Water Quality Branch

Water Quality Assessment And Objectives For The Nechako River

Overview Report

Ministry Of Environment And Parks

Prepared Pursuant To Section 2(E) Of The
Environment Management Act, 1981

Original Signed By Ben Marr
Deputy Minister
January 20, 1987

Canadian Cataloguing in Publication Data
Swain, L. G. (Leslie Grant), 1950-
Takla-Nechako area, Nechako River water quality assessment and objectives

[Vol. 2] constitutes technical appendix
ISBN 0-7726-1752-x

1. Water quality - British Columbia - Nechako River Watershed.
I. Girard, R. II. BC Environment. Water Management Division.
III. Title

TD227.F7S845 1993 363.73'942'0971182 C93-092126-7

Ministry of Environment & Climate Change Strategy
Water Protection and Sustainability Branch
Environmental Sustainability and Strategic Policy Division
Mailing Address:
PO Box 9362
Stn Prov Govt
Victoria BC V8W 9M2
Telephone: 250 387-9481
Facsimile: 250 356-1202
Website: www.gov.bc.ca/water

FIGURES
FIGURE 1. Nechako River Basin Map

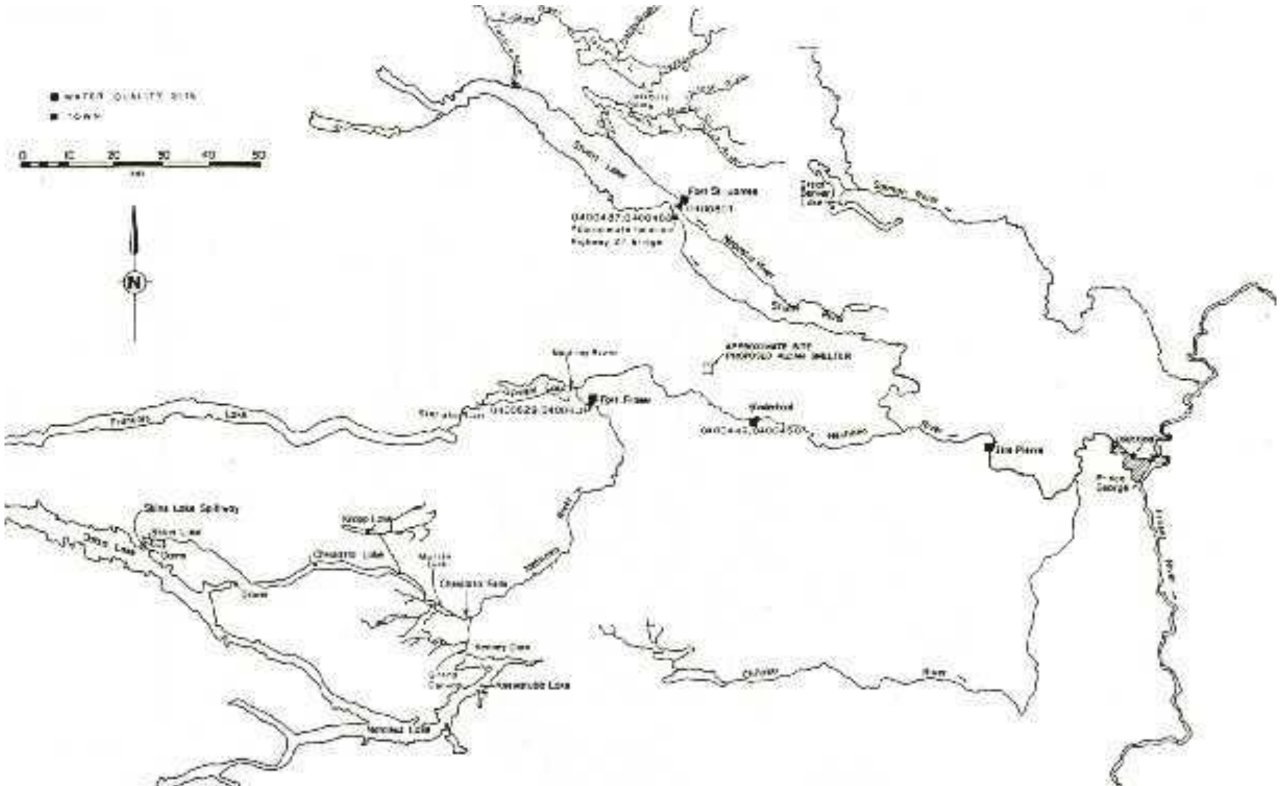
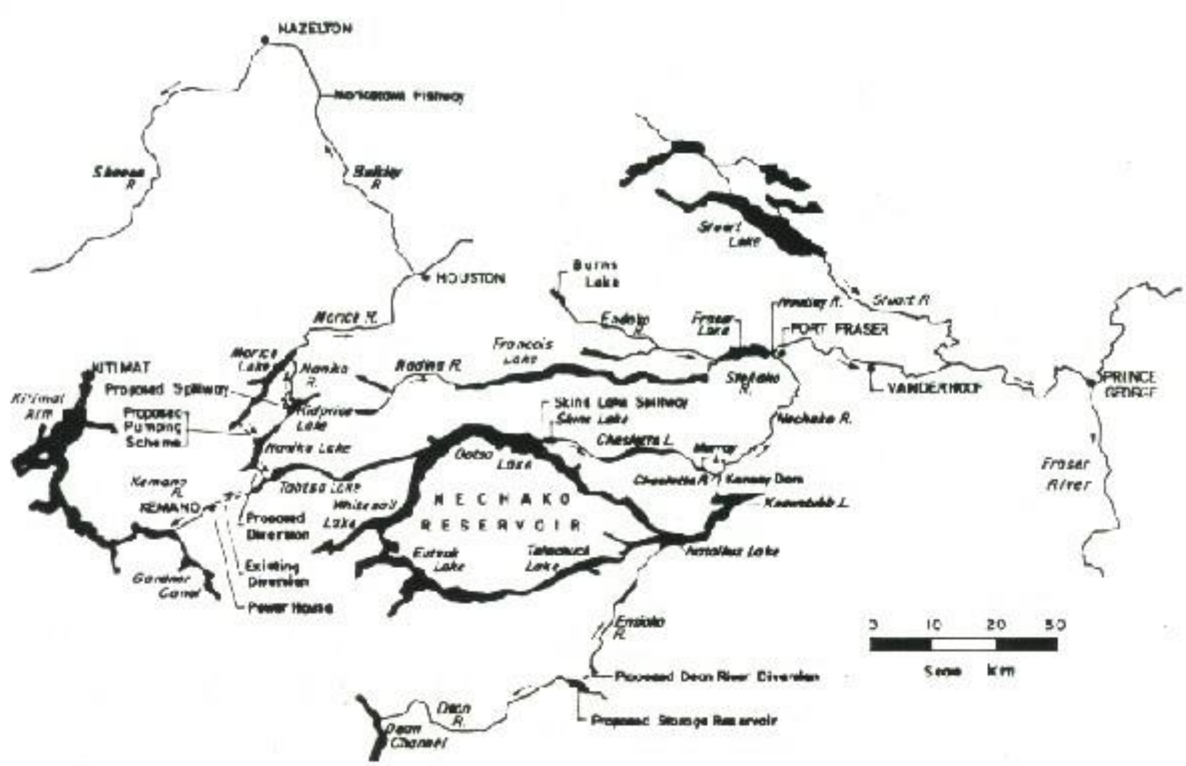


FIGURE I
NECHAKO RIVER BASIN

FIGURE 2. Nechako River Reservoir Map (post Kenney Dam)



PREFACE

Purpose of Water Quality Objectives

Water quality objectives are prepared for specific bodies of fresh, estuarine and coastal marine surface waters of British Columbia as part of the Ministry of Environment, Lands and Parks' mandate to manage water quality. Objectives are prepared only for those waterbodies and water quality characteristics that may be affected by human activity now or in the near future.

How Objectives Are Determined

Water quality objectives are based the BC approved and working criteria as well as national water quality guidelines. Water quality criteria and guidelines are safe limits of the physical, chemical, or biological characteristics of water, biota (plant and animal life) or sediment which protect water use. Objectives are established in British Columbia for waterbodies on a site-specific basis. They are derived from the criteria by considering local water quality, water uses, water movement, waste discharges, and socio-economic factors.

Water quality objectives are set to protect the most sensitive designated water use at a specific location. A designated water use is one that is protected in a given location and is one of the following:

- raw drinking water, public water supply, and food processing
- aquatic life and wildlife
- agriculture (livestock watering and irrigation)
- recreation and aesthetics
- industrial water supplies.

Each objective for a location may be based on the protection of a different water use, depending on the uses that are most sensitive to the physical, chemical or biological characteristics affecting that waterbody.

How Objectives Are Used

Water quality objectives routinely provide policy direction for resource managers for the protection of water uses in specific waterbodies. Objectives guide the evaluation of water quality, the issuing of permits, licences and orders, and the management of fisheries and the province's land base. They also provide a reference against which the state of water quality in a particular waterbody can be checked, and help to determine whether basin-wide water quality studies should be initiated.

Water quality objectives are also a standard for assessing the Ministry's performance in protecting water uses. While water quality objectives have no legal standing and are not directly enforced, these objectives become legally enforceable when included as a requirement of a permit, licence, order, or regulation, such as the Forest Practices Code Act, Water Act regulations or Waste Management Act regulations.

Objectives and Monitoring

Water quality objectives are established to protect all uses which may take place in a waterbody. Monitoring (sometimes called sampling) is undertaken to determine if all the designated water uses are being protected. The monitoring usually takes place at a critical time when a water quality specialist has determined that the water quality objectives may not be met. It is assumed that if all designated water uses are protected at the critical time, then they also will be protected at other times when the threat is less.

The monitoring usually takes place during a five week period, which allows the specialists to measure the worst, as well as the average condition in the water.

For some waterbodies, the monitoring period and frequency may vary, depending upon the nature of the problem, severity of threats to designated water uses, and the way the objectives are expressed (*i.e.*, mean value, maximum value).

INTRODUCTION

The water quality of the Nechako River and some of its tributaries (Figure 1) in the Takla-Nechako area was assessed by examining water quality data collected to about December 1983. This assessment was begun because of a proposal by Alcan to proceed with the Kemano Completion project. Although Alcan's proposal was subsequently postponed for an indefinite period the water quality assessment was completed so that water quality objectives would be in place. A detailed technical appendix was prepared and forms the basis for the conclusions presented here.

The Nechako River is one of the major tributaries to the Fraser River which it joins at Prince George. It originates from a former chain of lakes, now known as the Nechako Reservoir (Figure 2.), which drain an area of about 14,000 km^2 west of Prince George.

Before 1950, the Nechako River was formed by water draining eastwards from two sets of lakes. One set comprised Skins Lake which flowed into Cheslatta Lake then into Murray Lake and finally into the Nechako River at Cheslatta Falls. The second set originated from Knewstubb Lake as the combined flow from Ootsa, Entiako and Eutsuk Lake drainages, and after passing through the Grand Canyon of the Nechako was joined at Cheslatta Falls by water from the first set of lakes.

Since 1950, the larger lakes have been used as a storage reservoir for hydroelectric power. The power is generated at Kemano aout 240 km west from Cheslatta Falls, and is transmitted to Alcan's aluminum plant at Kitimat. To form the reservoir, the Kenney Dam was completed in 1952 at what became the outlet to Knewstubb Lake. The dam eliminated previous flows into the Nechako River at this point and backed water westward via Knewstubb and Natalkuz Lakes into Ootsa Lake. Excess water not required for power generation is released from Ootsa Lake into Skins Lake via the Skins Lake Spillway. The overflow travels via Cheslatta and Murray Lakes to the Nechako River.

Downstream from Cheslatta Falls the Nechako River flows in a north-easterly direction to Fort Fraser. Here it is joined by the Nautley River, a short river draining Francois Lake and Fraser lake from the west. The Nechako River then flows east past Vanderhoof and Isle Pierre into the Fraser River at Prince George. Major tributaries in this reach are the Stuart River which drain Stuart Lake from the north and the Chilako River which enters from the south near Prince George.

Kemano completion was a proposed Alcan project (Figure 2.) designed to increase hydroelectric power generated at Kemano while increasing aluminum smelting capacity at other new sites. It involved increasing the water supply to the Nechako Reservoir by diverting water from the Nanika River system which presently drains northward via the Morice River to the Bulkley River, and by decreasing the discharge to the Nechako River. It was contemplated that the flow and temperature of water entering the Nechako River would be controlled by building a dam at the outlet of Murray Lake and a cold water release structure at the Kenney Dam. This latter structure would once again allow water to flow from Knewstubb Lake into the Nechako River.

HYDROLOGY

The Nechako River has a drainage area of over 46,000 km^2. The average 7-day low flow (10-year return period) in the Nechako River at Fort Fraser is 23.1 m^3/s and increases to 55 m^3/s at Isle Pierre. These are regulated flows based on the 1978 to 1983 period. Should Alcan's proposed Kemano Completion project proceed the 7-day low flow (10-year return period) in the Nechako River at Isle Pierre would be about 45 m^3/s. This flow is based upon a low flow of 14.2 m^3/s at Cheslatta Falls (31%), 4.9 m^3/s from the Nautley River (11%) and 26.4 m^3/s from the Stuart River (58%).

Between 1980 and 1985 flows in the Nechako River were governed by a BC Supreme Court injunction which required certain minimum flows to protect spawning sockeye salmon passing through the Nechako River. These minimum flows could vary depending upon the year.

The Stuart River has a drainage area of over 15,000 km^2. The 7-day low flow (10-year return period) in the Stuart River has been about 26.4 m^3/s which is about 50% of the regulated post-Kemano 7-day low flow in the Nechako River at Vanderhoof. Should Alcan's proposed Kemano Completion project proceed or should Nechako River flows at Cheslatta Falls be reduced for some other reason, the flow contribution from the Stuart RIver (58%) will become more important in determining Nechako Riover water quality downstream from the Stuart River.

The Nautley River drains 6030 km^2 and has a 7-day average low flow (10-year return period) of 4.9 m^3/s. It contributes about 9% of the flow in the Nechako River at Isle Pierre which would increase to 11% should Alcan's proposed Kemano Completion project proceed.

The Chilako River drains 3390 km^2 and has a 7-day average low flow (10-year return period) of 3.4 m^3/s This is only about 6% of the 7-day average low flow (10-year return period) in the Nechako River at Isle Pierre or 7.5% of the Nechako River flow should Alcan's proposed Kemano Completion proceed.

WATER USES

The Nechako River and the Stuart River are extremely important migration routes for juvenile and returning adult salmon. Extensive areas of both rivers are used for spawning by adult salmon and the mouths of several tributaries are used for spawning by rainbow trout. Stuart Lake has extensive sockeye salmon stocks. There are at least 13 known species of resident fish found in the lake system in the upper reaches of the Stuart River watershed.

The Nechacko River also is used extensively for irrigation, livestock watering and drinking water, with some primary-contact recreation (*i.e.*, swimming). Water from the Chilako River is used by wildlife and only for irrigation and some non-licenced drinking water, while water from the Stuart River is also used by wildlife and for drinking water. Stuart Lake water is used for drinking water and by wildlife. Recreational use is also made of Stuart Lake both for primary-contact recreation (*i.e.*, swimming) and secondary-contact recreation (*i.e.*, boating, fishing). Burns and Fraser Lakes are used for primary and secondary contact recreation, drinking water, irrigation, livestock and used by wildlife and aquatic life.

WASTE DISCHARGES

Three treated domestic sewage discharges occur in this sub-basin. These are from Vanderhoof (population: 3800), Fort Fraser (population: 1500) and Fort St. James (population: 2300).

Fort St. James located near the start of the Stuart River at the outlet from Stuart Lake discharges as much as 3200 m^3/d of wastewater from a secondary treatment facility. The discharge is to the Necoslie River, a low flow river, about one km upstream from its confluence with the Stuart River. The Necoslie River has no salmon spawning and very little fisheries value although chinook salmon spawn at its mouth.

This discharge increases fecal coliforms, ammonia, BOD_5, orthophosphate and total phosphorus in the Necoslie River near its mouth. A concern about this discharge relates to maintaining water quality in the Necoslie downstream from the discharge to permit swimming. No impact from this discharge is expected in the Stuart River if recent improvements to the treatment system are as effective as anticipated.

The Village of Fort Fraser, located about 100 km west from Prince George, discharges as much as 250 m^3/d of wastewater to the Nechako River, following secondary treatment. The discharge increases only fecal coliforms in the river outside the initial dilution zone. The increase could affect use of the water by downstream consumers, but the closest downstream drinking water withdrawal is 25 km away. Therefore no concerns exist. The sewage treatment facility has just been expanded so that effluent quality should be improved. Should Alcan's Kemano Completion project proceed, dilution available for this wastewater in the Nechako River may decrease. Additional improvments could be required at this facility.

The Village of Vanderhoof discharges as much as 1640 m^3/d of treated municipal wastewater (secondary treatment) to the Nechako River. The discharge has at times increased values of fecal coliforms, ammonia, dissolved orthophosphorus and total dissolved phosphorus in the river. Downstream drinking water users could theoretically be affected by this discharge.

A mercury mine complex operated on Pinchi Lake in the 1940's, the 1960's and 1970's. Tailings which were discharged to Pinchi Lake in the 1940's are continuing to affect mercury concentrations in fish in this lake, which drains to Stuart Lake via Pinchi Creek.

Other point source waste discharges in this sub-basin are refuse sites or small domestic sewage facilities. No impacts are anticipated or have been measured from these waste discharges.

Non-point sources such as agriculture, forestry and unsewered residential developments can also affect water quality. These sources may be raising values of phosphorus, nitrogen and fecal coliforms in the sub-basin. Phosphorus potentially can increase algal growth; certain forms of nitrogen in extreme cases can be toxic to humans and aquatic life; fecal coliforms can necessitate more elaborate water treatment. The relatiuve impact of non-point sources compared to point discharges on river water quality is not known.

WATER QUALITY

The water quality in the Nechako River generally would be considered as good. This is reflected in low levels for nutrients, suspended solids and metals and high dissolved oxygen concentrastions. At present, the turbidity in the river can be increased dramatically when water is released by Alcan to supplement Nechako River flows. As well, some high natural aluminum concentrations have been evident. Total dissolved gas pressures near Cheslatta Falls can occasionally reach levels associated with acute gas bubble trauma and be of major concern for fish.

At present aquatic weed growths near Fort Fraser and Vanderhoof are abundant but these do not appear to be related to the discharges of treated municipal wastewater from these two centers>

The proposed Kemano Completion project could increase water clarity leading to a concern for greater aquatic plant growths and algal production. It extreme situations, which are unlikely, this could have a serious effect on salmonid fish. The possible detrimental effects could be offset by the capability to change temperature regimes in the river using the proposed cold water withdrawal structure at the Kenney Dam. Improved management of temperature regimes in the river could minimize stress on fish in the system as well as maximize the amount of water which could be used by Alcan for power production.

The Stuart River is considered to be soft with good buffering to acidic discharges and high dissolved oxygen levels. Some high iron, manganese and copper values have been measured but these metals were believed to be naturally occurring. No water chemistry data existed for Stuart Lake. However, tissues from fish collected from Stuart Lake had mercury values which met the working water quality criterion for human consumption.

Pinchi and Tezzeron Lakes, which drain to Stuart Lake, are both located in the Pinchi Lake Fault zone. This is a geological formation which contains numerous mercury-bearing ore deposits. Pinchi Lake had soft water, good buffering to acids, adequate dissolved oxygen and low suspended solids levels. The trophic status of the lake is unknown. The lake had some high lead and iron values but mercury levels in the water column generally were low. Fish in the lake contain high mercury levels in their flesh which are too high for human consumption.

Tezzeron Lake also had soft water, good buffering to acids, high dissolved oxygen and low suspended solids levels. The lake is probably oligotrophic according to phosphorus concentrations. Some maximum values for metals (cadmium, copper, iron and lead) exceeded working water quality criteria for aquatic life but these metals were believed to be naturally occurring. High values occurred as localized short-term peaks and therefore metals are not a major concern to aquatic life. Mercury values in most fish muscle met the working water quality criterion for human consumption but flesh from one northern squawfish exceeded the criterion. The mercury is likely naturally occurring due to the presence of the Pinchi Lake Fault zone

The Chilako River water was harder, had higher nutrient levels and was better buffered to acids than the Nechako River. Dissolved oxygen levels were good and some high metals have been associated with high suspended sediments during freshet. Therefore, the metals are likely bound to the solids and not available to aquatic life. One high dissolved mercury value probably reflects the fact that the Chilako River is influenced by the presence of the Pinchi Lake Fault zone.

PROVISIONAL WATER QUALITY OBJECTIVES

A summary of designated water uses and proposed provisional water quality objectives is given in Table 1. Provisional water quality objectives are proposed for the Nechako River, Necoslie River and the Stuart River. The objectives are based on working criteria for water quality and on available data on ambient water quality, waste discharges, water uses and river flows. The objectives will remain provisional until receiving water monitoring programs provide adequate data and the Ministry has established approved water quality criteria for the characteristics of concern.

Water quality objectives have no legal standing and would not be directly enforced. The objectives can be considered as policy guidelines for resource managers to protect water uses in the specified water bodies. They will guide the evaluation of water quality, the issuing of permits licences and orders and the management of the fisheries and the Province's land base. They will also provide a reference against which the state of water quality in a particular water body can be checked and serve to make decisions on whether to initiate basin-wide water quality studies.

Depending on the circumstances, water quality objectives may already be met in a water body, or may describe water quality conditions which can be met in the future. To limit the scope of the work, objectives are only being prepared for water bodies and water quality characteristics which may be affected by man's activities, now and in the foreseeable future.

Designated uses have been proposed for a number of water bodies, although objectives have not been proposed for them at this time. Should developments be proposed for these water bodies in the future appropriate objectives may be required, depending on the development. Water bodies which come under this category are Pinchi Creek, Ocock River, Tsilcoh River, Tezzeron Lake, Pinchi Lake, Tezzeron Creek, Hatdudatehl Creek and Stuart Lake. The designated uses for the water bodies are drinking water, aquatic life, wildlife, irrigation, livestock watering and primary and secondary contact recreation in the lakes only.

Designated water uses in lakes and rivers where objectives have been proposed are shown in Table 1. Fecal coliform objectives to permit recreation from June through August are proposed for the Nechako River from just above the Fort Fraser sewage discharge to the Nautley River and in the Necoslie River from just above the Fort St. James sewage discharge to the Stuart River. A more restrictive fecal coliform objective, applicable on a year-round basis to protect drinking water supplies, is proposed for the Stuart River and the entire length of the Nechako River, excluding the above area between the Fort Fraser outfall and the Nautley River. An area of the Stuart River to which this objective is not applicable is along its east bank from the Necoslie River to a point on the river 200 meters downstream from the Highway 27 bridge. This area is considered as a mixing zone for Necoslie River water with Stuart River water for the purpose of the fecal coliform objective only. In this area water withdrawals should only be undertaken with provision of a high level of water treatment.

Since the sewage treatment plants chlorinate, or may have to chlorinate their effluents in order to achieve the coliform objectives, an objective is proposed for total chlorine residual to protect aquatic life from chlorine toxicity.

Ammonia can also be toxic to aquatic life. An objective is proposed for the Nechako and Stuart Rivers. As a further aid in this regard, an objective for pH is also proposed. The upper portion of the pH range has been reduced purposely from the working water quality criteria since background pH values are naturally lower and the amount of ammonia can be increased safely at lower pH's.

An objective for nitrite is proposed since nitrite can be toxic to aquatic life. Nitrite can be formed when ammonia is oxidized. If further oxidation to convert nitrite to nitrate is inhibited, nitrite can be relatively high below such places as sewage treatment plant outfalls.

Minimum dissolved oxygen values are proposed as objectives in the Nechako and Stuart Rivers to protect the migration of salmon and resident salmonid populations.

Objectives for the average water temperature have been proposed for the following two locations on the Nechako River: just upstream from the Stuart River confluence to protect aquatic life and to permit upstream migration, and just downstream from Cheslatta Falls to permit spawning, growth of juvenile rainbow trout and egg incubation.

Since recreational use is made of the entire length of the river, objectives have been proposed for periphyton chlorophyll-*a*. This objective will help in maintaining low algal productivity thereby maintaining the aesthetic quality of the river.

High total dissolved gas pressures can cause gas bubble disease in fish. Alevin and juveniles are particularly susceptible. To protect these sensitive life stages an objective is proposed for total dissolved gas pressure along the length of the Nechako River.

MONITORING RECOMMENDATIONS

Monitoring programs have been proposed in Table 4. to check attainment of the provisional objectives and to develop new objectives. Monmitoring to check attainment of the objectives will take place at a practical sampling frequency and at points in the environment where objectives are most likely to be exceeded. Monitoring may need to be increased if it is believed that the objectives are not being attained. New data would be used in the future to finalize provisional objectives, revise objectives or develop new objectives.

The recommended monitoring program is based upon technical considerations. Regional priorities and available funding are factors which could either limit or expand the program.

TABLES

Table 1. Provisional Water Quality Objectives for the Nechako River

Water Body	Chilako River	Stuart River	Nechako River	Necoslie River

designated uses	drinking water (partial treatment), aquatic life, wildlife, livestock, irrigation	drinking water (disinfection), aquatic life, wildlife, livestock, irrigation, recreation	drinking water (partial treatment), aquatic life, wildlife, livestock, irrigation	recreation, livestock, irrigation
fecal coliforms	less than or equal to 100/100 mL 90th percentile	less than or equal to 10/100 mL 90th percentile	less than or equal to 100/100 mL 90th percentile	less than or equal to 200/100 mL geometric mean less than or equal to 400/100 mL 90th percentile
temperature	not applicable	not applicable	at Cheslatta Falls: less than or equal to 15 degrees Celsius as a mean at Stuart River: less than or equal to 20 degrees Celsius as a mean (July and August) less than or equal to 18 degrees Celsius as a mean (September to June)	not applicable
total gas pressure, % saturation	not applicable	not applicable	109% maximum	not applicable
total chlorine residual	not applicable	0.002 mg/L		not applicable

periphyton chlorophyll-*a*	**less than or equal to 100 mg/m^2 mean**	**less than or equal to 50 mg/m^2 mean**	**not applicable**
pH	**6.5 to 8.5**		**not applicable**
nitrite-nitrogen	**less than or equal to 0.02 mg/L mean; 0.06 mg/L maximum**		**not applicable**
ammonia-nitrogen	**ammonia guidelines**		**not applicable**
dissolved oxygen	**11.2 mg/L minimum when fish eggs are in "eyed" to hatch stage 8.0 mg/L minimum when fish eggs and/or larvae or alevin are present 7.75 mg/L minimum at all other times**		**not applicable**

Note: The objectives apply to discrete samples from all parts of the water bodies, except from initial dilution zones of effluents. These excluded dilution zones in streams are defined as extending 100 m downstream from the discharge point and no more than 50 percent across the width of the stream, from the surface to the bottom.

1. The fecal coliform geometric mean and 90th percentile are calculated from samples collected once per week for five weeks in a period no longer than 30 days.

2. The fecal coliform drinking water objective of less than or equal to 10/100 mL applies to the Stuart River except in an area along the east bank of the river from the Necoslie River to a distance of 200 m d/s from the Highway 27 bridge where the drinking water objective of less than or equal to 100/100 mL applies. Both objectives apply all year.

3. The fecal coliform drinking water objective of less than or equal to 100/100 mL applies to the Nechako River except in an area from the Fort Fraser outfall to the Nautley River. This objective applies year round. In the area from one kilometer d/s from the outfall to the Nautley River the recreation objective (200-400/100 mL) applies during the recreation season.

4. Since the total chlorine residual objective is less than the minimum detectable concentration it will be necessary to estimate the receiving water concentration using effluent loadings and stream flow. The objective applies only if the sewage effluent is chlorinated.

5. The nitrite-nitrogen average is calculated from samples collected once per week for five weeks in a period no longer than thirty days.

6. The periphyton chlorophyll-a average is calculated from at least five samples collected

randomly from natural substrates.
7. For dissolved oxygen the fish eggs typically would be in the "eyed" to hatch stage from October through December and May to June 15.
8. pH measurements can be made "in situ" but must be confirmed in the laboratory if the objective is exceeded.
9. Temperature objectives apply to the average of measurements made at river cross-sections approximately 100 m d/s from Cheslatta Falls and 100 m u/s from the Stuart River. Measurements are to be made at 0.2 and 0.8 of the depth at each of five points at each cross section. The five points are located as follows: where a depth of 1.6 m is achieved going out from shore, one half the distance from this point to the closest shore and at the mid point of the cross section. The average value outlined as objectives is the average of at least three sets of the aforementioned ten measurements, each set taken at approximately equal time interval during an eight-hour period.

Table 4. Recommended Water Quality Monitoring for the Nechako River Sub-basin

sites	frequency and timing	characteristics
Nechako River 100 m u/s from the Stuart River	once/week from mid July to mid August	temperature
Nechako River 100 m d/s from Cheslatta Falls	once/year from mid July to mid August or when the temperature 100 m above the Stuart River exceeds 20 degrees Celcius	temperature
Nechako River u/s from site 0400629 and d/s from site 0400631 (Fort Fraser) Nechako River u/s from site 0400449 and d/s from site 0400450 (Vanderhoof)	once/year from mid July to mid August once/year in February or March	pH; temperature; ammonia, nitrite and nitrate-nitrogen; dissolved orthophosphorus and oxygen; fecal coliforms; chlorine residual

Nechako River u/s from site 0400629 and d/s from site 0400631 (Fort Fraser) Nechako River u/s from site 0400449 and d/s from site 0400450 (Vanderhoof)	**once/year from mid July to mid August**	**chlorophyll-*a* periphyton samples, locations of aquatic plant growth and approximate density**
Nechako River at Prince George, site 0920066 Federal-Provincial Trend Monitoring Station	**once/2 weeks year round or a minimum of once/month**	**chlorophyll-*a* pH; temperature; specific conductivity; alkalinity; hardness; calcium; magnesium; nitrate; nitrite; total phosphorus, arsenic, mercury and selenium; total and dissolved copper, cadmium, iron, lead, manganese, zinc and aluminum; total dissolved phosphorus and nitrogen; fecal coliforms; TAC color; dissolved and suspended solids; turbidity; ammonia; phenol; phenolphthalein alkalinity; potassium; sodium; chloride; fluoride; silica; sulphate**
Necoslie River d/s from Fort St. James outfall, site 0400801 Stuart River at highway bridge, sites 0400487 and 0400488	**six times/year for the first year then once a year thereafter**	**pH, temperature, fecal coliforms, dissolved oxygen, ammonia and nitrite-nitrogen, chlorine residual**
Stuart River at highway bridge, sites 0400487 and 0400488	**once a year in the summer time**	**chlorophyll-*a* periphyton**
Chilako River, sites to be determined	**once year, frequency and timing to be determined**	**to determine impact of land use on water quality in the Nechako River basin; characteristics to be determined**
Stuart Lake at a minimum of one site but preferably at four sites with a minimum of four depths/site, surface, mid-depth and bottom	**four times/year for the first two years**	**pH; ammonia, nitrite, kjeldahl and nitrate-nitrogen; total, ortho and total dissolved phosphorus; chlorophyll-*a*; phytoplankton; zooplankton; total aluminum, copper, cadmium, chromium,**

		mercury, iron, manganese, lead and zinc; temperature and dissolved oxygen profiles; secchi depth
Stuart Lake at a minimum of one site but preferably at four sites with a minimum of four depths/site, surface, mid-depth and bottom	twice/year for the third and fourth years at spring overturn only in subsequent years	pH; ammonia, nitrite, kjeldahl and nitrate-nitrogen; total, ortho and total dissolved phosphorus; temperature and dissolved oxygen profiles; secchi depth
Pinchi Creek and Tachie River near the mouth	four times/year for the first two years	pH; ammonia, nitrite, kjeldahl and nitrate-nitrogen; total, ortho and total dissolved phosphorus; chlorophyll-*a*; total aluminum, copper, cadmium, chromium, mercury, iron, manganese, lead and zinc
Pinchi Creek and Tachie River near the mouth	twice/year in subsequent years	pH; ammonia, nitrite, kjeldahl and nitrate-nitrogen; total, ortho and total dissolved phosphorus
Pinchi Lake and Stuart Lake	once/year in August every ten years	water chemistry and up to five species of fish/lake, six to ten individuals, muscle tissue, per species: weight, length, arsenic, cadmium, copper, iron, lead, mercury, manganese, molybdenum, and zinc; random sampling of livers for metallothionein

Sampling may need to be increased to check objectives, depending on circumstances.

L. G. Swain, P.Eng
R. Girard
Water Management Branch
Ministry of Environment and Parks