B.Y.G.
NATURAL RESOURCES INC.

VISTA ENGINEERING

MT. NANSEN GOLD MINE

TAILINGS IMPOUNDMENT DRAINAGE CONTROL EVALUATION

Prepared By:
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Prepared For:
B.Y.G. Natural Resources Inc.
General Delivery
Carmacks, YT
YOV 1CO

290- 09
February 24, 1998

VISTA ENGINEERING

Our File: 290-09

February 24, 1998

B.Y.G. Natural Resources Inc.
General Delivery
Carmacks, YT
Y0V 1C0

Attention: Mr. Graham Dickson

Re: Tailings Impoundment Drainage Control – Evaluation of Alternatives

Please find enclosed seven copies of the above noted report.

Based on this evaluation, the most effective method of reducing the amount of runoff entering the tailings impoundment is to line the existing north and west diversion ditches with an impermeable membrane.

Construction of a diversion on the south shore is not recommended due to the presence of shallow permafrost and erodible soils. As well, this diversion would intercept only 2% of the total tailings impoundment watershed area.

Due to the difficulties involved with installation of the liners when soils are frozen, it is recommended that runoff during the 1998 freshet be collected in a sump and diverted around the tailings impoundment by pumping. The liners should be installed once the soils have thawed to a depth of approximately one meter.

The cost of liner installation is estimated at $65,000. An additional $20,000 should be budgeted for the construction of a temporary sump and rental of large capacity pumps.

It has been identified during this analysis that the original water balance model did not account for seepage from the diversion ditches. The water balance model should be updated to reflect this item as well as proposed improvements to the drainage system.

If you should have any questions or require additional information, please contact us at 393-3458.

Yours truly,

Vista Engineering

Victor Menkal, P.Eng.

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0.0 INTRODUCTION

Excessive amounts of runoff water have been entering the tailings impoundment at the Mt. Nansen gold mine. This has resulted in the suspension of milling operations and the treatment of large amounts of water from pond to prevent overtopping of the containment structures. As well, there are concerns that there will be insufficient storage to accommodate runoff during spring freshet.

This report evaluates alternatives for reducing the volume of runoff entering the tailings pond during spring freshet and the open water season.

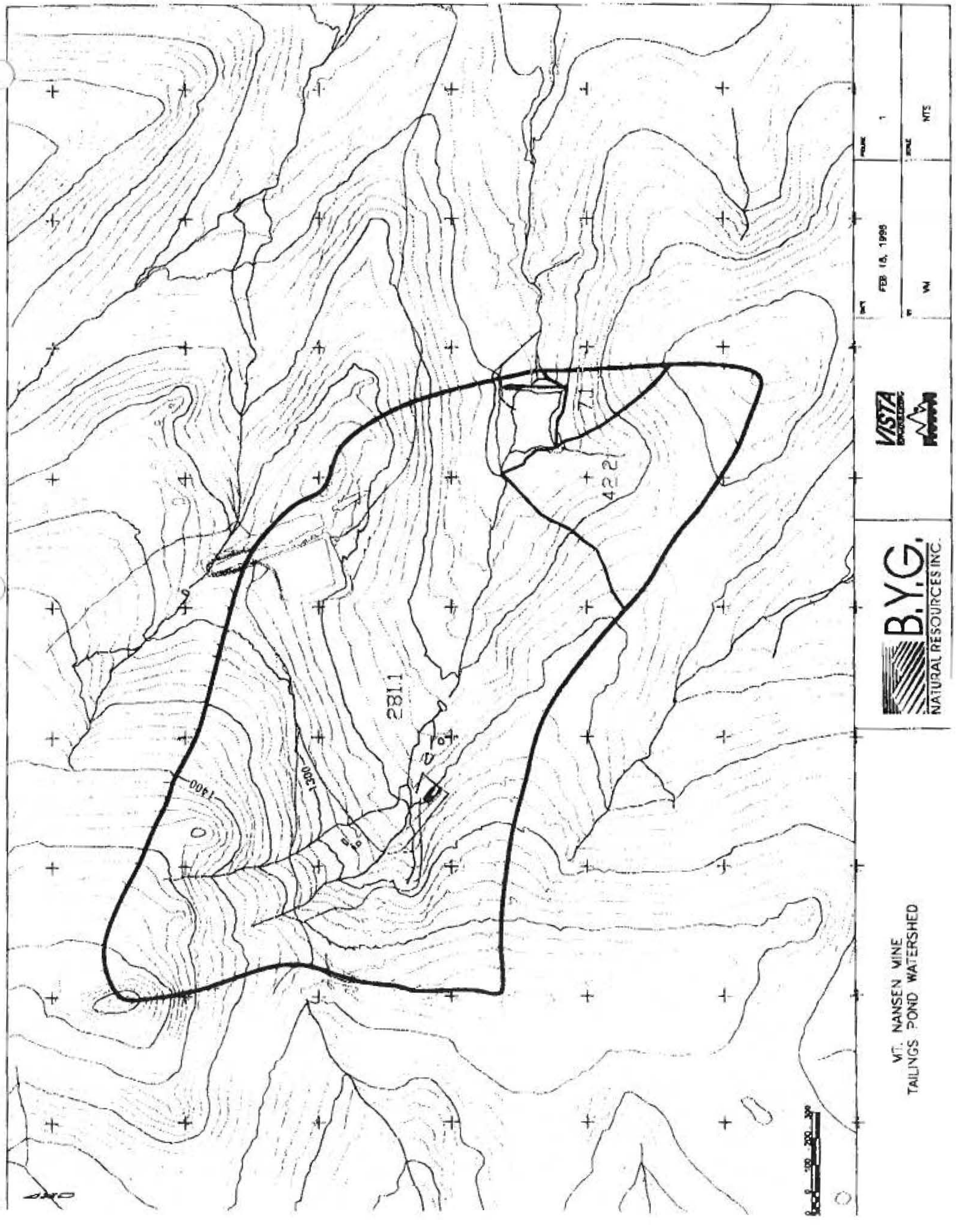
1.0 BACKGROUND

Figure 1 depicts the tailings pond and associated drainage area. Based on this drawing, the total area which drains into the tailings basin is approximately 330.4 hectares.

Surface drainage water is currently diverted by ditches on the north and west shores of the tailings impoundment. There is no diversion on the south shore of the tailings pond.

The north ditch diverts Dome Creek as well as intercepting surface runoff from the area directly north of the tailings impoundment. The total surface area which is serviced by this ditch is 281.1 hectares or approximately 85% of the total tailings impoundment drainage area.

The west diversion ditch extends to intercept the valley and stream located to the south west of the impoundment. This ditch intercepts 42.2 hectares or approximately 13% of the entire drainage area.


MT. NANSEN MINE
TAILINGS POND WATERSHED
B.Y.G.
NATURAL RESOURCES INC.
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Approximately 7.1 hectares or 2% of the watershed located to the south of the tailings pond is not diverted and drains directly into the tailings pond.

The existing ditches are unlined. Based on in-stream measurements completed in September 1997, approximately 50% of the water conveyed by the north diversion ditch enters the tailings pond by seeping through the permeable soils underlying the structure.

The original design brief for the tailings facility had assumed that the soils underlying the diversion ditches would be frozen and remain completely impermeable during spring freshet. Based on field observations of the performance of the structures it appears that there may be some seepage even under fully frozen conditions. This observation has not been confirmed by in-stream measurements.

For the purposes of this analysis, it has been assumed that 25% of water entering the ditches during spring freshet will seep into the tailings pond.

Field measurements of snow pack completed by B.Y.G. Natural Resources Inc. staff indicate that the current water equivalent of the snow pack in the tailings pond drainage basin is 53mm. Last years snow pack prior to spring freshet was 72mm and the design snow pack is 100mm.

Table 1.1 provides an estimate of water volumes generated during spring freshet using current and 1997 snowpack depths. As well the table provides estimates for total runoff including normal year and 200 year return wet year precipitation in addition to snow melt assuming that spring melt occurs in one month.

Table 1.2 provides an estimate of the water volumes which will enter the pond during spring freshet assuming that the diversion ditches will have a seepage rate of 25%. A runoff coefficient of 0.8 is used as it is expected that losses will be low due to frozen subsurface soils

Total Runoff During Spring Freshet
Runoff Coefficent 0.8
m^3

		Snowpack Feb 8 '98	Snowpack 1997	Design Snowpack	Avg year freshet	200 yr freshet
	Precip (mm)	50	75	100	130	170
South Catchment (ha)	7.1	2840	4260	5680	7384	9656
West Catchment (ha)	42.2	16880	25320	33760	43888	57392
North Catchment (ha)	281.1	112440	168660	224880	292344	382296
	Total	132210	198315	264420	343746	449514

Table 1.1

Runoff Entering Tailings Pond During Spring Freshet
Runoff Coefficent 0.8
25% Ditch Seepage
m^3

		Snowpack Feb 8 '98	Snowpack 1997	Design Snowpack	Avg year freshet	200 yr freshet
	Precip (mm)	50	75	100	130	170
South Catchment (ha)	7.1	2840	4260	5680	7384	9656
West Catchment (ha)	42.2	4220	6330	8440	10972	14348
North Catchment (ha)	281.1	28110	42165	56220	73086	95574
	Total	35220	52830	70440	91572	119748

Table 1.2

Yearly Runoff Entering Tailings Pond
Runoff Coefficent 0.6
25% Ditch Seepage During Freshet
50% Ditch Seepage During Open Water
m^3

		Avg Year Rainfall	Wet Year Rainfall
	Precip (mm	161	310
South Catchment (ha)	7.1	12539	18886
West Catchment (ha)	42.2	28823	47686
North Catchment (ha)	281.1	191991	317643
	Total	233514	384525

Table 1.3

Table 1.3 includes summer precipitation to provide an estimate for the total volumes entering the pond if it is assumed that there is 25% seepage during the freshet and 50% seepage during summer months. A runoff coefficient of 60% is assumed for summer months.

Based on these estimates, from 35,000 to 120,000 cubic meters could enter the pond during spring freshet depending on snowpack and rainfall during the freshet period. Over the entire summer, the volumes increase significantly to between 230,000 to 384,000 cubic meters depending on precipitation.

It should be noted that the estimates for seepage from ditches are approximate only as direct measurement of seepage was limited to one metering in the fall. In-stream measurements would need to be collected during spring freshet and early summer to determine the actual amount of seepage from the structures.

2.0 ALTERNATIVES TO REDUCE POND INFLOWS

2.1 Diversion Ditch on South Shore of Pond

An alternative to reduce drainage into the tailings pond would be to construct a diversion on the south side of the tailings pond. This is currently the only path for surface drainage to enter the tailings pond directly.

The soils in this area are unstable due to the presence of relatively warm permafrost at shallow depth, readily erodable silty soils and steep grades. It is expected that a conventional excavated ditch would result in permafrost degradation and erosion of the channel similar to that observed in the temporary diversion ditch (east of the dam) last spring and summer.

The drainage area is relatively small at 7.1 hectares or 2% of the entire drainage basin and contributes from 6,000 to 9,000 cubic meters during spring melt and from 12,500 to 18,900 cubic meters over the total year.

As the volume of runoff entering the pond from this catchment area is relatively low and there is a high potential for thaw degradation and erosion in this area, it is recommended that a drainage diversion not be constructed in this area.

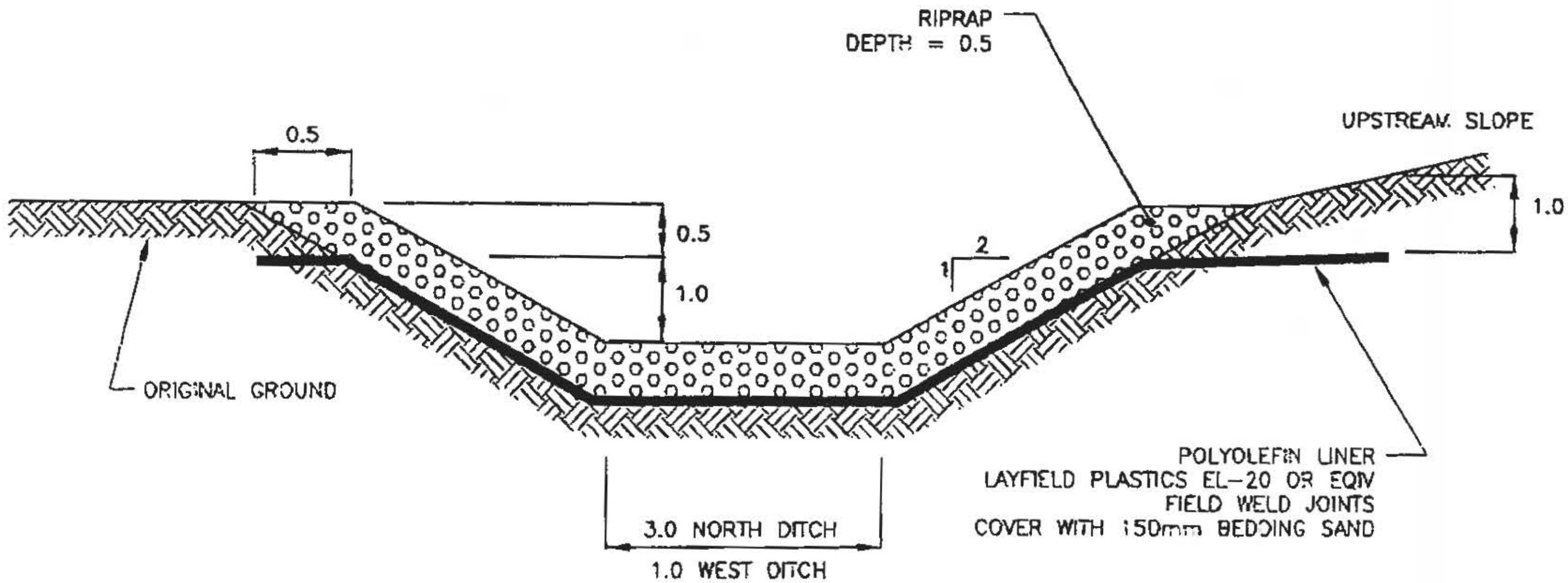
2.2 Lining Existing Ditches

As identified in tables 1.2 and 1.3, a significant volume of water may enter the tailings impoundment by seeping through the existing diversion ditches. Based on stream flow measurements collected in 1997, approximately 50% of the water which enters the ditches seeps into the tailings pond in the latter portions of the open water season. This is a result of the highly porous sandy and silty soils in which the structures have been constructed.

Over the course of the season, it is estimated that from 28,000 to 48,000 cubic meters of water may enter the tailings pond as seepage from the west diversion ditch. From 190,000 to 320,000 cubic meters may enter the pond from the primary (north) diversion ditch. The actual amount would be proportional to the precipitation amounts and actual seepage rates.

An impermeable membrane such as high density polyethylene (HDPE), PVC "Arctic Liner" or polyolefin could be used to significantly reduce seepage from these ditches. PVC is not recommended as it becomes brittle at low temperatures and may be subject to tearing during maintenance operations. HDPE is flexible at low temperatures but requires field welding of joints which normally requires factor personnel to complete, increasing installation costs. Layfield Plastics have

NOTE: CONCEPTUAL ONLY



EXISTING DITCH LINING DETAIL
TYPICAL SIDESLOPE SECTION

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DATE JANUARY 19, 1998	FIGURE 2.1
BY VM	SCALE NTS

developed a new polyolefin liner called "Enviro Liner" which is flexible at cold temperatures and is similarly priced to HDPE but can be field welded by on-site personnel using a factory supplied kit.

Figure 2.1 depicts a typical cross section using a liner.

The liner would need to be bedded in sand to protect the liner from tears. As the ditches need to be cleaned of ice prior to spring freshet, additional protection is also required in the form of armour riprap.

Where the ditches are located on a hill side slope, the effectiveness of the liner can be improved by extending and lowering upstream portion of the liner to intercept subsurface flows in the active layer.

3.0 CONSTRUCTION CONSIDERATIONS

3.1 By-pass Pumping

Frozen soils will make installation of liners prior to spring difficult especially in the north diversion ditch as the bed was fully saturated prior to freeze up.

Damage may result to the liner due the presence of frozen lumps in the sand bedding. Excavation of the existing riprap may require ripping making grade control difficult due to large pieces of frozen riprap. It is unlikely that this riprap could be replaced once the liner is installed with satisfactory results. Thawing of soils in the spring may also result in displacement of grade.

An alternative to winter construction would be to collect runoff in a sump and pump water past the diversion ditch until soils have thawed sufficiently to allow installation of the liners. A sump could be constructed at the confluence of the west and north diversion ditches and collected water pumped past the tailings pond. It is estimated that this system would eliminate most of the seepage associated with the north diversion ditch as well 60% of the water conveyed by the west ditch.

The size of pumps required to accommodate spring flow is dependent on the rate of flow during spring runoff. The peak flow would be dependent on a number of factors, primarily the rate of melt in the spring and the amount of precipitation which may occur simultaneously. An indirect estimate of the volume of flow can be made based on tailings pond water elevations in 1997.

Spring freshet was observed to commence at the beginning of April in 1997. Based on tailings pond water elevations, peak flow entering the tailings pond was approximately 3,600 cubic meters per day. The west diversion ditch was not constructed at this time.

Assuming a 25% rate of seepage, the peak water flow in the diversion ditch would have been 14,400 cubic meters per day. Allowing an additional 15% for water which will be collected by the west diversion ditch, the peak flow can be roughly estimated at 16,500 cubic meters per day or 690 cubic meters per hour.

The actual peak flow would be dependent on a number of factors including temperature, snow accumulation and rainfall.

At a peak flow rate of 690 cubic meters per hour, three 150mm, diesel driven pumps rated at 2,500 L/min would be required to accommodate the peak flow. As this flow would be of relatively short duration, an option may be to use fewer pumps and allow some of the runoff to flow into the north diversion ditch during the peak flow.

The sump should consist of a low berm with overflow structure and a sump for the pump intakes. Total storage volume of the sump should be approximately 1,000 cubic meters to allow for adequate control of the system.

It should be noted that the pumping system will be labour intensive and require continual monitoring during its operation. The discharge lines should be graded to allow for draining of the lines when the pumps are not in operation and continual monitoring and adjustment of pumping rate will be required to accommodate daily fluctuations in flow.

It is estimated that approximately 18,000 of water will enter the tailings pond during an average spring freshet from the south catchment area as well as seepage from the west diversion ditch if the pumping system is in place.

3.2 Implementation Sequence

The following identifies the implementation sequence for the proposed drainage control measures.

1. Clean ice from ditches
2. Rough grading of west ditch, especially at upper reaches
3. Construct collection sump
4. Install pumps and discharge lines
5. Order liners
6. Install liner in north diversion
7. Remove sump
8. Install liner in west diversion

DIVERSION OPTIONS
PRELIMINARY COST ESTIMATES

Option 1 - Line North Diversion

	Item	*Units*	*Quant*	*Unit Cost*	*Ext*
1	Liner	m2	3000	4	12000
2	Prep Hoe	Hours	20	225	4500
3	Labour	Hours	160	20	3200
4	Fill Hoe	Hours	20	225	4500
5	Dewatering	LS	1	2500	2500
					$26,700
				say	**$30,000**

Option 2 - Line West Diversion Extention

	Item	*Units*	*Quant*	*Unit Cost*	*Ext*
1	Liner	m2	2100	4	8400
2	Prep Hoe	Hours	20	225	4500
3	Labour	Hours	160	20	3200
4	Granular Cover	m3	1500	5	7500
5	Fill Hoe	Hours	20	225	4500
6	Dewatering	LS	1	2500	2500
					$30,600
				say	**$35,000**

Option 3 - Construct South Diversion Berm

	Item	*Units*	*Quant*	*Unit Cost*	*Ext*
1	Liner	m2	4900	4	19600
2	Cat	Hours	100	150	15000
3	Embankment	m3	4200	5	21000
3	Labour	Hours	200	20	4000
4	Granular Cover	m3	2800	5	14000
5	Hoe	Hours	50	225	11250
					$84,850
				say	**$90,000**

Option 4 - Spring Diversion by Pumping from Sumps

	Item	*Units*	*Quant*	*Unit Cost*	*Ext*
1	Sump	LS	1	10000	10000
2	Pump & piping rental	month	2	5000	10000
					$20,000

Table 4.1

Items 1 to 4 should be completed by mid March. The installation of the liners should commence once soils have thawed to a depth of one meter.

Due to the presence of silty and sandy soils along the ditch alignments, it should be possible to place the liner directly on the excavated and trimmed ditch sections. The soils excavated during installation can be used to provide a protective layer on top of the liner with a final backfill of 0.5m of riprap.

4.0 COST ESTIMATES

Table 4.1 presents preliminary cost estimates for lining the north and west ditch. As well, the cost of constructing a diversion berm on the south shore of the tailings impoundment has also been estimated.

It has been assumed that the existing riprap will be salvaged during the installation of the liner in the north diversion. Additional riprap material will be required for the west diversion. Due to the presence of sandy soils along both alignments, it should be possible to place the liner directly on the excavated and trimmed ditch surfaces. These soils can also be used for the protective cover over the liner.

The cost of lining the north and west diversion ditches is estimate at $65,000. An additional $10,000 should be budgeted for sump construction and pump rental.

DIVERSION OPTIONS
PRELIMINARY COST ESTIMATES

Option 1 - Line North Diversion

	Item	*Units*	*Quant*	*Unit Cost*	*Ext*
1	Liner	m2	3000	4	12000
2	Prep Hoe	Hours	30	225	6750
3	Labour	Hours	160	20	3200
4	Fill Hoe	Hours	20	225	4500
5	Dewatering	LS	1	2500	2500
					$28,950
			say		**$30,000**

Option 2 - Line West Diversion Extention

	Item	*Units*	*Quant*	*Unit Cost*	*Ext*
1	Liner	m2	2100	4	8400
2	Prep Hoe	Hours	30	225	6750
3	Labour	Hours	160	20	3200
4	Granular Cover	m3	1500	5	7500
5	Fill Hoe	Hours	20	225	4500
6	Dewatering	LS	1	2500	2500
					$32,850
			say		**$35,000**

Option 3 - Construct South Diversion Berm

	Item	*Units*	*Quant*	*Unit Cost*	*Ext*
1	Liner	m2	4900	4	19600
2	Cat	Hours	100	150	15000
3	Embankment	m3	4200	5	21000
3	Labour	Hours	200	20	4000
4	Granular Cover	m3	2800	5	14000
5	Hoe	Hours	50	225	11250
					$84,850
			say		**$90,000**

Option 4 - Spring Diversion by Pumping from Sumps

	Item	*Units*	*Quant*	*Unit Cost*	*Ext*
1	Sump	LS	1	10000	10000
2	Pump & piping rental	month	2	5000	10000
					$20,000

Table 4.1

5.0 CONCLUSIONS AND RECOMMENDATIONS

1. A considerable volume of water has been entering the tailings impoundment via seepage from the existing diversion ditches. During an average year freshet, this volume could be as high as 90,000 cubic meters assuming a 25% rate of seepage from ditches during spring conditions.

2. Over the open water period, the total seepage into the pond could be in excess of 200,000 cubic meters.

3. It appears that the original water balance model did not account for seepage from the ditches. The water balance should be updated to allow for this seepage as well as any improvements to the diversion structures.

4. Due to the presence of shallow permafrost, readily erodable soils, and relatively small drainage area, the construction of a drainage diversion on the south shore of the tailings impoundment is not recommended.

5. The most effective method of reducing the volume of runoff entering the tailings impoundment is to line the existing north and west diversion ditches with an impermeable lining.

6. Due to the difficulties associated with construction in frozen soils, it is recommended that water from the west diversion and Dome Creek be collected in a sump and pumped past the tailings impoundment during spring freshet.

7. The cost of installing liners in the north and west diversion ditches is estimated at $65,000. An additional $10,000 should be budgeted for the construction of the collection sump and rental of large capacity pumps.