WATER QUALITY ASSESSMENT OF Salmon River

Prepared by:
L. G. Swain, P. Eng.
B.C. Ministry of Environment

Prepared for:
B.C. Ministry of Environment
and
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EXECUTIVE SUMMARY

The Salmon River at Salmon Arm is located in the southern-interior portion of the province. Its headwaters originate about 15 km northeast from Salmon Lake. Some of the river's flow is diverted into Salmon Lake; much of that flow returns to the river via McInnis Creek, the outlet from Salmon Lake. From the confluence with McInnis Creek, the Salmon River flows northeast to Falkland, then southeast and east to Glenemma, and finally north to Salmon Arm before entering Shuswap Lake. The total length and drainage area of the Salmon River are approximately 120 km and 1510 km², respectively.

The Salmon River is an important tributary of Shuswap Lake, which drains into the South Thompson River. In addition to supporting anadromous salmonids, resident fish species and other aquatic organisms, the Salmon River and its tributaries provide important sources of raw water for domestic water supplies, irrigation, and livestock watering. Recreation and aesthetics also represent important uses of the aquatic environment, both of which generate social and economic benefits to area residents.

Concerns related to environmental quality conditions in the Salmon River are primarily associated with non-point source contaminant discharges. Such contaminants arise from a variety of land use activities, including forest management, agriculture and urban development. Contaminants of concern in the watershed include suspended solids, turbidity, ammonia, phosphorus, nitrogen, metals and fecal coliforms. In addition, water withdrawals from the river and nearby infiltration galleries have resulted in decreased stream flows and associated effects on water temperatures and other habitat features in the river.

CONCLUSIONS

- Flows fluctuate throughout the year, but peak in the May-June period on a yearly basis. Low flows seem to be consistent through most of the other months of the year.
• Water temperatures and dissolved oxygen often exceed water quality objectives, especially during the hot summer periods.

• Several metals exceeded guidelines or water quality objectives on occasion; however, these seemed to be correlated with turbidity and were likely in particulate form and not biologically available. Such metals included: aluminum, cobalt, chromium, copper, iron, lead, silver, and zinc. Cadmium also often exceeded guidelines, and was not always related to turbidity, which means that it could potentially be more available to aquatic life. This has just become evident over the past couple of years since the cadmium detection limit has decreased; cadmium will continue to be monitored at these low levels to track this potential concern.

• Colour values and fecal coliforms and E. Coli often exceeded guidelines for drinking water at the source; however, these were related to turbidity events and complete treatment of the source water would be needed prior to use for drinking.

• Arsenic values may be showing a slight increase in concentration through the period of record. This may be due to a larger groundwater contribution to the flow.

• Lithium and extractable silicon were showing distinct decreases in concentrations over time.

RECOMMENDATIONS

• We recommend monitoring be continued for the Salmon River at Salmon Arm to track the possible increases in variables, and guideline exceedences that have been identified in this report.

• Either trivalent and hexavalent forms of chromium should be measured in the future, or alternately, guidelines be developed for total chromium values.

• A statistical analysis of the data for arsenic, lithium, and silicon should be conducted to confirm whether the identified trends are real.
Water quality indicators that are important for future monitoring are:

- flow, water temperature, specific conductivity, pH, turbidity, hardness, and dissolved oxygen,
- appropriate forms of metals for comparison to their respective guidelines, and
- other variables related to drinking water such as colour, fecal coliforms and E. Coli.
ACKNOWLEDGEMENTS

The graphs in this report were prepared by Sacha Wassick of Environment Canada. The draft report was reviewed by Andrea Ryan from Environment Canada. We thank these individuals for their contributions to improving this document. Any errors or omissions are the responsibility of the author.
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Introduction
The Salmon River, near Salmon Arm B.C., is located in the southern-interior portion of the province (Figure 1). Its headwaters originate in the vicinity of Tahaetkun and Bouleau Mountains, south of Westwold and northeast of Merritt. The river's headwaters are located in Monte Hills Provincial Forest, some 15 km northeast from Salmon Lake. Some of the river's flow is diverted into Salmon Lake; much of that flow returns to the river via McInnis Creek, the outlet from Salmon Lake. From the confluence with McInnis Creek, the Salmon River flows northeast to Falkland, then southeast and east to Glenemma, and finally north to Salmon Arm before entering Shuswap Lake. The total length and drainage area of the Salmon River are approximately 120 km and 1510 km², respectively.

The Salmon River is an important tributary of Shuswap Lake, which drains into the South Thompson River. In addition to supporting anadromous salmonids, resident fish species and other aquatic organisms, the Salmon River and its tributaries provide important sources of raw water for domestic water supplies, irrigation, and livestock watering. Recreation and aesthetics also represent important uses of the aquatic environment, both of which generate social and economic benefits to area residents.

Concerns related to environmental quality conditions in the Salmon River are primarily associated with non-point source contaminant discharges. Such contaminants arise from a variety of land use activities, including forest management, agriculture and urban development. Contaminants of concern in the watershed include suspended solids, turbidity, ammonia, phosphorus, nitrogen, metals and fecal coliforms. In addition, water withdrawals from the river and nearby infiltration galleries have resulted in decreased stream flows and associated effects on water temperatures and other habitat features in the river.
This report discusses water quality data collected by the provincial and federal governments between 1985 and 2004 from a station on Salmon River near its mouth at Salmon Arm. Data for the Salmon River at Salmon Arm have been collected on a frequency of about once every two weeks. As well, twice per year, two additional samples are collected in order to ensure that there are two periods when weekly samples are collected during five consecutive weeks. In addition, quality assurance samples (blanks and replicates) are collected six times per year.
The state of the water quality was assessed by comparing the values to B.C.'s approved and working guidelines for water quality (B.C. Ministry of Environment, Lands and Parks, 2001), and by looking for any obvious trends in the data. Any levels or apparent trends that were found to be deleterious or potentially deleterious to sensitive water uses, including drinking water, aquatic life, wildlife, recreation, irrigation, and livestock watering were noted in the following variable-by-variable discussion.
The following water quality indicators are not discussed as they met all water quality guidelines and showed no clearly visible trends: phenolphthalein alkalinity, ammonia, barium, bromide, nitrite, total nitrogen, fixed non-filterable residue, fixed filterable residue, non-filterable residue, extractable silicon, and tin.

The following water quality indicators seemed to fluctuate through the year according to turbidity concentrations, but were below guideline values and had no other trends: antimony, beryllium, bismuth, dissolved organic carbon, gallium, lanthanum, manganese, nickel, total phosphorus, rubidium, thallium, and vanadium.

Other water quality indicators seemed to fluctuate through the year according to the specific conductivity of the water. For dissolved forms of many of these indicators, they would be a part of the measured conductivity, and this is to be expected. These types of indicators that were not measured above guideline values included: alkalinity, ammonia, boron, dissolved inorganic carbon, calcium, chloride, potassium, magnesium, molybdenum, nitrate, total dissolved nitrogen, pH, sodium, hardness, strontium, sulphate, and uranium.

**Flows** (Figure 2): fluctuate throughout the year, but peak in the May-June period on a yearly basis. Mean flows throughout the year are about 2 m$^3$/s; although mean peak flows are about 20 m$^3$/s. Absolute peak flows have been as high as 60 m$^3$/s.

**Aluminum** (Figure 3): values exceed the drinking water guideline; however, values have fluctuated with turbidity, are likely in particulate form, and not biologically available. There does not appear to be any trend in values during the period of record.

**Arsenic** (Figure 8): values have been below guidelines but seem to be increasing in value during the period of record. When we used a linear regression, we found that there was a weak correlation of values increasing through time ($R^2 = 0.05$). Total arsenic values also seem to increase with turbidity, meaning that higher values are likely in particulate form and not biologically available.
Cadmium (Figures 18 and 19): values seemed to fluctuate with turbidity, which means that higher values would be associated with particulate matter and would likely not be biologically available. Although values seem to be getting lower through the period of record, this is likely more a phenomenon related to decreasing detection limits and improved analytical capabilities through time, rather than a real decrease in concentration. Lower cadmium values, and their detection limits, during the 2003-2004 period also coincided with lower turbidity concentrations. Additional data need to be collected to determine whether turbidity and cadmium are in fact beginning to decline.

Cyanide (Figure 21): values generally were well below the maximum and 30-day average guidelines for weak-acid dissociable cyanide. One exception was a total cyanide value in October 2004. Since data for only one year have been collected, additional sampling is required before any trends might become evident.

Cobalt (Figure 22): values seemed to be correlated with turbidity, which means that higher cobalt values are associated with particulate matter and not likely biologically available. The occasional individual value has exceeded the BC guideline of 4 µg/L for the 30-day mean concentration; however, all individual values were well below the guideline for maximum concentrations of 110 µg/L. Lower cobalt values in 2003-2004 coincided with lower turbidity concentrations. Additional data need to be collected to determine whether turbidity and cobalt are in fact beginning to decline.

Colour: apparent colour (Figure 23) values from 1988 until 1998 seemed to fluctuate with turbidity and regularly exceeded the drinking water guideline of 15 TCU for true colour; however, this is to be expected since true colour is measured on a filtered sample (i.e., turbidity removed). True colour values (Figure 24) began to be measured in 1997 and were lower than apparent colour values, as expected; however, values seem to fluctuate with turbidity and regularly exceeded the drinking water guideline.

Chromium (Figure 25): values in the 1990’s exceeded the guideline for trivalent chromium and hexavalent chromium; however, since the year 2000, only the guideline for hexavalent chromium has been exceeded. Values seem to fluctuate with turbidity
values, meaning that the higher chromium values are likely in particulate form and not biologically available. There is a very weak trend identified using a linear regression ($R^2 = 0.017$) of decreasing concentrations through time; however, this is likely related to lower turbidity concentrations in the post-2000 period. We recommend that either trivalent and hexavalent forms of chromium be measured in the future or guidelines be developed for total chromium values.

**Copper** (Figures 26 and 27): values generally met the guidelines (hardness-dependent) for maximum and 30-day mean concentrations; however, when these were exceeded, turbidity values were also high. This means that the higher copper values are in particulate form and not likely biologically available. Higher values in the late 1980’s were quite high due to widespread contamination because of the failure of preservative vial cap liners between 1986 and 1991.

**E. Coli** (Figure 28) and **Fecal Coliforms** (Figure 31): regularly exceeded the water quality guideline and short and long-term water quality objectives, respectively, for drinking water sources. High fecal coliforms seem to be correlated with high turbidity concentrations. Drinking water taken from the Salmon River would require complete treatment.

**Fluoride** (Figure 29): values were measured only between 1988 and 1999. Values generally met the aquatic life guideline of 0.3 µg/L. High fluoride values coincided with periods of high specific conductivity and low river flows, suggesting that the fluoride was a result of groundwater contributions to the base flow of the river.

**Iron** (Figure 30): values regularly exceeded the guideline for the protection of aquatic life and drinking water supplies (aesthetics) of 300 µg/L. High iron values were correlated with high turbidity concentrations, meaning that the iron was in particulate form and not biologically available. It would also be removed in water treatment processes for drinking water supplies. Peak iron values since 2000 seem to be lower than during the previous decade; however, these lower values are likely the result of lower turbidity values during that period.
**Hardness** (Figure 33): values were strongly correlated with specific conductivity and low river flows, suggesting that the hardness was a result of groundwater contributions to the base flow of the river. Values throughout the year were generally higher than the 100 mg/L level for drinking water supplies.

**Lead** (Figure 36): values seem to correlate with turbidity, meaning that high lead values are in particulate form and not likely biologically available. Values were generally below all guidelines for aquatic life and drinking water supplies, with only two individual values exceeding the lowest BC 30-day mean guideline of 4.5 µg/L. Analytical detection limits for lead were reduced in 2003 from the 0.2 µg/L level, which means that in future years, trends to lower values might be suspected; however, the lower detection limits may be responsible for such observations.

**Lithium** (Figure 37): values have shown a strong decline during the period of record ($R^2 = 0.31$) but have always been below the BC guideline to protect aquatic life of 67 µg/L. Values also seem to be correlated with high specific conductivity and low flows, meaning that the lower values are likely associated with a groundwater contribution to base river flow.

**Dissolved Oxygen** (Figure 48): values seem to fluctuate with conductivity, which is not surprising in that conductivity peaks occur when there are low flows in the colder months of the year, and under normal situations, dissolved oxygen concentrations rise at colder temperatures. Only one value was slightly below the 8 mg/L water quality objective.

**Selenium** (Figure 56): values on occasion exceeded the guideline to protect aquatic life of 1 µg/L. Selenium values seemed to be correlated with specific conductivity with highest values occurring during low flow conditions.

**Silica and Silicon** (Figure 58): Values for extractable silicon have decreased considerably over the period from 1999 until 2002, with a linear regression having a $R^2$ value of 0.23.
Silver (Figures 59 and 60): values on occasion exceeded the BC aquatic life guideline of 0.1 µg/L, but this usually happened when detection limits were at that level. The detection limit for silver was reduced to 0.001 µg/L in early 2003, and no values have exceeded the guideline since that time. Data from that latter period seem to fluctuate with turbidity concentrations, meaning that the higher silver values are related to particulate and not likely biologically available.

Water Temperature (Figure 65): varies with flow and the time of year. Temperatures have exceeded objective levels especially during the hot summer periods.

Zinc (Figures 71 and 72): values fluctuate with turbidity, which means that high values are associated with particulate matter and not likely biologically available. Occasional values exceed aquatic life guidelines that are hardness-dependent.
REFERENCES


Salmon River at Hwy 1 Bridge
Aluminum Total (ug/L)
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CCME Al AW Guideline Max-5 ug/L
pH<6.5, Ca<4mg/L, DOC<2mg/L

Al Total
CCME Al AW/DW Guideline Max-100 ug/L
pH>6.5, Ca>4mg/L, DOC>2mg/L
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BC Max AW Guideline - 5.3 ug/L
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CCME/BC Max DW guideline - 5 ug/L
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- BC Max Cl AW Guideline - 600 mg/L
- BC Max Cl DW Guideline - 250 mg/L
- BC 30 Day AW Guideline - 150 mg/L
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BC Max DW Guideline - 500 ug/L
Salmon River at Hwy 1 Bridge
Copper Total (ug/L)
Figure 27

- BC Max DW Guideline - 500 ug/L
- CCME AW Guideline range 2 - 61.1 ug/L
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Salmon River at Hwy 1 Bridge
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- BC 30 Day DW Guideline - 1 mg/L
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- BC Max DW Guideline 50 ug/L
- BC Max AW Guideline Range 30.11-291.83 ug/L
- CCME Max AW Guideline range 1.2 - 11.4 ug/L
- BC 30 Day AW Guideline range 4.5 - 14.7 ug/L
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Canada – British Columbia Water Quality Monitoring Agreement
Salmon River at Hwy 1 Bridge
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Outlier Removed at: 03/10/1990 9:00 - 2.04 ug/L
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BC Max AW Mn Guideline range 1043.39-3537.44 ug/L
3BC 30 Day Aw Mn Guideline range 805.99-1801.8 ug/L
Salmon River at Hwy 1 Bridge
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- BC Max DW Guideline 250 ug/L
- BC Max AW Guideline 2000 ug/L
- 30-Day-BC AW Guideline 1000 ug/L
- CCME Max AW Guideline 73 ug/L
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- BC Max NO2 and NO3 DW Guideline 1 mg/L
- BC Max NO3 AW Guideline 200 mg/L
- BC Max NO 3 DW Guideline 10 mg/L
- 30-Day-BC NO3 AW Guideline 40 mg/L
- CCME Max NO3 DW Guideline 45 mg/L
- CCME Max NO3 AW Guideline 13 mg/L
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Figure 43
Salmon River at Hwy 1 Bridge
Nitrogen Nitrite (mg/L)
Figure 44

- BC Max NO2 and NO3 DW Guideline 1 mg/L
- CCME Max NO2 AW Guideline 0.06 mg/L
Salmon River at Hwy 1 Bridge
Nitrogen Total Dissolved (mg/L)
Figure 45
Salmon River at Hwy 1 Bridge
Nitrogen Total (mg/L)
Figure 46
Salmon River at Hwy 1 Bridge
Nickel Total (ug/L)
Figure 47

BC/CCME AW Ni Guideline Range 52.69-204.47 ug/L
Salmon River at Hwy 1 Bridge
Oxygen Dissolved (mg/L)
Figure 48

The minimum level of O₂ that should be maintained for all fish life stages:
- BC Max Long-term minimum
- BC Max O₂ Min Guideline
- BC Max Short-term Minimum
- 30-Day-BC O₂ AW Guideline

The minimum level of O₂ that should be maintained for all fish life stages:
- 30-Day-BC Objective - Greater than or equal to 8 mg/L Short-term
- BC-30-Day Objective - Greater than or equal to 11 mg/L Long-term
Salmon River at Hwy 1 Bridge
Phosphorus Total Dissolved (mg/L)
Figure 49

BC Max P Total DW Guideline - 10 ug/L
Salmon River at Hwy 1 Bridge
Total Phosphorus (mg/L)

Figure 50

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Salmon River at Hwy 1 Bridge
pH (relative units)
Figure 51
Salmon River at Hwy 1 Bridge
Rubidium Total (ug/L)
Figure 52
Salmon River at Hwy 1 Bridge
Residue Fixed Filterable (mg/L)
Figure 53
Salmon River at Hwy 1 Bridge
Residue Fixed Non-Filterable (mg/L)
Figure 54
Salmon River at Hwy 1 Bridge
Residue Non-Filterable (mg/L)
Figure 55
Salmon River at Hwy 1 Bridge
Selenium Total (ug/L)
Figure 56

- Se Total
- Se Extractable
- CCME Se AW Guideline
- BC Max/30-Day-BC AW Guideline
- BC/CCME Max Se DW Guideline - 10ug/L

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Salmon River at Hwy 1 Bridge
Silicon Extractable (mg/L)
Figure 57
Salmon River at Hwy 1 Bridge
Silica Dissolved and Reactive (mg/L)
Figure 58
Salmon River at Hwy 1 Bridge
Silver Total (ug/L)
Figure 59

Outlier Removed at: 30/04/1998 12:01 - 75.7 ug/L

BC Max AW Guideline range 0.1 - 3 ug/L

30 Day AW Guideline range 0.05 - 1.5 ug/L

Data point not shown on 7/10/90 -10ug/L
Salmon River at Hwy 1 Bridge
Silver Total (ug/L)
Figure 60

Silver Total
CCME Max AW Guideline
Turbidity (NTU)

BC Max AW Guideline range 0.1 - 3 ug/L
30 Day AW Guideline range 0.05 - 1.5 ug/L
Salmon River at Hwy 1 Bridge
Sodium Dissolved and Extractable (mg/L)
Figure 61
Salmon River at Hwy 1 Bridge
Specific Conductance (uS/cm)
Figure 62
Salmon River at Hwy 1 Bridge
Strontium Total (ug/L)
Figure 63
Salmon River at Hwy 1 Bridge
Sulphate Dissolved (mg/L)
Figure 64

- BC Max DW Sulphate Guideline - 500 mg/L
- BC Max AW Sulphate Guideline - 100 mg/L
Salmon River at Hwy 1 Bridge
Temperature Air and Water (deg C)
Figure 65

Air Temperature
Water Temperature
Max Objective
(Dec. 1 to Sept. 1)
Max Objective
(Oct. 1 to Nov. 30)
30-Day Objective
less than or equal to 14.2 all year
Salmon River at Hwy 1 Bridge
Tin Total (µg/L)
Figure 66
Salmon River at Hwy 1 Bridge
Thallium Total (ug/L)
Figure 67

Data point not shown at 9/15/93 - 0.5 ug/L
Salmon River at Hwy 1 Bridge
Turbidity (uS/cm)

Figure 68
Salmon River at Hwy 1 Bridge
Uranium Total (ug/L)
Figure 69

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Salmon River at Hwy 1 Bridge
Vanadium Total (ug/L)
Figure 70
Salmon River at Hwy 1 Bridge
Zinc Total (ug/L)
Figure 71

BC Max DW Guideline 5000 ug/L
Salmon River at Hwy 1 Bridge
Zinc Total (ug/L)
Figure 72

- BC Max DW Guideline 5000 ug/L
- BC Max AW Guideline Range 33-169.5 ug/L
- 30-Day-BC AW Guideline Range 7.5-144 ug/L