TECHNICAL SUPPLEMENT
TO THE
1985 ANNUAL REPORT OF THE COORDINATING COMMITTEE FOR WATER QUALITY IN THE OTTAWA RIVER

Water Quality Branch
Inland Waters Directorate

Doc. No. 1939h

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Abstract

The report presents and interprets the water quality data collected from 1979 to 1984 by federal and provincial governments as the mainstem of the Ottawa River, between Notre-Dame-du-Nord and Carillon Dam, and on the tributaries on the Quebec and Ontario side.

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Introduction

This report is a companion volume to the "1985 Annual Report of the Coordinating Committee for the Water Quality of the Ottawa River". It is a technical supplement giving the details of the water quality aspects of the mainstem of the Ottawa River and its tributaries.

The data used for this analysis have been collected by the Ministere de l'Environnement du Quebec (MEQ), the Ontario Ministry of the Environment (OMOE) and Environment Canada (EC). The data discussed in this report cover the period of 1979-1984 and in specific cases reference is made to earlier studies.

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1.0 MAJOR IONS

1.1 Introduction

Major ions enter aquatic systems primarily through the natural weathering processes on bedrock and overburden deposits. Other sources are anthropogenic, especially in the proximity of urban and industrial developments, and atmospheric.

This section of the report describes the spatial, temporal and seasonal variability in major ion concentrations in the mainstem and tributaries of the Ottawa River.

Sources of Data

Major ion data at five mainstem locations from the Ministère de l'Environnment du Québec (MEQ) water quality database for the period of 1979 to 1984, were evaluated. The station numbers and site descriptions are listed in table 1.1 and shown in figure 1.1.

The cations and anions discussed are:

Cations	Anions
Calcium (Ca^{2+})	Bicarbonate (HCO_3^-)
Magnesium (Mg^{2+})	Carbonate (CO_3^{2-})
Sodium (Na^+)	Chloride (Cl^-)
Potassium (K^+)	Sulphate (SO_4^{2-})

The Ontario Ministry of the Environment (OMOE) and MEQ are responsible for the water quality data collected from the Ontario and Quebec tributaries, respectively. The tributaries locations for which data were analyzed are given in Table 1.2. All major ions listed above were available for the tributaries situated in Quebec. Only bicarbonate and carbonate values were available for the tributary streams located in Ontario.

The MEQ data for the major ions were screened and subsequently grouped according to the comparability of the preservation, storage, sampling and analytical procedures used during the 1979 - 1984 period. These analytical techniques are described in "Parametres Numeriques du Dictionnaire" (MEQ, 1984). The bicarbonate and carbonate values were calculated as described in the NAQUADAT Dictionary (Environment Canada, 1984). Screened and calculated data were stored in a separate NAQUADAT file, called NAQOTTAWA, which was used for all subsequent interpretation.

Annual and seasonal mean concentrations and ranges were calculated. Standard statistical tests, at 95% confidence level, were applied to the screened data. One way ANOVA, Student's t-test, "goodness of fit", and Duncans' multiple range tests were used to detect spatial, temporal and seasonal changes at the mainstem stations and spatial differences at the MEQ stations on the tributaries. The seasons were defined from hydrographs and surface water temperature regimes.

1.2 SODIUM

Invertebrates and micro-organisms are the most sensitive to increased salinity. Sodium may replace potassium to a limited extent as a plant-nutritive element and could be an antagonistic agent against certain toxic salts.

1.2.1 Mainstem

Spatial Variation

Sodium data are summarized in table 1.3. The mean values for the 1979-1984 period in the mainstem of the Ottawa River increased downstream, from Notre-Dame-du-Nord (Station 1) to Carillon Dam (Station 10), from 1.23 to 3.05 $mg.L^{-1}$. Throughout the year the sodium levels upstream of Ottawa-Hull were similar and significantly lower than downstream, (Masson) Stations 7 and Carillon Dam, values (Figure 1.2). The increase in tributary sources coupled with the anthropogenic influences in the lower reaches of the Ottawa River Basin, ie. Ottawa-Hull region, may explain this rise of the dissolved sodium concentration in the lower Ottawa River.

The major anthropogenic contributor of sodium to the lower reaches of the Ottawa River was probably NaCl, used during the winter for snow and ice control. The similarity in the sodium and chloride concentration increases downstream of Ottawa-Hull and seasonal variations in the lower Ottawa River supports this explanation.

Temporal Variation

There were no significant changes in the sodium concentration during the study period (1979 - 1984) at any of the surveillance stations.

Seasonal Variation

Seasonal variation was not significant in the upstream reaches of the Ottawa River (Stations 1, 2 and 4) (Table 1.4).

In the lower reaches of the river, sodium levels recorded at Masson (Station 7) were lower in the summer (2.36 $mg.L^{-1}$) than in the other seasons. A similar seasonal pattern existed at Carillon Dam (Station 10). This may be attributed to a number of factors, including sodium loading during winter and spring from snow and ice control measures, especially in the proximity of urbanization (eg. Ottawa-Hull), and flow regime management.

1.2.2 Tributaries

Sodium concentrations for six Quebec tributaries are summarized in table 1.5. Annual mean concentrations during the study period for all six tributaries ranged from 0.83 to 3.20 $mg.L^{-1}$. The highest sodium mean concentrations occurred at Petite Nation River (Station 21). Petite Nation and the Rouge Rivers' sodium concentrations were significantly higher than the other tributary sodium levels. This may reflect the contribution of ions from the marine clays found at the mouths of these two Quebec tributaries. The sodium concentrations of the Kipawa River, near Temiscaming, were significantly lower than those of all other tributaries and the lowest 5-year mean concentration was observed at this sampling location.

1.3 CHLORIDE

Chloride ion is widely found in nature, generally as sodium (NaCl), potassium (KCl) and calcium ($CaCl_2$) salts. These salts enter to the natural waters by the weathering processes of sedimentary rocks and as a result of human activities such as road salting, chemical industries, sewage, irrigation drainage and refuse leachates.

Changes in the chloride concentrations of a water body may alter the biotic community. Invertebrates and micro-organisms seem to be more sensitive to salts, e.g. NaCl, than higher trophic levels.

1.3.1 Mainstem

Spatial Variation

During the 1979 - 1984 period the dissolved chloride annual mean concentrations ranged from 0.86 to 4.05 $mg.L^{-1}$ in the Ottawa River (Table 1.6). The upper Ottawa River chloride concentrations were significantly lower than the lower river values.

The values at Carillon Dam were three times higher than the values observed at Notre-Dame-du-Nord. A 50 - 100% increase in the chloride concentration occurred downstream from Ottawa-Hull. This was directly attributed to point and non-point sources, e.g. salt used for snow and ice control, originating from the populated areas located in this section of the river.

Temporal Variation

There were no significant increases in the chloride content of the ambient waters of the Ottawa River during the 1979 - 1984 period.

1.4 CALCIUM

1.4.1 Mainstem

Calcium is one of the two main components of the total hardness. Calcium contributes to the reduction of toxicity of certain chemical compounds to the aquatic fauna and consequently is beneficial to the aquatic environment. It is also essential for most life forms. High concentrations of calcium are relatively harmless to all organisms.

Spatial Variation

Calcium mean values at the mainstem locations in the Ottawa River are listed in table 1.9. Calcium concentrations ranged from 3.53 to 9.54 $mg.L^{-1}$, increasing in the downstream direction. Four distinctive zones for calcium concentration were identified. Notre-Dame-du-Nord (Zone 1), Lake Timiskaming and Portage du Fort (Zone 2), Masson (Zone 3) and Carillon Dam (Zone 4). The same four zones are also present for the magnesium and bicarbonate concentrations (See sections 1.7 and 1.8).

The gradual downstream increase in calcium concentration parallels the increased number of source loadings found along the length of the Ottawa River, especially in the Ottawa-Hull region. A major increase in calcium content occurred downstream from Notre-Dame-du-Nord, at Lake Timiskaming. This increase was a result of land development (i.e. mining, farms and forestry), increased weathering of sandstone rock and glacial deposits due to the impoundment characteristics of Lake Timiskaming, and the discharge management techniques used at the outlet of the lake.

The small calcium concentration decrease from Lake Timiskaming to Portage du Fort was probably due to the lack of calcium contributions from the prevalent granitic and gneiss bedrock formations along the length of this reach of the river, coupled with the atmospheric acid deposition that has been documented for the region (median pH = 4.0) and the H^+ contribution of the tributaries. These influences would tend to reduce the calcium content of the ambient waters.

Temporal Variation

There was no significant increase in calcium concentrations during the 1979 to 1984 period. The increase in the annual mean observed at Masson was not considered significant.

Seasonal Variation

Significant seasonal differences were observed for all stations, with the exception of Notre-Dame-du-Nord (Table 1.10). At the Lake Timiskaming outlet, the spring mean calcium concentration (5.8 $mg.L^{-1}$) was significantly lower than the remaining seasons (6.9-7.1 $mg.L^{-1}$) reflecting the spring dilution in Lake Timiskaming. The same effect probably explains the lower spring and summer concentrations observed at Portage du Fort (Chenaux Dam discharge).

In contrast, the calcium peak levels in the lower Ottawa River at Masson and Carillon Dam, occurred during the spring runoff and fall spate periods. This probably reflected anthropogenic non-point and point source influences located immediately upstream from these 2 locations, e.g. Ottawa-Hull region, and tributary influences.

1.4.2 Tributaries

Calcium concentrations for the six Quebec tributaries are summarized in table 1.11. The lowest annual calcium mean concentrations occurred in the Kipawa River, ranging from 2.53 to 2.89 $mg.L^{-1}$. These low levels were distinctly different from all other tributaries and they may relate to the acidification process occurring in this tributary.

The highest calcium values occurred at the mouth of the Petite Nation River. The mean values recorded at this station ranged from 8.64 to 10.67 $mg.L^{-1}$. The calcium in this tributary may originate in the marine clays that exist in the area of the mouth of the Petite Nation drainage basin.

1.5 SULPHATE

Sulphate concentrations are seldom high enough to affect adversely aquatic life. Dissolved sulphate may be reduced to sulphide, which then can volatize to the atmosphere as H_2S, precipitate as metal sulphide or be incorporated in living organisms. Sulphates also serve as an oxygen source for bacteria under anoxic conditions.

1.5.1 Mainstem

Spatial Variation

Sulphate mean values and standard deviations are listed in table 1.12. Sulphate levels increased slightly, but not significantly, from the upper to the lower reaches of the river. This trend may be a result of a number of sources including atmospheric deposition (acid rain), sedimentary rocks located along the Ottawa River, oxidation of organic materials, industrial discharges from the pulp mills, metalworking industries and mine drainage located along the length of the Ottawa River and its tributaries. Marine clays which dominate the lower end of the Ottawa River, may also contribute to the sulphate levels in that part of the river.

Temporal Variation

A slight, gradual decrease, statistically not significant, was observed from 1979 to 1984 in the upper part of the river.

Seasonal Variation

Summer mean concentrations were lowest for all stations, with the exception of Notre-Dame-du-Nord (Table 1.13). The summer mean sulphate value at Notre-Dame-du-Nord location was approximately the same as the other seasonal concentrations recorded at this station.

1.5.2 Tributaries

The annual mean sulphate levels, for the 1979 - 1984 period, ranged from 6.15 to 8.51 $mg.L^{-1}$ for most tributaries. The annual sulphate mean values recorded at the mouth of the Petite Nation and, in some years, Kipawa River were significantly higher than in all other tributaries (Table 1.14). This may be due to the sulphate contributions from the marine clays prevalent in the bottom sediments of these tributaries.

1.6 POTASSIUM

The potassium ion is an essential, although not limiting, element for plant growth. It is a common constituent of many minerals and is always present in surface waters. Certain algae may be sensitive to potassium salts.

1.6.1 Mainstem

Spatial Variation

Potassium mean values and standard deviations are summarized in table 1.15. The potassium concentration increased in a downstream direction from Notre-Dame-du-Nord to Carillon Dam. This probably reflected the increased potassium contributions from the marine clays and the anthroprogenic non-point and point sources prevalent in the lower Ottawa River drainage basin.

Temporal and Seasonal Variation

No significant temporal or seasonal variations were observed at any of the mainstem stations (Table 1.15 and 1.16).

1.6.2 Tributaries

Annual mean potassium concentrations for the major Quebec tributaries are listed in table 1.17. The potassium levels in the Petite Nation River were significantly higher than in the other Quebec tributaries. These high potassium values paralleled the other major ion concentrations of this Quebec tributary, reflecting the marine clay influence.

1.7 Magnesium

Magnesium is non-toxic to aquatic life and is one of two main elements contributing to total hardness. The toxicity of several toxic metals decreases as the water hardness increases. Thus water hardness confers a protection and has a beneficial effect on aquatic life.

1.7.1 Mainstem

Spatial Variation

The annual mean concentrations ranged from 1.05 to 2.77 $mg.L^{-1}$ during the study period (Table 1.18). They increased downstream from Notre-Dame-du-Nord to Carillon Dam.

The low content of the dissolved magnesium in the Ottawa River is consistent with the softwater nature of the system and the lack of contributions from the Canadian Shield drainage.

Temporal Variation

Although the annual mean magnesium concentration appear to have peaked in 1981 and then declined or leveled off, the differences are not significant.

Seasonal Variation

No significant seasonal differences were found for upper Ottawa River stations (Table 1.19). Downstream, the summer concentrations determined at Masson and Carillon Dam were lower than the values for the other seasons. This probably reflects the increased relative contribution from the tributaries, which have very low hardnesses.

1.7.2 Tributaries

Magnesium concentrations determined for the major Quebec tributaries are summarized in table 1.20. The lowest annual mean magnesium concentrations occurred in Kipawa River (0.71 - 0.83 $mg.L^{-1}$) and the highest values were recorded in the Petite Nation River (1.62 - 2.16 $mg.L^{-1}$). This slightly higher magnesium content of the Petite Nation River may originate with anthropogenic sources and marine clay deposits located at the mouth of this tributary.

1.8 BICARBONATE AND CARBONATE

1.8.1 Mainstem

Spatial Variation

Calculated bicarbonate values are summarized in table 1.21. All calculated carbonate values were zero. The bicarbonate mean value more than tripled from Notre-Dame-du-Nord to Carillon Dam. The low bicarbonate levels observed in the upper reaches of the Ottawa River reflect the upper basin's bedrock geology of granitic gneiss and granitoid intrusive rocks. The higher bicarbonate values recorded in the lower Ottawa River are probably due to both the limestone, marble and dolomite deposits, dominating the Ontario boundary, and the anthropogenic point and non-point sources, especially in the Ottawa-Hull region.

The Ontario Ministry of the Environment (OMOE) collected bicarbonate and carbonate data in 1971 and 1981. The OMOE mainstem station bicarbonate concentration ranges were similar to the levels observed at the corresponding MEQ mainstem stations. In the upper Ottawa River, at Otto Holden Dam (Station 3) and the Chenaux Dam headpond (Station 5), the bicarbonate values ranged from 14.0 to 25.0 $mg.L^{-1}$. In the lower Ottawa River, at Chats Falls (Station 6), the bicarbonate ranged between 23.0 and 58.0 $mg.L^{-1}$. At the Hawkesbury surveillance stations, below Ottawa-Hull, the range was 21.0 - 95.0 $mg.L^{-1}$. These ranges are based on a very small number of results.

Temporal Variability

There were no significant temporal trends at any of the mainstem stations.

Seasonal Variation

The seasonal bicarbonate variation was similar to that of magnesium and calcium: minimum levels occurred in the winter at Notre-Dame-du-Nord station, spring at the Lake Timiskaming outlet and Chenaux Dam discharge (Portage du Fort), and summer in the lower Ottawa River, at Masson and Carillon Dam (Table 1.22).

Low levels recorded in the spring at Lake Timiskaming and Portage du Fort (upper Ottawa River), parallel the dilutional effect of the spring melt and the increased influence of acidic waters depressing the bicarbonate availability.

Peak bicarbonate levels in the lower Ottawa occurred during periods of increased flow. These higher concentrations were attributed to the increased bicarbonate loading from tributary streams draining the natural limestone bedrock typical of the Ontario boundary and from anthropogenic non-point and point sources in the Ottawa-Hull region.

1.8.2 Tributaries

Quebec

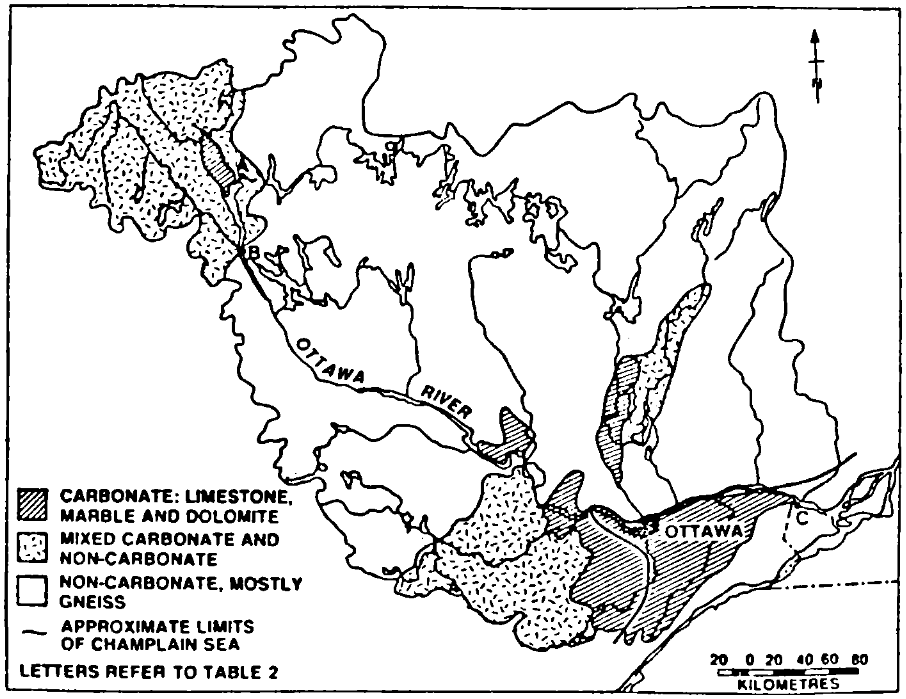
Bicarbonate concentrations recorded at Petite Nation River were the highest of the Quebec tributaries (Table 1.23). This was attributed to the marine clay deposits present at the mouth of this tributary. As in the case of other major ions, the lowest bicarbonate concentrations were recorded in the Kipawa River, which is significantly different from the other Quebec tributaries.

Ontario

Five of the seven Ontario tributaries drained primarily marble, limestone and dolomite deposits (Bonnechere, Madawaska, Mississippi, Rideau and South Nation Rivers). All of the bicarbonate levels recorded from these rivers were higher than the other eight, Ontario and Quebec, major tributaries draining the granitic rocks of the Canadian Shield (Table 1.24). The Madawaska River headwaters originated from parts of the Canadian Shield characteristic of granitoid intrusive rocks and gneiss bedrock. The bicarbonate concentration range of this river was the lowest of the above Ontario tributaries.

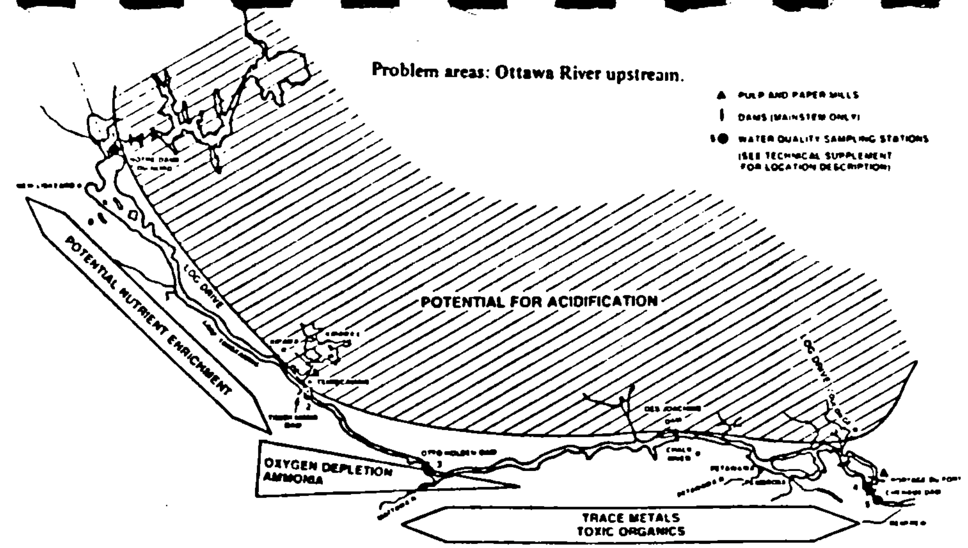
All of the tributaries, excluding the five alkaline tributaries located in Ontario, were classified as either highly sensitive or moderately sensitive to acidic wet and dry deposition based on a alkalinity classification set for the Ottawa River (See section 2.2).

Figure 1.1 Schematic Representation of the Ottawa River Basin



Carbonate and non-carbonate substrate zones in the Ottawa River Basin.

Problem areas: Ottawa River upstream.



Problem areas: Ottawa River downstream.

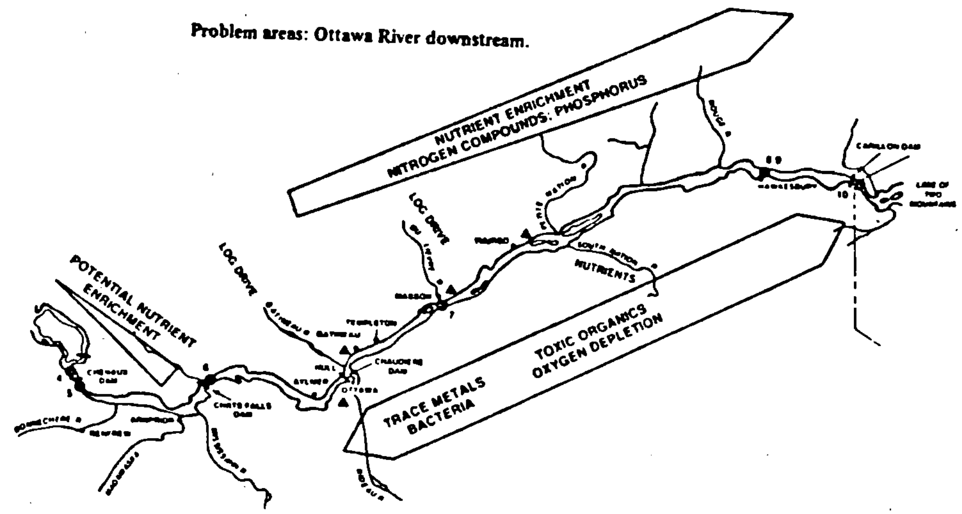


Table 1.1: Mainstem Locations Assessed for Major Ions.

NAQUADAT Code	MEQ Code	Station No.	Site Name	Latitude	Longitude	Description of Site
UPPER PART:						
00PQ02JC0001	04310010	1	Notre-Dame-Du-Nord	47D 35M 21S	79D 29M 6S	Bridge Crossing, downstream from Powerhouse Dam.
00PQ02JE0005	04310009	2	Lake Timiskaming	46D 42M 42S	79D 6M 3S	Dam Outlet from Lake Timiskaming.
00PQ02KC0006	04310008	4	Portage du Fort	45D 35M 3S	76D 40M 31S	Chenaux Dam Outlet from Lac Du Rocher Fendu.
LOWER PART:						
00PQ02LF0005	04310011	7	Masson	45D 31M 22S	76D 24M 39S	Ferry Crossing, Ottawa River near Masson, PQ.
00PQ02LB0009	04310002	10	Carillon Dam	45D 34M 4S	74D 23M 0S	Carillon Dam, reservoir outlet.

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Ontario			Quebec		
NAQUADAT Code	Station No.	Tributary	NAQUADAT Code	Station No.	Tributary
000T02A0002	12	Mattawa	00PQ02JE0004	11	Kipawa
000T02A0003	13	Petawawa	00PQ02KG0003	14	Coulonge
000T02A0005	15	Bonnechere	00PQ02LH0044	19	Gatineau
000T02A0006	16	Madawaska	00PQ02LF0004	20	Lièvre
000T02A0007	17	Mississippi	00PQ02LD0002	21	Petite Nation
000T02A0009	18	Rideau	00PQ02LC0013	23	Rouge
000T02A0010	22	South Nation			

Table 1.3: Dissolved Sodium Mean Values and Standard Deviations at the Mainstem Locations, Ottawa River Basin, for the Period of 1979-1984.

Year/Location	1 Notre-Dame-du-Nord	2 Lake Timiskaming	4 Portage du Fort mg.L-1	7 Masson	10 Carillon Dam
1979	1.30	1.60	2.30	1.80	2.70
1980	1.13 (0.10)4*	1.25 (0.24)4	2.00 (0.84)4	3.03 (1.41)4	3.08 (0.67)4
1981	1.08 (0.15)4	1.30 (0.25)4	1.68 (0.38)4	2.38 (0.41)4	2.98 (0.61)4
1982	1.31 (0.16)16	1.45 (0.22)16	1.95 (0.31)16	2.71 (0.39)15	3.06 (0.73)16
1983	1.34 (0.13)13	2.16 (2.54)17	1.97 (0.29)16	3.12 (0.75)17	3.04 (0.70)17
1984	1.3 (0.20)16	1.6 (0.10)17	1.9 (0.20)17	2.6 (0.90)16	3.1 (0.90)17
1979-1984	1.23 (0.12)5	1.55 (0.37)5	1.90 (0.13)5	2.77 (0.31)5	3.05 (0.05)5

( ) = Standard deviation
* = Number of results

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Season	Location 1 Notre-Dame-du-Nord	 2 Timiskaming Outlet	 4 Portage du Fort $mg.L^{-1}$	 7 Masson	 10 Carillon Dam
Spring	1.31 (0.17)8*	1.39 (0.15)9	1.71 (0.28)10	2.74 (0.57)9	2.84 (0.76)10
Summer	1.30 (0.15)9	1.48 (0.24)11	2.13 (0.46)10	2.36 (0.25)7	2.54 (0.29)7
Fall	1.20 (0.15)8	1.49 (0.25)8	1.90 (0.43)7	2.79 (0.87)11	3.15 (0.68)11
Winter	1.22 (0.21)6	2.71 (3.76)8	1.84 (0.20)7	3.40 (0.54)9	3.13 (0.42)8

( ) = Standard deviation
* = Number of results

Table 1.5: Sodium Mean Values and Standard Deviations for Six Quebec Tributaries, Ottawa River Basin, for the Period 1979-1984.

Station/ Year	11 Kipawa	14 Coulonge	19 Gatineau	20 Lievre ug.L^{-1}	21 Petite Nation	23 Rouge
1979	0.90	1.10	1.10	1.30	3.20	2.30
1980	0.93 (0.29)^{4*}	1.15 (0.87)^{4}	1.45 (0.44)^{4}	1.85 (0.75)^{4}	2.68 (1.43)^{4}	2.47 (1.27)^{3}
1981	0.83 (0.15)^{4}	0.90 (0.18)^{4}	1.08 (0.17)^{4}	1.20 (0.22)^{4}	2.48 (1.14)^{4}	2.05 (0.82)^{4}
1982	1.00 (0.15)^{16}	2.99 (3.66)^{14}	1.17 (0.23)^{15}	1.40 (0.26)^{11}	2.78 (1.26)^{12}	2.03 (0.92)^{10}
1983	1.04 (0.20)^{16}	3.04 (4.10)^{16}	1.18 (0.29)^{15}	1.27 (0.22)^{17}	3.13 (1.32)^{13}	2.26 (0.83)^{14}
1984	1.00 (0.30)^{14}	1.20 (0.60)^{13}	1.30 (0.30)^{17}	1.30 (0.10)^{16}	2.10 (0.70)^{13}	2.00 (0.90)^{15}
1979-1984	0.96 (0.08)^{5}	1.86 (1.06)^{5}	1.24 (0.14)^{5}	1.40 (0.26)^{5}	2.63 (0.38)^{5}	2.16 (0.20)^{5}

( ) = Standard deviation
* = Number of results

[redacted] 1.6[redacted] Chl[redacted] Mea[redacted]alues [redacted]tand[redacted] Devia[redacted] at [redacted]ainst[redacted]ocat[redacted] Otta[redacted]iver [redacted], fo[redacted] Per[redacted]of 19[redacted] 1984[redacted]

Year/Station	1 Notre-Dame-du-Nord	2 Lake Timiskaming	4 Portage du Fort mg.L-1	7 Masson	10 Carillon Dam
1979	0.98 (0.20)^{16*}	1.25 (0.40)^{17}	1.71 (0.40)^{17}	2.11 (1.00)^{17}	3.04 (1.00)^{17}
1980	1.05 (0.42)^{13}	1.10 (0.12)^{16}	1.93 (0.78)^{16}	2.28 (0.55)^{11}	3.05 (1.00)^{15}
1981	0.91 (0.15)^{16}	1.97 (2.25)^{17}	1.72 (0.26)^{17}	2.68 (0.78)^{15}	3.54 (0.88)^{17}
1982	0.91 (0.20)^{16}	1.06 (0.32)^{16}	1.69 (0.45)^{16}	2.98 (0.86)^{15}	3.50 (1.46)^{16}
1983	0.86 (0.15)^{3}	1.19 (0.29)^{17}	1.86 (0.46)^{16}	4.05 (1.68)^{17}	3.48 (1.24)^{17}
1984	1.00 (0.20)^{16}	1.30 (0.40)^{17}	1.90 (0.40)^{17}	3.10 (1.00)^{17}	3.50 (1.00)^{17}
1979-1984	0.95 (0.07)^{6}	1.31 (0.33)^{6}	1.80 (2.11)^{6}	2.87 (0.70)^{6}	3.35 (0.24)^{6}

( ) = Standard deviation
* = Number of results

Table 1.7: Chloride Seasonal Mean Values and Standard Deviations at the Mainstem Locations, Ottawa River Basin, for the Period of 1979 - 1983.

	Location				
Season	Notre-Dame-du-Nord	Timiskaming Outlet	Portage du Fort $mg.L^{-1}$	Masson	Carillon Dam
Spring	0.99 (0.18)8*	1.39 (0.68)9	1.49 (0.30)10	3.48 (1.39)9	3.77 (1.43)10
Summer	0.84 (0.16)10	1.36 (0.60)12	1.81 (0.43)11	2.42 (0.64)11	2.50 (0.70)11
Fall	0.89 (0.17)9	1.11 (0.22)9	1.90 (0.23)8	2.99 (0.36)9	3.84 (1.15)9
Winter	0.90 (0.24)8	1.07 (0.15)9	1.59 (0.38)9	3.92 (1.20)9	3.50 (0.86)9

( ) = Standard deviation
* = Number of results

[redacted] Table 1.[redacted] Chloride Mean Values [redacted] Standard Deviations for [redacted] Quebec Tributaries, [redacted] River Basin, [redacted] the Period 19[redacted]84.

Year/Station	11 Kipawa	14 Coulonge	19 Gatineau	20 Lievre mg.L^{-1}	21 Petite Nation	23 Rouge
1979	0.65 (0.22)^{15*}	0.91 (0.51)^{9}	1.12 (0.31)^{16}	1.38 (0.18)^{8}	3.16 (0.97)^{13}	3.04 (1.81)^{13}
1980	0.65 (0.21)^{17}	1.57 (1.93)^{15}	1.17 (0.43)^{16}	4.09 (4.74)^{8}	3.07 (1.49)^{12}	3.01 (1.29)^{14}
1981	0.86 (0.75)^{16}	2.02 (3.76)^{16}	3.11 (7.71)^{16}	1.34 (0.26)^{15}	2.55 (1.06)^{15}	3.50 (2.37)^{16}
1982	0.56 (0.35)^{16}	3.88 (0.62)^{15}	1.07 (0.36)^{16}	1.40 (0.35)^{12}	3.42 (1.82)^{12}	2.98 (1.72)^{10}
1983	0.67 (0.55)^{16}	4.06 (6.86)^{16}	1.20 (0.43)^{16}	1.18 (0.25)^{17}	3.38 (1.98)^{13}	3.08 (1.27)^{14}
1984	0.60 (0.70)^{14}	1.10 (0.90)^{15}	1.20 (0.50)^{17}	1.40 (0.40)^{16}	2.70 (1.30)^{13}	2.70 (1.40)^{15}
1979-1984	0.67 (0.10)^{6}	2.26 (1.38)^{6}	1.48 (0.80)^{6}	1.80 (1.13)^{6}	3.05 (0.36)^{6}	3.04 (0.26)^{6}

( ) = Standard deviation
* = Number of results

Table 1.9: Calcium Mean Values and Standard Deviations at the Mainstem Locations, Ottawa River Basin, for the Period of 1979 - 1984.

Year/Station	1 Notre-Dame-du-Nord	2 Lake Timiskaming	4 Portage du Fort mg.L-1	7 Masson	10 Carillon Dam
1979	3.56 (0.33)12*	6.09 (0.69)16	5.79 (0.68)17	6.42 (0.87)9	8.21 (1.62)17
1980	4.53 (1.94)12	6.67 (0.69)16	6.33 (0.92)16	7.21 (1.03)11	9.09 (1.73)15
1981	4.15 (2.04)16	6.90 (0.99)17	6.21 (1.14)17	8.97 (2.04)12	9.54 (2.27)17
1982	3.93 (0.68)16	7.46 (0.72)16	6.21 (0.74)16	8.97 (1.76)15	9.54 (2.19)16
1983	3.53 (0.39)13	7.46 (1.46)17	6.51 (0.68)16	9.30 (2.06)17	9.27 (1.86)17
1984	3.73 (0.53)16	7.09 (0.73)17	6.52 (0.64)17	8.51 (2.52)16	9.52 (2.24)17
1979-1984	3.91 (0.39)6	6.79 (0.48)6	6.27 (0.27)6	8.17 (1.11)6	9.27 (0.61)6

( ) = Standard deviation
* = Number of results

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Season	Location Notre-Dame-du-Nord	Timiskaming Outlet	Portage du Fort $mg.L^{-1}$	Masson	Carillon Dam
Spring	3.90 (0.45)^{7*}	5.85 (0.68)^{13}	5.72 (0.83)^{13}	9.05 (3.09)^{8}	9.48 (2.08)^{13}
Summer	3.82 (0.38)^{12}	7.07 (0.81)^{16}	5.84 (0.64)^{16}	6.89 (0.75)^{13}	8.05 (1.57)^{15}
Fall	3.70 (0.56)^{13}	6.95 (0.61)^{14}	6.29 (0.59)^{13}	8.78 (1.91)^{10}	9.71 (2.43)^{14}
Winter	4.81 (2.83)^{13}	6.95 (1.65)^{16}	6.76 (1.02)^{16}	8.96 (1.98)^{10}	9.18 (1.64)^{17}

( ) = Standard deviation
* = Number of results

Table 1.11: Calcium Mean Values and Standard Deviations For Six Québec Tributaries, Ottawa River Basin, for the Period 1979 - 1984.

Year/Station	11 Kipawa	14 Coulonge	19 Gatineau $mg.L^{-1}$	20 Lievre	21 Petite Nation	23 Rouge
1979	2.88 (0.29)16*	3.94 (0.61)9	5.11 (1.31)16	5.85 (0.53)8	8.64 (1.26)13	4.84 (1.32)13
1980	2.89 (0.37)17	5.46 (1.54)15	5.80 (1.48)16	7.38 (3.53)8	9.85 (1.71)12	5.50 (0.86)14
1981	2.53 (0.26)16	4.70 (1.18)16	6.29 (2.89)16	6.31 (0.77)14	9.03 (1.31)16	5.08 (1.41)16
1982	2.66 (0.17)16	5.99 (4.69)14	6.02 (1.59)15	7.22 (0.76)11	10.32 (2.52)12	5.80 (1.61)10
1983	2.77 (0.46)16	5.43 (2.23)16	5.66 (1.13)15	6.66 (0.88)17	10.67 (2.70)13	6.01 (1.23)14
1984	2.61 (0.17)14	4.25 (1.04)13	6.42 (1.31)17	6.87 (0.68)16	9.52 (1.30)13	5.39 (1.24)15
1979-1984	2.72 (0.15)6	4.46 (0.79)6	5.88 (0.48)6	6.72 (0.57)6	9.67 (0.77)6	5.44 (0.44)6

( ) = Standard deviation
* = Number of results

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Year/Station	1 Notre-Dame-du-Nord	2 Lake Timiskaming	4 Portage du Fort mg.L-1	7 Masson	10 Carillon Dam
1979	8.80 (0.80)12*	10.19 (0.65)15	10.62 (0.81)7	8.88 (2.53)9	11.72 (1.49)17
1980	8.22 (0.84)13	8.63 (0.94)16	8.81 (1.06)16	8.10 (1.16)11	9.58 (1.46)15
1981	7.94 (0.64)16	9.75 (2.80)17	9.22 (2.21)17	8.66 (1.11)15	9.92 (1.20)17
1982	7.84 (0.96)16	8.41 (0.66)16	9.00 (1.29)16	9.17 (0.89)15	9.53 (1.8516
1983	7.19 (0.83)13	8.71 (0.70)17	8.88 (1.18)16	9.21 (1.56)17	9.55 (1.72)17
1984	7.4 (0.8)16	8.2 (0.8)17	9.1 (1.3)17	8.9 (2.0)17	9.4 (1.6)17
1979-1984	7.90 (0.58)6	8.98 (0.80)6	9.27 (0.68)6	8.82 (0.41)6	9.95 (0.88)6

( ) = Standard deviation
* = Number of results

Table 1.13: Sulphate Seasonal Mean Values and Standard Deviations at the Mainstem Locations, Ottawa River Basin, for the Period of 1979 - 1983.

Season	Location Notre-Dame-du-Nord	Timiskaming Outlet	Portage du Fort $mg.L^{-1}$	Masson	Carillon Dam
Spring	7.93 (0.87)8*	8.89 (1.16)14	9.37 (1.53)14	8.95 (0.94)10	9.43 (1.56)14
Summer	8.11 (1.13)15	8.39 (0.76)18	8.44 (1.12)18	7.80 (1.05)17	8.97 (1.49)17
Fall	7.80 (0.71)14	9.03 (0.67)15	9.31 (0.92)14	8.70 (1.01)11	10.70 (2.19)15
Winter	8.01 (0.94)17	9.97 (2.58)19	9.74 (1.14)20	9.44 (0.87)13	10.54 (1.35)20

( ) = Standard deviation
* = Number of results

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Year/Station	11 Kipawa	14 Coulonge	19 Gatineau	20 Lievre	21 Petite Nation	23 Rouge
			mg.L^{-1}			
1979	9.97 (0.54) 15*	8.12 (1.15) 9	7.26 (1.18) 16	7.59 (1.19) 8	10.59 (1.26) 13	7.66 (1.53) 13
1980	13.69 (20.71) 17	7.73 (1.53) 15	6.28 (1.32) 16	8.51 (3.54) 7	9.82 (1.13) 12	7.01 (0.89) 14
1981	8.82 (0.87) 16	7.96 (1.33) 16	7.07 (2.43) 16	6.44 (0.96) 15	9.90 (1.31) 15	8.00 (3.03) 16
1982	7.91 (0.69) 16	7.57 (1.41) 15	6.21 (0.75) 16	6.83 (1.01) 12	10.63 (2.78) 12	6.85 (0.58) 10
1983	7.84 (0.63) 16	7.28 (1.69) 16	6.15 (1.04) 16	6.58 (0.96) 17	11.46 (4.01) 13	6.37 (1.12) 14
1984	7.8 (0.9) 14	6.4 (1.0) 15	6.4 (1.3) 17	6.5 (1.1) 16	9.1 (2.7) 13	6.3 (1.4) 15
1979-1984	9.34 (2.29) 16	7.51 (0.62) 6	6.56 (0.48) 6	7.96 (0.82) 6	10.25 (0.82) 6	7.10 (0.63) 6

( ) = Standard deviation
* = Number of results

Table 1.15: Potassium Mean Values and Standard Deviations at the Mainstem Locations, Ottawa River Basin, for the Period of 1979-1984.

Year/Station	1 Notre-Dame-du-Nord	2 Lake Timiskaming	4 Portage du Fort mg.L-1	7 Masson	10 Carillon Dam
1979	0.70	0.80	0.80	0.80	0.80
1980	0.88 $(0.22)^{4*}$	0.95 $(0.38)^{4}$	0.83 $(0.06)^{3}$	1.25 $(0.47)^{4}$	2.65 $(2.39)^{4}$
1981	0.74 $(0.18)^{4}$	0.78 $(0.09)^{4}$	0.81 $(0.07)^{4}$	0.89 $(0.14)^{4}$	1.08 $(0.16)^{4}$
1982	0.86 $(0.35)^{16}$	0.90 $(0.43)^{16}$	0.89 $(0.30)^{15}$	0.97 $(0.30)^{15}$	1.08 $(0.49)^{16}$
1983	0.75 $(0.07)^{13}$	0.81 $(0.10)^{16}$	0.78 $(0.14)^{16}$	0.94 $(0.12)^{17}$	0.95 $(0.20)^{17}$
1984	0.7 $(0.2)^{16}$	0.7 $(0.1)^{17}$	0.7 $(0.1)^{17}$	0.8 $(0.1)^{16}$	0.9 $(0.1)^{17}$
1979-1984	0.78 $(0.08)^{5}$	0.83 $(0.09)^{5}$	0.80 $(0.07)^{5}$	0.97 $(0.17)^{5}$	1.33 $(0.74)^{5}$

( ) = Standard deviation
* = Number of results

Table 1.16: Potassium Seasonal Mean Values and Standard Deviations at the Mainstem Locations, Ottawa River Basin, for the Period of 1979 - 1983.

Season	Location				
	Notre-Dame-du-Nord	Timiskaming Outlet	Portage du Fort $mg.L^{-1}$	Masson	Carillon Dam
Spring	0.79 (0.10)^{8*}	0.93 (0.52)^{9}	0.79 (0.10)^{10}	1.06 (0.22)^{9}	1.16 (0.46)^{10}
Summer	0.79 (0.16)^{9}	0.80 (0.27)^{11}	0.78 (0.04)^{9}	0.81 (0.09)^{9}	0.87 (0.08)^{7}
Fall	1.02 (0.45)^{8}	0.93 (0.36)^{8}	1.06 (0.64)^{7}	1.03 (0.41)^{11}	1.17 (0.48)^{11}
Winter	0.65 (0.08)^{6}	0.84 (0.14)^{8}	0.79 (0.04)^{7}	0.96 (0.13)^{8}	1.56 (1.88)^{8}

( ) = Standard deviation
* = Sample size

Table 1.17: Potassium Mean Values and Standard Deviations for Six Québec Tributaries, Ottawa River Basin, for the Period 1979 - 1984.

Year/ Station	11 Kipawa	14 Coulonge	19 Gatineau	20 Lievre	21 Petite Nation	23 Rouge
			mg.L^{-1}			
1979	0.70	0.70	0.70	0.70	1.10	0.70
1980	0.78 (0.22)^{4*}	0.73 (0.13)^{4}	0.93 (0.36)^{4}	1.23 (0.47)^{4}	1.67 (1.33)^{3}	1.03 (.56)^{4}
1981	0.67 (0.10)^{4}	0.70 (0.09)^{4}	0.67 (0.15)^{4}	0.75 (0.18)^{4}	1.57 (0.64)^{4}	0.74 (.21)^{4}
1982	0.80 (0.30)^{16}	1.01 (0.52)^{14}	0.77 (0.27)^{15}	0.90 (0.33)^{11}	1.38 (0.68)^{12}	0.84 (0.25)^{10}
1983	0.69 (0.12)^{16}	0.52 (0.24)^{16}	0.66 (0.10)^{15}	0.78 (0.10)^{17}	1.34 (0.31)^{13}	0.71 (0.14)^{14}
1984	0.6 (0.0)^{14}	0.6 (0.3)^{13}	0.6 (0.1)^{17}	0.7 (0.1)^{16}	1.0 (0.2)^{13}	0.6 (0.2)^{15}
1979-1984	0.71 (0.08)^{5}	0.78 (0.16)^{5}	0.73 (0.13)^{5}	0.87 (0.21)^{5}	1.39 (0.26)	0.79 (0.16)^{5}

( ) = Standard deviation
* = Number of results

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Year/Station	1 Notre-Dame-du-Nord	2 Lake Timiskaming	4 Portage du Fort mg.L-1	7 Masson	10 Carillon Dam
1979	1.05 (0.12)^{12*}	1.72 (0.14)^{16}	1.59 (0.13)^{17}	1.49 (0.29)^{8}	2.07 (0.54)^{17}
1980	1.36 (0.41)^{12}	1.82 (0.19)^{16}	1.73 (0.13)^{16}	1.60 (0.52)^{11}	2.23 (0.56)^{15}
1981	1.44 (0.50)^{16}	2.06 (0.47)^{17}	1.89 (0.34)^{17}	2.25 (0.49)^{12}	2.77 (0.58)^{17}
1982	1.28 (0.22)^{16}	1.90 (0.14)^{16}	1.74 (0.19)^{16}	2.24 (0.48)^{15}	2.39 (0.72)^{16}
1983	1.21 (0.10)^{3}	2.00 (0.15)^{7}	1.79 (0.16)^{16}	2.39 (0.62)^{13}	2.34 (0.53)^{17}
1984	1.26 (0.17)^{16}	2.02 (0.21)^{17}	1.82 (0.17)^{17}	2.14 (0.68)^{16}	2.35 (0.64)^{17}
1979-1984	1.27 (0.13)^{6}	1.92 (0.13)^{6}	1.76 (0.10)^{6}	2.02 (0.38)^{6}	2.36 (0.23)^{6}

( ) = Standard deviation
* = Number of results

Table 1.19: Magnesium Seasonal Mean Values and Standard Deviations at the Mainstem Locations, Ottawa River Basin, for the Period of 1979 - 1983.

Season	Notre-Dame-du-Nord	Timiskaming Outlet	Portage du Fort mg.L^{-1}	Masson	Carillon Dam
			Location		
Spring	1.44 (0.29)^{12*}	1.92 (0.42)^{18}	1.74 (0.34)^{18}	2.36 (0.68)^{13}	2.64 (0.59)^{18}
Summer	1.30 (0.20)^{16}	1.99 (0.23)^{20}	1.73 (0.21)^{20}	1.68 (0.33)^{14}	2.11 (0.60)^{16}
Fall	1.17 (0.14)^{17}	1.91 (0.20)^{18}	1.67 (0.17)^{17}	2.04 (0.53)^{17}	2.44 (0.74)^{21}
Winter	1.29 (0.54)^{19}	1.79 (0.22)^{21}	1.81 (0.16)^{22}	2.18 (0.68)^{15}	2.21 (0.45)^{22}

( ) = Standard deviation
* = Sample size

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Year/ Station	11 Kipawa	14 Coulonge	19 Gatineau	20 Lievre	21 Petite Nation	23 Rouge
			mg.L^{-1}			
1979	0.71 (0.07)^{16*}	0.78 (0.08)^{9}	0.99 (0.23)^{16}	0.99 (0.10)^{8}	1.62 (0.37)^{13}	0.91 (0.18)^{13}
1980	0.79 (0.07)^{17}	1.11 (0.32)^{15}	1.11 (0.31)^{16}	1.01 (0.53)^{8}	2.16 (1.28)^{11}	1.08 (0.16)^{14}
1981	0.83 (0.13)^{16}	1.09 (0.33)^{16}	1.39 (0.54)^{16}	1.18 (0.25)^{14}	1.89 (0.51)^{16}	1.08 0.33)^{16}
1982	0.74 (0.05)^{16}	1.22 (0.78)^{14}	1.18 (0.22)^{15}	1.21 (0.20)^{11}	1.88 (0.55)^{12}	1.07 (0.26)^{10}
1983	0.76 (0.04)^{16}	1.13 (0.54)^{16}	1.11 (0.21)^{15}	1.09 (0.17)^{13}	2.05 (0.48)^{13}	1.09 (0.30)^{14}
1984	0.74 (0.05)^{14}	0.88 (0.20)^{13}	1.19 (0.13)^{16}	1.12 (0.13)^{16}	1.69 (0.29)^{13}	0.97 (0.22)^{15}
1979-1984	0.76 (0.04)^{76}	1.04 (0.17)^{65}	1.16 (0.14)^{75}	1.10 (0.09)^{53}	1.88 (0.21)^{61}	1.03 (0.07)^{63}

( ) = Standard deviation
* = Number of results

Table 1.21: Bicarbonate Mean Values and Standard Deviations for Five Mainstem Stations, Ottawa River Basin, for the Period of 1979 - 1984.

Year/Station	1 Notre-Dame-du-Nord	2 Lake Timiskaming	4 Portage du Fort $mg.L^{-1}$	7 Masson	10 Carillon Dam
1979	8.20 (0.92)^{7*}	19.86 (4.88)^{10}	20.16 (8.56)^{11}	22.30 (3.42)^{7}	28.64 (9.02)^{12}
1980	9.83 (5.39)^{13}	19.53 (3.69)^{12}	17.00 (2.03)^{13}	20.34 (3.20)^{11}	25.47 (4.48)^{12}
1981	7.95 (2.64)^{17}	18.71 (3.22)^{17}	15.43 (3.67)^{16}	24.23 (10.35)^{15}	31.02 (10.38)^{16}
1982	8.10 (2.64)^{16}	18.66 (2.84)^{16}	15.31 (1.97)^{16}	27.02 (5.98)^{15}	29.00 (8.29)^{16}
1983	6.61 (0.93)^{13}	19.92 (2.93)^{17}	16.91 (2.03)^{16}	28.73 (7.68)^{17}	27.92 (6.74)^{13}
1984	7.2 (1.3)^{16}	20.1 (2.8)^{17}	17.4 (2.8)^{17}	25.5 (8.9)^{17}	28.5 (8.5)^{17}
1979-1984	7.98 (1.09)^{6}	19.46 (0.63)^{6}	17.04 (1.76)^{6}	24.69 (3.07)^{6}	28.43 (1.79)^{6}

( ) = Standard deviation
* = Number of results

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Season	Notre-Dame-du-Nord 1	Timiskaming Outlet 2	Portage du Fort 4	Masson 7	Carillon Dam 10
			mg.L^{-1}		
Spring	8.06 (1.09)8*	15.80 (3.06)8	17.58 (9.92)9	27.23 (7.58)6	32.06 (7.84)10
Summer	8.03 (1.75)11	21.05 (2.12)13	15.76 (2.54)13	21.03 (4.35)13	24.53 (5.13)12
Fall	8.26 (2.47)16	20.27 (2.94)16	15.49 (2.66)16	24.48 (4.49)15	29.93 (11.77)15
Winter	8.99 (5.24)14	17.97 (3.52)15	18.67 (2.38)14	28.19 (12.24)10	27.99 (5.69)16

( ) = Standard deviation
* = Sample size

Table 1.23: Bicarbonate Mean Values and Standard Deviations for Six Quebec Tributary Stations, Ottawa River Basin, for the Period of 1979-1984.

Year/Station	11 Kipawa	14 Coulonge	19 Gatineau $mg.L^{-1}$	20 Lievre	21 Petite Nation	23 Rouge
1979	5.70 (3.86)11*	10.02 (4.50)5	16.36 (4.63)12	18.30 (2.44)4	28.66 (6.84)9	14.50 (3.57)9
1980	4.18 (0.84)11	12.85 (4.48)11	14.90 (6.42)13	15.81 (3.50)4	23.98 (9.79)12	13.03 (3.92)11
1981	3.57 (0.96)16	10.60 (5.55)14	14.32 (3.39)17	15.85 (3.17)14	25.92 (7.51)15	13.74 (4.88)15
1982	2.30 (0.97)16	10.69 (7.23)13	15.64 (4.38)16	19.13 (2.31)12	27.25 (8.15)12	13.33 (6.97)10
1983	2.58 (1.50)16	11.81 (6.79)16	14.74 (4.47)16	16.32 (2.54)17	28.54 (7.57)13	12.84 (4.59)14
1984	2.3 (0.2)14	8.3 (2.5)15	16.7 (4.4)17	17.6 (2.1)16	29.6 (19.0)13	11.8 (3.9)15
1979-1984	3.73 (2.26)51	9.99 (2.12)43	15.22 (4.85)59	17.67 (3.04)31	26.83 (7.95)44	13.67 (4.85)45

( ) = Standard deviation
* = Number of results

Table 1.24: Bicarbonate Concentration Ranges for Thirteen Ottawa River Tributaries and the Mainstem Stations, Ottawa River Basin. ~~Carbonates = zero.~~

Ontario (1971-1981)				Quebec (1979-1983)		
Station (Figure No.)	Tributary	HCO_3^- ($mg.L^{-1}$)	Km*	HCO_3^- ($mg.L^{-1}$)	Station (Figure No.)	Tributary/Mainstem
			0**	3.7-9.8	1	Ottawa River
			120	1.5-6.1	11	Kipawa River
			120**	7.3-25.6	2	Ottawa River
12	Mattawa River	12.2-21.9	184			
13	Petawawa River	7.4-20.7	318			
			385	3.0-23.2	112	Coulonge River
			392**	8.5-21.9	25	Ottawa River
15	Bonnechere River	<u>62.2-123.0</u>	402			
16	Madawaska River	<u>34.1-73.1</u>	424			
17	Mississippi River	<u>92.6-142.0</u>	431			
18	Rideau River	<u>104.8-219.4</u>	466			
			468	9.8-28.0	141	Gatineau River
			495	9.8-25.6	148	du Lièvre River
			498**	11.0-54.9	50	Ottawa River
			521	14.6-43.2	152	Petite Nation River
22	South Nation River	<u>95.1-284.0</u>	522			
			564	5.1-24.4	156	Rouge River
			592**	13.4-52.4	81	Ottawa River

* Approximate distance downstream from Station 1 (Notre-Dame-du-Nord).
** Ottawa River Mainstem Station
___ Tributary drainage area underlain by limestone, marble and/or dolomite bedrock (50% - 100%).

Note. All carbonate concentrations were zero.

2.0 Parameters Related To Acid Rain

2.1 Introduction

The "acid rain" falling directly on aquatic ecosystems and the runoff from land receiving acidic deposition alter the chemistry of the receiving lakes and streams. This section evaluates the spatial, temporal and seasonal variations of pH, hardness and alkalinity, water quality parameters directly affected by acid deposition and runoff. The sensitivity of the Ottawa River to acid rain, especially in the upper reaches of the river, is also discussed.

In 1979, it was recognized that the alkalinity of the upper part of the Ottawa River, above Chenaux Dam, is the most susceptible to acid rain, because it is overlying siliceous bedrock (FPTWG, 1980). The total alkalinity determined in 1976 had not changed from the 1970 value, but the levels were low (20 $mg.L^{-1}$ as $CaCO_3$), enough to regard this reach of the river as susceptible to inputs of acidic precipitation (Galloway and Cowling, 1978).

Very few changes occurred in the hardness and pH ranges recorded in the upper Ottawa River (Lake Timiskaming to Chenaux Dam) from 1947 to 1970. During that period the total hardness values ranged from 26 to 37 $mg.L^{-1}$ and pH from 6.5 to 7.3 (Thomas, 1948 and 1963; OWRC, 1972).

Upstream of Lake Timiskaming, in the Quinze River, total hardness (10.6 - 19.9 $mg.L^{-1}$) and pH (6.1-7.2) were lower than the values for the rest of the Ottawa River, thus making this area more sensitive to acid rain.

The downstream part of the Ottawa River was considered to be least sensitive to acid loadings (OWRC, 1972). As in the upper part of the river, there were no significant changes in the pH and total hardness values measured in the Ottawa area from 1947 to 1970. The pH ranged from 7.0 to 7.9 and hardness values from 22 to 48 $mg.L^{-1}$. Alkalinity measurements recorded in the lower Ottawa River ranged from 16 to 32 $mg.L^{-1}$ (Thomas 1948; OWRC 1972).

Sources of Data

Both OMOE and MEQ measured the pH at locations on the mainstem of the Ottawa River and its tributaries. Most of these locations are listed in tables 1.1. and 1.2. The OMOE mainstem locations not included in these tables, are given in table 2.1.

The screening procedures and the statistical analysis were as described in section 1.1.2 for major ions.

2.2 pH

A pH range of 5-9 does not have any direct detrimental affects on fish. pH changes within this range, however, affect the toxicity of several common pollutants, such as heavy metals. Increasing acidity or alkalinity may make these substances more toxic (Alabaster and Lloyd, 1982).

2.2.1 Mainstem

Spatial Variation

Annual median pH values at the mainstem locations for the period 1979-1984 are summarized in table 2.2. Duncan's Multiple Range test indicated significant differences between the pH values of some of the stations (Figure 2.1).

The lowest mainstem pH values were recorded at Notre-Dame-du-Nord (Station 1). Anthropogenic influences affecting the pH levels at this location are small consisting of the small community of Notre-Dame-du-Nord and some sparsely distributed mining activities.

Slightly higher pH values were measured 120 Km downstream, at the Lake Timiskaming outlet (Station 2). OMOE data indicated high conductivity (195 umhos/cm), turbidity (37 FTU) and pH (7.78) values in the tributaries draining the rural area located northwest of Lake Timiskaming (OMOE, 1980). This influence and the impoundment characteristics of Lake Timiskaming probably improved the buffering capabilities of the lake water.

Minimal pH fluctuations occurred in a downstream direction from Lake Timiskaming to Portage du Fort. Most annual median values observed at Portage du Fort were less than the Lake Timiskaming levels, probably a result of the prevalent acidic drainage from the tributaries, the consistent acidic precipitation (median pH = 4.0; NAQUADAT, 1985), and the lack of any major buffering influences of the Canadian Shield in the 300 km reach of the upper Ottawa River from Lake Timiskaming to Chenaux Dam.

The median pH values in the Ottawa River, below Chenaux Dam, were higher than those in the upper part of the river. The highest mainstem pH, 8.7, was observed at Hawkesbury sampling locations (Station 8 and 9). This low H^+ concentration may have been caused by a number of factors, including vigorous photosynthetic activity by aquatic plants coupled with high temperature, supersaturation of dissolved gases, and direct discharge of wastes from anthropogenic sources.

Low pH values were found in the main channel at Perley Bridge - Hawkesbury (Station 8) in the period of August to October 1982 (Table 2.3). They were probably due to the Canadian International Paper (CIP) mill, located immediately upstream, and the Hawkesbury Sewage Treatment Plant effluent, which discharges downstream from CIP and may have influenced the water quality of the CIP plume. Data show that the mean pH of the CIP final discharge from their lagoon treatment system was 3.3 in October and December 1981 (OMOE, 1982). In December, 1982, the CIP mill was closed. In subsequent years (1983-1984) the pH in the Ottawa River adjacent to the abandoned plant site, increased; it ranged from 6.8 to 7.7, (OMOE, 1985).

Temporal Variation

In 1947, the pH values of Lake Timiskaming ranged from 6.6 to 7.4 (Thomas, 1948). In 1969 and 1970 the pH observed in the upper reach of the Ottawa River (Timiskaming Dam to Portage du Fort) was 7.2 to 8.0 (OWRC, 1972). These ranges were higher than the ranges recorded in this study (1979-1984) at the Lake Timiskaming outlet (6.4 to 8.0) and Portage du Fort area (5.6 to 7.7).

During the 1981 to 1983 period, the pH levels in the upper river increased significantly only at Chenaux Dam (Figure 2.2). This was probably caused by the high and variable alkalinity concentrations observed in the headpond of the Dam during this time, probably due to the discharge characteristics of the dam outlet and upstream sources of alkalinity.

In the lower Ottawa River (Chats Falls - Station 6 to Carillon Dam - Station 10), the same or approximately the same pH range was recorded as that observed in earlier studies, i.e. in the Ottawa area in the 1947 study (7.0-7.7; Thomas 1948) and 1968-1970 study in the lower Ottawa River (6.9-7.9; OWRC 1972).

Seasonal Variation

Seasonal median pH values are listed in Table 2.4. There were no significant seasonal differences in pH in either the upper or lower Ottawa River.

Conclusions

The pH range of values recorded throughout the Ottawa River from 1979 to 1984 were similar to previously reported findings in 1947 and 1970. In the 1981-1983 period only the Chenaux Dam pH values showed a statistically significant increase. This was a result of high and variable alkalinity concentrations in the headpond of Chenaux Dam at that time.

Low buffering capacity coupled with acidic drainage waters and atmospheric deposition were the main factors contributing to the relatively low pH levels in the upper Ottawa River. The low pH values in the Notre-Dame-du-Nord area may warrant concern regarding other environmental variables, such as metals.

The lower Ottawa River the pH values were influenced by the acidic drainage originating from the upper Ottawa River and the Quebec tributaries. Contributions of alkaline waters from the Ontario tributaries buffered this influence. Consequently, median pH levels recorded in the lower Ottawa River were slightly higher than in the upper reaches of the river.

Anthropogenic sources of organic and inorganic compounds were prominent influences on the low pH levels recorded along the nearshore areas in the vicinity of the major urban centres in the lower Ottawa River, e.g. CIP - Hawkesbury, Ontario.

2.2.2 Tributaries

Annual median pH values for the 13 Ottawa River tributaries, which were monitored, are summarized in table 2.5. The pH levels of the Ontario tributaries were significantly higher than those of Quebec tributaries. In the lower Ottawa River, this reflects the limestone and dolomite contributions of $CaCO_3$. The Ontario tributaries had also high concentrations of other major ions (See Chapter 1.0). The annual median pH showed low variability in each tributary during the 5-year period.

The pH values of the Petite Nation River (Station 21), ranging from 4.50 to 8.00 during the period of 1979-1983, were significantly higher than the other Quebec tributaries. This river predominately drains the Canadian Shield. At its mouth, however, where the sampling site is located, the bedrock material changes from granitic gneiss to carbonate rich quartzose sandstone and marine clay deposits.

Kipawa River (Station 11) pH values, ranging from 5.5 to 7.3, were significantly lower than the other tributaries' pH levels ($P<0.05$). This river drains granitic bedrock material and receives water from an acid stressed lake.

The pH values of the Quebec tributaries Rouge, Lièvre and Gatineau Rivers were lower (range 5.8 - 8.0) during this study than the reported values of the 1969-1970 study (range 6.9 - 8.3) (OWRC, 1972). The pH range for the Ontario tributaries were similar in the two studies, with the exception of the Petawawa and Mattawa Rivers which were slightly higher in the 1970 study.

Comparison with Water Quality Objective

The tentative pH water quality objective for the Ottawa River was set at 6.5 - 9.0. In seven of the ten mainstem stations and seven of the thirteen tributaries monitored several of the recorded pH values were below 6.5 (Table 2.1). Twenty-two percent of the pH results observed at the mainstem surveillance stations during the 5-year study period were below pH 7.0.

2.3 Total Hardness

The hardness contributes to the protection of aquatic life by attenuating the changes in pH. Calcium and magnesium, the "hardness" ions, usually combined with bicarbonate and carbonate, together with other ions (e.g. chloride, sulphate and sodium) form a good buffer system. Calcium and magnesium also affect the rate of respiration in certain invertebrates and fish and have an alternating effect on the toxicity of some heavy metals, such as lead.

2.3.1 Mainstem

Spatial Variation

Total hardness concentrations are summarized in Table 2.6. The Notre-Dame-du-Nord (Station 1) mean total hardness concentration (15.4 $mg.L^{-1}$ as $CaCO_3$) was the lowest amongst the mainstem stations. The highest values throughout the 1979-1983 period were observed at Carillon Dam (Station 10). The 5-year mean increased by 110% from Notre-Dame-du-Nord to Carillon Dam.

The smaller total hardness values in the upper Ottawa River, compared to the lower reaches of the river, were attributed to the lack of Ca^{+2} and Mg^{+2} contributions from the Canadian Shield in the upper reaches of the river. The total hardness in the lower Ottawa River was influenced by both the alkaline waters of the Ontario tributaries, dominating this reach of the river, and various anthropogenic source inputs, e.g. Ottawa-Hull area.

Temporal Variation

Total hardness annual mean values were similar at all mainstem stations with the exception of Masson (Station 7) during the study period. At this location the total hardness annual mean increased by over 50% during the period 1979 to 1983. This increase was probably related to the drainage from the Ottawa-Hull region and tributaries located upstream from Masson.

In August 1947, the total hardness of Lake Timiskaming was 28.3 $mg.L^{-1}$ and the total hardness range at the Timiskaming dam discharge was 21.6 - 37.5 $mg.L^{-1}$ (Thomas, 1948). These values were similar to the total hardness means in 1969 and 1970 in Lake Timiskaming (34 and 27 $mg.L^{-1}$, respectively). Comparable concentrations (26 - 33 $mg.L^{-1}$) occurred downstream at Chenaux Dam (Station 4), Masson (29 $mg.L^{-1}$) and Carillon Dam (31-37 $mg.L^{-1}$) (OWRC, 1972). At Petawawa, during the 1959 to 1961 period, the hardness ranged from 26 to 37 $mg.L^{-1}$ (Thomas, 1963). All of these earlier values are comparable to the values found in this study.

In conclusion, the total hardness values calculated in this study, from Lake Timiskaming to Carillon Dam, did not significantly differ from previous studies in 1947, 1959-1961 and 1969-1970.

Seasonal Variation

Seasonal total hardness concentrations are summarized in Table 2.7. The largest differences between the seasonal means were at Masson and Carillon Dam where the summer values were lower than the means for the other seasons.

2.3.2 Tributaries

The annual mean total hardness for six Quebec tributaries are listed in Table 2.8. The Kipawa River's (Station 11) hardness levels were the lowest amongst the six tributaries. The highest values occurred in the Petite Nation River (Station 21).

The lack of Ca^{+2} and Mg^{+2} contributions from the granitic shield area explain the low hardness values recorded in the Kipawa River. The high hardness concentrations observed in the Petite Nation River may be the result of the marine clay dominating the mouth of this tributary. This station location may not be representative of the ambient water quality conditions prevalent in the headwaters of this tributary.

Total hardness concentrations recorded in 1969 and 1970 from the Rouge, Lièvre and Gatineau Rivers ranged from 14 to 48 $mg.L^{-1}$ (OWRC, 1972). These mean levels were slightly higher than the values reported in this study.

The low hardness levels of the upper Ottawa River (Notre-Dame-du-Nord) and a number of Quebec tributaries (e.g. Kipawa River) could be detrimental to aquatic life.

2.4 Alkalinity

Alkalinity reflects the combined concentrations of carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-) ions. These two ions contribute to the buffer capacity of the aquatic system. Atmospheric deposition of strong acids and strong acid precursors on the Ottawa River (median rain pH = 4.0) can alter the chemistry of low buffered waters.

The change in the buffer capacity may have direct effects on the aquatic biota and indirect effects on organisms dependent upon aquatic biota. Some of the effects of acidification on the aquatic biota are the result of H^+ toxicity and of the toxicity of metals leached from the sediments due to the increased H^+ concentration. Bacteria, macrophytes, benthic algae, phytoplankton, zooplankton, benthic macroinvertebrates and fish can be effected by this acidification process (Dillon et al. 1983).

2.4.1 Mainstem

Spatial Variation

Annual mean alkalinity values are summarized in Table 2.9. The alkalinity values were significantly different at some of the 10 mainstem stations during the 5-year period. The results of the Duncan's Multiple Range Test are shown in Figure 2.1.

The 5-year mean alkalinity level increased in a downstream direction from Notre-Dame-du-Nord (Station 1) reaching a maximum at Chenaux Dam (Station 5) then decreasing to Carillon Dam (Station 10). Because of their low alkalinity, the upper reaches of the Ottawa River are considered moderately sensitive to acid rain. The lower Ottawa River was the least sensitive to acid rain.

The Chenaux Dam's high alkalinity and high variability may relate to a number of natural (eg. seasonal flow) and anthropogenic (eg. impoundment discharge) influences. The frequency of sampling in this reach of the Ottawa River was inadequate to determine the exact cause of the high variability.

The rise in alkalinity in a downstream direction may be attributed to a series of environmental factors, including an increase in the number of alkaline tributary sources, urban centres, rural developments and impoundments located along the length of the lower Ottawa River.

Temporal Variation

The data shows significant changes from 1979 to 1983 at three monitoring stations, Masson (Figure 2.3), Chenaux Dam discharge (Figure 2.4) and headpond (Figure 2.5). At Masson, the alkalinity increase, by 44% from 1979 to 1983. This increase may be related to weathering of the limestone bedrock, loading from alkaline tributary sources located in Ontario and urban point and non-point source runoff. There is no ready explanation of why the values and the trends at the Chenaux Dam headpond (Station 5) and discharge (Station 4) sampling points are so different. The fact that the 2 sites were sampled and analysed by different agencies can be a significant factor in this apparent disaepary. To confirm this difference and to be able to say whether or not physical, chemical and biological phenomena contribute to the difference and by how much require additional intensive surveys.

At Chenaux Dam, differences occurred in the headpond versus the discharge. Alkalinity increased in the headpond and decreased in the dam's discharge. The non significant annual decrease in alkalinity in the upper reaches of the Ottawa River could be due to the contribution of acidic deposition depressing available buffering agents.

Seasonal Variation

Significant seasonal variation occurred at the headpond of Chenaux Dam (Station 5) and discharge of Chats Falls Dam (Station 6). These stations are affected by dam flow regulation and not greatly influenced by industrial pollution.

Spring and winter values determined in the headpond of Chenaux Dam were unusually high and alkalinity data at this site were highly variable (Table 2.10). The sampling frequency at this station was inadequate for explaining the unusual alkalinity results determined by OMOE.

Although not always statistically significant, the summer alkalinity values at the stations below Chenaux Dam were lower than the values for the other seasons of the year. This was probably due to the reduced flows from the alkaline Ontario tributaries during the summer period and the precipitation of $CaCO_3$ during the summer period related to active photosynthesis.

2.4.2 Tributaries

Annual mean alkalinity concentrations for the Ontario and Quebec tributaries are summarized in Tables 2.11 and 2.12. The Quebec tributaries' alkalinity values were significantly lower than the values recorded for the Ontario tributaries, with the exception of Mattawa River (Station 12) and Petawawa River (Station 13). The Quebec tributaries and the Mattawa and Petawawa Rivers drain primarily granitoid bedrock of the Canadian Shield. Their annual mean alkalinity range was 1.67 - 23.57 $mg.L^{-1}$. These rivers can be classified as extremely sensitive (e.g. Kipawa River) or moderately sensitive to acid rain according to the criteria used by the Quebec and Ontario governments (See section 2.4.3).

The remaining Ontario tributaries (Bonnechere, Madawaska, Mississipi, Rideau and South Nation Rivers) drain limestone, marble and dolomite bedrock, including marine clay overburden in the vicinity of the South Nation River. Annual mean alkalinity values for these tributaries ranged from 34.2 to 186.0 $mg.L^{-1}$. These rivers are classified as not sensitive to acid rain.

Kipawa River (Station 11) was the only tributary showing a consistent downward trend in the mean alkalinity from 1979 to 1983 (Figure 2.6). This might reflect an ongoing acidification process in the river and its headwaters.

2.4.3 Sensitivity to Acid Rain

The Ontario and Quebec governments classify the sensitivity to acid rain of surface waters based on the following classification:

Sensitivity to Acid Rain	Alkalinity (as $mg.L^{-1}$ $CaCO_3$)
. Acidified	< 0
. Extreme Sensitivity	0 - 2.0
. Moderate Sensitivity	> 2.0 - 10.0
. Low Sensitivity	>10.0 - 25.0
. Not Sensitive	>25.0

Given this classification, only the Kipawa River would fall into the category of extreme sensitivity to acid rain. The remaining monitored tributaries and mainstem stations can be considered moderate (Notre-Dame-du-Nord and the Coulonge River) to not sensitive to acid rain.

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NAQUADAT Code	OMOE Code	Station	Site Name	Latitude	Longitude	Description of Site
OTO20A0001	18-0000-360-02	3	Otto Holden Dam	46D 22M 42.80S	078D 43M 39.67S	400 m from the PQ Shoreline
OTO20A0004	18-0000-240-02	5	Chenaux Dam	45D 35M 35.60S	076D 40M 27.70S	240 m from the PQ shoreline, Headpond of Chenaux Dam
OTO20A0008	18-0000-170-02	6	Chats Falls Dam	45D 28M 26.47S	076D 14M 52.81S	300 m from PQ shoreline
OTO20A0011	18-0000-078-83	8	Hawkesbury-Perley Bridge	45D 37M 05.89S	074D 35M 58.21S	Midchannel from Perley Bridge
OTO20A0012	18-0000-051082	9	Hawesbury - Channels 1&2	45D 36M 47.33S	074D 36M 19.11S	Composite sample nearshore channel on Ontario side

Table 2.2: Annual Median and Range of pH Values for 10 Mainstem Stations in the Ottawa River Basin for the Period 1979 to 1984.

Year	Station 1 Notre-Dame-du-Nord	2 Lake Timiskaming	3+ Otto Holden Dam	5+ Chenaux Dam	4 Portage du Fort	6+ Chats Falls	7 Masson	8+ Hawkesbury Perley Bridge	9+ Hawkesbury Channel 1&2	10 Carillon Dam
1979	6.60 (6.30-6.90)^{7*}	7.15 (6.70-7.40)^{10}	NS	NS	6.90 (6.00-7.70)^{11}	NS	7.00 (6.80-7.30)^{7}	NS	NS	7.05 (6.70-7.40)^{12}
1980	6.70 (5.50-7.10)^{13}	7.00 (6.50-7.20)^{12}	6.87 (6.33-7.20)^{8}	7.25 (7.10-7.40)^{2}	7.00 (6.50-7.30)^{13}	NS	7.00 (6.30-7.10)^{11}	NS	NS	7.05 (6.30-7.30)^{12}
1981	6.60 (6.20-6.80)^{17}	7.00 (6.40-7.40)^{17}	7.15 (6.57-7.75)^{10}	7.10 (6.70-7.40)^{8}	6.90 (6.40-7.20)^{16}	7.40 (7.10-7.81)^{8}	7.10 (6.70-7.50)^{15}	7.00 (7.00-7.10)^{3}	7.20 (6.90-7.70)^{3}	7.10 (6.40-7.30)^{16}
1982	6.85 (6.60-7.20)^{16}	7.30 (6.80-7.40)^{16}	7.25 (6.72-7.42)^{10}	7.70 (7.12-8.32)^{12}	7.15 (6.50-7.40)^{16}	7.66 (7.05-7.78)^{12}	7.30 (7.10-7.60)^{15}	7.10 (5.87-7.90)^{8}	7.25 (7.00-8.00)^{8}	7.20 (6.90-7.60)^{16}
1983	6.70 (6.40-6.90)^{13}	7.20 (6.90-7.40)^{17}	7.10 (6.80-7.27)^{9}	7.80 (7.30-8.15)^{11}	7.10 (6.80-7.30)^{16}	7.65 (7.24-7.73)^{10}	7.30 (7.09-7.40)^{17}	7.19 (6.90-8.70)^{7}	7.30 (7.10-8.70)^{7}	7.30 (7.00-7.40)^{17}
1984	6.70 (6.40-7.10)^{16}	7.10 (6.90-7.50)^{17}	7.08 (6.85-7.26)^{10}	7.56 (7.18-7.83)^{6}	6.90 (6.70-8.20)^{17}	7.70 (7.40-7.88)^{6}	7.10 (6.30-7.60)^{17}	7.38 (2.28-8.24)^{6**}	7.21 (2.35-7.60)^{6**}	7.10 (6.80-7.50)^{17}
1979-1984	6.60 (5.50-7.50)^{82}	7.05 (6.40-8.00)^{89}	7.00 (6.33-7.75)^{47}	7.70 (6.70-8.32)^{39}	6.90 (5.60-7.70)^{89}	7.60 (7.10-7.78)^{36}	7.05 (6.10-7.70)^{82}	7.10 (2.28-8.70)^{24}	7.25 (2.35-8.70)^{24}	7.05 (6.30-7.60)^{90}

( ) = concentration range
* = number of results
\+ = OMOE station; all others are MEQ stations
NS = not sampled
** = minimum pH values of 2.28, observed at Station 8, and 2.35, observed at Station 9 were considered outliers (ie. effluent slug).

Table 2.3: Ottawa River Mainstem pH Values recorded at Hawkesbury - Perley Bridge - Station 8 (OMOE data)

	YEAR			
	1981	1982	1983	1984
July	NS	7.13	7.14	7.46
August	NS	5.87	8.70	7.18
September	7.00	6.00	6.90	7.40
October	7.00	5.94	7.40	NS
November	NS	7.30	7.20	7.24

NS = not sampled

Table 2.4: Seasonal Median pH Values and Concentration Ranges at 10 Mainstem Locations in the Ottawa River Basin for the Period 1979 to 1984^{+}.

Season	1 Notre-Dame-du-Nord	2 Lake Timiskaming	3^{+} Otto Holden Dam	4 Portage du Fort	Station 5^{+} Chenaux Dam	6^{+} Chats Falls	7 Masson	8^{+} Hawkesbury Perley Bridge	9^{+} Hawkesbury Channel 1&2	10 Carillon Dam
Spring	6.65 (6.50-7.20)^{14*}	6.95 (6.50-7.40)^{14}	7.18 (6.80-7.35)^{18}	6.90 (6.50-7.70)^{15}	7.72 (6.70-8.06)^{7}	7.60 (7.10-7.74)^{5}	7.20 (6.80-7.40)^{8}	7.19 (2.28-8.24)^{5}	7.40 (7.40-7.50)^{3}	7.20 (6.80-7.40)^{16}
Summer	6.80 (5.50-7.40)^{16}	7.05 (6.60-7.80)^{8}	7.09 (6.80-7.42)^{16}	7.10 (6.50-7.40)^{18}	7.25 (7.80-7.85)^{9}	7.42 (7.30-7.50)^{9}	7.10 (6.70-7.40)^{13}	7.18 (5.87-8.70)^{9}	7.15 (7.00-8.70)^{6}	7.00 (6.40-7.20)^{13}
Fall	6.70 (6.20-7.50)^{23}	7.15 (6.40-8.00)^{22}	6.99 (6.33-7.39)^{17}	7.00 (6.00-7.70)^{22}	7.43 (7.20-7.99)^{11}	7.68 (7.50-7.81)^{10}	7.00 (6.30-7.50)^{25}	7.17 (5.90-7.40)^{10}	7.30 (6.90-7.70)^{8}	7.10 (6.30-7.60)^{25}
Winter	6.60 (6.00-7.20)^{20}	7.05 (6.60-7.40)^{20}	7.27 (6.57-7.75)^{5}	6.95 (6.50-7.30)^{20}	7.77 (7.10-8.32)^{12}	7.60 (7.05-7.88)^{12}	7.10 (6.10-7.70)^{17}	7.90	8.00	7.10 (6.40-7.50)^{21}

( ) = concentration range
* = number of results
\+ = OMOE stations - 1979-1984 data; Hawkesbury (Channel 1&2) = 1981-1983 data; all others MEQ stations - 1979-1983 data

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Year	11 Kipawa	12+ Mattawa	13+ Petawawa	14 Coulonge	15+ Bonnechere	16+ Madawaska	17+ Mississippi	18+ Rideau	19 Gatineau	20 Lièvre
1979	6.70 (5.60-7.00)^{11*}	NS	7.05 (6.80-7.50)^{4}	6.90 (6.00-7.80)^{5}	7.80 (7.40-7.90)^{3}	7.60 (7.30-7.90)^{5}	NS	7.90 (7.80-8.20)^{3}	7.30 (6.70-7.20)^{12}	7.00 (6.00-7.40)^{4}
1980	6.90 (5.60-7.00)^{11}	7.10 (6.40-7.30)^{8}	7.70	6.50 (5.90-7.30)^{13}	7.70 (7.70)^{2}	7.50 (7.20-7.80)^{9}	NS	7.80 (7.80)^{2}	7.30 (6.10-7.30)^{13}	6.90 (4.00-7.20)^{5}
1981	6.70 (5.50-7.20)^{16}	7.20 (6.70-7.50)^{9}	7.05 (6.80-7.80)^{4}	7.00 (6.30-7.70)^{15}	7.80 (7.10-7.90)^{9}	7.60 (7.30-7.70)^{9}	7.90 (7.60-8.30)^{7}	7.90 (7.60-8.00)^{8}	7.30 (6.50-7.80)^{17}	6.90 (6.50-7.80)^{14}
1982	7.00 (6.00-7.30)^{16}	7.27 (6.65-7.41)^{9}	7.35 (6.70-7.68)^{15}	7.15 (6.30-7.80)^{15}	7.84 (7.31-8.28)^{12}	7.78 (7.54-8.04)^{12}	8.06 (7.50-8.30)^{12}	8.12 (7.04-8.64)^{10}	7.50 (6.10-7.50)^{16}	7.00 (6.30-7.30)^{12}
1983	6.80 (5.70-6.30)^{16}	7.05 (6.65-7.28)^{9}	7.15 (7.00-7.70)^{6}	7.00 (6.40-8.00)^{16}	7.89 (7.54-8.06)^{12}	7.82 (7.55-7.92)^{11}	8.05 (7.81-8.18)^{12}	7.86 (7.56-8.43)^{9}	7.40 (6.80-7.20)^{16}	7.00 (6.60-7.10)^{17}
1984	6.30 (6.00-7.10)^{14}	7.17 (6.97-7.44)^{9}	7.14 (6.65-9.54)^{10}	6.90 (6.50-8.10)^{15}	7.81 (7.70-7.93)^{6}	8.25 (7.37-8.21)^{8}	8.05 (7.99-8.26)^{8}	8.02 (7.67-8.24)^{11}	7.00 (6.70-7.20)^{17}	7.00 (6.80-7.20)^{16}
1979-1984	6.20 (5.50-7.30)^{84}	7.10 (6.40-7.50)^{35}	7.10 (6.65-9.54)^{34}	6.90 (5.90-8.00)^{79}	7.80 (6.10-8.28)^{44}	7.60 (7.20-8.04)^{44}	8.00 (7.50-8.30)^{39}	7.90 (7.04-8.64)^{43}	7.00 (6.10-7.80)^{91}	7.00 (4.00-7.80)^{68}

( ) = concentration range
* = number of results
\+ = OMOE station; all others MEQ stations
NS = not sampled

	21 Petite Nation	22+ South Nation	23 Rouge
1979	7.30 (6.50-7.80)^{9}	7.75 (7.70-7.80)^{2}	7.00 (6.60-7.30)^{9}
1980	7.30 (4.50-8.00)^{12}	7.70 (7.70-7.70)^{3}	6.90 (5.80-7.40)^{11}
1981	7.30 (6.60-7.80)^{15}	7.80 (6.90-8.10)^{8}	6.90 (6.40-8.00)^{15}
1982	7.50 (7.00-7.70)^{12}	8.07 (7.61-8.47)^{10}	7.00 (6.70-7.70)^{10}
1983	7.40 (6.50-7.20)^{13}	7.93 (7.29-9.00)^{11}	7.00 (6.80-7.10)^{14}
1984	7.30 (7.00-7.50)^{13}	7.90 (7.42-8.47)^{10}	6.90 (6.50-7.30)^{15}
1979-1984	7.30 (4.50-8.00)^{74}	7.80 (6.90-9.00)^{44}	7.00 (5.80-8.00)^{74}

[redacted] 2.6 [redacted] An[redacted]ean [redacted] Har[redacted]* ([redacted]-1 [redacted]) fo[redacted]Q M[redacted]em S[redacted]s i[redacted] Ott[redacted]iver [redacted], fo[redacted] Per[redacted]f 19[redacted]1983. [redacted]

Year	Station 1 Notre-Dame-du-Nord	2 Lake Timiskaming	4 Portage du Fort	7 Masson	10 Carillon Dam
			($mg \cdot L^{-1}$ $CaCO_3$)		
1979	13.27 (1.04)	22.33 (2.45)	21.05 (1.99)	21.66 (2.45)	29.11 (6.72)
1980	17.94 (7.48)	24.17 (1.88)	22.80 (2.69)	23.34 (3.59)	31.33 (6.39)
1981	16.74 (7.90)	24.51 (4.70)	23.49 (4.49)	31.06 (8.04)	35.95 (7.76)
1982	14.93 (1.96)	25.20 (2.50)	22.42 (2.90)	31.12 (6.17)	34.33 (6.70)
1983	13.99 (1.64)	27.32 (4.97)	23.18 (2.52)	33.52 (8.31)	30.98 (6.03)
1979-1983	15.37 (2.03)	24.70 (2.04)	21.62 (2.46)	28.13 (5.30)	32.33 (2.84)

( ) = standard deviation

* Hardness annual means were calculated by summing the annual mean concentration of magnesium and calcium multiplied by 4.116 and 2.497, respectively.

Table 2.7 : Seasonal Mean Total Hardness* ~~(in mg.L^{-1} $CaCO_3$)~~ at 5 Mainstem Locations in the Ottawa River Basin, for the Period of 1979 - 1983.

Seasons	Station 1 Notre-Dame-du-Nord	2 Lake Timiskaming	4 Portage du Fort	7 Masson	10 Carillon Dam
			(mg.L^{-1} $CaCO_3$)		
Spring	15.67 (2.31)	22.51 (3.43)	21.44 (3.47)	32.31 (13.99)	34.54 (7.62)
Summer	13.66 (1.77)	25.84 (2.97)	21.70 (2.46)	24.11 (3.23)	28.78 (6.39)
Fall	15.50 (1.98)	25.21 (4.32)	22.58 (2.17)	30.31 (6.95)	34.29 (9.12)
Winter	17.32 (9.29)	24.72 (5.03)	24.33 (3.21)	31.34 (7.74)	32.02 (5.95)

( ) = standard deviation
* Calculated by summing the seasonal mean concentration of magnesium and calcium multiplied by 4.116 and 2.497, respectively.

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Year	11 Kipawa	14 Coulonge	19 Gatineau	20 Lievre	21 Petite Nation	23 Rouge
			Station			
			mg·L⁻¹ CaCO₃			
1979	10.11 (1.91)	12.83 (1.30)	16.78 (4.17)	18.30 (2.11)	28.29 (4.62)	15.64 (4.66)
1980	10.47 (1.19)	18.58 (5.24)	18.75 (5.40)	22.64 (15.61)	33.31 (9.56)	17.91 (2.16)
1981	9.64 (1.19)	15.35 (5.80)	21.93 (10.51)	20.62 (2.95)	29.58 (4.92)	16.27 (4.71)
1982	9.67 (0.61)	16.86 (8.08)	19.21 (4.56)	22.93 (3.14)	34.93 (8.13)	19.23 (4.79)
1983	9.77 (0.63)	19.60 (8.54)	19.09 (3.96)	21.04 (3.11)	33.84 (9.32)	19.68 (4.52)
1979-1983	9.93 (0.35)	16.64 (2.68)	19.15 (1.84)	21.11 (1.86)	31.99 (2.89)	17.75 (1.77)

( ) = standard deviation

* Hardness Seasonal means were calculated by summing the annual mean concentration of magnesium and calcium multiplied by 4.116 and 2.497, respectively.

Table 2.9: Annual Mean Alkalinity ~~(in mg.L^{-1} $CaCO_3$)~~ at 10 Mainstem Locations in the Ottawa River Basin for the Period 1979-1984.

mg·L^{-1} $CaCO_3$

Year	1 Notre-Dame-du-Nord	2 Lake Timiskaming	3^{+} Otto Holden Dam	4 Portage du Fort	Station 5^{+} Chenaux Dam	6^{+} Chats Falls	7 Masson	8^{+} Hawkesbury Perley Bridge	9^{+} Hawkesbury Channel 1&2	10 Carillon Dam
1979	5.82 (1.78)^{11*}	16.07 (3.79)^{14}	NS	15.47 (6.46)^{15}	NS	NS	17.00 (3.37)^{11}	NS	NS	22.60 (6.79)^{16}
1980	7.53 (4.16)^{16}	15.62 (3.30)^{15}	NS	14.02 (1.87)^{16}	NS	NS	16.89 (2.48)^{14}	NS	NS	20.91 (5.75)^{15}
1981	6.50 (2.17)^{17}	15.35 (2.64)^{17}	16.33 (1.23)^{9}	12.65 (3.00)^{16}	19.50 (14.47)^{8}	28.75 (11.91)^{8}	19.88 (8.48)^{15}	34.67 (11.37)^{3}	45.00 (28.69)^{3}	25.46 (8.52)^{16}
1982	6.64 (2.17)^{16}	15.33 (2.34)^{16}	17.31 (2.27)^{10}	12.56 (1.63)^{16}	52.97 (28.64)^{12}	29.57 (5.79)^{12}	22.20 (4.92)^{15}	23.08 (6.57)^{8}	29.14 (6.15)^{8}	23.81 (6.82)^{16}
1983	5.41 (0.77)^{13}	16.35 (2.41)^{17}	13.88 (1.66)^{16}	13.88 (1.66)^{16}	52.96 (18.45)^{11}	28.26 (7.67)^{10}	23.59 (6.32)^{17}	24.97 (6.05)^{7}	30.14 (9.98)^{7}	22.93 (5.54)^{17}
1984	5.90 (1.1)^{16}	16.5 (2.3)^{17}	18.62 (2.90)^{10}	14.3 (2.3)^{17}	42.83 (28.65)^{6}	31.30 (9.24)^{6}	20.9 (7.3)^{17}	21.38 (3.65)^{6}	25.98 (5.16)^{6}	23.4 (7.0)^{17}
1979-1984	6.42 (1.76)^{89}	15.44 (2.70)^{96}	16.33 (1.23)^{38}	13.79 (2.80)^{96}	42.72 (26.76)^{37}	28.91 (8.90)^{36}	20.92 (4.25)^{89}	25.74 (7.97)^{24}	32.17 (13.51)^{24}	23.81 (6.44)^{97}

( ) = standard deviation
* = number of results
NS = not sampled
\+ = OMOE Station; all others MEQ stations
Note: Alkalinity values of <0.1 mg.L^{-1} were measured at Stations 8 and 9 in 1984 but were considered as outliers (eg. effluent slug) and not included in the mean value.

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Season	1 Notre-Dame-du-Nord	2 Lake Timiskaming	3+ Otto Holden Dam	4 Portage du Fort	5+ Chenaux Dam	6+ Chats Falls	7 Masson	8+ Hawkesbury Perley Bridge	9+ Hawkesbury Channel 1&2	10 Carillon Dam
	Station									
Spring	6.63 (0.88)^{8*}	12.96 (2.51)^{8}	14.89 (1.75)^{8}	10.49 (3.54)^{8}	54.99 (31.90)^{7}	39.83 (4.12)^{4}	22.33 (6.22)^{6}	27.75 (4.18)^{4}	36.05 (6.73)^{4}	26.30 (6.43)^{10}
Summer	6.58 (1.44)^{11}	17.28 (1.73)^{13}	18.48 (2.55)^{12}	12.93 (2.09)^{13}	22.38 (16.25)^{9}	24.37 (4.99)^{10}	17.25 (3.58)^{13}	22.17 (6.35)^{9}	25.46 (4.58)^{7}	20.13 (4.21)^{12}
Fall	6.78 (2.04)^{16}	16.64 (2.42)^{16}	19.28 (2.49)^{13}	12.71 (2.18)^{16}	30.99 (17.42)^{8}	26.47 (11.12)^{9}	20.08 (3.67)^{15}	24.91 (8.85)^{10}	31.08 (17.08)^{10}	24.55 (9.65)^{15}
Winter	6.54 (2.25)^{16}	14.78 (2.71)^{17}	17.86 (1.08)^{5}	15.15 (1.82)^{17}	66.00 (13.23)^{11}	34.94 (5.24)^{12}	23.27 (9.12)^{12}	32.20	39.90	23.07 (4.44)^{18}

mg.L^{-1} CaCO$_3$

+OMOE station - 1981-1984 data; all others MEQ stations - 1979-1983 data
( ) = Standard deviation
* = number of results

Table 2.11: Annual Total Alkalinity Mean Concentrations ~~(in mg.L^{-1} CaCO$_3$)~~ for 6 MEQ Tributaries Stations in the Ottawa River Basin for the Period 1979 to 1983.

Year	11 Kipawa	14 Coulonge	19 Gatineau	20 Lievre	21 Petite Nation	23 Rouge
			Station			
			$mg \cdot L^{-1}$	$CaCO_3$		
1979	3.86 $(3.02)^{15*}$	7.25 $(3.96)^{8}$	12.94 $(3.90)^{16}$	13.88 $(2.03)^{8}$	22.00 $(5.86)^{13}$	11.54 $(3.15)^{13}$
1980	3.37 $(0.65)^{14}$	15.44 $(19.73)^{16}$	11.87 $(5.02)^{16}$	13.54 $(2.19)^{7}$	19.59 $(7.97)^{15}$	10.67 $(3.15)^{14}$
1981	2.88 $(0.80)^{16}$	8.69 $(4.56)^{14}$	11.75 $(2.79)^{17}$	13.00 $(2.60)^{14}$	21.29 $(6.19)^{15}$	11.27 $(4.01)^{15}$
1982	1.86 $(0.80)^{16}$	13.13 $(16.22)^{15}$	12.84 $(3.60)^{16}$	15.70 $(1.89)^{12}$	22.42 $(6.72)^{12}$	10.95 $(5.75)^{10}$
1983	2.08 $(1.24)^{16}$	9.68 $(5.58)^{16}$	12.09 $(3.67)^{16}$	13.39 $(2.09)^{17}$	23.46 $(6.24)^{13}$	10.54 $(3.78)^{14}$
1984	1.8 $(0.2)^{14}$	6.8 $(2.1)^{15}$	13.7 $(3.6)^{17}$	14.5 $(1.7)^{16}$	24.3 $(15.6)^{13}$	9.7 $(3.2)^{15}$
1979-1984	2.81 $(0.85)^{77}$	10.13 $(3.58)^{69}$	12.46 $(3.92)^{81}$	13.90 $(2.46)^{58}$	21.78 $(6.61)^{68}$	10.78 $(3.97)^{66}$

( ) = standard deviation
* = number of results

T[redacted]2.12[redacted] Annu[redacted]otal [redacted]init[redacted]n Co[redacted]rati[redacted] [redacted] [redacted]or 7[redacted] tri[redacted]es [redacted] Ott[redacted]iver[redacted]n f[redacted]
Period 1979 to 1984.

Year	12 Mattawa	13 Petawawa	15 Bonnechere	Station 16 Madawaska	17 Mississippi	18 Rideau	22 South Nation
				mg . L^{-1} $CaCO_3$			
1979	NS	11.25 (2.22)^{4}	63.00 (14.73)^{3}	40.80 (4.92)^{5}	NS	105.00 (18.38)^{2}	150.00 (15.56)^{2}
1980	NS	11.60	NS	40.78 (13.17)^{9}	NS	NS	NS
1981	13.00 (1.20)^{8}	9.78 (3.27)^{4}	68.33 (15.36)^{9}	39.35 (5.59)^{7}	99.14 (18.31)^{7}	149.00 (21.84)^{8}	173.86 (33.61)^{7}
1982	15.63 (4.15)^{8}	13.00 (2.00)^{10}	62.00 (21.00)^{12}	53.70 (6.00)^{12}	108.00 (6.00)^{12}	135.00 (22.00)^{11}	186.00 (30.00)^{10}
1983	17.68 (3.67)^{8}	13.88 (2.30)^{5}	62.50 (12.20)^{12}	45.50 (4.10)^{11}	90.70 (5.50)^{12}	127.19 (17.63)^{11}	156.30 (49.30)^{11}
1984	15.42 (2.48)^{9}	15.53 (7.96)^{10}	75.18 (13.22)^{6}	42.45 (4.63)^{8}	91.76 (3.03)^{8}	124.78 (15.55)^{11}	129.20 (50.65)^{10}
1979-1984	15.41 (3.00)^{17}	13.36 (4.92)^{34}	63.96 (17.00)^{42}	41.22 (6.99)^{52}	95.28 (9.71)^{39}	131.74 (21.33)^{40}	159.75 (45.52)^{40}

( ) = standard deviation
* = number of results
NS = not sampled

Figure 2.1: Duncan's Multiple Range Test ($P<0.05$) for Alkalinity and pH at the 10 Mainstem Stations, Ottawa River Basin, 1979-1983.

Parameter	Station 1	2	3	4	5	6	7	8	9	10
Alkalinity ($mg.L^{-1}$ $CaCO_3$)	6.4	15.4	16.3	13.8	43.0	28.9	20.9	25.7	32.2	23.1
pH	6.60	7.05	7.00	6.90	7.70	7.6	7.05	7.10	7.25	7.05

Figure 2.2 pH values at Chenaux Dam, 1981-1983.

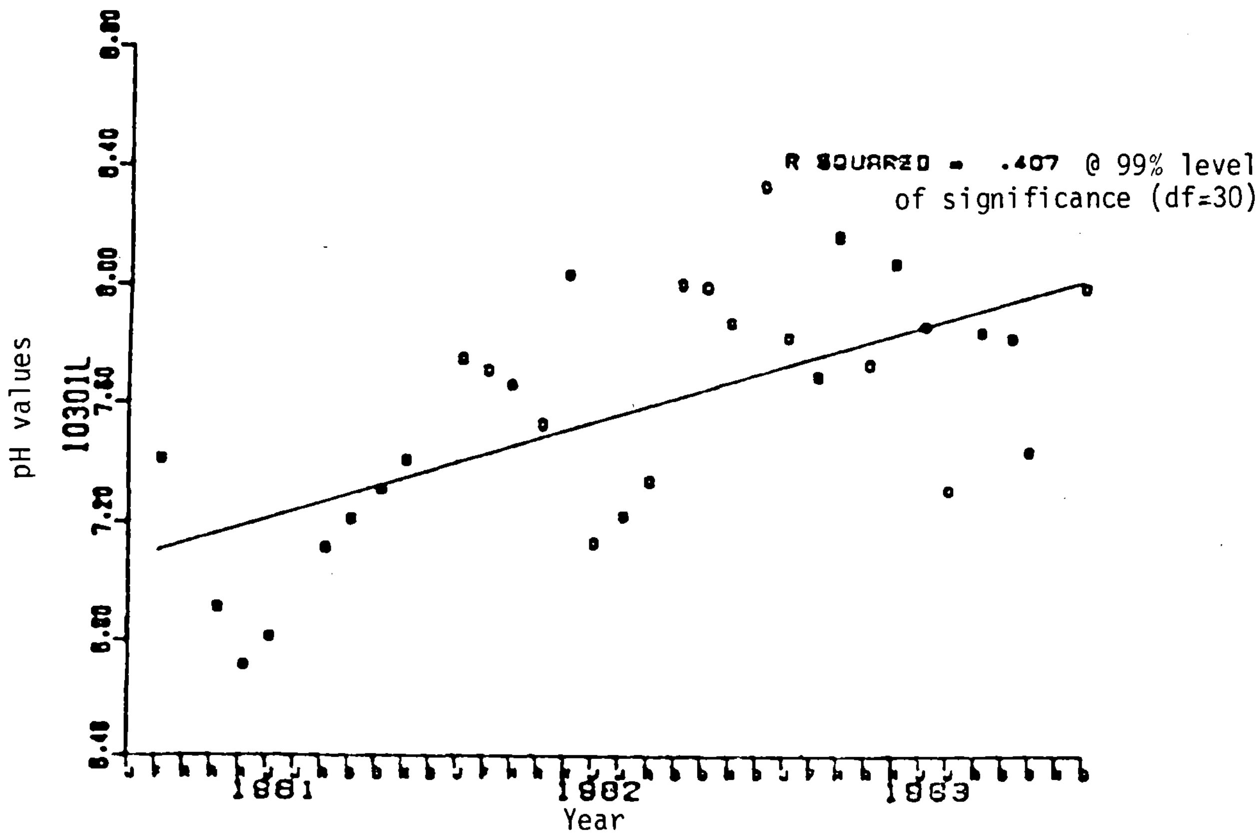

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Figure 2.3 Total Alkalinity Values at the Masson Sampling Location, 1979-1983.

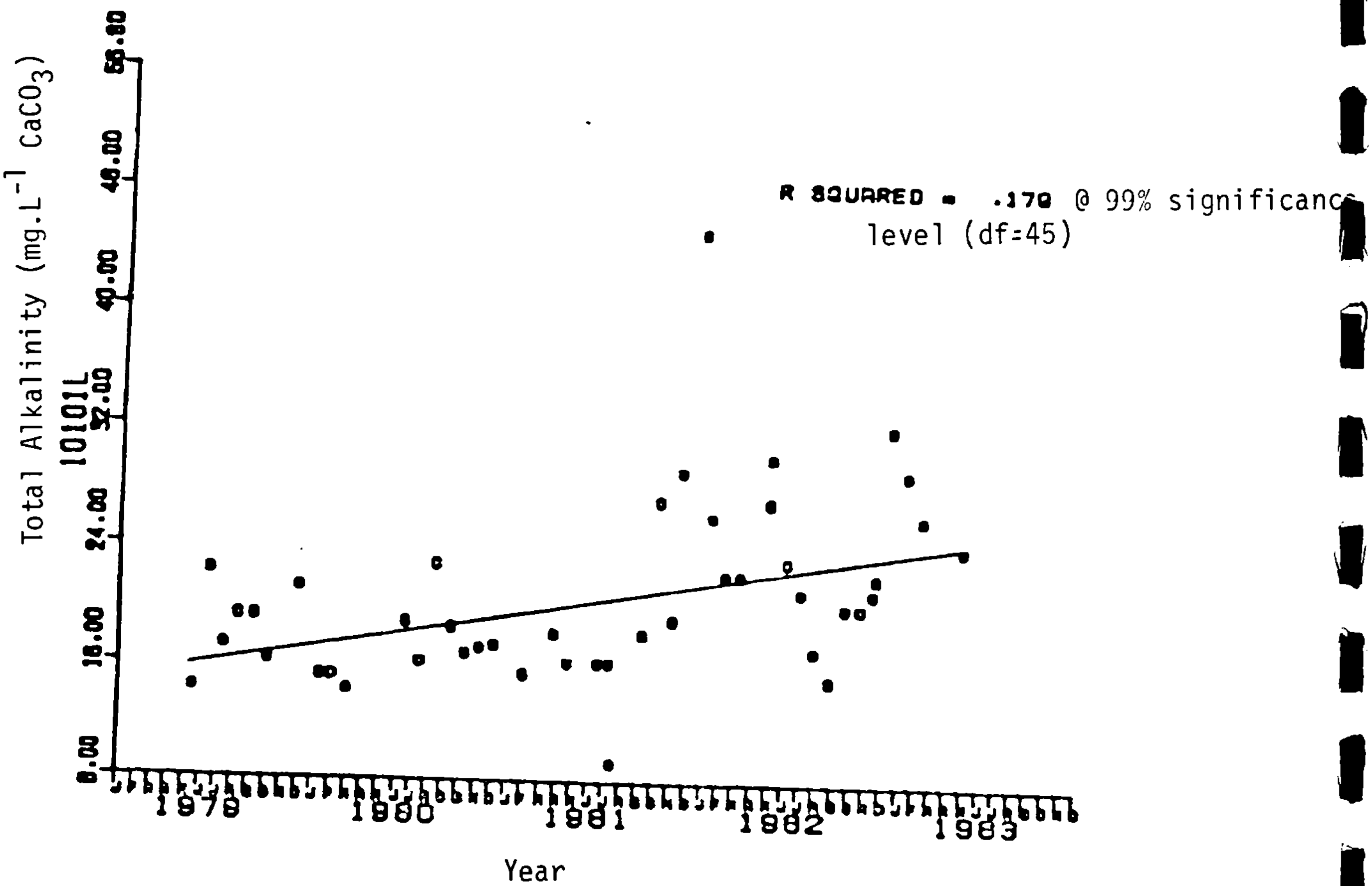


Figure 2.4 Total Alkalinity at the Chenaux Dam Discharge Sampling Location, 1979-1983.

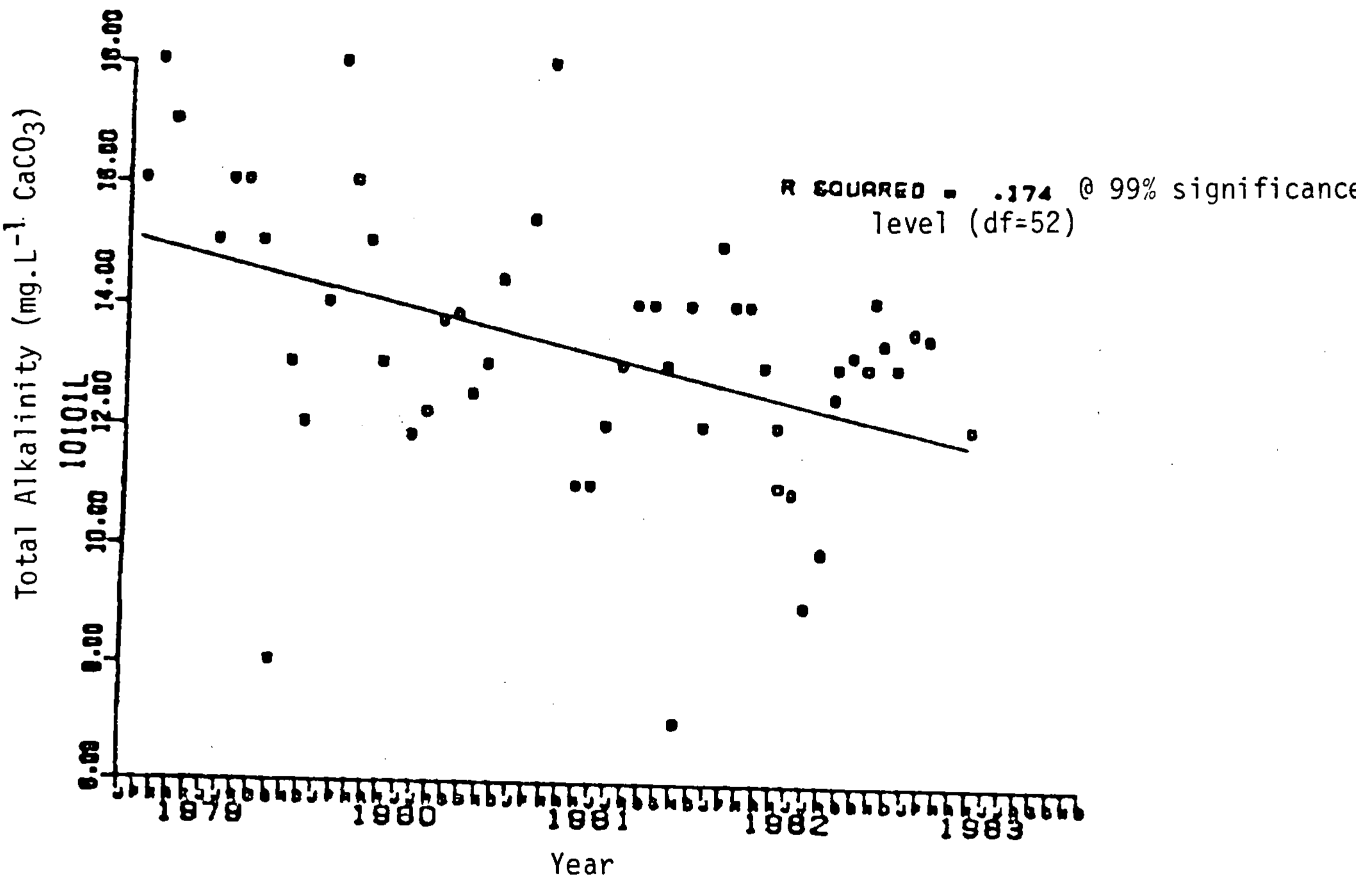


Figure 2.5 Total Alkalinity at the Chenaux Dam Headpond Sampling Location, 1979-1983.

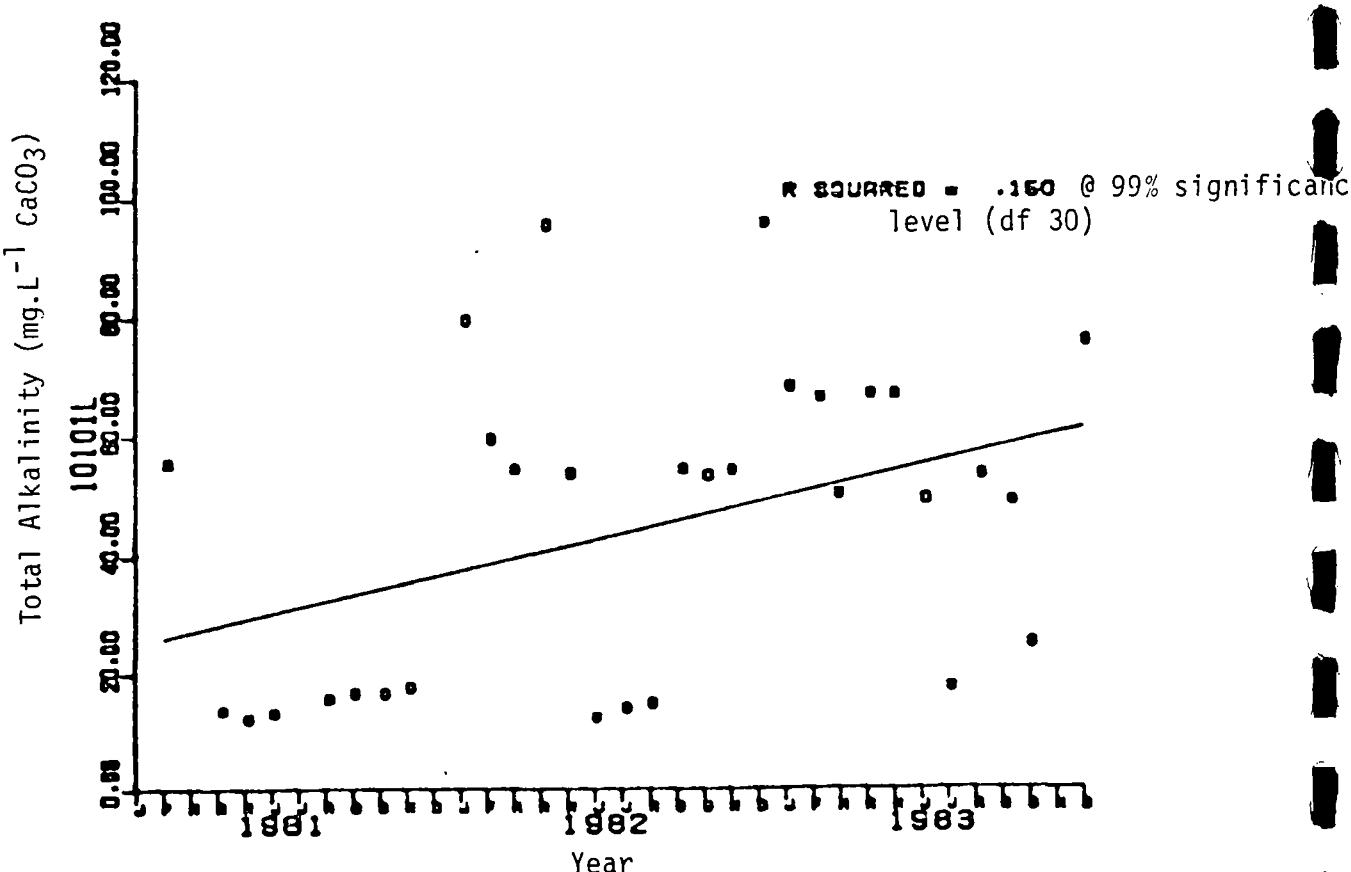
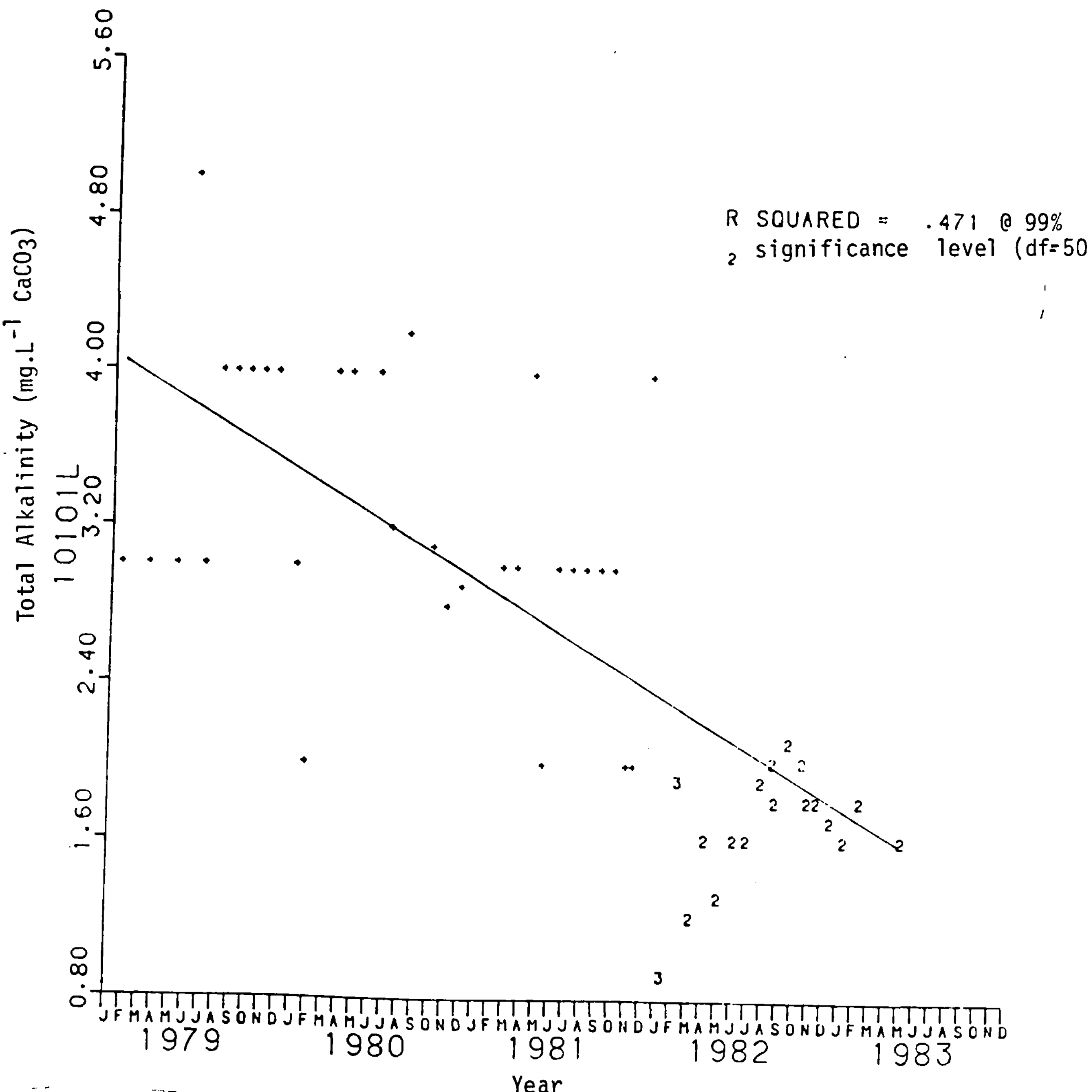


Figure 2.6 Total Alkalinity at the Kipawa River Sampling Location, 1979-1983.



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3.0 HEAVY METALS

Data Sources

Extractable copper, nickel, iron, zinc and lead in water were monitored by MEQ at Stations 1 (Notre Dame du Nord), 2 (Timiskaming), 4 (Portage du Fort), 7 (Masson), and 10 (Carillon Dam). The total form of these metals was measured by OMOE at Stations 3 (Otto Holden Dam), 5 (Chenaux Dam), 6 (Chats Falls), (Hawkesbury-Perley Bridge), and 9 (Hawkesbury Channels 1 & 2). The same metals were also measured in water samples as "extractable" from six Quebec and as "total" from seven Ontario tributaries.

The statistical analysis of the analytical results was conducted as described in section 1.

3.1 Copper

Copper is considered as an essential micronutrient, and is readily accumulated by plants and animals. Whole body concentrations tend to decrease with increasing trophic level, presumably due to organ specific accumulation and metabolic regulation in most consuming organisms. Copper is not biomagnified to any great extent (50). At high concentrations it becomes toxic to aquatic life. The proposed objective for the protection of aquatic life in the Ottawa River is 5 $ug.L^{-1}$.

3.1.1 Mainstem

Spatial Variation

The extractable copper concentration median values and ranges are shown in table 3.1. The concentration increased from Notre-Dame-du-Nord to Portage du Fort, where it reached a maximum, and then decreased in the Masson to Carillon Dam stretch of the river (see

Figure 3.1). The upper part of the river was also characterized by a wider range of values. Downstream at Carillon Dam, sedimentation processes, alkaline water, low copper contributions from low flow tributaries and biological assimilation contributed to the narrower concentration range (3-10 $ug.L^{-1}$) during most of the year.

The total copper results are summarized in table 3.2. They confirm the high extractable copper concentrations found at the Chenaux Dam discharge. The total copper concentrations recorded from the headpond of Chenaux Dam (Station 5) were significantly higher than the other mainstem stations. Ninety-five percent of the copper values determined at this station were above the detection limit, and 87% were exceeding the 5 $ug.L^{-1}$ objective for the protection of aquatic life (Figure 3.2).

The origin of the high copper levels at Chenaux Dam may be the result of a series of cumulative effects over a number of years. In 1982, the sediments upstream from the dam were found to have high concentrations of heavy metals, including copper (Table 3.3). The metals may have originated from the Canadian Shield drainage area and point sources. Other environmental influences partially contributing to the metal content in this reach of the Ottawa River include the leaching of metals from sediments and soils in the slightly acidic waters of the Shield area; the reduction in dissolved oxygen resulting from the nutrient loading from the sulphite mill in Timiskaming; the BOD loading from Consolidated Bathurst Ltd. at Portage du Fort; the runoff from the communities located in the area (e.g. Petawawa); and the sedimentation processes caused by the retention characteristics of Chenaux Dam.

Temporal Variation

Significant increases in the extractable copper concentrations were observed starting in 1982 at Notre-Dame-du-Nord and in 1981 at Portage du Fort (Figure 3.3). A significant increase in total copper concentration was observed only in the headpond of Chenaux Dam (Station 5), starting in 1982. Mobilization of copper from sediments combined with local influences probably caused these changes. The increases observed at other stations, in certain years, were only temporary, the values returning to their previous levels in the subsequent years.

In a previous study (1969-1970) most copper levels determined at 4 sites along the river were below the detection limit, with the exception of Brittania in 1970 (range 20 - 70 $ug.L^{-1}$) (OWRC, 1972). The other 3 stations included Otto Holden Dam (non-detectable = ND), Alexandria Bridge (ND-20 $ug.L^{-1}$) and Carillon Dam (ND-30 $ug.L^{-1}$) (Task Force, 1980). The detection limit during the 1972 to 1977 period was 10 $ug.L^{-1}$.

In this study (1981 - 1984) samples were preconcentrated to decrease the detection limit to 1 $ug.L^{-1}$. During this period, most total copper concentrations (<1-280 $ug.L^{-1}$) observed at all mainstem stations were higher than the 1969-1970 values.

Seasonal Variation

Seasonal concentration ranges and medians are given in table 3.4. Seasonal percent exceedance of the objective for the protection of aquatic life are shown in figure 3.4 for extractable copper and figure 3.5 for total copper.

The extractable copper seasonal median concentrations determined at all the mainstem stations were at or exceeded the tentative total copper water quality objective set for the Ottawa River (5 $ug.L^{-1}$). At four of the five locations the greatest percent exceedance took place in the spring or winter periods. At Masson the highest percent exceedance of the objective occurred during the summer. This high summer exceedance of the objective for the protection of aquatic life may be related to the low flow during that period combined with the anthropogenic influences from industrial and urban inputs from the Ottawa-Hull region.

Total copper seasonal variation was simmilar. Most seasonal total copper median values recorded at the 5 mainstem stations exceeded the water quality objective for the protection of aquatic life (5 $ug.L^{-1}$) (Table 3.4). The highest percent exceedances occurred in the headpond of Chenaux Dam, during the winter and spring. The lowest percent exceedance of the objective occurred at the discharges of Otto Holden Dam and Chats Falls Dam. Chenaux Dam is located between these stations (Figure 3.5).

The high copper values in water samples collected during the winter and spring at the Chenaux Dam sampling station could be related to the flow regime and the re-suspension of solids into the water column and the copper content of the Kipawa and Coulonge Rivers. The water quality aspects of this monitoring site warrants further study.

3.1.2 Tributaries

Tributary concentration ranges and medians are given in table 3.5 for extractable copper and table 3.6 for total copper.

Quebec

Median values were similar for all Quebec tributaries, but in the Kipawa, Coulonge and Gatineau Rivers the data showed greater variability. The percent non-compliance of the objective for the protection of aquatic life was also higher in these tributaries (Table 3.7). The high copper values in the Kipawa and Coulonge may explain the source of the high concentrations of metals in the sediments and water column of the Ottawa River at Chenaux Dam.

Ontario

Total copper concentration ranges were wide at the Bonnechere and South Nation Rivers. The percent exceedance of the objective recommended for the protection of aquatic life was over 80% for both tributaries. The lowest total copper concentrations and the lowest percent exceedances of the objective were found in the Madawaska and Mississippi Rivers (Table 3.7).

3.1.3 Sediment

Copper concentrations in the bottom sediments from Quinze Lake to Petawawa accounted for 40% of the 43% exceedance of the recommended guideline for open-water disposal of dredged materials (25 mg/kg) (Table 3.8). These high copper concentrations paralleled the high metal levels, including copper, observed in the water column of the Ottawa River especially at Chenaux Dam. The Quebec contaminant surveys confirmed these findings and in addition they indicated that non-compliance of the above objective also occurred in the lower Ottawa River, at Carillon Dam.

The suspended sediment analytical results show a 94% exceedance of the 25 mg/kg criteria set by OMOE (Table 3.9). The transport of copper via the suspended sediment load seems to play a major role in copper distribution in the Ottawa River. This distribution may be a direct result of impoundment discharge characteristics along the length of the Ottawa River. Further investigation should be conducted in light of this finding.

3.1.4 Fish

The results of fish tissue analysis are summarized in table 3.10. Copper concentrations in whole fish samples were below or at the recommended level for human consumption. Only 17 percent of the piscivorous fish exceeded the recommended guideline for human consumption.

3.2 Nickel

The information on the sublethal toxicity of nickel to aquatic life is sparse, but it appears that nickel is less toxic than other metals, e.g. copper and zinc.

The recommended objective for the protection of aquatic life in the Ottawa River is 25 $ug.L^{-1}$.

3.2.1 Mainstem

Spatial Variation

Extractable nickel median levels were similar for the five Quebec mainstem sampling stations (Table 3.11). All of the annual extractable nickel median values were below the tentative water quality objective set for total nickel (25 $ug.L^{-1}$) but some individual values exceeded this objective (Figure 3.6).

Total nickel levels recorded at Chenaux Dam headpond were significantly different from the other Ontario mainstem stations (Table 3.12). The only non-compliance total concentrations occurred at this station (Figure 3.6). The source of the high nickel concentrations has not been determined, but a 1982 sediment survey showed that the concentrations in the Petawawa area were high (7-20 mg/kg) (Table 3).

Temporal Variation

Nickel concentrations were below the detection limit at Britannia, upstream from Ottawa-Hull, in a 1969-1970 study (O.W.R.C., 1972), but they were high at Alexandria Bridge (100 $ug.L^{-1}$) in the heart of the Ottawa-Hull area in an earlier investigation (Thomas, 1963).

There were no significant changes in either the extractable or total nickel levels over the 1979-1983 or 1981-1984 period, respectively. Most extractable nickel concentrations were below the detection limit of 2.0 $ug.L^{-1}$ throughout the monitoring period. The only change was a decrease in the high total nickel concentrations in the headpond of Chenaux Dam. These values were highly variable (Table 3.12). At the other mainstem stations total nickel concentrations ranged consistently between 2-3 $ug.L^{-1}$ during the 1981-1984 study period.

Seasonal Variation

The seasonal extractable and total nickel concentration ranges and medians are summarized in Table 3.13. The seasonal percent exceedance of the objective for the protection of aquatic life are presented in figure 3.7, for extractable nickel and figure 3.8 for total nickel. Most of the extractable nickel seasonal values were at or below the detection limit (20.0 $ug.L^{-1}$) and all seasonal medians were below the tentative objective of 25 $ug.L^{-1}$ for the protection of aquatic life . A few results exceeded this objective during the fall at Portage du Fort (40 $ug.L^{-1}$), Masson and Carillon Dam (28 $ug.L^{-1}$) (Figure 3.7).

The sampling frequency and number of samples collected were low for the proper assessment of the total nickel concentrations in the Ottawa River. Some unusually high total nickel concentrations were found in the headpond of Chenaux Dam, especially in winter (up to 2700 $ug.L^{-1}$) and spring (up to 1700 $ug.L^{-1}$). As mentioned before exceedances of the guideline for the protection of aquatic life occurred at this location, especially during high flow periods.

3.2.2 Tributaries

Tributary concentration ranges and median values for both extractable and total nickel are given in tables 3.14 and 3.15, respectively.

Quebec

Extractable nickel median levels were not different for the six Quebec tributaries. Less than 5% of the nickel results exceeded the objective for the protection of aquatic life in all the Quebec tributaries (Table 3.7).

Ontario

Total nickel was intensively sampled only in 1984. All medians were at or below the detection limit of 2 $ug.L^{-1}$. Only one result, in the Bonnechere River in 1982, exceeded the objective for the protection of aquatic life (Table 3.15). It appears that this value is an outlier.

3.2.3 Sediment

The nickel concentrations in bottom and suspended sediment samples are summarized in table 3.8 and 3.9.

Nickel concentrations in sediment are usually higher than those in water, with sorption playing a relatively minor role. The OMOE criteria of acceptability for open-water disposal of dredged materials is 25 mg/kg. This guideline was exceeded in 7 of the 13 samples, primarily in the Templeton and Thurso locations (Table 3.8).

The nickel concentration range of the suspended material was similar to the bottom sediment ranges. The nickel levels exceeded the criteria of acceptability for open-water disposal of dredged materials in 10 of the 18 samples (Table 3.9). These samples were collected at Lemieux Island, located in the Ottawa-Hull area.

3.2.4 Fish

Nickel is bioaccumulated by some aquatic organisms; however most concentration factors are less than 10^3 (51,52). Bioconcentration factors are highest in aquatic plants, intermediate in invertebrates and lowest in fish (50). Whole fish concentrations for both benthivore and piscivore species were well below recommended guidelines for the protection of human consumers of fish (Table 3.10).

3.2.4 Fish

Nickel is bioaccumulated by some aquatic organisms; however most concentration factors are less than 10^3 (51,52). Bioconcentration factors are highest in aquatic plants, intermediate in invertebrates and lowest in fish (50). Whole fish concentrations for both benthivore and piscivore species were well below recommended guidelines for the protection of human consumers of fish (Table 3.10).

3.3 Iron

Iron is a micronutrient to plants and animals. The recommended objective for the protection of aquatic life is 300 ug.L^{-1}.

3.3.1 Mainstem

The extractable and total iron concentration ranges and medians are shown in tables 3.16 and 3.17, respectively. Compliance analysis of the iron data is shown in figure 3.9. The highest extractable iron percent exceedance of the objective occurred at Notre-Dame-du-Nord (66.2%).

During the 1981-1984 study period very high total iron concentrations (110-3900 ug.L^{-1}) with very high variability were observed in the head pond of Chenaux Dam. These very high iron levels occurred during the spring period, at high flows and turbidities (5.6 - 45.0 FTU). The lowest percent of non-compliance occurred at Chats Falls Dam, 40 km downstream from Chenaux Dam (Figure 3.9). Sedimentation of the metal probably occurs between the Chenaux and Chats Falls Dams and some dilution also occurs from the three major tributaries located in this reach of river.

Temporal Variation

During the 1979-1983 period there was an apparent slight downward trend in the extractable iron concentration at Notre-Dame-du-Nord, Portage du Fort and Masson. The data scatter, however, is too large to draw any definite conclusions. Figures 3.10 and 3.11 illustrate the situation at Notre-Dame-du-Nord and Portage du Fort.

The total iron median values from both Hawkesbury sampling locations showed marked declines from 1981 to 1984 although the concentration ranges were similar throughout the period (Table 3.17). The median values recorded at Hawkesbury (383-750 ug.L^{-1}) were similar to the total iron concentrations observed in the lower Ottawa River (200-900 ug.L^{-1}) during 1972 to 1978 study period (Task Force, 1980).

Seasonal Variation

Seasonal concentration ranges and medians are summarized in table 3.18. Seasonal percent exceedance of the objective for the protection of aquatic life is shown in figure 3.12 for extractable iron and figure 3.13 for total iron.

The summer median extractable iron concentrations observed at most stations were lower than the medians for the other seasons. The formation of stable complexes of iron with organic compounds and the biological accumulation of iron as a micronutrient during the productive summer months might have contributed to the lower iron concentrations in water.

The spring median levels of extractable iron were generally higher than the medians of all the other seasons, especially in the lower Ottawa River, at Masson and Carillon Dam. These high spring concentrations result from the spring runoff originating from the highly urban and industrialized section of the lower Ottawa River. Increased soil loss from the Ontario tributaries draining agricultural areas also contributed to the high iron concentrations observed during the springmelt.

The exceedances of the objective recommended for the protection of aquatic life were most frequent during the spring or fall periods at all stations (Figure 3.12). The highest number of seasonal exceedances occurred at Notre-Dame-du-Nord.

In the headpond of Chenaux Dam, the total iron median value for the spring (585 ug.L^{-1}) was much higher than the other seasonal median concentrations (155-237 ug.L^{-1}). This high spring concentration paralleled the other metal seasonal characteristics at this station.

At Otto Holden Dam the total iron median levels were similar for all seasons. This consistent iron concentration was probably partly related to the excessive BOD loading that occurs throughout the year from Tembec Forest Products Ltd., Temiscaming, Quebec. Iron levels in the water column were in part, governed by the redox conditions of the site. The BOD loading, including the ammonia from the mill, and Lake Timiskaming influenced the dissolved oxygen regime at Otto Holden Dam, especially during the ice covered winter period. Some high iron results were obtained in the winter at this station.

The iron concentrations in water samples collected at Chats Falls Dam, also had no seasonal pattern although the summer median was slightly lower than the winter value. The biological uptake and complexing of iron with organic compounds during the summer months could account for this. Sample sizes were small, but the highest percent exceedances occurred during the spring period again probably as a result increased iron input from land runoff at that time of the year (Figure 3.13).

3.3.2 Tributaries

Tributary concentration ranges and median values for both extractable and total iron are presented in tables 3.19 and 3.20, respectively.

Quebec

Kipawa River iron values were much lower than the other Quebec tributaries (Table 3.19). The highest median levels and concentrations were found in Petite Nation River. The highest percent exceedance of the objective also occurred at this site (Table 3.7).

Ontario

By far the highest median values and concentrations and most exceedances of the recommended objective for the protection of aquatic life occurred at the mouth of the South Nation River . The other Ontario tributaries with substantially high total iron concentrations were the Bonnechere and Rideau Rivers. The Bonnechere drains an area of the Canadian Shield and agricultural land and the Rideau drains agricultural and urban land. The percent exceedance of the objective observed in these two rivers was also higher than the other Ontario tributaries, apart from the South Nation River results.

3.3.3 Sediment

The results of iron analysis in suspended sediment samples are summarized in table 3.9.

In the presence of oxygen, the ferrous ion is oxidized and precipitates as ferric ion. Subsequently, iron is usually found as colloidal suspensions of ferric hydroxide particles (54). These flocs remain suspended in the water column or deposit in the bottom sediments. Under anaerobic conditions, iron is usually released back to the water in the ferrous form, but it also may combine with hydrogen sulfide to produce ferrous sulfide yielding black muds.

In the Ottawa River, either ferric or ferrous forms predominate certain reaches depending on the ambient water quality and bottom sediment conditions. The iron concentration in the suspended sediments collected at Lemieux Island were well above the OMOE criteria of acceptability for open-water disposal of dredged material (Table 3.9). Two thirds of the results also exceeded the "heavily polluted" guideline recommended by EPA (25 000 $mg.kg^{-1}$).

3.4 Zinc

3.4.1 Mainstem

Zinc is an essential element to plant and animal life and is readily bioaccumulated throughout the biotic community. Bioconcentration factors on the order of 10^3, for freshwater plants and fish, to 10^4 for freshwater invertebrates have been reported (51, 55). Above certain concentrations zinc is toxic to both aquatic flora and fauna. In the Ottawa River a maximum concentration of 30 $ug.L^{-1}$ has been recommended for the protection of aquatic life.

Spatial Variation

The extractable zinc concentrations were similar for the five Quebec mainstem stations located in the Ottawa River (Table 3.21). The stretch from Lake Timiskaming to Masson showed much higher variability, probably due to the variety of inputs in this part of the river.

The total zinc concentrations, measured by OMOE at the five Ontario mainstem locations, paralleled the extractable concentrations, i.e. a narrow range of median values combined with wide ranges of individual values at and downstream from Chenaux Dam (Table 3.22).

Total zinc values were extremely high and variable in the headpond of Chenaux Dam (2-2800 $ug.L^{-1}$) during the 1981 to 1984 period. High heavy metal concentrations were consistently observed at this location. Twenty percent of the total zinc values in the headpond of Chenaux Dam and 10% of the extractable results from the Chenaux Dam discharge, were above the tentative water quality objective for the protection of aquatic life (30 $ug.L^{-1}$) compared with only 3% of the Chats Falls total zinc values (Figure 3.14).

Temporal Variation

Total zinc concentrations in the Ottawa River between 1972 and 1977 were all below the detection limit (10 $ug.L^{-1}$) (Task Force 1980). The majority of zinc concentrations determined in the Ottawa River at Otto Holden Dam, Alexandria Bridge, in the Ottawa-Hull region, and Carillon Dam during the 1969-1970 survey were above the recommended objective of 30 $ug.L^{-1}$ (OWRC, 1972). Alexandria Bridge values were the highest, ranging from non-detectable to 200 $ug.L^{-1}$ (OWRC, 1972).

From 1979 to 1983 there were no significant increases of the extractable zinc at any of the mainstem stations, but concentration ranges were wide at Portage du Fort and Lake Timiskaming.

Substantial reductions of the total zinc median concentrations occurred from Chenaux Dam to Chats Falls Dam consistently from 1981 to 1984, similar to the pattern for copper, nickel, iron and lead. A sedimentation zone might be present between these two stations as well as a dilution effect due to the inflow of three major tributaries.

Total zinc concentrations in the lower Ottawa River during the 1981 - 1984 period seem to be lower than the levels found in previous studies, 1969 to 1977.

Seasonal Variation

Seasonal concentration ranges and medians are summarized in table 3.23. Seasonal percent exceedance of the objective for the protection of aquatic life are shown in figure 3.15 for extractable zinc and figure 3.16 for total zinc.

There were no seasonal patterns in the extractable zinc concentrations with the exception, perhaps, of the Notre-Dame-du-Nord sampling station. The spring median level (10 $ug.L^{-1}$) was lower than the other seasonal median values (15-20 $ug.L^{-1}$) at this location and this variation may be related to the flow regime characteristics of this station.

At the Lake Timiskaming outlet, the maximum seasonal values were greater than the corresponding results of the other mainstem locations. These high zinc values may stem from both the Canadian Shield drainage and the mining activity in Haileybury, located on the northwest shore of Lake Timiskaming. The low summer concentrations (4-80 $ug.L^{-1}$) may be related, apart from the natural cycling of zinc in the aquatic environment by biological assimilation and sedimenting detritus, to the dam discharge practices.

3.4.2 Tributaries

Tributary concentration ranges and median values for extractable and total zinc are given in tables 3.24 and 3.25, respectively.

Quebec

Extractable zinc medians were similar in all the Quebec tributaries. The ranges were also similar although ocassional high values, with no consistent pattern, were measured in some of the tributaries (Petite Nation and Rouge Rivers). The highest exceedances of the objective for the protection of aquatic life occurred in the upper tributaries Kipawa (16.2%) and Coulonge Rivers (16.4%) (Table 3.7).

Ontario

Total zinc concentration ranges were highly variable in tributaries draining the Canadian Shield (Mattawa, Petawawa and Bonnechere Rivers) (Table 3.25). The four year median value for the South Nation River was much higher than the medians of the remaining tributaries. The percent exceedance of the objective for the protection of aquatic life was also the highest at this station (28.2%) (Table 3.7). The Bonnechere River was the only other tributary concentrations with a relatively high non-compliance percentage (20.0%). The Mississippi River was the only tributary with total zinc concentrations well below the objective (Table 3.7).

3.4.3 Sediment

The zinc analytical results in bottom and suspended sediment samples are summarized in tables 3.8 and 3.9.

Zinc bottom sediment concentrations collected in the Ottawa River exceeded the criteria of acceptability for open-water disposal of dredged materials 38-49% of the time.

Zinc suspended sediment concentrations were high at Lemieux Island. One hundred percent of the observed values exceeded the objective for open-water disposal. This high non-compliance paralleled the exceedance of the iron and manganese sediment concentrations collected at this location. In the presence of suspended solids, much of the zinc is sorbed onto suspended and colloidal particles (56, 57). Coprecipitation and sorption of dissolved zinc by hydrous iron and manganese oxides can occur where high concentrations of reduced iron and manganese are introduced into aerobic surface waters (58). This in fact seems to be occurring at the Lemieux Island station, located in the Ottawa-Hull area.

3.3.4 Fish

The results of zinc analysis in fish tissue are shown in table 3.10.

Whole fish zinc concentrations only exceeded the recommended objective in the piscivore species.

3.5 Lead

Lead is bioaccumulated by aquatic organisms including bacteria, plants, invertebrates and fish. Decreasing pH increases the availability of divalent lead, the principal form believed to be accumulated by aquatic animals (59). Microcosm studies indicate that lead is not biomagnified (60).

Lead is toxic to aquatic organisms. The recommended guideline for the protection of aquatic life is 5 $\mu g.L^{-1}$.

3.5.1 Mainstem

Spatial Variation

Extractable and total lead annual medians and concentration ranges are given in tables 3.26 and 3.27, respectively. The Lake Timiskaming to Portage du Fort reach and Carillon Dam sampling station show higher median values for the 1979-1983 period than the other locations, where extractable lead was measured. This is not reflected, however, in the total lead results. The large discrepancy between the two sets of results, from two different agencies, is not easy to explain. Different field and laboratory methods are most likely the main factors contributing to this situation. Without quality control data it is impossible to say whether or not any other factors were involved or to establish any relationship between the two sets of results.

The reach of the Ottawa River located downstream from the Ottawa-Hull region, including Masson and Carillon Dam, shows some high concentrations of extractable lead. The greatest exceedance of the objective recommended for the protection of aquatic life (5 $ug.L^{-1}$) occurred at Carillon Dam (77.8%) (Figure 3.17). These high values are probably caused by point and non-point lead inputs from the urban centres predominating this reach of the river.

The highly variable total lead levels at Chenaux Dam paralleled those of iron, copper, nickel and zinc. Forty-six percent of the total lead values determined at Chenaux Dam from 1981 to 1984 exceeded the water quality objective recommended for the protection of aquatic life (Figure 3.17). Possible explanations for this exceedance are given in section 3.1.1.

Temporal Variation

Changes in analytical methods through the study period make it difficult to determine temporal trends for lead. The results from samples collected at Carillon Dam are the only ones showing some increase during the same period. The 1984 maximum results, however, show substantial increases at all stations, with the exception of Carillon Dam where the results decreased from the previously high levels. There is no immediate explaination. The frequency of sampling at the monitoring stations does not provide the information for an adequate assessment of the variability of lead in the Ottawa River.

The number of total lead determinations were sparse for most of the mainstem stations. Total lead median value at the Chenaux Dam sampling station decreased from 1981 (20 $ug.L^{-1}$) to 1983 (<3 $ug.L^{-1}$). The remaining mainstem stations did not show any significant change. The data, however, are inadequate for a proper evaluation of the temporal variation.

Seasonal Variation

Seasonal concentration ranges and medians are summarized in table 3.28. Seasonal percent exceedance of the objective for the protection of aquatic life are presented in figure 3.18 for extractable lead and figure 3.19 for total lead.

The dilution during the spring period reduced the extractable lead concentrations at all of the Quebec mainstem stations. This may explain, in part, the 300% rise in the extractable lead mean value from spring to fall at Carillon Dam. The extractable lead median values for all seasons recorded at Carillon Dam exceeded the recommended water quality objective for total lead (5 $ug.L^{-1}$).

The objective was also exceeded at other stations in different seasons (Figure 3.18). The total lead median values exceeded the objective only at Chenaux Dam during the summer and fall. The seasonal concentration ranges of total lead were higher at the Chenaux Dam site than the lead levels determined downstream from the Ottawa-Hull area, in the centre channel of the river, in the vicinity of Hawkesbury, Ontario (Figure 3.19).

3.5.2 Tributaries

Tributary median values and concentration ranges for extractable and total lead are given in tables 3.29 and 3.30.

Quebec

Extractable lead values were different among the tributaries. Higher concentrations were found in the Gatineau and Rouge Rivers than in the other tributaries. This was attributed to the urban runoff. The highest non-compliance of the objective recommended for aquatic life occurred in the Gatineau River (66.7%). The Rouge River non-compliance level was also high (59.3%) (Table 3.7).

Ontario

There were no differences in the total lead medians amongst the Ontario tributaries, with the exception of the Bonnechere River which had a higher value. The percent exceedance of the recommended objective, however, was low in this river (5.3%) and relatively high in the Petawawa (15.8%), Rideau (18.6%) and South Nation Rivers (36.7%).

3.5.3 Sediment

The bottom and suspended sediment analysis results are summarized in tables 3.8 and 3.9.

Only 17% of the bottom sediment samples of the Ottawa River exceeded the criteria of acceptability for open-water disposal of dredged materials. These exceedances occurred in the upper Ottawa River, near Petawawa, Ontario. The MEQ measured exceedances (8%) were found upstream of Notre-Dame-du-Nord in the Quinze Lake area.

Eighty-three percent of the lead in suspended sediment samples from the Lemieux Island site exceeded the criteria of acceptability for open-water disposal of dredged materials. The source of this lead is considered to be the urban runoff.

3.5.4 Fish

The fish tissue analysis results are shown in table 3.10. Lead concentrations in whole fish samples exceeded the recommended objective in the piscivore species, but not in the benthivore species.

3.6 Other Metals

3.6.1 Water

Water samples were also analyzed for arsenic, cadmium, mercury and chromium. The results were almost always below detection limits and below guidelines, but high concentrations were found in fish tissue and sediments (see below).

3.6.2 Sediment

Arsenic, cadmium, chromium and mercury concentrations in bottom sediment samples are summarized in table 3.8. Sediment concentrations of arsenic exceeded the criteria of acceptability for open-water disposal of dredged materials 66% of the time. The highest concentrations occurred in Lake Timiskaming sediments. Arsenic has previously been reported (4) in water in Farr Creek, which discharges into Lake Timiskaming on the Ontario side. This loading may be affecting the high concentrations found in the bottom sediments of the immediate area.

MEQ bottom sediment analysis showed 69% of the chromium and 15% of the mercury values above the criteria recommended for open-water disposal of dredged material. In the Environment Canada special studies there were no exceedances of the objective for these 2 metals. The chromium non-compliance values were widespread and the high mercury concentrations were isolated in the Templeton and Thurso areas. High concentrations of many other contaminants were also found in this area.

Cadmium bottom sediment concentrations were also found to exceed the objective for open-water disposal of dredged materials by both Environment Canada (EC) and Environment Quebec. The majority of the exceedances found by EC were observed in the upper Ottawa River and in the Ottawa-Hull area. The MEQ non-compliance values occurred at Chats Falls and Carillon Dams.

3.6.3 Fish

Arsenic, cadmium, chromium and mercury concentrations were determined in whole fish collected from various locations in the Ottawa River by MEQ. Both benthivorous and piscivorous tissues were analyzed.

There were no exceedances of the recommended arsenic objective for the protection of human consumers of fish, but 46% of the cadmium concentrations in benthivore species exceeded the criteria (Table 3.10). Twenty-nine percent of the piscivores, most of them caught in the Templeton and Thurso areas, also exceeded the cadmium objective. Both the chromium and mercury concentrations in piscivores exceeded the respective objectives recommended for the protection of human consumers of fish (Table 3.10).

The mercury exceedances occurred at stations downstream of Ottawa-Hull (Gatineau/Templeton, Thurso and Carillon). There were no exceedances found at the Ottawa station, upstream of the Chaudiere Falls. This suggests that mercury remains an environmental concern in the Ottawa River, especially in the downstream section from Ottawa to Carillon. However, fish collected from an upstream section between, Rolphton and Petawawa, in 1983, also showed exceedances of the guideline. MEQ data on whole fish samples show a decrease in the exceedance of the guideline from 1978 to 1980.

3.7 Conclusions

Within the Ottawa River basin, the most troublesome location because of metal concentrations is in the reach upstream from Chenaux Dam and immediately below. Most heavy metal concentrations, both extractable and total forms, were highest at this point in the river, both in the headpond and immediately downstream from the dam. These high levels are probably a result of the accumulation of these metals, originating from the Canadian Sheild drainage, in the sediments upstream from Chenaux Dam. Their mobilization and leaching to and from the sediments may be induced by low dissolved oxygen levels brought on by winter ice cover, nutrient and BOD loading from two pulp and paper mills, located upstream from this site, and the soft water nature of the river at this site. Sediment resuspension as a result of operational changes of the dams discharge characteristics may release metals into the water column in the form of suspended solids. In some cases, turbidity values were high when metal concentrations were high.

The high concentrations recorded at the Chenaux Dam headpond and discharge were reduced by up to 90% 40 km downstream, at the Chats Falls dam discharge. This is the other area that requires further investigation. Although the water concentrations are low, due in part to the dilution from the tributaries, there may be high sediment levels of zinc, copper, iron, nickel and lead in this reach of the Ottawa River.

Another area of concern is the urban runoff from Ottawa-Hull, which probably contributed to the high lead values observed occassionally downstream from these municipalities. Metal (Cd, Cr, Cu, Pb, Zn and Hg) levels in fish tissue exceeded the recommended levels for human consumption in the Ottawa River downstream from Ottawa-Hull.

Table 3.1: Annual Extractable Copper Concentration Ranges and Medians at Five Mainstem Stations, Ottawa River Basin, 1979 to 1984. ~~(ug.L-1).~~

Quebec Data

Year	Station 1 Notre Dame du Nord	Station 2 Lake Timiskaming	Station 4 Portage du Fort	Station 7 Masson	Station 10 Carillon Dam
			µg.L-1		
1979	5.95 (2.0-20.0) 10*	5.00 (2.0-9.0) 10	6.00 (1.0-25.2) 11	3.00 (1.0-47.0) 9	4.00 (1.0-9.5) 11
1980	4.00 (1.0-24.0) 12	9.50 (3.0-30.0) 16	4.50 (1.0-25.5) 16	6.00 (1.0-12.0) 11	5.00 (1.0-13.0) 15
1981	4.50 (3.0-36.0) 16	5.00 (1.0-12.0) 17	10.00 (1.0-19.0) 17	2.50 (1.0-7.0) 12	4.00 (1.0-10.0) 17
1982	8.50 (2.5-38.0) 16	5.50 (2.5-25.0) 16	13.00 (2.5-59.0) 16	6.00 (2.5-25.0) 15	4.25 (2.5-30.0) 16
1983	8.00 (2.5-13.0) 13	7.00 (2.5-25.0) 17	11.50 (2.5-37.0) 16	2.50 (2.5-11.0) 17	5.00 (2.5-18.0) 17
1984	6.00 (2.5-12.0) 16	6.00 (2.5-9.0) 17	8.00 (2.5-273.0) 17	3.80 (2.5-10.0) 16	2.50 (2.5-16.0) 17
1979-1984	5.40 (1.0-38.0) 83	6.00 (1.0-30.0) 93	8.90 (1.0-273.0) 93	4.00 (1.0-25.0) 80	4.00 (1.0-30.0) 93

( ) = range
* = number of results

Table 3.2: Annual Total Copper Concentration Ranges and Medians at Five Mainstem Stations, Ottawa River Basin, 1981-1984 ~~(ug.L^{-1}).~~

@ Ontario Data

Year	Station 3 Otto Holden Dam	Station 5 Chenaux Dam	Station 6 Chats Falls	Station 8 Hawkesbury Perley Bridge	Station 9 Hawkesbury Channel 1&2
			μg.L^{-1}		
1981	5 (1-210)^{10*}	6 (4-18) ^{10}	3 (<1-62)^{10}	8 (3-17)^{5}	8 (4-8)^{6}
1982	4 (2-7)^{10}	79 (2-240)^{12}	2 (<1-9)^{11}	21 (9-57)^{8}	47 (10-57)^{7}
1983	3 (2-6)^{9}	76 (5-150)^{12}	12 (1-29)^{10}	6 (<1-69) ^{6}	14 (6-280)^{4}
1984	2 (1-10)^{10}	62 (2-86)^{5}	2 (1-3)^{5}	3 (2-4)^{7}	3 (2-4)^{7}
1981-1984	3 (1-10)^{39}	60 (2-240)^{39}	3 (<1-62)^{36}	9 (2-69)^{26}	8 (2-280)^{24}

( ) = range
* = number of results

Table 3.3: Average and Range of Trace Metals Concentration in Bottom Sediments of the Ottawa River At Petawawa, Ontario, 1982.

As	Cd	Cr	Cu	Pb $mg.kg^{-1}$	Hg	Ni	Zn
45.2 (21.6 - 96.4)	1.9 (0.9 - 2.3)	9.4 (5.0 - 13.0)	36.4 (16.0 - 47.0)	59.0 (26.0 - 78)	0.17 (0.10 - 0.19)	14.0 (7.0 - 20.0)	156 (79 - 300)

Note: Average and range calculated from 5 transect values

Table 3.4: Seasonal Copper Concentration Ranges and Medians at 10 Mainstem Stations, Ottawa River Basin.

Metal Form Period and Agency	Station Number	Winter	Season Spring	Summer (ug.L^{-1})	Fall
Extractable 1979 - 1983 MEQ	1	8.0 (3-36)[15*]	7.0 (5-11)[8]	8.0 (2-20)[14]	6.5 (3-38)[15]
	2	8.0 (3-30)[15]	7.0 (4-22)[11]	9.0 (5-22)[16]	6.4 (4-20)[18]
	4	11.0 (2-37)[19]	10.0 (5-36)[13]	7.0 (4-29)[19]	8.4 (2-42)[16]
	7	6.5 (2-25)[13]	5.0 (3-8)[8]	7.0 (2-47)[11]	7.0 (2-17)[15]
	10	8.0 (2-18)[17]	6.0 (2-9)[9]	5.0 (3-10)[13]	4.6 (2-30)[18]
Total 1981 - 1984 OMOE	3	4.0 (2-6)[5]	4.0 (1-180)[8]	3.0 (2-130)[13]	3.0 (1-120)[13]
	5	65.0 (5-240)[9]	76.0 (10-94)[6]	8.0 (2-150)[9]	8.0 (2-20)[14]
	6	3.0 (1-62)[13]	2.5 (<1-8)[4]	2.0 (<1-29)[11]	2.0 (1-22)[9]
	8	(57)[1]	5.0 (<1-69)[7]	10.5 (<1-30)[9]	6.0 (2-50)[9]
	9	(47)[1]	7.0 (<1-280)[7]	8.0 (3-57)[8]	6.0 (2-57)[9]

( ) = range
* = number of results

Table 3.5: Annual Extractable Copper Concentration Ranges and Medians for Six Quebec Tributaries, Ottawa River Basin, 1979-1983.

	Station					
	11	14	19	20	21	23
Year	Kipawa	Coulonge	Gatineau	Lievre	Petite Nation	Rouge
			(ug.L^{-1})			
1979	4.5 (<2-8)^{8*}	2 (<2-7.4)^{7}	<2 (<2-10)^{11}	2 (<2-4.7)^{7}	<2 (<2-11)^{10}	<2 (<2-5)^{9}
1980	7 (<2-45)^{17}	3 (<2-33)^{15}	4 (<2-24)^{16}	9.5 (<2-124)^{9}	4.8 (<2-14)^{12}	5 (<2-15)^{14}
1981	4 (<2-12)^{13}	3.5 (<2-9)^{18}	2.5 (<2-10)^{16}	2 (<2-8)^{13}	3 (<2-23)^{16}	4 (<2-7)^{17}
1982	8 (5-12)^{9}	7.5 (5-62)^{12}	8 (7-41)^{12}	7.5 (5-14)^{6}	5.5 (5-9)^{6}	12 (8-32)^{4}
1983	12 (5-49)^{4}	12.5 (5-38)^{10}	7 (5-10)^{5}	6 (5-14)^{4}	12 (5-16)^{5}	8 (5-22)^{6}
1979-1983	6 (<2-49)^{51}	6 (<2-62)^{62}	5 (<2-41)^{60}	5 (<2-124)^{39}	4 (<2-23)^{49}	4.5 (<2-32)^{50}

( ) = range
* = number of results

Table 3.6: Annual Total Copper Concentration Ranges and Medians for Seven Ontario Tributaries, Ottawa River Basin, 1981-1984.

Year	12 Mattawa	13 Petawawa	15 Bonnechere	16 Madawaska (ug.L^{-1})	17 Missi-ssippi	18 Rideau	22 South Nation
1981	4 (<1-110)^{8}	5 (1-60)^{10}	6 (2-21)^{11}	1 (<1-9)^{11}	2 (<1-8)^{8}	4 (<1-8)^{10}	10 (5-510)^{10}
1982	3 (2-15)^{9}	3 (<1-18)^{9}	89 (4-130)^{12}	2 (<1-17)^{12}	3 (2-81)^{12}	4 (1-20)^{11}	68 (16-480)^{10}
1983	3 (1-130)^{9}	1 (<1-7)^{9}	67 (4-180)^{12}	1 (<1-27)^{11}	6 (<1-22)^{12}	7 (<1-16)^{11}	27 (3-210)^{11}
1984	2 (<1-3)^{9}	7 (<2-32)^{10}	69 (3-89)^{5}	1 (<1-3)^{7}	2 (2-3)^{6}	3 (1-5)^{11}	9 (6-420)^{9}
1981-1984	2 (<1-130)^{36}	5 (<1-60)^{38}	50 (2-180)^{40}	2 (<1-27)^{40}	2 (<1-81)^{38}	4 (<1-20)^{43}	24 (3-510)^{40}

( ) = number of results
* = range

Table 3.7: Percent Exceedance of the Water Quality Objective Recommended for the Protection of Aquatic Life.

Station No. and Tributaries	Copper 5 ug.L^{-1}	Nickel 25 ug.L^{-1}	Iron 300 ug.L^{-1}	Zinc 30 ug.L^{-1}	Lead 5 ug.L^{-1}
			Metal and Objective		
<u>Quebec (1979 - 1983)</u>			% Exceedance		
11 Kipawa River	64.7	4.5	0.0	16.2	5.3
14 Coulonge River	56.5	4.7	39.1	16.4	25.9
19 Gatineau River	53.3	4.4	28.6	11.8	66.7
20 Lievre River	48.7	3.3	27.3	12.0	20.0
21 Petite Nation River	44.9	2.6	58.5	15.5	37.5
23 Rouge River	50.0	5.1	43.3	6.8	59.3
<u>Ontario (1979 - 1984)</u>					
12 Mattawa River	30.6	0.0	NA	5.7	2.9
13 Petawawa River	39.5	0.0	10.0	5.3	15.8
15 Bonnechere River	82.5	14.3	42.1	20.0	5.3
16 Madawaska River	25.0	0.0	5.6	4.9	2.4
17 Mississippi River	28.9	0.0	13.5	0.0	2.6
18 Rideau River	39.5	0.0	30.8	4.7	18.6
22 South Nation River	95.0	0.0	97.4	28.2	36.7

NA = not applicable

Table 3.8: Metal Concentrations in the Bottom Sediment of the Ottawa River

Metal	Agency**	Concentration Range ($mg.kg^{-1}$)	Sample Size (No.)	Guideline* ($mg.kg^{-1}$)	Exceedance (%)
Arsenic	EC	1.7 - 96.4	35	3.0	91
	MEQ	<1.0 - 7.3	6	3.0	50
Cadmium	EC	<0.1 - 2.7	35	1.0	66
	MEQ	<0.1 - 10.7	13	1.0	15
Chromium	EC	0.7 - 13.0	35	25.	0
	MEQ	10.0 - 62.0	13	25.	69
Copper	EC	0.9 - 47.0	35	25.	43
	MEQ	7.0 - 130.0	13	25.	38
Lead	EC	1.6 - 78.0	35	50.	17
	MEQ	5.0 - 86.0	13	50.	8
Mercury	EC	<0.1 - 0.19	35	0.3	0
	MEQ	0.015 - 0.745	13	0.3	
Nickel	EC	1.1 - 20.0	35	25	0
	MEQ	9.0 - 39.0	13	25.	54
Zinc	EC	12.0 - 300.0	35	100.	49
	MEQ	41.0 - 640.0	13	100.	38

* OMOE guideline for open-water disposal of dredged materials

** EC = Environment Canada
MEQ - Ministry of Environment Quebec

Table 3.9: Metal Concentrations in the Suspended Sediments of the Ottawa River

Station

Variable	Agency	Concentration Range (mg.kg^{-1})	No. of Samples	Guideline* (mg.kg^{-1})	Exceedance (%)
Aluminum	EC	11400 - 18200	18	NA	NA
Cadmium	EC	0.9 - 3.8	18	1.0	94
Copper	EC	25 - 79	18	25	94
Iron	EC	22600 - 30600	18	10000	100
Lead	EC	41 - 97	18	50	83
Manganese	EC	1110 - 3360	18	500	100
Mercury	EC	0.08 - 0.14	18	0.3	0
Nickel	EC	23 - 30	18	25	56
Zinc	EC	161 - 256	18	100	100

* OMOE guideline for open-water disposal of dredged materials

Table 3.10: Metal Concentrations in the Fish of the Ottawa River

Variable	Trophic Type	Agency* and Year	Concentration Range ($mg.kg^{-1}$)	Number of Results	Guideline**	Percent Exceedance %
Arsenic	Benthivore[1]	MEQ 78&80	<.005 - 0.08	11	3.5	0
	Piscivore[2]	MEQ 78&80	<.005 - 0.121	14	3.5	0
Cadmium	Benthivore	MEQ 78&80	<.005 - 0.380	13	0.03	46
	Piscivore	MEQ 78&80	<.005 - 0.550	14	0.03	29
Chromium	Benthivore	MEQ 78	<.5 - 1.3	6	1.5	0
	Piscivore	MEQ 78	<.5 - 2.4	6	1.5	17
Copper	Benthivore	MEQ 78	0.69 - 1.19	7	1.25	0
	Piscivore	MEQ 78	0.28 - 1.27	6	1.25	17
Lead	Benthivore	MEQ 78&80	<.04 - 0.34	13	0.35	0
	Piscivore	MEQ 78&80	<.04 - 1.27	14	0.35	7
Mercury	Benthivore	MEQ 78	0.12 - 0.37	7	0.5	0
		MEQ 80	0.12 - 0.42	8	0.5	0
	Piscivore	MEQ 78	0.30 - 0.68	6	0.5	66
		MEQ 80	0.33 - 0.85	8	0.5	12.5
	Benthivore	OMOE 71&83	0.06 - 0.75	77	0.5	NA
	Piscivore	OMOE 71&83	0.05 - 2.50	482	0.5	NA
Nickel	Benthivore	MEQ 78	<.3	7	0.9	0
	Piscivore	MEQ 78	<.3 - 0.6	6	0.9	0
Zinc	Benthivore	MEQ 78&80	11.8 - 24.4	13	25	0
	Piscivore	MEQ 78&80	14.2 - 71.3	14	40	14

Notes:
1) Benthivore - white sucker, carp
2) Piscivore - walleye, yellow perch, pike
* MEQ samples based on 1-8 composited whole fish
MOE samples based on edible portion (fillet) of single specimens
** MEQ guideline based on the whole fish

Table 3.11: Annual Extractable Nickel Concentration Ranges and Medians at Five Mainstem Stations, Ottawa River Basin, 1979-1984 ~~(µg.L-1)~~.

Year	Station 1 Notre Dame du Nord	Station 2 Lake Timiskaming	Station 4 Portage du Fort	Station 7 Masson	Station 10 Carillon Dam
			µg.L-1		
1979	10 (10-20)^{10*}	10 (10-15)^{10}	10 (10-40)^{11}	10 (10-15)^{9}	10 (10-22.5)^{11}
1980	10 (10-10)^{12}	10 (10-10)^{16}	10 (10-10)^{16}	10 (10-28)^{11}	10 (10-28)^{15}
1981	10 (10-10)^{16}	10 (10-30)^{17}	10 (10-20)^{16}	10 (10-10)^{12}	10 (10-10)^{17}
1982	10 (5-10)^{3}	10 (5-10)^{3}	10 (5-10)^{3}	10 (5-10)^{3}	10 (5-10)^{3}
1983	5 (5-5)^{1}	5 (5-5)^{2}	5 (5-5)^{2}	5 (5-5)^{2}	5 (5-5)^{2}
1984	5 (5)^{4}	5 (5)^{5}	5 (5)^{4}	5 (5)^{3}	5 (5)^{3}
1979-1984	10.00 (5-10)^{46}	10.00 (5-30)^{53}	10 (5-40)^{52}	10 (5-28)^{40}	10 (5-28)^{51}

( ) = range
* = number of results

Table 3.12: Annual Total Nickel Concentration Ranges and Medians at Five Mainstem Stations, Ottawa River Basin, 1981-1984 ~~(ug.L^{-1})~~.

Year	3 Otto Holden Dam	5 Chenaux Dam	6 Chats Falls	8 Hawkesbury Perley Bridge	9 Hawkesbury Channel 1&2
1981	NS	8.0 (<2.0-1700.0)^{9}	<2.0 (<1.0-2.0)^{10}	<2.0 (<2.0-4.0)^{5}	2.0 (1.0-2.0)^{6}
1982	1.0 (<1.0-<2.0)^{9*}	4.0 (<1.0-2700.0)^{9}	<1.0 (<1.0-2.0)^{11}	NS	NS
1983	<2.0 (<2.0-10.0)^{9}	<2.0 (<1.0-210.0)^{9}	<2.0 (<2.0-5.0)^{9}	NS	NS
1984	<2.0 (1.0-3.0)^{10}	<2.0 (<1.0-2.0)^{5}	<1.0 (<1.0-1.0)^{5}	2.0 (1.0-3.0)^{7}	1.0 (<1.0-2.0)^{7}
1981-1984	<2.0 (<1.0-10.0)^{28}	2.0 (<1.0-2700.0)^{32}	<2.0 (<1.0-5.0)^{35}	2.0 (<2.0-3.0)^{12}	2.0 (<1.0-2.0)^{13}

( ) = range
* = number of results
NS = not sampled

Table 3.13: Seasonal Nickel Concentration Ranges and Medians for 10 Mainstem Stations, Ottawa River Basin ~~(µg.L⁻¹).~~

Metal Form Period and Agency	Station	Winter	Spring	Summer	Fall
			Season µg·L⁻¹		
Extractable 1979 - 1983 MEQ	1	(<20)^{12*}	(<20)^{5}	(<20)^{10}	(<20)^{12}
	2	(<20)^{12}	(<20)^{9}	(<20)^{12}	(<20)^{13}
	4	(<20)^{12}	(<20)^{7}	(<20)^{13}	(<20-40)^{13}
	7	(<20)^{9}	(<20)^{5}	(<20)^{7}	(<10-28)^{12}
	10	(20-30)^{13}	(<20)^{7}	(<20)^{10}	(<20-28)^{16}
Total 1981 - 1984 OMOE	3	<2 (<2)^{3}	<2 (<2-1)^{6}	<2 (<2-3)^{10}	1 (<2-10)^{9}
	5	<1 (<1-2700)^{10}	6 (2-2700)^{6}	8 (8-210)^{5}	2 (1-120)^{11}
	6	1 (<1-2)^{11}	<2 (<1-2)^{3}	<2 (<1-<2)^{11}	<1 (<-5)^{10}
	8	NS	2 (<2-3)^{3}	2 (<2-2)^{4}	1 (1-2)^{4}
	9	NS	2 (1-2)^{4}	2 (<1-2)^{5}	2 (<1-2)^{4}

NS = not sampled

( ) = range

* = number of results

Table 3.14: Annual Extractable Nickel Concentration Ranges and Medians for Six Quebec Tributaries, Ottawa River Basin, 1979-1983 ~~(ug.L-1)~~ μg·L^{-1}.

	Station					
	11	14	19	20	21	23
Year	Kipawa	Coulonge	Gatineau	Lievre	Petite Nation	Rouge
1979	<20 (<20-<30)^{10*}	<20 (<20-30)^{7}	<20 (<20-30)	<20 (<20-20)^{5}	<20 (<20)^{9}	<20 (<20-27)^{7}
1980	<20 (<20-32)^{17}	<20 (<20-20)^{15}	<20 (<20-28)^{16}	<20 (<20-28)^{8}	<20 (<20-32)^{11}	<20 (<20-20)^{14}
1981	<20 (<20-25)^{13}	<20 (<20-20)^{18}	<20 (<20-20)^{16}	<20 (<20)^{14}	<20 (<20)^{16}	<20 (<20-56)^{16}
1982	NA	<10, <20	<10 (<10-<20)^{3}	<10	<20 (<10-<20)^{3}	<10
1983	<20 (<10-<20)^{4}	<10	<10	<10	NS	<10
1979-1983	<20 (<10-32)^{44}	<20 (<20-30)^{43}	<20 (<10-30)^{45}	<20 (<20-28)^{30}	<20 (<10-32)^{39}	<20 (<10-56)^{39}

NS = not sampled
NA = not applicable
( ) = range
* = number of results

Table 3.15: Annual Total Nickel Concentration Ranges and Medians for Seven Ontario Tributaries, Ottawa River Basin, 1981-1984 ~~(ug.L^{-1})~~.

	Station						
	12	13	15	16	17	18	22
Year	Mattawa	Petawawa	Bonnechere	Madawaska	Missi-ssippi	Rideau	South Nation
				µg·L^{-1}			
1981	NS	NS	NS	<3 (<1-<3)^{11}	NS	2 (<2-2)^{10}	NS
1982	<1 (<1-1)^{8*}	NS	<1, 1400	NS	NS	NS	NS
1983	<2 (<2-3)^{9}	NS	NS	NS	NS	NS	NS
1984	<2 (<1-2)^{9}	<1 (<1-<2)^{4}	<1 (<1-3)^{5}	<1 (<1-2)^{7}	<1 (<1-4)^{6}	<2 (<1-4)^{8}	<2 (<1-8)^{9}
1981-1984	<2 (<1-3)^{26}	<1 (<1-<2)^{4}	<1 (<1-1400)^{7}	<2 (<1-2)^{18}	<1 (<1-4)^{6}	2 (<1-4)^{18}	2 (<1-8)^{9}

NS = not sampled
( ) = range
* = number of results

Table 3.16: Extractable Iron Annual Medians and Concentration Ranges for Five Mainstem Stations, Ottawa River Basin, 1979-1984 ~~($\mu g \cdot L^{-1}$)~~. $\mu g \cdot L^{-1}$

Year	Station 1 Notre Dame du Nord	Station 2 Lake Timiskaming	Station 4 Portage du Fort	Station 7 Masson	Station 10 Carillon Dam
1979	420 (320-730)[12*]	285 (190-390)[16]	280 (120-630)[17]	280 (150-810)[9]	300 (210-800)[17]
1980	450 (160-740)[12]	200 (70-390)[16]	315 (140-460)[16]	380 (110-230)[11]	280 (160-1680)[15]
1981	265 (100-700)[16]	160 (80-720)[17]	220 (50-400)[17]	145 (70-710)[12]	200 (90-840)[17]
1982	245 (90-640)[16]	155 (70-260)[16]	205 (130-340)[16]	190 (150-710)[15]	260 (130-920)[16]
1983	380 (250-660)[13]	220 (120-620)[17]	225 (120-320)[16]	200 (110-330)[17]	250 (150-630)[17]
1984	380 (230-680)[16]	230 (160-350)[17]	210 (140-560)[17]	220 (150-380)[16]	210 (140-640)[17]
1979-1984	360 (90-740)[85]	200 (70-720)[99]	230 (50-630)[99]	210 (70-810)[80]	260 (90-1680)[99]

( ) = range
* = number of results

Table 3.17: Total Iron Annual Medians and Concentration Ranges for Five Mainstem Stations, Ottawa River Basin, 1981 to 1984 ~~($ug.L^{-1}$)~~. $\mu g.L^{-1}$

Year	Station 3 Otto Holden Dam	5 Chenaux Dam	6 Chats Falls	8 Hawkesbury Perley Bridge	9 Hawkesbury Channel 1&2
1981	210*	350 (200-1900)^{7}	300 (150-350)^{8}	450 (400-1400)^{3}	750 (700-1150)^{3}
1982	245 (150-350)^{9*}	200 (150-620)^{11}	215 (125-260)^{12}	NS	NS
1983	303 (190-378)^{8}	165 (110-3900)^{12}	215 (165-365)^{10}	NS	NS
1984	313 (215-870)^{10}	243 (130-1900)^{6}	205 (160-250)^{6}	383 (265-985)^{7}	410 (315-1200)^{7}
1981-1984	300 (150-870)^{28}	205 (110-3900)^{36}	215 (125-365)^{36}	393 (265-1400)^{10}	525 (315-1150)^{10}

* = number of results
NS = not sampled

Table 3.18: Seasonal Iron Concentration Ranges and Medians for 10 Mainstem Stations, Ottawa River Basin (~~ug.L-1~~), 1979-1984.

Metal Form Period and Agency	Station	Winter	Spring	Summer	Fall
			µg.L-1		
Extractable 1979 - 1983 MEQ	1	380 (90-530)21*	360 (110-700)12	330 (100-500)16	400 (180-740)17
	2	250 (80-720)23	260 (90-390)18	185 (70-290)20	165 (120-390)18
	4	260 (150-500)24	240 (50-630)19	190 (100-290)20	290 (150-400)17
	7	195 (90-810)16	250 (70-2300)13	195 (100-310)16	230 (90-530)17
	10	245 (130-380)24	305 (90-168)18	235 (140-330)16	270 (150-580)21
Total 1981 - 1984 OMOE	3	330 (310-870)3	300 (244-350)5	288 (150-378)10	270 (185-335)10
	5	155 (<50-605)12	585 (400-3900)6	210 (165-410)9	237 (150-1900)10
	6	247 (195-400)12	212 (175-300)4	1/7 (130-365)10	185 (125-350)10
	8	NS	684 (383-985)2	360 (265-1400)4	340 (280-455)4
	9	NS	868 (536-1200)2	463 (325-1100)4	540 (315-750)4

NS = not sampled

( ) = range

* = number of results

Table 3.19: Annual Extractable Iron Concentration Ranges and Medians for Six Quebec Tributaries, Ottawa River Basin, 1979-1983 ~~(ug.L^{-1})~~

	Station					
	11	14	19	20	21	23
Year	Kipawa	Coulonge	Gatineau	Lievre	Petite Nation	Rouge
			µg.L^{-1}			
1979	40 (30-100)^{9*}	295 (180-420)^{10}	280 (150-900)^{17}	300 (180-430)^{9}	480 (120-2260)^{14}	340 (50-960)^{14}
1980	50 (30-80)^{9}	330 (100-410)^{15}	280 (100-790)^{16}	210 (<30-1600)^{8}	585 (200-6500)^{12}	310 (50-1330)^{14}
1981	40 (30-120)^{5}	200 (<30-360)^{18}	240 (<30-560)^{16}	180 (50-720)^{14}	205 (110-2880)^{16}	170 (30-640)^{17}
1982	30 (<20-130)^{14}	290 (190-1290)^{14}	200 (140-560)^{17}	200 (160-460)^{11}	300 (20-1040)^{13}	335 (200-950)^{10}
1983	30 (<20-60)^{12}	260 (40-790)^{12}	220 (160-240)^{11}	210 (150-360)^{13}	385 (190-2100)^{10}	270 (190-740)^{11}
1981-1983	40 (<20-130)^{49}	270 (<30-1290)^{69}	240 (<30-900)^{11}	210 (<30-1600)^{55}	400 (20-6500)^{65}	280 (30-1330)^{67}

( ) = range
* = number of results

Table 3.20: Annual Total Iron Concentration Ranges and Medians for Six Ontario Tributaries, Ottawa River Basin, 1979-1984 ~~(ug.L-1).~~

Year	13 Petawawa	15 Bonnechere	16 Madawaska	17 Mississippi	18 Rideau	19 South Nation
			µg·L-1			
1981	300 (150-300)[3]	300 (<50-500)[9]	150 (130-350)[5]	250 (100-500)[6]	350 (250-450)[7]	1260 (820-4400)[7]
1982	198 (105-290)[10]	255 (150-610)[11]	185 (100-780)[12]	175 (170-480)[12]	200 (50-710)[10]	1050 (540-3525)[10]
1983	135 (78-225)[7]	178 (115-3775)[12]	145 (100-260)[11]	200 (120-735)[11]	255 (90-5100)[11]	2050 (550-5350)[11]
1984	185 (145-770)[10]	200 (105-2000)[6]	215 (150-215)[8]	180 (160-285)[8]	185 (120-1125)[11]	1680 (145-4850)[10]
1981-1984	187 (78-770)[30]	240 (<50-3775)[38]	175 (100-780)[36]	200 (100-735)[37]	250 (50-5100)[39]	1600 (145-5350)[38]

( ) = range
* = number of results

Table 3.21: Annual Extractable Zinc and Concentration Ranges and Medians for Five Mainstem Stations, Ottawa River Basin, 1979-1984 ~~(ug.L-1)~~.

Year	Station 1 Notre Dame du Nord	2 Lake Timiskaming	4 Portage du Fort	7 Masson	10 Carillon Dam
			µg.L^{-1}		
1979	15.30 (2.0-29.0)[10*]	6.70 (2.5-18.3)[10]	7.00 (2.0-19.0)[11]	6.00 (2.5-46.8)[9]	9.40 (2.0-35.5)[11]
1980	14.75 (8.0-33.0)[12]	14.00 (2.0-124.0)[16]	10.00 (2.0-71.5)[16]	8.00 (2.0-172.0)[11]	11.50 (2.0-31.0)[15]
1981	10.00 (20.-40.0)[15]	5.00 (2.0-40.0)[17]	10.00 (2.0-50.0)[16]	7.50 (2.0-20.0)[12]	5.00 (2.0-20.0)[16]
1982	20.00 (5.0-80.0)[16]	10.00 (5.0-16.0)[16]	10.00 (5.0-620.0)[16]	10.00 (5.0-100.0)[15]	10.00 (5.0-30.0)[16]
1983	5.00 (5.0-50.0)[13]	10.00 (5.0-330.0)[17]	10.00 (5.0-320.0)[16]	5.00 (5.0-40.0)[17]	10.00 (5.0-40.0)[17]
1984	5.00 (5.0-40.0)[16]	5.00 (5.0-30.0)[17]	5.00 (5.0-20.0)[16]	5.00 (5.0-10.0)[16]	5.00 (5.0-20.0)[17]
1979-1984	10.00 (2.0-80.0)[82]	10.00 (2.0-330.0)[93]	10.00 (2.0-620.0)[92]	8.00 (2.0-172.0)[76]	10.00 (2.0-40.0)[92]

( ) = range
* = number of results

Table 3.22: Annual Total Zinc Concentration Ranges and Medians for Five Mainstem Stations Ottawa River Basin, 1981 ~~to~~ 1984 ~~(ug.L-1)~~.

Year	3 Otto Holden Dam	5 Chenaux Dam	6 Chats Falls Dam	8 Hawkesbury-Perley Bridge	9 Hawkesbury Channel 1&2
			µg.L-1		
1981	7.5 (4-17)[10]	10.5 (4-150)[10]	3.0 (1-8)[10]	15.0 (10-20)[5]	13.0 (6-30)[11]
1982	6.5 (4-12)[10]	8.0 (5-590)[12]	5.0 (<1-110)[12]	17.0 (9-68)[8]	7.5 (9-115)[6]
1983	4.0 (1-10)[9]	7.0 (2-2800)[12]	4.0 (2-6)[9]	4.5 (<1-24)[4]	5.0 (<1-66)[4]
1984	6.0 (3-18)[10]	8.0 (5-13)[5]	4.0 (1-24)[5]	6.0 (4-19)[7]	5.0 (4-9)[7]
1981-1984	6.0 (1-18)[39]	9.0 (2-2800)[39]	4.0 (<1-110)[36]	10.5 (<1-68)[24]	6.0 (<1-115)[23]

(   ) = range
* = number of results

Table 3.23: Seasonal MEQ Extractable and OMOE Total Zinc Concentration Ranges and Medians for 10 Mainstem Stations, Ottawa River Basin, ~~for the Period~~ 1979-1984 ~~(MEQ) and 1981-1984 (OMOE) ($\mu g.L^{-1}$)~~.

Metal Form Period Agency	Station	Winter	Spring	Summer	Fall
Extractable 1979-1983 MEQ	1	15 (<4-22)^{16*}	10 (<5-30)^{13}	20 (6-80)^{15}	18 (<4-50)^{15}
	2	10 (<4-330)^{18}	10 (<5-160)^{15}	10 (4-80)^{20}	10 (5-124)^{15}
	4	10 (<4-20)^{17}	10 (<4-30)^{17}	10 (<4-72)^{18}	10 (<4-50)^{15}
	7	10 (<4-172)^{15}	10 (<5-20)^{12}	10 (<4-60)^{15}	10 (4-100)^{14}
	10	10 (<4-31)^{17}	10 (<5-30)^{15}	10 (<4-40)^{16}	10 (<4-30)^{18}
Total 1981-1984 OMOE	3	11 (5-18)^{5}	7 (1-13)^{8}	5 (3-11)^{13}	6 (3-17)^{13}
	5	6 (3-590)^{11}	9 (4-150)^{7}	9 (5-2800)^{9}	10 (4-570)^{12}
	6	5 (2-16)^{12}	3 (<1-24)^{4}	3 (1-110)^{11}	2 (1-8)^{10}
	8	(14)^{1}	11 (<1-68)^{7}	12 (<1-19)^{7}	10 (3-20)^{9}
	9	(20)^{1}	23 (<1-115)^{7}	10 (9-17)^{9}	10 (<1-60)^{9}

( ) = range
* = number of results

Table 3.24: Annual Extractable Zinc Concentration Ranges and Medians for Six Quebec Tributaries, Ottawa River Basin, 1979-1983 ~~(ug.L-1).~~ µg.L-1

Year	Station 11 Kipawa	Station 14 Coulonge	Station 19 Gatineau	Station 20 Lievre	Station 21 Petite Nation	Station 23 Rouge
1979	11.9 (<5-36.8)[10*]	13.2 (<5-18)[9]	7.1 (<4-21.7)[11]	6 (<4-12.5)[7]	6.9 (4-13)[10]	8.5 (<5-12.5)[9]
1980	9 (<4-280.0)[17]	12.5 (<4-45)[15]	10.3 (4.5-38.5)[16]	16.5 (9-2500)[8]	10.3 (<4-64)[12]	8.0 (<4-20.5)[13]
1981	10 (<5-20)[12]	<20 (<4-<30)[18]	<20 (<4-20)[13]	<10 (<4-<20)[11]	6.0 (<4-60)[14]	<10 (<4-130)[16]
1982	20 (<10-40)[16]	10 (<10-300)[14]	15 (<10-600)[17]	10 (<10-40)[11]	10 (<10-30)[12]	10 (<10-30)[8]
1983	10 (<10-30)[12]	10 (<10-130)[12]	10 (<10-610)[11]	10 (<10-40)[13]	10 (<10-40)[10]	20 (<10-30)[13]
1979-1984	12 (<10-280)[68]	10 (<4-300)[68]	10 (<4-610)[68]	10 (<4-2500)[50]	9.0 (4-64)[58]	<10 (<4-130)[59]

( ) = range
* = number of results

Table 3.25: Annual Total Zinc Concentration Ranges and Medians for Seven Ontario Tributaries, Ottawa River Basin, 1981-1984 ~~(µg.L^{-1})~~.

Year	Station 12 Mattawa	13 Petawawa	15 Bonnechere	16 Madawaska	17 Missi-ssippi	18 Rideau	22 South Nation
	µg·L^{-1}						
1981	8 (4-26)^{8}	3 (2-29)^{10}	7 (4-32)^{11}	2 (<1-100)^{11}	1 (<1-4)^{8}	5 (2-63)^{10}	9 (5-100)^{9}
1982	8 (1-84)^{9}	2 (<1-1900)^{9}	14 (4-2200)^{12}	3 (<1-28)^{12}	2 (<1-6)^{12}	4 (<1-23)^{11}	16 (2-570)^{10}
1983	7 (<1-6000)^{9}	2 (<1-22)^{9}	4 (4-5200)^{12}	2 (1-5)^{11}	3 (1-7)^{12}	5 (<1-32)^{11}	25 (<1-53)^{11}
1984	5 (2-22)^{9}	5 (2-17)^{10}	8 (5-9)^{5}	3 (1-36)^{7}	4 (2-24)^{6}	4 (3-11)^{11}	10 (2-120)^{9}
1981-1984	7.5 (<1-6000)^{35}	3 (<1-1900)^{38}	9 (4-5200)^{40}	3 (<1-100)^{41}	3 (<1-24)^{38}	4 (<1-63)^{43}	23 (<1-570)^{39}

( ) = range

[illegible] = number of results

Table 3.26: Annual Extractable Lead Concentration Ranges and Medians for Five Mainstem Stations, Ottawa River Basin, 1979-1983 ~~(ug.L-1)~~.

Year	Station 1 Notre Dame du Nord	2 Lake Timiskaming	4 Portage du Fort	7 Masson	10 Carillon Dam
			µg.L-1		
1979	7.5 (7.5-15.0) 10*	7.5 (7.5-7.5) 10	7.5 (7.5-7.5) 11	7.5 (7.5-7.5) 9	7.5 (7.5-30.0) 11
1980	7.5 (7.5-20.0) 12	7.5 (7.5-20.0) 16	7.5 (7.5-20.0) 16	7.5 (7.5-110.0) 11	7.5 (7.5-20.0) 15
1981	2.5 (2.5-10.0) 16	2.5 (2.5-20.0) 17	2.5 (2.5-26.0) 17	2.5 (2.5-24.0) 12	7.5 (2.5-36.0) 17
1982	2.0 (1.0-14.0) 3	7.0 (1.0-21.0) 11	2.0 (1.0-9.0) 11	2.0 (1.0-42.0) 11	8.0 (1.0-248.0) 12
1983	1.0 (1.0-6.0) 13	1.0 (1.0-14.0) 17	1.0 (1.0-6.0) 16	1.0 (1.0-6.0) 17	8.0 (1.0-124.0) 17
1984	7.5 (1.0-58.0) 16	7.5 (1.0-28.0) 17	7.5 (1.0-17.0) 17	7.5 (1.0-7.5) 16	7.5 (1.0-37.0) 17
1979-1984	3.5 (1.0-58.0) 70	7.5 (1.0-28.0) 88	6.0 (1.0-26.0) 88	3.0 (1.0-110.0) 76	7.5 (1.0-248.0) 89

( ) = range
* = number of results

Table 3.27: Annual Total Lead Concentration Ranges and Medians for Five OMOE Mainstem Stations, Ottawa River Basin, 1981-1984 ~~(ug.L^{-1})~~.

Year	Station 3 Otto Holden Dam	5 Chenaux Dam	6 Chats Falls	8 Hawkesbury Perley Bridge	9 Hawkesbury Channel 1&2
			µg.L^{-1}		
1981	<3 (<3-5)^{10*}	20 (<3-72)^{10}	<3 (<3)^{10}	50 (<3-87)^{5}	10 (3-51)^{6}
1982	<3 (<3-5)^{10}	4 (<3-130)^{12}	<3 (<3-6)^{12}	<3 (<3-8)^{8}	7 (4-7)^{3}
1983	<3 (<3)^{10}	<3 (<3-190)^{12}	<3 (<3-4)^{10}	<3 (<3-3)^{6}	7
1984	<3 (<3)^{10}	<3 (<3-24)^{5}	<3 (<3)^{5}	<3 (<3-7)^{7}	<3 (<3)^{7}
1981-1984	<3 (<3-5)^{40}	4 (<3-190)^{39}	<3 (<3-6)^{37}	<3 (<3-87)^{26}	3 (<3-51)^{17}

( ) = range
* = number of results

Table 3.28: Seasonal Lead Concentration Ranges and Medians for 10 Mainstem Stations, Ottawa River Basin (ug.L-1).

Metal Form Period and Agency	Station	Winter	Spring	Summer	Fall
		Season			
Extractable 1979-1983 MEQ	1	2.5 (<2-3)^{4*}	4.0 (<2-4)^{4}	<2 (<2-11)^{6}	4 (<2-20)^{8}
	2	5.5 (<2-20)^{6}	2 (<2-10)^{5}	6.5 (2-21)^{10}	2.5 (<2-20)^{8}
	4	2.0 (<2-16)^{5}	<2 (<2-4)^{6}	<2 (<2-9)^{6}	5.5 (<2-26)^{8}
	7	6.0 (<2-110)^{7}	<2 (<2-3)^{6}	<2 (<2-2)^{7}	2 (<2-24)^{8}
	10	8.0 (<2-30)^{7}	5 (<2-40)^{7}	12 (<2-124)^{9}	20 (<2-248)^{13}
Total 1981-1984 OMOE	3	<3 (<3-5)^{5}	<3 (<3-5)^{8}	<3 (<3-5)^{14}	<3 (<3-5)^{8}
	5	<3 (<3-66)^{11}	<3 (<3-72)^{7}	13 (10-190)^{9}	21 (<3-50)^{12}
	6	<3 (<3)^{12}	<3 (<3-6)^{4}	<3 (<3)^{11}	<3 (<3-4)^{10}
	8	NS	<3 (<3-67)^{6}	<3 (<3-87)^{7}	<3 (<3-8)^{7}
	9	NS	5 (<3-51)^{6}	<3 (<3-10)^{7}	3 (<3-7)^{7}

NS = not sampled
( ) = range
* = number of results

Table 3.29: Annual Extractable Lead Concentration Ranges and Medians for Six Quebec Tributaries, Ottawa River Basin, 1979-1983 ~~(ug. L^{-1})~~.

	Station					
	11	14	19	20	21	23
Year	Kipawa	Coulonge	Catineau	Lievre	Petite Nation	Rouge
			μg.L-1			
1979	NA	NA	28 (17-50)^{3}	NA	15	15
1980	20 (17-23)^{5*}	20 (20)^{2}	20 (15-24)^{7}	30 (20,40)^{2}	20 (20)^{3}	25 (20-134)^{4}
1981	16 (8,24)^{2}	5	12 (6-33)^{7}	14 (12-18)^{3}	12 (<2-140)^{3}	22 (8-25)^{3}
1982	2 (<2-14)^{11}	2 (<2-6)^{12}	3 (<2-90)^{14}	2 (<2-3)^{8}	2 (<2-6)^{7}	3 (<2-76)^{8}
1983	3 (<2-84)^{12}	<2 (<2-21)^{12}	15 (<2-163)^{11}	<2 (<2)^{12}	<2 (<2-12)^{10}	4 (<2-118)^{11}
1979-1983	7 (<2-84)^{30}	<2 (<2-21)^{27}	17 (<2-163)^{42}	<2 (<2-40)^{25}	2 (<2-140)^{24}	8 (<2-134)^{27}

( ) = range
* = number of results

Table 3.30: Annual Total Lead Concentration Ranges and Medians for Seven Ontario Tributaries, Ottawa River Basin, 1981-1984 ~~(ug. L-1)~~.

Year	12 Mattawa	13 Petawawa	15 Bonnechere	16 Madawaska	17 Missi-ssippi	18 Rideau	22 South Nation
				$\mu g \cdot L^{-1}$			
1981	<3 (<3-4)^{8*}	<3 (<3-960)^{10}	20 (<3-59)^{11}	<3 (<3)^{11}	<3 (<2-<3)^{8}	<3 (<3-11)^{10}	<3 (<3-77)^{10}
1982	<3 (<3-5)^{9}	<3 (<3-29)^{9}	7 (<3-240)^{12}	<3 (<3-3)^{12}	<3 (<3-5)^{12}	3 (<3-10)^{11}	6 (<3-55)^{10}
1983	<3 (<3-4)^{9}	<3 (<3)^{9}	<3 (<3-480)^{12}	<3 (<3-5)^{11}	<3 (<3-4)^{12}	<3 (<3-13)^{11}	<3 (<3-9)^{11}
1984	<3 (<3-4)^{9}	<3 (<3-<4)^{10}	4 (<3-25)^{5}	<3 (<3)^{7}	<3 (<3)^{6}	<3 (<3-3)^{11}	<3 (<3)^{9}
1981-1984	<3 (<3-5)^{35}	<3 (<3-960)^{38}	7 (<3-480)^{40}	<3 (<3-5)^{41}	<3 (<3-5)^{38}	<3 (<3-13)^{43}	<3 (<3-77)^{30}

( ) = range
* = number of results

Figure 3.1: Duncans Multiple Range Tests for Extractable Metals, 1979-1983. (Mean values, in $\mu g.L^{-1}$, included)

Sampling Station	Notre Dame du Nord 1	Timiskaming Dam 2	Portage+ du Fort 4	Masson 7	Carillon Dam 10
	Surveillance Stations				
Iron ($3\ ug.L^{-1}$)*	352	221	251	303	283
Lead ($5\ ug.L^{-1}$)	8	10	9	11	23
Copper ($5\ ug.L^{-1}$)	9	9	13	7	7

* Objective for the protection of aquatic life
\+ Portage du Fort = immediately downstream from Chenaux Dam discharge

Duncans Multiple Range test described in Section _______.

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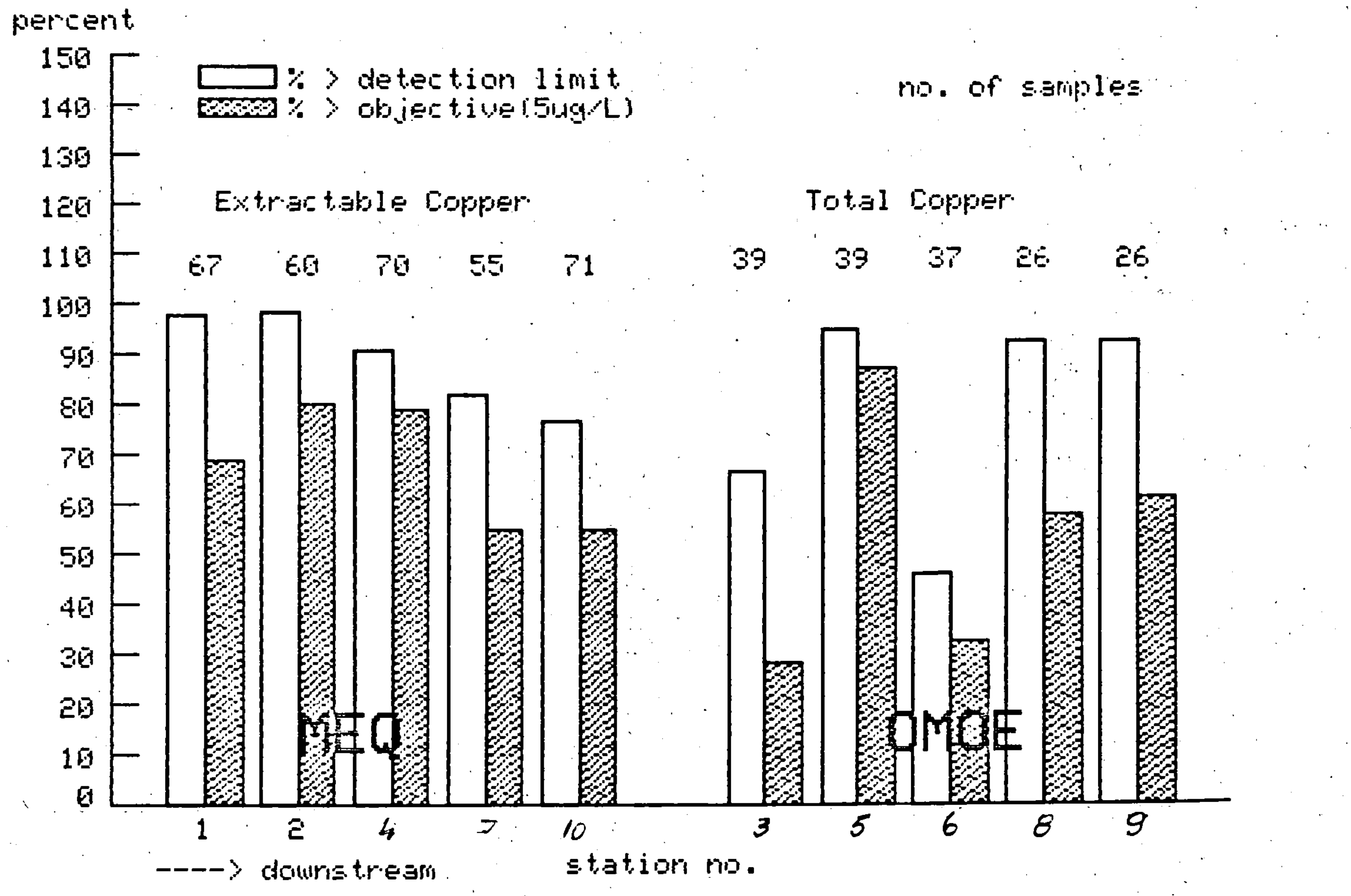
(60) Lu, P.Q., R.L. Metcalf, R.F.

Figure 3.2

Fig. : Compliance Analysis For Copper 1979-83 (MEQ) & 1981-84 (OMOE)



Station (MEQ Data)
1 Notre Dame du Nord
2 Lake Timiskaming
4 Portage du Fort
7 Masson
10 Carillon Dam

Station (OMOE Data)
3 Otto Holden Dam
5 Chenaux Dam
6 Chats Falls
8 Hawkesbury – Perley Bridge
9 Hawkesbury – Channels 1 & 2

Figure 3.3 Extractable Cooper Concentrations at the Portage du Fort Sampling Location (MEQ Data), 1979-1983 .

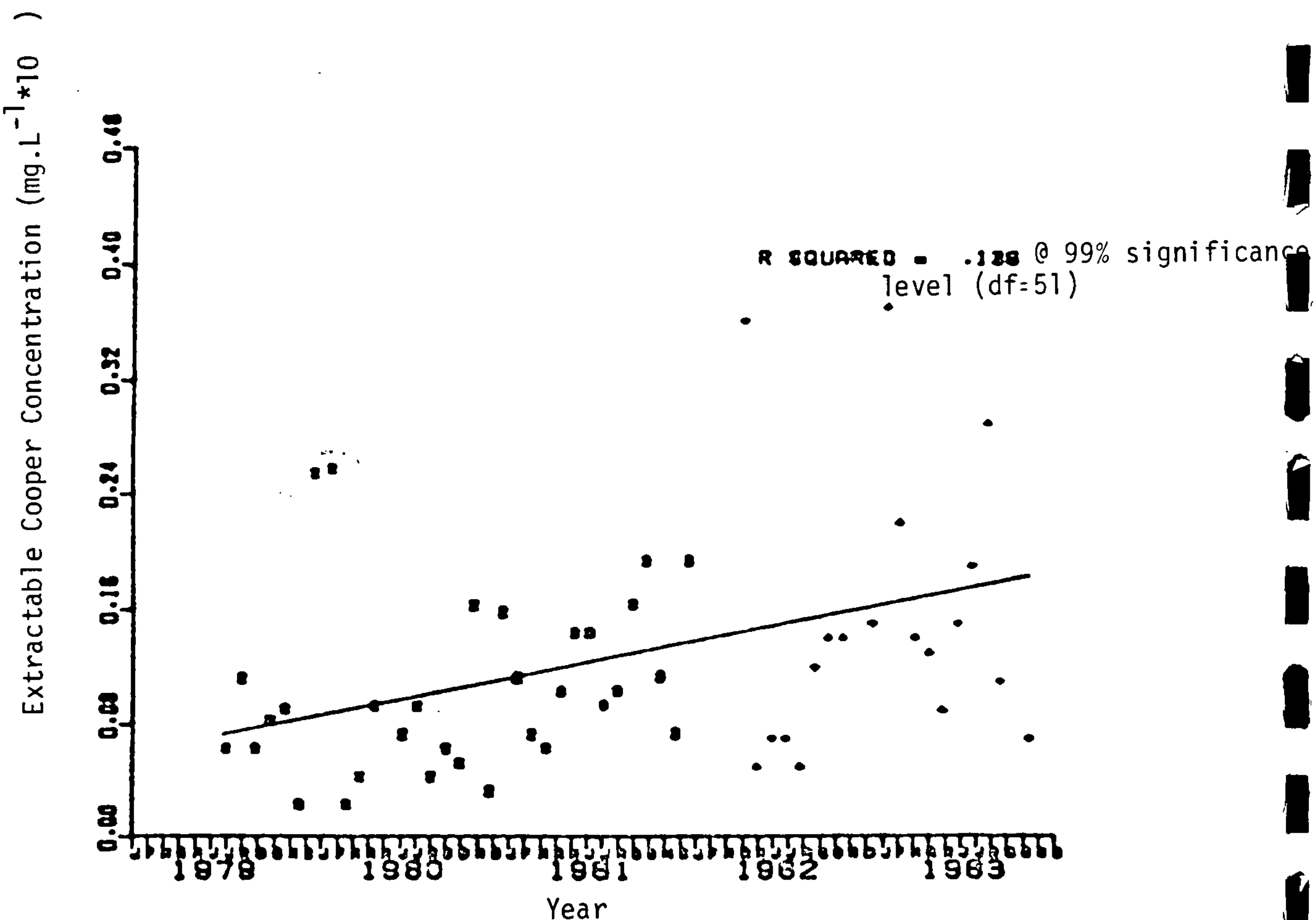


Figure 3.4 Seasonal Percent Exceedances for Extractable Copper at Five Ottawa River Mainstem Sampling Locations (MEQ Data)

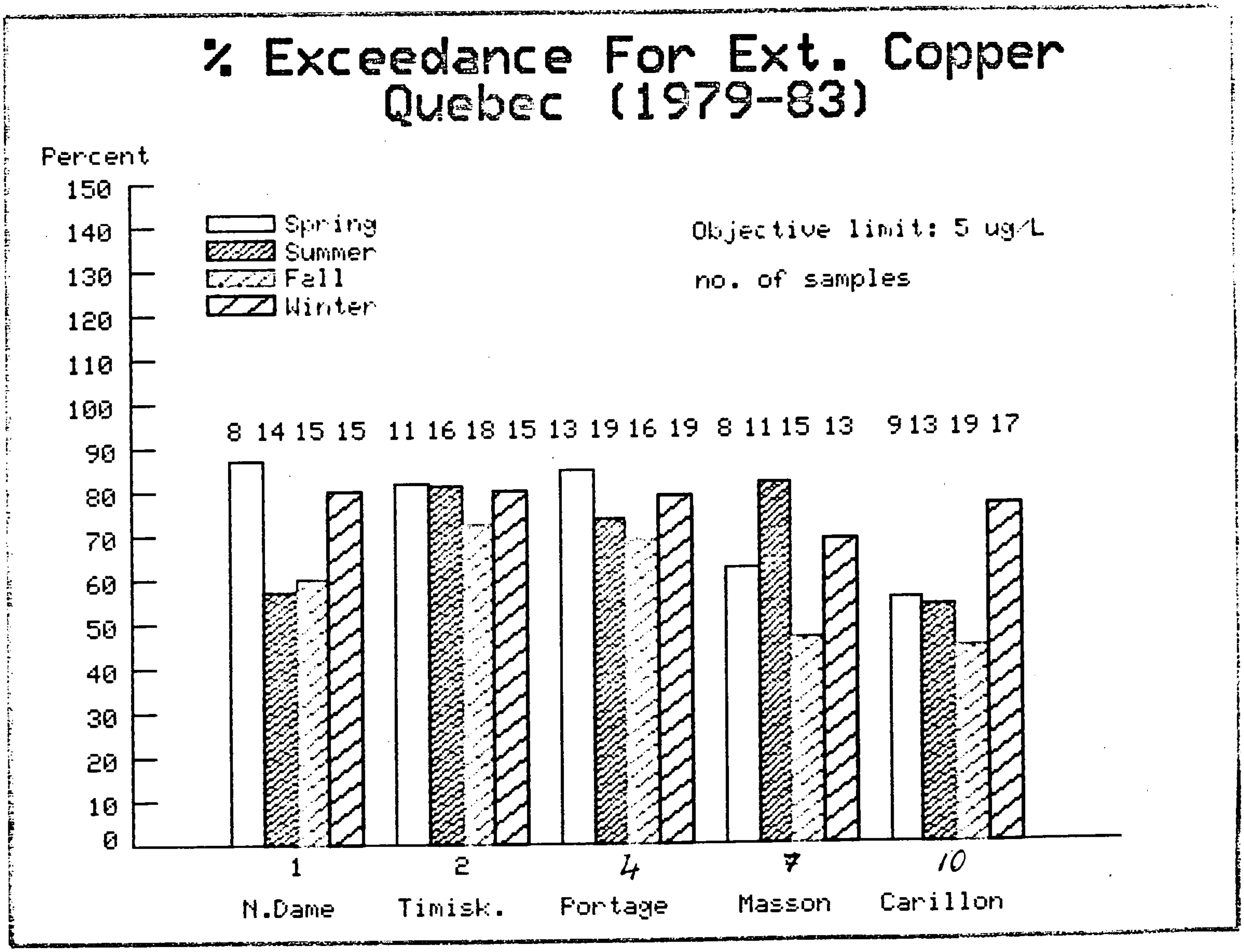


Figure 3.5 Seasonal Percent Total Copper Exceedances at Five Ottawa River Mainstem Sampling Locations (OMOE Data).

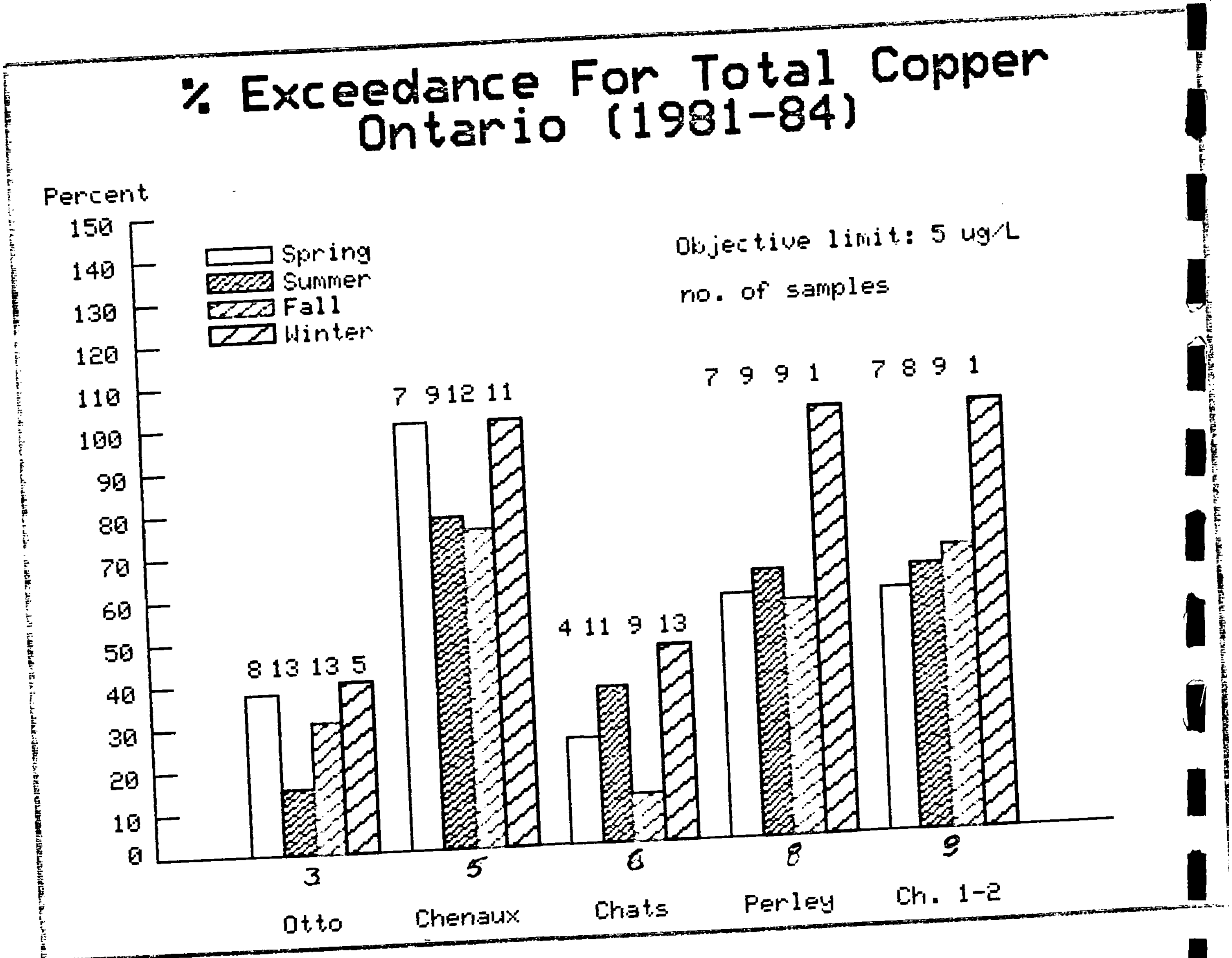


Figure 3.6

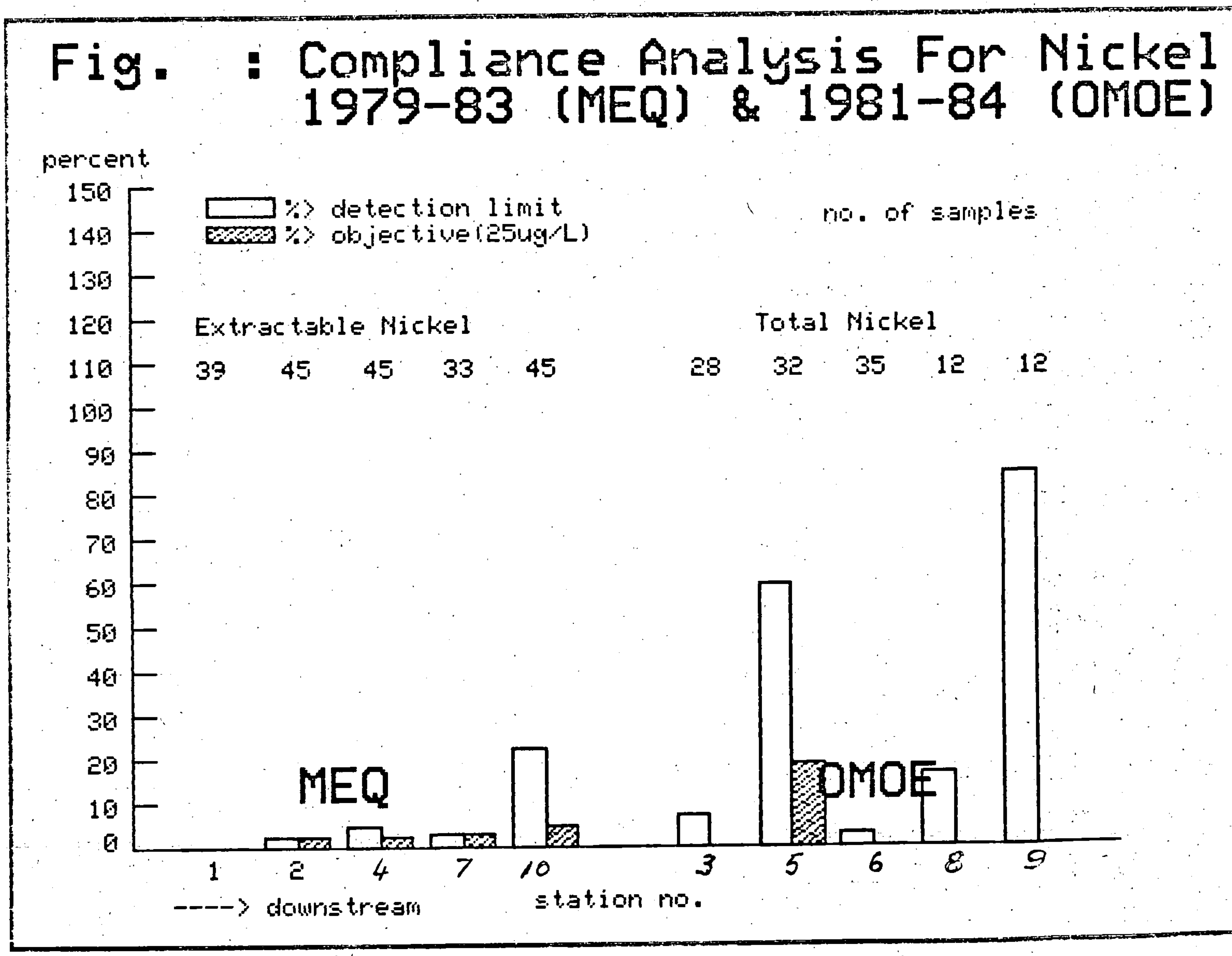


Fig. : Compliance Analysis For Nickel
1979-83 (MEQ) & 1981-84 (OMOE)
percent
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
%> detection limit
%> objective(25ug/L)
no. of samples
Extractable Nickel
Total Nickel
39
45
45
33
45
28
32
35
12
12
MEQ
OMOE
1
2
4
7
10
3
5
6
8
9
----> downstream
station no.

Figure 3.7 Seasonal Percent Exceedances for Extractable Nickel at Five Ottawa River Mainstem Sampling Locations (MEQ Data).

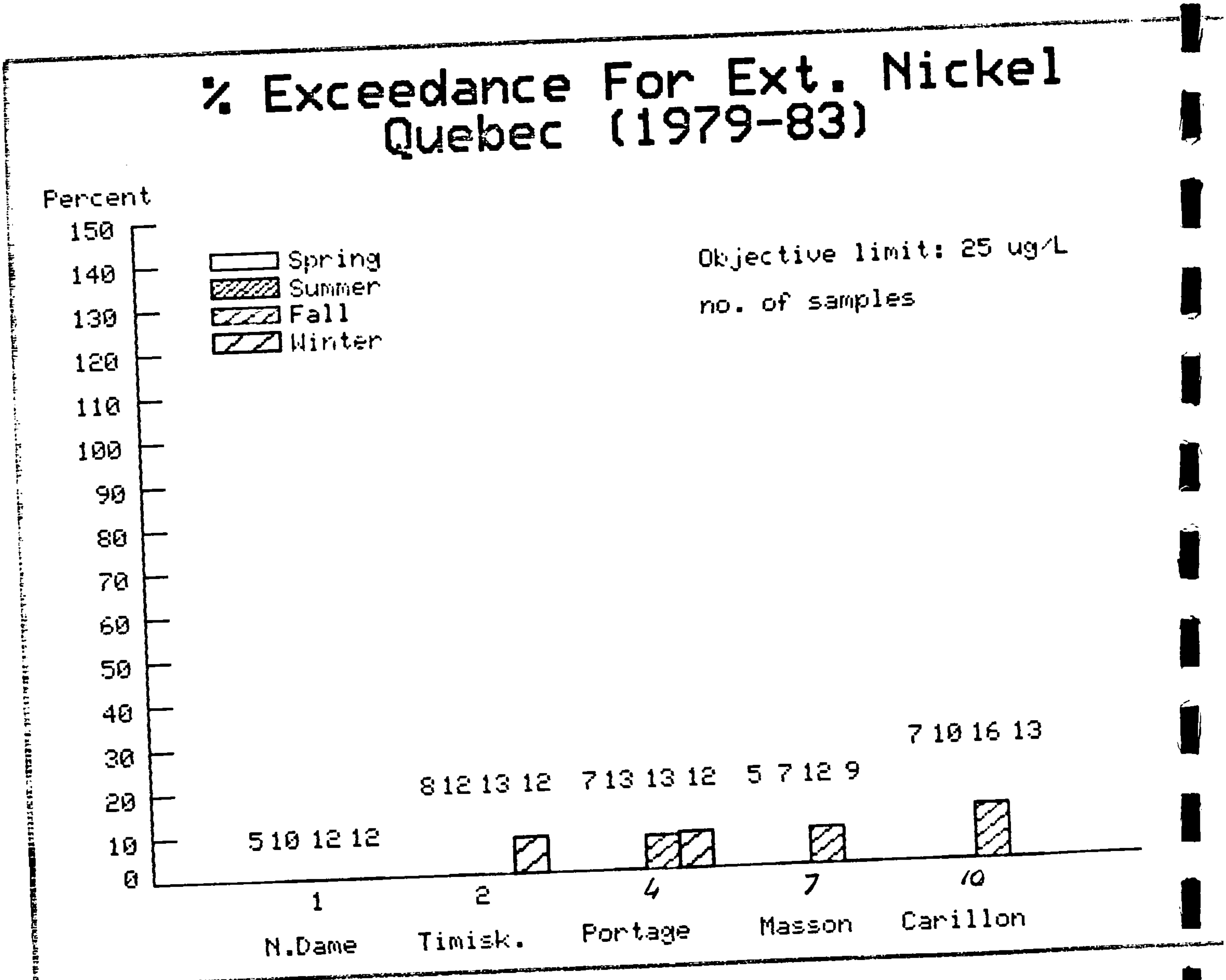


Figure 3.8 Seasonal Percent Exceedances for Total Nickel at Five Ottawa River Mainstem Sampling Locations (OMOE data).

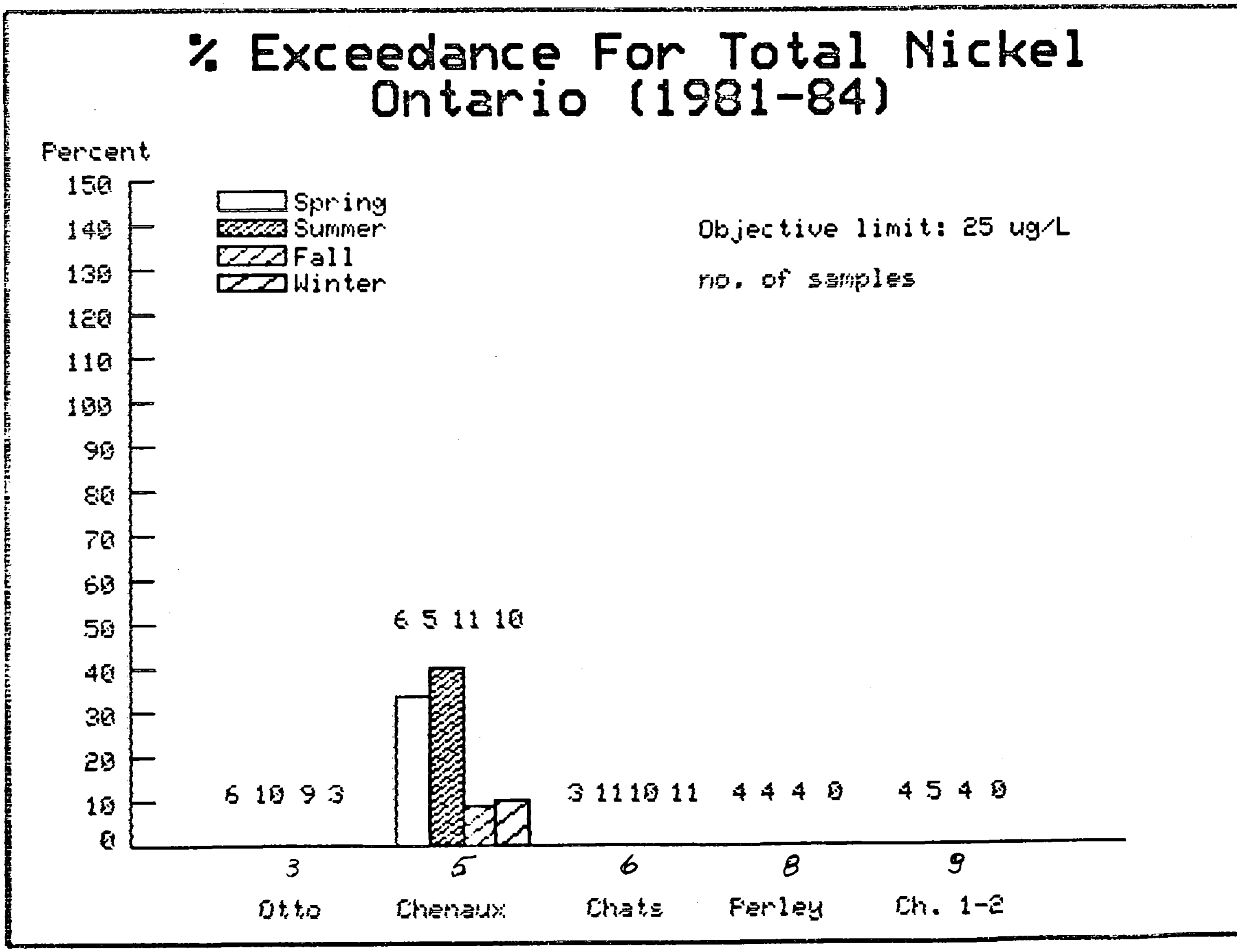


Figure 3.10 Extractable Iron Concentration at the Notre Dame du Nord Sampling Location, 1979-1983.

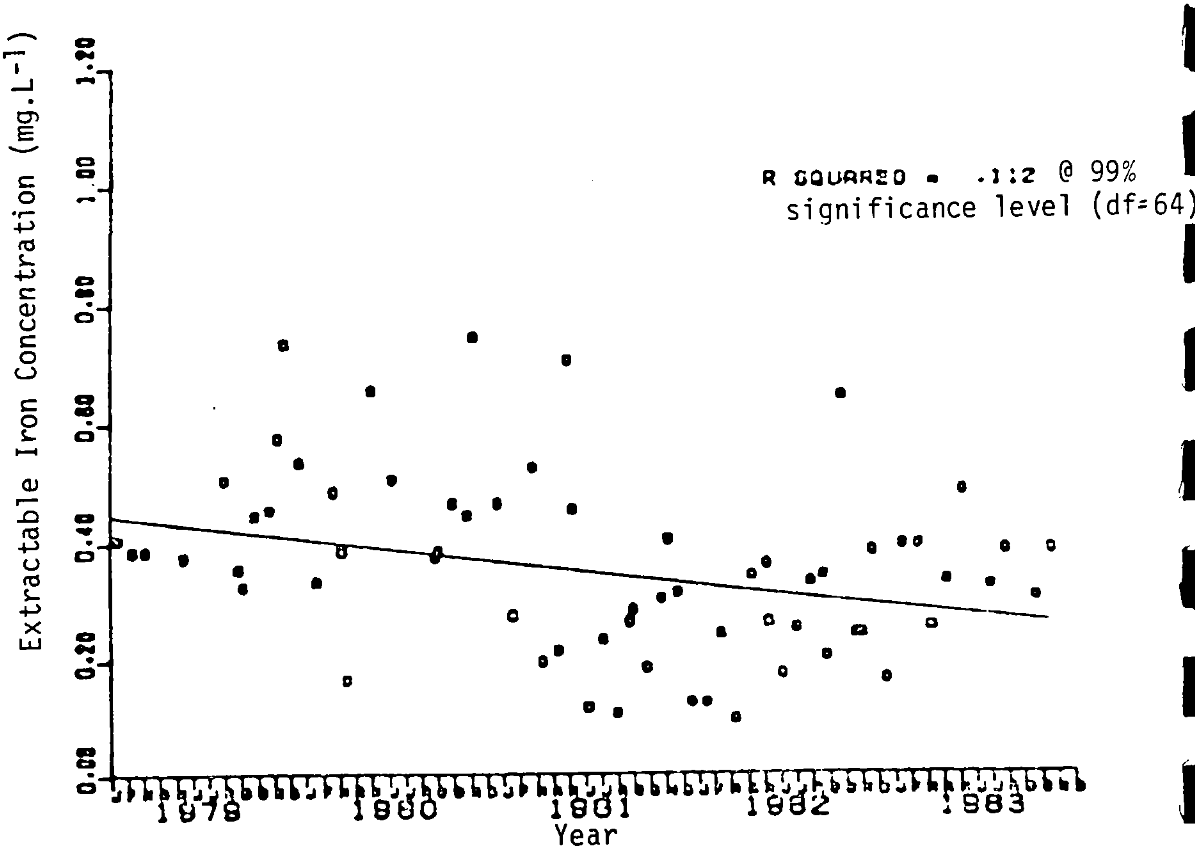


Figure 3.9

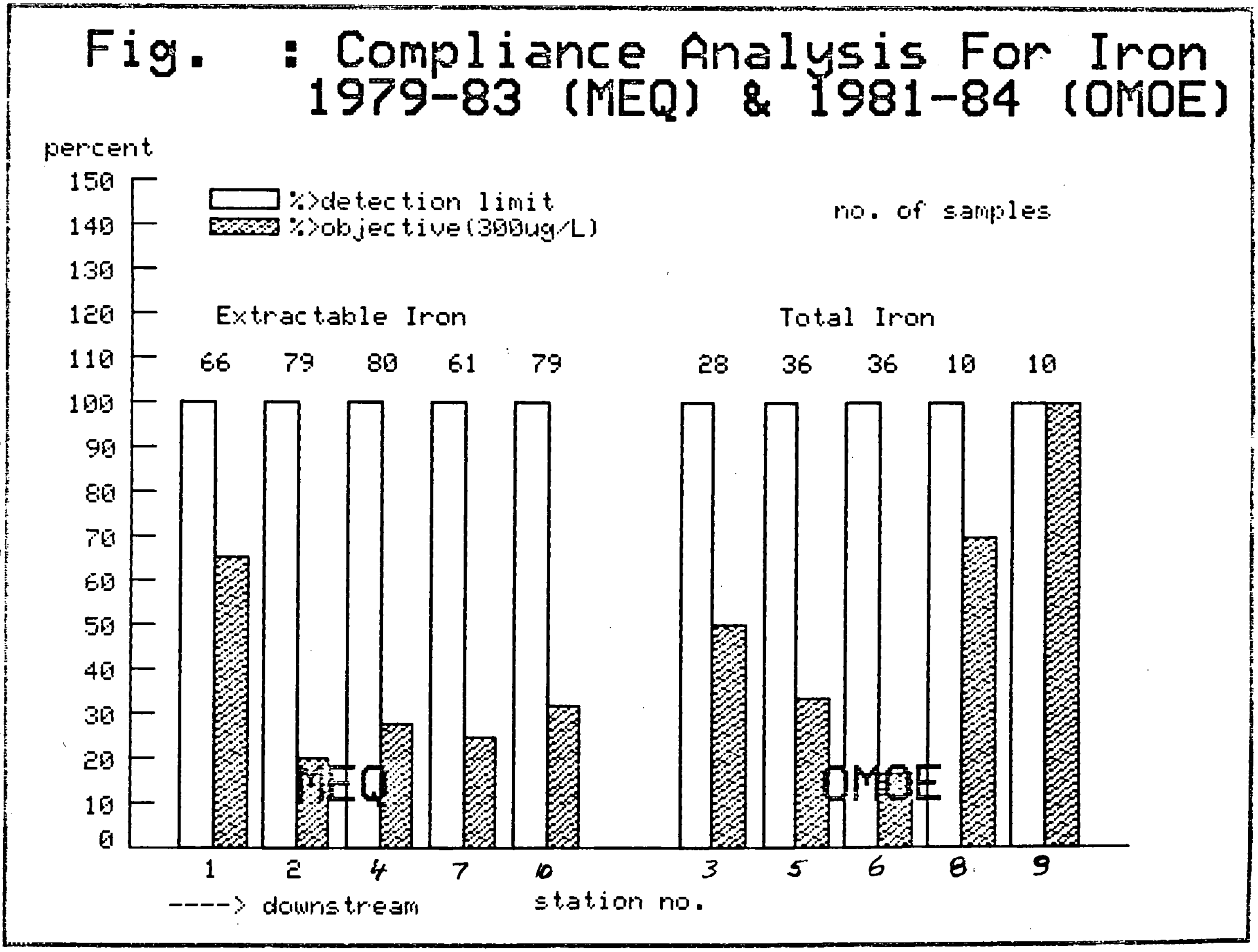


Fig. : Compliance Analysis For Iron
1979-83 (MEQ) & 1981-84 (OMOE)
percent
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
%>detection limit
%>objective(300ug/L)
no. of samples
Extractable Iron
Total Iron
66
79
80
61
79
28
36
36
10
10
MEQ
OMOE
1
2
4
7
10
3
5
6
8
9
----> downstream
station no.

Figure 3.11 Extractable Iron Concentration at the Portage du Fort Sampling Location, 1979-1983.

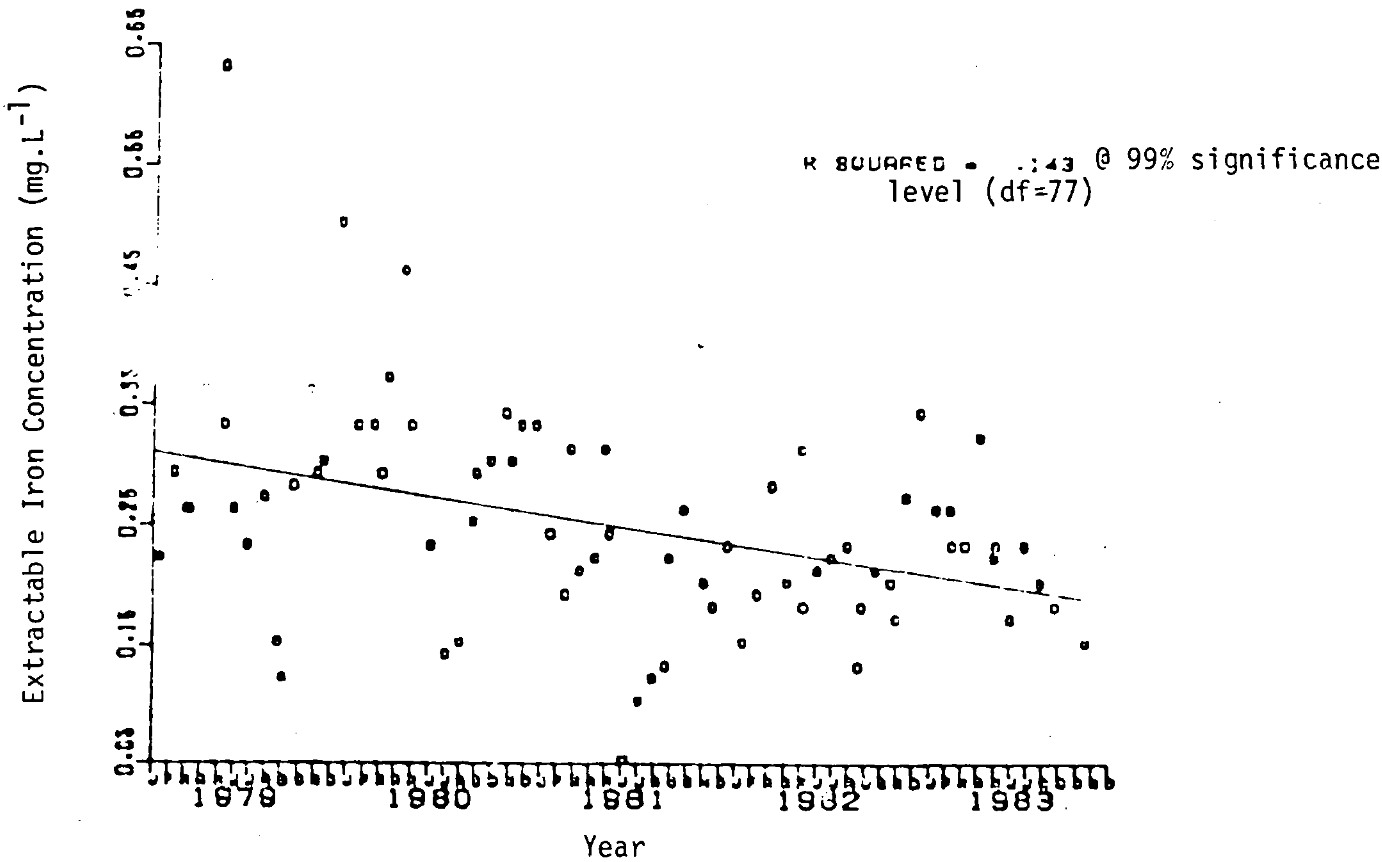


Figure 3.12 Seasonal Percent Exceedances for Extractable Iron at Five Ottawa River Mainstem Sampling Locations (MEQ Data).

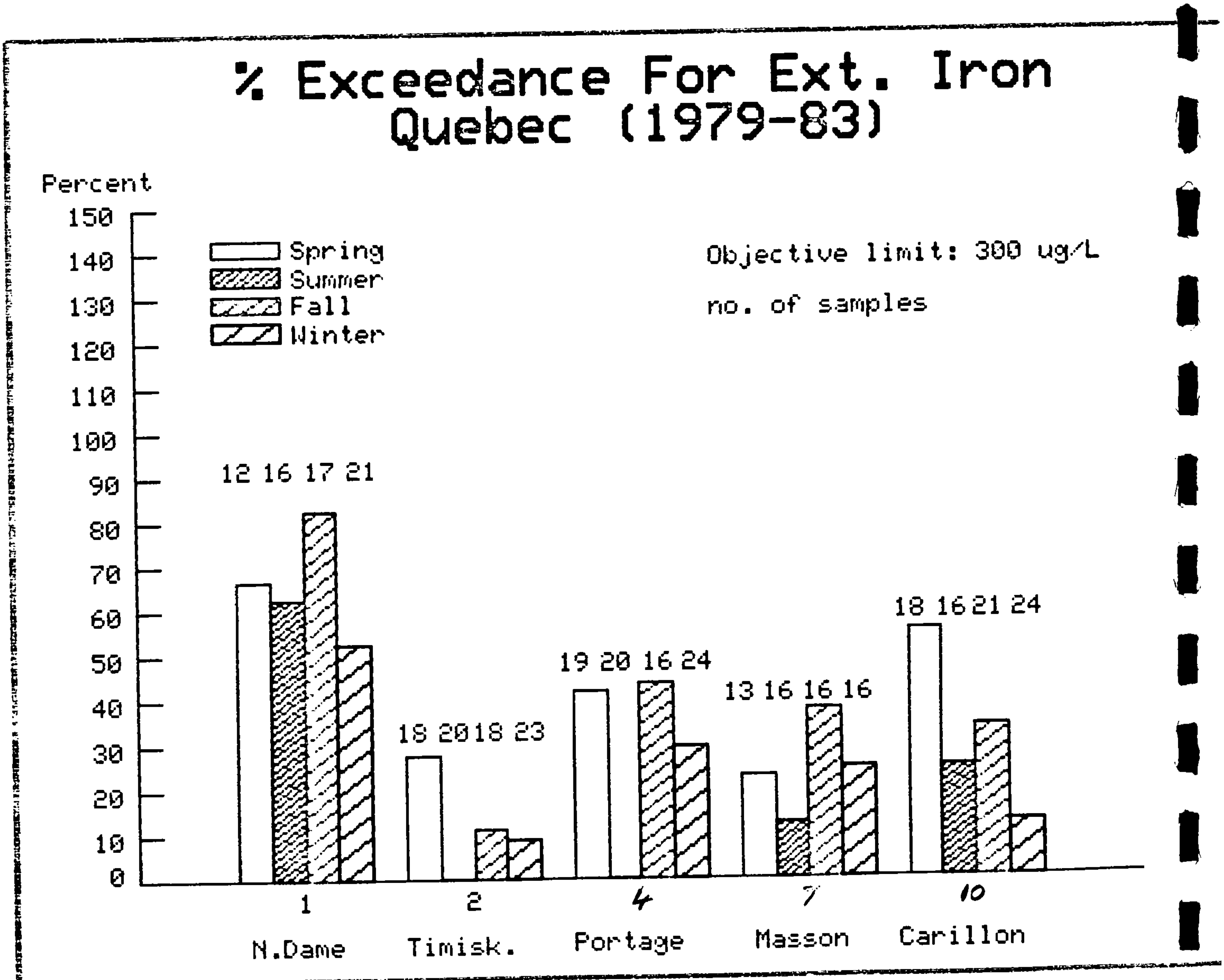


Figure 3.13 Seasonal Percent Exceedances for Total Iron at Five Ottawa River Mainstem Sampling Locations (OMOE Data).

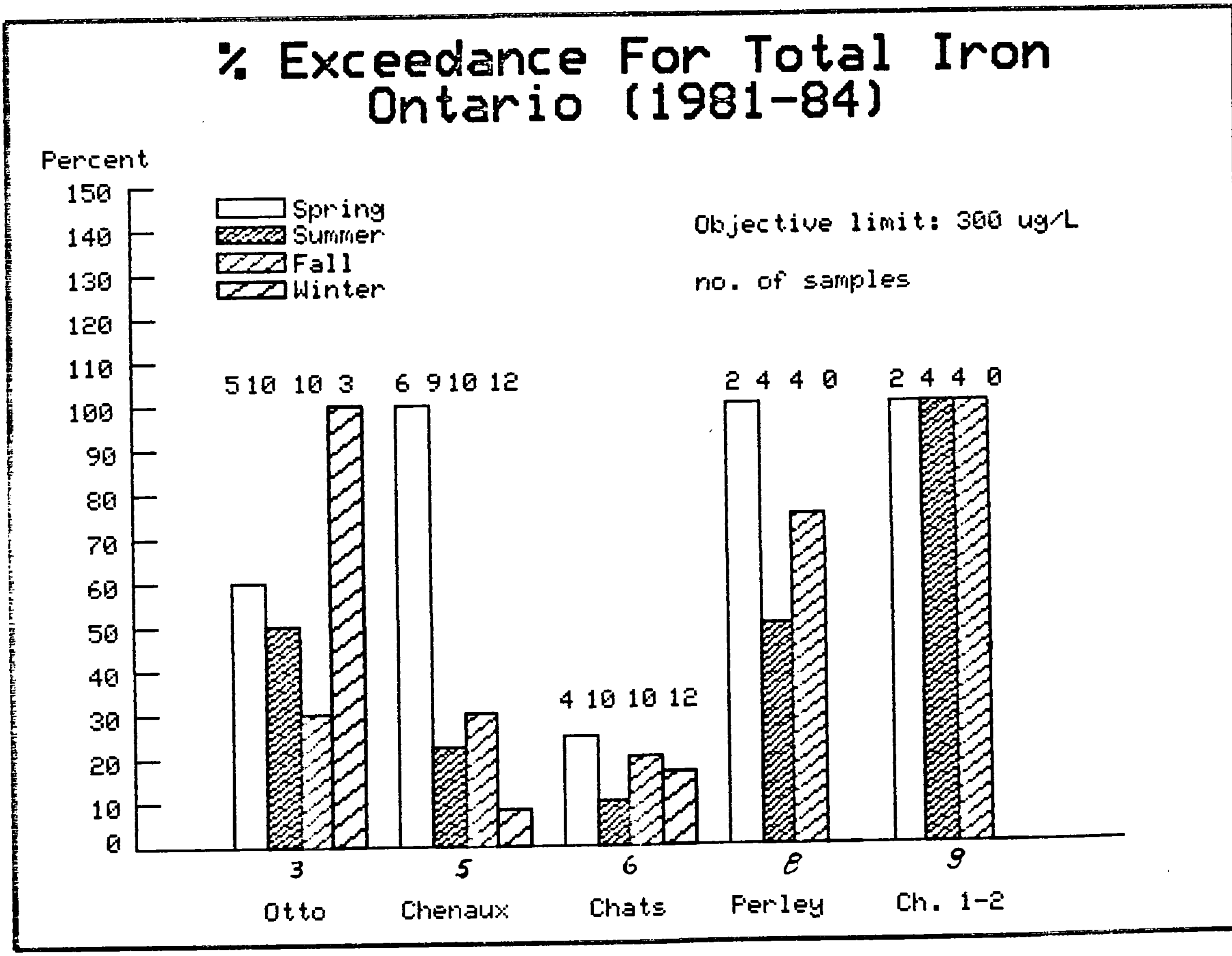


Figure 3.14

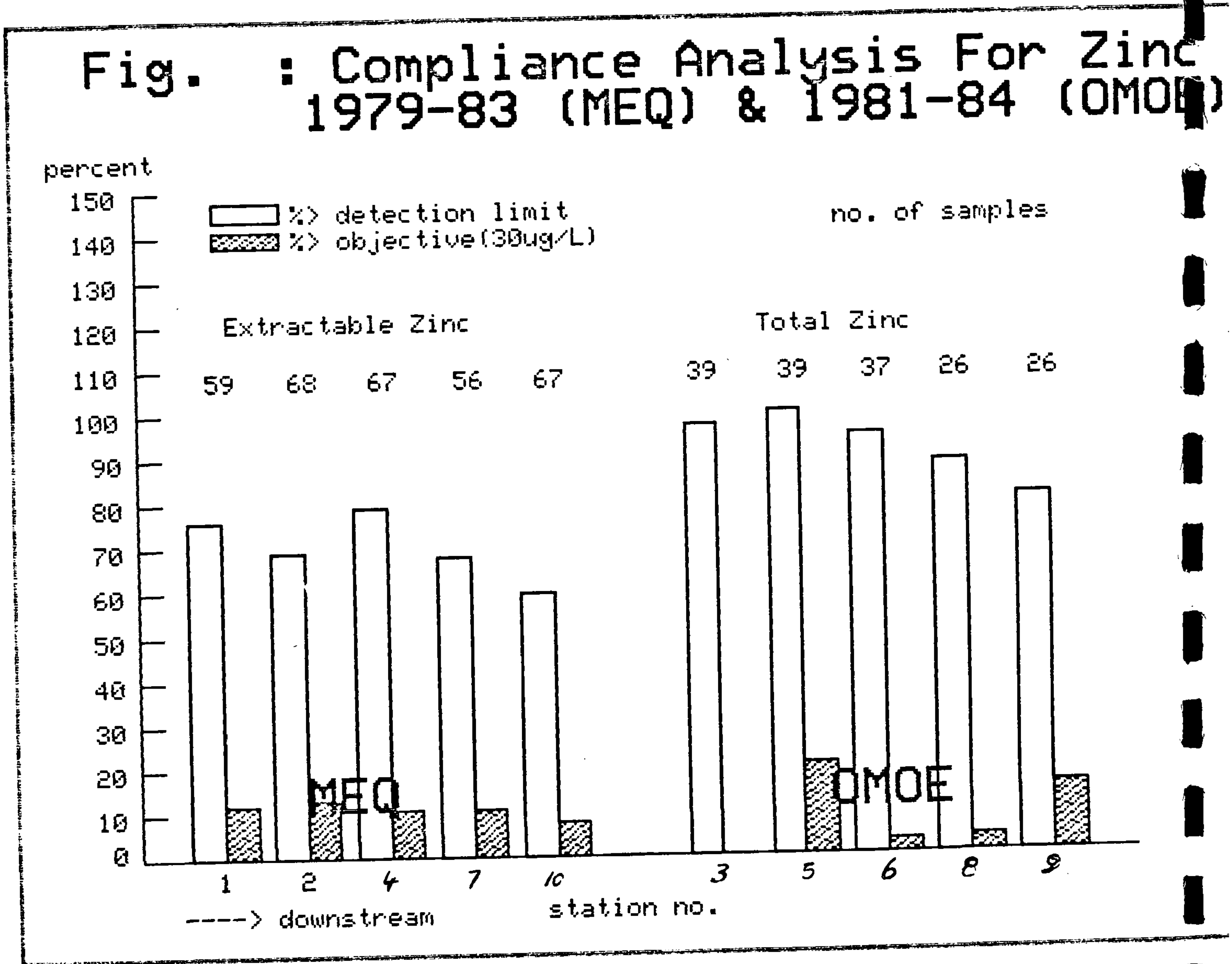


Fig. : Compliance Analysis For Zinc
1979-83 (MEQ) & 1981-84 (OMOE)
percent
%> detection limit
%> objective(30ug/L)
no. of samples
Extractable Zinc
Total Zinc
59
68
67
56
67
39
39
37
26
26
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
MEQ
OMOE
1
2
4
7
10
3
5
6
8
9
----> downstream
station no.

Figure 3.15 Seasonal Percent Exceedances for Extractable Zinc at Five Ottawa River Mainstem Sampling Locations (MEQ Data).

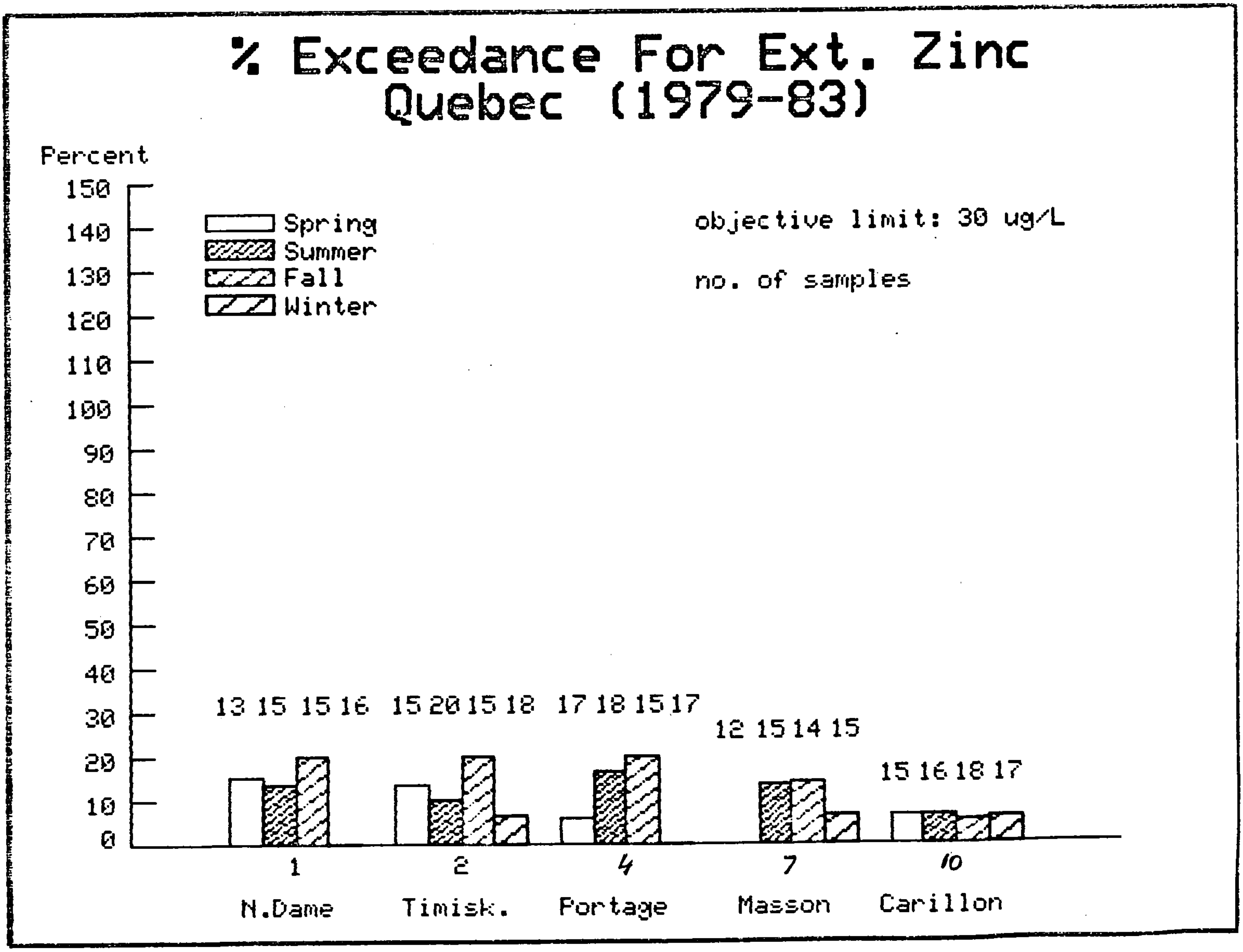


Figure 3.16 Seasonal Percent Exceedances for Total Zinc at Five Ottawa River Mainstem Sampling Locations (OMOE data).

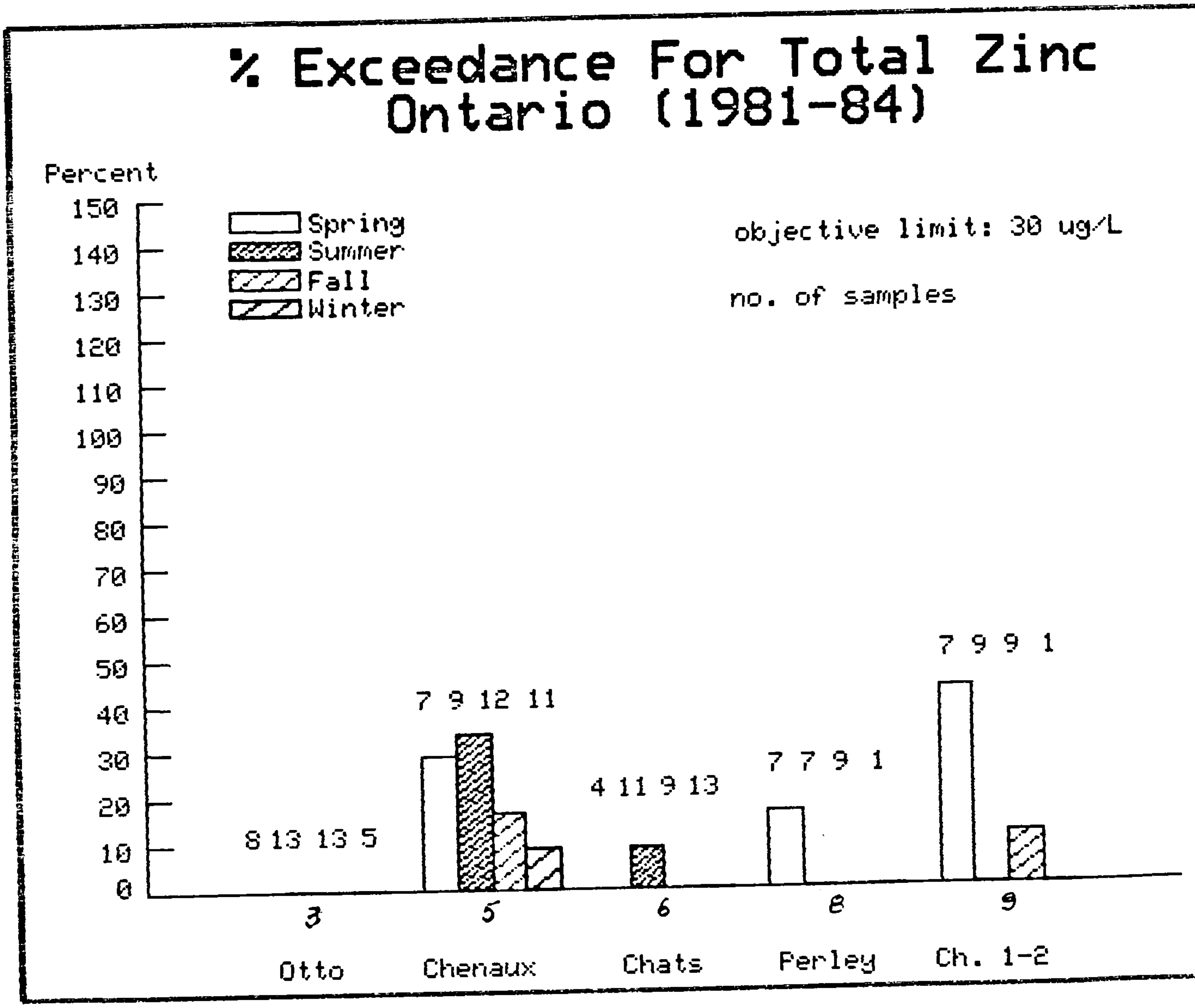


Figure 3.17

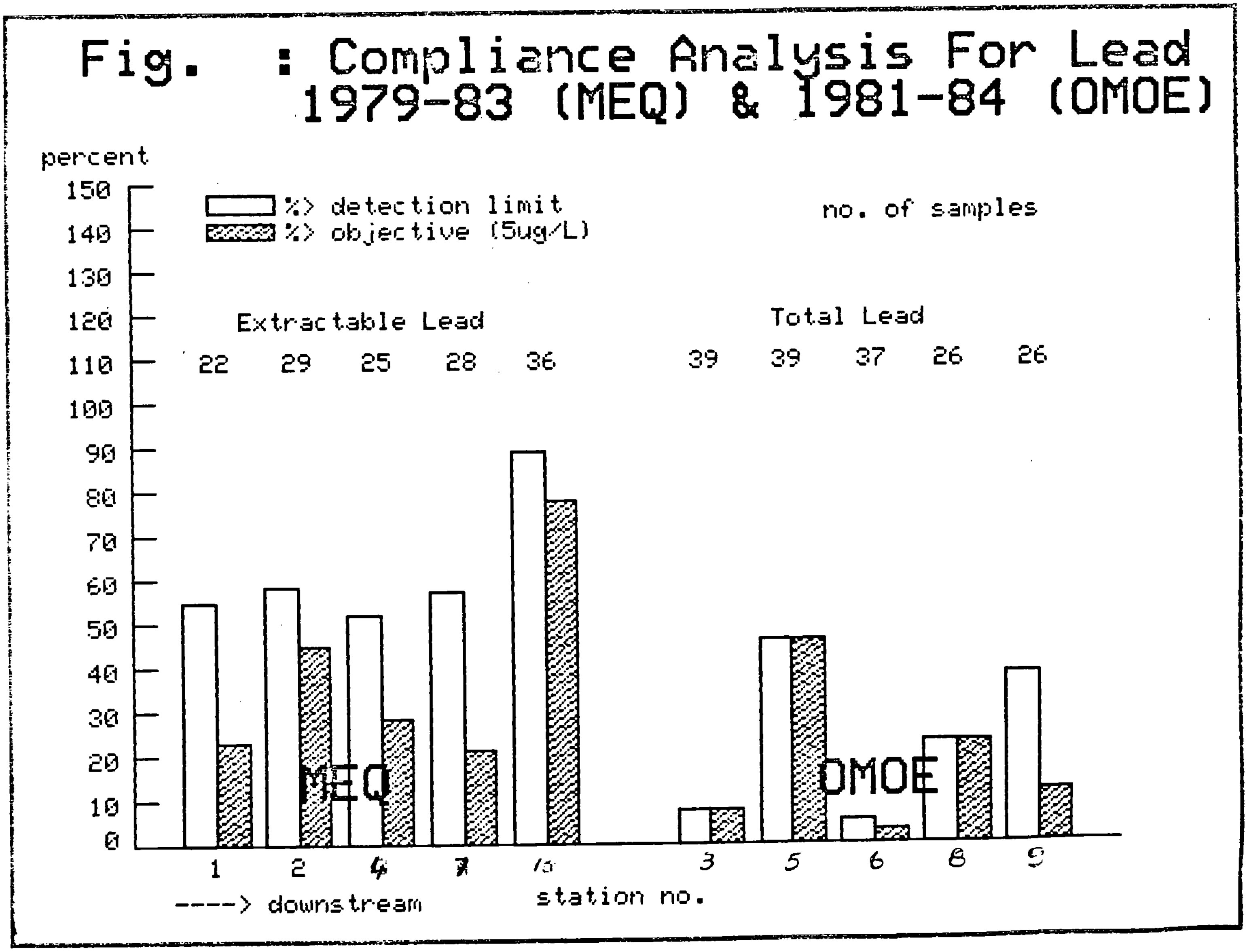


Fig. : Compliance Analysis For Lead
1979-83 (MEQ) & 1981-84 (OMOE)
percent
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
%> detection limit
%> objective (5ug/L)
no. of samples
Extractable Lead
Total Lead
22 29 25 28 36
39 39 37 26 26
MEQ
OMOE
1 2 4 7 10
3 5 6 8 9
----> downstream
station no.

Figure 3.18 Seasonal Percent Exceedances for Extractable Lead at Five Ottawa River Mainstem Sampling Locations (MEQ Data).

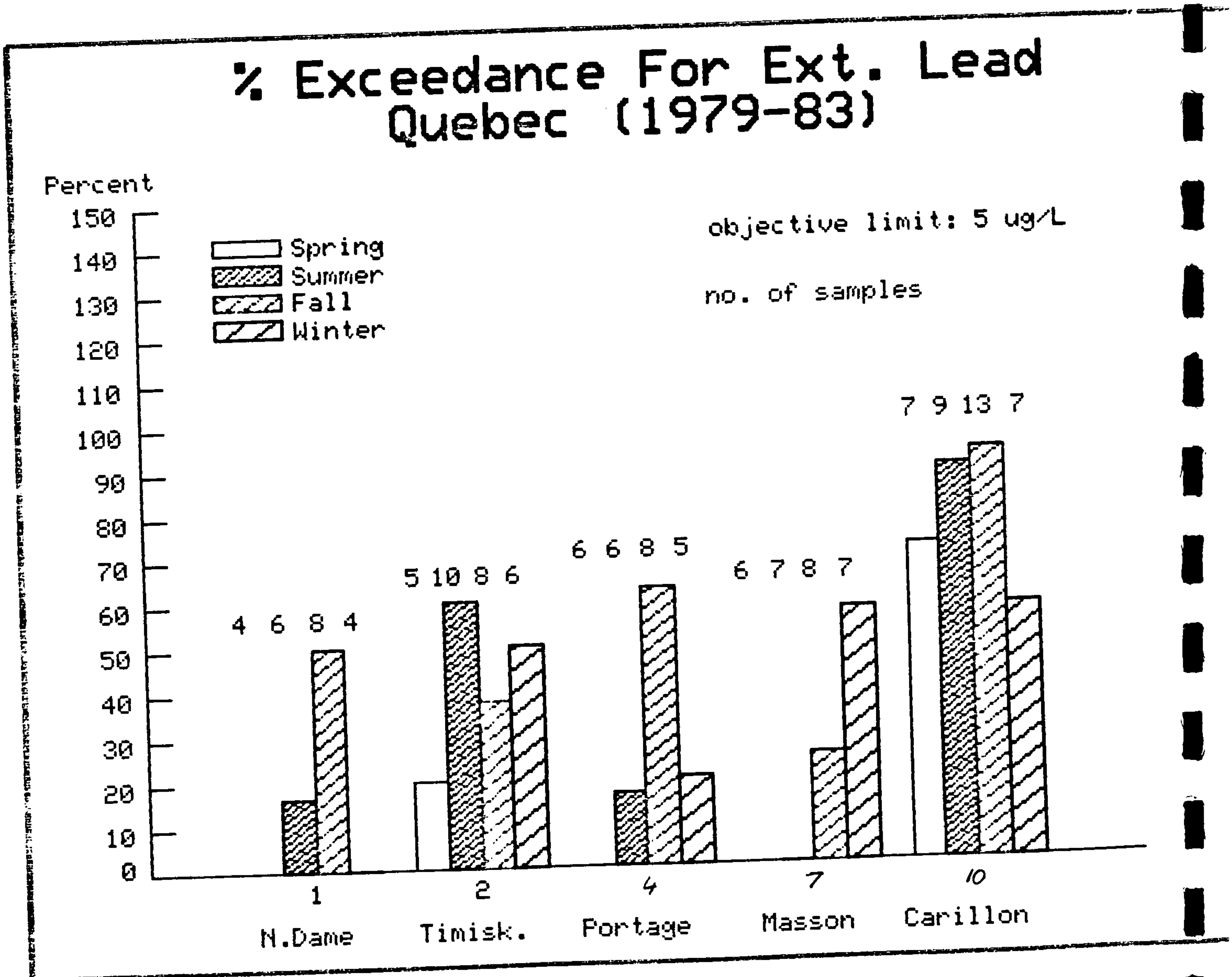
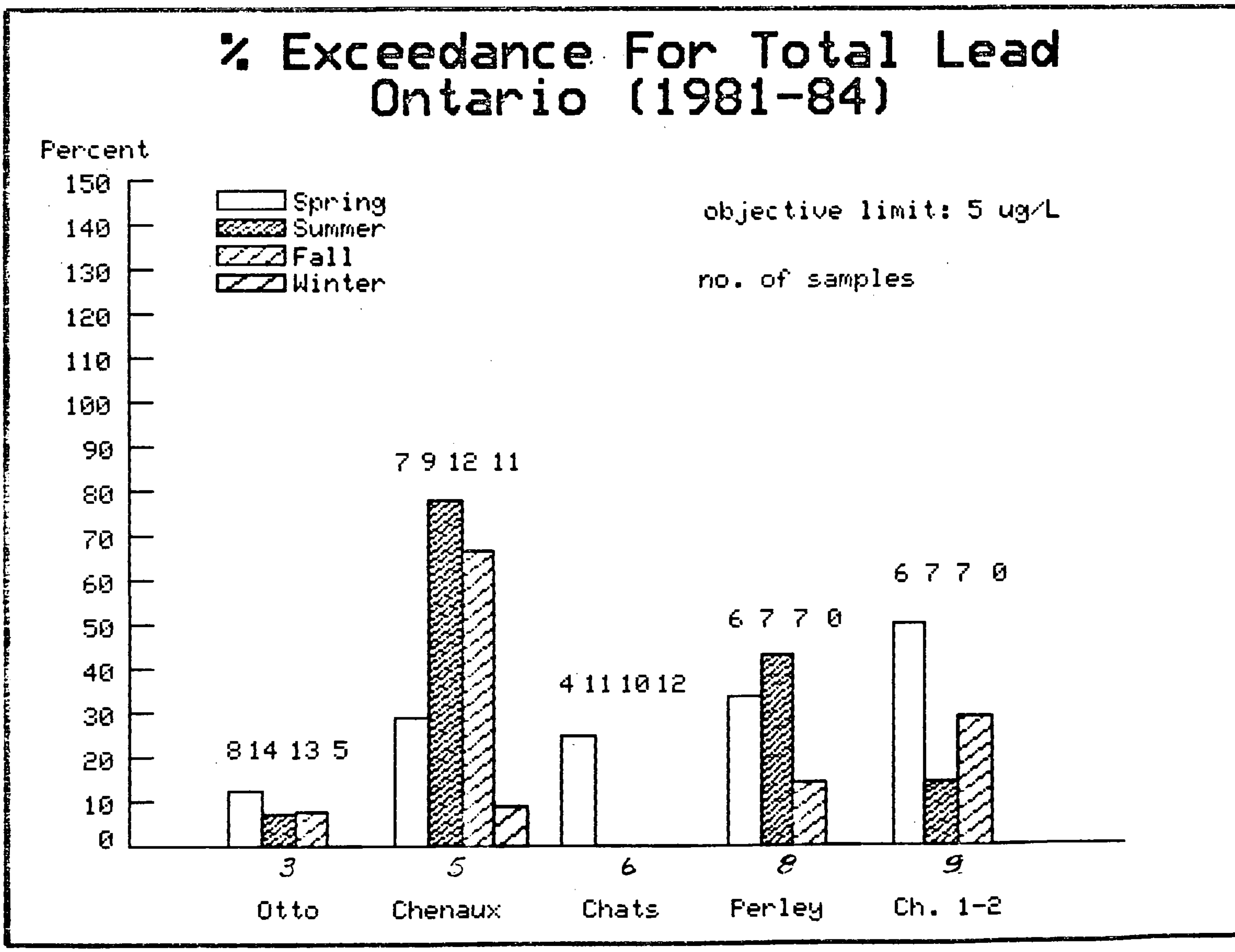


Figure 3.19 Seasonal Percent Exceedances for Total Lead at Five Ottawa River Mainstem Sampling Locations (OMOE Data).



4.0 Toxic Organic Substances

4.1 Introduction

Studies on the presence of toxic organic substances in biota, water and sediment samples from the Ottawa River have been carried out for the past seven years by the ministries of the environment for Quebec (MEQ) (6) and Ontario (OMOE) (5) and the federal departments of Health and Welfare (8) and Environment (4, 7). Over the years new analytical techniques and improved collection procedures have expanded the list of toxic organic compounds found in the Ottawa River. Polyaromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and organochlorine pesticides (e.g. DDT) predominate the list of organic substances found in the biota, water and sediment of the Ottawa River (Tables 4.1 - 4.4). Of the over seventy compounds analyzed in the water, sediment or fish samples 29 were not detected and 49 were detected in various concentrations. Two exceeded the Canadian guidelines for consumption of fish (PCBs and DDT) and one, 1,2-dichloroethane, exceeded drinking water guidelines (Tables 4.1 and 4.2). Seven compounds exceeded the recommended OMOE guidelines for aquatic life (Table 4.2).

4.2 Fish

Both OMOE and MEQ have carried out fish tissue analysis for PCBs and DDT in the Ottawa River. The results of these studies are summarized in table 4.1. The MEQ results represent concentrations obtained from whole fish samples while the OMOE data were based on samples of fish fillet (edible portion). The concentration of contaminants in fish tissues might not represent a contamination problem at the location of capture because of the migratory habits of the sport fish, especially those of northern pike, walleye and suckers. Fish migration may extend several kilometers in either direction from the point of collection.

The results show that PCBs and DDT concentrations in fish from the Ottawa River exceeded in a few cases the Canadian guidelines both for human consumption of fish and the protection of fish-eating birds (5,12). This contamination occurred primarily downstream from the Ottawa-Hull area in the tributaries of the Lièvre River, at Masson and the Gatineau River in the Hull area, as well as on the mainstem of the Ottawa River at Templeton. Trace amounts of PCBs and DDT were found in fish in the Thurso and Carillon Dam sections of the Ottawa River. Although, tissues from both the benthivorous and piscivorous fish species collected by each agency contained similar concentrations, maximum PCBs levels measured in fish fillets collected by Ontario were slightly higher (25%) than the whole fish PCBs levels, obtained by MEQ.

DDT was higher in the piscivorous fish species (walleye, northern pike) than the benthivorous species (white sucker). This was true for both the whole fish and fillet.

4.3 Water

Environment Canada and Health and Welfare Canada have been monitoring Ottawa River water for the presence of organic contaminants. Studies carried out by Environment Canada have been focused in the National Capital Region, upstream of Ottawa, at Fitzroy Harbour (Chats Falls Generating Station), and downstream of Ottawa, at the Quebec-Ontario border (Carillon). Health and Welfare Canada has conducted studies at water treatment facilities (Britannia and Lemieux Island) in the City of Ottawa.

Table 4.2 shows the wide variety of substances that have been analysed: five classes of organic compounds, including organochlorine pesticides, PCBs, mono and polycyclic aromatic compounds, phthalate esters and halogenated aliphatics. Organochlorine pesticides and PCBs have been the most frequently analyzed ~~classes of compounds~~ with 85 samples collected. In this group there was a high frequency of detection for a number of compounds, but no compound exceeded the recommended guidelines for drinking water. Only PCBs could be considered to be a problem, with a 29% exceedence rate of the guideline for the protection of aquatic life. Dieldrin has the next highest frequency of exceedence, 6%, of the guideline for the protection of aquatic life. Over half of the samples analysed for organochlorine compounds and PCBs were unfiltered. It is not known what portion of the contaminants was absorbed onto the particulate phase of the sample nor what portion was available for biological uptake.

~~The monocyclic aromatic or~~ chlorobenzene group was the next highest in terms of sampling frequency. Although the compounds in this group were detected frequently, the concentrations were very low, posing no environmental concern.

Very few samples have been collected for PAHs, phthalate esters, aromatic hydrocarbons, and halogenated hydrocarbons. Although the frequency of detections is high, where a guideline exists there was only one exceedance - 1,2 dichloroethane. Thus the limited available data suggest that these parameters are not of concern.

In summary, although trace organic substances have been found in the water of the Ottawa River, when compared with the available guidelines for the protection of aquatic life there were few exceedances for some compounds, PCBs being the most frequent. Continued monitoring and source identification for this group of compounds is recommended so that remedial actions may be taken to resolve this issue.

4.4 Sediment

Bottom Sediment

PCBs, DDT isomers, seven chlorobenzenes and one PAH were detected in the bottom sediment of the Ottawa River (Table 4.3). There are no guidelines for concentrations of toxic substances in sediments as there are in the case of water. The guidelines for open-water disposal of dredged materials, although not the most appropriate, are presently the only available reference levels one can use to compare the sediment concentrations found in this study. The only organic compounds included in these guidelines are the PCBs and the p,p'-DDT. The PCBs exceeded the criteria of acceptability for open-water disposal of dredged materials. The exceedances occurred from La Cave, near Mattawa, Ontario, through to Carillon Dam (approximately 400 km stretch). The PCBs in the bottom sediments could originate from a number of sources including atmospheric deposition, hydroelectric facilities, urban surface runoff, treatment plant effluents and industrial point source discharges.

Suspended Sediment

Alpha-BHC, PCBs, eight chlorobenzenes and three PAHs were detected in the suspended sediments collected from Chats Falls, Lemieux Island and Carillon Dam (Table 4.4). The PCBs exceeded the objective for open-water disposal of dredged materials. Most of these exceedances occurred at the Chats Falls hydroelectric facility; the remaining occurred at Carillon Dam. As in the case of bottom sediments, it must be noted that this objectives is not the most appropriate for comparing suspended sediments concentrations. It is, however, the only sediment-related guideline currently existing in the scientific literature.

Table 4.1: PCBs and DDT Concentration Range and Percent Exceedance in Benthivorous and Piscivorous Fish Species

Compound	Trophic Type	Agency*	Concentration Range $mg.kg^{-1}$	Number Results	Guideline+	Percent Exceedance
PCBs	Benthivore**	Quebec 1978-1980	0.290 - 2.620	28	2.0 mg/kg	14
	Piscivore++	Quebec 1978-1980	0.203 - 2.070	33	2.0 mg/kg	3
	Benthivore***	Ontario 1978-1982	N.D. - 3.280	15	2.0 mg/kg	NA
	Piscivore+++	Ontario 1982-1983	N.D. - 2.719	211	2.0 mg/kg	NA
DDT	Benthivore**	Quebec 1978-1980	0.045-0.077	25	5.0 mg/kg	0
	Piscivore++++	Quebec 1978-1980	0.081-0.541	21	5.0 mg/kg	0
	Benthivore**	Ontario 1982	N.D. - 0.002	6	5.0 mg/kg	0
	Piscivore+++	Ontario 1972-1982	N.D. - 11.121	130	5.0 mg/kg	NA

+ = Guideline for the protection of human consumers of fish
* In Quebec, whole fish composites of 1 to 3 fish/site;
In Ontario, fish fillet, 1 fish/site
** Benthivore = white sucker
*** Benthivore = white sucker and carp
++ Piscivore = Walleye and Pike
+++ Piscivore = Walleye, Yellow Perch, Northern Pike
++++ Piscivore = Walleye

NA = detailed Ontario data were not available to determine % exceedance

Table 4.2: Trace Organic Contaminants in Raw Water - Ottawa River

Compound	Agency	Concentration Range ($ng.L^{-1}$)	Sample Size	Frequency of Detections (%)	Aquatic Life Guideline ($ng.L^{-1}$)	Guideline Exceedance (%)	Human Health Guideline ($ng.L^{-1}$)	Guideline Exceedance (%)
Organochlorine Pesticides and Polychlorinated Biphenyls (PCBs)								
Σ DDT and Metabolites	EC	ND - 3.1	85	14	3.0[a]	1	30,000	0
p,p' - DDT	EC	ND - 1.7	85	8	-	-	-	-
o,p' - DDT	EC	ND - 1.8	85	7	-	-	-	-
p,p' - TDE	EC	ND	85	0	-	-	-	-
p,p' - DDE	EC	ND - 1.6	85	8	-	-	-	-
p,p' - Methoxychlor	EC	ND - 4.0	85	16	40*,[a]	0	100,000++	0
Heptachlor	EC	ND	85	2	1 [a]	0	3,000*	0
Heptachlor Epoxide	EC	ND - 2.0	85	16	1 [a]	2	3,000*	0
Alpha-Endosulfan	EC	ND - 2.3	85	12	3 [a]	0	74,000+	0
Beta-Endosulfan	EC	ND - 8.6	85	5	3 [a]	1	74,000+	0
Alpha-Chlordane	EC	ND - 1.1	85	6	60 [a]	0	7,000++	0
Gamma-Chlordane	EC	ND - 1.3	85	9	60 [a]	0	7,000++	0
Lindane	EC	ND - 8.3	85	85	10 [a]	0	4,000++	0
Alpha-BHC	EC	ND - 11.1	85	93	10 [a]	5	9.2+	5
Mirex	EC	ND	85	0	1 [a]	0	-	-
Endrin	EC	ND - 2.3	85	6	2 [a]	1	200++	0
Dieldrin	EC	ND - 3.9	85	21	1 [a]	6	70++	0
Aldrin	EC	ND	85	0	1 [a]	0	70++	0
PCBs (Total)	EC	ND - 33.0	85	29	1 [a]	29	300[a]	0
Chlorinated Aromatic Hydrocarbons								
1,3 - Dichlorobenzene	EC	ND - 0.4	37	16	-	-	620,000**	0
1,4 - Dichlorobenzene	EC	ND - 1.5	37	19	-	-	620,000**	0
1,2 - Dichlorobenzene	EC	ND - 4.0	37	19	-	-	620,000**	0
1,3,5 - Trichlorobenzene	EC	ND - 0.02	37	11	-	-	-	
1,2,4 - Trichlorobenzene	EC	ND - 0.2	37	32	-	-	-	
1,2,3 - Trichlorobenzene	EC	ND - 0.09	37	22	-	-	-	
1,2,4,5 - Tetrachlorobenzene	EC	ND - 1.3	37	8	-	-	38,000+	
1,2,3,5 - Tetrachlorobenzene	EC	ND	37	0	-	-	-	
1,2,3,4 - Tetrachlorobenzene	EC	ND - 0.03	37	27	-	-	-	
Pentachlorobenzene	EC	ND - 0.03	37	24	-	-	74,000+	
Hexachlorobenzene	EC	ND - 0.1	37	22	-	-	10*	0

Table 4.2: Trace Organic Contaminants in Raw Water - Ottawa River (continued)

Compound	Agency	Concentration Range ($ng.L^{-1}$)	Sample Size	Frequency of Detections (%)	Aquatic Life Guideline ($ng.L^{-1}$)	Guideline Exceedance (%)	Human Health Guideline ($ng.L^{-1}$)	Guideline Exceedance (%)
Polyaromatic Hydrocarbons								
Naphthalene	EC-NHW	2.4 - 34.8	5	100	-	-	-	-
Methylnaphthalene	EC-NHW	ND - 4.1	5	40	-	-	-	-
Dimethylnaphthalene	EC-NHW	ND - 17.3	5	40	-	-	-	-
Biphenyl	EC-NHW	ND - 0.3	5	40	-	-	-	-
Acenaphthalene	EC-NHW	ND - 0.5	5	40	-	-	-	-
Bibenzyl	EC-NHW	ND - 1.0	5	40	-	-	-	-
Fluorene	EC-NHW	ND - 0.9	5	40	-	-	-	-
Phenanthrene and Anthracene	EC-NHW	ND - 9.8	5	40	-	-	-	-
1-Methyl-Phenanthrene	EC-NHW	ND - 34.4	5	20	-	-	-	-
Fluoranthene	EC-NHW	ND - 1.4	5	100	-	-	-	-
Pyrene	EC-NHW	ND - 1.7	5	100	-	-	-	-
Benz-(a)-Anthrancene + Triphenylene + Crysene	EC-NHW	ND - 0.005	5	20	-	-	-	-
Oxygenated Polyaromatic Hydrocarbons								
9-Fluorenone	NHW	1.2 - 10.4	2	100	-	-	-	-
Perinaphtenone	NHW	0.3 - 2.8	2	100	-	-	-	-
Acenaphthenequinone	NHW	0.9 - 10.6	2	100	-	-	-	-
Anthraquinone	NHW	0.9 - 4.7	2	100	-	-	-	-
Phthalate Esters								
Dioctyl Phthalate	EC-NHW	Trace - 0.46	3	100	200 [a]	0	-	-
Dibutyl Phthalate	EC-NHW	Trace - 2.3	3	100	400 [a]	0	34,000,000	0

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Table 4.2: Trace Organic Contaminants in Raw Water - Ottawa River (continued)

Compound	Agency	Concentration Range ($ng.L^{-1}$)	Sample Size	Frequency of Detections (%)	Aquatic Life Guideline ($ng.L^{-1}$)	Guideline Exceedance (%)	Human Health Guideline ($ng.L^{-1}$)	Guideline Exceedance (%)
Halogenated Hydrocarbons								
Dichlorodifluoromethane	NWW	ND	2	0				
Bromoform	NHW	ND	2	0	-	-	1,400,000	0
Chloromethane	NHW	ND	2	0	-	-	3,800,000	0
Dichloromethane	NHW	ND, 50000	2	50	-	-	350,000 **	0
Chloroform	NHW	2500, 24000	2	100	+	-	30,000 *	0
Dichlorobromomethane	NHW	ND	2	0	-	-	-	-
Chlorodibromomethane	NHW	ND	2	0	+	-	-	-
Chloroethylene	NHW	ND	2	0	-	-	-	-
Vinylidene chloride	NHW	ND	2	0	-	-	-	-
trans - 1,2 Dichloroethylene	NHW	ND, 18000	2	50	+	-	70,000 **	0
1,1 Dichloroethane	NHW	ND	2	0	-	-	-	-
1,2 Dichloroethane	NHW	ND, 30000	2	50	-	-	10,000 *	50
Trichloroethylene	NHW	ND	2	0	-	-	30,000 *	0
1,1, 2, Trichloroethane	NHW	ND	2	0	-	-	200,000 **	0
1,1,2,2 Tetrachloroethylene	NHW	ND, 1000	2	50	-	-	680,000 **	0
1,1,2,2 tetrachloroethane	NHW	ND	2	0	-	-		
1,2 Dichloropropane	NHW	ND	2	0	-	-	560 *	0
1,3 Dichloropropane	NHW	ND	2	0	-	-		
Aromatic Hydrocarbons								
Benzene	NHW	ND	2	0	+	-	10,000 *	0
Toluene	NHW	ND	2	0	-	-	2,000,000 **	
Chlorobenzene	NHW	ND	2	0	-	-	20,000	
Ethyl - benzene	NHW	ND	2	0	-	-	680,000 **	0
p-Xylene	NHW	ND	2	0	-	-	440,000 **	0
m-Xylene	NHW	ND	2	0	-	-	440,000 **	0
o-Xylene	NHW	ND	2	0	-	-	440,000 **	0

* = WHO 1984
** = US EPA 1985
\+ = US EPA 1980
++ = NHW 1978 (MAC)
a = OMOE
EC = Environment Canada

[redacted] bl[redacted]3: [redacted] Tr[redacted] org[redacted] Co[redacted]min[redacted] Con[redacted] ra[redacted]s i[redacted] tto[redacted] dim[redacted]s - [redacted] awa[redacted] er [redacted]

Compound	Agency	Concentration Range (mg.kg^{-1})	Number of Results	Frequency of Detection (%)	Guideline* mg.kg^{-1}	Exceedance (%)
Organochlorine Pesticides and PCBs						
p,p' - DDT	EC-MEQ	<0.004 - 0.005	41	2	0.10	0
o,p' - DDT	EC-MEQ	<0.004	41	0	NA	-
p,p' - TDE	EC-MEQ	<0.004 - 0.011	41	2	NA	NA
p,p' - DDE	EC-MEQ	<0.004 - 0.010	41	10	NA	NA
p,p' - Methoxychlor	EC	<0.004	35	0	NA	-
Heptachlor	EC	<0.004	35	0	NA	-
Heptachlor Epoxide	EC	<0.004	35	0	NA	-
Alpha Endosulfan	EC	<0.004	35	0	NA	-
Beta Endosulfan	EC	<0.004	35	0	NA	-
Alpha Chlordane	EC	<0.004	35	0	NA	-
Gamma Chlordane	EC	<0.004	35	0	NA	-
Gamma BHC (Lindane)	EC	<0.004	35	0	NA	-
Alpha BHC	EC	<0.004	35	0	NA	-
Mirex	EC	<0.004	35	0	NA	-
Endrin	EC	<0.004	35	0	NA	-
Dieldrin	EC	<0.004	35	0	NA	-
PCBs (Total)	EC-MEQ	<0.020 - 0.080	41	24	0.050	17
Chlorobenzenes						
1,3-Dichlorobenzene	EC	<0.050 - 0.073	35	29	NA	NA
1,4-Dichlorobenzene	EC	<0.050 - 0.086	35	6	NA	NA
1,2-Dichlorobenzene	EC	<0.050 - 0.064	35	9	NA	NA
1,3,5-Trichlorobenzene	EC	<0.005	35	0	NA	-
1,2,4-Trichlorobenzene	EC	<0.005 - 0.014	35	6	NA	NA
1,2,3-Trichlorobenzene	EC	<0.005 - 0.010	35	3	NA	NA
1,2,4,5-Tetrachlorobenzene	EC	<0.005	35	0	NA	-
1,2,3,5-Tetrachlorobenzene	EC	<0.005	35	0	NA	-
1,2,3,4-Tetrachlorobenzene	EC	<0.005 - 0.006	35	3	NA	NA
Pentachlorobenzene	EC	<0.005 - 0.011	35	3	NA	NA
Hexachlorobenzene	EC	<0.004	35	0	NA	-

Table 4.3: Trace organic Contaminant Concentrations in Bottom Sediments - Ottawa River (continued)

Compound	Agency	Concentration Range $mg.kg^{-1}$	Number of Results	Frequency of Detection (%)	Guideline* $mg.kg^{-1}$	Exceedance (%)
PAH's						
Indene	EC	<0.050	35	0	NA	-
1,2,3,4-Tetrahydronaphthalene	EC	<0.050	35	0	NA	-
2-Methylnaphthalene	EC	<0.050	35	0	NA	-
Quinoline	EC	<0.050	35	0	NA	-
1-Methylnaphthalene	EC	<0.050	35	0	NA	-
Beta-Chloronaphthalene	EC	<0.050	35	0	NA	-
Acenapthalene	EC	<0.050	35	0	NA	-
Acenapthene	EC	<0.050	35	0	NA	-
Fluorene	EC	<0.050	35	0	NA	-
Phenanthrene	EC	<0.050	35	0	NA	-
Fluoranthene	EC	<0.050 - 0.120	35	3	NA	-
Pyrene	EC	<0.050	35	0	NA	-

MEQ = Ministiere d'Environnement du Québec
EC = Environment Canada
NA = not available
* = guideline for open-water disposal of dredged materials

Table 4.4: Trace Organic Contaminant Concentrations in Suspended Sediments - Ottawa River

Compound	Agency	Concentration Range mg.kg-1	Number of Results	Frequency of Detection (%)	Guideline* mg.kg-1	Exceedance (%)
Organochlorine Pesticides and PCB's						
p,p' - DDT	EC	<0.004	35	0	0.010	NA
o,p' - DDT	EC	<0.004	35	0	NA	NA
p,p' - TDE	EC	<0.004	35	0	NA	NA
p,p' - DDE	EC	<0.004 - 0.016	35	3	NA	NA
p,p' - Methoxychlor	EC	<0.004	35	0	NA	NA
Heptachlor	EC	<0.004	35	0	NA	NA
Heptachlor Epoxide	EC	<0.004	35	0	NA	NA
Alpha-Endosulfan	EC	<0.004	35	0	NA	NA
Beta-Endosulfan	EC	<0.004	35	0	NA	NA
Alpha-Chlordane	EC	<0.004	35	0	NA	NA
Gamma-Chlordane	EC	<0.004	35	0	NA	NA
Gamma-BHC (Lindane)	EC	<0.004	35	0	NA	NA
Alpha-BHC	EC	<0.004 - 0.052	35	23	NA	NA
Mirex	EC	<0.004	35	8	NA	NA
Endrin	EC	<0.004	35	0	NA	NA
Dieldrin	EC	<0.004	35	0	NA	NA
PCBs (Total)	EC	<0.09 - 0.16	35	17	0.050	17
Chlorobenzenes						
1,3-Dichlorobenzene	EC	<0.050	35	0	NA	NA
1,4-Dichlorobenzene	EC	<0.050 - 0.240	35	3	NA	NA
1,2-Dichlorobenzene	EC	<0.050	35	0	NA	NA
1,3,5-Trichlorobenzene	EC	<0.005	35	0	NA	NA
1,2,4-Trichlorobenzene	EC	<0.005	35	0	NA	NA
1,2,3-Trichlorobenzene	EC	<0.005	35	0	NA	NA
1,2,4,5-Tetrachlorobenzene	EC	<0.005	35	0	NA	NA
1,2,3,5-Tetrachlorobenzene	EC	<0.005	35	0	NA	NA
1,2,3,4-Tetrachlorobenzene	EC	<0.005	35	0	NA	NA
Pentachlorobenzene	EC	<0.005	35	0	NA	NA
Hexachlorobenzene	EC	<0.004	35	0	NA	NA

Table 4.4: Trace Organic Contaminant Concentrations in Suspended Sediments - Ottawa River (continued)

Compound	Agency	Concentration Range mg.kg^{-1}	Number of Results	Frequency of Detection (%)	Guideline* mg.kg^{-1}	Exceedance (%)
PAH's						
Indene	EC	<0.050	12	0	NA	-
1,2,3,4-Tetrahydronaphthalene	EC	<0.050	12	0	NA	-
2-Methylnaphthalene	EC	<0.050	12	0	NA	-
Quinoline	EC	<0.050 - 5.4	12	33	NA	NA
1-Methylnaphthalene	EC	<0.050	12	0	NA	-
Beta-Chloronaphthalene	EC	<0.050 - 8.56	12	66	NA	NA
Acenaphthalene	EC	<0.050 - 0.69	12	8	NA	NA
Acenaphthene	EC	<0.050	12	0	NA	-
Fluorene	EC	<0.050	12	0	NA	-
Phenanthrene	EC	<0.050	12	0	NA	-
Fluoranthene	EC	<0.050	12	0	NA	-
Pyrene	EC	<0.050	12	0	NA	-

EC = Environment Canada
NA = not available
* = guideline for open-water disposal of dredged materials

5.0 NUTRIENTS

5.1 Introduction

The "nutrient" water quality parameters consist of various chemical and physical forms of phosphorous, nitrogen and carbon. The term "nutrient" reflects their importance in the growth of aquatic life. If any of these three elements is absent, the growth of aquatic life is hindered.

Nutrient inputs into aquatic systems originate from a number of natural and anthropogenic processes, including weathering, urban and rural surface runoff, especially from fertilized agricultural lands and livestock operations, atmospheric wet and dry deposition, biological assimilation and degradation, industrial activities (e.g. pulp and paper mills) and forestry practices. Other influences on the nutrient concentrations, especially in the Ottawa River, are the impoundments and seasonal discharge characteristics.

The concern for phosphorous loading in the Ottawa River was already addressed by modifying certain sewage treatment plants (STPs) to reduce the phosphorus contribution to the recipient waters. This action of Ontario Ministry of Environment (OMOE) together with the implementation of the phosphorus reduction measures of the Canada Water Act of 1970 have contributed to lowering levels of total phosphorus throughout the interprovincial section of the river (Task Force Report, 1977).

This chapter reports on spatial, temporal and seasonal variations of the nutrient data collected by OMOE and MEQ from the mainstem stations and thirteen major tributaries entering the Ottawa River.

Data Sources and Analysis

The agency and the type of nutrient data collected are shown in table 5.1.

Table 5.1 Agency and the Type of Nutrient Data Collected.

AGENCY	NITROGEN	AGENCY	PHOSPHORUS
OMOE	Total Nitrogen	OMOE, MEQ	Phosphorus - Total
OMOE, MEQ	Total Kjeldahl Nitrogen		
OMOE	Dissolved Ammonia (Filtered)		
MEQ	Total Ammonia (Unfiltered)		
OMOE	Nitrogen -Nitrite		Other
OMOE	Nitrogen -Nitrate	OMOE, MEQ	Dissolved Oxygen
MEQ	Nitrogen -Nitrite + Nitrate		

The frequency of sampling at some of the monitoring stations during the course of the study period was inadequate for interpreting the data collected. Changes in analytical methods in 1982 for the phosphorus-dissolved and particulate added to the difficulties of analyzing and interpreting the data. As a result the total phosphorus was the only one considered in the statistical assessment of the phosphorus data base. Statistical analysis, including one-way ANOVA, Duncan's Multiple Range Test, Students' t-Test, mean and standard deviation, was limited to nutrient data that had adequate sample sizes and frequencies of collection during the study period 1977 to 1984. The data analysis also included comparisons with the 1971-1977 of results as reported in the Task Force Report (1977).

5.2 Total Nitrogen

5.2.1 Mainstem

Spatial Variation

The spatial variation of the total nitrogen concentrations is shown in figure 5.1. (The total nitrogen analysis was discontinued after 1981.) High concentrations and variability occurred at Otto Holden Dam (Station 3), Hawkesbury-Perley Bridge (Station 8) and Hawkesbury-Channel 1 and 2 (Station 9). These stations were located downstream from sulphite process pulp and paper mills. The Tembec Forest Products mill effluent discharge directly affected the total nitrogen levels at Otto Holden Dam, 40 km downstream. The CIP-Hawkesbury mill and Hawkesbury sewage treatment plant directly influenced the nearshore total nitrogen concentrations recorded at Station 9 and indirectly influenced the mainchannel Station 8. The gradual decline in total nitrogen mean values in a downstream direction, from Otto Holden Dam to Chats Falls Dam, was probably due to the nitrification process, i.e. the oxidation of various nitrogen forms to nitrates, taking place in this stretch of the river.

The increase from Chats Falls to Hawkesbury was attributed to the nutrient sources originating from the Ottawa-Hull region, Ontario tributaries, draining primarily agricultural land, and two sulphite process pulp and paper mills operating in Masson, Quebec, and Hawkesbury, Ontario.

Temporal Variation

The total nitrogen concentration temporal variations at the various mainstem stations are shown in figure 5.2. Otto Holden Dam annual mean values declined from 1971 to 1973 as a result of the sulphite pulp and paper mill shutdown, but then went back up after start-up of

Tembec Forest Products Ltd. mill located at Timiskaming, Quebec. The last available value, in 1981, seems to indicate lower values again. More data are needed to confirm this. There were no significant changes in the levels of total nitrogen at the Chats Fall and Chenaux Dams stations over the 1971-1981 period.

The high variability at Hawkesbury-Perley Bridge, the coefficient of variance ranged from 40 to 102% throughout the study period (1971 to 1981), makes any long-term trend in the total nitrogen concentration at this location difficult to detect. This high variability was probably due to the combination of flow and direct point sources located in the area, i.e. Hawkesbury STP and CIP sulphite process discharge. The temporal changes at the nearshore station Hawkesbury-Channel 1 and 2 were similar to the mainchannel temporal variations (Figure 5.2).

Seasonal Variation

Total nitrogen concentration data arranged by month are shown in figure 5.3. Total nitrogen summer mean concentrations were lower than the other seasons at all sampling locations, except Otto Holden Dam. At this station the winter and spring mean values were lower than the summer and fall values. The low flow period during the summer governed, in part, by the flow regulation of the Lake Timiskaming impoundment discharge, combined with the continual discharge of nitrogen constituents into the Ottawa River by the sulphite process mill in Timiskaming, may have contributed to the high summer nitrogen concentrations at Otto Holden Dam.

The high late fall and winter values at the other locations are probably due to low biological activity in the river during that period of the year.

5.2.2 Tributaries

Ontario

The total nitrogen concentration annual means and the corresponding standard deviations are summarized in table 5.2. The South Nation River had the highest concentrations and they were accompanied by high variability of the results. This river was considered to impair the water quality at its confluence with the Ottawa River (Task Force, 1977).

There were no significant changes in any of the tributaries in the 1977-1981 period. The high single value in 1981 at Petawawa must be confirmed by additional data, before it can be said that an increase has occurred at this location.

5.3 Total Kjeldahl Nitrogen

Total Kjeldahl Nitrogen (TKN) measures both ammonia and organic nitrogen. Both of these forms of nitrogen are present in nitrogenous organic detritus from natural biological activities. Elevated levels of TKN will contribute to the overall abundance of nutrients in water and subsequently eutrophication.

5.3.1 Mainstem

Spatial Variation

Total Kjeldahl Nitrogen annual mean concentrations are presented in figure 5.4. The lowest annual mean values occurred at the Lake Timiskaming outlet (Station 2). The impoundment characteristics of Lake Timiskaming may have influenced the TKN mean values.

Both the Otto Holden Dam (Station 3) and Hawkesbury stations (No. 8 and 9) are downstream from pulp mills that introduce high levels of nitrogen constituents into the waters of the Ottawa River. This explains the peaks of figure 5.4 at these locations. The maximum annual mean of TKN concentration were recorded at Hawkesbury-Perley Bridge (Station 8). The TKN levels observed at this station were, in part, directly affected by the CIP-Hawkesbury mill plume and nutrient sources upstream and they were significantly higher than any of the other mainstem station TKN values.

Temporal Variation

There were no significant TKN changes during the 1977-1984 period at any of the ten Ottawa River mainstem locations sampled (figure 5.5).

Seasonal Variation

There were no significant seasonal differences at any of the mainstem locations except at Station 4 - Chenaux Dam discharge. The summer TKN concentrations at this station were significantly lower than the values during the rest of the year (figure 5.6).

It was evident, during this study, that the placement of sampling stations immediately downstream from impoundment discharges influenced seasonal and temporal nutrient variations. Seasonal fluctuations would be primarily affected by the management of the flow regime governed by the responsible regulatory agency (ie. Ontario or Quebec Hydro).

5.3.2 Tributaries

Quebec

The Quebec tributaries' TKN concentrations were lower than the Ontario tributaries' TKN levels (Tables 5.3 and 5.4). The Gatineau River had the lowest TKN levels.

Ontario

High TKN annual mean levels were recorded in the Rideau and South Nation Rivers. The Rideau River nutrient levels were influenced by extensive agricultural land drainage, recreational activity and the runoff from a number of urban communities, including the City of Ottawa. The South Nation River nutrient loading also stemmed from agricultural activities and erosion from the prevelent marine clay characteristics of the overburden dominating this watershed.

5.4 Ammonia

Ammonia nitrogen, i.e. the sum of NH_3 (free ammonia) and NH_4^+ (ammonium ion) concentrations, in surface waters originates from industrial waste discharges and from the decomposition of nitrogenous organic matter. Unionized ammonia is toxic to fish by reducing the oxygen carrying capacity of the blood. Ammonia also exerts a high oxygen demand in its conversion to nitrite and nitrate compounds. Both these compounds promote the growth of algae and other aquatic plants. The amount of unionzed ammonia present in a water body depends on the amount of ammonium ion present, the pH, temperature and the dissolved oxygen concentration. Within the pH range of most surface waters the ammonia nitrogen will exist mainly as NH_4^+.

Ammonia is rarely found in rivers and lakes in concentrations high enough to be harmful to humans. To protect the aquatic life, concentrations in surface waters should not exceed 0.02 $\mu g.L^{-1}$ of unionized ammonia. The dissolved ammonia concentrations determined by OMOE during the period 1971-1984 were below the proposed water quality objective for the Ottawa River.

The data from MOE and MEQ were treated separately because the analytical procedures for ammonia were not comparable in the two agencies.

5.4.1 Mainstem

Spatial Variation

Dissolved Ammonia. Data collected by OMOE were summarized in figure 5.7.

The highest ammonia values occurred at Otto Holden Dam (Station 3) and 460 km downstream, at Hawkesbury (Stations 8 and 9) (figure 5.7).

Pulp and paper mills (sulphite process) were major contributors of ammonia at these locations. Substantial amounts of nitrogen in the form of ammonia originate from spent sulphite liquors (Fed.-Prov. Working Group on Water Quality in the Ottawa River, 1978). The lowest ammonia concentrations were found at Chats Falls Dam (Station 6).

The reduction in ammonia concentration from Otto Holden Dam to Chenaux Dam during was attributed to the oxidation of ammonia to the nitrate form (see also section 5.7). There are no industrial nitrogen sources of any magnitude along the 225 Km reach of river separating these two stations.

Total Ammonia. A summary of total (unfiltered) ammonia concentrations determined by MEQ for the period 1979-1984 is given in table 5.5. The variation between the MEQ mainstem stations reflected the same influences as the OMOE results. Three the five locations sampled had higher values, viz. stations 4, 7 and 10. Two of these locations, Portage du Fort (Station 4) and Carillon Dam (Station 10), are located 225 km and 30 km, respectively, downstream from sulphite process discharges.

Temporal Variation

Dissolved Ammonia. The temporal variations of dissolved (filtered) ammonia are shown in figure 5.8.

The CIP Timiskaming mill, closed down in 1971, re-opened in late 1973 by Tembec Forest Products. After its re-openning, the annual mean concentration at Otto Holden Dam increased almost 6-fold. The fluctuating pattern since 1979 was probably caused by production levels and operational changes of the Tembec Forest Products mill and the flow regime of the river.

The changes in dissolved ammonia concentration occurring at Otto Holden Dam together with the CIP Kipawa Mill, shut down in 1971, were reflected in an attenuated form in the concentration changes occurring at Chenaux Dam, i.e. a decrease to 1973, then an increase to 1980 and a fluctuating pattern since then. The decrease in the ammonia levels from Otto Holden Dam to Chenaux Dam points once more to the existence of a nitrification zone in this reach of the Ottawa River.

Filtered ammonia concentrations determined at Chats Falls Dam (Station 6) were too variable and infrequently sampled to adequately explain the high variability of the results during the period 1971 to 1984 (Figure 5.8).

The CIP sulphite process mill located in Hawkesbury directly influenced the ammonia levels at both stations 8 and 9 during its period of operation. The concentrations at Station 9 during 1979 to 1981 were lower than the nearshore Station 8 values but followed the same annual pattern. The ammonia data available after the CIP-Hawkesbury Mill closure, in 1982, was collected in 1984. While they show approximately the same or slightly reduced concentrations at Station 9, in the mainchannel of the Ottawa River, the levels have increased significantly at the nearshore location (Station 8). There is no explanation for this at this time.

<u>Total Ammonia</u>. An increase in the total ammonia levels from 1979 to 1984 was observed at Masson and a decrease, after 1981, at Carillon Dam reflecting the closure of the Hawkesbury mill in 1982.

Seasonal Variation

Only total ammonia data from MEQ were in sufficient number to assess seasonal differences (Table 5.6). As a rule, downstream from Lake Timiskaming the winter (December to March) means were higher than the means for the other scenarios. In most cases, however, the seasonal differences were not significant.

5.4.2 Tributaries

Ontario

Dissolved (filtered) total ammonia mean values and concentration ranges are summarized in table 5.7. The Mattawa, Rideau and South Nation Rivers had higher total ammonia concentrations than the other tributaries. There is no consistent temporal pattern in these data.

Quebec

The total ammonia results are summarized in table 5.8. The concentrations in the various tributaries were similar but the variability of the data was high with the exception of the Kipawa River. There were no temporal trends in the data.

5.5 Dissolved Nitrate and Nitrite

Nitrate (NO_3^-) is the most stable and the principal form of combined nitrogen found in natural waters. Nitrite (NO_2^-) is a form of nitrogen that is usually found in minute quantities in surface waters. Nitrite is unstable in the presence of oxygen. It occurs as an intermediate form in the nitrification (between ammonia and nitrates) or dinitrification process (between nitrates and nitrogen gas).

The presence of nitrates in concentrations greater than 5 mg/L may reflect unsanitary conditions. Excessive amounts of nitrates may result in prolific plant growth. Plants are capable of converting nitrates to organic nitrogen.

5.5.1 Mainstem

Spatial Variation

The concentrations of these two ions were measured by the OMOE at five Ottawa River mainstem locations. MEQ measured the sum of the concentrations of these two ions at five different locations on the Ottawa River. The results are summarized in figures 5.9 and 5.10, respectively.

The concentrations increased in a downstream direction from Notre-Dame-du-Nord to Chenaux Dam, then decreased slightly to Carillon Dam. The increase was attributed to the high organic nitrogen and ammonia levels contributed by natural processes and the Tembec Forest Products Mill effluent (sulphite process). The oxidation of the organic nitrogen and free ammonia to nitrite and nitrate, occurring in the reach of the Ottawa River situated between Otto Holden Dam and Chenaux Dam at approximately 225 Km, would contribute to the increased concentrations observed at Chenaux Dam sampling location.

For the remaining part of the river the available but limited data do not show any significant trends.

Dissolved nitrite concentrations in the Ottawa River were similar until one reaches the Hawkesbury area (Table 5.9). Although the CIP mill closed in 1982 the nitrite as well as dissolved ammonia levels have increased at this location.

Temporal Variation

After re-opening the Tembec Forest Products sulphite process mill in 1973, the dissolved nitrate mean levels, increased significantly at Chenaux Dam (figure 5.11). This increase was also reported by a 1977 report (Task Force 1977) for the 1973-1977 period. The remaining sampling locations showed no trend or only a slight upward trend up to about 1979-1980.

Seasonal Variation

Spring mean dissolved nitrate values were significantly higher at Otto Holden and Chats Falls dams, and the two Hawkesbury sampling locations. In the headpond of Chenaux Dam, the fall mean value was significantly higher than the remaining seasons (Figure 5.12). This may be a result of flow management practices at the Chenaux Dam, nutrient loading from Tembec Forest Products Ltd. and Consolidated Bathurst Ltd. pulp mills, and the productivity of the ecosystem (Nitrobacter, Nitrosomonas) based on the availability of nitrogen and ammonia in the ambient waters of the Ottawa River.

In the summer months, June-August, the concentration of dissolved nitrate reached a minimum at all stations.

The dissolved nitrate + nitrite values, measured by MEQ, showed a similar pattern, i.e. the lowest values were reached in the summer with high spring values at all sampling sites. In addition the NO_3^- + NO_2^- also peaked during the fall months, i.e. November-December, at all sampling locations with the exception of Notre-Dame-du-Nord (Figure 5.14).

5.5.2 Tributaries

In the period 1979-1984 the South Nation River had the highest mean concentration of dissolved nitrate + nitrite reflecting the consistently high values found in the water sample collected at the sampling site on this tributary (Figure 5.15). Relatively high concentrations were also found in water samples from the Petite Nation and Rideau Rivers. The dissolved NO_3^- + NO_2^- concentrations paralleled the patterns of the other nitrogen parameters observed in these rivers. They drain primarily agricultural and recreational land. Soil loss and stream bank erosion were also considered important sources of nutrients entering the tributaries.

5.6 Total Phosphorus

Phosphorus can occur in numerous organic or inorganic forms, and can be present in waters as dissolved or particulate species. Phosphorus is an essential plant nutrient and therefore in many cases a limiting factor for plant growth. In water, the combined form of the element is continually changing due to the processes of decomposition and synthesis between organically bound forms and oxidized inorganic forms.

5.6.1 Mainstem

Spatial Variation

Total phosphorus annual mean concentrations are shown in figure 5.15. Although the means and the ranges varied along the length of the river, there was a trend of increased levels in a downstream direction throughout the 1977-1984 period. A similar spatial trend existed from 1971 to 1977 (Task Force, 1977). Annual total phosphorus increases ranged from 100 to 267%, from Otto Holden Dam (Station 3) to Hawkesbury-Perley Bridge (Station 8).

The high total phosphorus concentrations observed downstream from the Ottawa-Hull area, at the Hawkesbury surveillance stations, and Carillon Dam may be due to tributary loadings (South Nation River) and surface runoff from urban areas.

Temporal Variation

Total phosphorus 1971-1984 annual means and ranges at the five OMOE sampling locations on the mainstem of the Ottawa River are shown in figure 5.16.

In the headpond of Chenaux Dam (Station 5), total phosphorus annual mean concentrations decreased from 1971 to 1979. Since 1982 the values are increasing reaching new highs. It appears that the phosphorus remedial measures taken by the provincial and federal governments are not effective in lowering the total phosphorus levels in this reach of the river. Further investigations are required to determine the source of the increase in the total phosphorus concentration in the Chenaux Dam headpond.

The only significant long-term (1971-1984) trend occurred at Chats Falls (figure 5.17). Total phosphorus mean levels at this location declined by 68% from 1976 (40 $\mu g.L^{-1}$) to 1980 (13 $\mu g.L^{-1}$) and fluctuated between 14 and 23 $\mu g.L^{-1}$ during the 1981 to 1984 period. It seems that in this reach of the Ottawa River the remedial measures undertaken by the provincial and federal governments in the 1970's resulted in the reduced total phosphorus concentrations since 1978. Tributaries also showed a significant decrease of total phosphorus in this reach of the Ottawa River (see Section 5.6.2).

There were no long-term trends in total phosphorus concentrations from Masson to Carillon Dam. Values were relatively high at both stations. A significant decline in the total phosphorus concentration occurred in early 1970's at Hawkesbury-Channel 1 & 2 sampling location.

Seasonal Variation

Significant seasonal differences were found only in the headpond of Chenaux Dam for the period 1978-1983. The spring total phosphorus mean level 40 $\mu g.L^{-1}$ was higher than the fall (21 $\mu g.L^{-1}$) and winter (25 $\mu g.L^{-1}$) concentrations.

5.6.2 Tributaries

Ontario

The highest tributary total phosphorus mean values occurred at the mouth of the South Nation River for the entire sampling period (1971 to 1984). The peak annual mean concentration (218 $\mu g.L^{-1}$) occurred in 1981 at this station. The variability was also high during the same year. Since 1981 the phosphorus concentrations at this location have declined (Table 5.10). Significant declines in phosphorus concentrations have also occurred in the Rideau and the Bonnechere Rivers. The lowest percent exceedance of the objective occurred in the Petawawa and Madawaska Rivers (figure 5.18). The total phosphorus concentration in the South Nation during the 1979-1984 ice free period exceeded the water quality objective 100% of the time.

Total phosphorus loading from the tributaries draining agricultural land, the South Nation and Rideau Rivers in particular, seem to contribute significantly to the phosphorus levels in the mainstem of the Ottawa River.

Quebec

The results for six Quebec tributaries are summarized in Table 5.11. The lowest total phosphorus concentrations occurred in the Kipawa River. Amongst the other tributaries, the Lièvre showed both higher variability and higher total phosphorus concentrations.

5.6.3 Comparison with Water Quality Objectives

The proposed phosphorus objective for the Ottawa River for the ice free period, is 30 μg/L. This objective was frequently exceeded both on the mainstem of the river as well as in its tributaries. The highest percent exceedance on the mainstem occurred in the headpond of the Chenaux Dam (figure 5.19). The percent exceedances on the tributaries were even higher reaching 100% in the South Nation River (figure 5.18). On the Quebec side, the Petite Nation and Lièvre Rivers were also identified as major phosphorus contributors to the Ottawa River.

It appears that improved municipal treatment facilities and the reduction in the phosphorus content of detergents have not had the desired impact. It is very possible that the major contributors to the phosphorus in the waters of the Ottawa River and its tributaries are not the urban centres but agricultural activities, such as runoff from fertilized land or livestock operations.

5.7 Dissolved Oxygen

The amount of dissolved oxygen in surface waters depends on the temperature, salinity, turbulence (mixing) of the water, and atmospheric pressure (decreasing with altitude). The dissolved oxygen concentration is subject to diurnal and seasonal fluctuations due, in part, to variations in temperature, photosynthetic activity and river discharge. Biodepletion and re-aeration processes control the dissolved oxygen concentrations. The decomposition of organic wastes and oxidation of inorganic wastes reduce the dissolved oxygen levels.

The dissolved oxygen concentrations has no adverse physiological effect on man. Adequate amounts must be available for fish and other aquatic organisms. Many aerobic organisms cannot survive below certain levels of dissolved oxygen. Waters with high concentrations of dissolved oxygen are not acceptable for industrial applications, since the presence of dissolved oxygen increases the corrosiveness of a water.

5.7.1 Mainstem

Temporal Variation

There were no significant changes in the dissolved oxygen concentrations at the sampling sites along the mainstem of the Ottawa River during the 1979-1984 period with the exception of Chenaux Dam site where, since 1980, high values were found (Figure 5.20).

The dissolved oxygen concentrations were always greater than 5.0 mg/L with the exception of Otto Holden Dam where occasionally the readings were down to 4.0 mg/L. To protect the aquatic life the dissolved oxygen concentrations should be above 47% saturation or approximately 5.0 mg/L during the winter and 4.2 mg/L during the summer. A comparison of the dissolved oxygen and total ammonia concentrations at this site (Figure 5.22) explains, at least partly, the changes in the DO concentrations. Oxygen is being used to convert ammonia to nitrate (nitrification), thus explaining the low dissolved oxygen concentrations when the total ammonia levels are high.

Spatial Variation

Annual mean dissolved oxygen values in the mainstem of the Ottawa River ranged from approximately 9.0 to 14 mg/L with the exception of Otto Holden Dam sampling location, where the annual means ranged between 7.0 and 9.4 mg/L, significantly lower than the rest.

5.7.2 Tributaries

Dissolved oxygen mean levels for both the Quebec and Ontario tributaries were well above the tentative water quality objective set for the Ottawa River (47% saturation minimum or approximately 4.2 $mg.L^{-1}$ for summer temperatures). On occasion the level of DO in the Petawawa and South Nation Rivers dropped below the objective (Figure 5.29).

Table 5.2. Total Nitrogen Annual Mean Concentrations and Standard Deviations for Seven OMOE Tributaries, Ottawa River Basin, ~~for the Period~~ 1977-1981.

Year	12 Mattawa	13 Petawawa	15 Bonnechere	Station 16 Madawaska mg.L^{-1}	17 Mississippi	18 Rideau	22 South Nation
1977	.745 (.413)^{13*}	.428 (.209)^{2}	.507 (.122)^{9}	.366 (.047)^{10}	.599 (.330)^{7}	.948 (.280)^{11}	1.36 (.498)^{11}
1978	.693 (2.40)^{12}	.390	.555	.320	.626 (.291)^{9}	NS	NS
1979	.662 (.111)^{12}	.349 (.064)^{6}	.539 (.214)^{5}	.382 (.022)^{6}	.568 (.122)^{2}	.792 (.101)^{5}	1.811 (.964)^{5}
1980	.655 (.169)^{9}	.405 (.040)^{4}	.515 (.143)^{7}	NS	.538 (.110)^{10}	.873 (.160)^{11}	1.678 (.621)^{6}
1981	.670	.812	NS	NS	NS	NS	1.898

* = number of results
( ) = range
NS = not sampled

Table 5.3. Total Kjeldahl Nitrogen Ranges and Annual Mean Concentrations ~~(mg/L)~~ at ~~six~~ Sampling Sites Located on Quebec Tributaries to the Ottawa River, 1979-1984.

Year	Station 11 Kipawa R.	Station 14 Coulonge R.	Station 19 Gatineau R.	Station 20 Lièvre R. mg.L^{-1}	Station 21 Petite Nation R.	Station 23 Rouge R.
1979	0.141 (0.09 - 0.23)[27]*	0.266 (0.15 - 0.64)[17]	0.167 (0.05 - 0.28)[29]	0.188 (0.17 - 0.22)[11]	0.236 (0.12 - 0.42)[21]	0.361 (0.13 - 3.20)[20]
1980	0.227 (0.11 - 0.52)[27]	0.298 (0.15 - 1.16)[28]	0.214 (0.11 - 0.73)[27]	1.675 (0.14 - 6.8)[13]	0.232 (0.08 - 0.50)[26]	0.206 (0.12 - 0.59)[24]
1981	0.747 (0.09 - 17.0)[29]	0.313 (0.15 - 0.88)[29]	0.182 (0.10 - 0.29)[29]	0.182 (0.11 - 0.35)[24]	0.268 (0.04 - 1.15)[26]	0.224 (0.10 - 0.48)[35]
1982	0.139 (0.04 - 0.25)[28]	0.315 (0.11 - 1.56)[27]	0.192 (0.05 - 0.42)[29]	0.168 (0.10 - 0.34)[23]	0.186 (0.03 - 0.31)[24]	0.181 (0.09 - 0.40)[20]
1983	0.150 (0.11 - 0.22)[28]	0.301 (0.11 - 1.22)[27]	0.185 (0.10 - 0.39)[30]	0.192 (0.11 - 0.31)[30]	0.187 (0.06 - 0.32)[23]	0.162 (0.10 - 0.22)[23]
1984	0.16 (0.10 - 0.38)[23]	0.29 (0.15 - 0.69)[23]	0.23 (0.11 - 0.59)[29]	0.22 (0.11 - 0.60)[27]	0.23 (0.11 - 0.32)[24]	0.19 (0.13 - 0.41)[26]
1979-1984	0.267 ~~162~~ (0.04 - 17.00)[162]	0.299 (0.11 - 1.56)[151]	0.195 (0.05 - 0.73)[173]	0.713 (0.10 - 6.8)[128]	0.224 (0.04 - 1.15)[144]	0.278 ~~138~~ (0.09 - 3.20)[138]

* = number of results
( ) = range

Table 5.4. Total Kjeldahl Nitrogen Ranges and Annual Mean Concentrations ($mg.L^{-1}$) at Sampling Sites Located on Ontario Tributaries to the Ottawa River, 1979-1984.

Year	Station 12 Mattawa R.	13 Petawawa R.	15 Bonnechere R.	16 Madawaska R. $mg.L^{-1}$	17 Mississippi R.	18 Rideau R.	22 South Nation R.
1979	0.489 (0.290-0.700)^{12}*	0.283 (0.240-0.390)^{6}	0.464 (0.300-0.840)^{5}	0.315 (0.250-0.360)^{6}	0.445 (0.460-0.430)^{2}	0.674 (0.66-0.720)^{5}	0.984 (0.720-1.250)^{5}
1980	0.511 (0.370-0.860)^{9}	0.343 (0.270-0.380)^{4}	0.410 (0.220-0.550)^{7}	-	0.442 (0.340-0.530)^{10}	0.730 (0.490-0.950)^{11}	1.100 (0.680-1.500)^{7}
1981	0.468 (0.28-0.98)^{9}	0.790^{1}	-	-	-	-	0.680
1982	0.43 (0.39-0.47)^{2}	-	0.33^{1}	-	-	-	-
1983	-	0.260^{1}	-	-	-	-	-
1984	0.440 (0.380-0.500)^{2}	0.340 (0.280-0.480)^{4}	0.412 (0.280--0.520)^{6}	0.272 (0.240-0.470)^{8}	0.478 (0.350-0.630)^{8}	0.705 (0.470-1.370)^{8}	0.902 (0.270-1.300)^{10}
1979-1984	0.483 (0.290-0.980)^{34}	0.343^{1} (0.240-0.790)^{16}	0.421 (0.220-0.840)^{19}	0.290 (0.240-0.470)^{14}	0.457 (0.340-0.630)^{20}	0.710 (0.470-1.370)^{24}	0.970 (0.270-1.500)^{23}

* = number of results
( ) = range

Table 5.5. Total Ammonia Annual Mean Values and Concentration Ranges for Five MEQ Ottawa River Mainstem Locations, ~~for the Period~~ 1979-1984.

Year	Station 1 Notre-Dame-du-Nord (mg.L^{-1})	Station 2 Lake Timiskaming (mg.L^{-1})	Station 4 Portage du Fort (mg.L^{-1})	Station 7 Masson (mg.L^{-1})	Station 10 Carillon Dam (mg.L^{-1})
1979	.037 (.01 - .25)^{18*}	.020 (.01 - .14)^{25}	.075 (.01 - 20)^{27}	.031 (0.1 - .10)^{19}	.089 (.03 - .22)^{29}
1980	.048 (.02 - .12)^{28}	.023 (.01 - .09)^{25}	.082 (.01 - .16)^{28}	.045 (.01 - .10)^{23}	.103 (.04 - .16)^{28}
1981	.035 (.01 - .12)^{29}	.021 (.01 - .06)^{30}	.074 (.01 - .15)^{28}	.070 (.02 - .15)^{25}	.106 (.04 - .39)^{30}
1982	.039 (.01 - .22)^{27}	.028 (.01 - .12)^{29}	.051 (.01 - .13)^{27}	.087 (.02 - .17)^{27}	.091 (.04 - .16)^{29}
1983	.027 (.01 - .08)^{23}	.017 (.01 - .03)^{30}	.042 (.01 - .10)^{29}	.074 (.01 - .13)^{30}	.052 (.01 - .09)^{29}
1984	.02 (.01 - .05)^{28}	.02 (.01 - .11)^{29}	.05 (.01 - .13)^{29}	.08 (.01 - .17)^{29}	.05 (.01 - .14)^{29}

* = number of results
( ) = range

Table 5.6. Seasonal Total Ammonia Mean Concentration for Five MEQ Ottawa River Mainstem Sampling Locations Stations, Ottawa River Basin, 1979-1983.

Season	Station 1 Notre-Dame-du-Nord	2 Lake Timiskaming	4 Portage du Fort $mg.L^{-1}$	7 Masson	10 Corillon Dam
Spring	.039 (.020) 14**	.022 (.014) 26	.078 (.039) 27	.059 (.023) 20	.074 (.030) 26
Summer	.039 (.040) 27	.029 (.023) 32	.039 (.019) 34	.050 (.034) 30	.091 (.036) 33
Fall	.037 (.043) 31	.020 (.013) 34	.032 (.032) 31	.057 (.035) 34	.075 (.031) 37
Winter	.044 (.027) 35	.021 (.021) 40	.115 (.038) 39	.095 (.032) 26	.114 (.062) 40

( ) = Standard deviation.
** = Sample size.

Table 5.7. Dissolved Ammonia Annual Means and Concentration Ranges for Seven OMOE Tributaries, Ottawa River Basin, ~~for the Period~~ 1977-1984.

Year	12 Mattawa	13 Petawawa	15 Bonnechere	Station 16 Madawaska $mg.L^{-1}$	17 Mississippi	18 Rideau	22 South Nation
1977	0.094 (.006 - .238)^{13*}	.012 (.006 - .018)^{2}	.045 (.006 - .096)^{9}	.014 (.004 - .034)^{10}	.067 (.010 - 1.40)^{9}	.095 (.140 - .324)^{11}	.111 (.002 - .266)^{11}
1978	.085 (.014 - .220)^{12}	.006	.088	.020	.047 (.010 - .150)^{10}	NS	NS
1979	.092 (.022 - .190)^{12}	.011 (.001 - .020)^{6}	.032 (.016 - .044)^{5}	.035 (.010 - .058)^{6}	.010 (.010)^{2}	.055 (.049 - .062)^{5}	.049 (.002 - .084)^{5}
1980	.127 (.044 - .350)^{9}	.020 (.010 - .040)^{5}	.050 (.020 - .090)^{7}	NS	.036 (.020 - .090)^{10}	.052 (.010 - .080)^{12}	.133 (.020 - .460)^{6}
1981	.099 (.010 - .270)^{9}	.018 (.010 - .030)^{5}	.042 (.010 - .080)^{9}	.020	.043 (.020 - .080)^{6}	.050	.108 (.004 - .300)^{7}
1982	.065 (.024 - .166)^{8}	.021 (.012 - .026)^{10}	.028 (.004 - .088)^{8}	.015 (.020 - .038)^{8}	.017 (.002 - .038)^{9}	.087 (.002 - .216)^{6}	.045 (.004 - .142)^{8}
1983	.101 (.036 - .158)^{8}	.017 (.008 - .032)^{6}	.063 (.004 - .410)^{10}	.021 (.002 - .048)^{6}	.026 (.002 - .054)^{10}	.032 (.002 - .102)^{8}	.091 (.004 - .440)^{8}
1984	.066 (.032 - .124)^{8}	.033 (.008 - .076)^{10}	.049 (.010 - .082)^{6}	.023 (.010 - .050)^{8}	.043 (.012 - .110)^{8}	.068 (.022 - .174)^{11}	.143 (.006 - .396)^{10}

* = number of results
( ) = range
NS = not sampled

Table 5.8. Total Ammonia (NH_4-N) Annual Means and Concentration Ranges for Six MEQ Tributaries, Ottawa River Basin, ~~for the Period~~ 1979-1981.

Year	Station 11 Kipawa	Station 14 Coulonge	Station 19 Gatineau	Station 20 Lièvre $mg.L^{-1}$	Station 21 Petite Nation	Station 23 Rouge
1979	.020 (.005 - .050)^{27*}	.047 (.005 - .200)^{17}	.023 (.010 - .050)^{29}	.037 (.005 - .130)^{11}	.031 (.005 - .080)^{21}	.102 (.005 - .830)^{20}
1980	.033 (.010 - .060)^{27}	.068 (.005 - .600)^{28}	.046 (.005 - .330)^{27}	1.145 (.005 - 4.60)^{13}	.046 (.005 - .110)^{26}	.043 (.005 - .150)^{24}
1981	.024 (.005 - .080)^{29}	.055 (.005 - .210)^{29}	.032 (.020 - .080)^{29}	.031 (.010 - .080)^{24}	.048 (.010 - .260)^{26}	.035 (.030 - .090)^{35}
1982	.024 (.010 - .080)^{28}	.050 (.010 - .19)^{27}	.031 (.010 - 0.70)^{29}	.030 (.010 - .060)^{23}	.030 (.010 - .060)^{24}	.029 (.010 - .080)^{20}
1983	.021 (.010 - .060)	.043 .010 - .110)^{27}	.027 .010 - .060)^{30}	.028 (.010 - .060)^{30}	.025 (.010 - .080)^{23}	.024 (.010 - .005)^{23}
1984	.02 (.010 - .070)	.04 (.010 - .150)	.03 (.010 - .080)	.02 (.010 - .060)	.02 (.010 - .070)	.02 (.010 - .060)

* = number of results
( ) = range

Table 5.9. Dissolved Nitrite Annual Means and Standard Deviations for Five OMOE Ottawa River Mainstem Sampling Locations, ~~for the Period~~ 1977-1984.

Year	Station 3 Otto Holden	5 Chenaux	6 Chats Falls mg.L^{-1}	8 Perley Bridge	9 Channel 1 & 2
1977	.004 (.001)13*	.004 (.001)9	.015 (.024)7	.005 (.001)11	.006 (.001)11
1978	.005 (.001)12	.005	.006 (.004)10	.004*	.005
1979	.005 (.001)12	.005 (.001)6	.005 (.001)2	.006 (.002)5	.006 (.001)6
1980	.006 (.002)10	.007 (.004)7	.006 (.004)11	.004 (.000)2	.004 (.000)2
1981	.004	NS	NS	.016 (.009)3	.022 (.011)3
1982	NS	NS	NS	NS	NS
1983	NS	NS	NS	NS	NS
1984	.005 (.001)2	.006 (.007)6	.006 (.003)6	.009 (.004)7	.021 (.022)7

* = number of results
( ) = standard deviation
NS = not sampled

Table 5.10. Total Phosphorus Annual Means and Standard Deviations for Seven Ontario Tributaries, Ottawa River Basin, ~~for the Period~~ 1979-1984.

Year	12 Mattawa	13 Petawawa	15 Bonnechere	Station 16 Madawaska mg.L^{-1}	17 Mississippi	18 Rideau	22 South Nation
1979	.027 (.036)^{12*}	.007 (.002)^{6}	.030 (.005)^{5}	.015 (.007)^{6}	.023 (.004)^{2}	.069 (.035)^{4}	.149 (.079)^{5}
1980	.016 (.005)^{9}	.014 (.003)^{5}	.029 (.016)^{7}	.023 (.034)^{11}	.027 (.011)^{10}	.039 (.015)^{11}	115 (.043)^{7}
1981	.071 (.103)^{9}	.034 (.037)^{6}	.029 (.005)^{9}	.018 (.004)^{7}	.066 (.095)^{6}	.052 (.020)^{8}	.218 (.303)^{8}
1982	.030 (.025)^{9}	.016 (.023)^{10}	.072 (.007)^{12}	.016 (.036)^{11}	.030 (.040)^{10}	.051	.126
1983	.042 (.056)^{10}	.014 (.004)^{7}	.032 (.031)^{11}	.019 (.005)^{11}	.032 (.015)^{12}	.068 (.051)^{11}	.153 (.076)^{11}
1984	.014 (.004)^{9}	.018 (.020)^{10}	.027 (.016)^{6}	.013 (.001)^{8}	.022 (.004)^{8}	.037 (.021)^{11}	.092 (.052)^{9}

* = number of samples.

Table 5.11. Total Phosphorus Annual Means and Standard Deviations for Six Quebec Tributaries, Ottawa River Basin, ~~for the Period~~ 1979-1984.

Year	Station 11 Kipawa	 14 Coulonge	 19 Gatineau	 20 Lièvre $mg.L^{-1}$	 21 Petite Nation	 23 Rouge
1979	0.013 $(0.08)^{27*}$	0.017 $(0.07)^{17}$	0.024 $(0.013)^{29}$	0.042 $(0.046)^{11}$	0.036 $(0.022)^{21}$	0.066 $(0.0157)^{20}$
1980	0.024 $(0.011)^{27}$	0.037 $(0.029)^{28}$	0.037 $(0.034)^{26}$	0.0107 $(0.0139)^{13}$	0.046 $(0.039)^{26}$	0.034 $(0.019)^{23}$
1981	0.018 $(0.013)^{29}$	0.035 $(0.044)^{29}$	0.031 $(0.026)^{29}$	0.032 $(0.024)^{24}$	0.037 $(0.021)^{26}$	0.033 $(0.021)^{25}$
1982	0.012 $(0.07)^{28}$	0.022 $(0.017)^{27}$	0.020 $(0.010)^{29}$	0.029 $(0.021)^{23}$	0.033 $(0.029)^{24}$	0.027 $(0.022)^{20}$
1983	0.013 $(0.06)^{28}$	0.025 $(0.011)^{27}$	0.018 $(0.07)^{30}$	0.029 $(0.019)^{30}$	0.043 $(0.054)^{23}$	0.031 $(0.028)^{23}$
1984	0.014 $(0.09)^{23}$	0.026 $(0.014)^{23}$	0.025 $(0.018)^{29}$	0.028 $(0.014)^{28}$	0.033 $(0.021)^{24}$	0.029 $(0.016)^{26}$
1979-1984	0.016 $(0.05)^{6}$	0.027 $(0.08)^{6}$	0.026 $(0.07)^{6}$	0.045 $(0.031)^{6}$	0.039 $(0.05)^{6}$	0.037 $(0.015)^{6}$

( ) = standard deviation
* = sample size

Figure 5.1: Spatial Variation of Total Nitrogen Concentrations at Five OMOE Ottawa River Mainstem Locations, for the Period 1977-1981.

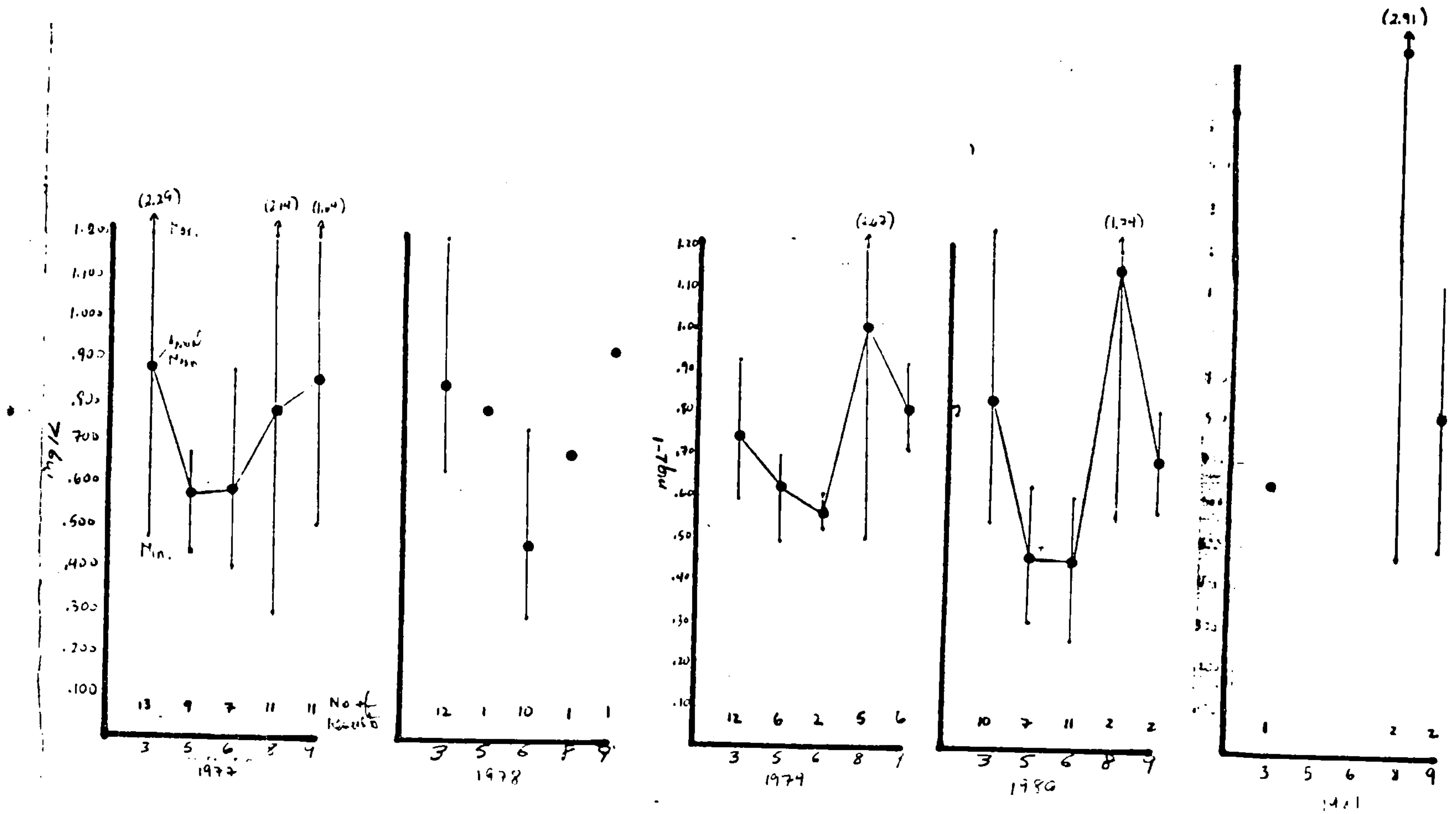


Figure 5.2: Temporal Variation in Total Nitrogen Concentration at Five OMOE Ottawa River Mainstem Locations, for the Period 1971-1983.

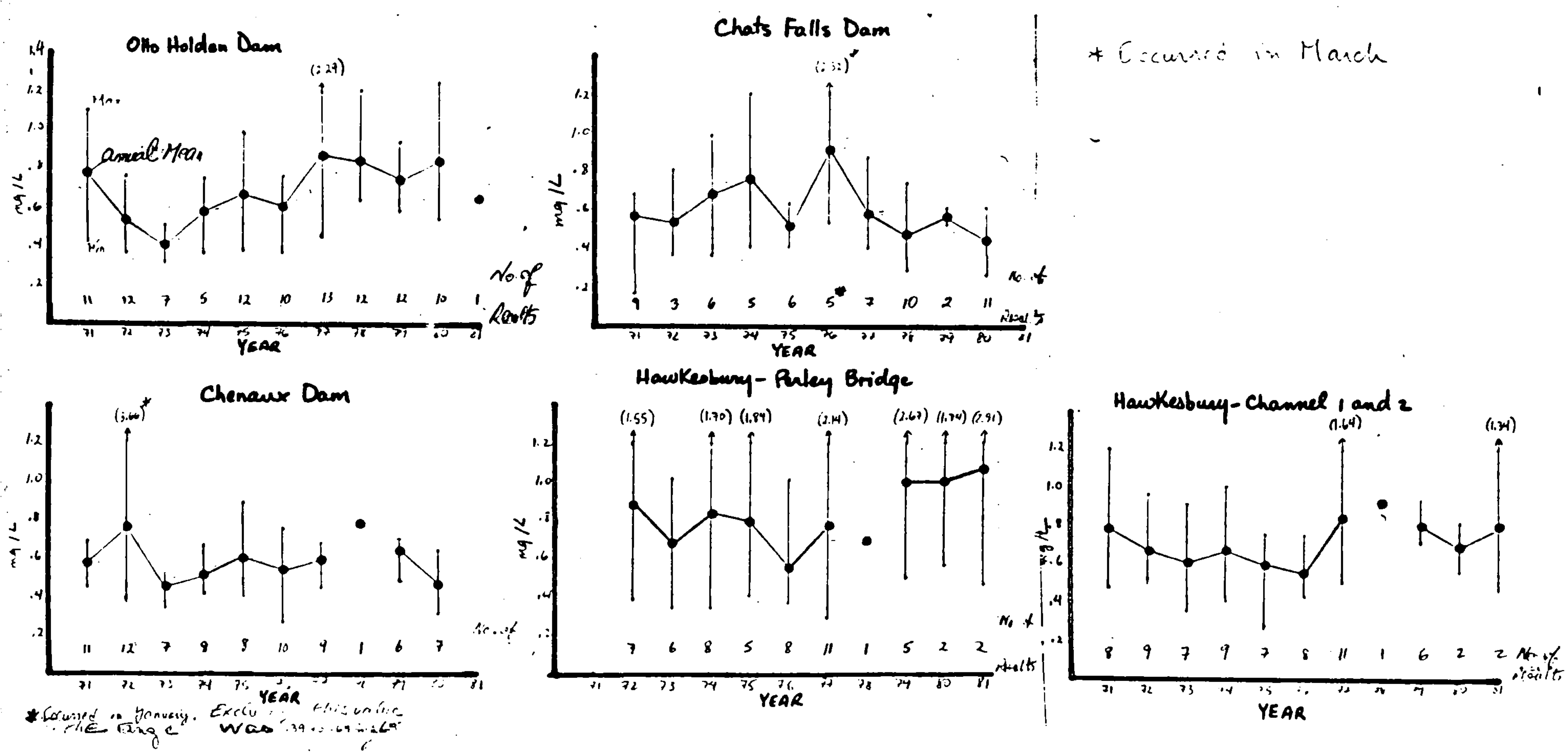


Figure 5.3: Seasonal Variation of Total Nitrogen Concentrations at Five OMO[Ottawa River] Mainstem Locations, for the Period 1971-1980.

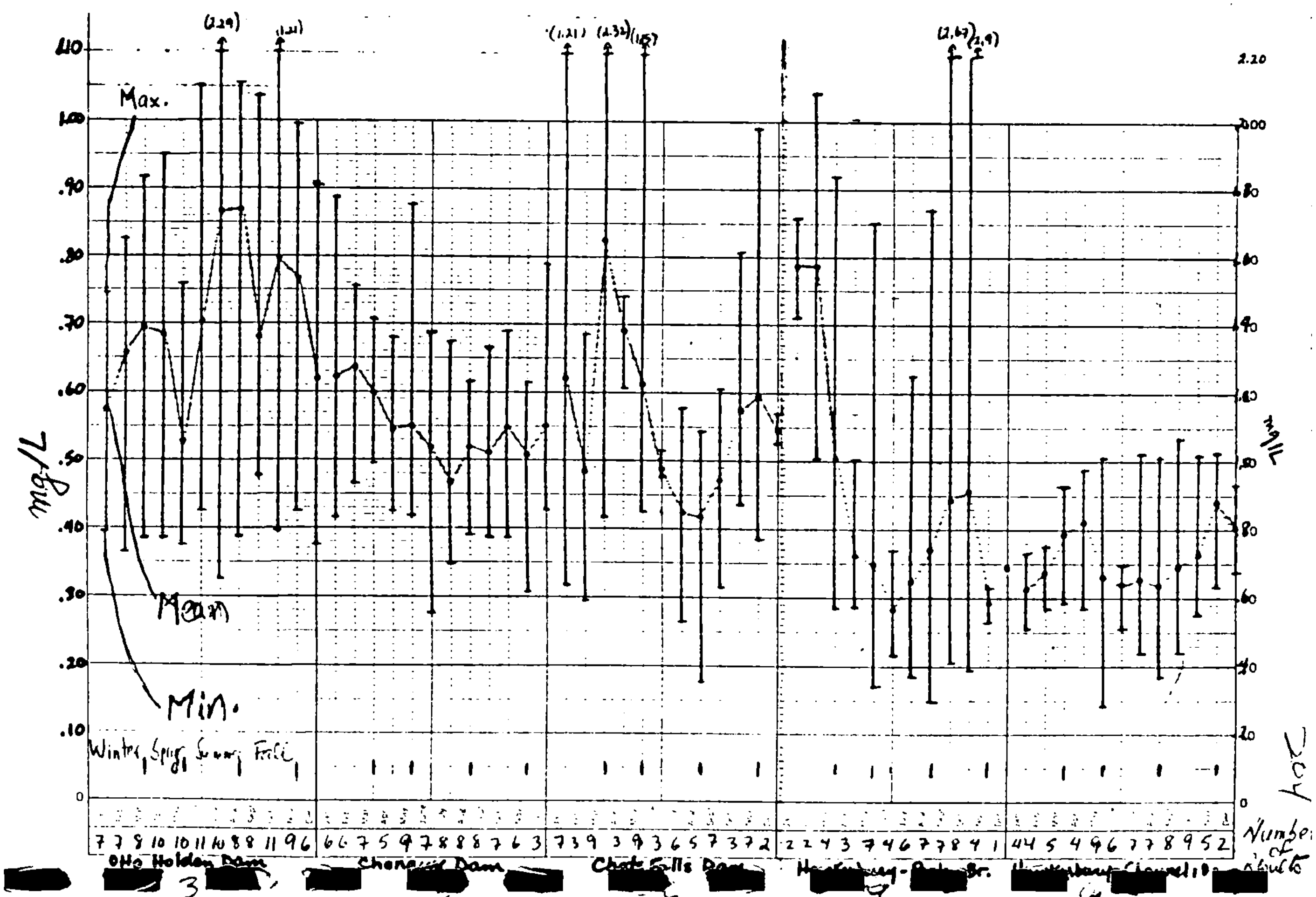


Figure 5.4: Total Kjeldahl Nitrogen Concentrations at Ten Ottawa River Mainstem Locations, for the Period 1977-1984.

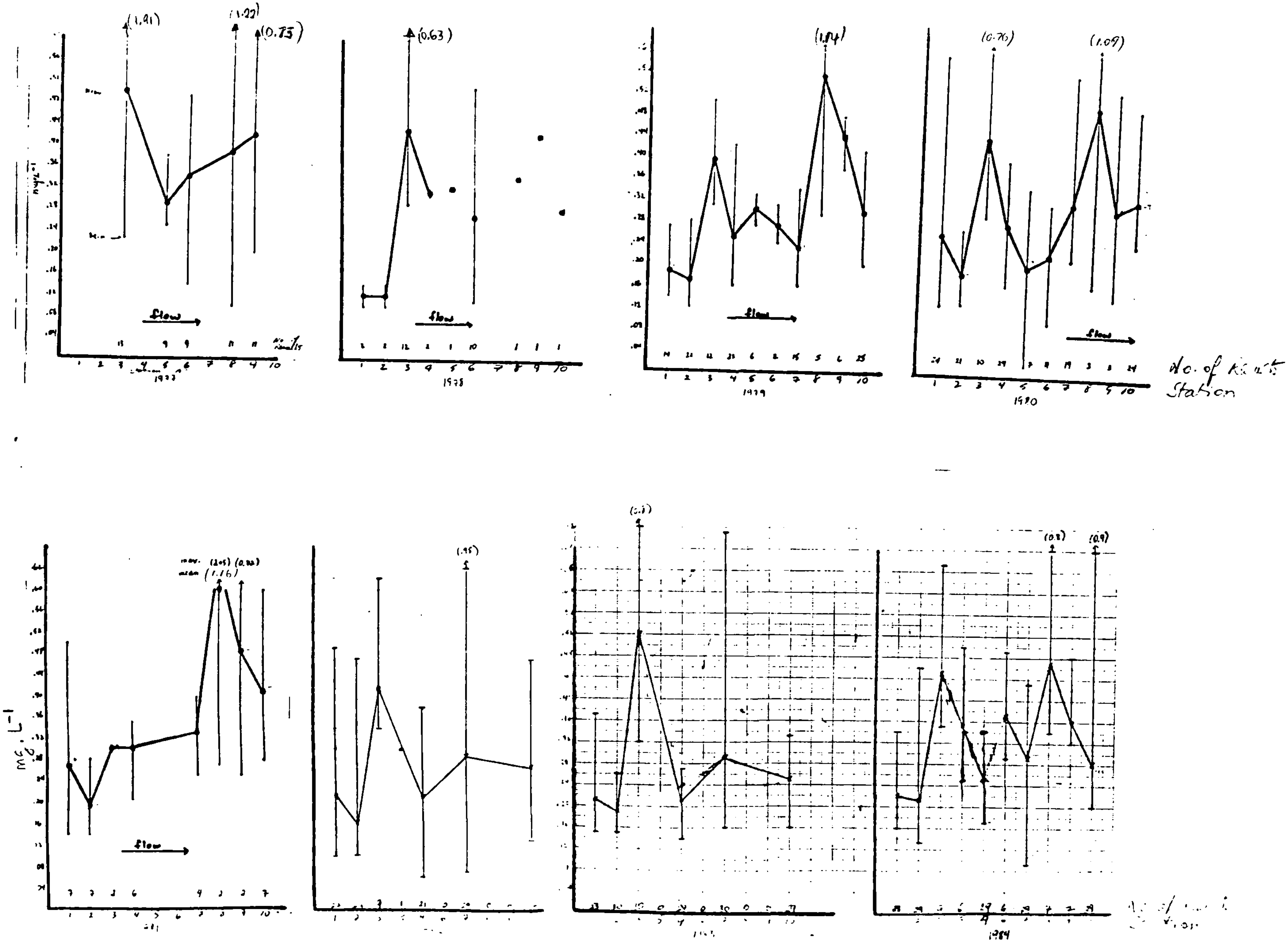


Figure 5.5: Total Kjeldahl Nitrogen Concentrations at Ten Ottawa River Mainstem Locations, for the Period 1978-1984.

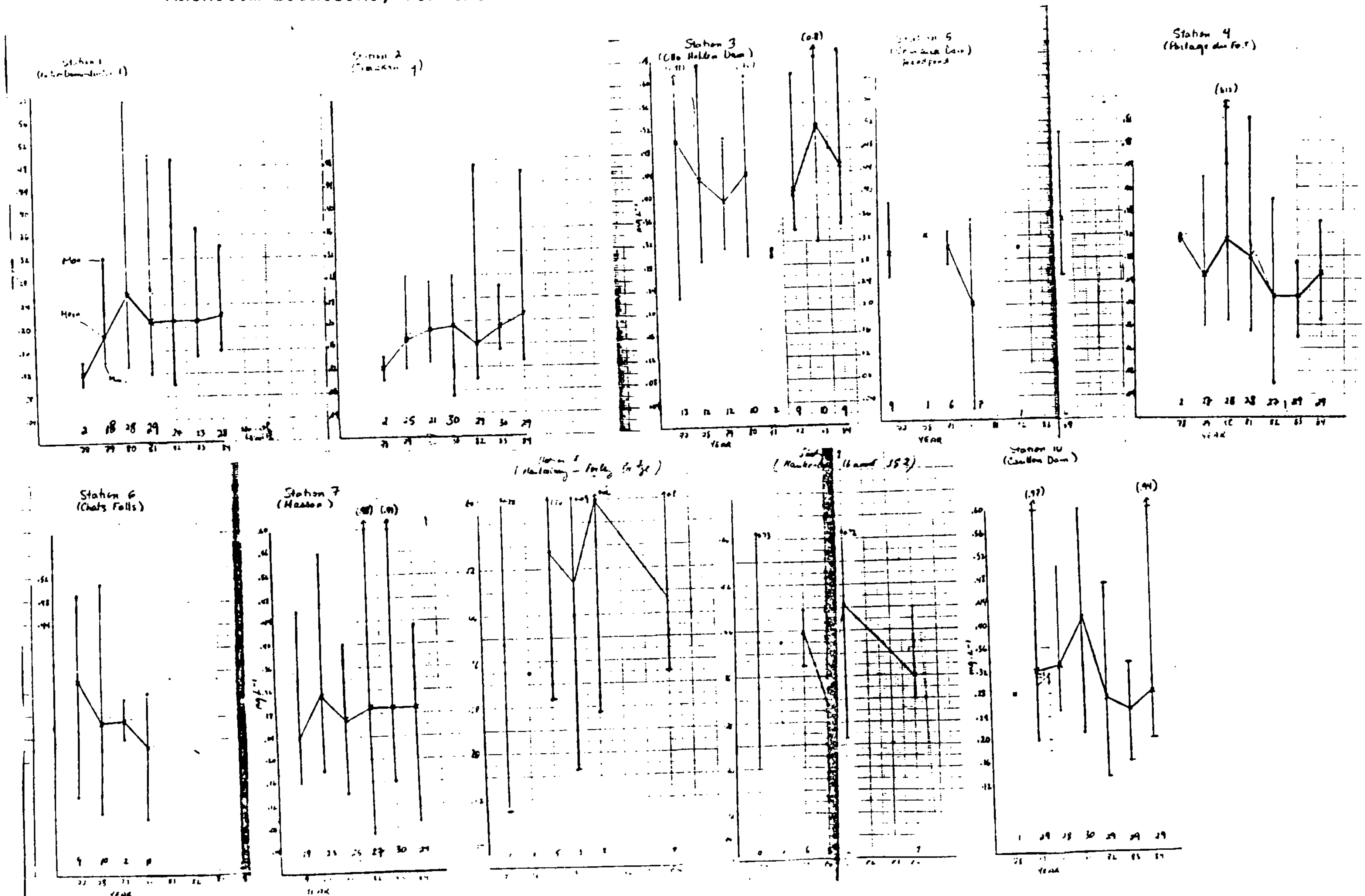


Figure 5.6: The TKN Monthly Concentrations at the Chenaux Dam Discharge (Station 4), for the Period 1979-1981.

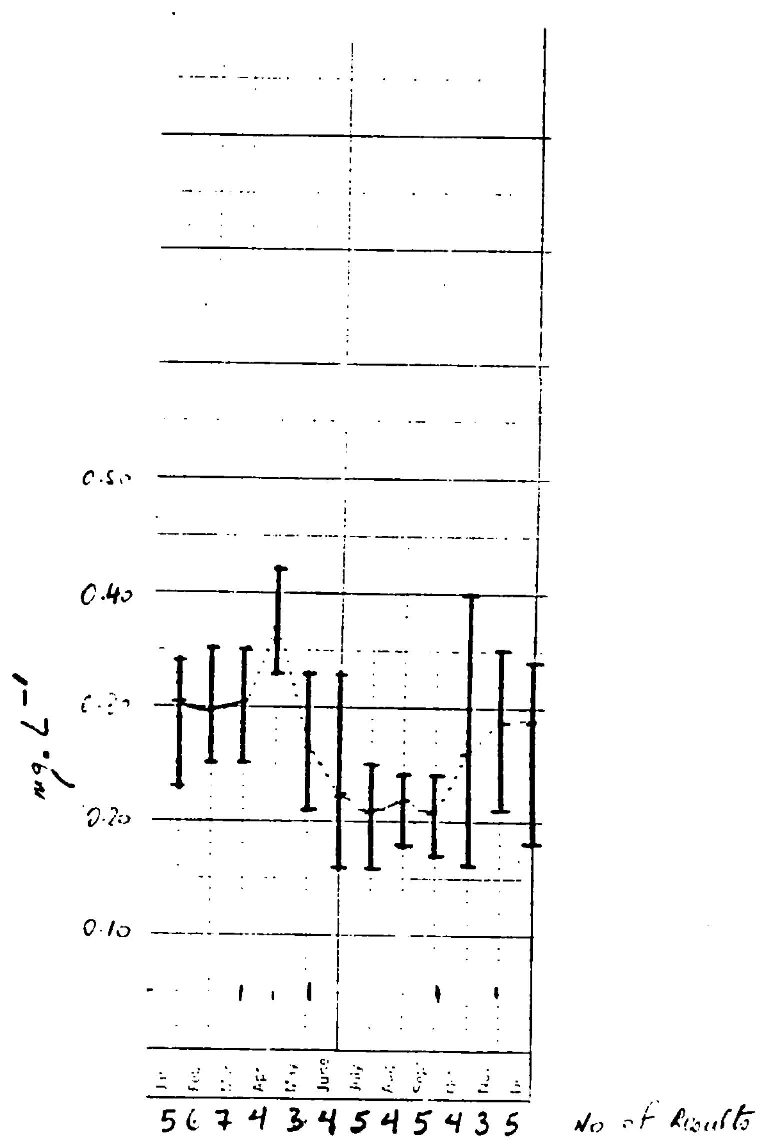


Figure 5.7: Dissolved Ammonia Concentrations at Five OMOE Ottawa River Mainstem Locations, for the Period 1977-1981.

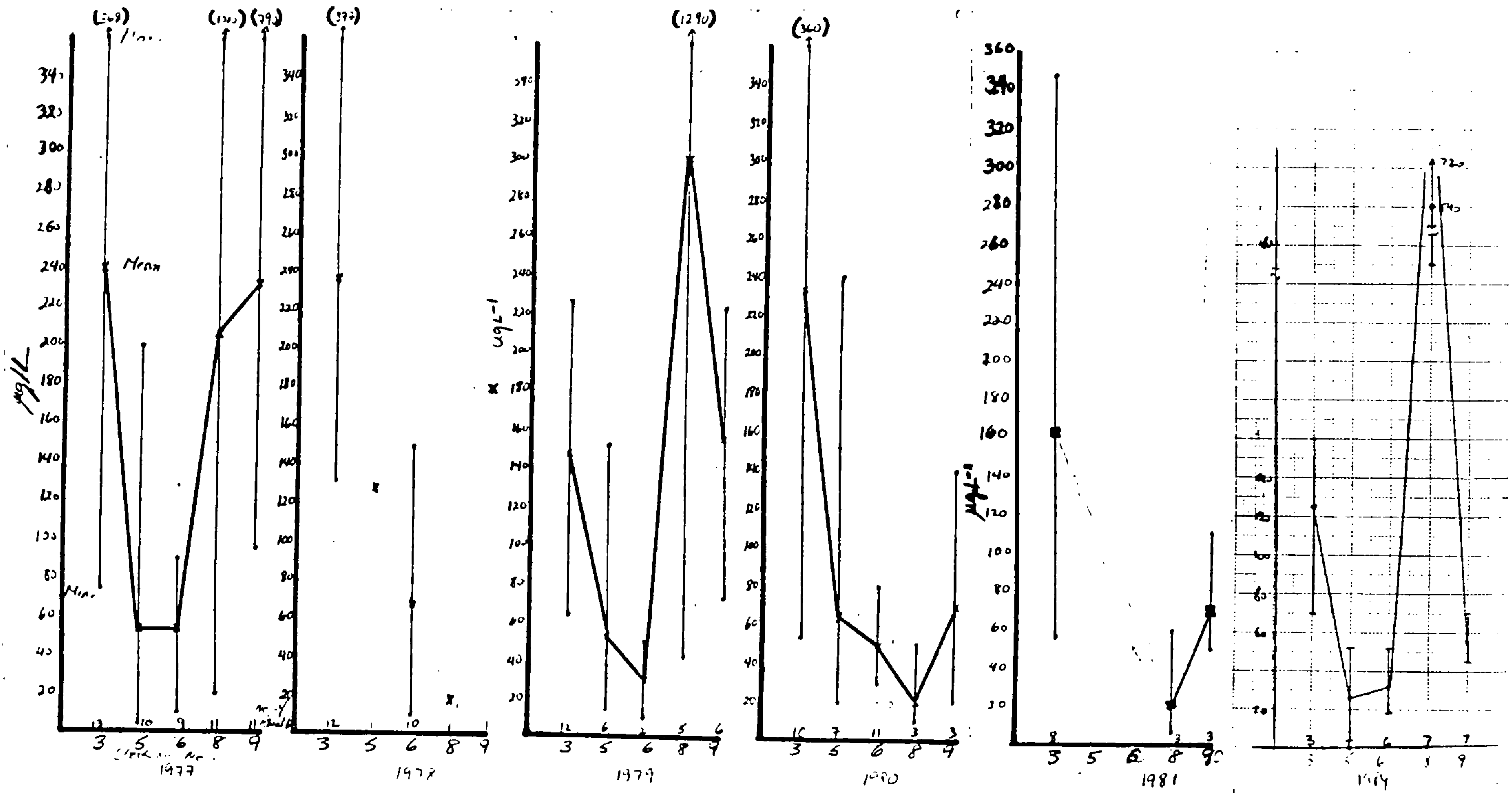


Figure 5.8: Dissolved Ammonia Concentrations at Five OMOE Ottawa River Mainstem locations, for the Period 1971-1984.

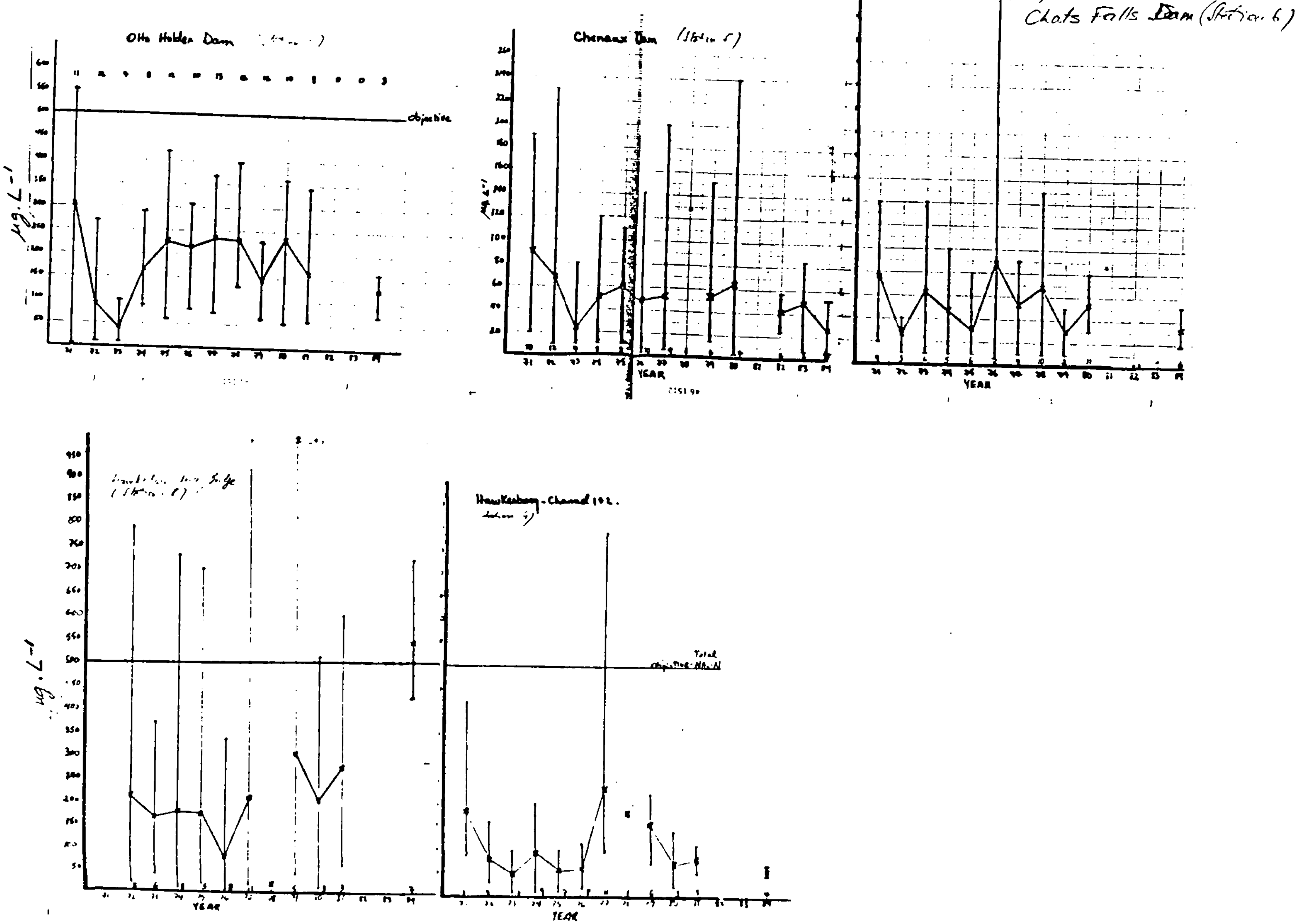


Figure 5.9: Dissolved Nitrate + Nitrite Annual Mean Concentrations and Ranges at Five MEQ Ottawa River Mainstem Locations, for the Period of 1979-1984.

Show only mean and range

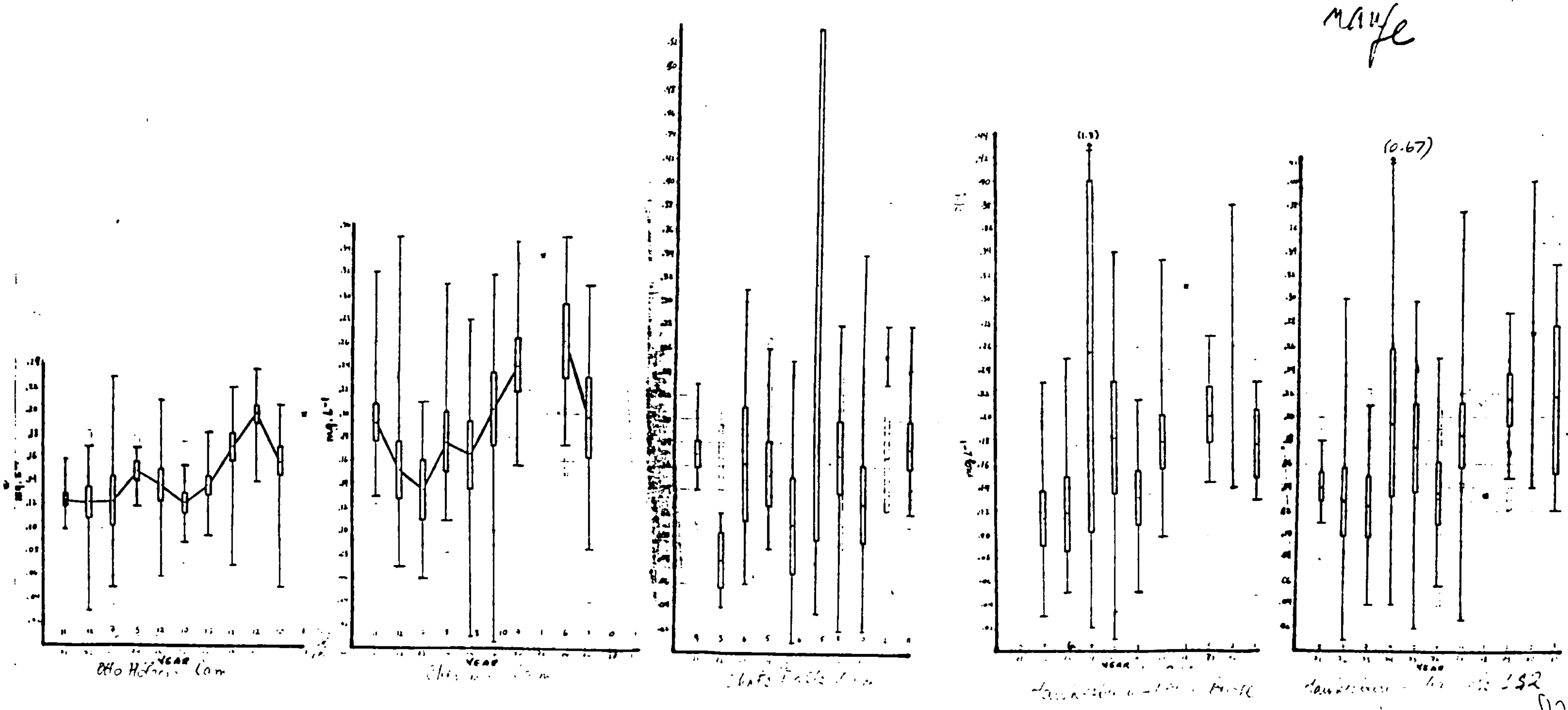


Figure 5.10: Dissolved Nitrate Annual Mean Concentrations and Ranges at Five OMOE Ottawa River Mainstem Locations, for the Period of 1971-1981.

Show only mean and range

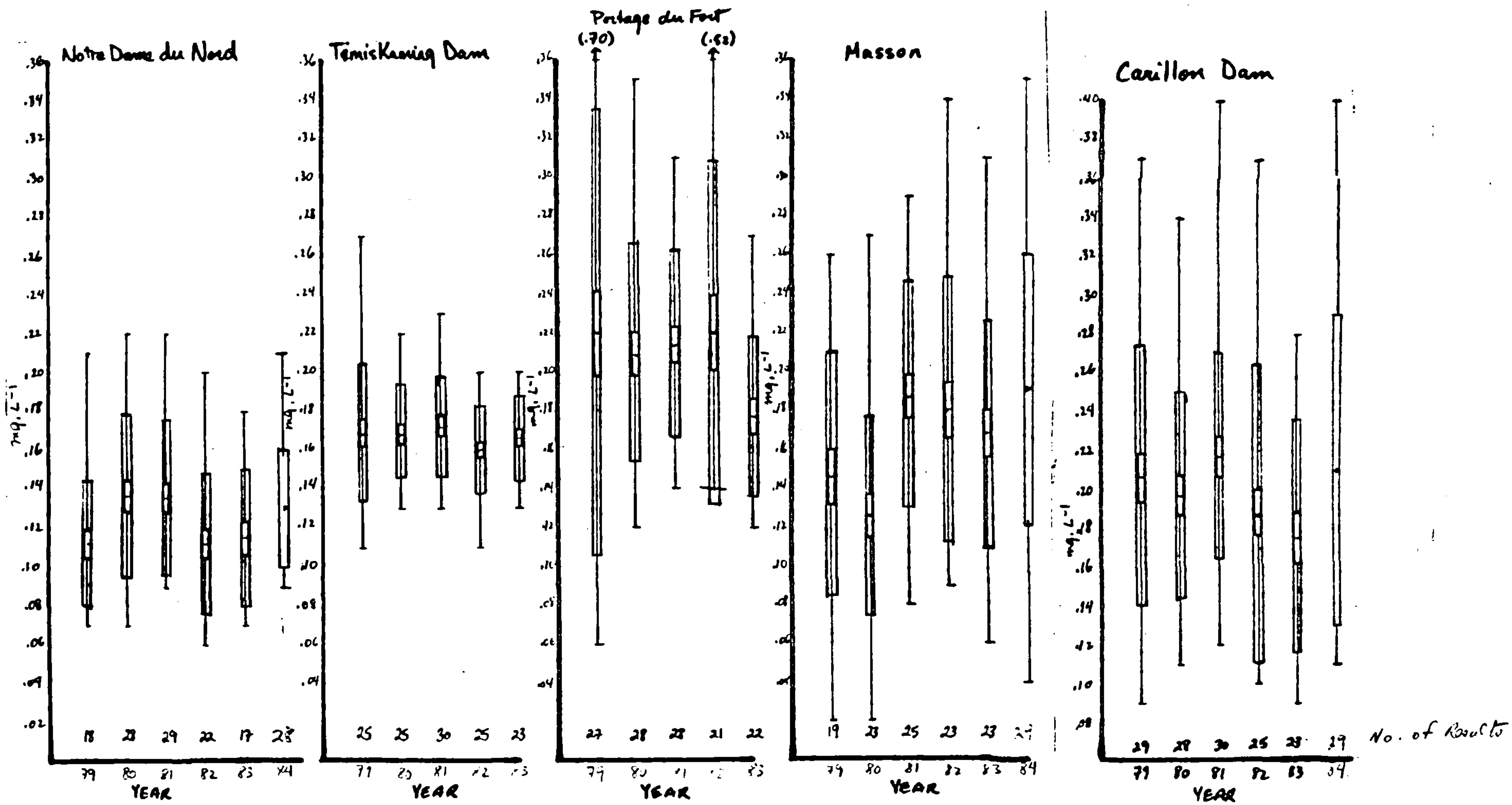
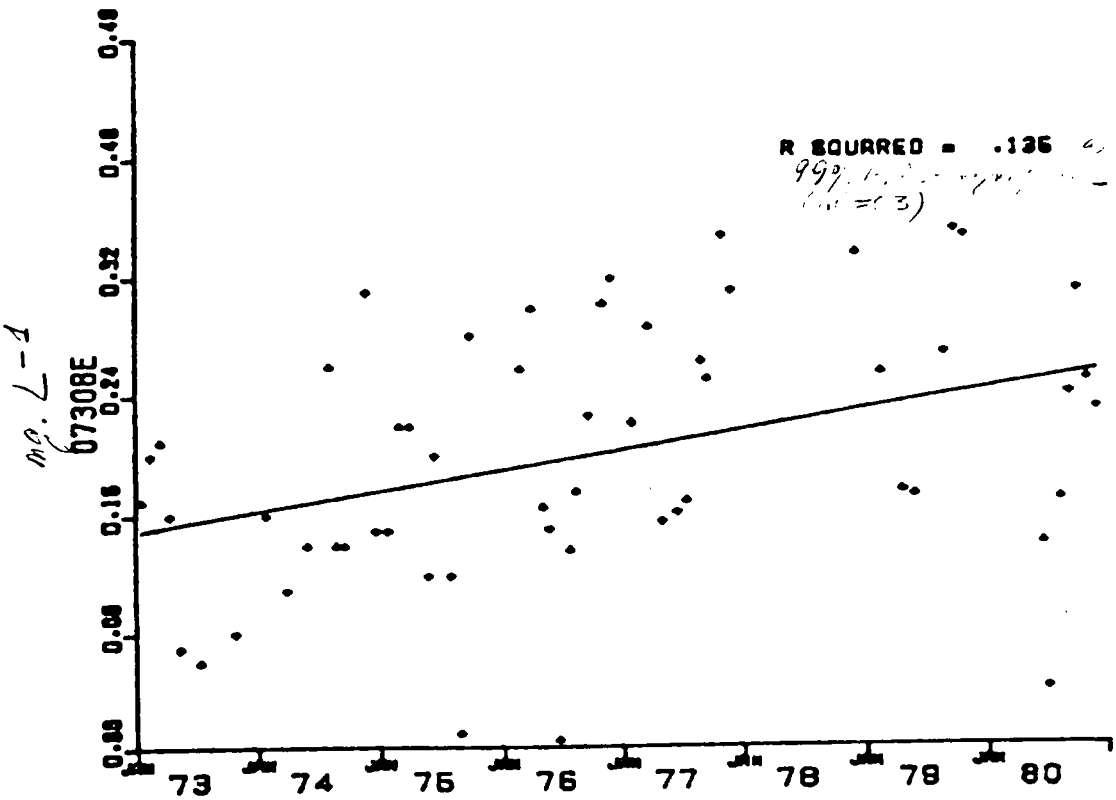


Figure 5.11: The Dissolved Nitrate Concentrations at the Chenaux Dam OMOE Sampling Location.



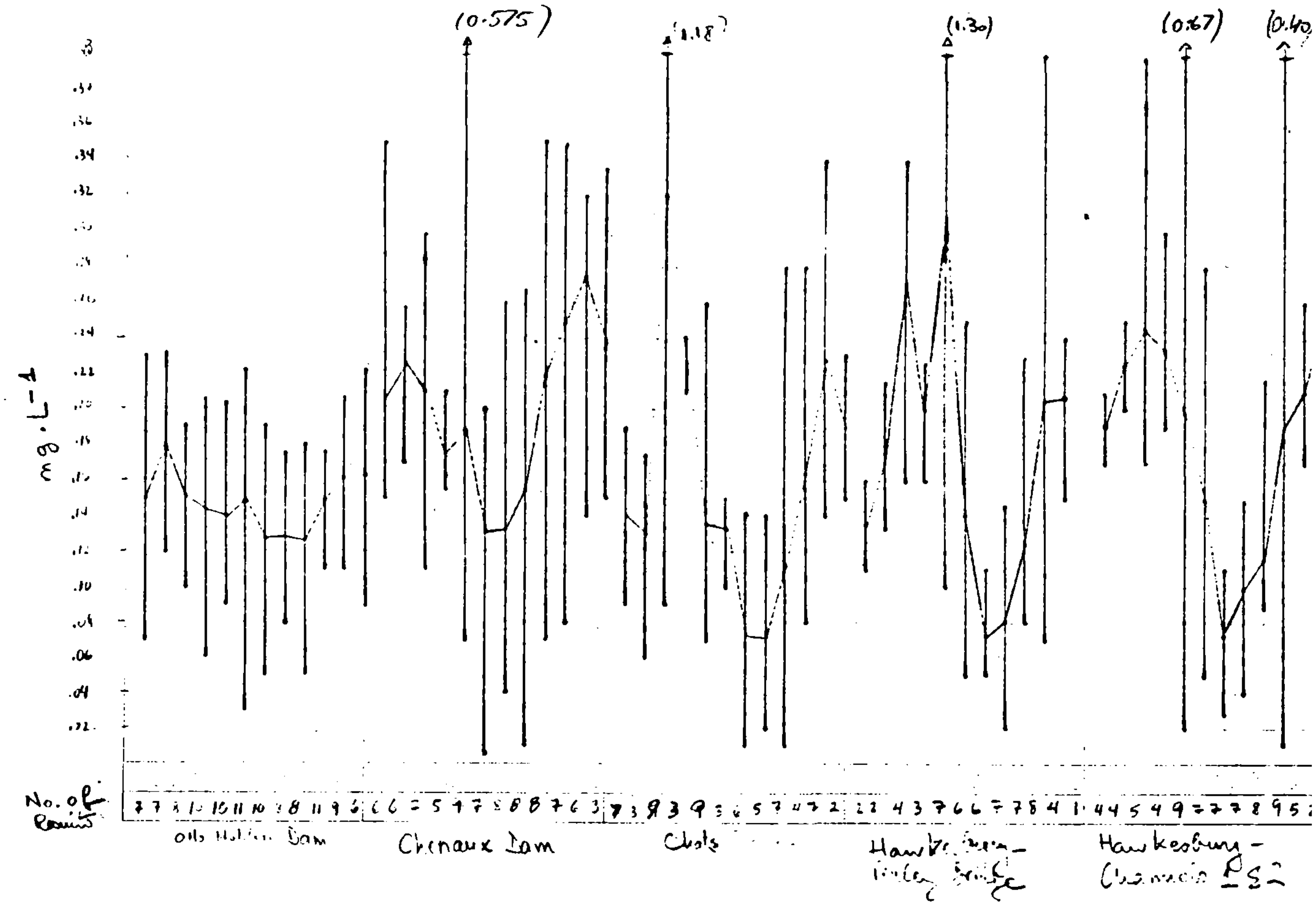


Figure 5.12: The 1971-1981 Monthly Ranges and Means of Dissolved Nitrate at the Five OMOE Mainstem Stations of the Ottawa River.

Figure 5.13: The 1979-1983 Monthly Ranges and Means of Dissolved Nitrate + Nitrite at Five MEQ Sampling Sites on the Mainstem of the Ottawa River.

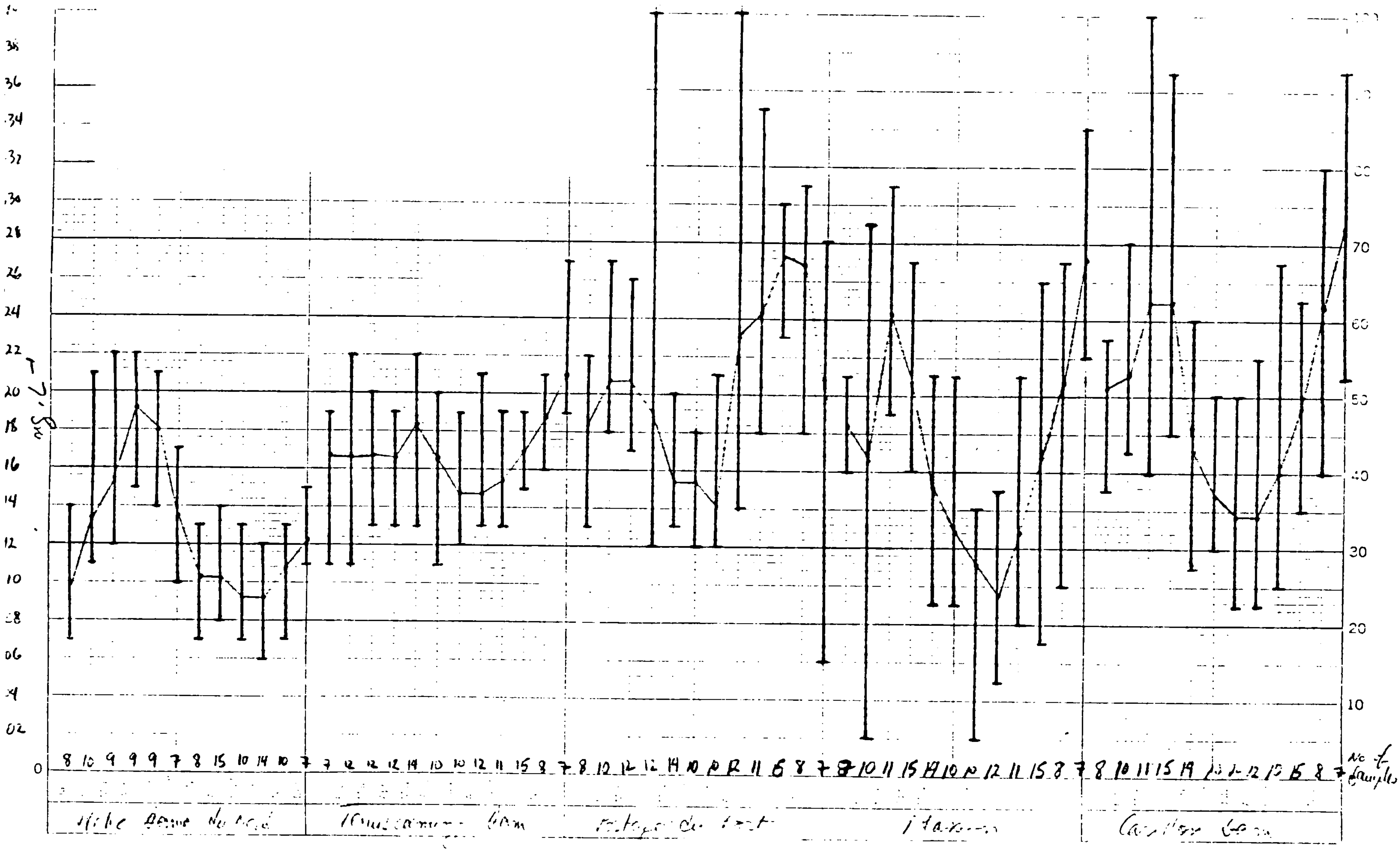


Figure 5.14: Dissolved Nitrate + Nitrite Mean Concentrations and Ranges for the 1979-1984 Period in the Tributaries to the Ottawa River.

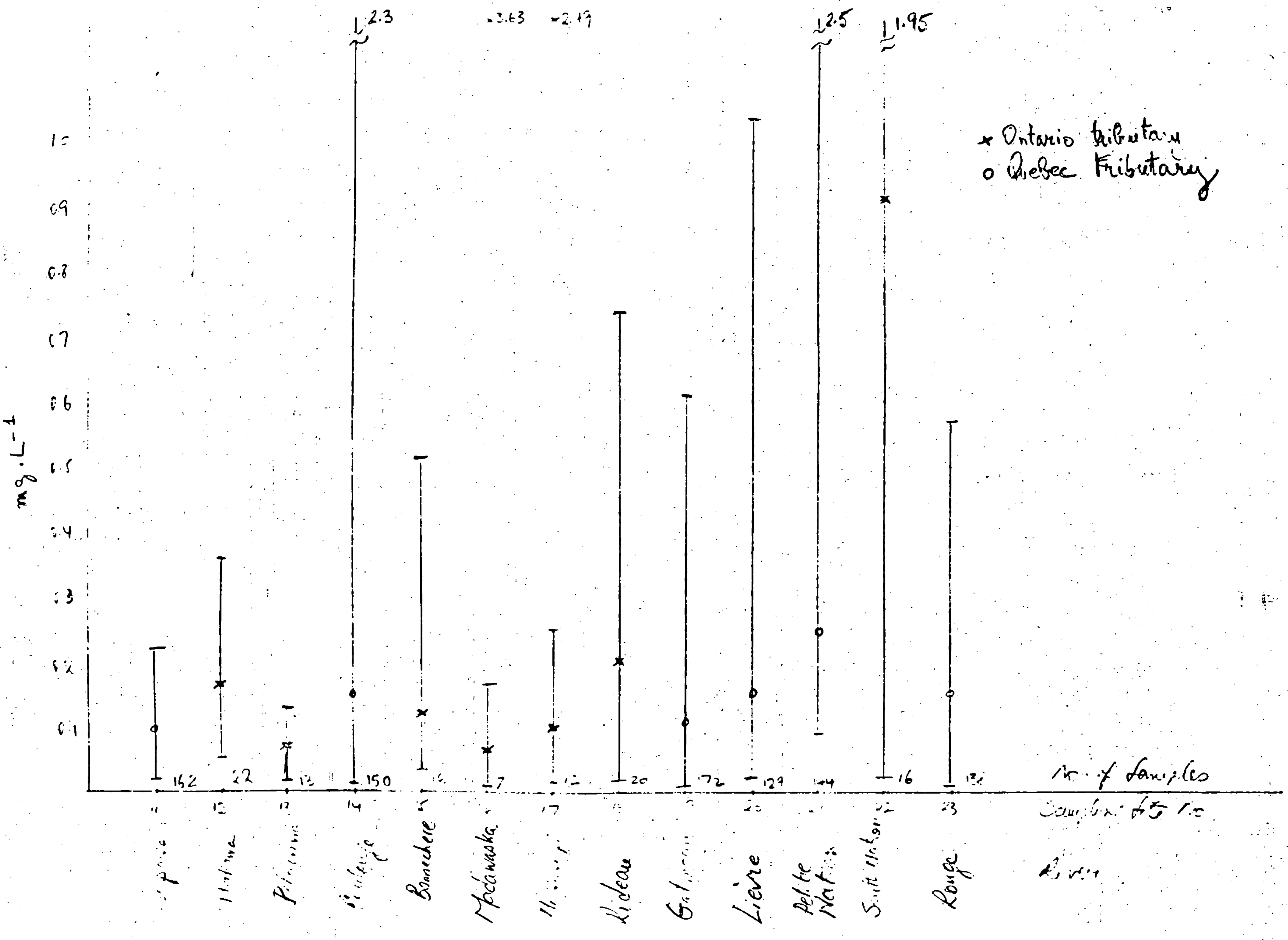


Figure 5.16: Total Phosphorous Concentrations at Five OMOE Ottawa River Mainstem Sampling Locations, for the Period 1977-1984.

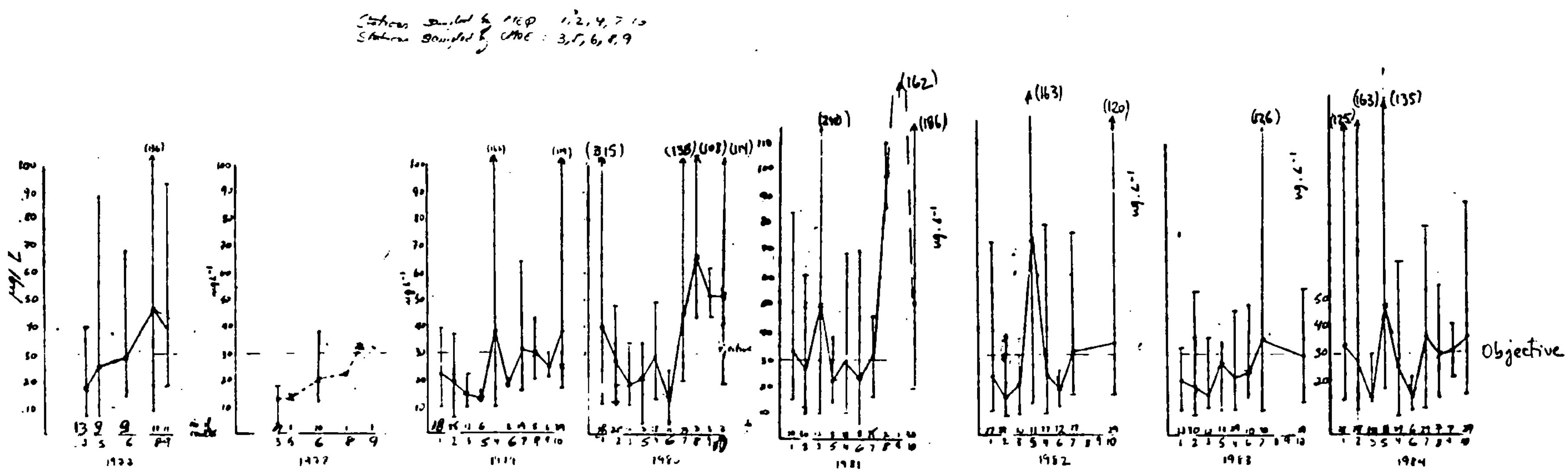


Figure 5.17: Total Phosphorus Concentrations at Five OMOE Ottawa River Mainstem Sampling Locations.

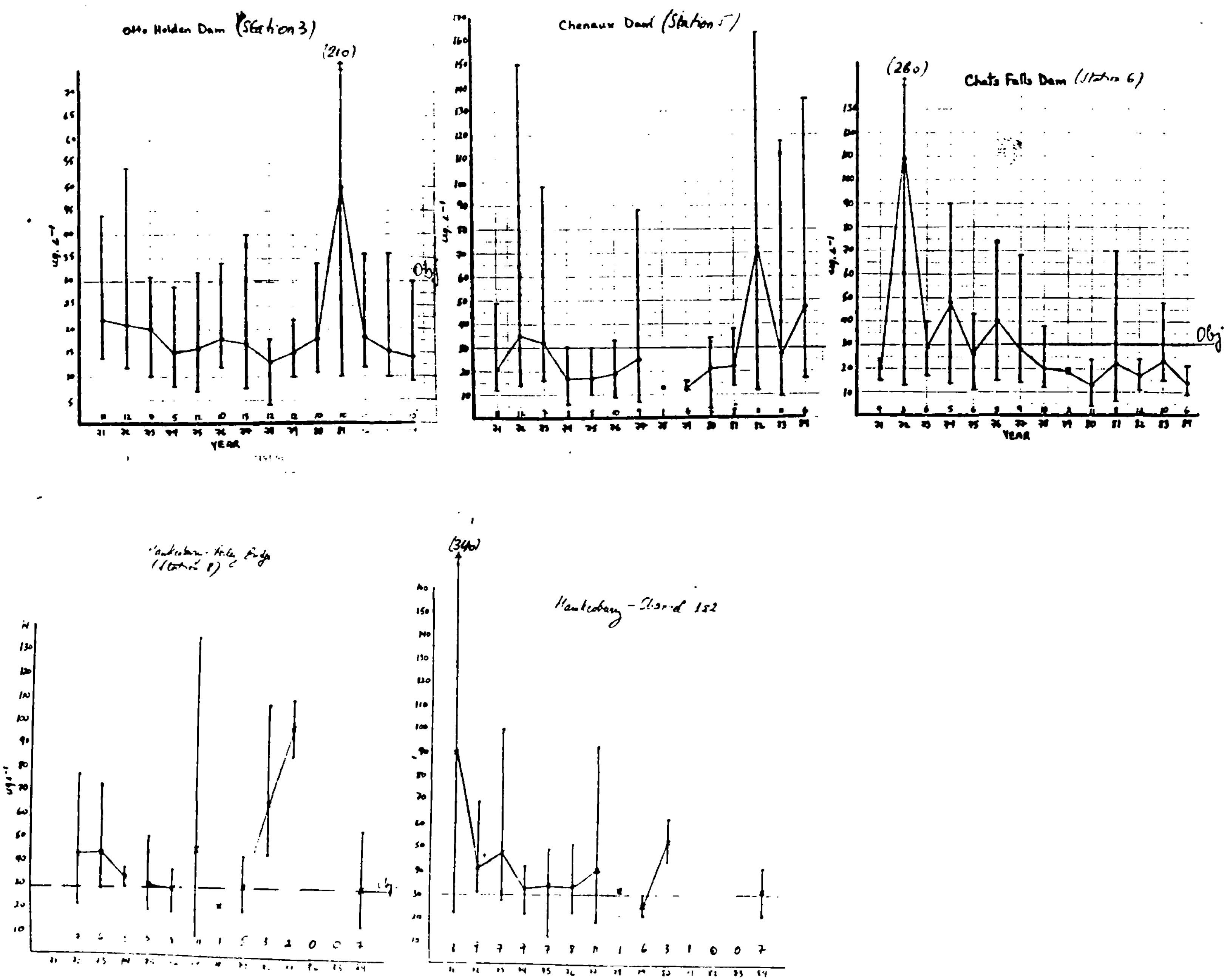


Figure 5.17: Total Phosphorus Concentrations at Chats Falls Dam Sampling Location.

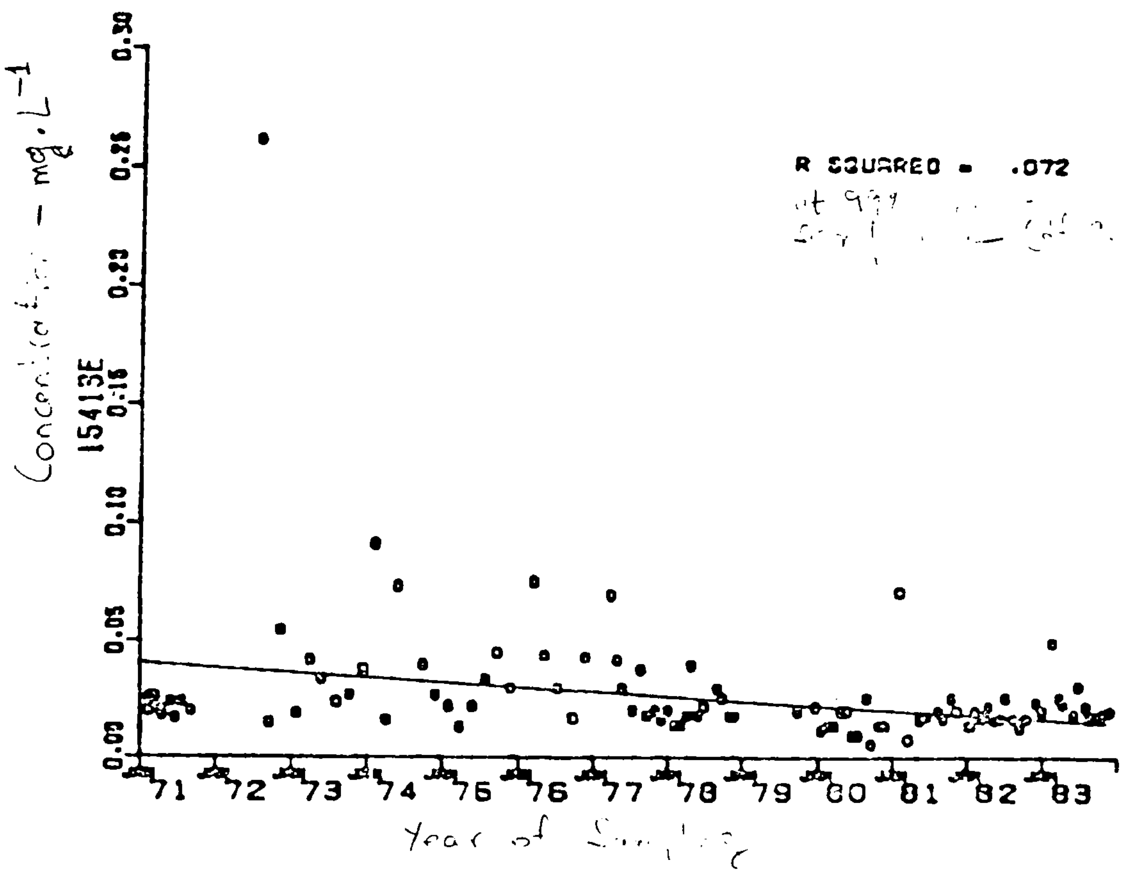


Figure 5.20:

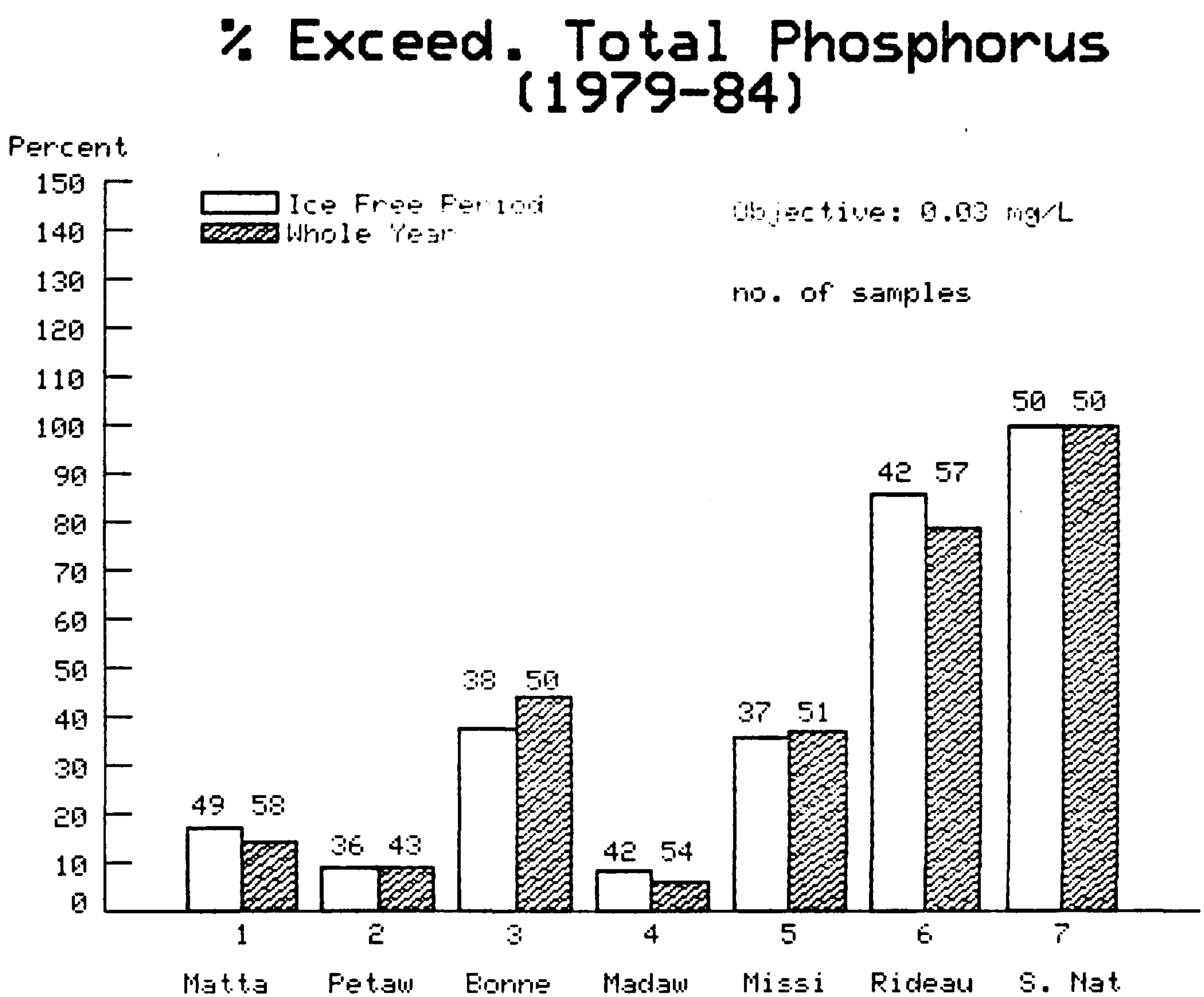
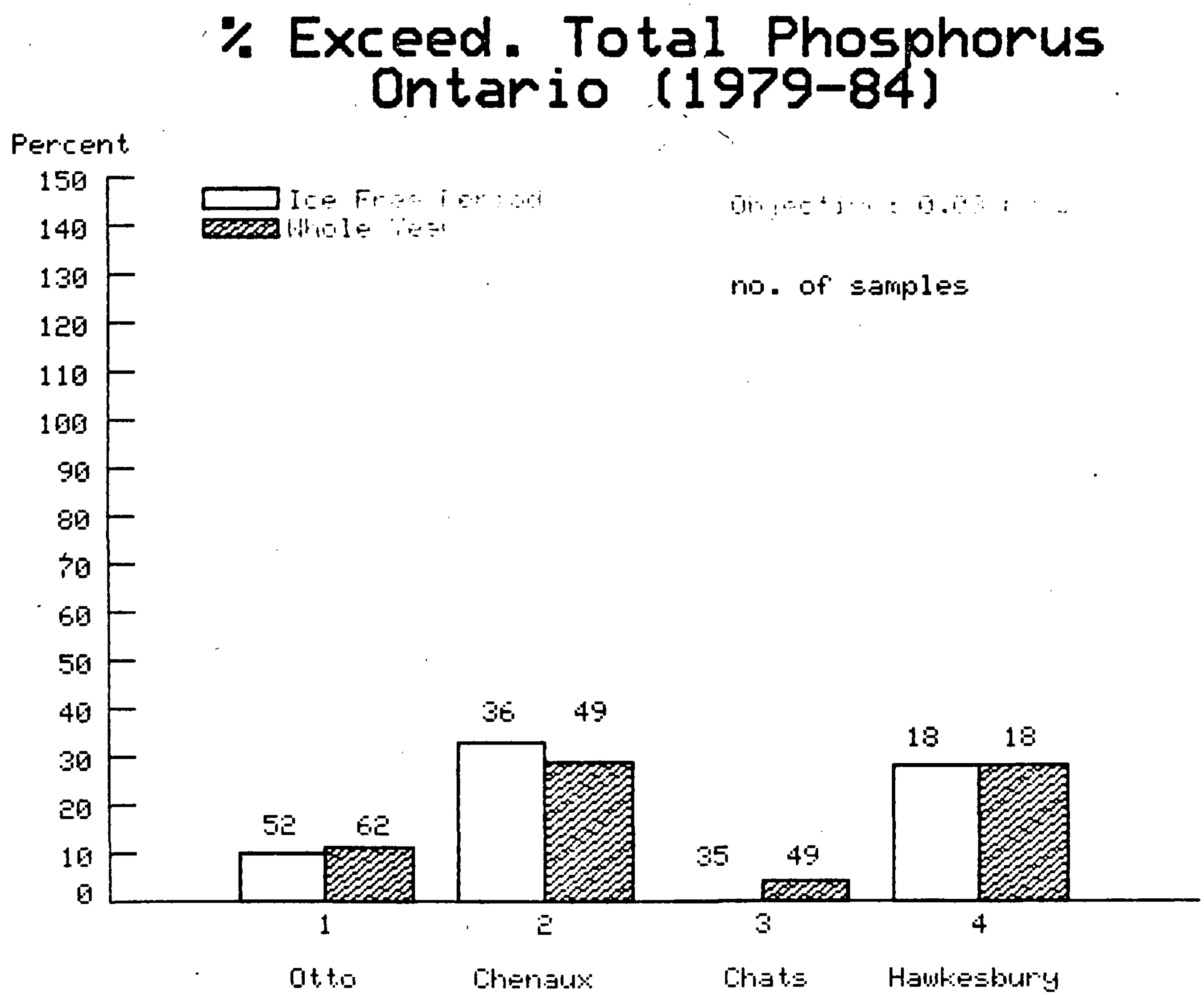

% Exceed. Total Phosphorus
(1979-84)
Percent
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Ice Free Period
Whole Year
Objective: 0.03 mg/L
no. of samples
49 58
36 43
38 50
42 54
37 51
42 57
50 50
1
2
3
4
5
6
7
Matta
Petaw
Bonne
Madaw
Missi
Rideau
S. Nat

Figure 5.19:



% Exceed. Total Phosphorus
Ontario (1979-84)
Percent
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Ice Free Period
Whole Year
no. of samples
52
62
36
49
35
49
18
18
1
2
3
4
Otto
Chenaux
Chats
Hawkesbury

Figure 5.20: Annual Means and Ranges of Dissolved Oxygen Concentrations at the Sampling Locations on the Mainstem of the Ottawa River.

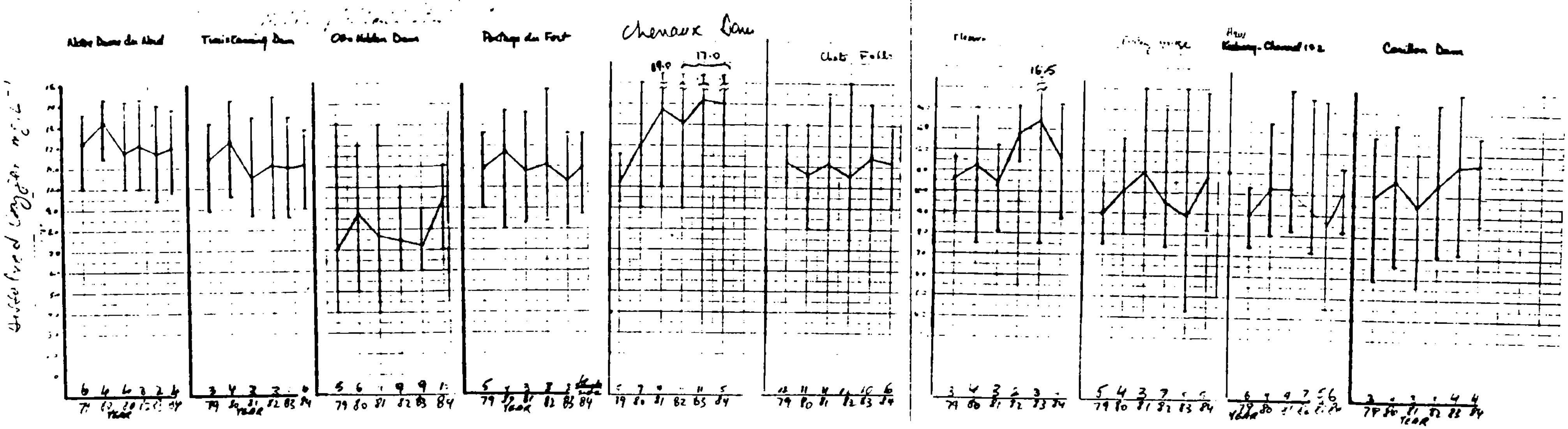


Figure 5.21: Annual Means and Ranges for Dissolved Oxygen and Total Ammonia Concentrations at the Otto Holden Dam Sampling Site on the Ottawa River.

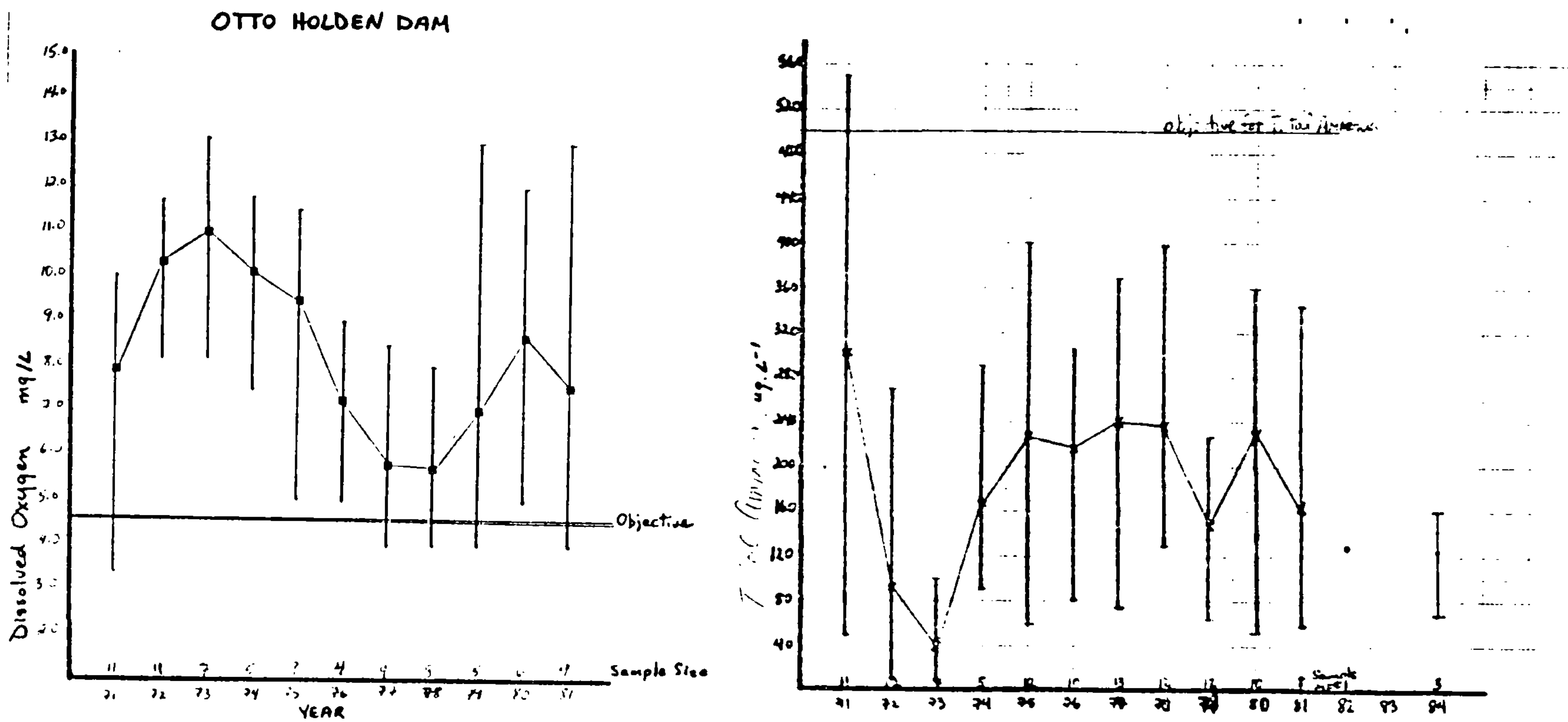
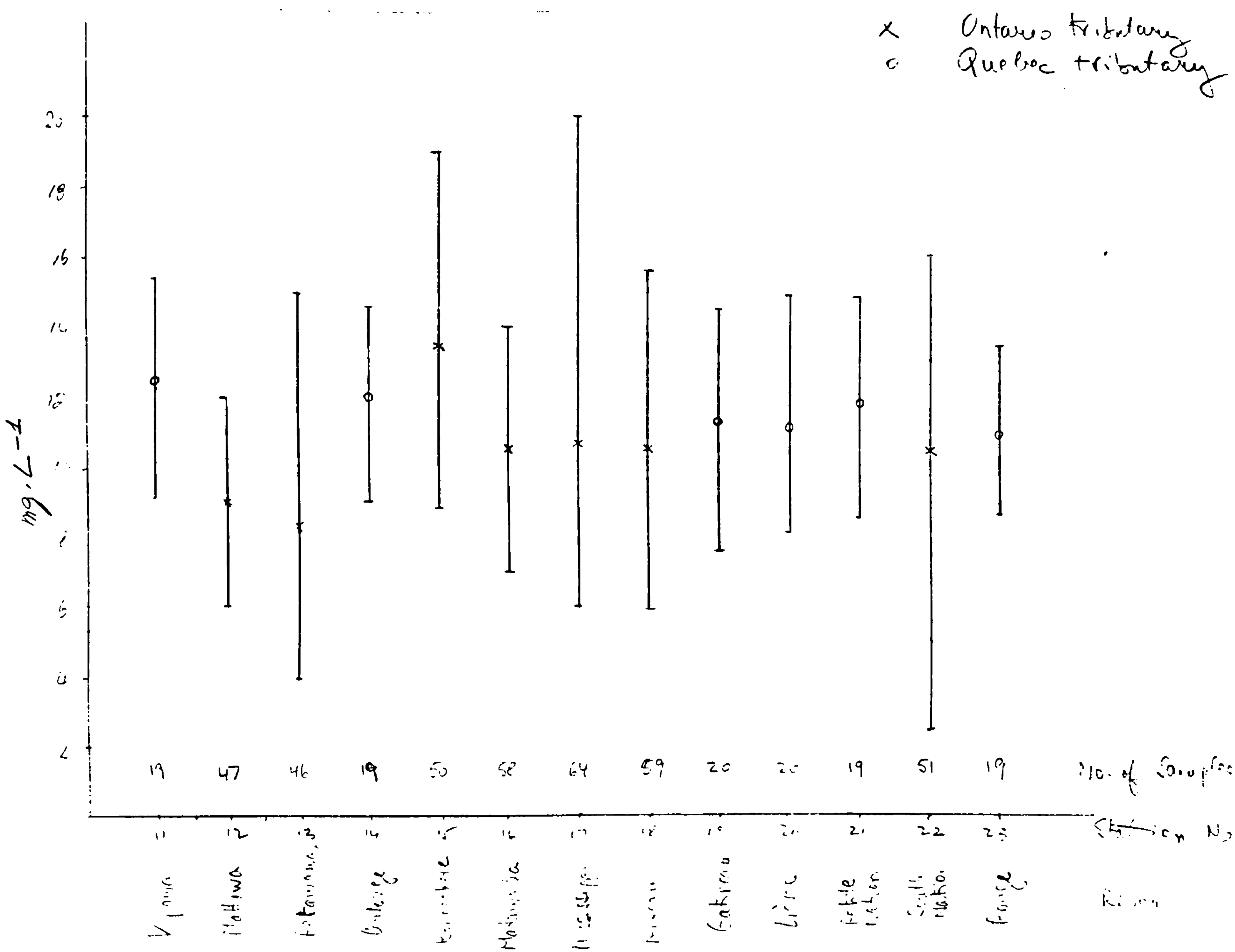


Figure 5.23: Dissolved Oxygen Concentrations of the Ontario and Quebec Tributaries to the Ottawa River Ranges and Means, 1979-1984.



6.0 PHYSICAL PARAMETERS

6.1 Turbidity

Turbidity is a measure of the suspended particles, such as silt, clay, organic matter, plankton and microscopic organisms, in water which are usually held in suspension by turbulent flow and Brownian movement.

High turbidity reduces photosynthesis of submerged, rooted aquatic vegetation and algae; this reduced plant growth may in turn suppress fish productivity. Ultimately, turbidity can affect aquatic biological communities.

The proposed water quality objective for the Ottawa River is 5 FTU.

6.1.1 Mainstem

The turbidity values for the period of 1979-1984 at locations on the mainstem of the Ottawa River are summarized in table 6.1.

Spatial Variation

The turbidity mean values along the Ottawa River, from Notre-Dame-du-Nord to Carillon Dam, were very similar with the exception of Perley Bridge and Channel 1&2 sampling locations (stations 8 and 9), in the Hawkesbury area. The number of results available from the two monitoring stations was inadequate for proper statistical assessment. Individual values were up to 100 percent higher than the results at most other stations (Table 6.1).

Temporal Variation

Turbidity mean values were similar from year to year (1979-1984) for most mainstem stations. The only significant increase occurred at Notre-Dame-du-Nord. The annual mean value increased from 4.3 FTU in 1979 to 6.7 FTU in 1984.

Seasonal Variation

The Notre-Dame-du-Nord turbidity mean value was significantly lower in the winter (3.2 FTU) than the remaining seasons (5.2-5.9 FTU). These last values were above the recommended objective for the Ottawa River of 5 FTU. The highest mean turbidity value occured in the spring at this station.

At the other end of the river, at the Hawkesbury stations, the fall mean values of 10.7 and 11.4 FTU were higher than the 4.2-6.6 FTU range for the means for the other seasons. The high fall levels paralleled the total nitrogen seasonal pattern at these two stations.

At the remaining mainstem stations seasonal variation was similar. The winter and spring mean values were higher than the summer and fall. For example, the spring mean values of 3.5 and 6.8 FTU, of samples from the headpond of the Chenaux Dam and from immediately downstream of the dam discharge, were significantly higher than the summer (1.8 and 2.4 FTU) and fall (1.8 and 2.2 FTU) means but similar to the winter mean values (3.2 and 4.0 FTU).

6.1.2 Tributaries

The mean values and the standard deviations for the six Quebec and seven Ontario tributaries for the 1979-1984 period are given in table 6.2.

The tributaries of the upper Ottawa River and the Quebec tributaries in the lower Ottawa River, excluding Petite Nation River, were less turbid than the Ontario tributaries draining into the lower Ottawa River.

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Quebec

The turbidity mean values recorded at Kipawa River and Coulonge River ranged from 0.4 to 2.0 FTU. The annual mean turbidity values for the Quebec tributaries of the lower Ottawa River, excluding the Petite Nation River levels, ranged from 1.7 to 4.3 FTU. The Petite Nation annual mean values ranged from 4.7 to 13.8 FTU during the six year study period (Table 6.2). Marine clays located at the mouth of this river may be contributing to the high turbidity values.

Ontario

The turbidity annual mean values of the Ontario tributaries ranged from 0.7 to 40.6 FTU during the 1979-1984 period. The Mattawa and Petawawa Rivers, in the upper reaches of the Ottawa River, had low turbidities with mean values ranging from 0.7 to 3.2 FTU. The only Ontario tributary with high turbidity annual means, 8.1-40.6 FTU, was the South Nation River. The prevalent erosion and agricultural land use activities dominating this watershed contributed to the high turbidity measurements.

6.1.3 Comparison with the Water Quality Objective

The proposed turbidity objective for the Ottawa River is 5 FTU. Annual means above this suggested objective occurred at Notre-Dame-du-Nord (1982 to 1984), the headpond of Chenaux Dam (1981, 1984), both Hawkesbury stations and Carillon Dam (1980 to 1984).

The turbidity mean levels of samples from the headpond of Chenaux Dam increased from 2.0 to 6.9 from 1980 to 1981. The mean values in 1981 and 1984 exceeded the proposed turbidity objective of 5 FTU. The exceedances were caused by a high spring values. At the same time total iron levels reached 1900 $\mu g.L^{-1}$. Discharge management techniques at the dam most likely resuspend sediment and distribute potential contaminants downstream.

The proposed objective was also exceeded by the annual mean turbidity values on the following tributaries: Bonnechere (8.4 FTU, in 1983), Rideau (14.4 FTU, in 1983), Petite Nation (6.7 - 12.9 FTU, in 1980-1984) and South Nation (8.1-40.6 FTU, in 1979-1984). The South Nation River loading of suspended solids parallels the other high loading observed in this tributary for other chemical constitutents.

6.2 Conductivity

Conductivity is a measurement of a water's ability to conduct an electrical current. The conductivity of water is dependent on its ionic concentrations and temperature. As more dissolved ionic species are added, the specific conductivity increases. Temperature increases also results in conductivity increases.

Conductivity has no major biological implications.

6.2.1 Mainstem

The 1979-1984 conductivity mean annual values for the sampling locations on the mainstem of the Ottawa River are given in table 6.3.

Spatial Variation

The mean values at Notre-Dame-du-Nord (36.8-43.0 umhos/cm) were significantly lower than the values at the remaining stations on the Ottawa River (59.2-387 umhos/cm).

The headpond of Chenaux Dam and at the Hawkesbury surveillance stations had high annual means, reflecting the high concentrations of the various chemical constituents observed at these stations.

Temporal Variation

There was no significant increase in the conductivity from 1979 to 1984 in the upper Ottawa River, from Notre-Dame-du-Nord to the Portage du Fort. At Chenaux Dam the annual means approximately doubled over the same period. This increase paralleled the increases of alkalinity and heavy metals at this location.

Downstream from Ottawa-Hull, at Masson, the mean conductivity values increased slightly over the six-year period from 65.6 umhos/cm to 80.6 umhos/cm.

Stations 8 and 9 (Hawkesbury-main channel and nearshore, respectively) were directly influenced by the CIP pulp and paper mill and Hawkesbury sewage treatment plant effluent plume during 1979-1982. The high conductivity values during 1981-1982 at these locations also influenced the values farther downstream, at Carillon Dam. In December 1982, the CIP mill shutdown and the conductivity levels and variability were reduced.

Seasonal Variation

The average spring conductivity (60 umhos/cm) was significantly lower than the average values for the remaining seasons (69 umhos/cm) at Otto Holden Dam. This low spring value was probably the result of the dilutional effect of the spring runoff.

In the headpond of Chenaux Dam, the winter mean (105 umhos/cm) was significantly higher than the means for the other seasons (55-59 umhos/cm). This high winter mean paralleled the seasonal trends of other chemical constitutents, including the heavy metals, during the winter period (see Section 3.0). It can be attributed to the tributaries, Petawawa and Coulonge Rivers, and the suspended solids and BOD loading originating from the Consolidated Bathurst Ltd., pulp and paper kraft mill at Portage du Fort, Quebec. Alkalinity values were also unusually high at this station.

The summer mean value (68 umhos/cm) was significantly lower than the winter mean (86 umhos/cm) at Masson. The higher winter mean reflected the concentration increases of major ions during the winter period at this station.

The highest seasonal means occurred at Chats Falls. The mean values for winter (139 umhos/cm), spring (113 umhos/cm), summer (103 umhos/cm) and fall (119 umhos/cm) were probably influenced by the high ion contribution of the Chenaux Dam discharge water and the three Ontario tributaries, Bonnechere, Madawaska and Mississippi Rivers, located immediately upstream of the Chats Falls Dam.

The lowest seasonal means occurred at Notre-Dame-du-Nord. The concentration range for all the seasons was 36 to 42 umhos/cm. This range reflected the low ion content of this reach of the Ottawa River. At the furthest station downstream, Carillon Dam, the conductivity measurements were homogenous throughout the seasons (76-90 umhos/cm).

6.2.2 Tributaries

The annual means and their standard deviations are shown in table 6.4.

Quebec

The Kipawa River conductivity mean value (31.2 umhos/cm) was significantly lower than the other tributary mean levels. The Kipawa River was considered acid stressed and lacked a high ion content contribution from the surrounding shield drainage.

Tributary conductivity mean values determined at Coulonge, Gatineau, Lièvre and Rouge Rivers sampling locations were similar and ranged from 36.4 to 71.8 umhos/cm.

Ontario

The annual means of the South Nation River (481-595 umhos/cm during 1979-1983) were significantly higher than any of the corresponding values on the other tributaries. The South Nation River, drains primarily agricultural land and marine clay overburden. The highest nutrient and turbidity levels were found in this tributary for the entire study period. There is no explanation for the large decrease in the 1984 value.

The Rideau River also had consistent high annual means, 301.4-346.9 umhos/cm, over the entire study period.

The only Ontario tributary conductivity annual means that were comparable to the Quebec tributary mean values were the Mattawa and Petawawa Rivers. These two Ontario tributaries drain primarily the Canadian Shield area.

[redacted] Table 6.1: [redacted] Tur[redacted]ty [redacted] Values [redacted]nd Stan[redacted]rd De[redacted]ions [redacted]en [redacted]stem *Sampling* [redacted]ions [redacted] the [redacted] R[redacted], fo[redacted] period [redacted] 1979 [redacted] (F[redacted]

Year	Station 1 Notre-Dame-du-Nord	2 Lake Timiskaming	3 Otto Holden Dam	4 Portage du Fort	5 Chenaux Dam	6 Chats Falls Dam	7 Masson	8 Perley Bridge	9 Channel 1 & 2	10 Carillon Dam
						(FTU)				
1979	4.3 $(2.1)^{12*}$	3.5 $(0.9)^{16}$	4.6 $(1.2)^{12}$	2.7 $(1.5)^{16}$	2.7 $(0.8)^{6}$	3.9 $(1.4)^{2}$	2.7 $(0.8)^{11}$	3.7 $(0.9)^{5}$	3.7 $(1.1)^{6}$	3.3 $(1.9)^{16}$
1980	4.3 $(2.3)^{17}$	2.4 $(1.1)^{15}$	2.7 $(1.0)^{10}$	2.9 $(1.4)^{16}$	2.0 $(0.7)^{7}$	2.5 $(1.3)^{11}$	4.6 $(6.3)^{13}$	8.8 $(7.4)^{3}$	9.3 $(8.4)^{3}$	4.8 $(5.8)^{17}$
1981	4.4 $(2.6)^{16}$	3.9 $(3.1)^{10}$	2.8 $(1.3)^{17}$	2.8 $(1.5)^{15}$	6.9 $(15.4)^{8}$	2.0 $(0.3)^{8}$	4.1 $(3.4)^{13}$	10.5 $(8.4)^{3}$	9.8 $(10.2)^{2}$	5.6 $(5.0)^{17}$
1982	6.0 $(2.6)^{16}$	3.0 $(1.0)^{16}$	2.8 $(1.3)^{10}$	2.5 $(0.9)^{16}$	3.8 $(3.4)^{11}$	2.16 $(0.63)^{11}$	3.1 $(1.5)^{15}$	NS	NS	6.4 $(11.6)^{16}$
1983	5.5 $(2.3)^{13}$	3.2 $(1.0)^{17}$	3.0 $(1.4)^{8}$	3.1 $(2.0)^{16}$	3.1 $(1.6)^{10}$	2.52 $(0.71)^{10}$	2.9 $(1.0)^{17}$	NS	NS	3.4 $(1.8)^{17}$
1984	6.7 $(2.5)^{16}$	3.7 $(0.9)^{17}$	4.1 $(1.2)^{10}$	2.5 $(1.4)^{17}$	10.4 $(17.0)^{6}$	3.9 $(1.6)^{6}$	4.0 $(5.3)^{17}$	8.6 $(6.4)^{7}$	7.5 $(6.7)^{7}$	3.9 $(4.0)^{17}$

( ) = Standard Deviations
* = number of results
NS = not sampled

Table 6.2: Turbidity Mean Values and Standard Deviations for Six MEQ Tributaries and Seven OMOE tributaries, Ottawa River Basin, ~~for the period~~ 1979-1984 ~~(FTU)~~.

Year	11 Kipawa	12+ Mattawa	13+ Petawawa	14 Coulonge	15+ Bonnechere	16+ Madawaska	Station 17+ Mississippi	18+ Rideau	19 Gatineau	20 Lièvre	21 Petite Nation	22+ South Nation	23 Rouge
							(FTU)						
1979	0.5 (0.1)^{16*}	3.5 (1.4)^{12}	1.1 (0.3)^{6}	1.2 (0.8)^{10}	3.1 (0.6)^{6}	2.2 (0.6)^{6}	2.9 (0.0)^{2}	4.5 (2.9)^{5}	2.0 (1.6)^{16}	1.7 (0.8)^{7}	4.7 (1.9)^{11}	31.8 (19.8)^{11}	2.3 (1.3)^{11}
1980	2.0 (4.8)^{16}	2.0 (0.6)^{9}	0.7 (0.1)^{4}	2.0 (2.3)^{17}	2.6 (1.6)^{7}	NS	2.0 (1.6)^{7}	2.9 (3.3)^{17}	2.4 (2.2)^{15}	4.1 (4.6)^{8}	12.9 (23.3)^{14}	18.0 (11.6)^{7}	3.4 (3.7)^{14}
1981	1.5 (3.5)^{17}	2.2 (1.2)^{9}	0.7 (0.1)^{3}	1.8 (0.8)^{17}	1.5	2.2 (1.1)^{7}	NS	2.9 (1.6)^{7}	3.0 (3.3)^{17}	3.0 (3.6)^{14}	8.6 (9.9)^{16}	8.1 (2.1)^{4}	4.3 (4.3)^{14}
1982	0.5 (0.2)^{16}	2.2 (0.9)^{9}	1.1 (0.5)^{10}	1.7 (1.6)^{15}	4.5 (3.3)^{11}	2.8 (2.2)^{12}	3.3 (3.9)^{11}	3.8 (3.9)^{11}	2.8 (2.5)^{16}	3.0 (2.5)^{12}	10.2 (12.0)^{12}	28.0 (19.0)^{10}	3.7 (2.7)^{10}
1983	0.4 (0.2)^{16}	2.8 (1.2)^{7}	0.9 (0.2)^{6}	1.3 (1.0)^{16}	8.4 (16.3)^{12}	2.7 (1.3)^{12}	3.9 (3.1)^{12}	14.4 (20.7)^{8}	2.0 (0.7)^{16}	2.2 (1.4)^{17}	13.8 (20.7)^{13}	40.6 (20.7)^{13}	2.4 (1.5)^{14}
1984	0.4 (0.1)^{14}	3.2 (1.1)^{8}	2.4 (2.6)^{10}	1.0 (0.3)^{15}	4.7 (2.8)^{5}	3.3 (0.9)^{8}	4.1 (0.8)^{8}	5.4 (5.9)^{11}	2.5 (3.1)^{17}	2.1 (2.0)^{16}	6.7 (7.0)^{13}	26.3 (23.5)^{10}	2.1 (1.6)^{15}

( ) = standard deviation
* = number of results
\+ = Ontario Tributary
NS = not sampled

Table 6.3: Conductivity Mean Values and Standard Deviations for Ten Mainstem Stations, ~~Ottawa River Basin, for the period~~ 1979-1984 ~~(umhos/cm)~~.

	Station									
Year	1 Notre-Dame-du-Nord	2 Lake Timiskaming	3 Otto Holden Dam	4 Portage du Fort	5 Chenaux Dam	6 Chats Falls Dam	7 Masson	8 Perley Bridge	9 Channel 1 & 2	10 Carillon Dam
1979	36.8 (3.3)^{12}*	61.2 (4.6)^{16}	67.4 (5.2)^{12}	61.4 (5.3)^{17}	65.8 (4.5)^{6}	87.0 (12.7)^{2}	65.6 (8.3)^{9}	84.4 (17.9)^{5}	215.8 (301.2)^{6}	84.4 (14.9)^{17}
1980	43.0 (14.6)^{12}	61.7 (25.8)^{16}	65.3 (5.7)^{10}	59.7 (8.1)^{16}	72.0 (28.9)^{7}	103.6 (47.1)^{11}	65.5 (8.7)^{10}	87.7 (12.7)^{3}	90.7 (11.9)^{3}	78.7 (14.6)^{15}
1981	39.6 (7.1)^{19}	66.6 (21.1)^{20}	62.2 (5.3)^{10}	59.9 (7.7)^{19}	95.8 (102.8)^{8}	95.7 (15.8)^{7}	83.7 (24.2)^{15}	387.0 (480.6)^{3}	126.3 (55.2)^{3}	97.5 (21.3)^{20}
1982	39.5 (5.5)^{27}	61.5 (6.6)^{29}	67.1 (6.5)^{10}	59.2 (6.8)^{27}	141.0 (65.0)^{11}	113.0 (84.0)^{11}	84.3 (15.7)^{27}	100.8 (18.8)^{8}	98.1 (20.9)^{8}	89.2 (16.2)^{29}
1983	37.3 (5.1)^{23}	62.0 (4.9)^{30}	68.7 (6.4)^{8}	61.2 (5.3)^{29}	137.6 (45.1)^{11}	83.2 (18.0)^{10}	87.3 (20.6)^{30}	82.5 (18.8)^{7}	95.4 (30.0)^{7}	84.3 (14.1)^{29}
1984	38.4 (4.2)^{28}	61.4 (4.7)^{29}	64.8 (6.8)^{10}	60.7 (5.2)^{29}	119.6 (64.8)^{6}	94.1 (29.6)^{6}	80.6 (22.3)^{29}	72.9 (9.3)^{6}	84.9 (14.8)^{6}	85.1 (18.1)^{29}

( ) = standard deviation
* = number of results

Table 6.4: Conductivity Mean Values and Standard Deviations for Six MEQ Tributaries and Seven OMOE Tributaries, Ottawa River Basin, ~~for the period~~ 1979-1984 ~~(umhos/cm)~~.

Year	11 Kipawa	12+ Mattawa	13+ Petawawa	14 Coulonge	15+ Bonnechere	16+ Madawaska	Station 17+ Mississippi	18+ Rideau	19 Gatineau	20 Lièvre	21 Petite Nation	22+ South Nation	23 Rouge
							umhos · cm^{-1}						
1979	31.6 (1.7)^{16*}	64.0 (4.5)^{12}	47.5 (1.9)^{6}	36.4 (6.6)^{9}	108.9 (9.3)^{6}	220.0 (21.2)^{2}	220.0 (21.2)^{2}	301.4 (29.5)^{5}	48.3 (13.6)^{16}	51.1 (2.8)^{8}	79.1 (11.8)^{13}	481.0 (60.0)^{5}	53.3 (14.0)^{13}
1980	32.2 (2.1)^{17}	60.7 (6.5)^{9}	49.0 (2.7)^{4}	48.2 (17.2)^{15}	107.6 (8.5)^{7}	210.5 (18.6)	210.5 (18.6)^{10}	325.3 (64.1)^{12}	45.9 (10.6)^{17}	71.8 (28.4)^{8}	80.5 (15.7)^{12}	499.3 (32.2)^{7}	49.0 (11.3)^{14}
1981	32.2 (3.3)^{19}	62.8 (14.7)^{9}	55.8 (17.3)^{5}	44.7 (17.0)^{19}	110.3 (9.2)^{6}	230.0 (20.7)^{6}	230.0 (20.7)^{6}	346.9 (46.7)^{8}	57.3 (37.7)^{19}	50.5 (9.6)^{17}	78.4 (11.5)^{19}	495.0 (74.8)^{8}	58.2 (28.3)^{18}
1982	30.3 (1.4)^{28}	67.1 (12.3)^{9}	52 (4)^{10}	57.7 (34.4)^{28}	194.0 (119)^{11}	111.0 (9)^{12}	227.0 (17.0)^{12}	330.0 (59.0)^{10}	50.1 (10.4)^{29}	56.9 (6.6)^{23}	87.6 (22.7)^{24}	535.0 (79.0)^{10}	55.0 (16.2)^{20}
1983	30.7 (2.2)^{28}	63.2 (7.9)^{8}	48.5 (1.7)^{6}	64.0 (44.6)^{28}	158.7 (29.7)^{12}	106.4 (5.9)^{12}	208.2 (19.6)^{12}	319.2 (54.9)^{8}	47.2 (9.5)^{30}	51.5 (6.7)^{30}	86.3 (24.2)^{23}	595.2 (512.5)^{11}	51.9 (11.4)^{23}
1984	29.4 (2.4)^{23}	56.6 (6.1)^{9}	51.8 (13.5)^{10}	44.7 (20.7)^{23}	193.2 (31.4)^{6}	115.6 (6.6)^{8}	214.4 (10.2)^{9}	329.3 (51.9)^{11}	64.2 (75.6)^{29}	52.6 (5.1)^{28}	75.9 (12.6)^{24}	111.0 (163.6)^{10}	48.7 (9.5)^{26}

( ) = standard deviation
* = number of results

7.0 RADIONUCLIDES

7.1 Sources

Radionuclides may enter the aqueous environment via several mechanisms. The main pathways are the interactions of cosmic rays with the atmospheric nuclides, fallout of the fission products from nuclear weapons testing in the atmosphere, nuclear fuel cycle activities (e.g., uranium mining and milling and nuclear-power generation) and weathering of rock formations containing naturally-occurring uranium, thorium and their decay products. Major contributions to radioactivity levels in the aqueous medium have resulted from fallout due to nuclear-weapons testing in the atmosphere after the second World War. Those radionuclides in the atmosphere, generated or released, reach the aquatic systems mainly through precipitation scavenging. Releases from nuclear fuel cycle activities are usually in the form of air emissions and/or through effluent discharges; their contribution to environmental radiation has usually been very small. Also, the contribution from the uranium and thorium decay series is usually not significant in Canada.

7.2 Effects

Nuclides emitting ionizing radiation usually cause damage at the molecular and cellular levels, primarily when ingested or inhaled. The radiation consists of alpha and beta particles, and gamma rays. An alpha particle is most detrimental because of its high energy levels; it consists of two protons and two neutrons. A beta particle is composed of a mass and a single charge equal to that of an electron. A gamma photon is a form of electromagnetic radiation of short wage-length. Somatic effects are generally related to the magnitude of radiation energy deposited in body tissue.

In SI units, absorbed dose is expressed in "Gray" which corresponds to one joule of energy per kilogram of tissue. Biological effectiveness of absorbed dose is measured in "Sievert" which is a product of absorbed energy times a qualifying factor characteristic of the nature of ionizing radiation.

7.3 Guidelines

In order to protect the general public from excessive radiation exposure, revised guidelines for the consumption of drinking water were proposed by the Health and Welfare Canada in 1978; recommended limits are shown in Table 7.1. These guidelines are based on dose-response relationship as recommended by the International Commission on Radiological Protection (ICRP 1977). Maximum acceptable concentrations (MAC) in drinking water have been derived which correspond to 1% of the ICRP recommended annual occupational dose equivalent limit for continuous exposure. Target concentrations (TC) correspond to 10% of the MAC. The annual risks of adverse health effects to an individual member of the public that continues to consume water at MAC and TC limits are 10^{-6} and 10^{-7}, respectively.

7.4 Radionuclide Levels

The radionuclides monitoring of the Ottawa River has been carried out by several government agencies. The Chalk River Nuclear Laboratories (CRNL) of the Atomic Energy of Canada Limited (AECL) has three monitoring stations in the vicinity of the laboratories at Chalk River, Ontario. These stations are located at Rolphton, Deep River and Pembroke. The Rolphton station is located upstream of the water intake/discharge for the nuclear-power generation station (NPD), and provides the background levels of radionuclides in the Ottawa River. The Deep River station is located downstream from the NPD between Rolphton and Pembroke. The station at Pembroke is located downstream from the nuclear laboratories of the AECL. Samples were collected daily, composited monthly and analyzed for selected radionuclides.

Annual mean data for the Pembroke station are presented in Table 7.2. From these data, it is apparent that only three radionuclides, viz, strontium-90, cesium-137 and tritium are in measurable concentrations and the others, viz, cerium-144, ruthenium-106 and cobalt-60, are below or slightly above the detection limit. When compared with drinking water guidelines (Table 7.1), mean values for radionuclides strontium-90, cesium-137 and tritium represent only 3.7, 0.16 and 0.55 per cent of the target concentration, respectively.

The levels of strontium and cesium seem to decrease with time whereas those of tritium were unaffected. For strontium and cesium, the trends are in agreement with those observed by Durham and Joshi (1984) for the Great Lakes. Fallout from nuclear weapons testing in the atmosphere appears to be the major contributor of radioactivity in the Ottawa River, and reasons for the decrease are principally reduced fallout inputs due to a treaty in 1963 banning the testing of nuclear weapons in the atmosphere. This aspect is clearly demonstrated by the long-term monitoring data from these three stations (Meyerhof 1984) (Figure 1).

To assess the impact of NPD operations at Rolphton and that of CNRL at Chalk River on the Ottawa River water quality, the means for the 1979-1983 period were calculated (Table 7.3). Nuclear activities have definitely affected the radiological characteristics of this river at these stations. From Rolphton to Pembroke, tritium and cesium levels have increased about two-fold whereas the increase in strontium levels was only marginal.

Very few data are available regarding the concentration of radionuclides in the sediments or biota of the Ottawa River. Sediments readily adsorb radionuclides from the water column via chemisorption, physisorption and/or ion exchange, and thus they can be a potential source. For example, the adsorbed radionuclides may be easily released back into the water column under acidic conditions. Biota, especially fish, serve as a pathway for radionuclides from aquatic environments to humans. Future radionuclides monitoring should include both biota and sediments.

Conclusions

The present radionuclide levels in the Ottawa River are well below the recommended guidelines for drinking water. However, due to the presence of NPD and CRNL on the shores of the Ottawa River, the monitoring of readionuclides in the Ottawa River should continue at least at the present level. Sediment and biota data will be useful in understanding the pathway of these radionuclides to human beings.

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Table 7.1: Recommended guidelines for radionuclides in drinking water*

**Radionuclide	Maximum Acceptable Concentration	Target Concentration
Cesium-137	50	5
Iodine-131	10	1
Radium-226	1	0.1
Strontium-90	10	1
Tritium	40,000	4,000
Uranium	0.02 mg/L	0.001 mg/L

*Source: Guidelines for Canadian Drinking Water Quality 1978, Health and Welfare Canada.

** In units of Bq/L unless specified

Table 7.2: Average Annual Concentration of Radionuclides in the Ottawa River Water at Pembroke, Ontario*

	Radionuclide Concentration, mBq/L					
Year	Strontium-90 +Yttrium-90	Cerium-144	Ruthenium-106	Cesium-137	Cobalt-60	Tritium
1978	59	15	2.2	11.1	1.8	2.4×10^4
1979	44	11	11.1	7.4	7.4	2.6×10^4
1980	37	2.6	7.4	7.4	2.6	2.2×10^4
1981	30	4.0	7.0	10.0	4.0	2.4×10^4
1982	26	5.0	7.0	6.0	3.0	2.3×10^4
1983	26	3.0	6.4	5.2	2.5	1.6×10^4
Mean	37	-	-	7.8	-	2.2×10^4

*Source: AECL Annual Reports

Table 7.3: Average Concentration of Radionuclides in the Ottawa River Water, ~~during~~ 1979 to 1983*

Location	Average Radionuclide Concentration, Bq/m^3		
	Cesium-137	Strontium-90	Tritium
Rolphton	3.8	14.4	9.9×10^3
Deep River	4.0	13.0	17.2×10^3
Pembroke	7.5	16.4	22.2×10^3

*Source: AECL Annual Reports

8.0 WATER QUALITY OBJECTIVES

8.1 Background

Water quality objectives are defined as limiting characteristics of water, sediment or biota which have been negotiated to protect the agreed uses of a water body. They may be physical, chemical, radiological or biological in nature and may be numerical or narrative.

In 1971, water quality objectives were proposed for the Ottawa River by the Régie des Eaux du Québec (Quebec Water Board) and the Ontario Water Resources Commission (1). The objectives (termed "standards" in the 1971 report) were either numerical or narrative; some of the numerical objectives varied from reach to reach of the river. Narrative objectives were set for taste, odor, oil and other immiscible chemicals, nutrients and temperature. Numerical objectives were set for pH, alkalinity, coliformes, enterococci, radioactivity, dissolved oxygen, dissolved solids, turbidity and colour.

Although these objectives were never formally adopted by the provincial governments, they served for a time as reference points for data interpretation. They also helped stimulate and orient some pollution control programs.

No new objectives or modifications to the 1971 objectives have been proposed since then. In the interim, the scientific informatic available for the formulation of objectives has greatly expanded and a lot of experience has been gained in the practical use of objectives. The proposed 1971 objectives are now out of date.

For this reason the 1981 report of the federal-provincial technical working group recommended that water quality objectives be established for the river. This item was also included in the terms of reference of the coordinating committee. The coordinating committee decided, at its first meeting in April 1983, to set up an objectives subcommittee. The subcommittee met four times during the 1983-84 fiscal year and the results of its work are summarized here.

8.2 Water Uses

Objectives were developed to protect the following uses:

a) Raw municipal water supply. The number of communities taking raw water directly from the interprovincial sector of the Ottawa River prior to treatment as of 1984 was 22, 10 on the Ontario side and 12 on the Quebec side.

b) Aquatic life. This category includes warm water (non-salmonid) fish and other resident organisms. The decision to exclude salmonids was based on the policy of the Ontario Ministry of Natural Resources which considers the Ottawa to be a non-salmonid river for purposes of its management plan.

c) Contact recreation. There are a number of bathing beaches along the Ottawa River, particularly in the national capital region. Water sports such as water skiing, boardsailing, canoeing and sailing are practiced along the river segment under study.

d) Aesthetics. There are some 5000 cottages along the river (5) and a number of parks, marines and other developments for which the appearance of the river is important. The river also flows through the National Capital area and forms the backdrop for the Parliament Buildings.

e) Protection of consumers of fish. Sport fishing is important in the Ottawa River and there is also some commercial fishing. In addition, some fish-eating birds such as ospreys, herons, kingfishers, cormorants and loons are found in the basin.

The subcommittee felt that other uses, such as agricultural and industrial, are either unimportant or are adequately protected by objectives that protect the above uses.

8.3 Scientific Basis of Objectives

The setting of appropriate water quality objectives, particularly for aquatic life, is complex because of the large number of organisms to be protected, their wide range of tolerances, the large number of substances and other environmental factors that affect the organisms, and the possibility of synergistic or antagonistic interactions among these various substances. In addition, the available data bases are often incomplete.

The subcommittee has set some tentative objectives based on the available criteria and guidelines. These proposed objectives are used only as benchmarks in interpreting water quality data and they presented in Table 8.1.

At present, a task force of the Canadian Council of Resource and Environment Ministers (CCREM) is preparing the Canadian Water Quality Guidelines. These guidelines will be presented to Council in 1986. They will provide the basic scientific information needed by provincial and federal agencies to assess water quality problems and to assist in establishing water quality objectives. The objectives adopted by the subcommittee for the Ottawa River will likely need revision once these guidelines are available.

Table 8.1
Proposed Water Quality Objectives for the Ottawa River

Metals	
Chromium	0.05 mg/L
Copper	0.005 mg/L
Nickel	0.025 mg/L
Manganese	0.05 mg/L
Mercury	0.001 mg/L in water 0.5 mg/kg in the edible portion of fish
Zinc	0.03 mg/L
Other	
Ammonia: un-ionized	0.02 mg/L as N
total	0.5 mg/L as N
Nitrates + nitrites	10 mg/L as N
Oxygen (dissolved)	47% saturation minimum
pH	between 6.5 and 9.0
Phosphorus (total, average for the ice free period)	0.02 mg/L

Note: Unless otherwise indicated, all objectives are maximum permissible values and refer to the total form of the parameter.

8.4 Problems Encountered in Setting Objectives

A number of problems or uncertainties limited the number of objectives it could set.

One problem was related to the toxic organic compounds. Traces of these are not efficiently removed by standard water treatment processes and since the use of the Ottawa River as a source for drinking water is important, the concentration of carcinogens in the river should ideally be zero. Since this is impossible in practice, it is necessary to determine an acceptable level of risk. Governments in Canada, the United States and elsewhere are wrestling with this question. The subcommittee decided to wait for the latest revision of the Canadian Drinking Water Guidelines and for the Canadian Water Quality Guidelines, prepared under the auspices of CCREM, before proposing objectives for the toxic organic compounds.

The second problem involved trace metals. The subcommittee did not expect that the trace metals other than mercury will be an issue, because the 1981 Contaminants Task Force report stated that none had been observed. However, monitoring data now available show that several metals frequently exceed the tentative objectives.

Furthermore, the available data are usually for the total form of the metals, while objectives should probably apply to the biologically available portion of the metals. These questions will be taken up by the Coordinating Committee during 1986.

8.5 Rationale for Water Quality Objectives

The following is a brief rationale for the tentative water quality objectives (see section 8.3) adopted by the Objectives Subcommittee. The rationale is taken mainly from the minutes of subcommittee meetings during 1983 and 1984.

Chromium

The objectives of 0.05 mg/L is based on the widely accepted criterion for drinking water supplies.

Copper

The objectives of 0.005 mg/L for total copper follows the Ontario and Great Lakes objectives. It was noted that the form of copper greatly influences its toxicity and that some data on the form of copper, especially during the spring flood, might allow a more appropriate objectives to be set.

Nickel

The objectives of 0.025 mg/L follows the Ontario and Great Lakes objectives and the federal (WQB) guidelines for aquatic life.

Manganese

The objectives of 0.05 mg/L for total manganese follows the commonly accepted drinking water criteria. Current levels of manganese seem to be below this objective.

Mercury

For mercury, the subcommittee recommended an objective of 0.5 mg/kg in the edible portion of fish from the river, to protect consumers of fish. This objectives is based on both the federal Department of National Health and Welfare guideline for commercial fish and the Ontario guideline for protection of fish-eating birds.

The subcommittee noted that although shiners and young of the year are useful fish for trend analysis, it is the level of mercury in the edible portion of adult fish which is most pertinent to consumer-protection.

The mercury in some fish species in the Ottawa currently exceeds the 0.5 mg/kg guideline despite the fact that nearly all monitoring data for water are below the detection limit of 0.05 ug/L. The committee recommended an objectives of 1 ug/L (0.001 mg/l) for mercury in water to protect drinking water supplies. This is based on the 1978 Canadian drinking water guidelines and is also very close to the EPA maximum acceptable concentration (1983 draft criteria) for protection of aquatic life from toxic effects (as distinguished from accumulation).

Zinc

The objectives of 0.03 mg/L is based on recent EPA criteria for soft water as well as Ontario and Great Lakes objectives.

Alkalinity

It was impossible to set an objectives which could be compared meaningfully to monitoring data and which would ensure protection of aquatic life because the alkalinity in most of the Ottawa River is already low and is decreasing, in certain reaches of the river due to acid rain. It was therefore decided to interpret alkalinity results on the basis of sensitivity to acid rain (see Chapter 2).

Ammonia

An objectives of 0.05 mg/L, as N, was recommended for un-ionized ammonia, to protect aquatic life, and 0.5 mg/L, as N, for total ammonia to protect drinking water. This is the same as the values proposed by the IJC for the Great Lakes in 1978. To calculate un-ionized ammonia, temperature and pH determinations must be made in addition to total ammonia.

Nitrate and nitrite

An objectives 10 mg/L of nitrate + nitrite (as N) was recommended for protection of drinking water supplies. A separate objectives for nitrite was not set as it appears that its levels in the river are always negligible.

Dissolved oxygen

For dissolved oxygen a minimum value of 47% of saturation, which corresponds to the Ontario objective for warm water biota, was recommended. This value translates into a range of 7 mg/L at 0° C to 4 mg/L at 20° C and above.

pH

A range of 6.5 to 9.0, recommended by a number of agencies, was proposed for the protection of aquatic life.

Total Phosphorus

The objectives proposed for total phosphorus is 0.02 mg/L for the ice free period. This value is based on the Ontario objectives and related information which suggest 0.02 mg/L to avoid nuisance concentrations of algae in lakes and 0.03 mg/L to avoid excessive plant growth in rivers.

Since the current levels of phosphorus in the river are fairly close to the proposed objective, the aquatic plant growth and nutrient levels must be monitored to determine the adequacy of this objective.

Unlike most other objectives, the total phosphorus objective applies to the mean of the monitoring results, and to the ice-free period.

TOC and TKN

It was decided that objectives were not necessary for total Kjeldahl nitrogen (TKN) and total organic carbon (TOC). These parameters should not present a problem in the Ottawa River system if the objectives for related parameters such as total phosphorus, nitrates, ammonia and dissolved oxygen are met.

9.0 REMEDIAL PROGRAMS

The waters of the Ottawa River receive effluents from municipalities and industries, and agricultural runoff from both the Provinces of Ontario and Quebec. The municipal and industrial effluents, but not those from non-point sources, are treated prior to discharge to the river. Urban drainage and other indirect and diffuse sources such as from agriculture continue to cause pollution problems. In the National Capital Area, due to the number of facilities, federal activities make a significant contribution to the amount of effluent discharged from treatment systems. Environment Canada activities, such as participation on the Regional Municipality of Ottawa-Carleton Technical Pollution Abatement Committee, ensures that federal departments and agencies adopt policies, programs and activities that take into account environmental quality concerns along the Ottawa River.

9.1 Municipal Pollution Control Programs

9.1.1 Ontario

Under a Federal-Provincial Accord for Environmental Protection, Ontario has agreed to adopt pollution control requirements at least as stringent as national requirements. Table 9.1 lists the municipal treatment systems along the Ottawa River owned and operated by municipalities or by the Province of Ontario. Treatment systems include conventional activated sludge with phosphorus removal, extended aeration, waste stabilization ponds, and primary treatment with phosphorus removal and chlorination. All municipalities on the Ontario side are providing sewage treatment prior to discharge to the river. At Hawkesbury, which previously had no treatment, an activated sludge sewage treatment plant was constructed and placed in operation during 1978. This facility provides phosphorus removal and effluent disinfection. Other changes to municipal sewage treatment systems on the Ontario side of the river, which have occurred since 1976, have reduced pollutant loadings to the river.

1. New Liskeard

Expansion of the New Liskeard waste treatment system should have been completed during 1985. Two new aeration cells and phosphorus removal were being incorporated into the waste treatment process and the capacity of the system upgraded to 8273.7 m^3/d. The system remains as continuous discharge facility.

2. Haileybury - North Cobalt

The Haileybury - North Cobalt waste treatment system, previously referred to as the Bucke Township system (in the 1978 Federal-Provincial Working Group Report), has remained unchanged.

3. Haileybury

Expansion of the Haileybury contact stabilization facility was scheduled for completion during 1985. The capacity of the treatment system was being increased to 2727.6 m^3/d and phosphorus removal facilities incorporated into the system.

4. Mattawa

Expansion of the Mattawa waste stabilization ponds to a capacity of 1091.0 m^3/d was completed during 1980. The system has four lagoon cells. Three of the cells are currently in use and the system is operated as a seasonal discharge facility.

5. Pembroke

Expansion of the primary sewage treatment plant at Pembroke was scheduled for completion during 1985. The plan capacity will increase to 22730 m^3/d and will have phosphorus removal and chloriantion equipment.

6. Petawawa

Expansion of the primary sewage treatment facility at Petawawa was scheduled for completion during 1985. The plan capacity will increase to 4546 m^3/d and will be equipped for phosphorus removal and chlorination.

7. Rockland

The Rockland waste treatment system has been modified from a seasonal discharge lagoon to an aerated lagoon followed by a facultative lagoon with a continuous discharge. Batch chemical treatment is practiced for phosphorus removal. The capacity of the Rockland facility has been increased to 2545.8 m^3/d.

8. Hawkesbury

The Hawkesbury activated sludge sewage treatment plant was constructed and placed into operation on schedule during 1978. The 12274.2 m^3/d treatment plant provides phosphorus removal and effluent disinfection.

The Ontario Ministry of Environment requires phosphorus removal at all sewage treatment plants with a capacity of more than 4500 m^3/d. With the exception of Pembroke, all major municipalities continue to be in compliance. As noted above, the Pembroke plant is undergoing an expansion program which includes phosphorus removal and chlorination. As indicated in Table 9.1, the total phosphorus loading to the river from municipal waste treatment plants in Ontario has not changed since 1976, but has been reduced by approximately 75% since 1969. The provincial phosphorus control program and the federal regulation of 1970 reducing the phosphorus content of detergents to 8.7% by weight followed by the provisions of the Canada Water Act, in 1973, which restricted the phosphorus content to 2.2% by weight, were the primary reasons for this reduction.

In 1983 the total BOD_5 loading from municipalities listed in Table 9.1 was 12,615.6 kg/d. This increase from the 1976 loading level of 10,169.5 kg/d (Federal-Provincial Working Group 1978) is due, in part, to the increase in population of municipalities along the river and in particular an increased population in the Regional Municipality of Ottawa-Carleton. Also the 1978 report provided data on the basis of population statistics. The estimate was probably lower than would have been indicated by actual measured values.

9.1.2 Quebec

In Quebec, sixteen (16) municipalities having a population of approximately 193,680 discharge effluents to the Ottawa River. Since 1976, a 70% reduction has been effected in municipal BOD_5 and a 74% reduction in phosphorus (Table 9.2). Quebec, as seen by the reductions in BOD_5 and phosphorus loading, has shown its commitment to controlling Ottawa River pollution. By the end of May 1984, six treatment plants were in operation and eight (8) municipalities had agreed to a provincial sewage treatment program. By following this program, in two to three years, 96% of the population on the Quebec side of the river will have wastewater treatment.

One major municipal sewage treatment plant to come into operation since 1976 is located at Templeton, Quebec. The plan serves the Outaouais Regional Communities including parts of Aylmer, Hull and Gatineau. This activated sludge sewage treatment plant reduced the hourly discharge of BOD_5 by 84% and of phosphorus by 86% based on 1983 data (Table 9.2).

9.2 Industrial Pollution Control Programs

The major industrial wastewater source on the Ottawa River is the pulp and paper industry. There are currently six mills operating in the basin, five of which are located in Quebec. the total BOD_5 discharge to the river is estimated at 284,577 kg/d (Table 9.3). This represents a 36% decrease in total in BOD_5 loading since 1976. The total suspended solids discharge to the river is estimated at 98,882 kg/d. This represent a 46% decrease in suspended solids loading since 1976. This decrease in loadings is due in large part, to the closing of the Canadian International Paper (CIP) plant in Hawkesbury. Other industries contribute organic waste to the Ottawa River but their contribution is insignificant in comparison to the larger pulp and paper industry. The changes which have occurred in the pulp and paper sector since 1976 in Ontario and Quebec are described here.

9.2.1 Ontario

The CIP mill at Hawkesbury, which had been a major contributor of BOD_5 to the river, has ceased operations. The closing of this plant eliminated 99% of the BOD_5 entering the Ottawa River from major industrial sources on the Ontario side. The E.B. Eddy Mill in Ottawa has completed an abatement program which has reduced suspended solids and BOD_5 loadings to 450 and 1,660 kg/d, respectively (1983 average). The E.B. Eddy Mill in Ottawa has also completed an abatement program which separated its sanitary wastes from the process wastes. The mill sanitary wastes are now treated separately in a package sewage treatment plant.

9.2.2 Quebec

The pulp and paper industry continues to be the major source of BOD_5 and suspended solids on the Quebec side of the Ottawa river. The names of the pulp and paper mills together with estimates of their BOD_5 and suspended solids loadings are given in Table 9.3.

In general, there has been less than 3% increase in BOD_5 loadings to the river since 1976 from mills operating on the Quebec side. Overall, the data indicates a 30% reduction in BOD_5 loadings since 1969. The recent increase could be due in part to increases in production levels. The data shows production levels for Quebec mills increasing by almost 6% during the same period.

There has been a 45% reduction in suspended solids discharges to the river from Quebec mills since 1976. Further reductions can be anticipated with the completion of a suspended solids reductions project planned for 1985 at the Tembec Forest Products mill at Temiscaming.

9.3 Agricultural Inputs

No remedial programs have been undertaken to address the agricultural runoff problem along the Ottawa River. The agricultural industry, particularly livestock operations, can significantly pollute an aquatic environment. Fertilizers, pesticides and herbicides may leach into the water system or runoff directly into the river. In addition, inappropriate farmland drainage and agricultural practices can accelerate erosion, increase water turbidity and contribute to high nutrient levels.

9.4 Other Discharges

A proposal currently exists to construct a snow dumping facility on the Ottawa River. The Ontario Ministry of the Environment has developed conditions for approval should the Regional Municipality of Ottawa-Carleton proceed with this program. One of those conditions is the submission of an annual water quality report which will be used to determine whether or not the facility can continue to be used one year to the next. Subsequent approval for the snow dumping program will be based on a review of that report.

Table 9.1 - MUNICIPAL DISCHARGES TO THE OTTAWA RIVER - ONTARIO

Municipality	Population Served		BOD5 Loading Kg/day		Phos. Loading Kg/day		Type of Treatment		Chlorination	Comments
	1976*	1983**	1976*	1983	1976*	1983	1976*	1983		
New Liskeard	5,800	6,513	82	62	18	10.7	SP	SP	Not required	Expansion within P removal to be completed in 1985. Also serves Dymond Twp. Sewers - 6% combined, 94% sanitary.
Haileybury (N. Cobalt)	600	800	4.5	9.8	0.5	1.1	LS	LS	Not required	Expansion with P removal to be completed in 1985. Sewers - 100% sanitary.
Haileybury	4,700	4,141	35	40.4	7	3.4	CS	CS	Seasonal	Plant overload due to infiltration. Sewers - 100% sanitary.
Mattawa	2,000	2,686	10	48.1	2	3.4	LS	LS	Not required	Expansion in 1980. Sewers - 5% combined, 95% sanitary.
Deep River	5,480	5,000	77	83.5	5	7	P	P	Year-round	Sewers - 100% sanitary.
Petawawa	10,700	11,700	176	182.4	9	15.4	P	Pp	Year-round	Sewers - 100% sanitary.
Pembroke	18,100	17,000	980	204	57	6.7	P	P	Seasonal	Hydraulically overloaded. Primary plant with P removal to be completed in 1985.
Nepean	45,000	90,310	204	204	41	23	AS	ASp	Year-round	Sewers - 100% sanitary.
Ottawa-Carleton	436,000	495,088	7,802	11,681	265	368.7	Pp	Pp	Year-round	Sewers - 33% combined, 67% sanitary.
Rockland	3,825	2,978	31	19.9	4	3.7	LS	LSp	Not required	Sewers - 100% sanitary.
L'Original	1,313	1,561	6	4.4	2.0	6.1	EA	EA	Year-round	Sewers - 100% sanitary.
Hawkesbury	9,600	9,623	762	76.1	45	6.6	nil	ASp	Nil	Secondary plant with P removal completed in 1978; sewers - 18% combined, 82% sanitary.
ONTARIO TOTALS	498,118	647,400	10,169.5	12,615.6	455.5	455.8				

Treatment Abbreviations

AS - Conventional Activated Sludge
CS - Contact Stabilization
SP - Waste Stabilization Pond
LS - Seasonal Discharge Waste Stabilization Pond

P - Primary
P - Phosphorus Removal
EA - Extended Aeration

*As reported in 1978 Ottawa River Report

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Table 9.2 - MUNICIPAL DISCHARGES TO THE OTTAWA RIVER - QUEBEC

Municipality	Population Served		BOD_5 Loading Kg/day		Phos. Loading Kg/day		Type of Treatment		Chlorination	Comments
	1976*	1983**	1976*	1983	1976*	1983	1976*	1983		
Ville Marie	2,020	2,300	156	177.1	5	5.75	None	None	-	Sewers
Témiscamingue	2,210	2,300	170	177.1	5	5.75	None	None	-	Sewers-combined
Chapeau	500	300	38	23.1	1	0.75	None	None	-	Sewers - no storm sewers
Fort-Coulonge	1,648	1,640	20	126.3	2	4.1	SP	SP	Nil	Sewers-separate, partial storm sewers
Campbell's Bay	1,250	1,275	100	98.2	3	3.2	None	None	-	Sewers-separate, no storm sewers
Shawville*	1,750	1,850	23	21.4	2	0.7	EA	EA	Year-round	Extended Aeration - storm sewers
Pontiac	400	600	31	46.2	1	1.5	None	None	-	Sewers-separate - no storm sewers
Aylmer*	19,000	25,000								
Hull*	65,100	65,000	11,453	1,848	440	60	None	AS	Year-round (Jan. 84)	Sewers-combined - separate plus storm sewers
Gatineau*	65,100	70,000								
Erco Buckingham	13,046	14,500	1,006	1,116.5	29	36.3	None	None	-	Sewers-combined and separate
Thurso	3,150	3,240	268	249.5	7	8.1	None	None	-	Sewers-partial storm sewers
Papineauville	1,370	1,545	16	17.8	2	0.57	AS	AS	Year-round	Activated Sludge. Sewers-separate, partial storm sewers
Montebello	1,250	1,250	109	96.3	3	0.47	None	None	-	Proposed secondary treatment. Sewers combined and separate, no storm sewers
Fasset	623	880	48	67.8	2	0.33	None	None	-	Proposed secondary treatment, no storm sewers
Greenville	1,500	2,000	88	154	6	5	None	None	-	Sewers-separate, storm sewers
QUEBEC TOTAL	180,017	193,680	13,527	4,219	505	132.5				

Treatment Abbreviations

SP - Waste Stabilization Pond
EA - Extended Aeration
AS - Conventional Activated Sludge

*As reported in 1978 Ottawa River Report
**As reported in the National Inventory of Water Equipment (1981)

Table 9.3 - MAJOR INDUSTRIES DISCHARGING TO THE OTTAWA RIVER

Industry	Type	Production tons/day 1969*	1976**	1984	BOD^5 Loading Kg/day 1969*	1976**	1984	BOD^5 Target Loadings Kg/day E.C. Regs. (1)	Suspended Solids kg/day 1969*	1976**	1984	S.S. Target Loadings Kg/day E.C. Regs. (1)	Comments
ONTARIO													
E.B. Eddy Company, Ottawa	Paper Mill	180	220	163	2,540	2,270	1,660	2,270	11,430	3,630	450	2,360	Sanitary waste - separate treatment
CIP Hawkesbury	Sulphite Mill	230	260	-	102,960	170,550	-	-	4,080	3,080	-	-	Plant closed
QUEBEC													
Tembec (1973) CIP Kipawa (1969)	Sulphite Mill Dissolving Pulp	360	380	439	175,085	179,170	180,950	140,940	37,280	68,040	57,748	7,290	Partial waste liquor recovery. Suspended Solids reduction project planned for 1985.
CIP Gatineau	Sulphite (1969) Mechanical (1972)	1,500	1,600	1,548	127,910	45,810	58,950	17,928	39,370	68,040	20,100	14,940	Primary clarifer. Second sludge thickner in operation Sept. 1984.
Consol. Bath. Portage du Fort	Kraft	450	540	571	16,330	11,340	5,227	26,358	7,710	10,610	3,523	8,595	Secondary treatment system in operation. BOD^5 and SS objectives attained.
E.B. Eddy Cie Hull	Sulphite (1969) Mechanical (1972)	580	410	456	45,490	3,860	3,423	900	33,110	9,620	3,413	4,950	Primary clarifer in operation. SS objective attained in 1984.
J. McLaren Masson	Sulphite	390	380	428	22,700	21,140	12,673	20,800	11,520	9,750	9,793	9,776	Ultra high yield pulping process in operation. BOD^5 objective attained.
Cie. Thurso	Kraft	290	250	319	17,330	14,330	21,694	18,753	3,540	11,790	3,855	4,606	New sedimentation basins. BOD^5 objectives should be attained in 1985; new recovery boiler and liquor recovery system will be in operation.
TOTAL QUEBEC		3,570	3,560	3,761	404,845	275,650	282,917	225,679	132,530	177,840	98,432	50,157	
GRAND TOTAL		3,980	4,050	3,924	510,345	448,470	284,577	227,949	148,040	184,560	98,882	52,517	

* As reported in 1971 Ottawa River Report
** As reported in 1978 Ottawa River Report
1. Federal requirement calculated from 1983 average daily production totals

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