Evaluation of Techniques for Flood Quantile Estimation in Canada

by

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Examining Committee Membership

The following are the members who served on the Examining Committee for this thesis. The decision of the Examining Committee is by majority vote.

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Author's Declaration

This thesis consists of material all of which I authored or co-authored: see Statement of Contributions included in the thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Statement of Contributions

Chapter 2 was produced by Shabnam Mostofi Zadeh in collaboration with Donald Burn. Shabnam Mostofi Zadeh conceived of the presented idea, developed the models, carried out the experiments, and performed the computations under the supervision of Donald Burn. Donald Burn contributed to the interpretation of the results and provided input on the written manuscript.

Chapter 3 was completed in collaboration with Martin Durocher, Postdoctoral Fellow of the Department of Civil and Environmental Engineering, University of Waterloo, Donald Burn of the Department of Civil and Environmental Engineering, University of Waterloo, and Fahim Ashkar, of University of Moncton. The original ideas in this work were jointly conceived by the group. Martin Durocher developed the methodology and performed the computations. Shabnam Mostofi Zadeh contributed the manual threshold selections for the dataset. Donald Burn supervised the project. All authors discussed the results and contributed to the final manuscript.

Chapter 4 was again a collaborative work with the above-mentioned co-authors. Shabnam Mostofi Zadeh developed the proposed regional estimation models, performed the computations, and prepared the manuscript. Martin Durocher was instrumental in developing the automatic threshold selection method. Donald Burn supervised the research and assisted with analyzing the results. Fahim Ashkar provided feedback. Shabnam Mostofi Zadeh wrote the manuscript. All the co-authors provided comments and consultation on the manuscript.

Chapter 5 was a collaborative work between Shabnam Mostofi Zadeh, Donald Burn and Nicole O'Brien. Shabnam Mostofi Zadeh planned the research, extracted the necessary dataset, performed most of the computations and analyzed the results. Donald Burn supervised the research and provided guidance and feedback. Nicole O'Brien carried out the simulations required for the field significance test. Shabnam Mostofi Zadeh wrote the manuscript with inputs from all co-authors.

Abstract

As one of the most destructive natural hazards, floods have a strong and devastating influence on various aspects of human society and the environment. Damages from floods can include property loss, destruction of infrastructure, loss of life, social and economic disruption from evacuations, and environmental degradation. Floods are inevitable natural events but their impacts on people and the environment can be reduced by putting mitigation measures in place. Underestimation of flood discharges will lead to increase flood risk, while overestimation will lead to unnecessary increased construction costs.

Effective mitigation measures require a solid understanding of the frequency of floods. How frequently a flood event of a given magnitude may be expected to occur, known as frequency analysis, is of great importance. However, estimation of these frequencies is difficult since extreme events are by definition rare and the length of the recorded data for these events is often short. Thus, flood frequency analysis is essentially a problem of information scarcity. Methods of incorporating related samples of data to reach more accurate conclusions, known as regional (or pooled) frequency analysis, are well established and documented in the literature. In Canada, there has been limited research into a standard and formalized procedure for flood frequency analysis. There are no national guidelines for flood frequency analysis in Canada, unlike in other jurisdictions such as USA, UK, and Australia, and there is thus a lack of a standardized approach for flood quantile estimation.

The research in this thesis investigates different approaches in flood frequency analysis to improve flood quantile estimation. This research develops and applies a standardized approach to estimate extreme flood quantiles in Canada. In the context of pooled flood frequency analysis, this work investigates different approaches for flood quantile estimation that consider annual maximum flow series and also peaks-over-threshold series, including techniques to extract events exceeding the threshold. Changes in extreme flow magnitude and frequency over time are also explored in a multi-temporal and multi-faceted approach.

A pooling technique in the context of super regions was developed that improved quantile estimation in comparison to more traditional grouping methods. This work has led to the development of a semi-automated threshold selection method instrumental in extracting peaks-over-threshold series for a large dataset of gauging stations. The semi-automated threshold selection method was employed in developing an effective pooling method that promotes using peaks-over-threshold series in flood

frequency analysis. The proposed method generally provided better quantile estimates than those obtained by using annual maximum series. The thesis also investigates the nature of changes in flooding events in Canada and studies the characteristics of the observed temporal trends in the flow series.

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Dedication

I dedicate this thesis first and foremost, to my beloved husband, Vandad for his unconditional love, helping me to find and realize my potential, and support me throughout this journey. I also dedicate this thesis, to my loving parents who have been a source of encouragement and inspiration to me throughout my life.

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Chapter 1
Introduction

Floods rank as one of the most damaging forms of natural disaster in the world (Noto and Loggia, 2009), claiming lives and affecting millions of people worldwide (Balica et al., 2013). Floods cost Canadians many millions of dollars every year in infrastructure and property damage, lost production, and loss of life (Environment Canada, 2010). In 1997, "the flood of the century" occurred in the Red River watershed and was considered the worst flooding event in Manitoba since 1852. In 2011, Manitoba was again subject to extensive flooding that cost millions of dollars (Manitoba 2011 Flood Review Task Force (MFRTF), 2013). In 2013, Alberta's most devastating and damaging flood event, the unprecedented floods of the Bow and Elbow Rivers in southern Alberta, occurred with estimated costs of $6 billion (Watersmart Solutions, 2014).

The occurrence of severe floods is a reality that Canada, similar to other parts of the world, has to face. While floods are inevitable natural events and cannot be eliminated, their impact on people and society can be reduced by putting mitigation measures in place. Effective mitigation measures require a solid understanding of the frequency of floods. It is essential to accurately estimate the probability of exceedance of extreme events to design appropriate infrastructure to protect humans and property from the impacts of extreme events. In a statistical approach, the future evolution of the process under study (flood events) is described based on analysis of past measurements in terms of probability of occurrence (Meylan et al., 2012). How frequently a flood event of a given magnitude may be expected to occur, known as frequency analysis, is essential for effective design of flood protection infrastructure, reservoir management, etc. Frequency analysis is a statistical method of estimation that consists of studying past events to determine the probabilities of occurrence of these events in the future. The objective of frequency analysis is to relate the magnitude of events to their frequency of occurrence through a probability distribution (Faber, 2010). However, estimation of these frequencies is difficult because extreme events are, by definition, rare and the data record is often short. In addition, there are numerous sources of uncertainty about the physical processes that give rise to observed events. For these reasons, a statistical approach to the analysis of flood data is often desirable (Hosking and Wallis, 1997).

Estimates of the probability of exceedance of extreme flows are generally obtained for a site of interest using the available record of peak events. Procedures for statistical frequency analysis of a single set of data are well established in the literature. For most gauging stations, flood records are too short to allow reliable estimation of the long return period floods typically required in design assessments. In addition, it is often the case that many related samples of data (observations at different locations) are available for analysis and more accurate conclusions can be reached by analyzing all of the data samples together rather than by using only a single sample (Hosking and Wallis, 1997). This approach is known as regional (pooled) flood frequency analysis. Recent research in frequency analysis advocates the use of a regional (pooled) approach to quantile estimation wherein extreme event information from a collection of sites is combined (pooled) for the estimation of an extreme event quantile for a target site of interest (Burn, 1990; Ilorme and Griffis, 2013). The recommendation is therefore to pool data from groups of catchments (FEH, 1999).

Regional frequency analysis has been an established method for many years. The index-flood procedure introduced by Dalrymple (1960) is an early example. As mentioned in FEH (1999), flood frequency estimation is a developing science, and methods will continue to evolve. Many methodological advancements have been proposed during the past years on different aspects of regional flood frequency analysis, including: the use of peaks-over-threshold flows instead of traditional annual maximum flows; methodologies to estimate frequency distribution parameters; methodologies to define similarities between sites; methodologies to construct pooling groups of similar sites; choosing an appropriate pooled frequency model; and flood frequency analysis in the presence of nonstationarity in the data, just to name a few. The problem in flood frequency analysis is thus not a lack of models and estimation methods. On the contrary, there is an excess of models and estimation methods, and the approach chosen can significantly influence the design value (Gottschalk and Krasovskaia, 2002).

Some jurisdictions have formalized flood frequency analysis into a standardized procedure, such as Bulletin 17C in the United States (England et al., 2018), the Flood Estimation Handbook (FEH, 1999) in UK, and Peak Flow Estimation-Book 3 (Ball et al., 2016). The methodologies used in both the UK and Australia are based on a pooled frequency analysis approach, specifically a focused pooling group approach. Canada, however, does not have national guidelines for flood frequency analysis. Different procedures are used across the country without vetted benchmarks for validation. Such ad hoc procedures involve some arbitrariness and most procedures used in practice do not capitalize on the methodological progress that has appeared in the scientific literature (FloodNet NSERC, 2014).

This research explores different methodologies in flood frequency analysis and develops a standardized approach to the estimation of extreme flood quantiles. The developed approaches are applied to a large dataset of hydrometric stations across Canada. This research is part of a Canadian research network called FloodNet. FloodNet is a collaborative nation-wide effort to improve knowledge on flood processes, their impact and enhance flood forecasting and management in Canada. The FloodNet team is working on the issues of flood estimation and forecasting and will examine the impact of floods on people and society. The approaches developed in this research contribute towards advancing the knowledge of flood regimes in Canada with the goal of developing the tools needed to establish a standardized approach to flood frequency analysis for Canada. An important research challenge is the complexity of the space-time dynamics of extreme flood events driven by the large diversity of geographic, meteorological, and hydro-climatic conditions in Canada.

The statistical techniques used in flood frequency analysis have been developed based on the assumption of independently and identically distributed (IID) hydrometric data. The presence of an increasing or decreasing trend in the moments of a distribution fitted to the data is a means of detecting the absence of IID data (Cole, 2001). To ensure data are free of inhomogeneities, monotonic increasing/decreasing trends in the hydrometric data were explored in this study. This work used a nonparametric trend test that can address the effect of serial correlation (Yue et al., 2002; Onoz and Bayazit, 2012) since serial correlation (autocorrelation) within a data record can affect the results of trend testing (Yue et al., 2002). This thesis explores the nature of flooding events and characterizes the changing nature of records displaying both increasing and decreasing temporal trend.

Standardized approaches based on regional (pooled) frequency analysis using annual maximum series (AMAX) were developed. Broad scale approaches to improve flood quantile estimation were examined. A single numeric that measures the similarity/dissimilarity between sites was utilized to define the hydrologically similar neighborhood of a target site. This work investigated the effect of employing catchment physiographic-climate characteristics and also several flood seasonality measures as the between-site similarity metrics. Moreover, this study established a super region technique that in a hierarchical process employs these two types of similarity metrics. A large dataset of catchments across Canada was used to compare the proposed method with more traditional approaches. The effectiveness of these techniques both in terms of constructing homogeneous pooling groups and accurately estimating extreme flow quantiles was demonstrated for the catchments under study.

Peaks-over-threshold (POT) data are an alternative to the annual maximum series. The POT model avoids AMAX drawbacks by considering flood peaks above a certain threshold level and allows capturing more information regarding the flood phenomena in comparison with AMAX (Lang et al., 1999). Peaks that are not included in the AMAX series, but are still relatively high, will be considered in the POT series. Choosing an appropriate threshold level, assuring the independence of the data series, lack of a standardized methodology, and difficulty in automating the process have been identified as major difficulties in using the POT method in the practice of design flood estimation (Lang et al., 1999; Solari and Losada, 2012, Bezak et al., 2014). This study contributed toward developing a semi-automated threshold selection method. In this research, the behavior of automatic threshold selection based on the Anderson-Darling goodness of fit test was investigated and then the automatic method was calibrated using super regions defined using catchment characteristics. The super regions were identified by clustering sites based on drainage area and mean annual precipitation. This classification allows better understanding of the impact of catchment scale and climate for the target site.

Despite the theoretical advantage of the POT model, some practical aspects of flood frequency analysis using AMAX or POT series are still subject to an ongoing debate. The present research is an effort towards a wider use of the POT method by proposing a standardized methodology and a semi-automated process that can facilitate performing pooled POT frequency analysis by practitioners especially for large-scale datasets. In this study, a formalized framework for conducting pooled frequency analysis using data from both POT and AMAX series was introduced. A systematic approach was introduced to construct homogeneous pooling groups and improve quantile estimation. This framework was verified by comparing the performance of the best identified pooled flood estimation procedure based on POT series with that obtained from a pooled analysis based on AMAX series.

1.1 Objectives

The overall objective of this thesis is to develop methodologies and techniques to improve flood quantile estimation when using AMAX and POT extreme flow series. More specifically, the objectives of this research include:

1) The development of a pooling technique that improves the flood quantile estimation using annual maximum series in comparison with traditional approaches (Chapter 2).

2) The development of a semi-automated approach to identify thresholds for extracting peak events over a threshold to augment the extreme event series (Chapter 3).

3) The development of an effective pooling technique that improves flood quantile estimation using peaks-over-threshold series (Chapter 4).

4) The development of an evaluation process to compare the performance of quantile estimates based on AMAX- and POT- based pooling groups (Chapter 4).

5) The analysis of the type of changes and trends observed in flood event series for Canadian watersheds (Chapter 5).

1.2 Thesis Organization

Chapters 2 to 5 of this thesis are provided in the form of manuscripts that have been published, accepted or submitted in scientific journals. Chapter 2 was accepted in the Canadian Water Resources Journal (Mostofi Zadeh and Burn, 2019). Chapter 3 was published in Hydrological Processes (Durocher et al., 2018). Chapter 4 was accepted in Hydrological Sciences Journal (Mostofi Zadeh et al., 2019). Chapter 5 is presented as a manuscript submitted to Journal of Hydrology: Regional Studies. Transition paragraphs are included here to facilitate the transition from each chapter to the next and to aid in the readability of this thesis. Chapter 6 presents the overall conclusions from this research and the potential for future research based on this work. The list of references follows Chapter 6.

Chapter 2

A Super Region Approach to Improve Pooled Flood Frequency Analysis

This chapter is built upon the accepted article with the same title in the Canadian Water Resources Journal. Minor differences between the paper and the chapter have been made to facilitate consistency and coherence.

Mostofi Zadeh, S. and Burn, D. H. 2019. A super region approach to improve pooled flood frequency analysis. *Canadian Water Resources Journal*. doi: 10.1080/07011784.2018.1548946.

Summary

Floods are known as one of the most damaging natural hazards with devastating influence on people and the environment. Accurately estimating flood frequencies is essential for effective design of flood mitigation systems. Estimation of these frequencies is difficult since extreme events are rare and the length of recorded data is often short. In such situations, extreme flow information from a number of similar sites is combined (pooled) to augment the available at-site information. Pooled flood frequency analysis is a well-known approach used to improve the estimation of extreme flow quantiles at sites with short data records. Identification of pooling groups that will effectively transfer extreme flow information is thus essential. The present research proposes an approach to improve flood quantile estimates through utilizing the concept of super regions integrated with seasonality-based similarity measures to conduct pooled frequency analysis for extreme flow events. To identify homogeneous regions, this study focuses on the region of influence (ROI), or focussed pooling group approach among hydrological neighborhood techniques. To define the hydrologically similar neighborhood of a target site, a single numeric that measures similarity/dissimilarity between sites is usually utilized. This work investigates the effect of employing catchment physiographic-climate characteristics and several flood seasonality statistics as the similarity measures. Moreover, this study explores and establishes a super region technique that in a hierarchical process employs the two types of similarity measures. A large dataset of catchments across Canada was used to compare the proposed method with more traditional approaches. The effectiveness of these techniques both in terms of constructing homogeneous pooling groups and accurately estimating extreme flow quantiles is explored for the catchments under study.

The proposed super region approach was shown to form more reliable homogeneous pooling groups. Analyzing confidence intervals of quantile estimates obtained from pooled and at-site estimates revealed promising improvement.

2.1 Introduction

Floods rank as one of the most damaging form of natural disaster in the world (Noto and Loggiga, 2009), claiming lives and affecting millions of people worldwide (Balica et al., 2013). While floods are inevitable natural events, their impact on people and the environment can be reduced by putting mitigation measures in place. Effective mitigation measures require a solid understanding of the frequency of floods. It is crucial to accurately estimate the relationship between extreme flow quantiles and the associated recurrence interval to design appropriate infrastructure and plan river engineering works. For these purposes, a sufficiently long streamflow record is required at the site of interest; however, at many hydrometric gauges, the observation period is shorter than desired. To compensate for the short data record, regional (pooled) flood frequency analysis can be employed to trade-off between the spatial and temporal characterization of extreme flow (Zrinji and Burn, 1994). In such situations, extreme event information from a collection of sites (hydrological neighbors) that are in some way similar is combined to improve the accuracy and the precision of the extreme flow quantile at a target site. Identification of pooling groups that result in effective transformation of extreme flow information is an important requirement for pooled frequency analysis. The pooled sites defined can be considered homogeneous with respect to extreme flow characteristics.

Pooling groups are usually formed based on a measure of between-site similarity. Possible similarity measures include *at-site statistics* (quantities estimated from extreme flow magnitude measurements) and *site characteristics*, such as watershed physiographic characteristics, climatic characteristics, and timing of peak flows. It is strongly preferred to form the pooling groups based on site characteristics and to use at-site statistics only to validate the homogeneity of the proposed pooling group as the latter are generally based on the same data (Burn et al., 1997; Hosking and Wallis, 1997). Catchment physiographic and climatic characteristics have traditionally been used to define similarities (see, for example, De Coursey, 1973; Mosley, 1981; Acreman and Sinclair, 1986; Nathan and McMahon, 1990; Fovell and Fovell, 1993; and Zrinji and Burn, 1994). Difficulties can occur when using these characteristics since complex interactions between them do not guarantee similar hydrologic responses in watersheds (Burn et al., 1997). Chebana et al. (2014) discussed the complexity of using catchment characteristics, more specifically the effect of different catchment sizes in estimating flow. In addition, these types of data are not always readily available. As an alternative, the timing and regularity of peak flows (flood seasonality) were introduced as a measure of catchment similarity (Reed 1994; Burn, 1997). Seasonality statistics have been successfully employed in identification of pooling groups in several pooled frequency analyses (e.g., Zrinji and Burn, 1996; Burn 1997; FEH, 1999; Merz et al., 1999; Castellarin et al., 2001; Cunderlik and Burn, 2006 a,b; Ouarda et al., 2006; Sarhadi and Modarres, 2011; O'Brien and Burn, 2014; Formetta et al., 2018). The idea of using seasonality measures in a multi-level approach to establish flood frequency regions has been introduced by De Michele and Rosso (2002). They used seasonality indices to cluster basins with similar flood generation process and in the next level they used simple scale invariance to verify the homogeneity of the identified regions. To date, there has been only limited research that has systematically compared the performance of the two general types of similarity measures and their relative merits compared to other multi-level procedures.

Different procedures have been applied in the past to delineate regions that can be considered to be homogeneous. The focused pooling group approach (Reed et al., 1999) selects a potentially unique group of catchments that are nearest to the subject site in attribute space to form a pooling group for that site. The focused pooling group approach, and its modifications, have been extensively applied as a pooling technique in flood frequency analysis (e.g., Zrinji and Burn, 1994; 1996; Tasker et al., 1996; Burn, 1997; FEH, 1999; Castellarin et al. 2001; Grover et al., 2002; Latraverse et al., 2002; Eng et al., 2005; Merz and Blosch, 2005; Shu and Ouarda, 2008; Das and Cunnane, 2011; Micevski et al., 2015).

The effective identification of a pooling group is governed by two fundamental principles, the homogeneity of the group and its size (Castellarin et al., 2001). The aim is to form a group of sites that approximately satisfies the homogeneity condition (Hosking and Wallis, 1997) so that the extreme flow information can be effectively transferred from sites within the region to the site of interest. Burn and Goel (2000) indicated that, in addition to satisfying the homogeneity condition, pooling groups should be sufficiently large. A larger pooling group implies that more extreme flow information is incorporated into the estimation of extreme flow quantiles thus improving the estimates, provided that the extreme flow information is sufficiently similar to the target site. It has been suggested by FEH (1999) that a pooling group should ideally contain $5T$ station-years of data to provide an effective estimate of flood events with a return period of T years. However, as the size of pooling group is increased, there is a tendency for the homogeneity of the group to decrease (Hosking and Wallis, 1997). Thus, there is a trade-off between the required characteristics for a region, which enforces the selection of an appropriate balancing point (Reed et al., 1999).

Pooled frequency analysis has been the subject of extensive research in the past decades generating an abundance of approaches. As Gottschalk and Krasovskaia (2002) stated, the problem in flood frequency analysis is thus not a lack of models and estimation methods. The focus should be on the approach that in the best possible way takes into consideration the regional information available. The objective of this study is to provide a framework to compare the effectiveness of employing different between-site similarity measures in improving pooled flood frequency analysis. This research also investigates the super regions concept, a technique that in a hierarchical process employs two types of similarity measures to form more reliable homogenous pooling groups and more accurate flood estimates. A large dataset of catchments in Canada is used to illustrate the merits of the proposed method. Flood risk poses a unique and complex challenge in Canada. Floods in Canada are known as the most frequent natural disaster, causing millions of dollars in damage and affecting hundreds of thousands of people (Environment Canada, 2010; Oulahen, 2015). The present research is an effort towards the development of a flood estimation approach in Canada aiming to examine broad scale approaches to improve the flood quantile estimation and to develop unified procedures for flood frequency analysis across the country.

2.2 Methodology

Identifying pooling groups of homogeneous sites is one of the initial steps in pooled flood frequency analysis. Selection of variables that are used to define similarity (or dissimilarity) between catchments is an essential requirement for regionalization (Burn, 1997). In this section, two general types of variables, site characteristics and flood seasonality measures, are explored as a means of defining catchment similarity. Next, the super region concept is introduced to form a hierarchical pooling process. A pooling scheme is outlined to construct homogeneous focused pooling groups both with and without the use of super regions. This is followed by the description of a method to compare the performance of different pooling techniques.

2.2.1 Site Characteristics Similarity Measures

Pooling groups were traditionally formed by identifying groups of similar sites in a space of site characteristics. These characteristics must be judged to be of importance in defining a site's physiographic and climate characteristics. These characteristics could include indicators of watershed climate, such as precipitation amounts throughout the year, monthly or annual temperature of the watershed, and indicators of watershed physiography such as geographic location, drainage area, elevation changes, slope, length of streams within the watershed, area covered by waterbodies, etc.

Site characteristics should be closely studied to identify subsets of variables that do not exhibit collinearity and are best linked with variations in the catchment flood events. Moreover, since the observed scales of the variables are different, standardization (transformation) methods are required to overcome the scale differences (Hosking and Wallis, 1997). The identified site characteristics can then be employed in the definition of the dissimilarity between catchments.

2.2.2 Flood Seasonality Similarity Measures

The timing and regularity of flood events have been introduced as a measure of similarity in catchment hydrologic response (Bayliss and Jones, 1993; Burn 1997; Cunderlik et al., 2004). Catchments with similarities in the timing and regularity of flood response can be considered as potential members of the same pooling group for pooled flood frequency analysis (Ouarda et al. 2006). Seasonality measures describe the timing and regularity of flood events and can be defined using directional statistics (Fisher, 1993).

Following Burn (1997), the date of occurrence of the peak flow for a flood event is defined as a directional statistics by converting the Julian date, where January 1 is day 1 and December 31 is day 365 (or 366), of the flood occurrence of event i to an angular value using:

$$\theta_i = (Julian\ Date)_i \frac{2\pi}{lenyr} \tag{2-1}$$

where θ_i is the angular value (radians) for the date for event i and $lenyr$ is the number of days in a year. From a sample of n events, the x- and y-coordinates of the mean date can be determined as;

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} cos(\theta_i);\ \bar{y} = \frac{1}{n}\sum_{i=1}^{n} sin(\theta_i) \tag{2-2}$$

where $\bar{x}$ and $\bar{y}$ represent the x- and y-coordinates of the mean event date. The mean event date can then be defined from:

$$MD = tan^{-1}\left(\frac{\bar{y}}{\bar{x}}\right)\left(\frac{lenyr}{2\pi}\right) \tag{2-3}$$

where MD represents the average date of occurrence of the flood event. A measure of the regularity of the n extreme event occurrences can be determined through:

$$\bar{r} = \sqrt{\bar{x}^2 + \bar{y}^2} \tag{2-4}$$

where $\bar{r}$ characterizes the dimensionless spread of the data in a given catchment and ranges from 0 (low regularity) to 1 (high regularity).

Chen et al. (2013) discussed the importance of including flood magnitude information in the identification of flood seasonality. They suggested using flood magnitudes as weights to take into account their effect in defining the timing and regularity of flood events as follows:

$$\bar{x}' = \frac{\sum_{i=1}^{n} q_i cos(\theta_i)}{\sum_{i=1}^{n} q_i} ; \bar{y}' = \frac{\sum_{i=1}^{n} q_i sin(\theta_i)}{\sum_{i=1}^{n} q_i} \tag{2-5}$$

where q_i is the flow magnitude for event i.

Values of MD and $\bar{r}$ can be estimated using the newly defined weighted seasonality measures, $\bar{x}'$and $\bar{y}'$. The seasonality measures discussed above can then be employed in the definition of the dissimilarity between catchments as described in Section 2.2.4.

2.2.3 Similarity Measures in a Super Region Context

In addition to forming pooling groups based on physiographic-climate characteristics of catchments and statistics representing timing and regularity of floods, this study investigates a procedure that in a hierarchical process employs these two types of similarity measures to form more reliable homogenous pooling groups. The aim here is to explore the effect of major grouping of catchments based on catchment physiographic and climatological factors as an initial step in pooled flood frequency.

Mean annual precipitation (MAP) and basin area were selected in this analysis as catchment descriptor surrogates of climate and scale controls. Studies have shown that these catchment descriptors exert significant control on the frequency regime of hydrological extremes. They are regarded as covariates representing the spatially distributed and complex hydrological processes controlling the catchment flood response (see Salinas et al. (2014) and references therein).

A catchment dataset can be divided into subsets (super regions) based on values of the drainage area and MAP, such as catchments with small to large drainage areas and drier to wetter mean annual precipitation. The idea here is to identify a *super region* of catchments that have similarity in their MAP and drainage area and investigate the effect of using super regions as an initial step in the pooling group formation. For this purpose, a clustering analysis on the catchment descriptors was performed to avoid arbitrary divisions based on ranges in drainage size and MAP. For each of the identified *super regions*, seasonality statistics of catchments representing timing and regularity of floods can be estimated. Catchments associated with each super region are employed in a pooling analysis based on seasonality measures.

2.2.4 Distance Measure

The dissimilarity between catchments can be represented by a single numerical value that will define the separation (distance) of two catchments in the attribute space. In the literature, distance metrics have been used to form hydrological neighborhoods and different distance metrics have been introduced (e.g. Tasker, 1982; Lance and Williams, 1996; Castellarin et al., 2001). An appropriate distance measure can be obtained using the Euclidean distance between catchments in the site characteristics space. Thus, a distance measure can be defined as:

$$D_{ij} = \left[\sum_{m=1}^{M} \left(x_m^i - x_m^j\right)^2\right]^{1/2} \qquad (2\text{-}6)$$

where D_{ij} is the distance between site i and j; x_m^i is the value of attribute m for site i; and M is the number of considered attributes. Small values for D_{ij} indicate that the corresponding catchments exhibit more similarity in the site characteristics space. It should be noted that in addition to the similarity measures discussed above, the geographic coordinates of hydrometric sites were also employed as one of the site attributes. This will also ensure the closeness of the sites in their physical distance. In addition to distance metrics introduced in the past, some recent studies (Chebana and Ouarda, 2008; Wazneh et al., 2016) proposed a similarity measure derived from the depth function.

2.2.5 Catchment Grouping Scheme

The approach taken herein to forming a pooling group for a target site is to arrange the sites in order of their pairwise dissimilarity as described in Section 2.2.4. The first 25 sites with minimum pairwise dissimilarities with the target site are utilized as an initial cut-off point for including stations in the pooling group of the target site. After identifying an acceptably homogenous pooling group, the next stage is the choice of an appropriate pooled frequency distribution. There are many families of distribution that might be candidates for fitting to a regional data set. Their suitability as candidates can be evaluated by applying a goodness-of-fit test. The statistical test described by Hosking and Wallis (1997) is used to select the frequency distribution with the best fit to the pooled data. The selected distribution can be used to estimate the flood quantiles for different return periods for a target site in the pooling group. For further details please refer to Hosking and Wallis (1997).

For each site, three distinct initial pooling groups were constructed using the site characteristic similarities, seasonality measures, and combination of both in a hierarchical super region process. In a two-step process, the relative merits of seasonality based pooling groups in comparison with catchment characteristic pooling groups will be determined and then the potential improvement obtained by employing super regions will be evaluated. The pooling groups resulting from application of the described pooling technique are subsequently evaluated for their hydrologic homogeneity.

The objective of pooling analysis is to form groups of sites that approximately satisfy the homogeneity condition (Hosking and Wallis, 1997). The homogeneity test proposed by Hosking and Wallis (1993) was used for this evaluation. In this homogeneity test, a statistic (H) based on the weighted variance of the L-coefficient of variation ($L - CV$) is derived such that the statistic calculated is:

$$V = \left\{ \sum_{i=1}^{N} n_i (t^{(i)} - t^R)^2 / \sum_{i=1}^{N} n_i \right\}^{1/2} \tag{2-7}$$

where N is the number of sites in the pooling group; n_i is the sample size for site i; $t^{(i)}$ and t^R are the sample $L - CV$ and regional average $L - CV$ respectively. Simulation experiments are then carried out to estimate the theoretical mean (μ_V) and standard deviation (σ_V) of V. This results in the following heterogeneity measure:

$$H = \frac{V - \mu_V}{\sigma_V} \tag{2-8}$$

A region can be considered homogeneous if $H < 1$, possibly heterogeneous if $1 \leq H < 2$, and definitely heterogeneous if $H \geq 2$. Hosking and Wallis (1997) stated that the H-value criterion is a useful guideline and approximate homogeneity is sufficient to ensure that regional frequency analysis is much more accurate than at-site analysis. The goal in this study is to successfully delineate homogeneous pooling groups for the catchments under study using different similarity measures.

If the initially formed pooling group is determined to be unacceptably heterogeneous, revisions are required to be performed on the group while still satisfying the goal for the number of station-years of data. Catchments whose removal leads to the greatest improvement in the heterogeneity statistic of the group are sequentially selected to leave the pooling group to enhance the homogeneity of the pooling group.

2.2.6 Pooling Approach Comparison

When investigating different pooling techniques for flood frequency analysis, it is essential to evaluate the performance of the different pooling methods. Different pooling schemes will result in different pooling groups, some of which will perform better than others. An estimate of uncertainty in the resulting pooled growth curve has been discussed in FEH (1999) as one way of evaluation. FEH (1999) employed the Pooled Uncertainty Measure (PUM) for this analysis, which has also been adopted in this work.

PUM summarizes the average difference between pooled and at-site growth factors for a target return period. This measure is obtained by averaging results over the sites with long flow records. For a target return period T, the T-year at-site and pooled growth factors are obtained for all the long-record sites. The difference between these growth factors is used as a measure of the associated error in the pooled growth curve. PUM is a weighted average of these differences taken over all available long-record sites and measured on a logarithmic scale. The Pooled Uncertainty Measure for return period T, PUM_T is defined by:

$$PUM_T = \sqrt{\frac{\sum_{i=1}^{M_{long}} n_i \left(lnx_{T_i} - lnx_{T_i}^{P}\right)^2}{\sum_{i=1}^{M_{long}} n_i}} \tag{2-9}$$

where M_{long} is the number of long-record sites, n_i is the record length of the i^{th} site, x_{T_i} is the T-year site growth factor for site i, and $x_{T_i}^{P}$ is the T-year pooled growth factor for site i. Lower values of PUM indicate a better pooling method.

It is recommended that uncertainty in the pooled quantile estimate is also quantified by constructing confidence intervals. Several approaches have been identified to quantify the uncertainty in either pooled or at-site quantile estimates (e.g., Burn, 2003; Hall et al., 2004). In this study, the parametric resampling approach (Hosking, 2013) was employed to construct confidence intervals. This approach has been reported (Hosking, 2013) to provide more realistic estimates of error bounds. This procedure generates realizations of data from a region and requires specification of a distribution function for the pooling group, considers the effect of average cross correlation between sites in the pooling group, and reflects the heterogeneity of the pooling group. The parametric resampling approach can also be employed for at-site confidence interval estimation. A narrower confidence interval corresponds to more precise estimate and is preferred to an estimate with a wider confidence interval (Burn, 2014). Thus, the ratio of confidence interval width for the two estimates was investigated here.

2.3 Application

In this section, the delineation of pooling groups using the two traditional techniques and the proposed hierarchical super region approach are applied and compared using a collection of catchments in Canada.

2.3.1 Description of Dataset and Study Area

The analysis presented in this Chapter focuses on annual maximum flow series (AMS) for hydrometric gauges in Canada. 1338 gauges located across the country with unregulated flows and at least 20 years of flow record were initially selected for the analysis.

Trends in the individual AMS were evaluated using the Mann-Kendall (Kendall, 1975; Mann, 1945) non-parametric test for trend. The block bootstrap (BBS) approach (Önöz and Bayazit, 2012) was used in conjunction with the trend test; the BBS approach involves resampling data in blocks to estimate the significance of the test statistic from the data sample while reflecting the serial correlation present in the data set. Sites exhibiting significant increasing or decreasing trends were removed from the collection of catchments under study. Nonstationary frequency analysis should be considered for these sites. A total of 1114 hydrometric stations passed the data screening and were selected for further analysis. Figure 2-1 top section shows the location of these catchments. Appendix A provides a list of these stations.

In addition to annual maximum flow series, a dataset of 69 catchment physiographic and climate descriptors is available for a subset of 771 catchments of our dataset. The catchment variables can be grouped into categories such as watershed morphology, topography, hydrology, landscape pattern, infrastructure, and climate. Figure 2-1 bottom section shows the location of the catchments in this subset. A list of the reduced dataset can also be found in Appendix A.

Mean annual precipitation (MAP) of the watersheds is another dataset requirement in our analysis. MAP estimates were obtained from 10 km gridded climate data that includes daily precipitation for Canada over the 30 year period 1981-2010 (most recent climate normal). Grids were interpolated utilizing a thin plate smoothing spline technique (ANUSPLIN) originally developed by the Australia

National University (Hutchinson, 2004). MAP for different locations across Canada can be extracted from the data in Figure 2-2. Table 2-1 describes the 771 catchment data set in terms of drainage area, MAP, and record length of AMS. This subset of catchments was utilized to further investigate the merits of different between site similarity schemes in identifying homogenous pooling groups.

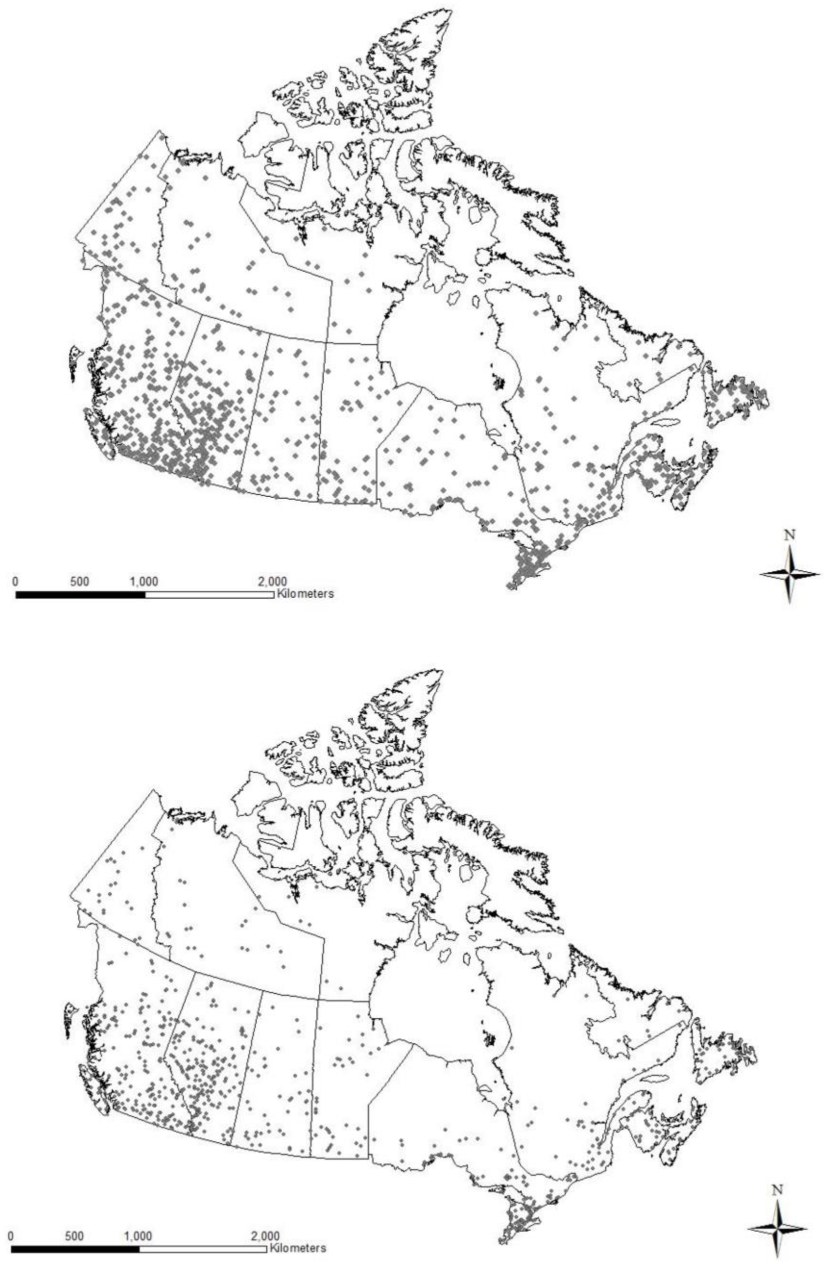


Figure 2-1: Location of 1114 hydrometric gauges in Canada (top). Location of 771 hydrometric gauges in Canada (bottom).

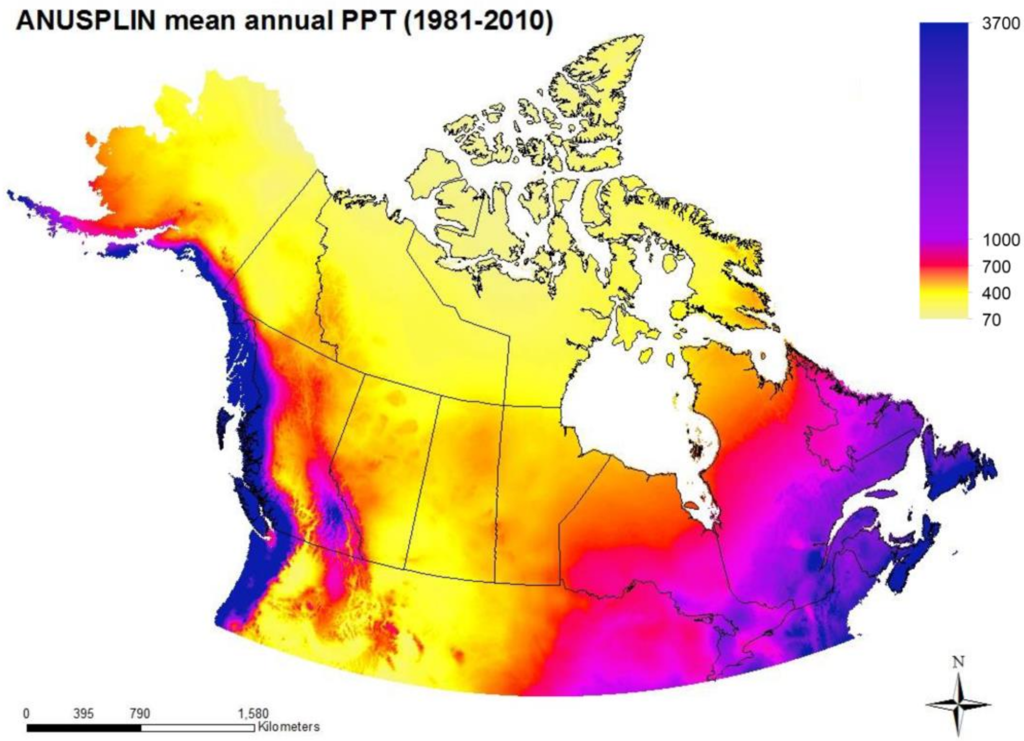


Figure 2-2: Mean annual precipitation for locations in Canada.

Table 2-1: Summary of 771 hydrometric gauges data set.

	Area (km^2)	MAP (mm/yr)	n (yr)
Min	0.5	168.4	19
1st quartile	144.9	461.7	25
Median	459.7	664.7	36
Mean	2829.4	786.9	39
3rd quartile	1993.9	1014.8	48
Max	48866.5	3103.1	111

2.3.2 Results and Discussions

2.3.2.1 Site Characteristics Pooling Groups

The data set of 69 different physiographic and climate characteristics was examined in detail to identify the principal variables in describing the annual maximum flows of the catchments. Irrelevant characteristics to the catchment flows were removed from the dataset. Variables that were representing different statistics of the same catchment characteristics were eliminated (e.g., mean and median catchment elevation would not both be considered). Catchment characteristics that were highly correlated with each other were identified and the most relevant ones were kept in the analysis. It was concluded that a site's geographic location (latitude and longitude), drainage area, mean annual precipitation, percentage of watershed covered by waterbodies, and stream length in the catchment are the principal catchment descriptors for this analysis.

Transformation and standardization were applied on the selected site characteristics to overcome the scale differences. Distance (dissimilarity) between catchments was determined by employing the selected attributes in the Euclidean distance measure. The catchment grouping scheme introduced in Section 2.2.5 was applied to identify pooling groups based on site characteristics. Table 2-2 provides the results of the regionalization approach based on site characteristics applied to the dataset obtained from Canadian catchments. Table 2-2 reveals the percentage of sites for which the constructed pooling group was determined as homogeneous, possibly homogeneous, or heterogeneous. Utilizing this approach results in forming a pooling group that 94.4% of time was assessed as homogenous. The percentage of times when different frequency distributions were identified as the best fit to the pooled data is also summarized in this table with the generalized extreme value distribution being the most commonly selected distribution.

Table 2-2: Summary of region formation based on site characteristics and seasonality measures

		$H < 1$	$1 \leq H < 2$	$2 \leq H < 3$	$H > 3$	GEV	GNO	GLO	PE3	GPA	WKB
Without Super Regions	Site characteristics	94.4%	5.1%	0.5%	0%	36.1%	20.8%	20.0%	14.5%	4.9%	3.8%
	$\bar{x}$ & $\bar{y}$	95.1%	3.9%	0.6%	0.4%	28.8%	23%	30.1%	11.4%	4.9%	1.8%
	MD & $\bar{r}$	94%	3.9%	1.4%	0.6%	28.1%	15.3%	38.4%	12.2%	1.8%	4.2%
	weighted $\bar{x}$ & weighted $\bar{y}$	93.6%	4.3%	1.2%	0.9%	27.1%	19.8%	35.1%	8.4%	7.3%	2.2%
	weighted MD & weighted $\bar{r}$	95.2%	3.2%	1.2%	0.4%	26.3%	18.8%	39.9%	8.0%	5.3%	1.6%
With Super Regions	$\bar{x}$ & $\bar{y}$	88.3%	9.3%	1.4%	1%	32.3%	26.3%	17.1%	14.5%	6.7%	3%
	MD & $\bar{r}$	88.1%	9.3%	1.8%	0.8%	34.6%	24.1%	18.8%	14.1%	5.4%	2.9%
	weighted $\bar{x}$ & weighted $\bar{y}$	88.6%	8.9%	1.2%	1.3%	30.9%	26.2%	18.4%	14.9%	6.4%	3.2%
	weighted MD & weighted $\bar{r}$	89.7%	8.4%	1.5%	0.4	29.6%	30.9%	20.1%	12.1%	5.2%	2.2%

GEV- Generalized extreme value distribution; GNO- Generalized normal distribution; GLO- Generalized logistic distribution; PE3- Pearson type III distribution; GPA- Generalized Pareto distribution; WKB- Wakeby distribution

2.3.2.2 Seasonality Based Pooling Groups

Figure 2-3 illustrates, in seasonality space, the mean date and regularity of flood events for the subset of Canadian catchments. As expected, the flood regime for these stations exhibits a high degree of variability across the data set as it is driven by the large diversity of geographic and meteorological conditions across the country. These stations exhibit either nival, pluvial or mixed hydrologic regimes expressing different regularity in the flood seasonality (Burn and Whitfield, 2016).

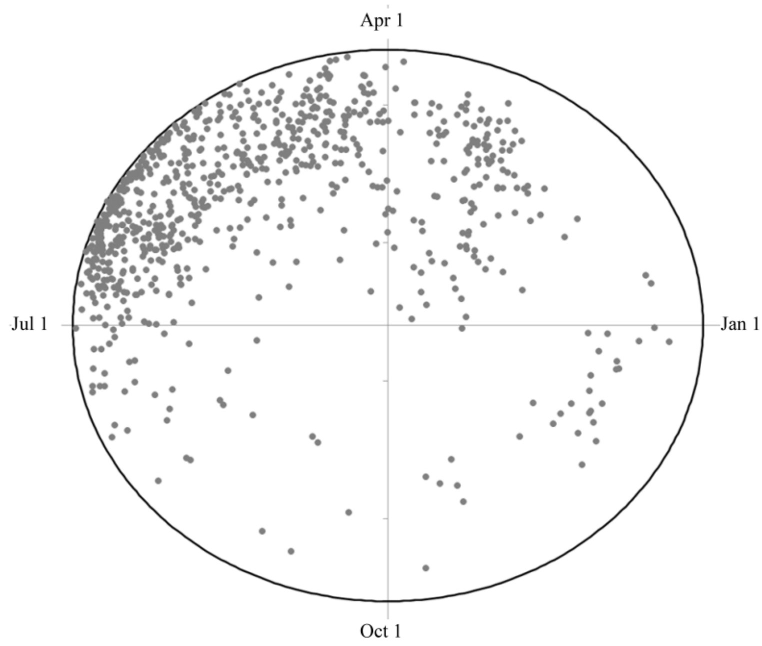


Figure 2-3: Mean annul flood date and flood regularity for the hydrometric stations.

The seasonality measures discussed in Section 2.2.2 were employed to quantify between site similarities and perform pooled flood frequency analysis on the collection of 771 catchments. One objective here is to compare the performance of these different seasonality measures in successfully constructing pooling groups for the sites under study. The combination of seasonality statistics, $\bar{x}$ and $\bar{y}$; MD and $\bar{r}$; and also their weighted modifications, were employed respectively in the definition of between site dissimilarity using Euclidean distance in the attribute space. The pooling framework proposed in Section 2.2.5 was employed to identify the most effective pooling groups. Table 2-2 also provides the results of regionalization based on the seasonality measures. A substantial percentage (94.5% on average for the four seasonality similarity measures) of the formed pooling groups were identified as homogeneous. It seems that employing different seasonality measures will not impose a significant difference in constructing homogeneous pooling groups, as the percentage of successful homogeneous pooling groups are almost identical among these seasonality measures. Generalized logistic frequency distribution appeared as the most commonly selected distribution.

2.3.2.3 Super Region Based Pooling Groups

As proposed in the Methodology, drainage area and MAP can be used to group the catchments into subsets (super regions) that represent similar properties in the size of drainage area and amount of annual precipitation. For this purpose, agglomerative hierarchical clustering is used to form super regions. For the dataset of catchments under study, six super regions were identified after preliminary trials as they enhance the representation of variation in drainage area and precipitation. Figure 2-4 plots MAP against drainage area for the catchments under study; the six super regions are also shown in this figure.

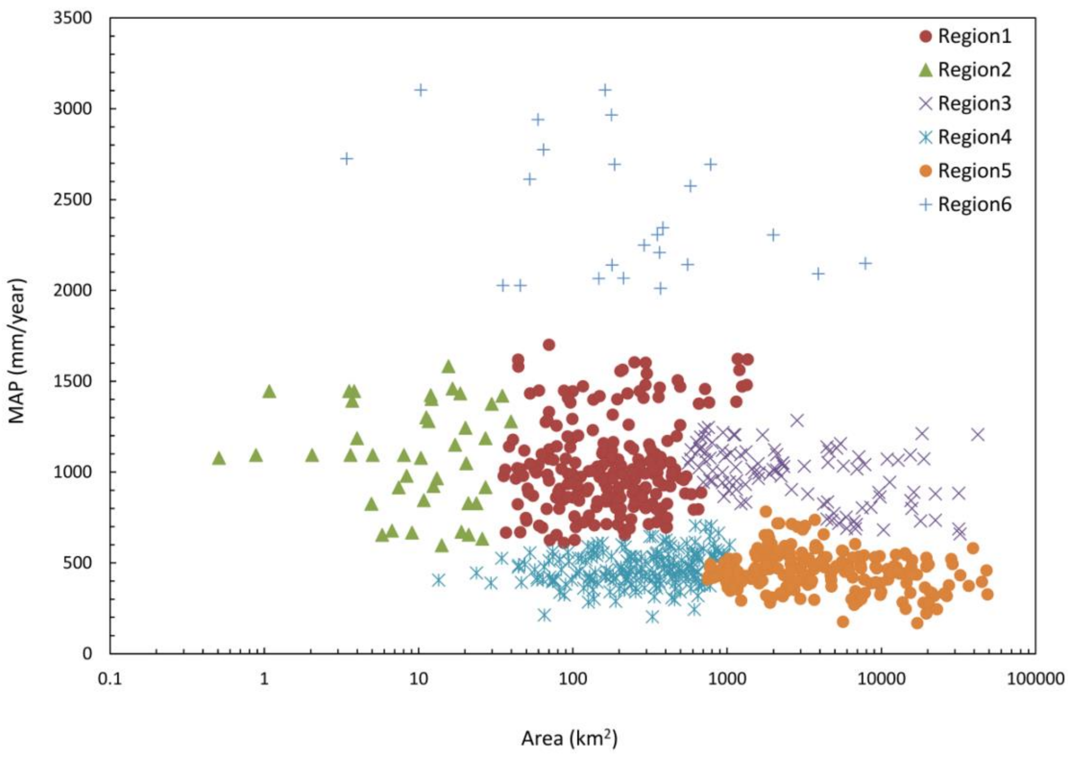


Figure 2-4: Catchment characteristics of 771 Canadian catchments.

Within each super region, seasonality statistics as per the previous section, were estimated and employed in the pooling analysis. Table 2-2 provides the percentage of sites among all super regions for which the constructed pooling group was determined as homogeneous, possibly homogeneous, or heterogeneous. The percentage of times when different frequency distributions were identified as the best fit to the pooled data is also summarized in this table. In addition, Figure 2-5 illustrates the results of homogeneity test for all super regions based on the average percentages for different seasonality measures. Each super region has a different number of assigned catchments, however, from these results it can be concluded that each super region was highly successful for identifying a large number of homogeneous and acceptably homogenous pooling groups. A small percentage of sites, 1.5%, 6.9%, and 4.2% in super regions 4, 5 and 6, respectively, were identified as heterogeneous. It has been noted by Hosking and Wallis (1997) that moderately heterogeneous regions may still offer valuable information concerning quantiles for return periods of rare events.

2.3.2.4 Comparison of the Results

PUMs have been evaluated for pooling groups formed by using site characteristics, different seasonality measures, and also in the case of considering super regions. 17 sites with record length more than 90 years were considered for this analysis, as it can be assumed that reliable at-site estimates can be obtained from these long-record sites. Table 2-3 presents the result of PUMs. Comparison of the numbers provided in Table 2-3 indicates that pooling groups formed by employing seasonality measures have superior PUM values for different return periods in comparison with groups formed using site-characteristics as similarity measures. In addition, regardless of which seasonality measure has been used, PUMs are lower when the super region framework was applied. Therefore, based on the subset of 771 catchments, it can be inferred that employing the hierarchical super region framework improves the pooled flood quantile estimation for different return periods.

Table 2-3: PUM results based on different pooling techniques.

Return Period	Site characteristics	$\bar{x}$ & $\bar{y}$		MD & $\bar{r}$		Weighted $\bar{x}$ & $\bar{y}$		Weighted MD & $\bar{r}$	
2	0.089	0.082	0.037	0.103	0.042	0.076	***0.034***	0.087	0.047
5	0.044	0.033	0.026	0.043	0.034	0.038	***0.021***	0.040	0.034
10	0.124	0.092	0.047	0.118	0.063	0.100	***0.035***	0.104	0.063
20	0.204	0.156	0.080	0.198	0.101	0.168	***0.063***	0.176	0.103
50	0.311	0.243	0.130	0.305	0.156	0.260	***0.107***	0.273	0.161
100	0.390	0.310	0.173	0.389	0.201	0.332	***0.145***	0.348	0.206

Notes: For the seasonality measures, the first entry is without the use of super regions and the second is with super regions. For each row, the entry underlined gives the best result without super regions and the entry in ***bold italics*** gives the best result with super regions.

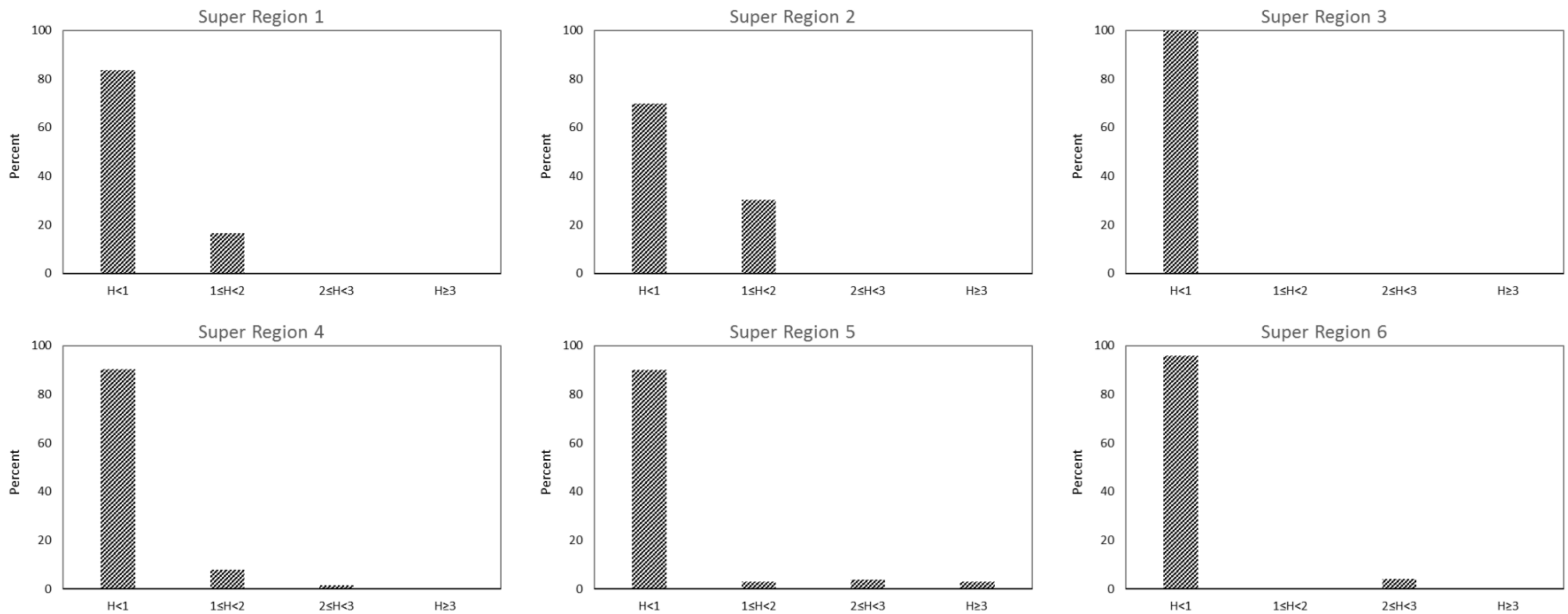


Figure 2-5: Percentage of identified homogeneous pooling groups for six super regions.

2.3.2.5 Expanded Super Regions

As utilizing seasonality measures in the context of super regions was judged to perform better than other techniques for the reduced set of catchments, it was decided to employ this technique and expand it over the entire collection of 1114 hydrometric stations. Recall that catchment characteristic data were only available for 771 of these catchments. Drainage area and MAP were again used for the expanded dataset to assemble new super regions based on the expanded set of stations. After preliminary trials, a set of six super regions (different from the previous super regions) was developed for the expanded dataset to discretize drainage sizes and MAP. Figure 2-6 plots MAP against drainage area for all the catchments under study and distinguishes super regions with similarities in drainage area size and MAP.

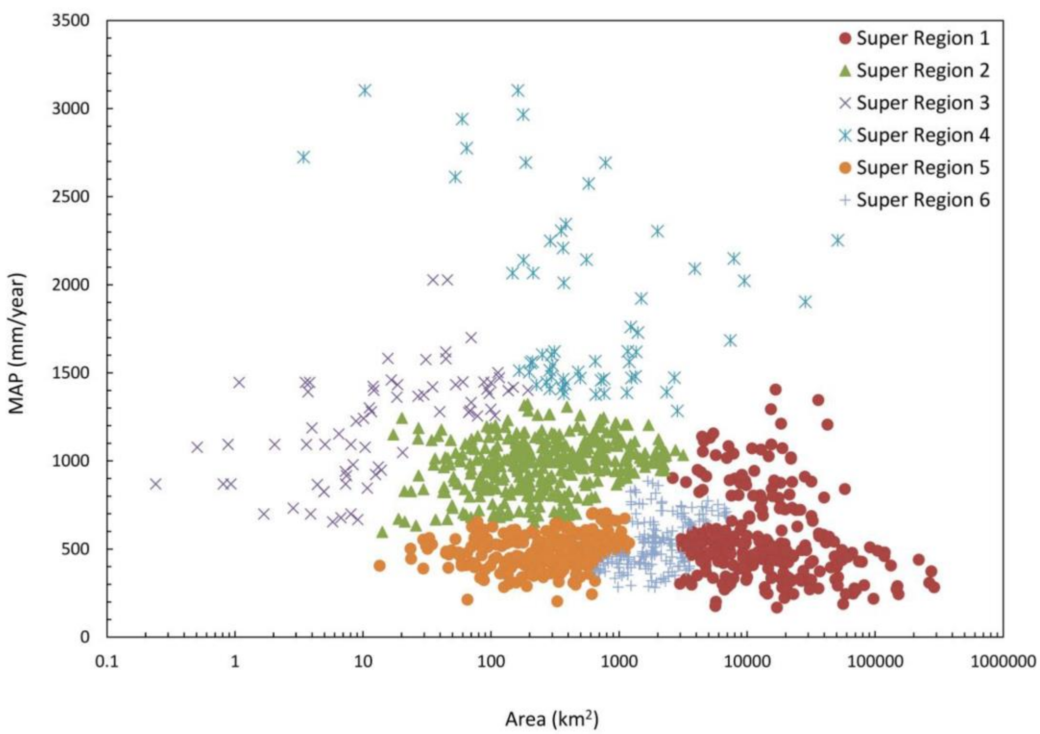


Figure 2-6: Identified super regions based on expanded dataset.

The focused pooling approach was utilized based on the four seasonality measures for each super region and the sites therein. Results for the identified homogeneous pooling groups were again very promising. PUM analysis was performed on a set of long record sites. Table 2-4 demonstrates the result of PUM analysis for the expanded dataset along with PUM estimates of the reduced dataset with super regions in the analysis. For all seasonality measures, there was better agreement between the pooled and at-site quantiles for shorter return periods while the agreement decreased as the return period increased. This behavior is reasonable for regional models as the uncertainty in both estimates increases with longer return periods. The results for the four seasonality measures are quite similar with a slight advantage for MD and r (unweighted version). It is therefore recommended that seasonality based on MD and r be used to form pooling groups.

Table 2-4: PUM results for reduced and expanded datasets.

Return Period	$\bar{x}$ & $\bar{y}$		MD & $\bar{r}$		Weighted $\bar{x}$ & $\bar{y}$		Weighted MD & $\bar{r}$	
2	0.037	0.038	0.042	0.039	<u>0.034</u>	***0.036***	0.047	0.047
5	0.026	0.028	0.034	0.031	<u>0.021</u>	0.030	0.034	***0.027***
10	0.047	0.061	0.063	***0.056***	<u>0.035</u>	0.062	0.063	0.059
20	0.080	0.099	0.101	***0.090***	<u>0.063</u>	0.098	0.103	0.096
50	0.130	0.153	0.156	***0.142***	<u>0.107</u>	0.147	0.161	0.146
100	0.173	0.196	0.201	***0.186***	<u>0.145</u>	***0.186***	0.206	***0.186***

Notes: For the seasonality measures, the first entry is with the use of super regions for the reduced dataset and the second is with super regions for expanded dataset. For each row, the entry underlined gives the best result for the reduced and the entry in bold italics gives the best result with expanded super regions.

2.3.2.6 Confidence Interval Uncertainty Analysis

The proposed pooled approach to estimate flood quantiles based on using different seasonality measures in a super region context was compared with the results from applying an at-site estimate. The primary basis of comparison was the width of the 95% confidence interval obtained by parametric resampling approach.

18 sites with long recorded flows (more than 90 years) were selected for this analysis. Figure 2-7 provides box plots of the ratio of confidence interval widths of pooled quantile over at-site quantile for these sites based on MD and r as the similarity measure. It can be concluded that, as expected, the ratio of the confidence interval widths decreases as the return period increases, implying an increased advantage for the pooled approach as the length of the return period increases. For return periods in excess of 5 years, there is a clear advantage for the pooled approach even though the at-site estimates are based on more than 90 years of record. It is also clear that there are some sites for which the at-site approach provides narrower confidence interval widths than the pooled approach. These sites will be examined in further detail in future work. Figure 2-8 helps visualize the comparison between the at-site

and pooled quantile estimates and the estimated confidence intervals for sample site 01AK001, which demonstrates the superiority of the pooled estimates for this long record site.

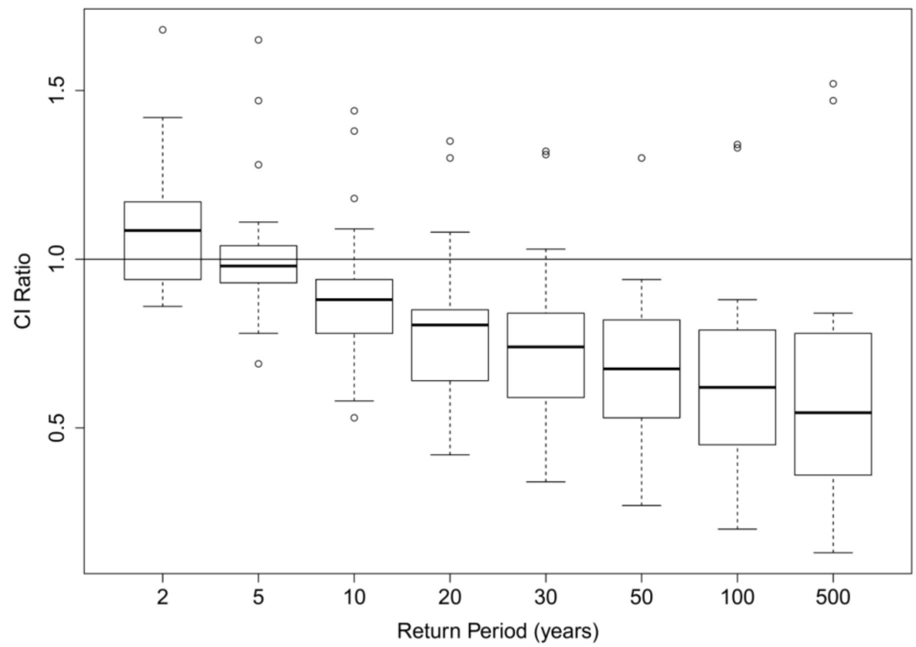


Figure 2-7: Box plots of the ratio of confidence interval widths for 18 long recorded sites.

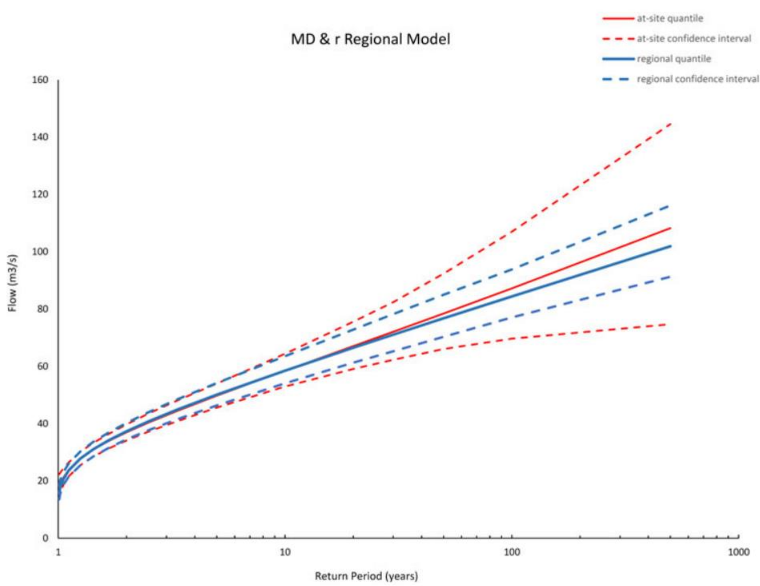


Figure 2-8: Quantile estimation and confidence interval comparison for site 01AK001.

2.4 Conclusions

This study has examined broad scale approaches to improve flood quantile estimation. The focused pooling approach was employed to form pooling groups based on different between site similarity measures. This work has investigated the performance of pooling group formation based on catchment physiographic-climate characteristics and several flood seasonality statistics to define similarity/dissimilarity between sites. In addition, a framework was developed that employs these two types of similarity measure in a hierarchical process using super regions. Each catchment has been characterized in terms of size and mean annual precipitation as rough surrogates for scale control and climate and was categorized as belonging to one super region.

Comparisons between the proposed pooling techniques were performed on a subset of 771 catchments in Canada for which catchment characteristic data are available. Each pooling technique was able to identify a large number of homogeneous pooling groups. The pooled Uncertainty Measure (PUM) was adopted to evaluate the performance of different pooling approaches in terms of accuracy of flood quantile estimates. Pooled quantiles estimated based on site-characteristic similarities showed less agreement with at-site estimates of long record sites, while seasonality based pooling groups resulted in better estimates of pooled quantiles. When the super region framework was applied, the PUMs exhibited substantial improvement in the quantile estimates.

Pooled estimates using the super regions are preferred to those without super regions, so the concept was employed on the expanded dataset of 1114 hydrometric stations from across Canada. Six super regions with similarity in their size and precipitation were distinguished and pooling groups were formed by utilizing the focused pooling approach for the sites within each identified super region. The adopted approach was able to identify very promising homogeneous pooling groups for most catchments under study. Results of PUM analysis demonstrated that quantile estimates based on super regions are preferred and typically result in substantive improvements in comparison with estimates obtained without the use of super regions. Among different seasonality measures employed in this study, the combination of MD and $\bar{r}$ statistics resulted in pooling groups that provided better quantile estimates. In addition, analysis of uncertainty based on constructing confidence intervals for both at-site and pooled quantile estimates revealed that there is generally less uncertainty associated with the pooled quantiles than the at-site quantiles for the presented pooled flood frequency approach.

Transition Paragraph A

Annual maximum series (AMAX) and Partial duration series, also known as Peaks-Over-Threshold (POT), are two types of time series that are commonly considered for modelling extreme events. The simplicity of extracting AMAX series comes with some shortcomings in this type of extreme series. Some significantly large floods that are not the largest event in a year will be neglected in this series (Bacova-Mitkova and Onderka, 2010) thus causing some information loss about the extreme events. Moreover, inclusion of the maximum event in each year in the series may introduce some low events in the series that are still the largest value in the year (Bezak et al., 2014). POT time series avoid these drawbacks by extracting peaks above a prescribed threshold level (Lang et al., 1999). However, the POT approach has been relatively unpopular in the practice of design flood estimation. A major difficulty in employing the POT method has been described as choosing the appropriate threshold level (Bezak et al., 2014). The previous chapter focused on employing AMAX series in pooled flood quantile estimation and demonstrated approaches for improving these estimates. This chapter[1], focuses on techniques to automatically identify the threshold level for a POT series. The objective of this chapter is to develop a hybrid method to combine automatic threshold selection methods based on a goodness-of-fit test and to calibrate this based on catchment characteristics of Canadian watersheds.

[1] Durocher, M., Mostofi Zadeh, S., Burn, D.H., and Ashkar, F. (2018). Comparison of automatic procedures for selecting flood peaks over threshold based on goodness-of-fit tests. *Hydrological Processes*. 32(18): 2874-2887.

Chapter 3

Comparison of Automatic Procedures for Selecting Flood Peaks-Over-Threshold based on Goodness-of-Fit Tests

This chapter is built upon the published article with the same title in Hydrological Processes. Minor differences between the published paper and the chapter have been made to facilitate consistency and coherence.

Durocher, M, Mostofi Zadeh, S., Burn, D. H., and Ashkar. F. 2018. Comparison of Automatic Procedures for Selecting Flood Peaks Over Threshold based on Goodness-of-fit tests. *Hydrological Processes*. 32(18): 2874-2887.

Summary

In comparison to the traditional analysis of annual maximums, the peaks over threshold (POT) method provides many advantages when performing flood frequency analysis and trend analysis. However, the choice of the threshold remains an important question without definite answers and common visual diagnostic tools are difficult to reproduce on a large scale. This study investigates the behavior of some automatic methods for threshold selection based on the generalized Pareto model for flood peak exceedances of the threshold and the Anderson-Darling (AD) test for fitting this model. In particular, the choice of a critical significance level to define an interval of acceptable values is addressed. First, automatic methods are investigated using a simulation study to assess fitting and prediction performance in a controlled environment. It is shown that p-values approximated by an existing table of critical values can speed up computation without affecting the quality of the outcomes. Secondly, a case study compares automatically and manually selected thresholds for 285 sites across Canada by flood regime and super regions based on site characteristics. Correspondences are examined in terms of prediction of flood quantiles and trend analysis. Results show that trend detection is sensitive to the threshold selection method when studying the evolution of the number of peaks per year. Finally, a hybrid method is developed to combine automatic methods and is calibrated on the basis of super regions. The outcomes of the hybrid method are shown to more closely reproduce the estimates of the manually selected thresholds while reducing the model uncertainty.

3.1 Introduction

Peaks over threshold (POT) models have a long history in the estimation of hydrological risk in terms of the so-called return periods (Ashkar and Rousselle, 1983; Rosbjerg et al., 1992; Tavares and Da Silva, 1983). In most cases, flood frequency analysis is performed using POT assuming that flood peaks above a well-chosen threshold are independent and identically distributed (i.i.d) according to a Generalized Pareto Distribution (GPD). The most common alternative to POT in flood frequency analysis is the analysis of annual maximum flood peaks, which is often preferred for its simplicity. POT results depend on the subjective choice of a threshold and a declustering algorithm that identifies independent peaks from daily time series. However, limiting a study to the annual maximums has the drawback of limiting the amount of information extracted from the daily data. In-depth comparisons between these two approaches has been the subject of several studies, which generally conclude that POT is relatively more efficient (Bezak et al., 2014; Madsen et al., 1997). In particular, it is generally accepted that for thresholds associated with at least 1.6 peaks per year (PPY), POT will provide better predictive performance than annual maximums (Cunnane, 1973).

Over the years, several methods were proposed to select the threshold in POT analysis, but no superior method has been generally adopted, even though it is largely accepted that threshold choice has a crucial impact on the analysis outcomes (Önöz and Bayazit, 2001). Among the existing methods for selecting a threshold, graphical methods such as the mean residual life plot or the GPD shape stability plot are widely applied in practice (Coles, 2001). Both rely on the assumption that for every threshold higher than a well-chosen level, the shape parameter of the GPD is stable. However, graphical or manual methods require expertise and make the evaluation of the total uncertainty impossible (*i.e.*, including the choice of the threshold) (Beguería, 2005). Moreover, the task of physically looking at a large number of graphics requires time, which does not represent a practical solution for routinely performing frequency analysis on large databases.

In order to select a threshold without human intervention, some studies proposed to select thresholds associated with a specific exceedance rate that depends on site characteristics, where an acceptable range of values should be between 1.2 and 3.0 PPY (Irvine and Waylen, 1986; Lang et al., 1999). However, choosing a threshold based on a specific exceedance rate does not ensure that model assumptions are respected. Further insight can be provided by formally testing the hypothesis of a GPD. In this line, Davison and Smith (1990) suggested the goodness-of-fit test of Anderson-Darling (AD) to identify a range of thresholds where GPD cannot be rejected statistically. One option to automate the task of choosing a threshold according to the output of an AD test consists in selecting the lowest threshold among a set of valid candidates. This strategy aims at optimizing the model accuracy by keeping the most peaks available for which GPD provides an adequate fit. Examples of such application was presented by Choulakian and Stephens (2001) on Canadian rivers and by Li et al. (2005) on extreme precipitation in South-West Australia. However, according to Solari et al. (2017) the range of valid thresholds derived from this strategy can be larger than what is practically acceptable, which motivated them to investigate the selection of thresholds associated with the highest p-value. Their study showed that, in some situations, their approach led to higher and more relevant thresholds.

In trend analysis, POT is also an important approach to investigate the evolution of floods in the context of climate change (Collins et al., 2014). For a majority of rivers in Canada, the seasonal snowmelt is the most important event, even though other important flood disasters, such as the recent series of major floods in the urban region of Toronto (Kovacs et al., 2014), are the consequence of extreme rainfalls. Consequently, limiting flood frequency analysis to only annual maximum peaks does not properly account for the diversity of flood generating processes.

Cunderlik and Ouarda (2009) studied the timing and magnitude of flood peaks in Canada and showed that for several rivers seasonal snowmelt events are now occurring earlier during the year and that an increasing number of flood peaks are taking place in the fall. Burn et al. (2016) observed no significant trend in magnitude for rainfall floods but noticed a decrease in the magnitude of the snowmelt events. These studies illustrate the advantage of the use of POT in trend analysis of floods. However, like flood frequency analysis based on POT, these outcomes are sensitive to the choice of the threshold and an informed decision must be made.

The present study is part of the research project FloodNet (2015), an initiative that includes the objective to coordinate the efforts of several experts in various fields to better understand and manage issues related to floods in Canada. Ongoing investigations within this project involve working towards guidelines for performing frequency analysis using the data collected by Water Survey Canada (WSC, 2017), which includes over 1900 hydrometric stations. In that context, manually identifying thresholds for the whole database is unrealistic. Therefore, one objective is to investigate the behavior of automatic selection methods that would allow to carry out POT for that database. The methods to be proposed and investigated are based on p-values of the AD test where existing and new variations of the procedures are considered. The properties of the different automatic methods are explored in terms of the correspondence between estimated flood quantiles and the coherence in detected trends. First, a simulation study is performed to explore the statistical properties of the automatic methods to be proposed. Then, manually selected thresholds obtained from previous studies for 285 sites in Canada are revisited and used as benchmarks. The discrepancies between the estimated flood quantiles associated with a 100 year return period (Q100) and detected trends are explored in light of flood regimes and super regions defined based on site characteristics. A second objective is to present recommendations for selecting thresholds that are adapted to the different hydrologic conditions. In this line, a hybrid method is proposed to combine automatic methods that is calibrated by super region to reproduce with more fidelity the manual method while reducing model uncertainty.

This Chapter is organized as follows. Section 2 describes the methodologies used for trend and flood frequency analysis. Sections 3 and 4 respectively investigate the automatic methods presented in Section 2 using a simulation study and a case study. Finally, Section 5 discusses and summarizes the important conclusions of the study.

3.2 Methodology

3.2.1 Trend Analysis

Detection of trends may be performed on different characteristics of POT data, such as the magnitude or the number of events. For testing the presence of trends in the magnitude, the nonparametric test of Mann-Kendall is used. Autocorrelations in time series can lead to higher rates of false positive in trend analysis due to an underestimated dispersion. Consequently, the significance levels of the tests are evaluated by block bootstraps. The test of Mann-Kendall is based on the ranks of the observations and thus it allows to test against the alternative hypothesis of a monotonic trend without a direct specification of the form of the trend. This strategy is, however, not appropriate for testing trend with categorical data as it may result in a large number of ties. With such data logistic regression is preferred for testing trends in the number of events. The adopted model is a particular case of the generalized linear model (McCullagh and Nelder, 1989), where the probability of exceedance of each day is represented by a binomial variable. The hypothesis of no trend is derived by testing the hypothesis of a null slope. To compensate for the effect of autocorrelations in the uncertainty of the model a variable dispersion parameter is used (Frei and Schär, 2001).

3.2.2 Peaks-Over-Threshold

The POT model considers i.i.d samples of GPD exceedances. To help make the independence assumption of the extracted peaks more acceptable, the declustering method presented in Lang et al. (1999) is adopted, which verifies that all extracted peaks respect the following two conditions on the interarrival time R and the (minimal) intermediate flow x_{min}:

$$R > 5 + log\left(\frac{A}{1.609^2}\right) \quad \text{and} \quad x_{min} \quad < 0.75\, min(x_i, x_j) \qquad (3\text{-}1)$$

where x_i and x_j represent sequential peaks of daily river discharge (m^3/s) and A is the drainage area of the basin (km^2). The first condition aims at ensuring that two consecutive peaks are separated by a sufficient period of time R (in days) that depends on the drainage area A. The second condition makes sure that intermediate flows x_{min} between two peaks x_i and x_j reach at least a level as low as 75% of the lowest peak. If two peaks do not meet these conditions, the lowest one is discarded.

The most common distribution to describe the exceedances $x_i - u$, $i = 1, \dots, n$, knowing $x_i > u$ is the Generalized Pareto distribution with cumulative distribution function:

$$F(x) = 1 - \left(1 - \kappa\frac{x-u}{\alpha}\right)^{1/\kappa} \qquad (3\text{-}2)$$

where $\alpha > 0$ is a scale parameter and κ is the shape parameter. The special case $\kappa = 0$ is treated as an exponential distribution. Maximum likelihood theory is used to estimate the parameters, and the estimated flood quantile associated with a T-year return periods is:

$$z_T = u + \frac{\alpha}{\kappa}[1 - (365.242Tm)^{-\kappa}] \qquad (3\text{-}3)$$

where m is the proportion of peaks based on the total number of daily observations. See for instance Coles (2001).

As mentioned earlier, the automatic methods of interest are based on the significance level of the AD test for a given threshold, which rejects the hypothesis of a GPD distribution F when the distance between F and the empirical cumulative distribution function F_n is large in respect of a weighting function Ψ:

$$A_{\psi}^{2} = n\int_{-\infty}^{\infty}[F_n(x) - F(x)]^2\,\psi(x)dF(x) \tag{3-4}$$

The classical statistic A^2 for the AD test is obtained by considering $\psi(x) = \{F(x)[1 - F(x)]\}^{-1}$, which gives more importance to the fitting of both tails. When analyzing extreme values, more importance is sometimes accorded to the upper tail of the distribution. Therefore, a modified AD test was suggested and uses the statistic A_U^2 defined by $\psi(x) = \{1 - F(x)\}^{-1}$. More details on the application of the modified AD test can be found in Heo et al. (2013). In general, the distribution of the statistics A_{ψ}^2 does not have an explicit form and evaluation of the significance level of the test must rely on bootstrap procedures. Alternatively, a table containing several critical values for the classical AD test A^2 was provided by Choulakian and Stephens (2001). Intermediate critical values can be approximated by linear interpolation of the table, but due to the limitations of the table, interpolated p-values must be restricted between 0.001 and 0.5, the lowest and highest provided p-values.

3.2.3 Automatic Methods for Threshold Selection

All automatic procedures considered in this study start by specifying a set of threshold candidates $u_1, \ldots, u_r$. Here the thresholds are chosen among the set of ordered observations and for which a suitable step is selected to control r the number of candidates. After the declustering algorithm, the exceedance rate is verified to be between 1 and 5 PPY. This upper boundary may be considered high in comparison to common practical recommendations, but this decision is taken in order to not be too restrictive on the automatic method. The notation RATE1.6 will be used to designate a threshold associate with an exceedance rate of 1.6 PPY.

The AD test provides a mechanism to identify a subset of threshold candidates for which the GPD distribution is a reasonable assumption. The statistic of the AD test cannot be used directly as a general measure of goodness-of-fit because its distribution depends on the size of the sample (Solari et al., 2017). Alternatively, the p-value provides a dimensionless quantity that is better suited for selecting the threshold. Therefore, the graphic of the p-values p_i associated with threshold u_i, or simply the p-value plot, is a valuable tool that can help the selection of the threshold. Similarly, to other graphical techniques, the selection of the threshold can be related to the property of GPD shape stability that states that for a well-chosen threshold u^*, all higher thresholds $u > u^*$ are GPD with identical shapes κ (Coles, 2001). It implies that for thresholds that are too low, the p-values should be near zero to indicate the inadequacy of the GPD assumption. Above u^*, the p-values are sufficiently high to not reject the GPD. Notice that selecting too low a threshold does not have the same consequences as selecting too high a threshold. The former case results in not correctly estimating the shape parameter, while the latter case implies that relevant information is ignored.

Figure 3-1 presents an example of the p-value plot for one site located on the St-John River in New Brunswick, Canada. Two types of automatic methods are considered, where one consists in choosing a threshold using the highest p-value and the other using the first threshold higher than a critical p-value p^*. The first method is referred to as the maxPV-based method and the second method is referred to as the significance-based method. The notation MAXPV and SGNF05 are used to designate the threshold associated to the maxPV-based and the significance-based method with $p^* = 0.05$. Figure 3-1illustrates these two thresholds inside the p-value plot and in the GPD shape stability plot. The latter suggests a threshold around $u = 1000$ m^3/s, which is coherent with MAXPV. On the other hand, it indicates that SGNF05 is perhaps too low.

Solari et al. (2017) investigated the maxPV-based method to avoid the tendency of the significance-based method to select unrealistically low thresholds. Although similar in principle, our methodology differs from theirs as they used a modified AD test and a GPD with 3 parameters fitted by L-moments. In context of a large database, the utilization of bootstrap resampling technique can rapidly become time consuming. Being able to rely on an already existing table of critical values of the AD test, like the one presented by Choulakian and Stephens (2001), carries a significant advantage in terms of practic ality and computing time. However, this table was not initially designed for interpolating all possible p-values but presents only a few p-values that are relevant for hypothesis testing. Moreover, this will have a direct impact on the maxPV-based method, because p-value above 0.5 cannot be interpolated and the maximums cannot be identified, given that the highest p-value is 0.5.

In general, a p-value can be seen as a continuous measure of the compatibility of the data with the entire model (Greenland et al., 2016), but as far as we know no theoretical argument has been provided to show that MAXPV will lead to better estimates and its empirical behavior has been studied in a limited number of situations (Solari et al., 2017). Since the p-values p_i are computed from nested samples (except perhaps some differences due to declustering) they are likely autocorrelated. Therefore, it is reasonable to assume that local maximums will exist after reaching GPD shape stability. The specific pattern observed in Figure 3-1, showing a slow decrease after a sudden rise of the p-values up to MAXPV, makes the maxPV-based method an interesting option in that situation. However, one should not expect such a behavior to be systematically repeated.

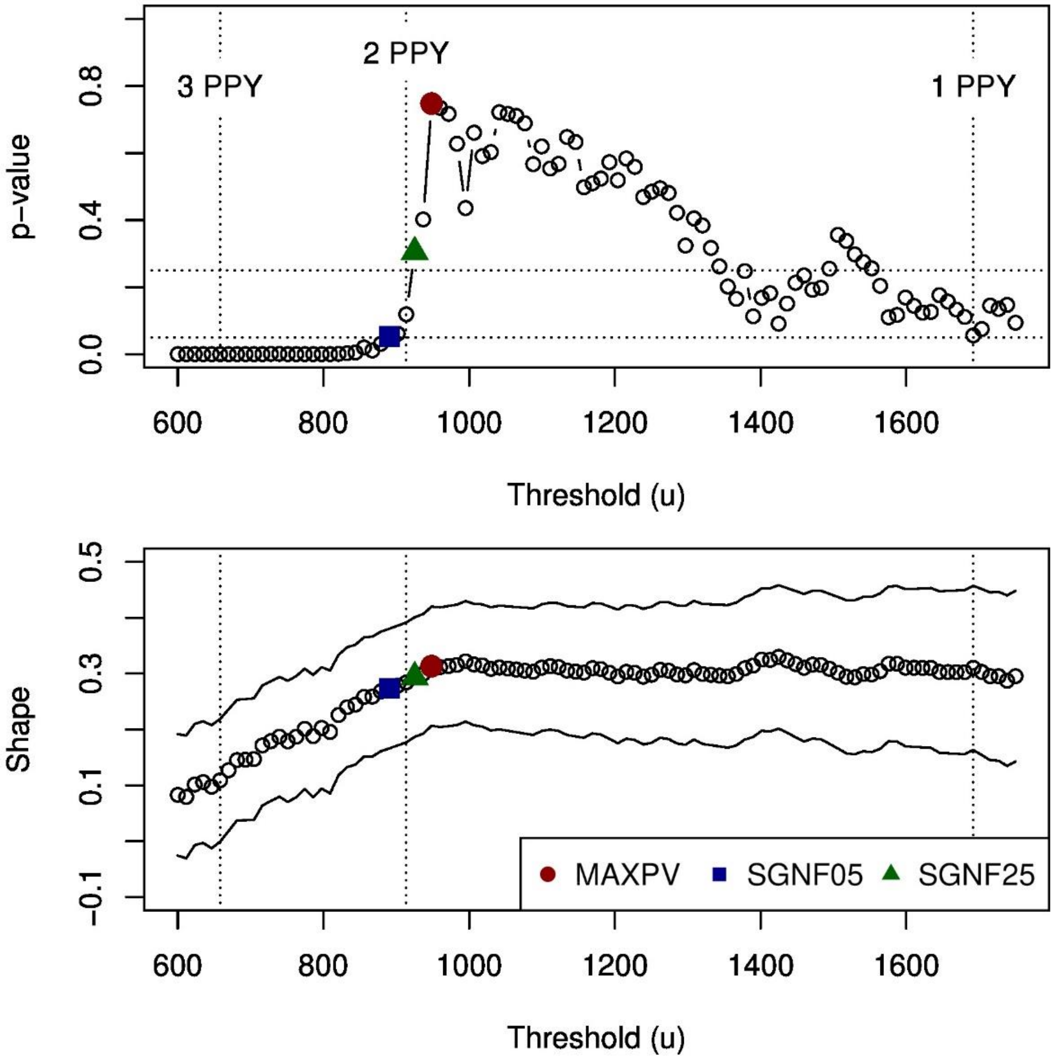


Figure 3-1: P-value plot and generalized Pareto distribution shape stability plot for St. John River in New Brunswick, Canada. PPY: peaks per year.

The present study explores simple alternatives to MAXPV and SGNF05. A simple generalization of the significance-based method SGNF05, which is based on only one critical p-value, consists in verifying a series of decreasing critical p-values $p_l^* > p_{l+1}^*$ where $l = 1, \ldots, L$. The first threshold associated with a p-value respecting $p_i > p_L^*$ is sought and chosen as usual. However, if there is no threshold that respects this condition, the same process is repeated for $l - 1$ until satisfaction. For example in Figure 3-1 if $p_l^* = 0.1,\ 0.5, 0.9$; no threshold respects p_l^*> 0.9, but there is one that respects p_l^* > 0.5 and so, the threshold is selected using that critical value, which ends up selecting the same threshold as MAXPV. This generalization of the significance-based method aims at being easier to implement in large databases as it could *a priori* use larger critical p-values and select proper alternatives when required. In the present study, the series of p-value considered is: 0.05, 0.10, 0.25 and 0.50. The notation SGNF50 is used to designate the method where the p-value is $p_L^* = 0.50$. Note that using a dense series of critical p-values, for instance from 0.05 to 1 by step of 0.01, the significance-based method will behave like MAXPV, which indicates the flexibility and importance of the choice of the series of critical p-values.

Figure 3-1 shows a progressive transition in the p-value plot between $u = 900$ and $u = 1000$ m^3/s, which could be explained by the fact that the non-GPD exceedances are gradually removed until being negligible. In that interval, the p-values pass from nearly zero to almost 0.8. Note that SGNF05 is located at the very beginning of that transition period, while MAXPV is at the end. Interestingly, the threshold chosen from the GPD shape stability plot is also at the end of that transition period. When using the p-value plot as a graphical diagnostic tool, it is a reasonable choice to select the end of that transition period as the selected threshold, because it tells us that a form of stability in the outcomes of the AD test has occurred. However, automatically identifying that end point is not an easy task as the p-value plot does not follow a specific pattern. In this line, a simple approach could be to use the step function that returns the arithmetic mean of the p-values before and after candidate threshold u_k:

$$h_k(u_i) = \begin{cases} (k-1)^{-1} \sum_{j=1}^{k-1} p_j & u_i < u_k \\ (r-k+1)^{-1} \sum_{j=k}^{r} p_j & u_i \geq u_k \end{cases} \tag{3-5}$$

The threshold can be determined as a change point by evaluating h_k at each candidate threshold to find the index K that minimizes the least squares criterion:

$$K = \underset{k=1,\dots,r}{argmin} \sum_{i=1}^{r} [p_i - h_k(u_i)]^2 \tag{3-6}$$

This automatic method will be called the split-based method and its threshold denoted SPLIT. In general, it should lead to higher threshold than SGNF05 as the best change point is expected to be found at the middle of the transition period. In particular, notice that SPLIT coincides with SNGF25 in Figure Figure 3-1.

Finally, a *hybrid* method is proposed to improve the reliability of the estimated flood quantiles by combining two automatic methods. The procedure is described as follows, which depends on a critical value δ^* and the choice of a T-year return period:

1- Find thresholds u_1 and u_2 using the two automatic methods as well as the threshold RATE1.0 associated to 1 PPY denoted u^*. The relation $u_1 < u_2 < u^*$ is assumed.

2- Compute flood quantiles z_1 and z^* associated with $u_1$and u^*.

3- Compute the relative discrepancy $\delta_1 = (z_1 - z^*)/z^*$.

   a. If $|\delta_1| \leq \delta^*$ use threshold u_1.

   b. Otherwise use the higher threshold u_2.

The rationale of the hybrid method is that RATE1.0 is a relatively high threshold that serves as benchmark and is chosen here as the highest accepted threshold among all candidates. If the flood quantile z_1 of the lower of the two automatic methods is discordant with RATE1.0 in terms of relative discrepancy, there are reasonable doubts that the threshold u_1 might be too low. Therefore, the higher threshold u_2 is preferred. If not, the lowest threshold $u_1$should be kept as it includes more peaks and should reduce the uncertainty of the quantile prediction.

Note that the present hybrid method represents a simple way of choosing between two candidates, but that the procedures could easily be adapted to other circumstances by including as benchmarks multiple exceedance rates, the shape parameter itself or the flood quantile estimated from the annual maximum approach. The choice of the return period T in the procedure may affect the outcomes of the analysis and thus should be coherent with the quantiles of interest to ensure its specific stability. Moreover, the shape parameter plays an important role in the extrapolation of longer return periods that exceed the length of the recorded data (Coles, 2001). Consequently, longer return period should provide a proxy for the stability of the shape parameter.

3.3 Simulation Study

The properties of the automatic methods are explored through a simulation study where synthetic data are sampled from a mixed distribution:

$$F(x) = (1-\tau)F_L(x) + \tau F_R(x) \tag{3-7}$$

composed of two truncated distributions F_L and F_R joined at the point $x = 0$. Assuming the respective continuous density f_L and f_R, the following conditions: $F_L(0) = 1$, $F_R(0) = 0$ and $f_L(0) = f_R(0)$, are imposed to ensure the correct definition of the mixed distribution and the continuity of the density. The utilization of mixed distributions in the validation of POT model was discussed in more detail by Scarrott & MacDonald (2012).

In the present simulation study, the right distribution F_R is GPD with a scale parameter $\alpha = 1$ and one of the following three shape parameters: -0.2, 0 and 0.2, corresponding to heavy, medium and light tails. For the left distribution F_L, two options are considered: uniform and lognormal distribution with proper truncation and translation. The utilization of a uniform distribution creates a clear change point in the density function, while the truncated lognormal distribution creates a density function with a "smoother" transition around $x = 0$. To draw a random sample of size $5n$ from the mixed distribution, first a sub-sample of n GPD elements is generated to represent the right distribution F_R , followed by a sub-sample of $4n$ elements of the left distribution F_L. Such an approach strictly imposes the proportion $\tau = 0.2$ of GPD elements. Figure 3-2 illustrates the density of the mixed distributions describe above, but where GPD parameter shapes -0.4 and 0.4 are chosen to better illustrate the influence of this parameter on the distribution's right tail.

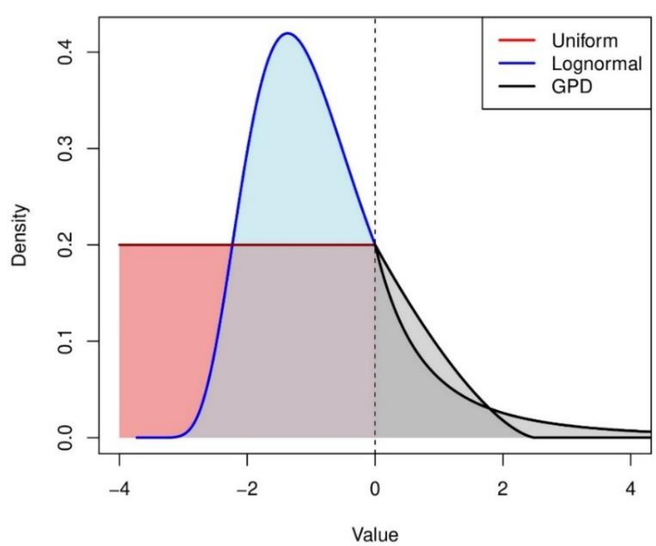


Figure 3-2: Illustration of the density of the mixed distribution based on two truncated distributions. At the right, the shapes of the GPD are κ = -0.4 (tending to ∞) and κ = 0.4 (bounded).

In the following, Monte-Carlo experiments based on a given mixed distribution are repeated 1000 times and for each of them, p-values are evaluated for a series of threshold candidates using a bootstrap sample of size 1000. Figure 3-3 presents the histogram of the thresholds selected by the automatic methods for these Monte-Carlo experiments when the GPD shape parameter is $\kappa = 0$. The histogram for maxPV-based method is shown to be largely dispersed, while the histograms for the significance-based and the split-based methods have their density more concentrated around a more identifiable mode. With the uniform left distribution, the automatically chosen thresholds are generally lower than the expected threshold $u = 0$, except for the maxPV-based method. This tendency to systematically select lower threshold is more pronounced when using a truncated lognormal left distribution, which is expected due to a smoother transition. One can see that increasing the critical p-value for the significance-based method reduces the magnitude of this tendency to underestimate the threshold, but the underestimation is still clearly present. The SPLIT method appears to behave similarly to the significance-based method with a critical p-value between around 0.10 and 0.25. Similar results are obtained using different choices of sample size and GPD shape but are not reported.

Unlike empirical studies, Monte-Carlo experiments specify model parameters and allow direct measurement of the quality of the estimations. The accuracy of the estimated GPD shape parameter is evaluated using the root mean square errors (RMSE) and is presented in Table 3-1when a truncated lognormal left distribution is used. One can see that the best estimation is obtained by the significance-based method and is very similar to the one of the split-based method. The maxPV-based method is underperforming in comparison to the other automatic methods. For medium and heavy tails ($\kappa \leq 0$), SGNF25 seems slightly superior, while SGNF05 and SGNF10 are better for light tails. Notice that based on these results using a critical p-value greater than 0.25 does not bring any advantage. Similarly, the estimation performance for the flood quantile Q100 is evaluated using relative root mean square errors (RRMSE) and is reported in Table 3-1. For computing Q100 an exceedance rate of 2 PPY is assumed, which implies for instance that when n = 100 the peaks were treated as if they were extracted from 50 years of data. The result of the automatic methods reveals that SGNF05 is systematically outperforming the other automatic methods. It suggests that including more peaks in the estimation of the GPD contributes to reduce the uncertainties of the scale parameter and so, the variability of predicted Q100. According to the RRMSE the split-based method has performances in terms of RRMSE between those of SGNF10 and SGNF25, which indicates that a significance-based method with significance levels in this range behave like a split-based method.

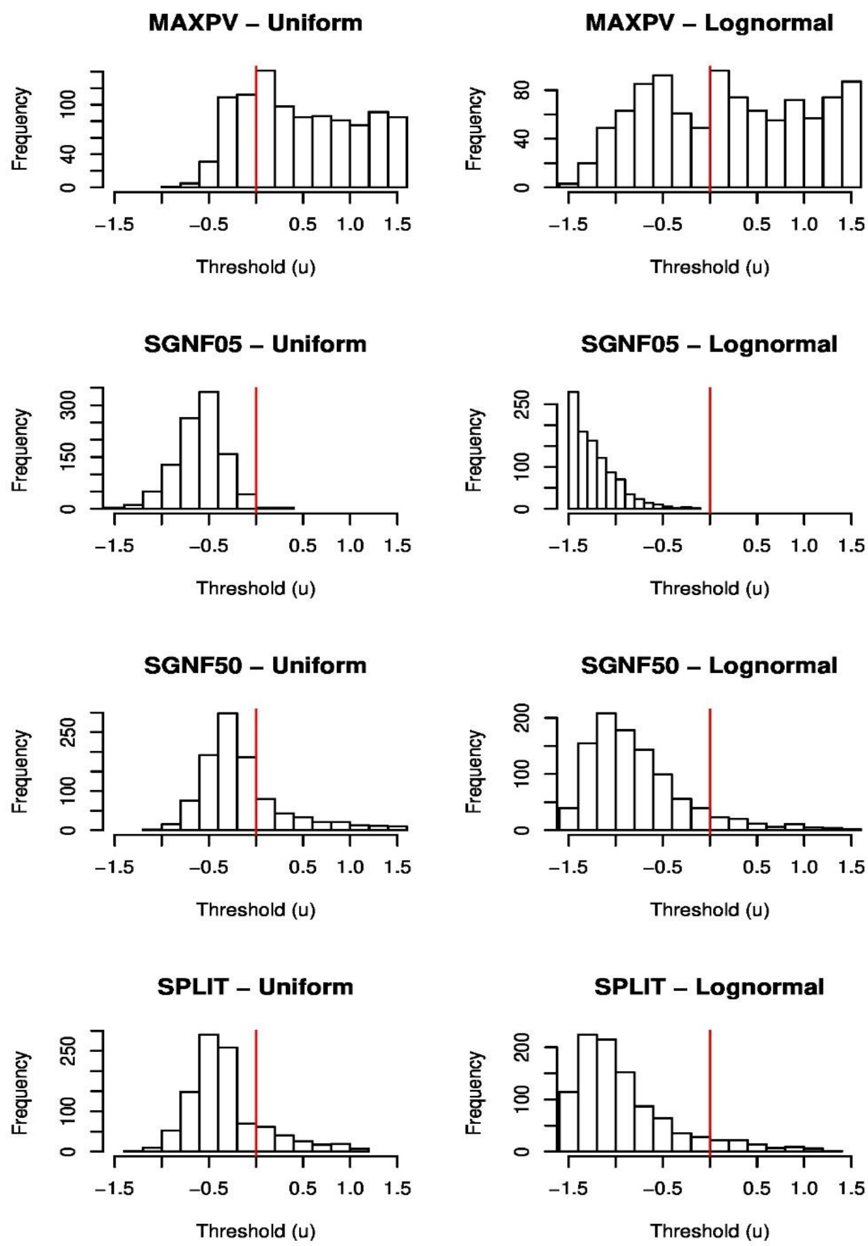


Figure 3-3: Histogram of thresholds from 1000 repetitions of Monte-Carlo experiments by automatic methods. Each sample of size 1000 has 200 GPD elements with shape parameter equal to zero.

Table 3-1: Comparison of fitting and predicting performance for the mixed distribution by automatic method. The left distribution is a truncated lognormal and the GPD right distribution has a sample of size n and shape κ.

Criteria	n	κ	MAXPV	SGNF05	SGNF10	SGNF25	SGNF50	SPLIT
RMSE shape	**50**	**-0.2**	0.25	0.20	0.20	**0.19**	0.20	0.20
		0	0.23	0.15	**0.14**	**0.14**	0.17	0.16
		0.2	0.22	**0.08**	0.09	0.10	0.12	0.11
	100	**-0.2**	0.21	0.17	0.16	**0.15**	**0.15**	0.16
		0	0.21	0.11	0.11	**0.10**	0.12	0.12
		0.2	0.19	**0.06**	**0.06**	0.07	0.09	0.08
	200	**-0.2**	0.14	0.12	0.11	**0.10**	0.11	0.11
		0	0.14	0.09	**0.08**	**0.08**	**0.08**	0.09
		0.2	0.15	**0.05**	**0.05**	**0.05**	0.07	0.06
RRMSE Q100 (%)	**50**	**-0.2**	79.3	**35.1**	39.0	46.1	60.6	43.0
		0	39.3	**23.2**	24.1	27.5	33.2	26.2
		0.2	19.4	**15.5**	15.7	16.7	18.1	16.3
	100	**-0.2**	49.8	**27.7**	29.4	36.5	44.8	32.8
		0	26.9	**17.3**	18.2	20.3	23.8	19.3
		0.2	13.3	**11.5**	11.8	12.1	12.9	11.8
	200	**-0.2**	35.8	**22.2**	24.6	28.3	31.4	25.6
		0	22.0	**14.7**	15.8	17.7	20.0	16.9
		0.2	10.7	**8.9**	9.2	9.7	10.3	9.2

Bold indicates best result in each row.

Similar comparisons among automatic methods are observed when a uniform left distribution is considered, but lower estimation accuracies in GPD shape and Q100 (i.e., higher RMSE and RRMSE) are systematically found, although the same right distribution is used. For instance, the RMSE of SGNF25 for $\kappa = 0$ and size $n = 100$ decreases from 14% in the uniform case to 10% in in lognormal case. Two reasons that can explain this outcome is that non-GPD elements coming from the truncated lognormal distribution are more coherent with GPD and hence affect the estimation less. Additionally, the thresholds with the truncated lognormal distribution are lower, which tend to reduce model uncertainties by including more observations. Note that the mixed distribution with a uniform left distribution is less realistic as such clear change point in the density is unlikely to be found in practice. Results of the Monte-Carlo experiments using a uniform left distribution are provided in Table 3-2.

To evaluate the sensitivity of the automatic method to the choice of goodness-of-fit test, the same Monte-Carlo experiments are reproduced using the modified AD test by reevaluating the p-values via the table of Choulakian and Stephens (2001). Table 3-3 presents similar results as Table 3-1 for the different goodness-of-fit tests, Bootstrap AD, Modified AD and Table AD. The comparison between the classical AD test using Bootstrap or Table shows almost identical results for the significance-based method. On the other hand, the maximum p-value is rarely unique and so MAXPV is selected as the lowest threshold. Therefore, using a table led to better results, because the restriction of the p-value between 0.001 and 0.50 makes it behave similarly to SGNF50. Another finding is that the classical AD test is slightly more accurate than the modified AD test for the medium and heavy tails, while the reverse is true for light tails. Overall, the difference is relatively small, and the only substantial difference appears to be in computing time.

Table 3-2: Comparison of fitting and predicting performance for the mixed distribution by automatic method. The left distribution is a truncated uniform and the GPD right distribution has a sample of size n and shape κ. See also Table 3-1.

Criteria	n	κ	MAXPV	SGNF05	SGNF10	SGNF25	SGNF50	SPLIT
RMSE shape	**50**	**-0.2**	0.28	0.27	0.25	**0.24**	**0.24**	0.25
		0	0.25	0.24	0.23	**0.21**	**0.21**	0.22
		0.2	0.24	0.21	0.20	**0.19**	**0.19**	0.20
	100	**-0.2**	0.22	0.18	0.17	**0.15**	0.16	0.17
		0	0.22	0.16	0.15	**0.14**	0.16	0.16
		0.2	0.21	0.15	**0.14**	**0.14**	0.15	**0.14**
	200	**-0.2**	0.15	0.12	0.12	**0.11**	0.12	0.12
		0	0.15	0.11	**0.10**	**0.10**	0.11	**0.10**
		0.2	0.17	0.10	**0.09**	**0.09**	0.11	0.10
RRMSE Q100 (%)	**50**	**-0.2**	74.0	**39.3**	43.0	52.5	61.6	44.7
		0	38.8	**24.7**	26.5	30.8	34.9	26.8
		0.2	21.1	**15.7**	16.0	18.3	19.1	16.4
	100	**-0.2**	51.7	**31.5**	34.2	40.3	46.2	36.4
		0	27.2	**18.9**	19.8	22.4	25.0	20.2
		0.2	13.9	**11.1**	11.4	12.4	13.3	11.7
	200	**-0.2**	39.3	**26.8**	29.4	32.8	36.4	29.2
		0	22.2	**16.5**	17.4	19.5	21.4	17.6
		0.2	11.2	**9.5**	9.9	10.5	10.9	9.8

Bold indicates best result in each row.

Table 3-3: Comparison of fitting and predicting performance for the mixed distribution by goodness-of-fit tests. See Error! Reference source not found. **for details.**

			AD		Modified AD		Table AD	
Criteria_	n	κ	**MAXPV**	**SGNF25**	**MAXPV**	**SGNF25**	**MAXPV**	**SGNF25**
RMSE Shape	**50**	**-0.2**	0.25	**0.19**	0.27	0.20	0.20	**0.19**
		0.0	0.23	**0.14**	0.26	0.16	0.16	**0.14**
		0.2	0.22	**0.10**	0.24	0.11	0.12	**0.10**
	100	**-0.2**	0.21	**0.15**	0.22	0.16	**0.15**	**0.15**
		0.0	0.21	**0.10**	0.23	0.12	0.11	**0.10**
		0.2	0.19	**0.07**	0.22	0.08	0.09	**0.07**
RRMSE Q100 (%)	**50**	**-0.2**	79.3	**46.1**	80.1	48.2	62.1	46.4
		0	39.3	**27.5**	39.6	28.6	33.1	**27.5**
		0.2	19.4	16.7	19.2	**16.4**	18.3	16.7
	100	**-0.2**	49.8	**36.5**	49.5	37.2	44.8	**36.5**
		0.0	26.9	**20.3**	27.2	**20.3**	23.8	**20.3**
		0.2	13.3	12.1	13.5	**11.9**	12.9	12.1

Bold indicates best result in each row.

3.4 Case Study

3.4.1 Data

Previous studies conducted by Burn et al. (2016) and MacDonald and Burn (2014) used POT to investigate trends in timing and magnitude of flood peaks in Canada. Combining this previous work led to a database of 285 stations in which thresholds were selected manually following the same instructions and using graphical diagnostic tools other than the p-value plot (see Lang et al. (1999) and Burn et al. (2016) for further details). A list of these stations is available in Appendix B. Some of these stations were extracted from the Canadian Reference Hydrometric Basin Network (RHBN), whose stations have been screened for the influences of regulation, diversion or land use changes. Stations from the RHBN are considered to have good quality data. The stations not from the RHBN are all unregulated stations but may not necessarily meet the more rigorous requirements for inclusion in the RHBN. Record lengths for the available sites range between 23 and 104 years with an average of 52 years. These sites of interest can be classified in three categories depending on their flood regimes: Nival, Mixed and Pluvial (Burn et al., 2010). For a large number of sites, classification into flood regime was achieved using a combination of the visual examination of the hydrograph and the classification results from other studies (Burn et al., 2010; Whitfield and Cannon, 2000). Timing of flood events can be represented as a circular statistic with a yearly average $\bar{d}$ and a regularity measure $\bar{r}$ between 0 and 1, which respectively indicates random and perfect recurrence of the peaks (Burn, 1997). Classification in flood regime produced clusters in the seasonal space $(\bar{d}, \bar{r})$ where further assignments were deduced using the distance in the seasonal space between the sites of interest and the cluster centers. The top of Figure 3-4 presents the locations of the sites by flood regimes and on the right their positions in the seasonal space. Sites with pluvial regimes are found exclusively in coastal parts of Canada and sites with mixed regimes are essentially found in the southeastern part. The rest of the sites have been classified as having a nival regime.

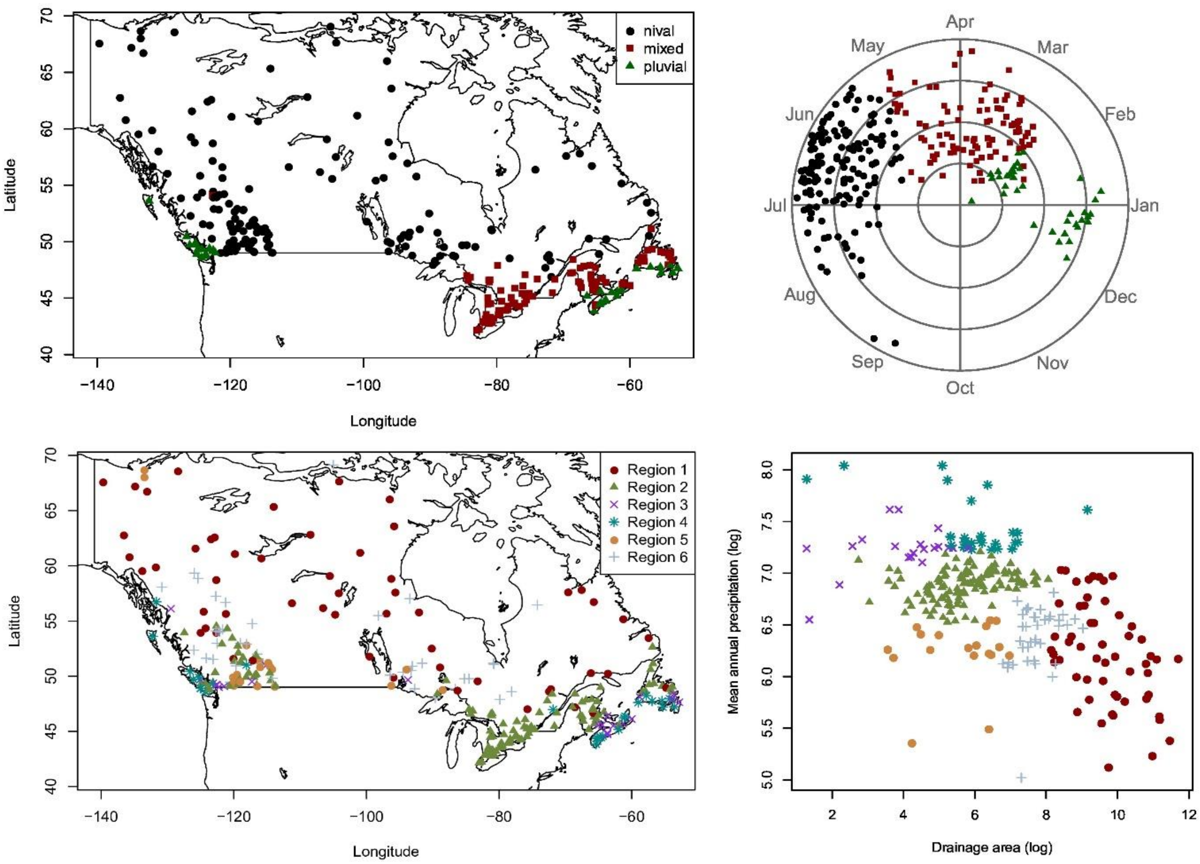


Figure 3-4: At left, site locations by flood regimes (top) and super regions (bottom). At right, positions in the seasonal space (top) and characteristic space (bottom).

An alternative way to classify the sites of interest will be referred to as super regions; a similar classification was initially introduced by Salinas et al. (2014) that created groups that allow better understanding of the impact of catchment scales and climate for sites in Austria, Italy and Slovakia.

The super regions regroup clusters of sites based on drainage area (km^2) and mean annual precipitation (mm). After experimentation, six super regions are delineated by the agglomerative hierarchical method (Ward, 1963) using standardized variables. The result of the classification is presented on the bottom of Figure 3-4 in the geographical and characteristic space. Sites of interest cover a large spectrum of drainage areas and mean annual precipitation. Table 3-4 shows an important correspondence in the number of sites between the super regions and the flood regimes. The wetter sites are in super regions 3 and 4, which are almost exclusively associated with a pluvial regime, while super region 2 is in majority composed of sites with mixed regime. Similarly, super regions 1, 5 and 6 mostly include sites having a nival regime. In particular, super region 1 regroups the largest watersheds that are located in the northern part of Canada.

Table 3-4: Association in number of sites between flood regime and super regions.

Regime	Super region 1	2	3	4	5	6	Total
Nival	51	32	5	3	20	37	148
Mixed	4	83	5	6	0	2	100
Pluvial	0	7	12	18	0	0	37
Total	55	122	22	27	20	39	285

3.4.2 Comparison of the Automatic Selection Procedures

In this study, an important part of the analysis is to compare the outcomes of the automatic methods with those of the manual method. Table 3-5 summarizes some characteristics by flood regimes and super regions. Following the results of the simulation study, the p-value plot of the classical AD test is evaluated using a table of critical values (Choulakian and Stephens, 2001), except for the maxPV-based method where bootstrap is used.

In the top of Table 3-5, one can see the exceedance rate in PPY. For the manual method, the latter is found between 1.8 PPY for nival regime and 2.5 PPY for pluvial regime, which is reasonable in regards of the literature. The super regions associated in majority to a nival regime are 1, 6 and 5 in increasing order of drainage area. Respectively, Table 3-5 shows that they are associated with a decrease in exceedance rate. The largest watersheds are found in super region 1 and represent the more northerly locations where floods are largely dominated by seasonal snowmelt events. Therefore, it is normal that floods in this super region occur with more regularity and that relevant thresholds are found closer to 1 PPY. The maxPV-based method is having a similar exceedance rate to the manual method for the nival and mixed regime, but results in a slightly higher rate for the pluvial regime. The significance-based and the split-based methods have substantially larger PPY, which often results in selecting the upper bound of 5 PPY. This illustrates the tendency of these two selection methods to choose lower thresholds in comparison to the manual method.

Table 3-5: Characteristics of the automatic methods by flood regimes and super regions.

		Regime			**Super Region**						
Criteria	**Methods**	**Nival**	**Mixed**	**Pluvial**	**1**	**2**	**3**	**4**	**5**	**6**	**Total**
Exceedance rate (PPY)	MAN	1.8	2.3	2.5	1.6	2.3	2.4	2.4	2.1	1.8	2.1
	MAXPV	1.8	2.3	3.1	1.8	2.2	2.7	2.8	1.7	1.9	2.2
	SGNF05	3.0	4.5	4.9	2.5	4.3	4.7	4.6	3.5	2.9	3.8
	SGNF25	2.7	4.0	4.7	2.3	3.9	4.4	4.3	2.9	2.8	3.4
	SPLIT	2.7	4.0	4.6	2.2	3.8	4.5	4.2	2.9	2.6	3.4
Rejected GPD (%)	MAN	22.3	5.0	5.4	29.1	7.4	4.5	3.7	30.0	17.9	14.0
	SGNF05	**7.4**	**0.0**	**0.0**	**14.5**	**0.0**	**0.0**	**0.0**	**0.0**	**7.7**	**3.9**
	SPLIT	31.8	13.0	5.4	32.7	18.9	9.1	7.4	30	28.2	21.8
	RATE1.5	22.3	5.0	5.4	34.5	4.9	18.2	0.0	20.0	17.9	14.0
	RATE2.0	27.0	13.0	2.7	38.2	12.3	4.5	3.7	10.0	35.9	19.0
Trend in magnitude (%)	MAXPV	11.5	11.0	**13.5**	**7.3**	11.5	9.1	**11.1**	15.0	17.9	11.6
	SGNF05	11.5	18.0	16.2	9.1	17.2	9.1	18.5	10.0	15.4	14.4
	SGNF25	10.8	12.0	18.9	**7.3**	12.3	13.6	18.5	15.0	**12.8**	12.3
	SPLIT	**10.1**	15.0	**13.5**	9.1	13.9	9.1	14.8	10.0	**12.8**	12.3
	RATE1.5	12.8	10.0	16.2	**7.3**	11.5	9.1	14.8	20.0	17.9	12.3
	RATE2.0	12.2	**8.0**	16.2	10.9	**9.8**	**4.5**	**11.1**	**5.0**	23.1	11.2
Trend in nb. events (%)	MAXPV	**2.7**	11.0	24.3	**1.8**	11.5	13.6	14.8	**0.0**	5.1	8.4
	SGNF05	4.1	29.0	13.5	5.5	23.8	9.1	11.1	5.0	5.1	14.0
	SGNF25	**2.7**	17.0	13.5	3.6	13.9	9.1	11.1	**0.0**	5.1	9.1
	SPLIT	**2.7**	24.0	16.2	3.6	19.7	9.1	14.8	5.0	**2.6**	**11.9**
	RATE1.5	3.4	11.0	13.5	**1.8**	10.7	9.1	**3.7**	10.0	5.1	7.4
	RATE2.0	**2.7**	**6.0**	**5.4**	**1.8**	**4.9**	**4.5**	**3.7**	5.0	5.1	4.2
RRMSD Q100 (%)	MAXPV	6.6	10.0	7.7	3.8	9.1	9.3	5.9	14.0	4.8	8.1
	SGNF05	21.1	31.7	10.1	8.2	29.0	9.6	9.4	47.4	19.2	24.4
	SGNF25	15.6	13.2	8.1	8.1	12.4	8.3	6.9	30.0	18.1	14.0
	SPLIT	12.6	10.3	9.1	7.6	9.7	10.0	7.6	17.1	18.3	11.5
	RATE1.5	**5.0**	**7.4**	7.2	**3.4**	**6.6**	5.8	8.5	**10.3**	**2.8**	6.2
	RATE2.0	9.5	8.3	**5.3**	6.6	7.4	**4.5**	**6.1**	20.0	8.1	8.6
ACV Q100 (%)	MAN	25.3	27.4	26.3	21.0	26.1	31.2	28.1	32.0	26.6	26.2
	MAXPV	25.5	27.9	25.4	20.5	27.1	29.9	27.4	31.8	26.3	26.3
	SGNF05	24.3	25.9	**23.2**	20.5	25.1	**26.5**	**23.7**	33.2	**24.7**	24.7
	SGNF25	24.4	**25.3**	**23.2**	20.5	24.9	26.8	24.3	**30.7**	25.0	24.6
	SPLIT	**23.9**	**25.3**	24.0	**20.4**	**24.5**	27.2	24.4	30.9	24.8	24.4
	RATE1.5	25.8	29.5	27.5	21.3	27.9	32.1	29.8	32.8	26.7	27.3
	RATE2.0	25.5	28.2	26.9	21.9	26.7	32.3	27.5	33.5	27.4	26.6

Bold indicates best result in each row.

For methods apart from the maxPV-based and significance-based methods, no assessment of the quality of the GPD approximation is done directly. To verify the validity of the GPD assumption, Table 3-5 reports the percentage of sites where the null hypothesis of the AD test is rejected at a 5% significance level. For MAN and RATE1.5, the proportion of rejections equals about 5% of the sites for a mixed or pluvial regime but is more than 20% for a nival regime. Table 3-5 also indicates that the AD test rejects the GPD for several sites using the split-based method; in particular, it reaches 32.7% for super region 1. Visual examination of the split-based method on Canadian sites indicated that in some situations the p-value plot exhibited complex patterns that resulted in inadequate thresholds. Such situations were rare in the simulation study but appear more often in the case study where samples are not drawn from a known mixed distribution. SGNF05 is also included to illustrate the situation where the GPD was never a good approximation.

It was found that only sites having a nival regime fall in that category with a proportion of 7.4%. Consequently, it shows that the high percentages of rejection of the AD test are not generally due to the impossibility of finding a threshold that is not rejected. Visual examination of some sites suggested that rejections are false positive, because the candidate thresholds immediately before and after are not rejected.

The selection of a threshold can affect the fitting of the GPD, but also the conclusions of trend analysis. A sensitivity analysis of the trends detected using a POT approach can be carried out by examining the correspondence between the conclusion of the automatic and the manual methods. Table 3-5 includes the percentages of sites where the conclusions differ at a 5% significance level. In general, it indicates that trends in magnitude differ typically between 10% and 20% of the time but is not superior for any automatic method. Note that the Mann-Kendall test is used for detecting trends in magnitude and that p-values are approximated by bootstrap. Consequently, they can disagree due to resampling. When testing trend for the average number of events, the rate-based method appears to be the method having the most similar conclusions with the manual method. Sites with a nival regime show overall a good agreement for all automatic methods (< 5%), while a weaker correspondence is observed with sites having a mixed regime. This is especially true for the significance-based and split-based methods (>15%). In such situations, one of the flood events is normally due to seasonal snowmelt events and the additional events are caused by extreme rainfalls. Therefore, the threshold controls the proportion of rainfall events. In this case, trend detection of two distinct populations may not evolve in the same direction, which leads to different conclusions.

In the estimation of Q100 the comparison between the automatic and the manual methods is done based on the relative discrepancy $\tilde{\delta}_i^{(\text{method})}$ for the i-th site. This is identical to the relative discrepancy $\delta_i^{(\text{method})}$ computed with RATE1.0 in the description of the hybrid method, except that the benchmark is now the manual method. Table 3-5 reports the relative root mean square discrepancies (RRMSD) that summarizes the correspondence by flood regime and super regions. The maxPV-based and the rate-based methods generally have a good agreement (RRMSD < 10%), with an advantage to the rate-based method when the best exceedance rate is considered for each group. The super region 5 includes smaller and drier watersheds and is associated with the largest RRMSD for all automatic methods. The RRMSD of the significance-based and the split-based methods are considerably higher than the other automatic methods. However, visual examination shows that these high RRMSD do not represent well the actual correspondence with the manual method in several sites. It is found that only few sites have very large relative discrepancies. For instance, the RRMSD associated with SGNF25 for the three flood regimes are 15.6%, 13.2% and 8.1%, but after removing the relative discrepancies $\tilde{\delta}_i^{(\text{SGNF25})} > 0.25$that represents only 6% of the sites, the RRMSD becomes 5.0%, 7.0% and 8.1%. This indicates that in these few situations the selected thresholds may be problematic, even though they are coherent with the manual method in large majority. A similar behavior is observed for SGNF05, but the proportion of sites with $\tilde{\delta}_i^{(\text{SGNF25})} > 0.25$ increases to 12%, which illustrates that the problem is related to the selection of too low a threshold.

A systematic tendency to select higher thresholds than the manual method should lead to lower RRMSD than the contrary. Nevertheless, a threshold that is too high comes at the cost of ignoring peaks that could contribute to reduce the model uncertainty. Although the manual method is used as a benchmark, it is not necessarily the best possible option. As the true modeling error cannot be evaluated in practice, Table 3-5 presents the average coefficient of variation of Q100 (ACV (%)) for the different flood regimes and super regions. The ACV measures the variability as the standard deviation standardized by the predicted value, which accounts for the scaling effect of each site. One can see that significance-based and split-based methods have the lowest ACV. In general, MAXPV is also slightly better than the manual and the rate-based methods. One can see that the sites having the largest watersheds (super region 1) have less variability than those in the other super regions. At the opposite end, the sites associated with the drier and smaller watersheds (super region 5) have the largest variability. Differences in terms of ACV are overall relatively small for a nival regime ($\lesssim$0.01) but are more substantial for the mixed and the pluvial regimes.

3.4.3 Calibration of an Adapted Hybrid Method

In the previous sections, no automatic method was shown to be globally superior to the others, but two of them have demonstrated interesting properties. The significance-based method selected in general lower thresholds, which contributed to reduce the uncertainty in the prediction of Q100. However, the comparison in Section 4.2 also indicated that in some cases this method resulted in large relative discrepancies with the manual method associated with problematic choices of thresholds. The present section investigates the hybrid method proposed in Section 2.3 to combine SGNF25 with an adapted rate-based method. Note that the following selection method will be semi-automatic as it will be calibrated with regards to the super regions.

Figure 3-5 presents the relative discrepancies $\tilde{\delta}_i^{(\mathrm{SGNF25})}$ between SGNF25 and the manual method where the sites illustrated by red circles are discordant sites, i.e. where the relative discrepancy between SGNF25 and RATE1.0 is greater than a critical value of 0.25 ($\delta_i^{(\mathrm{SGNF25})} > 0.25$). One can see that in a convenient way, the concept of discordant site identifies here the largest relative discrepancies with respect to the manual method, which cannot be identified in practice. As the significance-based method generally has lower thresholds, the hybrid method essentially consists in selecting SGNF25 if a site is not discordant or the adapted rate-based method otherwise.

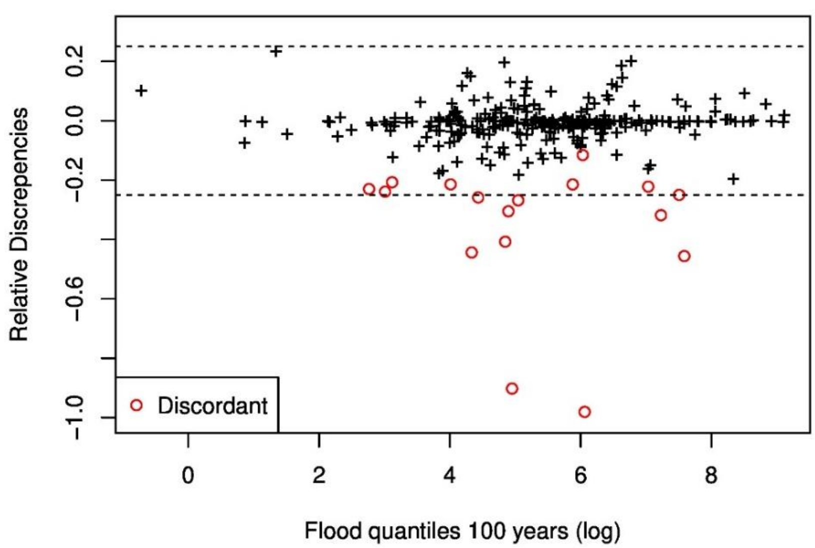


Figure 3-5: Relative discrepancies $\tilde{\delta}_i^{(\mathrm{SGNF25})}$ between SGNF25 and the manual method for Q100. Circles indicate discordant sites between SGNF25 and RATE1.0 according to $\delta_i^{(\mathrm{SGNF25})} > 0.25$.

The exceedance rates used for the adapted rate-based method are chosen to improve RRMSD inside each super region. The concept of super region is preferred over flood regime, since there is a good association between them, but super regions bring additional information about site characteristics. In addition, it is very straightforward to assign a site to a super region while classifying the hydrologic regime for a site is more difficult, especially when there is a large number of sites to be classified. To select the adapted exceedance rate of each super region, the RRMSD is obtained by steps of 0.1 PPY. The evolution of the exceedance rate is shown to be noisy, but changing points were visually identified where RRMSD starts growing rapidly. Using these changing points results in similar RRMSD to the global minimums but includes more peaks in the POT analysis. The adapted exceedance rates for the super regions 1 to 6 are respectively: 1.6, 1.9, 2.1, 2.3, 1.3 and 1.5.

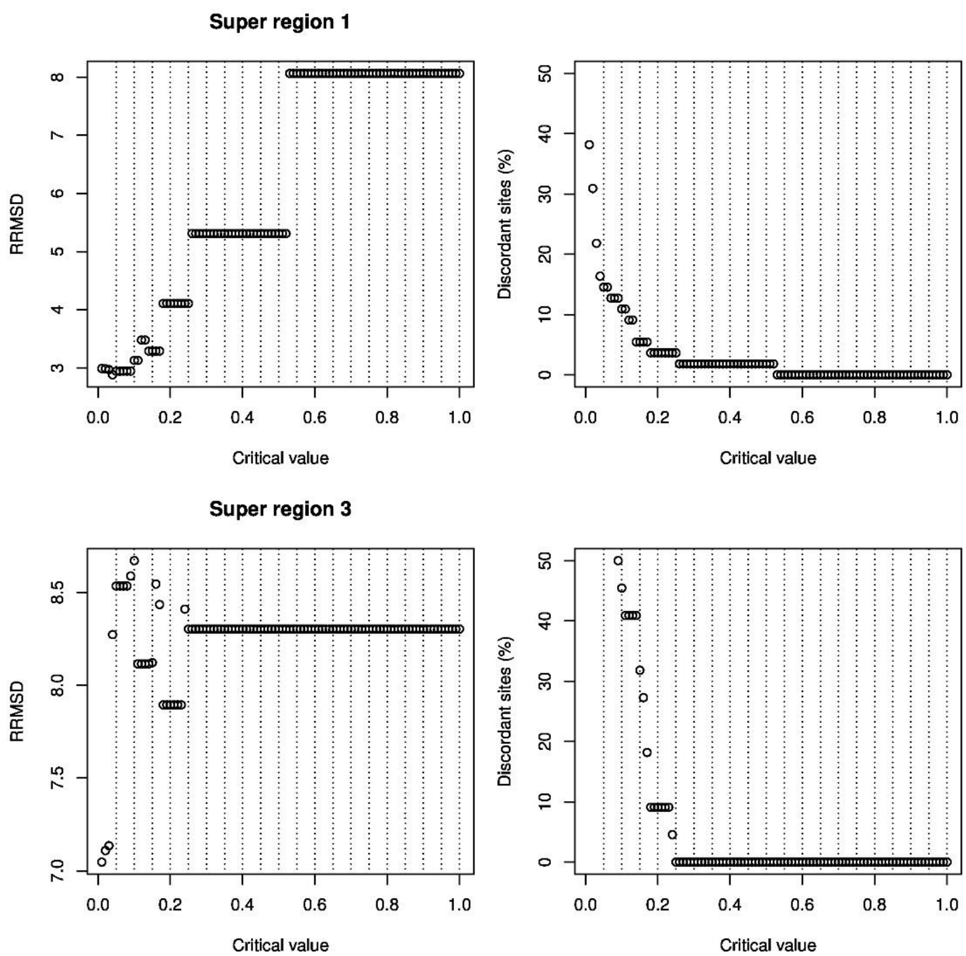


Figure 3-6: Illustration of the calibration of the hybrid method for super regions 1 and 3 in respect of the critical value δ^*.

The calibration of the hybrid method also requires the selection of a critical value δ^* that bounds the relative discrepancy $\delta_i^{(\mathrm{SGNF25})}$ accepted for the significance-based method. Choosing a small critical value will result in frequent utilization of the rate-based method, which risks increasing the ACV. On the other hand, a large critical value will tend to systematically prefer SGNF25, but risks to include sites with large discrepancies. Figure 3-6 illustrates the trade-off controlled by the critical value δ^* in terms of RRMSD (left) and percentage of discordant sites (right) for the super regions 1 and 3. In general, the best critical values are found between 15% and 25%. For super regions 3 and 4 (associated with a pluvial regime), it is found that relative discrepancies $\delta_i^{(\mathrm{SGNF25})}$ never exceed 25%. Therefore, the identification of the discordant site does not improve the RRMSD and hence the hybrid method is identical to SGNF25. For the other super regions, the number of discordant sites is found to be between 5.5% and 10.3%.

Table 3-6: Characteristics of the semi-parametric methods by regime and super regions.

		Regime			Super Region						
Criteria		**Nival**	**Mixed**	**Pluvial**	**1**	**2**	**3**	**4**	**5**	**6**	**Total**
Critical (%)		-	-	-	15	25	25	25	25	15	-
Discordant (%)		6.8	8.0	2.7	5.5	8.2	0.0	0.0	10.0	10.3	6.7
Exceedance	Hybrid	2.5	3.8	4.7	2.0	3.6	4.4	4.3	2.4	2.3	3.2
rate (PPY)	SGNF25	2.7	4.0	4.7	2.3	3.9	4.4	4.3	2.9	2.8	3.5
	RATES	1.7	2.0	2.2	1.6	1.9	2.1	2.3	1.3	1.5	1.8
Rejected	Hybrid	8.1	2.0	**0.0**	**14.5**	1.6	**0.0**	**0.0**	5.0	**7.7**	4.9
GPD (%)	SGNF25	**7.4**	**0.0**	**0.0**	**14.5**	**0.0**	**0.0**	**0.0**	**0.0**	**7.7**	**3.9**
	RATES	23.0	7.0	2.7	34.5	9.0	0.0	3.7	20.0	17.9	14.7
RRMSD	Hybrid	4.6	7.5	7.1	3.1	6.9	8.3	6.9	**6.3**	4.4	**6.1**
Q100 (%)	SGNF25	15.6	13.2	8.1	8.1	12.4	8.3	6.9	30	18.1	14.0
	RATES	**4.0**	**7.1**	**4.6**	**2.6**	**6.5**	**3.9**	**5.4**	7.7	**2.8**	**5.4**
ACV	Hybrid	**24.1**	**25.2**	**23.1**	**20.3**	**24.7**	**26.8**	**24.3**	**30.6**	**24.5**	**24.4**
Q100 (%)	SGNF25	24.4	25.3	23.2	20.5	24.9	**26.8**	**24.3**	30.7	25.0	24.6
	RATES	25.4	28.2	28.2	21.3	26.7	32.0	27.2	31.8	26.7	26.5

Bold indicates best result in column.

The results associated with the calibrated hybrid method are presented in Table 3-6 and compared to SGNF25 and the adapted rate-based method (RATES). The results are also summarized by flood regimes, even though the hybrid method is not calibrated accordingly. For the discordant sites in the hybrid method, it is likely that the AD test rejects the GPD more often than SGNF25. Nevertheless, Table 3-6 shows that except for super region 5, the GPD hypothesis of the discordant site is generally not rejected. As expected, a drastic improvement is seen between SGNF25 and the hybrid method in terms of RRMSD. The correspondence of the predicted Q100 is overall good with RRMSD less than 8.3%. For the hybrid method, the total RRMSD that is computed on all sites is 6.1%. This is better than the 14.0% of the SGNF25 and only slightly inferior to the 5.4% of the adapted rate-based method. At the same time, the ACV of Q100 shows small improvements for the hybrid method.

3.5 Conclusions

In several sites, visual examinations of MAXPV were associated with a relevant choice of threshold, which coincided with the end of a transition period in the p-value plot. However, the simulation study showed that this interesting behavior is not systematic and thus often led to unnecessarily high thresholds, which increased model uncertainty. Consequently, seeking the maximum p-value can be an interesting approach when an expert judgment is added to the interpretation of the p-value plot, but does not represent a valuable solution to automate POT analysis on a large scale. Throughout the analysis, the results of the split-based and significance-based methods were found to be similar and showed a connection in the nature of the two methods when a significance level between 25% and 10% was used. However, during the investigation of the Canadian sites, the split-based method often resulted in the rejection of the hypothesis of a GPD by the AD test. This proved that the split-based method is not robust, because it cannot adapt well to the complex patterns found in practice in the p-value plot. This drawback is not shared by the significance-based method, but on the other hand, the significance-based method resulted in large relative discrepancies with the manual method in some sites, which suggested the selection of a threshold where GPD shape stability was not reached. In the end, all automatic methods of interest presented some drawbacks that need to be addressed further. But the present study also considered semi-parametric methods that were calibrated in respect of super regions. The adapted rate-based method appeared to be the best way to obtain the greatest correspondence with the results of the manual methods in terms of the predicted Q100. Nevertheless, the hybrid method combining the significance-based and the adapted rate-based method was shown overall to be a better option. The correspondence between the hybrid method and the manual method was found to be close to that of the adapted rate-based method, while reducing the model uncertainty and limiting the number of sites where the AD test rejects the hypothesis of a GPD.

The present study has also looked at the impact of the automatic method in the context of trend analysis. The results showed that the choice of an automatic method has an important impact on the conclusions of trend tests. For trends in magnitude, results have not shown any clear signs of a superior method. On the other hand, for trend in the number of events, good agreements were observed for sites with a nival regime, but not for those with a mixed or pluvial regime. In these latter cases, the rate-based method provided much better correspondence in terms of conclusion of the trend tests, which was explained by the fact that the thresholds control the ratio between two or more populations with distinct behavior of flood events, which may exist.

Finally, the simulation study showed that using an already published table of critical values to approximate the p-values of the classical AD test through interpolation led to results as good as using bootstrapping and slightly improved over the use of the modified AD test. Therefore, using automatic methods to select threshold does not represent an important computational burden. Indeed, the computational cost of the hybrid method is mostly the time required for fitting of the GPD at each threshold candidate. The hybrid method can be directly applied to any other sites in Canada if the drainage area and the mean annual precipitation are known. Outside Canada, the same approach could also be useful; modifications to the methodology or calibration with local data may be desirable particularly if the hydrologic regimes of the study area differ dramatically from those found in a cold region environment, such as Canada. To not restrict too much the behavior of the automatic method in the comparison analysis, the present study has accepted a large range of exceedance rates PPY in its methodology. In practice, one could prefer to impose smaller boundaries on PPY, such as PPY less than 3 for example rather than less than 5, which would be closer to what is more commonly accepted.

Transition Paragraph B

Throughout the completion of Chapter 3, an effective approach was proposed to identify threshold levels for flood events and subsequently extract POT series. This approach can be applied to a large size dataset. In this Chapter[1] the discussed threshold selection methodology is adopted, and POT series are extracted for a large dataset of Canadian hydrometric stations. The objective of this Chapter is to promote a formalized approach to pooled flood quantile estimation using POT series. Furthermore, approaches to evaluate the performance of pooled quantile estimation using AMAX series (discussed in Chapter 2) and also POT series will be covered in this Chapter.

[1]Mostofi Zadeh, S., Durocher, M., Burn, D. H., & Ashkar, F. (2019). Pooled flood frequency analysis: A comparison based on Peaks-Over-Threshold and annual maximum series. Hydrological Sciences Journal. doi: 10.1080/02626667.2019.1577556.

Chapter 4

Pooled Flood Frequency Analysis: A Comparison Based on Peaks-Over-Threshold and Annual Maximum Series

This chapter is built upon the accepted article with the same title in the Hydrological Sciences Journal. Minor differences between the paper and the chapter have been made to facilitate consistency and coherence.

Mostofi Zadeh, S., Durocher, M., Burn, D. H., and Ashkar, F. 2019. Pooled Flood Frequency Analysis: A Comparison Based on Peaks-Over-Threshold and Annual Maximum Series. *Hydrological Sciences Journal*. doi: 10.1080/02626667.2019.1577556.

Summary

Despite some theoretical advantages of peaks-over-threshold (POT) series over annual maximum (AMAX) series, some practical aspects of flood frequency analysis using AMAX or POT series are still subject to debate. Only minor attention has been given to the POT method in the context of pooled frequency analysis. The objective of this research is to develop a framework to promote the implementation of pooled frequency modelling based on POT series. The framework benefits from a semi-automated threshold selection method. This study introduces a formalized and effective approach to construct homogeneous pooling groups. The proposed framework also offers means to compare the performance of pooled flood estimation based on AMAX or POT series. An application of the framework is presented for a large collection of Canadian catchments. The proposed POT pooling technique generally improved flood quantile estimation in comparison to the AMAX pooling scheme, and achieved smaller uncertainty associated with the quantile estimates.

4.1 Introduction

Flood risk assessment based on flood magnitude associated with recurrence interval T (the so-called T-year flood) is important in designing infrastructure, construction and operating river engineering works. Two approaches are commonly considered for modelling of extreme flood events: (1) the annual maximum (AMAX) series and (2) the partial duration series also denoted as peaks-over-threshold (POT). The AMAX series, which uses only the largest flow in each year, may exclude significantly large floods if several of them occurred in a year; and this could result in a loss of flood-related information (Langbein, 1949; Lang et al., 1999; Bacova-Mitkova and Onderka, 2010; Bezak et al., 2014). Another shortcoming of AMAX series is inclusion of some very low discharges in the series that are still the maximum value in the year (Bezak et al., 2014). Thus, incorporation of these events can alter the outcome of the extreme value analysis (Bhunya et al., 2012). However, AMAX series are straightforward to obtain and the most commonly available form of data (FEH, 1999). POT data are an alternative to the AMAX series. The POT model avoids AMAX drawbacks by considering flood peaks above a certain threshold level and allows capturing more information regarding the flood phenomena in comparison with AMAX (Lang et al., 1999). Peaks that are not included in the AMAX series, but are still relatively high, will be considered in the POT series. However, an additional analytical complexity is inherent in the use of POT series. Bezak et al. (2014) described choosing an appropriate threshold level and assuring the independence of the data series as major difficulties in using the POT method. Lang et al. (1999) identified these difficulties as a reason why the POT model remains relatively unpopular and underemployed in the practice of design flood estimation. Solari and Losada (2012) noted the lack of standardized methodology for threshold selection and the difficulty in automating the process as further complications of employing the POT model.

Based on the discussion above, two essential aspects of POT analysis are: (1) determination of the threshold level; and (2) identification of independent exceedances that do not include multiple exceedances associated with the same event (Madsen et al., 1997b). Several methods have been suggested to deal with these two elements. Different criteria have been proposed in the literature to verify the independence hypothesis (e.g., USWRC, 1976; Cunnane, 1979; FEH, 1999). The most commonly accepted practice is to decluster the data (Solari and Losada, 2012). Declustering corresponds to filtering the dependent observations (Coles, 2001). The exceedances above a threshold that are separated by less than a minimum time span form a cluster. Selecting the maximum value in each cluster helps in achieving the needed statistical independence among the POT observations. Additionally, several approaches have been recommended for appropriate threshold selection. Lang et al. (1999) provided a summary of these approaches. Among proposed threshold selection methods are: fixing the average number of exceedances per year for a specific climate condition or geographical location (Taesombut and Yevjevich, 1978; Konecny and Nachtnebel, 1985; FEH, 1999; Bacova-Mitkova and Onderka, 2010; Bezak et al., 2014); selection based on a given return period (Dalrymple, 1960; Cunnane, 1973; Waylen and Woo, 1982; Irvine and Waylen, 1986); or selection based on a predefined frequency factor k: $u = \bar{x} + kS_x$ where $\bar{x}$ and S_x are the mean and standard deviation for the series of daily values (Rosbjerg et al., 1992; Madsen and Rosbjerg, 1997; Gottschalk and Krasovskaia, 2012). Other proposed threshold selection methods are based on a fixed quantile of nonexceedance probability (Solari and Losada, 2012), on a verification of the Poisson process hypothesis and dispersion index (Cunnane, 1979; Ashkar and Rousselle, 1987), or on a graphical method and visual inspection of various plots (Lang et al., 1999; Coles, 2001; Burn et al., 2016). The widely used plots include mean residual life plot, which is a plot of the mean flood excess above a given threshold versus a range of threshold values, and a stability plot of the shape parameter of the generalized Pareto exceedances distribution for thresholds higher than a well-chosen level (Burn et al., 2016, Durocher et al., 2018). Durocher et al. (2018) developed a hybrid threshold selection method, where they investigated the behavior of automatic threshold selection based on the Anderson-Darling goodness of fit test, and then calibrated the automatic method with super regions defined using catchment characteristics. They identified super regions by clustering sites based on drainage area and mean annual precipitation. This classification allows better understanding of the impact of catchment scale and climate for the target site.

Previous research provided insight into the application of AMAX and POT methods in frequency analysis (e.g., Cunnane, 1973; Tavares and Da Silva, 1983; Madsen et al., 1997a,b; Bacova-Mitkova and Onderka, 2010; Bhunya et al., 2012). Despite the theoretical basis of the POT model that has helped in its adoption, some practical aspects of flood frequency analysis using AMAX or POT series are still subject to an ongoing debate. Lang et al. (1999) have recommended performing flood frequency analysis with both AMAX and POT models. In either case, the objective is to estimate as accurately as possible the relationship between extreme flood flows and their associated recurrence intervals. Observed flow records used to assess flood frequency at a site are generally short relative to the return period of interest and spatial coverage of stream gauging stations is sparse, thus limiting the reliability of the needed flood estimates at the site. To overcome this problem and avoid unreliable extrapolation, regional (pooled) information can be used by introducing more data from sites with similar hydrological behavior to trade between space and time (Zrinji and Burn, 1994). Pooled frequency analyses using AMAX series, including the widely used index-flood method, have been applied extensively (e.g., Hosking and Wallis, 1993; FEH, 1999; Grover et al., 2002; Noto and La Loggia, 2009; Saf, 2009; O'Brien and Burn, 2014). In the context of pooled frequency analysis, only minor attention has been given to the POT method. In fact, only a few studies have performed pooled analysis of POT series, mostly based on an index flood algorithm, such as the study by Madsen and Rosbjerg (1997). Using simulation, these authors showed their index flood model to be a robust and efficient estimation method.

For small to moderate sample sizes, their regional estimator was superior to the at-site estimator even in extremely heterogeneous regions. Madsen et al. (1997b) compared AMAX and POT series in a regional index flood context. The performance was evaluated by simulation studies in terms of the accuracy of T-year event estimators. It was demonstrated that for estimation in homogeneous regions, the POT index flood model in general was more efficient in regions where the distribution function has a negative shape parameter of generalized Pareto distribution, i.e. a distribution with a thick tail that extends to $+\infty$, whereas in regions with positive shape parameter the AMAX model was preferable. In addition to the simulation study, Madsen et al. (1997b) discussed the challenges of identifying homogeneous groups in a real data application; however, they did not provide a comprehensive comparison of the performance of regional estimation methods based on AMAX and POT datasets. Gottschalk and Krasovskaia (2002) provided relations between flood estimates based on AMAX and POT series. Their suggested approach was illustrated using a regional dataset of daily precipitation and runoff records for Costa Rica. Datasets were traditionally subdivided into two different climate and physiographic regions.

To date, POT data have not been widely used in practice despite it having been shown that there are theoretical advantages in using POTs (Madsen and Rosbjerg, 1997; Madsen et al., 1997b; Lang et al., 1999). The present research is an effort toward a wider use of the POT method by proposing a standardized methodology and a semi-automated process that can facilitate performing pooled POT frequency analysis by practitioners especially for large-scale datasets. The objective of the study is to introduce a formalized framework for conducting pooled frequency analysis using data from both POT and AMAX series. This framework employs a recently introduced, practical, and semi-automated method for extracting POT series from hydrometric data. This research takes advantage of a regional POT model introduced by Madsen et al. (1997b) but differs from previous studies that either assumed regional homogeneity or used a subjective grouping of datasets or applied the same basin characteristics partitioning point to define pooling groups of both POT and AMAX datasets. This research differs from these previous studies in that it introduces a systematic approach to construct homogeneous pooling groups and improve quantile estimation which can be adopted in future studies. This framework is verified by comparing the performance of the best identified pooled flood estimation procedure based on POT series with that obtained from a pooled analysis based on AMAX series.

The rest of this Chapter is organized as follows. Section 4.2 discusses the methodology involved in the semi-automated POT extraction and provides a general description of the adopted pooled frequency methods. Also introduced in Section 4.2 are procedures to evaluate the performance of pooled frequency estimation using POT or AMAX series. Section 4.3 presents an application of the proposed methods, starting with a description of the available data and the extracted POTs for a large collection of hydrometric stations in Canada. This is followed by results and discussion of forming POT- and AMAX- based pooling groups along with comparisons of the pooling techniques. Finally, Section 4.4 presents conclusions from this study.

4.2 Methodology

The proposed framework includes a semi-automated process to extract POTs and a formalized method to perform pooled frequency analysis. Required steps to implement the pooling technique involve data screening, super region formation, defining between-site similarities, identifying homogeneous pooling groups, flood quantile estimation and examining the accuracy of quantile estimates. Within the proposed framework, in a first step, AMAX or POT data can be used in the definition of between-site similarities and then, as a second step, either AMAX or POT data can be used to estimate quantiles at a site of interest. Results for each of the four combinations (two methods for defining between-site similarities combined with two methods for quantile estimation) are evaluated to determine a preferred approach. Details of the proposed framework are outlined in the following subsections.

4.2.1 Peaks-Over-Threshold Extraction

The first step in this analysis is the identification of an appropriate threshold value for recorded flow series, followed by the extraction of POT series based on that selected threshold. The threshold can be selected using the hybrid method developed by Durocher et al. (2018). Their proposed approach facilitates the identification of an effective threshold selection for a data set containing a large number of sites and it is briefly described in the following.

To satisfy the independence assumption of the extracted peaks, the declustering method presented in Lang et al. (1999) was adopted. The POT extraction method assumes that exceedances above a well-chosen threshold will follow a generalized Pareto distribution, with constant shape parameter. This property is known as threshold stability. In an initial step, the p-value of the Anderson-Darling (AD) goodness of fit test is evaluated for a large range of candidate threshold values and the first threshold associated with a p-value greater than a critical p-value (typically 0.25) is considered as the first candidate. This candidate tends to ensure that the generalized Pareto distribution is a reasonable choice. In general, such threshold will lead to higher accuracy in the estimation of the flood quantile in comparison to other automatic methods. However, in some situations this threshold was found to be too low and thus it does not properly reach threshold stability. A second candidate is obtained by selecting the threshold associated with a fixed exceedance rate. Specific exceedance rates were obtained by comparing the threshold selected according to expert knowledge from 281 hydrometric stations in Canada. A drawback associated with this second candidate is that it can lead to situations where a generalized Pareto distribution is not an appropriate choice. Additionally, the second candidate is generally higher than the first and often results in less accurate estimation of the flood quantiles. The hybrid selection method is a procedure designed to select one of these two candidates. More precisely, if the flood quantile estimate of the first candidate is consistent with the estimate from a threshold associated with a fixed exceedance rate of 1 event per year, for instance a relative difference between them of less than 15%, then the first candidate is selected, otherwise the higher threshold between the two candidates is selected. This hybrid selection method is shown to remain accurate in the estimation of the flood quantile while mitigating the risk of selecting too low a threshold. The interested reader can refer to Durocher et al. (2018) for further details where specific calibration settings were validated.

4.2.2 POT Pooled Flood Frequency

4.2.2.1 Data Screening and Identifying Super Regions

The data used in pooled frequency analysis must initially be screened to ensure the satisfaction of the independent and identically distributed (IID) data assumption. The presence of a temporal trend in peak flows will result in rejection of this assumption. Thus, the extracted POTs are evaluated in terms of trends in the individual exceedances using the Mann-Kendall nonparametric trend test (Mann, 1945; Kendall, 1975). The presence of statistically significant serial correlation in data series can impair the robustness of trend detection (Wang et al., 2015). To mitigate the impact of serial correlation, the block bootstrap (BBS) approach (Onoz and Bayazit, 2012) is employed in conjunction with the trend test. Trends in the number of events over time (counts) for individual POT series are evaluated using logistic regression (please refer to Frei and Schär (2001) for more details on logistic regression). The screened data can then be utilized to construct pooling groups.

The proposed methodology examines the effect of major classification of sites based on their catchment physiographic and climatologic attributes as an initial step in pooled flood frequency. Mean annual precipitation (MAP) and basin area were selected as catchment descriptor surrogates of climate and scale controls. Studies have shown that these catchment descriptors exert significant control on the frequency regime of hydrological extremes (see Salinas et al. (2014) and references therein). Clusters of sites, known here as super regions, are formed by grouping sites based on similarity in drainage area and MAP.

4.2.2.2 Pooling Group Formation

In pooled flood frequency analysis, extreme event information from a collection of sites that show similar extreme hydrological behavior is pooled to help improve the accuracy of the extreme flow estimation at a target site. The goal is to form pooling groups that approximately satisfy the homogeneity condition. In each pooling group, the sites' frequency distributions are identical apart from a site-specific scale factor (Hosking and Wallis, 1997). Identification of these pooling groups is an important component of pooled flood frequency analysis (Burn et al., 1997). Different approaches exist to delineate these pooling groups. In this study, the focused pooling group approach (Reed et al., 1999) was employed. The focused pooling group approach selects a potentially unique group of catchments that are most comparable to the target site to form a pooling group for that site. The focused pooling group approach and its modifications have been applied extensively as a pooling technique in flood frequency analysis (e.g., Zrinji and Burn, 1994; 1996; Tasker et al., 1996; Burn, 1997; FEH, 1999; Castellarin et al. 2001; Grover et al., 2002; Latraverse et al., 2002; Eng et al., 2005; Merz and Blosch, 2005; Shu and Ouarda, 2008; Das and Cunnane, 2011; Micevski et al., 2015). This approach typically involves defining similarity between sites and a cut-off point that determines whether or not to include a site in the pooling group.

Identification of pooling groups of similar sites is the next critical step in performing pooled flood frequency analysis. Selection of variables to define similarity (or dissimilarity) between catchments is an essential prerequisite in this stage (Burn, 1997). In this study, hydrological response properties concerning the timing and variability of peak flow events are explored. Catchments showing similarity in these variables can be considered as potential members of the same pooling group for pooled flood frequency analysis (Ouarda et al., 2006). These variables will henceforth be called seasonality measures.

4.2.2.3 Flood Seasonality Measures

Since their introduction into the hydrological literature, seasonality measures have been successfully employed as a measure of similarity in catchment hydrological response in several studies (Bayliss and Jones, 1993; Burn, 1997; Cunderlik et al., 2004; O'Brien and Burn, 2014).

The angular value of the date of a peak occurrence is calculated following Burn (1997) by:

$$\theta_i = (Julian\ Date)_i \frac{2\pi}{lenyr} \quad (4\text{-}1)$$

where θ_i is the angular value (radians) for the date of occurrence for event i and $lenyr$ is the number of days in a year. For a sample of n events, the coordinates of the mean flood date are defined as:

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} cos(\theta_i);\ \bar{y} = \frac{1}{n}\sum_{i=1}^{n} sin(\theta_i) \quad (4\text{-}2)$$

where n is the number of peak events and $\bar{x}$ and $\bar{y}$ are the coordinates of mean flood date. The mean event date can be determined by:

$$MD = tan^{-1}\left(\frac{\bar{y}}{\bar{x}}\right)\left(\frac{lenyr}{2\pi}\right) \quad (4\text{-}3)$$

where MD is a measure of the average time of occurrence of the flood event for a given catchment. A measure of the variability of the occurrences of peak events can be defined through:

$$\bar{r} = \sqrt{\bar{x}^2 + \bar{y}^2} \quad (4\text{-}4)$$

where $\bar{r}$ ranges from 0 (low regularity) to 1 (high regularity) and represents the dimensionless spread of the data for each catchment.

Chen et al. (2013) pointed out the importance of including flood magnitude information in the definition of flood seasonality and suggested using it as a weight to consider the effect of event magnitude in defining the timing and regularity of flood events as follows:

$$\bar{x}' = \frac{\sum_{i=1}^{n} q_i cos(\theta_i)}{\sum_{i=1}^{n} q_i};\ \bar{y}' = \frac{\sum_{i=1}^{n} q_i sin(\theta_i)}{\sum_{i=1}^{n} q_i} \quad (4\text{-}5)$$

where q_i is the flow magnitude for event i.

In the next step of the analysis, the seasonality measures discussed above are employed in the definition of the similarity/dissimilarity between catchments.

4.2.2.4 Similarity Statistics

A single numeric that defines the separation (distance) of two catchments in the seasonality space is used to define dissimilarity. Several distance metrics have been suggested in the past (e.g., Webster and Burrough, 1972; Lance and Williams, 1966; Castellarin et al., 2001). The separation of two catchments in seasonality space based on Euclidean distance is defined as:

$$D_{ij} = \left[\sum_{m=1}^{M} \left(x_m^i - x_m^j\right)^2\right]^{1/2} \tag{4-6}$$

where D_{ij} is the distance (dissimilarity) between catchments i and j; x_m^i is the value of the mth hydrological response property for catchment i; and M is the number of considered characteristics. A smaller value of D_{ij} demonstrates more similarity between two corresponding catchments in flood seasonality space.

4.2.2.5 Catchment Grouping Process

Different strategies are available to finalize the pooling group for each site. Castellarin et al. (2001) stated that the homogeneity of a pooling group and its size are two fundamental principles in effective identification of pooling groups. Burn and Goel (2000) implied that pooling groups should be sufficiently large. FEH (1999) suggested that a pooling group should ideally contain $5T$ station-years of data to provide an effective quantile estimate at return period T. Hosking and Wallis (1997) stated that no substantial benefit is gained when forming regions with more than 20-25 sites. In this study, the first 25 sites with minimum pairwise dissimilarities with the target site were selected as initial pooling groups while ensuring that there are at least 500 station-years of data in the pooled group. For each site, four different types of initial pooling groups were created using different combinations of seasonality measures discussed for POT series.

The initial pooling groups obtained from the above technique are evaluated for homogeneity. For this purpose, the commonly used homogeneity test (H-statistic) proposed by Hosking and Wallis (1993) was used. Please refer to Hosking and Wallis (1997) for more details on this test. The H statistic was recommended as a guideline to consider a pooling group homogeneous ($H < 1$), possibly heterogeneous ($1 \leq H < 2$), and heterogeneous ($H \geq 2$).

If there is heterogeneity in the initial pooling group, revisions are performed on the pooling group while still satisfying the target number of station-years. The approach taken for revision is that catchments whose removal leads to the greatest improvement in the homogeneity statistic of the group are sequentially removed from the pooling group to enhance the group homogeneity while maintaining 500 station-years of data.

4.2.2.6 Flood Quantile Estimation

The identified pooling groups can then be used to estimate the pooled flood quantile for POT flow series. This study follows Madsen and Rosbjerg (1997) and Madsen et al. (1997b) for pooled flood modelling of POT series and quantile estimation. The model is composed of the most commonly used Poisson distribution for modelling the number of threshold exceedances in any fixed time interval (Onoz and Bayazit, 2001) and the most commonly used generalized Pareto (GP) distribution for modelling the exceedances (e.g., Van Montfort and Witter, 1985; Rosbjerg et al., 1992; Lang et al., 1999; Solari et al., 2017; Durocher et al. 2018). Hosking and Wallis (1997) goodness-of-fit test can also be applied to identify the appropriate 2-parameter distribution for POT series. The model is described below following Madsen and Rosbjerg (1997).

4.2.2.6.1 At-Site T-year Flood Quantile

By allowing q_i to be the time series of flows for the site of interest, introducing a threshold level q_o, and considering the independence criteria, the POT series is obtained using $x_i = q_i - q_0$. The occurrence of peaks is assumed to follow a Poisson process, so the number of exceedances N in t years is Poisson distributed with the following probability function:

$$P\{N(t) = n\} = \frac{(\lambda t)^n}{n!} \exp(-\lambda t) \quad n = 0,1,2, \ldots. \tag{4-7}$$

where λ equals the expected number of exceedances per year and can be estimated by:

$$\hat{\lambda} = \frac{N}{t} \tag{4-8}$$

The exceedance magnitudes x_i are assumed to be independent and identically distributed following the GP distribution. The cumulative distribution function of GP with the scale and shape parameters σ and ξ respectively is:

$$\begin{cases} F(x) = 1 - \exp\left(-\frac{x}{\sigma}\right) & \xi = 0 \\ F(x) = 1 - \left(1 - \xi \frac{x}{\sigma}\right)^{1/\xi} & \xi \neq 0 \end{cases} \tag{4-9}$$

For $\xi = 0$ (in the limit), the GP distribution reduces to the exponential distribution. The range of x is $0 \leq x < \infty$ for negative shape parameters, whereas an upper limit, $0 \leq x < \sigma/\xi$ exists for positive shape parameters.

The T-year event, x_T, is defined as the $(1 - 1/\lambda T)$ quantile in the distribution of threshold exceedances. Therefore, by inverting equation (4-9) one obtains:

$$\begin{cases} x_T = F^{-1}(1 - 1/\lambda T) = \sigma \times \ln(\lambda T) & \xi = 0 \\ x_T = F^{-1}(1 - 1/\lambda T) = \dfrac{\sigma}{\xi}\left[1 - (1/\lambda T)^{\xi}\right] & \xi \neq 0 \end{cases} \tag{4-10}$$

The L-moment estimates of the GP distribution parameters are given by:

$$\hat{\sigma} = \hat{\lambda}_1 \left(\frac{1}{\hat{\tau}_2} - 1\right) \tag{4-11}$$

$$\hat{\xi} = \frac{1}{\hat{\tau}_2} - 2 \tag{4-12}$$

where $\hat{\lambda}_1$ is an estimate of the first L-moment and $\hat{\tau}_2$ is an estimate of L coefficient of variation. Please refer to Hosking (1990) for further details on the L-moments estimates.

4.2.2.6.2 Pooled T-year Flood Quantile

Consider a pooling group to have M sites with POT records x_{ij}, where $i = 1,2, \dots, M$ and $j = 1,2, \dots, N_i$. The index-flood method assumes that the distributions of events at different sites in the pooling group are identical (unique growth curve for the pooling group) except for scale (index-flood parameter). Employing the mean of exceedances as the index-flood parameter, Madsen and Rosbjerg (1997) expressed the pooled T-year event estimator as:

$$\hat{x}_{T_i} = \hat{\mu}_t \frac{1 + \hat{\xi}^R}{\hat{\xi}^R}\left[1 - \left(\frac{1}{\hat{\lambda}_t T}\right)^{\hat{\xi}^R}\right] \tag{4-13}$$

That is, the mean estimate of the exceedances, $\hat{\mu}_t$, and the Poisson parameter estimate, $\hat{\lambda}_t$ are calculated from at-site data, whereas the shape parameter is estimated from the pooled data. To estimate the pooled shape parameter, $\hat{\xi}^R$, the weighted average of L-moment ratios is used as follows:

$$\hat{\xi}^R = \frac{1}{\hat{\tau}_2^R} - 2 \tag{4-14}$$

$$\hat{\tau}_2^R = \frac{\sum_{i=1}^{M} w_i \hat{\tau}_2}{\sum_{i=1}^{M} w_i} \tag{4-15}$$

where w_i is equal to the record length, in years, at site i. Madsen and Rosbjerg (1997) indicated that cross correlation may have a significant impact on the regional shape parameter estimator. Interaction between site cross-correlation and estimation of the regional shape parameter is an area of future research. Employing the quantile estimation methods described above, the pooled and at-site quantiles were determined for all the pooling groups identified.

4.2.3 AMAX Pooled Flood Frequency

AMAX pooled frequency analysis follows proposed steps similar to those described for the POT dataset in Section 4.2.2. AMAX series are extracted for the same set of hydrometric stations and seasonality measures are estimated for AMAX series at each station. Initial focused pooling groups are then formed for each station using close stations in the seasonality space within each identified super region. Revisions to the pooling groups are performed as necessary. Following the Hosking and Wallis (1997) methodology for index-flood frequency analysis, the best frequency distribution is identified for each pooling group and pooled quantiles are estimated. In this study, the generalized logistic, generalized extreme value (GEV), generalized normal, Pearson type III, and generalized Pareto models were considered as potential candidates for the frequency distribution.

4.2.4 Approach to Evaluate POT and AMAX Pooling Groups

A focus of this research is to provide means of investigating the performance of pooling techniques in quantile estimation using both POT and AMAX series. Two sets of analyses are proposed to compare the performance of AMAX- and POT- based pooling groups. As discussed, AMAX and POT data are used in the definition of between-site similarities and with each of these two possibilities, AMAX and POT data are used to estimate quantiles at a site of interest following the discussed quantile estimation method. The obtained quantiles for each of the following four combinations, as described in Table 4-1, are evaluated to determine a preferred approach.

Table 4-1: Combinations of similarity measures and extreme flow data.

		Between-site similarity	
		AMAX	POT
Quantile estimation using:	AMAX	AA	PA
	POT	AP	PP

It is expected that employing AMAX versus POT in defining pooling groups will result in diverse pooling groups with unequal performance. Thus, it is essential to evaluate the performance of distinctive pooling groups to select the best performing pooling method. Two methods are presented here to conduct the evaluation, one based on errors in quantile estimates and the other based on the width of confidence limits, as discussed below.

4.2.4.1 Error in Quantile Estimates

FEH (1999) introduced an estimate of uncertainty in the resulting pooled growth curve as one way of evaluating different pooling groups. A similar approach that summarizes the average difference between pooled and at-site growth curves at various return periods has been adopted in this study. This measure is obtained by averaging over the sites with long flow records, since it can be assumed they provide reliable at-site estimates. For all long-record sites, the T-year at-site and pooled growth curves are obtained using the identified pooling groups. The measure of associated error in the pooled growth curve for different return periods is described as follows:

$$RMSE_T = \sqrt{\frac{\sum_{i=1}^{N_{long}} \left(lnq_{T_i} - lnq_{T_i}^{P}\right)^2}{N_{long}}} \tag{4-16}$$

where $RMSE_T$ is an uncertainty measure for return period T, N_{long} is the number of long-record sites, q_{T_i} is the T-year site growth factor for site i, and $q_{T_i}^{P}$ is the T-year pooled growth factor for site i. Lower values of $RMSE_T$ indicate a superior pooling group.

In addition to $RMSE_T$ for different return periods, $RMSE_F$ is used to compare the entire at-site and pooled frequency distributions. $RMSE_F$ is defined as follow for each long-record site:

$$RMSE_{F_i} = \sqrt{\frac{\sum_{j=1}^{t} \left(\frac{lnq_{T_j} - lnq_{T_j}^{P}}{lnq_{T_j}}\right)^2}{t}} \tag{4-17}$$

where $RMSE_{F_i}$ is an uncertainty measure between at-site and pooled quantiles for site i, t is the number of return periods estimated, q_{T_j} is the T_j-year site growth factor, and $q_{T_j}^{P}$ is the T_j-year pooled growth factor.

4.2.4.2 Confidence Interval Ratio

Uncertainty in the pooled quantile estimates is utilized as the second method of evaluation. In this study, uncertainty quantified by constructing confidence intervals for estimated quantiles is explored. Among approaches to assess uncertainty, the parametric resampling approach (Hosking, 2013) is adopted to construct confidence intervals for pooled quantiles. This approach generates realizations of data in the pooling group and requires specification of a frequency distribution for the pooling group. This approach reflects the average cross correlation between sites in the pooling group and accounts for the existence of heterogeneity within the group. Hosking (2013) reported that this approach provides more realistic estimates of confidence intervals.

The basis of the comparison is the width of the 95% confidence interval. A narrower confidence interval indicates a more precise estimate and is preferred to an estimate with wider confidence interval. In this study, the ratio of the width of the confidence interval to the quantile estimate for each return period is proposed as a measure of performance of the pooling groups.

4.3 Application

The presented framework to perform pooled frequency analysis for AMAX and POT series in the context of super regions is demonstrated on a collection of hydrometric stations in Canada. Model performance and comparisons are also evaluated.

4.3.1 Description of Dataset and Study Area

The suggested approach in this research is illustrated using flow records from a collection of hydrometric gauges, with unregulated flows, located across Canada. Trends in AMAX series were initially examined for the available dataset; removing 224 stations with trends in the AMAX data reduced the dataset to 919 stations. Appendix C provides a list of these stations. Figure 4-1 shows the location of these gauges. The large diversity of geographical, meteorological, and hydro-climatic conditions in Canada is an inevitable challenge for such a vast database.

4.3.1.1 POT Flow Series

Following Burn and Whitfield (2016), the collection of sites was reviewed to identify the dominant hydrological regime using the mean date of occurrence of flood events in the seasonality space. For more information please refer to Burn and Whitfield (2016). Figure 4-1 illustrates the locations of the stations with nival, mixed and pluvial regimes in geographical space. Stations displaying pluvial and mixed flood response are mostly located on the east and west coasts of Canada, and some in southern Ontario. Central parts of Canada and higher latitude mostly correspond to the nival regime. Initially the average number of peaks to be extracted per year (PPY) was bounded between 1 and 5. In light of the nature of catchment flows in Canada and the existence of different hydrological regimes dominated by snowmelt, rainfall or mixed events, assembling up to 5 PPY was considered to provide sufficient extreme event information when using POT series rather than AMAX (PPY=1). Next, the hybrid threshold selection method was applied to the dataset and based on the algorithm of the adopted threshold selection method, the best threshold was identified from the set of initial thresholds yielding 1-5 PPY for each station. For gauges with the nival hydrological regime, for which flood events correspond to snowmelt response, the maximum of 5 PPY was considered to be too high a value. For the case of stations having a mostly nival regime, the upper bound of 2.5 PPY was considered for identifying the best threshold. For each station, based on the discussed criteria, a threshold was identified, and POT series were extracted. The maximum likelihood parameter estimation technique within the hybrid threshold selection method was unable to fit a GP distribution to the POT series of 25 stations. Thus, they were removed from the rest of the analysis. Figure 4-2 provides the frequency of identified PPY for the stations.

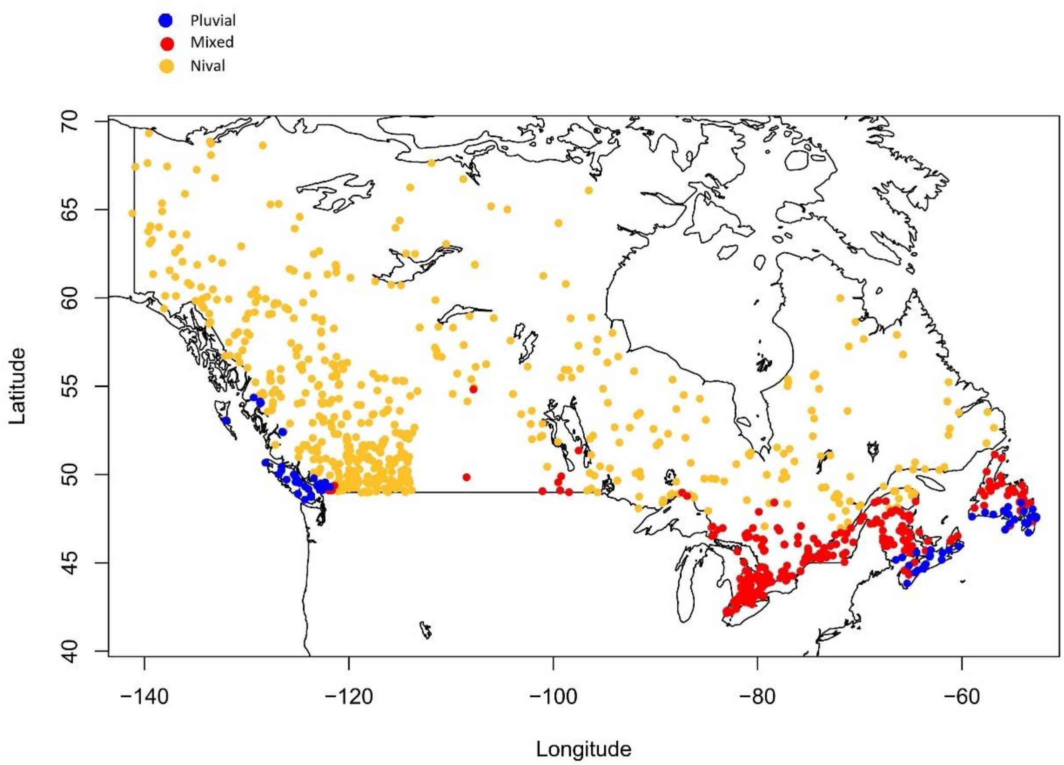


Figure 4-1: Location of hydrometric stations with different hydrological regimes.

The next step of data screening involves trend analysis. For the set of POT series obtained, trends in both exceedance magnitudes and number of events per year over time for individual stations were examined at 5% significance level. Table 4-2 provides a summary of the trend test analysis. For a larger number of stations, a significant trend in number of events per year was identified rather than trend in exceedance magnitudes. Increasing trend in number of events per year was shown by 14.88% of sites, while only 4.47% had decreasing trend. There were fewer stations (52) with significant trends in exceedance magnitudes, 1.57% of total number of stations exhibiting increasing and 4.25% of stations decreasing trend. For the rest of the analysis, sites having trend in either the magnitude of exceedances or the number of events per year were excluded, with 684 stations remaining in the dataset. Stations with significant trend are identified in Appendix C.

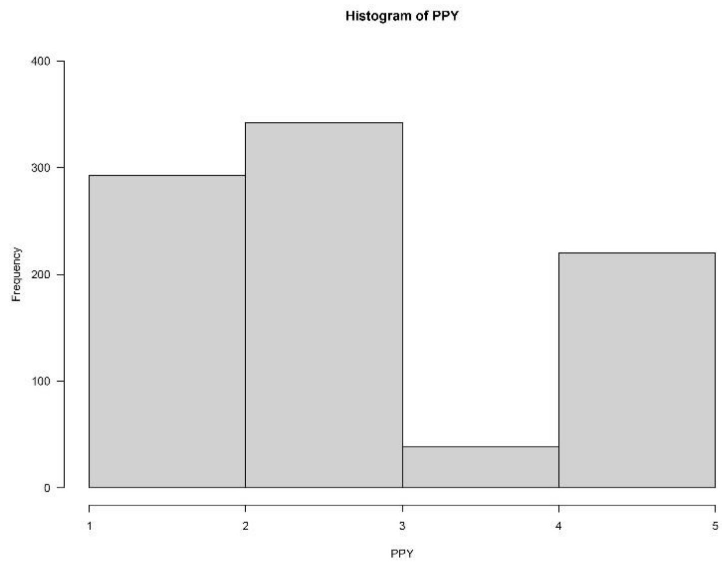


Figure 4-2: Histogram of range of PPY selected for the hydrometric stations.

Table 4-2: Summary of trend analysis of POT data for 894 hydrometric stations.

	Increasing	Decreasing
Trend in exceedance magnitudes	14 (1.57%)	38 (4.25%)
Trend in number of events per year	133 (14.88%)	40 (4.47%)

4.3.1.2 AMAX Flow Series

The AMAX series representing the highest flow value in each year was also extracted for the same set of data. Both POT and AMAX contain some of the highest extreme values, while lesser magnitude extreme flows might only appear in the POT series or only in the AMAX series, as can be seen from

Figure 4-3, which provides an example of differences in the amount of data acquired with AMAX and POT series.

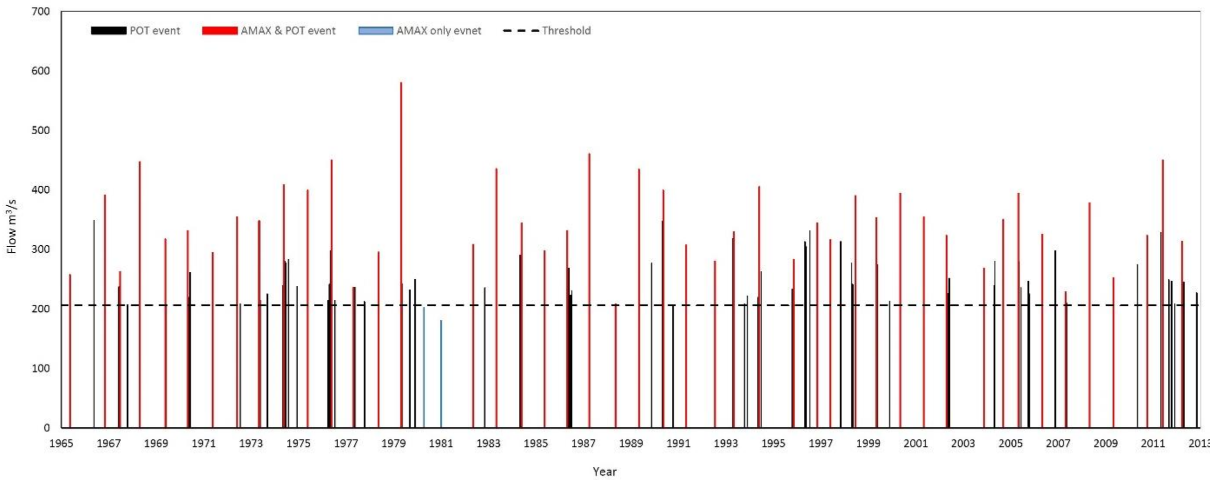


Figure 4-3: An example of data obtained from AMAX and POT series for a hydrometric station

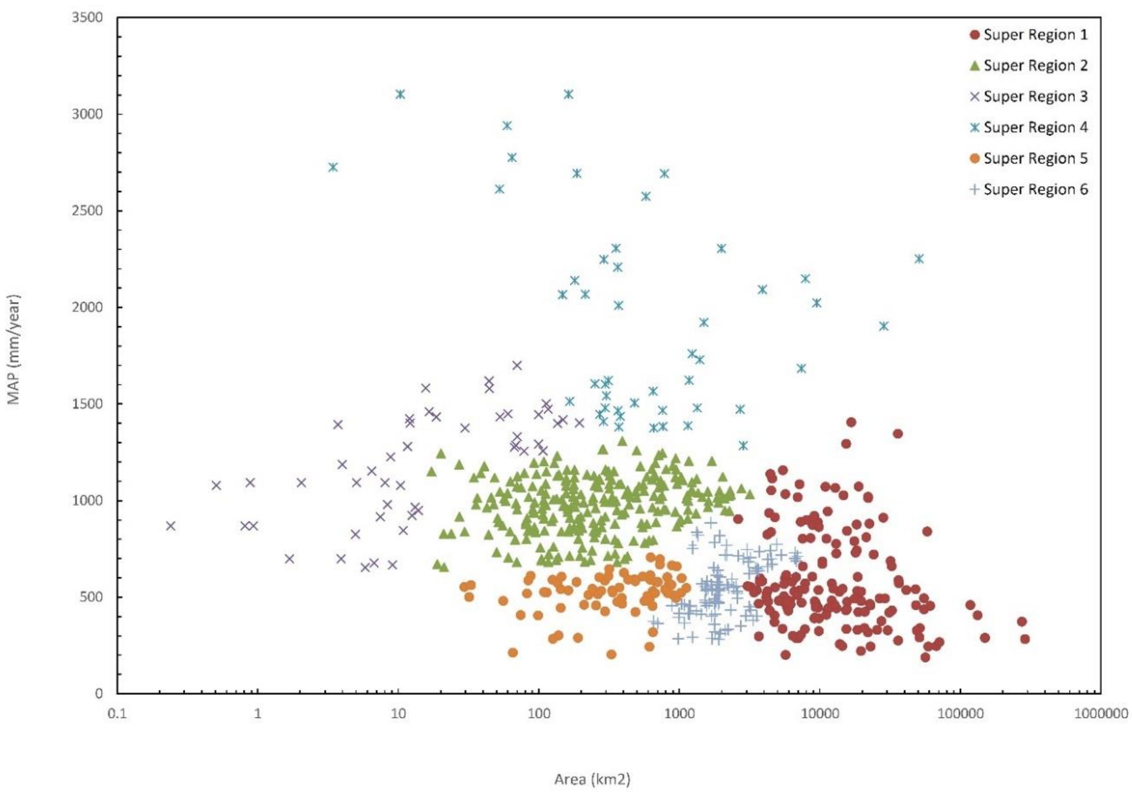


Figure 4-4: Super regions based on characteristics of hydrometric stations.

4.3.1.3 Super Regions

As was proposed in the Methodology section, drainage area and MAP are used to group the catchments into subsets (super regions) that represent similar properties in the size of drainage area and amount of annual precipitation. Following Mostofi Zadeh and Burn (2019), agglomerative hierarchical clustering is used to form super regions. For the dataset of catchments under study, six super regions were identified after preliminary trials as they enhance the representation of variation in drainage area and precipitation. Figure 4-4 plots MAP against drainage area for the catchments under study; the six super regions are also presented in this figure.

4.3.2 Results and Discussion

4.3.2.1 Analysis of POT-based Pooling Groups

Figure 4-5(top) plots the catchments in unweighted seasonality space, based on POT events, for the data set under study. Within each super region, the seasonality statistics, $\bar{x}$ and $\bar{y}$, and also their weighted modifications, were employed in the definition of between-site dissimilarity using Euclidean distance in the seasonality space. Table 4-3 provides the summary of average homogeneity test results for the identified pooling groups in all the super regions. A considerable number of the pooling groups formed using POT series (PP) were classified as homogeneous (>87.1%) and a small percentage (<12.9%) as possibly homogenous. Hosking and Wallis (1997) indicate that moderately heterogeneous regions may still offer valuable information concerning quantile estimates for extreme events. Constructing pooling groups with different seasonality measures does not result in a substantive change in homogeneity, as can be seen by comparing the rows in Table 4-3. Adopting the methodology described in Section 4.2.2.6, flood quantiles were estimated for different return periods, for both cases of considering only at-site data and using pooling groups.

The approach discussed in Section 4.2.4 was employed to compare the performance of pooling groups containing POT or AMAX series. The homogeneity of the pooling groups using AMAX data (PA) was also examined; the results are provided in the two bottom lines of Table 4-3. Similar to the case of POT pooling groups (PP), the approach taken resulted in a large number of homogeneous pooling groups. Next, following the methodology of Hosking and Wallis (1997), the frequency distribution with best fit to each pooling group was identified. This was followed by quantile estimations using both pooled and at-site data.

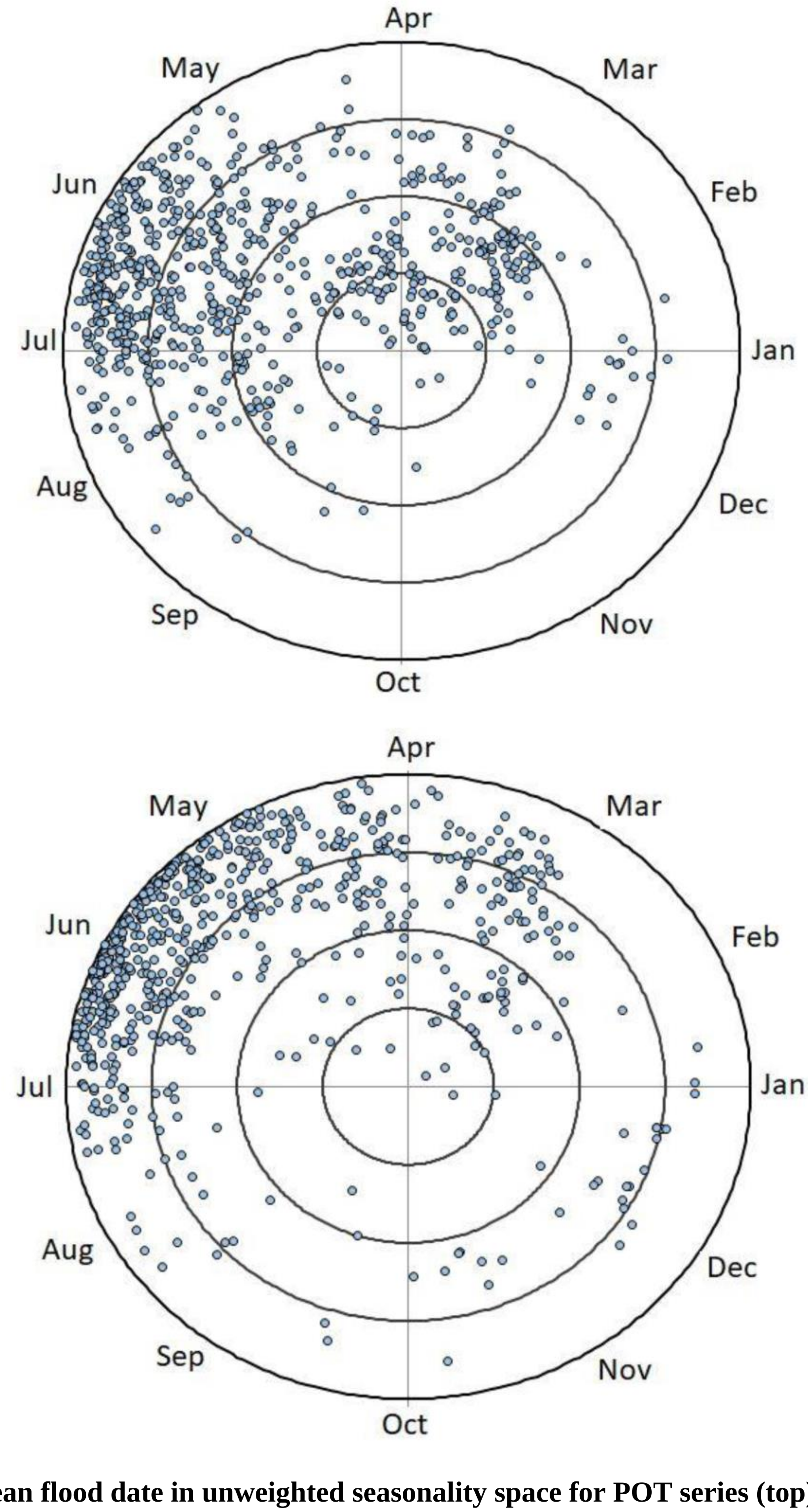


Figure 4-5: Mean flood date in unweighted seasonality space for POT series (top) and AMAX series (bottom)

Table 4-3: Summary of the homogeneity tests for pooling groups formed by POT statistics

		$H < 1$	$1 \leq H < 2$	$H \geq 2$
		Homogenous	Possibly homogenous	Heterogeneous
POT Series (PP)	$\bar{x}$ & $\bar{y}$	89.9%	10.1%	0%
	weighted $\bar{x}$ & weighted $\bar{y}$	87.1%	12.9%	0%
AMAX Series (PA)	$\bar{x}$ & $\bar{y}$	87.3%	13.6%	1.8%
	weighted $\bar{x}$ & weighted $\bar{y}$	83.3%	12.9%	3.8%

4.3.2.2 Analysis of AMAX-based Pooling Groups

In the same manner as with POT series, this time AMAX statistics were employed to construct pooling groups. Seasonality statistics were estimated using AMAX data. Figure 4-5(bottom) plots the catchments in unweighted seasonality space, based on AMAX events. By comparing Figures 4-5(top) and (bottom) one can conclude that AMAX events are more regular ($\bar{r}$ closer to 1) especially for sites having snowmelt events with mean flood date between mid-Spring to mid-Summer (nival regime). Lower regularity in the POT series is inevitable since there is more than one extreme flow event per year and these events have different occurrence times.

Table 4-4: Summary of the homogeneity tests for pooling groups formed by AMAX statistics.

		$H < 1$	$1 \leq H < 2$	$H \geq 2$
		homogenous	Possibly homogenous	heterogeneous
AMAX Series (AA)	$\bar{x}$ & $\bar{y}$	85.4%	11.8%	2.8%
	weighted $\bar{x}$ & weighted $\bar{y}$	87.1%	11.4%	1.5%
POT Series (AP)	$\bar{x}$ & $\bar{y}$	85.5%	14.5%	0%
	weighted $\bar{x}$ & weighted $\bar{y}$	86%	14%	0%

Table 4-4 provides a summary of the homogeneity test for pooling groups formed using AMAX data (AA). Again, for a large portion of stations (>85.4%) homogeneous pooling groups, for a small percentage (<11.8%) possibly homogeneous pooling groups, and for a few (<2.8%) heterogeneous pooling groups were identified. No substantive differences are noted when employing the two different seasonality measures, namely the one based on the unweighted statistics of Eq. (4-2) and the other based on the weighted statistics of Eq. (4-5). The best-fit distribution to the pooled data was determined and flood quantiles were estimated for different return periods, for both at-site data and using pooling groups.

The approach discussed in Section 4.2.4 was employed to facilitate the performance comparison of pooling groups containing AMAX or POT series. In this experiment, additional information (POT events) was introduced in the pooling groups (AP). The pooling groups including new data were also inspected for their homogeneity. The results are provided in the bottom two lines of Table 4-4 and reveal a high percentage of pooling groups (>85.5%) that can be considered homogeneous. Likewise, at-site and pooled quantile estimates for the new pooling groups containing POT series were estimated.

4.3.2.3 POT and AMAX Pooling Group Comparison

4.3.2.3.1 Error in Quantile Estimates

$RMSE_T$ described in Eq (4-16) was studied for four types of pooling groups: those formed by POT seasonality measures (either PP or PA), and those formed by their AMAX counterparts (AA, AP). N_{long} =32 stations with AMAX series longer than 60 years were considered for this analysis.

Table 4-5: Summary of $RMSE_T$ of different pooling techniques using POT (AMAX) series.

Return Period	PP(PA)		AP(AA)	
	$\bar{x}$ & $\bar{y}$	Weighted $\bar{x}$ & $\bar{y}$	$\bar{x}$ & $\bar{y}$	Weighted $\bar{x}$ & $\bar{y}$
2	0.025 (0.050)	**0.023** (0.058)	0.025 (0.051)	0.024 (0.048)
5	0.030 (0.038)	0.031 (0.048)	**0.029** (0.041)	0.030 (0.037)
10	0.059 (0.078)	0.058 (0.100)	0.058 (0.083)	**0.056** (0.072)
20	0.094 (0.122)	0.098 (0.152)	0.092 (0.130)	**0.088** (0.113)
50	0.144 (0.182)	0.136 (0.218)	0.140 (0.193)	**0.133** (0.171)

Bold indicates best result in each row.

Table 4-5 (left half) provides the $RMSE_T$ estimates for pooling groups formed by POT seasonality measures both using the POT series (PP) and the AMAX series (PA) in the pooling group. Investigating this table reveals that regardless of the seasonality measures used to construct the pooling groups, PP groups to estimate the quantiles have lower RMSE compared with the PA pooling groups. The POT series benefited from using larger amounts of pooled information and therefore higher accuracy quantile estimates were obtained. By looking at these results one can conclude that for PP pooling groups formed using weighted $\bar{x}$ and $\bar{y}$ seasonality measures resulted in the lowest $RMSE_T$, while for the PA method, pooling groups formed using $\bar{x}$ and $\bar{y}$ seasonality measure resulted in the lowest $RMSE_T$.

Table 4-5 (right half) also depicts the $RMSE_T$ estimates for pooling groups formed by AMAX statistics with both using AMAX series (AA) and POT series (AP) in the pooling group. The AP pooling groups are seen here to produce lower $RMSE_T$ than the AA pooling groups. Greater improvements can be seen for longer return periods. From this table, it can be inferred that employing the weighted $\bar{x}$ and $\bar{y}$ seasonality measure produced the lowest $RMSE_T$ among AP pooling groups (bold numbers), and also AA pooling groups.

A parallel comparison of the left and right divisions of Tables 4-5 concludes that pooling groups formed with the AMAX seasonality statistics (either AA or AP) are superior to those formed by their POT-based counterparts (either PP or AP). To point out the best performing quantile estimation method, one can select the weighted $\bar{x}$ and $\bar{y}$ seasonality measure of AMAX data to identify similar stations as inputs in pooling groups. Using the AA pooling method and the AP pooling method in this pooling scheme results in the lowest $RMSE_T$ for AMAX and POT flow series respectively. For the rest of the analysis only these two combinations were examined further.

To better indicate the merits of employing super regions as an initial step in the proposed pooling scheme, another experiment was conducted without using super regions. The dataset was treated as a whole, and best pooling groups were identified with similar approaches as discussed before. Table 4-6 summarizes the parallel comparison of $RMSE_T$ for the best identified AMAX and POT pooling technique, AA and AP, respectively with and without using super regions. Employing the super region approach was found to improve $RMSE_T$ in both AMAX (AA) and POT (AP) pooling groups formation.

Table 4-6: Summary of $RMSE_T$ with or without employing super regions.

Return Period	With Super Regions		Without Super Regions	
	AP	AA	AP	AA
2	**0.024**	0.048	0.056	0.076
5	**0.030**	0.037	0.064	0.068
10	**0.056**	0.072	0.086	0.090
20	**0.088**	0.113	0.112	0.119
50	**0.133**	0.171	0.145	0.178

Bold indicates best result in each row.

In addition to $RMSE_T$ for different return periods, $RMSE_F$ as defined in Eq (4-17) was also examined to compare the entire at-site and pooled frequency distribution. Table 4-7 provides the $RMSE_F$ of long-record sites with pooling groups formed based on best performing POT (AP) and AMAX (AA) pooling techniques. Investigating Table 4-7 reveals that using the AP pooling technique will generally result in lowering the $RMSE_F$, although some stations do not follow this general pattern. Figure 4-6 shows the location of long-record stations where $RMSE_F$ of AMAX (AA) or POT (AP) pooling groups are superior. The AP pooling technique surpasses the AA approach for the majority (69%) of long-record stations. These stations are located mostly in coastal areas and the southeastern part of the country. Table 4-8 summarizes the information about the stations where AA quantile estimation was superior. Instances where the AA pooling approach improved the quantile estimation were associated with hydrometric stations belonging to regions identified with the nival regime and mostly snowmelt events. This implies that stations with the nival regime and smaller PPY may benefit less from the POT approach.

Table 4-7: $RMSE_F$ comparison for two pooling techniques.

Station	AP pooling group	AA pooling group	Station	AP pooling group	AA pooling group
01AD002	**0.0280**	0.0393	05QA002	0.9487	**0.1188**
01AD003	**0.0124**	0.0984	08HB014	**0.0706**	0.0714
01BP001	**0.0129**	0.2378	08JB003	0.3885	**0.1568**
01EO001	**0.0904**	0.0907	08KB001	**0.4436**	0.6610
01FB001	**0.0287**	0.0298	08LD001	**0.6496**	1.0306
02EA005	**0.0363**	0.3407	08MG005	0.9526	**0.3423**
02GG002	**0.0863**	0.1159	08MH001	**0.0451**	0.4076
02OJ007	**0.1451**	2.6004	08NA002	3.5211	**0.8336**
02YQ001	**0.1353**	0.3982	08NE039	**0.3555**	1.3179
02ZH001	**0.0529**	0.1479	08NE074	**0.8281**	1.4742
02ZK001	**0.0670**	0.1573	08NE077	**0.1150**	0.1336
02ZM006	**0.0335**	0.1981	08NL007	0.8993	**0.6720**
04JC002	0.2235	**0.0235**	08NL024	**0.2917**	1.0311
04LJ001	**0.0148**	0.1350	08NN013	**0.1382**	2.1737
05AA022	0.4182	**0.2596**	09AC001	0.1654	**0.1653**
05PA012	0.0570	**0.0132**	09BC001	0.2068	**0.1469**

Bold indicates winning pooling technique for each site.

Figure 4-6: Locations of sites where AA or AP analysis provides the lower $RMSE_F$

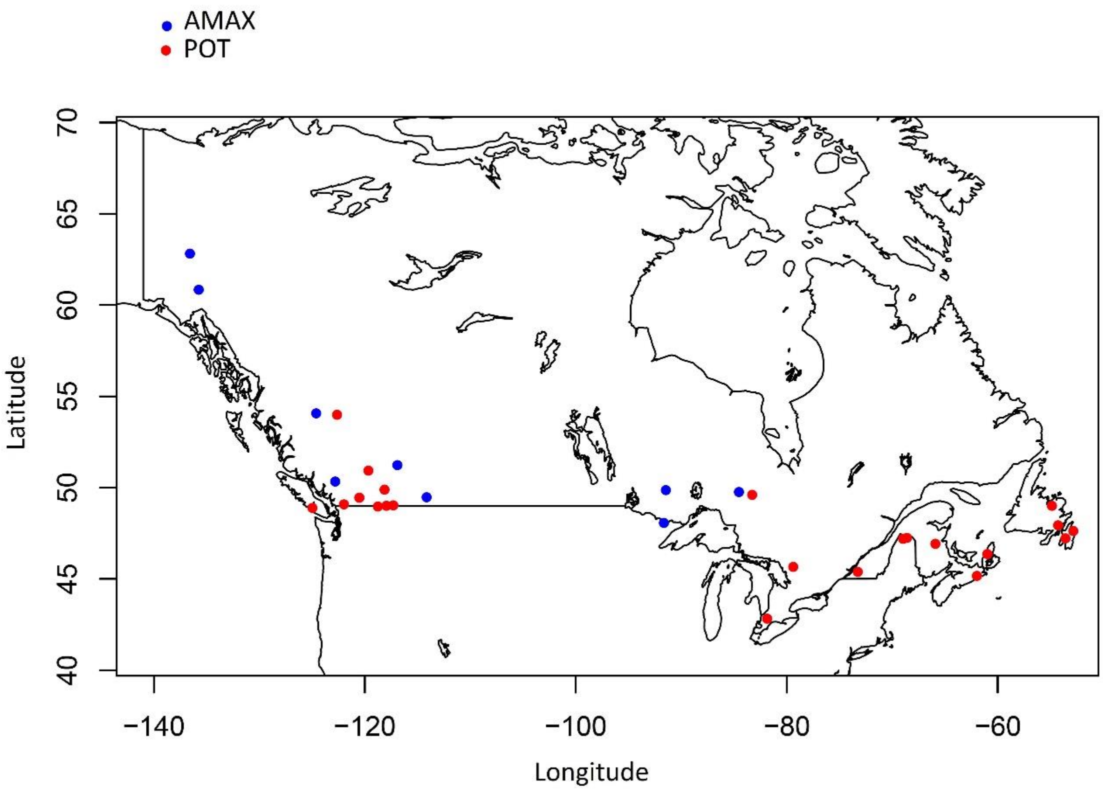


Table 4-8: Stations where AMAX quantile estimation was superior.

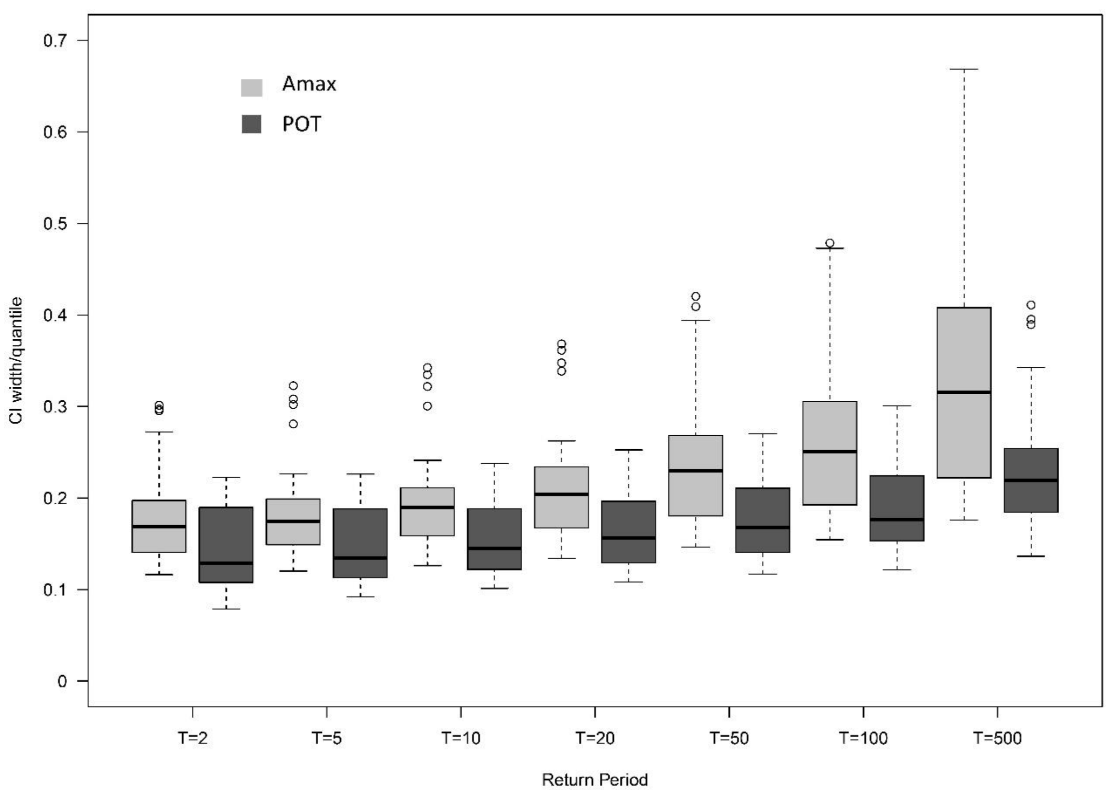
Station	Regime*	Record Length (years)	Drainage Area (km^2)
04JC002	N	65	2180
05AA022	N	62	821
05PA012	N	75	4510
05QA002	N	79	6230
08JB003	N	60	6030
08MG005	N	69	2100
08NA002	N	93	6660
08NL007	N	71	1810
09AC001	N	61	7050
09BC001	N	60	48900

* Regime N=Nival; Regime M=Mixed; Regime P=Pluvial

4.3.2.3.2 Confidence Interval Ratio

Uncertainty in the pooled quantile estimates was utilized as the second method of evaluation of pooling groups. The same long-record sites were again chosen for this analysis. The ratios of confidence interval width to quantile estimates were quantified for pooling groups formed using best identified techniques for POT (AP) and AMAX (AA) series. Figure 4-7 provides a boxplot of the confidence interval width divided by estimated quantile ratio for the pooling groups of long-record sites, formed by AP data and also AA series. In both pooling groups, the ratio increases as the return period increases. Parallel comparison of different return periods strongly indicates the advantage of quantile estimation using AP flood data over AA. This implies less uncertainty when flood quantiles are estimated with the use of the AP pooling technique.

Figure 4-7: Ratio of confidence interval width to quantile estimates for pooling groups formed by AA and AP.



4.4 Conclusions

This study has established a set of coherent guidelines to contribute to promoting the use of the POT model in pooled frequency analysis. This research aimed to provide a general framework to perform pooled frequency analysis for both AMAX and POT data series. An effective process to form pooling groups was introduced. A systematic approach was employed to compare and analyze the quantile estimates obtained based on these two types of models.

An application of the methodology was illustrated on a large dataset of 684 hydrometric stations in Canada. The focused pooling approach was employed to form four combinations of pooling groups based on both AMAX and POT series and based on different between-site similarity measures. Using the proposed pooling techniques, a promising number of homogeneous pooling groups were formed for each considered pooling technique. Pooled and at-site quantile estimates were obtained for both POT- and AMAX-based pooling groups. Quantile estimates were also examined while altering the seasonality statistics used to identify the closest sites in seasonality space.

The accuracy of T-year event estimates of pooled and at-site quantiles for long-record sites was investigated. Groups formed using AMAX distance statistics while using POT series (AP) have lower $RMSE_T$ compared to using AMAX series (AA) especially for longer return periods. The best pooling groups for using AMAX and POT series are formed with the weighted $\bar{x}$ and $\bar{y}$ seasonality of AMAX-based data, identified as AA and AP, respectively. Moreover, pooled and at-site quantiles for entire frequency distributions were compared for the long-record sites. It was concluded that using AP to form pooling group in the super region context will generally result in more compatibility between at-site and pooled quantiles. Less benefit may be obtained by employing the AP method for stations with the nival hydrological regime and smaller number of peaks per year.

The ratio of the width of confidence interval to quantile estimate revealed that there is less uncertainty associated with pooled quantiles obtained using POT (AP) series than AMAX (AA) series. The final conclusion of this research is that POT pooling groups generally provide improved pooled quantile estimation over AMAX pooling groups. The former have smaller uncertainties in the quantile estimations as well. The proposed framework can certainly be applied in other parts of the world to improve pooled flood quantile estimation.

Transition Paragraph C

In Chapters 2 to 4, techniques to improve flood frequency estimates using AMAX data, an effective method to extract POT series for a large dataset, and a framework to perform pooled frequency analysis using POT series were presented. The introduced approaches were based on the fundamental assumption in classic flood frequency analysis that extreme events at a given station are independent and identically distributed (IID) (Faulkner, et al., 2016). The absence of IID data can be determined, in many instances, by the presence of an increasing or decreasing trend in the data (Coles, 2001). Therefore, in the discussed approaches, data showing departure from these assumptions were excluded from the analysis. Nonetheless, accurate identification of existing trends is essential before the application of flood frequency analysis techniques to ensure that this form of inhomogeneity is adequately addressed. The objective of this Chapter[1] is to provide insight into the types of trends observed, and the temporal and spatial changes in trends, for the studied dataset.

[1]Mostofi Zadeh, S., Burn, D. H., & O'Brien, N. (2019). Detection of Trends in Flood Magnitude and Frequency in Canada. Submitted to *Journal of Hydrology: Regional Studies*.

Chapter 5

Detection of Trends in Flood Magnitude and Frequency in Canada

This chapter is built upon a submitted article with the same title in Journal of Hydrology: Regional Studies. Minor differences between the submitted paper and the chapter have been made to facilitate consistency and coherence.

Mostofi Zadeh, S., Burn, D. H., and O'Brien, N. 2019. Detection of Trends in Flood Magnitude and Frequency in Canada. Submitted to *Journal of Hydrology: Regional Studies*.

Summary

Changes and variation in flood regimes in Canada are examined using a large-scale dataset of hydrometric gauging stations from across the country. This study analyses the significant trends in time series of both Annual Maximum streamflows (AMAX) and Peaks-Over-Threshold (POT) series of hydrometric data. POT series are extracted from daily flow data for each watershed using a semi-automated threshold selection method. Since flood regimes are complex by nature, a multi-temporal and multifaceted approach was employed to identify and properly characterize the types of changes. Common time periods of the most recent 30-, 40-, 50-, and 60-years were studied. Trends were investigated both in terms of flood magnitude and frequency of these time series. Changes were examined using different groupings of sites based on dominant hydro-climatic regions, drainage area size, and land-use changes based on hydrologic reference stations. Examination of the results leads to important insights about the nature of changes in flood magnitude and frequency. An increased number of threshold exceeding events (frequency) is strongly observed from this analysis. Flow magnitudes in AMAX and POT series show more increasing trends in the most recent time windows while there are more decreasing trends in longer time periods.

5.1 Introduction

Flood regimes are expected to change due to intensification of the hydrological cycle as a result of climate change (Milly et al., 2002). Numerous recent flood events around the world lead to growing concern that flood hazard is increasing with flood events becoming more frequent and severe. Changes in extreme environmental events have become a very active research area. During the last decade, many studies around the world have focused on the concept of time-dependence, or nonstationarity, of extreme events to explore the changes and provided evidence of statistically significant trends in extreme flow series (Petrow and Merz, 2009; O'Brien and Burn, 2014; Mallakpour and Villarini, 2015; Tan and Gan, 2015; Burn et al., 2016; Hodgkins et al., 2017; Burn and Whitfield, 2018; Mangini et al, 2018; Do et al., 2018). According to Koutsoyiannis (2006) a hydrologic time series is usually regarded as stationary if the time series does not have trends or shifts in its mean or variance. The source of nonstationarity in hydrological records can be a natural catastrophe or periodicity (forest fires, El Nino, solar activities), anthropogenic activity (land use changes due to deforestation, urbanization) or changing climate (Cunderlik and Burn, 2003). As climate change progresses and anthropogenic changes become more prominent, the time dependence in peak flow records may become increasingly common. Accounting for these temporal trend changes is important for many hydrological applications, such as design and risk assessment of critical infrastructure (Burn et al., 2010; Rosner et al. 2014). Reviewing the literature on trend detection indicates the complexity of flood regimes and the associated requirement for a multifaceted approach to understand the types of observed changes and their likeliness of occurrence in the future (Burn and Whitfield, 2017).

Temporal trends in Canadian streamflows have been examined in several studies focusing either on a specific region or watershed in Canada or studying trends across the country. A summary of some of the research exploring trends in Canadian streamflow follows. Burn et al. (2004) conducted a study of the trends of several hydrological variables within the Liard River basin in northern Canada. Among the variables under study, summer flows indicated a weak decreasing trend and a weaker decreasing trend was observed in the annual flows. St. George (2007) detected statistically significant increasing trends in the streamflows along the Winnipeg River as did Whitfield (2001) in the northern part of British Columbia. Burn et al. (2008) performed trend analysis on streamflow data for a collection of stations on the Canadian Prairies. Results of the analysis were decreasing trends in the spring flow volume and peak flow, earlier occurrence of spring peak date, and decreasing trends in seasonal runoff volume. A total of 68 stations in Canada representing diverse hydrological conditions were studied by Burn et al. (2010) for detecting trends in extreme hydrological events. It was concluded that peak annual flows are generally becoming smaller and earlier. Zhang et al. (2001) reported trends for 11 hydrometric variables for Canadian catchments and generally observed decreasing trend in streamflows. Burn and Hag Elnur (2002) and Whitfield and Cannon (2000) observed major regional differences and variability of streamflow trends across Canada, with both increases and decreases in precipitation and streamflow. Burn and Whitfield (2016) examined changes in the flood regime for watersheds across Canada. They concluded that reference hydrometric watersheds (catchments with pristine conditions and good quality data) exhibit decreasing trends in flood magnitude while non-reference hydrometric watersheds displayed increasing trends. Tan and Gan (2015) found evidence of trends in annual maximum flow series from 145 stations over Canada. Burn and Whitfield (2018) reported changes in flood regimes and shifts in dominant flood generation process in hydrometric reference stations with centennial length data in Canada and northern United States. They used Peaks-Over-Threshold (POT) data to explore changes to the magnitude, timing, volume and duration of threshold exceedances.

One of the main methodological concerns when performing trend analysis is the definition of the "flood" variable (Mangini et al., 2018). Two types of flood series are used for trend analysis, the annual maximum flood (AMAX) series, as most commonly used in the literature, and the POT approach. Even though AMAX series have been widely used, this series is unable to represent the complexity in the flood regime (Burn and Whitfield, 2017). The advantages and disadvantages of using each type of series have been discussed in previous studies (Madsen and Rosbjerg, 1997; Mostofi Zadeh et al., 2019). Employing POT series allows detection of trends in both the magnitude of flood events exceeding the threshold and also the number of exceedances per year.

There have not been many studies investigating trends in POT series. These studies are either performed at a regional scale (Robson, 2002; Petrow and Merez, 2009; and Vormoor et al., 2016 in Europe) or at a large scale but with low spatial resolution database (Mediero et al., 2015 in Europe; Burn and Whitfield, 2017 and 2018 in Canada). Investigating flood trends using both AMAX and POT series in a large-scale, high spatial resolution dataset has been done in Europe (Mangini et al, 2018) but, to the best of our knowledge, has not previously been done in Canada. The focus of this paper is to detect evidence of statistically significant flood trends for a large number of hydrometric stations across Canada using both AMAX and POT approaches. For the latter, an automated threshold selection method was adopted that facilitates extracting POT series for a large dataset. This research aims to detect trends in flood magnitude and frequency across Canada with a multi-temporal process, for the most recent record lengths of 30 to 60 years. Trend signals from different hydro-climatic regions and catchments with different characteristics will be also investigated to better understand the behavior of changes in flood series.

The remainder of this paper is organized as follows. The flood series considered in this study, methods to extract POT data and procedures to conduct trend analysis are outlined in Section 2. Section 3 describes the data utilized in this study and watershed classifications used to further analyze trend signals. The results of the analysis are presented in Section 4, followed by conclusions from this study in Section 5.

5.2 Methodology

5.2.1 Flood Series

AMAX and POT approaches are used in this study to compile flood series. The AMAX series uses only the largest flow in each year. This may exclude large floods if several of them occurred in a single year and could therefore result in a loss of flood-related information (Bacova-Mitkova and Onderka, 2010). In addition, some very low discharges that are still the maximum value in the year might be included in AMAX series (Bezak et al., 2014). The POT model avoids AMAX drawbacks by considering flood peaks above a certain threshold level and allows capturing more information regarding the flood phenomena in comparison with AMAX (Lang et al., 1999). Choosing an appropriate threshold level and assuring the independence of the data series are major difficulties in using the POT method (Bezak et al., 2014). Lang et al. (1999) identified these difficulties as a reason that the POT model remains relatively unpopular and underemployed in practice. Solari and Losada (2012) noted the lack of standardized methodology for threshold selection and the difficulty in automating the process as further complications of employing the POT model.

Durocher et al. (2018) developed a semi-automated process to identify thresholds. Mostofi Zadeh et al. (2019) applied this process on a large dataset to extract POT series for Canadian catchments. In this study, the same POT dataset will be examined for trend analysis in the magnitude of peaks over threshold and the number of events per year (frequency). The interested reader can refer to the two abovementioned studies for further details.

5.2.2 Test for Statistical Significance

Changes in hydrological time series can be evaluated using parametric or nonparametric approaches. Trend evaluation of hydrometric data is commonly carried out using the nonparametric Mann-Kendall test (Kendall, 1975; Mann, 1945) and was applied in this study to detect monotonic trends in flood magnitudes. Significant serial correlation in a data series can impair the robustness of trend detection (Wang et al., 2015) given the assumption of serial independence of data by the Mann-Kendall test (Önöz and Bayazit, 2012). The Block Bootstrap (BBS) approach (Önöz and Bayazit, 2012) will be employed to mitigate this effect. In the BBS approach, data are resampled in blocks for a large number of times to estimate the significance of the observed Mann-Kendall test statistic from the data sample while reflecting the serial correlation present in the data set (Burn et al., 2016). As discussed by Önöz and Bayazit (2012), if data are serially dependent, bootstrapping is performed in blocks so that the autocorrelation in the data is replicated. The block length should be chosen so that data points one block apart are approximately independent. The block size depends upon the number of contiguous significant serial correlations (Khaliq et al., 2009). Khaliq et al. (2009) provide a detailed description of the steps involved in implementing the BBS approach.

The Mann-Kendall test is not recommended to detect trends in number of events (frequency) in the POT series, since numerous tied values may exist and introduce difficulties in the rank correlation procedure (Frei and Schär, 2001). For this purpose, the logistic regression test will be employed. Please refer to Frei and Schär (2001) for more details on logistic regression.

5.2.3 Field Significance

When significant trends are detected at a local scale, it is necessary to assess their field significance and examine if similar results are also observed at the neighbouring sites (Burn and Hag Elnur, 2002; Svensson et al., 2006; Petrow and Merz, 2009; Burn and Whitfield, 2017 and 2018). In field significance analysis, the objective is to assess whether the number of sites with significant local trend can be regarded as significant at a regional (field) scale.

For all trend analyses, a group block bootstrapping approach (GBBS) is employed, whereby increasing and decreasing trends are assessed separately. The algorithm operates by initially applying vector resampling in blocks to preserve the correlation structure of the data, therefore preserving the cross correlation in the original data but neglecting temporal order (Burn and Hag Elnur, 2002; Renard et al., 2008; Burn et al., 2016). This process continues until the desired record lengths are attained for all the included hydrometric datasets. For each resampled streamflow record, trend is assessed using the Hamed and Rao (1998) variance correction technique, which accounts for the effects of serial correlation on the variance of the Mann-Kendall test through the use of an effective sample size by considering all significant lags of autocorrelation. Using the developed empirical distribution of identified trends, the Yue et al. (2003) methodology is used to determine significance.

5.3 Data

5.3.1 Peak Flow Dataset

Daily flow data are available for hydrometric stations across Canada from the HYDAT database provided by Environment and Climate Change Canada Historical Hydrometric Data website (https://wateroffice.ec.gc.ca/mainmenu/historical_data_index_e.html). The dataset analyzed in this study consists of 894 gauging stations, with unregulated flows and at least 20 years of recorded data. This provides a high spatial resolution dataset with good spatial coverage of the country. Figure 5-1 shows the location of these hydrometric stations across Canada. Following Mostofi Zadeh et al. (2019), AMAX and POT series were extracted from the daily flow series available for each station. Figure 5-1 also illustrates the spatial pattern of the average number of Peaks Per Year (PPY) for POT series of each site. Stations with pluvial hydrologic regime that experience more rainfall-based events have larger PPY and are mostly located on the east and west coasts of Canada, as well as some in southern Ontario. Stations located in other parts of the country with nival (primarily floods as snowmelt events) or mixed hydrologic regime experience a lower number of peaks per year. Nival stations were identified with average PPY of less than 2.5.

Gauging stations have different periods of record and may contain gaps in the recorded time series. Figure 5-2 depicts the number of stations with records available each year for 1900 to 2018. The data availability and reliability of information contained is one of the main concerns in trend analysis (Merz and Petrow, 2009). A balance must be achieved between long flow series, which will generally provide poor spatial coverage, and better spatial coverage with time series that are short in comparison to the duration of long term cycles related to climatic indices. To address this trade-off, a multi temporal approach was implemented by changing the start year for trend analysis, using 10 year increments. Four common periods of 30, 40, 50 and 60 years reflecting short to long data records were selected for trend analysis. All common time periods end in 2016. Time series with more than 5% of the time window as missing values were excluded from the dataset. This results in 482, 391, 259, and 103 stations to be included in 30- to 60-year time windows, respectively. Appendix D provides a list of these stations. The obtained AMAX and POT datasets will help us in identifying large scale spatial patterns of trends detected in different time periods.

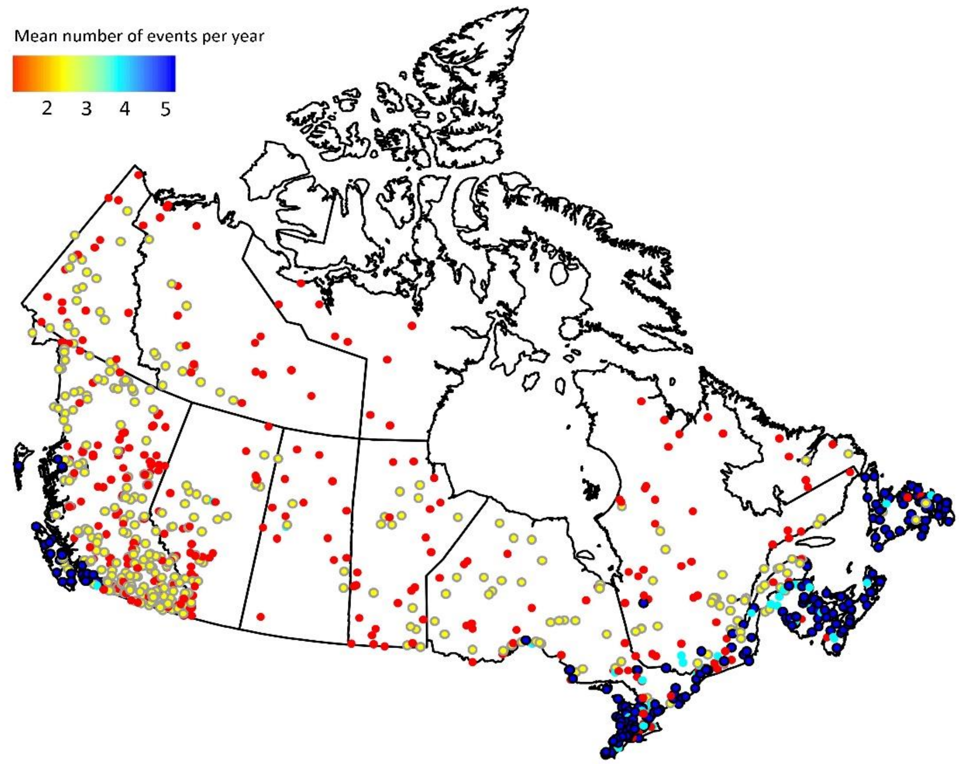


Figure 5-1 Location of hydrometric stations in this study.

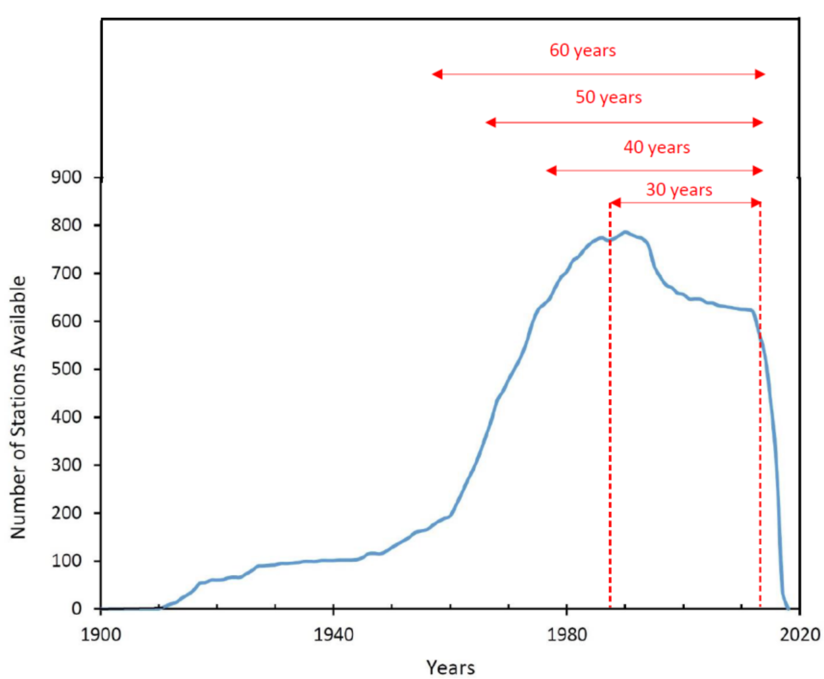


Figure 5-2 Available time periods of daily flow time series.

5.3.2 Hydro-Climatic Regions

Since flood regimes are complex by nature, it is essential to employ various grouping techniques to properly understand the types of changes in the time series. This study aims to determine the patterns of detected significant trends within large scale hydro-climatic regions in Canada. ESWG (1995) identified 15 Terrestrial Ecozones in Canada, representing large and generalized climatic, geologic and physiographic characteristics. A modified (aggregated) version of the Ecozones was considered with six major regions: Northern, Atlantic, Central, Prairies, Mountains, and Pacific. These regions reflect different hydro-climatic regions across the country and are shown in Figure 5-3. The characterization of the six hydro-climatic regions is presented below (for more detail, please refer to ESWG, 1995).

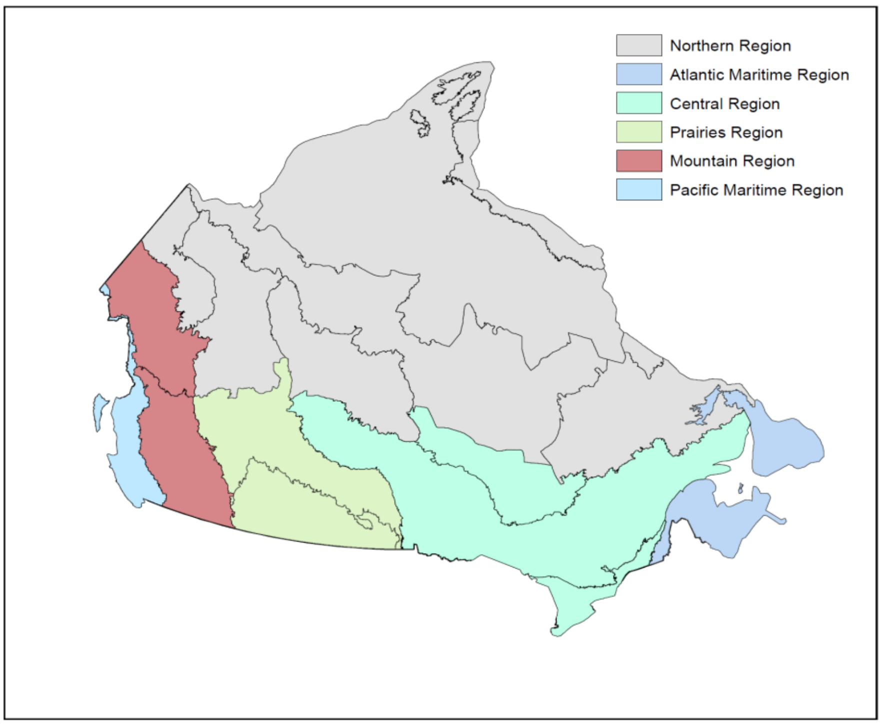


Figure 5-3 Six Hydro-Climatic regions in Canada.

The Northern region occupies the northern part of Canada. Climate in this vast region is very cold and dry, while it is somewhat milder and more humid in the southern portions of the region. Because of harsh climate and shallow soil cover, the vegetation is sparse. The Atlantic region is marked by cool summers and short, cold to moderately cold winters with high precipitation range because of the proximity to the Atlantic Ocean. Forests grow well in this area. Mean annual precipitation varies from 900 mm inland to over 1500 mm near the coast. The Central region has long cold winters and warm summers but is modified by maritime conditions in its coastal margins in Atlantic Canada. This region is mostly forested. The Prairies region is known for long cold winters and short hot to warm summers. The Prairies region is characterized by relatively little topographic relief and limited forests. Mean annual precipitation has extreme variability in this region. The Mountains region is characterized by mountain ranges that contain numerous high peaks that are separated by wide valleys and lowlands. This region has ranges of cold, subhumid to semiarid climate. It is marked by long cold winters and short warm summers. Mean annual precipitation is lowest in valleys within the rain shadow of the coastal ranges and increases in the interior ranges. The Pacific region has some of the warmest and wettest climate conditions in Canada. Climate ranges from a relatively mild humid maritime at low elevations to cool and very humid at higher elevations.

5.3.3 Catchment Characteristics

The relationship between catchment characteristics and significant trends detected in the flood series are also explored in this study. Two types of characteristics are considered. Temporal trends in peak flows will be calculated separately for three ranges of catchment drainage area sizes. Stations are classified based on watershed area (small ≤ 200 km^2; medium between 200 and 2000 km^2 or large ≥ 2000 km^2).

Trend signals from catchments with pristine and non-pristine conditions are also studied. Stations with pristine conditions over time are obtained from the Canadian Reference Hydrometric Basin Network (RHBN) (Brimley et al, 1999). These reference sites are known to have good quality data and do not experience the influence of regulation, diversions, or land use changes (Burn and Whitfield, 2017). These stations were specifically identified to assist in the study of the impact of climate change.

5.4 Results

5.4.1 Trend in Annual Maximum Series

The results of trend analysis in annual maximum flood series (AMAX) for periods of 30 to 60 years are depicted in Figure 5-4. The top section of Table 5-1 summarizes the number and percentage of sites with significant trend (5% local significance level) in their AMAX series with results provided separately for increasing versus decreasing trend. Field significance, evaluated at the 5% significance level, is also indicated in Table 5-1. For the 30-year time window (1987-2016), most of the detected trends in AMAX series are increasing. This trend pattern indicates the possible existence of a common driver of changes in extreme events in recent years. A strong large-scale spatially coherent pattern is observed as stations with decreasing trend are mostly located on the west coast of the country. In the 40-year time window (1977-2016), the percentage of significant increasing trends reduces to 4.6%, and the percentage of significant decreasing trends increases, in comparison with the 30-year period, to 2.3%. No obvious spatial pattern is noticed for detected changes in AMAX series in 40 year period. For the 50-year time window (1967-2016), most of the detected significant trends are decreasing (3.86% of stations), with the exception of two hydrometric stations on the east coast (0.77% of stations) with positive trend. Analysis of trends in AMAX series for the longest time period (1957-2016), reveals that most of the stations considered in this dataset have no significant trend. Decreasing trends are observed in only two hydrometric stations (1.94% of stations) as shown in Figure 5-4. No increasing trend was observed in the AMAX series dataset of this time period. The AMAX series do not show trends that are field significant, at the 5% level, for any time period considered.

5.4.2 Trend in Peaks-Over-Threshold Series

The results of multi temporal trend analysis of the POT magnitude series are presented in Figure 5-5. The middle section of Table 5-1 describes the number and percentage of sites with significant positive and negative trends in magnitudes of their POT series, detected at the 5% significance level. In the 30-year time window (1987-2016), a greater percentage of significant increasing trends (4.56%) are detected in comparison to decreasing trends (1.66%). Most of the stations in the central and northern regions of the country, as depicted in Figure 5-5, have no significant trend over this time period. No obvious spatial pattern can be observed for sites with significant trend in this time period. Analysis of the 40-year time period (1977-2016) reveals that the percentage of sites with increasing trend in POT magnitude series reduces to 3.58%, while the percentage of sites with decreasing trends increases to 2.81%. In the 50-year time window (1967-2016), the percentage of detected positive trends in POT magnitude has a similar declining pattern and reduces to 1.93%. While the number of detected negative trends stays similar to the number detected in the 40-year time window, the percentage of stations with negative trend has increased in the 50 year period. Significant decreasing trend are the only observed trend for POT magnitudes with 60-year time window (1957-2016) consisting of 5.83% of the stations considered in this time period. POT magnitude series considered in all time periods, do not show trends that are field significant at the 5% significance level.

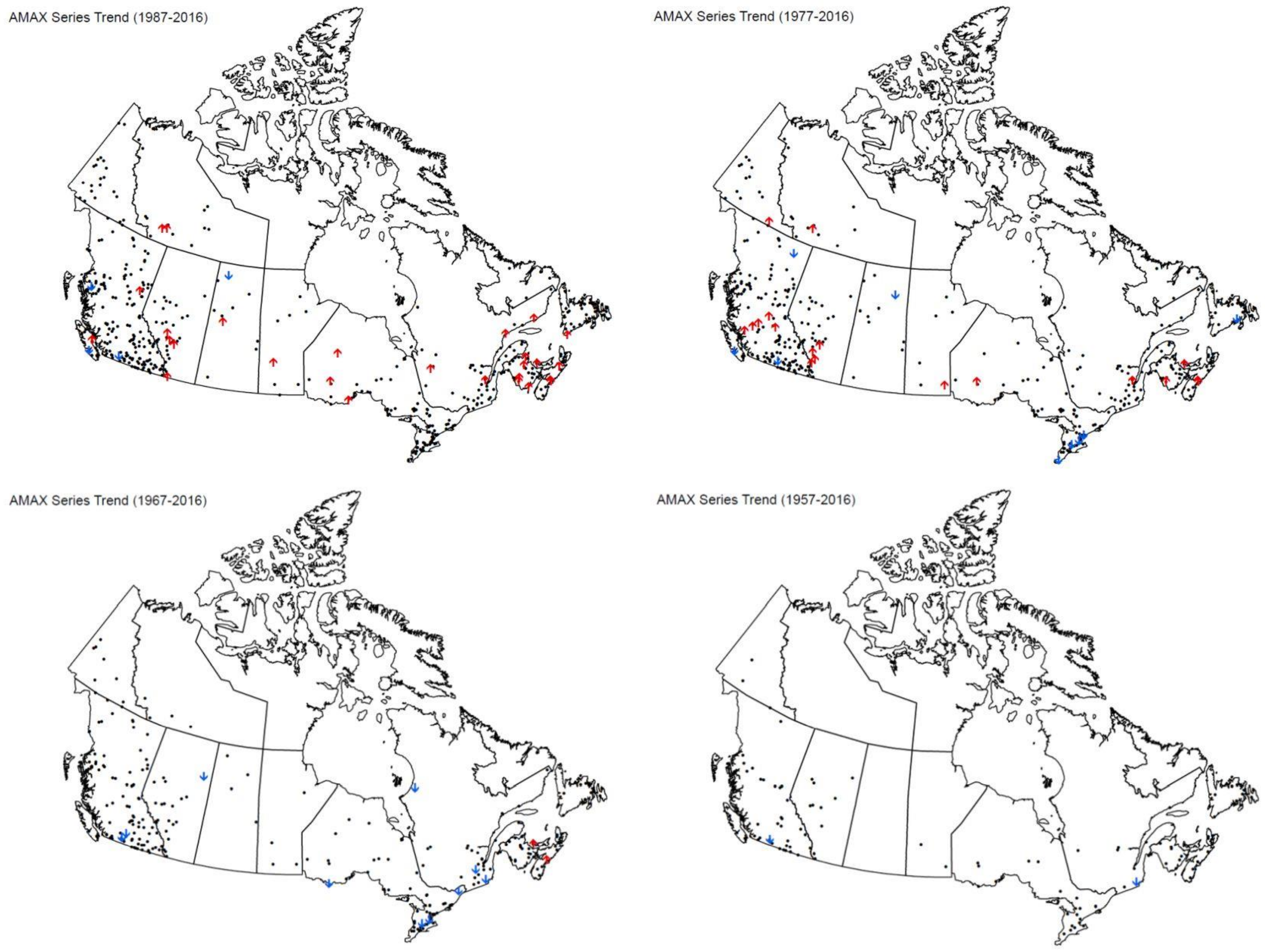


Figure 5-4 Trends in AMAX flood series. Arrows indicate statistically significant increasing trend (Red) and decreasing trend (blue). Dot symbols represent no trend.

Table 5-1 Description of number (percentage) of detected trends at 5% significant level in each time period. (30 -, 40-, 50-, and 60-year windows starting from 1987, 1977, 1967, and 1957 respectively)

		Increasing		Decreasing		Total
AMAX series	30-year window	27	(5.60%)	4	(0.83%)	482
	40-year window	18	(4.60%)	9	(2.30%)	391
	50-year window	2	(0.77%)	10	(3.86%)	259
	60-year window	0	(0%)	2	(1.94%)	103
POT series magnitude	30-year window	22	(4.56%)	8	(1.66%)	482
	40-year window	14	(3.58%)	11	(2.81%)	391
	50-year window	5	(1.93%)	11	(4.25%)	259
	60-year window	0	(0%)	6	(5.83%)	103
POT series number of events	30-year window	28	(5.81%)	7	(1.45%)	482
	40-year window	***33***	***(8.44%)***	2	(0.51%)	391
	50-year window	***20***	***(7.72%)***	6	(2.32%)	259
	60-year window	***10***	***(9.71%)***	5	(4.85%)	103

*Entries in bold and italic are field significant at 5% level.

One can observe similar patterns between the detected trends in AMAX and POT magnitudes. Since extraction of POT series provides more flood information compared to AMAX series, more reliable conclusions can be drawn from these series. By parallel comparison of these two series in each temporal period, one can conclude that fewer stations in POT series have significant increasing trend in comparison to AMAX series, while more stations exhibit decreasing trend.

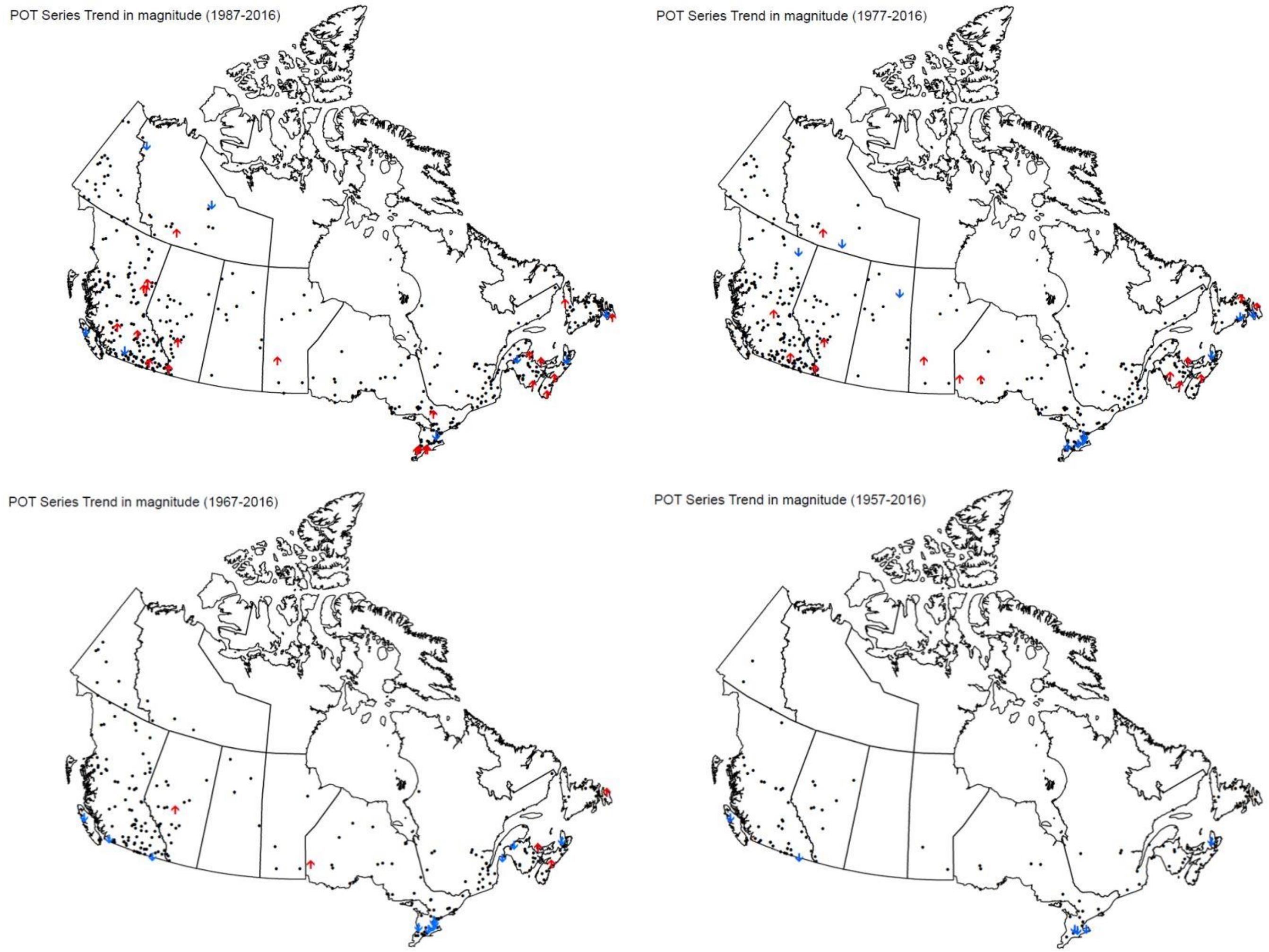


Figure 5-5 Trends in POT flood magnitude series. Arrows indicate statistically significant increasing trend (Red) and decreasing trend (blue). Dot symbols represent no trend.

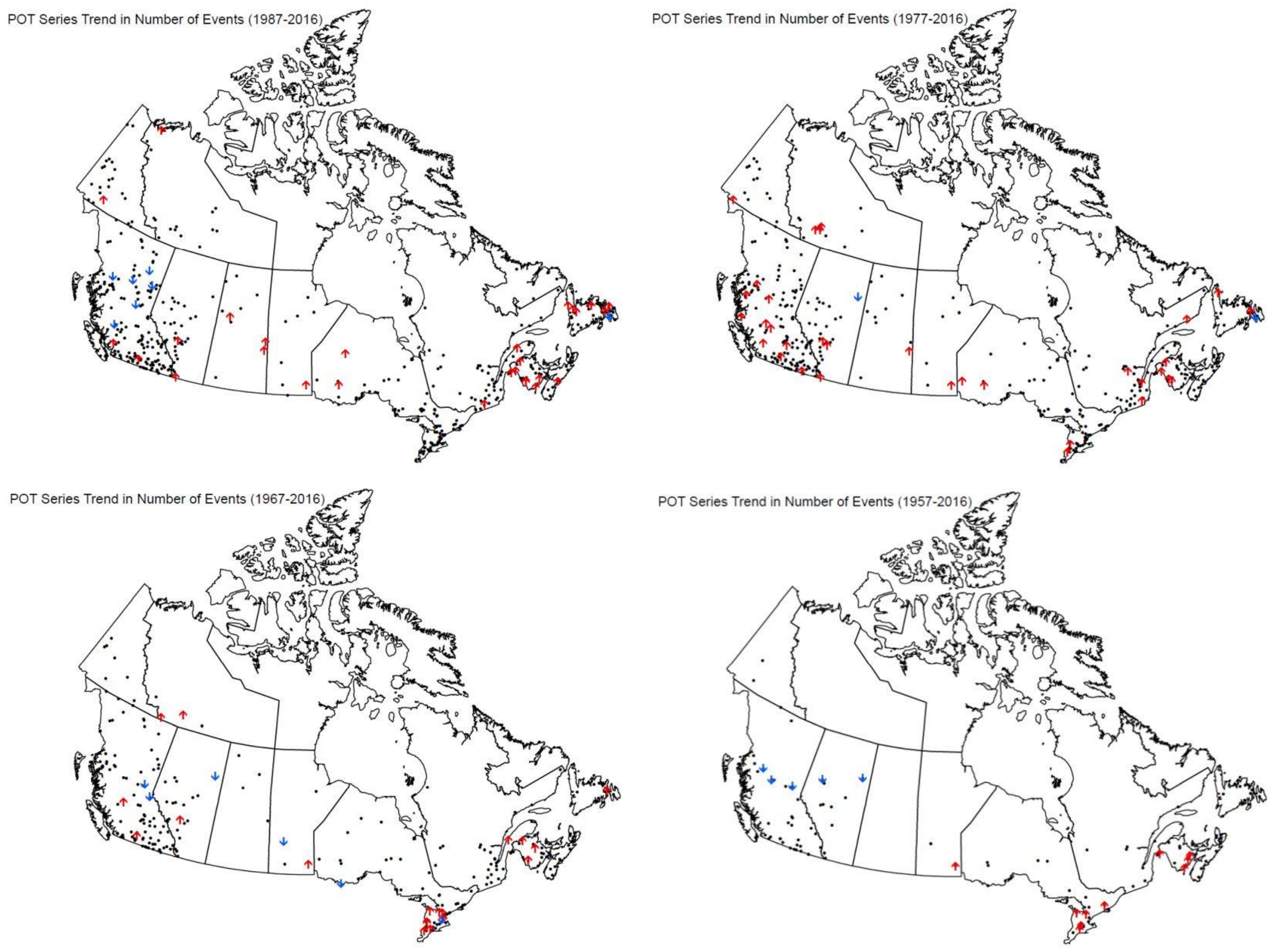


Figure 5-6 Trends in POT flood frequency series. Arrows indicate statistically significant increasing trend (Red) and decreasing trend (blue). Dot symbols represent no trend.

The results of multi temporal trend analysis of the POT number of events (frequency) series are presented in Figure 5-6. The bottom section of Table 5-1 summarizes the number and percentage of sites with significant positive and negative trends in the number of events for POT series detected at the 5% significance level. In the 30-year time window, a larger percentage of sites (5.81%) is detected with significant positive trends in comparison with 1.45% of sites exhibiting negative trends. Most of the stations with a decreasing number of events in the 30 year period are in the west region (mountainous region) of the country. In the 40-year time period, the percentage of sites with significant positive trend (8.44%) reveals a strong increase. Only two stations (0.51% of the sites) exhibited decreasing number of events per year in this time period. Similarly, in the 50-year time period, the percentage of stations exhibiting an increasing trend (7.72%) is greater than the percentage of stations with a decreasing trend (2.32%). The same pattern is observed in the 60-year time window. The largest percentage of sites (9.71%) with significant positive trend was detected in POT frequencies and for the 60-year time period. Stations exhibiting decreasing trend are all located in the west part of the country, while the stations with increasing trend are in the eastern and southern parts of Canada. The 40, 50, and 60 year time period of increasing POT frequency are the only time series for which field significance was attained.

Comparison of frequency and magnitudes of POT series reveals that a greater percentage of significant increasing trends exists in frequency time series for all temporal periods and this pattern does not change as the time window increases.

5.4.3 Trend in Different Hydro-climatic Regions

The overall trend results for stations within the six defined hydro-climatic regions are summarized in Table 5-2. For each hydro-climatic region, in more recent time periods, the percentage of identified significant trends is higher, implying occurrence of changes in recent years, and this percentage reduces as the length of the temporal window increases. In addition, for each hydro-climatic region in a fixed period of time, the frequency of events generally has the highest percentage of increasing trends. In the 30-year time window, stations in the Prairies region exhibit the largest percentage of increasing trends in the magnitude time series, both AMAX and POT, in comparison with other hydro-climatic regions. Stations in the Atlantic region displayed the largest percentage (16.1% of stations) of increasing trend in the POT frequencies. Detected trends for these three groups were determined to be field significant. Stations in the Northern region followed by the Atlantic region displayed the greatest percentage of identified stations with significant trend in the 40-year time period.

Table 5-2 Description of number (percentage) of stations with significant trend at 5% significance level in Hydro-Climatic regions. (30 -, 40-, 50-, and 60-year windows starting from 1987, 1977, 1967, and 1957 respectively).

	AMAX-30years				**POTs-30years**				**Frequency-30years**				
	Increasing		Decreasing		Increasing		Decreasing		Increasing		Decreasing		Total
Atlantic	10	10.8%	0	0.0%	7	7.5%	3	3.2%	***15***	***16.1%***	1	1.1%	93
Central	7	5.1%	1	0.7%	5	3.6%	1	0.7%	4	2.9%	0	0.0%	137
Prairies	***5***	***12.5%***	0	0.0%	***4***	***10.0%***	0	0.0%	4	10.0%	1	2.5%	40
Mountain	2	1.4%	1	0.7%	5	3.4%	1	0.7%	3	2.0%	3	2.0%	148
Pacific	1	2.6%	2	5.3%	0	0.0%	1	2.6%	1	2.6%	1	2.6%	38
Northern	2	7.7%	0	0.0%	1	3.8%	2	7.7%	1	3.8%	1	3.8%	26
	AMAX-40years				**POTs-40years**				**Frequency-40years**				
	Increasing		Decreasing		Increasing		Decreasing		Increasing		Decreasing		Total
Atlantic	4	5.9%	1	1.5%	6	8.8%	3	4.4%	7	10.3%	1	1.5%	68
Central	3	2.7%	5	4.5%	2	1.8%	6	5.4%	8	7.1%	0	0.0%	112
Prairies	2	5.6%	0	0.0%	2	5.6%	0	0.0%	3	8.3%	1	2.8%	36
Mountain	7	5.3%	1	0.8%	3	2.3%	0	0.0%	9	6.9%	0	0.0%	131
Pacific	1	3.8%	1	3.8%	0	0.0%	0	0.0%	3	11.5%	0	0.0%	26
Northern	1	5.6%	1	5.6%	1	5.6%	***2***	***11.1%***	***3***	***16.7%***	0	0.0%	18
	AMAX-50years				**POTs-50years**				**Frequency-50years**				
	Increasing		Decreasing		Increasing		Decreasing		Increasing		Decreasing		Total
Atlantic	2	4.2%	1	2.1%	3	6.3%	3	6.3%	5	10.4%	0	0.0%	48
Central	0	0.0%	5	6.1%	1	1.2%	5	6.1%	***10***	***12.2%***	2	2.4%	82
Prairies	0	0.0%	1	4.8%	1	4.8%	0	0.0%	1	4.8%	2	9.5%	21
Mountain	0	0.0%	2	2.5%	0	0.0%	1	1.2%	2	2.5%	2	2.5%	81
Pacific	0	0.0%	0	0.0%	0	0.0%	2	10.0%	0	0.0%	0	0.0%	20
Northern	0	0.0%	***1***	***14.3%***	0	0.0%	0	0.0%	***2***	***28.6%***	0	0.0%	7
	AMAX-60years				**POTs-60years**				**Frequency-60years**				
	Increasing		Decreasing		Increasing		Decreasing		Increasing		Decreasing		Total
Atlantic	0	0.0%	1	3.7%	0	0.0%	1	3.7%	***4***	***14.8%***	0	0.0%	27
Central	0	0.0%	0	0.0%	0	0.0%	***3***	***11.5%***	***6***	***23.1%***	0	0.0%	26
Prairies	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	***2***	***22.2%***	9
Mountain	0	0.0%	1	3.1%	0	0.0%	1	3.1%	0	0.0%	3	9.4%	32
Pacific	0	0.0%	0	0.0%	0	0.0%	***1***	***11.1%***	0	0.0%	0	0.0%	9
Northern	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0

*Entries in bold and italic are field significant at 5% level.

Decreasing trends in POT magnitude series and increasing trends in POT frequency series within the 1977 to 2016 period were indicated as field significant. In the 50-year time window, the Northern region exhibits the largest percentage of decreasing trends in AMAX and the largest percentage of increasing trends in the frequency of events. This is followed by the Central Region. Detected increasing trends in POT frequencies within the Northern and Central regions were field significant. In addition, sites within the Northern region with decreasing trends in the AMAX series were field significant at the 5% significance level. For the longest time window, AMAX and POT series in all hydro-climatic regions have no significant increasing trends and few decreasing trends. Stations in the Central and Pacific regions with decreasing trends were detected as field significant. The frequency of events in this time window exhibited increasing trends at 14.8% and 23.1% of the sites in the Atlantic and Central regions, respectively, both field significant at the 5% level. No increasing trends were detected in other regions. 22.2% and 9.4% of sites exhibited decreasing trend in the Prairies (also field significant) and the Mountains region, respectively. Decreasing trends were not detected in other regions.

5.4.4 Variation in Trends with Catchment Characteristics

Table 5-3 presents the trend results for AMAX, POT magnitudes and frequencies series based on identifying RHBN and non-RHBN sites in a multi temporal pattern. RHBN sites exhibit both increasing and decreasing significant trends, with a larger percentage of sites exhibiting increasing trends in the most recent time window. In the 30-year time period, a greater percentage of sites in RHBN category exhibit increasing trend in all three types of data series. Somewhat similar percentages of sites in RHBN and non-RHBN categories have significant decreasing trends. Positive trends in 30 year period of both AMAX and POT magnitude time series of RHBN sites were identified as field significant. Analysis of longer duration time series of AMAX and POT presented exclusively significant decreasing trends. The trend study of frequency of events shows a substantially larger percentage of sites with increasing trend than decreasing trend for both RHBN and non-RHBN sites. The percentages of non-RHBN sites with increasing trends in POT frequency for 40- and 50-year time periods were field significant.

Table 5-4 provides the trend results for studied time series based on catchment classification. For shorter time periods, a larger percentage of sites is observed with significant increasing trends than is observed for decreasing trends. For the 60-year time window, decreasing trends in AMAX and POT magnitudes are exclusively observed with only medium sized watersheds with trends in POT magnitudes being field significant. For the 60-year period frequency time series, positive trends are the only detected trends in small and medium sized drainage areas, with the latter being field significant.

Within these time series, decreasing trend was only observed in large watersheds and was determined to be field significant. Other than that, no noteworthy patterns are observed from this classification. The general lack of patterns in trend results as a function of watershed size implies that the trends are not greatly affected by different flood generating processes suggesting that the observed changes are mostly climate-driven.

Table 5-3 Description of number (percentage) of RHBN and non RHBN stations with significant trend at 5% significance level. (30 -, 40-, 50-, and 60-year windows starting from 1987, 1977, 1967, and 1957 respectively)

	AMAX-30years				**POTs-30years**				**Frequency-30years**				
	Increasing		Decreasing		Increasing		Decreasing		Increasing		Decreasing		Total
RHBN	***11***	***9.32%***	0	0.00%	***11***	***9.32%***	3	2.54%	8	6.78%	2	1.69%	118
Non RHBN	16	4.40%	4	1.10%	11	3.02%	5	1.37%	20	5.49%	5	1.37%	364
	AMAX-40years				**POTs-40years**				**Frequency-40years**				
	Increasing		Decreasing		Increasing		Decreasing		Increasing		Decreasing		Total
RHBN	4	3.39%	3	2.54%	8	6.78%	6	5.08%	8	6.78%	0	0.00%	118
Non RHBN	14	5.13%	6	2.20%	6	2.20%	5	1.83%	***25***	***9.16%***	2	0.73%	273
	AMAX-50years				**POTs-50years**				**Frequency-50years**				
	Increasing		Decreasing		Increasing		Decreasing		Increasing		Decreasing		Total
RHBN	2	2.06%	3	3.09%	3	3.09%	4	4.12%	5	5.15%	1	1.03%	97
Non RHBN	0	0.00%	7	4.32%	2	1.23%	7	4.32%	***15***	***9.26%***	5	3.09%	162
	AMAX-60years				**POTs-60years**				**Frequency-60years**				
	Increasing		Decreasing		Increasing		Decreasing		Increasing		Decreasing		Total
RHBN	0	0.00%	2	4.00%	0	0.00%	2	4.00%	5	10.00%	1	2.00%	50
Non RHBN	0	0.00%	0	0.00%	0	0.00%	4	7.55%	5	9.43%	4	7.55%	53

*Entries in bold and italic are field significant at 5% level.

5.5 Discussion

The trend results presented in this paper illustrate the advantages of using POT series rather than, or in addition to, AMAX series for providing a better understanding of the nature of changes in flood events. The use of POT dataset allows examination of the frequency of flood events along with traditional flood magnitude measures. Floods are by nature complex, especially in a large geographic area, such as Canada, with several different flood generating processes. Thus POT datasets are required to properly assess the possible changes in floods over time.

Table 5-4 Description of number (percentage) of stations with significant trend in catchment size grouping at 5% significance level. (30 -, 40-, 50-, and 60-year windows starting from 1987, 1977, 1967, and 1957 respectively)

	AMAX-30years				**POTs-30years**				**Frequency-30years**				
	Increasing		Decreasing		Increasing		Decreasing		Increasing		Decreasing		Total
Small	8	5.84%	1	0.73%	7	5.11%	4	2.92%	8	5.84%	1	0.73%	137
Medium	10	5.08%	2	1.02%	9	4.57%	2	1.02%	11	5.58%	3	1.52%	197
Large	9	6.08%	1	0.68%	6	4.05%	2	1.35%	9	6.08%	3	2.03%	148
	AMAX-40years				**POTs-40years**				**Frequency-40years**				
	Increasing		Decreasing		Increasing		Decreasing		Increasing		Decreasing		Total
Small	5	5.38%	5	5.38%	4	5.11%	4	2.92%	6	6.45%	1	1.08%	93
Medium	6	3.66%	2	1.22%	6	4.57%	4	1.02%	12	7.32%	0	0.00%	164
Large	7	5.22%	2	1.49%	4	4.05%	3	1.35%	***15***	***11.19%***	1	0.75%	134
	AMAX-50years				**POTs-50years**				**Frequency-50years**				
	Increasing		Decreasing		Increasing		Decreasing		Increasing		Decreasing		Total
Small	2	3.92%	2	3.92%	3	5.88%	3	5.88%	***6***	***11.76%***	1	1.96%	51
Medium	0	0.00%	4	3.67%	1	0.92%	7	6.42%	8	7.34%	1	0.92%	109
Large	0	0.00%	4	4.04%	1	1.01%	1	1.01%	6	6.06%	4	4.04%	99
	AMAX-60years				**POTs-60years**				**Frequency-60years**				
	Increasing		Decreasing		Increasing		Decreasing		Increasing		Decreasing		Total
Small	0	0.00%	0	0.00%	0	0.00%	1	9.09%	1	9.09%	0	0.00%	11
Medium	0	0.00%	2	4.35%	0	0.00%	***5***	***10.87%***	***7***	***15.22%***	0	0.00%	46
Large	0	0.00%	0	0.00%	0	0.00%	0	0.00%	2	4.35%	***5***	***10.87%***	46

*Entries in bold and italic are field significant at 5% level.

Changes were observed in the trend signals from a given station and for a given flood series in different time periods. Therefore, it is important to employ a multi-temporal approach to be able to capture all relevant trend behaviour for the catchment under study. Through using flood variables derived from a POT dataset, it was demonstrated that all flood classifications exhibit a large percentage of increasing trend in the number of events. The trend results based on the multi-temporal period of record indicated generally more increasing trends rather than decreasing trend in flood frequencies. The multi-temporal trend analysis reveals that a larger number of increasing trends was detected in recent years in all three types of flood series. The positive trend signal weakens, and negative trend signal gets stronger, as the length of the time period increases. The longest time series of AMAX and POT magnitudes only exhibited significant decreasing trends.

Differences were observed in the results when catchments were classified by the hydro-climatic regions and catchment characteristics (pristine condition and drainage size). In more recent time periods, for all hydro-climatic regions, the percentage of identified significant trends is higher, implying the occurrence of changes in recent years, and this percentage reduces as the length of the temporal window increases. In addition, for each hydro-climatic region in a fixed period of time, the frequency of events generally has the highest percentage of increasing trends. Changes were also observed depending on whether or not a station is part of a reference hydrologic network (RHBN site). The contrast between RHBN and non-RHBN stations is particularly noticeable for the 30-year time window. RHBN stations generally have proportionally more significant positive trends detected and more of these results are field significant. When catchments were classified based on watershed size, no noteworthy patterns in the trend results were observed, except observing that all decreasing trends for the 60-year time series of flood frequencies occur within large watersheds (a field significant result).

While comparing results from a diverse collection of trend studies is a challenge, due to different study locations and flood variables that are investigated, comparison of the results from this research revealed agreements with some of the conclusions from earlier research examining flood changes. Previous work (e.g. Petrow and Merz, 2009; Burn et al., 2010; Mediero et al, 2015; Vormoor et al, 2016; Burn and Whitfield, 2018) reported both increases and decreases for flood magnitude measures. Studies that have examined POT data generally reported an increase in the frequency of peak over threshold events. These outcomes are consistent with the analysis presented in this paper. The temporal patterns in flood variables have been observed in other studies as well. Mediero et al. (2015) grouped European hydrometric stations into five geographic regions and studied trends in a multi temporal approach. Merz et al. (2016) examined the temporal clustering of flood occurrences (peaks over threshold) and identified flood-rich and flood-poor periods for catchments in Germany. Less temporal clustering was observed with increasing threshold and time scale in comparison to significant temporal clustering noticed for low thresholds and time scales. Burn and Whitfield (2018) conducted a multi-temporal analysis on centennial length streamflow and examined the trends that would be inferred if only shorter records were available. They reported that analysing trends in different time periods resulted in identifying sites for which both significant increasing and decreasing trends were observed. They identified this non-constant behaviour of flood variables as an indicator of the existence of flood-rich and flood-poor periods.

The present paper identified significant increasing trends in flood magnitude variables for the recent time periods (30 and 40 years) as well as decreasing trends for longer time periods (60 year). This is accompanied with increasing number of events per year as the time period increases.

5.6 Conclusions

Flood changes in a large dataset of hydrometric stations distributed across Canada were examined using both AMAX and POT series. The results from the multi-temporal approach conducted in this research reveal the importance of the selected time period of flow series for implementing trend and change analysis. The trends in flood variables point to increases in frequency of flood events, and increases in flood magnitude for the most recent time periods, while more decreasing trends are observed in longer time periods for flood magnitudes. The observed increasing trends in flood variables in most recent years supports the growing concern about increases in the severity of flood events. Although these changes are occurring in flood events in Canada in recent years, further changes can be expected in the future as a result of the impacts of land-use and climate changes.

The nature of changes is different for different hydro-climatic regions and more specifically for different flood-generating processes. More changes both in increasing and decreasing trends were observed in the Atlantic hydro-climatic region of Canada in comparison to other regions. Differences were noted from the trend study of RHBN hydrometric stations, for which the impact of land-use changes are minimal, and other catchments. RHBN sites exhibited more changes than non-RHBN sites in flood variables for both the shortest and longest time periods. This emphasizes the importance of climate change effects on flood variables. Strong patterns in trend signals were not observed when the catchments were classified by size.

The observed changes in flood magnitude and frequency in Canadian catchments, and the complexity of these changes, stresses that a comprehensive understanding of these changes is necessary particularly when performing flood frequency analysis for flood protection planning involving infrastructure with a long design life.

Chapter 6
General Conclusions

How frequently a flood event of a given magnitude is expected to be equaled or exceeded at a given location, known as frequency analysis, is essential for effective design of instream structures, design of flood protection infrastructure, reservoir management, and floodplain management. Frequency analysis is a statistical method of estimation that consists of studying past events to determine the probabilities of occurrence of these events in the future. Estimation of these frequencies is difficult because extreme events are rare and for most gauging stations, flood records are too short to allow reliable estimation of the long return period floods typically required in design assessments. This thesis examines approaches to flood quantile estimation wherein extreme event information from a collection of sites is combined (pooled) for the estimation of an extreme event quantile for a target site of interest in addition to studying temporal trends in the extreme events. The overall contributions of this research aid in establishing a standardized and accurate approach for estimating extreme flood quantiles. The effectiveness of the developed approaches was examined on a large dataset of hydrometric stations across Canada. The key findings of this research are outlined below.

6.1 Summary of Results and Conclusions

Approaches to improve flood quantile estimation using Annual Maximum (AMAX) flow series was developed in Chapter 2. An approach was proposed to improve flood quantile estimates through utilizing the concept of super regions integrated with seasonality-based similarity measures in conducting pooled frequency analysis. The proposed approach was able to identify very promising homogeneous pooling groups for most catchments under study. Important outcomes from this work are summarized below.

- The performance of pooling group formation based on catchment physiographic-climate characteristics and several flood seasonality statistics to define similarity/dissimilarity between sites was investigated.
- A framework was developed that employed these two general types of similarity measure in a hierarchical process through the use of super regions, a process to classify catchments based on their scale control and climatic characteristics.

- The performance of the pooling approaches was evaluated resulting in quantiles estimated based on seasonality based pooling groups showing less error in comparison to site-characteristic similarities, while employing the super region framework substantially improved the quantile estimates.
- Less uncertainty was found in quantile estimates obtained based on the proposed pooling technique, thus confirming the improved precision of the results.

The purpose of Chapter 3 is the development of an approach to choose threshold levels for hydrometric flow series that allows extraction of peaks-over-threshold as an alternative flow series for performing flood frequency estimation. The approach was built upon the behavior of some automatic methods for threshold selection based on the generalized Pareto model for flood peak exceedances of the threshold and the Anderson-Darling (AD) goodness of fit test. A simulation study was used to assess the fitting and prediction performance of some automatic threshold selection methods. Moreover, automatic and manual selected thresholds for a collection of sites across Canada were compared based on site characteristics. A hybrid model was developed to combine automatic methods and was calibrated based on super regions. The conclusions of this chapter are as follows:

- Evaluation of maximum p-value (MAXPV) concluded that this method does not represent a valuable solution to automatic POT analysis on a large scale.
- The results of the split-based and significance-based methods were found to be similar. However, the split-based method often results in the rejection of the hypothesis of GPD by the AD test when applied to Canadian sites and was therefore determined to not be a robust approach.
- The adapted rate-based model, which was calibrated based on super regions, resulted in the greatest correspondence with results of the manual methods.
- The hybrid method combining the significance-based and adapted rate-based approaches was shown to more closely reproduce the estimates of manually selected thresholds while reducing the uncertainty and limiting the number of sites where the AD test rejects the hypothesis of GPD.
- The examination of the impact of automatic method in the context of trend analysis showed that the choice of an automatic method has an important impact on the conclusions of trend tests.

Chapter 4 builds upon the previous Chapter and contributes to the application of peaks-over-threshold (POT) series in the context of pooled flood frequency analysis. The purpose of this Chapter is the development of a practical framework that enables extracting POT series in a semi-automated fashion and promoting a formalized and effective approach to utilize the underemployed POT series in a pooled flood frequency context. The proposed framework also provides a means of comparison of quantile estimates when using POT or AMAX series in pooled quantile estimation. The conclusions from Chapter 4 are presented below:

- The focused pooling approach in the context of super regions was employed to form four combinations of pooling groups based on both AMAX and POT series and based on different between-site similarity measures.
- The accuracy of T-year event estimates of pooled and at-site quantiles were investigated for POT- and AMAX-based pooling groups. Less error was found in groups formed using AMAX based similarity measures while using POT data as the flow series (AP) in comparison with using AMAX data as the flow series (AA). In general, using AP to form pooling groups in the super region context will results in more compatibility between at-site and pooled quantiles for long record length sites.
- The merits of employing super region as an initial step in the proposed pooling technique was evaluated. It was concluded the pooling groups formed without using super regions always generated larger errors in quantile estimates.
- Evaluation of the entire frequency distribution concluded that less benefit may be obtained by employing the AP method for stations with a nival hydrological regime and a smaller number of peaks per year.
- The application of the proposed pooling technique illustrates that flood quantile estimation generally improves when using POT series in comparison to AMAX series and achieved smaller uncertainty associated with the quantile estimates.

Numerous recent flood events have led to growing concern that flood hazard is increasing and events are becoming more severe. Therefore, it is necessary to quantify the nonstationary behavior of flood events. The purpose of Chapter 5 was to study the types of changes and variations in time series of both AMAX and POT series in a large-scale dataset of hydrometric gauges in Canada. Trends were investigated both in terms of flood magnitude and frequency of these time series. A multi-temporal (studying the most recent 30, 40, 50 and 60 years of data) and multifaceted approach (different grouping of sites based on dominant hydro-climatic region, drainage area, and effect of land-use changes) were employed to properly characterize the types of changes in extreme flow series. The conclusions of this chapter are as follows:

- An increased frequency of extreme events (number of threshold exceeding events) was observed.
- The magnitude of extreme flows, in both AMAX and POT series, showed more increasing trends in the most recent time periods, while more decreasing trends were observed in longer time periods.
- Different hydro-climatic regions and more specifically different flood-generating processes resulted in observing different types of changes. More changes both in increasing and decreasing trends were observed in the Atlantic hydro-climatic region of Canada in comparison to other regions.
- The importance of climate change effect on flood variables was studied through the differences noted from the trend study of catchments with minimal land-use changes (RHBN sites). RHBN sites exhibited more changes than non-RHBN sites in flood variables for both the shortest and longest time periods.

6.2 Future Research

The techniques developed in this research established a formalized framework to enhance pooled flood frequency analysis utilizing independent identically distributed (IID) time series both in AMAX and POT series. However, the existence of significant trends in flood magnitude and frequency emphasize the necessity of developing techniques that incorporate nonstationarity in a changing climate. Future work may focus on improvement of pooling technique especially using POT series. This may be carried out considering nonstationarity in threshold level over time and also in the index-flood. Trend testing in both the mean and variance of time series is also worth exploring. More research is needed to develop a statistical test that identifies the heterogeneity level of pooling groups where nonstationarity is present in the data.

The POT pooling framework presented in Chapter 4 indicated that generally pooling estimates using POT data series surpassed pooling groups with AMAX data series. Further research can elaborate more on the conditions such as prevailing flood regime, selected threshold level, average number of peaks per year that contribute to AMAX pooling groups being superior.

Trend analysis in Chapter 5 was performed using mean daily flow series. Future research can investigate the evolution of instantaneous peak series. In addition, it is beneficial to take into consideration any changes that have been made in recording systems of hydrometric stations.

The techniques to improve pooled quantile estimates presented in this research could also be applied to other extreme hydrological variables, such as extreme rainfall events.

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Appendix A

List of Stations Used in Chapter 2

Station Number	Station Name	Removed	Reduced Dataset
01AD002	SAINT JOHN RIVER AT FORT KENT		
01AD003	ST. FRANCIS RIVER AT OUTLET OF GLASIER LAKE		
01AE001	FISH RIVER NEAR FORT KENT		
01AF007	GRANDE RIVIERE AT VIOLETTE BRIDGE		✓
01AF009	IROQUOIS RIVER AT MOULIN MORNEAULT		✓
01AG002	LIMESTONE STREAM AT FOUR FALLS		
01AJ003	MEDUXNEKEAG RIVER NEAR BELLEVILLE		
01AJ004	BIG PRESQUE ISLE STREAM AT TRACEY MILLS		
01AJ010	BECAGUIMEC STREAM AT COLDSTREAM		✓
01AJ011	COLD STREAM AT COLDSTREAM		
01AK001	SHOGOMOC STREAM NEAR TRANS CANADA HIGHWAY		✓
01AK005	MIDDLE BRANCH NASHWAAKSIS STREAM NEAR ROYAL ROAD		
01AK006	MIDDLE BRANCH NASHWAAKSIS STREAM AT SANDWITH'S FARM	Yes	
01AK007	NACKAWIC STREAM NEAR TEMPERANCE VALE		✓
01AK008	EEL RIVER NEAR SCOTT SIDING		
01AL002	NASHWAAK RIVER AT DURHAM BRIDGE	Yes	
01AL003	HAYDEN BROOK NEAR NARROWS MOUNTAIN		
01AL004	NARROWS MOUNTAIN BROOK NEAR NARROWS MOUNTAIN		✓
01AM001	NORTH BRANCH OROMOCTO RIVER AT TRACY	Yes	
01AN001	CASTAWAY STREAM NEAR CASTAWAY		
01AN002	SALMON RIVER AT CASTAWAY		✓
01AP002	CANAAN RIVER AT EAST CANAAN		✓
01AP004	KENNEBECASIS RIVER AT APOHAQUI		✓
01AP006	NEREPIS RIVER NEAR FOWLERS CORNER	Yes	
01AQ001	LEPREAU RIVER AT LEPREAU		✓
01BC001	RESTIGOUCHE RIVER BELOW KEDGWICK RIVER		✓
01BD002	MATAPEDIA (RIVIERE) EN AMONT DE LA RIVIERE ASSEMETQUAGAN		
01BD008	MATAPEDIA (RIVIERE) PRES DE AMQUI		✓
01BE001	UPSALQUITCH RIVER AT UPSALQUITCH		✓
01BF001	NOUVELLE (RIVIERE) AU PONT		
01BG005	CASCAPEDIA (RIVIERE) EN AVAL DU RUISSEAU BERRY		✓
01BG009	BONAVENTURE (RIVIERE) EN AMONT DU RUISSEAU CREUX	Yes	
01BH001	DARTMOUTH (RIVIERE) PRES DE CORTEREAL		
01BH002	YORK (RIVIERE) A SUNNY BANK	Yes	
01BH005	DARTMOUTH (RIVIERE) EN AMONT DU RUISSEAU DU PAS DE DAME		✓
01BH007	GRANDE-RIVIERE OUEST (LA)		
01BH010	YORK (RIVIERE) A 1,4 KM EN AVAL DU RUISSEAU DINNER ISLAND		✓
01BJ001	TETAGOUCHE RIVER NEAR WEST BATHURST		
01BJ003	JACQUET RIVER NEAR DURHAM CENTRE		✓
01BJ007	RESTIGOUCHE RIVER ABOVE RAFTING GROUND BROOK		✓
01BJ010	MIDDLE RIVER NEAR BATHURST	Yes	
01BJ012	EEL RIVER NEAR DUNDEE		✓
01BL001	BASS RIVER AT BASS RIVER		
01BL002	RIVIERE CARAQUET AT BURNSVILLE		✓
01BL003	BIG TRACADIE RIVER AT MURCHY BRIDGE CROSSING		✓
01BO001	SOUTHWEST MIRAMICHI RIVER AT BLACKVILLE		✓
01BO002	RENOUS RIVER AT MCGRAW BROOK		
01BO003	BARNABY RIVER BELOW SEMIWAGAN RIVER		
01BP001	LITTLE SOUTHWEST MIRAMICHI RIVER AT LYTTLETON		✓
01BP002	CATAMARAN BROOK AT REPAP ROAD BRIDGE	Yes	
01BQ001	NORTHWEST MIRAMICHI RIVER AT TROUT BROOK		✓

Station Number	Station Name	Removed	Reduced Dataset
01BR001	KOUCHIBOUGUAC RIVER NEAR VAUTOUR		
01BS001	COAL BRANCH RIVER AT BEERSVILLE		✓
01BU002	PETITCODIAC RIVER NEAR PETITCODIAC		✓
01BU003	TURTLE CREEK AT TURTLE CREEK		
01BV004	BLACK RIVER AT GARNET SETTLEMENT		✓
01BV006	POINT WOLFE RIVER AT FUNDY NATIONAL PARK		✓
01CA003	CARRUTHERS BROOK NEAR ST. ANTHONY		✓
01CC005	WEST RIVER AT RIVERDALE		✓
01DB002	BEAR RIVER EAST BRANCH AT BEAR RIVER		
01DC003	PARADISE BROOK NEAR PARADISE		
01DD004	SHARPE BROOK AT LLOYDS		
01DG003	BEAVERBANK RIVER NEAR KINSAC		✓
01DG006	SHUBENACADIE RIVER AT ENFIELD		
01DH003	FRASER BROOK NEAR ARCHIBALD		
01DH005	SALMON RIVER AT UNION		
01DJ005	GREAT VILLAGE RIVER NEAR SCRABBLE HILL	Yes	
01DL001	KELLEY RIVER (MILL CREEK) AT EIGHT MILE FORD		✓
01DN004	WALLACE RIVER AT WENTWORTH CENTRE		
01DO001	RIVER JOHN AT WELSFORD		
01DP004	MIDDLE RIVER OF PICTOU AT ROCKLIN	Yes	
01DR001	SOUTH RIVER AT ST. ANDREWS		✓
01EC001	ROSEWAY RIVER AT LOWER OHIO		✓
01ED005	MERSEY RIVER BELOW GEORGE LAKE		✓
01ED007	MERSEY RIVER BELOW MILL FALLS		✓
01EE005	MOOSE PIT BROOK AT TUPPER LAKE	Yes	
01EF001	LAHAVE RIVER AT WEST NORTHFIELD		✓
01EG002	GOLD RIVER AT MOSHER'S FALLS		
01EH003	EAST RIVER AT ST. MARGARETS BAY		
01EJ001	SACKVILLE RIVER AT BEDFORD		✓
01EJ004	LITTLE SACKVILLE RIVER AT MIDDLE SACKVILLE		✓
01EN002	LISCOMB RIVER AT LISCOMB MILLS	Yes	
01EO001	ST. MARYS RIVER AT STILLWATER		✓
01ER001	CLAM HARBOUR RIVER NEAR BIRCHTOWN	Yes	
01FA001	RIVER INHABITANTS AT GLENORA		✓
01FB001	NORTHEAST MARGAREE RIVER AT MARGAREE VALLEY		✓
01FB003	SOUTHWEST MARGAREE RIVER NEAR UPPER MARGAREE		✓
01FD001	WRECK COVE BROOK NEAR WRECK COVE		
01FH001	GRAND RIVER AT LOCH LOMOND	Yes	
01FJ001	SALMON RIVER AT SALMON RIVER BRIDGE		
01FJ002	MACASKILLS BROOK NEAR BIRCH GROVE	Yes	
02AA001	PIGEON RIVER AT MIDDLE FALLS	Yes	
02AB008	NEEBING RIVER NEAR THUNDER BAY		✓
02AB014	NORTH CURRENT RIVER NEAR THUNDER BAY		✓
02AB017	WHITEFISH RIVER AT NOLALU	Yes	
02AB019	MCVICAR CREEK AT THUNDER BAY		✓
02AB021	CURRENT RIVER AT STEPSTONE		✓
02AC001	WOLF RIVER AT HIGHWAY NO. 17		✓
02AC002	BLACK STURGEON RIVER AT HIGHWAY NO. 17		✓
02AD010	BLACKWATER RIVER AT BEARDMORE		✓
02AE001	GRAVEL RIVER NEAR CAVERS		✓
02BA002	STEEL RIVER NEAR TERRACE BAY		
02BA003	LITTLE PIC RIVER NEAR COLDWELL		✓
02BA005	WHITESAND RIVER ABOVE SCHREIBER AT MINOVA MINE		✓
02BB002	BLACK RIVER NEAR MARATHON		
02BB003	PIC RIVER NEAR MARATHON		✓
02BD003	MAGPIE RIVER NEAR MICHIPICOTEN		
02BF001	BATCHAWANA RIVER NEAR BATCHAWANA		✓

Station Number	Station Name	Removed	Reduced Dataset
02BF002	GOULAIS RIVER NEAR SEARCHMONT		✓
02BF004	BIG CARP RIVER NEAR SAULT STE. MARIE		✓
02BF005	NORBERG CREEK (SITE A) ABOVE BATCHAWANA RIVER		✓
02BF006	NORBERG CREEK (SITE B) AT OUTLET OF TURKEY LAKE		✓
02BF007	NORBERG CREEK (SITE C) AT OUTLET OF LITTLE TURKEY LAKE		✓
02BF008	NORBERG CREEK (SITE D) BELOW WISHART LAKE		✓
02BF009	NORBERG CREEK (SITE E) BELOW BATCHAWANA LAKE		✓
02BF012	NORBERG CREEK (SITE F) AT OUTLET OF BATCHAWANA LAKE		✓
02BF013	TRIBUTARY TO NORBERG CREEK AT TURKEY LAKE		✓
02CA002	ROOT RIVER AT SAULT STE. MARIE		✓
02CB003	AUBINADONG RIVER ABOVE SESABIC CREEK		✓
02CF007	WHITSON RIVER AT CHELMSFORD		✓
02CF008	WHITSON RIVER AT VAL CARON		✓
02CF011	VERMILION RIVER NEAR VAL CARON		✓
02CF012	JUNCTION CREEK BELOW KELLEY LAKE		✓
02CG003	BLUE JAY CREEK NEAR TEHKUMMAH		✓
02DB007	CONISTON CREEK ABOVE WANAPITEI RIVER		✓
02DC012	STURGEON RIVER AT UPPER GOOSE FALLS		✓
02DD008	DUCHESNAY RIVER NEAR NORTH BAY		
02DD012	VEUVE RIVER NEAR VERNER		✓
02DD013	LA VASE RIVER AT NORTH BAY		✓
02DD014	CHIPPEWA CREEK AT NORTH BAY		✓
02DD015	COMMANDA CREEK NEAR COMMANDA		✓
02EA005	NORTH MAGNETAWAN RIVER NEAR BURK'S FALLS		✓
02EA010	NORTH MAGNETAWAN RIVER ABOVE PICKEREL LAKE		✓
02EC002	BLACK RIVER NEAR WASHAGO		✓
02EC009	HOLLAND RIVER AT HOLLAND LANDING		✓
02EC010	SCHOMBERG RIVER NEAR SCHOMBERG		✓
02EC011	BEAVER RIVER NEAR BEAVERTON		✓
02EC018	PEFFERLAW BROOK NEAR UDORA		✓
02ED003	NOTTAWASAGA RIVER NEAR BAXTER		✓
02ED007	COLDWATER RIVER AT COLDWATER	Yes	
02ED009	WILLOW CREEK ABOVE LITTLE LAKE	Yes	
02ED010	WILLOW CREEK AT MIDHURST	Yes	
02ED014	PINE RIVER NEAR EVERETT	Yes	
02ED015	MAD RIVER AT AVENING		✓
02ED017	HOGG CREEK NEAR VICTORIA HARBOUR		✓
02ED024	NORTH RIVER AT THE FALLS		✓
02ED026	NOTTAWASAGA RIVER AT HOCKLEY		✓
02ED101	NOTTAWASAGA RIVER NEAR ALLISTON		✓
02ED102	BOYNE RIVER AT EARL ROWE PARK	Yes	
02FA002	STOKES RIVER NEAR FERNDALE		✓
02FA004	SAUBLE RIVER AT ALLENFORD		✓
02FB007	SYDENHAM RIVER NEAR OWEN SOUND		✓
02FC004	ROCKY SAUGEEN RIVER NEAR TRAVERSTON		
02FC011	CARRICK CREEK NEAR CARLSRUHE		✓
02FC016	SAUGEEN RIVER ABOVE DURHAM	Yes	
02FD001	PINE RIVER AT LURGAN		✓
02FD002	LUCKNOW RIVER AT LUCKNOW		✓
02FE008	MIDDLE MAITLAND RIVER NEAR BELGRAVE	Yes	
02FE009	SOUTH MAITLAND RIVER AT SUMMERHILL		✓
02FE010	BOYLE DRAIN NEAR ATWOOD		✓
02FE011	MAITLAND RIVER NEAR HARRISTON		
02FE013	MIDDLE MAITLAND RIVER ABOVE ETHEL		
02FE014	BLYTH BROOK BELOW BLYTH		✓
02FF004	SOUTH PARKHILL CREEK NEAR PARKHILL		✓
02FF007	BAYFIELD RIVER NEAR VARNA		✓

Station Number	Station Name	Removed	Reduced Dataset
02FF008	PARKHILL CREEK ABOVE PARKHILL RESERVOIR		✓
02GA010	NITH RIVER NEAR CANNING		✓
02GA017	CONESTOGO RIVER AT DRAYTON		
02GA018	NITH RIVER AT NEW HAMBURG		✓
02GA037	SCHNEIDER CREEK AT KITCHENER	Yes	
02GA038	NITH RIVER ABOVE NITHBURG		
02GA041	GRAND RIVER NEAR DUNDALK		✓
02GA043	HUNSBURGER CREEK NEAR WILMOT CENTRE		✓
02GB007	FAIRCHILD CREEK NEAR BRANTFORD		✓
02GB009	KENNY CREEK NEAR BURFORD		
02GC002	KETTLE CREEK AT ST. THOMAS		✓
02GC010	BIG OTTER CREEK AT TILLSONBURG		✓
02GC011	BIG CREEK NEAR KELVIN		✓
02GC018	CATFISH CREEK NEAR SPARTA		✓
02GC021	VENISON CREEK NEAR WALSINGHAM		✓
02GC029	KETTLE CREEK ABOVE ST. THOMAS		✓
02GC030	CATFISH CREEK AT AYLMER		✓
02GC031	DODD CREEK BELOW PAYNES MILLS		✓
02GD004	MIDDLE THAMES RIVER AT THAMESFORD		✓
02GD009	TROUT CREEK NEAR ST. MARYS	Yes	
02GD010	FISH CREEK NEAR PROSPECT HILL		✓
02GD019	TROUT CREEK NEAR FAIRVIEW		✓
02GD020	WAUBUNO CREEK NEAR DORCHESTER		
02GD021	THAMES RIVER AT INNERKIP		✓
02GE005	DINGMAN CREEK BELOW LAMBETH		✓
02GE007	MCGREGOR CREEK NEAR CHATHAM		✓
02GG002	SYDENHAM RIVER NEAR ALVINSTON		✓
02GG003	SYDENHAM RIVER AT FLORENCE		✓
02GG004	BEAR CREEK ABOVE WILKESPORT		
02GG005	SYDENHAM RIVER AT STRATHROY		✓
02GG006	BEAR CREEK NEAR PETROLIA		✓
02GG009	BEAR CREEK BELOW BRIGDEN		✓
02GH002	RUSCOM RIVER NEAR RUSCOM STATION		✓
02GH003	CANARD RIVER NEAR LUKERVILLE		✓
02GH004	TURKEY CREEK AT WINDSOR		
02GH011	LITTLE RIVER AT WINDSOR		✓
02HA006	TWENTY MILE CREEK AT BALLS FALLS		✓
02HA014	REDHILL CREEK AT HAMILTON		✓
02HA020	TWENTY MILE CREEK ABOVE SMITHVILLE		✓
02HB004	EAST SIXTEEN MILE CREEK NEAR OMAGH		✓
02HB012	GRINDSTONE CREEK NEAR ALDERSHOT		✓
02HB021	ANCASTER CREEK AT ANCASTER		✓
02HB022	BRONTE CREEK AT CARLISLE		✓
02HB023	SPENCER CREEK AT HIGHWAY NO. 5		✓
02HC009	EAST HUMBER RIVER NEAR PINE GROVE		✓
02HC013	HIGHLAND CREEK NEAR WEST HILL	Yes	
02HC018	LYNDE CREEK NEAR WHITBY		✓
02HC019	DUFFINS CREEK ABOVE PICKERING		✓
02HC023	COLD CREEK NEAR BOLTON		
02HC025	HUMBER RIVER AT ELDER MILLS		✓
02HC028	LITTLE ROUGE CREEK NEAR LOCUST HILL		✓
02HC029	LITTLE DON RIVER AT DON MILLS		
02HC030	ETOBICOKE CREEK BELOW QUEEN ELIZABETH HIGHWAY		✓
02HC031	WEST HUMBER RIVER AT HIGHWAY NO. 7		✓
02HC032	EAST HUMBER RIVER AT KING CREEK		
02HC033	MIMICO CREEK AT ISLINGTON		✓
02HC038	WEST DUFFINS CREEK ABOVE GREEN RIVER	Yes	

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02HC047	HUMBER RIVER NEAR PALGRAVE		✓
02HC049	DUFFINS CREEK AT AJAX		✓
02HD002	GANARASKA RIVER NEAR DALE	Yes	
02HD006	BOWMANVILLE CREEK AT BOWMANVILLE		✓
02HD007	SOPER CREEK AT BOWMANVILLE	Yes	
02HD008	OSHAWA CREEK AT OSHAWA	Yes	
02HD009	WILMOT CREEK NEAR NEWCASTLE		✓
02HD012	GANARASKA RIVER ABOVE DALE	Yes	
02HD013	HARMONY CREEK AT OSHAWA		
02HE001	BLOOMFIELD CREEK AT BLOOMFIELD		
02HG001	MARIPOSA BROOK NEAR LITTLE BRITAIN		
02HJ001	JACKSON CREEK AT PETERBOROUGH	Yes	
02HK007	COLD CREEK AT ORLAND		✓
02HK008	RAWDON CREEK NEAR WEST HUNTINGDON		✓
02HL003	BLACK RIVER NEAR ACTINOLITE		✓
02HL004	SKOOTAMATTA RIVER NEAR ACTINOLITE	Yes	
02HL005	MOIRA RIVER NEAR DELORO		✓
02HM004	WILTON CREEK NEAR NAPANEE		✓
02HM005	COLLINS CREEK NEAR KINGSTON		✓
02JB003	KINOJEVIS (RIVIERE) EN AVAL DE LA RIVIERE VILLEMONTEL		
02JB004	KINOJEVIS (RIVIERE) EN AVAL DU LAC PREISSAC		
02JB013	KINOJEVIS (RIVIERE) A 0,3 KM EN AMONT DU PONT-ROUTE A CLERICY		✓
02JC008	BLANCHE RIVER ABOVE ENGLEHART		✓
02JE015	KIPAWA (RIVIERE) EN AVAL DE LANIEL		
02KA003	PERCH LAKE OUTLET NEAR CHALK RIVER		
02KA004	PERCH LAKE INLET NO. 1 NEAR CHALK RIVER		
02KA006	PERCH LAKE INLET NO. 3 NEAR CHALK RIVER		
02KA007	PERCH LAKE INLET NO. 4 NEAR CHALK RIVER		
02KD002	YORK RIVER NEAR BANCROFT	Yes	
02KF011	CARP RIVER NEAR KINBURN	Yes	
02KF016	MISSISSIPPI RIVER BELOW MARBLE LAKE		✓
02KJ003	DUMOINE (RIVIERE) AU LAC DUMOINE		
02KJ007	KIPAWA (RIVIERE) AU LAC DUMOINE		
02LA007	JOCK RIVER NEAR RICHMOND	Yes	
02LB006	CASTOR RIVER AT RUSSELL		✓
02LB007	SOUTH NATION RIVER AT SPENCERVILLE	Yes	
02LB008	BEAR BROOK NEAR BOURGET		✓
02LB012	EAST BRANCH SCOTCH RIVER NEAR ST. ISIDORE DE PRESCOTT		
02LB017	NORTH BRANCH SOUTH NATION RIVER NEAR HECKSTON		
02LB020	SOUTH CASTOR RIVER AT KENMORE	Yes	
02LB022	PAYNE RIVER NEAR BERWICK		✓
02LC027	DONCASTER (RIVIERE) AU LAC ELEVE		✓
02LC043	SAINT-LOUIS (RUISSEAU) A 0,3 KM DE LA RIVIERE DU DIABLE		✓
02LD001	PETITE NATION (RIVIERE DE LA) A PORTAGE-DE-LA-NATION		
02LD002	PETITE NATION (RIVIERE DE LA) PRES DE COTE-SAINT-PIERRE		
02LD005	PETITE NATION (RIVIERE DE LA) AU PONT A 1,6 KM EN AMONT DE RIPON	Yes	
02LG005	GATINEAU (RIVIERE) AUX RAPIDES CEIZUR		✓
02LH002	DESERT (RIVIERE) EN AMONT DE LA RIVIERE DE L'AIGLE		
02LH004	PICANOC (RIVIERE) PRES DE WRIGHT		
02MB006	LYN CREEK NEAR LYN		✓
02MC001	RAISIN RIVER NEAR WILLIAMSTOWN	Yes	
02MC025	SAINT-LAURENT (FLEUVE)(CHENAL BEAUHARNOIS) - LES CHENAUX	Yes	
02MC026	RIVIERE BEAUDETTE NEAR GLEN NEVIS		✓
02MC028	RIVIERE DELISLE NEAR ALEXANDRIA		✓
02NE007	CROCHE (RIVIERE) A LA CROCHE		
02NE011	CROCHE (RIVIERE) A 2,6 KM EN AVAL DU RUISSEAU CHANGY	Yes	
02NF003	MATAWIN (RIVIERE) A SAINT-MICHEL-DES-SAINTS	Yes	

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02OA035	MILLE ILES (RIVIERE DES) EN AVAL DU LAC DES DEUX MONTAGNES		
02OA057	ANGLAIS (RIVIERE DES) A 1,1 KM EN AVAL DU PONT-ROUTE A TRES-SAINT-SACREMENT		
02OB037	ACHIGAN (RIVIERE DE L') A L'EPIPHANIE		✓
02OD003	NICOLET (RIVIERE) A 5,8 KM EN AVAL DE LA RIVIERE BULSTRODE		✓
02OE018	HALL (RIVIERE) PRES D'EAST HEREFORD		
02OE027	EATON (RIVIERE) PRES DE LA RIVIERE SAINT-FRANCOIS-3		✓
02OE032	SAUMON (RIVIERE AU) A 1,9 KM EN AMONT DE LA MOFFAT		✓
02OG007	YAMASKA NORD (RIVIERE) A VAL-SHEFFORD		✓
02OG026	DAVID (RIVIERE) AU PONT-ROUTE A SAINT-DAVID		✓
02OH008	BROCHETS (RIVIERE AUX) A 0,7 KM EN AVAL DU RUISSEAU GROAT	Yes	
02OJ001	RICHELIEU (RIVIERE) A SAINT-JEAN		
02OJ007	RICHELIEU (RIVIERE) AUX RAPIDES FRYERS		
02OJ024	HURONS (RIVIERE DES) EN AVAL DU RUISSEAU SAINT-LOUIS-2		✓
02OJ026	L'ACADIE (RIVIERE) PRES DE L'AUTOROUTE NO. 10	Yes	
02PA007	BATISCAN (RIVIERE) A 3,4 KM EN AVAL DE LA RIVIERE DES ENVIES		✓
02PB006	SAINTE-ANNE (RIVIERE) (BRAS DU NORD DE LA) EN AMONT		✓
02PC009	PORTNEUF (RIVIERE) PRES DE PORTNEUF		
02PD002	MONTMORENCY (RIVIERE) A 0,6 KM EN AVAL DU BARRAGE DES MARCHES NATURELLES		✓
02PD004	MONTMORENCY (RIVIERE) EN AMONT DE LA RIVIERE BLANCHE		✓
02PD012	EAUX VOLEES (RUISSEAU DES) EN AMONT DU CHEMIN DU BELVEDERE		✓
02PD013	EAUX VOLEES (RUISSEAU DES) PRES DE LA RIVIERE MONTMORENCY	Yes	
02PD014	AULNAIES OUEST (RUISSEAU DES) EN AMONT DU CHEMIN DU BELVEDERE		✓
02PD015	AULNAIES (RUISSEAU DES) PRES DU RUISSEAU DES EAUX VOLEES		✓
02PE009	GOUFFRE (RIVIERE DU) A BAIE-SAINT-PAUL	Yes	
02PE014	DAUPHINE (RIVIERE) A L' ILE D'ORLEANS		✓
02PG004	LOUP (RIVIERE DU) A LA ROUTE NO. 289	Yes	
02PG006	LOUP (RIVIERE DU) A SAINT-JOSEPH-DE-KAMOURASKA		✓
02PG022	OUELLE (RIVIERE) PRES DE SAINT-GABRIEL-DE-KAMOURASKA		✓
02PJ007	BEAURIVAGE (RIVIERE) A SAINTE-ETIENNE		✓
02PJ030	FAMINE (RIVIERE) A SAINT-GEORGES		✓
02PL001	BECANCOUR (RIVIERE) A LYSTER	Yes	
02PL005	BECANCOUR (RIVIERE) A 2,1 KM EN AMONT DE LA RIVIERE PALMER		✓
02PL007	BECANCOUR (RIVIERE) PRES DE SAINT-SYLVERE	Yes	
02QA002	RIMOUSKI (RIVIERE) A 3,7 KM EN AMONT DU PONT-ROUTE 132		✓
02QA017	NEIGETTE (RIVIERE)		
02QB011	CAP CHAT (RIVIERE) A CAP-CHAT		
02QC001	MADELEINE (RIVIERE) A RIVIERE-LA-MADELEINE		
02QC009	SAINTE-ANNE (RIVIERE) A 9,7 KM EN AMONT DU PONT-ROUTE 132		✓
02RB004	MANOUANE (RIVIERE) A LA SORTIE DU LAC DUHAMEL		✓
02RC011	PERIBONCA (PETITE RIVIERE)		✓
02RD002	MISTASSIBI (RIVIERE)		
02RD003	MISTASSINI (RIVIERE) EN AMONT DE LA RIVIERE MISTASSIBI		✓
02RF001	CHAMOUCHOUANE (RIVIERE) A LA TETE DE LA CHUTE AUX SAUMONS		✓
02RF002	ASHUAPMUSHUAN (RIVIERE) EN AVAL DE LA RIVIERE DU CHEF		✓
02RF006	CHAMOUCHOUANE (RIVIERE) EN AVAL DU PONT DE LA ROUTE NO 167		
02RF009	SAUMONS (RIVIERE AUX) PRES DE L'EMBOUCHURE	Yes	
02RG005	METABETCHOUANE (RIVIERE) EN AMONT DE LA CENTRALE S.R.P.C.		✓
02RH027	PIKAUBA (RIVIERE) EN AMONT DE LA RIVIERE APICA		✓
02RH035	ECORCES (RIVIERE AUX) EN AMONT DU PONT-ROUTE 169	Yes	
02RH045	VALIN (RIVIERE) A 3,5 KM DE L'EMBOUCHURE		✓
02RH047	SAINTE-MARGUERITE NORD-EST(RIVIERE) PRES DE LA RIV. STE.MARGUERITE-1		
02RH049	PETIT SAGUENAY (RIVIERE)		
02SC002	PORTNEUF (RIVIERE) EN AMONT DES CHUTES PHILIAS	Yes	
02UA003	GODBOUT (RIVIERE) A 1,6 KM EN AMONT DU PONT-ROUTE 138		✓
02UC002	MOISIE (RIVIERE) A 5,1 KM EN AMONT DU PONT DU Q.N.S.L.R.		✓
02VA001	TONNERRE (RIVIERE AU)		
02VB004	MAGPIE (RIVIERE) A LA SORTIE DU LAC MAGPIE		✓

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02VC001	ROMAINE (RIVIERE) AU PONT DE LA Q.I.T.		✓
02WA001	NABISIPI (RIVIERE) A 2.4 KM DE L'EMBOUCHURE		
02WB003	NATASHQUAN (RIVIERE) A 0,6 KM EN AVAL DE LA DECHARGE DU LAC ALIESTE		✓
02XA003	LITTLE MECATINA RIVER ABOVE LAC FOURMONT		✓
02XC001	SAINT-PAUL (RIVIERE) A 0,5 KM DU RUISSEAU CHANION		✓
02YA001	STE. GENEVIEVE RIVER NEAR FORRESTERS POINT		
02YA002	BARTLETTS RIVER NEAR ST. ANTHONY	Yes	
02YC001	TORRENT RIVER AT BRISTOL'S POOL	Yes	
02YD002	NORTHEAST BROOK NEAR RODDICKTON		✓
02YE001	GREAVETT BROOK ABOVE PORTLAND CREEK POND		✓
02YG001	MAIN RIVER AT PARADISE POOL	Yes	
02YJ001	HARRYS RIVER BELOW HIGHWAY BRIDGE	Yes	
02YK002	LEWASEECHJEECH BROOK AT LITTLE GRAND LAKE	Yes	
02YK004	HINDS BROOK NEAR GRAND LAKE		
02YK005	SHEFFIELD BROOK NEAR TRANS CANADA HIGHWAY	Yes	
02YK008	BOOT BROOK AT TRANS-CANADA HIGHWAY		✓
02YL001	UPPER HUMBER RIVER NEAR REIDVILLE		✓
02YL004	SOUTH BROOK AT PASADENA	Yes	
02YL005	RATTLER BROOK NEAR MCIVERS		✓
02YL008	UPPER HUMBER RIVER ABOVE BLACK BROOK		✓
02YL011	COPPER POND BROOK NEAR CORNER BROOK LAKE		✓
02YM001	INDIAN BROOK AT INDIAN FALLS		
02YM003	SOUTH WEST BROOK NEAR BAIE VERTE		✓
02YM004	INDIAN BROOK DIVERSION ABOVE BIRCHY LAKE		✓
02YN002	LLOYDS RIVER BELOW KING GEORGE IV LAKE		✓
02YO006	PETERS RIVER NEAR BOTWOOD		✓
02YO008	GREAT RATTLING BROOK ABOVE TOTE RIVER CONFLUENCE		✓
02YO012	SOUTHWEST BROOK AT LEWISPORTE		✓
02YQ001	GANDER RIVER AT BIG CHUTE		✓
02YQ005	SALMON RIVER NEAR GLENWOOD		✓
02YR001	MIDDLE BROOK NEAR GAMBO		✓
02YR002	RAGGED HARBOUR RIVER NEAR MUSGRAVE HARBOUR		
02YR003	INDIAN BAY BROOK NEAR NORTHWEST ARM		✓
02YS001	TERRA NOVA RIVER AT EIGHT MILE BRIDGES		
02YS003	SOUTHWEST BROOK AT TERRA NOVA NATIONAL PARK		✓
02YS005	TERRA NOVA RIVER AT GLOVERTOWN		✓
02YS006	NORTHWEST RIVER AT TERRA NOVA NATIONAL PARK		✓
02ZA002	HIGHLANDS RIVER AT TRANS-CANADA HIGHWAY		✓
02ZB001	ISLE AUX MORTS RIVER BELOW HIGHWAY BRIDGE		✓
02ZC002	GRANDY BROOK BELOW TOP POND BROOK		✓
02ZD002	GREY RIVER NEAR GREY RIVER		✓
02ZE001	SALMON RIVER AT LONG POND		
02ZE004	CONNE RIVER AT OUTLET OF CONNE RIVER POND		✓
02ZF001	BAY DU NORD RIVER AT BIG FALLS		✓
02ZG001	GARNISH RIVER NEAR GARNISH		✓
02ZG002	TIDES BROOK BELOW FRESHWATER POND		
02ZG003	SALMONIER RIVER NEAR LAMALINE		✓
02ZG004	RATTLE BROOK NEAR BOAT HARBOUR		✓
02ZH001	PIPERS HOLE RIVER AT MOTHERS BROOK		✓
02ZH002	COME BY CHANCE RIVER NEAR GOOBIES		✓
02ZJ001	SOUTHERN BAY RIVER NEAR SOUTHERN BAY		✓
02ZJ002	SALMON COVE RIVER NEAR CHAMPNEYS		✓
02ZJ003	SHOAL HARBOUR RIVER NEAR CLARENVILLE		✓
02ZK001	ROCKY RIVER NEAR COLINET		✓
02ZK002	NORTHEAST RIVER NEAR PLACENTIA		✓
02ZK003	LITTLE BARACHOIS RIVER NEAR PLACENTIA	Yes	
02ZK004	LITTLE SALMONIER RIVER NEAR NORTH HARBOUR	Yes	

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02ZL004	SHEARSTOWN BROOK AT SHEARSTOWN		✓
02ZL005	BIG BROOK AT LEAD COVE		✓
02ZM006	NORTHEAST POND RIVER AT NORTHEAST POND		✓
02ZM008	WATERFORD RIVER AT KILBRIDE		✓
02ZM009	SEAL COVE BROOK NEAR CAPPAHAYDEN	Yes	
02ZM016	SOUTH RIVER NEAR HOLYROOD		✓
02ZM018	VIRGINIA RIVER AT PLEASANTVILLE		✓
02ZM020	LEARY BROOK AT PRINCE PHILIP DRIVE		✓
02ZN001	NORTHWEST BROOK AT NORTHWEST POND	Yes	
02ZN002	ST. SHOTTS RIVER NEAR TREPASSEY		✓
03AB002	WASWANIPI (RIVIERE) A LA CHUTE ROUGE		✓
03AC001	BELL (RIVIERE) A SENNETERRE-2	Yes	
03AC002	MEGISCANE (RIVIERE) PRES DE MEGISCANE		
03AC004	BELL (RIVIERE) EN AMONT DU LAC MATAGAMI		✓
03AD001	NOTTAWAY (RIVIERE) A LA TETE DU LAC SOSCUMICA		
03BA003	TEMISCAMIE (RIVIERE) PRES DE LAC ALBANEL		
03BB002	RUPERT (RIVIERE DE) ET LE CHENAL CHIPASTOUC		
03BC002	RUPERT (RIVIERE DE) EN AVAL DU LAC NEMISCAU		
03BD002	BROADBACK (RIVIERE) A LA SORTIE DU LAC QUENONISCA		✓
03BE001	BROADBACK (RIVIERE) EN AVAL DE LA RIVIERE OUASOUAGAMI		
03BF001	PONTAX (RIVIERE) A 60,4 KM DE L'EMBOUCHURE		✓
03CB004	EASTMAIN (RIVIERE) A LA TETE DE LA GORGE PROSPER		
03CC001	EASTMAIN (RIVIERE) A LA TETE DE LA GORGE DE BASILE	Yes	
03DA002	GRANDE RIVIERE (LA) EN AVAL DU LAC PUISSEAUX		
03DC002	GRANDE RIVIERE (LA) EN AMONT DE LA RIVIERE DE PONTOIS	Yes	
03DD002	DE PONTOIS (RIVIERE) EN AMONT DE LA RIVIERE SAKAMI		
03DD003	DE PONTOIS (RIVIERE) PRES DE LA GRANDE RIVIERE		
03EA001	BALEINE (GRANDE RIVIERE DE LA) A LA SORTIE DU LAC BIENVILLE		
03EC001	DENYS (RIVIERE) PRES DE LA GRANDE RIVIERE DE LA BALEINE		
03ED001	BALEINE (GRANDE RIVIERE DE LA) EN AMONT DE LA RIVIERE DENYS-1		✓
03ED004	COATS (RIVIERE) PRES DE LA GRANDE RIVIERE DE LA BALEINE		
03FA003	LOUPS MARINS (LAC DES) DANS LE BASSIN VERSANT DE LA RIVIERE NASTAPOCA	Yes	
03FC007	BOUTIN (RIVIERE) A LA SORTIE DES LAC MOLLET-2		
03FC008	BALEINE (PETITE RIVIERE DE LA) EN AMONT DU CHENAL ANCEL		
03HA001	ARNAUD (PAYNE)(RIVIERE) EN AMONT DE LA RIVIERE HAMELIN-1		
03JB001	FEUILLES (RIVIERE AUX) EN AVAL DE LA RIVIERE PELADEAU		
03KA001	MELEZES (RIVIERE AUX) EN AMONT DE LA RIVIERE DU GUE		
03KC004	MELEZES (RIVIERE AUX) A 7,6 KM EN AMONT DE LA CONFLUENCE AVEC LA KOKSOAK		✓
03LD004	SWAMPY BAY (RIVIERE)	Yes	
03LF002	CANIAPISCAU (RIVIERE) A 1,0 KM EN AMONT DE LA CHUTE DE LA PYRITE	Yes	
03MB002	BALEINE (RIVIERE A LA) A 40,2 KM DE L'EMBOUCHURE	Yes	
03MC001	TUNULIC (RIVIERE) PRES DE L'EMBOUCHURE		
03MD001	GEORGE (RIVIERE) A LA SORTIE DU LAC DE LA HUTTE SAUVAGE		✓
03NF001	UGJOKTOK RIVER BELOW HARP LAKE		✓
03OC003	ATIKONAK RIVER ABOVE PANCHIA LAKE		✓
03OE003	MINIPI RIVER BELOW MINIPI LAKE		✓
03OE010	BIG POND BROOK BELOW BIG POND		✓
03PB002	NASKAUPI RIVER BELOW NASKAUPI LAKE		
03QC001	EAGLE RIVER ABOVE FALLS		✓
03QC002	ALEXIS RIVER NEAR PORT HOPE SIMPSON		✓
04AA004	HAYES RIVER BELOW TROUT FALLS		✓
04AC005	GODS RIVER BELOW ALLEN RAPIDS	Yes	
04AC007	ISLAND LAKE RIVER NEAR ISLAND LAKE		
04AD002	GODS RIVER NEAR SHAMATTAWA		
04CA002	SEVERN RIVER AT OUTLET OF MUSKRAT DAM LAKE		
04CA003	ROSEBERRY RIVER ABOVE ROSEBERRY LAKES		
04CA004	SEVERN RIVER AT OUTLET OF DEER LAKE		

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04CB001	WINDIGO RIVER ABOVE MUSKRAT DAM LAKE		
04CC001	SEVERN RIVER AT LIMESTONE RAPIDS		
04CD002	SACHIGO RIVER BELOW OUTLET OF SACHIGO LAKE	Yes	
04CE002	FAWN RIVER BELOW BIG TROUT LAKE	Yes	
04DA001	PIPESTONE RIVER AT KARL LAKE		
04DB001	ASHEWEIG RIVER AT STRAIGHT LAKE		
04DC001	WINISK RIVER BELOW ASHEWEIG RIVER TRIBUTARY		
04DC002	SHAMATTAWA RIVER AT OUTLET OF SHAMATTAWA LAKE		
04EA001	EKWAN RIVER BELOW NORTH WASHAGAMI RIVER	Yes	
04FA001	OTOSKWIN RIVER BELOW BADESDAWA LAKE		
04FA002	KAWINOGANS RIVER NEAR PICKLE CROW		
04FA003	PINEIMUTA RIVER AT EYES LAKE		
04FB001	ATTAWAPISKAT RIVER BELOW ATTAWAPISKAT LAKE		
04FC001	ATTAWAPISKAT RIVER BELOW MUKETEI RIVER		
04GA002	CAT RIVER BELOW WESLEYAN LAKE	Yes	
04GB004	OGOKI RIVER ABOVE WHITECLAY LAKE	Yes	
04GB005	BRIGHTSAND RIVER AT MOBERLEY	Yes	
04JA002	KABINAKAGAMI RIVER AT HIGHWAY NO. 11		
04JC002	NAGAGAMI RIVER AT HIGHWAY NO. 11		✓
04JC003	SHEKAK RIVER AT HIGHWAY NO. 11	Yes	
04JD005	PAGWACHUAN RIVER AT HIGHWAY NO. 11		✓
04JF001	LITTLE CURRENT RIVER AT PERCY LAKE		✓
04KA001	KWETABOHIGAN RIVER NEAR THE MOUTH		
04KA002	HALFWAY CREEK AT MOOSONEE		
04LJ001	MISSINAIBI RIVER AT MATTICE		✓
04LM001	MISSINAIBI RIVER BELOW WABOOSE RIVER		
04MD004	PORCUPINE RIVER AT HOYLE		✓
04MF001	NORTH FRENCH RIVER NEAR THE MOUTH		
04NA001	HARRICANA (RIVIERE) 3,1 KM EN AVAL DU PONT-ROUTE 111 A AMOS	Yes	
04NB001	TURGEON (RIVIERE) EN AMONT DE LA RIVIERE HARRICANA		
05AA001	OLDMAN RIVER NEAR COWLEY		
05AA002	CROWSNEST RIVER NEAR LUNDBRECK		
05AA003	CASTLE RIVER NEAR COWLEY		
05AA004	PINCHER CREEK AT PINCHER CREEK		✓
05AA008	CROWSNEST RIVER AT FRANK		✓
05AA022	CASTLE RIVER NEAR BEAVER MINES		✓
05AA023	OLDMAN RIVER NEAR WALDRON'S CORNER		
05AA027	RACEHORSE CREEK NEAR THE MOUTH		✓
05AA028	CASTLE RIVER AT RANGER STATION		✓
05AA030	GOLD CREEK NEAR FRANK		✓
05AA909	TODD CREEK NEAR HIGHWAY NO.22		✓
05AB005	TROUT CREEK NEAR GRANUM		✓
05AB013	BEAVER CREEK NEAR BROCKET		✓
05AB028	WILLOW CREEK ABOVE CHAIN LAKES		
05AB029	MEADOW CREEK NEAR THE MOUTH		✓
05AC030	SNAKE CREEK NEAR VULCAN		✓
05AD003	WATERTON RIVER NEAR WATERTON PARK		
05AD035	PRAIRIE BLOOD COULEE NEAR LETHBRIDGE		✓
05AE005	ROLPH CREEK NEAR KIMBALL		
05AE032	SWIFTCURRENT CREEK AT MANY GLACIER		
05AF010	MANYBERRIES CREEK AT BRODIN'S FARM		✓
05AH037	GROS VENTRE CREEK NEAR DUNMORE		✓
05AH041	PEIGAN CREEK NEAR PAKOWKI ROAD		✓
05AH047	SAM LAKE TRIBUTARY NEAR SCHULER		✓
05AH050	BOXELDER CREEK AT HARGRAVE'S RANCH		✓
05BA001	BOW RIVER AT LAKE LOUISE	Yes	
05BB001	BOW RIVER AT BANFF	Yes	

Station Number	Station Name	Removed	Reduced Dataset
05BC002	SPRAY RIVER NEAR SPRAY LAKES		
05BC003	SPRAY CREEK AT SPRAY LAKES		
05BD002	CASCADE RIVER NEAR BANFF	Yes	
05BF016	MARMOT CREEK MAIN STEM NEAR SEEBE		✓
05BF017	MIDDLE FORK CREEK NEAR SEEBE		
05BF018	TWIN CREEK NEAR SEEBE	Yes	
05BF019	CABIN CREEK NEAR SEEBE	Yes	
05BG006	WAIPAROUS CREEK NEAR THE MOUTH		✓
05BH009	JUMPINGPOUND CREEK NEAR THE MOUTH		
05BH013	JUMPINGPOUND CREEK NEAR COX HILL		✓
05BJ004	ELBOW RIVER AT BRAGG CREEK		✓
05BJ005	ELBOW RIVER ABOVE GLENMORE DAM		
05BJ010	ELBOW RIVER AT SARCEE BRIDGE		✓
05BK001	FISH CREEK NEAR PRIDDIS		✓
05BL012	SHEEP RIVER AT OKOTOKS		✓
05BL013	THREEPOINT CREEK NEAR MILLARVILLE		✓
05BL014	SHEEP RIVER AT BLACK DIAMOND		✓
05BL019	HIGHWOOD RIVER AT DIEBEL'S RANCH		✓
05BL022	CATARACT CREEK NEAR FORESTRY ROAD		✓
05BL023	PEKISKO CREEK NEAR LONGVIEW		✓
05BL027	TRAP CREEK NEAR LONGVIEW		✓
05BM014	WEST ARROWWOOD CREEK NEAR ARROWWOOD		✓
05BM018	WEST ARROWWOOD CREEK NEAR ENSIGN		✓
05CA001	RED DEER RIVER NEAR SUNDRE		
05CA002	JAMES RIVER NEAR SUNDRE		✓
05CA004	RED DEER RIVER ABOVE PANTHER RIVER		✓
05CA009	RED DEER RIVER BELOW BURNT TIMBER CREEK		✓
05CA011	BEARBERRY CREEK NEAR SUNDRE		✓
05CB001	LITTLE RED DEER RIVER NEAR THE MOUTH		✓
05CB002	LITTLE RED DEER RIVER NEAR WATER VALLEY		✓
05CB004	RAVEN RIVER NEAR RAVEN		✓
05CC001	BLINDMAN RIVER NEAR BLACKFALDS		✓
05CC007	MEDICINE RIVER NEAR ECKVILLE		✓
05CC008	BLINDMAN RIVER NEAR BLUFFTON		✓
05CC009	LLOYD CREEK NEAR BLUFFTON		✓
05CC010	BLOCK CREEK NEAR LEEDALE		✓
05CC011	WASKASOO CREEK AT RED DEER		✓
05CD006	HAYNES CREEK NEAR HAYNES		✓
05CD007	PARLBY CREEK AT ALIX		✓
05CE002	KNEEHILLS CREEK NEAR DRUMHELLER		✓
05CE006	ROSEBUD RIVER BELOW CARSTAIRS CREEK		✓
05CE010	RAY CREEK NEAR INNISFAIL		✓
05CE011	RENWICK CREEK NEAR THREE HILLS		✓
05CE018	THREEHILLS CREEK BELOW RAY CREEK		✓
05CE020	MICHICHI CREEK AT DRUMHELLER		✓
05CG004	BULLPOUND CREEK NEAR WATTS		✓
05CG006	FISH CREEK ABOVE LITTLE FISH LAKE		✓
05CK001	BLOOD INDIAN CREEK NEAR THE MOUTH	Yes	
05CK005	ALKALI CREEK NEAR THE MOUTH	Yes	
05DA006	NORTH SASKATCHEWAN RIVER AT SASKATCHEWAN CROSSING		
05DA007	MISTAYA RIVER NEAR SASKATCHEWAN CROSSING		✓
05DA009	NORTH SASKATCHEWAN RIVER AT WHIRLPOOL POINT		✓
05DA010	SILVERHORN CREEK NEAR THE MOUTH		✓
05DB001	CLEARWATER RIVER NEAR ROCKY MOUNTAIN HOUSE		
05DB002	PRAIRIE CREEK NEAR ROCKY MOUNTAIN HOUSE		✓
05DB005	PRAIRIE CREEK BELOW LICK CREEK		✓
05DB006	CLEARWATER RIVER NEAR DOVERCOURT	Yes	

Station Number	Station Name	Removed	Reduced Dataset
05DC006	RAM RIVER NEAR THE MOUTH		✓
05DC011	NORTH RAM RIVER AT FORESTRY ROAD		✓
05DC012	BAPTISTE RIVER NEAR THE MOUTH	Yes	
05DD004	BROWN CREEK AT FORESTRY ROAD		✓
05DD007	BRAZEAU RIVER BELOW CARDINAL RIVER		✓
05DD009	NORDEGG RIVER AT SUNCHILD ROAD		✓
05DE007	ROSE CREEK NEAR ALDER FLATS		✓
05DE009	TOMAHAWK CREEK NEAR TOMAHAWK		✓
05DF003	BLACKMUD CREEK NEAR ELLERSLIE		✓
05DF004	STRAWBERRY CREEK NEAR THE MOUTH		✓
05DF006	WHITEMUD CREEK NEAR ELLERSLIE		✓
05DF007	WEST WHITEMUD CREEK NEAR IRETON		✓
05EA001	STURGEON RIVER NEAR FORT SASKATCHEWAN		✓
05EA005	STURGEON RIVER NEAR VILLENEUVE	Yes	
05EA010	STURGEON RIVER NEAR MAGNOLIA BRIDGE		✓
05EB902	POINTE-AUX-PINS CREEK NEAR ARDROSSAN		✓
05EC002	WASKATENAU CREEK NEAR WASKATENAU		✓
05EC005	REDWATER RIVER NEAR THE MOUTH		✓
05ED002	ATIMOSWE CREEK NEAR ELK POINT		✓
05EE005	STRETTON CREEK NEAR MARWAYNE		✓
05EE006	VERMILION RIVER TRIBUTARY NEAR BRUCE		✓
05EE009	VERMILION RIVER AT VEGREVILLE		✓
05EF005	BIG GULLY CREEK NEAR MAIDSTONE	Yes	
05FA001	BATTLE RIVER NEAR PONOKA		✓
05FA012	PIPESTONE CREEK NEAR WETASKIWIN		✓
05FA014	MASKWA CREEK NO. 1 ABOVE BEARHILLS LAKE	Yes	
05FA024	WEILLER CREEK NEAR WETASKIWIN		✓
05FB002	IRON CREEK NEAR HARDISTY		✓
05FC002	BIGKNIFE CREEK NEAR GADSBY		✓
05FC004	PAINTEARTH CREEK NEAR HALKIRK		✓
05FC007	YOUNG CREEK NEAR CASTOR		✓
05FE002	BUFFALO CREEK AT HIGHWAY NO. 41		✓
05FF003	CUT KNIFE CREEK NEAR CUT KNIFE	Yes	
05GA008	SOUNDING CREEK NEAR OYEN		✓
05GA010	KILLARNEY LAKE TRIBUTARY NEAR CHAUVIN		✓
05GA012	SOUNDING CREEK NEAR CHINOOK		✓
05GB004	MUDDY LAKE INFLOW NEAR REVENUE		✓
05GC007	OPUNTIA LAKE WEST INFLOW		✓
05GF001	SHELL BROOK NEAR SHELLBROOK	Yes	
05GF002	STURGEON RIVER NEAR PRINCE ALBERT	Yes	
05GG010	GARDEN RIVER NEAR HENRIBOURG	Yes	
05HA015	BRIDGE CREEK AT GULL LAKE		✓
05HD036	SWIFT CURRENT CREEK BELOW ROCK CREEK		✓
05HG021	INVERNESS CREEK NEAR BRODERICK		✓
05HH002	CROMARTY CREEK NEAR BIRCH HILLS		✓
05HH003	KOHLESCHMIDT CREEK NEAR ROSTHERN	Yes	
05JA003	MCDONALD CREEK NEAR MCCORD		✓
05JB004	NOTUKEU CREEK ABOVE ADMIRAL RESERVOIR		✓
05JB007	MOSQUITO CREEK NEAR PAMBRUN		✓
05JC004	RUSHLAKE CREEK ABOVE HIGHFIELD RESERVOIR		✓
05JC007	FLOWING WELL WEST INFLOW NEAR FLOWING WELL		✓
05JF011	COTTONWOOD CREEK NEAR LUMSDEN		✓
05JF014	HUNTER CREEK NEAR RICHARDSON		✓
05JG001	SANDY CREEK NEAR CARON		✓
05JG013	RIDGE CREEK NEAR BRIDGEFORD		✓
05JH005	LEWIS CREEK NEAR IMPERIAL	Yes	
05JJ009	SALINE CREEK NEAR NOKOMIS	Yes	

Station Number	Station Name	Removed	Reduced Dataset
05JM010	EKAPO CREEK NEAR MARIEVAL	Yes	
05KB003	CARROT RIVER NEAR ARMLEY	Yes	
05KB006	LEATHER RIVER NEAR STAR CITY		✓
05KB011	DOGHIDE RIVER NEAR RUNCIMAN		✓
05KC001	CARROT RIVER NEAR SMOKY BURN		✓
05KE005	WHITE FOX RIVER NEAR GARRICK	Yes	
05KF001	BALLANTYNE RIVER ABOVE BALLANTYNE BAY		✓
05KG002	STURGEON-WEIR RIVER AT OUTLET OF AMISK LAKE		
05KG007	STURGEON-WEIR RIVER AT LEAF RAPIDS		✓
05KH007	CARROT RIVER NEAR TURNBERRY		✓
05LA003	DUCK CREEK NEAR KELVINGTON	Yes	
05LB004	LOISELLE CREEK NEAR HUDSON BAY		✓
05LC001	RED DEER RIVER NEAR ERWOOD		✓
05LC004	RED DEER RIVER NEAR THE MOUTH		✓
05LD001	OVERFLOWING RIVER AT OVERFLOWING RIVER		✓
05LE001	SWAN RIVER AT SWAN RIVER		
05LE004	WOODY RIVER NEAR BOWSMAN	Yes	
05LE005	ROARING RIVER NEAR MINITONAS		✓
05LE006	SWAN RIVER NEAR MINITONAS		✓
05LE008	SWAN RIVER NEAR NORQUAY		✓
05LE010	BIRCH RIVER NEAR BIRCH RIVER		✓
05LH005	WATERHEN RIVER NEAR WATERHEN		
05LJ005	OCHRE RIVER AT OCHRE RIVER		✓
05LJ007	TURTLE RIVER NEAR LAURIER		✓
05LJ027	MCKINNON CREEK NEAR MCCREARY		✓
05LJ045	WILSON RIVER NEAR ASHVILLE		✓
05LJ801	WILSON CREEK NEAR MCCREARY		
05LL014	PINE CREEK NEAR MELBOURNE		✓
05LL015	BIG GRASS RIVER NEAR GLENELLA		✓
05MA020	QUILL CREEK NEAR QUILL LAKE		✓
05MA021	MAGNUSSON CREEK NEAR WYNYARD	Yes	
05MC001	ASSINIBOINE RIVER AT STURGIS	Yes	
05MC002	STONY CREEK NEAR STENEN	Yes	
05MC003	LILIAN RIVER NEAR LADY LAKE	Yes	
05MD005	SHELL RIVER NEAR INGLIS	Yes	
05MD007	SHELL RIVER NEAR ROBLIN	Yes	
05MD010	STONY CREEK NEAR KAMSACK	Yes	
05ME003	BIRDTAIL CREEK NEAR BIRTLE		✓
05ME007	SMITH CREEK NEAR MARCHWELL		✓
05ME009	SCISSOR CREEK NEAR MCAULEY		✓
05MF001	LITTLE SASKATCHEWAN RIVER NEAR MINNEDOSA	Yes	
05MF008	ROLLING RIVER NEAR ERICKSON	Yes	
05MG008	OAK RIVER AT SHOAL LAKE		
05MH007	EPINETTE CREEK NEAR CARBERRY		✓
05NB033	MOSELEY CREEK NEAR HALBRITE		✓
05NB035	COOKE CREEK NEAR GOODWATER		✓
05ND011	SHEPHERD CREEK NEAR ALAMEDA		✓
05NE003	PIPESTONE CREEK ABOVE MOOSOMIN LAKE	Yes	
05NF002	ANTLER RIVER NEAR MELITA		
05NF006	LIGHTNING CREEK NEAR CARNDUFF	Yes	
05NF010	ANTLER RIVER NEAR WAUCHOPE	Yes	
05NG010	OAK CREEK NEAR STOCKTON		✓
05OA007	BADGER CREEK NEAR CARTWRIGHT		
05OB016	SNOWFLAKE CREEK NEAR SNOWFLAKE	Yes	
05OB021	MOWBRAY CREEK NEAR MOWBRAY		
05OC019	BUFFALO CREEK NEAR ROSENFELD		
05OD001	ROSEAU RIVER NEAR DOMINION CITY	Yes	

Station Number	Station Name	Removed	Reduced Dataset
05OD004	ROSEAU RIVER AT GARDENTON		
05OD031	SPRAGUE CREEK NEAR SPRAGUE		
05OE004	RAT RIVER NEAR SUNDOWN		✓
05OF017	SOUTH TOBACCO CREEK NEAR MIAMI		✓
05PA006	NAMAKAN RIVER AT OUTLET OF LAC LA CROIX		
05PA012	BASSWOOD RIVER NEAR WINTON		
05PB014	TURTLE RIVER NEAR MINE CENTRE	Yes	
05PB018	ATIKOKAN RIVER AT ATIKOKAN		✓
05PD015	LAKE 240 OUTLET NEAR KENORA	Yes	
05PD017	LAKE 470 OUTLET NEAR KENORA		
05PD023	LAKE 239 OUTLET NEAR KENORA		
05PH003	WHITEMOUTH RIVER NEAR WHITEMOUTH		✓
05PJ001	BIRD RIVER AT OUTLET OF BIRD LAKE		✓
05QA001	ENGLISH RIVER NEAR SIOUX LOOKOUT		
05QA002	ENGLISH RIVER AT UMFREVILLE		✓
05QA004	STURGEON RIVER AT MCDOUGALL MILLS		✓
05QC003	TROUTLAKE RIVER ABOVE BIG FALLS	Yes	
05QE008	CEDAR RIVER BELOW WABASKANG LAKE	Yes	
05QE009	STURGEON RIVER AT OUTLET OF SALVESEN LAKE		✓
05QE012	LONG-LEGGED RIVER BELOW LONG-LEGGED LAKE	Yes	
05RA001	MANIGOTAGAN RIVER NEAR MANIGOTAGAN		✓
05RA002	BLACK RIVER NEAR MANIGOTAGAN	Yes	
05RB003	BLOODVEIN RIVER ABOVE BLOODVEIN BAY	Yes	
05RC001	BERENS RIVER ABOVE BERENS LAKE		
05RD007	BERENS RIVER AT OUTLET OF LONG LAKE		
05RD008	PIGEON RIVER AT OUTLET OF ROUND LAKE		
05RE001	POPLAR RIVER AT OUTLET OF WEAVER LAKE	Yes	
05SA002	BROKENHEAD RIVER NEAR BEAUSEJOUR		✓
05SD003	FISHER RIVER NEAR DALLAS		✓
05TB002	GRASS RIVER AT WEKUSKO FALLS	Yes	
05TD001	GRASS RIVER ABOVE STANDING STONE FALLS		✓
05TE002	BURNTWOOD RIVER ABOVE LEAF RAPIDS		✓
05TF002	FOOTPRINT RIVER ABOVE FOOTPRINT LAKE		✓
05TG002	TAYLOR RIVER NEAR THOMPSON		✓
05TG003	ODEI RIVER NEAR THOMPSON		✓
05TG006	SAPOCHI RIVER NEAR NELSON HOUSE		✓
05UA003	GUNISAO RIVER AT JAM RAPIDS	Yes	
05UF004	KETTLE RIVER NEAR GILLAM		✓
05UG001	LIMESTONE RIVER NEAR BIRD	Yes	
05UH001	ANGLING RIVER NEAR BIRD		✓
05UH002	WEIR RIVER ABOVE THE MOUTH	Yes	
06AA001	BEAVER RIVER NEAR GOODRIDGE		✓
06AA002	AMISK RIVER AT HIGHWAY NO. 36		✓
06AB001	SAND RIVER NEAR THE MOUTH	Yes	
06AB002	WOLF RIVER AT OUTLET OF WOLF LAKE	Yes	
06AC001	JACKFISH CREEK NEAR LA COREY	Yes	
06AD001	BEAVER RIVER NEAR DORINTOSH	Yes	
06AD006	BEAVER RIVER AT COLD LAKE RESERVE	Yes	
06AD010	MEADOW RIVER BELOW MEADOW LAKE		✓
06AF001	COLD RIVER AT OUTLET OF COLD LAKE		✓
06AF005	WATERHEN RIVER NEAR GOODSOIL		✓
06AG001	BEAVER RIVER BELOW WATERHEN RIVER		✓
06AG002	DORE RIVER NEAR THE MOUTH		✓
06BA002	DILLON RIVER BELOW DILLON LAKE		✓
06BB003	CHURCHILL RIVER NEAR PATUANAK		
06BB004	KEELEY RIVER AT OUTLET OF KEELEY LAKE	Yes	
06BB005	CANOE RIVER NEAR BEAUVAL		✓

Station Number	Station Name	Removed	Reduced Dataset
06BC001	MUDJATIK RIVER NEAR FORCIER LAKE		
06BD001	HAULTAIN RIVER ABOVE NORBERT RIVER		✓
06CD002	CHURCHILL RIVER ABOVE OTTER RAPIDS		
06CE001	FOSTER RIVER ABOVE CHURCHILL RIVER	Yes	
06DA002	COCHRANE RIVER NEAR BROCHET		✓
06DA004	GEIKIE RIVER BELOW WHEELER RIVER		✓
06DA005	WHEELER RIVER BELOW RUSSELL LAKE	Yes	
06DC001	WATHAMAN RIVER BELOW WATHAMAN LAKE	Yes	
06EA007	PAGATO RIVER AT OUTLET OF PAGATO LAKE		
06FA001	GAUER RIVER BELOW THORSTEINSON LAKE		✓
06FB002	LITTLE BEAVER RIVER NEAR THE MOUTH		✓
06FC001	LITTLE CHURCHILL RIVER ABOVE RECLUSE LAKE		✓
06FD002	DEER RIVER NORTH OF BELCHER		✓
06GA001	SOUTH SEAL RIVER ABOVE FOX LAKE	Yes	
06GB001	NORTH SEAL RIVER BELOW STONY LAKE		
06GD001	SEAL RIVER BELOW GREAT ISLAND		✓
06HB002	THLEWIAZA RIVER ABOVE OUTLET SEALHOLE LAKE		✓
06JC002	THELON RIVER ABOVE BEVERLY LAKE	Yes	
06KC003	DUBAWNT RIVER AT OUTLET OF MARJORIE LAKE		
06LA001	KAZAN RIVER AT OUTLET OF ENNADAI LAKE		✓
06LC001	KAZAN RIVER ABOVE KAZAN FALLS		
06MA006	THELON RIVER BELOW OUTLET OF SCHULTZ LAKE		
07AA001	MIETTE RIVER NEAR JASPER	Yes	
07AA002	ATHABASCA RIVER NEAR JASPER	Yes	
07AA004	MALIGNE RIVER NEAR JASPER		
07AC001	WILDHAY RIVER NEAR HINTON		✓
07AC007	BERLAND RIVER NEAR THE MOUTH		✓
07AC008	LITTLE BERLAND RIVER AT HIGHWAY NO. 40		✓
07AD001	ATHABASCA RIVER AT ENTRANCE		
07AD002	ATHABASCA RIVER AT HINTON		✓
07AE001	ATHABASCA RIVER NEAR WINDFALL		✓
07AF002	MCLEOD RIVER ABOVE EMBARRAS RIVER		✓
07AF003	WAMPUS CREEK NEAR HINTON		✓
07AF010	SUNDANCE CREEK NEAR BICKERDIKE		✓
07AF013	MCLEOD RIVER NEAR CADOMIN		✓
07AF014	EMBARRAS RIVER NEAR WEALD		✓
07AF015	GREGG RIVER NEAR THE MOUTH		✓
07AG001	MCLEOD RIVER NEAR WOLF CREEK		
07AG003	WOLF CREEK AT HIGHWAY NO. 16A		✓
07AG004	MCLEOD RIVER NEAR WHITECOURT		✓
07AG007	MCLEOD RIVER NEAR ROSEVEAR		✓
07AG008	GROAT CREEK NEAR WHITECOURT		✓
07AH001	FREEMAN RIVER NEAR FORT ASSINIBOINE	Yes	
07AH002	CHRISTMAS CREEK NEAR BLUE RIDGE		✓
07AH003	SAKWATAMAU RIVER NEAR WHITECOURT	Yes	
07BA002	RAT CREEK NEAR CYNTHIA		✓
07BA003	LOVETT RIVER NEAR THE MOUTH		✓
07BB002	PEMBINA RIVER NEAR ENTWISTLE		✓
07BB003	LOBSTICK RIVER NEAR STYAL	Yes	
07BB005	LITTLE PADDLE RIVER NEAR MAYERTHORPE		✓
07BB011	PADDLE RIVER NEAR ANSELMO		✓
07BB014	COYOTE CREEK NEAR CHERHILL		✓
07BC002	PEMBINA RIVER AT JARVIE		✓
07BC006	DAPP CREEK AT HIGHWAY NO. 44		✓
07BC007	WABASH CREEK NEAR PIBROCH		✓
07BE001	ATHABASCA RIVER AT ATHABASCA		
07BE003	PORTER CREEK ABOVE BAPTISTE LAKE		✓

Station Number	Station Name	Removed	Reduced Dataset
07BE004	STONY CREEK NEAR TAWATINAW		✓
07BF001	EAST PRAIRIE RIVER NEAR ENILDA		✓
07BF002	WEST PRAIRIE RIVER NEAR HIGH PRAIRIE		✓
07BF009	SALT CREEK NEAR GROUARD		✓
07BG004	LILY CREEK NEAR SLAVE LAKE		✓
07BJ001	SWAN RIVER NEAR KINUSO		✓
07BJ003	SWAN RIVER NEAR SWAN HILLS		✓
07BK001	LESSER SLAVE RIVER AT SLAVE LAKE		✓
07BK005	SAULTEAUX RIVER NEAR SPURFIELD		✓
07BK006	LESSER SLAVE RIVER AT HIGHWAY NO. 2A		
07BK007	DRIFTWOOD RIVER NEAR THE MOUTH	Yes	
07BK009	SAWRIDGE CREEK NEAR SLAVE LAKE		✓
07CA003	FLAT CREEK NEAR BOYLE		✓
07CA005	PINE CREEK NEAR GRASSLAND		✓
07CA006	WANDERING RIVER NEAR WANDERING RIVER	Yes	
07CA008	BABETTE CREEK NEAR COLINTON		✓
07CA012	LOGAN RIVER NEAR THE MOUTH		✓
07CA013	OWL RIVER BELOW PICHE RIVER		✓
07CB002	HOUSE RIVER AT HIGHWAY NO. 63		✓
07CD001	CLEARWATER RIVER AT DRAPER	Yes	
07CD004	HANGINGSTONE RIVER AT FORT MCMURRAY		✓
07CD005	CLEARWATER RIVER ABOVE CHRISTINA RIVER		✓
07CD006	CLEARWATER RIVER AT OUTLET OF LLOYD LAKE		
07CE002	CHRISTINA RIVER NEAR CHARD		✓
07CE003	PONY CREEK NEAR CHARD		✓
07DA001	ATHABASCA RIVER BELOW FORT MCMURRAY		
07DA006	STEEPBANK RIVER NEAR FORT MCMURRAY		✓
07DA008	MUSKEG RIVER NEAR FORT MACKAY		✓
07DA018	BEAVER RIVER ABOVE SYNCRUDE		✓
07DB001	MACKAY RIVER NEAR FORT MACKAY	Yes	
07DC001	FIREBAG RIVER NEAR THE MOUTH	Yes	
07DD002	RICHARDSON RIVER NEAR THE MOUTH		✓
07EA001	FINLAY RIVER AT WARE	Yes	
07EA002	KWADACHA RIVER NEAR WARE		
07EA004	INGENIKA RIVER ABOVE SWANNELL RIVER		✓
07EA005	FINLAY RIVER ABOVE AKIE RIVER		✓
07EA007	AKIE RIVER NEAR THE 760 M CONTOUR		✓
07EB001	FINLAY RIVER AT FINLAY FORKS		
07EB002	OSPIKA RIVER ABOVE ALEY CREEK		✓
07EC002	OMINECA RIVER ABOVE OSILINKA RIVER		✓
07EC003	MESILINKA RIVER ABOVE GOPHERHOLE CREEK		✓
07EC004	OSILINKA RIVER NEAR END LAKE		✓
07ED001	NATION RIVER NEAR FORT ST. JAMES		
07ED003	NATION RIVER NEAR THE MOUTH		✓
07EE007	PARSNIP RIVER ABOVE MISINCHINKA RIVER		✓
07EE009	CHUCHINKA CREEK NEAR THE MOUTH		✓
07EE010	PACK RIVER AT OUTLET OF MCLEOD LAKE		✓
07FA001	HALFWAY RIVER NEAR FARRELL CREEK (LOWER STATION)		
07FA005	GRAHAM RIVER ABOVE COLT CREEK		✓
07FA006	HALFWAY RIVER NEAR FARRELL CREEK		✓
07FB001	PINE RIVER AT EAST PINE		✓
07FB002	MURRAY RIVER NEAR THE MOUTH		✓
07FB003	SUKUNKA RIVER NEAR THE MOUTH		✓
07FB004	DICKEBUSCH CREEK NEAR THE MOUTH		✓
07FB005	QUALITY CREEK NEAR THE MOUTH		
07FB006	MURRAY RIVER ABOVE WOLVERINE RIVER		✓
07FB008	MOBERLY RIVER NEAR FORT ST. JOHN		✓

Station Number	Station Name	Removed	Reduced Dataset
07FB009	FLATBED CREEK AT KILOMETRE 110 HERITAGE HIGHWAY		✓
07FC001	BEATTON RIVER NEAR FORT ST. JOHN		✓
07FC003	BLUEBERRY RIVER BELOW AITKEN CREEK		✓
07FD001	KISKATINAW RIVER NEAR FARMINGTON		✓
07FD004	ALCES RIVER AT 22ND BASE LINE		✓
07FD006	SADDLE RIVER NEAR WOKING		✓
07FD007	POUCE COUPE RIVER BELOW HENDERSON CREEK	Yes	
07FD009	CLEAR RIVER NEAR BEAR CANYON		✓
07FD011	HINES CREEK ABOVE GERRY LAKE		✓
07FD012	MONTAGNEUSE RIVER NEAR HINES CREEK		✓
07FD013	EUREKA RIVER NEAR WORSLEY		✓
07FD910	RYCROFT SURVEY NO. 3 NEAR RYCROFT		✓
07GA001	SMOKY RIVER ABOVE HELLS CREEK		✓
07GA002	MUSKEG RIVER NEAR GRANDE CACHE		✓
07GB001	CUTBANK RIVER NEAR GRANDE PRAIRIE		✓
07GC002	PINTO CREEK NEAR GRANDE PRAIRIE		✓
07GD001	BEAVERLODGE RIVER NEAR BEAVERLODGE		✓
07GD002	BEAVERTAIL CREEK NEAR HYTHE		
07GE001	WAPITI RIVER NEAR GRANDE PRAIRIE		✓
07GE003	GRANDE PRAIRIE CREEK NEAR SEXSMITH		✓
07GE007	BEAR RIVER NEAR VALHALLA CENTRE		✓
07GF001	SIMONETTE RIVER NEAR GOODWIN	Yes	
07GF008	DEEP VALLEY CREEK NEAR VALLEYVIEW		✓
07GG001	WASKAHIGAN RIVER NEAR THE MOUTH		✓
07GG002	LITTLE SMOKY RIVER AT LITTLE SMOKY		✓
07GG003	IOSEGUN RIVER NEAR LITTLE SMOKY		✓
07GH002	LITTLE SMOKY RIVER NEAR GUY		✓
07GH004	PEAVINE CREEK NEAR FALHER		✓
07GJ001	SMOKY RIVER AT WATINO		
07HA003	HEART RIVER NEAR NAMPA	Yes	
07HA005	WHITEMUD RIVER NEAR DIXONVILLE	Yes	
07HB001	CADOTTE RIVER AT OUTLET CADOTTE LAKE		✓
07HC001	NOTIKEWIN RIVER AT MANNING	Yes	
07HC002	BUCHANAN CREEK NEAR MANNING		✓
07HF002	KEG RIVER AT HIGHWAY NO. 35	Yes	
07JA003	WILLOW RIVER NEAR WABASCA		✓
07JC001	LAFOND CREEK NEAR RED EARTH CREEK	Yes	
07JC002	REDEARTH CREEK NEAR RED EARTH CREEK		✓
07JD002	WABASCA RIVER AT HIGHWAY NO. 88	Yes	
07JD003	JACKPINE CREEK AT HIGHWAY NO. 88		✓
07JD004	TEEPEE CREEK NEAR LA CRETE		✓
07JF002	BOYER RIVER NEAR FORT VERMILION		✓
07JF003	PONTON RIVER ABOVE BOYER RIVER		✓
07KE001	BIRCH RIVER BELOW ALICE CREEK		✓
07LB002	WATERFOUND RIVER BELOW THERIAU LAKE		✓
07LD002	CREE RIVER AT OUTLET OF WAPATA LAKE		
07LE002	FOND DU LAC RIVER AT OUTLET OF BLACK LAKE		
07MA003	DOUGLAS RIVER NEAR CLUFF LAKE		✓
07MB001	MACFARLANE RIVER AT OUTLET OF DAVY LAKE		✓
07NB008	DOG RIVER NEAR FITZGERALD		
07OA001	SOUSA CREEK NEAR HIGH LEVEL		✓
07OB001	HAY RIVER NEAR HAY RIVER		
07OB003	HAY RIVER NEAR MEANDER RIVER		✓
07OB004	STEEN RIVER NEAR STEEN RIVER		✓
07OB006	LUTOSE CREEK NEAR STEEN RIVER		✓
07OC001	CHINCHAGA RIVER NEAR HIGH LEVEL	Yes	
07PA001	BUFFALO RIVER AT HIGHWAY NO. 5		

Station Number	Station Name	Removed	Reduced Dataset
07PB002	LITTLE BUFFALO RIVER BELOW HIGHWAY NO. 5		
07QC003	THOA RIVER NEAR INLET TO HILL ISLAND LAKE	Yes	
07QD004	TALTSON RIVER ABOVE PORTER LAKE OUTFLOW		✓
07RD001	LOCKHART RIVER AT OUTLET OF ARTILLERY LAKE		✓
07SA002	SNARE RIVER BELOW GHOST RIVER		✓
07SA004	INDIN RIVER ABOVE CHALCO LAKE		✓
07SB010	CAMERON RIVER BELOW REID LAKE		✓
07SB013	BAKER CREEK AT OUTLET OF LOWER MARTIN LAKE		✓
07SC002	WALDRON RIVER NEAR THE MOUTH		✓
07TA001	LA MARTRE RIVER BELOW OUTLET OF LAC LA MARTRE	Yes	
07UC001	KAKISA RIVER AT OUTLET OF KAKISA LAKE		
08AA008	SEKULMUN RIVER AT OUTLET OF SEKULMUN LAKE		✓
08AA009	GILTANA CREEK NEAR THE MOUTH		✓
08AB001	ALSEK RIVER ABOVE BATES RIVER		✓
08AB002	ALSEK RIVER NEAR YAKUTAT		
08AC001	TAKHANNE RIVER AT KM 167 HAINES HIGHWAY		✓
08AC002	TATSHENSHINI RIVER NEAR DALTON POST	Yes	
08BB001	TAKU RIVER NEAR TULSEQUAH		
08BB002	SLOKO RIVER NEAR ATLIN		
08BB005	TAKU RIVER NEAR JUNEAU		
08CB001	STIKINE RIVER ABOVE GRAND CANYON		
08CC001	KLAPPAN RIVER NEAR TELEGRAPH CREEK		
08CD001	TUYA RIVER NEAR TELEGRAPH CREEK		✓
08CE001	STIKINE RIVER AT TELEGRAPH CREEK		✓
08CF001	STIKINE RIVER ABOVE BUTTERFLY CREEK		
08CF003	STIKINE RIVER NEAR WRANGELL		
08CG001	ISKUT RIVER BELOW JOHNSON RIVER		
08CG003	ISKUT RIVER AT OUTLET OF KINASKAN LAKE		
08CG004	ISKUT RIVER ABOVE SNIPPAKER CREEK		
08CG005	MORE CREEK NEAR THE MOUTH		
08CG006	FORREST KERR CREEK ABOVE 460 M CONTOUR	Yes	
08DA005	SURPRISE CREEK NEAR THE MOUTH	Yes	
08DB001	NASS RIVER ABOVE SHUMAL CREEK		✓
08DC006	BEAR RIVER ABOVE BITTER CREEK		
08DD001	UNUK RIVER NEAR STEWART		
08EB003	SKEENA RIVER AT GLEN VOWELL		
08EB004	KISPIOX RIVER NEAR HAZELTON		✓
08EB005	SKEENA RIVER ABOVE BABINE RIVER		
08EC001	BABINE RIVER AT BABINE		
08EC013	BABINE RIVER AT OUTLET OF NILKITKWA LAKE		✓
08ED001	NANIKA RIVER AT OUTLET OF KIDPRICE LAKE		✓
08ED002	MORICE RIVER NEAR HOUSTON		✓
08EE003	BULKLEY RIVER NEAR HOUSTON	Yes	
08EE004	BULKLEY RIVER AT QUICK		✓
08EE008	GOATHORN CREEK NEAR TELKWA		✓
08EE012	SIMPSON CREEK AT THE MOUTH		✓
08EE013	BUCK CREEK AT THE MOUTH		✓
08EE020	TELKWA RIVER BELOW TSAI CREEK		✓
08EE025	TWO MILE CREEK IN DISTRICT LOT 4834		✓
08EF001	SKEENA RIVER AT USK		✓
08EF005	ZYMOETZ RIVER ABOVE O.K. CREEK		✓
08EG006	KITSUMKALUM RIVER NEAR TERRACE		
08EG011	ZYMAGOTITZ RIVER NEAR TERRACE		
08EG012	EXCHAMSIKS RIVER NEAR TERRACE		✓
08FA002	WANNOCK RIVER AT OUTLET OF OWIKENO LAKE		✓
08FB002	BELLA COOLA RIVER NEAR HAGENSBORG		
08FB004	SALLOOMT RIVER NEAR HAGENSBORG		✓

Station Number	Station Name	Removed	Reduced Dataset
08FB005	NUSATSUM RIVER NEAR HAGENSBORG		
08FB006	ATNARKO RIVER NEAR THE MOUTH	Yes	
08FB007	BELLA COOLA RIVER ABOVE BURNT BRIDGE CREEK	Yes	
08FC003	DEAN RIVER BELOW TANSWANKET CREEK		✓
08FE003	KEMANO RIVER ABOVE POWERHOUSE TAILRACE		✓
08FF001	KITIMAT RIVER BELOW HIRSCH CREEK		✓
08FF002	HIRSCH CREEK NEAR THE MOUTH		✓
08FF003	LITTLE WEDEENE RIVER BELOW BOWBYES CREEK		✓
08GA024	CHEAKAMUS RIVER NEAR MONS		
08GA061	MACKAY CREEK AT MONTROYAL BOULEVARD		✓
08GA071	ELAHO RIVER NEAR THE MOUTH		✓
08GA072	CHEAKAMUS RIVER ABOVE MILLAR CREEK		✓
08GB013	CLOWHOM RIVER NEAR CLOWHOM LAKE		✓
08GD004	HOMATHKO RIVER AT THE MOUTH		✓
08GD005	HOMATHKO RIVER BELOW NUDE CREEK		
08GD007	MOSLEY CREEK NEAR DUMBELL LAKE		
08GD008	HOMATHKO RIVER AT INLET TO TATLAYOKO LAKE		✓
08GE002	KLINAKLINI RIVER EAST CHANNEL (MAIN) NEAR THE MOUTH	Yes	
08HA001	CHEMAINUS RIVER NEAR WESTHOLME	Yes	
08HA003	KOKSILAH RIVER AT COWICHAN STATION		✓
08HA010	SAN JUAN RIVER NEAR PORT RENFREW		✓
08HA016	BINGS CREEK NEAR THE MOUTH		✓
08HA026	CUSHEON CREEK AT OUTLET OF CUSHEON LAKE	Yes	
08HB002	ENGLISHMAN RIVER NEAR PARKSVILLE		✓
08HB014	SARITA RIVER NEAR BAMFIELD		✓
08HB024	TSABLE RIVER NEAR FANNY BAY		
08HB025	BROWNS RIVER NEAR COURTENAY		✓
08HB032	MILLSTONE RIVER AT NANAIMO		✓
08HB048	CARNATION CREEK AT THE MOUTH		✓
08HB074	CRUICKSHANK RIVER NEAR THE MOUTH		✓
08HB075	DOVE CREEK NEAR THE MOUTH		✓
08HC002	UCONA RIVER AT THE MOUTH		✓
08HD001	CAMPBELL RIVER AT OUTLET OF CAMPBELL LAKE		
08HD011	OYSTER RIVER BELOW WOODHUS CREEK		✓
08HD015	SALMON RIVER ABOVE CAMPBELL LAKE DIVERSION	Yes	
08HE006	ZEBALLOS RIVER NEAR ZEBALLOS		✓
08HF004	TSITIKA RIVER BELOW CATHERINE CREEK		✓
08HF005	NIMPKISH RIVER ABOVE WOSS RIVER		✓
08HF006	SAN JOSEF RIVER BELOW SHARP CREEK		✓
08JA002	OOTSA RIVER AT OOTSA LAKE		
08JA004	TETACHUCK RIVER NEAR OOTSA LAKE		
08JA005	TAHTSA RIVER NEAR OOTSA LAKE		
08JA014	VAN TINE CREEK NEAR THE MOUTH	Yes	
08JA015	LAVENTIE CREEK NEAR THE MOUTH		✓
08JB002	STELLAKO RIVER AT GLENANNAN		✓
08JB003	NAUTLEY RIVER NEAR FORT FRASER		✓
08JD006	DRIFTWOOD RIVER ABOVE KASTBERG CREEK		✓
08JE001	STUART RIVER NEAR FORT ST. JAMES		✓
08JE004	TSILCOH RIVER NEAR THE MOUTH		✓
08KA001	DORE RIVER NEAR MCBRIDE		✓
08KA004	FRASER RIVER AT HANSARD		✓
08KA005	FRASER RIVER AT MCBRIDE		✓
08KA007	FRASER RIVER AT RED PASS	Yes	
08KA008	MOOSE RIVER NEAR RED PASS		
08KA009	MCKALE RIVER NEAR 940 M CONTOUR		✓
08KB001	FRASER RIVER AT SHELLEY		✓
08KB003	MCGREGOR RIVER AT LOWER CANYON		✓

Station Number	Station Name	Removed	Reduced Dataset
08KB006	MULLER CREEK NEAR THE MOUTH		✓
08KC001	SALMON RIVER NEAR PRINCE GEORGE		✓
08KC003	MUSKEG RIVER NORTH OF JOANNE LAKE		
08KD001	BOWRON RIVER NEAR WELLS		
08KD003	WILLOW RIVER NEAR WILLOW RIVER		
08KD004	BOWRON RIVER NEAR HANSARD		
08KD006	WILLOW RIVER ABOVE HAY CREEK		✓
08KD007	BOWRON RIVER BELOW BOX CANYON	Yes	
08KE009	COTTONWOOD RIVER NEAR CINEMA		
08KE016	BAKER CREEK AT QUESNEL		✓
08KE024	LITTLE SWIFT RIVER AT THE MOUTH		✓
08KF001	NAZKO RIVER ABOVE MICHELLE CREEK		
08KG001	WEST ROAD RIVER NEAR CINEMA		✓
08KG003	BAEZAEKO RIVER AT LOT 10262	Yes	
08KH001	QUESNEL RIVER AT LIKELY		✓
08KH003	CARIBOO RIVER BELOW KANGAROO CREEK		
08KH006	QUESNEL RIVER NEAR QUESNEL	Yes	
08KH010	HORSEFLY RIVER ABOVE MCKINLEY CREEK		✓
08KH014	MITCHELL RIVER AT OUTLET OF MITCHELL LAKE		
08KH019	MOFFAT CREEK NEAR HORSEFLY		✓
08LA001	CLEARWATER RIVER NEAR CLEARWATER STATION		✓
08LA004	MURTLE RIVER ABOVE DAWSON FALLS		
08LA007	CLEARWATER RIVER AT OUTLET OF CLEARWATER LAKE		
08LA008	MAHOOD RIVER AT OUTLET OF MAHOOD LAKE		
08LA013	CLEARWATER RIVER AT OUTLET OF HOBSON LAKE	Yes	
08LB012	PAUL CREEK AT THE OUTLET OF PINANTAN LAKE		
08LB020	BARRIERE RIVER AT THE MOUTH		✓
08LB022	NORTH THOMPSON RIVER NEAR BARRIERE		
08LB024	FISHTRAP CREEK NEAR MCLURE		✓
08LB038	BLUE RIVER NEAR BLUE RIVER		✓
08LB047	NORTH THOMPSON RIVER AT BIRCH ISLAND		✓
08LB050	MANN CREEK NEAR BLACKPOOL		
08LB064	NORTH THOMPSON RIVER AT MCLURE		✓
08LB069	BARRIERE RIVER BELOW SPRAGUE CREEK		✓
08LB076	HARPER CREEK NEAR THE MOUTH		✓
08LC040	VANCE CREEK BELOW DEAFIES CREEK		✓
08LD001	ADAMS RIVER NEAR SQUILAX		✓
08LD002	HIUIHILL CREEK ABOVE DIVERSIONS	Yes	
08LE024	EAGLE RIVER NEAR MALAKWA		✓
08LE027	SEYMOUR RIVER NEAR SEYMOUR ARM		✓
08LE031	SOUTH THOMPSON RIVER AT CHASE		✓
08LE075	SALMON RIVER ABOVE SALMON LAKE		
08LE077	CORNING CREEK NEAR SQUILAX		✓
08LE108	EAST CANOE CREEK ABOVE DAM		✓
08LF022	THOMPSON RIVER AT SPENCES BRIDGE		
08LF051	THOMPSON RIVER NEAR SPENCES BRIDGE	Yes	
08LF081	AMBUSTEN CREEK NEAR THE MOUTH		
08LF084	ANDERSON CREEK ABOVE DIVERSIONS		
08LF094	JOE ROSS CREEK NEAR THE MOUTH	Yes	
08LG008	SPIUS CREEK NEAR CANFORD		✓
08LG016	PENNASK CREEK NEAR QUILCHENA		✓
08LG032	GUICHON CREEK BELOW QUENVILLE CREEK		
08LG048	COLDWATER RIVER NEAR BROOKMERE		✓
08LG056	GUICHON CREEK ABOVE TUNKWA LAKE DIVERSION		✓
08MA001	CHILKO RIVER NEAR REDSTONE		✓
08MA002	CHILKO RIVER AT OUTLET OF CHILKO LAKE		✓
08MA003	TASEKO RIVER AT OUTLET OF TASEKO LAKES		✓

Station Number	Station Name	Removed	Reduced Dataset
08MA006	LINGFIELD CREEK NEAR THE MOUTH		✓
08MB005	CHILCOTIN RIVER BELOW BIG CREEK		✓
08MB006	BIG CREEK ABOVE GROUNDHOG CREEK		✓
08MB007	BIG CREEK BELOW GRAVEYARD CREEK		✓
08ME004	BRIDGE RIVER AT LAJOIE FALLS		
08ME023	BRIDGE RIVER (SOUTH BRANCH) BELOW BRIDGE GLACIER		✓
08ME025	YALAKOM RIVER ABOVE ORE CREEK		✓
08MF003	COQUIHALLA RIVER NEAR HOPE		
08MF062	COQUIHALLA RIVER BELOW NEEDLE CREEK		✓
08MF065	NAHATLATCH RIVER BELOW TACHEWANA CREEK		✓
08MF068	COQUIHALLA RIVER ABOVE ALEXANDER CREEK	Yes	
08MG001	CHEHALIS RIVER NEAR HARRISON MILLS		✓
08MG003	GREEN RIVER NEAR PEMBERTON	Yes	
08MG004	GREEN RIVER NEAR RAINBOW		
08MG005	LILLOOET RIVER NEAR PEMBERTON		✓
08MG006	RUTHERFORD CREEK NEAR PEMBERTON		
08MG007	SOO RIVER NEAR PEMBERTON		
08MG008	BIRKENHEAD RIVER AT MOUNT CURRIE	Yes	
08MG013	HARRISON RIVER NEAR HARRISON HOT SPRINGS		✓
08MG019	PLACE CREEK NEAR BIRKEN		
08MH001	CHILLIWACK RIVER AT VEDDER CROSSING		
08MH006	NORTH ALOUETTE RIVER AT 232ND STREET, MAPLE RIDGE		✓
08MH016	CHILLIWACK RIVER AT OUTLET OF CHILLIWACK LAKE	Yes	
08MH018	MAHOOD CREEK NEAR NEWTON		
08MH020	MAHOOD CREEK NEAR SULLIVAN	Yes	
08MH029	SUMAS RIVER NEAR HUNTINGDON	Yes	
08MH056	SLESSE CREEK NEAR VEDDER CROSSING	Yes	
08MH076	KANAKA CREEK NEAR WEBSTER CORNERS		✓
08MH103	CHILLIWACK RIVER ABOVE SLESSE CREEK		
08MH104	ANDERSON CREEK AT THE MOUTH	Yes	
08MH141	COQUITLAM RIVER ABOVE COQUITLAM LAKE		✓
08MH147	STAVE RIVER ABOVE STAVE LAKE		✓
08MH155	NICOMEKL RIVER AT 203 STREET, LANGLEY		✓
08NA002	COLUMBIA RIVER AT NICHOLSON		✓
08NA006	KICKING HORSE RIVER AT GOLDEN		✓
08NA012	TOBY CREEK NEAR ATHALMER		
08NA024	WINDERMERE CREEK NEAR WINDERMERE		
08NA037	CARBONATE CREEK NEAR MCMURDO		
08NA045	COLUMBIA RIVER NEAR FAIRMONT HOT SPRINGS	Yes	
08NB005	COLUMBIA RIVER AT DONALD	Yes	
08NB012	BLAEBERRY RIVER ABOVE WILLOWBANK CREEK		✓
08NB013	GOLD RIVER ABOVE BACHELOR CREEK		
08NB014	GOLD RIVER ABOVE PALMER CREEK		✓
08NB015	BLAEBERRY RIVER BELOW ENSIGN CREEK		
08NB016	SPLIT CREEK AT THE MOUTH		✓
08NB019	BEAVER RIVER NEAR THE MOUTH		✓
08NC004	CANOE RIVER BELOW KIMMEL CREEK	Yes	
08ND006	COLUMBIA RIVER AT TWELVE MILE FERRY		
08ND009	DOWNIE CREEK NEAR REVELSTOKE		
08ND012	GOLDSTREAM RIVER BELOW OLD CAMP CREEK		✓
08ND013	ILLECILLEWAET RIVER AT GREELEY		✓
08ND014	JORDAN RIVER ABOVE KIRKUP CREEK		
08ND018	STITT CREEK AT THE MOUTH		
08ND019	KIRBYVILLE CREEK NEAR THE MOUTH		
08NE001	INCOMAPPLEUX RIVER NEAR BEATON		
08NE006	KUSKANAX CREEK NEAR NAKUSP	Yes	
08NE008	BEATON CREEK NEAR BEATON	Yes	

Station Number	Station Name	Removed	Reduced Dataset
08NE039	BIG SHEEP CREEK NEAR ROSSLAND		✓
08NE074	SALMO RIVER NEAR SALMO		
08NE077	BARNES CREEK NEAR NEEDLES		✓
08NE087	DEER CREEK AT DEER PARK		✓
08NE110	INONOAKLIN CREEK ABOVE VALLEY CREEK		✓
08NE114	HIDDEN CREEK NEAR THE MOUTH		✓
08NE117	KUSKANAX CREEK AT 1040 M CONTOUR		
08NF001	KOOTENAY RIVER AT KOOTENAY CROSSING		✓
08NF002	KOOTENAY RIVER AT CANAL FLATS		
08NF005	ALBERT RIVER AT 1310 M CONTOUR		
08NF006	PALLISER RIVER IN LOT SL49	Yes	
08NG005	KOOTENAY RIVER AT WARDNER		
08NG012	ST. MARY RIVER AT WYCLIFFE	Yes	
08NG042	KOOTENAY RIVER AT NEWGATE	Yes	
08NG046	ST. MARY RIVER NEAR MARYSVILLE	Yes	
08NG051	SKOOKUMCHUCK CREEK NEAR SKOOKUMCHUCK	Yes	
08NG053	KOOTENAY RIVER NEAR SKOOKUMCHUCK	Yes	
08NG065	KOOTENAY RIVER AT FORT STEELE		✓
08NG076	MATHER CREEK BELOW HOULE CREEK		✓
08NG077	ST. MARY RIVER BELOW MORRIS CREEK		✓
08NG078	CAVEN CREEK BELOW BLOOM CREEK		
08NH001	DUNCAN RIVER NEAR HOWSER		
08NH005	KASLO RIVER BELOW KEMP CREEK		✓
08NH006	MOYIE RIVER AT EASTPORT		
08NH007	LARDEAU RIVER AT MARBLEHEAD	Yes	
08NH016	DUCK CREEK NEAR WYNNDEL		✓
08NH032	BOUNDARY CREEK NEAR PORTHILL	Yes	
08NH034	MOYIE RIVER AT MOYIE		
08NH066	LARDEAU RIVER AT GERRARD		
08NH084	ARROW CREEK NEAR ERICKSON		✓
08NH115	SULLIVAN CREEK NEAR CANYON		✓
08NH119	DUNCAN RIVER BELOW B.B. CREEK		✓
08NH120	MOYIE RIVER ABOVE NEGRO CREEK		✓
08NH130	FRY CREEK BELOW CARNEY CREEK		✓
08NH131	CARNEY CREEK BELOW PAMBRUN CREEK		
08NH132	KEEN CREEK BELOW KYAWATS CREEK		✓
08NJ013	SLOCAN RIVER NEAR CRESCENT VALLEY		✓
08NJ014	SLOCAN RIVER AT SLOCAN CITY		
08NJ026	DUHAMEL CREEK ABOVE DIVERSIONS		✓
08NJ027	HARROP CREEK NEAR HARROP		
08NJ061	REDFISH CREEK NEAR HARROP		✓
08NJ129	FELL CREEK NEAR NELSON		
08NJ130	ANDERSON CREEK NEAR NELSON		✓
08NJ160	LEMON CREEK ABOVE SOUTH LEMON CREEK		✓
08NJ168	FIVE MILE CREEK ABOVE CITY INTAKE		✓
08NK002	ELK RIVER AT FERNIE		✓
08NK012	ELK RIVER AT STANLEY PARK		
08NK016	ELK RIVER NEAR NATAL		✓
08NK018	FORDING RIVER AT THE MOUTH		✓
08NK019	GRAVE CREEK AT THE MOUTH		
08NK020	MICHEL CREEK BELOW NATAL	Yes	
08NK021	FORDING RIVER BELOW CLODE CREEK		
08NK022	LINE CREEK AT THE MOUTH		✓
08NK026	HOSMER CREEK ABOVE DIVERSIONS		✓
08NL004	ASHNOLA RIVER NEAR KEREMEOS		
08NL007	SIMILKAMEEN RIVER AT PRINCETON		
08NL024	TULAMEEN RIVER AT PRINCETON		✓

Station Number	Station Name	Removed	Reduced Dataset
08NL036	WHIPSAW CREEK BELOW LAMONT CREEK		
08NL038	SIMILKAMEEN RIVER NEAR HEDLEY		
08NL050	HEDLEY CREEK NEAR THE MOUTH		✓
08NL069	PASAYTEN RIVER ABOVE CALCITE CREEK		
08NL070	SIMILKAMEEN RIVER ABOVE GOODFELLOW CREEK		
08NL071	TULAMEEN RIVER BELOW VUICH CREEK		✓
08NM015	VASEUX CREEK ABOVE DUTTON CREEK		
08NM035	BELLEVUE CREEK NEAR OKANAGAN MISSION		
08NM133	BULL CREEK NEAR CRUMP		
08NM134	CAMP CREEK AT MOUTH NEAR THIRSK		✓
08NM137	DAVES CREEK NEAR RUTLAND		
08NM142	COLDSTREAM CREEK ABOVE MUNICIPAL INTAKE		✓
08NM171	VASEUX CREEK ABOVE SOLCO CREEK		✓
08NM173	GREATA CREEK NEAR THE MOUTH		✓
08NM174	WHITEMAN CREEK ABOVE BOULEAU CREEK		✓
08NM240	TWO FORTY CREEK NEAR PENTICTON		✓
08NM241	TWO FORTY-ONE CREEK NEAR PENTICTON		✓
08NM242	DENNIS CREEK NEAR 1780 METRE CONTOUR	Yes	
08NN002	GRANBY RIVER AT GRAND FORKS		✓
08NN012	KETTLE RIVER NEAR LAURIER		
08NN013	KETTLE RIVER NEAR FERRY		
08NN015	WEST KETTLE RIVER NEAR MCCULLOCH		✓
08NN019	TRAPPING CREEK NEAR THE MOUTH		✓
08NN022	WEST KETTLE RIVER BELOW CARMI CREEK		
08NN023	BURRELL CREEK ABOVE GLOUCESTER CREEK		✓
08NP001	FLATHEAD RIVER AT FLATHEAD		
08NP004	CABIN CREEK NEAR THE MOUTH		✓
08OA002	YAKOUN RIVER NEAR PORT CLEMENTS	Yes	
08OA003	PREMIER CREEK NEAR QUEEN CHARLOTTE	Yes	
08OB002	PALLANT CREEK NEAR QUEEN CHARLOTTE		✓
08PA001	SKAGIT RIVER NEAR HOPE		
09AA006	ATLIN RIVER NEAR ATLIN	Yes	
09AA007	LUBBOCK RIVER NEAR ATLIN		
09AA010	LINDEMAN CREEK NEAR BENNETT		
09AA012	WHEATON RIVER NEAR CARCROSS	Yes	
09AA013	TUTSHI RIVER AT OUTLET OF TUTSHI LAKE		✓
09AA014	FANTAIL RIVER AT OUTLET OF FANTAIL LAKE		
09AA015	WANN RIVER NEAR ATLIN		
09AB008	M'CLINTOCK RIVER NEAR WHITEHORSE		
09AB009	YUKON RIVER ABOVE FRANK CREEK		
09AC001	TAKHINI RIVER NEAR WHITEHORSE		✓
09AC004	TAKHINI RIVER AT OUTLET OF KUSAWA LAKE		
09AC007	IBEX RIVER NEAR WHITEHORSE		✓
09AE001	TESLIN RIVER NEAR TESLIN		
09AE003	SWIFT RIVER NEAR SWIFT RIVER		✓
09AE004	GLADYS RIVER AT OUTLET OF GLADYS LAKE		
09AE006	MORELY RIVER AT KM 1251 ALASKA HIGHWAY	Yes	
09AG001	BIG SALMON RIVER NEAR CARMACKS		
09AH001	YUKON RIVER AT CARMACKS		
09AH003	BIG CREEK NEAR THE MOUTH		✓
09AH004	NORDENSKIOLD RIVER BELOW ROWLINSON CREEK		✓
09BA001	ROSS RIVER AT ROSS RIVER		✓
09BB001	SOUTH MACMILLAN RIVER AT KILOMETRE 407 CANOL ROAD		
09BC001	PELLY RIVER AT PELLY CROSSING		✓
09BC004	PELLY RIVER BELOW VANGORDA CREEK		✓
09CA002	KLUANE RIVER AT OUTLET OF KLUANE LAKE	Yes	
09CA004	DUKE RIVER NEAR THE MOUTH		✓

Station Number	Station Name	Removed	Reduced Dataset
09CB001	WHITE RIVER AT KILOMETRE 1881.6 ALASKA HIGHWAY	Yes	
09CD001	YUKON RIVER ABOVE WHITE RIVER		
09DC002	STEWART RIVER AT MAYO		
09DD003	STEWART RIVER AT THE MOUTH		
09DD004	MCQUESTEN RIVER NEAR THE MOUTH		✓
09EA003	KLONDIKE RIVER ABOVE BONANZA CREEK		✓
09EA004	NORTH KLONDIKE RIVER NEAR THE MOUTH		✓
09EB001	YUKON RIVER AT DAWSON		
09EB003	INDIAN RIVER ABOVE THE MOUTH		✓
09ED001	YUKON RIVER AT EAGLE		
09FB001	PORCUPINE RIVER BELOW BELL RIVER		
09FC001	OLD CROW RIVER NEAR THE MOUTH		
09FD001	PORCUPINE RIVER AT OLD CROW	Yes	
09FD002	PORCUPINE RIVER NEAR INTERNATIONAL BOUNDARY		
10AA001	LIARD RIVER AT UPPER CROSSING		✓
10AA004	RANCHERIA RIVER NEAR THE MOUTH		✓
10AA005	BIG CREEK AT KM 1084.8 ALASKA HIGHWAY	Yes	
10AB001	FRANCES RIVER NEAR WATSON LAKE		✓
10AC002	DEASE RIVER AT MCDAME		
10AC003	DEASE RIVER AT OUTLET OF DEASE LAKE		
10AC004	BLUE RIVER NEAR THE MOUTH		
10AC005	COTTONWOOD RIVER ABOVE BASS CREEK		✓
10AD001	HYLAND RIVER NEAR LOWER POST		
10BA001	TURNAGAIN RIVER ABOVE SANDPILE CREEK		
10BB001	KECHIKA RIVER AT THE MOUTH		
10BB002	KECHIKA RIVER ABOVE BOYA CREEK		
10BC001	COAL RIVER AT THE MOUTH		
10BE001	LIARD RIVER AT LOWER CROSSING		
10BE004	TOAD RIVER ABOVE NONDA CREEK		✓
10BE005	LIARD RIVER ABOVE BEAVER RIVER		
10BE006	LIARD RIVER ABOVE KECHIKA RIVER		
10BE007	TROUT RIVER AT KILOMETRE 783.7 ALASKA HIGHWAY		✓
10BE009	TEETER CREEK NEAR THE MOUTH		✓
10BE013	SMITH RIVER NEAR THE MOUTH	Yes	
10CA001	FONTAS RIVER NEAR THE MOUTH		✓
10CB001	SIKANNI CHIEF RIVER NEAR FORT NELSON		✓
10CC002	FORT NELSON RIVER ABOVE MUSKWA RIVER		
10CD001	MUSKWA RIVER NEAR FORT NELSON		✓
10CD003	RASPBERRY CREEK NEAR THE MOUTH		✓
10CD004	BOUGIE CREEK AT KILOMETRE 368 ALASKA HIGHWAY		✓
10CD005	ADSETT CREEK AT KILOMETRE 386.0 ALASKA HIGHWAY		✓
10EA003	FLAT RIVER NEAR THE MOUTH		✓
10EB001	SOUTH NAHANNI RIVER ABOVE VIRGINIA FALLS		✓
10EC001	SOUTH NAHANNI RIVER ABOVE CLAUSEN CREEK		
10ED001	LIARD RIVER AT FORT LIARD		
10ED002	LIARD RIVER NEAR THE MOUTH		
10ED003	BIRCH RIVER AT HIGHWAY NO. 7		✓
10ED007	BLACKSTONE RIVER AT HIGHWAY NO. 7	Yes	
10ED009	SCOTTY CREEK AT HIGHWAY NO. 7	Yes	
10FA002	TROUT RIVER AT HIGHWAY NO. 1		✓
10FB005	JEAN-MARIE RIVER AT HIGHWAY NO. 1		✓
10GA001	ROOT RIVER NEAR THE MOUTH		✓
10GB006	WILLOWLAKE RIVER ABOVE METAHDALI CREEK		✓
10GC002	HARRIS RIVER NEAR THE MOUTH		
10GC003	MARTIN RIVER AT HIGHWAY NO. 1	Yes	
10HB005	REDSTONE RIVER 63 KM ABOVE THE MOUTH		✓
10HC003	BIG SMITH CREEK NEAR HIGHWAY NO. 1		

Station Number	Station Name	Removed	Reduced Dataset
10JA002	CAMSELL RIVER AT OUTLET OF CLUT LAKE	Yes	
10JC003	GREAT BEAR RIVER AT OUTLET OF GREAT BEAR LAKE		
10KA007	BOSWORTH CREEK NEAR NORMAN WELLS		✓
10KB001	CARCAJOU RIVER BELOW IMPERIAL RIVER		✓
10LA002	ARCTIC RED RIVER NEAR THE MOUTH		✓
10LC003	RENGLENG RIVER BELOW HIGHWAY NO. 8 (DEMPSTER HIGHWAY)	Yes	
10LC007	CARIBOU CREEK ABOVE HIGHWAY NO. 8 (DEMPSTER HIGHWAY)		✓
10MA001	PEEL RIVER ABOVE CANYON CREEK		✓
10MA002	OGILVIE RIVER AT KILOMETRE 197.9 DEMPSTER HIGHWAY		
10MA003	BLACKSTONE RIVER NEAR CHAPMAN LAKE AIRSTRIP		✓
10MC002	PEEL RIVER ABOVE FORT MCPHERSON		
10MD001	FIRTH RIVER NEAR THE MOUTH		
10NC001	ANDERSON RIVER BELOW CARNWATH RIVER		
10ND002	TRAIL VALLEY CREEK NEAR INUVIK		✓
10ND004	HANS CREEK ABOVE ESKIMO LAKES		✓
10PB001	COPPERMINE RIVER AT OUTLET OF POINT LAKE		✓
10PC005	FAIRY LAKE RIVER NEAR OUTLET OF NAPAKTULIK LAKE		✓
10QA001	TREE RIVER NEAR THE MOUTH		✓
10QC001	BURNSIDE RIVER NEAR THE MOUTH		✓
10QD001	ELLICE RIVER NEAR THE MOUTH		✓
10RA001	BACK RIVER BELOW BEECHY LAKE		✓
10RA002	BAILLIE RIVER NEAR THE MOUTH		✓
10RC001	BACK RIVER ABOVE HERMANN RIVER		
10TF001	FRESHWATER CREEK NEAR CAMBRIDGE BAY	Yes	
11AA026	SAGE CREEK AT Q RANCH NEAR WILDHORSE		✓
11AA032	NORTH FORK MILK RIVER ABOVE ST. MARY CANAL		
11AB070	MCRAE COULEE AT INTERNATIONAL BOUNDARY		
11AB075	LYONS CREEK AT INTERNATIONAL BOUNDARY		✓
11AB117	BATTLE CREEK AT ALBERTA BOUNDARY		✓
11AC025	DENNIEL CREEK NEAR VAL MARIE		✓
11AE008	POPLAR RIVER AT INTERNATIONAL BOUNDARY		
11AE009	ROCK CREEK BELOW HORSE CREEK NEAR INTERNATIONAL BOUNDARY	Yes	
11AE014	EAST POPLAR RIVER ABOVE COOKSON RESERVOIR	Yes	

Appendix B

List of Stations Used in Chapter 3

Station Number	Station Name
02ZM006	SAINT JOHN RIVER AT FORT KENT
02ZK001	ST. FRANCIS RIVER AT OUTLET OF GLASIER LAKE
02ZJ001	BIG PRESQUE ISLE STREAM AT TRACEY MILLS
02YR003	BECAGUIMEC STREAM AT COLDSTREAM
02ZH002	SHOGOMOC STREAM NEAR TRANS CANADA HIGHWAY
02YS003	SALMON RIVER AT CASTAWAY
02YR001	CANAAN RIVER AT EAST CANAAN
02ZH001	KENNEBECASIS RIVER AT APOHAQUI
02YQ001	LEPREAU RIVER AT LEPREAU
02ZG001	RESTIGOUCHE RIVER BELOW KEDGWICK RIVER
02YO006	UPSALQUITCH RIVER AT UPSALQUITCH
02ZF001	DARTMOUTH (RIVIERE) EN AMONT DU RUISSEAU DU PAS DE DAME
02YK005	JACQUET RIVER NEAR DURHAM CENTRE
02YA001	RIVIERE CARAQUET AT BURNSVILLE
03QC002	SOUTHWEST MIRAMICHI RIVER AT BLACKVILLE
02ZD002	LITTLE SOUTHWEST MIRAMICHI RIVER AT LYTTLETON
02YC001	NORTHWEST MIRAMICHI RIVER AT TROUT BROOK
02YL001	COAL BRANCH RIVER AT BEERSVILLE
03QC001	PETITCODIAC RIVER NEAR PETITCODIAC
02YN002	POINT WOLFE RIVER AT FUNDY NATIONAL PARK
02YK002	CARRUTHERS BROOK NEAR ST. ANTHONY
02YJ001	WILMOT RIVER NEAR WILMOT VALLEY
02ZA002	BEAVERBANK RIVER NEAR KINSAC
02ZB001	KELLEY RIVER (MILL CREEK) AT EIGHT MILE FORD
01FJ002	MIDDLE RIVER OF PICTOU AT ROCKLIN
01FB001	SOUTH RIVER AT ST. ANDREWS
01FB003	ROSEWAY RIVER AT LOWER OHIO
01FA001	MERSEY RIVER BELOW GEORGE LAKE
03NF001	MERSEY RIVER BELOW MILL FALLS
01DR001	LAHAVE RIVER AT WEST NORTHFIELD
01EO001	GOLD RIVER AT MOSHER'S FALLS
01DP004	SACKVILLE RIVER AT BEDFORD
02VC001	LITTLE SACKVILLE RIVER AT MIDDLE SACKVILLE
01CB004	ST. MARYS RIVER AT STILLWATER
01EJ001	RIVER INHABITANTS AT GLENORA
01DG003	NORTHEAST MARGAREE RIVER AT MARGAREE VALLEY
01EJ004	SOUTHWEST MARGAREE RIVER NEAR UPPER MARGAREE
01CA003	MACASKILLS BROOK NEAR BIRCH GROVE
01EG002	PIGEON RIVER AT MIDDLE FALLS
01DL001	NEEBING RIVER NEAR THUNDER BAY
01EF001	WOLF RIVER AT HIGHWAY NO. 17
01BH005	BLACKWATER RIVER AT BEARDMORE
01BV006	LITTLE PIC RIVER NEAR COLDWELL
01BS001	PIC RIVER NEAR MARATHON
01BL002	BATCHAWANA RIVER NEAR BATCHAWANA
01BU002	GOULAIS RIVER NEAR SEARCHMONT
01ED005	ROOT RIVER AT SAULT STE. MARIE
01ED007	WHITSON RIVER AT CHELMSFORD
01AP002	WHITSON RIVER AT VAL CARON
01EC001	JUNCTION CREEK BELOW KELLEY LAKE
01AP004	NORTH MAGNETAWAN RIVER NEAR BURK'S FALLS

Station Number	Station Name
01AN002	BLACK RIVER NEAR WASHAGO
03MD001	STOKES RIVER NEAR FERNDALE
01BO001	SYDENHAM RIVER NEAR OWEN SOUND
01BQ001	SAUGEEN RIVER NEAR PORT ELGIN
01BP001	SOUTH PARKHILL CREEK NEAR PARKHILL
01BJ003	BAYFIELD RIVER NEAR VARNA
02UC002	PARKHILL CREEK ABOVE PARKHILL RESERVOIR
01AQ001	NITH RIVER NEAR CANNING
01BE001	KETTLE CREEK AT ST. THOMAS
01AK001	BIG OTTER CREEK AT TILLSONBURG
01AJ010	CATFISH CREEK NEAR SPARTA
01BC001	MIDDLE THAMES RIVER AT THAMESFORD
03MB002	TROUT CREEK NEAR ST. MARYS
01AJ004	FISH CREEK NEAR PROSPECT HILL
02QA002	TROUT CREEK NEAR FAIRVIEW
01AD002	DINGMAN CREEK BELOW LAMBETH
01AD003	SYDENHAM RIVER NEAR ALVINSTON
03KC004	SYDENHAM RIVER AT STRATHROY
02PJ007	BEAR CREEK NEAR PETROLIA
02OE027	RUSCOM RIVER NEAR RUSCOM STATION
02PB006	CANARD RIVER NEAR LUKERVILLE
02RG005	EAST SIXTEEN MILE CREEK NEAR OMAGH
02RD002	EAST HUMBER RIVER NEAR PINE GROVE
02RF001	COLD CREEK NEAR BOLTON
02NE011	HUMBER RIVER AT ELDER MILLS
02NF003	ETOBICOKE CREEK BELOW QUEEN ELIZABETH HIGHWAY
03FA003	WEST HUMBER RIVER AT HIGHWAY NO. 7
02MC001	EAST HUMBER RIVER AT KING CREEK
02LB008	MIMICO CREEK AT ISLINGTON
02LB006	BOWMANVILLE CREEK AT BOWMANVILLE
02LB007	WILMOT CREEK NEAR NEWCASTLE
02LG005	GANARASKA RIVER ABOVE DALE
02LA007	JACKSON CREEK AT PETERBOROUGH
02MB006	SKOOTAMATTA RIVER NEAR ACTINOLITE
02LH004	MOIRA RIVER NEAR DELORO
02KF011	WILTON CREEK NEAR NAPANEE
02HM005	COLLINS CREEK NEAR KINGSTON
02HM004	BLANCHE RIVER ABOVE ENGLEHART
02KB001	PETAWAWA RIVER NEAR PETAWAWA
02HL004	YORK RIVER NEAR BANCROFT
02HL005	CARP RIVER NEAR KINBURN
02KD002	JOCK RIVER NEAR RICHMOND
04NA001	CASTOR RIVER AT RUSSELL
02HJ001	SOUTH NATION RIVER AT SPENCERVILLE
02HD012	BEAR BROOK NEAR BOURGET
02HD009	GATINEAU (RIVIERE) AUX RAPIDES CEIZUR
02HD006	PICANOC (RIVIERE) PRES DE WRIGHT
02EC002	LYN CREEK NEAR LYN
02EA005	RAISIN RIVER NEAR WILLIAMSTOWN
02HC033	CROCHE (RIVIERE) A 2,6 KM EN AVAL DU RUISSEAU CHANGY
02HC030	MATAWIN (RIVIERE) A SAINT-MICHEL-DES-SAINTS
02HC009	EATON (RIVIERE) PRES DE LA RIVIERE SAINT-FRANCOIS-3
02HC032	SAINTE-ANNE (RIVIERE) (BRAS DU NORD DE LA) EN AMONT
02HC025	BEAURIVAGE (RIVIERE) A SAINTE-ETIENNE
02HC031	RIMOUSKI (RIVIERE) A 3,7 KM EN AMONT DU PONT-ROUTE 132
02HC023	MISTASSIBI (RIVIERE)
02HB004	CHAMOUCHOUANE (RIVIERE) A LA TETE DE LA CHUTE AUX SAUMONS

Station Number	Station Name
02JC008	METABETCHOUANE (RIVIERE) EN AMONT DE LA CENTRALE S.R.P.C.
02GA010	MOISIE (RIVIERE) A 5,1 KM EN AMONT DU PONT DU Q.N.S.L.R.
02GC010	ROMAINE (RIVIERE) AU PONT DE LA Q.I.T.
04MF001	STE. GENEVIEVE RIVER NEAR FORRESTERS POINT
04KA001	TORRENT RIVER AT BRISTOL'S POOL
02FB007	HARRYS RIVER BELOW HIGHWAY BRIDGE
02GD019	LEWASEECHJEECH BROOK AT LITTLE GRAND LAKE
02GD004	SHEFFIELD BROOK NEAR TRANS CANADA HIGHWAY
02CF008	UPPER HUMBER RIVER NEAR REIDVILLE
02GC018	LLOYDS RIVER BELOW KING GEORGE IV LAKE
02CF012	PETERS RIVER NEAR BOTWOOD
02GD009	GANDER RIVER AT BIG CHUTE
02CF007	MIDDLE BROOK NEAR GAMBO
02GC002	INDIAN BAY BROOK NEAR NORTHWEST ARM
02GD010	SOUTHWEST BROOK AT TERRA NOVA NATIONAL PARK
02FC001	HIGHLANDS RIVER AT TRANS-CANADA HIGHWAY
02FA002	ISLE AUX MORTS RIVER BELOW HIGHWAY BRIDGE
02GE005	GREY RIVER NEAR GREY RIVER
02FF007	BAY DU NORD RIVER AT BIG FALLS
02GG005	GARNISH RIVER NEAR GARNISH
02FF008	PIPERS HOLE RIVER AT MOTHERS BROOK
02FF004	COME BY CHANCE RIVER NEAR GOOBIES
02GG002	SOUTHERN BAY RIVER NEAR SOUTHERN BAY
02GG006	ROCKY RIVER NEAR COLINET
02GH002	NORTHEAST POND RIVER AT NORTHEAST POND
02GH003	LOUPS MARINS (LAC DES) DANS LE BASSIN VERSANT DE LA RIVIERE NASTAPOCA
04LJ001	MELEZES (RIVIERE AUX) A 7,6 KM EN AMONT DE LA CONFLUENCE AVEC LA KOKSOAK
02BF002	BALEINE (RIVIERE A LA) A 40,2 KM DE L'EMBOUCHURE
02CA002	GEORGE (RIVIERE) A LA SORTIE DU LAC DE LA HUTTE SAUVAGE
02BF001	UGJOKTOK RIVER BELOW HARP LAKE
04JC002	EAGLE RIVER ABOVE FALLS
04JD005	ALEXIS RIVER NEAR PORT HOPE SIMPSON
02BB003	GODS RIVER NEAR SHAMATTAWA
02BA003	PIPESTONE RIVER AT KARL LAKE
02AD010	CAT RIVER BELOW WESLEYAN LAKE
02AC001	OGOKI RIVER ABOVE WHITECLAY LAKE
04GB004	NAGAGAMI RIVER AT HIGHWAY NO. 11
02AB008	PAGWACHUAN RIVER AT HIGHWAY NO. 11
02AA001	KWETABOHIGAN RIVER NEAR THE MOUTH
04DA001	MISSINAIBI RIVER AT MATTICE
04GA002	NORTH FRENCH RIVER NEAR THE MOUTH
04AD002	HARRICANA (RIVIERE) 3,1 KM EN AVAL DU PONT-ROUTE 111 A AMOS
05PB014	CROWSNEST RIVER AT FRANK
05QC003	OLDMAN RIVER NEAR WALDRON'S CORNER
05QE008	WATERTON RIVER NEAR WATERTON PARK
05UH002	BELLY RIVER NEAR MOUNTAIN VIEW
05PD023	PIPESTONE RIVER NEAR LAKE LOUISE
05QE012	BOW RIVER AT BANFF
05QE009	MARMOT CREEK MAIN STEM NEAR SEEBE
06FB002	WAIPAROUS CREEK NEAR THE MOUTH
06LC001	ELBOW RIVER AT BRAGG CREEK
05PH003	SHEEP RIVER AT BLACK DIAMOND
06GD001	CATARACT CREEK NEAR FORESTRY ROAD
05OE004	MISTAYA RIVER NEAR SASKATCHEWAN CROSSING
05SA002	NORTH SASKATCHEWAN RIVER AT WHIRLPOOL POINT
10RC001	SILVERHORN CREEK NEAR THE MOUTH
05TD001	WATERHEN RIVER NEAR WATERHEN

Station Number	Station Name
05TG002	RAT RIVER NEAR SUNDOWN
05LH005	TURTLE RIVER NEAR MINE CENTRE
06LA001	LAKE 239 OUTLET NEAR KENORA
10QD001	WHITEMOUTH RIVER NEAR WHITEMOUTH
06DA004	TROUTLAKE RIVER ABOVE BIG FALLS
06CD002	CEDAR RIVER BELOW WABASKANG LAKE
10TF001	STURGEON RIVER AT OUTLET OF SALVESEN LAKE
07LE002	LONG-LEGGED RIVER BELOW LONG-LEGGED LAKE
06BD001	BROKENHEAD RIVER NEAR BEAUSEJOUR
07RD001	GRASS RIVER ABOVE STANDING STONE FALLS
07CD001	TAYLOR RIVER NEAR THOMPSON
05AD005	WEIR RIVER ABOVE THE MOUTH
05AD003	HAULTAIN RIVER ABOVE NORBERT RIVER
10PB001	CHURCHILL RIVER ABOVE OTTER RAPIDS
05AA023	GEIKIE RIVER BELOW WHEELER RIVER
05BL014	LITTLE BEAVER RIVER NEAR THE MOUTH
05AA008	SEAL RIVER BELOW GREAT ISLAND
05BJ004	KAZAN RIVER AT OUTLET OF ENNADAI LAKE
05BL022	KAZAN RIVER ABOVE KAZAN FALLS
05BG006	MIETTE RIVER NEAR JASPER
05BF016	ATHABASCA RIVER NEAR JASPER
05BB001	CLEARWATER RIVER AT DRAPER
07OB001	OMINECA RIVER ABOVE OSILINKA RIVER
08NF001	CHUCHINKA CREEK NEAR THE MOUTH
05BA002	PINE RIVER AT EAST PINE
08NH084	BLUEBERRY RIVER BELOW AITKEN CREEK
05DA009	WASKAHIGAN RIVER NEAR THE MOUTH
08NH016	FOND DU LAC RIVER AT OUTLET OF BLACK LAKE
08NH131	HAY RIVER NEAR HAY RIVER
05DA010	LOCKHART RIVER AT OUTLET OF ARTILLERY LAKE
05DA007	TUYA RIVER NEAR TELEGRAPH CREEK
08NH130	ISKUT RIVER BELOW JOHNSON RIVER
08NH005	SURPRISE CREEK NEAR THE MOUTH
08NB005	NANIKA RIVER AT OUTLET OF KIDPRICE LAKE
07GG001	ATNARKO RIVER NEAR THE MOUTH
08NJ130	CAPILANO RIVER ABOVE INTAKE
08NE006	MACKAY CREEK AT MONTROYAL BOULEVARD
07AA002	CHEMAINUS RIVER NEAR WESTHOLME
08ND013	KOKSILAH RIVER AT COWICHAN STATION
07AA001	SAN JUAN RIVER NEAR PORT RENFREW
08NE077	BINGS CREEK NEAR THE MOUTH
08ND012	ENGLISHMAN RIVER NEAR PARKSVILLE
08LE027	SPROAT RIVER NEAR ALBERNI
08KA007	SARITA RIVER NEAR BAMFIELD
08NN019	BROWNS RIVER NEAR COURTENAY
08NN015	CARNATION CREEK AT THE MOUTH
08LB038	UCONA RIVER AT THE MOUTH
08NM171	OYSTER RIVER BELOW WOODHUS CREEK
08NC004	TSITIKA RIVER BELOW CATHERINE CREEK
08NM174	STELLAKO RIVER AT GLENANNAN
08LD001	STUART RIVER NEAR FORT ST. JAMES
10FA002	FRASER RIVER AT RED PASS
08NM173	MCKALE RIVER NEAR 940 M CONTOUR
08LB076	FRASER RIVER AT SHELLEY
08NL004	MCGREGOR RIVER AT LOWER CANYON
08NM134	MULLER CREEK NEAR THE MOUTH
08LA001	SALMON RIVER NEAR PRINCE GEORGE

Station Number	Station Name
08NL050	WILLOW RIVER ABOVE HAY CREEK
08LG016	BOWRON RIVER BELOW BOX CANYON
08KA009	BAKER CREEK AT QUESNEL
08NL007	LITTLE SWIFT RIVER AT THE MOUTH
08NL070	CLEARWATER RIVER NEAR CLEARWATER STATION
08KB006	BLUE RIVER NEAR BLUE RIVER
07FB001	HARPER CREEK NEAR THE MOUTH
07FC003	ADAMS RIVER NEAR SQUILAX
08MH016	SEYMOUR RIVER NEAR SEYMOUR ARM
08KB003	PENNASK CREEK NEAR QUILCHENA
08KE024	CHILKO RIVER AT OUTLET OF CHILKO LAKE
08KD007	BIG CREEK ABOVE GROUNDHOG CREEK
08MH029	LILLOOET RIVER NEAR PEMBERTON
08KD006	NORTH ALOUETTE RIVER AT 232ND STREET, MAPLE RIDGE
08KE016	CHILLIWACK RIVER AT OUTLET OF CHILLIWACK LAKE
08MH076	SUMAS RIVER NEAR HUNTINGDON
08MH006	KANAKA CREEK NEAR WEBSTER CORNERS
07EE009	COLUMBIA RIVER AT DONALD
08KB001	CANOE RIVER BELOW KIMMEL CREEK
10CD001	GOLDSTREAM RIVER BELOW OLD CAMP CREEK
08KC001	ILLECILLEWAET RIVER AT GREELEY
10CB001	KUSKANAX CREEK NEAR NAKUSP
08MG005	BARNES CREEK NEAR NEEDLES
10GB006	KOOTENAY RIVER AT KOOTENAY CROSSING
08GA061	KASLO RIVER BELOW KEMP CREEK
08MB006	DUCK CREEK NEAR WYNNDEL
08GA010	ARROW CREEK NEAR ERICKSON
10GA001	FRY CREEK BELOW CARNEY CREEK
08HA003	CARNEY CREEK BELOW PAMBRUN CREEK
08HA001	ANDERSON CREEK NEAR NELSON
08HA016	ASHNOLA RIVER NEAR KEREMEOS
08MA002	SIMILKAMEEN RIVER AT PRINCETON
08JE001	HEDLEY CREEK NEAR THE MOUTH
08HB002	SIMILKAMEEN RIVER ABOVE GOODFELLOW CREEK
08HA010	CAMP CREEK AT MOUTH NEAR THIRSK
07EC002	VASEUX CREEK ABOVE SOLCO CREEK
08HB008	GREATA CREEK NEAR THE MOUTH
08HB014	WHITEMAN CREEK ABOVE BOULEAU CREEK
08HB048	WEST KETTLE RIVER NEAR MCCULLOCH
08JB002	TRAPPING CREEK NEAR THE MOUTH
08HB025	YAKOUN RIVER NEAR PORT CLEMENTS
08HD011	ATLIN RIVER NEAR ATLIN
10BE004	TAKHINI RIVER NEAR WHITEHORSE
10EB001	SWIFT RIVER NEAR SWIFT RIVER
10BE007	PELLY RIVER AT PELLY CROSSING
08FB006	OLD CROW RIVER NEAR THE MOUTH
08HC002	TOAD RIVER ABOVE NONDA CREEK
08HF004	TROUT RIVER AT KILOMETRE 783.7 ALASKA HIGHWAY
08ED001	SIKANNI CHIEF RIVER NEAR FORT NELSON
10NC001	MUSKWA RIVER NEAR FORT NELSON
08DA005	SOUTH NAHANNI RIVER ABOVE VIRGINIA FALLS
08CD001	TROUT RIVER AT HIGHWAY NO. 1
08CG001	ROOT RIVER NEAR THE MOUTH
09AE003	WILLOWLAKE RIVER ABOVE METAHDALI CREEK
08OA002	ARCTIC RED RIVER NEAR THE MOUTH
10LA002	CARIBOU CREEK ABOVE HIGHWAY NO. 8 (DEMPSTER HIGHWAY)
10LC007	PEEL RIVER ABOVE FORT MCPHERSON

Station Number	Station Name
10ND002	ANDERSON RIVER BELOW CARNWATH RIVER
09AA006	TRAIL VALLEY CREEK NEAR INUVIK
10MC002	COPPERMINE RIVER AT OUTLET OF POINT LAKE
09AC001	ELLICE RIVER NEAR THE MOUTH
09BC001	BACK RIVER ABOVE HERMANN RIVER
09FC001	FRESHWATER CREEK NEAR CAMBRIDGE BAY

Appendix C

List of Stations Used in Chapter 4

Station Number	Station Name	Trend in Exceedances	Trend in Number of Events
01AD002	SAINT JOHN RIVER AT FORT KENT		
01AD003	ST. FRANCIS RIVER AT OUTLET OF GLASIER LAKE		
01AE001	FISH RIVER NEAR FORT KENT		
01AF007	GRANDE RIVIERE AT VIOLETTE BRIDGE		✓
01AF009	IROQUOIS RIVER AT MOULIN MORNEAULT		
01AG002	LIMESTONE STREAM AT FOUR FALLS		
01AJ003	MEDUXNEKEAG RIVER NEAR BELLEVILLE		
01AJ004	BIG PRESQUE ISLE STREAM AT TRACEY MILLS		
01AJ010	BECAGUIMEC STREAM AT COLDSTREAM		✓
01AJ011	COLD STREAM AT COLDSTREAM		
01AK001	SHOGOMOC STREAM NEAR TRANS CANADA HIGHWAY		✓
01AK005	MIDDLE BRANCH NASHWAAKSIS STREAM NEAR ROYAL ROAD	✓	
01AK007	NACKAWIC STREAM NEAR TEMPERANCE VALE		
01AK008	EEL RIVER NEAR SCOTT SIDING		
01AL003	HAYDEN BROOK NEAR NARROWS MOUNTAIN		
01AL004	NARROWS MOUNTAIN BROOK NEAR NARROWS MOUNTAIN		
01AN001	CASTAWAY STREAM NEAR CASTAWAY		
01AN002	SALMON RIVER AT CASTAWAY		
01AP002	CANAAN RIVER AT EAST CANAAN		✓
01AP004	KENNEBECASIS RIVER AT APOHAQUI		✓
01AQ001	LEPREAU RIVER AT LEPREAU		✓
01BC001	RESTIGOUCHE RIVER BELOW KEDGWICK RIVER		
01BD002	MATAPEDIA (RIVIERE) EN AMONT DE LA RIVIERE ASSEMETQUAGAN		
01BD008	MATAPEDIA (RIVIERE) PRES DE AMQUI		
01BE001	UPSALQUITCH RIVER AT UPSALQUITCH		✓
01BF001	NOUVELLE (RIVIERE) AU PONT		
01BG005	CASCAPEDIA (RIVIERE) EN AVAL DU RUISSEAU BERRY		
01BH001	DARTMOUTH (RIVIERE) PRES DE CORTEREAL		
01BH005	DARTMOUTH (RIVIERE) EN AMONT DU RUISSEAU DU PAS DE DAME		
01BH007	GRANDE-RIVIERE OUEST (LA)	✓	
01BH010	YORK (RIVIERE) A 1,4 KM EN AVAL DU RUISSEAU DINNER ISLAND		
01BJ001	TETAGOUCHE RIVER NEAR WEST BATHURST		✓
01BJ003	JACQUET RIVER NEAR DURHAM CENTRE		✓
01BJ007	RESTIGOUCHE RIVER ABOVE RAFTING GROUND BROOK		✓
01BJ012	EEL RIVER NEAR DUNDEE		✓
01BL001	BASS RIVER AT BASS RIVER		
01BL002	RIVIERE CARAQUET AT BURNSVILLE		
01BL003	BIG TRACADIE RIVER AT MURCHY BRIDGE CROSSING		
01BO001	SOUTHWEST MIRAMICHI RIVER AT BLACKVILLE		✓
01BO002	RENOUS RIVER AT MCGRAW BROOK		
01BO003	BARNABY RIVER BELOW SEMIWAGAN RIVER		
01BP001	LITTLE SOUTHWEST MIRAMICHI RIVER AT LYTTLETON		
01BQ001	NORTHWEST MIRAMICHI RIVER AT TROUT BROOK		✓
01BR001	KOUCHIBOUGUAC RIVER NEAR VAUTOUR		✓
01BS001	COAL BRANCH RIVER AT BEERSVILLE		
01BU002	PETITCODIAC RIVER NEAR PETITCODIAC	✓	✓
01BU003	TURTLE CREEK AT TURTLE CREEK		
01BV004	BLACK RIVER AT GARNET SETTLEMENT		✓
01BV006	POINT WOLFE RIVER AT FUNDY NATIONAL PARK		
01CA003	CARRUTHERS BROOK NEAR ST. ANTHONY		

Station Number	Station Name	Trend in Exceedances	Trend in Number of Events
01CC005	WEST RIVER AT RIVERDALE		
01DB002	BEAR RIVER EAST BRANCH AT BEAR RIVER	✓	
01DC003	PARADISE BROOK NEAR PARADISE		
01DD004	SHARPE BROOK AT LLOYDS		
01DG003	BEAVERBANK RIVER NEAR KINSAC	✓	
01DG006	SHUBENACADIE RIVER AT ENFIELD		
01DH003	FRASER BROOK NEAR ARCHIBALD		✓
01DH005	SALMON RIVER AT UNION		
01DL001	KELLEY RIVER (MILL CREEK) AT EIGHT MILE FORD		
01DN004	WALLACE RIVER AT WENTWORTH CENTRE		
01DO001	RIVER JOHN AT WELSFORD	✓	
01DR001	SOUTH RIVER AT ST. ANDREWS		✓
01EC001	ROSEWAY RIVER AT LOWER OHIO	✓	✓
01ED005	MERSEY RIVER BELOW GEORGE LAKE		✓
01ED007	MERSEY RIVER BELOW MILL FALLS		
01EF001	LAHAVE RIVER AT WEST NORTHFIELD	✓	
01EG002	GOLD RIVER AT MOSHER'S FALLS		
01EH003	EAST RIVER AT ST. MARGARETS BAY		✓
01EJ001	SACKVILLE RIVER AT BEDFORD		
01EJ004	LITTLE SACKVILLE RIVER AT MIDDLE SACKVILLE		
01EO001	ST. MARYS RIVER AT STILLWATER		
01FA001	RIVER INHABITANTS AT GLENORA		
01FB001	NORTHEAST MARGAREE RIVER AT MARGAREE VALLEY		
01FB003	SOUTHWEST MARGAREE RIVER NEAR UPPER MARGAREE	✓	✓
01FD001	WRECK COVE BROOK NEAR WRECK COVE		✓
01FJ001	SALMON RIVER AT SALMON RIVER BRIDGE		✓
02AB008	NEEBING RIVER NEAR THUNDER BAY		
02AB014	NORTH CURRENT RIVER NEAR THUNDER BAY		
02AB019	MCVICAR CREEK AT THUNDER BAY	✓	
02AB021	CURRENT RIVER AT STEPSTONE		
02AC001	WOLF RIVER AT HIGHWAY NO. 17		
02AC002	BLACK STURGEON RIVER AT HIGHWAY NO. 17		
02AD010	BLACKWATER RIVER AT BEARDMORE		
02AE001	GRAVEL RIVER NEAR CAVERS		
02BA002	STEEL RIVER NEAR TERRACE BAY		
02BA003	LITTLE PIC RIVER NEAR COLDWELL		
02BA005	WHITESAND RIVER ABOVE SCHREIBER AT MINOVA MINE		
02BB002	BLACK RIVER NEAR MARATHON		
02BB003	PIC RIVER NEAR MARATHON		
02BD003	MAGPIE RIVER NEAR MICHIPICOTEN		✓
02BF001	BATCHAWANA RIVER NEAR BATCHAWANA		
02BF002	GOULAIS RIVER NEAR SEARCHMONT		
02BF004	BIG CARP RIVER NEAR SAULT STE. MARIE		
02BF005	NORBERG CREEK (SITE A) ABOVE BATCHAWANA RIVER		
02BF006	NORBERG CREEK (SITE B) AT OUTLET OF TURKEY LAKE		
02BF007	NORBERG CREEK (SITE C) AT OUTLET OF LITTLE TURKEY LAKE		
02BF008	NORBERG CREEK (SITE D) BELOW WISHART LAKE		✓
02BF009	NORBERG CREEK (SITE E) BELOW BATCHAWANA LAKE		
02BF012	NORBERG CREEK (SITE F) AT OUTLET OF BATCHAWANA LAKE		
02BF013	TRIBUTARY TO NORBERG CREEK AT TURKEY LAKE		
02CA002	ROOT RIVER AT SAULT STE. MARIE		
02CB003	AUBINADONG RIVER ABOVE SESABIC CREEK		
02CF007	WHITSON RIVER AT CHELMSFORD		
02CF008	WHITSON RIVER AT VAL CARON		
02CF011	VERMILION RIVER NEAR VAL CARON		
02CF012	JUNCTION CREEK BELOW KELLEY LAKE		

Station Number	Station Name	Trend in Exceedances	Trend in Number of Events
02CG003	BLUE JAY CREEK NEAR TEHKUMMAH		
02DB007	CONISTON CREEK ABOVE WANAPITEI RIVER		
02DC012	STURGEON RIVER AT UPPER GOOSE FALLS		
02DD008	DUCHESNAY RIVER NEAR NORTH BAY		
02DD012	VEUVE RIVER NEAR VERNER		
02DD013	LA VASE RIVER AT NORTH BAY		
02DD014	CHIPPEWA CREEK AT NORTH BAY		
02DD015	COMMANDA CREEK NEAR COMMANDA		
02EA005	NORTH MAGNETAWAN RIVER NEAR BURK'S FALLS		
02EA010	NORTH MAGNETAWAN RIVER ABOVE PICKEREL LAKE		
02EC002	BLACK RIVER NEAR WASHAGO		✓
02EC009	HOLLAND RIVER EAST BRANCH AT HOLLAND LANDING		✓
02EC010	SCHOMBERG RIVER NEAR SCHOMBERG		
02EC011	BEAVER RIVER NEAR BEAVERTON	✓	
02EC018	PEFFERLAW BROOK NEAR UDORA		
02ED003	NOTTAWASAGA RIVER NEAR BAXTER	✓	✓
02ED015	MAD RIVER AT AVENING		
02ED017	HOGG CREEK NEAR VICTORIA HARBOUR		
02ED024	NORTH RIVER AT THE FALLS		
02ED026	NOTTAWASAGA RIVER AT HOCKLEY		
02ED101	NOTTAWASAGA RIVER NEAR ALLISTON	✓	✓
02FA002	STOKES RIVER NEAR FERNDALE		
02FA004	SAUBLE RIVER AT ALLENFORD		
02FB007	SYDENHAM RIVER NEAR OWEN SOUND		✓
02FC004	ROCKY SAUGEEN RIVER NEAR TRAVERSTON		
02FC011	CARRICK CREEK NEAR CARLSRUHE		
02FD001	PINE RIVER AT LURGAN		
02FD002	LUCKNOW RIVER AT LUCKNOW		
02FE009	SOUTH MAITLAND RIVER AT SUMMERHILL		✓
02FE010	BOYLE DRAIN NEAR ATWOOD	✓	✓
02FE011	MAITLAND RIVER NEAR HARRISTON		
02FE013	MIDDLE MAITLAND RIVER ABOVE ETHEL		
02FE014	BLYTH BROOK BELOW BLYTH		
02FF004	SOUTH PARKHILL CREEK NEAR PARKHILL		
02FF007	BAYFIELD RIVER NEAR VARNA		✓
02FF008	PARKHILL CREEK ABOVE PARKHILL RESERVOIR		
02GA010	NITH RIVER NEAR CANNING		✓
02GA017	CONESTOGO RIVER AT DRAYTON		
02GA018	NITH RIVER AT NEW HAMBURG	✓	
02GA038	NITH RIVER ABOVE NITHBURG		✓
02GA041	GRAND RIVER NEAR DUNDALK		
02GA043	HUNSBURGER CREEK NEAR WILMOT CENTRE		
02GB007	FAIRCHILD CREEK NEAR BRANTFORD		
02GB009	KENNY CREEK NEAR BURFORD		
02GC002	KETTLE CREEK AT ST. THOMAS		
02GC010	BIG OTTER CREEK AT TILLSONBURG		
02GC011	BIG CREEK NEAR KELVIN		
02GC018	CATFISH CREEK NEAR SPARTA		
02GC021	VENISON CREEK NEAR WALSINGHAM		
02GC029	KETTLE CREEK ABOVE ST. THOMAS		
02GC030	CATFISH CREEK AT AYLMER		
02GC031	DODD CREEK BELOW PAYNES MILLS	✓	
02GD004	MIDDLE THAMES RIVER AT THAMESFORD		✓
02GD010	FISH CREEK NEAR PROSPECT HILL	✓	
02GD019	TROUT CREEK NEAR FAIRVIEW		
02GD020	WAUBUNO CREEK NEAR DORCHESTER		

Station Number	Station Name	Trend in Exceedances	Trend in Number of Events
02GD021	THAMES RIVER AT INNERKIP		
02GE005	DINGMAN CREEK BELOW LAMBETH		✓
02GE007	MCGREGOR CREEK NEAR CHATHAM		
02GG002	SYDENHAM RIVER NEAR ALVINSTON		
02GG003	SYDENHAM RIVER AT FLORENCE		
02GG004	BEAR CREEK ABOVE WILKESPORT		
02GG005	SYDENHAM RIVER AT STRATHROY		
02GG006	BEAR CREEK NEAR PETROLIA		✓
02GG009	BEAR CREEK BELOW BRIGDEN		
02GH002	RUSCOM RIVER NEAR RUSCOM STATION		
02GH003	CANARD RIVER NEAR LUKERVILLE		
02GH004	TURKEY CREEK AT WINDSOR		
02GH011	LITTLE RIVER AT WINDSOR		
02HA006	TWENTY MILE CREEK AT BALLS FALLS	✓	
02HA014	REDHILL CREEK AT HAMILTON		
02HA020	TWENTY MILE CREEK ABOVE SMITHVILLE		
02HB004	EAST SIXTEEN MILE CREEK NEAR OMAGH		
02HB012	GRINDSTONE CREEK NEAR ALDERSHOT	✓	
02HB021	ANCASTER CREEK AT ANCASTER		
02HB022	BRONTE CREEK AT CARLISLE		
02HB023	SPENCER CREEK AT HIGHWAY NO. 5		
02HC009	EAST HUMBER RIVER NEAR PINE GROVE		
02HC018	LYNDE CREEK NEAR WHITBY		✓
02HC019	DUFFINS CREEK ABOVE PICKERING		
02HC023	COLD CREEK NEAR BOLTON		
02HC025	HUMBER RIVER AT ELDER MILLS		
02HC028	LITTLE ROUGE CREEK NEAR LOCUST HILL		
02HC029	LITTLE DON RIVER AT DON MILLS		✓
02HC030	ETOBICOKE CREEK BELOW QUEEN ELIZABETH HIGHWAY	✓	✓
02HC031	WEST HUMBER RIVER AT HIGHWAY NO. 7		✓
02HC032	EAST HUMBER RIVER AT KING CREEK		
02HC033	MIMICO CREEK AT ISLINGTON		
02HC047	HUMBER RIVER NEAR PALGRAVE		
02HC049	DUFFINS CREEK AT AJAX		
02HD006	BOWMANVILLE CREEK AT BOWMANVILLE		
02HD009	WILMOT CREEK NEAR NEWCASTLE		
02HD013	HARMONY CREEK AT OSHAWA		✓
02HE001	BLOOMFIELD CREEK AT BLOOMFIELD		
02HG001	MARIPOSA BROOK NEAR LITTLE BRITAIN		
02HK007	COLD CREEK AT ORLAND		
02HK008	RAWDON CREEK NEAR WEST HUNTINGDON		
02HL003	BLACK RIVER NEAR ACTINOLITE		✓
02HL005	MOIRA RIVER NEAR DELORO		
02HM004	WILTON CREEK NEAR NAPANEE		
02HM005	COLLINS CREEK NEAR KINGSTON		
02JB003	KINOJEVIS (RIVIERE) EN AVAL DE LA RIVIERE VILLEMONTEL		
02JB004	KINOJEVIS (RIVIERE) EN AVAL DU LAC PREISSAC		
02JB013	KINOJEVIS (RIVIERE) A 0,3 KM EN AMONT DU PONT-ROUTE A CLERICY		
02JC008	BLANCHE RIVER ABOVE ENGLEHART		
02JE015	KIPAWA (RIVIERE) EN AVAL DE LANIEL		
02KA003	PERCH LAKE OUTLET NEAR CHALK RIVER		✓
02KA004	PERCH LAKE INLET NO. 1 NEAR CHALK RIVER		
02KA006	PERCH LAKE INLET NO. 3 NEAR CHALK RIVER		
02KA007	PERCH LAKE INLET NO. 4 NEAR CHALK RIVER		
02KF016	MISSISSIPPI RIVER BELOW MARBLE LAKE		
02KJ003	DUMOINE (RIVIERE) AU LAC DUMOINE	✓	

Station Number	Station Name	Trend in Exceedances	Trend in Number of Events
02KJ007	KIPAWA (RIVIERE) AU LAC DUMOINE		
02LB006	CASTOR RIVER AT RUSSELL		
02LB008	BEAR BROOK NEAR BOURGET		
02LB017	NORTH BRANCH SOUTH NATION RIVER NEAR HECKSTON		✓
02LB022	PAYNE RIVER NEAR BERWICK		
02LC027	DONCASTER (RIVIERE) AU LAC ELEVE		
02LC043	SAINT-LOUIS (RUISSEAU) A 0,3 KM DE LA RIVIERE DU DIABLE		
02LD001	PETITE NATION (RIVIERE DE LA) A PORTAGE-DE-LA-NATION		
02LD002	PETITE NATION (RIVIERE DE LA) PRES DE COTE-SAINT-PIERRE		
02LG005	GATINEAU (RIVIERE) AUX RAPIDES CEIZUR		
02LH002	DESERT (RIVIERE) EN AMONT DE LA RIVIERE DE L'AIGLE		
02LH004	PICANOC (RIVIERE) PRES DE WRIGHT		✓
02MB006	LYN CREEK NEAR LYN		
02MC026	RIVIERE BEAUDETTE NEAR GLEN NEVIS		
02MC028	RIVIERE DELISLE NEAR ALEXANDRIA		
02NE007	CROCHE (RIVIERE) A LA CROCHE		
02OA035	MILLE ILES (RIVIERE DES) EN AVAL DU LAC DES DEUX MONTAGNES		
02OA057	ANGLAIS (RIVIERE DES) A 1,1 KM EN AVAL DU PONT-ROUTE A TRES-SAINT-SACREMENT		
02OB037	ACHIGAN (RIVIERE DE L') A L'EPIPHANIE		
02OD003	NICOLET (RIVIERE) A 5,8 KM EN AVAL DE LA RIVIERE BULSTRODE		
02OE018	HALL (RIVIERE) PRES D'EAST HEREFORD		
02OE027	EATON (RIVIERE) PRES DE LA RIVIERE SAINT-FRANCOIS-3		
02OE032	SAUMON (RIVIERE AU) A 1,9 KM EN AMONT DE LA MOFFAT		
02OG007	YAMASKA NORD (RIVIERE) A VAL-SHEFFORD		
02OG026	DAVID (RIVIERE) AU PONT-ROUTE A SAINT-DAVID		
02OJ001	RICHELIEU (RIVIERE) A SAINT-JEAN		
02OJ007	RICHELIEU (RIVIERE) AUX RAPIDES FRYERS		
02OJ024	HURONS (RIVIERE DES) EN AVAL DU RUISSEAU SAINT-LOUIS-2		
02PA007	BATISCAN (RIVIERE) A 3,4 KM EN AVAL DE LA RIVIERE DES ENVIES		
02PB006	SAINTE-ANNE (RIVIERE) (BRAS DU NORD DE LA) EN AMONT		
02PC009	PORTNEUF (RIVIERE) PRES DE PORTNEUF		
02PD002	MONTMORENCY (RIVIERE) A 0,6 KM EN AVAL DU BARRAGE DES MARCHES NATURELLES		✓
02PD004	MONTMORENCY (RIVIERE) EN AMONT DE LA RIVIERE BLANCHE		
02PD012	EAUX VOLEES (RUISSEAU DES) EN AMONT DU CHEMIN DU BELVEDERE		✓
02PD014	AULNAIES OUEST (RUISSEAU DES) EN AMONT DU CHEMIN DU BELVEDERE		✓
02PD015	AULNAIES (RUISSEAU DES) PRES DU RUISSEAU DES EAUX VOLEES		✓
02PE014	DAUPHINE (RIVIERE) A L' ILE D'ORLEANS		
02PG006	LOUP (RIVIERE DU) A SAINT-JOSEPH-DE-KAMOURASKA		
02PG022	OUELLE (RIVIERE) PRES DE SAINT-GABRIEL-DE-KAMOURASKA		
02PJ007	BEAURIVAGE (RIVIERE) A SAINTE-ETIENNE		✓
02PJ030	FAMINE (RIVIERE) A SAINT-GEORGES		
02PL005	BECANCOUR (RIVIERE) A 2,1 KM EN AMONT DE LA RIVIERE PALMER		
02QA002	RIMOUSKI (RIVIERE) A 3,7 KM EN AMONT DU PONT-ROUTE 132		
02QA017	NEIGETTE (RIVIERE)		
02QB011	CAP CHAT (RIVIERE) A CAP-CHAT		
02QC001	MADELEINE (RIVIERE) A RIVIERE-LA-MADELEINE		
02QC009	SAINTE-ANNE (RIVIERE) A 9,7 KM EN AMONT DU PONT-ROUTE 132		
02RB004	MANOUANE (RIVIERE) A LA SORTIE DU LAC DUHAMEL		
02RC011	PERIBONCA (PETITE RIVIERE)		
02RD002	MISTASSIBI (RIVIERE)		
02RD003	MISTASSINI (RIVIERE) EN AMONT DE LA RIVIERE MISTASSIBI		
02RF001	ASHUAPMUSHUAN (RIVIERE) A LA TETE DE LA CHUTE AUX SAUMONS		
02RF002	ASHUAPMUSHUAN (RIVIERE) EN AVAL DE LA RIVIERE DU CHEF		
02RF006	CHAMOUCHOUANE (RIVIERE) EN AVAL DU PONT DE LA ROUTE NO 167		

Station Number	Station Name	Trend in Exceedances	Trend in Number of Events
02RG005	METABETCHOUANE (RIVIERE) EN AMONT DE LA CENTRALE S.R.P.C.		✓
02RH027	PIKAUBA (RIVIERE) EN AMONT DE LA RIVIERE APICA		
02RH045	VALIN (RIVIERE) A 3,5 KM DE L'EMBOUCHURE		
02RH047	SAINTE-MARGUERITE NORD-EST(RIVIERE) PRES DE LA RIV. STE.MARGUERITE-1		
02RH049	PETIT SAGUENAY (RIVIERE)		
02UA003	GODBOUT (RIVIERE) A 1,6 KM EN AMONT DU PONT-ROUTE 138		
02UC002	MOISIE (RIVIERE) A 5,1 KM EN AMONT DU PONT DU Q.N.S.L.R.		
02VA001	TONNERRE (RIVIERE AU)	✓	
02VB004	MAGPIE (RIVIERE) A LA SORTIE DU LAC MAGPIE		
02VC001	ROMAINE (RIVIERE) AU PONT DE LA Q.I.T.		
02WA001	NABISIPI (RIVIERE) A 2.4 KM DE L'EMBOUCHURE		✓
02WB003	NATASHQUAN (RIVIERE) A 0,6 KM EN AVAL DE LA DECHARGE DU LAC ALIESTE		✓
02XA003	LITTLE MECATINA RIVER ABOVE LAC FOURMONT		
02XC001	SAINT-PAUL (RIVIERE) A 0,5 KM DU RUISSEAU CHANION		
02YA001	STE. GENEVIEVE RIVER NEAR FORRESTERS POINT		
02YD002	NORTHEAST BROOK NEAR RODDICKTON		✓
02YE001	GREAVETT BROOK ABOVE PORTLAND CREEK POND		✓
02YK004	HINDS BROOK NEAR GRAND LAKE		
02YK008	BOOT BROOK AT TRANS-CANADA HIGHWAY	✓	✓
02YL001	UPPER HUMBER RIVER NEAR REIDVILLE		✓
02YL005	RATTLER BROOK NEAR MCIVERS		
02YL008	UPPER HUMBER RIVER ABOVE BLACK BROOK		✓
02YL011	COPPER POND BROOK NEAR CORNER BROOK LAKE		
02YM001	INDIAN BROOK AT INDIAN FALLS		
02YM003	SOUTH WEST BROOK NEAR BAIE VERTE		
02YM004	INDIAN BROOK DIVERSION ABOVE BIRCHY LAKE		
02YN002	LLOYDS RIVER BELOW KING GEORGE IV LAKE		
02YO006	PETERS RIVER NEAR BOTWOOD		
02YO008	GREAT RATTLING BROOK ABOVE TOTE RIVER CONFLUENCE		
02YO012	SOUTHWEST BROOK AT LEWISPORTE		
02YQ001	GANDER RIVER AT BIG CHUTE		
02YQ005	SALMON RIVER NEAR GLENWOOD		
02YR001	MIDDLE BROOK NEAR GAMBO		
02YR002	RAGGED HARBOUR RIVER NEAR MUSGRAVE HARBOUR		
02YR003	INDIAN BAY BROOK NEAR NORTHWEST ARM	✓	
02YS001	TERRA NOVA RIVER AT EIGHT MILE BRIDGES		
02YS003	SOUTHWEST BROOK AT TERRA NOVA NATIONAL PARK		
02YS005	TERRA NOVA RIVER AT GLOVERTOWN		
02YS006	NORTHWEST RIVER AT TERRA NOVA NATIONAL PARK		
02ZA002	HIGHLANDS RIVER AT TRANS-CANADA HIGHWAY		
02ZB001	ISLE AUX MORTS RIVER BELOW HIGHWAY BRIDGE		✓
02ZC002	GRANDY BROOK BELOW TOP POND BROOK		
02ZD002	GREY RIVER NEAR GREY RIVER		✓
02ZE001	SALMON RIVER AT LONG POND		
02ZE004	CONNE RIVER AT OUTLET OF CONNE RIVER POND		
02ZF001	BAY DU NORD RIVER AT BIG FALLS		
02ZG001	GARNISH RIVER NEAR GARNISH		✓
02ZG002	TIDES BROOK BELOW FRESHWATER POND		
02ZG003	SALMONIER RIVER NEAR LAMALINE		
02ZG004	RATTLE BROOK NEAR BOAT HARBOUR		
02ZH001	PIPERS HOLE RIVER AT MOTHERS BROOK		
02ZH002	COME BY CHANCE RIVER NEAR GOOBIES		✓
02ZJ001	SOUTHERN BAY RIVER NEAR SOUTHERN BAY		
02ZJ002	SALMON COVE RIVER NEAR CHAMPNEYS		
02ZJ003	SHOAL HARBOUR RIVER NEAR CLARENVILLE		
02ZK001	ROCKY RIVER NEAR COLINET		

Station Number	Station Name	Trend in Exceedances	Trend in Number of Events
02ZK002	NORTHEAST RIVER NEAR PLACENTIA	✓	✓
02ZL004	SHEARSTOWN BROOK AT SHEARSTOWN		
02ZL005	BIG BROOK AT LEAD COVE		✓
02ZM006	NORTHEAST POND RIVER AT NORTHEAST POND		
02ZM008	WATERFORD RIVER AT KILBRIDE		
02ZM016	SOUTH RIVER NEAR HOLYROOD		
02ZM018	VIRGINIA RIVER AT PLEASANTVILLE		
02ZM020	LEARYS BROOK AT PRINCE PHILIP DRIVE		
02ZN002	ST. SHOTTS RIVER NEAR TREPASSEY		
03AB002	WASWANIPI (RIVIERE) A LA CHUTE ROUGE		✓
03AC002	MEGISCANE (RIVIERE) PRES DE MEGISCANE		
03AC004	BELL (RIVIERE) EN AMONT DU LAC MATAGAMI		
03AD001	NOTTAWAY (RIVIERE) A LA TETE DU LAC SOSCUMICA		
03BA003	TEMISCAMIE (RIVIERE) PRES DE LAC ALBANEL		
03BB002	RUPERT (RIVIERE DE) ET LE CHENAL CHIPASTOUC		
03BC002	RUPERT (RIVIERE DE) EN AVAL DU LAC NEMISCAU	✓	
03BD002	BROADBACK (RIVIERE) A LA SORTIE DU LAC QUENONISCA		
03BE001	BROADBACK (RIVIERE) EN AVAL DE LA RIVIERE OUASOUAGAMI		
03BF001	PONTAX (RIVIERE) A 60,4 KM DE L'EMBOUCHURE		✓
03CB004	EASTMAIN (RIVIERE) A LA TETE DE LA GORGE PROSPER		
03DA002	GRANDE RIVIERE (LA) EN AVAL DU LAC PUISSEAUX	✓	
03DD002	DE PONTOIS (RIVIERE) EN AMONT DE LA RIVIERE SAKAMI		
03DD003	DE PONTOIS (RIVIERE) PRES DE LA GRANDE RIVIERE		
03EA001	BALEINE (GRANDE RIVIERE DE LA) A LA SORTIE DU LAC BIENVILLE	✓	
03EC001	DENYS (RIVIERE) PRES DE LA GRANDE RIVIERE DE LA BALEINE		
03ED001	BALEINE (GRANDE RIVIERE DE LA) EN AMONT DE LA RIVIERE DENYS-1		
03ED004	COATS (RIVIERE) PRES DE LA GRANDE RIVIERE DE LA BALEINE		
03FC007	BOUTIN (RIVIERE) A LA SORTIE DES LAC MOLLET-2		
03FC008	BALEINE (PETITE RIVIERE DE LA) EN AMONT DU CHENAL ANCEL		
03HA001	ARNAUD (PAYNE)(RIVIERE) EN AMONT DE LA RIVIERE HAMELIN-1		
03JB001	FEUILLES (RIVIERE AUX) EN AVAL DE LA RIVIERE PELADEAU		
03KA001	MELEZES (RIVIERE AUX) EN AMONT DE LA RIVIERE DU GUE		
03KC004	MELEZES (RIVIERE AUX) A 7,6 KM EN AMONT DE LA CONFLUENCE AVEC LA KOKSOAK		✓
03MC001	TUNULIC (RIVIERE) PRES DE L'EMBOUCHURE		
03MD001	GEORGE (RIVIERE) A LA SORTIE DU LAC DE LA HUTTE SAUVAGE		✓
03NF001	UGJOKTOK RIVER BELOW HARP LAKE		
03OC003	ATIKONAK RIVER ABOVE PANCHIA LAKE		
03OE003	MINIPI RIVER BELOW MINIPI LAKE		
03OE010	BIG POND BROOK BELOW BIG POND		
03PB002	NASKAUPI RIVER BELOW NASKAUPI LAKE		
03QC001	EAGLE RIVER ABOVE FALLS		
03QC002	ALEXIS RIVER NEAR PORT HOPE SIMPSON		
04AA004	HAYES RIVER BELOW TROUT FALLS		
04AC007	ISLAND LAKE RIVER NEAR ISLAND LAKE		
04AD002	GODS RIVER NEAR SHAMATTAWA		✓
04CA002	SEVERN RIVER AT OUTLET OF MUSKRAT DAM LAKE		
04CA003	ROSEBERRY RIVER ABOVE ROSEBERRY LAKES		
04CA004	SEVERN RIVER AT OUTLET OF DEER LAKE		✓
04CB001	WINDIGO RIVER ABOVE MUSKRAT DAM LAKE		
04CC001	SEVERN RIVER AT LIMESTONE RAPIDS	✓	
04DA001	PIPESTONE RIVER AT KARL LAKE		
04DB001	ASHEWEIG RIVER AT STRAIGHT LAKE		
04DC001	WINISK RIVER BELOW ASHEWEIG RIVER TRIBUTARY		
04DC002	SHAMATTAWA RIVER AT OUTLET OF SHAMATTAWA LAKE		
04FA001	OTOSKWIN RIVER BELOW BADESDAWA LAKE		✓

Station Number	Station Name	Trend in Exceedances	Trend in Number of Events
04FA002	KAWINOGANS RIVER NEAR PICKLE CROW		✓
04FA003	PINEIMUTA RIVER AT EYES LAKE		✓
04FB001	ATTAWAPISKAT RIVER BELOW ATTAWAPISKAT LAKE		✓
04FC001	ATTAWAPISKAT RIVER BELOW MUKETEI RIVER		
04JA002	KABINAKAGAMI RIVER AT HIGHWAY NO. 11		
04JC002	NAGAGAMI RIVER AT HIGHWAY NO. 11		
04JD005	PAGWACHUAN RIVER AT HIGHWAY NO. 11		
04JF001	LITTLE CURRENT RIVER AT PERCY LAKE		
04KA001	KWETABOHIGAN RIVER NEAR THE MOUTH		
04KA002	HALFWAY CREEK AT MOOSONEE		
04LJ001	MISSINAIBI RIVER AT MATTICE		
04LM001	MISSINAIBI RIVER BELOW WABOOSE RIVER		
04MD004	PORCUPINE RIVER AT HOYLE	✓	
04MF001	NORTH FRENCH RIVER NEAR THE MOUTH		
04NB001	TURGEON (RIVIERE) EN AMONT DE LA RIVIERE HARRICANA		
05AA001	OLDMAN RIVER NEAR COWLEY		
05AA002	CROWSNEST RIVER NEAR LUNDBRECK		
05AA003	CASTLE RIVER NEAR COWLEY		
05AA008	CROWSNEST RIVER AT FRANK		✓
05AA022	CASTLE RIVER NEAR BEAVER MINES		
05AA023	OLDMAN RIVER NEAR WALDRON'S CORNER		
05AB028	WILLOW CREEK ABOVE CHAIN LAKES		
05AD003	WATERTON RIVER NEAR WATERTON PARK		✓
05BC002	SPRAY RIVER NEAR SPRAY LAKES		
05BC003	SPRAY CREEK AT SPRAY LAKES		
05BF016	MARMOT CREEK MAIN STEM NEAR SEEBE		
05BF017	MIDDLE FORK CREEK NEAR SEEBE		✓
05BG006	WAIPAROUS CREEK NEAR THE MOUTH		
05BH009	JUMPINGPOUND CREEK NEAR THE MOUTH		
05BJ004	ELBOW RIVER AT BRAGG CREEK		
05BJ005	ELBOW RIVER ABOVE GLENMORE DAM		
05BL014	SHEEP RIVER AT BLACK DIAMOND		
05BL022	CATARACT CREEK NEAR FORESTRY ROAD		
05CA009	RED DEER RIVER BELOW BURNT TIMBER CREEK		
05CB001	LITTLE RED DEER RIVER NEAR THE MOUTH		
05CB004	RAVEN RIVER NEAR RAVEN		
05CC001	BLINDMAN RIVER NEAR BLACKFALDS		✓
05CC007	MEDICINE RIVER NEAR ECKVILLE		
05DA007	MISTAYA RIVER NEAR SASKATCHEWAN CROSSING		
05DA009	NORTH SASKATCHEWAN RIVER AT WHIRLPOOL POINT		
05DA010	SILVERHORN CREEK NEAR THE MOUTH		
05DB001	CLEARWATER RIVER NEAR ROCKY MOUNTAIN HOUSE		
05DB002	PRAIRIE CREEK NEAR ROCKY MOUNTAIN HOUSE		
05DC006	RAM RIVER NEAR THE MOUTH		
05DD009	NORDEGG RIVER AT SUNCHILD ROAD		
05FA001	BATTLE RIVER NEAR PONOKA		
05HD036	SWIFT CURRENT CREEK BELOW ROCK CREEK		
05KC001	CARROT RIVER NEAR SMOKY BURN		
05KF001	BALLANTYNE RIVER ABOVE BALLANTYNE BAY		
05KG002	STURGEON-WEIR RIVER AT OUTLET OF AMISK LAKE		
05KG007	STURGEON-WEIR RIVER AT LEAF RAPIDS		
05KH007	CARROT RIVER NEAR TURNBERRY		
05LC001	RED DEER RIVER NEAR ERWOOD		✓
05LC004	RED DEER RIVER NEAR THE MOUTH		
05LE001	SWAN RIVER AT SWAN RIVER		
05LE006	SWAN RIVER NEAR MINITONAS		

Station Number	Station Name	Trend in Exceedances	Trend in Number of Events
05LE008	SWAN RIVER NEAR NORQUAY		
05LH005	WATERHEN RIVER NEAR WATERHEN		
05LL014	PINE CREEK NEAR MELBOURNE		
05MG008	OAK RIVER AT SHOAL LAKE		
05NF002	ANTLER RIVER NEAR MELITA		
05NG010	OAK CREEK NEAR STOCKTON		
05OA007	BADGER CREEK NEAR CARTWRIGHT		
05OB021	MOWBRAY CREEK NEAR MOWBRAY		
05OD004	ROSEAU RIVER AT GARDENTON		✓
05OD031	SPRAGUE CREEK NEAR SPRAGUE		
05OE004	RAT RIVER NEAR SUNDOWN		✓
05PA006	NAMAKAN RIVER AT OUTLET OF LAC LA CROIX		
05PA012	BASSWOOD RIVER NEAR WINTON		
05PB018	ATIKOKAN RIVER AT ATIKOKAN		
05PD017	LAKE 470 OUTLET NEAR KENORA		
05PD023	LAKE 239 OUTLET NEAR KENORA		
05PH003	WHITEMOUTH RIVER NEAR WHITEMOUTH		
05PJ001	BIRD RIVER AT OUTLET OF BIRD LAKE		
05QA001	ENGLISH RIVER NEAR SIOUX LOOKOUT		
05QA002	ENGLISH RIVER AT UMFREVILLE		
05QA004	STURGEON RIVER AT MCDOUGALL MILLS		
05QE009	STURGEON RIVER AT OUTLET OF SALVESEN LAKE		
05RA001	MANIGOTAGAN RIVER NEAR MANIGOTAGAN		✓
05RC001	BERENS RIVER ABOVE BERENS LAKE		
05RD007	BERENS RIVER AT OUTLET OF LONG LAKE		
05RD008	PIGEON RIVER AT OUTLET OF ROUND LAKE		
05SA002	BROKENHEAD RIVER NEAR BEAUSEJOUR		
05SD003	FISHER RIVER NEAR DALLAS		
05TD001	GRASS RIVER ABOVE STANDING STONE FALLS		
05TE002	BURNTWOOD RIVER ABOVE LEAF RAPIDS		
05TF002	FOOTPRINT RIVER ABOVE FOOTPRINT LAKE		
05TG002	TAYLOR RIVER NEAR THOMPSON		
05TG003	ODEI RIVER NEAR THOMPSON		
05TG006	SAPOCHI RIVER NEAR NELSON HOUSE		
05UF004	KETTLE RIVER NEAR GILLAM		
05UH001	ANGLING RIVER NEAR BIRD		
06AD010	MEADOW RIVER BELOW MEADOW LAKE		
06AF001	COLD RIVER AT OUTLET OF COLD LAKE		✓
06AF005	WATERHEN RIVER NEAR GOODSOIL		
06AG001	BEAVER RIVER BELOW WATERHEN RIVER	✓	
06AG002	DORE RIVER NEAR THE MOUTH		
06BA002	DILLON RIVER BELOW DILLON LAKE		
06BB003	CHURCHILL RIVER NEAR PATUANAK		
06BB005	CANOE RIVER NEAR BEAUVAL		
06BC001	MUDJATIK RIVER NEAR FORCIER LAKE		
06BD001	HAULTAIN RIVER ABOVE NORBERT RIVER		
06CD002	CHURCHILL RIVER ABOVE OTTER RAPIDS		
06DA002	COCHRANE RIVER NEAR BROCHET		
06DA004	GEIKIE RIVER BELOW WHEELER RIVER		
06EA007	PAGATO RIVER AT OUTLET OF PAGATO LAKE		
06FA001	GAUER RIVER BELOW THORSTEINSON LAKE		
06FB002	LITTLE BEAVER RIVER NEAR THE MOUTH		
06FC001	LITTLE CHURCHILL RIVER ABOVE RECLUSE LAKE		
06FD002	DEER RIVER NORTH OF BELCHER		
06GB001	NORTH SEAL RIVER BELOW STONY LAKE		
06GD001	SEAL RIVER BELOW GREAT ISLAND		

Station Number	Station Name	Trend in Exceedances	Trend in Number of Events
06HB002	THLEWIAZA RIVER ABOVE OUTLET SEALHOLE LAKE		
06KC003	DUBAWNT RIVER AT OUTLET OF MARJORIE LAKE		
06LA001	KAZAN RIVER AT OUTLET OF ENNADAI LAKE		✓
06LC001	KAZAN RIVER ABOVE KAZAN FALLS		
06MA006	THELON RIVER BELOW OUTLET OF SCHULTZ LAKE		
07AA004	MALIGNE RIVER NEAR JASPER		
07AD001	ATHABASCA RIVER AT ENTRANCE		✓
07AD002	ATHABASCA RIVER AT HINTON		
07AE001	ATHABASCA RIVER NEAR WINDFALL		
07AF002	MCLEOD RIVER ABOVE EMBARRAS RIVER		
07AG001	MCLEOD RIVER NEAR WOLF CREEK		✓
07AG003	WOLF CREEK AT HIGHWAY NO. 16A		
07AG007	MCLEOD RIVER NEAR ROSEVEAR		
07BB002	PEMBINA RIVER NEAR ENTWISTLE		✓
07BC002	PEMBINA RIVER AT JARVIE		
07BE001	ATHABASCA RIVER AT ATHABASCA		✓
07BF002	WEST PRAIRIE RIVER NEAR HIGH PRAIRIE		
07BJ001	SWAN RIVER NEAR KINUSO		
07BK001	LESSER SLAVE RIVER AT SLAVE LAKE	✓	✓
07BK006	LESSER SLAVE RIVER AT HIGHWAY NO. 2A		✓
07CD004	HANGINGSTONE RIVER AT FORT MCMURRAY		✓
07CD005	CLEARWATER RIVER ABOVE CHRISTINA RIVER		✓
07CD006	CLEARWATER RIVER AT OUTLET OF LLOYD LAKE		
07DA001	ATHABASCA RIVER BELOW FORT MCMURRAY		
07DA006	STEEPBANK RIVER NEAR FORT MCMURRAY		
07DA008	MUSKEG RIVER NEAR FORT MACKAY		✓
07DD002	RICHARDSON RIVER NEAR THE MOUTH		
07EA002	KWADACHA RIVER NEAR WARE		
07EA004	INGENIKA RIVER ABOVE SWANNELL RIVER		
07EA005	FINLAY RIVER ABOVE AKIE RIVER		
07EA007	AKIE RIVER NEAR THE 760 M CONTOUR		
07EB002	OSPIKA RIVER ABOVE ALEY CREEK		
07EC002	OMINECA RIVER ABOVE OSILINKA RIVER		
07EC003	MESILINKA RIVER ABOVE GOPHERHOLE CREEK		
07EC004	OSILINKA RIVER NEAR END LAKE		
07ED001	NATION RIVER NEAR FORT ST. JAMES		
07ED003	NATION RIVER NEAR THE MOUTH		
07EE007	PARSNIP RIVER ABOVE MISINCHINKA RIVER		
07EE009	CHUCHINKA CREEK NEAR THE MOUTH		
07EE010	PACK RIVER AT OUTLET OF MCLEOD LAKE		
07FA001	HALFWAY RIVER NEAR FARRELL CREEK (LOWER STATION)		
07FA005	GRAHAM RIVER ABOVE COLT CREEK	✓	✓
07FA006	HALFWAY RIVER NEAR FARRELL CREEK		
07FB001	PINE RIVER AT EAST PINE		
07FB002	MURRAY RIVER NEAR THE MOUTH		
07FB003	SUKUNKA RIVER NEAR THE MOUTH		
07FB004	DICKEBUSCH CREEK NEAR THE MOUTH		
07FB005	QUALITY CREEK NEAR THE MOUTH		
07FB006	MURRAY RIVER ABOVE WOLVERINE RIVER		
07FB008	MOBERLY RIVER NEAR FORT ST. JOHN		
07FB009	FLATBED CREEK AT KILOMETRE 110 HERITAGE HIGHWAY		
07FC001	BEATTON RIVER NEAR FORT ST. JOHN		
07FC003	BLUEBERRY RIVER BELOW AITKEN CREEK		
07FD001	KISKATINAW RIVER NEAR FARMINGTON		✓
07FD004	ALCES RIVER AT 22ND BASE LINE		
07GA001	SMOKY RIVER ABOVE HELLS CREEK		

Station Number	Station Name	Trend in Exceedances	Trend in Number of Events
07GA002	MUSKEG RIVER NEAR GRANDE CACHE		
07GE001	WAPITI RIVER NEAR GRANDE PRAIRIE		
07GG001	WASKAHIGAN RIVER NEAR THE MOUTH		
07GH002	LITTLE SMOKY RIVER NEAR GUY		
07GJ001	SMOKY RIVER AT WATINO		✓
07KE001	BIRCH RIVER BELOW ALICE CREEK		
07LB002	WATERFOUND RIVER BELOW THERIAU LAKE		
07LD002	CREE RIVER AT OUTLET OF WAPATA LAKE		
07LE002	FOND DU LAC RIVER AT OUTLET OF BLACK LAKE		
07MA003	DOUGLAS RIVER NEAR CLUFF LAKE		
07MB001	MACFARLANE RIVER AT OUTLET OF DAVY LAKE		
07NB008	DOG RIVER NEAR FITZGERALD		
07OB001	HAY RIVER NEAR HAY RIVER		
07PA001	BUFFALO RIVER AT HIGHWAY NO. 5		
07QD004	TALTSON RIVER ABOVE PORTER LAKE OUTFLOW		✓
07RD001	LOCKHART RIVER AT OUTLET OF ARTILLERY LAKE		
07SA002	SNARE RIVER BELOW GHOST RIVER		✓
07SA004	INDIN RIVER ABOVE CHALCO LAKE		
07SB010	CAMERON RIVER BELOW REID LAKE		
07SB013	BAKER CREEK AT OUTLET OF LOWER MARTIN LAKE		
07SC002	WALDRON RIVER NEAR THE MOUTH		
07UC001	KAKISA RIVER AT OUTLET OF KAKISA LAKE		✓
08AA008	SEKULMUN RIVER AT OUTLET OF SEKULMUN LAKE		
08AA009	GILTANA CREEK NEAR THE MOUTH		
08AB001	ALSEK RIVER ABOVE BATES RIVER		✓
08AB002	ALSEK RIVER NEAR YAKUTAT		
08AC001	TAKHANNE RIVER AT KM 167 HAINES HIGHWAY		
08BB001	TAKU RIVER NEAR TULSEQUAH		
08BB002	SLOKO RIVER NEAR ATLIN		
08BB005	TAKU RIVER NEAR JUNEAU		
08CB001	STIKINE RIVER ABOVE GRAND CANYON		
08CC001	KLAPPAN RIVER NEAR TELEGRAPH CREEK		
08CD001	TUYA RIVER NEAR TELEGRAPH CREEK		
08CE001	STIKINE RIVER AT TELEGRAPH CREEK		
08CF001	STIKINE RIVER ABOVE BUTTERFLY CREEK		
08CF003	STIKINE RIVER NEAR WRANGELL		
08CG001	ISKUT RIVER BELOW JOHNSON RIVER		
08CG003	ISKUT RIVER AT OUTLET OF KINASKAN LAKE		
08CG004	ISKUT RIVER ABOVE SNIPPAKER CREEK		
08CG005	MORE CREEK NEAR THE MOUTH		
08DB001	NASS RIVER ABOVE SHUMAL CREEK		✓
08DC006	BEAR RIVER ABOVE BITTER CREEK		
08DD001	UNUK RIVER NEAR STEWART		
08EB003	SKEENA RIVER AT GLEN VOWELL	✓	
08EB004	KISPIOX RIVER NEAR HAZELTON		
08EB005	SKEENA RIVER ABOVE BABINE RIVER		✓
08EC001	BABINE RIVER AT BABINE		
08EC013	BABINE RIVER AT OUTLET OF NILKITKWA LAKE		
08ED001	NANIKA RIVER AT OUTLET OF KIDPRICE LAKE		✓
08ED002	MORICE RIVER NEAR HOUSTON		
08EE004	BULKLEY RIVER AT QUICK	✓	✓
08EE008	GOATHORN CREEK NEAR TELKWA		
08EE012	SIMPSON CREEK AT THE MOUTH		✓
08EE013	BUCK CREEK AT THE MOUTH		
08EE020	TELKWA RIVER BELOW TSAI CREEK		
08EE025	TWO MILE CREEK IN DISTRICT LOT 4834		

Station Number	Station Name	Trend in Exceedances	Trend in Number of Events
08EF001	SKEENA RIVER AT USK		✓
08EF005	ZYMOETZ RIVER ABOVE O.K. CREEK		
08EG011	ZYMAGOTITZ RIVER NEAR TERRACE		
08EG012	EXCHAMSIKS RIVER NEAR TERRACE		
08FA002	WANNOCK RIVER AT OUTLET OF OWIKENO LAKE		
08FB002	BELLA COOLA RIVER NEAR HAGENSBORG		✓
08FB004	SALLOOMT RIVER NEAR HAGENSBORG		
08FB005	NUSATSUM RIVER NEAR HAGENSBORG		
08FC003	DEAN RIVER BELOW TANSWANKET CREEK		
08FE003	KEMANO RIVER ABOVE POWERHOUSE TAILRACE		✓
08FF001	KITIMAT RIVER BELOW HIRSCH CREEK		
08FF002	HIRSCH CREEK NEAR THE MOUTH		
08FF003	LITTLE WEDEENE RIVER BELOW BOWBYES CREEK		
08GA024	CHEAKAMUS RIVER NEAR MONS	✓	
08GA061	MACKAY CREEK AT MONTROYAL BOULEVARD		
08GA071	ELAHO RIVER NEAR THE MOUTH		✓
08GA072	CHEAKAMUS RIVER ABOVE MILLAR CREEK		
08GB013	CLOWHOM RIVER NEAR CLOWHOM LAKE		
08GD004	HOMATHKO RIVER AT THE MOUTH		
08GD005	HOMATHKO RIVER BELOW NUDE CREEK		
08GD007	MOSLEY CREEK NEAR DUMBELL LAKE		✓
08GD008	HOMATHKO RIVER AT INLET TO TATLAYOKO LAKE		
08HA003	KOKSILAH RIVER AT COWICHAN STATION		✓
08HA010	SAN JUAN RIVER NEAR PORT RENFREW		
08HA016	BINGS CREEK NEAR THE MOUTH		
08HB002	ENGLISHMAN RIVER NEAR PARKSVILLE		
08HB014	SARITA RIVER NEAR BAMFIELD		
08HB024	TSABLE RIVER NEAR FANNY BAY		
08HB025	BROWNS RIVER NEAR COURTENAY		✓
08HB032	MILLSTONE RIVER AT NANAIMO		✓
08HB048	CARNATION CREEK AT THE MOUTH		
08HB074	CRUICKSHANK RIVER NEAR THE MOUTH		
08HB075	DOVE CREEK NEAR THE MOUTH		
08HC002	UCONA RIVER AT THE MOUTH		
08HD001	CAMPBELL RIVER AT OUTLET OF CAMPBELL LAKE		
08HD011	OYSTER RIVER BELOW WOODHUS CREEK		
08HE006	ZEBALLOS RIVER NEAR ZEBALLOS	✓	
08HF004	TSITIKA RIVER BELOW CATHERINE CREEK		
08HF005	NIMPKISH RIVER ABOVE WOSS RIVER		
08HF006	SAN JOSEF RIVER BELOW SHARP CREEK		
08JA015	LAVENTIE CREEK NEAR THE MOUTH		
08JB002	STELLAKO RIVER AT GLENANNAN		✓
08JB003	NAUTLEY RIVER NEAR FORT FRASER		
08JD006	DRIFTWOOD RIVER ABOVE KASTBERG CREEK		
08JE001	STUART RIVER NEAR FORT ST. JAMES		
08JE004	TSILCOH RIVER NEAR THE MOUTH		
08KA001	DORE RIVER NEAR MCBRIDE		✓
08KA004	FRASER RIVER AT HANSARD		
08KA005	FRASER RIVER AT MCBRIDE		
08KA008	MOOSE RIVER NEAR RED PASS	✓	
08KA009	MCKALE RIVER NEAR 940 M CONTOUR		
08KB001	FRASER RIVER AT SHELLEY		
08KB003	MCGREGOR RIVER AT LOWER CANYON		✓
08KB006	MULLER CREEK NEAR THE MOUTH		
08KC001	SALMON RIVER NEAR PRINCE GEORGE		
08KC003	MUSKEG RIVER NORTH OF JOANNE LAKE		

Station Number	Station Name	Trend in Exceedances	Trend in Number of Events
08KD001	BOWRON RIVER NEAR WELLS		
08KD003	WILLOW RIVER NEAR WILLOW RIVER		
08KD004	BOWRON RIVER NEAR HANSARD		
08KD006	WILLOW RIVER ABOVE HAY CREEK		
08KE009	COTTONWOOD RIVER NEAR CINEMA		
08KE016	BAKER CREEK AT QUESNEL		
08KE024	LITTLE SWIFT RIVER AT THE MOUTH		
08KF001	NAZKO RIVER ABOVE MICHELLE CREEK		
08KG001	WEST ROAD RIVER NEAR CINEMA		
08KH001	QUESNEL RIVER AT LIKELY		
08KH003	CARIBOO RIVER BELOW KANGAROO CREEK		✓
08KH010	HORSEFLY RIVER ABOVE MCKINLEY CREEK		✓
08KH014	MITCHELL RIVER AT OUTLET OF MITCHELL LAKE		
08KH019	MOFFAT CREEK NEAR HORSEFLY		
08LA001	CLEARWATER RIVER NEAR CLEARWATER STATION		✓
08LA004	MURTLE RIVER ABOVE DAWSON FALLS		✓
08LA007	CLEARWATER RIVER AT OUTLET OF CLEARWATER LAKE	✓	
08LA008	MAHOOD RIVER AT OUTLET OF MAHOOD LAKE		✓
08LB012	PAUL CREEK AT THE OUTLET OF PINANTAN LAKE		
08LB020	BARRIERE RIVER AT THE MOUTH		✓
08LB022	NORTH THOMPSON RIVER NEAR BARRIERE		
08LB024	FISHTRAP CREEK NEAR MCLURE		
08LB038	BLUE RIVER NEAR BLUE RIVER		✓
08LB047	NORTH THOMPSON RIVER AT BIRCH ISLAND		
08LB050	MANN CREEK NEAR BLACKPOOL		
08LB064	NORTH THOMPSON RIVER AT MCLURE		
08LB069	BARRIERE RIVER BELOW SPRAGUE CREEK		
08LB076	HARPER CREEK NEAR THE MOUTH		
08LC040	VANCE CREEK BELOW DEAFIES CREEK	✓	
08LD001	ADAMS RIVER NEAR SQUILAX		
08LE024	EAGLE RIVER NEAR MALAKWA		✓
08LE027	SEYMOUR RIVER NEAR SEYMOUR ARM		✓
08LE031	SOUTH THOMPSON RIVER AT CHASE		
08LE075	SALMON RIVER ABOVE SALMON LAKE		
08LE077	CORNING CREEK NEAR SQUILAX		
08LE108	EAST CANOE CREEK ABOVE DAM		
08LF022	THOMPSON RIVER AT SPENCES BRIDGE		
08LF081	AMBUSTEN CREEK NEAR THE MOUTH		
08LF084	ANDERSON CREEK ABOVE DIVERSIONS		
08LG008	SPIUS CREEK NEAR CANFORD	✓	✓
08LG016	PENNASK CREEK NEAR QUILCHENA		
08LG048	COLDWATER RIVER NEAR BROOKMERE		
08LG056	GUICHON CREEK ABOVE TUNKWA LAKE DIVERSION		
08MA001	CHILKO RIVER NEAR REDSTONE		✓
08MA002	CHILKO RIVER AT OUTLET OF CHILKO LAKE		✓
08MA003	TASEKO RIVER AT OUTLET OF TASEKO LAKES		
08MA006	LINGFIELD CREEK NEAR THE MOUTH		
08MB005	CHILCOTIN RIVER BELOW BIG CREEK		✓
08MB006	BIG CREEK ABOVE GROUNDHOG CREEK	✓	
08MB007	BIG CREEK BELOW GRAVEYARD CREEK		
08ME004	BRIDGE RIVER AT LAJOIE FALLS		
08ME023	BRIDGE RIVER (SOUTH BRANCH) BELOW BRIDGE GLACIER		
08ME025	YALAKOM RIVER ABOVE ORE CREEK		
08MF003	COQUIHALLA RIVER NEAR HOPE		
08MF062	COQUIHALLA RIVER BELOW NEEDLE CREEK		
08MF065	NAHATLATCH RIVER BELOW TACHEWANA CREEK		

Station Number	Station Name	Trend in Exceedances	Trend in Number of Events
08MG001	CHEHALIS RIVER NEAR HARRISON MILLS		✓
08MG004	GREEN RIVER NEAR RAINBOW		✓
08MG005	LILLOOET RIVER NEAR PEMBERTON		
08MG006	RUTHERFORD CREEK NEAR PEMBERTON		
08MG007	SOO RIVER NEAR PEMBERTON		
08MG013	HARRISON RIVER NEAR HARRISON HOT SPRINGS		
08MH001	CHILLIWACK RIVER AT VEDDER CROSSING		
08MH006	NORTH ALOUETTE RIVER AT 232ND STREET, MAPLE RIDGE		✓
08MH018	MAHOOD CREEK NEAR NEWTON		✓
08MH076	KANAKA CREEK NEAR WEBSTER CORNERS	✓	
08MH103	CHILLIWACK RIVER ABOVE SLESSE CREEK		
08MH141	COQUITLAM RIVER ABOVE COQUITLAM LAKE		
08MH147	STAVE RIVER ABOVE STAVE LAKE		
08MH155	NICOMEKL RIVER AT 203 STREET, LANGLEY		
08NA002	COLUMBIA RIVER AT NICHOLSON		
08NA006	KICKING HORSE RIVER AT GOLDEN		✓
08NA012	TOBY CREEK NEAR ATHALMER		
08NA024	WINDERMERE CREEK NEAR WINDERMERE		✓
08NB012	BLAEBERRY RIVER ABOVE WILLOWBANK CREEK		
08NB013	GOLD RIVER ABOVE BACHELOR CREEK		
08NB014	GOLD RIVER ABOVE PALMER CREEK		
08NB015	BLAEBERRY RIVER BELOW ENSIGN CREEK	✓	
08NB016	SPLIT CREEK AT THE MOUTH		
08NB019	BEAVER RIVER NEAR THE MOUTH		
08ND006	COLUMBIA RIVER AT TWELVE MILE FERRY		
08ND009	DOWNIE CREEK NEAR REVELSTOKE		✓
08ND012	GOLDSTREAM RIVER BELOW OLD CAMP CREEK		
08ND013	ILLECILLEWAET RIVER AT GREELEY		
08ND014	JORDAN RIVER ABOVE KIRKUP CREEK		
08ND018	STITT CREEK AT THE MOUTH		
08ND019	KIRBYVILLE CREEK NEAR THE MOUTH		
08NE001	INCOMAPPLEUX RIVER NEAR BEATON		
08NE039	BIG SHEEP CREEK NEAR ROSSLAND		
08NE074	SALMO RIVER NEAR SALMO		
08NE077	BARNES CREEK NEAR NEEDLES		
08NE087	DEER CREEK AT DEER PARK		
08NE110	INONOAKLIN CREEK ABOVE VALLEY CREEK		
08NE114	HIDDEN CREEK NEAR THE MOUTH		
08NE117	KUSKANAX CREEK AT 1040 M CONTOUR		
08NF001	KOOTENAY RIVER AT KOOTENAY CROSSING		✓
08NF002	KOOTENAY RIVER AT CANAL FLATS		✓
08NF005	ALBERT RIVER AT 1310 M CONTOUR		
08NG005	KOOTENAY RIVER AT WARDNER		✓
08NG065	KOOTENAY RIVER AT FORT STEELE		
08NG076	MATHER CREEK BELOW HOULE CREEK		
08NG077	ST. MARY RIVER BELOW MORRIS CREEK		
08NG078	CAVEN CREEK BELOW BLOOM CREEK		
08NH001	DUNCAN RIVER NEAR HOWSER		✓
08NH005	KASLO RIVER BELOW KEMP CREEK		✓
08NH006	MOYIE RIVER AT EASTPORT		✓
08NH016	DUCK CREEK NEAR WYNNDEL		✓
08NH034	MOYIE RIVER AT MOYIE		
08NH066	LARDEAU RIVER AT GERRARD		✓
08NH084	ARROW CREEK NEAR ERICKSON		✓
08NH115	SULLIVAN CREEK NEAR CANYON		
08NH119	DUNCAN RIVER BELOW B.B. CREEK		

Station Number	Station Name	Trend in Exceedances	Trend in Number of Events
08NH120	MOYIE RIVER ABOVE NEGRO CREEK		
08NH130	FRY CREEK BELOW CARNEY CREEK		
08NH131	CARNEY CREEK BELOW PAMBRUN CREEK		✓
08NH132	KEEN CREEK BELOW KYAWATS CREEK		
08NJ013	SLOCAN RIVER NEAR CRESCENT VALLEY		✓
08NJ014	SLOCAN RIVER AT SLOCAN CITY		✓
08NJ026	DUHAMEL CREEK ABOVE DIVERSIONS		
08NJ061	REDFISH CREEK NEAR HARROP		
08NJ129	FELL CREEK NEAR NELSON	✓	
08NJ130	ANDERSON CREEK NEAR NELSON		
08NJ160	LEMON CREEK ABOVE SOUTH LEMON CREEK		
08NJ168	FIVE MILE CREEK ABOVE CITY INTAKE		
08NK002	ELK RIVER AT FERNIE		
08NK012	ELK RIVER AT STANLEY PARK		
08NK016	ELK RIVER NEAR NATAL		
08NK018	FORDING RIVER AT THE MOUTH		
08NK019	GRAVE CREEK AT THE MOUTH		
08NK021	FORDING RIVER BELOW CLODE CREEK		
08NK022	LINE CREEK AT THE MOUTH		
08NK026	HOSMER CREEK ABOVE DIVERSIONS		
08NL004	ASHNOLA RIVER NEAR KEREMEOS		✓
08NL007	SIMILKAMEEN RIVER AT PRINCETON		
08NL024	TULAMEEN RIVER AT PRINCETON		
08NL036	WHIPSAW CREEK BELOW LAMONT CREEK		
08NL038	SIMILKAMEEN RIVER NEAR HEDLEY		
08NL050	HEDLEY CREEK NEAR THE MOUTH		
08NL069	PASAYTEN RIVER ABOVE CALCITE CREEK		
08NL070	SIMILKAMEEN RIVER ABOVE GOODFELLOW CREEK		
08NL071	TULAMEEN RIVER BELOW VUICH CREEK		
08NM015	VASEUX CREEK ABOVE DUTTON CREEK		
08NM035	BELLEVUE CREEK NEAR OKANAGAN MISSION	✓	
08NM133	BULL CREEK NEAR CRUMP	✓	✓
08NM134	CAMP CREEK AT MOUTH NEAR THIRSK		✓
08NM137	DAVES CREEK NEAR RUTLAND		✓
08NM142	COLDSTREAM CREEK ABOVE MUNICIPAL INTAKE		
08NM171	VASEUX CREEK ABOVE SOLCO CREEK		
08NM173	GREATA CREEK NEAR THE MOUTH	✓	
08NM174	WHITEMAN CREEK ABOVE BOULEAU CREEK		
08NM240	TWO FORTY CREEK NEAR PENTICTON		
08NM241	TWO FORTY-ONE CREEK NEAR PENTICTON		
08NN002	GRANBY RIVER AT GRAND FORKS		✓
08NN012	KETTLE RIVER NEAR LAURIER		✓
08NN013	KETTLE RIVER NEAR FERRY		
08NN015	WEST KETTLE RIVER NEAR MCCULLOCH		
08NN019	TRAPPING CREEK NEAR THE MOUTH		
08NN022	WEST KETTLE RIVER BELOW CARMI CREEK	✓	
08NN023	BURRELL CREEK ABOVE GLOUCESTER CREEK		
08NP001	FLATHEAD RIVER AT FLATHEAD	✓	✓
08NP004	CABIN CREEK NEAR THE MOUTH		
08OB002	PALLANT CREEK NEAR QUEEN CHARLOTTE		
08PA001	SKAGIT RIVER NEAR HOPE		
09AA007	LUBBOCK RIVER NEAR ATLIN		
09AA010	LINDEMAN CREEK NEAR BENNETT		
09AA013	TUTSHI RIVER AT OUTLET OF TUTSHI LAKE		
09AA014	FANTAIL RIVER AT OUTLET OF FANTAIL LAKE		
09AA015	WANN RIVER NEAR ATLIN		

Station Number	Station Name	Trend in Exceedances	Trend in Number of Events
09AB008	M'CLINTOCK RIVER NEAR WHITEHORSE		
09AB009	YUKON RIVER ABOVE FRANK CREEK		
09AC001	TAKHINI RIVER NEAR WHITEHORSE		
09AC004	TAKHINI RIVER AT OUTLET OF KUSAWA LAKE		
09AC007	IBEX RIVER NEAR WHITEHORSE		
09AE001	TESLIN RIVER NEAR TESLIN		
09AE003	SWIFT RIVER NEAR SWIFT RIVER		
09AE004	GLADYS RIVER AT OUTLET OF GLADYS LAKE		
09AG001	BIG SALMON RIVER NEAR CARMACKS		
09AH001	YUKON RIVER AT CARMACKS		
09AH003	BIG CREEK NEAR THE MOUTH		
09AH004	NORDENSKIOLD RIVER BELOW ROWLINSON CREEK		
09BA001	ROSS RIVER AT ROSS RIVER		
09BB001	SOUTH MACMILLAN RIVER AT KILOMETRE 407 CANOL ROAD		
09BC001	PELLY RIVER AT PELLY CROSSING		
09BC004	PELLY RIVER BELOW VANGORDA CREEK		
09CA004	DUKE RIVER NEAR THE MOUTH		
09CD001	YUKON RIVER ABOVE WHITE RIVER		
09DC002	STEWART RIVER AT MAYO		✓
09DD003	STEWART RIVER AT THE MOUTH		
09DD004	MCQUESTEN RIVER NEAR THE MOUTH		
09EA003	KLONDIKE RIVER ABOVE BONANZA CREEK		
09EA004	NORTH KLONDIKE RIVER NEAR THE MOUTH		
09EB001	YUKON RIVER AT DAWSON		✓
09EB003	INDIAN RIVER ABOVE THE MOUTH		
09ED001	YUKON RIVER AT EAGLE		
09FB001	PORCUPINE RIVER BELOW BELL RIVER		
09FC001	OLD CROW RIVER NEAR THE MOUTH		
09FD002	PORCUPINE RIVER NEAR INTERNATIONAL BOUNDARY		
10AA001	LIARD RIVER AT UPPER CROSSING		
10AA004	RANCHERIA RIVER NEAR THE MOUTH		
10AB001	FRANCES RIVER NEAR WATSON LAKE		
10AC002	DEASE RIVER AT MCDAME		
10AC003	DEASE RIVER AT OUTLET OF DEASE LAKE		
10AC004	BLUE RIVER NEAR THE MOUTH		
10AC005	COTTONWOOD RIVER ABOVE BASS CREEK		
10AD001	HYLAND RIVER NEAR LOWER POST		
10BA001	TURNAGAIN RIVER ABOVE SANDPILE CREEK		✓
10BB001	KECHIKA RIVER AT THE MOUTH		
10BB002	KECHIKA RIVER ABOVE BOYA CREEK	✓	
10BC001	COAL RIVER AT THE MOUTH		
10BE001	LIARD RIVER AT LOWER CROSSING		✓
10BE004	TOAD RIVER ABOVE NONDA CREEK		
10BE005	LIARD RIVER ABOVE BEAVER RIVER		
10BE006	LIARD RIVER ABOVE KECHIKA RIVER		
10BE007	TROUT RIVER AT KILOMETRE 783.7 ALASKA HIGHWAY		
10BE009	TEETER CREEK NEAR THE MOUTH		
10CA001	FONTAS RIVER NEAR THE MOUTH		
10CB001	SIKANNI CHIEF RIVER NEAR FORT NELSON		✓
10CC002	FORT NELSON RIVER ABOVE MUSKWA RIVER		
10CD001	MUSKWA RIVER NEAR FORT NELSON		✓
10CD003	RASPBERRY CREEK NEAR THE MOUTH		
10CD004	BOUGIE CREEK AT KILOMETRE 368 ALASKA HIGHWAY		
10CD005	ADSETT CREEK AT KILOMETRE 386.0 ALASKA HIGHWAY		
10EA003	FLAT RIVER NEAR THE MOUTH		✓
10EB001	SOUTH NAHANNI RIVER ABOVE VIRGINIA FALLS	✓	

Station Number	Station Name	Trend in Exceedances	Trend in Number of Events
10EC001	SOUTH NAHANNI RIVER ABOVE CLAUSEN CREEK		
10ED001	LIARD RIVER AT FORT LIARD		✓
10ED002	LIARD RIVER NEAR THE MOUTH		
10ED003	BIRCH RIVER AT HIGHWAY NO. 7		✓
10FA002	TROUT RIVER AT HIGHWAY NO. 1		
10FB005	JEAN-MARIE RIVER AT HIGHWAY NO. 1		✓
10GA001	ROOT RIVER NEAR THE MOUTH		
10GB006	WILLOWLAKE RIVER ABOVE METAHDALI CREEK		
10GC002	HARRIS RIVER NEAR THE MOUTH		
10HB005	REDSTONE RIVER 63 KM ABOVE THE MOUTH		
10HC003	BIG SMITH CREEK NEAR HIGHWAY NO. 1		
10JC003	GREAT BEAR RIVER AT OUTLET OF GREAT BEAR LAKE		
10KA007	BOSWORTH CREEK NEAR NORMAN WELLS		
10KB001	CARCAJOU RIVER BELOW IMPERIAL RIVER		✓
10LA002	ARCTIC RED RIVER NEAR THE MOUTH		✓
10LC007	CARIBOU CREEK ABOVE HIGHWAY NO. 8 (DEMPSTER HIGHWAY)		
10MA001	PEEL RIVER ABOVE CANYON CREEK		
10MA002	OGILVIE RIVER AT KILOMETRE 197.9 DEMPSTER HIGHWAY		
10MA003	BLACKSTONE RIVER NEAR CHAPMAN LAKE AIRSTRIP		
10MC002	PEEL RIVER ABOVE FORT MCPHERSON		
10MD001	FIRTH RIVER NEAR THE MOUTH		
10NC001	ANDERSON RIVER BELOW CARNWATH RIVER		
10ND002	TRAIL VALLEY CREEK NEAR INUVIK		
10ND004	HANS CREEK ABOVE ESKIMO LAKES		
10PB001	COPPERMINE RIVER AT OUTLET OF POINT LAKE		
10PC005	FAIRY LAKE RIVER NEAR OUTLET OF NAPAKTULIK LAKE		✓
10QA001	TREE RIVER NEAR THE MOUTH		✓
10QC001	BURNSIDE RIVER NEAR THE MOUTH		
10QD001	ELLICE RIVER NEAR THE MOUTH		
10RA001	BACK RIVER BELOW BEECHY LAKE		
10RA002	BAILLIE RIVER NEAR THE MOUTH		
10RC001	BACK RIVER ABOVE HERMANN RIVER		✓

Appendix D

List of Stations Used in Chapter 5

30-year window:

Station Number	Station Name	Trend in AMAX	Trend in POT exceedances	Trend in POT events
01AD002	SAINT JOHN RIVER AT FORT KENT			
01AD003	ST. FRANCIS RIVER AT OUTLET OF GLASIER LAKE			
01AE001	FISH RIVER NEAR FORT KENT			✓
01AF007	GRANDE RIVIERE AT VIOLETTE BRIDGE			✓
01AJ003	MEDUXNEKEAG RIVER NEAR BELLEVILLE			
01AJ004	BIG PRESQUE ISLE STREAM AT TRACEY MILLS			
01AJ010	BECAGUIMEC STREAM AT COLDSTREAM			
01AK001	SHOGOMOC STREAM NEAR TRANS CANADA HIGHWAY			✓
01AK007	NACKAWIC STREAM NEAR TEMPERANCE VALE	✓		✓
01AL004	NARROWS MOUNTAIN BROOK NEAR NARROWS MOUNTAIN	✓		
01AN002	SALMON RIVER AT CASTAWAY			
01AP002	CANAAN RIVER AT EAST CANAAN			
01AP004	KENNEBECASIS RIVER AT APOHAQUI			✓
01AQ001	LEPREAU RIVER AT LEPREAU	✓	✓	✓
01BC001	RESTIGOUCHE RIVER BELOW KEDGWICK RIVER			
01BD008	MATAPEDIA (RIVIERE) PRES DE AMQUI			
01BE001	UPSALQUITCH RIVER AT UPSALQUITCH		✓	✓
01BG005	CASCAPEDIA (RIVIERE) EN AVAL DU RUISSEAU BERRY			
01BH005	DARTMOUTH (RIVIERE) EN AMONT DU RUISSEAU DU PAS DE DAME			
01BH010	YORK (RIVIERE) A 1,4 KM EN AVAL DU RUISSEAU DINNER ISLAND			
01BJ003	JACQUET RIVER NEAR DURHAM CENTRE			
01BJ007	RESTIGOUCHE RIVER ABOVE RAFTING GROUND BROOK			
01BJ012	EEL RIVER NEAR DUNDEE			
01BL002	RIVIERE CARAQUET AT BURNSVILLE	✓	✓	
01BL003	BIG TRACADIE RIVER AT MURCHY BRIDGE CROSSING			
01BO001	SOUTHWEST MIRAMICHI RIVER AT BLACKVILLE			
01BP001	LITTLE SOUTHWEST MIRAMICHI RIVER AT LYTTLETON			
01BQ001	NORTHWEST MIRAMICHI RIVER AT TROUT BROOK	✓		
01BS001	COAL BRANCH RIVER AT BEERSVILLE			
01BU002	PETITCODIAC RIVER NEAR PETITCODIAC			
01BV006	POINT WOLFE RIVER AT FUNDY NATIONAL PARK			
01CA003	CARRUTHERS BROOK NEAR ST. ANTHONY	✓	✓	
01DG003	BEAVERBANK RIVER NEAR KINSAC	✓	✓	
01DL001	KELLEY RIVER (MILL CREEK) AT EIGHT MILE FORD			
01DR001	SOUTH RIVER AT ST. ANDREWS	✓		
01EC001	ROSEWAY RIVER AT LOWER OHIO		✓	
01ED007	MERSEY RIVER BELOW MILL FALLS			
01EF001	LAHAVE RIVER AT WEST NORTHFIELD			
01EJ001	SACKVILLE RIVER AT BEDFORD	✓		
01EJ004	LITTLE SACKVILLE RIVER AT MIDDLE SACKVILLE			✓
01EO001	ST. MARYS RIVER AT STILLWATER			
01FA001	RIVER INHABITANTS AT GLENORA		✓	
01FB001	NORTHEAST MARGAREE RIVER AT MARGAREE VALLEY			
01FB003	SOUTHWEST MARGAREE RIVER NEAR UPPER MARGAREE			
02AB008	NEEBING RIVER NEAR THUNDER BAY	✓		
02AB019	MCVICAR CREEK AT THUNDER BAY			
02AB021	CURRENT RIVER AT STEPSTONE			
02AC002	BLACK STURGEON RIVER AT HIGHWAY NO. 17			
02AD010	BLACKWATER RIVER AT BEARDMORE			

Station Number	Station Name	Trend in AMAX	Trend in POT exceedances	Trend in POT events
02BA003	LITTLE PIC RIVER NEAR COLDWELL			
02BA005	WHITESAND RIVER ABOVE SCHREIBER AT MINOVA MINE			
02BB003	PIC RIVER NEAR MARATHON			
02BF001	BATCHAWANA RIVER NEAR BATCHAWANA			
02BF002	GOULAIS RIVER NEAR SEARCHMONT			
02BF004	BIG CARP RIVER NEAR SAULT STE. MARIE			
02BF005	NORBERG CREEK (SITE A) ABOVE BATCHAWANA RIVER			
02BF006	NORBERG CREEK (SITE B) AT OUTLET OF TURKEY LAKE			
02BF007	NORBERG CREEK (SITE C) AT OUTLET OF LITTLE TURKEY LAKE			
02BF008	NORBERG CREEK (SITE D) BELOW WISHART LAKE			
02BF009	NORBERG CREEK (SITE E) BELOW BATCHAWANA LAKE			
02BF012	NORBERG CREEK (SITE F) AT OUTLET OF BATCHAWANA LAKE			
02CA002	ROOT RIVER AT SAULT STE. MARIE			
02CB003	AUBINADONG RIVER ABOVE SESABIC CREEK			
02CF007	WHITSON RIVER AT CHELMSFORD			
02CF008	WHITSON RIVER AT VAL CARON			
02CF012	JUNCTION CREEK BELOW KELLEY LAKE			
02DB007	CONISTON CREEK ABOVE WANAPITEI RIVER			
02DC012	STURGEON RIVER AT UPPER GOOSE FALLS			
02DD013	LA VASE RIVER AT NORTH BAY			
02DD014	CHIPPEWA CREEK AT NORTH BAY			
02DD015	COMMANDA CREEK NEAR COMMANDA			
02EA005	NORTH MAGNETAWAN RIVER NEAR BURK'S FALLS		✓	
02EA010	NORTH MAGNETAWAN RIVER ABOVE PICKEREL LAKE			
02EC002	BLACK RIVER NEAR WASHAGO			
02EC009	HOLLAND RIVER EAST BRANCH AT HOLLAND LANDING			
02EC018	PEFFERLAW BROOK NEAR UDORA			
02ED003	NOTTAWASAGA RIVER NEAR BAXTER			
02ED015	MAD RIVER AT AVENING			
02ED017	HOGG CREEK NEAR VICTORIA HARBOUR			
02ED024	NORTH RIVER AT THE FALLS			
02FA002	STOKES RIVER NEAR FERNDALE			
02FB007	SYDENHAM RIVER NEAR OWEN SOUND			
02FE009	SOUTH MAITLAND RIVER AT SUMMERHILL			
02FF004	SOUTH PARKHILL CREEK NEAR PARKHILL			
02FF007	BAYFIELD RIVER NEAR VARNA			
02FF008	PARKHILL CREEK ABOVE PARKHILL RESERVOIR			
02GA010	NITH RIVER NEAR CANNING			
02GA018	NITH RIVER AT NEW HAMBURG			
02GA038	NITH RIVER ABOVE NITHBURG			
02GB007	FAIRCHILD CREEK NEAR BRANTFORD			
02GC002	KETTLE CREEK AT ST. THOMAS			
02GC018	CATFISH CREEK NEAR SPARTA		✓	
02GC029	KETTLE CREEK ABOVE ST. THOMAS			
02GC031	DODD CREEK BELOW PAYNES MILLS		✓	
02GD004	MIDDLE THAMES RIVER AT THAMESFORD			
02GD021	THAMES RIVER AT INNERKIP			
02GE005	DINGMAN CREEK BELOW LAMBETH			
02GG002	SYDENHAM RIVER NEAR ALVINSTON			
02GG003	SYDENHAM RIVER AT FLORENCE			
02GG006	BEAR CREEK NEAR PETROLIA		✓	
02GG009	BEAR CREEK BELOW BRIGDEN		✓	
02GH002	RUSCOM RIVER NEAR RUSCOM STATION			
02GH003	CANARD RIVER NEAR LUKERVILLE			
02HA006	TWENTY MILE CREEK AT BALLS FALLS			
02HA020	TWENTY MILE CREEK ABOVE SMITHVILLE			
02HB004	EAST SIXTEEN MILE CREEK NEAR OMAGH			

Station Number	Station Name	Trend in AMAX	Trend in POT exceedances	Trend in POT events
02HB012	GRINDSTONE CREEK NEAR ALDERSHOT			
02HB022	BRONTE CREEK AT CARLISLE			
02HB023	SPENCER CREEK AT HIGHWAY NO. 5			
02HC009	EAST HUMBER RIVER NEAR PINE GROVE			
02HC018	LYNDE CREEK NEAR WHITBY			
02HC028	LITTLE ROUGE CREEK NEAR LOCUST HILL			
02HC030	ETOBICOKE CREEK BELOW QUEEN ELIZABETH HIGHWAY			
02HC031	WEST HUMBER RIVER AT HIGHWAY NO. 7		✓	
02HC033	MIMICO CREEK AT ISLINGTON			
02HC049	DUFFINS CREEK AT AJAX			
02HK007	COLD CREEK AT ORLAND			
02HL003	BLACK RIVER NEAR ACTINOLITE			
02HL005	MOIRA RIVER NEAR DELORO			
02HM004	WILTON CREEK NEAR NAPANEE			
02HM005	COLLINS CREEK NEAR KINGSTON			
02JB013	KINOJEVIS (RIVIERE) A 0,3 KM EN AMONT DU PONT-ROUTE A CLERICY			
02JC008	BLANCHE RIVER ABOVE ENGLEHART			
02KF016	MISSISSIPPI RIVER BELOW MARBLE LAKE			
02LC027	DONCASTER (RIVIERE) AU LAC ELEVE			
02LC043	SAINT-LOUIS (RUISSEAU) A 0,3 KM DE LA RIVIERE DU DIABLE			
02LG005	GATINEAU (RIVIERE) AUX RAPIDES CEIZUR			
02MC026	RIVIERE BEAUDETTE NEAR GLEN NEVIS			
02OA057	ANGLAIS (RIVIERE DES) A 1,1 KM EN AVAL DU PONT-ROUTE A TRES-SAINT-SACREMENT			
02OB037	ACHIGAN (RIVIERE DE L') A L'EPIPHANIE			
02OD003	NICOLET (RIVIERE) A 5,8 KM EN AVAL DE LA RIVIERE BULSTRODE			
02OE027	EATON (RIVIERE) PRES DE LA RIVIERE SAINT-FRANCOIS-3			
02OE032	SAUMON (RIVIERE AU) A 1,9 KM EN AMONT DE LA MOFFAT			
02OG007	YAMASKA NORD (RIVIERE) A VAL-SHEFFORD			
02OG026	DAVID (RIVIERE) AU PONT-ROUTE A SAINT-DAVID			
02OJ007	RICHELIEU (RIVIERE) AUX RAPIDES FRYERS			
02OJ024	HURONS (RIVIERE DES) EN AVAL DU RUISSEAU SAINT-LOUIS-2			✓
02PA007	BATISCAN (RIVIERE) A 3,4 KM EN AVAL DE LA RIVIERE DES ENVIES			
02PB006	SAINTE-ANNE (RIVIERE) (BRAS DU NORD DE LA) EN AMONT			
02PD002	MONTMORENCY (RIVIERE) A 0,6 KM EN AVAL DU BARRAGE DES MARCHES NATURELLES			
02PD012	EAUX VOLEES (RUISSEAU DES) EN AMONT DU CHEMIN DU BELVEDERE			
02PD014	AULNAIES OUEST (RUISSEAU DES) EN AMONT DU CHEMIN DU BELVEDERE			
02PD015	AULNAIES (RUISSEAU DES) PRES DU RUISSEAU DES EAUX VOLEES	✓		
02PE014	DAUPHINE (RIVIERE) A L' ILE D'ORLEANS			
02PG006	LOUP (RIVIERE DU) A SAINT-JOSEPH-DE-KAMOURASKA			
02PG022	OUELLE (RIVIERE) PRES DE SAINT-GABRIEL-DE-KAMOURASKA			
02PJ007	BEAURIVAGE (RIVIERE) A SAINTE-ETIENNE			
02PJ030	FAMINE (RIVIERE) A SAINT-GEORGES			
02PL005	BECANCOUR (RIVIERE) A 2,1 KM EN AMONT DE LA RIVIERE PALMER			
02QA002	RIMOUSKI (RIVIERE) A 3,7 KM EN AMONT DU PONT-ROUTE 132			
02QC009	SAINTE-ANNE (RIVIERE) A 9,7 KM EN AMONT DU PONT-ROUTE 132			✓
02RC011	PERIBONCA (PETITE RIVIERE)			
02RD003	MISTASSINI (RIVIERE) EN AMONT DE LA RIVIERE MISTASSIBI			
02RF001	ASHUAPMUSHUAN (RIVIERE) A LA TETE DE LA CHUTE AUX SAUMONS			
02RG005	METABETCHOUANE (RIVIERE) EN AMONT DE LA CENTRALE S.R.P.C.			
02RH027	PIKAUBA (RIVIERE) EN AMONT DE LA RIVIERE APICA			
02RH045	VALIN (RIVIERE) A 3,5 KM DE L'EMBOUCHURE			
02UA003	GODBOUT (RIVIERE) A 1,6 KM EN AMONT DU PONT-ROUTE 138			

Station Number	Station Name	Trend in AMAX	Trend in POT exceedances	Trend in POT events
02UC002	MOISIE (RIVIERE) A 5,1 KM EN AMONT DU PONT DU Q.N.S.L.R.	✓		
02VB004	MAGPIE (RIVIERE) A LA SORTIE DU LAC MAGPIE			
02VC001	ROMAINE (RIVIERE) AU PONT DE LA Q.I.T.			
02WB003	NATASHQUAN (RIVIERE) A 0,6 KM EN AVAL DE LA DECHARGE DU LAC ALIESTE	✓		
02XA003	LITTLE MECATINA RIVER ABOVE LAC FOURMONT			
02XC001	SAINT-PAUL (RIVIERE) A 0,5 KM DU RUISSEAU CHANION			
02YD002	NORTHEAST BROOK NEAR RODDICKTON			
02YE001	GREAVETT BROOK ABOVE PORTLAND CREEK POND		✓	✓
02YK008	BOOT BROOK AT TRANS-CANADA HIGHWAY			✓
02YL001	UPPER HUMBER RIVER NEAR REIDVILLE			
02YL005	RATTLER BROOK NEAR MCIVERS			
02YL008	UPPER HUMBER RIVER ABOVE BLACK BROOK			✓
02YM003	SOUTH WEST BROOK NEAR BAIE VERTE			
02YN002	LLOYDS RIVER BELOW KING GEORGE IV LAKE			
02YO006	PETERS RIVER NEAR BOTWOOD			
02YO008	GREAT RATTLING BROOK ABOVE TOTE RIVER CONFLUENCE			
02YO012	SOUTHWEST BROOK AT LEWISPORTE			
02YQ001	GANDER RIVER AT BIG CHUTE			
02YQ005	SALMON RIVER NEAR GLENWOOD			✓
02YR001	MIDDLE BROOK NEAR GAMBO			
02YR003	INDIAN BAY BROOK NEAR NORTHWEST ARM			
02YS003	SOUTHWEST BROOK AT TERRA NOVA NATIONAL PARK			
02YS005	TERRA NOVA RIVER AT GLOVERTOWN			
02ZA002	HIGHLANDS RIVER AT TRANS-CANADA HIGHWAY			
02ZB001	ISLE AUX MORTS RIVER BELOW HIGHWAY BRIDGE	✓		
02ZC002	GRANDY BROOK BELOW TOP POND BROOK			
02ZD002	GREY RIVER NEAR GREY RIVER			
02ZE004	CONNE RIVER AT OUTLET OF CONNE RIVER POND			
02ZF001	BAY DU NORD RIVER AT BIG FALLS			
02ZG001	GARNISH RIVER NEAR GARNISH			
02ZG003	SALMONIER RIVER NEAR LAMALINE			
02ZG004	RATTLE BROOK NEAR BOAT HARBOUR			
02ZH001	PIPERS HOLE RIVER AT MOTHERS BROOK			
02ZH002	COME BY CHANCE RIVER NEAR GOOBIES			✓
02ZJ001	SOUTHERN BAY RIVER NEAR SOUTHERN BAY			
02ZJ002	SALMON COVE RIVER NEAR CHAMPNEYS			
02ZJ003	SHOAL HARBOUR RIVER NEAR CLARENVILLE			
02ZK001	ROCKY RIVER NEAR COLINET			
02ZK002	NORTHEAST RIVER NEAR PLACENTIA		✓	✓
02ZL004	SHEARSTOWN BROOK AT SHEARSTOWN			
02ZL005	BIG BROOK AT LEAD COVE			✓
02ZM006	NORTHEAST POND RIVER AT NORTHEAST POND			
02ZM008	WATERFORD RIVER AT KILBRIDE			
02ZM016	SOUTH RIVER NEAR HOLYROOD			
02ZM018	VIRGINIA RIVER AT PLEASANTVILLE			
02ZM020	LEARYS BROOK AT PRINCE PHILIP DRIVE			
02ZN002	ST. SHOTTS RIVER NEAR TREPASSEY		✓	
03AB002	WASWANIPI (RIVIERE) A LA CHUTE ROUGE			
03AC004	BELL (RIVIERE) EN AMONT DU LAC MATAGAMI	✓		
03BD002	BROADBACK (RIVIERE) A LA SORTIE DU LAC QUENONISCA			
03BF001	PONTAX (RIVIERE) A 60,4 KM DE L'EMBOUCHURE			
03ED001	BALEINE (GRANDE RIVIERE DE LA) EN AMONT DE LA RIVIERE DENYS-1			
03NF001	UGJOKTOK RIVER BELOW HARP LAKE			
03QC001	EAGLE RIVER ABOVE FALLS			
03QC002	ALEXIS RIVER NEAR PORT HOPE SIMPSON			

Station Number	Station Name	Trend in AMAX	Trend in POT exceedances	Trend in POT events
04DA001	PIPESTONE RIVER AT KARL LAKE	✓		✓
04JC002	NAGAGAMI RIVER AT HIGHWAY NO. 11			
04JD005	PAGWACHUAN RIVER AT HIGHWAY NO. 11			
04KA001	KWETABOHIGAN RIVER NEAR THE MOUTH			
04LJ001	MISSINAIBI RIVER AT MATTICE			
04LM001	MISSINAIBI RIVER BELOW WABOOSE RIVER			
04MF001	NORTH FRENCH RIVER NEAR THE MOUTH			
05AA008	CROWSNEST RIVER AT FRANK		✓	
05AA022	CASTLE RIVER NEAR BEAVER MINES			
05AD003	WATERTON RIVER NEAR WATERTON PARK	✓		✓
05BG006	WAIPAROUS CREEK NEAR THE MOUTH			
05BJ004	ELBOW RIVER AT BRAGG CREEK			
05BL014	SHEEP RIVER AT BLACK DIAMOND			
05BL022	CATARACT CREEK NEAR FORESTRY ROAD			
05CA009	RED DEER RIVER BELOW BURNT TIMBER CREEK			
05CB001	LITTLE RED DEER RIVER NEAR THE MOUTH	✓	✓	
05CB004	RAVEN RIVER NEAR RAVEN			
05CC001	BLINDMAN RIVER NEAR BLACKFALDS			
05CC007	MEDICINE RIVER NEAR ECKVILLE			
05DA007	MISTAYA RIVER NEAR SASKATCHEWAN CROSSING			
05DA009	NORTH SASKATCHEWAN RIVER AT WHIRLPOOL POINT			
05DA010	SILVERHORN CREEK NEAR THE MOUTH			
05DB002	PRAIRIE CREEK NEAR ROCKY MOUNTAIN HOUSE	✓		✓
05DC006	RAM RIVER NEAR THE MOUTH			
05DD009	NORDEGG RIVER AT SUNCHILD ROAD	✓		
05FA001	BATTLE RIVER NEAR PONOKA			
05HD036	SWIFT CURRENT CREEK BELOW ROCK CREEK			
05KH007	CARROT RIVER NEAR TURNBERRY			✓
05LC001	RED DEER RIVER NEAR ERWOOD			✓
05LH005	WATERHEN RIVER NEAR WATERHEN	✓	✓	
05LL014	PINE CREEK NEAR MELBOURNE			
05OB021	MOWBRAY CREEK NEAR MOWBRAY			
05PA012	BASSWOOD RIVER NEAR WINTON			
05PB018	ATIKOKAN RIVER AT ATIKOKAN			
05PH003	WHITEMOUTH RIVER NEAR WHITEMOUTH			✓
05QA002	ENGLISH RIVER AT UMFREVILLE			✓
05QA004	STURGEON RIVER AT MCDOUGALL MILLS	✓		
05QE009	STURGEON RIVER AT OUTLET OF SALVESEN LAKE			
05TE002	BURNTWOOD RIVER ABOVE LEAF RAPIDS			
05TG003	ODEI RIVER NEAR THOMPSON			
05UF004	KETTLE RIVER NEAR GILLAM			
06AG002	DORE RIVER NEAR THE MOUTH	✓		
06BA002	DILLON RIVER BELOW DILLON LAKE			
06BB005	CANOE RIVER NEAR BEAUVAL			✓
06BD001	HAULTAIN RIVER ABOVE NORBERT RIVER			
06DA004	GEIKIE RIVER BELOW WHEELER RIVER			
06FB002	LITTLE BEAVER RIVER NEAR THE MOUTH			
07AD002	ATHABASCA RIVER AT HINTON			
07AF002	MCLEOD RIVER ABOVE EMBARRAS RIVER			
07AG007	MCLEOD RIVER NEAR ROSEVEAR			
07BB002	PEMBINA RIVER NEAR ENTWISTLE			
07BC002	PEMBINA RIVER AT JARVIE			
07BE001	ATHABASCA RIVER AT ATHABASCA			
07BF002	WEST PRAIRIE RIVER NEAR HIGH PRAIRIE			
07BJ001	SWAN RIVER NEAR KINUSO			
07DA001	ATHABASCA RIVER BELOW FORT MCMURRAY			
07EA004	INGENIKA RIVER ABOVE SWANNELL RIVER			

Station Number	Station Name	Trend in AMAX	Trend in POT exceedances	Trend in POT events
07EA005	FINLAY RIVER ABOVE AKIE RIVER			
07EB002	OSPIKA RIVER ABOVE ALEY CREEK			
07EC002	OMINECA RIVER ABOVE OSILINKA RIVER			✓
07EC003	MESILINKA RIVER ABOVE GOPHERHOLE CREEK			
07EC004	OSILINKA RIVER NEAR END LAKE			
07ED003	NATION RIVER NEAR THE MOUTH			
07EE007	PARSNIP RIVER ABOVE MISINCHINKA RIVER			
07EE009	CHUCHINKA CREEK NEAR THE MOUTH			
07EE010	PACK RIVER AT OUTLET OF MCLEOD LAKE			
07FA006	HALFWAY RIVER NEAR FARRELL CREEK			
07FB001	PINE RIVER AT EAST PINE			
07FB002	MURRAY RIVER NEAR THE MOUTH		✓	
07FB003	SUKUNKA RIVER NEAR THE MOUTH	✓	✓	
07FB006	MURRAY RIVER ABOVE WOLVERINE RIVER			
07FB008	MOBERLY RIVER NEAR FORT ST. JOHN		✓	✓
07FB009	FLATBED CREEK AT KILOMETRE 110 HERITAGE HIGHWAY			
07FC001	BEATTON RIVER NEAR FORT ST. JOHN			
07FD001	KISKATINAW RIVER NEAR FARMINGTON			
07FD004	ALCES RIVER AT 22ND BASE LINE			
07GE001	WAPITI RIVER NEAR GRANDE PRAIRIE			
07GG001	WASKAHIGAN RIVER NEAR THE MOUTH			
07GH002	LITTLE SMOKY RIVER NEAR GUY			
07GJ001	SMOKY RIVER AT WATINO			
07MA003	DOUGLAS RIVER NEAR CLUFF LAKE			
07MB001	MACFARLANE RIVER AT OUTLET OF DAVY LAKE	✓		
07OB001	HAY RIVER NEAR HAY RIVER			
07SA002	SNARE RIVER BELOW GHOST RIVER			
07SA004	INDIN RIVER ABOVE CHALCO LAKE		✓	
07SB010	CAMERON RIVER BELOW REID LAKE			
07SB013	BAKER CREEK AT OUTLET OF LOWER MARTIN LAKE			
08AA008	SEKULMUN RIVER AT OUTLET OF SEKULMUN LAKE			
08AA009	GILTANA CREEK NEAR THE MOUTH			
08AB001	ALSEK RIVER ABOVE BATES RIVER			
08AC001	TAKHANNE RIVER AT KM 167 HAINES HIGHWAY			
08CD001	TUYA RIVER NEAR TELEGRAPH CREEK			
08CE001	STIKINE RIVER AT TELEGRAPH CREEK			
08CF003	STIKINE RIVER NEAR WRANGELL			
08CG001	ISKUT RIVER BELOW JOHNSON RIVER			
08DB001	NASS RIVER ABOVE SHUMAL CREEK			
08EB004	KISPIOX RIVER NEAR HAZELTON			✓
08EC013	BABINE RIVER AT OUTLET OF NILKITKWA LAKE			
08ED001	NANIKA RIVER AT OUTLET OF KIDPRICE LAKE			
08ED002	MORICE RIVER NEAR HOUSTON			
08EE004	BULKLEY RIVER AT QUICK			
08EE008	GOATHORN CREEK NEAR TELKWA			
08EE012	SIMPSON CREEK AT THE MOUTH			
08EE013	BUCK CREEK AT THE MOUTH			
08EE020	TELKWA RIVER BELOW TSAI CREEK			
08EE025	TWO MILE CREEK IN DISTRICT LOT 4834			
08EF001	SKEENA RIVER AT USK			
08EF005	ZYMOETZ RIVER ABOVE O.K. CREEK			
08EG012	EXCHAMSIKS RIVER NEAR TERRACE			
08FA002	WANNOCK RIVER AT OUTLET OF OWIKENO LAKE			
08FC003	DEAN RIVER BELOW TANSWANKET CREEK			
08FE003	KEMANO RIVER ABOVE POWERHOUSE TAILRACE			
08FF001	KITIMAT RIVER BELOW HIRSCH CREEK	✓		
08FF002	HIRSCH CREEK NEAR THE MOUTH			

Station Number	Station Name	Trend in AMAX	Trend in POT exceedances	Trend in POT events
08FF003	LITTLE WEDEENE RIVER BELOW BOWBYES CREEK			
08GA071	ELAHO RIVER NEAR THE MOUTH			✓
08GA072	CHEAKAMUS RIVER ABOVE MILLAR CREEK			
08GD004	HOMATHKO RIVER AT THE MOUTH			
08GD008	HOMATHKO RIVER AT INLET TO TATLAYOKO LAKE			✓
08HA003	KOKSILAH RIVER AT COWICHAN STATION			
08HA010	SAN JUAN RIVER NEAR PORT RENFREW			
08HA016	BINGS CREEK NEAR THE MOUTH			
08HB002	ENGLISHMAN RIVER NEAR PARKSVILLE			
08HB014	SARITA RIVER NEAR BAMFIELD			
08HB025	BROWNS RIVER NEAR COURTENAY			
08HB032	MILLSTONE RIVER AT NANAIMO			
08HB048	CARNATION CREEK AT THE MOUTH	✓		
08HB075	DOVE CREEK NEAR THE MOUTH			
08HD011	OYSTER RIVER BELOW WOODHUS CREEK	✓		
08HE006	ZEBALLOS RIVER NEAR ZEBALLOS		✓	
08HF004	TSITIKA RIVER BELOW CATHERINE CREEK			
08HF005	NIMPKISH RIVER ABOVE WOSS RIVER			
08JA015	LAVENTIE CREEK NEAR THE MOUTH			
08JB002	STELLAKO RIVER AT GLENANNAN			
08JB003	NAUTLEY RIVER NEAR FORT FRASER			
08KA001	DORE RIVER NEAR MCBRIDE			
08KA004	FRASER RIVER AT HANSARD			
08KA005	FRASER RIVER AT MCBRIDE			
08KA009	MCKALE RIVER NEAR 940 M CONTOUR			
08KB001	FRASER RIVER AT SHELLEY			✓
08KB003	MCGREGOR RIVER AT LOWER CANYON			
08KH010	HORSEFLY RIVER ABOVE MCKINLEY CREEK			
08KH019	MOFFAT CREEK NEAR HORSEFLY			
08LA001	CLEARWATER RIVER NEAR CLEARWATER STATION		✓	
08LB020	BARRIERE RIVER AT THE MOUTH			
08LB038	BLUE RIVER NEAR BLUE RIVER			
08LB047	NORTH THOMPSON RIVER AT BIRCH ISLAND			
08LB064	NORTH THOMPSON RIVER AT MCLURE			
08LB069	BARRIERE RIVER BELOW SPRAGUE CREEK			
08LB076	HARPER CREEK NEAR THE MOUTH			
08LC040	VANCE CREEK BELOW DEAFIES CREEK			
08LD001	ADAMS RIVER NEAR SQUILAX			
08LE024	EAGLE RIVER NEAR MALAKWA			
08LE027	SEYMOUR RIVER NEAR SEYMOUR ARM			
08LE077	CORNING CREEK NEAR SQUILAX			
08LE108	EAST CANOE CREEK ABOVE DAM			
08LG016	PENNASK CREEK NEAR QUILCHENA			
08LG048	COLDWATER RIVER NEAR BROOKMERE		✓	
08MA001	CHILKO RIVER NEAR REDSTONE			
08MA002	CHILKO RIVER AT OUTLET OF CHILKO LAKE			
08MA003	TASEKO RIVER AT OUTLET OF TASEKO LAKES			
08MA006	LINGFIELD CREEK NEAR THE MOUTH			
08MB005	CHILCOTIN RIVER BELOW BIG CREEK			
08MB006	BIG CREEK ABOVE GROUNDHOG CREEK		✓	
08MB007	BIG CREEK BELOW GRAVEYARD CREEK			
08ME023	BRIDGE RIVER (SOUTH BRANCH) BELOW BRIDGE GLACIER			
08ME025	YALAKOM RIVER ABOVE ORE CREEK			
08MG001	CHEHALIS RIVER NEAR HARRISON MILLS			
08MG005	LILLOOET RIVER NEAR PEMBERTON			
08MG013	HARRISON RIVER NEAR HARRISON HOT SPRINGS			
08MH006	NORTH ALOUETTE RIVER AT 232ND STREET, MAPLE RIDGE			

Station Number	Station Name	Trend in AMAX	Trend in POT exceedances	Trend in POT events
08MH103	CHILLIWACK RIVER ABOVE SLESSE CREEK			
08MH141	COQUITLAM RIVER ABOVE COQUITLAM LAKE			
08MH147	STAVE RIVER ABOVE STAVE LAKE			
08MH155	NICOMEKL RIVER AT 203 STREET, LANGLEY			
08NA002	COLUMBIA RIVER AT NICHOLSON			
08NA006	KICKING HORSE RIVER AT GOLDEN			
08NB012	BLAEBERRY RIVER ABOVE WILLOWBANK CREEK			
08NB014	GOLD RIVER ABOVE PALMER CREEK			
08NB016	SPLIT CREEK AT THE MOUTH			
08NB019	BEAVER RIVER NEAR THE MOUTH			
08ND012	GOLDSTREAM RIVER BELOW OLD CAMP CREEK			
08ND013	ILLECILLEWAET RIVER AT GREELEY			
08NE039	BIG SHEEP CREEK NEAR ROSSLAND			
08NE074	SALMO RIVER NEAR SALMO			
08NE077	BARNES CREEK NEAR NEEDLES			
08NE087	DEER CREEK AT DEER PARK			
08NE110	INONOAKLIN CREEK ABOVE VALLEY CREEK			
08NE114	HIDDEN CREEK NEAR THE MOUTH			
08NF001	KOOTENAY RIVER AT KOOTENAY CROSSING			
08NG065	KOOTENAY RIVER AT FORT STEELE			
08NG076	MATHER CREEK BELOW HOULE CREEK			
08NG077	ST. MARY RIVER BELOW MORRIS CREEK			
08NH005	KASLO RIVER BELOW KEMP CREEK			
08NH006	MOYIE RIVER AT EASTPORT			
08NH016	DUCK CREEK NEAR WYNNDEL			
08NH084	ARROW CREEK NEAR ERICKSON			
08NH115	SULLIVAN CREEK NEAR CANYON			
08NH119	DUNCAN RIVER BELOW B.B. CREEK			
08NH120	MOYIE RIVER ABOVE NEGRO CREEK			
08NH130	FRY CREEK BELOW CARNEY CREEK			
08NH132	KEEN CREEK BELOW KYAWATS CREEK			
08NJ013	SLOCAN RIVER NEAR CRESCENT VALLEY			
08NJ130	ANDERSON CREEK NEAR NELSON			
08NJ160	LEMON CREEK ABOVE SOUTH LEMON CREEK			
08NJ168	FIVE MILE CREEK ABOVE CITY INTAKE		✓	
08NK002	ELK RIVER AT FERNIE			
08NK016	ELK RIVER NEAR NATAL			
08NK018	FORDING RIVER AT THE MOUTH			
08NK022	LINE CREEK AT THE MOUTH			
08NK026	HOSMER CREEK ABOVE DIVERSIONS			
08NL004	ASHNOLA RIVER NEAR KEREMEOS			
08NL007	SIMILKAMEEN RIVER AT PRINCETON			
08NL024	TULAMEEN RIVER AT PRINCETON			
08NL038	SIMILKAMEEN RIVER NEAR HEDLEY			
08NL050	HEDLEY CREEK NEAR THE MOUTH			
08NL069	PASAYTEN RIVER ABOVE CALCITE CREEK			
08NL071	TULAMEEN RIVER BELOW VUICH CREEK	✓		
08NM134	CAMP CREEK AT MOUTH NEAR THIRSK			
08NM171	VASEUX CREEK ABOVE SOLCO CREEK			
08NM173	GREATA CREEK NEAR THE MOUTH			
08NM240	TWO FORTY CREEK NEAR PENTICTON			
08NM241	TWO FORTY-ONE CREEK NEAR PENTICTON			✓
08NN002	GRANBY RIVER AT GRAND FORKS			
08NN012	KETTLE RIVER NEAR LAURIER			
08NN013	KETTLE RIVER NEAR FERRY			
08NN015	WEST KETTLE RIVER NEAR MCCULLOCH			
08NN019	TRAPPING CREEK NEAR THE MOUTH			

Station Number	Station Name	Trend in AMAX	Trend in POT exceedances	Trend in POT events
08NN023	BURRELL CREEK ABOVE GLOUCESTER CREEK			
08NP004	CABIN CREEK NEAR THE MOUTH			
09AC001	TAKHINI RIVER NEAR WHITEHORSE			✓
09AE003	SWIFT RIVER NEAR SWIFT RIVER			
09AH003	BIG CREEK NEAR THE MOUTH			
09AH004	NORDENSKIOLD RIVER BELOW ROWLINSON CREEK			
09BA001	ROSS RIVER AT ROSS RIVER			
09BC001	PELLY RIVER AT PELLY CROSSING			
09BC004	PELLY RIVER BELOW VANGORDA CREEK			
09CA004	DUKE RIVER NEAR THE MOUTH			
09CD001	YUKON RIVER ABOVE WHITE RIVER			
09DD003	STEWART RIVER AT THE MOUTH			
09DD004	MCQUESTEN RIVER NEAR THE MOUTH			
09EA003	KLONDIKE RIVER ABOVE BONANZA CREEK			
09EA004	NORTH KLONDIKE RIVER NEAR THE MOUTH			
09EB003	INDIAN RIVER ABOVE THE MOUTH			
09FC001	OLD CROW RIVER NEAR THE MOUTH			
09FD002	PORCUPINE RIVER NEAR INTERNATIONAL BOUNDARY			
10AA001	LIARD RIVER AT UPPER CROSSING			
10AA004	RANCHERIA RIVER NEAR THE MOUTH			
10AB001	FRANCES RIVER NEAR WATSON LAKE			
10AC005	COTTONWOOD RIVER ABOVE BASS CREEK			
10BE001	LIARD RIVER AT LOWER CROSSING			
10BE004	TOAD RIVER ABOVE NONDA CREEK			
10BE007	TROUT RIVER AT KILOMETRE 783.7 ALASKA HIGHWAY			
10BE009	TEETER CREEK NEAR THE MOUTH			
10CB001	SIKANNI CHIEF RIVER NEAR FORT NELSON			✓
10CD001	MUSKWA RIVER NEAR FORT NELSON			
10CD003	RASPBERRY CREEK NEAR THE MOUTH			
10CD004	BOUGIE CREEK AT KILOMETRE 368 ALASKA HIGHWAY			
10CD005	ADSETT CREEK AT KILOMETRE 386.0 ALASKA HIGHWAY			
10EA003	FLAT RIVER NEAR THE MOUTH			
10EB001	SOUTH NAHANNI RIVER ABOVE VIRGINIA FALLS			
10ED001	LIARD RIVER AT FORT LIARD			
10ED002	LIARD RIVER NEAR THE MOUTH			
10ED003	BIRCH RIVER AT HIGHWAY NO. 7	✓		
10FA002	TROUT RIVER AT HIGHWAY NO. 1		✓	
10FB005	JEAN-MARIE RIVER AT HIGHWAY NO. 1	✓		
10LA002	ARCTIC RED RIVER NEAR THE MOUTH		✓	
10MC002	PEEL RIVER ABOVE FORT MCPHERSON			
10ND002	TRAIL VALLEY CREEK NEAR INUVIK			✓

40-year window:

Station Number	Station Name	Trend in AMAX	Trend in POT exceedances	Trend in POT events
01AD002	SAINT JOHN RIVER AT FORT KENT			
01AD003	ST. FRANCIS RIVER AT OUTLET OF GLASIER LAKE			
01AF007	GRANDE RIVIERE AT VIOLETTE BRIDGE			✓
01AJ003	MEDUXNEKEAG RIVER NEAR BELLEVILLE			
01AJ004	BIG PRESQUE ISLE STREAM AT TRACEY MILLS			
01AJ010	BECAGUIMEC STREAM AT COLDSTREAM			✓
01AK001	SHOGOMOC STREAM NEAR TRANS CANADA HIGHWAY			
01AK007	NACKAWIC STREAM NEAR TEMPERANCE VALE	✓		✓
01AL004	NARROWS MOUNTAIN BROOK NEAR NARROWS MOUNTAIN		✓	
01AN002	SALMON RIVER AT CASTAWAY			
01AP002	CANAAN RIVER AT EAST CANAAN			
01AP004	KENNEBECASIS RIVER AT APOHAQUI			
01AQ001	LEPREAU RIVER AT LEPREAU		✓	
01BC001	RESTIGOUCHE RIVER BELOW KEDGWICK RIVER			
01BE001	UPSALQUITCH RIVER AT UPSALQUITCH			✓
01BG005	CASCAPEDIA (RIVIERE) EN AVAL DU RUISSEAU BERRY			
01BH005	DARTMOUTH (RIVIERE) EN AMONT DU RUISSEAU DU PAS DE DAME			
01BH010	YORK (RIVIERE) A 1,4 KM EN AVAL DU RUISSEAU DINNER ISLAND			
01BJ003	JACQUET RIVER NEAR DURHAM CENTRE			
01BJ007	RESTIGOUCHE RIVER ABOVE RAFTING GROUND BROOK			
01BL002	RIVIERE CARAQUET AT BURNSVILLE			
01BL003	BIG TRACADIE RIVER AT MURCHY BRIDGE CROSSING			
01BO001	SOUTHWEST MIRAMICHI RIVER AT BLACKVILLE			
01BP001	LITTLE SOUTHWEST MIRAMICHI RIVER AT LYTTLETON			
01BQ001	NORTHWEST MIRAMICHI RIVER AT TROUT BROOK			
01BS001	COAL BRANCH RIVER AT BEERSVILLE			
01BU002	PETITCODIAC RIVER NEAR PETITCODIAC			
01BV006	POINT WOLFE RIVER AT FUNDY NATIONAL PARK			
01CA003	CARRUTHERS BROOK NEAR ST. ANTHONY	✓	✓	
01DG003	BEAVERBANK RIVER NEAR KINSAC	✓	✓	
01DL001	KELLEY RIVER (MILL CREEK) AT EIGHT MILE FORD			
01DR001	SOUTH RIVER AT ST. ANDREWS			
01EC001	ROSEWAY RIVER AT LOWER OHIO			
01ED007	MERSEY RIVER BELOW MILL FALLS			
01EF001	LAHAVE RIVER AT WEST NORTHFIELD			
01EJ001	SACKVILLE RIVER AT BEDFORD	✓		
01EO001	ST. MARYS RIVER AT STILLWATER			
01FA001	RIVER INHABITANTS AT GLENORA			
01FB001	NORTHEAST MARGAREE RIVER AT MARGAREE VALLEY			
01FB003	SOUTHWEST MARGAREE RIVER NEAR UPPER MARGAREE		✓	
02AB008	NEEBING RIVER NEAR THUNDER BAY			
02AC002	BLACK STURGEON RIVER AT HIGHWAY NO. 17			
02AD010	BLACKWATER RIVER AT BEARDMORE			
02BA003	LITTLE PIC RIVER NEAR COLDWELL			
02BB003	PIC RIVER NEAR MARATHON			
02BF001	BATCHAWANA RIVER NEAR BATCHAWANA			
02BF002	GOULAIS RIVER NEAR SEARCHMONT			
02BF004	BIG CARP RIVER NEAR SAULT STE. MARIE			
02CA002	ROOT RIVER AT SAULT STE. MARIE			
02CB003	AUBINADONG RIVER ABOVE SESABIC CREEK			
02CF007	WHITSON RIVER AT CHELMSFORD			
02CF008	WHITSON RIVER AT VAL CARON			
02CF012	JUNCTION CREEK BELOW KELLEY LAKE			
02DB007	CONISTON CREEK ABOVE WANAPITEI RIVER			

Station Number	Station Name	Trend in AMAX	Trend in POT exceedances	Trend in POT events
02DD013	LA VASE RIVER AT NORTH BAY			
02DD014	CHIPPEWA CREEK AT NORTH BAY			
02DD015	COMMANDA CREEK NEAR COMMANDA			
02EA005	NORTH MAGNETAWAN RIVER NEAR BURK'S FALLS			
02EA010	NORTH MAGNETAWAN RIVER ABOVE PICKEREL LAKE			
02EC002	BLACK RIVER NEAR WASHAGO			
02EC009	HOLLAND RIVER EAST BRANCH AT HOLLAND LANDING			
02ED003	NOTTAWASAGA RIVER NEAR BAXTER			
02FA002	STOKES RIVER NEAR FERNDALE			
02FB007	SYDENHAM RIVER NEAR OWEN SOUND			
02FE009	SOUTH MAITLAND RIVER AT SUMMERHILL			
02FF004	SOUTH PARKHILL CREEK NEAR PARKHILL		✓	
02FF007	BAYFIELD RIVER NEAR VARNA			✓
02FF008	PARKHILL CREEK ABOVE PARKHILL RESERVOIR			
02GA010	NITH RIVER NEAR CANNING		✓	
02GA018	NITH RIVER AT NEW HAMBURG	✓		
02GA038	NITH RIVER ABOVE NITHBURG			
02GB007	FAIRCHILD CREEK NEAR BRANTFORD			
02GC002	KETTLE CREEK AT ST. THOMAS			
02GC018	CATFISH CREEK NEAR SPARTA			
02GD004	MIDDLE THAMES RIVER AT THAMESFORD			
02GD021	THAMES RIVER AT INNERKIP			
02GE005	DINGMAN CREEK BELOW LAMBETH			
02GG002	SYDENHAM RIVER NEAR ALVINSTON			
02GG006	BEAR CREEK NEAR PETROLIA			✓
02GH002	RUSCOM RIVER NEAR RUSCOM STATION	✓		
02GH003	CANARD RIVER NEAR LUKERVILLE			
02HA006	TWENTY MILE CREEK AT BALLS FALLS			
02HB004	EAST SIXTEEN MILE CREEK NEAR OMAGH	✓		
02HB012	GRINDSTONE CREEK NEAR ALDERSHOT		✓	
02HC009	EAST HUMBER RIVER NEAR PINE GROVE		✓	
02HC018	LYNDE CREEK NEAR WHITBY			
02HC019	DUFFINS CREEK ABOVE PICKERING	✓		
02HC028	LITTLE ROUGE CREEK NEAR LOCUST HILL			
02HC030	ETOBICOKE CREEK BELOW QUEEN ELIZABETH HIGHWAY		✓	
02HC031	WEST HUMBER RIVER AT HIGHWAY NO. 7			
02HC033	MIMICO CREEK AT ISLINGTON			
02HL003	BLACK RIVER NEAR ACTINOLITE			
02HL005	MOIRA RIVER NEAR DELORO			
02HM004	WILTON CREEK NEAR NAPANEE			
02HM005	COLLINS CREEK NEAR KINGSTON			
02JB013	KINOJEVIS (RIVIERE) A 0,3 KM EN AMONT DU PONT-ROUTE A CLERICY			
02JC008	BLANCHE RIVER ABOVE ENGLEHART			
02LB006	CASTOR RIVER AT RUSSELL			
02LC027	DONCASTER (RIVIERE) AU LAC ELEVE			
02LC043	SAINT-LOUIS (RUISSEAU) A 0,3 KM DE LA RIVIERE DU DIABLE			
02LG005	GATINEAU (RIVIERE) AUX RAPIDES CEIZUR			
02OA057	ANGLAIS (RIVIERE DES) A 1,1 KM EN AVAL DU PONT-ROUTE A TRES-SAINT-SACREMENT			
02OB037	ACHIGAN (RIVIERE DE L') A L'EPIPHANIE			
02OD003	NICOLET (RIVIERE) A 5,8 KM EN AVAL DE LA RIVIERE BULSTRODE			
02OE027	EATON (RIVIERE) PRES DE LA RIVIERE SAINT-FRANCOIS-3			✓
02OE032	SAUMON (RIVIERE AU) A 1,9 KM EN AMONT DE LA MOFFAT			
02OG007	YAMASKA NORD (RIVIERE) A VAL-SHEFFORD			
02OG026	DAVID (RIVIERE) AU PONT-ROUTE A SAINT-DAVID			
02OJ007	RICHELIEU (RIVIERE) AUX RAPIDES FRYERS			

Station Number	Station Name	Trend in AMAX	Trend in POT exceedances	Trend in POT events
02OJ024	HURONS (RIVIERE DES) EN AVAL DU RUISSEAU SAINT-LOUIS-2			
02PA007	BATISCAN (RIVIERE) A 3,4 KM EN AVAL DE LA RIVIERE DES ENVIES			
02PB006	SAINTE-ANNE (RIVIERE) (BRAS DU NORD DE LA) EN AMONT			
02PD002	MONTMORENCY (RIVIERE) A 0,6 KM EN AVAL DU BARRAGE DES MARCHES NATURELLES			
02PD012	EAUX VOLEES (RUISSEAU DES) EN AMONT DU CHEMIN DU BELVEDERE			
02PD014	AULNAIES OUEST (RUISSEAU DES) EN AMONT DU CHEMIN DU BELVEDERE			
02PD015	AULNAIES (RUISSEAU DES) PRES DU RUISSEAU DES EAUX VOLEES	✓		
02PE014	DAUPHINE (RIVIERE) A L' ILE D'ORLEANS			✓
02PG006	LOUP (RIVIERE DU) A SAINT-JOSEPH-DE-KAMOURASKA			
02PJ007	BEAURIVAGE (RIVIERE) A SAINTE-ETIENNE			
02PJ030	FAMINE (RIVIERE) A SAINT-GEORGES			
02PL005	BECANCOUR (RIVIERE) A 2,1 KM EN AMONT DE LA RIVIERE PALMER			
02QA002	RIMOUSKI (RIVIERE) A 3,7 KM EN AMONT DU PONT-ROUTE 132			
02QC009	SAINTE-ANNE (RIVIERE) A 9,7 KM EN AMONT DU PONT-ROUTE 132			
02RC011	PERIBONCA (PETITE RIVIERE)			
02RD003	MISTASSINI (RIVIERE) EN AMONT DE LA RIVIERE MISTASSIBI			
02RF001	ASHUAPMUSHUAN (RIVIERE) A LA TETE DE LA CHUTE AUX SAUMONS			
02RG005	METABETCHOUANE (RIVIERE) EN AMONT DE LA CENTRALE S.R.P.C.			✓
02RH027	PIKAUBA (RIVIERE) EN AMONT DE LA RIVIERE APICA			
02RH045	VALIN (RIVIERE) A 3,5 KM DE L'EMBOUCHURE			
02UA003	GODBOUT (RIVIERE) A 1,6 KM EN AMONT DU PONT-ROUTE 138			
02UC002	MOISIE (RIVIERE) A 5,1 KM EN AMONT DU PONT DU Q.N.S.L.R.			
02VB004	MAGPIE (RIVIERE) A LA SORTIE DU LAC MAGPIE			
02VC001	ROMAINE (RIVIERE) AU PONT DE LA Q.I.T.			
02WB003	NATASHQUAN (RIVIERE) A 0,6 KM EN AVAL DE LA DECHARGE DU LAC ALIESTE			✓
02XA003	LITTLE MECATINA RIVER ABOVE LAC FOURMONT			
02XC001	SAINT-PAUL (RIVIERE) A 0,5 KM DU RUISSEAU CHANION			
02YD002	NORTHEAST BROOK NEAR RODDICKTON			✓
02YL001	UPPER HUMBER RIVER NEAR REIDVILLE			
02YM003	SOUTH WEST BROOK NEAR BAIE VERTE			
02YN002	LLOYDS RIVER BELOW KING GEORGE IV LAKE			
02YO006	PETERS RIVER NEAR BOTWOOD			
02YQ001	GANDER RIVER AT BIG CHUTE			
02YR001	MIDDLE BROOK NEAR GAMBO			
02YR003	INDIAN BAY BROOK NEAR NORTHWEST ARM		✓	
02YS003	SOUTHWEST BROOK AT TERRA NOVA NATIONAL PARK			
02ZB001	ISLE AUX MORTS RIVER BELOW HIGHWAY BRIDGE			
02ZF001	BAY DU NORD RIVER AT BIG FALLS	✓	✓	
02ZG001	GARNISH RIVER NEAR GARNISH			
02ZG003	SALMONIER RIVER NEAR LAMALINE			
02ZH001	PIPERS HOLE RIVER AT MOTHERS BROOK			
02ZH002	COME BY CHANCE RIVER NEAR GOOBIES			✓
02ZJ001	SOUTHERN BAY RIVER NEAR SOUTHERN BAY			
02ZK001	ROCKY RIVER NEAR COLINET			
02ZK002	NORTHEAST RIVER NEAR PLACENTIA		✓	✓
02ZM006	NORTHEAST POND RIVER AT NORTHEAST POND		✓	
02ZM008	WATERFORD RIVER AT KILBRIDE			
03AB002	WASWANIPI (RIVIERE) A LA CHUTE ROUGE			
03AC004	BELL (RIVIERE) EN AMONT DU LAC MATAGAMI			
03BD002	BROADBACK (RIVIERE) A LA SORTIE DU LAC QUENONISCA			
03BF001	PONTAX (RIVIERE) A 60,4 KM DE L'EMBOUCHURE			
03ED001	BALEINE (GRANDE RIVIERE DE LA) EN AMONT DE LA RIVIERE DENYS-1			

Station Number	Station Name	Trend in AMAX	Trend in POT exceedances	Trend in POT events
03NF001	UGJOKTOK RIVER BELOW HARP LAKE			
03QC001	EAGLE RIVER ABOVE FALLS			
03QC002	ALEXIS RIVER NEAR PORT HOPE SIMPSON			
04DA001	PIPESTONE RIVER AT KARL LAKE			
04FC001	ATTAWAPISKAT RIVER BELOW MUKETEI RIVER			
04JC002	NAGAGAMI RIVER AT HIGHWAY NO. 11			
04JD005	PAGWACHUAN RIVER AT HIGHWAY NO. 11			
04KA001	KWETABOHIGAN RIVER NEAR THE MOUTH			
04LJ001	MISSINAIBI RIVER AT MATTICE			
04LM001	MISSINAIBI RIVER BELOW WABOOSE RIVER			
04MF001	NORTH FRENCH RIVER NEAR THE MOUTH			
05AA008	CROWSNEST RIVER AT FRANK		✓	
05AA022	CASTLE RIVER NEAR BEAVER MINES			
05AD003	WATERTON RIVER NEAR WATERTON PARK			✓
05BG006	WAIPAROUS CREEK NEAR THE MOUTH	✓		
05BJ004	ELBOW RIVER AT BRAGG CREEK			
05BL014	SHEEP RIVER AT BLACK DIAMOND	✓		
05BL022	CATARACT CREEK NEAR FORESTRY ROAD	✓		
05CA009	RED DEER RIVER BELOW BURNT TIMBER CREEK			
05CB001	LITTLE RED DEER RIVER NEAR THE MOUTH	✓	✓	✓
05CB004	RAVEN RIVER NEAR RAVEN			
05CC001	BLINDMAN RIVER NEAR BLACKFALDS			
05CC007	MEDICINE RIVER NEAR ECKVILLE			
05DA007	MISTAYA RIVER NEAR SASKATCHEWAN CROSSING			
05DA009	NORTH SASKATCHEWAN RIVER AT WHIRLPOOL POINT			
05DA010	SILVERHORN CREEK NEAR THE MOUTH			
05DB002	PRAIRIE CREEK NEAR ROCKY MOUNTAIN HOUSE			✓
05DC006	RAM RIVER NEAR THE MOUTH			
05DD009	NORDEGG RIVER AT SUNCHILD ROAD			
05FA001	BATTLE RIVER NEAR PONOKA			
05HD036	SWIFT CURRENT CREEK BELOW ROCK CREEK			
05KH007	CARROT RIVER NEAR TURNBERRY			
05LC001	RED DEER RIVER NEAR ERWOOD			✓
05LH005	WATERHEN RIVER NEAR WATERHEN		✓	
05LL014	PINE CREEK NEAR MELBOURNE			
05PA012	BASSWOOD RIVER NEAR WINTON			
05PH003	WHITEMOUTH RIVER NEAR WHITEMOUTH	✓		✓
05QA002	ENGLISH RIVER AT UMFREVILLE			✓
05QA004	STURGEON RIVER AT MCDOUGALL MILLS	✓	✓	
05QE009	STURGEON RIVER AT OUTLET OF SALVESEN LAKE		✓	✓
05TG003	ODEI RIVER NEAR THOMPSON			
05UF004	KETTLE RIVER NEAR GILLAM			
06AG002	DORE RIVER NEAR THE MOUTH			
06BA002	DILLON RIVER BELOW DILLON LAKE			
06BB005	CANOE RIVER NEAR BEAUVAL			
06BD001	HAULTAIN RIVER ABOVE NORBERT RIVER			
06DA004	GEIKIE RIVER BELOW WHEELER RIVER	✓	✓	
06FB002	LITTLE BEAVER RIVER NEAR THE MOUTH			
07AD002	ATHABASCA RIVER AT HINTON			
07AF002	MCLEOD RIVER ABOVE EMBARRAS RIVER			
07BB002	PEMBINA RIVER NEAR ENTWISTLE			
07BC002	PEMBINA RIVER AT JARVIE			
07BE001	ATHABASCA RIVER AT ATHABASCA			
07BF002	WEST PRAIRIE RIVER NEAR HIGH PRAIRIE			
07BJ001	SWAN RIVER NEAR KINUSO			
07DA001	ATHABASCA RIVER BELOW FORT MCMURRAY			✓
07EA004	INGENIKA RIVER ABOVE SWANNELL RIVER			

Station Number	Station Name	Trend in AMAX	Trend in POT exceedances	Trend in POT events
07EA005	FINLAY RIVER ABOVE AKIE RIVER			
07EC002	OMINECA RIVER ABOVE OSILINKA RIVER			
07EC003	MESILINKA RIVER ABOVE GOPHERHOLE CREEK			
07EE007	PARSNIP RIVER ABOVE MISINCHINKA RIVER			
07EE009	CHUCHINKA CREEK NEAR THE MOUTH			
07FB001	PINE RIVER AT EAST PINE			
07FB002	MURRAY RIVER NEAR THE MOUTH			
07FB003	SUKUNKA RIVER NEAR THE MOUTH			
07FB006	MURRAY RIVER ABOVE WOLVERINE RIVER			
07FC001	BEATTON RIVER NEAR FORT ST. JOHN			
07FC003	BLUEBERRY RIVER BELOW AITKEN CREEK			
07FD001	KISKATINAW RIVER NEAR FARMINGTON			
07GE001	WAPITI RIVER NEAR GRANDE PRAIRIE			
07GG001	WASKAHIGAN RIVER NEAR THE MOUTH			
07GH002	LITTLE SMOKY RIVER NEAR GUY			
07GJ001	SMOKY RIVER AT WATINO			
07MA003	DOUGLAS RIVER NEAR CLUFF LAKE			
07MB001	MACFARLANE RIVER AT OUTLET OF DAVY LAKE			
07OB001	HAY RIVER NEAR HAY RIVER		✓	
07SA004	INDIN RIVER ABOVE CHALCO LAKE			
07SB010	CAMERON RIVER BELOW REID LAKE			
08AA009	GILTANA CREEK NEAR THE MOUTH			
08AB001	ALSEK RIVER ABOVE BATES RIVER			✓
08CD001	TUYA RIVER NEAR TELEGRAPH CREEK			
08CE001	STIKINE RIVER AT TELEGRAPH CREEK			
08CG001	ISKUT RIVER BELOW JOHNSON RIVER			
08DB001	NASS RIVER ABOVE SHUMAL CREEK			
08EB004	KISPIOX RIVER NEAR HAZELTON			
08EC013	BABINE RIVER AT OUTLET OF NILKITKWA LAKE			
08ED001	NANIKA RIVER AT OUTLET OF KIDPRICE LAKE			
08ED002	MORICE RIVER NEAR HOUSTON			
08EE004	BULKLEY RIVER AT QUICK			
08EE008	GOATHORN CREEK NEAR TELKWA			
08EE012	SIMPSON CREEK AT THE MOUTH			✓
08EE013	BUCK CREEK AT THE MOUTH			
08EE020	TELKWA RIVER BELOW TSAI CREEK			
08EF001	SKEENA RIVER AT USK			
08EF005	ZYMOETZ RIVER ABOVE O.K. CREEK			
08EG012	EXCHAMSIKS RIVER NEAR TERRACE			
08FA002	WANNOCK RIVER AT OUTLET OF OWIKENO LAKE			✓
08FC003	DEAN RIVER BELOW TANSWANKET CREEK			
08FE003	KEMANO RIVER ABOVE POWERHOUSE TAILRACE			✓
08FF001	KITIMAT RIVER BELOW HIRSCH CREEK			
08FF002	HIRSCH CREEK NEAR THE MOUTH			
08FF003	LITTLE WEDEENE RIVER BELOW BOWBYES CREEK			
08GD004	HOMATHKO RIVER AT THE MOUTH	✓		
08HA003	KOKSILAH RIVER AT COWICHAN STATION			
08HA016	BINGS CREEK NEAR THE MOUTH			
08HB002	ENGLISHMAN RIVER NEAR PARKSVILLE			
08HB014	SARITA RIVER NEAR BAMFIELD			
08HB048	CARNATION CREEK AT THE MOUTH	✓		
08HD011	OYSTER RIVER BELOW WOODHUS CREEK			
08HE006	ZEBALLOS RIVER NEAR ZEBALLOS			
08HF004	TSITIKA RIVER BELOW CATHERINE CREEK			
08JA015	LAVENTIE CREEK NEAR THE MOUTH			
08JB002	STELLAKO RIVER AT GLENANNAN			
08JB003	NAUTLEY RIVER NEAR FORT FRASER			✓

Station Number	Station Name	Trend in AMAX	Trend in POT exceedances	Trend in POT events
08JE004	TSILCOH RIVER NEAR THE MOUTH			
08KA001	DORE RIVER NEAR MCBRIDE			
08KA004	FRASER RIVER AT HANSARD			
08KA005	FRASER RIVER AT MCBRIDE			
08KA009	MCKALE RIVER NEAR 940 M CONTOUR			
08KB001	FRASER RIVER AT SHELLEY			
08KB003	MCGREGOR RIVER AT LOWER CANYON			
08KB006	MULLER CREEK NEAR THE MOUTH			
08KE016	BAKER CREEK AT QUESNEL	✓	✓	
08KE024	LITTLE SWIFT RIVER AT THE MOUTH			
08KH010	HORSEFLY RIVER ABOVE MCKINLEY CREEK	✓		
08KH019	MOFFAT CREEK NEAR HORSEFLY			
08LA001	CLEARWATER RIVER NEAR CLEARWATER STATION			
08LB020	BARRIERE RIVER AT THE MOUTH			
08LB024	FISHTRAP CREEK NEAR MCLURE			
08LB047	NORTH THOMPSON RIVER AT BIRCH ISLAND			
08LB064	NORTH THOMPSON RIVER AT MCLURE			
08LB069	BARRIERE RIVER BELOW SPRAGUE CREEK			
08LB076	HARPER CREEK NEAR THE MOUTH			
08LD001	ADAMS RIVER NEAR SQUILAX			✓
08LE024	EAGLE RIVER NEAR MALAKWA			
08LE027	SEYMOUR RIVER NEAR SEYMOUR ARM			
08LG016	PENNASK CREEK NEAR QUILCHENA			
08LG048	COLDWATER RIVER NEAR BROOKMERE			
08MA001	CHILKO RIVER NEAR REDSTONE	✓		✓
08MA002	CHILKO RIVER AT OUTLET OF CHILKO LAKE	✓		
08MA006	LINGFIELD CREEK NEAR THE MOUTH			
08MB005	CHILCOTIN RIVER BELOW BIG CREEK			✓
08MB006	BIG CREEK ABOVE GROUNDHOG CREEK			
08MB007	BIG CREEK BELOW GRAVEYARD CREEK			
08MG005	LILLOOET RIVER NEAR PEMBERTON			✓
08MG013	HARRISON RIVER NEAR HARRISON HOT SPRINGS			
08MH006	NORTH ALOUETTE RIVER AT 232ND STREET, MAPLE RIDGE			
08MH076	KANAKA CREEK NEAR WEBSTER CORNERS			
08MH103	CHILLIWACK RIVER ABOVE SLESSE CREEK			
08NA002	COLUMBIA RIVER AT NICHOLSON			
08NA006	KICKING HORSE RIVER AT GOLDEN			
08NB012	BLAEBERRY RIVER ABOVE WILLOWBANK CREEK			
08NB014	GOLD RIVER ABOVE PALMER CREEK			
08NB016	SPLIT CREEK AT THE MOUTH			
08ND012	GOLDSTREAM RIVER BELOW OLD CAMP CREEK			
08ND013	ILLECILLEWAET RIVER AT GREELEY			
08NE039	BIG SHEEP CREEK NEAR ROSSLAND			
08NE074	SALMO RIVER NEAR SALMO			
08NE077	BARNES CREEK NEAR NEEDLES		✓	
08NE087	DEER CREEK AT DEER PARK			
08NE114	HIDDEN CREEK NEAR THE MOUTH			
08NF001	KOOTENAY RIVER AT KOOTENAY CROSSING			
08NG065	KOOTENAY RIVER AT FORT STEELE			
08NG076	MATHER CREEK BELOW HOULE CREEK			
08NG077	ST. MARY RIVER BELOW MORRIS CREEK			
08NH005	KASLO RIVER BELOW KEMP CREEK			
08NH006	MOYIE RIVER AT EASTPORT			
08NH016	DUCK CREEK NEAR WYNNDEL			✓
08NH084	ARROW CREEK NEAR ERICKSON			
08NH115	SULLIVAN CREEK NEAR CANYON			
08NH119	DUNCAN RIVER BELOW B.B. CREEK			

Station Number	Station Name	Trend in AMAX	Trend in POT exceedances	Trend in POT events
08NH120	MOYIE RIVER ABOVE NEGRO CREEK			
08NH130	FRY CREEK BELOW CARNEY CREEK			
08NH132	KEEN CREEK BELOW KYAWATS CREEK			
08NJ013	SLOCAN RIVER NEAR CRESCENT VALLEY			
08NJ130	ANDERSON CREEK NEAR NELSON			
08NJ160	LEMON CREEK ABOVE SOUTH LEMON CREEK			
08NK002	ELK RIVER AT FERNIE			
08NK016	ELK RIVER NEAR NATAL			
08NK018	FORDING RIVER AT THE MOUTH			
08NK022	LINE CREEK AT THE MOUTH			
08NL004	ASHNOLA RIVER NEAR KEREMEOS			
08NL007	SIMILKAMEEN RIVER AT PRINCETON			
08NL024	TULAMEEN RIVER AT PRINCETON			
08NL038	SIMILKAMEEN RIVER NEAR HEDLEY			
08NL050	HEDLEY CREEK NEAR THE MOUTH			
08NL069	PASAYTEN RIVER ABOVE CALCITE CREEK			
08NL070	SIMILKAMEEN RIVER ABOVE GOODFELLOW CREEK			
08NL071	TULAMEEN RIVER BELOW VUICH CREEK			
08NM134	CAMP CREEK AT MOUTH NEAR THIRSK			
08NM142	COLDSTREAM CREEK ABOVE MUNICIPAL INTAKE			
08NM171	VASEUX CREEK ABOVE SOLCO CREEK			
08NM173	GREATA CREEK NEAR THE MOUTH			✓
08NM174	WHITEMAN CREEK ABOVE BOULEAU CREEK			
08NN002	GRANBY RIVER AT GRAND FORKS			
08NN012	KETTLE RIVER NEAR LAURIER			
08NN013	KETTLE RIVER NEAR FERRY			
08NN015	WEST KETTLE RIVER NEAR MCCULLOCH			
08NN019	TRAPPING CREEK NEAR THE MOUTH	✓		
08NN023	BURRELL CREEK ABOVE GLOUCESTER CREEK			
08NP004	CABIN CREEK NEAR THE MOUTH			
09AC001	TAKHINI RIVER NEAR WHITEHORSE			
09AE003	SWIFT RIVER NEAR SWIFT RIVER			
09AH003	BIG CREEK NEAR THE MOUTH			
09BA001	ROSS RIVER AT ROSS RIVER			
09BC001	PELLY RIVER AT PELLY CROSSING			
09BC004	PELLY RIVER BELOW VANGORDA CREEK			
09CD001	YUKON RIVER ABOVE WHITE RIVER			
09DD003	STEWART RIVER AT THE MOUTH			
09DD004	MCQUESTEN RIVER NEAR THE MOUTH			
09EA003	KLONDIKE RIVER ABOVE BONANZA CREEK			
09EA004	NORTH KLONDIKE RIVER NEAR THE MOUTH			
10AA001	LIARD RIVER AT UPPER CROSSING			
10AB001	FRANCES RIVER NEAR WATSON LAKE	✓		
10AC005	COTTONWOOD RIVER ABOVE BASS CREEK			
10BE001	LIARD RIVER AT LOWER CROSSING			
10BE004	TOAD RIVER ABOVE NONDA CREEK			
10BE007	TROUT RIVER AT KILOMETRE 783.7 ALASKA HIGHWAY			
10BE009	TEETER CREEK NEAR THE MOUTH			
10CB001	SIKANNI CHIEF RIVER NEAR FORT NELSON			
10CD001	MUSKWA RIVER NEAR FORT NELSON	✓	✓	
10EA003	FLAT RIVER NEAR THE MOUTH			
10EB001	SOUTH NAHANNI RIVER ABOVE VIRGINIA FALLS			
10ED001	LIARD RIVER AT FORT LIARD			
10ED002	LIARD RIVER NEAR THE MOUTH			✓
10ED003	BIRCH RIVER AT HIGHWAY NO. 7			✓
10FA002	TROUT RIVER AT HIGHWAY NO. 1		✓	
10FB005	JEAN-MARIE RIVER AT HIGHWAY NO. 1	✓		✓

Station Number	Station Name	Trend in AMAX	Trend in POT exceedances	Trend in POT events
10LA002	ARCTIC RED RIVER NEAR THE MOUTH			
10MC002	PEEL RIVER ABOVE FORT MCPHERSON			

50-year window:

Station Number	Station Name	Trend in AMAX	Trend in POT exceedances	Trend in POT events
01AD002	SAINT JOHN RIVER AT FORT KENT			
01AD003	ST. FRANCIS RIVER AT OUTLET OF GLASIER LAKE		✓	
01AJ003	MEDUXNEKEAG RIVER NEAR BELLEVILLE			
01AJ004	BIG PRESQUE ISLE STREAM AT TRACEY MILLS			
01AK001	SHOGOMOC STREAM NEAR TRANS CANADA HIGHWAY			
01AK007	NACKAWIC STREAM NEAR TEMPERANCE VALE			✓
01AP002	CANAAN RIVER AT EAST CANAAN			
01AP004	KENNEBECASIS RIVER AT APOHAQUI			
01AQ001	LEPREAU RIVER AT LEPREAU			
01BC001	RESTIGOUCHE RIVER BELOW KEDGWICK RIVER			
01BE001	UPSALQUITCH RIVER AT UPSALQUITCH		✓	✓
01BH005	DARTMOUTH (RIVIERE) EN AMONT DU RUISSEAU DU PAS DE DAME			
01BJ003	JACQUET RIVER NEAR DURHAM CENTRE			
01BJ007	RESTIGOUCHE RIVER ABOVE RAFTING GROUND BROOK			
01BL002	RIVIERE CARAQUET AT BURNSVILLE			
01BO001	SOUTHWEST MIRAMICHI RIVER AT BLACKVILLE			✓
01BP001	LITTLE SOUTHWEST MIRAMICHI RIVER AT LYTTLETON			
01BQ001	NORTHWEST MIRAMICHI RIVER AT TROUT BROOK			
01BS001	COAL BRANCH RIVER AT BEERSVILLE			
01BU002	PETITCODIAC RIVER NEAR PETITCODIAC			
01BV006	POINT WOLFE RIVER AT FUNDY NATIONAL PARK			
01CA003	CARRUTHERS BROOK NEAR ST. ANTHONY	✓	✓	
01DG003	BEAVERBANK RIVER NEAR KINSAC	✓	✓	
01DL001	KELLEY RIVER (MILL CREEK) AT EIGHT MILE FORD			
01DR001	SOUTH RIVER AT ST. ANDREWS			
01EC001	ROSEWAY RIVER AT LOWER OHIO			
01ED007	MERSEY RIVER BELOW MILL FALLS			
01EF001	LAHAVE RIVER AT WEST NORTHFIELD			
01EJ001	SACKVILLE RIVER AT BEDFORD			
01EO001	ST. MARYS RIVER AT STILLWATER			
01FA001	RIVER INHABITANTS AT GLENORA			
01FB001	NORTHEAST MARGAREE RIVER AT MARGAREE VALLEY			
01FB003	SOUTHWEST MARGAREE RIVER NEAR UPPER MARGAREE		✓	
02AB008	NEEBING RIVER NEAR THUNDER BAY			
02BB003	PIC RIVER NEAR MARATHON			
02BF001	BATCHAWANA RIVER NEAR BATCHAWANA			
02BF002	GOULAIS RIVER NEAR SEARCHMONT			
02CF007	WHITSON RIVER AT CHELMSFORD			
02EA005	NORTH MAGNETAWAN RIVER NEAR BURK'S FALLS			
02EA010	NORTH MAGNETAWAN RIVER ABOVE PICKEREL LAKE			
02EC002	BLACK RIVER NEAR WASHAGO			
02EC009	HOLLAND RIVER EAST BRANCH AT HOLLAND LANDING			✓
02ED003	NOTTAWASAGA RIVER NEAR BAXTER			✓
02FB007	SYDENHAM RIVER NEAR OWEN SOUND			✓
02FE009	SOUTH MAITLAND RIVER AT SUMMERHILL			✓
02FF004	SOUTH PARKHILL CREEK NEAR PARKHILL			
02FF007	BAYFIELD RIVER NEAR VARNA		✓	✓
02GA010	NITH RIVER NEAR CANNING		✓	
02GA018	NITH RIVER AT NEW HAMBURG	✓		
02GB007	FAIRCHILD CREEK NEAR BRANTFORD			
02GC002	KETTLE CREEK AT ST. THOMAS			
02GC010	BIG OTTER CREEK AT TILLSONBURG			
02GC018	CATFISH CREEK NEAR SPARTA			
02GD004	MIDDLE THAMES RIVER AT THAMESFORD			
02GE005	DINGMAN CREEK BELOW LAMBETH			✓
02GG002	SYDENHAM RIVER NEAR ALVINSTON			

Station Number	Station Name	Trend in AMAX	Trend in POT exceedances	Trend in POT events
02GG006	BEAR CREEK NEAR PETROLIA			✓
02HA006	TWENTY MILE CREEK AT BALLS FALLS			
02HB004	EAST SIXTEEN MILE CREEK NEAR OMAGH	✓		✓
02HB012	GRINDSTONE CREEK NEAR ALDERSHOT		✓	
02HC009	EAST HUMBER RIVER NEAR PINE GROVE			
02HC018	LYNDE CREEK NEAR WHITBY			
02HC019	DUFFINS CREEK ABOVE PICKERING			
02HC025	HUMBER RIVER AT ELDER MILLS		✓	
02HC028	LITTLE ROUGE CREEK NEAR LOCUST HILL			
02HC030	ETOBICOKE CREEK BELOW QUEEN ELIZABETH HIGHWAY		✓	✓
02HC031	WEST HUMBER RIVER AT HIGHWAY NO. 7			
02HC033	MIMICO CREEK AT ISLINGTON			✓
02HD009	WILMOT CREEK NEAR NEWCASTLE			
02HL003	BLACK RIVER NEAR ACTINOLITE			
02HL005	MOIRA RIVER NEAR DELORO			
02HM004	WILTON CREEK NEAR NAPANEE			
02HM005	COLLINS CREEK NEAR KINGSTON			
02JB013	KINOJEVIS (RIVIERE) A 0,3 KM EN AMONT DU PONT-ROUTE A CLERICY			
02JC008	BLANCHE RIVER ABOVE ENGLEHART			
02LB006	CASTOR RIVER AT RUSSELL	✓		
02LC043	SAINT-LOUIS (RUISSEAU) A 0,3 KM DE LA RIVIERE DU DIABLE			
02OD003	NICOLET (RIVIERE) A 5,8 KM EN AVAL DE LA RIVIERE BULSTRODE			
02OE027	EATON (RIVIERE) PRES DE LA RIVIERE SAINT-FRANCOIS-3	✓		
02OG007	YAMASKA NORD (RIVIERE) A VAL-SHEFFORD			
02OG026	DAVID (RIVIERE) AU PONT-ROUTE A SAINT-DAVID			
02OJ007	RICHELIEU (RIVIERE) AUX RAPIDES FRYERS			
02PA007	BATISCAN (RIVIERE) A 3,4 KM EN AVAL DE LA RIVIERE DES ENVIES	✓		
02PB006	SAINTE-ANNE (RIVIERE) (BRAS DU NORD DE LA) EN AMONT			
02PD002	MONTMORENCY (RIVIERE) A 0,6 KM EN AVAL DU BARRAGE DES MARCHES NATURELLES			
02PD012	EAUX VOLEES (RUISSEAU DES) EN AMONT DU CHEMIN DU BELVEDERE			
02PD014	AULNAIES OUEST (RUISSEAU DES) EN AMONT DU CHEMIN DU BELVEDERE			
02PE014	DAUPHINE (RIVIERE) A L' ILE D'ORLEANS			
02PJ007	BEAURIVAGE (RIVIERE) A SAINTE-ETIENNE			
02PJ030	FAMINE (RIVIERE) A SAINT-GEORGES			
02PL005	BECANCOUR (RIVIERE) A 2,1 KM EN AMONT DE LA RIVIERE PALMER			
02QA002	RIMOUSKI (RIVIERE) A 3,7 KM EN AMONT DU PONT-ROUTE 132			✓
02RD003	MISTASSINI (RIVIERE) EN AMONT DE LA RIVIERE MISTASSIBI			
02RF001	ASHUAPMUSHUAN (RIVIERE) A LA TETE DE LA CHUTE AUX SAUMONS			
02RG005	METABETCHOUANE (RIVIERE) EN AMONT DE LA CENTRALE S.R.P.C.			
02RH027	PIKAUBA (RIVIERE) EN AMONT DE LA RIVIERE APICA			
02UC002	MOISIE (RIVIERE) A 5,1 KM EN AMONT DU PONT DU Q.N.S.L.R.			
02VC001	ROMAINE (RIVIERE) AU PONT DE LA Q.I.T.			
02XC001	SAINT-PAUL (RIVIERE) A 0,5 KM DU RUISSEAU CHANION			
02YL001	UPPER HUMBER RIVER NEAR REIDVILLE			
02YQ001	GANDER RIVER AT BIG CHUTE			
02YR001	MIDDLE BROOK NEAR GAMBO			
02YS003	SOUTHWEST BROOK AT TERRA NOVA NATIONAL PARK			
02ZB001	ISLE AUX MORTS RIVER BELOW HIGHWAY BRIDGE			
02ZF001	BAY DU NORD RIVER AT BIG FALLS			
02ZG001	GARNISH RIVER NEAR GARNISH			
02ZH001	PIPERS HOLE RIVER AT MOTHERS BROOK			
02ZH002	COME BY CHANCE RIVER NEAR GOOBIES			✓
02ZK001	ROCKY RIVER NEAR COLINET			

Station Number	Station Name	Trend in AMAX	Trend in POT exceedances	Trend in POT events
02ZM006	NORTHEAST POND RIVER AT NORTHEAST POND		✓	
03AB002	WASWANIPI (RIVIERE) A LA CHUTE ROUGE			
03AC004	BELL (RIVIERE) EN AMONT DU LAC MATAGAMI			
03ED001	BALEINE (GRANDE RIVIERE DE LA) EN AMONT DE LA RIVIERE DENYS-1	✓		
03QC001	EAGLE RIVER ABOVE FALLS			
04DA001	PIPESTONE RIVER AT KARL LAKE			
04DB001	ASHEWEIG RIVER AT STRAIGHT LAKE			
04FC001	ATTAWAPISKAT RIVER BELOW MUKETEI RIVER			
04JC002	NAGAGAMI RIVER AT HIGHWAY NO. 11			
04JD005	PAGWACHUAN RIVER AT HIGHWAY NO. 11			
04KA001	KWETABOHIGAN RIVER NEAR THE MOUTH			
04LJ001	MISSINAIBI RIVER AT MATTICE			
04MF001	NORTH FRENCH RIVER NEAR THE MOUTH			
05AA008	CROWSNEST RIVER AT FRANK			
05AA022	CASTLE RIVER NEAR BEAVER MINES			
05AD003	WATERTON RIVER NEAR WATERTON PARK			
05BG006	WAIPAROUS CREEK NEAR THE MOUTH			
05BL014	SHEEP RIVER AT BLACK DIAMOND			
05CB001	LITTLE RED DEER RIVER NEAR THE MOUTH			
05CC001	BLINDMAN RIVER NEAR BLACKFALDS			
05DA007	MISTAYA RIVER NEAR SASKATCHEWAN CROSSING			
05DA009	NORTH SASKATCHEWAN RIVER AT WHIRLPOOL POINT			
05DA010	SILVERHORN CREEK NEAR THE MOUTH			
05DB002	PRAIRIE CREEK NEAR ROCKY MOUNTAIN HOUSE			✓
05KH007	CARROT RIVER NEAR TURNBERRY			
05LH005	WATERHEN RIVER NEAR WATERHEN			✓
05LL014	PINE CREEK NEAR MELBOURNE			
05PA012	BASSWOOD RIVER NEAR WINTON	✓		✓
05PH003	WHITEMOUTH RIVER NEAR WHITEMOUTH			✓
05QA002	ENGLISH RIVER AT UMFREVILLE			
05QA004	STURGEON RIVER AT MCDOUGALL MILLS			
05QE009	STURGEON RIVER AT OUTLET OF SALVESEN LAKE		✓	
05UF004	KETTLE RIVER NEAR GILLAM			
06BD001	HAULTAIN RIVER ABOVE NORBERT RIVER			
06DA004	GEIKIE RIVER BELOW WHEELER RIVER			
07AD002	ATHABASCA RIVER AT HINTON			
07AF002	MCLEOD RIVER ABOVE EMBARRAS RIVER			
07AG003	WOLF CREEK AT HIGHWAY NO. 16A			
07BB002	PEMBINA RIVER NEAR ENTWISTLE		✓	
07BC002	PEMBINA RIVER AT JARVIE			
07BE001	ATHABASCA RIVER AT ATHABASCA			
07DA001	ATHABASCA RIVER BELOW FORT MCMURRAY	✓		✓
07EE007	PARSNIP RIVER ABOVE MISINCHINKA RIVER			
07FB001	PINE RIVER AT EAST PINE			
07FC001	BEATTON RIVER NEAR FORT ST. JOHN			
07FC003	BLUEBERRY RIVER BELOW AITKEN CREEK			
07FD001	KISKATINAW RIVER NEAR FARMINGTON			
07GE001	WAPITI RIVER NEAR GRANDE PRAIRIE			
07GH002	LITTLE SMOKY RIVER NEAR GUY			
07GJ001	SMOKY RIVER AT WATINO			
07MB001	MACFARLANE RIVER AT OUTLET OF DAVY LAKE			
07OB001	HAY RIVER NEAR HAY RIVER			
08CD001	TUYA RIVER NEAR TELEGRAPH CREEK			
08CE001	STIKINE RIVER AT TELEGRAPH CREEK			
08CG001	ISKUT RIVER BELOW JOHNSON RIVER			
08DB001	NASS RIVER ABOVE SHUMAL CREEK			
08EB004	KISPIOX RIVER NEAR HAZELTON			

Station Number	Station Name	Trend in AMAX	Trend in POT exceedances	Trend in POT events
08ED002	MORICE RIVER NEAR HOUSTON			
08EE004	BULKLEY RIVER AT QUICK			
08EE008	GOATHORN CREEK NEAR TELKWA			
08EF001	SKEENA RIVER AT USK			
08EF005	ZYMOETZ RIVER ABOVE O.K. CREEK			
08EG012	EXCHAMSIKS RIVER NEAR TERRACE			
08FA002	WANNOCK RIVER AT OUTLET OF OWIKENO LAKE			
08FF001	KITIMAT RIVER BELOW HIRSCH CREEK			
08FF002	HIRSCH CREEK NEAR THE MOUTH			
08FF003	LITTLE WEDEENE RIVER BELOW BOWBYES CREEK			
08HA003	KOKSILAH RIVER AT COWICHAN STATION			
08HA016	BINGS CREEK NEAR THE MOUTH			
08HB014	SARITA RIVER NEAR BAMFIELD			
08HE006	ZEBALLOS RIVER NEAR ZEBALLOS		✓	
08JB002	STELLAKO RIVER AT GLENANNAN			
08JB003	NAUTLEY RIVER NEAR FORT FRASER			
08KA001	DORE RIVER NEAR MCBRIDE			✓
08KA004	FRASER RIVER AT HANSARD			
08KA005	FRASER RIVER AT MCBRIDE			
08KB001	FRASER RIVER AT SHELLEY			
08KB003	MCGREGOR RIVER AT LOWER CANYON			✓
08KE016	BAKER CREEK AT QUESNEL			
08KH010	HORSEFLY RIVER ABOVE MCKINLEY CREEK			
08KH019	MOFFAT CREEK NEAR HORSEFLY			
08LA001	CLEARWATER RIVER NEAR CLEARWATER STATION			
08LB020	BARRIERE RIVER AT THE MOUTH			
08LB047	NORTH THOMPSON RIVER AT BIRCH ISLAND			
08LB064	NORTH THOMPSON RIVER AT MCLURE			
08LB069	BARRIERE RIVER BELOW SPRAGUE CREEK			
08LD001	ADAMS RIVER NEAR SQUILAX			
08LE024	EAGLE RIVER NEAR MALAKWA			
08LE027	SEYMOUR RIVER NEAR SEYMOUR ARM			
08LG016	PENNASK CREEK NEAR QUILCHENA	✓		
08LG048	COLDWATER RIVER NEAR BROOKMERE			
08MA001	CHILKO RIVER NEAR REDSTONE			✓
08MA002	CHILKO RIVER AT OUTLET OF CHILKO LAKE			
08MG005	LILLOOET RIVER NEAR PEMBERTON			
08MG013	HARRISON RIVER NEAR HARRISON HOT SPRINGS			
08MH001	CHILLIWACK RIVER AT VEDDER CROSSING			
08MH006	NORTH ALOUETTE RIVER AT 232ND STREET, MAPLE RIDGE			
08MH076	KANAKA CREEK NEAR WEBSTER CORNERS		✓	
08MH103	CHILLIWACK RIVER ABOVE SLESSE CREEK			
08NA002	COLUMBIA RIVER AT NICHOLSON			
08ND012	GOLDSTREAM RIVER BELOW OLD CAMP CREEK			
08ND013	ILLECILLEWAET RIVER AT GREELEY			
08NE039	BIG SHEEP CREEK NEAR ROSSLAND			
08NE074	SALMO RIVER NEAR SALMO			
08NE077	BARNES CREEK NEAR NEEDLES			
08NE087	DEER CREEK AT DEER PARK			
08NF001	KOOTENAY RIVER AT KOOTENAY CROSSING			
08NG065	KOOTENAY RIVER AT FORT STEELE			
08NH005	KASLO RIVER BELOW KEMP CREEK			
08NH006	MOYIE RIVER AT EASTPORT		✓	
08NH084	ARROW CREEK NEAR ERICKSON			
08NH115	SULLIVAN CREEK NEAR CANYON			
08NH119	DUNCAN RIVER BELOW B.B. CREEK			
08NH120	MOYIE RIVER ABOVE NEGRO CREEK			

Station Number	Station Name	Trend in AMAX	Trend in POT exceedances	Trend in POT events
08NJ013	SLOCAN RIVER NEAR CRESCENT VALLEY			
08NJ130	ANDERSON CREEK NEAR NELSON			
08NK002	ELK RIVER AT FERNIE			
08NK016	ELK RIVER NEAR NATAL			
08NK018	FORDING RIVER AT THE MOUTH			
08NK022	LINE CREEK AT THE MOUTH			
08NL004	ASHNOLA RIVER NEAR KEREMEOS			
08NL007	SIMILKAMEEN RIVER AT PRINCETON	✓		
08NL024	TULAMEEN RIVER AT PRINCETON			
08NL038	SIMILKAMEEN RIVER NEAR HEDLEY			
08NM134	CAMP CREEK AT MOUTH NEAR THIRSK			✓
08NM142	COLDSTREAM CREEK ABOVE MUNICIPAL INTAKE			
08NN002	GRANBY RIVER AT GRAND FORKS			
08NN012	KETTLE RIVER NEAR LAURIER			
08NN013	KETTLE RIVER NEAR FERRY			
08NN015	WEST KETTLE RIVER NEAR MCCULLOCH			
08NN019	TRAPPING CREEK NEAR THE MOUTH			
09AA013	TUTSHI RIVER AT OUTLET OF TUTSHI LAKE			
09AC001	TAKHINI RIVER NEAR WHITEHORSE			
09AE003	SWIFT RIVER NEAR SWIFT RIVER			
09BA001	ROSS RIVER AT ROSS RIVER			
09BC001	PELLY RIVER AT PELLY CROSSING			
09CD001	YUKON RIVER ABOVE WHITE RIVER			
09DD003	STEWART RIVER AT THE MOUTH			
09EA003	KLONDIKE RIVER ABOVE BONANZA CREEK			
10AA001	LIARD RIVER AT UPPER CROSSING			
10AB001	FRANCES RIVER NEAR WATSON LAKE			
10AC005	COTTONWOOD RIVER ABOVE BASS CREEK			
10BE001	LIARD RIVER AT LOWER CROSSING			
10BE004	TOAD RIVER ABOVE NONDA CREEK			
10BE007	TROUT RIVER AT KILOMETRE 783.7 ALASKA HIGHWAY			
10CB001	SIKANNI CHIEF RIVER NEAR FORT NELSON			
10CD001	MUSKWA RIVER NEAR FORT NELSON			
10EB001	SOUTH NAHANNI RIVER ABOVE VIRGINIA FALLS			
10ED001	LIARD RIVER AT FORT LIARD			✓
10FA002	TROUT RIVER AT HIGHWAY NO. 1			✓

60-year window:

Station Number	Station Name	Trend in AMAX	Trend in POT exceedances	Trend in POT events
01AD002	SAINT JOHN RIVER AT FORT KENT			✓
01AD003	ST. FRANCIS RIVER AT OUTLET OF GLASIER LAKE			
01AK001	SHOGOMOC STREAM NEAR TRANS CANADA HIGHWAY			
01AP004	KENNEBECASIS RIVER AT APOHAQUI			✓
01AQ001	LEPREAU RIVER AT LEPREAU			✓
01BE001	UPSALQUITCH RIVER AT UPSALQUITCH			
01BP001	LITTLE SOUTHWEST MIRAMICHI RIVER AT LYTTLETON			
01BQ001	NORTHWEST MIRAMICHI RIVER AT TROUT BROOK			
01BU002	PETITCODIAC RIVER NEAR PETITCODIAC			✓
01CA003	CARRUTHERS BROOK NEAR ST. ANTHONY			
01DG003	BEAVERBANK RIVER NEAR KINSAC			
01EC001	ROSEWAY RIVER AT LOWER OHIO			
01EF001	LAHAVE RIVER AT WEST NORTHFIELD			
01EO001	ST. MARYS RIVER AT STILLWATER			
01FB001	NORTHEAST MARGAREE RIVER AT MARGAREE VALLEY			
01FB003	SOUTHWEST MARGAREE RIVER NEAR UPPER MARGAREE		✓	
02AB008	NEEBING RIVER NEAR THUNDER BAY			
02CF007	WHITSON RIVER AT CHELMSFORD			
02EA005	NORTH MAGNETAWAN RIVER NEAR BURK'S FALLS			
02EC002	BLACK RIVER NEAR WASHAGO			
02ED003	NOTTAWASAGA RIVER NEAR BAXTER			✓
02FB007	SYDENHAM RIVER NEAR OWEN SOUND			✓
02GA010	NITH RIVER NEAR CANNING		✓	
02GA018	NITH RIVER AT NEW HAMBURG		✓	✓
02GD004	MIDDLE THAMES RIVER AT THAMESFORD			✓
02GG002	SYDENHAM RIVER NEAR ALVINSTON			
02HA006	TWENTY MILE CREEK AT BALLS FALLS		✓	
02HB004	EAST SIXTEEN MILE CREEK NEAR OMAGH			
02HC009	EAST HUMBER RIVER NEAR PINE GROVE			
02HL003	BLACK RIVER NEAR ACTINOLITE			✓
02OE027	EATON (RIVIERE) PRES DE LA RIVIERE SAINT-FRANCOIS-3	✓		
02OJ007	RICHELIEU (RIVIERE) AUX RAPIDES FRYERS			
02PJ007	BEAURIVAGE (RIVIERE) A SAINTE-ETIENNE			
02QA002	RIMOUSKI (RIVIERE) A 3,7 KM EN AMONT DU PONT-ROUTE 132			
02RD003	MISTASSINI (RIVIERE) EN AMONT DE LA RIVIERE MISTASSIBI			
02RF001	ASHUAPMUSHUAN (RIVIERE) A LA TETE DE LA CHUTE AUX SAUMONS			
02VC001	ROMAINE (RIVIERE) AU PONT DE LA Q.I.T.			
02YL001	UPPER HUMBER RIVER NEAR REIDVILLE			
02YQ001	GANDER RIVER AT BIG CHUTE			
02YR001	MIDDLE BROOK NEAR GAMBO			
02ZB001	ISLE AUX MORTS RIVER BELOW HIGHWAY BRIDGE			
02ZF001	BAY DU NORD RIVER AT BIG FALLS			
02ZG001	GARNISH RIVER NEAR GARNISH			
02ZH001	PIPERS HOLE RIVER AT MOTHERS BROOK			
02ZK001	ROCKY RIVER NEAR COLINET			
02ZM006	NORTHEAST POND RIVER AT NORTHEAST POND			
03AC004	BELL (RIVIERE) EN AMONT DU LAC MATAGAMI			
04JC002	NAGAGAMI RIVER AT HIGHWAY NO. 11			
04LJ001	MISSINAIBI RIVER AT MATTICE			
05AA022	CASTLE RIVER NEAR BEAVER MINES			
05AD003	WATERTON RIVER NEAR WATERTON PARK			
05CB001	LITTLE RED DEER RIVER NEAR THE MOUTH			
05LH005	WATERHEN RIVER NEAR WATERHEN			
05PA012	BASSWOOD RIVER NEAR WINTON			

Station Number	Station Name	Trend in AMAX	Trend in POT exceedances	Trend in POT events
05PH003	WHITEMOUTH RIVER NEAR WHITEMOUTH			✓
05QA002	ENGLISH RIVER AT UMFREVILLE			
05QA004	STURGEON RIVER AT MCDOUGALL MILLS			
07AF002	MCLEOD RIVER ABOVE EMBARRAS RIVER			
07AG003	WOLF CREEK AT HIGHWAY NO. 16A			
07BB002	PEMBINA RIVER NEAR ENTWISTLE			
07BE001	ATHABASCA RIVER AT ATHABASCA			
07DA001	ATHABASCA RIVER BELOW FORT MCMURRAY			✓
07GH002	LITTLE SMOKY RIVER NEAR GUY			
07GJ001	SMOKY RIVER AT WATINO			✓
08DB001	NASS RIVER ABOVE SHUMAL CREEK			
08ED002	MORICE RIVER NEAR HOUSTON			
08EE004	BULKLEY RIVER AT QUICK			✓
08EF001	SKEENA RIVER AT USK			
08HA003	KOKSILAH RIVER AT COWICHAN STATION			
08HB014	SARITA RIVER NEAR BAMFIELD			
08HE006	ZEBALLOS RIVER NEAR ZEBALLOS		✓	
08JB002	STELLAKO RIVER AT GLENANNAN			✓
08JB003	NAUTLEY RIVER NEAR FORT FRASER			
08KA004	FRASER RIVER AT HANSARD			
08KA005	FRASER RIVER AT MCBRIDE			
08KB001	FRASER RIVER AT SHELLEY			
08KB003	MCGREGOR RIVER AT LOWER CANYON			✓
08LA001	CLEARWATER RIVER NEAR CLEARWATER STATION			
08LB047	NORTH THOMPSON RIVER AT BIRCH ISLAND			
08LB064	NORTH THOMPSON RIVER AT MCLURE			
08LD001	ADAMS RIVER NEAR SQUILAX			
08MG005	LILLOOET RIVER NEAR PEMBERTON			
08MG013	HARRISON RIVER NEAR HARRISON HOT SPRINGS			
08MH001	CHILLIWACK RIVER AT VEDDER CROSSING			
08MH006	NORTH ALOUETTE RIVER AT 232ND STREET, MAPLE RIDGE			
08NA002	COLUMBIA RIVER AT NICHOLSON			
08NE039	BIG SHEEP CREEK NEAR ROSSLAND			
08NE074	SALMO RIVER NEAR SALMO			
08NE077	BARNES CREEK NEAR NEEDLES			
08NE087	DEER CREEK AT DEER PARK			
08NF001	KOOTENAY RIVER AT KOOTENAY CROSSING			
08NH006	MOYIE RIVER AT EASTPORT		✓	
08NJ013	SLOCAN RIVER NEAR CRESCENT VALLEY			
08NK016	ELK RIVER NEAR NATAL			
08NL004	ASHNOLA RIVER NEAR KEREMEOS			
08NL007	SIMILKAMEEN RIVER AT PRINCETON	✓		
08NL024	TULAMEEN RIVER AT PRINCETON			
08NN012	KETTLE RIVER NEAR LAURIER			
08NN013	KETTLE RIVER NEAR FERRY			
09AC001	TAKHINI RIVER NEAR WHITEHORSE			
09BC001	PELLY RIVER AT PELLY CROSSING			
10AA001	LIARD RIVER AT UPPER CROSSING			
10BE001	LIARD RIVER AT LOWER CROSSING			