THE 1990 SUMMER WATER TEMPERATURE AND FLOW MANAGEMENT PROJECT

NECHAKO FISHERIES CONSERVATION PROGRAM
Technical Report No. RM90-2

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ABSTRACT

The 1990 Nechako River Summer Water Temperature and Flow Management Project was undertaken to attempt to prevent mean daily water temperatures in the Nechako River above Stuart River (at Finmoore) from exceeding 20.0°C (68.0°F), and to control flows in the Nechako River below Cheslatta Falls and at Vanderhoof during the water temperature control period (July 20 to August 20). In 1990, mean daily water temperatures in the Nechako River above Stuart River exceeded the temperature criterion on thirteen days (July 22-26, July 29-31, August 11-14, and August 20) during the water control period (July 20 to August 20), with a maximum mean daily temperature of 21.0°C (69.8°F), recorded on August 12.

The first exceedance of the temperature criterion occurred from July 22 to July 26, inclusive. On July 20, in response to a predicted warming trend the Skins Lake Spillway release was increased from 170 m^3/s (6,000 cfs) to 453 m^3/s (16,000 cfs). The spillway release was maintained at 453 m^3/s (16,000 cfs) until July 22 when a predicted cooling trend prompted the spillway release to be decreased to 14.2 m^3/s (500 cfs). However, a warming trend was predicted the following day, July 23 and the spillway release was increased to 453 m^3/s (16,000 cfs). On July 24 the spillway release was reduced to 283 m^3/s (10,000 cfs) to avoid exceeding the maximum allowable flow in the Nechako River below Cheslatta Falls.

The second exceedance of the temperature criterion occurred from July 29 to July 31, inclusive. During this period, flow in the Nechako River below Cheslatta Falls was at the maximum allowable level of 283 m^3/s (10,000 cfs), and thus no further action could be taken.

The third exceedance of temperature criterion occurred from August 11 to August 14, inclusive. On August 9, the Skins Lake Spillway release was increased from 170 m^3/s (6,000 cfs) to 453 m^3/s (16,000 cfs) in response to a predicted warming trend. On August 10 the spillway release was reduced to 283 m^3/s (10,000 cfs) to avoid exceeding the maximum allowable flow in the Nechako River below Cheslatta Falls. The spillway release was maintained at 283 m^3/s (10,000 cfs) until August 12 when a predicted cooling trend prompted the spillway release to be decreased to 14.2 m^3/s (500 cfs) where it was maintained through to August 15.

The fourth exceedance of the temperature criterion occurred on August 20. A strong upward observed trend was predicted on August 19. However, no downstream benefit would be realized on August 20, and the spillway release was maintained at 14.2 m^3/s (500 cfs).

Over the duration of the 1990 Summer Water Temperature and Flow Management Project, the total volume of water released was 8,219.2 m^3/s-d (290,261 cfs-d). The volume released for cooling purposes was 6,161.2 m^3/s-d (217,583 cfs-d). The average flow over the operational period (July 10 to August 20) was 195.7 m^3/s (6,911 cfs).

INTRODUCTION

Control of the Nechako River water temperature for protection of fish resources is a concern of both government agencies and Alcan Smelters and Chemicals Ltd. Each summer between 1981 and 1984, Alcan, Triton Environmental Consultants Ltd. (formerly Envirocon Pacific Ltd.), and the Department of Fisheries and Oceans (DFO) undertook a joint water temperature monitoring and control project. In 1985, no water temperature monitoring and control project was implemented as Alcan maintained a constant Skins Lake Spillway release of 283 m^3/s (10,000 cfs) providing the maximum allowable flow in the Nechako River below Cheslatta Falls for the entire period of concern. In 1986 and 1987, Triton Environmental Consultants Ltd. (Triton), on behalf of Alcan, carried out an independent water temperature and flow management project similar to the one used during the

summer of 1984 (Envirocon 1985). Since 1988, Triton has carried out analogous water temperature and flow management projects (Triton 1995a, 1995b) under the auspices of the Nechako Fisheries Conservation Program (NFCP).

The Nechako River Summer Water Temperature and Flow Management Project currently being used was designed and developed by Triton in 1982 and has been successfully implemented by Triton since 1983. The project is comprised of an operational period (July 10 to August 20), a water temperature control period (July 20 to August 20), and a flow control period (July 10 to September 6). The objectives of the Summer Water Temperature and Flow Management Project are to attempt to prevent water temperatures in the Nechako River above the Stuart River confluence from exceeding 20.0°C (68.0°F) during the water temperature control period, and to control flows in the Nechako River below Cheslatta Falls and at Vanderhoof during the flow control period. The latter objective includes reducing the flow in the Nechako River below Cheslatta Falls to the chinook salmon spawning flow by September 6.

The study area included in the Summer Water Temperature and Flow Management Project is shown in Figure 1. Unless otherwise stated, the location of the Nechako River above Stuart River refers to the Nechako River at Finmoore.

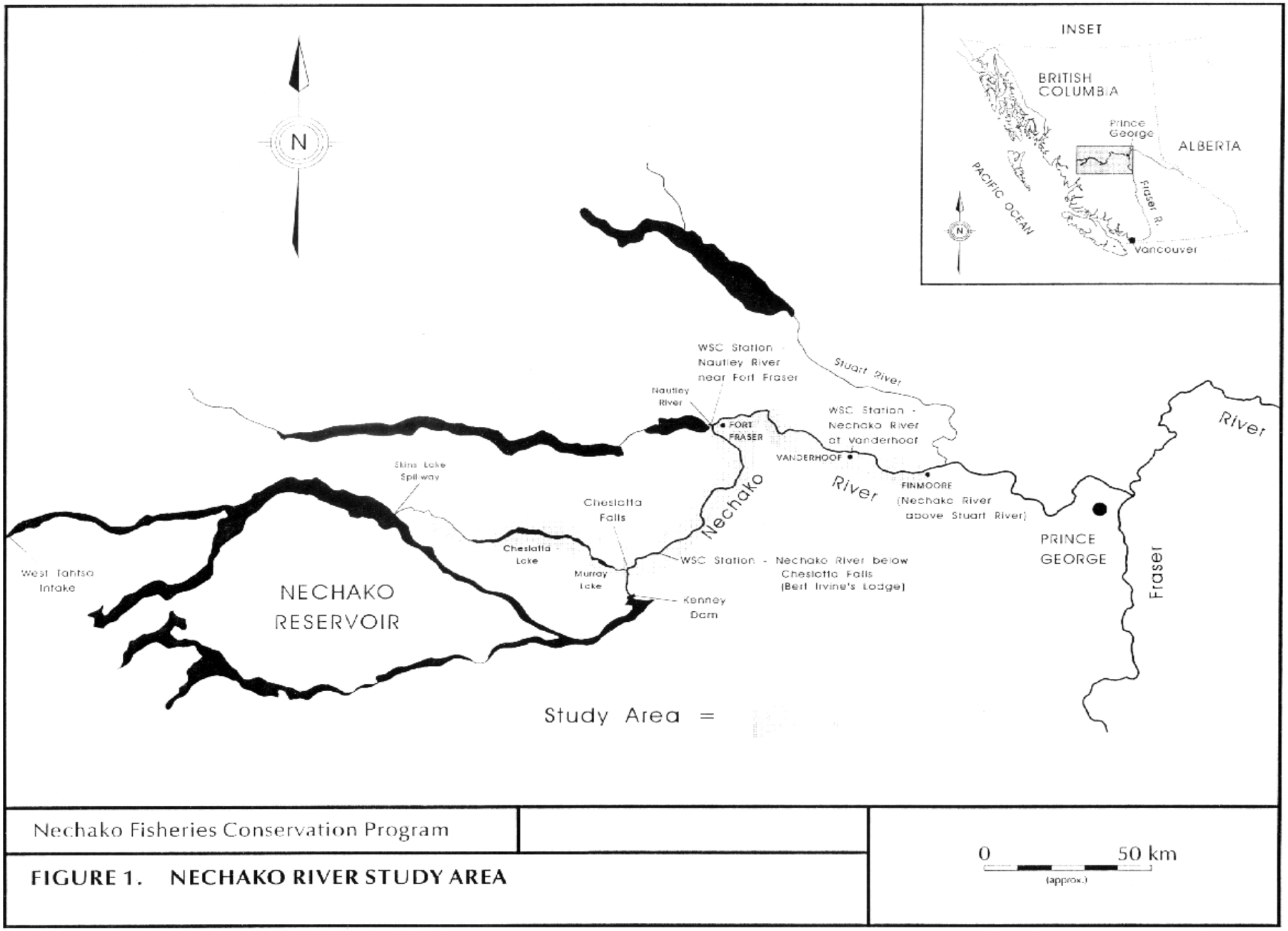
This report reviews the 1990 Summer Water Temperature and Flow Management Project and includes an outline of Triton's method of determining Skins Lake Spillway releases, a summary of Triton's 1990 Skins Lake Spillway release recommendations for the period July 10 to September 6 inclusive, and a summary of observed flows (July 10 to September 6) and water temperatures (July 10 to August 20) at various locations along the Nechako River. Also discussed is the volume of cooling water used in the 1990 Summer Water Temperature and Flow Management Project.

METHODS

Management of the Nechako River flows and water temperatures was accomplished using water temperature predictions based on five-day meteorological forecasts to determine scheduling of Skins Lake Spillway releases required to meet project objectives. The Summer Water Temperature and Flow Management Project is a computer based project utilizing an unsteady-state flow routing model and an unsteady-state water temperature prediction model designed to compute the conditions in the Nechako River defined by the nature of the meteorological conditions. Mathematical modelling of flows and water temperatures in the Nechako River was performed daily during the period July 10 to August 20, inclusive.

Daily operations followed the protocol defined in the Settlement Agreement (Anon. 1987), and involved collection of water temperature and river stage data from several locations in the study area, and development of five-day meteorological forecasts. Water temperatures were obtained daily from recorders maintained in the Nechako River below Cheslatta Falls (at Bert Irvine's Lodge), in the Nechako River at Fort Fraser (upstream of Nautley River), in the Nechako River above Stuart River and in the Nautley River. River stages were obtained daily from recorders maintained in the Nechako River below Cheslatta Falls, in the Nechako River at Vanderhoof and from a staff gauge in the Nautley River. Five-day meteorological forecasts were obtained from World Weatherwatch (formerly Meteorological and Environmental Planning Ltd. (MEP)), a subconsultant to Triton.

River stage and minimum and maximum water temperature data were obtained daily by Triton (staff member resident in Vanderhoof) for each location identified except the Nechako River below Cheslatta Falls. Each morning, hourly water temperature and river stage data recorded by the data collection platform located at Nechako River below Cheslatta Falls were obtained via computer link to Water Survey of Canada (WSC), Vancouver. In addition, spot and corresponding recorded water temperatures were collected at each location during these daily site visits and used to adjust the recorded water temperatures. Adjustment was included to provide an ongoing check of each thermograph, and was performed in the following manner. If the spot temperature was higher than the thermograph record, the thermograph record was adjusted to agree with the observed spot temperature for that day. If the thermograph record was higher than the spot temperature, the thermograph record was not adjusted. This procedure was implemented as a conservative measure.


INSET
BRITISH COLUMBIA
Prince George
ALBERTA
PACIFIC OCEAN
Fraser R.
Vancouver
N
WSC Station - Nautley River near Fort Fraser
Stuart River
Nautley River
FORT FRASER
WSC Station - Nechako River at Vanderhoof
VANDERHOOF
FINMOORE (Nechako River above Stuart River)
River
Skins Lake Spillway
Chesletta Falls
Nechako River
PRINCE GEORGE
Fraser
Chesletta Lake
Murray Lake
WSC Station - Nechako River below Chesletta Falls (Bert Irvine's Lodge)
West Tahtsa Intake
NECHAKO RESERVOIR
Kenney Dam
Study Area =
Nechako Fisheries Conservation Program
FIGURE 1. NECHAKO RIVER STUDY AREA
0
50 km
(approx.)

Skins Lake Spillway releases documented in this report are the releases requested by Triton. All Nechako River and Nautley River flow data documented in this report are preliminary data. The values presented are part of the database utilized in the daily operation of the Summer Water Temperature and Flow Management Project. These data have not been updated as it is the preliminary data that was used in real-time modelling of the Nechako River system. Therefore, values presented in this report may differ slightly from those reported by WSC.

The first 10 days of the operational period, July 10 to July 19, are utilized for system start up, for initialization of the data base required to schedule Skins Lake Spillway releases necessary to meet project water temperature objectives during the control period commencing July 20, and for increase of the flows in the Nechako River from spring flows to the minimum cooling flow of 170 m^3/s (6,000 cfs) required below Cheslatta Falls. The 1990 Skins Lake Spillway spring base release as determined by NFCP was 49.0 m^3/s (1,730 cfs). On July 10, the operational period commenced with an observed flow of 56.1 m^3/s (1,981 cfs) in the Nechako River below Cheslatta Falls. On July 11, 1990, the Skins Lake Spillway release was increased from the spring base release to 227 m^3/s (8,000 cfs) to ensure flows in the Nechako River below Cheslatta Falls reached the minimum cooling flow of 170 m^3/s (6,000 cfs) by July 20 (the beginning of the water temperature control period).

Throughout the operational period of the project, water temperatures in the Nechako River were calculated daily for the previous day, the current day and each of the next 4 days. These calculations were based on observed and five-day forecast meteorological data, observed water temperature and computed flow data. Forecast water temperature predictions were tabulated and reviewed daily to identify trends in water temperature changes. These trends are the same as those used in the water temperature and flow management projects since 1984 (Envirocon Ltd. 1985), and are best explained through reference to Table 1. Assuming the current day is July 16, entries corresponding to the current day's operation are represented by the letter c. Entries co and cs represent the observed and calculated water temperatures, respectively, for the previous day (July 15). Entries c1 through c5 represent predicted water temperatures computed using the current day's five-day meteorological forecast and an assumed current day's flow regime. The entry rc represents the current day Skins Lake Spillway release required to meet project objectives.

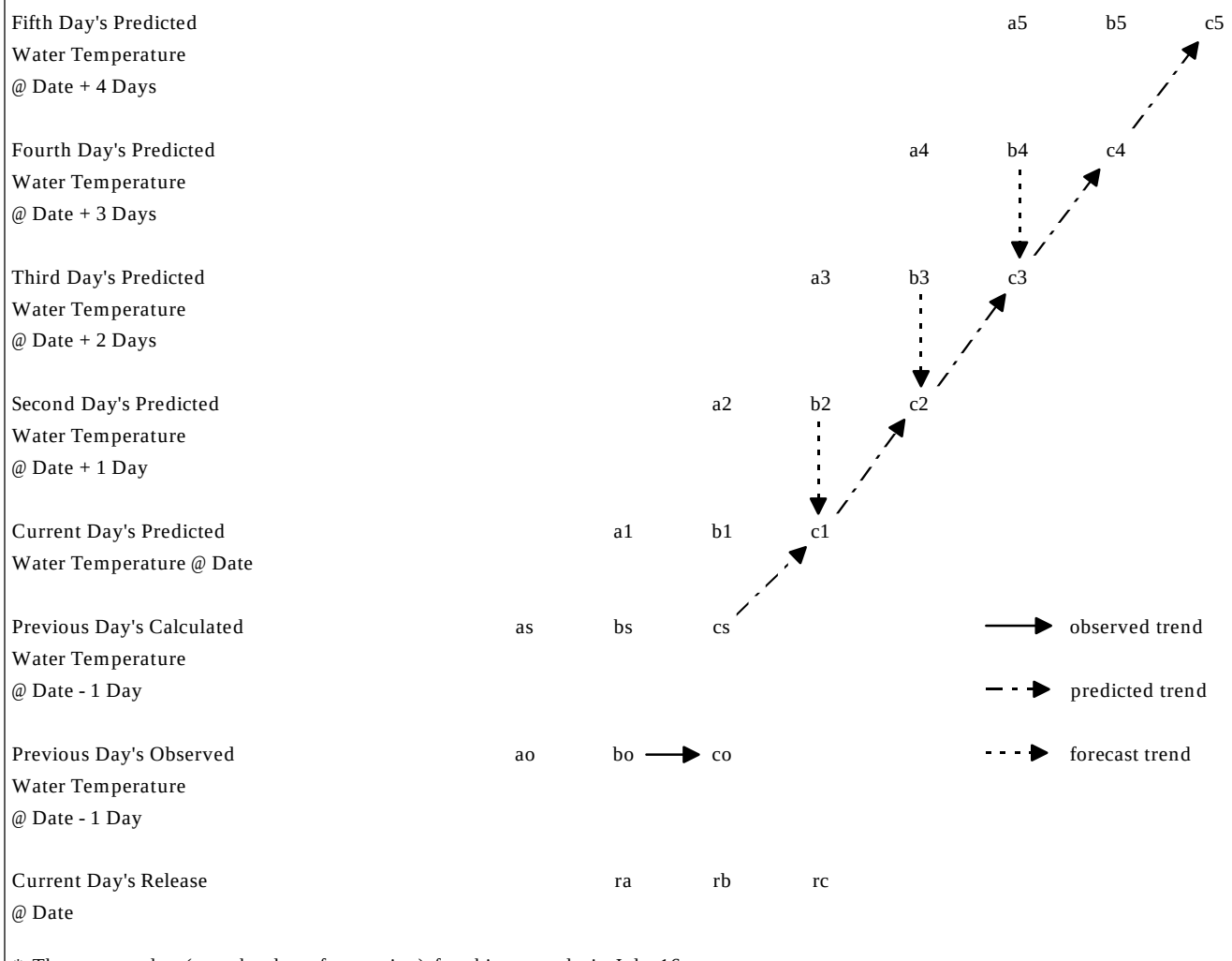
The following three trends in water temperature changes were reviewed on a day-by-day basis:

1. Observed trend; developed from observed mean daily water temperatures measured in the Nechako River above Stuart River each day (bo and co in Table 1). The difference in observed water temperatures for the previous two days is extrapolated over the next 5 days to determine the observed water temperature trend.
2. Predicted trend; developed from the predicted water temperatures for the previous day and the following five days (cs,c1,c2,c3,c4,c5, in Table 1). These data represent the predicted trend.
3. Forecast trend; developed from the difference between the current five-day and previous five-day predictions for the same calendar days (c3 and b4, c2 and b3, c1 and b2 in Table 1). Differences between forecasted data on coincident dates for the next 3 days only are averaged and added to the 5th day predicted temperature to determine the trend in forecasted temperatures.

A numerical example of how the trends are calculated is presented in Appendix A.

Each day predicted water temperatures for the five-day forecast period were checked and the three trends were calculated. If two of the three trends indicated that the water temperature in the Nechako River above Stuart River could potentially exceed 19.4°C (67.0°F) then an increase in the Skins Lake Spillway release was required. When this occurred the current day's release was revised and the flow and temperature models were rerun using the modified flow regime. Results of each day's final computer run were subsequently used to initialize water temperatures for the following day's computations. Entries in Table 1 represent each day's final cooling water release and resultant predicted water temperatures.

Table 1
Daily Operations to Manage Water Temperatures in the Nechako River above Stuart River



* The current day (e.g. the day of operation) for this example is July 16

The following release criteria were used with the three trends identified above to determine the timing and magnitude of Skins Lake Spillway releases:

1. When two of the three trends show an increase in water temperature in the Nechako River above Stuart River, and these trends show that potentially the water temperature could exceed 19.4°C (67.0°F), increase the Skins Lake Spillway release according to criteria 2 and 3 below.

2. Operate Skins Lake Spillway such that flow in the Nechako River below Cheslatta Falls ranges between 170 m³/s (6,000 cfs) and 283 m³/s (10,000 cfs) as required, and flow in the Nechako River above Stuart River does not exceed 340 m³/s (12,000 cfs). It is understood that the flow in the Nechako River below Cheslatta Falls is to be not less than 170 m³/s (6,000 cfs) by July 20, and is to be reduced to approximately 31.2 m³/s (1,100 cfs) by September 6.

3. At any time of release, increase Skins Lake Spillway from the current level to 453 m³/s (16,000 cfs) directly to achieve the flow changes in the Nechako River as fast as possible.

4. During cooling periods when two of three trends in forecasted water temperatures are decreasing and these trends indicate that potentially the water temperature could drop below 19.4°C (67.0°F) within the forecast period (5 days), reduce the Skins Lake Spillway release from the current level to 14.2 m^3/s (500 cfs).

RESULTS

Predicted and observed mean daily water temperatures for the Nechako River above Stuart River, Skins Lake Spillway releases and changes in Skins Lake Spillway releases over the duration of the project operational period (July 10 to August 20) are summarized in Table 2.

Observed mean daily water temperatures in the Nechako River above Stuart River are tabulated in Table 3 and plotted in Figure 2. The maximum observed mean daily water temperature recorded during the water temperature control period (July 20 to August 20) was recorded as 21.0°C (69.8°F) on Augus 12. The maximum observed mean daily water temperature recorded during the operational period (July 10 to August 20) was recorded as 21.7°C (71.1°F) on July 11 and 12. The minimum observed mean daily water temperature recorded during the water temperature control period (July 20 to August 20) was recorded as 18.4°C (65.1°F) on August 3. The minimum observed mean daily water temperature recorded during the operational period (July 10 to August 20) was recorded as 17.9°C (64.2°F) on July 18. A summary of mean daily water temperatures recorded in the Nechako River below Cheslatta Falls, near Fort Fraser and above Stuart River, and in the Nautley River near Fort Fraser (July 10 to August 20) is presented in Appendix B.

As outlined in *Methods*, during the water temperature control period Skins Lake Spillway releases required for water temperature control were to be such that flows in the Nechako River below Cheslatta Falls were to range between 170 m^3/s (6,000 cfs) and 283 m^3/s (10,000 cfs) and flows at Vanderhoof were not to exceed 340 m^3/s (12,000 cfs).

Skins Lake Spillway releases and corresponding flows in the Nechako River below Cheslatta Falls and at Vanderhoof are plotted in Figure 3. Daily Skins Lake Spillway releases, Nautley River flows and flows in the Nechako River below Cheslatta Falls and at Vanderhoof are tabulated in Appendix C. A day-by-day record of Triton's Skins Lake Spillway release recommendations and the reasoning behind them is presented in Table 4.

During the water temperature control period, measured flows in the Nechako River below Cheslatta Falls (based on preliminary WSC data from the WSC data collection platform at Bert Irvine's Lodge) ranged between a maximum of 289 m^3/s (10,206 cfs) on August 1 and a minimum of 114 m^3/s (4,026 cfs) on August 20. Flows measured in the Nechako River at Vanderhoof ranged between a maximum of 314 m^3/s (11,089 cfs) on August 2 and a minimum of 163 m^3/s (5,756 cfs) on August 20. Following the water temperature control period, the mean daily flow in the Nechako River below Cheslatta Falls was reduced to 34.4 m^3/s (1,215 cfs) by September 6. The recorded maximum mean daily flow in the Nechako River below Cheslatta Falls exceeded the previously stated limit for flood control by 2.1%.

DISCUSSION

Decision criteria used to determine Skins Lake Spillway releases during the 1990 Summer Water Temperature and Flow Management Project were identical to those used during summer water temperature and flow management projects since 1984. Discussion of the 1990 Summer Water Temperature and Flow Management Project has been divided into four sections. The first section reviews the collection and use of observed field data. Types of data include water temperature, flow, and meteorological data (observed and forecast). The second section discusses occurrences of mean daily water temperatures in excess of 20.0°C (68.0°F) in the Nechako River above Stuart River. The third section discusses the volume of water used during the 1990 Summer Water Temperature and Flow Management Project. The fourth section discusses instances when judgment was exercised (based on experience gained in previous years' operation of the Summer Water Temperature and Flow Management Project) during the application of the release criteria.

Table 2
Predicted and Observed Mean Daily Water Temperatures in the Nechako River above Stuart River, July 10 to August 20, 1990

	JULY																					
Date	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
5th Day's Predicted Water Temperature at Date + 4 Days					22.1	21.6	22.7	20.7	19.0	18.8	18.3	18.7	19.2	19.3	19.1	19.1	18.8	19.2	18.9	19.2	20.3	20.4
4th Day's Predicted Water Temperature at Date + 3 Days				22.3	22.0	23.3	21.2	19.3	19.1	18.0	18.1	18.7	19.2	19.7	19.8	19.0	19.4	19.2	19.1	20.1	20.3	20.1
3rd Day's Predicted Water Temperature at Date + 2 Days			22.3	22.3	23.6	21.4	19.6	19.4	18.1	17.8	17.9	18.8	19.8	20.6	19.8	19.9	19.7	19.7	20.0	20.0	20.1	20.5
2nd Day's Predicted Water Temperature at Date + 1 Day		22.6	22.3	23.4	21.6	19.6	19.7	18.5	17.8	17.5	18.4	19.3	20.6	20.8	20.6	20.2	20.6	20.4	19.9	20.1	20.6	20.6
Current Day's Predicted Water Temperature at Date	21.7	22.0	22.7	21.8	20.0	20.1	19.2	18.0	18.1	18.3	18.9	20.0	21.1	21.0	20.7	20.8	20.9	20.3	20.1	20.4	20.9	20.3
Previous Day's Calculated Water Temperature at Date - 1 Day	21.6	22.1	22.2	20.9	20.3	19.9	18.8	18.3	18.4	18.6	19.1	20.1	21.1	21.0	20.7	20.9	20.8	20.3	20.2	20.6	20.8	20.1
Previous Day's Observed Water Temperature at Date - 1 Day	**20.5**	**21.7**	**21.7**	**20.6**	**19.7**	**19.3**	**18.4**	**18.0**	**17.9**	**18.2**	**18.6**	**19.6**	**20.1**	**20.7**	**20.6**	**20.3**	**20.6**	**19.9**	**19.8**	**20.2**	**20.2**	**20.2**
Current Day's Skins Lake Spillway Release at Date (m^3/s)	49.0	49.0 to 227 @ 1600 hrs	227	227	227	227	227	227	227 to 170 @ 1600 hrs	170	170 to 453 @ 1600 hrs	453	453 to 14.2 @ 1600 hrs	14.2 to 453 @ 1600 hrs	453 to 283 @ 1600 hrs	283	283	283	283	283	283	283

Table 2 (Continued)
Predicted and Observed Mean Daily Water Temperatures in the Nechako River above Stuart River, July 10 to August 20, 1990

	AUGUST																			
Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
5th Day's Predicted Water Temperature at Date + 4 Days	19.9	19.2	18.9	19.3	19.3	19.2	19.4	18.7	19.2	19.3	19.9	19.3	20.0	19.3	19.4	19.1	18.7	18.7	18.4	18.7
4th Day's Predicted Water Temperature at Date + 3 Days	19.8	19.2	19.3	19.0	19.0	19.6	18.8	19.2	19.2	19.6	19.4	20.4	20.1	20.1	19.3	19.4	18.7	18.3	18.6	18.9
3rd Day's Predicted Water Temperature at Date + 2 Days	19.9	19.6	18.8	18.6	19.2	19.3	19.6	19.4	19.1	19.1	20.4	20.5	20.9	20.1	20.1	18.9	18.7	18.6	19.0	18.9
2nd Day's Predicted Water Temperature at Date + 1 Day	19.7	19.1	18.4	18.3	19.2	20.4	19.9	18.8	18.7	20.0	20.5	21.2	20.8	20.4	19.4	19.2	18.8	19.1	19.1	20.1
Current Day's Predicted Water Temperature at Date	19.5	19.5	18.2	18.7	20.2	20.5	19.2	18.7	19.5	20.2	20.9	21.3	20.7	20.4	19.9	19.2	19.3	19.4	20.0	20.7
Previous Day's Calculated Water Temperature at Date - 1 Day	19.7	19.4	18.4	18.9	20.2	20.3	18.7	18.9	19.7	20.3	20.9	21.3	20.8	20.6	19.9	19.4	19.3	19.7	20.2	
Previous Day's Observed Water Temperature at Date - 1 Day	**19.9**	**18.6**	**18.4**	**18.7**	**19.7**	**19.8**	**19.1**	**18.8**	**19.2**	**19.9**	**20.8**	**21.0**	**20.8**	**20.5**	**19.9**	**19.5**	**19.4**	**19.9**	**19.7**	**20.1**
Current Day's Skins Lake Spillway Release at Date (m^3/s)	283 to 14.2 @ 1600 hrs	14.2	14.2	14.2	14.2 to 170 @ 0800 hrs 170 to 453 @ 1600 hrs	453	453 to 283 @ 2000 hrs	283 to 14.2 @ 1400 hrs	14.2 to 453 @ 1600 hrs	453 to 283 @ 1600 hrs	283	283 to 18.4 @ 1400 hrs	18.4 to 13.7 @ 0900 hrs	13.7	13.7 to 170 @ 1600 hrs	170 to 14.2 @ 1300 hrs	14.2	14.2	14.2	14.2

Table 3
Observed Mean Daily Water Temperatures in the Nechako River above Stuart River, July 10 to August 20, 1990

Date	Water Temperature (°C)	Date	Water Temperature (°C)
10-Jul	20.5	1-Aug	19.9
11-Jul	21.7	2-Aug	18.6
12-Jul	21.7	3-Aug	18.4
13-Jul	20.6	4-Aug	18.7
14-Jul	19.7	5-Aug	19.7
15-Jul	19.3	6-Aug	19.8
16-Jul	18.4	7-Aug	19.1
17-Jul	18.0	8-Aug	18.8
18-Jul	17.9	9-Aug	19.2
19-Jul	18.2	10-Aug	19.9
20-Jul	18.6	11-Aug	20.8
21-Jul	19.6	12-Aug	21.0
22-Jul	20.1	13-Aug	20.8
23-Jul	20.7	14-Aug	20.5
24-Jul	20.6	15-Aug	19.9
25-Jul	20.3	16-Aug	19.5
26-Jul	20.6	17-Aug	19.4
27-Jul	19.9	18-Aug	19.9
28-Jul	19.8	19-Aug	19.7
29-Jul	20.2	20-Aug	20.1
30-Jul	20.2		
31-Jul	20.2		

Figure 2
Observed Mean Daily Temperatures in the Nechako River
above Stuart River, July 10 to August 20, 1990

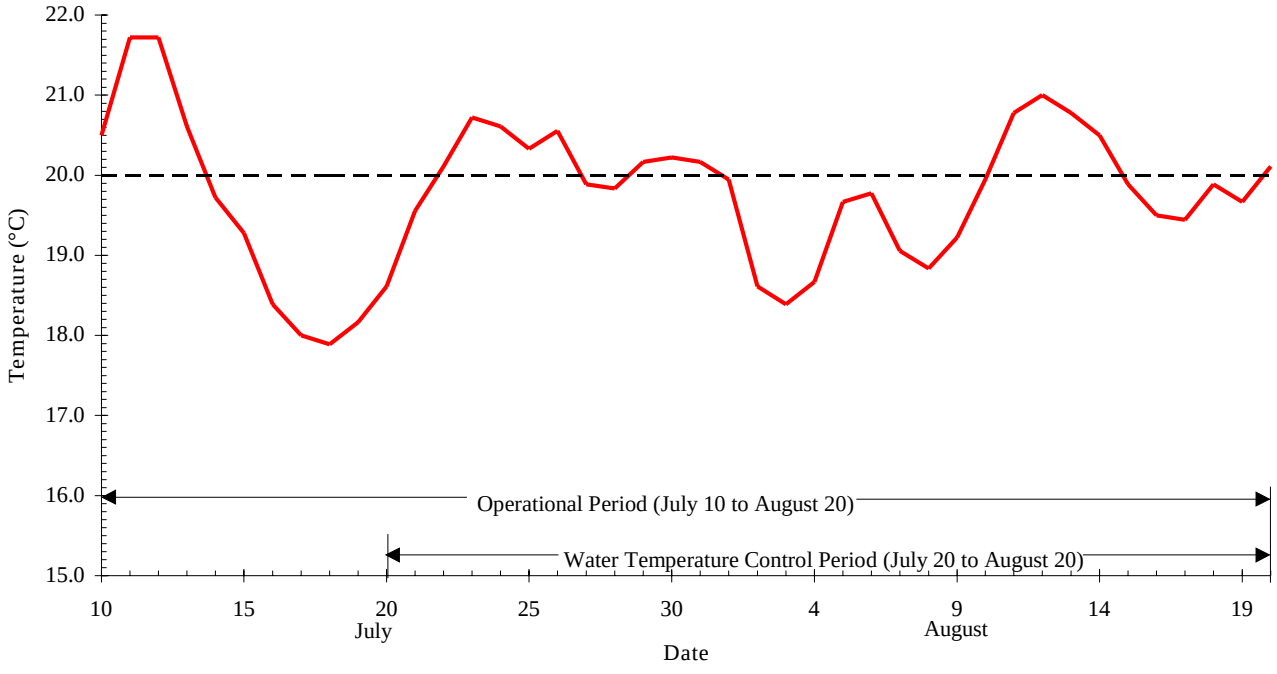
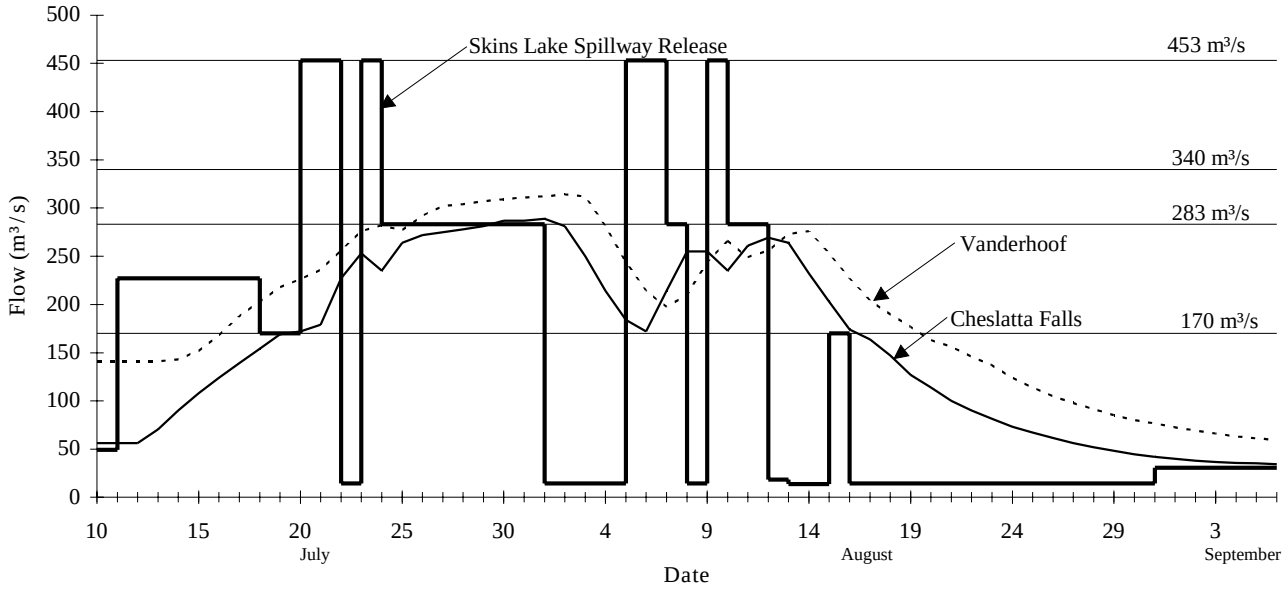


Figure 3
Skins Lake Spillway Releases and Flows in the Nechako River below Cheslatta Falls and at Vanderhoof, July 10 to September 6, 1990



Note: Vanderhoof flow data from July 10 to July 31 are published WSC values as gauged flows were unavailable during this time

Table 4
Rationale for Skins Lake Spillway Release Changes, July 10 to September 6, 1990

Date 1990	Old Setting (m^3/s)	New Setting (m^3/s)	Time of Change (hrs)	Reason for Changing SLS Release Setting
11-Jul	49.0	227	1600	To ensure base flow of 170 m^3/s below Cheslatta Falls by July 20
18-Jul	227	170	1600	To maintain base flows of 170 m^3/s
20-Jul	170	453	1600	In response to a predicted warming trend
22-Jul	453	14.2	1600	In response to a predicted cooling trend
23-Jul	14.2	453	1600	In response to a predicted warming trend
24-Jul	453	283	1600	To avoid exceedence of 283 m^3/s below Cheslatta Falls
1-Aug	283	14.2	1600	In response to a predicted cooling trend
5-Aug	14.2	170	0800	To maintain base flows of 170 m^3/s
5-Aug	170	453	1600	In response to a predicted warming trend
7-Aug	453	283	2000	To avoid exceedence of 283 m^3/s below Cheslatta Falls
8-Aug	283	14.2	1400	In response to a predicted cooling trend
9-Aug	14.2	453	1600	In response to a predicted warming trend
10-Aug	453	283	1600	To avoid exceedence of 283 m^3/s below Cheslatta Falls
12-Aug	283	18.4	1400	In response to a predicted cooling trend Note: A setting of 14.2 m^3/s was requested, however the gate was inadvertently set to 18.4 m^3/s
13-Aug	18.4	13.7	0900	To correct for incorrect gate setting of August 12
15-Aug	13.7	170	1600	To maintain base flows of 170 m^3/s
16-Aug	170	14.2	1300	In response to a predicted cooling trend
31-Aug	14.2	30.8	2000	To achieve spawning flow in the Nechako River below Cheslatta Falls by Sept. 6

Observed Data

Triton's modelling procedure is based on the premise that the best way to forecast water temperatures is to initialize computations with observed conditions. For this reason, the quality of the field data used in the modelling process directly affects the accuracy of the computed water temperatures. Therefore, data must be collected accurately and consistently to ensure that random errors are kept to a minimum. Consistency in data collection techniques will ensure any systematic errors maintain a constant bias throughout the project.

In 1990, flow data obtained from gauging stations in the Nechako River below Cheslatta Falls, in the Nechako River at Vanderhoof and in the Nautley River near Fort Fraser appeared to be of a reasonable quality. Changes in flows in the Nechako River below Cheslatta Falls and in the Nechako River at Vanderhoof responded as expected in response to changes in Skins Lake Spillway releases. The Nautley River flow regime was typical for the time of year. The ability to obtain hourly stage data from the gauging station located in the Nechako River below Cheslatta Falls proved very useful in verifying the daily predictions of the flow model and accounting for changes in the local inflow to the Cheslatta/ Murray Lakes system.

As stated previously, spot and corresponding recorder (thermograph) water temperatures were collected in the Nechako River at Fort Fraser (upstream of the Nautley River), in the Nechako River above Stuart River and in the Nautley River during each site visit. The thermograph water temperatures were not consistently higher or lower than their associated spot temperatures. These data were used in adjustment of water temperatures and the method applied is that outlined previously.

Observed and forecast meteorological data were obtained daily from World Weatherwatch, a subconsultant to Triton. Forecast weather data obtained from World Weatherwatch was developed using observed weather data from the Atmospheric Environmental Service (AES) station at Prince George Airport and from the meteorological monitoring station installed by Triton at Fort Fraser. The observed and forecast weather data received from World Weatherwatch was used to estimate water temperatures in the Nechako River below Cheslatta Falls and in the Nautley River for the previous day, current day, and following four days. A listing of the observed and forecast meteorological data is provided in Appendix D. The accuracy of the forecast meteorological data has a direct effect on the accuracy of the forecast river water temperatures.

Occurrences of Water Temperatures in the Nechako River above Stuart River Exceeding Water Temperature Criterion

Mean daily water temperatures in the Nechako River above Stuart River exceeded 20.0°C (68.0°F) on thirteen days during the water temperature control period of July 20 to August 20. Prior to the water temperature control period, mean daily water temperatures in the Nechako River above Stuart River exceeded 20.0°C (68.0°F) from July 10 to July 13, inclusive.

During the water temperature control period, the first exceedance of the temperature criterion occurred from July 22 to July 26, inclusive. Mean daily temperatures reached 20.7°C (69.3°F) on July 23. This warming trend was predicted on July 20, and the Skins Lake Spillway release was increased from 170 m^3/s (6,000 cfs) to 453 m^3/s (16,000 cfs). The spillway release was maintained at 453 m^3/s (16,000 cfs) until July 22 when a predicted cooling trend prompted the spillway release to be decreased to 14.2 m^3/s (500 cfs). However, a warming trend was predicted the following day, July 23 and the spillway release was increased to 453 m^3/s (16,000 cfs). Note that the cooling trend predicted on July 22 did occur and the mean daily water temperature in the Nechako River above Stuart River dropped to 19.9°C (67.8°F) on July 27, five days hence. On July 24 the spillway release was reduced to 283 m^3/s (10,000 cfs) to avoid exceeding the maximum allowable flow in the Nechako River below Cheslatta Falls. The release of 283 m^3/s (10,000 cfs) was maintained through to August 1.

The second exceedance of temperature criterion occurred from July 29 to July 31, inclusive. The recorded mean daily temperature on all three days was 20.2°C (68.4°F). Predicted water temperatures were within range of observed values. During this period flow in the Nechako River below Cheslatta Falls was at the maximum allowable level of 283 m^3/s (10,000 cfs), and thus no further action could be taken.

The third exceedance of temperature criterion occurred from August 11 to August 14, inclusive. A maximum mean daily temperature of 21.0°C (69.8°F) was recorded on August 12. This warming trend was predicted on August 9, and the Skins Lake Spillway release was increased from 170 m^3/s (6,000 cfs) to 453 m^3/s (16,000 cfs). On August 10 the spillway release was reduced to 283 m^3/s (10,000 cfs) to avoid exceeding the maximum allowable flow in the Nechako River below Cheslatta Falls. The spillway release was maintained at 283 m^3/s (10,000 cfs) until August 12 when a predicted cooling trend prompted the spillway release to be decreased to 14.2 m^3/s (500 cfs) where it was maintained through to August 15.

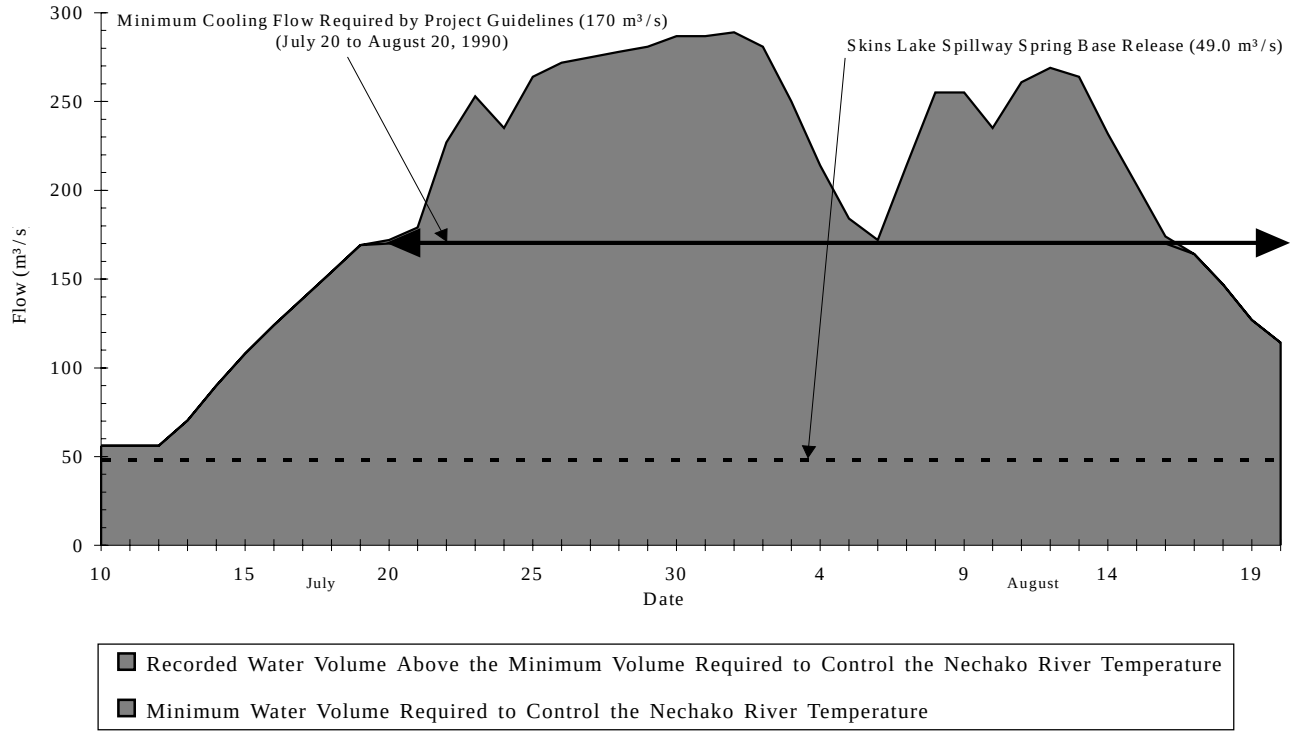
The fourth exceedance of the temperature criterion occurred on August 20 with a recorded mean daily temperature of 20.1°C (68.2°F). Cooling trends were predicted consistently through the latter few days of the water temperature control period. A strong upward observed trend was predicted on August 19. However, no downstream benefit would be realized on August 20, and the spillway release was maintained at 14.2 m^3/s (500 cfs).

Volume of Water Used

Figure 4 illustrates the observed flows in the Nechako River below Cheslatta Falls for the 1990 Summer Water Temperature and Flow Management Project. Also indicated is the minimum cooling flow of 170 m^3/s (6,000 cfs) in the Nechako River below Cheslatta Falls, and the Skins Lake Spillway release of 49.0 m^3/s (1,730 cfs) required as part of the "Annual Water Allocation" defined in the Settlement Agreement. Skins Lake Spillway releases in excess of 49.0 m^3/s (1,730 cfs) are considered releases used for cooling purposes.

The total volume of water released during the 1990 Summer Water Temperature and Flow Management Project was 8,219.2 m^3/s-d (290,261 cfs-d). The volume released for cooling purposes was 6,161.2 m^3/s-d (217,583 cfs-d). The average flow over the operational period (July 10 to August 20) was 195.7 m^3/s (6,911 cfs). Volume calculations are presented in Appendix E.

Figure 4
Flows in the Nechako River below Cheslatta Falls Resulting from Skins Lake Spillway Releases, July 10 to August 20, 1990



Application of the Summer Water Temperature and Flow Management Project Release Criteria

The Summer Water Temperature and Flow Management Project is very sensitive to the accuracy of meteorological forecasting. If a change in temperature direction occurs over a prolonged period of time (3 or 4 days), inaccurate meteorological forecasts may predict the reversal of the temperature direction prematurely. In these instances, it may be required to exercise judgment when applying the Summer Water Temperature and Flow Management Project release criteria used with the three water temperature trends. Experience gained in the operation of the Summer Water Temperature and Flow Management Project since 1984 has assisted in developing the judgment required to make exceptions to the release criteria during such events, which has proven to be beneficial in terms of managing downstream water temperatures.

On four occasions during the operational period of the 1990 Summer Water Temperature and Flow Management Project, judgment was applied and exceptions to the release criteria were made. This occurred when meteorological forecasts and/or the three water temperature trends did not clearly indicate which Skins Lake Spillway release should be implemented.

The first exception was made on July 24, when one of three water temperature trends indicated that the water temperature could exceed 19.4°C (67.0°F) in the Nechako River above Stuart River within the forecast period (5 days). The other two trends showed no potential to exceed 19.4°C (67.0°F). Following the release criteria under these conditions, the release from Skins Lake Spillway should have been decreased from the current release of 283 m^3/s (10,000 cfs) to 14.2 m^3/s (500 cfs). However, the observed trend was up and the meteorological forecast on July 22 predicting cooling rather than warming had resulted in the Skins Lake Spillway being reduced to 14.2 m^3/s (500 cfs). Therefore, as a conservative measure, it was decided to maintain the Skins Lake Spillway release at 283 m^3/s (10,000 cfs) until a cooling trend was clearly established. The following day's observed trend and forecast trend clearly indicated a continued warm trend, thus the Skins Lake Spillway release was maintained at 283 m^3/s (10,000 cfs).

The second and third instances when exceptions to the release criteria were made occurred on July 30 and 31. On July 30 one of three water temperature trends indicated that the water temperature could exceed 19.4°C (67.0°F) in the Nechako River above Stuart River within the forecast period (5 days). The other two trends showed no potential to exceed 19.4°C (67.0°F). Following the release criteria under these conditions, the release from Skins Lake Spillway should have been decreased from the current release of 283 m^3/s (10,000 cfs) to 14.2 m^3/s (500 cfs). However, the observed trend and the forecast trend were up and there was no indication of a distinct cooling trend in the forecast. Therefore, as a conservative measure, it was decided to maintain the Skins Lake Spillway release at 283 m^3/s (10,000 cfs) until a cooling trend was clearly established. The following day, July 31, had one trend exceeding 19.4°C (67.0°F) and the other two trends very close to 19.4°C (67.0°F). Based on these considerations and the fact that the there was still no indication of a clearly established cooling trend it was decided to maintain the Skins Lake Spillway release at 283 m^3/s (10,000 cfs). The cooling event did materialize on August 1 with the temperatures in the Nechako River above Stuart River cooling slightly.

The fourth exception to the release criteria was made on August 10, when one of three water temperature trends indicated that the water temperature could exceed 19.4°C (67.0°F) in the Nechako River above Stuart River within the forecast period (5 days). The other two trends showed no potential to exceed 19.4°C (67.0°F). Following the release criteria under these conditions, the Skins Lake Spillway release should have been decreased from 453 m^3/s (16,000 cfs) to 14.2 m^3/s (500 cfs). However, the observed trend's fifth day temperature was 21.2°C (70.1°F) and the forecast trend was up and had a fifth day predicted temperature of 19.4°C (66.9°F). Based on these considerations and to allow for a clear temperature trend to materialize, it was decided to decrease the Skins Lake Spillway release from 453 m^3/s (16,000 cfs) to 283 m^3/s (10,000 cfs) in order to prevent exceeding 283 m^3/s (10,000 cfs) in the Nechako River below Cheslatta Falls. The following day's observed trend and forecast trend clearly indicated a continued warm trend, and the Skins Lake Spillway release was maintained at 283 m^3/s (10,000 cfs).

REFERENCES

Anon. 1987. Settlement Agreement 1987.

Envirocon Limited. 1985. Review of the 1984 Nechako River Hydrothermal Monitoring and Control Program. Technical Memorandum 1941/C. Chapter 2.0, Methods. Prepared for Alcan Smelters and Chemicals Ltd.

Triton Environmental Consultants Ltd. 1995a. The 1988 Summer Water Temperature and Flow Management Project. Nechako Fisheries Conservation Program Technical Report No. RM88-5.

Triton Environmental Consultants Ltd. 1995b. The 1989 Summer Water Temperature and Flow Management Project. Nechako Fisheries Conservation Program Technical Report No. RM89-2.

APPENDIX A

Numerical Example of Water Temperature Trend Calculations

Appendix A
Numerical Example of Water Temperature Trend Calculation

From data for July 16 date of operation (Table A1).

1. Observed Trend

   The observed trend is down by 0.4°C from 19.7°C (J14) to 19.3°C (J15). Take the previous day's observed temperature 19.3°C (J15) and extrapolate the trend for 5 days at -0.4°C. The observed trend shows that the water temperature could potentially reach 19.3°C + 5(-0.4°C) = 17.3°C.

2. Predicted Trend

   The predicted trend is the difference between the previous day's computed water temperature (J15) and the fifth day predicted water temperature (J20). The predicted trend is down from 19.9°C to 18.3°C with the potential to reach 18.3°C.

3. Forecast Trend

   The forecast trend for the current day of July 16 is based on the first, second and third day forecasts.

July 16	19.2 - 19.7	=	down 0.5°C
July 17	18.5 - 19.4	=	down 0.9°C
July 18	18.1 - 19.1	=	down 1.0°C

   Mean of 3 differences = down 0.8°C

   This mean of -0.8°C is added to the fifth day predicted water temperature to give 18.3°C + (-0.8°C) = 17.5°C.

   The forecast trend is down 0.8°C with the potential to reach 17.5°C.

Table A1
Predicted and Observed Mean Daily Water Temperatures in the Nechako River above Stuart River, 1990

	JULY												
Date	10	11	12	13	14	15	16	17	18	19	20	21	22
5th Day's Predicted Water Temperature at Date + 4 Days					22.1	21.6	22.7	20.7	19.0	18.8	18.3		
4th Day's Predicted Water Temperature at Date + 3 Days				22.3	22.0	23.3	21.2	19.3	19.1	18.0			
3rd Day's Predicted Water Temperature at Date + 2 Days			22.3	22.3	23.6	21.4	19.6	19.4	18.1				
2nd Day's Predicted Water Temperature at Date + 1 Day		22.6	22.3	23.4	21.6	19.6	19.7	18.5					
Current Day's Predicted Water Temperature at Date	21.7	22.0	22.7	21.8	20.0	20.1	19.2						
Previous Day's Calculated Water Temperature at Date - 1 Day	21.6	22.1	22.2	20.9	20.3	19.9							
Previous Day's Observed Water Temperature at Date - 1 Day	20.5	21.7	21.7	20.6	19.7	19.3							
Current Day's Skins Lake Spillway Release at Date (m^3/s)	49.0	49.0 to 227 @ 1600 hrs	227	227	227	227	227						

APPENDIX B

Mean Daily Water Temperatures in the Nechako and Nautley Rivers, 1990

Appendix B
Mean Daily Water Temperatures in the Nechako and Nautley Rivers, 1990

Date	Nechako River Cheslatta Falls (°C)	Nechako River Fort Fraser (°C)	Nechako River above Stuart River (°C)	Nautley Fort Fraser (°C)
10-Jul	17.6	19.7	20.5	19.6
11-Jul	18.2	20.5	21.7	20.7
12-Jul	17.1	19.7	21.7	19.8
13-Jul	17.6	18.2	20.6	19.5
14-Jul	17.4	18.3	19.7	19.4
15-Jul	17.1	18.2	19.3	19.4
16-Jul	16.7	17.9	18.4	18.2
17-Jul	16.5	17.3	18.0	18.4
18-Jul	16.6	17.0	17.9	17.5
19-Jul	16.5	17.5	18.2	17.5
20-Jul	16.8	18.7	18.6	17.8
21-Jul	17.1	19.1	19.6	19.3
22-Jul	17.0	19.2	20.1	19.4
23-Jul	16.9	18.2	20.7	20.1
24-Jul	17.3	19.4	20.6	20.3
25-Jul	17.6	19.3	20.3	19.7
26-Jul	17.8	19.2	20.6	19.8
27-Jul	17.7	19.0	19.9	19.3
28-Jul	17.9	18.9	19.8	19.7
29-Jul	18.1	19.2	20.2	19.9
30-Jul	18.3	19.1	20.2	20.1
31-Jul	18.3	19.2	20.2	20.1

Date	Nechako River Cheslatta Falls (°C)	Nechako River Fort Fraser (°C)	Nechako River above Stuart River (°C)	Nautley Fort Fraser (°C)
1-Aug	18.0	19.0	19.9	19.0
2-Aug	17.7	17.6	18.6	18.3
3-Aug	17.3	18.0	18.4	18.6
4-Aug	17.4	18.7	18.7	19.0
5-Aug	17.8	19.4	19.7	19.0
6-Aug	17.8	18.9	19.8	19.5
7-Aug	17.2	18.0	19.1	18.7
8-Aug	17.3	18.6	18.8	19.2
9-Aug	17.5	18.9	19.2	19.0
10-Aug	17.7	19.0	19.9	20.2
11-Aug	18.0	19.3	20.8	20.3
12-Aug	18.1	19.4	21.0	20.2
13-Aug	18.1	19.3	20.8	19.8
14-Aug	18.3	19.4	20.5	19.5
15-Aug	17.9	19.2	19.9	19.6
16-Aug	17.8	18.7	19.5	19.4
17-Aug	17.8	18.8	19.4	19.3
18-Aug	18.0	19.0	19.9	19.5
19-Aug	18.4	20.0	19.7	19.4
20-Aug	18.8	N / A	20.1	N / A

N/A - Temperatures not available

APPENDIX C

Mean Daily Skins Lake Spillway Releases and Flows in the Nechako and Nautley Rivers, 1990

Appendix C
Mean Daily Skins Lake Spillway Release and Flows in the Nechako and Nautley River, 1990

Date	Skins Lake Spillway Release (m^3/s)	Nechako River Cheslatta Falls (m^3/s)	Nechako River At Vanderhoof (m^3/s)	Nautley Fort Fraser (m^3/s)
10-Jul	49.0	56.1	141	52.9
11-Jul	49.0 to 227 @1600 hrs	56.1	141	52.3
12-Jul	227	56.1	141	52.3
13-Jul	227	70.4	141	51.2
14-Jul	227	90.0	143	49.5
15-Jul	227	108	152	48.4
16-Jul	227	124	168	47.9
17-Jul	227	139	188	47.4
18-Jul	227 to 170 @1600 hrs	154	203	47.4
19-Jul	170	169	218	46.8
20-Jul	170 to 453 @1600 hrs	172	226	N/A
21-Jul	453	179	236	45.3
22-Jul	453 to 14.2 @1600 hrs	227	256	43.6
23-Jul	14.2 to 453 @1600 hrs	253	276	42.3
24-Jul	453 to 283 @1600 hrs	235	282	41.8
25-Jul	283	264	277	41.3
26-Jul	283	272	292	40.3
27-Jul	283	275	302	35.1
28-Jul	283	278	304	39.3
29-Jul	283	281	307	36.4
30-Jul	283	287	309	36.0
31-Jul	283	287	311	35.1
1-Aug	283 to 14.2 @1600 hrs	289	312	35.1
2-Aug	14.2	281	314	32.9
3-Aug	14.2	250	312	32.1
4-Aug	14.2	214	281	31.7
5-Aug	14.2 to 170 @800 hrs 170 to 453 @1600 hrs	184	244	30.6
6-Aug	453	172	214	30.6
7-Aug	453 to 283 @2000 hrs	214	198	29.1
8-Aug	283 to 14.2 @1400 hrs	255	210	28.1
9-Aug	14.2 to 453 @1600 hrs	255	244	28.1

Appendix C (Continued)
Mean Daily Skins Lake Spillway Release and Flows in the Nechako and Nautley River, 1990

Date	Skins Lake Spillway Release (m^3/s)	Nechako River Cheslatta Falls (m^3/s)	Nechako River At Vanderhoof (m^3/s)	Nautley Fort Fraser (m^3/s)
10-Aug	453 to 283 @1600 hrs	235	266	27.3
11-Aug	283	261	249	26.7
12-Aug	283 to 18.4 @1400 hrs	269	256	26.0
13-Aug	18.4 to 13.7 @900 hrs	264	273	25.1
14-Aug	13.7	232	276	25.4
15-Aug	13.7 to 170 @1600 hrs	203	253	25.1
16-Aug	170 to 14.2 @1300 hrs	174	227	24.8
17-Aug	14.2	164	204	25.1
18-Aug	14.2	147	190	24.5
19-Aug	14.2	127	177	23.8
20-Aug	14.2	114	163	23.5
21-Aug	14.2	100	156	23.3
22-Aug	14.2	90.2	146	23.2
23-Aug	14.2	81.2	137	22.1
24-Aug	14.2	73.2	124	21.6
25-Aug	14.2	66.9	114	20.6
26-Aug	14.2	61.5	105	19.7
27-Aug	14.2	56.2	97.8	20.1
28-Aug	14.2	51.9	91.5	19.4
29-Aug	14.2	48.2	85.2	18.5
30-Aug	14.2	44.8	80.1	18.3
31-Aug	14.2 to 30.8 @ 2000 hrs	41.9	76.5	18.4
1-Sep	30.8	39.8	72.6	18.3
2-Sep	30.8	38.0	69.1	17.8
3-Sep	30.8	36.6	66.1	17.5
4-Sep	30.8	35.5	63.2	17.3
5-Sep	30.8	35.2	61.1	16.6
6-Sep	30.8	34.4	59.6	16.5

Note: Vanderhoof flow data from July 10 to July 31 are published WSC values as guaged flows were unavailable during this time

APPENDIX D
Observed and Forecast Meteorological Data

15.90	701.00	0.46	9.20	5.60	93.80	68.80	9 7 90
18.00	730.00	0.10	8.00	4.00	94.20	52.00	10 7 90
21.50	695.00	0.30	9.00	7.00	94.00	45.00	
19.50	630.00	0.40	10.00	10.00	93.80	54.00	
16.50	700.00	0.20	8.00	10.00	94.00	57.00	
17.00	700.00	0.20	7.00	7.00	94.40	52.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED JUL 10/90

19.70	724.00	0.18	9.40	6.20	94.00	55.80	10 7 90
21.00	700.00	0.10	11.50	7.00	94.00	55.00	11 7 90
20.00	670.00	0.35	12.00	10.00	93.60	60.00	
16.00	570.00	0.45	9.50	13.00	94.00	65.00	
16.00	705.00	0.20	7.00	6.00	94.10	55.00	
17.50	590.00	0.40	9.00	9.00	93.80	57.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED JUL 11/90

21.70	721.00	0.18	11.30	7.70	93.80	55.50	11 7 90
21.50	660.00	0.37	12.00	9.00	93.50	58.00	12 7 90
18.00	680.00	0.35	9.50	11.00	93.80	58.00	
17.00	720.00	0.20	8.50	8.00	94.20	57.00	
18.00	675.00	0.30	9.00	7.00	93.80	56.00	
19.00	482.00	0.55	11.00	9.00	93.40	60.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED JUL 12/90

18.70	676.00	0.34	10.90	9.30	93.60	62.10	12 7 90
16.50	700.00	0.20	5.50	12.00	94.40	48.00	13 7 90
16.00	724.00	0.15	6.50	9.00	94.30	53.00	
16.50	675.00	0.35	8.00	7.00	93.70	57.00	
17.50	489.00	0.60	10.00	9.00	93.10	61.00	
16.50	458.00	0.65	11.00	10.00	93.20	69.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED JUL 13/90

15.50	528.00	0.17	4.00	14.00	94.30	50.90	13 7 90
14.50	608.00	0.24	4.50	5.00	94.30	51.00	14 7 90
16.50	570.00	0.45	7.50	7.00	93.60	55.00	
16.00	450.00	0.60	9.00	9.00	93.10	63.00	
15.50	420.00	0.70	9.50	10.00	93.20	67.00	
15.00	420.00	0.70	9.00	9.00	93.50	67.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED JUL 14/90

14.80	598.60	0.38	3.50	4.10	94.20	50.60	14 7 90
16.50	363.00	0.85	8.00	6.50	93.50	57.00	15 7 90
16.00	500.00	0.70	9.00	9.00	93.30	63.00	
15.50	420.00	0.75	9.50	10.00	93.40	67.00	
15.50	420.00	0.80	9.50	9.00	93.50	67.00	
15.50	362.00	0.80	10.00	9.00	93.50	70.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED JUL 15/90

15.50	397.00	0.79	8.60	6.30	93.40	64.30	15 7 90
15.00	433.00	0.70	6.30	13.00	93.40	56.00	16 7 90
15.00	424.00	0.75	8.00	11.00	93.80	63.00	
15.00	360.00	0.85	9.50	10.00	93.60	70.00	
15.50	336.00	0.80	9.00	7.00	93.50	65.00	
16.00	550.00	0.55	8.00	5.00	93.40	59.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED JUL 16/90

13.80	382.00	0.70	4.20	12.00	93.40	52.90	16 7 90
12.50	555.00	0.40	5.00	9.00	93.90	60.00	17 7 90
14.00	545.00	0.40	6.50	11.00	93.80	61.00	
14.00	542.00	0.40	6.50	10.00	94.10	61.00	
15.00	580.00	0.30	7.00	8.00	93.80	59.00	
16.50	690.00	0.25	7.00	4.00	94.10	53.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED JUL 17/90

12.50	541.30	0.45	4.80	6.80	93.90	62.00	17 7 90
13.50	220.00	0.78	7.50	6.00	94.20	67.00	18 7 90
15.00	580.00	0.35	6.00	5.00	94.40	55.00	
15.00	630.00	0.20	6.00	4.00	94.40	55.00	
15.00	690.00	0.15	6.00	5.00	94.00	55.00	
17.00	590.00	0.25	8.00	8.00	93.80	55.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED JUL 18/90

13.50	410.90	0.74	8.20	6.80	94.20	71.20	18 7 90
15.00	630.00	0.15	5.00	10.00	94.40	51.00	19 7 90
15.00	660.00	0.10	5.00	7.00	94.50	51.00	
15.50	700.00	0.10	6.00	4.00	94.20	53.00	
17.00	590.00	0.25	8.00	7.00	94.00	55.00	
17.50	510.00	0.55	9.00	10.00	93.50	57.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED JUL 19/90

Appendix D (Continued)
Observed and Forecast Meteorological Data

15.50	699.00	0.17	5.10	12.60	94.40	52.80	19 7 90
17.00	713.00	0.05	6.50	11.00	94.40	50.00	20 7 90
18.00	710.00	0.05	7.00	5.00	94.30	49.00	
18.50	600.00	0.25	8.00	7.00	93.80	50.00	
18.50	510.00	0.45	9.00	9.00	93.30	54.00	
18.00	472.00	0.55	9.50	12.00	93.50	58.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED JUL 20/90

17.50	712.40	0.05	5.30	10.80	94.30	48.60	20 7 90
17.50	710.00	0.05	7.00	4.00	94.10	50.00	21 7 90
19.50	670.00	0.20	10.50	6.00	93.40	56.00	
19.50	510.00	0.50	11.00	9.00	93.20	58.00	
18.00	445.00	0.60	10.50	12.00	93.30	62.00	
17.50	510.00	0.40	9.50	10.00	93.50	59.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED JUL 21/90

17.50	699.40	0.06	6.40	2.50	94.00	53.30	21 7 90
18.50	661.00	0.10	8.00	4.00	93.50	50.00	22 7 90
19.50	510.00	0.50	10.50	8.00	93.20	58.00	
17.00	376.00	0.75	11.00	11.00	93.20	68.00	
17.00	440.00	0.65	10.50	10.00	93.40	66.00	
16.50	485.00	0.50	9.00	11.00	93.60	61.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED JUL 22/90

18.80	685.40	0.09	7.00	3.20	93.40	50.30	22 7 90
21.00	540.00	0.45	10.00	5.00	93.00	50.00	23 7 90
20.50	485.00	0.50	11.00	5.00	93.00	54.00	
19.50	410.00	0.60	11.00	8.00	93.30	58.00	
17.50	502.00	0.50	10.00	11.00	93.40	61.00	
17.00	670.00	0.30	7.50	10.00	93.60	54.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED JUL 23/90

20.10	599.20	0.41	9.80	4.50	92.90	53.80	23 7 90
19.50	580.00	0.33	11.50	7.00	93.00	60.00	24 7 90
19.50	490.00	0.50	11.00	7.00	93.00	58.00	
18.50	460.00	0.50	11.00	11.00	93.20	62.00	
16.00	530.00	0.40	8.00	10.00	93.50	58.00	
16.50	610.00	0.30	7.00	9.00	93.60	53.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED JUL 24/90

Appendix D (Continued)
Observed and Forecast Meteorological Data

19.20	621.30	0.28	11.10	8.80	92.90	62.30	24 7 90
20.00	540.00	0.35	12.50	8.50	93.00	62.00	25 7 90
18.00	543.00	0.40	11.00	10.00	93.30	60.00	
16.50	442.00	0.64	9.50	12.00	93.70	63.00	
17.00	590.00	0.40	8.00	10.00	93.80	55.00	
17.00	665.00	0.15	7.50	7.00	94.10	54.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED JUL 25/90

20.90	618.00	0.21	12.20	6.10	93.00	61.70	25 7 90
21.50	615.00	0.25	8.00	12.00	93.40	42.00	26 7 90
18.00	600.00	0.35	8.00	11.00	93.70	52.00	
18.00	670.00	0.05	8.00	7.00	94.10	52.00	
18.50	667.00	0.10	8.00	6.00	93.90	50.00	
19.50	600.00	0.20	9.50	10.00	93.80	52.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED JUL 26/90

20.40	681.40	0.23	6.60	14.30	93.30	42.30	26 7 90
17.50	682.00	0.10	6.00	12.00	94.10	47.00	27 7 90
17.50	675.00	0.10	7.00	9.00	94.30	50.00	
18.50	665.00	0.15	8.00	6.00	94.30	50.00	
19.50	655.00	0.15	9.00	9.00	93.90	51.00	
19.50	620.00	0.20	9.00	10.00	93.70	51.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED JUL 27/90

17.40	650.00	0.15	6.30	7.90	94.00	49.30	27 7 90
17.00	650.00	0.10	7.50	4.00	94.30	54.00	28 7 90
18.00	660.00	0.10	8.00	6.00	94.30	52.00	
19.00	630.00	0.25	8.50	8.00	93.80	51.00	
18.50	590.00	0.30	9.00	10.00	93.50	54.00	
17.00	590.00	0.35	9.00	10.00	93.50	59.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED JUL 28/90

17.90	661.40	0.12	7.90	4.10	94.30	56.20	28 7 90
19.00	660.00	0.10	9.00	6.00	94.10	52.00	29 7 90
20.00	650.00	0.15	10.50	7.00	93.70	54.00	
18.00	490.00	0.45	10.00	12.00	93.30	60.00	
16.00	453.00	0.60	9.00	11.00	93.20	63.00	
15.00	530.00	0.55	7.50	12.00	93.30	61.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED JUL 29/90

Appendix D (Continued)
Observed and Forecast Meteorological Data

20.00	661.00	0.08	9.50	4.30	94.00	55.60	29 7 90
21.00	580.00	0.22	10.50	4.00	93.70	51.00	30 7 90
19.00	500.00	0.45	10.00	11.00	93.40	56.00	
16.50	500.00	0.45	9.00	13.00	93.50	61.00	
15.50	500.00	0.45	8.00	10.00	93.60	61.00	
15.50	495.00	0.45	8.00	7.00	93.70	61.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED JUL 30/90

20.10	534.40	0.40	9.50	5.40	93.60	54.80	30 7 90
21.50	500.00	0.55	10.00	14.00	93.40	48.00	31 7 90
17.50	470.00	0.60	10.00	13.00	93.40	61.00	
16.50	450.00	0.65	10.00	10.00	93.60	65.00	
15.50	550.00	0.45	8.50	8.00	93.70	63.00	
16.50	470.00	0.60	8.00	8.00	94.00	57.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED JUL 31/90

20.50	386.40	0.47	8.00	15.50	93.30	46.80	31 7 90
17.50	530.00	0.36	5.00	12.00	93.30	44.00	1 8 90
16.00	417.00	0.70	8.00	10.00	93.70	59.00	
15.50	414.00	0.65	10.00	8.00	93.90	70.00	
16.50	535.00	0.45	8.00	5.00	93.60	57.00	
18.00	459.00	0.55	9.00	8.00	93.40	56.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED AUG 01/90

16.90	507.90	0.48	4.20	9.40	93.30	44.00	1 8 90
13.50	480.00	0.70	5.00	8.00	93.70	56.00	2 8 90
15.00	421.00	0.65	8.00	7.00	94.10	63.00	
17.00	550.00	0.45	9.00	6.00	94.00	59.00	
18.00	442.00	0.55	8.00	9.00	93.50	52.00	
17.00	547.00	0.40	8.00	8.00	93.70	55.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED AUG 02/90

13.80	464.00	0.53	6.20	7.70	93.70	62.10	2 8 90
16.00	421.00	0.55	9.00	8.00	94.10	63.00	3 8 90
18.50	550.00	0.30	9.00	6.00	94.20	54.00	
20.00	601.00	0.25	9.00	9.00	93.70	49.00	
17.50	456.00	0.55	9.00	11.00	93.40	57.00	
15.50	610.00	0.20	7.00	7.00	93.60	57.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED AUG 03/90

Appendix D (Continued)
Observed and Forecast Meteorological Data

15.90	432.30	0.71	10.00	6.80	94.10	70.20	3 8 90
17.00	550.00	0.28	10.00	3.00	94.20	63.00	4 8 90
19.00	570.00	0.30	10.50	7.00	93.50	58.00	
16.50	350.00	0.65	10.00	12.00	93.30	65.00	
15.00	550.00	0.20	7.00	10.00	93.80	59.00	
14.50	625.00	0.15	6.00	6.00	94.30	55.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED AUG 04/90

18.60	610.70	0.25	10.70	3.70	94.10	64.00	4 8 90
20.50	615.00	0.30	10.50	5.00	93.60	53.00	5 8 90
17.00	450.00	0.45	9.00	12.00	93.90	59.00	
14.00	590.00	0.25	7.00	7.00	94.10	63.00	
14.00	630.00	0.15	5.00	4.00	94.20	55.00	
16.00	620.00	0.15	6.00	4.00	94.20	51.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED AUG 05/90

23.00	622.80	0.31	9.00	6.90	93.40	46.90	5 8 90
20.00	430.00	0.65	7.50	10.00	93.50	44.00	6 8 90
16.00	520.00	0.45	7.00	7.00	94.00	55.00	
16.50	465.00	0.55	8.00	6.00	94.10	57.00	
16.50	590.00	0.25	7.00	6.00	94.10	53.00	
18.00	570.00	0.25	8.00	7.00	94.00	52.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED AUG 06/90

18.90	446.00	0.74	5.30	10.30	93.50	43.30	6 8 90
14.50	420.00	0.70	6.00	6.00	94.00	57.00	7 8 90
17.50	550.00	0.40	7.00	5.00	94.10	50.00	
17.50	600.00	0.25	6.00	7.00	94.10	47.00	
18.50	605.00	0.20	7.00	5.00	94.10	47.00	
20.00	600.00	0.20	8.00	4.00	93.80	43.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED AUG 07/90

14.30	352.00	0.60	5.60	4.00	94.10	57.60	7 8 90
15.00	530.00	0.40	7.50	2.00	94.10	61.00	8 8 90
17.00	600.00	0.25	8.00	5.00	94.00	55.00	
17.50	605.00	0.20	8.00	6.00	93.90	54.00	
19.50	480.00	0.45	10.50	10.00	93.40	56.00	
18.00	430.00	0.60	9.00	13.00	93.40	56.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED AUG 08/90

Appendix D (Continued)
Observed and Forecast Meteorological Data

15.80	527.00	0.40	7.70	0.30	94.00	63.50	8 8 90
20.50	550.00	0.30	10.50	2.00	94.10	53.00	9 8 90
21.00	599.00	0.20	10.50	4.00	94.20	51.00	
20.50	599.00	0.10	10.00	6.00	93.90	51.00	
20.50	550.00	0.25	10.00	10.00	93.60	51.00	
19.00	499.00	0.35	9.00	11.00	93.40	52.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED AUG 09/90

20.00	597.00	0.32	10.40	1.50	94.10	56.90	9 8 90
19.50	599.00	0.05	10.50	3.00	94.30	56.00	10 8 90
20.00	595.00	0.05	10.50	5.00	94.30	54.00	
20.00	590.00	0.25	10.00	7.00	93.80	53.00	
19.00	423.00	0.45	10.50	10.00	93.40	58.00	
18.50	395.00	0.65	10.00	13.00	93.30	58.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED AUG 10/90

20.40	610.00	0.10	10.40	2.40	94.10	57.40	10 8 90
23.50	602.00	0.10	11.00	7.00	94.10	47.00	11 8 90
23.00	598.00	0.25	11.00	7.00	93.70	47.00	
20.50	423.00	0.55	11.50	9.00	93.00	56.00	
18.50	395.00	0.65	10.00	10.00	93.00	58.00	
18.00	520.00	0.40	9.00	13.00	93.20	56.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED AUG 11/90

23.00	599.00	0.14	10.60	5.30	93.90	50.00	11 8 90
23.00	520.00	0.25	11.00	5.00	93.50	50.00	12 8 90
20.50	460.00	0.55	11.50	8.00	93.00	56.00	
18.00	330.00	0.70	11.00	6.00	93.00	64.00	
17.50	385.00	0.70	10.00	7.00	93.00	61.00	
16.50	470.00	0.55	8.50	6.00	92.90	59.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED AUG 12/90

22.60	548.90	0.27	11.00	3.40	93.50	52.40	12 8 90
23.00	510.00	0.35	10.50	7.00	93.20	45.00	13 8 90
21.00	510.00	0.35	10.00	7.00	92.90	49.00	
17.00	395.00	0.65	9.50	6.00	93.00	61.00	
17.00	327.00	0.70	10.00	9.00	93.00	63.00	
16.00	400.00	0.65	8.00	11.00	93.40	59.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED AUG 13/90

Appendix D (Continued)
Observed and Forecast Meteorological Data

22.80	528.20	0.25	11.00	5.50	93.10	49.40	13 8 90
18.50	319.00	0.60	11.50	5.00	93.00	65.00	14 8 90
17.50	370.00	0.60	11.00	6.00	93.00	66.00	
16.00	328.00	0.70	9.50	6.00	93.30	65.00	
16.00	480.00	0.55	7.50	8.00	93.40	57.00	
16.50	430.00	0.40	8.00	10.00	93.50	57.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED AUG 14/90

18.30	389.80	0.54	11.90	3.80	93.00	67.80	14 8 90
17.00	400.00	0.60	10.50	10.00	92.80	66.00	15 8 90
16.00	380.00	0.70	9.50	7.00	93.00	65.00	
14.50	280.00	0.80	9.00	7.00	93.40	70.00	
15.50	470.00	0.50	7.00	10.00	93.50	57.00	
16.00	500.00	0.35	7.00	11.00	93.80	55.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED AUG 15/90

16.70	340.50	0.59	10.90	6.90	92.80	69.80	15 8 90
17.00	346.00	0.85	11.50	5.00	93.00	70.00	16 8 90
16.00	290.00	0.90	11.50	7.00	93.20	75.00	
15.50	335.00	0.85	11.50	8.00	93.40	77.00	
16.00	440.00	0.50	9.00	10.00	93.70	63.00	
16.00	470.00	0.35	7.50	8.00	93.80	57.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED AUG 16/90

16.30	378.00	0.83	11.50	2.80	93.10	74.80	16 8 90
16.50	347.00	0.85	11.50	5.00	93.30	72.00	17 8 90
17.00	385.00	0.70	11.00	7.00	93.30	68.00	
16.50	470.00	0.45	9.00	10.00	93.40	61.00	
16.50	420.00	0.50	8.00	10.00	93.50	57.00	
16.50	420.00	0.50	8.00	10.00	93.30	57.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED AUG 17/90

16.60	339.10	0.62	11.10	4.50	93.20	72.10	17 8 90
15.00	370.00	0.55	10.00	5.00	93.30	65.00	18 8 90
17.00	460.00	0.45	10.00	6.00	93.40	60.00	
17.00	400.00	0.50	10.00	8.00	93.40	60.00	
16.50	410.00	0.50	10.00	10.00	93.10	63.00	
15.00	350.00	0.70	9.50	15.00	93.10	70.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED AUG 18/90
17 08 90 RAD VALUE THAT OF F.FRASER (339.10) AS P.GEORGE N/A

16.30	476.60	0.44	10.10	3.80	93.40	68.80	18 8 90
17.00	540.00	0.10	9.50	3.50	93.80	63.00	19 8 90
17.50	480.00	0.30	10.00	6.00	93.40	61.00	
15.50	370.00	0.65	10.00	10.00	92.90	70.00	
13.50	280.00	0.70	9.00	15.00	93.00	74.00	
11.50	420.00	0.45	6.00	15.00	93.60	69.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED AUG 19/90

17.40	569.20	0.08	8.80	3.00	93.70	61.90	19 8 90
19.20	560.00	0.12	8.50	4.00	93.50	51.00	20 8 90
18.50	460.00	0.50	9.50	10.00	92.80	56.00	
14.50	320.00	0.75	9.50	15.00	92.70	72.00	
13.50	280.00	0.75	8.00	14.00	93.00	72.00	
12.00	280.00	0.75	7.00	12.00	93.00	72.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

WORLD WEATHERWATCH FORECAST ISSUED AUG 20/90

APPENDIX E

Summer Water Temperature and Flow Management Project Reservoir Release Volume Calculations for July 10 to August 20, 1990

Appendix E
Summer Water Temperature and Flow Management Project Reservoir Release Volume Calculations
for July 10 to August 20, 1990

Skins Lake Spillway base release for the period July 10 (191) to August 20 (232) = 49.0 m^3/s (1,730 cfs)
Therefore, Summer Water Temperature and Flow Management Project Base Volume = (232 - 190) * 49.0
= 2,058.0 m^3/s-days

Time period (Julian Day)	Time (hrs)	Flow Rate (m^3/s)	Volume (m^3/s-hrs)
July 10(192) @ 0000 hrs to July 11(192) @ 1600hrs	40	49.0	1,960
July 11(192) @ 1600 hrs to July 18 (199) @ 1600 hrs	168	227	38,136
Jul 18 (199) @ 1600 hrs to July 20 (201) @ 1600 hrs	48	170	8,160
Jul 20 (201) @ 1600 hrs to July 22(203) @ 1600 hrs	48	453	21,744
July 22 (203) @ 1600 hrs to July 23(204) @ 1600 hrs	24	14.2	341
July 23(204) @ 1600 hrs to July 24(205) @1600 hrs	24	453	10,872
July 24 (205) @ 1600 hrs to August 1 (213) @ 1600 hrs	192	283	54,336
August 1 (213) @ 1600 hrs to August 5 (217) @ 0800 hrs	88	14.2	1,250
August 5 (217) @ 0800 hrs to August 5 (217) @ 1600 hrs	8	170	1,360
August 5 (217) @ 1600 hrs to August 7 (219) @ 2000 hrs	52	453	23,556
August 7 (219) @ 2000 hrs to August 8 (220) @ 1400 hrs	18	283	5,094
August 8 (220) @ 1400 hrs to August 9 (221) @ 1600 hrs	26	14.2	369
August 9 (221) @ 1600 hrs to August 10 (222) @ 1600 hrs	24	453	10,872
August 10 (222) @ 1600 hrs to August 12 (224) @ 1400 hrs	46	283	13,018
August 12 (224) @ 1400 hrs to August 13(225) @ 0900 hrs	19	18.4	350
August 13 (225) @ 0900 hrs to August 15 (227) @ 1600 hrs	55	13.7	753
August 15 (227) @ 1600 hrs to August 16 (228) @ 1300 hrs	21	170	3,570
August 16 (228) @ 1300 hrs to August 20 (232) @ 2400 hrs	107	14.2	1,519
Total	1008 (42 days)		197,260

Total Release Volume
= 197,260 m^3/s-hrs
= 8,219.2 m^3/s-days

Therefore, Volume Released for Cooling Purpos
= Total Volume - Base Volume
= 8,219.2 - 2,058.0
= 6,161.2 m^3/s-days

Average Flow over Summer Management Perio
(July 10 to August 20, 1990)
= 8,219.2 m^3/s-days / 42 days
= 195.7 m^3/s
= 6,911 cfs