February 27/89

TO: Engineering Supervisor

FROM: Environmental Co-ordinator

SUBJECT: LIMESTONE TREATMENT TESTS

INTRODUCTION

The purpose of this report is to summarize past work on limestone treatment and suggest a course of action for future tests and plant modification.

CONCLUSIONS AND RECOMMENDATIONS

A half dozen areas have been selected as potential limestone quarry sites (Cyr, Decmember 07/88)- TABLE I. A cost estimate has been drawn on the quantities of limestone to be used with tonnages estimated on the neutralizing relationship of CaO to limestone (Tables II - IV).

Transportation costs appear to be the controlling factor in selecting prospective sites. Because of their proximity, two sites near Granisle appear to be cost effective. Both the CART claims held by Equity and those held by Sydlik have similar neutralizing potential, hence represent a similar annual cost for neutralization. Further work should be carried out on Equity's claims (CART) to evaluate consistency of the product and determination of strip ratios, if any.

Results of recent testwork indicate material from the CART claim along with a portion CaO can reduce treatment costs by about 30%. This estimate was based on $25 limestone which appears to approximate recent estimates. Should mining costs be on the high side then Dahl Lake limestone may become viable.

In reviewing test results (Development Engineer January 20, 1989 TABLE III) it is noted that sludge volumes were far in excess of those produced in prior tests (Patterson, September 1988) for limestone and slaked lime applications. Where limestone and lime were used together then volumes of sludge were similar. The data might indicate a breakdown of floc in the latter tests due to extended reaction times. Further testwork should be carried out to reduce reaction times and to improve sludge settlement. From the first (Patterson) testwork it was noted that sludge produced from limestone treatment represented about 25% of that produced through conventional lime addition.

In considering future testwork the following statement from a U.S. Bureau of Mines report might apply; "The use of coarse limestone, with abrasive agitiation to provide a large surface of air-water-limestone interfaces appears to be the key to making limestone neutralization work. Fixed bed, coarse limestone and finely pulverized limestone reactors have failed in the past because surface coatings of neutralization products have hindered further reaction. Only in a dynamic system are reactive surfaces continuously renewed."

This might indicate that future testwork be carried out in a tube mill where grinding and neutralization occur together. Failing adequate retention times, this perhaps can be extended to a three stage process of primary grinding, following by secondary grinding and neutralization with final ph adjustment in reaction tanks of about 60 minutes retention.

In order to assess the grinding index and reaction times of limestone while grinding, further lab scale test work will be required. To accomplish this a tube mill should be built in which grinding tests will be run on limestone products followed by neutralization of A.M.D. Lab design and grinding media sizing should be handled by metallurgical people.

The same limestone addition criteria would apply as in past tests. Reaction times in relationship to ph change should be monitored and compared to past tests and from test data scale up for pilot plant work. Pilot plant work would best be handled by a student given full responsibility for completing the test work through to final report.

Heavy metal removal from A.M.D. (Table IV - Development Eng. Report) did not meet permit specification however is sufficiently close such that a minor improvement in ph will polish final effluent.

Whereas this treatment proposal seems appropriate, neutralization within a grinding circuit containing a low solids to liquid ratio may not be possible. Alternate methods such as treatment within a vertical ball mill or within self asperated floatation cells has also been suggested.

As for modification to the existing treatment arrangement the following changes are proposed;

1) Connect reaction tanks #1 and #2 via 16 inch plastic line at bottom of tanks.

2) Remove riser pipes @ discharge from tanks to facilitate Gypsum cleanup and increase retention time in second tank.

3) Install agitator in reaction pond and activate by May 1989.

4) Install Toyo sludge pump in small settling pond and discharge sludge to tailing pond. Set up and test recycle to treatment plant.

Cost estimates made on the purchase of a horizontal or vertical calcining unit indicate that a suitable unit could be purchased for approximately $4,000,000 Canadian. Under most optimistic projections, payback period would be upwards of 30 years and would at best be a breakeven proposition. It was therefore decided that purchasing a calciner is not feasible for Equity Silver Mines and will not be considered further.

DISCUSSION

To date, there have been 6 areas sited as a potential sources of limestone for use in neutralization of A.M.D. Chemical analyses have been run on each to determine acid neutralization potential in relationship to meg HCl/g of material to neutralize, per cent Ca, Mg, Fe and insoluble products along with percent CaC03 calculated on the basis of Ca content. Of the sites, the Dahl Lake, Sydlik and CART deposits (light material) have the highest CaC03 content whereas the Dahl Lake and A.M.D. claim have the greatest neutralizing potential. Due to their locations the A.M.D. claims and Marl deposit in the Terrace area might be ruled out. Test results on the products are summarized in table I.

Future investigation of limestone sources would appear to be suited to the Dahl Lake, Sydlik, and CART Deposits. The latter two appear to have a high percentage of insoluble product, however this does not appear to have a significant effect on neutralization potential or reaction rates.

Table I

SAMPLE	NEUTRAL. POTENTIAL	% Ca	% CaCO3 A.A.	%CaCO3 CALC.	mg/l Mg	mg/l Fe	% INSOL
DAHL	19.9 18.3	37.6 35.7	 89.1		3700 2420	602 390	1.98 0.50
MARL	17.8	32.8	81.9	89.1	3820	3280	6.43
A.M.D. TERRACE	19.0	32.5			1328	784	6.33
CART (dark)	17.11 16.05	33.3 32.5	83.2 81.2	85.6	1650 1500	2200 1900	8.05 11.76
CART (light)	14.99 17.49	29.8 35.7	74.4 89.1	75.0	1720 1710	3900 540	19.25 5.03
FULTON Westgarde	15.71	31.0	77.4	78.6	2035	1600	28.80
SYDLIK	18.50						

Three cost scenarios have been applied to the sites being investigated. Tables II ,III, and IV illustrate potential costs of mining the products based on high, low and expected estimates. Unit mining costs were worked out by Glen Duthie (January 1989).

An annual tonnage estimate of the various limestone products has been prorated on the basis of neutralizing potential in relationship to lime. All have been increased by a further 38% to reflect a surplus requirement indicated by testwork. The low side estimate make the Sydlik and CART Claims attractive, whereas high side estimates favour buying reject limestone from the Dahl Lake deposit. A detailed feasibility will be required, however for the time being those cost estimates used put deposit costs in perspective.

Results of past testwork indicate reaction times with limestone are far too slow once solutions reach ph 4.5 - 5.0. Limestone particles become coated with iron hydroxides and gypsum blinding available surface area thus slow down the neutralization reaction. Reaction rates to ph 5.0 vary between 6 - 10 minutes, to 6.0 between 30 and 45 minutes and to 7.0 anywhere from 150 to 500 minutes.

Prior to completing final plans for a pilot plant, it would seem appropriate to complete another set of tests to assess reaction rates under more rigorous grinding and agitation. For this it is proposed we construct a small tube mill (lab scale) to assess grinding properties of limestone followed by neutralization of A.M.D.

A grind size of about 75% passing 100 mesh seems appropriate and has been arbitrarily selected as the slurry will undergo a second stage of grinding during the neutralization step. Limestone slurry produced from the initial stage of grinding should be as concentrated as feasibly possible. Grinding properties should be monitored to accomodate scaling up the test work to pilot plant size.

As with past tests, select an A.M.D. sample with an acidity in the 10,000 mg/L equivalent CaC03 range. Fill the tube mill with a working load of A.M.D., measure the volume then calculate the dry weight equivalent of limestone required to neutralize. Add an additional 20% (rather than 38% previously used) to insure sufficient product to complete the reaction. Reaction rates should be monitored at short intervals up to a maximum retention time of 10 minutes. Solution from the tube mill should then be removed and placed in an open vessel with agitation and aeration. Again monitor ph with time up to 60 minutes then adjust to a terminal ph of 8.3 with lime. It is not known at this time if there will be sufficient aeration in the tube mill to remove C02 although as the mill is open ended and through the cascading action, a good portion should be driven off.

In scaling up a system it is impractical to think that peak flows and acidities can be handled directly but rather will require storage to attenuate peaks. The annual volume of A.M.D. to be treated will be in the neighbourhood of 900,000 m3; 800,000 m3 from the waste dump and plant site and 100,000 m3 from Number 1 Dam Seepage. Assuming we treat for 8 months out of the year and availability of the system is 75% then average flow rates through the plant will be 3.47 m3/min or 915 usg/m. At an average acidity of 9,500 mg/l CaC03 or 9.5 kg/m3 (1988 average) plus 20% surplus limestone at 85% purity then the average limestone requirement will be:

$$3.47\ \frac{m3}{min} \times 9.5\ kg/m3 \times \frac{100\%}{85\%} \times 120\% = 46\ kg/min\ or\ 2.8\ t/hr$$

Feed size would be in he neighbourhood of 3/4 inch. During the initial stage of grinding particle size has been estimated to be 100 mesh however may be too fine as grinding will occur during the second stage of neutralization. Grinding indexes will have to worked out and capital expenditure for mills estimated on 3 to 6 tonnes/hour capacity. A contingency (6 tonne/ hour) is built into the estimate to accomodate increased flow and acidity.

As for the pilot plant, it seems practical to construct a tube mill 1/10th the scale of the plant required. The diameter and length will be dictated by grinding indexes as well as retention times established in our next set ot tests. Because of timing and availabilty, limestone should be purchased from Dahl Lake. This product is already fine and may not require primary grinding.

Operating and design specs for the pilot plant would be:

Flow: 100 usg/min or 0.38 m3/min

Acidity: 9,500 mg/l or 9.5 kg/m3 CaC03

Grinding: $9.5\ kg/m3 \times 0.38\ m3/min \times \frac{100\%}{85\%} \times 120\% = 5.10kg/min$

or 306 kg/hour = 0.306 tonnes/hour

Retention: (Neutralization) minimun 5 minutes for primary treatment in tube mill - uncertain of grinding time required for limestone

Secondary: 2 tanks with total of 60 minutes retention (11 m3 each). Agitation and aeration in first tank. Add lime to 2nd tank with final discharge of ph 8.3.

Eighty tonnes of Dahl Lake limestone could be purchased for roughly $2,000 and would supply our needs for 11 days of continuous testing. Addition quantities could be ordered as required. The logistics of procuring a bulk sample from the Fulton Lake area should also be considered.

Realizing there are inherent problems with operating grinding mills with low solids content, an alternate approach to the tube mill concept has been considered. Because rigorous agitation and aeration is required , it has been suggested (pers. comm. Yeoman Feb. 03/89) that neutralization be achieved in self aspirated floatation cells. Grinding would be accomplished in a ball or tube mill followed by neutralization in floatation cells. It is possible that agitation in this system might be sufficient to provide the required abrasion of limestone particles needed to accelerate neutralization.

The general arrangement for the conceptual ideas discussed are illustrated in Figures I through III (attached).

Details for modifying the existing treatment plant to increase retention times will be addressed by work order.

There was also mention in the terms of reference for this assessement to investigate alternate treatment products. Rather than deal with this assessement directly I have attached a summary of products available as reported by S.R.K. Consultants - report to B.C. Task Force on A.M.D.

A work schedule is attached to provide guidance in implementing test work, design of pilot plant and present plant modification.

TABLE II

POTENTIAL LIMESTONE SITES & PROJECTED COSTS LOW SIDE

PRODUCT LOCATION	ACID NEUTRAL.	TONNES REQUIRED	TONNES 38% PLUS	MINING	LOADING	ROYALITY $/TONNE	CRUSH	GRIND	TRANS	TOTAL	TOTAL ANNUAL
CaO	31.5	4500								132.00	594000.00
DAHL LK.	19.9	7100	9798			3.50		1.00	20.00	24.50	240051.00
A.M.D.	19.0	7460	10295	2.64	2.28		0.18	1.00	20.00	26.10	268694.28
MARL	17.8	8100	11178		4.00	2.00		1.00	20.00	27.00	301806.00
SYDLIK	18.5	7662	10574	2.64	2.28	2.00	0.18	1.00	12.00	20.10	212528.56
CART	16.1	8804	12150	2.64	2.28		0.18	1.00	12.00	18.10	219906.31

TABLE III

POTENTIAL LIMESTONE SITES & PROJECTED COSTS HIGH SIDE

PRODUCT LOCATION	ACID NEUTRAL.	TONNES REQUIRED	TONNES 38% PLUS	MINING	LOADING	ROYALITY $/TONNE	CRUSH	GRIND	TRANS	TOTAL	TOTAL ANNUAL
CaO	31.5	4500								132.00	594000.00
DAHL LK.	19.9	7100	9798			4.40		2.00	20.00	26.40	258667.20
A.M.D.	19.0	7460	10295	3.37	3.47		0.35	2.00	20.00	29.19	300505.21
MARL	17.8	8100	11178		6.00	2.00		2.00	20.00	30.00	335340.00
SYDLIK	18.5	7662	10574	3.37	3.47	2.00	0.35	2.00	18.00	29.19	308642.22
CART	16.1	8804	12150	3.37	3.47		0.35	2.00	18.00	27.19	330345.45

TABLE IV

POTENTIAL LIMESTONE SITES & PROJECTED COSTS EXPECTED

PRODUCT LOCATION	ACID NEUTRAL.	TONNES REQUIRED	TONNES 38% PLUS	MINING	LOADING	ROYALITY $/TONNE	CRUSH	GRIND	TRANS	TOTAL	TOTAL ANNUAL
CaO	31.5	4500								132.00	594000.00
DAHL LK.	19.9	7100	9798			4.00		1.50	20.00	25.50	249849.00
A.M.D.	19.0	7460	10295	3.00	2.87		0.30	1.50	20.00	27.67	284857.12
MARL	17.8	8100	11178		5.00	1.50		1.50	20.00	28.00	312984.00
SYDLIK	18.5	7662	10574	3.00	2.87	1.50	0.30	1.50	15.00	24.17	255562.95
CART	16.1	8804	12150	3.00	2.87		0.30	1.50	15.00	22.67	275429.62

PILOT PLANT G.A.

Figure I (Feed Size < ¼")

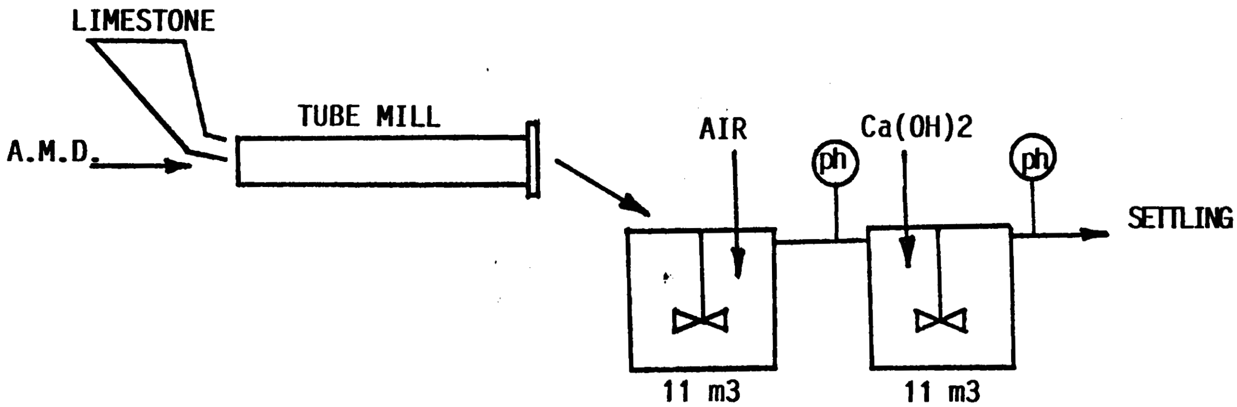


Figure II (Feed Size 3/4"+)

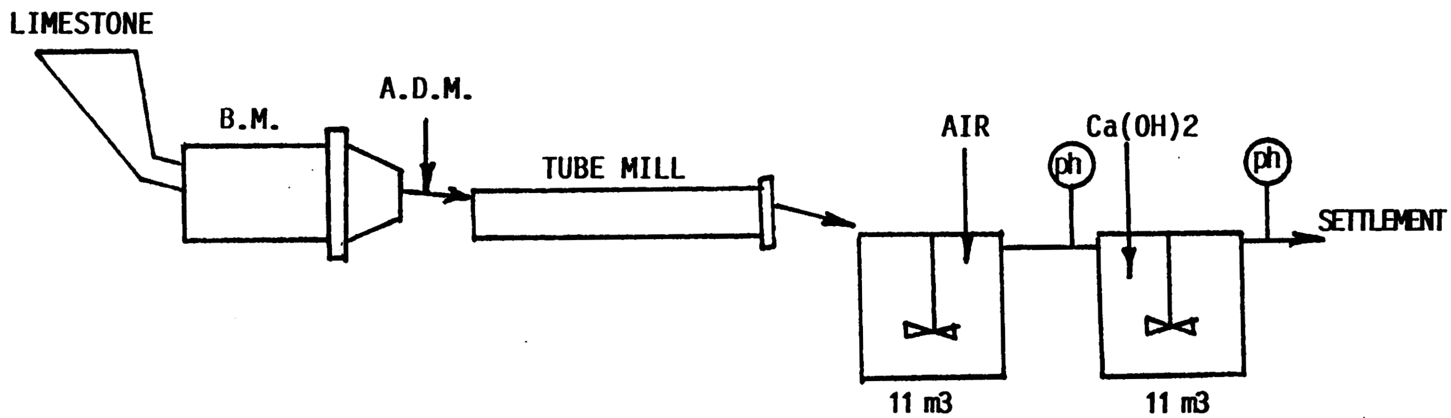
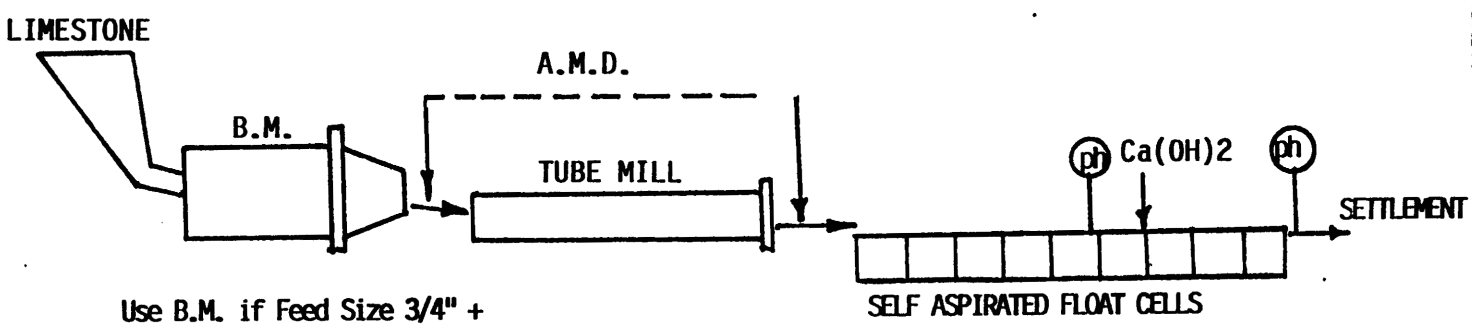


Figure III (G.A. Depends on Feed Size)



LIMESTONE TREATMENT TESTWORK
WORK SCHEDULE

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|      PROJECT       | FEBRUARY     MARCH        APRIL             MAY            JUNE             JULY           AUGUST          SEPTEMBER |
|    DESCRIPTION     | 6 13 20 27  6 13 20 27  3 10 17 24  1  8 15 22 29  5 12 19 26  3 10 17 24 31  7 14 21 28    4 11 18 25 |
|--------------------------------------------------------------------------------------------------------------------------------|
|TEST PROPOSAL       | *
|TEST WORK           |   ******************
|REPORT              |                      *
|DESIGN PILOT PLANT  |                        *********
|CONTRUCT PILOT PLANT|                                 ***************
|STUDENT TO OPERATE  |                                        *
|PILOT TEST WORK     |                                                ************************************
|REPORT ON TEST WORK |                                                                                 ************
|                    |
|LIMESTONE QUARRIES  |
|PRELIM. ASSESSMENT  | *
|SHIPPING OPTIONS    |   *********************
|SHIP FROM DAHL LAKE |                        ***************
|INVESTIGATE ALTERN. |                        ********************* O N   G O I N G ************************
|SITES               |
|FEASIBILITY         |                                                                                              *** ?  ? ***|
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