DORIS NORTH PROJECT
HYDROCLIMATIC PARAMETER RE-EVALUATION
2006

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Executive Summary

Background

Miramar Hope Bay Limited (MHBL) proposes to construct and operate a new underground gold mine ("Doris North Project") in the West Kitikmeot Region of Nunavut. The project is located 685 km northeast of Yellowknife and 160 km southwest of Cambridge Bay. The mine is on Inuit-owned land, approximately 5 km south of the Arctic Ocean.

Intervenor submissions during regulatory hearings (INAC 2004, 2006a) suggested that estimates of mean annual precipitation and mean annual runoff derived in the Meteorology and Hydrology Baseline Study (the baseline study) (AMEC 2003) could be low, and result in inaccurate water balance modelling. During preparation of the Environmental Impact Statement for the project, two sets of hydroclimatic values were used. One set ("dry case") was based on the values presented in the baseline study, and the second set ("wet case") was based on a wetter scenario as suggested by regulators and intervenors.

Objectives

This report was prepared to comply in part with NIRB Project Certificate Condition 14, which states that "MHBL shall collect additional precipitation, evaporation and runoff data and incorporate it into a revised water balance to be submitted to the NWB as part of the water licence application." The objective of this report is to re-evaluate baseline hydroclimatic parameters, including mean annual rainfall, snowfall and precipitation, evaporation, and water yield. The water balance focuses on the Tail Lake tailings impoundment and Doris Lake and outflow as a source of water supply and for disposal of treated tailings decant water. Because these waterbodies have the capacity to store water, the water balance is most sensitive to annual values, and the cumulative effects of successive years of precipitation, rather than short-duration events. Therefore, the focus of this report is to establish whether the mean annual values presented in the baseline study are accurate or whether they should be revised for use in future water balance modelling.

Data Sources

Data used during the baseline study included long-term climatic and hydrometric data reported by Environment Canada (Environment Canada 2006; Hydat 2006), as well as short-term climatic and hydrometric data collected in the Doris North area (Rescan 2002).

Subsequent to the baseline study, MHBL has undertaken additional studies from which climatic and hydrometric data are available for the period 2003 to 2006 (RL&L/Golder 2003; Golder 2005, 2006a, 2006b). Additional relevant climatic data were received from Indian and Northern Affairs Canada (INAC 2006b), and a precipitation analysis by the Canadian Institute for Climate Studies (CICS 2004) was also considered.

Summary of Results

Monthly and annual rainfall in the Doris North area are similar to that recorded at the Environment Canada climate station at Cambridge Bay. This is based on three years of concurrent data for the two stations, and is further supported by nine years of concurrent data for Cambridge Bay and the INAC Walker Bay climate station. Thus, the recommendations of the baseline study are supported.

Comparison of snowfall at the local and regional climate stations is complicated by the use of different measurement methods (snow-on-ground, snowfall gauging and snowcourse surveys) and by variations in snow density, consolidation, melt and sublimation of the snowpack, exposure and wind redistribution. However, the snow water equivalent displays a decreasing trend to the north, and snow water equivalents measured at Doris North from 2004 to 2006 are consistent with those reported for the Environment Canada climate station at Cambridge Bay. Thus, the recommendations of the baseline study are supported.

Based on the recommendations of the baseline study with regards to mean annual rainfall and snowfall at Doris North, it follows that recommendations with regards to mean annual precipitation are also supported.

The conclusions of the baseline report with regards to lake evaporation are further supported by the new data. Previous studies have established a decreasing gradient in lake evaporation to the northeast, and have established reliable long-term mean values at sites to the southwest. The baseline estimate is supported by these observations, as well as one year of local pan evaporation data and three years of local calculated evaporation data.

A decreasing gradient in water yield to the northeast exists in the region surrounding Doris North. Local annual water yield data are only available for five years, but indicate that water yields at Doris North are lower than those for the Ellice River, as suggested by the baseline study. The mean annual water yield measured at Doris North over the monitoring period is less than that estimated by the baseline study, but given the short monitoring period and the fact that monitoring took place during regional dry conditions, it is unlikely to be representative of long-term conditions. The baseline study conclusion that the

mean annual water yield at Doris North is substantially lower than that of the Ellice River is supported by the additional data collected subsequent to the baseline study.

Recommendations

Water balance modelling for the Doris North project currently considers two sets of data. One set reflects the conditions estimated by the baseline study (dry case) and one set incorporates higher runoff estimates, as suggested by intervenors and regulators (wet case). Both of these cases were modelled to account for uncertainty in local conditions.

The climate and hydrology data that were collected during post-baseline monitoring (2003 to 2006) are consistent with the results of the baseline study, and do not support the suggestion that conditions at Doris North are similar to those of areas to the west (Kugluktuk) or south (Ellice River watershed). This supports use of the “dry case” scenario for water balance modelling at Doris North.

However, the available data include only three years of complete annual data (precipitation, evaporation and water yields for 2004 to 2006) and an additional two years of partial annual data (water yields for 1997 and 2000). Furthermore, it appears that the three years of complete data occurred during years that may have been drier than average in the region. Therefore, it would still be prudent to model the “wet case” scenario to continue to account for existing uncertainty.

It is recommended that climate and hydrology monitoring continue at Doris North, prior to and during operations. This will provide additional data to confirm local hydroclimatic conditions and to provide vital input for water management and adaptive management planning during project construction, operations and closure.

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1.0 INTRODUCTION

1.1 PROJECT DESCRIPTION

Miramar Hope Bay Limited (MHBL) proposes to construct and operate a new underground gold mine ("Doris North Project") in the West Kitikmeot Region of Nunavut. The project is located 685 km northeast of Yellowknife and 160 km southwest of Cambridge Bay. The mine is on Inuit owned land, approximately 5 km south of the Arctic Ocean. The nearest communities are Umingmaktok, located 65 km to the west, and Bathurst Inlet located 110 km to the southwest. The general location of the project is shown in Figure 1.1.

1.2 STUDY OBJECTIVES

Intervenor submissions during regulatory hearings (INAC 2004, 2006a) suggested that estimates of mean annual precipitation and mean annual runoff derived in the Meteorology and Hydrology Baseline Study (the baseline study) (AMEC 2003) could be low, and result in inaccurate water balance modelling. During preparation of the Environmental Impact Statement for the project, two sets of hydroclimatic values were used. One set was based on the values presented in the baseline study, and the second set was based on a wetter scenario as suggested by regulators and intervenors.

This report was prepared to comply in part with NIRB Project Certificate Condition 14, which states that "MHBL shall collect additional precipitation, evaporation and runoff data and incorporate it into a revised water balance to be submitted to the NWB as part of the water licence application." The objective of this report is to re-evaluate baseline hydroclimatic parameters, including mean annual rainfall, snowfall and precipitation, evaporation and water yield. The water balance focuses on the Tail Lake tailings impoundment and Doris Lake and outflow as a source of water supply and for disposal of treated tailings decant water. Because these waterbodies have the capacity to store water, the water balance is most sensitive to annual values, and the cumulative effects of successive years of precipitation, rather than short-duration events. Therefore, the focus of this report is to establish whether the mean annual values presented in the baseline study are accurate or whether they should be revised for use in future water balance modelling.

1.3 DATA SOURCES

Data used during the baseline study included long-term climatic and hydrometric data reported by Environment Canada (Environment Canada 2006; Hydat 2006), as well as short-term climatic and hydrometric data collected in the Doris North area (Rescan 2002).

100 0 100

SCALE KILOMETRES

REFERENCE

BASE MAP PROVIDED BY RESCAN, FEBRUARY 17, 1998

Miramar MINING CORPORATION

TITLE

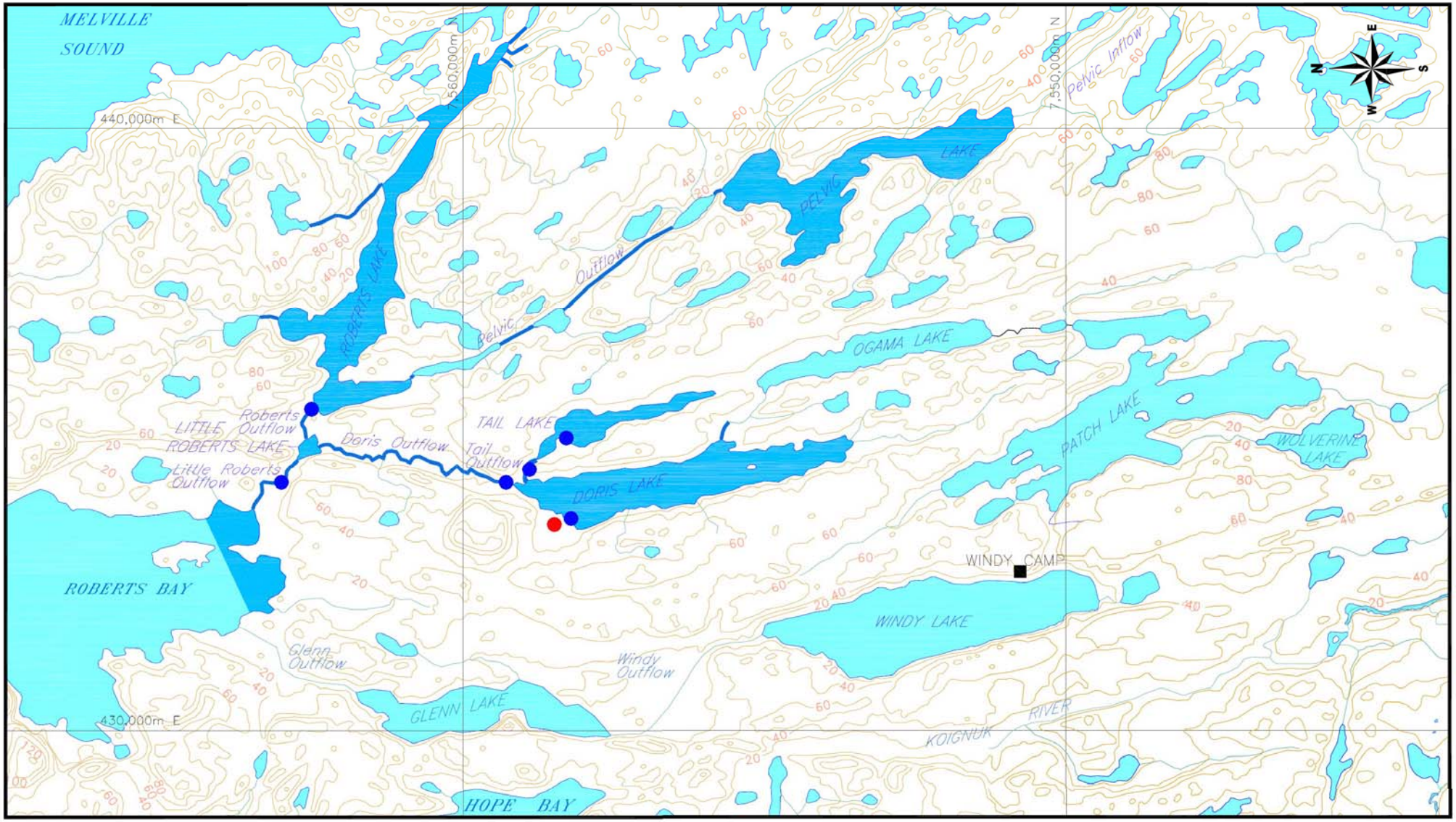
HOPE BAY BELT
PROJECT LOCATION MAP

Golder Associates
Calgary, Alberta

PROJECT 03-1370-007.3000			FILE No.	Project Location
DESIGN	JP	12/07/02	SCALE 1:4000000	REV. 0
CADD	PSR	18/11/03		
CHECK	AL			
REVIEW				

FIGURE: 1.1

R:\CAD\7000\022-7009\ Drawing file: Project Location Map.dwg Jul 12, 2002 - 2:38pm



LEGEND

- Sampled Lakes or Ocean
- Sampled Stream
- Climate Station
- Hydrometric Station

Miramar MINING CORPORATION

1.2 0 1.2
Scale Km

NOTE : CONTOUR INTERVAL 20 m

REFERENCE
BASE MAP PROVIDED BY RESCAN, 22 JANUARY 2001

TITLE
CLIMATIC AND HYDROMETRIC MONITORING SITES AT THE DORIS NORTH PROJECT

Golder Associates
Edmonton, Alberta

PROJECT No.	05-1373-014	FILE No.	1730439		
DESIGN	AS	25/10/04	SCALE	As shown	REV. 0
CADD	SC	25/10/04			
CHECK	AS	25/11/04			
REVIEW					

FIGURE: 1.2

Subsequent to the baseline study, MHBL has undertaken additional studies from which climatic and hydrometric data are available for the period 2003 to 2006 (RL&L/Golder 2003; Golder 2005, 2006a, 2006b). Additional relevant climatic data were received from Indian and Northern Affairs Canada (INAC 2006b), and a precipitation analysis by the Canadian Institute for Climate Studies (CICS 2004) was also considered.

1.4 OVERVIEW OF REPORT

The report summarizes and assesses available climatic and hydrometric data relevant to the Doris North project, including information considered during the baseline study and information collected or identified subsequent to the baseline study.

Section 2 of the report summarizes the data and results from the baseline study, as well as wetter scenario parameters suggested by regulators and interveners. Section 3 addresses mean annual precipitation, including rainfall and snowfall. Section 4 addresses mean annual evaporation, and Section 5 addresses mean annual water yield (runoff). Section 6 of the report provides conclusions and recommendations arising from the report.

More detailed summaries are included for data provided by Environment Canada (Appendix A) and INAC (Appendix B), and for data collected during the baseline study (Appendix C) and subsequent to the baseline study (Appendix D).

2.0 BASELINE HYDROCLIMATIC DATA

2.1 EIS BASELINE STUDY

2.1.1 Precipitation

The baseline study (AMEC 2003) presented values of monthly precipitation, snowfall and rainfall that were derived by multiple regression of Boston Camp rainfall data with data from the regional Environment Canada climate stations at Kugluktuk, Cambridge Bay and Lupin. Monthly snowfall values were derived using the same regression equation, due to a paucity of reliable snowfall data at Boston Camp. Values were derived for the period 1959 to 2001, and these were used to calculate monthly and annual mean values.

Rainfall and snowfall undercatch values for Doris North were estimated based on values reported by Metcalfe et al. (1994) for Environment Canada stations at Kugluktuk and Cambridge Bay. The mean annual precipitation values for Doris North and regional stations, as presented in the baseline study, are presented in Table 2.1.

Table 2.1 Derived Mean Annual Precipitation (AMEC 2003)

Location	Rainfall (mm)		Snowfall (cm)		Precipitation (mm)	
	Recorded	Corrected	Recorded	Corrected	Recorded	Corrected
Doris North	72	86	71	121	139	207
Undercatch Factor		1.19		1.71		1.53
Cambridge Bay	71	86	82	156	141	234
Undercatch Factor		1.21		1.91		1.66
Kugluktuk	121	141	146	220	235	327
Undercatch Factor		1.17		1.51		1.39
Lupin	143	n/a	130	n/a	274	n/a
Undercatch Factor		n/a		n/a		n/a

2.1.2 Lake Evaporation

The baseline study (AMEC 2003) presented derived values of mean monthly evaporation based primarily on regional data from the Lupin, Salmita and Koala climate stations. The baseline study also considered the one year, 1997, of pan evaporation data for Boston Camp that was considered reliable. The derived baseline mean annual evaporation data for Doris North are presented in

Table 2.2. It was also suggested that values for individual years could vary from the mean by +/-20%.

Table 2.2 Derived Mean Lake Evaporation (AMEC 2003)

Period	Days with Evaporation	Portion of Annual Evaporation	Mean Evaporation (mm)
June	15	0.16	35
July	31	0.43	95
August	31	0.35	77
September	30	0.06	13
Annual	105	1.00	220

2.1.3 Water Yield

The baseline study (AMEC 2003) presented derived values of mean monthly water yield based on correlations between short-term weekly data collected at Doris Lake and concurrent data reported for the Environment Canada hydrometric station on the Ellice River. Estimates for Tail Lake were then derived based on correlations between short-term weekly data collected at Tail and Doris lakes. The derived baseline mean monthly and annual water yields for Doris and Tail lakes are presented in Table 2.3.

Table 2.3 Derived Mean Water Yields for Doris and Tail Lakes (AMEC 2003)

Period	Doris Lake Outflow (mm)	Tail Lake Outflow (mm)
June	57.4	60.0
July	35.6	28.3
August	15.0	8.8
September	19.2	11.0
October	6.7	2.9
Annual	134	111

2.2 INTERVENOR AND REGULATOR OPINIONS

2.2.1 Precipitation

INAC (2004) suggested that the mean annual precipitation at Doris North could be as high as that reported for Kugluktuk, or up to 327 mm. An Environment Canada expert (Spence 2004) indicated that the mean annual precipitation of 207 mm (corrected for undercatch), as recommended in the baseline study, was reasonable. It was further indicated that the most conservative upper estimate of mean annual precipitation would be approximately 225 mm.

INAC (2006a) acknowledges that the lower estimates of mean annual precipitation are consistent with the baseline estimates of mean annual water yield, but provide unrealistically high runoff coefficient estimates if a larger water yield estimate of 180 mm is adopted (refer to Section 2.2.3).

2.2.2 Lake Evaporation

INAC (2004) stated that for lake evaporation, MHBL "adopted the value of 220 mm water for purposes of water balance analysis, with the proviso that this value could vary by +/-20 percent. In INAC's opinion, this value is acceptable, provided that its value is varied within an appropriate range as part of assessing sensitivity in the water balance analysis."

2.2.3 Water Yield

An Environment Canada expert (Spence 2004; Environment Canada 2004) indicated that the estimated baseline mean annual water yield of 134 mm for Doris Lake and 111 mm for Tail Lake could be low, and suggested that the actual mean annual water yield could be as large as 180 mm.

INAC (2004) questioned the approach by which long-term water yields for Doris and Tail lakes were estimated, and suggested that using a runoff coefficient approach would be more appropriate. Based on runoff coefficients of approximately 60%, as observed at Snap Lake, Diavik and Ekati, a mean annual water yield of approximately 131 mm would be appropriate.

INAC (2006a) suggested that if a mean annual water yield of 180 mm was adopted, a mean annual precipitation value of 300 mm would be realistic, based observed regional runoff coefficients. They also pointed out that a mean annual water yield of 180 mm and mean annual precipitation estimates of 207 to 225 mm indicate unrealistically high runoff coefficients of 80% to 87%.

3.0 ANNUAL PRECIPITATION

3.1 INTRODUCTION

Long-term precipitation data in the Doris North area are sparse. The Doris North Project Meteorology and Hydrology Baseline report (AMEC 2003) identified three Environment Canada climate stations with long-term periods of record. The baseline study judged local data collected at Boston and Windy Camps during the baseline study (Rescan 2002) to be unreliable. Local climate data have been collected by MHBL at the Doris North climate station since its installation in May 2003 (RL&L/Golder 2003; Golder 2005, 2006a, 2006b). Additional data for the period 1996 to 2005 are also available from the INAC Walker Bay climate station, located approximately 70 km from Doris North. Derived annual precipitation estimates for the Doris North project area are also available from the Canadian Institute for Climate Studies (CICS 2004).

Locations of these climate stations are shown in Figure 3.1.

3.2 ENVIRONMENT CANADA

Environment Canada currently operates long-term climate stations at the sites listed in Table 3.1. Data from these stations up to 2001 provided a basis for the derived Doris North precipitation values presented by AMEC (2003).

Table 3.1 Regional Environment Canada Climate Stations

Site	Station	Number	Period of Record	Elevation	Location	Distance and Direction from Doris North
Cambridge Bay	Cambridge Bay	2400600	1929 – 2006	27.4 m	69° 06’ N 105° 08’ W	125 km NW
Kugluktuk	Kugluktuk	2300902	1978 – 2001	22.6 m	67° 49’ N 115° 08’ W	350 km W
	Coppermine	2300900	1930 – 1977			
Lupin-Contwoyto	Lupin	23026HN	1982 – 2006	490.1 m	65° 45’ N 111° 15’ W	323 km SW
	Contwoyto Lake	2300850	1959 - 1981			

Annual rainfall, snowfall and precipitation data for these stations are presented in Appendix A, and a summary of the available data is provided in Table 3.2. These data are uncorrected for undercatch (refer to Section 3.4).

The data show that the long-term mean rainfall, snowfall and precipitation at Cambridge Bay is 58%, 56% and 59% of that at Kugluktuk, and is 50%, 62% and 52% of that at Lupin. These comparative values are similar for the concurrent period of record 1959 to 2005.

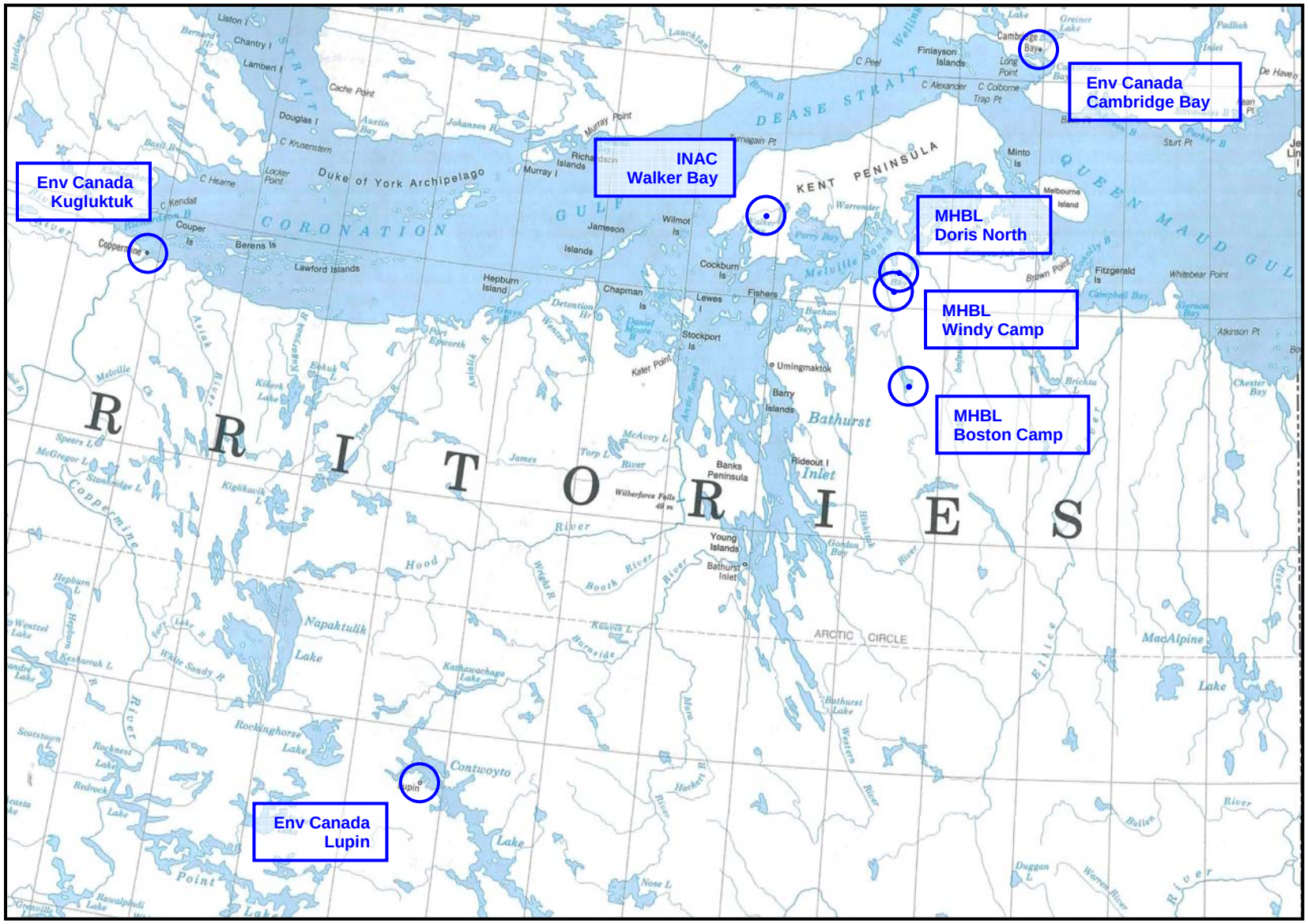


Figure 3.1 Locations of Climate Stations

Table 3.2 Regional Environment Canada Climate Stations

Site	Distance from Doris North	Period of Record	Statistic	Rainfall (mm)	Snowfall (cm)	Precipitation (mm)
Cambridge Bay	125 km NW	1949 to 2005[a]	Maximum	152.9	129.8	215.0
			Mean	70.8	77.2	138.5
			Minimum	26.6	41.0	81.4
Kugluktuk	350 km W	1935 to 2005[b]	Maximum	249.8	269.0	403.7
			Mean	123.1	137.2	234.4
			Minimum	33.4	46.0	109.7
Lupin-Contwoyto	323 km SW	1959 to 2005	Maximum	316.1	176.7	429.5
			Mean	140.4	124.9	265.5
			Minimum	73.8	38.5	164.6

(a) Excluding snowfall and precipitation for years with missing data: 1946 and 1979.
(b) Excluding rainfall, snowfall and precipitation for years with missing data: 1993.

Canadian climate data for the period 1961 to 1990 (a 30-year "normal") have been interpolated to a 50 km grid by the CICS (2004). This method applied an inverse square distance weighting scheme to monthly data. These estimates are uncorrected for undercatch, and are thus consistent with the data presented in Table 3.2. The closest grid point to the Doris North project is located at 68° 03' 22" N, 107° 16' 08" W, and provides a mean annual precipitation estimate of 136.6 mm (uncorrected for undercatch).

3.3 INDIAN AND NORTHERN AFFAIRS CANADA

INAC currently operates a climate station at Walker Bay, Nunavut, as part of the EMAN-North program. The station is located on the Kent Peninsula, at 68° 21' N, 108° 05' W, approximately 70 km WNW of the Doris North project. This station has operated since the spring of 1996. A summary of available rainfall data for the calendar years 1996 through 2005 and of available early spring snow-on-ground data for the calendar years 1999 through 2005 is presented in Table 3.3. Detailed data are presented in Appendix B.

The uncorrected mean annual rainfall at the INAC Walker Bay station is similar to that recorded at the Environment Canada Cambridge Bay station. Snow-on-ground values are not directly comparable to snowfall data, due to potential differences in snow density. This is discussed further in Section 3.6.

Table 3.3 Summary of Annual Precipitation Data from INAC Walker Bay Station

Year	Annual Rainfall (mm)	Maximum Spring Snow-on-Ground (cm)
1996	77.1	-
1997	90.7	-
1998	65.2	-
1999	64.9	56.0
2000	72.8	52.0
2001	82.2	64.0
2002	68.2	53.0
2003	118.7	62.0
2004	47.0	38.0
2005	71.8	61.0
Mean	75.9	55.1

3.4 DORIS NORTH BASELINE PROGRAM 1993-2002

The Doris North baseline data collection program included an automated climate station that was installed near Boston Camp in August 1993 and operated through May 2002. A Nipher shielded snow gauge was also operated at Windy Camp during 1997 and this was moved to Boston Camp in June 1998. Available data from this program were summarized by Rescan (2002), and are presented in Appendix C. AMEC (2003) stated that "the snowfall data… are judged to be unreliable, as they are based not on direct measurements but on calculations and assumptions that cannot be validated." The only years without data gaps from which annual rainfall can be calculated are 1998 (101.5 mm) and 1999 (86.1 mm).

The Meteorology and Hydrology Baseline report (AMEC 2003) presented a discussion of precipitation undercatch in the Canadian north. This is a recognized phenomenon whereby measured values of rainfall and snowfall are lower than actual values, due to wind effects and the inability to accurately measure "trace" events. Derived undercatch values are presented in Table 3.4.

Table 3.4 Derived Undercatch Values for Doris North

Parameter	Undercatch Value
Rainfall	1.19
Snowfall	1.71
Total Precipitation	1.53

3.5 DORIS NORTH POST-BASELINE PROGRAM 2003-2006

Subsequent to the Meteorology and Hydrology Baseline report (AMEC 2003), additional climate data were collected at the Doris North climate station for the period May 2003 to September 2006 and at the Boston climate station for the period July 2006 to September 2006. Early spring snowcourse surveys were also undertaken in 2004, 2005 and 2006 (RL&L/Golder 2003; Golder 2005, 2006a, 2006b). Monthly and annual rainfall and snow water equivalents measured during the post-baseline program are presented in Table 3.5.

Table 3.5 Rainfall and Snow Water Equivalents at Doris North, 2003 to 2006

Period	Rainfall (mm)	Snow Water Equivalent (mm)	Period	Rainfall (mm)	Snow Water Equivalent (mm)
Spring 2003	-	-	Spring 2005	-	65.5[b]
May 2003	-	-	May 2005	0.0	-
June 2003	-	-	June 2005	16.5	-
July 2003	-	-	July 2005	27.2	-
August 2003	-	-	August 2005	31.2	-
September 2003	6.9	-	September 2005	3.0	-
October 2003	0.0	-	October 2005	0.0	-
Runoff Year 2004	49.3	-	Runoff Year 2005	78.0	65.5
Spring 2004	-	56.1[b]	Spring 2006	-	79.0[b]
May 2004	0.0	-	May 2006	0.0	-
June 2004	6.4	-	June 2006	10.9	-
July 2004	11.9	-	July 2006	22.1	-
August 2004	15.5	-	August 2006	9.4	-
September 2004	15.5	-	September 2006	2.0[a]	-
October 2004	0.0	-	October 2006	-	-
Runoff Year 2004	49.3	56.1	Runoff Year 2006	44.5[a]	79.0

(a) through 8 September 2006
(b) averaged across seven terrain types

3.6 ANALYSIS AND DISCUSSION

The Meteorology and Hydrology Baseline report (AMEC 2003) concluded that uncorrected mean annual rainfall, snowfall and precipitation at the Doris North Project were similar to those recorded at the Environment Canada climate station at Cambridge Bay. This conclusion was based on multiple regressions between short-term monthly rainfall data from Boston Camp and Environment Canada climate stations at Cambridge Bay, Kugluktuk and Lupin, and the assumption that the same correlation relationship would apply to snowfall and precipitation. Data collected or acquired subsequent to the baseline study now allow direct comparison over concurrent periods.

3.6.1 Rainfall

Concurrent rainfall data for the three Environment Canada climate stations discussed in Section 3.2, the INAC climate station discussed in Section 3.3, the Boston Camp climate station discussed in Section 3.4 and the Doris North climate station discussed in Section 3.5 are presented in Table 3.6.

Table 3.6 Concurrent Seasonal Rainfall Data, 1996 to 2006

Period	Doris North (mm)	Boston (mm)	Walker Bay (mm)	Cambridge Bay (mm)	Kugluktuk (mm)	Lupin (mm)
May-96	-	0.3	0.5	4.4	21	8.2
Jun-96	-	16.0	7.8	8.4	7.7	38.4
Jul-96	-	25.4	18.5	6.4	53.9	57.7
Aug-96	-	-	31.4	45.2	19.5	149.2
Sep-96	-	5.1	18.8	20.6	69.1	62.6
Oct-96	-	-	0.1	0.0	1.4	0.0
May-Oct 1996	-	-	77.1	85.0	172.6	316.1
May-97	-	-	0.1	2.6	2.0	6.2
Jun-97	-	-	18.4	31.2	7.2	18.4
Jul-97	-	-	26.0	27.2	35.7	18.2
Aug-97	-	-	28.2	18.1	28.0	56.0
Sep-97	-	-	18.0	8.6	32.1	20.6
Oct-97	-	0.3	0.0	0.0	0.0	0.8
May-Oct 1997	-	-	90.7	87.7	105.0	120.2
May-98	-	5.7			8.4	10.4
Jun-98	-	19.6	13.1	0.4	25.4	38.4
Jul-98	-	8.9	16.4	10.2	42.0	32.2
Aug-98	-	47.0	16.0	12.8	61.9	57.4
Sep-98	-	16.0	9.2	12.4	20.7	30.0
Oct-98	-	4.3	10.5	26.2	12.8	4.6
May-Oct 1998	-	101.5	65.2	62.0	171.2	173.0
May-99	-	0.5	1.2	0.0	0.0	5.6
Jun-99	-	0.3	17.6	17.0	4.4	19.2
Jul-99	-	53.6	22.2	40.5	65.8	60.2
Aug-99	-	7.6	5.3	13.2	18.6	54.0
Sep-99	-	24.1	18.3	8.4	66.1	67.4
Oct-99	-	0.0	0.3	0.0	1.3	0.0
May-Oct 1999	-	86.1	64.9	79.1	156.2	206.4
May-00	-	1.0	0.3	0.0	2.0	0.0
Jun-00	-	-	3.1	1.8	5.8	4.8
Jul-00	-	12.4	14.5	9.2	46.0	27.2
Aug-00	-	14.0	24.7	35.7	33.4	46.2
Sep-00	-	34.4	28.8	9.7	66.7	32.6
Oct-00	-	0.5	1.4	0.0	7.0	0.0
May-Oct 2000	-	-	72.8	56.4	160.9	110.8

Table 3.6 Concurrent Seasonal Rainfall Data, 1996 to 2006 (continued)

Period	Doris North (mm)	Boston (mm)	Walker Bay (mm)	Cambridge Bay (mm)	Kugluktuk (mm)	Lupin (mm)
May-01	-	1.4	0.0	0.8	2.7	4.8
Jun-01	-	7.0	4.9	4.0	5.4	0.4
Jul-01	-	-	36.7	42.2	46.1	44.4
Aug-01	-	-	28.6	31.0	26.4	46.2
Sep-01	-	-	11.4	11.8	36.9	7.2
Oct-01	-	3.6	0.6	0.0	4.2	1.2
May-Oct 2001	-	-	82.2	89.8	121.7	104.2
May-02	-	-	0.4	0.0	0.0	0.0
Jun-02	-	-	24.1	9.0	17.0	33.8
Jul-02	-	-	12.8	8.6	31.3	67.0
Aug-02	-	-	24.6	33.0	25.3	91.4
Sep-02	-	-	6.0	3.8	15.4	39.6
Oct-02	-	-	0.3	0.0	0.2	0.2
May-Oct 2002	-	-	68.2	54.4	89.2	232.0
May-03	-	-	4.3	0.4	12.7	5.4
Jun-03	-	-	7.2	2.2	3.8	9.6
Jul-03	-	-	22.2	36.2	26.0	44.0
Aug-03	-	-	67.3	34.4	132.9	69.2
Sep-03	6.9	-	16.6	11.0	27.7	14.6
Oct-03	0.0	-	1.1	0.8	12.0	1.4
May-Oct 2003	-	-	118.7	85	215.1	144.2
May-04	0.0	-	0.0	0.2	0.0	0.2
Jun-04	6.4	-	6.3	11.6	23.0	20.8
Jul-04	11.9	-	18.7	21.6	41.6	12.2
Aug-04	15.5	-	13.4	16.8	36.8	110.6
Sep-04	15.5	-	8.6	9.8	27.3	33.6
Oct-04	0.0	-	0.0	0.0	0.6	0.2
May-Oct 2004	49.3	-	47.0	60.0	129.3	177.6
May-05	0.0	-	0.0	0.0	2.4	0.0
Jun-05	16.5	-	38.0	17.0	36.8	57.6
Jul-05	27.2	-	30.9	32.0	67.2	28.0
Aug-05	31.2	-	-	17.8	49.4	62.4
Sep-05	3.0	-	-	4.8	4.6	6.2
Oct-05	0.0	-	-	0.0	2.8	0.0
May-Oct 2005	78.0	-	-	71.6	163.2	154.2
May-06	0.0	-	-	1.8	4.8	5.0
Jun-06	10.9	-	-	7.0	9.0	-
Jul-06	22.1	20.1	-	20.2	27.6	-
Aug-06	9.4	19.1	-	14.0	47.2	-
Sep-06	2.0	0.3	-	0.0	17.4	-
May-Sep 2006	44.5	n/a	-	43.0	106.0	n/a

The uncorrected rainfall data presented in Table 3.6 show that:

- There is a close correlation between rainfall data from the INAC Walker Bay and Environment Canada Cambridge Bay climate stations. Monthly and annual data for the concurrent period May 1996 to July 2005 are compared in Figure 3.2. The figure clearly shows that annual rainfall at Lupin and Kugluktuk are greater than that at Walker Bay.

- There are close correlations between rainfall data from Doris North and from the Cambridge Bay and Walker Bay climate stations. Monthly and annual data for the concurrent period September 2003 to September 2006 are compared in Figure 3.3. The figure clearly shows that annual rainfall at Lupin and Kugluktuk are greater than that at Doris North.

The available concurrent rainfall data show that conditions similar to those at Cambridge Bay exist at Walker Bay on the Kent Peninsula area of the mainland, approximately 145 km to the southwest, and that additional concurrent data show that conditions are similar at the Doris North climate station.

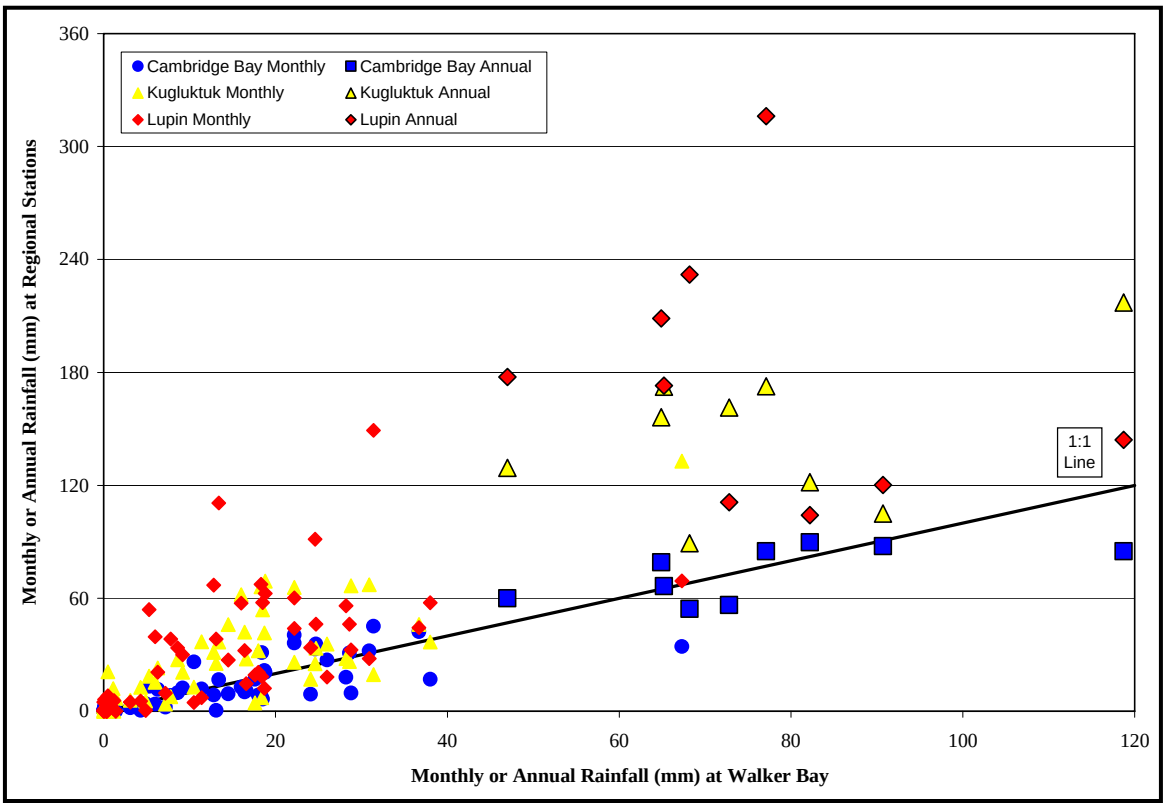


Figure 3.2 Comparison of Walker Bay Rainfall to Regional Station Rainfall

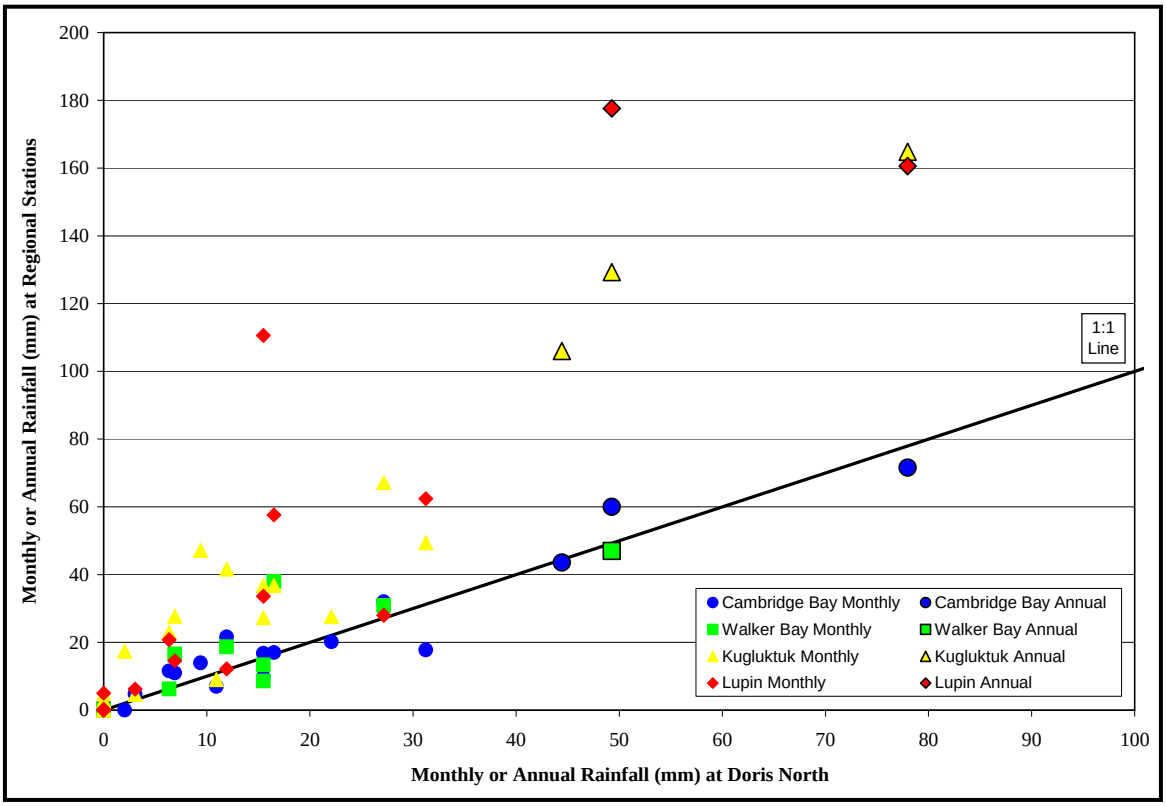


Figure 3.3 Comparison of Doris North Rainfall to Regional Station Rainfall

3.6.2 Snowfall

Varying methods for measurement and data presentation make it difficult to make direct comparisons of snowfall data from different stations. Environment Canada stations report daily snowfall and snow-on-ground depth data, whereas the INAC Walker Bay station reports daily snow-on-ground data. The Doris North baseline program reported snow water equivalent data, derived based on snow-on-ground data, but only intermittent data are available, and AMEC (2003) noted that these data were "judged to be unreliable". The baseline program also incorporated a Nipher shielded snow gauge, but this was not monitored on a consistent basis. Post-baseline snow monitoring consists of annual snowcourse surveys conducted in early spring, which provide snow water equivalent depths.

Available concurrent snow-on-ground data for the winters of 1996-97 through 2005-2006 are presented in Table 3.7, along with snow water equivalent data. For Environment Canada stations, snow water equivalents were calculated by subtracting reported rainfall depths from reported total precipitation depths, while for the Doris North area, they were based on late winter snowcourse surveys.

Table 3.7 Concurrent Seasonal Snow Data, 1996 to 2006

	End of Month Snow on Ground (cm)			Snow Water Equivalent for Month (mm)			
Period	Walker Bay	Cambridge Bay	Kugluktuk	Doris North	Cambridge Bay	Kugluktuk	Lupin
Sep-96	-	0	0	-	2.2	1.4	6.2
Oct-96	-	6	7	-	12.4	13.1	12.4
Nov-96	-	16	12	-	2.6	6.4	13.6
Dec-96	-	22	19	-	10.0	7.9	6.6
Jan-97	-	15	20	-	9.2	7.4	6.6
Feb-97	-	23	18	-	5.0	8.0	6.6
Mar-97	-	26	16	-	3.6	3.8	6.8
Apr-97	-	26	25	-	3.8	13.6	12.8
May-97	-	18	3	-	3.2	18.9	21.0
Winter 96-97					**52.0**	**80.5**	**92.6**
Sep-97	-	1	0	-	13.8	0.6	4.8
Oct-97	-	15	17	-	17.6	34.2	45.4
Nov-97	-	21	7	-	4.8	7.2	12.6
Dec-97	-	24	22	-	7.8	10.8	17.8
Jan-98	-	27	11	-	3.2	3.1	5.2
Feb-98	-	30	16	-	6.2	10.8	7.2
Mar-98	-	30	12	-	3.6	5.7	5.6
Apr-98	-	35	11	-	6.6	3.7	17.8
May-98	-	24	0	-	1.2	10.7	8.8
Winter 97-98					**64.8**	**86.8**	**125.2**
Sep-98	0	T	0	-	0.6	0.0	31.8
Oct-98	10	5	8	-	20.8	13.1	47.1
Nov-98	11	17	18	-	15.6	12.5	17.0
Dec-98	34	18	19	-	5.4	10.0	21.6
Jan-99	33	23	18	-	2.2	7.6	9.6
Feb-99	36	31	23	-	5.2	5.6	6.6
Mar-99	47	35	17	-	14.0	6.4	14.4
Apr-99	54	29	26	-	2.9	15.0	22.8
May-99	49	32	14	-	10.0	14.0	19.6
Winter 98-99					**76.7**	**84.2**	**190.5**
Sep-99	1	2	0	-	6.8	0.2	17.8
Oct-99	8	11	13	-	2.4	19.5	23.8
Nov-99	12	19	21	-	4.8	14.7	13.4
Dec-99	25	17	36	-	3.2	28.9	30.8
Jan-00	29	21	27	-	1.8	5.4	3.8
Feb-00	42	27	32	-	4.2	5.7	5.4
Mar-00	50	missing	34	-	3.8	5.6	7.0
Apr-00	49	30	27	-	3.0	7.1	12.2
May-00	48	33	6	-	3.6	11.5	18.6
Winter 99-00					**33.6**	**98.6**	**132.8**
Sep-00	0	1	6	-	6.2	4.8	26.0
Oct-00	15	17	30	-	12.2	38.1	43.4
Nov-00	22	23	30	-	5.2	11.5	14.0
Dec-00	31	27	20	-	3.2	5.3	7.8
Jan-01	35	37	22	-	9.2	16.4	6.4
Feb-01	41	32	25	-	0.6	7.2	7.0
Mar-01	44	47	24	-	5.0	10.1	24.6
Apr-01	54	49	23	-	4.8	5.3	30.2
May-01	59	57	14	-	16.6	10.9	35.4
Winter 00-01					**63.0**	**109.6**	**194.8**

Table 3.7 Concurrent Seasonal Snow Data, 1996 to 2006 (continued)

	End of Month Snow on Ground (cm)			Snow Water Equivalent for Month (mm)			
Period	Walker Bay	Cambridge Bay	Kugluktuk	Doris North	Cambridge Bay	Kugluktuk	Lupin
Sep-01	2	0	0	-	2.0	2.4	2.2
Oct-01	16	6	16	-	3.6	17.6	18.8
Nov-01	19	10	29	-	6.6	12.6	27.6
Dec-01	31	15	27	-	4.8	14.2	12.0
Jan-02	32	18	33	-	4.0	12.5	7.6
Feb-02	46	22	31	-	1.8	1.6	2.2
Mar-02	48	19	40	-	3.2	6.9	6.4
Apr-02	49	21	50	-	2.8	8.7	15.8
May-02	52	20	13	-	6.8	7.4	4.4
Winter 01-02					**35.6**	**83.9**	**97.0**
Sep-02	11	1	3	-	1.2	3.4	12.6
Oct-02	19	19	3	-	19.0	4.0	14.0
Nov-02	44	16	33	-	5.0	16.6	20.2
Dec-02	47	22	40	-	5.2	9.8	11.2
Jan-03	49	25	28	-	10.4	3.2	3.8
Feb-03	53	26	25	-	1.2	2.6	0.4
Mar-03	56	32	37	-	8.4	9.1	19.8
Apr-03	59	34	19	-	7.2	2.2	3.4
May-03	53	32	0	-	6.4	5.0	16.8
Winter 02-03					**64.0**	**55.9**	**102.2**
Sep-03	0	0	0	-	1.8	0.4	21.4
Oct-03	8.5	8	9	-	6.8	7.0	27.0
Nov-03	17.5	25	28	-	14.8	26.9	31.3
Dec-03	26	23	33	-	3.8	11.6	15.6
Jan-04	31	28	33	-	3.0	7.0	10.8
Feb-04	30	31	32	-	10.4	3.7	12.4
Mar-04	29	28	33	-	4.2	6.4	9.2
Apr-04	28	34	28	-	4.2	8.9	18.4
May-04	37	31	27	-	4.2	18.2	5.8
Winter 03-04				**56.1**	**53.2**	**90.1**	**151.9**
Sep-04	2	7	9	-	8.0	4.4	27.6
Oct-04	14	13	15	-	14.8	8.4	29.0
Nov-04	34	22	11	-	13.4	12.7	30.2
Dec-04	35	21	18	-	2.4	7.8	3.4
Jan-05	48	24	21	-	4.0	8.0	14.2
Feb-05	50	25	22	-	2.6	1.5	6.2
Mar-05	50	28	24	-	7.4	3.7	12.6
Apr-05	59	37	17	-	10.6	12.9	12.4
May-05	39	10	0	-	1.0	0.8	11.2
Winter 04-05				**65.5**	**64.2**	**60.2**	**146.8**
Sep-05	-	2	1	-	2.6	2.6	20.4
Oct-05	-	16	16	-	8.0	21.7	33.2
Nov-05	-	23	27	-	9.4	16.7	20.2
Dec-05	-	28	44	-	6.8	10.9	12.4
Jan-06	-	29	35	-	4.4	6.0	14.6
Feb-06	-	31	32	-	5.4	5.2	6.8
Mar-06	-	39	45	-	5.2	14.6	16.8
Apr-06	-	32	32	-	5.6	11.9	16.8
May-06	-	10	0	-	4.2	3.4	4.2
Winter 05-06				**79.0**	**51.6**	**93.0**	**145.4**

The data presented in Table 3.6 show that there are no clear correlations between data at the various stations. Snow-on-ground data provide measurements at one location only, and snow depths can be affected by variations in snow density, consolidation, melt and sublimation of the snowpack, exposure and redistribution by wind. Therefore, values from different locations should not be compared directly.

The snow water equivalent data in Table 3.6 are not corrected for undercatch, and as noted in Section 2.1, different sites may have different undercatch factors. Conventional undercatch factors do not apply to the values from Doris North; however, the snow water equivalents measured during the snowcourse surveys do not consider water that may be lost into soil due to early season or late winter snowmelt or sublimation losses during the winter season. Pomeroy et al. (1999) stated that "calculations of blowing snow transport in a rolling arctic basin north of Inuvik, NWT suggest that 28% of seasonal snowfall is sublimated during redistribution from tundra surfaces," and Pomeroy and Gray (1995) stated that "blowing snow in open areas can remove up to three-fourths of annual snowfall. If fetches are large, most of this snow sublimates in transit." Given the high proportion of lake area in the Doris North area, sublimation losses could be large.

Therefore, values from different locations should not be compared directly. However, the data presented in Table 3.6 do show a general trend of decreasing snow water equivalents to the north, and similar uncorrected values for Cambridge Bay and Doris North. Based on these observations, as well as relative proximity, it appears reasonable to accept the snowfall estimates proposed by the baseline study.

3.6.3 Precipitation

Based on the assessments of mean annual rainfall and snow water equivalent in the preceding sections, it is reasonable to accept the baseline study recommendation of 139 mm (uncorrected for undercatch) and 207 mm (corrected for undercatch) for mean annual precipitation at Doris North.

4.0 LAKE EVAPORATION

4.1 ENVIRONMENT CANADA

Evaporation monitoring data in the north have been noted as being extremely sparse. Prowse (1990) noted that only five evaporation pans operated in the Northwest Territories and Nunavut, and Environment Canada currently only reports pan evaporation normals for two sites in the Northwest Territories and Nunavut, those being Yellowknife (62° 27’ N, 114° 26’ W) and Resolute (74° 43’ N, 94° 59’ W). Neither of these sites is close enough to Doris North to provide any meaningful data.

4.2 INDIAN AND NORTHERN AFFAIRS CANADA

INAC installed an automatic climate station within a shallow pond at the Salmita mine site (64° 03’ N, 111° 11’ W) in 1992, and data from this station have been used to calculate lake evaporation rates (Reid 2004) for the years 1994 to 2004. Salmita is located approximately 160 km south of Lupin and approximately 480 km SSW of Doris North. Lake evaporation rates calculated using the Penman equation are presented in Table 4.1.

Table 4.1 Calculated Lake Evaporation at Salmita Mine, 1994-2004

Year	Calculated Lake Evaporation (mm)
1994	336
1995	261
1996	283
1997	243
1998	348
1999	295
2000	278
2001	296
2002	232
2003	327
2004	242
Mean	286

4.3 DORIS NORTH BASELINE PROGRAM 1993-2002

A pan evaporation gauge was operated at Windy Camp in 1995 and 1996, and at Boston Camp in 1997, 1998 and 2000 (Rescan 2002). However, due to data collection problems, the only year with reliable data was 1997 (AMEC 2003).

The baseline report examined lake evaporation data for the Salmita mine (refer to Section 4.2) as well as data collected at the Lupin (65° 45' N, 111° 15' W) and Ekati Koala (64° 48' N, 110° 56' W) mines. These data are presented in Table 4.2.

Table 4.2 Calculated Lake Evaporation at Lupin and Ekati Mines

Year	Calculated Lake Evaporation (mm)	
	Lupin Mine	Ekati Mine
1983	260[a]	-
1984	320[a]	-
1992	300	-
1993	220	-
1994	-	270[b]
1995	-	340[b]
1996	-	356[b]
Mean	275	322

(a) Based on pan evaporation measurements and a correction factor of 0.81.
(b) Based on pan evaporation measurements and a correction factor of 0.75.

The baseline report used the single year of pan evaporation data from Boston Camp, applying a correction factor of 0.81 to the measured value of 271 mm to calculate a lake evaporation value of 220 mm. The baseline report also suggested a regional decreasing lake evaporation trend of 20 mm per 150 km to the northeast, indicating a lake evaporation value of approximately 235 mm for Doris North.

The monthly lake evaporation values recommended by the baseline report, based on data from Boston Camp and regional stations, are presented in Table 4.3.

Table 4.3 Derived Mean Lake Evaporation (AMEC 2003)

Period	Days with Evaporation	Portion of Annual Evaporation	Mean Lake Evaporation (mm)
June	15	0.16	35
July	31	0.43	95
August	31	0.35	77
September	30	0.06	13
Annual	105	1.00	220

4.4 DORIS NORTH BASELINE PROGRAM 2003-2006

No direct measurements of lake evaporation were performed during the post-baseline program. However, data from the Doris North climate station were used as input to the WREVAP program (Morton et al. 1985) to estimate the monthly evaporation from Doris and Tail lakes. Evaporation from Doris Lake and Tail Lake were calculated separately, because lake evaporation is affected by the mean lake depth.

The WREVAP model requires accurate temperature, humidity and solar radiation data from a station with surroundings similar to the area of interest. The program is not recommended for use near "sharp environmental discontinuities, such as a high-latitude coastline… because of advection of heat and water vapour in the lower layers of the atmosphere." However, the program documentation indicates "that the effects of such advections can decrease to near zero with [in] 300 m, but this finding may not be generally applicable." Doris Lake is approximately 4 km from the Roberts Bay coastline at its closest point, so it is assumed that the WREVAP model is applicable. Lake evaporation was calculated using the CRLE (Complementary Relationship Lake Evaporation) model component. Calculated evaporation estimates for the years 2004 to 2006 are presented in Table 4.4.

Table 4.4 Doris North Calculated Lake Evaporation 2004 to 2006

Month	Lake Evaporation		
	Baseline Report[a]	Doris Lake CRLE[b]	Tail Lake CRLE[b]
June 2004	35 mm	7 mm	23 mm
July 2004	95 mm	51 mm	86 mm
August 2004	77 mm	85 mm	79 mm
September 2004	13 mm	66 mm	38 mm
2004 Annual Total	**220 mm**	**209 mm**	**226 mm**
June 2005	35 mm	10 mm	29 mm
July 2005	95 mm	68 mm	92 mm
August 2005	77 mm	81 mm	69 mm
September 2005	13 mm	57 mm	37 mm
2005 Annual Total	**220 mm**	**216 mm**	**227 mm**
June 2006	35 mm	28 mm	40 mm
July 2006	95 mm	83 mm	114 mm
August 2006	77 mm	104 mm	98 mm
September 2006	13 mm	85 mm	56 mm
2006 Annual Total[c]	**220 mm**	**286 mm**	**308 mm**

[a] Source: AMEC 2003.
[b] Calculated using WREVAP model component CRLE (Morton et al. 1985). Calculated values for October and 50% of June were neglected due to ice cover.
[c] Solar radiation and air temperature measured at the Doris North climate station were greater in 2006 than for either 2004 or 2005. Data subsequent to the final climate station download on 9 September 2006 were estimated.

Calculated values for Tail Lake are approximately 5% to 8% greater due to the shallower depth of Tail Lake and its ability to warm up sooner in the summer.

4.5 ANALYSIS AND DISCUSSION

Evaporation data are extremely sparse in the north, but it is generally accepted that annual values should decrease with increases in latitude, due to colder temperatures and a shorter ice-free season. Therefore, it is reasonable that the mean annual values at Doris North should be lower than those reported for Lupin, Salmita and Ekati-Koala, that is, less than 275 mm.

Four years of data for Doris Lake (1997 and 2004 to 2006) provide a mean annual lake evaporation value of 233 mm, which is slightly greater than the baseline estimate of 220 mm. Given the limited amount of available data, it is reasonable to continue to use the baseline value.

5.0 WATER YIELD

5.1 INTRODUCTION

Runoff data relevant to the Doris North water balance include regional stream discharge data from Environment Canada (HYDAT 2006), and local monitoring data collected during the hydrology baseline study (Rescan 2002) and post-baseline study (RL&L/Golder 2003; Golder 2005, 2006a, 2006b).

Runoff hydrographs in the region typically display the largest peak during spring runoff. The flow typically recedes for the remainder of the year, with secondary peaks occurring due to summer and autumn rainfall.

5.2 ENVIRONMENT CANADA

Long-term Environment Canada hydrometric data are available from the regional stations listed in Table 5.1. Calculated mean annual water yields for these stations are presented in the table. Calculated annual water yields for each station are presented in Appendix A.

Table 5.1 Regional Environment Canada Climate Stations

Station	Number	Period of Record[a]	Drainage Area	Location	Mean Annual Water Yield
Tree River near the Mouth	10QA001	1968 – present	5,810 km^2	67° 38’ 06” N 111° 54’ 08” W	194 mm (28 years)
Hood River near the Mouth	10QB001	1993 – present	not reported	67° 21’ 00” N 108° 56’ 06” W	153 mm (4 years)
Burnside River near the Mouth	10QC001	1976 [a] – present	16,800 km^2	66° 44’ 00” N 108° 48’ 08” W	267 mm (18 years)
Gordon River near the Mouth	10QC002	1977 – 1984	1,530 km^2	66° 48’ 36” N 107° 06’ 04” W	197 mm (16 years)
Ellice River near the Mouth	10QD001	1971[b] – present	16,900 km^2	67° 42’ 42” N 104° 08’ 27” W	172 mm (17 years)
Freshwater Creek near Cambridge Bay	10TF001	1970 – present	1,490 km^2	69° 07’ 52” N 104° 59’ 26” W	86 mm (27 years)

(a) At the time of this assessment, data were available for active stations through the end of 2005 (2004 for Freshwater Creek).

(b) Environment Canada has advised that data collected prior to 1984 should not be considered accurate and are not used in subsequent analyses.

The available data show great variations in water yields throughout the region. However, in general, water yields are greater in the south and west and smaller in the north and east. This is consistent with the precipitation data as presented in Table 3.2.

An Environment Canada expert (Spence 2004; Environment Canada 2004) indicated that the estimated baseline mean annual water yield of 134 mm for Doris Lake and 111 mm for Tail Lake could be low. It was suggested that, based on stream discharge data from regional hydrometric stations on the mainland, the actual mean annual water yield could be as large as 180 mm.

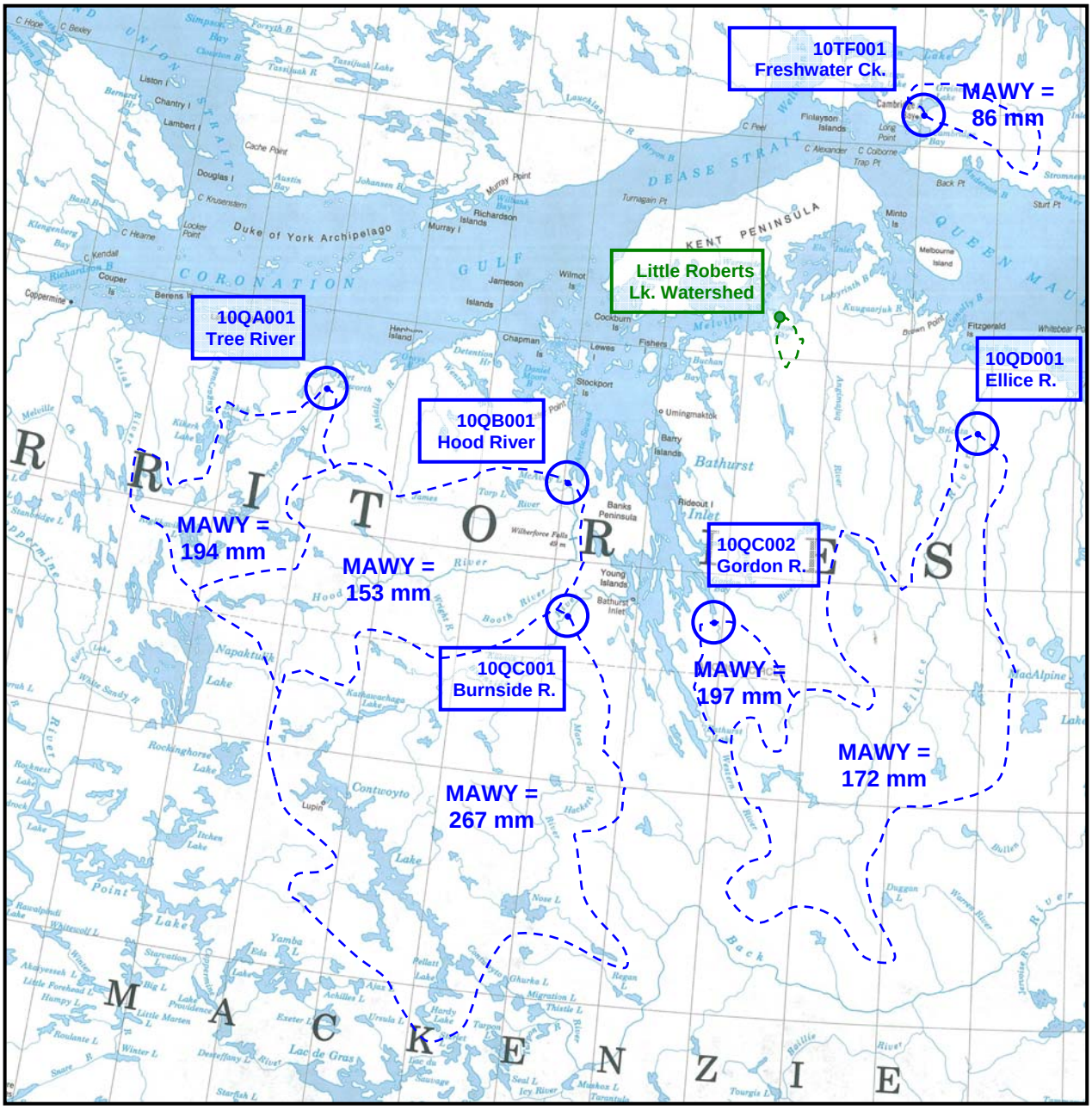


Figure 5.1 Locations of Hydrometric Stations Relative to Doris North Area

5.3 DORIS NORTH BASELINE PROGRAM 1993-2002

Hydrometric data collected at Doris North were summarized in a data compilation report by Rescan (2002), and were further analysed in the EIS baseline meteorology and hydrology report (AMEC 2003). Monitoring location details are summarized in Table 5.2.

Table 5.2 Hydrometric Monitoring at Doris North, 1993-2002

Station	Drainage Area (km^2)	1993	1994	1995	1996	1997	1998	1999	2000
Glenn Lake Outflow	31.6	-	-	-	08/03 – 08/23	06/15 – 09/12	06/03 – 08/21	-	06/15 – 09/11
Ogama Lake Outflow	71.9	-	-	(b)	08/02 – 08/22	06/17 – 09/12	-	-	-
Ogama Lake Inflow	64.4	-	-	-	-	06/17 – 09/12	-	-	-
Fickle Duck Lake Outflow[a]	32.0	(b)	(b)	(b)	(b)	(b)	-	-	-
Pelvic Lake Outflow	49.2	-	-	-	-	-	-	-	06/17 – 09/12
Doris Lake Outflow	93.1	-	-	-	08/03 – 08/22	07/15 – 09/12	06/30 – 08/21	-	06/16 – 09/11
Tail Lake Outflow	4.4	-	-	-	-	-	-	-	06/16 – 09/12
Koignuk River		-	-	-	(b)	-	-	-	-
Stickleback Lake Outflow	2.8	(b)	(b)	(b)	(b)	08/26 – 09/13	05/29 – 08/21	-	-
Aimaoktok River	769	-	-	(b)	06/13 - 08/06	06/15 - 09/13	05/31 – 08/21	-	-
Patch Lake		-	-	-	-	(b)	-	-	-
Doris Lake		-	-	-	(b)	(b)	-	-	-
Tail Lake		-	-	-	(b)	(b)	-	-	-
Windy Lake		-	-	-	-	(b)	-	-	-

(a) Called Trout Lake Outflow in Rescan (2002).
(b) Manual measurements only; no continuous monitoring.

From 1993 to 1995, only sporadic manual discharge measurements were undertaken at selected locations. In 1996, 1997, 1998 and 2000, continuous monitoring was undertaken using automated hydrometric stations. Hydrographs measured at Doris North area stations (Doris, Glenn, Ogama, Pelvic and Tail lake outflows) are presented in Appendix C.

Unfortunately, continuous monitoring generally did not commence until after the spring flood peak had occurred, making it impossible to calculate annual water yields. Flood peaks were only captured for the Doris Lake outflow in 1997 and 2000. The calculated annual water yield for Doris Lake outflow was 132 mm in 1997 and 97 mm in 2000.

5.4 DORIS NORTH BASELINE PROGRAM 2003-2006

Subsequent to the Meteorology and Hydrology Baseline report (AMEC 2003), additional hydrometric data were collected at Doris North between June 2003 and September 2006 (RL&L/Golder 2003; Golder 2005, 2006a, 2006b). Year-round monitoring of lake water levels and early installation of monitoring equipment allowed water yields to be calculated for the period 2004 to 2006.

Locations of hydrometric stations at Doris North and measured annual water yields are presented in Table 5.3. Hydrographs for these stations are presented in Appendix D.

Table 5.3 Hydrometric Monitoring at Doris North, 2003-2006

Station	Location	Drainage Area	Annual Water Yield			
			2003	2004	2005	2006
Doris Lake Outflow	68° 08’ 30” N 106° 35’ 14” W	93.1 km^2	(a)	62 mm	83 mm	73 mm
Tail Lake Outflow	68° 08’ 19” N 106° 34’ 59” W	4.4 km^2	(b)	42 mm	84 mm	53 mm
Roberts Lake Outflow	68° 10’ 10” N 106° 34’ 55” W	97.8 km^2	(a)	61 mm	100 mm	72 mm
Little Roberts Lake Outflow	68° 10’ 20” N 106° 34’ 59” W	198.9 km^2	(a)	64 mm	90 mm	68 mm

(a) Monitoring in 2003 did not commence until after the spring runoff peak. No annual water yield can be calculated.
(b) This location was not monitored in 2003.

5.5 ANALYSIS AND DISCUSSION

The Meteorology and Hydrology Baseline Study (AMEC 2003) stated that “the Ellice and Gordon River gauges are the closest to the project site and were considered as being more likely representative of the Hope Bay area on the basis of the following factors: proximity to the project site; basin characteristics similar to those on the project site; and similar response to spring snowmelt and rainfall events with respect to both timing and relative magnitude of peaks.” The report went on to derive a mean annual water yield at the Doris Lake outflow of 134 mm, and a mean annual water yield at the Tail Lake outflow of 111 mm. These were based on correlations of available weekly water yield data from the

Doris and Tail lake outflows and regional data from the Ellice River. However, during project hearings in 2004 and 2006, regulators and interveners suggested that the derived mean annual water yields should be similar to those reported for the Ellice River.

Regional data, as presented in Section 5.2, show a great variation in mean annual water yield with location. Watersheds located in the south and west tend to have greater precipitation and higher water yields, while those in the north and east tend to have less precipitation and lower water yields. Elevation also increases to the south, and ground elevation has been noted as being correlated to higher precipitation (Linsley et al. 1982).

It was established in Section 3 that annual precipitation at Doris North is similar to that recorded at Cambridge Bay, whereas annual precipitation to the east (Kugluktuk) and south (Lupin) is greater. The Ellice River watershed is located to the south, and has a reported mean annual water yield of 172 mm, while the Freshwater Creek watershed, located near Cambridge Bay, has a reported mean annual water yield of 86 mm. Actual water yields measured at the Doris Lake outflow are summarized in Table 5.4, where they are compared to concurrent data from Freshwater Creek and the Ellice River.

Table 5.4 Concurrent Annual Water Yields at Doris Lake Outflow, Freshwater Creek and Ellice River

Year	Doris Lake Outflow	Freshwater Creek	Ellice River
1997	132 mm	131 mm	not reported
2000	97 mm	65 mm	not reported
2004	62 mm	83 mm	153 mm
2005	83 mm	72 mm	133 mm
2006	73 mm	not reported	133 mm
Mean	89 mm	88 mm	140 mm
Long-term Mean	134 mm[a]	86 mm[b]	172 mm[b]

(a) Value derived by AMEC (2003).
(b) Values calculated from data reported by Environment Canada.

The limited amount of concurrent data show that the 1997 annual water yield for the Doris Lake outflow was approximately equal to the derived long-term mean, whereas all other values were below the long-term mean. However, for the years 2000 and 2004 to 2006, other regional values are also below the long-term mean, which may indicate that these were relatively dry years.

The available water yield data show that it is likely that Doris North area annual water yields fall between those calculated for the Ellice River watershed, located to the north, and the Freshwater Creek watershed, located to the south. Given that only five years of usable annual water yield data are available for the Doris North area, and most of those years were likely drier than average, it is reasonable to accept the baseline water yield values until such time as additional data are available.

5.6 LOCAL BASIN WATER BALANCES

As a check on the independently measured or calculated hydroclimatic parameters, water balances can be calculated for the Doris Lake and Tail Lake watersheds, where complete annual data are available for the years 2004 to 2006. These are presented for Doris Lake in Table 5.5 and for Tail Lake in Table 5.6.

Table 5.5 Calculated Doris Lake Water Balances, 2004 to 2006

Parameter	Baseline	2004	2005	2006
Rainfall (mm)[a]	86	59	93	53
Snow Water Equivalent (mm)[b]	121	56	66	79
Total Annual Input (mm)	207	115	158	132
Water Yield (mm)	134	62	83	73
Lake Evaporation (mm)[c]	42	40	41	54
Calculated Other Losses (mm)[d]	35	13	34	5

(a) Baseline and measured values adjusted using undercatch factor of 1.19.
(b) Baseline values only adjusted for undercatch using factor of 1.71.
(c) Based on 19% lake area in the watershed.
(d) Baseline values include snowfall sublimation; monitoring values do not.

Table 5.6 Calculated Tail Lake Water Balances, 2004 to 2006

Parameter	Baseline	2004	2005	2006
Rainfall (mm)[a]	86	59	93	53
Snow Water Equivalent (mm)[b]	121	56	66	79
Total Annual Input (mm)	207	115	158	132
Water Yield (mm)	111	42	84	53
Lake Evaporation (mm)[c]	40	41	41	55
Calculated Other Losses (mm)[d]	56	32	33	24

(a) Baseline and measured values adjusted using undercatch factor of 1.19.
(b) Baseline values only adjusted for undercatch using factor of 1.71.
(c) Based on 18% lake area in the watershed.
(d) Baseline values include snowfall sublimation; monitoring values do not.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 SUMMARY OF RESULTS

6.1.1 Precipitation

The data and analysis presented in Section 3 show that monthly and annual rainfall in the Doris North area is similar to that recorded at the Environment Canada climate station at Cambridge Bay. This is based on three years of concurrent data for the two stations, and is further supported by nine years of concurrent data for Cambridge Bay and the INAC Walker Bay climate station. Thus, the recommendations of the baseline study are supported.

Comparison of snowfall at the local and regional climate stations is complicated by the use of different measurement methods (snow-on-ground, snowfall gauging and snowcourse surveys) and by variations in snow density, consolidation, melt and sublimation of the snowpack, exposure and wind redistribution. However, the data and analysis presented in Section 3 show that snow water equivalent displays a decreasing trend to the north, and snow water equivalents measured at Doris North from 2004 to 2006 are consistent with those reported for the Environment Canada climate station at Cambridge Bay. Thus, the recommendations of the baseline study are supported.

Based on the recommendations of the baseline study with regards to mean annual rainfall and snowfall at Doris North, it follows that recommendations with regards to mean annual precipitation are also supported.

6.1.2 Lake Evaporation

The data and analysis presented in Section 4 support the conclusions of the baseline report with regards to lake evaporation. Previous studies have established a decreasing gradient in lake evaporation to the northeast, and have established reliable long-term mean values at sites to the southwest. The baseline estimate is supported by these observations, as well as one year of local pan evaporation data and three years of local calculated evaporation data.

6.1.3 Water Yield

The data and analysis presented in Section 5 show that a decreasing gradient in water yield to the northeast exists in the region surrounding Doris North. Local annual water yield data are only available for five years, but indicate that water yields at Doris North are in fact lower than those for the Ellice River, as suggested by the baseline study. The mean annual water yield measured at Doris North over the monitoring period is in fact less than that estimated by the

baseline study, but given the short monitoring period and because it took place during regional dry conditions, it is unlikely to be representative of long-term conditions. The baseline study conclusion that the mean annual water yield at Doris North is substantially lower than that of the Ellice River is supported by the additional data collected subsequent to the baseline study.

6.2 RECOMMENDATIONS

Water balance modelling for the Doris North project currently considers two sets of data. One set reflects the conditions estimated by the baseline study (dry case) and one set incorporates higher runoff estimates, as suggested by intervenors and regulators (wet case). Both of these cases were modelled to account for uncertainty in local conditions.

The climate and hydrology data that were collected during post-baseline monitoring (2003 to 2006) are consistent with the results of the baseline study, and do not support the suggestion that conditions at Doris North are similar to those of areas to the west (Kugluktuk) or south (Ellice River watershed). This supports use of the “dry case” scenario for water balance modelling at Doris North.

However, the available data include only three years of complete annual data (precipitation, evaporation and water yields for 2004 to 2006) and an additional two years of partial annual data (water yields for 1997 and 2000). Furthermore, it appears that the three years of complete data occurred during years which may have been drier than average in the region. Therefore, it would still be prudent to model the “wet case” scenario to continue to account for existing uncertainty.

INAC (2006a) pointed out an inconsistency in the “wet case” parameters, in that the recommended mean annual precipitation (207 mm) and mean annual water yield (180 mm) resulted in an unrealistically high runoff coefficient of 87%. This is acknowledged. In response to this and other comments, SRK consulting has decided to run additional water balance sensitivity analyses, beyond the cases previously examined. The following cases will be run to demonstrate the robustness of the water balance:

- Tail Lake mean annual water yield of 180 mm and mean annual precipitation of 300 mm;
- Tail Lake mean annual water yield of 131 mm and mean annual precipitation of 207 mm, based on a runoff coefficient of 0.60, as discussed in Section 2.2.3;

- Tail Lake mean annual water yield of 111 mm, mean annual precipitation of 207 mm and evaporation of 233 mm, based on the derived lake evaporation from Section 4.5; and
- Additional runs using the 2004, 2005 and 2006 Tail Lake precipitation, water yield and lake evaporation as presented in Table 5.6.

It is recommended that climate and hydrology monitoring continue at Doris North, prior to and during operations. This will provide additional data to confirm local hydroclimatic conditions, and to provide vital input for water management and adaptive management planning during project construction, operations and closure.

7.0 CLOSURE

We trust the information contained in this report is sufficient for your present needs. Should you have any questions regarding the project, please do not hesitate to contact the undersigned.

Yours truly,

GOLDER ASSOCIATES LTD.

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APPENDIX A

ENVIRONMENT CANADA
CLIMATE AND HYDROLOGY DATA SUMMARY

Environment Canada currently operates climate stations at Kugluktuk, NU, Cambridge Bay, NU and Lupin, NT. These are the closest active, long-term stations to Doris North. Details of these stations are presented in Table A1.

Table A1 – Details of Environment Canada Climate Stations

	Kugluktuk A	Cambridge Bay A	Lupin
Station No.	2200902 (previously 2200900)	2400600	22026HN (previously 2200850)
Latitude	67° 49' N	69° 06' N	65° 45' N
Longitude	115° 08' W	105° 08' W	111° 15' W
Elevation	22.6 m	27.4 m	490.1 m
Period of Record	October 1930 – September 2006	January 1929 – September 2006	January 1959 – May 2006

Annual rainfall, snowfall and precipitation data are not available for the full periods of record at each station, due to periods where data were not collected. At Kugluktuk Airport, annual data are available for the years 1935 to 1945, 1947 to 1978 and 1980 to 2005. At Cambridge Bay Airport, annual data are available for the years 1949 to 1992 and 1993 to 2005. At Lupin, annual data are available for the full period of record. These data are presented in Table A2.

A summary of annual water yield data for regional Environment Canada hydrometric stations is provided in Table A3.

Table A2 – Annual Rainfall, Snowfall and Precipitation at Kugluktuk, Cambridge Bay and Lupin-Contwoyto

Year	Kugluktuk A			Cambridge Bay A			Lupin-Contwoyto		
	Rainfall (mm)	Snowfall (cm)	Precip (mm)	Rainfall (mm)	Snowfall (cm)	Precip (mm)	Rainfall (mm)	Snowfall (cm)	Precip (mm)
1935	102.0	157.8	259.7	-	-	-	-	-	-
1936	103.2	128.1	231.3	-	-	-	-	-	-
1937	151.1	119.9	271.0	-	-	-	-	-	-
1938	140.3	81.5	221.8	-	-	-	-	-	-
1939	182.6	80.6	263.2	-	-	-	-	-	-
1940	110.7	162.9	273.6	-	-	-	-	-	-
1941	100.2	221.6	321.7	-	-	-	-	-	-
1942	125.5	155.6	281.1	-	-	-	-	-	-
1943	179.2	125.0	304.2	-	-	-	-	-	-
1944	112.9	165.7	278.6	-	-	-	-	-	-
1945	165.3	82.7	248.0	-	-	-	-	-	-
1946	93.3	-	-	-	-	-	-	-	-
1947	170.1	128.5	298.6	-	-	-	-	-	-
1948	248.6	155.2	403.7	-	-	-	-	-	-
1949	68.1	131.3	199.4	97.4	60.7	158.2	-	-	-
1950	112.9	108.1	221.0	112.6	48.4	160.8	-	-	-
1951	114.2	72.9	187.1	60.4	72	132.4	-	-	-
1952	57.3	86.4	144.4	44.3	70.6	114.8	-	-	-
1953	152.3	49.6	201.9	80	48.2	128.1	-	-	-
1954	71.7	77.5	149.3	34.3	47.1	81.4	-	-	-
1955	94.2	46.0	140.1	84.3	59.7	144	-	-	-
1956	145.2	59.6	204.8	90.7	79.5	170.2	-	-	-
1957	76.2	74.7	150.9	70.3	79.6	149.9	-	-	-
1958	85.2	91.7	176.9	31.6	73.5	105.2	-	-	-
1959	78.0	144.0	222.0	59.8	75.4	135	151.9	175.5	327.3
1960	162.6	106.6	269.2	79.3	62.1	141.4	139.1	165.6	304.7
1961	80.2	83.0	163.2	39.2	72.1	111.1	193.2	118.2	311.4
1962	62.7	47.0	109.7	43.7	71.5	114.9	79.7	118.6	198.3
1963	145.8	94.0	234.4	128.6	97	215	113.4	138.4	252.3
1964	77.6	102.5	185.3	39.6	115.9	134.5	135.4	112.8	248.1
1965	73.0	99.2	194.0	37.6	93.9	125.4	85.8	78.8	164.6
1966	163.7	57.2	213.8	123.3	60.3	176.8	154.4	38.5	192.9
1967	129.7	78.4	207.9	91.5	88.7	167.3	176.9	131.5	317.6
1968	51.3	110.8	161.9	65.6	105.5	154.9	79.0	176.7	255.5
1969	98.3	113.5	211.7	83.5	64.3	135.3	151.1	82.6	233.7
1970	130.0	77.0	201.0	77.3	74	131.4	150.9	111.1	262.0
1971	118.1	90.8	204.6	121.5	108.2	195.8	143.7	166.5	310.2
1972	57.1	178.9	222.9	49.3	112.1	125.3	103.1	129.6	233.3
1973	180.0	111.3	279.5	62.8	84.9	124.5	164.3	91.6	255.7
1974	79.3	133.4	211.5	54.7	92.3	128.9	124.3	155.1	279.2

Table A2 – Annual Rainfall, Snowfall and Precipitation at Kugluktuk and Cambridge Bay (continued)

Year	Kugluktuk A			Cambridge Bay A			Lupin-Contwoyto		
	Rainfall (mm)	Snowfall (cm)	Precip (mm)	Rainfall (mm)	Snowfall (cm)	Precip (mm)	Rainfall (mm)	Snowfall (cm)	Precip (mm)
1975	52.4	191.8	242.9	42.7	98.3	126.2	99.8	91.1	190.9
1976	174.5	202.1	380.8	60.5	57.7	110.3	177.8	116.4	294.4
1977	68.9	174.2	233.8	69.7	68	130.6	99.2	142.2	241.4
1978	33.4	167.7	166.1	86.9	46.2	130.5	109.4	164.8	274.2
1979	103.9	-	-	59.2	68.1	125.7	125.2	107.6	232.8
1980	135.0	170.7	304.1	74.2	65	137	81.2	86.3	167.5
1981	144.6	168.6	287.5	90.5	41.1	129.1	151.9	107.1	259.0
1982	145.2	101.7	236.0	74.1	73.8	144.7	105.9	97.0	202.9
1983	249.8	111.3	345.2	40.8	56.5	96	185.5	160.5	346.0
1984	177.2	151.6	282.2	64.4	69	130.7	148.9	100.9	249.8
1985	183.6	166.5	298.6	51.6	84.2	127.2	153.9	126.9	280.8
1986	70.4	192.0	226.0	39.5	96.6	130.8	108.2	125.3	233.5
1987	165.3	149.1	284.9	148.1	86	208.6	170.9	137.1	308.0
1988	184.2	118.4	285.2	152.9	41	179.7	135.1	70.2	205.3
1989	78.9	150.1	185.0	50.6	88.5	122.2	90.4	111.1	201.5
1990	90.8	117.1	175.6	67.8	98.8	145	124.9	86.8	211.7
1991	123.6	174.3	257.2	54.8	122	153.4	133.1	138.4	271.5
1992	80.0	179.4	231.8	26.6	129.8	125.6	73.8	132.2	206.0
1993	161.3	147.8	293.5	-	-	-	151.6	110.7	262.3
1994	136.9	127.1	248.5	61.8	94.6	145.6	130.2	96.4	226.6
1995	46.3	149.4	125.7	48.2	108.6	140.8	150.0	138.0	288.0
1996	172.6	176.8	252.2	85	89.6	171.2	316.1	113.4	429.5
1997	105.0	205.2	210.4	87.7	75.2	159.3	120.2	139.8	260.0
1998	172.4	177.1	242.0	66.4	68.3	126.4	173.0	162.4	335.1
1999	156.2	249.1	268.1	79.1	63.9	133	208.6	164.6	373.2
2000	161.3	264.9	264.4	56.4	49.2	100.8	111.0	141.4	252.4
2001	121.7	269.0	219.2	89.8	69.8	148	104.2	170.4	274.6
2002	89.2	190.8	166.1	54.4	58.8	104.8	232.0	97.6	329.6
2003	217.1	168.3	286.3	85	88.6	154.6	144.2	148.3	292.5
2004	129.3	229.3	207.2	60	87.6	129.8	177.6	147.6	325.2
2005	162.6	232.0	243.8	71.6	61.2	126.2	160.6	147.2	307.8
2006[a]	106.0	114.7	147.5	44	32	73.4	-	-	-
Maximum[a]	249.8	269.0	403.7	152.9	129.8	215.0	316.1	176.7	429.5
Mean[a]	123.1	137.2	234.4	70.8	77.2	138.5	140.4	124.9	265.5
Minimum[a]	33.4	46.0	109.7	26.6	41.0	81.4	73.8	38.5	164.6

(a) Only partial year data to the end of September are available for 2006. Maximum, mean and minimum annual values are calculated based on tabulated values excluding partial year data from 2006.

Table A3 – Annual Water Yield Recorded at Regional Environment Canada Hydrometric Stations

Year	10QA001 Tree R.		10QB001 Hood R.		10QC001 Burnside R.		10QC002 Gordon R.		10QD001 Ellice R.		10TF001 Freshwater Ck.	
	Water Yield	Days with Data	Water Yield	Days with Data	Water Yield	Days with Data	Water Yield	Days with Data	Water Yield	Days with Data	Water Yield	Days with Data
1969	200	365	0	0	0	0	0	0	0	0	0	0
1970	216	365	0	0	0	0	0	0	0	0	22	133
1971	172	365	0	0	0	0	0	0	0	0	30	157
1972	205	366	0	0	0	0	0	0	0	0	22	289
1973	165	365	0	0	0	0	0	0	0	0	83	164
1974	144	365	0	0	0	0	0	0	0	0	78	116
1975	171	365	0	0	0	0	0	0	0	0	55	365
1976	212	366	0	0	0	0	0	0	0	0	58	346
1977	196	365	0	0	0	0	36	137	0	0	36	341
1978	127	313	0	0	0	0	174	365	0	0	110	365
1979	146	365	0	0	0	0	180	365	0	0	75	365
1980	158	366	0	0	0	0	126	366	0	0	85	366
1981	227	365	0	0	0	0	169	365	0	0	63	365
1982	197	365	0	0	0	0	176	365	0	0	107	365
1983	265	365	0	0	0	0	159	245	0	0	79	365
1984	210	366	0	0	311	366	93	216	158	366	62	202
1985	208	365	0	0	352	365	255	245	255	365	97	184
1986	243	365	0	0	298	365	210	252	214	365	78	195
1987	210	365	0	0	260	365	285	248	234	365	102	199
1988	35	175	0	0	259	366	197	245	214	366	144	201
1989	177	365	0	0	202	365	200	365	158	365	83	365
1990	134	365	0	0	184	365	182	365	181	365	59	365
1991	144	365	0	0	176	365	155	365	112	365	83	365
1992	168	366	0	0	253	366	199	366	156	366	77	366
1993	254	365	0	0	321	365	265	365	180	365	93	365
1994	155	365	130	365	194	365	227	365	146	365	75	365
1995	119	304	114	365	207	365	0	0	127	365	96	365
1996	43	63	226	366	359	366	0	0	199	366	77	319
1997	129	140	105	319	162	348	0	0	123	256	131	365
1998	148	153	159	153	183	153	0	0	126	119	72	365
1999	153	145	166	144	271	147	0	0	37	59	86	365
2000	152	245	137	153	272	366	0	0	138	105	65	366
2001	266	365	156	190	350	365	0	0	159	109	135	365
2002	170	319	141	365	169	318	0	0	170	365	56	365
2003	188	365	0	0	233	365	0	0	153	365	83	365
2004	211	366	0	0	286	366	0	0	133	366	72	366
2005	197	365	0	0	294	365	0	0	133	365	0	0
Mean[a]	194		153		267		197		172		86	

(a) Mean values are calculated based on years with complete data only. Years with less than 365 days (366 in leap years) are deemed complete if missing data are during probably zero-flow periods. Cells with red shading indicate that annual water yields cannot be calculated due to missing data. Cells with green shading indicate that annual water yields can be calculated because complete annual data are available, or that missing data occur during likely zero-flow periods.

APPENDIX B

INDIAN AND NORTHERN AFFAIRS CANADA
CLIMATE AND HYDROLOGY DATA SUMMARY

A climate station is located at Walker Bay, Nunavut for recording local weather. The station is located at (68°21' N, 108°05' W) and is operated by Indian and Northern Affairs Canada (INAC). The automatic station records the following parameters: air temperature, relative humidity, wind speed, wind direction, ground temperature at three depths, precipitation, solar radiation, and snow depth. The Walker Bay site is located on the Kent Peninsula, approximately 70 km WNW of the Doris North climate station, and is described (Bean and Henry 2002) as:

> "The Walker Bay study area is a shallow valley transected by a small sinuous river on the north-central coast of the Northwest Territories. The valley is characterized by a fine-grained mosaic of ponds 0.10-1.00 m deep, small lakes and meadows of various shapes on a silt bed. This site is characterized by a low arctic ecoclimate with a mean annual temperature of –14°C, a summer mean of 2°C and a winter mean of –28.5°C. Daily temperatures are above 0°C for 115 days on average each year. Annual rainfall is approximately 7.3 cm and snowfall is within 80 cm every year. Several creeks and rivers drain the area and low gradient, permafrost and extreme hardness of the rock aggravate the drainage conditions causing a maze of lakes and rivers. The flora of the area is comprised of a nearly continuous cover of dwarf shrub tundra vegetation, consisting of dwarf Betula, Salix, Dryas spp., and Vaccinium spp. and wet sites are dominated by Salix and sedges."

The Walker Bay station was established in the spring of 1996 and is visited annually to download data and perform maintenance. The station blew down in August 2005, and was not visited again until June 2006, so no data are available for that period. Field repairs were performed in June 2006, and a full reconstruction of the station is planned for 2007.

Monthly rainfall data are presented in Table B1 and cumulative annual data are presented in Figure B1.

Table B1 – Walker Bay Monthly Rainfall Data for Period 1996 to 2005

Month	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Mean
Jan	-	-	-	-	-	-	-	-	-	-	-
Feb	-	-	-	-	-	-	-	-	-	-	-
Mar	-	-	-	-	-	-	-	-	-	-	-
Apr	-	-	-	-	-	-	-	-	-	-	-
May	0.5	0.1	-	1.2	0.3	0.0	0.4	4.3	0.0	0.0	0.8
Jun	7.8	18.4	13.1	17.6	3.1	4.9	24.1	7.2	6.3	38.0	14.1
Jul	18.5	26.0	16.4	22.2	14.5	36.7	12.8	22.2	18.7	30.9	21.9
Aug	31.4	28.2	16.0	5.3	24.7	28.6	24.6	67.3	13.4	2.9[a]	26.6
Sep	18.8	18.0	9.2	18.3	28.8	11.4	6.0	16.6	8.6	-	15.1
Oct	0.1	0.0	10.5	0.3	1.4	0.6	0.3	1.1	0.0	-	1.6
Nov	-	-	-	-	-	-	-	-	-	-	-
Dec	-	-	-	-	-	-	-	-	-	-	-
Annual	77.1	90.7	65.2	64.9	72.8	82.2	68.2	118.7	47.0	71.8	80.0

(a) Partial data through August 7th due to station damage.

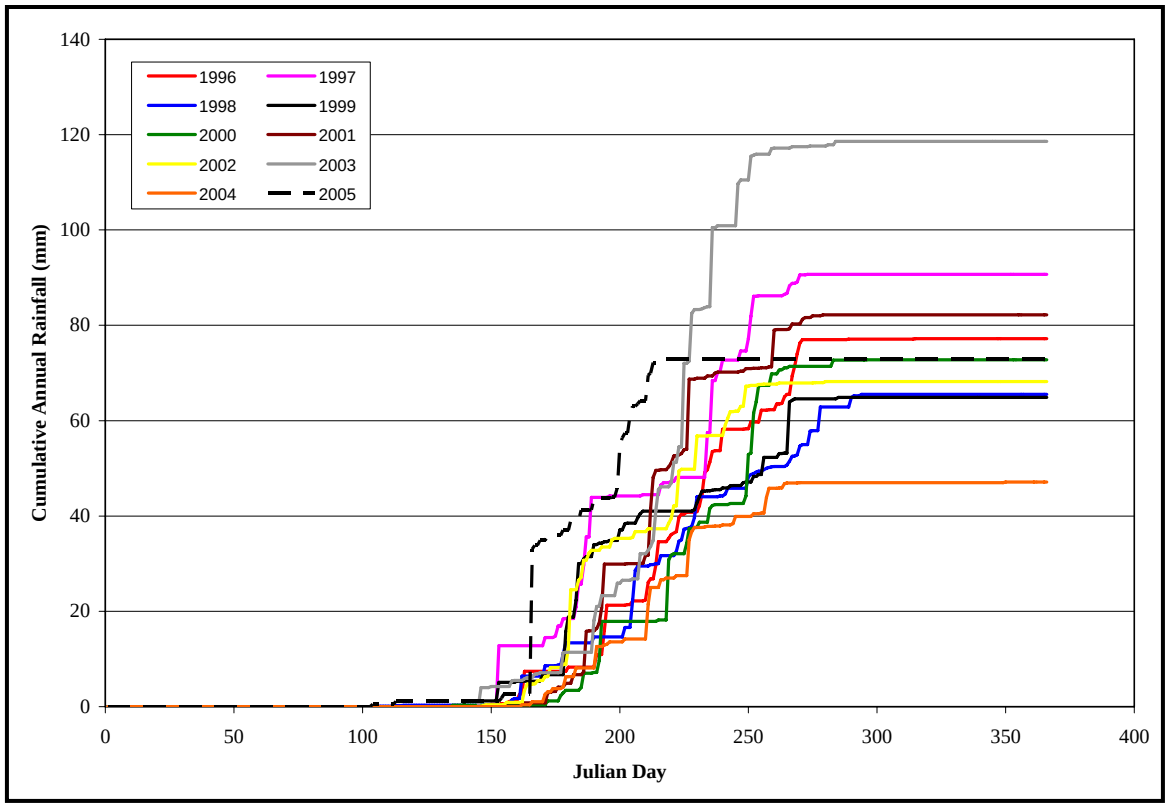

Figure B1 – Cumulative Annual Rainfall at INAC Walker Bay Climate Station

Snow-on-ground data for complete data years are presented in Table B2, and cumulative annual data are presented in Figure B2.

Table B2 – Walker Bay Snow-on-Ground Values for End of Period, 1998-99 to 2004-05

Period Ending	Winter of Years						
	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05
30-Sep	0.0	1.0	0.0	2.0	11.0	0.0	2.0
15-Oct	0.0	9.0	11.0	15.0	14.0	11.6	8.0
31-Oct	0.0	8.0	15.0	16.0	19.0	8.5	14.0
15-Nov	12.0	13.0	20.0	21.0	31.0	19.6	19.0
30-Nov	11.0	12.0	0.0	19.0	0.0	17.5	34.0
15-Dec	27.0	0.0	24.0	23.0	46.0	0.0	33.0
31-Dec	34.0	0.0	31.0	0.0	0.0	0.0	35.0
15-Jan	34.0	29.0	0.0	31.0	49.0	25.0	0.0
31-Jan	33.0	0.0	35.0	32.0	49.0	31.0	48.0
15-Feb	34.0	37.0	35.0	45.0	50.0	30.0	49.0
28-Feb	36.0	42.0	0.0	46.0	53.0	30.0	50.0
15-Mar	45.0	47.0	39.0	46.0	59.0	28.0	50.0
31-Mar	47.0	50.0	44.0	48.0	56.0	29.0	50.0
15-Apr	48.0	49.0	51.0	46.0	61.0	28.0	58.0
30-Apr	54.0	49.0	0.0	49.0	59.0	28.0	59.0
15-May	52.0	48.0	63.0	46.0	58.0	36.0	57.0
31-May	49.0	48.0	59.0	52.0	53.0	37.0	39.0
15-Jun	5.0	1.0	5.0	0.0	18.0	0.0	0.0
30-Jun	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum	56.0	52.0	64.0	53.0	62.0	38.0	61.0

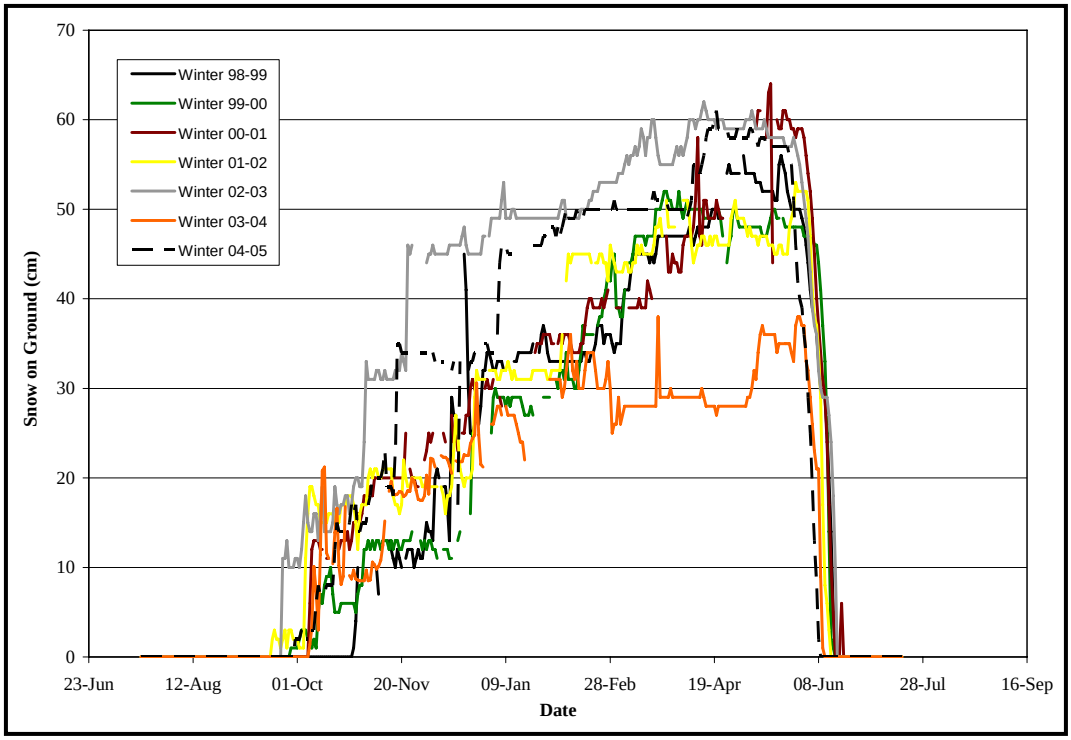

Figure B2 – Cumulative Annual Snow-on-Ground at INAC Walker Bay Climate Station

APPENDIX C

DORIS NORTH BASELINE
CLIMATE AND HYDROLOGY DATA SUMMARY

Baseline data were collected on the Hope Bay Belt between 1993 and 2002, and were reported by Rescan (2002). These data provided the local basis for the subsequent baseline meteorology and hydrology report (AMEC 2003).

A summary of monthly rainfall and snow water equivalent precipitation as reported by Rescan (2002) is presented in Table C1.

Hydrographs from Doris North area hydrometric stations, derived from data presented by Rescan (2002) are presented in Figures C1 to C5.

Table C1 – Total Monthly and Snow Water Equivalent Precipitation, 1993-2002

Month	Boston Camp Rain (mm)	Boston Camp Total SWE Calculated from Ultrasonic Gauge (mm)	Cambridge Bay Airport Total Precipitation (mm)	Lupin (Echo Bay Mine) Total Precipitation (mm)
August 1993	25.5[a]	n/a	n/a	n/a
September	n/a[b]	n/a	n/a	n/a
October	n/a[b]	n/a	n/a	n/a
November	n/a[b]	n/a	n/a	n/a
December	n/a[b]	n/a	n/a	n/a
January 1994	n/a[b]	n/a	n/a	n/a
February	n/a[b]	n/a	n/a	n/a
March	n/a[b]	n/a	n/a	n/a
April	n/a[c]	n/a	n/a	n/a
May	n/a[c]	n/a	n/a	n/a
June	n/a[c]	n/a	n/a	n/a
July	n/a[c]	n/a	n/a	n/a
August	n/a[c]	n/a	n/a	n/a
September	n/a	n/a	n/a	n/a
October	n/a	n/a	n/a	n/a
November	n/a	n/a	n/a	n/a
December	0.0[d]	1.3[d]	n/a	n/a
January 1995	0	8.7	n/a	n/a
February	0	10.8	n/a	n/a
March	0	10	n/a	n/a
April	0	2.2[e]	n/a	n/a
May	n/a	n/a	n/a	n/a
June	n/a	n/a	n/a	n/a
July	n/a	n/a	n/a	n/a
August	n/a	n/a	n/a	n/a
September	n/a	n/a	n/a	n/a
October	n/a	n/a	n/a	n/a
November	0	0.7	4.8	7.4
December	0	1	2.2	23.8
January 1996	0	7.3	1.5	5.8
February	0	13	4.3	18.4
March	0	8.5	n/a	4.4
April	0.5	14	n/a	8
May	0.3	19.8	n/a	24.8
June	16	0	n/a	54
July	25.4	0	n/a	57.7
August	79.2[f]	0	n/a	131.8
September	5.1	16.5[g]	22.8	n/a
October	n/a	22.5	12.4	13
November	n/a	20.1	2.6	13.6
December	n/a	16.1	10	6.6

Table C1 – Total Monthly and Snow Water Equivalent Precipitation, 1993-2002 (continued)

Month	Boston Camp Rain (mm)	Boston Camp Total SWE Calculated from Ultrasonic Gauge (mm)	Cambridge Bay Airport Total Precipitation (mm)	Lupin (Echo Bay Mine) Total Precipitation (mm)
January 1997	n/a	4.3	9.2	6
February	n/a	4.3	5	6.6
March	n/a	5.6	3.6	6.8
April	n/a	4.5	3.8	12.8
May	n/a	10.3	5.8	27.2
June	n/a	0	33.2	21.2
July	n/a	0	26.4	18.2
August	0.3[h]	0	18.7	58.7
September	8.9[k]	7.7[i]	22.4	25.4
October	0.3	10.9[j]	17.6	46.2
November	0	14.6	4.8	12.6
December	0	12	7.8	17.8
January 1998	0	7	3.2	5.2
February	0	10.4	6.2	7.2
March	0	10.4	3.6	5.6
April	0	9.7	6.6	17.8
May	5.7	7.6	1.6	19.2
June	19.6	0	10.2	38.4
July	8.9	0	n/a	n/a
August	47	0	61.9[r]	57.4
September	16	0	20.7[r]	61.8
October	4.3	13.6	25.9[r]	51.7
November	0	22.6	12.5[r]	17
December	0	12.9	7.7[r]	21.6
January 1999	0	8.2	5.6[r]	9.6
February	0	9.9	4.6[r]	6.6
March	0	9.1	6.4[r]	14.4
April	0	13.8	15.0[r]	25
May	0.5	11	18.4[r]	25.2
June	0.3	0	25.4[r]	19.6
July	53.6	0	64.0[r]	62.4
August	7.6	0	12.4[r]	57.2
September	24.1	2.3	65.5[r]	85.2
October	0	n/a[k]	20.8[r]	23.8
November	0	n/a[k]	16.0[r]	9.8
December	0	n/a[k]	43.5[r]	30.8
January	0	n/a[k]	5.8[r]	3.8
February	0	n/a[k]	6.5[r]	5.4
March	0	n/a[k]	5.6[r]	7
April	0	n/a[k]	6.8[r]	12.4

Table C1 – Total Monthly and Snow Water Equivalent Precipitation, 1993-2002 (continued)

Month	Boston Camp Rain (mm)	Boston Camp Total SWE Calculated from Ultrasonic Gauge (mm)	Cambridge Bay Airport Total Precipitation (mm)	Lupin (Echo Bay Mine) Total Precipitation (mm)
May 2000	1	n/a[k]	15.0[r]	18.6
June	3.3[l]	n/a[k]	14.2[r]	5
July	12.4	0	46.0[r]	27.2
August	14	0	32.6[r]	49.2
September	34.4	13	71.5[r]	58.6
October	0.5	13.2	45.1[r]	43.4
November	0	23.8	11.7[r]	14
December	0	12.1	5.4[r]	7.8
January 2001	0	30.2	6.4	n/a
February	0	7	7	n/a
March	0	10.1[n]	24.6	n/a
April	0.3	5.9[n]	30.2	n/a
May	1.4	14.8[n]	40.2	n/a
June	7	5.7[n]	6.4	n/a
July	2.3[m]	n/a	n/a	n/a
August	0.0[m]	n/a	n/a	n/a
September	6.3[m]	4.3[o]	n/a	n/a
October	3.6	14.5	n/a	n/a
November	0	n/a[q]	n/a	n/a
December	0	n/a[q]	n/a	n/a
January 2002	0	9.8[q]	n/a	n/a
February	0	0.7[q]	n/a	n/a
March	0	n/a[q]	n/a	n/a
April	0	n/a[q]	n/a	n/a
May	0.0[p]	n/a[q]	n/a	n/a

n/a = no data are available because there were problems with the sensor (tipping bucket rain gauge or ultrasonic snow depth gauge) or the datalogger.

a) July 30 to August 29, 1993. The total rain is available for this period but the daily rainfall is not.

b) No precipitation data available due to power failure at meteorological station.

c) Rainfall data are available from April 12 to August 2, 1994 but only in a graphical format.

d) Data available for December 26 to 31, 1994.

e) Data available for April 1 to 10, 1995.

f) No data available from the Boston station's tipping bucket rain gauge; these data were from the Windy Lake manual rain gauge.

g) SWE data from the ultrasonic snow depth gauge began September 4, 1996.

h) Tipping bucket rain gauge data only available for August 28 to 31, 1997.

i) SWE data were only available from the ultrasonic snow depth gauge for September 1 to 11, 1997.

j) SWE data from the ultrasonic snow depth gauge were only available for October 8 to 31, 1997.

k) The ultrasonic snow depth gauge was out of service; therefore, no SWE data are available. The sensor was back in service on June 19, 2000.

l) Rain data only available for June 18 to 30, 2000 due to a damaged tipping bucket rain gauge.

m) Data are not available from the tipping bucket rain gauge from July 6 to September 12, 2001.

n) The ultrasonic snow gauge was not working, therefore SWE data from Kugluktuk (Coppermine) was used.

o) Data available from the ultrasonic snow gauge September 13 to 30, 2001.

p) Data available only from May 1 to 8, 2002.

q) Several days of SWE data are missing because the ultrasonic snow gauge was only working intermittently.

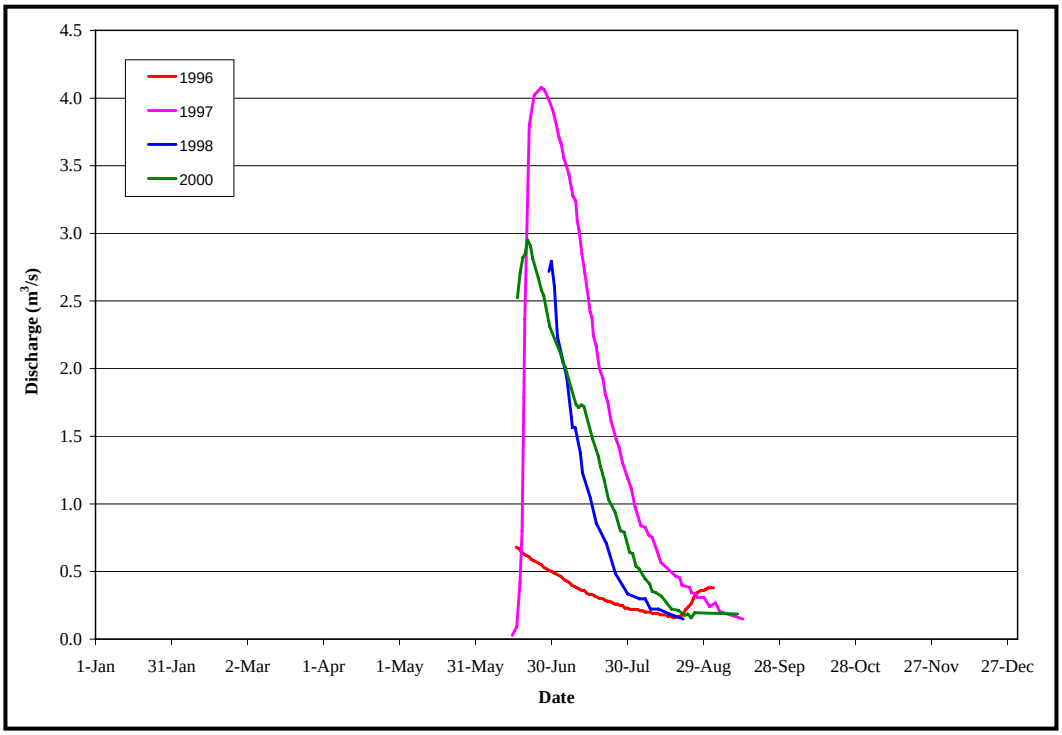

Figure C1 – Doris Lake Outflow Hydrographs, 1996, 1997, 1998 and 2000

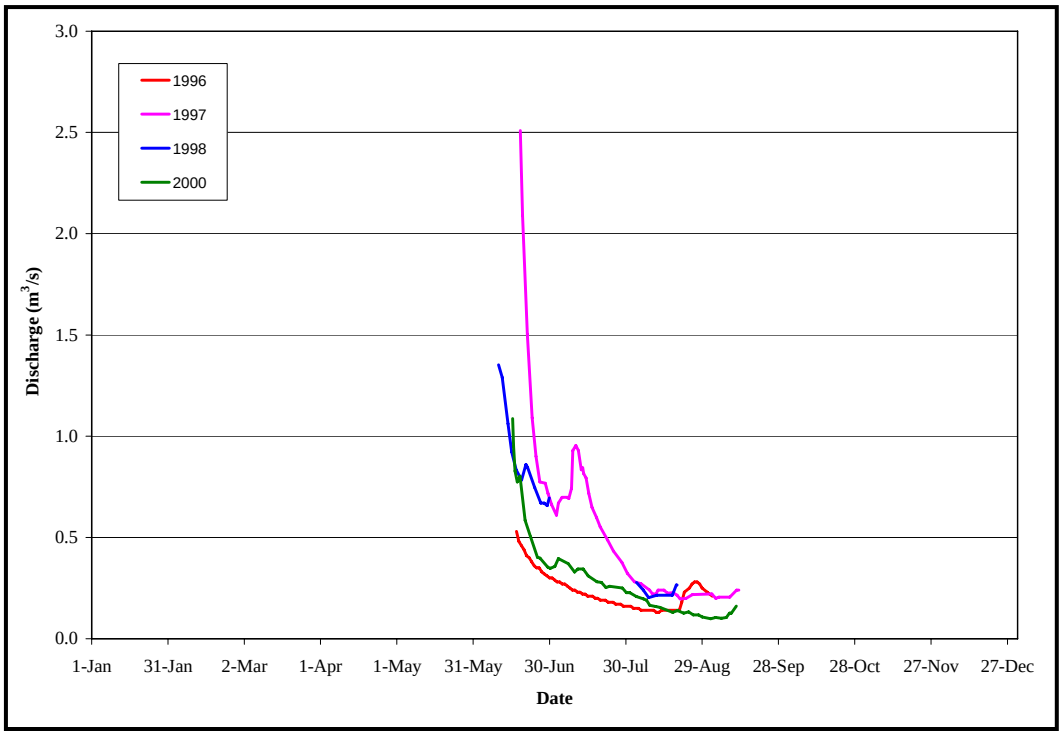

Figure C2 – Glenn Lake Outflow Hydrographs, 1996, 1997, 1998 and 2000

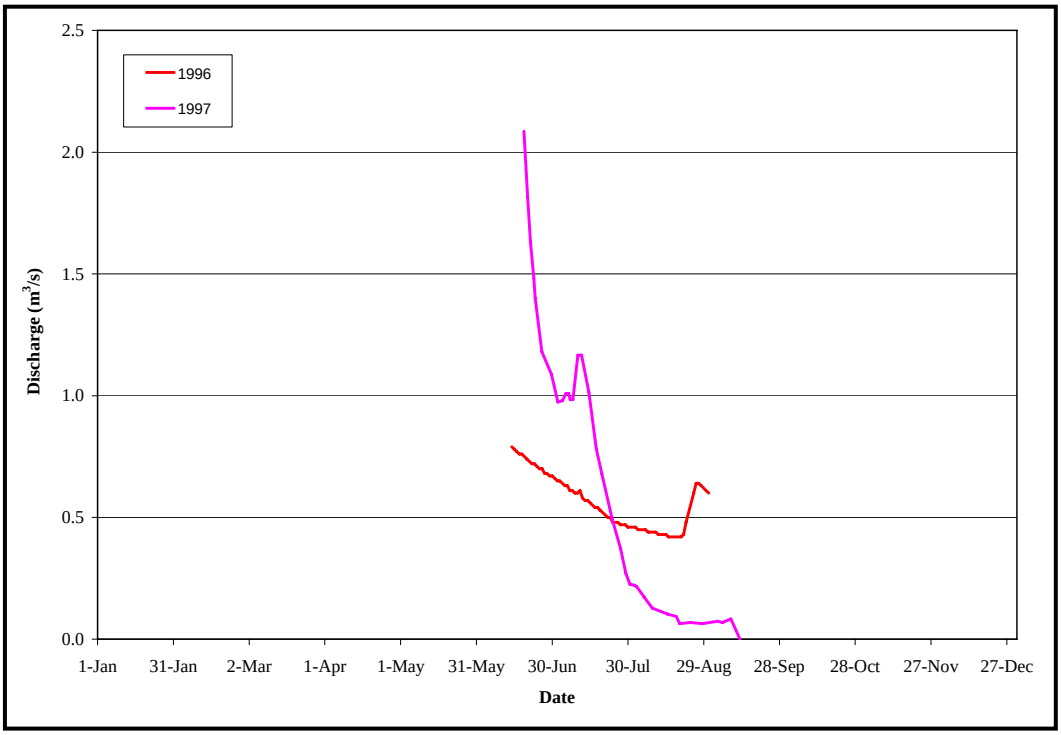

Figure C3 – Ogama Lake Outflow Hydrographs, 1996 and 1997

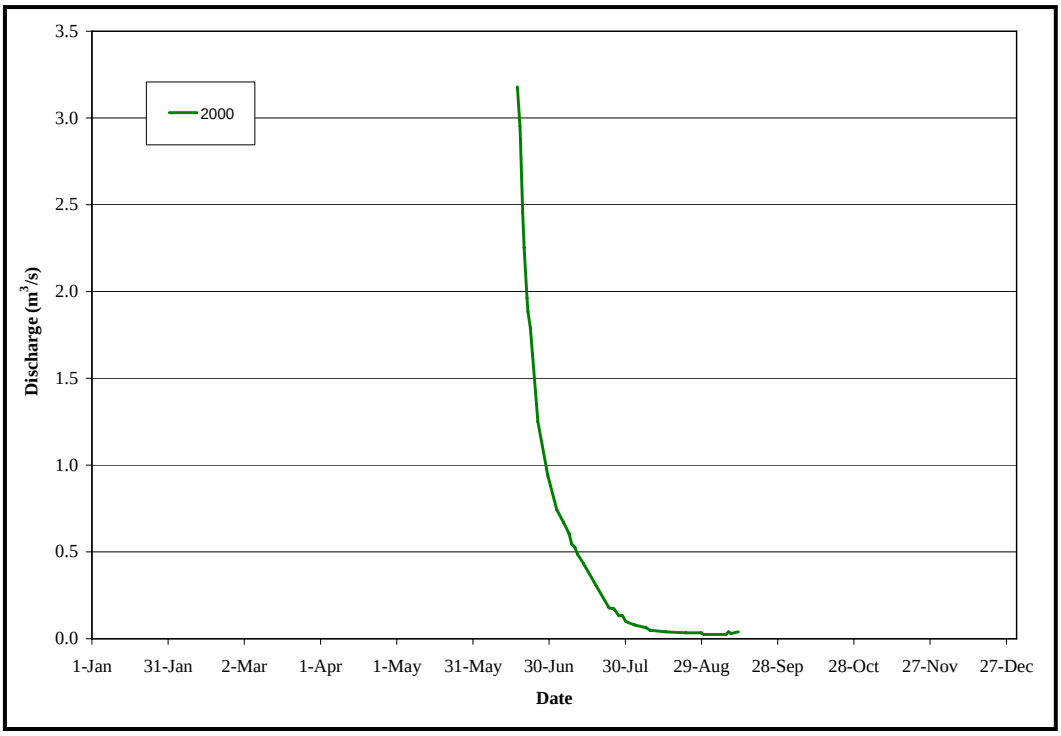

Figure C4 – Pelvic Lake Outflow Hydrograph, 2000

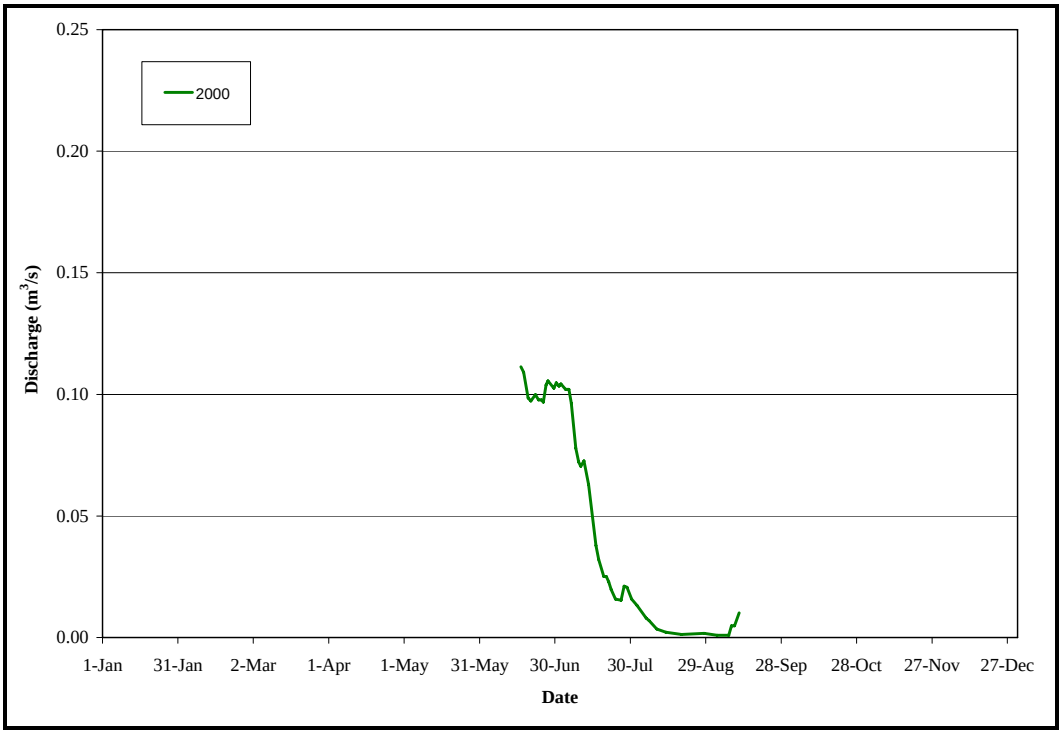

Figure C5 – Tail Lake Outflow Hydrograph, 2000

APPENDIX D

DORIS NORTH POST-BASELINE
CLIMATE AND HYDROLOGY DATA SUMMARY

The Doris North post-baseline climate and hydrology data collection program includes data collected between June 2003 and September 2006. A summary of available data is presented in Table D1. Additional data were collected in 2006 in the area south of Doris Lake but are not presented in this report. Summary charts for the data listed in Table D1 are provided below.

Table D1 – Doris North Post-Baseline Climate and Hydrology Data

Station	Parameters	2003	2004	2005	2006
Doris North	Climatic[a]	-	28/2 – 31/12	Full season	1/1 – 9/9
Doris North Snowcourse	Snow Water Equivalent	-	5/5 – 6/5	9/5 – 12/5	30/4
Doris Lake Outflow	Discharge	Partial	Full season	Full season	Full season
Roberts Lake Outflow	Discharge	Partial	Full season	Full season	Full season
Little Roberts Lake Outflow	Discharge	Partial	Full season	Full season	Full season
Tail Lake Outflow	Discharge	-	Full season	Full season	Full season
Doris Lake	Water Level	-	Partial	8/6 – 31/12	1/1 – 9/9
Tail Lake	Water Level	-	Full year	Full year	1/1 – 9/9
Derived Lake Evaporation		-	Full season	Full season	Full season

(b) The Doris North climate station measures air temperature, relative humidity, wind speed and direction, rainfall and solar radiation.

Rainfall Data Collected at Doris North Climate Station – 2004 to 2006

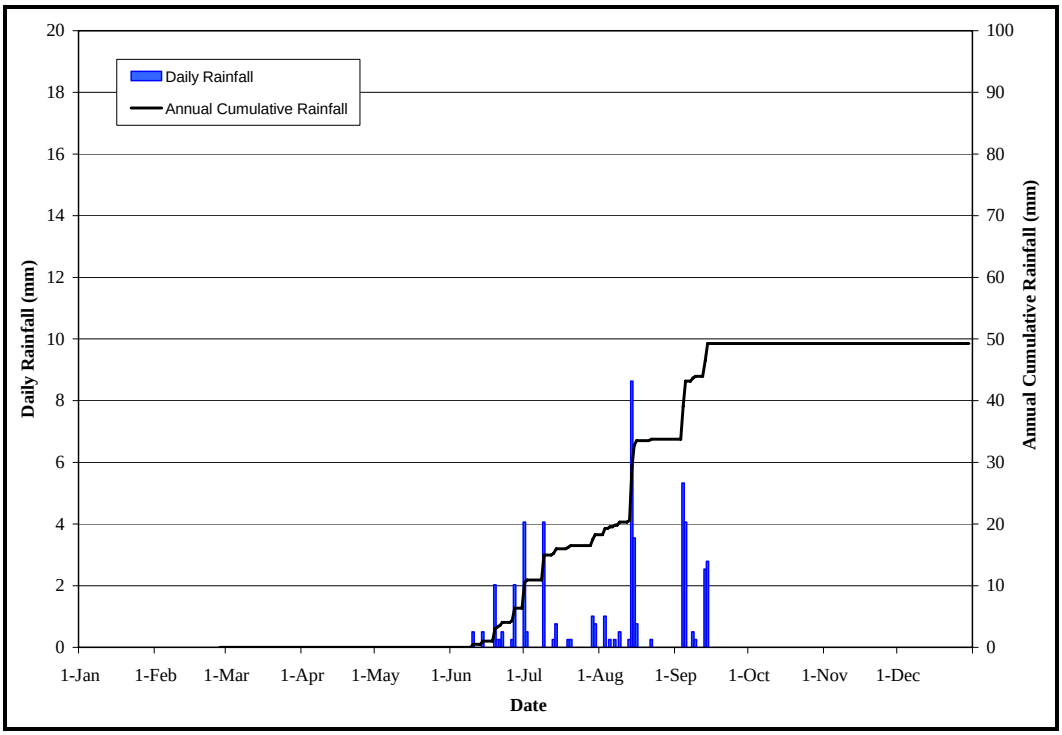

Figure D1 – Daily and Annual Rainfall at Doris North Climate Station - 2004

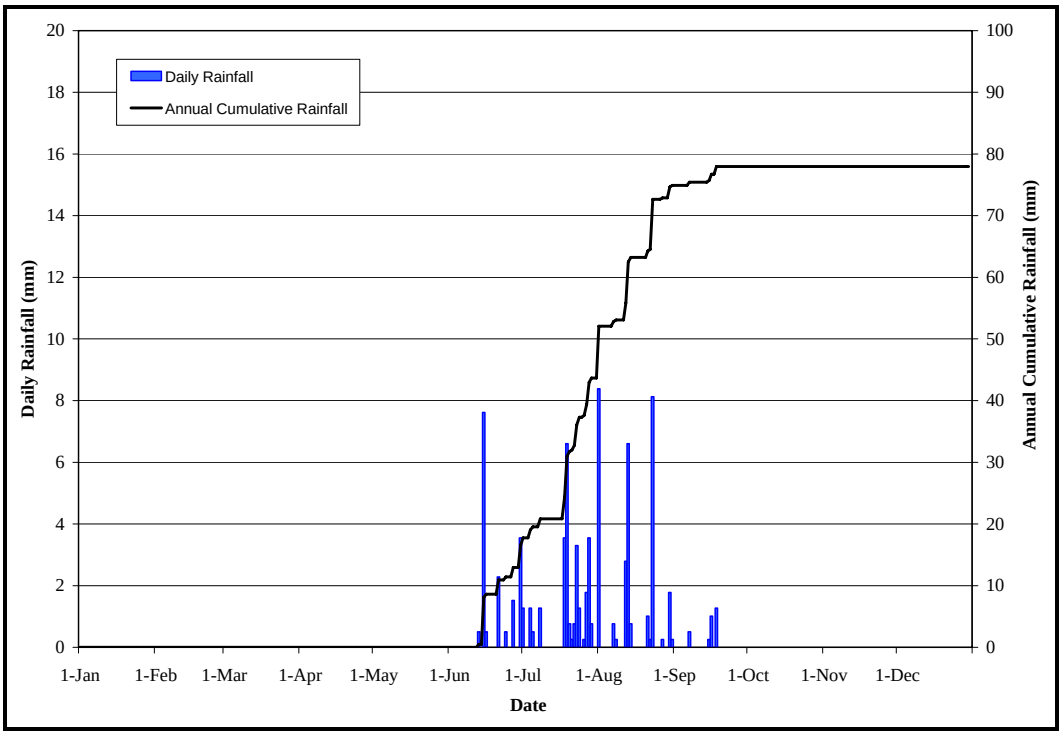

Figure D2 – Daily and Annual Rainfall at Doris North Climate Station - 2005

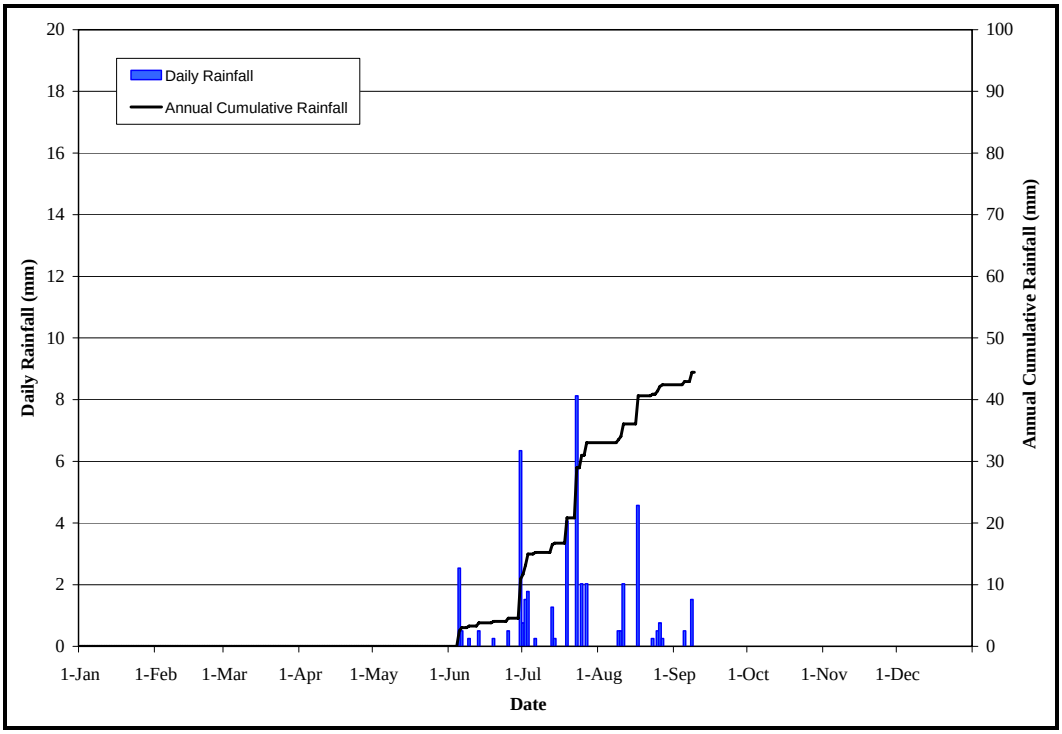

Figure D3 – Daily and Annual Rainfall at Doris North Climate Station - 2006

Snowcourse Survey Data from Doris North Area – 2004 to 2006

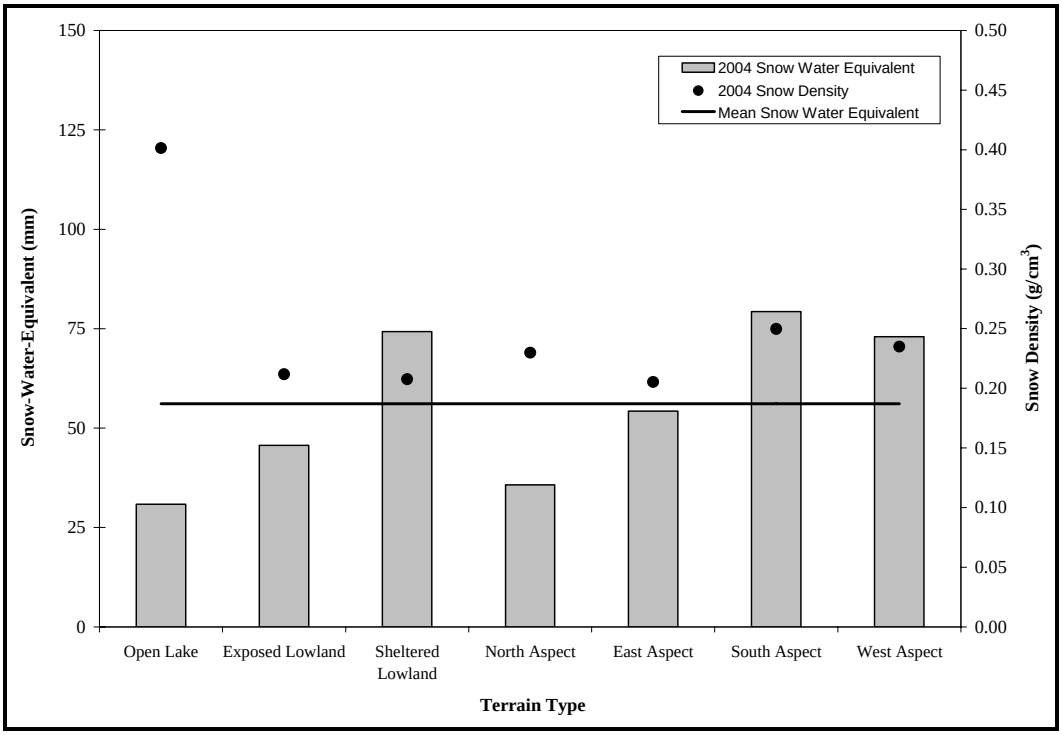

Figure D4 – Snowcourse Survey Data for Doris North Area - 2004

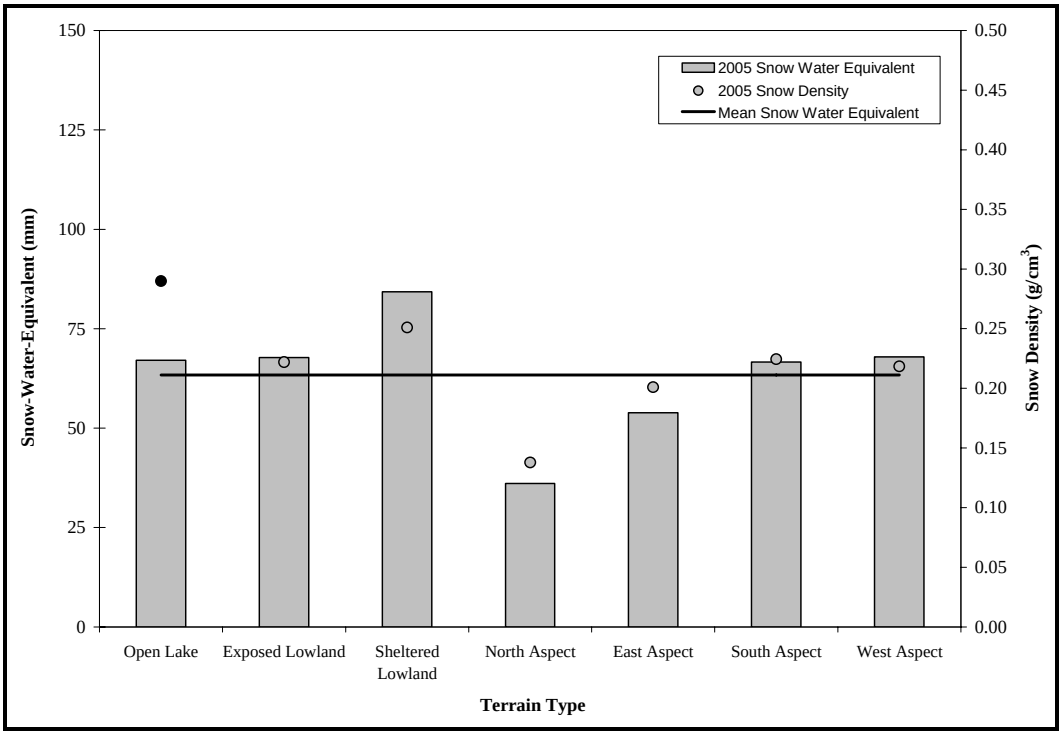

Figure D5 – Snowcourse Survey Data for Doris North Area - 2005

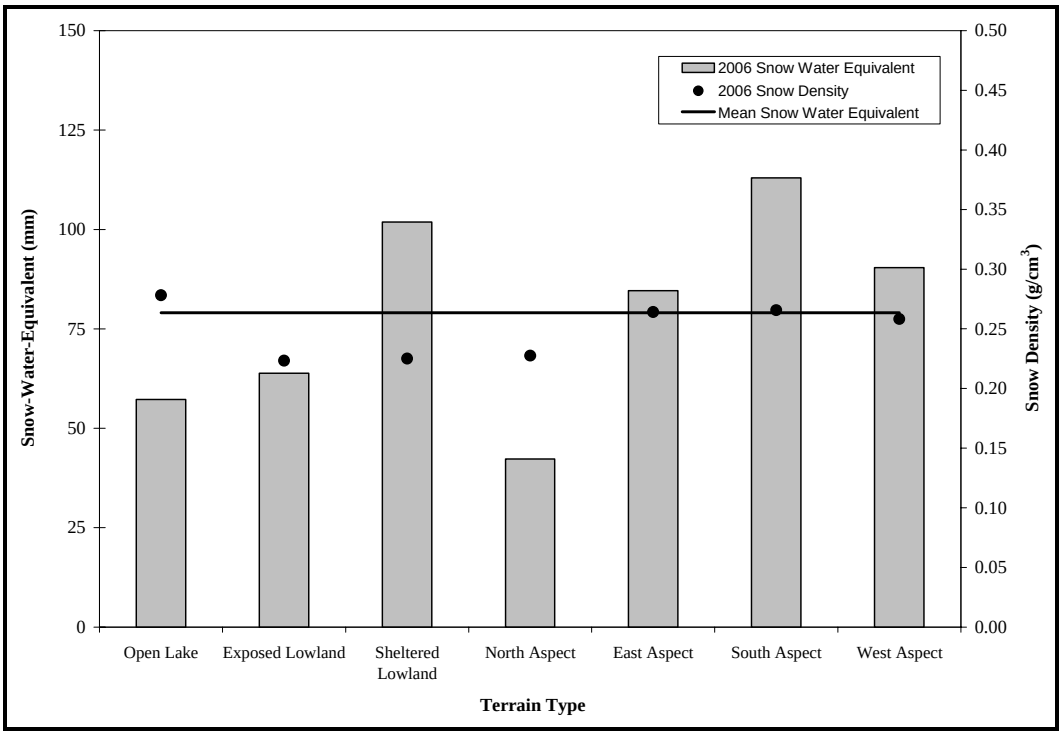

Figure D6 – Snowcourse Survey Data for Doris North Area - 2006

Hydrology Data Collected at Doris Lake Outflow – 2003 to 2006

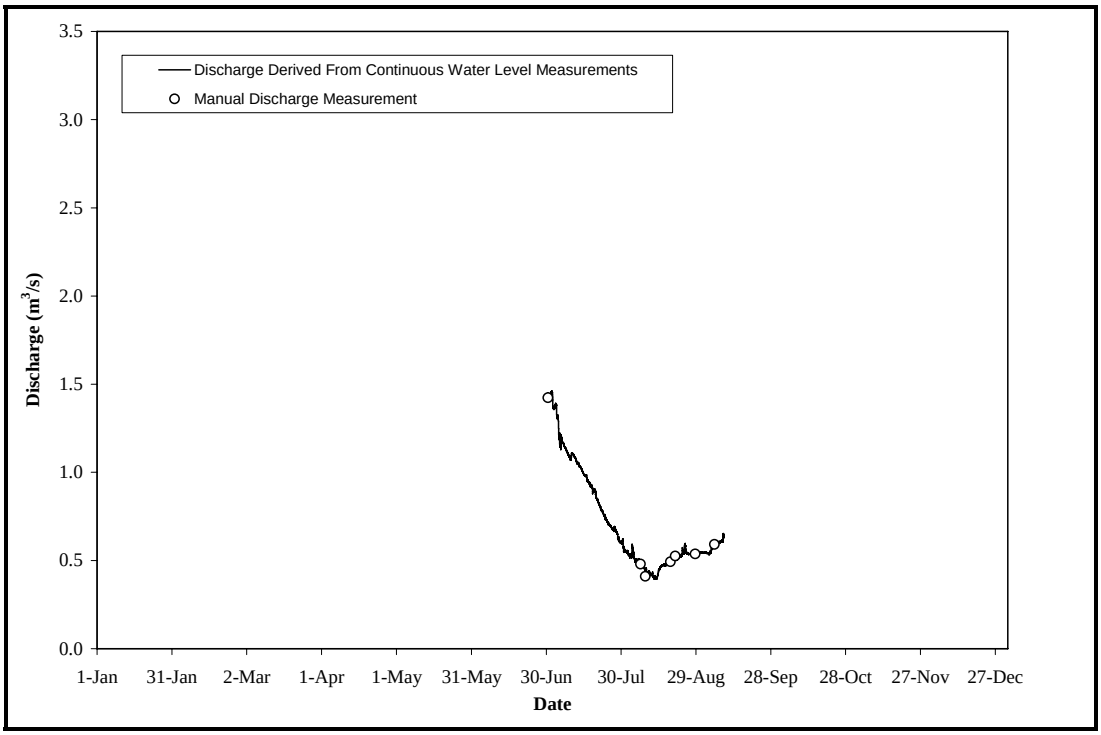

Figure D7 – Doris Lake Outflow Hydrograph - 2003

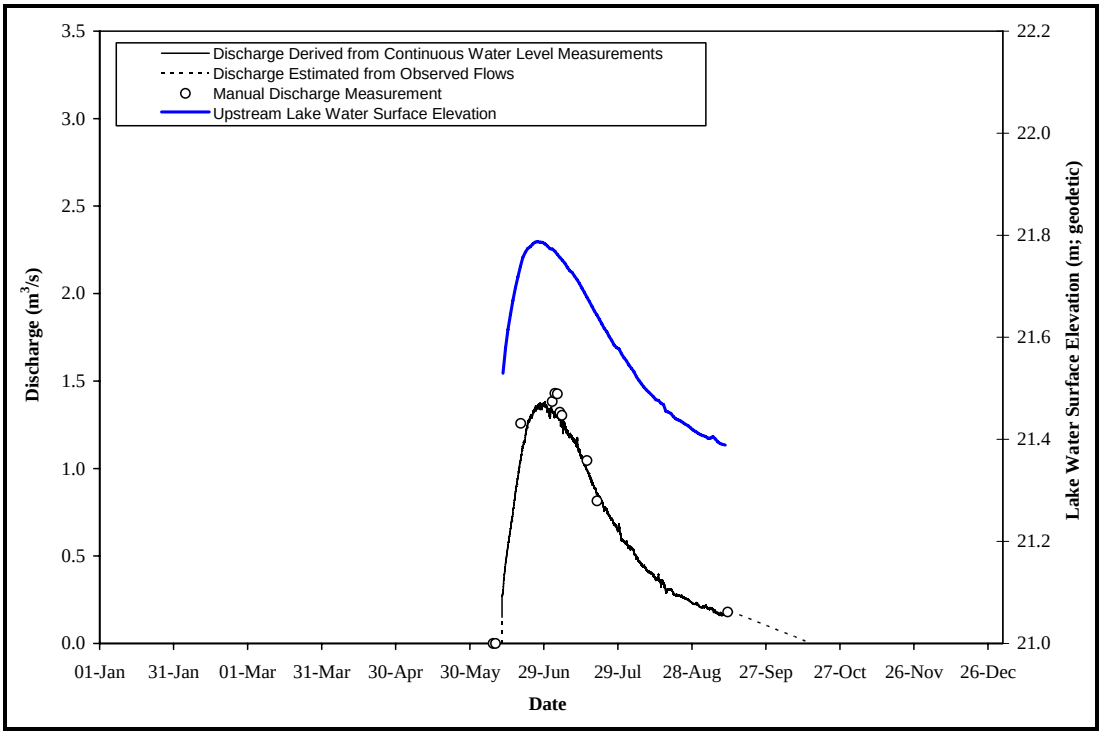

Figure D8 – Doris Lake Outflow Hydrograph - 2004

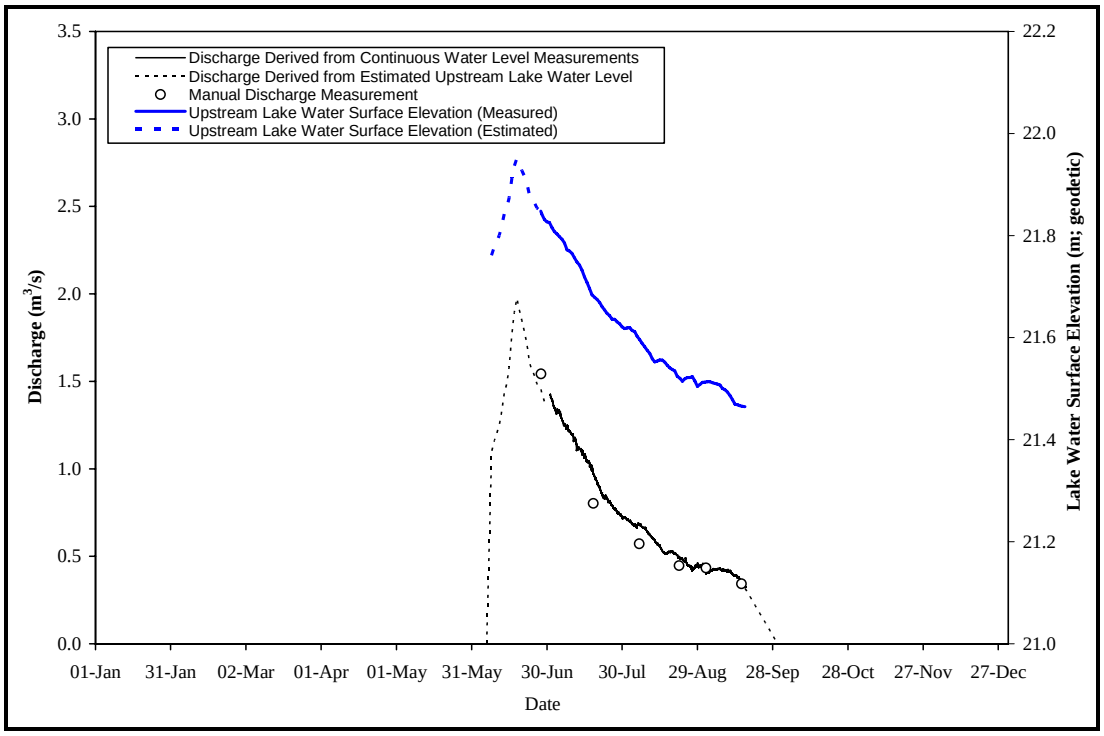

Figure D9 – Doris Lake Outflow Hydrograph - 2005

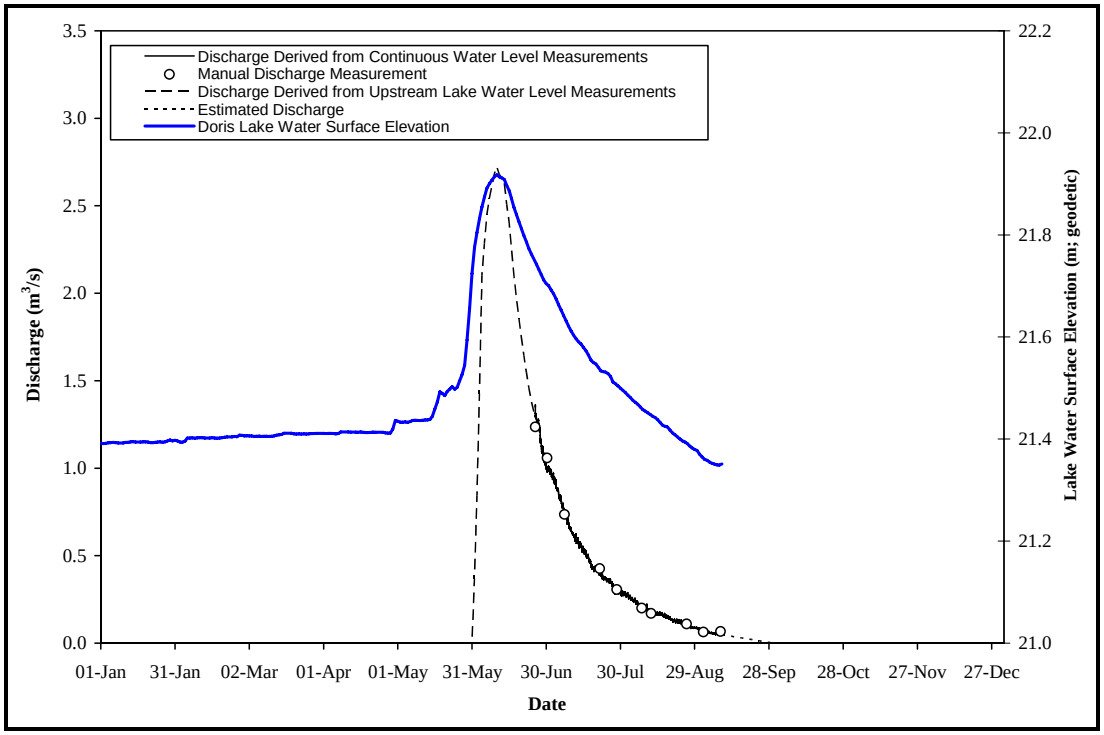

Figure D10 – Doris Lake Outflow Hydrograph - 2006

Hydrology Data Collected at Roberts Lake Outflow – 2003 to 2006

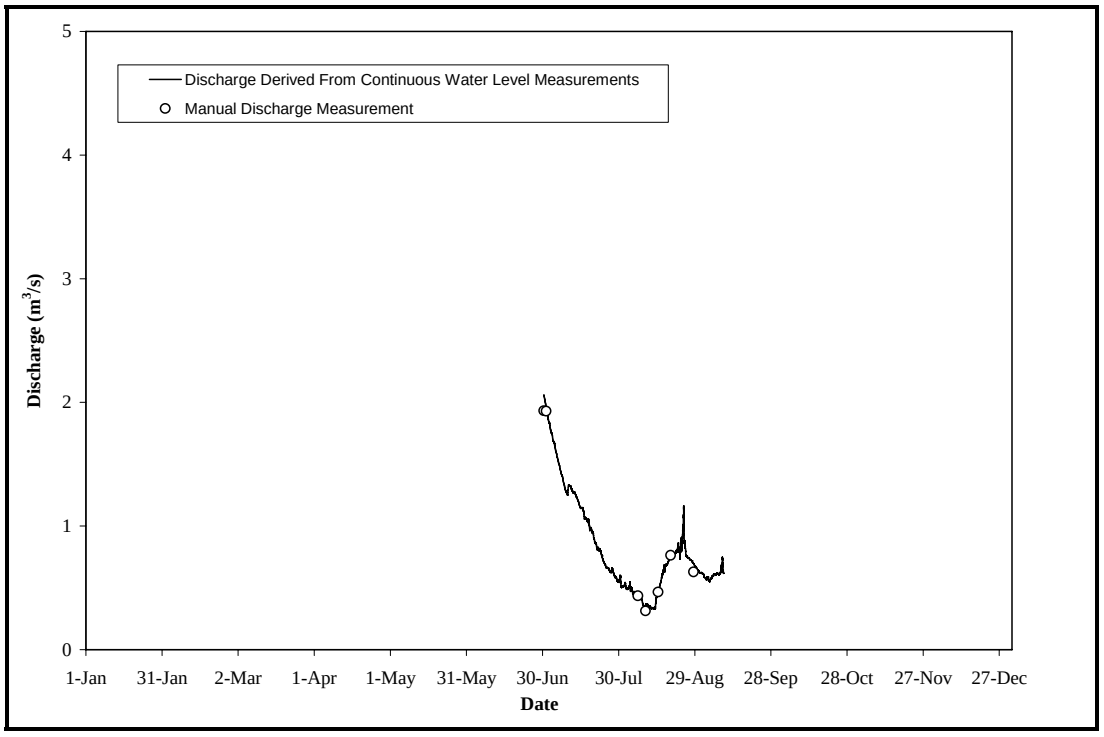

Figure D11 – Roberts Lake Outflow Hydrograph - 2003

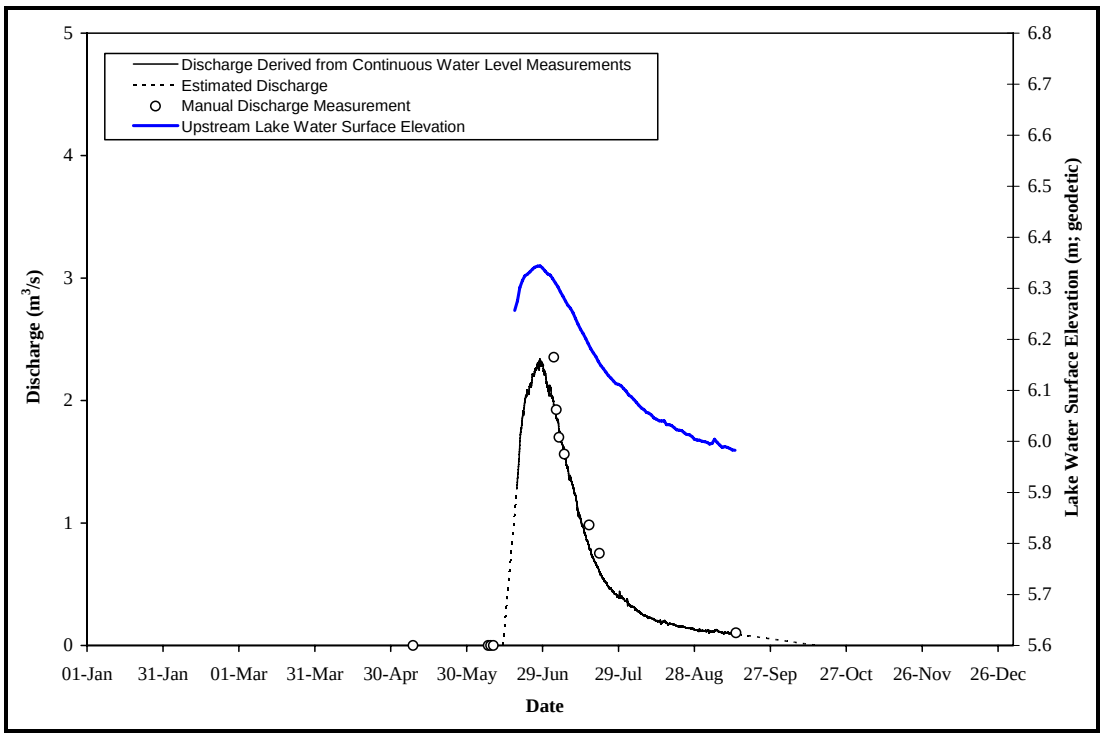

Figure D12 – Roberts Lake Outflow Hydrograph - 2004

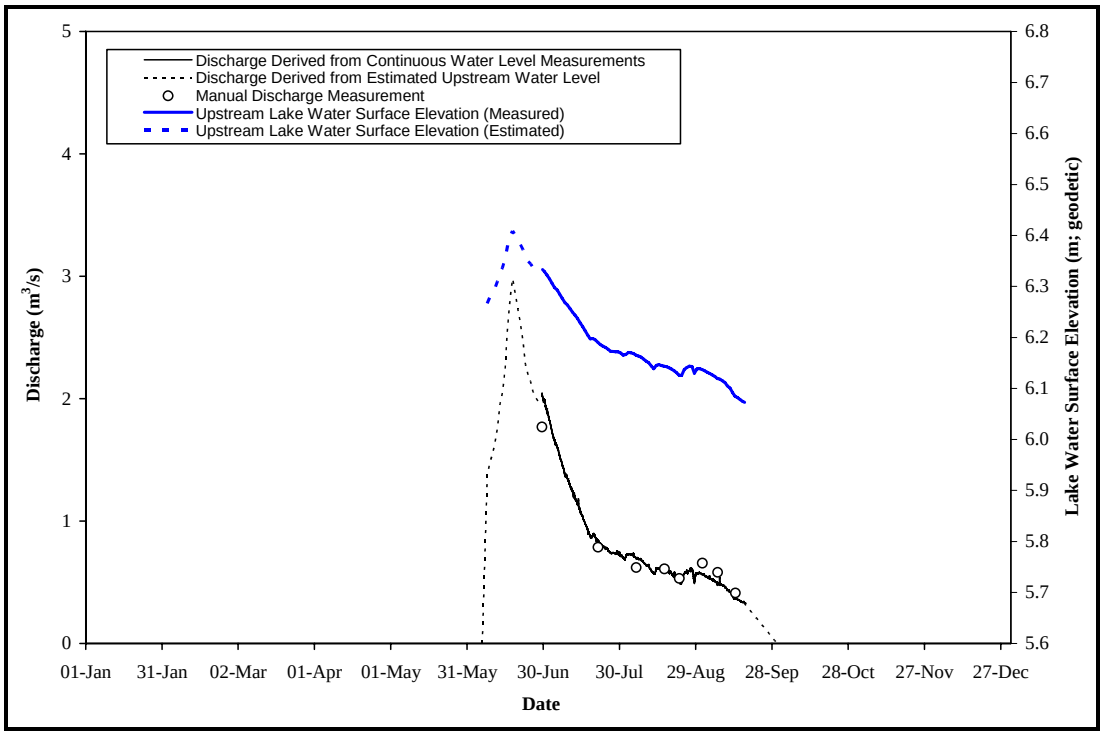

Figure D13 – Roberts Lake Outflow Hydrograph - 2005

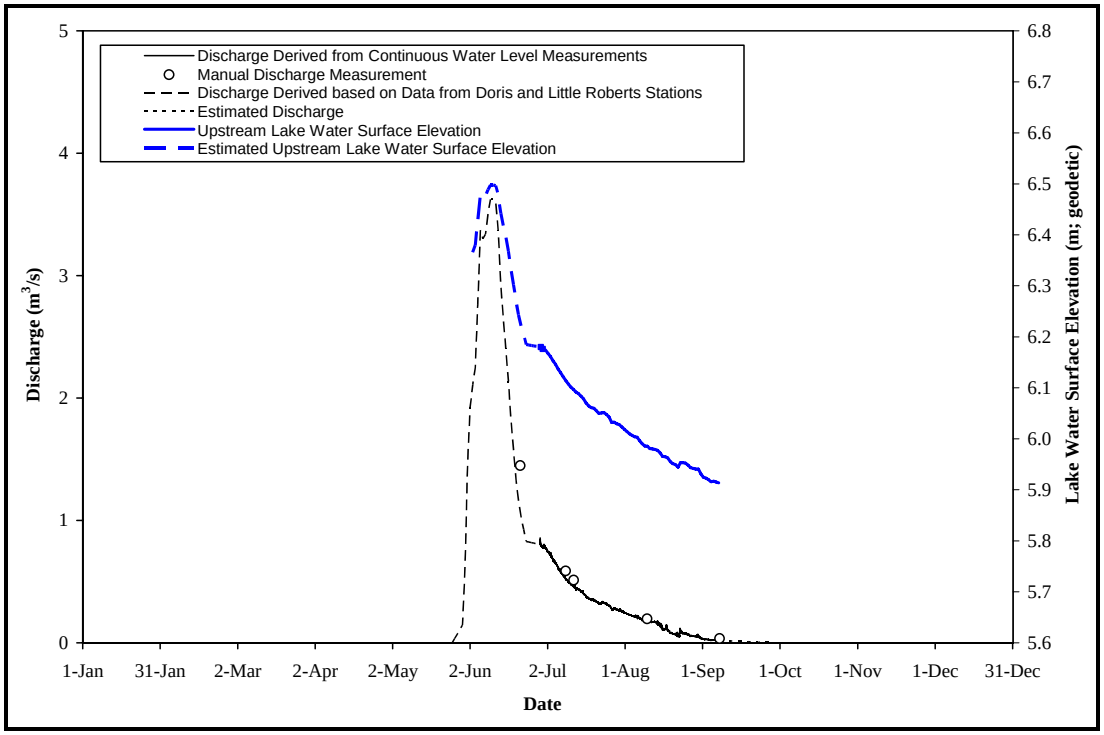

Figure D14 – Roberts Lake Outflow Hydrograph - 2006

Hydrology Data Collected at Little Roberts Lake Outflow – 2003 to 2006

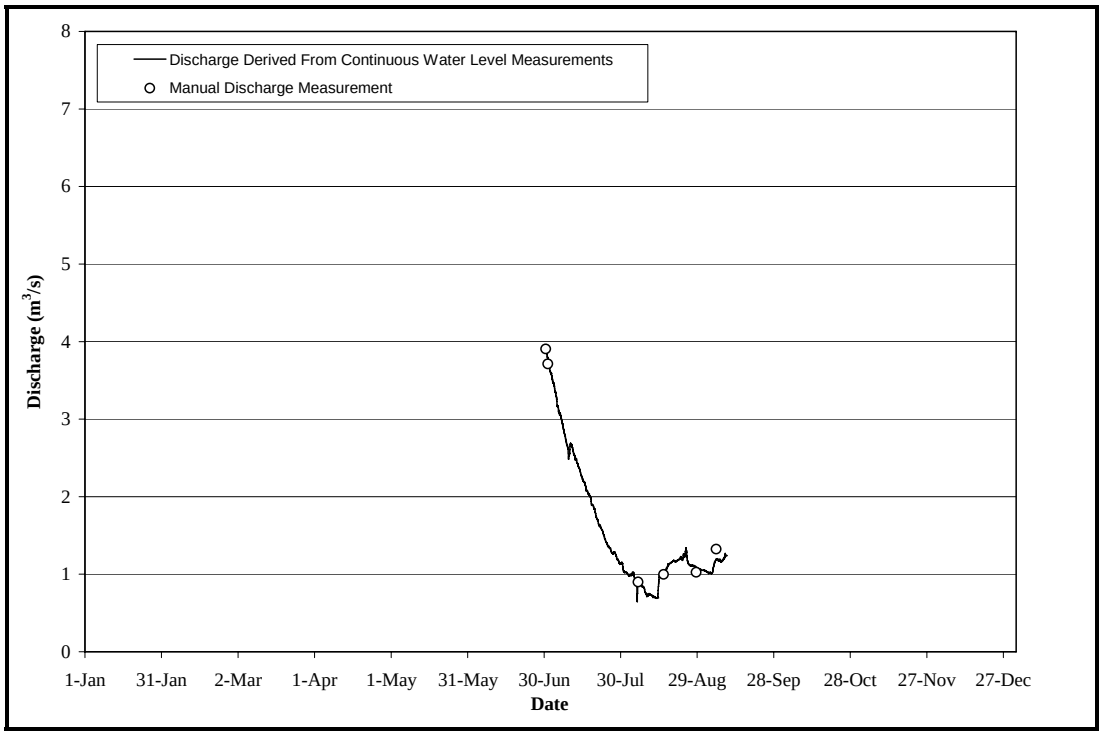

Figure D15 – Little Roberts Lake Outflow Hydrograph - 2003

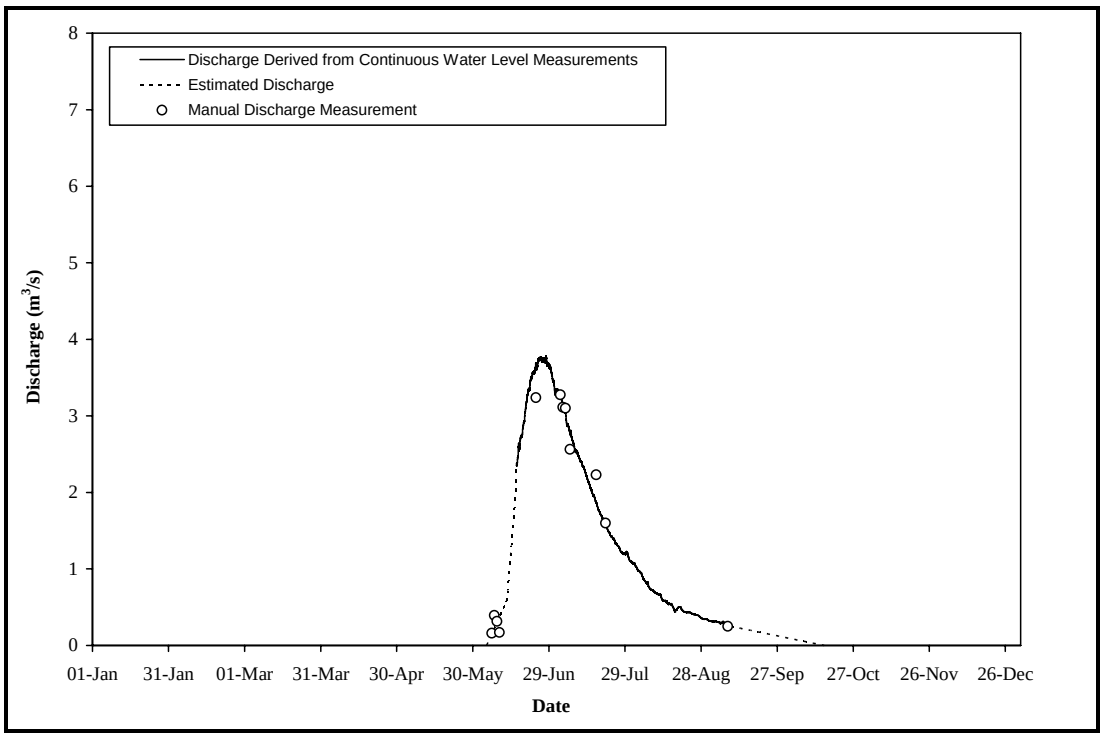

Figure D16 – Little Roberts Lake Outflow Hydrograph - 2004

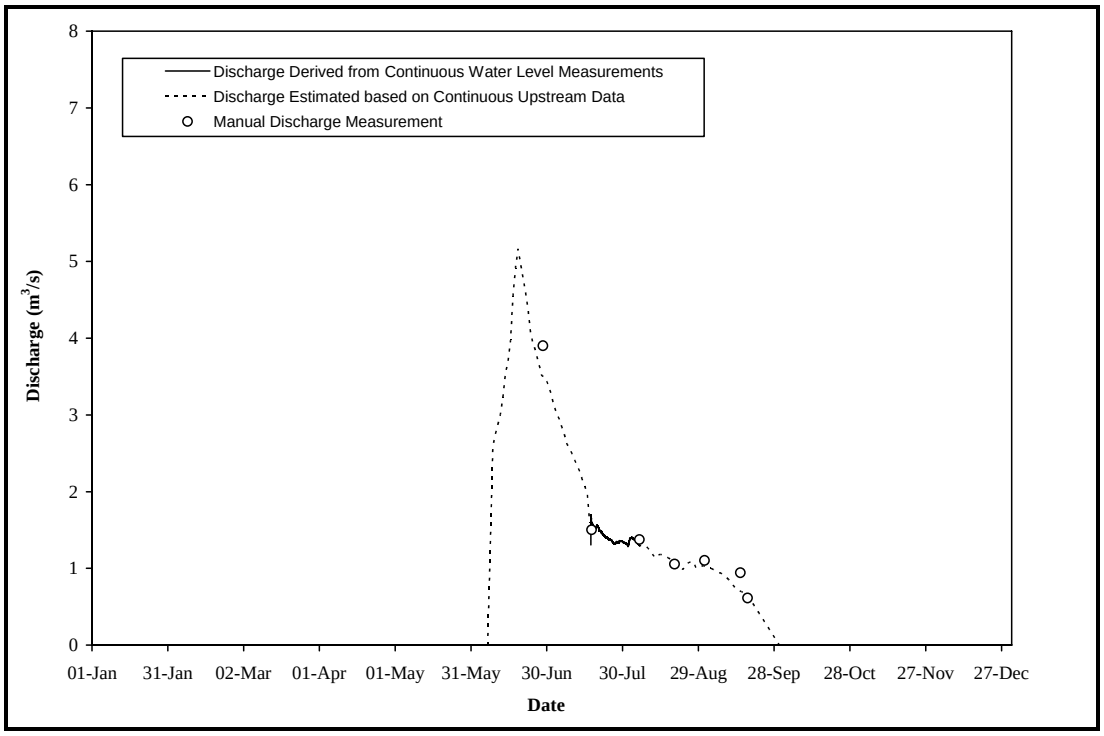

Figure D17 – Little Roberts Lake Outflow Hydrograph - 2005

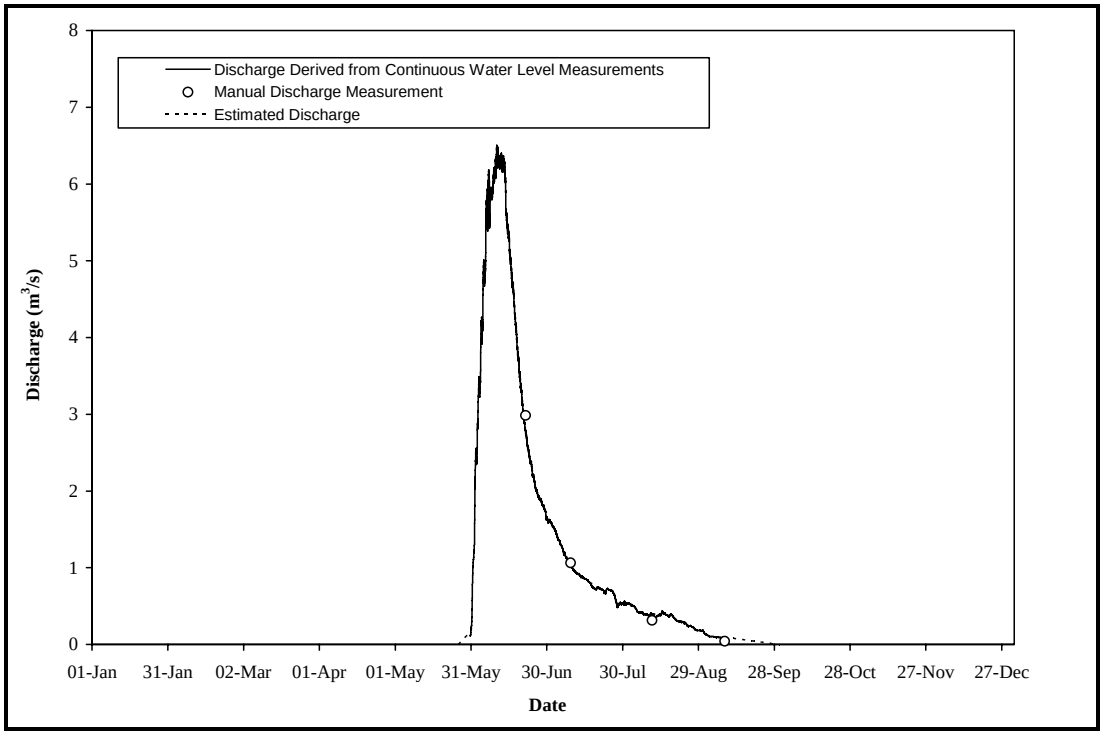

Figure D18 – Little Roberts Lake Outflow Hydrograph - 2006

Hydrology Data Collected at Tail Lake Outflow – 2004 to 2006

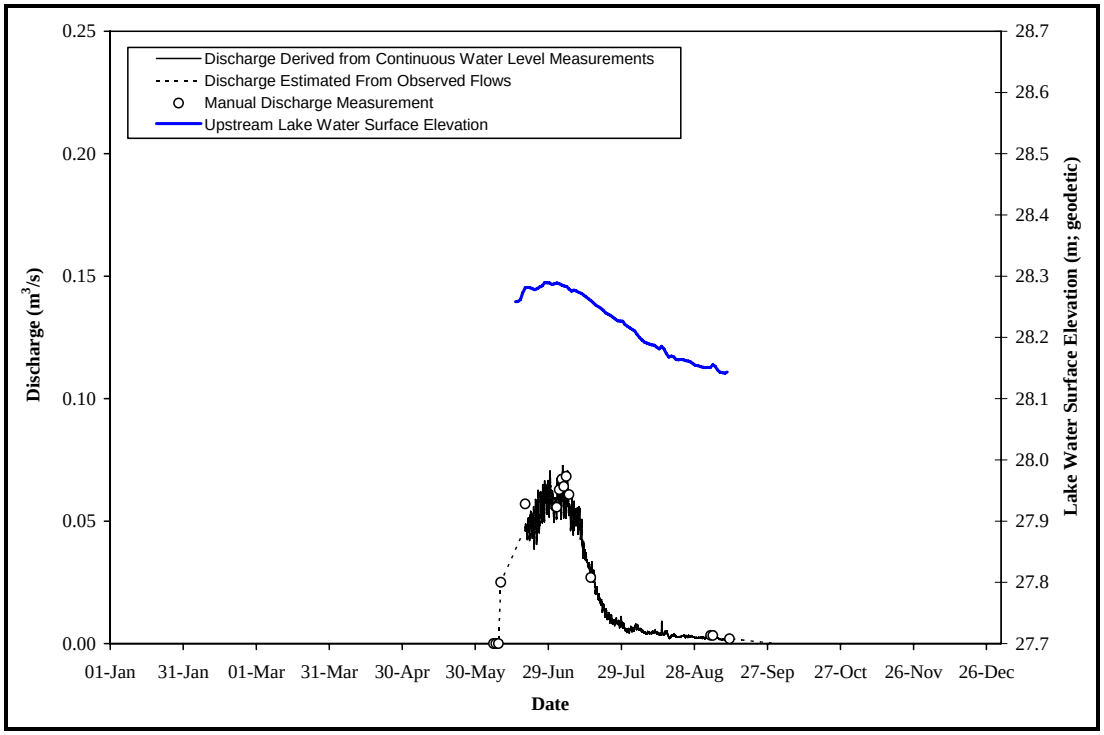

Figure D19 – Little Roberts Lake Outflow Hydrograph - 2004

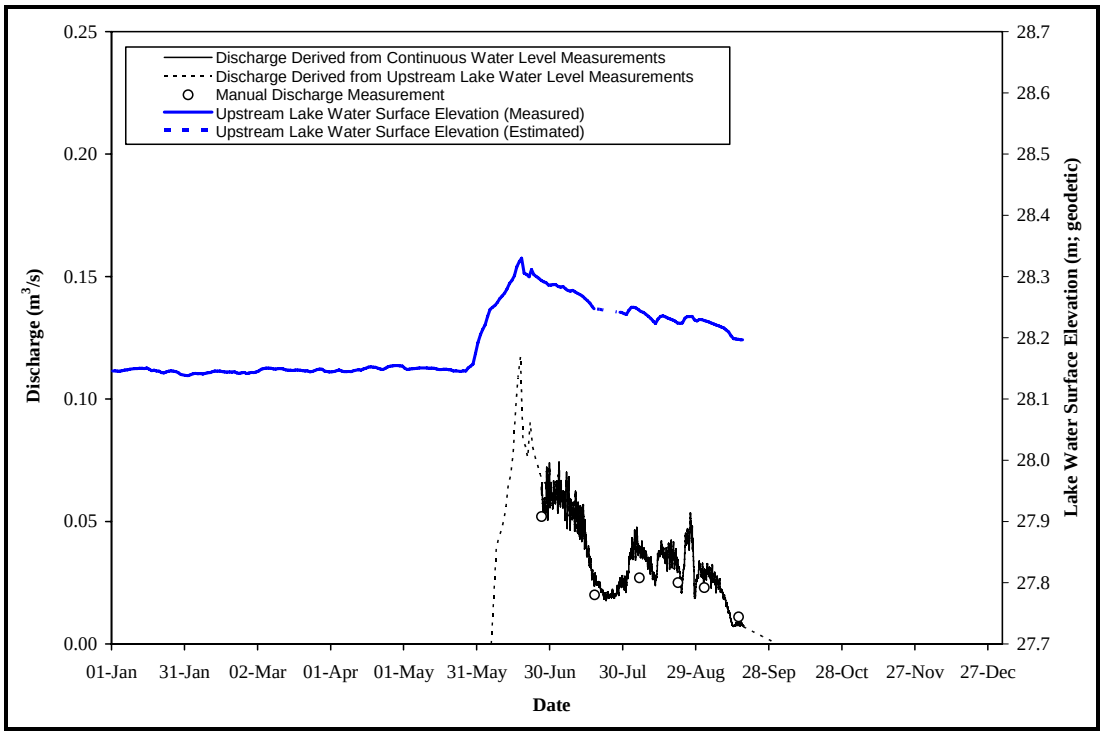

Figure D20 – Little Roberts Lake Outflow Hydrograph - 2005

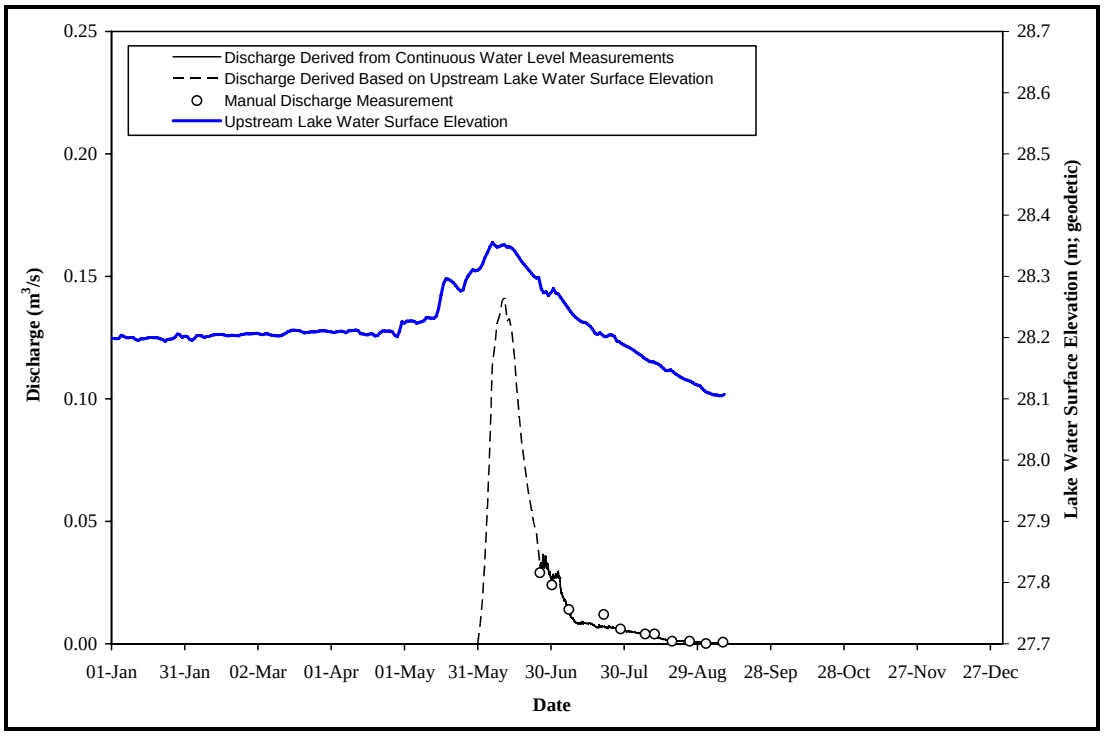

Figure D21 – Tail Lake Outflow Hydrograph - 2006

Hydrology Data Collected at Doris Lake – 2004 to 2006

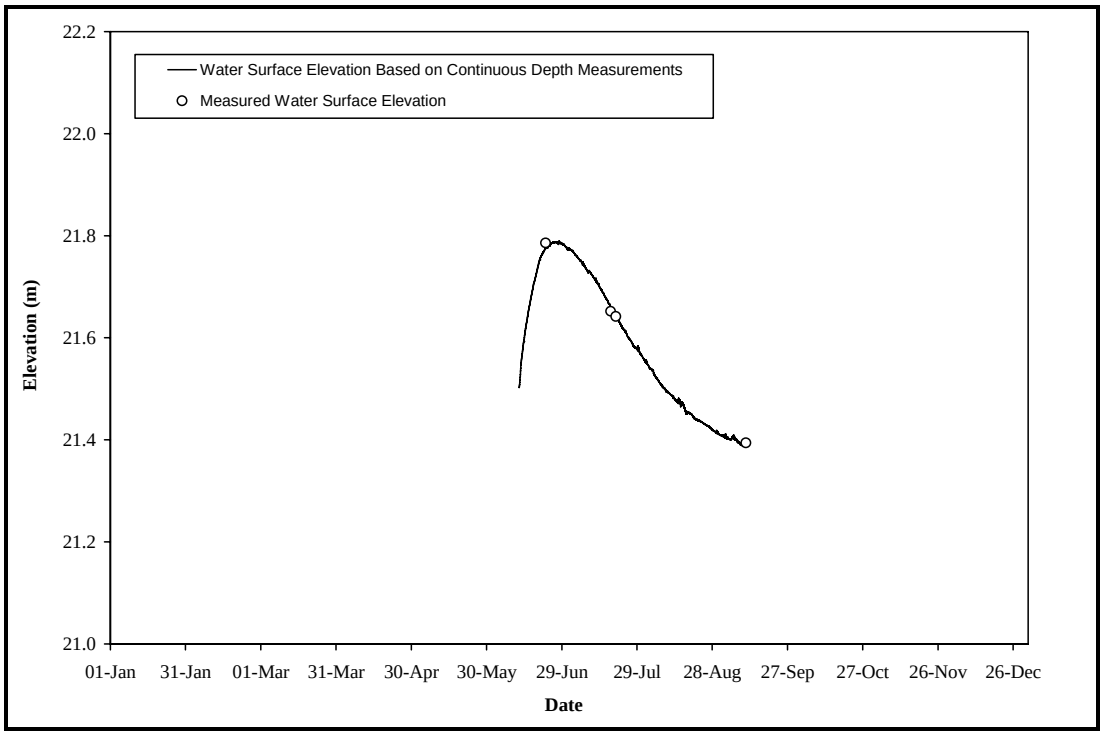

Figure D22 – Doris Lake Hydrograph - 2004

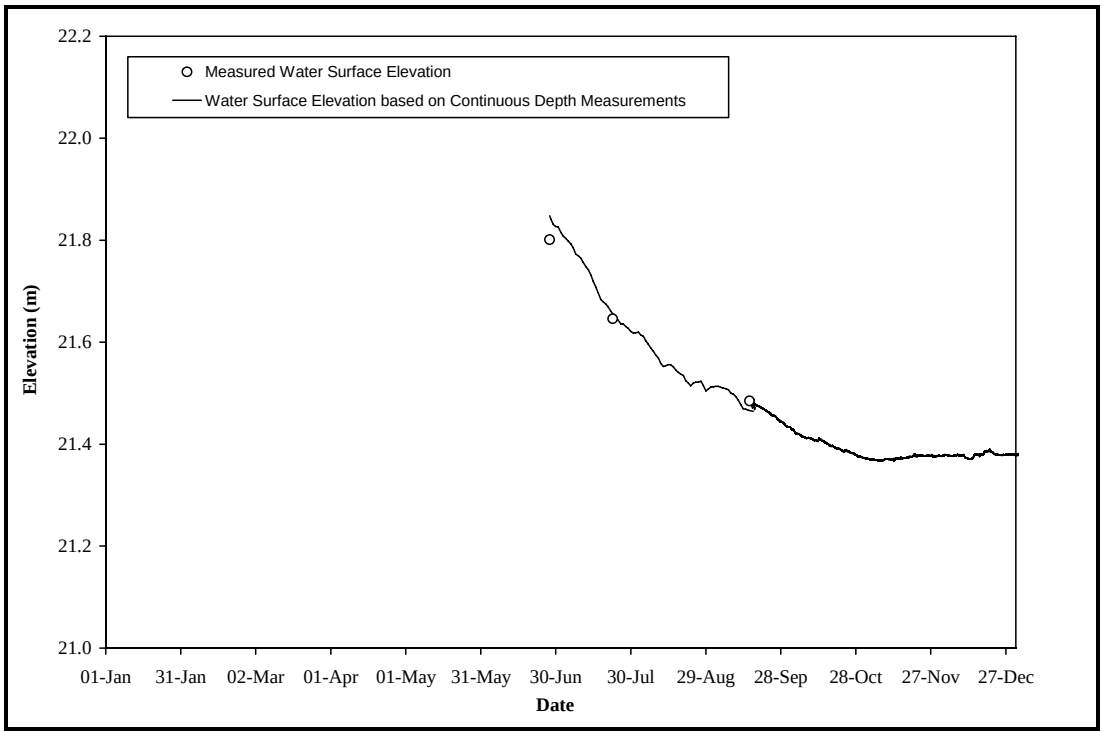

Figure D23 – Doris Lake Hydrograph - 2005

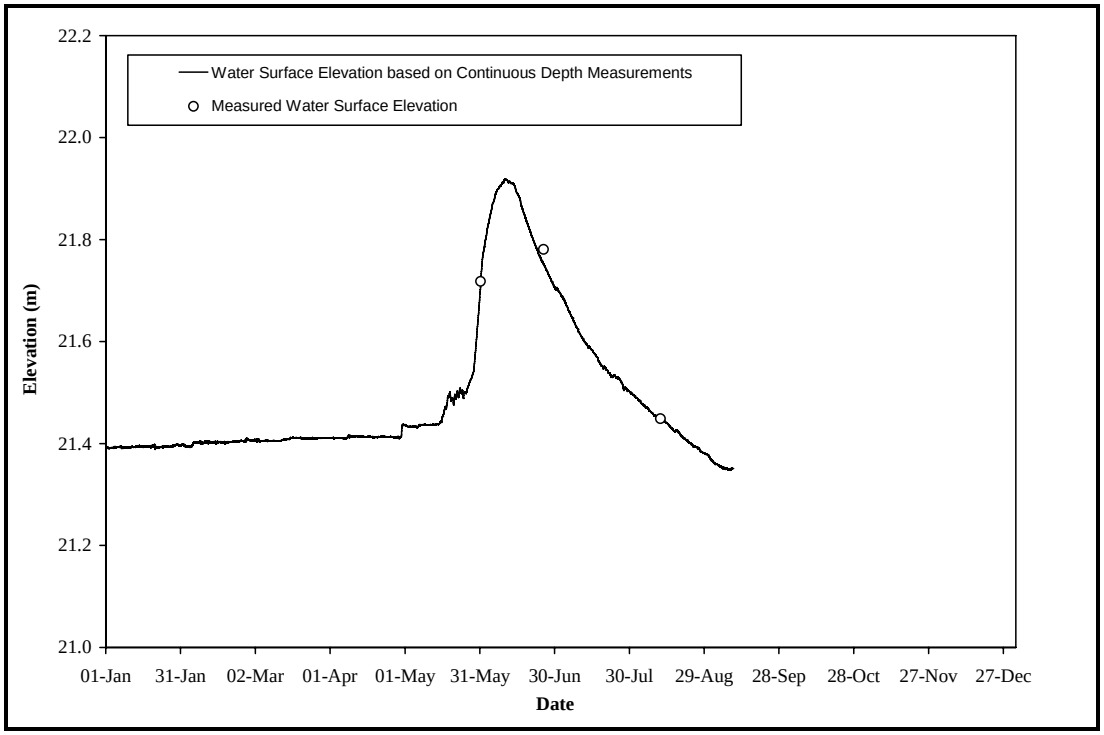

Figure D24 – Doris Lake Hydrograph - 2006

Hydrology Data Collected at Tail Lake – 2004 to 2006

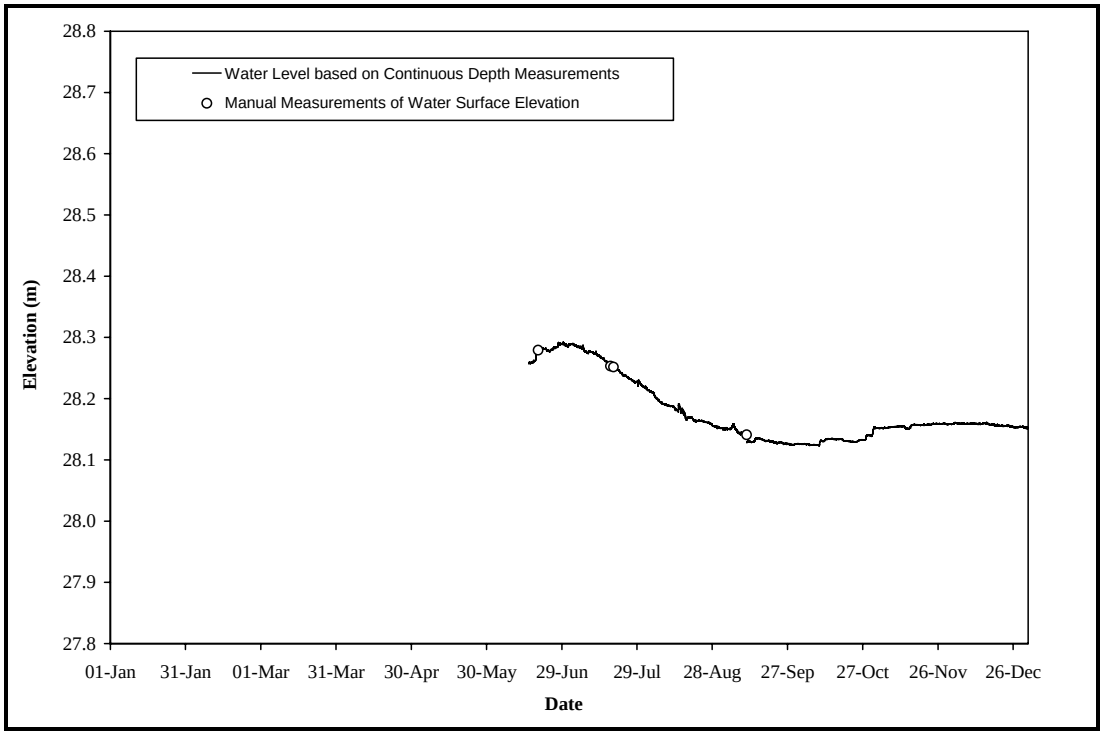

Figure D25 – Tail Lake Hydrograph - 2004

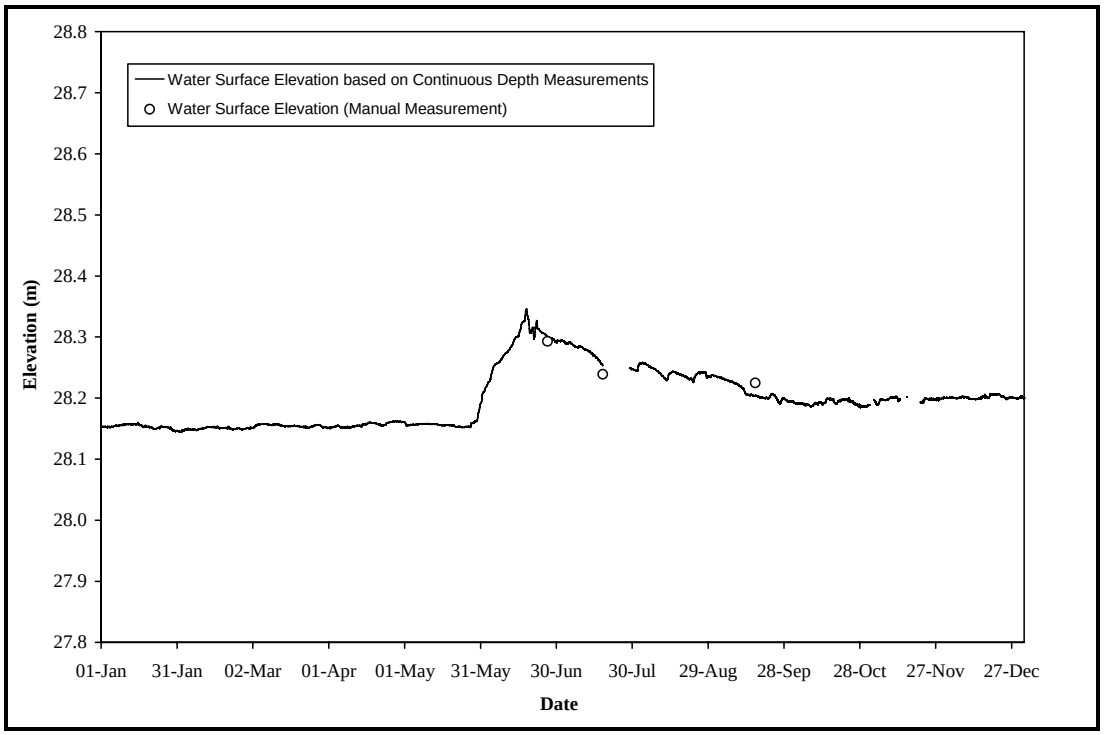

Figure D26 – Tail Lake Hydrograph - 2005

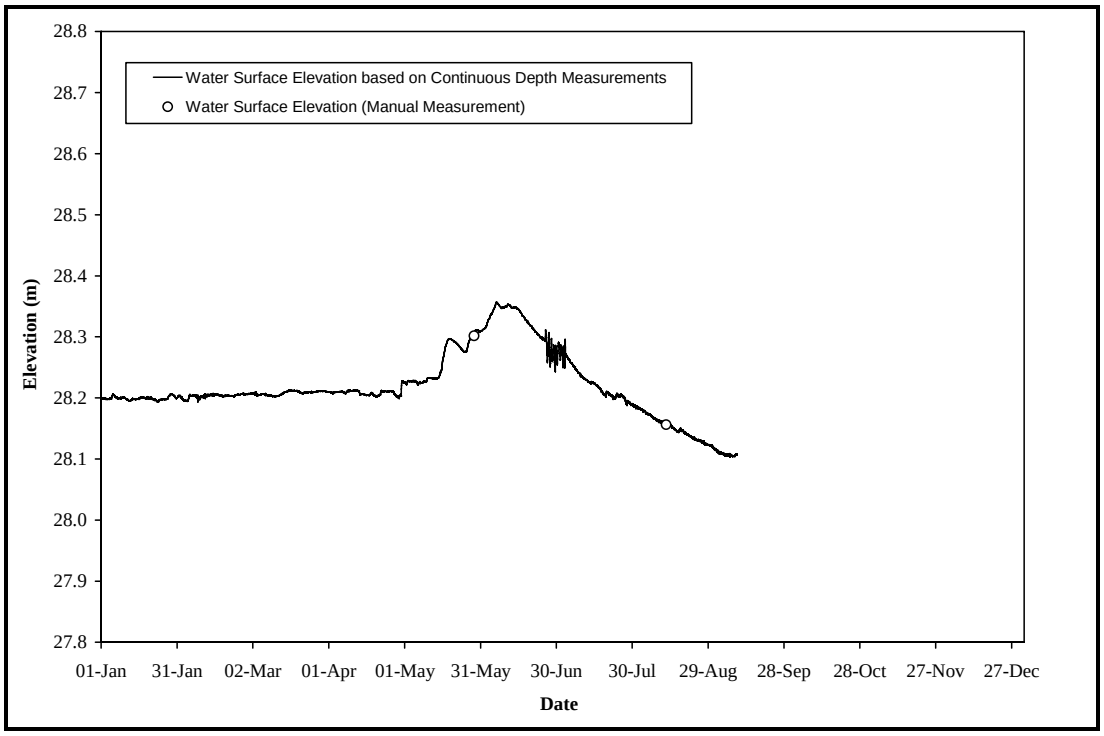

Figure D27 – Tail Lake Hydrograph - 2006