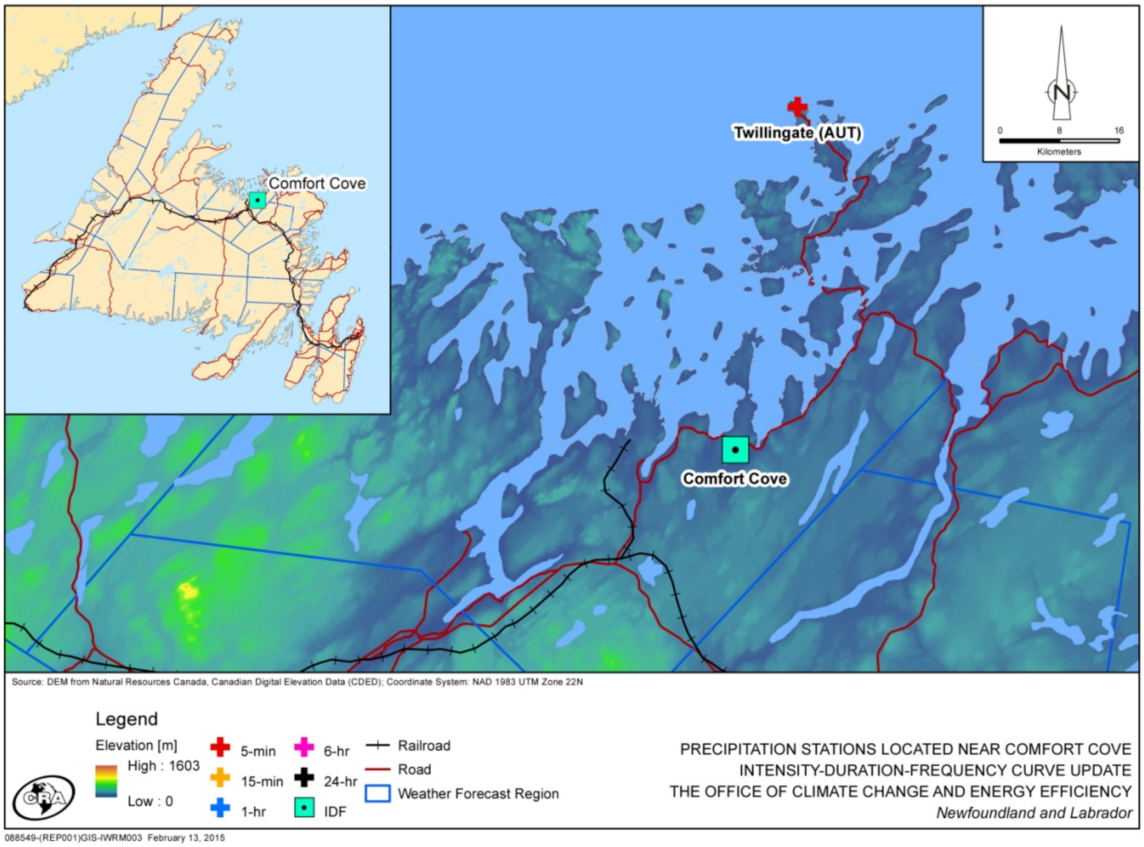

Figure 4.22 Precipitation Stations Located Near Comfort Cove

Comfort Cove was updated as a Case 4 station, by creating a new IDF curve at Twillingate (AUT), using the TBRG, 1-hr and 6-hr data recorded at that station. There were 10 years of TBRG data at this station (2004-2013), but EC's QA/QC process rejected 2010, 2011, and 2013, leaving only 7 years of data. Therefore, the TBRG data for 2004-2009 and 2012 were used for the new IDF curve. There were five years of 1-hr data (2004-2006, 2013-2014) and 13 years of 6-hr data (1995-2014, some years missing or removed due to incomplete data). The QA/QC process focused on the years that EC rejected, and on whether the 6-hr data can be combined with the TBRG and 1-hr data. In 2010, the TBRG recorded the highest precipitation for the 24-hr duration during Hurricane Igor (September 21, 2010). Due to high winds during this storm, the TBRG may have under-recorded the precipitation (and this may have been the reason that EC rejected the year). However, the TBRG recorded a large amount of precipitation during this event, and it represents the highest amount of precipitation recorded at this station in its history. Therefore, the high precipitation totals for the 12-hr and 24-hr durations from Hurricane Igor were left in the analysis. In 2011, the TBRG recorded the annual maxima for the 1-, 2-, 6-, and 12-hr durations during a May 30 precipitation event. It represented the highest recorded precipitation for the 1-hr duration, a high precipitation for the 2-hr duration, and an average precipitation for the 6-hr duration. Therefore, these precipitation totals were left in the analysis. In 2013, 1-hr data were available for comparison with the TBRG data. Both measurement methods recorded the highest precipitation on August 31st. However, the 1-hr data had higher totals for all durations. Therefore, the 1-hr precipitation totals were used instead of the TBRG data. For 2014, the 1-hr precipitation totals were used since there were no TBRG data. Figure 4.23 shows the years of data available for each duration. Durations from 1 hour to 24 hours were generated.

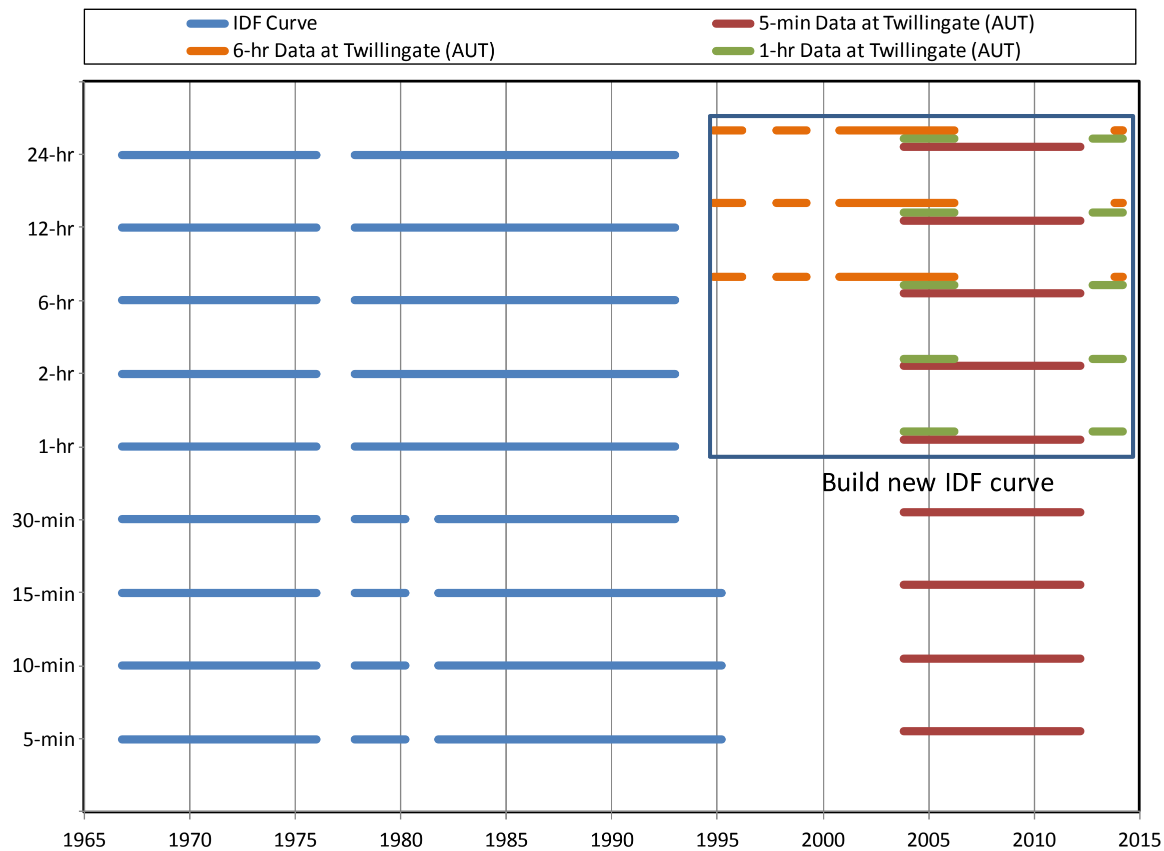

Figure 4.23 Comfort Cove Data Availability by Year

The annual maxima time series were developed for the TBRG, 1-hr, and 6-hr. Statistical analysis was performed to compare the different measurement techniques to ensure that they could be combined to produce an IDF curve. The results of the statistical analysis are included in Appendix B. The annual maxima from the TBRG and the 1-hr precipitation weighing data were found to be homogeneous, but the annual maxima from the TBRG and the 6-hr precipitation weighing data were not found to be homogeneous. The means and standard deviations of the three types of data were also compared. The 6-hr data were found to be lower than the TBRG and 1-hr data. The means and ranges of the TBRG and 1-hr were similar. Therefore, only the TBRG and 1-hr data were used in the IDF curve. Goodness-of-fit tests were performed to ensure that the Gumbel distribution could be used to fit the data set. The tests showed that the combined TBRG and 1-hr data could be modelled with the Gumbel distribution.

The IDF curve was generated using the Gumbel distribution and the tables and figures are included in Appendix C for the durations of 1-hr and longer. The quantile-quantile and return level plots indicated that the data were a good fit with the Gumbel distribution. There were no data outside of the 95 percent confidence limits. The trend plot showed that there were no significant trends at any of the durations. However, as only the durations of 1-hr and longer were generated, the EC IDF curve for Comfort Cove is also included in Appendix C. If durations shorter than 1-hr are required, the Comfort Cove curve must be referenced.

The updated IDF curve has increased as compared to the EC IDF curve for Comfort Cove (V2.3, 2015) at most return periods for most durations (Table 4.23). There were many increases larger than 5 percent and some decreases larger than 5 percent. Therefore, where the decreases were larger than 5 percent, users should exercise caution when using the updated IDF curve, or use the EC IDF curve instead. The 24-hr duration is more than 5 percent higher for all return periods. The new IDF curve includes two recent extreme precipitation events (2010 and 2013) that were not included in the Comfort Cove IDF curve.

Table 4.23 Twillingate (AUT) Summary of Changes

Return Period [years]	***Percent Change in Precipitation Amount [percent] (Change in Precipitation Amount [mm])***								
	5-min	***10-min***	***15-min***	***30-min***	***1-hr***	***2-hr***	***6-hr***	***12-hr***	***24-hr***
2	N/A	N/A	N/A	N/A	**30.3 (4.1)**	**42.2 (7.5)**	**21.5 (6.3)**	**16.8 (6.2)**	**15.7 (7.0)**
5	N/A	N/A	N/A	N/A	**11.9 (2.3)**	**22.4 (5.5)**	**7.0 (2.7)**	**9.2 (4.5)**	**13.7 (7.9)**
10	N/A	N/A	N/A	N/A	4.8 (1.1)	**14.3 (4.1)**	0.8 (0.3)	**5.9 (3.3)**	**12.8 (8.4)**
25	N/A	N/A	N/A	N/A	-1.2 (-0.3)	**7.1 (2.4)**	**-5.0 (-2.7)**	2.7 (1.8)	**12.0 (9.1)**
50	N/A	N/A	N/A	N/A	-4.5 (-1.4)	3.1 (1.2)	**-8.3 (-4.9)**	0.9 (0.6)	**11.5 (9.6)**
100	N/A	N/A	N/A	N/A	**-7.0 (-2.5)**	-0.2 (-0.1)	**-11.0 (-7.1)**	-0.6 (-0.5)	**11.1 (10.1)**

Notes:
Percent change is calculated between the EC IDF curve (V2.3, 2015) for Comfort Cove and the IDF curve generated using TBRG and 1-hr precipitation data at Twillingate (AUT).
Red numbers indicate that the precipitation estimate decreased due to the updated data.
Bold numbers indicate a change of more than 5 percent.
N/A indicates that this duration was not developed at this station.

4.5.2 St. Anthony

St. Anthony is located near the head of the Great Northern Peninsula, around the St. Anthony Harbour. It is located at the end of route 430. It has a humid subarctic climate with severe winters, no dry season, cool and short summers, and a strong seasonality (Köppen-Geiger classification: Dfc). Average total annual precipitation is approximately 1,150 mm.

The EC IDF curve for St. Anthony includes data from 1971 to 1995. When the tipping bucket was removed, precipitation monitoring ended at the station. However, in the year 2000, precipitation monitoring commenced in the St. Anthony Airport area, approximately 43 km away. There are four precipitation stations near the airport, they are all within 2 km of each other, and can potentially be combined to produce one curve. One station was excluded due to a large amount of missing data, leaving three stations available for the IDF curve update. 1-hr and 6-hr precipitation data were recorded at one of the stations, and only 6-hr precipitation data were recorded at the other two. The stations are listed in Table 4.24 and shown on Figure 4.24.

Table 4.24 St. Anthony Station Listing

Station Name	*ID*	*Latitude*	*Longitude*	*Elevation [m]*	*Distance to IDF [km]*	*Type of Data*	*Years*
St. Anthony (IDF)	8403401	51°22'00" N	55°36'00" W	11.5	0.00	5-min	1971-1995
St. Anthony	8403389	51°23'31" N	56°04'08" W	32.9	40.96	6-hr	2009-current
St. Anthony	8403399	51°23'00" N	56°06'00" W	29.3	43.61	1-hr	2004-current
St. Anthony	8403399	51°23'00" N	56°06'00" W	29.3	43.61	6-hr	2000-current
St. Anthony AWOS	8403403	51°23'00" N	56°06'00" W	32.9	43.61	6-hr	2010-2013

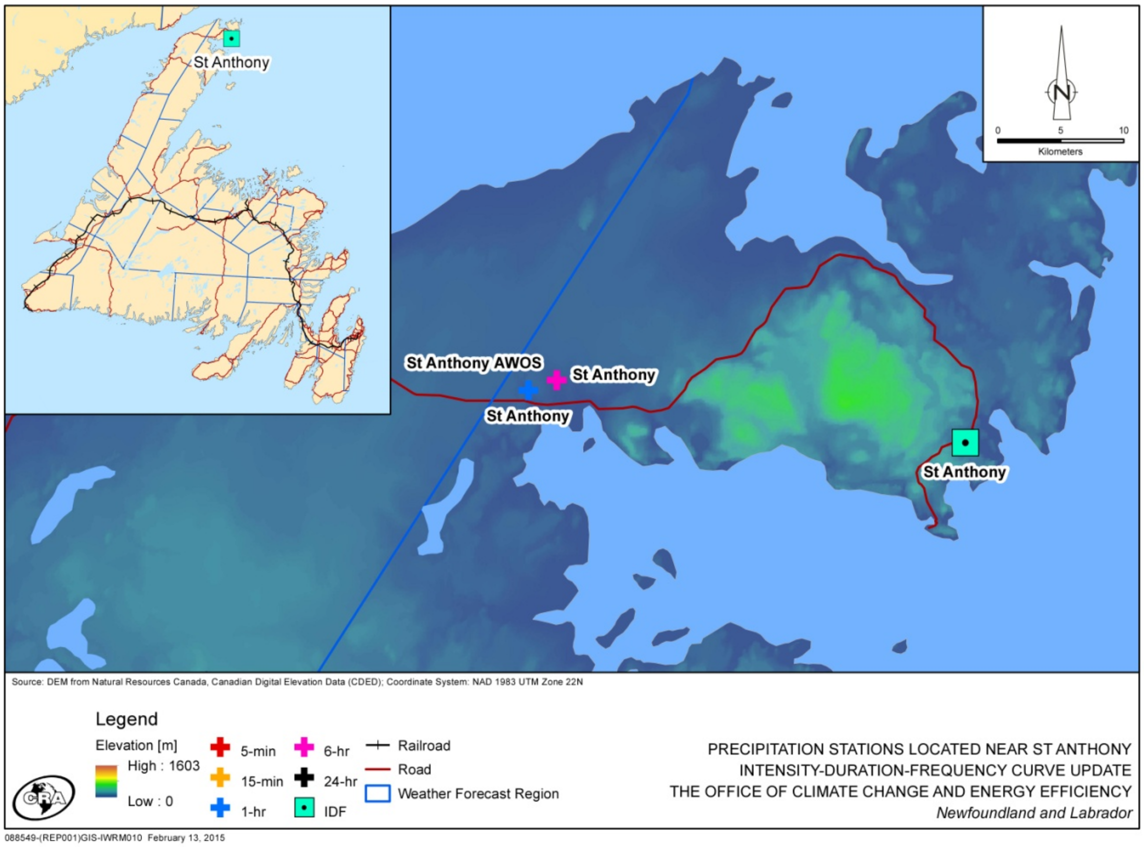

Figure 4.24 Precipitation Stations Located Near St. Anthony

St. Anthony was updated as a Case 4 station, by creating a new IDF curve using the 1-hr and 6-hr data recorded at the airport stations. Figure 4.25 shows the years of data available for each duration. There were 10 years of hourly data. Two of the years were missing data, but the annual maxima were reasonable, so the years were left in the analysis. There were some additional 6-hr data. There were three sources of 6-hr data: St. Anthony (8403399) with 13 years of data, St. Anthony (8403389) with 4-5 years of data, and St. Anthony AWOS (8403403) with 3-4 years of data.

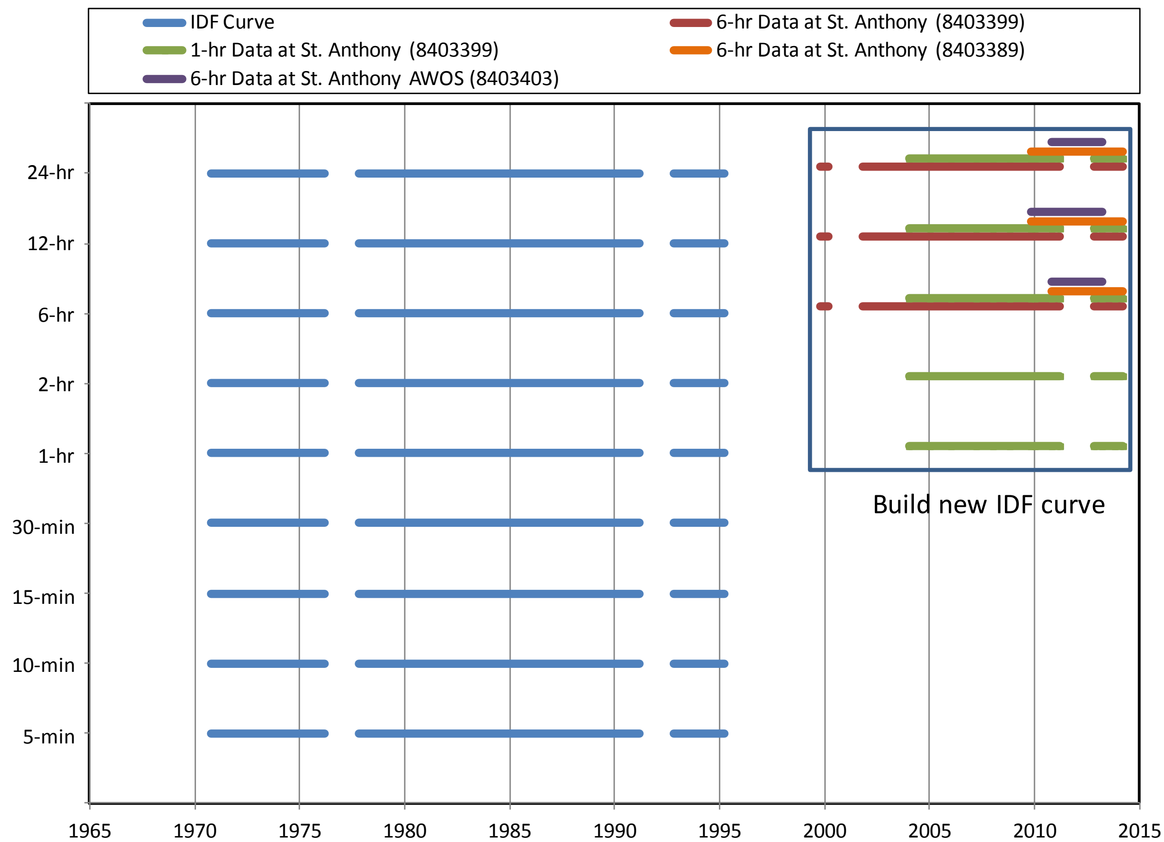

Figure 4.25 St. Anthony Data Availability by Year

The three sources of 6-hr precipitation weighing data were compared with statistical tests. The results of the statistical analysis are included in Appendix B. The 6-, 12-, and 24-hr annual maxima time series from the different stations were not homogeneous, and hence could not be combined to produce the IDF curve. The means and standard deviations of the two shorter stations were lower than the means and standard deviations of the longest station (the difference in mean was statistically significant while the difference in the standard deviation was not). Therefore, the stations were not combined and the curve was generated using only the data from St. Anthony (8403399). Goodness-of-fit tests were performed on the data from the single station to ensure that the Gumbel distribution could be used to fit the data from St. Anthony (8403399). The tests showed that the data could be modelled with the Gumbel distribution.

The IDF curve was generated using the Gumbel distribution and the tables and figures are included in Appendix C for the durations of 1-hr and longer. The quantile-quantile and return level plots indicated that the data were a good fit with the Gumbel distribution. There were no data outside of the 95 percent confidence limits. The trend plot showed that there were no significant trends at any of the durations. However, as only the durations of 1-hr and longer were generated, the EC IDF curve for St. Anthony is also included in Appendix C. If durations shorter than 1-hr are required, the EC St. Anthony IDF curve must be referenced.

The new IDF curve was compared to the existing EC St. Anthony IDF curve in Table 4.25. The new St. Anthony (8403399) IDF curve has increased more than 5 percent for the 1-, 2-, and 6-hr durations, as compared to the EC IDF curve (V2.3, 2015). The new St. Anthony (8403399) IDF curve crosses the EC IDF curve for the 12-hr duration, and the new 24-hr IDF curve has decreased more than 5 percent. Therefore, users should exercise caution when using the updated IDF curve for the 24-hr duration, or use the EC IDF curve instead.

Table 4.25 St. Anthony Summary of Changes

Return Period [years]	*Percent Change in Precipitation Amount [percent] (Change in Precipitation Amount [mm])*								
	5-min	*10-min*	*15-min*	*30-min*	*1-hr*	*2-hr*	*6-hr*	*12-hr*	*24-hr*
2	N/A	N/A	N/A	N/A	**49.4 (6.2)**	**22.0 (4.0)**	**7.2 (2.2)**	**7.0 (2.8)**	-3.1 (-1.6)
5	N/A	N/A	N/A	N/A	**67.0 (10.4)**	**29.2 (6.3)**	**12.1 (4.4)**	3.4 (1.6)	**-7.3 (-4.6)**
10	N/A	N/A	N/A	N/A	**75.4 (13.2)**	**32.8 (7.9)**	**14.6 (5.9)**	1.5 (0.8)	**-9.3 (-6.6)**
25	N/A	N/A	N/A	N/A	**83.6 (16.8)**	**36.4 (9.9)**	**17.1 (7.8)**	-0.3 (-0.2)	**-11.2 (-9.2)**
50	N/A	N/A	N/A	N/A	**88.5 (19.4)**	**38.5 (11.4)**	**18.7 (9.2)**	-1.4 (-0.9)	**-12.4 (-11.1)**
100	N/A	N/A	N/A	N/A	**92.5 (22.0)**	**40.4 (12.8)**	**20.0 (10.6)**	-2.4 (-1.7)	**-13.4 (-12.9)**

Notes:
Percent change is calculated between the EC IDF curve (V2.3, 2015) for St. Anthony (8403401) and the IDF curve generated using 6-hr and 1-hr precipitation data at St. Anthony (8403399).
Red numbers indicate that the precipitation estimate decreased due to the updated data.
Bold numbers indicate a change of more than 5 percent.
N/A indicates that this duration was not developed at this station.

4.6 No Updating

4.6.1 Battle Harbour LOR

Battle Harbour LOR is located on a small island off the southeastern part of Labrador, approximately 21 km east of Mary's Harbour. The area has significant historical value, as it was a stopover location for ships travelling along the Labrador coast. It has a subarctic climate that has severe winters, no dry season, cool and short summers, and strong seasonality (Köppen-Geiger classification: Dfc). Average total annual precipitation is approximately 950 mm.

The EC IDF curve for Battle Harbour LOR includes data from 1972 to 1983. In 1983, the precipitation monitoring focus for the region was moved to the Mary's Harbour area with the

Mary's Harbour A IDF beginning in 1983. Mary's Harbour is the closest area with precipitation data to Battle Harbour LOR, and its IDF curve was also updated during this project (see Section 4.3.2). Therefore, the IDF curve for Battle Harbour LOR was not updated, and users can reference the updated Mary's Harbour A IDF curve for this region. The stations are listed in Table 4.26 and shown on Figure 4.26.

Table 4.26 Battle Harbour LOR Station Listing

Station Name	*ID*	*Latitude*	*Longitude*	*Elevation [m]*	*Distance to IDF [km]*	*Type of Data*	*Years*
Battle Harbour LOR (IDF)	8500398	52°15'00" N	55°36'00"W	9.4	0.00	5-min	1972-1983
Mary's Harbour	850B5R1	52°18'13" N	55°49'57" W	11.6	21.36	6-hr	1993-2013
Mary's Harbour A	8502591	52°18'13" N	55°50'01" W	10.6	21.46	5-min	1983-1995
Mary's Harbour A	8502591	52°18'13" N	55°50'01" W	10.6	21.46	6-hr	1983-1998
Mary's Harbour A	8502592	52°18'10" N	55°50'52" W	10.6	22.64	1-hr	2014

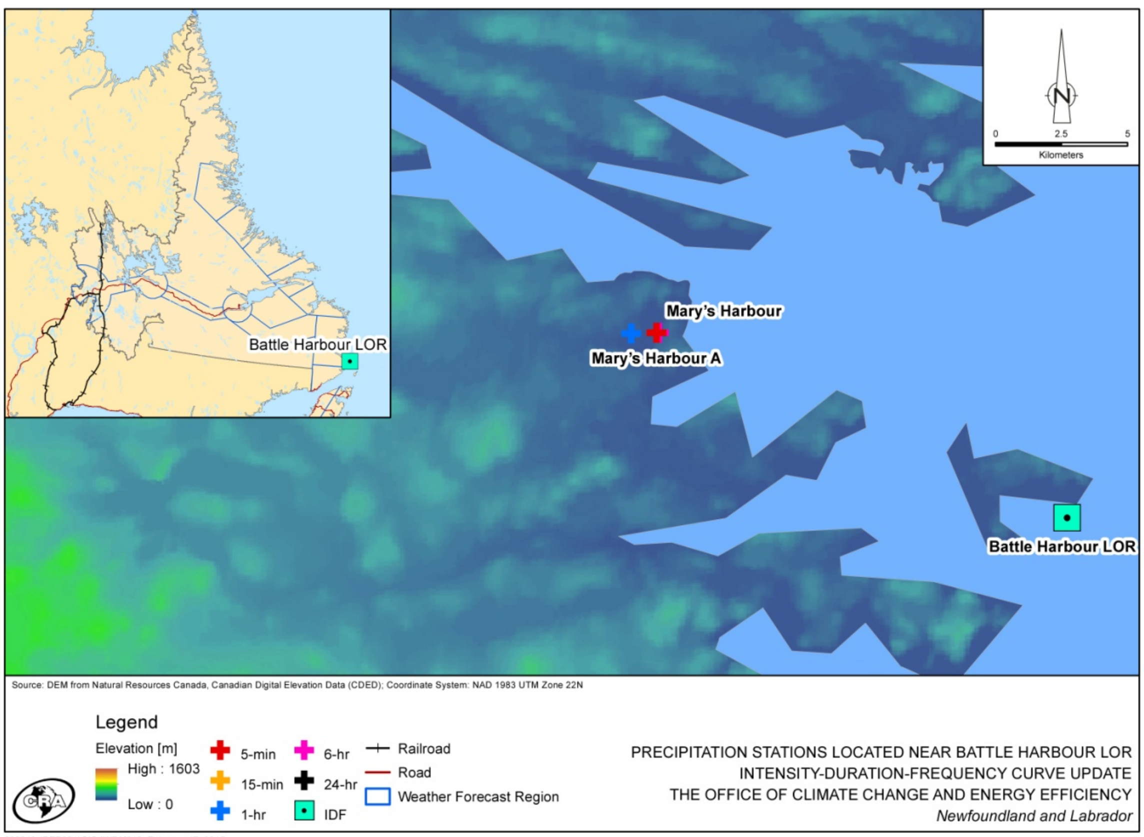

Figure 4.26 Precipitation Stations Located Near Battle Harbour LOR

Section 5.0 Future Climate IDF Curves

5.1 Overview

The main assumption in the development and application of IDF curves is that the historical precipitation records are stationary and as such can be used to represent future climate conditions. However, this assumption is justifiably questionable under changing climate conditions. Consequently, IDF curves that rely only on historical observations will likely misrepresent future climate conditions (Srivastav et al., 2015; Sugahara et al., 2009).

Canada's climate has warmed significantly over the past century. Due to its high latitude, Canada has experienced greater rates of warming than other regions of the world. According to Lemmen et al. (2008), an increase of 1.3°C in mean air temperature has been observed in Canada from 1948 to 2006. Projections of future climate indicate that air temperatures will continue to rise throughout the 21st century (IPCC, 2013).

In Newfoundland and Labrador, the increase in air temperature is predicted to be most pronounced in winter and smaller in summer and autumn. By the mid-21st century, air temperatures are expected to rise by 2-3°C in Newfoundland and by 3-4°C in Labrador (relative to the 20th century mean). Air temperature changes will vary strongly with latitude, potentially increasing to 4-6°C in northern Labrador (relative to the 20th century mean). Seasonal differences in projected changes are expected to be generally smaller in Newfoundland than Labrador due to the moderating influence of the ocean on Newfoundland (Finnis, 2013).

Increased concentrations of greenhouse gases (GHGs) will not only increase air temperatures, but also evaporation, which in turn will enhance the atmospheric moisture content, and consequently, extreme precipitation rates (Trenberth, 1999). According to IPCC (2013), heavy precipitation events are expected to increase both in frequency and intensity under changing climate conditions. The return period of extreme precipitation events could be reduced by a factor of two or more by the end of this century (Kharin et al., 2007).

Given the coarse spatial and temporal resolution of GCM outputs, predictions of future climate IDF curves are typically derived for daily or sub-daily (6- and 12-hr) durations only. Lines et al. (2009) used the Statistical Downscaling Model (SDSM) to downscale total daily precipitation amounts from the Canadian Coupled General Circulation Model version 2 (CGCM2) and the Hadley Research Center's Hadley Climate Model version 3 (HadCM3) running the SRES emission scenario experiment B2 for 14 weather stations in Atlantic Canada. For the stations located in Newfoundland and Labrador the authors found that the extreme 24-hour precipitation amounts for the return periods of 10, 50, and 100 years increased by 9 to 31 percent (largest increase was observed for the 2050s time horizon).

Finnis (2013) derived 6-, 12-, and 24-hr IDF projections for Newfoundland and Labrador from an ensemble of seven regional climate model (RCM) simulations produced for the North American Regional Climate Change Assessment Project (NARCCAP) for the 2038-2070 time horizon. The projected mean increase ranged from 1 to 37 percent for the 6-hr precipitation totals, 4 to 24 percent for the 12-hr precipitation totals, and 4 to 19 percent for the 24-hr precipitation totals. There was a very large variability observed among different model results, ranging from -40 to +70 percent for the 6-hr duration, -32 to +50 percent for the 12-hr duration, and -23 percent to +53 percent for the 24-hr duration. In many regions of Newfoundland and Labrador the current 100-year event was projected to become the 50-year event by the mid-21st century.

The increasing extreme precipitation trends predicted by GCMs and RCMs are not captured in historical records unequivocally. Vincent and Mekis (2006) and Mekis and Vincent (2011) evaluated changes in daily precipitation extremes in Canada and found a significant increase in the number of days with precipitation, but no conclusive evidence of consistent changes in extreme precipitation amounts. Other studies have confirmed that there are more stations with increasing trends than stations with decreasing trends; however, most of these changes were not statistically significant (Hogg and Hogg, 2010; Mailhot and Talbot, 2011; Shephard et al., 2014).

There are several possible reasons for the lack of consistent evidence of climate change in the historical data. CSA (2012) suggests that the lack of density in EC's precipitation network may be one of the reasons for non-consistent, non-significant patterns of changes in daily precipitation extremes across the country. There may just not be sufficient number of stations to enable patterns to be identified. The trend analysis in this report followed the EC methodology for trend analysis, and was performed using only the annual maximum precipitation of each year. However, there may be two or more significant precipitation events in one year. A Partial Duration Series (PDS) analysis selects all events with precipitation greater than a certain threshold. A trend analysis performed using the PDS may provide more consistent evidence of climate change. Finally, the IDF curve record lengths are often short (10-20 years). More reliable and accurate trend estimates are obtained when there are long record lengths (at least 30 years).

5.2 Derivation of Future Climate IDFs

Currently, there is no standard or accepted methodology to derive IDF curves for future climate conditions. However, several approaches have been developed in recent years for predicting changes in extreme precipitation resulting from climate change. CSA (2012) provides a review of recent approaches that are potentially applicable to the development of future climate IDF curves. These approaches have been expanded in this report with other approaches found in literature. A brief summary is provided below:

- **Extrapolation of Trends in Precipitation Data**. Trends identified in the time series of annual maximum rainfall intensities/amounts are extrapolated into the future. The main limitation of this approach is the assumption that current trends in rainfall intensity will remain the same in the future (Denault et al., 2006).
- **Use of Upper Confidence Intervals of Current Climate IDF Curves**. Confidence intervals account for estimation of uncertainty due to sampling variability. This uncertainty can be used as an approximation to account for potential uncertainty due to climate change (Wang and McBean, 2013). The main limitation of this approach is that the prediction cannot be attributed to a specific future time horizon.
- **Non-stationary Frequency Analysis**. This method has mainly been developing for flood frequency analysis; however, the principles are also fully applicable to rainfall frequency analysis. This technique is basically an extension of trend extrapolation which assumes the mean of the series is non-stationary; in non-stationary frequency analysis all parameters of the distribution function can be assumed to be non-stationary (Vasiliades et al., 2015; Cheng and AghaKouchak, 2014; Tramblay et al., 2013).
- **Direct Interpretation of GCM/RCM Outputs**. GCM produce gridded outputs with spatial scales ranging from 100 to 500 km and daily temporal scales. RCM outputs have higher spatial and temporal resolutions but are forced by GCMs and there are fewer runs of RCMs available. The main limitation is that rainfall durations shorter than the time step of the GCMs/RCMs are not captured by the models and hence cannot be analyzed.
- **Delta Approach (scale factors)**. GCM or RCM projected changes in longer-term precipitation (annual, monthly, daily) are applied to short-term precipitation (sub-daily). The main limitation is that this approach assumes that the changes in short-term rainfall will increase at the same rate as the longer-term rainfall. As CSA (2012) states, "changes in the atmospheric processes governing rainfall production will not likely be uniform for short to long time durations", which is supported by recent trends in regional precipitation (IPCC, 2007). Examples of studies utilizing this approach conducted in Atlantic Canada include CCPE (2008) and ACASA (2011).
- **Statistical Modelling**. Several approaches fall under this category, including statistical downscaling (SDSM, see Coulibaly and Shi, 2005), regional frequency analysis applied to RCM outputs (Mailhot et al., 2006, 2007), and statistical models relating parameters of historical IDF probability distribution functions to GCM/RCM precipitation distribution functions (Schardong et al., 2015; Srivastav et al., 2015). Common limitations include assumptions of stationarity in the scaling approaches and statistical relationships linking historical and predicted extreme rainfall intensities.

- **Stochastic Modelling**. Unlike the previous approaches, stochastic weather generators (e.g., K-nn weather generator, Prodanovic and Simonovic, 2008) generate time series of new precipitation data (rainfall events that were previously not observed in historical observations). Weather generators are conditioned on large-scale weather variables from GCMs. The main limitation includes the assumption of stationarity in the scaling approaches inherent in a weather generator methodology (CSA, 2012).

Each of the approaches summarized above has its own strengths and weaknesses. The approaches differ in their levels of complexity, data requirements, ease of use, and cost of implementation, among other factors. Regardless of which approach is used, some of the common challenges of future climate IDF modelling include:

- Projected future increases in extreme precipitation are not supported by historical observations. This may result from monitoring networks having inadequate densities for capturing the variability/change in extreme precipitation events.
- Most current approaches are based on GCM predictions and thus are limited by the accuracy of the GCMs. The spatial and temporal resolution of GCMs is particularly inadequate for capturing localized short-term extreme precipitation events. Indeed, recent studies have revealed underestimation of precipitation extremes by GCMs (see e.g., Allan and Soden, 2008; Min et al., 2011).
- There are many uncertainties involved in projecting future climate. The main uncertainties include climate modelling (representation of atmospheric processes, model resolution, downscaling, etc.), climate scenarios (future GHG emissions, population, global economy, etc.), and natural climate variability (low frequency oscillations, ocean-atmosphere interactions, etc.).
- Uncertainties in future climate modeling result in a large variation in projected changes. Available GCM projections agree that air temperature will increase in North America. However, projections of future precipitation from different models are more variable; in some regions model projections disagree on both the sign and magnitude of the changes (ACASA, 2011).
- There are many studies describing anticipated changes in future climate and their potential impacts on socioeconomic activities and the environment. However, there is a lack of benchmark studies evaluating various approaches for deriving future climate projections. There is also a lack of studies focusing on practical implementation of the findings.

For the reasons summarized above, the existing approaches for predicting changes in extreme precipitation in the future are "not ready" for practical (design) implementation.

5.3 Approach

A statistical modelling approach that relates parameters of historical IDF probability distribution functions to GCM projected precipitation distribution functions was selected for the purposes of this project. The main reason for selecting this approach was that it allows the development of IDF curves for all rainfall durations and can be based on predictions from many different GCMs. The modelling utilized a new tool (IDF_CC) developed at the University of Western Ontario (Schardong et al., 2015).

The IDF_CC tool fits the Gumbel distribution to annual maximum intensities using the method of moments. The Equidistant Quantile Matching (EQM) algorithm is applied to the IDF updating procedure (Srivastav et al., 2014). This algorithm captures the distribution of changes between the projected time period and the baseline period (temporal downscaling) in addition to spatial downscaling of the annual maximum precipitation (AMP) derived from the GCM data. In EQM, quantile-mapping functions are directly applied to annual maximum precipitation to establish the statistical relationships between the AMP of GCM and sub-daily observed (historical) data (Srivastav et al., 2015).

The IDF_CC tool includes projections from 22 different GCMs. In order to reduce uncertainty due to choice of the GCMs, the tool applies a skill score algorithm to rank the GCMs provided in the tool. The IDF_CC tool adopts a skill score based on quantile regression (QRSS) proposed by Srivastav et al. (2015). Table 5.1 lists the GCMs together with the names of the climate research centres where they are developed.

Table 5.1 Global Circulation Models Available in the IDF_CC Tool

GCM	*Climate Research Centre*	*Country*
bcc_csm1_1	Beijing Climate Center, China Meteorological Administration	China
bcc_csm1_1 m	Beijing Climate Center, China Meteorological Administration	China
BNU-ESM	College of Global Change and Earth System Science	China
CanESM2	Canadian Centre for Climate Modeling and Analysis	Canada
CCSM4	National Center of Atmospheric Research	USA
CNRM-CM5	Centre National de Recherches Météorologiques and Centre Européen de Recherches et de Formation Avancée en Calcul Scientifique	France
CSIRO-Mk3-6-0	Australian Commonwealth Scientific and Industrial Research Organization in collaboration with the Queensland Climate Change Centre of Excellence	Australia
CESM1-CAM5	National Center of Atmospheric Research	USA
FGOALS_g2	IAP (Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing, China) and THU (Tsinghua University)	China
GFDL-CM3	National Oceanic and Atmospheric Administration's Geophysical Fluid Dynamic Laboratory	USA
GFDL-ESM2G	National Oceanic and Atmospheric Administration's Geophysical Fluid Dynamic Laboratory	USA
HadGEM2-AO	Met Office Hadley Centre	United Kingdom
HadGEM2-ES	Met Office Hadley Centre	United Kingdom
IPSL-CM5A-LR	Institut Pierre Simon Laplace	France
IPSL-CM5A-MR	Institut Pierre Simon Laplace	France
MIROC5	Japan Agency for Marine-Earth Science and Technology	Japan
MIROC-ESM	Japan Agency for Marine-Earth Science and Technology	Japan
MIROC-ESM-CHEM	Japan Agency for Marine-Earth Science and Technology	Japan
MPI-ESM-LR	Max Planck Institute for Meteorology	Germany

GCM	*Climate Research Centre*	*Country*
MPI-ESM-MR	Max Planck Institute for Meteorology	Germany
MRI-CGCM3	Meteorological Research Institute	Japan
NorESM1-M	Norwegian Climate Center	Norway

Using an ensemble of climate models and scenarios is recommended when projecting future rainfall information (CSA, 2012). According to the Canadian Climate Change Scenarios Network (CCCSN) the use of an ensemble approach (multi-model means/medians) provides the best projected climate change signal (CCCSN, 2013). Consequently, in this study, rather than ranking and using individual GCMs, an ensemble mean projection was constructed from the individual GCMs. The IDF_CC tool calculates ensemble projections using all 22 GCMs summarized in Table 5.1. The individual model projections were not weighted in the construction of an ensemble and the ensemble was calculated as the median value in the IDF_CC tool.

One of the main advantages of IDF_CC is that it is based on the IPCC 5 (IPCC, 2013) future climate scenarios for various representative concentration pathways (RCPs). RCPs are the latest generation of scenarios that provide input to climate models. They are based on projections of GHG concentrations as well as land use and land cover factors (Moss et al., 2008). Each RCP defines a specific emissions trajectory and subsequent radiative forcing (change in the balance between incoming and outgoing radiation to the atmosphere caused primarily by changes in atmospheric composition). There are three RCP scenarios included in the IDF_CC tool:

- RCP 2.6: Pathway where radiative forcing peaks at 3 W/m^2 by mid-century and then returns to 2.6 W/m^2 by 2100
- RCP 4.5: Intermediate stabilization pathway in which radiative forcing is stabilized at 4.5 W/m^2 shortly after 2100
- RCP 8.5: High pathway with radiative forcing greater than 8.5 W/m^2 by 2100 and continues to rise in the future

RCP 2.6 represents a low emission scenario that assumes strict policy changes and reduction of GHG emissions in the near future. RCP 8.5 is the worst-case, high emission scenario that assumes a future with no policy changes to reduce emissions. Finally, RCP 4.5 is the 'middle of the road' scenario that assumes some emission reductions in the future.

The RCP 4.5 scenario was selected for this study as it represents the most likely future scenario. The IDF curves were calculated for the RCP 4.5 scenario for three time horizons: 2011-2040 (2020s), 2041-2070 (2050s), and 2071-2100 (2080s). The historical period 1900-2005 was used as the baseline period.

The future IDF curves were generated for the IDF curves updated in this study. In addition, the remaining IDF curves that were updated by EC were also included in the analysis to provide complete projections for all IDF curves available in the Province.

5.4 Results

Future climate IDFs were derived for the RCP 4.5 scenario for three time horizons (2020s, 2050s, and 2080s). Appendix D provides the individual IDF estimates for all 19 IDF stations in the Province. The two new IDF stations established in this project (St. Anthony and Twillingate) were not analyzed as they have incomplete IDF curves at this point (short duration intensities are not yet available). The discontinued (but complete) EC IDF stations St. Anthony (8403401) and Comfort Cove (8401259) were analyzed instead. In summary, the analysis included 11 IDF curves updated in this study and eight IDF curves updated by EC.

Figure 5.1 depicts the 19 stations ranked according to the average increase of rainfall amounts calculated from all IDF durations and return periods. The average increase of rainfall amounts ranged from:

- 5 percent (Gander Airport CS) to 20 percent (Argentia) for the 2020s time horizon
- 12 percent (Gander Airport CS) to 31 percent (Argentia) for the 2050s time horizon
- 14 percent (Gander Airport CS) to 33 percent (Daniels Harbour) for the 2080s time horizon

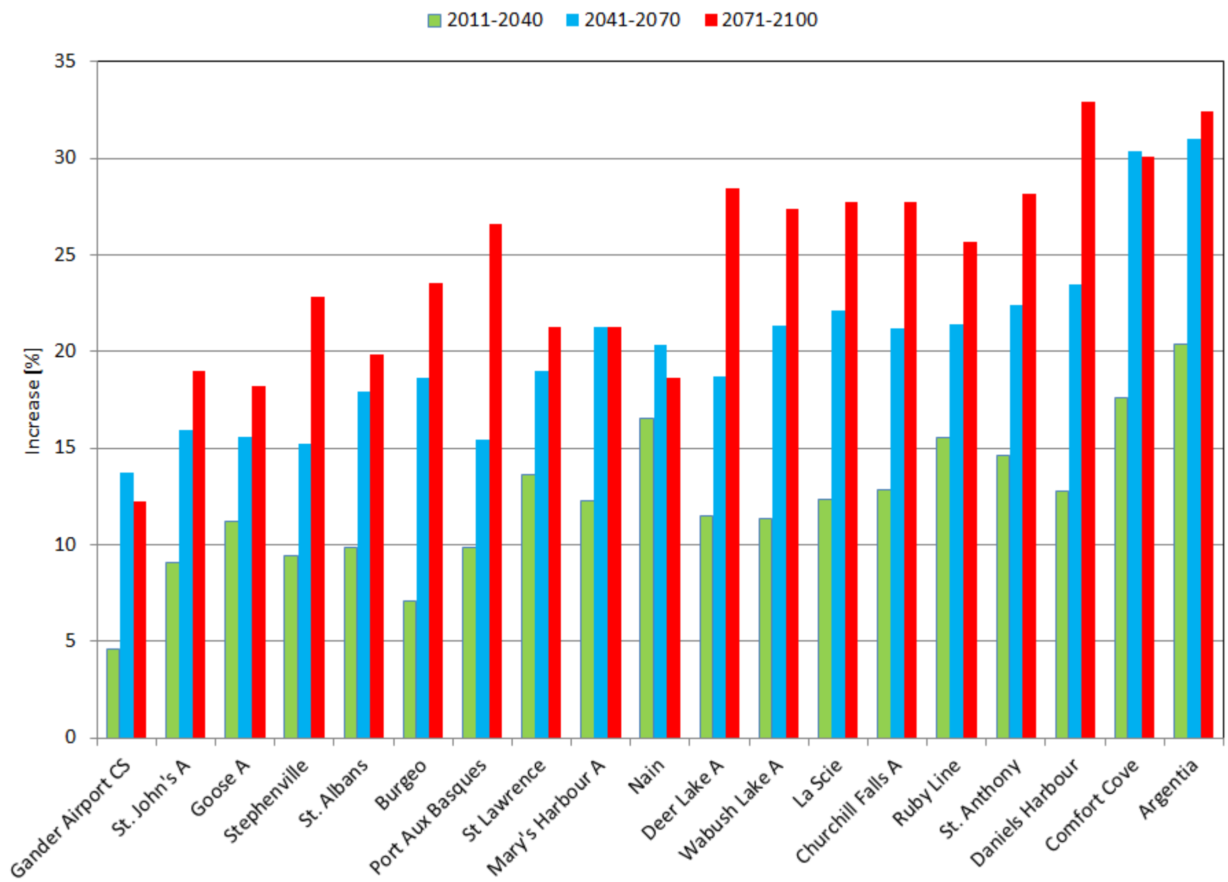

Figure 5.1 Average Increase of IDF Rainfall Amounts at Analyzed Stations

There is no apparent regional trend in the distribution of projected precipitation increases in the Province; IDF stations with the highest/lowest increases are not grouped in any particular geographic areas. Also, there is no apparent difference in projected precipitation increases for stations located in Labrador versus stations located in Newfoundland.

Precipitation amounts for the 25-, 50-, and 100-year return periods were compared for the existing and future IDF curves. It was found that the current 100-year return period will become the 50-year return period for all precipitation durations at 10 of the analyzed stations in the 2020s. Another six stations will have the 100-year return periods become the 50-year events at some of the durations in the 2020s. At three stations (Burgeo, Gander Airport CS, and Wabush Lake A), the future 50-year precipitation amounts will not exceed the current 100-year amounts.

The situation is predicted to be more dramatic in the 2080s when current 100-year return period will become the 25-year return period for all precipitation durations at 13 of the analyzed stations. Another three stations will have the 100-year return periods become the

25-year events at some of the durations in the 2080s. At three stations (Gander Airport CS, Goose A, and Nain), the future 25-year precipitation amounts will not exceed the current 100-year amounts in the 2080s time horizon.

Figure 5.2 shows the average increase of IDF rainfall amounts in the Province for different rainfall durations. The results suggest that the shortest duration rainfall amounts/intensities will increase more than the longer duration rainfall amounts/intensities. This is in good accordance with findings from other studies (see e.g., CSA, 2012). The results presented on Figure 5.2 also suggest that the differences in projected changes for the short and long duration intensities will become more pronounced in the later time horizons (the difference between 5 min and 24 hour increases is only 3 percent in the 2020s, 5 percent in the 2050s, and 7 percent in the 2080s).

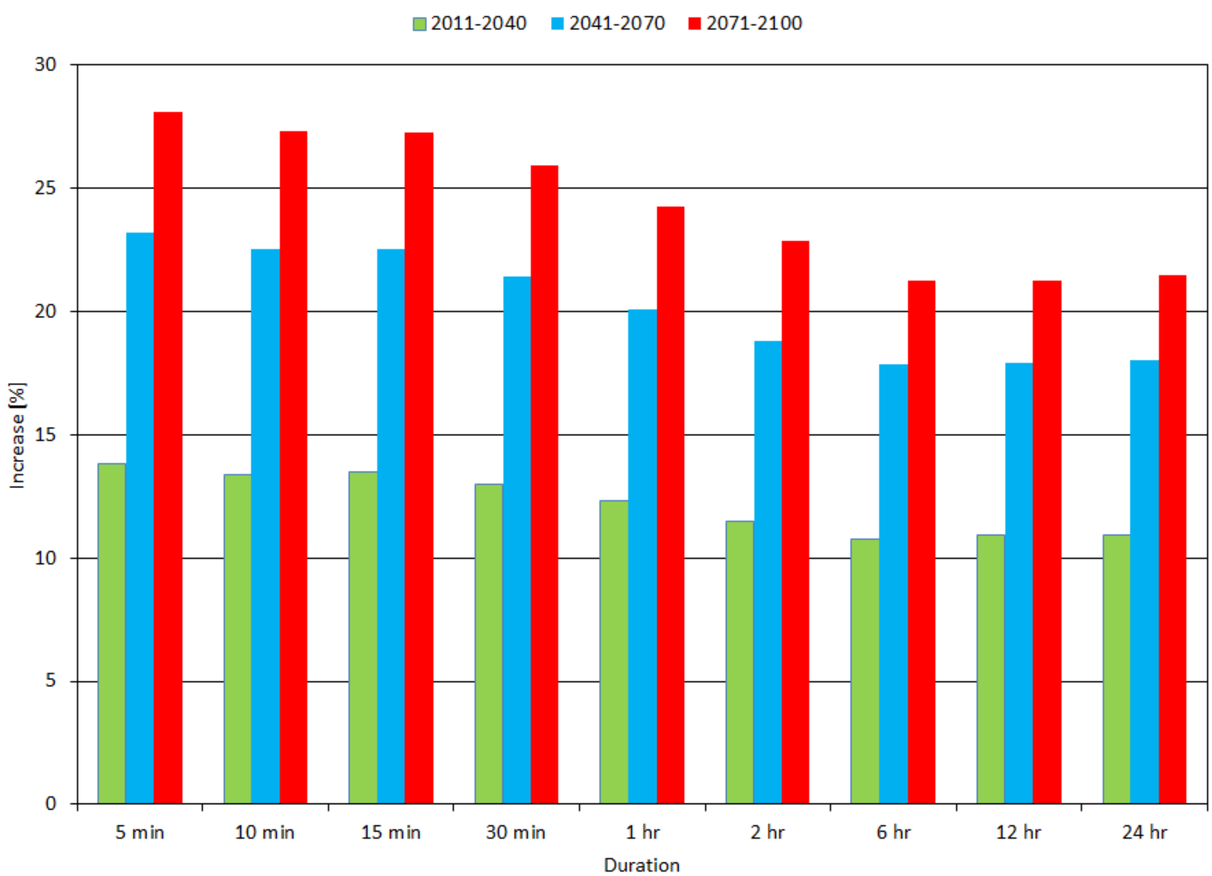

Figure 5.2 Average Increase of IDF Rainfall Amounts for Different Rainfall Durations

Figure 5.3 depicts the average increase of IDF rainfall amounts in the Province for different rainfall return periods. A pattern similar to the one for the rainfall durations (Figure 5.2) is observed. The results show that the small return period events will increase more than the large return period events. The differences in projected changes for the small and large return period events however will only slightly increase in the later time horizons (the differences between 2-year and 100-year return period increases is 3 percent in the 2020s and 2050s, and 4 percent in the 2080s).

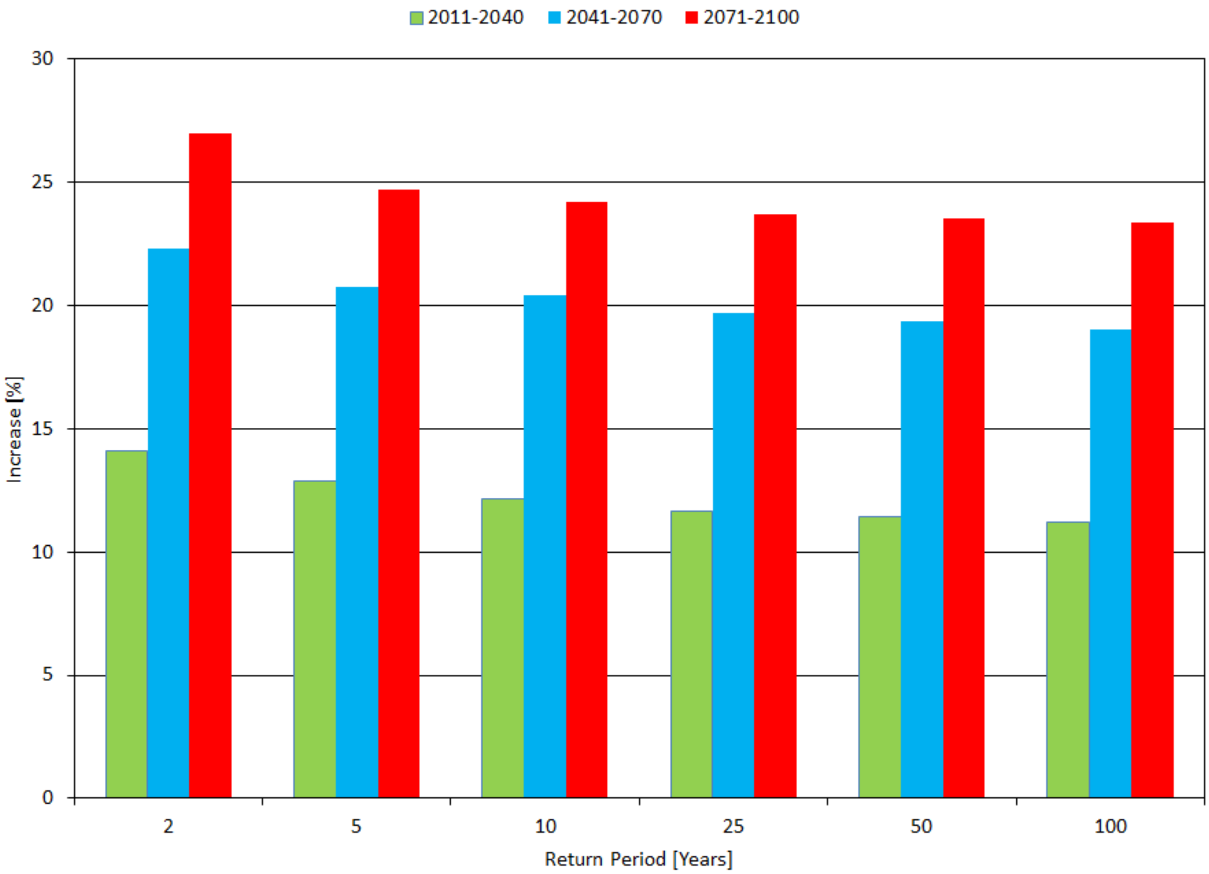

Figure 5.3 Average Increase of IDF Rainfall Amounts for Different Rainfall Return Periods

The average increase of rainfall amounts in the Province calculated from all durations and return periods for the three time horizons is:

- 2011-2040: 12 percent increase
- 2041-2070: 20 percent increase
- 2071-2100: 24 percent increase

It is noted that the predicted increases of rainfall amounts/intensities correspond well with results reported in other studies, particularly Lines et al. (2009) who reported an increase of 9 to 31 percent for 24-hour precipitation amounts in the 2050s, and Finnis (2013) who reported an increase of 1 to 37 percent for 6-hour precipitation, 4 to 24 percent for 12-hour precipitation, and 4 to 19 percent for 24-hour precipitation in the 2050s.

Differences in reported projections can be attributed to a number of factors such as data sets used in the analysis, downscaling of GCM projections, type of GCMs, methodology for deriving future climate IDFs, and emission scenarios. The future climate IDF projections derived in this report are recommended for the following reasons.

- A complete set of IDF curves is available (all rainfall durations from 5 minutes to 24 hours).
- The IDF projections are available for three main future time horizons (2011-2040, 2041-2070, and 2071-2100).
- The IDF curves were constructed using the recommended ensemble modelling approach utilizing projections from 22 different GCMs.
- Latest IPCC emission scenarios (AR5) were used for deriving the future IDFs.
- The analysis was undertaken with the IDF_CC tool - a new methodology developed specifically for deriving future climate IDFs in Canada.

Section 6.0 Conclusions

In this study, 12 of the 13 IDF curves generated from inactive EC TBRG stations were updated. In addition, a new IDF curve for the southwestern part of St. John's was developed (Ruby Line). Due to the sparse precipitation monitoring network in Newfoundland and Labrador, not all durations were updated at all stations. Table 6.1 provides a summary of the durations that were updated for each station. The table also includes notes about potential future curves, where appropriate. There were six stations where only the 6-, 12-, and 24-hr durations were updated, due to a lack of hourly/sub-hourly data in the nearby vicinity of the station. However, five of these stations have the potential for future curves/newer data that will allow at least the durations from 1-hr to 24-hr to be developed/updated.

Table 6.1 Summary of Durations Updated for Each Station

Station Name	***Data Availability Case***	***Durations Updated***	***Notes***
Daniels Harbour	Case 1	6-hr, 12-hr, 24-hr	
Gander Airport CS	Case 1	All durations	
La Scie	Case 1	1-hr, 2-hr, 6-hr, 12-hr, 24-hr	
Port Aux Basques	Case 1	6-hr, 12-hr, 24-hr	Future: new curve at Wreckhouse
Wabush Lake A	Case 1	6-hr, 12-hr, 24-hr	Future: 1-hr data being collected at Wabush A (8504177)
Deer Lake A	Case 1 and 2	6-hr, 12-hr, 24-hr	Future: new curve at Cormack RCS, Hinds Lake Control and/or Humber River near Humber Village Bridge
Churchill Falls A	Case 2	6-hr, 12-hr, 24-hr	Future: 1-hr data being collected at Churchill Falls A (8501132)
Mary's Harbour A	Case 2	1-hr, 2-hr, 6-hr, 12-hr, 24-hr	
St. John's A	Case 2	All durations	
Ruby Line	Case 2	All durations	
St. Albans	Case 3	6-hr, 12-hr, 24-hr	Future: new curve at Long Pond Intake
Comfort Cove	Case 4	1-hr, 2-hr, 6-hr, 12-hr, 24-hr	New Curve at Twillingate (AUT)
St. Anthony	Case 4	1-hr, 2-hr, 6-hr, 12-hr, 24-hr	New Curve at St. Anthony (8403399)
Battle Harbour LOR	N/A	N/A	No nearby data

The EC methodology for IDF curve generation was used, resulting in some of the IDF curves decreasing from the EC IDF curves (V2.3). Since it is not expected that IDF curves will decrease in the future climate, users are cautioned to use the updated IDF curves with care or to use the EC IDF curves whenever the updated IDF curves decreased from the EC IDF curves.

The differences between the updated IDF curves and the EC IDF curves (V2.3) were found for each station. Table 6.2 shows the direction of change for each duration. An upwards arrow indicates that the updated IDF curves were greater than the EC IDF curves. The arrow is coloured red if the change was greater than 5 percent. The stations are listed in the following order: stations in northeast Newfoundland, stations in southwest Newfoundland, and stations in Labrador. Figure 6.1 shows the direction of change for the durations of 1-hr and longer for each station on a map. The directions of change for the 5- to 30-min durations were not included in the Figure because they were only updated for three stations.

The changes between the updated IDF curves and the EC IDF curves (V2.3) followed a regional pattern. For the island of Newfoundland, the northeast stations generally increased for the durations of 1-hr and longer and the southwest stations in Newfoundland generally decreased for the durations of 1-hr and longer. The La Scie IDF curve was an exception to this pattern. However, only two or three years of data were added to this station, which may have impacted the results. The stations in Labrador generally increased for the durations of 1-hr and longer. The Labrador stations are more continental in their weather patterns. If these regional weather patterns continue, then the IDF curves for Labrador and northeast Newfoundland may under-represent the precipitation in a few years.

The regional pattern generally follows the weather patterns in Newfoundland; in the past decade, there have been several major storms that strongly affected the eastern part of Newfoundland. These were extra-tropical storms (moving in from the Atlantic), and there were large precipitation amounts for the durations of 1-hr and longer. Therefore, it was to be expected that the eastern stations would show increases in precipitation.

Table 6.2 Summary of Changes from EC IDF V2.3 Curves

Station Name	***Direction of Change***								
	5-min	***10-min***	***15-min***	***30-min***	***1-hr***	***2-hr***	***6-hr***	***12-hr***	***24-hr***
Gander Airport CS	↗	↗	↗	↗	↗	↗	↗	↗	↗
La Scie	-	-	-	-	↘	↘	↘	↘	↗
St. John's A	↘	↘	↘	↗	↗	↗	↗	↗	↗
Ruby Line	↘	↘	↘	↘	↗	↗	↗	↗	↗
St. Anthony	-	-	-	-	↗	↗	↗	both	↘
Twillingate (AUT)	-	-	-	-	both	↗	both	↗	↗
Deer Lake A	-	-	-	-	-	-	↘	↗	↗
Daniels Harbour	-	-	-	-	-	-	↘	↘	↘
Port Aux Basques	-	-	-	-	-	-	↘	↘	↘
St. Albans	-	-	-	-	-	-	↘	↘	↘
Churchill Falls A	-	-	-	-	-	-	↗	↗	↗
Mary's Harbour A	-	-	-	-	↗	↗	↗	↗	↘
Wabush Lake A	-	-	-	-	-	-	↗	↗	↗

Notes:
Red arrows indicate that at least one of the return periods for that duration changed by more than 5 percent.
Both indicates that the change was in both directions (three return periods increased, three return periods decreased) for this duration

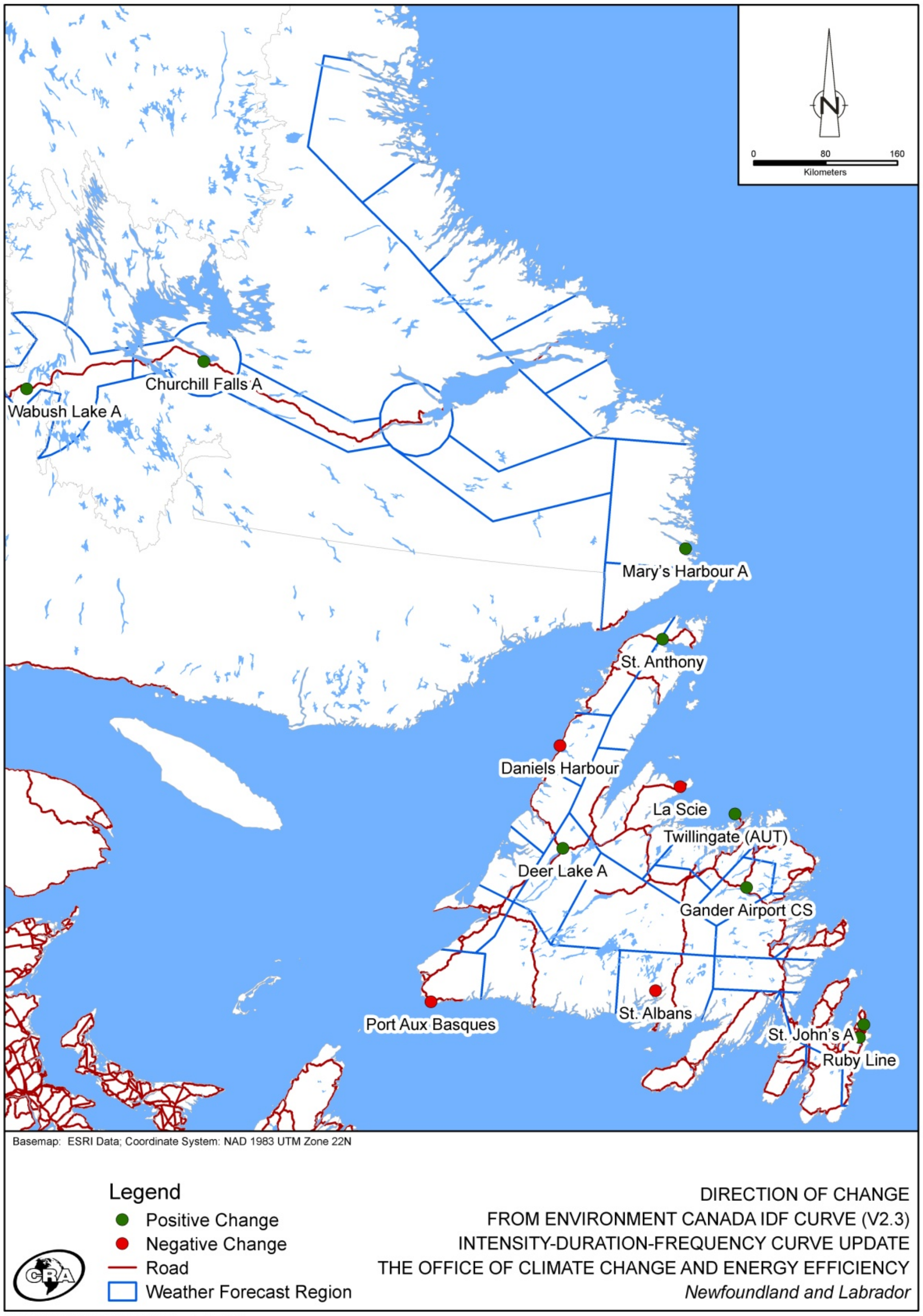

Figure 6.1 Direction of Change from Environment Canada IDF Curve (V2.3)

The EC trend test was used to determine the magnitude, direction, and statistical significance of long-term trends in the precipitation annual maxima. EC introduced this test to determine if there is evidence of consistent trends (increases/decreases) in the extreme precipitation. This test was applied to the precipitation data for the updated IDF curves. Table 6.3 provides a summary of the slopes of the trend lines for each duration for each IDF curve. Note that the six EC IDF curves have been added to this table, so that the complete regional picture may be seen. The stations are listed in the following order: stations in northeast Newfoundland, stations in southwest Newfoundland, and stations in Labrador. The regional trend pattern is less obvious than the regional change pattern discussed above. Some of the northeast stations in Newfoundland have positive trends for the durations of 1-hr and longer, and some are statistically significant. The rest of the regions in Newfoundland and Labrador show some positive trends and some negative trends. There are very few statistically significant trends.

Table 6.3 Summary of Trends in IDF Curves

Station Name	*Direction of Change*								
	5-min	*10-min*	*15-min*	*30-min*	*1-hr*	*2-hr*	*6-hr*	*12-hr*	*24-hr*
Argentia (AUT)	-0.07	-0.16	-0.17	-0.10	0.03	-0.15	-0.20	-0.27	-0.38
Gander Airport CS	0.01	0.00	0.00	0.01	0.05	0.09	0.20	0.27	0.35
La Scie	0.09	0.23	0.47	0.80	0.06	-0.07	-0.18	-0.32	0.62
St. John's A	-0.01	0.01	0.03	0.07	0.14	0.24	0.32	0.23	0.34
Ruby Line	0.02	0.08	0.07	-0.05	-0.04	0.11	-0.30	-0.80	-0.81
St. Anthony	-	-	-	-	-0.65	-0.28	-0.85	0.09	-0.07
Twillingate (AUT)	-	-	-	-	-0.16	0.00	0.98	1.27	0.72
Deer Lake A	0.00	0.01	0.02	0.07	0.08	0.16	-0.05	0.13	0.13
Burgeo	-0.01	0.00	0.04	0.01	-0.05	-0.10	-0.21	-0.19	-0.22
Daniels Harbour	0.01	0.03	0.05	0.11	0.11	0.08	-0.11	0.05	0.17
Port Aux Basques	0.00	0.02	0.01	0.09	0.13	-0.17	-0.30	-0.56	-0.37
St. Albans	-0.04	-0.04	-0.01	-0.21	0.03	-0.36	-0.09	-0.12	0.07
St. Lawrence	0.02	0.00	0.06	0.14	0.22	0.25	0.04	0.03	0.19
Stephenville A	0.03	0.02	0.04	0.10	0.11	0.12	0.21	0.15	0.01
Churchill Falls A	0.04	-0.05	-0.05	0.09	0.09	0.00	-0.05	0.06	0.07
Goose A	0.00	0.01	0.01	0.01	0.02	0.03	0.00	-0.05	-0.02
Mary's Harbour A	-0.14	-0.02	0.05	0.11	0.04	0.26	0.07	0.24	0.31
Nain	0.00	-0.04	-0.01	0.08	0.05	0.00	0.02	-0.24	-0.16
Wabush Lake A	0.00	0.00	-0.01	-0.12	-0.19	-0.36	0.00	-0.11	-0.12

Notes:
Red numbers indicate that the trend is statistically significant at the 5 percent level of significance and positive.
Blue numbers indicate that the trend is statistically significant at the 5 percent level of significance and negative.

Shephard et al. (2014) performed a trend analysis using the EC IDF curves, and found that 4 percent of IDF stations showed a significant positive trend and 1.6 percent showed a significant negative trend. Regionally, the Atlantic Provinces showed a decrease for the 5- to 15-min duration rainfall, and an increase for the 1- and 2-hr duration rainfall (1- to 2-hr). Shephard et al. (2014) stated that the historical data do not show conclusive evidence of climate change at this time. Other authors (Hogg and Hogg, 2010; Mailhot and Talbot, 2011) have performed similar analyses, and have also concluded that there is no conclusive evidence of climate change in the historical data. For the updated IDF curves completed as part of this project, there is no conclusive evidence of trends in the data.

There are several possible reasons for the lack of consistent evidence of climate change in the historical data. The trend analysis was performed on the annual maxima, and therefore does not account for multiple extreme precipitation events occurring during the same year. There is some evidence that the number of days with precipitation has increased even though the daily totals have not increased (Vincent and Mekis, 2006; Mekis and Vincent, 2011). The record length for a trend analysis based on IDF curves is often only 10 to 20 years long, which is not long enough for trend analysis (it is recommended that at least 30 years of data be used). Finally, CSA (2012) has suggested that the lack of density in EC's precipitation network may be another reason for non-consistent, non-significant trends in daily precipitation extremes across the country, as there are not enough stations to allow patterns to be discerned.

Although there was no conclusive evidence of climate change in the data according to the trend analysis, there was a strong regional pattern in the sign of the changes from the EC IDF curves (V2.3) to the updated IDF curves. The EC IDF curves (V2.3) in Labrador and in the northeast part of Newfoundland in particular were out-of-date (the precipitation amounts were too low). A large number of the changes were greater than 5 percent. Therefore, even where there is no significant trend in the data, regular updates of IDF curves must be performed to ensure that the natural variability in the climate is captured and to utilize a longer climatic dataset so that a more accurate estimation of the IDF curves is obtained. Environment Canada performs an IDF curve update every three years. A lower updating frequency (five years) is acceptable currently, as there is little evidence of consistent trends in precipitation extremes. However, if statistically significant trends are identified in the Province, it may be necessary to increase the frequency of IDF updates to three years.

The future climate IDF curves were generated with the IDF_CC tool. The RCP 4.5 scenario was used to develop the curves for three time horizons (2011-2040, 2041-2070, and 2071-2100). The projected average increase in precipitation amount was 12 percent for 2011-2040, 20 percent for 2041-2070, and 24 percent for 2071-2100. There was no regional pattern visible in the amount of increase at each station; all stations increased by similar amounts. For most stations, the 100-year return period precipitation amount was projected to become the 50-year return period precipitation amount by mid-century and become the 25-year return period precipitation amount by the end of the century. The shortest rainfall durations are projected to increase more than the longer durations. The smaller rainfall return periods are projected to increase more than the longer return periods.

The future climate change projections were in a similar range as those reported by other authors (Lines et al., 2009; Finnis, 2013). However, the future climate IDF projections derived in this report have several advantages over previous studies. The IDF_CC tool used in this report allowed future climate IDF projections for all rainfall durations from 5-min to 24-hr, for three time horizons. The RCP 4.5 emission scenario used in this study came from the latest IPCC report (AR5) and therefore represents the most up-to-date methodology for future climate change predictions. The future climate IDF curves were generated from an ensemble of 22 GCMs, which is the recommended approach. Finally, the methodology used in this analysis (the IDF_CC tool) was developed specifically for deriving future climate IDFs in Canada.

Section 7.0 Recommendations

This project has identified gaps in IDF curve coverage for the Province of Newfoundland and Labrador. The recommendations to address these gaps are detailed below.

1. **Enhance the precipitation intensity monitoring network in the Province.** There were several stations that could only be updated for the 6-, 12-, and 24-hr durations. While a partial update is useful for planning, 6-hr data are not optimal for use in IDF curve preparation. Therefore, it would be beneficial to strategically place the precipitation intensity monitoring in the areas where it is needed the most, installing automated 5-min, 15-min, and/or 1-hr weighing gauges (preferably 5-min or 15-min) so that more data are available for future IDF curve updates. In particular, Daniels Harbour, Deer Lake A, Port Aux Basques, and St. Albans do not have any short duration (1-hr or less) precipitation monitoring. There are short duration EC stations near Deer Lake A and Port Aux Basques, but it will be several years before an IDF curve can be developed for these stations. Installation of a short duration precipitation monitoring gauge near these stations would allow these stations to be updated until new curves can be generated at the nearby locations.
2. **Increase the archiving frequency in the Province.** The Department of Environment and Conservation stations and the Hydro stations archive precipitation data hourly. However, the data are collected using tipping buckets. If the data were archived at a duration of 5-min or 15-min, the data would allow more durations to be updated. This would be particularly valuable if these stations are used for development of IDF curves in the future (when enough data have been collected).
3. **Develop IDF curves for the weather forecast regions that do not currently have an IDF curve** (Figure 7.1). The use of regional analysis techniques may be useful for developing IDF curves where there are no current IDF curves. This would improve infrastructure design and planning in these regions of the Province by providing better estimates of extreme precipitation.
4. **Investigate potential impacts of increased winter precipitation.** GCM results for the Province indicate increases in winter precipitation. IDF curves do not account for winter precipitation that falls as snow. Increased snow accumulation and melt may have significant impacts on infrastructure and public safety. In addition, as the air temperature increases, more winter precipitation may fall as rain. Therefore, it would be beneficial to investigate the potential impacts of increased winter precipitation.
5. **Perform an analysis using the Partial Duration Series (PDS) as the next step in trend analysis of extreme precipitation in the Province.** The trend analysis performed in this report was based on the annual maximum precipitation for each year and did not capture the case where two or more extreme precipitation events occurred in the same

year. PDS analysis selects all events with precipitation greater than a certain threshold, regardless of which year they occurred in. Trend analysis performed using the PDS may result in more consistent evidence of climate change than a trend analysis performed using only the annual maxima.

6. **Update the Province's flood risk mapping inventory with the new IDF curves.** It is recommended that the updated IDF curves and the future climate IDF curves be used to update the flood risk maps. This would increase public safety by providing both up-to-date flood risk areas and a tool for long term development planning.

7. **Repeat the IDF curve update regularly every 3-5 years.** EC produces new curves every three years. Five years is acceptable at this time to ensure that the curves remain up-to-date, as there is little evidence of long-term trends in the data (and therefore the stations are stationary through time). However, if/when statistically significant trends are identified in the data, it may be necessary to increase the updating frequency to three years.

Figure 7.1 Weather Forecast Regions Without an IDF Curve

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Appendix A

Listing of Stations

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Section 1.0 Listing of Precipitation Stations in Newfoundland and Labrador

The following sections list the precipitation stations in Newfoundland and Labrador. Sections 1.1 to 1.5 list the Environment Canada stations by type of data recorded (tipping bucket stations, 15-minute stations, 1-hour stations, 6-hour stations, and 24-hour stations). The stations are listed in the order: active stations in order of increasing Climate ID and then inactive stations in order of increasing Climate ID. Inactive stations are shaded grey. Section 1.6 lists the Provincial Real-Time Water Resources Data stations in order of increasing Climate ID. Section 1.7 lists the City of St. John's Rainfall Network Stations, in alphabetical order. Section 1.8 lists the Hydro Stations, in alphabetical order.

1.1 Environment Canada Tipping Bucket Data Stations

Station Name	*Climate ID*	*Latitude*	*Longitude*	*First Year*	*Last Year*	*# of Years*	*Status*
Argentia (AUT)	8400104	47.29	-53.99	2003	2013	11	Active
Badger (AUT)	8400301	48.97	-56.07	2005	2013	9	Active
Bonavista	8400601	48.67	-53.11	2006	2013	7	Active
Burgeo Nl	8400801	47.62	-57.62	2006	2013	8	Active
St Johns West Climate	8403603	47.51	-52.78	2010	2013	4	Active
St Lawrence	8403619	46.92	-55.38	2007	2013	7	Active
Stephenville A	8403800	48.53	-58.55	1967	2013	47	Active
Stephenville RCS	8403820	48.56	-58.57	2009	2013	4	Active
Terra Nova Nat Park CS	8403851	48.56	-53.97	2007	2013	7	Active
Twillingate (AUT)	8404025	49.68	-54.80	2004	2013	10	Active
Wreckhouse	8404343	47.71	-59.31	2008	2013	5	Active
Goose A	8501900	53.32	-60.42	1961	2013	53	Active
Hopedale (AUT)	8502400	55.45	-60.22	2005	2013	8	Active
Nain	8502799	56.55	-61.68	2004	2013	10	Active
Argentia A	8400102	47.30	-54.00	1976	1986	11	Inactive
Buchans A	8400700	48.85	-56.83	1960	1965	6	Inactive
Burgeo	8400798	47.62	-57.62	1967	1995	29	Inactive
Cape Race (AUT)	8401000	46.66	-53.08	1969	1976	2	Inactive
Comfort Cove	8401259	49.27	-54.88	1967	1996	30	Inactive
Daniels Harbour	8401400	50.24	-57.58	1969	1996	28	Inactive
Deer Lake A	8401501	49.22	-57.40	1965	2002	38	Inactive
Gander Int'l A	8401700	48.95	-54.58	1960	2008	49	Inactive
Gander Airport CS	8401705	48.95	-54.57	2003	2012	10	Inactive
La Scie	8402520	49.92	-55.67	1984	1995	12	Inactive
Placentia	8402956	47.23	-54.02	1970	1975	6	Inactive
Port Aux Basques	8402975	47.57	-59.15	1974	1997	24	Inactive
St Albans	8403290	47.87	-55.85	1968	1983	16	Inactive
St Andrews	8403300	47.77	-59.33	1960	1966	7	Inactive
St Anthony	8403401	51.37	-55.60	1970	1996	27	Inactive
St John's A	8403506	47.62	-52.74	1961	1997	37	Inactive
St John's West CDA	8403600	47.52	-52.78	1991	1995	5	Inactive
St Lawrence	8403615	46.92	-55.38	1968	1996	29	Inactive
Terra Nova Nat Park HQ	8403852	48.55	-53.98	1989	1995	7	Inactive
Wreckhouse	8404340	47.71	-59.31	2007	2007	1	Inactive
Battle Harbour LOR	8500398	52.25	-55.60	1971	1983	13	Inactive
Churchill Falls A	8501132	53.55	-64.10	1969	1992	24	Inactive

Station Name	Climate ID	Latitude	Longitude	First Year	Last Year	# of Years	Status
Mary's Harbour A	8502591	52.30	-55.83	1983	1995	13	Inactive
Nain A	8502800	56.55	-61.68	1993	2011	17	Inactive
Twin Falls A	8504060	53.63	-64.48	1967	1968	2	Inactive
Wabush Lake A	8504175	52.93	-66.87	1973	2003	30	Inactive
St Anthony A	840C401	51.38	-56.10	1994	1994	1	Inactive

1.2 Environment Canada 15-minute Stations

Station Name	Climate ID	Latitude	Longitude	First Year	Last Year	# of Years	Status
Argentia (AUT)	8400104	47.29	-53.99	2006	2015	10	Active
Badger (AUT)	8400301	48.97	-56.07	2013	2015	3	Active
Bonavista	8400601	48.67	-53.11	2006	2015	10	Active
Burgeo Nl	8400801	47.62	-57.62	2006	2015	10	Active
Cormack RCS	8401295	49.32	-57.39	2012	2015	4	Active
Englee (AUT)	8401538	50.72	-56.11	2013	2015	3	Active
Ferolle Point (AUT)	8401565	51.02	-57.10	2014	2015	2	Active
Gander Airport CS	8401705	48.95	-54.57	2013	2015	3	Active
Millertown RCS	8402757	48.82	-56.54	2013	2015	3	Active
St Johns West Climate	8403603	47.51	-52.78	2010	2015	6	Active
St Lawrence	8403619	46.92	-55.38	2006	2015	10	Active
Stephenville RCS	8403820	48.56	-58.57	2008	2015	8	Active
Terra Nova Nat Park CS	8403851	48.56	-53.97	2006	2015	10	Active
Wreckhouse	8404343	47.71	-59.31	2006	2015	10	Active
Hopedale (AUT)	8502400	55.45	-60.22	2008	2015	8	Active
Wabush A	8504177	52.92	-66.86	2014	2015	2	Active

1.3 Environment Canada 1-hour Stations

Station Name	Climate ID	Latitude	Longitude	First Year	Last Year	# of Years	Status
Argentia (AUT)	8400104	47.29	-53.99	2004	2015	12	Active
Badger (AUT)	8400301	48.97	-56.07	2004	2015	12	Active
Bonavista	8400601	48.67	-53.11	2006	2015	10	Active
Burgeo Nl	8400801	47.62	-57.62	2006	2015	10	Active
Cape Race (AUT)	8401000	46.66	-53.08	2004	2015	12	Active
Cormack RCS	8401295	49.32	-57.39	2012	2015	3	Active
Corner Brook	8401298	48.93	-57.92	2004	2015	12	Active
Englee (AUT)	8401538	50.72	-56.11	2003	2015	13	Active
Ferolle Point (AUT)	8401565	51.02	-57.10	2004	2015	12	Active
Gander Airport CS	8401705	48.95	-54.57	2005	2015	11	Active
La Scie	8402520	49.92	-55.67	2004	2015	6	Active
Millertown RCS	8402757	48.82	-56.54	2013	2015	3	Active
Rocky Harbour CS	8403097	49.57	-57.88	2013	2015	3	Active
St. Anthony	8403389	51.39	-56.07	2014	2015	2	Active
St Anthony	8403399	51.38	-56.10	2004	2015	11	Active
St Johns West Climate	8403603	47.51	-52.78	2010	2015	6	Active
St Lawrence	8403619	46.92	-55.38	2006	2015	10	Active
Stephenville RCS	8403820	48.56	-58.57	2008	2015	8	Active
Terra Nova Nat Park CS	8403851	48.56	-53.97	2006	2015	10	Active
Twillingate (AUT)	8404025	49.68	-54.80	2004	2015	7	Active
Wreckhouse	8404343	47.71	-59.31	2006	2015	10	Active
Churchill Falls A	8501131	53.56	-64.11	2014	2015	2	Active
Hopedale (AUT)	8502400	55.45	-60.22	2004	2015	7	Active
Mary's Harbour A	8502592	52.30	-55.85	2014	2015	2	Active

Station Name	Climate ID	Latitude	Longitude	First Year	Last Year	# of Years	Status
Nain	8502799	56.55	-61.68	2004	2015	11	Active
Wabush A	8504177	52.92	-66.86	2014	2015	2	Active
Burgeo 2	8400800	47.62	-57.62	2004	2006	3	Inactive
Pools Island	840BR7C	49.11	-53.58	2010	2012	3	Inactive
St Lawrence	8403616	46.92	-55.38	2004	2006	3	Inactive

1.4 Environment Canada 6-hour Stations

Station Name	Climate ID	Latitude	Longitude	First Year	Last Year	# of Years	Status
Argentia (AUT)	8400104	47.29	-53.99	1992	2015	24	Active
Badger (AUT)	8400301	48.97	-56.07	1992	2015	23	Active
Bonavista	8400601	48.67	-53.11	2006	2015	10	Active
Burgeo Nl	8400801	47.62	-57.62	2006	2015	10	Active
Cape Race (AUT)	8401000	46.66	-53.08	1947	2015	46	Active
Cormack RCS	8401295	49.32	-57.39	2012	2015	3	Active
Corner Brook	8401298	48.93	-57.92	2007	2015	9	Active
Deer Lake A	8401502	49.21	-57.39	2012	2015	4	Active
Englee (AUT)	8401538	50.72	-56.11	1993	2015	23	Active
Ferolle Point (AUT)	8401565	51.02	-57.10	1992	2015	22	Active
Gander Intl A	8401703	48.94	-54.57	2012	2015	4	Active
Gander Airport CS	8401705	48.95	-54.57	2005	2015	11	Active
Millertown RCS	8402757	48.82	-56.54	2013	2015	3	Active
Port Aux Basques	8402975	47.57	-59.15	1966	2015	50	Active
Rocky Harbour CS	8403097	49.57	-57.88	2000	2015	16	Active
St. Anthony	8403389	51.39	-56.07	2009	2015	7	Active
St Anthony	8403399	51.38	-56.10	1999	2015	16	Active
St. John's Intl A	8403505	47.62	-52.75	2012	2015	4	Active
St Johns West Climate	8403603	47.51	-52.78	2010	2015	6	Active
St Lawrence	8403619	46.92	-55.38	2006	2015	10	Active
Stephenville A	8403801	48.54	-58.55	2014	2015	2	Active
Stephenville RCS	8403820	48.56	-58.57	2008	2015	8	Active
Terra Nova Nat Park CS	8403851	48.56	-53.97	2000	2015	16	Active
Twillingate (AUT)	8404025	49.68	-54.80	1992	2015	20	Active
Wreckhouse	8404343	47.71	-59.31	2006	2015	10	Active
Cartwright	8501100	53.71	-57.03	1947	2015	69	Active
Churchill Falls A	8501131	53.56	-64.11	2011	2015	5	Active
Goose A	8501900	53.32	-60.42	1947	2015	69	Active
Hopedale (AUT)	8502400	55.45	-60.22	1947	2015	56	Active
Mary's Harbour A	8502592	52.30	-55.85	2013	2015	3	Active
Nain	8502799	56.55	-61.68	2004	2015	11	Active
Nain A	8502800	56.55	-61.68	1984	2015	33	Active
Wabush A	8504177	52.92	-66.86	2014	2015	2	Active
Argentia A	8400102	47.30	-54.00	1976	1986	11	Inactive
Bay D'Espoir St Albans	8400415	47.97	-55.85	1967	1967	1	Inactive
Bonavista	8400600	48.67	-53.11	1959	1997	48	Inactive
Buchans A	8400700	48.85	-56.83	1947	1965	19	Inactive
Burgeo	8400798	47.62	-57.62	1966	1995	30	Inactive
Burgeo 2	8400800	47.62	-57.62	1997	2006	10	Inactive
Comfort Cove	8401259	49.27	-54.88	1967	1996	30	Inactive
Daniels Harbour	8401400	50.24	-57.58	1947	1998	68	Inactive
Daniels Harbour 2	8401410	50.23	-57.58	1996	1999	4	Inactive
Deer Lake	8401500	49.17	-57.43	1995	1995	1	Inactive
Deer Lake A	8401501	49.22	-57.40	1965	2002	48	Inactive
Gander Int'l A	8401700	48.95	-54.58	1947	2012	66	Inactive
Grand Bank	8402000	47.10	-55.77	1947	1966	20	Inactive
La Scie	8402520	49.92	-55.67	1984	1995	22	Inactive
Placentia	8402956	47.23	-54.02	1970	1975	6	Inactive
Sagona Island	8403255	47.37	-55.79	1993	2003	10	Inactive

Station Name	Climate ID	Latitude	Longitude	First Year	Last Year	# of Years	Status
St Albans	8403290	47.87	-55.85	1976	1983	8	Inactive
St Andrews	8403300	47.77	-59.33	1947	1966	20	Inactive
St Anthony	8403400	51.37	-55.58	1947	1965	19	Inactive
St Anthony	8403401	51.37	-55.60	1970	1996	27	Inactive
St Anthony A	8403402	51.40	-56.08	1966	1970	5	Inactive
St Anthony AWOS	8403403	51.38	-56.10	2009	2014	6	Inactive
St John's A	8403506	47.62	-52.74	1947	2012	66	Inactive
St John's West CDA CS	8403605	47.52	-52.78	2000	2005	6	Inactive
St Lawrence	8403615	46.92	-55.38	1966	1997	32	Inactive
St Lawrence	8403616	46.92	-55.38	1994	2006	11	Inactive
Stephenville A	8403800	48.53	-58.55	1966	2014	49	Inactive
Trepassey	8403970	46.73	-53.17	1966	1966	1	Inactive
Twillingate	8404000	49.68	-54.82	1950	1967	17	Inactive
Winterland	8404241	47.14	-55.33	1999	2014	16	Inactive
Battle Harbour Lor	8500398	52.25	-55.60	1957	1983	27	Inactive
Belle Isle	8500500	51.88	-55.38	1947	1969	23	Inactive
Cape Harrison	8500900	54.77	-58.45	1950	1961	12	Inactive
Churchill Falls	8501130	53.56	-64.09	1992	2011	20	Inactive
Churchill Falls A	8501132	53.55	-64.10	1968	1993	26	Inactive
Mary's Harbour A	8502591	52.30	-55.83	1983	2013	31	Inactive
Saglek	8503249	58.33	-62.59	1989	1993	5	Inactive
Twin Falls A	8504060	53.63	-64.48	1967	1968	2	Inactive
Wabush Lake A	8504175	52.93	-66.87	1960	2013	55	Inactive
Wabush A	8504176	52.92	-66.86	2013	2014	2	Inactive
Pools Island	840BR7C	49.11	-53.58	2010	2012	3	Inactive
St Anthony A	840C401	51.38	-56.10	2001	2004	2	Inactive
Makkovik A	8502NHR	55.08	-59.19	1999	1999	1	Inactive
Mary's Harbour	850B5R1	52.30	-55.83	1992	2013	22	Inactive

1.5 Environment Canada 24-hour Stations

Station Name	Climate ID	Latitude	Longitude	First Year	Last Year	# of Years	Status
Bay D'Espoir Gen Stn	8400413	47.98	-55.80	1967	2015	5	Active
Branch	8400666	46.88	-53.97	1983	2015	1	Active
Brownsdale	8400675	48.03	-53.12	1998	2015	6	Active
Burnt Pond	8400812	48.17	-57.33	1972	2015	19	Active
Cormack	8401286	49.32	-57.40	1980	2015	10	Active
Corner Brook	8401300	48.95	-57.95	1933	2015	2	Active
Cow Head	8401335	49.91	-57.79	1982	2015	6	Active
Deer Lake	8401500	49.17	-57.43	1933	2015	6	Active
Lethbridge	8402544	48.35	-53.90	1954	2015	2	Active
Plum Point	8402958	51.07	-56.88	1972	2015	3	Active
Point Leamington	8402966	49.33	-55.40	1982	2015	2	Active
Sops Arm White Bay	8403690	49.77	-56.88	1980	2015	10	Active
South Brook Pasadena	8403693	49.02	-57.62	1985	2015	3	Active
Argentia A	8400100	47.30	-54.00	1945	1970	13	Inactive
Argentia A	8400102	47.30	-54.00	1976	1986	11	Inactive
Argentia (AUT)	8400104	47.29	-53.99	2004	2007	6	Inactive
Arnolds Cove	8400135	47.75	-54.00	1971	1994	45	Inactive
Avondale CDA	8400225	47.42	-53.23	1955	1996	43	Inactive
Badger	8400300	48.98	-56.05	1955	1967	6	Inactive
Badger (AUT)	8400301	48.97	-56.07	1973	2007	1	Inactive
Badger C	8400309	48.97	-56.05	1988	1989	1	Inactive
Baie Verte	8400350	49.98	-56.18	1958	1995	3	Inactive
Baie Verte Junction	8400359	49.45	-56.43	1989	1994	3	Inactive
Bay D'Espoir 1	8400411	47.88	-55.83	1965	1965	10	Inactive
Bay D'Espoir 2	8400412	47.98	-55.80	1965	1967	19	Inactive
Bay D'Espoir Long Pond	8400414	47.98	-55.82	1982	1997	1	Inactive

Station Name	Climate ID	Latitude	Longitude	First Year	Last Year	# of Years	Status
Bay D'Espoir St Albans	8400415	47.97	-55.85	1966	1968	5	Inactive
Benton	8400505	48.90	-54.42	1988	1993	64	Inactive
Bishops Falls	8400549	49.02	-55.50	1988	1993	13	Inactive
Bishops Falls	8400550	49.02	-55.47	1955	1961	37	Inactive
Bishops Falls Peat Mine	8400552	49.05	-55.42	1980	1984	46	Inactive
Black Duck	8400570	48.57	-58.37	1981	2004	45	Inactive
Boat Harbour	8400578	47.43	-54.84	1982	2009	2	Inactive
Bonavista	8400600	48.67	-53.11	1956	2006	10	Inactive
Bonavista	8400601	48.67	-53.11	2006	2007	37	Inactive
Botwood	8400650	49.15	-55.35	1937	1995	2	Inactive
Buchans	8400698	48.82	-56.87	1965	2011	58	Inactive
Buchans	8400699	48.82	-56.85	1937	1947	2	Inactive
Buchans A	8400700	48.85	-56.83	1943	1965	3	Inactive
Buchans Junction	8400711	48.85	-56.47	1988	1997	1	Inactive
Burgeo	8400798	47.62	-57.62	1966	1995	10	Inactive
Burgeo 2	8400800	47.62	-57.62	1939	2006	3	Inactive
Burgeo Nl	8400801	47.62	-57.62	2006	2007	45	Inactive
Burin	8400810	47.00	-55.17	1909	1931	1	Inactive
Cape Broyle	8400850	47.10	-52.93	1955	1997	2	Inactive
Cape Norman	8400940	51.63	-55.90	1882	1946	10	Inactive
Cape Race (AUT)	8401000	46.66	-53.08	1920	2007	3	Inactive
Cape St George	8401053	48.47	-59.27	1974	1977	1	Inactive
Cappahayden	8401070	46.87	-52.95	1981	1999	2	Inactive
Carbonear	8401075	47.73	-53.23	1972	1974	37	Inactive
Carmanville	8401078	49.40	-54.27	1982	2003	13	Inactive
Carol Lake Project	8401080	52.95	-66.90	1959	1960	8	Inactive
Cartyville	8401102	48.23	-58.82	1982	2010	6	Inactive
Cat Arm River	8401104	50.08	-56.92	1983	1984	58	Inactive
Channel	8401125	47.62	-59.15	1874	1951	6	Inactive
Charleston	8401128	48.38	-53.67	1989	2013	6	Inactive
Clarenville	8401140	48.15	-53.97	1978	1982	19	Inactive
Clarenville	8401141	48.36	-53.96	1982	2012	45	Inactive
Clunys	8401150	47.20	-52.95	1955	1960	11	Inactive
Colinet	8401200	47.22	-53.55	1938	1992	19	Inactive
Colinet Peat Bog CDA	8401250	47.22	-53.50	1957	1979	2	Inactive
Colinet Peat Bog CDA	8401251	47.23	-53.52	1980	1996	20	Inactive
Come By Chance	8401257	47.80	-54.00	1968	1995	3	Inactive
Comfort Cove	8401259	49.27	-54.88	1967	1996	8	Inactive
Comfort Cove Decca	8401260	49.35	-54.87	1962	1965	1	Inactive
Corner Brook	8401298	48.93	-57.92	1993	2007	8	Inactive
Corner Brook Avalon Tel	8401302	48.95	-57.95	1960	1963	1	Inactive
Daniels Harbour	8401400	50.24	-57.58	1946	2007	11	Inactive
Deer Lake A	8401501	49.22	-57.40	1965	2008	76	Inactive
Deer Lake Cooltap	8401503	49.22	-57.40	2012	2014	1	Inactive
Devil Cove	8401506	50.02	-56.77	1988	1988	1	Inactive
Dover	8401518	48.88	-53.97	1983	1984	43	Inactive
Doyles	8401524	47.83	-59.18	1980	1981	6	Inactive
Doyles CDA EPF	8401525	47.83	-59.20	1954	1963	1	Inactive
Dunville	8401528	47.27	-53.92	1990	1997	2	Inactive
Ebbegunbaeg Lake	8401530	48.30	-56.42	1972	1974	45	Inactive
Englee (AUT)	8401538	50.72	-56.11	2005	2007	64	Inactive
Exploits Dam	8401550	48.77	-56.60	1956	2009	3	Inactive
Ferolle Point (AUT)	8401565	51.02	-57.10	2005	2007	13	Inactive
Flowers Cove	8401582	51.30	-56.73	1971	1980	6	Inactive
Flowers Cove	8401583	51.33	-56.68	1980	2008	1	Inactive
Flowers Island	8401585	51.30	-56.75	1967	1970	46	Inactive
Fogo	8401599	49.72	-54.30	1990	2004	3	Inactive
Fogo	8401600	49.72	-54.28	1873	1950	6	Inactive
Fogo	8401601	49.72	-54.27	1972	1989	1	Inactive
Fortune	8401618	47.07	-55.82	1980	1989	2	Inactive

Station Name	***Climate ID***	***Latitude***	***Longitude***	***First Year***	***Last Year***	***# of Years***	***Status***
Gallants	8401642	48.70	-58.23	1982	2013	1	Inactive
Gambo	8401650	48.75	-54.23	1957	1991	10	Inactive
Gambo	8401651	48.78	-54.21	1982	2006	1	Inactive
Gander Int'l A	8401700	48.95	-54.58	1937	2012	3	Inactive
Gander Airport CS	8401705	48.95	-54.57	2005	2007	46	Inactive
Gander Bay South	8401711	49.27	-54.48	1983	1995	1	Inactive
Garnish	8401728	47.23	-55.36	1982	2009	2	Inactive
Glenwood	8401799	48.98	-54.85	1990	2003	46	Inactive
Glenwood	8401800	49.00	-54.87	1937	1977	76	Inactive
Goobies	8401880	47.95	-53.97	1978	2011	43	Inactive
Grand Bank	8401999	47.10	-55.75	1990	1997	6	Inactive
Grand Bank	8402000	47.10	-55.77	1934	1966	2	Inactive
Grand Falls	8402050	48.93	-55.67	1934	2009	10	Inactive
Grand Lake	8402052	49.08	-57.20	1978	1984	20	Inactive
Grand Lake	8402053	49.08	-57.18	1984	1990	2	Inactive
Grey River	8402057	47.58	-57.10	1982	1997	1	Inactive
Gull Pond	8402060	49.20	-56.15	1964	1971	64	Inactive
Hampden	8402065	49.55	-56.87	1958	1962	6	Inactive
Hampden White Bay	8402069	49.53	-56.87	1983	1996	8	Inactive
Harbour Breton	8402071	47.47	-55.83	1983	2014	76	Inactive
Harbour Deep	8402073	50.37	-56.52	1990	2002	58	Inactive
Harbour Grace	8402075	47.72	-53.15	1957	1958	13	Inactive
Harbour Grace	8402076	47.68	-53.20	1979	1993	46	Inactive
Hawke's Bay	8402078	50.60	-57.18	1984	2006	76	Inactive
Hearts Content	8402080	47.87	-53.38	1961	2002	43	Inactive
Heatherton	8402100	48.28	-58.55	1954	1956	20	Inactive
Hinds Lake	8402210	49.05	-57.13	1978	1979	3	Inactive
Holyrood	8402300	47.38	-53.13	1952	1970	58	Inactive
Holyrood	8402303	47.38	-53.12	1996	2009	3	Inactive
Holyrood Gen Stn	8402309	47.45	-53.10	1970	2011	20	Inactive
Holyrood Ultramar	8402310	47.38	-53.13	1961	1982	10	Inactive
Hope Brook	8402383	47.73	-58.08	1989	1997	37	Inactive
Howley	8402415	49.17	-57.12	1987	1990	3	Inactive
Indian Bay B.B.	8402436	49.04	-53.88	1987	2011	8	Inactive
Isle Aux Morts	8402450	47.58	-58.97	1982	2004	8	Inactive
Jacksons Arm	8402470	49.87	-56.82	1982	1982	2	Inactive
Jacksons Arm	8402471	49.87	-56.78	1982	1995	76	Inactive
Jeffrey's	8402474	48.23	-58.83	1992	1995	1	Inactive
Lake Ambrose	8402500	48.58	-56.65	1955	1957	46	Inactive
Lamaline	8402516	46.87	-55.13	1983	1998	10	Inactive
La Scie	8402520	49.92	-55.67	1984	2007	58	Inactive
Lockleven	8402563	48.17	-58.87	1987	1997	45	Inactive
Lockston	8402565	48.40	-53.38	1966	1999	6	Inactive
Logy Bay	8402568	47.62	-52.66	1969	2004	11	Inactive
Long Harbour	8402569	47.42	-53.82	1969	1999	6	Inactive
Lookout Brook	8402588	48.35	-58.30	1956	1956	8	Inactive
Markland	8402590	47.32	-53.55	1981	1994	8	Inactive
Marystown	8402592	47.17	-55.15	1970	1972	11	Inactive
Middle Arm	8402644	49.68	-56.08	1988	2014	1	Inactive
Millertown	8402755	49.00	-56.35	1934	1946	3	Inactive
Mobile	8402759	47.25	-52.85	1993	1996	5	Inactive
Musgrave Harbour	8402770	49.45	-53.98	1978	2009	1	Inactive
New Chelsea	8402840	48.03	-53.22	1961	1991	2	Inactive
North East Pond River	8402873	47.63	-52.83	1970	1975	2	Inactive
North Harbour	8402874	47.13	-53.67	1988	2007	43	Inactive
Petty Harbour	8402925	47.47	-52.72	1955	1999	2	Inactive
Piccadilly	8402945	48.55	-58.92	1980	1989	2	Inactive
Pierres Brook	8402950	47.28	-52.82	1955	1978	10	Inactive
Placentia	8402956	47.23	-54.02	1970	1975	2	Inactive
Placentia Junction	8402957	47.40	-53.60	1989	1990	2	Inactive

Station Name	Climate ID	Latitude	Longitude	First Year	Last Year	# of Years	Status
Pointe Riche	8402968	50.70	-57.42	1882	1941	76	Inactive
Pools Cove	8402972	47.68	-55.43	1978	2001	8	Inactive
Pools Cove Fortune Bay	8402973	47.70	-55.58	1979	2000	19	Inactive
Port Aux Basques	8402975	47.57	-59.15	1909	2007	20	Inactive
Port Aux Basques Channel	8403000	47.62	-59.15	1952	1953	6	Inactive
Port Blandford	8403008	48.35	-54.17	1982	2006	1	Inactive
Port Saunders	8403040	50.65	-57.20	1979	2001	5	Inactive
Portugal Cove	8403044	47.65	-52.82	1998	2006	1	Inactive
Portugal Cove, Conc.Bay	8403045	47.62	-52.83	1987	1996	1	Inactive
Port Union	8403050	48.50	-53.08	1966	2014	1	Inactive
Purbeck's Cove	8403060	49.75	-56.65	1988	1993	58	Inactive
Rattling Brook Depot	8403075	48.97	-55.53	1956	1957	58	Inactive
Red Cliff	8403082	48.95	-55.75	1991	1996	6	Inactive
Red Harbour PB	8403083	47.30	-55.01	1989	2006	2	Inactive
Rattling Brk Norris Arm	8403085	49.07	-55.30	1958	2008	1	Inactive
Robert's Arm	8403093	49.50	-55.82	1982	1996	19	Inactive
Rocky Harbour	8403096	49.57	-57.88	1972	1993	43	Inactive
Rocky Harbour CS	8403097	49.57	-57.88	1993	2007	8	Inactive
Roddickton	8403098	50.87	-56.12	1971	1990	10	Inactive
Round Harbour	8403210	49.85	-55.67	1977	1993	20	Inactive
St Albans	8403290	47.87	-55.85	1968	1983	8	Inactive
St Andrews	8403300	47.77	-59.33	1943	1966	3	Inactive
St Anthony	8403399	51.38	-56.10	2006	2007	8	Inactive
St Anthony	8403400	51.37	-55.58	1945	1965	76	Inactive
St Anthony	8403401	51.37	-55.60	1970	1996	10	Inactive
St Anthony A	8403402	51.40	-56.08	1966	1970	43	Inactive
St Brendans	8403410	48.87	-53.67	1971	1974	3	Inactive
St Bride's	8403417	46.92	-54.18	1988	2001	1	Inactive
St Bride's	8403418	46.92	-54.17	1984	1987	3	Inactive
St Georges	8403448	48.42	-58.50	1895	1945	1	Inactive
St Georges	8403450	48.43	-58.47	1956	1993	8	Inactive
St John's	8403500	47.57	-52.70	1874	1956	8	Inactive
St John's	8403501	47.58	-52.73	1957	1975	6	Inactive
St John's A	8403506	47.62	-52.74	1942	2012	8	Inactive
St John's Thorburn Road	8403523	47.57	-52.80	1988	1995	1	Inactive
St John's West CDA	8403600	47.52	-52.78	1950	1996	2	Inactive
St John's West CDA CS	8403605	47.52	-52.78	1996	2007	5	Inactive
St Lawrence	8403615	46.92	-55.38	1966	1997	3	Inactive
St Lawrence	8403616	46.92	-55.38	2004	2006	2	Inactive
St Shotts	8403617	46.63	-53.58	1971	1995	2	Inactive
St Stephens	8403618	46.77	-53.62	1989	1997	8	Inactive
St Lawrence	8403619	46.92	-55.38	2006	2007	1	Inactive
Salmonier	8403620	47.27	-53.33	1967	1977	1	Inactive
Salmonier Nature Park	8403621	47.27	-53.28	1977	2006	6	Inactive
Salmonier Nature Park	8403622	47.26	-53.29	2001	2007	6	Inactive
Salt Pond	8403623	47.09	-55.20	1974	2006	1	Inactive
Sandy Point	8403635	48.67	-58.45	1889	1912	2	Inactive
Seal Cove	8403650	47.45	-53.07	1961	1988	37	Inactive
Sibley's Cove	8403667	48.05	-53.10	1989	1998	3	Inactive
Signal Hill	8403669	47.57	-52.68	1984	2001	6	Inactive
Snooks Arm	8403680	49.87	-55.72	1958	1963	2	Inactive
South Branch	8403691	47.95	-58.97	1989	1997	11	Inactive
Springdale	8403700	49.50	-56.08	1955	1993	8	Inactive
Springdale GB Farm	8403702	49.45	-56.17	1980	1999	3	Inactive
Stanhope	8403775	49.27	-55.10	1988	1997	64	Inactive
Stephenville A	8403800	48.53	-58.55	1942	2012	11	Inactive
Stephenville Crossing	8403815	48.57	-58.43	1967	1967	10	Inactive
Sunnyside	8403818	47.87	-53.93	1971	1995	2	Inactive
Swift Current	8403825	47.89	-54.21	1984	2011	8	Inactive
Terra Nova Community	8403850	48.50	-54.22	1957	1989	6	Inactive

Station Name	Climate ID	Latitude	Longitude	First Year	Last Year	# of Years	Status
Terra Nova Nat Park CS	8403851	48.56	-53.97	1996	2007	19	Inactive
Terra Nova Nat Park HQ	8403852	48.55	-53.98	1962	1996	6	Inactive
Terra Nova Nat Park S	8403854	48.45	-54.02	1962	1969	20	Inactive
Terrenceville	8403858	47.67	-54.72	1980	1994	11	Inactive
Thornlea T.B.	8403860	47.62	-53.73	1987	1997	13	Inactive
Tilt Cove	8403866	49.88	-55.63	1958	1963	2	Inactive
Tompkins	8403870	47.78	-59.23	1981	1997	46	Inactive
Topsail	8403875	47.53	-52.92	1961	1967	2	Inactive
Tors Cove	8403950	47.22	-52.85	1955	1993	5	Inactive
Trepassey	8403970	46.73	-53.17	1966	1966	2	Inactive
Trepassey	8403971	46.77	-53.37	1982	1990	3	Inactive
26 Mile Depot	8403990	48.42	-57.07	1962	1962	1	Inactive
Twillingate	8404000	49.68	-54.82	1950	1967	6	Inactive
Twillingate (AUT)	8404025	49.68	-54.80	2004	2007	10	Inactive
Upper Salmon	8404080	48.18	-56.17	1981	1983	8	Inactive
Victoria	8404100	47.77	-53.22	1961	2002	20	Inactive
Westbrook St Lawrence	8404201	46.95	-55.38	1957	1995	6	Inactive
Western Arm Brook	8404210	51.18	-56.77	1981	2011	5	Inactive
Whalesback	8404225	49.60	-56.00	1965	1969	8	Inactive
Whitbourne	8404234	47.42	-53.54	1991	2014	2	Inactive
Whitbourne T.B.	8404235	47.32	-53.55	1987	1990	1	Inactive
Wiltondale	8404237	49.40	-57.62	1989	1997	58	Inactive
Winterland	8404240	47.17	-55.30	1981	2006	37	Inactive
Winterland	8404241	47.14	-55.33	2005	2007	2	Inactive
Wooddale Bishop's Falls	8404310	49.03	-55.55	1974	2011	1	Inactive
Woody Point	8404320	49.50	-57.92	1971	1995	1	Inactive
Wreckhouse	8404343	47.71	-59.31	2006	2007	6	Inactive
Ashuanipi	8500200	52.53	-66.23	1948	1950	2	Inactive
Battle Harbour	8500395	52.28	-55.58	1947	1983	5	Inactive
Battle Harbour LOR	8500398	52.25	-55.60	1957	1983	1	Inactive
Battle Harbour Marys R	8500400	52.32	-55.83	1956	1983	6	Inactive
Belle Isle	8500500	51.88	-55.38	1871	1969	8	Inactive
Cape Harrison	8500900	54.77	-58.45	1943	1961	45	Inactive
Cartwright	8501100	53.71	-57.03	1934	2012	64	Inactive
Churchill Falls	8501130	53.56	-64.09	2006	2007	6	Inactive
Churchill Falls A	8501132	53.55	-64.10	1968	1993	1	Inactive
Esker 2	8501548	53.87	-66.42	1972	1978	3	Inactive
Forteau	8501615	51.47	-56.97	1871	1878	2	Inactive
Goose A	8501900	53.32	-60.42	1941	2012	13	Inactive
Gull Island	8502059	53.00	-61.50	1975	1976	1	Inactive
Hebron	8502200	58.22	-62.58	1947	1957	43	Inactive
Hopedale (AUT)	8502400	55.45	-60.22	1942	2007	2	Inactive
Makkovik	8502589	55.08	-59.18	1983	1985	64	Inactive
Mary's Harbour A	8502591	52.30	-55.83	1983	1998	1	Inactive
Menihek Rapids	8502600	54.47	-66.62	1952	1961	3	Inactive
Mile 163	8502700	52.27	-65.68	1952	1953	19	Inactive
Mile 224	8502750	52.93	-66.23	1955	1955	5	Inactive
Nain	8502799	56.55	-61.68	2004	2007	3	Inactive
Nain A	8502800	56.55	-61.68	1927	2012	46	Inactive
North West River	8502875	53.53	-60.15	1906	1973	8	Inactive
North West River	8502876	53.52	-60.15	1984	1985	13	Inactive
Nutak	8502900	57.47	-61.83	1948	1953	10	Inactive
Point Amour	8502960	51.47	-56.85	1889	1935	1	Inactive
Port Hope Simpson	8503018	52.53	-56.30	1983	1988	45	Inactive
Red Bay	8503081	51.73	-56.43	1990	1996	6	Inactive
Rigolet	8503090	54.18	-58.43	1973	1975	1	Inactive
Ross Bay	8503100	52.98	-66.23	1953	1953	2	Inactive
Ross Bay BNC	8503200	53.03	-66.23	1954	1954	1	Inactive
Saglek	8503249	58.33	-62.59	1989	1993	6	Inactive
Saglek	8503250	58.48	-62.65	1955	1960	64	Inactive

Station Name	***Climate ID***	***Latitude***	***Longitude***	***First Year***	***Last Year***	***# of Years***	***Status***
Sandgirt Lake	8503630	53.83	-65.50	1939	1948	3	Inactive
Twin Falls	8504050	53.50	-64.52	1960	1967	6	Inactive
Twin Falls A	8504060	53.63	-64.48	1967	1968	1	Inactive
Wabush Lake Cooltap	8504173	52.93	-66.87	2012	2014	2	Inactive
Wabush Lake A	8504175	52.93	-66.87	1960	2008	2	Inactive
West St Modeste	8504216	51.60	-56.70	1990	2002	8	Inactive
West St Modeste	8504217	51.58	-56.72	1984	1987	8	Inactive
Butlerville	8400QJK	47.58	-53.32	1988	2013	37	Inactive
Doyles	8401EK4	47.85	-59.25	1981	2011	6	Inactive
North East Pond River 2	8402H73	47.63	-52.83	1976	1979	2	Inactive
Paradise	8402R20	47.53	-52.83	1989	1990	76	Inactive
Paradise	8402RB0	47.53	-52.85	1991	1995	37	Inactive
Paradise River	8402RK0	47.62	-54.43	1990	1991	6	Inactive
Seal Cove CB	8403FN0	47.45	-53.07	1989	1991	6	Inactive
Grates Cove	840B053	48.17	-52.94	2004	2004	64	Inactive
Lourdes	840B5HH	48.65	-58.98	1990	2011	19	Inactive
St Anthony A	840C401	51.38	-56.10	2001	2008	2	Inactive
St Mary's	840C616	46.92	-53.57	1982	2000	10	Inactive
Great Barasway P.B.	840K0NC	47.13	-54.07	1987	1996	2	Inactive
Main Brook	840KE88	51.18	-56.02	1983	2011	10	Inactive
Roddickton North	840L0R9	50.88	-56.12	1991	1999	2	Inactive
Mciver's	840M001	49.07	-58.12	1996	2011	2	Inactive
Makkovik A	8502NHR	55.08	-59.19	1986	2011	6	Inactive
Churchill Falls	850A131	53.53	-63.97	1993	1998	76	Inactive
Mary's Harbour	850B5R1	52.30	-55.83	2005	2007	2	Inactive

1.6 Provincial Real-Time Water Resources Data Stations

All stations record precipitation every hour by unheated tipping buckets.

Station Name	***ID***	***Latitude***	***Longitude***	***First Year***	***Last Year***	***# of Years***	***Status***
Pippy Park in St. Johns	NLENCL0001	47.59	-52.73	2008	2015	8	Active
Exploits River at Badger East of Stadium	NLENCL0002	48.97	-56.03	2008	2015	8	Active
Humber River at Humber Village Bridge (Weather)	NLENCL0003	48.98	-57.76	2009	2015	7	Active
Churchill River at end of Mud Lake Road	NLENCL0004	53.34	-60.19	2010	2015	6	Active
Sandy Lake near Birchy Narrows (Camp 55)	NLENCL0005	49.27	-56.85	2010	2015	6	Active
Muskrat Falls MET	NLENCL0006	53.25	-60.78	2014	2015	2	Active

1.7 City of St. John's Rainfall Network Stations

All stations record precipitation every 5 minutes by heated tipping buckets.

Station Name	***ID***	***Latitude***	***Longitude***	***First Year***	***Last Year***	***# of Years***	***Status***
Municipal Depot	N/A	47.55	-52.74	2000	2015	16	Active
Ruby Line Pumping Station	N/A	47.49	-52.80	1997	2015	19	Active
Windsor Lake	N/A	47.61	-52.77	1999	2015	17	Active

1.8 Hydro Stations

All stations record precipitation every hour by unheated tipping buckets.

Station Name	***ID***	***Latitude***	***Longitude***	***First Year***	***Last Year***	***# of Years***	***Status***
Burnt Dam Spillway	N/A	48.16	-57.34	2009	2015	7	Active
Cat Arm Intake	N/A	50.04	-56.79	2008	2015	8	Active
Cat Arm Reservoir	N/A	50.17	-57.02	2010	2015	6	Active
Hinds Lake Control	N/A	49.05	-57.13	2009	2015	7	Active
Long Pond Intake	N/A	47.99	-55.82	2008	2015	8	Active
Meelpaeg Reservoir - Ebbegunbaeg Control	N/A	48.30	-56.42	2009	2015	7	Active

Appendix B

Results of the Statistical Analysis

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Section 1.0 Description of Statistical Tests

1.1 Statistical Homogeneity Testing

For this analysis, it was necessary to test two samples of data (the original IDF curve data and the donor data) to determine if they come from the same parent distribution. There are many types of univariate, two-sample statistical tests available, including tests for differences in distribution shape, mean, variance, skewness, and kurtosis, among others. EC generates IDF curves using the Gumbel distribution. The Gumbel distribution is a two-parameter, exponential distribution. Therefore, to ensure that the donor station data are homogeneous with the IDF curve data, it was decided to test the similarity of the distribution shape, the mean, and the variance, using tests that are robust to non-normal data. In addition, the overlapping data (the period of time where both types of precipitation measurement were active) were compared to determine if there was a strong correlation between the different measurement methods. This section describes the statistical tests chosen for this analysis.

The nonparametric two-sample Kolmogorov-Smirnov (Kolmogorov, 1933; Smirnov, 1948) test was chosen as the homogeneity test for similarity of the empirical distributions of the two samples. This test does not assume a distribution type for the data and only tests to determine if the two samples are similar to each other. It is sensitive to differences in both the mean and the shape of the empirical distributions. The test assumes a null hypothesis: that the two sets of data come from the same distribution. To calculate the test statistic, the largest difference between the two empirical cumulative distributions for both samples of data is found. The test statistic is compared to a table of critical values, at the chosen level of significance. If the test statistic is larger than the critical value, the null hypothesis is rejected and the alternate hypothesis (the two sets of data do not come from the same distribution) is accepted.

The nonparametric two-sample Mann-Whitney (Mann and Whitney, 1947) test was chosen as the homogeneity test for differences in the means of the two samples. The test does not assume anything about the distribution of the data, only that each observation is independent of the other observations. It is robust to outliers and non-normality. The test assumes a null hypothesis: that the two sets of data have the same mean. To calculate the test statistic, the data are ranked (regardless of group membership) and the ranks in each group are used instead of the actual data. The test statistic is compared to a table of critical values, at the chosen level of significance. If the test statistic is larger than the critical value, the null hypothesis is rejected and the alternate hypothesis (the two sets of data have different means) is accepted.

The two-sample Brown-Forsythe (Brown and Forsythe, 1974) test was chosen as the homogeneity test for differences in the variance of the two samples. The test does not assume a distribution type for the data, but does assume that the data come from a continuous distribution. The test is a modification of the Levene test (Levene, 1960), and uses the median instead of the mean as the definition of the central location point of the data. It is more robust than the Levene test to non-normality and outliers in the data. It has been shown to outperform many other variance tests (Conover et al., 1981). The test assumes a null hypothesis: that the two sets of data have the same variance. To calculate the test statistic, the squared differences between the data and the median are used. The test statistic is compared to a table of critical values, at the chosen level of significance. If the test statistic is larger than the critical value, the null hypothesis is rejected and the alternate hypothesis (the two sets of data have different variances) is accepted.

For this analysis, a 5 percent level of significance was chosen for all statistical tests. The tests were calculated using the "R" statistical analysis package (R Core Team, 2014). The tests returned a "p-value", which is the lowest level of significance at which the null hypothesis of homogeneity can be rejected. If the p-value was less than 0.05 (5 percent), the test indicated that the null hypothesis should be rejected and the two samples could not be assumed to be homogeneous.

If there were at least five data points in the time series, the above statistical tests were performed. In addition, a statistical summary comparing the means, standard deviations, and ranges of the two data sets was also prepared. If there were less than five data points in the time series, a statistical summary was produced but the statistical tests were not performed, because the tests are not robust to low numbers of data points. When there are very few data points, the degree of uncertainty in the test is very high which tends to result in a large number of Type I and Type II errors (false positives and false negatives). The statistical summary compared the means, standard deviations, and ranges of the two data sets.

1.2 Statistical Goodness-of-Fit Testing

After the data were checked for suitability with the above tests, the donor data were then added to the IDF curve data, and used to estimate the updated IDF curves. EC uses the Gumbel distribution for all IDF curves. Therefore, the Gumbel distribution was tested to determine if it was suitable for the updated IDF curves. Two goodness-of-fit tests were used: Kolmogorov-Smirnov and Chi-Square.

The Kolmogorov-Smirnov test was used in its one-parameter form for the goodness-of-fit test. The empirical cumulative distribution function (of the data) was compared to the theoretical Gumbel cumulative distribution function. The location and shape parameters of the Gumbel distribution were calculated from the data. The test assumes a null hypothesis: that the data follow a Gumbel distribution. To calculate the test statistic, the largest difference between the empirical cumulative distribution function and the theoretical Gumbel cumulative distribution function is found. The test statistic is compared to a table of critical values, at the chosen level of significance. If the test statistic is larger than the critical value, the null hypothesis is rejected and the alternate hypothesis (the data do not follow a Gumbel distribution) is accepted.

The Chi-Square goodness-of-fit test is a discrete parameter test (it is also known as Pearson's Chi-Square test). In order to calculate the test, the data must be divided into ranges, and the number of samples in each range must be determined. This results in loss of information and resolution in the data and represents a weakness of the test, particularly when the number of data points is small. The test is sensitive to the number of ranges chosen and the probabilities of each range. The use of equi-probable bins reduces the sensitivity. For a small number of observations, most authors recommend that the expected number of data points in each range should not be less than 5 (e.g., Croarkin and Tobias, 2015). For a large number of observations (35 or more), the number of ranges was chosen according to D'Agostino and Stephens (1986).

$$if\ N < 35, N_{ranges} = integer\left(\frac{N}{5}\right) \quad (1\text{-}1)$$
$$if\ N \geq 35, N_{ranges} = integer(1.88N^{0.4}) \quad (1\text{-}2)$$

where:

N_{ranges} is the number of ranges to use for the test
N is the number of data points

Each range was set to have an equal probability. The range limits were chosen as the quantiles of the theoretical Gumbel distribution with the given probabilities. For example, for four ranges each range has a probability of 0.25, so the range limits were set to 0, the quantile for a cumulative probability of 0.25, the quantile for a cumulative probability of 0.5, the quantile for a cumulative probability of 0.75, and the quantile for a cumulative probability of 1.00 (infinity). The number of data points in each range was tabulated. The test assumes a null hypothesis: that there is no difference between the actual number of data points and the expected number of data points in each range. The test statistic calculates the squared difference between the actual number of data points in each range and the expected number of data points in each range. The test statistic is compared to a table of critical values, at the chosen level of significance. If the test statistic is larger than the critical value, the null hypothesis is rejected and the alternate hypothesis (there is a difference between the actual number of data points and the expected number of data points in each range) is accepted. If the alternate hypothesis is accepted, the data do not follow the theoretical Gumbel distribution.

As for the statistical analysis for suitability, a 5 percent level of significance was chosen. The tests were calculated using the "R" statistical analysis package (R Core Team, 2014), and the p-value was used to accept or reject the null hypothesis.

1.3 Trend Testing

In the most recent release of IDF curves (V2.3, 2015), EC performed trend testing using the Mann-Kendall test combined with the Sen's slope estimator. This method was chosen as the trend test for this project. The method tests whether the data have a significant trend or can be considered to be stationary. The trend analysis was performed using the updated data set, and included both the EC IDF data and the updated data. EC's methodology is explained in detail in Shephard, et al. (2014). It is described briefly below.

The Mann-Kendall test (Mann, 1945; Kendall, 1975) is a nonparametric test that determines if there is a statistically significant monotonic trend in a set of data. The trend can be either increasing or decreasing, and does not have to be linear. The test assumes a null hypothesis: that the data do not have a trend. To calculate the test statistic, the sign of the difference between each two data points is found. If the difference is negative, a -1 is assigned; if the difference is positive, a +1 is assigned. The total of all of the signs of the differences is found. The test statistic is compared to a table of critical values, at the chosen level of significance. If the test statistic is larger than the critical value, the null hypothesis is rejected and the alternate hypothesis (there is a trend in the data) is accepted.

The Sen's slope (Theil, 1950; Sen, 1968) estimator is a robust, nonparametric method of determining the linear slope of the trend in a set of data. It is relatively insensitive to outliers (as compared to least-squares regression). The slope is defined as the median of the slopes between all pairs of points in the data set.

The EC trend testing method combines these two tests. The Mann-Kendall test is used to determine if there is a statistically significant trend in the data. The Sen's slope estimator is used to determine the magnitude of the slope. The confidence limits for the magnitude of the slope are found using the variance of the Mann-Kendall test statistic.

The EC method also corrects for autocorrelation in the data, as autocorrelation could cause an apparent trend in the data. The Mann-Kendall test is known to falsely identify trends when there is autocorrelation in the data (Von Storch and Navarra, 1995). Therefore, the portion of the trend that is due to autocorrelation is removed from the time series using an iterative process. The trend after the autocorrelation has been removed is then tested to determine if it is significant. The final slope and its 95 percent confidence limits are calculated for each duration. If the confidence limits for the slope are both positive or both negative, then the trend is statistically significant at the 5 percent level of significance. If the confidence limits include zero, then the trend is not statistically significant at the 5 percent level of significance.

Section 2.0 Statistical Analysis for Case 1 Stations

2.1 Daniels Harbour

The statistical homogeneity tests were applied to the annual maxima of the two data sets (from the IDF curve and from the weighing gauge) for each of the 6-, 12-, and 24-hr durations. The p-values for the tests are summarized in Table 2.1. For each duration, the correlation for the overlap period of the weighing gauge and the IDF curve data was high. For the overlap period, the 6-hr data did not come from the same distribution, but the 12- and 24-hr data did come from the same distribution. The 6-hr precipitation weighing gauge data were underestimated compared to the IDF curve 6-hr data for the overlap period, and as a result the two sets of data were not homogeneous. For the newer data sets and the data sets with the entire period of data from the weighing gauge, the statistical tests showed that the data come from the same distribution at the 5 percent level of significance.

Table 2.1 Daniels Harbour Statistical Homogeneity Tests

Duration	*Homogeneity Test*	*Overlapping Period[1]: IDF Curve Data & Weighing Gauge Data*	*Newer Data Period[2]: IDF Curve Data & Weighing Gauge Data*	*Entire Period[3]: IDF Curve Data & Weighing Gauge Data*
6-hr	Correlation Coefficient	0.85	N/A	N/A
	Kolmogorov-Smirnov	0.03[3]	0.59	0.08
	Mann-Whitney	0.06	0.24	0.06
	Brown-Forsythe	0.31	0.42	0.27
12-hr	Correlation Coefficient	0.94	N/A	N/A
	Kolmogorov-Smirnov	0.97	0.86	0.99
	Mann-Whitney	0.80	0.84	0.94
	Brown-Forsythe	0.92	0.14	0.44
24-hr	Correlation Coefficient	0.96	N/A	N/A
	Kolmogorov-Smirnov	0.99	0.20	0.96
	Mann-Whitney	0.92	0.31	0.71
	Brown-Forsythe	0.65	0.10	0.27

Notes:
1. Weighing gauge data from Daniels Harbour for 1969 to 1995
2. Weighing gauge data from Daniels Harbour for 1996 to 2014.
3. Weighing gauge data from Daniels Harbour for 1969 to 2014.
4. Red numbers indicate that the null hypothesis was rejected for this statistical test at the 5 percent significance level.

The newer 6-hr data were compared to the IDF data in Table 2.2. The means and standard deviations of the newer data were lower than the means and standard deviations of the IDF curve data for all three durations. The differences were not statistically significant. However, the addition of these data to the IDF curve data resulted in decreased Gumbel precipitation estimates, as the newer data were generally lower than the IDF curve data.

Table 2.2 Daniels Harbour 6-hr Data Summary

Duration	*Statistic*	*IDF Curve Data*	*6-hr Data*[1]
6-hr	Number of data points	26	16
	Mean [mm]	34.2	30.0
	Standard Deviation [mm]	10.8	8.4
	Minimum/Maximum [mm]	16.4/58.5	20.0/47.0
12-hr	Number of data points	26	16
	Mean [mm]	45.0	41.5
	Standard Deviation [mm]	16.5	7.7
	Minimum/Maximum [mm]	28.2/83.7	27.0/56.0
24-hr	Number of data points	26	14
	Mean [mm]	58.4	57.4
	Standard Deviation [mm]	25.7	11.9
	Minimum/Maximum [mm]	28.2/114.3	41.0/84.0

Notes:
1. Weighing gauge data from Daniels Harbour for 1996 to 2014.

The 6-hr precipitation weighing data were added to the IDF curve data, and the goodness-of-fit tests were applied to the augmented data set. All durations were tested. The p-values of the tests are summarized in Table 2.3. In general, both tests showed that the data fit the Gumbel distribution. There was one exception: according to the Chi-Square test, the 12-hr data did not fit the Gumbel distribution, but the Kolmogorov-Smirnov test indicated that the 12-hr data did fit the Gumbel distribution. Since only one of the tests indicated that the 12-hr data did not fit the Gumbel distribution, and all of the rest of the durations fit the Gumbel distribution well, the Gumbel distribution was used for this station.

Table 2.3 Daniels Harbour Goodness-of-Fit Testing

Duration	*Updated*	*Kolmogorov-Smirnov Test*	*Chi-Square Test*
5-min	No	0.18	0.05
10-min	No	0.52	0.11
15-min	No	0.81	0.46
30-min	No	0.94	0.92
1-hr	No	1.00	0.92
2-hr	No	0.71	0.86
6-hr	Yes	0.88	0.45
12-hr	Yes	0.45	0.03[1]
24-hr	Yes	0.47	0.41

Notes:
1. Red numbers indicate that the null hypothesis was rejected for this statistical test at the 5 percent significance level.

The trend testing (Table 2.4) showed that there were non-significant positive trends in the EC IDF data. After adding the newer data, the trends decreased (becoming negative for the 6-hr duration). The newer data were generally lower, and had lower standard deviations, and this was reflected in the decreasing slopes. However, the updated trends were not statistically significant.

Table 2.4 Daniels Harbour Trend Testing

Duration	*Updated*	*EC Sen's Slope [mm/yr] (95 percent Confidence Limits)*	*Updated Sen's Slope [mm/yr] (95 percent Confidence Limits)*
5-min	No	0.01 (0.11, -0.09)	N/A
10-min	No	0.02 (0.13, -0.06)	N/A
15-min	No	0.04 (0.19, -0.07)	N/A
30-min	No	0.11 (0.28, -0.10)	N/A
1-hr	No	0.11 (0.40, -0.15)	N/A
2-hr	No	0.08 (0.47, -0.32)	N/A
6-hr	Yes	0.33 (0.85, -0.15)	-0.11 (0.18, -0.33)
12-hr	Yes	0.26 (0.84, -0.27)	0.05 (0.27, -0.17)
24-hr	Yes	0.17 (1.17, -0.84)	0.17 (0.47, -0.20)

2.2 Gander Airport CS

The statistical homogeneity tests were applied to the IDF curve data and the 1-hr precipitation weighing gauge data for this station, but each series had very few data points. The IDF curve data came from more than one location, and only five of the points came from Gander Airport CS. Therefore, the tests were applied only to these five points. The annual maximum data for 2010 were added to these data as they came from the same data source (and were therefore homogeneous). The 1-hr and 6-hr data were available for the period from 2006 to 2010, a period of 5 years. The newer data tests could not be performed as there were only two data points (2012 and 2013), but the entire period data tests were performed. The p-values of the tests are summarized in Table 2.5. The statistical tests for the overlapping period of data indicated that the two methods were homogeneous for all durations. Using the entire period of 1-hr weighing gauge data, the statistical tests indicated that the data came from the same distribution.

Table 2.5 Gander Airport CS Statistical Homogeneity Tests

Duration	*Homogeneity Test*	*Overlapping Period[1]: IDF Curve Data & Weighing Gauge Data*	*Newer Data Period: IDF Curve Data & Weighing Gauge Data*	*Entire Period[2]: IDF Curve Data & Weighing Gauge Data*
1-hr	Correlation Coefficient	0.85	N/A	N/A
	Kolmogorov-Smirnov	0.87	N/A	0.43
	Mann-Whitney	0.84	N/A	0.53
	Brown-Forsythe	0.31	N/A	0.15
2-hr	Correlation Coefficient	0.96	N/A	N/A
	Kolmogorov-Smirnov	0.82	N/A	0.74
	Mann-Whitney	0.75	N/A	0.47
	Brown-Forsythe	0.46	N/A	0.28
6-hr	Correlation Coefficient	0.83	N/A	N/A
	Kolmogorov-Smirnov	1.00	N/A	0.43
	Mann-Whitney	1.00	N/A	0.30
	Brown-Forsythe	0.29	N/A	0.12
12-hr	Correlation Coefficient	0.98	N/A	N/A
	Kolmogorov-Smirnov	1.00	N/A	0.53
	Mann-Whitney	1.00	N/A	0.37
	Brown-Forsythe	0.35	N/A	0.21
24-hr	Correlation Coefficient	1.00	N/A	N/A
	Kolmogorov-Smirnov	0.87	N/A	0.43
	Mann-Whitney	1.00	N/A	0.30
	Brown-Forsythe	0.56	N/A	0.16

Notes:
1. Weighing gauge data from Gander Airport CS for 2006 to 2010.
2. Weighing gauge data from Gander Airport CS for 2006 to 2013.

There was only one annual maximum in the 15-min data: 2013. Therefore, the statistical tests could not be performed. The 15-min data matched well with the 1-hr data for all durations of 1-hr and longer and also matched well with the 6-hr data for all durations of 6-hr and longer. The 1-hr data were included in the statistical tests above, and the tests indicated that the 1-hr data came from the same underlying distribution as the IDF curve data. Therefore, it was assumed that the 15-min data also came from the same distribution. The 1-hr and 15-min data were compared to the IDF data in Table 2.6. For the 15-min and 30-min durations, the 15-min data were within the observed variation of the IDF curve data. For the longer durations, the 1-hr and 15-min data were outside of the observed variation. However, since both sets of data agreed with the QA/QC'd 6-hr data, they were assumed to be correct. These results indicate the effect of the large precipitation events in the recent years at this station.

Table 2.6 Gander Airport 1-hr and 15-min Data Summary

Duration	*Statistic*	*IDF Curve Data*	*1-hr Data*[1]	*15-min Data*[2]
15-min	Number of data points	6	N/A	1
	Mean [mm]	10.4	N/A	10.0
	Standard Deviation [mm]	5.0	N/A	N/A
	Minimum/Maximum [mm]	5.4/18.0	N/A	10.0/10.0
30-min	Number of data points	6	N/A	1
	Mean [mm]	13.1	N/A	14.0
	Standard Deviation [mm]	4.9	N/A	N/A
	Minimum/Maximum [mm]	7.6/20.0	N/A	14.0/14.0
1-hr	Number of data points	6	3	1
	Mean [mm]	16.6	22.7	23.9
	Standard Deviation [mm]	3.7	3.7	N/A
	Minimum/Maximum [mm]	11.6/20	18.5/25.7	23.9/23.9
2-hr	Number of data points	6	3	1
	Mean [mm]	23.6	32.5	41.3
	Standard Deviation [mm]	6.1	7.7	N/A
	Minimum/Maximum [mm]	18.0/32.6	25.7/40.9	41.3/41.3
6-hr	Number of data points	6	3	1
	Mean [mm]	40.8	58.6	70.3
	Standard Deviation [mm]	6.5	8.5	N/A
	Minimum/Maximum [mm]	35.0/53.2	52.5/68.3	70.3/70.3
12-hr	Number of data points	6	3	1
	Mean [mm]	51.6	83.1	101.0
	Standard Deviation [mm]	11.4	16.5	N/A
	Minimum/Maximum [mm]	38.2/70.4	65.9/98.8	101.0/101.0
24-hr	Number of data points	6	3	1
	Mean [mm]	59.7	122.1	124.5
	Standard Deviation [mm]	19.6	17.4	N/A
	Minimum/Maximum [mm]	43.2/98.4	103.6/138.2	124.5/124.5

Notes:
1. 1-hr Weighing gauge data from Gander Airport CS for 2010 to 2013.
2. 1-hr Weighing gauge data from Gander Airport CS for 2013.

The additional data were added to the IDF curve data, and the goodness-of-fit tests were applied to the augmented data set. All durations were tested. The p-values of the tests are summarized in Table 2.7. Both tests showed that the data fit the Gumbel distribution for all durations. Therefore, the Gumbel distribution was used for this station.

Table 2.7 Gander Airport CS Goodness-of-Fit Testing

Duration	*Updated*	*Kolmogorov-Smirnov Test*	*Chi-Square Test*
5-min	Yes	0.63	0.25
10-min	Yes	0.94	0.89
15-min	Yes	0.93	0.97
30-min	Yes	0.60	0.48
1-hr	Yes	0.64	0.29
2-hr	Yes	0.52	0.29
6-hr	Yes	0.91	0.75
12-hr	Yes	0.63	0.25
24-hr	Yes	0.42	0.13

The trend testing (Table 2.8) showed that there were statistically significant trends in the EC IDF data for the 6-, and 12-, and 24-hr durations. After adding the newer data, the trends increased. The newer data were generally higher, and this was reflected in the increasing slopes. The updated trends for the 6-, 12-, and 24-hr durations were still statistically significant.

Table 2.8 Gander Airport CS Trend Testing

Duration	*Updated*	*EC Sen's Slope [mm/yr] (95 percent Confidence Limits)*	*Updated Sen's Slope [mm/yr] (95 percent Confidence Limits)*
5-min	Yes	0.00 (0.03, -0.02)	0.01 (0.03, -0.02)
10-min	Yes	-0.01 (0.03, -0.05)	0.00 (0.04, -0.04)
15-min	Yes	-0.01 (0.04, -0.06)	0.00 (0.05, -0.05)
30-min	Yes	0.00 (0.06, -0.06)	0.01 (0.07, -0.05)
1-hr	Yes	0.02 (0.09, -0.04)	0.05 (0.12, -0.02)
2-hr	Yes	0.07 (0.15, -0.02)	0.09 (0.18, -0.00)
6-hr	Yes	0.15 (0.29, 0.02)	0.20 (0.37, 0.05)
12-hr	Yes	0.20 (0.32, 0.07)	0.27 (0.43, 0.10)
24-hr	Yes	0.27 (0.45, 0.06)	0.35 (0.54, 0.10)

Notes:
Red numbers indicate that the Sen slope was statistically significant (positive) at the 5 percent significance level.

2.3 La Scie

For this station, there were 6-hr data and 1-hr data. There were sufficient data to perform the statistical tests for the 6-hr data, but insufficient data to perform the statistical tests for the 1-hr data. Therefore, the statistical homogeneity tests for this station were applied for the IDF curve and the 6-hr weighing gauge data at the station. The 6-hr weighing gauge data were tested against the IDF curve data with the statistical tests. The p-values of the tests are summarized in Table 2.9. The statistical tests with the overlapping data indicated that the two methods were homogeneous for all durations. However, the correlation coefficients were low (less than 0.8). This was mainly due to a single outlier, where the 6-hr data identified a storm in

October, 1992 when the TBRG was not active. The 6-hr data for the storm in October, 1992 passed the QA/QC, and the temperatures were above 0°C. However, a different storm was used in the IDF curve. There were only three newer annual maxima in the 6-hr weighing gauge data (2003, 2004, and 2006), so the statistical tests were not performed for the newer period. Using the entire period of the 6-hr weighing gauge data, the statistical tests also indicated that the data came from the same distribution as the IDF data.

Table 2.9 La Scie Statistical Homogeneity Tests

Duration	*Homogeneity Test*	*Overlapping Period[1]: IDF Curve Data & Weighing Gauge Data*	*Newer Data Period: IDF Curve Data & Weighing Gauge Data*	*Entire Period[2]: IDF Curve Data & Weighing Gauge Data*
6-hr	Correlation Coefficient	0.73	N/A	N/A
	Kolmogorov-Smirnov	0.99	N/A	0.99
	Mann-Whitney	0.76	N/A	0.70
	Brown-Forsythe	0.56	N/A	0.55
12-hr	Correlation Coefficient	0.77	N/A	N/A
	Kolmogorov-Smirnov	1.00	N/A	0.99
	Mann-Whitney	0.95	N/A	0.74
	Brown-Forsythe	0.95	N/A	0.91
24-hr	Correlation Coefficient	0.79	N/A	N/A
	Kolmogorov-Smirnov	1.00	N/A	0.92
	Mann-Whitney	0.90	N/A	0.78
	Brown-Forsythe	0.60	N/A	0.53

Notes:
1. Weighing gauge data from La Scie for 1984 to 1995.
2. Weighing gauge data from La Scie for 1984 to 2006.

There were only two annual maxima in the 1-hr data. Therefore, the statistical tests were not performed. The 1-hr data matched well with the 6-hr data for all durations of 6-hr and longer. The 6-hr data were included in the statistical tests above, and the tests indicated that the 6-hr data came from the same underlying distribution as the IDF curve data. Therefore, it was assumed that the 1-hr data also came from the same distribution. The 6-hr and 1-hr data were compared to the IDF data in Table 2.10. The data were within the observed variation of the IDF curve data for all durations. However, the means were generally lower, except for the 24-hr duration.

Table 2.10 La Scie 6-hr and 1-hr Data Summary

Duration	*Statistic*	*IDF Curve Data*	*6-hr Data*[1]	*1-hr Data*[2]
1-hr	Number of data points	12	N/A	2
	Mean [mm]	11.4	N/A	11.0
	Standard Deviation [mm]	3.9	N/A	N/A
	Minimum/Maximum [mm]	6.3/17.2	N/A	10.1/11.9
2-hr	Number of data points	12	N/A	2
	Mean [mm]	16.5	N/A	16.1
	Standard Deviation [mm]	5.2	N/A	N/A
	Minimum/Maximum [mm]	9.0/27.0	N/A	13.7/20.8
6-hr	Number of data points	11	3	2
	Mean [mm]	28.7	27.0	31.7
	Standard Deviation [mm]	9.8	8.9	N/A
	Minimum/Maximum [mm]	15.6/47.3	20.0/37.7	21.8/42.8
12-hr	Number of data points	11	3	2
	Mean [mm]	42.4	36.3	41.4
	Standard Deviation [mm]	13.4	9.5	N/A
	Minimum/Maximum [mm]	24.1/68.6	29.0/47.0	28.8/49.7
24-hr	Number of data points	11	3	2
	Mean [mm]	53.8	56.0	66.9
	Standard Deviation [mm]	13.3	17.4	N/A
	Minimum/Maximum [mm]	34.5/79.7	36.0/68.0	41.2/68.6

Notes:
1. 6-hr Weighing gauge data from La Scie for 2003, 2004 and 2006.
2. 1-hr Weighing gauge data from La Scie for 2004 and 2006.

The additional data were added to the IDF curve data, and the goodness-of-fit tests were applied to the augmented data set. All durations were tested. The p-values of the tests are summarized in Table 2.11. Both tests showed that the data fit the Gumbel distribution for all durations. Therefore, the Gumbel distribution was used for this station.

Table 2.11 La Scie Goodness-of-Fit Testing

Duration	*Updated*	*Kolmogorov-Smirnov Test*	*Chi-Square Test*
5-min	No	1.00	1.00
10-min	No	0.97	0.56
15-min	No	0.94	1.00
30-min	No	0.95	1.00
1-hr	Yes	0.92	0.59
2-hr	Yes	0.95	1.00
6-hr	Yes	0.99	0.59
12-hr	Yes	0.96	0.59
24-hr	Yes	0.67	0.29

The trend testing (Table 2.12) showed that there were non-statistically significant trends in the EC IDF data. The 2-, 6-, and 12-hr durations were decreasing, and the 24-hr duration was increasing. The newer data increased the trends for the 2-, 6-, and 12-hr durations, and decreased the trend for the 24-hr duration. The updated trends were not statistically significant.

Table 2.12 La Scie Trend Testing

Duration	*Updated*	*EC Sen's Slope [mm/yr] (95 percent Confidence Limits)*	*Updated Sen's Slope [mm/yr] (95 percent Confidence Limits)*
5-min	No	0.09 (0.36, -0.17)	N/A
10-min	No	0.23 (0.63, -0.13)	N/A
15-min	No	0.47 (1.17, -0.10)	N/A
30-min	No	0.80 (1.51, -0.33)	N/A
1-hr	Yes	0.34 (0.95, -0.56)	0.06 (0.63, -0.42)
2-hr	Yes	-0.11 (1.11, -1.11)	-0.07 (0.39, -0.66)
6-hr	Yes	-0.70 (1.57, -3.32)	-0.18 (0.69, -1.30)
12-hr	Yes	-0.97 (3.07, -3.59)	-0.32 (0.86, -2.01)
24-hr	Yes	0.90 (4.25, -2.35)	0.62 (1.81, -1.09)

2.4 Port Aux Basques

The statistical homogeneity tests for this station were applied for the IDF curve and the 6-hr weighing gauge data at the station. There was no overlap between the 6-hr weighing gauge data and the IDF curve data. Therefore, only the newer 6-hr weighing gauge data were tested with the statistical tests. The p-values of the statistical tests are summarized in Table 2.13. The tests indicated that the distribution was similar and the mean was homogeneous with the IDF curve data for all durations, but the variance was not homogeneous for the 6-hr duration.

Table 2.13 Port Aux Basques Statistical Homogeneity Tests

Duration	*Homogeneity Test*	*Overlapping Period: IDF Curve Data & Weighing Gauge Data*	*Newer Data Period[1]: IDF Curve Data & Weighing Gauge Data*	*Entire Period: IDF Curve Data & Weighing Gauge Data*
6-hr	Correlation Coefficient	N/A	N/A	N/A
	Kolmogorov-Smirnov	N/A	0.23	N/A
	Mann-Whitney	N/A	0.18	N/A
	Brown-Forsythe	N/A	0.03[2]	N/A
12-hr	Correlation Coefficient	N/A	N/A	N/A
	Kolmogorov-Smirnov	N/A	0.19	N/A
	Mann-Whitney	N/A	0.09	N/A
	Brown-Forsythe	N/A	0.08	N/A

Duration	*Homogeneity Test*	*Overlapping Period: IDF Curve Data & Weighing Gauge Data*	*Newer Data Period[1]: IDF Curve Data & Weighing Gauge Data*	*Entire Period: IDF Curve Data & Weighing Gauge Data*
24-hr	Correlation Coefficient	N/A	N/A	N/A
	Kolmogorov-Smirnov	N/A	0.16	N/A
	Mann-Whitney	N/A	0.11	N/A
	Brown-Forsythe	N/A	0.06	N/A

Notes:
1. Weighing gauge data for Port Aux Basques for 1997 to 2014.
2. Red numbers indicate that the null hypothesis was rejected for this statistical test at the 5 percent significance level.

The newer 6-hr data were compared to the IDF data in Table 2.14. The means and standard deviations of the newer data were lower than the means and standard deviations of the IDF curve data for all three durations. The differences were not statistically significant, except for the difference in variance for the 6-hr data. However, the addition of these data to the IDF curve data resulted in decreased Gumbel precipitation estimates, as the newer data were generally lower than the IDF curve data.

Table 2.14 Port Aux Basques 6-hr Data Summary

Duration	*Statistic*	*IDF Curve Data*	*6-hr Data[1]*
6-hr	Number of data points	19	14
	Mean [mm]	47.4	39.9
	Standard Deviation [mm]	15.5	8.5
	Minimum/Maximum [mm]	22.5/74.1	25.0/57.0
12-hr	Number of data points	19	14
	Mean [mm]	60.7	51.9
	Standard Deviation [mm]	17.3	10.4
	Minimum/Maximum [mm]	32.0/92.0	39.0/72.0
24-hr	Number of data points	20	15
	Mean [mm]	75.1	63.9
	Standard Deviation [mm]	22.3	14.0
	Minimum/Maximum [mm]	42.4/118.0	42.0/100.0

Notes:
1. Weighing gauge data from Port Aux Basques for 1999 to 2014.

The additional data were added to the IDF curve data, and the goodness-of-fit tests were applied to the augmented data set. All durations were tested. The p-values of the tests are summarized in Table 2.15. Both tests showed that the data fit the Gumbel distribution for all durations. Therefore, the Gumbel distribution was used for this station.

Table 2.15 Port Aux Basques Goodness-of-Fit Testing

Duration	*Updated*	*Kolmogorov-Smirnov Test*	*Chi-Square Test*
5-min	No	0.33	0.06
10-min	No	0.89	0.95
15-min	No	0.90	0.81
30-min	No	0.87	0.95
1-hr	No	0.84	0.81
2-hr	No	0.75	0.69
6-hr	Yes	0.57	0.14
12-hr	Yes	0.93	0.90
24-hr	Yes	1.00	0.72

The trend testing (Table 2.16) showed that there were non-statistically significant negative trends for the 6-, 12-, and 24-hr durations in the EC IDF data. The newer data had a lower mean than the EC IDF data and the trends were still negative after the update. The updated trends were not statistically significant.

Table 2.16 Port Aux Basques Trend Testing

Duration	*Updated*	*EC Sen's Slope [mm/yr] (95 percent Confidence Limits)*	*Updated Sen's Slope [mm/yr] (95 percent Confidence Limits)*
5-min	No	0.00 (0.12, -0.07)	N/A
10-min	No	0.02 (0.23, -0.23)	N/A
15-min	No	0.01 (0.32, -0.30)	N/A
30-min	No	0.09 (0.51, -0.37)	N/A
1-hr	No	0.13 (0.62, -0.27)	N/A
2-hr	No	-0.17 (0.70, -0.84)	N/A
6-hr	Yes	-0.53 (1.08, -2.10)	-0.30 (0.02, -0.71)
12-hr	Yes	-0.41 (1.97, -2.02)	-0.56 (0.02, -1.34)
24-hr	Yes	-0.85 (3.12, -4.94)	-0.37 (0.39, -1.28)

2.5 Wabush Lake A

The statistical homogeneity tests were applied to the annual maxima of the two data sets (from the IDF curve and from the weighing gauge) at each of the 6-, 12-, and 24-hr durations. The p-values for the statistical tests are summarized in Table 2.17. For each duration, the correlation between the overlapping weighing gauge data and the IDF curve data was high, and the overlapping weighing gauge data and IDF curve data came from the same distribution. The newer data and all of the 6-hr weighing gauge data also tested as homogeneous with the IDF curve data.

Table 2.17 Wabush Lake A Statistical Homogeneity Tests

Duration	*Homogeneity Test*	*Overlapping Period[1]: IDF Curve Data & Weighing Gauge Data*	*Newer Data Period[2]: IDF Curve Data & Weighing Gauge Data*	*Entire Period[3]: IDF Curve Data & Weighing Gauge Data*
6-hr	Correlation Coefficient	0.87	N/A	N/A
	Kolmogorov-Smirnov	0.86	0.59	0.99
	Mann-Whitney	0.45	0.39	0.76
	Brown-Forsythe	0.42	0.80	0.53
12-hr	Correlation Coefficient	0.84	N/A	N/A
	Kolmogorov-Smirnov	0.83	0.76	0.96
	Mann-Whitney	0.65	0.43	0.94
	Brown-Forsythe	0.45	0.90	0.64
24-hr	Correlation Coefficient	0.89	N/A	N/A
	Kolmogorov-Smirnov	0.97	0.59	0.99
	Mann-Whitney	0.92	0.36	0.68
	Brown-Forsythe	0.92	0.87	0.97

Notes:
1. Weighing gauge data from Wabush Lake A for 1974 to 2003.
2. Weighing gauge data from Wabush Lake A for 2004 to 2012.
3. Weighing gauge data from Wabush Lake A for 1974 to 2012.

The newer 6-hr data were compared to the IDF data in Table 2.18. The means of the newer data were higher than the IDF curve for all three durations. The standard deviations and ranges were higher for the 12- and 24-hr durations. Therefore, the newer data were generally higher than the existing IDF curve data, and the precipitation at this station has been increasing relative to the EC IDF Curve.

Table 2.18 Wabush Lake A 6-hr Data Summary

Duration	*Statistic*	*IDF Curve Data*	*6-hr Data[1]*
6-hr	Number of data points	27	9
	Mean [mm]	21.8	23.4
	Standard Deviation [mm]	6.6	6.2
	Minimum/Maximum [mm]	9.2/36.6	15.0/33.0
12-hr	Number of data points	27	9
	Mean [mm]	28.9	31.8
	Standard Deviation [mm]	7.7	9.9
	Minimum/Maximum [mm]	14.5/45.6	21.0/53.0
24-hr	Number of data points	27	9
	Mean [mm]	35.9	39.6
	Standard Deviation [mm]	9.9	10.9
	Minimum/Maximum [mm]	19.7/62.0	30.6/66.0

Notes:
1. Weighing gauge data from Wabush Lake A for 2004 to 2012.

The 6-hr precipitation weighing data were added to the IDF curve data, and the goodness-of-fit tests were applied to the augmented data set. All durations were tested. The p-values of the tests are summarized in Table 2.19. In general, both tests showed that the data fit the Gumbel distribution. There was one exception: according to the Chi-Square Test, the 15-min data did not fit the Gumbel distribution. However, this duration was not updated, and EC has produced the IDF curve with the Gumbel distribution in the past. Therefore it was not changed and the Gumbel distribution was used for this station.

Table 2.19 Wabush Lake A Goodness-of-Fit Testing

Duration	*Updated*	*Kolmogorov-Smirnov Test*	*Chi-Square Test*
5-min	No	0.68	0.15
10-min	No	0.63	0.13
15-min	No	0.26	0.00[1]
30-min	No	0.83	0.66
1-hr	No	0.68	0.53
2-hr	No	0.48	0.12
6-hr	Yes	0.83	0.42
12-hr	Yes	0.90	0.94
24-hr	Yes	0.99	0.47

Notes:
1. Red numbers indicate that the null hypothesis was rejected for this statistical test at the 5 percent significance level.

The trend testing (Table 2.20) showed that there were negative trends in the EC IDF data (statistically significant for the 2-hr duration). The newer data were higher, however, and after adding the newer data, the trends increased in value (became closer to zero).

Table 2.20 Wabush Lake A Trend Testing

Duration	*Updated*	*EC Sen's Slope [mm/yr] (95 percent Confidence Limits)*	*Updated Sen's Slope [mm/yr] (95 percent Confidence Limits)*
5-min	No	0.00 (0.10, -0.10)	N/A
10-min	No	0.00 (0.11, -0.15)	N/A
15-min	No	-0.01 (0.11, -0.16)	N/A
30-min	No	-0.12 (0.08, -0.35)	N/A
1-hr	No	-0.19 (0.01, -0.44)	N/A
2-hr	No	-0.36 (-0.11, -0.63)	N/A
6-hr	Yes	-0.32 (0.01, -0.65)	0.00 (0.25, -0.26)
12-hr	Yes	-0.38 (0.41, -1.03)	-0.11 (0.32, -0.46)
24-hr	Yes	-0.45 (0.27, -0.99)	-0.27 (0.32, -0.42)

Notes:
Blue numbers indicate that the Sen slope was statistically significant (negative) at the 5 percent significance level.

Section 3.0 Statistical Analysis for Case 1 and Case 2 Stations

3.1 Deer Lake A

The statistical homogeneity tests were applied to the annual maxima of the two data sets (from the IDF curve and from the weighing gauges at both stations) at each of the 6-, 12-, and 24-hr durations. The data for the station at Deer Lake A (8401502) were combined with the data for the station at Deer Lake A (8401501) prior to performing the statistical tests as the two stations are less than 1 km apart. The p-values for the tests are summarized in Table 3.1. For each duration, the correlation between the overlapping weighing gauge data and the IDF curve data was high, and the overlapping weighing gauge data and IDF curve data come from the same distribution. For the newer data set, most of the statistical tests showed that the data came from the same probability distribution at the 5 percent level of significance (the exception is highlighted in red). As the majority of the tests indicated that the data sets were homogeneous, it was concluded that these data could be combined to produce a new IDF curve for this station.

Table 3.1 Deer Lake A Statistical Homogeneity Tests

Duration	*Homogeneity Test*	*Overlapping Period[1]: IDF Curve Data & Weighing Gauge Data*	*Newer Data Period[2]: IDF Curve Data & Weighing Gauge Data*	*Entire Period[3]: IDF Curve Data & Weighing Gauge Data*
6-hr	Correlation Coefficient	0.85	N/A	N/A
	Kolmogorov-Smirnov	0.54	0.63	0.62
	Mann-Whitney	0.18	0.28	0.15
	Brown-Forsythe	0.59	0.91	0.72
12-hr	Correlation Coefficient	0.92	N/A	N/A
	Kolmogorov-Smirnov	0.61	0.37	0.92
	Mann-Whitney	0.45	0.26	0.85
	Brown-Forsythe	0.49	0.33	0.27
24-hr	Correlation Coefficient	0.91	N/A	N/A
	Kolmogorov-Smirnov	0.99	0.19	0.68
	Mann-Whitney	0.94	0.09	0.55
	Brown-Forsythe	0.65	0.01[4]	0.17

Notes:
1. Weighing gauge data from Deer Lake A (8401501) for 1966 to 2002.
2. Weighing gauge data from Deer Lake A (8401501) and Deer Lake A (8401502) from 2003 to 2014.
3. Weighing gauge data from Deer Lake A (8401501) and Deer Lake A (8401502) from 1966 to 2014.
4. Red numbers indicate that the null hypothesis was rejected for this statistical test at the 5 percent significance level.

The newer 6-hr data for both Deer Lake A (8401501) and Deer Lake A (8401502) were compared to the IDF data in Table 3.2. The means of the newer data were lower than the IDF curve data for the 6-hr duration and higher than the IDF curve for the 12- and 24-hr durations. The standard deviations and ranges were higher for the 12- and 24-hr durations. Therefore, the precipitation at this station has generally been increasing, but the precipitation estimates may decrease for the 6-hr duration.

Table 3.2 Deer Lake A 6-hr Data Summary

Duration	*Statistic*	*IDF Curve Data*	*6-hr Data from Deer Lake A (8401501)*[1]	*6-hr Data from Deer Lake A (8401502)*[2]
6-hr	Number of data points	36	9	3
	Mean [mm]	30.9	29.9	23.7
	Standard Deviation [mm]	7.6	8.7	1.5
	Minimum/Maximum [mm]	18.2/46.9	18.0/43.0	22.0/25.0
12-hr	Number of data points	36	9	3
	Mean [mm]	38.4	45.6	32.0
	Standard Deviation [mm]	8.8	9.7	5.0
	Minimum/Maximum [mm]	25.7/59.0	28.0/58.0	27.0/37.0
24-hr	Number of data points	36	9	3
	Mean [mm]	44.6	59.9	38.7
	Standard Deviation [mm]	10.1	15.9	3.2
	Minimum/Maximum [mm]	26.7/70.1	35.2/80.0	35.0/41.0

Notes:
1. Weighing gauge data from Deer Lake A (8401501) for 2003 to 2011.
2. Weighing gauge data from Deer Lake A (8401502) for 2012 to 2014.

The 6-hr precipitation weighing data were added to the IDF curve data, and the goodness-of-fit tests were applied to the augmented data set. All durations were tested. The p-values of the tests are summarized in Table 3.3. Both tests showed that the data fit the Gumbel distribution. Therefore, the Gumbel distribution was used for this station.

Table 3.3 Deer Lake A Goodness-of-Fit Testing

Duration	*Updated*	*Kolmogorov-Smirnov Test*	*Chi-Square Test*
5-min	No	0.47	0.34
10-min	No	0.83	0.42
15-min	No	0.79	0.62
30-min	No	0.42	0.57
1-hr	No	0.69	0.47
2-hr	No	1.00	0.99
6-hr	Yes	0.83	0.78
12-hr	Yes	0.86	0.74
24-hr	Yes	0.71	0.23

The trend testing (Table 3.4) showed that there were non-statistically significant positive trends in the EC IDF data. The newer data generally continued the trend (except for the 6-hr duration) and after adding the newer data, the trends stayed the same or increased. The updated trends were not statistically significant.

Table 3.4 Deer Lake A Trend Testing

Duration	*Updated*	*EC Sen's Slope [mm/yr] (95 percent Confidence Limits)*	*Updated Sen's Slope [mm/yr] (95 percent Confidence Limits)*
5-min	No	0.00 (0.05, -0.05)	N/A
10-min	No	0.01 (0.09, -0.06)	N/A
15-min	No	0.02 (0.11, -0.07)	N/A
30-min	No	0.07 (0.17, -0.03)	N/A
1-hr	No	0.08 (0.21, -0.01)	N/A
2-hr	No	0.16 (0.32, -0.02)	N/A
6-hr	Yes	0.05 (0.30, -0.24)	0.05 (0.12, -0.23)
12-hr	Yes	0.13 (0.39, -0.18)	0.13 (0.34, -0.08)
24-hr	Yes	0.04 (0.36, -0.32)	0.13 (0.43, -0.13)

Section 4.0 Statistical Analysis for Case 2 Stations

4.1 Churchill Falls A

The statistical homogeneity tests for this station were applied for the IDF curve and the 6-hr weighing gauge data at the nearby station. There was no overlap in the data, and therefore the overlap period analysis was not performed. The p-values of the statistical tests are summarized in Table 4.1. The statistical tests indicated that the newer 6-hr weighing gauge data and the IDF 6-hr data came from the same distribution. The entire period was not analyzed because the entire period was the same period as the newer period.

Table 4.1 Churchill Falls A Statistical Homogeneity Tests

Duration	*Homogeneity Test*	*Overlapping Period: IDF Curve Data & Weighing Gauge Data*	*Newer Data Period[1]: IDF Curve Data & Weighing Gauge Data*	*Entire Period: IDF Curve Data & Weighing Gauge Data*
6-hr	Correlation Coefficient	N/A	N/A	N/A
	Kolmogorov-Smirnov	N/A	0.51	N/A
	Mann-Whitney	N/A	0.57	N/A
	Brown-Forsythe	N/A	0.26	N/A
12-hr	Correlation Coefficient	N/A	N/A	N/A
	Kolmogorov-Smirnov	N/A	0.31	N/A
	Mann-Whitney	N/A	0.17	N/A
	Brown-Forsythe	N/A	0.98	N/A
24-hr	Correlation Coefficient	N/A	N/A	N/A
	Kolmogorov-Smirnov	N/A	0.80	N/A
	Mann-Whitney	N/A	0.43	N/A
	Brown-Forsythe	N/A	0.87	N/A

Notes:
1. Weighing gauge data from Churchill Falls (8501130) for 1993 to 2011.

In late 2011, the station was moved to Churchill Falls A (8501131). There were between 1 and 3 annual maxima available at this station (some data were removed because they were marked as raw). The newer 6-hr data from Churchill Falls A (8501131) and Churchill Fall (8501130) were compared to the IDF data in Table 4.2. The means of the newer data were higher than the IDF curve for all three durations. The standard deviations and ranges were higher for the 6- and 24-hr durations. Therefore, the newer data were generally higher than the existing IDF curve data, and the precipitation at this station has been increasing relative to the EC IDF curve.

Table 4.2 Churchill Falls A 6-hr Data Summary

Duration	*Statistic*	*IDF Curve Data*	*6-hr Data from Churchill Falls (8501130)*[1]	*6-hr Data from Churchill Falls A (8501131)*[2]
6-hr	Number of data points	23	15	1
	Mean [mm]	21.6	23.2	19.0
	Standard Deviation [mm]	6.3	8.3	N/A
	Minimum/Maximum [mm]	12.7/35.8	13.0/41.0	19.0/19.0
12-hr	Number of data points	23	16	2
	Mean [mm]	28.9	31.3	32.5
	Standard Deviation [mm]	8.2	7.3	N/A
	Minimum/Maximum [mm]	18.8/53.3	19.0/45.0	32.0/33.0
24-hr	Number of data points	23	16	2
	Mean [mm]	36.3	38.5	41.2
	Standard Deviation [mm]	8.8	9.5	N/A
	Minimum/Maximum [mm]	22.7/59.9	29.0/66.0	38.8/43.5

Notes:
1. Weighing gauge data from Churchill Falls (8501130) for 1994 to 2011.
2. Weighing gauge data from Churchill Falls A (8501131) for 2012 to 2013.

The 6-hr precipitation weighing data were added to the IDF curve data, and the goodness-of-fit tests were applied to the augmented data set. All durations were tested. The p-values of the tests are summarized in Table 4.3. Both tests showed that the data fit the Gumbel distribution. Therefore, the Gumbel distribution was used for this station.

Table 4.3 Churchill Falls A Goodness-of-Fit Testing

Duration	*Updated*	*Kolmogorov-Smirnov Test*	*Chi-Square Test*
5-min	No	1.00	0.92
10-min	No	0.88	0.76
15-min	No	0.61	0.99
30-min	No	0.89	0.84
1-hr	No	0.96	0.46
2-hr	No	0.41	0.27
6-hr	Yes	0.99	0.92
12-hr	Yes	0.99	0.89
24-hr	Yes	0.97	0.15

The trend testing (Table 4.4) showed that there were no statistically significant negative trends in the EC IDF data for the 6-, 12-, and 24-hr durations. The newer data were generally higher however, and after adding the newer data, the trends increased in value, becoming positive for the 12- and 24-hr durations. The updated trends were not statistically significant at this location.

Table 4.4 Churchill Falls A Trend Testing

Duration	*Updated*	*EC Sen's Slope [mm/yr] (95 percent Confidence Limits)*	*Updated Sen's Slope [mm/yr] (95 percent Confidence Limits)*
5-min	No	0.04 (0.21, -0.10)	N/A
10-min	No	-0.05 (0.25, -0.20)	N/A
15-min	No	-0.05 (0.32, -0.20)	N/A
30-min	No	0.08 (0.44, -0.19)	N/A
1-hr	No	0.09 (0.36, -0.16)	N/A
2-hr	No	0.00 (0.27, -0.20)	N/A
6-hr	Yes	-0.22 (0.21, -0.60)	-0.05 (0.14, -0.23)
12-hr	Yes	-0.31 (0.18, -0.78)	0.06 (0.24, -0.15)
24-hr	Yes	-0.13 (0.35, -0.79)	0.07 (0.26, -0.11)

4.2 Mary's Harbour A

The statistical homogeneity tests for this station were applied for the IDF curve and the 6-hr weighing gauge data at the Mary's Harbour A (8502591) station and Mary's Harbour (850B5R1) station. The Mary's Harbour (850B5R1) station is less than 1 km away from the IDF curve station. Therefore, the data were assumed to be homogeneous with the 6-hr weighing data at the IDF curve station. The p-values of the statistical tests are summarized in Table 4.5. The correlation coefficient between the precipitation weighing gauge data and the TBRG data was low (less than 0.8) for the 6-hr duration; however, the statistical tests indicated that the data come from the same distribution. The newer data and all of the data tested as homogeneous.

Table 4.5 Mary's Harbour A Statistical Homogeneity Tests

Duration	*Homogeneity Test*	*Overlapping Period[1]: IDF Curve Data & Weighing Gauge Data*	*Newer Data Period[2]: IDF Curve Data & Weighing Gauge Data*	*Entire Period[3]: IDF Curve Data & Weighing Gauge Data*
6-hr	Correlation Coefficient	0.72	N/A	N/A
	Kolmogorov-Smirnov	0.73	0.36	0.61
	Mann-Whitney	0.72	0.50	0.83
	Brown-Forsythe	0.35	0.66	0.38
12-hr	Correlation Coefficient	0.86	N/A	N/A
	Kolmogorov-Smirnov	1.00	1.00	1.00
	Mann-Whitney	1.00	0.91	0.94
	Brown-Forsythe	0.99	0.44	0.62

Duration	*Homogeneity Test*	*Overlapping Period[1]: IDF Curve Data & Weighing Gauge Data*	*Newer Data Period[2]: IDF Curve Data & Weighing Gauge Data*	*Entire Period[3]: IDF Curve Data & Weighing Gauge Data*
24-hr	Correlation Coefficient	0.85	N/A	N/A
	Kolmogorov-Smirnov	0.97	0.97	0.92
	Mann-Whitney	0.87	0.89	1.00
	Brown-Forsythe	0.79	0.59	0.71

Notes:
1. Weighing gauge data from Mary's Harbour A (8502591) for 1983 to 1995.
2. Weighing gauge data from Mary's Harbour (850B5R1) for 1996 to 2013.
3. Weighing gauge data from combined Mary's Harbour A (8502591) and Mary's Harbour (850B5R1) for 1983 to 2013.

The 1-hr Mary's Harbour A (8502592) station had only one annual maximum (2014), which was insufficient for performing the statistical tests. The 1-hr data were checked against the 6-hr QA/QC'd data, and showed good agreement for the 6-, 12-, and 24-hr durations. The newer 6-hr data from Mary's Harbour (850B5R1) and 1-hr data from Mary's Harbour A (8502592) were compared to the IDF data in Table 4.6. The means of the newer data were higher than the IDF curve for all durations except for the 6-hr duration at Mary's Harbour (850B5R1). The standard deviations and ranges were higher for most durations, except for the 24-hr data at Mary's Harbour (850B5R1). Therefore, the newer data were generally higher than the existing IDF curve data, and the precipitation at this station has been increasing relative to the EC IDF curve.

Table 4.6 Mary's Harbour A 6-hr and 1-hr Data Summary

Duration	*Statistic*	*IDF Curve Data*	*6-hr Data[1]*	*1-hr Data[2]*
1-hr	Number of data points	12	N/A	1
	Mean [mm]	9.4	N/A	10.8
	Standard Deviation [mm]	1.8	N/A	N/A
	Minimum/Maximum [mm]	6.2/11.6	N/A	10.8/10.8
2-hr	Number of data points	12	N/A	1
	Mean [mm]	13.7	N/A	17.8
	Standard Deviation [mm]	3.2	N/A	N/A
	Minimum/Maximum [mm]	8.4/20.4	N/A	17.8/17.8
6-hr	Number of data points	12	16	1
	Mean [mm]	25.6	24.1	35.8
	Standard Deviation [mm]	5.7	7.0	N/A
	Minimum/Maximum [mm]	16.5/33.4	15.0/39.0	35.8/35.8
12-hr	Number of data points	12	16	1
	Mean [mm]	33.7	35.8	48.2
	Standard Deviation [mm]	9.5	12.8	N/A
	Minimum/Maximum [mm]	17.2/55.0	21.0/66.0	48.2/48.2

Duration	*Statistic*	*IDF Curve Data*	*6-hr Data*[1]	*1-hr Data*[2]
24-hr	Number of data points	12	16	1
	Mean [mm]	42.2	43.4	50.9
	Standard Deviation [mm]	15.8	13.9	N/A
	Minimum/Maximum [mm]	21.2/78.0	22.6/74.5	50.9/50.9

Notes:
1. 6-hr Weighing gauge data from Mary's Harbour (850B5R1) for 1996 to 2013
2. 1-hr Weighing gauge data from Mary's Harbour A (8502592) for 2014.

The 6-hr and 1-hr precipitation weighing data were added to the IDF curve data, and the goodness-of-fit tests were applied to the augmented data set. All durations were tested. The p-values of the tests are summarized in Table 4.7. Both tests showed that the data fit the Gumbel distribution. Therefore, the Gumbel distribution was used for this station.

Table 4.7 Mary's Harbour A Goodness-of-Fit Testing

Duration	*Updated*	*Kolmogorov-Smirnov Test*	*Chi-Square Test*
5-min	No	0.58	1.00
10-min	No	0.52	0.25
15-min	No	0.77	0.56
30-min	No	0.97	0.56
1-hr	Yes	0.23	0.17
2-hr	Yes	0.89	0.41
6-hr	Yes	0.79	0.64
12-hr	Yes	1.00	0.76
24-hr	Yes	0.82	0.94

The trend testing (Table 4.8) showed that there were positive trends in the EC IDF data for durations from 1-hr and longer (statistically significant for the 2- and 12-hr durations). The newer data had a higher mean but also higher variability, which lowered the trends. For the updated trends, only the 2-hr duration was statistically significant.

Table 4.8 Mary's Harbour A Trend Testing

Duration	*Updated*	*EC Sen's Slope [mm/yr] (95 percent Confidence Limits)*	*Updated Sen's Slope [mm/yr] (95 percent Confidence Limits)*
5-min	No	-0.14 (0.06, -0.35)	N/A
10-min	No	-0.02 (0.22, -0.26)	N/A
15-min	No	0.05 (0.31, -0.23)	N/A
30-min	No	0.11 (0.33, -0.23)	N/A
1-hr	Yes	0.04 (0.48, -0.31)	0.04 (0.26, -0.02)
2-hr	Yes	0.33 (0.99, 0.07)	0.26 (0.85, 0.10)
6-hr	Yes	0.67 (1.55, -0.10)	0.07 (0.32, -0.23)
12-hr	Yes	1.12 (2.68, 0.11)	0.24 (0.71, -0.20)
24-hr	Yes	2.08 (4.84, -1.04)	0.31 (0.87, -0.24)

Notes:
Red numbers indicate that the Sen slope was statistically significant (positive) at the 5 percent significance level.

4.3 St. John's A

4.3.1 St. John's A

The statistical homogeneity tests for this station were applied for the St. John's A IDF curve data and the Windsor Lake data. There was no overlap between the IDF curve data and the Windsor Lake data, and therefore the overlapping period tests were not performed. The p-values of the statistical tests are summarized in Table 4.9. The statistical tests indicated that the Windsor Lake data and the St. John's A IDF curve data were homogeneous for most durations of 30-min and less. The longer durations do not come from the same distribution.

Table 4.9 St. John's A Statistical Homogeneity Tests

Duration	*Homogeneity Test*	*Overlapping Period: IDF Curve Data & Windsor Lake TBRG Data*	*Newer Data Period[1]: IDF Curve Data & Windsor Lake TBRG Data*	*Entire Period: IDF Curve Data & Windsor Lake TBRG Data*
5-min	Correlation Coefficient	N/A	N/A	N/A
	Kolmogorov-Smirnov	N/A	0.57	N/A
	Mann-Whitney	N/A	0.71	N/A
	Brown-Forsythe	N/A	0.04[2]	N/A
10-min	Correlation Coefficient	N/A	N/A	N/A
	Kolmogorov-Smirnov	N/A	0.47	N/A
	Mann-Whitney	N/A	0.59	N/A
	Brown-Forsythe	N/A	0.07	N/A
15-min	Correlation Coefficient	N/A	N/A	N/A
	Kolmogorov-Smirnov	N/A	0.31	N/A
	Mann-Whitney	N/A	0.25	N/A
	Brown-Forsythe	N/A	0.27	N/A

Duration	*Homogeneity Test*	*Overlapping Period: IDF Curve Data & Windsor Lake TBRG Data*	*Newer Data Period[1]: IDF Curve Data & Windsor Lake TBRG Data*	*Entire Period: IDF Curve Data & Windsor Lake TBRG Data*
30-min	Correlation Coefficient	N/A	N/A	N/A
	Kolmogorov-Smirnov	N/A	0.39	N/A
	Mann-Whitney	N/A	0.07	N/A
	Brown-Forsythe	N/A	0.62	N/A
1-hr	Correlation Coefficient	N/A	N/A	N/A
	Kolmogorov-Smirnov	N/A	0.05[2]	N/A
	Mann-Whitney	N/A	0.02[2]	N/A
	Brown-Forsythe	N/A	0.15	N/A
2-hr	Correlation Coefficient	N/A	N/A	N/A
	Kolmogorov-Smirnov	N/A	0.01[2]	N/A
	Mann-Whitney	N/A	0.00[2]	N/A
	Brown-Forsythe	N/A	0.33	N/A
6-hr	Correlation Coefficient	N/A	N/A	N/A
	Kolmogorov-Smirnov	N/A	0.03[2]	N/A
	Mann-Whitney	N/A	0.01[2]	N/A
	Brown-Forsythe	N/A	0.22	N/A
12-hr	Correlation Coefficient	N/A	N/A	N/A
	Kolmogorov-Smirnov	N/A	0.03[2]	N/A
	Mann-Whitney	N/A	0.01[2]	N/A
	Brown-Forsythe	N/A	0.09	N/A
24-hr	Correlation Coefficient	N/A	N/A	N/A
	Kolmogorov-Smirnov	N/A	0.03[2]	N/A
	Mann-Whitney	N/A	0.00[2]	N/A
	Brown-Forsythe	N/A	0.06	N/A

Notes:
1. St. John's A IDF data from 1949 to 1996, Windsor Lake data from 1999 to 2014.
2. Red numbers indicate that the null hypothesis was rejected for this statistical test at the 5 percent significance level.

The heterogeneity identified in Table 4.9 may be due to changing climatic conditions in the more recent data. The stations are located very close to each other, and should be homogeneous. Therefore, to confirm that the Windsor Lake data may be combined with the St. John's A data, Wadden (2002) performed a correlation analysis on the daily precipitation totals. Wadden (2002) performed the correlation analysis on the dates with more than 20 mm of precipitation. This analysis also correlated all of the data (including dates with zero precipitation) and the dates with more than 10 mm of precipitation. The correlation analysis was performed for the entire overlapping data period of 1999 to 2011. Table 4.10 lists the correlation coefficients and the means and standard deviations for daily precipitation at the St. John's A and Windsor Lake stations. The daily precipitation totals were highly correlated, but the Windsor Lake data have a higher mean and standard deviation than the St. John's A data. The differences in mean and standard deviation were not significant at the 5 percent significance level. Therefore, the Windsor Lake data may be used to update the St. John's A IDF curve, as the heterogeneity that was discovered by the statistical tests in Table 4.9 was assumed to be due to climate variability/change.

Table 4.10 St. John's A Correlation Analysis

	St. John's A/Windsor Lake[2]		
Statistic	***All Dates***	***At least 10 mm of precipitation***	***At least 20 mm of precipitation***
Correlation Coefficient	0.88	0.84	0.79
Mean [mm]	3.3/3.7	24.9/25.3	37.0/37.8
Standard Deviation [mm]	8.1/8.5	14.3/15.9	14.4/16.9

Notes:
1. Daily precipitation totals from St. John's A and Windsor Lake for 1999 to 2011.

The annual maxima for the Windsor Lake station were compared to the IDF data in Table 4.11. The means of the newer data were higher than the IDF curve for all durations except for the 5-min duration. The standard deviations and ranges were higher for durations of 30-min and longer. Therefore, the newer data were generally higher than the existing IDF curve data, and the precipitation at this station has been increasing relative to the IDF curve.

Table 4.11 St. John's A 5-min Data Summary

Duration	***Statistic***	***IDF Curve Data***	***5-min Data[1]***
5-min	Number of data points	35	13
	Mean [mm]	5.0	4.6
	Standard Deviation [mm]	2.0	0.9
	Minimum/Maximum [mm]	1.6/10.2	3.2/6.3
10-min	Number of data points	35	13
	Mean [mm]	7.4	7.5
	Standard Deviation [mm]	2.7	1.6
	Minimum/Maximum [mm]	3.2/13.2	4.8/10.3
15-min	Number of data points	35	13
	Mean [mm]	9.3	10.0
	Standard Deviation [mm]	3.4	2.4
	Minimum/Maximum [mm]	4.6/17.0	6.6/14.6
30-min	Number of data points	35	13
	Mean [mm]	13.2	15.6
	Standard Deviation [mm]	4.5	5.0
	Minimum/Maximum [mm]	6.9/25.4	9.0/27.2
1-hr	Number of data points	36	13
	Mean [mm]	18.3	24.2
	Standard Deviation [mm]	5.5	8.1
	Minimum/Maximum [mm]	8.6/29.7	15.3/41.1

Duration	*Statistic*	*IDF Curve Data*	*5-min Data*[1]
2-hr	Number of data points	36	13
	Mean [mm]	25.2	34.2
	Standard Deviation [mm]	8.9	11.5
	Minimum/Maximum [mm]	13.1/52.6	20.6/62.0
6-hr	Number of data points	35	13
	Mean [mm]	42.8	56.7
	Standard Deviation [mm]	11.4	19.2
	Minimum/Maximum [mm]	25.7/80.3	33.3/107.1
12-hr	Number of data points	35	13
	Mean [mm]	54.3	72.8
	Standard Deviation [mm]	12.8	27.7
	Minimum/Maximum [mm]	34.5/82.4	38.1/147.7
24-hr	Number of data points	36	13
	Mean [mm]	64.4	87.3
	Standard Deviation [mm]	14.7	26.3
	Minimum/Maximum [mm]	38.6/89.2	54.9/149.6

Notes:
1. 5-min data from Windsor Lake for 1999 to 2014.

The Windsor Lake data were added to the IDF curve data, and the goodness-of-fit tests were applied to the augmented data set. All durations were tested. The p-values of the tests are summarized in Table 4.12. Both tests showed that the data fit the Gumbel distribution. Therefore, the Gumbel distribution was used for this station.

Table 4.12 St. John's A Goodness-of-Fit Testing

Duration	*Updated*	*Kolmogorov-Smirnov Test*	*Chi-Square Test*
5-min	Yes	0.60	0.78
10-min	Yes	0.90	0.43
15-min	Yes	0.80	0.33
30-min	Yes	0.99	0.96
1-hr	Yes	0.93	0.81
2-hr	Yes	0.76	0.81
6-hr	Yes	0.82	0.36
12-hr	Yes	0.70	0.28
24-hr	Yes	1.00	0.88

The trend testing (Table 4.13) showed that there were positive trends in the EC IDF data for durations of 10-min to 6-hr, and negative trends for the other durations. There were no statistically significant trends. After adding the newer data, most trends were positive. The trend was statistically significant for the 1-, 2- and 6-hr durations. The Hurricane Gabrielle event in 2001 was a known outlier in the data. Therefore, the trends were also calculated with Hurricane Gabrielle excluded from the data. The trends were slightly lower (maximum difference of 0.04 mm/year) but still positive. The 1-, 2-, and 6-hr duration trends were still significant without Hurricane Gabrielle. Therefore, the inclusion of Hurricane Gabrielle in the trend calculation did not strongly affect the trend analysis.

Table 4.13 St. John's A Trend Testing

Duration	*Updated*	*EC Sen's Slope [mm/yr] (95 percent Confidence Limits)*	*Updated Sen's Slope [mm/yr] (95 percent Confidence Limits)*
5-min	Yes	-0.02 (0.04, -0.08)	-0.01 (0.02, -0.04)
10-min	Yes	0.00 (0.09, -0.08)	0.01 (0.06, -0.04)
15-min	Yes	0.03 (0.12, -0.09)	0.03 (0.08, -0.03)
30-min	Yes	0.06 0.19, -0.08)	0.07 (0.15, -0.00)
1-hr	Yes	0.13 (0.32, -0.07)	0.14 (0.27, 0.03)
2-hr	Yes	0.21 (0.42, -0.05)	0.24 (0.39, 0.11)
6-hr	Yes	0.26 (0.60, -0.10)	0.32 (0.52, 0.10)
12-hr	Yes	-0.01 (0.43, -0.46)	0.23 (0.54, -0.03)
24-hr	Yes	-0.09 (0.45, -0.51)	0.34 (0.70, -0.02)

Notes:
Red numbers indicate that the Sen slope was statistically significant (positive) at the 5 percent significance level.

4.3.2 Ruby Line

The statistical homogeneity tests for this station were applied for the combined St. John's West data and the Ruby Line data. The overlap period was not tested due to the small number of overlapping data points (2010, 2011, and 2013). Therefore, only the newer data and entire period tests were performed. The p-values of the statistical tests are summarized in Table 4.14. The statistical tests indicated that the St. John's West data and the Ruby Line data were homogeneous for most durations (exceptions are highlighted in red).

Table 4.14 Ruby Line Statistical Homogeneity Tests

Duration	*Homogeneity Test*	*Overlapping Period: St. John's W & Ruby Line Data*	*Newer Data Period[1]: St. John's W & Ruby Line Data*	*Entire Period[2]: St. John's W & Ruby Line Data*
5-min	Correlation Coefficient	N/A	N/A	N/A
	Kolmogorov-Smirnov	N/A	0.34	0.44
	Mann-Whitney	N/A	0.29	0.31
	Brown-Forsythe	N/A	0.03[3]	0.02[3]
10-min	Correlation Coefficient	N/A	N/A	N/A
	Kolmogorov-Smirnov	N/A	0.66	0.68
	Mann-Whitney	N/A	0.37	0.36
	Brown-Forsythe	N/A	0.11	0.05
15-min	Correlation Coefficient	N/A	N/A	N/A
	Kolmogorov-Smirnov	N/A	0.77	0.68
	Mann-Whitney	N/A	0.59	0.44
	Brown-Forsythe	N/A	0.32	0.19

Duration	*Homogeneity Test*	*Overlapping Period: St. John's W & Ruby Line Data*	*Newer Data Period[1]: St. John's W & Ruby Line Data*	*Entire Period[2]: St. John's W & Ruby Line Data*
30-min	Correlation Coefficient	N/A	N/A	N/A
	Kolmogorov-Smirnov	N/A	0.90	0.99
	Mann-Whitney	N/A	0.80	0.65
	Brown-Forsythe	N/A	0.73	0.60
1-hr	Correlation Coefficient	N/A	N/A	N/A
	Kolmogorov-Smirnov	N/A	0.92	0.89
	Mann-Whitney	N/A	0.80	0.98
	Brown-Forsythe	N/A	0.90	0.95
2-hr	Correlation Coefficient	N/A	N/A	N/A
	Kolmogorov-Smirnov	N/A	0.57	0.66
	Mann-Whitney	N/A	0.50	0.57
	Brown-Forsythe	N/A	0.97	0.84
6-hr	Correlation Coefficient	N/A	N/A	N/A
	Kolmogorov-Smirnov	N/A	0.39	0.42
	Mann-Whitney	N/A	0.55	0.57
	Brown-Forsythe	N/A	1.00	1.00
12-hr	Correlation Coefficient	N/A	N/A	N/A
	Kolmogorov-Smirnov	N/A	0.32	0.66
	Mann-Whitney	N/A	0.19	0.38
	Brown-Forsythe	N/A	0.29	0.29
24-hr	Correlation Coefficient	N/A	N/A	N/A
	Kolmogorov-Smirnov	N/A	0.28	0.24
	Mann-Whitney	N/A	0.19	0.17
	Brown-Forsythe	N/A	0.57	0.50

Notes:

1. St. John's West CDA and St. John's West Climate data from 1991 to 1995 and 2010 to 2013, Ruby Line data from 1997 to 2009 and 2014.
2. St. John's West CDA and St. John's West Climate data from 1991 to 1995 and 2010 to 2013, Ruby Line data from 1997 to 2014.
3. Red numbers indicate that the null hypothesis was rejected for this statistical test at the 5 percent significance level.

The distance between the Ruby Line and St. John's West stations is approximately 2.8 km. This is close to the maximum distance of 3 km. Therefore, the suitability of these stations was further tested with the correlation analysis performed by Wadden (2002). There were 16 years of overlapping data (1997 to 2007, 2010 to 2014). This analysis correlated all of the data (including dates with zero precipitation), the dates with more than 10 mm of precipitation, and the dates with more than 20 mm of precipitation. Table 4.15 lists the correlation coefficients and the means and standard deviations for daily precipitation at the St. John's West and Ruby Line stations. The daily precipitation totals were not highly correlated (correlation coefficients were less than 0.8). Therefore, the Ruby Line station is not close enough to the St. John's West stations to receive similar precipitation.

Table 4.15 Ruby Line Correlation Analysis

	St. John's/Ruby Line[1]		
Statistic	***All Dates***	***At least 10 mm of precipitation***	***At least 20 mm of precipitation***
Correlation Coefficient	0.73	0.65	0.68
Mean [mm]	3.5/3.8	21.8/22.9	33.5/36.2
Standard Deviation [mm]	7.6/8.1	13.1/14.2	16.2/16.9

Notes:
1. Daily precipitation totals from combined St. John's West CDA CS and St. John's West Climate stations and Ruby Line station for 1997 to 2014

Although the annual maxima were homogeneous between the St. John's West stations and the Ruby Line station, the correlation analysis showed that the stations are too far apart to receive similar precipitation. Therefore, the IDF curve was created using the data from the Ruby Line station alone. The means, standard deviations, minimums, and maximums for the annual maxima for the Ruby Line station are listed in Table 4.16.

Table 4.16 Ruby Line 5-min Data Summary

Duration	***Statistic***	***5-min Data***[1]
5-min	Number of data points	16
	Mean [mm]	4.3
	Standard Deviation [mm]	1.1
	Minimum/Maximum [mm]	2.8/7.2
10-min	Number of data points	16
	Mean [mm]	6.8
	Standard Deviation [mm]	1.5
	Minimum/Maximum [mm]	4.9/11.1
15-min	Number of data points	16
	Mean [mm]	8.6
	Standard Deviation [mm]	2.2
	Minimum/Maximum [mm]	6.2/15.1
30-min	Number of data points	16
	Mean [mm]	12.8
	Standard Deviation [mm]	4.6
	Minimum/Maximum [mm]	8.0/27.1
1-hr	Number of data points	16
	Mean [mm]	19.9
	Standard Deviation [mm]	7.8
	Minimum/Maximum [mm]	12.2/41.7
2-hr	Number of data points	16
	Mean [mm]	30.8
	Standard Deviation [mm]	11.2
	Minimum/Maximum [mm]	19.0/56.4

Duration	*Statistic*	*5-min Data*[1]
6-hr	Number of data points	16
	Mean [mm]	49.9
	Standard Deviation [mm]	15.8
	Minimum/Maximum [mm]	36.3/95.9
12-hr	Number of data points	16
	Mean [mm]	64.1
	Standard Deviation [mm]	22.5
	Minimum/Maximum [mm]	42.5/133.1
24-hr	Number of data points	16
	Mean [mm]	76.6
	Standard Deviation [mm]	23.1
	Minimum/Maximum [mm]	46.3/135.9

Notes:
1. Ruby Line data for 1997 to 2014.

The goodness-of-fit tests were applied to the Ruby Line data. All durations were tested. The p-values of the tests are summarized in Table 4.17. Both tests showed that the data fit the Gumbel distribution. Therefore, the Gumbel distribution was used for this station.

Table 4.17 Ruby Line Goodness-of-Fit Testing

Duration	*Updated*	*Kolmogorov-Smirnov Test*	*Chi-Square Test*
5-min	Yes	0.86	0.94
10-min	Yes	0.99	0.78
15-min	Yes	0.98	0.94
30-min	Yes	0.64	0.78
1-hr	Yes	0.61	0.78
2-hr	Yes	0.73	0.94
6-hr	Yes	0.56	0.37
12-hr	Yes	0.76	0.65
24-hr	Yes	0.99	0.94

The trend testing (Table 4.18) showed that there were no statistically significant trends in the Ruby Line data. In general, the short durations had positive trends, and the long durations had negative trends. Since this is a new IDF curve, the EC IDF trends were not presented.

Table 4.18 Ruby Line Trend Testing

Duration	*Updated*	*EC Sen's Slope [mm/yr] (95 percent Confidence Limits)*	*Updated Sen's Slope [mm/yr] (95 percent Confidence Limits)*
5-min	Yes	N/A	0.02 (0.11, -0.08)
10-min	Yes	N/A	0.08 (0.24, -0.08)
15-min	Yes	N/A	0.07 (0.30, -0.13)
30-min	Yes	N/A	-0.05 (0.30, -0.36)
1-hr	Yes	N/A	-0.04 (0.54, -0.58)
2-hr	Yes	N/A	0.11 (0.88, -0.95)
6-hr	Yes	N/A	-0.30 (0.75, -0.21)
12-hr	Yes	N/A	-0.80 (0.72, -2.86)
24-hr	Yes	N/A	-0.81 (1.57, -2.73)

Notes:
1. There are no EC Sen's Slope estimates because this is a new IDF curve.

Section 5.0 Statistical Analysis for Case 3 Stations

5.1 St. Albans

The statistical homogeneity tests were applied to the annual maxima of the two data sets (from the IDF curve and from the two daily stations). The p-values of the statistical tests are summarized in Table 5.1. The correlation between the IDF 24-hr maxima and the Bay D'Espoir Gen Stn 24-hr maxima was high, and the overlapping Bay D'Espoir Gen Stn 24-hr data were homogeneous with the IDF curve 24-hr data. There was no overlap between the IDF 24-hr maxima and the Harbour Breton 24-hr maxima, but there was an overlap between the Harbour Breton 24-hr data and the Bay D'Espoir Gen Stn 24-hr data. Therefore, the overlapping period tests for Harbour Breton were performed by comparing the data to the Bay D'Espoir Gen Stn data. The Harbour Breton data do not correlate strongly with the Bay D'Espoir Gen Stn data, but the two data sets were homogeneous except for a change in variance. For both stations, the statistical tests showed that the newer data were not statistically similar to the EC IDF 24-hr data. This could indicate a change in mean precipitation due to climatic variability between the two time periods. As the tests showed that the overlap period data for Bay D'Espoir Gen Stn correlated well and were homogeneous with the IDF curve data, it was concluded that it could be used to extend the IDF curve. The Harbour Breton data were not homogeneous with the Bay D'Espoir Gen Stn data and did not correlate well with the data. However, the Harbour Breton may include some useful information. Therefore, these data will also be examined to determine if they provide an expanded estimate for the IDF curve.

Table 5.1 St. Albans Statistical Homogeneity Tests

Duration (Station)	*Homogeneity Test*	*Overlapping Period*	*Newer Data Period[1]: IDF Curve Data & Station Data*	*Entire Period[2]: IDF Curve Data & Station Data*
24-hr (Bay D'Espoir Gen Stn)	Correlation Coefficient	0.84[3]	N/A	N/A
	Kolmogorov-Smirnov	0.57[3]	0.26	0.30
	Mann-Whitney	0.29[3]	0.04[5]	0.06
	Brown-Forsythe	0.85[3]	0.02[5]	0.13
24-hr (Harbour Breton)	Correlation Coefficient	0.26[4]	N/A	N/A
	Kolmogorov-Smirnov	0.25[4]	0.14	N/A
	Mann-Whitney	0.55[4]	0.03[5]	N/A
	Brown-Forsythe	0.03[4,5]	0.40	N/A

Notes:
1. Station data from 1984 to 2014.
2. Station data from 1969 to 2014.
3. Overlap between St. Albans and Bay D'Espoir Gen Stn for 1969 to 1983.
4. Overlap between Bay D'Espoir Gen Stn and Harbour Breton for 1984 to 2014.
5. Red numbers indicate that the null hypothesis was rejected for this statistical test at the 5 percent significance level.

The 1-hr Hydro station is located almost 14 km away from the St. Albans station, and therefore was only used to update the 6-, 12-, and 24-hr durations. The annual maxima were confirmed with the Bay D'Espoir Gen Stn or Harbour Breton data for four years. There were insufficient data for performing the statistical tests. Table 5.2 shows a listing of the mean, standard deviation, minimum points and maximum points for the IDF curve data, the 24-hr data from Bay D'Espoir Gen Stn, the 24-hr data from Harbour Breton, and the 1-hr data from Long Pond Intake. The data were within the observed variation of the IDF curve data for the 6-, 12-, and 24-hr durations. However, the 24-hr data from Bay D'Espoir Gen Stn and from Harbour Breton had statistically significant lower means and standard deviations than the 24-hr EC IDF curve data. If these data were used to generate a new IDF curve, there would be a large decrease in the precipitation estimates for the 24-hr duration. The 1-hr data from Long Pond Intake were also less than the EC IDF curve data, but the difference was much lower.

Table 5.2 St. Albans and Donor Stations Data Summary

Duration	*Statistic*	*IDF Curve Data*	*24-hr Data from Bay D'Espoir Gen Stn*[1]	*24-hr Data from Harbour Breton*[2]	*1-hr Data from Long Pond Intake*[3]
6-hr	Number of data points	14	N/A	N/A	4
	Mean [mm]	48.4	N/A	N/A	46.7
	Standard Deviation [mm]	6.6	N/A	N/A	6.0
	Minimum/Maximum [mm]	38.7/60.5	N/A	N/A	39.3/51.9
12-hr	Number of data points	14	N/A	N/A	4
	Mean [mm]	66.5	N/A	N/A	60.9
	Standard Deviation [mm]	15.4	N/A	N/A	10.3
	Minimum/Maximum [mm]	45.2/93.0	N/A	N/A	48.0/73.3
24-hr	Number of data points	14	23	31	4
	Mean [mm]	88.2	69.4	68.7	73.8
	Standard Deviation [mm]	30.1	14.2	23.2	16.9
	Minimum/Maximum [mm]	46.5/147.6	49.6/104.0	38.2/122.0	59.4/95.7

Notes:
1. Data from Bay D'Espoir Gen Stn station for 1984 to 2014.
2. Data from Harbour Breton station for 1984 to 2014.
3. Data from Long Pond Intake Hydro station for 2009 to 2014.

For this station, several different IDF curves were attempted. The first IDF curve used both the Bay D'Espoir Gen Stn and the Long Pond Intake data. However, this resulted in small decreases for the 6-, and 12-hr durations, and a large decrease for the 24-hr duration (34 mm for the 100-year return interval), and the IDF curve was discontinuous. IDF curves using only the Bay D'Espoir Gen Stn or the Harbour Breton data could only be updated for the 24-hr duration. The last IDF curve used only the Long Pond Intake data. This resulted in small decreases in precipitation estimates for the 6-, 12-, and 24-hr durations. Therefore, the St. Albans IDF curve was updated using only the Long Pond Intake data.

The Long Pond Intake data were added to the IDF curve data, and the goodness-of-fit tests were applied to the augmented data set. All durations were tested. The p-values of the tests are summarized in Table 5.3. Both tests showed that the data fit the Gumbel distribution. Therefore, the Gumbel distribution was used for this station.

Table 5.3 St. Albans Goodness-of-Fit Testing

Duration	*Updated*	*Kolmogorov-Smirnov Test*	*Chi-Square Test*
5-min	No	0.91	0.59
10-min	No	0.95	1.00
15-min	No	0.90	0.59
30-min	No	0.92	0.59
1-hr	No	0.87	1.00
2-hr	No	0.97	0.59
6-hr	Yes	0.59	0.14
12-hr	Yes	0.86	0.85
24-hr	Yes	0.98	1.00

The trend testing (Table 5.4) showed that there were non-statistically significant trends in the EC IDF data. The newer data increased the trend for the 6-hr duration, and decreased the trends for the 12- and 24-hr durations. The updated trends were not statistically significant.

Table 5.4 St. Albans Trend Testing

Duration	*Updated*	*EC Sen's Slope [mm/yr] (95 percent Confidence Limits)*	*Updated Sen's Slope [mm/yr] (95 percent Confidence Limits)*
5-min	No	-0.04 (0.16, -0.22)	N/A
10-min	No	-0.04 (0.26, -0.35)	N/A
15-min	No	-0.01 (0.30, -0.41)	N/A
30-min	No	-0.21 (0.19, -0.58)	N/A
1-hr	No	0.03 (0.54, -0.78)	N/A
2-hr	No	-0.36 (0.15, -1.02)	N/A
6-hr	Yes	-0.31 (0.80, -1.22)	-0.09 (0.20, -0.39)
12-hr	Yes	0.10 (2.61, -1.72)	-0.12 (0.60, -0.62)
24-hr	Yes	1.59 (5.60, -2.63)	0.07 (1.21, -0.91)

Section 6.0 Statistical Analysis for Case 4 Stations

6.1 Comfort Cove

The statistical homogeneity tests were applied to the annual maxima of the TBRG data, the 1-hr weighing gauge data, and the 6-hr weighing gauge data at Twillingate. The p-values of each of the statistical tests are summarized in Table 6.1 for the 1-hr data and Table 6.2 for the 6-hr data. The 1-hr precipitation weighing gauge data were homogeneous with the TBRG data (only the entire period tests were performed, due to the small number of overlap and newer data points). Therefore, these data sources could be combined to produce an IDF curve. The 6-hr precipitation weighing gauge data were not homogeneous with the TBRG totals. Most of the 6-hr precipitation weighing gauge data were older than the TBRG data, and therefore the results may indicate climatic variability/changes at this station and/or differences in measurement technique. Due to the heterogeneity between the older weighing gauge 6-hr data and the newer TBRG data, these data were not combined to produce the new IDF curve.

Table 6.1 Twillingate Statistical Homogeneity Tests (TBRG and 1-hr data)

Duration	*Homogeneity Test*	*Overlapping Period: TBRG Data & 6-hr Weighing Gauge Data*	*Newer Period[1]: TBRG Data & 6-hr Weighing Gauge Data*	*Entire Period[2]: TBRG Data & 6-hr Weighing Gauge Data*
1-hr	Correlation Coefficient	N/A	N/A	N/A
	Kolmogorov-Smirnov	N/A	N/A	0.93
	Mann-Whitney	N/A	N/A	0.67
	Brown-Forsythe	N/A	N/A	0.80
2-hr	Correlation Coefficient	N/A	N/A	N/A
	Kolmogorov-Smirnov	N/A	N/A	0.66
	Mann-Whitney	N/A	N/A	0.58
	Brown-Forsythe	N/A	N/A	0.51
6-hr	Correlation Coefficient	N/A	N/A	N/A
	Kolmogorov-Smirnov	N/A	N/A	0.66
	Mann-Whitney	N/A	N/A	0.37
	Brown-Forsythe	N/A	N/A	0.59
12-hr	Correlation Coefficient	N/A	N/A	N/A
	Kolmogorov-Smirnov	N/A	N/A	0.66
	Mann-Whitney	N/A	N/A	0.68
	Brown-Forsythe	N/A	N/A	0.10
24-hr	Correlation Coefficient	N/A	N/A	N/A
	Kolmogorov-Smirnov	N/A	N/A	0.92
	Mann-Whitney	N/A	N/A	0.77
	Brown-Forsythe	N/A	N/A	0.63

Notes:
1. Twillingate TBRG data from 2004 to 2013, 1-hr weighing gauge data from 2004-2006, 2013-2014.
2. Twillingate TBRG data from 2004 to 2013, 6-hr weighing gauge data from 2004-2006, 2013-2014.
3. Red numbers indicate that the null hypothesis was rejected for this statistical test at the 5 percent significance level.

Table 6.2 Twillingate Statistical Homogeneity Tests (TBRG and 6-hr data)

Duration	***Homogeneity Test***	***Overlapping Period: TBRG Data & 6-hr Weighing Gauge Data***	***Non-Overlap Period[1]: TBRG Data & 6-hr Weighing Gauge Data***	***Entire Period[2]: TBRG Data & 6-hr Weighing Gauge Data***
6-hr	Correlation Coefficient	N/A	N/A	N/A
	Kolmogorov-Smirnov	N/A	0.28	0.40
	Mann-Whitney	N/A	0.39	0.47
	Brown-Forsythe	N/A	0.00[3]	0.01[3]
12-hr	Correlation Coefficient	N/A	N/A	N/A
	Kolmogorov-Smirnov	N/A	0.11	0.16
	Mann-Whitney	N/A	0.07	0.05[3]
	Brown-Forsythe	N/A	0.22	0.19
24-hr	Correlation Coefficient	N/A	N/A	N/A
	Kolmogorov-Smirnov	N/A	0.00[3]	0.00[3]
	Mann-Whitney	N/A	0.00[3]	0.00[3]
	Brown-Forsythe	N/A	0.92	0.77

Notes:
1. Twillingate TBRG data from 2005 to 2013, 6-hr weighing gauge data from 1995 to 2004.
2. Twillingate TBRG data from 2005 to 2013, 6-hr weighing gauge data from 1995 to 2014.
3. Red numbers indicate that the null hypothesis was rejected for this statistical test at the 5 percent significance level.

The TBRG, 6-hr precipitation weighing gauge, and 1-hr precipitation weighing gauge were compared in Table 6.3. The earlier 6-hr precipitation weighing gauge data were generally lower than the TBRG and 1-hr precipitation weighing gauge data. Therefore, including the 6-hr data in the IDF curve would decrease the precipitation estimates. For most durations, the TBRG and 1-hr precipitation weighing gauge data had similar means and similar ranges.

Table 6.3 Twillingate 6-hr and 1-hr Data Summary

Duration	***Statistic***	***TBRG Data***	***6-hr Precipitation Weighing Gauge Data***	***1-hr Precipitation Weighing Gauge Data***
1-hr	Number of data points	8	N/A	2
	Mean [mm]	18.8	N/A	16.6
	Standard Deviation [mm]	4.5	N/A	N/A
	Minimum/Maximum [mm]	13.6/25.0	N/A	11.2/22.0
2-hr	Number of data points	8	N/A	2
	Mean [mm]	25.8	N/A	27.2
	Standard Deviation [mm]	4.0	N/A	N/A
	Minimum/Maximum [mm]	20.6/32.6	N/A	19.2/35.1

Duration	*Statistic*	*TBRG Data*	*6-hr Precipitation Weighing Gauge Data*	*1-hr Precipitation Weighing Gauge Data*
6-hr	Number of data points	8	11	2
	Mean [mm]	35.0	25.3	43.9
	Standard Deviation [mm]	6.1	10.9	N/A
	Minimum/Maximum [mm]	26.4/46.4	14.0/40.0	43.8/44.0
12-hr	Number of data points	8	11	2
	Mean [mm]	42.3	27.1	57.2
	Standard Deviation [mm]	7.8	10.0	N/A
	Minimum/Maximum [mm]	33.2/56.0	14.0/40.0	47.0/67.4
24-hr	Number of data points	8	11	2
	Mean [mm]	52.1	28.9	63.5
	Standard Deviation [mm]	13.7	9.7	N/A
	Minimum/Maximum [mm]	37.4/82.4	14.0/40.0	47.6/79.4

The TBRG and 1-hr precipitation weighing gauge data were combined, and the goodness-of-fit tests were applied to the combined data. Durations of 1-hr and longer were tested. The p-values of the tests are summarized in Table 6.4. Both tests showed that the data fit the Gumbel distribution. Therefore, the Gumbel distribution was used for this station.

Table 6.4 Twillingate Goodness-of-Fit Testing

Duration	*Updated*	*Kolmogorov-Smirnov Test*	*Chi-Square Test*
5-min	No	N/A	N/A
10-min	No	N/A	N/A
15-min	No	N/A	N/A
30-min	No	N/A	N/A
1-hr	Yes	0.79	0.53
2-hr	Yes	0.96	0.53
6-hr	Yes	0.89	0.53
12-hr	Yes	0.95	0.53
24-hr	Yes	0.57	0.21

The trend testing (Table 6.5) showed that there were no statistically significant trends in the Twillingate data for durations of 1-hr and longer. Since this is a new IDF curve, the EC IDF trends were not presented.

Table 6.5 Twillingate Trend Testing

Duration	*Updated*	*EC Sen's Slope [mm/yr] (95 percent Confidence Limits)*	*Updated Sen's Slope [mm/yr] (95 percent Confidence Limits)*
5-min	No	N/A	N/A
10-min	No	N/A	N/A
15-min	No	N/A	N/A
30-min	No	N/A	N/A
1-hr	Yes	N/A	-0.16 (1.21, -1.31)
2-hr	Yes	N/A	0.00 (1.21, -1.47)
6-hr	Yes	N/A	0.98 (2.11, -1.25)
12-hr	Yes	N/A	1.27 (4.11, -1.07)
24-hr	Yes	N/A	0.72 (5.32, -1.07)

Notes:
1. There are no EC Sen's Slope estimates because this is a new IDF curve.

6.2 St. Anthony

The three sources of 6-hr data were compared with the statistical homogeneity tests to determine if the missing data in St. Anthony (8403399) could be filled in using the data from the other two stations. The statistical homogeneity tests were applied to the annual maxima of the 12- and 24-hr data sets from St. Anthony (8403399) and St. Anthony (8403389) (the 6-hr data set had only 4 data points). The p-values of each of statistical tests are summarized in Table 6.6. The results indicated that the 6-hr data at the two stations were not homogeneous.

Table 6.6 St. Anthony Statistical Homogeneity Tests

Duration	*Homogeneity Test*	*Overlapping Period: St. Anthony (8403399) & St. Anthony (8403389)*	*Newer Data Period: St. Anthony (8403399) & St. Anthony (8403389)*	*Entire Period[1]: St. Anthony (8403399) & St. Anthony (8403389)*
6-hr	Correlation Coefficient	N/A	N/A	N/A
	Kolmogorov-Smirnov	N/A	N/A	N/A
	Mann-Whitney	N/A	N/A	N/A
	Brown-Forsythe	N/A	N/A	N/A
12-hr	Correlation Coefficient	N/A	N/A	N/A
	Kolmogorov-Smirnov	N/A	N/A	0.05
	Mann-Whitney	N/A	N/A	0.00[2]
	Brown-Forsythe	N/A	N/A	0.12

Duration	Homogeneity Test	Overlapping Period: St. Anthony (8403399) & St. Anthony (8403389)	Newer Data Period: St. Anthony (8403399) & St. Anthony (8403389)	Entire Period[1]: St. Anthony (8403399) & St. Anthony (8403389)
24-hr	Correlation Coefficient	N/A	N/A	N/A
	Kolmogorov-Smirnov	N/A	N/A	0.06
	Mann-Whitney	N/A	N/A	0.03[2]
	Brown-Forsythe	N/A	N/A	0.57

Notes:
1. Weighing gauge data (6-hr) at both locations: 2000 to 2014 for St. Anthony (8403399) and 2010 to 2014 for St. Anthony (8403389).
2. Red numbers indicate that the null hypothesis was rejected for this statistical test at the 5 percent significance level.

The means and standard deviations for all three stations were compared in Table 6.7. The means and standard deviations for the two potential donor stations (St. Anthony, 8403389, and St. Anthony AWOS, 8403403) were lower than the means and standard deviations for St. Anthony (8403399). The difference in the means was statistically significant. The three overlapping years (2010, 2011 and 2014) did not always show agreement on the date of the annual maximum for each duration. Therefore, the data from the three stations were not homogeneous and were not combined. There were 10 years of 1-hr data at St. Anthony (8403399). The 1-hr data compared well with the 6-hr data at St. Anthony (8403399).

Table 6.7 St. Anthony 6-hr and 1-hr Data Summary

Duration	Statistic	St. Anthony (8403399) 1-hr Weighing Gauge Data	St. Anthony (8403399) 6-hr Weighing Gauge Data	St. Anthony (8403389) 6-hr Weighing Gauge Data	St. Anthony AWOS (8403403) 6-hr Weighing Gauge Data
1-hr	Number of data points	10	N/A	N/A	N/A
	Mean [mm]	20.1	N/A	N/A	N/A
	Standard Deviation [mm]	8.2	N/A	N/A	N/A
	Minimum/Maximum [mm]	11.4/39.9	N/A	N/A	N/A
2-hr	Number of data points	10	N/A	N/A	N/A
	Mean [mm]	23.0	N/A	N/A	N/A
	Standard Deviation [mm]	6.9	N/A	N/A	N/A
	Minimum/Maximum [mm]	14.2/39.9	N/A	N/A	N/A
6-hr	Number of data points	10	13	4	3
	Mean [mm]	33.1	29.8	25.0	24.0
	Standard Deviation [mm]	10.1	7.9	2.2	1.0
	Minimum/Maximum [mm]	24.0/58.7	20.0/43.0	23.0/28.0	23.0/25.0
12-hr	Number of data points	10	13	5	4
	Mean [mm]	42.4	41.7	31.4	30.5
	Standard Deviation [mm]	6.5	9.3	3.0	2.6
	Minimum/Maximum [mm]	34.0/58.7	31.0/59.0	27.0/35.0	27.0/33.0

Duration	***Statistic***	***St. Anthony (8403399) 1-hr Weighing Gauge Data***	***St. Anthony (8403399) 6-hr Weighing Gauge Data***	***St. Anthony (8403389) 6-hr Weighing Gauge Data***	***St. Anthony AWOS (8403403) 6-hr Weighing Gauge Data***
24-hr	Number of data points	10	13	5	3
	Mean [mm]	48.4	51.3	38.8	38.7
	Standard Deviation [mm]	7.8	10.7	8.9	12.5
	Minimum/Maximum [mm]	41.3/64.7	40.0/74.0	30.0/53.0	30.0/53.0

The 6-hr precipitation weighing gauge annual maximum data from St. Anthony (8403399) were tested with the goodness-of-fit tests to determine if the Gumbel distribution may be used to model the data. The 1-, 2-, 6-, 12-, and 24-hr durations were tested. The p-values of the tests are summarized in Table 6.8. Both goodness-of-fit tests showed that the data fit the Gumbel distribution.

Table 6.8 St. Anthony Goodness-of-Fit Testing

Duration	***Updated***	***Kolmogorov-Smirnov Test***	***Chi-Square Test***
5-min	No	N/A	N/A
10-min	No	N/A	N/A
15-min	No	N/A	N/A
30-min	No	N/A	N/A
1-hr	Yes	0.91	1.00
2-hr	Yes	0.61	0.53
6-hr	Yes	1.00	0.78
12-hr	Yes	0.49	0.78
24-hr	Yes	0.50	0.41

The trend testing (Table 6.9) showed that there were no statistically significant trends in the St. Anthony data for durations of 1-hr and longer. Since this is a new IDF curve, the EC IDF trends were not presented.

Table 6.9 St. Anthony Trend Testing

Duration	*Updated*	*EC Sen's Slope [mm/yr] (95 percent Confidence Limits)*	*Updated Sen's Slope [mm/yr] (95 percent Confidence Limits)*
5-min	No	N/A	N/A
10-min	No	N/A	N/A
15-min	No	N/A	N/A
30-min	No	N/A	N/A
1-hr	Yes	N/A	-0.65 (1.08, -2.49)
2-hr	Yes	N/A	-0.28 (1.17, -1.88)
6-hr	Yes	N/A	-0.85 (0.57, -2.21)
12-hr	Yes	N/A	0.09 (2.68, -4.06)
24-hr	Yes	N/A	-0.07 (3.18, -2.70)

Notes:
1. There are no EC Sen's Slope estimates because this is a new IDF curve.

Appendix C

Updated IDF Curves

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Section 1.0 Methodology and Symbols

This section describes the methodology used for deriving the updated IDF curves. For the 13 IDF stations that were updated during this project, there were modifications made to the standard Environment Canada (EC) formats for the tables and formats. This Section also describes the formatting changes.

Environment Canada uses the Gumbel distribution for all of the IDF curves across Canada, fitted with the method of moments. The methodology is described in detail in the Canadian Standards Association (CSA) Technical Guide (2012).

When EC performs an IDF update, EC collects the new data, performs the QA/QC, and then adds the data to the existing IDF curve. The Gumbel distribution is then fitted to the augmented data set. Frequently, this results in updated IDF curves that are lower than the previous IDF curves (for some or all combinations of durations and return periods). The supporting argument for this methodology is that a more accurate estimation of the IDF curves is obtained from longer observation records. The estimates for the parameters of the Gumbel distribution become more accurate with a larger number of data points.

Another approach would be to not update a duration if it is decreasing. The supporting argument for this approach is that precipitation is expected to increase in the future climate and as such, from an engineering safety perspective, IDF curves should not decrease during an update. For this project, EC's methodology was followed. Some of the updated IDF curves decreased from the previous EC IDF curves. However, in view of the expectation of increases in precipitation in the future climate, the changes from the previous EC IDF curves are clearly documented. When the updated IDF curve was much lower than the EC IDF curve, users are cautioned to use the updated IDF curve with care or to use the EC IDF curve.

For this update, the three tables and four figures produced by EC were reproduced for each updated IDF curve. However, as various data sources were used to perform the update (e.g., 6-hr weighing gauge data for some stations, TBRG data for other stations), it was not always possible to update all durations at a station. In order to make it clear which durations were updated and which durations were not updated, the standard format used by EC was modified for the tables and figures. The durations that were not updated are still presented, but are equal to the existing EC IDF curve (V2.3, 2015).

The header was modified to include information about what station(s) were used to update each station (Figure 1.1). The following information is listed: the type of data (e.g., 5-min, 1-hr, 6-hr), the station name and climate ID, and the years of data. The information about the donor station(s) is printed in red. The latitude/longitude/elevation line was moved down one line.

```
=================================================================================

 DEER LAKE A                                        NL         8401501
 Updated with 6-hr data measured at Deer Lake A (8401501): 2003-2011
 Updated with 6-hr data measured at Deer Lake A (8401502): 2012-2014
 Latitude:   49 13'N    Longitude: 57 24'W    Elevation/Altitude: 21         m
 Years/Années :   1966 - 2014          # Years/Années :     36

=================================================================================
```

Origin of updated data

Figure 1.1 Example of Changes to Header

EC's Table 1 for each IDF curve lists the data used for each duration. The table has ten columns: the first column is the year, and the next nine columns are the precipitation amounts for each duration in that year. EC uses "-99.9" when data were missing for a duration. A tag was added to the beginning of each line (Figure 1.2). For the IDF data prepared by EC, the tag is *EC-IDF*. The IDF data added during this update are tagged with *UPDATE*. If there were no data available for a particular duration, the duration was filled with "NM" (no measurements). Data were only marked missing (-99.9) if the data existed but were removed during QA/QC. In addition, the updated data were coloured red.

```
*EC-IDF*  1990    3.4     5.9     7.8    10.4    16.4    26.7    43.9    47.0    57.4
*EC-IDF*  1991    3.1     4.6     5.7     7.4    11.2    19.1    31.9    44.0    48.6
*EC-IDF*  1992    1.3     1.8     2.5     4.6     9.2    13.0    16.4    28.5    35.2
*EC-IDF*  1993    4.3     8.4    10.2    13.6    13.8    16.4    32.5    41.0    43.1
*EC-IDF*  1994    5.0     7.1     7.3    11.9    18.6    20.0    27.6    34.8    55.2
*EC-IDF*  1995    3.2     5.0     7.0    10.8    15.8    24.4    58.5    83.7   114.3
*UPDATE*  1996     NM      NM      NM      NM      NM      NM    32.0    32.0   -99.9
*UPDATE*  1998     NM      NM      NM      NM      NM      NM    24.0    43.0    66.0
*UPDATE*  2000     NM      NM      NM      NM      NM      NM    20.0    37.0    49.0
*UPDATE*  2001     NM      NM      NM      NM      NM      NM    33.0    40.0    60.0
*UPDATE*  2003     NM      NM      NM      NM      NM      NM    29.0    56.0    84.0
*UPDATE*  2004     NM      NM      NM      NM      NM      NM    38.0    38.5   -99.9
```

These data are updated data.

Figure 1.2 Example of Changes to Table 1

EC's Table 2 is divided into two parts. Table 2a lists the calculated depths of precipitation (in mm) for each return period, as calculated by the Gumbel distribution. Table 2b lists the calculated precipitation intensities and the confidence limits (in mm/hour). The precipitation estimates and confidence limits are converted to mm/hour by multiplying by a conversion factor that transforms the precipitation estimate into an hourly intensity (Table 1.1).

Table 1.1 Conversion Factor for Each Duration

	5-min	*10-min*	*15-min*	*30-min*	*1-hr*	*2-hr*	*6-hr*	*12-hr*	*24-hr*
Conversion Factor	12	6	4	2	1	1/2	1/6	1/12	1/24

The Gumbel distribution is a two-parameter extreme value distribution. It is fitted to the data using the method of moments. The mean and standard deviation of the data are calculated, and used to calculate the distribution parameters. There must be at least 10 years of valid data. The precipitation estimates for 6 return periods are calculated: 2-, 5-, 10-, 25-, 50-, and 100-year return periods. The following formulas are used.

$$x_T = \bar{x} + K_T s_x \quad (1\text{-}1)$$

$$K_T = -\frac{\sqrt{6}}{\pi}\left[0.5772 + ln\left(ln\left(\frac{T}{T-1}\right)\right)\right] \quad (1\text{-}2)$$

where:

x_T is the precipitation estimate at return period T [mm]
$\bar{x}$ is the mean of the observations [mm]
s_x is the standard deviation of the observations [mm]
T is the return period of interest (2, 5, 10, 25, 50, or 100) [years]

The confidence limits on the precipitation amounts are calculated with the following formula.

$$x_{95\%} = x_T \pm 1.96 s_x \sqrt{\frac{1+1.14K_T+1.1K_T^2}{N}} \quad (1\text{-}3)$$

where:

$x_{95\%}$ are the 95% confidence limits for the precipitation amounts [mm]
N is the total number of observations

For both Table 2a and Table2b, tags were added to each line to indicate whether the duration was updated or not (Figures 1.3 and 1.4). If the duration was not updated, the line was tagged with *EC-IDF*. If the duration was updated, the line was tagged with *UPDATE*. In addition, the updated durations were also coloured red. In addition, a note was added to the bottom of the table to describe the type of data used for the update and which durations were updated.

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
EC-IDF 5 min	3.9	5.8	7.0	8.6	9.7	10.8	36
EC-IDF 10 min	5.7	8.1	9.7	11.7	13.2	14.7	36
EC-IDF 15 min	7.0	9.6	11.3	13.5	15.1	16.7	36
EC-IDF 30 min	9.8	12.7	14.6	17.0	18.7	20.5	36
EC-IDF 1 h	13.4	16.8	19.1	21.9	24.1	26.2	36
EC-IDF 2 h	18.8	24.4	28.1	32.8	36.3	39.7	36
UPDATE 6 h	29.0	35.8	40.3	45.9	50.1	54.3	48
UPDATE 12 h	37.8	46.0	51.4	58.3	63.4	68.5	48
UPDATE 24 h	45.0	56.2	63.6	73.0	79.9	86.8	48

* 6-hr data were used for the update: shorter durations were not updated

These durations were updated.

Figure 1.3 Example of Changes to Table 2a

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
EC-IDF 5 min	47.3	69.5	84.1	102.7	116.4	130.0	36
	+/- 7.5	+/- 12.7	+/- 17.1	+/- 23.0	+/- 27.6	+/- 32.1	36
EC-IDF 10 min	34.3	48.6	58.2	70.2	79.1	87.9	36
	+/- 4.9	+/- 8.2	+/- 11.1	+/- 15.0	+/- 17.9	+/- 20.8	36
EC-IDF 15 min	27.9	38.3	45.1	53.8	60.2	66.6	36
	+/- 3.5	+/- 5.9	+/- 8.0	+/- 10.8	+/- 12.9	+/- 15.1	36
EC-IDF 30 min	19.7	25.4	29.2	33.9	37.5	41.0	36
	+/- 1.9	+/- 3.3	+/- 4.4	+/- 5.9	+/- 7.1	+/- 8.3	36
EC-IDF 1 h	13.4	16.8	19.1	21.9	24.1	26.2	36
	+/- 1.2	+/- 2.0	+/- 2.6	+/- 3.6	+/- 4.3	+/- 5.0	36
EC-IDF 2 h	9.4	12.2	14.1	16.4	18.1	19.9	36
	+/- 0.9	+/- 1.6	+/- 2.2	+/- 2.9	+/- 3.5	+/- 4.1	36
UPDATE 6 h	4.8	6.0	6.7	7.7	8.4	9.1	48
	+/- 0.3	+/- 0.6	+/- 0.8	+/- 1.0	+/- 1.2	+/- 1.4	48
UPDATE 12 h	3.2	3.8	4.3	4.9	5.3	5.7	48
	+/- 0.2	+/- 0.3	+/- 0.5	+/- 0.6	+/- 0.7	+/- 0.9	48
UPDATE 24 h	1.9	2.3	2.6	3.0	3.3	3.6	48
	+/- 0.1	+/- 0.2	+/- 0.3	+/- 0.4	+/- 0.5	+/- 0.6	48

* 6-hr data were used for the update: shorter durations were not updated

These durations were updated.

Figure 1.4 Example of Changes to Table 2b

EC's Table 3 lists the information about the fit of the straight line through the intensities. The parameters and other information are presented in the same format that is used by EC. There were no changes to the format of this table (Figure 1.5).

Statistics/Statistiques	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans
Mean of RR/Moyenne de RR	18.0	24.8	29.3	34.9	39.2	43.3
Std. Dev. /Écart-type (RR)	15.7	23.1	28.0	34.2	38.8	43.4
Std. Error/Erreur-type	1.8	1.5	1.5	1.5	1.6	1.7
Coefficient (A)	12.7	16.8	19.4	22.7	25.2	27.6
Exponent/Exposant (B)	-0.565	-0.594	-0.607	-0.619	-0.625	-0.631
Mean % Error/% erreur moyenne	5.2	3.0	3.0	3.2	3.3	3.4

Figure 1.5 Example of Table 3

The first figure produced by EC is the IDF curve figure. This figure plots the information in Table 2b with the straight line fit in Table 3. Note that if the “Mean % Error” for the 10-year return period is greater than 12%, curved interpolation lines are plotted on the figure instead of the straight line. However, Table 3 always includes the information about the straight line fit. EC's format is to mark the intensities with an "X". If the confidence limits are greater than 25 percent of the intensity value, then EC adds a circle around the "X". If the average confidence limit for all nine durations at a particular return period is less than 25 percent, then a solid line is used for the straight line fit. If the average confidence limit is greater than 25 percent, then a dashed line is used for the straight line fit. For this update, the format was modified slightly (Figure 1.6). Updated durations were marked with a "+" (circled if the confidence limits were greater than 25 percent of the intensity value). Updated durations were also coloured red. Some extra information was added to the right of the IDF curve to indicate which years of data were added to the IDF curve during the update. The extra information was also coloured red.

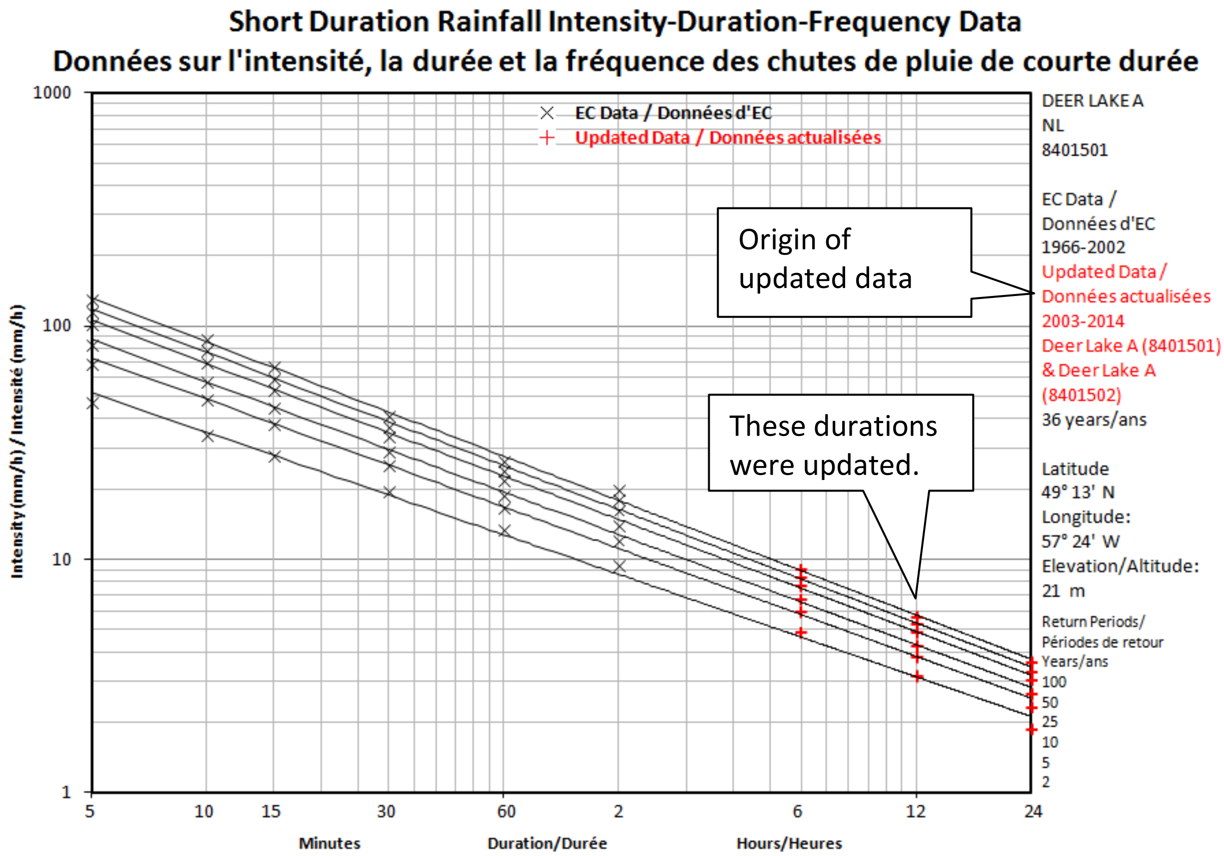

Figure 1.6 Example of Changes to IDF Curve

The second and third figures produced by EC are the quantile-quantile and the return period plots. These figures use the empirical return period for each data point, as calculated by the following formula.

$$T_{emp} = \frac{N+0.25}{r-0.375} \quad (1\text{-}4)$$

where:

T_{emp} is the empirical return period for the data point
r is the rank of the data point (the data are ordered from largest to smallest)

For the quantile-quantile plot, the empirical return period is used to calculate the Gumbel estimate using equations 1-1 and 1-2 above. The original data are plotted on the y-axis, and the Gumbel estimates are plotted on the x-axis. If the data are a perfect fit, they will line up exactly along the 1:1 line included on the figure. For the return period plot, the original data are plotted on the y-axis, and the empirical return periods are plotted on the x-axis. If the data are a perfect fit, they will line up exactly along the fitted Gumbel distribution line that is also included on the figure. This figure also includes the 95% confidence limits (calculated with equation 1-3 above). If there are any data points outside of the confidence limits, they may represent outliers. EC's format is to use small circles to represent the data points. For the quantile-quantile plot, EC plots the 1:1 line in red. For the return period plot, the Gumbel distribution is plotted with a red line and the 95 percent confidence limits are plotted with dashed red lines. For this update, the updated data were plotted as a filled circle and coloured red (Figures 1.7 and 1.8). These changes allow the user to determine how well the updated data fit with the Gumbel distribution.

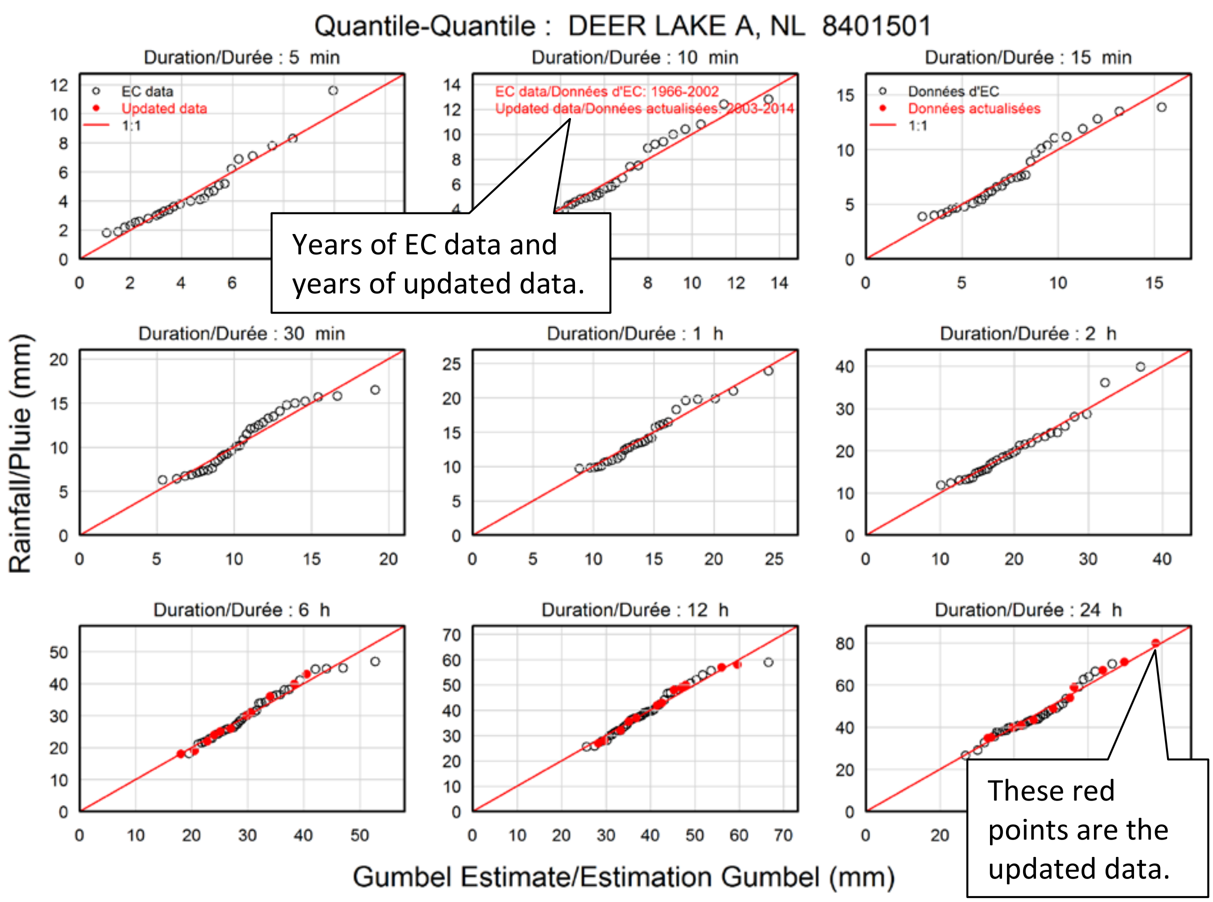

Figure 1.7 Example of Changes to Quantile-Quantile Plot

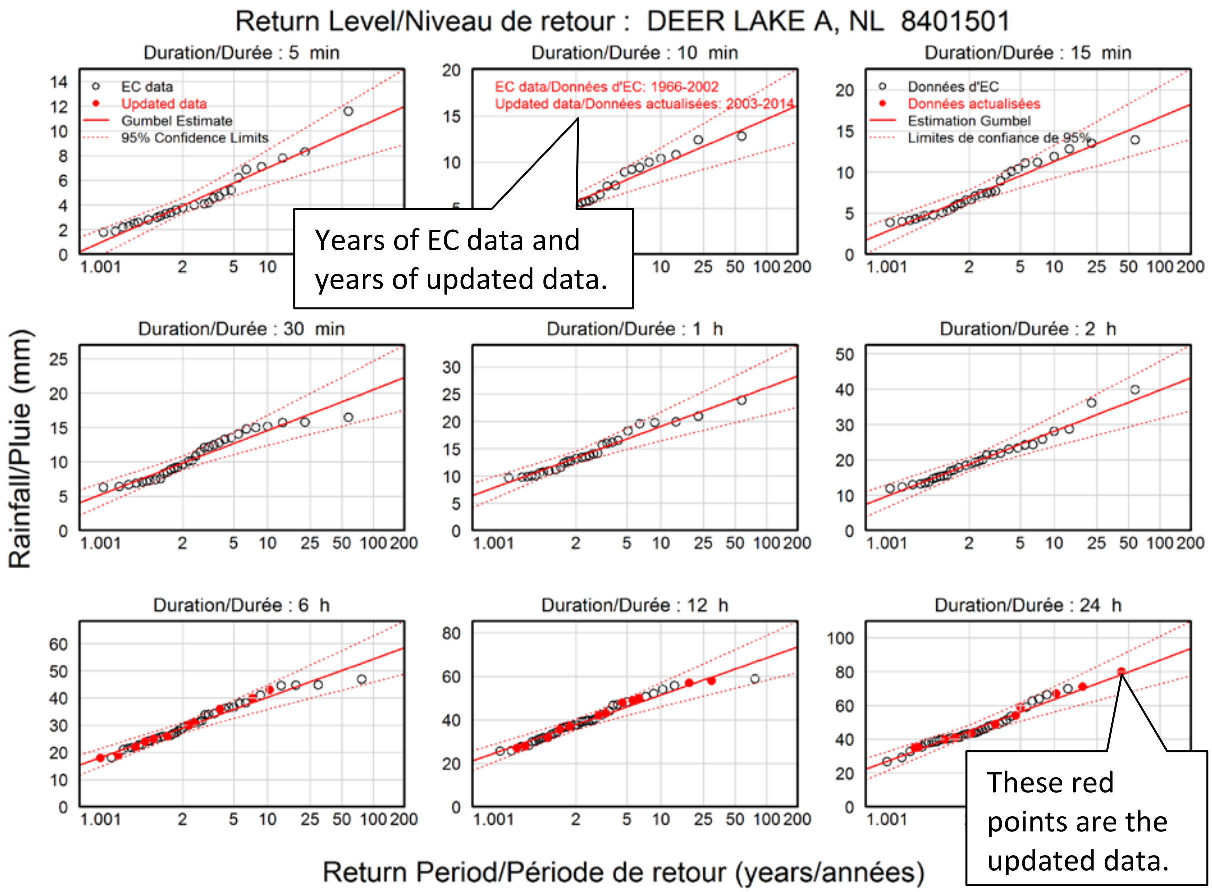

Figure 1.8 Example of Changes to Return Level Plot

The fourth figure produced by EC is the trend plot. This plot shows if the data have a significant trend or can be considered to be stationary. EC's methodology is explained in detail in Shephard, et al. (2014). Briefly, the methodology uses the Mann-Kendall test with the Sen's slope estimator to determine the linear trend in the data. However, some of the trend may be due to autocorrelation in the data. The method may falsely identify a trend when it is really simply autocorrelation in the data. Therefore, the portion of the trend that is due to autocorrelation is removed from the time series using an iterative process. The trend after the autocorrelation has been removed is then tested to determine if it is significant. The final slope and its 95 percent confidence limits are shown for each duration. The fitted linear trend is also included in the plots. If the trend is significant and positive, it is printed in red. If the trend is significant and negative, it is printed in blue. If the trend is not significant, it is printed in black. The data are plotted as small circles in EC's format. For this update, the updated data were plotted as a filled circle and coloured red (Figure 1.9). These changes allow the user to determine how the updated data have changed the trend of the original EC data.

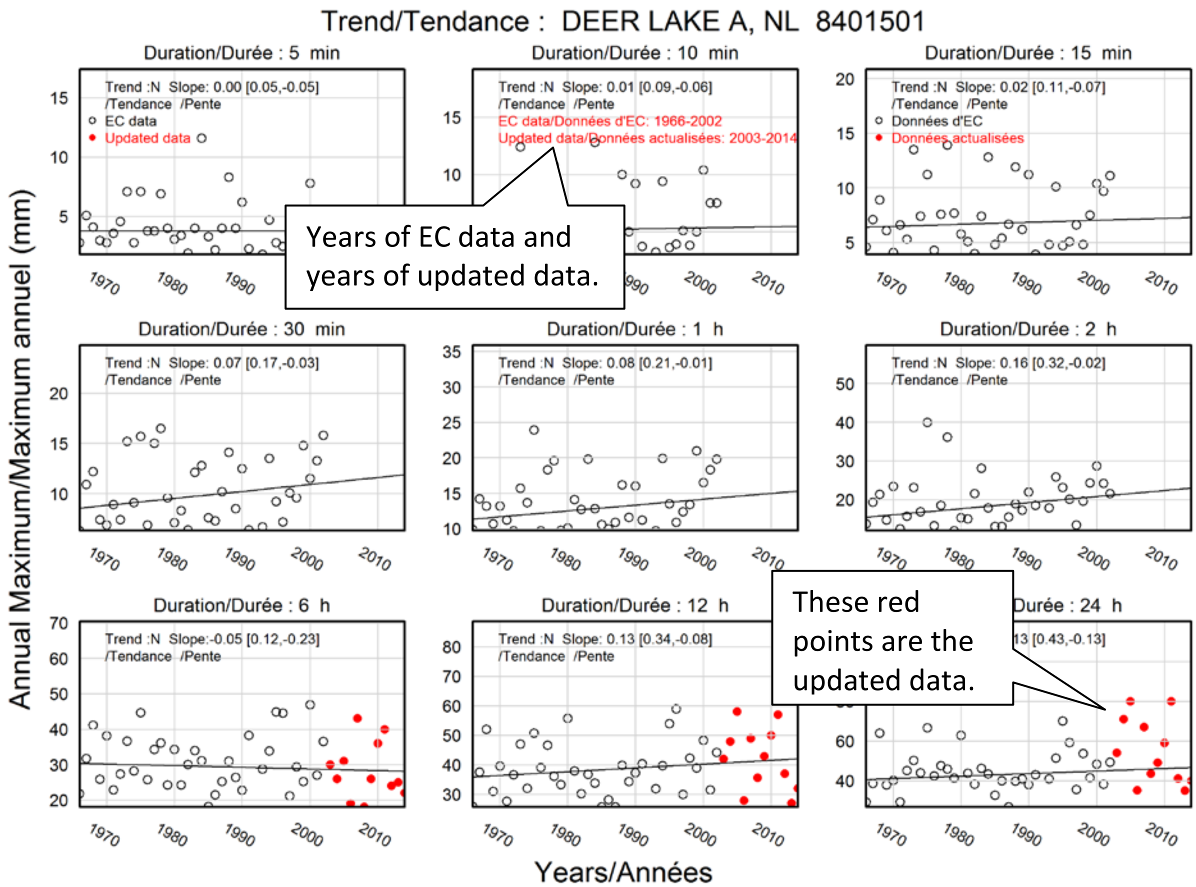

Figure 1.9 Example of Changes to Trend Plot

The remainder of this Appendix presents the updated IDF curves (tables and figures for each IDF curve). For completeness, the IDF stations that were not updated during this project are also included. The EC IDF V2.3 curves are included. Table 1.2 lists the stations and the Section numbers. Note that there are two IDF curves for the area of St. John's: St. John's A and Ruby Line.

Table 1.2 Listing of Stations

Station Name	***Station ID***	***Section***	***Type of IDF Curve***
Argentia (AUT)	8400104	2	EC IDF V2.3
Burgeo	8400801	3	EC IDF V2.3
Comfort Cove	8401259	4	Updated by creating a curve at Twillingate (AUT) (8404025)
Daniels Harbour	8401400	5	Updated
Deer Lake A	8401501	6	Updated
Gander Airport CS	8401705	7	Updated
La Scie	8402520	8	Updated
Port Aux Basques	8402975	9	Updated
St. Albans	8403290	10	Updated
St. Anthony	8403401	11	Updated by creating a curve at St. Anthony (8403399)
St. John's A	8403506	12	Updated St. John's A and Ruby Line
St. Lawrence	8403619	13	EC IDF V2.3
Stephenville A	8403800	14	EC IDF V2.3
Battle Harbour LOR	8500398	Not included	N/A
Churchill Falls A	8501132	15	Updated
Goose A	8501900	16	EC IDF V2.3
Mary's Harbour A	8502591	17	Updated
Nain	8502799	18	EC IDF V2.3
Wabush Lake A	8504175	19	Updated

Section 2.0 Argentia (AUT) – EC-IDF V2.3

This station was not updated during this project. This is the EC IDF curve (V2.3, 2015).

Environment Canada/Environnement Canada

Short Duration Rainfall Intensity-Duration-Frequency Data
Données sur l'intensité, la durée et la fréquence des chutes de pluie de courte durée

Gumbel - Method of moments/Méthode des moments

2014/12/21

==

ARGENTIA (AUT) NL 8400104

Latitude: 47 17'N Longitude: 53 59'W Elevation/Altitude: 19 m

Years/Années : 1980 - 2013 # Years/Années : 15

==

****

Table 1: Annual Maximum (mm)/Maximum annuel (mm)

****

Year Année	5 min	10 min	15 min	30 min	1 h	2 h	6 h	12 h	24 h
1980	8.3	14.7	17.0	17.0	17.0	19.0	34.8	41.0	46.2
1981	6.6	12.3	18.1	23.0	25.8	31.7	58.5	73.6	91.6
1982	4.6	7.9	10.7	15.8	20.5	34.0	61.3	69.4	69.4
1983	5.9	11.2	14.4	16.2	17.3	23.8	39.3	55.6	68.2
1984	4.7	8.0	9.0	10.1	10.4	20.2	39.4	51.0	53.0
1985	3.5	5.3	7.9	12.0	15.4	29.5	39.8	44.3	57.6
1986	3.1	4.8	7.2	11.3	15.0	16.7	30.4	44.5	66.4
2004	4.2	7.8	9.6	11.6	19.2	26.6	46.8	73.2	108.6
2005	3.8	6.6	8.4	14.8	21.2	25.2	33.2	42.8	52.6
2006	7.2	11.4	12.6	14.2	23.4	29.4	31.8	38.3	66.6
2007	5.2	10.4	15.6	24.0	38.0	61.0	150.8	200.4	204.8
2008	5.4	9.6	13.0	20.4	23.0	24.0	35.2	46.8	53.2
2009	3.0	5.4	7.0	11.2	16.4	24.4	34.4	42.0	43.4
2012	4.0	5.6	7.4	11.2	18.0	20.0	29.0	41.2	43.8
2013	3.0	5.6	7.2	10.8	16.4	22.0	35.0	45.2	56.4
# Yrs. Années	15	15	15	15	15	15	15	15	15
Mean Moyenne	4.8	8.4	11.0	14.9	19.8	27.2	46.6	60.6	72.1
Std. Dev. Écart-type	1.6	3.0	3.8	4.5	6.3	10.6	30.3	40.5	40.8
Skew. Dissymétrie	0.80	0.59	0.64	0.96	1.67	2.56	3.28	3.33	2.80
Kurtosis	3.47	2.95	2.58	3.37	7.63	11.10	14.35	14.69	11.72

*-99.9 Indicates Missing Data/Données manquantes

Warning: annual maximum amount greater than 100-yr return period amount
Avertissement : la quantité maximale annuelle excède la quantité pour une période de retour de 100 ans

Year/Année	Duration/Durée	Data/Données	100-yr/ans
2007	2 h	61.0	60.3
2007	6 h	150.8	141.8
2007	12 h	200.4	187.6
2007	24 h	204.8	200.0

****

Table 2a : Return Period Rainfall Amounts (mm)
Quantité de pluie (mm) par période de retour

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
5 min	4.6	6.0	6.9	8.1	9.0	9.9	15
10 min	7.9	10.6	12.4	14.6	16.3	17.9	15
15 min	10.4	13.8	16.0	18.8	20.9	23.0	15
30 min	14.2	18.2	20.8	24.1	26.6	29.1	15
1 h	18.8	24.4	28.1	32.8	36.3	39.7	15
2 h	25.4	34.8	40.9	48.7	54.5	60.3	15
6 h	41.7	68.5	86.2	108.7	125.3	141.8	15
12 h	54.0	89.7	113.4	143.4	165.6	187.6	15
24 h	65.4	101.4	125.3	155.4	177.8	200.0	15

****

Table 2b:

Return Period Rainfall Rates (mm/h) - 95% Confidence limits
Intensité de la pluie (mm/h) par période de retour - Limites de confiance de 95%

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
5 min	54.8	71.9	83.1	97.4	107.9	118.4	15
	+/- 8.9	+/- 15.1	+/- 20.4	+/- 27.4	+/- 32.8	+/- 38.3	15
10 min	47.7	63.7	74.3	87.8	97.7	107.6	15
	+/- 8.4	+/- 14.2	+/- 19.2	+/- 25.9	+/- 31.0	+/- 36.1	15
15 min	41.5	55.1	64.0	75.4	83.8	92.1	15
	+/- 7.1	+/- 12.0	+/- 16.2	+/- 21.9	+/- 26.2	+/- 30.5	15
30 min	28.3	36.3	41.6	48.3	53.2	58.1	15
	+/- 4.2	+/- 7.1	+/- 9.5	+/- 12.9	+/- 15.4	+/- 17.9	15
1 h	18.8	24.4	28.1	32.8	36.3	39.7	15
	+/- 2.9	+/- 5.0	+/- 6.7	+/- 9.0	+/- 10.8	+/- 12.6	15
2 h	12.7	17.4	20.5	24.4	27.3	30.1	15
	+/- 2.5	+/- 4.1	+/- 5.6	+/- 7.5	+/- 9.0	+/- 10.5	15
6 h	6.9	11.4	14.4	18.1	20.9	23.6	15
	+/- 2.3	+/- 4.0	+/- 5.3	+/- 7.2	+/- 8.6	+/- 10.0	15
12 h	4.5	7.5	9.5	11.9	13.8	15.6	15
	+/- 1.6	+/- 2.6	+/- 3.6	+/- 4.8	+/- 5.8	+/- 6.7	15
24 h	2.7	4.2	5.2	6.5	7.4	8.3	15
	+/- 0.8	+/- 1.3	+/- 1.8	+/- 2.4	+/- 2.9	+/- 3.4	15

****

Table 3: Interpolation Equation / Équation d'interpolation: R = A*T^B

R = Interpolated Rainfall rate (mm/h)/Intensité interpolée de la pluie (mm/h)
RR = Rainfall rate (mm/h) / Intensité de la pluie (mm/h)
T = Rainfall duration (h) / Durée de la pluie (h)

****

Statistics/Statistiques	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans
Mean of RR/Moyenne de RR	24.2	32.4	37.9	44.7	49.8	54.9
Std. Dev. /Écart-type (RR)	19.7	25.5	29.4	34.2	37.9	41.5
Std. Error/Erreur-type	5.5	5.9	6.4	7.2	7.9	8.6
Coefficient (A)	17.6	24.7	29.3	35.1	39.4	43.6
Exponent/Exposant (B)	-0.546	-0.502	-0.485	-0.471	-0.463	-0.457
Mean % Error/% erreur moyenne	8.4	8.4	9.3	10.3	10.9	11.5

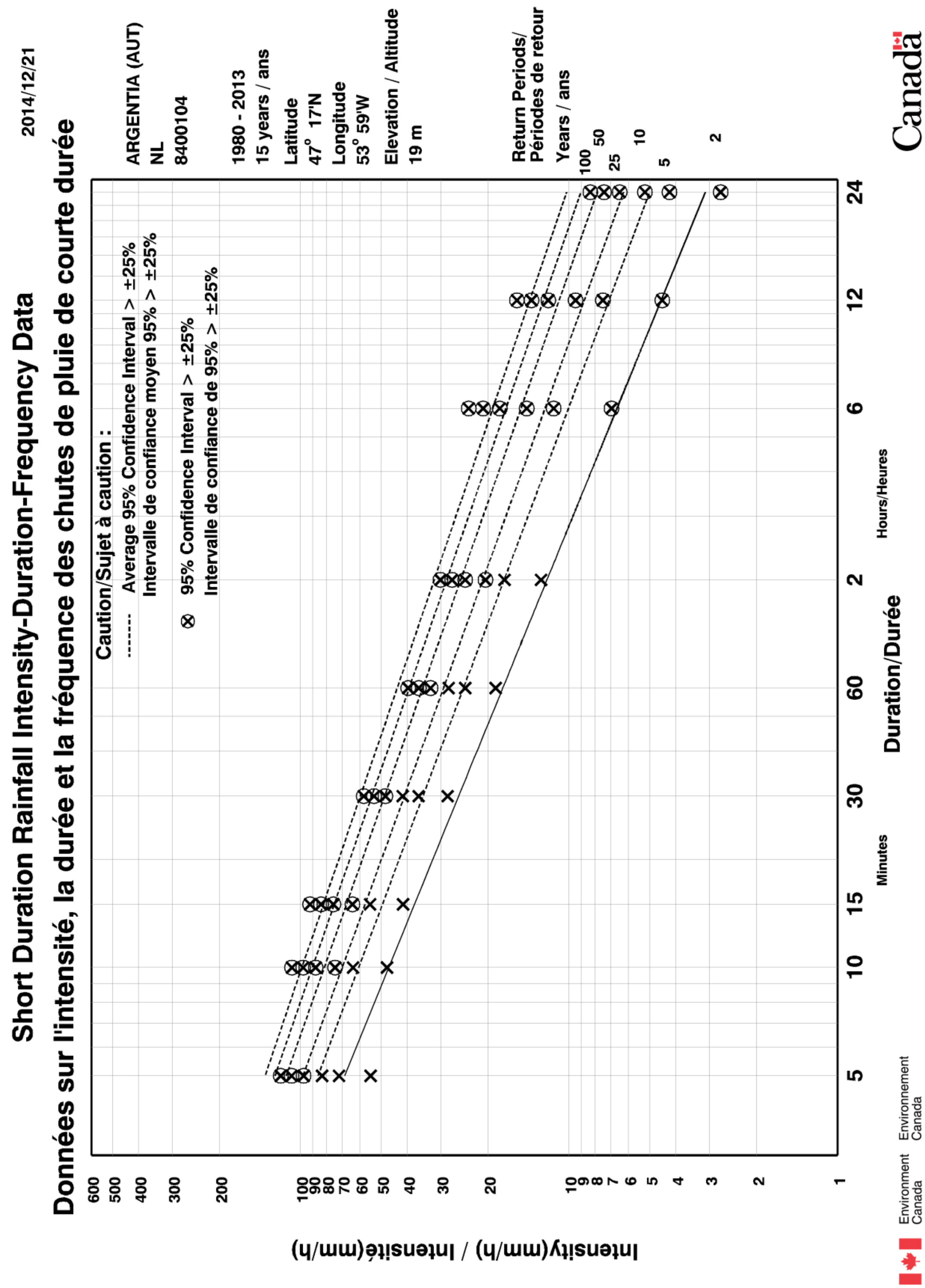

Figure 2.1 Argentia (AUT) IDF Curve – EC-IDF V2.3

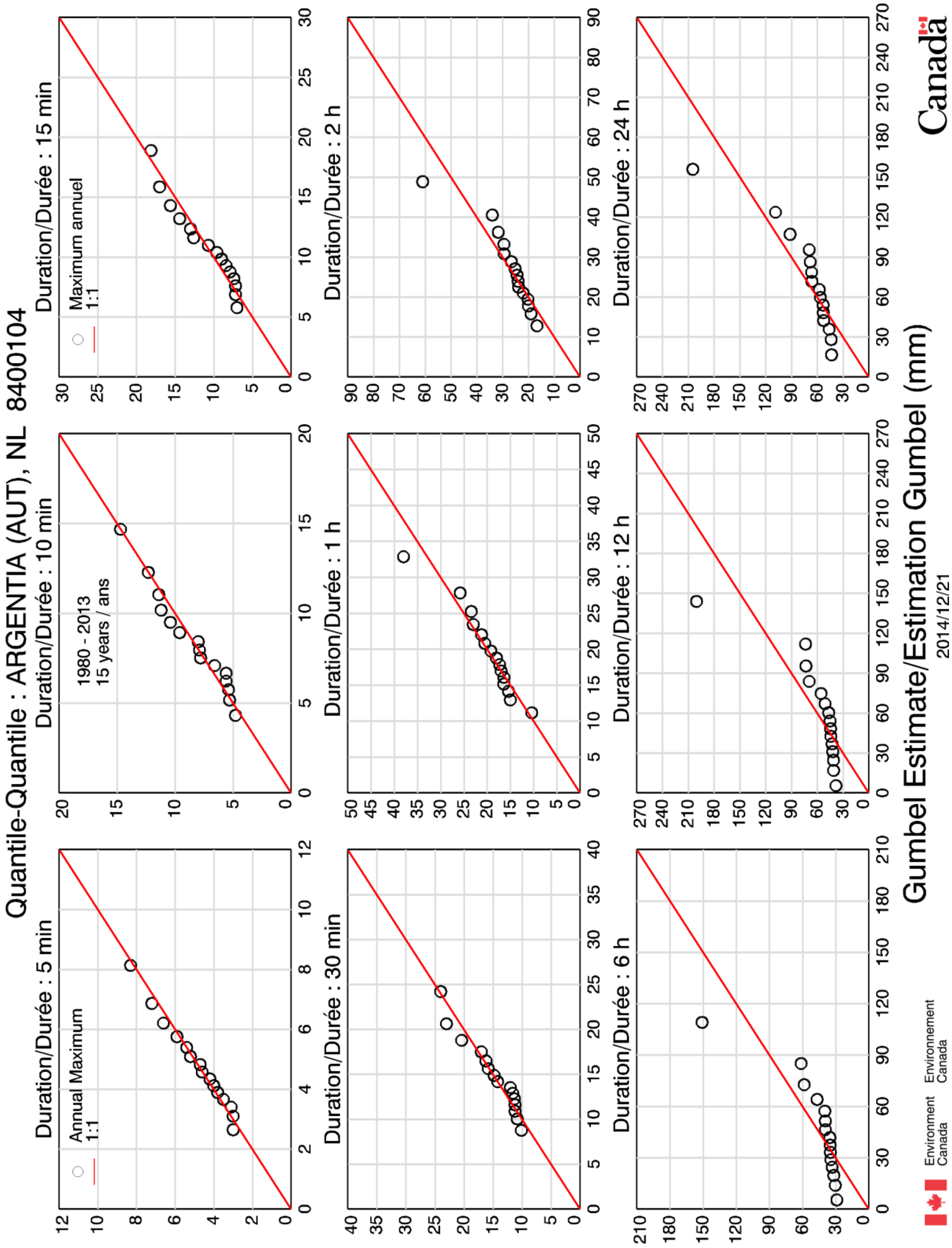

Figure 2.2 Argentia (AUT) Quantile-Quantile Plot – EC-IDF V2.3

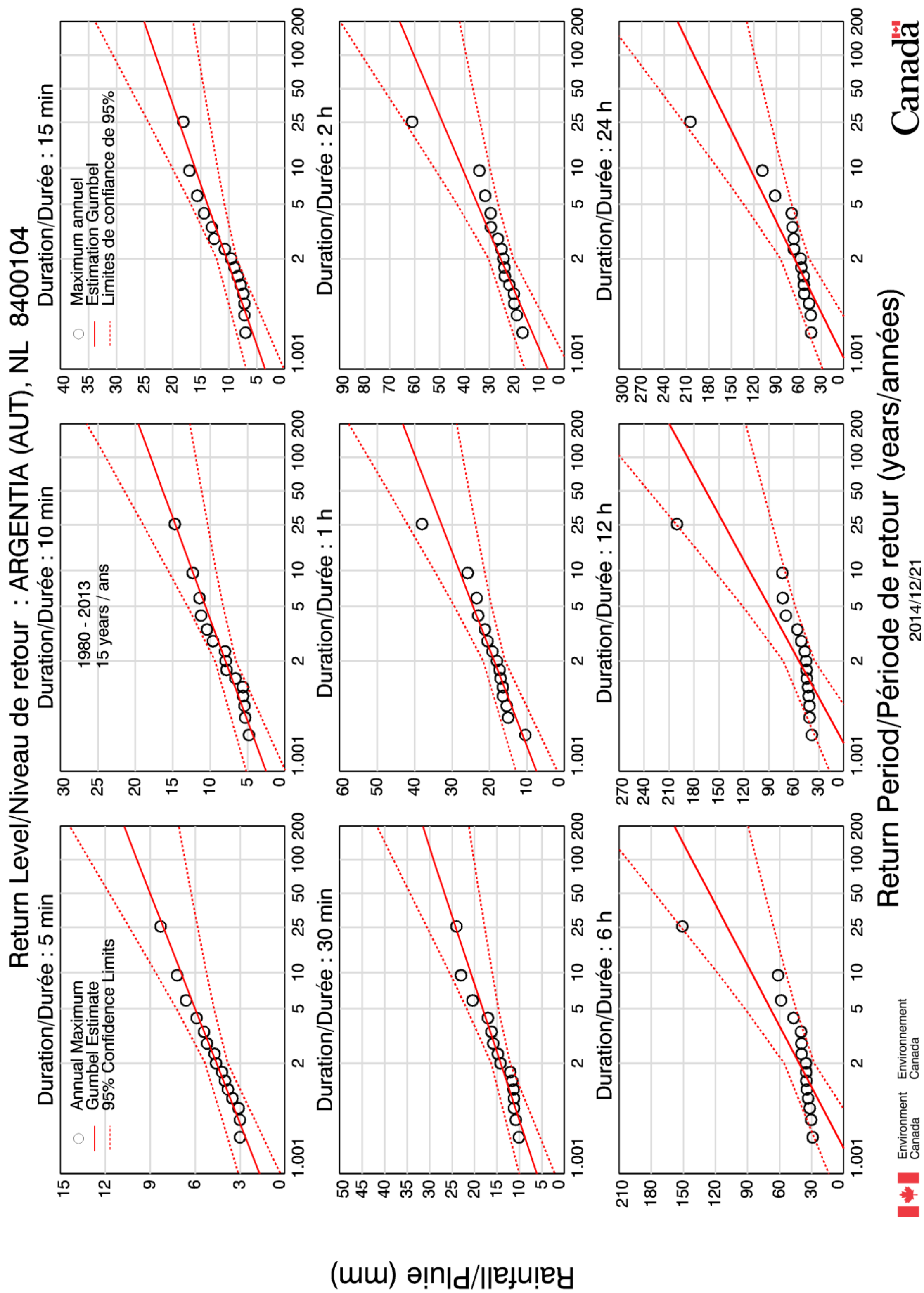

Figure 2.3 **Argentia (AUT) Return Level Plot – EC-IDF V2.3**

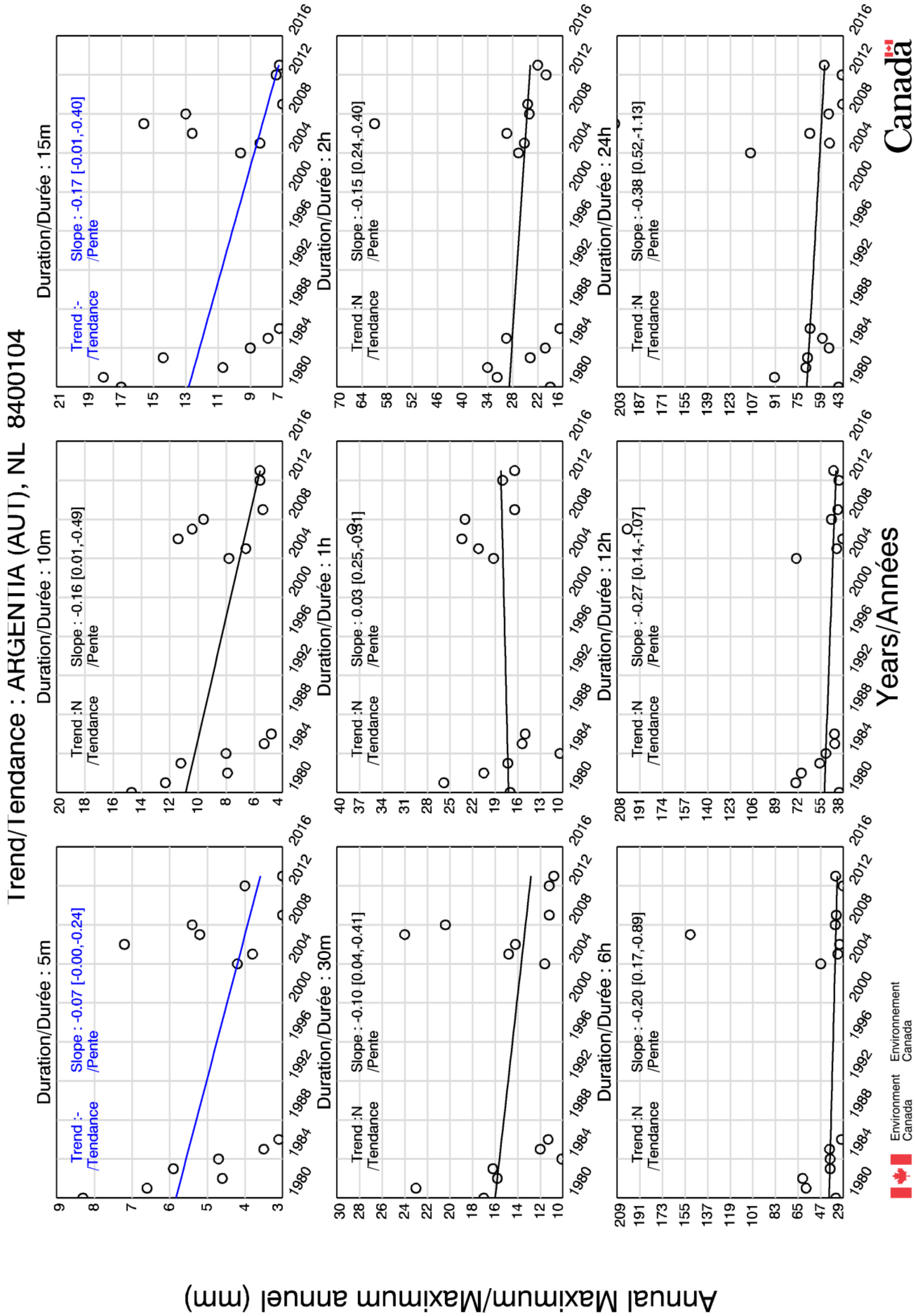

Figure 2.4 Argentia (AUT) Trend Plot – EC-IDF V2.3

Section 3.0 Burgeo – EC-IDF V2.3

This station was not updated during this project. This is the EC IDF curve (V2.3, 2015).

Environment Canada/Environnement Canada

Short Duration Rainfall Intensity-Duration-Frequency Data
Données sur l'intensité, la durée et la fréquence des chutes de pluie de courte durée

Gumbel - Method of moments/Méthode des moments

2014/12/21

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NAIN NL 8502799

Latitude: 56 33'N Longitude: 61 41'W Elevation/Altitude: 7 m

Years/Années : 1993 - 2013 # Years/Années : 17

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****

Table 1: Annual Maximum (mm)/Maximum annuel (mm)

****

Year Année	5 min	10 min	15 min	30 min	1 h	2 h	6 h	12 h	24 h
1993	3.8	6.0	6.2	7.4	8.8	11.6	18.8	19.8	24.7
1994	2.2	3.6	4.4	6.0	10.1	16.2	37.5	43.5	59.6
1997	1.4	1.9	2.6	3.7	6.0	10.4	19.4	31.1	49.8
1998	3.7	5.4	7.6	9.5	11.7	13.7	25.2	42.2	47.1
1999	6.5	7.0	7.2	8.3	12.7	19.0	25.2	39.0	50.5
2000	-99.9	-99.9	-99.9	-99.9	-99.9	16.0	25.5	29.1	32.8
2001	1.9	2.5	2.7	4.1	6.9	10.6	18.4	30.1	33.7
2002	3.1	5.6	6.2	6.8	8.8	15.1	27.5	45.7	59.4
2003	2.5	4.8	5.8	6.2	8.7	11.7	15.9	26.6	38.7
2004	3.6	5.0	6.9	8.5	11.9	12.7	-99.9	-99.9	31.4
2005	2.1	2.3	2.9	5.4	8.1	14.8	29.9	31.4	35.2
2006	2.1	2.8	3.6	4.8	7.8	10.4	17.2	28.9	46.0
2007	2.1	2.8	3.5	5.0	7.5	12.9	25.3	38.7	43.7
2008	2.6	4.8	7.1	12.9	17.6	24.8	46.9	53.3	54.5
2009	1.2	1.4	2.0	3.7	5.7	9.8	19.0	24.5	32.5
2010	2.7	3.9	5.8	7.8	8.0	13.3	-99.9	-99.9	58.0
2011	3.3	4.4	4.6	7.4	11.5	18.5	33.0	39.8	41.6
2012	3.8	6.0	7.2	9.0	15.2	18.8	23.0	30.2	47.4
2013	3.2	4.8	5.6	8.8	9.8	9.8	19.2	21.6	27.8
# Yrs. Années	18	18	18	18	18	19	17	17	19
Mean Moyenne	2.9	4.2	5.1	7.0	9.8	14.2	25.1	33.9	42.9
Std. Dev. Écart-type	1.2	1.6	1.8	2.4	3.1	4.0	8.1	9.2	10.9
Skew. Dissymétrie	1.48	-0.13	-0.29	0.65	1.03	1.11	1.36	0.44	0.04
Kurtosis	7.05	2.51	2.11	4.10	4.28	4.60	5.32	3.08	2.32

*-99.9 Indicates Missing Data/Données manquantes

****

Table 2a: Return Period Rainfall Amounts (mm)
Quantité de pluie (mm) par période de retour

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
5 min	2.7	3.7	4.5	5.3	6.0	6.7	18
10 min	3.9	5.3	6.3	7.4	8.3	9.2	18
15 min	4.8	6.4	7.5	8.9	9.9	10.9	18
30 min	6.6	8.7	10.1	11.8	13.1	14.4	18
1 h	9.3	12.1	13.9	16.2	18.0	19.7	18
2 h	13.6	17.1	19.4	22.3	24.5	26.6	19
6 h	23.8	31.0	35.7	41.8	46.2	50.7	17
12 h	32.3	40.4	45.8	52.6	57.6	62.6	17
24 h	41.1	50.7	57.1	65.1	71.1	77.0	19

****

Table 2b:
Return Period Rainfall Rates (mm/h) - 95% Confidence limits
Intensité de la pluie (mm/h) par période de retour - Limites de confiance de 95%

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
5 min	32.2	45.0	53.5	64.2	72.1	80.0	18
	+/- 6.1	+/- 10.4	+/- 14.0	+/- 18.9	+/- 22.6	+/- 26.3	18
10 min	23.4	31.9	37.5	44.6	49.9	55.1	18
	+/- 4.1	+/- 6.9	+/- 9.3	+/- 12.5	+/- 14.9	+/- 17.4	18
15 min	19.2	25.7	30.1	35.5	39.6	43.6	18
	+/- 3.1	+/- 5.3	+/- 7.1	+/- 9.6	+/- 11.5	+/- 13.4	18
30 min	13.1	17.3	20.1	23.7	26.3	28.9	18
	+/- 2.0	+/- 3.4	+/- 4.6	+/- 6.2	+/- 7.4	+/- 8.6	18
1 h	9.3	12.1	13.9	16.2	18.0	19.7	18
	+/- 1.3	+/- 2.2	+/- 3.0	+/- 4.1	+/- 4.9	+/- 5.7	18
2 h	6.8	8.5	9.7	11.2	12.2	13.3	19
	+/- 0.8	+/- 1.4	+/- 1.9	+/- 2.5	+/- 3.0	+/- 3.5	19
6 h	4.0	5.2	6.0	7.0	7.7	8.4	17
	+/- 0.6	+/- 1.0	+/- 1.3	+/- 1.8	+/- 2.2	+/- 2.5	17
12 h	2.7	3.4	3.8	4.4	4.8	5.2	17
	+/- 0.3	+/- 0.6	+/- 0.8	+/- 1.0	+/- 1.2	+/- 1.4	17
24 h	1.7	2.1	2.4	2.7	3.0	3.2	19
	+/- 0.2	+/- 0.3	+/- 0.4	+/- 0.6	+/- 0.7	+/- 0.8	19

****

Table 3: Interpolation Equation / Équation d'interpolation: R = A*T^B

R = Interpolated Rainfall rate (mm/h)/Intensité interpolée de la pluie (mm/h)
RR = Rainfall rate (mm/h) / Intensité de la pluie (mm/h)
T = Rainfall duration (h) / Durée de la pluie (h)

****

Statistics/Statistiques	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans
Mean of RR/Moyenne de RR	12.5	16.8	19.7	23.3	25.9	28.6
Std. Dev. /Écart-type (RR)	10.5	14.7	17.5	21.0	23.6	26.2
Std. Error/Erreur-type	0.4	0.4	0.4	0.4	0.5	0.6
Coefficient (A)	9.4	12.3	14.2	16.6	18.4	20.2
Exponent/Exposant (B)	-0.510	-0.529	-0.538	-0.546	-0.550	-0.554
Mean % Error/% erreur moyenne	2.9	2.8	3.0	3.2	3.4	3.5

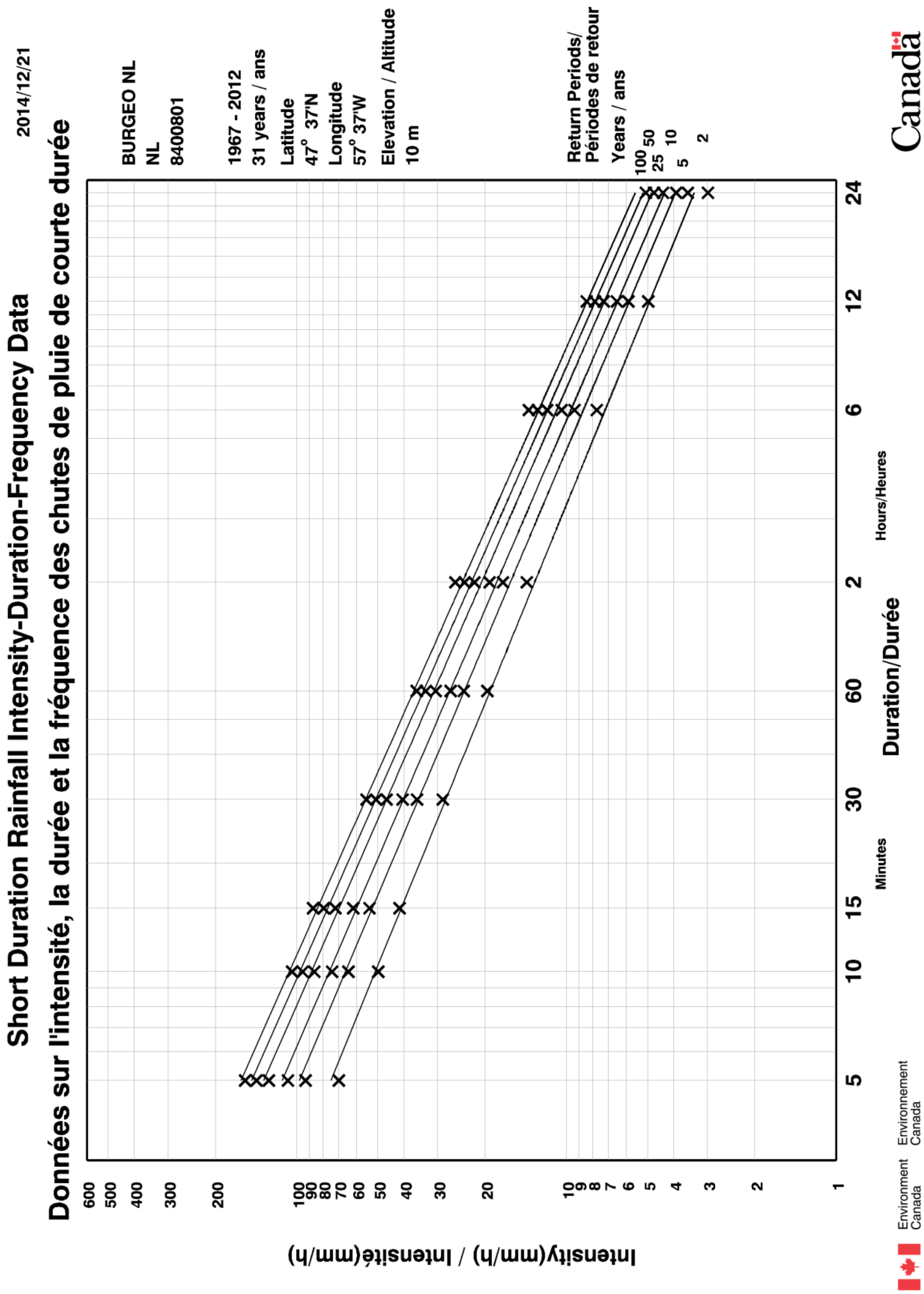

Figure 3.1 Burgeo IDF Curve – EC-IDF V2.3

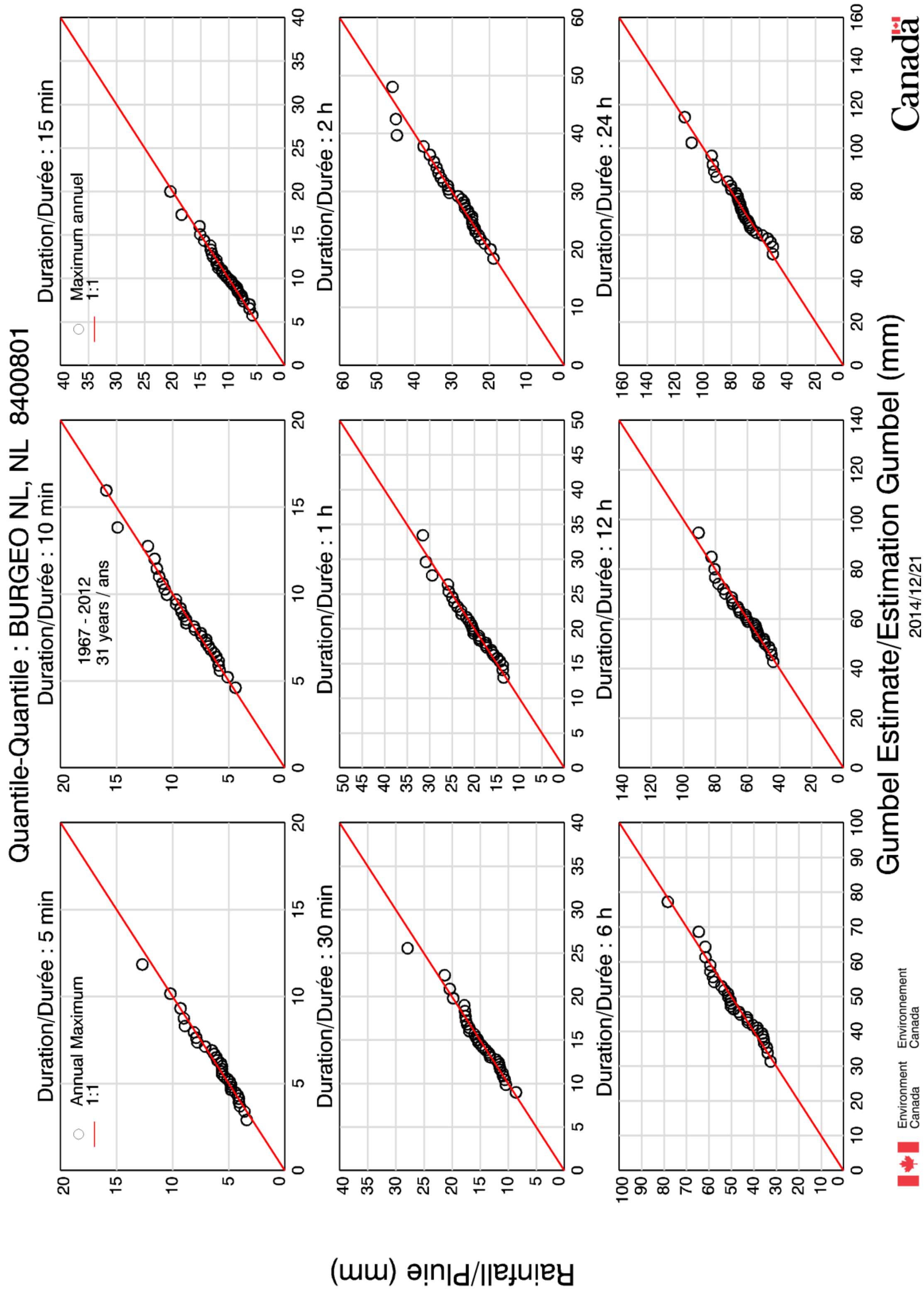

Figure 3.2 Burgeo Quantile-Quantile Plot – EC-IDF V2.3

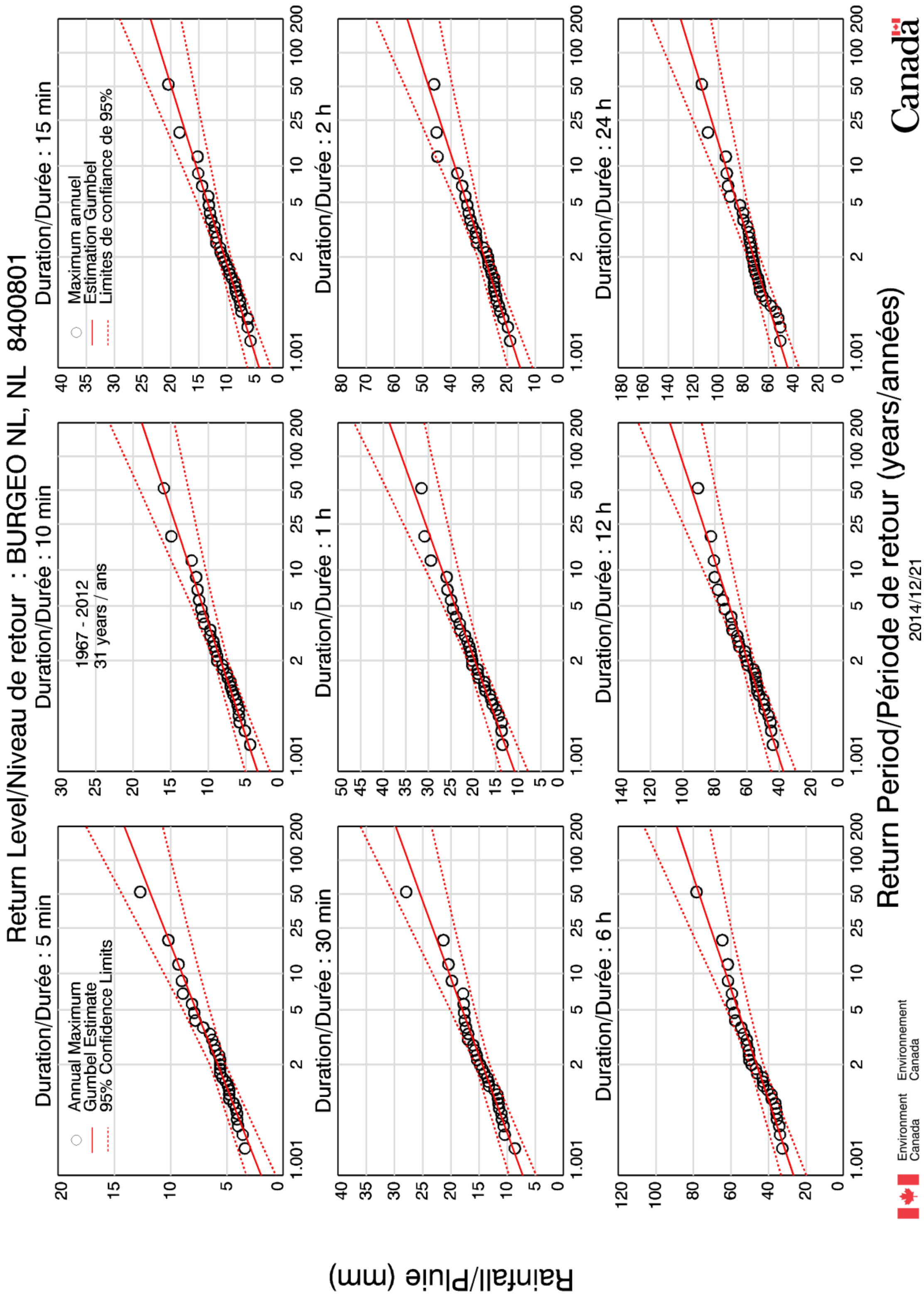

Figure 3.3 Burgeo Return Level Plot – EC-IDF V2.3

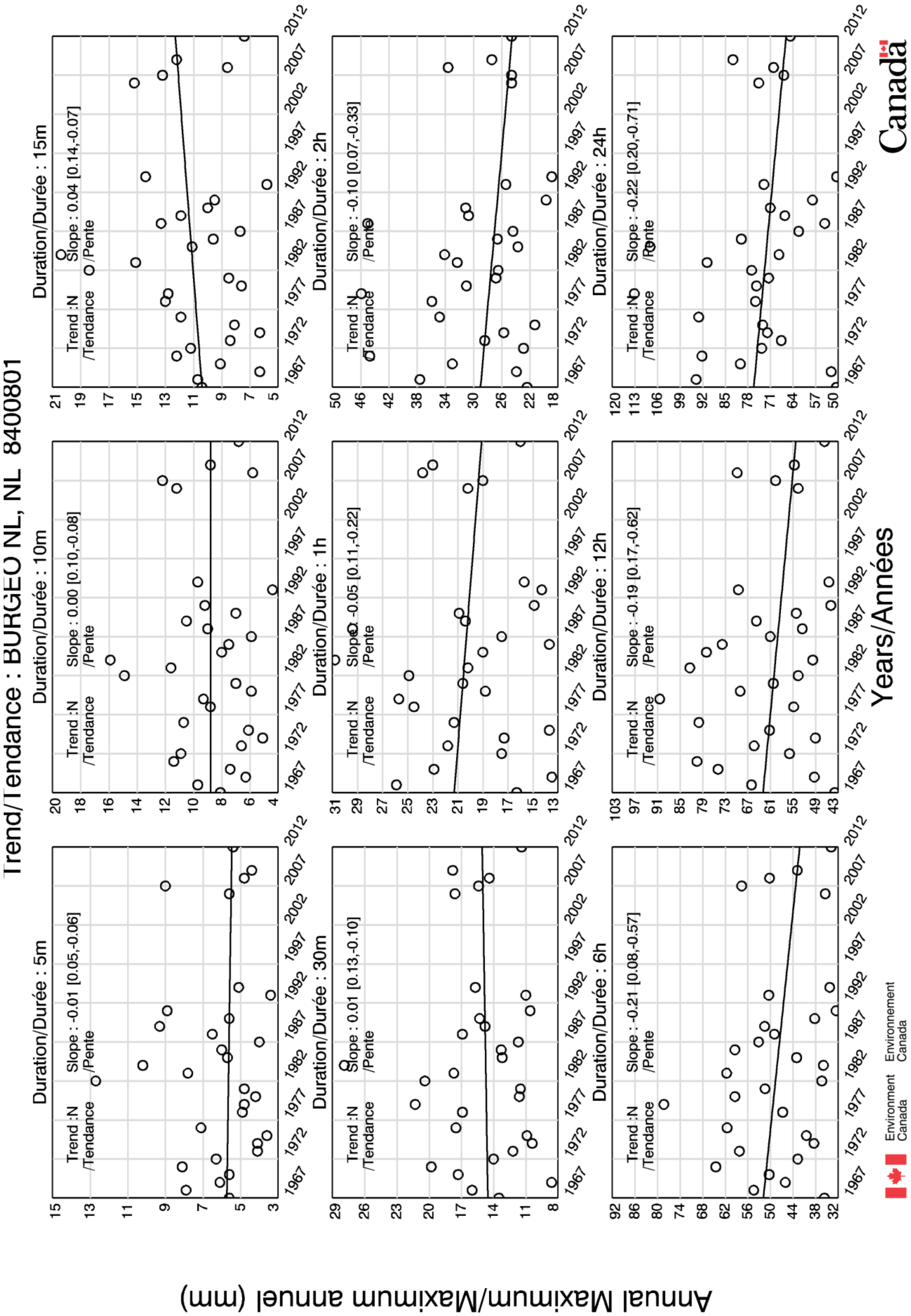

Figure 3.4 Burgeo Trend Plot – EC-IDF V2.3

Section 4.0 Comfort Cove

The IDF curve for Comfort Cove station was updated by creating a new IDF curve at Twillingate (AUT). There were insufficient data to create a full IDF curve at Twillingate (AUT). For short durations (5, 10-, 15-, and 30-min) users must consult the original Comfort Cove curve. For long durations, the Twillingate (AUT) curve may be used.

Table 4.1 presents the changes between the Comfort Cove IDF curve and the Twilingate (AUT) curve.

Table 4.1 Differences Between IDF Curves for Twillingate (AUT) and Comfort Cove

Percent Difference in Precipitation Amount [%] (Difference in Precipitation Amount [mm])						
	Return Period [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	N/A	N/A	N/A	N/A	N/A	N/A
10-min	N/A	N/A	N/A	N/A	N/A	N/A
15-min	N/A	N/A	N/A	N/A	N/A	N/A
30-min	N/A	N/A	N/A	N/A	N/A	N/A
1-hr	**30.3 (4.1)**	**11.9 (2.3)**	4.8 (1.1)	-1.2 (-0.3)	-4.5 (-1.4)	**-7.0 (-2.5)**
2-hr	**42.2 (7.5)**	**22.4 (5.5)**	**14.3 (4.1)**	**7.1 (2.4)**	3.1 (1.2)	-0.2 (-0.1)
6-hr	**21.5 (6.3)**	**7.0 (2.7)**	0.8 (0.3)	**-5.0 (-2.7)**	**-8.3 (-4.9)**	**-11.0 (-7.1)**
12-hr	**16.8 (6.2)**	**9.2 (4.5)**	**5.9 (3.3)**	2.7 (1.8)	0.9 (0.6)	-0.6 (-0.5)
24-hr	**15.7 (7.0)**	**13.7 (7.9)**	**12.8 (8.4)**	**12.0 (9.1)**	**11.5 (9.6)**	**11.1 (10.1)**

Notes:
Red numbers indicate that the updated IDF curve is lower than the EC-IDF V2.3 IDF curve for that duration and return period.
Bold numbers indicate changes greater than 5 percent.

Where there are decreases greater than 5 percent, users should exercise caution when using the updated IDF curve, or use the EC IDF curve. Section 4.1 presents the IDF curves for Comfort Cove (EC-IDF V2.3). Section 4.2 presents the IDF curves for Twillingate (AUT).

4.1 Comfort Cove – EC-IDF V2.3

Environment Canada/Environnement Canada

Short Duration Rainfall Intensity-Duration-Frequency Data
Données sur l'intensité, la durée et la fréquence des chutes
de pluie de courte durée

Gumbel - Method of moments/Méthode des moments

2014/12/21

COMFORT COVE NL 8401259

Latitude: 49 16'N Longitude: 54 53'W Elevation/Altitude: 99 m

Years/Années : 1967 - 1995 # Years/Années : 27

Table 1: Annual Maximum (mm)/Maximum annuel (mm)

Year Année	5 min	10 min	15 min	30 min	1 h	2 h	6 h	12 h	24 h
1967	5.8	10.4	13.0	15.5	20.6	25.1	28.4	33.3	34.0
1968	3.6	6.1	6.6	6.6	9.1	13.0	20.1	30.5	38.9
1969	5.3	8.4	11.7	16.8	24.1	35.3	62.2	81.3	91.7
1970	18.3	27.9	33.8	37.1	39.6	39.6	39.6	39.6	45.2
1971	2.5	4.1	6.1	11.4	12.7	12.7	31.2	43.4	45.2
1972	6.1	9.1	9.1	11.9	14.0	18.5	37.1	45.7	46.0
1973	7.6	11.4	14.5	18.8	19.6	25.1	37.3	48.8	59.4
1974	3.6	5.1	6.9	10.4	13.7	16.0	21.6	29.0	38.9
1975	5.1	8.1	10.2	16.0	17.0	17.3	34.3	35.1	35.6
1976	3.3	5.8	7.4	10.9	13.7	16.3	19.0	31.5	35.3
1978	5.1	5.3	5.5	7.0	8.6	11.0	16.3	21.0	24.2
1979	3.0	5.1	7.1	7.1	7.1	10.1	16.2	26.1	31.9
1980	2.9	5.7	6.5	9.9	11.4	15.6	22.9	35.0	42.1
1981	-99.9	-99.9	-99.9	-99.9	8.3	16.4	26.0	31.5	46.2
1982	2.5	3.5	5.0	6.5	10.8	14.6	25.9	34.0	39.7
1983	3.1	6.2	9.3	10.3	14.6	25.4	47.5	54.2	57.1
1984	4.1	5.5	7.6	10.4	15.1	18.2	24.4	30.0	40.4
1985	4.8	6.2	8.7	13.5	14.7	19.0	41.7	46.2	47.1
1986	2.6	3.3	4.0	5.8	10.2	16.4	35.0	44.4	60.3
1987	3.6	5.8	6.3	9.3	11.8	12.4	19.0	27.9	30.7
1988	3.2	4.9	6.0	7.3	13.0	16.2	21.4	27.2	40.0
1989	4.2	8.0	9.8	17.8	25.4	34.8	40.6	56.6	59.0
1990	3.9	4.9	5.6	7.6	9.8	14.1	26.4	31.1	51.5
1991	4.0	4.7	5.1	5.7	8.6	12.3	29.6	33.3	40.5
1992	4.6	6.0	6.5	7.4	8.2	13.2	32.3	50.5	58.5
1993	7.2	12.1	17.4	19.2	19.2	19.2	35.3	37.8	47.6
1994	3.8	5.1	6.6	9.5	11.2	19.7	37.2	43.9	63.5
1995	3.5	6.1	6.5	9.4	17.2	23.5	42.4	53.3	70.4
# Yrs. Années	27	27	27	27	28	28	28	28	28
Mean Moyenne	4.7	7.2	9.0	11.8	14.6	19.0	31.1	39.4	47.2
Std. Dev. Écart-type	3.0	4.7	5.8	6.5	6.8	7.5	10.6	12.5	14.1
Skew.	3.73	3.54	3.25	2.44	2.03	1.44	0.84	1.45	1.22

Dissymétrie Kurtosis	19.11	17.72	15.46	11.08	8.71	4.83	4.38	6.40	5.56

*-99.9 Indicates Missing Data/Données manquantes

Warning: annual maximum amount greater than 100-yr return period amount
Avertissement: la quantité maximale annuelle excède la quantité pour une période de retour de 100 ans

Year/Année	Duration/Durée	Data/Données	100-yr/ans
1969	12 h	81.3	78.6
1969	24 h	91.7	91.3
1970	5 min	18.3	14.2
1970	10 min	27.9	22.0
1970	15 min	33.8	27.3
1970	30 min	37.1	32.2
1970	1 h	39.6	36.1

****

Table 2a: Return Period Rainfall Amounts (mm)
Quantité de pluie (mm) par période de retour

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
5 min	4.2	6.9	8.7	10.9	12.6	14.2	27
10 min	6.4	10.6	13.3	16.8	19.4	22.0	27
15 min	8.0	13.2	16.6	20.9	24.2	27.3	27
30 min	10.8	16.5	20.3	25.1	28.7	32.2	27
1 h	13.5	19.5	23.5	28.6	32.3	36.1	28
2 h	17.7	24.4	28.7	34.3	38.4	42.4	28
6 h	29.4	38.7	44.9	52.8	58.6	64.3	28
12 h	37.3	48.4	55.7	65.0	71.8	78.6	28
24 h	44.9	57.3	65.5	75.9	83.7	91.3	28

****

Table 2b:

Return Period Rainfall Rates (mm/h) - 95% Confidence limits
Intensité de la pluie (mm/h) par période de retour - Limites de confiance de 95%

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
5 min	50.6	82.7	104.0	130.8	150.7	170.5	27
	+/- 12.6	+/- 21.2	+/- 28.6	+/- 38.6	+/- 46.1	+/- 53.8	27
10 min	38.7	63.6	80.1	100.9	116.4	131.7	27
	+/- 9.8	+/- 16.4	+/- 22.2	+/- 29.9	+/- 35.8	+/- 41.7	27
15 min	32.1	52.8	66.5	83.8	96.6	109.3	27
	+/- 8.1	+/- 13.6	+/- 18.4	+/- 24.8	+/- 29.7	+/- 34.6	27
30 min	21.5	33.0	40.6	50.2	57.3	64.4	27
	+/- 4.5	+/- 7.6	+/- 10.2	+/- 13.8	+/- 16.5	+/- 19.2	27
1 h	13.5	19.5	23.5	28.6	32.3	36.1	28
	+/- 2.3	+/- 3.9	+/- 5.3	+/- 7.1	+/- 8.5	+/- 9.9	28
2 h	8.9	12.2	14.4	17.1	19.2	21.2	28
	+/- 1.3	+/- 2.1	+/- 2.9	+/- 3.9	+/- 4.7	+/- 5.4	28
6 h	4.9	6.5	7.5	8.8	9.8	10.7	28
	+/- 0.6	+/- 1.0	+/- 1.4	+/- 1.8	+/- 2.2	+/- 2.6	28
12 h	3.1	4.0	4.6	5.4	6.0	6.6	28
	+/- 0.4	+/- 0.6	+/- 0.8	+/- 1.1	+/- 1.3	+/- 1.5	28
24 h	1.9	2.4	2.7	3.2	3.5	3.8	28
	+/- 0.2	+/- 0.3	+/- 0.5	+/- 0.6	+/- 0.7	+/- 0.9	28

****

Table 3: Interpolation Equation / Équation d'interpolation: R = A*T^B

R = Interpolated Rainfall rate (mm/h)/Intensité interpolée de la pluie (mm/h)
RR = Rainfall rate (mm/h) / Intensité de la pluie (mm/h)
T = Rainfall duration (h) / Durée de la pluie (h)

****

Statistics/Statistiques	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans
Mean of RR/Moyenne de RR	19.5	30.7	38.2	47.6	54.6	61.6
Std. Dev. /Écart-type (RR)	17.5	29.3	37.1	46.9	54.3	61.5
Std. Error/Erreur-type	2.8	5.7	7.7	10.3	12.3	14.3
Coefficient (A)	13.3	19.6	23.7	28.8	32.6	36.4
Exponent/Exposant (B)	-0.589	-0.641	-0.661	-0.678	-0.687	-0.695
Mean % Error/% erreur moyenne	5.0	5.8	6.1	6.5	6.6	6.8

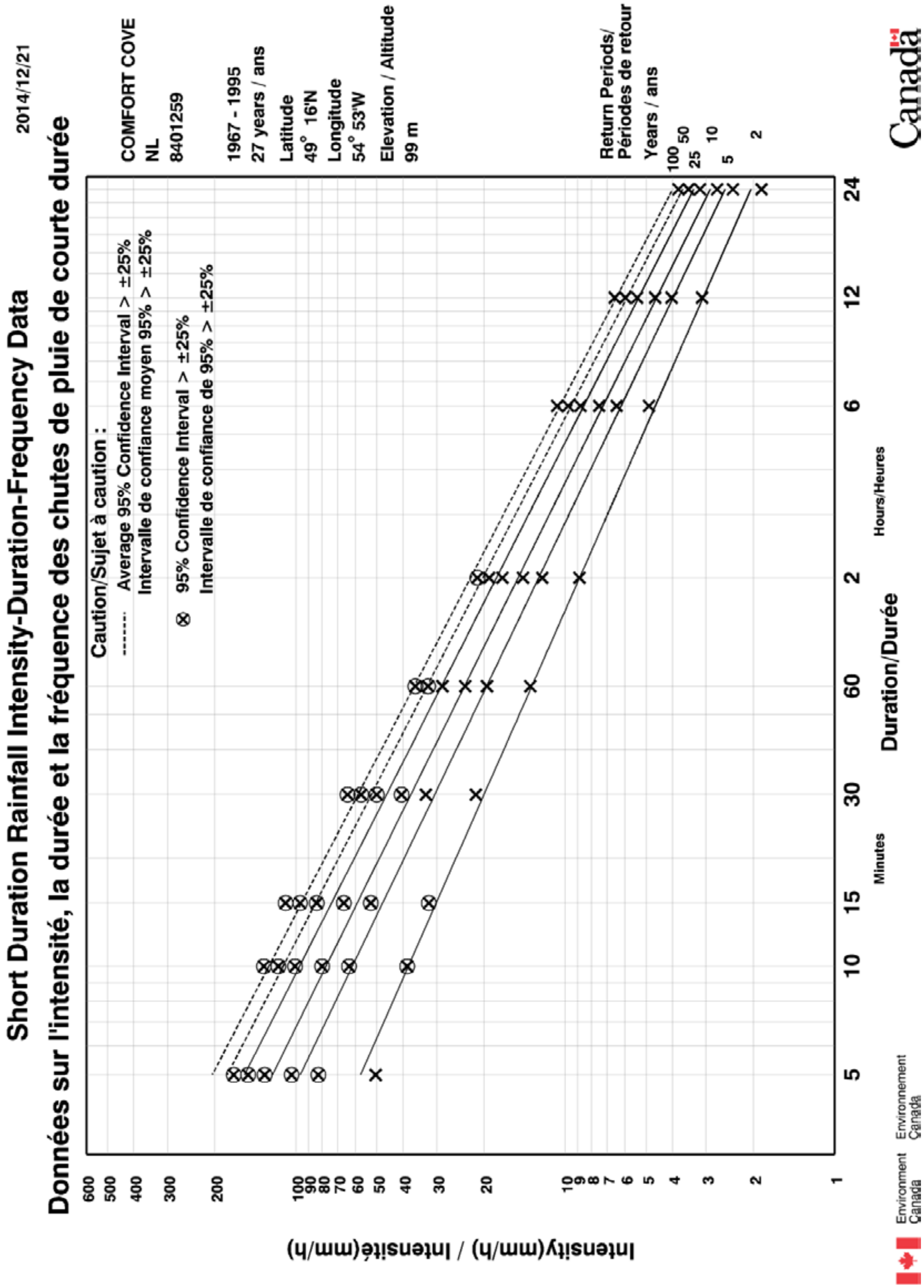

Figure 4.1 Comfort Cove IDF Curve – EC-IDF V2.3

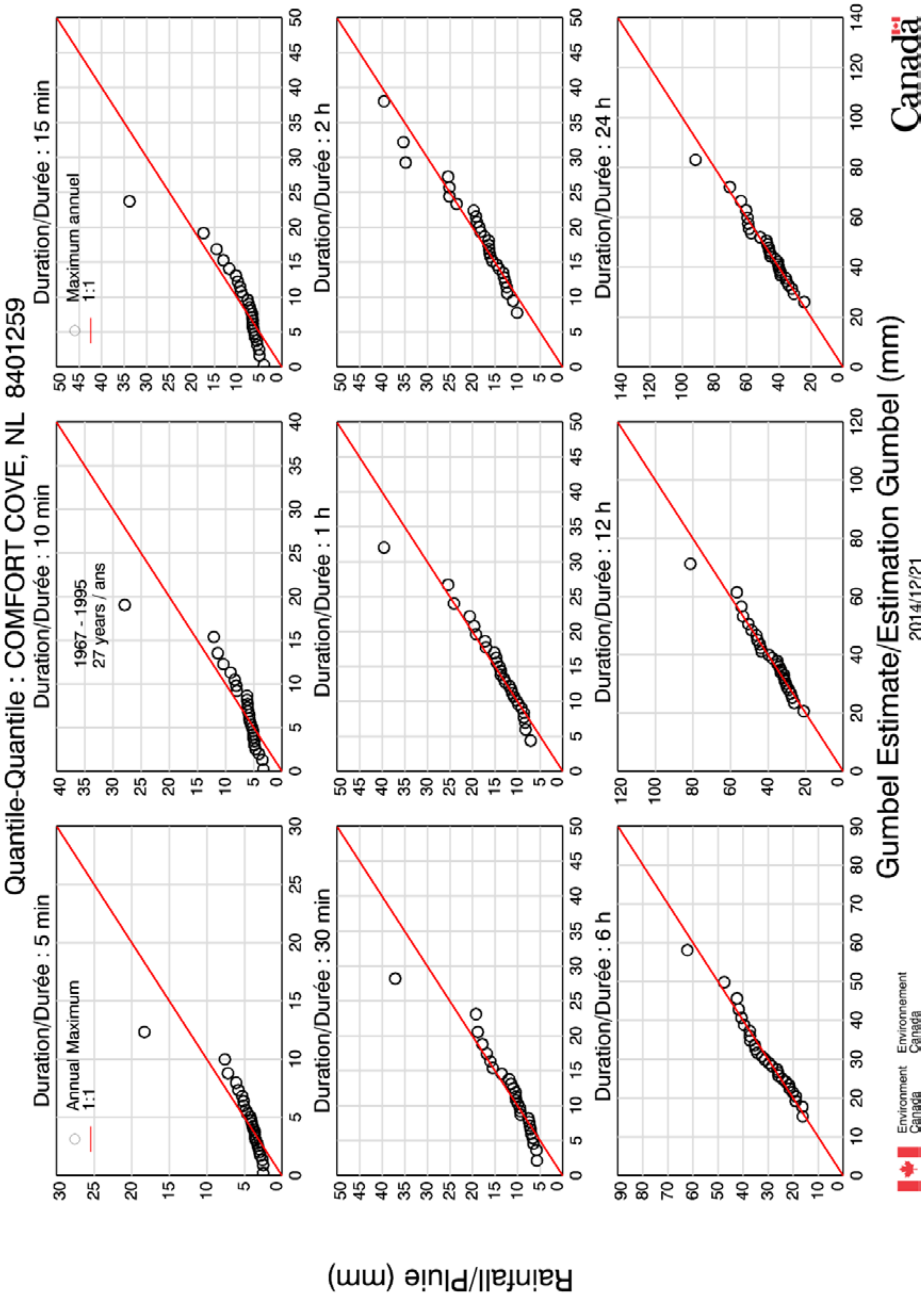

Figure 4.2 Comfort Cove Quantile-Quantile Plot – EC-IDF V2.3

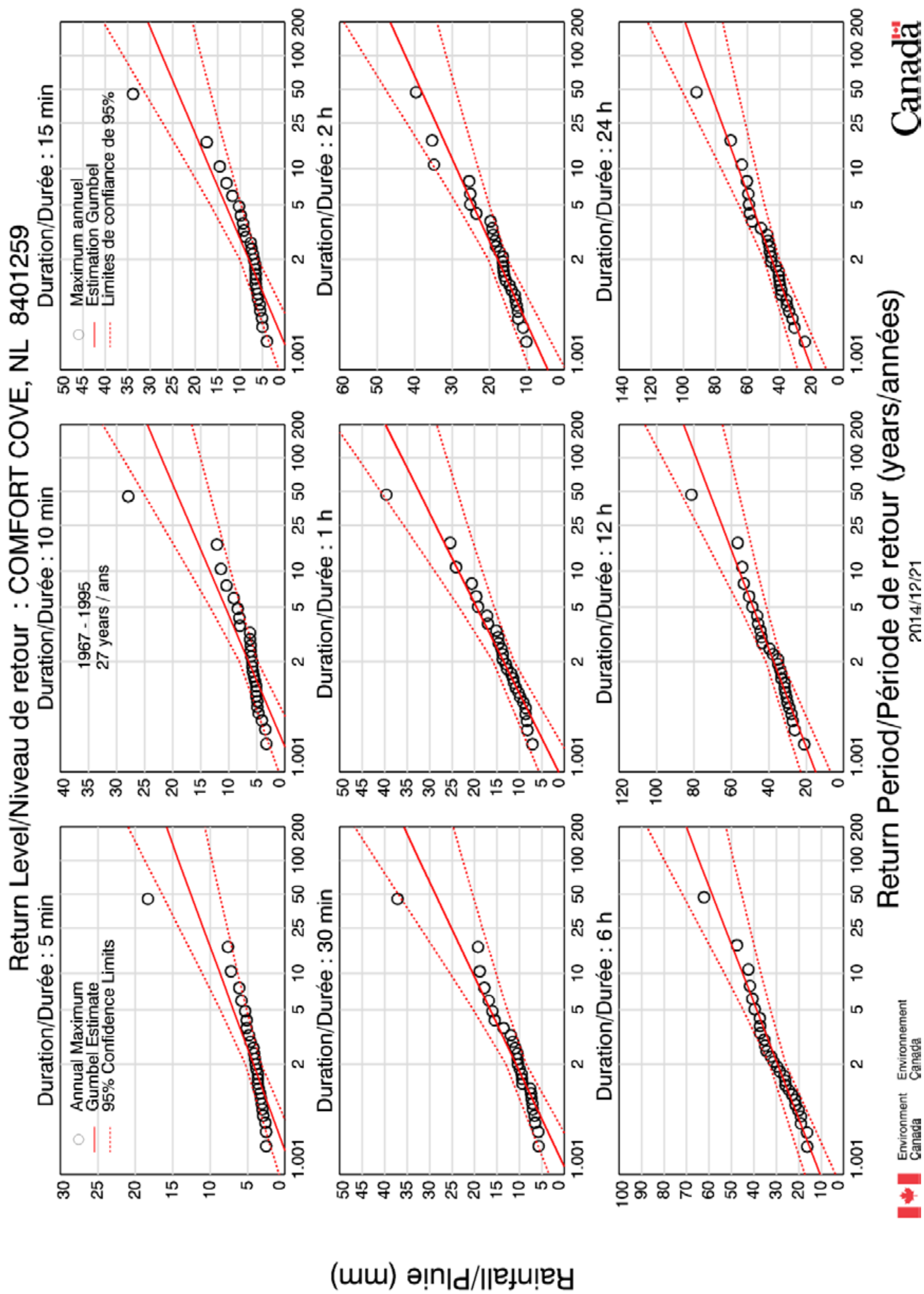

Figure 4.3 Comfort Cove Return Level Plot – EC-IDF V2.3

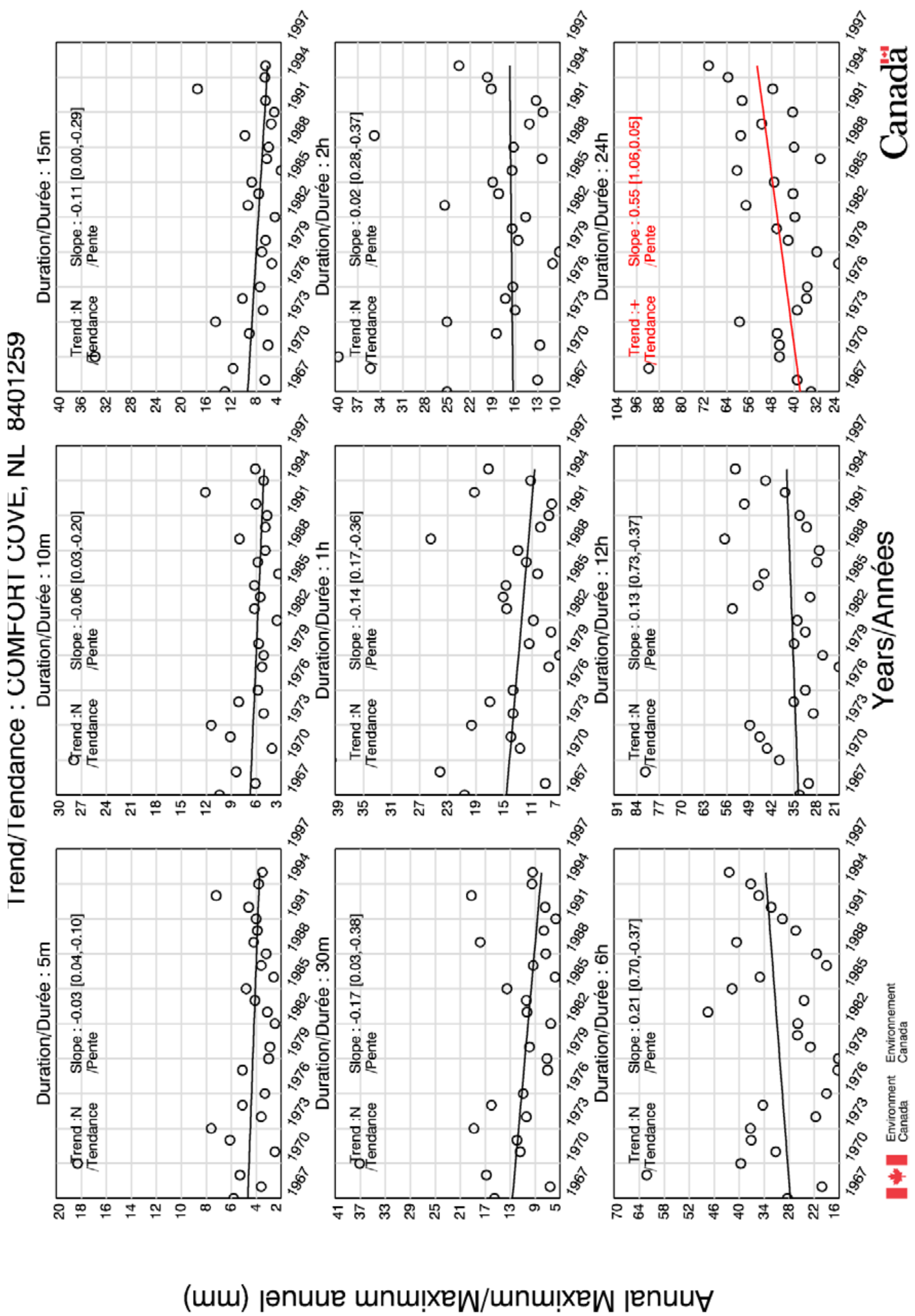

Figure 4.4 Comfort Cove Trend Plot – EC-IDF V2.3

4.2 Twillingate (AUT)

Office of Climate Change and Energy Efficiency

Short Duration Rainfall Intensity-Duration-Frequency Data
Données sur l'intensité, la durée et la fréquence des chutes de pluie de courte durée

Gumbel - Method of moments/Méthode des moments

2015/03/20

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TWILLINGATE NL 8404025
Generated with 5-min and 1-hr data measured at Twillingate (AUT) (8402520): 2004-2014
Latitude: 49 41'N Longitude: 54 48'W Elevation/Altitude: 92.3 m
Years/Années : 2004 - 2014 # Years/Années : 7

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****

Table 1: Annual Maximum (mm)/Maximum annuel (mm)

****

	Year Année	5 min	10 min	15 min	30 min	1 h	2 h	6 h	12 h	24 h
UPDATE	2004	4.2	6.2	6.6	8.4	16.4	23.8	35.2	56.0	59.2
UPDATE	2005	4.4	7.8	10.0	14.6	24.0	32.6	33.2	33.2	37.4
UPDATE	2006	4.6	4.8	5.6	9.2	15.6	25.8	32.2	39.6	45.8
UPDATE	2007	4.6	7.2	8.6	11.6	13.6	20.6	40.2	45.0	45.4
UPDATE	2008	7.8	15.6	21.4	22.4	23.4	28.4	34.8	35.2	50.8
UPDATE	2009	3.6	6.0	6.8	8.8	15.6	21.0	26.4	35.8	46.6
UPDATE	2010	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	44.8	82.4
UPDATE	2011	-99.9	-99.9	-99.9	-99.9	25.0	28.4	31.2	-99.9	-99.9
UPDATE	2012	8.2	13.6	14.6	14.6	17.0	25.8	46.4	48.8	49.0
UPDATE	2013	-99.9	-99.9	-99.9	-99.9	11.2	19.2	44.0	67.4	79.4
UPDATE	2014	NM	NM	NM	NM	22.0	35.1	43.8	47.0	47.6
	# Yrs. Années	7	7	7	7	10	10	10	10	10
	Mean Moyenne	5.3	8.7	10.5	12.8	18.4	26.1	36.7	45.3	54.4
	Std. Dev. Écart-type	1.9	4.2	5.7	5.0	4.8	5.2	6.5	10.5	15.0
	Skew. Dissymétrie	1.09	1.09	1.44	1.33	0.13	0.41	0.13	1.00	1.26
	Kurtosis	4.02	4.28	6.09	6.22	2.58	3.35	2.94	4.82	4.36

*-99.9 Indicates Missing Data/Données manquantes
* NM Indicates No Measurements/Aucunes mesures

****

Table 2a: Return Period Rainfall Amounts (mm)
Quantité de pluie (mm) par période de retour

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années

EC-IDF 5 min	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	7
EC-IDF 10 min	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	7
EC-IDF 15 min	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	7
EC-IDF 30 min	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	7
UPDATE 1 h	17.6	21.9	24.7	28.2	30.9	33.5	10
UPDATE 2 h	25.2	29.8	32.9	36.7	39.5	42.4	10
UPDATE 6 h	35.7	41.4	45.3	50.1	53.7	57.2	10
UPDATE 12 h	43.6	52.8	59.0	66.7	72.5	78.2	10
UPDATE 24 h	51.9	65.2	73.9	85.0	93.2	101.4	10

* There were insufficient data to generate the IDF curve for 5, 10, 15, 30-min

****

Table 2b :

Return Period Rainfall Rates (mm/h) - 95% Confidence limits
Intensité de la pluie (mm/h) par période de retour - Limites de confiance de 95%

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
EC-IDF 5 min	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	7
	+/--99.9	+/--99.9	+/--99.9	+/--99.9	+/--99.9	+/--99.9	7
EC-IDF 10 min	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	7
	+/--99.9	+/--99.9	+/--99.9	+/--99.9	+/--99.9	+/--99.9	7
EC-IDF 15 min	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	7
	+/--99.9	+/--99.9	+/--99.9	+/--99.9	+/--99.9	+/--99.9	7
EC-IDF 30 min	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	7
	+/--99.9	+/--99.9	+/--99.9	+/--99.9	+/--99.9	+/--99.9	7
UPDATE 1 h	17.6	21.9	24.7	28.2	30.9	33.5	10
	+/- 2.7	+/- 4.6	+/- 6.2	+/- 8.4	+/- 10.1	+/- 11.7	10
UPDATE 2 h	12.6	14.9	16.4	18.3	19.8	21.2	10
	+/- 1.5	+/- 2.5	+/- 3.4	+/- 4.5	+/- 5.4	+/- 6.3	10
UPDATE 6 h	5.9	6.9	7.5	8.4	8.9	9.5	10
	+/- 0.6	+/- 1.0	+/- 1.4	+/- 1.9	+/- 2.3	+/- 2.7	10
UPDATE 12 h	3.6	4.4	4.9	5.6	6.0	6.5	10
	+/- 0.5	+/- 0.8	+/- 1.1	+/- 1.5	+/- 1.8	+/- 2.1	10
UPDATE 24 h	2.2	2.7	3.1	3.5	3.9	4.2	10
	+/- 0.4	+/- 0.6	+/- 0.8	+/- 1.1	+/- 1.3	+/- 1.5	10

* There were insufficient data to generate the IDF curve for 5, 10, 15, 30-min

****

Table 3: Interpolation Equation / Équation d'interpolation: R = A*T^B

R = Interpolated Rainfall rate (mm/h)/Intensité interpolée de la pluie (mm/h)
RR = Rainfall rate (mm/h) / Intensité de la pluie (mm/h)
T = Rainfall duration (h) / Durée de la pluie (h)

****

Statistics/Statistiques	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans
Mean of RR/Moyenne de RR	4.7	5.6	6.3	7.1	7.7	8.3
Std. Dev. /Écart-type (RR)	5.5	6.7	7.5	8.6	9.4	10.1
Std. Error/Erreur-type	0.9	0.6	0.4	0.3	0.4	0.5
Coefficient (A)	18.8	22.6	25.1	28.3	30.6	32.9
Exponent/Exposant (B)	-0.667	-0.662	-0.660	-0.658	-0.656	-0.655
Mean % Error/% erreur moyenne	4.6	2.0	1.6	1.7	2.2	2.6

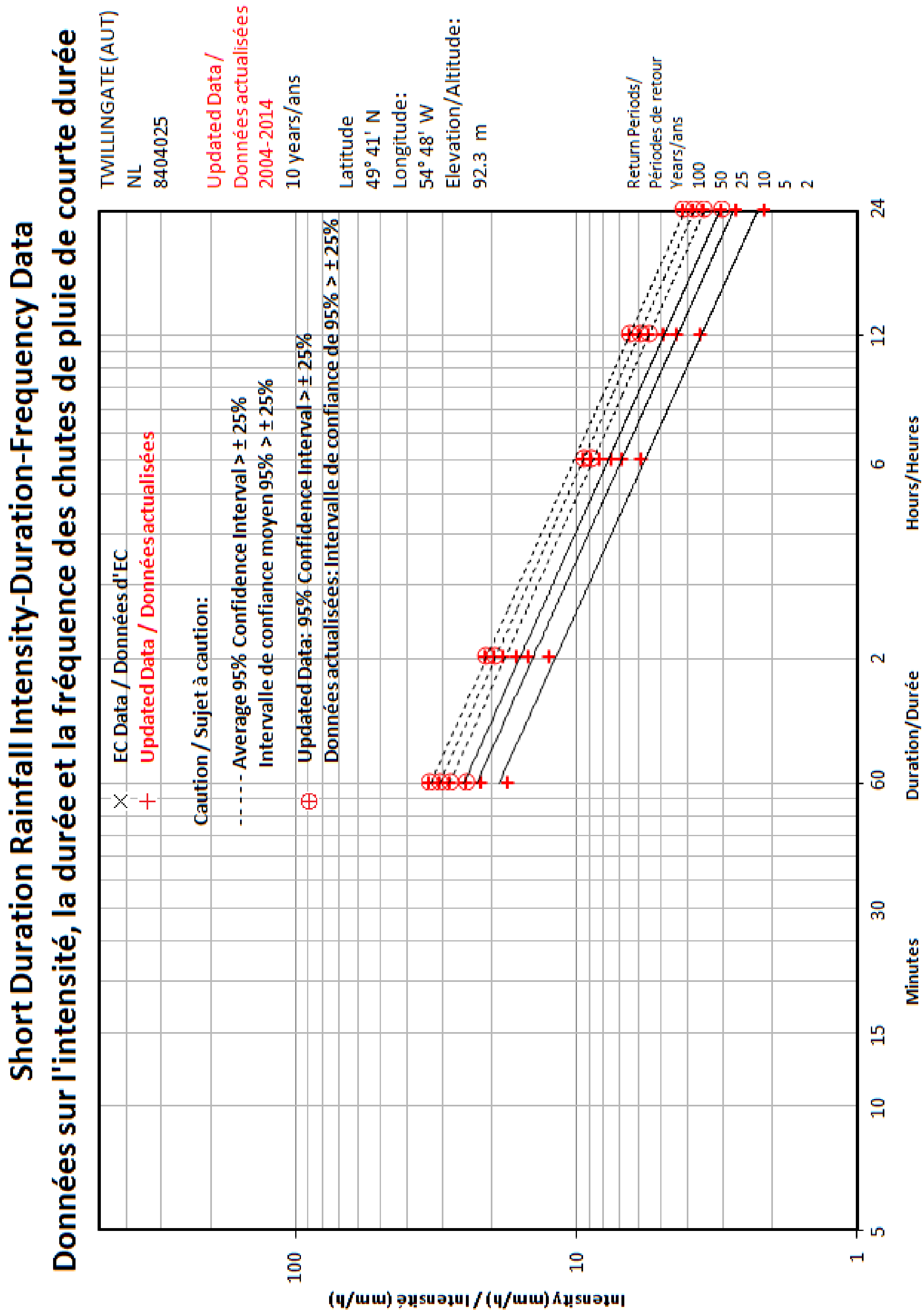

Figure 4.5 Twillingate (AUT) IDF Curve – Updated

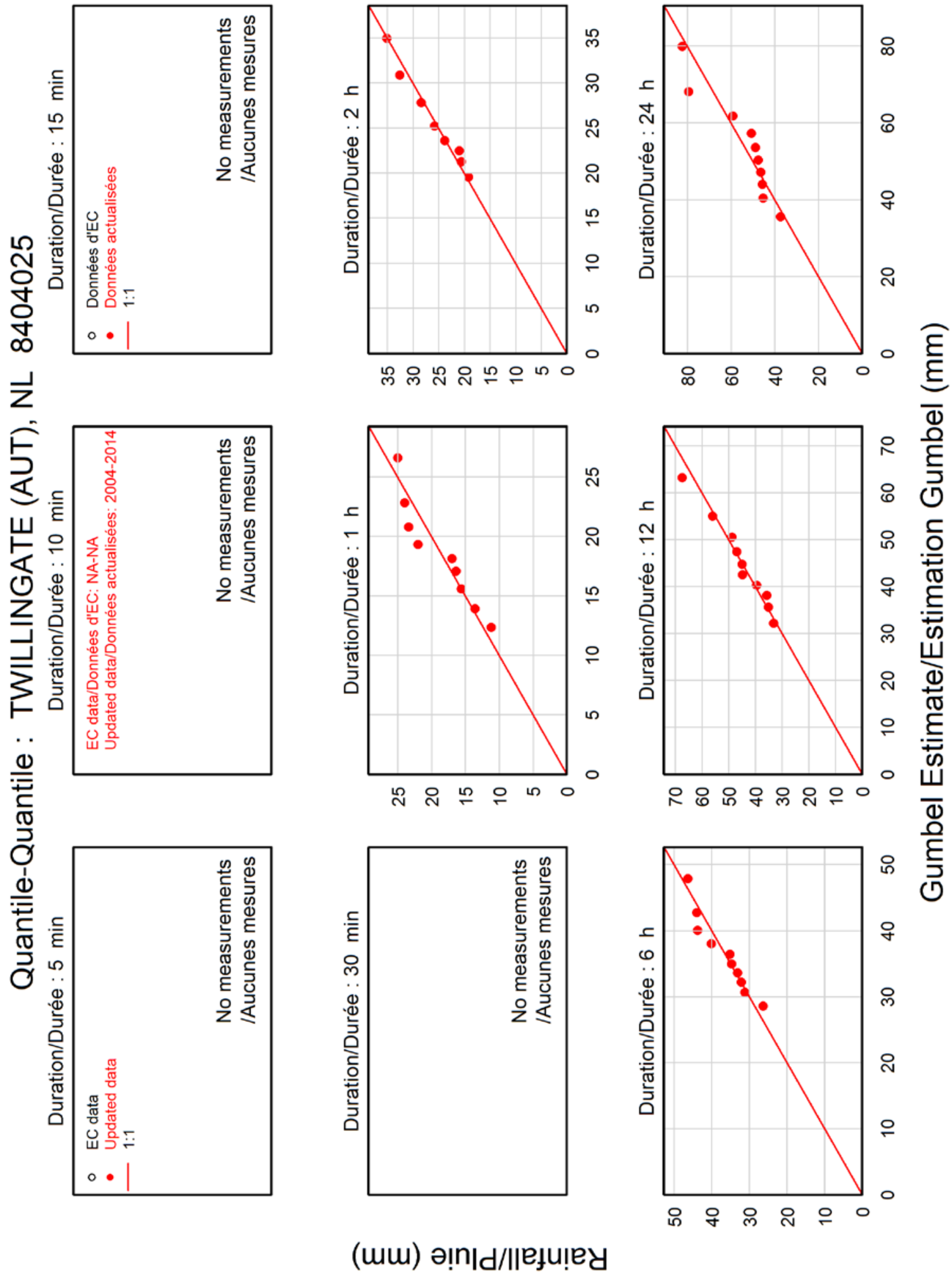

Figure 4.6 Twillingate (AUT) Quantile-Quantile Plot – Updated

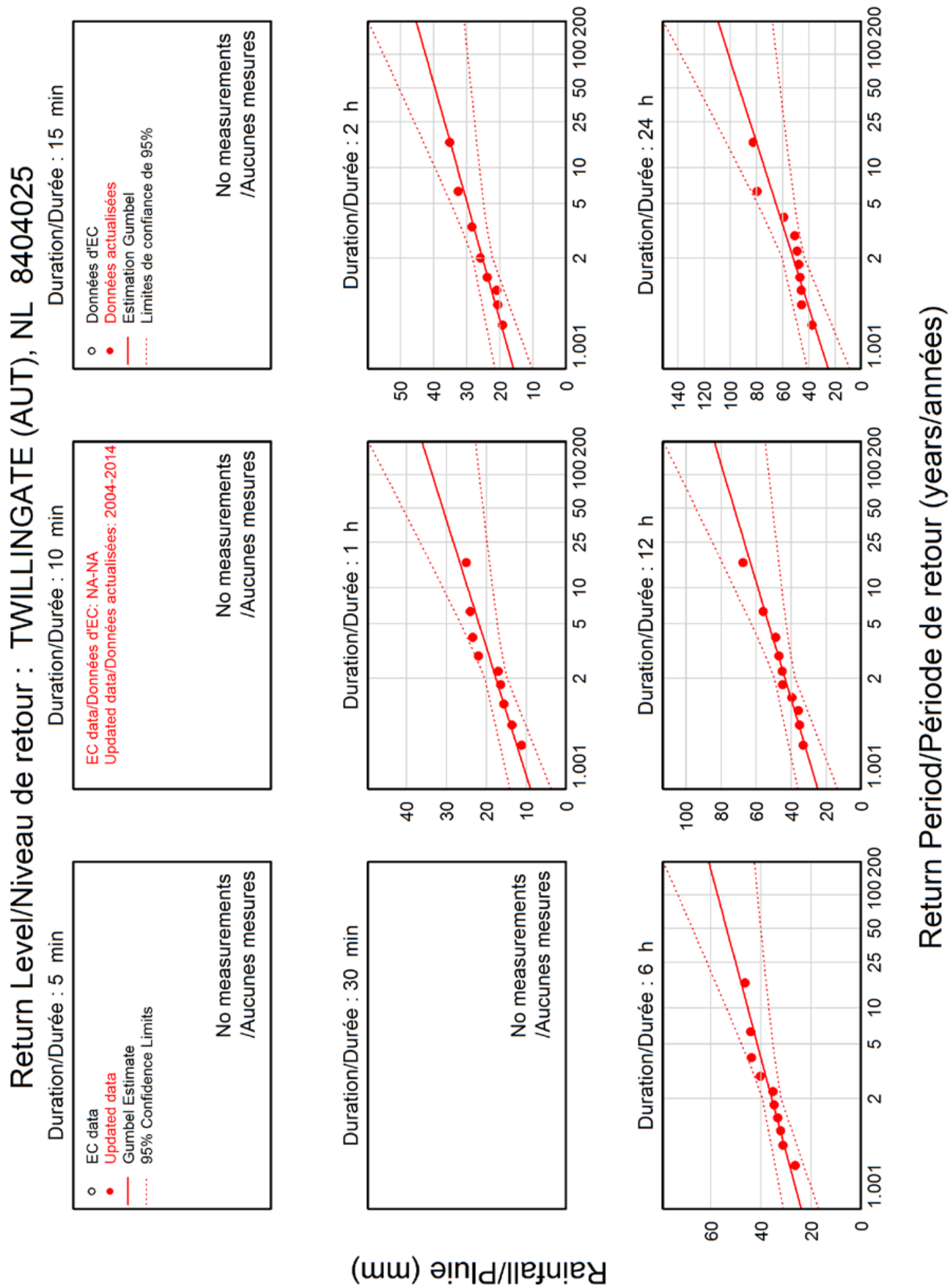

Figure 4.7 Twillingate (AUT) Return Level Plot – Updated

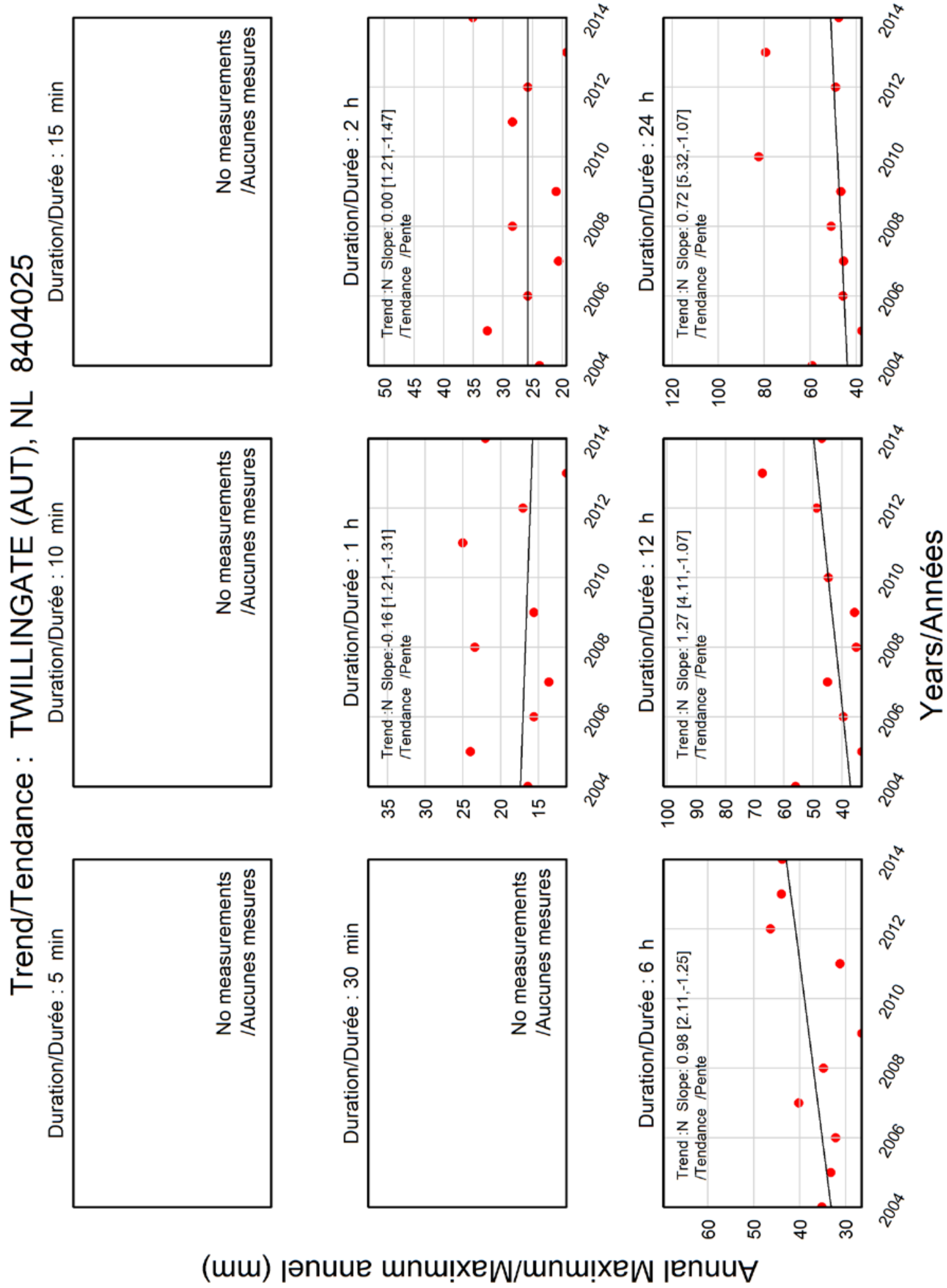

Figure 4.8 Twillingate (AUT) Trend Plot – Updated

Section 5.0 Daniels Harbour

The IDF curve for Daniels Harbour station was updated using 6-hr weighing gauge data at Daniels Harbour. Only the 6-, 12-, and 24-hr durations were updated.

Table 5.1 presents the changes between the updated IDF curve and the EC-IDF V2.3 curve.

Table 5.1 Differences Between IDF Curves for Daniels Harbour

	Percent Difference in Precipitation Amount [%] (Difference in Precipitation Amount [mm])					
	Return Period [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	N/A	N/A	N/A	N/A	N/A	N/A
10-min	N/A	N/A	N/A	N/A	N/A	N/A
15-min	N/A	N/A	N/A	N/A	N/A	N/A
30-min	N/A	N/A	N/A	N/A	N/A	N/A
1-hr	N/A	N/A	N/A	N/A	N/A	N/A
2-hr	N/A	N/A	N/A	N/A	N/A	N/A
6-hr	-4.5 (-1.5)	**-5.1 (-2.1)**	**-5.3 (-2.6)**	**-5.6 (-3.1)**	**-5.7 (-3.5)**	**-5.8 (-3.9)**
12-hr	-2.2 (-0.9)	**-5.8 (-3.3)**	**-7.3 (-4.9)**	**-8.7 (-6.8)**	**-9.5 (-8.3)**	**-10.1 (-9.8)**
24-hr	0.5 (0.3)	-4.2 (-3.2)	**-6.1 (-5.6)**	**-7.7 (-8.5)**	**-8.6 (-10.7)**	**-9.3 (-12.9)**

Notes:
Red numbers indicate that the updated IDF curve is lower than the EC-IDF V2.3 IDF curve for that duration and return period.
Bold numbers indicate changes greater than 5 percent.

Where there are decreases greater than 5 percent, users should exercise caution when using the updated IDF curve, or use the EC IDF curve.

The updated IDF curves for Daniels Harbour are included below.

Office of Climate Change and Energy Efficiency

Short Duration Rainfall Intensity-Duration-Frequency Data
Données sur l'intensité, la durée et la fréquence des chutes de pluie de courte durée

Gumbel - Method of moments/Méthode des moments

2015/03/20

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DANIELS HARBOUR NL 8401400
Updated with 6-hr data measured at Daniels Harbour (8401400): 1996-2014

Latitude: 50 14'N Longitude: 57 35'W Elevation/Altitude: 19 m
Years/Années : 1969 - 2014 # Years/Années : 26

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Table 1: Annual Maximum (mm)/Maximum annuel (mm)

****

	Year Année	5 min	10 min	15 min	30 min	1 h	2 h	6 h	12 h	24 h
EC-IDF	1969	2.5	4.8	5.3	7.4	10.4	12.2	23.4	28.2	28.2
EC-IDF	1970	2.5	2.8	3.8	7.1	9.9	15.0	25.1	31.5	40.9
EC-IDF	1971	4.6	8.1	9.9	10.4	17.5	22.1	27.7	38.9	42.9
EC-IDF	1972	3.0	5.8	6.6	9.4	14.5	22.9	31.0	37.8	37.8
EC-IDF	1973	4.1	6.1	8.4	8.6	15.0	28.7	48.8	65.3	103.9
EC-IDF	1974	4.8	6.1	6.6	8.4	14.7	19.6	30.0	38.1	62.0
EC-IDF	1975	1.8	3.0	3.8	5.1	7.4	11.4	19.6	29.2	41.7
EC-IDF	1976	3.0	5.3	5.3	5.3	9.1	16.3	27.7	40.9	53.6
EC-IDF	1977	4.8	5.8	6.9	8.9	11.2	12.7	30.2	38.6	46.2
EC-IDF	1978	3.1	4.5	5.3	5.8	8.7	13.1	30.3	34.4	53.3
EC-IDF	1979	3.6	5.6	7.1	12.9	18.4	25.3	45.0	80.2	109.4
EC-IDF	1980	4.7	5.2	6.5	10.7	11.7	18.8	28.7	46.4	61.8
EC-IDF	1981	5.5	8.0	11.2	13.9	22.8	26.8	46.8	53.8	65.7
EC-IDF	1982	5.2	7.4	8.0	8.4	10.9	19.7	44.8	72.8	91.3
EC-IDF	1983	14.8	18.1	18.9	20.7	25.2	27.4	34.6	38.7	51.7
EC-IDF	1984	5.5	6.0	6.9	9.8	14.0	23.7	55.9	75.0	111.1
EC-IDF	1985	5.2	8.3	8.9	8.9	11.9	17.4	32.6	34.0	47.2
EC-IDF	1986	2.1	3.9	4.2	4.2	5.6	9.0	20.9	28.6	29.0
EC-IDF	1987	5.4	7.7	11.5	21.3	31.3	33.2	39.6	42.0	42.0
EC-IDF	1989	3.6	5.3	6.2	7.3	13.5	21.2	34.6	37.8	45.1
EC-IDF	1990	3.4	5.9	7.8	10.4	16.4	26.7	43.9	47.0	57.4
EC-IDF	1991	3.1	4.6	5.7	7.4	11.2	19.1	31.9	44.0	48.6
EC-IDF	1992	1.3	1.8	2.5	4.6	9.2	13.0	16.4	28.5	35.2
EC-IDF	1993	4.3	8.4	10.2	13.6	13.8	16.4	32.5	41.0	43.1
EC-IDF	1994	5.0	7.1	7.3	11.9	18.6	20.0	27.6	34.8	55.2
EC-IDF	1995	3.2	5.0	7.0	10.8	15.8	24.4	58.5	83.7	114.3
UPDATE	1996	NM	NM	NM	NM	NM	NM	32.0	32.0	-99.9
UPDATE	1998	NM	NM	NM	NM	NM	NM	24.0	43.0	66.0
UPDATE	2000	NM	NM	NM	NM	NM	NM	20.0	37.0	49.0
UPDATE	2001	NM	NM	NM	NM	NM	NM	33.0	40.0	60.0
UPDATE	2003	NM	NM	NM	NM	NM	NM	29.0	56.0	84.0
UPDATE	2004	NM	NM	NM	NM	NM	NM	38.0	38.5	-99.9
UPDATE	2005	NM	NM	NM	NM	NM	NM	47.0	47.0	57.0
UPDATE	2006	NM	NM	NM	NM	NM	NM	47.0	53.0	57.0
UPDATE	2007	NM	NM	NM	NM	NM	NM	30.0	39.0	53.0
UPDATE	2008	NM	NM	NM	NM	NM	NM	34.0	50.0	59.0

UPDATE	2009	NM	NM	NM	NM	NM	NM	23.0	41.0	41.0
UPDATE	2010	NM	NM	NM	NM	NM	NM	30.0	48.0	77.0
UPDATE	2011	NM	NM	NM	NM	NM	NM	26.0	41.0	49.0
UPDATE	2012	NM	NM	NM	NM	NM	NM	24.0	36.0	54.0
UPDATE	2013	NM	NM	NM	NM	NM	NM	21.0	27.0	43.0
UPDATE	2014	NM	NM	NM	NM	NM	NM	22.0	35.0	54.0
	# Yrs. Années	26	26	26	26	26	26	42	42	40
	Mean Moyenne	4.2	6.2	7.4	9.7	14.2	19.8	32.6	43.7	58.0
	Std. Dev. Écart-type	2.5	3.0	3.2	4.2	5.7	6.1	10.1	13.8	21.7
	Skew. Dissymétrie	3.20	2.56	1.82	1.38	1.29	0.18	0.81	1.51	1.36
	Kurtosis	16.52	13.13	8.62	5.47	5.37	2.70	3.28	5.02	4.46

*-99.9 Indicates Missing Data/Données manquantes
* NM Indicates No Measurements/Aucunes mesures

Warning: annual maximum amount greater than 100-yr return period amount
Avertissement : la quantité maximale annuelle excède la quantité pour une période de retour de 100 ans

Year/Année	Duration/Durée	Data/Données	100-yr/ans
1983	5 min	14.8	12.0
1983	10 min	18.1	15.5
1983	15 min	18.9	17.5

****

Table 2a: Return Period Rainfall Amounts (mm)
Quantité de pluie (mm) par période de retour

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
EC-IDF 5 min	3.8	6.0	7.5	9.3	10.6	12.0	26
EC-IDF 10 min	5.7	8.3	10.1	12.3	13.9	15.5	26
EC-IDF 15 min	6.8	9.7	11.6	14.0	15.8	17.5	26
EC-IDF 30 min	9.0	12.8	15.3	18.4	20.7	23.0	26
EC-IDF 1 h	13.2	18.3	21.6	25.9	29.0	32.1	26
EC-IDF 2 h	18.8	24.3	27.8	32.4	35.7	39.1	26
UPDATE 6 h	30.9	39.8	45.7	53.1	58.6	64.1	42
UPDATE 12 h	41.4	53.6	61.7	71.9	79.5	87.1	42
UPDATE 24 h	54.5	73.6	86.3	102.3	114.2	126.0	40

* 6-hr data were used for the update: shorter durations were not updated

****

Table 2b:

Return Period Rainfall Rates (mm/h) - 95% Confidence limits
Intensité de la pluie (mm/h) par période de retour - Limites de confiance de 95%

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
EC-IDF 5 min	45.9	72.2	89.5	111.5	127.8	143.9	26
	+/- 10.5	+/- 17.6	+/- 23.8	+/- 32.1	+/- 38.4	+/- 44.8	26
EC-IDF 10 min	34.1	49.9	60.3	73.5	83.3	93.0	26
	+/- 6.3	+/- 10.6	+/- 14.3	+/- 19.3	+/- 23.1	+/- 26.9	26
EC-IDF 15 min	27.4	38.8	46.4	56.0	63.1	70.1	26
	+/- 4.6	+/- 7.7	+/- 10.4	+/- 14.0	+/- 16.8	+/- 19.5	26
EC-IDF 30 min	18.1	25.6	30.5	36.8	41.4	46.0	26
	+/- 3.0	+/- 5.0	+/- 6.8	+/- 9.2	+/- 11.0	+/- 12.8	26

```
*EC-IDF*   1 h       13.2      18.3      21.6      25.9      29.0      32.1       26
                +/-   2.0 +/-   3.4 +/-   4.6 +/-   6.2 +/-   7.4 +/-   8.6       26
*EC-IDF*   2 h        9.4      12.1      13.9      16.2      17.9      19.5       26
                +/-   1.1 +/-   1.8 +/-   2.5 +/-   3.3 +/-   4.0 +/-   4.6       26
*UPDATE*   6 h        5.2       6.6       7.6       8.9       9.8      10.7       42
                +/-   0.5 +/-   0.8 +/-   1.1 +/-   1.4 +/-   1.7 +/-   2.0       42
*UPDATE* 12 h         3.5       4.5       5.1       6.0       6.6       7.3       42
                +/-   0.3 +/-   0.5 +/-   0.7 +/-   1.0 +/-   1.2 +/-   1.4       42
*UPDATE* 24 h         2.3       3.1       3.6       4.3       4.8       5.2       40
                +/-   0.3 +/-   0.4 +/-   0.6 +/-   0.8 +/-   0.9 +/-   1.1       40
     * 6-hr data were used for the update: shorter durations were not updated

********************************************************************************

Table 3: Interpolation Equation / Équation d'interpolation: R = A*T^B

R = Interpolated Rainfall rate (mm/h)/Intensité interpolée de la pluie (mm/h)
RR = Rainfall rate (mm/h) / Intensité de la pluie (mm/h)
 T = Rainfall duration (h) / Durée de la pluie (h)

********************************************************************************

       Statistics/Statistiques      2      5     10     25     50    100
                                yr/ans yr/ans yr/ans yr/ans yr/ans yr/ans
      Mean of RR/Moyenne de RR    17.7   25.7   31.0   37.7   42.6   47.5
    Std. Dev. /Écart-type (RR)    15.2   23.7   29.3   36.4   41.7   47.0
        Std. Error/Erreur-type     1.0    0.5    1.0    1.8    2.4    3.0
               Coefficient (A)    12.9   18.0   21.3   25.5   28.6   31.6
         Exponent/Exposant (B) -0.530 -0.558 -0.570 -0.579 -0.585 -0.589
 Mean % Error/% erreur moyenne     3.1    1.1    2.0    2.8    3.3    3.7
```

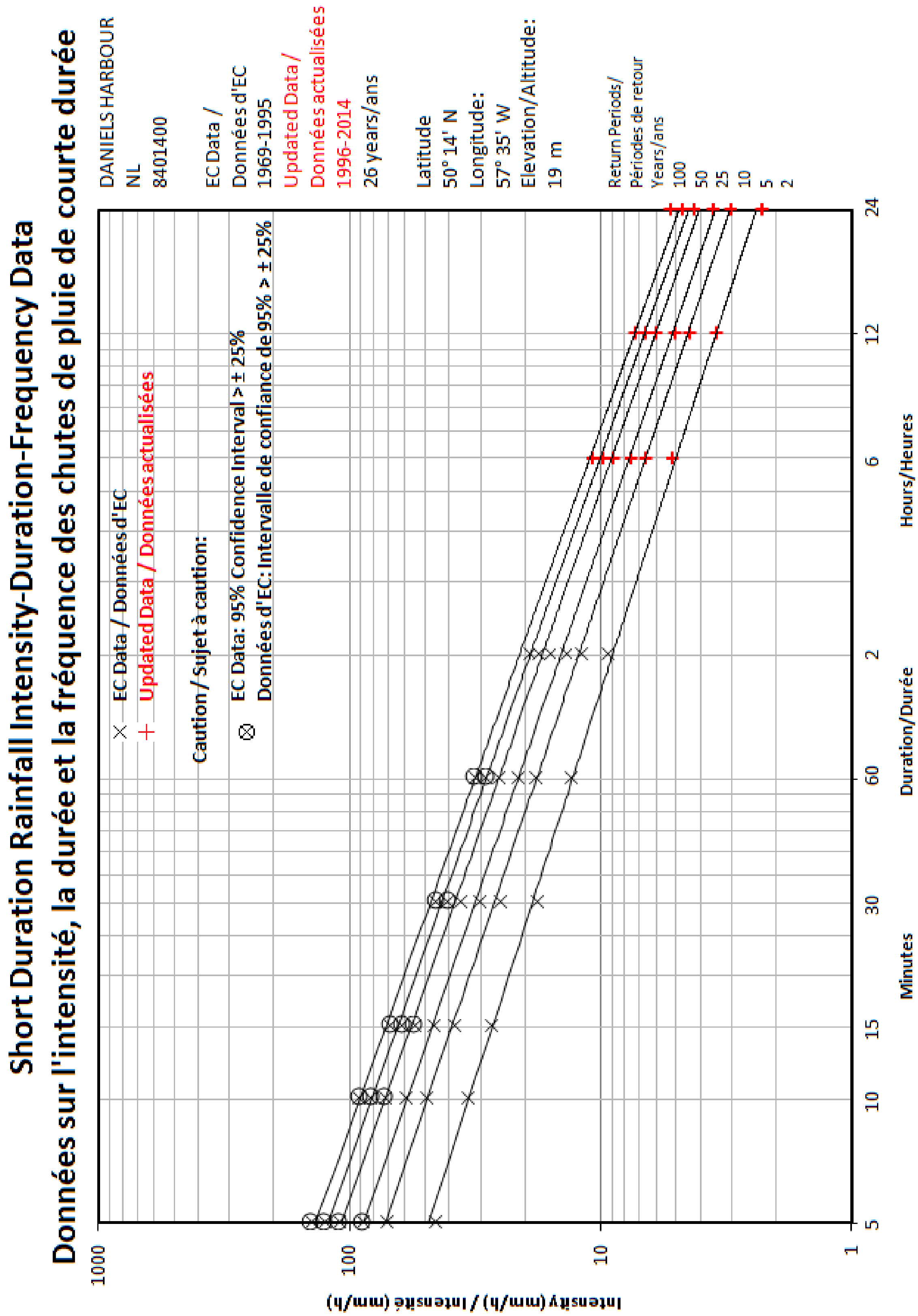

Figure 5.1 Daniels Harbour IDF Curve – Updated

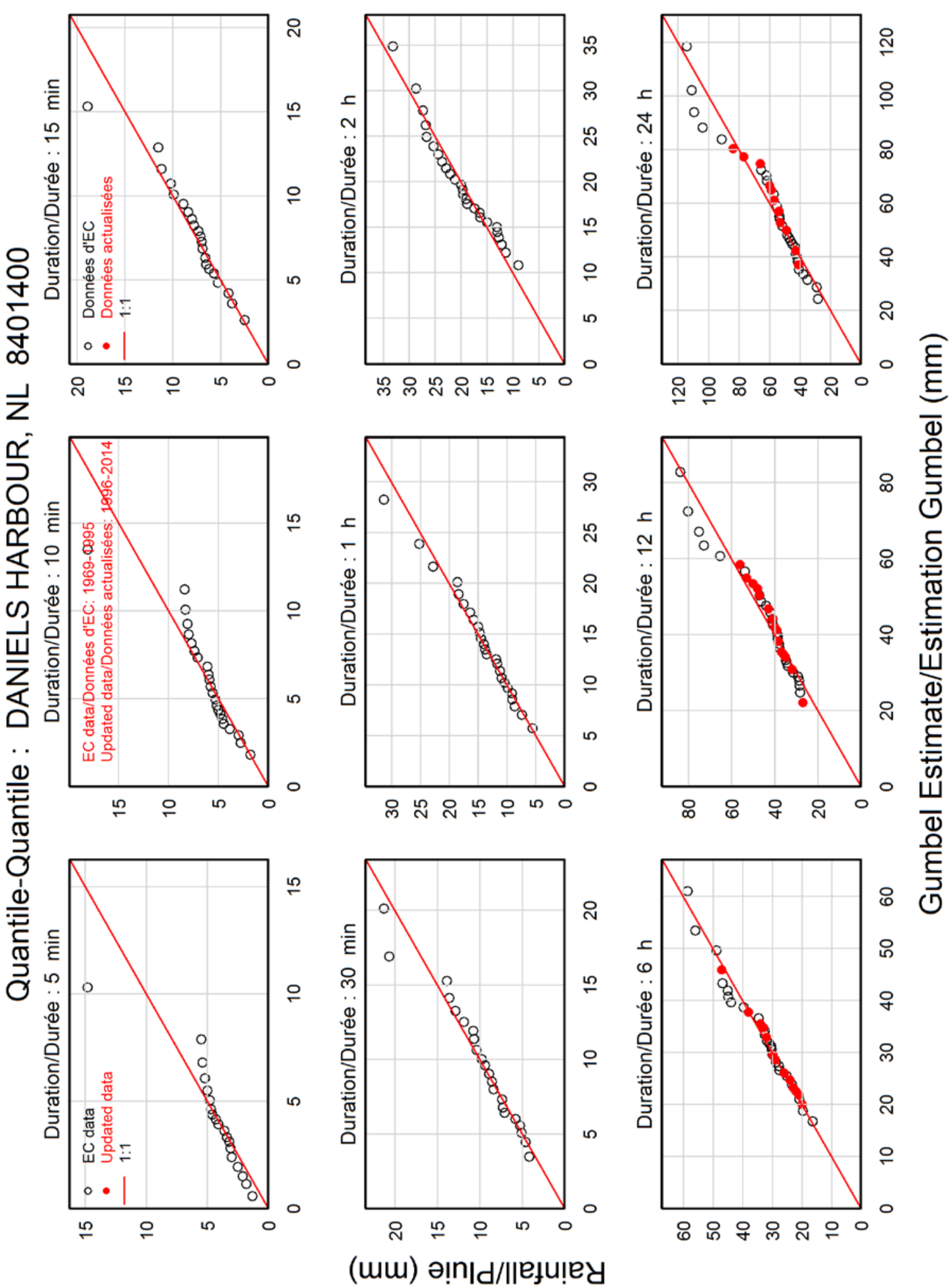

Figure 5.2 Daniels Harbour Quantile-Quantile Plot – Updated

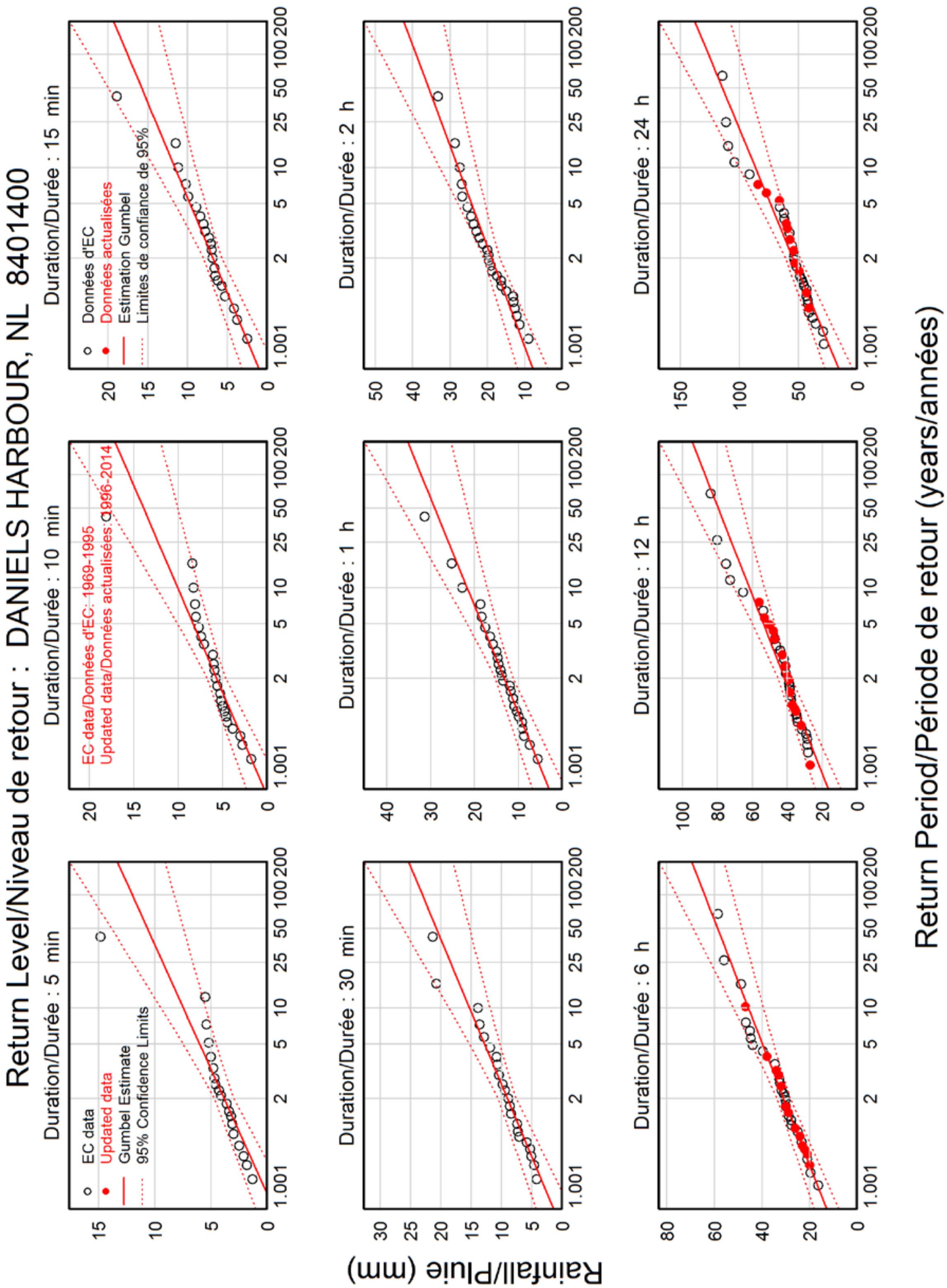

Figure 5.3 Daniels Harbour Return Level Plot – Updated

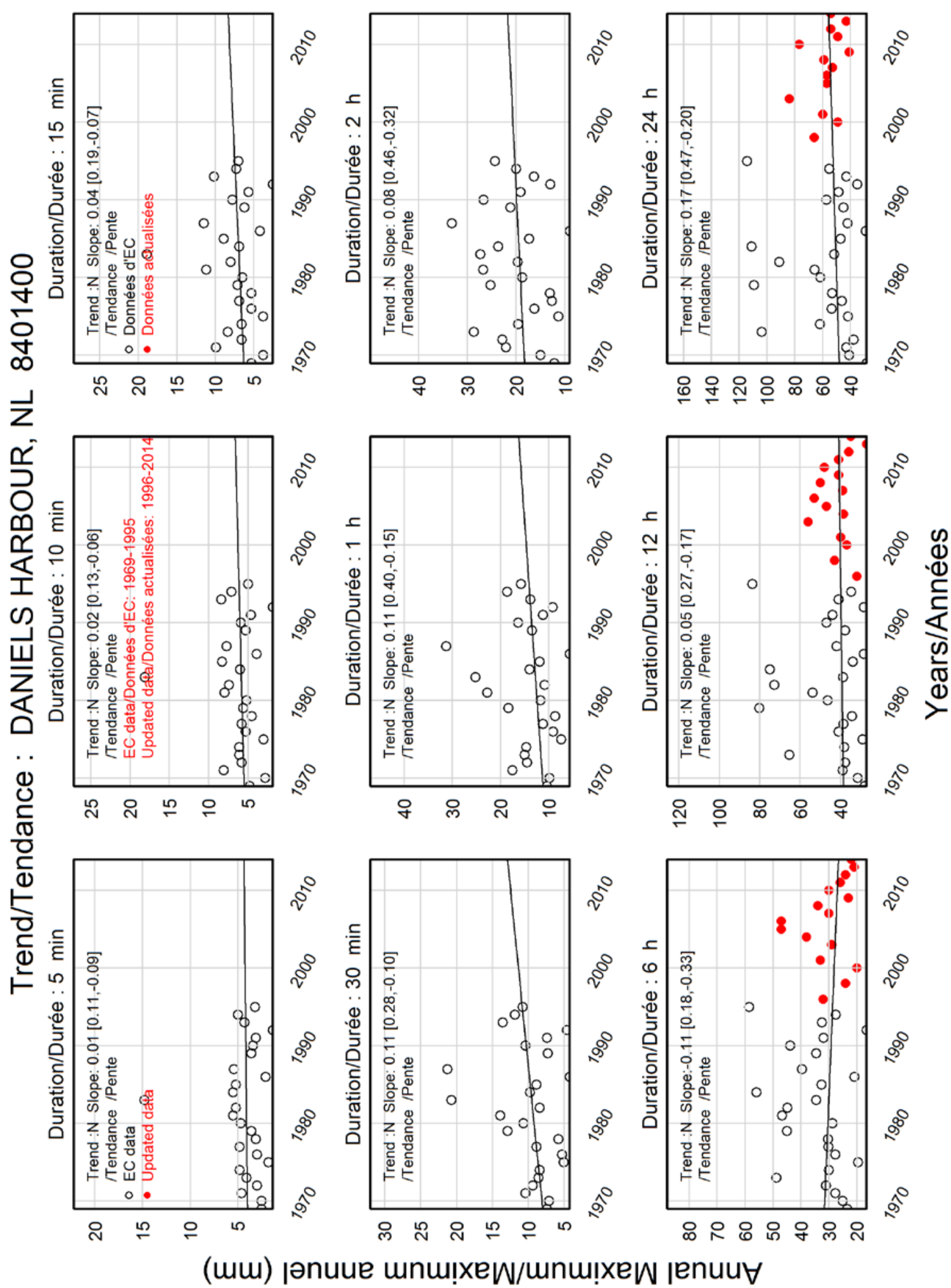

Figure 5.4 Daniels Harbour Trend Plot – Updated

Section 6.0 Deer Lake A

The IDF curve for Deer Lake A station was updated using 6-hr weighing gauge data at Deer Lake A (8401501) and Deer Lake A (8401502). Only the 6-, 12-, and 24-hr durations were updated.

Table 6.1 presents the changes between the updated IDF curve and the EC-IDF V2.3 curve.

Table 6.1 Differences Between IDF Curves for Deer Lake A

Percent Difference in Precipitation Amount [%] (Difference in Precipitation Amount [mm])						
	Return Period [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	N/A	N/A	N/A	N/A	N/A	N/A
10-min	N/A	N/A	N/A	N/A	N/A	N/A
15-min	N/A	N/A	N/A	N/A	N/A	N/A
30-min	N/A	N/A	N/A	N/A	N/A	N/A
1-hr	N/A	N/A	N/A	N/A	N/A	N/A
2-hr	N/A	N/A	N/A	N/A	N/A	N/A
6-hr	-2.3 (-0.7)	-1.6 (-0.6)	-1.3 (-0.5)	-1.0 (-0.5)	-0.8 (-0.4)	-0.6 (-0.3)
12-hr	2.4 (0.9)	3.0 (1.3)	3.2 (1.6)	3.5 (2.0)	3.7 (2.3)	3.8 (2.5)
24-hr	4.9 (2.1)	**8.3 (4.3)**	**10.0 (5.8)**	**11.7 (7.7)**	**12.8 (9.0)**	**13.6 (10.4)**

Notes:
Red numbers indicate that the updated IDF curve is lower than the EC-IDF V2.3 IDF curve for that duration and return period.
Bold numbers indicate changes greater than 5 percent.

The updated IDF curves for Deer Lake A are included below.

Office of Climate Change and Energy Efficiency

Short Duration Rainfall Intensity-Duration-Frequency Data
Données sur l'intensité, la durée et la fréquence des chutes de pluie de courte durée

Gumbel - Method of moments/Méthode des moments

2015/03/20

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DEER LAKE A NL 8401501
Updated with 6-hr data measured at Deer Lake A (8401501): 2003-2011
Updated with 6-hr data measured at Deer Lake A (8401502): 2012-2014
Latitude: 49 13'N Longitude: 57 24'W Elevation/Altitude: 21 m
Years/Années : 1966 - 2014 # Years/Années : 36

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Table 1: Annual Maximum (mm)/Maximum annuel (mm)

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	Year Année	5 min	10 min	15 min	30 min	1 h	2 h	6 h	12 h	24 h
EC-IDF	1966	2.8	3.0	4.6	6.3	9.9	13.7	21.8	25.9	29.2
EC-IDF	1967	5.1	5.8	7.1	10.9	14.2	19.3	31.7	37.6	38.6
EC-IDF	1968	4.1	6.1	8.9	12.2	13.2	21.3	41.1	52.1	64.0
EC-IDF	1969	3.0	4.8	6.1	7.4	10.7	14.7	25.9	31.0	37.8
EC-IDF	1970	2.8	3.0	4.1	6.9	13.2	23.4	38.1	39.6	40.1
EC-IDF	1971	3.6	5.6	6.6	8.9	11.2	12.4	22.9	27.7	29.2
EC-IDF	1972	4.6	4.8	5.3	7.4	9.7	15.7	27.4	36.6	45.0
EC-IDF	1973	7.1	12.4	13.5	15.2	15.7	23.1	36.6	47.0	50.3
EC-IDF	1974	2.8	5.3	7.4	9.1	13.7	16.8	28.2	32.0	43.9
EC-IDF	1975	7.1	8.9	11.2	15.7	23.9	39.9	44.7	50.8	66.5
EC-IDF	1976	3.8	3.8	4.3	6.9	9.7	13.2	25.7	39.1	42.4
EC-IDF	1977	3.8	7.4	7.6	15.0	18.3	18.5	34.3	46.7	47.5
EC-IDF	1978	6.9	10.8	13.9	16.5	19.6	36.1	36.1	36.1	45.9
EC-IDF	1979	4.0	6.5	7.7	9.6	9.8	11.9	24.2	33.3	41.2
EC-IDF	1980	3.1	4.9	5.8	7.1	10.1	15.3	34.3	55.7	62.7
EC-IDF	1981	3.4	4.4	5.1	8.3	14.1	15.0	24.3	37.9	43.8
EC-IDF	1982	1.9	3.0	4.0	6.4	12.7	21.5	30.0	30.2	38.3
EC-IDF	1983	4.0	6.5	7.4	12.1	19.8	28.1	34.0	36.8	46.3
EC-IDF	1984	11.6	12.8	12.8	12.8	12.8	17.8	31.1	33.8	43.3
EC-IDF	1985	3.3	4.6	4.8	7.6	10.6	13.0	18.2	25.7	32.7
EC-IDF	1986	2.2	4.3	5.4	7.3	10.0	13.0	21.5	28.2	39.9
EC-IDF	1987	4.0	5.7	6.7	10.2	10.9	15.5	25.2	25.7	26.7
EC-IDF	1988	8.3	10.0	11.9	14.1	16.2	18.9	31.0	39.8	39.8
EC-IDF	1989	4.0	5.0	6.2	8.5	11.6	17.2	26.4	34.4	40.8
EC-IDF	1990	6.2	9.2	11.2	12.5	16.0	21.9	22.8	37.3	38.0
EC-IDF	1991	2.3	3.7	3.9	6.4	11.2	18.5	38.2	40.4	43.0
EC-IDF	1993	1.8	3.2	4.8	6.7	9.7	17.8	28.7	31.9	40.8
EC-IDF	1994	4.7	9.4	10.1	13.5	19.9	25.8	33.9	39.7	51.3
EC-IDF	1995	2.8	3.6	4.7	9.2	13.5	23.1	44.9	54.0	70.1
EC-IDF	1996	2.5	3.9	5.1	7.2	10.9	20.1	44.6	59.0	59.1
EC-IDF	1997	3.6	5.1	6.6	10.1	12.4	13.4	21.1	30.0	35.6
EC-IDF	1998	2.6	3.8	4.8	9.6	13.4	19.6	29.4	42.3	53.6
EC-IDF	1999	3.3	5.0	7.5	14.8	21.0	24.3	25.2	39.0	41.4
EC-IDF	2000	7.8	10.4	10.4	11.5	16.5	28.7	46.9	48.3	48.3
EC-IDF	2001	5.2	7.5	9.7	13.3	18.3	24.2	27.0	31.5	38.2
EC-IDF	2002	4.2	7.5	11.1	15.8	19.8	21.5	36.5	44.2	49.2

UPDATE	2003	NM	NM	NM	NM	NM	NM	30.0	42.0	54.0
UPDATE	2004	NM	NM	NM	NM	NM	NM	26.0	48.0	71.0
UPDATE	2005	NM	NM	NM	NM	NM	NM	31.0	58.0	80.0
UPDATE	2006	NM	NM	NM	NM	NM	NM	19.0	28.0	35.2
UPDATE	2007	NM	NM	NM	NM	NM	NM	43.0	49.0	67.0
UPDATE	2008	NM	NM	NM	NM	NM	NM	18.0	35.6	43.6
UPDATE	2009	NM	NM	NM	NM	NM	NM	26.0	43.0	49.0
UPDATE	2010	NM	NM	NM	NM	NM	NM	36.0	50.0	59.0
UPDATE	2011	NM	NM	NM	NM	NM	NM	40.0	57.0	80.0
UPDATE	2012	NM	NM	NM	NM	NM	NM	24.0	37.0	41.0
UPDATE	2013	NM	NM	NM	NM	NM	NM	25.0	27.0	35.0
UPDATE	2014	NM	NM	NM	NM	NM	NM	22.0	32.0	40.0
	# Yrs. Années	36	36	36	36	36	36	48	48	48
	Mean Moyenne	4.3	6.2	7.5	10.4	14.0	19.8	30.3	39.3	47.1
	Std. Dev. Écart-type	2.1	2.7	2.9	3.2	3.9	6.3	7.7	9.3	12.7
	Skew. Dissymétrie	1.64	0.98	0.76	0.43	0.81	1.34	0.49	0.47	1.00
	Kurtosis	6.26	3.25	2.63	2.03	2.89	5.41	2.53	2.49	3.66

*-99.9 Indicates Missing Data/Données manquantes
* NM Indicates No Measurements/Aucunes mesures

Warning: annual maximum amount greater than 100-yr return period amount
Avertissement : la quantité maximale annuelle excède la quantité pour une période de retour de 100 ans

Year/Année	Duration/Durée	Data/Données	100-yr/ans
1975	2 h	39.9	39.7
1984	5 min	11.6	10.8

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Table 2a: Return Period Rainfall Amounts (mm)
Quantité de pluie (mm) par période de retour

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
EC-IDF 5 min	3.9	5.8	7.0	8.6	9.7	10.8	36
EC-IDF 10 min	5.7	8.1	9.7	11.7	13.2	14.7	36
EC-IDF 15 min	7.0	9.6	11.3	13.5	15.1	16.7	36
EC-IDF 30 min	9.8	12.7	14.6	17.0	18.7	20.5	36
EC-IDF 1 h	13.4	16.8	19.1	21.9	24.1	26.2	36
EC-IDF 2 h	18.8	24.4	28.1	32.8	36.3	39.7	36
UPDATE 6 h	29.0	35.8	40.3	45.9	50.1	54.3	48
UPDATE 12 h	37.8	46.0	51.4	58.3	63.4	68.5	48
UPDATE 24 h	45.0	56.2	63.6	73.0	79.9	86.8	48

* 6-hr data were used for the update: shorter durations were not updated

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Table 2b:

Return Period Rainfall Rates (mm/h) - 95% Confidence limits
Intensité de la pluie (mm/h) par période de retour - Limites de confiance de 95%

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
EC-IDF 5 min	47.3	69.5	84.1	102.7	116.4	130.0	36
	+/- 7.5	+/- 12.7	+/- 17.1	+/- 23.0	+/- 27.6	+/- 32.1	36
EC-IDF 10 min	34.3	48.6	58.2	70.2	79.1	87.9	36

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              +/-  4.9 +/-  8.2 +/- 11.1 +/- 15.0 +/- 17.9 +/- 20.8       36
*EC-IDF* 15 min     27.9     38.3     45.1     53.8     60.2     66.6       36
              +/-  3.5 +/-  5.9 +/-  8.0 +/- 10.8 +/- 12.9 +/- 15.1       36
*EC-IDF* 30 min     19.7     25.4     29.2     33.9     37.5     41.0       36
              +/-  1.9 +/-  3.3 +/-  4.4 +/-  5.9 +/-  7.1 +/-  8.3       36
*EC-IDF*  1 h       13.4     16.8     19.1     21.9     24.1     26.2       36
              +/-  1.2 +/-  2.0 +/-  2.6 +/-  3.6 +/-  4.3 +/-  5.0       36
*EC-IDF*  2 h        9.4     12.2     14.1     16.4     18.1     19.9       36
              +/-  0.9 +/-  1.6 +/-  2.2 +/-  2.9 +/-  3.5 +/-  4.1       36
*UPDATE*  6 h        4.8      6.0      6.7      7.7      8.4      9.1       48
              +/-  0.3 +/-  0.6 +/-  0.8 +/-  1.0 +/-  1.2 +/-  1.4       48
*UPDATE* 12 h        3.2      3.8      4.3      4.9      5.3      5.7       48
              +/-  0.2 +/-  0.3 +/-  0.5 +/-  0.6 +/-  0.7 +/-  0.9       48
*UPDATE* 24 h        1.9      2.3      2.6      3.0      3.3      3.6       48
              +/-  0.1 +/-  0.2 +/-  0.3 +/-  0.4 +/-  0.5 +/-  0.6       48
     * 6-hr data were used for the update: shorter durations were not updated

********************************************************************************

Table 3: Interpolation Equation / Équation d'interpolation: R = A*T^B

R = Interpolated Rainfall rate (mm/h)/Intensité interpolée de la pluie (mm/h)
RR = Rainfall rate (mm/h) / Intensité de la pluie (mm/h)
 T = Rainfall duration (h) / Durée de la pluie (h)

********************************************************************************

       Statistics/Statistiques      2      5     10     25     50    100
                              yr/ans yr/ans yr/ans yr/ans yr/ans yr/ans
      Mean of RR/Moyenne de RR   18.0   24.8   29.3   34.9   39.2   43.3
    Std. Dev. /Écart-type (RR)   15.7   23.1   28.0   34.2   38.8   43.4
        Std. Error/Erreur-type    1.8    1.5    1.5    1.5    1.6    1.7
               Coefficient (A)   12.7   16.8   19.4   22.7   25.2   27.6
         Exponent/Exposant (B) -0.565 -0.594 -0.607 -0.619 -0.625 -0.631
 Mean % Error/% erreur moyenne    5.2    3.0    3.0    3.2    3.3    3.4
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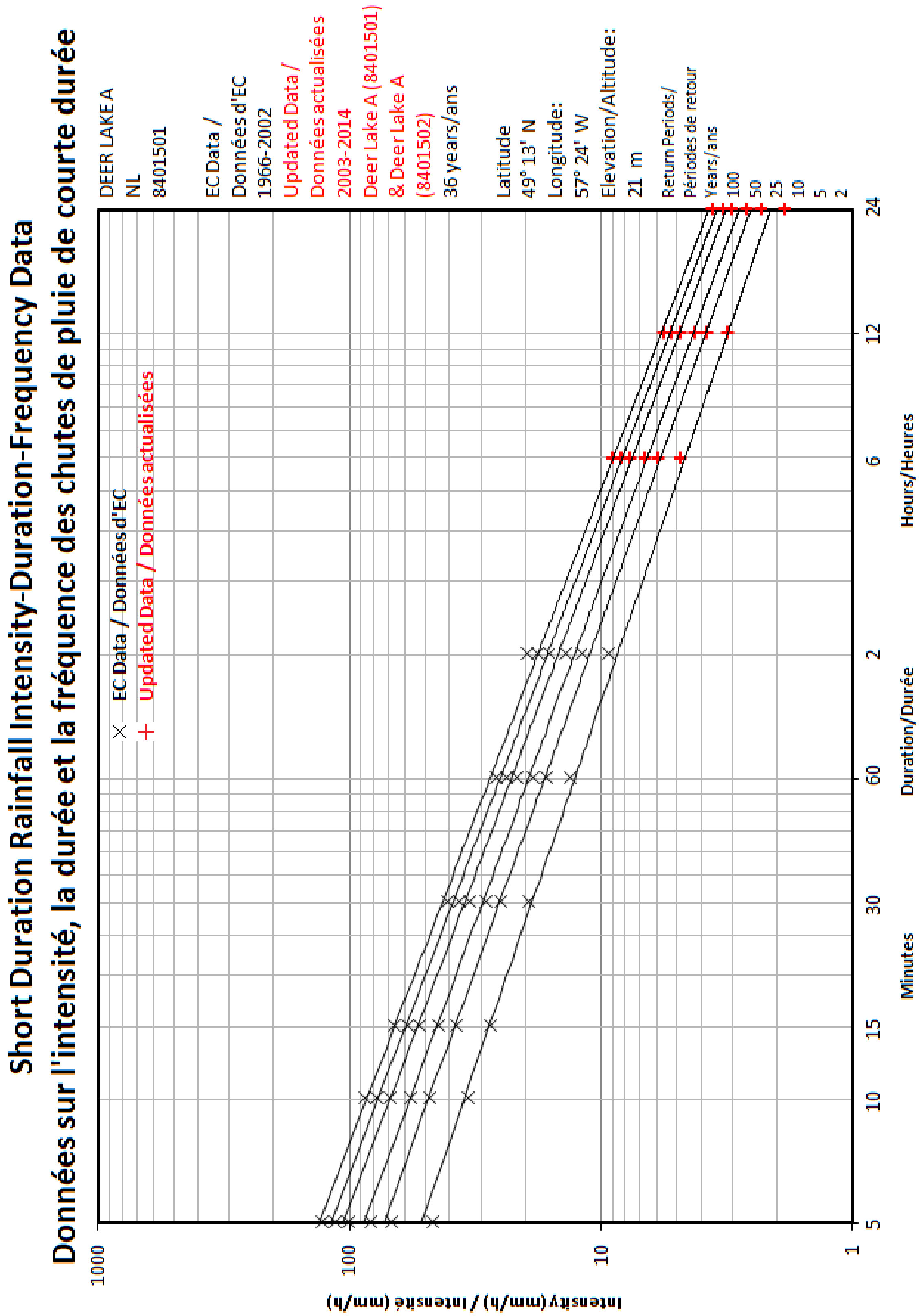

Figure 6.1 Deer Lake A IDF Curve – Updated

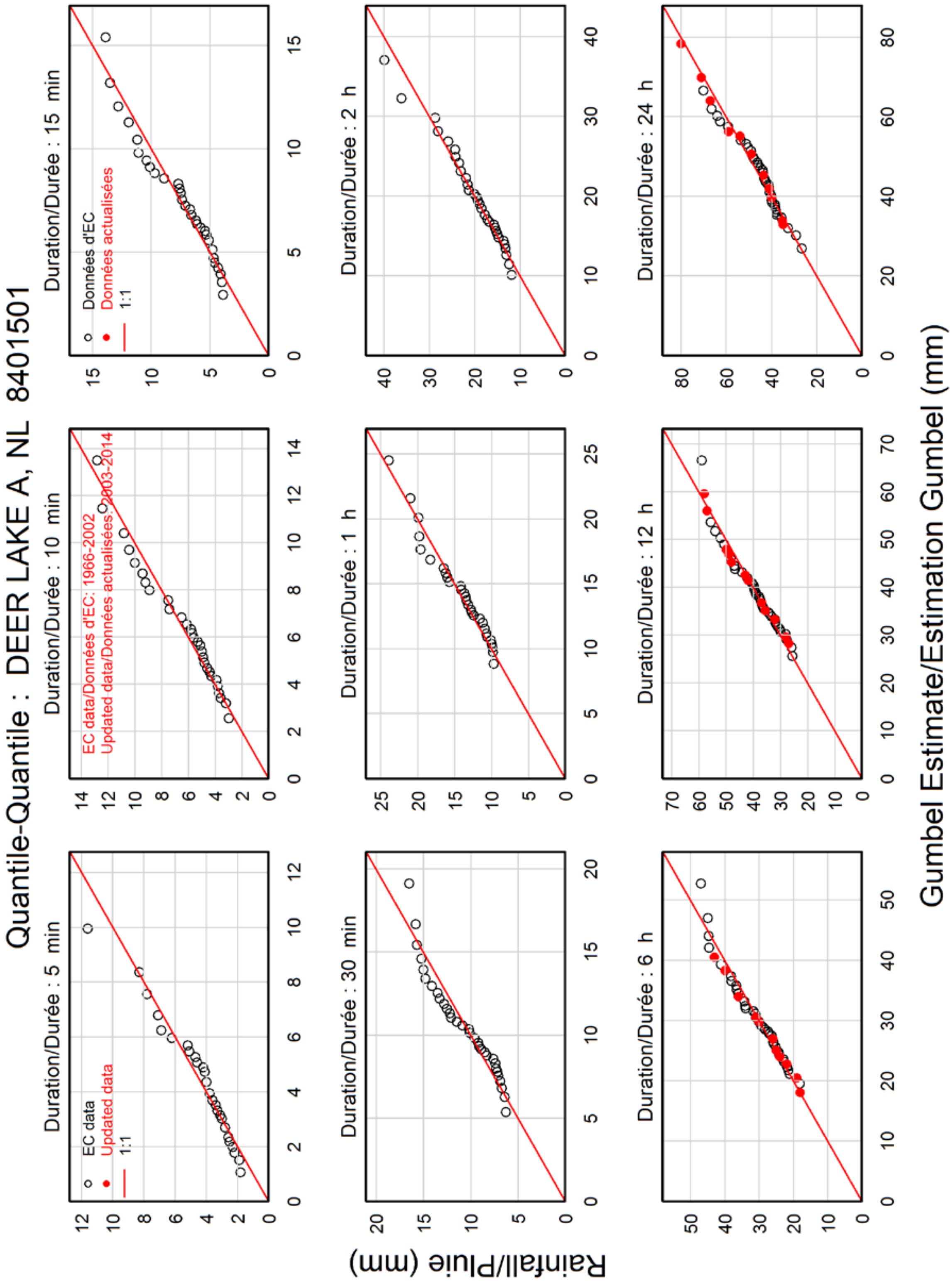

Figure 6.2 Deer Lake A Quantile-Quantile Plot – Updated

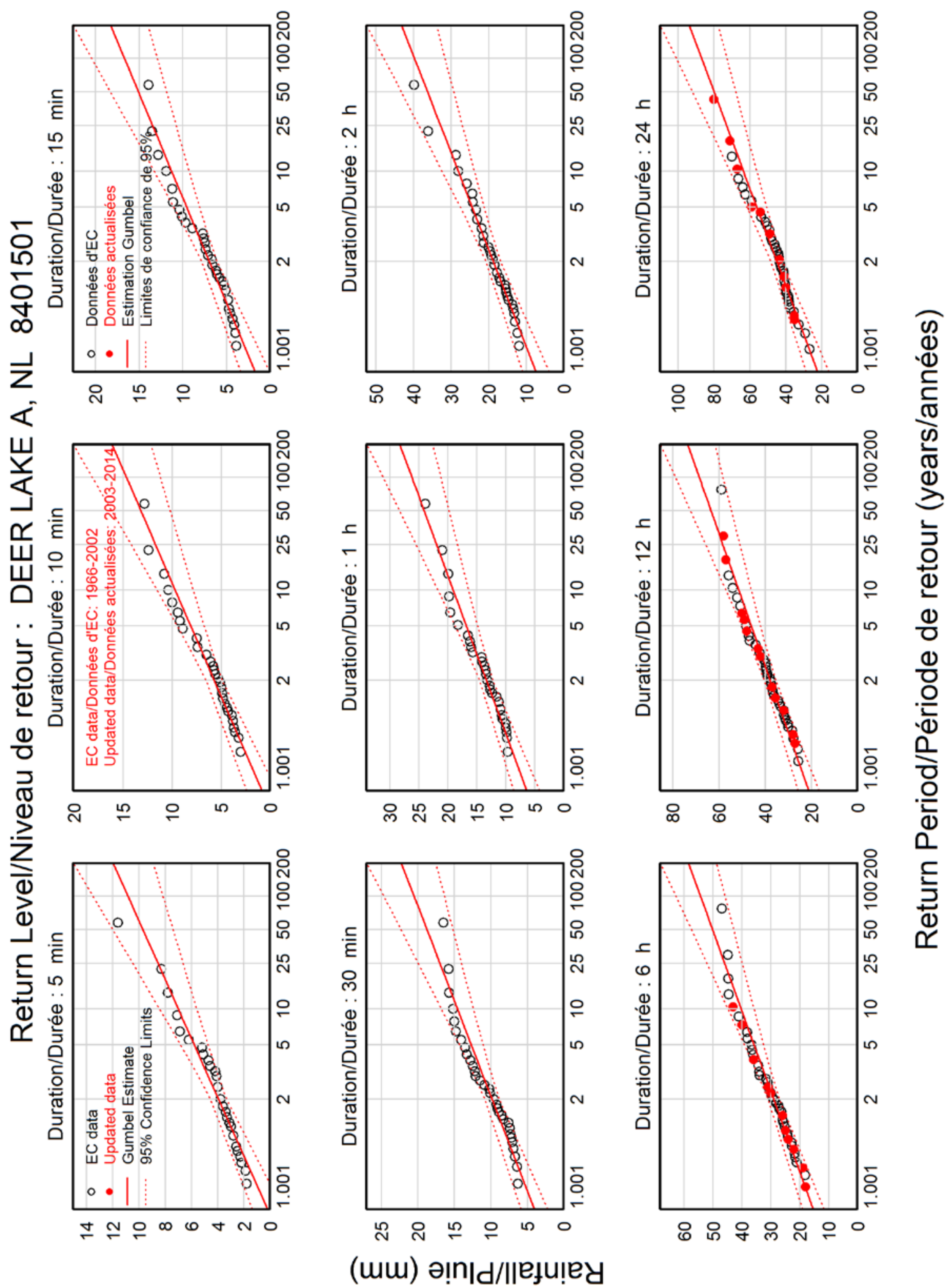

Figure 6.3 Deer Lake A Return Level Plot – Updated

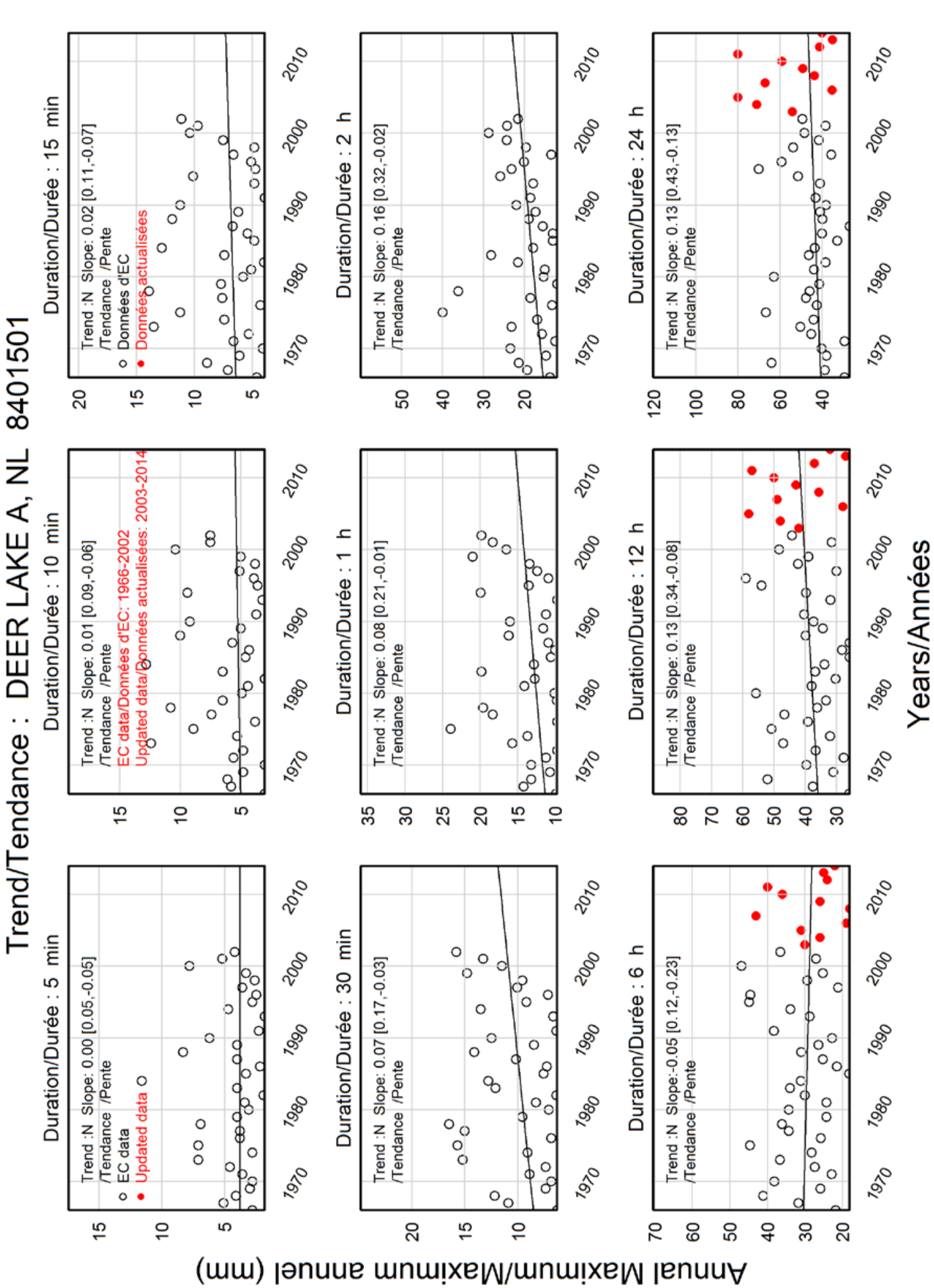

Figure 6.4 Deer Lake A Trend Plot – Updated

Section 7.0 Gander Airport CS

The IDF curve for Gander Airport CS station was updated using 5-min, 15-min, and 1-hr weighing gauge data at Gander Airport CS. All durations were updated.

Table 7.1 presents the changes between the updated IDF curve and the EC-IDF V2.3 curve.

Table 7.1 Differences Between IDF Curves for Gander Airport CS

Percent Difference in Precipitation Amount [%] (Difference in Precipitation Amount [mm])						
	Return Period [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	0.7 (0.0)	0.5 (0.0)	0.4 (0.0)	0.3 (0.0)	0.3 (0.0)	0.3 (0.0)
10-min	1.3 (0.1)	1.6 (0.1)	1.7 (0.2)	1.8 (0.2)	1.9 (0.3)	1.9 (0.3)
15-min	1.9 (0.1)	2.3 (0.3)	2.4 (0.3)	2.5 (0.4)	2.6 (0.5)	2.7 (0.5)
30-min	1.6 (0.2)	1.3 (0.2)	1.2 (0.2)	1.1 (0.2)	1.0 (0.3)	1.0 (0.3)
1-hr	2.5 (0.3)	2.6 (0.5)	2.7 (0.6)	2.7 (0.7)	2.7 (0.8)	2.8 (0.9)
2-hr	2.7 (0.5)	4.1 (1.0)	4.8 (1.3)	**5.4 (1.7)**	**5.7 (2.0)**	**6.0 (2.4)**
6-hr	3.2 (0.9)	**6.2 (2.4)**	**7.6 (3.3)**	**8.9 (4.5)**	**9.7 (5.4)**	**10.4 (6.2)**
12-hr	3.6 (1.4)	**8.8 (4.3)**	**11.2 (6.2)**	**13.6 (8.6)**	**14.9 (10.4)**	**16.1 (12.2)**
24-hr	4.7 (2.2)	**12.3 (7.4)**	**15.7 (10.9)**	**18.9 (15.3)**	**20.7 (18.5)**	**22.2 (21.7)**

Notes:
Red numbers indicate that the updated IDF curve is lower than the EC-IDF V2.3 IDF curve for that duration and return period.
Bold numbers indicate changes greater than 5 percent.

The updated IDF curves for Gander Airport CS are included below.

Office of Climate Change and Energy Efficiency

Short Duration Rainfall Intensity-Duration-Frequency Data
Données sur l'intensité, la durée et la fréquence des chutes de pluie de courte durée

Gumbel - Method of moments/Méthode des moments

2015/03/20

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GANDER AIRPORT CS NL 8401705
Updated with 5-min, 15-min, and 1-hr data measured at Gander Airport CS (8401705): 2010-2013
Latitude: 48 57'N Longitude: 54 34'W Elevation/Altitude: 151 m
Years/Années : 1939 - 2013 # Years/Années : 68

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Table 1: Annual Maximum (mm)/Maximum annuel (mm)

****

	Year Année	5 min	10 min	15 min	30 min	1 h	2 h	6 h	12 h	24 h
EC-IDF	1939	6.1	7.6	11.4	11.4	13.0	16.0	26.7	32.0	35.1
EC-IDF	1941	3.6	5.1	6.6	8.1	13.5	19.6	35.1	39.1	58.7
EC-IDF	1942	3.0	5.6	7.6	9.4	13.0	25.1	61.5	81.5	103.4
EC-IDF	1945	4.1	4.3	4.6	4.6	7.4	14.0	24.1	25.7	30.0
EC-IDF	1946	2.5	3.8	4.6	6.9	9.9	13.5	20.8	24.4	40.9
EC-IDF	1947	4.1	6.6	8.6	13.2	14.0	14.2	32.3	32.3	32.3
EC-IDF	1948	7.1	11.4	13.5	14.7	19.3	22.1	33.8	46.7	53.3
EC-IDF	1949	15.2	22.9	27.9	40.6	46.2	46.5	51.1	51.6	52.3
EC-IDF	1950	4.6	8.9	10.9	12.2	14.5	16.0	21.3	42.7	50.0
EC-IDF	1951	4.6	7.6	9.7	12.7	20.8	-99.9	-99.9	-99.9	98.3
EC-IDF	1952	7.6	8.6	11.2	15.7	17.5	18.0	23.6	27.7	29.5
EC-IDF	1953	4.6	9.1	12.2	16.8	18.3	22.1	29.2	41.9	47.2
EC-IDF	1954	4.3	7.1	7.9	9.9	11.2	18.0	27.2	37.3	41.4
EC-IDF	1955	4.6	7.6	9.7	10.4	11.7	18.3	24.1	31.0	35.1
EC-IDF	1956	2.0	3.3	4.8	7.4	14.5	16.3	21.3	26.9	31.0
EC-IDF	1958	2.5	4.8	5.1	9.4	12.4	19.3	40.4	44.7	49.5
EC-IDF	1959	2.8	5.1	5.3	5.8	7.6	10.9	25.9	32.3	38.1
EC-IDF	1960	5.6	6.3	6.3	8.1	9.4	14.7	31.5	33.0	33.0
EC-IDF	1961	3.6	5.3	7.6	13.7	18.8	31.2	33.3	33.5	38.9
EC-IDF	1962	6.3	12.7	15.2	25.1	27.2	31.2	31.2	32.8	36.6
EC-IDF	1963	8.4	10.7	12.4	15.2	15.5	23.1	46.7	49.5	49.5
EC-IDF	1964	4.1	5.8	6.3	8.4	10.9	19.6	35.3	38.4	38.9
EC-IDF	1965	2.5	2.8	3.3	5.8	8.4	13.2	24.9	39.1	39.9
EC-IDF	1966	9.1	12.7	14.7	17.8	17.8	20.1	26.9	37.3	38.9
EC-IDF	1967	4.3	6.1	7.6	9.9	10.9	13.0	29.5	35.6	39.1
EC-IDF	1968	8.6	9.1	9.1	9.7	10.4	12.4	21.6	37.8	45.0
EC-IDF	1969	3.6	6.6	6.6	6.6	9.1	14.2	23.4	36.3	45.0
EC-IDF	1970	2.8	5.1	6.1	9.1	13.2	15.7	21.6	27.4	45.0
EC-IDF	1971	3.0	3.3	3.6	5.1	7.6	12.4	26.7	43.4	55.9
EC-IDF	1972	2.0	2.8	3.0	4.1	6.3	9.7	16.3	20.6	30.2
EC-IDF	1973	4.3	6.9	8.9	14.7	18.5	22.1	29.7	40.6	46.0
EC-IDF	1974	2.5	3.6	4.6	7.6	11.9	17.0	21.1	27.9	36.8
EC-IDF	1975	5.1	6.3	7.1	10.2	12.4	14.5	26.7	37.6	41.7
EC-IDF	1976	4.3	6.1	6.1	8.4	11.9	17.8	24.4	33.8	38.6
EC-IDF	1977	5.1	5.6	6.6	8.4	10.7	16.5	29.7	37.6	38.9
EC-IDF	1978	5.3	5.9	6.9	7.3	9.2	12.9	20.8	21.2	21.2

EC-IDF	1979	6.1	8.7	9.3	10.3	13.1	19.1	26.0	31.1	40.8
EC-IDF	1980	5.8	8.3	8.7	11.4	15.4	23.9	30.3	47.0	59.3
EC-IDF	1981	2.8	4.4	5.9	7.9	12.9	16.6	29.8	38.1	70.1
EC-IDF	1982	2.9	3.9	4.3	6.2	9.3	12.3	23.8	33.0	42.0
EC-IDF	1983	4.6	6.9	8.4	13.4	15.2	15.6	26.0	33.8	40.8
EC-IDF	1984	5.2	6.3	7.5	8.4	10.0	19.2	36.8	37.4	46.6
EC-IDF	1985	4.1	4.8	5.2	6.4	10.3	16.5	24.4	36.0	38.2
EC-IDF	1986	5.4	7.9	8.3	10.9	15.1	24.2	46.7	64.6	68.9
EC-IDF	1987	2.1	3.1	3.7	6.2	10.7	16.9	29.1	35.9	45.4
EC-IDF	1988	4.2	6.0	8.9	14.7	18.3	28.5	45.8	46.0	52.8
EC-IDF	1989	3.9	7.7	10.7	15.8	20.2	21.3	30.7	43.9	55.4
EC-IDF	1990	5.6	7.5	8.1	10.1	11.0	12.3	23.3	43.3	75.4
EC-IDF	1991	4.7	6.6	6.6	7.7	11.9	17.8	31.4	33.8	45.9
EC-IDF	1992	4.4	7.4	11.1	12.5	12.5	17.5	42.6	61.2	64.2
EC-IDF	1993	3.2	5.3	7.8	10.8	17.0	27.7	48.9	53.7	60.6
EC-IDF	1994	3.3	6.6	7.2	7.6	11.4	16.5	20.1	26.6	32.8
EC-IDF	1995	7.9	8.1	8.3	9.2	10.6	15.8	39.6	65.6	71.5
EC-IDF	1996	6.3	9.3	10.5	11.2	14.6	19.6	34.2	50.3	67.5
EC-IDF	1997	3.8	5.8	6.2	8.8	12.0	16.7	31.6	54.8	57.6
EC-IDF	1998	8.0	10.7	12.3	18.5	18.5	18.7	33.1	40.7	59.1
EC-IDF	1999	3.2	4.3	5.6	8.6	12.8	18.2	25.8	44.1	57.0
EC-IDF	2000	6.8	12.2	13.2	19.8	24.5	28.4	32.0	33.4	41.0
EC-IDF	2001	3.0	4.0	4.9	9.6	10.6	14.6	24.3	-99.9	33.8
EC-IDF	2002	8.0	10.8	13.9	18.4	21.1	32.9	37.6	37.6	45.2
EC-IDF	2003	3.9	4.5	6.0	9.4	14.0	20.9	44.3	61.8	89.1
EC-IDF	2004	3.5	5.4	7.9	11.0	14.0	19.7	34.4	44.6	68.4
EC-IDF	2005	7.8	7.8	11.2	16.0	19.4	32.6	37.8	38.2	43.2
EC-IDF	2006	4.0	5.4	5.4	7.6	12.2	20.8	35.0	44.0	52.0
EC-IDF	2007	3.6	5.2	7.0	8.0	11.6	18.0	41.2	48.8	51.4
EC-IDF	2008	6.4	11.6	14.4	15.6	18.4	20.0	37.4	49.8	54.2
EC-IDF	2009	3.0	4.8	6.4	11.2	18.2	29.8	53.2	58.6	59.0
UPDATE	2010	7.0	13.4	18.0	20.0	25.7	25.7	52.5	84.7	138.2
UPDATE	2012	NM	NM	NM	NM	18.5	30.9	55.0	65.9	103.6
UPDATE	2013	NM	NM	10.0	14.0	23.9	41.3	70.3	101.0	124.5
	# Yrs. Années	68	68	69	69	70	69	69	68	70
	Mean Moyenne	4.8	7.0	8.5	11.3	14.6	19.9	32.7	42.2	52.0
	Std. Dev. Écart-type	2.2	3.2	4.0	5.5	5.9	6.9	10.7	14.6	21.6
	Skew. Dissymétrie	1.86	2.08	2.03	2.58	2.49	1.54	1.26	1.70	1.98
	Kurtosis	9.15	10.66	10.35	14.01	13.71	6.03	4.71	7.02	7.65

*-99.9 Indicates Missing Data/Données manquantes
* NM Indicates No Measurements/Aucunes mesures

Warning: annual maximum amount greater than 100-yr return period amount
Avertissement : la quantité maximale annuelle excède la quantité pour une période de retour de 100 ans

Year/Année	Duration/Durée	Data/Données	100-yr/ans
1949	5 min	15.2	11.7
1949	10 min	22.9	17.1
1949	15 min	27.9	21.0
1949	30 min	40.6	28.5
1949	1 h	46.2	33.2
1949	2 h	46.5	41.7
2010	24 h	138.2	119.8
2013	6 h	70.3	66.2
2013	12 h	101.0	88.0
2013	24 h	124.5	119.8

****

Table 2a: Return Period Rainfall Amounts (mm)
Quantité de pluie (mm) par période de retour

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
UPDATE 5 min	4.5	6.4	7.7	9.3	10.5	11.7	68
UPDATE 10 min	6.5	9.3	11.2	13.6	15.4	17.1	68
UPDATE 15 min	7.8	11.4	13.7	16.6	18.8	21.0	69
UPDATE 30 min	10.4	15.3	18.5	22.5	25.6	28.5	69
UPDATE 1 h	13.6	18.8	22.3	26.7	29.9	33.2	70
UPDATE 2 h	18.7	24.9	28.9	34.1	37.9	41.7	69
UPDATE 6 h	30.9	40.4	46.6	54.5	60.4	66.2	69
UPDATE 12 h	39.8	52.7	61.3	72.0	80.1	88.0	68
UPDATE 24 h	48.5	67.6	80.2	96.2	108.1	119.8	70

* 5-min, 15-min, 1-hr data were used for the update: all durations were updated

****

Table 2b:

Return Period Rainfall Rates (mm/h) - 95% Confidence limits
Intensité de la pluie (mm/h) par période de retour - Limites de confiance de 95%

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
UPDATE 5 min	53.6	76.9	92.3	111.8	126.3	140.6	68
	+/- 5.7	+/- 9.7	+/- 13.1	+/- 17.6	+/- 21.1	+/- 24.6	68
UPDATE 10 min	39.0	56.1	67.4	81.7	92.3	102.8	68
	+/- 4.2	+/- 7.1	+/- 9.6	+/- 12.9	+/- 15.5	+/- 18.0	68
UPDATE 15 min	31.4	45.4	54.7	66.5	75.2	83.8	69
	+/- 3.4	+/- 5.8	+/- 7.8	+/- 10.5	+/- 12.6	+/- 14.7	69
UPDATE 30 min	20.9	30.6	37.0	45.1	51.1	57.1	69
	+/- 2.4	+/- 4.0	+/- 5.4	+/- 7.3	+/- 8.7	+/- 10.2	69
UPDATE 1 h	13.6	18.8	22.3	26.7	29.9	33.2	70
	+/- 1.3	+/- 2.1	+/- 2.9	+/- 3.9	+/- 4.7	+/- 5.5	70
UPDATE 2 h	9.4	12.4	14.5	17.0	18.9	20.8	69
	+/- 0.8	+/- 1.3	+/- 1.7	+/- 2.3	+/- 2.8	+/- 3.2	69
UPDATE 6 h	5.2	6.7	7.8	9.1	10.1	11.0	69
	+/- 0.4	+/- 0.7	+/- 0.9	+/- 1.2	+/- 1.4	+/- 1.7	69
UPDATE 12 h	3.3	4.4	5.1	6.0	6.7	7.3	68
	+/- 0.3	+/- 0.4	+/- 0.6	+/- 0.8	+/- 1.0	+/- 1.1	68
UPDATE 24 h	2.0	2.8	3.3	4.0	4.5	5.0	70
	+/- 0.2	+/- 0.3	+/- 0.4	+/- 0.6	+/- 0.7	+/- 0.8	70

* 5-min, 15-min, 1-hr data were used for the update: all durations were updated

****

Table 3: Interpolation Equation / Équation d'interpolation: R = A*T^B

R = Interpolated Rainfall rate (mm/h)/Intensité interpolée de la pluie (mm/h)
RR = Rainfall rate (mm/h) / Intensité de la pluie (mm/h)
T = Rainfall duration (h) / Durée de la pluie (h)

****

Statistics/Statistiques	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans
Mean of RR/Moyenne de RR	19.8	28.2	33.8	40.9	46.1	51.3
Std. Dev. /Écart-type (RR)	18.0	26.1	31.5	38.3	43.3	48.3
Std. Error/Erreur-type	1.5	2.6	3.4	4.4	5.1	5.9
Coefficient (A)	13.7	19.1	22.7	27.2	30.5	33.8
Exponent/Exposant (B)	-0.577	-0.593	-0.599	-0.605	-0.608	-0.610
Mean % Error/% erreur moyenne	3.5	3.2	3.2	3.8	4.3	4.6

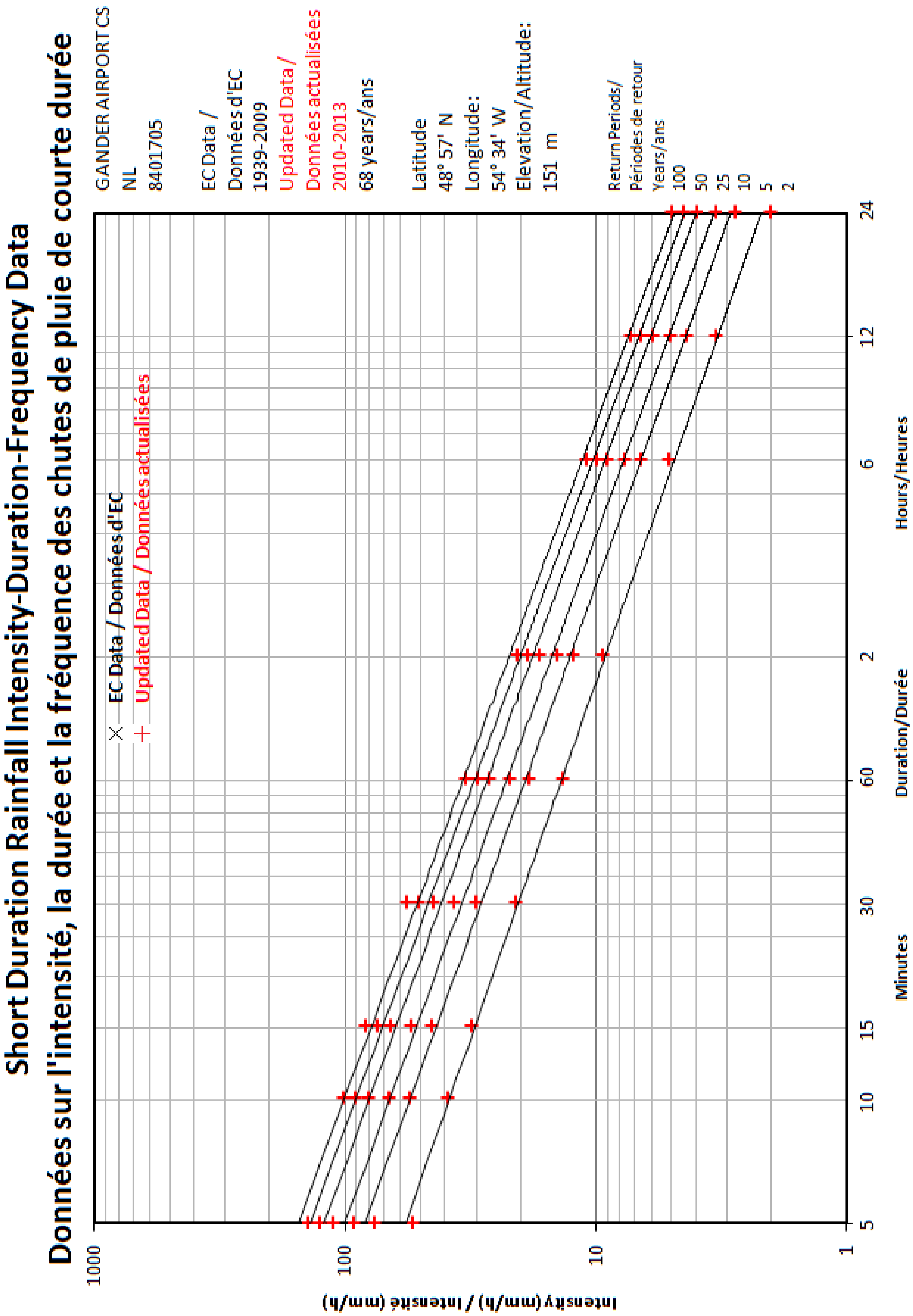

Figure 7.1 Gander Airport CS IDF Curve – Updated

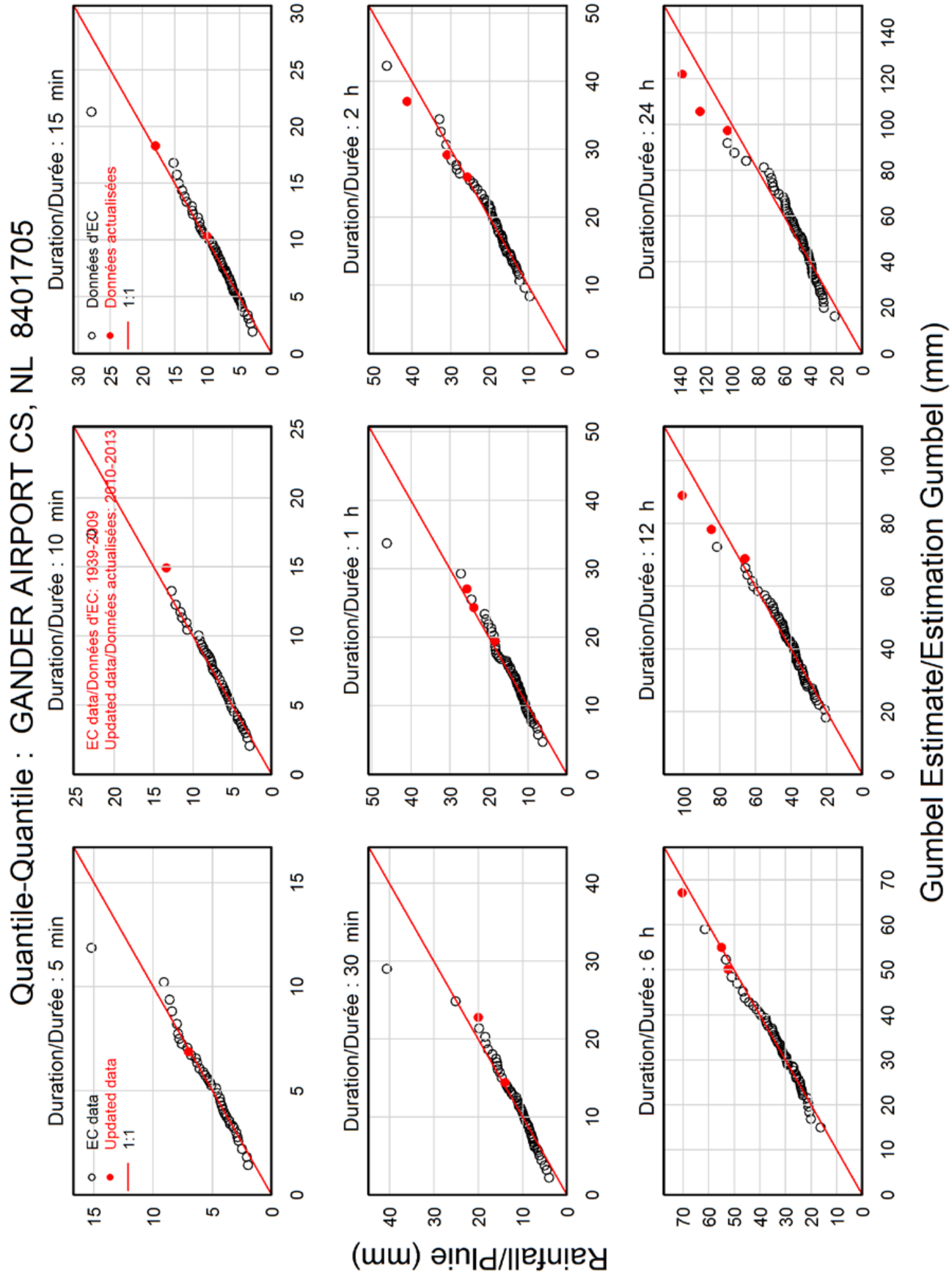

Figure 7.2 Gander Airport CS Quantile-Quantile Plot – Updated

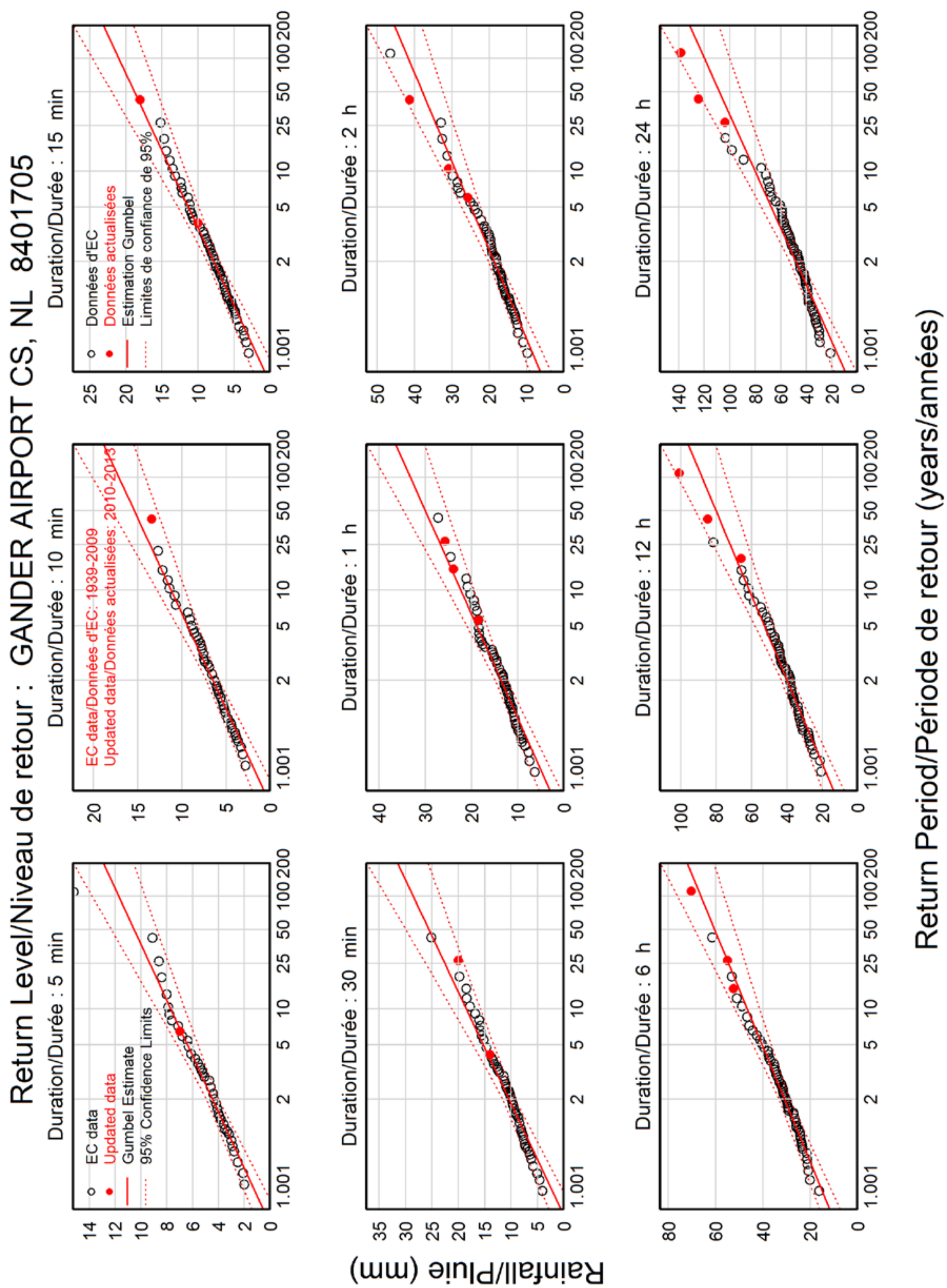

Figure 7.3 Gander Airport CS Return Level Plot – Updated

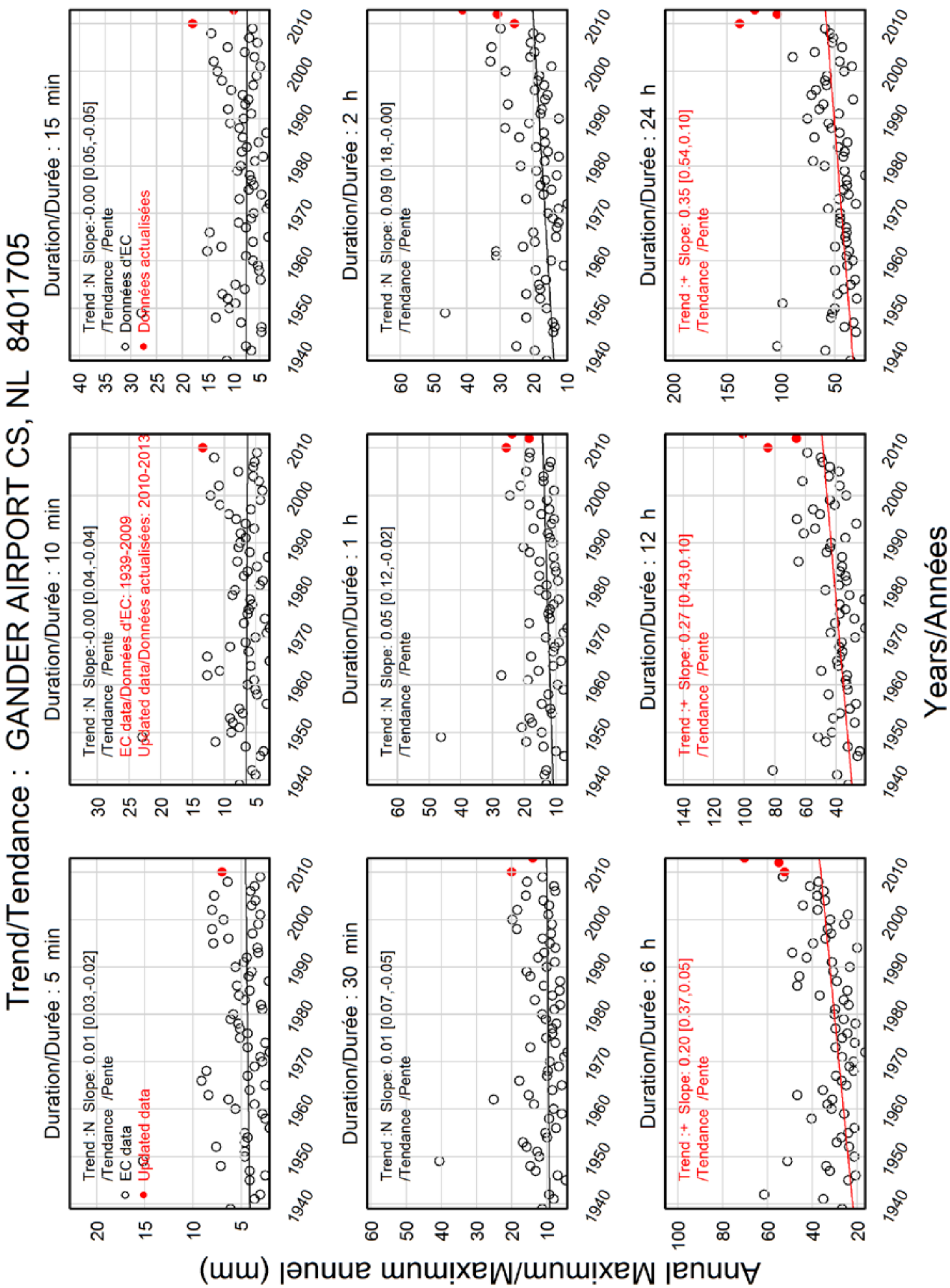

Figure 7.4 Gander Airport CS Trend Plot – Updated

Section 8.0 La Scie

The IDF curve for La Scie station was updated using 1-hr and 6-hr weighing gauge data at La Scie. Durations of 1-hr and longer were updated.

Table 8.1 presents the changes between the updated IDF curve and the EC-IDF V2.3 curve.

Table 8.1 Differences Between IDF Curves for La Scie

Percent Difference in Precipitation Amount [%] (Difference in Precipitation Amount [mm])						
	Return Period [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	N/A	N/A	N/A	N/A	N/A	N/A
10-min	N/A	N/A	N/A	N/A	N/A	N/A
15-min	N/A	N/A	N/A	N/A	N/A	N/A
30-min	N/A	N/A	N/A	N/A	N/A	N/A
1-hr	0.0 (0.0)	-1.8 (-0.3)	-2.6 (-0.4)	-3.3 (-0.6)	-3.8 (-0.8)	-4.1 (-1.0)
2-hr	0.0 (0.0)	-1.4 (-0.3)	-2.1 (-0.5)	-2.7 (-0.7)	-3.0 (-0.9)	-3.3 (-1.1)
6-hr	-0.4 (-0.1)	-1.7 (-0.6)	-2.2 (-0.9)	-2.7 (-1.3)	-3.0 (-1.6)	-3.3 (-1.9)
12-hr	-2.4 (-1.0)	-3.2 (-1.7)	-3.6 (-2.1)	-3.9 (-2.7)	-4.1 (-3.2)	-4.2 (-3.6)
24-hr	1.1 (0.5)	1.4 (0.9)	1.5 (1.1)	1.7 (1.4)	1.8 (1.6)	1.9 (1.8)

Notes:
Red numbers indicate that the updated IDF curve is lower than the EC-IDF V2.3 IDF curve for that duration and return period.

The updated IDF curves for La Scie are included below.

```
                Office of Climate Change and Energy Efficiency

           Short Duration Rainfall Intensity-Duration-Frequency Data
          Données sur l'intensité, la durée et la fréquence des chutes
                            de pluie de courte durée

                 Gumbel - Method of moments/Méthode des moments

                                   2015/03/20

================================================================================

 LA SCIE                                                NL        8402520
 Updated with 6-hr and 1-hr data measured at La Scie (8402520): 2003-2006
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Latitude: 49 55'N Longitude: 55 40'W Elevation/Altitude: 194 m
Years/Années : 1984 - 2006 # Years/Années : 12

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Table 1: Annual Maximum (mm)/Maximum annuel (mm)

****

	Year Année	5 min	10 min	15 min	30 min	1 h	2 h	6 h	12 h	24 h
EC-IDF	1984	3.2	3.6	4.7	7.6	10.4	15.0	-99.9	-99.9	-99.9
EC-IDF	1985	2.4	3.1	3.5	5.6	9.8	16.4	25.5	40.1	53.8
EC-IDF	1986	3.3	4.0	4.7	5.9	10.6	18.2	42.6	68.6	79.7
EC-IDF	1987	2.9	5.1	5.7	6.7	9.1	15.3	28.2	38.6	40.6
EC-IDF	1988	1.9	2.7	2.9	4.6	7.2	11.9	20.7	32.0	34.5
EC-IDF	1989	2.1	3.7	5.4	9.7	17.2	27.0	47.3	53.4	53.4
EC-IDF	1990	4.7	7.3	8.8	11.0	14.1	16.9	22.0	29.8	42.4
EC-IDF	1991	2.9	3.5	4.3	4.9	6.5	11.6	24.4	34.3	57.6
EC-IDF	1992	1.8	2.2	2.9	4.0	6.3	9.0	15.6	24.1	41.6
EC-IDF	1993	4.0	5.4	6.0	9.3	17.1	25.2	36.5	57.0	66.1
EC-IDF	1994	5.8	7.3	9.7	12.9	13.6	16.4	30.8	50.5	61.9
EC-IDF	1995	3.6	6.1	9.1	13.1	14.4	14.6	22.0	37.6	60.0
UPDATE	2003	NM	NM	NM	NM	NM	NM	20.0	29.0	36.0
UPDATE	2004	NM	NM	NM	NM	11.9	18.4	37.0	48.7	68.6
UPDATE	2006	NM	NM	NM	NM	10.1	13.8	26.3	34.1	65.2
	# Yrs. Années	12	12	12	12	14	14	14	14	14
	Mean Moyenne	3.2	4.5	5.6	7.9	11.3	16.4	28.5	41.3	54.4
	Std. Dev. Écart-type	1.2	1.7	2.4	3.2	3.6	4.9	9.2	12.6	13.7
	Skew. Dissymétrie	0.91	0.55	0.69	0.48	0.27	0.97	0.77	0.77	0.07
	Kurtosis	4.31	2.89	3.01	2.65	2.79	4.59	3.37	3.57	2.76

*-99.9 Indicates Missing Data/Données manquantes
* NM Indicates No Measurements/Aucunes mesures

****

Table 2a: Return Period Rainfall Amounts (mm)
Quantité de pluie (mm) par période de retour

****

Duration/Durée		2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
EC-IDF	5 min	3.0	4.1	4.8	5.6	6.3	6.9	12
EC-IDF	10 min	4.2	5.7	6.7	8.0	9.0	9.9	12
EC-IDF	15 min	5.3	7.3	8.7	10.5	11.8	13.1	12
EC-IDF	30 min	7.4	10.2	12.1	14.5	16.2	18.0	12
UPDATE	1 h	10.7	13.9	16.0	18.6	20.6	22.5	14
UPDATE	2 h	15.6	19.9	22.8	26.4	29.0	31.7	14
UPDATE	6 h	27.0	35.1	40.5	47.4	52.4	57.5	14
UPDATE	12 h	39.2	50.3	57.7	67.0	74.0	80.8	14
UPDATE	24 h	52.1	64.2	72.2	82.3	89.8	97.2	14

* 6-hr and 1-hr data were used for the update: shorter durations were not updated

****

Table 2b:

Return Period Rainfall Rates (mm/h) - 95% Confidence limits
Intensité de la pluie (mm/h) par période de retour - Limites de confiance de 95%

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
EC-IDF 5 min	36.3	48.8	57.2	67.7	75.5	83.3	12
	+/- 7.4	+/- 12.5	+/- 16.8	+/- 22.7	+/- 27.1	+/- 31.6	12
EC-IDF 10 min	25.3	34.4	40.5	48.1	53.8	59.4	12
	+/- 5.4	+/- 9.0	+/- 12.2	+/- 16.5	+/- 19.7	+/- 22.9	12
EC-IDF 15 min	21.0	29.4	34.9	41.9	47.1	52.3	12
	+/- 4.9	+/- 8.3	+/- 11.2	+/- 15.1	+/- 18.1	+/- 21.0	12
EC-IDF 30 min	14.8	20.5	24.2	29.0	32.5	36.0	12
	+/- 3.3	+/- 5.6	+/- 7.6	+/- 10.2	+/- 12.2	+/- 14.2	12
UPDATE 1 h	10.7	13.9	16.0	18.6	20.6	22.5	14
	+/- 1.7	+/- 2.9	+/- 3.9	+/- 5.3	+/- 6.3	+/- 7.4	14
UPDATE 2 h	7.8	10.0	11.4	13.2	14.5	15.8	14
	+/- 1.2	+/- 2.0	+/- 2.7	+/- 3.6	+/- 4.3	+/- 5.0	14
UPDATE 6 h	4.5	5.9	6.8	7.9	8.7	9.6	14
	+/- 0.7	+/- 1.2	+/- 1.7	+/- 2.3	+/- 2.7	+/- 3.2	14
UPDATE 12 h	3.3	4.2	4.8	5.6	6.2	6.7	14
	+/- 0.5	+/- 0.9	+/- 1.1	+/- 1.5	+/- 1.9	+/- 2.2	14
UPDATE 24 h	2.2	2.7	3.0	3.4	3.7	4.1	14
	+/- 0.3	+/- 0.5	+/- 0.6	+/- 0.8	+/- 1.0	+/- 1.2	14

* 6-hr and 1-hr data were used for the update: shorter durations were not updated

****

Table 3: Interpolation Equation / Équation d'interpolation: R = A*T^B

R = Interpolated Rainfall rate (mm/h)/Intensité interpolée de la pluie (mm/h)
RR = Rainfall rate (mm/h) / Intensité de la pluie (mm/h)
T = Rainfall duration (h) / Durée de la pluie (h)

****

Statistics/Statistiques	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans
Mean of RR/Moyenne de RR	14.0	18.9	22.1	26.2	29.2	32.2
Std. Dev. /Écart-type (RR)	11.6	15.8	18.7	22.3	24.9	27.6
Std. Error/Erreur-type	0.2	0.6	1.0	1.5	1.9	2.3
Coefficient (A)	10.7	14.2	16.4	19.3	21.4	23.6
Exponent/Exposant (B)	-0.489	-0.506	-0.514	-0.521	-0.525	-0.529
Mean % Error/% erreur moyenne	1.6	2.6	3.4	4.3	4.7	5.1

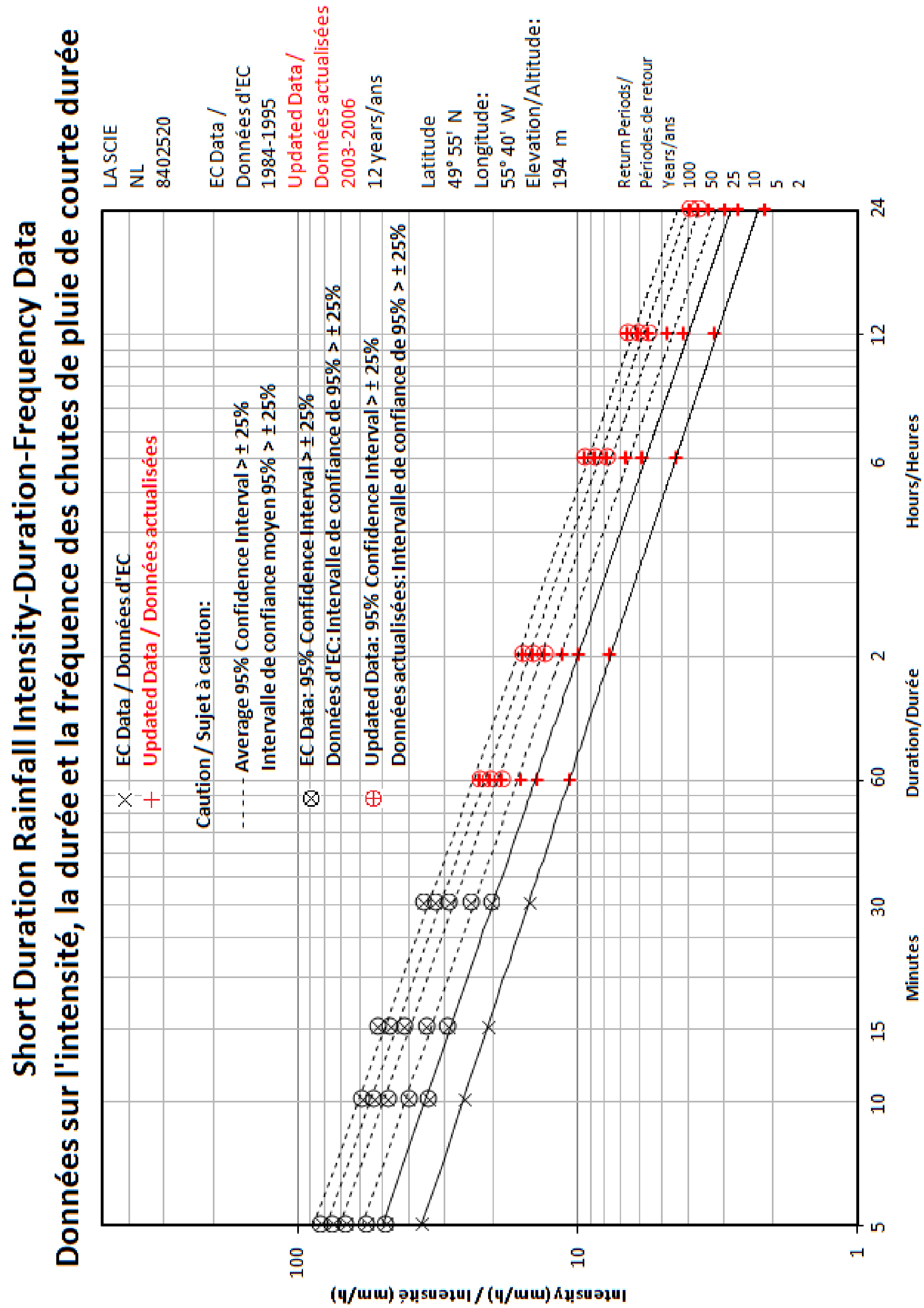

Figure 8.1 La Scie IDF Curve – Updated

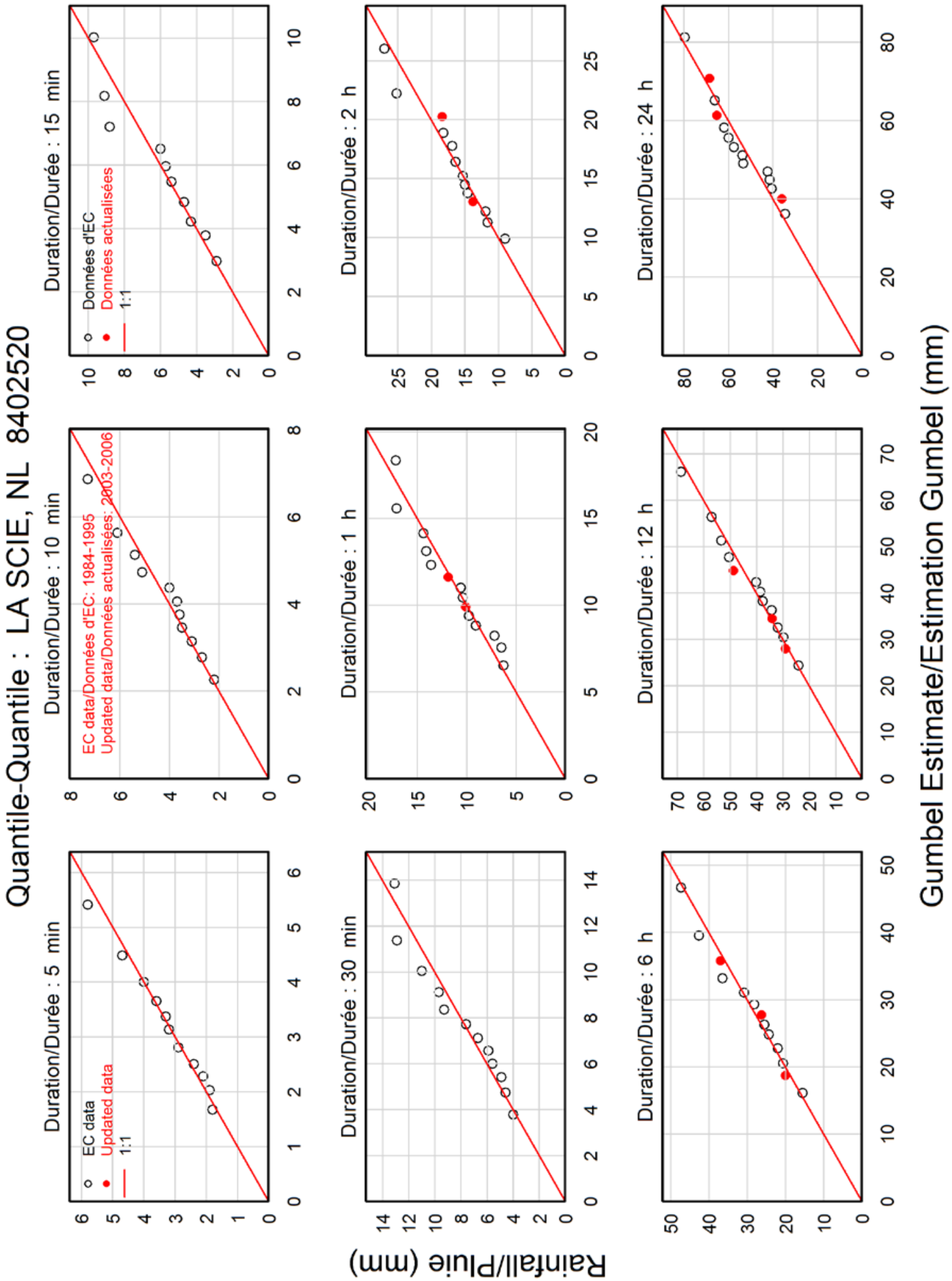

Figure 8.2 La Scie Quantile-Quantile Plot – Updated

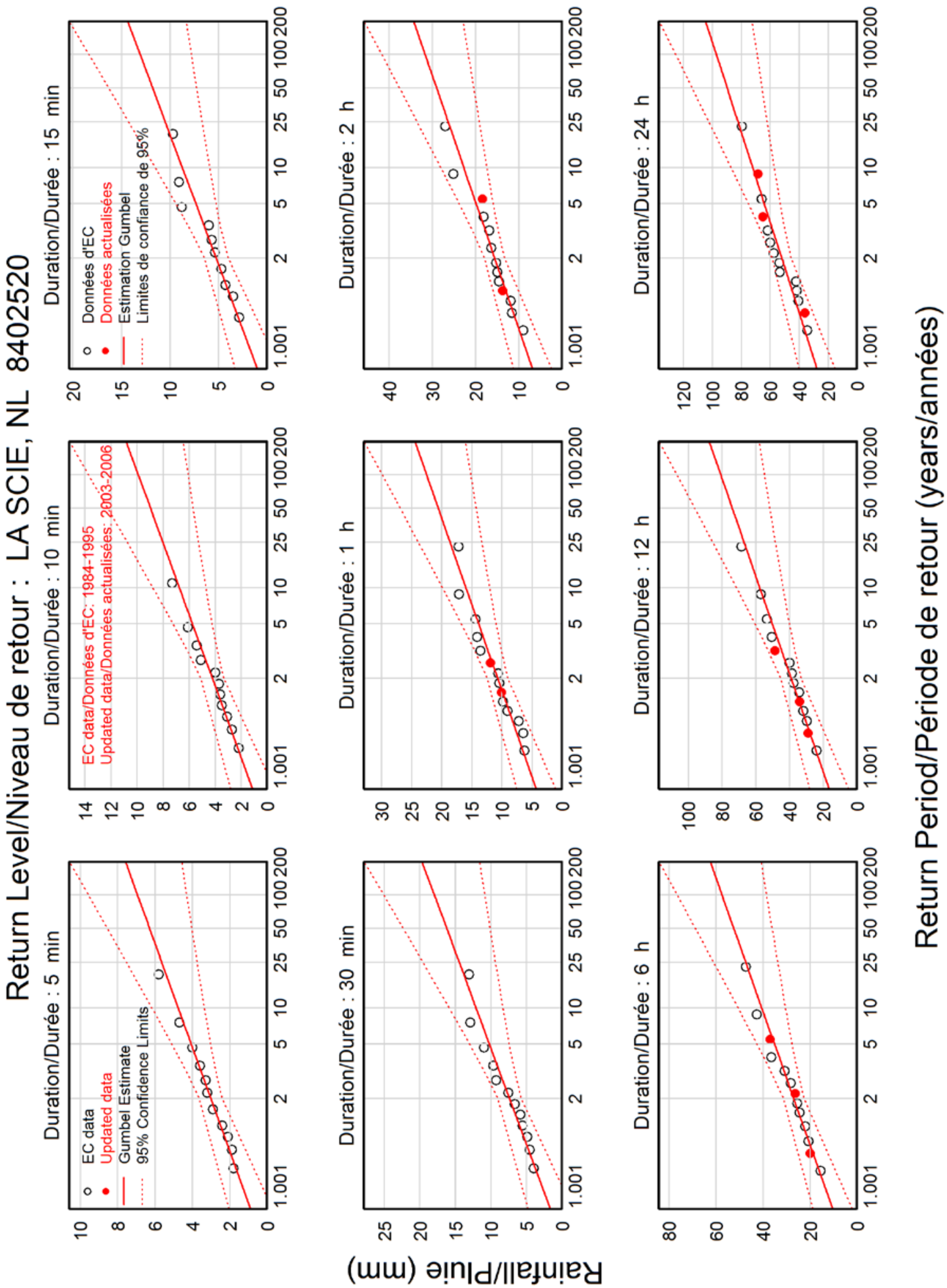

Figure 8.3 La Scie Return Level Plot – Updated

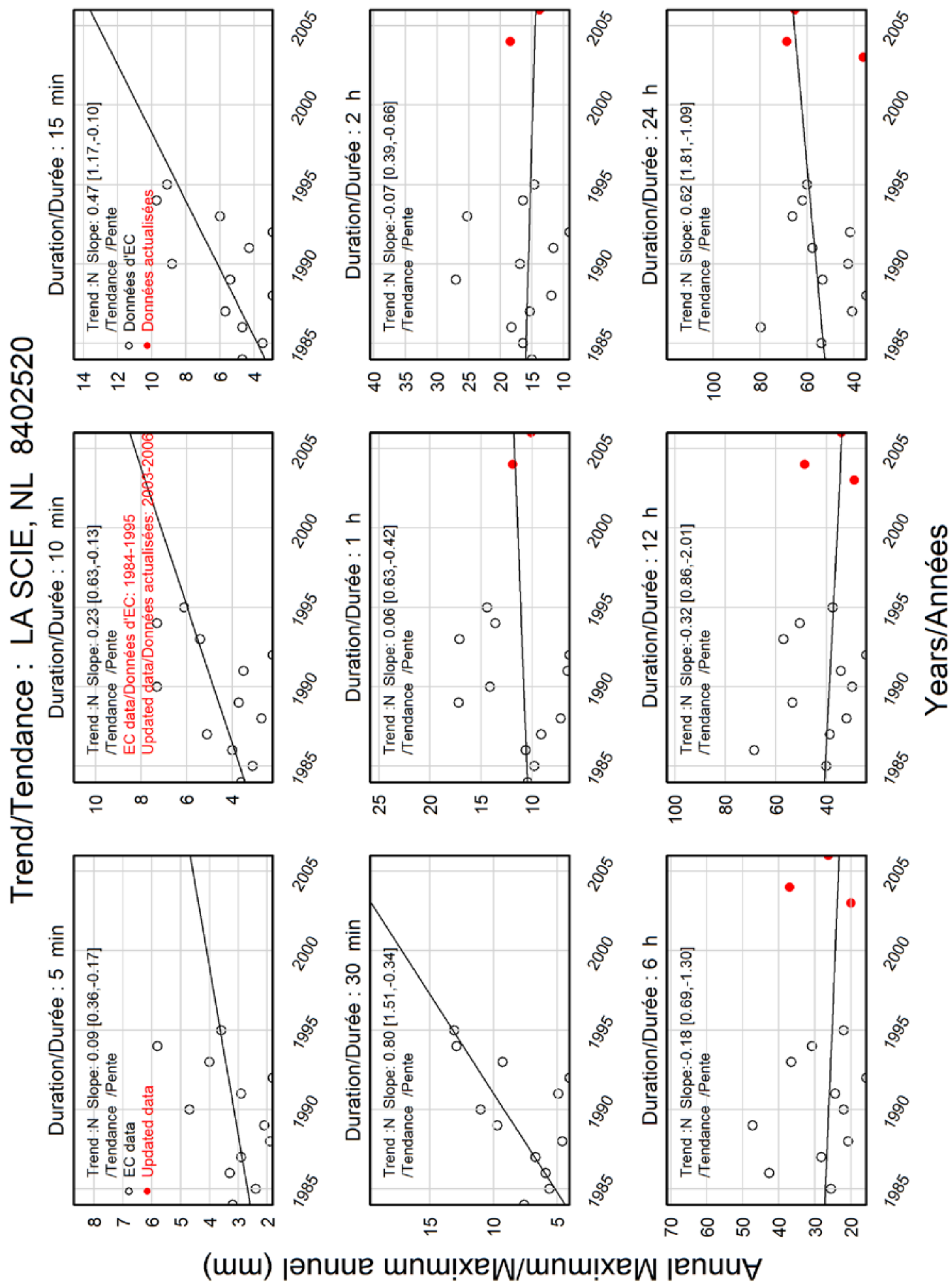

Figure 8.4 La Scie Trend Plot – Updated

Section 9.0 Port Aux Basques

The IDF curve for Port Aux Basques station was updated using 6-hr weighing gauge data at Port Aux Basques. The 6-, 12-, and 24-hr durations were updated

Table 9.1 presents the changes between the updated IDF curve and the EC-IDF V2.3 curve.

Table 9.1 Differences Between IDF Curves for Port Aux Basques

Percent Difference in Precipitation Amount [%] (Difference in Precipitation Amount [mm])						
	Return Period [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	N/A	N/A	N/A	N/A	N/A	N/A
10-min	N/A	N/A	N/A	N/A	N/A	N/A
15-min	N/A	N/A	N/A	N/A	N/A	N/A
30-min	N/A	N/A	N/A	N/A	N/A	N/A
1-hr	N/A	N/A	N/A	N/A	N/A	N/A
2-hr	N/A	N/A	N/A	N/A	N/A	N/A
6-hr	**-7.3 (-3.3)**	**-8.8 (-5.2)**	**-9.4 (-6.4)**	**-10.0 (-8.0)**	**-10.4 (-9.1)**	**-10.7 (-10.3)**
12-hr	**-6.0 (-3.5)**	**-7.5 (-5.5)**	**-8.2 (-6.9)**	**-8.9 (-8.6)**	**-9.3 (-9.8)**	**-9.6 (-11.1)**
24-hr	**-6.0 (-4.3)**	**-7.4 (-6.7)**	**-8.0 (-8.4)**	**-8.7 (-10.4)**	**-9.0 (-12.0)**	**-9.3 (-13.5)**

Notes:
Red numbers indicate that the updated IDF curve is lower than the EC-IDF V2.3 IDF curve for that duration and return period.
Bold numbers indicate changes greater than 5 percent.

Where there are decreases greater than 5 percent, users should exercise caution when using the updated IDF curve, or use the EC IDF curve.

The updated IDF curves for Port Aux Basques are included below.

Office of Climate Change and Energy Efficiency

Short Duration Rainfall Intensity-Duration-Frequency Data
Données sur l'intensité, la durée et la fréquence des chutes de pluie de courte durée

Gumbel - Method of moments/Méthode des moments

2015/03/20

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PORT AUX BASQUES NL 8402975
Updated with 6-hr data measured at Port Aux Basques (8402975): 1999-2014

Latitude: 47 34'N Longitude: 59 9'W Elevation/Altitude: 39 m
Years/Années : 1975 - 2014 # Years/Années : 19

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Table 1: Annual Maximum (mm)/Maximum annuel (mm)

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	Year Année	5 min	10 min	15 min	30 min	1 h	2 h	6 h	12 h	24 h
EC-IDF	1975	5.1	8.9	9.7	12.2	14.7	22.4	43.7	53.1	76.2
EC-IDF	1976	3.3	5.1	6.1	7.9	12.5	20.1	35.3	50.6	65.8
EC-IDF	1977	4.6	7.4	9.7	16.5	20.8	31.5	52.1	53.3	64.8
EC-IDF	1978	3.0	4.1	5.8	8.1	13.1	25.4	45.4	52.7	58.2
EC-IDF	1979	4.6	6.8	8.9	14.3	20.5	30.2	60.3	69.3	118.0
EC-IDF	1980	4.8	9.2	12.9	16.0	16.5	24.4	60.1	92.0	108.3
EC-IDF	1981	4.2	6.0	7.4	12.9	20.2	37.8	72.8	85.2	87.2
EC-IDF	1982	5.0	7.1	8.2	9.9	13.8	24.8	45.4	67.6	89.8
EC-IDF	1983	4.7	9.4	14.1	20.8	29.4	44.5	67.6	73.8	75.4
EC-IDF	1984	2.5	4.8	7.2	14.4	19.4	25.7	48.4	78.6	99.6
EC-IDF	1985	4.6	6.2	9.4	17.2	27.0	44.4	74.1	86.6	86.8
EC-IDF	1986	10.7	11.7	15.7	19.4	19.7	20.7	22.5	32.0	44.2
EC-IDF	1987	3.1	4.7	6.1	10.0	14.3	18.4	34.9	42.3	48.3
EC-IDF	1988	2.9	5.7	5.7	6.7	9.9	15.1	31.9	45.2	45.2
EC-IDF	1989	6.5	10.6	13.5	23.5	32.4	51.4	59.3	61.0	61.4
EC-IDF	1990	4.7	7.6	9.8	13.9	17.8	22.0	34.0	51.0	83.4
EC-IDF	1991	3.9	3.9	4.8	7.3	10.9	17.9	23.0	33.1	42.4
EC-IDF	1993	4.1	6.2	8.9	11.6	18.5	19.3	37.6	63.1	71.7
EC-IDF	1995	5.0	9.4	11.0	14.1	20.1	31.1	53.1	62.7	70.0
EC-IDF	1996	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	106.0
UPDATE	1999	NM	NM	NM	NM	NM	NM	41.0	43.0	63.0
UPDATE	2000	NM	NM	NM	NM	NM	NM	36.0	45.0	59.0
UPDATE	2001	NM	NM	NM	NM	NM	NM	36.0	60.0	71.0
UPDATE	2002	NM	NM	NM	NM	NM	NM	34.0	66.0	71.0
UPDATE	2003	NM	NM	NM	NM	NM	NM	45.0	55.0	56.0
UPDATE	2004	NM	NM	NM	NM	NM	NM	57.0	72.0	75.5
UPDATE	2005	NM	NM	NM	NM	NM	NM	25.0	39.0	49.5
UPDATE	2006	NM	NM	NM	NM	NM	NM	36.0	41.0	42.0
UPDATE	2007	NM	NM	NM	NM	NM	NM	30.0	53.0	73.0
UPDATE	2008	NM	NM	NM	NM	NM	NM	44.0	48.0	51.0
UPDATE	2009	NM	NM	NM	NM	NM	NM	48.0	60.0	69.0
UPDATE	2010	NM	NM	NM	NM	NM	NM	36.0	47.0	54.0
UPDATE	2011	NM	NM	NM	NM	NM	NM	-99.9	-99.9	100.0
UPDATE	2012	NM	NM	NM	NM	NM	NM	52.0	60.0	65.0
UPDATE	2013	NM	NM	NM	NM	NM	NM	32.0	40.0	58.0
UPDATE	2014	NM	NM	NM	NM	NM	NM	36.0	50.0	75.0

# Yrs. Années	19	19	19	19	19	19	34	34	36
Mean Moyenne	4.6	7.1	9.2	13.5	18.5	27.7	43.8	56.8	70.4
Std. Dev. Écart-type	1.8	2.3	3.1	4.7	6.0	10.2	13.4	15.0	19.5
Skew. Dissymétrie	2.37	0.45	0.59	0.42	0.83	1.06	0.60	0.58	0.64
Kurtosis	10.95	2.75	2.99	3.08	3.80	3.68	3.00	3.08	3.11

*-99.9 Indicates Missing Data/Données manquantes
* NM Indicates No Measurements/Aucunes mesures

Warning: annual maximum amount greater than 100-yr return period amount
Avertissement : la quantité maximale annuelle excède la quantité pour une période de retour de 100 ans

Year/Année	Duration/Durée	Data/Données	100-yr/ans
1986	5 min	10.7	10.1

****

Table 2a: Return Period Rainfall Amounts (mm)
Quantité de pluie (mm) par période de retour

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
EC-IDF 5 min	4.3	5.9	6.9	8.2	9.2	10.1	19
EC-IDF 10 min	6.7	8.7	10.0	11.7	12.9	14.2	19
EC-IDF 15 min	8.7	11.4	13.3	15.5	17.3	18.9	19
EC-IDF 30 min	12.7	16.9	19.6	23.1	25.7	28.2	19
EC-IDF 1 h	17.5	22.8	26.4	30.8	34.2	37.4	19
EC-IDF 2 h	26.1	35.1	41.0	48.5	54.1	59.7	19
UPDATE 6 h	41.6	53.5	61.3	71.3	78.6	85.9	34
UPDATE 12 h	54.4	67.6	76.4	87.6	95.8	104.0	34
UPDATE 24 h	67.2	84.4	95.8	110.2	120.8	131.4	36

* 6-hr data were used for the update: shorter durations were not updated

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Table 2b:

Return Period Rainfall Rates (mm/h) - 95% Confidence limits
Intensité de la pluie (mm/h) par période de retour - Limites de confiance de 95%

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
EC-IDF 5 min	51.7	70.4	82.8	98.5	110.1	121.6	19
	+/- 8.7	+/- 14.7	+/- 19.9	+/- 26.8	+/- 32.1	+/- 37.4	19
EC-IDF 10 min	40.4	52.3	60.2	70.2	77.6	84.9	19
	+/- 5.6	+/- 9.4	+/- 12.7	+/- 17.1	+/- 20.5	+/- 23.8	19
EC-IDF 15 min	34.8	45.8	53.0	62.2	69.0	75.8	19
	+/- 5.1	+/- 8.6	+/- 11.7	+/- 15.7	+/- 18.8	+/- 21.9	19
EC-IDF 30 min	25.5	33.8	39.2	46.2	51.3	56.4	19
	+/- 3.9	+/- 6.5	+/- 8.8	+/- 11.9	+/- 14.2	+/- 16.5	19
EC-IDF 1 h	17.5	22.8	26.4	30.8	34.2	37.4	19
	+/- 2.5	+/- 4.2	+/- 5.7	+/- 7.6	+/- 9.1	+/- 10.7	19
EC-IDF 2 h	13.0	17.5	20.5	24.3	27.1	29.8	19
	+/- 2.1	+/- 3.5	+/- 4.8	+/- 6.4	+/- 7.7	+/- 9.0	19
UPDATE 6 h	6.9	8.9	10.2	11.9	13.1	14.3	34
	+/- 0.7	+/- 1.2	+/- 1.6	+/- 2.1	+/- 2.5	+/- 3.0	34
UPDATE 12 h	4.5	5.6	6.4	7.3	8.0	8.7	34
	+/- 0.4	+/- 0.7	+/- 0.9	+/- 1.2	+/- 1.4	+/- 1.7	34

```
*UPDATE* 24 h        2.8       3.5       4.0       4.6       5.0       5.5        36
                +/-  0.2 +/-  0.4 +/-  0.6 +/-  0.7 +/-  0.9 +/-  1.0        36
     * 6-hr data were used for the update: shorter durations were not updated

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Table 3: Interpolation Equation / Équation d'interpolation: R = A*T^B

R = Interpolated Rainfall rate (mm/h)/Intensité interpolée de la pluie (mm/h)
RR = Rainfall rate (mm/h) / Intensité de la pluie (mm/h)
 T = Rainfall duration (h) / Durée de la pluie (h)

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Statistics/Statistiques	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans
Mean of RR/Moyenne de RR	21.9	29.0	33.6	39.5	43.9	48.3
Std. Dev. /Écart-type (RR)	17.3	23.3	27.2	32.2	35.9	39.6
Std. Error/Erreur-type	3.2	4.1	4.8	5.6	6.3	7.0
Coefficient (A)	16.6	21.6	25.0	29.2	32.3	35.4
Exponent/Exposant (B)	-0.515	-0.526	-0.531	-0.536	-0.539	-0.541
Mean % Error/% erreur moyenne	7.4	8.2	8.6	8.9	9.1	9.3

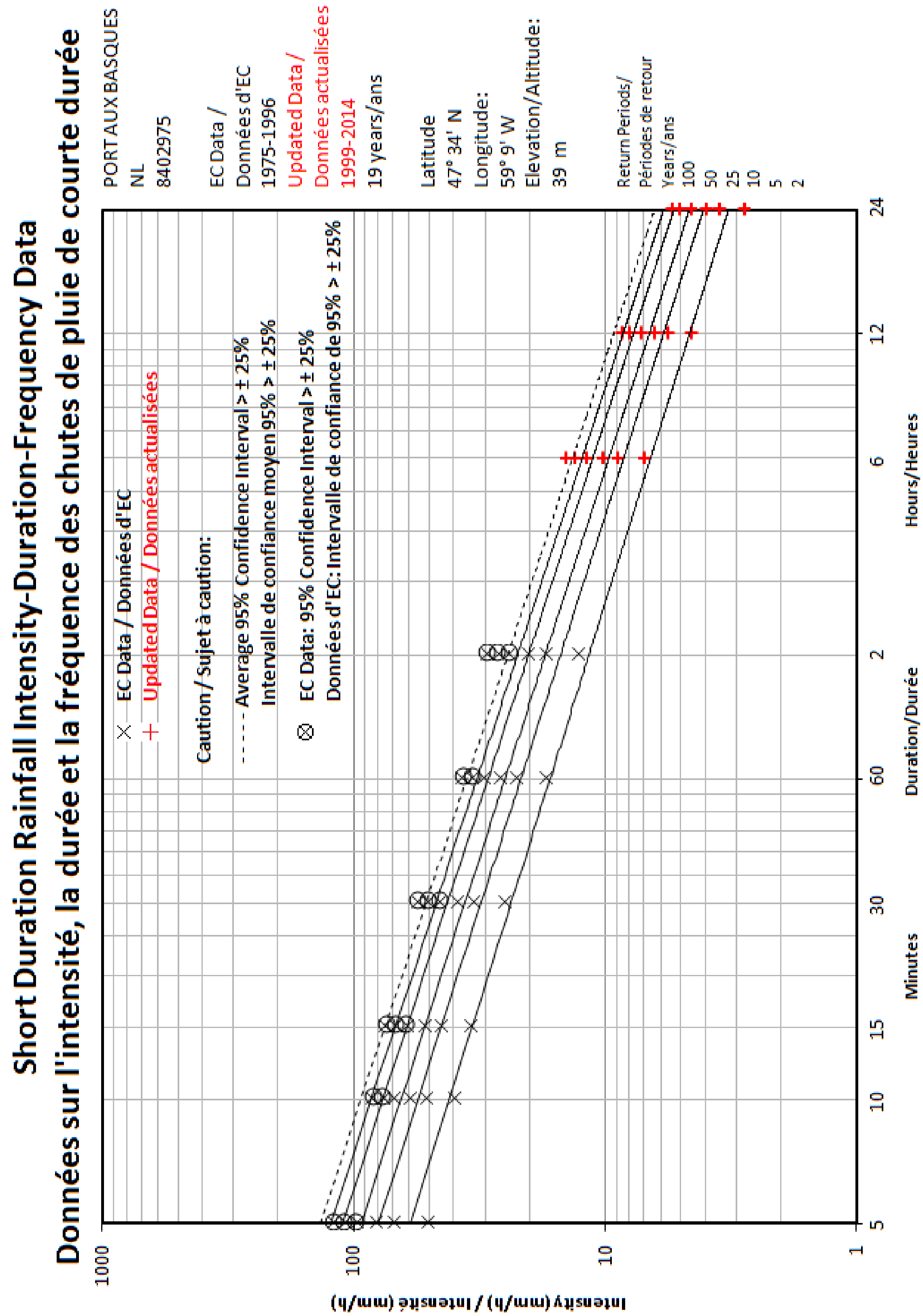

Figure 9.1 Port Aux Basques IDF Curve – Updated

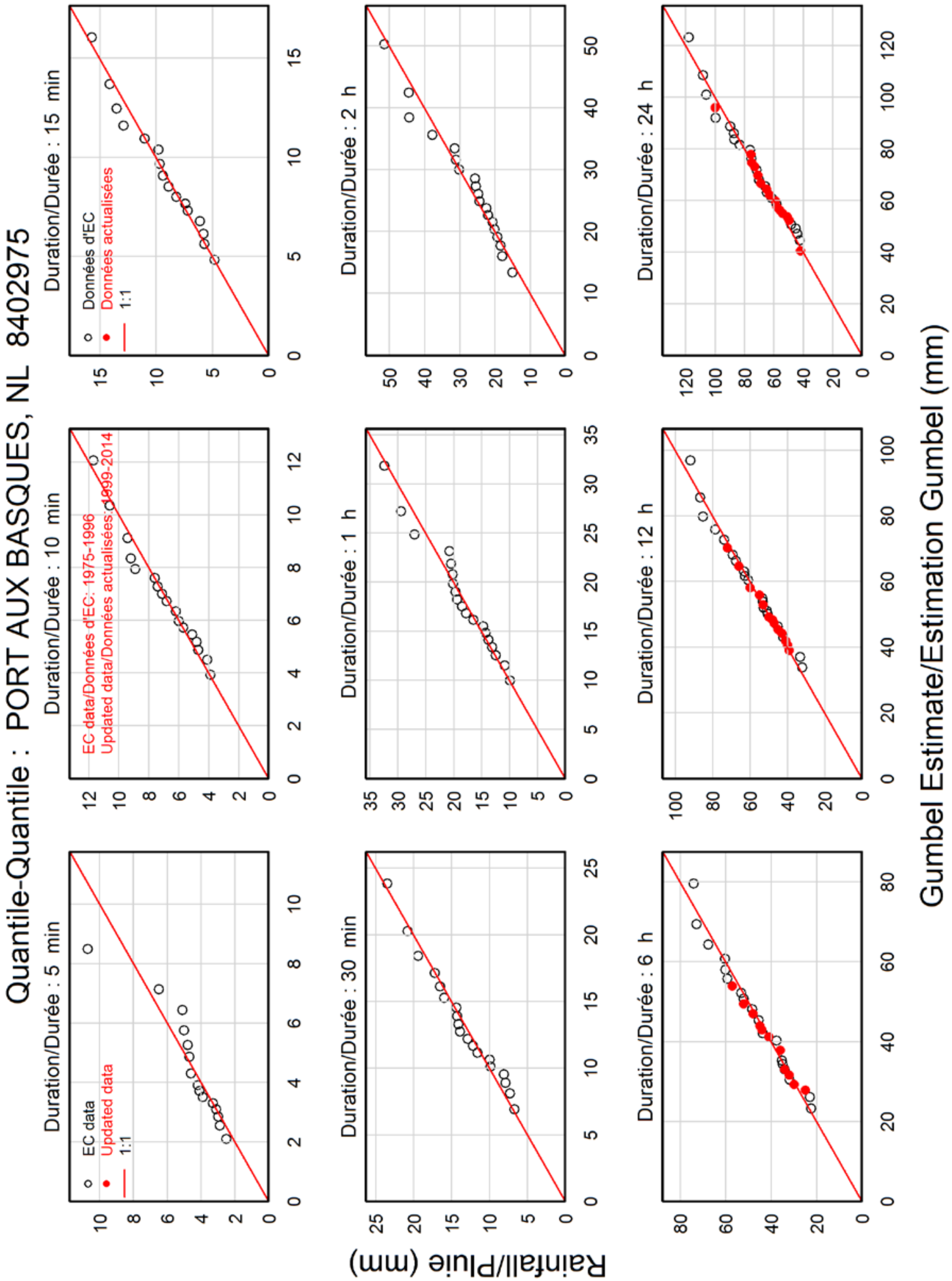

Figure 9.2 Port Aux Basques Quantile-Quantile Plot – Updated

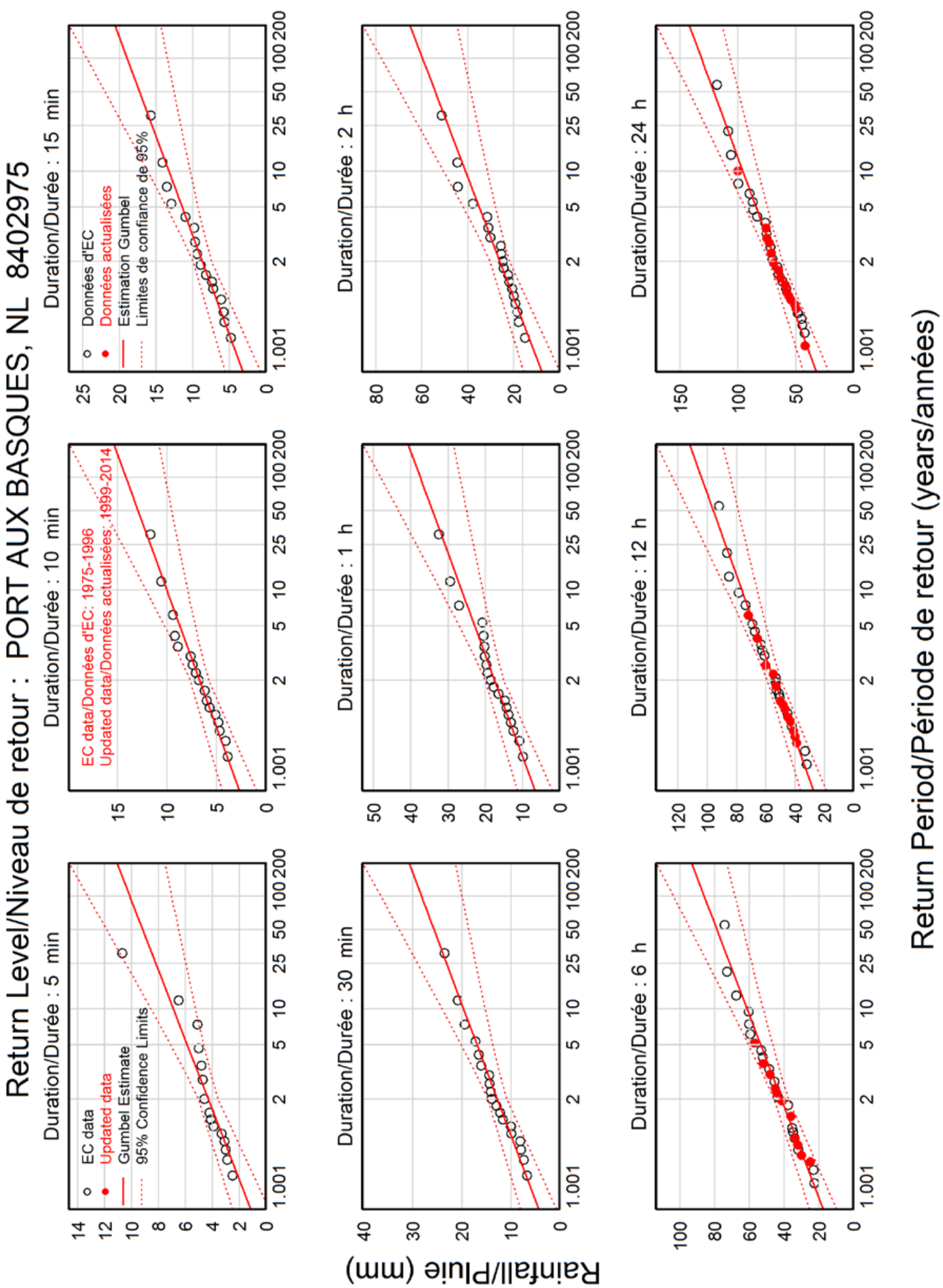

Figure 9.3 **Port Aux Basques Return Level Plot – Updated**

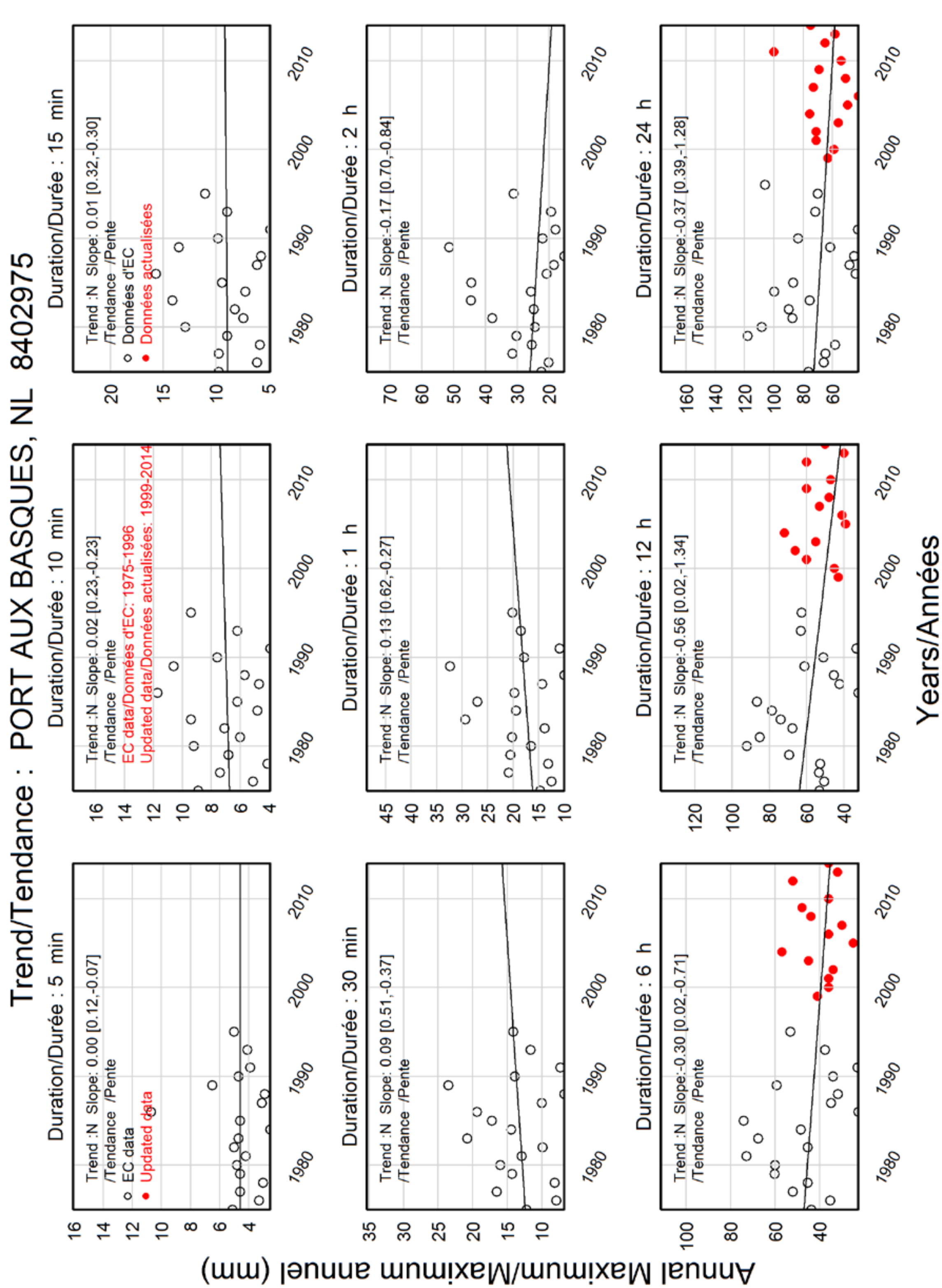

Figure 9.4 Port Aux Basques Trend Plot – Updated

Section 10.0 St. Albans

The IDF curve for St. Albans station was updated using 1-hr tipping bucket data at Long Pond Intake. The 6-, 12-, and 24-hr durations were updated

Table 10.1 presents the changes between the updated IDF curve and the EC-IDF V2.3 curve.

Table 10.1 Differences Between IDF Curves for St. Albans

Percent Difference in Precipitation Amount [%] (Difference in Precipitation Amount [mm])						
	Return Period [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	N/A	N/A	N/A	N/A	N/A	N/A
10-min	N/A	N/A	N/A	N/A	N/A	N/A
15-min	N/A	N/A	N/A	N/A	N/A	N/A
30-min	N/A	N/A	N/A	N/A	N/A	N/A
1-hr	N/A	N/A	N/A	N/A	N/A	N/A
2-hr	N/A	N/A	N/A	N/A	N/A	N/A
6-hr	-0.9 (-0.4)	-1.2 (-0.6)	-1.3 (-0.8)	-1.5 (-0.9)	-1.6 (-1.1)	-1.7 (-1.2)
12-hr	-2.0 (-1.3)	-2.8 (-2.2)	-3.1 (-2.7)	-3.5 (-3.4)	-3.7 (-4.0)	-3.9 (-4.5)
24-hr	-3.4 (-2.9)	-4.3 (-4.8)	-4.7 (-6.0)	**-5.1 (-7.6)**	**-5.3 (-8.8)**	**-5.4 (-9.9)**

Notes:
Red numbers indicate that the updated IDF curve is lower than the EC-IDF V2.3 IDF curve for that duration and return period.
Bold numbers indicate changes greater than 5 percent.

Where there are decreases greater than 5 percent, users should exercise caution when using the updated IDF curve, or use the EC IDF curve.

The updated IDF curves for St. Albans are included below.

Office of Climate Change and Energy Efficiency

Short Duration Rainfall Intensity-Duration-Frequency Data
Données sur l'intensité, la durée et la fréquence des chutes de pluie de courte durée

Gumbel - Method of moments/Méthode des moments

2015/03/20

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ST ALBANS NL 8403290
Updated with 1-hr data measured at Long Pond Intake (Hydro): 2009-2014

Latitude: 47 52'N Longitude: 55 51'W Elevation/Altitude: 13 m
Years/Années : 1969 - 2014 # Years/Années : 14

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Table 1: Annual Maximum (mm)/Maximum annuel (mm)

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	Year Année	5 min	10 min	15 min	30 min	1 h	2 h	6 h	12 h	24 h
EC-IDF	1969	4.6	7.6	11.4	18.0	21.1	33.3	56.1	63.8	72.1
EC-IDF	1970	3.8	4.8	6.3	9.9	14.7	26.2	42.7	54.4	65.8
EC-IDF	1971	5.6	6.9	7.6	10.7	13.7	24.6	60.5	93.0	93.7
EC-IDF	1972	4.1	6.9	8.6	15.0	21.3	29.2	46.7	65.8	67.6
EC-IDF	1973	7.4	9.4	12.2	16.3	26.7	35.8	54.4	85.1	141.0
EC-IDF	1974	3.6	5.8	7.6	10.9	15.7	25.9	44.2	45.2	46.5
EC-IDF	1975	5.1	8.9	9.7	12.2	14.7	22.4	43.7	53.1	76.2
EC-IDF	1976	4.3	7.9	8.6	11.2	17.3	30.2	43.9	64.5	117.9
EC-IDF	1978	6.9	11.0	14.9	17.0	22.4	25.4	53.0	81.2	89.6
EC-IDF	1979	4.8	7.1	8.5	14.4	18.9	26.9	38.7	51.7	71.2
EC-IDF	1980	4.0	6.2	7.5	12.5	16.5	25.4	54.6	76.3	82.0
EC-IDF	1981	6.5	9.2	10.5	12.1	19.4	28.4	48.5	77.9	105.4
EC-IDF	1982	4.7	6.5	8.8	11.8	13.9	20.6	41.7	49.8	59.2
EC-IDF	1983	1.6	3.2	4.6	9.0	14.5	24.4	53.4	83.8	147.6
UPDATE	2009	NM	NM	NM	NM	NM	NM	39.3	48.0	59.4
UPDATE	2010	NM	NM	NM	NM	NM	NM	51.1	61.5	78.5
UPDATE	2013	NM	NM	NM	NM	NM	NM	44.4	73.3	95.7
UPDATE	2014	NM	NM	NM	NM	NM	NM	51.9	60.8	61.7
	# Yrs. Années	14	14	14	14	14	14	18	18	18
	Mean Moyenne	4.8	7.2	9.1	12.9	17.9	27.0	48.3	66.1	85.1
	Std. Dev. Écart-type	1.5	2.0	2.6	2.8	3.9	4.1	6.3	14.4	27.9
	Skew. Dissymétrie	-0.08	-0.11	0.66	0.56	0.90	0.72	0.20	0.27	1.04
	Kurtosis	4.22	3.91	4.51	2.86	3.81	4.07	2.47	2.40	3.93

*-99.9 Indicates Missing Data/Données manquantes
* NM Indicates No Measurements/Aucunes mesures

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Table 2a: Return Period Rainfall Amounts (mm)
Quantité de pluie (mm) par période de retour

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
EC-IDF 5 min	4.5	5.9	6.7	7.8	8.7	9.5	14
EC-IDF 10 min	6.9	8.7	9.9	11.3	12.4	13.5	14
EC-IDF 15 min	8.6	10.9	12.4	14.3	15.8	17.2	14
EC-IDF 30 min	12.5	14.9	16.5	18.6	20.1	21.6	14
EC-IDF 1 h	17.3	20.7	23.0	25.8	28.0	30.1	14
EC-IDF 2 h	26.4	30.0	32.4	35.4	37.6	39.8	14
UPDATE 6 h	47.2	52.8	56.5	61.2	64.6	68.1	18
UPDATE 12 h	63.7	76.4	84.8	95.5	103.4	111.2	18
UPDATE 24 h	80.5	105.2	121.5	142.2	157.5	172.7	18

* 6-hr data were used for the update: shorter durations were not updated

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Table 2b:

Return Period Rainfall Rates (mm/h) - 95% Confidence limits
Intensité de la pluie (mm/h) par période de retour - Limites de confiance de 95%

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
EC-IDF 5 min	54.5	70.3	80.8	94.0	103.8	113.5	14
	+/- 8.6	+/- 14.5	+/- 19.6	+/- 26.4	+/- 31.6	+/- 36.8	14
EC-IDF 10 min	41.5	52.1	59.1	68.0	74.6	81.2	14
	+/- 5.8	+/- 9.7	+/- 13.1	+/- 17.7	+/- 21.2	+/- 24.7	14
EC-IDF 15 min	34.5	43.7	49.7	57.4	63.0	68.7	14
	+/- 5.0	+/- 8.4	+/- 11.3	+/- 15.3	+/- 18.3	+/- 21.3	14
EC-IDF 30 min	24.9	29.8	33.1	37.2	40.2	43.2	14
	+/- 2.7	+/- 4.5	+/- 6.1	+/- 8.2	+/- 9.8	+/- 11.4	14
EC-IDF 1 h	17.3	20.7	23.0	25.8	28.0	30.1	14
	+/- 1.9	+/- 3.1	+/- 4.2	+/- 5.7	+/- 6.8	+/- 8.0	14
EC-IDF 2 h	13.2	15.0	16.2	17.7	18.8	19.9	14
	+/- 1.0	+/- 1.6	+/- 2.2	+/- 3.0	+/- 3.6	+/- 4.2	14
UPDATE 6 h	7.9	8.8	9.4	10.2	10.8	11.3	18
	+/- 0.4	+/- 0.8	+/- 1.0	+/- 1.4	+/- 1.6	+/- 1.9	18
UPDATE 12 h	5.3	6.4	7.1	8.0	8.6	9.3	18
	+/- 0.5	+/- 0.9	+/- 1.2	+/- 1.6	+/- 1.9	+/- 2.2	18
UPDATE 24 h	3.4	4.4	5.1	5.9	6.6	7.2	18
	+/- 0.5	+/- 0.8	+/- 1.1	+/- 1.5	+/- 1.8	+/- 2.1	18

* 6-hr data were used for the update: shorter durations were not updated

****

Table 3: Interpolation Equation / Équation d'interpolation: R = A*T^B

R = Interpolated Rainfall rate (mm/h)/Intensité interpolée de la pluie (mm/h)
RR = Rainfall rate (mm/h) / Intensité de la pluie (mm/h)
T = Rainfall duration (h) / Durée de la pluie (h)

****

Statistics/Statistiques	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans
Mean of RR/Moyenne de RR	22.5	27.9	31.5	36.0	39.4	42.7
Std. Dev. /Écart-type (RR)	17.8	23.0	26.5	30.9	34.2	37.4
Std. Error/Erreur-type	1.4	1.0	1.2	1.7	2.3	2.8
Coefficient (A)	17.4	21.2	23.7	26.9	29.2	31.5
Exponent/Exposant (B)	-0.485	-0.493	-0.497	-0.501	-0.504	-0.506
Mean % Error/% erreur moyenne	4.1	1.6	2.9	4.6	5.8	6.8

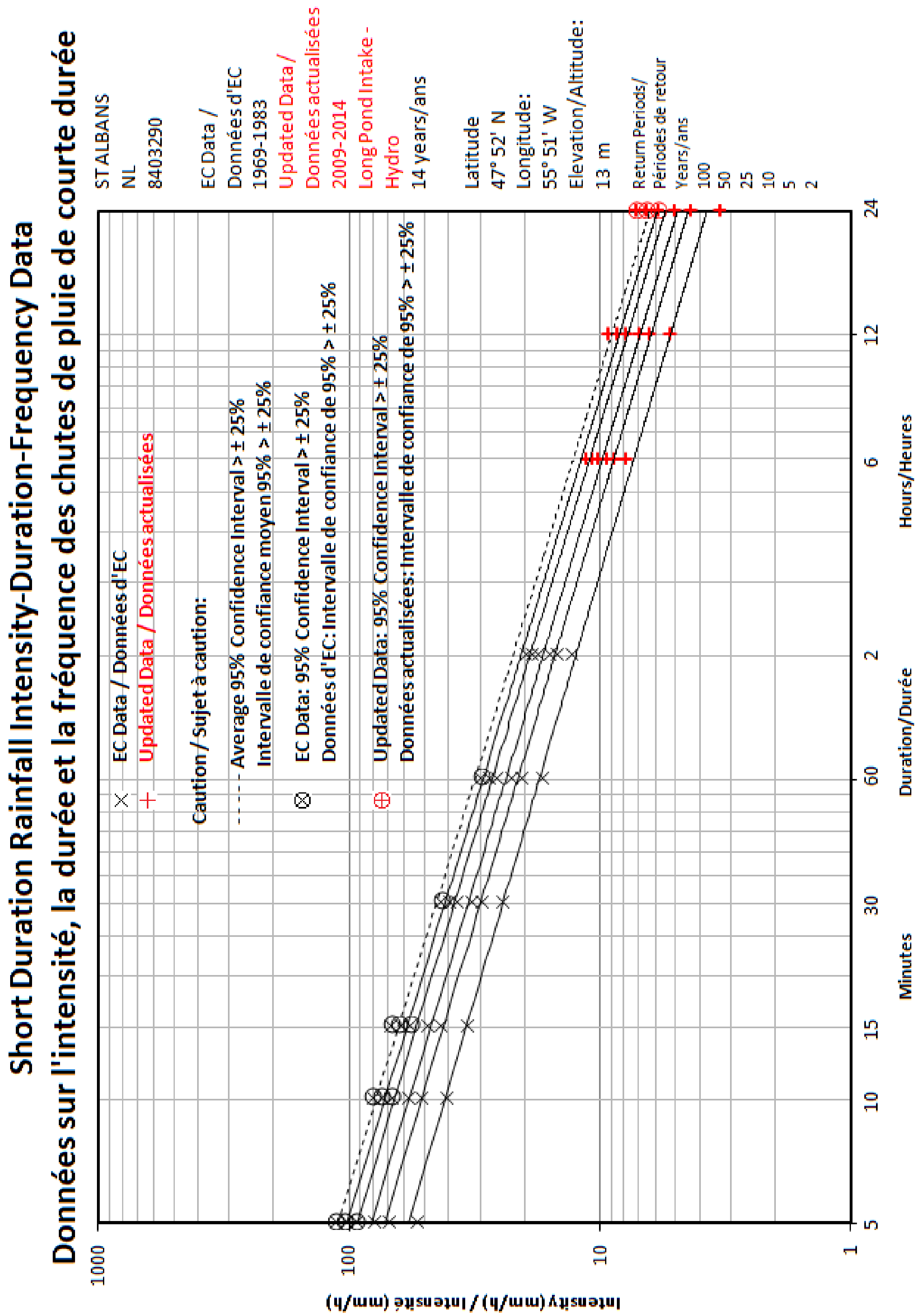

Figure 10.1 St Albans IDF Curve – Updated

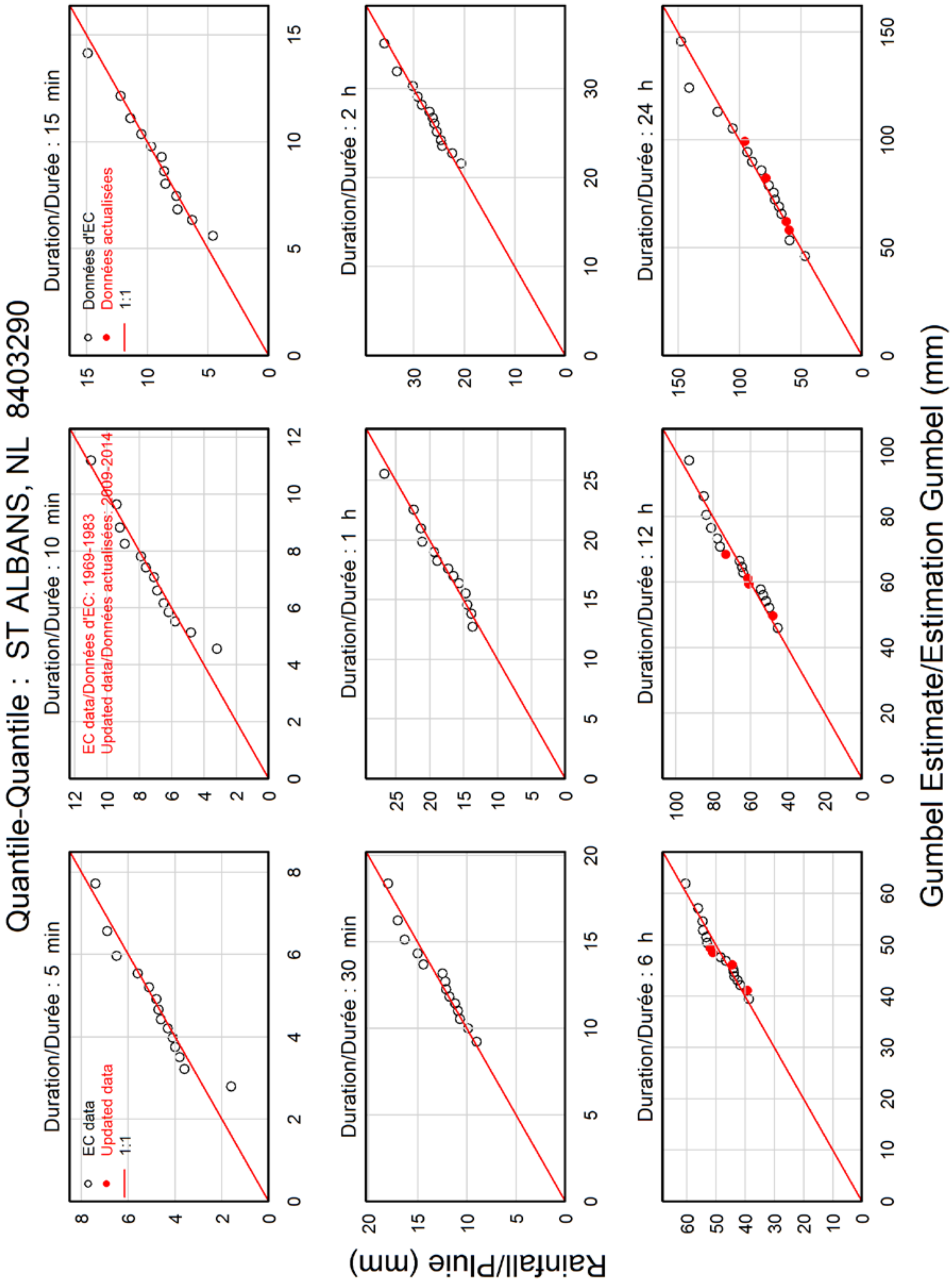

Figure 10.2 St Albans Quantile-Quantile Plot – Updated

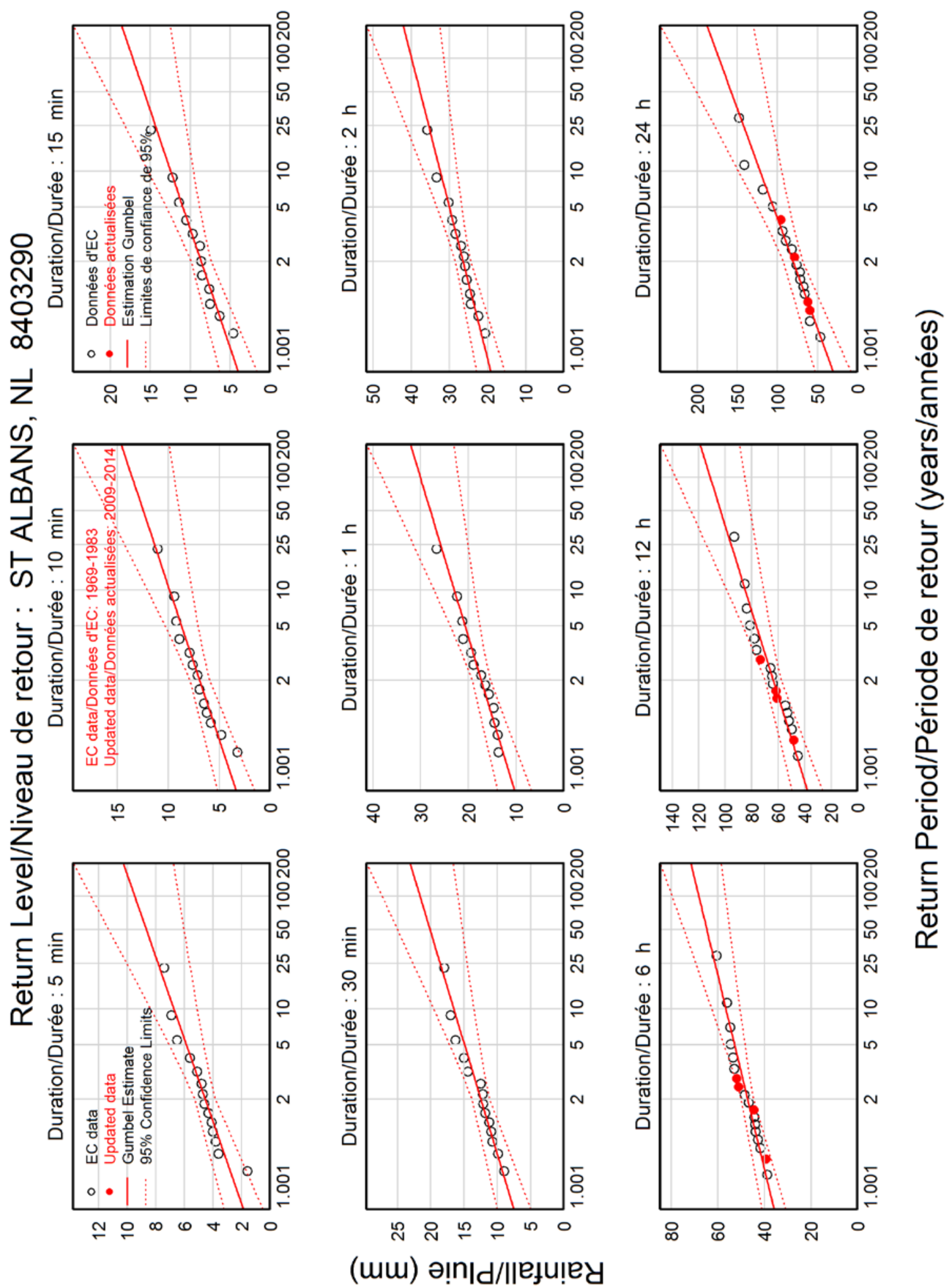

Figure 10.3 St Albans Return Level Plot – Updated

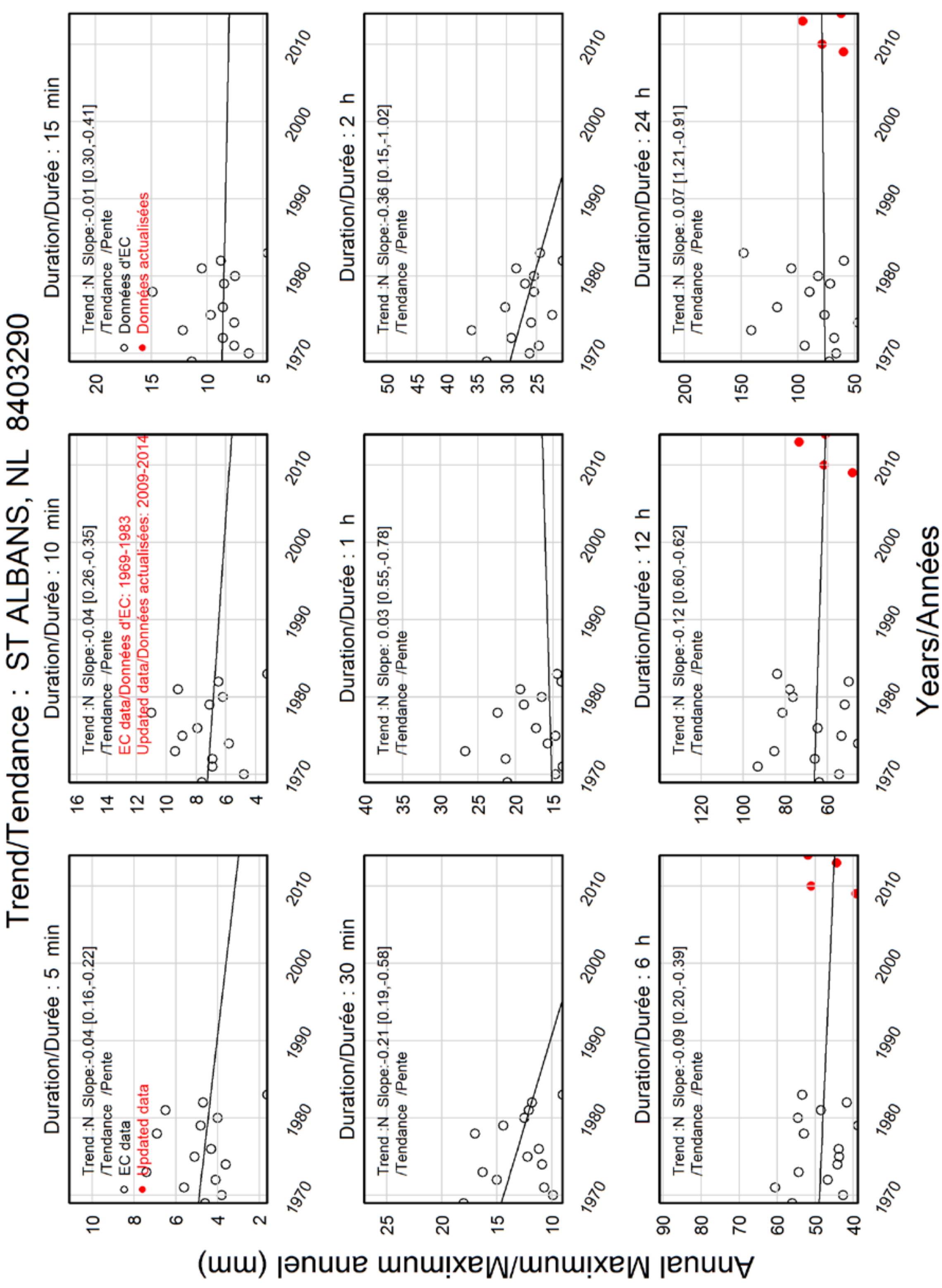

Figure 10.4 St Albans Trend Plot – Updated

Section 11.0 St. Anthony

The IDF curve for St. Anthony station was updated by creating a new IDF curve at St. Anthony (8403399). There were insufficient data to create a full IDF curve at St. Anthony (8403399). For short durations (5, 10-, 15-, and 30-min) users must consult the original St. Anthony curve. For long durations, the St. Anthony (8403399) curve may be used.

Table 11.1 presents the changes between the St. Anthony IDF curve and the updated St. Anthony (8403399) curve.

Table 11.1 Differences Between IDF Curves for St. Anthony (8403399) and St. Anthony

Percent Difference in Precipitation Amount [%] (Difference in Precipitation Amount [mm])						
	Return Period [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	N/A	N/A	N/A	N/A	N/A	N/A
10-min	N/A	N/A	N/A	N/A	N/A	N/A
15-min	N/A	N/A	N/A	N/A	N/A	N/A
30-min	N/A	N/A	N/A	N/A	N/A	N/A
1-hr	**49.4 (6.2)**	**67.0 (10.4)**	**75.4 (13.2)**	**83.6 (16.8)**	**88.5 (19.4)**	**92.5 (22.0)**
2-hr	**22.0 (4.0)**	**29.2 (6.3)**	**32.8 (7.9)**	**36.4 (9.9)**	**38.5 (11.4)**	**40.4 (12.8)**
6-hr	**7.2 (2.2)**	**12.1 (4.4)**	**14.6 (5.9)**	**17.1 (7.8)**	**18.7 (9.2)**	**20.0 (10.6)**
12-hr	**7.0 (2.8)**	3.4 (1.6)	1.5 (0.8)	-0.3 (-0.2)	-1.4 (-0.9)	-2.4 (-1.7)
24-hr	-3.1 (-1.6)	**-7.3 (-4.6)**	**-9.3 (-6.6)**	**-11.2 (-9.2)**	**-12.4 (-11.1)**	**-13.4 (-12.9)**

Notes:
Red numbers indicate that the updated IDF curve is lower than the EC-IDF V2.3 IDF curve for that duration and return period.
Bold numbers indicate changes greater than 5 percent.

Where there are decreases greater than 5 percent, users should exercise caution when using the updated IDF curve, or use the EC IDF curve.

Section 11.1 presents the IDF curves for St. Anthony (EC-IDF V2.3). Section 11.2 presents the IDF curves for St. Anthony (8403399).

11.1 St. Anthony (8403401)

Environment Canada/Environnement Canada

Short Duration Rainfall Intensity-Duration-Frequency Data
Données sur l'intensité, la durée et la fréquence des chutes de pluie de courte durée

Gumbel - Method of moments/Méthode des moments

2014/12/21

ST ANTHONY NL 8403401

Latitude: 51 22'N Longitude: 55 36'W Elevation/Altitude: 11 m

Years/Années : 1971 - 1995 # Years/Années : 23

Table 1: Annual Maximum (mm)/Maximum annuel (mm)

Year Année	5 min	10 min	15 min	30 min	1 h	2 h	6 h	12 h	24 h
1971	8.4	13.7	16.3	18.3	18.8	22.4	35.3	47.8	52.6
1972	2.3	4.1	6.1	7.1	9.9	18.5	34.8	47.2	54.6
1973	3.6	5.3	6.6	8.6	11.7	12.4	28.2	41.1	59.2
1974	2.5	3.3	4.3	6.9	10.2	17.3	39.6	49.3	49.8
1975	3.8	4.8	6.1	10.9	16.3	23.1	33.5	40.1	43.4
1976	2.8	5.6	7.4	10.4	12.2	19.6	27.4	29.7	35.1
1978	2.0	3.9	5.7	8.8	14.3	18.4	25.4	33.3	51.6
1979	2.7	4.1	5.4	8.4	13.5	21.0	30.1	47.0	71.3
1980	4.7	6.6	8.8	14.1	19.1	24.3	34.9	37.2	37.9
1981	8.1	13.1	15.1	16.5	16.7	20.1	45.9	59.1	74.6
1982	4.3	4.9	7.4	9.5	13.0	18.5	27.4	34.2	37.1
1983	6.8	10.8	13.2	14.2	16.8	30.2	43.6	58.6	67.8
1984	4.4	5.9	8.9	10.0	15.9	17.5	26.5	33.2	39.8
1985	2.4	3.8	5.8	8.4	11.2	14.8	31.0	51.1	80.7
1986	2.1	3.1	4.5	8.9	11.5	14.9	21.2	25.2	32.4
1987	2.4	3.8	4.7	6.0	8.8	12.9	26.1	31.3	43.2
1988	1.7	2.9	4.2	7.3	10.4	18.4	35.0	49.4	50.2
1989	2.3	3.9	4.6	7.9	10.7	15.7	28.7	34.2	48.6
1990	7.8	11.2	12.3	14.6	18.2	23.2	44.8	46.0	55.6
1991	2.9	4.3	5.3	8.2	9.6	15.0	23.2	40.5	44.1
1993	2.7	3.3	4.0	7.1	10.2	16.2	30.4	40.5	53.9
1994	3.2	5.4	5.6	6.5	7.8	13.6	26.6	39.4	68.4
1995	2.2	3.4	5.0	8.2	15.0	20.2	32.1	45.2	74.2
# Yrs. Années	23	23	23	23	23	23	23	23	23
Mean Moyenne	3.7	5.7	7.3	9.9	13.1	18.6	31.8	41.8	53.3
Std. Dev. Écart-type	2.1	3.2	3.6	3.4	3.4	4.2	6.7	8.9	13.9
Skew. Dissymétrie	1.37	1.62	1.49	1.24	0.36	0.84	0.72	0.19	0.44
Kurtosis	3.94	4.69	4.46	3.91	2.25	4.41	3.22	2.91	2.56

*-99.9 Indicates Missing Data/Données manquantes

****

Table 2a: Return Period Rainfall Amounts (mm)
Quantité de pluie (mm) par période de retour

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
5 min	3.4	5.2	6.4	8.0	9.1	10.2	23
10 min	5.2	8.0	9.9	12.3	14.1	15.8	23
15 min	6.7	9.8	11.9	14.6	16.6	18.5	23
30 min	9.3	12.3	14.3	16.8	18.6	20.4	23
1 h	12.6	15.6	17.5	20.0	21.9	23.7	23
2 h	17.9	21.6	24.1	27.2	29.5	31.8	23
6 h	30.7	36.6	40.6	45.5	49.2	52.9	23
12 h	40.3	48.1	53.3	59.9	64.8	69.6	23
24 h	51.0	63.3	71.4	81.6	89.2	96.8	23

****

Table 2b:

Return Period Rainfall Rates (mm/h) - 95% Confidence limits
Intensité de la pluie (mm/h) par période de retour - Limites de confiance de 95%

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
5 min	40.9	62.8	77.3	95.6	109.2	122.7	23
	+/- 9.3	+/- 15.7	+/- 21.1	+/- 28.5	+/- 34.1	+/- 39.7	23
10 min	31.0	48.2	59.5	73.9	84.5	95.0	23
	+/- 7.3	+/- 12.3	+/- 16.5	+/- 22.3	+/- 26.7	+/- 31.1	23
15 min	26.7	39.4	47.8	58.4	66.2	74.0	23
	+/- 5.4	+/- 9.0	+/- 12.2	+/- 16.5	+/- 19.7	+/- 23.0	23
30 min	18.6	24.6	28.5	33.5	37.2	40.9	23
	+/- 2.5	+/- 4.3	+/- 5.8	+/- 7.8	+/- 9.3	+/- 10.8	23
1 h	12.6	15.6	17.5	20.0	21.9	23.7	23
	+/- 1.3	+/- 2.1	+/- 2.9	+/- 3.9	+/- 4.7	+/- 5.4	23
2 h	9.0	10.8	12.1	13.6	14.8	15.9	23
	+/- 0.8	+/- 1.3	+/- 1.8	+/- 2.4	+/- 2.9	+/- 3.4	23
6 h	5.1	6.1	6.8	7.6	8.2	8.8	23
	+/- 0.4	+/- 0.7	+/- 1.0	+/- 1.3	+/- 1.5	+/- 1.8	23
12 h	3.4	4.0	4.4	5.0	5.4	5.8	23
	+/- 0.3	+/- 0.5	+/- 0.6	+/- 0.9	+/- 1.0	+/- 1.2	23
24 h	2.1	2.6	3.0	3.4	3.7	4.0	23
	+/- 0.2	+/- 0.4	+/- 0.5	+/- 0.7	+/- 0.8	+/- 0.9	23

****

Table 3: Interpolation Equation / Équation d'interpolation: R = A*T^B

R = Interpolated Rainfall rate (mm/h)/Intensité interpolée de la pluie (mm/h)
RR = Rainfall rate (mm/h) / Intensité de la pluie (mm/h)
T = Rainfall duration (h) / Durée de la pluie (h)

****

Statistics/Statistiques	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans
Mean of RR/Moyenne de RR	16.6	23.8	28.5	34.5	39.0	43.4
Std. Dev. /Écart-type (RR)	13.7	21.6	26.9	33.6	38.6	43.6
Std. Error/Erreur-type	1.8	2.5	3.3	4.4	5.3	6.2

Coefficient (A)	12.3	16.5	19.1	22.4	24.9	27.3
Exponent/Exposant (B)	-0.523	-0.571	-0.591	-0.610	-0.620	-0.629
Mean % Error/% erreur moyenne	4.8	3.9	4.9	6.2	6.9	7.6

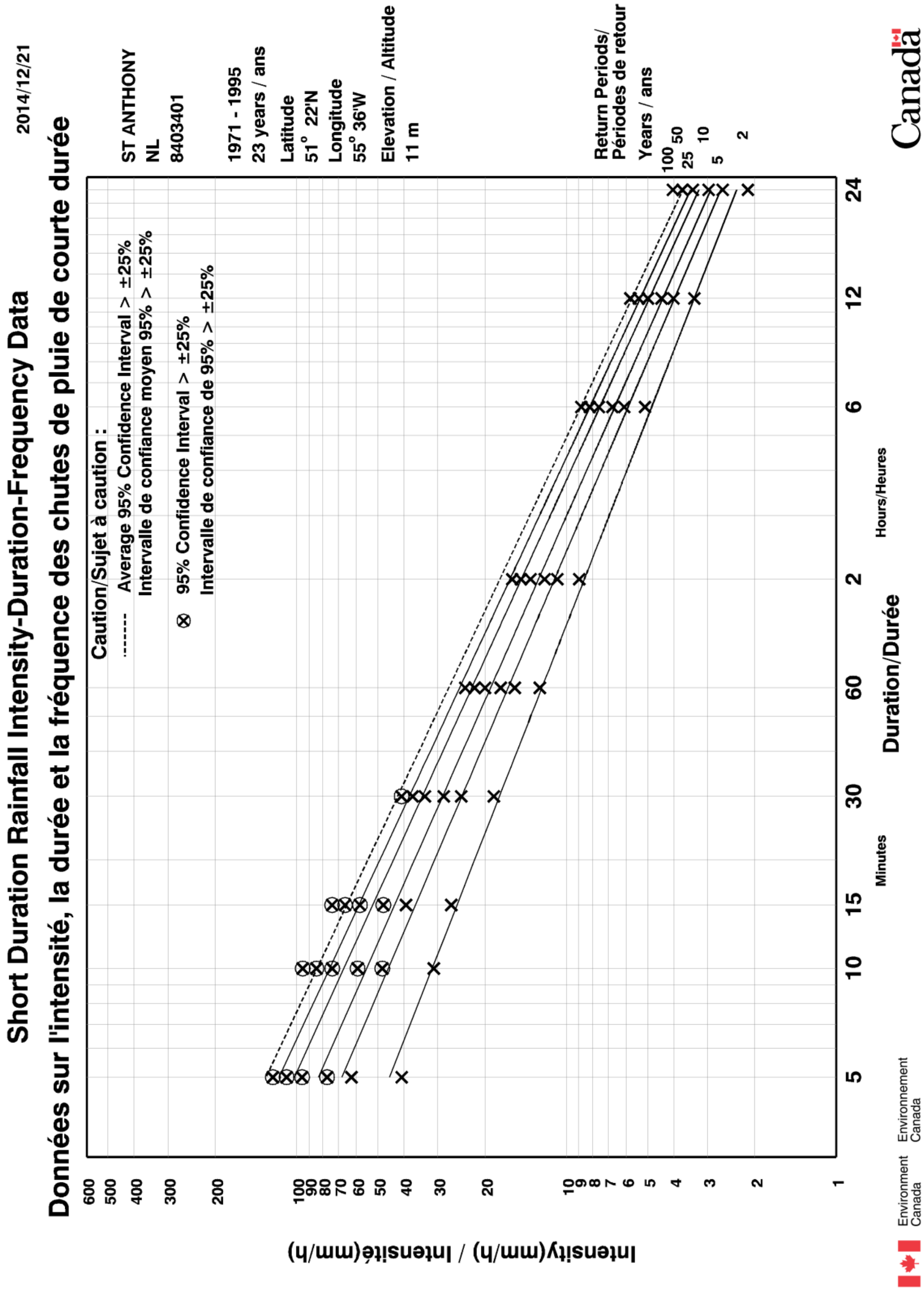

Figure 11.1 St Anthony IDF Curve – EC-IDF V2.3

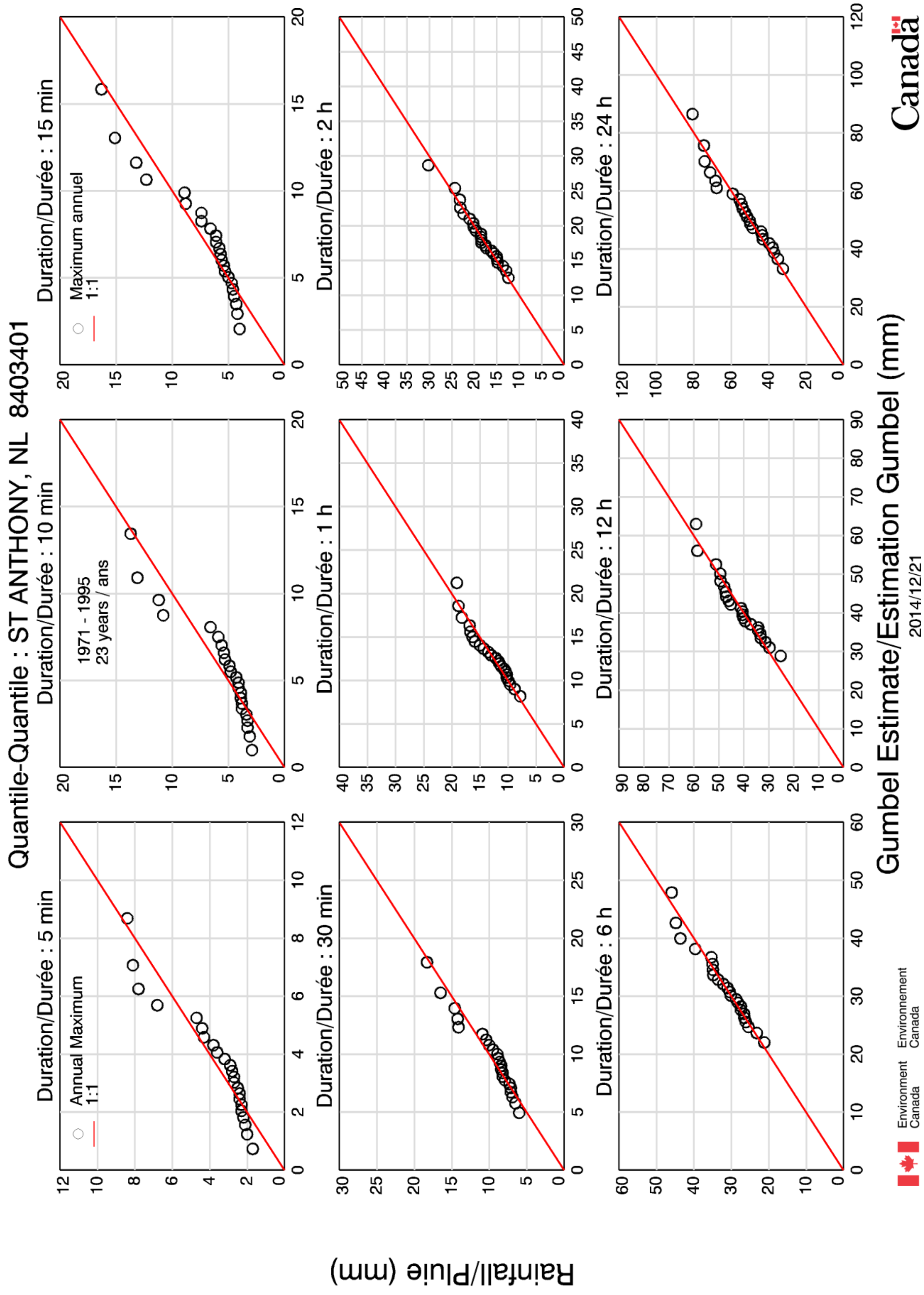

Figure 11.2 St Anthony Quantile-Quantile Plot – EC-IDF V2.3

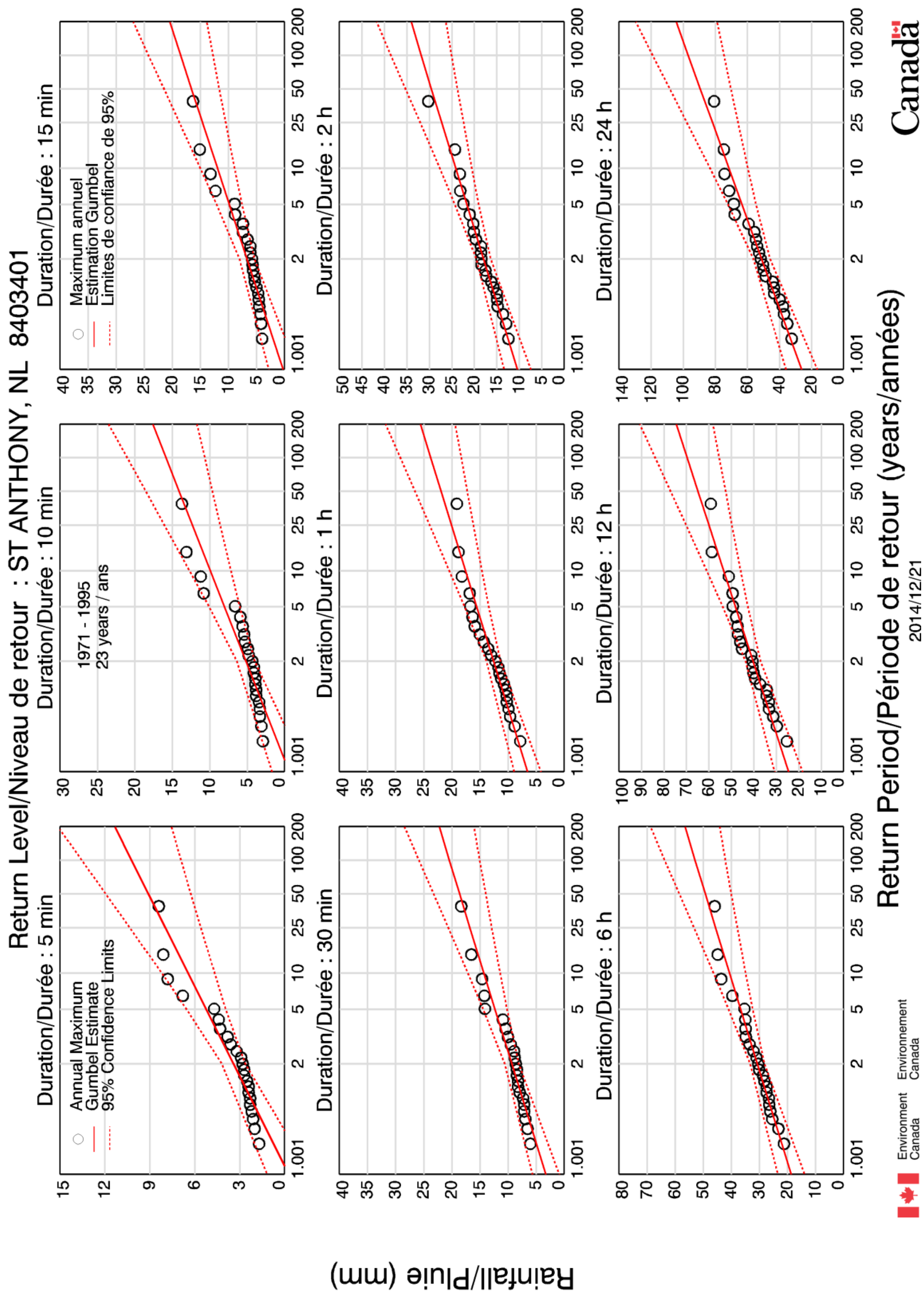

Figure 11.3 St Anthony Return Level Plot – EC-IDF V2.3

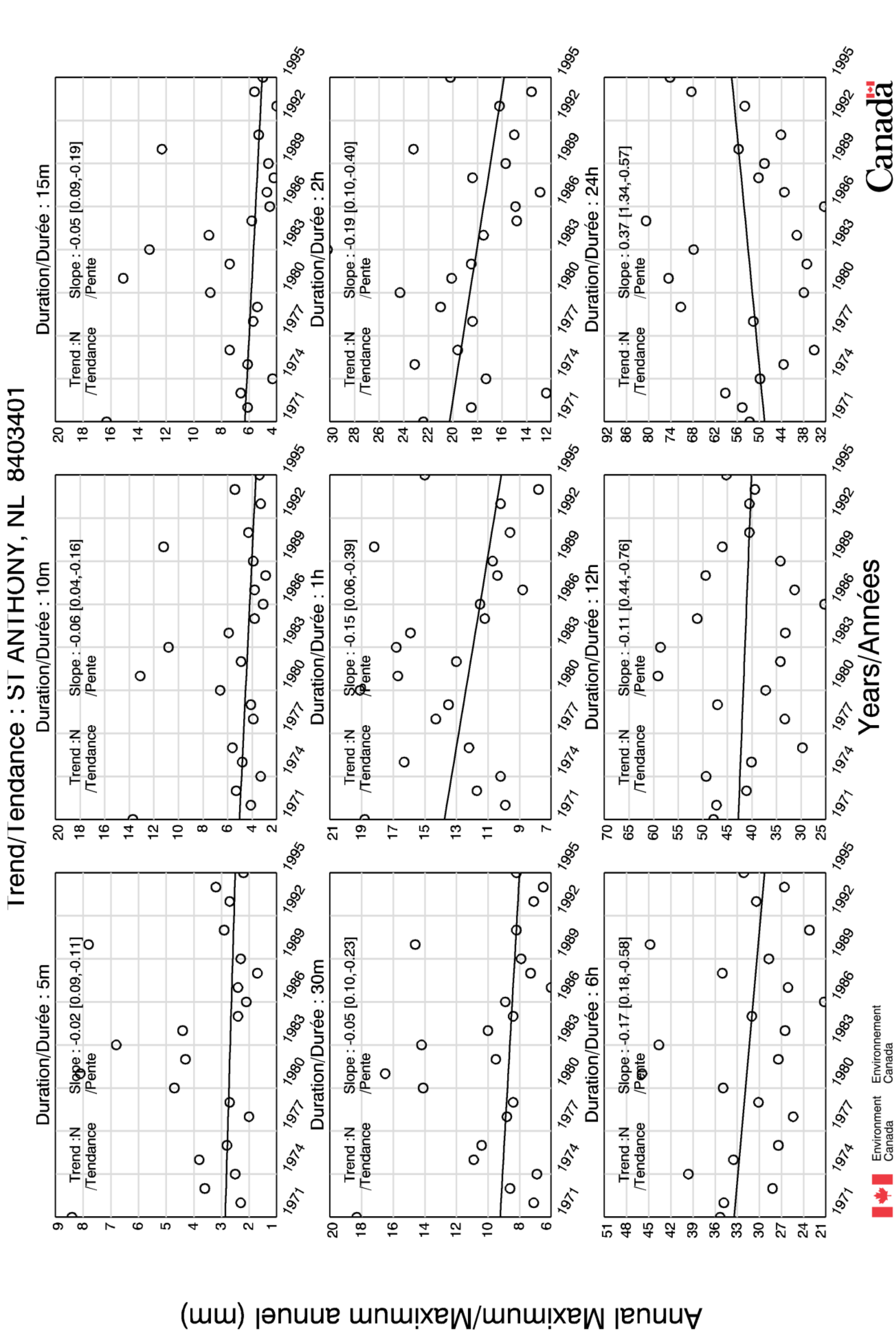

Figure 11.4 St Anthony Trend Plot – EC-IDF V2.3

11.2 St. Anthony (8403399)

Office of Climate Change and Energy Efficiency

Short Duration Rainfall Intensity-Duration-Frequency Data
Données sur l'intensité, la durée et la fréquence des chutes de pluie de courte durée

Gumbel - Method of moments/Méthode des moments

2015/03/20

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ST ANTHONY NL 8403399
Generated with 6-hr and 1-hr data measured at St. Anthony (8403399): 2000-2014

Latitude: 51 23'N Longitude: 56 6'W Elevation/Altitude: 29.3 m
Years/Années : 2000 - 2014 # Years/Années : 10

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****

Table 1: Annual Maximum (mm)/Maximum annuel (mm)

****

	Year Année	5 min	10 min	15 min	30 min	1 h	2 h	6 h	12 h	24 h
UPDATE	2000	NM	NM	NM	NM	NM	NM	39.0	43.0	45.0
UPDATE	2002	NM	NM	NM	NM	NM	NM	43.0	59.0	74.0
UPDATE	2003	NM	NM	NM	NM	NM	NM	35.0	51.0	62.0
UPDATE	2004	NM	NM	NM	NM	24.0	25.8	58.7	58.7	58.7
UPDATE	2005	NM	NM	NM	NM	16.4	20.5	29.7	43.6	47.1
UPDATE	2006	NM	NM	NM	NM	16.6	19.8	26.8	34.0	41.6
UPDATE	2007	NM	NM	NM	NM	19.3	19.3	28.4	41.1	41.9
UPDATE	2008	NM	NM	NM	NM	39.9	39.9	39.9	39.9	43.4
UPDATE	2009	NM	NM	NM	NM	17.7	20.9	24.0	44.0	46.9
UPDATE	2010	NM	NM	NM	NM	23.2	24.3	30.9	38.6	41.3
UPDATE	2011	NM	NM	NM	NM	21.1	25.9	31.7	41.6	64.7
UPDATE	2013	NM	NM	NM	NM	11.5	14.2	26.2	38.9	51.4
UPDATE	2014	NM	NM	NM	NM	11.4	19.5	34.4	43.4	46.8
	# Yrs. Années	0	0	0	0	10	10	13	13	13
	Mean Moyenne	-99.9	-99.9	-99.9	-99.9	20.1	23.0	34.4	44.4	51.1
	Std. Dev. Écart-type	-99.9	-99.9	-99.9	-99.9	8.2	6.9	9.3	7.5	10.4
	Skew. Dissymétrie	-99.90	-99.90	-99.90	-99.90	1.64	1.71	1.57	1.11	1.10
	Kurtosis	-99.90	-99.90	-99.90	-99.90	7.38	7.73	6.56	4.20	3.84

*-99.9 Indicates Missing Data/Données manquantes
* NM Indicates No Measurements/Aucunes mesures

****

Table 2a: Return Period Rainfall Amounts (mm)
Quantité de pluie (mm) par période de retour

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
EC-IDF 5 min	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	0
EC-IDF 10 min	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	0
EC-IDF 15 min	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	0
EC-IDF 30 min	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	0
UPDATE 1 h	18.8	26.0	30.8	36.8	41.3	45.7	10
UPDATE 2 h	21.9	28.0	32.0	37.1	40.9	44.6	10
UPDATE 6 h	32.9	41.1	46.5	53.3	58.4	63.5	13
UPDATE 12 h	43.1	49.8	54.2	59.7	63.8	67.9	13
UPDATE 24 h	49.4	58.6	64.7	72.5	78.2	83.9	13

* There were insufficient data to generate the IDF curve for 5, 10, 15, 30-min

****

Table 2b:

Return Period Rainfall Rates (mm/h) - 95% Confidence limits
Intensité de la pluie (mm/h) par période de retour - Limites de confiance de 95%

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
EC-IDF 5 min	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	0
	+/--99.9	+/--99.9	+/--99.9	+/--99.9	+/--99.9	+/--99.9	0
EC-IDF 10 min	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	0
	+/--99.9	+/--99.9	+/--99.9	+/--99.9	+/--99.9	+/--99.9	0
EC-IDF 15 min	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	0
	+/--99.9	+/--99.9	+/--99.9	+/--99.9	+/--99.9	+/--99.9	0
EC-IDF 30 min	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	0
	+/--99.9	+/--99.9	+/--99.9	+/--99.9	+/--99.9	+/--99.9	0
UPDATE 1 h	18.8	26.0	30.8	36.8	41.3	45.7	10
	+/- 4.6	+/- 7.8	+/- 10.6	+/- 14.2	+/- 17.0	+/- 19.9	10
UPDATE 2 h	10.9	14.0	16.0	18.6	20.4	22.3	10
	+/- 2.0	+/- 3.3	+/- 4.5	+/- 6.0	+/- 7.2	+/- 8.4	10
UPDATE 6 h	5.5	6.8	7.8	8.9	9.7	10.6	13
	+/- 0.8	+/- 1.3	+/- 1.7	+/- 2.4	+/- 2.8	+/- 3.3	13
UPDATE 12 h	3.6	4.1	4.5	5.0	5.3	5.7	13
	+/- 0.3	+/- 0.5	+/- 0.7	+/- 1.0	+/- 1.1	+/- 1.3	13
UPDATE 24 h	2.1	2.4	2.7	3.0	3.3	3.5	13
	+/- 0.2	+/- 0.4	+/- 0.5	+/- 0.7	+/- 0.8	+/- 0.9	13

* There were insufficient data to generate the IDF curve for 5, 10, 15, 30-min

****

Table 3: Interpolation Equation / Équation d'interpolation: R = A*T^B

R = Interpolated Rainfall rate (mm/h)/Intensité interpolée de la pluie (mm/h)
RR = Rainfall rate (mm/h) / Intensité de la pluie (mm/h)
T = Rainfall duration (h) / Durée de la pluie (h)

****

Statistics/Statistiques	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans
Mean of RR/Moyenne de RR	4.5	5.9	6.9	8.0	8.9	9.8
Std. Dev. /Écart-type (RR)	5.6	7.8	9.2	11.0	12.4	13.7
Std. Error/Erreur-type	0.4	0.9	1.2	1.6	1.9	2.2
Coefficient (A)	18.3	24.8	29.2	34.6	38.7	42.7
Exponent/Exposant (B)	-0.677	-0.728	-0.751	-0.773	-0.787	-0.798
Mean % Error/% erreur moyenne	3.3	3.1	3.2	4.3	4.9	5.4

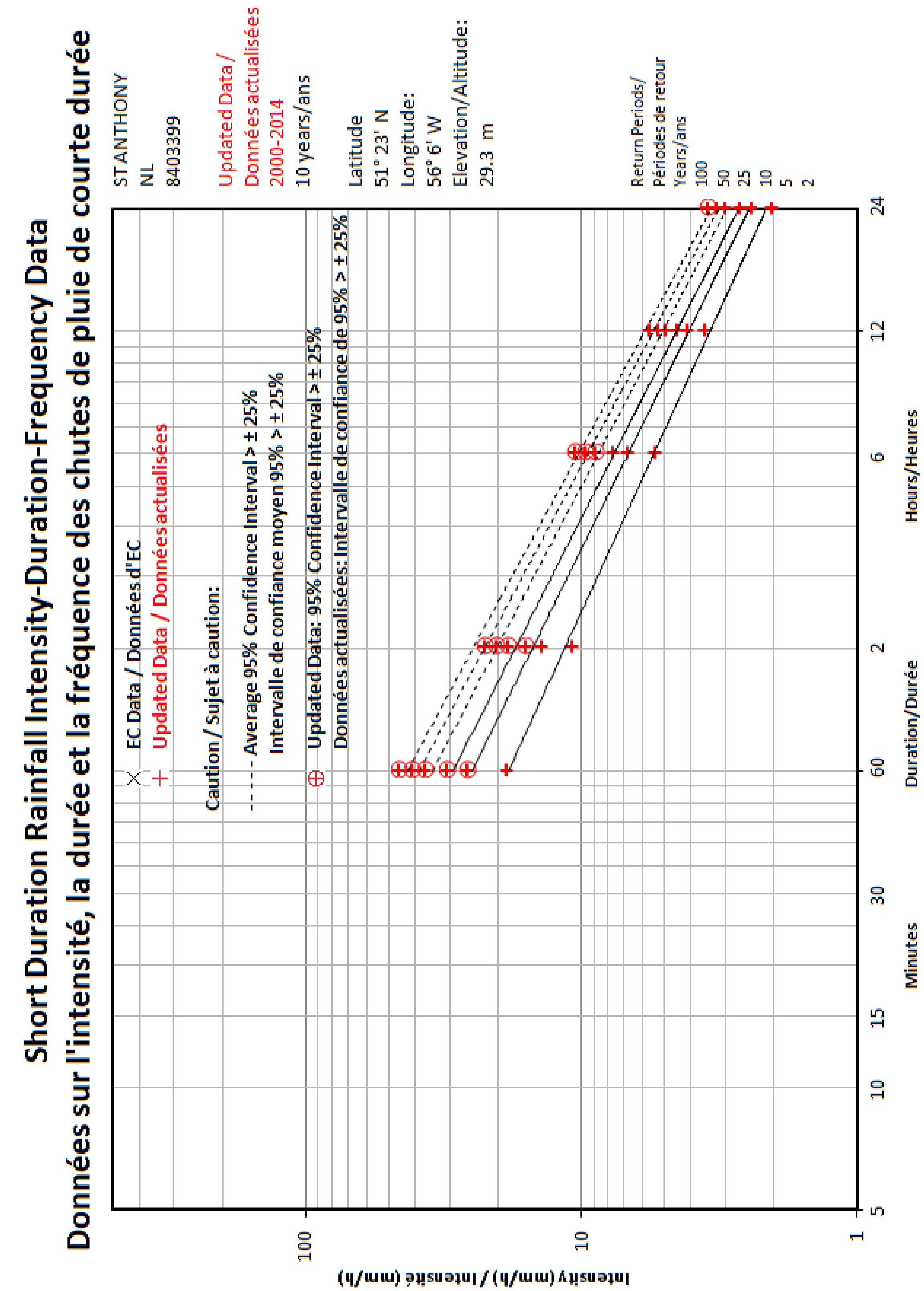

Figure 11.5 St Anthony (8403399) IDF Curve – Updated

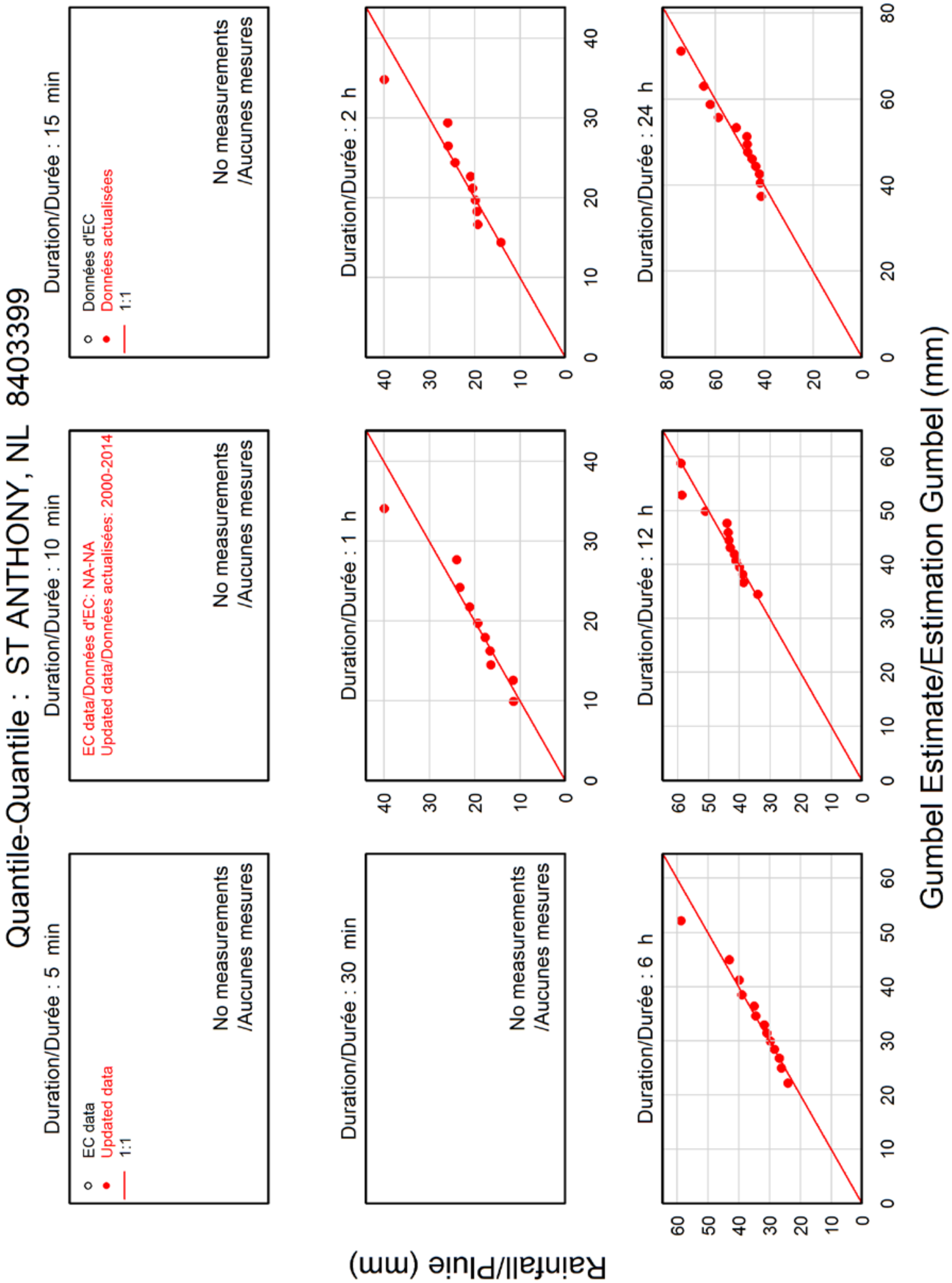

Figure 11.6 St Anthony (8403399) Quantile-Quantile Plot – Updated

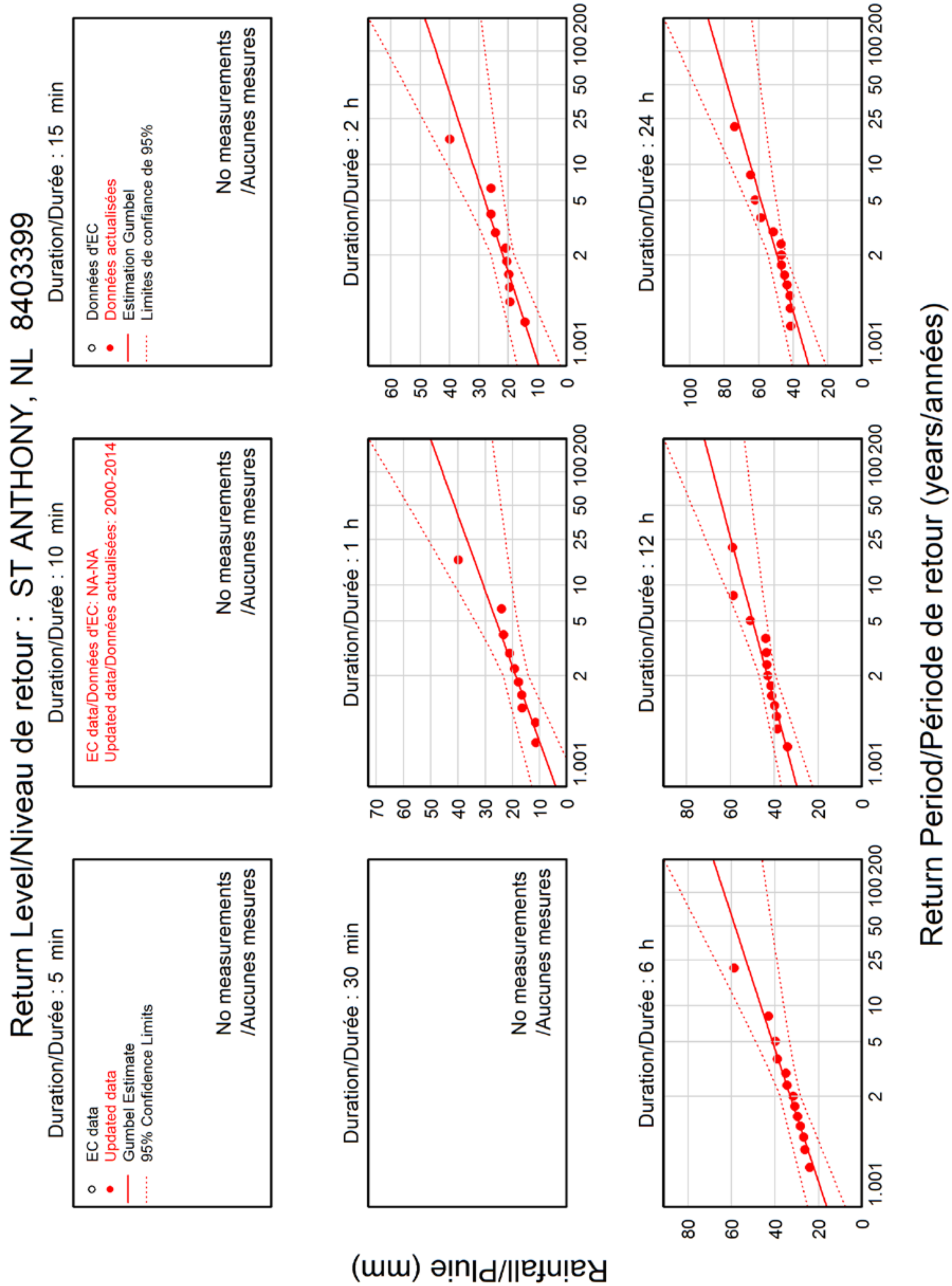

Figure 11.7 St Anthony (8403399) Return Level Plot – Updated

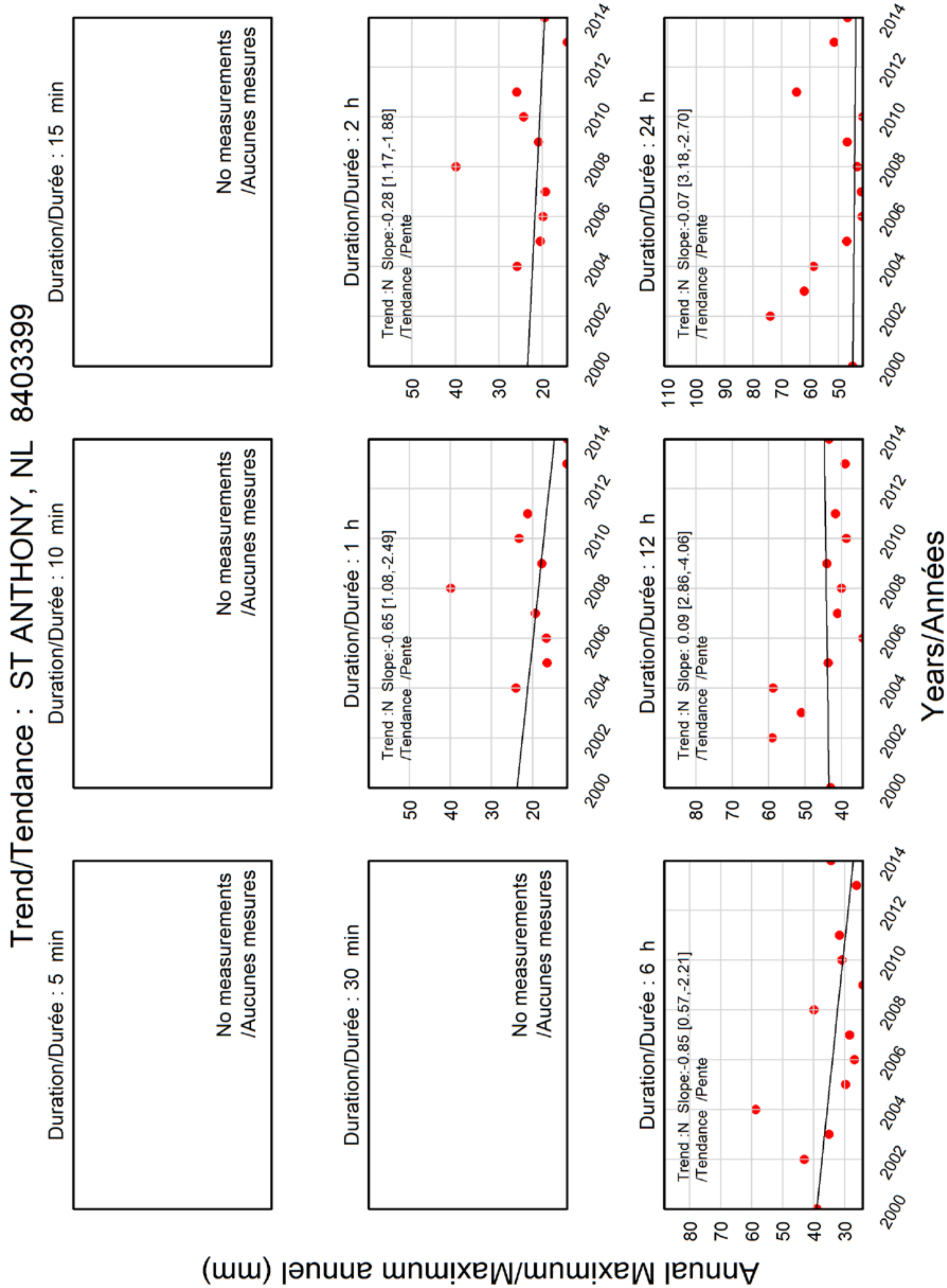

Figure 11.8 St Anthony (8403399) Trend Plot – Updated

Section 12.0 St. John's A

The IDF curve for St. John's A station was updated by using 5-min tipping bucket data from Windsor Lake (City of St. John's station). In addition, a new IDF curve was generated at Ruby Line (City of St. John's station). All durations were updated.

Table 12.1 presents the changes between the updated IDF curve and the EC-IDF V2.3 curve for St. John's A. Table 12.2 presents the changes between the Ruby Line IDF curve and the EC-IDF V2.3 curve for St. John's A.

Table 12.1 Differences Between IDF Curves for St. John's A

Percent Difference in Precipitation Amount [%] (Difference in Precipitation Amount [mm])						
	Return Period [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	-1.7 (-0.1)	-4.3 (-0.3)	**-5.3 (-0.4)**	**-6.2 (-0.6)**	**-6.8 (-0.7)**	**-7.2 (-0.8)**
10-min	1.0 (0.1)	-1.7 (-0.2)	-2.8 (-0.3)	-3.8 (-0.5)	-4.4 (-0.6)	-4.9 (-0.8)
15-min	2.6 (0.2)	0.1 (0.0)	-1.0 (-0.1)	-2.0 (-0.3)	-2.5 (-0.5)	-2.9 (-0.6)
30-min	**5.0 (0.6)**	**5.0 (0.8)**	**5.0 (1.0)**	**5.0 (1.1)**	**5.1 (1.3)**	**5.1 (1.4)**
1-hr	**7.8 (1.4)**	**11.0 (2.5)**	**12.5 (3.2)**	**13.8 (4.1)**	**14.6 (4.8)**	**15.3 (5.4)**
2-hr	**9.1 (2.2)**	**10.9 (3.4)**	**11.6 (4.3)**	**12.3 (5.3)**	**12.7 (6.1)**	**13.0 (6.9)**
6-hr	**7.7 (3.1)**	**12.5 (6.4)**	**14.8 (8.5)**	**17.0 (11.3)**	**18.4 (13.3)**	**19.5 (15.3)**
12-hr	**7.5 (3.9)**	**15.5 (9.9)**	**19.4 (13.8)**	**23.3 (18.8)**	**25.7 (22.5)**	**27.7 (26.2)**
24-hr	**8.1 (5.1)**	**13.9 (10.5)**	**16.8 (14.0)**	**19.6 (18.6)**	**21.4 (21.9)**	**22.8 (25.3)**

Notes:
Red numbers indicate that the updated IDF curve is lower than the EC-IDF V2.3 IDF curve for that duration and return period.
Bold numbers indicate changes greater than 5 percent.

Where there are decreases greater than 5 percent, users should exercise caution when using the updated IDF curve, or use the EC IDF curve.

Table 12.2 Differences Between IDF Curves for Ruby Line and St. John's A

	Percent Difference in Precipitation Amount [%] (Difference in Precipitation Amount [mm])					
	Return Period [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	**-11.3 (-0.5)**	**-20.7 (-1.3)**	**-24.6 (-1.9)**	**-28.1 (-2.5)**	**-30.0 (-3.0)**	**-31.6 (-3.5)**
10-min	**-5.4 (-0.4)**	**-14.7 (-1.4)**	**-18.7 (-2.0)**	**-22.3 (-2.9)**	**-24.4 (-3.5)**	**-26.0 (-4.1)**
15-min	**-5.2 (-0.5)**	**-12.6 (-1.5)**	**-15.7 (-2.2)**	**-18.5 (-3.0)**	**-20.1 (-3.6)**	**-21.4 (-4.3)**
30-min	-3.4 (-0.4)	-1.8 (-0.3)	-1.1 (-0.2)	-0.4 (-0.1)	0.0 (0.0)	0.3 (0.1)
1-hr	**6.8 (1.2)**	**14.6 (3.2)**	**18.1 (4.6)**	**21.5 (6.3)**	**23.4 (7.6)**	**25.0 (8.9)**
2-hr	**22.0 (5.2)**	**23.0 (7.3)**	**23.4 (8.6)**	**23.8 (10.3)**	**24.0 (11.6)**	**24.2 (12.8)**
6-hr	**15.6 (6.4)**	**20.2 (10.3)**	**22.3 (12.9)**	**24.4 (16.1)**	**25.7 (18.5)**	**26.7 (20.9)**
12-hr	**15.7 (8.2)**	**26.4 (16.8)**	**31.5 (22.4)**	**36.7 (29.5)**	**39.8 (34.8)**	**42.4 (40.1)**
24-hr	**17.3 (10.8)**	**24.2 (18.2)**	**27.6 (23.1)**	**31.0 (29.3)**	**33.1 (33.9)**	**34.8 (38.5)**

Notes:
Red numbers indicate that the updated IDF curve is lower than the EC-IDF V2.3 IDF curve for that duration and return period.
Bold numbers indicate changes greater than 5 percent.

Where there are decreases greater than 5 percent, users should exercise caution when using the updated IDF curve, or use the EC IDF curve. Section 12.1 presents the IDF curve tables and figures for St. John's A. Section 12.2 presents the IDF curve tables and figures for Ruby Line.

12.1 St. John's A

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Office of Climate Change and Energy Efficiency

Short Duration Rainfall Intensity-Duration-Frequency Data
Données sur l'intensité, la durée et la fréquence des chutes
de pluie de courte durée

Gumbel - Method of moments/Méthode des moments

2015/03/20

================================================================================
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ST JOHN'S A NL 8403506
Updated with 5-min data measured at Windsor Lake (City of St. John's Station) : 1999 - 2014
Latitude: 47 37'N Longitude: 52 44'W Elevation/Altitude: 140 m
Years/Années : 1949 - 2014 # Years/Années : 48

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****

Table 1: Annual Maximum (mm)/Maximum annuel (mm)

****

	Year Année	5 min	10 min	15 min	30 min	1 h	2 h	6 h	12 h	24 h
EC-IDF	1949	8.9	8.9	10.2	17.5	28.2	52.6	61.7	62.0	63.5
EC-IDF	1961	3.0	4.3	5.3	6.9	8.6	13.5	25.7	35.6	38.6
EC-IDF	1962	2.8	4.6	4.6	8.1	13.0	20.6	33.8	54.9	59.7
EC-IDF	1963	10.2	11.2	11.7	13.7	18.5	23.6	40.9	52.3	57.9
EC-IDF	1964	4.3	6.9	7.9	11.2	19.3	28.2	54.9	72.6	77.5
EC-IDF	1965	5.3	7.4	9.9	13.0	17.8	19.6	32.3	51.8	59.7
EC-IDF	1966	8.4	13.2	17.0	25.4	29.7	43.7	48.5	64.5	85.3
EC-IDF	1967	2.3	3.8	5.3	9.9	10.9	16.3	29.5	44.4	58.4
EC-IDF	1968	6.3	12.7	13.7	14.7	17.5	22.4	41.9	55.1	61.7
EC-IDF	1969	5.6	7.1	8.4	8.6	11.7	19.0	30.7	34.5	48.3
EC-IDF	1970	5.6	7.1	10.7	15.2	16.3	19.6	42.4	62.5	87.4
EC-IDF	1971	6.3	10.4	14.5	16.0	19.0	22.1	34.3	41.1	77.7
EC-IDF	1972	4.8	5.3	6.6	10.9	15.0	20.6	47.8	72.6	89.2
EC-IDF	1973	5.3	6.9	7.9	10.4	16.5	30.0	49.5	65.8	67.1
EC-IDF	1974	3.6	5.6	6.3	9.9	16.3	22.4	42.4	53.3	72.9
EC-IDF	1975	8.1	10.4	12.2	17.8	19.0	19.6	46.5	71.9	82.3
EC-IDF	1976	3.6	4.8	6.1	8.4	12.7	19.0	33.8	42.2	53.6
EC-IDF	1977	3.8	5.6	7.6	11.7	17.5	23.4	38.6	40.4	41.4
EC-IDF	1978	4.0	5.9	7.4	7.6	12.9	13.1	27.1	37.6	43.0
EC-IDF	1979	3.2	4.2	5.9	10.2	16.2	18.1	29.3	41.9	49.2
EC-IDF	1980	3.2	6.1	7.4	12.2	17.4	23.9	33.6	41.6	69.8
EC-IDF	1981	-99.9	-99.9	-99.9	-99.9	15.0	22.4	46.7	72.5	82.6
EC-IDF	1982	5.1	9.0	12.9	17.1	24.5	35.9	80.3	82.4	84.0
EC-IDF	1983	1.6	3.2	4.8	9.6	19.2	26.5	47.3	52.8	54.7
EC-IDF	1984	5.0	9.9	13.0	21.5	27.1	36.6	61.0	74.0	75.3
EC-IDF	1985	5.2	7.1	9.8	11.3	14.1	18.5	36.0	54.9	82.9
EC-IDF	1986	3.1	4.8	7.2	14.3	23.3	27.9	40.2	58.9	70.6
EC-IDF	1987	5.1	7.3	8.6	16.2	23.5	24.2	30.6	36.6	46.8
EC-IDF	1988	6.6	10.6	13.2	17.4	23.4	25.9	44.8	45.8	49.0
EC-IDF	1989	2.9	4.5	6.2	8.0	10.9	19.7	43.4	51.6	51.6
EC-IDF	1990	3.7	5.9	6.5	12.6	19.2	28.5	48.1	68.7	85.2
EC-IDF	1991	7.8	11.4	15.9	23.3	28.8	29.5	51.2	52.2	59.7
EC-IDF	1993	4.4	7.0	7.6	11.5	20.0	31.3	47.6	49.4	55.3
EC-IDF	1994	6.2	9.1	10.3	12.6	12.8	14.9	-99.9	-99.9	67.5
EC-IDF	1995	5.2	9.8	14.5	16.6	27.6	46.7	55.9	58.8	61.6
EC-IDF	1996	4.8	6.2	7.4	10.2	15.4	27.2	40.2	44.0	48.4
UPDATE	1999	3.2	5.0	6.6	9.0	15.3	25.1	42.4	63.4	99.3
UPDATE	2000	3.8	6.7	8.6	13.0	21.5	29.9	43.4	58.9	70.5
UPDATE	2001	4.8	8.8	11.5	19.5	33.7	62.0	107.1	147.7	149.6
UPDATE	2003	5.5	8.6	11.3	19.3	32.4	42.2	50.4	76.1	92.4
UPDATE	2004	3.9	7.4	10.6	17.2	23.6	26.1	59.0	71.5	76.6
UPDATE	2005	5.0	7.1	8.4	13.1	21.2	28.6	65.4	82.3	98.9
UPDATE	2006	4.8	8.1	11.1	17.5	30.4	36.4	51.9	53.7	58.5
UPDATE	2007	6.3	10.3	14.6	27.2	41.1	48.1	79.2	104.2	104.9
UPDATE	2009	5.0	6.6	7.4	10.6	16.9	24.7	46.7	58.2	65.0
UPDATE	2010	4.1	7.5	10.2	14.2	21.2	36.2	62.7	75.0	113.8

UPDATE	2011	3.2	4.8	7.3	12.0	15.7	20.6	33.3	38.1	54.9
UPDATE	2013	4.4	6.6	8.5	11.3	15.9	27.2	46.3	56.1	76.3
UPDATE	2014	5.5	9.6	13.3	19.4	25.8	37.9	48.7	61.0	73.7
	# Yrs. Années	48	48	48	48	49	49	48	48	49
	Mean Moyenne	4.9	7.4	9.5	13.9	19.9	27.6	46.6	59.3	70.5
	Std. Dev. Écart-type	1.7	2.4	3.2	4.7	6.7	10.3	15.0	19.6	20.8
	Skew. Dissymétrie	0.92	0.48	0.54	0.90	0.94	1.32	1.73	2.15	1.29
	Kurtosis	4.29	2.76	2.54	3.67	3.99	4.95	7.87	10.98	6.15

*-99.9 Indicates Missing Data/Données manquantes
*   NM Indicates No Measurements/Aucunes mesures

Warning: annual maximum amount greater than 100-yr return period amount
Avertissement : la quantité maximale annuelle excède la quantité pour une période de retour de 100 ans

Year/Année	Duration/Durée	Data/Données	100-yr/ans
2001	2 h	62.0	60.0
2001	6 h	107.1	93.8
2001	12 h	147.7	120.7
2001	24 h	149.6	135.8
2007	1 h	41.1	41.0

****

Table 2a: Return Period Rainfall Amounts (mm)
Quantité de pluie (mm) par période de retour

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
UPDATE 5 min	4.6	6.1	7.2	8.5	9.4	10.4	48
UPDATE 10 min	7.0	9.1	10.5	12.3	13.6	14.9	48
UPDATE 15 min	8.9	11.7	13.6	15.9	17.6	19.3	48
UPDATE 30 min	13.1	17.2	20.0	23.4	26.0	28.6	48
UPDATE 1 h	18.8	24.7	28.6	33.6	37.3	41.0	49
UPDATE 2 h	25.9	35.0	41.1	48.7	54.4	60.0	49
UPDATE 6 h	44.1	57.4	66.2	77.3	85.6	93.8	48
UPDATE 12 h	56.1	73.4	84.9	99.3	110.1	120.7	48
UPDATE 24 h	67.1	85.5	97.7	113.1	124.5	135.8	49

* 5-min data were used for the update: all durations were updated

****

Table 2b:

Return Period Rainfall Rates (mm/h) - 95% Confidence limits
Intensité de la pluie (mm/h) par période de retour - Limites de confiance de 95%

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
UPDATE 5 min	55.3	73.7	86.0	101.5	112.9	124.3	48
	+/- 5.4	+/- 9.1	+/- 12.4	+/- 16.7	+/- 19.9	+/- 23.2	48
UPDATE 10 min	42.0	54.8	63.2	73.9	81.8	89.6	48
	+/- 3.7	+/- 6.3	+/- 8.5	+/- 11.5	+/- 13.7	+/- 16.0	48
UPDATE 15 min	35.8	46.9	54.3	63.6	70.5	77.4	48
	+/- 3.3	+/- 5.5	+/- 7.4	+/- 10.0	+/- 12.0	+/- 14.0	48
UPDATE 30 min	26.2	34.4	39.9	46.9	52.0	57.1	48
	+/- 2.4	+/- 4.1	+/- 5.5	+/- 7.5	+/- 8.9	+/- 10.4	48
UPDATE 1 h	18.8	24.7	28.6	33.6	37.3	41.0	49

```
                +/-  1.7 +/-  2.9 +/-  3.9 +/-  5.3 +/-  6.3 +/-  7.4       49
*UPDATE*  2 h       12.9      17.5      20.5      24.3      27.2      30.0       49
                +/-  1.3 +/-  2.2 +/-  3.0 +/-  4.1 +/-  4.9 +/-  5.7       49
*UPDATE*  6 h        7.3       9.6      11.0      12.9      14.3      15.6       48
                +/-  0.7 +/-  1.1 +/-  1.5 +/-  2.0 +/-  2.4 +/-  2.8       48
*UPDATE* 12 h        4.7       6.1       7.1       8.3       9.2      10.1       48
                +/-  0.4 +/-  0.7 +/-  1.0 +/-  1.3 +/-  1.6 +/-  1.8       48
*UPDATE* 24 h        2.8       3.6       4.1       4.7       5.2       5.7       49
                +/-  0.2 +/-  0.4 +/-  0.5 +/-  0.7 +/-  0.8 +/-  1.0       49
     * 5-min data were used for the update: all durations were updated

********************************************************************************

Table 3: Interpolation Equation / Équation d'interpolation: R = A*T^B

R = Interpolated Rainfall rate (mm/h)/Intensité interpolée de la pluie (mm/h)
RR = Rainfall rate (mm/h) / Intensité de la pluie (mm/h)
 T = Rainfall duration (h) / Durée de la pluie (h)

********************************************************************************

       Statistics/Statistiques      2      5     10     25     50    100
                              yr/ans yr/ans yr/ans yr/ans yr/ans yr/ans
      Mean of RR/Moyenne de RR   22.9   30.1   35.0   41.1   45.6   50.1
    Std. Dev. /Écart-type (RR)   18.3   24.2   28.2   33.1   36.8   40.5
        Std. Error/Erreur-type    3.0    3.9    4.6    5.4    6.0    6.6
               Coefficient (A)   17.2   22.5   26.1   30.6   34.0   37.3
         Exponent/Exposant (B) -0.521 -0.525 -0.527 -0.528 -0.529 -0.530
 Mean % Error/% erreur moyenne    7.4    7.9    8.2    8.4    8.6    8.8
```

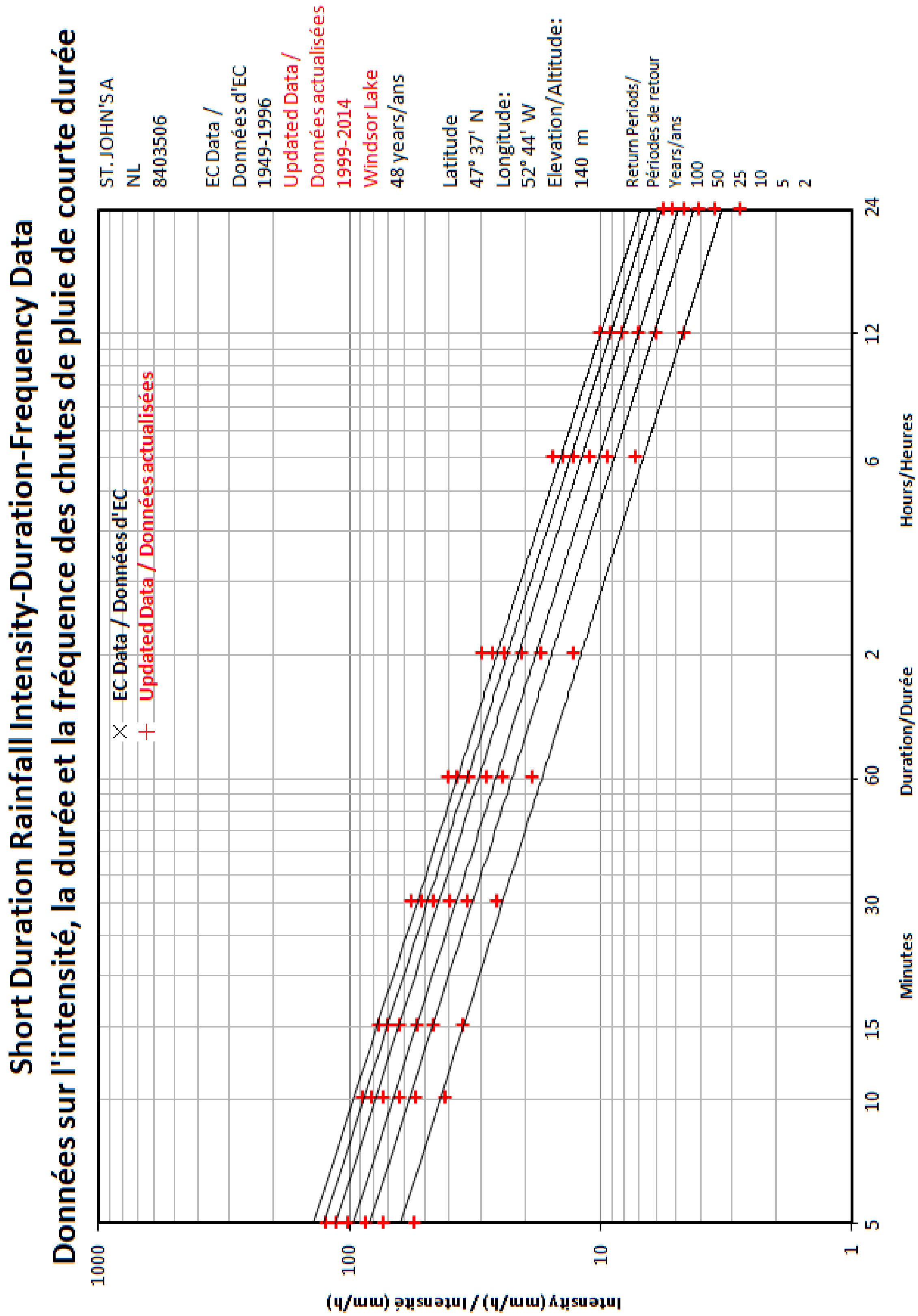

Figure 12.1 St John's A IDF Curve – Updated

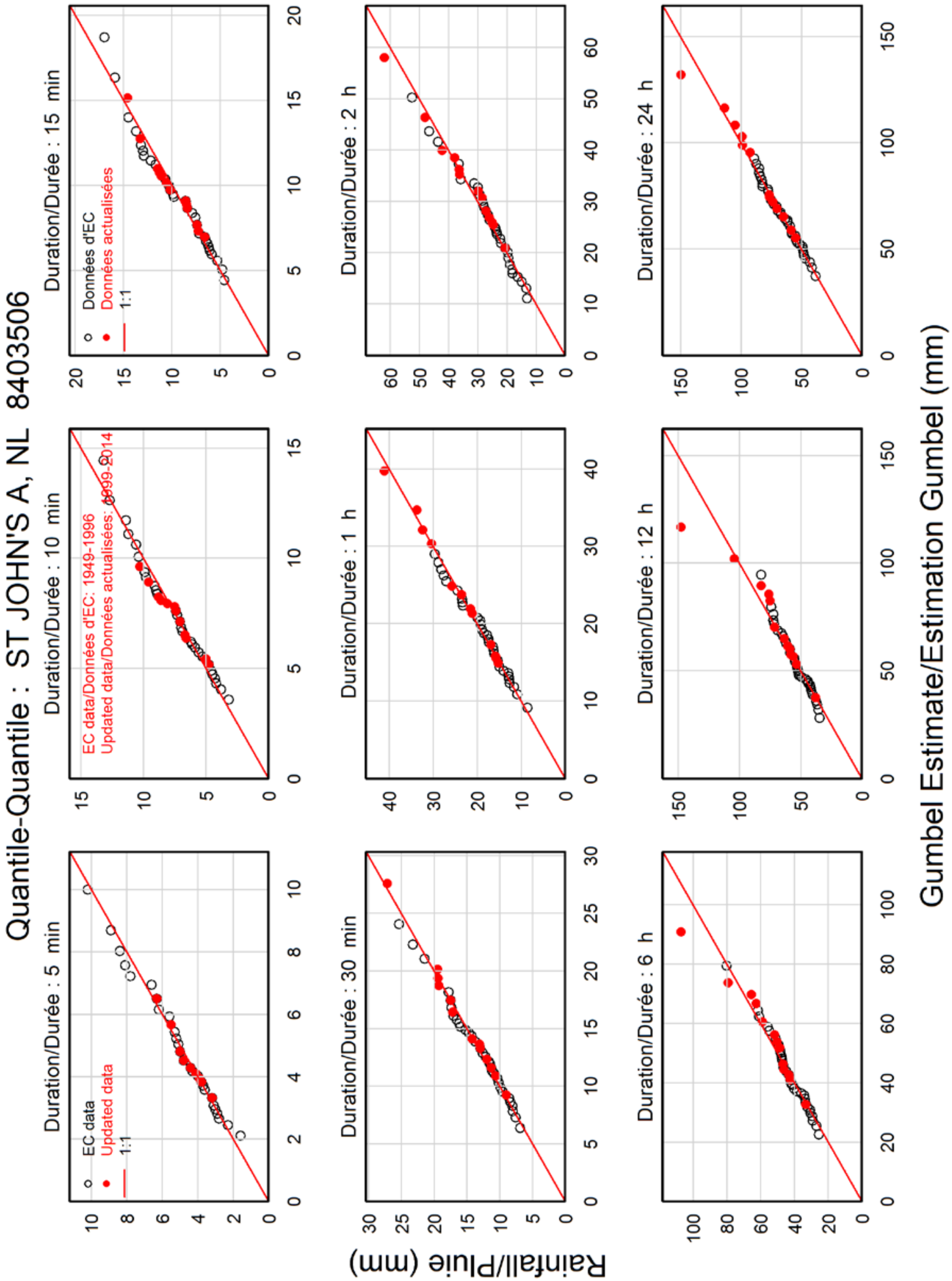

Figure 12.2 St John's A Quantile-Quantile Plot – Updated

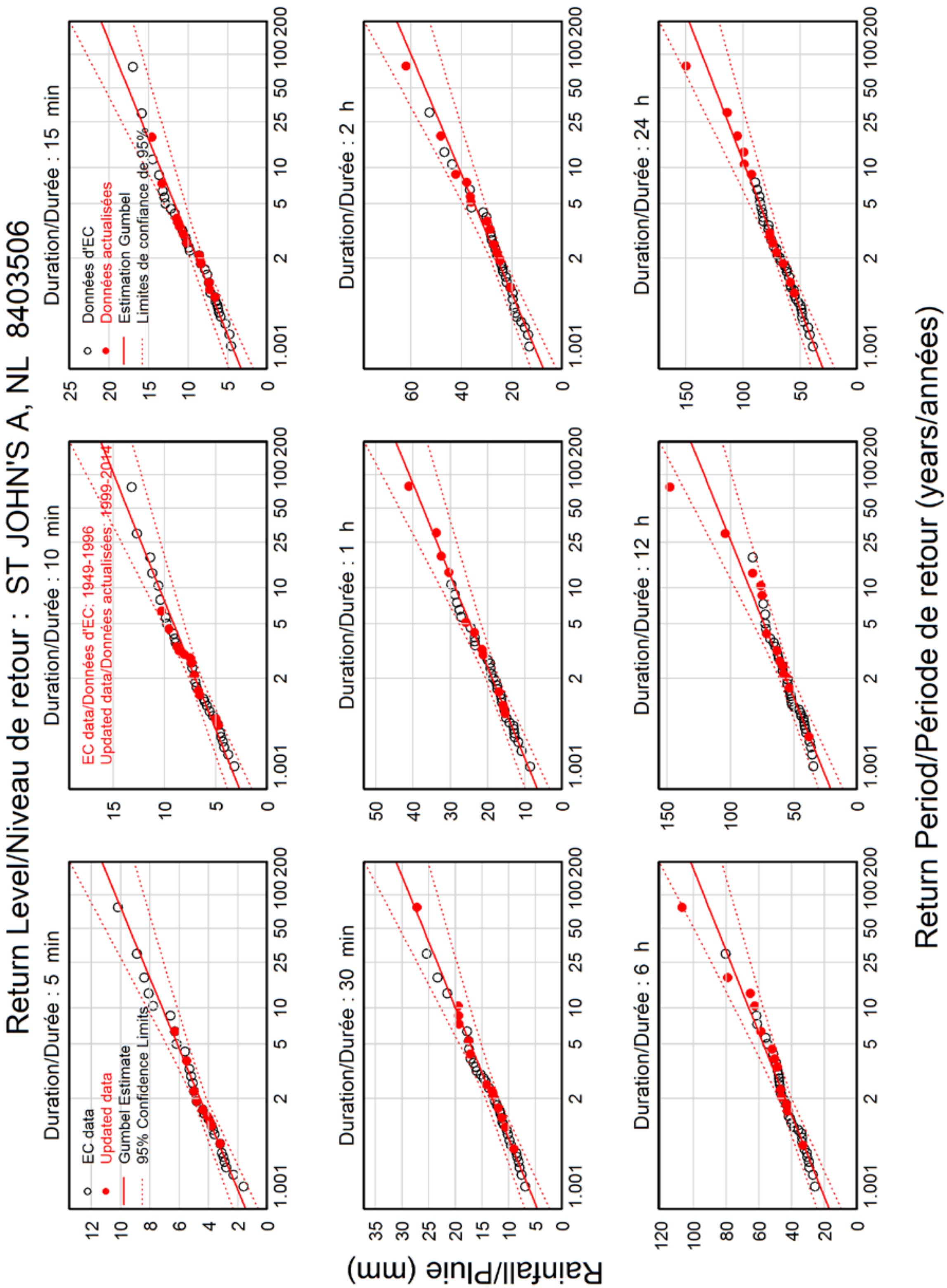

Figure 12.3 St John's A Return Level Plot – Updated

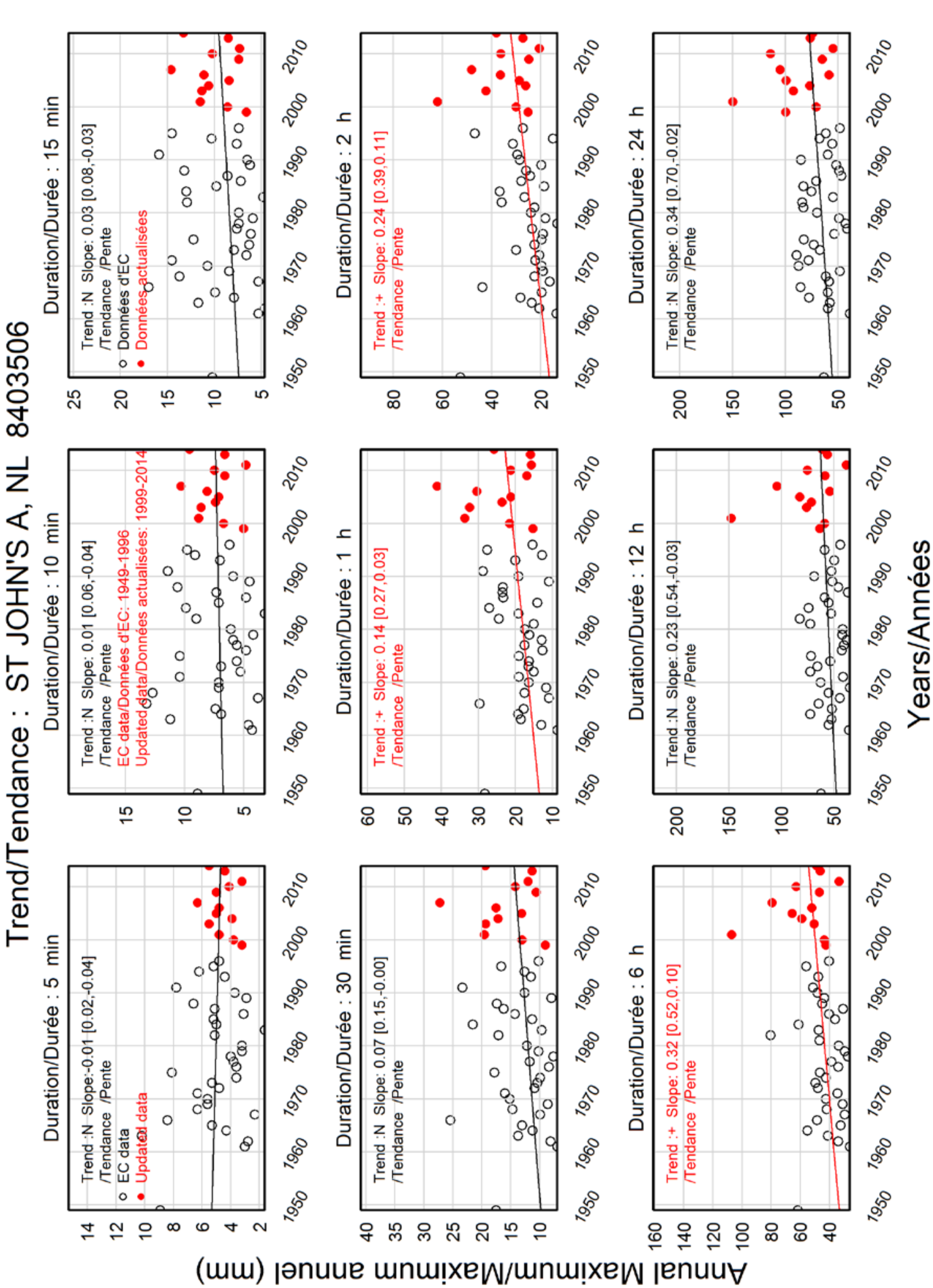

Figure 12.4 St John's A Trend Plot – Updated

12.2 Ruby Line

Office of Climate Change and Energy Efficiency

Short Duration Rainfall Intensity-Duration-Frequency Data
Données sur l'intensité, la durée et la fréquence des chutes de pluie de courte durée

Gumbel - Method of moments/Méthode des moments

2015/03/20

==

RUBY LINE NL City of St. John's Station

Latitude: 47 29'24" N Longitude: 52 47'46" W Elevation/Altitude: 151 m
Years/Années : 1997 - 2014 # Years/Années : 16

==

****

Table 1: Annual Maximum (mm)/Maximum annuel (mm)

****

	Year Année	5 min	10 min	15 min	30 min	1 h	2 h	6 h	12 h	24 h
UPDATE	1997	4.7	4.9	6.2	8.0	12.2	21.9	46.1	61.4	68.3
UPDATE	1998	3.6	5.8	6.8	11.9	21.3	33.0	56.0	76.0	95.8
UPDATE	1999	4.0	5.8	6.7	9.4	15.3	25.4	37.1	55.4	83.2
UPDATE	2000	3.5	5.5	7.8	14.2	20.3	30.8	48.1	62.0	73.1
UPDATE	2001	5.1	8.6	11.0	18.6	32.6	55.5	95.9	133.1	135.9
UPDATE	2002	3.5	6.7	9.5	13.2	16.1	26.4	44.0	45.0	46.3
UPDATE	2004	4.1	7.4	9.6	13.1	22.5	22.6	43.8	55.2	58.7
UPDATE	2005	3.7	7.2	10.5	14.4	22.2	35.2	43.0	62.9	77.4
UPDATE	2006	2.8	5.1	6.4	8.6	12.2	19.0	36.3	42.5	53.5
UPDATE	2007	7.2	11.1	15.1	27.1	41.7	56.4	76.4	91.0	91.9
UPDATE	2008	5.0	8.0	8.3	11.4	15.6	23.2	45.9	57.8	63.1
UPDATE	2009	4.3	5.9	7.8	10.3	16.0	26.5	49.6	74.6	75.1
UPDATE	2010	5.7	7.2	8.4	11.4	21.4	34.9	56.3	65.3	111.2
UPDATE	2011	4.3	6.4	6.8	10.2	14.6	23.8	37.4	44.9	72.0
UPDATE	2013	3.6	7.0	8.4	10.3	12.8	21.9	37.1	47.7	55.5
UPDATE	2014	4.2	6.5	8.7	12.5	21.0	36.3	45.9	51.2	64.0
	# Yrs. Années	16	16	16	16	16	16	16	16	16
	Mean Moyenne	4.3	6.8	8.6	12.8	19.9	30.8	49.9	64.1	76.6
	Std. Dev. Écart-type	1.1	1.5	2.2	4.6	7.8	11.2	15.8	22.5	23.1
	Skew. Dissymétrie	1.38	1.46	1.67	2.22	1.72	1.50	2.06	2.13	1.24
	Kurtosis	6.01	6.43	7.02	9.15	6.60	5.08	7.68	8.73	5.08

*-99.9 Indicates Missing Data/Données manquantes
* NM Indicates No Measurements/Aucunes mesures

****

Table 2a: Return Period Rainfall Amounts (mm)
Quantité de pluie (mm) par période de retour

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
UPDATE 5 min	4.2	5.1	5.7	6.5	7.1	7.6	16
UPDATE 10 min	6.6	7.9	8.8	9.9	10.8	11.6	16
UPDATE 15 min	8.3	10.2	11.6	13.2	14.4	15.7	16
UPDATE 30 min	12.0	16.1	18.8	22.2	24.7	27.3	16
UPDATE 1 h	18.6	25.5	30.1	35.9	40.2	44.4	16
UPDATE 2 h	29.0	38.8	45.4	53.7	59.8	65.9	16
UPDATE 6 h	47.3	61.3	70.5	82.2	90.8	99.4	16
UPDATE 12 h	60.4	80.3	93.5	110.1	122.4	134.6	16
UPDATE 24 h	72.8	93.2	106.7	123.8	136.5	149.1	16

* 5-min data were used for the update: all durations were updated

****

Table 2b:

Return Period Rainfall Rates (mm/h) - 95% Confidence limits
Intensité de la pluie (mm/h) par période de retour - Limites de confiance de 95%

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
UPDATE 5 min	49.9	61.1	68.5	77.8	84.8	91.6	16
	+/- 5.7	+/- 9.6	+/- 12.9	+/- 17.4	+/- 20.9	+/- 24.3	16
UPDATE 10 min	39.4	47.5	52.9	59.7	64.7	69.7	16
	+/- 4.1	+/- 7.0	+/- 9.4	+/- 12.7	+/- 15.2	+/- 17.7	16
UPDATE 15 min	33.0	41.0	46.2	52.9	57.8	62.7	16
	+/- 4.0	+/- 6.8	+/- 9.2	+/- 12.4	+/- 14.8	+/- 17.3	16
UPDATE 30 min	24.1	32.2	37.6	44.4	49.5	54.5	16
	+/- 4.1	+/- 7.0	+/- 9.4	+/- 12.7	+/- 15.2	+/- 17.7	16
UPDATE 1 h	18.6	25.5	30.1	35.9	40.2	44.4	16
	+/- 3.5	+/- 5.9	+/- 8.0	+/- 10.8	+/- 12.9	+/- 15.1	16
UPDATE 2 h	14.5	19.4	22.7	26.8	29.9	32.9	16
	+/- 2.5	+/- 4.2	+/- 5.7	+/- 7.7	+/- 9.2	+/- 10.7	16
UPDATE 6 h	7.9	10.2	11.8	13.7	15.1	16.6	16
	+/- 1.2	+/- 2.0	+/- 2.7	+/- 3.6	+/- 4.3	+/- 5.1	16
UPDATE 12 h	5.0	6.7	7.8	9.2	10.2	11.2	16
	+/- 0.8	+/- 1.4	+/- 1.9	+/- 2.6	+/- 3.1	+/- 3.6	16
UPDATE 24 h	3.0	3.9	4.4	5.2	5.7	6.2	16
	+/- 0.4	+/- 0.7	+/- 1.0	+/- 1.3	+/- 1.6	+/- 1.9	16

* 5-min data were used for the update: all durations were updated

****

Table 3: Interpolation Equation / Équation d'interpolation: R = A*T^B

R = Interpolated Rainfall rate (mm/h)/Intensité interpolée de la pluie (mm/h)
RR = Rainfall rate (mm/h) / Intensité de la pluie (mm/h)
T = Rainfall duration (h) / Durée de la pluie (h)

****

Statistics/Statistiques	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans
Mean of RR/Moyenne de RR	21.7	27.5	31.3	36.2	39.8	43.3
Std. Dev. /Écart-type (RR)	16.3	19.7	21.9	24.8	26.9	29.1
Std. Error/Erreur-type	2.8	4.4	5.6	7.1	8.2	9.3
Coefficient (A)	17.0	21.9	25.2	29.2	32.2	35.2
Exponent/Exposant (B)	-0.483	-0.471	-0.466	-0.461	-0.458	-0.455
Mean % Error/% erreur moyenne	8.2	11.1	12.4	13.6	14.3	14.9

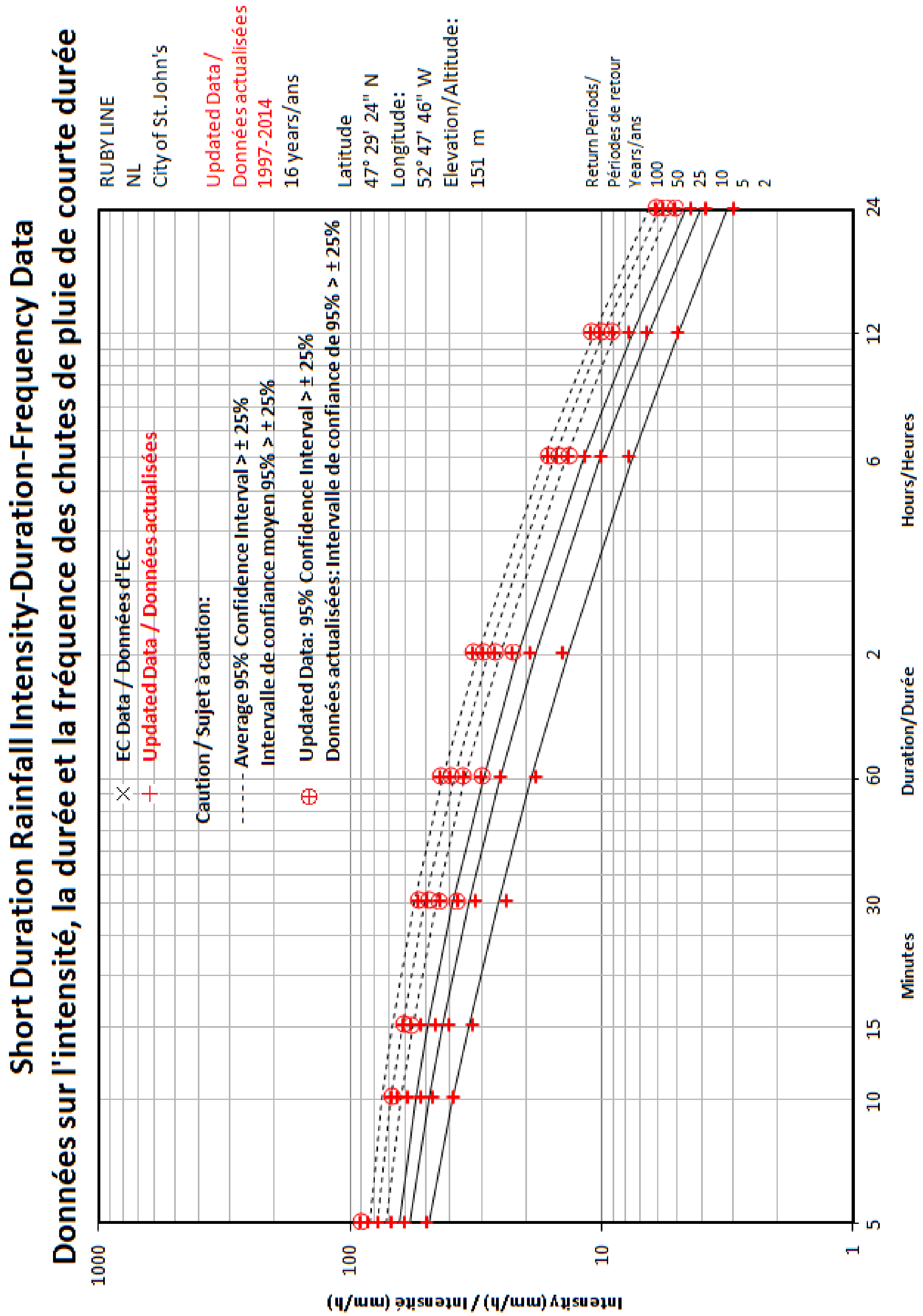

Figure 12.5 Ruby Line IDF Curve – Updated

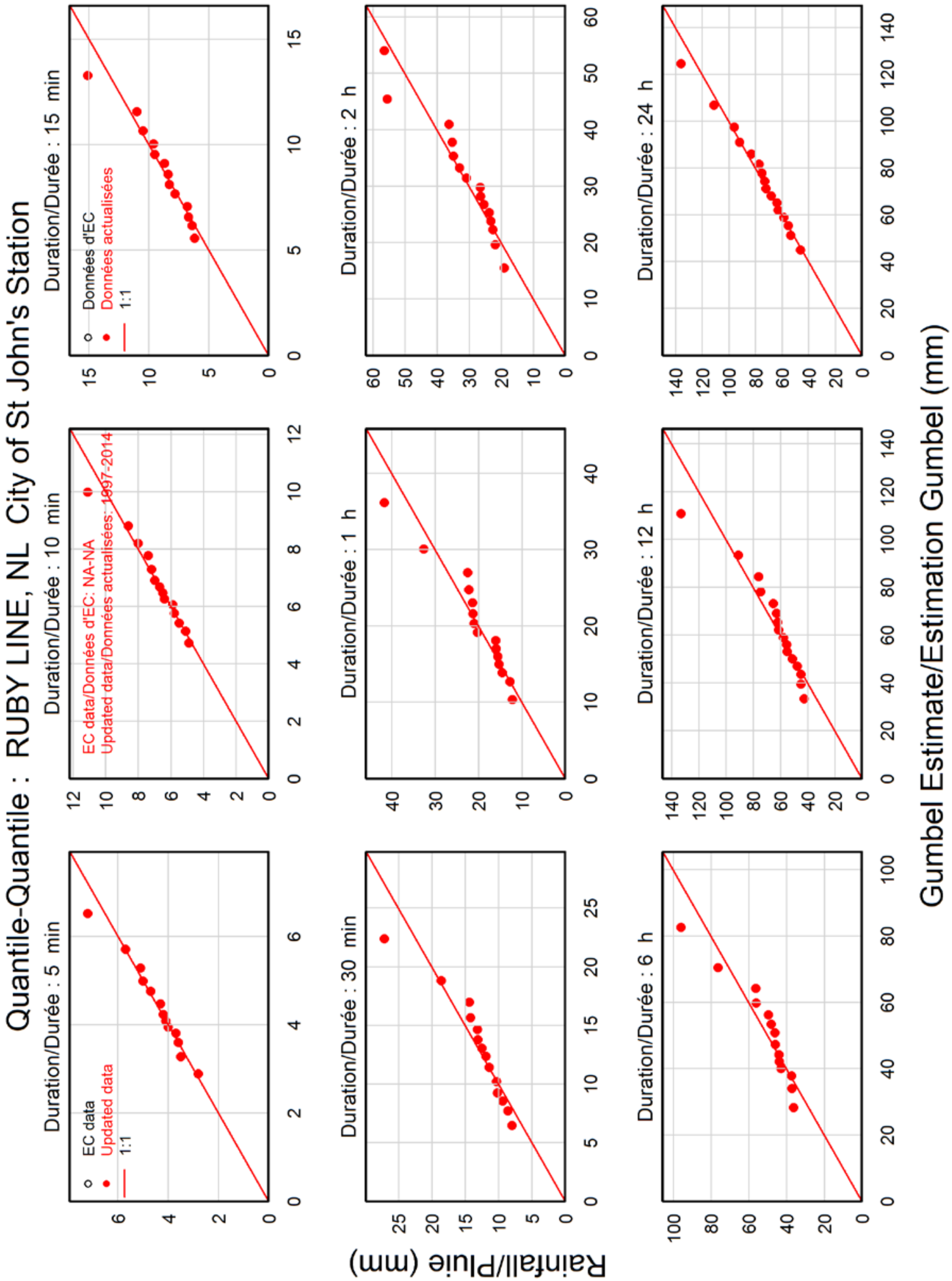

Figure 12.6 Ruby Line Quantile-Quantile Plot – Updated

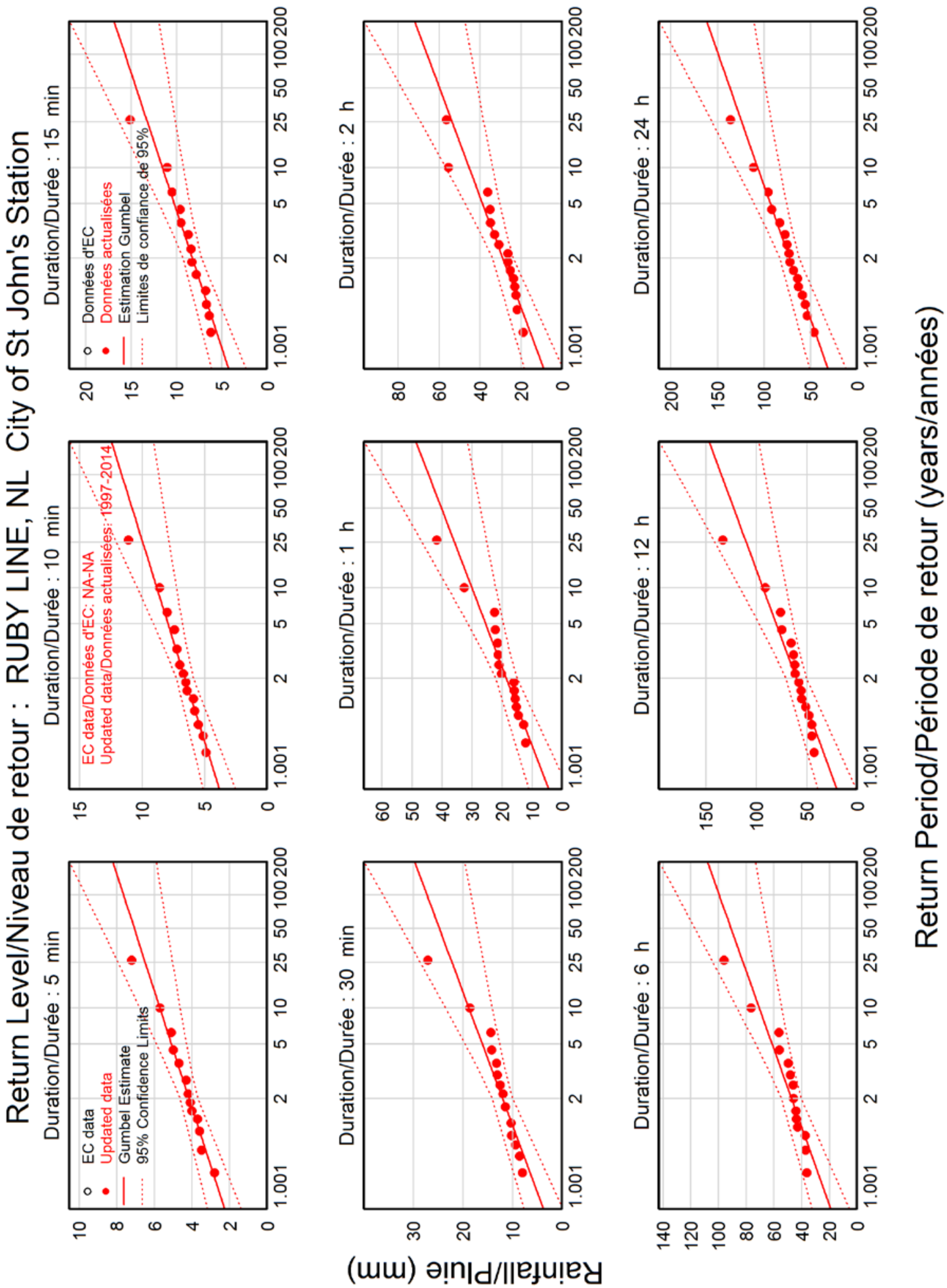

Figure 12.7 Ruby Line Return Level Plot – Updated

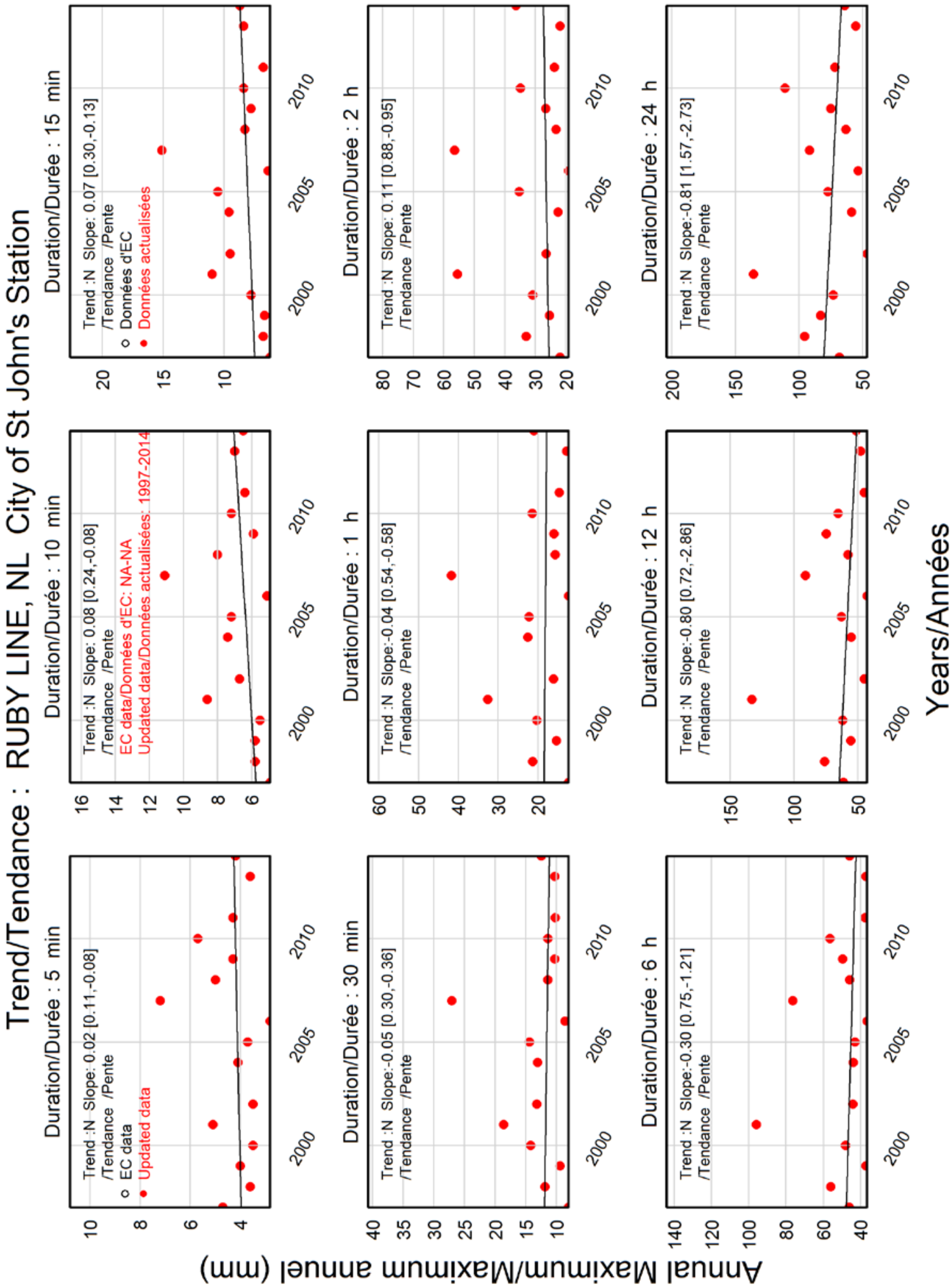

Figure 12.8 Ruby Line Trend Plot – Updated

Section 13.0 St Lawrence – EC-IDF V2.3

This station was not updated during this project. This is the EC IDF curve (V2.3, 2015).

Environment Canada/Environnement Canada

Short Duration Rainfall Intensity-Duration-Frequency Data
Données sur l'intensité, la durée et la fréquence des chutes de pluie de courte durée

Gumbel - Method of moments/Méthode des moments

2014/12/21

==

ST LAWRENCE NL 8403619

Latitude: 46 55'N Longitude: 55 23'W Elevation/Altitude: 48 m

Years/Années : 1969 - 2013 # Years/Années : 33

****

Table 1: Annual Maximum (mm)/Maximum annuel (mm)

****

Year Année	5 min	10 min	15 min	30 min	1 h	2 h	6 h	12 h	24 h
1969	4.6	7.1	8.4	11.7	15.7	23.4	54.6	62.7	66.5
1970	5.1	9.7	11.7	14.0	26.2	38.1	61.0	83.8	104.9
1971	3.6	5.6	7.1	13.7	18.3	19.8	30.0	40.4	49.5
1972	6.1	10.7	10.9	16.3	21.3	37.1	52.1	59.2	66.3
1973	4.8	8.4	11.7	14.2	22.9	33.0	59.7	63.2	76.5
1974	5.1	9.4	14.2	21.1	34.0	50.3	64.5	72.9	74.4
1975	5.3	8.1	8.9	13.2	17.8	26.4	49.5	74.7	84.8
1976	5.8	6.9	7.6	10.2	12.4	21.6	36.8	43.7	43.7
1977	5.3	7.9	9.1	11.4	21.8	25.7	57.9	71.1	71.1
1978	4.8	9.6	12.6	20.9	25.5	33.7	68.3	72.0	78.7
1979	8.2	13.7	17.3	26.0	34.2	43.8	75.2	79.2	79.6
1980	4.2	8.2	9.0	13.0	17.3	25.1	34.6	41.9	49.6
1981	5.8	6.3	6.9	8.7	13.7	17.9	32.4	46.1	54.5
1982	6.0	11.3	13.7	18.5	19.3	27.9	39.2	61.6	76.7
1983	7.8	11.8	14.1	19.7	27.4	40.4	76.7	89.9	98.6
1984	4.8	9.0	11.3	17.7	31.9	40.6	65.0	67.7	101.5
1985	5.8	6.7	7.5	11.0	14.2	27.6	47.0	54.2	54.4
1986	7.4	9.3	9.3	9.3	13.3	18.9	44.0	52.0	71.9
1987	4.4	7.6	10.9	18.4	32.2	49.8	62.8	62.8	62.8
1988	5.4	6.5	7.6	14.0	22.2	29.2	55.5	80.5	92.8
1989	5.0	7.3	9.2	14.0	22.5	42.2	66.0	71.1	71.1
1990	5.6	7.3	10.3	18.3	31.6	42.0	47.9	56.8	67.6
1991	5.7	6.8	8.6	14.8	22.3	30.7	52.6	53.8	53.8
1992	9.9	12.2	12.9	16.1	24.6	33.4	39.2	71.4	97.2
1993	8.1	16.2	20.2	26.3	30.3	33.4	45.7	54.6	55.2
1994	4.7	6.8	9.9	12.7	25.1	38.3	53.8	58.2	85.0
1995	5.2	6.7	9.6	19.1	32.7	58.0	95.5	111.5	116.1
1996	5.0	7.9	9.9	14.7	22.0	27.6	37.1	48.8	58.2
2007	6.0	12.0	18.0	28.8	28.8	32.4	64.9	81.4	107.6
2008	4.6	9.0	11.4	17.0	23.0	27.2	34.4	51.8	61.6
2009	6.4	9.0	10.8	21.0	24.4	45.2	65.8	71.2	71.2
2012	3.8	6.6	9.6	15.8	28.2	41.4	62.0	71.4	76.8
2013	7.0	14.0	20.4	29.8	41.0	42.2	48.6	63.2	64.2
# Yrs.	33	33	33	33	33	33	33	33	33

Années									
Mean	5.7	9.0	11.2	16.7	24.2	34.1	53.9	65.0	74.1
Moyenne									
Std. Dev.	1.4	2.5	3.5	5.3	6.9	9.8	14.7	15.1	18.4
Écart-type									
Skew.	1.25	1.14	1.28	0.89	0.25	0.36	0.51	0.76	0.54
Dissymétrie									
Kurtosis	4.95	4.05	4.37	3.62	2.90	2.90	3.70	4.56	2.83

*-99.9 Indicates Missing Data/Données manquantes

****

Table 2a: Return Period Rainfall Amounts (mm)
Quantité de pluie (mm) par période de retour

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
5 min	5.5	6.7	7.5	8.5	9.2	10.0	33
10 min	8.5	10.8	12.3	14.1	15.5	16.9	33
15 min	10.6	13.8	15.8	18.5	20.4	22.3	33
30 min	15.8	20.5	23.7	27.6	30.5	33.4	33
1 h	23.0	29.2	33.2	38.4	42.2	45.9	33
2 h	32.5	41.1	46.8	54.1	59.4	64.7	33
6 h	51.5	64.5	73.1	84.0	92.0	100.0	33
12 h	62.5	75.9	84.7	95.9	104.2	112.5	33
24 h	71.0	87.3	98.1	111.7	121.9	131.9	33

****

Table 2b :

Return Period Rainfall Rates (mm/h) - 95% Confidence limits
Intensité de la pluie (mm/h) par période de retour - Limites de confiance de 95%

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
5 min	65.4	79.9	89.5	101.6	110.6	119.5	33
	+/- 5.1	+/- 8.6	+/- 11.7	+/- 15.7	+/- 18.8	+/- 21.9	33
10 min	51.2	64.7	73.6	84.9	93.2	101.5	33
	+/- 4.8	+/- 8.0	+/- 10.9	+/- 14.6	+/- 17.5	+/- 20.4	33
15 min	42.6	55.1	63.4	73.8	81.6	89.2	33
	+/- 4.4	+/- 7.5	+/- 10.1	+/- 13.6	+/- 16.2	+/- 18.9	33
30 min	31.7	41.1	47.3	55.2	61.1	66.9	33
	+/- 3.3	+/- 5.6	+/- 7.6	+/- 10.3	+/- 12.3	+/- 14.3	33
1 h	23.0	29.2	33.2	38.4	42.2	45.9	33
	+/- 2.2	+/- 3.7	+/- 4.9	+/- 6.7	+/- 8.0	+/- 9.3	33
2 h	16.2	20.6	23.4	27.0	29.7	32.4	33
	+/- 1.5	+/- 2.6	+/- 3.5	+/- 4.7	+/- 5.6	+/- 6.5	33
6 h	8.6	10.8	12.2	14.0	15.3	16.7	33
	+/- 0.8	+/- 1.3	+/- 1.7	+/- 2.4	+/- 2.8	+/- 3.3	33
12 h	5.2	6.3	7.1	8.0	8.7	9.4	33
	+/- 0.4	+/- 0.7	+/- 0.9	+/- 1.2	+/- 1.5	+/- 1.7	33
24 h	3.0	3.6	4.1	4.7	5.1	5.5	33
	+/- 0.2	+/- 0.4	+/- 0.5	+/- 0.7	+/- 0.9	+/- 1.0	33

****

Table 3: Interpolation Equation / Équation d'interpolation: R = A*T^B

R = Interpolated Rainfall rate (mm/h)/Intensité interpolée de la pluie (mm/h)
RR = Rainfall rate (mm/h) / Intensité de la pluie (mm/h)
T = Rainfall duration (h) / Durée de la pluie (h)

****

Statistics/Statistiques	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans
Mean of RR/Moyenne de RR	27.4	34.6	39.3	45.3	49.7	54.1
Std. Dev. /Écart-type (RR)	21.9	27.3	30.9	35.4	38.8	42.2
Std. Error/Erreur-type	4.9	7.5	9.3	11.5	13.1	14.8
Coefficient (A)	20.3	25.5	29.0	33.3	36.6	39.8
Exponent/Exposant (B)	-0.538	-0.543	-0.546	-0.548	-0.549	-0.550
Mean % Error/% erreur moyenne	10.2	11.7	12.5	13.3	13.8	14.2

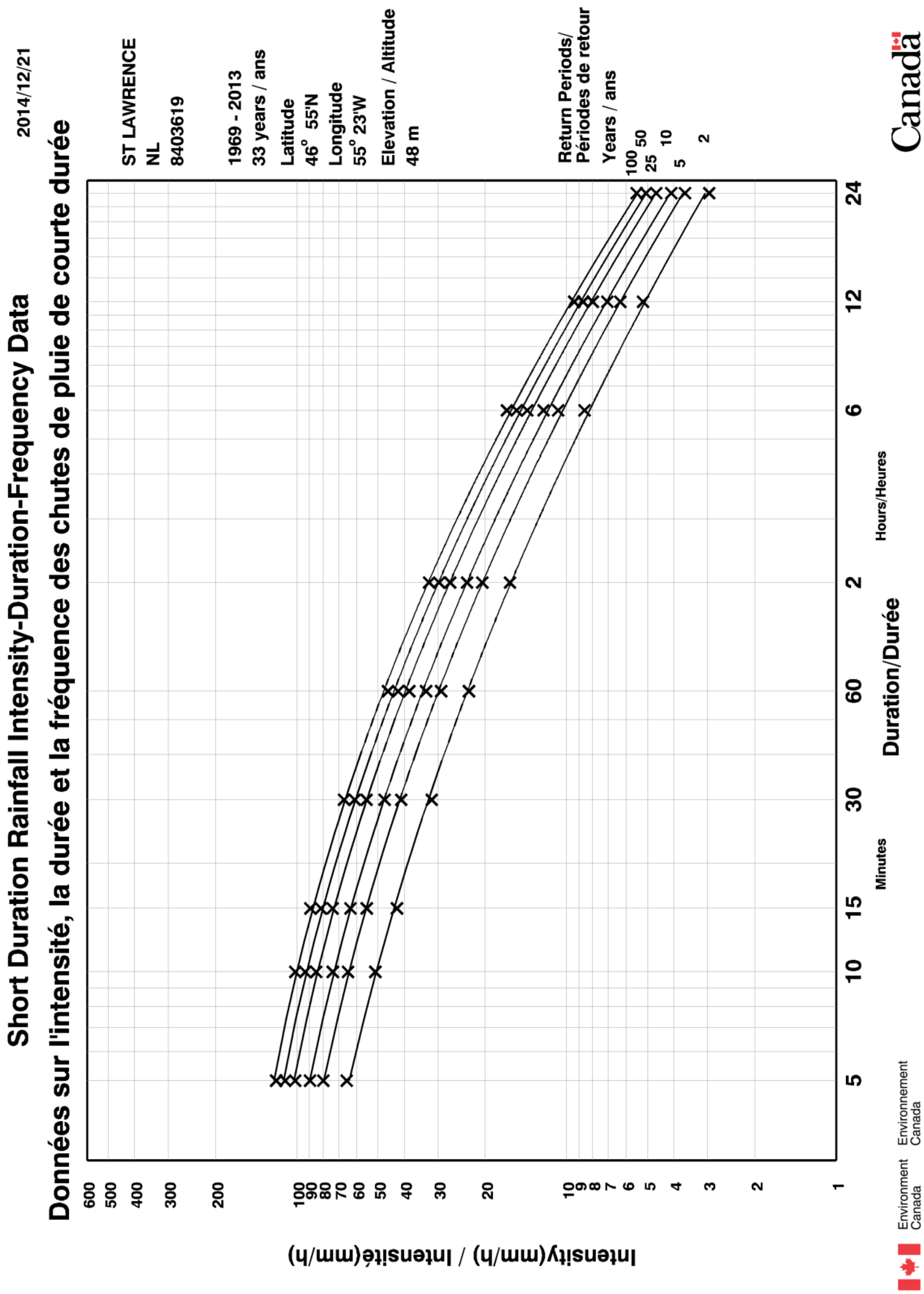

Figure 13.1 St Lawrence IDF Curve – EC-IDF V2.3

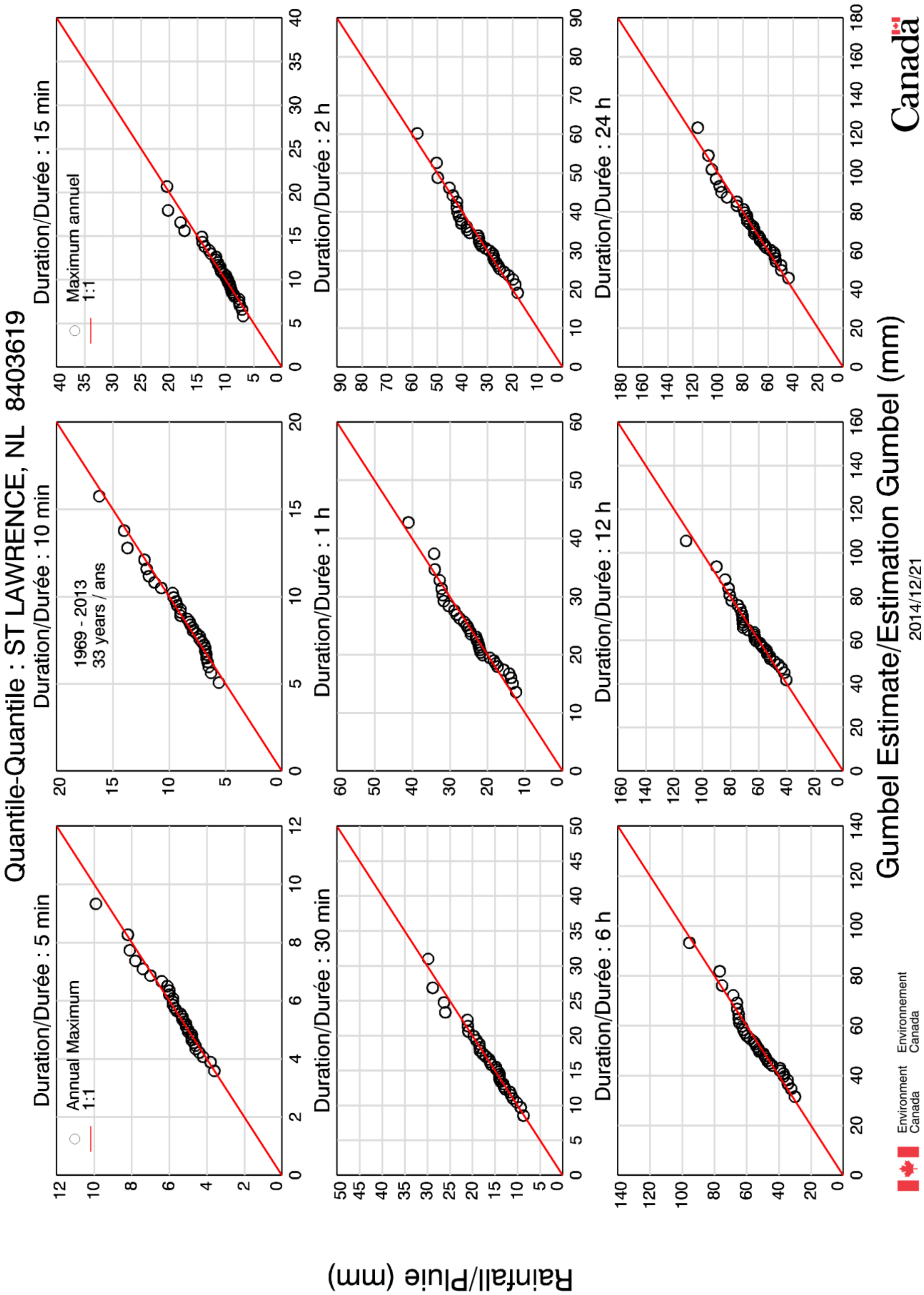

Figure 13.2 St Lawrence Quantile-Quantile Plot – EC-IDF V2.3

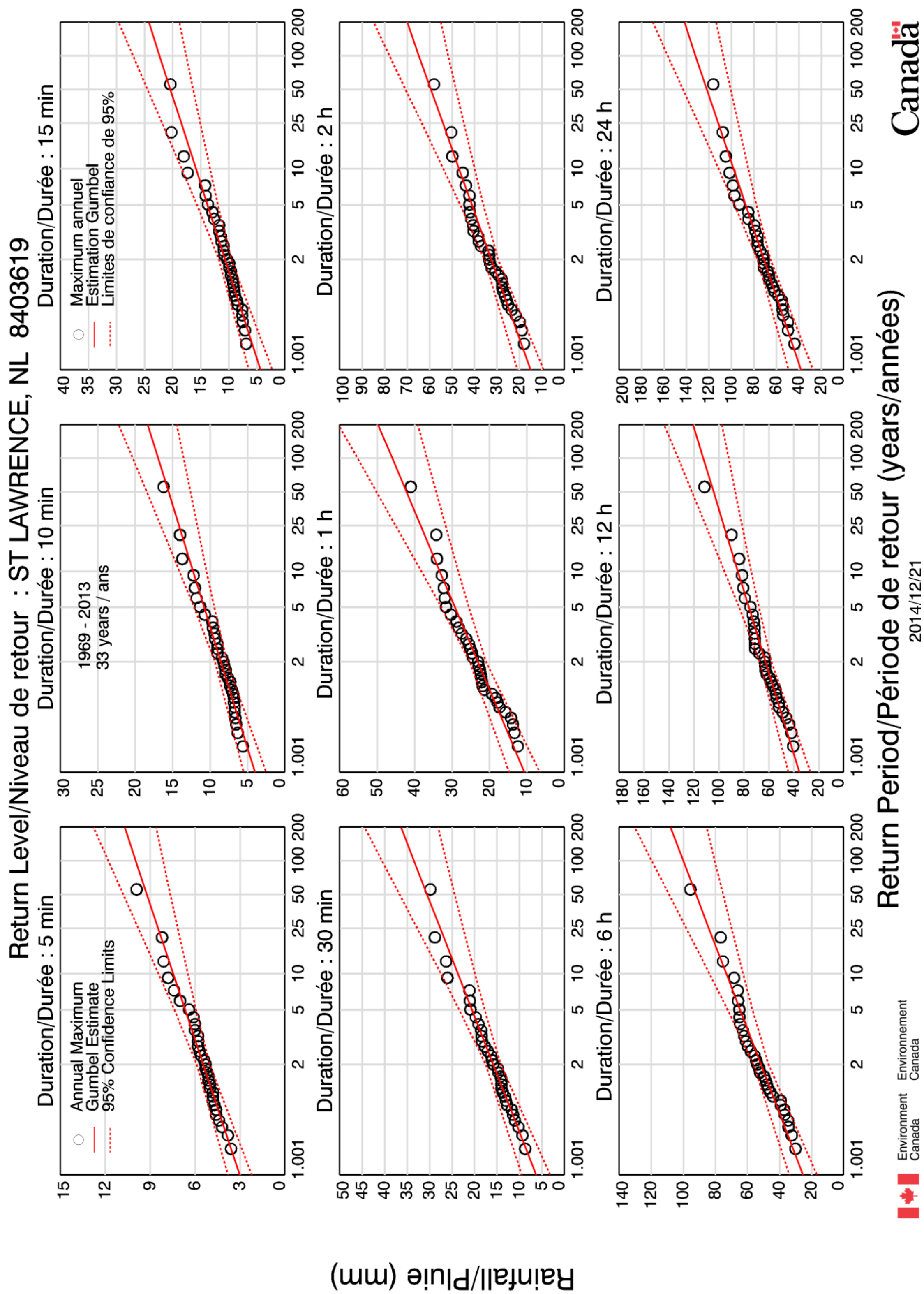

Figure 13.3 St Lawrence Return Level Plot – EC-IDF V2.3

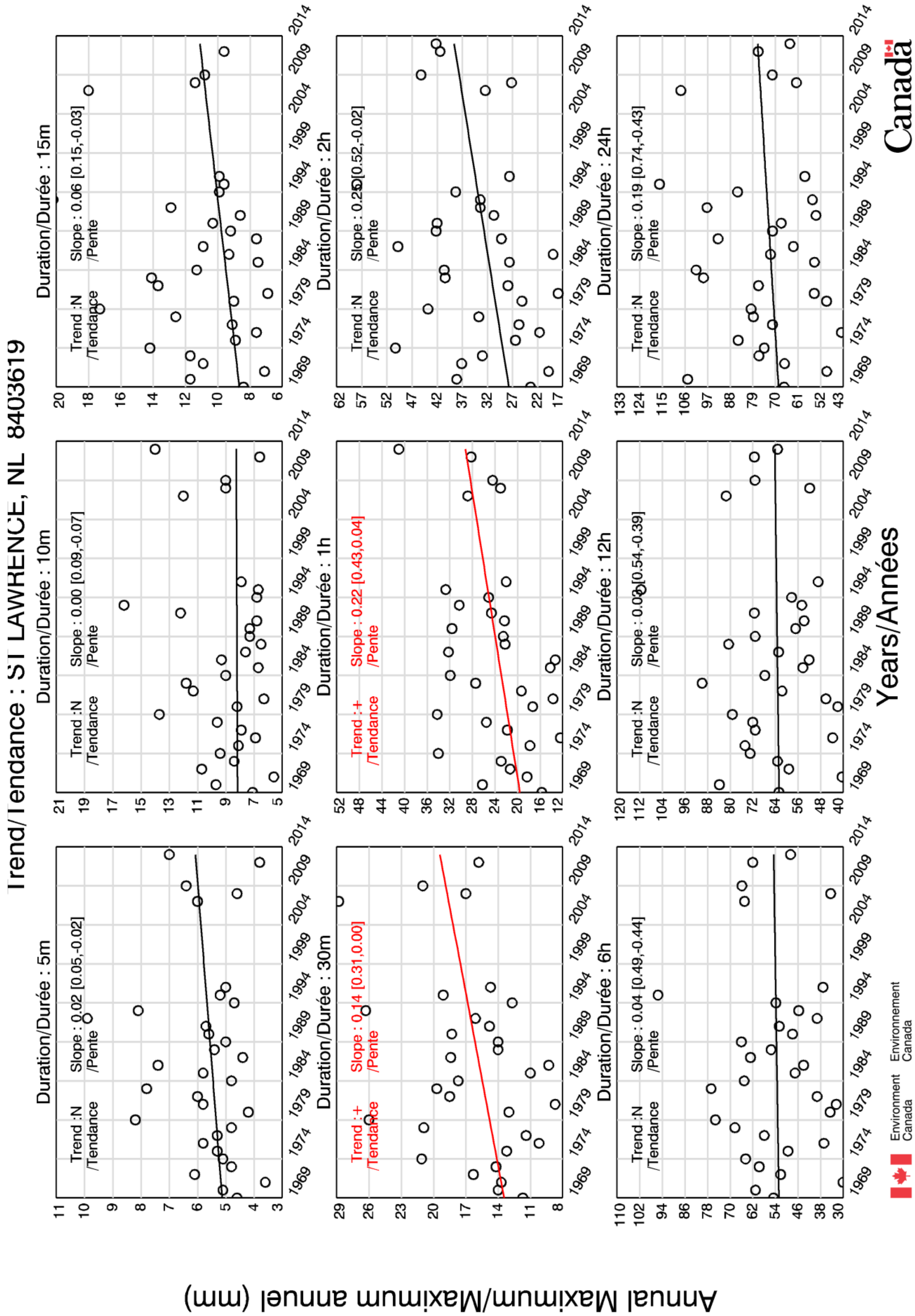

Figure 13.4 St Lawrence Trend Plot – EC-IDF V2.3

Section 14.0 Stephenville A – EC-IDF V2.3

This station was not updated during this project. This is the EC IDF curve (V2.3, 2015).

Environment Canada/Environnement Canada

Short Duration Rainfall Intensity-Duration-Frequency Data
Données sur l'intensité, la durée et la fréquence des chutes
de pluie de courte durée

Gumbel - Method of moments/Méthode des moments

2014/12/21

===

STEPHENVILLE A NL 8403800

Latitude: 48 32'N Longitude: 58 33'W Elevation/Altitude: 24 m

Years/Années : 1967 - 2012 # Years/Années : 43

****

Table 1: Annual Maximum (mm)/Maximum annuel (mm)

****

Year Année	5 min	10 min	15 min	30 min	1 h	2 h	6 h	12 h	24 h
1967	4.3	7.9	8.9	14.0	18.0	18.5	25.4	38.6	51.8
1968	4.1	6.9	8.1	8.6	14.0	17.0	36.6	52.8	70.6
1969	2.3	3.3	4.1	5.8	7.6	14.5	29.7	48.3	58.4
1970	4.8	8.6	8.6	9.1	14.0	21.6	39.6	41.4	54.9
1971	3.8	5.6	7.9	11.2	16.8	21.6	37.6	47.5	57.4
1972	6.1	7.4	9.1	12.7	15.7	25.1	40.9	43.4	48.8
1973	2.8	5.3	7.1	10.7	20.6	37.6	49.0	52.8	89.7
1974	3.3	4.3	6.6	11.4	18.5	25.7	47.0	60.5	63.0
1975	5.6	8.6	9.4	9.9	14.5	16.3	32.8	36.3	41.1
1976	3.0	5.3	6.6	7.9	10.4	13.5	22.9	33.8	36.6
1978	2.3	3.3	4.6	7.9	11.2	17.3	23.5	34.3	42.0
1979	5.1	10.1	13.6	16.7	22.6	33.5	74.4	87.5	98.0
1980	4.6	6.4	7.8	11.4	18.0	19.6	36.3	44.4	59.4
1981	3.1	5.0	5.5	7.3	10.4	16.0	31.1	34.0	52.1
1982	3.3	4.0	5.4	6.6	11.1	14.2	30.0	35.7	44.8
1983	3.8	6.0	7.4	10.0	14.6	20.9	45.3	52.2	82.4
1984	4.5	5.5	6.8	10.2	13.8	18.2	28.1	41.1	63.2
1985	2.9	5.5	6.4	8.0	9.9	13.3	23.0	31.8	32.6
1986	3.6	6.2	7.3	10.4	16.8	22.3	23.7	33.8	46.1
1987	4.6	7.8	9.4	14.0	18.0	27.4	41.0	44.0	49.9
1988	6.5	10.8	14.2	21.7	22.2	22.4	53.1	56.0	56.0
1989	4.4	7.9	9.7	11.5	17.7	29.6	47.1	59.5	97.5
1990	9.4	18.7	23.2	33.2	41.5	46.3	51.5	54.6	88.9
1991	3.8	5.9	6.8	8.8	13.4	23.6	46.4	52.8	55.9
1993	6.8	11.7	14.8	20.7	21.6	25.4	32.4	42.2	56.5
1994	3.8	6.2	6.4	10.6	17.1	18.1	31.5	54.8	69.4
1995	7.9	8.8	10.8	14.0	26.0	45.3	82.5	97.6	134.5
1996	3.4	6.4	9.3	17.7	23.1	30.1	47.8	67.1	68.4
1997	6.1	8.8	9.9	13.8	14.5	17.1	24.7	31.4	46.0
1998	6.8	12.9	16.3	19.9	24.6	30.3	38.2	41.6	52.5
1999	5.1	5.1	6.5	10.8	18.2	25.1	32.8	37.9	40.4
2000	4.2	6.1	8.1	12.0	14.2	24.2	45.5	48.7	58.8
2001	3.5	4.0	5.0	8.5	12.7	18.3	33.5	40.4	57.9

2002	4.4	6.2	8.6	13.8	19.6	25.2	58.0	59.4	60.5
2003	6.1	7.1	10.7	14.7	16.0	19.9	36.6	41.0	52.7
2004	3.4	4.8	6.0	8.5	13.5	21.8	33.6	39.9	65.3
2005	4.8	6.2	9.0	13.2	14.6	24.4	60.3	106.6	138.4
2006	5.1	5.9	8.1	11.4	21.2	24.1	35.8	50.6	55.5
2007	5.4	5.8	8.4	11.2	13.6	20.6	43.3	47.9	62.6
2008	4.2	4.2	5.6	9.4	13.2	24.8	53.4	56.6	57.2
2009	12.4	14.4	14.8	21.0	37.1	37.1	50.2	53.4	53.4
2010	4.4	6.0	8.0	13.4	18.2	22.0	26.2	41.4	47.9
2012	4.5	8.1	10.4	23.2	26.8	32.7	40.8	49.2	68.8
# Yrs. Années	43	43	43	43	43	43	43	43	43
Mean Moyenne	4.8	7.1	8.9	12.7	17.6	23.8	40.1	49.4	62.5
Std. Dev. Écart-type	1.9	3.0	3.6	5.3	6.6	7.7	13.1	16.0	22.2
Skew. Dissymétrie	2.00	1.88	1.93	1.79	1.74	1.22	1.16	1.99	1.93
Kurtosis	8.84	7.68	8.22	7.39	7.39	4.70	5.01	7.76	7.39

*-99.9 Indicates Missing Data/Données manquantes

Warning: annual maximum amount greater than 100-yr return period amount
Avertissement : la quantité maximale annuelle excède la quantité pour une période de retour de 100 ans

Year/Année	Duration/Durée	Data/Données	100-yr/ans
1990	10 min	18.7	16.6
1990	15 min	23.2	20.1
1990	30 min	33.2	29.3
1990	1 h	41.5	38.2
1995	6 h	82.5	81.2
1995	24 h	134.5	132.1
2005	12 h	106.6	99.6
2005	24 h	138.4	132.1
2009	5 min	12.4	10.7

****

Table 2a: Return Period Rainfall Amounts (mm)
Quantité de pluie (mm) par période de retour

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
5 min	4.4	6.1	7.2	8.6	9.6	10.7	43
10 min	6.6	9.3	11.0	13.3	14.9	16.6	43
15 min	8.3	11.4	13.5	16.2	18.2	20.1	43
30 min	11.8	16.5	19.6	23.5	26.4	29.3	43
1 h	16.5	22.3	26.2	31.0	34.6	38.2	43
2 h	22.5	29.3	33.8	39.5	43.7	47.9	43
6 h	37.9	49.5	57.2	66.9	74.1	81.2	43
12 h	46.8	60.9	70.3	82.1	90.9	99.6	43
24 h	58.9	78.5	91.4	107.8	120.0	132.1	43

****

Table 2b:

Return Period Rainfall Rates (mm/h) - 95% Confidence limits
Intensité de la pluie (mm/h) par période de retour - Limites de confiance de 95%

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années

5 min	53.3	73.3	86.6	103.3	115.7	128.1	43
	+/- 6.2	+/- 10.5	+/- 14.1	+/- 19.1	+/- 22.8	+/- 26.6	43
10 min	39.6	55.6	66.2	79.6	89.5	99.4	43
	+/- 5.0	+/- 8.4	+/- 11.3	+/- 15.2	+/- 18.2	+/- 21.2	43
15 min	33.1	45.8	54.2	64.8	72.7	80.5	43
	+/- 3.9	+/- 6.6	+/- 9.0	+/- 12.1	+/- 14.5	+/- 16.8	43
30 min	23.7	33.0	39.2	47.0	52.8	58.6	43
	+/- 2.9	+/- 4.9	+/- 6.6	+/- 8.9	+/- 10.6	+/- 12.4	43
1 h	16.5	22.3	26.2	31.0	34.6	38.2	43
	+/- 1.8	+/- 3.0	+/- 4.1	+/- 5.5	+/- 6.6	+/- 7.7	43
2 h	11.3	14.7	16.9	19.8	21.9	24.0	43
	+/- 1.1	+/- 1.8	+/- 2.4	+/- 3.2	+/- 3.9	+/- 4.5	43
6 h	6.3	8.3	9.5	11.1	12.3	13.5	43
	+/- 0.6	+/- 1.0	+/- 1.4	+/- 1.8	+/- 2.2	+/- 2.6	43
12 h	3.9	5.1	5.9	6.8	7.6	8.3	43
	+/- 0.4	+/- 0.6	+/- 0.8	+/- 1.1	+/- 1.3	+/- 1.6	43
24 h	2.5	3.3	3.8	4.5	5.0	5.5	43
	+/- 0.3	+/- 0.4	+/- 0.6	+/- 0.8	+/- 0.9	+/- 1.1	43

****

Table 3: Interpolation Equation / Équation d'interpolation: R = A*T^B

R = Interpolated Rainfall rate (mm/h)/Intensité interpolée de la pluie (mm/h)
RR = Rainfall rate (mm/h) / Intensité de la pluie (mm/h)
T = Rainfall duration (h) / Durée de la pluie (h)

****

Statistics/Statistiques	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans
Mean of RR/Moyenne de RR	21.1	29.0	34.3	40.9	45.8	50.7
Std. Dev. /Écart-type (RR)	17.7	24.7	29.3	35.2	39.6	43.9
Std. Error/Erreur-type	2.4	3.7	4.6	5.8	6.6	7.5
Coefficient (A)	15.4	20.9	24.5	29.0	32.4	35.7
Exponent/Exposant (B)	-0.542	-0.554	-0.559	-0.564	-0.567	-0.569
Mean % Error/% erreur moyenne	6.2	5.8	5.7	5.5	5.5	5.6

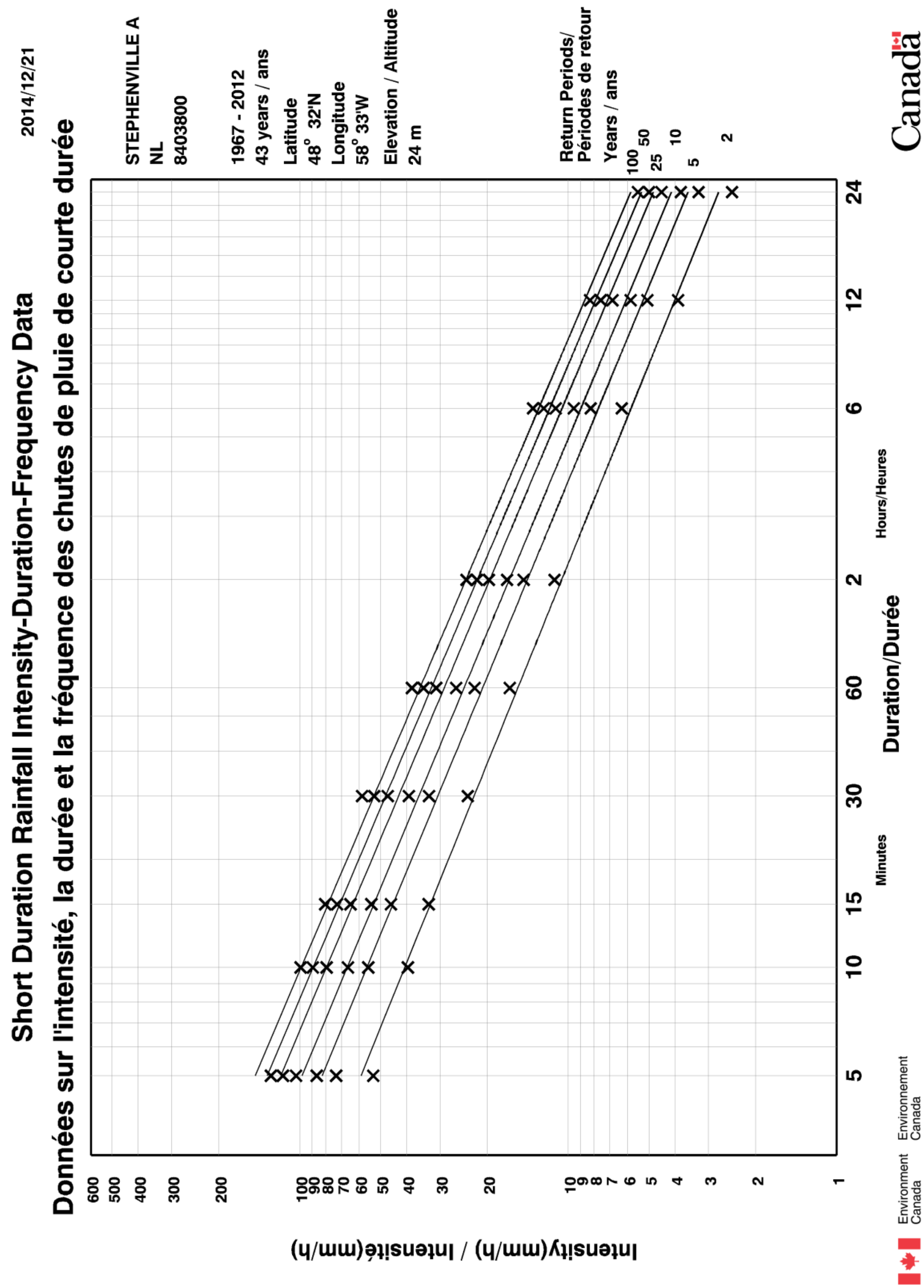

Figure 14.1 Stephenville A IDF Curve – EC-IDF V2.3

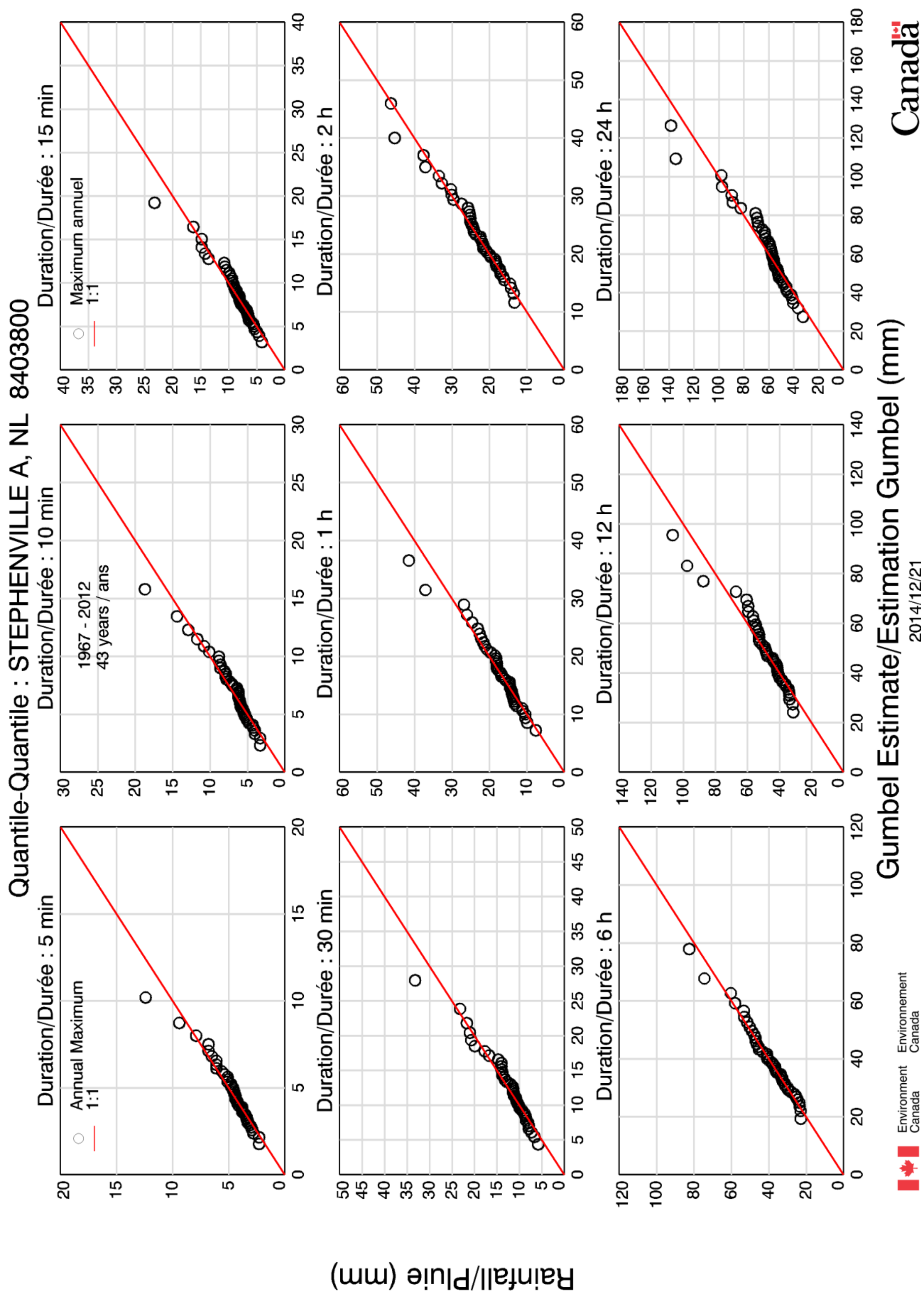

Figure 14.2 Stephenville A Quantile-Quantile Plot – EC-IDF V2.3

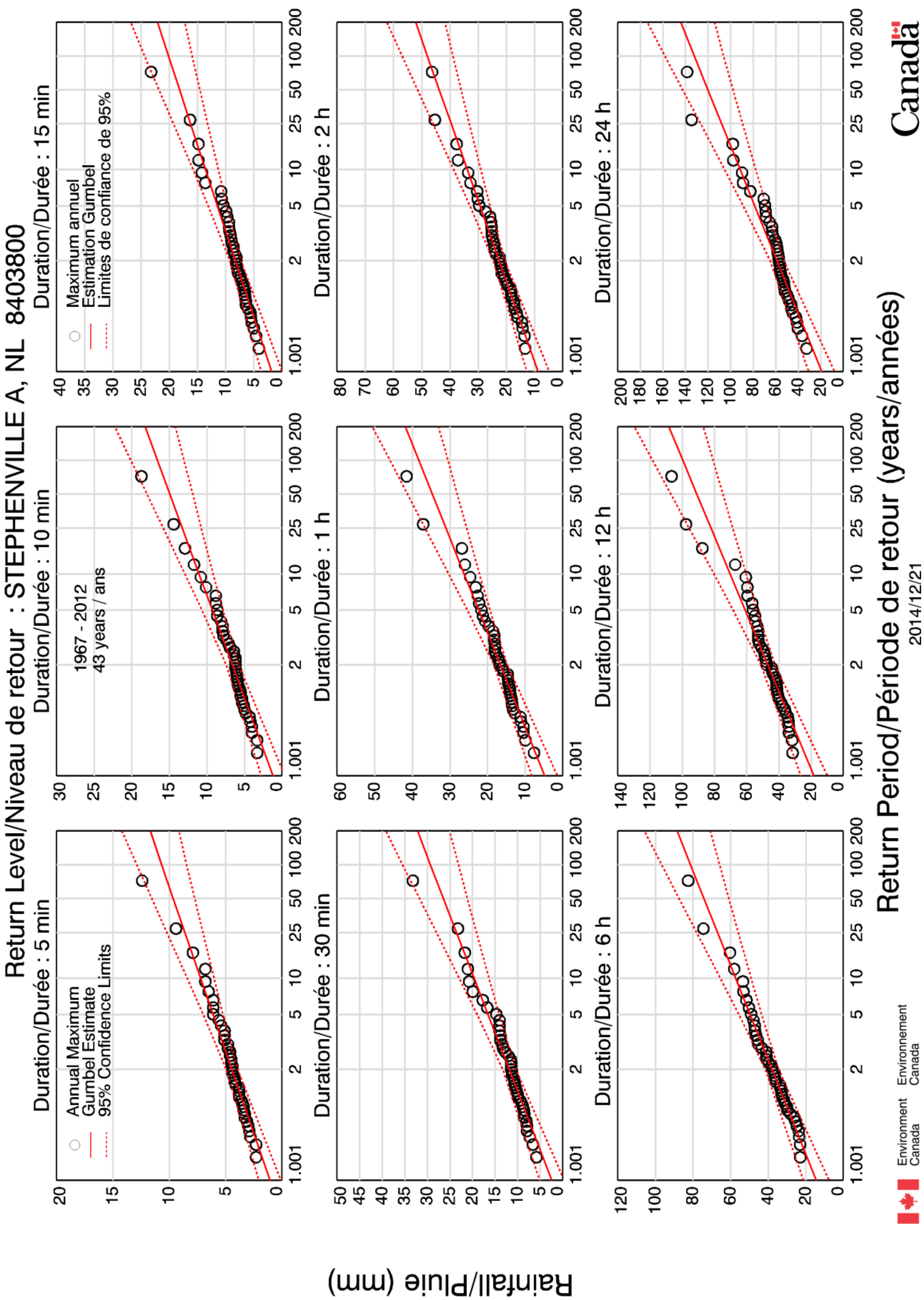

Figure 14.3 Stephenville A Return Level Plot – EC-IDF V2.3

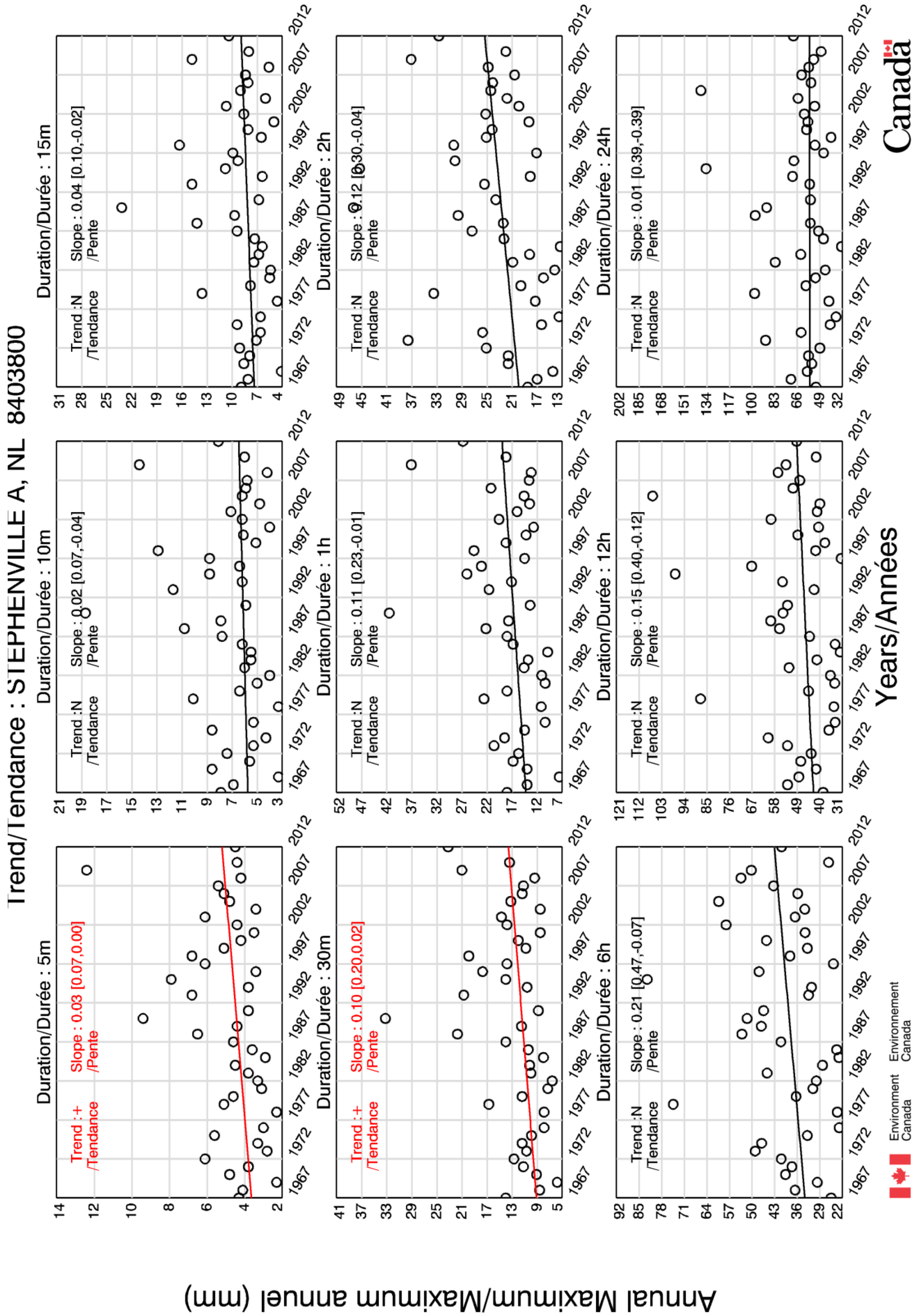

Figure 14.4 Stephenville A Trend Plot – EC-IDF V2.3

Section 15.0 Churchill Falls A

The IDF curve for Churchill Falls A station was updated using 6-hr weighing gauge data at Churchill Falls (8501130) and Churchill Falls A (8501131). The 6-, 12-, and 24-hr durations were updated

Table 15.1 presents the changes between the updated IDF curve and the EC-IDF V2.3 curve.

Table 15.1 Differences Between IDF Curves for Churchill Falls A

Percent Difference in Precipitation Amount [%] (Difference in Precipitation Amount [mm])						
	Return Period [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	N/A	N/A	N/A	N/A	N/A	N/A
10-min	N/A	N/A	N/A	N/A	N/A	N/A
15-min	N/A	N/A	N/A	N/A	N/A	N/A
30-min	N/A	N/A	N/A	N/A	N/A	N/A
1-hr	N/A	N/A	N/A	N/A	N/A	N/A
2-hr	N/A	N/A	N/A	N/A	N/A	N/A
6-hr	2.1 (0.4)	4.2 (1.1)	**5.2 (1.5)**	**6.1 (2.1)**	**6.6 (2.5)**	**7.0 (2.9)**
12-hr	4.3 (1.2)	2.1 (0.7)	1.1 (0.4)	0.1 (0.0)	-0.5 (-0.3)	-1.0 (-0.5)
24-hr	3.1 (1.1)	2.6 (1.1)	2.4 (1.2)	2.2 (1.2)	2.1 (1.2)	2.0 (1.3)

Notes:
Red numbers indicate that the updated IDF curve is lower than the EC-IDF V2.3 IDF curve for that duration and return period.
Bold numbers indicate changes greater than 5 percent.

The updated IDF curves for Churchill Falls A are included below.

Office of Climate Change and Energy Efficiency

Short Duration Rainfall Intensity-Duration-Frequency Data
Données sur l'intensité, la durée et la fréquence des chutes de pluie de courte durée

Gumbel - Method of moments/Méthode des moments

2015/03/20

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CHURCHILL FALLS A NL 8501132
Updated with 6-hr data measured at Churchill Falls (8501130): 1994 - 2011
Updated with 6-hr data measured at Churchill Falls A (8501131): 2012 - 2013
Latitude: 53 33'N Longitude: 64 6'W Elevation/Altitude: 439 m
Years/Années : 1969 - 2013 # Years/Années : 23

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Table 1: Annual Maximum (mm)/Maximum annuel (mm)

****

	Year Année	5 min	10 min	15 min	30 min	1 h	2 h	6 h	12 h	24 h
EC-IDF	1969	6.6	7.9	8.4	8.4	9.7	16.0	33.8	44.4	49.3
EC-IDF	1970	3.0	6.1	7.1	9.1	10.2	12.2	21.6	27.9	29.5
EC-IDF	1971	3.0	4.6	5.8	7.1	8.9	10.2	13.5	20.6	28.2
EC-IDF	1972	4.8	5.6	5.8	6.6	10.7	17.5	26.4	31.0	32.8
EC-IDF	1973	4.6	8.4	10.7	12.2	13.7	14.0	21.8	30.7	35.1
EC-IDF	1974	3.8	5.6	5.8	6.1	7.1	9.7	12.7	18.8	29.5
EC-IDF	1975	4.3	5.1	5.3	6.1	9.1	16.5	35.8	53.3	59.9
EC-IDF	1976	5.1	7.4	8.1	9.4	11.2	11.7	19.6	30.7	38.1
EC-IDF	1978	3.7	5.3	5.8	5.8	8.2	12.4	21.9	38.4	48.7
EC-IDF	1979	5.9	6.1	7.3	10.2	11.8	16.5	29.0	33.7	36.8
EC-IDF	1980	2.9	5.2	7.9	13.3	16.0	18.7	20.0	25.6	29.7
EC-IDF	1981	5.8	7.7	10.1	14.3	14.4	16.1	16.9	25.4	39.4
EC-IDF	1982	3.4	3.6	5.1	8.6	14.3	18.4	20.4	24.2	38.6
EC-IDF	1983	3.7	3.7	3.7	6.7	8.6	10.3	18.3	20.7	22.7
EC-IDF	1984	4.9	6.2	8.1	10.3	11.0	13.7	23.7	32.4	43.6
EC-IDF	1985	4.4	4.8	5.1	7.5	8.1	11.5	14.2	22.3	30.9
EC-IDF	1986	8.3	11.7	13.5	14.7	15.0	15.2	23.9	28.2	48.5
EC-IDF	1987	9.6	15.7	18.4	20.2	20.2	21.2	26.0	27.6	33.1
EC-IDF	1988	3.7	3.9	4.8	6.8	7.5	9.7	15.3	24.2	34.6
EC-IDF	1989	6.3	8.0	12.0	16.0	17.2	17.4	18.4	24.7	29.3
EC-IDF	1990	8.6	10.1	10.6	13.3	13.3	13.3	16.5	26.1	36.3
EC-IDF	1991	2.1	3.6	5.1	7.4	9.8	16.4	29.8	34.8	34.8
EC-IDF	1992	2.0	2.5	3.3	3.8	5.1	8.9	16.6	20.1	25.5
UPDATE	1994	NM	NM	NM	NM	NM	NM	-99.9	29.0	36.0
UPDATE	1995	NM	NM	NM	NM	NM	NM	41.0	45.0	66.0
UPDATE	1996	NM	NM	NM	NM	NM	NM	35.0	35.0	38.0
UPDATE	1997	NM	NM	NM	NM	NM	NM	24.0	34.0	41.0
UPDATE	1998	NM	NM	NM	NM	NM	NM	22.0	26.0	29.0
UPDATE	1999	NM	NM	NM	NM	NM	NM	28.0	31.0	35.0
UPDATE	2000	NM	NM	NM	NM	NM	NM	13.0	19.0	29.0
UPDATE	2001	NM	NM	NM	NM	NM	NM	20.0	35.0	36.6
UPDATE	2002	NM	NM	NM	NM	NM	NM	15.0	28.0	30.0
UPDATE	2003	NM	NM	NM	NM	NM	NM	25.0	29.0	36.0
UPDATE	2005	NM	NM	NM	NM	NM	NM	29.0	38.0	40.0
UPDATE	2006	NM	NM	NM	NM	NM	NM	25.0	41.0	48.0
UPDATE	2007	NM	NM	NM	NM	NM	NM	17.0	30.0	37.0

UPDATE 2008	NM	NM	NM	NM	NM	NM	13.0	22.0	33.0
UPDATE 2009	NM	NM	NM	NM	NM	NM	13.0	21.0	31.0
UPDATE 2011	NM	NM	NM	NM	NM	NM	28.0	38.0	50.0
UPDATE 2012	NM	NM	NM	NM	NM	NM	19.0	32.0	38.8
UPDATE 2013	NM	NM	NM	NM	NM	NM	-99.9	33.0	43.5
# Yrs. Années	23	23	23	23	23	23	39	41	41
Mean Moyenne	4.8	6.5	7.7	9.7	11.4	14.2	22.1	30.0	37.4
Std. Dev. Écart-type	2.0	3.0	3.5	4.0	3.7	3.4	7.0	7.6	8.9
Skew. Dissymétrie	0.91	1.55	1.43	0.95	0.63	0.12	0.72	0.84	1.24
Kurtosis	3.65	6.31	5.68	3.83	3.41	2.45	3.29	4.10	5.14

*-99.9 Indicates Missing Data/Données manquantes
* NM Indicates No Measurements/Aucunes mesures

Warning: annual maximum amount greater than 100-yr return period amount
Avertissement : la quantité maximale annuelle excède la quantité pour une période de retour de 100 ans

Year/Année	Duration/Durée	Data/Données	100-yr/ans
1995	24 h	66.0	65.2

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Table 2a: Return Period Rainfall Amounts (mm)
Quantité de pluie (mm) par période de retour

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
EC-IDF 5 min	4.5	6.3	7.4	8.9	10.0	11.1	23
EC-IDF 10 min	6.0	8.6	10.4	12.6	14.2	15.8	23
EC-IDF 15 min	7.1	10.3	12.3	15.0	16.9	18.8	23
EC-IDF 30 min	9.1	12.6	15.0	17.9	20.1	22.3	23
EC-IDF 1 h	10.8	14.0	16.1	18.8	20.8	22.8	23
EC-IDF 2 h	13.7	16.7	18.7	21.2	23.0	24.9	23
UPDATE 6 h	21.0	27.2	31.3	36.5	40.3	44.2	39
UPDATE 12 h	28.8	35.5	40.0	45.6	49.8	54.0	41
UPDATE 24 h	35.9	43.8	49.0	55.5	60.4	65.2	41

* 6-hr data were used for the update: shorter durations were not updated

****

Table 2b:

Return Period Rainfall Rates (mm/h) - 95% Confidence limits
Intensité de la pluie (mm/h) par période de retour - Limites de confiance de 95%

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
EC-IDF 5 min	53.7	75.1	89.3	107.2	120.5	133.7	23
	+/- 9.1	+/- 15.3	+/- 20.7	+/- 27.9	+/- 33.4	+/- 38.9	23
EC-IDF 10 min	35.9	51.7	62.2	75.4	85.2	95.0	23
	+/- 6.7	+/- 11.3	+/- 15.3	+/- 20.6	+/- 24.6	+/- 28.7	23
EC-IDF 15 min	28.6	41.1	49.4	59.8	67.6	75.3	23
	+/- 5.3	+/- 8.9	+/- 12.1	+/- 16.3	+/- 19.5	+/- 22.7	23
EC-IDF 30 min	18.2	25.2	29.9	35.8	40.2	44.6	23
	+/- 3.0	+/- 5.1	+/- 6.8	+/- 9.2	+/- 11.0	+/- 12.8	23
EC-IDF 1 h	10.8	14.0	16.1	18.8	20.8	22.8	23
	+/- 1.4	+/- 2.3	+/- 3.1	+/- 4.2	+/- 5.0	+/- 5.9	23
EC-IDF 2 h	6.8	8.3	9.3	10.6	11.5	12.4	23

```
                 +/-  0.6 +/-  1.1 +/-  1.4 +/-  2.0 +/-  2.3 +/-  2.7       23
*UPDATE*  6 h         3.5       4.5       5.2       6.1       6.7       7.4       39
                 +/-  0.3 +/-  0.6 +/-  0.8 +/-  1.0 +/-  1.2 +/-  1.4       39
*UPDATE* 12 h         2.4       3.0       3.3       3.8       4.2       4.5       41
                 +/-  0.2 +/-  0.3 +/-  0.4 +/-  0.5 +/-  0.7 +/-  0.8       41
*UPDATE* 24 h         1.5       1.8       2.0       2.3       2.5       2.7       41
                 +/-  0.1 +/-  0.2 +/-  0.2 +/-  0.3 +/-  0.4 +/-  0.4       41
     * 6-hr data were used for the update: shorter durations were not updated

********************************************************************************

Table 3: Interpolation Equation / Équation d'interpolation: R = A*T^B

R = Interpolated Rainfall rate (mm/h)/Intensité interpolée de la pluie (mm/h)
RR = Rainfall rate (mm/h) / Intensité de la pluie (mm/h)
 T = Rainfall duration (h) / Durée de la pluie (h)

********************************************************************************
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Statistics/Statistiques	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans
Mean of RR/Moyenne de RR	17.9	25.0	29.6	35.5	39.9	44.3
Std. Dev. /Écart-type (RR)	18.1	25.8	30.9	37.4	42.2	47.0
Std. Error/Erreur-type	0.8	2.2	3.2	4.4	5.3	6.2
Coefficient (A)	11.3	15.0	17.4	20.5	22.8	25.0
Exponent/Exposant (B)	-0.639	-0.669	-0.683	-0.695	-0.702	-0.708
Mean % Error/% erreur moyenne	3.4	5.5	6.6	7.7	8.3	8.8

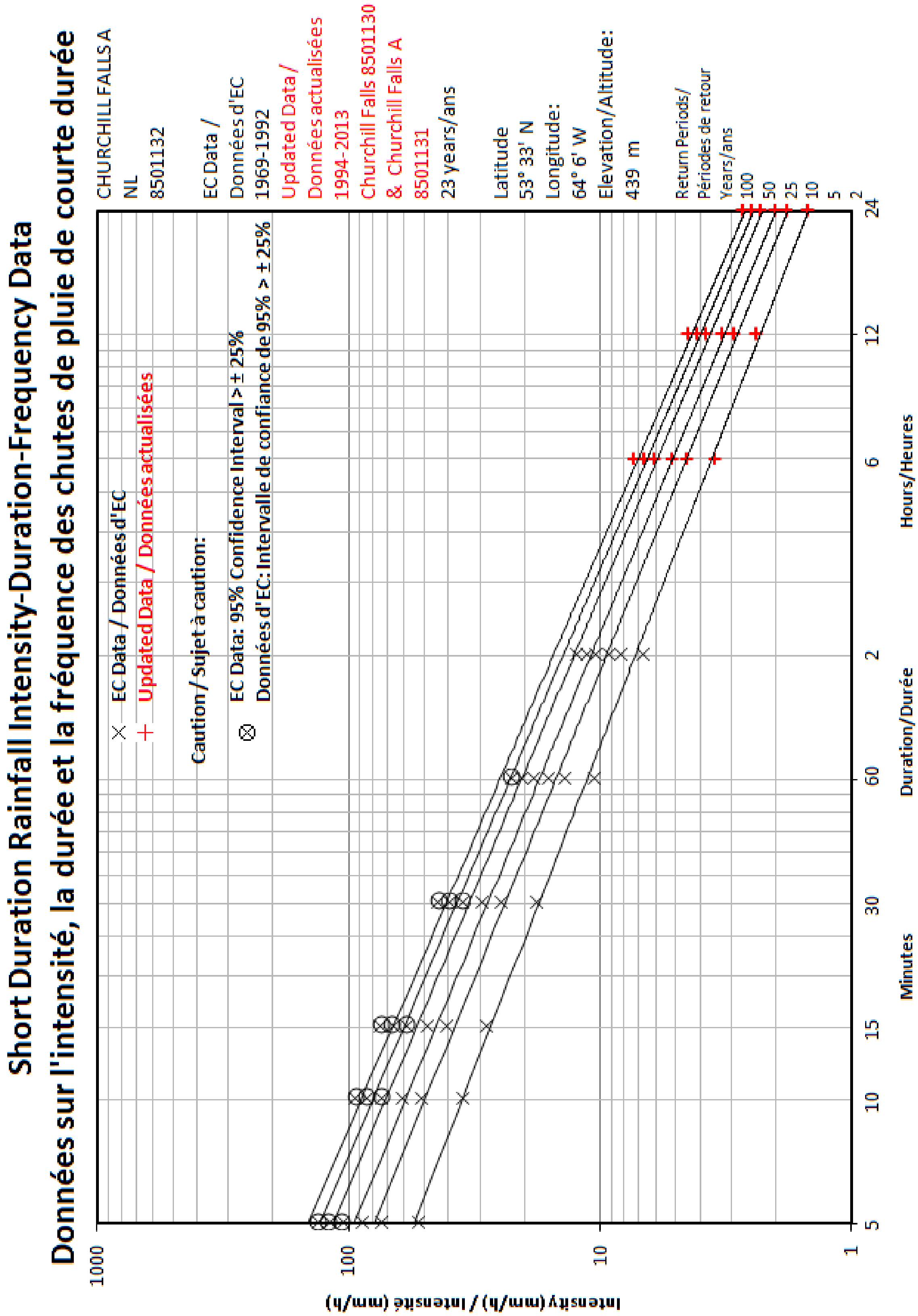

Figure 15.1 Churchill Falls A IDF Curve – Updated

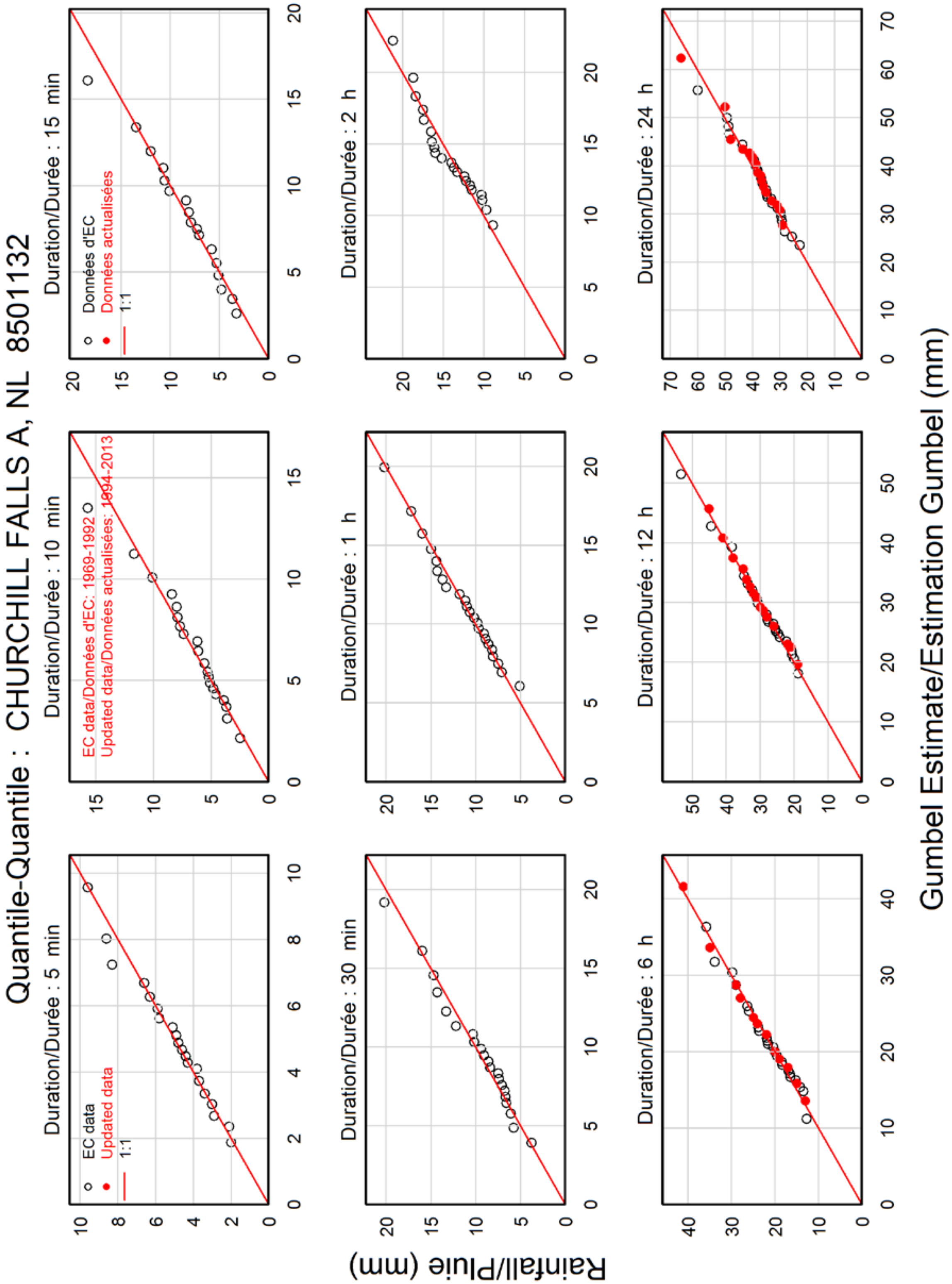

Figure 15.2 Churchill Falls A Quantile-Quantile Plot – Updated

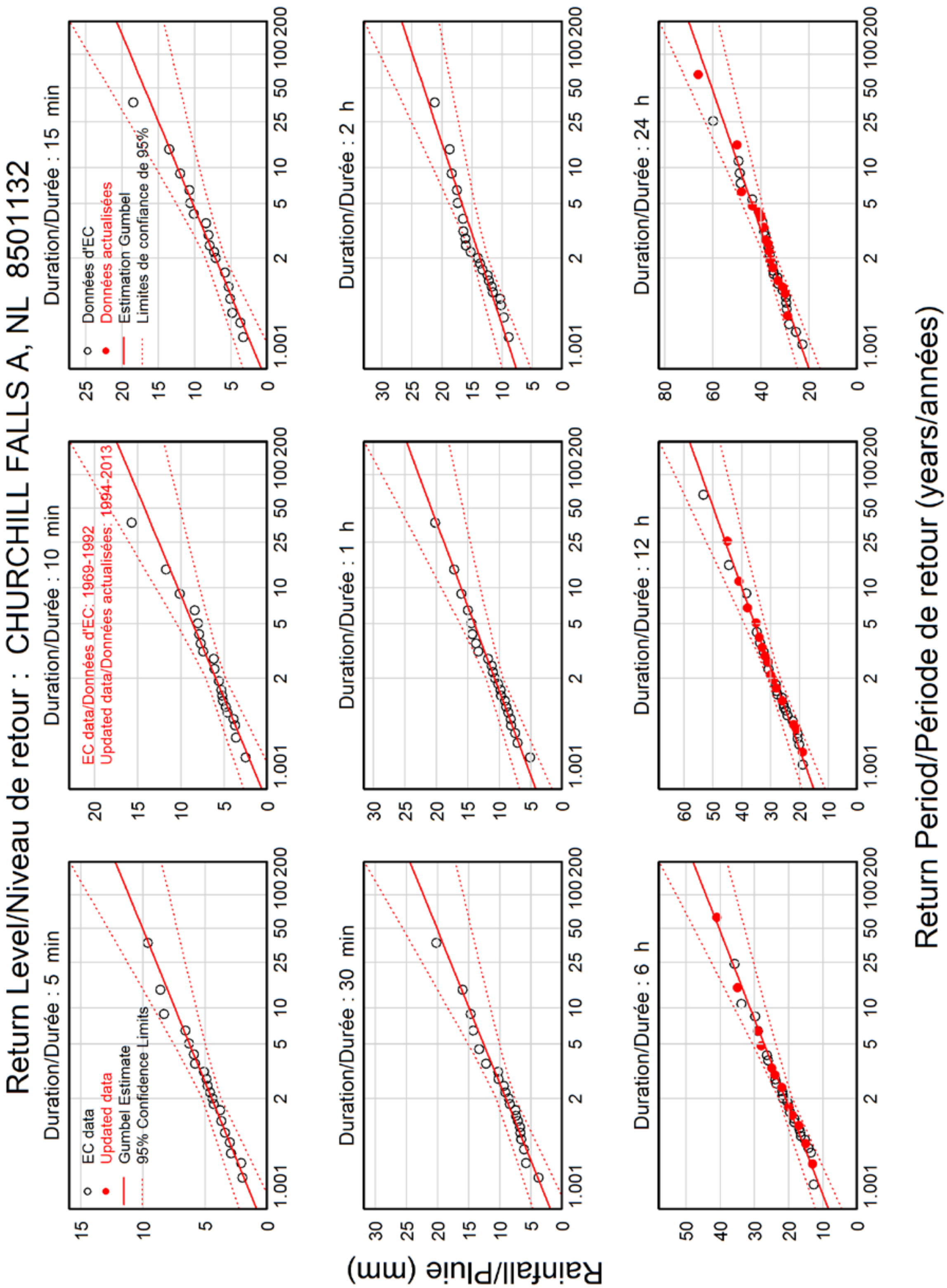

Figure 15.3 Churchill Falls A Return Level Plot – Updated

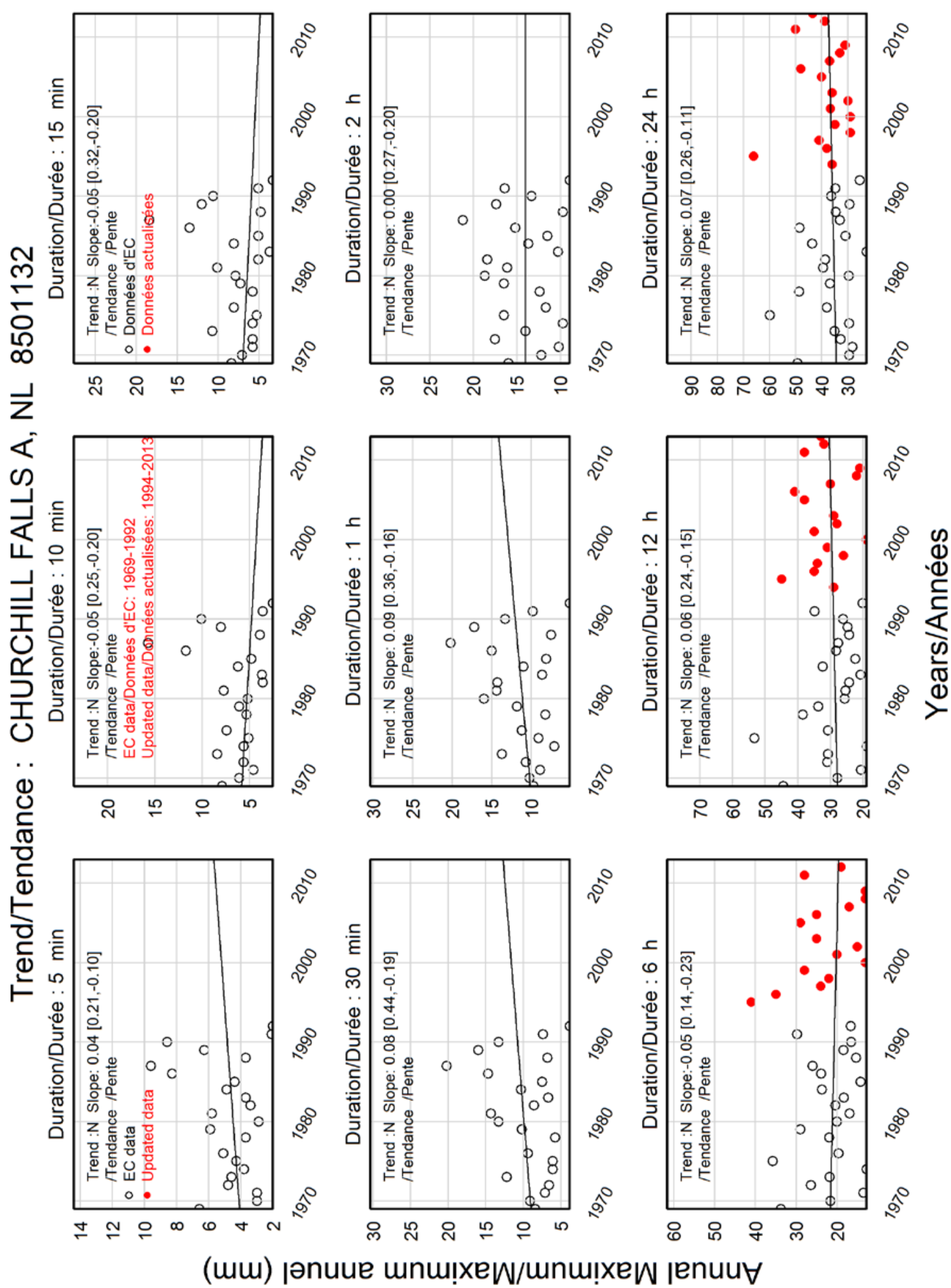

Figure 15.4 Churchill Falls A Trend Plot – Updated

Section 16.0 Goose A – EC-IDF V2.3

This station was not updated during this project. This is the EC IDF curve (V2.3, 2015).

Environment Canada/Environnement Canada

Short Duration Rainfall Intensity-Duration-Frequency Data
Données sur l'intensité, la durée et la fréquence des chutes de pluie de courte durée

Gumbel - Method of moments/Méthode des moments

2014/12/21

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GOOSE A NL 8501900

Latitude: 53 19'N Longitude: 60 25'W Elevation/Altitude: 48 m

Years/Années : 1961 - 2013 # Years/Années : 50

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Table 1: Annual Maximum (mm)/Maximum annuel (mm)

****

Year Année	5 min	10 min	15 min	30 min	1 h	2 h	6 h	12 h	24 h
1961	2.3	4.1	4.1	7.1	8.4	12.7	22.9	37.6	57.4
1962	4.1	5.1	6.3	6.9	6.9	9.9	20.6	33.0	37.8
1963	11.2	20.1	24.6	33.3	35.6	39.1	61.2	67.8	75.2
1966	5.8	11.2	11.4	11.4	11.4	14.2	26.7	44.2	59.9
1967	5.6	8.9	9.1	13.5	15.7	17.3	18.3	24.4	36.8
1968	2.5	3.6	4.3	5.3	8.1	13.5	24.4	31.7	44.7
1969	2.8	5.3	7.6	8.6	15.5	16.3	28.4	37.3	38.1
1970	4.1	6.6	8.9	11.7	15.7	24.4	30.2	36.8	46.2
1971	5.3	7.1	7.9	8.1	8.1	9.4	20.6	29.7	31.7
1972	5.1	7.4	9.1	10.4	14.0	14.2	20.1	31.0	39.6
1973	6.3	9.9	12.4	15.0	19.3	31.7	38.9	40.9	41.1
1974	3.0	4.6	5.1	6.9	10.7	11.2	22.1	33.3	43.9
1975	4.1	5.1	6.1	7.9	9.1	11.7	13.7	18.0	18.8
1976	3.3	3.6	5.6	8.6	10.7	14.2	30.2	44.2	50.3
1977	3.8	4.1	4.1	4.8	6.6	8.1	19.3	27.2	31.2
1978	3.0	3.6	4.6	5.6	8.4	12.1	21.3	26.0	33.8
1979	3.9	4.7	4.7	4.7	8.0	10.6	24.0	30.2	36.3
1980	1.9	3.3	5.2	6.8	8.1	10.6	26.3	33.6	44.3
1981	2.2	4.0	4.8	6.5	10.6	19.4	44.6	60.0	68.0
1982	1.4	1.7	2.5	4.7	8.8	13.9	20.9	22.5	22.8
1983	3.7	7.3	7.3	8.8	10.5	13.0	26.0	32.4	43.6
1984	3.2	4.3	4.9	5.9	8.1	11.1	21.4	24.2	29.5
1985	4.5	5.2	5.4	7.0	8.3	15.3	28.8	40.3	47.3
1986	5.6	9.0	9.8	10.5	11.2	12.5	24.7	32.9	40.9
1987	5.5	6.6	6.8	7.9	11.8	18.2	21.0	31.7	36.4
1988	2.6	3.6	4.0	5.5	7.2	14.3	24.8	28.9	30.8
1989	6.2	6.6	6.6	6.6	7.4	12.6	22.7	35.3	56.6
1990	4.5	7.1	8.3	9.6	9.8	10.8	18.4	23.4	27.2
1991	4.4	8.0	10.4	16.8	17.4	17.4	26.3	37.8	43.2
1992	2.5	3.2	4.0	6.7	8.8	11.1	18.2	25.2	33.1
1993	2.8	4.3	5.0	6.3	10.8	11.9	15.1	24.9	34.1

1994	3.1	4.2	4.7	6.2	12.2	15.1	26.8	34.4	39.8
1995	4.6	5.2	6.3	7.9	13.0	16.9	20.0	22.2	29.8
1996	3.9	5.4	7.4	11.6	15.9	21.5	25.3	34.8	51.1
1997	3.7	5.3	6.2	7.3	10.0	13.3	26.7	39.7	55.1
1998	5.4	10.5	11.9	15.7	15.9	15.9	17.8	25.3	34.3
1999	8.2	11.9	15.8	15.8	18.5	22.3	28.0	43.8	72.2
2000	3.5	4.1	5.7	6.3	8.2	12.2	24.0	29.5	32.2
2001	7.1	7.3	8.7	13.0	13.6	13.6	26.9	35.0	50.6
2002	5.1	6.3	7.1	7.3	8.5	16.1	28.2	41.3	52.5
2003	2.8	4.4	5.4	8.8	9.6	11.2	19.1	22.7	32.9
2004	4.4	7.3	9.9	13.3	14.3	15.9	38.8	40.4	47.7
2005	1.9	2.4	3.2	5.4	9.6	15.6	28.6	31.6	40.6
2006	6.9	10.8	15.0	20.3	20.3	20.3	20.5	26.6	37.1
2007	2.6	4.8	5.4	9.2	11.4	13.4	24.5	30.5	41.9
2008	3.8	6.3	8.2	10.9	16.2	23.1	29.2	45.7	61.6
2009	5.1	7.5	11.3	15.8	17.4	17.6	-99.9	40.4	58.4
2010	8.3	12.3	13.0	13.8	14.4	15.6	21.4	33.5	41.2
2011	5.1	6.1	6.7	7.6	9.0	15.0	22.6	22.6	31.0
2012	2.1	3.1	4.2	4.8	6.0	8.1	18.8	29.2	39.2
2013	3.1	3.7	3.7	4.2	7.2	10.9	24.1	35.8	39.6
# Yrs. Années	51	51	51	51	51	51	50	51	51
Mean Moyenne	4.3	6.2	7.5	9.5	11.8	15.2	25.1	33.6	42.5
Std. Dev. Écart-type	1.9	3.2	3.9	5.0	5.0	5.6	7.8	9.2	12.0
Skew. Dissymétrie	1.30	1.96	2.08	2.44	2.36	2.21	2.51	1.39	0.77
Kurtosis	5.74	9.01	9.47	11.87	11.96	9.82	12.27	6.63	3.65

*-99.9 Indicates Missing Data/Données manquantes

Warning: annual maximum amount greater than 100-yr return period amount
Avertissement : la quantité maximale annuelle excède la quantité pour une période de retour de 100 ans

Year/Année	Duration/Durée	Data/Données	100-yr/ans
1963	5 min	11.2	10.2
1963	10 min	20.1	16.2
1963	15 min	24.6	19.7
1963	30 min	33.3	25.3
1963	1 h	35.6	27.5
1963	2 h	39.1	32.7
1963	6 h	61.2	49.4
1963	12 h	67.8	62.3

****

Table 2a: Return Period Rainfall Amounts (mm)
Quantité de pluie (mm) par période de retour

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
5 min	4.0	5.6	6.7	8.1	9.1	10.2	51
10 min	5.7	8.5	10.4	12.8	14.5	16.2	51
15 min	6.8	10.3	12.6	15.4	17.6	19.7	51
30 min	8.7	13.1	16.1	19.8	22.6	25.3	51
1 h	11.0	15.4	18.3	22.0	24.8	27.5	51
2 h	14.3	19.2	22.5	26.6	29.6	32.7	51
6 h	23.8	30.7	35.2	40.9	45.2	49.4	50
12 h	32.1	40.1	45.5	52.3	57.3	62.3	51
24 h	40.6	51.2	58.2	67.1	73.7	80.3	51

****

Table 2b:

Return Period Rainfall Rates (mm/h) - 95% Confidence limits
Intensité de la pluie (mm/h) par période de retour - Limites de confiance de 95%

****

Duration/Durée		2 yr/ans		5 yr/ans		10 yr/ans		25 yr/ans		50 yr/ans		100 yr/ans	#Years Années
5 min		47.6		67.5		80.6		97.3		109.6		121.9	51
	+/-	5.7	+/-	9.6	+/-	12.9	+/-	17.4	+/-	20.8	+/-	24.2	51
10 min		34.3		51.2		62.4		76.6		87.1		97.5	51
	+/-	4.8	+/-	8.1	+/-	11.0	+/-	14.8	+/-	17.7	+/-	20.6	51
15 min		27.3		41.1		50.2		61.8		70.3		78.8	51
	+/-	3.9	+/-	6.6	+/-	8.9	+/-	12.1	+/-	14.4	+/-	16.8	51
30 min		17.3		26.3		32.2		39.6		45.2		50.7	51
	+/-	2.5	+/-	4.3	+/-	5.8	+/-	7.8	+/-	9.3	+/-	10.9	51
1 h		11.0		15.4		18.3		22.0		24.8		27.5	51
	+/-	1.3	+/-	2.1	+/-	2.9	+/-	3.9	+/-	4.6	+/-	5.4	51
2 h		7.2		9.6		11.2		13.3		14.8		16.3	51
	+/-	0.7	+/-	1.2	+/-	1.6	+/-	2.1	+/-	2.6	+/-	3.0	51
6 h		4.0		5.1		5.9		6.8		7.5		8.2	50
	+/-	0.3	+/-	0.6	+/-	0.7	+/-	1.0	+/-	1.2	+/-	1.4	50
12 h		2.7		3.3		3.8		4.4		4.8		5.2	51
	+/-	0.2	+/-	0.3	+/-	0.4	+/-	0.6	+/-	0.7	+/-	0.8	51
24 h		1.7		2.1		2.4		2.8		3.1		3.3	51
	+/-	0.1	+/-	0.2	+/-	0.3	+/-	0.4	+/-	0.5	+/-	0.5	51

****

Table 3: Interpolation Equation / Équation d'interpolation: R = A*T^B

R = Interpolated Rainfall rate (mm/h)/Intensité interpolée de la pluie (mm/h)
RR = Rainfall rate (mm/h) / Intensité de la pluie (mm/h)
T = Rainfall duration (h) / Durée de la pluie (h)

****

Statistics/Statistiques	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans
Mean of RR/Moyenne de RR	17.0	24.6	29.7	36.1	40.8	45.5
Std. Dev. /Écart-type (RR)	16.1	23.6	28.6	34.9	39.6	44.2
Std. Error/Erreur-type	1.1	3.5	5.1	7.2	8.8	10.4
Coefficient (A)	11.4	15.8	18.7	22.4	25.2	27.9
Exponent/Exposant (B)	-0.595	-0.629	-0.643	-0.656	-0.663	-0.669
Mean % Error/% erreur moyenne	3.2	4.7	5.3	6.1	6.5	6.9

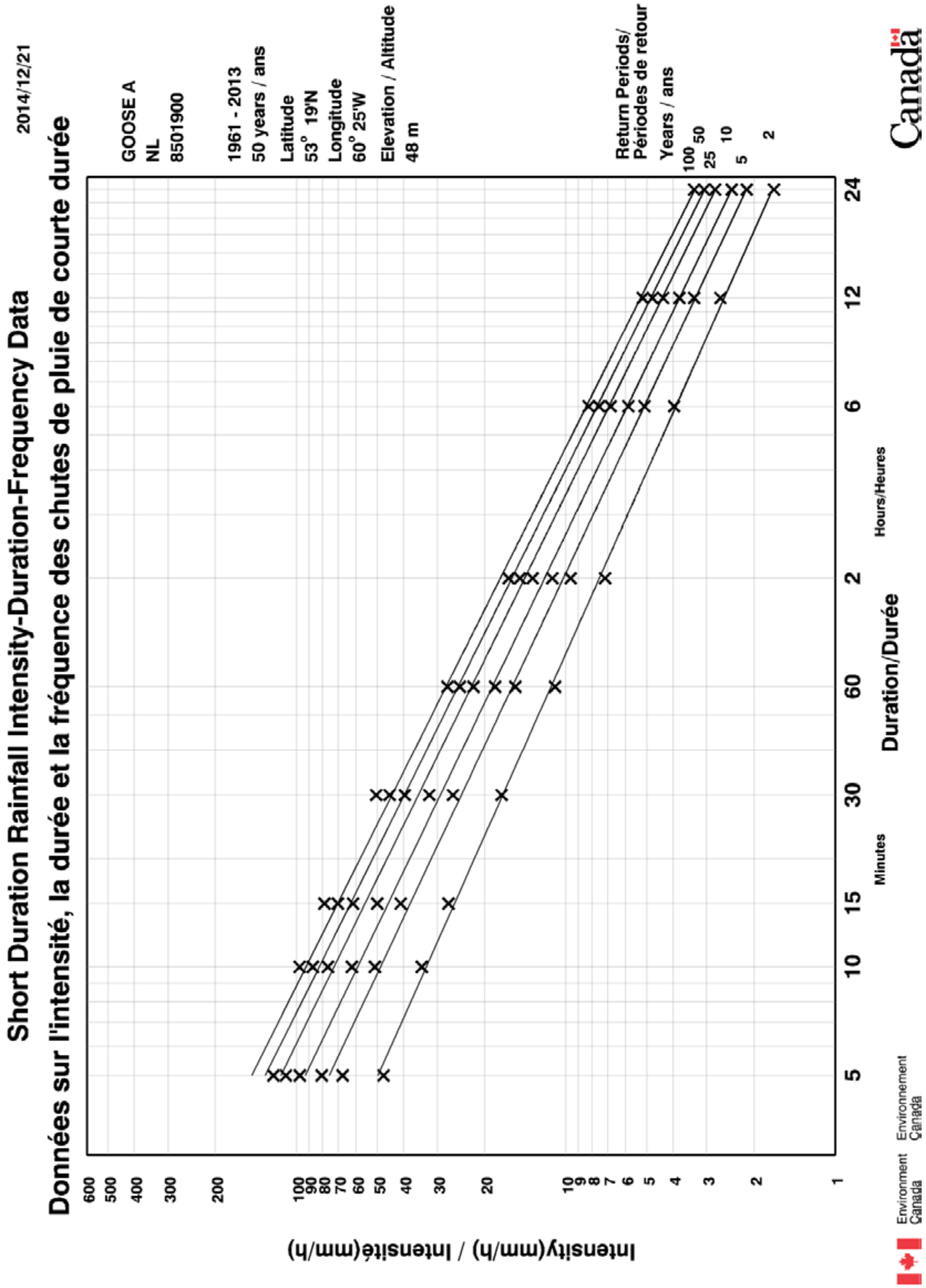

Figure 16.1 Goose A IDF Curve – EC-IDF V2.3

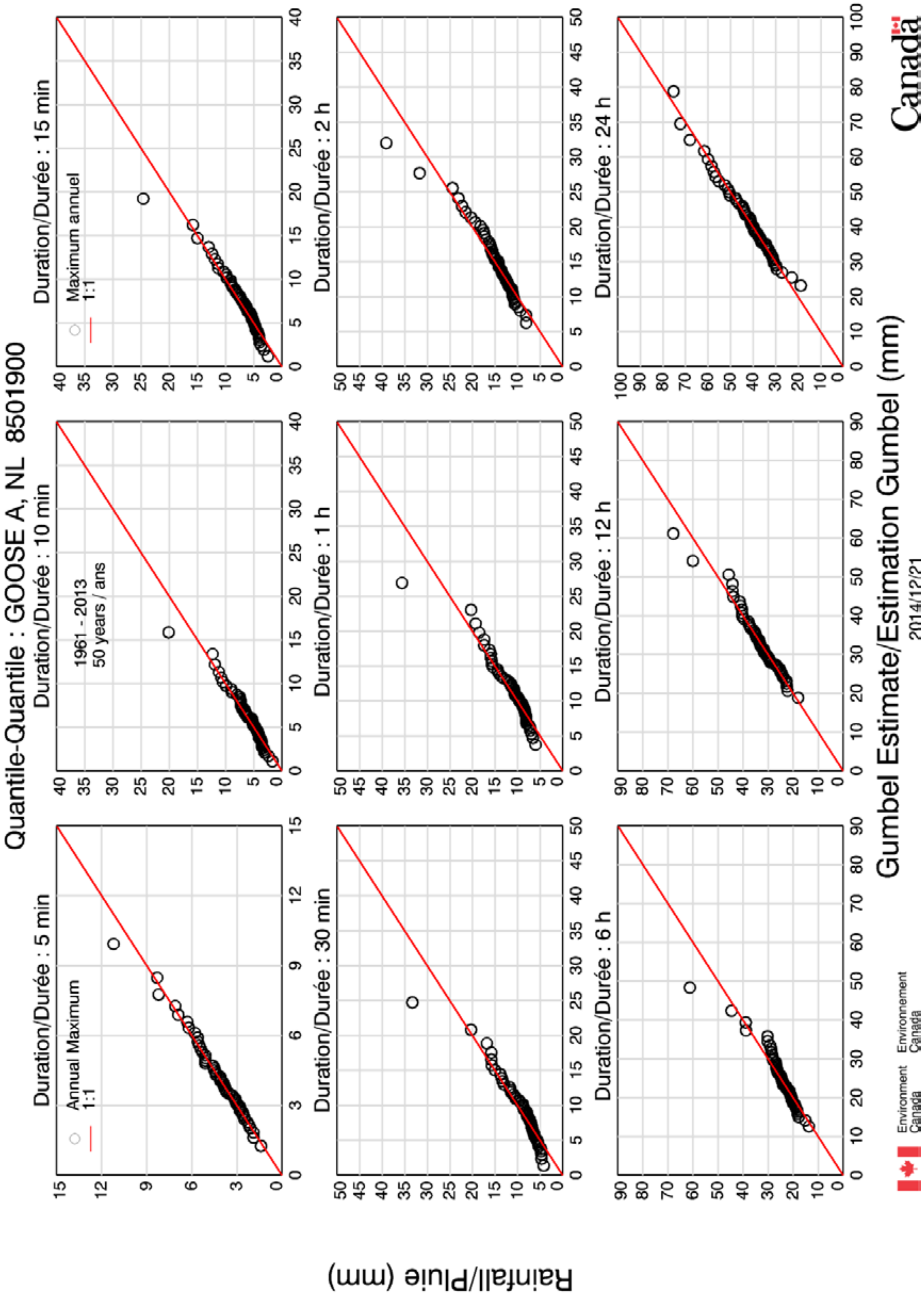

Figure 16.2 Goose A Quantile-Quantile Plot – EC-IDF V2.3

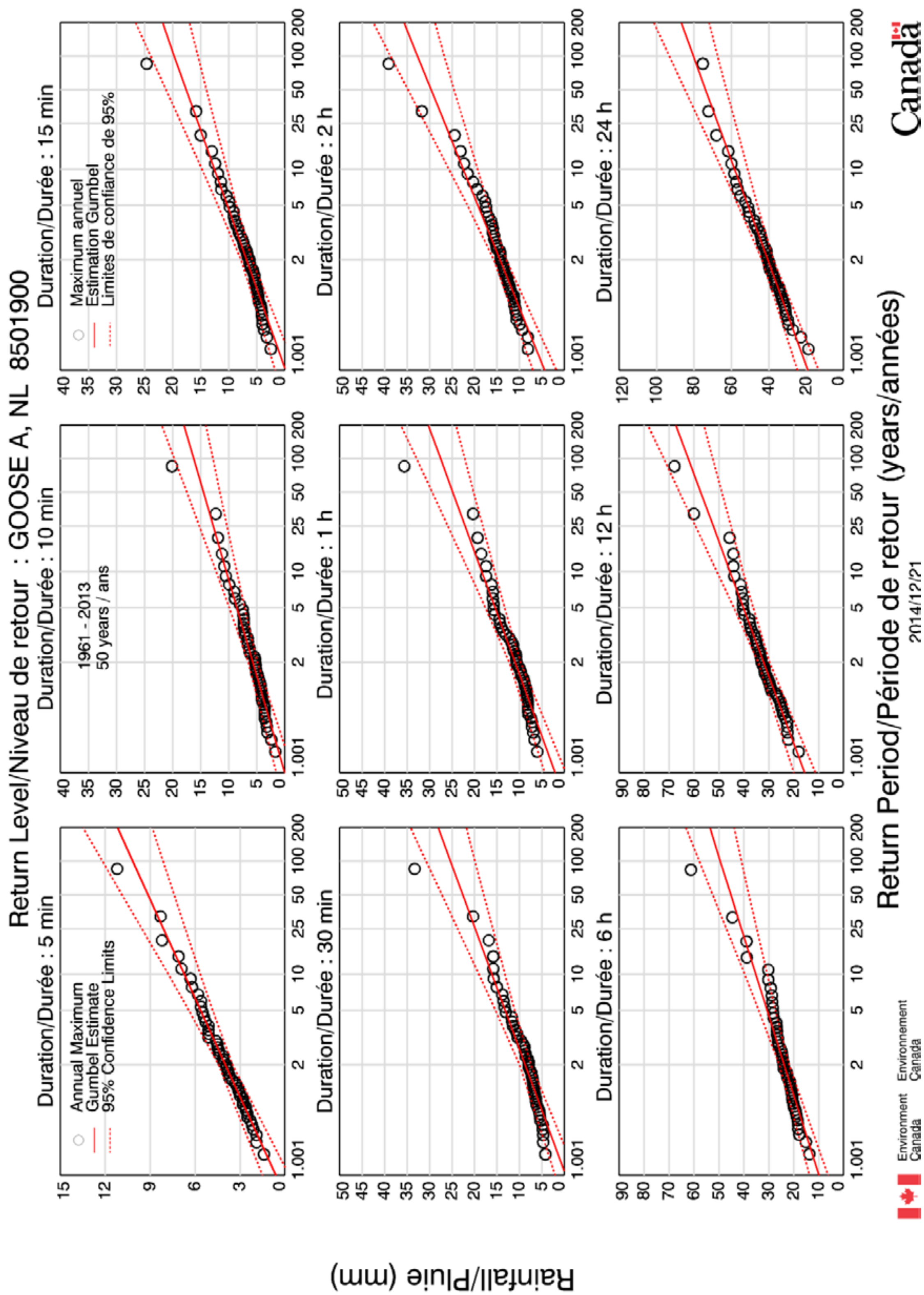

Figure 16.3 Goose A Return Level Plot – EC-IDF V2.3

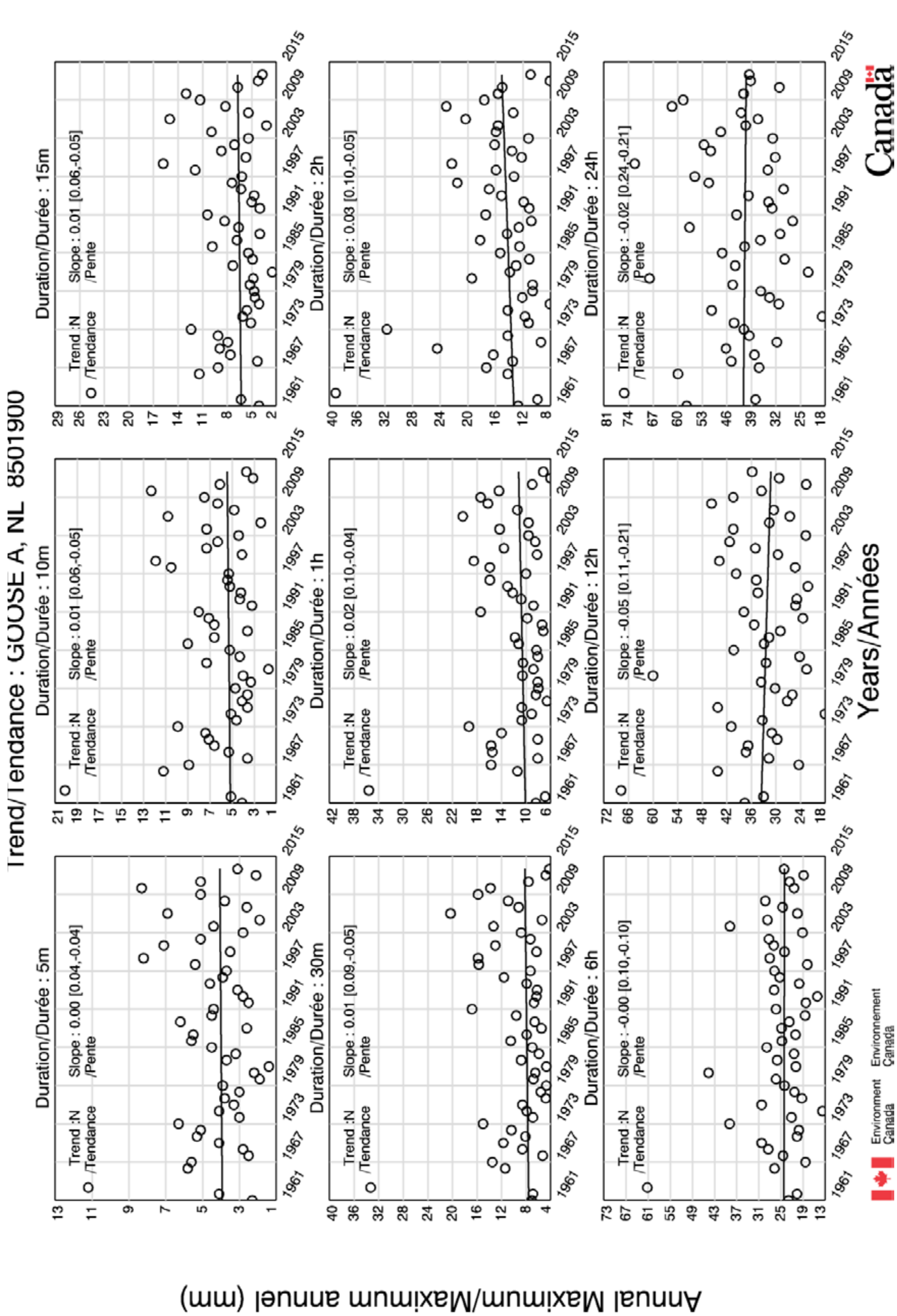

Figure 16.4 Goose A Trend Plot – EC-IDF V2.3

Section 17.0 Mary's Harbour A

The IDF curve for Mary's Harbour A station was updated using 1-hr and 6-hr weighing gauge data at Mary's Harbour (850B5R1) and Mary's Harbour A (8502592). Durations of 1-hr and longer were updated

Table 17.1 presents the changes between the updated IDF curve and the EC-IDF V2.3 curve.

Table 17.1 Differences Between IDF Curves for Mary's Harbour A

Percent Difference in Precipitation Amount [%]
(Difference in Precipitation Amount [mm])

	Return Period [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	N/A	N/A	N/A	N/A	N/A	N/A
10-min	N/A	N/A	N/A	N/A	N/A	N/A
15-min	N/A	N/A	N/A	N/A	N/A	N/A
30-min	N/A	N/A	N/A	N/A	N/A	N/A
1-hr	1.2 (0.1)	0.8 (0.1)	0.5 (0.1)	0.3 (0.0)	0.1 (0.0)	0.0 (0.0)
2-hr	2.3 (0.3)	2.2 (0.4)	2.2 (0.4)	2.2 (0.4)	2.2 (0.5)	2.2 (0.5)
6-hr	-2.6 (-0.7)	0.6 (0.2)	2.1 (0.7)	3.7 (1.4)	4.7 (1.9)	**5.5 (2.4)**
12-hr	4.1 (1.3)	**7.5 (3.0)**	**9.0 (4.2)**	**10.5 (5.6)**	**11.4 (6.6)**	**12.1 (7.7)**
24-hr	3.0 (1.2)	-0.3 (-0.2)	-1.7 (-1.0)	-2.9 (-2.2)	-3.6 (-3.0)	-4.2 (-3.8)

Notes:
Red numbers indicate that the updated IDF curve is lower than the EC-IDF V2.3 IDF curve for that duration and return period.
Bold numbers indicate changes greater than 5 percent.

The updated IDF curves for Mary's Harbour A are included below.

Office of Climate Change and Energy Efficiency

Short Duration Rainfall Intensity-Duration-Frequency Data
Données sur l'intensité, la durée et la fréquence des chutes de pluie de courte durée

Gumbel - Method of moments/Méthode des moments

2015/03/20

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MARY'S HARBOUR A NL 8502591
Updated with 6-hr data measured at Mary's Harbour (850B5R1): 1996-2013
Updated with 1-hr data measured at Mary's Harbour A (8502592): 2014
Latitude: 52 18'N Longitude: 55 50'W Elevation/Altitude: 10 m
Years/Années : 1983 - 2014 # Years/Années : 12

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****

Table 1: Annual Maximum (mm)/Maximum annuel (mm)

****

	Year Année	5 min	10 min	15 min	30 min	1 h	2 h	6 h	12 h	24 h
EC-IDF	1983	3.4	4.0	4.4	6.4	10.0	11.9	21.7	25.6	25.7
EC-IDF	1984	3.9	4.3	5.3	6.0	7.2	11.6	20.7	29.0	38.8
EC-IDF	1985	1.8	2.7	3.5	6.2	10.8	13.0	32.7	42.2	43.3
EC-IDF	1986	4.6	4.6	4.6	5.7	6.2	8.4	16.5	17.2	21.2
EC-IDF	1987	2.5	3.9	4.9	6.8	9.4	12.5	22.7	28.4	35.0
EC-IDF	1988	3.9	5.3	5.5	8.4	10.0	12.3	23.3	34.5	51.6
EC-IDF	1989	4.0	6.2	7.0	7.5	11.6	13.2	21.9	30.6	31.6
EC-IDF	1990	2.1	3.5	5.1	9.9	11.0	18.4	33.4	36.2	49.1
EC-IDF	1991	3.8	3.8	3.8	6.8	8.6	15.4	22.7	29.0	29.0
EC-IDF	1993	2.0	4.0	5.0	7.0	10.8	20.4	33.2	55.0	78.0
EC-IDF	1994	2.5	4.6	6.7	8.4	10.5	14.6	28.6	38.1	45.9
EC-IDF	1995	1.1	1.5	2.1	3.7	6.7	13.2	29.9	38.5	57.7
UPDATE	1996	NM	NM	NM	NM	NM	NM	23.0	30.0	43.0
UPDATE	1997	NM	NM	NM	NM	NM	NM	25.0	32.0	35.8
UPDATE	1998	NM	NM	NM	NM	NM	NM	39.0	50.0	66.0
UPDATE	1999	NM	NM	NM	NM	NM	NM	18.0	28.0	28.0
UPDATE	2000	NM	NM	NM	NM	NM	NM	15.0	21.0	22.6
UPDATE	2001	NM	NM	NM	NM	NM	NM	23.0	40.0	44.0
UPDATE	2002	NM	NM	NM	NM	NM	NM	19.0	26.0	35.0
UPDATE	2003	NM	NM	NM	NM	NM	NM	27.0	39.0	43.0
UPDATE	2004	NM	NM	NM	NM	NM	NM	20.0	29.0	31.0
UPDATE	2005	NM	NM	NM	NM	NM	NM	27.0	38.0	54.0
UPDATE	2008	NM	NM	NM	NM	NM	NM	35.0	66.0	74.5
UPDATE	2009	NM	NM	NM	NM	NM	NM	20.0	35.0	44.0
UPDATE	2010	NM	NM	NM	NM	NM	NM	25.0	35.0	43.0
UPDATE	2011	NM	NM	NM	NM	NM	NM	16.0	21.0	36.0
UPDATE	2012	NM	NM	NM	NM	NM	NM	34.0	58.0	58.5
UPDATE	2013	NM	NM	NM	NM	NM	NM	19.0	24.0	36.0
UPDATE	2014	NM	NM	NM	NM	10.8	17.8	35.8	48.2	50.9
	# Yrs. Années	12	12	12	12	13	13	29	29	29
	Mean Moyenne	3.0	4.0	4.8	6.9	9.5	14.1	25.1	35.3	43.2
	Std. Dev. Écart-type	1.1	1.2	1.3	1.6	1.8	3.2	6.6	11.4	14.3

Skew. Dissymétrie	-0.17	-0.40	-0.30	-0.05	-0.89	0.51	0.48	0.95	0.76
Kurtosis	2.56	5.03	4.37	4.77	3.11	3.81	2.47	4.03	3.61

*-99.9 Indicates Missing Data/Données manquantes
*   NM Indicates No Measurements/Aucunes mesures

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Table 2a: Return Period Rainfall Amounts (mm)
Quantité de pluie (mm) par période de retour

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
EC-IDF 5 min	2.8	3.8	4.4	5.2	5.8	6.4	12
EC-IDF 10 min	3.8	4.9	5.6	6.5	7.1	7.8	12
EC-IDF 15 min	4.6	5.8	6.6	7.5	8.3	9.0	12
EC-IDF 30 min	6.6	8.0	8.9	10.1	11.0	11.8	12
UPDATE 1 h	9.2	10.8	11.8	13.1	14.1	15.1	13
UPDATE 2 h	13.5	16.4	18.3	20.7	22.5	24.2	13
UPDATE 6 h	24.0	29.9	33.7	38.6	42.2	45.8	29
UPDATE 12 h	33.4	43.6	50.3	58.7	65.0	71.2	29
UPDATE 24 h	40.8	53.4	61.8	72.3	80.1	87.9	29

* 6-hr and 1-hr data were used for the update: shorter durations were not updated

****

Table 2b:

Return Period Rainfall Rates (mm/h) - 95% Confidence limits
Intensité de la pluie (mm/h) par période de retour - Limites de confiance de 95%

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
EC-IDF 5 min	33.4	45.1	52.8	62.6	69.8	77.0	12
	+/- 6.9	+/- 11.6	+/- 15.6	+/- 21.0	+/- 25.2	+/- 29.3	12
EC-IDF 10 min	23.0	29.3	33.5	38.8	42.7	46.6	12
	+/- 3.7	+/- 6.2	+/- 8.4	+/- 11.4	+/- 13.6	+/- 15.8	12
EC-IDF 15 min	18.4	23.1	26.2	30.2	33.1	36.0	12
	+/- 2.8	+/- 4.7	+/- 6.3	+/- 8.5	+/- 10.2	+/- 11.8	12
EC-IDF 30 min	13.3	16.1	17.9	20.2	21.9	23.7	12
	+/- 1.6	+/- 2.7	+/- 3.7	+/- 5.0	+/- 6.0	+/- 7.0	12
UPDATE 1 h	9.2	10.8	11.8	13.1	14.1	15.1	13
	+/- 0.9	+/- 1.5	+/- 2.0	+/- 2.7	+/- 3.3	+/- 3.8	13
UPDATE 2 h	6.8	8.2	9.1	10.3	11.2	12.1	13
	+/- 0.8	+/- 1.4	+/- 1.8	+/- 2.5	+/- 3.0	+/- 3.5	13
UPDATE 6 h	4.0	5.0	5.6	6.4	7.0	7.6	29
	+/- 0.4	+/- 0.6	+/- 0.8	+/- 1.1	+/- 1.3	+/- 1.6	29
UPDATE 12 h	2.8	3.6	4.2	4.9	5.4	5.9	29
	+/- 0.3	+/- 0.5	+/- 0.7	+/- 1.0	+/- 1.2	+/- 1.4	29
UPDATE 24 h	1.7	2.2	2.6	3.0	3.3	3.7	29
	+/- 0.2	+/- 0.3	+/- 0.5	+/- 0.6	+/- 0.7	+/- 0.8	29

* 6-hr and 1-hr data were used for the update: shorter durations were not updated

****

Table 3: Interpolation Equation / Équation d'interpolation: R = A*T^B

R = Interpolated Rainfall rate (mm/h)/Intensité interpolée de la pluie (mm/h)
RR = Rainfall rate (mm/h) / Intensité de la pluie (mm/h)
T = Rainfall duration (h) / Durée de la pluie (h)

****

Statistics/Statistiques	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans
Mean of RR/Moyenne de RR	12.5	15.9	18.2	21.1	23.2	25.3
Std. Dev. /Écart-type (RR)	10.7	14.3	16.7	19.7	21.9	24.2
Std. Error/Erreur-type	0.3	1.4	2.3	3.4	4.2	5.0
Coefficient (A)	9.4	11.8	13.4	15.4	16.8	18.3
Exponent/Exposant (B)	-0.508	-0.508	-0.508	-0.508	-0.508	-0.508
Mean % Error/% erreur moyenne	3.3	4.8	6.0	7.1	7.7	8.4

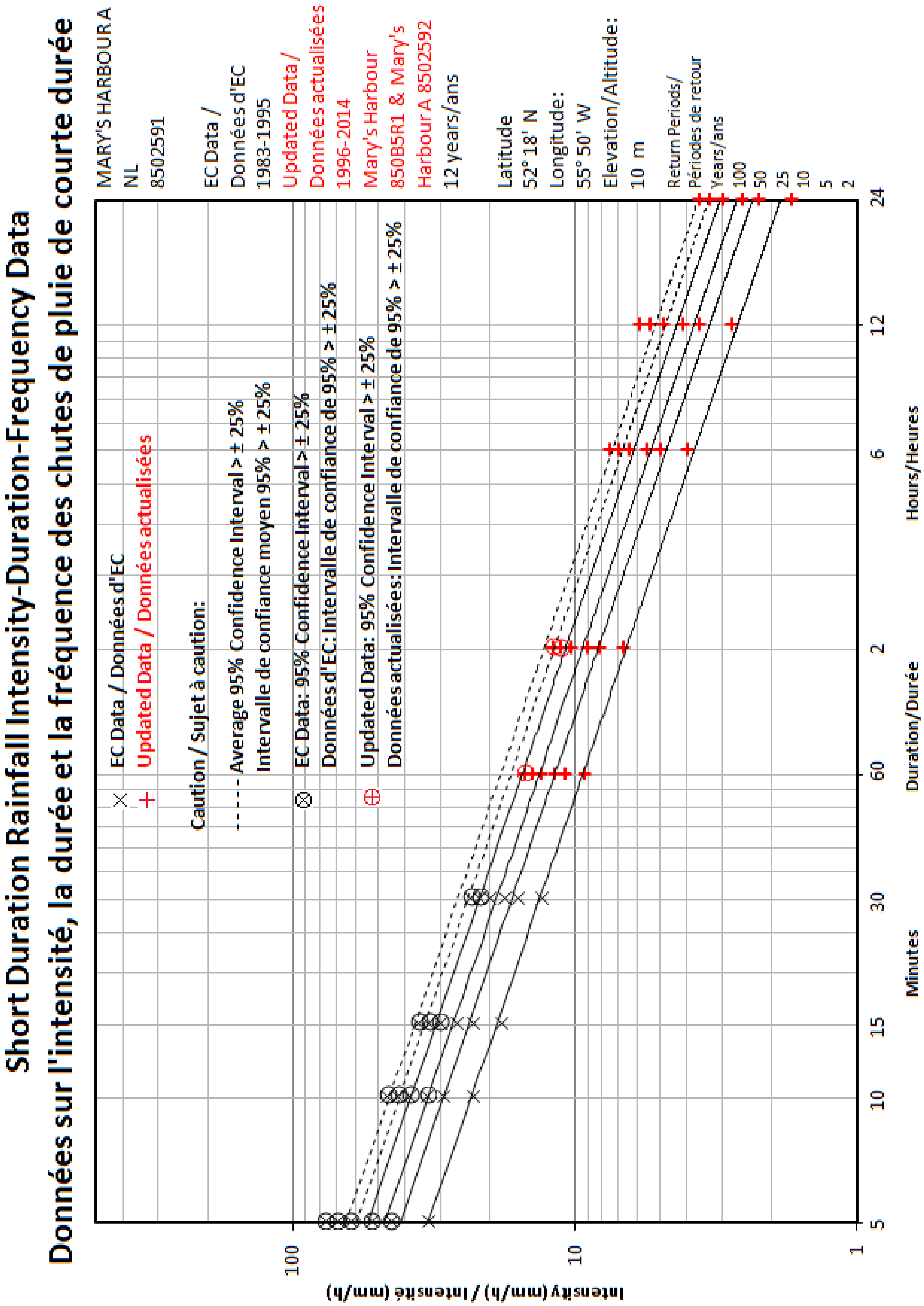

Figure 17.1 Mary's Harbour A IDF Curve – Updated

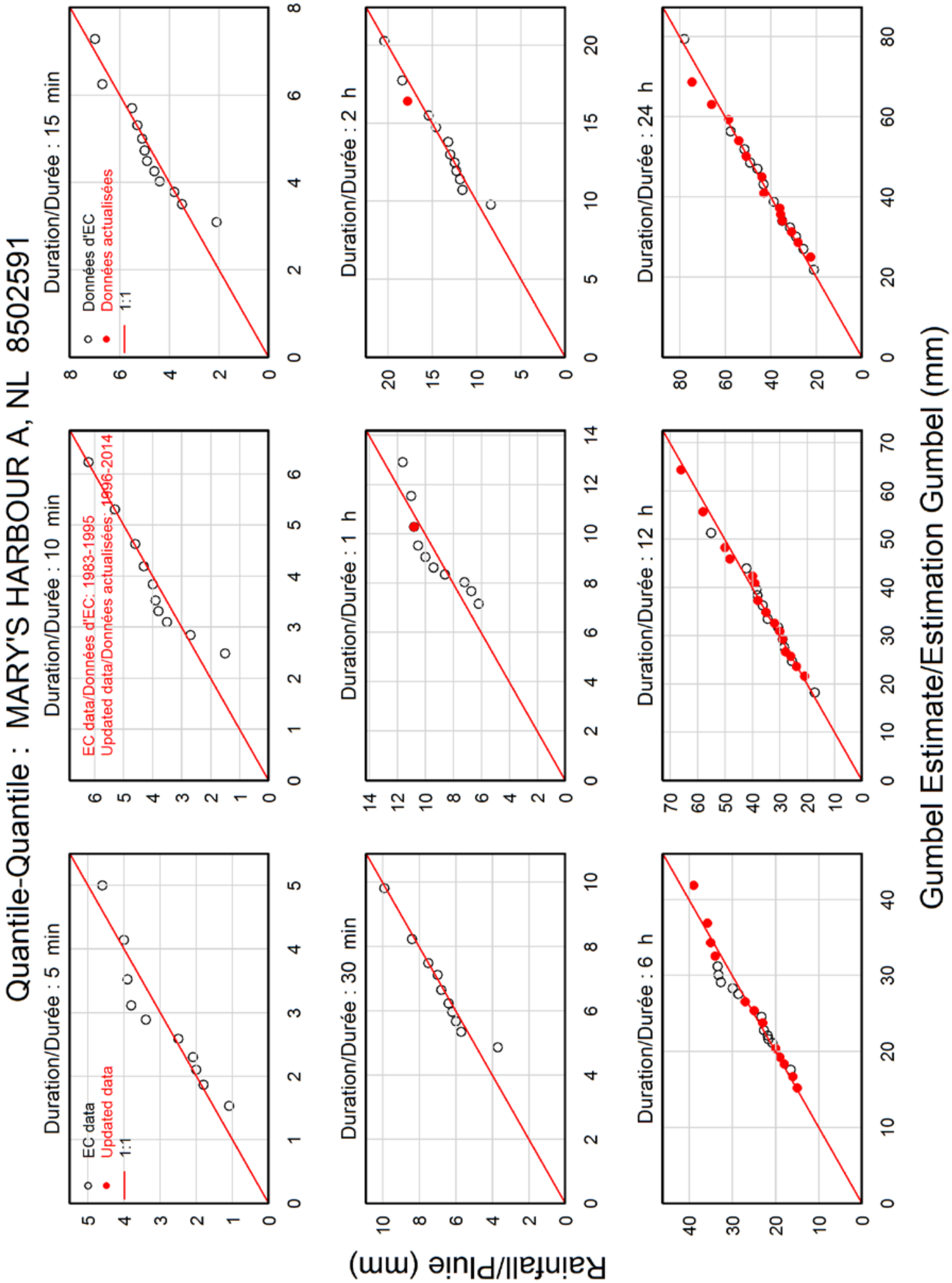

Figure 17.2 Mary's Harbour A Quantile-Quantile Plot – Updated

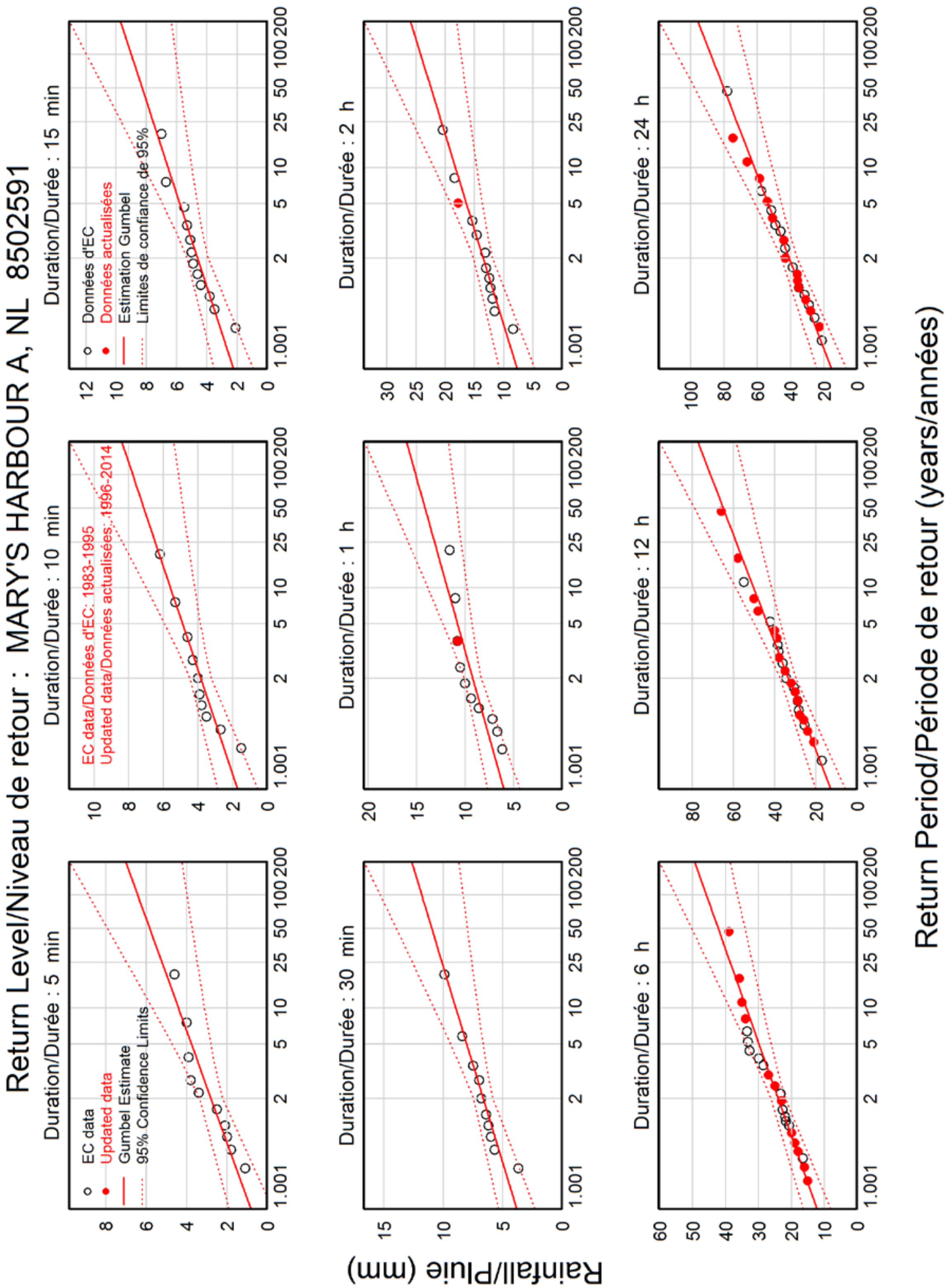

Figure 17.3 Mary's Harbour A Return Level Plot – Updated

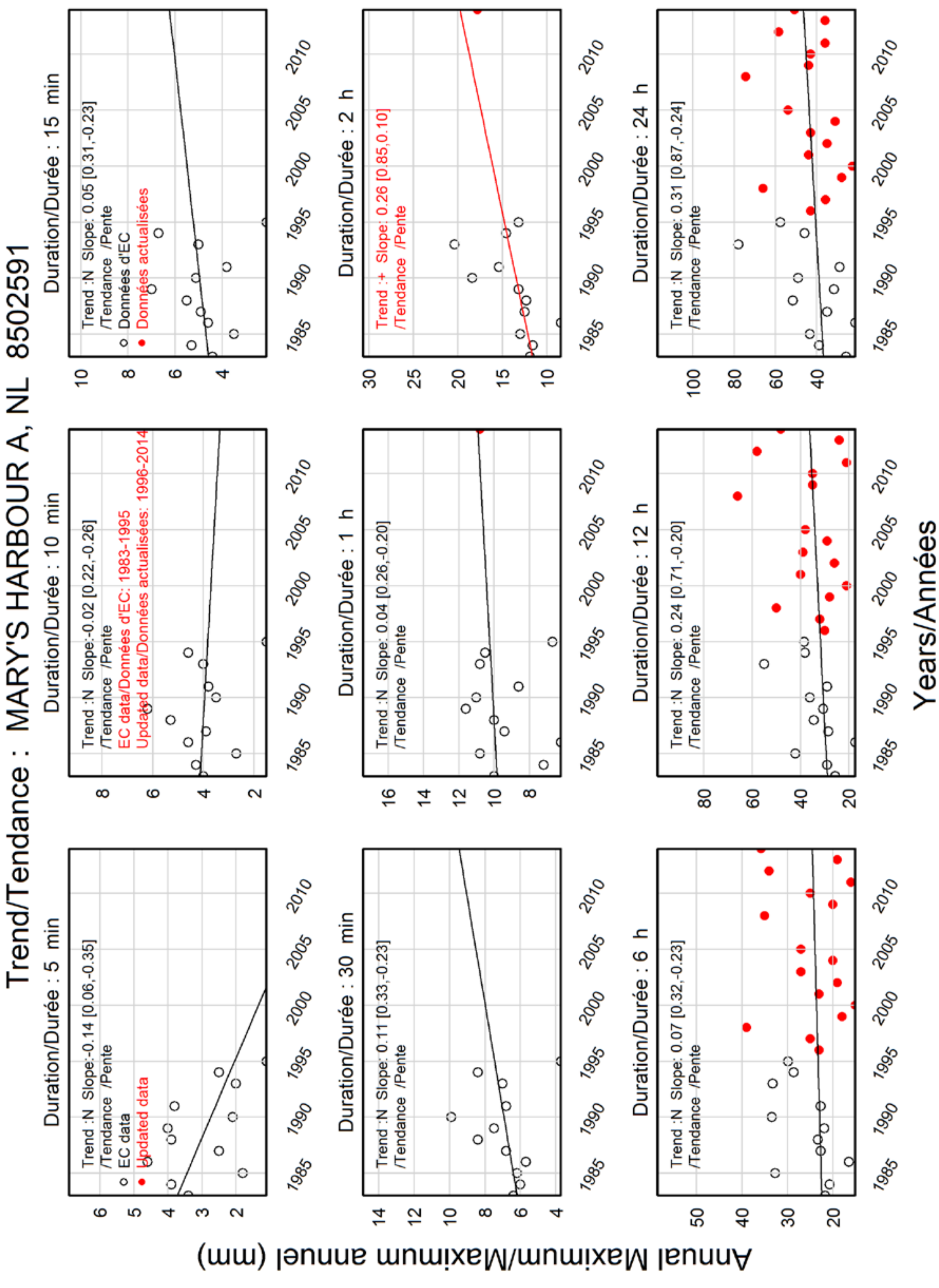

Figure 17.4 Mary's Harbour A Trend Plot – Updated

Section 18.0 Nain – EC-IDF V2.3

This station was not updated during this project. This is the EC IDF curve (V2.3, 2015).

Environment Canada/Environnement Canada

Short Duration Rainfall Intensity-Duration-Frequency Data
Données sur l'intensité, la durée et la fréquence des chutes de pluie de courte durée

Gumbel - Method of moments/Méthode des moments

2014/12/21

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NAIN NL 8502799

Latitude: 56 33'N Longitude: 61 41'W Elevation/Altitude: 7 m

Years/Années : 1993 - 2013 # Years/Années : 17

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Table 1: Annual Maximum (mm)/Maximum annuel (mm)

****

Year Année	5 min	10 min	15 min	30 min	1 h	2 h	6 h	12 h	24 h
1993	3.8	6.0	6.2	7.4	8.8	11.6	18.8	19.8	24.7
1994	2.2	3.6	4.4	6.0	10.1	16.2	37.5	43.5	59.6
1997	1.4	1.9	2.6	3.7	6.0	10.4	19.4	31.1	49.8
1998	3.7	5.4	7.6	9.5	11.7	13.7	25.2	42.2	47.1
1999	6.5	7.0	7.2	8.3	12.7	19.0	25.2	39.0	50.5
2000	-99.9	-99.9	-99.9	-99.9	-99.9	16.0	25.5	29.1	32.8
2001	1.9	2.5	2.7	4.1	6.9	10.6	18.4	30.1	33.7
2002	3.1	5.6	6.2	6.8	8.8	15.1	27.5	45.7	59.4
2003	2.5	4.8	5.8	6.2	8.7	11.7	15.9	26.6	38.7
2004	3.6	5.0	6.9	8.5	11.9	12.7	-99.9	-99.9	31.4
2005	2.1	2.3	2.9	5.4	8.1	14.8	29.9	31.4	35.2
2006	2.1	2.8	3.6	4.8	7.8	10.4	17.2	28.9	46.0
2007	2.1	2.8	3.5	5.0	7.5	12.9	25.3	38.7	43.7
2008	2.6	4.8	7.1	12.9	17.6	24.8	46.9	53.3	54.5
2009	1.2	1.4	2.0	3.7	5.7	9.8	19.0	24.5	32.5
2010	2.7	3.9	5.8	7.8	8.0	13.3	-99.9	-99.9	58.0
2011	3.3	4.4	4.6	7.4	11.5	18.5	33.0	39.8	41.6
2012	3.8	6.0	7.2	9.0	15.2	18.8	23.0	30.2	47.4
2013	3.2	4.8	5.6	8.8	9.8	9.8	19.2	21.6	27.8
# Yrs. Années	18	18	18	18	18	19	17	17	19
Mean Moyenne	2.9	4.2	5.1	7.0	9.8	14.2	25.1	33.9	42.9
Std. Dev. Écart-type	1.2	1.6	1.8	2.4	3.1	4.0	8.1	9.2	10.9
Skew. Dissymétrie	1.48	-0.13	-0.29	0.65	1.03	1.11	1.36	0.44	0.04
Kurtosis	7.05	2.51	2.11	4.10	4.28	4.60	5.32	3.08	2.32

*-99.9 Indicates Missing Data/Données manquantes

****

Table 2a: Return Period Rainfall Amounts (mm)
Quantité de pluie (mm) par période de retour

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
5 min	2.7	3.7	4.5	5.3	6.0	6.7	18
10 min	3.9	5.3	6.3	7.4	8.3	9.2	18
15 min	4.8	6.4	7.5	8.9	9.9	10.9	18
30 min	6.6	8.7	10.1	11.8	13.1	14.4	18
1 h	9.3	12.1	13.9	16.2	18.0	19.7	18
2 h	13.6	17.1	19.4	22.3	24.5	26.6	19
6 h	23.8	31.0	35.7	41.8	46.2	50.7	17
12 h	32.3	40.4	45.8	52.6	57.6	62.6	17
24 h	41.1	50.7	57.1	65.1	71.1	77.0	19

****

Table 2b:

Return Period Rainfall Rates (mm/h) - 95% Confidence limits
Intensité de la pluie (mm/h) par période de retour - Limites de confiance de 95%

****

Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
5 min	32.2	45.0	53.5	64.2	72.1	80.0	18
	+/- 6.1	+/- 10.4	+/- 14.0	+/- 18.9	+/- 22.6	+/- 26.3	18
10 min	23.4	31.9	37.5	44.6	49.9	55.1	18
	+/- 4.1	+/- 6.9	+/- 9.3	+/- 12.5	+/- 14.9	+/- 17.4	18
15 min	19.2	25.7	30.1	35.5	39.6	43.6	18
	+/- 3.1	+/- 5.3	+/- 7.1	+/- 9.6	+/- 11.5	+/- 13.4	18
30 min	13.1	17.3	20.1	23.7	26.3	28.9	18
	+/- 2.0	+/- 3.4	+/- 4.6	+/- 6.2	+/- 7.4	+/- 8.6	18
1 h	9.3	12.1	13.9	16.2	18.0	19.7	18
	+/- 1.3	+/- 2.2	+/- 3.0	+/- 4.1	+/- 4.9	+/- 5.7	18
2 h	6.8	8.5	9.7	11.2	12.2	13.3	19
	+/- 0.8	+/- 1.4	+/- 1.9	+/- 2.5	+/- 3.0	+/- 3.5	19
6 h	4.0	5.2	6.0	7.0	7.7	8.4	17
	+/- 0.6	+/- 1.0	+/- 1.3	+/- 1.8	+/- 2.2	+/- 2.5	17
12 h	2.7	3.4	3.8	4.4	4.8	5.2	17
	+/- 0.3	+/- 0.6	+/- 0.8	+/- 1.0	+/- 1.2	+/- 1.4	17
24 h	1.7	2.1	2.4	2.7	3.0	3.2	19
	+/- 0.2	+/- 0.3	+/- 0.4	+/- 0.6	+/- 0.7	+/- 0.8	19

****

Table 3: Interpolation Equation / Équation d'interpolation: R = A*T^B

R = Interpolated Rainfall rate (mm/h)/Intensité interpolée de la pluie (mm/h)
RR = Rainfall rate (mm/h) / Intensité de la pluie (mm/h)
T = Rainfall duration (h) / Durée de la pluie (h)

****

Statistics/Statistiques	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans
Mean of RR/Moyenne de RR	12.5	16.8	19.7	23.3	25.9	28.6
Std. Dev. /Écart-type (RR)	10.5	14.7	17.5	21.0	23.6	26.2
Std. Error/Erreur-type	0.4	0.4	0.4	0.4	0.5	0.6
Coefficient (A)	9.4	12.3	14.2	16.6	18.4	20.2
Exponent/Exposant (B)	-0.510	-0.529	-0.538	-0.546	-0.550	-0.554
Mean % Error/% erreur moyenne	2.9	2.8	3.0	3.2	3.4	3.5

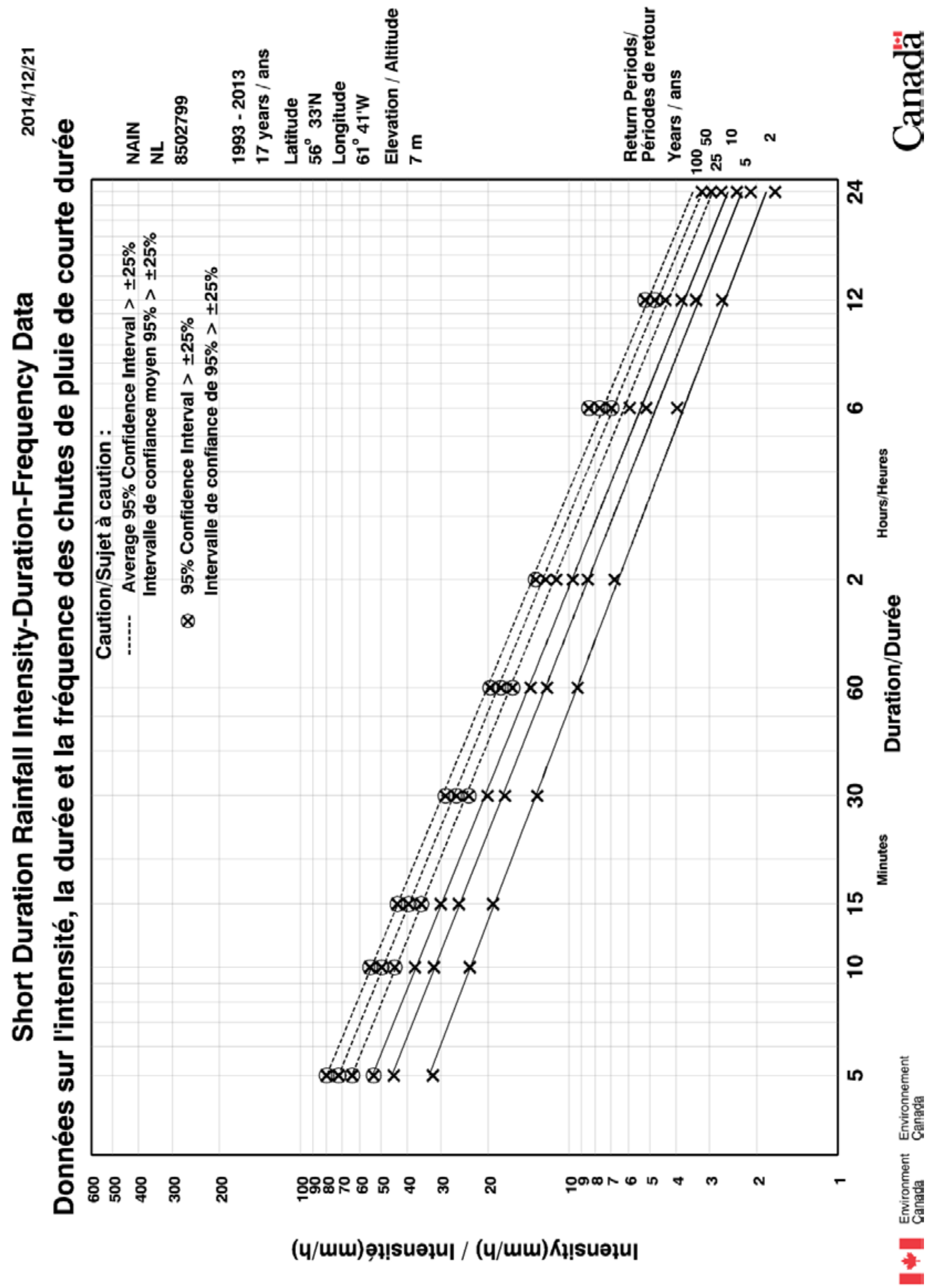

Figure 18.1 Nain IDF Curve – EC-IDF V2.3

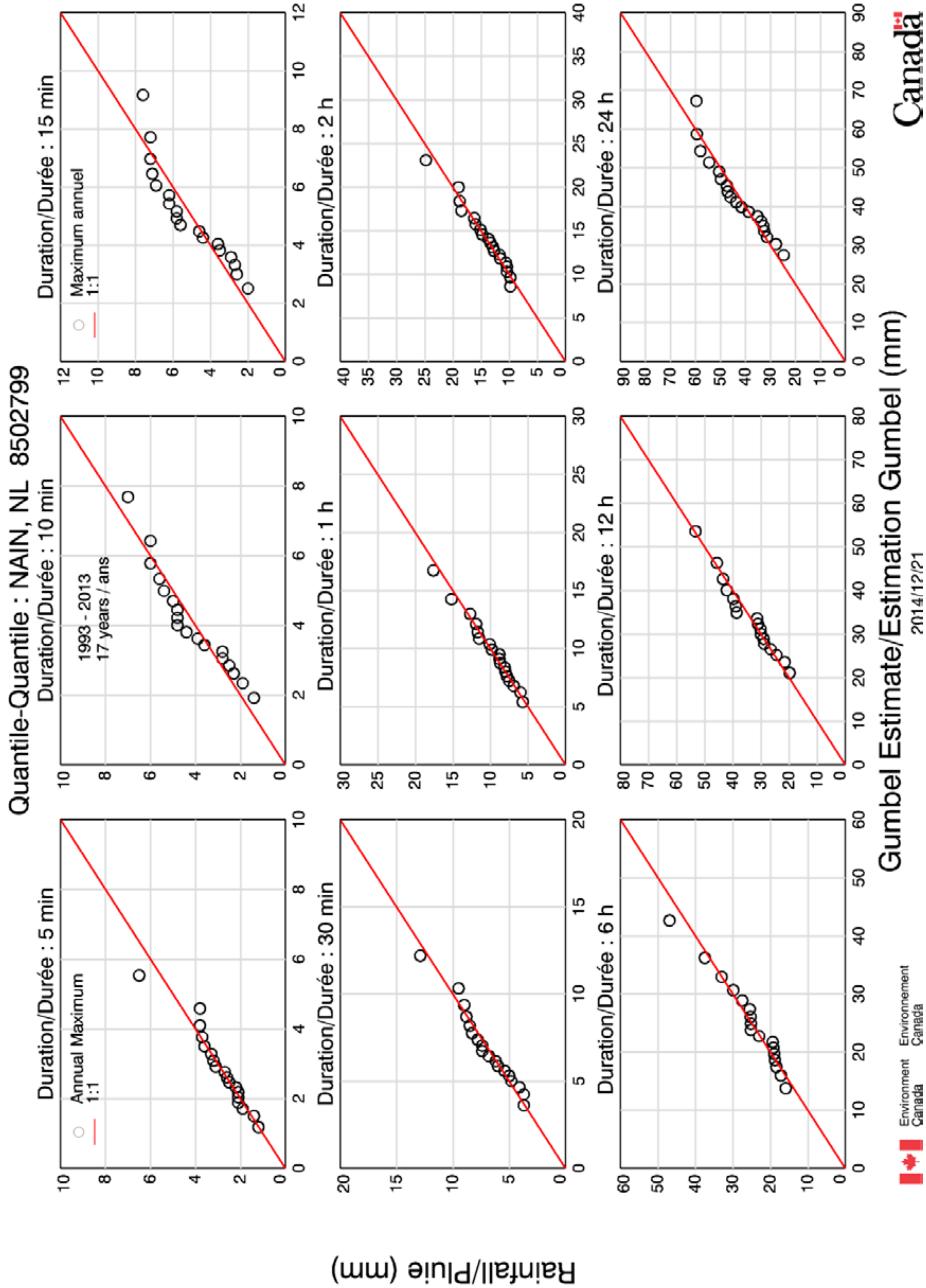

Figure 18.2 Nain Quantile-Quantile Plot – EC-IDF V2.3

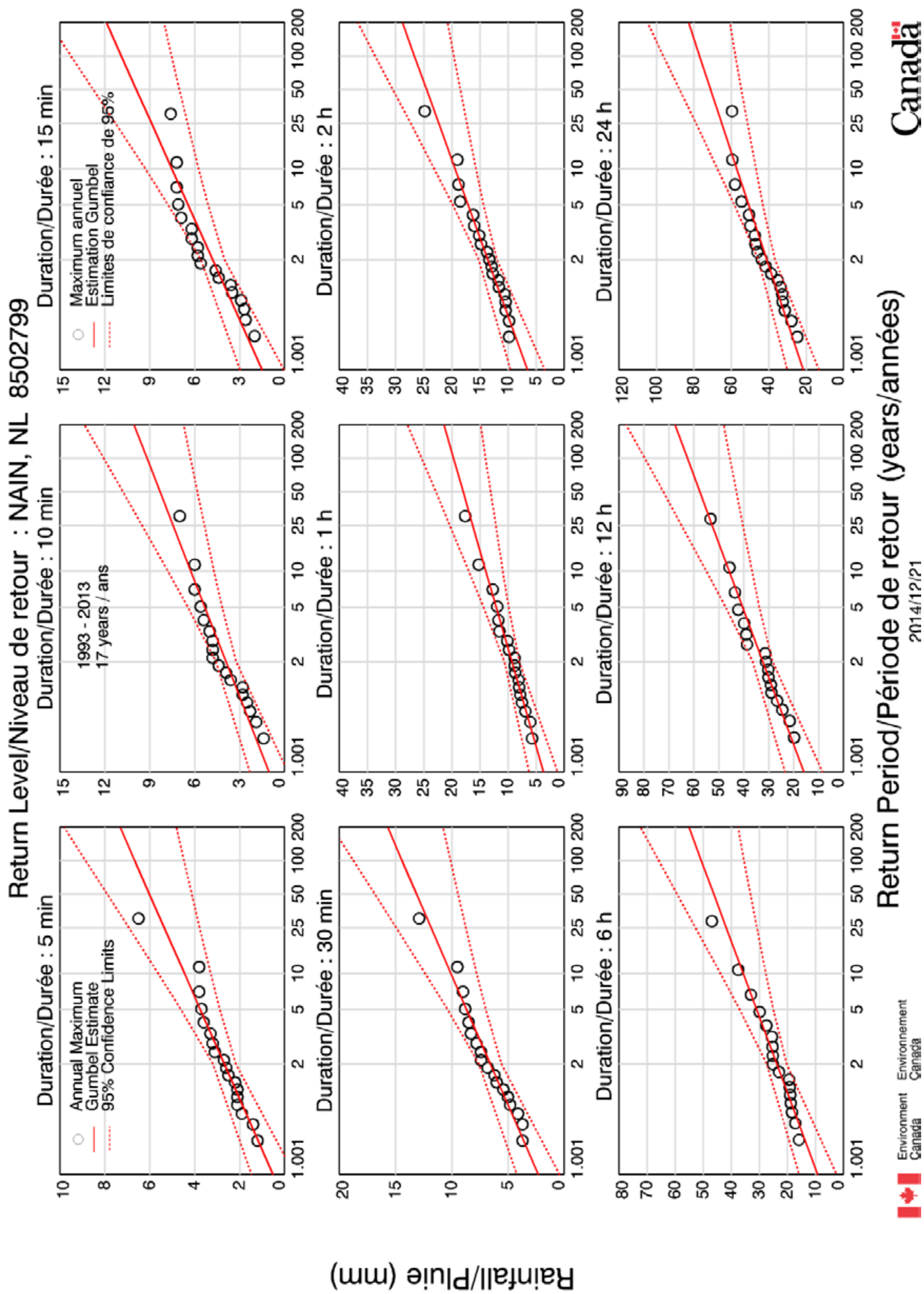

Figure 18.3 Nain Return Level Plot – EC-IDF V2.3

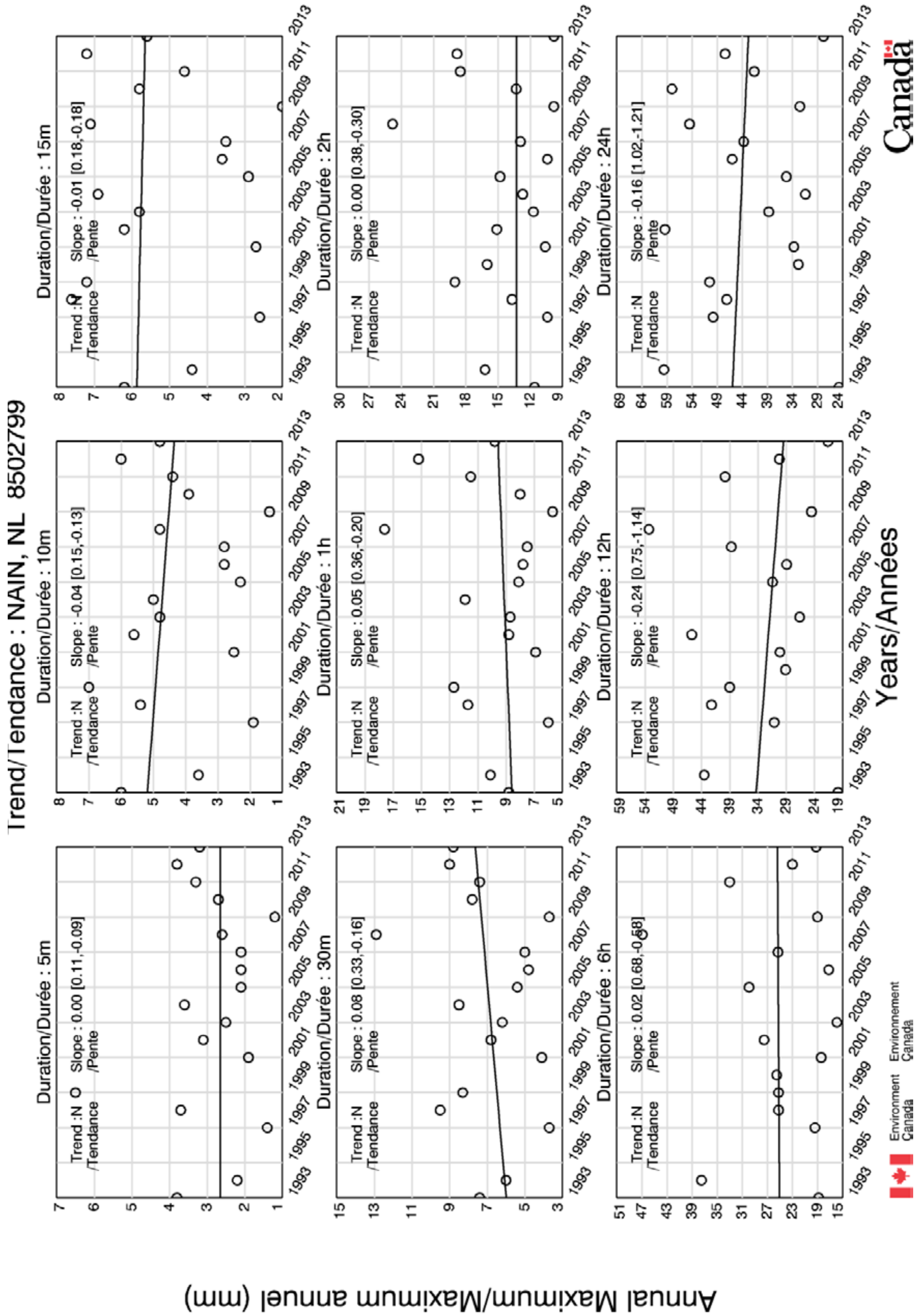

Figure 18.4 Nain Trend Plot – EC-IDF V2.3

Section 19.0 Wabush Lake A

The IDF curve for Wabush Lake A station was updated using 6-hr weighing gauge data at Wabush Lake A. The 6-, 12-, and 24-hr durations were updated

Table 19.1 presents the changes between the updated IDF curve and the EC-IDF V2.3 curve.

Table 19.1 Differences Between IDF Curves for Wabush Lake A

Percent Difference in Precipitation Amount [%] (Difference in Precipitation Amount [mm])						
	Return Period [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	N/A	N/A	N/A	N/A	N/A	N/A
10-min	N/A	N/A	N/A	N/A	N/A	N/A
15-min	N/A	N/A	N/A	N/A	N/A	N/A
30-min	N/A	N/A	N/A	N/A	N/A	N/A
1-hr	N/A	N/A	N/A	N/A	N/A	N/A
2-hr	N/A	N/A	N/A	N/A	N/A	N/A
6-hr	2.1 (0.4)	1.2 (0.3)	0.7 (0.2)	0.3 (0.1)	0.1 (0.0)	-0.1 (-0.1)
12-hr	2.3 (0.6)	3.2 (1.1)	3.7 (1.4)	4.1 (1.8)	4.4 (2.1)	4.6 (2.4)
24-hr	2.6 (0.9)	2.5 (1.1)	2.5 (1.2)	2.5 (1.4)	2.5 (1.5)	2.5 (1.7)

Notes:
Red numbers indicate that the updated IDF curve is lower than the EC-IDF V2.3 IDF curve for that duration and return period.

The updated IDF curves for Wabush Lake A are included below.

Office of Climate Change and Energy Efficiency

Short Duration Rainfall Intensity-Duration-Frequency Data
Données sur l'intensité, la durée et la fréquence des chutes de pluie de courte durée

Gumbel - Method of moments/Méthode des moments

2015/03/20

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WABUSH LAKE A NL 8504175
Updated with 6-hour data measured at Wabush Lake A (8504175): 2004-2012

Latitude: 52 56'N Longitude: 66 52'W Elevation/Altitude: 551 m
Years/Années : 1974 - 2012 # Years/Années : 25

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Table 1: Annual Maximum (mm)/Maximum annuel (mm)

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	Year Année	5 min	10 min	15 min	30 min	1 h	2 h	6 h	12 h	24 h
EC-IDF	1974	6.6	10.4	13.5	21.1	26.2	28.4	32.0	32.0	35.3
EC-IDF	1975	4.6	5.8	6.1	6.9	8.1	11.9	20.8	24.6	34.3
EC-IDF	1976	2.8	3.8	5.1	9.7	12.2	16.5	21.8	25.9	35.6
EC-IDF	1977	2.5	3.6	4.3	6.1	10.2	16.5	18.8	37.1	38.1
EC-IDF	1978	8.1	11.1	11.8	15.9	21.2	24.6	26.6	31.6	41.9
EC-IDF	1979	2.7	4.2	5.8	8.8	10.8	17.2	25.5	34.3	39.4
EC-IDF	1980	4.2	7.6	10.6	16.4	21.2	27.8	32.6	42.2	43.2
EC-IDF	1981	3.9	4.9	6.0	11.6	17.5	21.2	27.3	38.6	62.0
EC-IDF	1982	4.8	4.8	5.2	10.2	11.2	12.8	19.9	34.8	46.6
EC-IDF	1983	-99.9	-99.9	-99.9	-99.9	13.3	17.7	20.0	22.9	26.2
EC-IDF	1984	7.7	14.5	18.3	20.0	24.9	25.2	29.4	35.6	43.3
EC-IDF	1985	3.2	5.3	7.2	10.6	11.7	12.4	17.2	24.8	24.8
EC-IDF	1986	4.0	4.9	5.3	6.2	6.4	11.9	18.4	23.7	33.0
EC-IDF	1987	2.2	3.7	4.5	5.6	9.0	10.4	16.5	24.0	33.0
EC-IDF	1988	4.7	5.7	6.0	6.7	8.9	12.5	17.7	23.2	29.2
EC-IDF	1989	3.9	6.8	7.3	10.0	14.5	17.4	21.0	27.7	34.2
EC-IDF	1990	-99.9	-99.9	-99.9	-99.9	7.7	11.8	25.4	38.3	59.1
EC-IDF	1991	2.8	4.0	5.5	9.1	10.5	20.2	36.6	45.6	46.2
EC-IDF	1993	10.4	12.8	15.3	20.3	25.3	25.9	26.7	26.9	33.9
EC-IDF	1994	2.9	4.1	4.8	6.0	6.6	7.1	9.2	14.5	19.7
EC-IDF	1995	3.0	5.2	6.2	6.8	8.7	12.7	12.9	17.6	27.6
EC-IDF	1996	7.6	7.6	7.6	8.6	8.6	9.6	17.3	23.2	27.4
EC-IDF	1997	3.2	4.3	5.3	7.7	9.2	10.3	19.8	34.7	41.1
EC-IDF	1998	1.2	2.1	2.7	4.1	6.5	8.2	13.7	21.2	25.5
EC-IDF	2000	8.1	10.7	11.1	11.1	11.1	11.1	17.0	25.0	31.4
EC-IDF	2001	4.0	4.8	5.8	6.7	6.7	7.7	15.4	19.8	26.6
EC-IDF	2003	4.5	6.7	9.8	16.7	17.6	17.9	28.6	30.2	31.2
UPDATE	2004	NM	NM	NM	NM	NM	NM	29.0	37.0	38.0
UPDATE	2005	NM	NM	NM	NM	NM	NM	15.0	24.0	32.0
UPDATE	2006	NM	NM	NM	NM	NM	NM	20.0	28.0	30.6
UPDATE	2007	NM	NM	NM	NM	NM	NM	19.0	29.0	34.0
UPDATE	2008	NM	NM	NM	NM	NM	NM	19.0	21.0	36.0
UPDATE	2009	NM	NM	NM	NM	NM	NM	22.0	26.0	43.0
UPDATE	2010	NM	NM	NM	NM	NM	NM	33.0	53.0	66.0
UPDATE	2011	NM	NM	NM	NM	NM	NM	31.0	40.0	44.0

UPDATE 2012 NM NM NM NM NM NM 23.0 28.0 33.0
-- # Yrs. 25 25
25 25 27 27 36 36 36 Années Mean 4.5 6.4 7.6
10.5 12.8 15.8 22.2 29.6 36.8 Moyenne Std. Dev. 2.3 3.2 3.8 5.0
6.1 6.3 6.5 8.3 10.2 Écart-type Skew. 1.04 1.23 1.40 0.98 1.07
0.64 0.36 0.72 1.19 Dissymétrie Kurtosis 3.72 4.01 4.69 3.11 3.23 2.62
2.70 3.67 4.86
*-99.9 Indicates Missing Data/Données manquantes
* NM Indicates No Measurements/Aucunes mesures

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Table 2a: Return Period Rainfall Amounts (mm)
Quantité de pluie (mm) par période de retour

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Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
EC-IDF 5 min	4.2	6.2	7.5	9.2	10.4	11.7	25
EC-IDF 10 min	5.9	8.7	10.5	12.8	14.6	16.3	25
EC-IDF 15 min	7.0	10.4	12.6	15.4	17.5	19.6	25
EC-IDF 30 min	9.7	14.1	17.0	20.7	23.5	26.2	25
EC-IDF 1 h	11.8	17.2	20.8	25.3	28.7	32.0	27
EC-IDF 2 h	14.8	20.4	24.1	28.7	32.2	35.6	27
UPDATE 6 h	21.1	26.8	30.6	35.4	38.9	42.4	36
UPDATE 12 h	28.2	35.6	40.4	46.6	51.1	55.6	36
UPDATE 24 h	35.2	44.1	50.1	57.6	63.2	68.7	36

* 6-hr data were used for the update: shorter durations were not updated

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Table 2b:

Return Period Rainfall Rates (mm/h) - 95% Confidence limits
Intensité de la pluie (mm/h) par période de retour - Limites de confiance de 95%

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Duration/Durée	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans	#Years Années
EC-IDF 5 min	50.1	74.1	90.1	110.2	125.2	140.0	25
	+/- 9.8	+/- 16.5	+/- 22.3	+/- 30.1	+/- 36.0	+/- 41.9	25
EC-IDF 10 min	35.1	51.9	63.0	77.0	87.4	97.8	25
	+/- 6.8	+/- 11.5	+/- 15.5	+/- 20.9	+/- 25.1	+/- 29.2	25
EC-IDF 15 min	28.1	41.5	50.4	61.7	70.0	78.3	25
	+/- 5.5	+/- 9.2	+/- 12.5	+/- 16.8	+/- 20.1	+/- 23.4	25
EC-IDF 30 min	19.4	28.2	34.1	41.4	46.9	52.4	25
	+/- 3.6	+/- 6.1	+/- 8.2	+/- 11.0	+/- 13.2	+/- 15.4	25
EC-IDF 1 h	11.8	17.2	20.8	25.3	28.7	32.0	27
	+/- 2.1	+/- 3.6	+/- 4.8	+/- 6.5	+/- 7.8	+/- 9.1	27
EC-IDF 2 h	7.4	10.2	12.0	14.4	16.1	17.8	27
	+/- 1.1	+/- 1.8	+/- 2.5	+/- 3.4	+/- 4.0	+/- 4.7	27
UPDATE 6 h	3.5	4.5	5.1	5.9	6.5	7.1	36
	+/- 0.3	+/- 0.5	+/- 0.7	+/- 1.0	+/- 1.2	+/- 1.4	36
UPDATE 12 h	2.4	3.0	3.4	3.9	4.3	4.6	36
	+/- 0.2	+/- 0.3	+/- 0.5	+/- 0.6	+/- 0.8	+/- 0.9	36
UPDATE 24 h	1.5	1.8	2.1	2.4	2.6	2.9	36
	+/- 0.1	+/- 0.2	+/- 0.3	+/- 0.4	+/- 0.5	+/- 0.5	36

* 6-hr data were used for the update: shorter durations were not updated

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Table 3: Interpolation Equation / Équation d'interpolation: R = A*T^B

R = Interpolated Rainfall rate (mm/h)/Intensité interpolée de la pluie (mm/h)
RR = Rainfall rate (mm/h) / Intensité de la pluie (mm/h)
T = Rainfall duration (h) / Durée de la pluie (h)

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Statistics/Statistiques	2 yr/ans	5 yr/ans	10 yr/ans	25 yr/ans	50 yr/ans	100 yr/ans
Mean of RR/Moyenne de RR	17.7	25.8	31.2	38.0	43.1	48.1
Std. Dev. /Écart-type (RR)	17.0	25.3	30.9	37.9	43.1	48.3
Std. Error/Erreur-type	2.0	4.0	5.3	7.1	8.4	9.8
Coefficient (A)	11.4	15.9	18.8	22.6	25.3	28.1
Exponent/Exposant (B)	-0.635	-0.670	-0.685	-0.698	-0.706	-0.712
Mean % Error/% erreur moyenne	3.7	5.4	6.2	6.9	7.3	7.6

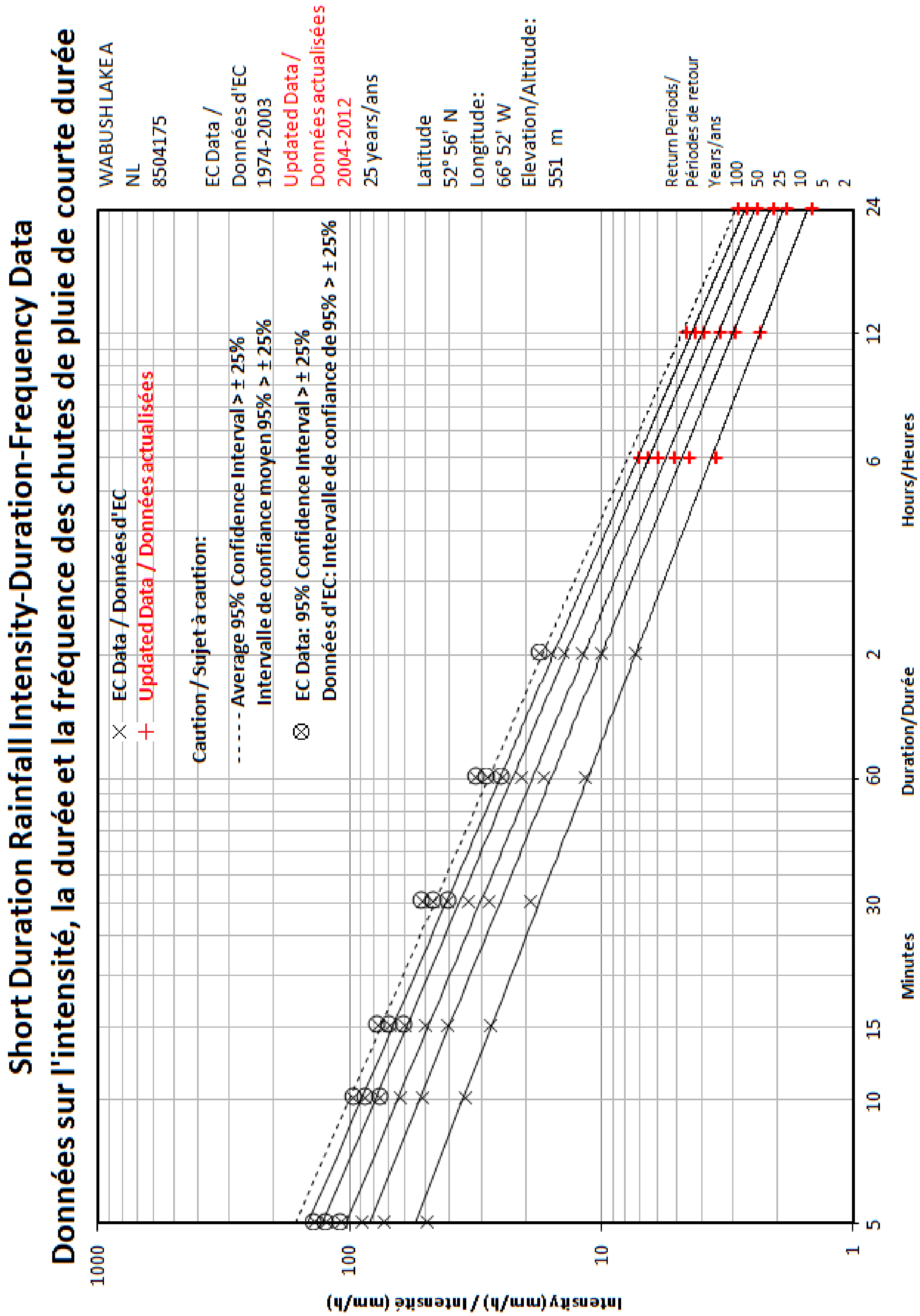

Figure 19.1 Wabush Lake A IDF Curve – Updated

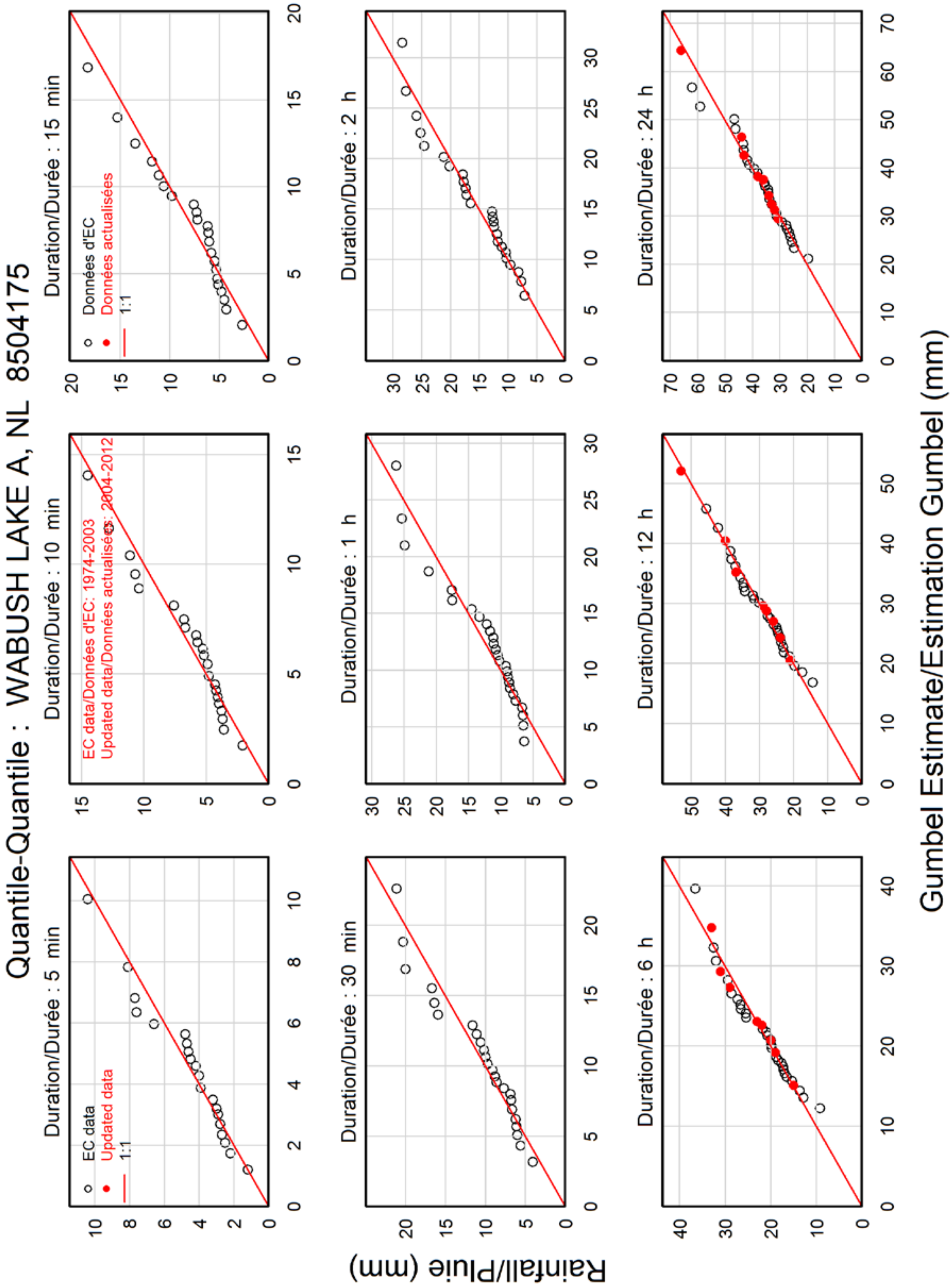

Figure 19.2 Wabush Lake A Quantile-Quantile Plot – Updated

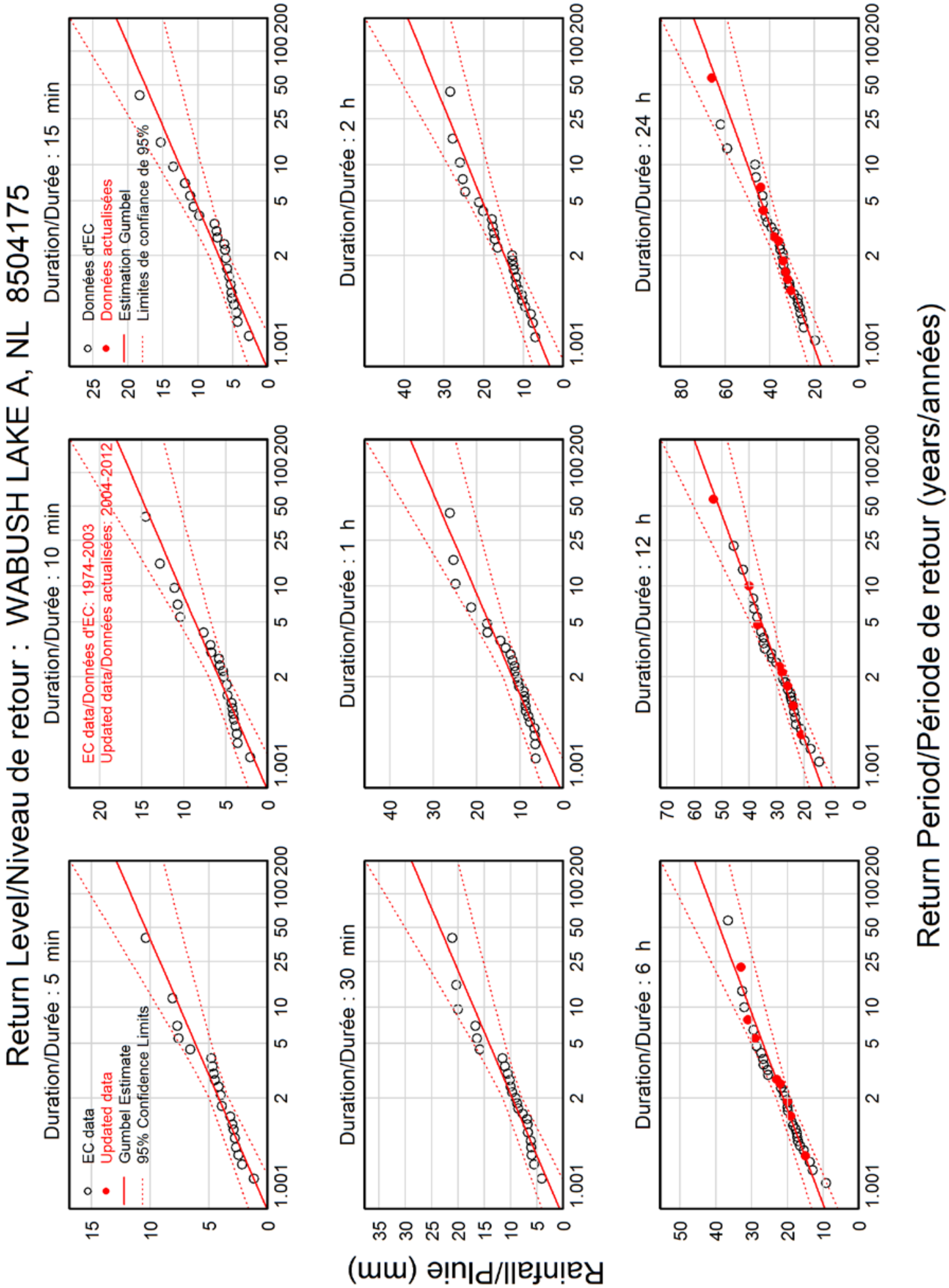

Figure 19.3 Wabush Lake A Return Level Plot – Updated

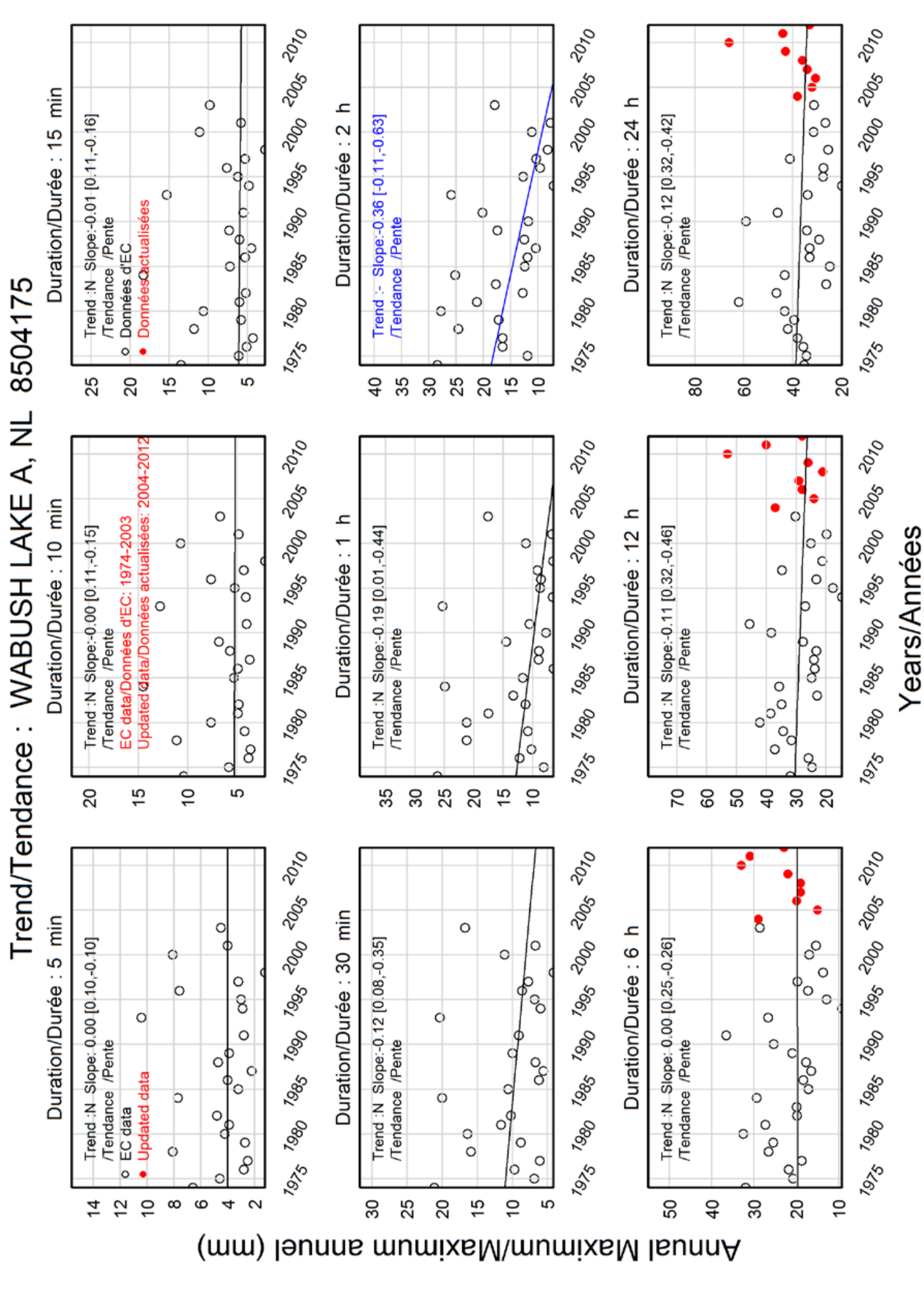

Figure 19.4 Wabush Lake A Trend Plot – Updated

Appendix D

Future IDF Curves

List of Tables

Table 1.1 Future IDF Curves for Argentia (AUT) (8400104)

Future IDF Curve for 2011-2040 Time Horizon Projected Precipitation Amount [mm]						
Duration	***Return Interval [years]***					
	2	***5***	***10***	***25***	***50***	***100***
5-min	5.3	7.0	8.1	9.6	10.6	11.7
10-min	9.3	12.5	14.6	17.3	19.3	21.3
15-min	12.2	16.1	18.8	22.3	24.8	27.3
30-min	16.3	20.9	24.1	28.2	31.1	34.1
1-hr	21.7	28.3	32.7	38.4	42.6	46.8
2-hr	30.3	41.3	48.7	58.1	65.1	72.0
6-hr	56.7	87.2	108.7	135.1	154.6	174.1
12-hr	74.0	114.7	143.4	178.6	204.7	230.6
24-hr	84.3	126.6	155.4	191.3	217.9	244.4
Future IDF Curve for 2041-2070 Time Horizon Projected Precipitation Amount [mm]						
Duration	***Return Interval [years]***					
	2	***5***	***10***	***25***	***50***	***100***
5-min	5.7	7.5	8.8	10.3	11.4	12.4
10-min	10.2	13.6	15.9	18.7	20.8	22.8
15-min	13.2	17.5	20.5	24.0	26.6	29.2
30-min	17.5	22.5	26.0	30.2	33.3	36.3
1-hr	23.4	30.5	35.4	41.3	45.6	49.9
2-hr	33.1	45.0	53.1	62.8	70.1	77.1
6-hr	63.8	97.9	121.3	149.2	169.9	190.3
12-hr	84.0	129.7	160.4	196.7	224.9	251.0
24-hr	95.1	140.9	172.5	209.8	237.7	265.1
Future IDF Curve for 2071-2100 Time Horizon Projected Precipitation Amount [mm]						
Duration	***Return Interval [years]***					
	2	***5***	***10***	***25***	***50***	***100***
5-min	5.9	7.6	8.8	10.3	11.4	12.4
10-min	10.5	13.6	16.0	18.8	20.8	22.8
15-min	13.6	17.6	20.6	24.2	26.7	29.2
30-min	18.0	22.6	26.2	30.4	33.4	36.3
1-hr	24.1	30.6	35.6	41.6	45.7	49.9
2-hr	34.3	45.2	53.5	63.3	70.3	77.1
6-hr	67.2	98.5	122.3	150.6	170.6	190.3
12-hr	88.0	129.7	161.5	199.3	225.9	252.3
24-hr	99.7	141.7	173.7	211.8	238.6	265.1

Table 1.2 Future IDF Curves for Burgeo (8400801)

Future IDF Curve for 2011-2040 Time Horizon Projected Precipitation Amount [mm]						
Duration	***Return Interval [years]***					
	2	***5***	***10***	***25***	***50***	***100***
5-min	6.6	8.6	9.8	11.3	12.5	13.6
10-min	9.3	11.8	13.4	15.3	16.8	18.3
15-min	11.6	14.8	16.8	19.3	21.1	23.0
30-min	15.8	19.5	21.8	24.7	26.8	29.0
1-hr	21.4	26.0	28.8	32.3	35.0	37.7
2-hr	30.7	37.3	41.3	46.3	50.1	54.0
6-hr	50.1	60.6	67.0	75.1	81.1	87.2
12-hr	64.0	75.8	83.0	92.1	98.9	105.8
24-hr	77.3	91.4	99.8	110.6	118.6	126.9
Future IDF Curve for 2041-2070 Time Horizon Projected Precipitation Amount [mm]						
Duration	***Return Interval [years]***					
	2	***5***	***10***	***25***	***50***	***100***
5-min	7.4	9.7	11.0	12.8	14.2	15.5
10-min	10.3	13.2	15.0	17.2	19.0	20.7
15-min	12.9	16.5	18.8	21.7	23.9	26.1
30-min	17.3	21.5	24.1	27.5	30.0	32.6
1-hr	23.2	28.5	31.7	35.8	39.0	42.1
2-hr	33.3	40.8	45.4	51.3	55.9	60.4
6-hr	54.2	66.1	73.4	82.8	90.0	97.2
12-hr	68.6	82.0	90.3	100.9	109.0	117.1
24-hr	82.9	98.8	108.6	121.2	130.9	140.5
Future IDF Curve for 2071-2100 Time Horizon Projected Precipitation Amount [mm]						
Duration	***Return Interval [years]***					
	2	***5***	***10***	***25***	***50***	***100***
5-min	7.6	10.0	11.6	13.6	15.1	16.5
10-min	10.6	13.6	15.6	18.2	20.1	21.9
15-min	13.2	17.0	19.6	22.9	25.3	27.7
30-min	17.7	22.1	25.1	28.9	31.7	34.4
1-hr	23.7	29.2	32.8	37.6	41.1	44.4
2-hr	33.9	41.9	47.1	53.9	58.9	63.6
6-hr	55.1	67.7	76.0	86.7	94.8	102.3
12-hr	69.6	83.8	93.2	105.4	114.4	122.9
24-hr	84.2	101.1	112.2	126.7	137.2	147.3

Table 1.3 Future IDF Curves for Comfort Cove (8401259)

Future IDF Curve for 2011-2040 Time Horizon Projected Precipitation Amount [mm]						
Duration	***Return Interval [years]***					
	2	***5***	***10***	***25***	***50***	***100***
5-min	5.6	8.6	10.5	12.8	14.7	16.6
10-min	8.6	13.2	16.1	19.8	22.7	25.6
15-min	10.8	16.5	20.1	24.7	28.3	31.9
30-min	13.8	20.0	24.2	29.2	33.3	37.3
1-hr	16.7	23.3	27.6	32.9	37.2	41.5
2-hr	21.2	28.4	33.2	39.0	43.7	48.4
6-hr	34.2	44.5	51.2	59.5	66.1	72.7
12-hr	43.0	55.2	63.1	72.9	80.8	88.5
24-hr	51.3	64.9	73.9	84.9	93.7	102.4
Future IDF Curve for 2041-2070 Time Horizon Projected Precipitation Amount [mm]						
Duration	***Return Interval [years]***					
	2	***5***	***10***	***25***	***50***	***100***
5-min	6.4	9.7	12.0	14.5	16.4	18.4
10-min	9.8	15.0	18.5	22.4	25.4	28.4
15-min	12.2	18.7	23.1	27.9	31.6	35.3
30-min	15.4	22.2	27.3	33.0	37.1	41.4
1-hr	18.4	25.6	30.9	36.8	41.2	45.7
2-hr	23.1	31.0	36.8	43.3	48.1	53.1
6-hr	37.0	48.1	56.3	65.6	72.4	79.3
12-hr	46.3	59.5	69.1	80.1	88.1	96.4
24-hr	55.0	69.8	80.6	93.0	102.0	111.3
Future IDF Curve for 2071-2100 Time Horizon Projected Precipitation Amount [mm]						
Duration	***Return Interval [years]***					
	2	***5***	***10***	***25***	***50***	***100***
5-min	6.8	9.8	11.7	14.2	16.1	18.1
10-min	10.4	15.1	18.0	21.9	24.9	28.0
15-min	13.0	18.7	22.4	27.3	31.1	34.9
30-min	16.1	22.7	26.8	32.1	36.3	40.6
1-hr	19.0	26.0	30.3	36.1	40.6	45.1
2-hr	23.7	31.4	36.2	42.5	47.5	52.4
6-hr	37.8	48.8	55.5	64.5	71.4	78.4
12-hr	47.3	60.2	68.2	78.8	87.0	95.2
24-hr	56.1	70.6	79.5	91.5	100.8	110.0

Table 1.4 Future IDF Curves for Daniels Harbour (8401400)

Future IDF Curve for 2011-2040 Time Horizon Projected Precipitation Amount [mm]						
	Return Interval [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	4.9	7.3	8.9	10.9	12.3	13.7
10-min	7.0	9.9	11.8	14.2	15.8	17.5
15-min	8.2	11.4	13.5	16.1	17.9	19.7
30-min	10.8	15.0	17.8	21.1	23.5	25.9
1-hr	15.7	21.3	25.1	29.5	32.8	36.0
2-hr	21.3	27.5	31.5	36.3	39.8	43.2
6-hr	32.9	42.8	49.1	57.1	63.1	68.8
12-hr	44.8	57.4	65.5	75.7	83.0	90.3
24-hr	60.3	80.0	92.7	108.6	120.0	131.3
Future IDF Curve for 2041-2070 Time Horizon Projected Precipitation Amount [mm]						
	Return Interval [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	5.7	8.3	9.9	12.1	13.6	15.0
10-min	7.9	11.0	13.0	15.6	17.4	19.2
15-min	9.3	12.7	14.9	17.6	19.6	21.5
30-min	12.2	16.7	19.5	23.1	25.7	28.2
1-hr	17.5	23.5	27.4	32.3	35.8	39.2
2-hr	23.4	29.9	34.0	39.2	42.9	46.6
6-hr	35.2	45.8	52.7	61.4	67.8	74.2
12-hr	47.9	61.6	70.4	81.5	89.7	97.9
24-hr	65.4	86.6	100.3	117.7	130.5	143.3
Future IDF Curve for 2071-2100 Time Horizon Projected Precipitation Amount [mm]						
	Return Interval [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	6.0	8.8	10.9	13.4	15.3	17.2
10-min	8.2	11.7	14.1	17.1	19.5	21.8
15-min	9.6	13.4	16.0	19.3	21.9	24.4
30-min	12.7	17.6	21.1	25.4	28.7	32.0
1-hr	18.1	24.7	29.5	35.3	39.8	44.2
2-hr	24.1	31.2	36.2	42.4	47.2	52.0
6-hr	35.9	47.4	55.2	65.4	72.7	80.0
12-hr	49.0	63.8	74.0	87.2	96.7	106.1
24-hr	67.0	90.2	106.2	126.8	141.6	156.5

Table 1.5 Future IDF Curves for Deer Lake A (8401501)

Future IDF Curve for 2011-2040 Time Horizon Projected Precipitation Amount [mm]						
	Return Interval [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	4.7	6.7	8.0	9.6	10.9	12.1
10-min	6.7	9.3	11.0	13.1	14.7	16.3
15-min	8.1	10.9	12.7	15.0	16.7	18.4
30-min	11.3	14.4	16.4	18.9	20.7	22.6
1-hr	15.1	18.9	21.3	24.4	26.6	28.8
2-hr	21.4	27.4	31.2	36.0	39.7	43.2
6-hr	30.9	38.7	43.8	50.2	54.9	59.6
12-hr	41.4	50.4	56.3	63.7	69.3	74.7
24-hr	50.0	62.6	70.8	81.1	88.9	96.4
Future IDF Curve for 2041-2070 Time Horizon Projected Precipitation Amount [mm]						
	Return Interval [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	5.1	7.2	8.7	10.6	11.9	13.2
10-min	7.2	10.0	11.9	14.3	16.0	17.7
15-min	8.7	11.6	13.7	16.3	18.1	19.9
30-min	11.9	15.1	17.4	20.2	22.2	24.2
1-hr	15.9	19.8	22.6	25.9	28.3	30.7
2-hr	22.7	28.9	33.4	38.7	42.6	46.5
6-hr	32.0	40.1	45.8	53.0	58.1	63.2
12-hr	42.7	52.1	58.7	66.8	72.7	78.5
24-hr	51.9	64.9	74.1	85.2	93.4	101.5
Future IDF Curve for 2071-2100 Time Horizon Projected Precipitation Amount [mm]						
	Return Interval [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	5.4	8.0	9.6	11.8	13.4	14.9
10-min	7.7	10.9	13.1	15.9	17.9	19.9
15-min	9.2	12.7	15.0	18.0	20.1	22.3
30-min	12.5	16.2	18.8	22.0	24.3	26.7
1-hr	16.7	21.1	24.2	28.0	30.8	33.6
2-hr	24.0	31.2	36.1	42.3	46.8	51.3
6-hr	33.2	42.6	48.8	56.7	62.5	68.3
12-hr	44.2	54.9	62.1	71.1	77.8	84.4
24-hr	54.0	68.7	78.6	91.1	100.3	109.4

Table 1.6 Future IDF Curves for Gander Airport CS (8401705)

Future IDF Curve for 2011-2040 Time Horizon Projected Precipitation Amount [mm]						
Duration	***Return Interval [years]***					
	2	***5***	***10***	***25***	***50***	***100***
5-min	4.8	6.6	7.8	9.3	10.5	11.6
10-min	6.9	9.6	11.4	13.6	15.4	17.1
15-min	8.3	11.7	13.9	16.7	18.8	20.9
30-min	11.2	15.7	18.6	22.3	25.2	28.0
1-hr	14.6	19.5	22.7	26.8	29.9	33.0
2-hr	20.2	26.5	30.5	35.7	39.7	43.6
6-hr	33.4	43.5	50.0	58.5	64.9	71.1
12-hr	43.8	57.9	66.9	78.7	87.6	96.3
24-hr	54.6	75.1	88.3	105.6	118.5	131.2
Future IDF Curve for 2041-2070 Time Horizon Projected Precipitation Amount [mm]						
Duration	***Return Interval [years]***					
	2	***5***	***10***	***25***	***50***	***100***
5-min	5.1	7.2	8.7	10.4	11.7	13.0
10-min	7.4	10.5	12.6	15.3	17.2	19.2
15-min	8.9	12.7	15.4	18.7	21.1	23.5
30-min	11.9	17.1	20.7	25.1	28.4	31.6
1-hr	15.4	20.9	24.9	29.6	33.1	36.6
2-hr	21.1	28.0	32.9	38.8	43.2	47.5
6-hr	34.9	45.8	53.7	63.0	69.9	76.8
12-hr	45.9	61.1	71.8	84.6	94.1	103.6
24-hr	57.7	79.8	95.4	114.2	128.1	141.9
Future IDF Curve for 2071-2100 Time Horizon Projected Precipitation Amount [mm]						
Duration	***Return Interval [years]***					
	2	***5***	***10***	***25***	***50***	***100***
5-min	5.1	7.2	8.5	10.3	11.6	12.8
10-min	7.3	10.4	12.4	15.0	16.9	18.8
15-min	8.8	12.6	15.1	18.3	20.6	23.0
30-min	11.9	17.0	20.3	24.6	27.7	30.9
1-hr	15.3	20.8	24.4	29.1	32.5	35.9
2-hr	21.1	27.9	32.4	38.2	42.5	46.8
6-hr	34.7	45.7	52.9	62.1	69.0	75.8
12-hr	45.8	60.8	70.7	83.4	92.8	102.2
24-hr	57.4	79.4	93.9	112.4	126.2	139.9

Table 1.7 Future IDF Curves for La Scie (8402520)

Future IDF Curve for 2011-2040 Time Horizon Projected Precipitation Amount [mm]						
	Return Interval [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	3.5	4.7	5.4	6.3	7.0	7.7
10-min	4.9	6.6	7.7	9.0	10.0	11.0
15-min	6.2	8.5	10.0	11.9	13.2	14.6
30-min	8.8	11.9	13.9	16.3	18.2	20.0
1-hr	12.2	15.7	17.9	20.7	22.7	24.8
2-hr	17.6	22.4	25.4	29.2	31.9	34.7
6-hr	30.8	39.8	45.5	52.7	57.9	63.2
12-hr	44.5	56.7	64.6	74.3	81.5	88.7
24-hr	57.8	71.1	79.6	90.2	98.0	105.8
Future IDF Curve for 2041-2070 Time Horizon Projected Precipitation Amount [mm]						
	Return Interval [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	3.8	5.1	5.9	6.9	7.7	8.5
10-min	5.3	7.2	8.4	9.9	11.0	12.2
15-min	6.8	9.3	11.0	13.1	14.6	16.2
30-min	9.5	12.9	15.2	18.0	20.0	22.2
1-hr	13.0	16.8	19.4	22.5	24.8	27.2
2-hr	18.8	23.9	27.4	31.7	34.8	38.1
6-hr	33.0	42.8	49.4	57.4	63.4	69.5
12-hr	47.4	60.7	69.8	80.8	88.9	97.3
24-hr	61.0	75.5	85.3	97.2	106.0	115.1
Future IDF Curve for 2071-2100 Time Horizon Projected Precipitation Amount [mm]						
	Return Interval [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	4.0	5.3	6.2	7.2	8.0	8.8
10-min	5.7	7.6	8.8	10.3	11.5	12.6
15-min	7.3	9.9	11.6	13.7	15.2	16.7
30-min	10.1	13.7	16.0	18.8	20.9	22.9
1-hr	13.8	17.7	20.3	23.4	25.7	28.0
2-hr	19.8	25.1	28.7	32.9	36.1	39.2
6-hr	34.8	45.0	51.8	59.8	65.8	71.7
12-hr	49.9	63.8	73.1	84.0	92.2	100.2
24-hr	63.8	78.8	88.9	100.7	109.5	118.3

Table 1.8 Future IDF Curves for Port Aux Basques (8402975)

Future IDF Curve for 2011-2040 Time Horizon Projected Precipitation Amount [mm]						
Duration	***Return Interval [years]***					
	2	***5***	***10***	***25***	***50***	***100***
5-min	5.1	6.7	7.8	9.2	10.2	11.2
10-min	7.7	9.7	11.1	12.9	14.2	15.5
15-min	10.0	12.9	14.8	17.2	19.0	20.8
30-min	14.8	19.0	21.9	25.6	28.3	30.9
1-hr	20.1	25.6	29.3	34.1	37.6	41.0
2-hr	30.5	39.7	46.0	54.0	59.9	65.6
6-hr	44.7	56.7	65.0	75.4	83.1	90.8
12-hr	57.5	71.0	80.2	91.9	100.5	109.1
24-hr	71.8	89.5	101.7	117.0	128.4	139.7
Future IDF Curve for 2041-2070 Time Horizon Projected Precipitation Amount [mm]						
Duration	***Return Interval [years]***					
	2	***5***	***10***	***25***	***50***	***100***
5-min	5.4	7.0	8.2	9.7	10.8	11.9
10-min	8.1	10.2	11.7	13.6	15.0	16.4
15-min	10.6	13.5	15.5	18.1	20.1	22.0
30-min	15.6	20.0	23.0	27.0	29.9	32.8
1-hr	21.2	26.9	30.7	35.8	39.6	43.4
2-hr	32.3	41.8	48.4	57.0	63.4	69.7
6-hr	46.5	59.2	67.8	78.9	87.2	95.5
12-hr	59.5	73.8	83.5	95.8	105.2	114.4
24-hr	74.3	93.0	105.6	121.9	134.0	146.1
Future IDF Curve for 2071-2100 Time Horizon Projected Precipitation Amount [mm]						
Duration	***Return Interval [years]***					
	2	***5***	***10***	***25***	***50***	***100***
5-min	5.8	7.7	9.1	10.8	12.2	13.5
10-min	8.7	11.0	12.8	15.0	16.7	18.5
15-min	11.4	14.6	17.0	20.1	22.5	24.9
30-min	16.7	21.7	25.3	30.0	33.6	37.2
1-hr	22.7	29.0	33.8	39.7	44.4	49.0
2-hr	34.8	45.5	53.5	63.5	71.3	79.2
6-hr	48.8	63.3	73.6	86.7	96.4	106.0
12-hr	62.2	78.4	89.9	104.6	115.5	126.4
24-hr	77.7	98.8	113.7	132.8	146.9	160.9

Table 1.9 Future IDF Curves for St Albans (8403290)

Future IDF Curve for 2011-2040 Time Horizon Projected Precipitation Amount [mm]						
Duration	***Return Interval [years]***					
	2	***5***	***10***	***25***	***50***	***100***
5-min	5.2	6.6	7.6	8.8	9.8	10.7
10-min	7.8	9.7	11.0	12.7	13.9	15.1
15-min	9.7	12.2	13.9	16.1	17.7	19.2
30-min	13.7	16.3	18.1	20.5	22.1	23.8
1-hr	18.9	22.6	25.2	28.5	30.8	33.2
2-hr	28.1	32.0	34.7	38.1	40.6	43.1
6-hr	49.4	55.4	59.6	64.9	68.8	72.6
12-hr	68.5	82.1	91.5	103.6	112.3	120.9
24-hr	89.6	116.0	134.2	157.6	174.4	191.1
Future IDF Curve for 2041-2070 Time Horizon Projected Precipitation Amount [mm]						
Duration	***Return Interval [years]***					
	2	***5***	***10***	***25***	***50***	***100***
5-min	5.7	7.3	8.3	9.6	10.6	11.5
10-min	8.5	10.6	11.9	13.7	15.0	16.3
15-min	10.7	13.4	15.1	17.3	19.1	20.7
30-min	14.7	17.6	19.4	21.8	23.6	25.4
1-hr	20.3	24.4	27.0	30.3	32.9	35.4
2-hr	29.6	33.9	36.6	40.1	42.8	45.4
6-hr	51.4	58.1	62.4	67.9	72.1	76.3
12-hr	73.0	88.3	98.0	110.4	120.0	129.7
24-hr	98.3	128.0	146.9	170.9	189.5	208.4
Future IDF Curve for 2071-2100 Time Horizon Projected Precipitation Amount [mm]						
Duration	***Return Interval [years]***					
	2	***5***	***10***	***25***	***50***	***100***
5-min	5.9	7.4	8.5	9.7	10.6	11.6
10-min	8.7	10.8	12.3	13.9	15.1	16.4
15-min	10.9	13.6	15.5	17.6	19.2	20.9
30-min	14.9	17.8	19.9	22.1	23.8	25.6
1-hr	20.7	24.8	27.6	30.8	33.1	35.7
2-hr	30.0	34.2	37.3	40.6	43.0	45.7
6-hr	51.9	58.7	63.4	69.1	73.1	77.0
12-hr	74.1	89.5	100.4	113.2	122.4	131.3
24-hr	100.5	130.4	151.5	176.4	194.2	211.5

Table 1.10 Future IDF Curves for St Anthony (8403401)

Future IDF Curve for 2011-2040 Time Horizon Projected Precipitation Amount [mm]						
Duration	***Return Interval [years]***					
	2	***5***	***10***	***25***	***50***	***100***
5-min	4.3	6.2	7.6	9.6	11.0	12.3
10-min	6.5	9.5	11.8	14.8	17.0	19.1
15-min	8.1	11.5	14.0	17.3	19.8	22.2
30-min	10.6	13.8	16.2	19.4	21.7	23.9
1-hr	13.8	17.1	19.5	22.7	25.0	27.2
2-hr	19.5	23.6	26.6	30.4	33.3	36.1
6-hr	33.3	39.7	44.5	50.7	55.3	59.8
12-hr	43.7	52.2	58.5	66.7	72.8	78.8
24-hr	56.3	69.6	79.5	92.3	101.8	111.1
Future IDF Curve for 2041-2070 Time Horizon Projected Precipitation Amount [mm]						
Duration	***Return Interval [years]***					
	2	***5***	***10***	***25***	***50***	***100***
5-min	4.8	7.0	8.4	10.2	11.6	12.9
10-min	7.4	10.8	13.0	15.9	18.0	20.1
15-min	9.2	12.9	15.4	18.5	20.9	23.2
30-min	11.5	15.2	17.5	20.5	22.7	24.9
1-hr	14.7	18.5	20.8	23.8	26.0	28.2
2-hr	20.6	25.3	28.2	31.8	34.6	37.4
6-hr	35.0	42.5	47.1	52.9	57.4	61.8
12-hr	46.0	55.8	61.9	69.7	75.5	81.4
24-hr	59.9	75.3	84.8	96.9	106.1	115.2
Future IDF Curve for 2071-2100 Time Horizon Projected Precipitation Amount [mm]						
Duration	***Return Interval [years]***					
	2	***5***	***10***	***25***	***50***	***100***
5-min	5.2	7.4	8.9	10.8	12.3	13.7
10-min	8.0	11.5	13.7	16.7	19.0	21.3
15-min	9.8	13.7	16.2	19.5	22.0	24.6
30-min	12.3	15.9	18.2	21.4	23.8	26.1
1-hr	15.5	19.2	21.5	24.7	27.1	29.5
2-hr	21.6	26.1	29.0	33.0	36.0	38.9
6-hr	36.6	43.8	48.5	54.8	59.5	64.3
12-hr	48.1	57.6	63.8	72.1	78.4	84.6
24-hr	63.2	78.0	87.7	100.6	110.5	120.2

Table 1.11 Future IDF Curves for St John's A (8403506)

Future IDF Curve for 2011-2040 Time Horizon Projected Precipitation Amount [mm]						
Duration	***Return Interval [years]***					
	2	***5***	***10***	***25***	***50***	***100***
5-min	4.8	6.4	7.5	8.8	9.7	10.7
10-min	7.4	9.8	11.2	13.0	14.4	15.8
15-min	9.6	12.7	14.7	17.1	18.9	20.8
30-min	14.4	19.0	22.0	25.6	28.3	31.0
1-hr	20.9	27.7	31.9	37.2	41.2	45.1
2-hr	29.0	39.2	45.5	53.5	59.5	65.4
6-hr	48.8	64.3	74.1	86.3	95.5	104.5
12-hr	61.4	81.9	95.1	111.3	123.4	135.5
24-hr	72.5	94.1	107.8	124.8	137.5	150.2
Future IDF Curve for 2041-2070 Time Horizon Projected Precipitation Amount [mm]						
Duration	***Return Interval [years]***					
	2	***5***	***10***	***25***	***50***	***100***
5-min	5.1	6.9	8.1	9.5	10.6	11.6
10-min	7.9	10.4	12.0	14.0	15.5	17.0
15-min	10.2	13.5	15.6	18.3	20.3	22.2
30-min	15.2	20.1	23.3	27.3	30.2	33.1
1-hr	22.1	29.2	33.8	39.4	43.7	48.0
2-hr	30.8	41.5	48.4	57.0	63.4	69.8
6-hr	51.5	67.8	78.3	91.3	101.0	110.8
12-hr	64.8	86.5	100.5	118.0	130.9	143.8
24-hr	76.1	98.9	113.6	131.9	145.5	159.0
Future IDF Curve for 2071-2100 Time Horizon Projected Precipitation Amount [mm]						
Duration	***Return Interval [years]***					
	2	***5***	***10***	***25***	***50***	***100***
5-min	5.2	7.0	8.2	9.8	11.0	12.1
10-min	8.0	10.5	12.2	14.4	16.0	17.7
15-min	10.4	13.7	15.9	18.8	21.0	23.2
30-min	15.5	20.4	23.7	28.1	31.3	34.5
1-hr	22.5	29.5	34.4	40.7	45.3	49.9
2-hr	31.5	42.1	49.4	59.0	66.0	72.9
6-hr	52.5	68.6	79.6	94.1	104.7	115.1
12-hr	66.1	87.6	102.2	121.3	135.5	149.3
24-hr	77.5	100.0	115.4	135.6	150.4	165.0

Table 1.12 Future IDF Curves for Ruby Line (City of St. John's Station)

Future IDF Curve for 2011-2040 Time Horizon Projected Precipitation Amount [mm]						
	Return Interval [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	4.7	5.8	6.4	7.4	8.0	8.7
10-min	7.3	8.9	9.9	11.2	12.2	13.1
15-min	9.3	11.7	13.1	15.1	16.5	17.9
30-min	14.2	19.0	22.0	26.1	28.9	31.8
1-hr	22.3	30.5	35.4	42.4	47.2	52.1
2-hr	34.2	45.9	53.0	63.0	69.9	76.8
6-hr	54.8	71.3	81.3	95.4	105.1	114.9
12-hr	71.0	94.6	108.8	128.9	142.7	156.6
24-hr	83.6	107.9	122.6	143.2	157.4	171.7
Future IDF Curve for 2041-2070 Time Horizon Projected Precipitation Amount [mm]						
	Return Interval [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	4.8	6.0	6.8	7.7	8.4	9.0
10-min	7.5	9.2	10.4	11.7	12.7	13.6
15-min	9.7	12.1	13.9	15.8	17.2	18.6
30-min	15.0	20.0	23.6	27.5	30.4	33.3
1-hr	23.6	32.1	38.1	44.9	49.8	54.7
2-hr	36.1	48.3	56.9	66.5	73.5	80.5
6-hr	57.4	74.6	86.7	100.3	110.2	120.0
12-hr	74.8	99.3	116.6	135.9	150.0	164.0
24-hr	87.5	112.8	130.5	150.4	164.9	179.3
Future IDF Curve for 2071-2100 Time Horizon Projected Precipitation Amount [mm]						
	Return Interval [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	5.0	6.2	6.9	7.9	8.6	9.3
10-min	7.8	9.5	10.6	12.0	13.1	14.1
15-min	10.1	12.5	14.1	16.2	17.8	19.3
30-min	15.8	20.8	24.1	28.4	31.6	34.7
1-hr	24.9	33.5	39.1	46.4	51.7	57.1
2-hr	38.0	50.3	58.2	68.6	76.3	84.0
6-hr	60.1	77.4	88.7	103.3	114.2	124.9
12-hr	78.7	103.3	119.3	140.2	155.6	171.0
24-hr	91.5	116.8	133.3	154.8	170.7	186.5

Table 1.13 Future IDF Curves for St Lawrence (8403619)

Future IDF Curve for 2011-2040 Time Horizon Projected Precipitation Amount [mm]						
Duration	***Return Interval [years]***					
	2	***5***	***10***	***25***	***50***	***100***
5-min	6.0	7.4	8.3	9.5	10.4	11.2
10-min	9.7	12.3	13.9	16.2	17.8	19.4
15-min	12.4	16.1	18.3	21.5	23.8	26.1
30-min	18.6	24.1	27.5	32.2	35.6	39.1
1-hr	26.7	33.8	38.2	44.2	48.7	53.2
2-hr	37.5	47.1	53.1	61.3	67.4	73.4
6-hr	58.3	72.8	81.7	94.1	103.2	112.3
12-hr	69.4	84.3	93.4	106.0	115.4	124.7
24-hr	78.7	97.1	108.4	123.8	135.3	146.8
Future IDF Curve for 2041-2070 Time Horizon Projected Precipitation Amount [mm]						
Duration	***Return Interval [years]***					
	2	***5***	***10***	***25***	***50***	***100***
5-min	6.4	7.8	8.7	9.9	10.8	11.7
10-min	10.3	13.0	14.6	16.9	18.6	20.2
15-min	13.2	16.9	19.3	22.5	24.8	27.1
30-min	19.9	25.4	28.8	33.6	37.1	40.5
1-hr	28.4	35.4	39.9	46.0	50.5	54.9
2-hr	40.0	49.5	55.5	63.9	70.0	75.9
6-hr	62.0	76.6	85.7	98.4	107.8	116.7
12-hr	73.2	88.2	97.5	110.5	120.2	129.3
24-hr	83.2	102.0	113.5	129.6	141.6	153.2
Future IDF Curve for 2071-2100 Time Horizon Projected Precipitation Amount [mm]						
Duration	***Return Interval [years]***					
	2	***5***	***10***	***25***	***50***	***100***
5-min	6.5	8.0	8.9	10.0	10.9	11.8
10-min	10.6	13.3	15.0	17.2	18.8	20.5
15-min	13.6	17.4	19.8	22.8	25.1	27.4
30-min	20.5	26.1	29.6	34.1	37.5	40.9
1-hr	29.1	36.3	40.7	46.5	51.1	55.5
2-hr	40.9	50.7	56.9	64.9	70.9	76.9
6-hr	63.4	78.5	87.9	100.0	109.2	118.4
12-hr	74.6	90.1	99.8	112.2	121.7	131.1
24-hr	85.0	104.4	116.5	131.9	143.6	155.3

Table 1.14 Future IDF Curves for Stephenville (8403800)

Future IDF Curve for 2011-2040 Time Horizon Projected Precipitation Amount [mm]						
Duration	***Return Interval [years]***					
	2	**5**	**10**	**25**	**50**	**100**
5-min	5.1	7.0	8.2	9.8	10.9	12.0
10-min	7.2	10.1	12.0	14.4	16.1	17.8
15-min	9.2	12.4	14.6	17.3	19.3	21.2
30-min	13.5	18.3	21.5	25.5	28.4	31.3
1-hr	18.6	24.8	29.0	34.2	38.1	41.9
2-hr	25.0	31.7	36.2	41.8	45.9	50.0
6-hr	42.3	54.1	62.0	71.7	78.9	86.0
12-hr	51.8	67.3	77.7	90.6	100.0	109.4
24-hr	65.1	86.4	100.7	118.6	131.8	144.8
Future IDF Curve for 2041-2070 Time Horizon Projected Precipitation Amount [mm]						
Duration	***Return Interval [years]***					
	2	**5**	**10**	**25**	**50**	**100**
5-min	5.4	7.3	8.6	10.2	11.4	12.7
10-min	7.7	10.7	12.7	15.2	17.1	19.0
15-min	9.7	13.1	15.4	18.3	20.4	22.6
30-min	14.3	19.3	22.6	26.9	30.1	33.2
1-hr	19.6	26.0	30.4	36.0	40.1	44.2
2-hr	26.2	33.2	37.9	43.9	48.4	52.8
6-hr	44.4	56.5	64.8	75.2	82.9	90.7
12-hr	54.4	70.3	81.0	94.7	104.8	114.9
24-hr	68.6	90.6	105.6	124.5	138.5	152.5
Future IDF Curve for 2071-2100 Time Horizon Projected Precipitation Amount [mm]						
Duration	***Return Interval [years]***					
	2	**5**	**10**	**25**	**50**	**100**
5-min	5.7	7.7	9.1	10.9	12.2	13.5
10-min	8.2	11.3	13.6	16.4	18.5	20.7
15-min	10.3	13.8	16.5	19.7	22.2	24.5
30-min	15.2	20.3	24.2	28.9	32.5	35.8
1-hr	20.7	27.4	32.3	38.4	43.0	47.3
2-hr	27.5	34.9	40.3	47.0	51.9	56.6
6-hr	46.5	59.4	68.7	80.3	88.8	96.9
12-hr	57.2	73.8	85.7	100.6	111.8	122.3
24-hr	72.4	95.6	112.0	132.7	148.8	163.6

Table 1.15 Future IDF Curves for Churchill Falls A (8501132)

Future IDF Curve for 2011-2040 Time Horizon Projected Precipitation Amount [mm]						
	Return Interval [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	5.3	7.4	8.6	10.4	11.7	13.0
10-min	7.2	10.3	12.0	14.6	16.4	18.3
15-min	8.5	12.3	14.4	17.5	19.8	22.0
30-min	10.6	14.9	17.3	20.8	23.3	25.9
1-hr	12.2	16.1	18.2	21.4	23.8	26.1
2-hr	15.0	18.6	20.6	23.6	25.8	27.9
6-hr	22.4	29.6	34.0	39.6	43.9	48.2
12-hr	31.0	38.6	43.1	49.1	53.7	58.3
24-hr	38.4	47.0	52.1	58.9	64.1	69.3
Future IDF Curve for 2041-2070 Time Horizon Projected Precipitation Amount [mm]						
	Return Interval [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	5.8	8.0	9.5	11.2	12.5	13.8
10-min	7.9	11.2	13.4	15.9	17.8	19.7
15-min	9.4	13.4	16.0	18.9	21.2	23.4
30-min	11.7	16.1	19.1	22.4	24.9	27.5
1-hr	13.1	17.2	19.9	22.9	25.2	27.5
2-hr	15.9	19.7	22.1	25.0	27.1	29.3
6-hr	23.7	31.4	36.5	42.9	47.4	51.9
12-hr	32.4	40.4	45.8	52.3	56.9	61.6
24-hr	40.0	49.2	55.3	62.7	68.0	73.3
Future IDF Curve for 2071-2100 Time Horizon Projected Precipitation Amount [mm]						
	Return Interval [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	6.1	8.4	10.0	12.0	13.4	14.8
10-min	8.4	11.8	14.2	17.1	19.2	21.2
15-min	10.0	14.1	16.9	20.4	22.8	25.2
30-min	12.4	16.9	20.1	24.0	26.8	29.5
1-hr	13.7	17.9	20.8	24.4	26.9	29.4
2-hr	16.5	20.3	23.0	26.3	28.7	31.0
6-hr	24.5	32.5	37.9	44.7	49.8	54.8
12-hr	33.3	41.6	47.1	54.1	59.3	64.5
24-hr	41.0	50.5	57.0	65.1	71.2	77.2

Table 1.16 Future IDF Curves for Goose A (8501900)

Future IDF Curve for 2011-2040 Time Horizon Projected Precipitation Amount [mm]						
Duration	***Return Interval [years]***					
	2	***5***	***10***	***25***	***50***	***100***
5-min	4.6	6.4	7.6	9.2	10.4	11.5
10-min	6.8	9.7	11.7	14.2	16.2	18.1
15-min	8.2	11.9	14.2	17.4	19.8	22.2
30-min	10.5	15.1	18.2	22.2	25.3	28.3
1-hr	12.9	17.3	20.3	24.2	27.2	30.1
2-hr	16.3	21.1	24.3	28.6	31.9	35.1
6-hr	26.1	33.0	37.4	43.5	48.1	52.7
12-hr	34.7	43.0	48.5	55.7	61.3	66.8
24-hr	45.0	56.2	63.5	73.4	81.0	88.4
Future IDF Curve for 2041-2070 Time Horizon Projected Precipitation Amount [mm]						
Duration	***Return Interval [years]***					
	2	***5***	***10***	***25***	***50***	***100***
5-min	4.7	6.7	8.0	9.6	10.7	11.9
10-min	6.9	10.3	12.4	15.0	16.9	18.9
15-min	8.4	12.5	15.1	18.3	20.7	23.1
30-min	10.8	16.0	19.3	23.3	26.3	29.4
1-hr	13.1	18.2	21.3	25.2	28.1	31.1
2-hr	16.5	22.1	25.6	29.8	33.0	36.2
6-hr	26.4	34.4	39.4	45.5	50.0	54.5
12-hr	35.1	44.6	50.7	58.0	63.5	68.9
24-hr	45.5	58.2	66.2	76.0	83.3	90.7
Future IDF Curve for 2071-2100 Time Horizon Projected Precipitation Amount [mm]						
Duration	***Return Interval [years]***					
	2	***5***	***10***	***25***	***50***	***100***
5-min	4.9	6.8	8.1	9.8	11.0	12.2
10-min	7.3	10.4	12.6	15.3	17.4	19.4
15-min	8.8	12.7	15.3	18.7	21.2	23.7
30-min	11.3	16.2	19.6	23.9	27.1	30.2
1-hr	13.7	18.4	21.7	25.8	28.9	31.9
2-hr	17.1	22.3	25.9	30.4	33.8	37.2
6-hr	27.2	34.8	39.8	46.3	51.2	55.9
12-hr	36.0	45.1	51.2	59.0	64.8	70.5
24-hr	46.7	58.8	66.9	77.3	85.0	92.6

Table 1.17 Future IDF Curves for Mary's Harbour A (8502591)

Future IDF Curve for 2011-2040 Time Horizon Projected Precipitation Amount [mm]						
	Return Interval [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	3.2	4.3	5.1	6.0	6.8	7.5
10-min	4.3	5.5	6.3	7.4	8.2	8.9
15-min	5.1	6.5	7.4	8.6	9.4	10.3
30-min	7.2	8.8	9.9	11.3	12.3	13.3
1-hr	9.9	11.7	12.9	14.5	15.6	16.7
2-hr	14.8	18.1	20.3	23.1	25.2	27.2
6-hr	26.4	33.2	37.7	43.6	48.1	52.2
12-hr	37.3	49.0	56.8	67.0	74.6	81.7
24-hr	45.7	60.0	69.5	81.9	91.2	99.9
Future IDF Curve for 2041-2070 Time Horizon Projected Precipitation Amount [mm]						
	Return Interval [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	3.5	4.8	5.6	6.6	7.4	8.1
10-min	4.6	6.0	6.9	8.0	8.8	9.6
15-min	5.5	7.0	8.0	9.3	10.2	11.0
30-min	7.7	9.5	10.6	12.1	13.2	14.2
1-hr	10.4	12.4	13.7	15.4	16.5	17.6
2-hr	15.7	19.4	21.7	24.8	26.9	28.9
6-hr	28.3	35.9	40.7	47.1	51.5	55.9
12-hr	40.6	53.8	62.0	73.1	80.7	88.3
24-hr	49.7	65.9	76.0	89.6	99.0	108.2
Future IDF Curve for 2071-2100 Time Horizon Projected Precipitation Amount [mm]						
	Return Interval [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	3.7	4.9	5.6	6.5	7.2	7.9
10-min	4.9	6.1	6.9	7.8	8.6	9.4
15-min	5.7	7.1	8.0	9.1	9.9	10.8
30-min	8.0	9.6	10.6	11.9	12.9	14.0
1-hr	10.7	12.5	13.7	15.1	16.3	17.4
2-hr	16.3	19.6	21.7	24.3	26.4	28.5
6-hr	29.4	36.2	40.7	46.3	50.4	54.7
12-hr	42.6	54.7	62.7	72.0	79.1	86.6
24-hr	52.2	66.6	76.0	87.8	96.4	105.4

Table 1.18 Future IDF Curves for Nain (8502799)

Future IDF Curve for 2011-2040 Time Horizon Projected Precipitation Amount [mm]						
	Return Interval [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	3.3	4.6	5.4	6.4	7.1	7.8
10-min	4.7	6.4	7.5	8.8	9.7	10.6
15-min	5.7	7.7	8.9	10.4	11.5	12.6
30-min	7.7	10.3	11.9	13.8	15.2	16.6
1-hr	10.8	14.2	16.4	18.9	20.7	22.5
2-hr	15.5	19.8	22.4	25.6	28.0	30.2
6-hr	27.8	36.5	42.0	48.6	53.4	58.1
12-hr	36.8	46.7	52.9	60.3	65.7	70.9
24-hr	46.4	58.1	65.5	74.2	80.7	86.9
Future IDF Curve for 2041-2070 Time Horizon Projected Precipitation Amount [mm]						
	Return Interval [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	3.4	4.6	5.5	6.6	7.5	8.3
10-min	4.8	6.4	7.6	9.1	10.3	11.4
15-min	5.9	7.7	9.1	10.8	12.2	13.4
30-min	8.0	10.3	12.1	14.3	16.1	17.7
1-hr	11.1	14.3	16.6	19.6	21.8	23.9
2-hr	15.9	19.8	22.7	26.5	29.3	32.0
6-hr	28.5	36.6	42.6	50.3	56.2	61.7
12-hr	37.7	46.8	53.5	62.2	68.8	75.0
24-hr	47.4	58.2	66.2	76.6	84.4	91.8
Future IDF Curve for 2071-2100 Time Horizon Projected Precipitation Amount [mm]						
	Return Interval [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	3.4	4.7	5.5	6.5	7.2	7.9
10-min	4.9	6.5	7.6	8.9	9.8	10.8
15-min	6.0	7.8	9.1	10.6	11.7	12.7
30-min	8.1	10.5	12.1	14.0	15.4	16.8
1-hr	11.3	14.5	16.6	19.1	21.0	22.8
2-hr	16.0	20.1	22.7	25.9	28.3	30.6
6-hr	28.9	37.1	42.6	49.2	54.0	58.8
12-hr	38.1	47.4	53.6	60.9	66.3	71.7
24-hr	47.9	58.9	66.3	75.0	81.5	87.9

Table 1.19 Future IDF Curves for Wabush Lake A (8504175)

Future IDF Curve for 2011-2040 Time Horizon Projected Precipitation Amount [mm]						
	Return Interval [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	5.0	7.2	8.6	10.2	11.5	12.7
10-min	7.0	10.0	12.0	14.3	16.0	17.8
15-min	8.4	12.0	14.4	17.2	19.2	21.3
30-min	11.5	16.3	19.3	23.0	25.7	28.5
1-hr	14.1	19.9	23.6	28.1	31.5	34.8
2-hr	17.1	23.1	27.0	31.6	35.1	38.5
6-hr	23.2	29.2	33.1	37.8	41.2	44.8
12-hr	31.0	39.1	44.3	50.7	55.3	60.1
24-hr	38.6	48.2	54.4	62.0	67.6	73.3
Future IDF Curve for 2041-2070 Time Horizon Projected Precipitation Amount [mm]						
	Return Interval [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	5.8	7.9	9.4	11.2	12.5	13.8
10-min	8.1	11.1	13.2	15.7	17.5	19.3
15-min	9.7	13.3	15.8	18.8	21.0	23.2
30-min	13.2	17.9	21.3	25.2	28.1	30.9
1-hr	16.1	21.9	26.0	30.8	34.4	37.9
2-hr	19.2	25.2	29.4	34.4	38.0	41.7
6-hr	24.9	31.0	35.1	40.2	44.0	47.7
12-hr	33.2	41.3	46.8	53.7	58.7	63.7
24-hr	41.3	51.0	57.6	65.7	71.7	77.6
Future IDF Curve for 2071-2100 Time Horizon Projected Precipitation Amount [mm]						
	Return Interval [years]					
Duration	***2***	***5***	***10***	***25***	***50***	***100***
5-min	6.1	8.5	9.9	11.8	13.3	14.7
10-min	8.5	11.9	13.9	16.4	18.5	20.5
15-min	10.2	14.2	16.7	19.7	22.3	24.7
30-min	13.9	19.2	22.4	26.4	29.7	32.9
1-hr	16.9	23.4	27.4	32.3	36.3	40.2
2-hr	20.1	26.7	30.8	35.9	40.1	44.1
6-hr	25.6	32.2	36.5	41.7	45.6	49.7
12-hr	34.0	42.8	48.6	55.5	60.7	66.1
24-hr	42.3	52.7	59.7	68.0	74.1	80.8