

RECONNAISSANCE OF WATER QUALITY CONDITIONS IN THE UPPER BRIDGE
RIVER SYSTEM AND SUGGESTIONS FOR MONITORING POTENTIAL EFFECTS
OF FORESTRY ACTIVITIES IN THE GUN LAKE WATERSHED

T.G. Northcote

Professor Emeritus

The University of British Columbia

Vancouver, Canada

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INTRODUCTION

Between 26 - 29 September 2003, on a Wells Gray Tour, I had the opportunity to evaluate visually the aquatic habitat and water quality conditions in several lakes and a few streams and rivers of the upper Bridge River system in southern-central British Columbia (Fig.1), and also to collect a few water samples for analysis.

The effects of human activities on aquatic habitat and water quality in the upper Bridge River system date back to the second half of the 19th century with mining exploration and development, followed in the mid 20th century by large-scale hydro-electric development, and more recently by forestry activities. The latter have the potential of affecting water quality conditions in several remarkably clear and recreationally important waters such as Gun and Tyaughton lakes, as of course do extensive shoreline cottage and house development.

The purpose of this report is to record and comment on the few observations and measurements of water quality conditions in the upper Bridge River system, to suggest where and when other such measurements should be made, and to indicate what parameters should be included especially with reference to tracking potential effects from the various activities of forestry. This now seems to be an issue of considerable concern to some of the populace, especially those in the Gun Lake area (pers. comm. N. Ashmore).

BACKGROUND AND METHODS

I have taught courses focused on inland water quality conditions (limnology) in the Department of Zoology, UBC, from 1958 to 1992, and also courses on fish–forestry interaction and water quality in the Department of Forest Sciences, UBC, from 1972 to 1992. In addition I have reviewed and conducted research on the multiple effects of human development on inland waters not only in B.C., but in other regions of Canada, USA, parts of Central and South America, as well as in Europe, Scandinavia, New Zealand and Australia.

Observations of past and present human activities on water drainages in the upper Bridge River were made by road travel and an aircraft flight. Where possible water samples were collected in clean, well rinsed 500 ml drinking-water plastic bottles. These were stored under cool conditions 27-29 September and refrigerated overnight 29-30 September before analysis started on 30 September. The samples were gradually warmed to about 20°C for spectrophotometric analyses, and to 25°C for pH and total dissolved solids analyses.

WATER QUALITY

1. Turbidity

As is well known, and evidenced by my turbidity reading of zero (Table 1), Gun Lake has extremely clear water, at present. I will say a little more about this later in relation to a separate measure - transparency - which can easily be made by an offshore method that I will describe. Tyaughton shoreline water is also fairly clear with a turbidity reading of one. Not surprisingly, the water in Bridge Glacier Lake at the uppermost end of the system and heavily laden with glacial flour, has a very high turbidity reading (158 units). Further down in the system with some settling out of glacial flour in the two reservoirs and with the additions of some clear tributary water, turbidity has dropped down to nine units. Most certainly the productivity of Downton and Carpenter reservoirs will be greatly reduced by their high turbidity, restricting light penetration to a very few metres at most.

2. Colour

The standard measure of the amount of brown-staining dissolved organic materials in water, mainly lignins and tannins common in bog and some marsh waters, used to be made visually by comparison of a graded series of platinum-cobalt solutions in clear glass Nessler tubes. Now it usually is done spectrophotometrically at a wave length of 455 nanometres (one thousand millionth of a metre), as I did. Again, as one would expect, Gun Lake water has virtually no brown staining (3.5 units), and Tyaughton Lake water has only slightly more (Table 1). Upper Bridge River water contains more brown staining materials (39 units), but still is low compared with some Queen Charlotte Island waters that I have measured (200 to 400 units). A reading for a lake on Chatham Island of offshore New Zealand I collected last February was over 3000 units and looked like very strong tea! Brown stains of inland waters differentially affect sunlight penetration and thereby productivity.

3. Conductivity.

The electrical conductivity of water provides an indirect measure of its total dissolved mineral content which by using an appropriate conversion factor (usually in the 0.4 to 0.6 range) gives an estimate of total dissolved solids (TDS). As would be expected, coming directly from Bridge glacial ice, the water in Bridge Glacier Lake is very low in conductivity and TDS - just over 18 μ mhos and 9.2 mg/L respectively. Further downstream Bridge River water has risen to over 40 mg/L TDS. Gun Lake water is nearly double that, with Tyaughton Lake nearly double again. Years ago I studied TDS differences, among other things, in lake waters over much of B.C. and showed that their basic biological productivity could be roughly estimated by this parameter (Northcote and Larkin 1956, Northcote and Larkin 1963).

4. Phosphate and nitrate

These are two key parameters for most biological growth, in soils as any gardener will confirm, and also in lakes, streams and rivers. However late summer is not the best time to measure them for prediction of biotic growth in the waters as these chemicals largely have been taken up in algal, invertebrate, and fish growth in aquatic ecosystems. They should be measured in late winter or early spring when they are circulating usually at their highest seasonal values.

The concentration of dissolved reactive phosphate (as P) in Gun and Tyaughton lakes is at the lowest detectable limit of my normal spectrophotometric technique (10 micrograms per litre, Table 1). Concentrations of both dissolved phosphate and nitrate are higher in Bridge River water downstream, as might be expected - in part probably coming from the partially decayed pink salmon carcasses that abounded there. Dissolved phosphate in Bridge Glacier Lake is highest of the four waters tested, but lowest in dissolved nitrate. The high phosphate value is surprising. I suspect that the fine glacial flour that I was unable to filter out may have interfered with phosphate analysis, giving an erroneously high value.

5. Silica (as silicate SiO_2)

This is another of the essential elements for production in lakes and flowing waters. It is assimilated by diatoms (an algal group whose cell walls are composed mainly of silica) and a few other algal groups. The levels evident in Gun and Tyaughton lakes are typical for hardwater lakes in early autumn (Wetzel 2001), whereas those in Bridge Glacier Lake and in Bridge River are low (Table 1).

6. Sulphur (as sulphate SO_4)

The levels recorded in Gun and Tyaughton lakes and in the Bridge River are all close to the average value given by Wetzel (2001) for oxygenated natural waters (range 5 - 30 mg/L). Sulphur is important in the synthesis of proteins by aquatic plants and animals. Sulphate is released during the weathering of rocks and soils. For example pyrite (FeS_2) with the action of oxygen and water forms iron sulphate and sulphuric acid.

7. Minor elements (micronutrients)

Of some nine minor elements, nearly all required for nutrition of plants and many animals (Wetzel 2001), I was able to determine concentrations of three - copper, iron, and manganese in upper Bridge River waters. Copper is required in electron transport during respiration and photosynthesis, as is iron, also important in enzyme activation as well as an oxygen carrier in nitrogen fixation. Manganese also is used in enzyme activation, in electron transport reactions especially for photosynthesis, and in cellular ribosome structure (the sites for protein synthesis in the cytoplasm).

The concentrations of copper, iron, and manganese in the waters I tested are mostly within the range of world lake and river averages given by Livingstone (1963) for these three elements - 10, 40 and 35 µg/L respectively, and those for a series of lakes by Wetzel (2001; Table 14-4). The rather high concentration of iron in Bridge Glacier Lake again may be a result of glacial flour interference in the analysis.

ADDITIONAL WORK ON WATER QUALITY CONDITIONS

1. Review of relevant previous studies

According to Balkwill (1991), water quality and related information is available for Anderson, Gun (Big), Gwyneth, Mowson Pond, Pearson Pond, and Tyaughton lakes. This should include some or all of the following parameters : a sounding map showing depth contours, vertical temperature and dissolved oxygen profiles, water transparency (Secchi disc readings), total dissolved solids (TDS) content, and fish data. For the 1960s or early 1970s Balkwill (1991) records TDS for the following: Anderson 91, Gwyneth 52, Gun 113, Mowson Pond 261, Pearson Pond 282, Seton 82, and Tyaughton 215 mg/L. Other parameters noted above should be available from Region 3 Fish and Wildlife Office, 1259 Dalhousie Drive, Kamloops, B.C., V2C 5Z5; tel (250) 371 6200; contact Ian McGregor and/or Brian Chan.

Some water quality data are listed for Seton Lake by Perrin and Blyth (1998) along with general comments about conditions in lakes of the southern central interior. Studies were

made in the 1990s to examine possible heavy metal uptake in serpentine rich areas of the Yalakom River watershed, specifically for Serpentine and Burkholder lakes, but results of this work by Drs. Schreier, Hall, Northcote and Ballard from UBC are still unpublished.

2. Collection of key information to monitor potential effects of future forestry activity in the Gun Lake watershed

(a) An appropriate scale map of the Gun Lake watershed

The 1: 50,000 scale map of the upper Bridge River valley produced by Aestech Consulting Inc. doesn't give elevation contours to permit accurate definition of the Gun Lake watershed. This should be done using at least a 1: 50,000 scale map with elevation contours shown, and preferably from a B.C. Forest Service map at 1: 20,000 scale with elevation contours, probably available in Lillooet or Kamloops Forestry offices. As I see it from the Aestech map, the Gun Lake watershed will include Alder and Pencosa creeks draining into Little Gun Lake and thereby via its outlet creek into the southwestern end of Gun Lake. Also included will be the two forks of an unnamed creek (on that map) draining into the middle of the northwestern side of Gun Lake, as well as Summer Creek about a kilometre further northeast. No creeks are shown along the southwestern side of Gun Lake but certainly some runoff will occur into the lake from the northwestern flanks of Mt. Zola. I would be prepared to work out the total drainage basin of Gun Lake, along with its major sub-basins using polar planimetry if a suitable scale map as indicated above could be provided. It also would be helpful to have the Forest Service show on such a map the areas and dates where logging roads and logging activity may already have been carried out, and also those which may be planned for the near future. There appears to be only one main line forestry road shown on the Aestech map, that up Slim Creek which would cross the northeastern portion of the Gun Lake watershed, but other branches or other forestry roads now may be present. Main road arteries and drainage culverting crossing subwatersheds also should be shown on the Gun Lake watershed map. These often cause fish passage or even total blockage problems, as well as back up sources of sediments and other materials.

(c) Design and conduction of a water quality monitoring programme on key tributaries to Gun Lake

Once the work outlined in (a) above is completed, it will be necessary to set up as soon as possible a series of tributary water quality sampling stations. I would be prepared to help in this and to carry out essential water quality analyses and their interpretation. Be assured that forestry companies, knowing that such work is being carried out, will be more likely to take special care in road construction, maintenance, and deactivation, as well as in the logging activities themselves.

(d) Shoreline and mid- Gun Lake water quality monitoring

At least a couple of near-surface shoreline and mid-lake stations should be set up. Monitoring should be done three times a year - once in early spring after ice-out and the lake enters into full vernal circulation, once in mid-summer, and once in mid to late autumn. In addition to some of the parameters shown in Table 1 for surface waters, water transparency measurements should be made at each of the mid-lake stations for the seasons indicated. This could be done in a few minutes from a boat using a standard Secchi disc (easily constructed locally, or available from me on loan with instructions for use).

(e) Water quality changes via forestry activities

Some of the parameters most likely to change quickly and noticeably as a result of the various activities associated with forestry are water temperature, suspended sediment load (turbidity), conductivity, total dissolved solids, nitrate and phosphate concentrations, and lake water transparency (Secchi disc depth readings). Several of these could be measured locally and others I should be able to help with.

(f) Community involvement and advice

I would be pleased to meet with the Gun Lake community to discuss the above suggestions and give advice as possible. Gun Lake is surely one of the most beautiful inland waters that I have seen and it would be a delight to visit it again when possible.

REFERENCES

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Fig. 1. Sketch map of the Bridge River system entering the Fraser River about 6 km north of Lillooet, B.C. Drawn and slightly reduced from the Lillooet map 78, *Canada Gazetteer Atlas*, Macmillan of Canada 1980. Lakes and reservoirs stippled, major glaciers and ice-fields in broken lines. Only those tributaries entering the Bridge River and Anderson-Seton systems are shown.

Table 1. Near-shore (5 cm depth) water quality conditions in three lakes and one river of the upper Bridge river system, British Columbia, September 2003.

Lake / river	Date / time	Turbidity FTU ^a	Colour Pt-Co ^b	Conductivity μ S per cm ^c	TDS ^d	PO4 - P μ g/L ^e	NO3 - N μ g/L ^f	Silicate mg/L	Sulphate mg/L	Copper μ g/L	Iron (total) μ g/L	Manganese μ g/L
Gun ^g	27 Sept. 14:30 h	0	3.5	154.8	79.2	10	40	5.96	14	10	10	50
Tyughton ^h	27 Sept. 15:15 h	1.0	5.5	310.0	150.5	10	50	6.49	16	70	10	10
Bridge R. ⁱ Glacier	28 Sept. 14:00 h	158.0	k	18.4	9.2	40	10	1.27	k	10	220	40
Bridge R. ^j	29 Sept. 10:15 h	9.0	39.0	88.5	44.2	25	70	4.42	10	20	30	30

^aforamazin standard turbidity units

^bplatinum-cobalt units

^c μ mhos/cm @ 25°C

^dTotal Dissolved Solids @ 25°C

^edissolved reactive phosphate expressed in micrograms of P per litre

^fdissolved nitrate expressed in micrograms of N per litre

^gin front of Norah Ashmore's cabin, northerly shore of Gun Lake

^hat Tyax Lodge boat dock

ⁱat Tyax Air Services dock, Bridge Glacier Lake

^jBridge River edge below Lillooet road near Russell Spring

^khigh glacial flour content probably interfered with analysis

