Appendix A
Data Review Findings Technical Memorandum
(Submitted January 30th, 2012)

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Data Review Findings - Draft

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Summary

A review of the Snap Lake WTP influent flow data and water quality data (influent and effluent) was conducted to determine the influent streams that contribute the most to the contaminant loading onto the water treatment plant (WTP). Additionally the WTP effluent water quality data was compared with the current license requirements and proposed future limits to identify the key contaminants of concern and to aid in selecting potential treatment approaches.

While the mine water constitutes the majority of the influent flow entering the WTP, the water management pond (WMP) contains high concentrations of total dissolved solids (TDS), nutrients (i.e. nitrate, nitrite, and ammonia), boron, strontium, chloride, and fluoride. In 2011, the nitrate mass loading from the WMP contributed to approximately 52 percent of the total mass entering the WTP; additionally, the WMP contributed to more than 10 percent of the total mass of ammonia, nitrite, TDS, and boron entering the WTP.

The existing WTP is in compliance with the current license requirements; however, total suspended solids (TSS) and nitrate concentrations occasionally approach the license limits. To further reduce TSS concentrations in the effluent, upgrades/modifications could be made to the existing treatment process. Side stream treatment of the WMP water for nutrient removal would be the most economical approach to ensure that nitrate levels do not exceed the current license limits.

Effluent limits proposed by the Mackenzie Valley Land and Water Board (MVLWB) are far more restrictive than the current license limits. Full treatment of the water to remove nutrients and metals would be required to comply with the new limits. Additionally, MVLWB has proposed new effluent limits for parameters which are currently not regulated (i.e. TDS, chloride, fluoride, strontium, manganese, etc.). If the proposed limits are adopted into the license requirements, advanced treatment processes such as reverse osmosis (RO) or electrodialysis reversal (EDR) will be required to remove TDS from at least a portion of the influent stream.

Existing Mine Water Quality and License Requirements

Existing WTP Influent

The current Snap Lake Mine WTP influent consists of mine water, water from the WMP, treated effluent from the sewage treatment plant (STP), water from the Process Plant, and North Pile leachate via the WMP. The North Pile is a permanent containment facility that stores the mining wastes produced from mining operations at Snap Lake. North Pile leachate is collected at various locations surrounding the facility and pumped to the WMP where it is stored until it can be sent to the WTP for treatment.

The primary purpose of the WTP is to treat the mine water, which contributes to the majority of the influent. Discharge flows from the mine water and WMP to the WTP from 2008 to 2011 are shown in Figure 1.

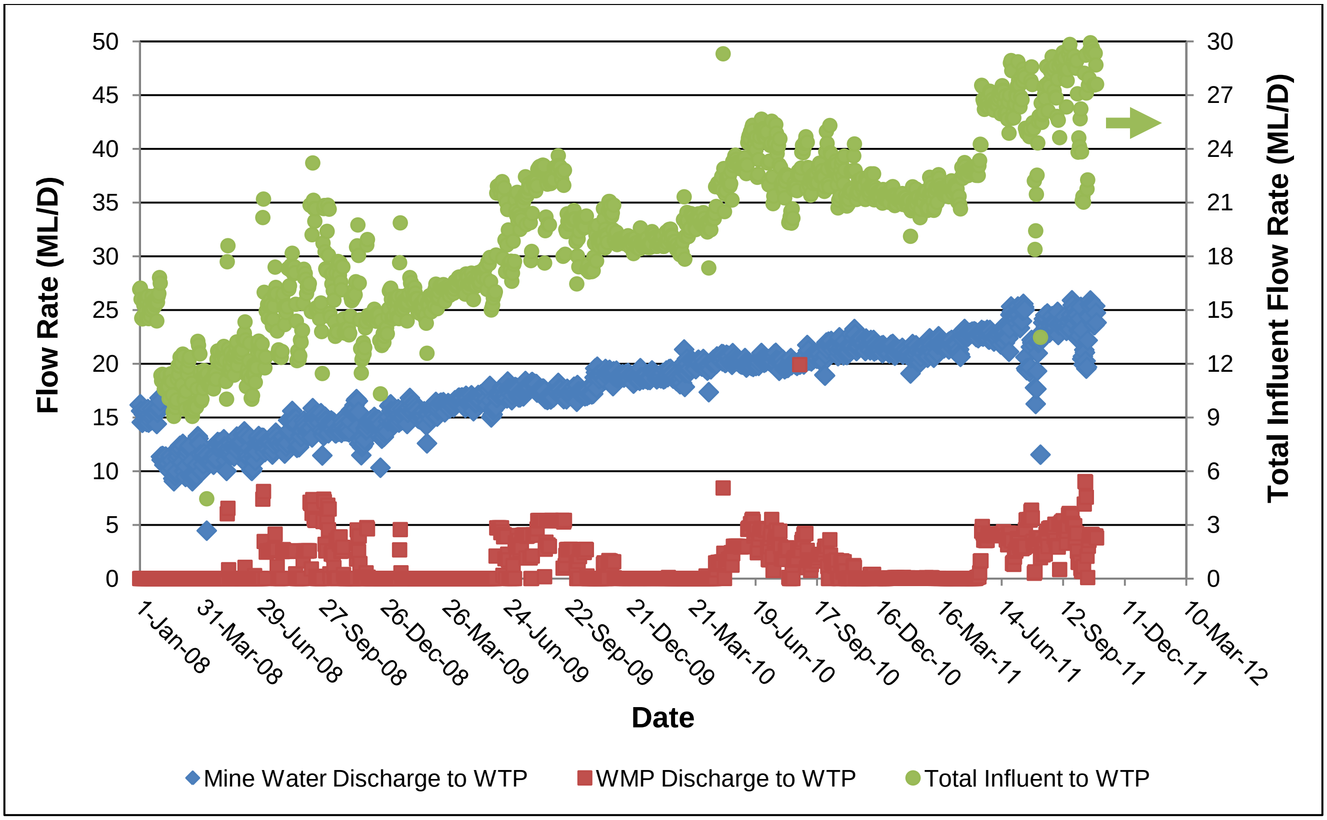


Figure 1: Discharge from the mine and WMP to the Snap Lake Mine WTP (2008-2011)

The flow rates of discharge from the mine water and WMP to the WTP are displayed on the left vertical axis and the total combined flow rate is displayed on the right vertical axis. The rate of mine water discharge has been steadily increasing over the last 4 years from 10 ML/D up to 25 ML/D. Discharge from the WMP fluctuates seasonally, typically ranging from 0 to 5ML/D during the spring to fall and ceasing in the winter. Figure 2 shows a plot of the percent contribution of the mine water and WMP to the total combined influent flow to the WTP.

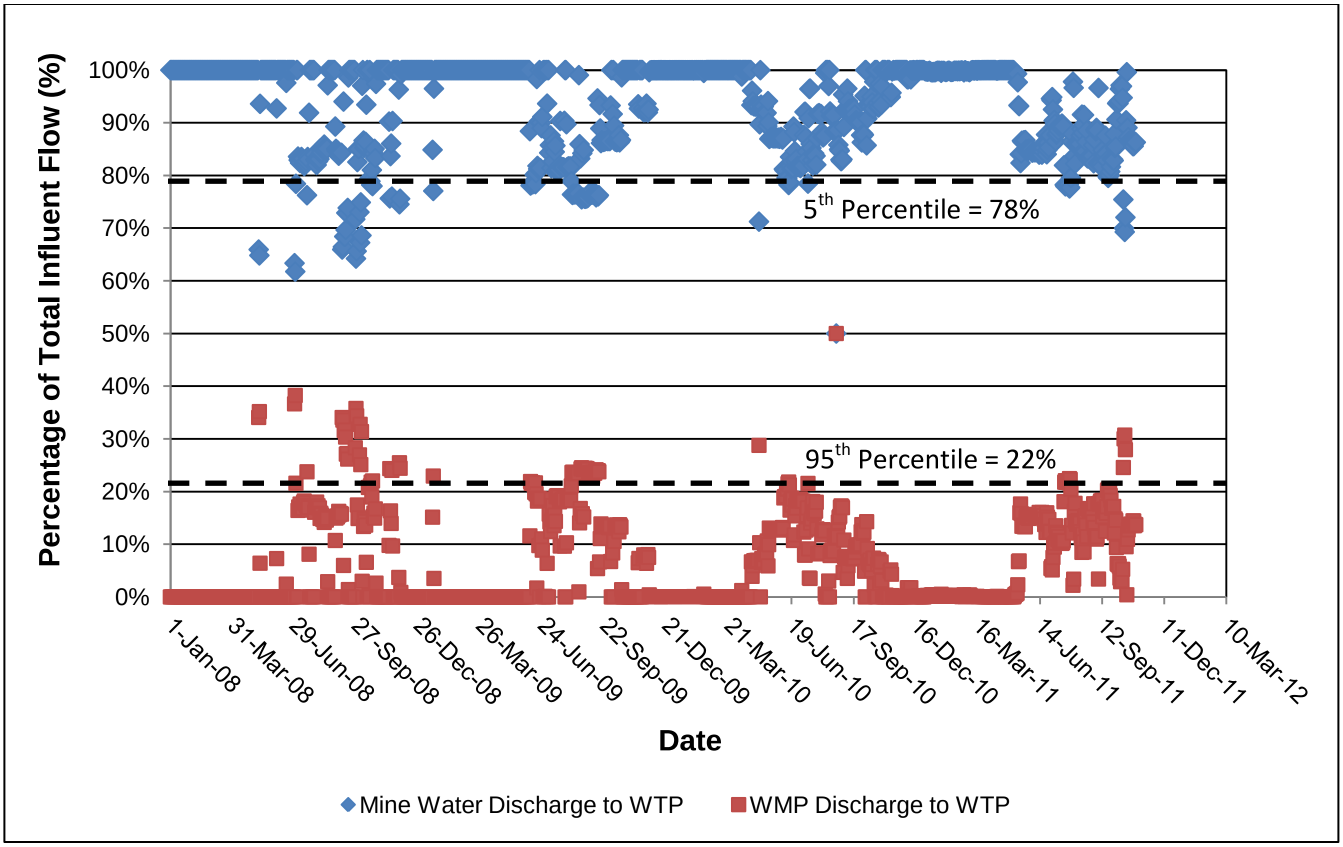


Figure 2: Percent contribution of mine and WMP flow to the total combined influent flow (2008-2011)

The mine water typically accounts for approximately 80 to 100 percent of the WTP influent; 80 percent during the summer when the flow from the WMP increase to approximately 5 ML/D (~20 percent of flow) and 100 percent during the winter when the WMP is not being discharged to the WTP. As the mine continues to increase production, mine water discharge will increase, while discharge from the WMP to the WTP is expected to remain the same (between 0 to 5 ML/D); hence, it will contribute less to the total combined influent flow (e.g. at 45 ML/D, contributes 0 to 10 percent).

Flows from the STP and Process Plant are minor and are added directly into the reactor tank. In 2010, the STP treated 55,814 m^3 of sewage (Table 1); this amounts to a flow of approximately 152,900 L/D (0.15 ML/D) into the Snap Lake Mine WTP, assuming that all the treated sewage effluent was directed into the WTP. Given that the combined influent flow to the WTP from the mine water and WMP ranged from 18 to 25 ML/D in 2010, the treated sewage contributes minimally to the influent flow (<1 percent). Additionally, 301,971 m^3 of treated mine water was recycled for use in the Process Plant. Assuming that all of the water from the Process Plant was sent back to the WTP after use, the total flow from the Process Plant to the WTP was approximately 827,300 L/D (0.83 ML/D) in 2010; hence the process water also contributes minimally to the influent flow (3 to 4 percent).

Leachate from the North Pile is collected in a network of ditches equipped with sumps; the sumps transport the seepage to the WMP, which stores the water until it can be sent to the WTP for treatment. Hence, the North Pile leachate has an influence on the water quality of the WMP.

The total combined flow to the WTP has been estimated as the summation of the mine water and WMP discharge to the WTP, as the discharge from the STP and Process Plant contributes a minuscule amount. The influent flow is shown in Figure 3 from 2008 to 2011. If mine production increases at the same rate observed over the last four years, the WTP will need to treat approximately 45 ML/D by mid-2015. Thus, expansions to the WTP capacity now will allow for approximately 3-4 more years of production if the current trend of increasing influent rates continues.

Table 1: Water use at the Snap Lake Mine in 2010

Water Use[1]	Volume (m^3)
Water used from Snap Lake in 2010	55,814
Discharge to Snap Lake	7,289,399
Water from mine	7,408,035
Water recycled for used in process plant	301,971
Treated sewage effluent	55,814
Surface water pumped to the WTP[2]	245,326

[1]All numbers are preliminary from 2010 unless otherwise noted
[2]2009 Water License Annual Report

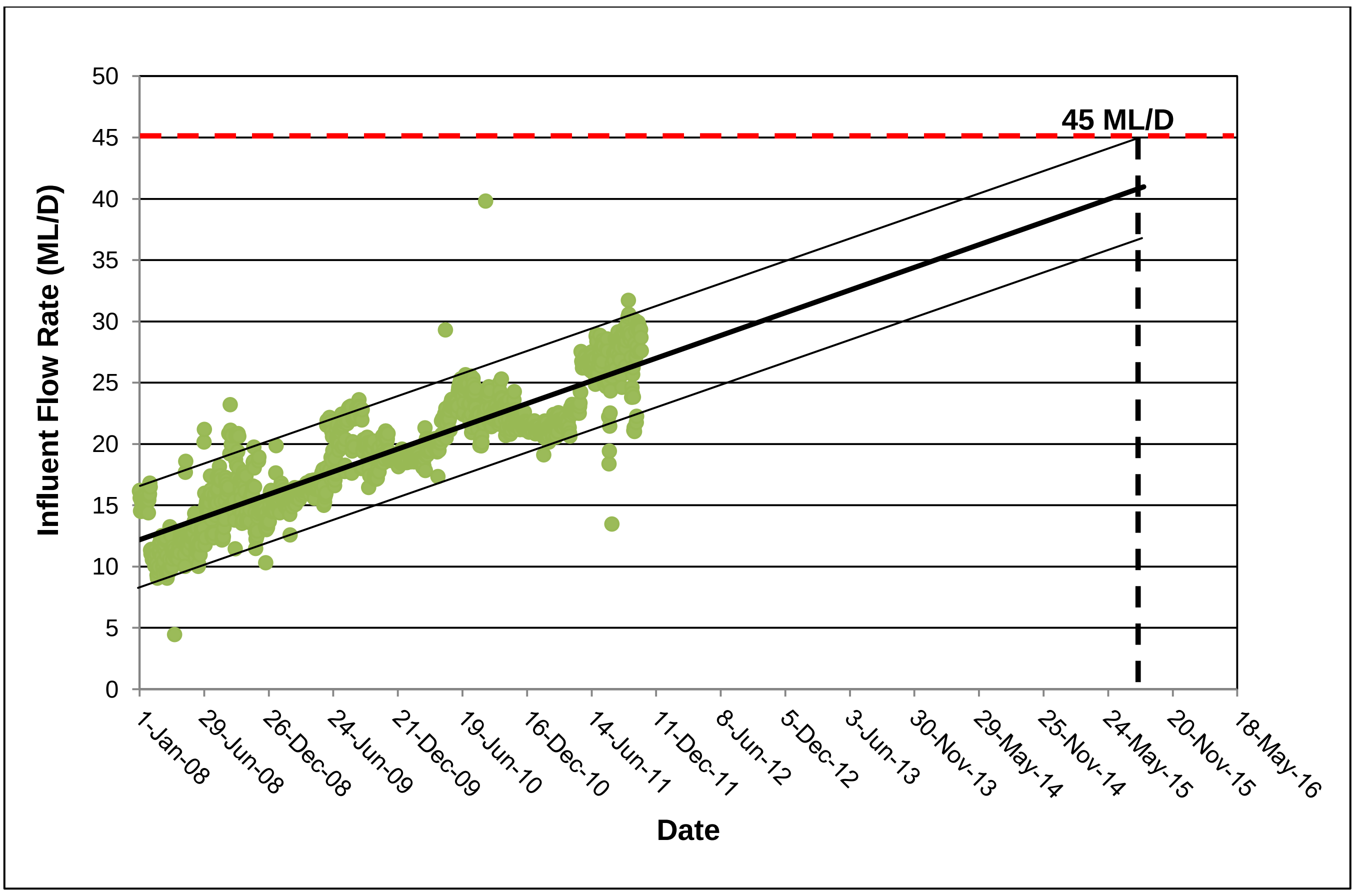


Figure 3: Approximate influent flow rate to the Snap Lake Mine WTP from 2008 to 2011

Mine Water Quality

Mine water quality data monitored includes an analysis of physical parameters (i.e. total dissolved solids, pH, etc.), nutrients, major ions, and metal concentrations. The typically chemistry of the mine water is shown in Table 2 based on the 2011 data.

Table 2: Mine water quality in 2011

Parameter	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)
Total Suspended Solids	63	636	3220
Total Dissolved Solids	360	517	810
Ammonia, NH_3-N	0.46	1.66	4.81
Nitrate, NO_3-N	2.01	4.14	30.7
Nitrite, NO_2-N	0.090	0.193	0.445
Aluminum	3.11	12.1	31.5
Arsenic	0.0011	0.0018	< 0.0040[1]
Barium	0.099	0.367	1.01
Boron	0.092	0.121	0.190
Cadmium	0.000015	0.00021	< 0.0008[2]
Chloride	120	237	310
Chromium	0.033	0.171	0.438
Copper	0.0029	0.014	0.040
Fluoride	0.278	0.351	0.420
Iron	4.08	21.0	56.6
Lead	0.00266	0.0162	0.0512
Manganese	0.126	0.437	0.997
Nickel	0.062	0.305	0.824
Strontium	1.55	1.76	2.20
Zinc	0.0133	0.0605	0.150

[1]The maximum concentration was < 4 µg/L; not clear how much less
[2]The maximum concentration was < 0.8 µg/L; not clear how much less

The mine water typically has low metal concentrations, except in the case of aluminum, iron, and strontium which exist at concentrations above 1 mg/L. The main contaminants of concern are TSS, TDS, and nutrients (i.e. ammonia, nitrate, and nitrite).

Water Management Pond Water Quality

The WMP water quality data monitored includes an analysis of physical parameters (i.e. total dissolved solids, pH, etc.), nutrients, major ions, and metal concentrations. The typically chemistry of the WMP water is shown in Table 3 based on the 2011 data.

Table 3: WMP water quality in 2011

Parameter	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)
Total Suspended Solids	1.0	9.4	209
Total Dissolved Solids	390	1359	4100

Parameter	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)
Ammonia, NH_3-N	0.987	6.15	14.7
Nitrate, NO_3-N	3.83	88	244
Nitrite, NO_2-N	0.094	0.367	1.09
Aluminum	0.010	0.144	1.08
Arsenic	0.00013	0.00022	< 0.0040[1]
Barium	0.039	0.095	0.220
Boron	0.149	0.581	1.37
Cadmium	0.000007	0.00018	0.0008
Chloride	124	343	825
Chromium	0.001	0.0017	0.0078
Copper	0.00047	0.00126	0.0033
Fluoride	0.304	0.553	1.18
Iron	0.044	0.266	1.70
Lead	0.00004	0.00022	0.00138
Manganese	0.025	0.140	0.783
Nickel	0.015	0.068	0.248
Strontium	0.744	2.15	5.49
Zinc	0.002	0.031	0.268

[1]The maximum concentration was < 4 µg/L; not clear how much less

The WMP water typically has much lower concentrations of TSS than the mine water, as solids will settle naturally to the bottom of the pond over time. In contrast, TDS and nutrient levels in the WMP are much higher than in the mine water. This may result from the accumulation of these contaminants over time due to the continuous discharge of North Pile leachate into the WMP. Additionally, surface run-off will enter the WMP and contribute to the elevated level of nutrients and TDS. Most of the metals exist at lower concentrations in the WMP than in the mine water; however, boron and strontium levels are higher in the WMP. Chloride and fluoride ions exist at higher concentrations in the WMP water, which contributes to a higher TDS.

North Pile Leachate Water Quality

The water quality of North Pile leachate is monitored at five different perimeter sump locations and includes an analysis of physical parameters (i.e. total dissolved solids, pH, etc.), nutrients, major ions, and metal concentrations. The typically chemistry of the leachate water is shown in Table 4 based on the 2011 data. Average values were calculated based on the concentrations observed at all five perimeter sumps.

Table 4: North Pile Leachate water quality in 2011

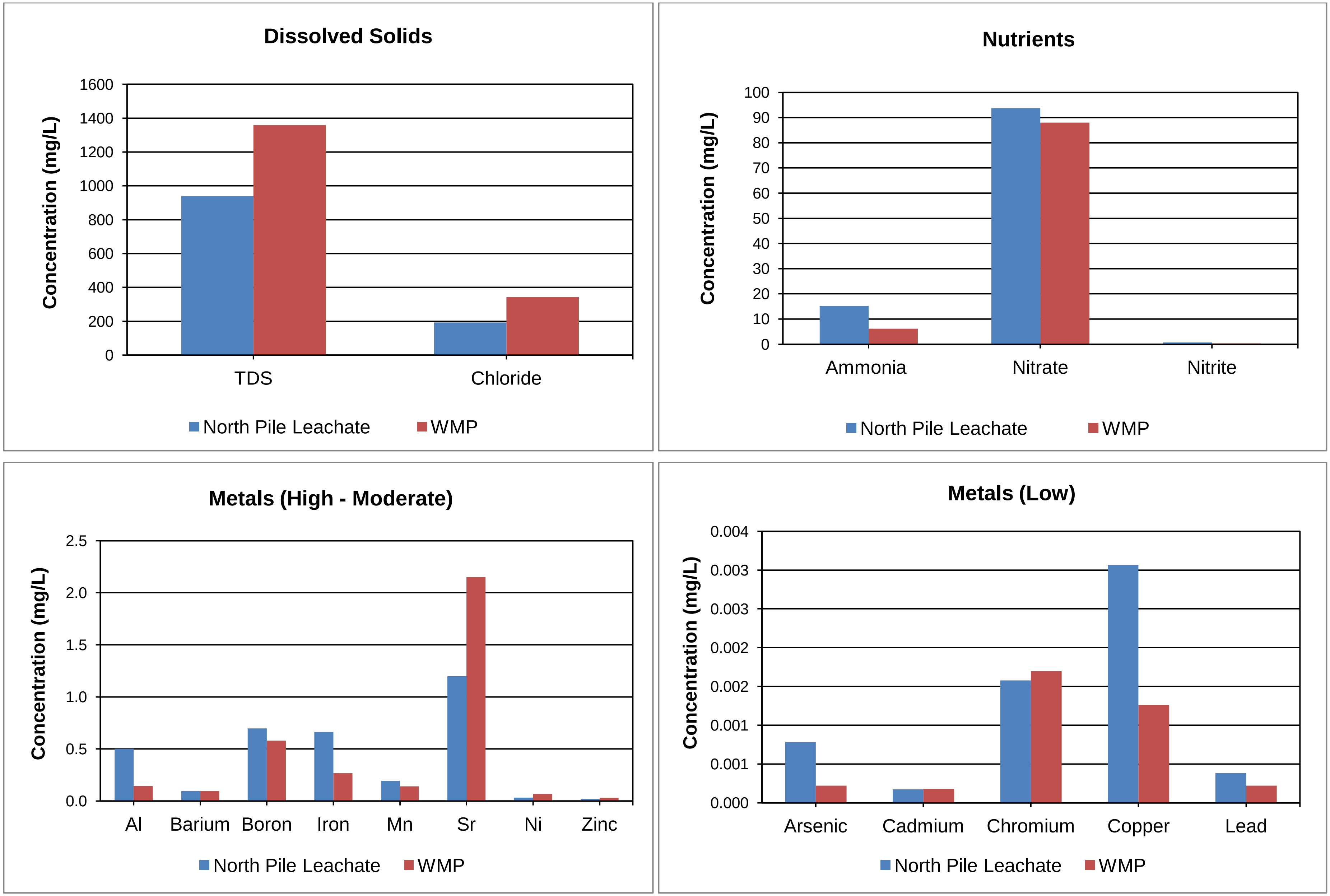
Parameter	Minimum (mg/L)	Average (mg/L)[1]	Maximum (mg/L)
Total Suspended Solids	3.0	12.6	101
Total Dissolved Solids	3.0	939	2130
Ammonia, NH_3-N	0.864	15.2	46

Parameter	Minimum (mg/L)	Average (mg/L)[1]	Maximum (mg/L)
Nitrate, NO_3-N	0.063	93.8	208
Nitrite, NO_2-N	0.018	0.694	1.91
Aluminum	0.0218	0.503	5.46
Arsenic	0.00013	0.0008	0.004
Barium	0.0182	0.0965	0.173
Boron	0.02	0.698	1.32
Cadmium	0.00005	0.00017	0.0008
Chloride	2.0	192	422
Chromium	0.00015	0.0016	0.0075
Copper	0.001	0.0031	0.012
Fluoride	0.070	0.561	1.35
Iron	0.046	0.664	4.17
Lead	0.00005	0.00038	0.0029
Manganese	0.0363	0.195	0.561
Nickel	0.0029	0.0319	0.0623
Strontium	0.019	1.197	2.15
Zinc	0.004	0.0189	0.0893

[1]Average was calculated based on readings taken from all North Pile perimeter sump locations in 2011

The North Pile leachate has a similar chemistry to the WMP water in terms of TDS, ammonia, nitrate, nitrite, and metal concentrations. Figure 4 shows a comparison of the concentrations of contaminants measured in the North Pile leachate and the WMP in 2011. Concentrations of nutrient and metals are typically higher in the leachate than in the WMP water. This is expected, as a variety of waste materials are deposited in the North Pile including processed kimberlite, mine rock, sewage biosolids, and construction wastes.

Figure 4: Comparison of water quality observed in WMP and North Pile leachate water in 2011.



Treated Sewage Effluent Water Quality

The treated sewage effluent from the STP is sent directly to the reactor tank at the WTP for additional treatment prior to discharge into Snap Lake. The treated sewage contributes to less than 1 percent of the flow into the WTP. TSS is in the treated sewage is typically low (<100 mg/L) compared to the mine water which accounts for the majority of the flow into the WTP; hence, the addition of the treated sewage has little to no affect on the TSS concentration in the WTP influent.

The average concentration of nutrients measured in the treated sewage is shown in Table 5 for 2010. Average values are shown for sampling point 1, 2, and 3 (MBR). Concentrations of nitrate measured at all three sampling points were between the average concentration measured in the mine water and the WMP; hence, the treated sewage should not have a significant effect on nitrate levels in the WTP influent.

Table 5: Average nutrient concentrations measured in the treated sewage effluent in 2010

Parameter	Sampling Point 1 (STP1)	Sampling Point 2 (STP2)	Sampling Point 3 (MBR3)
Ammonia, NH_3-N	2.78	0.23	15.6
Nitrate, NO_3-N	9.47	6.12	8.36
Nitrite, NO_2-N	0.459	0.152	0.253

Only one treated effluent sample collected in 2010 was analyzed for metal concentrations, the results are shown in Table 6. The treated effluent contained low levels of all metals (except zinc) relative to the average concentration measured in the mine water in 2010. Adding less than 0.5 ML/D of treated sewage into the reactor tank will not have a significant effect on the mass loading of metals into the WTP.

Table 6: Metal concentrations measured in the treated sewage effluent measured in January 2010 compared with the average mine water concentration in 2010.

Metal	Treated Sewage Concentration (mg/L)	Average Mine Water Concentration (mg/L)
Aluminum	0.046	6.42
Arsenic	0.0002	0.0027
Barium	0.0148	0.1957
Boron	0.0158	0.121
Cadmium	0.00005	0.0005
Chromium	0.0004	0.0896
Copper	0.0037	0.0128
Iron	0.031	10.94
Lead	0.0003	0.0084
Manganese	0.0541	0.2307
Nickel	0.004	0.1502
Strontium	0.262	1.68
Zinc	0.117	0.0432

Effluent Water Quality and Current License Requirements

The effluent quality is monitored as the water exits the WTP before it is discharged into Snap Lake. Current license limits require the removal of TSS, nutrients (i.e. ammonia, nitrate, and nitrite), and metals. The current license limits are show in Table 7, along with a summary of the minimum, average, and maximum concentrations of contaminants in the effluent in 2011. Effluent concentrations for all contaminants complied with the maximum grab limit and average monthly limit. However, TSS and nitrate occasionally approach these limits. A maximum grab sample 9 mg/L of TSS was reported on October 5, 2011 which is close to the limit of 14 mg/L. In the past (2010), a maximum grab sample of nitrate of 55.5 mg/L has been reported, which is just below current limit of 56 mg/L. Additionally, maximum grab samples of cadmium and zinc approached the maximum grab limit in 2011; however, average values were still quite low and there was some uncertainty expressed by the lab regarding the accuracy of these measurements.

Table 7: Summary of the contaminant concentrations in the effluent compared with the existing license limits

Parameter	Minimum	Average	Maximum	Maximum Grab Limit	Average Monthly Limit	In Compliance?
Total Suspended Solids (mg/L)	4	5.5	9	14	7	Yes
Ammonia, NH_3-N (mg/L)	0.56	1.33	2.57	20	-	Yes
Nitrate, NO_3-N (mg/L)	3.9	8.1	18.1	56	28	Yes
Nitrite, NO_2-N (mg/L)	0.07	0.15	0.41	2	1	Yes
Aluminum (ug/L)	7.8	29.9	< 160.0[1]	2000	1000	Yes
Arsenic (ug/L)	0.03	0.10	< 4.00[1]	40	20	Yes
Cadmium (ug/L)	0.006	0.009	< 0.800[1]	2.0	1.0	Yes
Chromium (ug/L)	0.07	0.47	3.20	40	20	Yes
Copper (ug/L)	0.24	0.50	< 4.00[1]	20	10	Yes
Nickel (ug/L)	7.4	9.9	13.2	100	50	Yes
Lead (ug/L)	0.04	0.09	< 0.40[1]	9	5	Yes
Zinc (ug/L)	1.6	2.5	< 16.0[1]	20	10	Yes

[1]The maximum concentration was listed as "<" µg/L; not clear how much less

To further reduce TSS concentrations in the effluent, upgrades could be made to the existing treatment process. Tube settlers or parallel plates could be added into the thickener to increase the settling capacity. Tube settlers and parallel plates work by reducing the vertical distance that a floc particle must fall before it can agglomerate to form a larger particle. Once larger particles are formed they will slide down the tubes/plates and settle to the tank bottom were they can be removed. Tube settlers are typically sloped at a 60 degree angle and arranged adjacent to one another to maximize the effective settling area. Tubes are constructed out of light weight PVC; as such, they can be supported with minimal structures. Support systems can be constructed out of stainless steel, painted carbon steel, or aluminum.

The addition of tube settlers may increase the capacity of the existing thicker from 20 to 25 percent. Additionally, TSS can be reduced by optimizing the coagulation process. Coagulation processes are typically optimized through jar testing to examine the affect of different coagulants, dosages, and water chemistry (pH and alkalinity) on the clarification process.

The existing WTP was primarily designed to remove TSS and not for nutrient removal. Thus, to reduce nitrate levels, a nutrient removal process would have to be added to the existing WTP. This could include ion-exchange units, membrane filtration, or biological nutrient removal. If the current license limits are maintained, side stream treatment of the WMP water for nutrient removal prior to blending with the mine water would be the most economical approach to ensure that nitrates levels do not exceed the license requirements.

Future License Requirements

The Mackenzie Valley Land and Water Board (MVLWB) has recently proposed new effluent quality criteria for the average monthly limits (Table 8).

Table 8: Proposed effluent criteria compared with existing license limits

Parameter	Current License Requirements (Average Monthly Limit)	Proposed Effluent Quality Criteria (Average Monthly Limit)	Affect on Limit
Total Suspended Solids (mg/L)	7	7	No Change
Total Dissolved Solids (mg/L)	n.a.	428	New
Ammonia, NH_3-N (mg/L)	n.a.	1.75	New
Nitrate, NO_3-N (mg/L)	28	3.83	More Restrictive
Nitrite, NO_2-N (mg/L)	1.0	0.06	More Restrictive
Aluminum (ug/L)	1000	100	More Restrictive
Arsenic (ug/L)	20	7.0	More Restrictive
Barium (ug/L)	n.a.	1500	New
Boron (ug/L)	n.a.	2300	New
Cadmium (ug/L)	1.0	0.042	More Restrictive
Chloride (mg/L)	n.a.	278	New
Chromium (ug/L)	20	13	More Restrictive
Copper (ug/L)	10	3.3	More Restrictive
Fluoride (mg/L)	n.a.	0.5	New
Manganese (ug/L)	n.a.	1500	New
Nickel (ug/L)	50	140	Less Restrictive
Strontium (ug/L)	n.a.	500	New
Lead (ug/L)	5.0	4.8	More Restrictive
Zinc (ug/L)	10	40	Less Restrictive
pH (minimum)	n.a.	6.3	New

Parameter	Current License Requirements (Average Monthly Limit)	Proposed Effluent Quality Criteria (Average Monthly Limit)	Affect on Limit
pH (maximum)	n.a.	10.4	New

TSS requirements will remain the same; however, the proposed requirements for nutrients and the majority of metals are more restrictive than under the current license limits. The limits for nitrate and nitrite have been reduced by a factor 7 and 17, respectively. Also, a new limit has been proposed for the average monthly concentration of ammonia; in the current license, only the maximum grab concentration and average annual loading of ammonia is regulated. If the proposed limits are approved, full treatment for nutrient removal will be required prior to discharging effluent into Snap Lake.

New limits have been proposed for TDS. To comply with the limits, advanced treatment processes would be required that remove TDS, such as RO or EDR. Additionally, some of the metals would have to be removed via lime precipitation to meet the proposed license requirements. Strontium is currently not regulated however it exists at high concentrations in the mine and WMP water and it is not removed sufficiently by the existing treatment process. The proposed limit for cadmium (0.042 mg/L) has been reduced by a factor of 24, which will not achievable using the existing treatment approach.

New limits have also been proposed for chloride and fluoride. While the current concentrations (2011) measured in the effluent are below the proposed limits, they do approach the limits occasionally; hence, partial treatment for the reduction of these ions will ensure that these limits are not exceeded in the future.

Table 9 shows a comparison of the proposed limits with the Canadian Environmental Quality Guidelines recommended by the Canadian Council of Ministers of the Environment (CCME) and the metal mining effluent limits listed under the Metal Mining Effluent Regulations (MMER). The proposed limits are slightly higher (less restrictive) than the CCME freshwater quality guideline values for most contaminants. All limits are significantly lower (more restrictive) than the MMER monthly mean and maximum grab sample limits.

Table 9: Proposed effluent criteria compared with existing license limits

Parameter	Proposed Effluent Quality Criteria (Average Monthly Limit)	Proposed Effluent Quality Criteria (Max Grab Limit)	CCME Guideline	MMER Limits (Monthly Mean/Max Grab)
Total Suspended Solids (mg/L)	7	14	Maximum Increase 5 mg/L[1]	15/30
Total Dissolved Solids (mg/L)	428	856	N.A	N.A
Ammonia, NH_3-N (mg/L)	1.75	3.5	1.83 to 12.6[2]	N.A
Nitrate, NO_3-N (mg/L)	3.83	7.66	2.935[3]	N.A
Nitrite, NO_2-N (mg/L)	0.06	0.12	0.06[3]	N.A
Aluminum (ug/L)	100	200	100[4]	N.A
Arsenic (ug/L)	7.0	14	5[3]	500/1000
Barium (ug/L)	1500	3000	N.A	N.A
Boron (ug/L)	2300	4600	1500[3]	N.A
Cadmium (ug/L)	0.042	0.084	0.012-0.021[5]	N.A
Chloride (mg/L)	278	556	120[3]	N.A
Chromium (ug/L)	13	26	N.A	N.A

Parameter	Proposed Effluent Quality Criteria (Average Monthly Limit)	Proposed Effluent Quality Criteria (Max Grab Limit)	CCME Guideline	MMER Limits (Monthly Mean/Max Grab)
Copper (ug/L)	3.3	6.6	2.0[5]	300/600
Fluoride (mg/L)	0.5	1.0	120[3]	N.A
Manganese (ug/L)	1500	3000	N.A	N.A
Nickel (ug/L)	140	280	38.3-64.8[5]	500/1000
Strontium (ug/L)	500	1000	N.A	N.A
Lead (ug/L)	4.8	9.6	1.0-1.66[5]	200/400
Zinc (ug/L)	40	80	30[3]	500/1000
pH (minimum)	6.3	6.3	6.5	N.A
pH (maximum)	10.4	10.4	9.0	N.A

[1] Maximum increase above background levels (long-term)
[2] Guideline range for temperature ranging from 5 to 15 ° C and pH ranging from 7.0 to 7.5 (ranges taken from Snap Lake Intake water quality in 2010)
[3] Long-term guideline
[4] Limit for a pH > 6.5
[5] Guideline range for hardness ranging from 30 to 60 mg/L as $CaCO_3$ (ranges taken from Snap Lake Intake water quality in 2010)
CCME = Canadian Council of Ministers of the Environment
MMER = Metal Mining Effluent Regulation
N.A. = Not available

Mass Balance Analysis of Influent

A mass balance of the major influent flows to the WTP was conducted to examine the percent contribution that each discharge (mine water and WMP) has on the total influent quality entering the WTP. The total mass of each contaminant entering the plant was tabulated for 2011 (January to October) by summing of the average monthly flows multiplied by the average monthly concentrations. This was tabulated for both the water coming from the mine and the WMP. The percent contribution of the total mass of each contaminant entering the WTP is shown in Figure 5 for the two different discharge streams. Only the contaminants with the highest percent contributions coming from the WMP are shown in the graph.

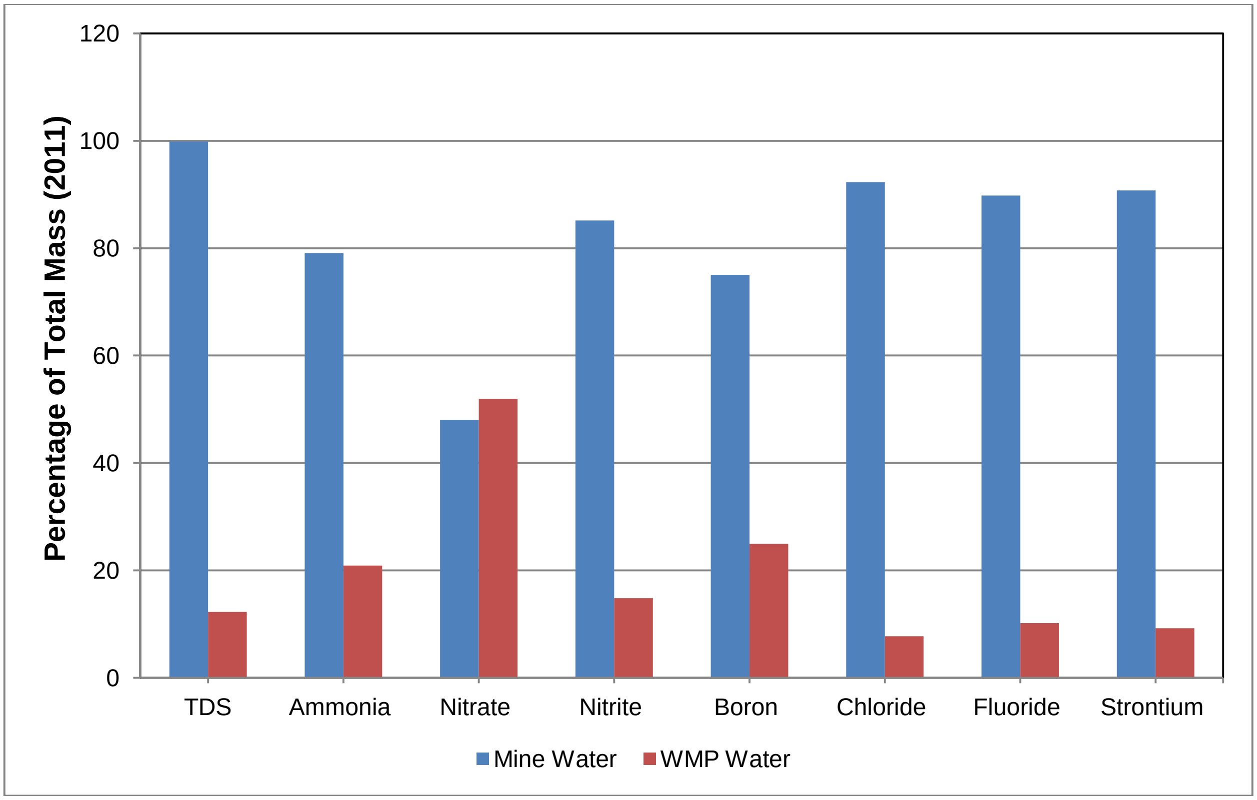


Figure 5: Mass balance of contaminants entering the WTP from the mine water and WMP (2011)

One of the major findings from the mass balance was that the mine discharge and WMP contributed almost equally to the total mass of nitrate entering the WTP in 2011, even though the WMP water only constituted approximately 10 percent of the total flow (volume basis). As such, large reductions in nitrate can be achieved by treating the water coming from the WMP (side stream treatment). This would be an economical approach to reducing nitrate concentrations to ensure continued compliance with the current nitrate license limit. However, if the proposed MVLWB license limits are approved, both the mine and WMP water would likely require full treatment for nutrient removal to comply with the new limits.

The WMP also contributed to a significant amount of the nitrite (~15 percent) and ammonia (~20 percent) mass entering the WTP in 2011. Side stream treatment of the WMP water for nutrient removal would be the most economical approach to ensure that nutrient levels do not exceed the current license limits. However, as with nitrate, the proposed limit for nitrite is a lot more stringent and compliance would require treatment of both the mine and WMP water. The proposed limit for ammonia may be achievable through the treatment of the WMP water and half of the mine water (i.e. blending).

As mentioned previously, the current license does not require TDS removal; the proposed limit would require an average monthly effluent concentration below 428 mg/L. The 2011 (January to October) average concentration of TDS in the mine water and WMP water was 517 mg/L and 1359 mg/L, respectively. The mass balance (Figure 5) shows that approximately 13 percent of the TDS load in 2011 came from the WMP. To achieve the proposed limit, both the WMP and mine water would need to be treated for TDS removal; however, since the average concentration of TDS in the mine water is only slightly above the proposed limit, it may be possible to treat half of the mine water, along with the all of the WMP water, and blend the treated stream with the untreated water to comply with the limit.

Although the WMP contributes a large percentage of the total mass of boron (~25 percent) to the WTP influent, it does not need to be removed under the current license requirements and the current influent levels are in compliance with the proposed limits.

Conclusions

A review of the Snap Lake WTP influent flow data and water quality data (influent and effluent) was conducted to determine the influent streams that contribute the most to the contaminant loading on the WTP, identify the key contaminants of concern, and to aid in selecting potential treatment approaches to meet the current and/or future license requirements. The findings of the review are summarized below:

- The current influent flow rate into the WTP is approaching its rated capacity (35 ML/D). The total influent flow into the WTP has been increasing steadily over the past 4 years. If the discharge from the mine continues to increase at the same rate relative to production, the WTP will require a treatment capacity of 45 ML/D by mid-2015
- Mine water constitutes the majority of the influent flow entering the WTP (typically > 80 percent). During the spring to fall, the WMP discharge contributes approximately 0 to 20 percent of the total influent flow. The treated sewage effluent and process water contribute minimally (<5 percent) to the total influent flow into the WTP.
- The WMP water contains high concentrations of TDS, nutrients (i.e. ammonia, nitrate, and nitrite), boron, strontium, chloride, and fluoride which exceed the concentrations measured in the mine water
- Although the WMP only contributed to approximately 10 percent of the total flow (volume basis) entering the WTP in 2011, the nitrate mass loading from the WMP contributed to approximately 52 percent of the total mass entering the WTP; additionally, the WMP contributed to more than 10 percent of the total mass of ammonia, nitrite, and TDS entering the WTP.
- The existing WTP is in compliance with the current license requirements; however, TSS and nitrate concentrations occasionally approach the license limits. To further reduce TSS concentrations in the effluent, upgrades/modifications could be made to the existing treatment process (i.e. tube settlers and coagulation optimization). To remove nitrate, a nutrient removal process could be added to the existing WTP (e.g. ion-exchange, membrane filtration, or biological nutrient removal).
- Effluent limits proposed by the MVLWB are far more restrictive than the current license limits in terms of nutrient and metal concentrations. Additionally, new effluent limits have been proposed for parameters which are currently not regulated (i.e. TDS, chloride, fluoride, strontium, manganese, etc.).
- If the proposed limits are adopted into the license requirements, in addition to expanding the WTP capacity to 45 ML/D, advanced treatment processes will be required to remove TDS (i.e. RO or EDR); full treatment of the water to remove nutrients and metals will also be required to comply with the new limits.

Appendix B
Kickoff Meeting Presentation Slides and Minutes
(December 15, 2011)

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De Beers Canada
Snap Lake Mine WTP Upgrades

Kickoff Presentation
Dec 15, 2011

Agenda

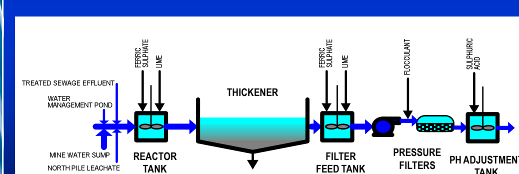
- Objectives
- Existing WTP
- Summary of Site Visit Findings
- Data Review
- Treatment Options
- Process Selection:
  - Best Case Scenario
  - Worst Case Scenario
- Additional Information Required
- Path Forward
- Updated Schedule

Project Objectives

- Increase WTP capacity to 45 ML/D
- Identify upgrades/process modification to improve the efficiency of the existing WTP
- Identify alternative treatment technologies/approaches to meet current compliance goals and future potential limits

Snap Lake Mine Existing WTP

- Waste streams include mine water, WMP, treated sewage effluent, North Pile leachate
- Water treatment involves: flocculation, thickening, filtration, and pH adjustment

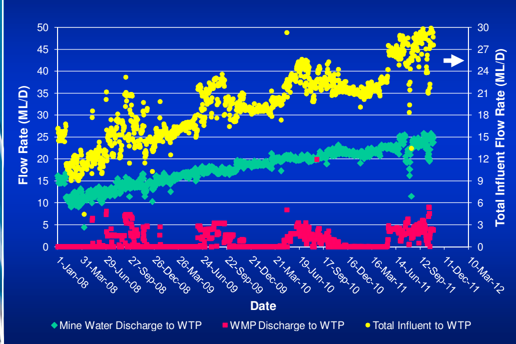


Summary of Site Visit Findings

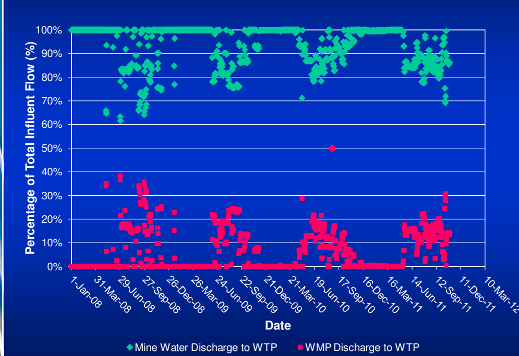
- Clarification
  - All tanks are operating beyond their maximum hydraulic capacity
  - Preliminary calculations suggest the thickener is operating at 125 % capacity
  - Clarified water turbidity is high at times (8 NTU) , approaching maximum design load for the filters (10 NTU)
  - Periodic sludge disposal causes turbidity levels to increase
  - Uneven flow distribution exiting the center chamber of the thickener
- Filtration
  - Pressure filter media show signs of "mud balling"
  - Filters are backwashed frequently (3 times/day/filter)
  - Filter feed pumps are operating beyond capacity (cavitation)
  - Excessive water hammer in piping upon backwash

Data Review

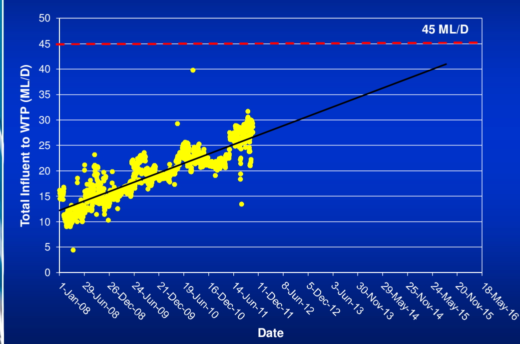
WTP Influent Flows (2008 – 2011)



Percentage of Total Influent Flow (2008 – 2011)



Future Expansion



Existing WTP Effluent Characteristics (2011)

Parameter	Minimum	Average	Maximum	Maximum Grab Limit	Average Monthly Limit	In Compliance?
Total Suspended Solids (mg/L)	4	5.5	9	14	7	Yes
Ammonia (mg/L)	0.56	1.33	2.57	20	-	Yes
Nitrate (mg/L)	3.9	8.1	18.1	56	28	Yes
Nitrite (mg/L)	0.07	0.15	0.41	2	1	Yes
Aluminum (ug/L)	7.8	29.9	160.0	2000	1000	Yes
Arsenic (ug/L)	0.03	0.10	4.00	40	20	Yes
Cadmium (ug/L)	0.006	0.009	0.800	2.0	1.0	Yes
Chromium (ug/L)	0.07	0.47	3.20	40	20	Yes
Copper (ug/L)	0.24	0.50	4.00	20	10	Yes
Nickel (ug/L)	7.4	9.9	13.2	100	50	Yes
Lead (ug/L)	0.04	0.09	0.40	9	5	Yes
Zinc (ug/L)	1.6	2.5	16.0	20	10	Yes

Proposed Effluent Requirements

Parameter	Current License Requirements (Average Monthly Limit)	Proposed Effluent Quality Criteria	
Total Suspended Solids (mg/L)	7	7	
Total Dissolved Solids (mg/L)	n.a.	428	New
Ammonia (mg/L)	n.a.	1.75	New
Nitrate (mg/L)	28	3.83	↓
Nitrite (mg/L)	1.0	0.06	↓
Aluminum (ug/L)	1000	100	↓
Arsenic (ug/L)	20	7.0	↓
Barium (ug/L)	n.a.	1500	New
Boron (ug/L)	n.a.	2300	New
Cadmium (ug/L)	1.0	0.042	↓
Chloride (mg/L)	n.a.	278	New
Chromium (ug/L)	20	13	↓
Copper (ug/L)	10	3.3	↓
Flouride (mg/L)	n.a.	0.5	New
Manganese (ug/L)	n.a.	1500	New
Nickel (ug/L)	50	140	↑
Strontium (ug/L)	n.a.	500	New
Lead (ug/L)	5.0	4.8	↓
Zinc (ug/L)	10	40	↑

Flow Balance – WTP Influent

- Majority of water comes from mine (80-100%)
- WMP flow can be significant during the summer (~20 %)
- Minor streams: treated sewage effluent and leachate

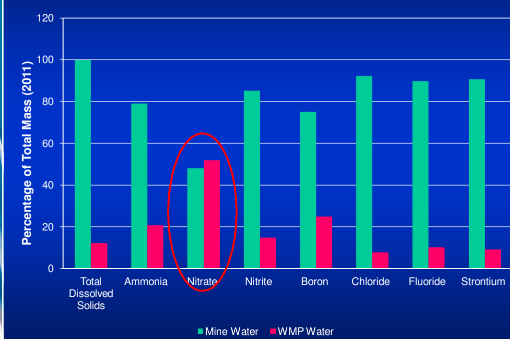
WTP Influent Quality

Parameter	Mine	WMP	Current License Limit	Proposed Limit
Total Suspended Solids (mg/L)	2640	39.0	7	7
Total Dissolved Solids (mg/L)	755	3193	-	428
Ammonia (mg/L)	2.5	10	-	1.75
Nitrate (mg/L)	10.6	238	28	3.83
Nitrite (mg/L)	0.3	0.6	1	0.06
Aluminum (ug/L)	31500	564	1000	100
Barium (ug/L)	1010	208	-	1500
Boron (ug/L)	190	1303	-	2300
Cadmium (ug/L)	0.8	0.5	1	0.042
Chloride (mg/L)	271	797	-	278
Chromium (ug/L)	438	3.2	20	13
Copper (ug/L)	40.1	1.8	10	3.3
Fluoride (mg/L)	0.4	0.9	-	0.5
Manganese (ug/L)	997	508	-	1500
Nickel (ug/L)	824	218	50	140
Lead (ug/L)	51.2	0.4	5	4.8
Strontium (ug/L)	2190	5313	-	500
Zinc (ug/L)	150	139	10	40

Still Need to Remove

Still Need to Remove

Mass Balance – WTP Influent (2011)



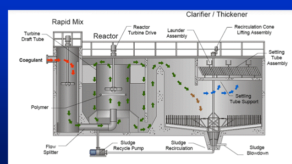
Treatment Options

Treatment Options: Physical Parameters

- **Total Suspended Solids (TSS)**
  - **Optimize current process (jar tests)**
  - **Upgrade current process (tube settlers)**
  - **Flow splitting/additional processes**
    - **High rate clarification (Densa Deg, Actiflo, Contrafast)**
- **Total Dissolved Solids (TDS)**
  - **Reverse Osmosis**
  - **Electrodialysis Reversal**

High Rate Clarification - TSS

- Densa Deg (Infilco Degremont Inc.)
  - Combines optimized flocculation, internal and external sludge recirculation, and plate settling
  - Removes TSS and heavy metals
  - Concrete (4 to 83 ML/D) or steel tanks (1 to 57 ML/D); 4.6 to 6.7 m in height
  - Rise rates from 14 to 36 m/h
  - Low waste volume
  - Solids 2 to 10 %



High Rate Clarification - TSS

- Actiflo® (Veolia Water)
  - Combines ballasted flocculation and lamella clarification with coagulants, microsand, and polymer addition
  - Removes TSS (70-90%) and heavy metals
  - Ideally suited for low temperatures (1◦C), fluctuating quality, brackish waters
  - High rise rates of 80-120 m/hr
  - APWW-4: 640 m^3/hr (8.2m x 3.6 m x 4.8 m)
  - Compact design; footprint for 30 ML/D ~ 10 m x 10 m
  - Separation of the sludge from microsand through hydrocyclone.
  - ActiFlo® Softening units also available to remove calcium, silica, heavy metals, fluorides, and suspended solids

High Rate Clarification - TSS

- CONTRAFAST® (Siemens)
  - High-rate sludge thickening clarifier/softener
  - Removal of TSS (80%), iron and manganese (90%), and hardness (50-60 %)
  - Rise rate of 14 m/h
  - Units available with capacities of approximately 0.9, 2, 4, and 8 ML/D
  - Custom units designed to any size or flow rate
  - Sludge 20% solids by weight

Reverse Osmosis (RO) - TDS

- High-pressure membrane, non-ion specific
- Primarily used to reduce high TDS (>90%)
- Can reduce nitrates/nitrites (65 to 85%)
- High quality feed required
- Membrane fouling
  - Scale control: involves pH adjustment, antiscalent, prior removal of metals (iron, strontium, manganese etc.)
  - Clogging: micro/ultrafiltration (MF/UF) membranes can be used as a pretreatment to remove TSS
  - Damage: chlorine can damage membranes
  - Cleaning required every 3 to 12 months
- Optimum treatment at pH 4.0 to 7.5 and 25◦C (at 5◦C capacity is ~1/2)
- ~75 % recovery rate (25 % RO Brine requires disposal)
- Permeate may require post-treatment to adjust alkalinity and pH prior to discharge

Electrodialysis Reversal (EDR) - TDS

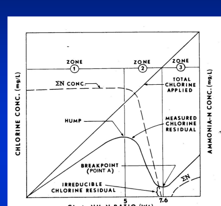
- Involves passing an electric current though a series of semi-permeable membranes to remove nitrogen and other ions.
- Can remove TDS, fluoride, chloride, nitrate, nitrite, iron, chromium
- Less sensitive than RO to particulates and metal oxides
- Longer membrane life (typically 10 years); chlorine-resistant membranes
- Provides about the same removal as RO, however removal is limited when treating soft waters, it is expensive, and requires full-time monitoring.
- Waste stream(10-20% of feed)

Treatment Options: Nutrients

- Ammonia
  - Breakpoint Chlorination
  - Air Stripping
  - Ion Exchange
  - RO or EDR
  - BNR or MBR
- Nitrate & Nitrite
  - Ion Exchange
  - RO or EDR
  - BNR or MBR

Breakpoint Chlorination - Ammonia

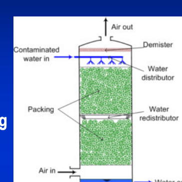
- Converts ammonia into nitrogen gas and nitrates/nitrites
- Zone 1: chlorine and ammonia react to form monochloramine; combined chlorine residual increases
- Zone 2: chemical oxidation of chloramines to dichloramine; available combined chlorine residual and ammonia decreases
- Zone 3: breakpoint; chlorine demand has been satisfied, additional chlorine appears as free residuals



- Issues:
  - Chlorine:Ammonia ratio must be 8:1 or greater
  - For 2-3 mg/L ammonia, 16-24 mg/L of chlorine may be required
  - Chlorine would require removal prior to discharge into Snap Lake
  - Occurs slower at low temperatures
  - Does not remove nitrates/nitrites

Air Stripping - Ammonia

- Transfers ammonia from water to air
- Raising the pH to 10.8 – 11.5 will convert ammonium hydroxide to ammonia gas
- Water flows downward through packing material; air flows up or across - stripping ammonia



- Does not remove nitrite and organic nitrogen
- Temperature, pH, airflow rate, and bed depth affect air stripper efficiency
- Issues:
  - At 20◦C - 90 to 95% ammonia removal efficiency; at 10◦C - 75 percent efficiency (best to enclose tower for cold weather conditions)
  - Calcium carbonate scaling in tower/feed lines

Ion Exchange – Ammonia/Nitrate/Nitrite

- Ammonia
  - Synthetic resins have low affinity for NH_4^+
  - Certain zeolites favor NH_4^+(clinoptilolite)
  - Resin in packed column or bed
  - Resin regenerated with lime – converts NH_4^+ to ammonia
  - Issue: calcium carbonate precipitation in resin bed (backwashing)
- Nitrate/nitrates
  - Resin in fixed bed or in a reactor (slurry)
  - Strong base anion resin (SO_4^{-2}>NO_3^->HCO_3^->Cl^-)
  - Nitrate-specific resins prefer nitrate over sulfate (Ex. Purolite A 520E)
  - Issues:
    - High TDS can reduce nitrate removal efficiencies (>500 mg/L)
    - Chloride is added to the water (TDS ↑)
    - Disposal of nitrate-containing brine

Biological Nutrient Removal - Ammonia/Nitrate/Nitrite

- Reduce ammonia and NO_3^-/NO_2^- levels
- Nitrification:
  - $NH_4^+ \rightarrow NO_2^- \rightarrow NO_3^-$ (nitrifiers)
  - Reaction proceeds at a slower rate in cold water
  - Aerobic conditions (DO ≥ 1.0 mg/L)
  - Alkalinity used as carbon source (50-100 mg/L)
  - Optimum pH 7.5 to 8.5
  - Heavy metals toxic to nitrifiers (chromium, copper, zinc, etc.)
  - Also inhibited by un-ionized ammonia and nitrous acid
- Denitrification:
  - $NO_3^- \rightarrow N_2$ (heterotrophic bacteria)
  - Reaction can occur between 5 and 30°C
  - Anoxic conditions (DO < 0.2 mg/L)
  - Organic carbon source as "food" (methanol, ethanol, acetic acid, etc.)
  - Optimum pH 7.0 to 8.0
  - Alkalinity is produced pH ↑

Membrane Bioreactor (MBR) Ammonia/Nitrate/Nitrite

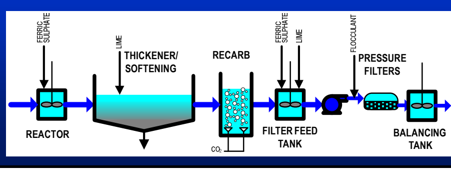
- Bioreactor and microfiltration membrane together
- Removes TSS and turbidity; may need to be combine with other processes to achieve high nitrate removals
- Advantages:
  - High volumetric loading rates (shorter retention times)
  - Longer SRTs (less sludge production)
  - Low DO concentrations (capable of simultaneous nitrification/denitrification)
  - High quality effluent (low TSS)
- Disadvantages:
  - High capital costs, high operating costs (energy), and the potential for membrane fouling
- Fouling control: air scour, backwashing (low/high chlorine residual), and chemical cleaning bath for membranes

Treatment Options: Metals & Major Ions

- Metals
  - Lime Precipitation
  - Ion Exchange - Metal concentrations are too high
  - Reverse Osmosis - Some metals can cause scaling
  - Greensand Filtration (Iron and manganese)
- Major Ions
  - Chloride/Flouride
    - Fluoride removed by lime softening
    - Reverse Osmosis (>90%)
    - Ion-Exchange (anion)

Lime Precipitation – Metals/Fluoride

- Removes heavy metals, certain organic compounds, fluoride, iron, manganese, and reduces turbidity
- Chemical precipitation followed by sedimentation/filtration to remove the precipitate
- Fe, Zn, and Cu require pH of 9.5; Ni and Cd require a higher pH (10.5 to 11)
- Adequate alkalinity > 50 mg/L as $CaCO_3$
- Lime could be added to the thickener
- Would require recarbonation to reduce the pH



Greensand Filtration

- Remove iron and manganese from water (potential membrane foulants)
- Potassium permanganate ($KMnO_4$) used to oxidize soluble iron and manganese (pH>5.5)
- Chlorine used to oxidize iron first (lower cost)
- Oxidized water is passed through filter (typically pressurized) containing greensand or sand/anthracite media
- Media is treated with $KMnO_4$ (manganese oxide coating)
- Issues:
  - Media requires periodic regeneration with $KMnO_4$
  - Regular backwashing of filter to remove oxidized iron and manganese particles.
  - $KMnO_4$ is toxic; must be handled with care
  - Adds chlorine and KMnO4 to the water which must be removed prior to membranes processes

Process Selection

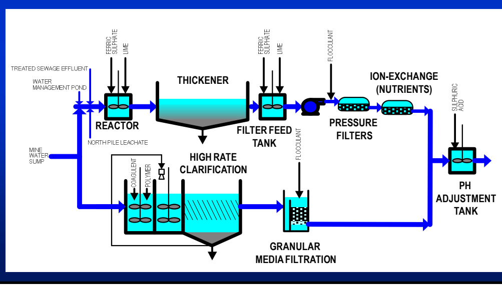
Best Case Scenario: No Change to License Requirements

Best Case Scenario

- Existing license limits do not change
- Expand WTP capacity to 45 ML/D
  - Upgrade existing treatment train
    - Add tube settlers to thickener to improve TSS removal and allow for a slight increase in capacity (~20 to 25%)
    - Optimize coagulation process to improve TSS removal (possible 10-20% improvement)
    - Convert pressure filters into ion-exchange units to address nutrient removal
  - Add additional processes/treatment train
  - ~~Build a new WTP with 45 ML/D capacity~~

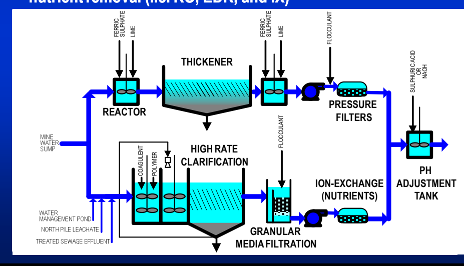
Option 1: De-rate Existing WTP + Second Treatment Train

- De-rate existing WTP capacity to ½ (17.5 ML/D)
- Convert 6 pressure filters (of 12) into ion-exchange units to remove nutrients (nitrate, ammonia, etc.)
- Second treatment train with high rate clarification (~30 ML/D)



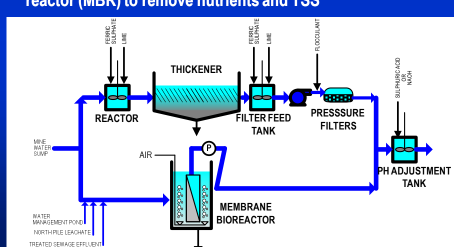
Option 2: Upgrade/Optimize Existing WTP + Second Treatment Train With Nutrient Removal

- Upgrade existing thickener (tube settlers) and optimize coagulation
- Second treatment train with high rate clarification (~30 ML/D) and nutrient removal (i.e. RO, EDR, and IX)



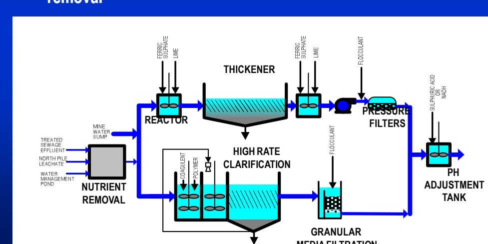
Option 3: Upgrade/Optimize Existing WTP + Second Treatment Train With Biological Nutrient Removal

- Upgrade existing thickener (tube settlers) and optimize coagulation
- Second treatment train (~30 ML/D) with a membrane biological reactor (MBR) to remove nutrients and TSS



Option 4: Side Stream Treatment for Nutrients

- Only treat a portion of the water containing high levels of nutrients (i.e. WMP, leachate, and treated sewage)
- Upgrade existing thickener and add a second train for TSS removal



Process Selection

Worst Case Scenario: Proposed Limits Become License Requirements

Worst Case Scenario

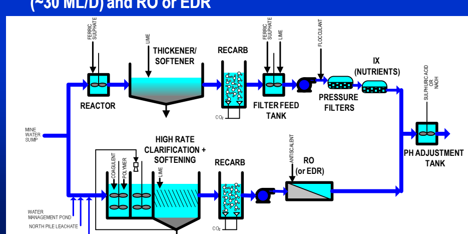
- Treat influent to remove:
  - TSS (additional train must remove) — High Rate Clarification or MF/UF
  - TDS (potential for blending; treat WMP train)
  - Nutrients
    - Ammonia (potential for blending; treat WMP train) — IX or Air Stripping (one train)
    - Nitrate (all trains must remove)
    - Nitrite (all trains must remove)
  - Metals & Major Ions
    - Strontium (all trains must remove)
    - Cadmium (all trains must remove)
    - Fluoride (potential for blending; treat WMP train)
    - Chloride (potential for blending; treat WMP train) — IX or RO (one train)

RO, EDR or IX

Lime Precipitation or RO

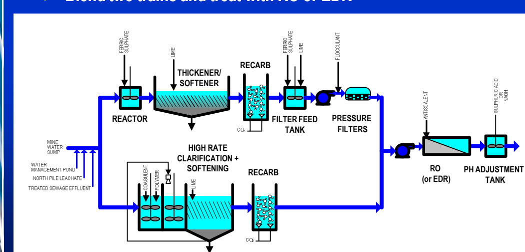
Option 1: RO/IX Blend

- De-rate existing WTP capacity to ½ (17.5 ML/D) and add lime softening
- Convert 6 pressure filters (of 12) into ion-exchange units to remove nutrients (nitrate/nitrate)
- Second treatment train with high rate clarification /lime softening (~30 ML/D) and RO or EDR



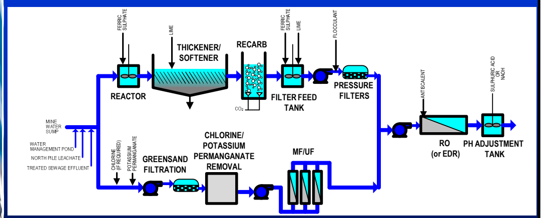
Option 2: Full RO

- Upgrade existing thickener (tube settlers), optimize coagulation, and add lime softening
- Second treatment train with high rate clarification /lime softening (~30 ML/D)
- Blend two trains and treat with RO or EDR

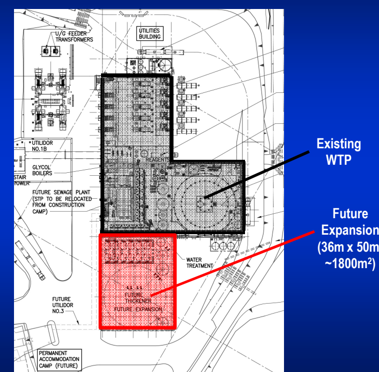


Option 3: Full RO with MF/UF (Second Train)

- Upgrade existing thickener (tube settlers), optimize coagulation, and add lime softening
- Second treatment train with greensand filtration and MF/UF (~30 ML/D)
- Blend two trains and treat with RO or EDR



Future Expansion Space



Additional Information Required

- Chemical feed data (lime, sulphuric acid, ferric sulphate, flocculant)
- Diagram showing the location of sampling points on a map
- Water quality data for treated sewage effluent, flow data into the WTP, and location of addition
- North Pile leachate addition points (blended in WMP or sent directly to WTP?)
- Flow data for leachate (if it is sent directly to the WTP)
- Background water quality data for Snap Lake
- Fluoride addition to the potable water?

Path forward

- De Beers provide additional information requested
- CH2M HILL will prepare a TM on the data review findings, including sampling/ monitoring recommendations
- Review of alternative technology summarized in a TM including:
  - Application
  - Advantages/disadvantages
  - Typical performance
  - Block flow diagrams, equipment lists
  - Preliminary layouts and cost estimates
- Treatment review workshop
- Finalize draft TM on alternative technologies

Updated Schedule

Task	Original Schedule	Revised Schedule
Project Award & Contract Execution	September 30th , 2011	
Project Data Submittal (by De Beers)	October 17th, 2011	
Kickoff Meeting	October 18th, 2011	December 15th, 2011
Data Gap Analysis	October 24th, 2011	January 13th, 2011
Alternatives Review and Draft TM Preparation	November 25th, 2011	February 17th, 2012
Alternatives Workshop	December 13th, 2011	March 5th, 2012
Comments Received (from De Beers)		March 16th, 2012
Final Deliverables Completion	December 23rd, 2011	March 23th, 2012

Snap Lake Mine WTP Upgrades – Kickoff Meeting – Dec 15, 2011 – Conference Call

ATTENDEES: Darrell Matchett-De Beers Canada Inc.
Kyle McDonald-De Beers Canada Inc.
Kelly Griffiths-CH2M HILL
Barry Williamson-CH2M HILL

FROM: Kelly Griffiths – CH2M HILL

DATE: January 12, 2012

The Consultant Team made a presentation to the De Beers Canada Inc. based on the Agenda items. The following minutes summarize discussions and resulting action items from the meeting. If there are any errors or omissions, please contact Barry Williamson.

ITEM	COMMENTS/DIRECTION	ACTION BY	COMPLETION DATE
1.0	**Existing Water Treatment Plant**		
1.1	The North Pile leachate does not flow directly into the WTP; it is directed into the Water Management Pond (WMP). The WMP water is sent to the WTP for treatment prior to discharge into Snap Lake. Water quality data provided for the WMP reflects the combined quality resulting from multiple sources (i.e. leachate, mine water, WTP, etc.) The WMP has approximately 3-days of storage capacity		
1.2	Process Plant water is sent to the WTP for treatment prior to discharge into Snap Lake. The flow of Process Plant water to the WTP is not monitored (no flow meter) as the line was added approximately one year ago. Water quality data is not available for the Process Plant discharge.		
1.3	The water quality of the treated effluent from the STP is monitored before it reaches the WTP. The treated effluent is sent directly to the reactor tank. Other addition points shown on the P&IDs are no	De Beers Canada Inc.	STP flow data received on December 20, 2011

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	longer in use. De Beers will send data on the discharge of the treated STP effluent to the WTP, as well as water quality data for the effluent.		
1.4	Upgrade/Adjustment: Installing a 600 person membrane bioreactors (MBRs) at the STP; currently using a SBR.		
1.5	Chemical Addition: Lime is currently not used at the WTP. Ferric sulphate is added in the reactor tank. Flocculant is added following the reactor tank which goes into the thickener; it is not added to the filters. Sulphuric acid is used as and when needed to adjust the pH of the treated water. De Beers will send chemical feed data for ferric sulphate, flocculant, and sulphuric acid.	De Beers Canada Inc.	
1.6	Upgrade/Adjustment: The filter manufacturer has recommended that De Beers increase the velocity during backwash to improve cleaning of the filters and decrease the backwash cleaning frequency. CH2M HILL to review applicability of this recommendation The filter feed pump has been programmed to operate at a target differential pressure and WTP operators are no longer seeing large fluctuations in differential pressure. The filters are still backwashed three times per day.	CH2M HILL	
1.7	Upgrade/Adjustment: De Beers is planning on raising the pH adjustment tank level by adding an additional wall (3 ft possibly) to provide additional head for discharge to Snap Lake (prevent freezing).		
1.8	Upgrade/Adjustment: De Beers is planning on changing the effluent flow meter to address friction losses.		
1.9	De Beers will send engineering report on pressure affected at different water flows.	De Beers Canada Inc.	
2.0	**Data Review**		
2.1	Over the last 4 years, discharge from the mine has		

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	increased linearly from 10 ML/D to 25 ML/D. If the current trend continues, the WTP will need to treat a capacity of 45 ML/D by 2016. De Beers is currently working on reducing the inflows to the mine by grouting openings beneath Snap Lake. This appears to be slowing down the increase in mine water discharge with respect to an increase in mining production.		
2.2	New license requirements may come into force by April, 2012. De Beers is currently working with the Mackenzie Valley Land and Water Board to determine acceptable effluent requirements. The Environmental Department will likely know what the new targets will be in January. De Beers will send information on the expected targets.	De Beers Canada Inc.	
3.0	**Treatment Options**		
3.1	Building a new 45 ML/D WTP is not the preferred option. De Beers would like to continue to use the equipment in the existing WTP and expand the capacity (upgrades + additional treatment train)		
3.2	Upgrade/Adjustment: De Beers conducted jar tests a couple years ago to confirm that the ferric dose is close to the optimal dose for coagulation. The dose was originally set up by AMEC. The reaction time might not be long enough though. Willing to look at different chemicals.		
3.3	Upgrade/Adjustment: The addition of tube settlers to the thickener to improve settling would require welding, which would result in the shut down of the existing WTP. The mine does not shut down. Options for managing the mine water would be to store the water in the WMP and/or pump a portion the water to the temporary WTP for treatment. Storing the mine water in the WMP may require an expansion (currently has ~3 days of storage). Additionally, upgrades could occur after a second treatment train is put into operation (high rate clarifier). *Preference: Densadeg as the high rate clarification		

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	unit.		
3.4	If a total dissolved solids (TDS) limit is incorporated into the license requirements, advanced treatment processes will be required. Reverse osmosis or electrodialysis reversal (EDR) could be used to remove TDS. RO produces a concentrated waste stream that would need to be disposed of. The brine will not be bound to any other chemicals and it will migrate from the North Pile => Leachate =>WMP		
3.5	Nutrients (ammonia, nitrate, and nitrite) will need to be removed from the mine and WMP water if the proposed license limits are approved. If the current license limits are maintained, side stream treatment for nutrient removal could be an option (only WMP stream). The temporary WTP could be converted into a nutrient removal system for the WMP. Air stripping for ammonia removal would be energy intensive since the Snap Lake Mine is located in an area with a cold climate. The air stripper could be housed indoors.		
3.6	Metal concentrations in the effluent comply with the current license limits. To comply with the proposed license limits some metals (ex. strontium) will need to be precipitated by raising the pH in the thickener/clarifier with lime softening. CO_2 (recarbonation) or sulphuric acid could be added following lime softening to bring the pH back down prior to discharge into Snap Lake.		
3.7	Hydraulic oil is used during drilling operations in the mine. Oil in the mine water could have an effect on the membrane/filter technologies selected. It is estimated that 100,000 gallons per year of oil is deposited into the mine water. Might be diluted to the extent that it has no effect. At 25 ML/D, the concentration of oil in the mine water would be approximately 0.041 mL/L (~30 to 40 mg/L)		
3.8	De Beers would prefer that the existing pressure filters were not converted into ion-exchange units,		

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	as the filter pressure vessels were damaged at start-up (filters were over pressurized). They are currently welded together, but there is some cracking. Might be best to leave the existing pressure filters alone.		
3.9	A MBR could be used in a second train to remove TSS and nutrients from the mine/WMP water; however, denitrification bugs require a food source. Sewage could be used as the food source, unless the STP water is treated with an MBR. Otherwise methanol, ethanol, or acetic acid would have to be added.		
3.10	De Beers will send CAD drawing files	De Beers	Received on December 15, 2011
4.0	**Path Forward**		
4.1	Project Completion Schedule • De Beers provide additional information requested • CH2MHILL will prepare a TM on the data review findings, including sampling/monitoring recommendations • Review of alternative technology summarized in a TM • Treatment review workshop • Finalize draft TM on alternative treatment technologies		
5.0	**Updated Project Schedule**		
5.1	Project Completion Schedule • Data Review Findings TM: Jan. 13, 2012 • Alternatives Review and Draft TM Preparation: Feb. 17, 2012 • Alternatives Workshop: March 5, 2012 • Comments Received (De Beers): March 16, 2012 • Final Deliverables		

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	Completion: March 23, 2012		