APPENDIX 11.III

Effect of the NICO Project on Surface Water Quantity

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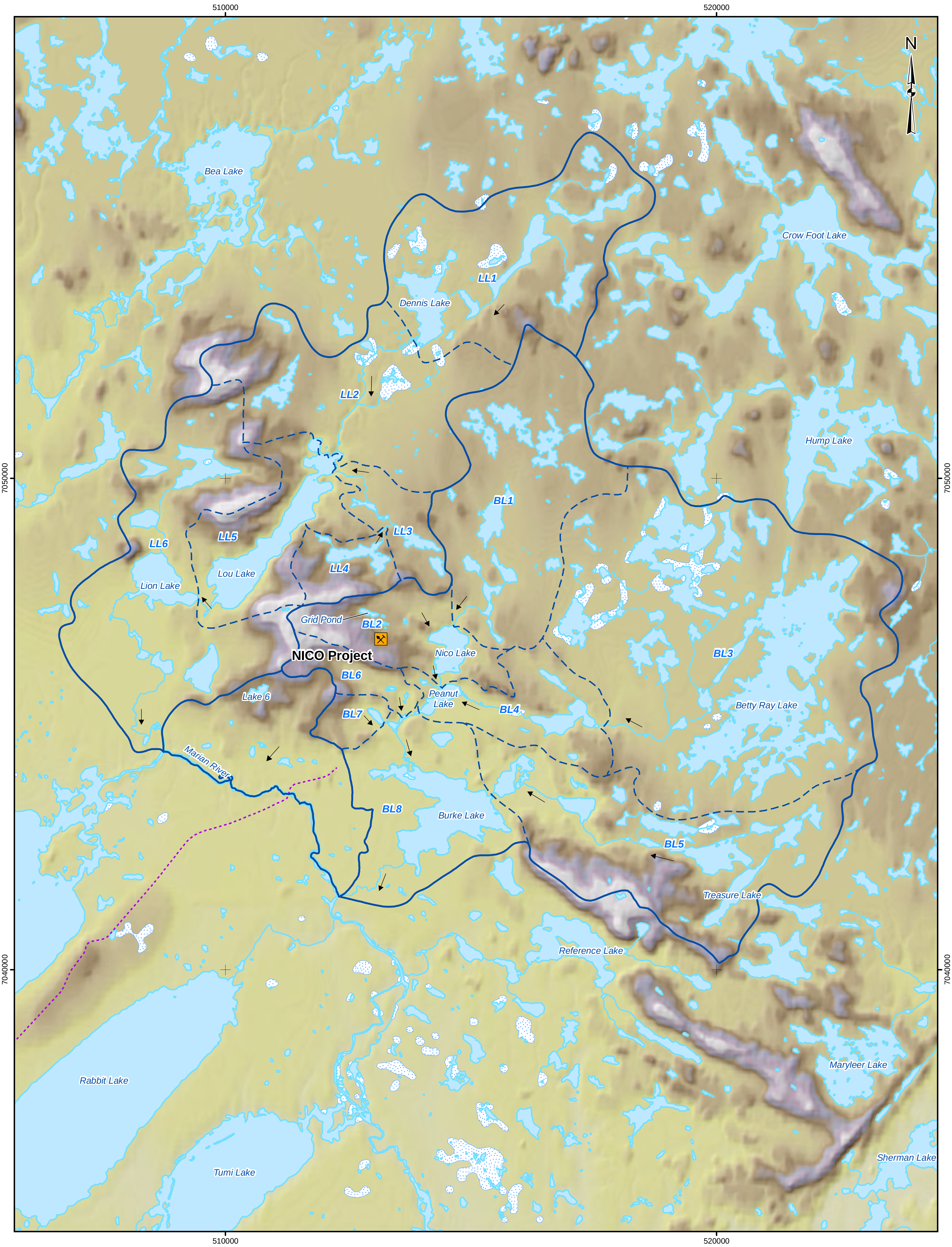
11.III.1 INTRODUCTION

This appendix provides details of the effects assessment to surface water quantity for the NICO Project. The NICO Project is anticipated to alter local surface water hydrology by extracting freshwater, discharging treated effluent, and augmenting streamflow in the receiving environment in the NICO Project area.

During operations, the fresh water requirements of the NICO Project will be met by water withdrawals from Lou Lake that will be distributed evenly throughout the year. Freshwater extraction will influence lake levels in Lou Lake and downstream flows at the outlet of sub-basins LL5 and LL6 (Figure 11.III.1-1), also referred to as Q_{LL5} and Q_{LL6}, respectively with units of cubic metres per second (m^3/s). Following closure, flow at the outlet of sub-basins LL5 and LL6 will return to natural conditions.

In the Burke Creek drainage, the NICO Project will influence water levels in Nico, Peanut, and Burke lakes, as well streamflows at the outlets of sub-basins BL2, BL4, and BL8 (Figure 11.III.1-1), which will also be referred to as Q_{BL2}, Q_{BL4}, and $Q_{BL8,}$ respectively, and have units of m^3/s. During operations and closure, runoff from much of the Grid Ponds Drainage Area (GPDA) will cease to flow towards Nico Lake. Post-closure, seepage from the Co-Disposal Facility (CDF) will drain to Nico Lake from Wetland Treatment System No. 1, 2, and 3 (Figure 11.III.1-2) located at the base of the CDF; Wetland Treatment System No. 1, 2, and 3 collect seepage water from the CDF. During operations, water from the Effluent Treatment Facility (ETF) will be discharged to Peanut Lake. Water is also expected to enter Peanut Lake due to overflow during annual spring runoff events. Post-closure and prior to Open Pit overflow, there will be no discharges directly into Peanut Lake. Once the Open Pit overflows, water from the Flooded Open Pit will runoff into Peanut Lake from Wetland Treatment System No. 4.

Adjustments to BL8 streamflow and Burke Lake water levels will be affected by changes upstream. The Marian River will be influenced by changes to streamflow entering from Lou Creek and Burke Creek resulting from the NICO Project during construction and operations and from Burke Creek only during Open Pit filling post-closure.



LEGEND

- NICO PROJECT
- PROPOSED NICO PROJECT ACCESS ROAD
- WATERCOURSE
- WATERBODY
- WETLAND
- SURFACE WATER FLOW DIRECTION
- MAJOR DRAINAGE BOUNDARY
- SUB-DRAINAGE BOUNDARY

Waterbody	Area (ha)
Nico Lake	50.60
Pond 8	0.51
Chalco Lake	32.80
Peanut Lake	20.90
Pond 12	1.72
Lou Lake	199.00
Burke Lake	231.00

3 0 3

SCALE 1:75,000 KILOMETRES

REFERENCE

Base data obtained from GeoGratis.
Projection: UTM Zone 11 Datum: NAD 83

FORTUNE MINERALS LIMITED
NICO DEVELOPER'S ASSESSMENT REPORT

TITLE

SUB-BASINS IN THE LOU LAKE AND BURKE LAKE WATERSHEDS

Golder Associates
Edmonton, Alberta

FILE No. E-Hydrol-003-GIS				
PROJECT No. 09-1373-1004			SCALE AS SHOWN	REV. 0
DESIGN	TL	16 Dec. 2008	FIGURE: 11.III.1-1	
GIS	ANK	19 Apr. 2011		
CHECK	GRA	4 May 2011		
REVIEW	GRA	4 May 2011		

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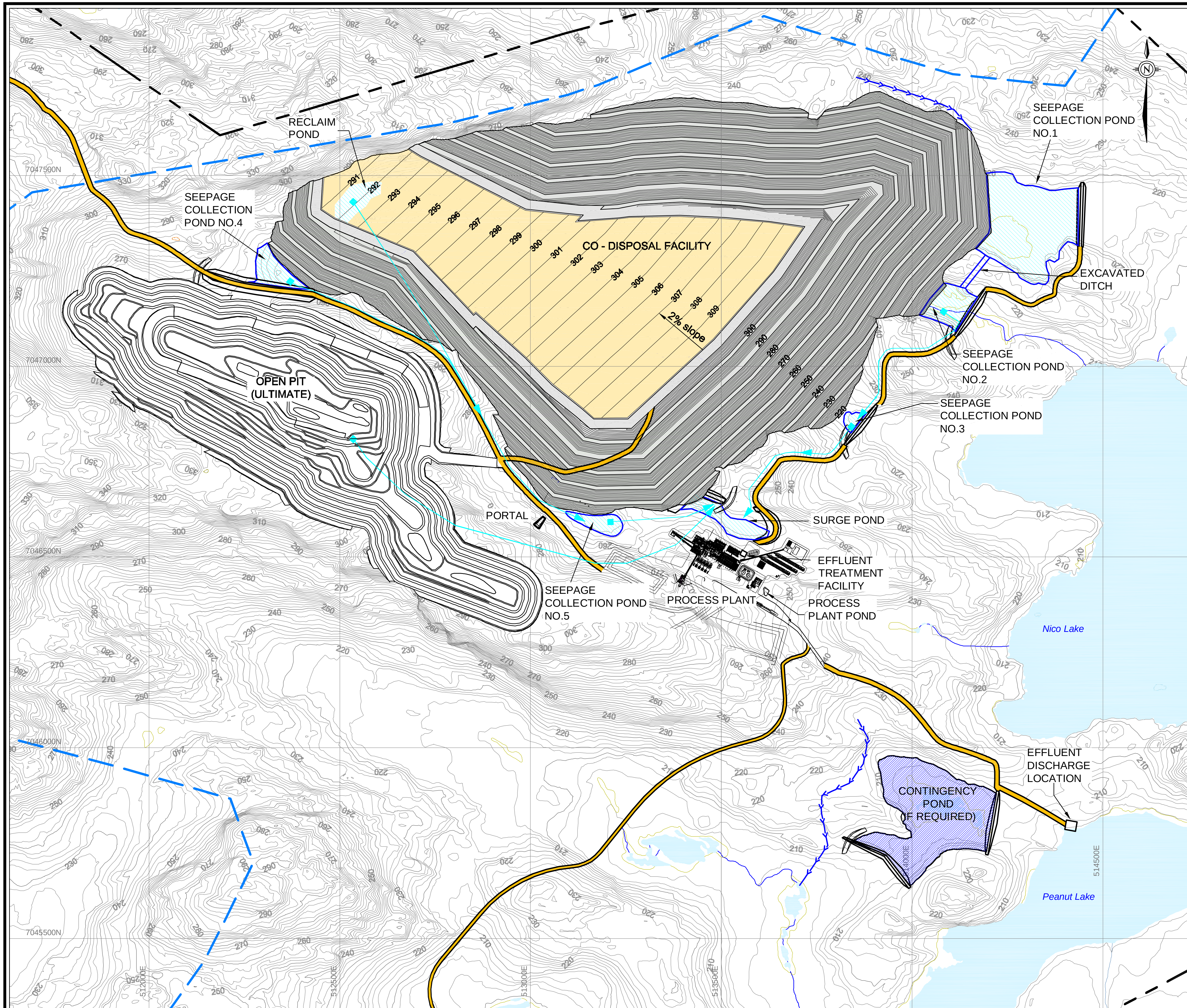

LEGEND

- DIVERSION DITCH
- PROJECT LEASE BOUNDARY
- WATERSHED
- RECLAIM BARGE / PUMP STATION
- ACCESS ROAD
- CO-DISPOSED TAILINGS AND MINE ROCK
- CONTINGENCY POND
- PERIMETER DYKE OF CO-DISPOSAL FACILITY
- RECLAIM POND
- SEEPAGE COLLECTION POND / SURGE POND
- WATER BODY

NOTES

1. All elevations (geodetic datum) and grid coordinates (UTM NAD 83, Zone 11) shown in this drawing are in metres.
2. Configuration shown assumes sub-economic ore is not processed.
3. Wetland treatment systems No. 1, 2, and 3 will be constructed and tested prior to closure, but will not operate until closure

REFERENCE

Base mapping provided in digital format by Fortune Minerals Limited received 20 February, 2004.

Process plant and mine infrastructure provided by Aker Solutions filename 0000g001d (plant site oct252010).dwg provided 26 October, 2010. Revised pits provided by P & E Mining Consultants, ultimate pit and topo.dxf on 26 January, 2010.

Project lease boundary provided by Fortune (8 October, 2008) with comments provided 19 December, 2009.

200 0 200 400

SCALE 1:10,000 METRES

FORTUNE MINERALS LIMITED
NICO DEVELOPER'S ASSESSMENT REPORT

TITLE

LAYOUT OF CO-DISPOSAL FACILITY AND WATER MANAGEMENT FACILITIES IN YEAR 18

Golder Associates
Edmonton, Alberta

FILE No: E-Hydrol-005-CAD .dwg			
PROJECT No: 09-1373-1004		SCALE AS SHOWN	REV. 0
DESIGN	IM	10 May 2011	FIGURE: 11.III.1-2
CAD	TDR	10 May 2011	
CHECK	GRA	10 May 2011	
REVIEW	GRA	10 May 2011	

PLOT DATE: May 12, 2011
FILENAME: T:\Projects\2010\10-1118-0046 (FML, NWT)\-LA-\10111180046LA11.III.1-2.dwg

The measurement endpoints for this analysis are average daily stream hydrographs at the outlets of watersheds BL2, BL4, BL8, LL5, LL6, and M1 (Figure 11.III.1-1), with adjustments for the different phases of the NICO Project. Local drainages other than those discussed here will not be affected by the activities of the NICO Project and are expected to maintain flow regimes within their natural range. Results from the residual effects analyses will not be classified and environmental significance will not be determined at this point but the dataset presented here can be used in further analyses. The measurement endpoints and residual effects presented here may be incorporated into determinations of the impact of the NICO Project on different valued components.

For the context of this document it is important to consider the net effects to local watersheds as a result of the NICO Project. The NICO Project is expected to remove approximately 2 km^2 (10%) of drainage area from the watershed reporting to the outlet of Nico Lake and redirect water collected in that area to Peanut Lake. This same project footprint is approximately 2.2% of the entire Burke Lake drainage which constitutes approximately 90.8 km^2.

11.III.2 METHODS

11.III.2.1 Daily Average Hydrograph

The influence of the NICO Project on local streamflow hydrology is presented in terms of an average daily streamflow hydrograph. To develop the historic daily average streamflow hydrograph from the flow record, a Julian day calendar, in which a year consists of 366 days, was adopted. The flow record was sorted by Julian day and the daily average streamflow values were averaged for a particular Julian Day (Annex G). The values used for the water extractions to and discharges from the NICO Project site originate from the site wide water balances presented in Appendix 3.III.

11.III.2.2 Lou Creek Basin

The impact of freshwater extraction on the daily average streamflow hydrograph for Lou Creek at stations LL5 and LL6 was evaluated. The daily average streamflow record derived from the flow record at station LL5 was converted to daily average stage at L-A (Lou Lake) based on the linear relationship between outflow and lake level (r^2=0.86) in Attachment 11.III.I (Figure III.I-1). The total daily rate of extraction was converted to a uniform lake depth by dividing the total daily extraction volume by the surface area of Lou Lake. This depth was subtracted from the daily average stage at L-A and a revised streamflow at station LL5 was calculated.

Flow into the Marian River at the outlet of sub-basin LL6 results from runoff generated in sub-basin LL6 as well as inflow from sub-basin LL5. The runoff generated within the LL6 sub-basin was taken to be independent of the NICO Project operations and remained unchanged during future estimates. In the daily average flow record, the runoff generated within the LL6 sub-basin was isolated by subtracting inflow from upstream, taken to be outflow from the LL5 sub-basin. To generate an adjusted discharge during operations to the Marian River from Lou Creek, the daily average streamflow from sub-basin LL5 was added to the average daily runoff generated within sub-basin LL6.

11.III.2.3 Burke Creek Basin

Nico Lake will be affected by the removal of the GPDA and associated runoff from its drainage basin. For the period of record, the daily average streamflow at station BL2 was converted to a daily average stage of Nico Lake based on the power relationship (R^2=0.89) in Attachment 11.III.I (Figure III.I-2). The daily average inflow to Nico Lake from the GPDA was converted from a volume to an equivalent water depth and subtracted from the daily average NICO Lake stage. An adjusted discharge at BL2 was then calculated from the adjusted stage. The change in Nico Creek streamflow at the outlet of sub-basin BL2, ΔQ_{BL2} (m^3/s), was calculated by subtracting the historic mean streamflow from the estimated streamflow during each NICO Project development phase.

During construction flows to Nico Lake from the Grid Ponds basin will continue until the CDF dykes have been constructed. During the operating period, Peanut Lake stage will be influenced by discharge from the ETF and the Sewage Treatment Plant (STP) and changes to discharge from Nico Creek. For the assessment, all three values were converted to a daily volume. Values for inflows from the ETF and STP in were converted from monthly average flows to daily average volumes. The daily average volumes were added to the daily average volume change from Nico Creek and the total change to inflows was converted to a daily average depth evenly distributed across the lake surface area. The change in inflow depth was added to the daily average lake stage calculated from the historic daily average streamflow using the linear equation (R^2=0.98) in Attachment 11.III.I (Figure III.I-3). This adjusted daily average lake stage was then converted to an adjusted daily average streamflow using the same linear equation in Figure III.I-3.

At post-closure, Nico Lake will receive discharge from Wetland Treatment Systems No. 1, 2, and 3 between May and October. To account for this, the average monthly runoff from Wetland Treatment Systems No. 1, 2, and 3 was evenly distributed into a daily average inflow into Nico Lake. The daily average inflow into Nico Lake from Wetland Treatment Systems No. 1, 2, and 3 is converted to a depth and subtracted from the daily average stage considering loses from the GPDA at Station B-E (Nico Lake). Using the power relationship in Attachment 11.III.I, the adjusted daily average stage was then converted into streamflow at BL2.

Post-closure and prior to Open Pit overflow, Peanut Lake will receive runoff from the mine site indirectly through increased discharge from Nico Lake via Nico Creek. The change in daily average flow from Nico Creek was converted to a daily volume which was in turn converted to a daily average depth distributed evenly across the lake surface area. This adjusted depth was used to calculate an adjusted Q_{BL4} using the linear relationship in Attachment 11.III.I. Following Open Pit overflow, Peanut Lake will receive inflow from the Open Pit through Wetland Treatment Systems No. 4. This method is similar to that previously described, but incorporates daily inflow from Wetland Treatment Systems No. 4.

Q_{BL8} was adjusted based on the changes to Q_{BL4}. For each Julian day, the flow generated within sub-basin BL8 was isolated by subtracting the inflows (i.e., outflow from sub-basins BL4, BL5, BL6, and BL7 from the BL8 outflow). For each phase of the NICO Project Q_{BL8} was calculated as the phase specific Q_{BL4} added to the outflows from BL5, BL6, and BL7 as well as the flow generated within sub-basin BL8 under average conditions.

11.III.2.4 Marian River

Changes to flows in the Marian River were evaluated at its confluence with Burke Creek. To this end, streamflow in the Marian River at its confluence with Burke Creek was assumed to equal flow in the Marian River at station M1 (Figure 11.III.1-1), Q_{M1}(m^3/s). The phase specific net daily change in inflow to the Marian River from Burke Creek and Lou Creek was estimated by summing the changes in Q_{BL8} and Q_{LL6} and adding the net change to Q_{M1}. For each phase of operations, the net daily change in flow from the Lou Creek and Burke Creek drainages was added to the historic Q_{M1} hydrograph to develop a forecasted Q_{M1}.

11.III.3 RESULTS

All values presented in Figures 11.III.3-1 and 11.III.3-8 are changes in streamflow relative to the historic daily average hydrograph for the location being described.

11.III.3.1 Lou Creek, LL5 and LL6

During operations, an annual average of 112 000 m^3 of freshwater will be extracted from Lou Lake at a constant rate of approximately 0.0036 m^3/s throughout the year. As a result, Q_{LL5} and Q_{LL6} are expected to be approximately 0.0032 m^3/s less than under natural conditions. This change in flow represents a maximum decrease in the mean annual discharge of approximately 3.7% at the outlet of Lou Lake. A more detailed effects assessment of Lou Creek is described in a Technical Memorandum entitled Lou Lake 1:25 Year Dry Water Level Analysis (Appendix 11.II).

11.III.3.2 Nico Creek, BL2

The expected change to Nico Creek streamflow, ΔQ_{BL2} (m^3/s) is summarized in Figure 11.III.3-1. During operations, Q_{BL2} will be reduced due to the removal of runoff from the GPDA. Post-closure, this reduction in inflow will be partially compensated for by inflows from Wetlands 1, 2, and 3 which collect seepage from the CDF. The shape of the post-closure curve in Figure 11.III.3-1 results from the fact that the data available for flows from the GPDA were daily while the flow from Wetland Treatment Systems No.s 1, 2, and 3, were monthly and had to be formatted into a daily average. During operations, the peak change in Q_{BL2} will be -1.22% of the historic average in early May. Post-closure the peak change in Q_{BL2} will increase by a maximum of 2.62% relative to the historic average in late May. The daily average Q_{BL2} hydrographs for all temporal phases are presented in Figure 11.III.3-2; however, as observed from the hydrograph, there is little noticeable change in the hydrograph.

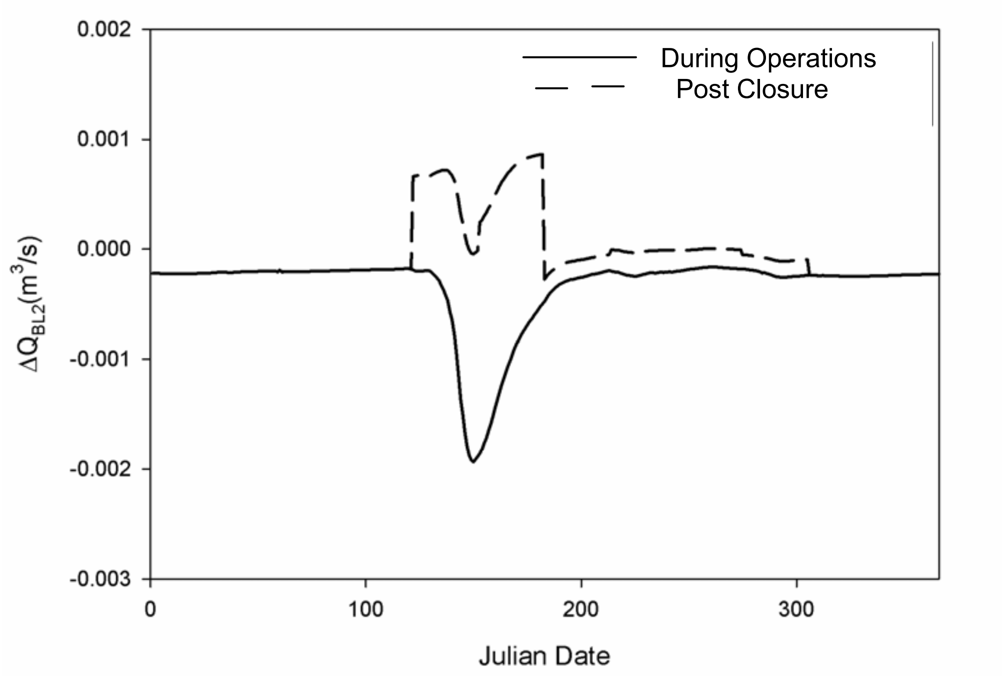

Figure 11.III.3-1: Expected Change to Nico Creek Streamflow, ΔQ_{BL2} (m^3/s)

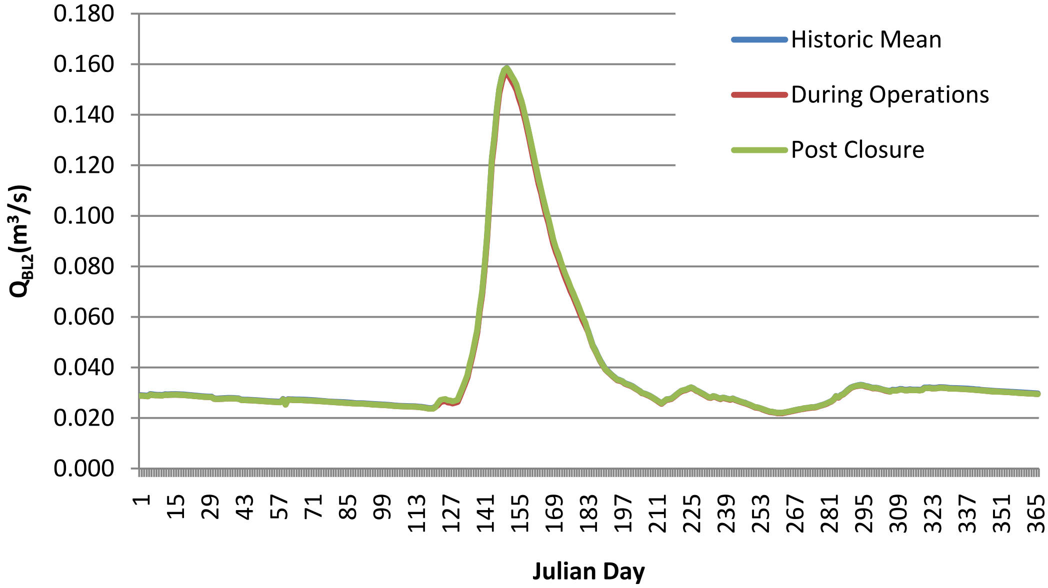

Figure 11.III.3-2: Q_{BL2} (m^3/s): Historic Mean During Operations and Post-Closure for Discharge from Nico Creek

11.III.3.3 Peanut Creek, BL4

During operations, Q_{BL4} will increase throughout the year as a result of discharge from the ETF. Discharge from the ETF is approximately 290 643 m^3/yr in the End Year and 114 788m^3/yr during the start-up Year. During the spring freshet, the increase to streamflow will be slightly less due to reduced Q_{BL2}. Post-closure and prior to pit overflow, Q_{BL4} will increase slightly during the spring freshet as a result of increased Q_{BL2}. Post-closure, after the overflow of the pit, flows will increase due to runoff from Wetland Treatment System No. 4 (Figure 11.III.3-3).

The maximum changes in the historic daily average for an individual Julian day at Q_{BL4} are 4%, 10%, 1%, and 22% during the start up year, end year, post-closure prior to pit overflow, and post-closure after pit overflow, respectively. During the start up year, end year, and post-closure after pit overflow, the maximum increase to Q_{BL4} relative to the historic average coincides with seasonal low flows in late September. Post-closure and prior to pit overflow, the peak 1% increase to the historic average occurs in early May at the beginning of the spring freshet.

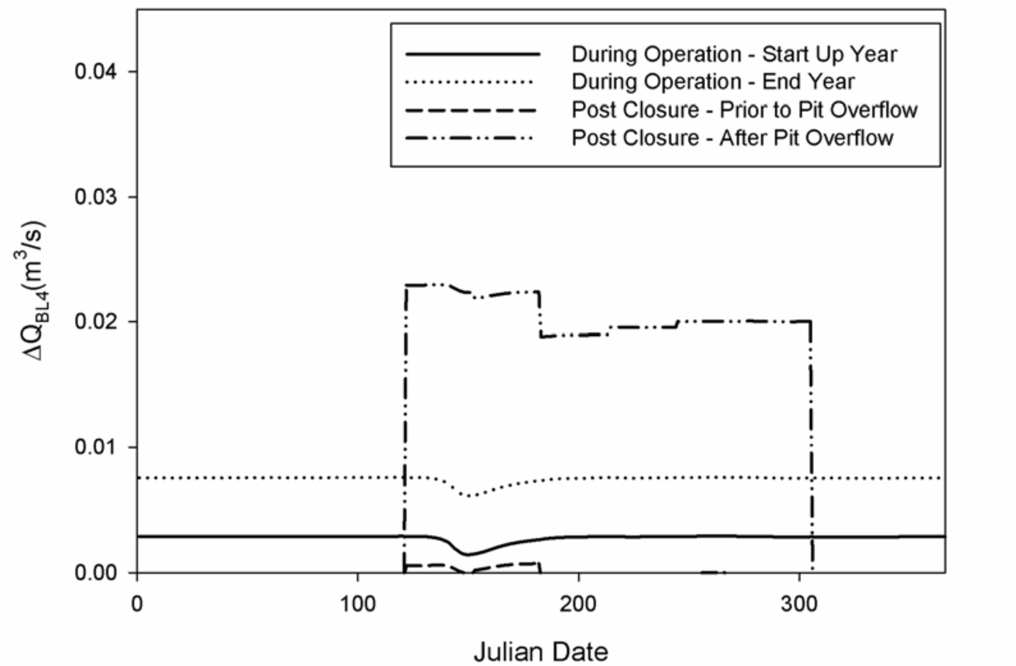

Figure 11.III.3-3: Expected Change to Peanut Creek Streamflow, Δ_{QBL4} (m^3/s)

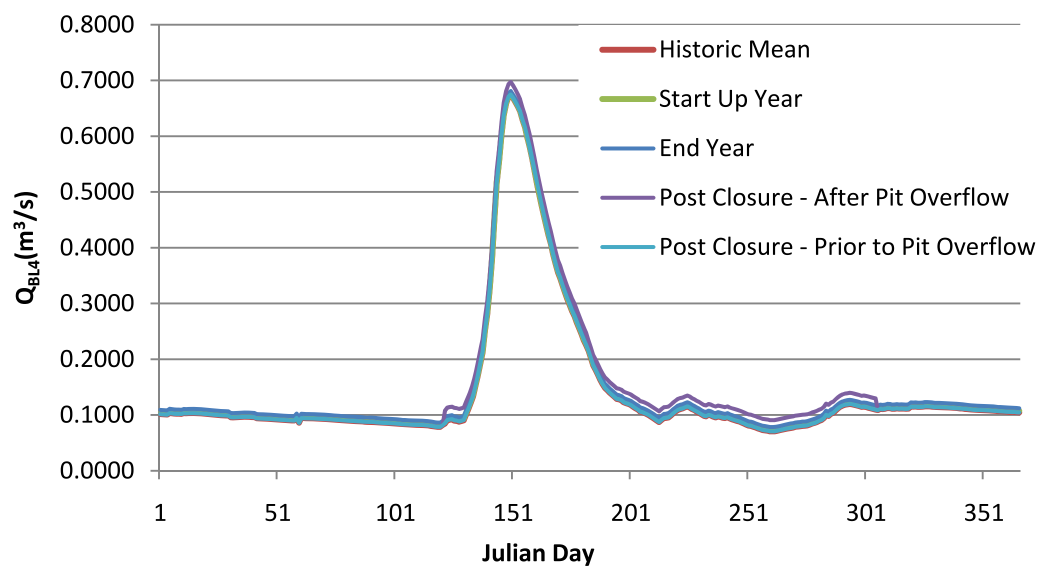

Figure 11.III.3-4: Peanut Creek, Q_{BL4} (m^3/s): Historic Mean During Operations and Post-Closure

11.III.3.4 Burke Creek, BL8

All changes to Q_{BL8} are the result of changes to Q_{BL4}. The peak daily influence on flows as a percentage of the historic average is 6%, 17%, 1%, and 44% of flows during the start-up year, end year, post-closure prior to Flooded Open Pit overflow, and post-closure after pit overflow, respectively. The relative increase is higher in Q_{BL8} than Q_{BL4} because Q_{BL8} is less than Q_{BL4} during late summer which is likely a product of attenuation within Burke Lake and beaver activity at the outlet of Burke Lake.

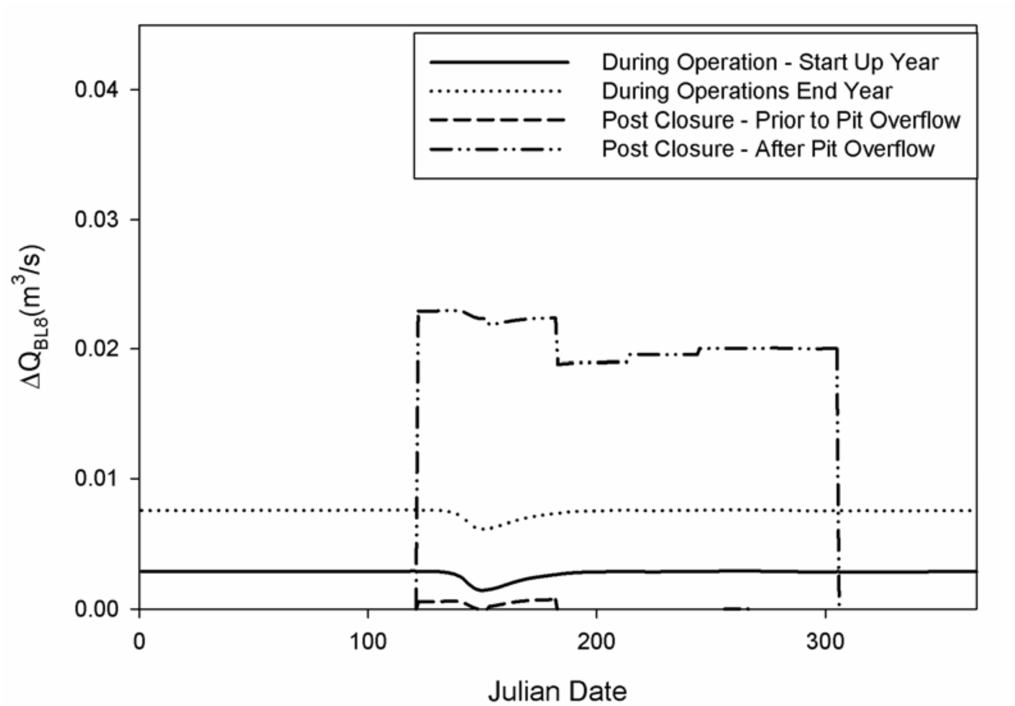

Figure 11.III.3-5: Expected Change to Burke Creek Streamflow, Δ_{QBL8} (m^3/s)

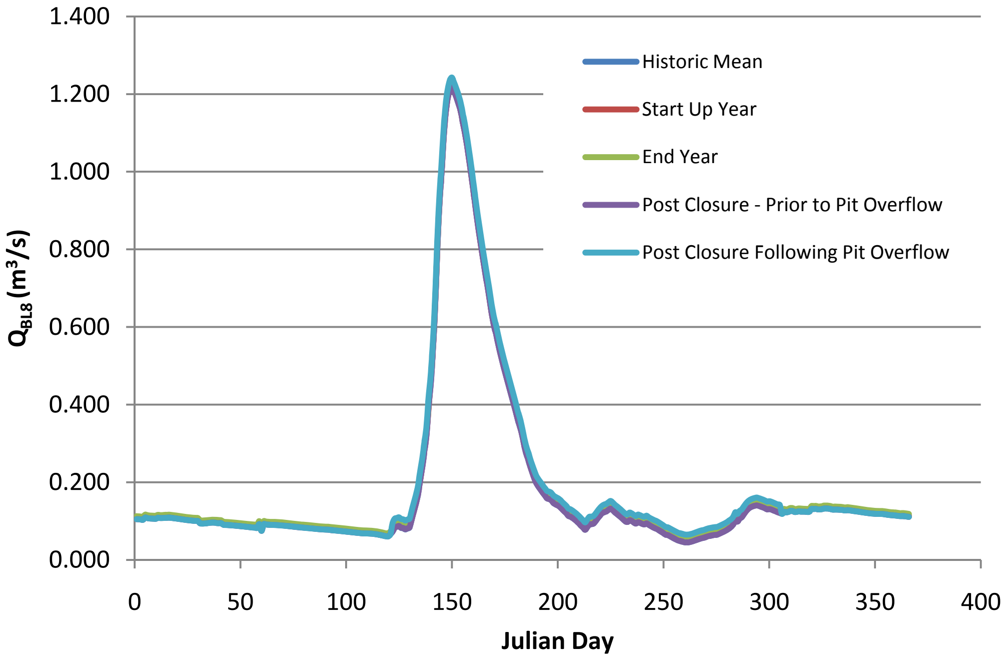

Figure 11.III.3-6: Burke Creek, Q_{BL8} (m^3/s): Historic Mean During Operations and Post-Closure

11.III.3.5 Marian River

In all phases of the NICO Project the net flow into the Marian River is expected to have a negligible increase. During operations, the decrease when water is extracted from the Lou Lake watershed Q_{LL6} is offset by the increases to Q_{BL8}. The magnitude of any changes is very small relative to flows in the Marian River. The percentage change to the historic average Q_{M1} peaks during early May at 0.25%, 0.74%, 0.03%, and 1.14%, respectively, for the start-up year, end year, post-closure prior to pit overflow, and post-closure after pit overflow, respectively. The peak influences on Q_{M1} occur early in the water year because small tributaries such as Lou Creek and Burke Creek peak while the hydrograph of the larger Marian River is still rising. The outlet of the Lou Lake Watershed is approximately 6 km upstream of the outlet from the Burke Lake Watershed.

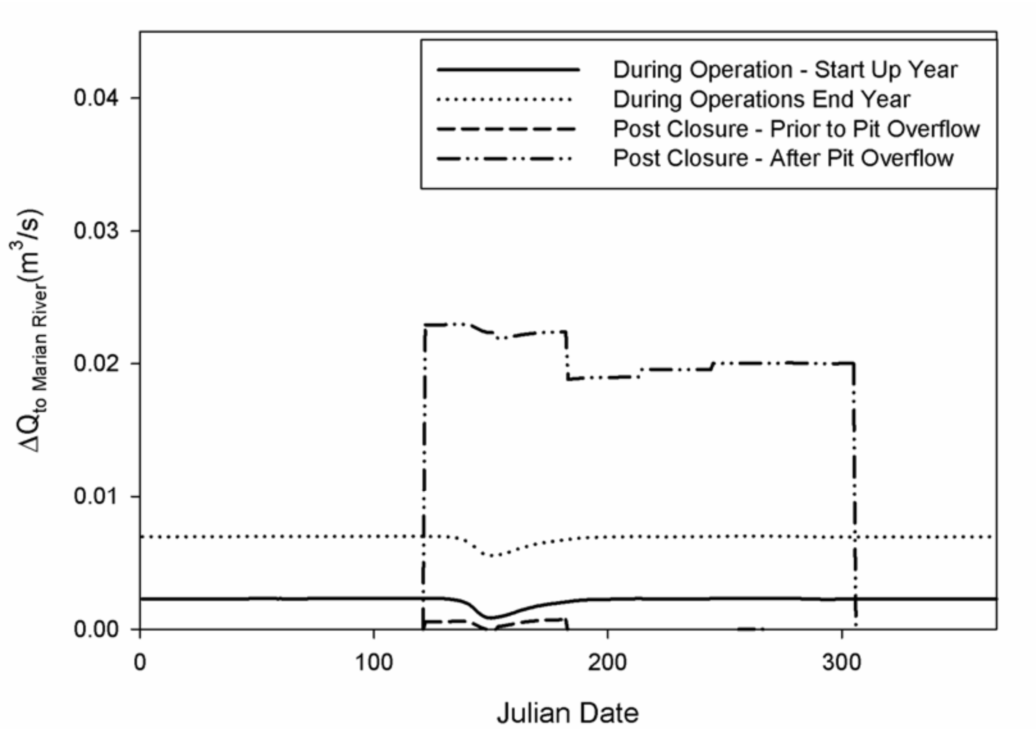

Figure 11.III.3-7: Expected Change to Marian River Streamflow, $\Delta_{QMarian}$ River (m^3/s)

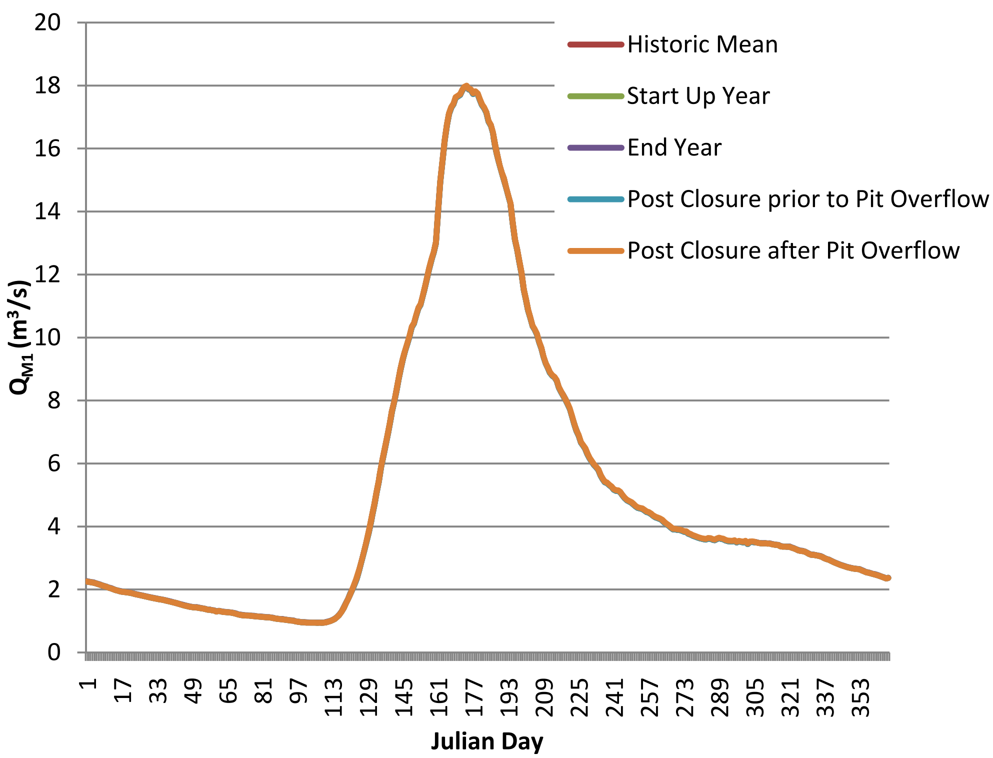

Figure 11.III.3-8: Q_{M1} (m^3/s): Historic Average During Operations, and Post-Closure for the Marian River

11.III.4 RESIDUAL EFFECTS SUMMARY

In Lou Creek, the relative influence of extractions on daily average flow does not exceed 3.7% of Q_{LL5} under natural conditions and decreases as flow moves downstream to Q_{LL6}. Post-closure, flow in Lou Creek will return to natural conditions. In the Burke Creek drainage, the highest influence on streamflow relative to historic averages comes at station BL8 late in the year during low flow periods. At this time Burke Creek would have considerable excess capacity to accept increased streamflows.

During operations, streamflows into the Marian River will be slightly reduced due to a small decrease in flow from Lou Creek and slightly increased due to augmented flow from the Burke Creek drainage. The increase of Burke Creek flows will offset the decrease to Lou Creek flows and result in a net increase to flow in the Marian River. The increase will be less than 0.008 m^3/s and induce a maximum increase of 0.74% of Q_{M1} flow under natural conditions. Accordingly, the changes to flow in Burke Creek and Lou Creek are not expected to significantly affect the flow of the Marian River.

Post-closure and prior to pit overflow, the change to Marian River flows will be minimal and limited only to the increased inflow into Nico Lake through Wetland Treatment Systems No. 1, 2, and 3. Following pit overflow, outflow from the decommissioned contingency pond, Wetland Treatment Systems No. 4, into Peanut Lake will slightly increase flows into the Marian River from the Burke Creek drainage, but by less than 0.025 m^3/s. This will be less than 1.14% of the historic average combined inflows from Lou Creek and Burke Creek.

11.III.5 UNCERTAINTY

The primary uncertainty in predicting impacts of the NICO Project on local streamflow results from the activity of beaver in the area. Based on past observations, beaver activity was especially problematic at the outlet of Peanut Lake. The construction of dams at the Peanut Lake outlet and in ponds immediately downstream can obscure any relationship between Peanut Lake stage and discharge out of Peanut Lake. When observing values collected in June, increases in stage correlated to increased discharge (R^2 = 0.98). Following June, increases to stage did not appear to affect discharge. It is expected that at this location beavers simply increase the elevation of their dams to meet the water levels following the spring flooding. Beaver could and likely will build dams at other points throughout the local study area that will affect the estimates presented here.

As a result, predictions are affected by uncertainty in projecting the influence of additional inflow to Peanut Lake and Peanut Lake outflow. It is possible that beaver activity will prevent NICO Project discharges to Peanut Lake and Nico Lake from increasing Q_{BL4} however this would likely be a product of attenuation created in those lakes and would serve to create additional storage in the lake while still allowing discharge from the outlets at a reduced rate. Unfortunately, there is no way to predict the activities of the beaver in the context of quantify its impact on local stream flow.

In the Burke Creek drainage, when the increased flows constitute the highest proportion of predicted streamflow, the uncertainty associated with predictions are highest. As a remedial action to the uncertainty associated with streamflow predictions out of Peanut Lake, the rating curve (Figure III.I-3) developed from observations made early in the year (June) was used. This will provide a conservative estimate of increases to flow out of Peanut Lake.

11.III.6 MONITORING AND FOLLOW-UP

A monitoring network is recommended to track surface water hydrology during the lifespan of the NICO Project. This data will assist with monitoring lake stages, stream discharges and can be incorporated into the environmental effects monitoring programs.

11.III.6.1 Closure

The document presented provides a detailed analysis of the impact of the NICO Project on surface water flows in Lou Creek and Burke Creek, as well as in the Marian River immediately downstream of Burke Creek. Additional information is available in different formats if required. As well, a detailed water balance has also been created for the Lou Lake drainage basin and is available upon request.

ATTACHMENT 11.III.I

Empirical Relationships Used

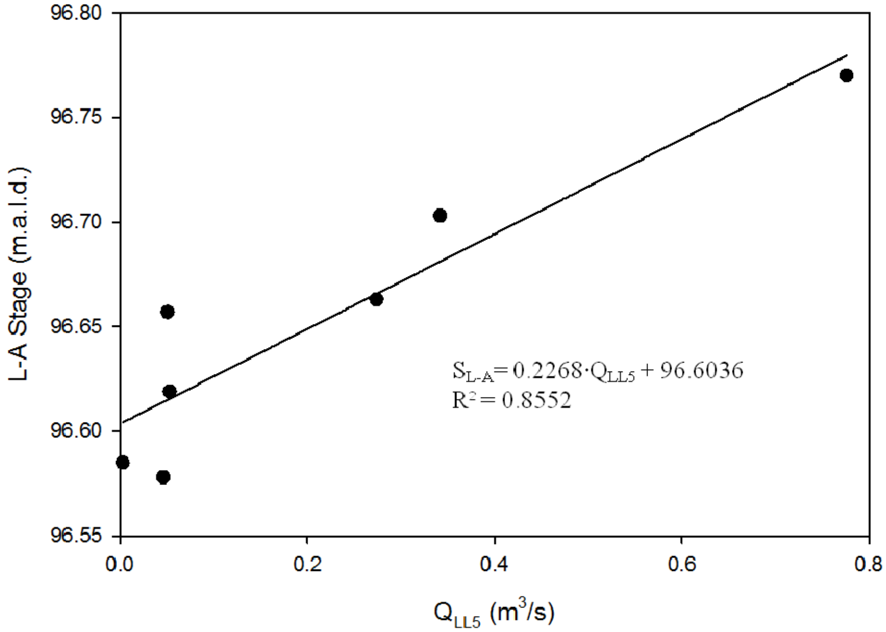

Figure III.I-1: Lou Lake Stage (L-A) vs. Discharge from Watershed LL5

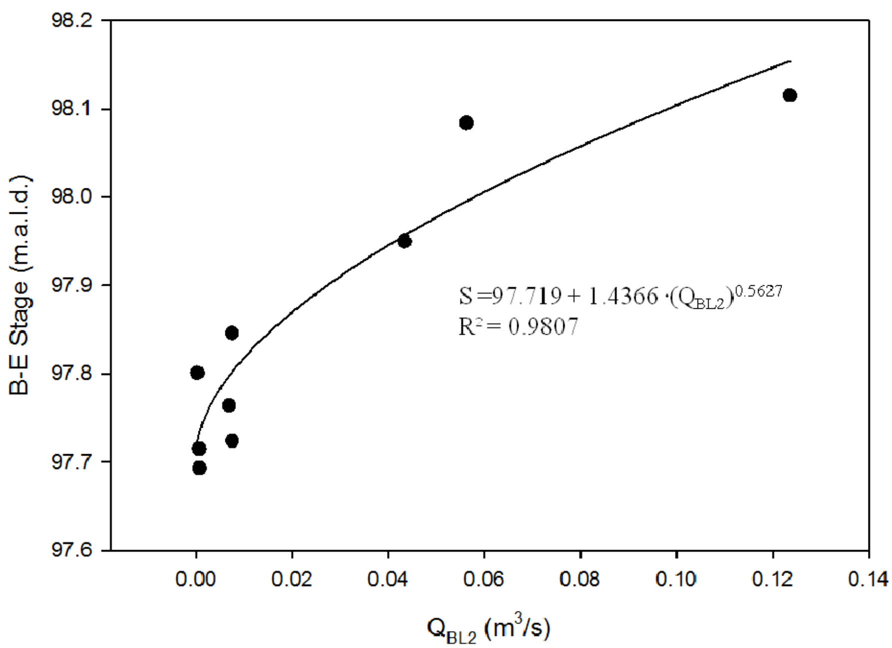

Figure III.I-2: Nico Lake Stage (B-E) vs. Discharge from Watershed BL2

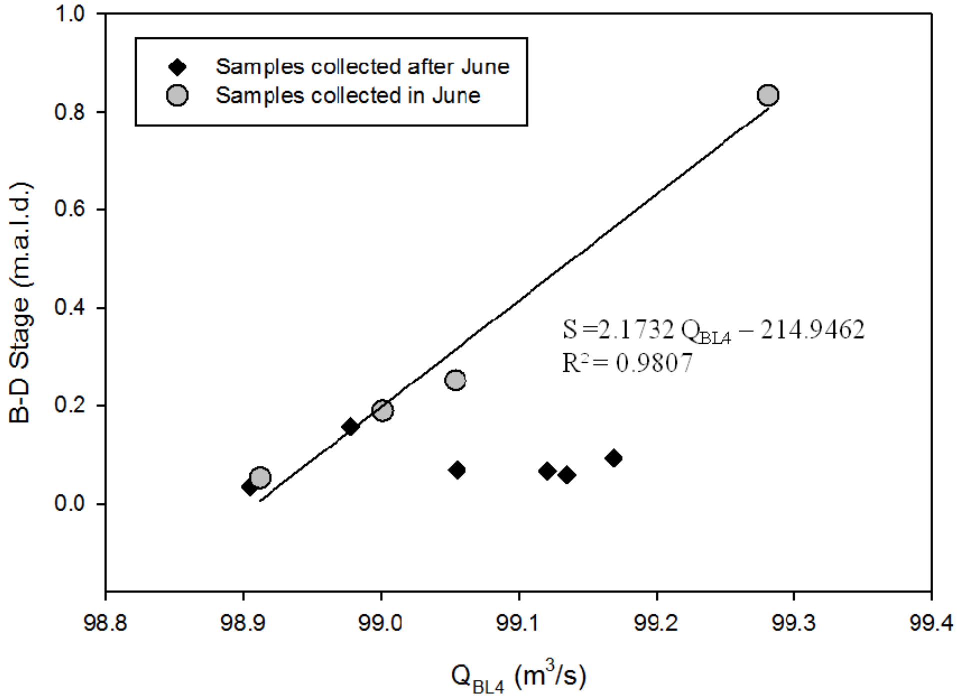

Figure III.I-3: Peanut Lake Stage (B-D) vs. Discharge from Watershed BL4