Analysis of Water Quality Trends for the Long-Term River Network: North Saskatchewan River, 1977-2002

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Prepared by:

Thorsten Hebben, M.Sc., P.Biol.
Limnologist/Water Quality Specialist

Environmental Monitoring and Evaluation Branch
Environmental Assurance

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Any comments, questions, or suggestions regarding the content of this document may be directed to:

Environmental Monitoring and Evaluation Branch
Alberta Environment
10th Floor, Oxbridge Place
9820 – 106th Street
Edmonton, Alberta T5K 2J6
Phone: (780) 427-6278
Fax: (780) 422-6712

Additional copies of this document may be obtained by contacting:

Information Centre
Alberta Environment
Main Floor, Oxbridge Place
9820 – 106th Street
Edmonton, Alberta T5K 2J6
Phone: (780) 427-2700
Fax: (780) 422-4086
Email: env.infocent@gov.ab.ca

EXECUTIVE SUMMARY

Over the past thirty to fifty years, major rivers throughout the province of Alberta have been undergoing regular monthly sampling for a wide range of water quality parameters. Known as the Long-Term River Network (LTRN), this monitoring initiative has resulted in an extensive database of water quality information for the Province. Due to the broad time span and continuity of these data, they lend themselves particularly well to statistical trend assessment – a very useful way of examining changes in the health of a water body over time. Often indicative of human activities in the basin, trends in water quality parameters can be analysed for a variety of purposes, including the evaluation of human impacts on water quality, the development and assessment of watershed management initiatives, and the prediction of future conditions.

The purpose of this report was to assess water quality conditions and trends in the North Saskatchewan River from 1977 to the end of 2002. Two LTRN sites are situated on the North Saskatchewan River. The first of these, at Devon, is located upstream of Edmonton and the region of highest population density. The second, at Pakan, is roughly 100 km downstream of Edmonton and facilitates examination of the potential water quality impacts of a fairly large urban centre. Results of trend assessment on these two sites suggest that a number of variables have undergone significant changes over the years. While some, such as hardness, sodium, magnesium, and sulphate have demonstrated significant increases at both sampling stations, others, including total phosphorus, total dissolved phosphorus, total nitrogen, total coliform bacteria, and fecal coliform bacteria, have shown significant decreases downstream of Edmonton at Pakan. These reductions, thought to be a result of upgrades to the Gold Bar Wastewater Treatment Plant in Edmonton, are indicative of marked improvements in river water quality. Although some variables, including pH, dissolved oxygen, nutrients, metals, and coliform bacteria, have exceeded guidelines in the past, most have done so infrequently. Those with a higher frequency of guideline exceedance, such as nutrients and bacteria, have shown significant decreasing trends up to 2003. On the whole, data collected from the North Saskatchewan River reflect good water quality.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

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1.0 INTRODUCTION

The North Saskatchewan River originates at the base of the Saskatchewan Glacier, in the Columbia Icefields of Alberta's Banff National Park. It winds eastward across the province, passing through a range of ecozones, including foothills, boreal forest, and aspen parkland, before crossing the border into Saskatchewan, some 830 km downstream. The river and its tributaries, which include the Brazeau, Clearwater, Nordegg and Ram Rivers, host a broad variety of recreational activities, including fishing, canoeing, and power boating. The watershed itself, comprising roughly 57,000 km^2, is one of the most developed in Alberta and supports a wide array of agricultural, industrial, and natural resource-based operations. It is also among the most heavily populated, containing one of the province's major urban and industrial centres at Edmonton (Mitchell 1994).

Flow in the North Saskatchewan River (NSR) is regulated by two dams. The first of these, the Big Horn Dam, is situated on the mainstem in the eastern slopes of the Rocky Mountains. Construction of the Big Horn Dam in 1972 resulted in creation of Abraham Lake reservoir. The second is the Brazeau Dam, located on the Brazeau River, a tributary to the NSR. The combined effect of these dams has been a redistribution of yearly flows, with an average decrease in pre-regulation summer flows and an increase in winter flows to roughly three times the natural value. In addition, daily river levels can fluctuate by up to one metre due to power plant operation (Mitchell 1994). In combination with municipal, agricultural, and industrial withdrawals and effluents, along with land-use activities that alter non-point runoff, this may have modified the physical, biological, and chemical characteristics of the river.

Two provincial Long-Term River Network (LTRN) water quality monitoring stations are located on the North Saskatchewan River. The first, at Devon, is situated upstream of the region of highest population density (Edmonton and surrounding communities) and provides data that reflect the general water quality of the upper watershed as well as the potential impacts of agriculture, forestry, oil and gas exploration, and small municipalities. The second, at Pakan, is located roughly 100 km downstream of Edmonton and incorporates the added influence of a relatively high-density urban and industrial centre. Water quality at both of these sites was monitored on a monthly basis between 1977 and 1987 by Environment Canada. Since then, the two stations have been maintained by Alberta Environment (AENV).

Although much information about a river can be derived from individual water quality data points, it is difficult to assess the overall state of a given stream based on knowledge obtained from a single sample or small group of samples. Since basin and water quality characteristics may vary greatly between rivers, it is not statistically defensible to evaluate the state of a stream relative to others that may or may not be comparable. Instead, it is of greater value to examine a particular water quality variable or group of variables in a given stream over time. In this manner, one can statistically assess a temporal change in a particular variable or suite of variables. This change over time, reported as a trend, can be increasing (statistically significant positive slope) or decreasing (significant negative slope). Given a temporally expansive data set, such as the one associated with the LTRN, trend assessments can be particularly useful in evaluating the overall water quality or health of a waterbody, as well as the effectiveness of stewardship or management initiatives. Hence, the objective of this report was to examine long-

term trends in a broad suite of water quality variables in the North Saskatchewan River, both upstream (at Devon) and downstream (at Pakan) of Edmonton.

2.0 METHODS

2.1 Parameter Selection and Treatment

In order to facilitate trend assessment of water quality data collected on a monthly basis, a minimum of five years' worth of results must be available for a given variable (Schertz *et al*. 1991, Stevens 2003). However, a minimum ten years worth of data, independent of sampling frequency, is recommended to ensure the robustness of particular trend analyses (Aaroner 1994). Hence, any parameters that did not meet this latter criterion were immediately excluded from trend analyses. All remaining data were carefully screened for extreme outliers, which, unless explained by sampler comments or concurrent variables, were removed from the data set. In certain cases, parameters deemed sufficiently similar by experts in the field were combined to create longer, more continuous data sets. Specifically, turbidity values (formerly measured in Jackson Turbidity Units (JTU) and more recently in Nephelometric Turbidity Units (NTU)) were merged over the entire sampling history. In addition, total dissolved solids (TDS) and filterable residue (FR) were combined as a single variable (TDS/FR). In cases where values for both TDS and FR were available for a given sample, the mean of the two was utilized. For pH, values measured in the laboratory were used in statistical analyses only if field data were unavailable for a given sample (note that pH values were not converted to hydrogen ion concentrations prior to statistical manipulation). Similarly, dissolved oxygen values reported from field data were given precedence over those obtained via Winkler titrations in the laboratory. Chlorophyll *a* data, which were obtained with a colourimeter prior to 1987 and via fluorometry after 1987, were also combined for the entire sampling period. Since apparent colour was evaluated sporadically in the past, and since the two variables cannot be combined, only true colour was statistically analyzed. Further information on analytical methods can be obtained from the Alberta Environment water quality sampling manual (AENV 2002), the Canadian Environmental Quality Guidelines (CCME 1999), or through the surface water quality homepage at: http://www3.gov.ab.ca/env/water/SWQ/index.cfm.

Although a broad range of metals has been analyzed over the 30-year history of the LTRN, various factors tend to restrict the number of analytes to which trend tests can be realistically applied. The first and most influential of these factors is the particular fraction (dissolved, total, extractable) of each metal that was examined. Since this changed over time for several different analytes and since the different fractions cannot be treated as the same entity, trend tests were immediately ruled out for the majority of metals. An additional consideration for many metals was a relatively high frequency of concentrations falling below the ability of contemporary analytical techniques to detect them. This can exert marked influence on trends, particularly if the detection limit changes over time. Hence, those metals demonstrating high incidence of values below detection (>50%) were also eliminated from trend analyses. Lastly, metals that have historically shown a tendency toward inaccurate or questionable analytical results were removed from the suite of statistically evaluated parameters.

A wide variety of trace organic compounds, including pesticides and other 'priority pollutants', are also analyzed at LTRN sites. However, these variables are usually only sampled a few times per year, are mostly below detection, and, hence, do not lend themselves to trend assessment. An

inventory of data for all LTRN sites can be accessed through online water quality reports at http://www3.gov.ab.ca/env/water/reports/water_quality_reports.cfm.

2.2 Statistical Analyses

As part of the LTRN program, a wide range of water quality parameters is routinely sampled at both the Devon and Pakan sites (Table 1). In order to determine if any of these variables have undergone significant changes (i.e., exhibited a significant trend) between 1977 and 2003, data were statistically evaluated using a comprehensive DOS-based software package by the name of WQHYDRO (Aroner 1994). Boxplots were constructed using the USGS library for the analysis of water resource data in S-Plus (Insightful Corporation).

2.2.1 Step Trends

The step trend is one of two primary hypotheses that can be considered in trend estimation. This hypothesis postulates that data collected prior to a specific point in time are from a distinctly different population than (i.e., have a significantly different median value from) data originating after that time (Hirsch *et al*. 1991). The second hypothesis – a monotonic trend – assumes that a data population shifts monotonically (i.e., increases or decreases with no reversal of direction) over time. Due to the aforementioned change in monitoring agencies, each water quality variable was examined for the presence of a step trend in 1987 using a seasonal Wilcoxon-Mann-Whitney test. Based on previous analyses, it is known that the agency changeover resulted in a step trend for several of the variables in question. This upward or downward shift in the median value of a given parameter, if neglected, can cause a Type I error during monotonic trend evaluation. In other words, a monotonic trend analysis of data containing a positive step trend may cause the statistician to reject the null hypothesis (i.e., no trend over time) and report an increasing tendency for a particular variable, despite the fact that the presumed trend was entirely the product of a temporally discrete basin intervention (e.g., termination of a point source discharge) or a change in analytical equipment, facilities, or techniques. Hence, in cases where the direction (increasing or decreasing) of a statistically significant monotonic trend coincided with that of a significant step trend, the monotonic trend results were rejected. For those parameters that exhibited a significant step in 1987, subsequent monotonic trend analyses were performed separately on pre- and post-1987 data (Figure 1).

2.2.2 Seasonality and Autocorrelation

Following evaluation of step trends, data were tested for seasonality and autocorrelation. Numerous water quality variables are known to undergo seasonal fluctuations in response to changing environmental conditions, such as ambient temperature, precipitation, or biotic activity. If left unaccounted for, these fluctuations may mask the presence of actual trends. Hence, variables were first graphed and visually examined for seasonal variability. They were then assessed using the Kruskal-Wallis test for seasonality.

Numerous variables may also be subject to autocorrelation or ‘serial correlation’, meaning that the measured value for a given parameter may be dependant on (correlated with) the immediately preceding values in a sampling sequence. For example, if dissolved oxygen concentration in a

river is low during January, it is likely that a subsequent measurement in February would also return a low value. This phenomenon can be a confounding factor during trend analysis and must be accounted for. In order to ascertain whether or not a particular water quality parameter was subject to autocorrelation, it was examined using a Kendall Tau Correlation Analysis and a Spearman Rank Correlation Analysis on deseasonalised and detrended data. In rare instances of disagreement between the two tests, the variable in question was subsequently analysed using trend statistics for both autocorrelated and non-autocorrelated data.

2.2.3 Monotonic Trends

For this report, the type of monotonic trend analysis applied to a given variable was dependent upon the results of tests for seasonality and autocorrelation (Figure 1). Variables that returned significant results for both seasonality and serial correlation were tested for trends over time using a Seasonal Kendall analysis that accounts for autocorrelation (Seasonal Kendall With Autocorrelation (SKWC)). Those that were seasonal but not autocorrelated were examined with a Seasonal Kendall test Without Autocorrelation (SKWOC). For non-seasonal data that were autocorrelated, a Mann-Kendall analysis was performed on quarterly data (MK(Q)). In the case of the NSR, quarters were defined as beginning December 1st, March 1st, June 1st, and September 1st. Lastly, non-seasonal data that did not exhibit significant autocorrelation were tested for trends using a Mann-Kendall analysis on monthly data (MK). For the purposes of this report, trends that demonstrated a significant slope at a confidence interval of 90% or greater were considered meaningful. Although trend analyses do occasionally report significance with a slope of zero, these typically result from a high frequency of values below detection and are not considered meaningful.

2.2.4 Additional Considerations

Although step trends, seasonality, and autocorrelation can have substantial impacts on statistical analyses, other potential effects must also be considered when evaluating water quality data. Censored values, for instance, can be an influential factor affecting trend statistics. When concentrations of a particular variable drop below the ability of contemporary instrumentation or techniques to reliably detect that substance, known as a detection limit, data are referred to as 'censored'. The results of a trend analysis on censored data may not be valid. This is particularly true of long-term data sets in which analytical techniques have been revised and perfected over time and currently give a higher resolution (lower detection limit) than they have in the past. Although this effect is difficult to account for statistically, visual examination of the data may help determine if trend results are truly representative or merely caused by a change in detection limits. For the purposes of this report, values below the detection limit (DL) were treated as half the DL, as recommended by the U.S. Environmental Protection Agency (1996). For example, data points below a DL of 0.1 mg/L were entered into the statistical analysis as 0.05 mg/L. It is generally agreed that variables with greater than 50% censorship do not lend themselves particularly well to monotonic trend assessments (Stevens 2003). Hence, for the purposes of the current report, water quality parameters with more than 50% censored data were not statistically analysed.

Another factor with the ability to modify trend results is stream flow. During high flow years, generally the result of high precipitation, certain products of non-point source runoff/overland flow (e.g., phosphorus and nitrogen) may appear in greater concentrations than they otherwise would. Conversely, during times of low flow, the impacts of point-source effluents, such as sewage treatment plants, may be amplified, since the lowered volume of water in a given stream can result in reduced dilution of the effluent in question. For the purposes of this report, flow values used for both sites (Devon and Pakan) were based on daily means measured at the Edmonton monitoring station (Station #05DF001). Flow-dependent changes may or may not be of interest, depending on the needs of the user. Hence, the following report addresses trends in both the raw data and, for those variables demonstrating a significant correlation with flow, in flow-adjusted values. Flow adjustment for each water quality variable was accomplished in WQHydro by running a series of different regressions between the variable of interest and flow. Based on the regression coefficient and standard error of each analysis, an appropriate regression equation was selected. A trend analysis was subsequently performed on flow-adjusted residuals from the chosen regression. Due to the nature of flow-adjusted data, the latter have not been communicated graphically.

2.3 Guideline Comparison

Water quality data analysed in this report were compared to surface water quality guidelines for use in Alberta (AENV 1999) and more recent updates from the Canadian Council of Ministers of the Environment (CCME 2003 and updates). Guidelines selected for comparison were the more stringent of those available for protection of aquatic life (PAL), recreation, or agricultural use.

3.0 RESULTS AND DISCUSSION

Basic descriptive statistics for all variables, post-1987, are listed in Tables 2 and 3. Due to the presence of step trends for a large proportion of variables, pre-1987 data were not included in the calculation of basic statistics. Trend and seasonality graphs for most analyzed variables are depicted in Figures 3 through 87. Seasonality boxplots are explained in Figure 2. For various reasons, including brief records and high frequency of censored data, some parameters are not displayed in graphical format. Raw results of statistical analyses can be viewed in Appendices I-XXXIX.

3.1 Devon Inorganics, Trends

3.1.1 Raw Data, 1977-2002

Analysis of LTRN data from Devon, prior to flow adjustment, suggests that twelve variables have undergone significant increasing or decreasing trends at the site since 1977 (Table 4). Of these, only sodium concentration (Figure 25), which showed an increasing tendency over the time frame in question, was not influenced by a step trend.

3.1.2 Flow-Adjusted Data, 1977-2002

When adjusted to account for the influence of flow, nine water quality variables at the Devon site exhibited significant trends between 1977 and 2003 (Table 4). Of these, three were not overtly linked to a step in 1987. Turbidity (Figure 15) and sodium concentration (Figure 25) both demonstrated increasing tendencies, while dissolved oxygen concentration (Figure 13) showed a significant decrease over the 26-year period.

3.1.3 Pre-1987

Prior to 1987, five variables demonstrated significant trends. Total alkalinity (Figure 9) increased in the NSR at Devon between 1977 and 1987, while calcium (Figure 27), magnesium (Figure 29), total nitrogen (Figure 57), and dissolved nitrogen (not shown) decreased during the same period. Following flow adjustment, these trends did not change.

3.1.4 Post-1987

Eleven water quality parameters at the Devon site exhibited post-1987 trends that were significant at a 90% or better confidence interval. Of these, hardness (Figure 11), total dissolved solids (TDS; Figure 21), magnesium (Figure 29), sulphate (Figure 39), and fecal coliform bacteria (Figure 67) have been increasing since 1987. Non-filterable residue (NFR; Figure 19), dissolved kjeldahl nitrogen (not shown), total kjeldahl nitrogen (Figure 53), total nitrogen (Figure 57), total phosphorus (Figure 59), and total coliform bacteria (Figure 65) have undergone a decreasing trend. Following flow adjustment, temperature (Figure 3), NFR (Figure 19), magnesium (Figure 29), total phosphorus (Figure 59), and fecal coliform bacteria (Figure 68) yielded positive post-1987 trends. Total coliforms (Figure 65) and dissolved kjeldahl nitrogen continued to show significant negative trends after flow adjustment.

3.2 Devon Metals, Trends

Three of the nine metals that were evaluated demonstrated significant long-term trends at the Devon sampling location after 1977 (Table 5). All of these appear to have been influenced by step trends in 1987. The dissolved fractions of boron (Figure 73), iron (Figure 77), and manganese (Figure 79) exhibited decreasing tendencies over the period in question. Subsequent to flow adjustment, these trends remained similar.

Prior to 1987, only boron displayed a significant trend, increasing both in terms of raw values and flow-adjusted data (Figure 73). Insufficient data and excessive censorship prevented pre-1987 trend assessment for the remaining metals.

Since 1987, dissolved aluminum (Figure 69), dissolved arsenic (Figure 71), and total lead (Figure 83) have demonstrated decreasing trends in the NSR at Devon in both raw and flow-adjusted data.

3.3 Devon, Guideline Comparison

With a few exceptions, water quality variables in the North Saskatchewan River at Devon have been compliant with Alberta Surface Water Quality (ASWQG) and Canadian Council of Ministers of the Environment Water Quality Guidelines (CCMEWQG; Tables 4, 5). Three elevated pH measurements between 1987 and 1991 (Figure 4) led to compliance values of 98% and 99% based on ASWQG and CCMEWQG, respectively. Dissolved oxygen levels at Devon were 100% compliant with both ASWQG and CCMEWQG. Two exceedances of CCMEWQG, which occurred between 1987 and 1990 (Figure 60), resulted in 99% compliance for total coliforms. Lastly, six values in excess of the 100 cells/100 mL CCMEWQG for fecal coliforms (Figure 67) led to 97% compliance for that variable.

Some exceedances were noted at the Devon sampling location for the nine metal constituents evaluated in this report (Table 5). Dissolved aluminum, dissolved arsenic, dissolved boron, and total nickel were 100% compliant with CCMEWQG. Two elevated total copper readings between 1999 and 2001 (Figure 75) led to a compliance rating of 98.4%, based on ASWQG. Similarly, two exceedances of dissolved iron between 1995 and 1998 (Figure 77) resulted in 99.2% compliance. Total lead (Figure 78, 91.3% compliance) exceeded CCMEWQG eleven times between 1992 and 2002. Total zinc (Figure 85, 93.7% compliance) was in excess of the CCMEWQG eight times during the same time frame.

3.4 Pakan Inorganics, Trends

3.4.1 Raw Data, 1977-2002

Seventeen variables at the Pakan site showed significant trends during the 1977-2002 period (Table 6). Of these, only temperature, which underwent a decrease (Figure 3), was unaffected by a step trend in 1987. Despite being influenced by a positive step trend in 1987, total ammonia (Figure 51) demonstrated an overall negative tendency.

3.4.2 Flow-Adjusted Data, 1977-2002

Following flow adjustment, 15 variables exhibited significant trends (Table 6). The majority of these were in the same direction as calculated steps and consistent with trends detected prior to flow adjustment. Exceptions included temperature (Figure 3), turbidity (Figure 15), non-filterable residue (Figure 19), potassium (Figure 23), and total ammonia (Figure 51), all of which no longer demonstrated significant trends after flow adjustment. Conversely, reactive silica (Figure 37) and chlorophyll *a* (Figure 63) took on significant increasing trends once the influence of flow was accounted for.

3.4.3 Pre-1987

Prior to 1987, calcium and magnesium (Figures 27, 29) demonstrated significant decreasing trends at Pakan, while total phosphorus (Figure 59) and fecal coliforms (Figure 67) increased. After flow adjustment, calcium, magnesium, and total phosphorus retained similar pre-1987 trends, while total dissolved phosphorus (Figure 61) and fecal coliforms no longer exhibited significant changes.

3.4.4 Post-1987

Statistical analysis revealed that fourteen water quality parameters have undergone a significant change (90% confidence interval) in the North Saskatchewan River at Pakan since 1987. Of those, total alkalinity (Figure 9), hardness (Figure 11), TDS (Figure 21), sodium (Figure 25), calcium (Figure 27), magnesium (Figure 29), and sulphate (Figure 39) have been on the rise. Turbidity (Figure 15), colour (Figure 17), total nitrogen (Figure 57), total phosphorus (Figure 59), total dissolved phosphorus (Figure 61), total coliforms (Figure 65), and fecal coliforms (Figure 67) have been decreasing, probably in part as a result of upgrades to the Gold Bar Waste Treatment Facility in Edmonton. Following flow adjustment on post-1987 data, five variables – hardness, sodium, calcium, magnesium, and sulphate – demonstrated increasing tendencies at the Pakan site. Nitrite and nitrate (Figure 55), total nitrogen (Figure 57), total phosphorus (Figure 59), total dissolved phosphorus (Figure 61), total coliforms (Figure 65), and fecal coliforms (Figure 67) exhibited a negative trend over the same time period after values were adjusted for correlation with stream flow.

3.5 Pakan Metals, Trends

Between 1977 and 2002, three metals displayed significant trends in the NSR at Pakan (Table 7). During this time, dissolved fractions of boron (Figure 73) and manganese (Figure 79) decreased, while dissolved iron (Figure 77) increased. All three were subject to step trends, although the direction of the step for dissolved iron, clearly driven by a change in detection limits, was opposite to the overall positive trend. Following flow adjustment, dissolved iron showed a negative trend. Dissolved boron and manganese did not show a significant correlation with flow.

Prior to 1987, dissolved boron exhibited an increasing trend and no significant correlation with flow. After 1987, boron no longer showed any significant tendency, while both dissolved

aluminum (Figure 69) and dissolved arsenic (Figure 71) demonstrated negative trends that did not change direction after flow adjustment.

3.6 Pakan, Guideline Comparison

Values of pH in the NSR at Pakan (Figure 5) demonstrated 93% compliance with ASWQG and 99% with CCMEWQG (Table 6). Aside from a single exceedance in 1999, all values above guidelines occurred between 1987 and 1991. Although dissolved oxygen (Figure 12) was 100% compliant with the CCME guideline, a minimum requirement of 8.3 mg/L between May 15 and July 30 to protect mayfly emergence resulted in 95.4% compliance with the ASWQ guideline.

Total nitrogen at Pakan (Figure 57) complied with ASWQG 68% of the time, while total phosphorus values (Figure 59) were compliant in 11% of samples. The relatively high population density in and around the city of Edmonton is presumed to have contributed to nutrient exceedances recorded in the NSR at Pakan. However, with improvements to treatment processes at the Gold Bar Wastewater Treatment Facility, the number of exceedances has been reduced in the past few years, as evidenced by decreasing trends for both of these parameters. Based on CCMEWQG, nitrite concentrations at the Pakan site have been 94% compliant.

Improvements at the Gold Bar Waste Treatment Facility appear to have resulted in marked decreasing trends in both total- and fecal coliform counts at the Pakan station (Figures 65, 67). Since 1977, these two variables have demonstrated 36% and 49% compliance with CCMEWQG, respectively.

4.0 CONCLUSION

Trend analyses performed on an extensive water quality data set for the two long term sampling sites on the North Saskatchewan River suggest that a number of variables have undergone significant changes over the years, particularly since 1987. Several decreasing trends, including those for nutrients (e.g., total nitrogen, total kjeldahl nitrogen, total phosphorus, total dissolved phosphorus) and bacteria (total coliforms and fecal coliforms), are indicative of encouraging and marked improvements in river water quality. It is likely that these decreases occurred in association with relatively recent upgrades to the Gold Bar Wastewater Treatment Facility in Edmonton, which discharges treated water to the NSR. Although a few variables at both Devon and Pakan have returned values exceeding guidelines over the years, most have done so infrequently. Many of those that have demonstrated a higher incidence of guideline exceedance have shown decreasing trends over time.

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Table 1 Core water quality variables sampled as part of Long-Term River Network monitoring since 1977.

Inorganics	Years of Record	Units
Temperature	1977-2002	°C
pH	1977-2002	
Conductivity	1977-2002	µS/cm
Phenolphthalein Alkalinity	1978-2002	mg/L $CaCO_3$
Total Alkalinity	1978-2002	mg/L $CaCO_3$
Hardness	1985-2002	mg/L $CaCO_3$
DO	1978-2002	mg/L CaCO3
Turbidity (JTU)	1977-1987	JTU
Turbidity (NTU)	1987-2002	NTU
Apparent Colour	1977-1981	Relative Units
	1987	
True Colour	1981-2002	Relative Units
Non-Filterable Residue	1977-2002	mg/L
Total Dissolved Solids	1982	mg/L
	1985-1986	
Filterable Residue	1987-2002	mg/L
Potassium	1977-2002	mg/L
Sodium	1977-2002	mg/L
Calcium	1977-2002	mg/L
Magnesium	1977-2002	mg/L
Bicarbonate	1982	mg/L
	1985-2002	
Carbonate	1985-2002	mg/L
Chloride	1977-2002	mg/L
Sulphate	1977-2002	mg/L
Reactive Silica	1977-2002	mg/L
Total Organic Carbon	1977-2002	mg/L
Particulate Organic Carbon	1978-1999	mg/L
Dissolved Organic Carbon	1977-2002	mg/L
Phenolics	1977-1999	mg/L
Particulate Nitrogen	1978-1999	mg/L
Dissolved Nitrogen	1978-1987	mg/L
Dissolved Kjeldahl Nitrogen	1987-1994	mg/L
	1995-1999	
Total Ammonia Nitrogen	1977-2002	mg/L
Total Kjeldahl Nitrogen	1977-1978	mg/L
	1987-2002	
Nitrite and Nitrate	1987-2002	mg/L
Total Nitrogen	1987-2002	mg/L
Nitrate	1999-2002	mg/L
Total Organic Nitrogen	1996-1999	mg/L
Nitrite	1999-2002	mg/L
Total Phosphorus	1977-2002	mg/L
Total Dissolved Phosphorus	1978-2002	mg/L
Particulate Phosphorus	1996-1999	mg/L
Chlorophyll a	1980-2002	mg/L
Total Coliforms	1977-1999	cells/100 mL
Fecal Coliforms	1977-2002	cells/100 mL
Fecal Streptococci	1977-1994	cells/100 mL
Escherichia coli	1996-2002	cells/100 mL

Metals	Years of Record	Units
Aluminum	1978-1980	mg/L
	1988-2002	
Arsenic	1978-2002	mg/L
Antimony	1999-2002	mg/L
Barium	1978-1980	mg/L
	1984-2002	
Beryllium	1999-2002	mg/L
Boron	1978-2002	mg/L
Cadmium	1978-2002	mg/L
Chromium	1978-1980	mg/L
	1992-2002	
Cobalt	1978-1997	mg/L
	1999-2002	
Copper	1978-1980	mg/L
	1984-2002	
Cyanide	1994-2002	mg/L
Fluoride	1978-2002	mg/L
Iron	1978-2002	mg/L
Lead	1978-1980	mg/L
	1983-2002	
Lithium	1978-1980	mg/L
	1999-2002	
Manganese	1978-2002	mg/L
Mercury	1978-2002	mg/L
Molybdenum	1978-1980	mg/L
	1999-2002	
Nickel	1978-1980	mg/L
	1983-2002	
Selenium	1978-2002	mg/L
Silver	1978-2002	mg/L
Strontium	1978-1980	mg/L
	1999-2002	
Thallium	1999-2002	mg/L
Tin	1999-2002	mg/L
Titanium	1999-2002	mg/L
Uranium	1999-2002	mg/L
Vanadium	1978-1980	mg/L
	1983-1997	
	1999-2002	
Zinc	1978-1980	mg/L
	1983-2002	
Zirconium	1999-2002	mg/L

Table 2 Summary statistics for inorganic water quality variables in the North Saskatchewan River at Devon and Pakan for the Period 1987-2002

	Temperature (°C)	pH	Conductivity (µS/cm)	Phenolphthalein Alkalinity (mg/L $CaCO_3$)	Total Alkalinity (mg/L $CaCO_3$)	Hardness (mg/L $CaCO_3$)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Colour (Relative Units)	Non-Filterable Residue (mg/L)	Total Dissolved Solids/ Filterable Residue (mg/L)	Potassium (mg/L)	Sodium (mg/L)
Devon													
Minimum	-0.31	6.90	209.0	0.0	89.8	99.0	7.5	0.0	1.0	0.2	100	0.39	2.7
1st Quartile	0.19	7.96	298.0	0.1	122.0	153.2	9.2	2.4	5.0	2.0	170	0.60	3.5
Mean	7.28	8.14	311.7	0.1	129.8	161.1	11.0	27.4	10.9	38.0	188	0.86	4.1
Median	4.29	8.13	309.0	0.1	130.0	158.6	11.4	4.7	10.0	5.2	187	0.70	4.0
3rd Quartile	14.91	8.30	326.0	0.1	137.0	170.0	12.5	16.3	10.0	21.0	201	0.89	4.6
Maximum	22.88	10.10	541.0	7.5	153.0	207.0	14.1	1070.0	56.0	1180.0	296	4.40	8.1
n	180	181	181	138	143	171	181	181	181	181	178	143	181
Standard Deviation	7.71	0.31	29.1	0.7	10.8	15.1	1.7	89.2	10.9	112.7	25	0.56	0.9
Standard Error	0.57	0.02	2.2	0.1	0.9	1.2	0.1	6.6	0.8	8.4	2	0.05	0.1
Pakan													
Minimum	-0.40	7.16	220.0	0.0	84.0	100.0	5.5	0.1	2.5	0.2	146	0.50	1.5
1st Quartile	0.15	7.83	323.0	0.1	126.0	158.6	9.0	2.2	5.0	3.0	190	1.00	6.5
Mean	7.87	8.03	340.4	0.6	132.1	165.9	10.5	35.5	13.6	56.2	217	1.40	7.8
Median	4.90	8.00	344.0	0.1	133.0	162.5	10.7	5.0	10.0	8.0	202	1.10	7.5
3rd Quartile	15.71	8.23	360.0	0.1	140.0	172.6	11.7	21.5	20.0	37.0	221	1.40	8.9
Maximum	24.00	9.60	460.6	16.8	162.0	210.0	15.0	1020.0	160.0	2009.0	2112	5.76	15.9
n	181	181	181	138	143	171	181	181	181	181	179	142	143
Standard Deviation	8.09	0.36	32.0	1.9	12.9	17.0	1.8	108.4	16.4	174.3	145	0.82	2.0
Standard Error	0.60	0.03	2.4	0.2	1.1	1.3	0.1	8.1	1.2	13.0	11	0.07	0.2

Table 2 Summary statistics for inorganic water quality variables in the North Saskatchewan River at Devon and Pakan for the period 1987-2002 (continued)

	Calcium (mg/L)	Magnesium (mg/L)	Bicarbonate (mg/L)	Carbonate (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulphate (mg/L)	Silica (mg/L)	Total Organic Carbon (mg/L)	Particulate Organic Carbon (mg/L)	Dissolved Organic Carbon (mg/L)	Phenol (mg/L)	Particulate Nitrogen (mg/L)	Dissolved Kjeldahl Nitrogen (mg/L)
Devon														
Minimum	27.5	7.4	110.0	0.0	0.0	0.06	22.1	2.40	0.2	0.1	0.1	0.000	0.01	0.01
1st Quartile	40.7	12.1	148.7	0.3	0.5	0.11	34.7	3.57	1.6	0.1	1.5	0.001	0.02	0.10
Mean	43.7	12.8	158.0	0.4	1.0	0.14	39.4	4.14	2.9	0.3	2.7	0.002	0.09	0.19
Median	43.4	12.8	157.0	0.3	0.7	0.13	40.1	4.16	2.4	0.1	2.1	0.001	0.04	0.16
3rd Quartile	46.8	13.6	167.0	0.3	1.1	0.14	43.3	4.64	3.3	0.3	3.0	0.001	0.10	0.23
Maximum	55.8	16.9	187.0	9.0	5.7	0.33	53.3	6.30	16.5	2.0	13.0	0.140	0.90	1.04
n	143	143	143	141	142	157	143	115	144	116	181	146	121	131
Standard Deviation	4.6	1.5	13.2	0.9	0.8	0.04	6.6	0.75	2.2	0.3	2.0	0.012	0.14	0.17
Standard Error	0.4	0.1	1.1	0.1	0.1	0.00	0.6	0.07	0.2	0.0	0.2	0.001	0.01	0.01
Pakan														
Minimum	26.8	7.7	102.4	0.0	0.8	0.09	23.6	0.01	1.2	0.1	1.2	0.001	0.01	0.03
1st Quartile	42.2	12.3	152.0	0.3	2.4	0.13	40.2	2.30	2.1	0.1	2.1	0.001	0.05	0.28
Mean	44.9	13.3	159.9	0.9	3.7	0.16	45.1	3.57	3.7	0.3	3.4	0.001	0.17	0.49
Median	44.8	13.2	160.9	0.3	3.4	0.15	45.6	4.00	2.9	0.2	2.7	0.001	0.09	0.48
3rd Quartile	47.9	14.2	170.7	0.3	4.4	0.17	49.5	4.73	4.3	0.4	3.9	0.001	0.22	0.64
Maximum	62.4	17.4	198.0	20.2	13.0	0.60	64.1	10.40	17.3	3.5	12.3	0.044	1.90	1.28
n	143	143	142	138	143	157	142	115	144	117	180	146	120	131
Standard Deviation	5.1	1.6	16.4	2.3	1.7	0.05	7.6	1.80	2.5	0.4	2.1	0.004	0.24	0.24
Standard Error	0.4	0.1	1.4	0.2	0.1	0.00	0.6	0.17	0.2	0.0	0.2	0.000	0.02	0.02

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Table 2 Summary statistics for inorganic water quality variables in the North Saskatchewan River at Devon and Pakan for the period 1987-2002 (continued)

	Ammonia (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Nitrite + Nitrate Nitrogen (mg/L)	Total Nitrogen (mg/L)	Nitrate Nitrogen (mg/L)	Total Organic Nitrogen (mg/L)	Total Phosphorus (mg/L)	Total Dissolved Phosphorus (mg/L)	Particulate Phosphorus (mg/L)	Chlorophyll *a* (mg/L)	Total Coliforms (cells/100 mL)	Fecal Coliforms (cells/100 mL)	Fecal Streptococci (cells/100 mL)
Devon													
Minimum	0.01	0.01	0.002	0.010	0.002	0.01	0.002	0.001	0.001	0.0001	2	1	1
1st Quartile	0.01	0.12	0.009	0.156	0.008	0.06	0.004	0.002	0.001	0.0004	11	2	4
Mean	0.02	0.25	0.043	0.295	0.051	0.22	0.034	0.005	0.020	0.0009	88	17	85
Median	0.01	0.19	0.038	0.220	0.032	0.12	0.008	0.002	0.004	0.0006	40	5	9
3rd Quartile	0.01	0.28	0.069	0.322	0.078	0.25	0.027	0.005	0.013	0.0011	88	10	27
Maximum	0.26	2.40	0.374	2.422	0.374	1.38	0.640	0.082	0.189	0.0052	1600	600	3200
n	175	180	180	180	36	32	181	181	32	180	144	179	85
Standard Deviation	0.03	0.27	0.041	0.272	0.065	0.30	0.074	0.008	0.041	0.0008	191	57	366
Standard Error	0.00	0.02	0.003	0.020	0.011	0.05	0.006	0.001	0.007	0.0001	16	4	40
Pakan													
Minimum	0.01	0.03	0.002	0.060	0.070	0.01	0.012	0.003	0.004	0.0003	5	2	1
1st Quartile	0.05	0.40	0.263	0.728	0.242	0.18	0.064	0.031	0.012	0.0019	635	20	12
Mean	0.25	0.65	0.336	0.980	0.303	0.40	0.119	0.057	0.039	0.0066	8380	440	147
Median	0.22	0.59	0.336	0.906	0.294	0.35	0.092	0.051	0.020	0.0049	2450	98	59
3rd Quartile	0.43	0.76	0.399	1.173	0.346	0.63	0.136	0.074	0.057	0.0081	6100	232	178
Maximum	0.79	3.80	0.700	4.500	0.605	1.22	1.150	0.159	0.237	0.0716	300000	25000	900
n	174	180	180	180	33	36	181	33	180	180	140	174	82
Standard Deviation	0.21	0.41	0.123	0.454	0.103	0.29	0.121	0.035	0.049	0.0082	28303	2061	216
Standard Error	0.02	0.03	0.009	0.034	0.017	0.05	0.009	0.003	0.008	0.0006	2392	156	24

Table 3 Summary statistics for selected metals in the North Saskatchewan River at Devon and Pakan for the period 1987-2002

	Dissolved Aluminum (mg/L)	Dissolved Arsenic (mg/L)	Dissolved Boron (mg/L)	Total Copper (mg/L)	Dissolved Iron (mg/L)	Dissolved Manganese (mg/L)	Total Nickel (mg/L)	Total Lead (mg/L)	Total Zinc (mg/L)
Devon									
Minimum	0.00	0.0001	0.00	0.000	0.01	0.001	0.000	0.0002	0.000
1st Quartile	0.01	0.0001	0.01	0.001	0.01	0.001	0.001	0.0004	0.005
Mean	0.01	0.0003	0.02	0.004	0.05	0.005	0.007	0.0019	0.015
Median	0.01	0.0002	0.01	0.002	0.01	0.002	0.004	0.0010	0.011
3rd Quartile	0.01	0.0004	0.02	0.004	0.02	0.003	0.007	0.0015	0.017
Maximum	0.07	0.0030	0.19	0.044	4.72	0.159	0.087	0.0260	0.124
n	121	120	118	115	178	174	114	112	112
Standard Deviation	0.01	0.0004	0.02	0.006	0.38	0.015	0.013	0.0038	0.018
Standard Error	0.00	0.0000	0.00	0.001	0.03	0.001	0.001	0.0004	0.002
Pakan									
Minimum	0.00	0.0001	0.01	0.000	0.01	0.001	0.000	0.0002	0.001
1st Quartile	0.01	0.0003	0.01	0.001	0.01	0.002	0.002	0.0008	0.009
Mean	0.02	0.0004	0.02	0.004	0.04	0.007	0.007	0.0027	0.018
Median	0.02	0.0004	0.01	0.002	0.01	0.002	0.004	0.0011	0.012
3rd Quartile	0.03	0.0005	0.03	0.005	0.01	0.006	0.008	0.0024	0.023
Maximum	0.27	0.0050	0.27	0.050	3.57	0.274	0.059	0.0214	0.092
n	120	123	116	115	178	175	114	112	114
Standard Deviation	0.03	0.0005	0.03	0.007	0.27	0.021	0.010	0.0040	0.017
Standard Error	0.00	0.0000	0.00	0.001	0.02	0.002	0.001	0.0004	0.002

Table 4 Water quality trends and guideline comparisons of long-term inorganics data in the North Saskatchewan River at Devon, 1977-2002.

Variable	Overall Trend (1977-2002)	Overall, Flow Adjusted	1987 Step Trend	Pre-1987 Trend	Pre-1987, Flow Adjusted	Post-1987 Trend	Post-1987, Flow Adjusted	Comments	ASWQG*	% Compliance	CCMEWQG**	% Compliance
Temperature	-	NS	-	NS	NS	NS	+	Equipment change in 1986.				
pH	NS	NS	NS						6.5-8.5	98	6.5-9.0	99
Conductivity	NS	NS	NS									
Total Alkalinity	+	+	+	+	+	NS	NS	Increasing pre-1987. Positive step in 1987.				
Hardness	ID	ID	ID	ID	ID	+	NS					
Dissolved Oxygen	NS	-	NS					Decreasing overall (flow-adjusted).	6.5[a]	100	6.5	100
Turbidity	NS	+	NS					Increasing overall (flow-adjusted).				
Colour	NS	NS	NS						<30[b]	100		
Non-Filterable Residue	-	NS	-	NS	NS	-	+	Decreasing post-1987. Negative step in 1987.				
TDS/Filterable Residue	ID	ID	ID	ID	ID	+	NS	Increasing post-1987. Positive step in 1987.				
Potassium	NS	NS	NS									
Sodium	+	+	NS					Increasing overall.				
Calcium	NS	NS	+	-	-	NS	NS	Decreasing pre-1987. Positive step in 1987.			1000[ls]	100
Magnesium	NS	NS	+	-	-	+	+	Decreasing pre-1987. Increasing post-1987. Positive step in 1987.				
Flow	-							Decreasing overall, 90% confidence interval.				
Bicarbonate	NS	NS	NS									
Carbonate	+	NS	+	NS	NS	NS	NS	Positive step in 1987.				
Chloride	NS	NS	NS								100-700[irr]	100
Fluoride	+	+	+	NS		NS	NS	Overall increase due to step trend.				
Reactive Silica	NS	NS	NS									
Sulphate	+	+	+	NS	NS	+	NS	Increasing post-1987. Lab change effect in 1987.				
Total Organic Carbon	NS	NS	-	NS	NS	NS	NS	Negative step in 1987.				
Particulate Organic Carbon	-	-	-	NS	NS	NS	NS	Negative step in 1987.				
Dissolved Organic Carbon	NS	NS	NS									

Table 4 Water quality trends and guideline comparisons of long-term inorganics data in the North Saskatchewan River at Devon, 1977-2002 (continued)

Variable	Overall Trend (1977-2002)	Overall, Flow Adjusted	1987 Step Trend	Pre-1987 Trend	Pre-1987, Flow Adjusted	Post-1987 Trend	Post-1987, Flow Adjusted	Comments	ASWQG*	% Compliance	CCMEWQG**	% Compliance
Phenolics	NS	NS	-	NS	NS	NS	NS	Negative step in 1987.			0.004	99
Particulate Nitrogen	NS	NS	NS									
Dissolved Nitrogen	ID	ID	ID	-	-	ID	ID	Decreasing pre-1987. No post-1987 data.				
Dissolved Kjeldahl Nitrogen	ID	ID	ID	ID	ID	-	-	Decreasing post-1987. No pre-1987 data.				
Total Ammonia Nitrogen	-	-	-	NS	NS	NS	NS	Increasing pre-1987. Change in detection limit in 1987. Highly censored data.			0.108-23.895[c]	100
Total Kjeldahl Nitrogen	ID	ID	ID	ID	ID	-	NS	Decreasing post-1987. Insufficient pre-1987 data.				
Nitrite and Nitrate Nitrogen	NS	NS	NS								100[ls]	100
Total Nitrogen	NS	+	+	-	-	-	NS	Positive step in 1987. Decreasing post-1987.	1.0	98		
Total Organic Nitrogen	NS	NS	ID									
Total Phosphorus	-	NS	-	NS	NS	-	+	Decreasing overall. Negative step in 1987. Decreasing post-1987.	0.05	83		
Total Dissolved Phosphorus	NS	NS	NS									
Chlorophyll a	NS	NS	-	NS	NS	NS	NS	Change in detection limit in 1987.				
Total Coliforms	NS	NS	+	NS	NS	-	-	Data gaps pre-1987. Decreasing post-1987.			1000/100ml	99
Fecal Coliforms	+	NS	+	NS	NS	+	+	Positive step in 1987. Increasing post-1987.			100/100ml incl. *E. coli*	97

*ASWQG - Alberta Surface Water Quality Guideline

**CCMEWQG - Canadian Council of Ministers of the Environment Water Quality Guideline

Unless otherwise indicated, presented values for both the ASWQG and CCMEWQG relate to protection of aquatic life.

+/- indicate increasing or decreasing trends, respectively.

[a]Minimum of 8.3 mg/L from May 15 to June 30 to protect emergence of mayfly species.

[b]Not to be increased by more than 30 units above natural level.

[c]Calculated as a function of pH and water temperature.

[ls]As determined for livestock consumption.

[irr]As determined for irrigation water.

NS - Not Significant. Any trends not reporting significance within a 90% confidence interval or reporting significance with a slope of '0'.

ID - Insufficient Data.

Pre- and post-1987 trends were not evaluated for variables lacking a significant step trend in 1987.

Table 5 Water quality trends and guideline compliance of long-term metals data in the North Saskatchewan River at Devon

Variable	Overall Trend (1977-2002)	Overall, Flow Adjusted	1987 Step Trend	Pre-1987 Trend	Pre-1987, Flow Adjusted	Post-1987 Trend	Post-1987, Flow Adjusted	Comments	ASWQG*	CCMEWQG**	% Compliance
Dissolved Aluminum	ID	ID	ID	ID	ID	-	-	Decreasing post-1987. Due to reduced sampling frequency?		100 µg/L[a]	100
Dissolved Arsenic	NS	NS	NS	ID	ID	-	-	Decreasing post-1987. Due to reduced sampling frequency?		5 µg/L	100
Dissolved Boron	-	-	-	+	+	NS	NS	Overall decrease due to step trend. Increasing pre-1987.		500-6000[irr]	100
Total Copper	ID	ID	ID	ID	ID	NS	NS		16-35 µg/L[b]		98.4
Dissolved Iron	-	-	-	ID	ID	+	NS	Overall decrease due to step trend. Increasing post-1987.		300 µg/L	99.2
Dissolved Manganese	-	-	-	ID	ID	NS	NS	Overall decrease due to step trend.			
Total Nickel	ID	ID	ID	ID	ID	NS	NS			110 µg/L[c]	100
Total Lead	ID	ID	ID	ID	ID	-	-	Decreasing post-1987.		2-7 µg/L	91.3
Total Zinc	ID	ID	ID	ID	ID	NS	NS			30 µg/L	93.7

*ASWQG = Alberta Surface Water Quality Guideline

**CCMEWQG = Canadian Council of Ministers of the Environment Guideline

Unless otherwise indicated, presented ASWQG and CCMEWQG values relate to the protection of aquatic life.

+/- indicate increasing or decreasing trends, respectively.

[a]Based on pH≥6.5 & [Ca2+]>4 mg/L.

[b]Based on hardness of 100-225 mg/L CaCO3.

[c]Based on hardness of 60-200 mg/L CaCO3.

[irr]As determined for irrigation water.

ID - Insufficient Data.

NS - Not Significant. Any trends not reporting significance within a 90% confidence interval or reporting significance with a slope of '0'.

Table 6 Water quality trends and guideline comparisons of long-term inorganics data in the North Saskatchewan River at Pakan, 1977-2002

Variable	Overall Trend (1977-2002)	Overall, Flow Adjusted	1987 Step Trend	Pre-1987 Trend	Pre-1987, Flow Adjusted	Post-1987 Trend	Post-1987, Flow Adjusted	Comments	ASWQG*	% Compliance	CCMEWQG**	% Compliance
Temperature	-	NS	NS					Overall negative trend.				
pH	NS	NS	NS						6.5-8.5	93	6.5-9.0	99
Conductivity	NS	NS	NS									
Total Alkalinity	+	+	+	NS	NS	+	NS	Increasing post-1987. Positive step in 1987.				
Hardness	NS	+	+	ID	ID	+	+	Increasing Post-1987. Positive step in 1987.				
Dissolved Oxygen	NS	NS	NS						6.5[a]	95.4	6.5	100
Turbidity	-	NS	-	NS	NS	-	NS	Decreasing post-1987. Negative step in 1987.				
Colour	NS	NS	NS	NS	NS	NS	NS		<30[b]	100		
Non-Filterable Residue	-	NS	-	NS	NS	-	NS	Decreasing post-1987. Negative step in 1987.				
TDS/Filterable Residue	ID	ID	ID	ID	ID	+	NS	Increasing post-1987.				
Potassium	+	NS	+	NS	NS	NS	NS	Positive step in 1987.				
Sodium	+	+	+	NS	NS	+	+	Increasing post-1987. Positive step in 1987.				
Calcium	NS	NS	+	-	-	+	+	Decreasing pre-1987 (flow adj). Increasing Post-1987. Positive step in 1987.			1000[ls]	100
Magnesium	NS	NS	+	-	-	+	+	Decreasing pre-1987 (flow adj). Increasing Post-1987. Positive step in 1987.				
Flow	NS											
Bicarbonate	NS	NS	NS									
Carbonate	NS	NS	+	NS	NS	NS	NS	Positive step in 1987.				
Chloride	+	+	+	NS	NS	NS	NS	Positive step in 1987.			100-700[irr]	100
Fluoride	+	+	+	NS	NS	NS	NS	Increasing overall due to step trend.				
Reactive Silica	NS	+	NS					Increasing overall (flow adjusted).				
Sulphate	+	+	+	NS	NS	+	+	Increasing post-1987. Positive step in 1987.				
Total Organic Carbon	-	-	-	NS	NS	NS	NS	Negative step in 1987.				
Particulate Organic Carbon	-	-	-	NS	NS	NS	NS	Negative step in 1987.				
Dissolved Organic Carbon	NS	NS	NS									

Table 6 Water quality trends and guideline comparisons of long-term inorganics data in the North Saskatchewan River at Pakan, 1977-2002 (continued)

Variable	Overall Trend (1977-2002)	Overall, Flow Adjusted	1987 Step Trend	Pre-1987 Trend	Pre-1987, Flow Adjusted	Post-1987 Trend	Post-1987, Flow Adjusted	Comments	ASWQG*	% Compliance	CCMEWQG**	% Compliance
Phenolics	NS	NS	-	NS	NS	NS	NS	Negative step in 1987.			0.004	99.6
Particulate Nitrogen	NS	NS	NS									
Dissolved Nitrogen	ID	ID	ID	NS	NS	ID	ID	No pre-1987 data.				
Dissolved Kjeldahl Nitrogen	ID	ID	ID	ID	ID	NS	NS	No post-1987 data.				
Total Ammonia Nitrogen	-	NS	+	NS	NS	NS	-	Increasing pre-1987. Decreasing post-1987. Negative step in 1987.			0.108-23.895[c]	100
Total Kjeldahl Nitrogen	ID	ID	ID	ID	ID	NS	NS	Minimal pre-1987 data.				
Nitrite and Nitrate Nitrogen	+	+	+	NS	NS	NS	-	Decreasing post-1987 (flow adjusted). Positive step in 1987.			100[ls]	100
Total Nitrogen	+	+	+	NS	NS	-	-	Decreasing post-1987. Positive step in 1987.	1.0	67		
Total Organic Nitrogen	NS	NS	ID									
Total Phosphorus	-	-	-	+	+	-	-	Increasing pre-1987. Decreasing post-1987. Negative step in 1987.	0.05	11		
Total Dissolved Phosphorus	-	-	-	+	NS	-	-	Increasing pre-1987. Decreasing post-1987. Negative step in 1987.				
Chlorophyll a	NS	+	NS					Increasing overall (flow adjusted).				
Total Coliforms	NS	NS	+	NS	NS	-	-	Decreasing post-1987. Positive step in 1987.			1000/100ml	36
Fecal Coliforms	-	-	-	+	NS	-	-	Increasing pre-1987. Decreasing post-1987. Negative step in 1987.			100/100ml (incl. *E. coli*)	49

*ASWQG - Alberta Surface Water Quality Guideline

**CCMEWQG - Canadian Council of Ministers of the Environment Water Quality Guideline

Unless otherwise indicated, presented values for both the ASWQG and CCMEWQG related to the protection of aquatic life.

+/- indicate increasing and decreasing trends, respectively.

[a]Minimum of 8.3 mg/L from May 15 to June 30 to protect emergence of mayfly species.

[b]Not to be increased by more than 30 units above natural level.

[c]Calculated as a function of pH and water temperature.

[ls]As determined for livestock consumption.

[irr]As determined for irrigation water.

NS - Not Significant. Any trends not reporting significance within a 90% confidence interval or reporting significance with a slope of '0'.

ID - Insufficient Data.

Pre- and post-1987 trends were not evaluated for variables lacking a significant step trend in 1987.

Table 7 Water quality trends and guideline comparisons of long-term metals data in the North Saskatchewan River at Pakan

Variable	Overall Trend	Overall, Flow Adjusted	1987 Step Trend	Pre-1987 Trend	Pre-1987, Flow Adjusted	Post-1987 Trend	Post-1987, Flow Adjusted	Comments	ASWQG*	CCMEWQG**	% Compliance
Dissolved Aluminum	ID	ID	ID	ID	ID	-	-	Decreasing post-1987.		100 µg/L[a]	97.5
Dissolved Arsenic	NS	NS	+	ID	ID	-	-	Decreasing post-1987.		5 µg/L	99.5
Dissolved Boron	-	NS	-	+	NS	NS	NS	Decreasing overall due to step trend. Increasing pre-1987.		500-6000	100
Total Copper	ID	ID	ID	ID	ID	NS	NS		16-35 µg/L[b]		96.9
Dissolved Iron	+	-	-	ID	ID	UC	NS	Increasing overall. Decreasing when adjusted for flow.		300 µg/L	99.2
Dissolved Manganese	-	NS	-	ID	ID	NS	NS	Decreasing overall, likely due to step trend.			
Total Nickel	ID	ID	ID	ID	ID	NS	NS			100-210 µg/L[c]	100
Total Lead	ID	ID	ID	ID	ID	NS	NS			2-7 µg/L[c]	85.6
Total Zinc	ID	ID	ID	ID	ID	NS	NS			30 µg/L	85.8

*ASWQG - Alberta Surface Water Quality Guideline

**CCMEWQG - Canadian Council of Ministers of the Environment Water Quality Guideline.

Unless otherwise indicated, presented values for both the ASWQG and CCMEWQG relate to the protection of aquatic life.

+/- indicate increasing or decreasing trends, respectively.

[a]Based on pH≥6.5 & [Ca2+]>4 mg/L.

[b]Based on hardness of 100-225 mg/L $CaCO_3$.

[c]Based on hardness of 60-200 mg/L $CaCO_3$.

NS - Not Significant. Any trends not reporting significance within a 90% confidence interval or reporting significance with a slope of '0'.

ID - Insufficient Data.

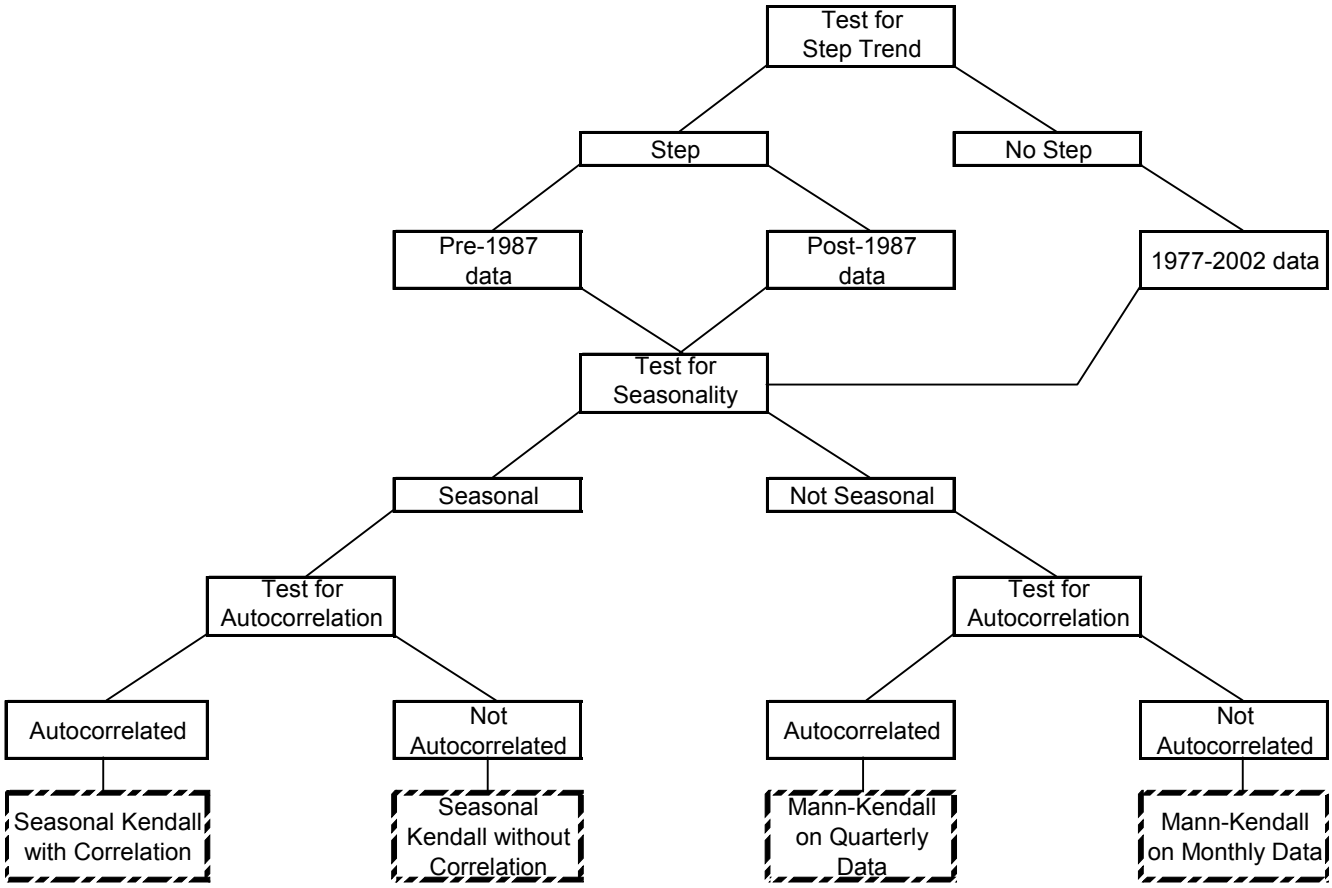


Figure 1 Flow diagram depicting process used to identify the appropriate trend analysis to apply for each variable at each long-term sampling location

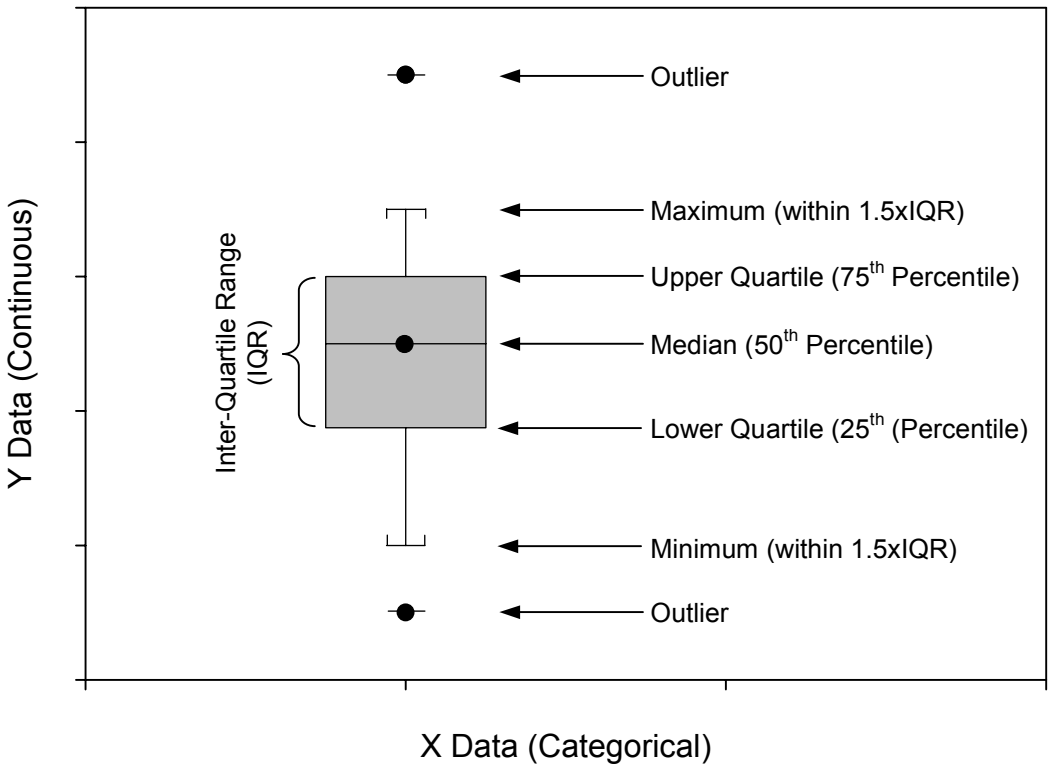
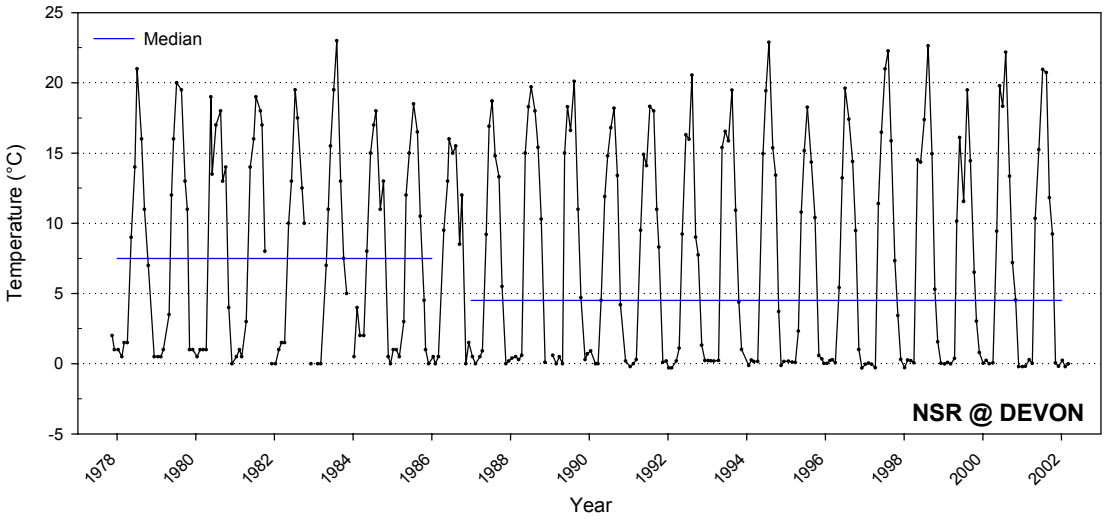
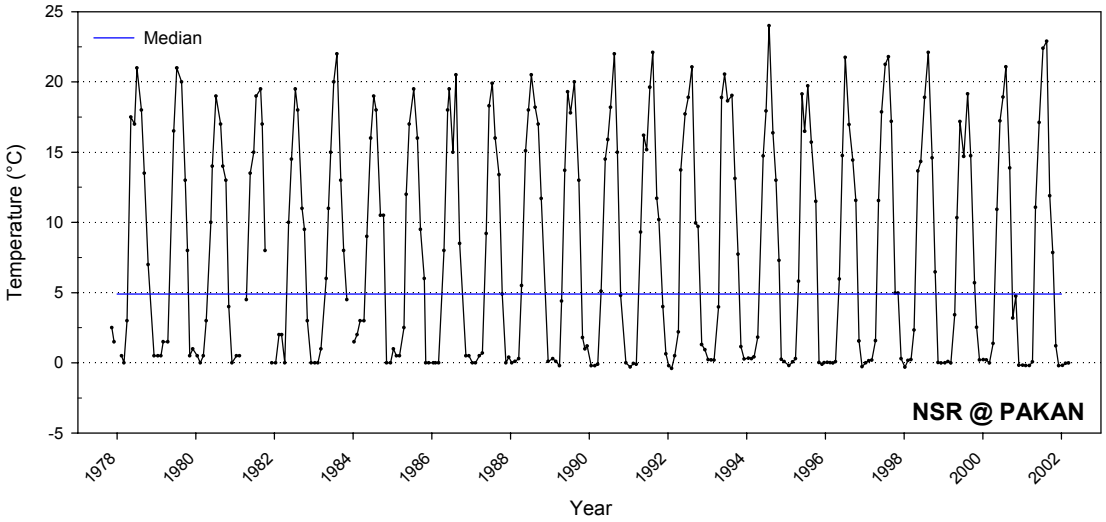


Figure 2 Key to box and whisker plot components



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0285	***	***	7.50	0.0000	NS	4.50	-0.0146	NS
Flow Adjusted								
0.0494	NS			-0.1458	NS		0.2379	**



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0112	**	NS	4.90	-	-	4.90	-	-
Flow Adjusted								
0.0174	NS			-	-		-	-

Figure 3 Water Temperature in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals.

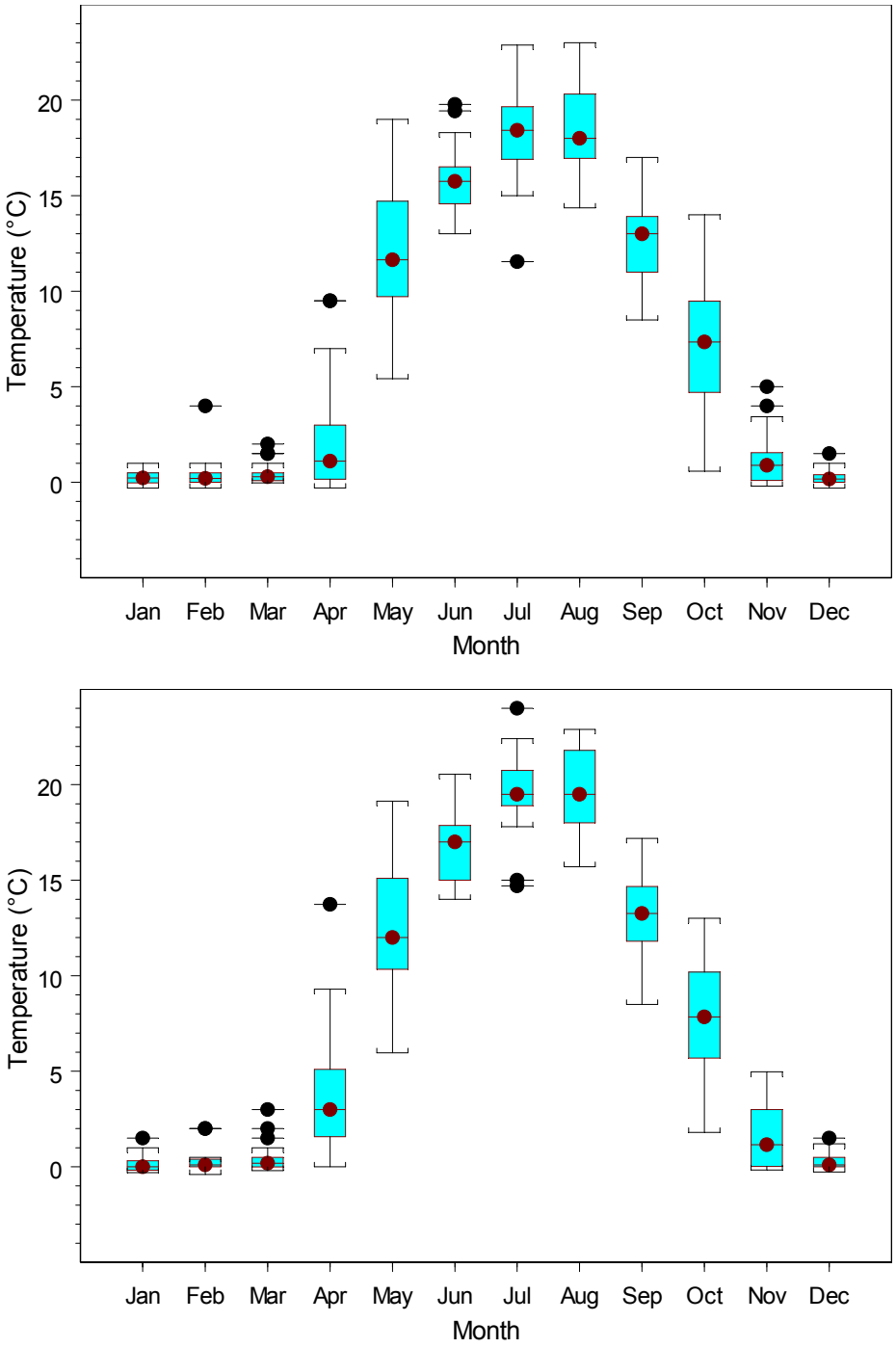


Figure 4 Boxplots depicting seasonality of water temperature in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.

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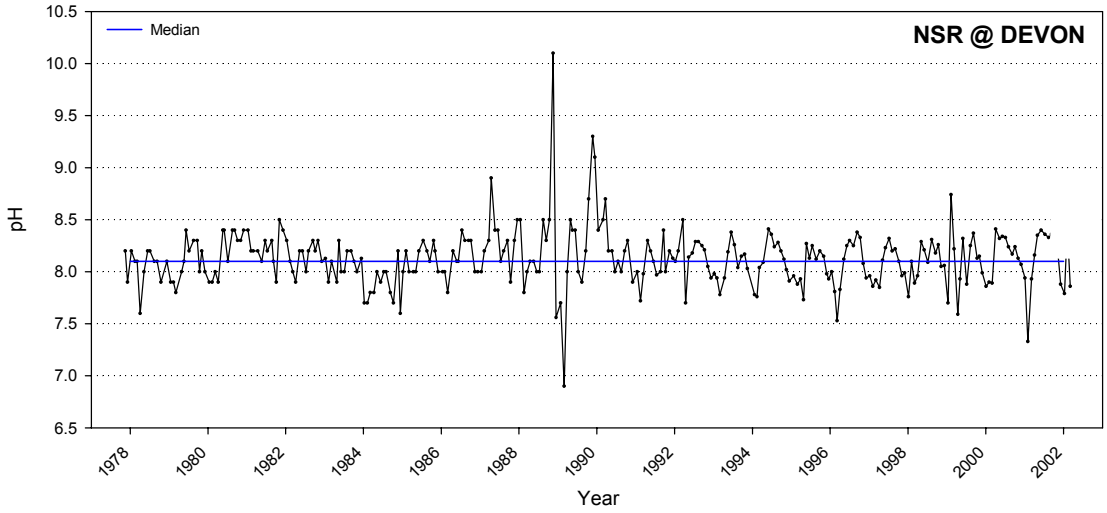
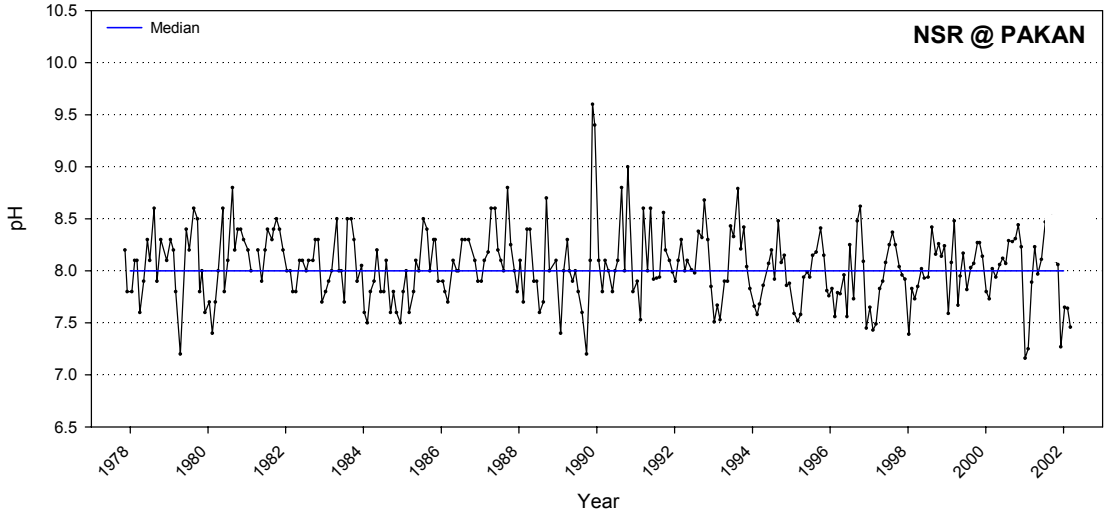


Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-	NS	NS	8.10	-	-	8.10	-	-
Flow Adjusted								
0.0002	NS			-	-		-	-



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0000	*	NS	8.00	-	-	8.00	-	-
Flow Adjusted								
-0.0005	NS			-	-		-	-

Figure 5 pH in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals.

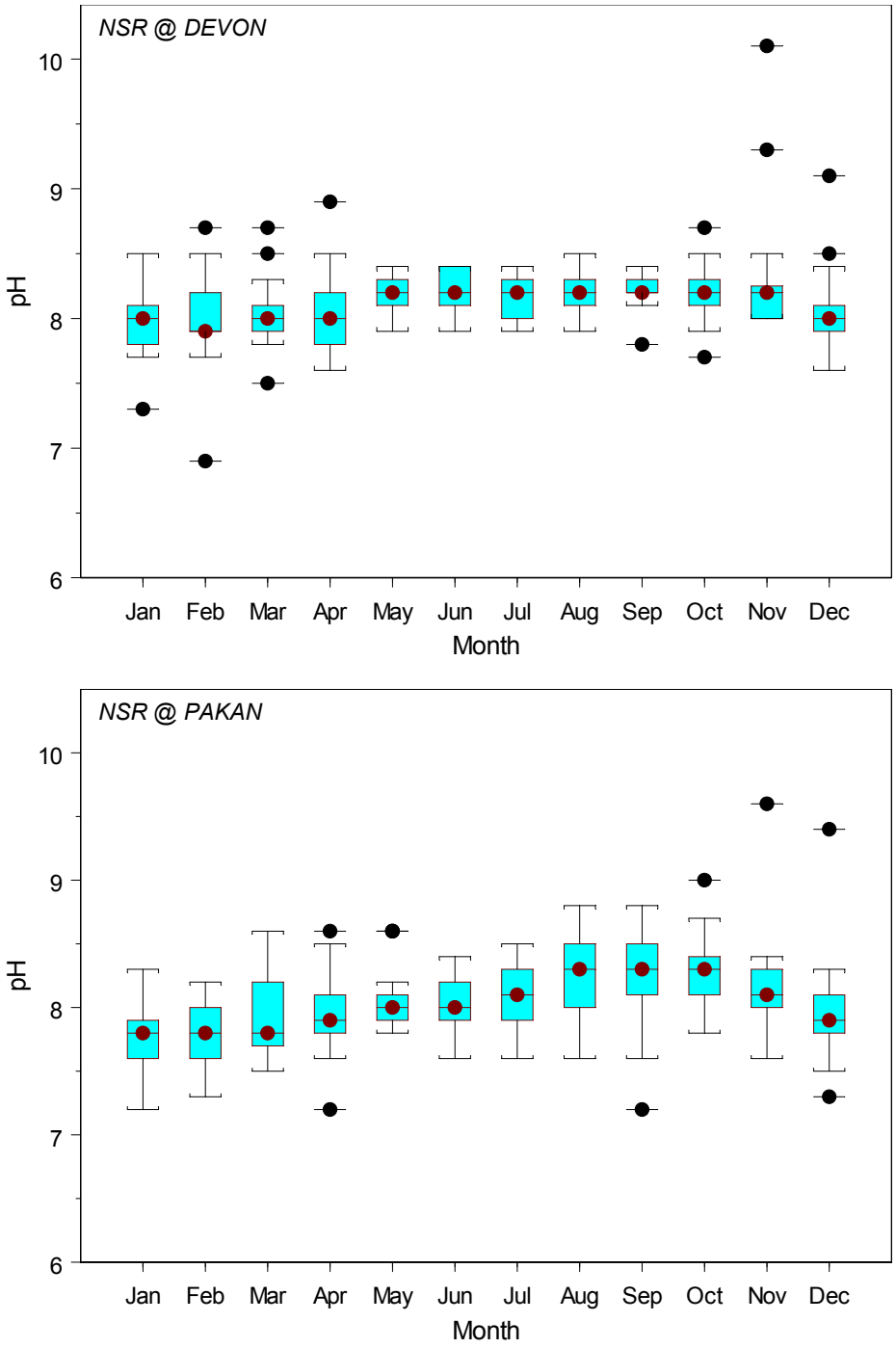
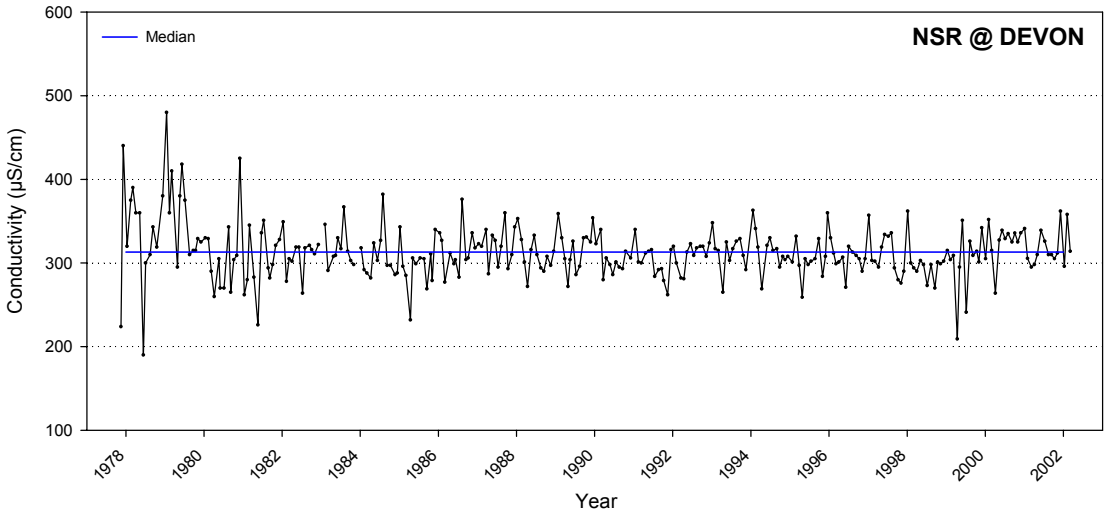
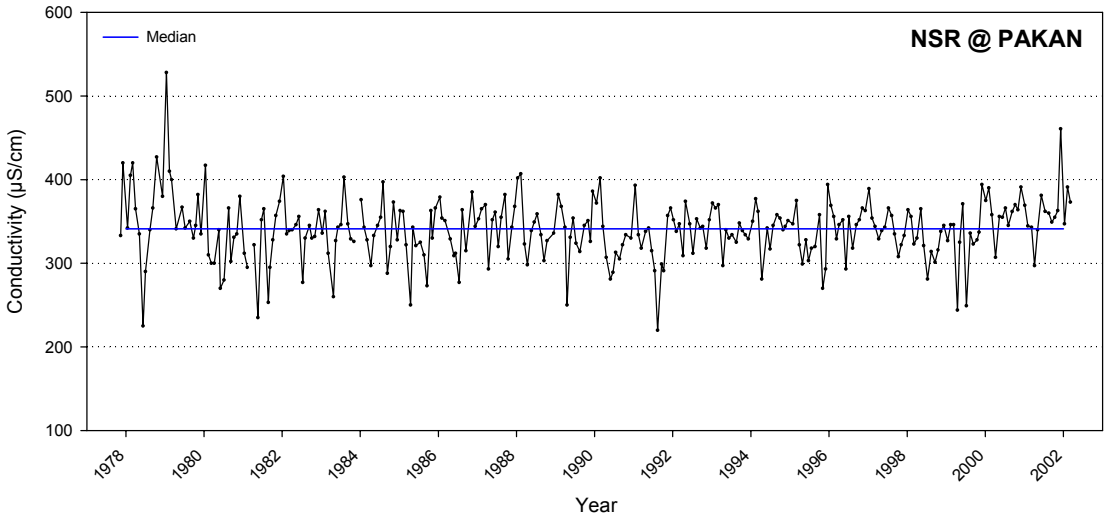


Figure 6 Boxplots depicting seasonality of pH in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.2495	NS	NS	309.00	-	-	309.00	-	-
Flow Adjusted								
-0.3310	NS			-	-		-	-



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0834	NS	NS	341.00	-	-	341.00	-	-
Flow Adjusted								
0.0996	NS			-	-		-	-

Figure 7 Conductivity in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals.

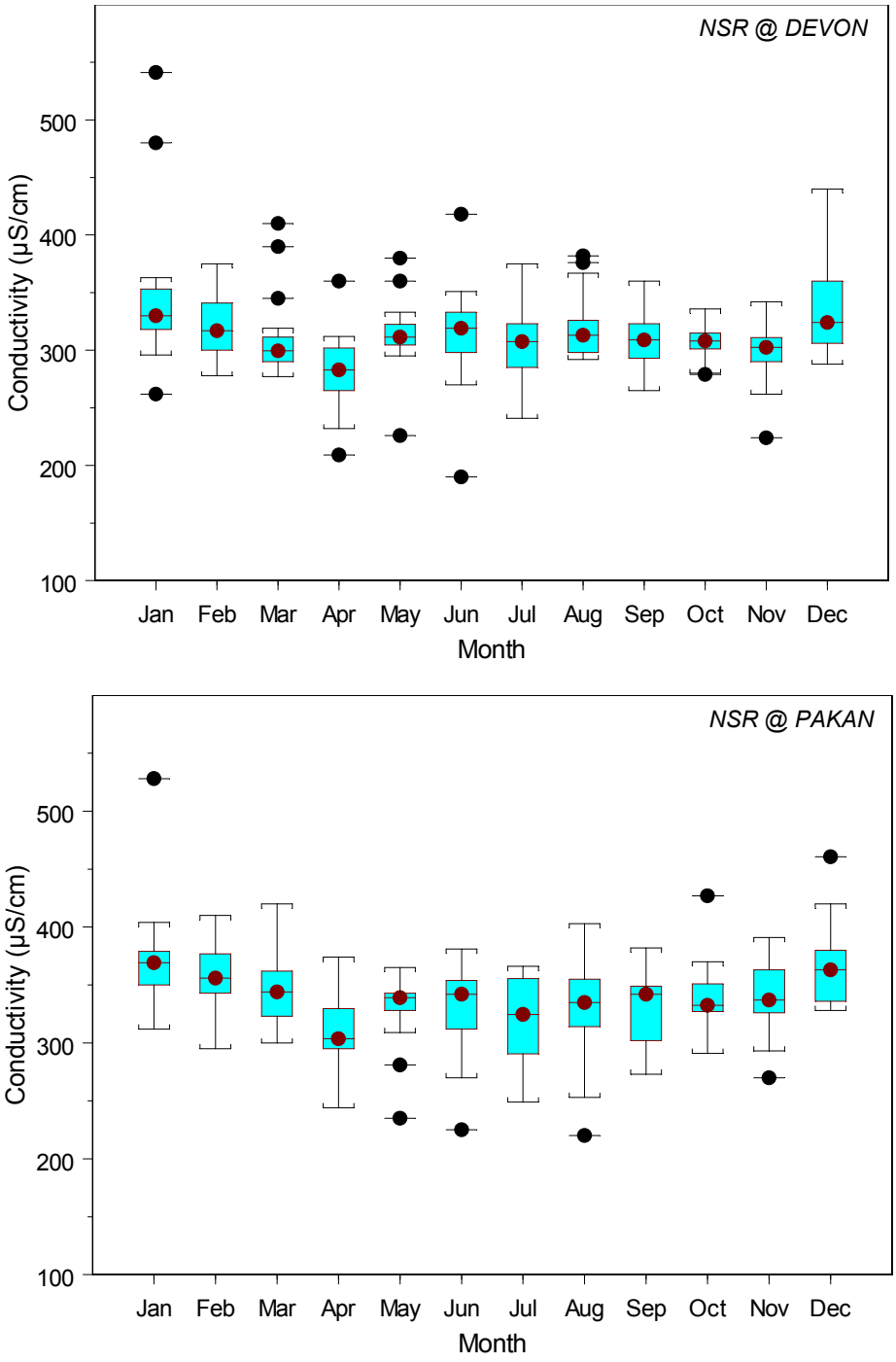
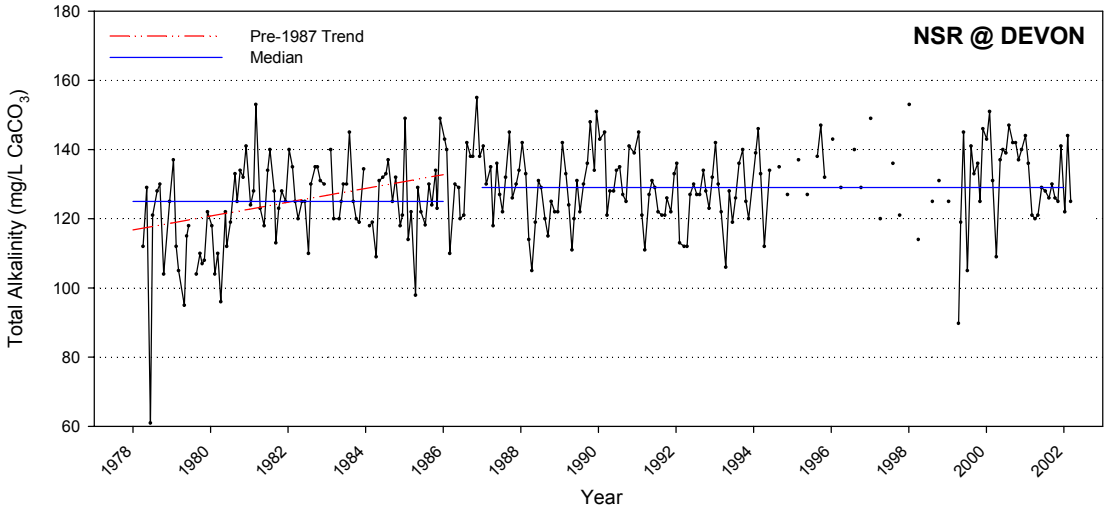
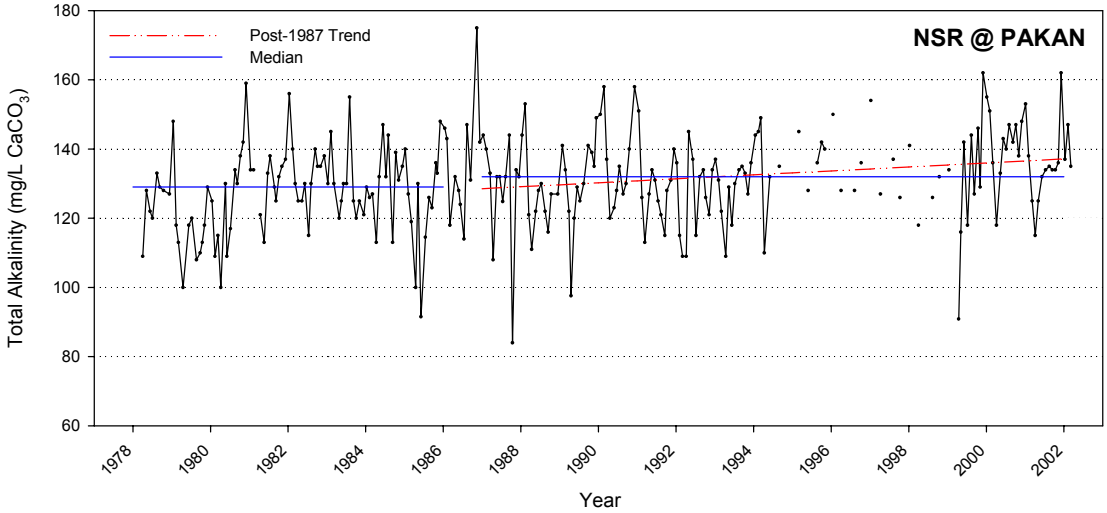


Figure 8 Boxplots depicting seasonality of conductivity in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.4209	***	***	125.00	1.9945	**	129.00	0.2800	NS
Flow Adusted								
0.3314	**			2.0983	**		0.0344	NS



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.4501	***	***	129.00	1.0011	NS	132.00	0.5727	*
Flow Adjusted								
0.3573	**			1.6670	NS		0.3591	NS

Figure 9 Total Alkalinity in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals.

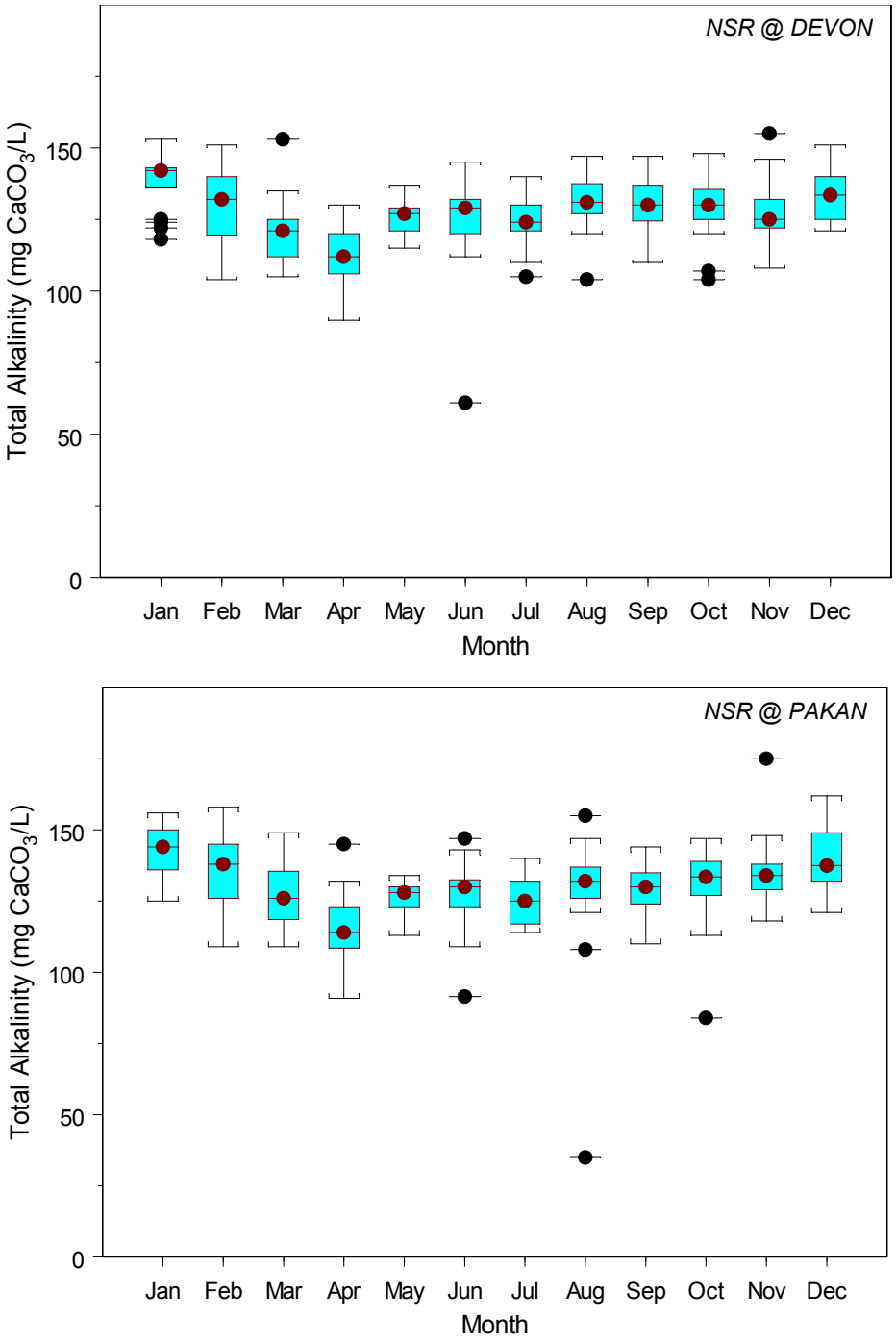
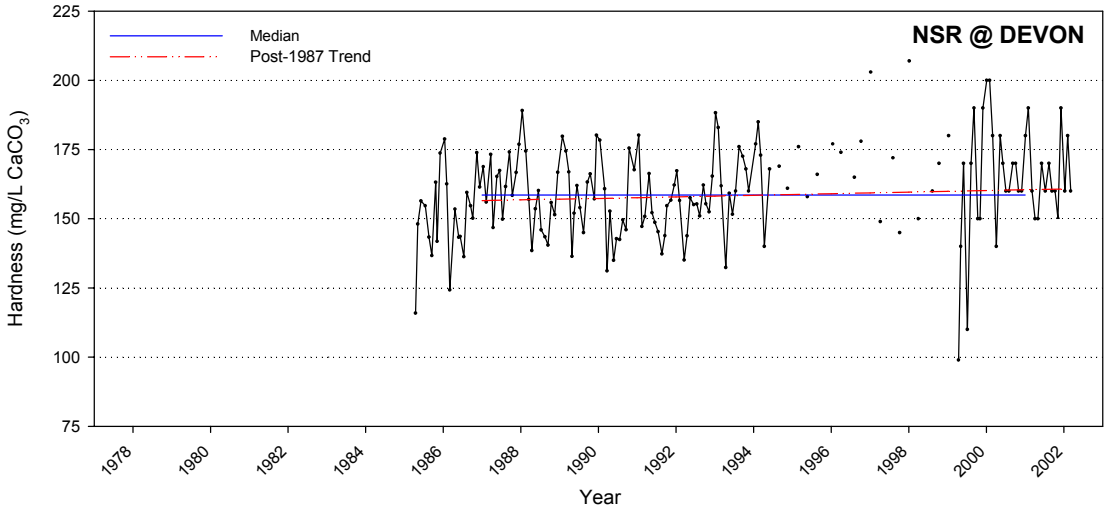
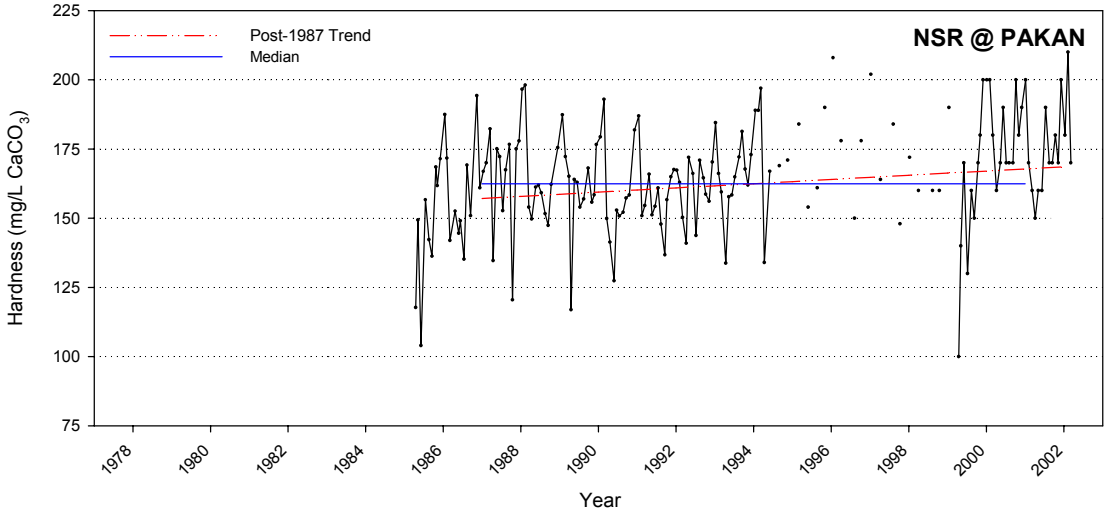


Figure 10 Boxplots depicting seasonality of total alkalinity in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
ID	ID	ID	153.50	ID	ID	158.59	0.2808	**
Flow Adjusted								
ID	ID			ID	ID		-	-



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
ID	ID	ID	151.75	ID	ID	162.48	0.7622	***
Flow Adjusted								
ID	ID			ID	ID		0.6059	***

Figure 11 Hardness in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals. ID = Insufficient Data.

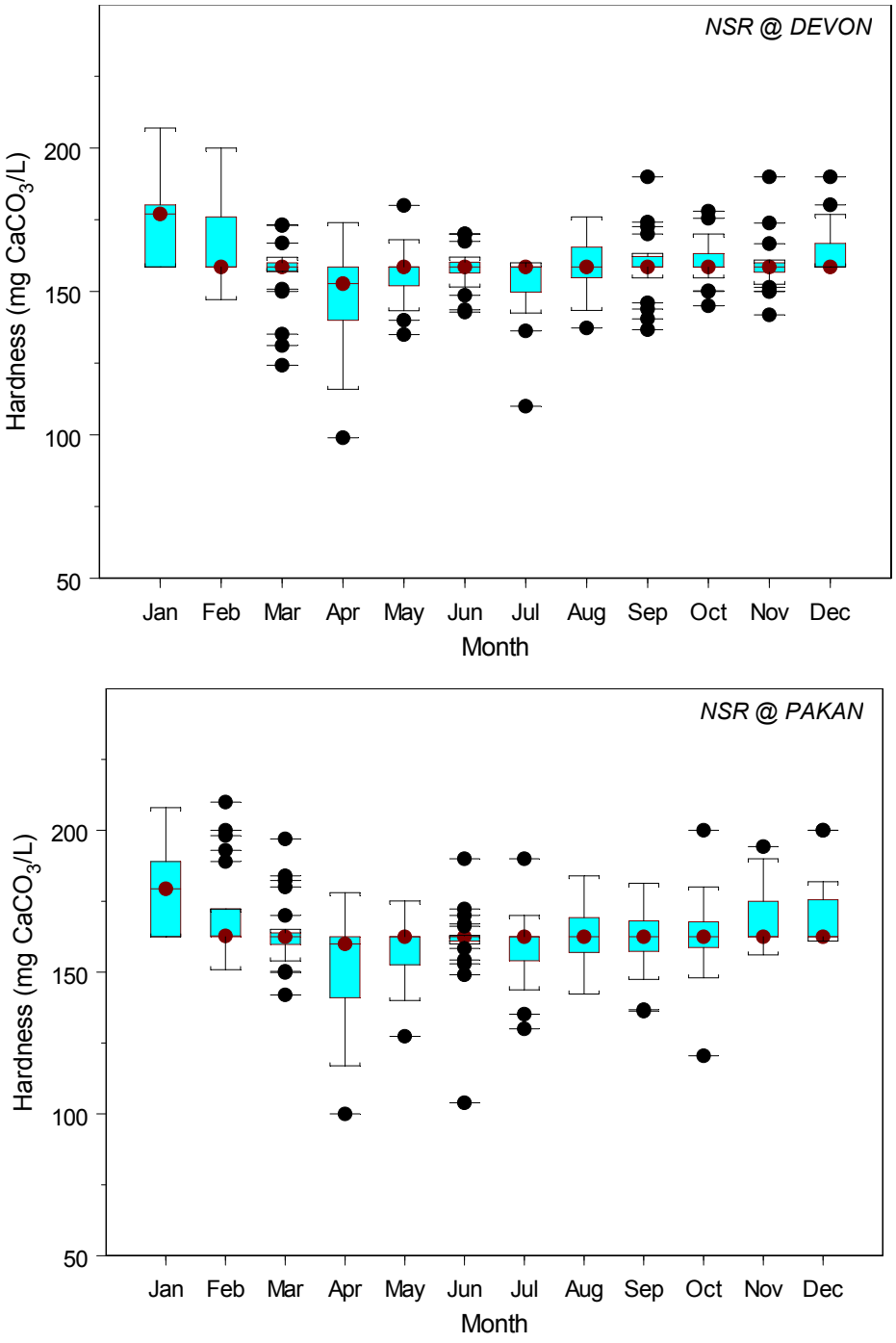
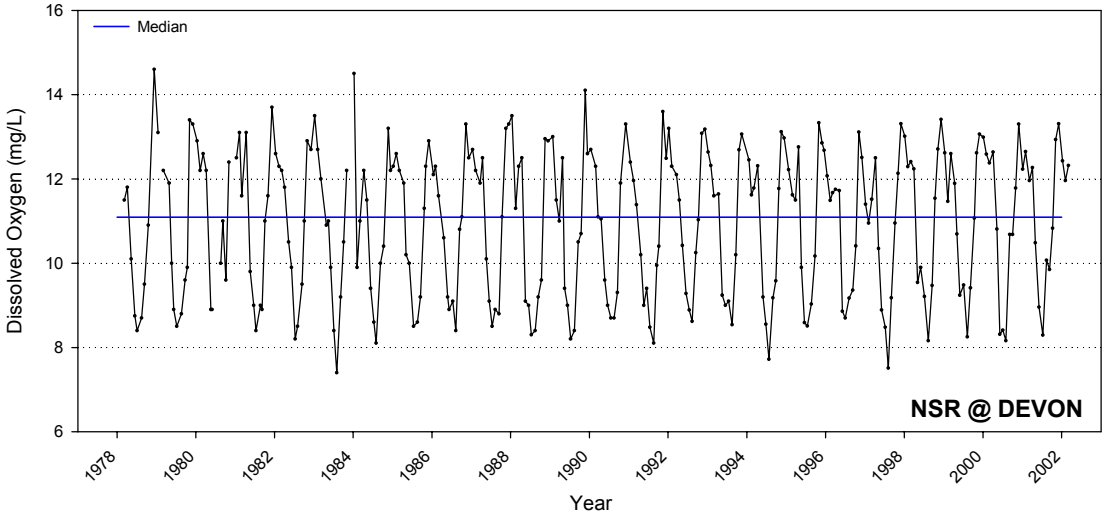
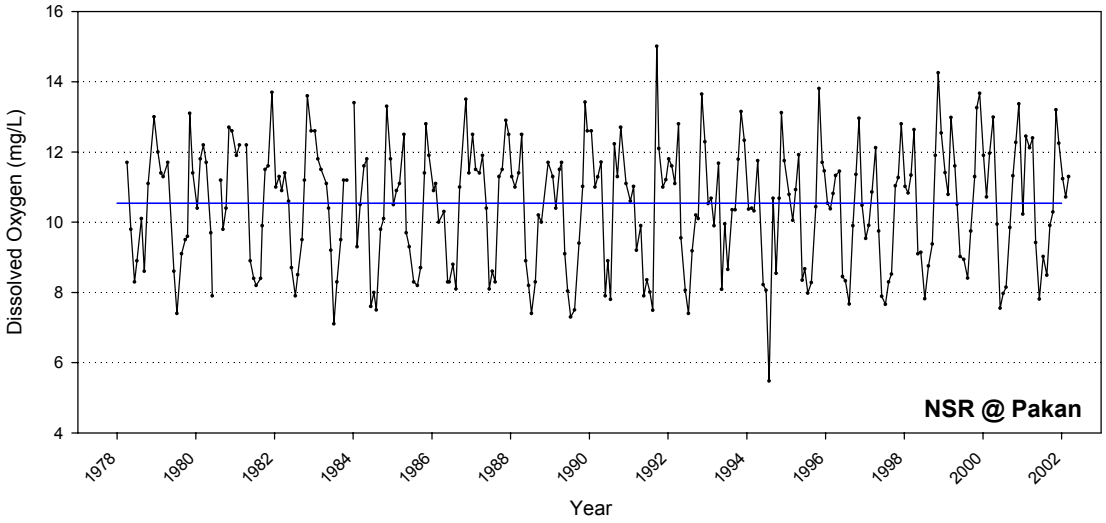


Figure 12 Boxplots depicting seasonality of hardness in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0000	NS	NS	11.09	-	-	11.09	-	-
Flow Adjusted								
-0.0155	**			-	-		-	-



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0019	NS	NS	10.54	-	-	10.54	-	-
Flow Adjusted								
-0.0104	NS			-	-		-	-

Figure 13 Dissolved oxygen concentration in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals.

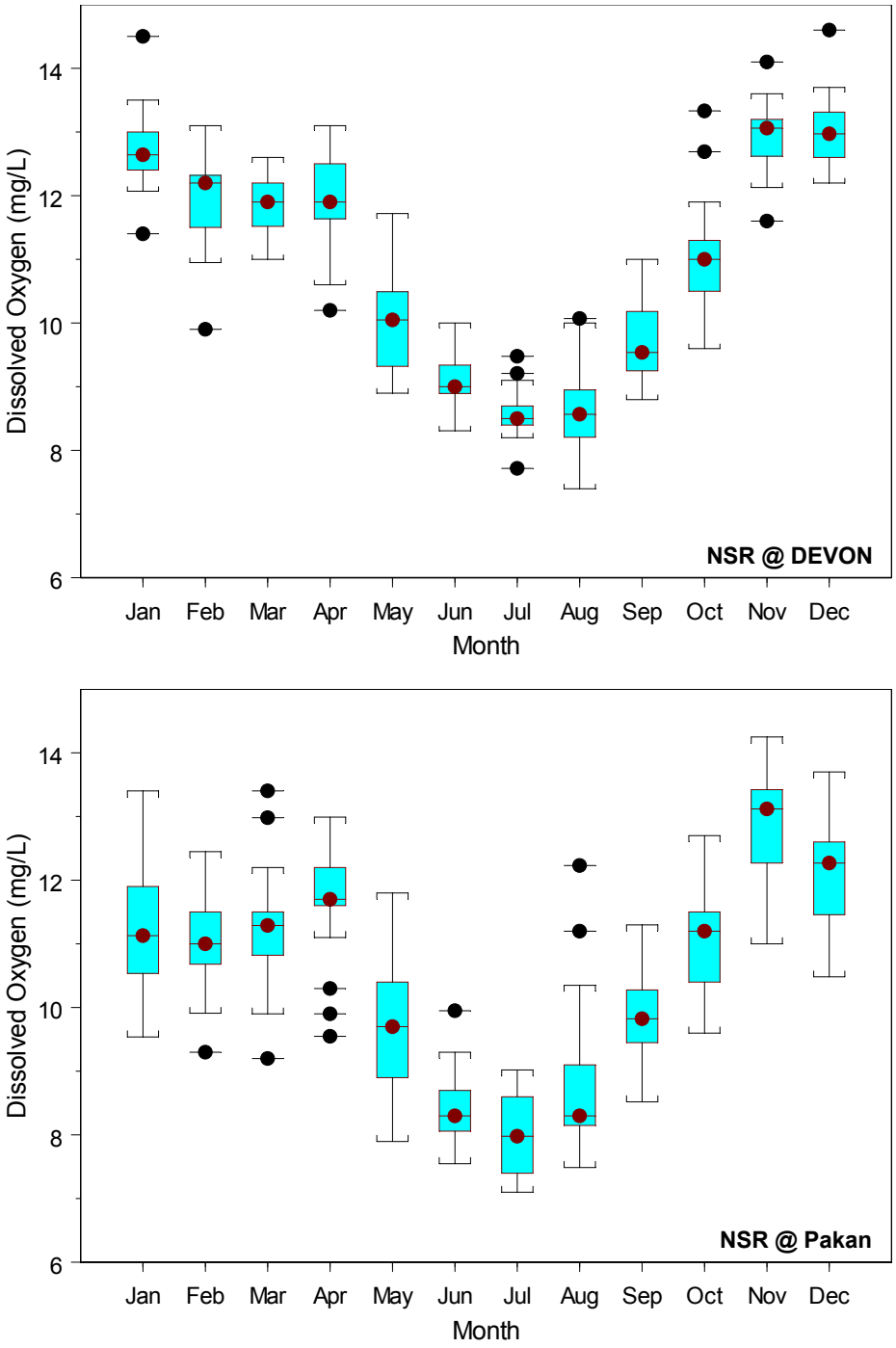
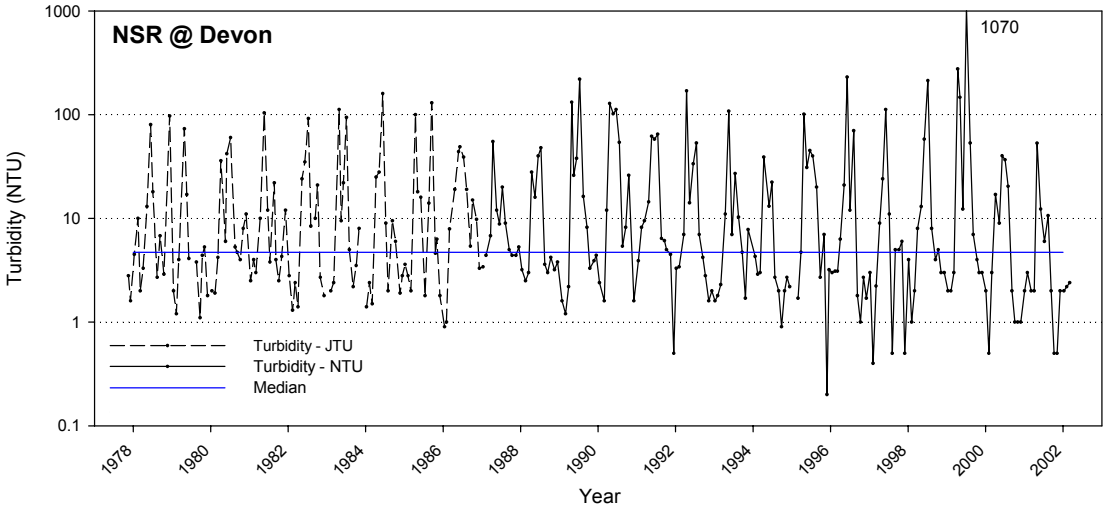
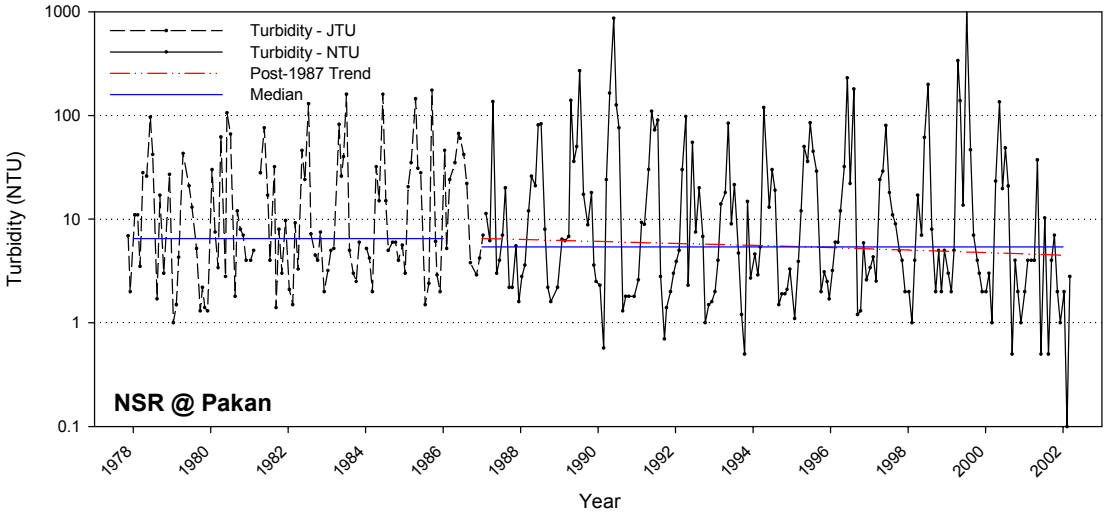


Figure 14 Boxplots depicting seasonality of dissolved oxygen in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0272	NS	NS	4.7	-	-	4.7	-	-
Flow Adjusted								
0.3625	***			-	-		-	-



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0687	**	*	6.5	0.2471	NS	5.4	-0.1330	**
Flow Adjusted								
0.0691	NS			0.2582	NS		0.3205	NS

Figure 15 Turbidity in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals.

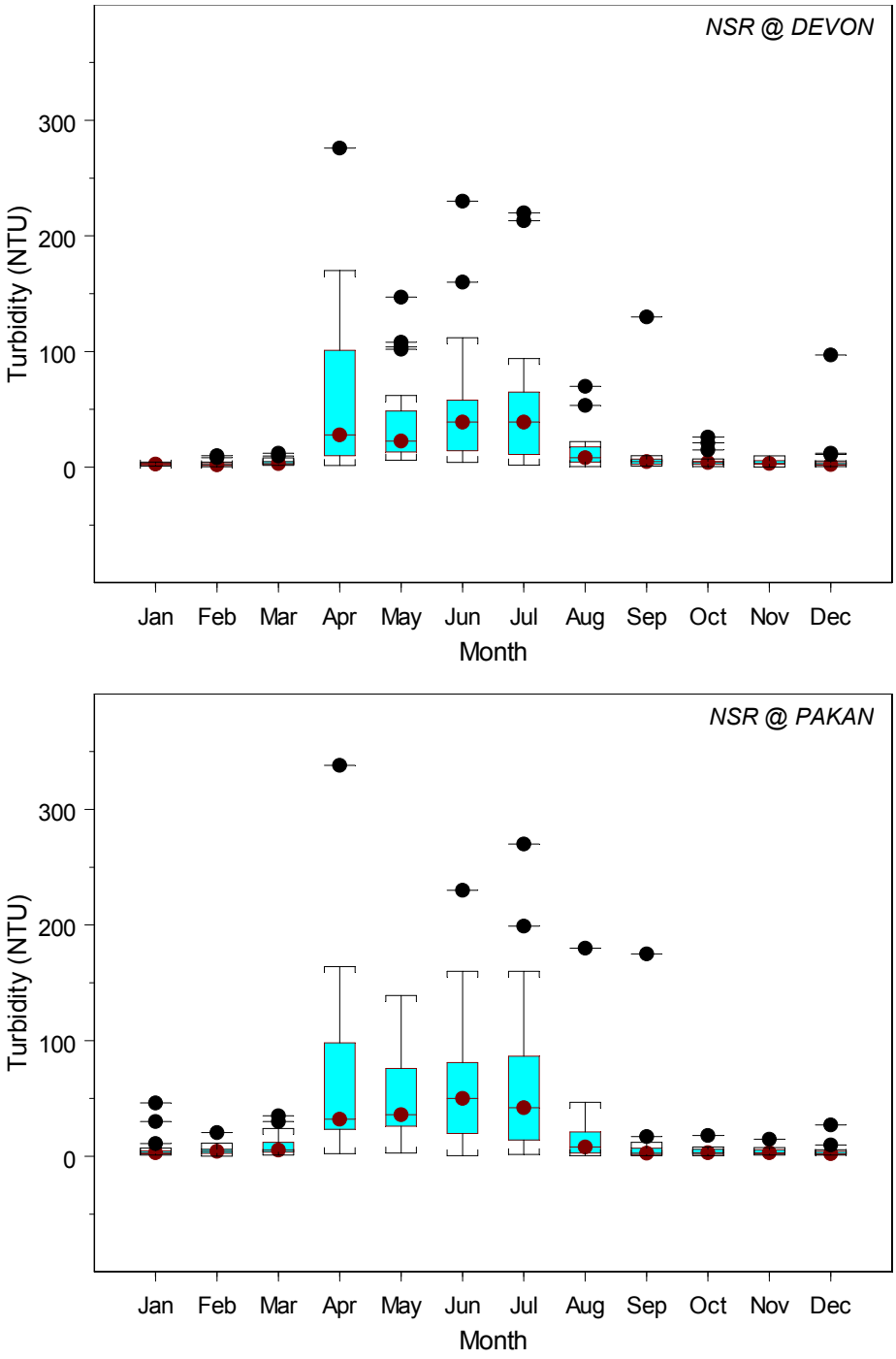
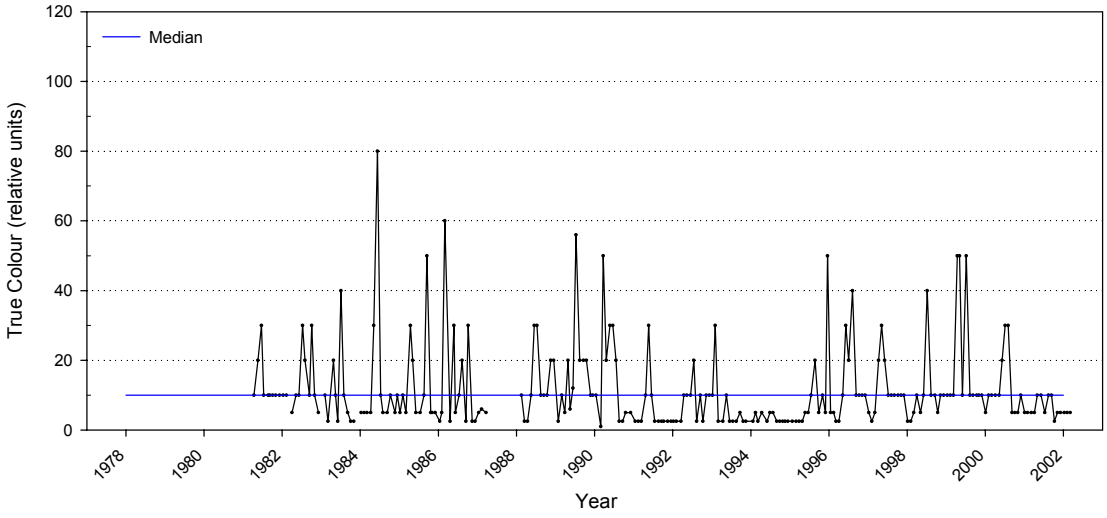
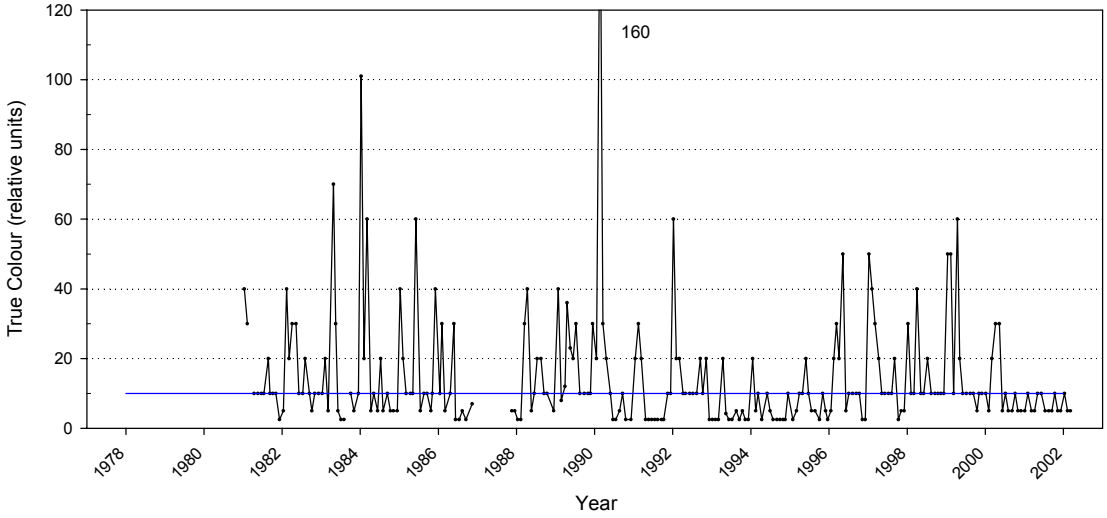


Figure 16 Boxplots depicting seasonality of turbidity in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0000	NS	NS	10	-	-	10	-	-
Flow Adjusted								
0.0076	NS			-	-		-	-



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0000	NS	*	10	-	-	10	-	-
Flow Adjusted								
0.0000	NS			-	-		-	-

Figure 17 Water colour in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals.

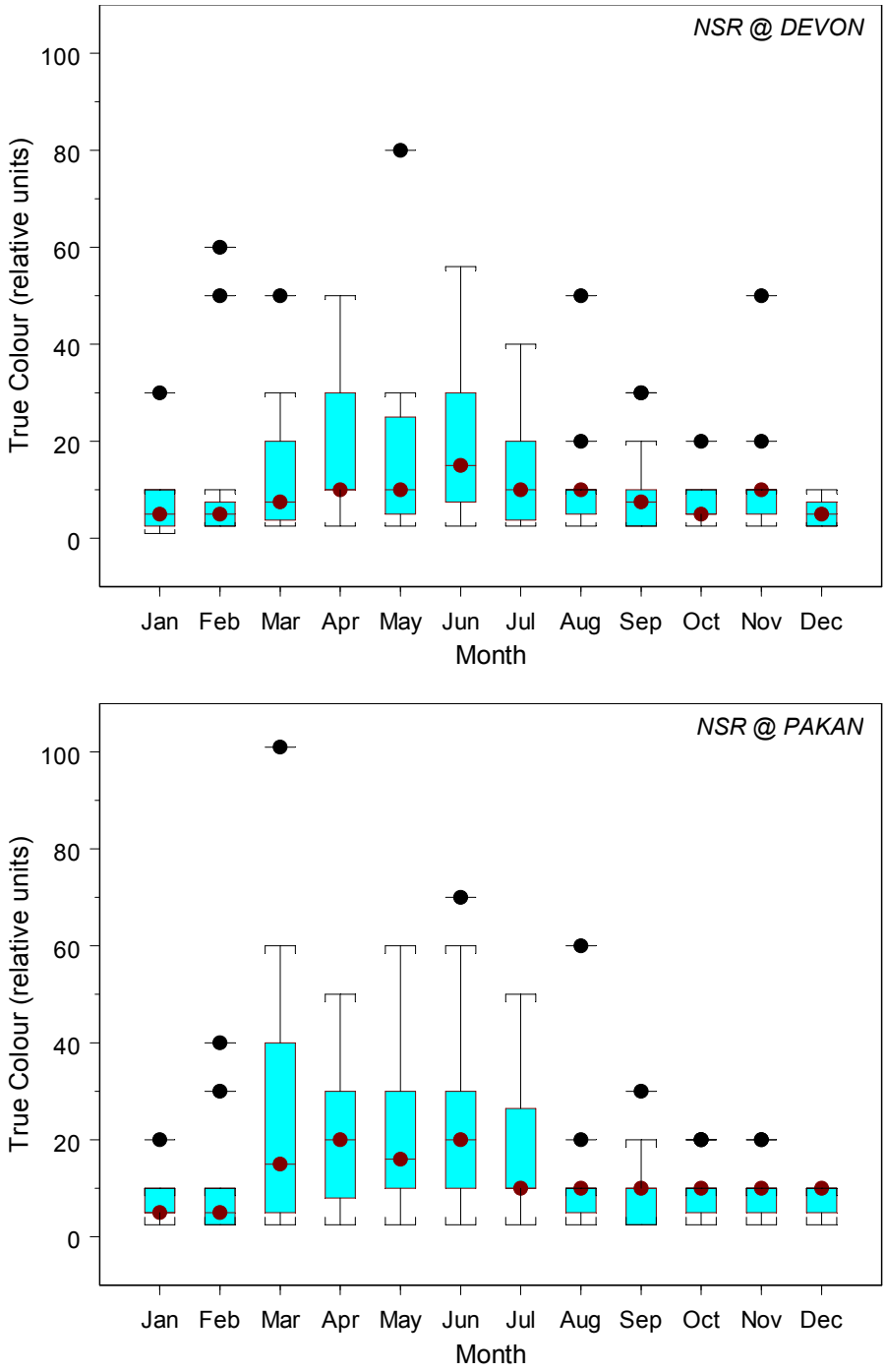
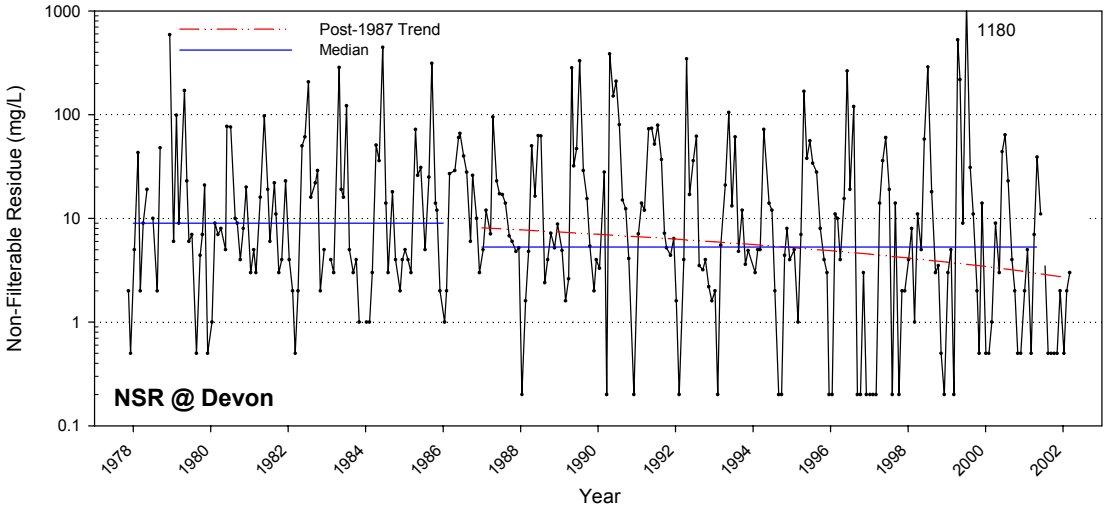
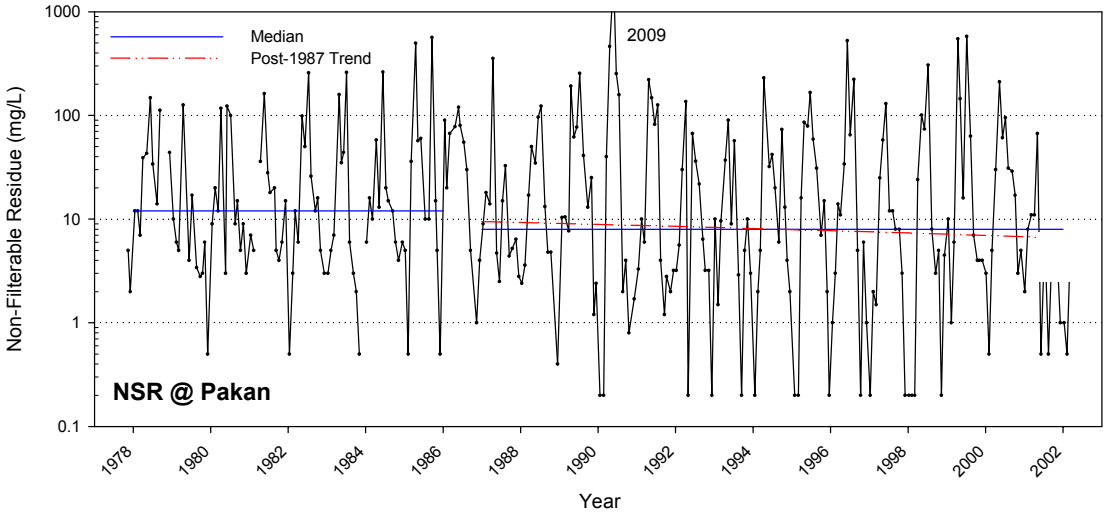


Figure 18 Boxplots depicting seasonality of true colour in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.1661	***	*	9.00	0.0000	NS	5.30	-0.3583	***
Flow Adjusted								
0.1156	NS			-0.9052	NS		0.8774	**



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.1201	**	*	12.00	0.2218	NS	8.00	-0.1939	*
Flow Adjusted								
0.0183	NS			0.6743	NS		0.1531	NS

Figure 19 Non-filterable residue in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals.

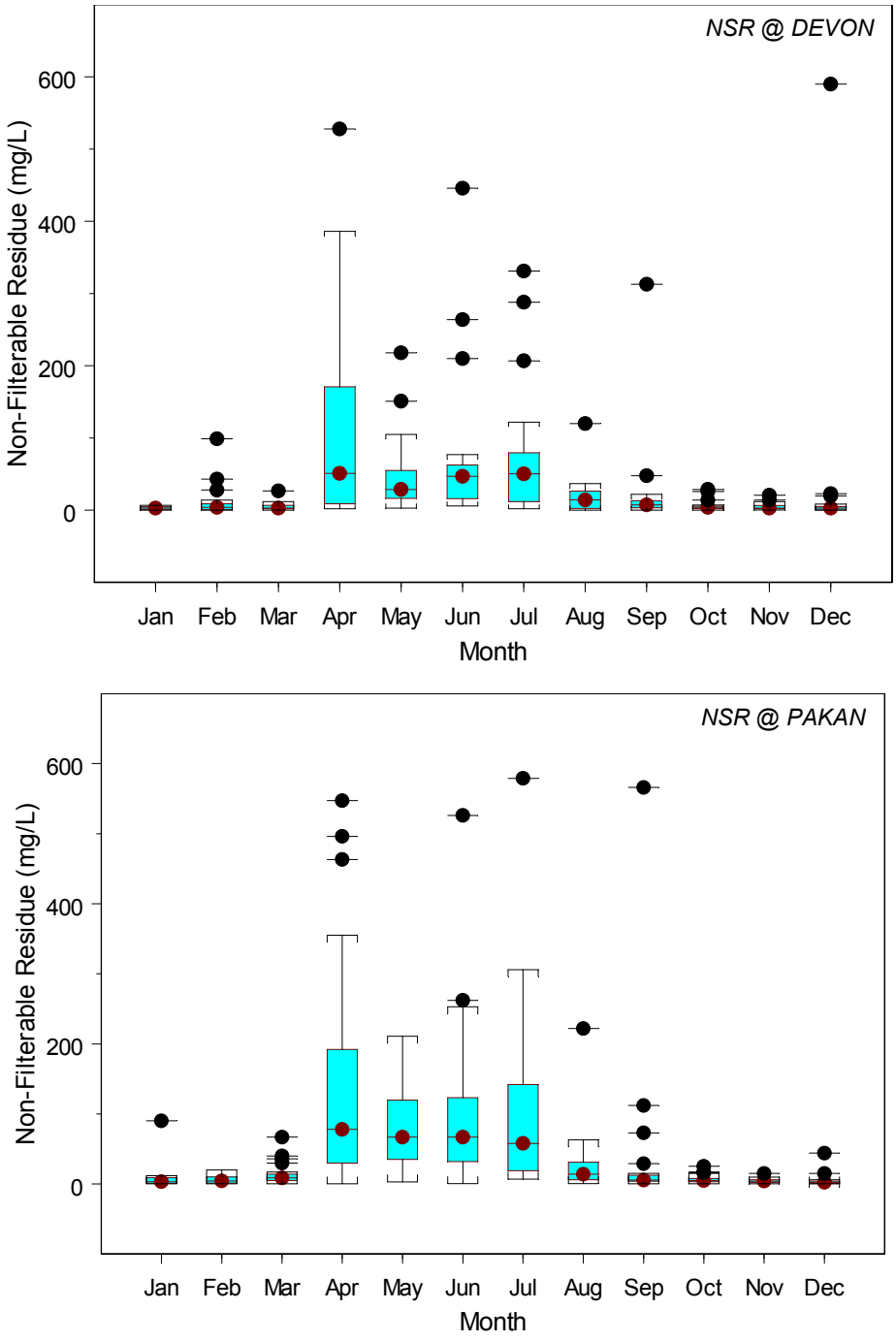
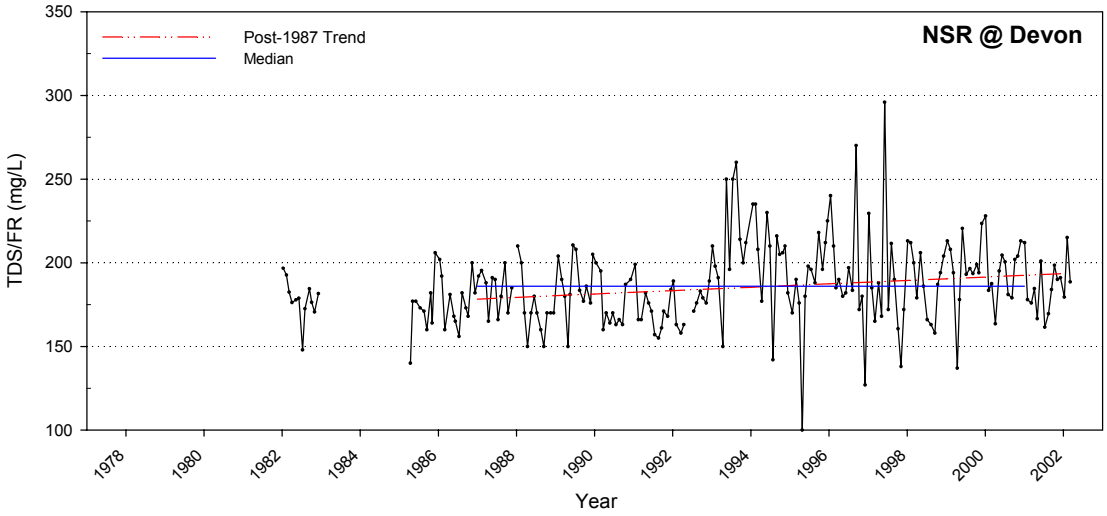
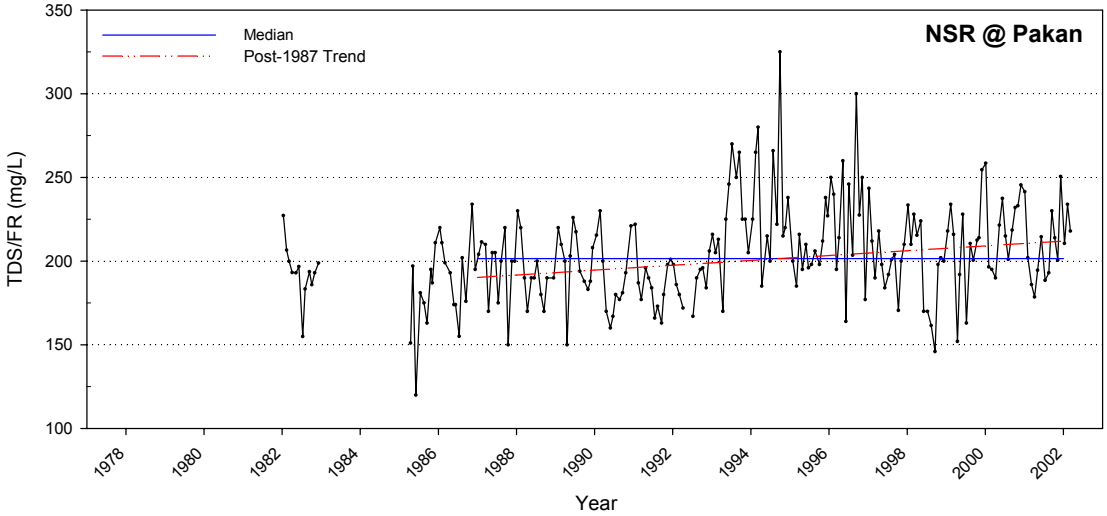


Figure 20 Boxplots depicting seasonality of non-filterable residue in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
ID	ID	ID	177.00	ID	ID	186.00	1.0083	***
Flow Adjusted								
ID	ID			ID	ID		0.0031	NS



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
ID	ID	ID	193.10	ID	ID	201.50	1.4464	*
Flow Adjusted								
ID	ID			ID	ID		0.0061	NS

Figure 21 Total dissolved solids/Filterable residue in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals. ID = Insufficient Data.

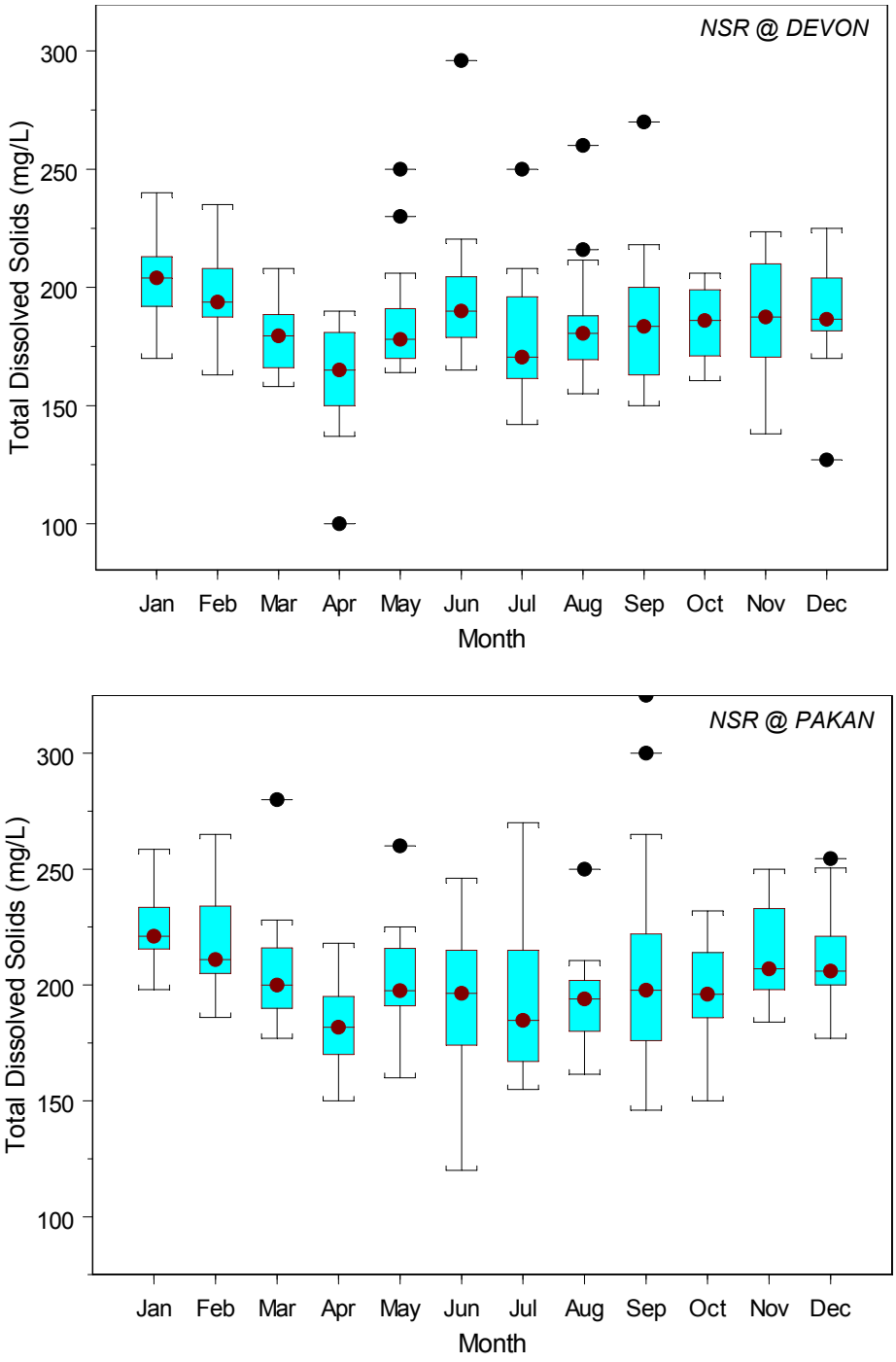
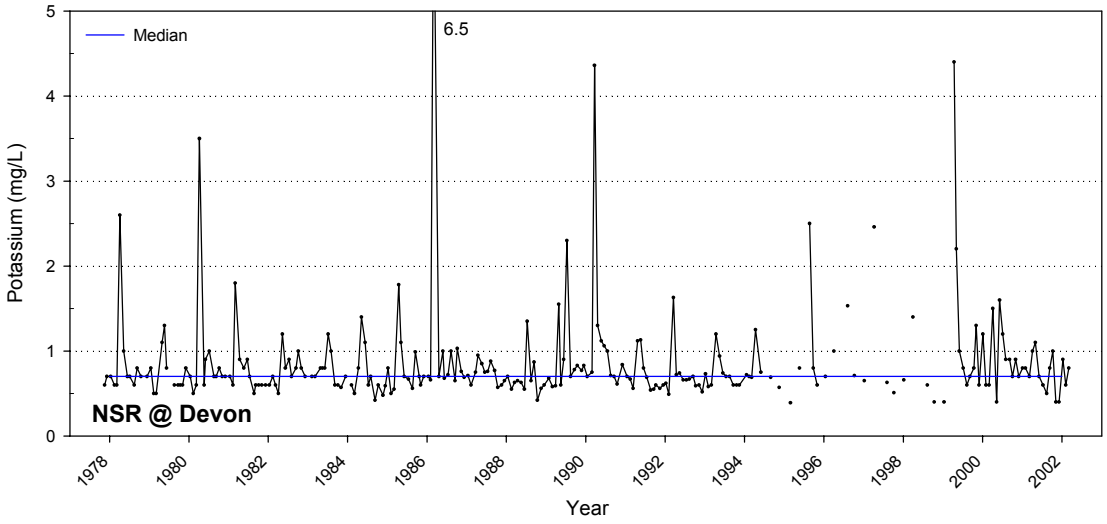
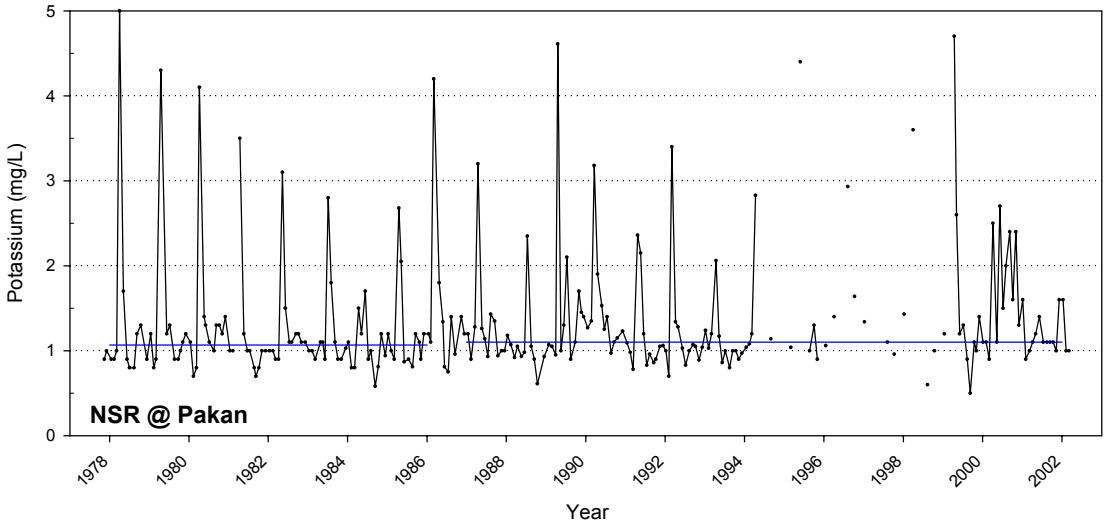


Figure 22 Boxplots depicting seasonality of total dissolved solids (filterable residue) in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0000	NS	NS	0.70	-	-	0.70	-	-
Flow Adjusted								
0.0033	NS			-	-		-	-



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0056	**	**	1.0650	0.0000	NS	1.1000	0.0091	NS
Flow Adjusted								
-	-			-	-		-	-

Figure 23 Potassium concentration in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals.

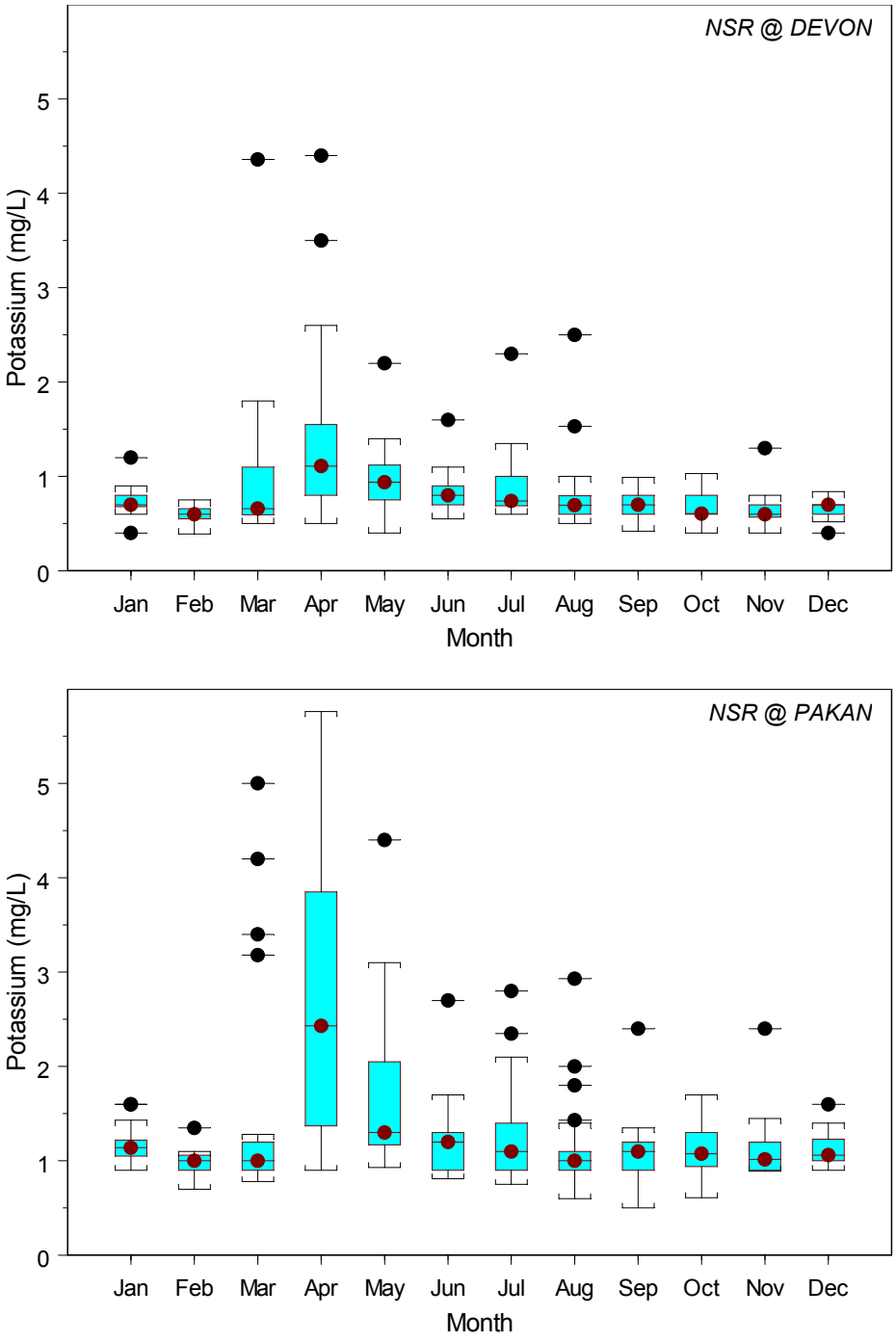
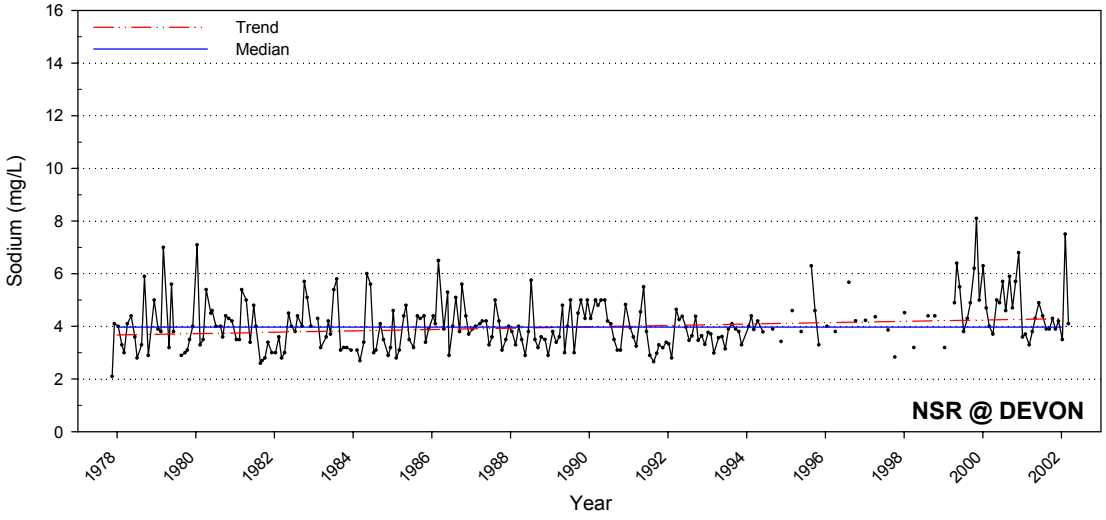
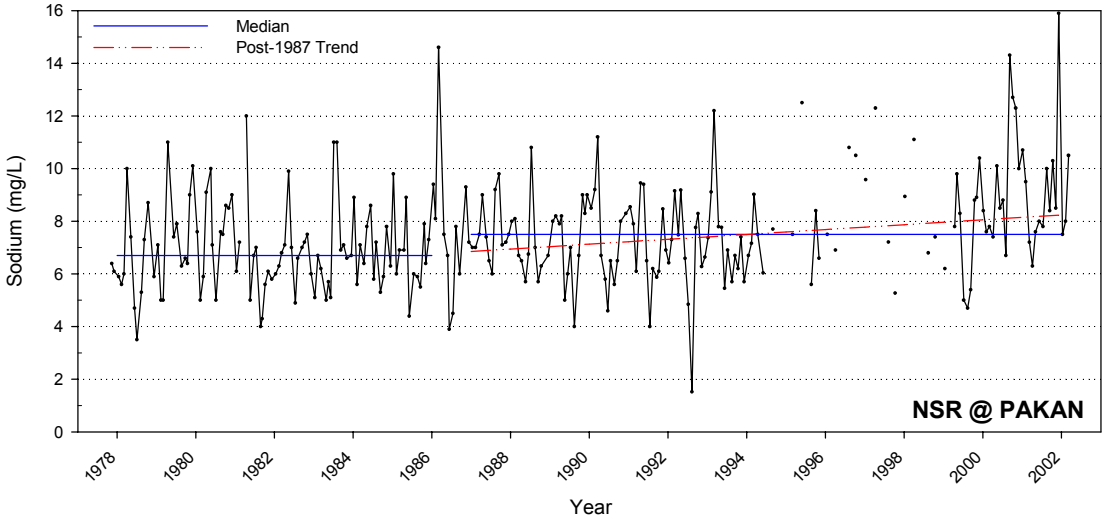


Figure 24 Boxplots depicting seasonality of potassium in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0259	**	NS	3.97	-	-	3.97	-	-
Flow Adjusted								
0.0306	***			-	-		-	-



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0698	***	***	6.70	0.0666	NS	7.50	0.0928	**
Flow Adjusted								
0.0700	***			0.0746	NS		0.0922	**

Figure 25 Sodium Concentration in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals.

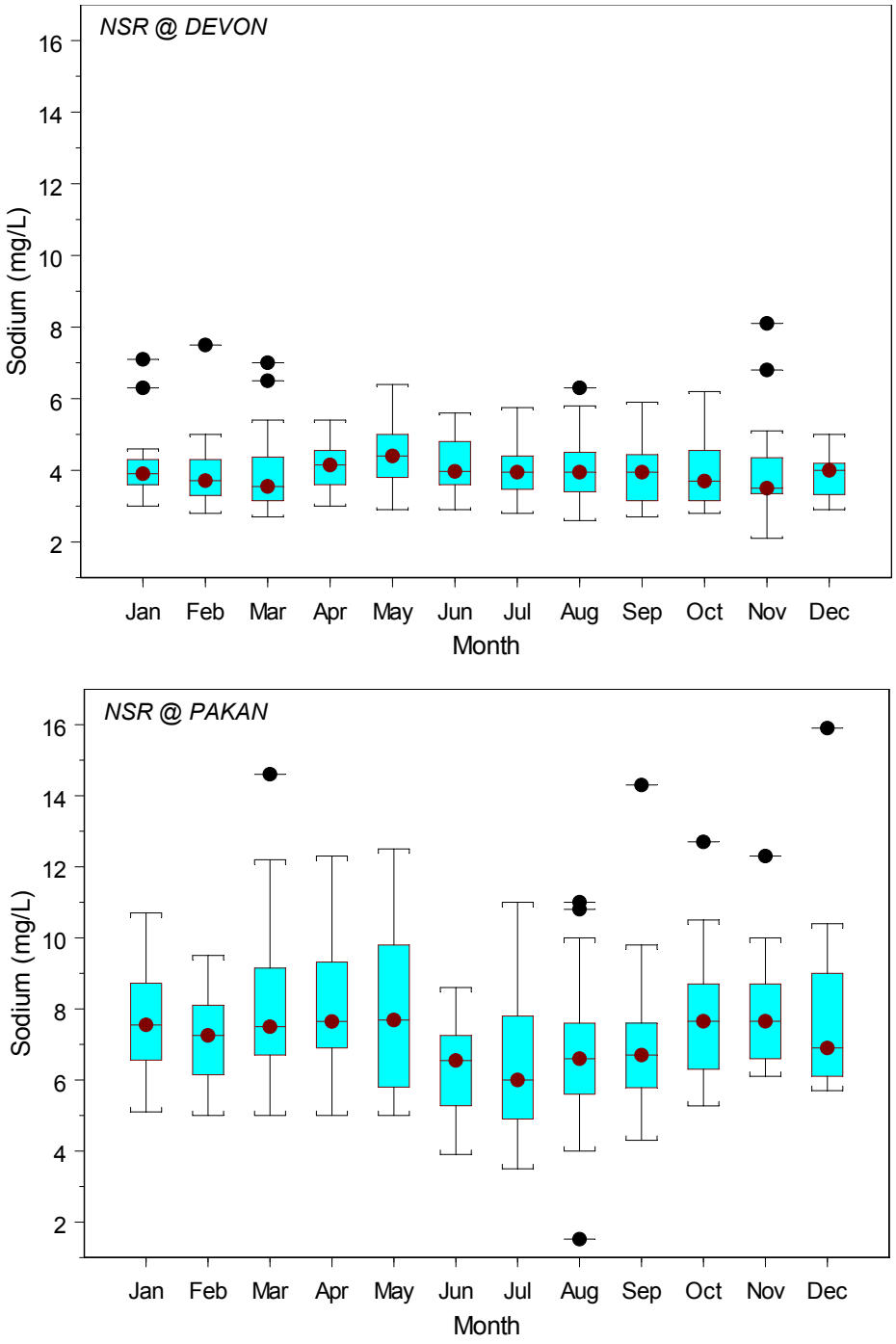
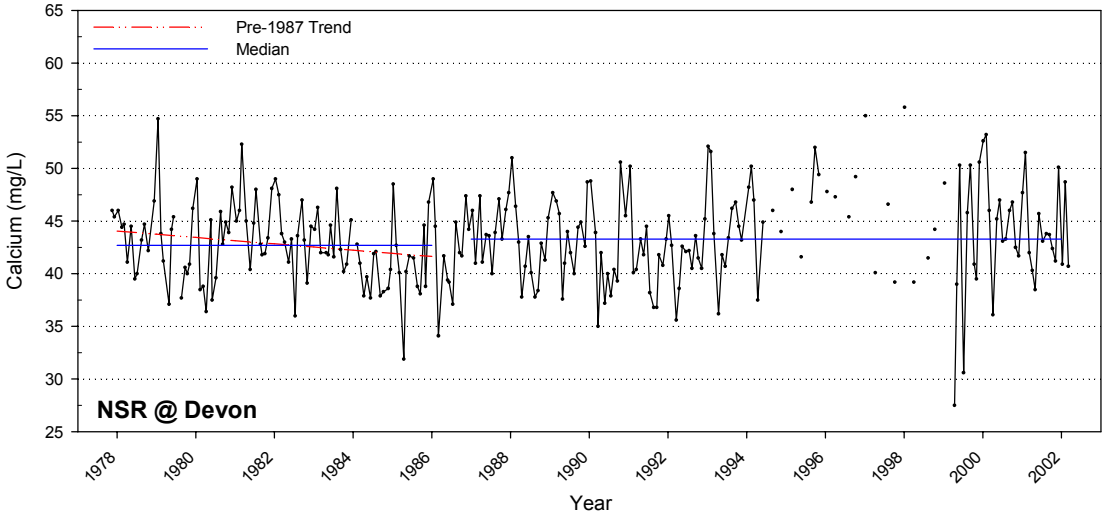
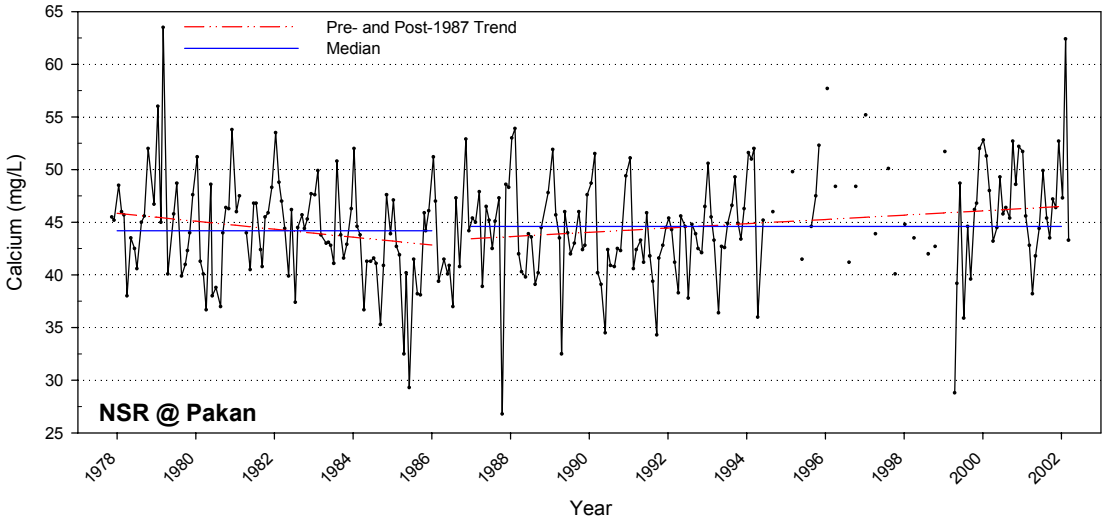


Figure 26 Boxplots depicting seasonality of sodium in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0584	NS	**	42.70	-0.3011	*	43.30	0.1071	NS
Flow Adjusted								
0.0147	NS			-0.2858	**		-0.0068	NS



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0625	NS	*	44.20	-0.3796	***	44.60	0.2045	*
Flow Adjusted								
0.0427	NS			-0.3749	**		0.1289	**

Figure 27 Calcium concentration in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals.

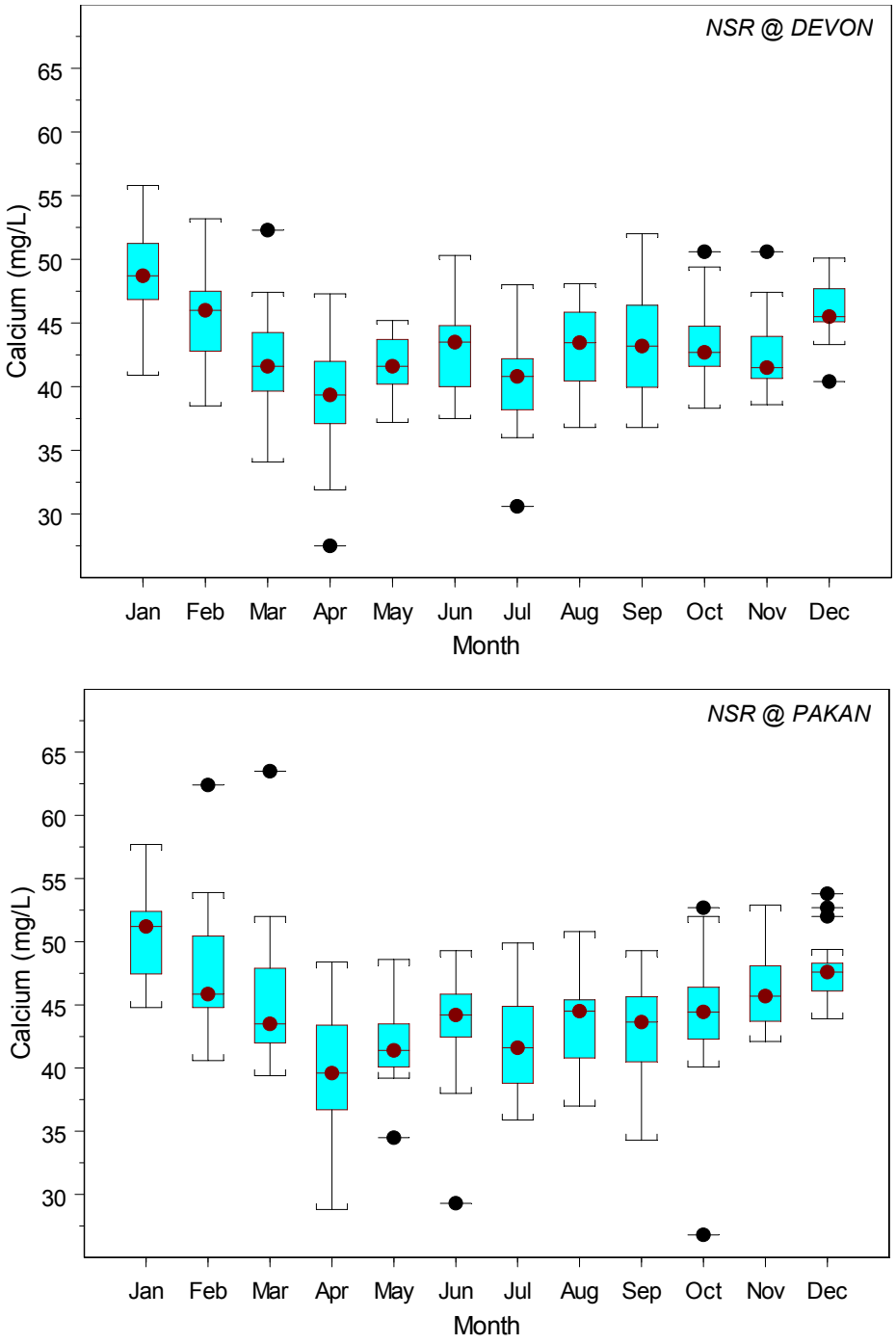
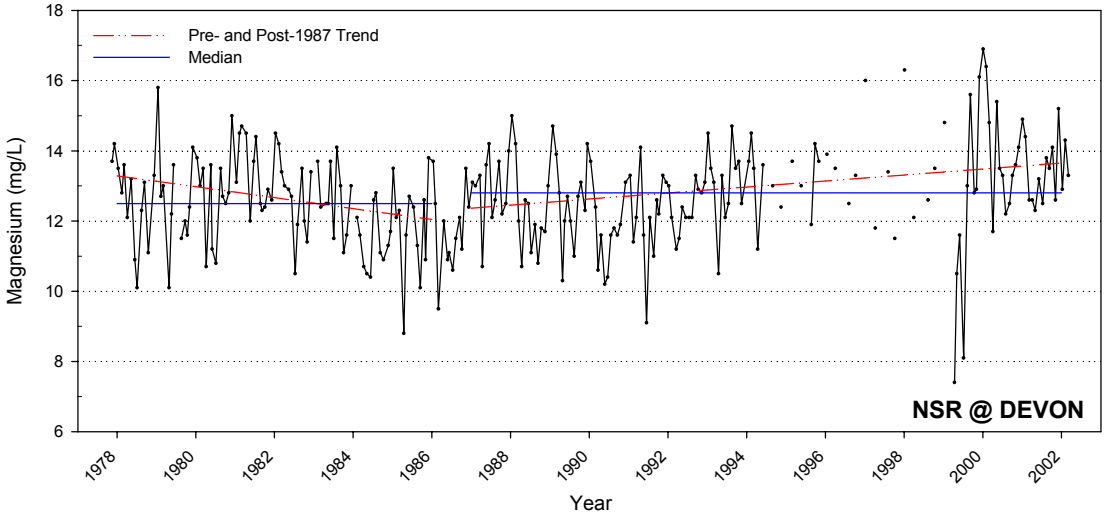
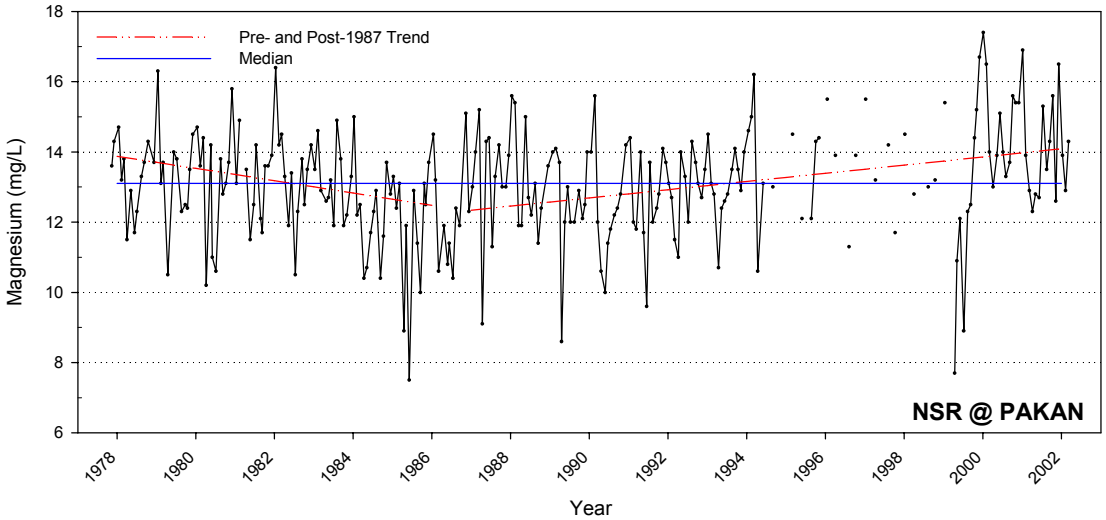


Figure 28 Boxplots depicting seasonality of calcium in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0334	NS	**	12.50	-0.1552	***	12.80	0.0856	**
Flow Adjusted								
0.0197	NS			-0.0955	***		0.0476	*



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0273	NS	*	13.10	-0.1750	***	13.10	0.1165	**
Flow Adjusted								
0.0018	NS			-0.0140	***		0.0743	**

Figure 29 Magnesium concentration in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals.

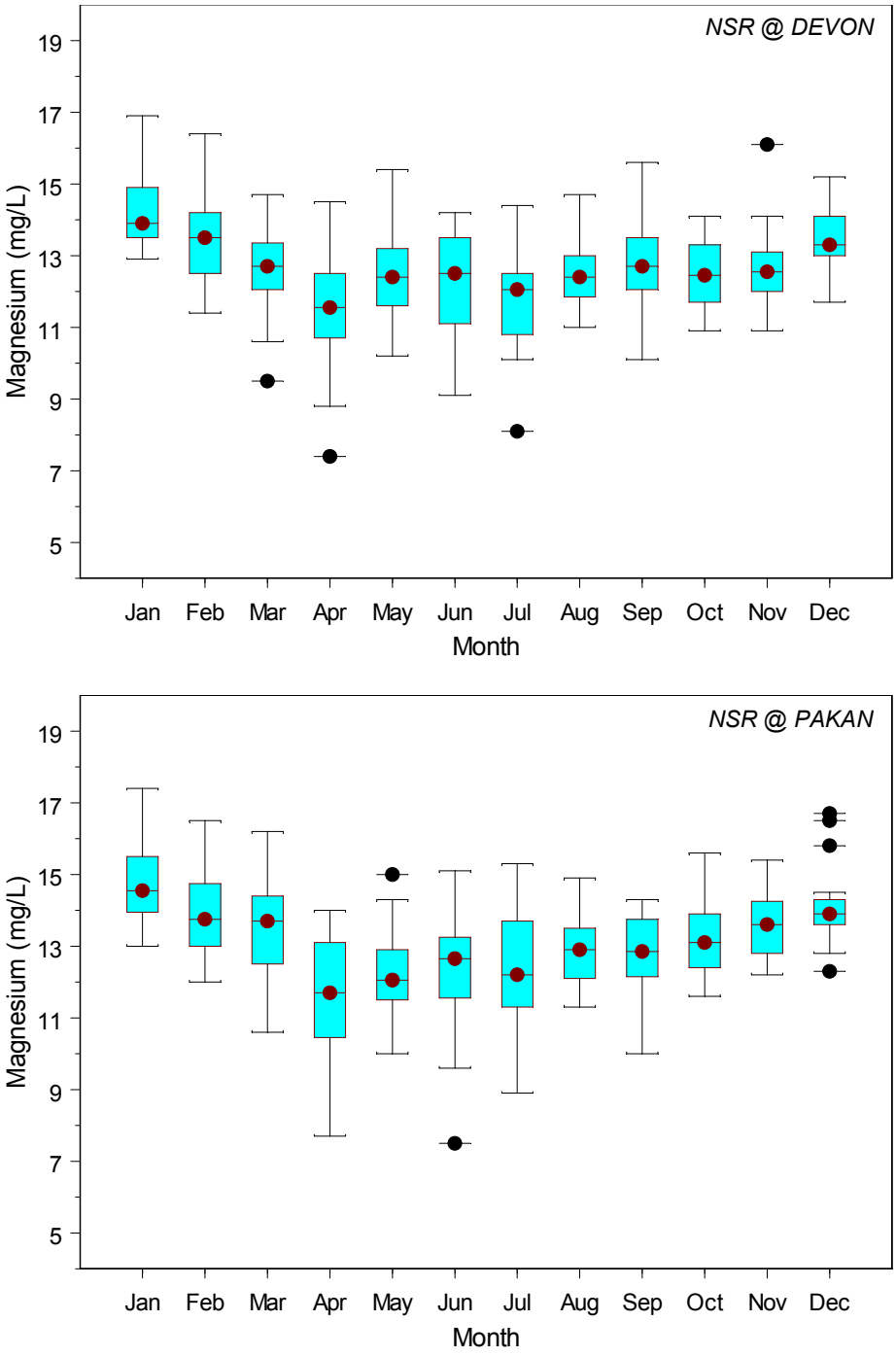
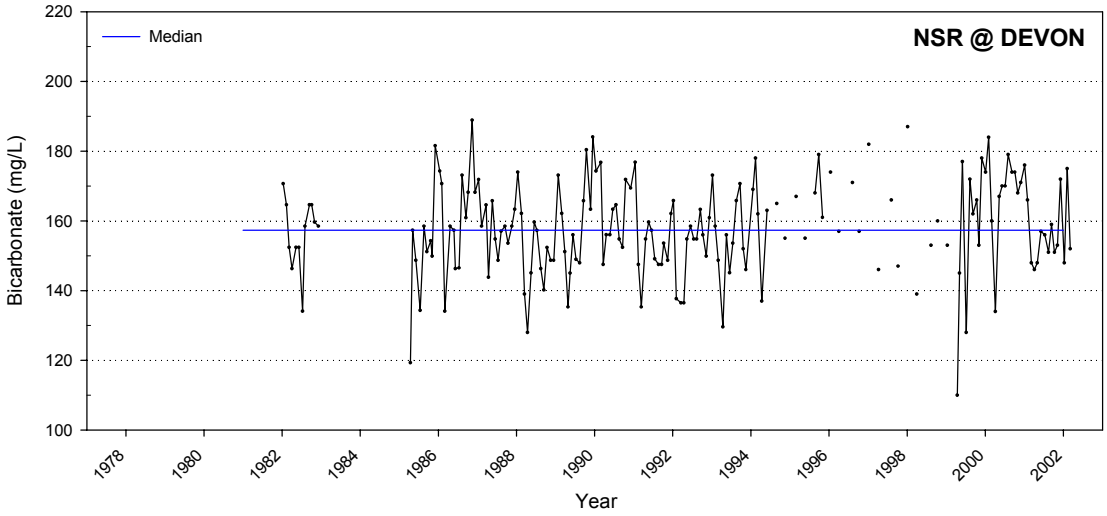
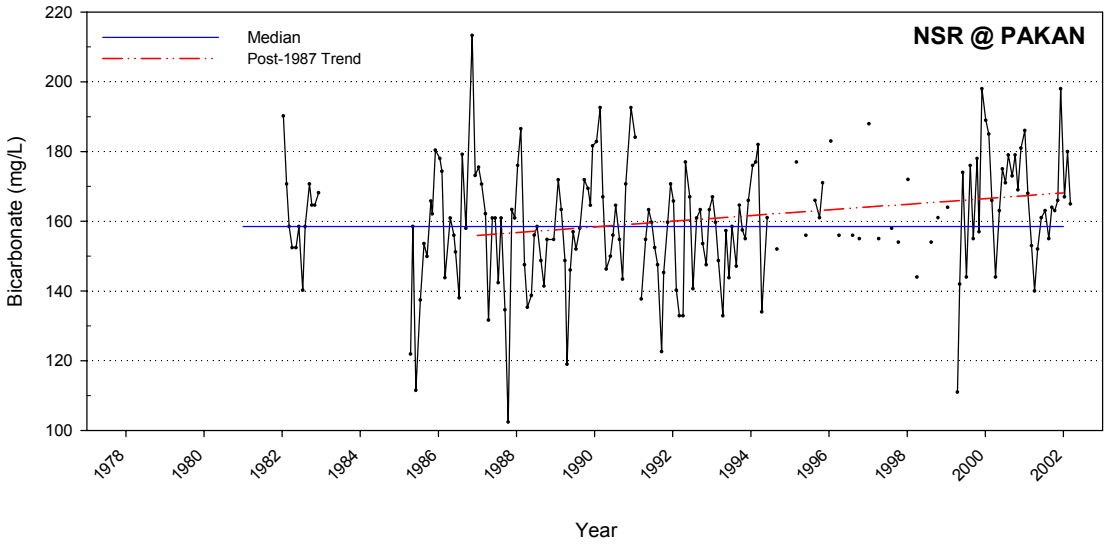


Figure 30 Boxplots depicting seasonality of magnesium in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
ID	ID	ID	157.30	ID	ID	157.30	0.3960	NS
Flow Adjusted								
ID	ID			ID	ID		-	-



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
ID	ID	ID	158.50	ID	ID	158.50	0.8133	**
Flow Adjusted								
ID	ID			ID	ID		-	-

Figure 31 Bicarbonate concentration in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals.

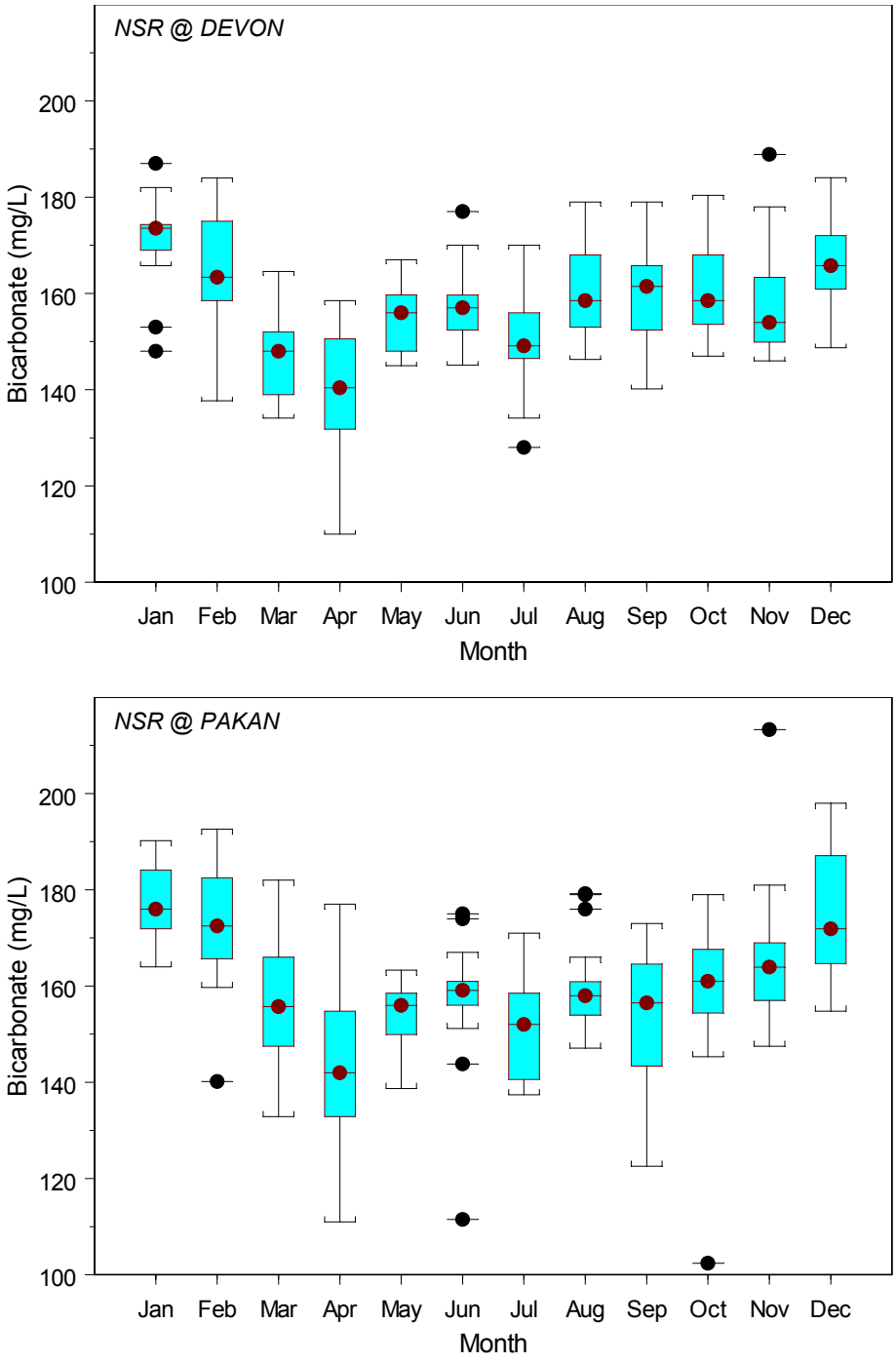
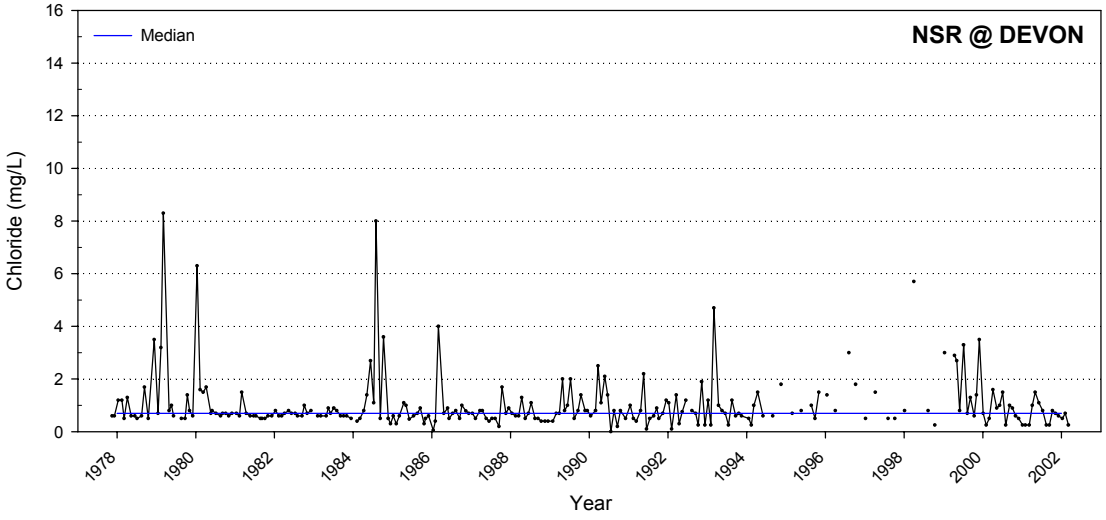
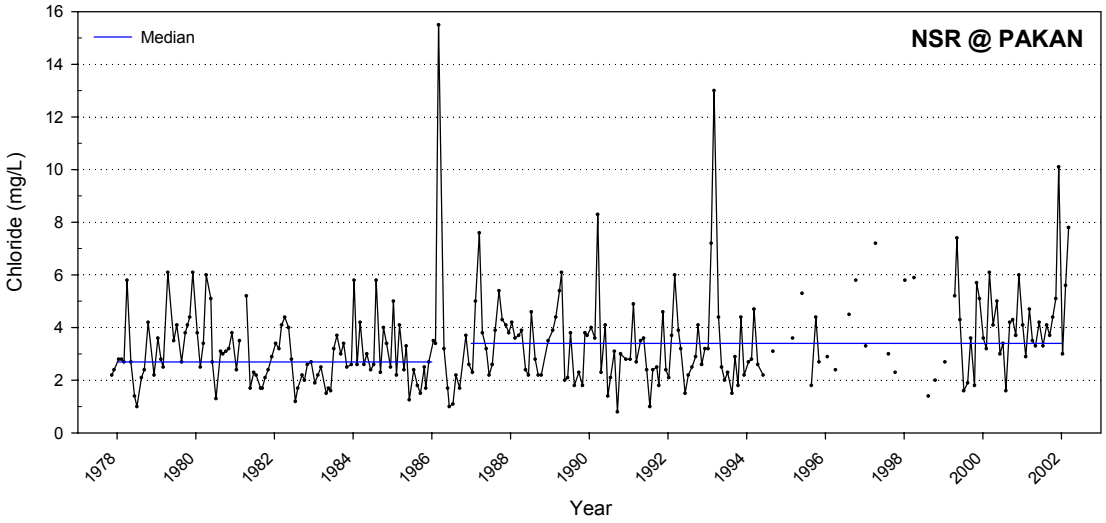


Figure 32 Boxplots depicting seasonality of bicarbonate concentration in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0000	NS	NS	0.70	-	-	0.70	-	-
Flow Adjusted								
-	-			-	-		-	-



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0299	**	***	2.7000	-0.0502	NS	3.4000	0.0333	NS
Flow Adjusted								
0.0108	**			-0.0209	NS		0.0082	NS

Figure 33 Chloride concentration in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals.

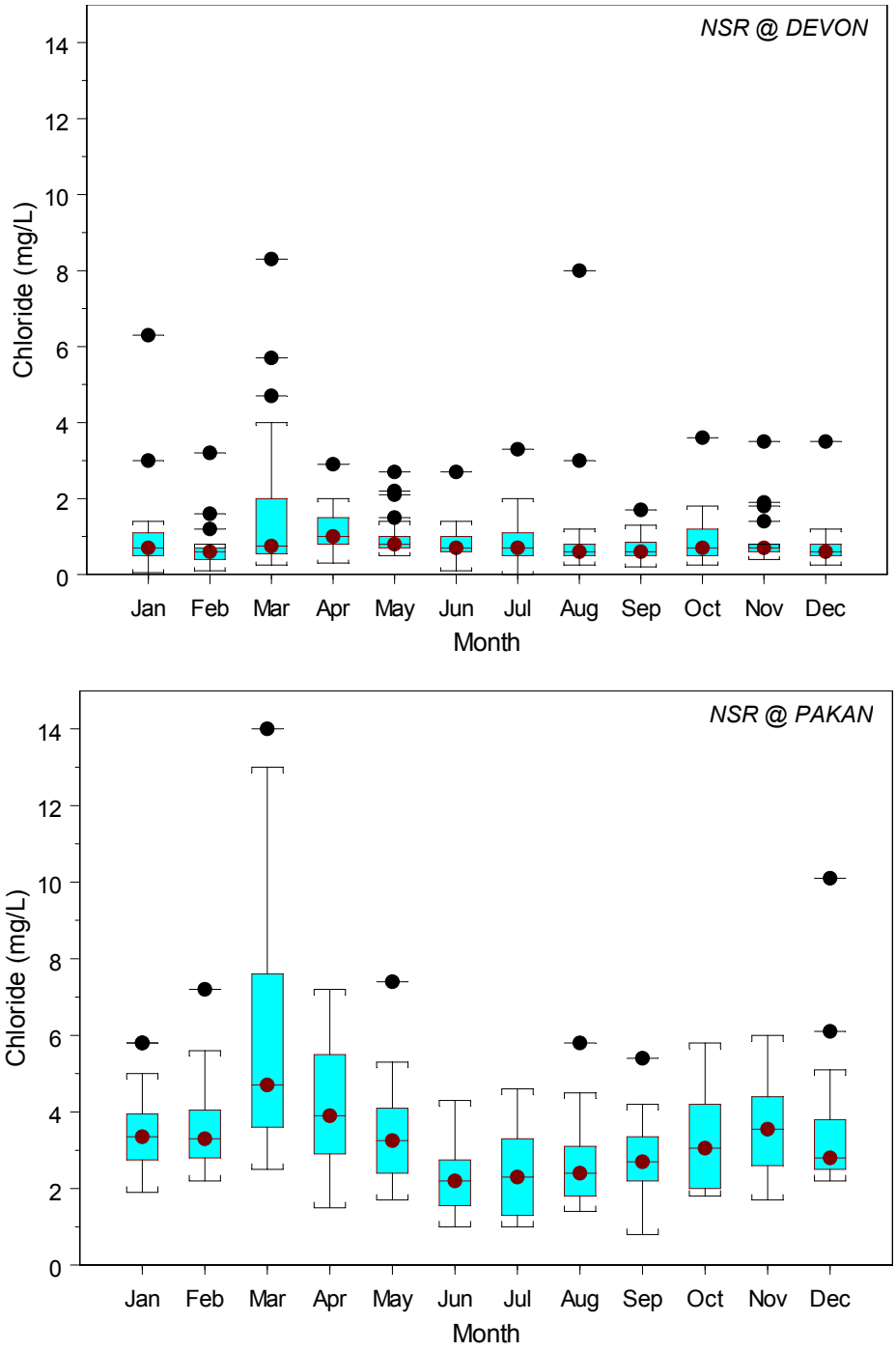
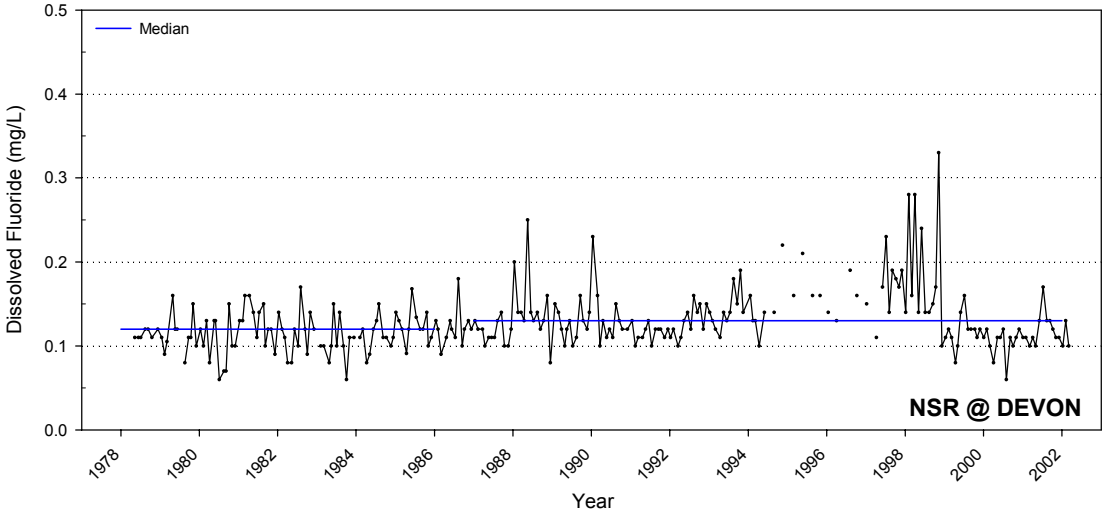
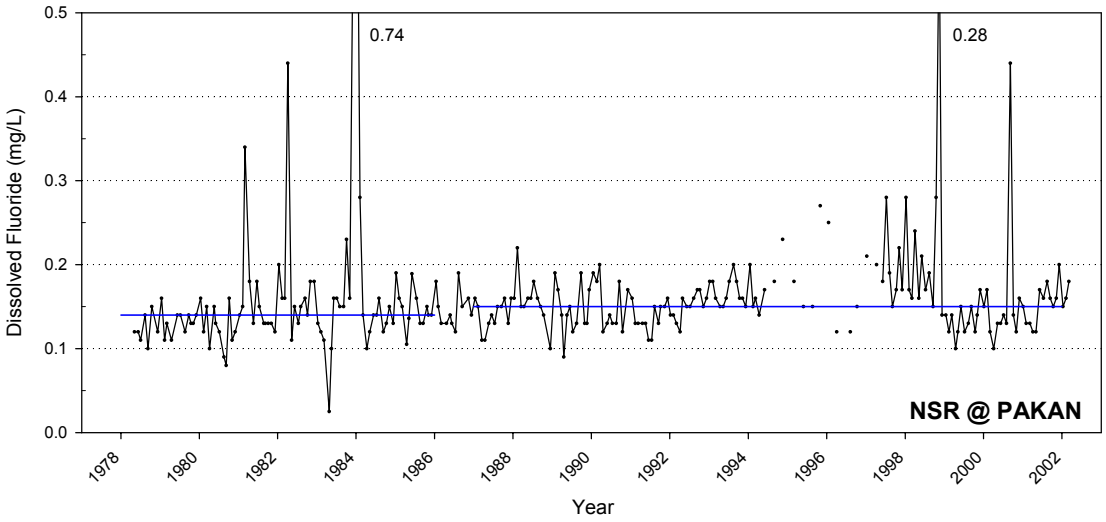


Figure 34 Boxplots depicting seasonality of chloride concentration in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0008	**	***	0.120	0.0000	NS	0.130	0.0000	NS
Flow Adjusted								
0.0072	**			-	-		-0.0002	NS



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0011	**	***	0.1400	0.0017	NS	0.1500	0.0000	NS
Flow Adjusted								
0.0070	**			0.0158	NS		0.0030	NS

Figure 35 Dissolved fluoride concentration in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals.

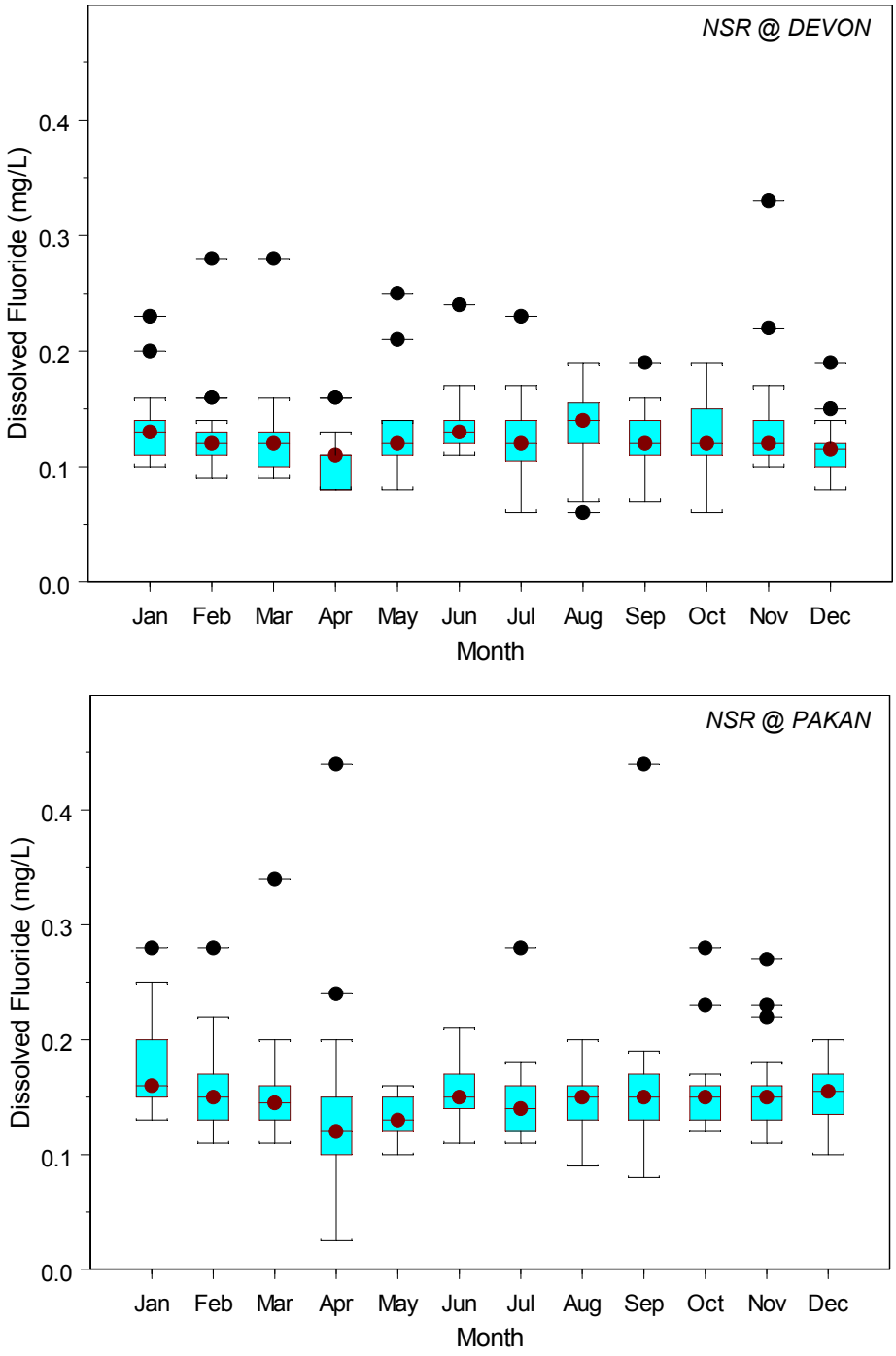
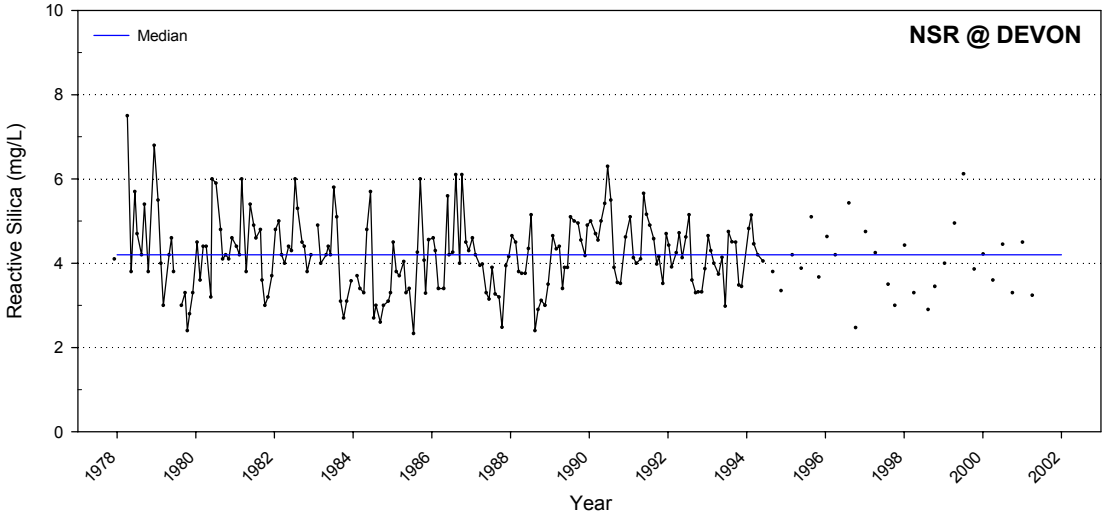
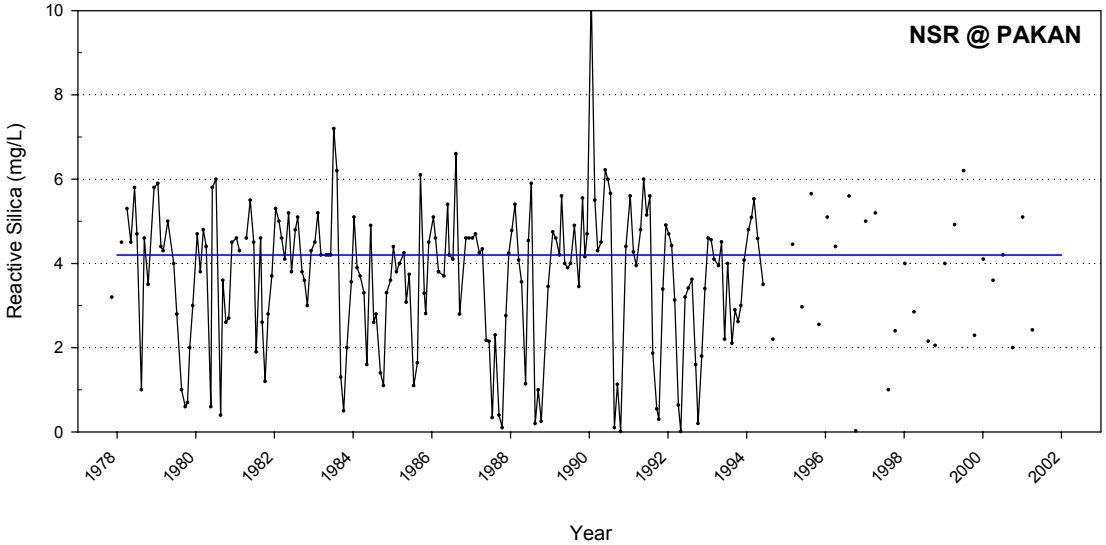


Figure 36 Boxplots depicting seasonality of dissolved fluoride concentration in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0000	NS	NS	4.20	-	-	4.20	-	-
Flow Adjusted								
-0.0028	NS			-	-		-	-



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0200	NS	NS	4.20	-	-	4.20	-	-
Flow Adjusted								
-0.0059	*			-	-		-	-

Figure 37 Reactive silica concentration in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals.

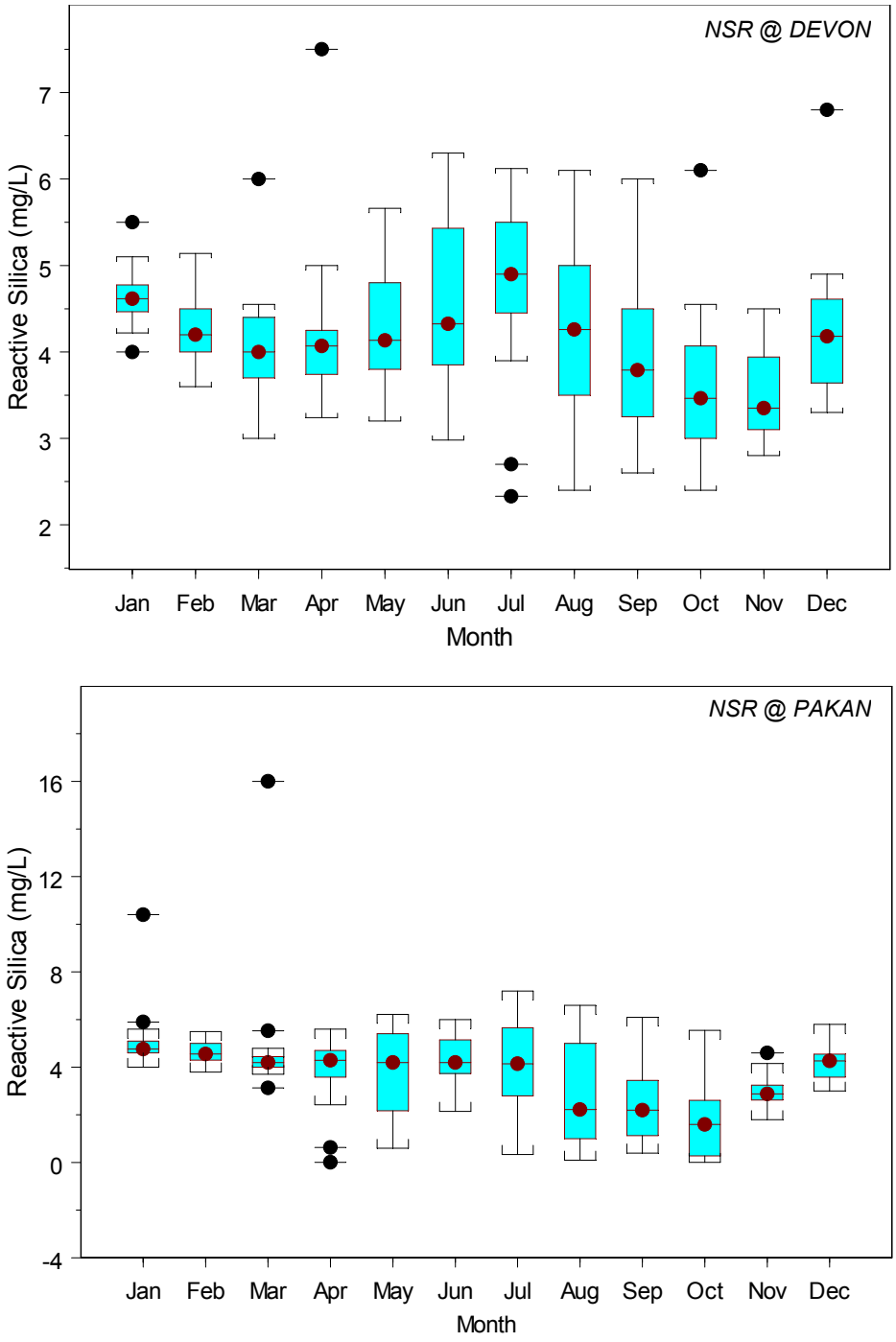
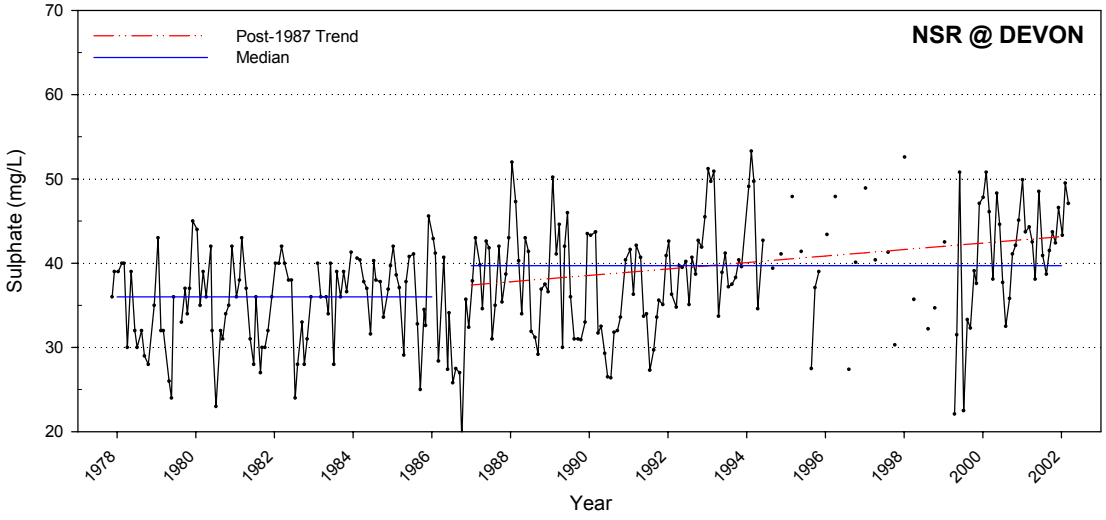
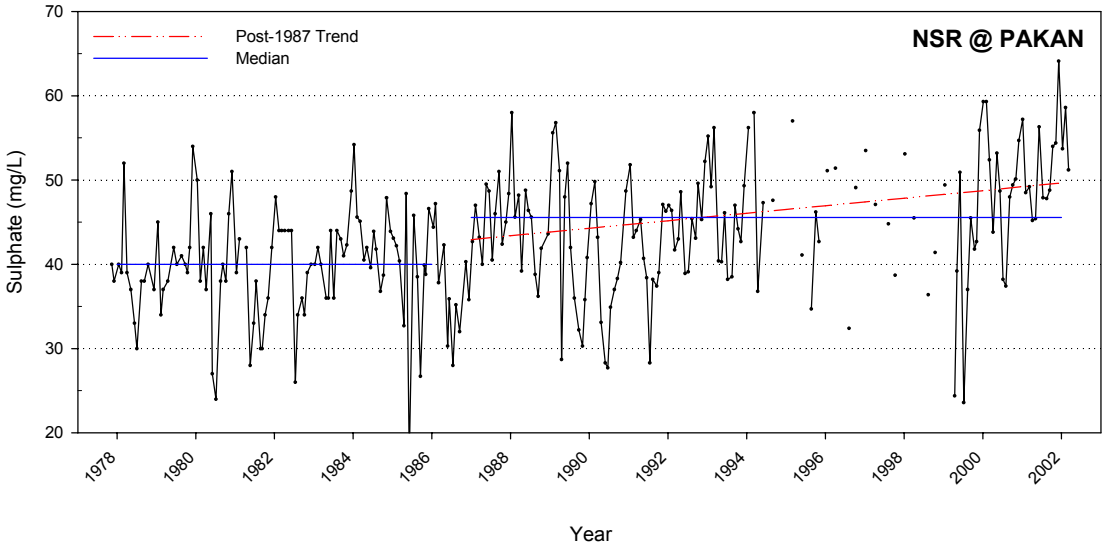


Figure 38 Boxplots depicting seasonality of reactive silica in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range. Note difference in y-axis scale.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.3621	***	***	36.00	0.1502	NS	39.70	0.3824	**
Flow Adjusted								
0.2695	***			0.1170	NS		0.1410	NS



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.4387	***	***	40.00	0.1000	NS	45.55	0.4474	**
Flow Adjusted								
0.0092	***			0.0924	NS		0.0070	**

Figure 39 Sulphate concentration in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals.

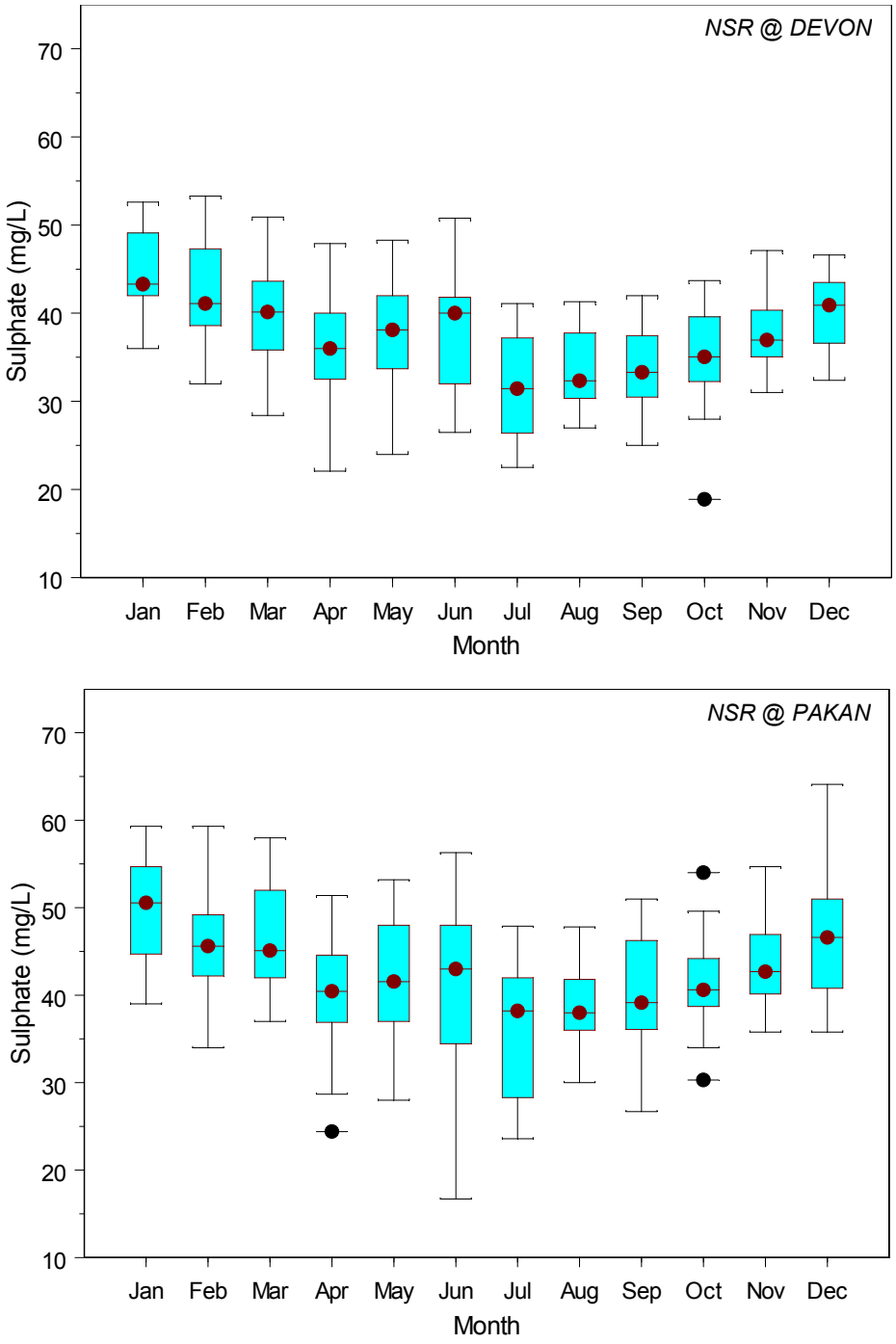
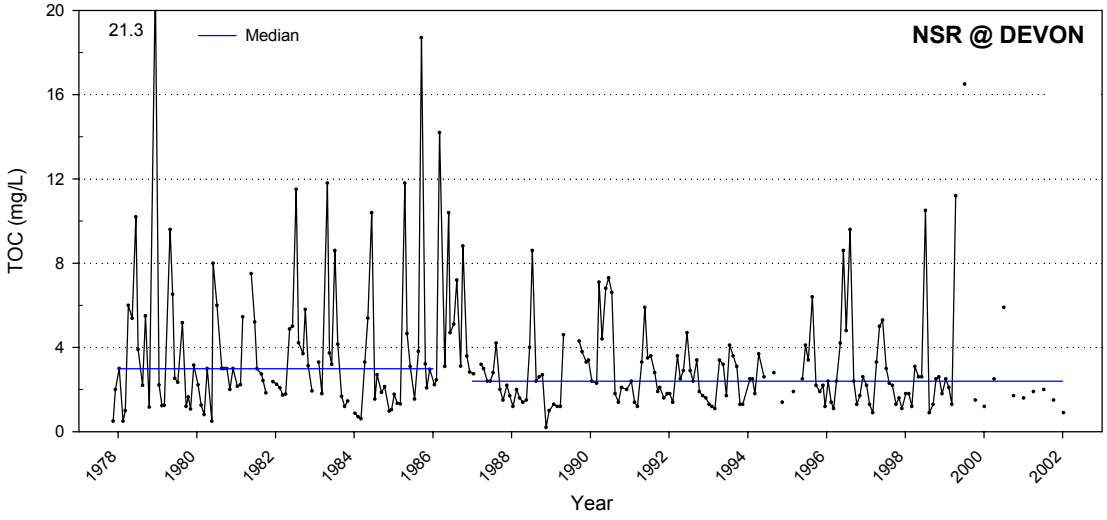
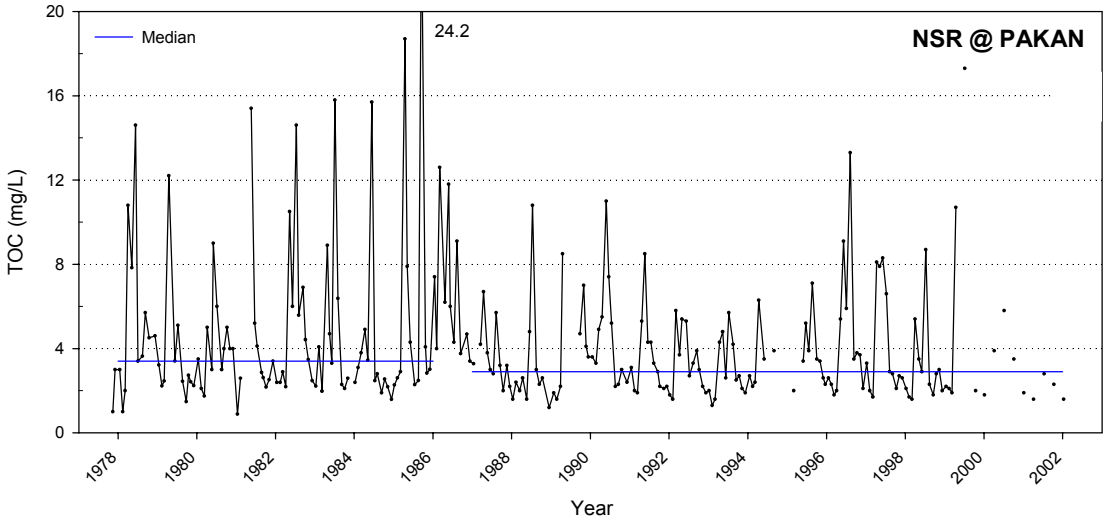


Figure 40 Boxplots depicting seasonality of sulphate concentration in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0250	NS	**	2.99	0.0725	NS	2.40	-0.0223	NS
Flow Adjusted								
-0.0156	NS			0.1039	NS		0.0186	NS



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0302	**	***	3.41	0.0922	NS	2.90	-0.0232	NS
Flow Adjusted								
-0.0395	**			0.0763	NS		-0.0045	NS

Figure 41 Total organic carbon concentration in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals.

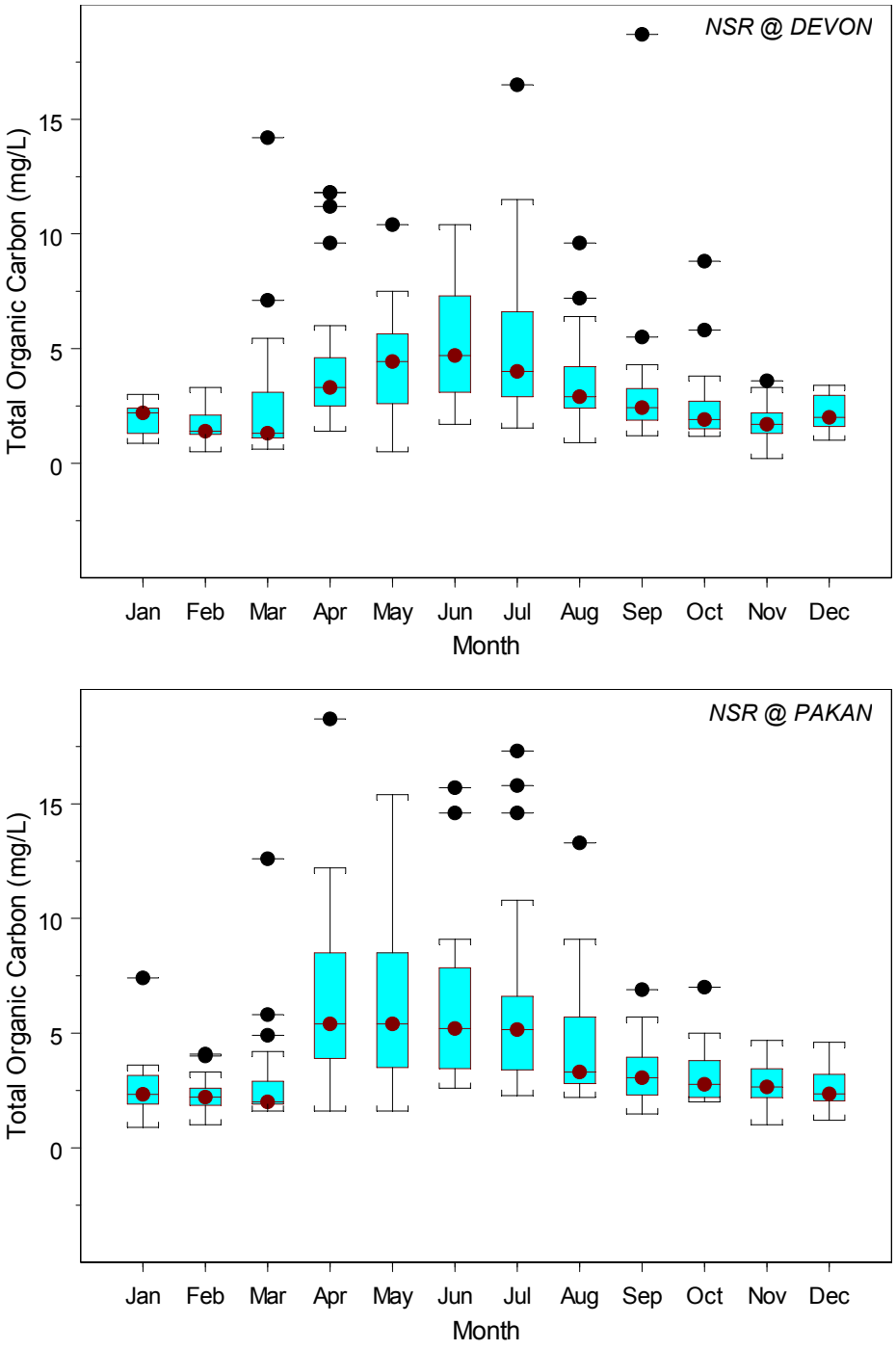
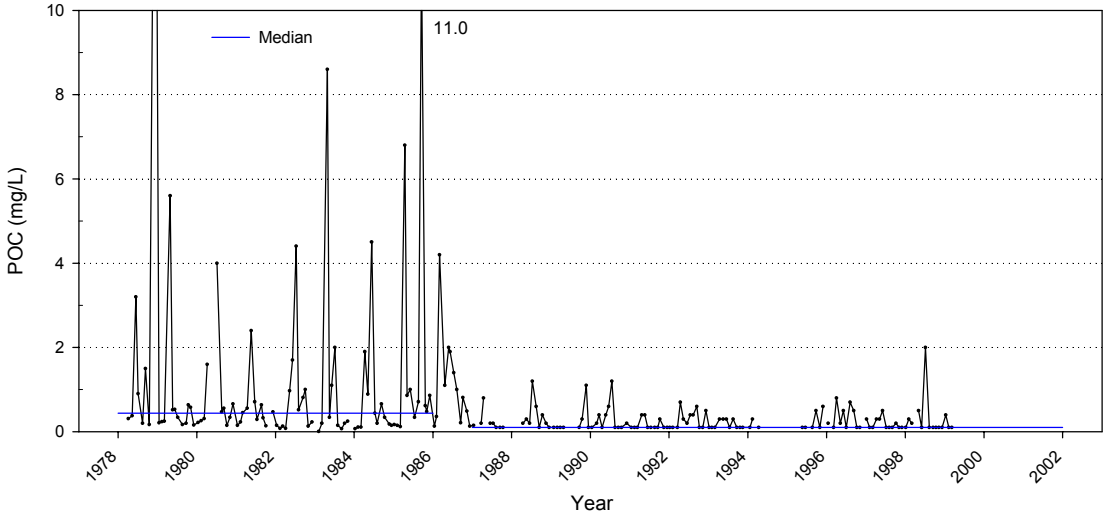
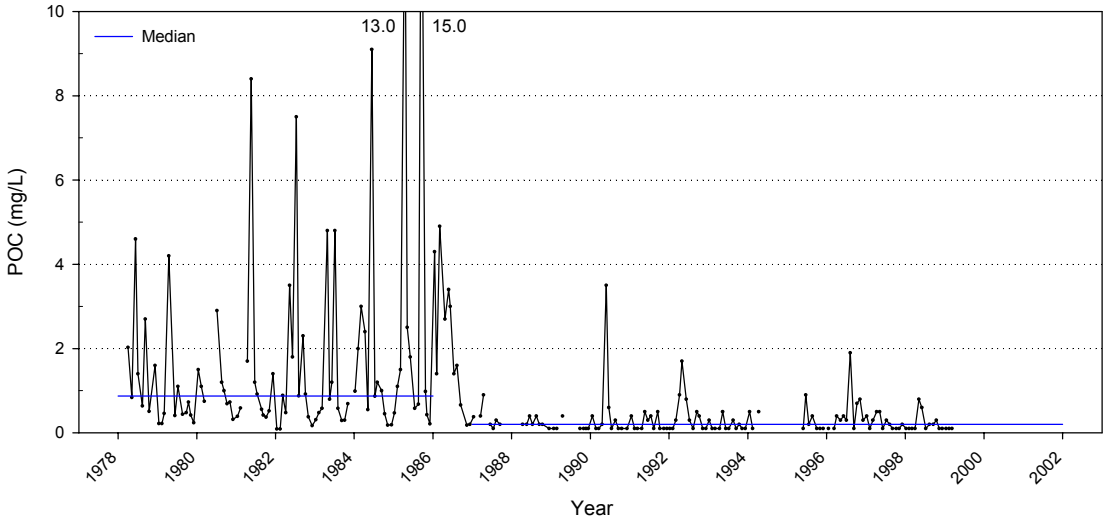


Figure 42 Boxplots depicting seasonality of total organic carbon in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0087	***	***	0.44	0.0100	NS	0.10	0.0000	NS
Flow Adjusted								
-0.0546	***			0.0533	NS		0.0008	NS



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0300	***	***	0.88	0.0922	NS	0.20	0.0000	NS
Flow Adjusted								
-0.0466	***			0.0604	NS		0.0027	NS

Figure 43 Particulate organic carbon concentration in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals.

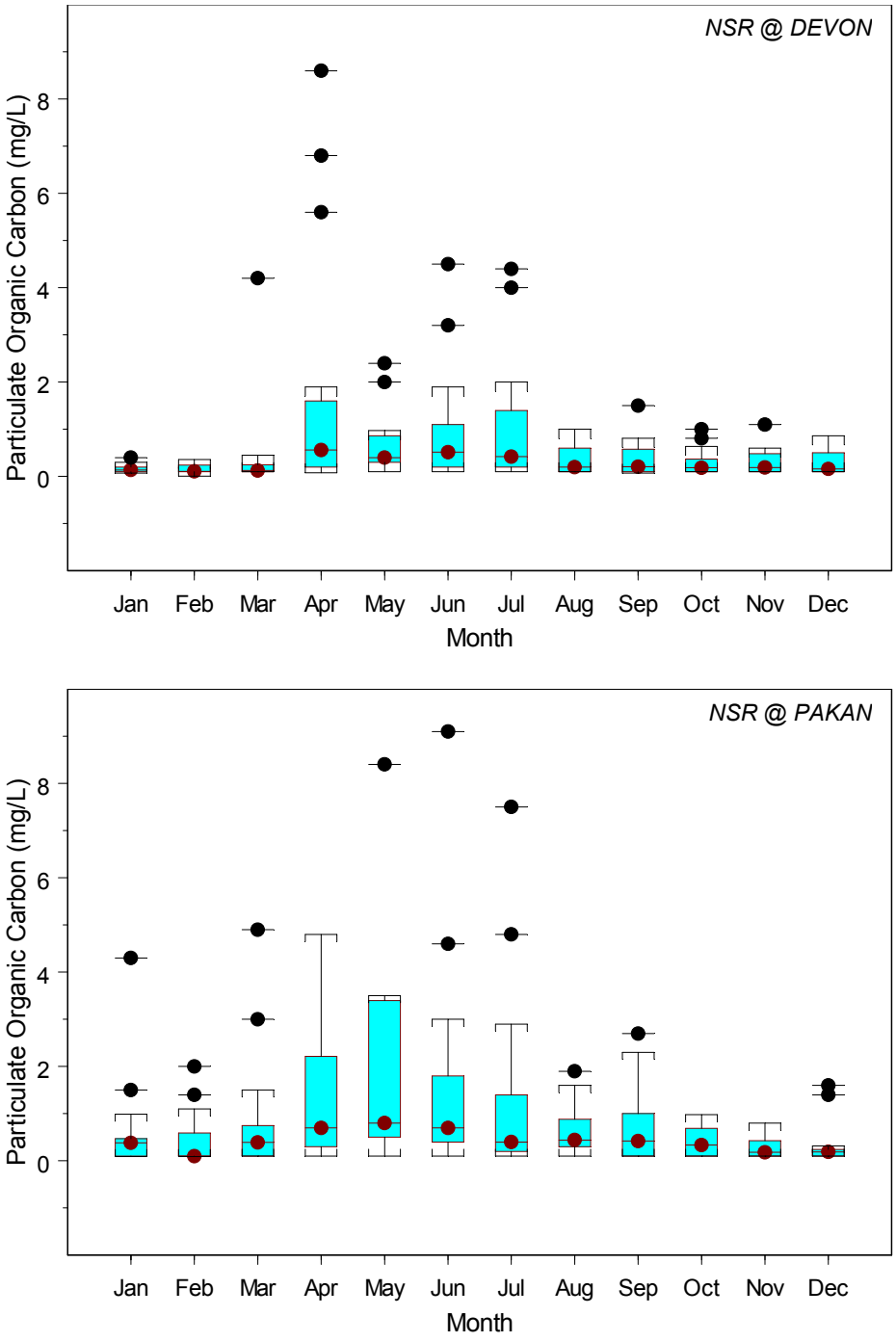
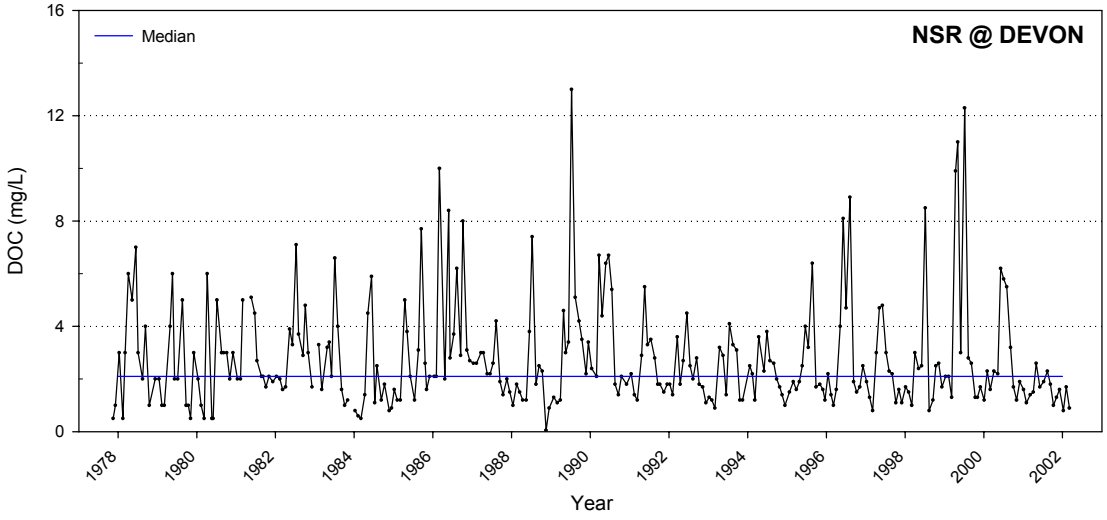
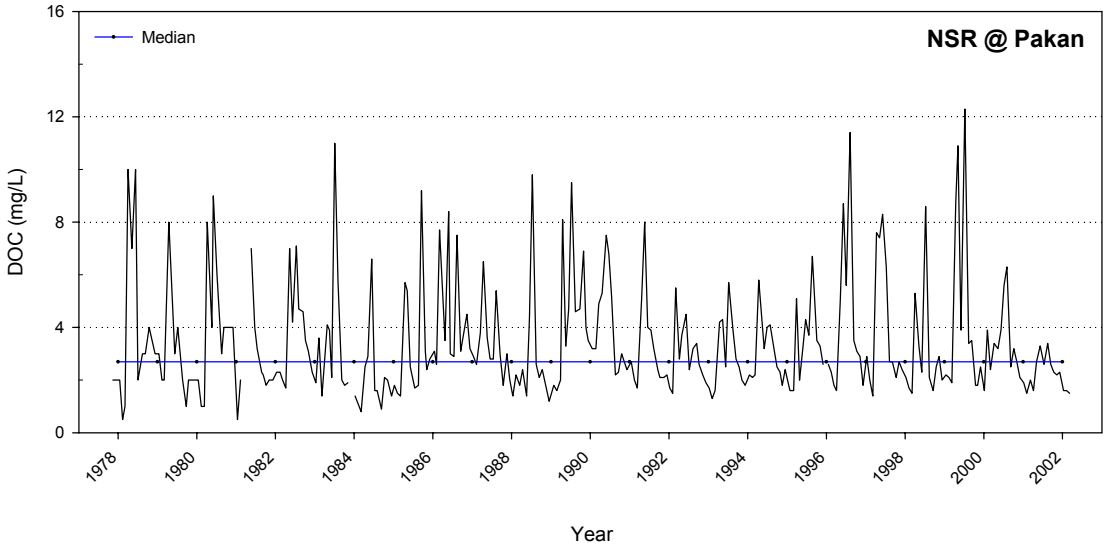


Figure 44 Boxplots depicting seasonality of particulate organic carbon in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0108	NS	NS	2.10	-	-	2.10	-	-
Flow Adjusted								
0.0103	NS			-	-		-	-



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0000	NS	NS	2.70	-	-	2.70	-	-
Flow Adjusted								
0.0080	NS			-	-		-	-

Figure 45 Dissolved organic carbon concentration in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals.

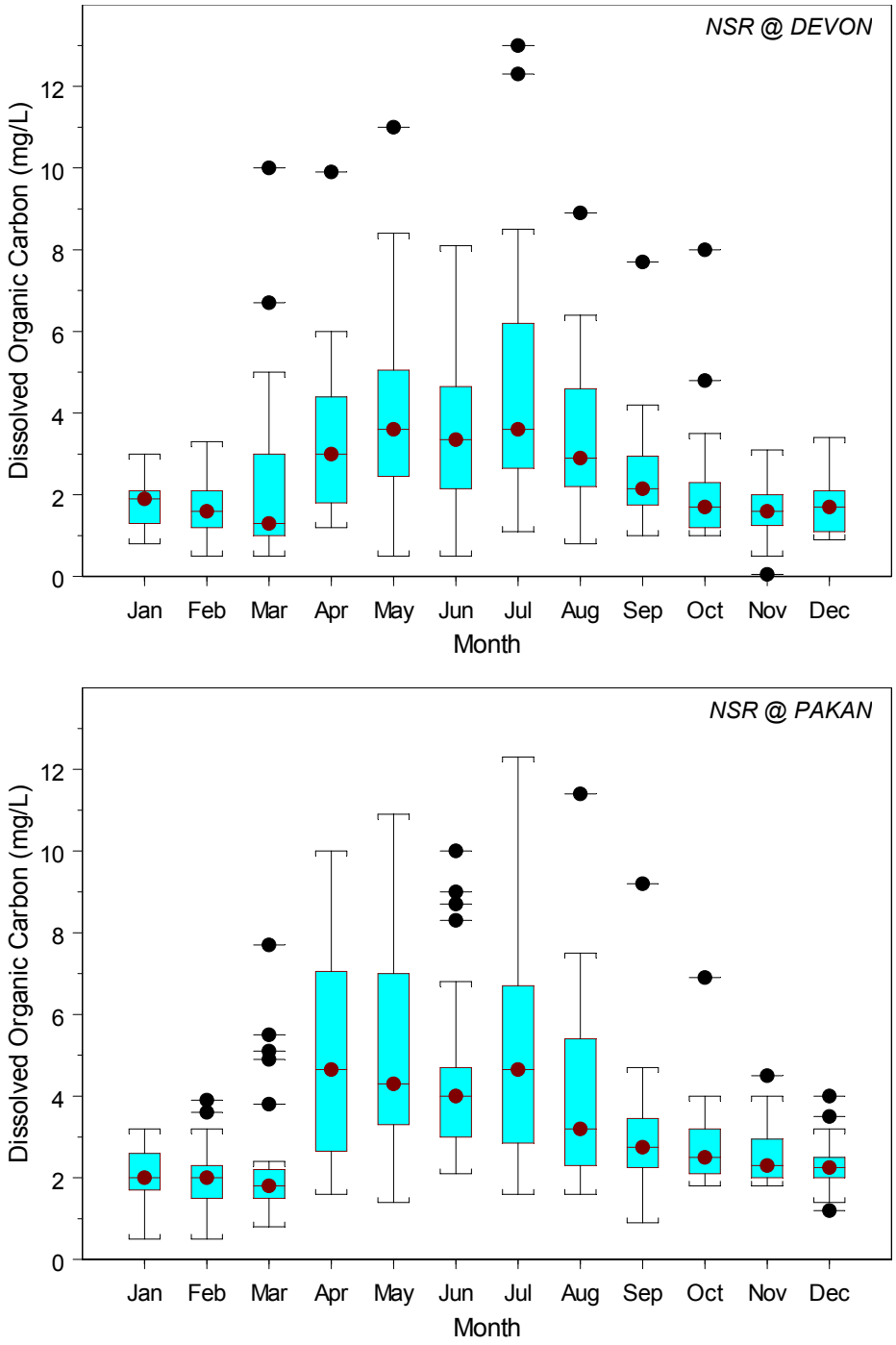
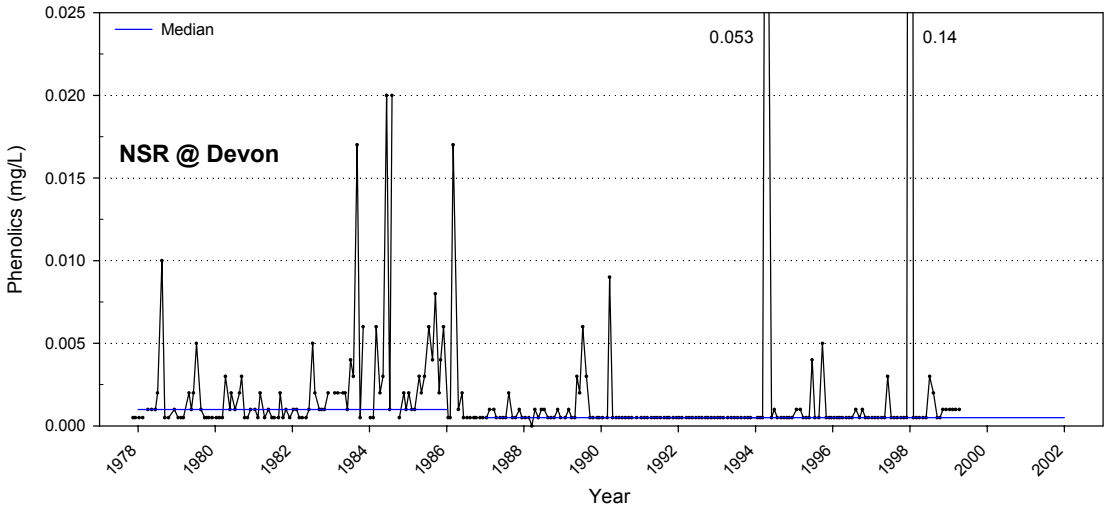
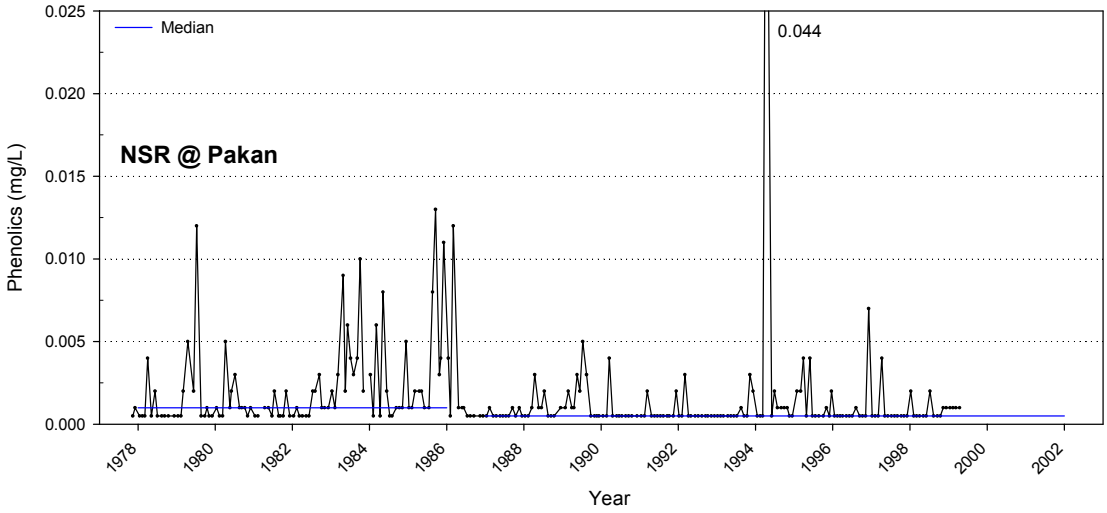


Figure 46 Boxplots depicting seasonality of dissolved organic carbon in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0000	*	***	0.0010	0.0000	NS	0.0005	0.0000	NS
Flow Corrected								
-	-			0.0928	NS		-	-



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0000	**	***	0.0001	0.0000	NS	0.0005	0.0000	NS
Flow Adjusted								
-	NS			0.0014	NS		-	NS

Figure 47 Phenolics concentration in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals.

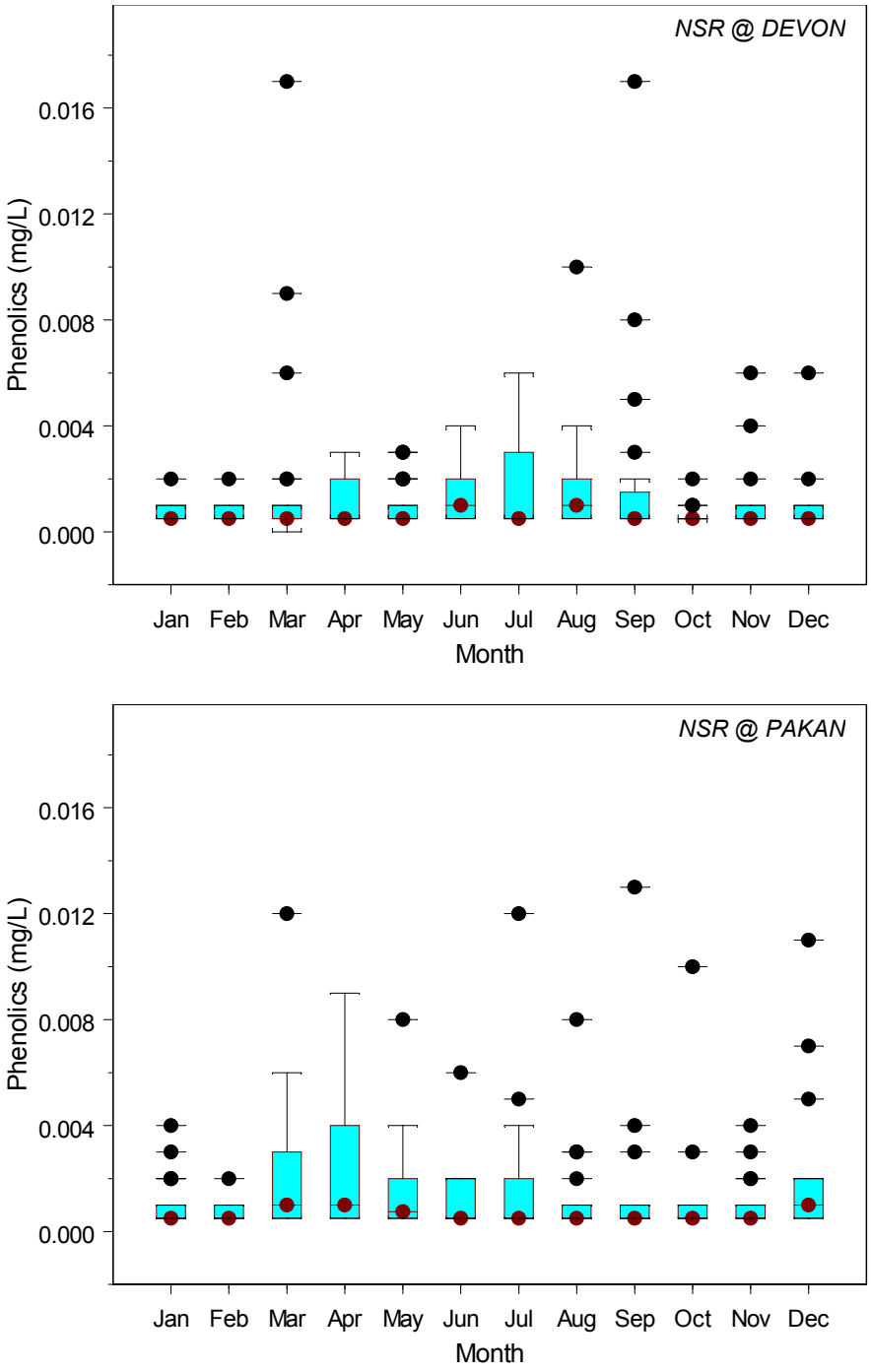
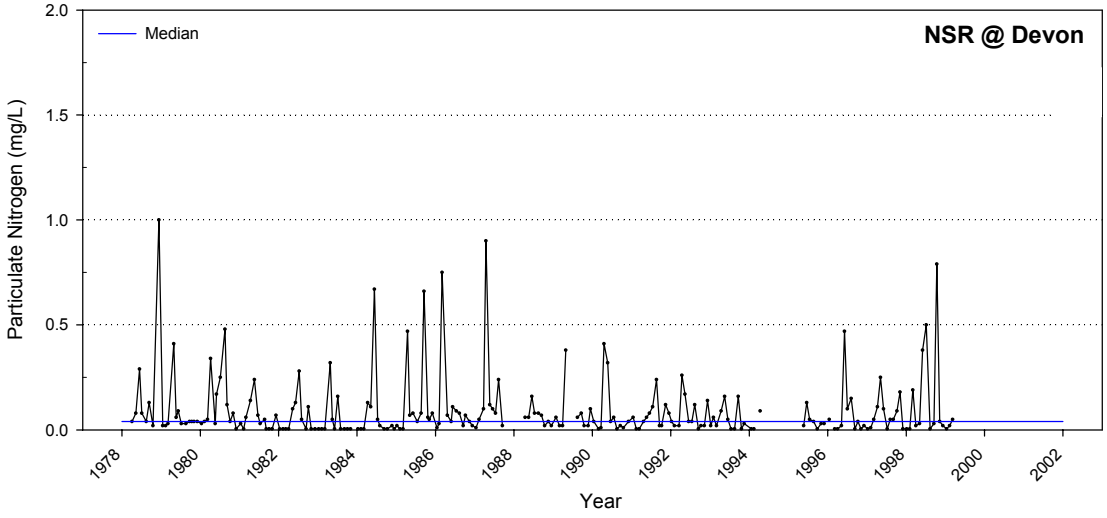
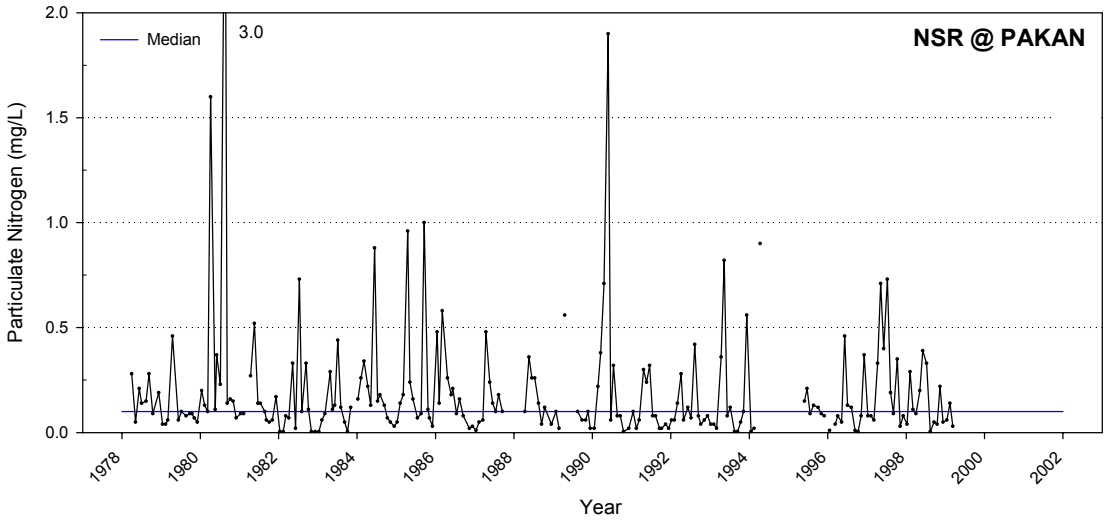


Figure 48 Boxplots depicting seasonality of phenolics concentration in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0000	NS	NS	0.04	-	-	0.04	-	-
Flow Adjusted								
0.0001	NS			-	-		-	-



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0003	NS	NS	0.10	-	-	0.10	-	-
Flow Adjusted								
-0.0023	NS			-	-		-	-

Figure 49 Particulate nitrogen concentration in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals.

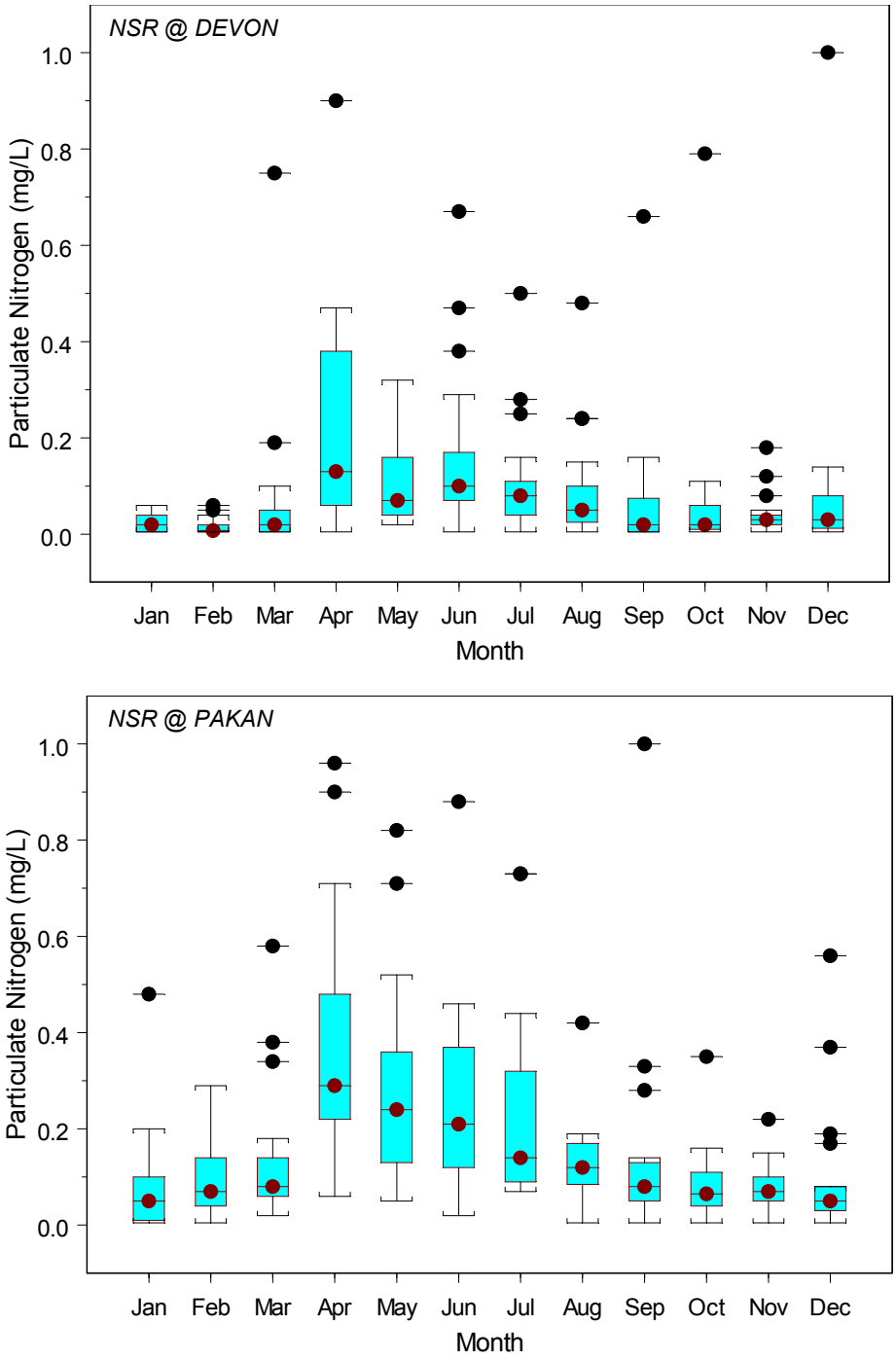
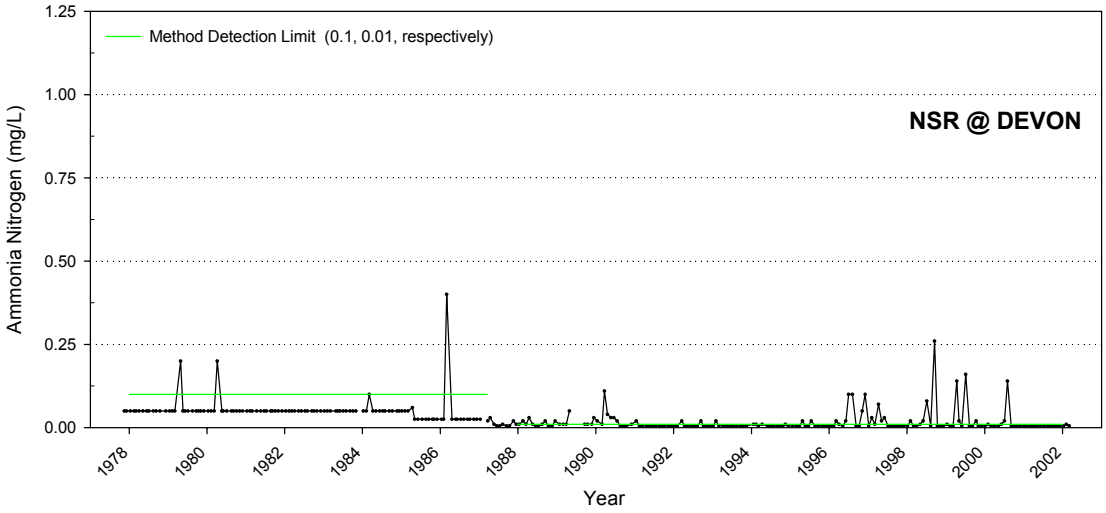
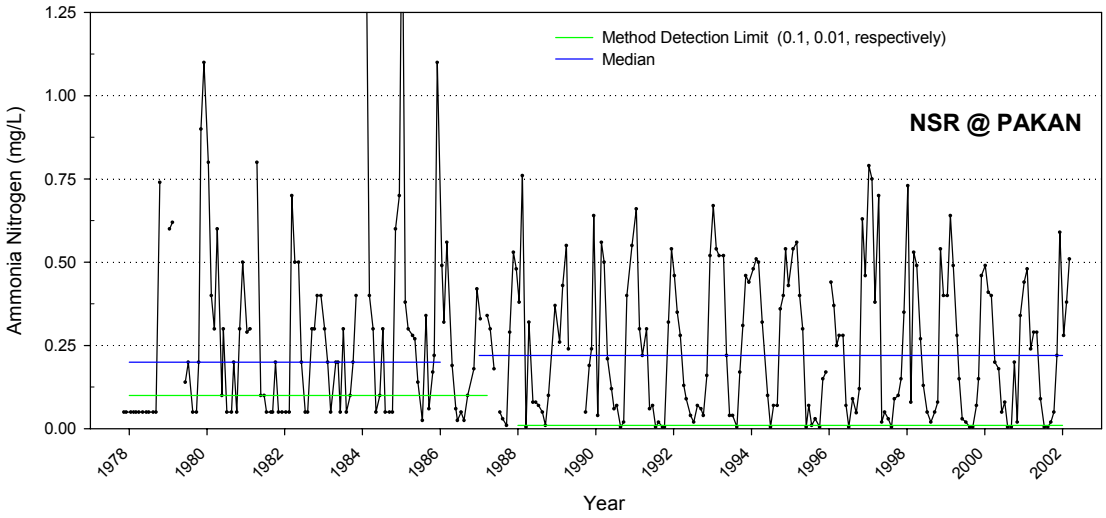


Figure 50 Boxplots depicting seasonality of particulate nitrogen in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0020	***	***	0.05	0.0000	**	0.005	0.0000	NS
Flow Adjusted								
-0.0021	***			-	NS		0.0001	NS



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0013	*	**	0.20	0.0000	NS	0.22	-0.0004	NS
Flow Adjusted								
-0.0019	NS			0.0047	NS		-0.0031	NS

Figure 51 Total ammonia nitrogen concentration in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals.

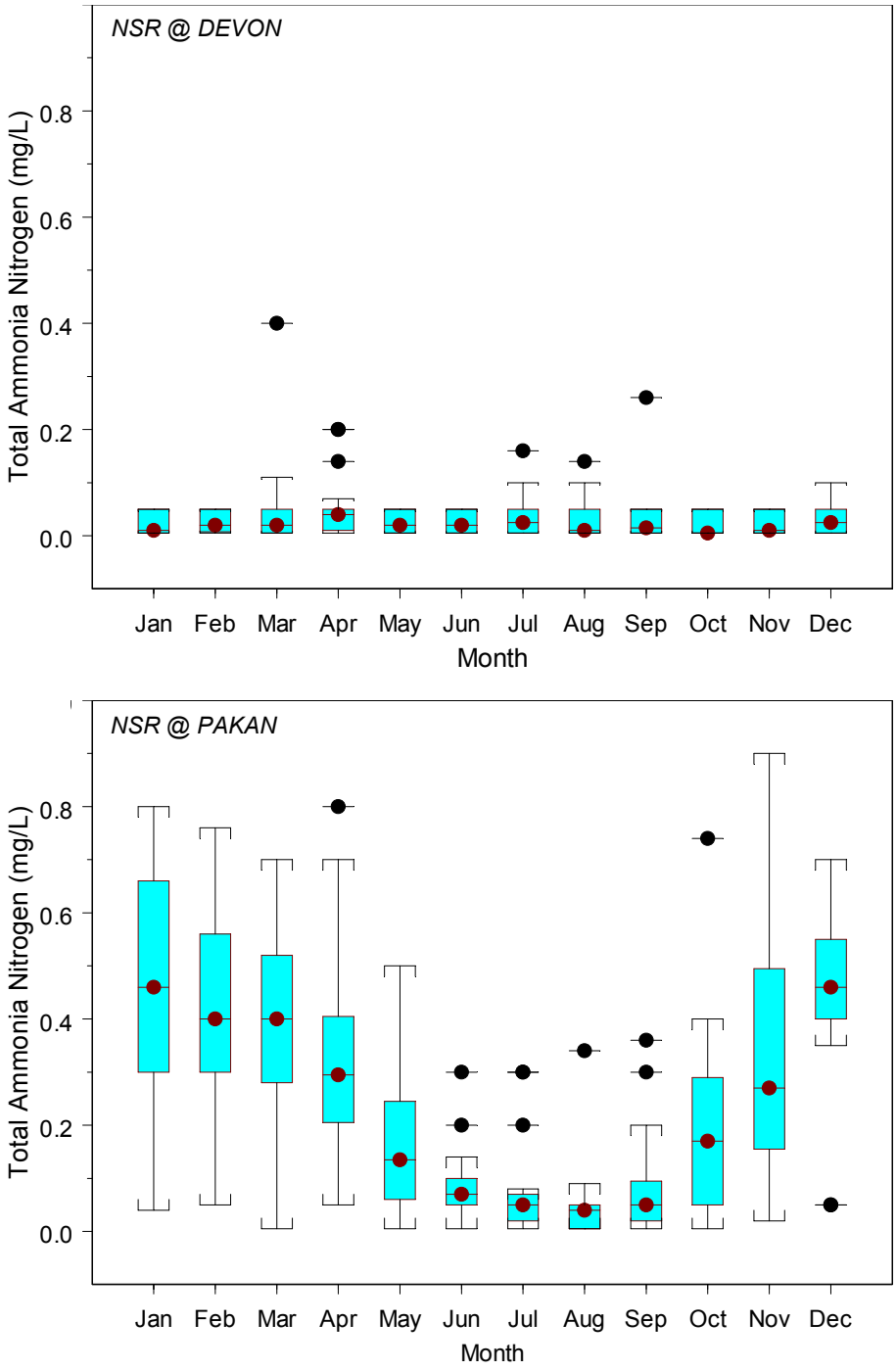
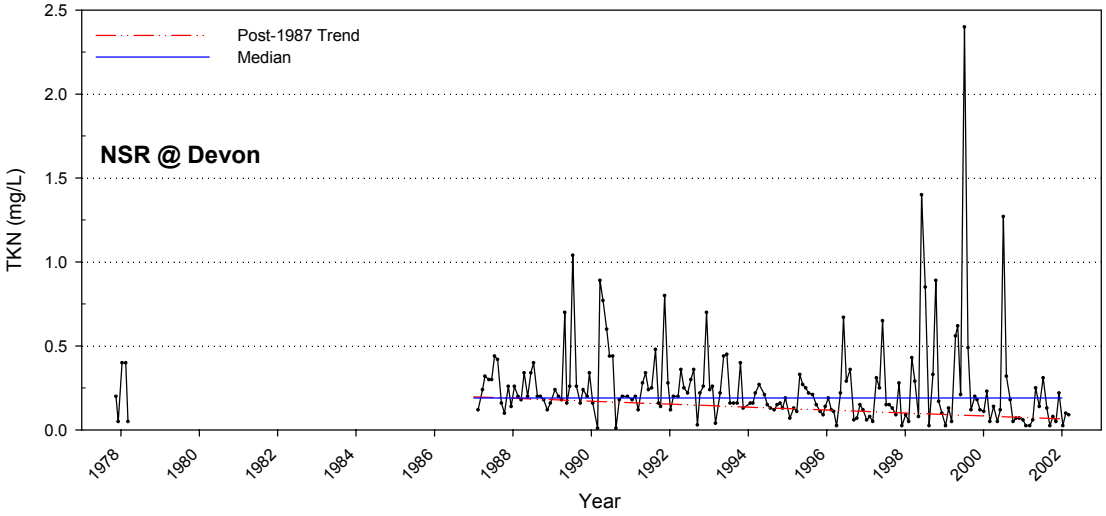
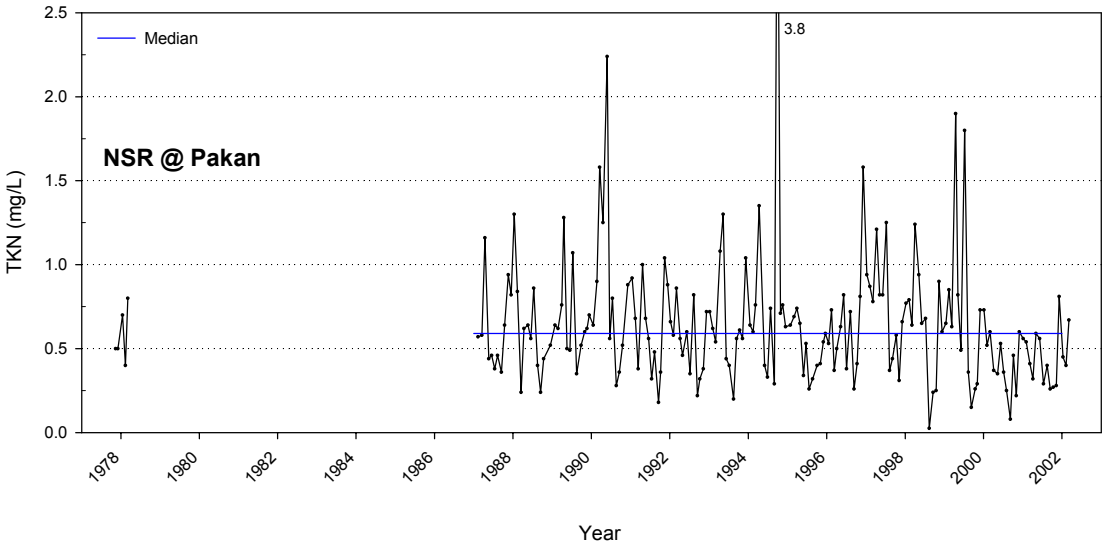


Figure 52 Boxplots depicting seasonality of total ammonia nitrogen in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
ID	ID	ID	ID	ID	ID	0.19	-0.0088	***
Flow Adjusted								
ID	ID			ID	ID		-0.0029	NS



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
ID	ID	ID	ID	ID	ID	0.59	-0.0085	NS
Flow Adjusted								
ID	ID			ID	ID		-0.0094	NS

Figure 53 Total Kjeldahl nitrogen concentration in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals. ID = Insufficient Data.

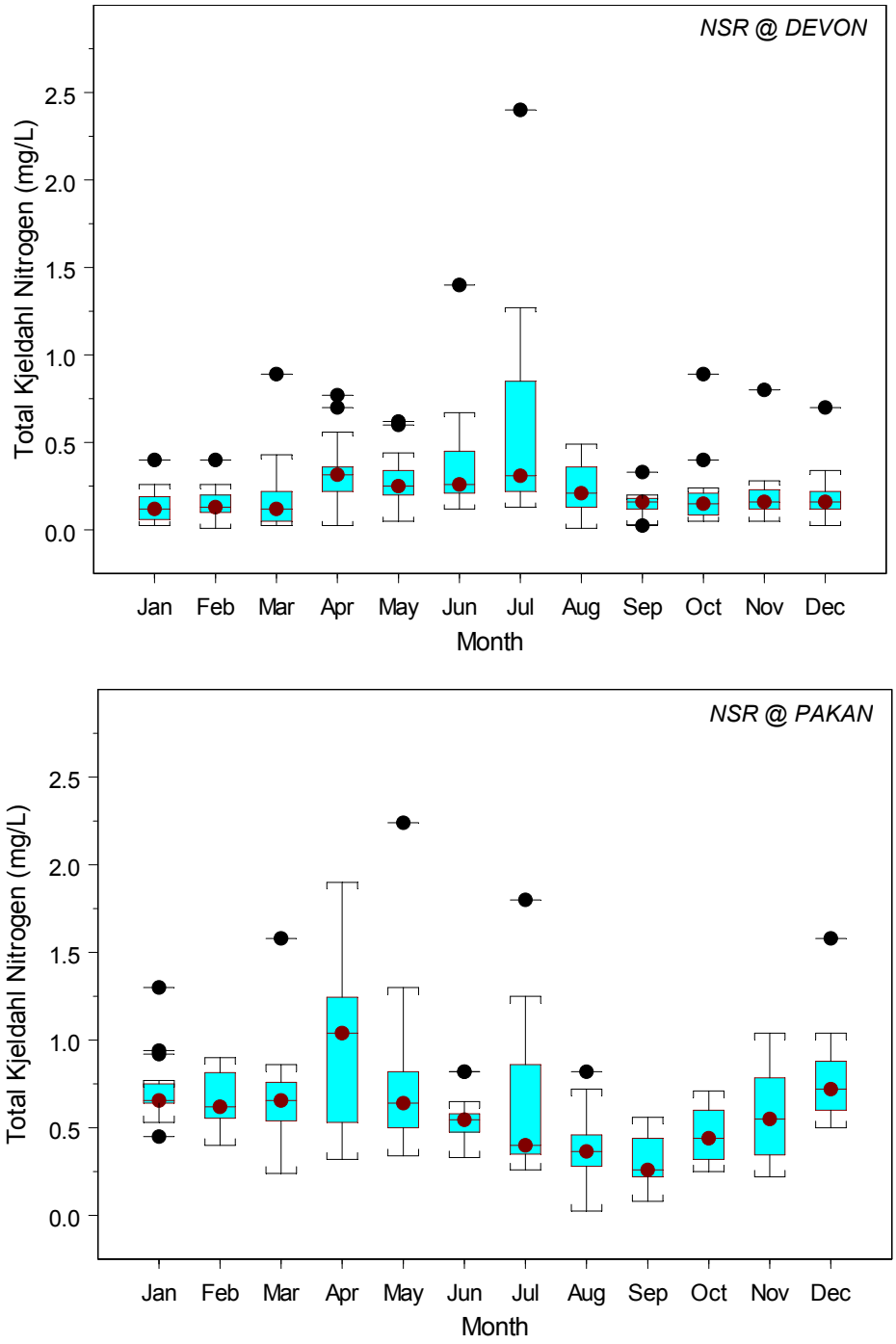
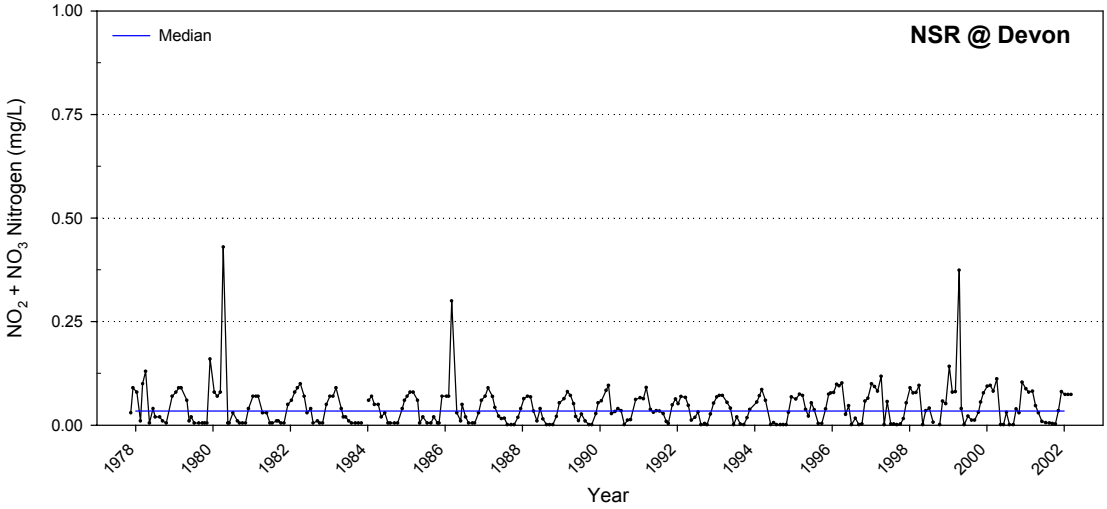
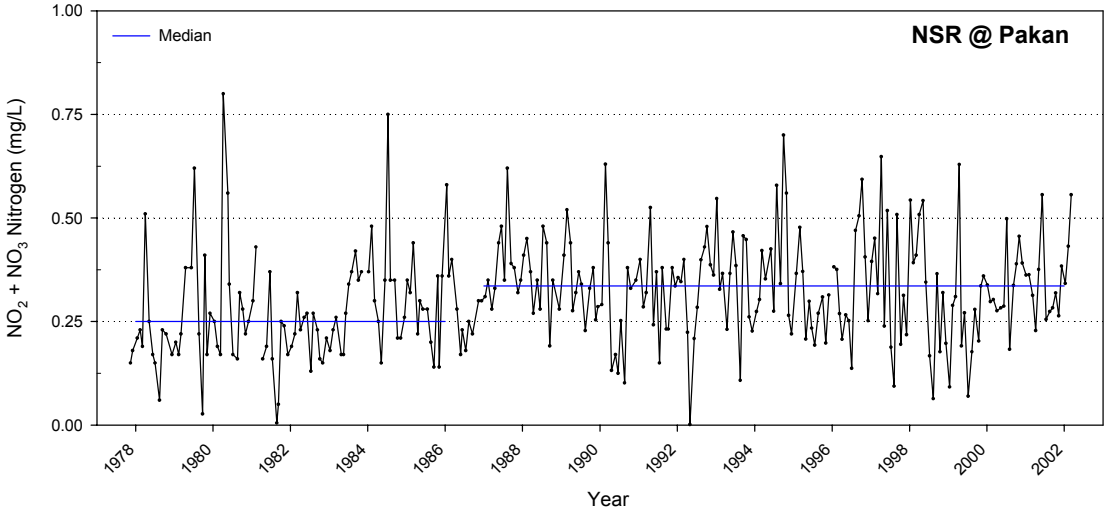


Figure 54 Boxplots depicting seasonality of total Kjeldahl nitrogen in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0000	NS	NS	0.034	-	-	0.034	-	-
Flow Adjusted								
0.0001	NS			-	-		-	-



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0043	***	***	0.25	0.0076	NS	0.34	-0.0026	NS
Flow Adjusted								
0.0037	**			0.0116	NS		-0.0030	**

Figure 55 Nitrite and nitrate nitrogen concentration in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals.

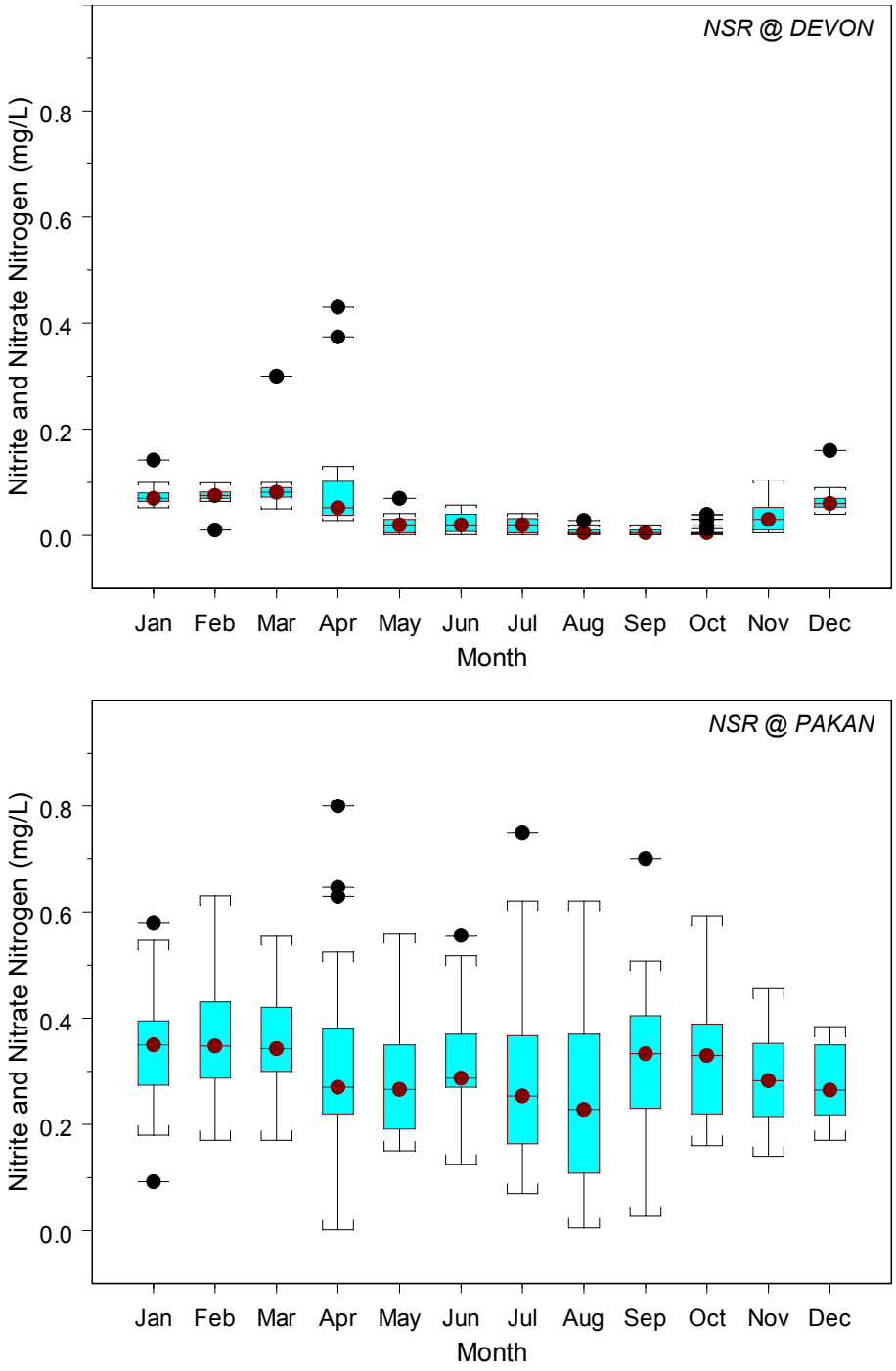
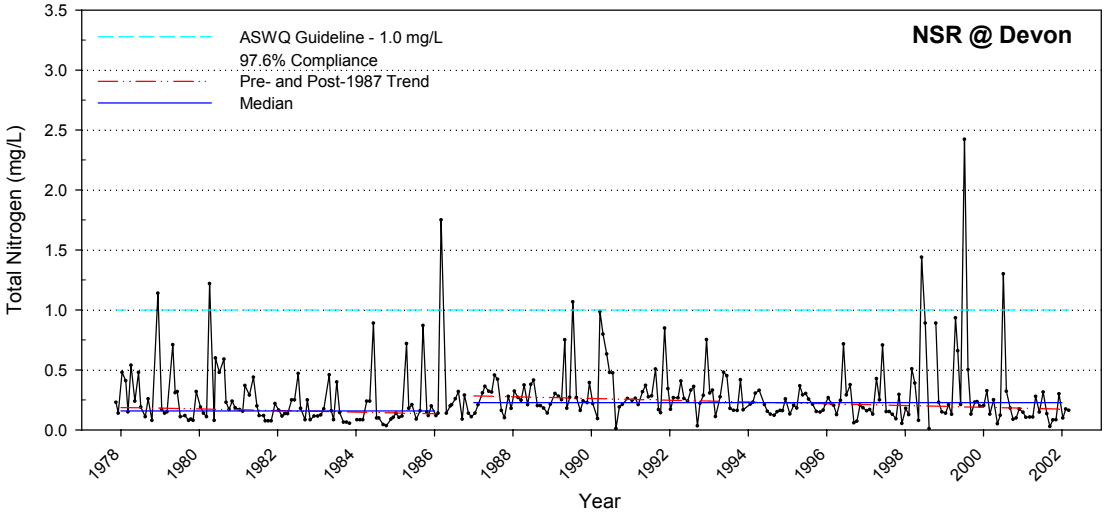
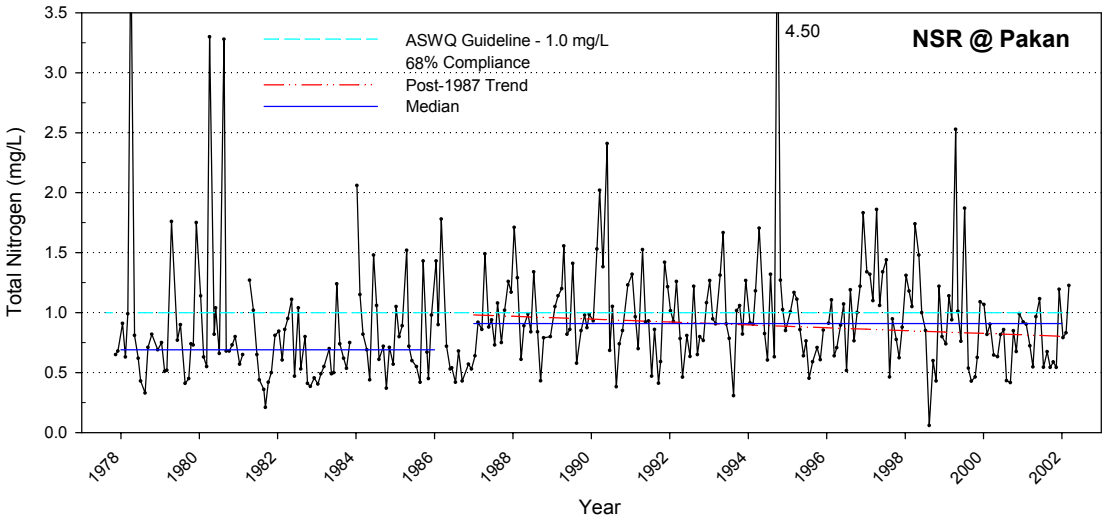


Figure 56 Boxplots depicting seasonality of nitrite and nitrate nitrogen in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0010	NS	***	0.16	-0.0066	**	0.23	-0.0073	***
Flow Adjusted								
0.0029	**			-0.0384	**		-0.0023	NS



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0083	*	***	0.69	-0.0045	NS	0.91	-0.0119	**
Flow Adjusted								
0.0077	*			-	-		-0.0132	**

Figure 57 Total nitrogen concentration in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals.

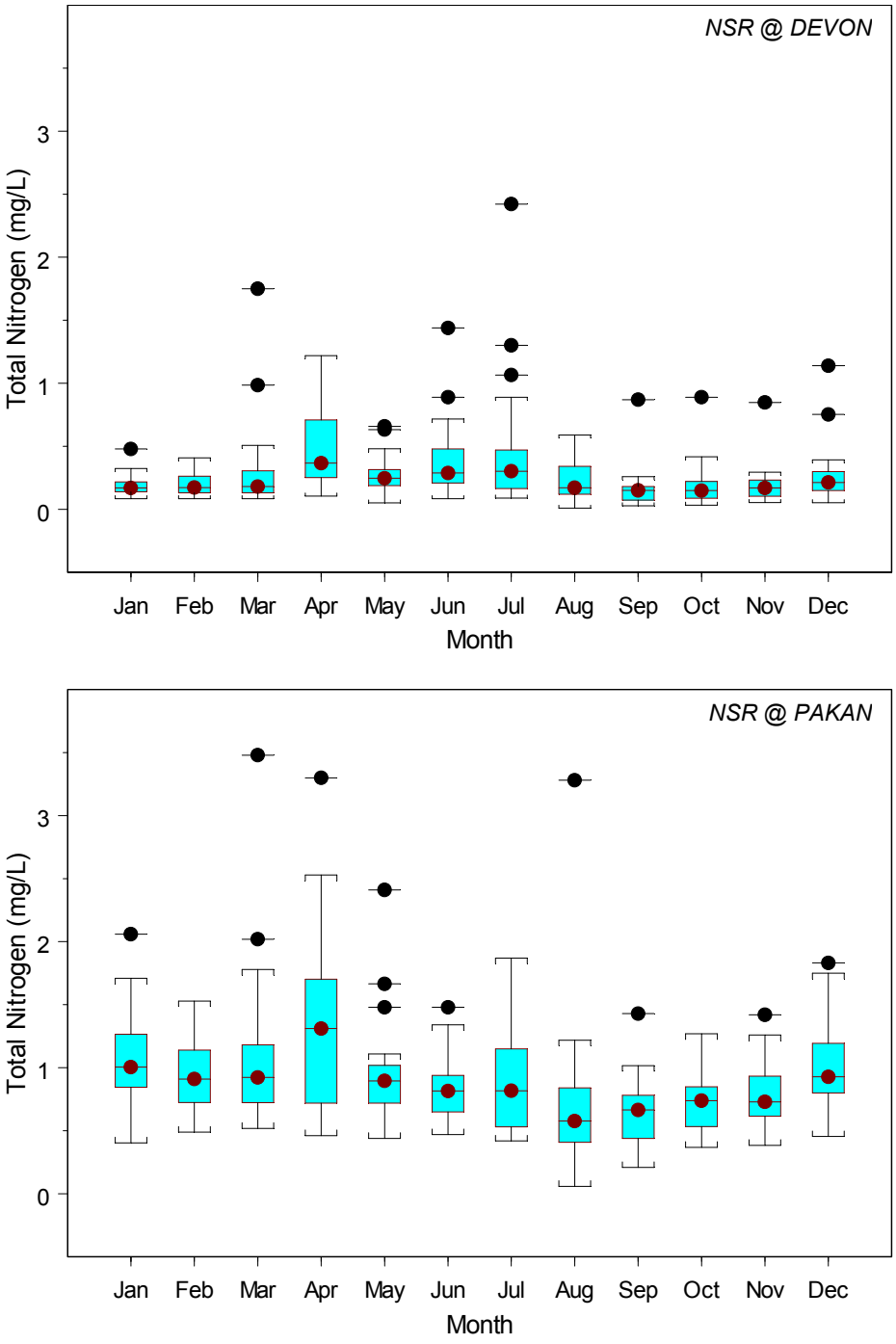
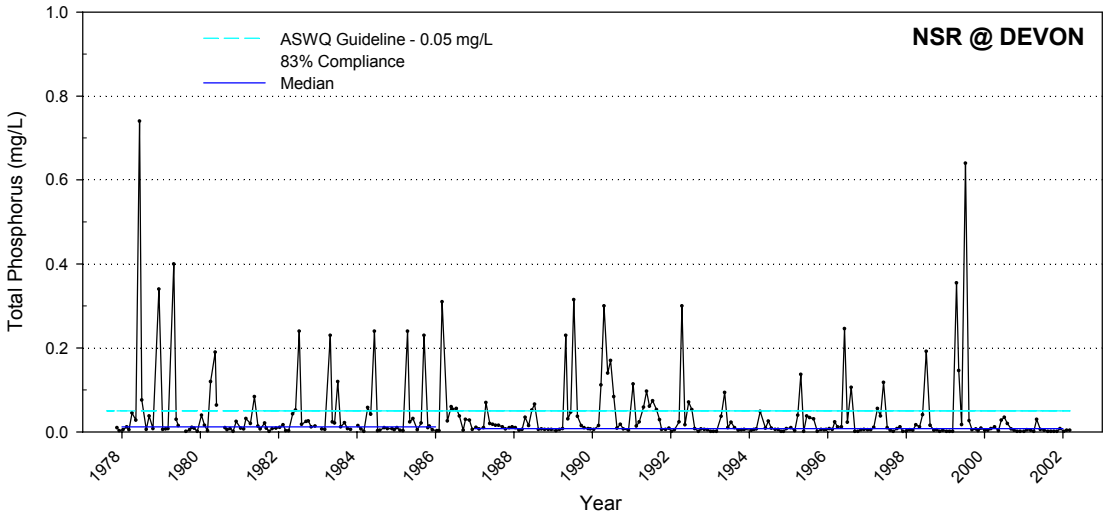
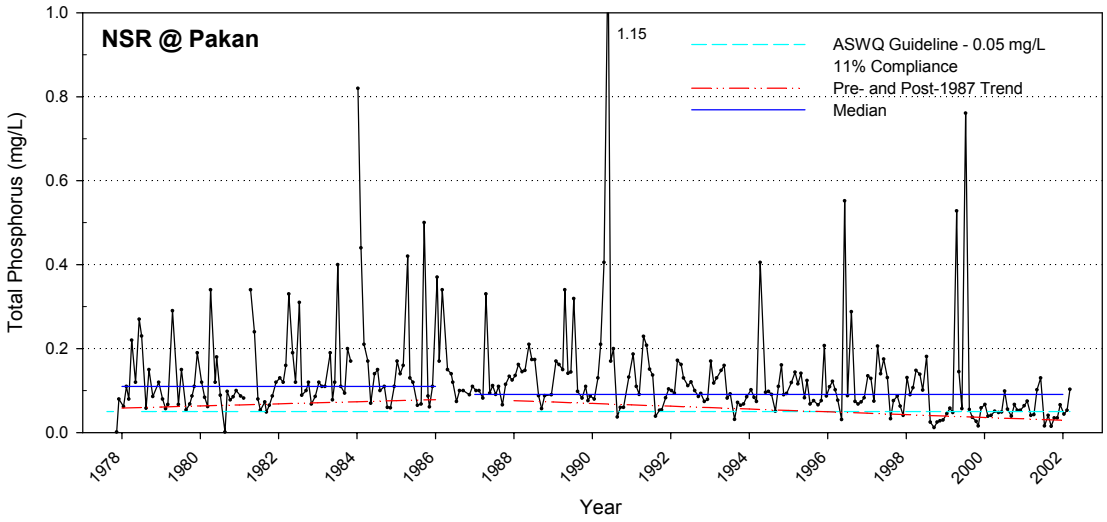


Figure 58 Boxplots depicting seasonality of total nitrogen in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0003	***	***	0.012	0.0000	NS	0.008	-0.0005	***
Flow Adjusted								
0.0001	NS			-0.0316	NS		0.0005	*



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0023	***	***	0.110	0.0043	**	0.091	-0.0051	***
Flow Adjusted								
-0.0022	***			0.0051	*		-0.0049	***

Figure 59 Total phosphorus concentration in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals.

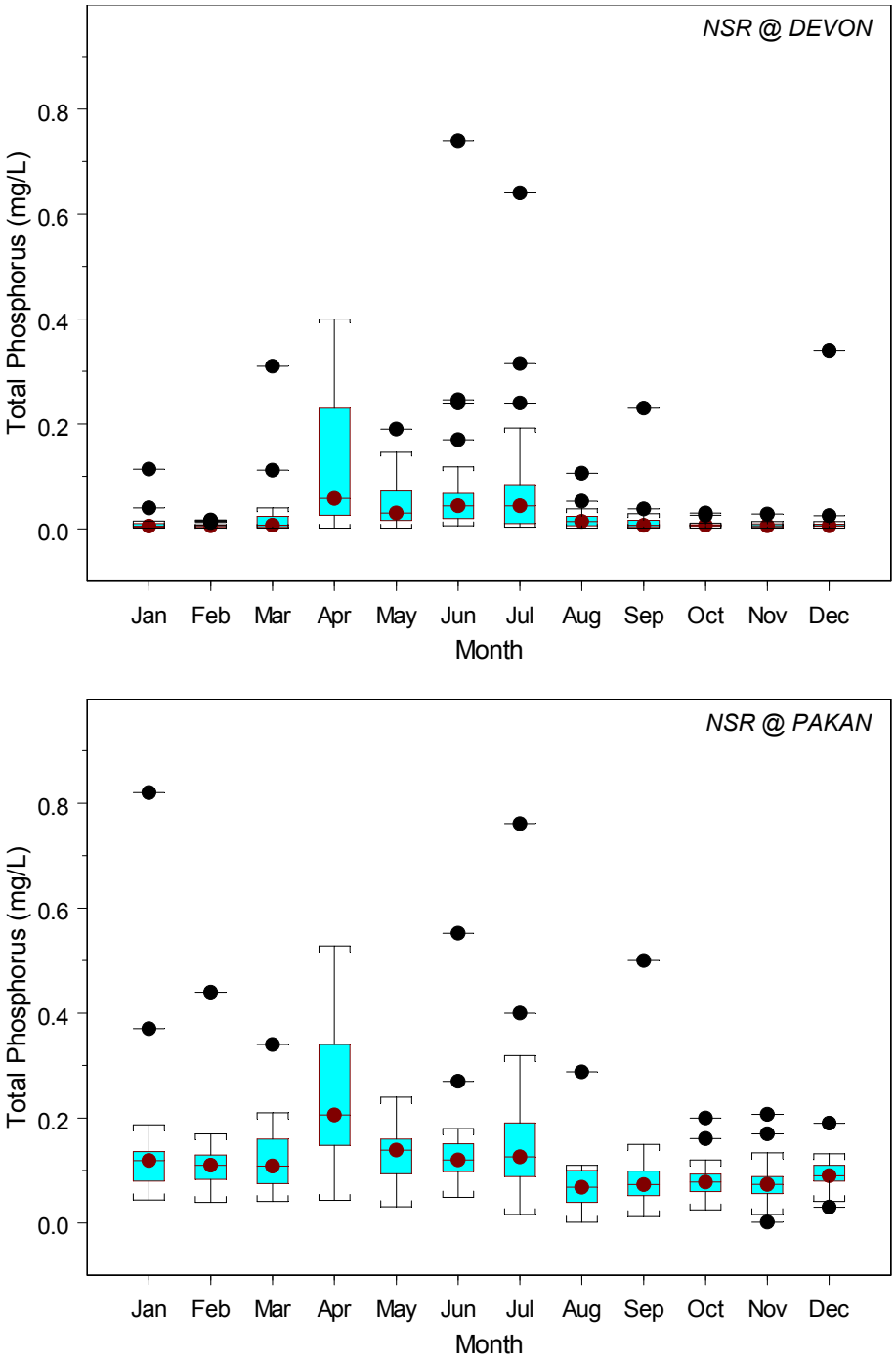
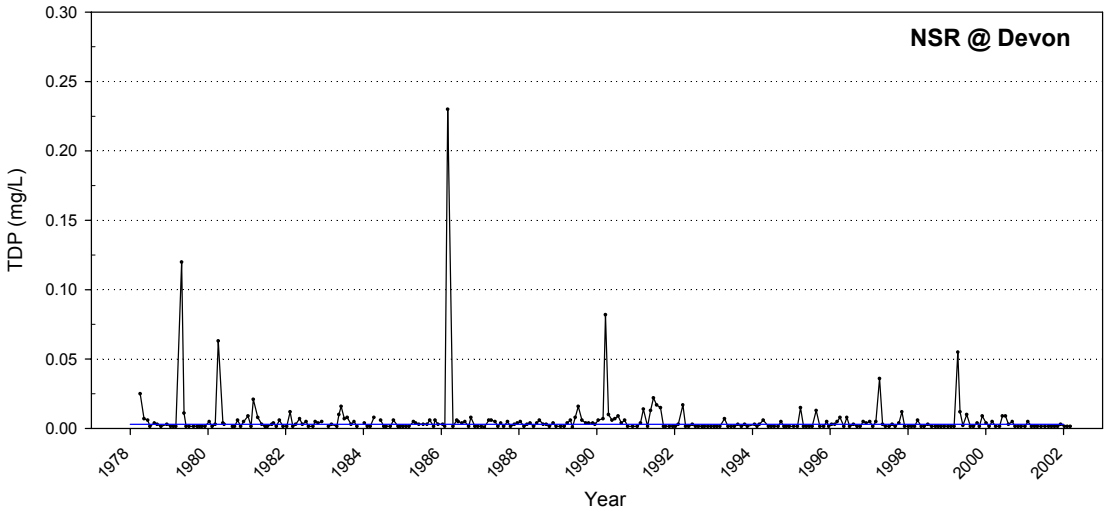
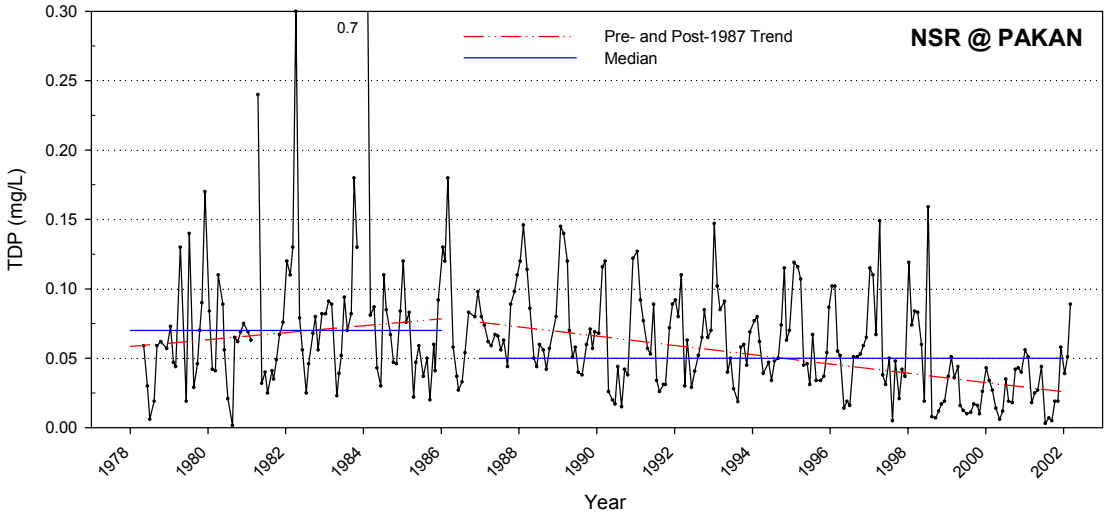


Figure 60 Boxplots depicting seasonality of total phosphorus in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0000	*	NS	0.0030	-	-	0.0030	-	-
Flow Adjusted								
-0.0034	NS			-	-		-	-



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0017	***	***	0.0700	0.0025	*	0.0500	-0.0033	***
Flow Adjusted								
-0.0020	***			0.0024	NS		-0.0036	***

Figure 61 Total dissolved phosphorus concentration in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals.

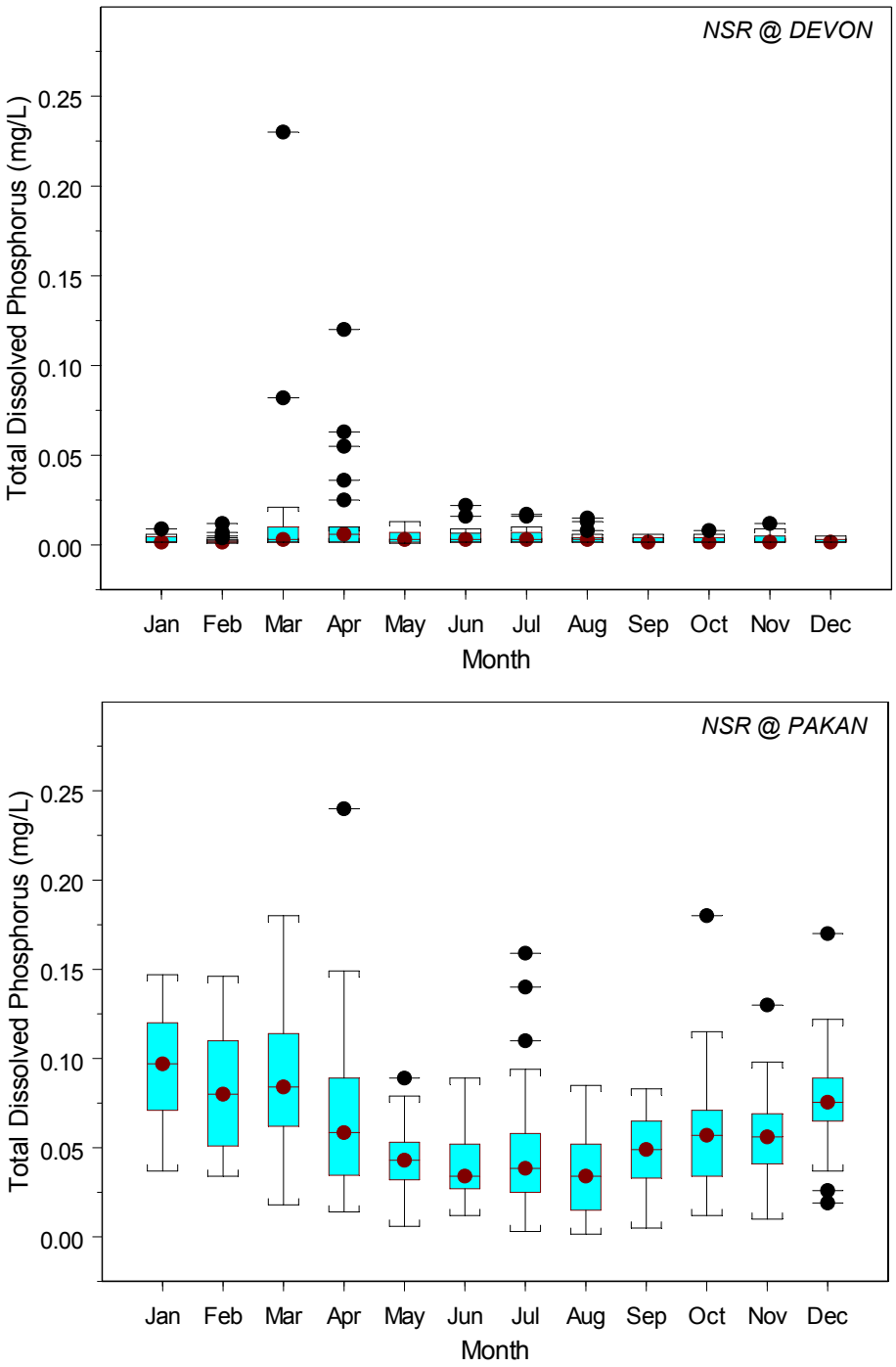
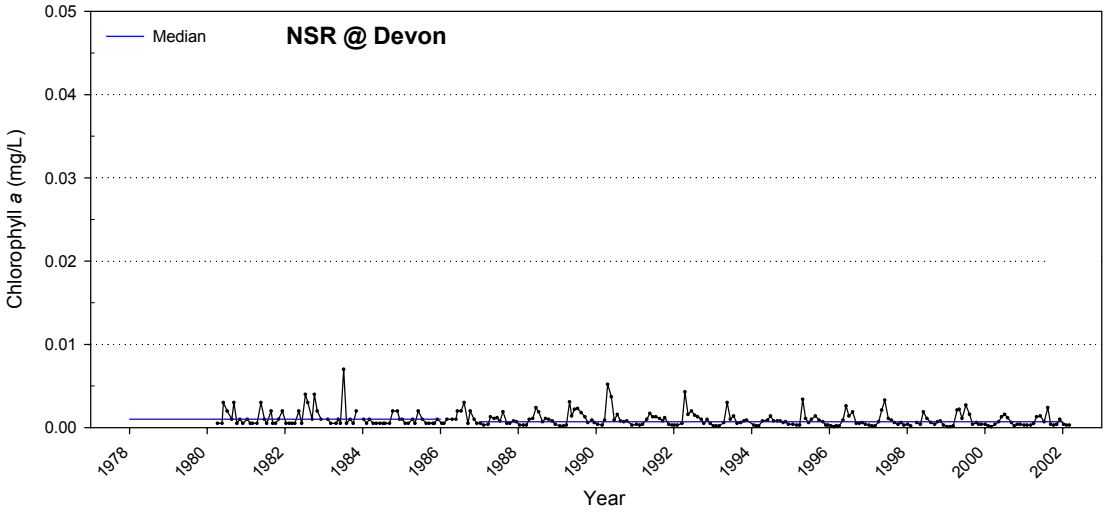
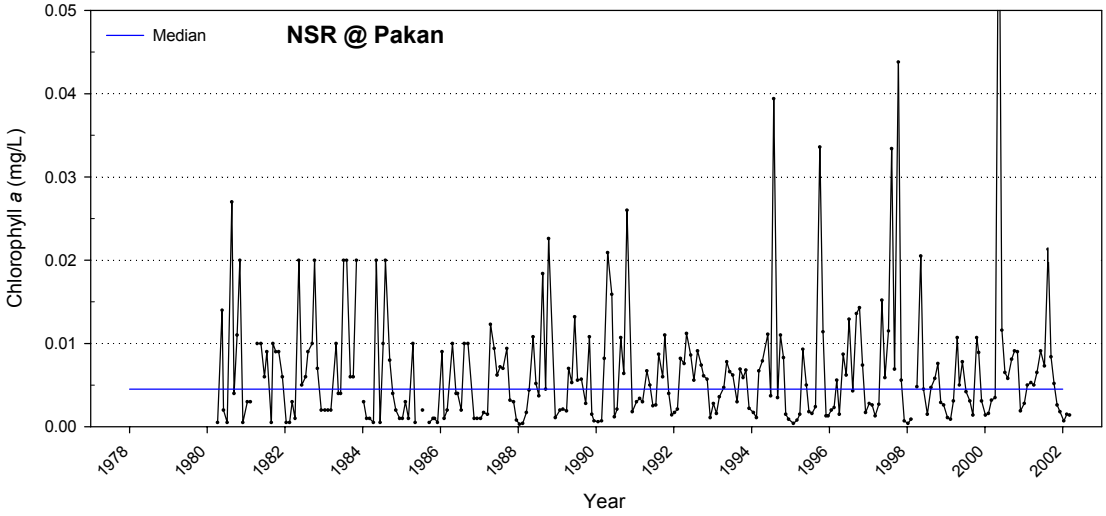


Figure 62 Boxplots depicting seasonality of total dissolved phosphorus (TDP) in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0000	NS	***	0.0010	0.0000	NS	0.0007	0.0000	NS
Flow Adjusted								
0.0000	NS			0.0000	NS		-0.0038	NS



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0000	*	NS	0.0045	-	-	0.0045	-	-
Flow Adjusted								
0.0161	*			-	-		-	-

Figure 63 Chlorophyll *a* concentration in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals.

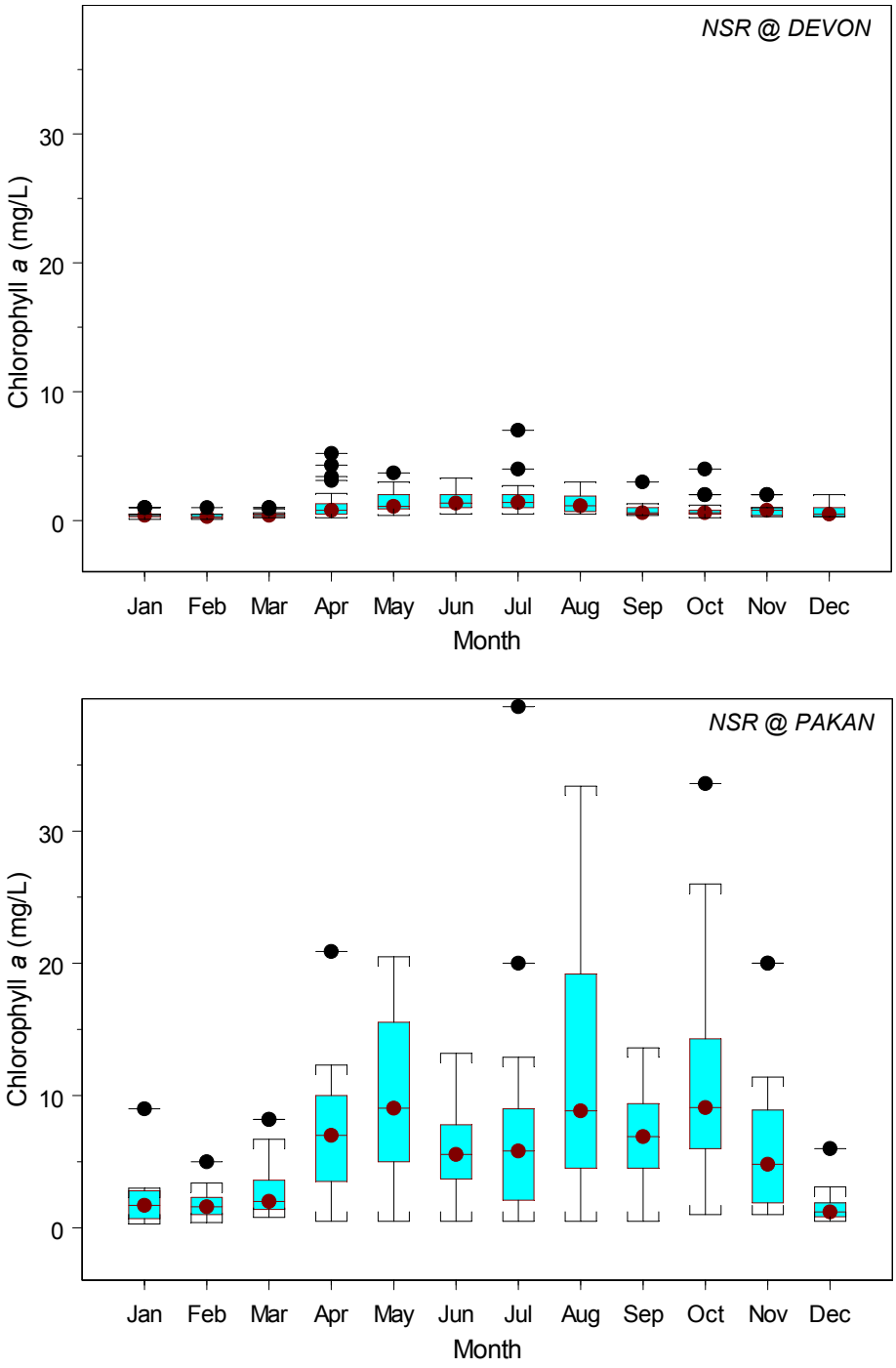
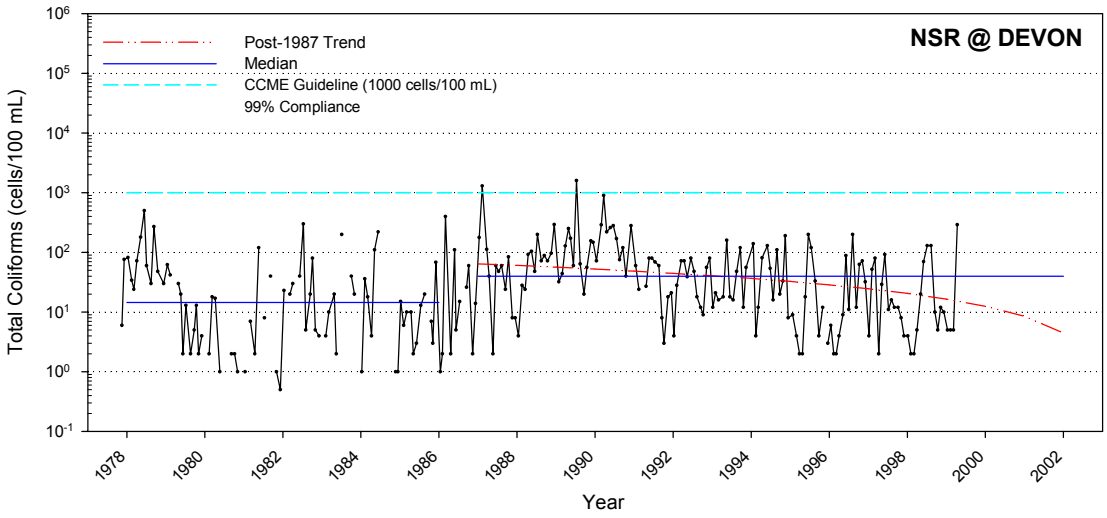
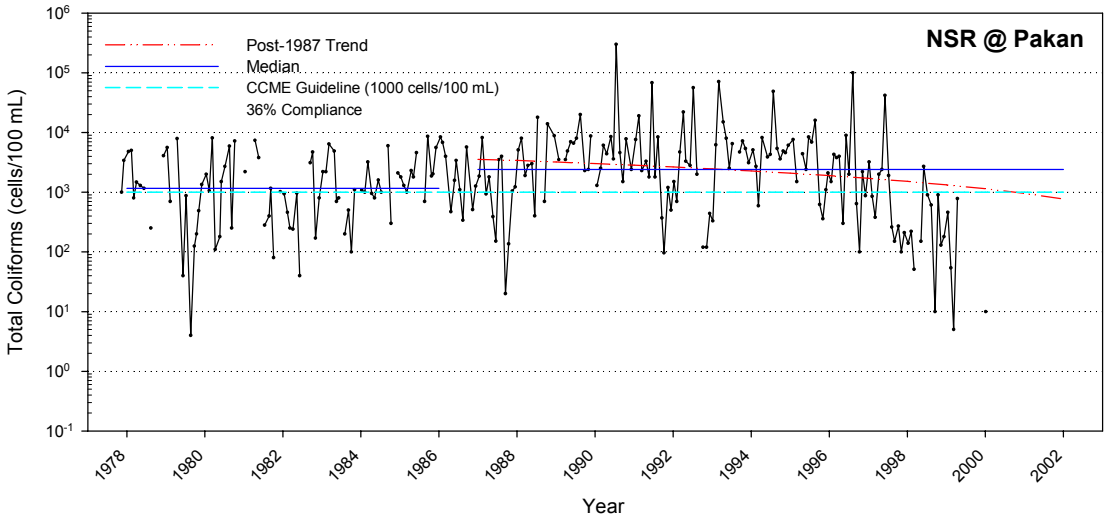


Figure 64 Boxplots depicting seasonality of chlorophyll *a* in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0000	NS	***	14.50	-1.3899	NS	40.00	-3.9857	***
Flow Adjusted								
0.0644	NS			-1.1581	NS		-0.1700	***



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
7.9282	NS	**	1160.00	60.1682	NS	2400.00	-186.2691	*
Flow Adjusted								
-15.3077	NS			-	NS		-258.9049	**

Figure 65 Total coliform bacteria in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals.

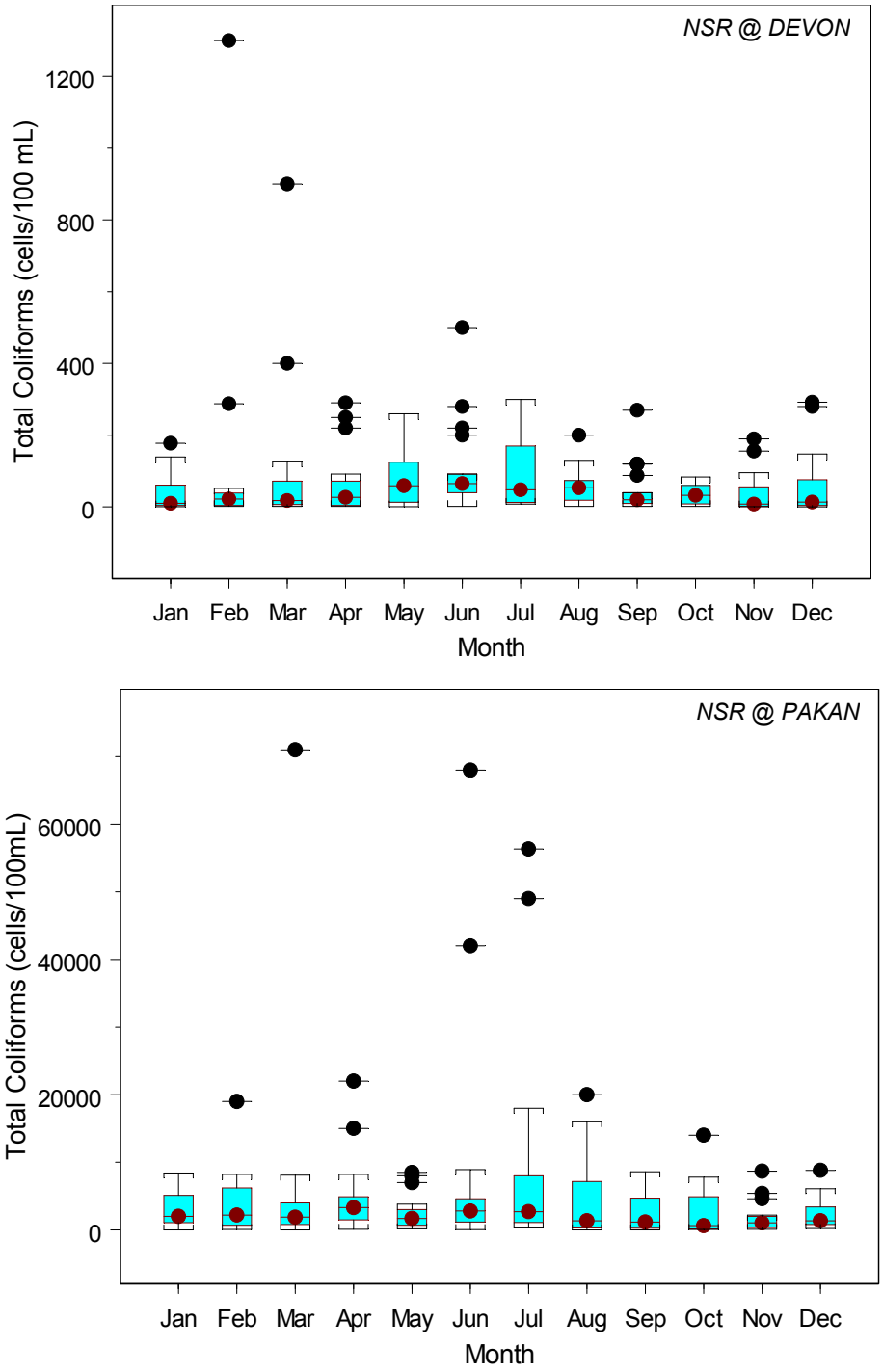
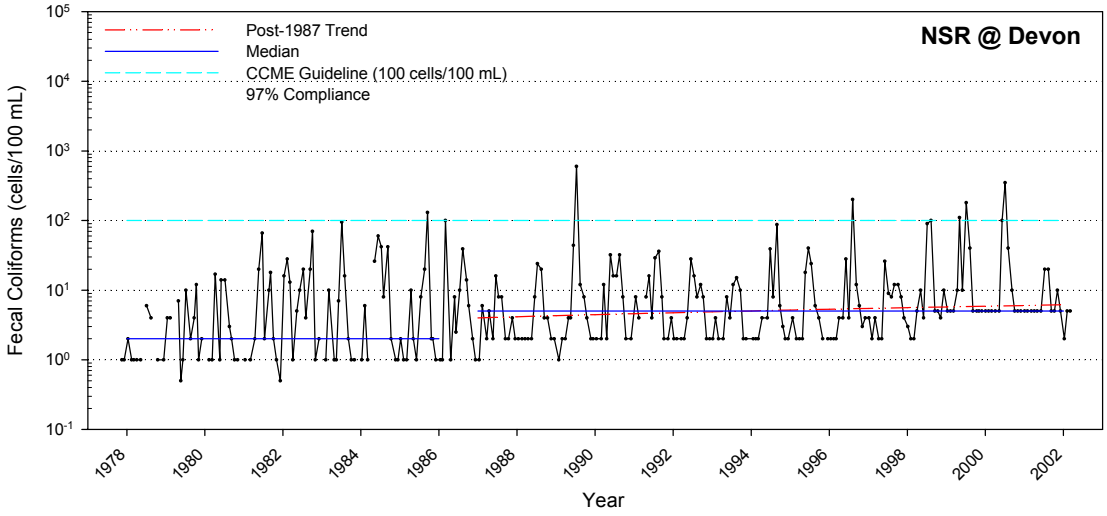
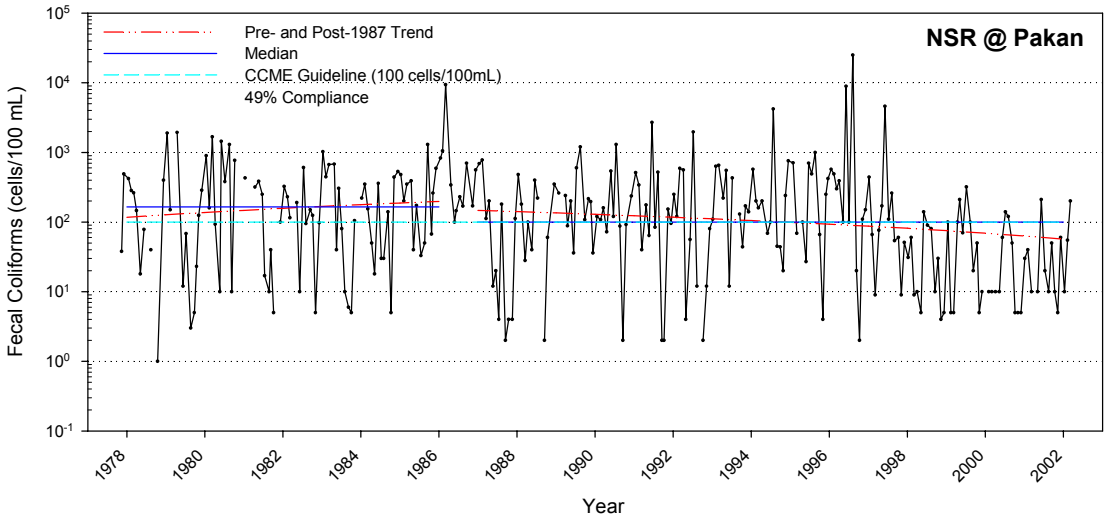


Figure 66 Boxplots depicting seasonality of total coliform counts in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.1306	***	***	2.00	0.0000	***	5.00	0.1446	***
Flow Adjusted								
0.0627	NS			0.0600	NS		0.0717	***



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-3.4465	**	***	164.50	10.0032	**	100.00	-6.0165	*
Flow Adjusted								
-4.8423	*			-	NS		-0.0944	*

Figure 67 Fecal coliform bacteria in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals.

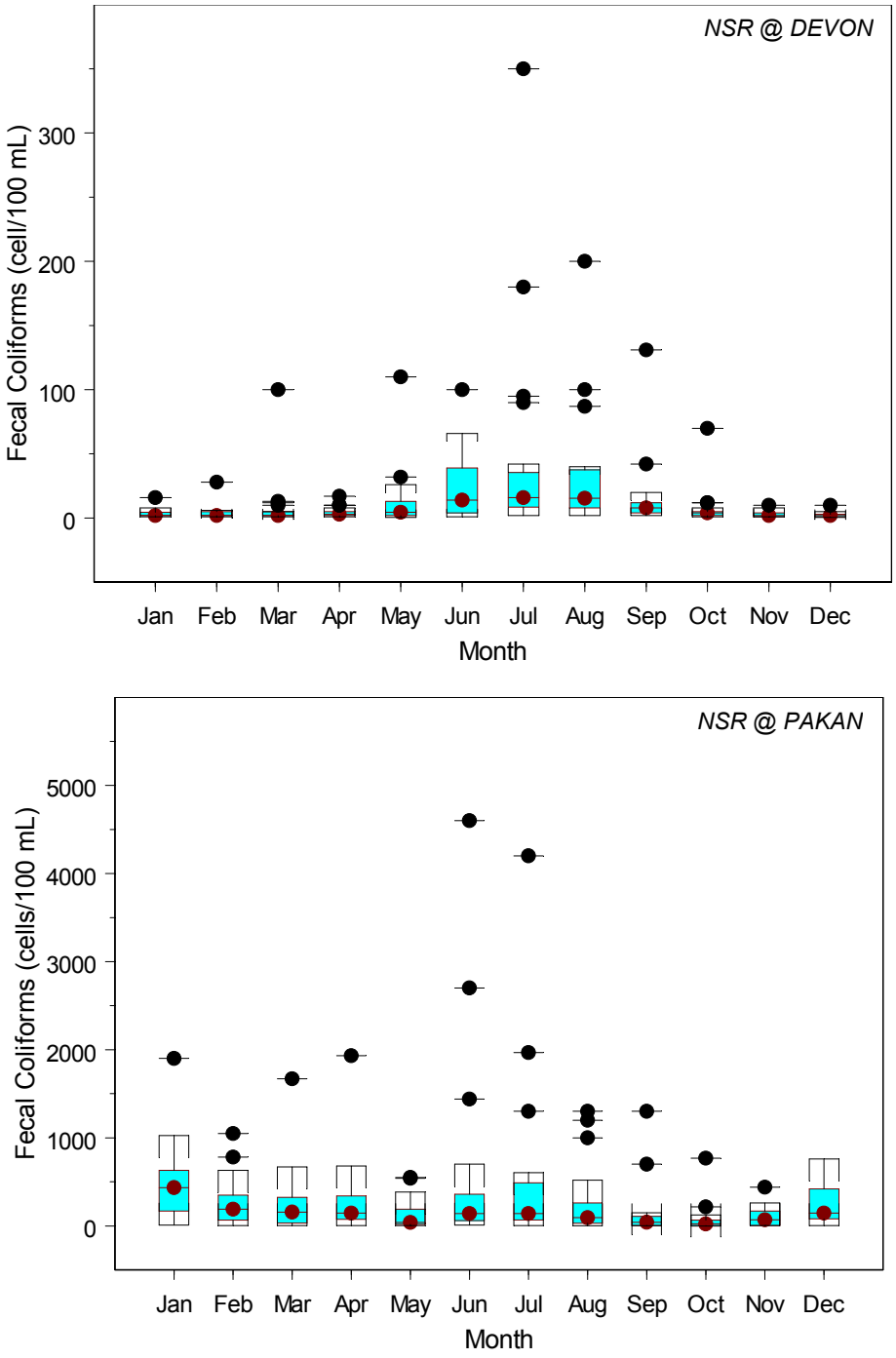
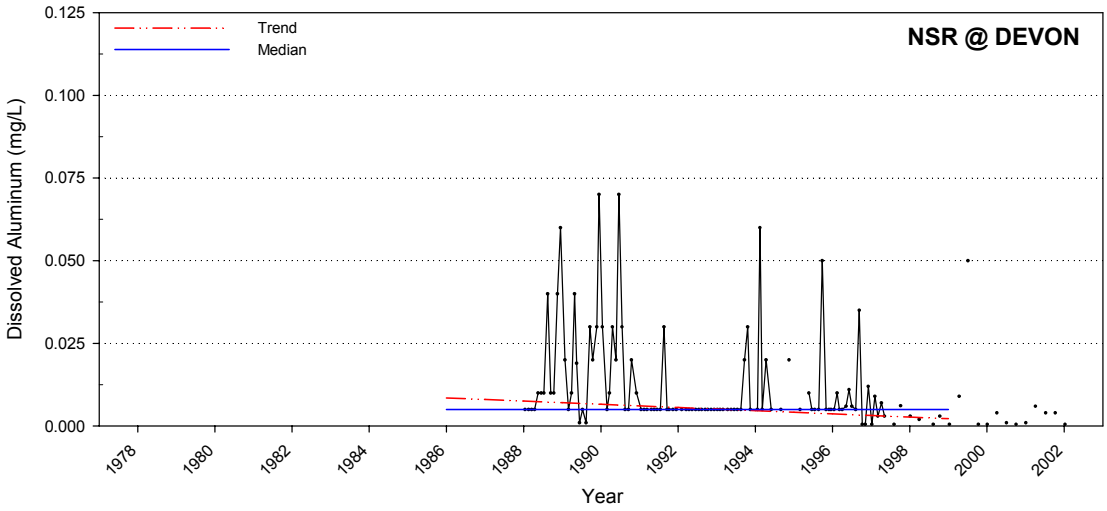
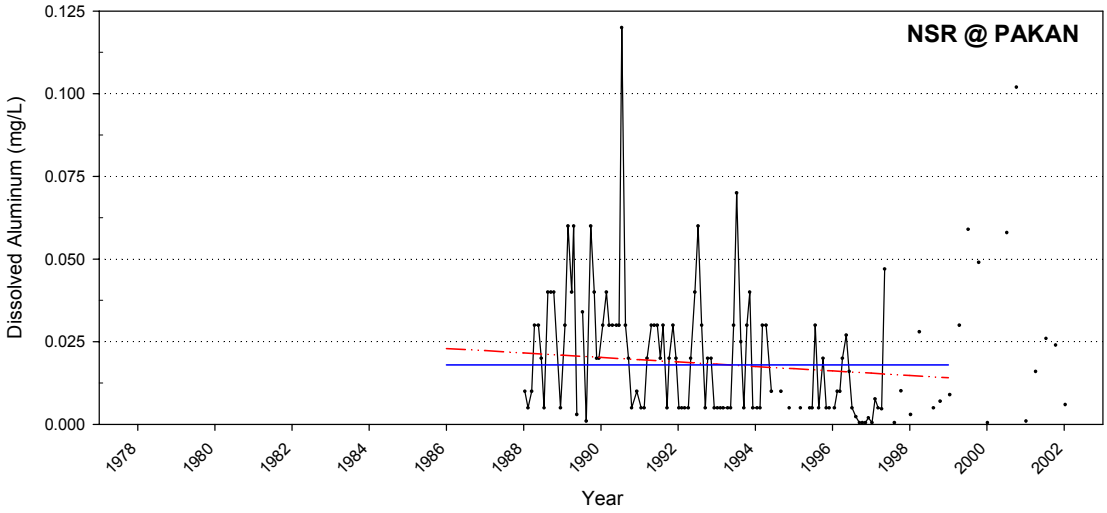


Figure 68 Boxplots depicting seasonality of fecal coliform counts in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
ID	ID	ID	ID	ID	ID	0.005	-0.0005	***
Flow Adjusted								
ID	ID			ID	ID		-0.0007	***



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
ID	ID	ID	ID	ID	ID	0.018	-0.0007	**
Flow Adjusted								
ID	ID			ID	ID		-0.0682	*

Figure 69 Dissolved aluminum concentration in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals. ID = Insufficient Data.

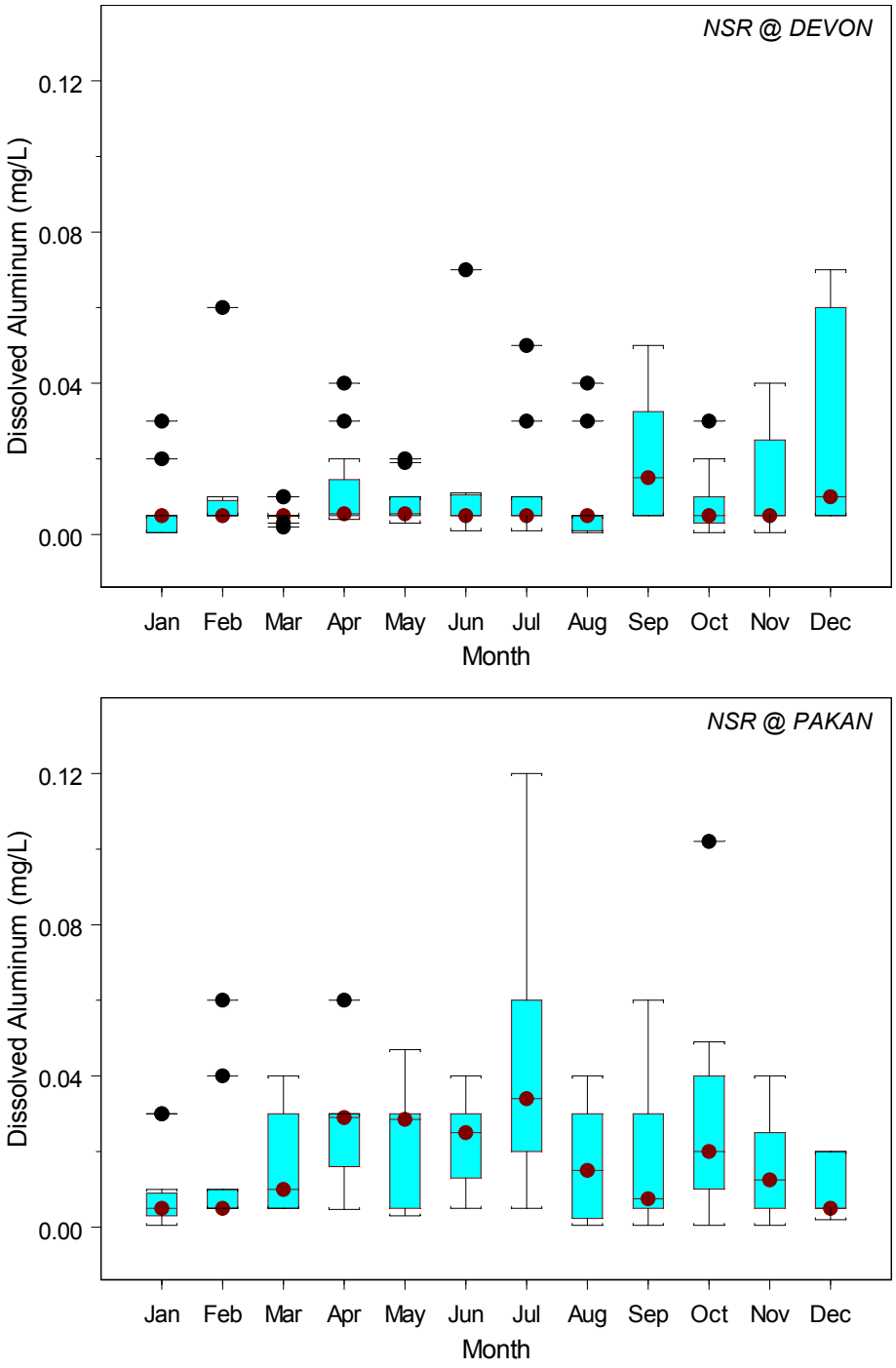
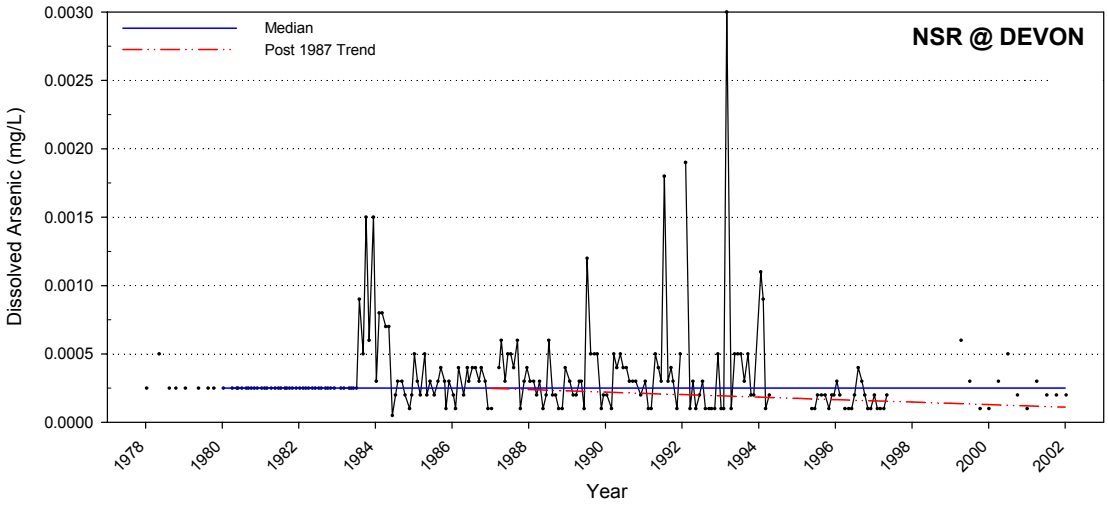
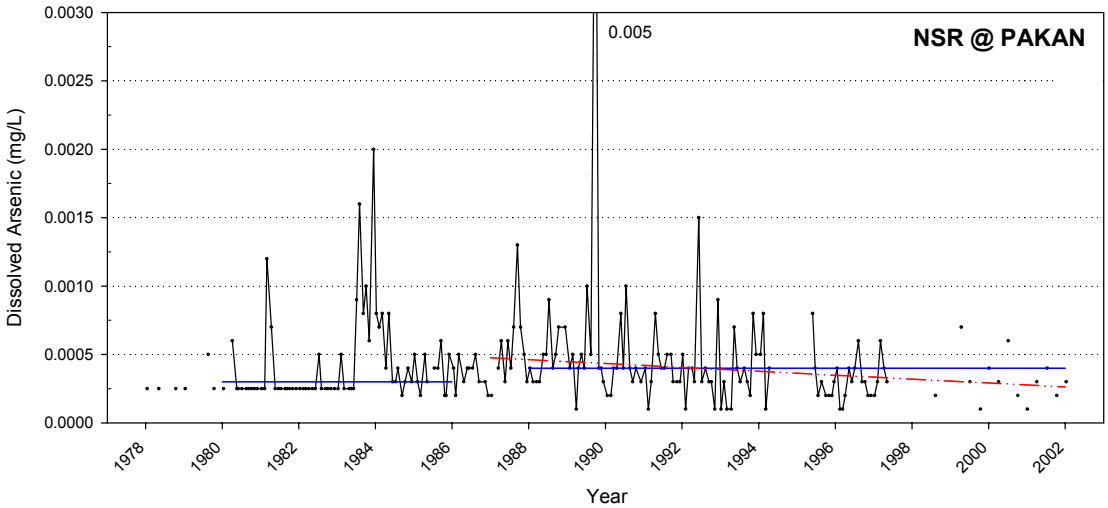


Figure 70 Boxplots depicting seasonality of dissolved aluminum concentration in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0000	NS	NS	0.0003	-	-	0.0003	-0.00001	**
Flow Adjusted								
-0.0106	NS			-	-		-0.03010	**



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0000	NS	*	0.0003	-	-	0.0004	-0.0001	**
Flow Adjusted								
0.0009	NS			-	-		-0.0430	**

Figure 71 Dissolved arsenic concentration in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals. ID = Insufficient Data.

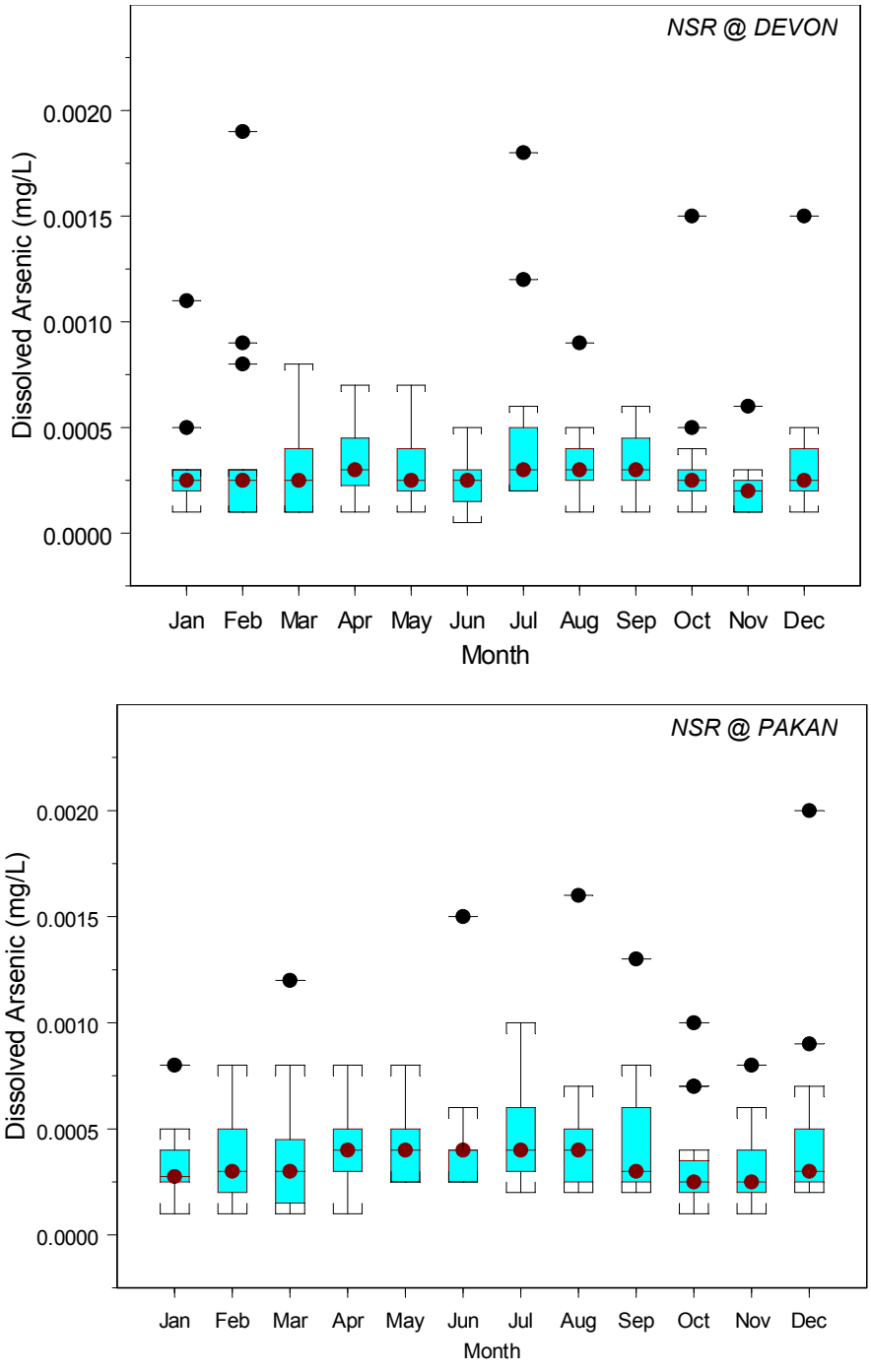
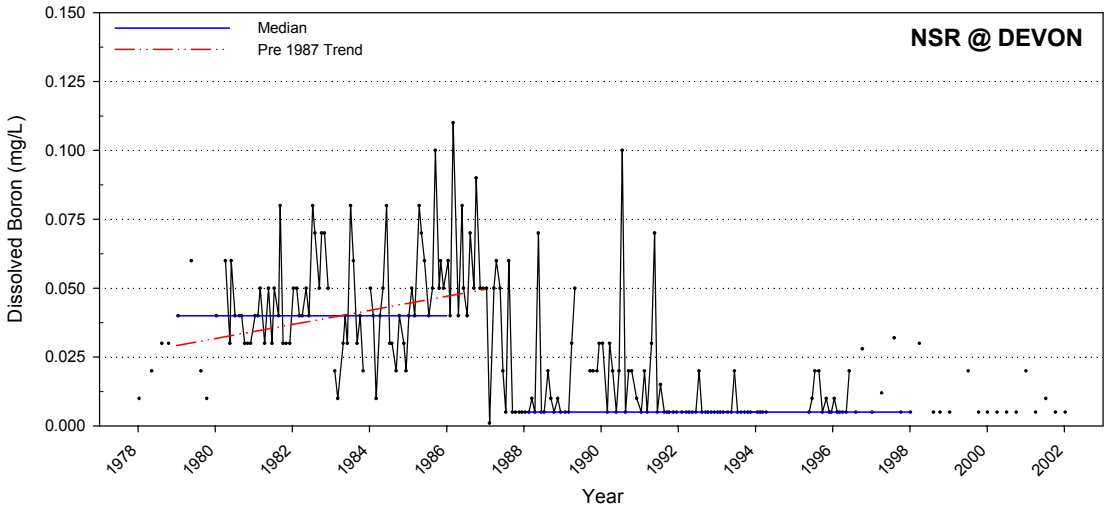
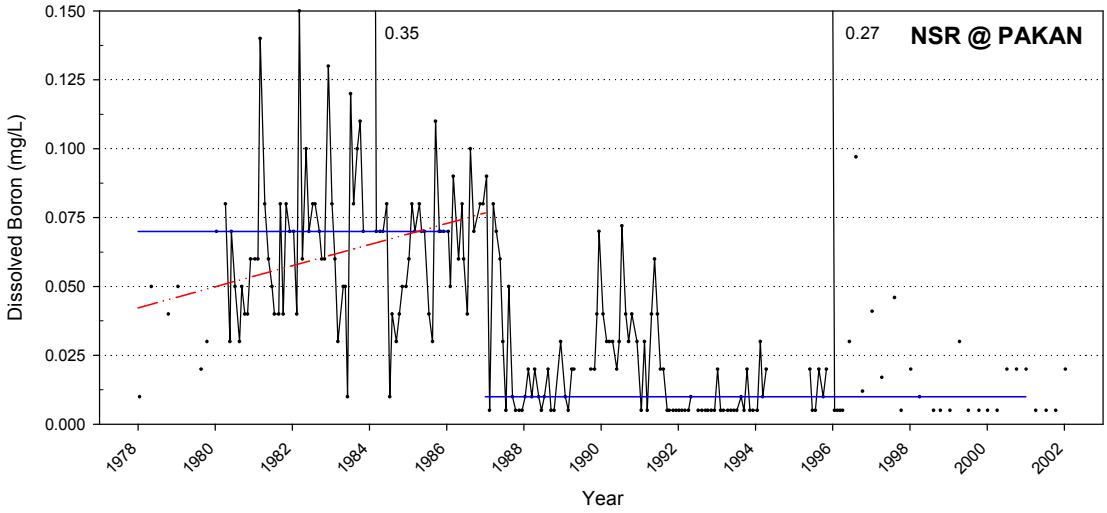


Figure 72 Boxplots depicting seasonality of dissolved arsenic concentration in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0013	***	***	0.040	0.0026	***	0.005	0.0000	**
Flow Adjusted								
-0.0014	***			0.0027	***		-0.0004	NS



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0020	***	***	0.070	0.0038	**	0.010	0.0000	NS
Flow Adjusted								
-	-			-	-		-	-

Figure 73 Dissolved boron concentration in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals. A significant slope of zero at Devon, post-1987, is likely related to a high frequency of non-detects.

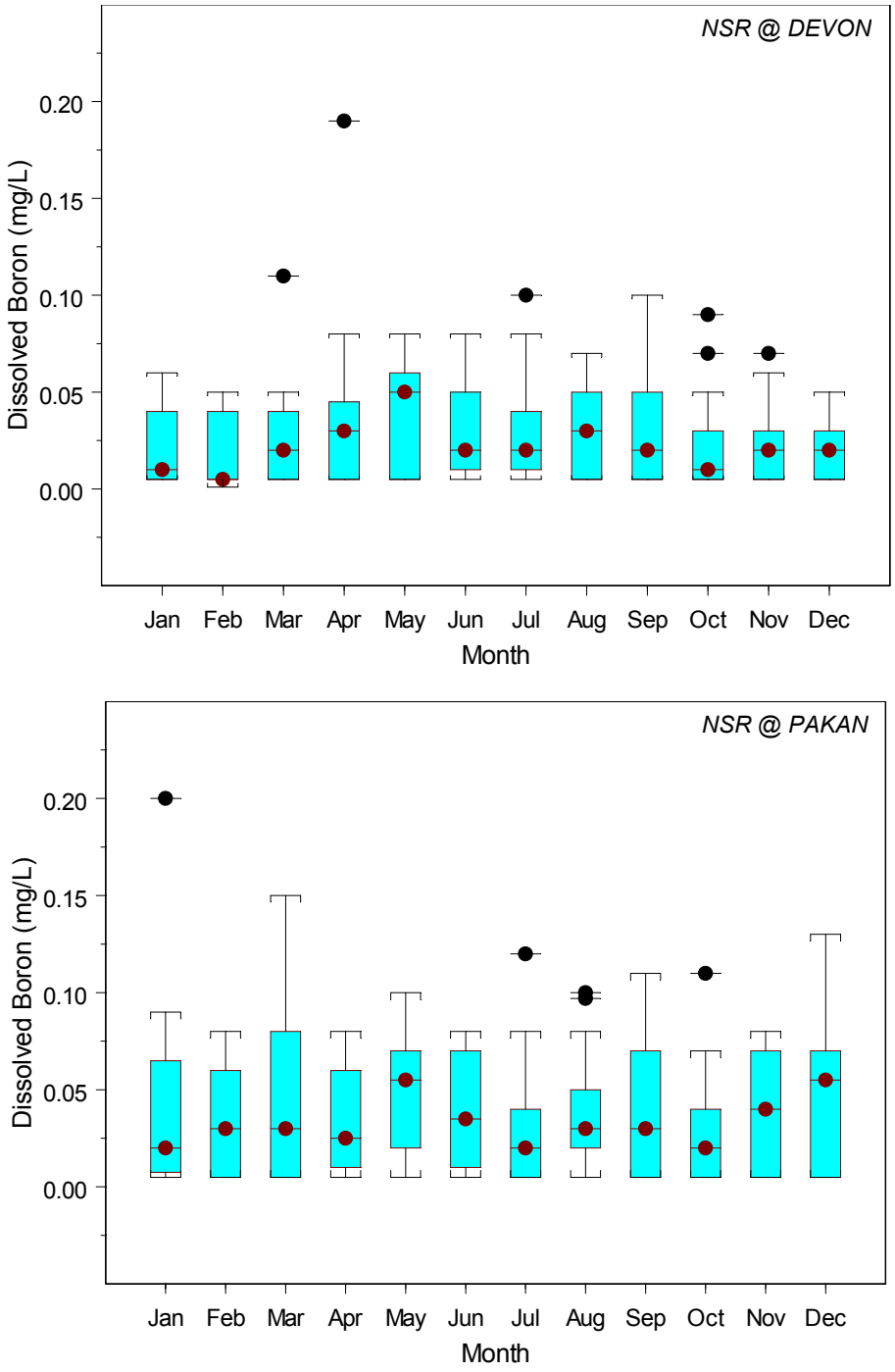
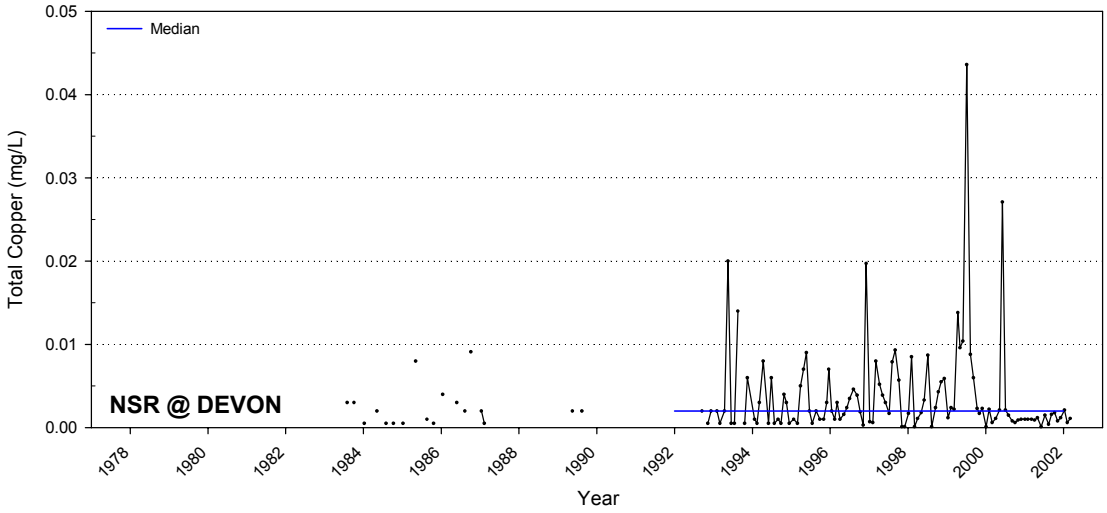
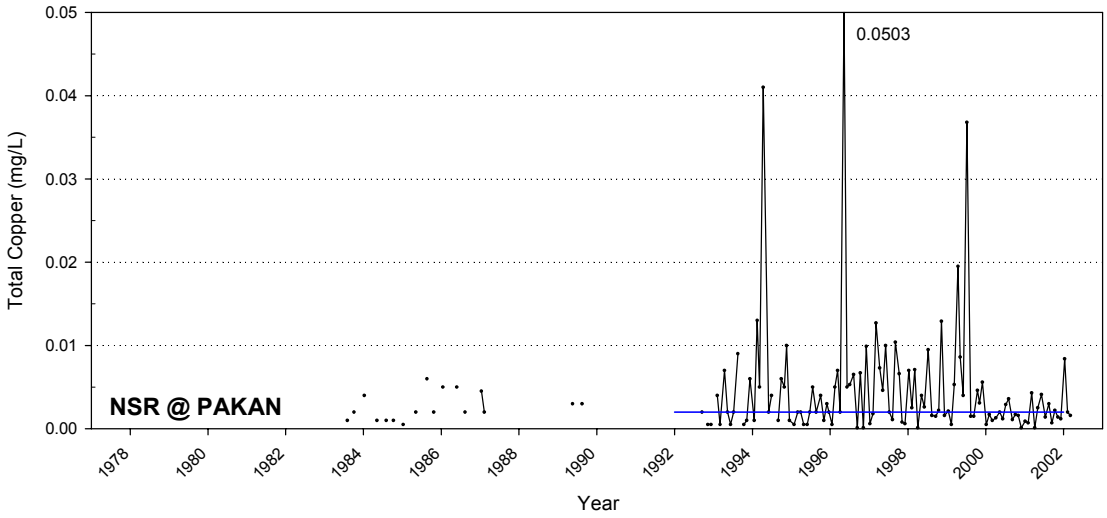


Figure 74 Boxplots depicting seasonality of dissolved boron concentration in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
ID	ID	ID	0.002	ID	ID	0.002	0.0000	NS
Flow Adjusted								
ID	ID			ID	ID		0.0001	NS



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
ID	ID	ID	0.002	ID	ID	0.002	-0.0001	NS
Flow Adjusted								
ID	ID			ID	ID		-0.0001	NS

Figure 75 Total copper concentration in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals. ID = Insufficient Data.

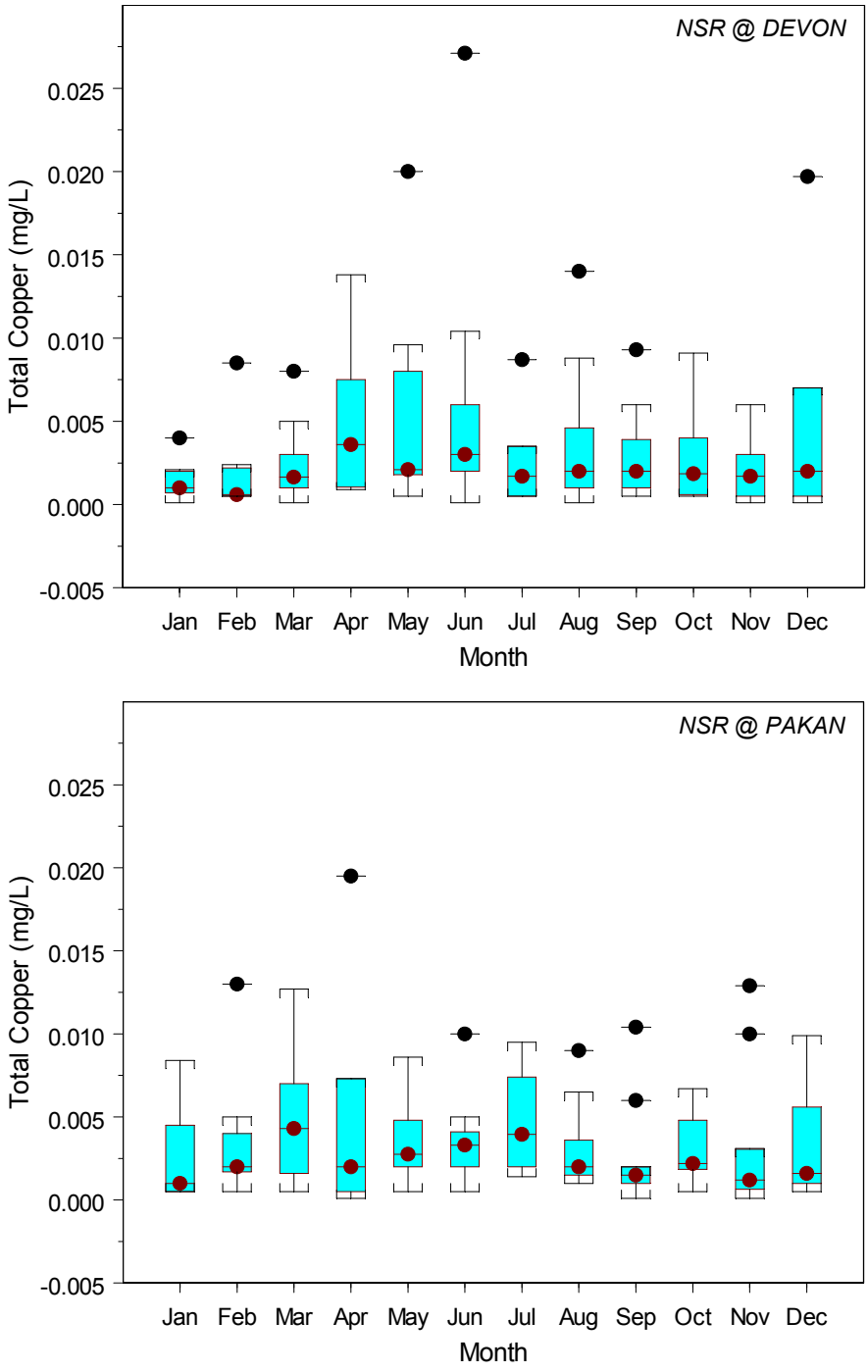
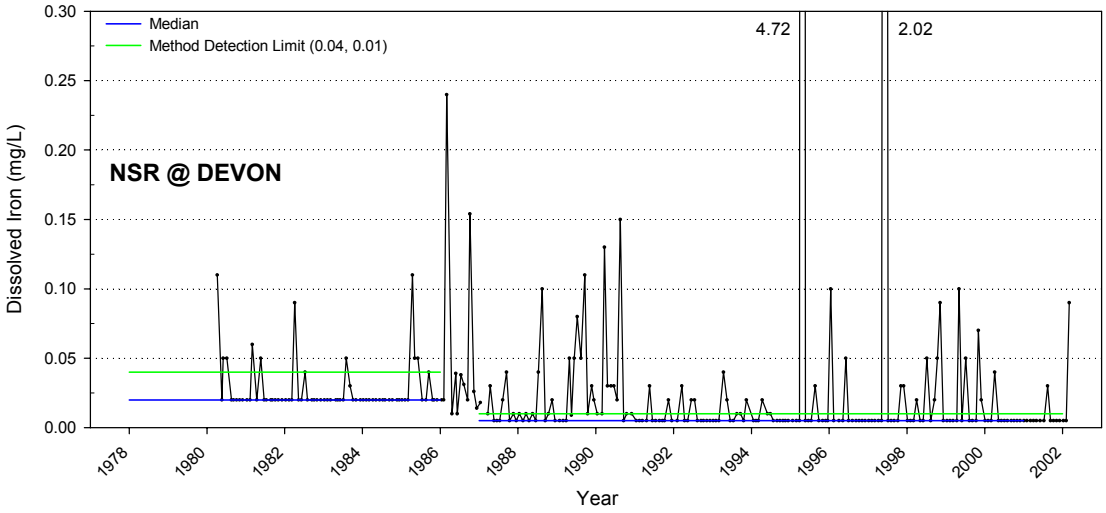
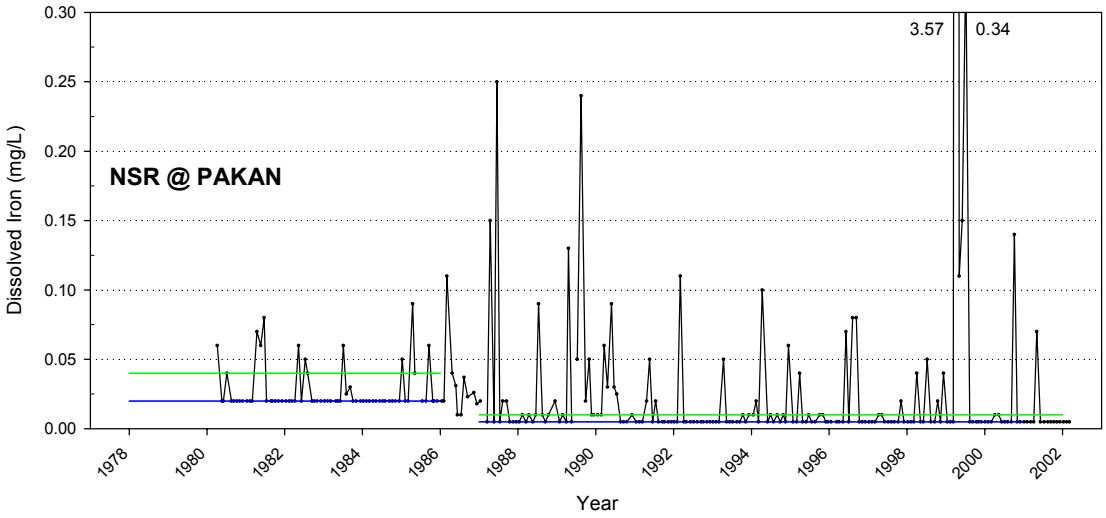


Figure 76 Boxplots depicting seasonality of total copper concentration in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0008	***	***	0.020	ID	ID	0.005	0.000	***
Flow Adjusted								
-0.0674	***			ID	ID		-0.0090	NS



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
0.0007	***	***	0.020	ID	ID	0.005	0.000	***
Flow Adjusted								
-0.0684	***			ID	ID		-0.0070	NS

Figure 77 Dissolved iron concentration in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals. ID = Insufficient Data.

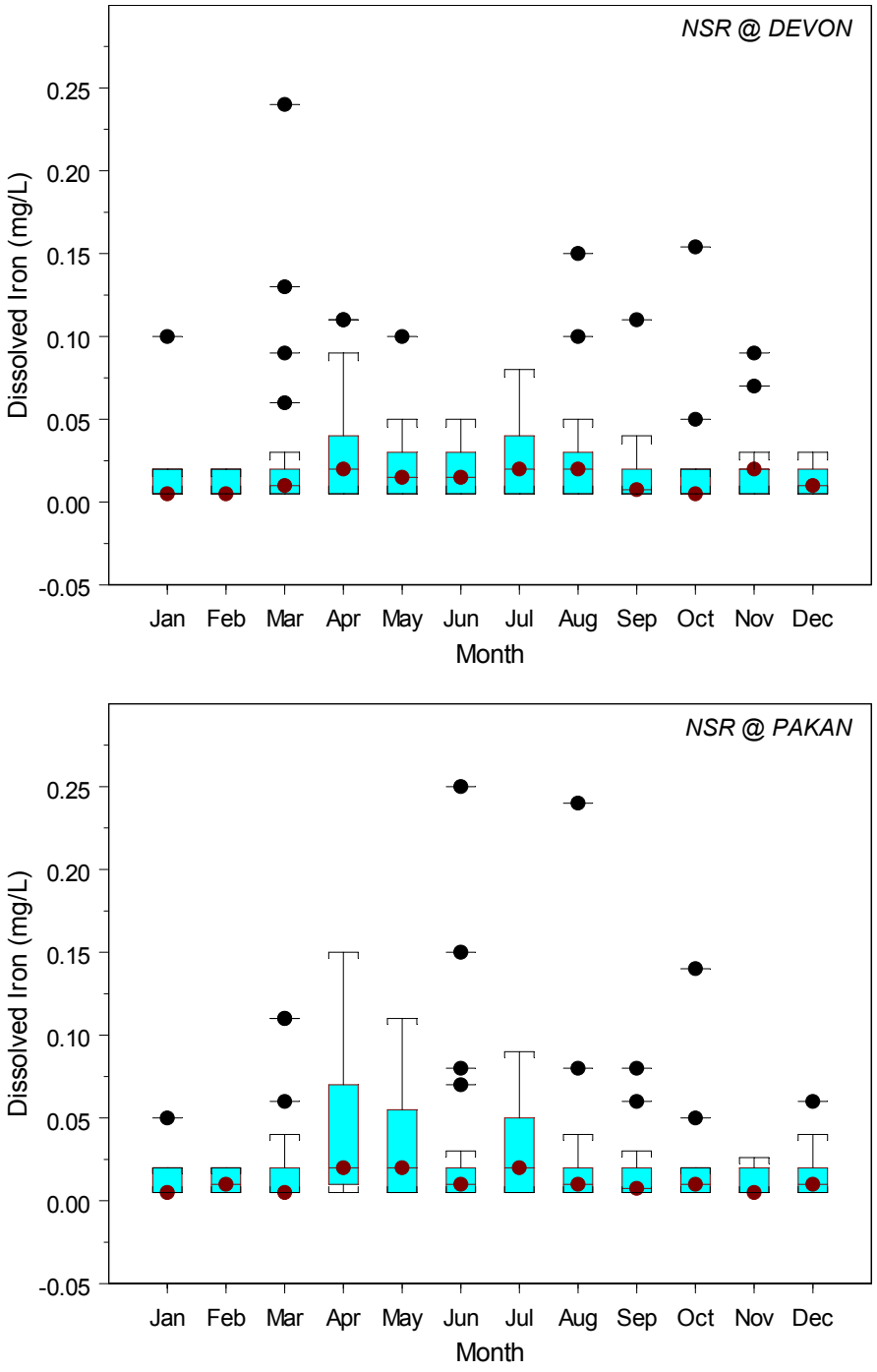
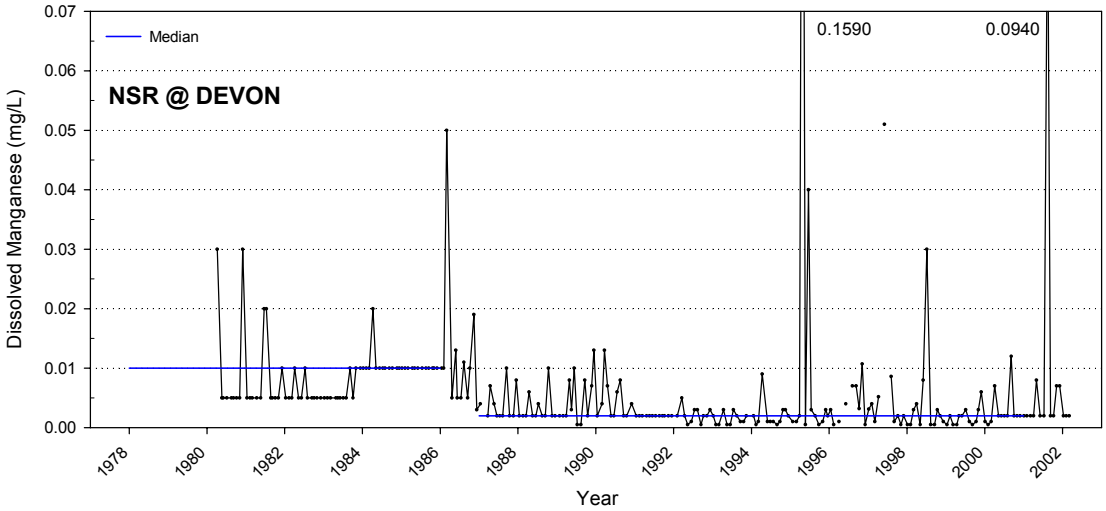
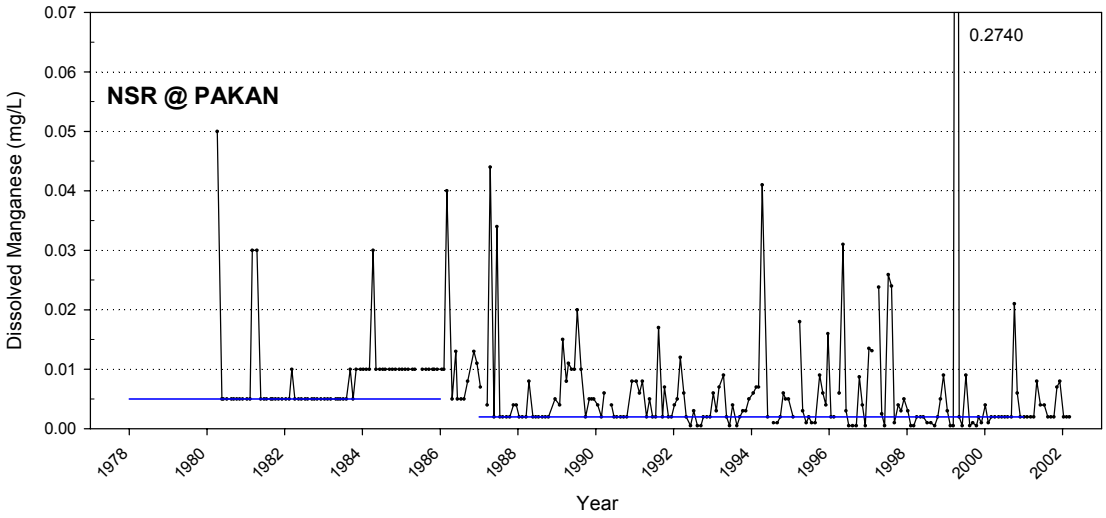


Figure 78 Boxplots depicting seasonality of dissolved iron concentration in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0002	***	***	0.010	ID	ID	0.002	0.0000	NS
Flow Adjusted								
-0.0724	***			ID	ID		-0.0107	NS



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-0.0002	***	***	0.005	ID	-	0.002	0.000	NS
Flow Adjusted								
-	-			-	-		-	-

Figure 79 Dissolved manganese concentration in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals.

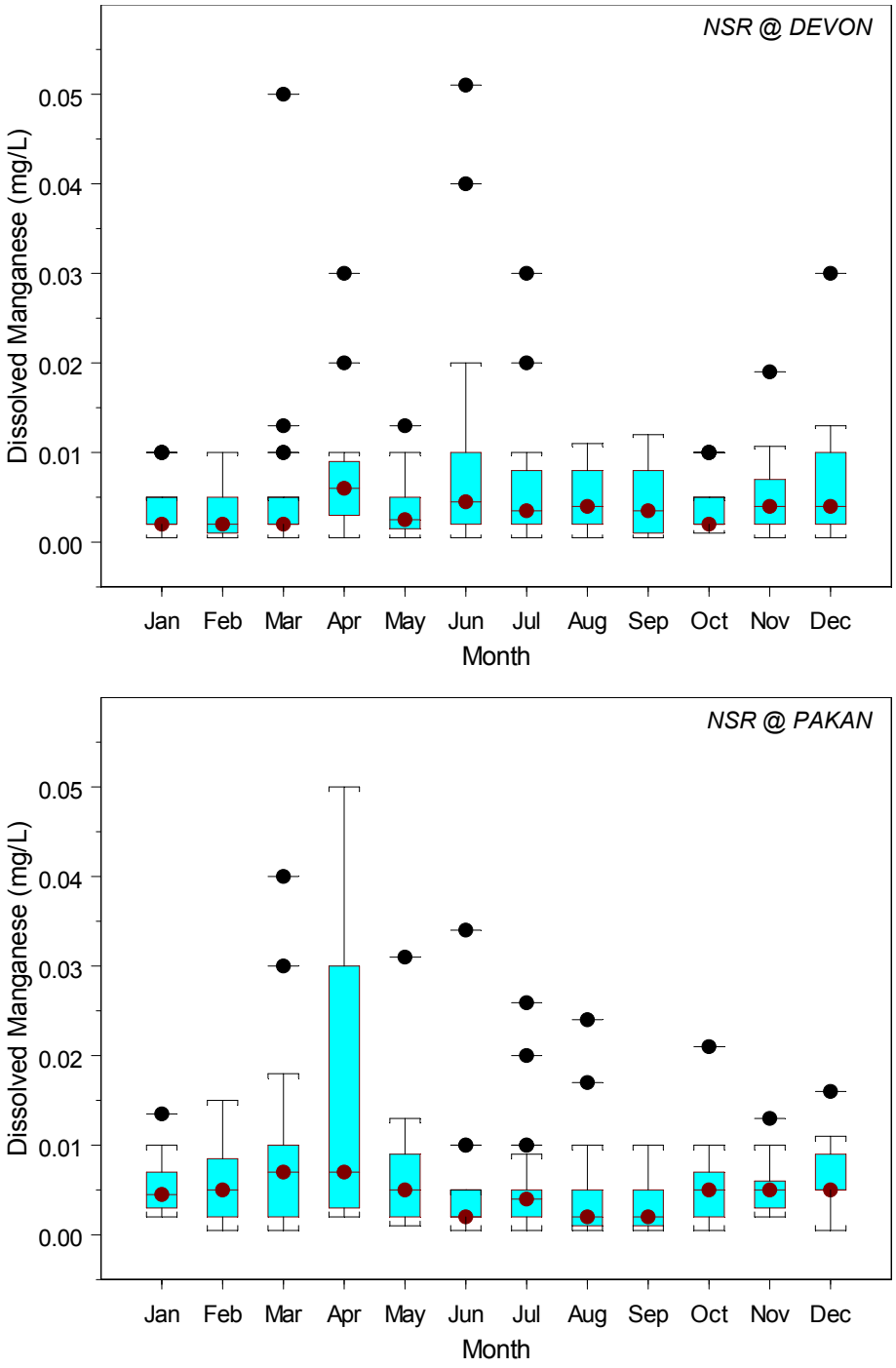
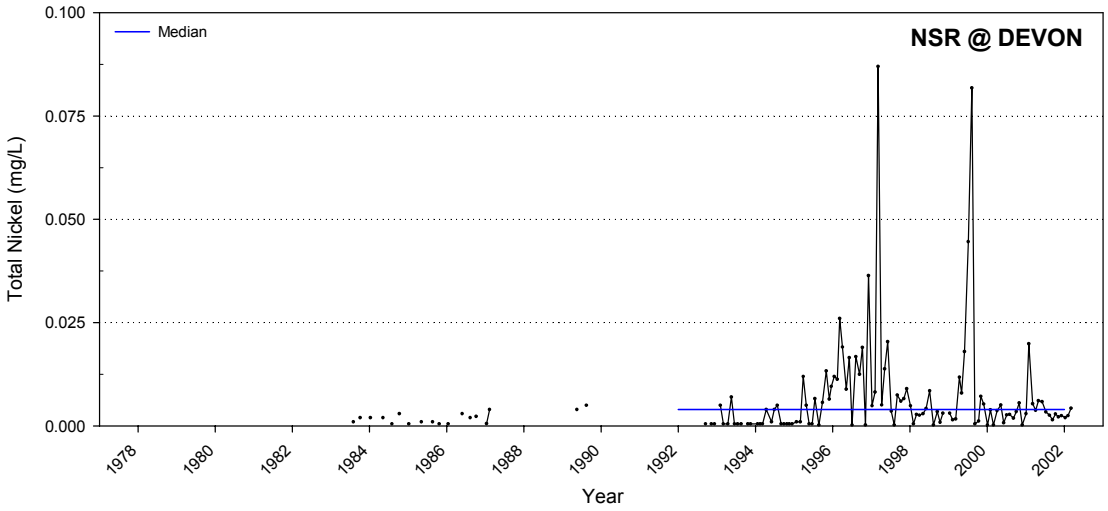
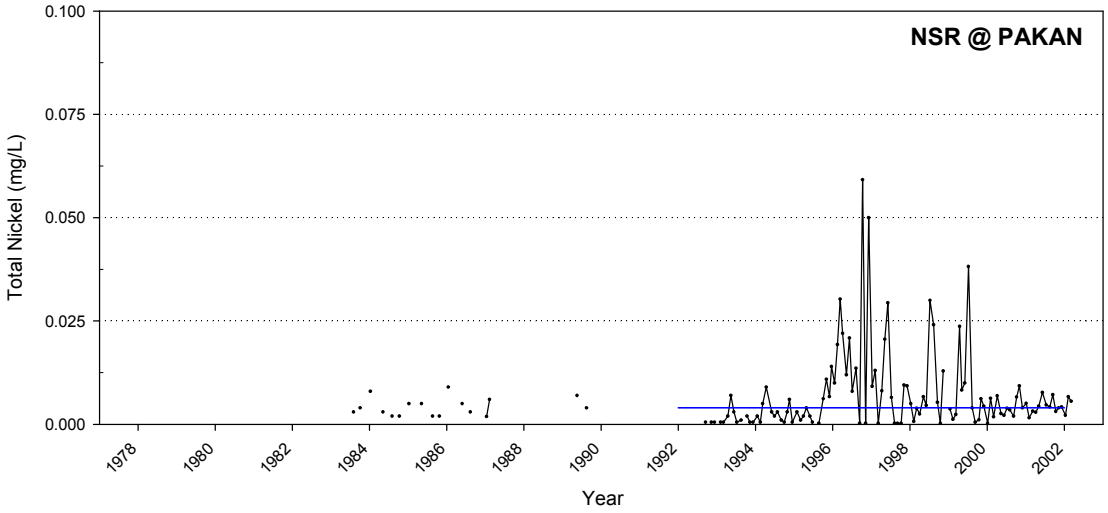


Figure 80 Boxplots depicting seasonality of dissolved manganese concentration in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
ID	ID	ID	ID	ID	ID	0.004	0.0000	NS
Flow Adjusted								
ID	ID			ID	ID		0.0000	NS



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
ID	ID	ID	ID	ID	ID	0.004	0.0002	NS
Flow Adjusted								
ID	ID			ID	ID		0.0001	NS

Figure 81 Total nickel concentration in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals. ID = Insufficient Data.

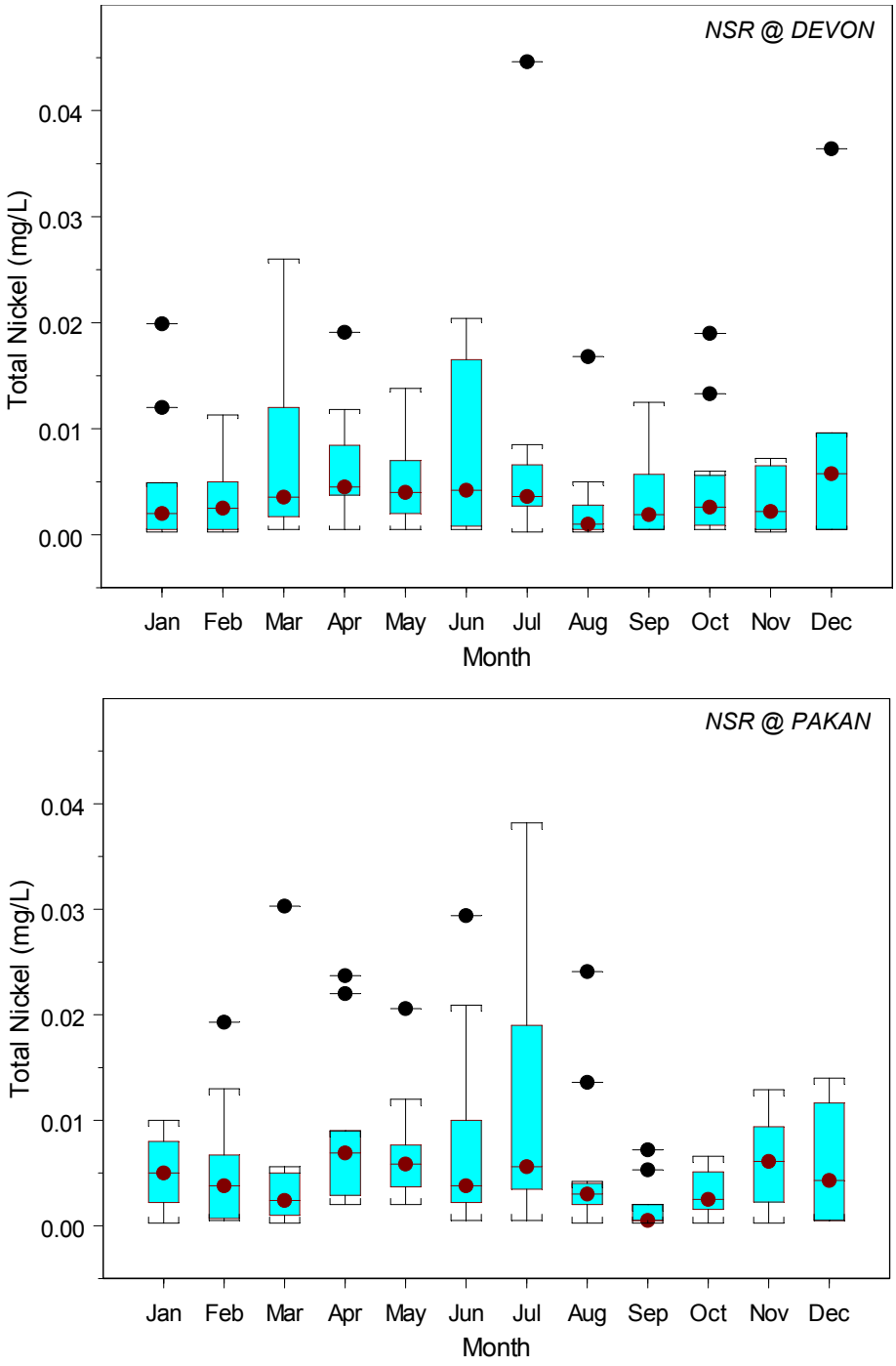
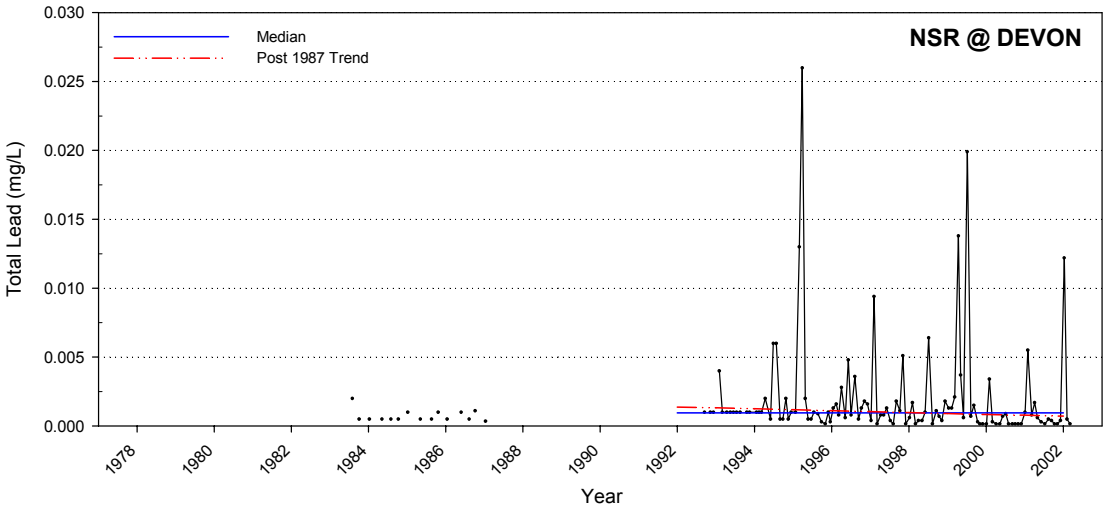
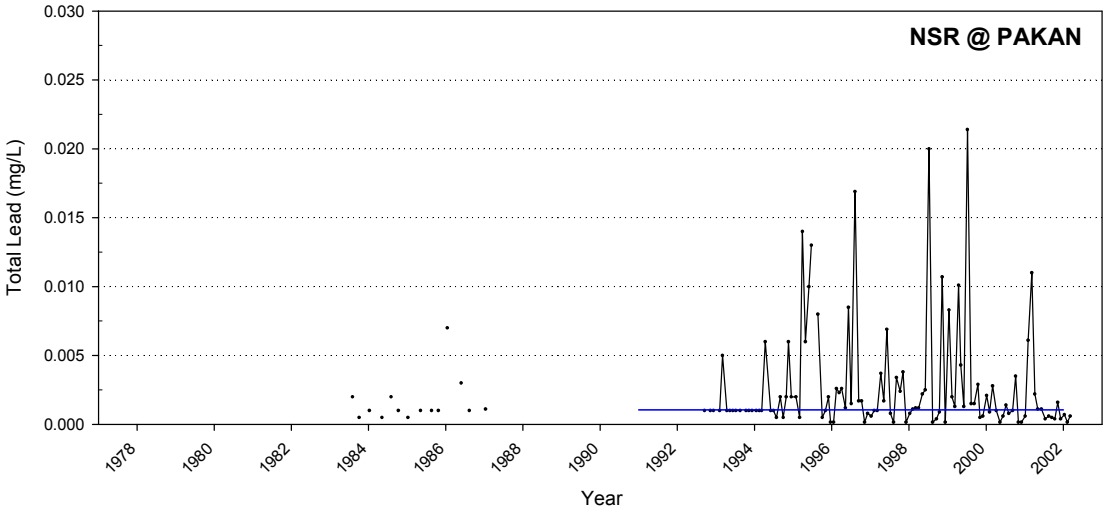


Figure 82 Boxplots depicting seasonality of total nickel concentration in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-	-	-	-	-	-	0.001	-0.0001	***
Flow Adjusted								
-	-			-	-		-0.0001	***



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-	-	-	-	-	-	0.018	0.0000	NS
Flow Adjusted								
-	-			-	-		0.0000	NS

Figure 83 Total lead concentration in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals. ID = Insufficient Data.

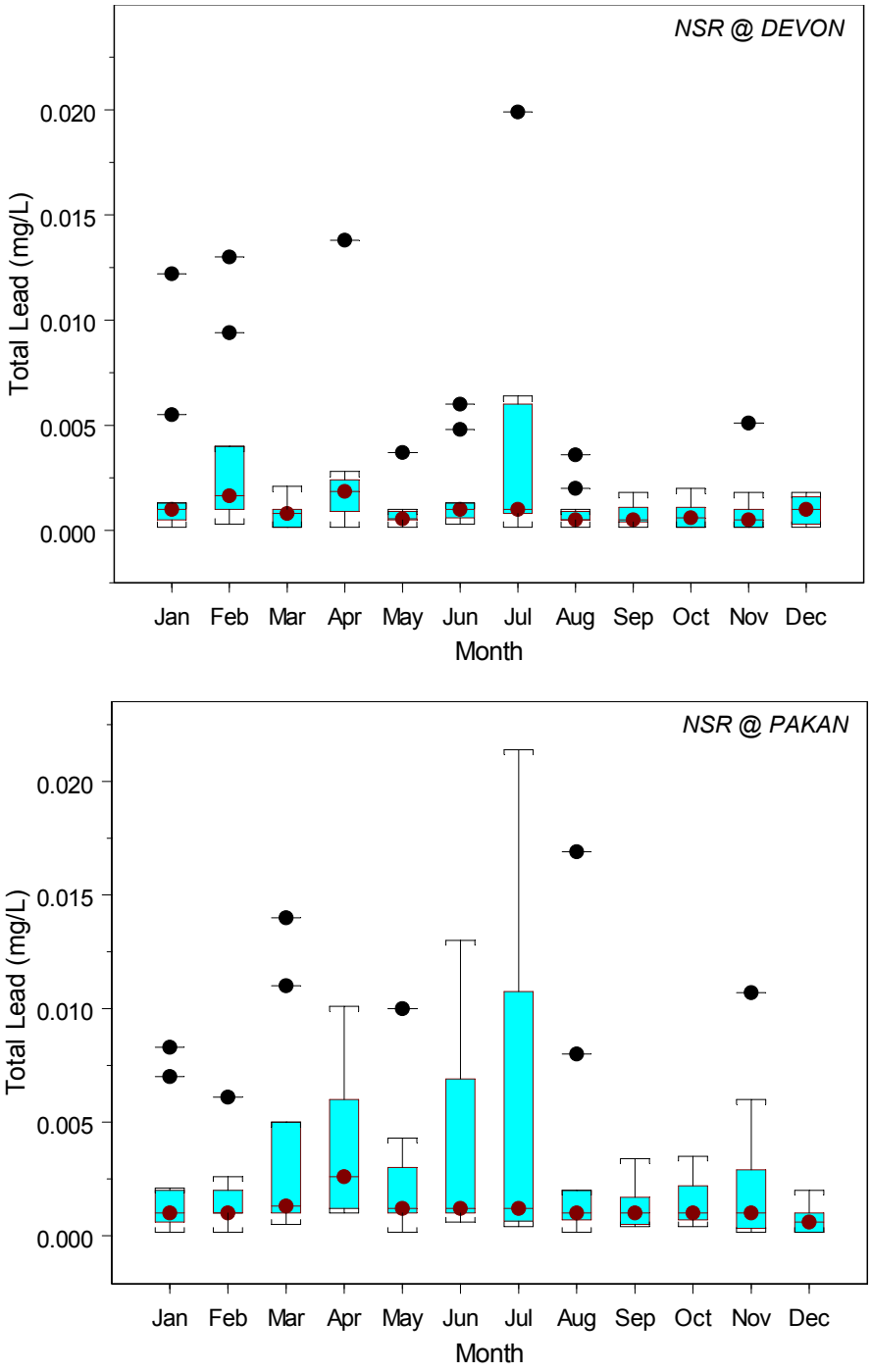
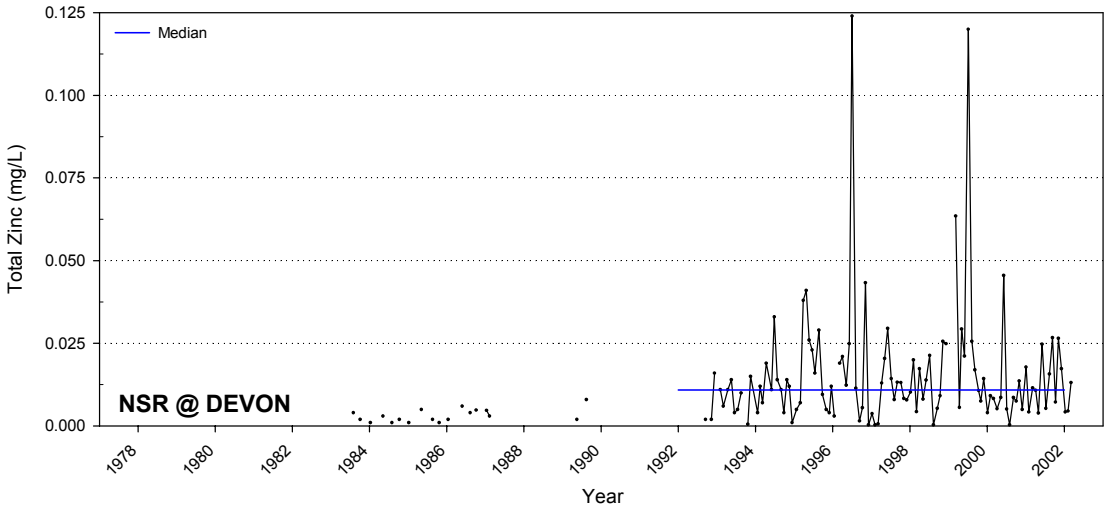
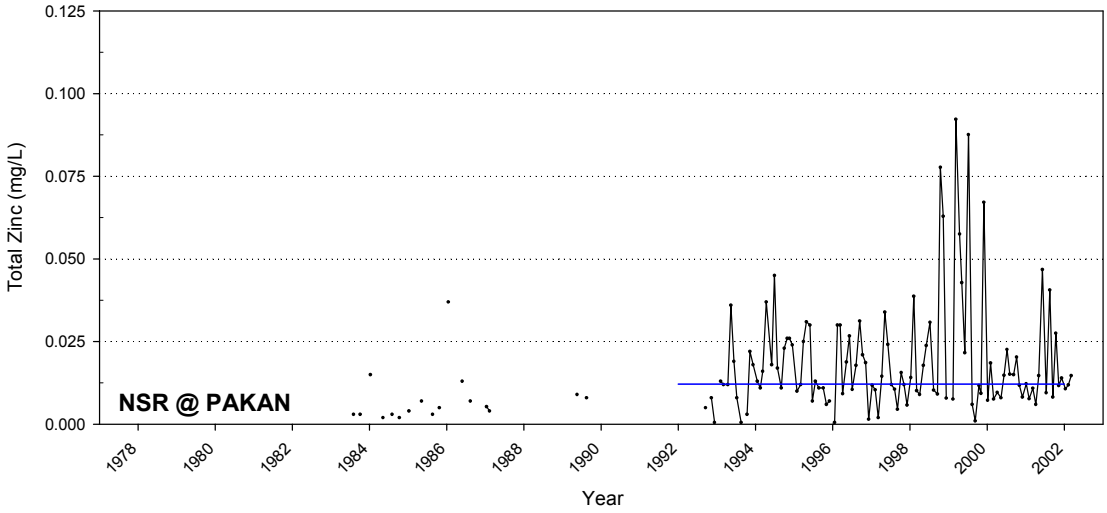


Figure 84 Boxplots depicting seasonality of total lead concentration in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-	-	-	-	-	-	0.011	0.0020	NS
Flow Adjusted								
-	-			-	-		0.0005	NS



Overall Trend		1987 Step Trend	Pre-1987			Post-1987		
Slope	Sig.	Significance	Median	Slope	Sig.	Median	Slope	Sig.
-	-	-	-	-	-	0.012	-0.0001	NS
Flow Adjusted								
-	-			-	-		-0.0001	NS

Figure 85 Total zinc concentration in the North Saskatchewan River at Devon and Pakan, 1977 through 2002. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals.

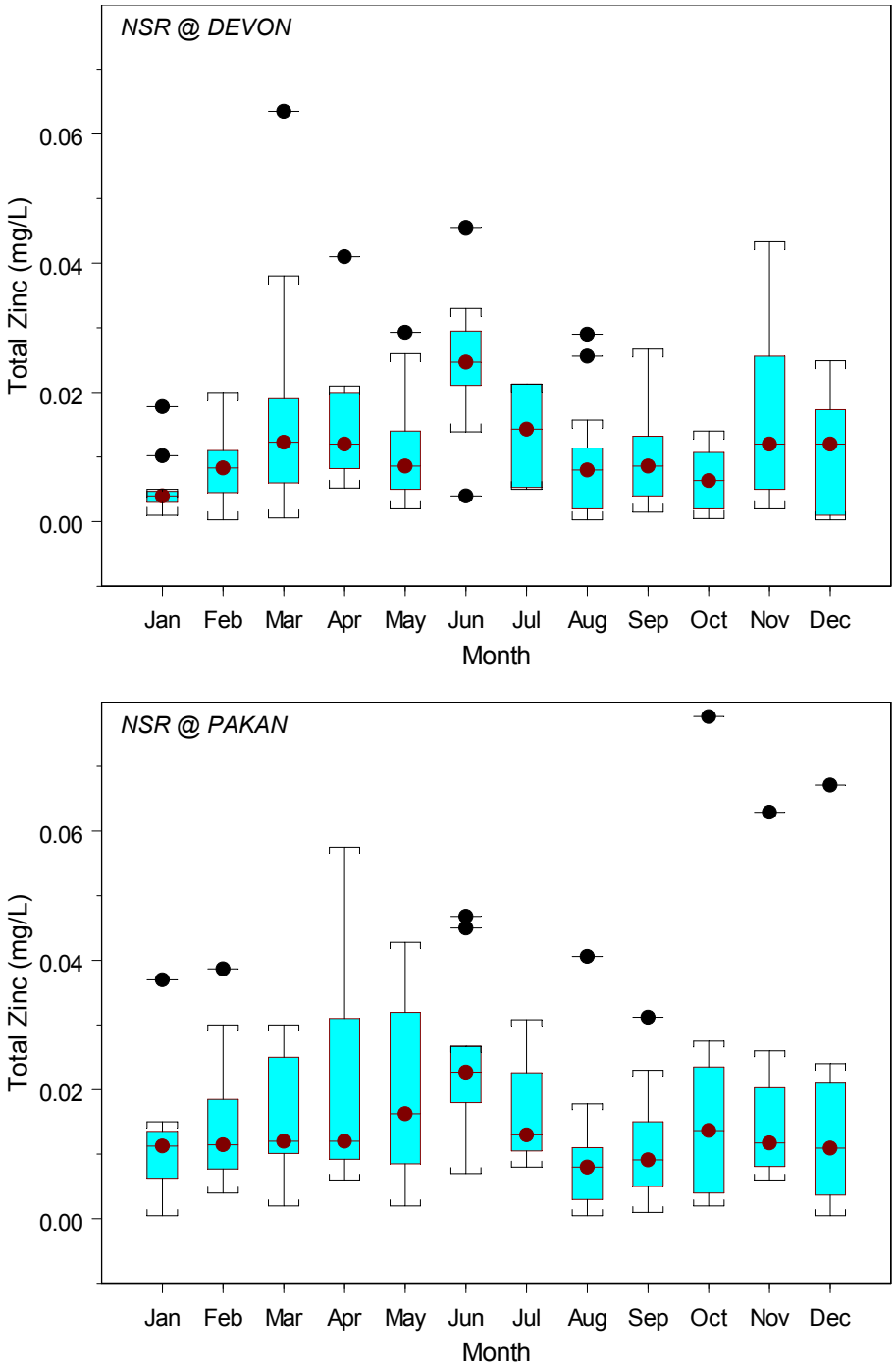


Figure 86 Boxplots depicting seasonality of total zinc concentration in the North Saskatchewan River at Devon and Pakan from 1977 through 2002. Some outliers may exceed axis range.

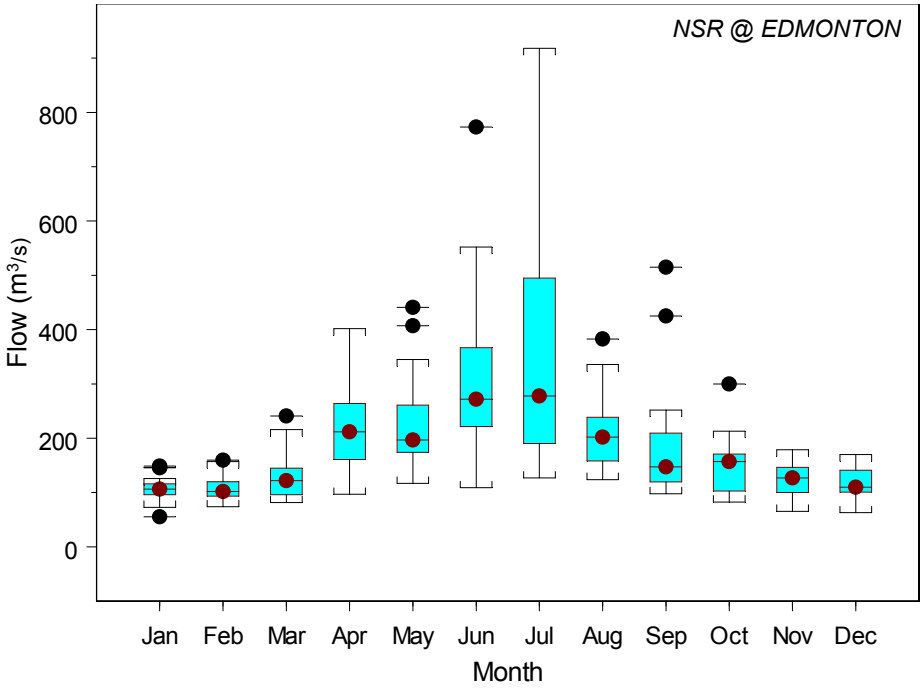


Figure 87 Boxplots depicting seasonality of flow in the North Saskatchewan River at Edmonton from 1977 through 2002. Some outliers may exceed axis range.

Appendix I Step trend analyses of Devon inorganic data, pre-January 1987 vs. post-January 1987. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals. NS = Not Significant.

Variable	Est. Diff. Btwn Time Periods	Median 1	Median 2	sig.
Temperature	-0.5000	7.5000	4.5000	***
pH	0.0000	8.1000	8.2000	NS
Conductivity	-1.5000	311.0000	309.0000	NS
Total Alkalinity	4.0000	125.0000	129.0000	***
Hardness	ID	-	-	-
DO	0.0000	11.0000	11.1000	NS
Turbidity	0.0000	5.1500	5.0000	NS
Colour	0.0000	10.0000	10.0000	NS
Non-Filterable Residue	-1.0000	9.0000	5.3000	*
TDS/Filterable Residue	ID	-	-	-
Potassium	0.0000	0.7000	0.7000	NS
Sodium	0.2000	3.8500	3.9500	NS
Calcium	0.9000	42.7000	43.3000	**
Magnesium	0.4000	12.5000	12.8000	**
Flow	-6.0000	151.0000	149.5000	NS
Bicarbonate	ID	-	-	-
Chloride	0.0000	0.7000	0.7300	NS
Fluoride	0.0100	0.1200	0.1300	***
Sulphate	4.4000	36.0000	39.7000	***
Total Organic Carbon	-0.4000	2.9900	2.4000	**
Particulate Organic Carbon	-0.2100	0.4400	0.1000	***
Dissolved Organic Carbon	-0.1000	2.1000	2.1000	NS
Phenolics	-0.0005	0.0010	0.0005	***
Particulate Nitrogen	0.0000	0.0400	0.0400	NS
Dissolved Nitrogen	ID	-	-	-
Dissolved Kjeldahl Nitrogen	ID	-	-	-
Total Ammonia	-0.0450	0.0500	0.0050	***
Total Kjeldahl Nitrogen	-0.0700	0.2000	0.2000	NS
Nitrite and Nitrate	-0.0010	0.0300	0.0370	NS
Total Nitrogen	0.0610	0.1575	0.2280	***
Total Phosphorus	-0.0030	0.0120	0.0080	***
Total Dissolved Phosphorus	0.0000	0.0030	0.0015	NS
Chlorophyll a	-0.0002	0.0010	0.0007	***
Total Coliforms	10.0000	14.5000	40.0000	***
Fecal Coliforms	1.0000	2.0000	5.0000	***
Reactive Silica	0.0000	4.2000	4.1600	NS

Appendix II Seasonality of Devon inorganic data, 1977-2002. Asterisks indicate significantly seasonal data at 90%(*), 95%(**), and 99%(***) confidence intervals. ID = Insufficient data, NS = Not Significant.

	Kruskal-Wallis Test Statistic	99%	95%	90%	75%	50%	sig.
Temperature	242.815	24.72	19.68	17.27	13.70		***
pH	59.908	24.72	19.68	17.27	13.70		***
Conductivity	55.299	24.72	19.68	17.27	13.70		***
Total Alkalinity	68.056	24.72	19.68	17.27	13.70		***
Hardness	ID	-	-	-	-		-
DO	241.904	24.72	19.68	17.27	13.70		***
Turbidity	154.052	24.72	19.68	17.27	13.70		***
Colour	38.193	24.72	19.68	17.27	13.70		***
Non-Filterable Residue	129.217	24.72	19.68	17.27	13.70		***
TDS/FR	ID	-	-	-	-		-
Potassium	70.220	24.72	19.68	17.27	13.70		***
Sodium	9.970	24.72	19.68	17.27	13.70	10.34	NS
Calcium	85.637	24.72	19.68	17.27	13.70		***
Magnesium	71.320	24.72	19.68	17.27	13.70		***
Flow	162.135	24.72	19.68	17.27	13.70		***
Bicarbonate	ID	-	-	-	-		-
Chloride	25.457	24.72	19.68	17.27	13.70		***
Fluoride Dissolved	26.057	24.72	19.68	17.27	13.70	10.34	***
Sulphate	81.552	24.72	19.68	17.27	13.70		***
Total Organic Carbon	89.803	24.72	19.68	17.27	13.70		***
Particulate Organic Carbon	39.461	24.72	19.68	17.27	13.70		***
Dissolved Organic Carbon	92.837	24.72	19.68	17.27	13.70		***
Phenol	17.096	24.72	19.68	17.27	13.70		*
Particulate Nitrogen	65.405	24.72	19.68	17.27	13.70		***
Dissolved Nitrogen	ID	-	-	-	-		-
Dissolved Kjeldahl Nitrogen	ID	-	-	-	-		-
Total Ammonia	9.862	24.72	19.68	17.27	13.70	10.34	NS
Total Kjeldahl Nitrogen	ID	-	-	-	-		-
Nitrite and Nitrate	209.568	24.72	19.68	17.27	13.70		***
Total Nitrogen	56.269	24.72	19.68	17.27	13.70		***
Total Phosphorus	107.250	24.72	19.68	17.27	13.70		***
Total Dissolved Phosphorus	26.618	24.72	19.68	17.27	13.70		***
Chlorophyll a	118.405	24.72	19.68	17.27	13.70		***
Total Coliforms	20.326	24.72	19.68	17.27	13.70		**
Fecal Coliforms	105.514	24.72	19.68	17.27	13.70		***
Reactive Silica	50.471	24.72	19.68	17.27	13.70		***

Appendix III Seasonality of Devon inorganic data, 1977-1987. Asterisks indicate significantly seasonal data at 90%(*), 95%(**), and 99%(***) confidence intervals. ID = Insufficient Data, NS = Not Significant.

Variable	Kruskal-Wallis Test Statistic	99%	95%	90%	75%	50%	sig.
Temperature	92.378	24.72	19.68	17.27	13.70		***
pH	25.085	24.72	19.68	17.27	13.70		***
Conductivity	17.200	24.72	19.68	17.27	13.70		NS
Total Alkalinity	20.423	24.72	19.68	17.27	13.70		**
Hardness	ID	-	-	-	-		-
DO	86.070	24.72	19.68	17.27	13.70		***
Turbidity	47.465	24.72	19.68	17.27	13.70		***
Colour	13.510	24.72	19.68	17.27	13.70		NS
Non-Filterable Residue	36.636	24.72	19.68	17.27	13.70		***
TDS/FR	ID	-	-	-	-		-
Potassium	32.853	24.72	19.68	17.27	13.70		***
Sodium	11.926	24.72	19.68	17.27	13.70	10.34	NS
Calcium	34.708	24.72	19.68	17.27	13.70		***
Magnesium	29.518	24.72	19.68	17.27	13.70		***
Flow	57.102	24.72	19.68	17.27	13.70		***
Bicarbonate	ID	-	-	-	-		-
Chloride	10.938	24.72	19.68	17.27	13.70	10.34	NS
Fluoride	14.215	24.72	19.68	17.27	13.70	10.34	NS
Sulphate	34.886	24.72	19.68	17.27	13.70		***
Total Organic Carbon	35.115	24.72	19.68	17.27	13.70		***
Particulate Organic Carbon	39.357	24.72	19.68	17.27	13.70		***
Dissolved Organic Carbon	26.368	24.72	19.68	17.27	13.70		***
Phenolics	20.016	24.72	19.68	17.27	13.70		**
Particulate Nitrogen	34.621	24.72	19.68	17.27	13.70		***
Dissolved Nitrogen	26.016	24.72	19.68	17.27	13.70		***
Dissolved Kjeldahl Nitrogen	ID	-	-	-	-		-
Total Ammonia	12.364	24.72	19.68	17.27	13.70	10.34	NS
Total Kjeldahl Nitrogen	ID	-	-	-	-		-
Nitrite and Nitrate	80.944	24.72	19.68	17.27	13.70		***
Total Nitrogen	26.914	24.72	19.68	17.27	13.70		***
Total Phosphorus	35.115	24.72	19.68	17.27	13.70		***
Total Dissolved Phosphorus	20.089	24.72	19.68	17.27	13.70		**
Chlorophyll a	13.305	24.72	19.68	17.27	13.70	10.34	NS
Total Coliforms	13.623	24.72	19.68	17.27	13.70	10.34	NS
Fecal Coliforms	34.718	24.72	19.68	17.27	13.70		***

Appendix IV Seasonality of Devon inorganic data, 1987-2002. Asterisks indicate significantly seasonal data at 90%(*), 95%(**), and 99%(***) confidence intervals. ID = Insufficient Data, NS = Not Significant.

	Kruskal-Wallis Test						
Variable	**Statistic**	**99%**	**95%**	**90%**	**75%**	**50%**	**sig.**
Temperature	153.079	24.72	19.68	17.27	13.70		***
pH	41.701	24.72	19.68	17.27	13.70		***
Conductivity	45.981	24.72	19.68	17.27	13.70		***
Total Alkalinity	53.358	24.72	19.68	17.27	13.70		***
Hardness	56.599	24.72	19.68	17.27	13.70		***
DO	156.904	24.72	19.68	17.27	13.70		***
Turbidity	111.592	24.72	19.68	17.27	13.70		***
Colour	30.168	24.72	19.68	17.27	13.70		***
Non-Filterable Residue	96.737	24.72	19.68	17.27	13.70		***
TDS/FR	94.409	24.72	19.68	17.27	13.70		***
Potassium	43.408	24.72	19.68	17.27	13.70		***
Sodium	3.779	24.72	19.68	17.27	13.70	10.34	NS
Calcium	55.990	24.72	19.68	17.27	13.70		***
Magnesium	49.829	24.72	19.68	17.27	13.70		***
Flow	108.616	24.72	19.68	17.27	13.70		***
Bicarbonate	52.215	24.72	19.68	17.27	13.70		***
Carbonate	13.611	24.72	19.68	17.27	13.70	10.34	NS
Chloride	21.392	24.72	19.68	17.27	13.70		**
Fluoride	19.347	24.72	19.68	17.27	13.70		*
Sulphate	62.588	24.72	19.68	17.27	13.70		***
Total Organic Carbon	59.724	24.72	19.68	17.27	13.70		***
Particulate Organic Carbon	17.290	24.72	19.68	17.27	13.70		*
Dissolved Organic Carbon	76.410	24.72	19.68	17.27	13.70		***
Phenolics	ID	-	-	-	-		-
Particulate Nitrogen	31.877	24.72	19.68	17.27	13.70		***
Dissolved Nitrogen	ID	-	-	-	-		-
Dissolved Kjeldahl Nitrogen	21.821	24.72	19.68	17.27	13.70		**
Total Ammonia	ID	-	-	-	-		-
Total Kjeldahl Nitrogen	45.586	24.72	19.68	17.27	13.70		***
Nitrite and Nitrate	136.144	24.72	19.68	17.27	13.70		***
Total Nitrogen	41.905	24.72	19.68	17.27	13.70		***
Total Phosphorus	82.598	24.72	19.68	17.27	13.70		***
Total Dissolved Phosphorus	20.614	24.72	19.68	17.27	13.70		**
Chlorophyll a	123.173	24.72	19.68	17.27	13.70		***
Total Coliforms	17.593	24.72	19.68	17.27	13.70	10.34	NS
Fecal Coliforms	90.518	24.72	19.68	17.27	13.70		***

Appendix V Autocorrelation of Devon inorganic data, 1977-2002. Asterisks denote significant autocorrelation at 90% (*), 95% (**), and 99% (***) confidence intervals. ID = Insufficient Data, NS = Not Significant.

	Kendall			Spearman		
Variable	**Tau**	**Z**	**sig.**	**Rho**	**Z**	**sig.**
Temperature	0.024147	0.5861	NS	0.031842	0.5183	NS
pH	0.247276	5.3742	***	0.309569	5.1336	***
Conductivity	0.103709	2.5483	**	0.150394	2.4758	**
Total Alkalinity	0.192567	4.1475	***	0.279888	4.0463	***
Hardness	ID	-	-	-	-	-
DO	0.019735	0.4730	NS	0.028959	0.4696	NS
Turbidity	0.015795	0.3846	NS	0.021083	0.3445	NS
Colour	0.235622	4.6118	***	0.302358	4.4745	***
Non-Filterable Residue	0.082973	2.0269	**	0.110726	1.8127	***
TDS/FR	ID	-	-	-	-	-
Potassium	0.094738	1.9854	**	0.122690	1.7948	*
Sodium	0.186867	4.0741	***	0.275518	4.0305	***
Calcium	0.120005	2.6146	***	0.177942	2.6152	***
Magnesium	0.165282	3.6037	***	0.249699	3.6528	***
Flow	0.201052	4.9774	***	0.294079	4.8768	***
Bicarbonate	ID	-	-	-	-	-
Chloride	-0.002630	-0.0525	NS	-0.004585	-0.0668	NS
Fluoride	0.204948	4.5877	***	0.300216	4.5132	***
Sulphate	0.188954	4.1197	***	0.272250	3.9827	***
Total Organic Carbon	0.157246	3.4822	***	0.223741	3.3262	***
Particulate Organic Carbon	0.162273	3.3743	***	0.227643	3.1789	***
Dissolved Organic Carbon	0.131657	3.2234	***	0.184695	3.0292	***
Phenolics	ID	-	-	-	-	-
Particulate Nitrogen	0.079566	1.6460	*	0.112250	1.6267	NS
Dissolved Nitrogen	0.056164	0.8250	NS	0.068665	0.6867	NS
Dissolved Kjeldahl Nitrogen	-0.079647	-1.3049	NS	-0.111714	-1.2390	NS
Total Ammonia	ID	-	-	-	-	-
Total Kjeldahl Nitrogen	ID	-	-	-	-	-
Nitrite and Nitrate	0.087235	2.0776	**	0.118581	1.9521	*
Total Nitrogen	0.083457	2.0502	**	0.124116	2.0432	**
Total Phosphorus	0.099836	2.4344	**	0.127001	2.0752	**
Total Dissolved Phosphorus	0.155291	3.2826	***	0.191172	3.0944	***
Chlorophyll a	0.061344	1.4183	NS	0.075694	1.1824	NS
Total Coliforms	0.223904	4.7301	***	0.311975	4.4559	***
Fecal Coliforms	0.038566	0.9148	NS	0.043428	0.6908	NS
Reactive Silica	0.679399	14.7762	***	0.852949	12.5357	***

Appendix VI Autocorrelation of Devon inorganic data, 1977-1987. Asterisks denote significant autocorrelation at 90% (*), 95% (**), and 99% (***) confidence intervals. The Rank von Neumann 'Q' statistic (RvN(Q)) was used when Kendall and Spearman tests provided conflicting results. ID = Insufficient Data, NS = Not Significant.

				Spearman			
Variable	**Kendall Tau**	**Z**	**sig.**	**Rho**	**Z**	**sig.**	**RvN(Q)**
Temperature	0.083899	1.1124	NS	0.112537	1.1141	NS	
pH	0.260986	3.5287	***	0.332957	3.4280	***	
Conductivity	0.044517	0.6589	NS	0.068842	0.6953	NS	
Total Alkalinity	0.106864	1.5326	NS	0.170838	1.6651	*	
Hardness	ID	-	-	-	-	-	
DO	-0.038716	-0.5356	NS	-0.060996	-0.5914	NS	
Turbidity	-0.027947	-0.4082	NS	-0.042924	-0.4292	NS	
Colour	-0.037843	-0.3800	NS	-0.048763	-0.3777	NS	
Non-Filterable Residue	0.118744	1.7083	*	0.172925	1.7206	*	
TDS/FR	ID	-	-	-	-	-	
Potassium	0.053046	0.7106	NS	0.078237	0.7824	NS	
Sodium	0.098413	1.4450	NS	0.143631	1.4363	NS	
Calcium	0.091791	1.3607	NS	0.137511	1.3888	NS	
Magnesium	0.073141	1.0721	NS	0.101123	1.0112	NS	
Flow	0.106690	1.6096	NS	0.157382	1.6203	NS	
Bicarbonate	ID	-	-	-	-	-	
Chloride	0.113529	1.4996	NS	0.139633	1.3963	NS	
Fluoride	0.018000	0.2541	NS	0.021541	0.2088	NS	
Sulphate	0.115580	1.6976	*	0.165192	1.6519	*	
Total Organic Carbon	0.105624	1.5369	NS	0.150540	1.4903	NS	
Particulate Organic Carbon	0.024888	0.3486	NS	0.027504	0.2638	NS	
Dissolved Organic Carbon	0.090328	1.3248	NS	0.140156	1.4016	NS	
Phenolics	0.148828	1.9259	*	0.189193	1.8729	*	
Particulate Nitrogen	0.095068	1.3519	NS	0.127696	1.2706	NS	
Dissolved Nitrogen	0.060280	0.8819	NS	0.072440	0.7208	NS	
Dissolved Kjeldahl Nitrogen	ID	-	-	-	-	-	
Total Ammonia	ID	-	-	-	-	-	
Total Kjeldahl Nitrogen	ID	-	-	-	-	-	
Nitrite and Nitrate	0.042808	0.5540	NS	0.050385	0.5138	NS	
Total Nitrogen	0.037078	0.5519	NS	0.042589	0.4343	NS	
Total Phosphorus	-0.030854	-0.4373	NS	-0.055974	-0.5541	NS	
Total Dissolved Phosphorus	-0.006600	-0.0836	NS	-0.007855	-0.0758	NS	
Chlorophyll a	-0.034787	-0.3658	NS	-0.042442	-0.3676	NS	
Total Coliforms	0.227417	2.7068	***	0.322129	2.6170	***	
Fecal Coliforms	0.043005	0.5507	NS	0.060878	0.5711	NS	

Appendix VII Autocorrelation of Devon inorganic data, 1987-2002. Asterisks denote significant autocorrelation at 90% (*), 95% (**), and 99% (***) confidence intervals. NS = Not Significant.

Variable	Kendall Tau	Z	Sig.	Spearman Rho	Z	Sig.	RvN(Q)
Temperature	0.038574	0.7346	NS	0.059412	0.7632	NS	
pH	0.237889	4.0351	***	0.297190	3.8405	***	
Conductivity	0.114143	2.1908	**	0.172189	2.2252	**	
Total Alkalinity	0.149216	2.3353	**	0.222057	2.3500	**	
Hardness	0.082841	1.5272	NS	0.119322	1.4808	NS	
DO	0.013286	0.2538	NS	0.022485	0.2906	NS	
Turbidity	0.059566	1.1355	NS	0.078415	1.0073	NS	
Colour	0.324217	5.2843	***	0.444731	5.1800	***	
Non-Filterable Residue	0.106571	2.0454	**	0.136055	1.7582	*	
TDS/FR	0.108414	2.0495	**	0.138601	1.7641	*	
Potassium	0.104196	1.6305	NS	0.150639	1.5942	NS	
Sodium	0.239557	3.7545	***	0.357294	3.7812	***	
Calcium	0.116697	1.8265	*	0.161352	1.7076	*	
Magnesium	0.124505	1.9482	*	0.185552	1.9637	**	
Flow	0.262664	5.0454	***	0.370729	4.7909	***	
Bicarbonate	0.178447	2.7921	***	0.259335	2.7445	***	
Chloride	-0.092270	-1.4276	NS	-0.141269	-1.4816	NS	
Fluoride	0.304784	4.8061	***	0.418198	4.7682	***	
Sulphate	0.214897	3.3629	***	0.307102	3.2501	***	
Total Organic Carbon	0.128397	2.0894	**	0.180718	1.9879	**	
Particulate Organic Carbon	-0.068865	-0.8478	NS	-0.084312	-0.8473	NS	
Dissolved Organic Carbon	0.117929	2.2635	**	0.169711	2.1932	**	
Phenolics	ID	-	-	-	-	-	
Particulate Nitrogen	0.102524	1.5172	NS	0.138336	1.4443	NS	
Dissolved Nitrogen	ID	-	-	-	-	-	
Dissolved Kjeldahl Nitrogen	-0.079647	-1.3049	NS	-0.111714	-1.2390	NS	**
Total Ammonia	ID	-	-	-	-	-	
Total Kjeldahl Nitrogen	0.011647	0.2215	NS	0.013629	0.1756	NS	
Nitrite and Nitrate	0.111702	2.1272	**	0.162820	2.0915	**	
Total Nitrogen	-0.012213	-0.2318	NS	-0.017577	-0.2258	NS	
Total Phosphorus	0.208872	4.0098	***	0.273916	3.5398	***	
Total Dissolved Phosphorus	0.189752	3.2658	***	0.240215	3.1043	***	
Particulate Phosphorus	0.172892	1.1769	NS	0.211858	1.1008	NS	
Chlorophyll a	0.072004	1.3657	NS	0.093389	1.2069	NS	NS
Total Coliforms	0.219049	3.7943	***	0.309372	3.6079	***	
Fecal Coliforms	0.023168	0.4380	NS	0.022607	0.2886	NS	

Appendix VIII Results of trend analyses for inorganic data at Devon, 1977-2002. Asterisks depict significant trends at 90% (*), 95%(**), and 99% (***) confidence intervals. SKWOC = Seasonal Kendall Analysis Without Autocorrelation, SKWC = Seasonal Kendal Analysis With Autocorrelation, MK = Mann-Kendall Analysis, MK (Q) = Mann-Kendall Analysis on Quarterly Data.

					Flow Adjusted		
Variable	**Trend Test**	**Slope**	**% Slope**	**sig.**	**Slope**	**% Slope**	**sig.**
Temperature	SKWOC	-0.0285	0.53	***	0.0494	3.83	*
pH	SKWC	-	-	NS	0.0002	21.04	NS
Conductivity	SKWC	-0.2495	0.08	NS	-0.3310	28.46	NS
Total Alkalinity	SKWC	0.4209	0.33	***	0.3314	39.62	**
Hardness	ID	-	-	-	-	-	-
DO	SKWOC	0.0000	0.00	NS	-0.0155	12.46	**
Turbidity	SKWOC	-0.0272	0.54	NS	0.3625	9.75	***
Colour	SKWC	0.0000	0.00	NS	0.0076	0.44	NS
Non-Filterable Residue	SKWC	-0.1661	2.37	***	0.2544	2.92	NS
TDS/Filterable Residue	ID	-	-	-	-	-	-
Potassium	SKWC	0.0000	0.00	NS	0.0033	3.01	NS
Sodium	MK (Q)	0.0259	0.66	**	0.0306	39.01	***
Calcium	SKWC	0.0584	0.14	NS	0.0147	17.04	NS
Magnesium	SKWC	0.0334	0.26	NS	0.0197	30.69	NS
Flow	SKWC	-1.0005	0.67	*			
Bicarbonate	ID	-	-	-	-	-	-
Carbonate	MK (Q)	0.0000	0.00	**	-	-	-
Chloride	SKWOC	0.0000	0.00	NS	-	-	-
Fluoride	SKWC	0.0008	0.70	**	0.0072	39.89	**
Sulphate	SKWC	0.3621	0.96	***	0.2695	77.25	***
Total Organic Carbon	SKWC	-0.0250	1.04	NS	-0.0156	3.69	NS
Particulate Organic Carbon	SKWC	-0.0087	4.13	***	-0.0546	77.14	***
Dissolved Organic Carbon	SKWC	-0.0108	0.52	NS	0.0103	5.65	NS
Phenol	SKWC	0.0000	0.00	*	-	-	-
Particulate Nitrogen	SKWOC	0.0000	0.00	NS	0.0001	0.41	NS
Dissolved Nitrogen	ID	-	-	-	-	-	-
Dissolved Kjeldahl Nitrogen	ID	-	-	-	-	-	-
Total Ammonia	MK (Q)	-0.0020	9.90	***	-0.0021	17.98	***
Total Kjeldahl Nitrogen	ID	-	-	-	-	-	-
Nitrite and Nitrate	SKWC	0.0000	0.00	NS	0.0001	1.40	NS
Total Nitrogen	SKWC	0.0010	0.49	NS	0.0029	7.34	**
Total Phosphorus	SKWC	-0.0003	2.85	***	0.0001	1.21	NS
Total Dissolved Phosphorus	SKWC	0.0000	0.00	*	-0.0034	0.74	NS
Chlorophyll a	SKWC	-0.0000	2.06	***	0.0000	4.93	NS
Total Coliforms	SKWC	0.0000	0.00	NS	0.0644	0.19	NS
Fecal Coliforms	SKWOC	0.1306	3.26	***	0.0627	34.14	NS
Reactive Silica	SKWC	0.0000	0.00	NS	-0.0028	37.60	NS

Appendix IX Results of trend analyses for inorganic data at Devon, 1977-1987. Asterisks depict significant trends at 90% (*), 95%(**), and 99% (***) confidence intervals. SKWOC = Seasonal Kendall Analysis Without Autocorrelation, SKWC = Seasonal Kendal Analysis With Autocorrelation, MK = Mann-Kendall Analysis, MK (Q) = Mann-Kendall Analysis on Quarterly Data, NS = Not Significant.

					Flow Adjusted		
Variable	**Test**	**Slope**	**% Slope**	**sig.**	**Slope**	**% Slope**	**sig.**
Temperature	SKWOC	0.0000	0.00	NS	-0.1458	19.34	NS
Total Alkalinity	SKWOC	1.9945	1.60	**	2.0983	-	**
Non-Filterable Residue	SKWC	0.0000	0.00	NS	-0.9052	9.08	NS
	SKWOC	0.0000	0.00	NS	-	-	-
Calcium	SKWOC	-0.3011	0.71	***	-0.2858	70.68	**
Magnesium	SKWOC	-0.1552	1.24	***	-0.0955	-	***
Bicarbonate	SKWC	0.3960	0.25	NS	0.1381	-	NS
Fluoride	MK	0.0000	0.00	NS	-	-	-
Sulphate	SKWC	0.1502	0.42	NS	0.1170	45.81	NS
	SKWOC	0.1502	0.42	NS	-	-	-
Total Organic Carbon	MK	0.0905	3.03	NS	0.0843	14.68	NS
Particulate Organic Carbon	SKWOC	0.0100	2.28	NS	0.0533		NS
Phenolics	SKWC	0.0000	0.00	NS	0.0928	44.63	NS
	SKWOC	0.0000	0.00	*	-	-	-
Total Nitrogen	SKWOC	-0.0066	4.21	**	-0.0384	-	**
Total Phosphorus	SKWOC	0.0000	0.00	NS	-0.0316	81.94	NS
Chlorophyll a	MK	0.0000	0.00	NS	0.0000	8.37	NS
Total Coliforms	MK(Q)	-1.3899	9.93	NS	-1.1581	7.78	NS
Fecal Coliforms	SKWOC	0.0000	0.00	***	0.0600	1.52	NS

Appendix X Results of trend analyses for inorganic data at Devon, 1987-2002. Asterisks depict significant trends at 90% (*), 95%(**), and 99% (***) confidence intervals. SKWOC = Seasonal Kendall Analysis Without Autocorrelation, SKWC = Seasonal Kendal Analysis With Autocorrelation, MK = Mann-Kendall Analysis, MK (Q) = Mann-Kendall Analysis on Quarterly Data.

					Flow Adjusted		
Variable	**Test**	**Slope**	**% Slope**	**sig.**	**Slope**	**% Slope**	**sig.**
Temperature	SKWOC	-0.0146	0.32	NS	0.2379	15.34	**
Total Alkalinity	SKWC	0.2800	0.22	NS	0.0344	8.02	NS
Hardness	SKWC	0.2808	0.18	NS	-0.0467	6.13	NS
Non-Filterable Residue	SKWC	-0.3583	6.76	***	0.8774	11.05	**
TDS/Filterable Residue	SKWC	1.0083	6.85	***	0.0031	64.47	NS
Calcium	SKWC	0.1071	0.25	NS	-0.0068	9.20	NS
Magnesium	SKWC	0.0856	0.67	**	0.0476	42.86	*
Fluoride	SKWC	0.0000	0.00	NS	0.00	0.02	NS
Sulphate	SKWC	0.3824	0.96	**	0.1410	-	NS
Total Organic Carbon	SKWC	-0.0223	0.93	NS	0.0186	18.18	NS
Particulate Organic Carbon	SKWOC	0.0000	0.00	NS	0.0008	1.05	NS
Phenolics	MK(Q)	0.0000	0.00	NS	-	-	-
Total Ammonia	SKWC	0.0000	0.00	NS	0.0001	1.67	NS
TKN	SKWOC	-0.0088	4.38	***	-0.0029	9.45	NS
Total Nitrogen	SKWOC	-0.0073	3.22	***	-0.0023	6.00	NS
Total Phosphorus	SKWC	-0.0005	6.25	***	0.0005	7.80	*
Chlorophyll a	SKWOC	0.0000	2.06	***	-0.0038	10.91	NS
Total Coliforms	SKWC	-3.9857	9.96	***	-0.1700	-	***
Fecal Coliforms	SKWOC	0.1446	2.89	***	0.0717	73.67	***

Appendix XI Step trend analyses of Devon metals data: Pre-1987 vs. post-1987. Asterisks denote significant step trends at 90% (*), 95% (**), and 99% (***) confidence intervals. ID = Insufficient Data.

Variable	Est. Diff. Btwn. Time Periods	Median 1	Median 2	Confidence
Dissolved Aluminum	ID	-	-	-
Dissolved Arsenic	0.0000	0.0003	0.0002	NS
Dissolved Boron	-0.0350	0.0400	0.0050	***
Total Copper	ID	-	-	-
Dissolved Iron	-0.0150	0.0200	0.0050	***
Dissolved Manganese	-0.0045	0.0100	0.0020	***
Total Nickel	ID	-	-	-
Total Lead	ID	-	-	-
Total Zinc	ID	-	-	-

Appendix XII Seasonality of Devon metals data, 1977-2002. Asterisks indicate significantly seasonal data at 90%(*), 95%(**), and 99%(***) confidence intervals. NS = Not Significant, ID = Insufficient Data.

Variable	Kruskal-Wallis Test Statistic	99%	95%	90%	75%	50%	sig.
Dissolved Aluminum	ID	-	-	-	-	-	-
Dissolved Arsenic	17.188	24.72	19.68	17.27	13.70	10.34	NS
Dissolved Boron	9.307	24.72	19.68	17.27	13.70	10.34	NS
Total Copper	ID	-	-	-	-	-	-
Dissolved Iron	18.651	24.72	19.68	17.27	13.70	10.34	*
Dissolved Manganese	15.316	24.72	19.68	17.27	13.70	10.34	NS
Total Nickel	ID	-	-	-	-	-	-
Total Lead	ID	-	-	-	-	-	-
Total Zinc	ID	-	-	-	-	-	-

Appendix XIII Seasonality of Devon metals data, 1977-1987. C = Excessive Censored Data, ID = Insufficient Data, NS = Not significant.

Variable	Kruskal-Wallis Test Statistic	99%	95%	90%	75%	50%	sig.
Dissolved Aluminum	ID	-	-	-	-	-	-
Dissolved Arsenic	C	-	-	-	-	-	-
Dissolved Boron	4.115	24.72	19.68	17.27	13.7	10.34	NS
Total Copper	ID	-	-	-	-	-	-
Dissolved Iron	C	-	-	-	-	-	-
Dissolved Manganese	C	-	-	-	-	-	-
Total Nickel	ID	-	-	-	-	-	-
Total Lead	ID	-	-	-	-	-	-
Total Zinc	ID	-	-	-	-	-	-

Appendix XIV Seasonality of Devon metals data, 1987-2002. Significance is depicted at 90% (*), 95% (*), and 99% (***) confidence intervals. NS = Not significant.

Variable	Kruskal-Wallis Test Statistic	99%	95%	90%	75%	50%	sig.
Dissolved Aluminum	16.847	24.72	19.68	17.27	13.7	10.34	NS
Dissolved Arsenic	20.139	24.72	19.68	17.27	13.7	10.34	**
Dissolved Boron	10.941	24.72	19.68	17.27	13.7	10.34	NS
Total Copper	9.035	24.72	19.68	17.27	13.7	10.34	NS
Dissolved Iron	17.585	24.72	19.68	17.27	13.7	10.34	*
Dissolved Manganese	18.372	24.72	19.68	17.27	13.7	10.34	*
Total Nickel	8.542	24.72	19.68	17.27	13.7	10.34	NS
Total Lead	16.808	24.72	19.68	17.27	13.7	10.34	NS
Total Zinc	20.847	24.72	19.68	17.27	13.7	10.34	**

Appendix XV Autocorrelation of Devon metals data, 1977-2002. Significance is denoted at 90% (*), 95% (**), and 99% (***) confidence intervals. ID = Insufficient Data.

	Kendall			Spearman		
Variable	**Tau**	**Z**	**sig.**	**Rho**	**Z**	**sig.**
Dissolved Aluminum	ID	-	-	-	-	-
Dissolved Arsenic	0.227592	4.1107	***	0.278521	3.7264	***
Dissolved Boron	0.277784	5.3028	***	0.394374	5.0628	***
Total Copper	ID	-	-	-	-	-
Dissolved Iron	0.188608	4.3719	***	0.246014	3.8271	***
Dissolved Manganese	0.248545	5.6553	***	0.346265	5.2968	***
Total Nickel	ID	-	-	-	-	-
Total Lead	ID	-	-	-	-	-
Total Zinc	ID	-	-	-	-	-

Appendix XVI Autocorrelation of Devon metals data, 1977-1987. C = Excessive Censored Data, ID = Insufficient Data, NS = Not Significant.

Variable	Kendall Tau	Z	sig.	Spearman Rho	Z	sig.
Dissolved Aluminum	ID	-	-	-	-	-
Dissolved Arsenic	C	-	-	-	-	-
Dissolved Boron	0.063728	0.8036	NS	0.096506	0.8358	NS
Total Copper	ID	-	-	-	-	-
Dissolved Iron	C	-	-	-	-	-
Dissolved Manganese	C	-	-	-	-	-
Total Nickel	ID	-	-	-	-	-
Total Lead	ID	-	-	-	-	-
Total Zinc	ID	-	-	-	-	-

Appendix XVII Autocorrelation of Devon metals data, 1987-2002. Significance is depicted at 90% (*), 95% (**), and 99% (**) confidence intervals. NS = Not Significant.

	Kendall			Spearman		
Variable	**Tau**	**Z**	**sig.**	**Rho**	**Z**	**sig.**
Dissolved Aluminum	0.193081	2.7412	***	0.269770	2.6016	***
Dissolved Arsenic	0.146800	2.1302	**	0.214049	2.1405	**
Dissolved Boron	0.010914	0.1252	NS	0.017144	0.1608	NS
Total Copper	0.127368	1.7938	*	0.172685	1.6742	*
Dissolved Iron	0.156143	2.4569	**	0.188559	2.3925	**
Dissolved Manganese	0.121228	1.9288	*	0.149927	1.8545	*
Total Nickel	0.193290	2.7235	***	0.280570	2.6911	***
Total Lead	-0.035848	-0.5054	NS	-0.048124	-0.467	NS
Total Zinc	0.047464	0.6556	NS	0.059486	0.5612	NS

Appendix XVIII Results of trend analyses for metals data at Devon, 1977-2002. Asterisks depict significant trends at 90% (*), 95%(**), and 99% (***) confidence intervals. SKWOC = Seasonal Kendall Analysis Without Autocorrelation, SKWC = Seasonal Kendal Analysis With Autocorrelation, MK = Mann-Kendall Analysis, MK (Q) = Mann-Kendall Analysis on Quarterly Data, NS = Not Significant, ID = Insufficient Data.

					Flow Adjusted		
Variable	**Test**	**Slope**	**% Slope**	**sig.**	**Slope**	**% Slope**	**sig.**
Dissolved Aluminum	ID	-	-	-	-	-	-
Dissolved Arsenic	MK (Q)	0.0000	0.00	NS	-0.0106	37.74	NS
Dissolved Boron	MK (Q)	-0.0013	6.57	***	-0.0014	15.53	***
Total Copper	ID	-	-	-	-	-	-
Dissolved Iron	SKWC	-0.0008	7.52	***	-0.0674	41.73	***
Dissolved Manganese	MK (Q)	-0.0002	6.46	***	-0.0724	-	***
Total Nickel	ID	-	-	-	-	-	-
Total Lead	ID	-	-	-	-	-	-
Total Zinc	ID	-	-	-	-	-	-

Appendix XIX Results of trend analyses for Devon metals data, 1977-1987. Significance is depicted at 90% (*), 95%(**), and 99% (***) confidence intervals. MK = Mann-Kendall Analysis, C = Excessive Censored Data, ID = Insufficient Data.

					Flow Adjusted		
Variable	**Test**	**Slope**	**%Slope**	**sig.**	**Slope**	**% Slope**	**sig.**
Dissolved Aluminum	ID	-	-	-	-	-	-
Dissolved Arsenic	C	-	-	-	-	-	-
Dissolved Boron	MK	0.00255	6.390	***	0.0027	-	***
Total Copper	ID	-	-	-	-	-	-
Dissolved Iron	C	-	-	-	-	-	-
Dissolved Manganese	C	-	-	-	-	-	-
Total Nickel	ID	-	-	-	-	-	-
Total Lead	ID	-	-	-	-	-	-
Total Zinc	ID	-	-	-	-	-	-

Appendix XX Results of trend analyses for Devon metals data, 1987-2002. Significance is depicted at 90% (*), 95%(**), and 99% (***) confidence intervals. SKWOC = Seasonal Kendall Analysis Without Autocorrelation, SKWC = Seasonal Kendal Analysis With Autocorrelation, MK = Mann-Kendall Analysis, MK (Q) = Mann-Kendall Analysis on Quarterly Data. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals.

					Flow Adjusted		
Variable	**Test**	**Slope**	**%Slope**	**sig.**	**Slope**	**% Slope**	**sig.**
Dissolved Aluminum	MK(Q)	-0.00049	-9.709	***	-0.0007	16.5269	***
Dissolved Arsenic	SKWC	-0.00001	-4.555	**	-0.0301		**
Dissolved Boron	MK	0.00000	0.000	**	-0.0040	10.3598	NS
Total Copper	MK(Q)	0.00001	0.847	NS	-0.0270	-5.2851	NS
Dissolved Iron	SKWC	0.00000	0.000	**	-0.0090	2.8286	NS
Dissolved Manganese	SKWC	0.00000	0.000	NS	-0.0107	13.7452	NS
Total Nickel	MK(Q)	0.00000	0.000	NS	0.0037	-0.8365	NS
Total Lead	MK	-0.00007	6.760	***	0.1361	8.0286	***
Total Zinc	SKWOC	0.00020	1.806	NS	-0.3857	-13.4716	NS

Appendix XXI Step trend analyses of Pakan inorganic data: Pre-January 1987 vs. post-January 1987. Significance is depicted at 90% (*), 95% (**), and 99% (***) confidence intervals. NS = Not Significant, ID = Insufficient Data.

Variable	Est. Diff. Btwn. Time Periods	Median 1	Median 2	sig.
Temperature	-0.1700	6.5000	4.9000	NS
pH	0.0000	8.1000	8.0000	NS
Conductivity	1.0000	340.0000	344.0000	NS
Total Alkalinity	4.0000	129.0000	132.0000	***
Hardness	ID	-	-	-
DO	-0.0500	10.9000	10.6800	NS
Turbidity	-0.9300	6.5000	5.4000	*
Colour	0.0000	10.0000	10.0000	NS
Non-Filterable Residue	-1.5000	12.0000	8.0000	*
TDS/Filterable Residue	ID	-	-	-
Potassium	0.0700	1.0650	1.1000	**
Sodium	0.7450	6.7000	7.5000	***
Calcium	0.8000	44.2000	44.6000	*
Magnesium	0.4000	13.1000	13.1000	*
Flow	-3.0000	147.0000	159.0000	NS
Bicarbonate	ID	-	-	-
Chloride	0.5000	2.7000	3.4000	***
Fluoride	0.0100	0.1400	0.1500	***
Sulphate	5.2000	40.0000	45.5500	***
Total Organic Carbon	-0.5000	3.4050	2.9000	***
Particulate Organic Carbon	-0.6200	0.8750	0.2000	***
Dissolved Organic Carbon	0.1000	2.7000	2.7000	NS
Phenolics	-0.0005	0.0001	0.0005	***
Particulate Nitrogen	-0.0100	0.1200	0.0900	NS
Dissolved Nitrogen	ID	-	-	-
Dissolved Kjeldahl Nitrogen	ID	-	-	-
Total Ammonia	-0.0300	0.2000	0.2200	**
Total Kjeldahl Nitrogen	ID	-	-	-
Nitrite and Nitrate	0.0730	0.2500	0.3360	***
Total Nitrogen	0.1955	0.6900	0.9090	***
Total Phosphorus	-0.0200	0.1100	0.0910	***
Total Dissolved Phosphorus	-0.0100	0.0700	0.0500	***
Chlorophyll a	0.0004	0.0400	0.0500	NS
Total Coliforms	600.0000	1160.0000	2400.0000	**
Fecal Coliforms	-43.0000	164.5000	100.0000	***
Reactive Silica	-0.2000	4.2000	4.0000	NS

Appendix XXII Seasonality of Pakan inorganic data, 1977-2002. Asterisks indicate significantly seasonal data at 90%(*), 95%(**), and 99%(***) confidence intervals. NS = Not Significant, ID = Insufficient Data.

Variable	Kruskal-Wallis Test Statistic	99%	95%	90%	75%	50%	sig.
Temperature	240.485	24.72	19.68	17.27	13.70		***
pH	81.045	24.72	19.68	17.27	13.70		***
Conductivity	65.859	24.72	19.68	17.27	13.70		***
Total Alkalinity	76.196	24.72	19.68	17.27	13.70		***
Hardness	ID	-	-	-	-		-
DO	192.572	24.72	19.68	17.27	13.70		***
Turbidity	132.563	24.72	19.68	17.27	13.70		***
Colour	43.392	24.72	19.68	17.27	13.70		***
Non-Filterable Residue	138.300	24.72	19.68	17.27	13.70		***
TDS/FR	ID	-	-	-	-		-
Potassium	57.658	24.72	19.68	17.27	13.70		***
Sodium	28.497	24.72	19.68	17.27	13.70		***
Calcium	94.408	24.72	19.68	17.27	13.70		***
Magnesium	78.147	24.72	19.68	17.27	13.70		***
Flow	170.750	24.72	19.68	17.27	13.70		***
Bicarbonate	ID	-	-	-	-		-
Chloride	57.806	24.72	19.68	17.27	13.70		***
Fluoride	33.874	24.72	19.68	17.27	13.70		***
Sulphate	63.420	24.72	19.68	17.27	13.70		***
Total Organic Carbon	92.600	24.72	19.68	17.27	13.70		***
Particulate Organic Carbon	33.391	24.72	19.68	17.27	13.70		***
Dissolved Organic Carbon	104.829	24.72	19.68	17.27	13.70		***
Phenolics	12.279	24.72	19.68	17.27	13.70	10.34	NS
Particulate Nitrogen	65.218	24.72	19.68	17.27	13.70		***
Dissolved Nitrogen	ID	-	-	-	-		-
Dissolved Kjeldahl Nitrogen	ID	-	-	-	-		-
Total Ammonia	143.753	24.72	19.68	17.27	13.70		***
Total Kjeldahl Nitrogen	ID	-	-	-	-		-
Nitrite and Nitrate	22.319	24.72	19.68	17.27	13.70		**
Total Nitrogen	48.960	24.72	19.68	17.27	13.70		***
Total Phosphorus	76.380	24.72	19.68	17.27	13.70		***
Total Dissolved Phosphorus	84.824	24.72	19.68	17.27	13.70		***
Chlorophyll a	104.594	24.72	19.68	17.27	13.70		***
Total Coliforms	14.914	24.72	19.68	17.27	13.70		NS
Fecal Coliforms	53.781	24.72	19.68	17.27	13.70		***
Reactive Silica	71.757	24.72	19.68	17.27	13.70		***

Appendix XXIII Seasonality of Pakan inorganic data, 1977-1987. Asterisks indicate significantly seasonal data at 90%(*), 95%(**), and 99%(***) confidence intervals. ID = Insufficient Data, NS = Not Significant.

Variable	Kruskal-Wallis Test Statistic	99%	95%	90%	75%	50%	sig.
Temperature	90.967	24.72	19.68	17.27	13.70		***
pH	30.370	24.72	19.68	17.27	13.70		***
Conductivity	22.436	24.72	19.68	17.27	13.70		**
Total Alkalinity	26.464	24.72	19.68	17.27	13.70		***
Hardness	ID	-	-	-	-		-
DO	74.716	24.72	19.68	17.27	13.70		***
Turbidity	40.796	24.72	19.68	17.27	13.70		***
Colour	18.556	24.72	19.68	17.27	13.70		*
Non-Filterable Residue	47.540	24.72	19.68	17.27	13.70		***
TDS/FR	ID	-	-	-	-		-
Potassium	27.457	24.72	19.68	17.27	13.70		***
Sodium	14.878	24.72	19.68	17.27	13.70		NS
Calcium	43.575	24.72	19.68	17.27	13.70		***
Magnesium	37.859	24.72	19.68	17.27	13.70		***
Flow	52.628	24.72	19.68	17.27	13.70		***
Bicarbonate	ID	-	-	-	-		-
Chloride	24.749	24.72	19.68	17.27	13.70		***
Fluoride	16.957	24.72	19.68	17.27	13.70	10.34	NS
Sulphate	26.454	24.72	19.68	17.27	13.70		***
Total Organic Carbon	34.347	24.72	19.68	17.27	13.70		***
Particulate Organic Carbon	36.225	24.72	19.68	17.27	13.70		***
Dissolved Organic Carbon	34.626	24.72	19.68	17.27	13.70		***
Phenolics	9.831	24.72	19.68	17.27	13.70	10.34	NS
Particulate Nitrogen	28.421	24.72	19.68	17.27	13.70		***
Dissolved Nitrogen	27.266	24.72	19.68	17.27	13.70		***
Dissolved Kjeldahl Nitrogen	ID						
Total Ammonia	31.555	24.72	19.68	17.27	13.70		***
Total Kjeldahl Nitrogen	ID						
Nitrite and Nitrate	10.246	24.72	19.68	17.27	13.70	10.34	NS
Total Nitrogen	22.340	24.72	19.68	17.27	13.70		**
Total Phosphorus	30.961	24.72	19.68	17.27	13.70		***
Total Dissolved Phosphorus	30.855	24.72	19.68	17.27	13.70		***
Chlorophyll a	20.683	24.72	19.68	17.27	13.70		**
Total Coliforms	14.470	24.72	19.68	17.27	13.70		NS
Fecal Coliforms	33.759	24.72	19.68	17.27	13.70		***

Appendix XXIV Seasonality of Pakan inorganic data, 1987-2002. Asterisks indicate significantly seasonal data at 90%(*), 95%(**), and 99%(***) confidence intervals. ID = Insufficient Data, NS = Not Significant.

Variable	Kruskal-Wallis Test Statistic	99%	95%	90%	75%	50%	sig.
Temperature	158.937	24.72	19.68	17.27	13.70		***
pH	58.849	24.72	19.68	17.27	13.70		***
Conductivity	52.861	24.72	19.68	17.27	13.70		***
Total Alkalinity	55.179	24.72	19.68	17.27	13.70		***
Hardness	53.524	24.72	19.68	17.27	13.70		***
DO	128.536	24.72	19.68	17.27	13.70		***
Turbidity	102.866	24.72	19.68	17.27	13.70		***
Colour	17.760	24.72	19.68	17.27	13.70		*
Non-Filterable Residue	100.906	24.72	19.68	17.27	13.70		***
TDS/FR	104.905	24.72	19.68	17.27	13.70		***
Potassium	32.934	24.72	19.68	17.27	13.70		***
Sodium	19.954	24.72	19.68	17.27	13.70		**
Calcium	54.837	24.72	19.68	17.27	13.70		***
Magnesium	42.835	24.72	19.68	17.27	13.70		***
Flow	120.609	24.72	19.68	17.27	13.70		***
Bicarbonate	57.185	24.72	19.68	17.27	13.70		***
Chloride	41.975	24.72	19.68	17.27	13.70		***
Fluoride	23.980	24.72	19.68	17.27	13.70		**
Sulphate	55.560	24.72	19.68	17.27	13.70		***
Total Organic Carbon	63.596	24.72	19.68	17.27	13.70		***
Particulate Organic Carbon	35.548	24.72	19.68	17.27	13.70		***
Dissolved Organic Carbon	77.229	24.72	19.68	17.27	13.70		***
Phenolics	ID	-	-	-	-		-
Particulate Nitrogen	45.605	24.72	19.68	17.27	13.70		***
Dissolved Nitrogen	ID	-	-	-	-		-
Dissolved Kjeldahl Nitrogen	65.447	24.72	19.68	17.27	13.70		***
Total Ammonia	114.861	24.72	19.68	17.27	13.70		***
Total Kjeldahl Nitrogen	54.664	24.72	19.68	17.27	13.70		***
Nitrite and Nitrate	19.369	24.72	19.68	17.27	13.70		**
Total Nitrogen	36.098	24.72	19.68	17.27	13.70		***
Total Phosphorus	53.674	24.72	19.68	17.27	13.70		***
Total Dissolved Phosphorus	61.048	24.72	19.68	17.27	13.70		***
Chlorophyll a	93.929	24.72	19.68	17.27	13.70		***
Total Coliforms	23.036	24.72	19.68	17.27	13.70		**
Fecal Coliforms	40.536	24.72	19.68	17.27	13.70		***

Appendix XXV Autocorrelation of Pakan inorganic data, 1977-2002. Asterisks denote significant autocorrelation at 90% (*), 95% (**), and 99% (***) confidence intervals. ID = Insufficient Data, NS = Not Significant.

	Kendall			Spearman		
Variable	**Tau**	**Z**	**sig.**	**Rho**	**Z**	**sig.**
Temperature	0.044959	1.0873	NS	0.069787	1.1317	NS
pH	0.168009	3.7196	***	0.220666	3.6192	***
Conductivity	0.102784	2.4957	**	0.149888	2.4400	**
Total Alkalinity	0.182979	3.9804	***	0.260597	3.8033	***
Hardness	ID	-	-	-	-	-
DO	0.050271	0.9908	NS	0.063472	0.9730	NS
Turbidity	0.026315	0.6410	NS	0.021590	0.3528	NS
Colour	0.173257	3.5136	***	0.225637	3.3315	***
Non-Filterable Residue	0.064117	1.5600	NS	0.079282	1.2931	NS
TDS/FR	ID	-	-	-	-	-
Potassium	0.142019	3.1238	***	0.200574	2.9614	***
Sodium	0.177824	3.9126	***	0.266491	3.9347	***
Calcium	0.091847	2.0204	**	0.135066	1.9942	**
Magnesium	0.125629	2.7640	***	0.181302	2.6769	***
Flow	0.244215	5.9774	***	0.344025	5.6424	***
Bicarbonate	ID	-	-	-	-	-
Chloride	0.104714	2.3036	**	0.160346	2.3675	**
Fluoride	0.223581	5.0847	***	0.326636	4.9859	***
Sulphate	0.187361	4.1032	***	0.277278	4.0751	***
Total Organic Carbon	0.172650	3.7917	***	0.245644	3.6189	***
Particulate Organic Carbon	0.249518	5.1567	***	0.350693	4.8720	***
Dissolved Organic Carbon	0.178558	4.2484	***	0.240960	3.9003	***
Phenolics	0.211413	4.0875	***	0.249950	3.8235	***
Particulate Nitrogen	0.082963	1.7549	*	0.114345	1.6251	NS
Dissolved Nitrogen	0.212069	3.0645	***	0.314846	3.0848	***
Dissolved Kjeldahl Nitrogen	0.090094	1.4653	NS	0.132160	1.4538	NS
Total Ammonia	0.120239	2.8523	***	0.175428	2.7904	***
Total Kjeldahl Nitrogen	ID	-	-	-	-	-
Nitrite and Nitrate	0.157936	3.8362	***	0.230048	3.7449	***
Total Nitrogen	0.377650	8.7448	***	0.521001	8.2047	***
Total Phosphorus	0.175864	4.2871	***	0.250692	4.0963	***
Total Dissolved Phosphorus	0.295944	7.1276	***	0.414230	6.6921	***
Chlorophyll a	0.006732	0.1533	NS	0.007852	0.1206	NS
Total Coliforms	0.262650	5.4750	***	0.386173	5.4064	***
Fecal Coliforms	0.159524	3.6860	***	0.239110	3.7043	***
Reactive Silica	0.541115	11.8878	***	0.716007	10.5474	***

Appendix XXVI Autocorrelation of Pakan inorganic data, 1977-1987. Asterisks denote significant autocorrelation at 90% (*), 95% (**), and 99% (***) confidence intervals. ID = Insufficient Data, NS = Not Significant.

	Kendall			Spearman		
Variable	**Tau**	**Z**	**sig.**	**Rho**	**Z**	**sig.**
Temperature	0.124955	1.6428	NS	0.163493	1.6019	NS
pH	0.161408	2.3908	NS	0.242990	2.4541	**
Conductivity	0.081493	1.1858	NS	0.116588	1.1542	NS
Total Alkalinity	0.193338	2.8119	***	0.290004	2.8562	***
Hardness	ID	-	-	-	-	-
DO	0.148810	0.2090	NS	0.029355	0.2831	NS
Turbidity	-0.089111	-1.3071	NS	-0.120503	-1.2050	NS
Colour	-0.066667	-0.7029	NS	-0.086474	-0.6864	NS
Non-Filterable Residue	0.016975	0.2446	NS	0.009507	0.0946	NS
TDS/FR	ID	-	-	-	-	-
Potassium	0.165291	2.3326	**	0.225744	2.2799	**
Sodium	0.142624	2.1188	**	0.208074	2.1014	**
Calcium	0.049842	0.7386	NS	0.073750	0.7448	NS
Magnesium	-0.064980	-0.9639	NS	-0.106053	-1.0711	NS
Flow	0.071573	1.0558	NS	0.107422	1.0849	NS
Bicarbonate	ID	-	-	-	-	-
Chloride	0.161426	2.3983	**	0.248139	2.5061	**
Fluoride	0.164746	2.3815	**	0.237916	2.3311	**
Sulphate	0.118561	1.7597	*	0.184924	1.8676	*
Total Organic Carbon	0.074818	1.0839	NS	0.092544	0.9115	NS
Particulate Organic Carbon	0.067002	0.9411	NS	0.109229	1.0420	NS
Dissolved Organic Carbon	0.136572	1.9302	*	0.176817	1.7414	*
Phenolics	0.156197	2.2801	**	0.222165	2.2216	**
Particulate Nitrogen	0.073374	1.0542	NS	0.108258	1.0552	NS
Dissolved Nitrogen	0.211429	3.0423	***	0.309999	3.0215	***
Dissolved Kjeldahl Nitrogen	ID	-	-	-	-	-
Total Ammonia	0.289474	4.0043	***	0.401580	3.9551	***
Total Kjeldahl Nitrogen	0.000000	0.0000	NS	0.000000	0.0000	NS
Nitrite and Nitrate	0.183488	2.6961	***	0.275096	2.7510	***
Total Nitrogen	0.151391	2.2259	**	0.217088	2.1709	**
Total Phosphorus	0.173549	2.5519	**	0.254693	2.5469	**
Total Dissolved Phosphorus	0.232903	3.3315	***	0.333759	3.2359	***
Chlorophyll a	-0.108386	-1.3283	NS	-0.163647	-1.3789	NS
Total Coliforms	0.160492	2.0270	**	0.222894	1.9174	*
Fecal Coliforms	0.008493	0.1119	NS	0.015021	0.1385	NS

Appendix XXVII Autocorrelation of Pakan inorganic data, 1987-2002. Asterisks denote significant autocorrelation at 90% (*), 95% (**), and 99% (***) confidence intervals. ID = Insufficient Data, NS = Not Significant.

	Kendall			Spearman		
	Tau	Z	sig.	Rho	Z	sig.
Temperature	0.039125	0.7458	NS	0.055279	0.7101	NS
pH	0.118924	2.0917	**	0.158351	2.0341	**
Conductivity	0.138145	2.6367	***	0.199582	2.5637	**
Total Alkalinity	0.149216	2.3353	**	0.222057	2.3500	**
Hardness	0.070602	1.2840	NS	0.101167	1.2390	NS
DO	0.147181	2.8099	***	0.211998	2.7232	***
Turbidity	0.074505	1.4217	NS	0.086773	1.1146	NS
Colour	0.321111	5.5014	***	0.422026	5.2542	***
Non-Filterable Residue	0.107407	2.0501	**	0.143013	1.8370	*
TDS/FR	0.102627	1.9532	*	0.136625	1.7497	*
Potassium	0.107955	1.7066	*	0.159783	1.7060	*
Sodium	0.209409	3.3117	***	0.315189	3.3653	***
Calcium	0.086299	1.3634	NS	0.127247	1.3586	NS
Magnesium	0.127500	2.0160	**	0.177530	1.8955	NS
Flow	0.339403	6.4801	***	0.477782	6.1372	***
Bicarbonate	0.122985	1.9280	*	0.181322	1.9189	*
Chloride	0.073887	1.1675	NS	0.106679	1.1390	NS
Fluoride	0.237251	3.8636	***	0.336994	3.9155	***
Sulphate	0.222047	3.4838	***	0.331639	3.5097	***
Total Organic Carbon	0.166429	2.6741	***	0.244701	2.6581	***
Particulate Organic Carbon	0.040325	0.5227	NS	0.049359	0.4936	NS
Dissolved Organic Carbon	0.134173	2.5442	**	0.191684	2.4473	**
Phenolics	0.074091	1.0495	NS	0.085334	0.9804	NS
Particulate Nitrogen	0.078413	1.1650	NS	0.100334	1.0281	NS
Dissolved Nitrogen	ID					
Dissolved Kjeldahl Nitrogen	0.090094	1.4653	NS	0.132160	1.4538	NS
Total Ammonia	0.039530	0.7273	NS	0.052421	0.6505	NS
Total Kjeldahl Nitrogen	0.127735	2.4296	**	0.194936	2.4964	**
Nitrite and Nitrate	0.090445	1.7138	*	0.129318	1.6510	*
Total Nitrogen	0.057447	1.0880	NS	0.084311	1.0764	NS
Total Phosphorus	0.141911	2.7080	***	0.197102	2.5318	**
Total Dissolved Phosphorus	0.251418	4.7959	***	0.369989	4.7526	***
Chlorophyll a	0.057499	1.0866	NS	0.080470	1.0274	NS
Total Coliforms	0.148439	2.4106	**	0.209557	2.2956	**
Fecal Coliforms	0.124240	2.2826	**	0.171829	2.1254	**

Appendix XXVIII Results of trend analyses for inorganic data at Pakan, 1977-2002. Asterisks depict significant trends at 90% (*), 95% (**), and 99% (***) confidence intervals. SKWOC = Seasonal Kendall Analysis Without Autocorrelation, SKWC = Seasonal Kendal Analysis With Autocorrelation, MK = Mann-Kendall Analysis, MK (Q) = Mann-Kendall Analysis on Quarterly Data, NS = Not Significant.

					Flow Adjusted		
Variable	**Test**	**Slope**	**% Slope**	**sig.**	**Slope**	**% Slope**	**sig.**
Temperature	SKWOC	-0.0112	0.22	**	0.0174	2.63	NS
pH	SKWC	0.0000	0.00	*	-0.0005	23.70	NS
Conductivity	SKWC	0.0834	0.02	NS	0.0996	5.76	NS
Total Alkalinity	SKWC	0.4501	0.35	***	0.3573	68.46	**
Hardness	ID	-	-	-	-	-	-
DO	SKWOC	-0.0019	0.02	NS	-0.0104	8.08	NS
Turbidity	SKWOC	-0.0687	1.15	**	0.0691	1.09	NS
Colour	SKWC	0.0000	0.00	NS	0.0000	0.00	NS
Non-Filterable Residue	SKWOC	-0.1201	1.20	**	0.0183	0.23	NS
TDS/Filterable Residue	ID	-	-	-	-	-	-
Potassium	SKWC	0.0056	0.51	**	-	-	-
Sodium	SKWC	0.0698	0.97	***	0.0700	16.41	***
Calcium	SKWC	0.0625	0.14	NS	0.0427	22.55	NS
Magnesium	SKWC	0.0273	0.21	NS	0.0018	38.53	NS
Flow	SKWC	-0.4418	0.28	NS	-	-	-
Bicarbonate	ID	-	-	-	-	-	-
Chloride	SKWC	0.0299	1.00	**	0.0108	20.46	**
Fluoride	SKWC	0.0011	0.74	**	0.0092		***
Sulphate	SKWC	0.4387	1.03	***	0.0070	33.16	**
Total Organic Carbon	SKWC	-0.0302	0.99	**	-0.0395	9.75	**
Particulate Organic Carbon	SKWC	-0.0300	7.51	***	-0.0466	17.88	***
Dissolved Organic Carbon	SKWC	0.0000	0.00	NS	0.0080	2.38	NS
Phenolics	MK (Q)	0.0000	0.00	**	-	-	-
Particulate Nitrogen	SKWOC	-0.0003	0.28	NS	-0.0023	4.83	NS
Dissolved Nitrogen	SKWC	-0.0078	1.51	NS	-0.0029	10.79	NS
Dissolved Kjeldahl Nitrogen	SKWOC	-0.0040	0.84	NS	-0.0019	7.76	NS
Total Ammonia	SKWC	-0.0013	0.65	*	-	-	-
Total Kjeldahl Nitrogen	ID	-	-	-	-	-	-
Nitrite and Nitrate	SKWC	0.0043	1.43	***	0.0037	24.67	**
Total Nitrogen	SKWC	0.0083	1.00	*	0.0077	8.50	*
Total Phosphorus	SKWC	-0.0023	2.35	***	-0.0022	11.71	***
Total Dissolved Phosphorus	SKWC	-0.0017	2.78	***	-0.0020	39.32	***
Chlorophyll a	SKWOC	0.0000	0.59	NS	0.0161	46.34	*
Total Coliforms	SKWC	7.9282	0.42	NS	-15.3077	0.80	NS
Fecal Coliforms	SKWC	-3.4465	3.13	**	-4.8423	2.11	*
Reactive Silica	SKWC	-0.0200	0.49	NS	-0.0059	2.02	*

Appendix XXIX Results of trend analyses for inorganic data at Pakan, 1977-1987. Asterisks depict significant trends at 90% (*), 95% (**), and 99% (***) confidence intervals. SKWOC = Seasonal Kendall Analysis Without Autocorrelation, SKWOC (Q) = SKWOC on Quarter Data, SKWC = Seasonal Kendal Analysis With Autocorrelation, MK = Mann-Kendall Analysis, MK (Q) = Mann-Kendall Analysis on Quarterly Data, NS = Not Significant.

					Flow Adjusted		
Variable	**Test**	**Slope**	**%Slope**	**sig.**	**Slope**	**% Slope**	**sig.**
Temperature	SKWOC	0.0000	0.00	NS	-0.1093	9.91	NS
Total Alkalinity	SKWC	1.0011	0.78	NS	1.1667	92.12	NS
	SKWOC	1.0011	0.78	*	-	-	-
	SKWOC(Q)	1.3497	1.05	NS	-	-	-
Hardness	ID	-	-	-	-	-	-
Turbidity	SKWOC	0.2471	3.80	NS	0.2582	8.95	NS
Colour	SKWOC	0.0000	0.00	NS	-0.0189	0.49	NS
Non-Filterable Residue	SKWOC	0.2218	1.85	NS	0.6743	41.68	NS
TDS/Filterable Residue	ID	-	-	-	-	-	-
Potassium	SKWC	0.0000	0.00	NS	-	-	-
	SKWOC	0.0000	0.00	NS	-	-	-
Sodium	MK(Q)	0.0000	0.00	NS	0.0737	38.29	NS
Calcium	SKWOC	-0.3796	0.86	***	-0.3749	-	**
Magnesium	SKWOC	-0.1750	1.34	***	-0.0140	-	***
Flow	SKWOC	1.1706	0.80	NS	-	-	-
Chloride	SKWC	-0.0502	1.86	NS	-0.0209	31.07	NS
	SKWOC	-0.0502	1.86	NS	-	-	-
	SKWOC(Q)	-0.0644	2.04	NS	-	-	-
Fluoride	MK(Q)	0.00166	1.19	NS	0.0158	-	NS
Sulphate	SKWC	0.1000	0.25	NS	0.0924	-	NS
	SKWOC	0.1000	0.25	NS	-	-	-
Total Organic Carbon	SKWOC	0.0922	2.71	NS	0.0763	12.61	NS
Particulate Organic Carbon	SKWOC	0.0301	3.44	NS	0.0604	17.73	NS
Phenolics	MK(Q)	0.0000	0.00	NS	0.0014	1.17	NS
Total Ammonia	SKWC	0.0000	0.00	NS	0.0047	7.94	NS
	SKWOC	0.0000	0.00	NS	-	-	-
Nitrite and Nitrate	MK(Q)	0.0076	3.02	NS	0.0116	42.27	NS
Total Nitrogen	SKWC	-0.0045	0.65	NS	-	-	-
	SKWOC	-0.0045	0.65	NS	-	-	-
Total Phosphorus	SKWC	0.0043	3.90	**	0.0051	17.07	*
	SKWOC	0.0043	3.90	**	-	-	-
Total Dissolved Phosphorus	SKWC	0.0025	3.56	*	0.0024	15.71	NS
	SKWOC	0.0025	3.56	**	-	-	-
Total Coliforms	MK(Q)	-38.7857	3.59	NS	-	-	-
Fecal Coliforms	SKWOC	10.0032	6.08	**	-	-	-

Appendix XXX Results of trend analyses for inorganic data at Pakan, 1987-2002. Asterisks depict significant trends at 90% (*), 95% (**), and 99% (***) confidence intervals. SKWOC = Seasonal Kendall Analysis Without Autocorrelation, SKWC = Seasonal Kendal Analysis With Autocorrelation, MK = Mann-Kendall Analysis, MK (Q) = Mann-Kendall Analysis on Quarterly Data, NS = Not Significant.

					Flow Adjusted		
Variable	**Test**	**Slope**	**%Slope**	**sig.**	**Slope**	**% Slope**	**sig.**
Temperature	SKWOC	-0.0122	0.25	NS	0.1257	30.97	*
Total Alkalinity	SKWC	0.5727	0.43	*	0.3591	43.15	NS
Hardness	SKWOC	0.7622	0.47	***	0.6059	-	***
Turbidity	SKWOC	-0.1330	2.46	**	0.3205	4.02	NS
Colour	SKWC	0.0000	0.00	NS	0.0264	1.09	NS
Non-Filterable Residue	SKWC	-0.1939	2.42	*	0.1531	1.77	NS
TDS/Filterable Residue	SKWC	1.4464	0.72	*	0.0061	29.54	NS
Potassium	SKWC	0.0091	0.82	NS	-	-	-
Sodium	SKWC	0.0928	1.24	**	0.0922	23.97	**
Calcium	SKWOC	0.2045	0.46	***	0.1289	62.15	**
Magnesium	SKWC	0.1165	0.89	**	0.0743	-	**
Flow	SKWC	-1.9364	1.22	NS	-	-	-
Bicarbonate	SKWC	0.8133	0.51	**	0.6019	-	*
Chloride	SKWOC	0.0333	0.98	NS	0.0082	13.20	NS
Fluoride	SKWC	0.0000	0.00	NS	0.0027	-12.45	NS
Sulphate	SKWC	0.4474	0.98	**	0.0070	-	**
Total Organic Carbon	SKWC	-0.0232	0.80	NS	-0.0045	1.70	NS
Particulate Organic Carbon	SKWOC	0.0000	0.00	NS	0.0027	2.61	NS
Phenol	MK	0.0000	0.00	NS	-	-	-
Total Ammonia	SKWOC	-0.0004	0.19	NS	-0.0031	74.67	NS
Total Kjeldahl Nitrogen	SKWC	-0.0085	1.44	NS	-0.0094	23.45	NS
Nitrite and Nitrate	SKWC	-0.0026	0.78	NS	-0.0030	28.77	**
Total Nitrogen	SKWOC	-0.0119	1.31	**	-0.0132	28.76	**
Total Phosphorus	SKWC	-0.0051	5.59	***	-0.0049	37.74	***
Total Dissolved Phosphorus	SKWC	-0.0033	6.69	***	-0.0036	-	***
Total Coliforms	SKWC	-186.2691	7.76	*	-258.9049	11.50	***
Fecal Coliforms	SKWC	-6.0165	6.02	*	-0.0944	95.69	*

Appendix XXXI Seasonality of Pakan metals data, 1977-2002. Asterisks indicate significantly seasonal data at 90%(*), 95%(**), and 99%(***) confidence intervals. NS = Not Significant.

Variable	Kruskal-Wallis Test Statistic	99%	95%	90%	75%	50%	sig.
Dissolved Aluminum	ID	-	-	-	-	-	-
Dissolved Arsenic	17.835	24.72	19.68	17.27	13.70	10.34	*
Dissolved Boron	8.458	24.72	19.68	17.27	13.70	10.34	NS
Total Copper	ID	-	-	-	-	-	-
Dissolved Iron	19.475	24.72	19.68	17.27	13.70	10.34	*
Dissolved Manganese	25.176	24.72	19.68	17.27	13.70	10.34	***
Total Nickel	ID	-	-	-	-	-	-
Total Lead	ID	-	-	-	-	-	-
Total Zinc	ID	-	-	-	-	-	-

Appendix XXXII Seasonality of Pakan metals data, 1977-1987. Asterisks indicate significantly seasonal data at 90%(*), 95%(**), and 99%(***) confidence intervals. NS = Not Significant, C = Excessive Censored Data, ID = Insufficient Data.

Variable	Kruskal-Wallis Test Statistic	99%	95%	90%	75%	50%	sig.
Dissolved Aluminum	ID	-	-	-	-	-	-
Dissolved Arsenic	C	-	-	-	-	-	-
Dissolved Boron	11.011	24.72	19.68	17.27	13.70	10.34	NS
Total Copper	ID	-	-	-	-	-	-
Dissolved Iron	C	-	-	-	-	-	-
Dissolved Manganese	C	-	-	-	-	-	-
Total Nickel	ID	-	-	-	-	-	-
Total Lead	ID	-	-	-	-	-	-
Total Zinc	ID	-	-	-	-	-	-

Appendix XXXIII Seasonality of Pakan metals data, 1987-2002. Asterisks indicate significantly seasonal data at 90%(*), 95%(**), and 99%(***) confidence intervals. NS = Not Significant, ID = Insufficient Data.

Variable	Kruskal-Wallis Test Statistic	99%	95%	90%	75%	50%	sig.
Dissolved Aluminum	22.738	24.72	19.68	17.27	13.7	10.34	**
Dissolved Arsenic	21.169	24.72	19.68	17.27	13.7	10.34	**
Dissolved Boron	10.493	24.72	19.68	17.27	13.7	10.34	NS
Total Copper	10.226	24.72	19.68	17.27	13.7	10.34	NS
Dissolved Iron	19.534	24.72	19.68	17.27	13.7	10.34	*
Dissolved Manganese	31.993	24.72	19.68	17.27	13.7	10.34	***
Total Nickel	14.221	24.72	19.68	17.27	13.7	10.34	NS
Total Lead	15.886	24.72	19.68	17.27	13.7	10.34	NS
Total Zinc	14.550	24.72	19.68	17.27	13.7	10.34	NS

Appendix XXXIV Autocorrelation of Pakan metals data, 1977-2002. Asterisks denote significant autocorrelation at 90% (*), 95% (**), and 99% (***) confidence intervals. NS = Not Significant.

	Kendall			Spearman		
Variable	**Tau**	**Z**	**sig.**	**Rho**	**Z**	**sig.**
Dissolved Aluminum	ID	-	-	-	-	-
Dissolved Arsenic	0.183953	3.3748	***	0.244888	3.2580	***
Dissolved Boron	0.384956	7.2406	***	0.526999	6.6661	***
Total Copper	ID	-	-	-	-	-
Dissolved Iron	0.223902	5.1215	***	0.256366	3.9384	***
Dissolved Manganese	0.245535	5.5544	***	0.333307	5.0968	***
Total Nickel	ID	-	-	-	-	-
Total Lead	ID	-	-	-	-	-
Total Zinc	ID	-	-	-	-	-

Appendix XXXV Autocorrelation of Pakan metals data, 1977-1987. NS = Not Significant, C = Excessive Censored Data, ID = Insufficient Data.

	Kendall			Spearman		
Variable	**Tau**	**Z**	**sig.**	**Rho**	**Z**	**sig.**
Dissolved Aluminum	ID	-	-	-	-	-
Dissolved Arsenic	C	-	-	-	-	-
Dissolved Boron	0.135509	1.7111	90%	0.189111	1.6377	NS
Total Copper	ID	-	-	-	-	-
Dissolved Iron	C	-	-	-	-	-
Dissolved Manganese	C	-	-	-	-	-
Total Nickel	ID	-	-	-	-	-
Total Lead	ID	-	-	-	-	-
Total Zinc	ID	-	-	-	-	-

Appendix XXXVI Autocorrelation of Pakan metals data, 1987-2002. NS = Not Significant.

Variable	Kendall Tau	Z	sig.	Spearman Rho	Z	sig.
Dissolved Aluminum	0.256431	3.505400	***	0.366606	3.399800	***
Dissolved Arsenic	-0.053638	-0.775900	NS	-0.073851	-0.738500	NS
Dissolved Boron	0.310813	3.7631	***	0.399795	3.6423	***
Total Copper	0.005342	0.072900	NS	0.006427	0.062600	NS
Dissolved Iron	0.044935	0.703900	NS	0.053845	0.679000	NS
Dissolved Manganese	0.145623	2.459700	**	0.185365	2.322600	**
Total Nickel	0.208920	2.951300	***	0.311273	2.985600	***
Total Lead	0.114930	1.637300	NS	0.167399	1.623000	NS
Total Zinc	0.042333	0.594400	NS	0.073105	0.701200	NS

Appendix XXXVII Results of trend analyses for metals data at Pakan, 1977-2002. Asterisks depict significant trends at 90% (*), 95% (**), and 99% (***) confidence intervals. SKWOC = Seasonal Kendall Analysis Without Autocorrelation, SKWC = Seasonal Kendal Analysis With Autocorrelation, MK = Mann-Kendall Analysis, MK (Q) = Mann-Kendall Analysis on Quarterly Data.

					Flow Adjusted		
Variable	**Test**	**Slope**	**% Slope**	**sig.**	**Slope**	**% Slope**	**sig.**
Dissolved Aluminum	ID	-	-	-	-	-	-
Dissolved Arsenic	SKWC	0.00000	0.00	NS	0.0009	1.00	NS
Dissolved Boron	MK(Q)	-0.00199	9.94	***	-	-	-
Total Copper	ID	-	-	-	-	-	-
Dissolved Iron	SKWC	-0.00075	7.49	***	-0.0684	40.36	***
Dissolved Manganese	SKWC	-0.00017	3.34	***	-	-	-
Total Nickel	ID	-	-	-	-	-	-
Total Lead	ID	-	-	-	-	-	-
Total Zinc	ID	-	-	-	-	-	-

Appendix XXXVIII Results of trend analyses for metals data at Pakan, 1977-1987. Asterisks depict significant trends at 90% (*), 95% (**), and 99% (***) confidence intervals. SKWOC = Seasonal Kendall Analysis Without Autocorrelation, SKWC = Seasonal Kendal Analysis With Autocorrelation, MK = Mann-Kendall Analysis, MK (Q) = Mann-Kendall Analysis on Quarterly Data, C = Excessive Censored Data, ID = Insufficient Data.

					Flow Adjusted		
Variable	**Test**	**Slope**	**% Slope**	**sig.**	**Slope**	**% Slope**	**sig.**
Dissolved Aluminum	ID	-	-	-	-	-	-
Dissolved Arsenic	C	-	-	-	-	-	-
Dissolved Boron	MK(Q)	0.00383	6.38	**	-	-	-
Total Copper	ID	-	-	-	-	-	-
Dissolved Iron	C	-	-	-	-	-	-
Dissolved Manganese	C	-	-	-	-	-	-
Total Nickel	ID	-	-	-	-	-	-
Total Lead	ID	-	-	-	-	-	-
Total Zinc	ID	-	-	-	-	-	-

Appendix XXXIX Results of trend analyses for metals data at Pakan, 1987-2002. Asterisks depict significant trends at 90% (*), 95% (**), and 99% (***) confidence intervals. SKWOC = Seasonal Kendall Analysis Without Autocorrelation, SKWC = Seasonal Kendal Analysis With Autocorrelation, MK = Mann-Kendall Analysis, MK (Q) = Mann-Kendall Analysis on Quarterly Data, ID = Insufficient Data.

					Flow Adjusted		
Variable	**Test**	**Slope**	**% Slope**	**sig.**	**Slope**	**% Slope**	**sig.**
Dissolved Aluminum	SKWC	-0.00068	-3.79	95%	-0.0682	-37.5759	90%
Dissolved Arsenic	SKWOC	-0.00001	-3.56	99%	-0.0430	-	99%
Dissolved Boron	MK(Q)	0.00000	0.00	NS	-	-	-
Total Copper	MK	-0.00008	-4.06	NS	0.0000	2.7516	NS
Dissolved Iron	SKWOC	0.00000	0.00	99%	-0.0073	2.3239	NS
Dissolved Manganese	SKWC	0.00000	0.00	NS	-	-	-
Total Nickel	MK(Q)	0.00016	4.01	NS	0.0001	-5.5003	NS
Total Lead	MK	-0.00003	-3.08	NS	0.0000	0.9121	NS
Total Zinc	MK	-0.00011	-0.85	NS	-0.0001	2.3801	NS