Denison Mines

Wheeler River Project

Final Environmental Impact Statement

November 2024

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NewFields

EcoMetrix Incorporated

Hydrological Effects Assessment Report

Denison Mines Wheeler River Project

Northern Saskatchewan

Prepared By:

NewFields Canada Mining & Environment
1002 Hurley Way
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Canada
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December 2021
680.0018.000

NewFields
Perspective. Vision. Solutions.

680.0018.000

EcoMetrix Incorporated
6800 Campobello Road
Mississauga, ON L5N 2L8

Date: August 26, 2022

ATTN: Jason Dietrich

RE: Denison Wheeler River Hydrological Information

Dear Mr. Dietrich,

This report presents the results of the development of hydrological data and impacts related to Denison Mines Corp. proposed Wheeler River Project (the Project). EcoMetrix Incorporated has retained NewFields Canada Mining & Environment ULC (NewFields) for preparation of this document for inclusion with the Environmental Impact Statement in support of the Project.

If you have any questions or require additional information, please contact the undersigned.

Best Regards,

NewFields Canada

Prepared By:

Tyrel J. Lloyd, M.Eng., P.Eng.
Senior Water Resources Engineer

TJL/tjl

EXECUTIVE SUMMARY

Denison Mines Corp. (Denison) has initiated the development of an Environmental Impact Assessment (EIA) to develop their Wheeler River Project (the Project). EcoMetrix Incorporated (EcoMetrix) is engaged by Denison and has retained NewFields Canada Mining & Environment ULC (NewFields) to provide hydrological assessment in support of the EIA.

Denison has proposed that the Project will consist of a 170 hectare (ha) footprint (75 ha infrastructure plus a 95 ha buffer) associated with an in-situ recovery (ISR) process. ISR allows for the mining of ore without a conventional pit, mine shaft, waste rock piles or tailings impoundment. Denison does not intend to have constant freshwater withdrawal or effluent discharge throughout operations; however, the Project is assessed in this document using a freshwater withdrawal rate of 40.5 cubic meters per hour (m^3/hour) and effluent discharge of 81.0 m^3/hour. The withdrawal and discharge rates are assessed independently to exaggerate the projected impacts and are assessed cumulatively with the site footprint and estimated changes to groundwater contributions through different temporal phases of the Project.

Denison initiated hydrometric baseline monitoring in 2011 which has continued to present at various locations around the Project. Assessment nodes for the EIA were typically selected coincident to existing stream stations, though others were added for other points of interest to the Project. Streamflow records at existing stations provide an understanding of the range of flows during open water conditions including snowmelt runoff, rainfall response to storm events and late summer low flow periods. Winter data are not available at most stations due to a lack of winter field monitoring programs. Long-term flow records with winter discharge are available from a Water Survey Canada hydrometric monitoring station located downstream of Russell Lake on the Wheeler River (Station ID 06DA005). Flow records from 06DA005 have been extended to the assessment nodes at the Project either through correlation or unit area runoff analysis.

LA-5 (Whitefish Lake) is an assessment node immediately downstream at the outlet of the lake adjacent to the main Project facilities. The extended flow record estimated for this node presents mean annual flows ranging from 0.867 to 2.990 cubic meters per second (m^3/s) with an average of 1.409 m^3/s. The projected withdrawal and discharge rates proposed for the Project are the largest influence on the hydrological impact of the Project; however, the largest predicted change in streamflow rate is -3.1% occurring at the LA-5 and SA-2 nodes (immediately downstream of the Project) during Operations and Decommissioning as projected against the 5th percentile low flow dataset in the month of March. Lake levels will deviate less than ±0.01 m due to all Project influences. All Project influences on the environment are expected to return to baseline conditions during the Post-Decommissioning phase of the Project.

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1. INTRODUCTION

The Wheeler River Project (Wheeler or the Project or Site) is a proposed uranium mine and processing plant in northern Saskatchewan, Canada. It is located in a relatively undisturbed area of the boreal forest about 4 kilometers (km) off of Highway 914 and approximately 35 km north-northeast of the Key Lake uranium operation.

Denison Mines Corp. (Denison) has an effective 95.0% ownership in the Project through a 90.0% direct interest and an additional 5.0% interest through its investment in JCU Exploration Company. The remaining 5.0% is owned by UEX Corporation. The Project will apply an innovative approach to uranium mining in Canada called in-situ recovery (ISR). The use of ISR mining at Wheeler means that there will be no need for a large open pit mining operation or multiple shafts to access underground mine workings; no workers will be underground as the ISR process is conducted from surface facilities. While this mining method has been used extensively on an international basis and currently accounts for more than 50% of global uranium production, it has not previously been used in Canada for uranium mining. Denison has completed research on international uranium ISR operations to understand best practices and incorporate lessons learned into the design of Wheeler. In order to implement ISR at Wheeler, Denison will apply existing technologies to eliminate the typical challenges experienced at some international uranium ISR operations.

ISR mining at Wheeler will involve injecting a mining solution into the uranium deposit through a series of cased drill holes (about 4 to 8 inches in diameter) called injection wells (more detail is provided in Denison, 2020). The mining solution proposed for Wheeler is a low pH or acidic solution. As the mining solution passes from the injection wells through the uranium deposit, it dissolves the uranium and leaves virtually all other minerals in the host rock in place. Once dissolved, the uranium-rich mining solution is recovered and pumped back up to the surface through another set of cased drill holes called recovery wells. The combination of injection and recovery wells is called a wellfield. Denison anticipates the wellfield will have the general arrangement of one recovery well in the centre surrounded by 6-8 injection wells with about 10-meter (m) spacing between wells. With these configuration options, the final wellfield may include approximately 310 wells over a 90 m x 900 m area (Denison, 2020).

To contain the solution within the uranium deposit and maximize recovery, as well as prevent interaction of the mining solution with surrounding groundwater, Denison will create an impermeable wall using conventional ground freezing technology. The freeze wall will encompass the deposit located at 400 m depth and the overlying sandstone from the basement rock to surface with the existing impermeable basement rock acting as a bottom barrier beneath the uranium deposit. The approximate area of the freeze containment is 90 m wide x 900 m long (Denison, 2020).

Newfields Canada Mining & Environment ULC (NewFields) has been retained by Denison through EcoMetrix Incorporated (EcoMetrix) to conduct an assessment of potential effects on surface water hydrology as a result of the Project. This report provides the effects assessment using the most up to date information available with respect to surface water hydrology for the defined study area, as well as the Project layout and water balance.

The surface water hydrology assessment has been completed to inform the Environmental Assessment (EA) which will be prepared to meet requirements of the coordinated provincial-federal EA as per the spirit of the Canada-Saskatchewan Agreement on Environmental Assessment Cooperation (2005). The cooperation agreement allows for the production of a single EA that meets the requirements of both levels of government, so that each level of government can make an independent decision.

1.1. Assessment Purpose and Objectives

The purpose of this assessment is to assess potential change to hydrological conditions (as represented by the "surface water quantity" Valued Component [VC]) in consideration of all life of mine (LOM) phases at the Site. Hydrological parameters of interest include flow regime in local streams and water levels in selected waterbodies. This assessment predicts changes to hydrological parameters through all temporal phases of the Project within the defined Local and Regional Study Areas.

This report is presented as a summary of existing conditions at Site and includes assessment of predicted changes to the aforementioned hydrological parameters. This report includes the following sections:

- Project overview and purpose of this assessment including identification of spatial and temporal study areas (Section 1.0);
- Discussion of regulatory framework used in this assessment (Section 2.0);
- Summary of existing conditions (Section 3.0);
- Methodology used in the impact assessment (Section 4.0); and,
- Presentation and discussion of the results of assessment (Section 5.0).

1.2. Assessment Boundaries

For this assessment, spatial and temporal boundaries have been defined in consideration of the proposed LOM plan and all associated activities. These boundaries are discussed in the following sections.

1.2.1. Spatial Boundaries

1.2.1.1. Project Study Area (PSA)

The Project Study Area (PSA) is the direct footprint of the Project. The PSA represents the area in which Project activities and components may occur and, as such, represents the area within which direct physical disturbance may occur as a result of the Project, either temporary or permanent. (i.e., the Project footprint; the area of maximum physical disturbance plus the buffer). This area is not VC-specific, but consistent throughout the EIA.

1.2.1.2. Local Study Area (LSA) and Regional Study Area (RSA)

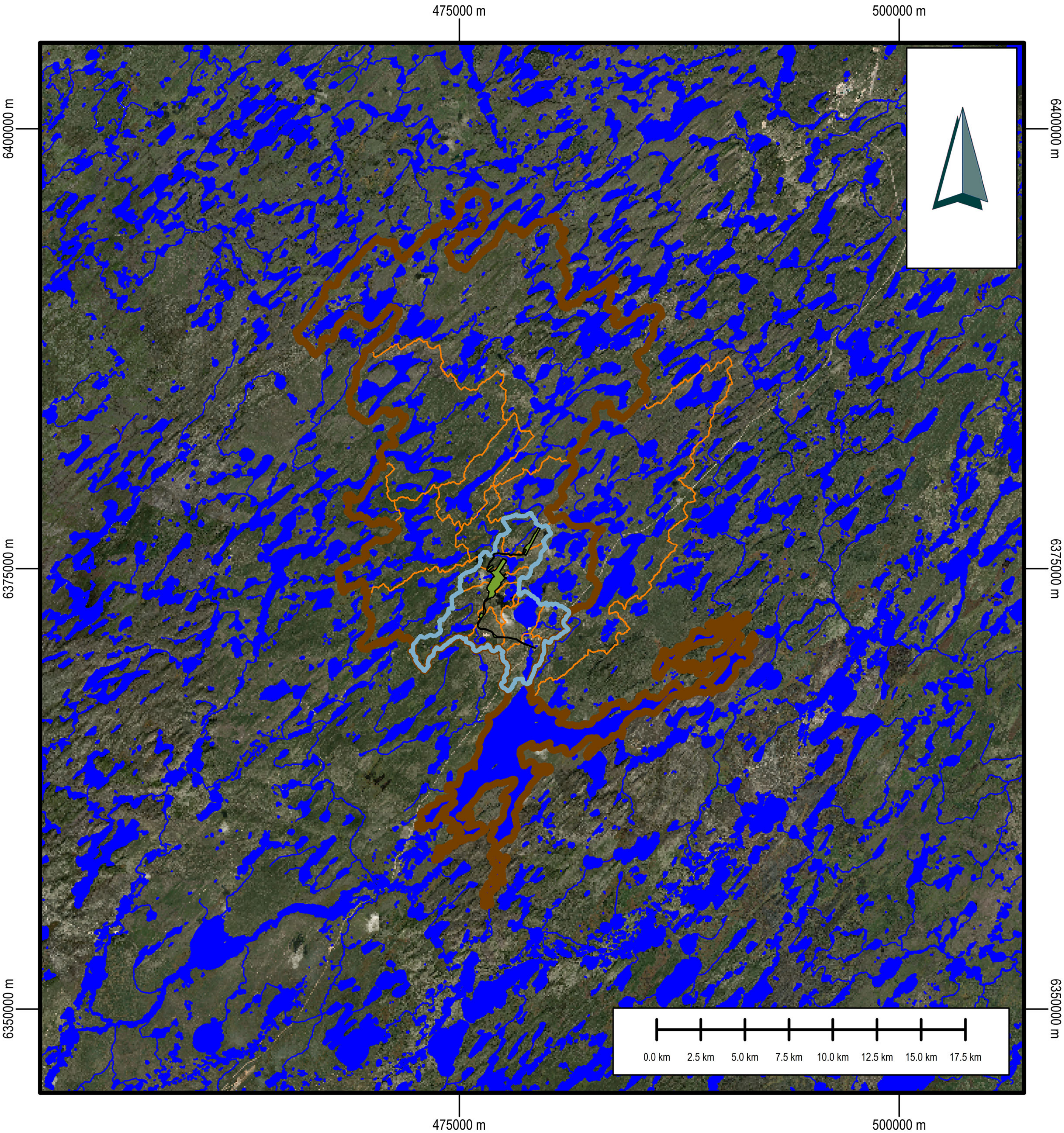
The Local Study Area (LSA) is the area that surrounds the Project Area where both direct and indirect effects resulting from Project activities can be reasonably measured. The LSA is established to assess the potential, largely direct effects of the Project and represents the extent to which there is a reasonable potential for the Project or Project-related activities to interact with and potentially adversely affect the VC. The LSA is derived from watershed boundaries local to the Project Area.

The Regional Study Area (RSA) is the area that surrounds and includes the LSA, established to assess the potential, largely indirect effects of the Project in a regional context. The RSA is large enough to capture the extent of potential effects (i.e., zone of influence) on a VC and defines the area within which cumulative effects may occur (i.e., cumulative effects assessment boundary). The RSA is bounded by the regional watershed area in which the Project Area is located.

The LSA for the assessment of the surface water quantity VC is based upon portions of watersheds containing direct footprint of the Site, as well as areas directly downstream which are influenced by the Site footprint or effluent discharge/water withdrawal effects (Figure 1-1). This area is selected based upon important waterbodies downstream (notably Whitefish and McGowan Lakes) of the Project which may be impacted through all temporal phases. The LSA extends from those waterbodies down to their inflow to Russell Lake.

The RSA for this assessment is based upon the whole watershed within which the Project is located and extends downstream to include the whole of Russell Lake (Figure 1-1). This is the area in which cumulative effects are assessed.

The watersheds within the area of the LSA are presented in Figure 1-2.



Legend:
- Site Study Area
- Waterbody
- Local Study Area
- Regional Study Area
- Stream Alignment
- Watershed Boundary

NewFields

Date: February 8, 2022

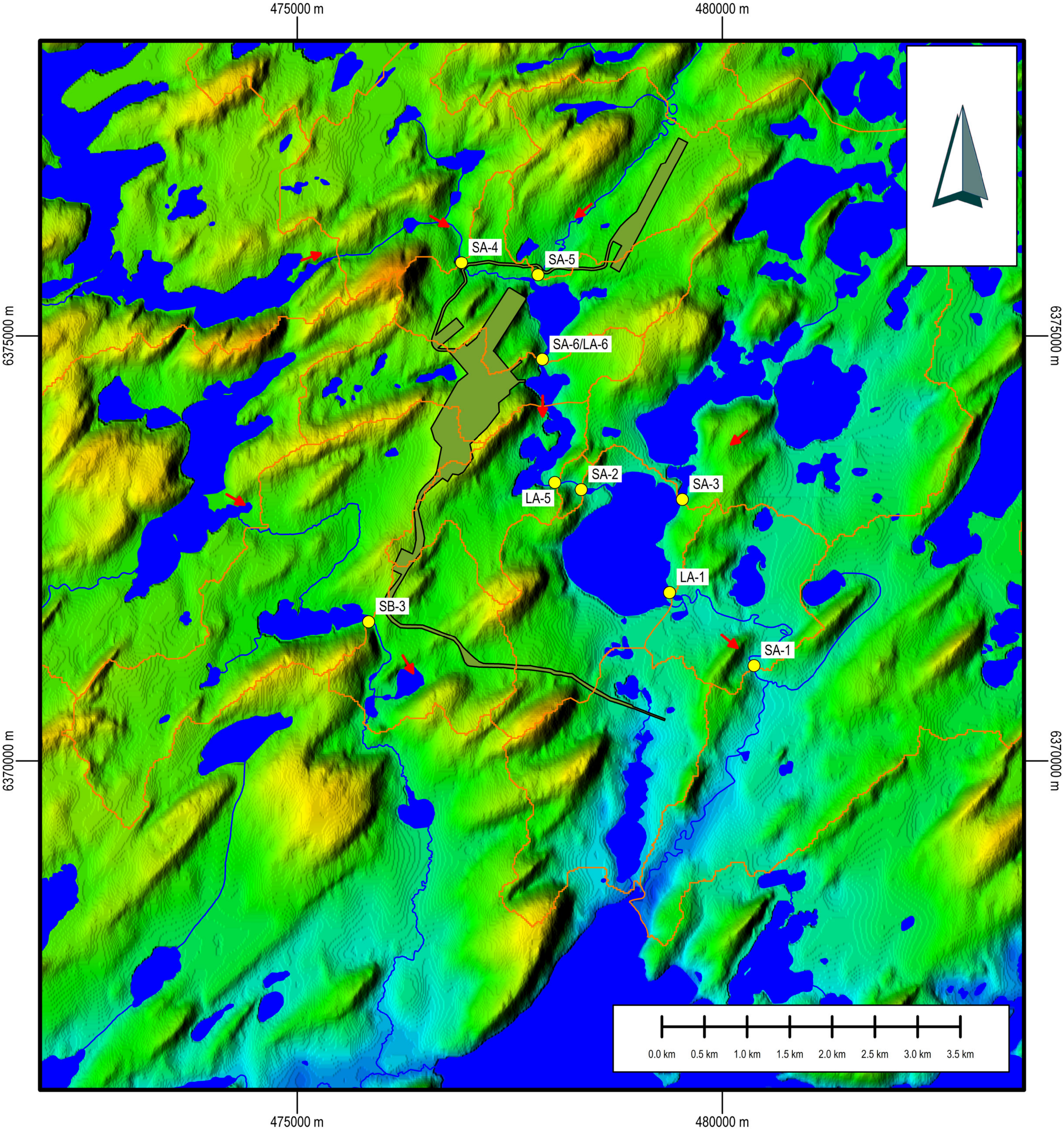
Project Number: 680.0018.000

Figure Title: Study Areas

Projection: UTM NAD83 Zone 13
References: World Imagery provided by Global Mapper

Figure: 1

Revision: 2



Legend:

- Site Study Area
- Waterbody
- Stream Alignment
- Watershed Boundary
- Assessment Node
- Flow Direction

NewFields	Date: February 8, 2022
Project Number: 680.0018.000	
Figure Title: Watersheds in Local Study Area	
Projection: UTM NAD83 Zone 13 References: Elevation model from CDEM NTS Mapsheets	**Figure: 2** **Revision: 4**

1.2.2. Temporal Boundaries Phases

The temporal boundaries of the Project are defined by the four mine life phases as outlined in Table 1-1.

TABLE 1-1: TEMPORAL BOUNDARIES FOR THE ENVIRONMENTAL ASSESSMENT

Phase	Year	Description of Activities
Site Construction	1 to 3	Development of access roads and air strip; clearing, level and grading of the project site, laydown area; wellfield and freeze hole drilling; ground freezing; batch plant operation (concrete); development of surface infrastructure (camp, administration buildings, plants, ponds, pads and support infrastructure); waste management (incineration and landfill operation); water management (including treatment); power generation – generators; groundwater supply and release; surface water supply and release; fuel management (e.g., propane for comfort heating; vehicle and aircraft fuel); on-site and off-site operation of vehicles and transportation of materials; air transportation for workers.
Operation	3 to 18	Operation of the ISR wellfield; wellfield and freeze wall drilling; operation of freeze wall; expansion of pond and pads; operation of the ISR processing plant and production of uranium concentrate; water withdrawal from groundwater or surface water body; management of surface water (including seepage and site run-off); water treatment of human waste (black, grey and kitchen water treated and discharged to an effluent pond) and process water; water release to groundwater and/or surface water body; waste management (incineration and landfill operation); hazardous waste management (temporary storage, handling, and off-site transportation); contaminated waste management (temporary storage, handling, and off-site transportation); storage and disposal of process waste rock and radioactive plant precipitates; on-site and off-site operation of vehicles and transportation of materials; power supply – generators and back-up generators; package and transport of nuclear substances; fuel management (e.g., propane for comfort heating; vehicle and aircraft fuel); air transportation for workers.
Decommissioning	18 to 23	Mining horizon remediation and thawing of freeze wall; process water treatment and release; closure of ISR and freeze wells and infrastructure; salvageable asset removal (including site power transmission lines and electrical infrastructure); demolition and disposal of non-salvageable surface infrastructure and materials; remediation of contaminated areas (wellfield, waste pads, ponds, water treatment location, and process plant area); reclamation disturbed areas (site, roads, camp, and airstrip); site water management, treatment and release; power generation – gensets; waste management (incineration and landfill operation); management of hazardous waste; on-site and off-site operation of vehicles and transportation of materials.
Post-decommissioning	23 to 33	Active: monitoring of vegetation growth; monitoring of surface and groundwater quality; monitoring of wildlife site Passive: conduct environmental monitoring as required Regulatory site inspections Engagement - Site visit from interested parties

2. REGULATORY FRAMEWORK

The Wheeler River Project Description has been reviewed by the Canadian Nuclear Safety Commission who have concluded that the project meets the definition of a “designated project”. As such, an Environmental Assessment is required under the *Canadian Environmental Assessment Act, 2012*. The project is also subject to Environmental Assessment requirements of the Government of Saskatchewan under *The Environmental Assessment Act* of Saskatchewan. In the context of local hydrology, the proponent is required to assess impacts of the Project within the context of the federal *Canadian Environmental Protection Act, 1999* and *the Fisheries Act*, as well as Surface Water Quality Objectives – Interim Edition from the Government of Saskatchewan.

3. EXISTING CONDITIONS

Denison initiated baseline hydrological monitoring in 2011 which has continued to present. Data are reported by EcoMetrix (2019) for the period 2011 to 2019. Though some periods in the reported baseline flow records are missing, notably winter data, the duration of monitoring at Site is sufficient for use to establish the long-term streamflow trends at the Site through relationships to long-term operating hydrometric gauging stations in the same watershed. As such, these records can be used to estimate long-term potential effects for the temporal phases and spatial study areas at the Site.

Baseline monitoring at the Project included streamflow monitoring, lake level monitoring and installation of stage dataloggers at various locations throughout two main watersheds reporting to Russell Lake identified as Watersheds A and B (EcoMetrix, 2019). Hydrometric monitoring at the Site has been carried out by several organizations since 2011 and recently the focus of each program has shifted to Watershed A stations predominantly in the vicinity of the Site. Hydrometric monitoring at streamflow stations by each organization has included measurement of stream discharge, water level survey and maintenance of in-stream dataloggers. The discussion of methodology used by each organization is provided by EcoMetrix (2019).

Critical locations of interest for this assessment include the following nodes (also in Table 3-1) which are coincident with baseline monitoring stations and/or watersheds of interest to the assessment (locations shown in Figure 1-2). The assessment nodes represent the collective watershed upstream.

- SA-1 – streamflow monitoring station on the stream colloquially known as the Icelander River located downstream of LA-1 (McGowan Lake);
- SA-2 – streamflow monitoring station situated downstream of outflow from LA-5 (Whitefish Lake) and upstream of inflow to LA-1 (McGowan Lake);
- SA-3 – streamflow monitoring station upstream of inflow to LA-1 (McGowan Lake);
- SA-4 – streamflow monitoring station upstream of inflow to LA-6 (Unnamed Lake);
- SA-5 – streamflow monitoring station upstream of inflow to LA-6 (Unnamed Lake);
- SA-6/LA-6 – streamflow and lake level monitoring station from LA-6 (Unnamed Lake) to inflow of LA-5 (Whitefish Lake);
- SB-3 – south Project drainage basin flowing to Russell Lake;

- LA-1 – McGowan Lake; and,
- LA-5 – Whitefish Lake.

Gross drainage areas for the above-mentioned locations are presented in Table 3-1.

TABLE 3-1: DRAINAGE AREAS FOR ASSESSMENT NODES

Location	Description	Gross Drainage Area (km²)
SA-1*	Icelander River flowing from McGowan Lake	280.6
SA-2*	Inflow to McGowan Lake from Whitefish Lake	257.4
SA-3*	Inflow to McGowan Lake	15.5
SA-4*	Inflow to LA-6 (Unnamed Lake) from Kratchkowski Lake	80.5
SA-5*	Inflow to LA-6	167.3
SA-6/LA-6*	Flow from LA-6 to Whitefish Lake	251.7
SB-3	Southern project drainage basin flowing to Russell Lake	24.9
LA-1	McGowan Lake	277.5
LA-5	Whitefish Lake	257.2
*Based on monitoring station		

Note:
Gross drainage is the total area (km^2 = square kilometers) of watershed that would generate runoff to a contributing point.

3.1. Baseline Streamflow Record Extension

The available baseline streamflow data for the Project covered a sufficient time period to support the assessment yet was not robust with respect to winter flow data. To ensure that seasonable variability in hydrology was adequately captured as part of the dataset used to assess potential effects, an additional step in data preparation was undertaken to fill in such seasonal gaps in the long-term record. This was accomplished by additional modelling (pro-rating) using a known continuous data source. Environment and Climate Change Canada (ECCC) operates hydrometric gauging stations across the country including one station located approximately 32 km downstream of the Project (i.e., the Project footprint and RSA lie within the watershed at that gauge). ECCC monitors flow rates on the Wheeler River below Russell Lake (Station 06DA005) and has reported historical data from 1973 to 2019 (ECCC 2021). Data prior to 1977 have frequent missing records and were not used for this assessment. Daily average discharge data from 06DA005 were used extending from 1977 to 2019 for modelling purposes. Monthly average discharge data for 06DA005 for the period of interest are provided in Appendix I.

To extend the discharge records from 06DA005 to other assessment nodes required correlation either through Unit Area Runoff relationships or same day discharge best fit correlation. The methodology used is discussed in Appendix II. The extended discharge records for each station were then processed to obtain monthly average discharge for each assessment node for purposes of the effect assessment for the Project. These data are presented in Appendix I with summary statistics presented in Table 3-2.

TABLE 3-2: SUMMARY STATISTICS FOR PROJECT RELEVANT NODES

Station	Gross Drainage Area (km^2)	Statistic	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Monthly Average	Monthly Average Yield ($m^3/s/km^2$)
SA-1 - Correlated from WSC Wheeler River Station	280.55	Max (m^3/s)	3.076	3.182	2.782	2.659	3.507	4.075	4.037	3.436	3.393	4.114	3.497	2.753	3.376	0.0120
		Average (m^3/s)	1.589	1.518	1.474	1.692	2.398	2.382	2.100	1.888	1.820	1.884	1.823	1.659	1.852	0.0066
		25th Percentile (m^3/s)	1.200	1.167	1.152	1.445	2.103	2.110	1.719	1.499	1.288	1.394	1.429	1.275	1.482	0.0053
		5th Percentile (m^3/s)	1.067	0.982	0.900	1.211	1.786	1.469	1.273	1.093	0.984	0.986	1.075	1.065	1.158	0.0041
		Min (m^3/s)	1.007	0.901	0.875	1.106	1.679	1.414	1.133	1.054	0.945	0.870	0.893	1.028	1.075	0.0038
SA-2 – Adjusted Unit Area Runoff from SA-6	257.36	Max (m^3/s)	2.840	2.999	2.446	2.312	3.532	4.554	4.485	3.410	3.346	4.632	3.522	2.379	3.372	0.0131
		Average (m^3/s)	1.147	1.089	1.040	1.221	1.972	1.972	1.658	1.442	1.394	1.463	1.376	1.199	1.414	0.0055
		25th Percentile (m^3/s)	0.799	0.778	0.770	0.991	1.592	1.613	1.220	1.023	0.862	0.942	0.969	0.852	1.034	0.0040
		5th Percentile (m^3/s)	0.712	0.660	0.613	0.810	1.278	1.008	0.852	0.734	0.663	0.663	0.716	0.710	0.785	0.0030
		Min (m^3/s)	0.675	0.613	0.598	0.755	1.177	0.956	0.759	0.705	0.638	0.596	0.609	0.688	0.731	0.0028
SA-3 - Adjusted Unit Area Runoff from SA-1	15.537	Max (m^3/s)	0.721	0.746	0.652	0.624	0.822	0.956	0.947	0.806	0.796	0.965	0.820	0.646	0.792	0.0510
		Average (m^3/s)	0.373	0.356	0.346	0.397	0.562	0.559	0.493	0.443	0.427	0.442	0.428	0.389	0.434	0.0280
		25th Percentile (m^3/s)	0.282	0.274	0.270	0.339	0.493	0.495	0.403	0.352	0.302	0.327	0.335	0.299	0.348	0.0224
		5th Percentile (m^3/s)	0.250	0.230	0.211	0.284	0.419	0.345	0.299	0.256	0.231	0.231	0.252	0.250	0.271	0.0175
		Min (m^3/s)	0.236	0.211	0.205	0.259	0.394	0.332	0.266	0.247	0.222	0.204	0.209	0.241	0.252	0.0162
SA-4 - Correlated from SA-6	80.498	Max (m^3/s)	0.662	0.695	0.579	0.550	0.803	1.008	0.994	0.779	0.765	1.023	0.801	0.566	0.769	0.0096
		Average (m^3/s)	0.298	0.285	0.274	0.315	0.478	0.478	0.410	0.363	0.352	0.367	0.348	0.310	0.357	0.0044
		25th Percentile (m^3/s)	0.221	0.216	0.214	0.264	0.398	0.402	0.316	0.272	0.235	0.254	0.260	0.233	0.274	0.0034
		5th Percentile (m^3/s)	0.200	0.188	0.177	0.223	0.329	0.268	0.233	0.205	0.189	0.189	0.201	0.200	0.217	0.0027
		Min (m^3/s)	0.192	0.177	0.174	0.210	0.307	0.257	0.211	0.199	0.183	0.173	0.176	0.195	0.204	0.0025
SA-5 - Unit Area Runoff from SA-6	167.32	Max (m^3/s)	1.802	1.901	1.557	1.474	2.232	2.866	2.823	2.156	2.116	2.915	2.226	1.516	2.132	0.0127
		Average (m^3/s)	0.751	0.715	0.684	0.797	1.263	1.263	1.068	0.934	0.904	0.947	0.893	0.783	0.917	0.0055
		25th Percentile (m^3/s)	0.535	0.522	0.517	0.654	1.027	1.040	0.796	0.674	0.574	0.624	0.640	0.568	0.681	0.0041
		5th Percentile (m^3/s)	0.481	0.448	0.419	0.541	0.832	0.664	0.568	0.495	0.451	0.450	0.484	0.480	0.526	0.0031
		Min (m^3/s)	0.458	0.419	0.410	0.508	0.769	0.632	0.510	0.476	0.435	0.409	0.417	0.466	0.492	0.0029
SA-6/LA-6 - Correlated from SA-1	251.69	Max (m^3/s)	2.711	2.859	2.343	2.218	3.357	4.312	4.247	3.243	3.183	4.384	3.348	2.280	3.207	0.0127
		Average (m^3/s)	1.129	1.075	1.029	1.199	1.900	1.900	1.607	1.405	1.360	1.425	1.343	1.178	1.379	0.0055
		25th Percentile (m^3/s)	0.805	0.785	0.778	0.984	1.545	1.565	1.198	1.014	0.864	0.939	0.963	0.854	1.024	0.0041
		5th Percentile (m^3/s)	0.724	0.675	0.631	0.814	1.252	0.999	0.854	0.744	0.678	0.677	0.728	0.722	0.791	0.0031
		Min (m^3/s)	0.689	0.631	0.617	0.764	1.157	0.951	0.767	0.717	0.655	0.615	0.627	0.701	0.741	0.0029
SB3 - UAR from SA-1	24.87	Max (L/s)	0.273	0.282	0.247	0.236	0.311	0.361	0.358	0.305	0.301	0.365	0.310	0.244	0.299	0.0120
		Average (L/s)	0.141	0.135	0.131	0.150	0.213	0.211	0.186	0.167	0.161	0.167	0.162	0.147	0.164	0.0066
		25th Percentile (L/s)	0.106	0.103	0.102	0.128	0.186	0.187	0.152	0.133	0.114	0.124	0.127	0.113	0.131	0.0053

Station	Gross Drainage Area (km²)	Statistic	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Monthly Average	Monthly Average Yield (m³/s/km²)
		5th Percentile (L/s)	0.095	0.087	0.080	0.107	0.158	0.130	0.113	0.097	0.087	0.087	0.095	0.094	0.103	0.0041
		Min (L/s)	0.089	0.080	0.078	0.098	0.149	0.125	0.100	0.093	0.084	0.077	0.079	0.091	0.095	0.0038
LA-1 - UAR from SA-1	277.52	Max (m³/s)	3.043	3.148	2.752	2.630	3.469	4.031	3.993	3.399	3.356	4.069	3.459	2.724	3.339	0.0120
		Average (m³/s)	1.572	1.502	1.458	1.674	2.372	2.356	2.078	1.868	1.800	1.863	1.803	1.641	1.832	0.0066
		25th Percentile (m³/s)	1.187	1.155	1.140	1.429	2.080	2.087	1.700	1.483	1.275	1.379	1.414	1.262	1.466	0.0053
		5th Percentile (m³/s)	1.055	0.971	0.890	1.198	1.767	1.453	1.260	1.082	0.974	0.975	1.063	1.053	1.145	0.0041
		Min (m³/s)	0.996	0.891	0.865	1.094	1.661	1.399	1.121	1.043	0.935	0.861	0.883	1.017	1.064	0.0038
LA-5 - UAR from SA-1	257.18	Max (m³/s)	2.820	2.917	2.550	2.437	3.215	3.735	3.701	3.150	3.110	3.771	3.205	2.524	3.095	0.0120
		Average (m³/s)	1.456	1.391	1.351	1.551	2.198	2.184	1.925	1.731	1.668	1.727	1.671	1.521	1.698	0.0066
		25th Percentile (m³/s)	1.100	1.070	1.056	1.324	1.928	1.934	1.576	1.374	1.181	1.278	1.310	1.169	1.358	0.0053
		5th Percentile (m³/s)	0.978	0.900	0.825	1.110	1.638	1.347	1.167	1.002	0.902	0.904	0.985	0.976	1.061	0.0041
		Min (m³/s)	0.923	0.826	0.802	1.014	1.539	1.296	1.039	0.966	0.866	0.798	0.819	0.943	0.986	0.0038

3.2. Low Flow Statistics

Low flow assessment statistics are required for water quality modelling when a proposed discharge is anticipated for a Project. The statistic required for the assessment, as required by the Saskatchewan Water Security Agency, is the seven-day average 1:10-year low flow return period (7Q10). This assessment requires tabulation of flow data series into one-week intervals with summary statistics of the low flow return periods generated from the Log-Pearson III analysis. The 7Q10 estimates are presented in Table 3-3 for assessment nodes LA-1 and LA-5 as these two waterbodies are anticipated to receive effluent discharge during operation phase of the project. The effects assessment associated with potential changes to water quality will be conducted under separate cover in support of the EA.

TABLE 3-3: 7Q10 ESTIMATED DISCHARGE

Assessment Node	7Q10 Flow Rate (m^3/s)
LA-1	0.874
LA-5	0.616

Note: m^3/s = cubic meters per second

3.3. Climate Change

3.3.1. Water Balance Influencing Climate Change Parameters

Climate change is recognized as a growing issue facing future developments. The Canadian Centre for Climate Services (CCCS, 2021) provides an online tool identifying potential changes to Mean Annual Temperature, Surface Wind Speed, Total Precipitation, and Snow Depth among other parameters based on location and timeframes within Canada. The four aforementioned parameters influence the water balance at the Project where the former affects evaporation and the latter impacts local runoff. The change to parameters presented in Table 3-4 are based on the projected time interval, emission scenario referred to as Representative Concentration Pathways (RCPs), as well as the predicted change referenced to the average of the period 1986 to 2005. The RCP scenarios represent projected plausible emissions based on potential future anthropogenic activity.

TABLE 3-4: CLIMATE CHANGE PARAMETER ESTIMATES

Parameter	Units	Time Period	Emission Scenario (Representative Concentration Pathway (RCP))		
			Low (RCP 2.6)	Moderate (RCP 4.5)	High (RCP 8.5)
Mean Temperature	°C	2021-2040	+1.3	+1.4	+1.6
		2041-2060	+1.7	+2.3	+3.2
		2061-2080	+1.7	+2.8	+4.8
		2081-2100	+1.7	+3.1	+6.2
Surface Wind Speed	% Change	2021-2040	-1.4	-1.3	-1.2
		2041-2060	-0.9	-1.3	-2.6
		2061-2080	-1.3	-0.9	-2.8
		2081-2100	-1.4	-1.6	-2.6
Total Precipitation	% Change	2021-2040	+3.6	+2.7	+5.0
		2041-2060	+5.7	+7.3	+8.1
		2061-2080	+5.3	+8.0	+9.4
		2081-2100	+5.7	+7.9	+10.7
Snow Depth	% Change	2021-2040	-9.0	-7.1	-9.7
		2041-2060	-7.6	-11.8	-16.0
		2061-2080	-7.5	-14.3	-30.5
		2081-2100	-12.0	-19.5	-38.6

Table 3-4 indicates that through all temporal phases of the Project, the mean annual temperature is expected to increase in a range of +1.3°C to +6.2°C above the normal for the period from 1986 to 2005 based on all RCPs. Wind speed is anticipated to decrease by -0.9% to -2.8% relative to the 1986 to 2005 average through all temporal phases and RCPs. Evaporation processes are a function of both temperature and wind speed as well as relative humidity and, through some models, solar and net radiation. An increase in temperature in the area will increase saturation vapour pressure of the air, thus creating a potential increase in evaporation. Decreasing wind speed, however, will reduce the ability for saturated air to be moved away from water surfaces thus decreasing potential evaporation. The two influences would not likely cancel out and will be dependent on data sets based on observation of climate change phenomena.

Table 3-4 indicates that total precipitation will increase in a range of 2.7% to 10.7% referenced to the 1986 to 2005 averages and that snow depth will decrease by -7.1% to -38.6%. Increased precipitation will increase the amount of flow from each assessment node watershed. Decreased snow depth may indicate a shorter snow accumulation period in the winter or potentially decreased snow fall during winter months. The decrease in snow depth may also mean that snow melt runoff events would be of lower magnitude and duration under future climate change scenarios.

Predictive modelling of future climate conditions is a challenging endeavour and unlikely to yield definitive assessment of the long-term impact of the Project; however, qualitative assessment of the Project effects can be based upon four chosen scenarios in the discussion of climate change:

- Mean precipitation static and increased evaporation;
- Increased precipitation and increased evaporation;
- Mean precipitation static and decreased evaporation; and,
- Increased precipitation and decreased evaporation.

These four scenarios allow for qualitative assessment of the Project based on varying probable climate conditions as discussed later in this report.

3.3.2. Climate Change Influenced Extreme Event Data

3.3.2.1. Intensity-Duration-Frequency Data

Intensity-Duration-Frequency (IDF) curves are used to estimate the sizing of water management structures around a Site. Often, the 1:100-year, 24-hour precipitation event is the design event used in analyses for water management. IDF curves are often specific to climate monitoring stations; however, the online tool IDF_CC Tool 5.0 developed by the Institute for Catastrophic Loss Reduction, FIDS – Facility for Intelligent Decision Support and Western University (2021) is available for presentation of IDF curves at ungauged locations and includes the ability to estimate future IDF curve values under influences from climate change IDF.

IDF data extracted from the online tool were selected for geographic location 57.51103°N, 105.37622°W. The baseline IDF curve data (Table 3-5) are based on a gridded data set extracted from the online tool. The climate change influenced IDF curve data (Table 3-6) are based on the time window of 2020 to 2050 under a climate condition scenario yielding the largest magnitude storm fall. The 1:100-year, 24-hour return period rainfall events for the baseline and climate change influence IDF curves are 79.9 and 88.6 millimeters (mm), respectively.

TABLE 3-5: BASELINE IDF CURVE DATA

Duration	Return Period (years) Rainfall (mm)						
	2	5	10	20	25	50	100
5 minutes	4.3	6.7	8.8	11.5	12.4	16.0	20.7
10 minutes	6.4	9.8	12.8	16.7	17.9	23.0	29.3
15 minutes	7.7	11.9	15.8	21.0	22.7	29.8	39.1
30 minutes	9.8	14.8	19.1	24.6	26.4	33.6	42.8
1 hour	12.3	17.9	22.8	29.0	31.0	39.1	49.7
2 hours	15.7	21.7	26.8	33.4	35.5	44.4	56.4
6 hours	24.1	31.7	37.5	43.8	45.8	52.9	60.7
12 hours	31.7	42.4	49.9	57.5	59.7	67.3	75.1
24 hours	38.3	50.7	58.4	65.6	67.5	73.9	79.9

TABLE 3-6: CLIMATE CHANGE INFLUENCED IDF CURVE DATA

Duration	Return Period (years) Rainfall (mm)						
	2	5	10	20	25	50	100
5 minutes	4.7	7.1	9.5	12.4	13.4	17.6	22.9
10 minutes	6.9	10.5	13.8	17.9	19.3	25.1	32.5
15 minutes	8.3	12.7	17.0	22.6	24.5	32.7	43.3
30 minutes	10.5	15.8	20.6	26.5	28.4	36.8	47.5
1 hour	13.3	19.2	24.6	31.3	33.4	42.9	55.1
2 hours	16.9	23.2	28.9	36.0	38.2	48.6	62.5
6 hours	26.0	33.9	40.4	47.2	49.4	57.9	67.3
12 hours	34.2	45.4	53.8	61.9	64.4	73.8	83.3
24 hours	41.3	54.3	63.0	70.7	72.8	81.0	88.6

3.3.2.2. Probable Maximum Precipitation Events

The Probable Maximum Precipitation (PMP) event is a design standard value for an extreme rainfall event. The PMP event does not have an estimated return period but instead is based upon the theoretical maximum amount of water that a storm could produce based on the maximum persisting dew point (Atmospheric & Hydrologic Sciences Division – Atmospheric Environment Branch [AES], 1999). Assessment completed AES (1999) indicate that a trend in the maximum persisting dew point is not shifting appreciably but no formal analysis of projected climate change impacts has been completed. Based on data presented by AES (1999), the estimated PMP event for the Project is 489.3 mm.

4. EFFECTS ASSESSMENT METHODOLOGY

There are four primary anticipated interactions with the Project on the surface water hydrology in the PSA and LSA. These include:

- Direct impacts:
  - Footprint – Direct overprinting (loss) or change to drainage area (watershed) due to Site footprint development.
  - Water Withdrawal – Fresh water withdrawal from LA-5 (Whitefish Lake) for purposes of mine process water and Site water balance.
  - Water Discharge – Mine water discharge to LA-5 for maintenance of Site water balance.
- Indirect impacts:
  - Groundwater – Changes to hydrogeological influences to local waterbodies.

The four temporal phases for the Project include Construction (Year 1 to 3), Operations (Year 3 to 18), Decommissioning (Year 18 to 23), and Post-Decommissioning (Year 23 to 33). Influence of each impact through the project is described in Table 4-1 where it is assumed that the worst case scenario of each impact is incurred.

TABLE 4-1: PROJECT IMPACTS THROUGH TEMPORAL PHASES

Temporal Phase	Projected Impact
Construction	▪ Footprint – Fully developed footprint by end of construction
Operations	▪ Footprint – Fully developed footprint ▪ Water Withdrawal – Potential freshwater withdrawal from LA-5 ▪ Water Discharge – Potential treated discharge to LA-5 ▪ Groundwater – Maximum projected change in groundwater contribution to LA-5
Decommissioning	▪ Footprint – Fully developed footprint ▪ Water Withdrawal – Potential freshwater withdrawal from LA-5 ▪ Water Discharge – Potential treated discharge to LA-5 ▪ Groundwater – Maximum projected change in groundwater contribution to LA-5
Post-decommissioning	▪ Returned to Pre-Development conditions

Flows and water levels under pre-development conditions were used as the baseline against which Project-related changes during the construction, operation, decommissioning and post-decommissioning stages were assessed. Pre-disturbance (baseline) watershed areas are presented in Figure 1-2 and expected changes to these watersheds were estimated for subsequent phases of the mine life. Changes in watershed areas are primarily a result of the construction of mine infrastructure and the implementation of the Water Management Plan (WMP). There are two scenarios considered separately for water withdrawal and treated effluent discharge to LA-5 relevant to both the operations and decommissioning stages. Groundwater is received in LA-5 under natural conditions and estimates of the changes to this contribution are evaluated for Operations and Decommissioning. The following sections discuss each projected impact.

4.1. Site Footprint

The site footprint consists of an access road from Highway 914 northwest through to the main Project facilities and extending northeast to the proposed airstrip. The road and airstrip are not considered to be impacts to hydrology. Both will potentially redirect some flow and have a small influence on times of concentration of runoff as well as infiltration rates but in general will have a very small influence and are not expected to change runoff volumes at assessment nodes. Project facilities will have influence on runoff to assessment nodes as Denison intends to collect all runoff water to Project facilities where it can be used in the ISR process and treated in the wastewater treatment plant prior to release to the environment. The assessment nodes impacted by project footprint are presented in Table 4-2.

TABLE 4-2: SITE FOOTPRINT IMPACTS

Impacted Assessment Node	Decrease in Drainage Area (km²)
SA-5	0.273
SA-6	0.566
SB-3	0.214

Note: km^2 = square kilometers.

4.2. Water Withdrawal and Effluent Discharge

The Project is assessed via two differing scenarios which reflect either water withdrawal from or effluent discharge to LA-5. For purposes of this assessment, Denison anticipates a maximum freshwater withdrawal of 40.5 m^3/hr (0.0113 m^3/s) and a maximum discharge rate of 81.0 m^3/hr (0.0225 m^3/s) for the Project. These withdrawal and discharge rates are assessed independently of each other and assumed to occur as a constant rate throughout all phases of the project.

4.3. Groundwater Discharge to LA-5

Hydrogeological impacts are anticipated from the Project and reported by others. Whitefish Lake (LA-5) is estimated under baseline conditions to receive 40 liters per second (L/s) from hydrogeological sources. Modelling for the project estimates a decrease in this input to 36 L/s during Operations and Decommissioning. This input is anticipated to return to pre-disturbance conditions for Post-Decommissioning.

4.4. Effects Assessment

Effects are assessed for each temporal stage of the project and for those assessment nodes projected to be impacted within their respective watersheds. The nodes relevant to this assessment include SA-1, SA-2 SA-6/LA-6, SB-3, LA-1 and LA-5. As discussed and presented in Table 4-1, projected impacts relate to footprint, water withdrawal/effluent discharge, and changes to groundwater contributions. For temporal stages influenced by water withdrawal/effluent discharge, two scenarios are presented for only water withdrawal or only effluent discharge to understand the magnitude of each without offsetting. This assumes that the withdrawal and discharge to/from LA-5 would not be happening simultaneously. Operations and De-commissioning are considered to be similar in project influence and are assessed together. From a hydrological perspective, post-decommissioning is anticipated to be a full return to pre-disturbance conditions resulting in a null effect.

Project impacts are assessed based on scenarios as presented in Table 4-3.

TABLE 4-3: PROJECT IMPACT SCENARIOS

Temporal Stage(s)	Scenario Number	Project Influence
Construction	1	▪ Fully Developed Site Footprint
Operations and Decommissioning with Water Withdrawal	2	▪ Fully Developed Site Footprint ▪ Freshwater Withdrawal from LA-5 ▪ Change in Groundwater Contribution to LA-5
Operations and Decommissioning with Effluent Discharge	3	▪ Fully Developed Site Footprint ▪ Effluent Discharge to LA-5 ▪ Change in Groundwater Contribution to LA-5

Based on the results of scenarios identified in Table 4-3, projected changes to water levels in target waterbodies can be assessed. Waterbodies LA-1, LA-5 and LA-6 are within impacted assessment nodes for the Project. The change to the water level of each waterbody can be estimated based on baseline water level survey data at the waterbody and coincident discharge measurement at downstream hydrometric gauging stations. The compilation of these two data sets creates a stage-outflow rating curve. The stage-outflow rating curve for LA-1 is developed from flow records at SA-1 (Figure 4-1) and LA-5 is developed from SA-2 (Figure 4-2). The stage-outflow curve for LA-6 (Figure 4-3) is the same rating curve as for SA-6 given the proximity between the station and the lake. These outflow rating curves can be used to assess the difference between water levels of the baseline and impacted discharges for each of the waterbodies.

FIGURE 4-1: LA-1 STAGE-OUTFLOW RATING CURVE

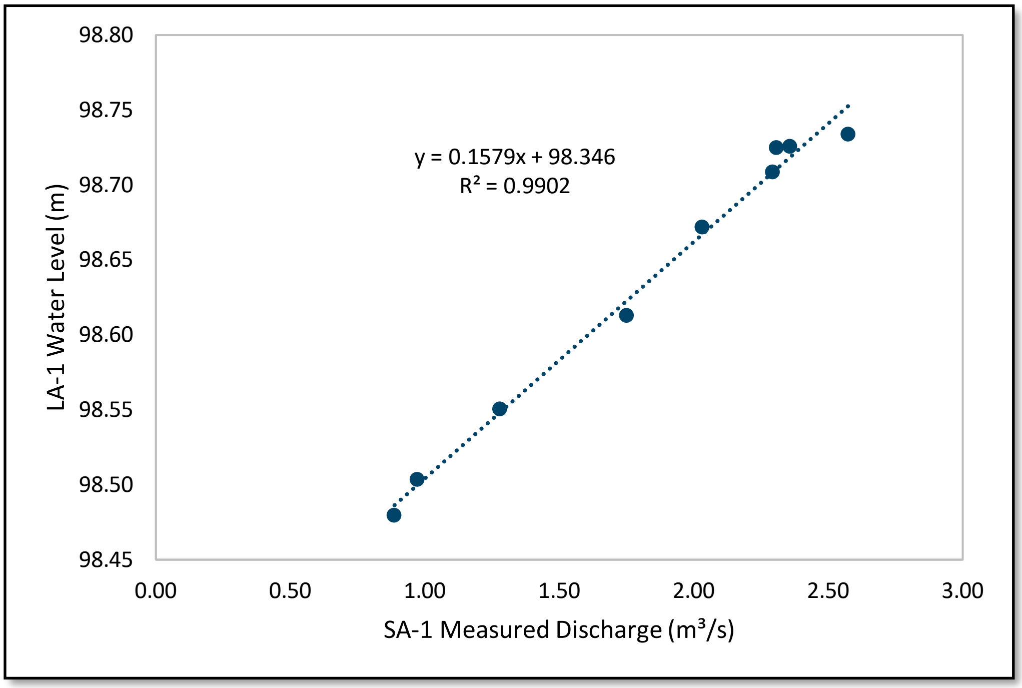


FIGURE 4-2: LA-5 STAGE-OUTFLOW RATING CURVE

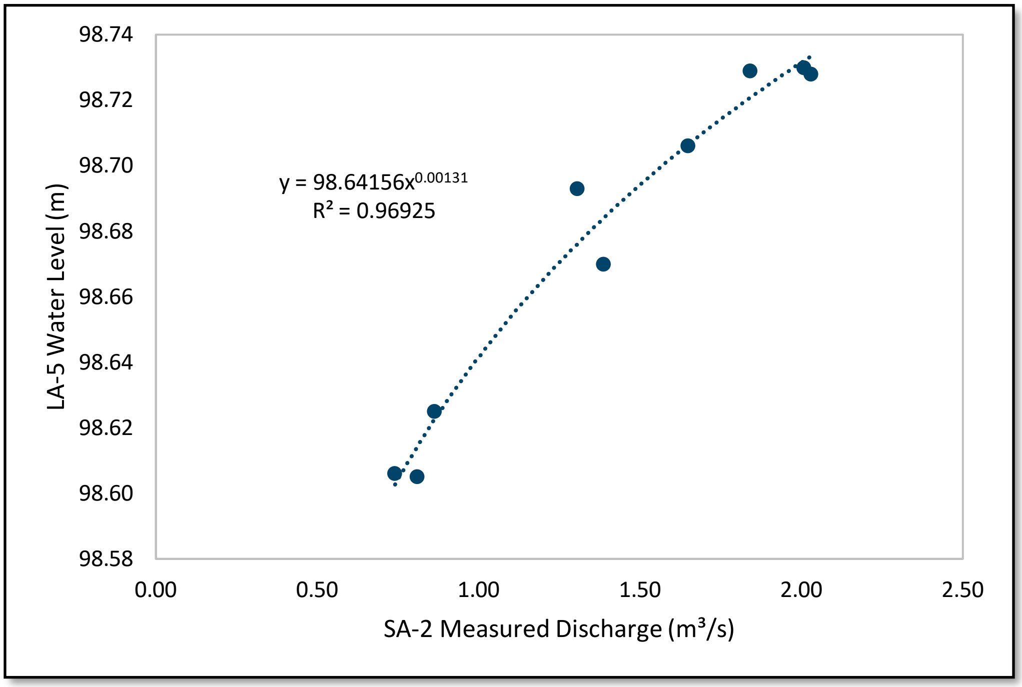
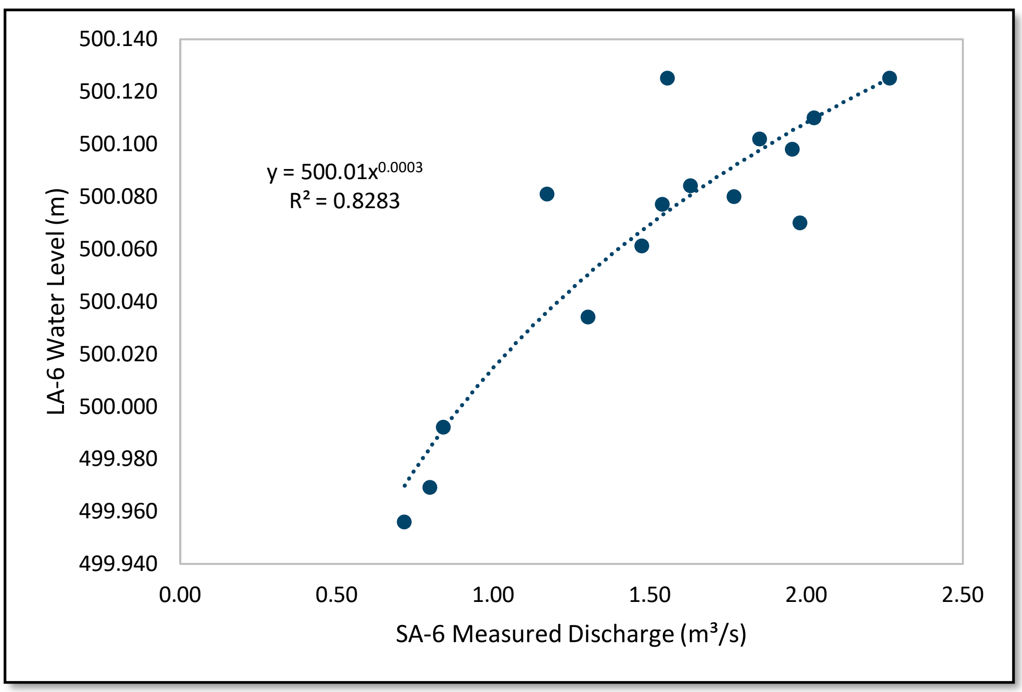


FIGURE 4-3: LA-6 STAGE-OUTFLOW RATING CURVE



5. RESULTS AND DISCUSSIONS

5.1. Assessment Results for Impact Scenarios

The three scenarios identified in Table 4-3 were assessed for their respective impact(s). The change to monthly and annual streamflow rates are projected based on those impacts for assessment nodes SA-1, SA-2, SA-6/LA-6, LA-1, LA-5 and SB-3. The change in flow rates were assessed for the mean and 5th percentile low flow statistics; these statistics are selected as being most representative of potential effects given the relatively small withdrawal/discharge rates with respect to baseline flow rates in the area. Further, the project is expected to have the greatest impact on baseline flow rates during very low flow conditions of which have not been observed in the measured record. The results of Scenarios 1, 2 and 3 are presented in Table 5-1, Table 5-2 and Table 5-3, respectively.

The largest estimated percentage change in flow through all scenarios is -3.10%. This magnitude of change occurs in Scenario 2 (water withdrawal during Operations and Decommissioning) for the month of March under the 5th percentile low flow data at assessment node LA-5 and SA-2 (immediately downstream of the Project). Under Scenario 3 (effluent discharge during Operations and Decommissioning), the largest estimated percentage change is 2.54% also occurring at LA-5/SA-2 during March of the 5th percentile low flow data set. The maximum observed change for any assessment node during Construction (Scenario 1) is less than 1%.

TABLE 5-1: SCENARIO 1 – CONSTRUCTION PHASE – EFFECTS RESULTS

Station	Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Monthly Average
SA-1	Baseline Scenario Average (m^3/s)	1.589	1.518	1.474	1.692	2.398	2.382	2.100	1.888	1.820	1.884	1.823	1.659	1.852
	Impacted Scenario Average (m^3/s)	1.585	1.514	1.470	1.688	2.392	2.376	2.095	1.884	1.815	1.879	1.819	1.655	1.848
	Percentage Change to Average Condition Flow (%)	**-0.24**	**-0.24**	**-0.23**	**-0.24**	**-0.26**	**-0.27**	**-0.26**	**-0.25**	**-0.25**	**-0.25**	**-0.25**	**-0.24**	**-0.25**
	Baseline Scenario 5th Percentile (m^3/s)	1.067	0.982	0.900	1.211	1.786	1.469	1.273	1.093	0.984	0.986	1.075	1.065	1.158
	Impacted Scenario 5th Percentile (m^3/s)	1.064	0.980	0.898	1.208	1.782	1.466	1.270	1.091	0.982	0.984	1.072	1.062	1.155
	Percentage Change to 5th Percentile Condition Flow (%)	**-0.23**	**-0.23**	**-0.23**	**-0.22**	**-0.23**	**-0.23**	**-0.22**	**-0.23**	**-0.23**	**-0.23**	**-0.23**	**-0.23**	**-0.23**
SA-2	Baseline Scenario Average (m^3/s)	1.147	1.089	1.040	1.221	1.972	1.972	1.658	1.442	1.394	1.463	1.376	1.199	1.414
	Impacted Scenario Average (m^3/s)	1.143	1.085	1.036	1.217	1.966	1.966	1.653	1.437	1.389	1.459	1.371	1.195	1.410
	Percentage Change to Average Condition Flow (%)	**-0.33**	**-0.33**	**-0.33**	**-0.33**	**-0.32**	**-0.32**	**-0.32**	**-0.32**	**-0.33**	**-0.32**	**-0.33**	**-0.33**	**-0.33**
	Baseline Scenario 5th Percentile (m^3/s)	0.712	0.660	0.613	0.810	1.278	1.008	0.852	0.734	0.663	0.663	0.716	0.710	0.785
	Impacted Scenario 5th Percentile (m^3/s)	0.710	0.657	0.611	0.807	1.274	1.004	0.849	0.732	0.661	0.661	0.714	0.708	0.782
	Percentage Change to 5th Percentile Condition Flow (%)	**-0.34**	**-0.34**	**-0.34**	**-0.34**	**-0.33**	**-0.33**	**-0.33**	**-0.34**	**-0.34**	**-0.34**	**-0.34**	**-0.34**	**-0.34**
SA-6/LA-6	Baseline Scenario Average (m^3/s)	1.129	1.075	1.029	1.199	1.900	1.900	1.607	1.405	1.360	1.425	1.343	1.178	1.379
	Impacted Scenario Average (m^3/s)	1.128	1.074	1.028	1.197	1.898	1.898	1.605	1.403	1.359	1.424	1.342	1.177	1.378
	Percentage Change to Average Condition Flow (%)	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**
	Baseline Scenario 5th Percentile (m^3/s)	0.724	0.675	0.631	0.814	1.252	0.999	0.854	0.744	0.678	0.677	0.728	0.722	0.791
	Impacted Scenario 5th Percentile (m^3/s)	0.723	0.674	0.630	0.814	1.251	0.998	0.853	0.743	0.677	0.677	0.727	0.721	0.791
	Percentage Change to 5th Percentile Condition Flow (%)	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**
LA-1	Baseline Scenario Average (m^3/s)	1.572	1.502	1.458	1.674	2.372	2.356	2.078	1.868	1.800	1.863	1.803	1.641	1.832
	Impacted Scenario Average (m^3/s)	1.568	1.498	1.455	1.670	2.366	2.350	2.072	1.863	1.795	1.859	1.799	1.637	1.828
	Percentage Change to Average Condition Flow (%)	**-0.24**	**-0.24**	**-0.24**	**-0.24**	**-0.27**	**-0.27**	**-0.26**	**-0.25**	**-0.25**	**-0.25**	**-0.25**	**-0.24**	**-0.25**
	Baseline Scenario 5th Percentile (m^3/s)	1.055	0.971	0.890	1.198	1.767	1.453	1.260	1.082	0.974	0.975	1.063	1.053	1.145
	Impacted Scenario 5th Percentile (m^3/s)	1.053	0.969	0.888	1.195	1.763	1.450	1.257	1.079	0.972	0.973	1.061	1.051	1.142
	Percentage Change to 5th Percentile Condition Flow (%)	**-0.23**	**-0.23**	**-0.24**	**-0.23**	**-0.24**	**-0.23**	**-0.23**	**-0.23**	**-0.23**	**-0.23**	**-0.23**	**-0.23**	**-0.23**
LA-5	Baseline Scenario Average (m^3/s)	1.146	1.088	1.039	1.220	1.971	1.971	1.657	1.441	1.393	1.462	1.375	1.198	1.413

Station	Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Monthly Average
	Impacted Scenario Average (m³/s)	1.142	1.085	1.036	1.216	1.964	1.964	1.652	1.436	1.388	1.458	1.370	1.194	1.409
	Percentage Change to Average Condition Flow (%)	**-0.33**	**-0.33**	**-0.33**	**-0.33**	**-0.32**	**-0.32**	**-0.32**	**-0.33**	**-0.33**	**-0.32**	**-0.33**	**-0.33**	**-0.33**
	Baseline Scenario 5th Percentile (m³/s)	0.712	0.659	0.612	0.809	1.277	1.007	0.851	0.734	0.663	0.662	0.716	0.710	0.784
	Impacted Scenario 5th Percentile (m³/s)	0.709	0.657	0.610	0.806	1.273	1.004	0.849	0.731	0.660	0.660	0.714	0.707	0.782
	Percentage Change to 5th Percentile Condition Flow (%)	**-0.34**	**-0.34**	**-0.34**	**-0.34**	**-0.33**	**-0.33**	**-0.33**	**-0.34**	**-0.34**	**-0.34**	**-0.34**	**-0.34**	**-0.34**
SB-3	Baseline Scenario Average (m³/s)	0.141	0.135	0.131	0.150	0.213	0.211	0.186	0.167	0.161	0.167	0.162	0.147	0.164
	Impacted Scenario Average (m³/s)	0.140	0.133	0.130	0.149	0.211	0.209	0.185	0.166	0.160	0.166	0.160	0.146	0.163
	Percentage Change to Average Condition Flow (%)	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**
	Baseline Scenario 5th Percentile (m³/s)	0.095	0.087	0.080	0.107	0.158	0.130	0.113	0.097	0.087	0.087	0.095	0.094	0.103
	Impacted Scenario 5th Percentile (m³/s)	0.094	0.086	0.079	0.106	0.157	0.129	0.112	0.096	0.087	0.087	0.094	0.094	0.102
	Percentage Change to 5th Percentile Condition Flow (%)	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**

TABLE 5-2: SCENARIO 2 - OPERATIONS AND DECOMMISSIONING PHASE - WATER WITHDRAWAL - EFFECTS RESULTS

Station	Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Monthly Average
SA-1	Baseline Scenario Average (m³/s)	1.589	1.518	1.474	1.692	2.398	2.382	2.100	1.888	1.820	1.884	1.823	1.659	1.852
	Impacted Scenario Average (m³/s)	1.568	1.497	1.454	1.671	2.375	2.359	2.078	1.867	1.798	1.862	1.802	1.638	1.831
	Percentage Change to Average Condition Flow (%)	**-1.30**	**-1.35**	**-1.38**	**-1.23**	**-0.97**	**-0.97**	**-1.06**	**-1.14**	**-1.18**	**-1.15**	**-1.17**	**-1.25**	**-1.16**
	Baseline Scenario 5th Percentile (m³/s)	1.067	0.982	0.900	1.211	1.786	1.469	1.273	1.093	0.984	0.986	1.075	1.065	1.158
	Impacted Scenario 5th Percentile (m³/s)	1.047	0.963	0.881	1.191	1.765	1.449	1.254	1.074	0.965	0.967	1.055	1.046	1.138
	Percentage Change to 5th Percentile Condition Flow (%)	**-1.81**	**-1.95**	**-2.11**	**-1.62**	**-1.18**	**-1.38**	**-1.55**	**-1.77**	**-1.94**	**-1.94**	**-1.80**	**-1.81**	**-1.69**
SA-2	Baseline Scenario Average (m³/s)	1.147	1.089	1.040	1.221	1.972	1.972	1.658	1.442	1.394	1.463	1.376	1.199	1.414
	Impacted Scenario Average (m³/s)	1.126	1.068	1.019	1.200	1.949	1.949	1.636	1.420	1.372	1.442	1.355	1.178	1.393
	Percentage Change to Average Condition Flow (%)	**-1.80**	**-1.88**	**-1.95**	**-1.71**	**-1.18**	**-1.18**	**-1.34**	**-1.50**	**-1.54**	**-1.48**	**-1.55**	**-1.74**	**-1.52**
	Baseline Scenario 5th Percentile (m³/s)	0.712	0.660	0.613	0.810	1.278	1.008	0.852	0.734	0.663	0.663	0.716	0.710	0.785
	Impacted Scenario 5th Percentile (m³/s)	0.693	0.641	0.594	0.790	1.257	0.987	0.832	0.715	0.644	0.644	0.697	0.691	0.765

Station	Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Monthly Average
	Percentage Change to 5th Percentile Condition Flow (%)	**-2.71**	**-2.90**	**-3.10**	**-2.42**	**-1.65**	**-2.01**	**-2.32**	**-2.64**	**-2.89**	**-2.89**	**-2.69**	**-2.72**	**-2.49**
SA-6/LA-6	Baseline Scenario Average (m^3/s)	1.129	1.075	1.029	1.199	1.900	1.900	1.607	1.405	1.360	1.425	1.343	1.178	1.379
	Impacted Scenario Average (m^3/s)	1.128	1.074	1.028	1.197	1.898	1.898	1.605	1.403	1.359	1.424	1.342	1.177	1.378
	Percentage Change to Average Condition Flow (%)	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**
	Baseline Scenario 5th Percentile (m^3/s)	0.724	0.675	0.631	0.814	1.252	0.999	0.854	0.744	0.678	0.677	0.728	0.722	0.791
	Impacted Scenario 5th Percentile (m^3/s)	0.723	0.674	0.630	0.814	1.251	0.998	0.853	0.743	0.677	0.677	0.727	0.721	0.791
	Percentage Change to 5th Percentile Condition Flow (%)	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**
LA-1	Baseline Scenario Average (m^3/s)	1.572	1.502	1.458	1.674	2.372	2.356	2.078	1.868	1.800	1.863	1.803	1.641	1.832
	Impacted Scenario Average (m^3/s)	1.551	1.481	1.438	1.653	2.349	2.333	2.055	1.846	1.779	1.842	1.782	1.620	1.811
	Percentage Change to Average Condition Flow (%)	**-1.31**	**-1.36**	**-1.39**	**-1.25**	**-0.98**	**-0.99**	**-1.07**	**-1.15**	**-1.19**	**-1.16**	**-1.18**	**-1.27**	**-1.17**
	Baseline Scenario 5th Percentile (m^3/s)	1.055	0.971	0.890	1.198	1.767	1.453	1.260	1.082	0.974	0.975	1.063	1.053	1.145
	Impacted Scenario 5th Percentile (m^3/s)	1.036	0.952	0.871	1.178	1.746	1.433	1.240	1.062	0.955	0.956	1.044	1.034	1.126
	Percentage Change to 5th Percentile Condition Flow (%)	**-1.83**	**-1.97**	**-2.13**	**-1.64**	**-1.19**	**-1.39**	**-1.57**	**-1.79**	**-1.97**	**-1.96**	**-1.82**	**-1.83**	**-1.70**
LA-5	Baseline Scenario Average (m^3/s)	1.456	1.391	1.351	1.551	2.198	2.184	1.925	1.731	1.668	1.727	1.671	1.521	1.698
	Impacted Scenario Average (m^3/s)	1.436	1.371	1.331	1.530	2.175	2.160	1.903	1.710	1.647	1.705	1.650	1.500	1.676
	Percentage Change to Average Condition Flow (%)	**-1.42**	**-1.47**	**-1.50**	**-1.35**	**-1.06**	**-1.06**	**-1.15**	**-1.25**	**-1.28**	**-1.25**	**-1.28**	**-1.37**	**-1.26**
	Baseline Scenario 5th Percentile (m^3/s)	0.978	0.900	0.825	1.110	1.638	1.347	1.167	1.002	0.902	0.904	0.985	0.976	1.061
	Impacted Scenario 5th Percentile (m^3/s)	0.958	0.881	0.806	1.090	1.617	1.326	1.147	0.983	0.883	0.885	0.966	0.957	1.042
	Percentage Change to 5th Percentile Condition Flow (%)	**-1.97**	**-2.12**	**-2.30**	**-1.77**	**-1.29**	**-1.50**	**-1.69**	**-1.93**	**-2.12**	**-2.12**	**-1.96**	**-1.98**	**-1.84**
SB-3	Baseline Scenario Average (m^3/s)	0.141	0.135	0.131	0.150	0.213	0.211	0.186	0.167	0.161	0.167	0.162	0.147	0.164
	Impacted Scenario Average (m^3/s)	0.140	0.133	0.130	0.149	0.211	0.209	0.185	0.166	0.160	0.166	0.160	0.146	0.163
	Percentage Change to Average Condition Flow (%)	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**
	Baseline Scenario 5th Percentile (m^3/s)	0.095	0.087	0.080	0.107	0.158	0.130	0.113	0.097	0.087	0.087	0.095	0.094	0.103
	Impacted Scenario 5th Percentile (m^3/s)	0.094	0.086	0.079	0.106	0.157	0.129	0.112	0.096	0.087	0.087	0.094	0.094	0.102
	Percentage Change to 5th Percentile Condition Flow (%)	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**

TABLE 5-3: SCENARIO 3 - OPERATIONS AND DECOMMISSIONING PHASE – EFFLUENT DISCHARGE - EFFECTS RESULTS

Station	Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Monthly Average
SA-1	Baseline Scenario Average (m^3/s)	1.589	1.518	1.474	1.692	2.398	2.382	2.100	1.888	1.820	1.884	1.823	1.659	1.852
	Impacted Scenario Average (m^3/s)	1.603	1.532	1.488	1.706	2.409	2.393	2.113	1.901	1.833	1.897	1.836	1.673	1.865
	Percentage Change to Average Condition Flow (%)	**0.88**	**0.93**	**0.97**	**0.81**	**0.47**	**0.48**	**0.59**	**0.69**	**0.72**	**0.69**	**0.72**	**0.83**	**0.71**
	Baseline Scenario 5th Percentile (m^3/s)	1.067	0.982	0.900	1.211	1.786	1.469	1.273	1.093	0.984	0.986	1.075	1.065	1.158
	Impacted Scenario 5th Percentile (m^3/s)	1.082	0.997	0.915	1.226	1.800	1.483	1.288	1.109	1.000	1.001	1.090	1.080	1.173
	Percentage Change to 5th Percentile Condition Flow (%)	**1.43**	**1.57**	**1.73**	**1.24**	**0.76**	**0.98**	**1.16**	**1.39**	**1.57**	**1.56**	**1.42**	**1.43**	**1.30**
SA-2	Baseline Scenario Average (m^3/s)	1.147	1.089	1.040	1.221	1.972	1.972	1.658	1.442	1.394	1.463	1.376	1.199	1.414
	Impacted Scenario Average (m^3/s)	1.160	1.103	1.054	1.235	1.983	1.983	1.670	1.455	1.407	1.476	1.389	1.213	1.427
	Percentage Change to Average Condition Flow (%)	**1.21**	**1.29**	**1.37**	**1.12**	**0.57**	**0.57**	**0.74**	**0.90**	**0.94**	**0.88**	**0.96**	**1.15**	**0.92**
	Baseline Scenario 5th Percentile (m^3/s)	0.712	0.660	0.613	0.810	1.278	1.008	0.852	0.734	0.663	0.663	0.716	0.710	0.785
	Impacted Scenario 5th Percentile (m^3/s)	0.727	0.675	0.628	0.824	1.292	1.022	0.867	0.749	0.679	0.678	0.732	0.725	0.800
	Percentage Change to 5th Percentile Condition Flow (%)	**2.14**	**2.34**	**2.54**	**1.85**	**1.06**	**1.42**	**1.74**	**2.07**	**2.32**	**2.33**	**2.13**	**2.15**	**1.92**
SA-6/LA-6	Baseline Scenario Average (m^3/s)	1.129	1.075	1.029	1.199	1.900	1.900	1.607	1.405	1.360	1.425	1.343	1.178	1.379
	Impacted Scenario Average (m^3/s)	1.128	1.074	1.028	1.197	1.898	1.898	1.605	1.403	1.359	1.424	1.342	1.177	1.378
	Percentage Change to Average Condition Flow (%)	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**
	Baseline Scenario 5th Percentile (m^3/s)	0.724	0.675	0.631	0.814	1.252	0.999	0.854	0.744	0.678	0.677	0.728	0.722	0.791
	Impacted Scenario 5th Percentile (m^3/s)	0.723	0.674	0.630	0.814	1.251	0.998	0.853	0.743	0.677	0.677	0.727	0.721	0.791
	Percentage Change to 5th Percentile Condition Flow (%)	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**	**-0.11**
LA-1	Baseline Scenario Average (m^3/s)	1.572	1.502	1.458	1.674	2.372	2.356	2.078	1.868	1.800	1.863	1.803	1.641	1.832
	Impacted Scenario Average (m^3/s)	1.586	1.516	1.472	1.687	2.383	2.368	2.090	1.881	1.813	1.876	1.817	1.655	1.845
	Percentage Change to Average Condition Flow (%)	**0.88**	**0.94**	**0.98**	**0.82**	**0.48**	**0.48**	**0.59**	**0.70**	**0.73**	**0.69**	**0.73**	**0.84**	**0.71**
	Baseline Scenario 5th Percentile (m^3/s)	1.055	0.971	0.890	1.198	1.767	1.453	1.260	1.082	0.974	0.975	1.063	1.053	1.145
	Impacted Scenario 5th Percentile (m^3/s)	1.070	0.987	0.906	1.213	1.781	1.467	1.274	1.097	0.989	0.991	1.078	1.069	1.160
	Percentage Change to 5th Percentile Condition Flow (%)	**1.45**	**1.59**	**1.75**	**1.25**	**0.76**	**0.99**	**1.18**	**1.40**	**1.58**	**1.58**	**1.43**	**1.45**	**1.31**
LA-5	Baseline Scenario Average (m^3/s)	1.456	1.391	1.351	1.551	2.198	2.184	1.925	1.731	1.668	1.727	1.671	1.521	1.698

Station	Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Monthly Average
	Impacted Scenario Average (m^3/s)	1.470	1.406	1.365	1.565	2.209	2.195	1.938	1.744	1.681	1.740	1.684	1.535	1.711
	Percentage Change to Average Condition Flow (%)	**0.95**	**1.01**	**1.05**	**0.88**	**0.52**	**0.52**	**0.64**	**0.75**	**0.79**	**0.75**	**0.79**	**0.90**	**0.77**
	Baseline Scenario 5th Percentile (m^3/s)	0.978	0.900	0.825	1.110	1.638	1.347	1.167	1.002	0.902	0.904	0.985	0.976	1.061
	Impacted Scenario 5th Percentile (m^3/s)	0.993	0.916	0.840	1.125	1.651	1.361	1.182	1.018	0.918	0.919	1.000	0.991	1.076
	Percentage Change to 5th Percentile Condition Flow (%)	**1.56**	**1.71**	**1.89**	**1.35**	**0.82**	**1.06**	**1.27**	**1.52**	**1.71**	**1.71**	**1.55**	**1.56**	**1.42**
SB-3	Baseline Scenario Average (m^3/s)	0.141	0.135	0.131	0.150	0.213	0.211	0.186	0.167	0.161	0.167	0.162	0.147	0.164
	Impacted Scenario Average (m^3/s)	0.140	0.133	0.130	0.149	0.211	0.209	0.185	0.166	0.160	0.166	0.160	0.146	0.163
	Percentage Change to Average Condition Flow (%)	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**
	Baseline Scenario 5th Percentile (m^3/s)	0.095	0.087	0.080	0.107	0.158	0.130	0.113	0.097	0.087	0.087	0.095	0.094	0.103
	Impacted Scenario 5th Percentile (m^3/s)	0.094	0.086	0.079	0.106	0.157	0.129	0.112	0.096	0.087	0.087	0.094	0.094	0.102
	Percentage Change to 5th Percentile Condition Flow (%)	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**	**-0.86**

5.2. Estimated Changes to Water Levels in LA-1, LA-5 and LA-6

Using the stage-outflow curves presented in Section 4.3, the potential change in water level in each of LA-1 (McGowan Lake), LA-5 (Whitefish Lake), and LA-6 (Unnamed Lake) can be estimated from the difference in flow rates between the baseline and impacted scenarios identified in Table 5-1, Table 5-2 and Table 5-3.

For LA-1, the largest predicted change in water level is -0.0037 m under average conditions for the months of May and June during withdrawal. For the discharge scenario, the maximum predicted change is 0.0025 m occurring in March using the 5th percentile dataset.

At LA-5, the largest predicted change in water level in a withdrawal scenario is -0.0041 m during March of the 5th percentile dataset. During a discharge scenario, the maximum predicted change is 0.0032 m in March of the 5th percentile dataset.

All expected water level effects to other lakes, including LA-6, within the vicinity of the Project are expected to have negligible effects with magnitudes also in the sub-centimeter range.

5.3. Effects Due to Climate Change

5.3.1. Climate Change Effects on Water Balance

As discussed in Section 3.3.1, climate change is projected to increase precipitation in the vicinity of the Project. Though this will result in an increase to runoff in the LSA, the potential implications to evaporative effects are unknown. Evaporation, being a function of air temperature, wind speed, relative humidity and radiation, may have a small increase given that air temperature may increase by as much as 6.2% (Table 3-4), though wind speed may similarly decrease by 2.6% in the same RCP scenario. Relative humidity is a representation of the ratio of actual to saturation vapour pressure and both are a function of temperature as well as vapour phase water in the air. Without a complete projected dataset for all parameters, as well as an accepted model, it is difficult to estimate the response of evaporation to these climatic influences.

NewFields has observed that augmenting the data in an existing dataset did not yield a consistent shift in evaporation which indicates the relationship to be dynamic. Any noted change between the datasets resulted in a change to evaporation rates of less than 5%. As such, given the small influence of evaporation and the variable range of predicted changes in precipitation and snow depth, the effects of climate change on the water balance are discussed qualitatively based on the four scenarios described in Section 3.3.1. The four projections for climate change scenarios are:

1. Mean precipitation static and increased evaporation – this projection would see an expectedly marginal decrease in flow rates from the area.
2. Increased precipitation and increased evaporation – this projection would at least partially cancel out with either increased or decreased flows in the area.
3. Mean precipitation static and decreased evaporation – this projection would result in increased flow rates from the Project.
4. Increased precipitation and decreased evaporation – this projection would also see increased flow rates from the Project.

Of the four potential climate change scenarios, only Projections 1 and 2 have the potential to result in a condition where flow rates decrease as a result of climate change. Any decrease in flow rates due to climate change would likely be marginal and not statistically detectable as a result of Projections 1 and 2. This is typically due to the already highly variable climate in Saskatchewan. Appreciable changes to the timing and magnitude of snow depth would have the potential to alter current flow rates, but are still unlikely to have substantial influence from the Project.

5.3.2. Climate Change Effects on Extreme Events

Extreme events are expected to change due to climate change. Qualitatively, climate change is expected to increase the frequency and magnitude of such events. Though the potential maximum PMP is not expected to increase as it is limited by the persistent dew point, the magnitude of the 1:100-year, 24-hour storm is expected to increase from 77.9 mm to 88.6 mm (approximately 10%). This may require consideration for greater storage and conveyance capacity for Project water management infrastructure.

5.4. Discussion

The low potential water withdrawal and discharge magnitudes proposed by Denison for the Project result in negligible impacts to the receiving environment within the LSA. The RSA is not assessed due to the much larger drainage area at the outlet of Russell Lake and greater attenuation of the signal of expected effects. All projected influences on streamflow from the Project are within +/- 5% of baseline conditions on a monthly average basis with the largest influence occurring during withdrawal at a magnitude of -3.1%. Lake levels are anticipated to have a similarly negligible impact with expected changes to water levels of LA-1 and LA-5 being less than 0.01 m.

Confidence in the assessment of projected effects to hydrology is quite high due to available hydrological data for the LSA. Uncertainty is minimal with the assumptions that water withdrawal and discharge scenarios presented herein represent the bounding case and hydrogeological modelling projections are not changed.

6. LIMITATIONS

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7. CLOSURE

NewFields would like to thank EcoMetrix for the support its personnel provided during this review. We trust that this information meets your needs at this time. Should any portion of this report require further information or clarification, please do not hesitate to contact the undersigned.

Sincerely,

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APPENDIX I

MONTHLY AVERAGE FLOW RECORDS

Table I-1: Wheeler River (06DA005) Monthly Average Discharge (m³/s)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean Annual
1977	26.85	25.68	20.95	23.67	30.77	35.45	35.14	30.18	29.38	26.91	23.90	22.52	27.62
1978	24.54	23.85	21.91	19.66	27.28	29.65	24.87	25.65	29.82	30.76	27.21	24.49	25.81
1979	27.19	28.08	24.72	21.03	25.32	27.72	25.21	24.50	23.13	23.87	24.56	21.64	24.75
1980	17.99	14.74	13.79	14.05	19.29	17.16	14.35	14.83	15.40	18.95	18.31	16.61	16.29
1981	16.66	17.39	17.14	17.79	24.88	21.32	15.77	11.36	8.93	9.44	11.09	11.46	15.27
1982	10.00	8.53	8.30	10.34	22.24	25.48	21.32	22.96	21.83	18.65	17.02	17.40	17.01
1983	16.88	15.88	15.54	17.10	20.79	25.52	20.31	16.90	18.04	19.35	19.79	18.42	18.71
1984	16.07	15.88	16.75	20.28	22.67	21.44	16.77	13.80	11.96	13.30	15.17	14.95	16.59
1985	15.06	14.79	15.43	16.55	28.95	25.36	22.95	18.78	17.68	16.74	17.16	16.02	18.79
1986	16.07	16.33	16.22	16.54	25.29	24.06	23.44	21.59	17.29	16.79	16.06	15.06	18.73
1987	14.73	14.79	15.08	19.02	22.84	18.04	12.43	9.90	10.14	9.57	10.48	10.15	13.93
1988	10.99	11.24	12.28	13.42	19.26	22.43	20.39	16.36	15.74	15.21	15.14	14.77	15.60
1989	15.16	15.97	15.16	14.59	23.81	24.89	22.93	17.99	16.15	15.29	14.52	14.46	17.58
1990	14.37	14.29	14.26	14.55	19.10	19.42	19.41	14.43	12.28	12.89	13.96	13.84	15.23
1991	12.95	12.84	13.02	15.17	21.78	23.45	20.47	16.26	15.78	15.50	14.55	14.36	16.34
1992	13.48	13.28	13.40	14.76	22.97	20.37	16.79	14.49	15.63	20.74	16.47	14.31	16.39
1993	13.23	12.73	12.25	15.11	16.98	13.24	12.57	18.13	17.25	15.58	15.39	13.89	14.70
1994	13.04	12.29	13.29	16.07	25.82	27.21	22.48	15.32	10.96	10.81	10.43	10.29	15.67
1995	10.29	10.03	10.73	14.25	18.46	21.25	15.95	19.67	20.76	18.33	17.68	14.25	15.97
1996	11.59	10.90	10.81	13.20	18.56	20.68	20.15	18.06	16.31	16.03	15.84	14.56	15.56
1997	13.91	13.43	13.09	14.22	20.21	21.55	18.95	20.27	25.82	35.77	30.68	23.46	20.95
1998	19.92	19.19	18.56	19.73	20.05	15.46	14.59	12.80	10.23	11.88	12.15	11.71	15.52
1999	11.15	9.72	8.37	13.32	18.99	16.37	14.13	14.03	11.53	10.80	11.57	10.76	12.56
2000	10.07	9.61	9.65	11.61	19.85	20.64	16.37	13.85	12.61	15.51	14.43	11.90	13.84
2001	11.14	10.16	10.47	12.79	18.30	16.54	14.94	12.41	14.10	15.75	14.35	13.61	13.71
2002	12.57	12.03	11.59	11.89	16.12	14.98	16.31	23.07	22.80	20.64	19.17	17.73	16.57
2003	15.41	12.52	10.76	14.62	23.22	21.17	20.30	16.85	16.36	19.20	20.18	17.91	17.38
2004	16.36	15.88	16.00	15.52	16.92	22.45	18.68	14.07	14.00	14.07	14.15	13.48	15.97
2005	12.97	12.63	12.28	17.62	24.35	21.17	18.53	24.70	24.18	24.26	23.18	21.14	19.75
2006	19.55	18.63	18.19	18.63	21.59	22.88	17.89	16.97	13.45	12.49	12.51	12.33	17.09
2007	11.84	11.40	11.21	16.12	25.72	19.05	13.78	12.42	14.17	19.52	20.11	17.14	16.04
2008	14.37	13.74	13.49	15.01	21.67	21.30	20.56	16.42	15.38	15.96	13.42	11.49	16.07
2009	10.49	9.98	9.84	15.28	23.46	25.05	28.16	25.00	23.69	21.68	19.51	17.06	19.10
2010	14.89	13.75	13.19	17.79	19.62	17.13	10.60	10.01	15.57	17.14	16.04	14.36	15.01
2011	13.67	12.57	11.87	12.91	18.11	14.68	14.25	13.29	10.13	8.26	8.46	9.67	12.32
2012	10.02	10.26	10.70	14.61	21.47	20.34	20.22	15.85	18.09	18.40	19.27	15.39	16.22
2013	13.71	11.80	11.06	12.41	19.34	20.43	17.82	12.82	10.33	9.26	10.02	9.97	13.25
2014	9.48	9.17	9.12	11.20	20.24	27.43	21.66	14.91	10.29	11.05	11.77	11.07	13.95
2015	11.19	11.18	10.52	13.45	15.35	13.06	11.68	11.15	11.11	11.70	12.36	10.89	11.97
2016	10.17	9.75	9.81	12.20	17.77	19.48	21.09	19.44	19.33	22.90	23.93	18.98	17.07
2017	16.22	15.71	15.11	16.99	20.89	20.12	15.70	11.21	9.06	12.97	16.54	17.45	15.66
2018	13.36	10.90	11.52	13.26	24.67	22.54	21.87	20.53	18.64	18.13	16.96	15.73	17.34
2019	15.88	15.49	15.37	15.94	18.43	19.30	22.42	22.86	24.85	21.73			19.23

Table I-2: SA-1 Monthly Average Discharge (m^3/s)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean Annual
1977	3.035	2.895	2.334	2.659	3.507	4.075	4.037	3.436	3.340	3.042	2.683	2.519	3.130
1978	2.759	2.678	2.446	2.182	3.088	3.372	2.799	2.892	3.393	3.505	3.078	2.753	2.912
1979	3.076	3.182	2.782	2.342	2.855	3.140	2.839	2.755	2.592	2.680	2.761	2.414	2.785
1980	1.986	1.607	1.498	1.529	2.138	1.888	1.562	1.618	1.685	2.098	2.023	1.824	1.788
1981	1.830	1.916	1.886	1.962	2.801	2.377	1.728	1.220	0.945	1.002	1.189	1.231	1.674
1982	1.066	0.901	0.875	1.106	2.486	2.872	2.377	2.572	2.438	2.063	1.872	1.917	1.879
1983	1.856	1.739	1.700	1.882	2.314	2.877	2.258	1.859	1.992	2.144	2.197	2.035	2.071
1984	1.762	1.739	1.841	2.256	2.537	2.391	1.843	1.499	1.288	1.442	1.657	1.632	1.824
1985	1.645	1.613	1.687	1.818	3.288	2.858	2.571	2.079	1.949	1.839	1.888	1.756	2.083
1986	1.762	1.792	1.779	1.816	2.850	2.702	2.629	2.409	1.903	1.845	1.761	1.645	2.075
1987	1.606	1.613	1.647	2.110	2.558	1.992	1.343	1.054	1.081	1.017	1.119	1.082	1.518
1988	1.177	1.206	1.325	1.455	2.135	2.509	2.267	1.796	1.724	1.662	1.654	1.611	1.710
1989	1.657	1.750	1.657	1.590	2.675	2.801	2.568	1.987	1.771	1.671	1.582	1.576	1.940
1990	1.565	1.556	1.552	1.586	2.116	2.153	2.152	1.572	1.325	1.394	1.517	1.504	1.666
1991	1.401	1.389	1.409	1.657	2.433	2.630	2.277	1.785	1.728	1.696	1.586	1.564	1.796
1992	1.462	1.439	1.453	1.610	2.573	2.266	1.846	1.579	1.712	2.309	1.808	1.557	1.801
1993	1.433	1.376	1.322	1.651	1.868	1.436	1.359	2.003	1.899	1.705	1.683	1.509	1.604
1994	1.412	1.325	1.440	1.762	2.915	3.078	2.514	1.676	1.174	1.157	1.114	1.098	1.722
1995	1.098	1.069	1.149	1.551	2.041	2.369	1.748	2.184	2.311	2.025	1.949	1.551	1.754
1996	1.246	1.167	1.158	1.430	2.053	2.302	2.239	1.994	1.790	1.757	1.735	1.587	1.705
1997	1.512	1.456	1.417	1.547	2.246	2.404	2.099	2.253	2.914	4.114	3.497	2.631	2.341
1998	2.212	2.126	2.052	2.189	2.227	1.692	1.591	1.384	1.092	1.279	1.309	1.259	1.701
1999	1.195	1.034	0.883	1.445	2.103	1.797	1.537	1.526	1.239	1.157	1.244	1.152	1.359
2000	1.074	1.021	1.026	1.249	2.204	2.297	1.796	1.505	1.363	1.697	1.572	1.281	1.507
2001	1.195	1.083	1.118	1.384	2.023	1.816	1.631	1.340	1.534	1.725	1.563	1.477	1.491
2002	1.358	1.296	1.246	1.280	1.768	1.636	1.791	2.584	2.552	2.296	2.124	1.955	1.824
2003	1.685	1.352	1.152	1.597	2.603	2.359	2.257	1.853	1.796	2.128	2.243	1.976	1.917
2004	1.795	1.740	1.753	1.697	1.861	2.511	2.067	1.531	1.523	1.531	1.539	1.462	1.751
2005	1.404	1.365	1.325	1.945	2.737	2.360	2.050	2.778	2.716	2.726	2.597	2.356	2.197
2006	2.169	2.060	2.009	2.060	2.409	2.562	1.974	1.867	1.459	1.349	1.351	1.331	1.883
2007	1.274	1.225	1.203	1.770	2.900	2.110	1.497	1.341	1.543	2.165	2.234	1.886	1.762
2008	1.565	1.492	1.463	1.640	2.419	2.375	2.287	1.803	1.682	1.749	1.455	1.235	1.764
2009	1.121	1.064	1.047	1.671	2.632	2.820	3.192	2.814	2.658	2.419	2.164	1.877	2.123
2010	1.625	1.493	1.429	1.963	2.177	1.887	1.133	1.068	1.704	1.886	1.758	1.564	1.641
2011	1.484	1.358	1.278	1.397	2.000	1.602	1.551	1.441	1.080	0.870	0.893	1.028	1.332
2012	1.068	1.095	1.144	1.593	2.395	2.262	2.248	1.736	1.997	2.033	2.136	1.683	1.783
2013	1.488	1.270	1.186	1.340	2.145	2.272	1.967	1.386	1.104	0.982	1.068	1.062	1.439
2014	1.007	0.972	0.966	1.201	2.252	3.105	2.417	1.628	1.098	1.185	1.266	1.186	1.524
2015	1.200	1.199	1.125	1.459	1.679	1.414	1.256	1.196	1.191	1.258	1.333	1.167	1.290
2016	1.085	1.037	1.045	1.316	1.960	2.160	2.350	2.155	2.142	2.565	2.686	2.102	1.884
2017	1.779	1.720	1.650	1.869	2.327	2.236	1.719	1.203	0.960	1.405	1.816	1.923	1.717
2018	1.449	1.167	1.238	1.438	2.775	2.522	2.442	2.284	2.062	2.001	1.866	1.722	1.914
2019	1.740	1.695	1.681	1.746	2.037	2.140	2.507	2.560	2.797	2.425			

Table I-3: SA-2 Monthly Average Discharge (m³/s)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean Annual
1977	2.777	2.576	1.855	2.312	3.532	4.554	4.485	3.410	3.247	2.792	2.285	2.073	2.992
1978	2.388	2.284	1.985	1.676	2.865	3.305	2.454	2.585	3.346	3.523	2.850	2.379	2.637
1979	2.840	2.999	2.446	1.860	2.572	2.937	2.497	2.384	2.167	2.282	2.392	1.947	2.444
1980	1.476	1.115	1.022	1.054	1.629	1.374	1.075	1.124	1.183	1.585	1.508	1.309	1.288
1981	1.314	1.398	1.368	1.444	2.456	1.911	1.230	0.815	0.638	0.673	0.792	0.821	1.238
1982	0.712	0.613	0.598	0.755	2.046	2.546	1.901	2.147	1.977	1.550	1.355	1.398	1.466
1983	1.340	1.230	1.195	1.369	1.826	2.561	1.768	1.346	1.482	1.635	1.693	1.521	1.580
1984	1.252	1.230	1.325	1.786	2.097	1.921	1.332	1.023	0.862	0.982	1.156	1.134	1.342
1985	1.145	1.118	1.182	1.309	3.201	2.525	2.151	1.569	1.431	1.323	1.371	1.245	1.631
1986	1.250	1.278	1.266	1.304	2.540	2.328	2.225	1.948	1.388	1.329	1.250	1.145	1.604
1987	1.111	1.117	1.147	1.660	2.137	1.485	0.905	0.705	0.721	0.681	0.745	0.721	1.095
1988	0.783	0.803	0.888	0.988	1.628	2.065	1.775	1.285	1.216	1.161	1.153	1.116	1.239
1989	1.156	1.239	1.156	1.098	2.337	2.451	2.141	1.478	1.260	1.170	1.091	1.086	1.472
1990	1.077	1.069	1.066	1.096	1.609	1.647	1.646	1.090	0.888	0.942	1.038	1.026	1.183
1991	0.945	0.935	0.951	1.163	1.980	2.216	1.788	1.284	1.220	1.191	1.095	1.076	1.320
1992	0.993	0.975	0.986	1.123	2.149	1.778	1.333	1.091	1.226	1.823	1.297	1.071	1.320
1993	0.970	0.926	0.885	1.154	1.352	0.981	0.917	1.495	1.386	1.199	1.179	1.031	1.123
1994	0.954	0.888	0.977	1.254	2.656	2.853	2.073	1.185	0.782	0.772	0.742	0.731	1.322
1995	0.731	0.713	0.771	1.065	1.534	1.893	1.239	1.711	1.824	1.509	1.431	1.069	1.291
1996	0.832	0.777	0.770	0.976	1.543	1.812	1.742	1.478	1.277	1.247	1.226	1.096	1.231
1997	1.033	0.988	0.958	1.067	1.752	1.932	1.588	1.758	2.652	4.632	3.522	2.229	2.009
1998	1.710	1.614	1.536	1.688	1.734	1.190	1.103	0.938	0.728	0.857	0.876	0.840	1.235
1999	0.796	0.692	0.603	0.991	1.592	1.289	1.055	1.048	0.826	0.771	0.830	0.767	0.938
2000	0.716	0.683	0.686	0.844	1.710	1.809	1.285	1.028	0.917	1.192	1.085	0.856	1.068
2001	0.795	0.722	0.745	0.938	1.513	1.307	1.135	0.902	1.058	1.218	1.075	1.004	1.034
2002	0.913	0.866	0.831	0.859	1.260	1.144	1.289	2.157	2.116	1.806	1.613	1.437	1.358
2003	1.182	0.909	0.766	1.144	2.182	1.881	1.762	1.338	1.286	1.619	1.745	1.459	1.440
2004	1.282	1.230	1.242	1.192	1.348	2.070	1.558	1.053	1.048	1.049	1.055	0.993	1.260
2005	0.947	0.917	0.888	1.462	2.357	1.890	1.552	2.414	2.331	2.342	2.174	1.877	1.763
2006	1.661	1.544	1.492	1.547	1.942	2.136	1.458	1.351	0.999	0.907	0.907	0.892	1.403
2007	0.851	0.816	0.801	1.298	2.586	1.613	1.025	0.900	1.072	1.659	1.734	1.375	1.311
2008	1.076	1.017	0.994	1.155	1.963	1.901	1.802	1.293	1.180	1.239	0.989	0.823	1.286
2009	0.746	0.709	0.699	1.192	2.238	2.471	3.017	2.465	2.254	1.951	1.658	1.361	1.730
2010	1.128	1.018	0.967	1.462	1.673	1.386	0.759	0.719	1.202	1.370	1.248	1.076	1.167
2011	1.011	0.912	0.854	0.946	1.486	1.115	1.068	0.978	0.723	0.596	0.609	0.688	0.915
2012	0.712	0.729	0.762	1.104	1.927	1.768	1.756	1.230	1.482	1.520	1.629	1.181	1.317
2013	1.015	0.848	0.790	0.902	1.649	1.779	1.463	0.934	0.739	0.660	0.712	0.708	1.017
2014	0.675	0.654	0.650	0.801	1.789	2.890	1.956	1.139	0.734	0.789	0.845	0.790	1.143
2015	0.799	0.798	0.748	0.996	1.177	0.956	0.839	0.797	0.794	0.840	0.894	0.777	0.868
2016	0.723	0.694	0.701	0.887	1.445	1.664	1.874	1.651	1.636	2.135	2.290	1.601	1.442
2017	1.267	1.212	1.152	1.352	1.846	1.746	1.220	0.803	0.649	0.959	1.302	1.407	1.243
2018	0.988	0.778	0.827	0.992	2.413	2.081	1.990	1.812	1.547	1.484	1.349	1.214	1.456
2019	1.230	1.189	1.177	1.239	1.521	1.636	2.065	2.139	2.439	1.960			

Table I-4: SA-3 Monthly Average Discharge (m^3/s)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean Annual
1977	0.712	0.679	0.547	0.624	0.822	0.956	0.947	0.806	0.783	0.713	0.629	0.591	0.734
1978	0.647	0.628	0.574	0.512	0.724	0.791	0.656	0.678	0.796	0.822	0.722	0.646	0.683
1979	0.721	0.746	0.652	0.549	0.670	0.736	0.666	0.646	0.608	0.628	0.648	0.566	0.653
1980	0.466	0.377	0.351	0.358	0.501	0.443	0.366	0.380	0.395	0.492	0.474	0.428	0.419
1981	0.429	0.449	0.442	0.460	0.657	0.558	0.405	0.286	0.222	0.235	0.279	0.289	0.393
1982	0.250	0.211	0.205	0.259	0.583	0.673	0.558	0.603	0.572	0.484	0.439	0.449	0.441
1983	0.435	0.408	0.399	0.441	0.543	0.675	0.530	0.436	0.467	0.503	0.515	0.477	0.486
1984	0.413	0.408	0.432	0.529	0.595	0.561	0.432	0.352	0.302	0.338	0.389	0.383	0.428
1985	0.386	0.378	0.396	0.426	0.771	0.670	0.603	0.488	0.457	0.431	0.443	0.412	0.488
1986	0.413	0.420	0.417	0.426	0.668	0.634	0.617	0.565	0.446	0.433	0.413	0.386	0.487
1987	0.377	0.378	0.386	0.495	0.600	0.467	0.315	0.247	0.254	0.238	0.263	0.254	0.356
1988	0.276	0.283	0.311	0.341	0.501	0.588	0.532	0.421	0.404	0.390	0.388	0.378	0.401
1989	0.389	0.410	0.389	0.373	0.627	0.657	0.602	0.466	0.415	0.392	0.371	0.370	0.455
1990	0.367	0.365	0.364	0.372	0.496	0.505	0.505	0.369	0.311	0.327	0.356	0.353	0.391
1991	0.329	0.326	0.330	0.389	0.571	0.617	0.534	0.419	0.405	0.398	0.372	0.367	0.421
1992	0.343	0.337	0.341	0.378	0.604	0.531	0.433	0.370	0.401	0.541	0.424	0.365	0.422
1993	0.336	0.323	0.310	0.387	0.438	0.337	0.319	0.470	0.445	0.400	0.395	0.354	0.376
1994	0.331	0.311	0.338	0.413	0.684	0.722	0.590	0.393	0.275	0.271	0.261	0.258	0.404
1995	0.257	0.251	0.269	0.364	0.479	0.555	0.410	0.512	0.542	0.475	0.457	0.364	0.411
1996	0.292	0.274	0.271	0.335	0.481	0.540	0.525	0.468	0.420	0.412	0.407	0.372	0.400
1997	0.355	0.342	0.332	0.363	0.527	0.564	0.492	0.528	0.683	0.965	0.820	0.617	0.549
1998	0.519	0.499	0.481	0.513	0.522	0.397	0.373	0.325	0.256	0.300	0.307	0.295	0.399
1999	0.280	0.243	0.207	0.339	0.493	0.421	0.361	0.358	0.291	0.271	0.292	0.270	0.319
2000	0.252	0.239	0.241	0.293	0.517	0.539	0.421	0.353	0.320	0.398	0.369	0.300	0.353
2001	0.280	0.254	0.262	0.325	0.474	0.426	0.382	0.314	0.360	0.405	0.367	0.346	0.350
2002	0.318	0.304	0.292	0.300	0.415	0.384	0.420	0.606	0.599	0.539	0.498	0.459	0.428
2003	0.395	0.317	0.270	0.374	0.610	0.553	0.529	0.435	0.421	0.499	0.526	0.463	0.449
2004	0.421	0.408	0.411	0.398	0.436	0.589	0.485	0.359	0.357	0.359	0.361	0.343	0.411
2005	0.329	0.320	0.311	0.456	0.642	0.554	0.481	0.652	0.637	0.639	0.609	0.553	0.515
2006	0.509	0.483	0.471	0.483	0.565	0.601	0.463	0.438	0.342	0.316	0.317	0.312	0.442
2007	0.299	0.287	0.282	0.415	0.680	0.495	0.351	0.315	0.362	0.508	0.524	0.442	0.413
2008	0.367	0.350	0.343	0.385	0.567	0.557	0.536	0.423	0.394	0.410	0.341	0.290	0.414
2009	0.263	0.249	0.246	0.392	0.617	0.661	0.749	0.660	0.623	0.567	0.508	0.440	0.498
2010	0.381	0.350	0.335	0.460	0.510	0.442	0.266	0.250	0.400	0.442	0.412	0.367	0.385
2011	0.348	0.318	0.300	0.328	0.469	0.376	0.364	0.338	0.253	0.204	0.209	0.241	0.312
2012	0.251	0.257	0.268	0.374	0.562	0.530	0.527	0.407	0.468	0.477	0.501	0.395	0.418
2013	0.349	0.298	0.278	0.314	0.503	0.533	0.461	0.325	0.259	0.230	0.250	0.249	0.338
2014	0.236	0.228	0.227	0.282	0.528	0.728	0.567	0.382	0.258	0.278	0.297	0.278	0.357
2015	0.282	0.281	0.264	0.342	0.394	0.332	0.295	0.281	0.279	0.295	0.313	0.274	0.303
2016	0.254	0.243	0.245	0.309	0.460	0.507	0.551	0.505	0.502	0.602	0.630	0.493	0.442
2017	0.417	0.403	0.387	0.438	0.546	0.524	0.403	0.282	0.225	0.329	0.426	0.451	0.403
2018	0.340	0.274	0.290	0.337	0.651	0.591	0.573	0.536	0.484	0.469	0.438	0.404	0.449
2019	0.408	0.397	0.394	0.410	0.478	0.502	0.588	0.600	0.656	0.569			

Table I-5: SA-4 Monthly Average Discharge (m³/s)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean Annual
1977	0.649	0.607	0.455	0.550	0.803	1.008	0.994	0.779	0.746	0.652	0.546	0.502	0.691
1978	0.568	0.546	0.483	0.416	0.667	0.757	0.581	0.609	0.765	0.802	0.664	0.566	0.619
1979	0.662	0.695	0.579	0.456	0.605	0.682	0.591	0.567	0.522	0.546	0.569	0.475	0.579
1980	0.373	0.293	0.272	0.279	0.406	0.350	0.284	0.295	0.308	0.397	0.380	0.336	0.331
1981	0.337	0.356	0.349	0.366	0.582	0.467	0.318	0.224	0.183	0.191	0.219	0.226	0.318
1982	0.200	0.177	0.174	0.210	0.495	0.601	0.465	0.517	0.481	0.389	0.346	0.356	0.368
1983	0.343	0.318	0.311	0.349	0.449	0.604	0.436	0.344	0.374	0.408	0.420	0.383	0.395
1984	0.323	0.318	0.340	0.439	0.507	0.469	0.341	0.272	0.235	0.262	0.302	0.297	0.342
1985	0.299	0.293	0.308	0.336	0.735	0.597	0.518	0.393	0.363	0.339	0.350	0.322	0.404
1986	0.323	0.329	0.327	0.335	0.599	0.555	0.533	0.475	0.353	0.340	0.323	0.300	0.399
1987	0.292	0.293	0.300	0.411	0.515	0.374	0.245	0.199	0.202	0.193	0.208	0.202	0.286
1988	0.217	0.222	0.241	0.264	0.406	0.500	0.438	0.331	0.315	0.303	0.301	0.293	0.319
1989	0.302	0.320	0.302	0.289	0.555	0.581	0.516	0.373	0.325	0.305	0.287	0.286	0.370
1990	0.284	0.282	0.282	0.288	0.402	0.410	0.410	0.287	0.241	0.254	0.275	0.273	0.307
1991	0.254	0.252	0.256	0.303	0.481	0.532	0.440	0.330	0.316	0.310	0.288	0.284	0.337
1992	0.265	0.261	0.263	0.294	0.517	0.438	0.341	0.287	0.317	0.448	0.333	0.283	0.337
1993	0.260	0.250	0.241	0.301	0.345	0.262	0.248	0.377	0.353	0.311	0.307	0.274	0.294
1994	0.256	0.241	0.262	0.324	0.622	0.664	0.501	0.308	0.217	0.214	0.207	0.205	0.335
1995	0.205	0.200	0.214	0.281	0.385	0.463	0.320	0.423	0.448	0.380	0.363	0.282	0.330
1996	0.228	0.215	0.214	0.261	0.387	0.446	0.431	0.373	0.329	0.322	0.318	0.288	0.318
1997	0.274	0.264	0.257	0.282	0.433	0.472	0.397	0.434	0.621	1.023	0.801	0.534	0.483
1998	0.424	0.403	0.386	0.419	0.429	0.309	0.290	0.252	0.204	0.234	0.238	0.230	0.318
1999	0.220	0.196	0.175	0.264	0.398	0.331	0.279	0.277	0.227	0.214	0.228	0.213	0.252
2000	0.201	0.194	0.194	0.231	0.423	0.445	0.331	0.273	0.248	0.310	0.286	0.234	0.281
2001	0.220	0.203	0.208	0.252	0.381	0.335	0.297	0.244	0.280	0.316	0.284	0.268	0.274
2002	0.247	0.236	0.228	0.234	0.325	0.299	0.331	0.519	0.511	0.444	0.403	0.364	0.345
2003	0.308	0.246	0.213	0.298	0.525	0.460	0.435	0.342	0.331	0.404	0.431	0.369	0.364
2004	0.330	0.319	0.321	0.310	0.345	0.501	0.391	0.278	0.277	0.278	0.279	0.265	0.324
2005	0.255	0.248	0.241	0.369	0.562	0.462	0.389	0.573	0.556	0.558	0.523	0.460	0.433
2006	0.413	0.388	0.376	0.388	0.473	0.515	0.369	0.345	0.266	0.245	0.246	0.242	0.356
2007	0.233	0.224	0.221	0.332	0.609	0.402	0.272	0.244	0.282	0.413	0.429	0.350	0.334
2008	0.284	0.271	0.265	0.301	0.478	0.465	0.443	0.332	0.307	0.320	0.264	0.226	0.330
2009	0.208	0.200	0.197	0.309	0.536	0.585	0.698	0.584	0.540	0.476	0.413	0.347	0.424
2010	0.296	0.271	0.259	0.369	0.416	0.352	0.211	0.202	0.312	0.349	0.322	0.284	0.304
2011	0.269	0.247	0.233	0.254	0.375	0.292	0.282	0.262	0.203	0.173	0.176	0.195	0.247
2012	0.200	0.204	0.212	0.290	0.470	0.436	0.434	0.318	0.374	0.382	0.406	0.307	0.336
2013	0.270	0.232	0.218	0.244	0.410	0.439	0.370	0.252	0.207	0.188	0.200	0.199	0.269
2014	0.192	0.187	0.186	0.221	0.440	0.672	0.476	0.298	0.205	0.218	0.231	0.218	0.295
2015	0.221	0.220	0.209	0.266	0.307	0.257	0.230	0.220	0.219	0.230	0.242	0.216	0.236
2016	0.203	0.196	0.198	0.241	0.366	0.413	0.459	0.411	0.408	0.515	0.547	0.400	0.363
2017	0.327	0.314	0.301	0.345	0.453	0.431	0.316	0.221	0.185	0.257	0.334	0.358	0.320
2018	0.264	0.216	0.227	0.264	0.573	0.503	0.484	0.445	0.388	0.375	0.345	0.315	0.366
2019	0.318	0.309	0.307	0.320	0.383	0.408	0.500	0.515	0.579	0.477			

Table I-6: SA-5 Monthly Average Discharge (m³/s)

Year	1	2	3	4	5	6	7	8	9	10	11	12	Mean Annual
1977	1.763	1.638	1.191	1.474	2.232	2.866	2.823	2.156	2.055	1.772	1.457	1.326	1.896
1978	1.521	1.457	1.271	1.080	1.818	2.091	1.562	1.644	2.116	2.226	1.808	1.516	1.676
1979	1.802	1.901	1.557	1.193	1.636	1.862	1.589	1.519	1.384	1.456	1.524	1.247	1.556
1980	0.955	0.731	0.673	0.693	1.050	0.892	0.706	0.736	0.773	1.023	0.975	0.851	0.838
1981	0.855	0.907	0.888	0.935	1.564	1.225	0.802	0.545	0.435	0.457	0.531	0.549	0.808
1982	0.481	0.419	0.410	0.508	1.309	1.619	1.219	1.372	1.266	1.001	0.880	0.907	0.949
1983	0.871	0.802	0.781	0.889	1.173	1.629	1.136	0.874	0.959	1.054	1.090	0.983	1.020
1984	0.816	0.802	0.862	1.148	1.341	1.232	0.866	0.674	0.574	0.648	0.757	0.743	0.872
1985	0.750	0.733	0.773	0.851	2.026	1.607	1.375	1.013	0.927	0.860	0.890	0.812	1.051
1986	0.815	0.832	0.825	0.849	1.616	1.484	1.420	1.248	0.901	0.864	0.815	0.750	1.035
1987	0.729	0.733	0.751	1.069	1.365	0.961	0.601	0.476	0.487	0.462	0.502	0.487	0.718
1988	0.525	0.537	0.590	0.652	1.050	1.321	1.141	0.837	0.794	0.760	0.755	0.732	0.808
1989	0.757	0.808	0.756	0.721	1.490	1.561	1.368	0.957	0.821	0.765	0.716	0.713	0.953
1990	0.707	0.703	0.701	0.719	1.038	1.061	1.061	0.715	0.590	0.624	0.683	0.676	0.773
1991	0.626	0.620	0.629	0.761	1.268	1.414	1.149	0.836	0.796	0.778	0.718	0.707	0.858
1992	0.655	0.644	0.651	0.736	1.373	1.143	0.867	0.716	0.800	1.171	0.844	0.704	0.859
1993	0.641	0.614	0.589	0.755	0.878	0.648	0.608	0.967	0.899	0.783	0.771	0.679	0.736
1994	0.631	0.590	0.646	0.818	1.688	1.810	1.326	0.774	0.524	0.518	0.499	0.493	0.860
1995	0.493	0.481	0.517	0.700	0.991	1.214	0.808	1.101	1.171	0.976	0.927	0.703	0.840
1996	0.555	0.521	0.517	0.645	0.997	1.164	1.120	0.956	0.832	0.813	0.800	0.719	0.803
1997	0.680	0.652	0.633	0.701	1.127	1.239	1.025	1.131	1.685	2.915	2.226	1.423	1.286
1998	1.100	1.041	0.993	1.087	1.115	0.778	0.724	0.621	0.491	0.571	0.583	0.560	0.805
1999	0.533	0.468	0.413	0.654	1.027	0.839	0.694	0.690	0.552	0.517	0.554	0.515	0.621
2000	0.483	0.463	0.465	0.563	1.101	1.162	0.837	0.677	0.608	0.779	0.712	0.570	0.702
2001	0.532	0.487	0.501	0.621	0.978	0.850	0.744	0.599	0.696	0.795	0.706	0.662	0.681
2002	0.606	0.577	0.555	0.572	0.821	0.749	0.839	1.378	1.353	1.160	1.040	0.931	0.882
2003	0.773	0.603	0.515	0.749	1.394	1.206	1.133	0.870	0.837	1.044	1.122	0.945	0.933
2004	0.834	0.803	0.810	0.779	0.876	1.324	1.006	0.692	0.690	0.690	0.694	0.655	0.821
2005	0.627	0.608	0.590	0.947	1.502	1.212	1.002	1.538	1.486	1.493	1.388	1.204	1.133
2006	1.070	0.998	0.965	1.000	1.244	1.365	0.944	0.877	0.659	0.602	0.602	0.593	0.910
2007	0.567	0.545	0.536	0.844	1.645	1.040	0.675	0.598	0.704	1.069	1.115	0.892	0.853
2008	0.707	0.670	0.656	0.756	1.258	1.219	1.158	0.842	0.771	0.808	0.653	0.550	0.837
2009	0.502	0.479	0.473	0.779	1.429	1.573	1.912	1.569	1.438	1.250	1.068	0.884	1.113
2010	0.739	0.671	0.639	0.946	1.077	0.899	0.510	0.485	0.785	0.889	0.814	0.707	0.763
2011	0.666	0.605	0.569	0.626	0.961	0.731	0.702	0.646	0.488	0.409	0.417	0.466	0.607
2012	0.481	0.492	0.512	0.724	1.235	1.136	1.129	0.802	0.959	0.982	1.050	0.772	0.856
2013	0.669	0.566	0.529	0.599	1.063	1.143	0.947	0.619	0.498	0.449	0.481	0.479	0.670
2014	0.458	0.445	0.443	0.536	1.150	1.833	1.253	0.746	0.494	0.529	0.564	0.529	0.748
2015	0.535	0.535	0.504	0.657	0.769	0.632	0.560	0.534	0.532	0.560	0.594	0.521	0.578
2016	0.488	0.469	0.474	0.589	0.936	1.072	1.202	1.064	1.055	1.364	1.461	1.033	0.934
2017	0.825	0.791	0.754	0.878	1.185	1.123	0.796	0.537	0.442	0.635	0.847	0.912	0.810
2018	0.652	0.522	0.552	0.654	1.537	1.331	1.274	1.164	0.999	0.960	0.877	0.792	0.943
2019	0.803	0.777	0.769	0.808	0.983	1.055	1.321	1.367	1.553	1.256			

Table I-7: SA-6/LA-6 Monthly Average Discharge (m³/s)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean Annual
1977	2.652	2.464	1.791	2.218	3.357	4.312	4.247	3.243	3.091	2.666	2.192	1.995	2.852
1978	2.288	2.191	1.912	1.624	2.735	3.145	2.350	2.473	3.183	3.349	2.720	2.280	2.521
1979	2.711	2.859	2.343	1.795	2.460	2.801	2.391	2.285	2.082	2.190	2.292	1.876	2.340
1980	1.437	1.100	1.012	1.043	1.580	1.341	1.063	1.108	1.163	1.539	1.467	1.281	1.261
1981	1.286	1.364	1.336	1.407	2.352	1.843	1.207	0.820	0.655	0.687	0.798	0.826	1.215
1982	0.724	0.631	0.617	0.764	1.969	2.436	1.834	2.063	1.905	1.506	1.324	1.364	1.428
1983	1.310	1.207	1.174	1.337	1.764	2.451	1.709	1.315	1.443	1.586	1.639	1.478	1.534
1984	1.228	1.207	1.296	1.726	2.017	1.853	1.302	1.014	0.864	0.975	1.138	1.117	1.311
1985	1.128	1.102	1.163	1.281	3.048	2.417	2.068	1.524	1.395	1.294	1.339	1.221	1.582
1986	1.226	1.252	1.241	1.276	2.431	2.233	2.136	1.878	1.355	1.300	1.226	1.128	1.557
1987	1.096	1.102	1.130	1.609	2.054	1.445	0.904	0.717	0.732	0.695	0.754	0.732	1.081
1988	0.790	0.808	0.888	0.981	1.579	1.987	1.717	1.259	1.194	1.143	1.136	1.101	1.215
1989	1.138	1.216	1.138	1.084	2.241	2.347	2.058	1.439	1.235	1.151	1.077	1.073	1.433
1990	1.064	1.057	1.054	1.082	1.561	1.597	1.596	1.076	0.888	0.939	1.027	1.017	1.163
1991	0.941	0.932	0.947	1.144	1.907	2.128	1.728	1.258	1.197	1.171	1.081	1.063	1.291
1992	0.986	0.969	0.979	1.107	2.065	1.719	1.304	1.078	1.203	1.761	1.270	1.059	1.292
1993	0.964	0.923	0.885	1.136	1.321	0.974	0.915	1.454	1.353	1.178	1.160	1.021	1.107
1994	0.949	0.888	0.971	1.230	2.539	2.723	1.994	1.165	0.789	0.779	0.751	0.741	1.293
1995	0.741	0.724	0.778	1.053	1.491	1.826	1.215	1.656	1.762	1.468	1.395	1.057	1.264
1996	0.836	0.784	0.778	0.970	1.499	1.751	1.685	1.438	1.251	1.223	1.204	1.082	1.208
1997	1.023	0.981	0.953	1.055	1.695	1.863	1.541	1.701	2.535	4.384	3.348	2.140	1.935
1998	1.655	1.566	1.493	1.635	1.678	1.170	1.089	0.935	0.738	0.859	0.877	0.843	1.211
1999	0.802	0.704	0.622	0.984	1.545	1.262	1.043	1.037	0.830	0.778	0.833	0.775	0.935
2000	0.727	0.697	0.699	0.847	1.655	1.748	1.258	1.019	0.915	1.172	1.072	0.858	1.056
2001	0.801	0.733	0.754	0.935	1.471	1.279	1.119	0.901	1.046	1.196	1.063	0.997	1.024
2002	0.911	0.867	0.834	0.860	1.236	1.127	1.262	2.073	2.035	1.745	1.565	1.401	1.326
2003	1.162	0.908	0.774	1.127	2.096	1.815	1.704	1.308	1.260	1.571	1.688	1.421	1.403
2004	1.255	1.207	1.219	1.172	1.318	1.992	1.514	1.041	1.037	1.038	1.044	0.985	1.235
2005	0.943	0.915	0.887	1.424	2.260	1.823	1.508	2.313	2.235	2.246	2.088	1.811	1.705
2006	1.610	1.501	1.451	1.504	1.872	2.053	1.420	1.320	0.991	0.905	0.906	0.891	1.369
2007	0.853	0.820	0.806	1.270	2.474	1.565	1.016	0.899	1.059	1.608	1.678	1.342	1.283
2008	1.064	1.008	0.986	1.137	1.892	1.834	1.741	1.266	1.160	1.216	0.982	0.827	1.259
2009	0.755	0.721	0.711	1.171	2.149	2.366	2.876	2.361	2.163	1.881	1.607	1.329	1.674
2010	1.112	1.009	0.961	1.424	1.621	1.353	0.767	0.730	1.181	1.338	1.224	1.063	1.148
2011	1.002	0.910	0.856	0.942	1.446	1.100	1.056	0.972	0.734	0.615	0.627	0.701	0.913
2012	0.724	0.740	0.770	1.089	1.858	1.709	1.699	1.207	1.443	1.478	1.580	1.162	1.288
2013	1.006	0.851	0.796	0.901	1.599	1.720	1.425	0.931	0.749	0.675	0.723	0.720	1.008
2014	0.689	0.669	0.666	0.806	1.729	2.757	1.885	1.122	0.744	0.796	0.848	0.796	1.126
2015	0.805	0.804	0.757	0.989	1.157	0.951	0.842	0.803	0.800	0.843	0.893	0.784	0.869
2016	0.733	0.706	0.713	0.887	1.408	1.612	1.808	1.601	1.586	2.053	2.197	1.554	1.405
2017	1.241	1.190	1.134	1.321	1.783	1.689	1.198	0.808	0.664	0.955	1.274	1.372	1.219
2018	0.981	0.785	0.830	0.984	2.312	2.002	1.917	1.751	1.503	1.444	1.319	1.192	1.418
2019	1.207	1.169	1.157	1.216	1.479	1.587	1.987	2.056	2.336	1.889			

Table I-8: SB-3 Monthly Average Discharge (m³/s)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean Annual
1977	0.269	0.257	0.207	0.236	0.311	0.361	0.358	0.305	0.296	0.270	0.238	0.223	0.277
1978	0.245	0.237	0.217	0.193	0.274	0.299	0.248	0.256	0.301	0.311	0.273	0.244	0.258
1979	0.273	0.282	0.247	0.208	0.253	0.278	0.252	0.244	0.230	0.238	0.245	0.214	0.247
1980	0.176	0.142	0.133	0.135	0.190	0.167	0.138	0.143	0.149	0.186	0.179	0.162	0.158
1981	0.162	0.170	0.167	0.174	0.248	0.211	0.153	0.108	0.084	0.089	0.105	0.109	0.148
1982	0.095	0.080	0.078	0.098	0.220	0.255	0.211	0.228	0.216	0.183	0.166	0.170	0.167
1983	0.165	0.154	0.151	0.167	0.205	0.255	0.200	0.165	0.177	0.190	0.195	0.180	0.184
1984	0.156	0.154	0.163	0.200	0.225	0.212	0.163	0.133	0.114	0.128	0.147	0.145	0.162
1985	0.146	0.143	0.150	0.161	0.291	0.253	0.228	0.184	0.173	0.163	0.167	0.156	0.185
1986	0.156	0.159	0.158	0.161	0.253	0.240	0.233	0.214	0.169	0.164	0.156	0.146	0.184
1987	0.142	0.143	0.146	0.187	0.227	0.177	0.119	0.093	0.096	0.090	0.099	0.096	0.135
1988	0.104	0.107	0.117	0.129	0.189	0.222	0.201	0.159	0.153	0.147	0.147	0.143	0.152
1989	0.147	0.155	0.147	0.141	0.237	0.248	0.228	0.176	0.157	0.148	0.140	0.140	0.172
1990	0.139	0.138	0.138	0.141	0.188	0.191	0.191	0.139	0.117	0.124	0.135	0.133	0.148
1991	0.124	0.123	0.125	0.147	0.216	0.233	0.202	0.158	0.153	0.150	0.141	0.139	0.159
1992	0.130	0.128	0.129	0.143	0.228	0.201	0.164	0.140	0.152	0.205	0.160	0.138	0.160
1993	0.127	0.122	0.117	0.146	0.166	0.127	0.120	0.178	0.168	0.151	0.149	0.134	0.142
1994	0.125	0.117	0.128	0.156	0.258	0.273	0.223	0.149	0.104	0.103	0.099	0.097	0.153
1995	0.097	0.095	0.102	0.137	0.181	0.210	0.155	0.194	0.205	0.180	0.173	0.137	0.155
1996	0.110	0.103	0.103	0.127	0.182	0.204	0.198	0.177	0.159	0.156	0.154	0.141	0.151
1997	0.134	0.129	0.126	0.137	0.199	0.213	0.186	0.200	0.258	0.365	0.310	0.233	0.208
1998	0.196	0.188	0.182	0.194	0.197	0.150	0.141	0.123	0.097	0.113	0.116	0.112	0.151
1999	0.106	0.092	0.078	0.128	0.186	0.159	0.136	0.135	0.110	0.103	0.110	0.102	0.120
2000	0.095	0.091	0.091	0.111	0.195	0.204	0.159	0.133	0.121	0.150	0.139	0.114	0.134
2001	0.106	0.096	0.099	0.123	0.179	0.161	0.145	0.119	0.136	0.153	0.139	0.131	0.132
2002	0.120	0.115	0.110	0.113	0.157	0.145	0.159	0.229	0.226	0.204	0.188	0.173	0.162
2003	0.149	0.120	0.102	0.142	0.231	0.209	0.200	0.164	0.159	0.189	0.199	0.175	0.170
2004	0.159	0.154	0.155	0.150	0.165	0.223	0.183	0.136	0.135	0.136	0.136	0.130	0.155
2005	0.124	0.121	0.117	0.172	0.243	0.209	0.182	0.246	0.241	0.242	0.230	0.209	0.195
2006	0.192	0.183	0.178	0.183	0.214	0.227	0.175	0.165	0.129	0.120	0.120	0.118	0.167
2007	0.113	0.109	0.107	0.157	0.257	0.187	0.133	0.119	0.137	0.192	0.198	0.167	0.156
2008	0.139	0.132	0.130	0.145	0.214	0.211	0.203	0.160	0.149	0.155	0.129	0.109	0.156
2009	0.099	0.094	0.093	0.148	0.233	0.250	0.283	0.249	0.236	0.214	0.192	0.166	0.188
2010	0.144	0.132	0.127	0.174	0.193	0.167	0.100	0.095	0.151	0.167	0.156	0.139	0.145
2011	0.132	0.120	0.113	0.124	0.177	0.142	0.137	0.128	0.096	0.077	0.079	0.091	0.118
2012	0.095	0.097	0.101	0.141	0.212	0.201	0.199	0.154	0.177	0.180	0.189	0.149	0.158
2013	0.132	0.113	0.105	0.119	0.190	0.201	0.174	0.123	0.098	0.087	0.095	0.094	0.128
2014	0.089	0.086	0.086	0.106	0.200	0.275	0.214	0.144	0.097	0.105	0.112	0.105	0.135
2015	0.106	0.106	0.100	0.129	0.149	0.125	0.111	0.106	0.106	0.112	0.118	0.103	0.114
2016	0.096	0.092	0.093	0.117	0.174	0.192	0.208	0.191	0.190	0.227	0.238	0.186	0.167
2017	0.158	0.152	0.146	0.166	0.206	0.198	0.152	0.107	0.085	0.125	0.161	0.170	0.152
2018	0.128	0.103	0.110	0.128	0.246	0.224	0.217	0.203	0.183	0.177	0.165	0.153	0.170
2019	0.154	0.150	0.149	0.155	0.181	0.190	0.222	0.227	0.248	0.215			

Table I-9: LA-1 Monthly Average Discharge (m³/s)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean Annual
1977	3.003	2.864	2.309	2.630	3.469	4.031	3.993	3.399	3.303	3.009	2.654	2.491	3.096
1978	2.729	2.649	2.420	2.158	3.054	3.336	2.769	2.861	3.356	3.468	3.045	2.724	2.881
1979	3.043	3.148	2.752	2.317	2.824	3.106	2.808	2.725	2.564	2.651	2.731	2.388	2.755
1980	1.965	1.590	1.482	1.512	2.115	1.868	1.545	1.601	1.666	2.075	2.001	1.805	1.769
1981	1.810	1.895	1.865	1.941	2.771	2.352	1.709	1.206	0.935	0.991	1.177	1.218	1.656
1982	1.055	0.891	0.865	1.094	2.460	2.841	2.352	2.544	2.411	2.041	1.852	1.896	1.858
1983	1.836	1.721	1.681	1.862	2.289	2.846	2.234	1.839	1.971	2.121	2.173	2.013	2.049
1984	1.743	1.721	1.821	2.232	2.510	2.366	1.823	1.483	1.275	1.426	1.639	1.614	1.804
1985	1.627	1.596	1.669	1.799	3.253	2.827	2.543	2.056	1.928	1.819	1.868	1.737	2.060
1986	1.743	1.772	1.760	1.797	2.820	2.673	2.601	2.383	1.883	1.826	1.741	1.627	2.052
1987	1.589	1.595	1.629	2.087	2.530	1.971	1.328	1.043	1.070	1.006	1.107	1.070	1.502
1988	1.165	1.193	1.310	1.440	2.112	2.482	2.243	1.776	1.705	1.644	1.636	1.594	1.692
1989	1.639	1.731	1.639	1.573	2.647	2.771	2.541	1.965	1.752	1.653	1.565	1.559	1.919
1990	1.548	1.539	1.535	1.569	2.093	2.130	2.128	1.555	1.310	1.379	1.501	1.488	1.648
1991	1.386	1.374	1.394	1.639	2.406	2.601	2.252	1.766	1.709	1.677	1.569	1.547	1.777
1992	1.447	1.423	1.438	1.593	2.546	2.241	1.826	1.561	1.693	2.284	1.788	1.541	1.782
1993	1.418	1.361	1.308	1.633	1.848	1.420	1.344	1.981	1.879	1.687	1.665	1.493	1.586
1994	1.397	1.311	1.425	1.743	2.883	3.045	2.487	1.658	1.161	1.144	1.102	1.086	1.704
1995	1.086	1.057	1.137	1.534	2.019	2.343	1.729	2.161	2.286	2.003	1.928	1.534	1.735
1996	1.233	1.155	1.145	1.415	2.031	2.277	2.215	1.972	1.770	1.738	1.717	1.569	1.686
1997	1.496	1.441	1.402	1.531	2.222	2.378	2.076	2.229	2.882	4.069	3.459	2.603	2.316
1998	2.188	2.103	2.030	2.166	2.203	1.673	1.574	1.369	1.080	1.266	1.295	1.246	1.683
1999	1.182	1.023	0.873	1.429	2.080	1.778	1.521	1.510	1.225	1.144	1.231	1.140	1.345
2000	1.062	1.010	1.015	1.236	2.181	2.273	1.777	1.488	1.348	1.679	1.555	1.267	1.491
2001	1.182	1.071	1.106	1.369	2.001	1.797	1.613	1.325	1.518	1.707	1.546	1.461	1.475
2002	1.343	1.282	1.233	1.266	1.749	1.618	1.771	2.557	2.524	2.271	2.101	1.934	1.804
2003	1.667	1.337	1.140	1.580	2.574	2.334	2.232	1.833	1.776	2.105	2.218	1.955	1.896
2004	1.776	1.721	1.734	1.679	1.841	2.484	2.044	1.514	1.507	1.514	1.523	1.446	1.732
2005	1.389	1.350	1.311	1.924	2.708	2.335	2.028	2.748	2.687	2.697	2.569	2.331	2.173
2006	2.145	2.038	1.987	2.038	2.383	2.534	1.953	1.846	1.444	1.334	1.336	1.316	1.863
2007	1.260	1.211	1.190	1.751	2.868	2.087	1.481	1.327	1.527	2.141	2.210	1.866	1.743
2008	1.548	1.476	1.448	1.622	2.393	2.350	2.263	1.783	1.664	1.730	1.440	1.221	1.745
2009	1.109	1.052	1.036	1.653	2.603	2.789	3.158	2.783	2.630	2.393	2.141	1.857	2.100
2010	1.607	1.477	1.414	1.942	2.153	1.866	1.121	1.056	1.685	1.866	1.739	1.547	1.623
2011	1.468	1.343	1.265	1.382	1.978	1.584	1.534	1.425	1.069	0.861	0.883	1.017	1.317
2012	1.057	1.083	1.132	1.576	2.369	2.237	2.223	1.717	1.976	2.011	2.113	1.664	1.763
2013	1.472	1.256	1.173	1.326	2.122	2.248	1.946	1.371	1.092	0.971	1.056	1.050	1.424
2014	0.996	0.962	0.956	1.188	2.227	3.072	2.391	1.611	1.087	1.172	1.252	1.174	1.507
2015	1.187	1.187	1.113	1.443	1.661	1.399	1.242	1.183	1.179	1.245	1.319	1.154	1.276
2016	1.073	1.026	1.034	1.302	1.939	2.137	2.324	2.132	2.119	2.537	2.657	2.080	1.863
2017	1.760	1.701	1.633	1.849	2.301	2.212	1.700	1.190	0.950	1.389	1.797	1.902	1.699
2018	1.434	1.155	1.224	1.423	2.745	2.495	2.416	2.260	2.040	1.980	1.845	1.703	1.893
2019	1.721	1.677	1.662	1.727	2.015	2.116	2.480	2.533	2.766	2.399			

Table I-10: LA-5 Monthly Average Flow (m³/s)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean Annual
1977	2.775	2.574	1.854	2.310	3.529	4.551	4.482	3.408	3.245	2.790	2.283	2.072	2.990
1978	2.386	2.282	1.984	1.675	2.863	3.303	2.452	2.584	3.344	3.521	2.848	2.377	2.635
1979	2.838	2.997	2.444	1.858	2.570	2.935	2.496	2.382	2.166	2.281	2.390	1.945	2.442
1980	1.475	1.114	1.021	1.054	1.628	1.373	1.074	1.123	1.182	1.584	1.507	1.308	1.287
1981	1.313	1.397	1.367	1.443	2.455	1.910	1.229	0.814	0.638	0.672	0.791	0.821	1.237
1982	0.712	0.612	0.598	0.754	2.044	2.544	1.900	2.145	1.975	1.549	1.354	1.397	1.465
1983	1.339	1.229	1.194	1.368	1.825	2.560	1.766	1.345	1.481	1.634	1.691	1.519	1.579
1984	1.251	1.229	1.324	1.785	2.095	1.920	1.331	1.022	0.862	0.981	1.155	1.133	1.341
1985	1.144	1.117	1.182	1.308	3.199	2.523	2.150	1.568	1.430	1.322	1.370	1.244	1.630
1986	1.250	1.277	1.266	1.303	2.538	2.327	2.223	1.947	1.387	1.328	1.249	1.145	1.603
1987	1.111	1.117	1.146	1.659	2.135	1.484	0.904	0.704	0.721	0.681	0.745	0.721	1.094
1988	0.783	0.803	0.887	0.987	1.627	2.063	1.774	1.284	1.215	1.160	1.153	1.115	1.238
1989	1.155	1.238	1.155	1.098	2.336	2.449	2.140	1.477	1.259	1.169	1.090	1.085	1.471
1990	1.076	1.068	1.066	1.095	1.607	1.646	1.645	1.089	0.888	0.942	1.037	1.026	1.182
1991	0.944	0.935	0.950	1.162	1.978	2.214	1.786	1.284	1.219	1.190	1.094	1.075	1.319
1992	0.992	0.974	0.985	1.122	2.147	1.777	1.332	1.090	1.225	1.821	1.296	1.070	1.319
1993	0.969	0.925	0.885	1.153	1.351	0.980	0.916	1.494	1.385	1.198	1.178	1.030	1.122
1994	0.953	0.887	0.977	1.253	2.654	2.851	2.072	1.184	0.781	0.771	0.741	0.731	1.321
1995	0.731	0.712	0.770	1.064	1.533	1.892	1.238	1.710	1.823	1.508	1.430	1.068	1.290
1996	0.832	0.776	0.770	0.975	1.542	1.811	1.741	1.477	1.276	1.246	1.225	1.095	1.230
1997	1.032	0.987	0.957	1.066	1.751	1.931	1.587	1.757	2.650	4.629	3.520	2.228	2.008
1998	1.708	1.613	1.535	1.687	1.733	1.189	1.102	0.938	0.728	0.857	0.876	0.839	1.234
1999	0.795	0.691	0.603	0.990	1.590	1.288	1.054	1.047	0.826	0.770	0.829	0.766	0.938
2000	0.715	0.683	0.686	0.844	1.709	1.808	1.284	1.028	0.916	1.191	1.084	0.855	1.067
2001	0.794	0.721	0.744	0.937	1.512	1.306	1.134	0.902	1.057	1.217	1.075	1.004	1.034
2002	0.913	0.866	0.830	0.858	1.260	1.143	1.288	2.156	2.115	1.804	1.612	1.436	1.357
2003	1.181	0.909	0.766	1.144	2.181	1.879	1.761	1.337	1.285	1.618	1.744	1.458	1.439
2004	1.281	1.229	1.241	1.191	1.348	2.069	1.557	1.052	1.048	1.048	1.055	0.992	1.259
2005	0.947	0.916	0.887	1.461	2.356	1.888	1.551	2.412	2.329	2.341	2.172	1.876	1.761
2006	1.660	1.543	1.491	1.546	1.940	2.134	1.457	1.350	0.998	0.906	0.907	0.891	1.402
2007	0.850	0.815	0.800	1.297	2.585	1.612	1.025	0.899	1.071	1.658	1.733	1.374	1.310
2008	1.076	1.016	0.993	1.154	1.962	1.900	1.801	1.292	1.179	1.238	0.988	0.822	1.285
2009	0.746	0.709	0.699	1.191	2.237	2.469	3.015	2.464	2.252	1.950	1.657	1.360	1.729
2010	1.127	1.017	0.966	1.461	1.672	1.385	0.759	0.718	1.201	1.369	1.247	1.075	1.166
2011	1.010	0.911	0.853	0.946	1.485	1.114	1.067	0.977	0.723	0.596	0.608	0.687	0.915
2012	0.712	0.729	0.761	1.103	1.925	1.766	1.755	1.229	1.481	1.519	1.628	1.181	1.316
2013	1.014	0.848	0.789	0.901	1.648	1.778	1.462	0.934	0.739	0.660	0.711	0.708	1.016
2014	0.674	0.653	0.650	0.800	1.788	2.888	1.955	1.138	0.733	0.789	0.845	0.789	1.142
2015	0.798	0.798	0.748	0.995	1.176	0.955	0.838	0.796	0.793	0.839	0.893	0.777	0.867
2016	0.722	0.693	0.701	0.886	1.444	1.663	1.872	1.650	1.635	2.134	2.288	1.600	1.441
2017	1.266	1.211	1.151	1.351	1.845	1.745	1.219	0.802	0.648	0.959	1.301	1.406	1.242
2018	0.987	0.777	0.826	0.991	2.411	2.079	1.989	1.811	1.546	1.483	1.348	1.213	1.455
2019	1.229	1.188	1.176	1.238	1.520	1.635	2.064	2.138	2.437	1.959			

APPENDIX II

CORRELATION METHODOLOGY

TECHNICAL MEMORANDUM

Privileged and Confidential 680.0018.000

FROM: Tyrel Lloyd, M.Eng., P.Eng., Senior Water Resources Engineer
PROJECT: Denison Wheeler River EIS
SUBJECT: Correlation Methodology
DATE: December 15, 2021

This document is prepared as a discussion of methodology used to extend stream flow records from Water Survey Canada's Wheeler River hydrometric monitoring station (06DA005) to assessment nodes associated with the Denison Mines Corp. (Denison) Wheeler River Project (the Project). EcoMetrix Inc. (EcoMetrix) has retained NewFields Canada Mining and Environment ULC (NewFields) to provide hydrological assessment in support of their components of work related to the Project's Environmental Impact Statement (EIS).

Denison initiated hydrometric monitoring at the Project in 2011. Several monitoring stations for streamflow and lake water level were incorporated at inception and throughout the duration since monitoring began and several organizations have been involved with data collection of these stations. Most stage-discharge rating curves at the Project are well developed and flow records during open water periods are reliable. Winter hydrometric monitoring was carried out in March 2014 but is the only winter monitoring program undertaken thus leaving gaps during ice covered periods.

The existing flow record for the Project provides information regarding snowmelt runoff, stream response to storm events and summer low flow data. Brevity of winter flow data is a knowledge gap which is infilled through extension of the flow records at relevant assessment nodes. The extension is completed through correlation of data from Environment and Climate Change Canada's Station 06DA005[1] to assessment nodes at the Project. The remainder of this document provides discussion of the methodology.

Station 06DA005 is located on the Wheeler River below Russell Lake. The gauge has operated from 1973 to 2019 and has a gross drainage area of 3030 km². The primary advantage to this station is that the Project and associated watersheds are within the watershed of 06DA005. Visual inspection of the flow records between 06DA005 and hydrographs at the Project yields similar trends in the data suggesting similar influences from regional hydrological processes. As such, 06DA005 was selected as the candidate for source data to represent flow volumes at the Project.

For the EIS there are nine assessment nodes used to assess impacts related to the Project (Figure 1 attached). The assessment nodes represent important locations within the Local Study Area relevant to the footprint or projected influence of the Project. Many assessment nodes are concurrent with past or current discharge monitoring stations with the exception of LA-1 and LA-5. At some locations the hydrograph data are readily available while at others the hydrographs are of short duration or not reported (Table 1). The amount of available hydrograph data influences the methodology used to extend the record. Table 1 also indicates the methodology used at each node.

Correlation for extension of data record is completed through analysis of same-day discharge values. For any data record available at an assessment node the same day discharge value from the source station is used for comparison (i.e., absolute value of the difference between the values). The subsequent deviations are then summed, and an equation is developed based on iterative processing to optimize the equation thus reducing the summation of the deviations. This methodology is preferred but can only be applied

[1] Environment and Climate Change Canada. 2021. Water Level and Flow Data. https://wateroffice.ec.gc.ca/index_e.html

where sufficient hydrograph length is available and considered to be of acceptable quality. Furthermore, the methodology incorporates hydrograph data at the Project thus representing actual conditions for each assessment node.

Table 1: Assessment Nodes Record Extension Method and Source Data

Assessment Node	Description	Drainage Area (km²)	Extension Method	Source Station
SA-1	Icelander River flowing from McGowan Lake	280.6	Correlation	06DA005
SA-2	Inflow to McGowan Lake from Whitefish Lake	257.4	Unit Area Runoff with Scaling and Offset	SA-6
SA-3	Inflow to McGowan Lake	15.5	Unit Area Runoff with Scaling	SA-1
SA-4	Inflow to LA-6 from Kratchkowski Lake	80.5	Correlation	SA-6
SA-5	Inflow to LA-6	167.3	Unit Area Runoff	SA-6
SA-6/LA-6	Flow from LA-6 to Whitefish Lake	251.7	Correlation	SA-1
SB-3	Southern project drainage basin flowing to Russell Lake	24.9	Unit Area Runoff	SA-1
LA-1	McGowan Lake	277.5	Unit Area Runoff	SA-1
LA-5	Whitefish Lake	257.2	Unit Area Runoff	SA-2

Unit area runoff (UAR) and UAR with offset is used where no hydrograph is available/acceptable at an assessment node. This methodology considers the ratio of mean monthly flow to drainage area (i.e., unit flow rate) and transfers that estimate to the assessment node by product of the assessment node's drainage area. Fit of the data is typically assessed visually to determine if the historically collected instantaneous discharge measurements "match" the estimated hydrograph; when the measurement data appear to be biased, likely due to groundwater input, geographical features in the watershed or similar influence, the hydrograph data are shifted to match the measured discharges.

Through these analyses monthly mean flow records were extended for each assessment nodes and reported within the EIS. These records represent the historical hydrograph for each assessment node for the Project. Should additional information regarding these analyses be required please contact the undersigned.

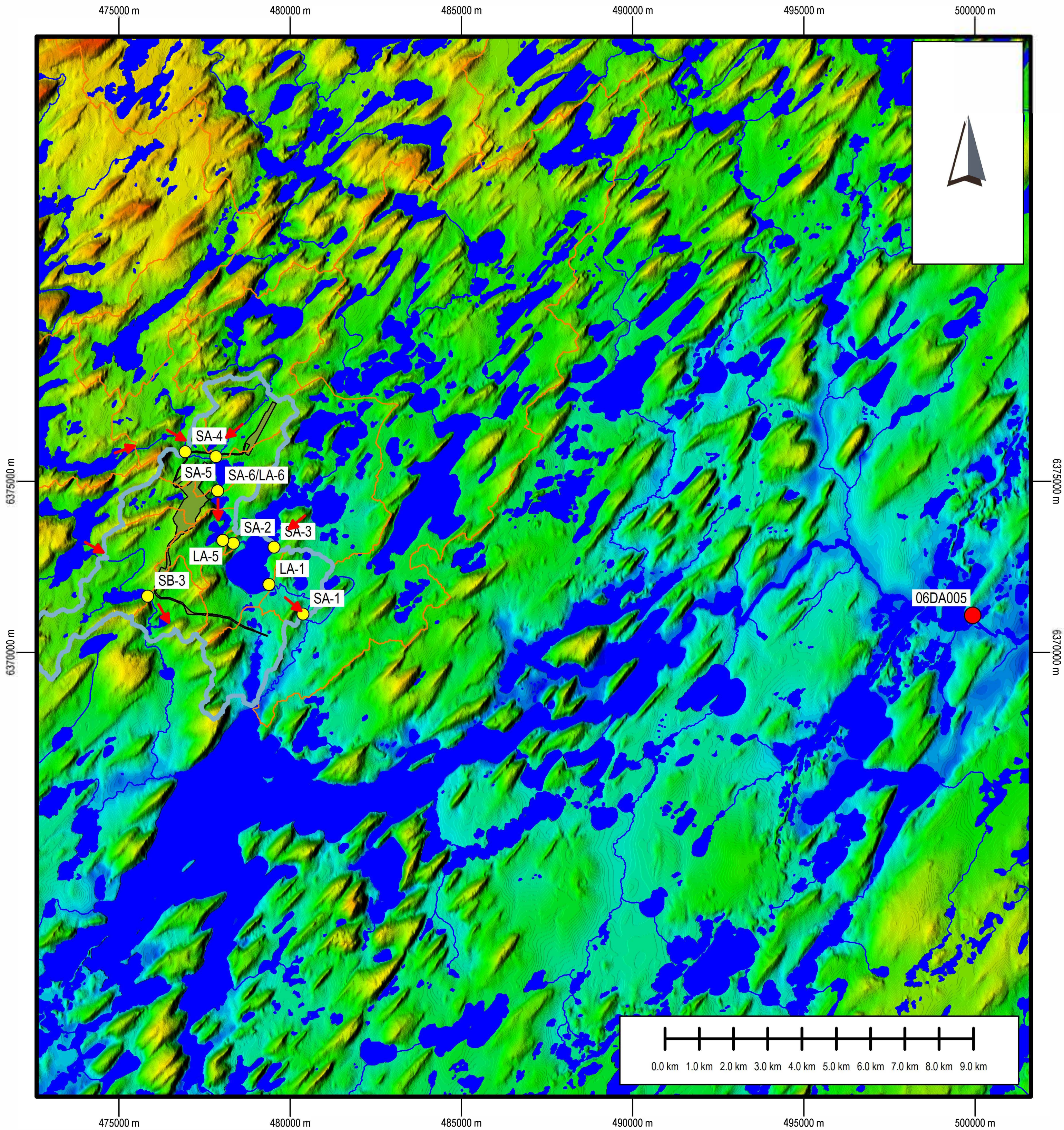
NewFields Canada Mining and Environment ULC

Tyrel J. Lloyd, M.Eng., P.Eng.
Senior Water Resources Engineer

TJL/tjl

Attachment: Figure 1 – Assessment Nodes and Water Survey Canada Station

https://newfields365-my.sharepoint.com/personal/lbotham_newfields_com/Documents/Projects/680.0018.000 - EcoMetrix - Denison Wheeler River EIS/Report/680.0018.000 - Tech Memo - 21 09 02 - Correlation Methodology.docx



Legend:

- Site Study Area
- Waterbody
- Local Study Area
- Stream Alignment
- Watershed Boundary
- Assessment Node
- Flow Direction
- Hydrometric Monitoring Station

NewFields	Date: August 30, 2021
Project Number: 680.0018.000	
Figure Title: Assessment Nodes and Water Survey Canada Station	
Projection: UTM NAD83 Zone 13 References: Elevation model from CDEM NTS Mapsheets	**Figure: 1** **Revision: 0**

NewFields

APPENDIX III

FIRT IR-102

Attachment IR-102

Number	IR-102
Comment From	ECCC
Category	Fish and Fish Habitat
Page # in EIS	
Section # in EIS	8.1.3.1 Appendix 8-C, including Appendix II, Table 1 (p. 2)
Comment	In response to IR-102 issued in first round of IRs: This response has not been accepted for the following reasons: 1. Given the limitation of data availability extension of flow records based on the nearest active WSC hydrometric station (Wheeler River (06DA005)) is acceptable although other methods are not shown to be explored by the proponent including rainfall-runoff modelling techniques (such model can be calibrated at 06DA005 thus computed flow at subbasins or sub watershed can be estimated with good degree of confidence), drainage area ratio method, etc. CNSC staff recommends proponent to consider aforementioned methods or similar or provide justification why other methods were not considered. 2. In Attachment IR-102 Figure 1 to 7 show the plots of measured versus the estimated daily flows using the relationship developed for extension of daily flows at SA-1, SA-2, SA-3, SA- 4, SA-5, SA-6, SB-3, LA-1 and LA-5. CNSC staff however finds it difficult to determine the predictive accuracy of the relationships based on visual comparisons. Therefore, CNSC staff requests that the proponent provide quantitative measures of prediction accuracy, for example in the form of Root Mean Square Error, correlation coefficient, etc., for the Equations presented in Table 1 of Attachment IR-102. In addition, CNSC staff requests that the proponent provide clarification on whether the current relationships are only limited to baseline characterization or will also be considered for estimation of design flows at SA-4 and SA-5 for culvert/crossing design for the access road. 3. Response to third part of the IR to be re-assessed when proponent addresses the above two comments ([1] and [2]).

Response:

1. Though other methods exist for extension of flow rates from 06DA005 to the RSA, the Proponent believes it sufficient to rely on the transfer method used in the water quantity (hydrology) component of the EIS. The transfer method is an advanced form of unit area transfer which incorporates additional algorithms to adjust to streamflow response. In some cases, unit area runoff without additional algorithms was used to transfer the record specifically for SA-5, SB-3, LA-1 and LA-5.

   The transfer method employed in the technical assessment (Appendix 8-C) and summarized in the EIS relies on measured data from the LSA and is compared to other measured data within the same watershed. A rainfall-runoff model would rely upon transfer of climate data to site from the closest meteorological station (Key Lake Mine) or interpolated grid data neither of which can be confirmed to accurately reflect site conditions.

2. To further confirm the viability of the chosen extension method, the Root Mean Square Error (RMSE) between the transfer method and the unit area runoff method was estimated for comparison. Baseline data reported by Ecometrix Incorporated (2019) present hydrometric monitoring data at several of the stations at the Project. These data represent the observed data set against which the synthesized data are checked. The baseline data in some cases are hydrographs from installed sensors and in other cases are point measurements of discharge. The observed and synthesized hydrographs were checked between coincident dates of available data. Two synthesized hydrographs are compared for RMSE, the first hydrographs are those developed using the transfer discussed in the EIS, technical support memo (Appendix 8-C) and previous response to this IR. The second hydrograph is developed using unit area runoff relationships.

   As mentioned above, four stations were developed using the unit area runoff method, therefore nullifying the utility of a method comparison for these locations. The remaining five stations include SA-1, SA-2, SA-3, SA-4 and SA-6. RMSE is a comparison of the differences between observed and synthesized data. The squared error is estimated between coincident data points and the RMSE for a dataset is the sum of that error. A perfectly matching data set would have an RMSE of 0 and a negative RMSE is not possible. The following table presents the estimated RMSE values for the two synthesized hydrographs at the relevant stations. For all stations, the reported transfer equation yields a better RMSE than unit area runoff.

Table 1: Hydrology Station Correlation Coefficients for RMSE Methods as Compared to Historical Data

Station	Reported Transfer Equation RMSE	Unit Area Runoff RMSE
SA-1	0.252	0.426
SA-2	0.317	0.381
SA-3	0.080	0.345
SA-4	0.090	0.118
SA-6	0.362	0.453

As a result, it is confirmed that the use of the reported transfer equation method is fit for use as part of the hydrology assessment and for the purposes of:

a) Baseline water quantity characterization
b) Estimates of change in water quantity as a result of the Operation; and,
c) Assessment of potential impacts to the environment as part of the EIS including for water quantity and all other components of Section 8 that may be influenced by changes in water quantity.

Therefore, no additional changes to the EIS with regard to this IR are required.

Date (for drafting version control): January 30, 2024