

Annexe XII

Gestion des eaux de surface sur le site minier (EXP, 2019)

(Documents Hatch : E357755-EXP-228-230-0003 et E357755-EXP-228-230-0005)

Moblan Lithium mine site: Site Surface Water Management

Executive Summary

Projet n° : GAT-000247883-10

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Date : 2019-02-12

The study is based on information provided by other consultants retained by Neotech Lithium-Québec, namely,

- Process plant global water balance flowchart from DRA-METCHEM;
- Sizing of the hydraulic retention pond at the process plant site from DRA-METCHEM;
- General site layout and preliminary design of the TSF from Exp geotechnical team;
- Preliminary results of groundwater modeling from Exp geotechnical team

The main objective of the prefeasibility study is to propose potential sources of water supply for the process plant and to identify points of discharges to the environment, based on "Directive 019" for Mining and the "Guide for stormwater management" from the Quebec Ministry of Environment. More specifically, water balance analysis is performed on the Tailing Storage Facility (TSF) reclaim pond, the process plant retention pond as well as the natural ponds P1 and P2, as there have been preliminarily identified as the potential water supply sources.

In a mine site, surface runoffs can be divided in two categories: Contaminated and non-contaminated. The design of the non-contaminated runoff drainage systems should respect the requirements and follow the recommendations in "Guide de gestion des eaux pluviales". The design of the contaminated runoff drainage systems should respect the requirements of "Directive 019 sur l'industrie minière".

According to Directive 019, a retention pond must be provided for contaminated runoffs. The volume of the retention pond must be enough to retain 24 hours of rainfall of a critical event plus 30 days of snowmelt. The quantity of snow corresponds to a recurrence period of 100 years. A factor of augmentation of 20% is applied to the calculated rainfall intensity to consider the effect of climate change, as directed in Directive 19 and "Guide de Gestion des Eaux Pluviales" from MDDELCC. The design 100-year 24-hr rainfall depth is estimated at 114 mm.

The snowmelt volume is estimated based on the following data and assumptions:

- The maximum snow accumulation depth in April observed at the Chibougamau-Chapais station is 898 mm;
- The snow accumulated on ground in April will melt in 30 days.
- The snow to water ratio is 10%
- The observed maximum depth of snow accumulated on ground at Chibougamou-Chapisi airport station 898 mm. The equivalent water depth of 30-day snowmelt is estimated at 89.8 mm

Calculations of surface runoff and snowmelt volume

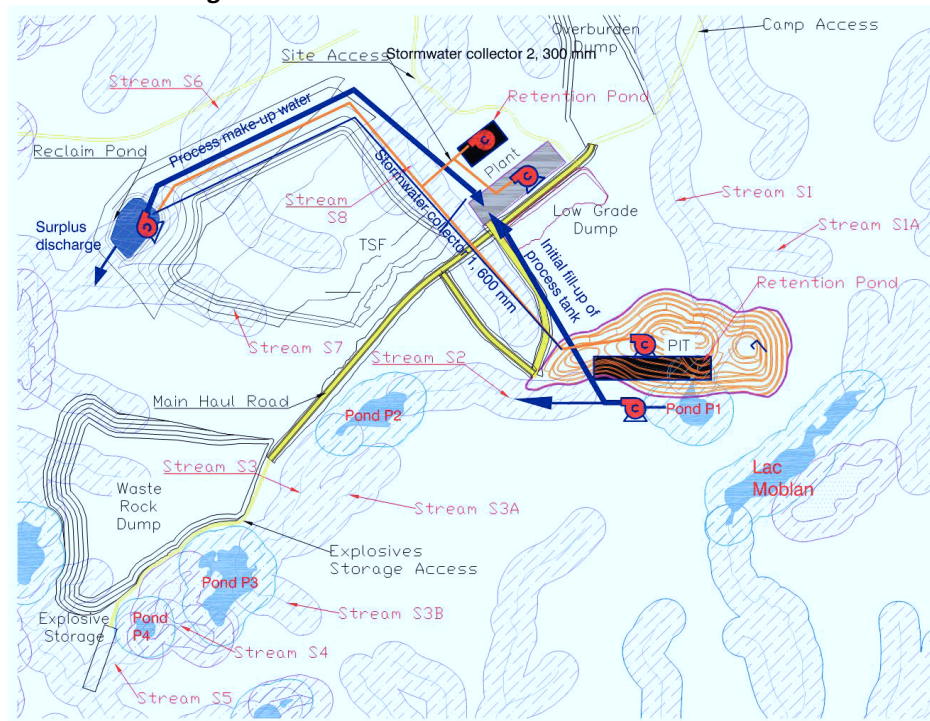
Description	TSF	Mine pit	Process plant
Catch basin area	59.5	30.9	9.6124
Runoff coefficient	0.82	0.82	0.82
100-yr 24-hr rainfall depth	114	114	114
30-day snowmelt	89.8	89.8	89.8
Volume of retention ponds	109 173	56 697	17 637

Based on the above recommendations, the list of required water infrastructure is presented below. The estimation is based on the preliminary information that are available at the time of this prefeasibility. Estimated cost for the following works will be precised at Design stage.

	Works	Description	Preliminary Design criteria	Estimated cost
A	Pumping station and pipe from Pond #P1 to Process plant and to the fire water tank	Initial fillup of the process tank Initial fillup of the fire water tank	Pump capacity: - Flow: 5000 m ³ /d (58 L/s) - Head: 15 m approx. Forcemain: - 250 mm dia. - 1200 m approx. Equipements: - 1 sump 2 m x 3.5 m - 2 submersibles pumps 15 kW approx.	Pumping station: 300 000\$ Forcemain: 1 000 000\$ Total: 1 300 000\$
B	Sormwater collector 1	Main stormwater collector between the pit to the reclaim pond	Gravity pipe Diameter: 600 mm Length: 2000 m With chambers for pipe connection Maximum flow of 12 000 m ³ /d	4 000 000\$
C	Sormwater collector 2	Connect the plant yard retention pond to Collector 1	Gravity pipe Diameter: 300 mm Length: 300 m With chambers for pipe connection Maximum flow of 1500 m ³ /d	300 000\$
D	Process plant retention pond and pumping station	Retention pond With a pumping station to Collector 2.	Retention pond volume: 18 000 m ³ Pump capacity: 2500 m ³ /d	1 500 000\$
E	Mine pit dewatering system including pumping stations.	To pump groundwater from pit dewatering to Collector 1	Pump flow according to the study of Numerical Groundwater Flow Model Pump head according to the actual depth of the dewatering system	The cost of the pumping station is to be gradually increased as the excavation of the pit grows. Pumps from P1 cost can be transferred here so no extra cost should be accounted at this stage.
F	Retention pond and pumping station for mine pit runoff	To pump stormwater from pit to Collector 1	Maintain a hydraulic retention pond of 57 000 m ³ all time at the bottom pof the pit, with a pumping station of 8 000 m ³ /d capacity to send stormwater to Collector 1.	Excavation costs included in mine operation costs. Pumping station to be gradually increased as the mine is excavated.

			Pump head depends on the elevation of the bottom of the pit.	
G	Pumping station from the reclaim pond to process plant	Principal process make-up water supply. To be used for process tank fill up, daily operation makeup.	Pump capacity: - Flow: 450 m ³ /d (5.2 L/s) - Head: 60 m Forcemain: - 75 mm dia. - 2000 m approx. Equipements: - 2 pumps on barge 5 kW	Cost included in the TSF reclaim pond design
H	Pumping station for process plant surplus water to Collector 2	To be used in daily operations, for discharge of process surplus water to the TSF retention pond	Pump capacity: - Flow: 250 m ³ /d (3 L/s) - Head: 5 m Gravity pipe: - 250 mm dia. - 150 m approx. Equipements: 2 lift pumps 0.5 kW	Pumping station: 150 000\$ Forcemain: 100 000\$ Total: 250 000\$

Figure 8-1: Water infrastructures locations on site



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REFERENCE DOCUMENT

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Site Surface Water
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Moblan Lithium mine site: Site Surface Water Management

Final

After comments

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1. Introduction

EXP services Inc has been retained by Neotech Lithium-Québec to perform a general overall surface water balance analysis and management plan, integrating all water use and planned discharges to the environment.

The study is based on information provided by other consultants retained by Neotech Lithium-Québec, namely,

- Process plant global water balance flowchart from DRA-METCHEM;
- Sizing of the hydraulic retention pond at the process plant site from DRA-METCHEM;
- General site layout and preliminary design of the TSF from Exp geotechnical team;
- Preliminary results of groundwater modeling from Exp geotechnical team

All these studies are on-going in parallel with the present study.

The main objective is to propose potential sources of water supply for the process plant and to identify points of discharges to the environment. More specifically, water balance analysis is performed on the Tailing Storage Facility (TSF) reclaim pond as well as the natural pond P1 and P2, as there have been preliminarily identified as the potential water supply sources.

This is a prefeasibility study. The analysis results, conclusions and recommendations are dependant on the findings of the other parallel studies. Assumptions made were specified. Should any of the input information changes, the analysis of the present study should be updated accordingly. It is planned that the design criteria and costs estimation for water supply, pumping stations and treatment units will be updated at a subsequent stage, at the time of preliminary and final design.

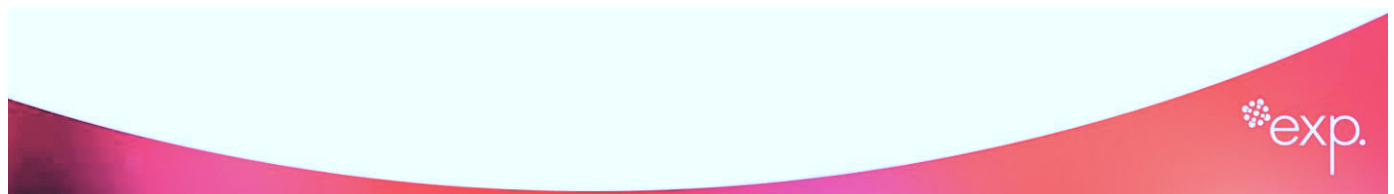
2. Summary description of the development project

The mine site is located approximately 350 km east of the southern tip of James Bay, and 110 km north of Chibougamau-Chapais airport. The site can be accessed by the Route du Nord.

The projected development occupies approximately a surface area of 400 ha. At the heart of the development is an open mine pit. It has been estimated that mining will take place for a period of approximately 12 years. When fully mined, the open pit will occupy a surface area of approximately 30 ha. Other Major constructions of the mine include a process building, a tailing storage facility (TSF), the TSF water reclaim pond, an explosive storage facility, a waste rock dump, a low-grade dump, and an overburden dump site, a worker's camp, and access roads. The preliminary general layout of the site had been prepared by DRA and is attached in Appendix 1.

3. Site hydrological characteristics

For the study, we have received from DRA the CAD drawings of contours and natural aquatic network of the site. Figure 3-1 shows the natural aquatic network of the site. Table 3-1 provides a list of hydraulic elements found on the site.



The mine site is in a mountainous area, with ground elevation varying approximatively between 400 m to 580 m. Due to the reliefs, the catch basins of the ponds are generally characterized by steep slopes and limited surface area. This type of catch basin normally generates higher runoff flow and have less storage capacity comparing to a flat catch basin.

Four natural ponds are found near the open pit and the projected haul road. For discussion, these ponds are identified as P1, P2, P3 and P4, respectively, as shown in figure 3-1. The bathymetry of the ponds is not available. Hatch has provided the following preliminary information:

- Unnamed pond #1 (P1): Area 1.4 ha / Maximum depth 4.2 m / very low potential time of water renewal
- Unnamed pond #2 (P2): Area 1.8 ha / Maximum depth 1.5 m in a very small portion of the pond/ very low potential time of water renewal
- Unnamed pond #6 (P3): Area 3.4 ha / Maximum depth n.a. / low potential time of water renewal

It should be noted that the watercourse off ponds P1 and P2 are intermittent water courses. Furthermore, Pond P2 had been identified by Hatch as a pond that feeds a very sensitive fish habitat including spawning areas.

Information on soil and groundwater of the site are provided by geotechnical study, in summary:

- The subsoil consists of predominantly a silty sand with a trace to some gravel.
- Groundwater was observed at shallow depths ranging from ground surface to about 1.5 m.

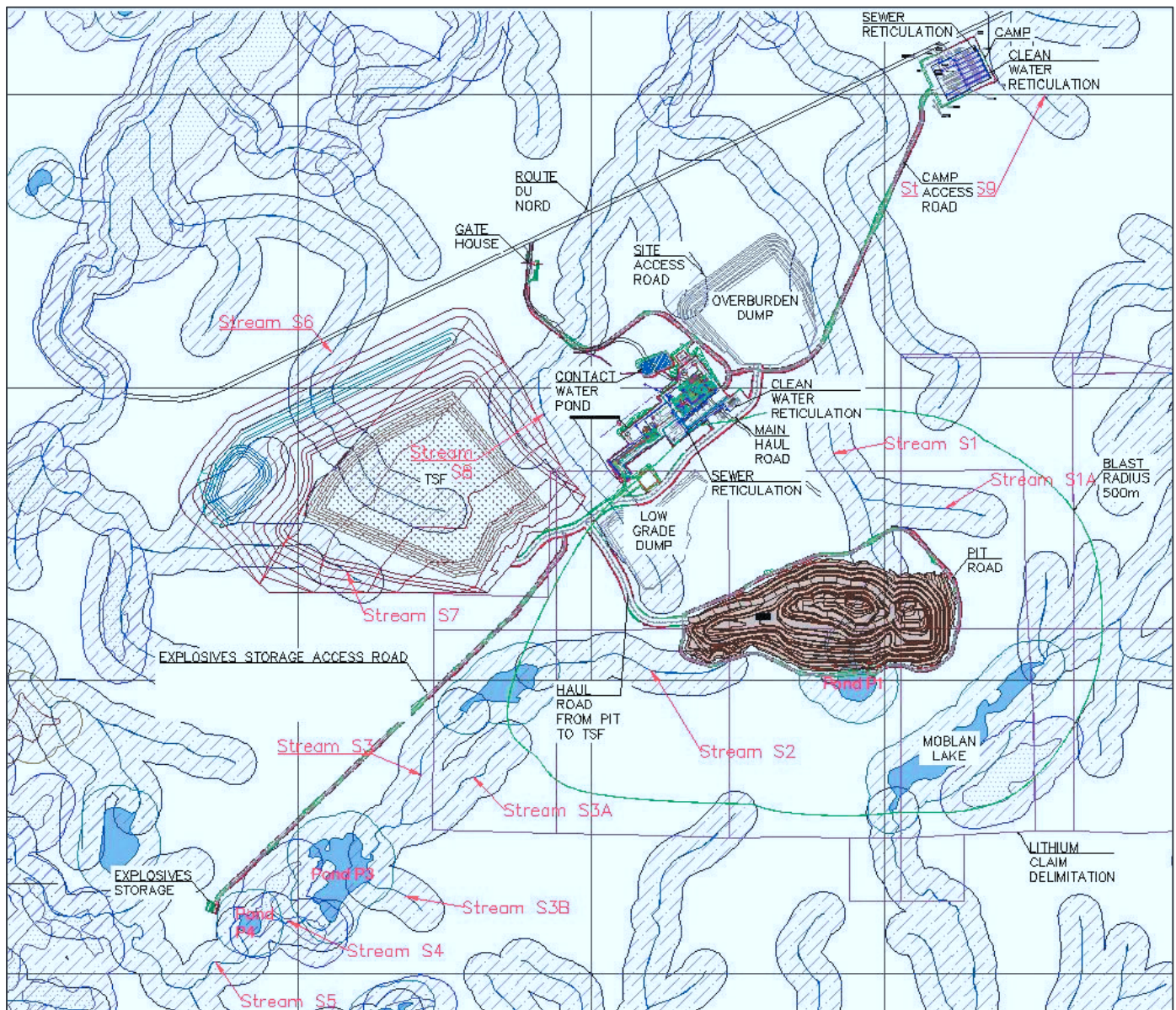


Figure 3-1 Natural aquatic network of the site (from DRA overall site layout drawing # A1-C2781-001-L, dated 2018-12-08)

Table 3-1 List of elements of natural aquatic system on site

Elements	Remarks
Pond P1	Water surface area: 1.4 ha Maximum depth: 4,2 m Catch basin area: 10,7 ha Outfall: Watercourse S1
Pond P2	Water surface area: 1.8 ha Maximum depth: 1.5 m Catch basin area: 30.4 ha Outfall: Watercourse S3
Pond P3	Water surface area: 3.4 ha Catch basin area: 47.7 ha Outfall: Watercourse S4
Pond P4	Information not available
Stream S1	Watercourse. Outfall of Pond P1
Stream S1A	Intermittent watercourse. Branch of S1
Stream S2	Intermittent watercourse.
Stream S3	Watercourse. Links P2 and P3
Stream S3A	Intermittent watercourse. Branch of S3
Stream S3B	Intermittent watercourse. Tributary to P3
Stream S4	Watercourse. Links P3 and P4
Stream S5	Watercourse. Outfall of pond P4
Stream S6	Watercourse. Outfall of TSF site
Stream S7	Watercourse. Outfall of TSF site
Stream S8	Intermittent watercourse
Stream S9	Watercourse. Next to the worker's camp

4. Meteorological data

Water balance analysis of a watershed requires long-term meteorological data such as rainfall and evapotranspiration. We have obtained daily meteorological data observed at Chibougamau-Chapais Airport station from 1982 to 2018, including rainfall, snowfall, temperature. The study assumes that these data apply to the mine site without need for any adjustment. Figures 4-1 to 4-3 show monthly statistics of these available meteorological data. Table 4-1 shows statistics of monthly and annual precipitation.

Site specific evapotranspiration data are not available. For the study, evaporation amount is estimated based on the following references:

- Hydrological atlas of Canada/Mean Annual Lake Evaporation
- Étude de l'évaporation nette du reservoir de l'Eastmain 1, Hydro Review – Juin 2014

Based on the Mean Annual Lake Evaporation atlas, the annual evaporation of the site is estimates at 350 mm. It is assumed that this annual evaporation amount applies to the entire catch basin of the ponds, including the pond and the land. It is further assumed that the monthly variation of evaporation follows the pattern as shown in Table 4-2. The variation pattern has been established based on the observed data presented in Étude de l'évaporation nette du reservoir de l'Eastmain 1, Hydro Review – Juin 2014. The Eastmain 1 reservoir is located at the perimeter of James Bay, approximatively 350 km west of the mine site and at the same altitude.

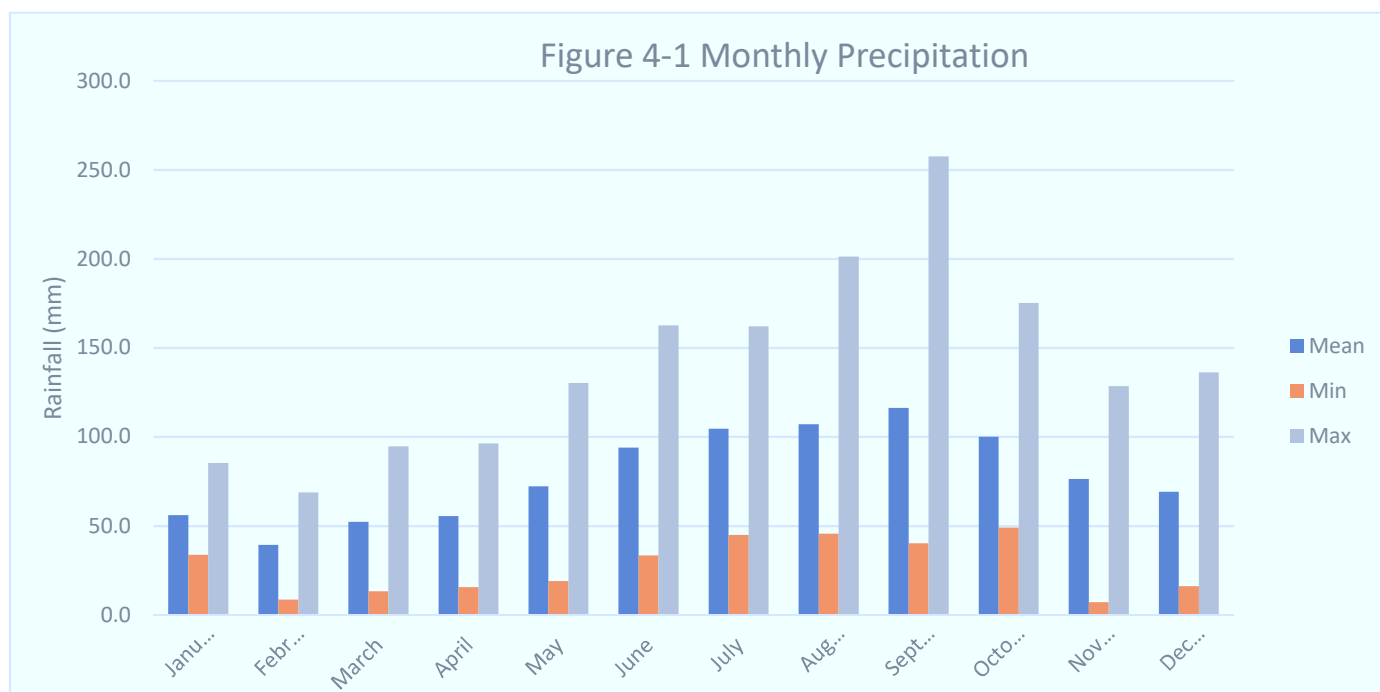


Figure 4-2 Monthly Temperature

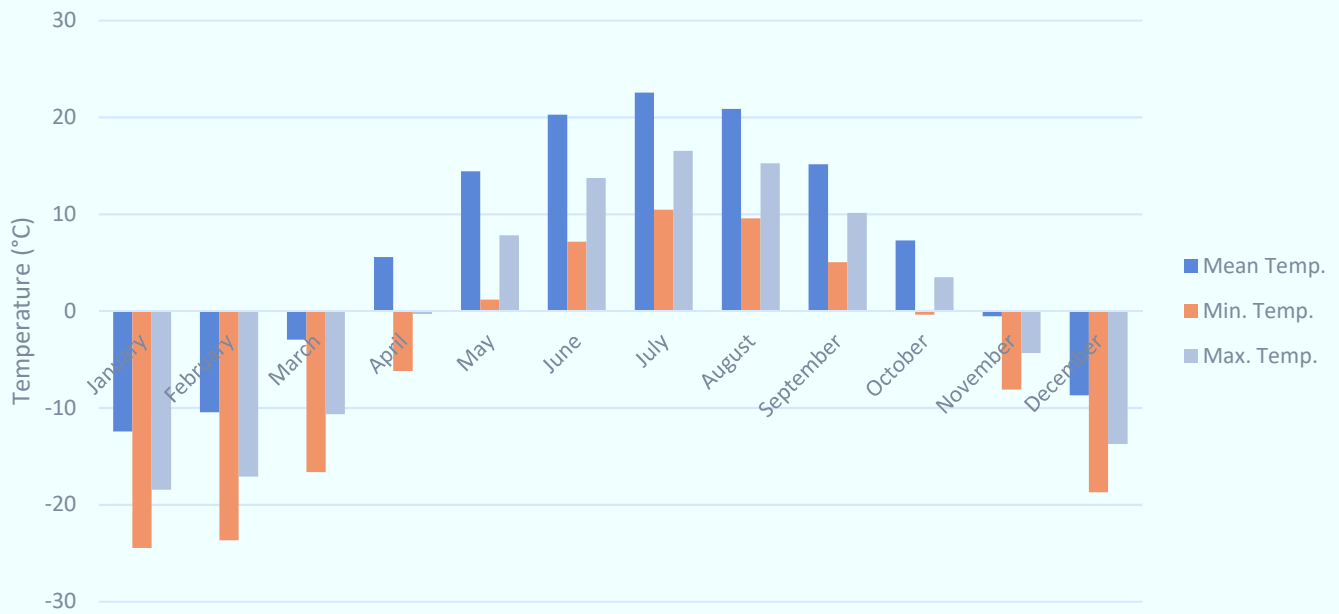


Figure 4-3 Snow on ground

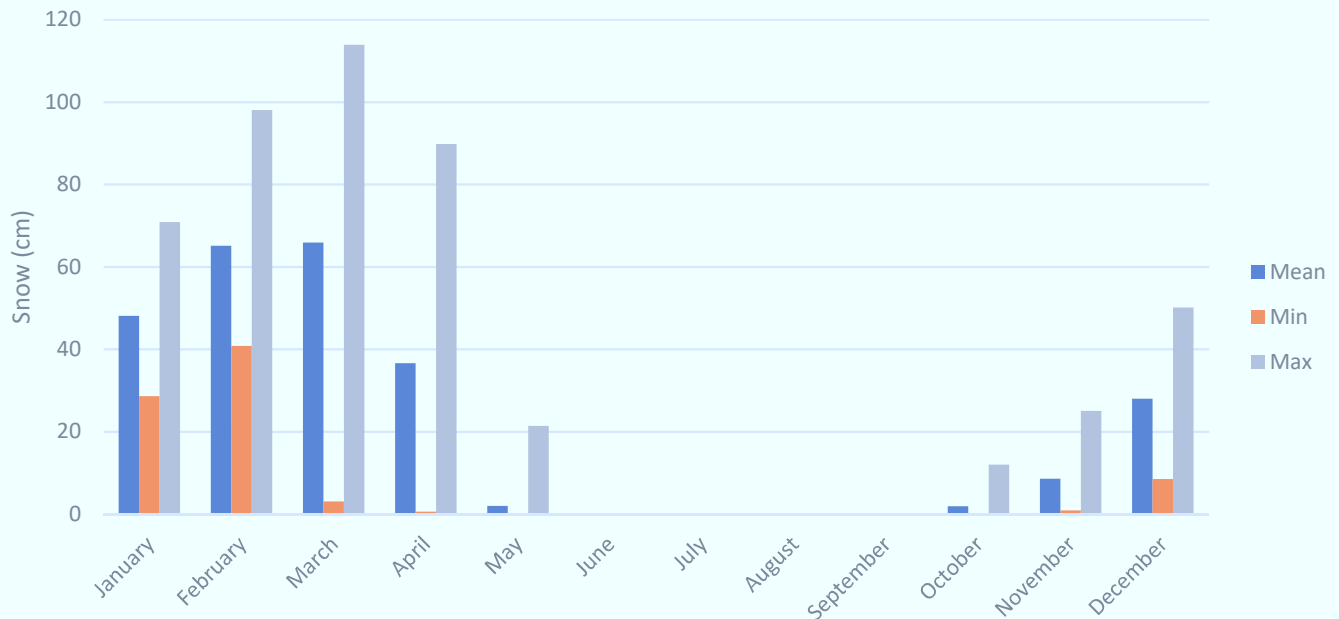


Table 4-1 Monthly and annual precipitation

Period	Moy (mm)	Min (mm)	Max (mm)
January	72	19	130
February	94	33	163
March	105	45	162
April	107	46	201
May	116	40	258
June	100	49	175
July	76	7	129
August	69	16	136
September	56	34	85
October	39	9	69
November	52	13	95
December	55	16	96
Annual	949	725	1,192

Table 4-2 Monthly and annual evaporation

Period	#days	Factor variation	Evaporation (mm)
January	31	1.0%	3.5
February	28	1.0%	3.5
March	31	2.0%	7.0
April	30	4.5%	15.8
May	31	9.5%	33.3
June	30	15.0%	52.5
July	31	18.5%	64.8
August	31	18.0%	63.0
September	30	13.5%	47.3
October	31	9.5%	33.3
November	30	5.5%	19.3
December	31	2.0%	7.0
Annual	365	100%	350

5. Water balance analysis

Water balance analyses are performed on the potential water supply sources: the TSF reclaim pond, and ponds P1 and P2. The purpose of the analysis is to verify the availability and sustainability of the potential water supply sources. The analyses estimate water yield of a given watershed over a long-time interval (monthly or annual). Water yield is the net amount of water flowing past a given point on a stream during a given period. Water yield can be described by a basic water balance equation:

$$Q = P + I - ET - G - dS - D$$

Where: Q = streamflow
P = precipitation
I = import of water into the watershed
ET = evapotranspiration
G = net export of ground water
dS = change in storage
D = diversions out of the watershed

The water balance terms for the study are described below.

5.1 Precipitation (P)

Monthly precipitation statistics area used for the analysis. The statistics are calculated based on observed daily data at Chibougamau-Chapais Airport station for the period of 1982 to 2018. Data from 1993 to 2004 are missing. Data of the years of 1982, 1992, 2005 and 2017 are incomplete.

For the study, we have made the following assumptions:

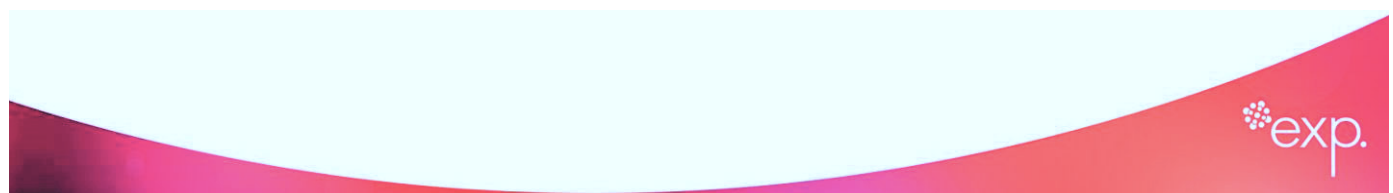
- Precipitation falls uniformly over the site with no spatial variation.
- Considering the effect of ice cover of the ponds, it is assumed that no precipitation will contribute to the ponds during the period of December to March.
- At the end of winter season (April), 10% of the snow depth on ground is converted to water.

5.2 Evapotranspiration (ET)

As described in section 4, monthly evaporation data are estimated using Hydrological atlas of Canada/Mean Annual Lake Evaporation Site and data from a site study at the Eastmain 1 reservoir of Hydro Quebec.

Due to the limited availability of data, the estimated monthly average evaporation data will be used for the analysis.

It is assumed that the estimated monthly average evaporation amount applies to all types of surfaces of the entire watershed, including water surface, forest, peatland, and soil.



5.3 Net export of ground water (G)

At the time of preparation of the report, subsoil characteristics of the bottom of the ponds is unknown. Boring tests at other locations of site indicate that the groundwater table is near soil surface. For the analysis, the net export of ground water (G) is omitted.

5.4 Change in moisture storage (dS)

For the study, moisture storage in plant surfaces, soil depression and soil moisture are neglected. Change in storage in the ponds is assumed to be zero if the resulting discharge is positive. In case the resulting discharge is negative. Water will be drawn from the tank. It is assumed that the maximum volumes of ponds P1 and P2 are respectively 19200 m³ and 9000 m³, as described in section 4.

5.5 Diversions out of the watershed (D)

For the ponds P1 and P2, the term Diversions out of the watershed (D) is neglected. For the TSF, D is equal to the negative value of total volume of the tailing moisture and the surplus from the process water tank.

5.6 Water balance analysis

The water balance analyses are shown in tables 5-1 to 5-3. We obtain the following preliminary conclusion based on the water balance analysis.

The TSF reclaim pond receives runoffs from the TSF, the process plant yard and the mine pit, as well as groundwater from the pit dewatering. Runoff of the TSF flows to the reclaim pond by gravity. The mine pit and the process plant yard are each equipped with a dedicated retention pond. Stormwater collected in the retention ponds is pumped to the reclaim pond. The table 5-1 shows that in an average year, the reclaim pond will discharge an average of approximately 1 756 m³/d plus the flow of mine dewatering, which varies from 45 m³/d in Year 1 to 1186 m³/d in Year 12 (See table 5-1a). However, in extreme dry summer months, evaporation will exceed precipitation. In this case, the process plant will have to use the reserve in the reclaim pond for the make-up water. It is estimated that in the extreme dry month, the plant may have to draw approximately 16 300 m³ of water from the reclaim pond for its need of make-up water.

For pond P1 catch basin, the average daily runoff will be approximately 176 m³/d. However, in dry summer months, evaporation will exceed precipitation, there will be no runoff. The result is consistent with that fact that the outfall of pond P1 is an intermittent watercourse. On the other hand, in a wet month, average daily runoff may reach as high as 750 m³/d.

For pond P2 catch basin, the average daily runoff will be approximately 500 m³/d. However, in dry summer months, evaporation will exceed precipitation, there will be no runoff. The result is consistent with that fact that the outfall of pond P2 is an intermittent watercourse. On the other hand, in a wet month, average daily runoff may reach as high as 2100 m³/d.

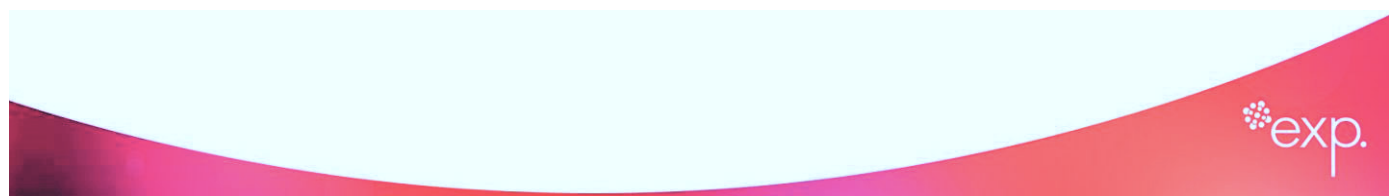


Table 5-1 Water balance analysis – TSF Reclaim pond

Month	#days	Précipitation			Snowmelt (mm)	Evaporation (mm)	Tailing moisture (m³/d)	Process surplus (m³/d)	Pit dewatering (m³/d)	Process make-up (m³/d)	Discharge		
		Avg. (mm)	Wet (mm)	Dry (mm)							Avg. (m³/d)	Wet (m³/d)	Dry (m³/d)
January	31	56.0	85.4	33.8		3.5	336	223	See Table 5-1a	-444	1810	2757	1093
February	28	39.3	68.8	8.6		3.5	336	223		-444	1395	2447	297
March	31	52.3	94.6	13.2		7.0	336	223		-444	1578	2941	315
April	30	55.5	96.2	15.6	36.6	15.8	336	223		-444	2659	4017	1330
May	31	72.2	130.3	19.1		33.3	336	223		-444	1373	3246	-342
June	30	94.0	162.6	33.4		52.5	336	223		-444	1500	3785	-522
July	31	104.5	162.0	44.9		64.8	336	223		-444	1398	3252	-525
August	31	107.0	201.2	45.6		63.0	336	223		-444	1536	4574	-446
September	30	116.2	257.5	40.2		47.3	336	223		-444	2413	7124	-120
October	31	100.0	175.2	49.0		33.3	336	223		-444	2268	4695	623
November	30	76.4	128.5	7.1		19.3	336	223		-444	2021	3757	-290
December	31	69.2	136.2	16.2		7.0	336	223		-444	2121	4283	412
Annual	365	949	1192	725		350	336	223	45 to 1186	-444	1756	2423	1144
Basin area													
- TSF	59.5	ha											
- Mine Pit	30.9	ha											
- Process plant	9.6	ha											
- Total	100	ha											

Table 5.1a - Estimated flow of mine dewatering*

Year 1	45	m³/d
Year 2	137	m³/d
Year 3	262	m³/d
Year 4	378	m³/d
Year 5	509	m³/d
Year 6	598	m³/d
Year 7	669	m³/d
Year 8	805	m³/d
Year 9	989	m³/d
Year 10	1104	m³/d
Year 11	1163	m³/d
Year 12	1186	m³/d

*Based on the preliminary results of Numerical Groundwater Flow Model

Table 5-2 Water balance analysis – Pond P1

Month	#days	Précipitation			Snowmelt (mm)	Evaporation (mm)	Runoff		
		Avg. (mm)	Wet (mm)	Dry (mm)			Avg. (m³/d)	Wet (m³/d)	Dry (m³/d)
January	31	-	-	-	36.6	3.5	-	-	-
February	28	-	-	-		3.5	-	-	-
March	31	-	-	-		7.0	-	-	-
April	30	55.5	96.2	15.6		15.8	272	417	130
May	31	72.2	130.3	19.1		33.3	135	335	-49
June	30	94.0	162.6	33.4		52.5	148	393	-68
July	31	104.5	162.0	44.9		64.8	137	336	-69
August	31	107.0	201.2	45.6		63.0	152	477	-60
September	30	116.2	257.5	40.2		47.3	246	750	-25
October	31	100.0	175.2	49.0		33.3	230	490	54
November	30	76.4	128.5	7.1		19.3	204	390	-43
December	31	-	-	-		7.0	-	-	-
Annual	365	949.0	1192.4	725.4		350	176	247	110
Catch basin:	10.7	ha							

Table 5-3 Water balance analysis – Pond P2

Month	#days	Précipitation			Snowmelt (mm)	Evaporation (mm)	Runoff		
		Avg. (mm)	Wet (mm)	Dry (mm)			Avg. (m³/d)	Wet (m³/d)	Dry (m³/d)
January	31	-	-	-	36.6	3.5	-	-	-
February	28	-	-	-		3.5	-	-	-
March	31	-	-	-		7.0	-	-	-
April	30	55.5	96.2	15.6		15.8	773	1186	369
May	31	72.2	130.3	19.1		33.3	382	952	-139
June	30	94.0	162.6	33.4		52.5	421	1116	-194
July	31	104.5	162.0	44.9		64.8	390	954	-195
August	31	107.0	201.2	45.6		63.0	432	1355	-171
September	30	116.2	257.5	40.2		47.3	699	2131	-71
October	31	100.0	175.2	49.0		33.3	654	1392	154
November	30	76.4	128.5	7.1		19.3	579	1107	-123
December	31	-	-	-		7.0	-	-	-
Annual	365	949.0	1192.4	725.4		350	499	702	313
Catch basin:	30.4	ha							

It is assumed that during the ice-cover period (December to March), precipitation will not contribute to the ponds. Process water demand may have to be satisfied by the storage of the ponds. It would be necessary to perform a bathymetry survey of the ponds in a future study, mostly to confirm the volume of pond P1.

We consider that ponds water quality in Total Solids is better than that of the reclaim pond discharge. We then recommend using the pond water for initial fill up of the process plant, and more importantly for fire protection. It is important to limit the use of water from pond P2 for only emergency situations, as the pond feeds a very sensitive fish habitat including spawning areas.

6. Management of Surface Runoffs

In a mine site, surface runoffs can be divided in two categories: Contaminated and non-contaminated.

The design of the non-contaminated runoff drainage systems should respect the requirements and follow the recommendations in "Guide de gestion des eaux pluviales". The design of the contaminated runoff drainage systems should respect the requirements of "Directive 019 sur l'industrie manière".

The study includes catch basins that are part of the mine's water supply scheme. These include the TSF, the mine pit, the pond P1 and the process plant yard. Runoffs to the pond P1 are considered non-contaminated. Runoffs from the other three catch basins are considered contaminated.

According to Directive 019, a retention pond must be provided for contaminated runoffs. The volume of the retention pond must be enough to retain 24 hours of rainfall of a critical event plus 30 days of snowmelt. The quantity of snow corresponds to a recurrence period of 100 years.

6.1 Summary description of the surface runoff management system

It has been proposed by the hydrogeological study to construct a reclaim pond at the TSF site. All contaminated surface runoff, process plant surplus water, as well as groundwater from the open pit dewatering will be sent to this reclaim pond. The supernatant of the reclaim pond will be recirculated back to the process plant as process make-up water. The surplus portion of the supernatant will be discharged to the environment (Stream S7).

More specifically, the reclaim pond will receive water from the following sources:

- **Surface runoff of the TSF;**
- **Stormwater from the process plant yard.** DRA has foreseen a retention pond at the process plant yard, which is sized for 100-year rainfall event. Water from the retention pond should be pumped to the reclaim pond at a flowrate of 2 500 m³/d (to empty the full retention basin in 7 days);
- **Water accumulated in the retention pond at the bottom of the mine pit.** It is proposed to maintain a retention pond at the bottom of the pit to collect the runoffs. Water from the retention pond will also be pumped to the reclaim pond at a flowrate of 8 000 m³/d;
- **Groundwater collected by the pit dewatering system.** The flow varies from 45 m³/d in Year 1 to 1186 m³/d in Year 12;
- **Process plant surplus water,** evaluated to be 223 m³/d by DRA.

Per requirement of Directive 019, the retention ponds will be sized for 100-year rainfall, plus 30 days of snowmelt volume. The stormwater sewers shall also be designed for 100-year rainfall.

The reclaim pond discharge water shall meet the quality requirement of Directive 019 (Tableau 2.1). The quality parameters include suspended solids, hydrocarbon, total cyanide, and some metals. At the time of the study, water quality of the contaminated runoffs is unknown. The reclaim pond provide a settling treatment for reduction of suspended solids. Additional treatment may be required should runoff water characteristics become available.

The natural pond P1 is an integral part of the water balance system, in that:

- The pond water will be used for initial fill-up of the process water tank as well as the fire protection water tank;
- The pond will be eventually be dried off and cut off from its actual outfall (Stream S1) as the excavation of the mine pit evolves.

It is proposed to install a pumping station for the initial fill up of the process water tanks and the fire water tank, as well as for transfer the pond water to stream S2.

6.2 Design rainfall intensity and snowmelt volume

Design rainfall intensities are calculated using the following IDF equation:

$$\text{Rainfall Intensity, } I \text{ (mm/h)} = a / (tc + b)^c$$

The IDF equation parameters are presented in table 6-1.

Table 6-1 IDF parameters (Chibougamau-Chapais station)

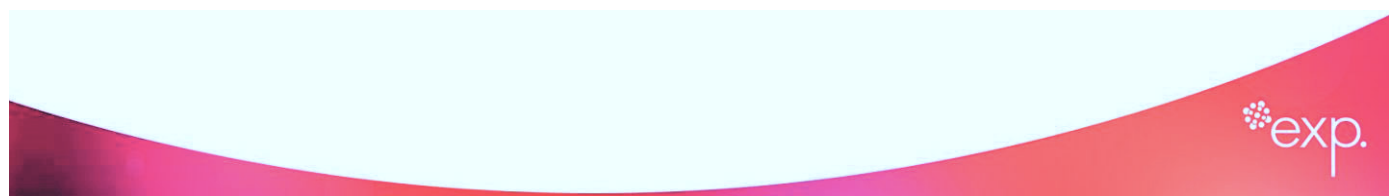
Parameter	2 yr	5 yr	10 yr	25 yr	100 yr
- IDF parameter, a	373.71	461.22	521.86	598.16	704.04
- IDF parameter, b	3.0	2.1	1.8	1.5	1.1
- IDF parameter, c	0.726	0.719	0.717	0.714	0.710

A factor of augmentation of 20% is applied to the calculated rainfall intensity to consider the effect of climate change, as directed in Directive 19 and “Guide de Gestion des Eaux Pluviales” from MDDELCC. The design 100-year 24-hr rainfall depth is estimated at 114 mm.

The snowmelt volume is estimated based on the following data and assumptions:

- The maximum snow accumulation depth in April observed at the Chibougamau-Chapais station is 898 mm;
- The snow accumulated on ground in April will melt in 30 days.
- The snow to water ratio is 10%

The observed maximum depth of snow accumulated on ground at Chibougamau-Chapais airport station 898 mm. The equivalent water depth of 30-day snowmelt is estimated at 89.8 mm



6.3 Calculations of surface runoff and snowmelt volume

Table 6-2 shows a summary of the calculations of surface runoff and snowmelt volume. The recommended minimum volumes for the retention ponds are:

- For TSF: 109 173 m³
- Mine pit: 56 697 m³
- Process plant yard: 17 673 m³

In the calculations for the mine pit, it is assumed that for the life of mine (LOM) of twelve (12) years, the proposed pit excavation stages with increasing pit depth over the entire area of the mine.

Table 6-2 Calculations of surface runoff and snowmelt volume

Description	TSF	Mine pit	Process plant
Catch basin area	59.5	30.9	9.6124
Runoff coefficient	0.82	0.82	0.82
100-yr 24-hr rainfall depth	114	114	114
30-day snowmelt	89.8	89.8	89.8
Volume of retention ponds	109 173	56 697	17 637

6.4 Calculations of runoffs of the catch basin of Pond P1

The runoffs of the catch basin of Pond P1 are considered non-contaminated. The pond water will be used for initial fill-up of the process water tank as well as the fire protection water tank. It had been decided that the fill-up time should be within 24 hours.

The pond will be eventually cut off from its actual outfall (Stream S1) as the excavation of the mine pit evolves. According to the preliminary results of Numerical Groundwater Flow Model, the pond P1 could be completely drained after the first year of excavation of the pit.

We proposed to install a temporary pumping station of 5000 m³/d (0.058 L/s) capacity. The pumping station will have dual purposes of,

- Initial fill-up of the process water tank and the fire water tank;
- Transfer the pond water to the stream S2 if the pond is cut off from its natural outfall. In this case, the pond P1 serves as a hydraulic retention pond for peak runoffs during extreme rainfall events.

Table 6-3 shows the calculations of surface runoffs of the catch basin of Pond P1.

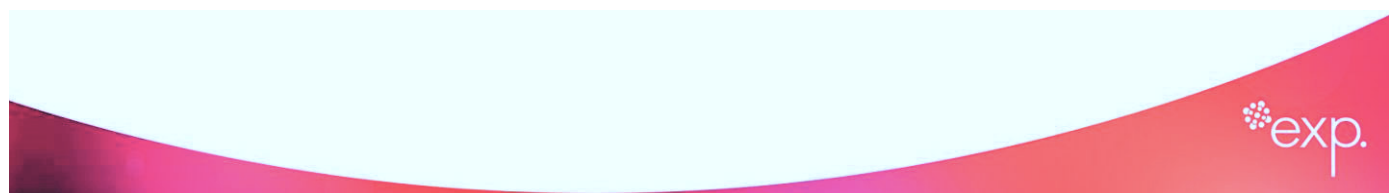


Table 6-3 Calculations of stormwater runoffs of Pond P1

Parameter	2 yr	5 yr	10 yr	25 yr	100 yr	Unit
Catch basin area	11.9					ha
Calculation of time of concentration	$tc = 3.26 (1.1 - C_p) L^{0.5} / S^{0.33}$					
Runoff coef., C_p	0.18					-
Length, L	460					m
Slope, S	19.20%					
Time of concentration, tc	24					min
Rainfall intensity, I	33.9	43.9	50.4	69.4	85.1	mm/h
Runoff, Q	0.20	0.26	0.30	0.41	0.51	m ³ /s

7. Water demand and discharges by the Mine Process plant facilities

7.1 Water demand

Water demands and discharges from the facilities of the mine's process plant has been estimated by DRA. Figure 5-1 shown a plant's water balance flow diagram. The flow diagram shows that, the process plant uses a huge quantity of water (10805 m³/d), and that 96% of the water (10361 m³/d) is recycled. That is, the process plant will require 444 m³/d of makeup water.

In summary, water demands by the process plant are as follows:

- Fresh makeup process water: 444 m³/d (non-potable)
- Drinking water: 28 m³/d (potable)

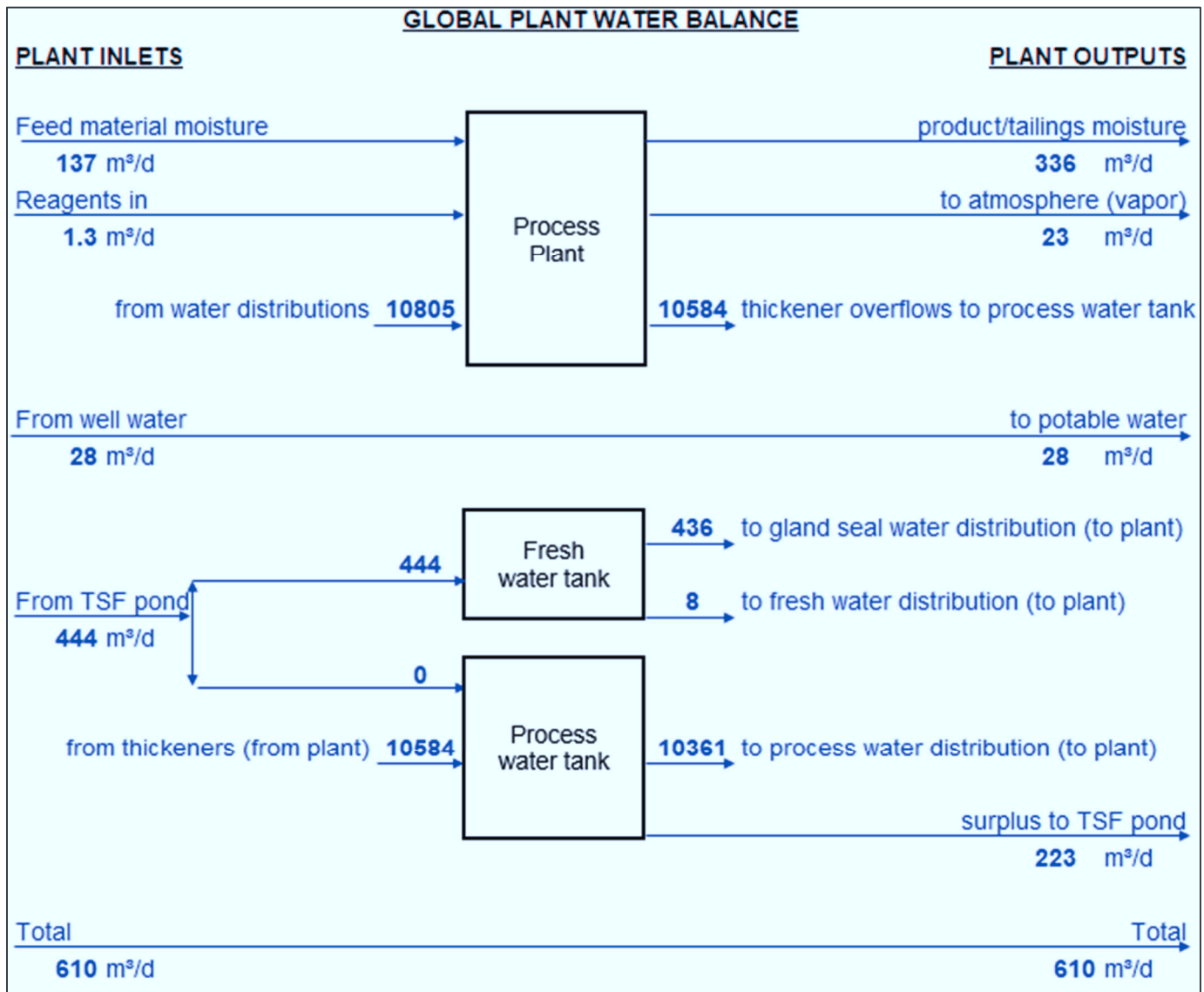


Figure 5-1 Process plant global water balance during operations (by DRA)

Furthermore, it has been established by DRA that an initial water demanded of 5000 m³ will be required to fill up the process water tank for plant start.

Water is also required for **fire protection**. We recommend that the plant be equipped with a fire water tank with fire pumps. The fire water demand should be established by the fire protection professionals. As for the fire water tank, DRA recommended a **fire water tank volume of 1000 m³**, with a fill-up time of 24 hours. We also recommend that the plant be equipped with a separate fire protection network. The fire protection water will be non-potable but should be good quality in terms of suspended solids to avoid pipe clogging after static water sedimentation.

7.2 Discharges

According to the global plant water balance flow chart (Figure 5-1), the total discharge from the facilities will be 610 m³/d. Based on the usage of water, the discharges can be divided into the following categories:

- **Sanitary wastewater discharge** (28 m³/d). It is assumed that the process plant's potable water consumption will be eventually discharged as sanitary wastewater. Sanitary wastewater should be collected by a separate sewer network and be treated by a wastewater treatment system before discharge to environment. This system is planned by DRA.
- **Product/tailing moisture** (336 m³/d). Tailing moisture will be recycled to the plant after treatment. Water balance analysis will be performed for the TSF by considering the amount of tailing moisture.
- The global plant water balance indicates that there will be 223 m³/d of **surplus from the process water tank**. The quality of the discharge is unknown. Considering that the surplus is generated from the process water tank, it is estimated that it will not contain any organic contaminant. For the study, we consider that the surplus water quality is acceptable for reuse after sedimentation. The surplus will be recycled to the TSF retention pond. This flow to the TSF is almost insignificant considering the volume of more than 150 000m³ (to be confirmed in final design stage). The Based on the water balance analysis, it is estimated that hydraulic retention time will be approximatively one month. This option will centralize the "contact water" to one treatment and one discharge point to the environment. This will be the only controlled point by the Ministry of Environment.

The worker's camp will have a separate sanitary wastewater collection and treatment system.

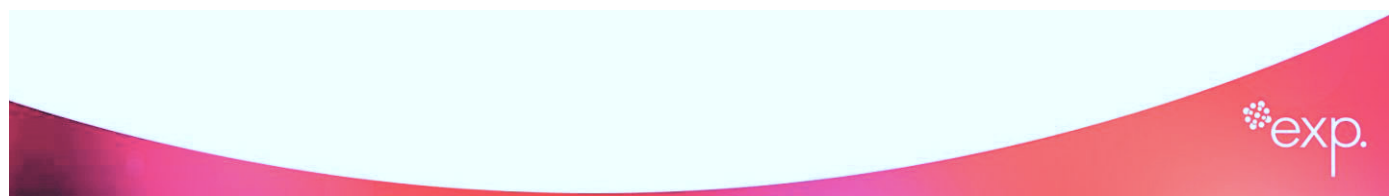
7.3 Potential sources of water supply

It had been determined by DRA that potable water in the plant will be supplied by wells. The total flow of these demands is 28 m³/d. Hydrogeologic report is under completion to confirm the source, quality and volume of potable water for the surrounding well.

The worker's camp, being located outside of the mine site, will have a separate water distribution network. Potable water of the worker's camp will also be drawn from wells. The camp is not included in the scope of the present study.

It was estimated that the ground water on the site may not have enough capacity to satisfy the demand of water by the plant process, especially for the initial demand of 5000 m³. It is therefore desired that the process plant water demand will be supplied by surface water sources.

Water sampling of the natural ponds as well as Moblan Lake has been conducted by Hatch. The analysis results are presented in "Rapport d'échantillonnage des eaux de surface et des sédiments" prepared by Hatch in December 2018. The analysis results demonstrate that water of these natural water bodies is of good quality and is suitable for raw water source to drinking water treatment plant and for fire protection. The quality requirement for the process is 100ppm solids while the surrounding ponds water quality is max 5 ppm. The ponds water quality is very high for process needs and fire protection.



By using the preliminary ponds dimensions presented in section 4, and by assuming that the ponds are of a cone shape, we have primarily estimated the volume of ponds P1 and P2 is respectively 19600 m³ and 9000 m³. It is estimated that the ponds may be covered by 1.5m to 2 m thick of ice during winter. The use of water from pond P2 should be limited to emergency situations only, as the pond feeds a very sensitive fish habitat including spawning areas.

With all these conservative assumptions, we estimate that the pond P1 has enough volume to initially fill up the process tank (5000 m³) as well as the fire water tank (1000 m³).

The make-up water required by process plant will be supplied from the reclaim pond. The reclaim pond receives runoffs from the TSF, the process plant yard and the mine pit, as well as groundwater from the pit dewatering. The water balance analysis demonstrates that, in an average year, the volume of water gained in the reclaim pond exceeds the need for the process's make-up water (444 m³/d). However, in the extreme dry summer months, the losses due to evaporation will surpass the gain from the precipitation. In this case, the process make-up water will have to be drawn from the reserve in the reclaim pond. It is estimated that in an extreme dry month, the plant may have to draw approximately 16 287 m³ of water from the reclaim pond for its need of make-up water.

7.4 Proposed surface water piping system

According to the preliminary design of the reclaim pond, the crest elevation of the dam will be 420 m. The lowest point of the perimeter of the mine pits is approximately 500 m, and the lowest point of the process plant yard is approximately 435 m. Therefore, we propose two gravity stormwater collectors to transport runoffs of these sites to the reclaim pond:

- Collector 1: from the mine pit to the reclaim pond. The proposed pipe is of 600 mm diameter, and the total length is approximately 2 000 m. The collector will receive runoff from the mine pit, the ground water from the pit dewatering. Furthermore, runoffs from the process plant yard will be connected to this collector.
- Collector 2: From the process plant to the collector 1. The proposed pipe is of 300 mm diameter, and the total length is approximately 300 m.

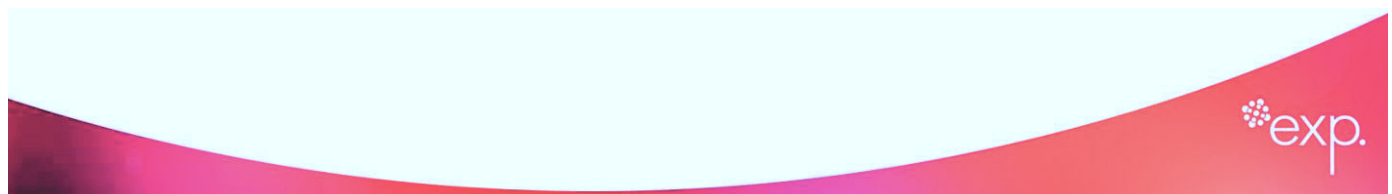
The mine pit

We propose to maintain a hydraulic retention pond at the bottom of the pit. The retention pond will have a volume of 57 000 m³ (See Section 6.3). Runoff water in the retention pond will be lifted to a reception chamber. Groundwater from dewatering of the pit will be collected by a separate collection system (surface ditches) and pumped also to the reception chamber.

The runoff and groundwater from the pit will flow by gravity in Collector 1 to the reclaim pond.

The proposed capacity of the stormwater pump associated with the retention pond is 8 000 m³/d. That is, the retention pond will be emptied in about 8 days. The pump head will vary depending on the elevation of the retention pond.

The process plant yard



Runoffs from the process plant yard is considered contaminated by DRA. It is proposed to install a hydraulic retention pond at the yard. The pond should have a volume of 18 000 m³. Water in the retention pond will be lifted by a pumping station into a reception chamber, from there water will flow in the Collector 2 to joint Collector 1, and eventually to the reclaim pond. The surplus water from the process (223 m³/d) will also be discharge into the reception chamber.

The proposed capacity of the stormwater pump is 2 500 m³/d. That is, the retention pond will be emptied in about 8 days.

The reclaim pond

According the preliminary design of the TSF, the reclaim pond will be constructed with an initial dam alavation 410 m for year 1 and raised to 415 m for year 2. At these levels, the facility will provide a storage volume of 182 184 m³ and 274 695 m³, respectively.

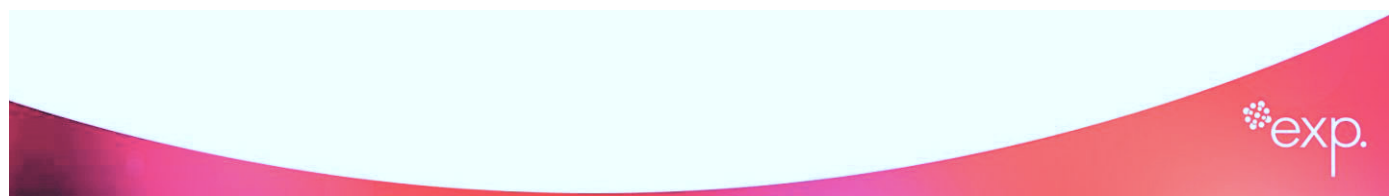
It is proposed to install a make-up water supply pump in the reclaim pond. The pump will have a capacity of 444 m³/d. Surplus from the reclaim pond will overflow to the watercourse S7.

The Pond P1

It is proposed to install a pumping station of 5 000 m³/d capacity at the pond P1,

- to pump water to the process plant for initial fill-up of the process water tank as well as the fire protection water tank;
- to transfer runoff of its catch basin to pond P2 when its natural outfall will be cutoff by the excavation of the pit.

Figure 7-1 shown the flowchart of the proposed surface water management system.



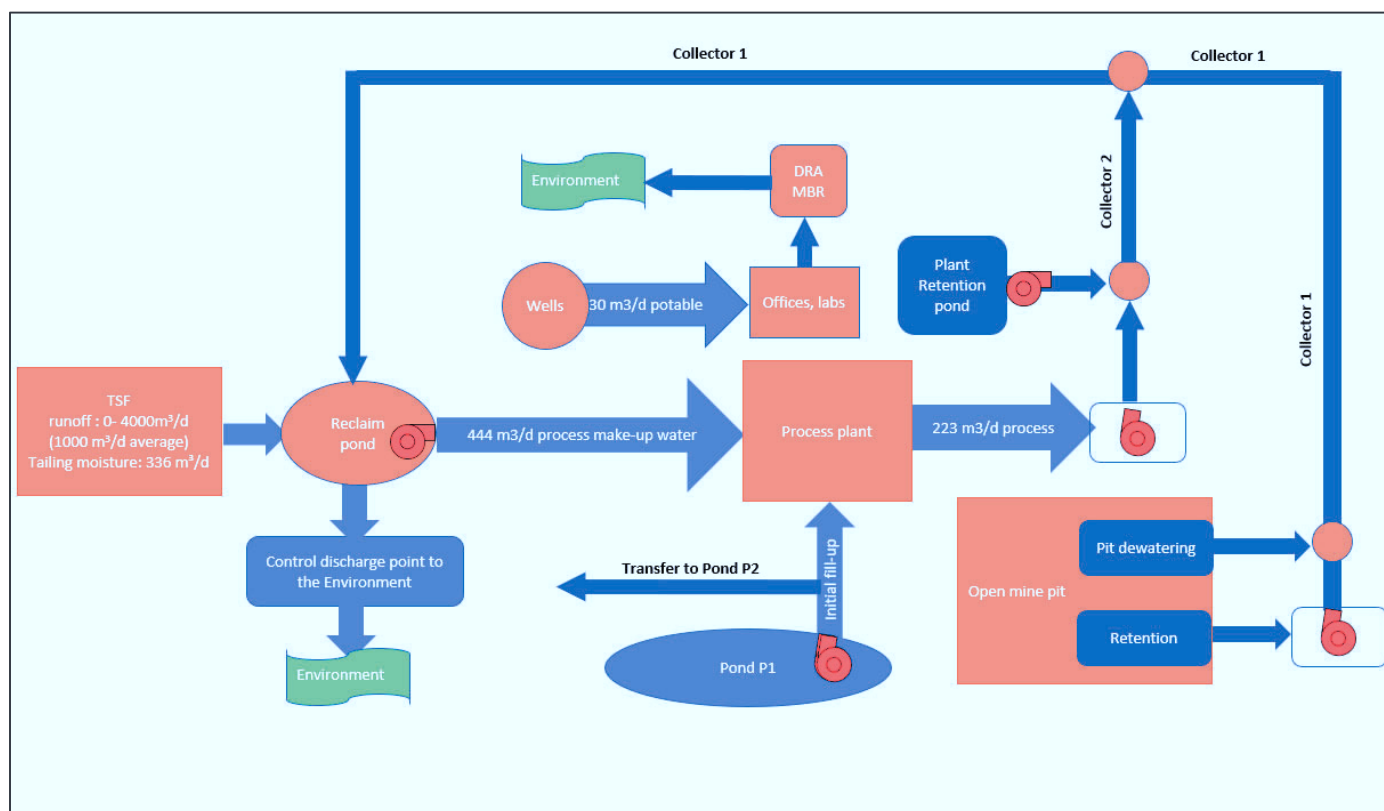


Figure 7-1 Proposed surface water management system

8. Conclusion and recommendations

Based on above data, a summary of sources of recommended water supply and discharge points is provided in the following table:

Water type	Volume or flow	Source/discharge point
Mine Start up phase		
Filling up process plant reservoir	5 000m ³ in 24h	From Pond#1
Filling up Fire protection reservoir	1 000m ³ in 24h	From Pond#1
Mining operation phase: water consumption		
Potable water for plant	28 m ³ /d	From wells
Process water make-up	Required: 415-444 m ³ /d	Water supply source: Reclaim pond
Emergency plant fill up	Required 5000m ³	Water supply source: Reclaim pond
Emergency fire tank fill up	1 000m ³	1 st year: pond P1. 2nd year and beyond: Wells
Mining operation phase: water discharge		
Sanitary wastewater discharge	28 m ³ /d	To DRA sanitary wastewater facility
Daily process water surplus	223 m ³ /d	To be pumped to reclaim pond
Emergency plant complete drainage	5000 m ³ to be drained occasionally	To be pumped to reclaim pond
Reclaim pond discharge	444 m ³ /d to process make-up 1756 m ³ /d to environment (average) plus the flow of pit dewatering	Reclaim pond to process plant/Environment
Surface runoff from the mine pit	To be retained in a hydraulic retention pond of 57 000 m ³ . and then pumped to the reclaim pond at a flow of 8000 m ³ /s	Mine pit to reclaim pond
Mining pit dewatering	Expected underground water to be drained Year 1: 45 m ³ /d Year 2: 137 m ³ /d Year 3: 262 m ³ /d Year 4: 378 m ³ /d Year 5: 509 m ³ /d Year 6: 598 m ³ /d Year 7: 669 m ³ /d Year 8: 805 m ³ /d Year 9: 989 m ³ /d Year 10: 1104 m ³ /d Year 11: 1163 m ³ /d Year 12: 1186 m ³ /d Will be pumped to the reclaim pond at a flow of 45 m ³ /d to 1000 m ³ /d	Mine pit to reclaim pond
Process plant	Surface runoff will be retained in a hydraulic retention pond of 18 000 m ³ , and then pumped to the reclaim pond at a flow of 2500 m ³ /d.	Process plant to reclaim pond

	Process surplus water will be pumped to the reclaim pond	
Mine Closure		
Mine water		Mine will fill up with underground water and excess should drain to natural watercourse

8.1 CAPEX Costs planning

Based on the above recommendations, the list of required water infrastructure is presented below. The estimation is based on the preliminary information that are available at the time of this prefeasibility. Estimated cost for the following works will be precised at Design stage.

	Works	Description	Preliminary Design criteria	Estimated cost
A	Pumping station and pipe from Pond #P1 to Process plant and to the fire water tank	Initial fillup of the process tank Initial fillup of the fire water tank	Pump capacity: - Flow: 5000 m ³ /d (58 L/s) - Head: 15 m approx. Forcemain: - 250 mm dia. - 1200 m approx. Equipements: - 1 sump 2 m x 3.5 m - 2 submersibles pumps 15 kW approx.	Pumping station: 300 000\$ Forcemain: 1 000 000\$ Total: 1 300 000\$
B	Sormwater collector 1	Main stormwater collector between the pit to the reclaim pond	Gravity pipe Diameter: 600 mm Length: 2000 m With chambers for pipe connection Maximum flow of 12 000 m ³ /d	4 000 000\$
C	Sormwater collector 2	Connect the plant yard retention pond to Collector 1	Gravity pipe Diameter: 300 mm Length: 300 m With chambers for pipe connection Maximum flow of 1500 m ³ /d	300 000\$
D	Process plant retention pond and pumping station	Retention pond With a pumping station to Collector 2.	Retention pond volume: 18 000 m ³ Pump capacity: 2500 m ³ /d	1 500 000\$

E	Mine pit dewatering system including pumping stations.	To pump groundwater from pit dewatering to Collector 1	<p>Pump flow according to the study of Numerical Groundwater Flow Model</p> <p>Pump head according to the actual depth of the dewatering system</p>	<p>The cost of the pumping station is to be gradually increased as the excavation of the pit grows.</p> <p>Pumps from P1 cost can be transferred here so no extra cost should be accounted at this stage.</p>
F	Retention pond and pumping station for mine pit runoff	To pump stormwater from pit to Collector 1	<p>Maintain a hydraulic retention pond of 57 000 m³ all time at the bottom of the pit, with a pumping station of 8 000 m³/d capacity to send stormwater to Collector 1.</p> <p>Pump head depends on the elevation of the bottom of the pit.</p>	<p>Excavation costs included in mine operation costs.</p> <p>Pumping station to be gradually increased as the mine is excavated.</p>
G	Pumping station from the reclaim pond to process plant	<p>Principal process make-up water supply.</p> <p>To be used for process tank fill up, daily operation makeup.</p>	<p>Pump capacity:</p> <ul style="list-style-type: none"> - Flow: 450 m³/d (5.2 L/s) - Head: 60 m <p>Forcemain:</p> <ul style="list-style-type: none"> - 75 mm dia. - 2000 m approx. <p>Equipements:</p> <ul style="list-style-type: none"> - 2 pumps on barge 5 kW 	Cost included in the TSF reclaim pond design
H	Pumping station for process plant surplus water to Collector 2	To be used in daily operations, for discharge of process surplus water to the TSF retention pond	<p>Pump capacity:</p> <ul style="list-style-type: none"> - Flow: 250 m³/d (3 L/s) - Head: 5 m <p>Gravity pipe:</p> <ul style="list-style-type: none"> - 250 mm dia. - 150 m approx. <p>Equipements:</p> <p>2 lift pumps 0.5 kW</p>	<p>Pumping station: 150 000\$</p> <p>Forcemain: 100 000\$</p> <p>Total: 250 000\$</p>

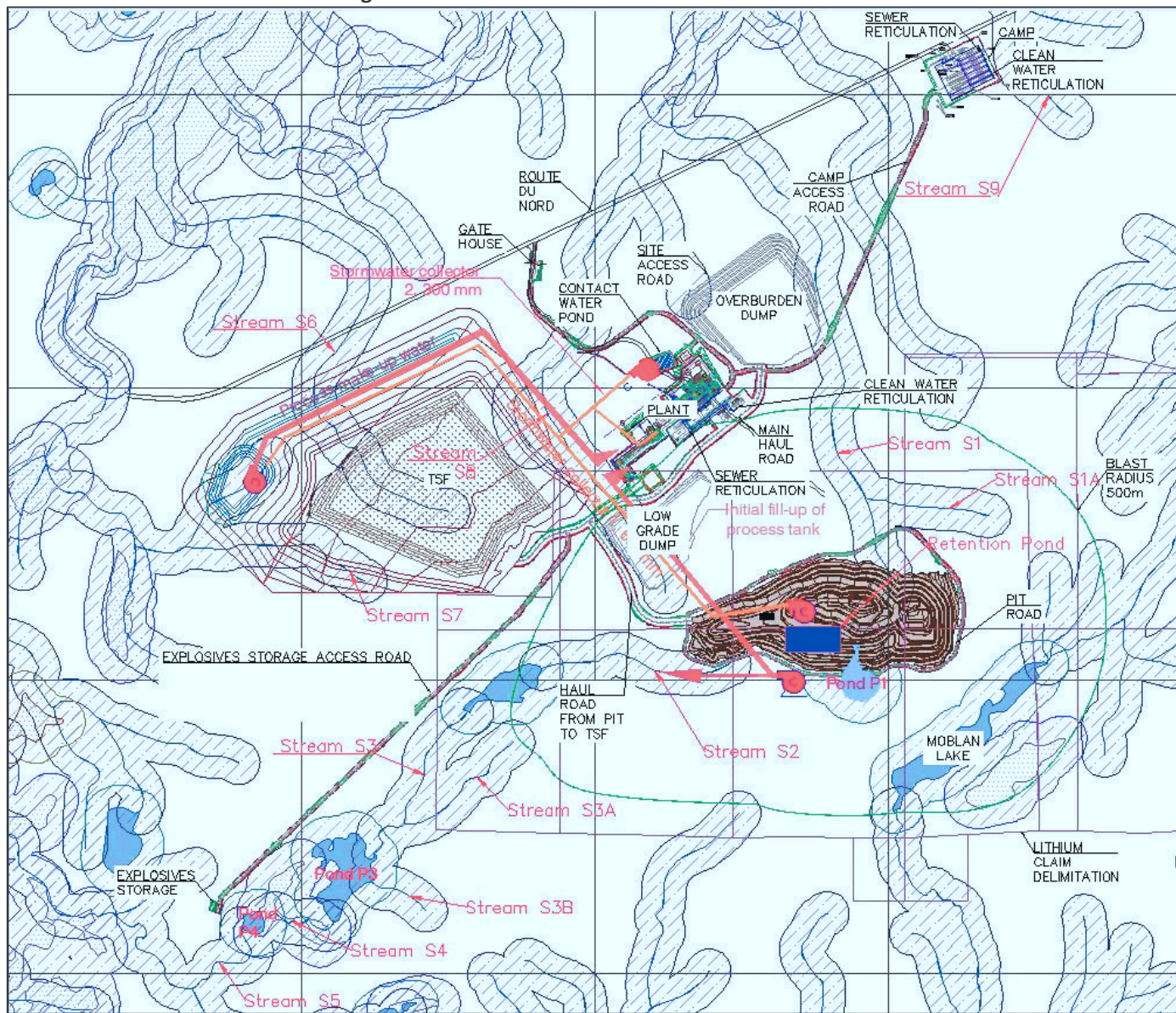
This cost estimation has been based on broad assumption of lengths and pumping requirements.

The next stage is the engineering preliminary design when field survey will confirm structural requirements for the forcemain, exact location and structural foundations of pumping stations, choice of pumps, etc.

Annual operation cost

Annual operation costs is the pumping power supply and operation and maintenance.

Figure 8-1: Water infrastructures locations on site





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