Title of document: **Water Balance Computations for Typical Wet and Dry Years**

Client: **GROUPE HÉMISPHÈRES**

Project: **HOWSE**

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REVISION INDEX

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1.0 INTRODUCTION

In 2015, SNC-Lavalin (SNC-Lavalin, 2015) developed a water management plan for the Howse project at a conceptual engineering level. Elements of this plan were used by Groupe Hémisphères to prepare an environmental impact study (EIS), including the results of water balance computations for a typical average year.

Following the EIS submission, a request from the EIS revision agency was to obtain additional water balance computations for wetter and drier years. In this context, Groupe Hémisphères mandated SNC-Lavalin to perform water balance computations for wetter and drier years.

2.0 DATA

The same data used for the development of Howse project Water Management Plan (SNC-Lavalin, 2015) was used for the present study.

Daily hydro-meteorological data time series, representative for the Howse project site, covering a period of up to 66 years (1948-2014), were obtained from Environment Canada nearby meteorological stations Schefferville A, Schefferville, and Fermont. This data consisted of:

- Temperature
- Precipitation
- Rainfall
- Snowfall
- Snow cover

Monthly lake evaporation values, compiled from measurements made during the period 1951 to 1980 for the Schefferville meteorological station (Rollings, 1997), are also used in the present study.

3.0 METHODOLOGY

The following methodology was used to determine typical wet and dry years representative for the Howse project site:

- The amount of annual runoff was used to determine if a particular year is a wet or a dry year.
- Hydrological years, starting October 1st, just before snow cover starts to accumulate, and ending September 30st are used.
- Available snow cover data from meteorological station Schefferville A, covering the period 1955 to 1993, was used with concomitant temperature and precipitation data to setup and calibrate a snowmelt model.
- This model was then applied to the whole period for which precipitation and temperature data is available (66 hydrological years) and daily runoff was computed.

- Runoff was computed using a runoff coefficient of 0.4 during the summer months (June-September) and 1.0 during the rest of the year (SNC-Lavalin, 2015). Then, a frequency analyses was performed on annual runoff, using a Log-Pearson type III probability distribution.
- Hydrological year 1978-1979 was selected as typical wet year because it resulted in an annual runoff of 794 mm, which is more than the runoff corresponding to a 100 years wet year return period (776 mm).
- Hydrological year 1996-1997 was selected as typical dry year because it resulted in an annual runoff of 343 mm, which is less than the runoff corresponding to a 100 years dry year return period (350 mm).

Typical wet and dry years monthly temperature, rainfall and snowfall values are used as inputs for the corresponding water balance computations The following steps were used to estimate evaporation corresponding to typical wet and dry years:

- Monthly temperature and precipitation data for typical average, wet, and dry years was used to compute potential evapotranspiration based on the Thornthwaite equation (Maidment, 1993).
- Annual potential evapotranspiration percentage differences between typical years were determined and applied to monthly lake evaporation values adopted for the typical average water balance computations (SNC-Lavalin, 2015) to obtain an estimation of typical wet and dry monthly lake evaporation values.

The following tables present the monthly data adopted for typical wet and dry years.

Table 3-1 : Monthly Data – Wet Year

Month	Rainfall [mm]	Snowfall [mm]	Snow sublimation [mm]	Runoff [mm]	Lake evaporation [mm]	Evapo-transpiration [mm]
Jan	0.0	62.4	0.0	0.0	0.0	0.0
Feb	0.0	61.6	0.0	0.0	0.0	0.0
Mar	0.2	101.9	0.0	0.2	0.0	0.0
Apr	60.2	42.2	0.0	60.2	0.0	0.0
May	73.1	26.0	0.0	547.2	0.0	0.0
Jun	82.3	0.0	0.0	32.9	109.6	38.4
Jul	149.5	0.0	0.0	59.8	103.3	36.2
Aug	76.9	0.0	0.0	30.7	73.8	25.8
Sep	100.5	2.4	0.0	41.2	48.5	17.0
Oct	21.3	64.8	0.0	21.3	0.0	0.0
Nov	0.0	63.3	0.0	0.0	0.0	0.0
Dec	0.0	51.9	0.0	0.0	0.0	0.0
Year	**564.0**	**476.5**	**0.0**	**793.5**	**335.2**	**117.3**

Table 3-2 : Monthly Data – Dry Year

Month	Rainfall [mm]	Snowfall [mm]	Snow sublimation [mm]	Runoff [mm]	Lake evaporation [mm]	Evapo-transpiration [mm]
Jan	0.0	17.6	0.0	0.0	0.0	0.0
Feb	0.0	1.8	0.0	0.0	0.0	0.0
Mar	0.0	9.7	0.0	0.0	0.0	0.0
Apr	2.9	21.0	0.0	2.9	0.0	0.0
May	43.2	23.8	0.0	195.0	0.0	0.0
Jun	35.1	0.0	0.0	14.1	99.4	34.8
Jul	170.8	0.0	0.0	68.3	93.6	32.8
Aug	42.6	0.0	0.0	17.0	66.9	23.4
Sep	67.4	0.0	0.0	27.0	43.9	15.4
Oct	7.8	14.3	0.0	7.8	0.0	0.0
Nov	10.4	27.2	0.0	10.4	0.0	0.0
Dec	0.0	36.4	0.0	0.0	0.0	0.0
Year	**380.3**	**151.8**	**0.0**	**342.5**	**303.8**	**106.3**

Pit dewatering values of 23 000 m^3/day and 8 400 m^3/day were adopted for typical wet and dry years respectively.

Then, water balance computations for typical wet and dry years were performed based on the same computations made for a typical average year in SNC-Lavalin (2015).

4.0 RESULTS

The following tables present monthly water balance computation results, for typical wet and dry years, for the three natural watersheds (Goodream Creek, Burnetta Creek, and Pinette Lake) impacted by the project. Existing and modified conditions are representative of site conditions before and after Howse project construction. Indicated drainage areas correspond to the drainage areas from SNC-Lavalin (2015).

Table 4-1 : Wet Year – Goodream Creek – Existing Conditions at Junction with Timmins 4 Sedimentation Pond 3 Outflow (316 ha)

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Inflow [m³]	Inflow [l/s]
Jan	197 059	0	0	0	0	0	0.0
Feb	194 533	0	0	0	0	0	0.0
Mar	321 800	632	0	632	0	632	0.2
Apr	133 268	190 112	0	190 112	0	190 112	73.3
May	82 108	230 850	0	1 728 058	0	1 728 058	645.2
Jun	0	259 903	155 942	103 961	103 961	0	0.0
Jul	0	472 121	283 273	188 848	114 174	74 674	27.9
Aug	0	242 711	145 627	97 085	81 553	15 532	5.8
Sep	7 579	317 379	194 975	129 983	53 592	76 391	29.5
Oct	204 638	67 265	0	67 265	0	67 265	25.1
Nov	199 901	0	0	0	0	0	0.0
Dec	163 900	0	0	0	0	0	0.0
Year	**1 504 787**	**1 780 973**	**779 816**	**2 505 944**	**353 280**	**2 152 664**	**68.3**

Table 4-2 : Wet Year – Goodream Creek – Modified Conditions at Junction with Timmins 4 Sedimentation Pond 3 Outflow (304 ha)

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Pumping from Pit [m³]	Inflow [m³]	Inflow [l/s]
Jan	189 696	0	0	0	0	0	0	0.0
Feb	187 264	0	0	0	0	0	0	0.0
Mar	309 776	608	0	608	0	0	608	0.2
Apr	128 288	183 008	0	183 008	0	0	183 008	70.6
May	79 040	222 224	0	1 663 488	0	210 000	1 873 488	699.5
Jun	0	250 192	150 115	100 077	100 077	0	0	0.0
Jul	0	454 480	272 688	181 792	109 908	7 896	79 780	29.8
Aug	0	233 642	140 185	93 457	78 506	1 642	16 594	6.2
Sep	7 296	305 520	187 690	125 126	51 589	8 077	81 614	31.5
Oct	196 992	64 752	0	64 752	0	0	64 752	24.2
Nov	192 432	0	0	0	0	0	0	0.0
Dec	157 776	0	0	0	0	0	0	0.0
Year	**1 448 560**	**1 714 426**	**750 678**	**2 412 308**	**340 080**	**227 615**	**2 299 844**	**72.9**

Table 4-3 : Wet Year – Goodream Creek – Existing Conditions at Junction with HOWSEB Outflow (1068 ha)

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Inflow [m³]	Inflow [l/s]
Jan	666 370	0	0	0	0	0	0.0
Feb	657 826	0	0	0	0	0	0.0
Mar	1 088 190	2 136	0	2 136	0	2 136	0.8
Apr	450 654	642 876	0	642 876	0	642 876	248.0
May	277 654	780 635	0	5 843 549	0	5 843 549	2 181.7
Jun	0	878 882	527 329	351 553	351 553	0	0.0
Jul	0	1 596 511	957 906	638 604	386 087	252 517	94.3
Aug	0	820 746	492 447	328 298	275 777	52 522	19.6
Sep	25 630	1 073 240	659 321	439 548	181 225	258 323	99.7
Oct	691 999	227 463	0	227 463	0	227 463	84.9
Nov	675 981	0	0	0	0	0	0.0
Dec	554 240	0	0	0	0	0	0.0
Year	**5 088 544**	**6 022 487**	**2 637 004**	**8 474 026**	**1 194 642**	**7 279 384**	**230.8**

Table 4-4 : Wet Year – Goodream Creek – Modified Conditions at Junction with HOWSEB Outflow (1162 ha)

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Pit dewatering [m³]	Inflow [m³]	Inflow [l/s]
Jan	725 338	0	0	0	0	713 000	713 000	266.2
Feb	716 038	0	0	0	0	644 000	644 000	266.2
Mar	1 184 486	2 325	0	2 325	0	713 000	715 325	267.1
Apr	490 533	699 765	0	699 765	0	690 000	1 389 765	536.2
May	302 224	849 714	0	6 360 653	0	713 000	7 073 653	2 641.0
Jun	0	956 655	573 993	382 662	382 662	690 000	690 000	266.2
Jul	0	1 737 788	1 042 673	695 115	420 253	713 000	987 862	368.8
Aug	0	893 375	536 025	357 350	300 181	713 000	770 169	287.5
Sep	27 898	1 168 212	717 666	478 444	197 262	690 000	971 182	374.7
Oct	753 235	247 591	0	247 591	0	713 000	960 591	358.6
Nov	735 799	0	0	0	0	690 000	690 000	266.2
Dec	603 286	0	0	0	0	713 000	713 000	266.2
Year	**5 538 836**	**6 555 425**	**2 870 357**	**9 223 905**	**1 300 357**	**8 395 000**	**16 318 548**	**517.5**

Table 4-5 : Wet Year – Burnetta Creek – Existing Conditions at Junction with HOWSEA Outflow (83 ha)

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Inflow [m³]	Inflow [l/s]
Jan	51 854	0	0	0	0	0	0.0
Feb	51 190	0	0	0	0	0	0.0
Mar	84 679	166	0	166	0	166	0.1
Apr	35 068	50 026	0	50 026	0	50 026	19.3
May	21 606	60 746	0	454 723	0	454 723	169.8
Jun	0	68 391	41 035	27 357	27 357	0	0.0
Jul	0	124 235	74 541	49 694	30 044	19 650	7.3
Aug	0	63 867	38 320	25 547	21 460	4 087	1.5
Sep	1 994	83 516	51 306	34 204	14 102	20 102	7.8
Oct	53 849	17 700	0	17 700	0	17 700	6.6
Nov	52 602	0	0	0	0	0	0.0
Dec	43 129	0	0	0	0	0	0.0
Year	**395 972**	**468 647**	**205 202**	**659 417**	**92 963**	**566 455**	**18.0**

Table 4-6 : Wet Year – Burnetta Creek – Modified Conditions at Junction with HOWSEA Outflow (143 ha)

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Total Inflow [m³]	Inflow [l/s]
Jan	88 982	0	0	0	0	0	0.0
Feb	87 842	0	0	0	0	0	0.0
Mar	145 309	285	0	285	0	285	0.1
Apr	60 177	85 845	0	85 845	0	85 845	33.1
May	37 076	104 241	0	780 307	0	780 307	291.3
Jun	0	117 360	70 416	46 944	46 944	0	0.0
Jul	0	213 187	127 912	85 275	51 555	33 719	12.6
Aug	0	109 597	65 758	43 839	36 825	7 013	2.6
Sep	3 422	143 313	88 041	58 694	24 199	34 495	13.3
Oct	92 405	30 374	0	30 374	0	30 374	11.3
Nov	90 266	0	0	0	0	0	0.0
Dec	74 009	0	0	0	0	0	0.0
Year	**679 489**	**804 201**	**352 127**	**1 131 563**	**159 524**	**972 039**	**30.8**

Table 4-7 : Wet Year – Pinette Lake – Existing Conditions at Pinette Lake Outlet (237 ha)

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Inflow [m³]	Inflow [l/s]
Jan	147 888	0	0	0	0	0	0.0
Feb	145 992	0	0	0	0	0	0.0
Mar	241 503	474	0	474	0	474	0.2
Apr	100 014	142 674	0	142 674	0	142 674	55.0
May	61 620	173 247	0	1 296 864	0	1 296 864	484.2
Jun	0	195 051	117 031	78 020	78 020	0	0.0
Jul	0	354 315	212 589	141 726	85 685	56 041	20.9
Aug	0	182 149	109 289	72 860	61 203	11 656	4.4
Sep	5 688	238 185	146 324	97 549	40 219	57 330	22.1
Oct	153 576	50 481	0	50 481	0	50 481	18.8
Nov	150 021	0	0	0	0	0	0.0
Dec	123 003	0	0	0	0	0	0.0
Year	**1 129 305**	**1 336 576**	**585 233**	**1 880 648**	**265 128**	**1 615 520**	**51.2**

Table 4-8 : Wet Year – Pinette Lake – Modified Conditions at Pinette Lake Outlet (228 ha)

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Inflow [m³]	Inflow [l/s]
Jan	142 397	0	0	0	0	0	0.0
Feb	140 571	0	0	0	0	0	0.0
Mar	232 536	456	0	456	0	456	0.2
Apr	96 300	137 376	0	137 376	0	137 376	53.0
May	59 332	166 814	0	1 248 710	0	1 248 710	466.2
Jun	0	187 809	112 685	75 123	75 123	0	0.0
Jul	0	341 159	204 695	136 464	82 503	53 960	20.1
Aug	0	175 386	105 231	70 154	58 931	11 223	4.2
Sep	5 477	229 341	140 891	93 927	38 726	55 201	21.3
Oct	147 874	48 607	0	48 607	0	48 607	18.1
Nov	144 451	0	0	0	0	0	0.0
Dec	118 436	0	0	0	0	0	0.0
Year	**1 087 373**	**1 286 948**	**563 503**	**1 810 818**	**255 283**	**1 555 535**	**49.3**

Table 4-9 : Dry Year – Goodream Creek – Existing Conditions at Junction with Timmins 4 Sedimentation Pond 3 Outflow (316 ha)

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Inflow [m³]	Inflow [l/s]
Jan	55 581	0	0	0	0	0	0.0
Feb	5 684	0	0	0	0	0	0.0
Mar	30 633	0	0	0	0	0	0.0
Apr	66 318	9 158	0	9 158	0	9 158	3.5
May	75 160	136 426	0	615 810	0	615 810	229.9
Jun	0	110 996	66 598	44 399	44 399	0	0.0
Jul	0	539 508	323 705	215 803	103 477	112 326	41.9
Aug	0	134 531	80 718	53 812	53 812	0	0.0
Sep	0	212 849	127 710	85 140	48 571	36 569	14.1
Oct	45 159	24 632	0	24 632	0	24 632	9.2
Nov	85 898	32 843	0	32 843	0	32 843	12.7
Dec	114 951	0	0	0	0	0	0.0
Year	**479 384**	**1 200 944**	**598 731**	**1 081 598**	**250 259**	**831 338**	**26.4**

Table 4-10 : Dry Year – Goodream Creek – Modified Conditions at Junction with Timmins 4 Sedimentation Pond 3 Outflow (304 ha)

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Pumping from Pit [m³]	Inflow [m³]	Inflow [l/s]
Jan	53 504	0	0	0	0	0	0	0.0
Feb	5 472	0	0	0	0	0	0	0.0
Mar	29 488	0	0	0	0	0	0	0.0
Apr	63 840	8 816	0	8 816	0	0	8 816	3.4
May	72 352	131 328	0	592 800	0	164 236	757 036	282.6
Jun	0	106 849	64 109	42 740	42 740	0	0	0.0
Jul	0	519 350	311 610	207 740	99 611	27 032	135 161	50.5
Aug	0	129 504	77 702	51 802	51 802	0	0	0.0
Sep	0	204 896	122 938	81 958	46 756	8 801	44 003	17.0
Oct	43 472	23 712	0	23 712	0	0	23 712	8.9
Nov	82 688	31 616	0	31 616	0	0	31 616	12.2
Dec	110 656	0	0	0	0	0	0	0.0
Year	**461 472**	**1 156 071**	**576 359**	**1 041 183**	**240 908**	**200 069**	**1 000 344**	**31.7**

Table 4-11 : Dry Year – Goodream Creek – Existing Conditions at Junction with HOWSEB Outflow (1068 ha)

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Inflow [m³]	Inflow [l/s]
Jan	187 950	0	0	0	0	0	0.0
Feb	19 222	0	0	0	0	0	0.0
Mar	103 586	0	0	0	0	0	0.0
Apr	224 259	30 969	0	30 969	0	30 969	11.9
May	254 160	461 333	0	2 082 405	0	2 082 405	777.5
Jun	0	375 342	225 205	150 137	150 137	0	0.0
Jul	0	1 824 386	1 094 632	729 754	349 916	379 838	141.8
Aug	0	454 925	272 955	181 970	181 970	0	0.0
Sep	0	719 765	431 859	287 906	164 246	123 660	47.7
Oct	152 710	83 296	0	83 296	0	83 296	31.1
Nov	290 469	111 062	0	111 062	0	111 062	42.8
Dec	388 716	0	0	0	0	0	0.0
Year	**1 621 072**	**4 061 078**	**2 024 651**	**3 657 499**	**846 269**	**2 811 230**	**89.1**

Table 4-12 : Dry Year – Goodream Creek – Modified Conditions at Junction with HOWSEB Outflow (1162 ha)

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Pit dewatering [m³]	Inflow [m³]	Inflow [l/s]
Jan	204 582	0	0	0	0	260 400	260 400	97.2
Feb	20 923	0	0	0	0	235 200	235 200	97.2
Mar	112 753	0	0	0	0	260 400	260 400	97.2
Apr	244 104	33 710	0	33 710	0	252 000	285 710	110.2
May	276 651	502 157	0	2 266 680	0	260 400	2 527 080	943.5
Jun	0	408 557	245 134	163 423	163 423	252 000	252 000	97.2
Jul	0	1 985 829	1 191 497	794 331	380 881	260 400	673 851	251.6
Aug	0	495 182	297 109	198 073	198 073	260 400	260 400	97.2
Sep	0	783 458	470 075	313 383	178 781	252 000	386 602	149.2
Oct	166 223	90 667	0	90 667	0	260 400	351 067	131.1
Nov	316 173	120 890	0	120 890	0	252 000	372 890	143.9
Dec	423 114	0	0	0	0	260 400	260 400	97.2
Year	**1 764 523**	**4 420 449**	**2 203 815**	**3 981 157**	**921 157**	**3 066 000**	**6 125 999**	**194.3**

Table 4-13 : Dry Year – Burnetta Creek – Existing Conditions at Junction with HOWSEA Outflow (83 ha)

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Inflow [m³]	Inflow [l/s]
Jan	14 626	0	0	0	0	0	0.0
Feb	1 496	0	0	0	0	0	0.0
Mar	8 061	0	0	0	0	0	0.0
Apr	17 451	2 410	0	2 410	0	2 410	0.9
May	19 778	35 899	0	162 045	0	162 045	60.5
Jun	0	29 208	17 525	11 683	11 683	0	0.0
Jul	0	141 967	85 180	56 787	27 229	29 558	11.0
Aug	0	35 401	21 240	14 160	14 160	0	0.0
Sep	0	56 009	33 606	22 404	12 781	9 623	3.7
Oct	11 883	6 482	0	6 482	0	6 482	2.4
Nov	22 603	8 642	0	8 642	0	8 642	3.3
Dec	30 248	0	0	0	0	0	0.0
Year	126 146	316 018	157 551	284 613	65 854	218 759	6.9

Table 4-14 : Dry Year – Burnetta Creek – Modified Conditions at Junction with HOWSEA Outflow (143 ha)

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Total Inflow [m³]	Inflow [l/s]
Jan	25 098	0	0	0	0	0	0.0
Feb	2 567	0	0	0	0	0	0.0
Mar	13 832	0	0	0	0	0	0.0
Apr	29 946	4 135	0	4 135	0	4 135	1.6
May	33 939	61 603	0	278 070	0	278 070	103.8
Jun	0	50 121	30 072	20 048	20 048	0	0.0
Jul	0	243 616	146 170	97 446	46 725	50 721	18.9
Aug	0	60 748	36 449	24 299	24 299	0	0.0
Sep	0	96 112	57 667	38 445	21 932	16 513	6.4
Oct	20 392	11 123	0	11 123	0	11 123	4.2
Nov	38 787	14 830	0	14 830	0	14 830	5.7
Dec	51 906	0	0	0	0	0	0.0
Year	216 467	542 288	270 358	488 397	113 005	375 392	11.9

Table 4-15 : Dry Year – Pinette Lake – Existing Conditions at Pinette Lake Outlet (237 ha)

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Inflow [m³]	Inflow [l/s]
Jan	41 712	0	0	0	0	0	0.0
Feb	4 266	0	0	0	0	0	0.0
Mar	22 989	0	0	0	0	0	0.0
Apr	49 770	6 873	0	6 873	0	6 873	2.7
May	56 406	102 384	0	462 150	0	462 150	172.5
Jun	0	83 300	49 980	33 320	33 320	0	0.0
Jul	0	404 888	242 933	161 955	77 657	84 298	31.5
Aug	0	100 962	60 577	40 385	40 385	0	0.0
Sep	0	159 738	95 843	63 895	36 451	27 444	10.6
Oct	33 891	18 486	0	18 486	0	18 486	6.9
Nov	64 464	24 648	0	24 648	0	24 648	9.5
Dec	86 268	0	0	0	0	0	0.0
Year	**359 766**	**901 279**	**449 333**	**811 712**	**187 813**	**623 899**	**19.8**

Table 4-16 : Dry Year – Pinette Lake – Modified Conditions at Pinette Lake Outlet (228 ha)

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Inflow [m³]	Inflow [l/s]
Jan	40 163	0	0	0	0	0	0.0
Feb	4 108	0	0	0	0	0	0.0
Mar	22 135	0	0	0	0	0	0.0
Apr	47 922	6 618	0	6 618	0	6 618	2.6
May	54 312	98 582	0	444 990	0	444 990	166.1
Jun	0	80 207	48 124	32 083	32 083	0	0.0
Jul	0	389 854	233 912	155 942	74 774	81 168	30.3
Aug	0	97 213	58 328	38 885	38 885	0	0.0
Sep	0	153 807	92 284	61 523	35 098	26 425	10.2
Oct	32 633	17 800	0	17 800	0	17 800	6.6
Nov	62 070	23 733	0	23 733	0	23 733	9.2
Dec	83 065	0	0	0	0	0	0.0
Year	**346 408**	**867 813**	**432 649**	**781 573**	**180 840**	**600 733**	**19.0**

The following tables summarize spring, summer and fall monthly maximum flow differences between existing and modified conditions for typical wet, average, and dry years.

Table 4-17 : Monthly Maximum Flow Differences - Goodream Creek at Timmins 4 SP3 Outflow

Month	Discharge Before Howse [l/s]			Discharge After Howse [l/s]			Percentage Difference [%]		
	Wet	Average	Dry	Wet	Average	Dry	Wet	Average	Dry
May	645	453	230	699	515	283	8%	14%	23%
Jun	0	0	0	0	0	0	0%	0%	0%
Jul	28	7	42	30	8	50	7%	12%	20%
Aug	6	16	0	6	18	0	7%	12%	0%
Sep	29	25	14	31	27	17	7%	12%	20%

Table 4-18 : Monthly Maximum Flow Differences - Goodream Creek at HOWSEB Outflow

Month	Discharge Before Howse [l/s]			Discharge After Howse [l/s]			Percentage Difference [%]		
	Wet	Average	Dry	Wet	Average	Dry	Wet	Average	Dry
May	2182	1533	777	2641	1923	944	21%	25%	21%
Jun	0	0	0	266	255	97	Infinity	Infinity	Infinity
Jul	94	25	142	369	282	252	291%	1037%	77%
Aug	20	56	0	288	315	97	1366%	467%	Infinity
Sep	100	83	48	375	345	149	276%	316%	213%

Table 4-19 : Monthly Maximum Flow Differences - Burnetta Creek at HOWSEA Outflow

Month	Discharge Before Howse [l/s]			Discharge After Howse [l/s]			Percentage Difference [%]		
	Wet	Average	Dry	Wet	Average	Dry	Wet	Average	Dry
May	170	119	61	291	205	104	72%	72%	72%
Jun	0	0	0	0	0	0	0%	0%	0%
Jul	7	2	11	13	3	19	72%	72%	72%
Aug	2	4	0	3	7	0	72%	72%	0%
Sep	8	6	4	13	11	6	72%	72%	72%

Table 4-20 : Monthly Maximum Flow Differences – Pinette Lake at Pinette Lake Outlet

Month	Discharge Before Howse [l/s]			Discharge After Howse [l/s]			Percentage Difference [%]		
	Wet	Average	Dry	Wet	Average	Dry	Wet	Average	Dry
May	484	340	173	466	328	166	-4%	-4%	-4%
Jun	0	0	0	0	0	0	0%	0%	0%
Jul	21	5	31	20	5	30	-4%	-4%	-4%
Aug	4	12	0	4	12	0	-4%	-4%	0%
Sep	22	18	11	21	18	10	-4%	-4%	-4%

Note that monthly maximum flow differences are the same for each type of typical year for Burnetta Creek and Pinette Lake because only drainage areas differences are applied for each typical year runoff. For Goodream Creek, these differences are not constant because pit dewatering values change and pit runoff is treated in priority in the existing Timmins 4 sedimentation pond 3.

The following tables present monthly water balance computation results, for typical wet and dry years, for the project infrastructures.

Table 4-21 : Dry Year – Sedimentation Basin HOWSEA (59 ha)

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Inflow [m³]	Inflow [l/s]
Jan	10 366	0	0	0	0	0	0.0
Feb	1 060	0	0	0	0	0	0.0
Mar	5 713	0	0	0	0	0	0.0
Apr	12 369	1 708	0	1 708	0	1 708	0.7
May	14 018	25 445	0	114 855	0	114 855	42.9
Jun	0	20 702	12 421	8 281	8 281	0	0.0
Jul	0	100 624	60 374	40 250	19 300	20 950	7.8
Aug	0	25 091	15 055	10 037	10 037	0	0.0
Sep	0	39 699	23 819	15 879	9 059	6 820	2.6
Oct	8 423	4 594	0	4 594	0	4 594	1.7
Nov	16 021	6 126	0	6 126	0	6 126	2.4
Dec	21 440	0	0	0	0	0	0.0
Year	**89 410**	**223 989**	**111 670**	**201 729**	**46 676**	**155 053**	**4.9**

Table 4-22 : Wet Year – Sedimentation Basin HOWSEA (59 ha)

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Inflow [m³]	Inflow [l/s]
Jan	36 754	0	0	0	0	0	0.0
Feb	36 282	0	0	0	0	0	0.0
Mar	60 019	118	0	118	0	118	0.0
Apr	24 856	35 458	0	35 458	0	35 458	13.7
May	15 314	43 056	0	322 301	0	322 301	120.3
Jun	0	48 475	29 085	19 390	19 390	0	0.0
Jul	0	88 056	52 833	35 222	21 295	13 928	5.2
Aug	0	45 268	27 161	18 107	15 210	2 897	1.1
Sep	1 414	59 195	36 365	24 243	9 995	14 248	5.5
Oct	38 167	12 546	0	12 546	0	12 546	4.7
Nov	37 284	0	0	0	0	0	0.0
Dec	30 569	0	0	0	0	0	0.0
Year	**280 659**	**332 170**	**145 444**	**467 385**	**65 890**	**401 494**	**12.7**

Table 4-23 : Dry Year – Sedimentation Basin HOWSEB (178 ha)

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Pit dewatering [m³]	Pumping from Pit [m³]	Inflow [m³]	Inflow [l/s]
Jan	31 363	0	0	0	0	260 400	0	260 400	97.2
Feb	3 208	0	0	0	0	235 200	0	235 200	97.2
Mar	17 285	0	0	0	0	260 400	0	260 400	97.2
Apr	37 422	5 168	0	5 168	0	252 000	0	257 168	99.2
May	42 412	76 982	0	347 490	0	260 400	0	607 890	227.0
Jun	0	62 633	37 580	25 053	25 053	252 000	0	252 000	97.2
Jul	0	304 434	182 661	121 774	58 390	260 400	0	323 783	120.9
Aug	0	75 913	45 548	30 365	30 365	260 400	0	260 400	97.2
Sep	0	120 107	72 064	48 043	27 408	252 000	0	272 635	105.2
Oct	25 483	13 900	0	13 900	0	260 400	0	274 300	102.4
Nov	48 470	18 533	0	18 533	0	252 000	0	270 533	104.4
Dec	64 865	0	0	0	0	260 400	0	260 400	97.2
Year	**270 508**	**677 670**	**337 853**	**610 325**	**141 217**	**3 066 000**	**0**	**3 535 109**	**112.1**

Table 4-24 : Wet Year – Sedimentation Basin HOWSEB (178 ha)

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Pit dewatering [m³]	Pumping from Pit [m³]	Inflow [m³]	Inflow [l/s]
Jan	111 197	0	0	0	0	713 000	0	713 000	266.2
Feb	109 771	0	0	0	0	644 000	0	644 000	266.2
Mar	181 586	356	0	356	0	713 000	0	713 356	266.3
Apr	75 200	107 276	0	107 276	0	690 000	0	797 276	307.6
May	46 332	130 264	0	975 110	0	713 000	267 964	1 956 074	730.3
Jun	0	146 659	87 995	58 663	58 663	690 000	0	690 000	266.2
Jul	0	266 409	159 845	106 564	64 426	713 000	10 075	765 213	285.7
Aug	0	136 957	82 174	54 783	46 019	713 000	2 096	723 860	270.3
Sep	4 277	179 091	110 021	73 347	30 241	690 000	10 307	743 413	286.8
Oct	115 474	37 957	0	37 957	0	713 000	0	750 957	280.4
Nov	112 801	0	0	0	0	690 000	0	690 000	266.2
Dec	92 486	0	0	0	0	713 000	0	713 000	266.2
Year	**849 123**	**1 004 970**	**440 036**	**1 414 057**	**199 349**	**8 395 000**	**290 442**	**9 900 149**	**313.9**

Table 4-25 : Dry Year –Timmins 4 Sedimentation Pond 3 (82 ha)

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Pumping from Pit [m³]	Inflow [m³]	Inflow [l/s]
Jan	14 372	0	0	0	0	0	0	0.0
Feb	1 470	0	0	0	0	0	0	0.0
Mar	7 921	0	0	0	0	0	0	0.0
Apr	17 149	2 368	0	2 368	0	0	2 368	0.9
May	19 435	35 277	0	159 237	0	164 236	323 473	120.8
Jun	0	28 702	17 221	11 481	11 481	0	0	0.0
Jul	0	139 507	83 704	55 803	26 757	27 032	56 078	20.9
Aug	0	34 787	20 872	13 915	13 915	0	0	0.0
Sep	0	55 039	33 023	22 016	12 560	8 801	18 257	7.0
Oct	11 677	6 369	0	6 369	0	0	6 369	2.4
Nov	22 212	8 493	0	8 493	0	0	8 493	3.3
Dec	29 724	0	0	0	0	0	0	0.0
Year	**123 960**	**310 542**	**154 821**	**279 681**	**64 712**	**200 069**	**415 037**	**13.2**

Table 4-26 : Wet Year – Timmins 4 Sedimentation Pond 3 (82 ha)

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Pumping from Pit [m³]	Inflow [m³]	Inflow [l/s]
Jan	50 956	0	0	0	0	0	0	0.0
Feb	50 303	0	0	0	0	0	0	0.0
Mar	83 212	163	0	163	0	0	163	0.1
Apr	34 461	49 159	0	49 159	0	0	49 159	19.0
May	21 232	59 693	0	446 844	0	210 000	656 844	245.2
Jun	0	67 206	40 324	26 882	26 882	0	0	0.0
Jul	0	122 082	73 249	48 833	29 523	7 896	27 205	10.2
Aug	0	62 761	37 656	25 104	21 088	1 642	5 658	2.1
Sep	1 960	82 068	50 417	33 611	13 858	8 077	27 831	10.7
Oct	52 916	17 394	0	17 394	0	0	17 394	6.5
Nov	51 691	0	0	0	0	0	0	0.0
Dec	42 382	0	0	0	0	0	0	0.0
Year	**389 110**	**460 527**	**201 646**	**647 990**	**91 352**	**227 615**	**784 254**	**24.9**

Table 4-27 : Dry Year –Howse Mine Pit (76 ha)

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Inflow [m³]	Inflow [l/s]
Jan	13 376	0	0	0	0	0	0.0
Feb	1 368	0	0	0	0	0	0.0
Mar	7 372	0	0	0	0	0	0.0
Apr	15 960	2 204	0	2 204	0	2 204	0.9
May	18 088	32 832	0	148 200	0	148 200	55.3
Jun	0	26 712	16 027	10 685	10 685	0	0.0
Jul	0	129 837	77 902	51 935	24 903	27 032	10.1
Aug	0	32 376	19 426	12 950	12 950	0	0.0
Sep	0	51 224	30 734	20 490	11 689	8 801	3.4
Oct	10 868	5 928	0	5 928	0	5 928	2.2
Nov	20 672	7 904	0	7 904	0	7 904	3.0
Dec	27 664	0	0	0	0	0	0.0
Year	**115 368**	**289 018**	**144 090**	**260 296**	**60 227**	**200 069**	**6.3**

Table 4-28 : Wet Year – Howse Mine Pit (76 ha)

Month	Snowfall [m³]	Rainfall [m³]	Infiltration [m³]	Net Runoff [m³]	Evapo-transpiration [m³]	Inflow [m³]	Inflow [l/s]
Jan	47 424	0	0	0	0	0	0.0
Feb	46 816	0	0	0	0	0	0.0
Mar	77 444	152	0	152	0	152	0.1
Apr	32 072	45 752	0	45 752	0	45 752	17.7
May	19 760	55 556	0	415 872	0	415 872	155.3
Jun	0	62 548	37 529	25 019	25 019	0	0.0
Jul	0	113 620	68 172	45 448	27 477	17 971	6.7
Aug	0	58 411	35 046	23 364	19 626	3 738	1.4
Sep	1 824	76 380	46 922	31 282	12 897	18 384	7.1
Oct	49 248	16 188	0	16 188	0	16 188	6.0
Nov	48 108	0	0	0	0	0	0.0
Dec	39 444	0	0	0	0	0	0.0
Year	**362 140**	**428 607**	**187 670**	**603 077**	**85 020**	**518 057**	**16.4**

5.0 REFERENCES

Maidment (1993): David R. Maidment, Handbook of Hydrology, McGraw-Hill, Inc., ISBN 0-07-039732-5, 1993.

Rollings (1997): Rollings, K., The Hydrology of Labrador, Hydrologic Modelling Section, Water Resources Management Division, Department of Environment and Labour, Government of Newfoundland and Labrador, June 1997.

SNC-Lavalin (2015): SNC-Lavalin, Technical Note, Conceptual Engineering for Howse Water Management Plan, 622834-4000-40ER-0005-03, Nov 2015.

SNC-Lavalin (2016): Technical Memorandum, Hydrogeology Modeling for the Howse Deposit – Scenario of Wet and Dry Years, Report no. 636981, March 2016.