Supporting Document L1

Water Treatment Update
(SENES, 2005)

REPORT ON

WATER TREATMENT UPDATE
GIANT MINE REMEDIATION PLAN

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TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 BACKGROUND

SENES Consultants Limited (2002) prepared a study of alternative treatment methods that could be applied to the treatment of waste waters that could arise from the remediation of the Giant Mine arsenic trioxide dust (Supporting Document 8 - Water Treatment, Arsenic Trioxide Management Alternatives Final Report, December 2002). At that time, a number of remediation options were under review including removal and disposal or reprocessing of the arsenic trioxide dust. For the alternatives study it was determined that, for any option, there would be a need for interim or long term collection and treatment of waste waters from the mine. The primary contaminant requiring treatment was arsenic. Waste water characteristics were projected to vary greatly for each option with arsenic concentration in mine waters containing 5 to 100 mg/L and processing and chamber wash waters containing upwards of 1,000 to 5,000 mg/L.

With the wide range of flows and arsenic concentrations, 5 treatment systems were evaluated. These included:

- Option No. 1 - Oxidation and Direct Precipitation with Iron- Oxidation with peroxide or chlorine followed by arsenate precipitation. Precipitants would normally be iron salts. This option is most applicable to low strength solutions as reagent costs are high. Sludges formed would be thickened/dewatered and disposed in a secure landfill. This is a BAT treatment process and widely used in the industry.

- Option No. 2 - Direct Precipitation with Lime - All arsenic would be precipitated with lime at high pH. The sludge would be dewatered and stabilized prior to disposal in a secure landfill. This process could be applied to medium and high strength wastes. Laboratory and related field experience indicates this process would meet BAT limits.

- Option No. 3 - Evaporation/Crystallization - Solutions are acidified, heated and crude crystalline arsenic trioxide is formed. The crude arsenic trioxide would be stabilized for secure surface disposal or sent to an arsenic recovery circuit where available. This process is most applicable to high strength solutions. The condensate would be "distilled water" but may still contain trace levels of arsenic from carryover from the evaporator. Therefore to assure BAT limits, it could be necessary to include a final polishing stage using an iron precipitation.

- Option No. 4 - Concentration followed by Evaporation/Crystallization- Low to medium strength solutions are filtered, concentrated by reverse osmosis such that evaporation/crystallization becomes an economic alternative to oxidation and precipitation. The crude arsenic trioxide would be stabilized for secure surface disposal or possibly sent to a recovery circuit. The RO unit can meet BAT discharge limits as long as sufficient stages of RO are used. The actual requirements would need to be confirmed. It may prove to be more economic to include a final polishing stage using iron precipitation rather than additional stages of RO.

- Option No. 5 - Concentration followed by direct precipitation with lime. Low to medium strength solutions are filtered concentrated by reverse osmosis such that direct precipitation with lime becomes an economic alternative to oxidation and precipitation. The crude calcium arsenate/arsenite would be stabilized for secure surface disposal or possibly sent to a recovery circuit. The process should produce BAT effluent quality.

Since the alternatives study was completed, an option has been selected for the long term management and this is in-situ freezing of the arsenic dust. For this option, the ground both within and around the arsenic trioxide chambers and stopes will be frozen to effectively inhibit future leaching of arsenic dust. With the freezing completed, arsenic levels in minewater are projected to decline, and may eventually reach levels low enough for direct discharge. However, arsenic levels are likely to remain above current discharge permit levels of 0.5 mg/L for an extended period, during and after implementation of the remediation plan, and as such will require treatment.

In 2002, the treatment options report only addressed waste water associated with the arsenic trioxide management project. With the Giant Mine now closed and the remediation plan for the surface works integrated with the closure of the underground mine, additional waste water must also be managed. The primary source of this additional water is arsenic contaminated runoff and seepage from the surface facilities.

1.2 SCOPE OF WORK

The scope of work for this evaluation was to:

- Update the treatment options report to reflect the proposed water flows and characteristics for the selected freezing alternative and the remediation plan for surface works.
- Select an appropriate option for long term treatment of the Giant Mine waste waters
- Prepared a conceptual design and cost estimate for the waste water treatment facility.

2.0 SELECTION OF THE PREFERRED ALTERNATIVE

2.1 WASTE WATER CHARACTERISTICS

The water management system proposed under the Remediation Plan would use the underground mine workings for storage of all waste waters prior to treatment. Thus, runoff from the tailings containment areas would be directed into the mine for storage, as long as it remains contaminated and requires treatment before discharge to the environment.

The estimated volumes and arsenic loads reporting to mine storage in a year with average climatic conditions are shown in the following tables. Table 2.1 shows estimates for the short-term, which covers the period while the underground freezing plan is being implemented. During this period, loadings from the underground mine may not effectively reduce below current levels. Treatment of runoff from the tailings containment areas is also expected to be required in the short-term.

TABLE 2.1
Estimated Short-term Volumes and Arsenic Loadings (Average Year)

Month	**Mine Groundwater**		**Mine Infiltration**		**Tailings Area Runoff**		**Combined Sources**		
	Volume (m^3)	Loading (As-kg)	Volume (m^3)	Loading (As-kg)	Volume (m^3)	Loading (As-kg)	Volume (m^3)	Loading (As-kg)	Equiv. Conc. (As mg/L)
January	17,900	54	0		0		17,900	54	3.0
February	16,100	48	0		0		16,100	48	3.0
March	17,900	54	0		0		17,900	54	3.0
April	17,300	52	2,700	343	3,900	4	23,800	399	16.7
May	17,900	54	67,500	8,576	96,500	97	181,900	8,726	48.0
June	17,300	52	27,000	3,430	38,600	39	82,900	3,521	42.5
July	17,900	54	9,500	1,201	13,500	14	40,800	1,268	31.1
August	17,900	54	9,500	1,201	13,500	14	40,800	1,268	31.1
September	17,300	52	10,800	1,372	15,400	15	43,500	1,439	33.1
October	17,900	54	8,100	1,029	11,600	12	37,500	1,094	29.1
November	17,300	52	0		0		17,300	52	3.0
December	17,900	54	0		0		17,900	54	3.0
ANNUAL	210,200	631	135,100	17,151	193,000	193	538,300	17,975	33.4

Estimates of water volumes and arsenic loadings for the long-term are shown in Table 2.2. In the long-term, the underground freezing would effectively eliminate loadings from the arsenic chambers and stopes, although lesser loadings from other mine materials would be expected to continue. The proposed covering of tailings is expected to reduce loadings to runoff in the tailings containment areas such that treatment of the runoff will not be required in the long-term.

TABLE 2.2
Estimated Long-term Volumes and Arsenic Loadings (Average Year)

Month	Mine Groundwater		Mine Infiltration		Tailings Area Runoff		Combined Sources		
	Volume (m^3)	Loading (As-kg)	Volume (m^3)	Loading (As-kg)	Volume (m^3)	Load (As-kg)	Volume (m^3)	Loading (As-kg)	Equiv. Conc. (As mg/L)
January	17,900	54	0	-	0	-	17,900	54	3.0
February	16,100	48	0	-	0	-	16,100	48	3.0
March	17,900	54	0	-	0	-	17,900	54	3.0
April	17,300	52	2,700	5	0	-	20,000	57	2.8
May	17,900	54	67,500	122	0	-	85,400	175	2.1
June	17,300	52	27,000	49	0	-	44,300	100	2.3
July	17,900	54	9,500	17	0	-	27,300	71	2.6
August	17,900	54	9,500	17	0	-	27,300	71	2.6
September	17,300	52	10,800	19	0	-	28,100	71	2.5
October	17,900	54	8,100	15	0	-	26,000	68	2.6
November	17,300	52	0	-	0	-	17,300	52	3.0
December	17,900	54	0	-	0	-	17,900	54	3.0
Annual Totals	210,200	631	135,100	243	0	-	345,300	874	2.5

Based upon the data in Table 2.1 and Table 2.2, arsenic concentrations in the feed to the treatment plant will average about 33 mg/L in the short term, decreasing to an annual average of 2 to 3 mg/L once the underground freezing and covering of tailings are fully effective.

Estimates of the increased volumes that would require storage and treatment under wet climatic conditions have been made, based on review of historical mine inflow volumes, and assessment of the tailings containment area water balance. Under climatic conditions approximately equivalent to the wettest year expected in a ten year period, total annual inflow to the mine (from infiltration, as well as groundwater) would be expected to increase by 28%. Annual runoff from the tailings containment areas would be expected to increase by 35% under these conditions. Thus, in the short-term, while tailings runoff is being treated, the total volume requiring treatment in a wet year would increase to about 700,000 cubic metres.

2.2 PREFERRED TREATMENT OPTION

The primary contaminant in the water is arsenic and treatment is to be provided to meet permit limits based on the Best Available Treatment (BAT) technology. The treatment options study (SENES, 2002) investigated five options which included utilization of alternative precipitating agents, concentration/precipitation technologies and evaporation. From the 2002 review, Option No. 1 - Oxidation and Direct Precipitation with Iron was selected as the preferred alternative for waste water streams with arsenic levels below about 250 mg/L. At higher arsenic concentrations, Option No. 2 - Direct Precipitation with Lime was shown to be more cost effective.

Based upon SENES (1999), the Best Available Technology for arsenic removal in mining effluents included: oxidation to assure all arsenic is converted from As(III) to As(V); iron addition to precipitate iron arsenate and; sedimentation to remove the suspended precipitate.

Operating performance was reviewed by SENES for all Canadian mines where arsenic was the primary contaminant removed. The best performing plants produced arsenic levels as follows:

Primary Contaminant	**# of BAT Plants Selected**	**Range of Annual Average Concentrations for the Best BAT Plants**	**95^{th} Percentile of Maximum Monthly Average Concentration for the Best BAT Plants**
Total As	3	0.025 to 0.18 mg/L	0.4 mg/L

Based upon the 2002 options review and SENES 1999, Option No. 1 - Oxidation and Direct Precipitation with Iron is selected as the preferred option for long term management of waste waters arising from the remediation of the Giant Mine.

With Option No. 1, it is expected that a well operated plant employing BAT technology could meet an average discharge level of about 0.1 mg/L of Arsenic.

3.0 CONCEPTUAL DESIGN

3.1 DESIGN BASIS

The water management system proposed under the Remediation Plan would use the underground mine workings for storage of all waste waters prior to treatment, thus avoiding the need to store contaminated water in ponds on surface. In order to keep the variation in mine water level within practical limits, water would be pumped from the mine, treated, and discharged to the environment throughout the year. The rate of treatment and discharge would be variable, so that additional volumes could be treated under wet climatic conditions, and adequate storage capacity would always be available. However, under average climatic conditions, the operating plan for the plant would be to maintain consistent treatment rates throughout the year.

The volumes of water requiring treatment and average arsenic concentrations of the combined water sources are shown in Table 2.1 and Table 2.2. Based upon these data the following design basis is recommended.

- Mean flow to the plant would be 1475 m^3/d to treat 538,000 m^3 in an average year, as required in the short-term, when tailings runoff would be treated. The mean flow in the short-term would increase to 1921 m^3/d to treat 700,000 m^3 in a wet year. Allowing for 10% plant downtime, and adding 20% contingency capacity, the plant design would allow a maximum treatment rate of 2560 m^3 per operating day. Mean flow to the plant in an average year would decrease to 946 m^3/d in the long-term.
- The annual average arsenic level in the flow to the plant is estimated to be 33 mg/L in the short-term. However, the arsenic level could be quite variable, depending on the efficiency of mixing of waters from various sources in the mine. Therefore, the plant design would allow the treatment of water with up to 100 mg/L arsenic. In the long-term, the annual average arsenic level is estimated to be 2.5 mg/L.

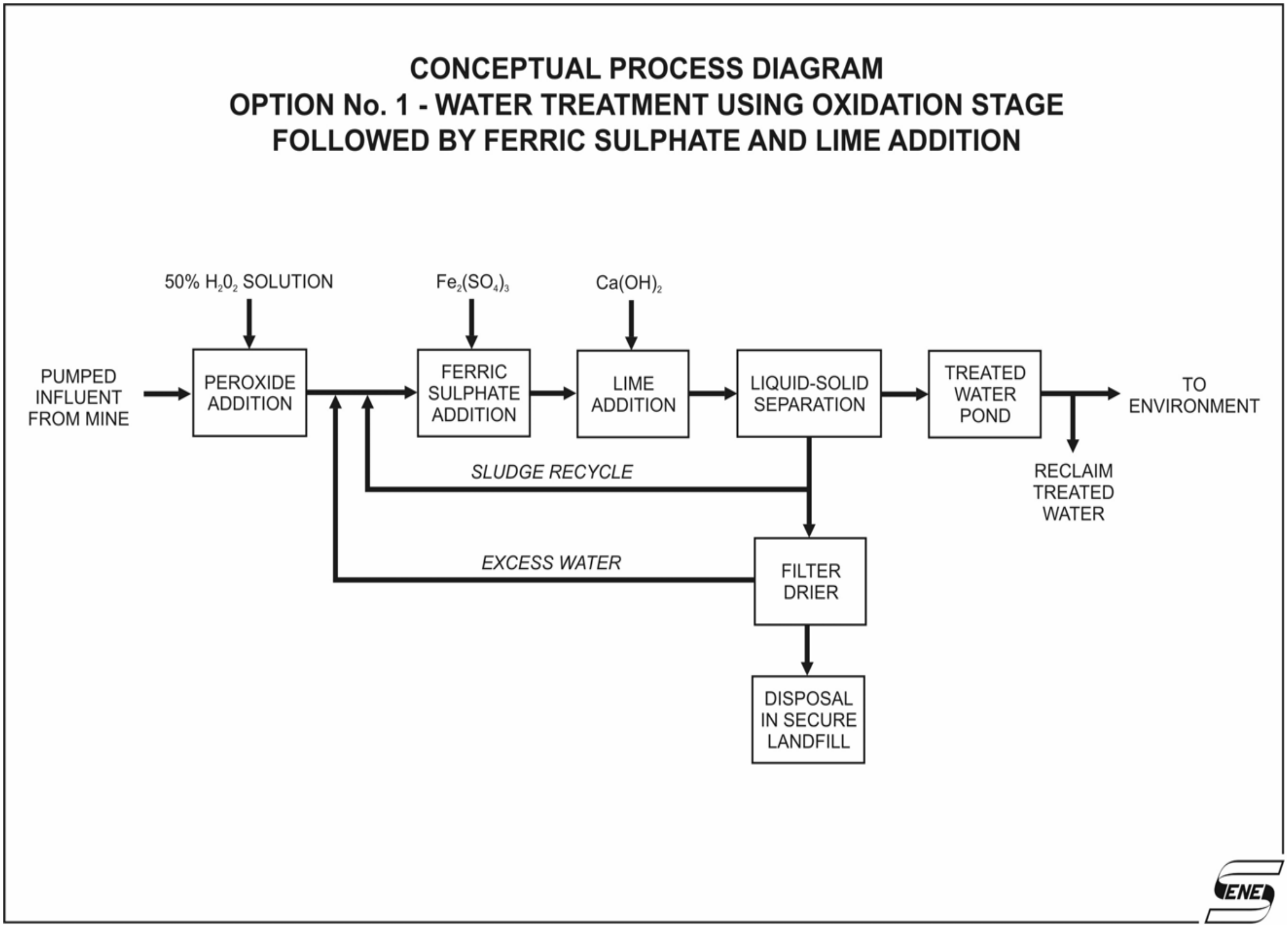
3.2 PROCESS DESCRIPTION

The process flow sheet for Option No. 1 is provided on the following page.

Water will be pumped directly from the mine into an open mixed tank and combined with a 50% hydrogen peroxide solution. The peroxide will be used to oxidize arsenite (As (III)) to arsenate (As(V)) in order to improve the performance of the subsequent precipitation stages. The oxidation of arsenite is represented by equation shown

$$As_2O_3 + 2H_2O_2 + H_2O \rightarrow 2H_3AsO_4$$

The mixing tank will provide 15 minutes of residence time at the design maximum flow (27 m^3). The addition of hydrogen peroxide would additionally remove minor amounts of fuel, oil or


CONCEPTUAL PROCESS DIAGRAM
OPTION No. 1 - WATER TREATMENT USING OXIDATION STAGE
FOLLOWED BY FERRIC SULPHATE AND LIME ADDITION
50% H_2O_2 SOLUTION
$Fe_2(SO_4)_3$
$Ca(OH)_2$
PUMPED INFLUENT FROM MINE
PEROXIDE ADDITION
FERRIC SULPHATE ADDITION
LIME ADDITION
LIQUID-SOLID SEPARATION
TREATED WATER POND
TO ENVIRONMENT
RECLAIM TREATED WATER
SLUDGE RECYCLE
EXCESS WATER
FILTER DRIER
DISPOSAL IN SECURE LANDFILL

grease should they be present in the wastewater. Experience to date has shown that much of the arsenic is already present as As(V) therefore peroxide addition may not be necessary on an ongoing basis.

Hydrogen peroxide is a clear liquid and has a distinctive pungent odour. It is miscible in water and is non-flammable. The product is a strong oxidant that can breakdown to form water and oxygen under certain conditions, and as such requires appropriate storage and handling. The product will be stored in a double wall and lined closed tank. The product would be stored as a 50% H_2O_2 solution – at this strength, the solution begins to freeze at about –52ºC. The operating and response procedures for the treatment plant would describe safe H_2O_2 storage and handling procedures, and health and safety requirements.

The theoretical peroxide demand is 0.91 g 50% H_2O_2 per 1 g As(III) oxidized. Assuming 1.3 times the stoichiometric demand, the estimated average H_2O_2 consumption for the treatment plant is summarized in Table 3.1.

TABLE 3.1
Estimated H_2O_2 Consumption

		Short-term Average Condition	Long-term Average Condition
Flow	m^3/d	1475	946
As(III) concentration	mg/L	33.4	2.5
As(III) loadings	kg/d	49.2	2.4
H_2O_2 requirement (50%)	kg/d	58.3	2.8
H_2O_2 requirement (50%)	kg/year	21,280	1,021

Ferric Sulphate Addition:

The overflow from the hydrogen peroxide addition tank will be piped to another mixed tank for ferric sulphate addition. Ferric sulphate will react with arsenate to form an insoluble compound as shown in the equation below

$$Fe^{3+} + AsO_4^{3-} \rightarrow FeAsO_4(s)$$

Based on a 5:1 weight ratio for Fe:As, there will be a 23.5:1 ferric sulphate [$Fe_2(SO_4)_3 \cdot 7H_20$]:As weight ratio. The ferric sulphate addition tank will provide 30 minutes of residence time (54 m^3). Estimated ferric sulphate consumption and precipitate production (e.g. $FeAsO_4$ + $Fe(OH)_3$) for typical flows are shown in Table 3.2.

TABLE 3.2
Estimated Ferric Sulphate Consumption and Sludge Production

		Short-term Average Condition	Long-term Average Condition
Flow	m^3/d	1475	946
As(III) concentration	mg/L	33.4	2.5
As(III) loadings	kg/d	49.2	2.4
Ferric Sulphate requirement	kg/d	1,160	55.6
Ferric Sulphate requirement	kg/year	422,500	20,300
Sludge Production	t/year	212	10.3

Lime Addition:

The overflow from the ferric sulphate mix tank will be directed to the lime mix tank where hydrated lime will be added to raise the pH to 8 to 9 range. Table 3.3 shows average lime consumption.

TABLE 3.3
Estimated Hydrated Lime Consumption

		Short-term Average Condition	Long-term Average Condition
Flow	m^3/d	1475	946
As(III) loadings	kg/d	49.2	2.4
Lime requirement	Kg/d	394	18.9
Lime requirement	Kg/year	143,900	6,900

Final Effluent Monitoring Pond:

The final effluent monitoring pond will provide at least 5 days of storage to allow water quality monitoring, and allow the water to be held and returned to the treatment process should there be a process upset. The treated water will be discharged to the environment, or reclaimed should there be a requirement to do so.

Sludge Production:

The estimated rate of sludge production is shown in Table 3.4. Sludge production will depend upon arsenic and antimony concentration as well as iron addition rate. For each kg of arsenic, there will be approximately 11.8 kg of dry sludge formed. This sludge will be comprised of iron hydroxide with ferric arsenate, ferric antimonite, calcium carbonate (formed in the reaction vessel) and any residual suspended particulate matter present in the raw water.

TABLE 3.4
Estimated Sludge Production

		Short-term	**Long-term**
As(III) loadings	kg/d	49.2	2.4
As(III) loadings	t/year	18	0.88
Sludge Production (dry)	t/year	212	10.3
Sludge Production (wet, 30% solids)	t/year	707	34.5
Volume at 30% solids	m^3/year	548	26.7

The sludge will be dewatered to 30% solids using a pressure filter, and the excess water collected at the filter will be returned to the ferric addition stage for treatment. The iron-stabilized sludge will be disposed in a secure location.

3.3 ESTIMATED COSTS

3.3.1 Operating Costs

A summary of the estimated operating costs is shown in Table 3.5. In the short-term, while arsenic loadings to the plant remain high and runoff from the tailings containment areas is treated, the estimated average operating cost is \$975,000/year or a unit cost of \$1.81/m^3. The operating cost is estimated to decrease to \$715,000/year in the long-term, or a unit cost of \$2.07/m^3.

Key assumptions included in the operating costs are as follows:

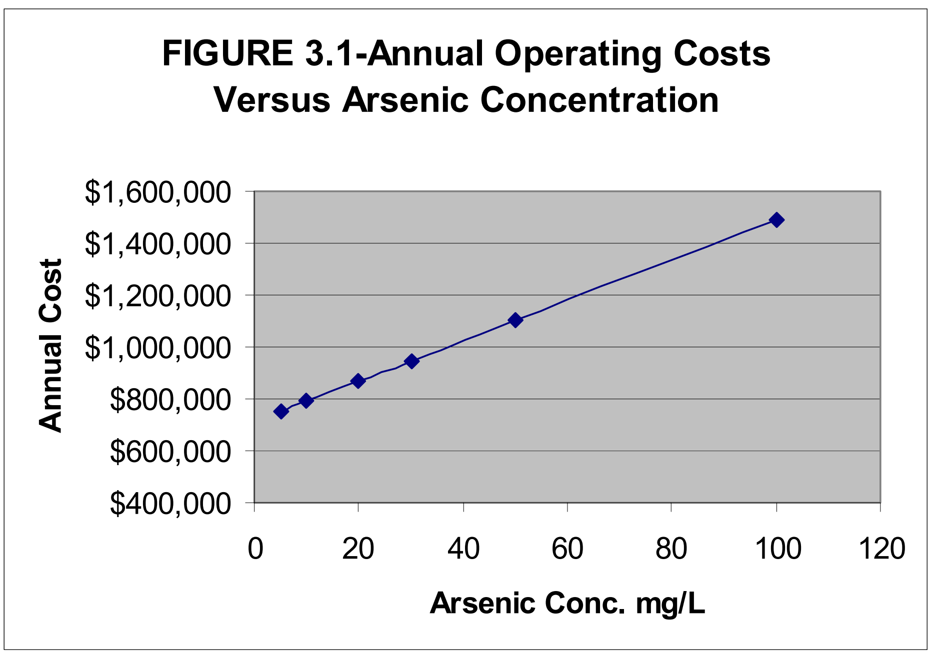
- Direct Labour includes 1 supervisor and 1 operator for 1 shift/d
- Indirect labour is included at 25% of direct labour cost or \$78,000/year
- Maintenance/Parts is assumed at about at 25% of the direct labour cost or \$78,000/year

Additional details of the operating cost estimates are provided in Appendix A.

Sludge disposal costs are not included. Given that the annual production is quite small (27 m^3/year in the long-term), the annual disposal cost would be low unless the sludge was disposed off site. Should average arsenic concentrations be higher than projected, operating costs will rise; however, increases in cost are not expected to be significant. As an indication of the potential variation in cost, annual operating costs as a function of arsenic concentrations are shown on Figure 3.1.

TABLE 3.5
Estimated Operating Costs (Rounded)

	Short-term		Long-term	
Item	Annual $	Cost/m^3	Annual $	Cost/m^3
Direct Labour	$311,000	$0.58	$311,000	$0.90
Indirect Labour	$78,000	$0.14	$78,000	$0.23
Reagents	$258,000	$0.48	$12,000	$0.04
Electrical Power	$102,000	$0.19	$88,000	$0.25
Maintenance/ Parts	$78,000	$0.14	$78,000	$0.23
Indirect supplies	$78,000	$0.14	$78,000	$0.23
Indirect Rentals	$20,000	$0.04	$20,000	$0.06
Environmental	$50,000	$0.09	$50,000	$0.14
Total	$975,000	$1.81	$715,000	$2.07



3.3.2 Capital Costs

The estimated capital construction cost for a new treatment plant capable of treating 2,560 m^3/d is $4,710,000. A break-down of these costs is shown on Table 3.6. Additional details of the capital cost estimate are provided in Appendix A.

The capital cost includes all equipment, equipment installation, process piping, electrical, and instrumentation, a new building to house the plant, an allowance for servicing, the treated water pond, 30% for indirect costs and a 25% contingency. Capital costs for equipment required to pump water from the mine to the treatment plant, and from the treated water pond to the point of discharge, are not included in this estimate.

An estimate of capital replacement costs would be required for long-term cash flow analyses for the project. An estimate of 3% of the original capital cost is recommended for ongoing capital costs per annum if the plant is to operate more than 30 to 40 years.

TABLE 3.6
Estimated Capital -2560 m^3/d Arsenic HDS Plant (Rounded)

CAPITAL COST ITEM			
Process Equipment			
Peroxide storage and mixing			$45,000
Ferric storage and make-up			$66,000
Lime storage & make-up			$192,000
Thickener			$237,000
Filter Press			$350,000
Reaction tanks			$94,000
Process services			$103,000
Subtotal Cost Process Equipment			**$1,087,000**
Installation of equipment	10%		$108,700
Process piping	30%		$326,100
Electrical	15%		$163,100
Instrumentation	15%		$163,000
Total Process Cost			**$1,847,900**
Building			$605,000
Service tie-in			$20,500
Treated Water Pond			$425,000
Total Direct Cost			**$2,898,400**
Spare parts	2%		$58,000
Construction overheads	13%		$376,800
Eng., Proc., Mgmt.	15%		$434,800
Total direct and indirect cost			**$ 3,768,000**
Contingency	25%		$942,000
Total Estimated Capital Cost			**$ 4,710,000**

REFERENCES

SENES Consultants Limited, 1999. *Report on Technologies Applicable to the Management of Canadian Mining Effluents*. Report to Environment Canada, March. (In conjunction with Lakefield Research Limited.)

SENES Consultants Limited, 2002. *Supporting Document 8 - Water Treatment, Arsenic Trioxide Management Alternatives Final Report*, Prepared for SRK Consulting, December 2002.

APPENDIX A – CAPITAL AND OPERATING COST ESTIMATES

1) CAPITAL COST- 2561 m^3/d HDS PLANT
2) SHORT TERM OPERATING COST
3) LONG TERM OPERATING COST

1) CAPITAL COST- 2561 m^3/d HDS PLANT

DESIGN FLOW	**2561 m3/day, 107 m3/hr, 1779 L/min, 471 USgpm**					
Item No.	**Description**	**Qty**	**Unit**	**Unit Cost**	**Cost**	**Cost**
Process Equipment:						
P1	Peroxide storage and mixing					
	- storage tank 30 m3	1	LS	$30,000	$30,000	
	- day tank	3000	gal cap	$4	$12,000	
	- agitator	1	lot	$3,000	$3,000	
					Subtotal	$45,000
P2	Ferric storage and make-up					
	- storage bin and feeder	1	lot	$40,000	$40,000	
	- mix tank	500	gal	$4	$2,000	
	- agitator	1	lot	$2,500	$2,500	
	- day tank	5000	gal	$3	$15,000	
	- agitator	1	lot	$2,500	$2,500	
	- tank platform	2	lot	$2,000	$4,000	
					Subtotal	$66,000
P3	Lime storage & make-up					
	- lime silo 40 t cap/storage tank	1		$94,000	$94,000	
	- slaker	1	LS	$66,000	$66,000	
	- lime slurry pump	1		$5,000	$5,000	
	- lime day tank	1	LS	$11,000	$11,000	
	- lime agitator	1	LS	$6,000	$6,000	
	- lime distr pumps	2	ea	$5,000	$10,000	
					Subtotal	$192,000
P4	Thickener					
	- thickener	9.0	m. diam. thickener		$150,000	
	- sludge return pump	3	ea	$14,000	$42,000	
	- Sludge transfer pump	2	ea	$14,000	$28,000	
	-miscellaneous pumps				$17,000	
					Subtotal	$237,000
P5	Filter Press					
	- filter press	1	LS	$125,000	$125,000	
	- filter cake bin	1	LS	$25,000	$25,000	
	- conveyor	1	LS	$25,000	$25,000	
	-instrumentation			$175,000	$175,000	
					Subtotal	$350,000

P6	Reaction tanks					
	- lime mix tank with agitator	1	7.5 m3	$20,000	$20,000	
	- mix tanks (peroxide, iron, lime)-total of 1 hour	3		$20,000	$60,000	
	- agitators	3		$4,667	$14,000	
					Subtotal	$94,000
P7	Process services					
	- compressor - service	1	LS	$30,000	$30,000	
	- compressor - instr.	1	LS	$25,000	$25,000	
	- Floc system	1	LS	$48,000	$48,000	
					Subtotal	$103,000
Total Process Equipment						**$ 1,087,000**
Process Building						
PB1	Building			250 m2	$500,000	
	- furnace and ducting				$25,000	
	- laboratory	1	LS	$50,000	$50,000	
	- cold storage building	1	LS	$30,000	$30,000	
					Subtotal	$605,000
PB2	Service tie-in					
	- Electric power	1	LS	$10,000	$10,000	
	- Municipal sewer	1	LS	$10,000	$10,000	
	- Phone	1	LS	$500	$500	
					Subtotal	$20,500
					Total building cost	**$ 625,500**
Water Ponds						
WP2	Treated Water Pond (5-days)	12,807		m3 capacity		
	- excavate pond	12,250	m3	$3	$36,750	
	- construct berms	6500	m3	$6	$39,000	
	- install liner	6500	m2	$50	$325,000	
	- fence pond area	445	m	$16	$7,118	
	- camera surveillance system	1	LS	$4,500	$4,500	
	- insulated feed pipeline	40	m	$40	$1,600	
	- submersible reclaim pump,	1	LS	$3,274	$3,274	
	- simplex starter	1	LS	$780	$780	
	- pump float controls & hose	1	LS	$800	$800	
	- chain block and stand	1	LS	$1,200	$1,200	
	- weir	1	LS	$5,000	$5,000	
					Water pond 2 materials installed	$425,022
	Total water ponds					**$ 425,022**
	Total process equipment					**$ 1,087,000**
	Installation of equipment				10%	$108,700

	Process piping		30%	$326,100
	Electrical		15%	$163,050
	Instrumentation		15%	$163,050
	Total process cost			**$ 1,847,900**
	Total building cost			$625,500
	Total water ponds cost			$425,022
	Total Direct Cost			**$ 2,898,422**
	Spare parts		2%	$57,968
	Construction overheads		13%	$376,795
	Eng., Proc., Mgnt		15%	$434,763
	Total direct + indirect cost			**$ 3,767,949**
	Contingency		25%	$941,987
Total Estimated Capital Cost				**$ 4,709,936**

2) SHORT TERM OPERATING COST

Option 1.0 - Operating Costs-Treatment using ferric sulphate and lime								
Flowrate		**1,475**	m3/day					
Influent As Concentration		**33.4**	mg/L					
		Supervisor/	Plant				Unit	
1.0 Direct Labour		Technician	Operator	Helper	Cost	Unit	Cost	Unit
	No.per shift	1	1	0				
	No. of shifts per day	1	1	0				
	Operators per day	1	1	0				
	Cost per man shift	$522	$330	$316				
	Cost per day	$522	$330	$0	$852	/day	**$0.58**	**/m3**
2.0 Indirect Labour (mostly mech/elect contractors)								
	Percent of Direct Labour	25%			$213	/day	**$0.14**	**/m3**
	Total Labour Costs				$1,065	/day	**$0.72**	**/m3**
3.0 Consumables								
3.1 Reagents								
	Influent As(III) conc.	33.4	mg As/L					
	Influent As(III) loading	49.26	kg As/day					
				Unit		Daily		
	Reagent	Consumption	Unit	Cost	Unit	Cost		
	Hydrogen Peroxide @50%	58	kg H2O2/day	***$1.04***	***/kg***	$60.31	**$0.04**	**/m3**
	Ferric Sulphate	1157.54	kg/day	***$0.46***	***/kg***	$532.47	**$0.36**	**/m3**
	Lime	394.06	kg/day	***$0.29***	***/kg***	$113.29	**$0.08**	**/m3**
	Total Reagents					$706.07		
3.2 Electrical Power								
		Kw in use	kwh/day	$/kwh				
Power Use		96.87	2324.86	***0.12***	/kwh	$278.98	**0.189171**	**/m3**
3.3 Maintenance/ Parts							**$0.14**	**/m3**
4.0 Indirect supplies (see below)		$213.11	/day				**$0.14**	**/m3**
5.0 Indirect Rentals		$55.74	/day				**$0.04**	**/m3**
6.0 Sludge fixation/disposal							***elsewhere***	
7.0 Environmental		$136.99	/day				**$0.09**	**/m3**
				Total Operating Cost			**$1.81**	**/m3**
					Cost per Litre		**$0.0018**	**/L**
					Cost per USgal		**$0.0068**	**/USgal**
					Cost per Igal		**$0.0081**	**/Igal**

**Item 4.0 and 5.0 Indirect Supplies/Rentals

	$/month	$/day
Indirect Supplies		
building heat	$3,000	
building maintenance	$200	
phone/fax/computer	$100	
loader operating	$1,800	
pick-up operating	$600	
shop operating	$500	
health and safety	$300	
environmental	$3,000	
Total	$9,500	**$311.48**
Indirect Rentals		
loader rental	$1,000	
pick-up rental	$600	
shop equipment	$100	
Total	$1,700	**$55.74**

3) LONG TERM OPERATING COST

OPTION 1.0 – LONG TERM OPERATING COSTS-CONTINUOUS TREATMENT USING FERRIC SULPHATE AND LIME							
Flowrate	**946**	m3/day					
Influent As Concentration	**2.5**	mg/L					
	Supervisor/	Plant				Unit	
1.0 Direct Labour	Technician	Operator	Helper	Cost	Unit	Cost	Unit
No.per shift	1	1	0				
No. of shifts per day	1	1	0				
Operators per day	1	1	0				
Cost per man shift	$522	$330	$316				
Cost per day	$522	$330	$0	$852	/day	**$0.90**	**/m3**
2.0 Indirect Labour (mostly mech/elect contractors)							
Percent of Direct Labour	***25%***			$213	/day	**$0.23**	**/m3**
Total Labour Costs				$1,065	/day	**$1.13**	**/m3**
3.0 Reagents							
Influent As(III) conc.	2.5	mg As/L					
Influent As(III) loading	2.37	kg As/day					
			Unit		Daily		
Reagent	Consumption	Unit	Cost	Unit	Cost		
Hydrogen Peroxide @50%	3	kg H2O2/day	***$1.04***	***/kg***	$2.90	**$0.00**	**/m3**
Ferric Sulphate	55.58	kg/day	***$0.46***	***/kg***	$25.57	**$0.03**	**/m3**
Lime	18.92	kg/day	***$0.29***	***/kg***	$5.44	**$0.01**	**/m3**

Total Reagents					$33.90		
3.2 Electrical Power							
	Kw in use	kwh/day	$/kwh				
Power Use	83.65	2007.60	***0.12***	/kwh	$240.91	**0.254663848**	**/m3**
3.3 Maintenance Parts						**$0.23**	**/m3**
4.0 Indirect supplies	$213.11	/day				**$0.23**	**/m3**
5.0 Indirect Rentals	$55.74	/day				**$0.06**	**/m3**
6.0 Sludge fixation/disposal						***elsewhere***	
7.0 Environmental	$136.99	/day				**$0.14**	**/m3**
			Total Operating Cost			**$2.07**	**/m3**
				Cost per Litre		**$0.0021**	**/L**
				Cost per USgal		**$0.0078**	**/USgal**
				Cost per Igal		**$0.0093**	**/Igal**