M.E.C.A. INFRASTRUCTURE REPORT

CHAPTER ONE

RAILROAD FEASIBILITY

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RAILROADS
M.E.C.A. EXECUTIVE SUMMARY

1. Piedra Parada - Montandon.

A number of possible rail routes have been indentified in Chapter one of this report, for moving sulfur product from the Piedra Parada mining area to the port of Chanaral. The routes herein are labled "A", "B", "C", and "D". The proposed routes would interfase with CODELCO's rail line at Montandon. The length of new construction necessary would vary from 96 - 105 kms, depending on which of the routes was selected. The cost of construction and rolling stock would vary from $16 - $25 million dollars. M.E.C.A reccomends route "C" as the superior route among the four routes under consideration.

Route "C" would require $16,000,000 for construction of new rail line, side track, rolling stock, and transfer areas. The freight cost per ton from Piedra Parada to Chanaral, including CODELCO charges, is forecasted to be $6.22 per ton. This is based on known operational charges and costs in Chile, and from preliminary discussions held with CODELCO personnel. Total length of rail haulage from Piedra Parada to Chanaral would be 251 kms, if route "C" were utilized.

2. Volcan de Copiapo - Chanaral.

The rail route for moving material from the Volcan area to Chanaral entails construction of new rail from Carrera Pinto, which would be the transfer point to interfase with Ferrocarriles del Norte railroad, to Vegas La Junta, a distance of 75 kms. From Vegas La Junta to the Volcan mines, a combination of small gauge rail, slurry, and trucking may be employed. We recommend construction of a slurry transport system, covering the 38 kms from the mines to Vegas La Junta. If necessary, the water would be reused by pumping the water back through a second, smaller line. This route is discussed in Chapter One of this report.

M.E.C.A recommends adoption of a slurry system, and flotation of ore on site to reduce the amount of material to be moved to Vegas La Junta. With strict water conservation, these goals may be met.

The cost of constructing the slurry line - rail combination to Carrera Pinto would be approximately $18,000,000, including allowances for rolling stock, transfer points, sidetrack, etc. The total length of haulage from Volcan to Chanaral is 257 kms, with freight costs per ton of sulfur forecasted to be $6.86 per ton, including Ferrocarriles del Norte charges. This tariff is based on known operational costs and charges in Chile, including preliminary discussions with personnel from Ferrocarriles del Norte.

3. Volcan de Copiapo - Caldera.

This route, discussed also in Chapter One of this report, initiates in the same manner as the route from Volcan to Chanaral, deviating only at Puquios, where the Cnanaral route connects north to Carrera Pinto; while the Caldera route continues west to Chulo, where it connects with Ferrocarriles del Norte line to Copiapo, continuing on to Caldera. Choice of routes depends on which port is selected for shiploading. The routes are seen to be comparable, except for a difference in operational costs in favor of the Caldera route.

The cost of constructing the slurry line - rail combination to Chulo would be approximately $20,000,000, including allowances as mentioned above. The total length of haulage from Volcan to Caldera is 244 kms, with freight costs per ton forecasted to be $5.94 (U.S.). This tariff is based on known operational costs and charges in Chile, including preliminary discussions with personnel from Ferrocarriles del Norte.

Note - All freight costs include allowances for maintenance purposes. Rail routes with steeper ascending and descending grades have slightly higher maintenance costs, which are reflected in the tariffs herein quoted, and the per ton/kilometer costs found in the freight tables hereafter.

INFRASTRUCTURE REPORT
SLURRY PIPELINE
M.E.C.A. EXECUTIVE SUMMARY

Transport of sulfur product from mining areas to existing rail facilities would most economically be transported employing a slurry pipeline. M.E.C.A. recommends adaption of slurry pipeline over rail transport for two reasons; first, lower initial capital outlay during the construction phase of the project, and secondly, lower operational costs during the life of the project.

The cost of constructing slurryline to Montandon is 40% less than the cost of constructing a new rail line over route C as previously mentioned. Also, the operational costs would be lowered by $1.09 per ton, for an annual savings of nearly $700,000.

Transport of ore from the Volcan de Copiapo area to rail receiving facilities via total slurry transport has not been considered sufficiently in depth to present basic analysis here; however, it is presumed that the parameters of cost and efficiency would be much the same as from the Piedra Parada area.

Port of Chanaral

The Port of Chanaral would be able to handle sulfur prill in amounts up to one million metric tons per year. Some of the present facilities would need upgrading, at an estimated cost of $500,000. A long term use contract must be negotiated with CODELCO officials, with probable posting of a surety bond. From previous discussions, port fees are estimated at $3.00 per metric ton.

Conclusion.

The cost of transporting sulfur product from Piedra Parada to Chanaral via a slurry line to Montandon, and transshipment aboard rail from Montandon to Chanaral is estimated at $5.13 per metric ton. The cost of slurryline construction is estimated at 10.5 million dollars.

The cost of transporting sulfur product from Piedra Parada to Chanaral via total rail is estimated at $6.22 per metric ton, at a capital cost of 16 million dollars.

Port costs are estimated at $3.00 per metric ton, with an initial, refundable capital investment of $500,000 dollars.

INFRASTRUCTURE REPORT
M.E.C.A. EXECUTIVE SUMMARY
CONSTRUCTION COMPARISONS

Area	Type of Transport	Capital Cost	Operational Cost per Ton
Piedra Parada - Chanaral	* Railroad "C"	$15,875,000	$6.22
	Slurry Pipeline	$10,545,000	$5.13
Volcan de Copiapo - Chanaral	* Railroad "A"	$18,061,000	$6.86
Volcan de Copiapo - Caldera	* Railroad "B"	$19,986,000	$5.94

* Railroad costs include $2,000,000 allowance for railcars, sidetracks, transfer points, etc. With estimated port fees at $3.00 per ton, none of the proposed transport systems - port combinations will exceed $10 per ton for transport from the mine areas with freight put aboard ship.

INFRASTRUCTURE REPORT
RAILROADS

Transport of sulfur from the Piedra Parada area may include the use of existing rail facilities now operated by CODELCO, which would lower initial capital outlay and expedite sulfur shipments.

In February, 1986, personnel from MECA Corp held preliminary discussions with CODELCO's El Salvador Division management personnel to inquire about interfacing a proposed large sulfur operation with existing CODELCO infrastructure, including railroad and port facilities. Discussions included the feasibility of constructing a rail receiving facility and spur for loading purposes at Montandon, for the loading of sulfur product for shipment to Chanaral. Also discussed was the amount of sulfur product which could be shipped monthly on CODELCO's rail without interfering with current rail schedules. It was determined on a preliminary basis that 50,000 metric tons-per-month of sulfur product could be handled by CODELCO on the existing railroad infrastructure without interrupting current rail operations. Amounts above 50,000 tons-per-month were not discussed but presumably would be handled on a non priority basis.

Figure 1 and Figure 2 show existing railroad infrastructure in Northern Chile, including the portion operated by CODELCO, which is the focus of this report.

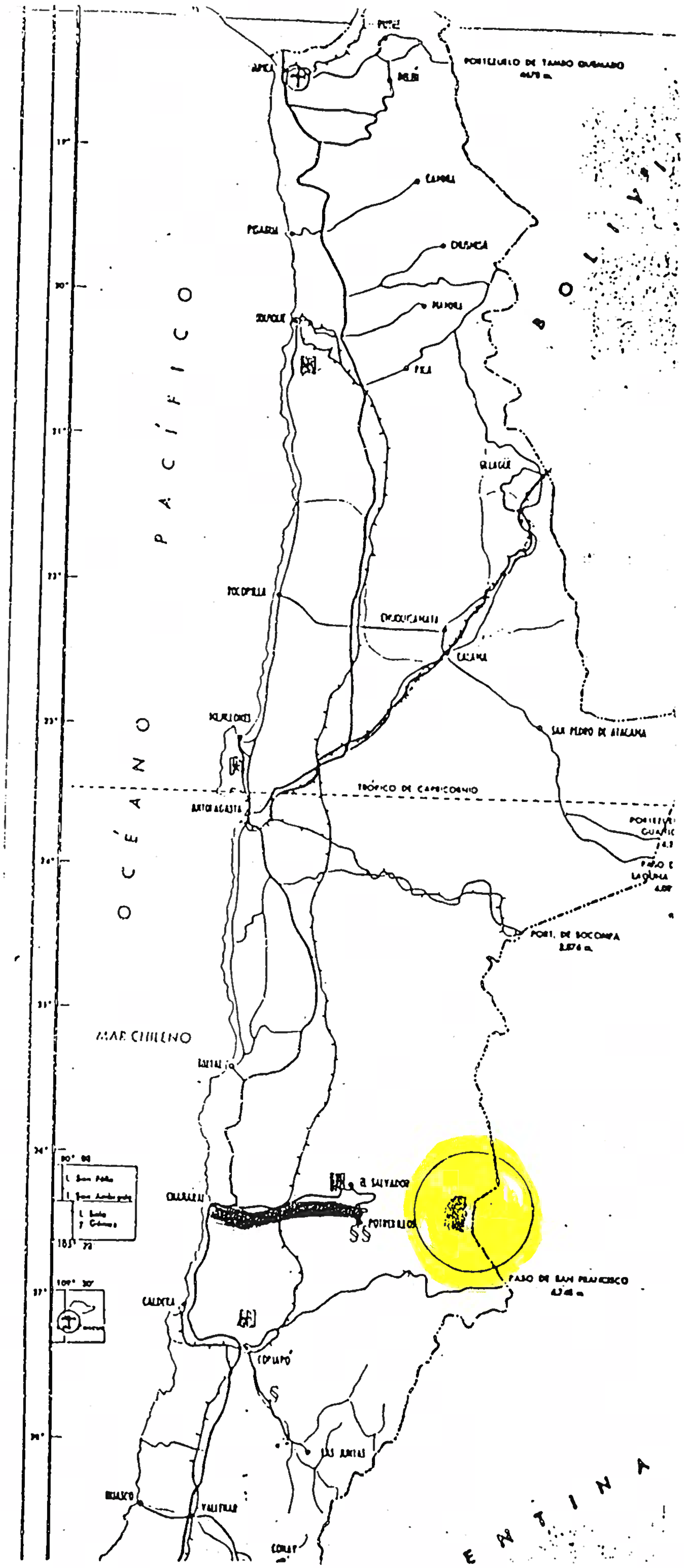
<u>Current Operations.</u>

The Barquito - Potrerillos rail line services CODELCO's El Salvador - Potrerillos copper operations. A flow diagram showing east and west bound freight traffic is shown in Figure 3. The disproportionately high eastward bound freight traffic indicates that some of the proposed sulfur transport west to Chanaral may be handled by CODELCO on a backhaul basis. Sulfur prill will have to be hauled in its own freight cars to prevent contamination, as the rail cars used by CODELCO handle copper concentrates and silica products. Since some of CODELCO's convoys return from Potrerillos to Llanta empty, perhaps a few sulfur cars per convoy could be backhauled on this portion of the rail line. Figure 3A gives a summary of the existing railroad, and some technical specifications.

FIGURE 1

NORTHERN CHILE

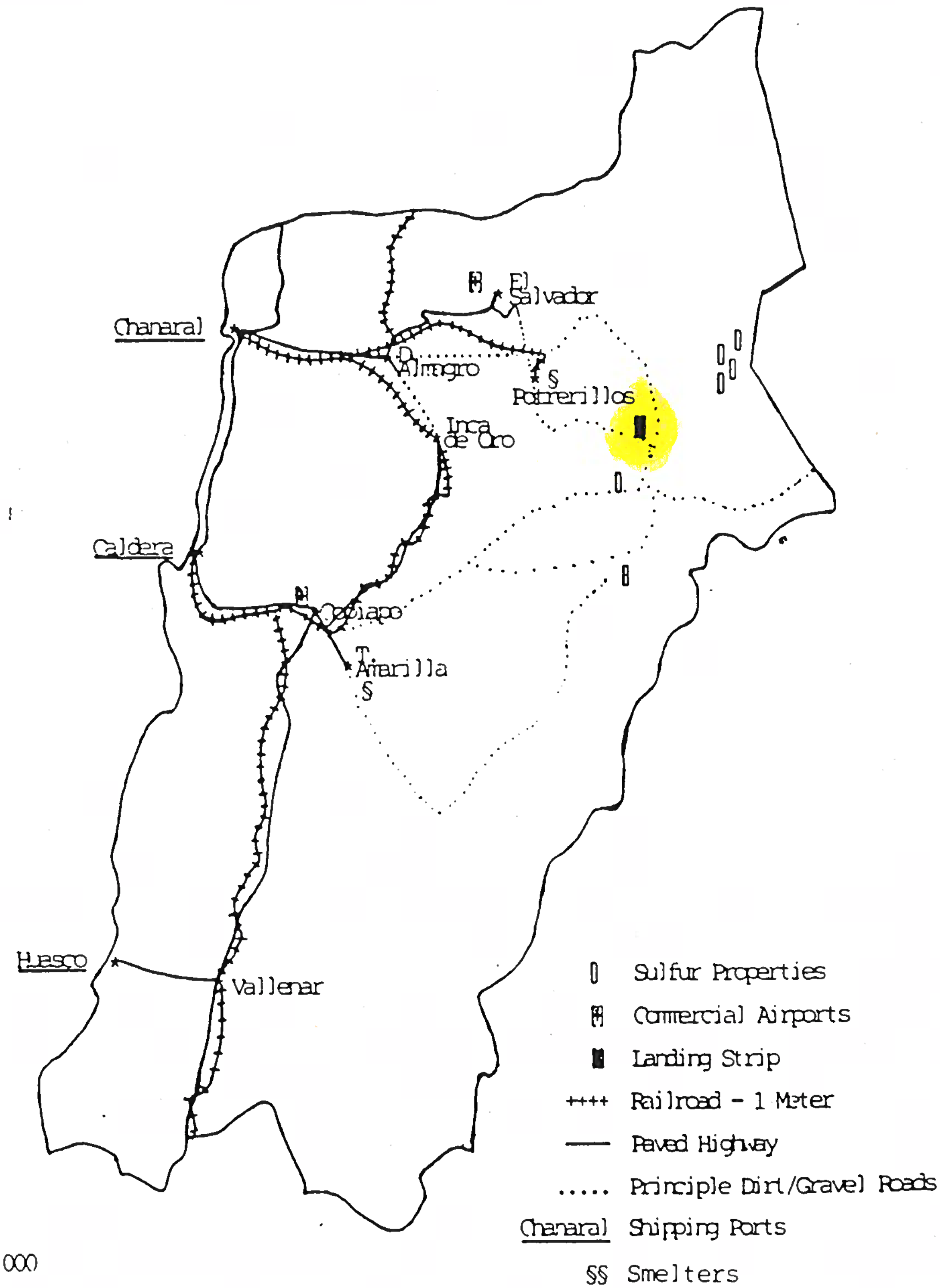
EXISTING INFRASTRUCTURE



網	Commercial Airports
§§	Smelters
———	Paved Highway (2 lane)
———	Secondary Graded
	Government Railroad
	British Operated Railroad
	CODELCO Operated Railroad
	Major Ports
⊙	MECA Sulfur Properties

FIGURE 2

ATACAMA REGION
EXISTING INFRASTRUCTURE



Scale 1:2,600,000

Current CODELCO Rail Traffic

(Exaggerated Scale)

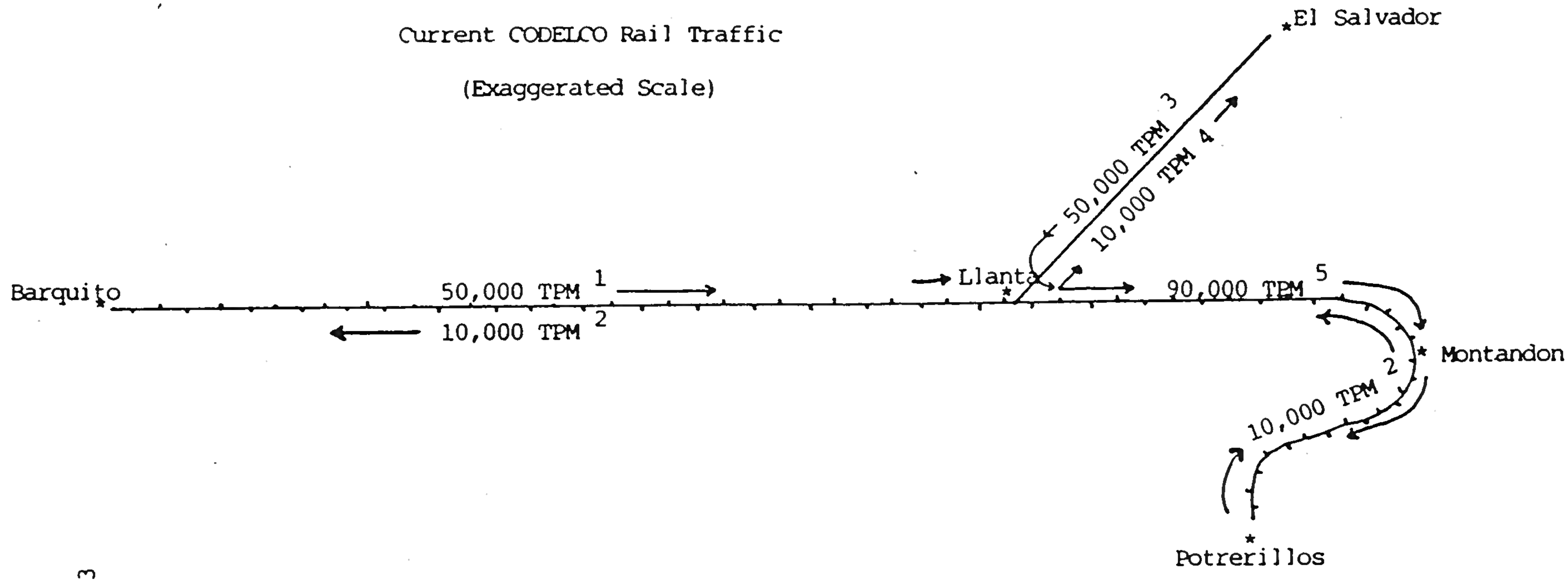


FIGURE 3

1. Fuel, Spare Parts, Silica, Chemicals.
2. Copper Blister.
3. Concentrates Slurried from El Salvador.
4. Fuel, Chemicals, and Spare Parts Off-loaded for transhipment to El Salvador.
5. Dried Concentrates, Fuel, Chemicals, Silica, and Spare Parts

Barquito - Llanta	50,000 TPM
Llanta - Potrerillos	90,000 TPM
Potrerillos - Barquito	10,000 TPM

TPM = Metric Tons per Month

FIGURE 3A

EXISTING RAILROAD SPECIFICATIONS

Map Location	Elevation	Distance	Grade	Side Track
Montandon	2375 m	(proposed transit point for sulfur)		
Confluence Rio de la Sal	1700 m	26 km	-2.4%	No
Estacion Llanta	1210 m	25 km	-2.0%	Yes
Diego De Almagro	790 m	25 km	-1.7%	Yes
Estacion Empalme	610 m	10 km	-1.6%	Yes
El Salado	410 m	20 km	-1.0%	Yes
Barquito	5 m	40 km	-1.0%	Yes
	Total:	146 km		

Railroad Width - 1 meter

Rail Ties - 23" on center

Roadbed - Compacted volcanic ash/gravel

Rail Weight - 80 lbs./meter (estimated, new)

Current Traffic - Barquito-Llanta 50,000 t/p/month
Llanta-Potrerillos 100,000 t/p/month
Potrerillos-Barquito 10,000 t/p/month

Locomotives - 800 H.P., 900 H.P., 1200 H.P., 1600 H.P.

Rail Cars - 40 ton Box, 30 ton bottom dump, with siding increasing to 40 tons

Fuel Tankers - Yes (capacity unknown)

Size of Convoy - 15 - 20 railcars, loaded, descending
(600 - 800 metric-ton-capacity)

Estimated Contract Haul Price per Ton Montandon-Barquito: $4.38
(3¢ per ton/km)

CODELCO can currently accomodate a minimum of 50,000 tons/month without any interruptions in their rail schedules.

New Rail Construction.

One alternative in moving sulfur product from the mining areas to Montandon is construction of a new rail line, connecting at Montandon with CODELCO's line. Preliminary studies indicate four possible routes, summarized below and shown in figures 4 through 7. Figure 8 is a scale drawing summarizing the information found in figures 4 through 7, including routes and map location points.

Route "A".

This route exits the mining area through the Panteon de Aliste Canyon, the steepest part of the route. The 7 kms of 5.7% downgrade will have to be modified. This may be accomplished by zig - zagging, where feasible, across the valley floor between the canyon walls, and before exiting onto the Perdernales plain, cutting into the canyon wall at a lessened grade and exiting gradually onto the plain. This section may be the most expensive of the route.

Once onto the plain, the route turns southward for some 15 kms, at a moderate 1.5% downgrade, then deviates west, traversing the plain some 22 kms at a modest 0.7% downgrade. At this point, the route intersects and follows the graded road leading in from El Salvador. After 11 kms of moderate upgrade, the route drops 752 meters in a distance of 26 kilometers of zig zag routing. This area will require heavy earth movement and grading in sections, as well as some intermittent blasting.

The line will end at the top of the canyon overlooking Montandon, which is the receiving area for sulfur to be shipped to Chanaral. The vertical drop here is some 545 meters at a 60° angle. We propose to tranfer the sulfur prill via a drop pipe at a 40° angle, which means construction of some 1400 meters of pipe. The prill would free fall to the valley floor below, where it would be captured for transhipment to Chanaral.

Route "A" has 5 sections of 3% or more downgrade which will require modification. In addition, convoys may have to be outfitted with special braking systems. Among the proposed new routes, we would tentatively rate route "A" as our 3rd choice for the construction of a new rail line.

FIGURE 4

NEW RAIL CONSTRUCTION
PIEDRA PARADA AREA
ALTERNATE ROUTE "A"

Map #	Elevation	± Change	Distance	Grade
#1	4150 m	(Proposed Piedra Parada transit area)		
#2	4200 m	+ 50 m	9 km	+0.6%
#3	4389 m	+189 m	5 km [2]	+3.7%
#4	4150 m	-239 m	7 km [2]	-3.4%
#5	3750 m	-400 m	7 km [3]	-5.7%
** #6	3520 m	-230 m	15 km	-1.5%
#7	3371 m	-159 m	22 km	-0.7%
#8	3450 m	+ 79 m	5 km	+1.6%
#9	3672 m	+222 m	6 km [2]	+3.7%
#10	3550 m	-122 m	7 km	-1.7%
#11	3370 m	-180 m	6 km [2]	-3.0%
#12	3150 m	-220 m	5 km [3]	-4.4%
#13	3000 m	-150 m	5 km [2]	-3.0%
* #14	2920 m	- 80 m	3 km	-2.7%
			=======	
		Total:	102 km	

* Sulfur prill will have to be transhipped from this area to a loading area on a spur of the railroad at Montandon, which is located in the canyon some 545 meters below #14. This may be accomplished by building a transfer pipe approximately 1400 meters in length and allowing the prill to free fall at a 40° angle to the valley floor below, using a constricted pipe and reverse air flow to slow the descent of the material.

** A possible location for a prilling operation.

[2] Sections requiring extra earth moving and grading.

[3] Sections requiring extra engineering, heavy earth movement and grading and some blasting.

Route "B".

Route "B" is initially the same as route "A". After exiting the Panteon de Alist Canyon onto the Pedernales Plain, the route would separate, turning Southwest. The route would intersect the canyon above Montandon but some 15 kms southwest of Montandon. The vertical drop here would be some 882 meters, and require a drop pipe some 2200 meters long. After reaching the valley floor via the drop pipe, the sulfur prill would then be transported via rail some 15 kms at a moderate 2.8% downgrade, and connect directly with the rail at Montandon. The 2.8% downgrade could be modified by zig zagging across the valley floor.

Of the proposed new rail routes, route "B" would be our second choice.

Route "C".

Route "C" exits the mining area using a more southerly route, the initial 21 kms of which cover very modest grades. At this point the route turns west, being parallel to and above the Rio Juncalito Canyon. This ten kilometer stretch is the most difficult of the route, covering very uneven terrain, and will require heavy earth movement and some blasting. Nevertheless, a moderate downgrade of 2.3% can be maintained with careful planning.

The route then traverses 20 kms of gentle downslope on an indirect course, with a moderate grade of some 2.0% (down), and exits onto the Leoncito Plain in the approximate vicinity of CODELCO's aqueduct pumping station. The route then turns northwest and intersects route "B", continuing on to the same area above the Montandon Canyon as route "B".

Route "C" has only one section of 3% downgrade, a mere 3 kilometers, which can easily be modified. Although the route is 9 kms longer than route "B", the cost of construction would be comparable, and because of the lessened grades, operational costs would be slightly less than those of route "B". Of the four proposed routes, Route "C" would be our first choice for the construction of a new rail line.

FIGURE 5
NEW RAIL CONSTRUCTION
PIEDRA PARADA AREA
ALTERNATE ROUTE "B"

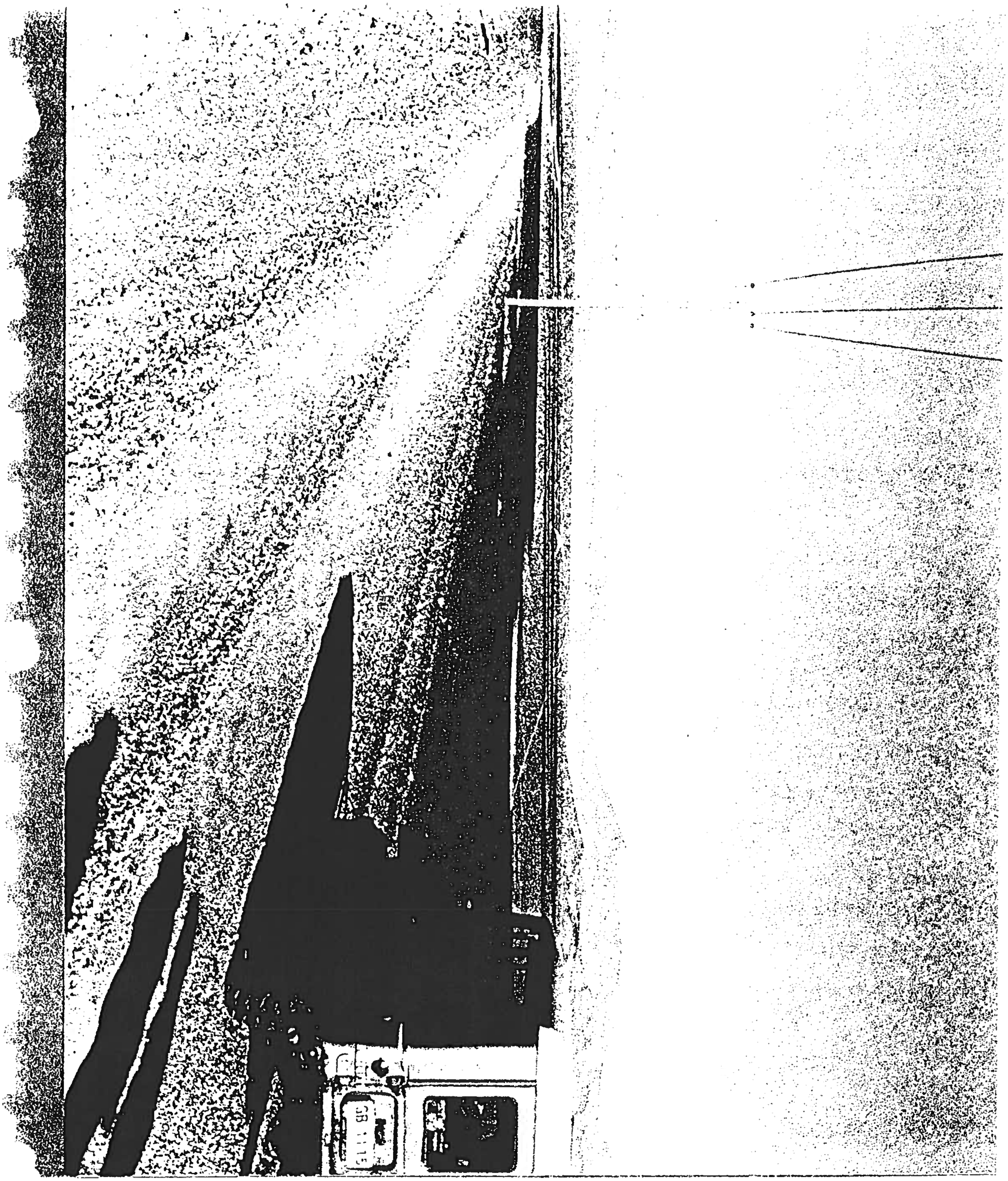
Map #	Elevation	± Change	Distance	Grade
#1	4150 m	(Proposed transit loading area)		
#2	4200 m	+ 50 m	9 km	+0.6%
#3	4389 m	+189 m	5 km [2]	+3.7%
#4	4150 m	-239 m	7 km [2]	-3.4%
#5	3750 m	-400 m	7 km [3]	-5.7%
** #6	3520 m	-230 m	15 km	-1.5%
#7	3500 m	- 20 m	24 km	-0.1%
#8	3725 m	+225 m	6 km [2]	+3.7%
#9	3630 m	- 95 m	3 km [2]	-3.2%
* #10	3682 m	+ 52 m	5 km	+1.0%
#11	2800 m	(transit loading area)		
#12	2375 m	-425 m	15 km	-2.8%
		Total:	96 km	

* Sulfur prill will have to be transhipped from this area to a loading area on a rail spur in the valley below, which is located some 882 meters below. This may be accomplished by building a transfer pipe system approximately 2200 meters in length and allowing the prill to free fall at a 40° angle to the valley floor below, using a constricted pipe and reverse air flow to slow the descent of the material.

** A possible location for a prilling operation.

[2] Sections requiring extra earth moving and grading.

[3] Sections requiring extra engineering, heavy earth movement and grading, and some blasting.



PEDERNALES PLAINS WITH RIO NEGRO SULFUR PROPERTY IN BACKGROUND

FIGURE 6

NEW RAIL CONSTRUCTION
PIEDRA PARADA AREA
ALTERNATE ROUTE "C"

Map Location	Elevation	± Change	Distance	Grade
#1	4150 m	(Proposed transit loading area for railhead)		
#2	4343 m	+193 m	12 km	+1.6%
#3	4330 m	- 12 m	9 km	-0.1%
#4	4100 m	-230 m	10 km [3]	-2.3%
#5	3700 m	-400 m	20 km	-2.0%
#6	3555 m	-145 m	9 km	-1.6%
#7	3500 m	- 55 m	16 km	-0.3%
#8	3725 m	+225 m	6 km [2]	+3.7%
#9	3630 m	- 95 m	3 km [2]	-3.2%
#10	3682 m	+ 52 m	5 km	+1.0%
* #11	2800 m	(Transit Point)		
#12	2375 m	-425 m	15 km =======	-2.8%
		Total:	105 km	

* Sulfur prill will be transhipped to the valley floor below in this area, along a 2200 meter long pipe system which will allow the prill to free fall at a 40° angle. Total vertical distance - 882 meters.

[2] Sections requiring extra earth moving and grading.

[3] Sections requiring extra engineering, heavy earth movement and grading, and some blasting.

Route "D".

Route "D" is the longest,most expensive of all the proposed routes, with the highest operating costs, and therefore would be our last choice among all the possible routes for the construction of a new rail line. Route "D", however, does have one advantage over the other proposed routes, which is a direct connection with the railroad at Montandon, and hence avoids the need for transshipment via a drop pipe. Convoys would also be able to transit from minesite to port and vice versa, ferrying fuel, supplies, and even laborers on a backhaul basis.

Route "D" initiates the same as route "C", and upon exiting onto the Leoncito Plain, heads southwest to the La Ola airstrip, and then follows the graded road west which leads in from Potrerillos. The 39 kms from Leoncito west are of very modest grade.

At this point, 25 kms of rail would be constructed, dropping the system from 3800 meters elevation to the valley floor below at 3239 m, for an average grade of 2.2%. The terrain in this area is extremely difficult and will require heavy earth movement and blasting along the entire 25 kms. Four different canyon systems converge in this area, within a radius of seven km. It is proposed to use these canyons in a slingshot fashion, allowing the railroad to zigzag downward until reaching the valley floor. At this point, 31 kms of rail would be built toward Montandon at an average downgrade of 2.75%, which could be lessened by zig zagging across the valley floor. The rail would connect directly at Montandon.

Alternates.

Routes "A","B",and "C" could each conceivably reach the valley floor below by cutting into the steep canyon walls, much in the same manner as CODELCO did from Montandon to Potrerillos. The proposition would, however, be extremely expensive and could perhaps add as much as 25 kms distance and $8,000,000 to each of the routes.

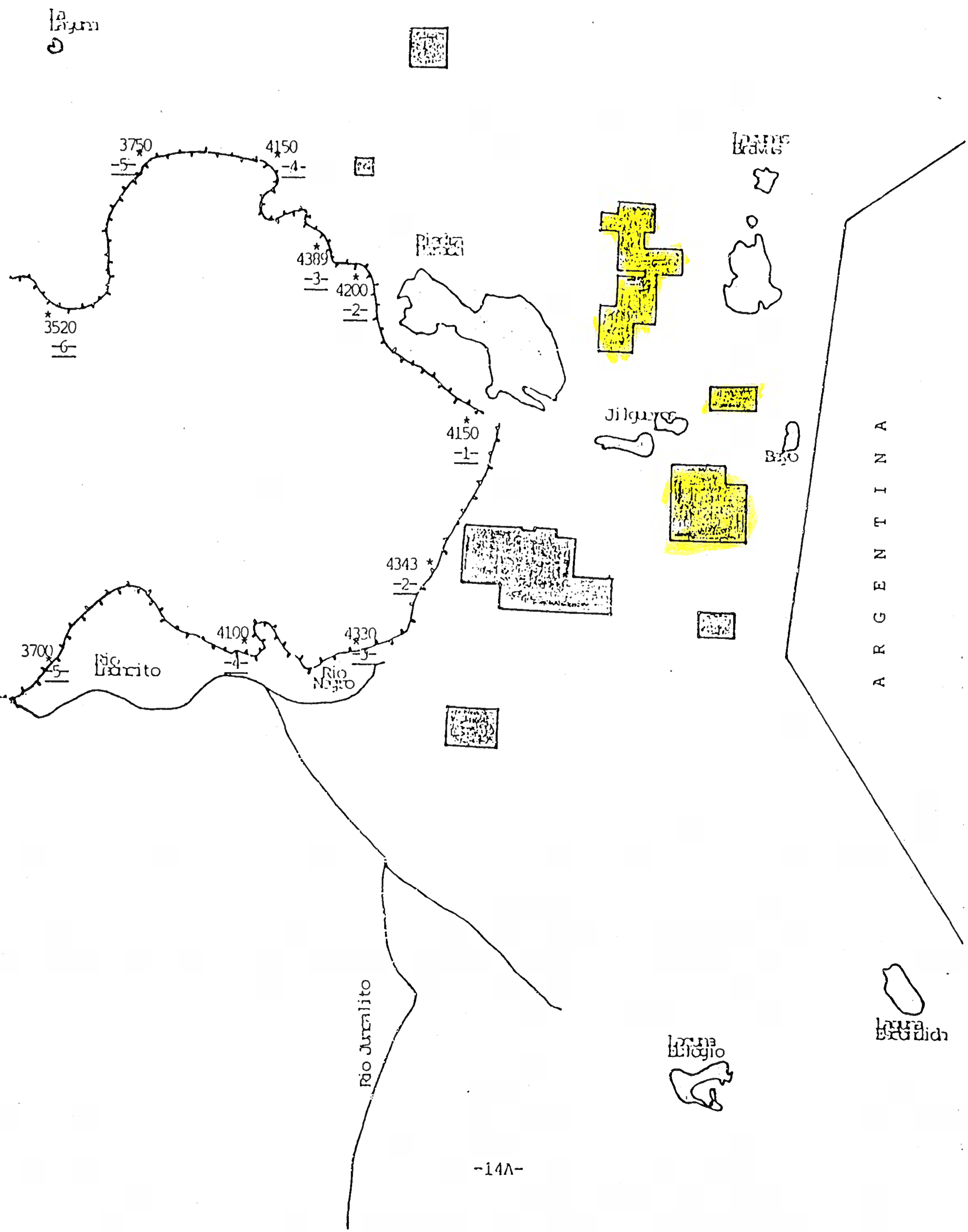
A summary of route comparisons is given in Figures 9 and 10. Figure 11 is a summary of pertinent information reguarding construction of new rail lines.

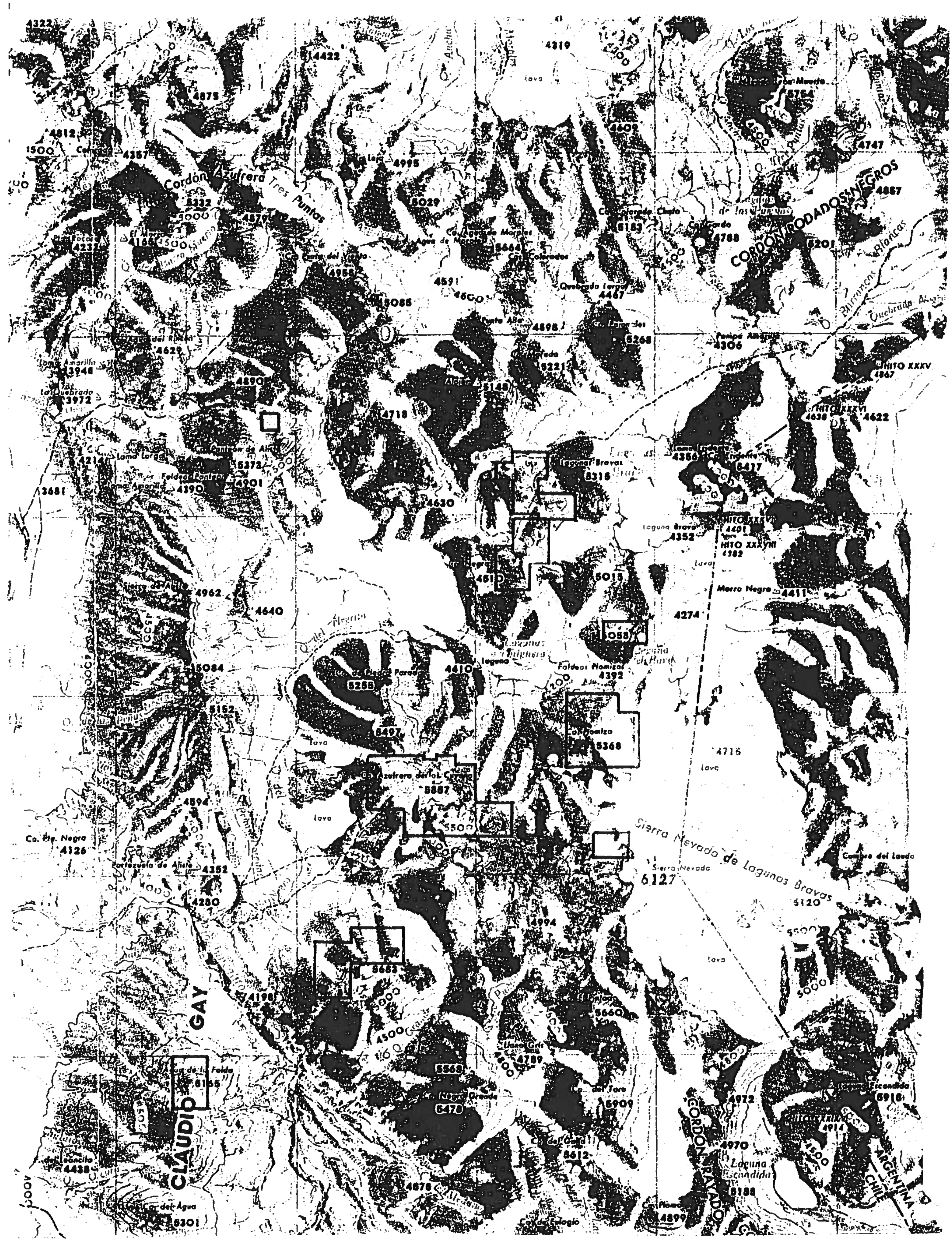
FIGURE 7

NEW RAIL CONSTRUCTION
PIEDRA PARADA - MONTANDON THRU RAIL
ALTERNATE ROUTE "D"

Map Location	Elevation	± Change	Distance	Grade
#1	4150 m	(Proposed transit loading area for railhead)		
#2	4342 m	+192 m	12 km	+1.6%
#3	4330 m	- 12 m	9 km	-0.1%
#4	4100 m	-230 m	10 km [3]	-2.3%
#5	3700 m	-400 m	20 km	-2.0%
#6	3672 m	- 28 m	12 km	-0.2%
#7	3873 m	+201 m	20 km	+1.0%
#8	3800 m	- 73 m	7 km	-1.0%
#9	3750 m	- 50 m	4 km [3]	-1.3%
#9A	3550 m	-200 m	7 km [3]	-2.9%
#10	3400 m	-155 m	7 km [3]	-2.2%
#10A	3239 m	-161 m	6 km [3]	-2.7%
#11	2800 m	-439 m	16 km	-2.7%
#12	2375 m	-425 m	15 km	-2.8%
			=======	
		Total:	145 km	

[3] Sections requiring extra engineering, heavy earth movement and grading, and some blasting.


3750
-5-
4150
-4-
4389
-3-
4200
-2-
3520
-6-
4150
-1-
4343
-2-
4100
-4-
4330
-3-
3700
-5-
A R G E N T I N A
Rio Juncalito



Cordón Azufrera Tres Puntos
CORDON RODADOS NEGROS
Laguna Brava
4352
HITO XXXV
4867
Morro Negro
4274
Sierra Nevada de Lagunas Bravas
Sierra Nevada
6127
6120
Lava
4716
Co. Azufrera de los Cuyanos
5887
Co. Pomizo
5368
Co. de Piedra Parada
5255
5497
Portezuelo de Aliste
4352
CLAUDIO
GAY
Co. Pta. Negra
4126
Co. del Agua
5201
CORDON RAYADO
Laguna Escondida
ARGENTINA
CHILE
Lagunas Bravas
5315
Pampa Amarilla
4306
5268
5221
5148
4718
4630
4640
4962
5084
5152
4894
4280
4198
5663
5660
5568
5478
5909
5612
4994
4789
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4899
4972
4970
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5029
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4788
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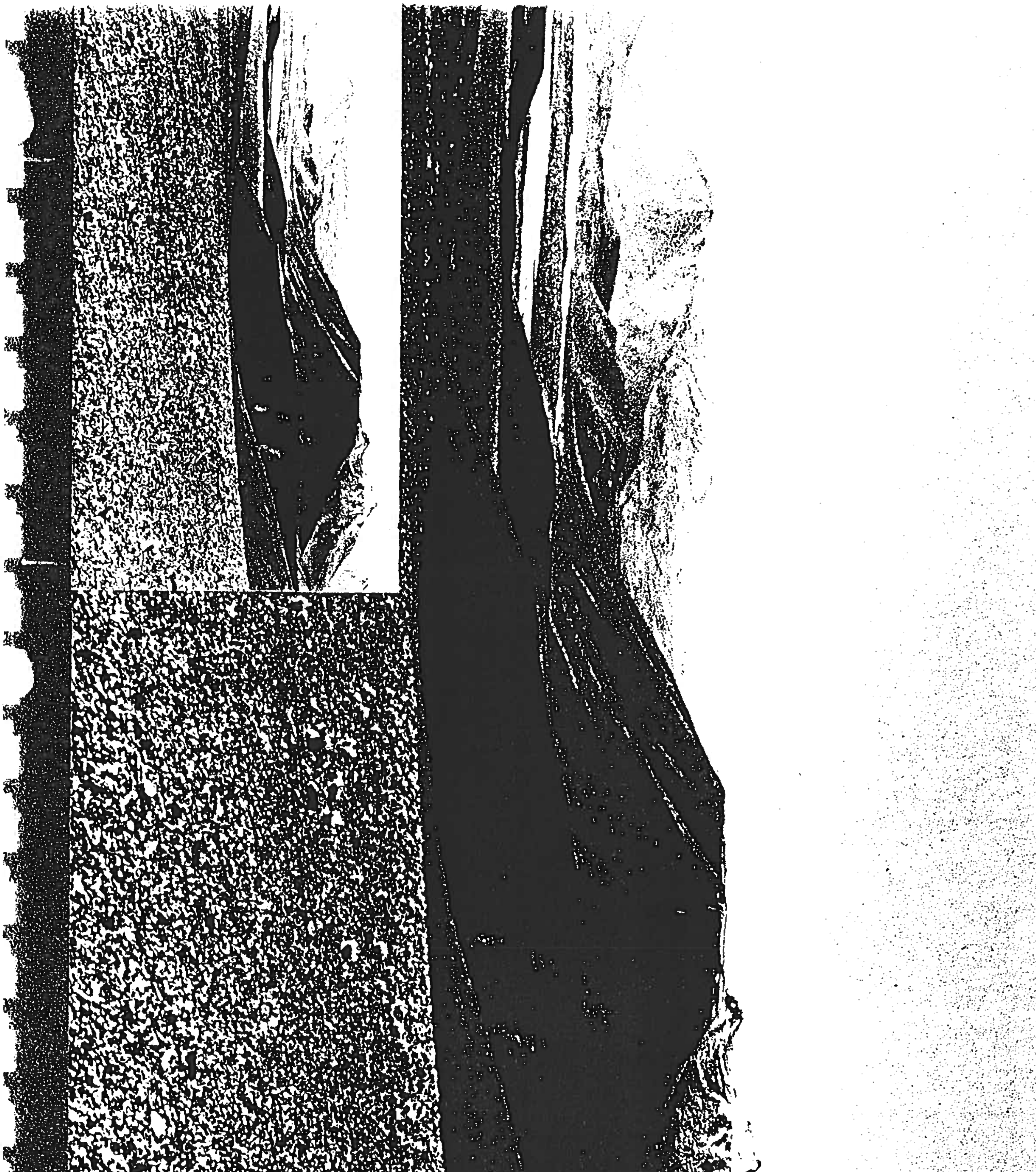


PIEDRA PARADA SALTBED WHERE ORE TRANSPORT WILL BEGIN

FIGURE 9

NEW RAIL CONSTRUCTION
RAIL ROUTE COMPARISON

Rail Route -	A	B	C	D
Total Length of New Construction	102 km	96 km	105 km	145 km
Length of Route Rating # [2]	29 km	21 km	5 km	0 km
Length of Route Rating # [3]	12 km	7 km	10 km	34 km
Loaded Ascending Grade 2% or Greater	11 km	11 km	6 km	0 km
Loaded Descending Grade 3% or Greater	25 km	17 km	3 km	0 km

[2] Sections requiring extra earth moving and grading.

[3] Sections requiring extra engineering, heavy earth movement and grading, and some blasting.

FIGURE 10

NEW RAIL CONSTRUCTION
CAPITAL AND OPERATIONAL COSTS

Rail Route -	A	B	C	D
Total Length of New Construction	102 km	96 km	105 km	145 km
* Estimated Cost of New Rail Construction	$16,000,000	$14,100,000	$13,875,000	$23,275,000
Estimated Cost for Rolling Stock, Sidetrack, Transfer Depot & Piping, etc.	$2,000,000	$2,000,000	$2,000,000	$1,500,000
Estimated Operational and Maintenance Costs per Ton/Km	2¼¢	2¢	1.75¢	1.75¢
Total Freight Cost per Ton, Piedra Parada - Montandon	$2.295	$1.92	$1.838	$2.538
Total Freight Cost per Year (600,000 Metric Tons Times Freight Cost) Piedra Parada - Montandon	$1,377,000	$1,152,000	$1,102,800	$1,522,800

* Cost of new construction is estimated as follows:

- Sections requiring normal grading only	$125,000/km
- Sections rating #2	$175,000/km
- Sections rating #3	$275,000/km

FIGURE 11

RAILROAD CONSTRUCTION NOTES

1. Ownership. Railroads in Chile are generally owned and operated by the government or state agencies such as CODELCO. Private entities may own and operate rail lines, as does the British owned Antofagasta-Bolivia R.R.

2. Construction. The government will not participate on any railroad project from a financial point of view. The Ferrocarriles del Norte currently loses money on its operations, and in fact is looking toward some divestiture.

   a) Costs. Ferrocarriles del Norte estimates the cost-per-kilometer of new rail construction at $100,000. This includes grading and formation of roadbed, materials such as ties, track, and hardware, and labor costs. Not included are the following items:

      - blasting of rock in canyon areas
      - bridge and culvert work
      - engineering (in Chile there are no suitable R.R. Eningeers)
      - aquisition of right of ways
      - construction of loading/unloading facilities
      - sidetracks

   b) Materials. Ferrocarriles has stated that it has no suitable materials for use in new rail construction. They carry a small inventory of mostly used parts for repairs. Ties can probably be manufactured in Chile, as there are large lumber mills in the South. The track rails and hardware may have to be imported.

   c) Subcontracting. There are few firms in Chile with engineering expertise needed for a large railroad type project. In fact, we have been advised from both Ferrocarriles del Norte and the Antofagasta-Bolivia R.R. to seek expertise from outside the country. The actual labor can be contracted within Chile, but supervision must mostly come from without.

3. Operations. Ferrocarriles del Norte will operate on a contract basis any portion of operations not contracted by CODELCO. There are also other agencies in Chile which will operate rail services on a contract basis.

4. Rolling Stock. Ferrocarriles del Norte has a large yard in La Serena with used box cars and bottom dump cars which can be refurbished for use in hauling sulfur prill. Apparently, locomotives can also be aquired in the sizes previously noted.

INFRASTRUCTURE REPORT
RAIL TRANSPORT
VOLCAN DE COPIAPO AREA

M.E.C.A. currently holds some 400 hectacres in mineral claims in the Volcan de Copiapo area, with options on an additional 100 hectacres. Although it is not planned to begin mining operations in this area first, it was decided to present a brief summary of ore transport feasibility via rail from the proposed processing area to the nearest rail receiving facilities. Thus, should the area later prove more favorable than the Piedra Parada area, a basis will have been laid for expanding a feasibility study of infrastructure.

Transport of sulfur material to port will require different routing here than that used from the Piedra Parada area. Because of circuitous routing, however, the distance to the port of Chanaral from both mineral areas is roughly equivilent. The ore shipped from the Volcan area has the advantage of choosing also from the ports of Caldera and Calderilla.

Ore mined from the pit areas at the Volcan will be transported to a processing area known as Vegas la Junta, a distance of 38 kms. Ore may be transported by truck or small gauge railroad. We recommend construction of a slurry transport system, covering the 38 kms from the mines to Vegas la Junta. If necessary, the water would be reused by pumping the water back through a second, smaller line. Adaption of a slurry system, combined with on site flotation of ore to reduce the amount of material to be moved would be our first choice.

From Vegas la Junta, new rail can be constructed covering 75 kms to Carrerra Pinto, which would be the transfer point to interfase with Ferrocarriles del Norte railroad to Chanaral. The cost of constructing the slurry pipeline - rail combination to Carrera Pinto would be approximately $18,000,000, which includes allowances for rolling stock, transfer points, sidetrack, etc. The total length of haulage from Volcan to Chanaral is 257 kms, with freight costs per ton forecasted to be $6.86, including Ferrocarriles de Norte charges. This tariff is based on known operational costs and charges in Chile, including preliminary discussions with personnel from Ferrocarriles del Norte.

INFRASTRUCTURE REPORT
RAIL TRANSPORT
VOLCAN DE COPIAPO AREA

Volcan de Copiapo - Caldera.

This route initiates in the same manner as the one from Volcan to Chanaral, deviating only at Puquios, where the Chanaral route connect north to Carrera Pinto, while the Caldera route continues west to Chulo, where it connects with Ferrocarriles del Norte line to Copiapo, continuing on to Caldera. Choice of routes depends on which port is selected for ship loading. The routes are comparable, except for a slight difference in operational costs in favor of the Caldera route.

The cost of constructing the slurry pipeline - rail combination to Chulo would be approximately $20,000,000 including allowances for rolling stock, transfer points, sidetrack, etc. The total length of haulage from Volcan to Caldera is 244 kms, with freight costs per ton forecasted to be $5.94 per ton. This tariff is based on known operational costs and charges in Chile, including preliminary discussions with personnel from Ferrocarriles del Norte.

The maps following show the proposed routes in relation to the sulfur properties and the connecting rail.

Further studies may show it beneficial to construct all slurry pipeline and eliminate rail haulage altogether.

RAIL TRANSPORT
VOLCAN DE COPIAPO AREA
M.E.C.A. SUMMARY

Water used in slurry transport and ore processing operations will likely need to be recycled for reuse. In the case of a slurry line, this will necessitate a double line, with a smaller return, and intermittent pumping stations.

A second option would be the construction of a small gauge rail line the 35 - 40 kms from the properties to Vegas La Junta, similar to those employed at older open pit copper operations, such as Phelp's Dodge Ajo, Arizona project. In any event, trucking of ore would be our last option. The route alternatives and their compositions are set forth below. (Minesite to Vegas La Junta)

	Route A	Route B	Route C
Kms of Trucking	25	0	0
Kms Small Gauge Rail	0	0	38
Kms 1 Meter Rail	11	0	C
Kms of Slurry Line	5	38	0
	====	====	====
Total:	41 km	38 km	38 km
Estimated Cost:	$2,875,000	$4,986,000	$2,850,000
Equipment Capital:	$2,000,000	$ 0	$ 750,000
	==========	==========	==========
Total:	$4,875,000	$4,986,000	$3,600,000

While Route C is slightly less capital intensive than either Routes A or B, Route B is our first choice because of lower operational and logistical costs. Ore would be processed at the minesite by flotation methods and then slurried to Vegas La Junta, where it would be transhipped via rail to either Chanaral or Caldera for shiploading.

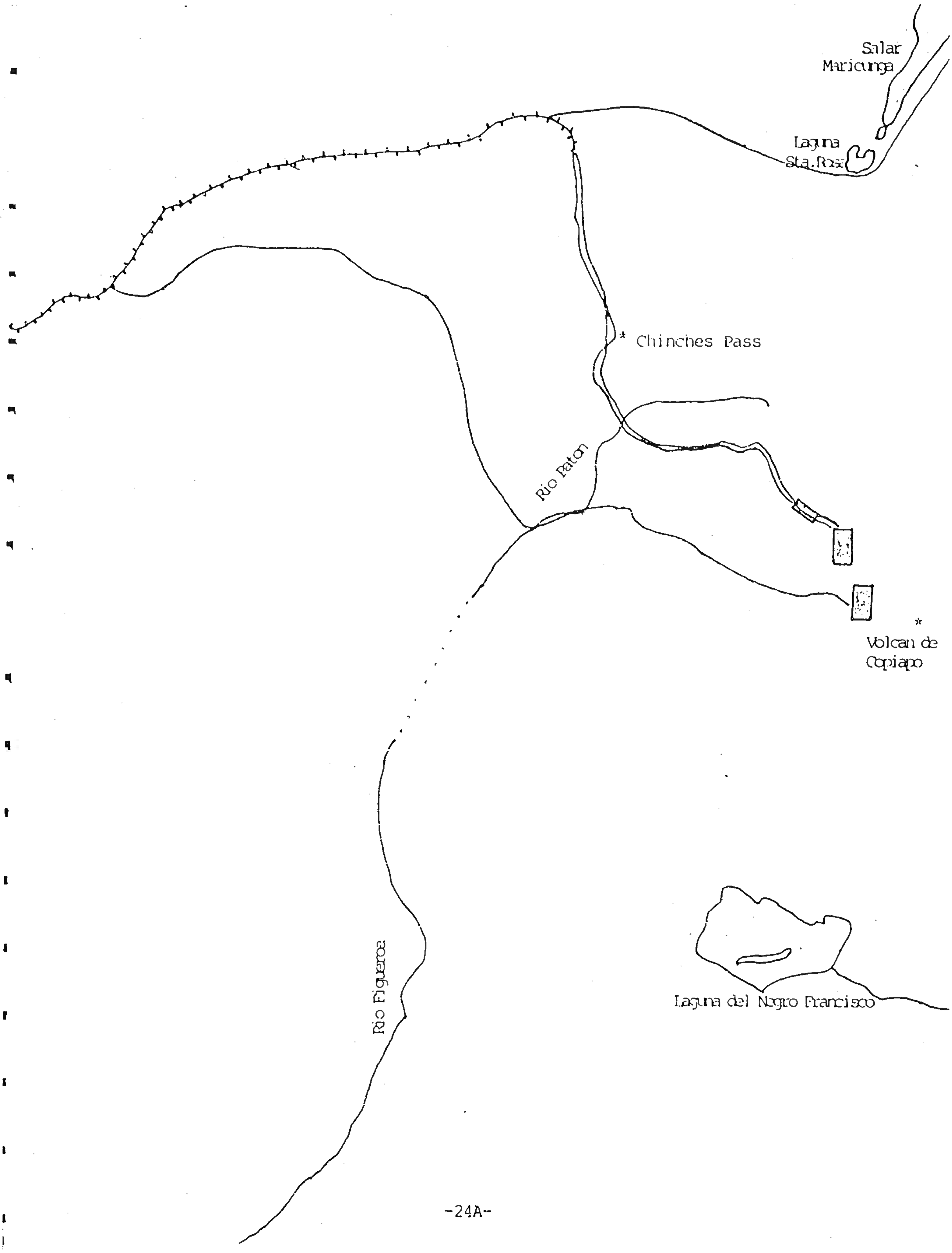
RAIL TRANSPORT
VOLCAN DE COPIAPO AREA
M.E.C.A. SUMMARY

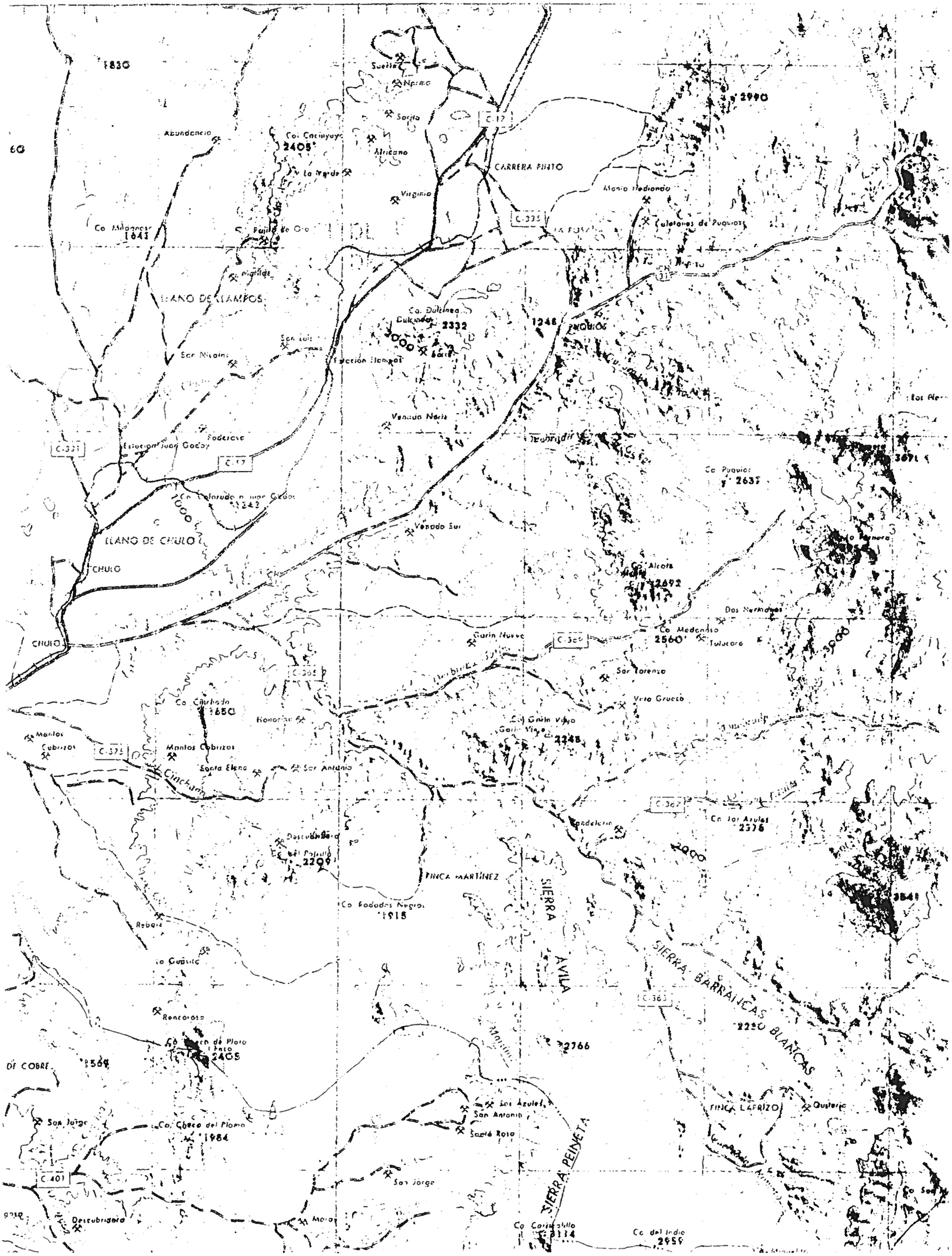
Route -	Chanaral	Caldera
Amount of new Construction from Vegas La Junta	75	100
Length of Route #[2]	10	10
Length of Route #[3]	8	0
Estimated Cost:	$11,075,000	$13,000,000
Cost of Slurry Line Volcan - Vegas La Junta	$ 4,986,000	$ 4,986,000
Total:	$16,061,000	$17,986,000
Total Distance from Volcan Sulfur Mines to Transfer Point	113	138
Operational Cost per ton/kilometer:	2¼¢	2¢
Volcan - Transfer Point	$2.543	$3.18
Transfer Point to Port Distance	144	106
Cost per ton/km	3¢	3¢
Transfer Point - Port	$4.32	$3.18
Total Freight Cost Volcan - Ports	$6.86	$5.94

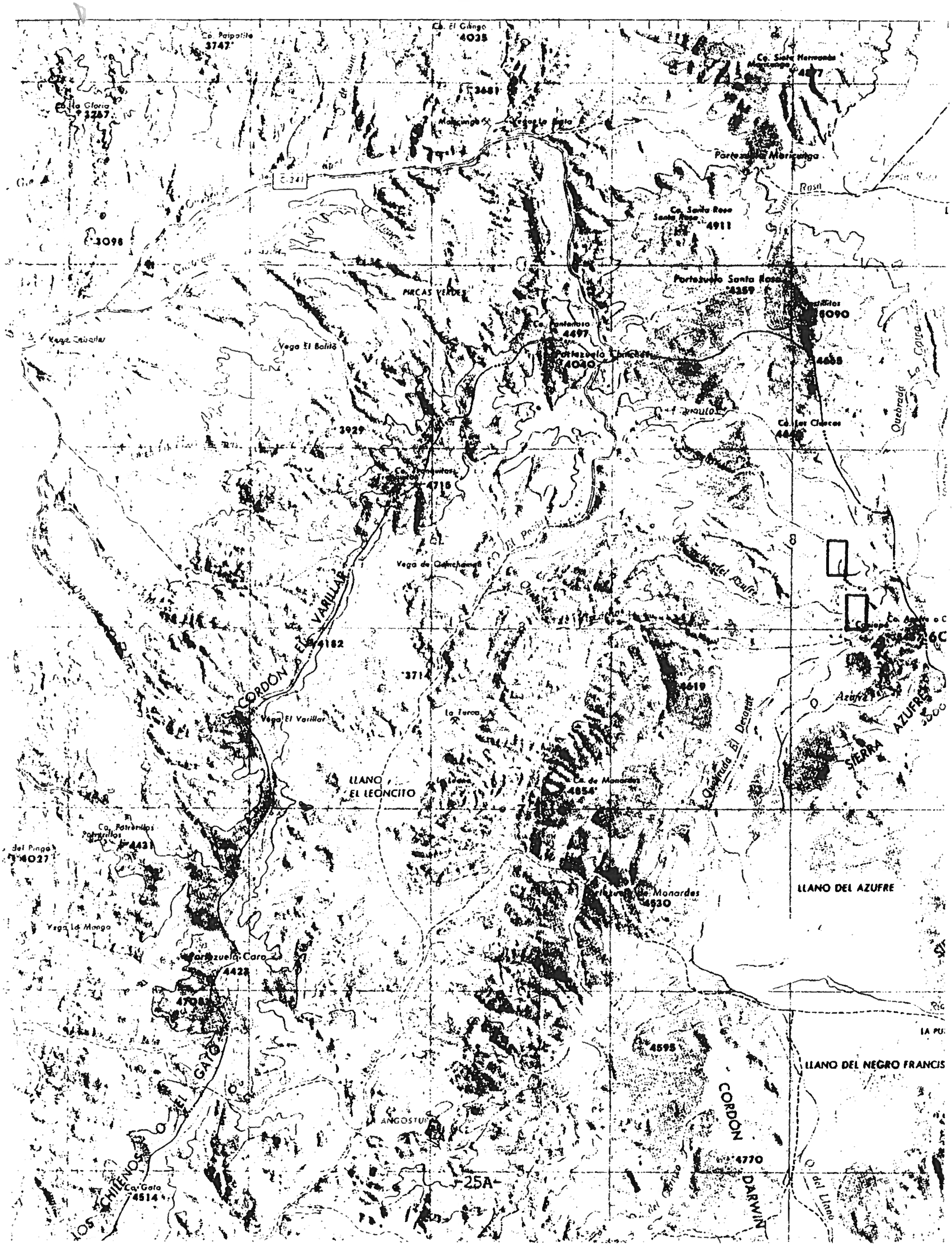
Transfer point for the Chanaral Route is Carrera Pinto, and transfer point for Caldera is Chulo.

[2] Sections of new construction requiring extra earth movement and grading.

[3] Sections of new construction requiring extra engineering, heavy earth movement and grading, and some blasting.


Salar
Mariounga
Laguna
Sta.Rosa
Chinches Pass
Rio Paton
Volcan de
Copiapo
Rio Figueroa
Laguna del Negro Francisco


1830
60
Abundancia
Co. Cachiyuyo
2405
La Verde
Norma
Sorita
Africano
Virginia
C-17
CARRERA PINTO
C-335
Monte Redondo
Caletones de Puquios
2990
Co. Milagros
1643
Pajito de Oro
Matilde
LLANO DE LLAMPOS
Co. Dulcinea
Dulcinea
2332
1246
PUQUIOS
San Luis
San Nicolas
Estacion Llampos
Venado Norte
Poderosa
Estacion Juan Godoy
C-331
C-17
1243
LLANO DE CHULO
CHULO
CHULO
Venado Sur
Co. Puquios
2637
La Venera
Co. Alcota
2692
Dos Hermanas
Co. Medanoso
2560
Garin Nuevo
C-369
C-365
San Lorenzo
Veta Gruesa
Co. Garin Viejo
Garin Viejo
2245
1650
Mantos Cobrizos
Mantos Cobrizos
C-375
Santa Elena
San Antonio
C-367
Candelaria
Co. Los Azules
2376
Descubridora
2209
FINCA MARTINEZ
SIERRA
AVILA
Co. Rodados Negros
1915
Rebeca
Rencorosa
SIERRA BARRANCAS BLANCAS
C-363
2220
2766
2405
DE COBRE
Los Azules
San Antonio
Santa Rosa
San Jorge
Co. Checo del Plomo
1984
C-401
San Jorge
SIERRA PEINETA
FINCA LA FRIZO
Quiteria
Descubridora
Co. del Indio
2959



Co. Paipotito
3747
Co. El Gringo
4035
Maricunga
Portezuelo Maricunga
Co. Santa Rosa
4911
3098
Portezuelo Santa Rosa
PIRCAS VERDES
Co. Pantanoso
4497
4040
Vega El Balito
3929
4718
CORDON EL VARILLAR
4182
Vega El Varillar
LLANO
EL LEONCITO
Co. de Monardes
4854
4619
Quebrada
SIERRA AZUFRERA
LLANO DEL AZUFRE
Co. Patrerillos
4431
4027
Vega La Manga
Portezuelo Caro
4428
4530
4595
LLANO DEL NEGRO FRANCIS
ANGOSTURA
CORDON DARWIN
4770
EL GATO
LOS CHILENOS
Co. Gato
4514
25A

M.E.C.A. INFRASTRUCTURE REPORT

CHAPTER TWO

SLURRY PIPELINE FEASIBILITY

INFRASTRUCTURE REPORT
SLURRY PIPELINE

By far the most efficient method of transporting sulfur product from the mining areas to existing railroad facilities is via a slurry pipeline. Two advantages in employing a slurry line as opposed to total rail transport are lower capital outlay during the initial construction phase and lower operational costs throughout the life of the project. The technical challenges involved in constructing an operating slurryline will be addressed hereafter.

Water.

It is essential to have at one's disposal sufficient water, not only for ore processing purposes, but also for the transport of the slurry itself. Initial reconnaisance in the Piedra Parada area showed sufficient water existing in the nearby brine lakes for both processing and slurry needs. Examination of aerial photos indicate that the water levels in some of the lakes may tend to vary somewhat. A NASA Landsat photo, taken on Feb 26, 1976 over the Piedra Parada area showed lower water levels in the Piedra Parada and Jilguero Lakes, and a depletion of waters in the Laguna del Bayo. Aerial photos taken of the region by the Chilean Air Force in March, 1983 show lake levels to be much the same as those subsequently found by M.E.C.A. personnel at later dates. The lower levels shown in the 1976 photo may be attributed in part to lower than usual precipitation for the year in question. February 26 also corresponds to the end of the Chilean Summer.

Laguna Brava.

The Laguna Brava is the largest sitting body of water within a 60 km radius. Lying adjacent to the lakes mentioned above, it apparently has a larger source feeding it than the other lakes in the region. Examination of the photographs studied above showed no variation in shoreline unlike the other lakes, indicating possibly more depth and probably a more dependable source. We assume the lake to be an outcropping of a subterranean water flow, perhaps fed from the high mountain range located 10 miles to the south, which has numerous peaks approaching 20,000'.

INFRASTRUCTURE REPORT
SLURRY PIPELINE

Laguna Brava appears sufficiently large to provide water for both processing and slurry needs, without seriously depleting the lakes waters. The main body of water covers approximately 7.5 kms of surface area, equal to 1,868 acres. A smaller body of water lies some 2 kilometers to the north, covering an additional 300 acres.

Because the lakes in the region will vary in salinity, it will be necessary to sample each lake and analyze the waters for impurities and levels of salt, and then determine which should be used for processing and which is appropriate for slurry needs. All other factors being equal, it appears that Laguna Brava would be the largest, most dependable source of water for both needs.

Water for Processing Purposes.

Water is an essential ingredient in the processing of sulfur ore. Water will be used in the flotation of the sulfur ore, disposal of tailings to a suitable area, and then recycled for use again in the processing plant. With efficient planning, 75% of process waters can be recycled.

Initial project parameters call for annual production of 600,000 tons (metric) of sulfur. To accomplish this, approximately 2 million tons of sulfur bearing ore, averaging 35% sulfur will have to be mined, crushed and processed. Water will be the main agent employed at the processing stage, and subsequent disposal of tailings. If efficient recycling technics are emplyed, we would hope for a consumption of one ton of water for each ten tons of ore processed. This would signify an annual consumption of 200,000 metric tons of water, or approximately 162 acre feet. The annual total may vary if the ratio of water consumption-to ore processed varies. Consumption of 162 acre feet would lower the main lake body of Laguna Brava by approximately 1" per year, assuming no replacement during years with heavier than usual precipitation. Concentric shoreline circles apparent in aerial photos shows the Laguna Brava to have had substantially more depth at earlier times.

INFRASTRUCTURE REPORT
SLURRY PIPELINE

Water for Slurry Pipeline.

Assuming a slurry mix of 50% water and 50% sulfur by volume, and 365 days per year of operation, the slurry line will require a maximum of 447,000 metric tons of water per year, equivilent to 362 acre feet. This would lower the main body of the Laguna Brava an additional 2.3" per year, assuming no replacement takes place.

M.E.C.A. commissioned Sunrise Engineering Inc., of Fillmore, Utah to outline some basic parameters for construction of a slurry pipeline from the Piedra Parada area to Montandon, where the sulfur would be transshipped aboard existing rail facilities to the port of Chanaral. The nine pages of their report and recommendations are included here. The M.E.C.A. map which follows shows the proposed route. A copy of a black and white aerial photo shows the relationship of the lakes to each other and the initial pipeline routing proposed in the Piedra Parada area.

SUNRISE ENGINEERING INC.

SUNRISE ENGINEERING INC.

FILLMORE, UT
MESA, AZ

71 WEST CENTER ST., FILLMORE, UTAH 84631 (801) 743-6151

February 20, 1988

Hal Gardner
2194 7th Ave.
Yuma, Arizona 85364

Re: Sulfer Slurry Pipeline in Chile

Dear Mr. Gardner:

Per your telephone request on February 5, 1988, I am summarizing herein preliminary design criteria for the referenced sulfer slurry pipeline. As you recall I was waiting for text I had ordered to confirm our preliminary recommendations. The text has arrived and includes research by the Colorado School of Mining Research Foundation sponsored by the Technical Committee on Pipe of the America Iron and Steel Institute and has proven to be a very satisfactory aid.

The following outlines the conditions we used for design:

Use: 1.0 cfs of slurry

50:50 by volume of sulfur:water

Pipeline Data

PI#	Pipe #	Length KM	+Uphill -Downhill Elevation Change M	Elevation M	(MECA Slurry Map Point)
0				1719	#1
	1	9	-385		
1				1334	#2
	2	9	+259		
2				1593	#3
	3	14	-869		
3				724	#4
	4	12	- 24		
4				700	#5
	5	14	0		
5				700	#6
	6	6	+220		
6				920	#7
	7	6	- 38		
7				882	#8
	8	3	-882		
8				0	#9

TOTAL 73 Km.

The following summarizes our findings which I outlined to you on the telephone:

1. Use a 6" diameter pipe. Steel pipe will probably be the best bet; however, Drisco or some other types of plastic based pipe may be better suited and more cost effective.

2. For most of the distance, the 6" steel pipe wall thickness need not be greater than 1/4 inch thick. Protective coatings should also be used.

3. Careful consideration must be given to air/vacuum relief facilities on the pipeline. This equipment must be designed after field review of the pipe alignment and will have an impact on the total pipeline cost.

4. Surge control equipment must be carefully designed and installed on the pipeline. This is probably the most critical need for the facility due to the catastrophic failure potential caused by water hammer. This can occur when filling the pipe, draining the pipe, and during normal operation after an event that changes the transport velocity of the fluid.

5. An estimated maximum of 660 horse power pump will be needed on the inlet side of the pipeline.

6. A Hazen Williams friction factor of C=90 has been assumed. This probably causes calculated friction losses to be higher than will actually be experienced but errors will only cause lower horse power requirements on the pump.

7. The elevation difference alone between the inlet and the discharge of the pipeline will cause approximately 0.83 cfs of slurry to flow through the pipeline. The pumps called for are sized to boost the flow rate up to the 1.0 cfs design rate.

8. To evaluate the effects of particle shape, size distribution, slurry composition, concentration on optimum transport velocity, and friction head loss, it is necessary to conduct large-scale pilot tests.

9. The preliminary design concentration of solids by weight is 67%. When the percent solids by weight are about 30-40 percent, the friction losses will be about equal to water in a clean pipe.

Above 30-40 percent the losses become higher. It may be advantageous to reduce the sulfer content per unit volume in the slurry. This would reduce the friction losses and reduce the horse power needs for pumping. This should be thoroughly analyzed for feasibility to assure the most cost effective configuration and operation is achieved.

10. A blockage of the pipeline at the discharge end would cause minimum pressures of 2442 psi. to develope at the discharge end. This may be too high for economical design of pipe wall thickness. I suggest special fuse plugs be designed to rupture at high pressure to prohibit excessive high pressure. These would be strategically placed along the pipeline to control damage in the event high pressure surges occur which would otherwise damage the pipeline.

11. The slurry pipeline intake and pumping works must be carefully designed to provide proper particle sizing of sulfer. Particles size should be such that it can be handled in commercially available pumps, pipe and preparation equipment.

12. For each pipe diameter and concentration combination there is one flow velocity which gives a minimum friction loss. Also another flow velocity exists below which solid particles will settle out on the bottom of the pipe. Further study must be done to determine these parameters for the actual site and field conditions.

I have enclosed a copy of my rough calculations for your use.

Sunrise Engineering, Inc. is extremely interested in assisting you further with the project. You suggested on the telephone that you plan to come up and visit regarding the feasibility study needs and areas where we can help. I would be happy to meet you in Salt Lake or at our offices in Fillmore or Mesa. We have specialized over the years in pipeline and mechanical installations of this type. We are also discussing full time employment right now with an experienced engineer who has direct slurry line design, construction, and installation experience. Regardless of the employment outcome, he is available to us as a resource for information. We enjoy an excellent reputation for common sense engineering judgement on successful projects.

In evaluating engineering companies, bigger is not necessarily better. I promise you will be pleased with your choice to use our professional services on the project.

I look forward to hearing from you.

Sincerely,

Alden C. Robinson, P.E.
Project Engineer

ACR:dde

Enclosure

Given: Q = 1.0 cfs of slurry
Sulfer
use 50% volume of slurry as sulfer
L = 73 Km = 45.36 miles = 239,513 ln.ft.
S.G. sulfer = 2.0
Density sulfer = 124.8 lb/ft³

FIND: RECOMMENDED PIPELINE SIZE
HORSE POWER NEEDS

SOLUTION.

$$C_v = \frac{\text{Volume of solids}}{\text{Total Volume of Slurry}}, \quad C_v = 50\%$$

(Total Volume of Slurry = 1.0 cfs)

volume of solid = .5 cfs = 30 ft³/min
volume of slurry : 1.0 cfs = 60 ft³/min.
volume of H_2O = Vol. slurry − Vol. solids
= 1.0 − 0.50 = 0.5 cfs = 30 ft³/min

weight of H_2O = (30 ft³/min)(62.4 lb/ft³)
= 1872 lb/min.

weight of sulfer = (30 ft³/min)(2)(62.4 lb/ft³)
= 3744 lb/min.

$$\text{Density of slurry} = \frac{\text{weight of slurry}}{\text{Vol. of slurry}}$$

$$= \frac{(1872\ \text{lb/min}) + (3744\ \text{lb/min})}{60\ \text{ft}^3/\text{min}}$$

$$= 93.6\ \text{lb/ft}^3$$

Specific Gravity of Slurry $= \dfrac{93.6 \text{ lb/ft}^3}{62.4 \text{ lb/ft}^3}$

$= 1.50$

Weight of Slurry $= (60 \text{ ft}^3/\text{min})(1.5)(62.4 \text{ lb/ft}^3)$
$= 5616 \text{ lb/min}$

Concentration by Weight $= \dfrac{\text{Weight of Solids}}{\text{Weight of Slurry}}$

$= \dfrac{3744 \text{ lb/min}}{5616 \text{ lb/min}}$

$= 0.67$ or 67% solids by weight.

Settling Velocity

This must be determined by lab analysis.

Assume:

20M to 1/8" particles

For 20M particle	$V_s = .003$ ft/sec.
For 1/8" particle	$V_s = 0.05$ ft/sec.
Coef. of Drag.	$C_D = 1.6$

Transport Velocity

Nominal Dia. - inches	4"	6"	8"
Area - ft^2	0.087	0.196	0.897
@ Slurry Flow Rate of 1.0 cfs			
Vel. - fps	11.5	5.1	1.1

Assume Critical Velocity of 4.4 fps for 6" pipe and 20M particle.

Use 6" pipe because velocity is greater than assumed critical velocity and 4" pipe is too high of velocity for friction loss criteria.

SUNRISE ENGINEERING INC.

PROJECT: Hal Gardner PROJ. NO. ______

SUBJECT: Sulfur Slurry Pipeline DATE: 2-22-88

BY: JCR CHK'D. BY: ______ SHT. 2 OF 4

Pipe wall thickness

use 60,000 psi minimum yield strength of steel

Internal pressure maximum is = 1719 meters
= 5640 feet
= 2442 psi.

$$t = \frac{PD}{2S}$$

$$= \frac{(2442)(6)}{(2)(30,000)}$$

$$= 0.244''$$

use 1/4" wall = 0.250" This is maximum thickness and can be decreased on uphill end of pipe line.

Check Flow capacity with out pumps:

use 6" pipe
Static head = 5640 ft.
L = 239,513 ft'

$$Q = 1.32\, C\, R^{.63} S^{.54} A$$

$$= (1.32)(90)(.125)^{.63}\left(\frac{5640}{239513}\right)^{.54} .196$$

$Q = 0.83$ cfs

PROJECT Hal Gardner PROJ. NO.

SUNRISE ENGINEERING INC.

SUBJECT Sulfer Slurry Pipe line DATE 2-22-88

BY ACR CHECKED BY SHT. 4 OF 4

[illegible]
This [illegible]
([illegible] figure friction loss)

Total head req'd to force 1.0 cfs slurry full distance of pipeline is:

$$h_L = \left(\frac{Q}{1.32\ C\ R^{.63} A} \right)^{1/.54} L \quad , \quad \text{let } D = 6'',\ A = 0.196\ ft^2,\ P = 1.57\ ft,\ R = A/P$$

$$= \left(\frac{1.0}{(1.32)(90)(.125)^{.63}(.196)} \right)^{1/.54} 239{,}513'$$

$$= 7967\ ft.$$

Head available from terrain:

1719 meters = 5640. ft.

Additional Head Needed by Pump.

$$H = 7967' - 5690'$$
$$= 2337 ft$$

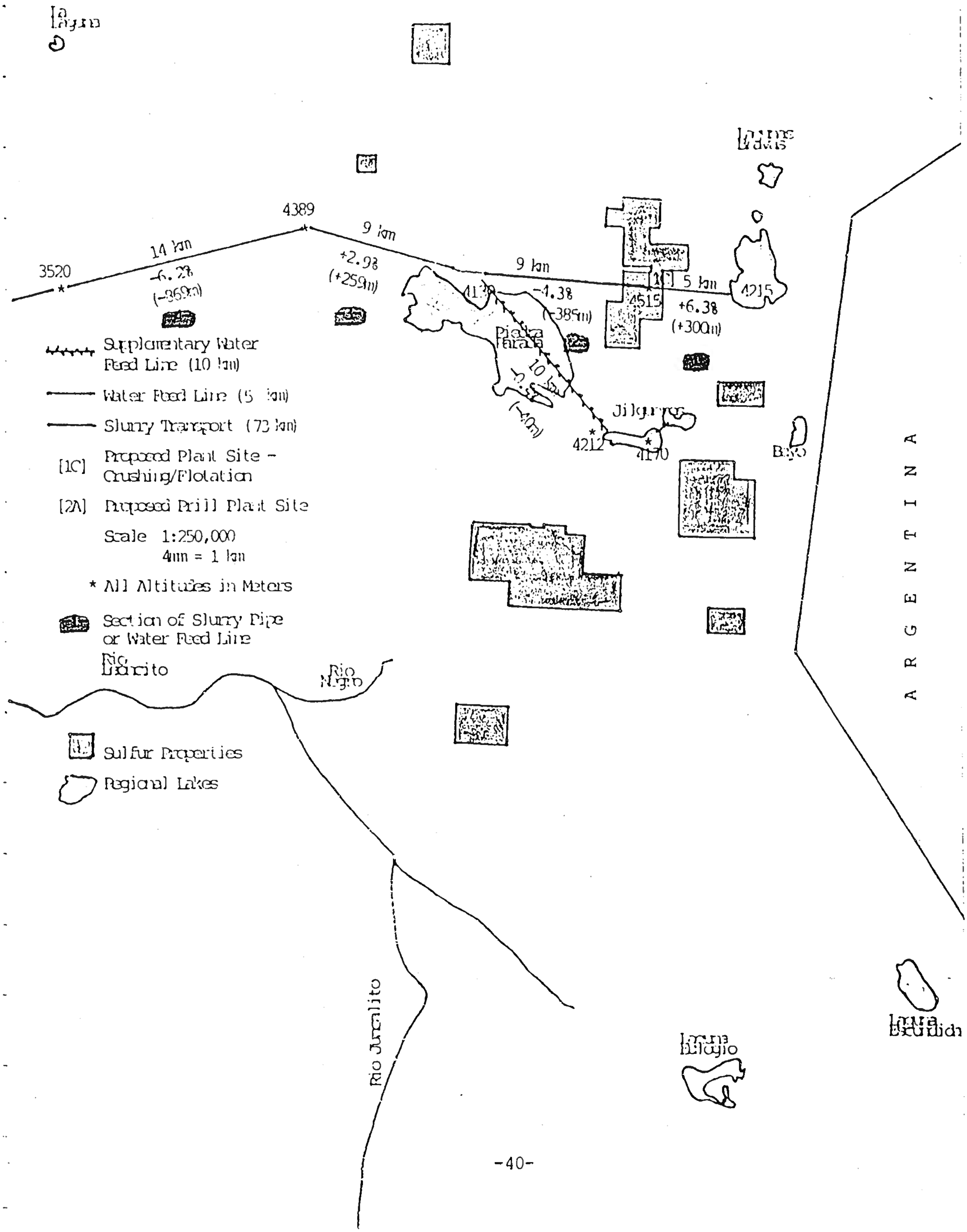
Horse Power Needs

$$H.P. = \frac{Q \gamma H}{550 \cdot e} \quad , \quad \text{let } \gamma = \text{Slurry Density} = 93.6\ lb/ft^3,\ e = 60\%$$

$$= \frac{(1.0)(93.6)(2337)}{550\ (.60)}$$

$$= 663\ H.P. \quad \text{or} \quad 494\ KW$$

Rail- Slurry Transport - Alternate Plan C



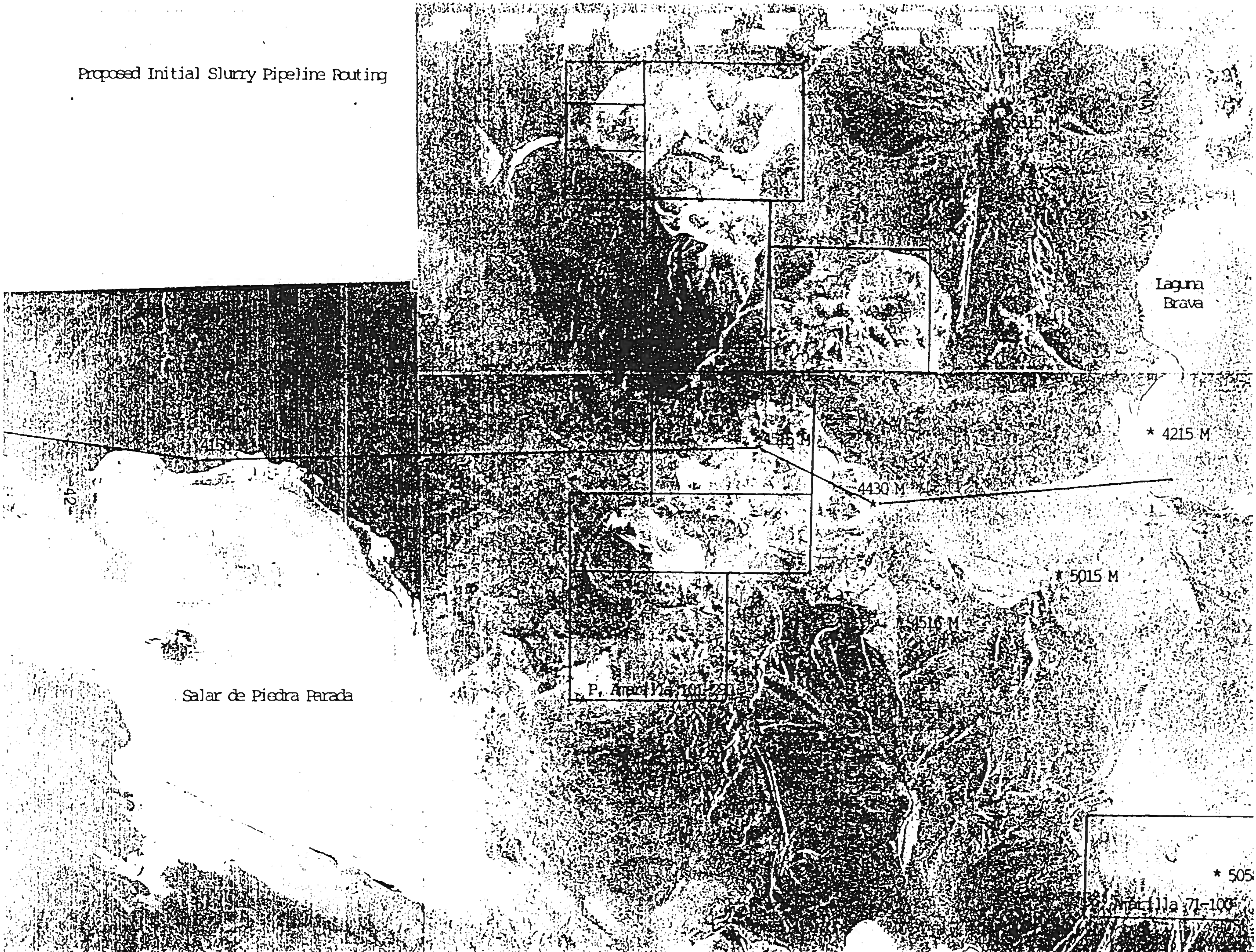
INFRASTRUCTURE REPORT
SLURRY PIPELINE

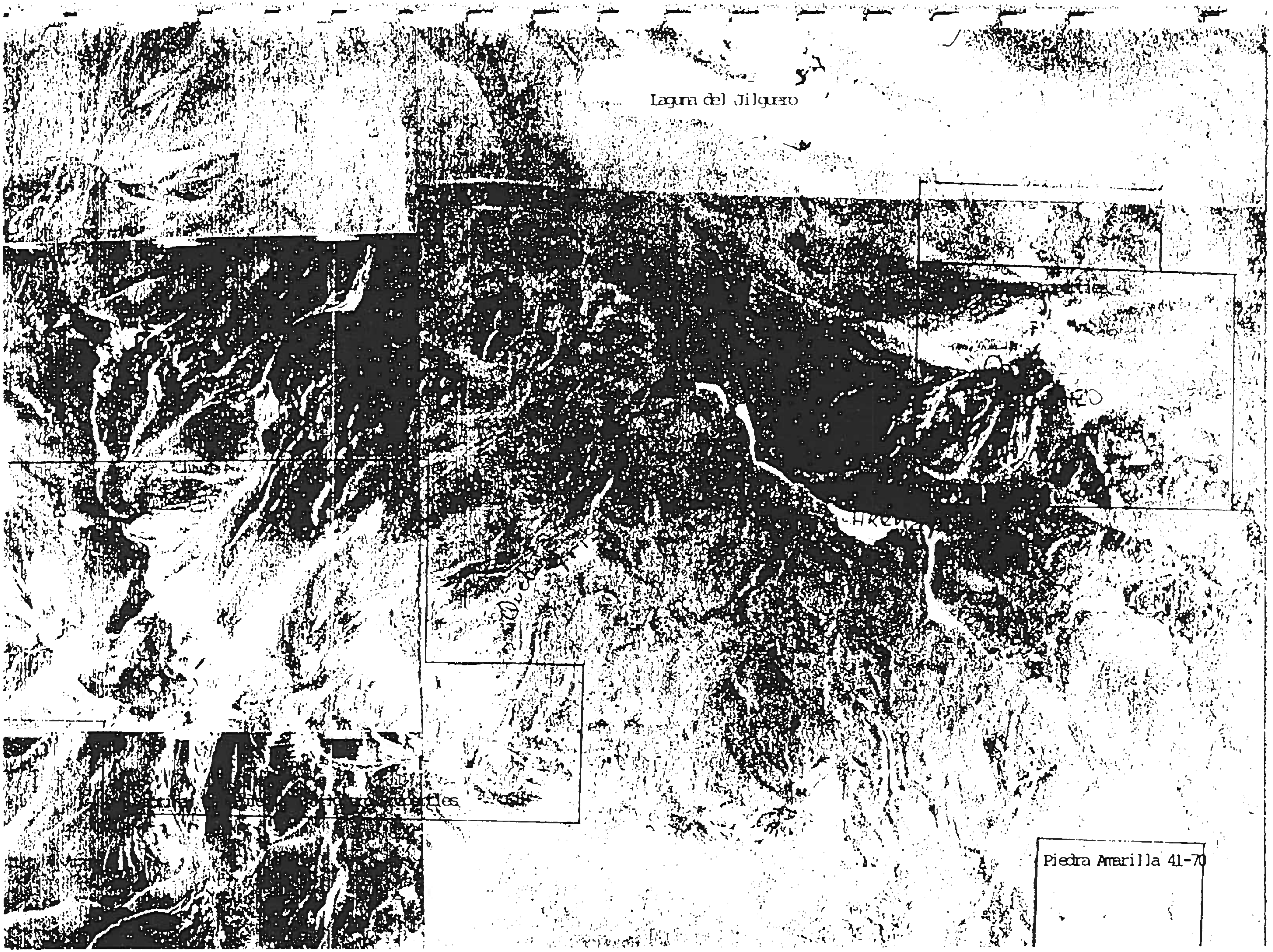
Map #	Distance	Beginning Elevation	± Change (Meters)	Comments
-0-	-	4215 m	-	Laguna Brava
-1-	* 5 km	4515 m	+ 300 m	Water Feedline to Processing Area
-2-	9 km	4130 m	- 385 m	Piedra Parada Area
-3-	9 km	4389 m	+ 259 m	Aliste Pass
-4-	14 km	3520 m	- 869 m	Pedernales Plain
-5-	12 km	3500 m	- 20 m	Pedernales Plain
-6-	14 km	3500 m	0 m	Pedernales Plain
-7-	6 km	3720 m	+ 220 m	Domeyko Range
-8-	6 km	3682 m	- 38 m	Overlooking Montandon Canyon
-9-	3 km	2800 m	- 882 m	Montandon Canyon
-10-	[2] 16 km	2375 m	- 425 m	Montandon
Slurryline:	89 km			

* Section -1- is not included as part of the slurryline since it is carrying only water to the processing area.

[2] Section -10- is not included in the Sunrise Engineering Report, but after consideration was included here. The 2.7% downgrade over the 16 kilometers will allow the slurry to flow at the same rate.

Proposed Initial Slurry Pipeline Routing




Laguna del Jilguero
Piedra Amarilla 41-70

INFRASTRUCTURE REPORT
SLURRY PIPELINE
COST ESTIMATES

Item	Number/ Distance	$/Foot or Unit	Total Cost
Water Feedline (6")	5 km	$ 15	$ 246,000
Retention/Storage Ponds	2	$100,000	$ 200,000
Tailings Disposal Line	2 km	$ 20	$ 131,000
Processing-Recycled Waterline	2 km	$ 15	$ 98,000
Water Feedline Pumps w/ Backup	4	$ 12,000	$ 48,000
Recylced Water Pumps w/ Backup	2	$ 12,000	$ 24,000
Slurryline Intake w/ Mixing Tanks	1	$1,000,000	$1,000,000
Slurryline	89 km	$ 25	$7,298,000
Vacuum Valves - Surge Control Equipment	?		$1,000,000 est.
Receiving Ponds-Facilities at Montandon	2	$250,000	$ 500,000 est.
		Total:	$10,545,000

Initially, the slurryline will gravity feed the entire 89 kilometers to Montandon. The distance may be shortened by 6 or 7 kms to Montandon by running a more direct route, with the disadvantage of have difficult access-roads for 10 or 12 kms of the distance.

The gravity fed 6" line will deliver 2,046 tons-per-day of 85% sulfur material, equivilent to an annual output of 634,750 metric tons of 100% sulfur. Output could later be increased annually an additional 125,000 metric tons by using the 660 H.P. pump at the head called for in the Sunrise Engineering report.

The estimated cost-per-ton of operating the slurryline on a year-round basis is 75¢ per metric ton, which includes fuel costs of the water feedlines and maintenance of the slurryline.

It's High-Level Growth for Chile

Infrastructure concessions pave way for foreign investment and modernization in Andean nation

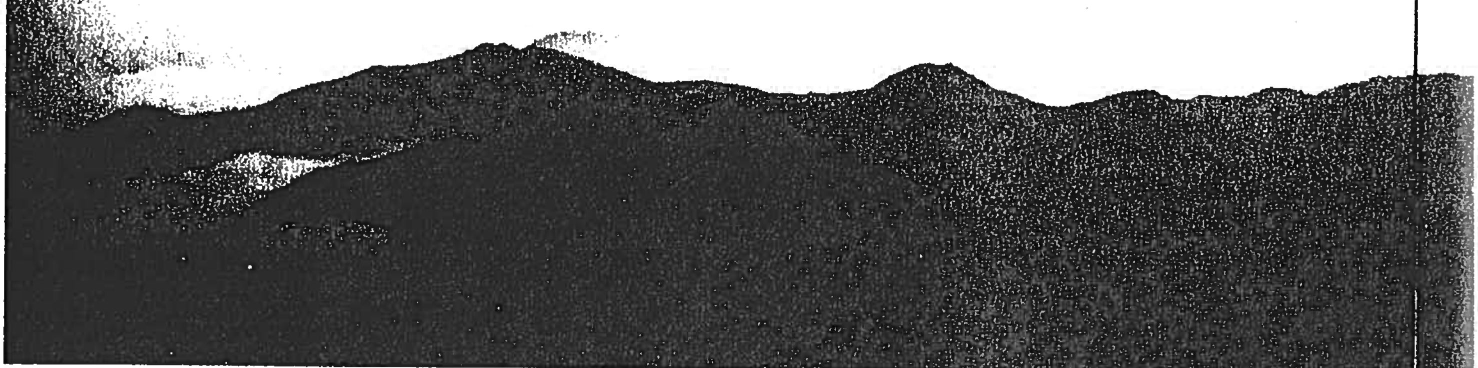


PHOTO BY [illegible] WRIGHT FOR ENR

Currency and stock fluctuations in Asia have suddenly made many U.S. engineering and construction firms rethink their previously bullish prospects there and beef up marketing south of the border. "Latin America is a lot closer to home—a one-day trip instead of two," says one investment advisor with experience in both markets. "There's also a lot more corruption in Asia than in South America." He adds that with one-fifth of the U.S. population now of Hispanic origin, "it's much easier to find common ground with our southern neighbors than to accentuate the differences."

South America is poised for a boom as the next century dawns—nowhere more so than in Chile and Brazil (see related story, p. 30). Some U.S. engineers and contractors are expanding a South American presence that that goes back decades. Others are enticed by improving economics. Chile's projected Gross Domestic Product growth of 7.2% in 1998, will outstrip even a healthy 6% annual average for the past 12 years.

Chile has an interesting problem these days, according to Carlos F. Capurro, senior commercial specialist at the U.S. embassy in Santiago. "The country suffers from excess money," he says.

Chile is well ahead of its neighbors in transferring state-owned business and investment to the private sector. The country's success since 1981 in privatizing its pension fund administration has paved the way for other free market initiatives. The government opened up energy and telecommunications to private investment starting in the 1980s, with dramatic results.

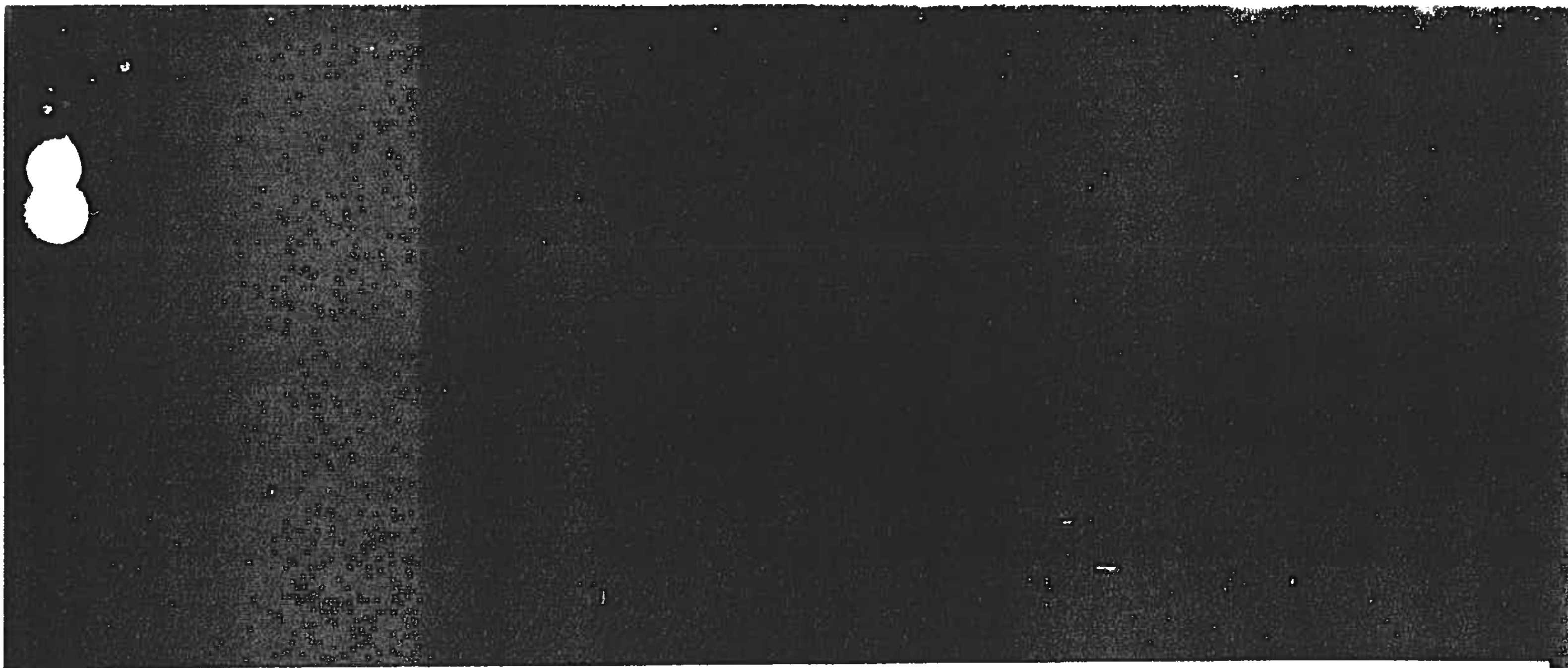
Nevertheless, Chile is starting to feel an economic pinch from years of underinvestment in infrastructure. The national road system needs rebuilding and expansion, especially around Santiago, which accounts for about one-third of the nation's 14.4-million population.

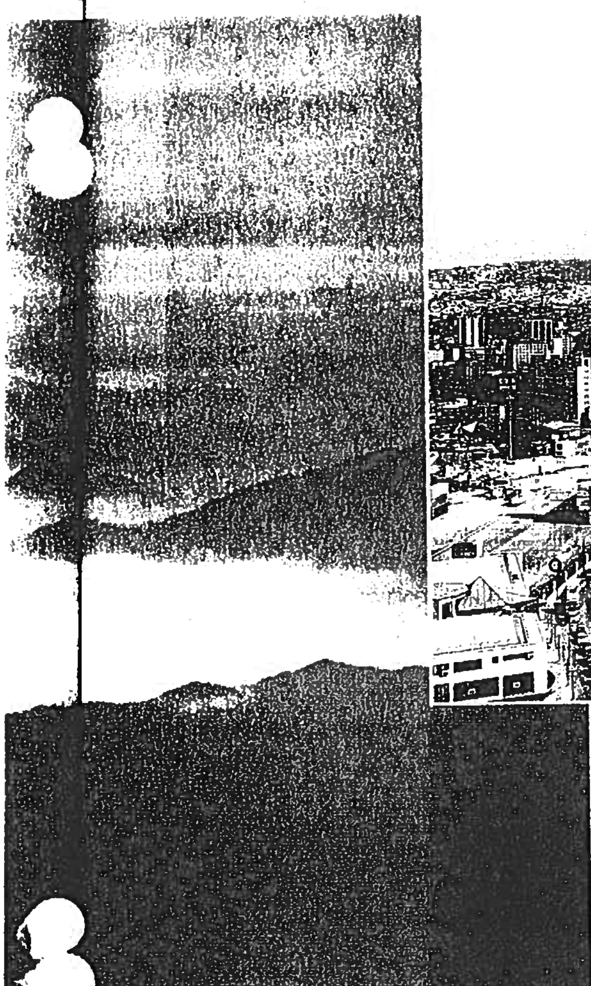
The city is looking to expand its subway system and construct a new road to Valparaiso, its major port and trade outlet. But Chile's port system is considered inadequate for a nation trying to position itself as Latin America's gateway to the Pacific Rim and North America. Regional airports, vital in a country that is 2,650 miles long and 250 miles wide, are struggling to handle increased traffic that has come with prosperity.

Water delivery and wastewater collection systems are good in urban zones, but hardpressed to keep up with inmigration. Rural systems are nonexistent or substandard. Wastewater treatment is minimal across the board, and there is a growing awareness that short ocean outfalls will no longer suffice in a country whose fisheries are a vital industry.

During the next five years, Chile expects its transportation and environmental infrastructure projects will require more than $9 billion, says CG/LA Infrastructure, a Cambridge, Mass., consulting group. Urban roads and highways will account for $6 billion, with $1.4 billion needed for airports, ports and roadways, and $2 billion more for water and wastewater treatment.

President Eduardo Frei would like to see some of the "excess money" in the





PUBLIC WORKS
The port of Valparaiso (top) is expanding its wastewater treatment system. A deep hard-rock tunnel will eventually route collector mains to a seaside treatment plant (model at right) that will feed an offshore outfall.

pension funds invested in infrastructure development. But he is equally committed to continue with what has worked so far: an economic framework favorable to international investment and a government moving from owner to regulator.

ENR. ART BY SUE PEARSALL FOR ENR

Chilean firm's cross-cultural practices build bilateral business

ROLANDO CARMONA JR. BELIEVES that there are definite differences in the way Latin Americans and North Americans approach business. Instead of bemoaning the dissimilarities, however, he believes in adapting the best features of each culture to gain a competitive advantage.

While big U.S. engineering and construction firms are trying to figure out how to succeed in Chile, Carmona's small Santiago-based civil engineering firm and mining equipment manufacturer is leveraging its hardrock mining expertise at home into exports through subsidiaries in other Latin American countries, North America, and Europe.

The 41-year-old general manager and principal of Drillco Tools S.A. is an avid student of business management gurus such as Peter Drucker, Tom Peters and Stephen Covey. He recently sponsored his own informal research project. "We had an intern from Notre Dame University down here last year," says Carmona. "His master's thesis was the differences between U.S. and Latin American business practices."

The entrepreneur arranged and helped coordinate numerous interviews with Chilean business people, economists, sociologists, academics and government officials. The interviews revealed a Chilean self-image of people who are often late, fail to follow through on promises and lack productivity, commitment and competitiveness, Carmona says. "We were surprised at our own perception of ourselves," he says. On the other hand, he notes that Latin culture is friendlier and more prone to interaction and openness. "We're better listeners," says Carmona.

CARMONA Listen to market, cut costs.

The interviewees' interpretation of U.S. business practices, on the other hand, was of "competitive, individualistic, highly focused go-getters," says Carmona. "But there is weak interaction. North Americans are not oriented to teamwork, not as willing to sacrifice personal ambition to group goals."

To make inroads into North American markets, Drillco had to be a good listener, Carmona says. In Chile, where labor is cheap, drill bits are built to last and resharpened several times, he notes. But in the U.S., they are disposable items. "At first, my products were over-engineered," he admits. "The U.S. sales price was equal to my production cost." Carmona reengineered an inexpensive, disposable bit and returned to establish outlets in five U.S. states.

Drillco boasts a 65% market share at home, but Carmona is still implementing North American ideas. Company engineers use computer-aided design and manufacturing tools to improve and expand the product line. The firm also shares detailed cost data with its 126 plant employees as the basis for profit sharing. So far, production costs have dropped by 8%. "It's not an entitlement," he says. "They earn it."

By Andrew G. Wright

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borne emissions in this decade. It plans to double that by 2000. Mining expansion near Antofagasta will also require more water in a barren region.

The transportation sector is also ripe for expansion, says Claudio Hohmann, minister of transport and telecommunications. "We've seen an explosion of mobility within the past decade and we have underinvested in our infrastructure in ports, airports and railways," he says. The answer is in private sector investment through concessions, but Hohmann says the government should make sure that money is not spent on foolish projects. "Miami has a beautiful light rail train, but no one uses it," he says.

> "We have seen an explosion in mobility...and underinvested in our infrastructure."
> —**CLAUDIO HOHMANN,** *Minster of Transport*

The government last month legalized the breakup of EMPORCHI, the state-owned company that operates 11 regional ports, into separate 30-year concessions. The ports of Valparaiso and San Antonio need at least $500 million in infrastructure investment. "We need cranes, modern technology," says Hohmann.

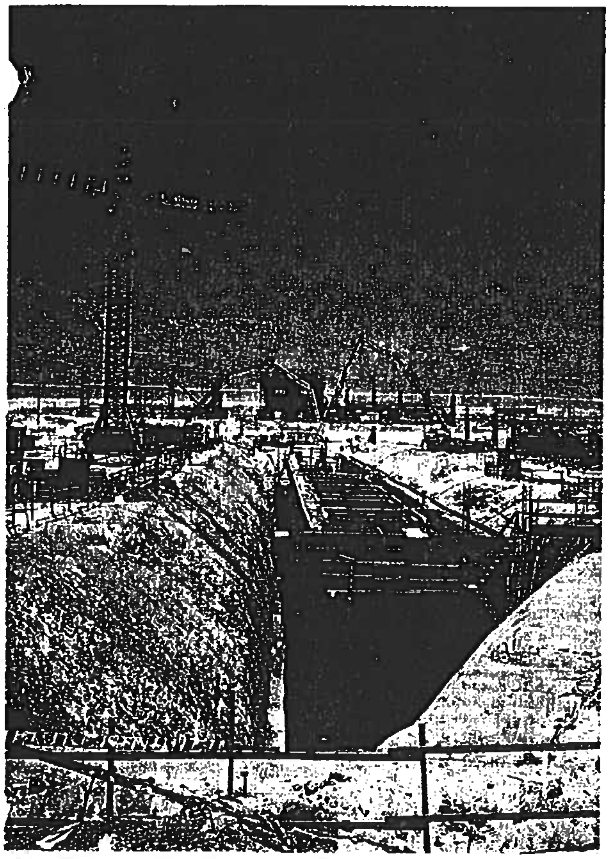
There are even bigger plans for a deepwater port at CODELCO's Mejillones site in the north. This $400-million plan, which is outside the EMPORCHI framework, is aimed at constructing a cargo terminal to serve the so-called "Post Panamax" class of ships now being built up to 300 m long with 18-m draft (ENR 11/10 p. 23). A port that can accommodate these huge vessels could provide a Pacific Rim trade outlet for Chile, as well as for Argentina, Bolivia, Paraguay and Brazil, economic observers say.

Highway and airport concessions are being parceled out by the Ministry of Public Works. Major projects include the Santiago International Airport terminal concession, three urban highway projects around the capital and eight concessions along 1,500 km of Route 5, the north-south artery in the middle of the country (see map, p. 28). Mexican-led teams, despite their own problems at home, have won three highway concessions to date, according to Salvador Fernandez, a ministry spokesman.

U.S. construction firms so far are buying bid documents, but are not yet bidding on concessions. "We'd like to see at least one U.S. winner, just for diversity's sake," Fernandez says. "Monopolies can be dangerous." ❑

By Andrew G. Wright in Santiago

PHOTOS BY ANDREW G. WRIGHT FOR ENR



COPPERING OUT Norm Shaw, Fluor project manager, surveys expansion at Escondida copper mine, the world's largest (top and left).

International and Chilean hardrock ıining engineer Cade-Idepe SA designed the tunnel as an alternative after another team pursuing a pipe-jacking approach ran into unanticipated rock outcropping and defaulted.

Juan Luis Tapia, ESVAL's chief of operations and projects, says the $120-million project will not be affected by the utility's expected move to a concession. The Black & Veatch-Cade-Idepe team is working on the treatment plant design, although it is not expected to be constructed before 2001, he says. Clinton O. Robinson, B&V International vice president, says his firm hooked up with Cade-Idepe for the tunnel alternative because of its hardrock mining expertise.

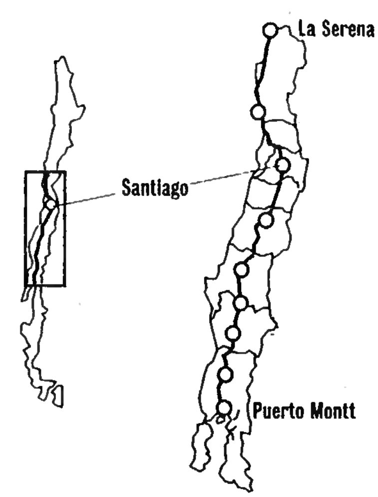
BEDROCK The way Norm Shaw sees it, all of Chile's economic progress has come "on the back of mining." Shaw is Fluor Daniel Corp.'s project manager of an oxide leaching addition to the Escondida mine in the Atacama Desert. Over the past decade, Fluor has performed engineering, procurement and construction management on $1.4 billion worth of work at Escondida, the world's largest copper mine. It is run by a joint venture led by two Australian firms, Broken Hill Pty. and Rio Tinto, that own 87.5%. A Japanese consortium owns 10% and the World Bank the remaining 2.5%.

The owners don't believe in long-term partnering arrangements, preferring instead to compete each phase. Bechtel Group Inc. gained a toehold last year, with a small contract, but Fluor subsequently took the oxide contract and has won six of seven major contracts bid to date.

It makes political and economic sense to use as few costly expatriates as possible, according to Shaw. But it also makes sense to minimize the number of local workers as well, since they have to be quartered at the remote job site, which is at an altitude of more than 10,000 ft in an area that hasn't seen rain in about 500 years. "This is not an easy environment to work in. We're trying to bring our North American safety culture to the job," he says, proud that Fluor recently passed 1.5 million hours on the job without a lost-time injury. Local contractors at first resisted bidding preconditions such as mandatory safety harnesses and heavy equipment roll bars, Shaw says, but eventually realized that the contractor was serious. "We've seen a cultural change within the past three or four years," he adds.

ASHERMAN

ROUTE 5 CONCESSIONS



DOTTED LINE Individual concessions (red line segments) cover 1,500 km.

"What we bring to the table is our training and job management systems, and where appropriate, the equipment," says Philip K. Asherman, Fluor's Latin American mining operating company president. Fluor leveraged its position as a procurement contractor to build business for its American Equipment Co. subsidiary in Santiago "There's plenty of local engineering talent available here," he says.

Chile's engineering schools produce about 5,000 graduates a year, says Carlos Andreani, head of energy investments for power conglomerate Endesa and president of the Chilean Engineers' Society. The challenge is to update the curriculum quickly enough to keep current. "We were slow before, but now we're starting to see very rapid changes," he says. "Things can become obsolete very fast."

The mining sector's continued expansion is also leading to other spinoff infrastructure development. CODELCO, the state-owned copper producer, has invested $260 million for environmental controls for mining-related effluent and air-

M.E.C.A. INFRASTRUCTURE REPORT

CHAPTER THREE

EXISTING PORT FACILITIES

THE PORT FACILITIES AT CHANARAL & BARQUITO

Port of Chanaral - Barquito

Location and History

Chanaral is located in the northern portion of Chile's Atacama Province some 600 miles north of Santiago, adjacent to Caleta Bay. Chanaral was originally founded as a mining colony which exploited the rich silver lodes discovered near there during the late 19th century. Caleta Bay is located at 26° 21' S. Latitude and 70° 38' W. Longitude.

Chanaral experienced two periods of fast paced growth, the first during 1919 and the early 1920's as Andes Copper Company completed facilities for off-loading copper at Barquito, near the southern edge of Caleta Bay. The facilities included docks and buildings which are still in use today. The second period of growth took place in the 1950's when a mechanical loading plant was completed for liftings of iron ore pellets produced from nearby iron mines. The mechanical loading plant is located about a mile north of Barquito and is referred to in shipping logs as Chanaral.

Chanaral experienced a severe depression during the early 1970's from which it has yet to recover. The closing of the iron ore mines due to world wide drop in iron and steel prices left many people out of work, and the town has experienced a high level of unemployment ever since. The economy of Chanaral is tied directly to port activity, and there are no secondary industries. Some who live in Chanaral commute during the week to small mining operations in the interior.

Commercial activity today is largely tied to shipments of copper blister by CODELCO at its Barquito facility. Shipments average 10,000 tons per month. Fuel, equipment, and supplies are also imported at Barquito and shipped via rail to CODELCO's El Salvador - Potrerillos facilities. Total import-export traffic at Chanaral is roughly 300,000 tons-per-year.

CODELCO purchased the iron ore loading facility from Japanese concerns and now owns all loading - unloading facilities at Caleta Bay. A new dock facility is presently under construction at Chanaral which will facilitate direct loading of copper products.

Proposal

Incorporation of the port facilities of Chanaral into our proposed sulfur project makes sense for a number of reasons. Chanaral would be the facility which most rapidly could be put on stream for the least amount of capital. It is also the closest port to the proposed sulfur mines in the Piedra Parada area. Rail service is also available from Montandon to the unloading facility at Chanaral, roughly two-thirds of the required transportation distance. Other than CODELCO, there are no other competing interests for any of the port facilities.

This report will cover in a brief way the facilities available for incorporation into the sulfur project, and terms for their use.

Unloading and Storage of Sulfur.

Sulfur arriving by rail is routed onto a sidetrack some 200 meters east of the storage yard. Bottom dump rail cars unload their product directly into a large bin hopper which holds perhaps 250 tons of material. The hopper feeds a 36" conveyor system which transports material along a series of 3 conveyors to the yard stacking conveyor.

Although the transport conveyor was built to high structural standards, much of the software has been cannibalized over the last 10 - 15 years of non-use, and will have to be replaced. This includes all electrical components and motors, belting, idlers, etc. Walkways need replacing, and most exposed metal surfaces of the supporting structures need sandblasting and painting.

The transport conveyor feed material onto the yard stacking conveyor, which is located some twenty meters above the storage yard base. The stacking conveyor is in need of improvements similar to those needed by the transport conveyor system. The transport conveyor system should be able to deliver in excess of 500 tons per hour of sulfur prill to the storage yard area. Since a typical train convoy will consist of 20 cars carrying a total of 800 tons, this means a convoy can be unloaded in less than two hours.

It should be noted here that the transport conveyor system has an additional feed hopper which is capable of receiving feed material from dump trucks. It is located some 80 meters from the rail receiving facility, along the side of the highway.

The floor of the storage yard presently consist of dirt, and is contaminated with small ore piles left as residual waste from the earlier days of iron ore pellet shipping, and some small barite piles left from materials shipped in 1984 - 1985. The yard would obviously require a cleanup of existing ore piles, and grading and an application of a suitable paved material to minimize contamination of sulfur prill. The storage area stores in excess of a shipload of material, and with careful planning may handle well in excess of 100,000 tons.

The overhead stacker drops materials vertically over an underground reclaim system which has a concrete gallery fed by 21 surface hoppers with feed gates. The surface hoppers feed onto an underground conveyor system, consisting of two 42" conveyor belts in a perpendicular configuration, 13 of the surface hoppers feeding a north-south belt and 8 feeding an east-west belt. The two underground conveyors, which both have variable speed capacity, converge onto the ships loading arm conveyor. All aspects of the underground reclaim system, including hoppers, gates, conveyors, loading boom, etc., are in good operational order.

CODELCO expended $300,000 in 1986-1987 refurbishing all aspects of the reclaim system, and for installation of a large dock adjacent to the loading boom. M.E.C.A. Personnel were present in May 1987 when this portion of the system was in full operation, providing rock and fill material for the new dock platform. All aspects of the system worked well, with the exception of the underground ventilating system which worked poorly. The air exchangers are antiquated and need replacing.

Rail Receiving Facility, Conveyor System
Overhead Stacker, Loading Boom

View From North

Loading Sulfur Aboard Vessels

Since the loading plant has but a single loading arm, the vessel must be maneuvered fore and aft during loading. The ship is moored to buoys and cushoined against the loading arm by a flexible resilient dock face. The dock tie up system and anchorage points should not create any serious problems for an appropriately sized sulfur vessel to tie up to and shift as necessary to accomodate the fixed ship loading arm.

The orientation of the dock face is parallel to the prevailing wind direction, and thus the facility should be usuable in all but the most severe wind conditions. Ship anchorage is with sand & mud bottom, in water 15-17 meters deep.

The ship loading system should be able to average 700 tons per hour to the hold of the vessel. Once allowances are made for hatch changes and ship moves, the average should be somewhere between 400-500 tons per hour, based on a sulfur bulk density of 1.2 tons/m^3, belt speed of 1.5m/sec., 20° trough idler with a 20° surcharge angle. Any variations in the above formula will affect the average delivered per hour to the hold of the ship. The quality of the ship loading conveyor appears adequate that its capacity could be further increased if desired.[1]

Power Supply

The dock facility is serviced electrically by three motor generator sets, with a total capacity of approximately 1,000 H.P. If mechanical failure should occur, any two of the three generators could supply sufficient power for the vital functions involved in ship loading. Two of the three generators were operating when M.E.C.A. personnel were present in May 1987. Power from the generators is funnelled to a series of distribution panels located in the generating room, and then is distributed throughout the storage yard. Vital motors all have independent start/stop and breaker systems.

CODELCO will incorporate an external source of electrical power from the Chilectra electric company sometime during 1988. The generators should be retained as backup in the advent of a power shortage. CODELCO's contract with Chilectra on the El Salto substation, which provides power to El Salvador - Potrerillos mining complexes, has strict limitations on the period of downtime allowed, such as no more than 30 minutes or so.

Present Port Use - Chanaral

The mechanical loading plant has no present customer use. In 1984-1985, some limited quantities of barite were loaded using the loading plant. Because of the world-wide oil depression, the exporting company has subsequently transferred most of its barite mining equipment to a more promissing silver operation, and therefore is not expected to reenter the barite market.

Ship Unloading - Chanaral

Upon completion of the new dock at Chanaral, CODELCO will transfer copper loading operations there from Barquito. This will permit direct ship loading and unloading of copper and its associated products, whereas they as currently loaded at Barquitos using barges which must transfer the products to vessels anchored offshore. The new dock will also allow direct unloading of large pieces of equipment such as cat loaders and dozers, which formerly had to be transshipped from larger ports. Presently the maximum crane capacity at Barquitos is approximately 18 tons, while the crane capacity of the new dock will be that of the ship cranes anchored alongside.

CODELCO's plans eventually call for unloading of copper concentrates from other parts of Chile, using the new dock facilities. The copper concentrates will be shipped via rail to Potrerillos to be refined. The copper ore at the El Salvador mine is quickly depleting, and as it plays out CODELCO will begin shipping excess concentrates from other points in Chile. This could potential translate into monthly unloadings of up to 50,000 tons of concentrate, which combined with the direct ship loading of refined copper could tie up the dock facilities for 10 - 15 days per month. This would leave approximately 15 days per month for the loading of sulfur prill. Under a carefully managed program, sulfur prill in excess of 100,000 tons monthly could be loaded at the complex. A 50,000 ton ship could be loaded in approximately 6 days using three shifts working around the clock, and assuming no mechanical downtime.

Barquitos

Barquitos was constructed in 1919 by Andes Copper Company. Most of the facility was constructed to high standards, and today CODELCO's port offices are housed there. In addition to the dock facility for direct rail unloading of copper blister onto barges, the facility has a number of other, older buildings. The old generating plant which was used to supply power to Potrerillos, is now used as a railcar repair facility. Other auxiliary buildings are used for storage of chemicals and supplies to be transshipped to El Salvador.

A series of large fuel storage tanks lie at the northern end of Barquitos. Tankers anchor offshore and unload diesel and other fuel products through an undersea fuel line. The fuel level in the storage tanks vary, depending on whether they are filled with fuel oil for the refinery or diesel for the machinery. Best guetimates are that the storage tanks are seldom more than 70% full, and therefore would provide extra capacity for our sulfur operations.

CODELCO pays ENAP (the national petroleum company) only after fuel has left the tanks, (through metered lines, we presume). The fuel tanks mostly gavity feed a rail depot, where rail tank cars can be loaded, 3 or 4 at a time. The system apparently has some type of booster pump capacity, presumably for when fuel levels in the tanks are low. Fuel may be imported from sources other than ENAP. It isn't clear whether capacities in the storage tanks will have to be negotiated with ENAP or with CODELCO.

Auxiliary Services

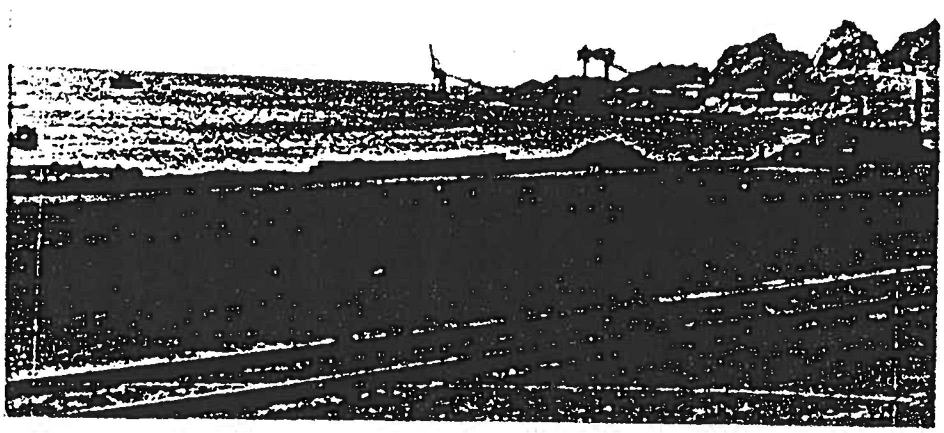
The Chilean Navy quarters a small contingent of naval personnel in Chanaral, who are charged with the responsibility of receiving incoming maritime traffic, including anchorage and tie up, and issuance of shore leave, which apparently is routinely granted.

Fuel Storage Tanks-

Barquito

Rail Yard
Auxiliary Buildings

Barquito



Loading Boom
Overhead Stacker

as seen from
Barquito

The government maintains a small customs office, which is under direction of the Valparaiso Maritime Office for Customs. Importation of any equipment may be made through Chanaral, after routine papers are cleared by the Central Bank. Other services may be contracted for in Chanaral, such as customs brokerage, sampling services, and other areas related to importation or shipments.

Although CODELCO sells its blister to many nations of Europe and Asia, there are in fact few facilities for visiting crews or ships. Potable water for ships is in short supply, and therefore ships are generally not allowed to tank up on water unless there is an emergency. Fuel for ships is much the same. Health and care facilities in Chanaral are primitive, at best, although CODELCO maintains a decent hospital facility at El Salvador, two hours distant. There are no consular offices in Chanaral.

Chanaral has inadequate phone and communications systems, unlike most of Chile which can be reached by direct dial from foreign sources. Phone communications are routed through phone operators in Copiapo. The port at Barquitos has only two phone lines, which during business hours are generally tied up. CODELCO conducts much of its communications via radio with El Salvador. Scattered residential phone lines are available in Chanaral and Barquitos.

Suitable housing for U.S. residents is in short supply. A few old residences in Barquitos would be available for rent from CODELCO, and were used by Andes Copper Personnel. With some refurbishing, they could become comfortable enough for personnel assigned to port operations. Educational oportunities in Chanaral are woefully inadequate, as are recreational facilities.

Weather

Chanaral has a moderate climate, tempered by the ocean. Nights are cool, and afternoons are lazily warm. During the winter months, early morning overcast consisting of low, thin clouds is not uncommon. Rainfall averages less than 1" per year. Strong afternoon sea breezes are common from 12 - 4 P.M. The days are almost always sunshiny, even in wintertime.

Environmental Considerations

Caleta Bay is joined on its northern third by the confuence of the Rio de la Sal. The riverbed is dry, and follows the valley through which the railroad to Potrerillos is routed. Rio de la Sal drains a large area of the pre-cordillera portion of the Andes. Only occasionally, however, does sufficient rainfall occur to permit actual runoff. We could substantiate only two "floods" in the last 65 years, one in 1922 and last year, August 1987. Last year covered much of the railroad with more than one foot of mud. Operations were resumed in about 4 days. Portions of lower Chanaral were flooded. All port facilities were untouched, as they lie about one mile south of the floodplain.

The Rio de la Sal channel is used by CODELCO to dispose of the tailings from the El Salvador flotation plant. Each year, more than six million tons of tailings are sloshed down the river channel, most of which eventually finds its way to Caleta Bay. The accumulation has caused the gradual slumping of the north-east portion of the bay, and created a large, artificial beach more than 3 miles long. During afternoon sea breezes, some of the fine tailings are blown inland back up the Rio de la Sal valley.

The mechanized loading area is separated from the tailings beach area by about 1/2 mile. A protruding rock-ridge some 50' or more in heigth protects the northern flank of the storage yard area from tailings which might swirl in from the north. It may be of some concern to ensure that the storage yard area remain completely free from beach tailings. This can probably be ensured by adding a "wind fence" some 20' high to the northern and eastern flanks of the storage yard.

Dust hazards associated with bulk loading of products can, in the case of sulfur, largely be eliminated by prilling the sulfur into small pellets. The under-ground portion of the reclaim system needs upgrading as far as the ventil-ation system is concerned. The westerly sea breezes should ventilate suf-ficiently all aspects of the outdoor ship loading of sulfur product.

The storage yard is located about 1/2 mile south of the town of Chanaral, and 1 mile north of the Barquitos complex. Although not likely, a fire in the storage yard could release nauseating sulfur dioxide gases. Such a fire would spread relatively slowly in the initial phases, but could conceivably consume all sulfur stockpiled in the yard. Contingencies should be made for extinguishing fires on a 24 hour basis. Cool ocean water could quickly douse any sulfur fire, and since the sulfur prills are not permeable to water, the sulfur product by and large would not be damaged. The impermeability of sulfur is an important aspect, when considering the possibility of rainfall or ocean spray.

Another environmental concern might be that of noise pollution created by convoys of trains arriving at different hours of the night to unload sulfur product, and its subsequent transfer to the storage yard. This was a common occurence when the iron ore mines were in operation, but it's been several years since convoys have arrived on a continual basis. CODELCO has probably two convoys which arrive daily, to leave copper blister and transport fuel on backhaul.

Economic Impact

CODELCO will not participate financially at this time in further refurbishing of port facilities. They will, however, rebate any monies invested in port upgrading on a pro rata basis as a deduction from normal port fees to the contracting party. Estimated costs of upgrading port facilities to handle unloading and loading of sulfur prill on a 50,000 ton-per-month basis is $500,000. This would include electrical components, transport conveyor, overhead stacker, rail unloading facilities, conditioning of storage yard, and complete spare parts inventory.

Port fees charged by CODELCO are negotiable on a long term contract. Loading contracts with multi-year extentions are available. CODELCO will require a performance bond of approximately $250,000 in order to sign a long term contract with an unproven party. The bond may possibly be waived if improvements to the port in excess to the bond amount are made.

CODELCO's port fees would include all overhead costs and labor, plus a profit margin. Apparently, the few shipments of barite made by Chile's Baritex were contracted for around $4.00 per ton. The barite was shipped only intermitently, and so was probably somewhat of a nuisance to CODELCO. Presumably, from unofficial discussions held with CODELCO officials on an informal basis, port fees of about $3.00 per ton or slightly less could be negotiated on a long term basis, on sulfur liftings of several hundred thousand tons per year.

A more intriguing possibility would be the outright purchase of some or all of the port facilities, including Barquito, from CODELCO. Certainly CODELCO would be interested in holding such discussions with a responsible party. CODELCO would almost assuredly require priority guarantees for handling of copper products on a long term basis. The purchase of the port facilities could be amortized and repaid in as little as four years, depending on total sulfur liftings. On a large scale operation, the actual costs to CODELCO for loading sulfur are probably less than $1.50 per ton. Not only would an operator have substantial annual savings in port fees, he would be guaranteed substantial business in the long term from CODELCO. More than 300,000 tons are imported/exported from Chanaral/Barquitos on an annual basis from CODELCO. This amount will probably double when unloading of copper concentrates begins in the future. Revenues from CODELCO alone would probably pay for the costs in operating the port on an annual basis.

Jobs and Labor. During the six month period of upgrading required at the storage yard, 40 - 50 labor positions will be created. Port operations and rail unloadings will add a total of 90 full time and part time jobs to the Chanaral area. The large number of jobs is due to the 24 hour loading requirements of ships, hence the necessity of contracting 3 shifts. Trains will also be unloaded on a 24 hour basis. The possibility exists that some of the train crews may also be headquartered in Chanaral, which could add dozens of other jobs.

An additional estimated 30 jobs will be created in Chanaral in direct support industries, including mechanical jobs, secretarial services, sampling-annalysis, staff support for customs and import brokers, etc.

The total number of jobs created in the Chanaral area directly tied to port, rail and direct support industries could vary from 150 - 200 jobs. Certainly a number of indirect jobs will be created by the spin-off of money injected into the depressed area, especially in the retail trade and services areas, such as hotels/restaurants, etc. The number of additional jobs indirectly created could easily equal those directly created.

Summary

The port of Chanaral can accept sulfur prill from bottom dump rail cars, at the rail unloading terminal. The sidetrack is capable of handling 25 rail cars at a time. The transport conveyor can deliver 500 tons/hour to the overhead stacker-storage yard area. The belt conveyors to the stacking yard require refurbishing. The yard needs cleaning up and paving. Much of the electrical control system must be replaced, and all components would require thorough testing prior to utilization. The reclaim system, including loading boom, are largely ready to operate and can deliver 500 tons/hour to the ships hold.

After a firm commitment from CODELCO, the port could be upgraded and ready to accept sulfur for shipment within six months, at an approximate cost of $500,000. With careful planning, the port could conceivably handle up to 1,000,000 tons per year of sulfur prill.

A few minor environmental issues need to be addressed

Overall, the project will add substantially to the economically depressed city of Chanaral, and will have a positive impact much greater than the creation of jobs and influx of capital.

The Ports of Caldera and Calderilla

Information for much of this report is taken from a summary report issued by Applied Engineering Science Group of Alberta, Canada. Visits were made to the ports of Caldera and Calderilla by M.E.C.A. personnel jointly with the Canadian group and subsequently.

Caldera.

Caldera was originally constructed for the same purpose as the port of Chanaral, for loading iron ore product. The construction specifications for Caldera are comparable to those of Chanaral.

This facility has an under rail receiving hopper to receive ore from bottom dump cars. The trackage can handle approximately 40 rail cars at a time. The rail connects with the Ferrocarriles del Norte line from Copiapo, and would receive material shipped from the Volcan de Copiapo area.

From the rail receiving hopper, sulfur prill would be conveyed up an inclined belt to the storage area, where the product is dumped into large, cement lined storage bins. The bins appear to be approximately 50 meters deep, with a probable capacity of 40,000 metric tons each.

The belt widths on the conveyors are similar to those used at Chanaral and therefore the throughput capacities are expected to be similar. Most of the equipment appears to be of heavy duty design, and similar to that found at Chanaral. The facility has been idle for a number of year, and will require a thorough overhaul similar to the effort and cost required at Chanaral. It is anticipated that most of the electrical system will require replacement. Caldera has five individual conveyor belts to accomplish the same ship loading task that Chanaral does with seven. Tie up and mooring facilities appeared to be adequate.

Calderilla.

Material shipped to this port is received by truck only, as there is no thru railroad. An estimated 5 kilometers of rail with an accompanying spur would need to be constructed. The present road accesses this port facility across a narrow causeway from the mainland. The limited size of the island would make it necessary to evaluate special design considerations in order to add a rail unloading facility into the present area.

Whereas the ports of Chanaral and Caldera can be leased or possibly purchased, Calderilla is for purchase only. Calderilla was not constructed to the same design specifications as Caldera and Chanaral.

The port of Calderilla has a stacking conveyor which feeds material from the truck dump to an unpaved storage area. The port storage area is equipped with an underground reclaim conveyor, which feed twin ship loaders. This facility has not been used for a number of years and would require more refurnishing than either Caldera or Chanaral in order to bring it into service.

SOURCES OF DATA

Applied Engineering Science Group (Canada)

CODELCO - El Salvador Division
Chanaral Port Division
La Ola Pumping Station

Empresa Nacional de Mineria (ENAMI)

Ferrocarriles del Norte

Fuerza Aerea de Chile - Air Photometric Service

SERNAGEOMIN - National Geological and Mining Service

Sociedad Nacional de Mineria (SONAMI)

Sunrise Engineering, Inc. (Utah)

Piedra Amarilla
Cash Flow Analysis Case 2
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			1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
Production Tonnes/year mill feed				360,000	360,000	360,000	1,080,100	1,080,100	1,080,100	1,080,100	1,080,100	1,080,100	1,080,100	1,080,100	1,080,100	1,080,100	11,681,00
S Grade %				20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0
Au Grade g/t				0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.7
Waste at Strip Ratio of 0.16 :1				57,600	57,600	57,600	172,816	172,816	172,816	172,816	172,816	172,816	172,816	172,816	172,816	172,816	1,900,96
Total mined material				417,600	417,600	417,600	1,252,916	1,252,916	1,252,916	1,252,916	1,252,916	1,252,916	1,252,916	1,252,916	1,252,916	1,252,916	13,761,95
Tonnes mined per day				2,320	2,320	2,320	6,961	6,961	6,961	6,961	6,961	6,961	6,961	6,961	6,961	6,961	5,68
Mill Recovery S %				83.30%	83.30%	83.30%	83.30%	83.30%	83.30%	83.30%	83.30%	83.30%	83.30%	83.30%	83.30%	83.30%	83.30
Mill Recovery Au %				80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00
S Conc. Produced Tonnes				70,560	70,560	70,560	211,700	211,700	211,700	211,700	211,700	211,700	211,700	211,700	211,700	211,700	2,328,67
Contained S Produced Tonnes				59,976	59,976	59,976	179,945	179,945	179,945	179,945	179,945	179,945	179,945	179,945	179,945	179,945	1,979,37
Au ounces payable				6,945	6,945	6,945	20,836	20,836	20,836	20,836	20,836	20,836	20,836	20,836	20,836	20,836	229,19
Acid Produced				179,928	179,928	179,928	539,834	539,834	539,834	539,834	539,834	539,834	539,834	539,834	539,834	539,834	5,936,12
Acid Produced tonnes per day				500	500	500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	
Acid Revenue @	50			8,996,400	8,996,400	8,996,400	26,991,699	26,991,699	26,991,699	26,991,699	26,991,699	26,991,699	26,991,699	26,991,699	26,991,699	26,991,699	296,906,19
Gold Revenue @	325			2,257,017	2,257,017	2,257,017	6,771,678	6,771,678	6,771,678	6,771,678	6,771,678	6,771,678	6,771,678	6,771,678	6,771,678	6,771,678	74,487,83
Interest Income Balance			5,000,000	6,000,000	7,200,000	8,640,000	10,368,000	12,441,600	14,929,920	17,915,904	21,499,085	25,798,902	30,958,682	37,150,419	44,580,502	53,496,603	
Interest Income on $5 million	20%			1,000,000	1,200,000	1,440,000	1,728,000	2,073,600	2,488,320	2,985,984	3,583,181	4,299,817	5,159,780	6,191,736	7,430,084	8,916,100	48,496,6
Total Revenue				**12,253,417**	**12,453,417**	**12,693,417**	**35,491,377**	**35,836,977**	**36,251,697**	**36,749,361**	**37,346,558**	**38,063,194**	**38,923,157**	**39,956,113**	**41,193,461**	**42,679,477**	**419,890,62**
Operating costs	$/tonne																
Contract Mining																	
Mining cost (6 mo mining period)	1.25			522,000	522,000	522,001	1,566,145	1,566,145	1,566,145	1,566,145	1,566,145	1,566,145	1,566,145	1,566,145	1,566,145	1,566,145	17,227,45
Process Plant																	
Processing	7.00			2,520,000	2,520,000	2,520,000	7,560,700	7,560,700	7,560,700	7,560,700	7,560,702	7,560,700	7,560,700	7,560,700	7,560,700	7,560,700	83,167,00
Contract Hauling																	
Short truck & Rail Haul to Acid Plant ($/tkm)	0.04	434.4		1,226,051	1,226,051	1,226,051	3,678,492	3,678,492	3,678,492	3,678,492	3,678,492	3,678,492	3,678,492	3,678,492	3,678,492	3,678,492	40,463,07
Acid Plant																	
Acid Plant	3.33			234,965	234,965	234,965	704,960	704,960	704,960	704,960	704,960	704,960	704,960	704,960	704,960	704,960	7,754,45
Total G & A																	
G&A Mine, Process, Acid Plant, Corp.				1,200,000	1,200,000	1,200,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	18,000,00
Total Operating cost				**5,703,015**	**5,703,015**	**5,703,015**	**15,010,297**	**15,010,297**	**15,010,297**	**15,010,297**	**15,010,297**	**15,010,297**	**15,010,297**	**15,010,297**	**15,010,297**	**15,010,297**	**167,212,01**
$/tonne sulfur				95.09	95.09	95.09	83.42	83.42	83.42	83.42	83.42	83.42	83.42	83.42	83.42	83.42	86.1
$/tonne acid				31.70	31.70	31.70	27.81	27.81	27.81	27.81	27.81	27.81	27.81	27.81	27.81	27.81	28.7
Indirect costs																	
Principal Repayment				1,500,000	1,500,000	1,500,000	4,100,000	4,100,000	4,100,000	4,100,000	4,100,000	4,100,000	4,100,000	4,100,000	4,100,000	3,000,000	45,000,00
Principal Balance				15,000,000	13,500,000	12,000,000	37,900,000	33,800,000	29,700,000	25,600,000	21,500,000	17,400,000	13,300,000	9,200,000	5,100,000	1,500,000	
Interest on Principal	24%			1,800,000	3,240,000	2,880,000	9,096,000	8,112,000	7,128,000	6,144,000	5,160,000	4,176,000	3,192,000	2,208,000	1,224,000	360,000	54,720,00
Owner Royalty				337,603	337,603	337,603	1,012,901	1,012,901	1,012,901	1,012,901	1,012,901	1,012,901	1,012,901	1,012,901	1,012,901	1,012,901	11,141,921
Before Tax Income				2,912,799	1,672,799	2,272,799	6,272,179	7,601,779	9,000,499	10,462,163	12,063,360	13,763,956	15,607,959	17,623,915	19,845,262	22,656,279	141,816,76
Corporate Income Tax	0.34			990,552	568,752	772,752	2,132,541	2,584,605	3,060,170	3,563,935	4,101,542	4,679,759	5,306,706	5,992,131	6,747,729	7,716,735	48,217,70
Subtotal Indirect Costs				**4,627,954**	**5,646,354**	**5,490,354**	**16,341,442**	**15,809,506**	**15,301,071**	**14,820,837**	**14,374,444**	**13,968,600**	**13,611,607**	**13,313,032**	**13,094,631**	**12,689,636**	**159,079,52**
Revenue Before Capital				1,922,447	1,104,047	1,500,047	4,139,638	5,017,174	5,940,329	6,919,227	7,961,617	9,084,237	10,301,253	11,631,784	13,098,533	14,979,544	93,599,08
Capital Expenditures																	
Development/Construction			9,500,000			29,000,000											38,500,00
Ongoing Capital				150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	1,950,00
Working Capital Change			500,000			1,000,000										(1,500,000)	(
Total Capital			10,000,000	150,000	150,000	30,150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	(1,350,000)	40,450,00
Net Cash Flow			(10,000,000)	1,772,447	954,047	(28,649,953)	3,989,638	4,867,174	5,750,329	6,766,227	7,311,817	8,934,237	10,151,253	11,481,784	12,948,533	16,329,544	53,149,08
Project NPV @10%			6,900,556														
Project IRR			13.09%														
Net Cash Flow to Venture Partners				1,772,447	954,047	1,350,047	3,989,638	4,867,174	5,790,329	6,768,227	7,611,617	8,924,237	10,151,25[illegible]	[illegible],481,784	12,948,533	16,329,544	93,149,080
S&S NCF	51%			903,948	486,564	688,524	2,034,715	2,482,259	2,953,068	3,451,796	3,984,027	4,556,461	5,177,139	5,855,710	6,603,752	8,326,066	47,5[illegible]6,031
Partner NCF (inc. Roy...)	49%			1,206,112	675,099	939,126	2,9[illegible]7,824	3,397,817	3,850,163	4,329,333	4,840,692	5,390,676	5,987,015	6,638,975	7,357,683	9,014,376	56,784,870

Pecos Amarillo
Cash Flow Analysis
August 28, 199?
11:57 AM

Case : 1
(000)

			1	2	3	4	5	6	7	8	9	10	11	Total
Production Tonnes/year mill feed				360,000	360,000	360,000	360,000	360,000	360,000	360,000	360,000	360,000	360,000	3,600,000
S Grade %				20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%
Au Grade g/t				0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Waste at Strip Ratio of 0.16 :1				57,600	57,600	57,600	57,600	57,600	57,600	57,600	57,600	57,600	57,600	576,000
Total mined material				417,600	417,600	417,600	417,600	417,600	417,600	417,600	417,600	417,600	417,600	4,176,000
Tonnes mined per day				2,320	2,320	2,320	2,320	2,320	2,320	2,320	2,320	2,320	2,320	2,320
Mill Recovery S %				83.30%	83.30%	83.30%	83.30%	83.30%	83.30%	83.30%	83.30%	83.30%	83.30%	83.30%
Mill Recovery Au %				80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%
S Conc Produced Tonnes				70,560	70,560	70,560	70,560	70,560	70,560	70,560	70,560	70,560	70,560	705,600
Contained S Produced Tonnes				59,976	59,976	59,976	59,976	59,976	59,976	59,976	59,976	59,976	59,976	599,760
Au ounces payable				6,945	6,945	6,945	6,945	6,945	6,945	6,945	6,945	6,945	6,945	69,447
Acid Produced				179,928	179,928	179,928	179,928	179,928	179,928	179,928	179,928	179,928	179,928	1,799,280
Acid Produced tonnes per day				500	500	500	500	500	500	500	500	500	500	
Acid Revenue $	50			8,996,400	8,996,400	8,996,400	8,996,400	8,996,400	8,996,400	8,996,400	8,996,400	8,996,400	8,996,400	89,964,000
Gold Revenue $	325			2,257,017	2,257,017	2,257,017	2,257,017	2,257,017	2,257,017	2,257,017	2,257,017	2,257,017	2,257,017	22,570,170
Interest Income Balance			5,000,000	6,000,000	7,200,000	8,640,000	10,368,000	12,441,600	14,929,920	17,915,904	21,499,085	25,798,902	30,958,682	
Interest Income on $5 million	20%			1,000,000	1,200,000	1,440,000	1,728,000	2,073,600	2,488,320	2,985,984	3,583,181	4,299,817	5,159,780	25,958,682
Total Revenue				12,253,417	12,453,417	12,693,417	12,981,417	13,327,017	13,741,737	14,239,401	14,836,598	15,553,234	16,413,197	138,492,852
Operating costs	$/tonne													
Contract Mining														
Mining cost (thru mining period)	1.25			522,000	522,000	522,000	522,000	522,000	522,000	522,000	522,000	522,000	522,000	5,220,000
Process Plant														
Processing	7.00			2,520,000	2,520,000	2,520,000	2,520,000	2,520,000	2,520,000	2,520,000	2,520,000	2,520,000	2,520,000	25,200,000
Contract Hauling														
Short truck & Rail Haul to Acid Plant ($/tkm)	0.01	434.4		1,226,051	1,226,051	1,226,051	1,226,051	1,226,051	1,226,051	1,226,051	1,226,051	1,226,051	1,226,051	12,260,506
Acid Plant														
Acid Plant	3.33			234,965	234,965	234,965	234,965	234,965	234,965	234,965	234,965	234,965	234,965	2,349,648
Total G & A														
G&A Mine, Process, AcidPlant, Corp				1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	12,000,000
Total Operating Cost				5,703,015	5,703,015	5,703,015	5,703,015	5,703,015	5,703,015	5,703,015	5,703,015	5,703,015	5,703,015	57,030,154
$/tonne sulfur				95.09	95.09	95.09	95.09	95.09	95.09	95.09	95.09	95.09	95.09	95.09
$/tonne acid				31.70	31.70	31.70	31.70	31.70	31.70	31.70	31.70	31.70	31.70	31.70
Indirect costs														
Principal Repayment				1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	15,000,000
Principal Balance				15,000,000	13,500,000	12,000,000	10,500,000	9,000,000	7,500,000	6,000,000	4,500,000	3,000,000	1,500,000	
Interest on Principal	24%			1,600,000	3,240,000	2,880,000	2,520,000	2,160,000	1,800,000	1,440,000	1,080,000	720,000	360,000	18,000,000
Owner Royalty				337,603	337,603	337,603	337,603	337,603	337,603	337,603	337,603	337,603	337,603	3,376,025
Before Tax Income				2,912,799	1,672,799	2,272,799	2,920,799	3,626,399	4,401,119	5,258,783	6,215,980	7,292,616	8,512,579	45,086,673
Corporate Income Tax	34%			990,352	568,752	772,752	993,072	1,232,976	1,496,381	1,787,986	2,113,433	2,479,489	2,894,277	15,329,469
Subtotal Indirect Costs				4,627,954	5,646,354	5,490,354	5,350,674	5,230,578	5,133,983	5,065,589	5,031,036	5,037,092	5,091,880	51,705,494
Revenue Before Capital				1,922,447	1,104,047	1,500,047	1,927,727	2,393,423	2,904,739	3,470,797	4,102,547	4,813,127	5,618,302	29,757,205
Capital Expenditures														
Development/Construction			9,500,000											9,500,000
Ongoing Capital				150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	1,500,000
Working Capital Change			500,000										(500,000)	0
Total Capital			10,000,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	(350,000)	11,000,000
Net Cash Flow			(10,000,000)	1,772,447	954,047	1,350,047	1,777,727	2,243,423	2,754,739	3,320,797	3,952,547	4,663,127	5,968,302	18,757,205
Project NPV @10%			4,911,746											
Project IRR			18.45%											
Net Cash Flow to Venture Partners				1,772,447	954,047	1,350,047	1,777,727	2,243,423	2,754,739	3,320,797	3,952,547	4,663,127	5,968,302	28,757,205
S&S NCF	51%			903,948	486,564	688,524	906,641	1,144,146	1,404,917	1,693,606	2,015,799	2,378,195	3,043,834	14,666,174
Pierce NCF (inc. Royalty)	49%			1,205,102	805,066	999,126	1,208,689	1,436,680	1,687,424	1,964,793	2,274,350	2,622,535	3,262,071	17,467,055

Piedra Amarilla
Cash Flow Analysis
August 28, 1997
11:57 AM

Case : 1
(000)

			1	2	3	4	5	6	7	8	9	10	11	Total
Production Tonnes/year mill feed				360,000	360,000	360,000	360,000	360,000	360,000	360,000	360,000	360,000	360,000	3,600,000
S Grade %				20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%
Au Grade g				0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Waste at Strip Ratio of 0.16:1				57,600	57,600	57,600	57,600	57,600	57,600	57,600	57,600	57,600	57,600	576,000
Total mined material				417,600	417,600	417,600	417,600	417,600	417,600	417,600	417,600	417,600	417,600	4,176,000
Tonnes mined per day				2,320	2,320	2,320	2,320	2,320	2,320	2,320	2,320	2,320	2,320	2,320
Mill Recovery S %				83.30%	83.30%	83.30%	83.30%	83.30%	83.30%	83.30%	83.30%	83.30%	83.30%	83.30%
Mill Recovery Au %				80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%
S Conc. Produced tonnes				70,560	70,560	70,560	70,560	70,560	70,560	70,560	70,560	70,560	70,560	705,600
Contained S Produced Tonnes				59,976	59,976	59,976	59,976	59,976	59,976	59,976	59,976	59,976	59,976	599,760
Au ounces payable				6,945	6,945	6,945	6,945	6,945	6,945	6,945	6,945	6,945	6,945	69,447
Acid Produced				179,928	179,928	179,928	179,928	179,928	179,928	179,928	179,928	179,928	179,928	1,799,280
Acid Produced tonnes per day				500	500	500	500	500	500	500	500	500	500	
Acid Revenue $	50			8,996,400	8,996,400	8,996,400	8,996,400	8,996,400	8,996,400	8,996,400	8,996,400	8,996,400	8,996,400	89,964,000
Gold Revenue $	325			2,257,017	2,257,017	2,257,017	2,257,017	2,257,017	2,257,017	2,257,017	2,257,017	2,257,017	2,257,017	22,570,170
Interest Income Balance			5,000,000	6,000,000	7,200,000	8,640,000	10,368,000	12,441,600	14,929,920	17,915,904	21,499,085	25,798,902	30,958,682	
Interest Income on $5 million	20%			1,000,000	1,200,000	1,440,000	1,728,000	2,073,600	2,488,320	2,985,984	3,583,181	4,299,817	5,159,780	25,953,682
Total Revenue				**12,253,417**	**12,453,417**	**12,693,417**	**12,981,417**	**13,327,017**	**13,741,737**	**14,239,401**	**14,836,598**	**15,553,234**	**16,413,197**	**138,492,852**
Operating costs	$/tonne													
Contract Mining														
Mining cost (Entire mining period)	1.25			522,000	522,000	522,000	522,000	522,000	522,000	522,000	522,000	522,000	522,000	5,220,000
Process Plant														
Processing	7.00			2,520,000	2,520,000	2,520,000	2,520,000	2,520,000	2,520,000	2,520,000	2,520,000	2,520,000	2,520,000	25,200,000
Contract Hauling														
Short truck & Rail Haul to Acid Plant ($/tm)	0.04	434.4		1,226,051	1,226,051	1,226,051	1,226,051	1,226,051	1,226,051	1,226,051	1,226,051	1,226,051	1,226,051	12,260,506
Acid Plant														
Acid Plant	3.33			234,965	234,965	234,965	234,965	234,965	234,965	234,965	234,965	234,965	234,965	2,349,648
Total G & A														
G&A Mine, Process, AcidPlant, Corp.				1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	12,000,000
Total Operating cost				**5,703,015**	**5,703,015**	**5,703,015**	**5,703,015**	**5,703,015**	**5,703,015**	**5,703,015**	**5,703,015**	**5,703,015**	**5,703,015**	**57,030,154**
$/tonne sulfur				95.09	95.09	95.09	95.09	95.09	95.09	95.09	95.09	95.09	95.09	95.09
$/tonne acid				31.70	31.70	31.70	31.70	31.70	31.70	31.70	31.70	31.70	31.70	31.70
Indirect costs														
Principal Repayment				1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	15,000,000
Principal Balance				15,000,000	13,500,000	12,000,000	10,500,000	9,000,000	7,500,000	6,000,000	4,500,000	3,000,000	1,500,000	
Interest on Principal	24%			1,800,000	3,240,000	2,880,000	2,520,000	2,160,000	1,800,000	1,440,000	1,080,000	720,000	360,000	18,000,000
Owner Royalty				337,603	337,603	337,603	337,603	337,603	337,603	337,603	337,603	337,603	337,603	3,376,025
Before Tax Income				2,912,799	1,672,799	2,272,799	2,920,799	3,626,399	4,401,119	5,258,783	6,215,980	7,292,616	8,512,579	45,086,673
Corporate Income Tax	34%			990,352	568,752	772,752	993,072	1,232,976	1,496,381	1,787,986	2,113,433	2,479,489	2,894,277	15,329,469
Subtotal Indirect Costs				**4,627,954**	**5,646,354**	**5,490,354**	**5,350,674**	**5,230,578**	**5,133,983**	**5,065,589**	**5,031,036**	**5,037,092**	**5,091,380**	**51,705,494**
Revenue Before Capital				1,922,447	1,104,047	1,500,047	1,927,727	2,393,423	2,904,739	3,470,797	4,102,547	4,813,127	5,618,302	29,757,205
Capital Expenditures														
Development/Construction			9,500,000											9,500,000
Ongoing Capital				150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	1,500,000
Working Capital Change			500,000										(500,000)	0
Total Capital			10,000,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	(350,000)	11,000,000
Net Cash Flow			(10,000,000)	1,772,447	954,047	1,350,047	1,777,727	2,243,423	2,754,739	3,320,797	3,952,547	4,663,127	5,968,302	18,757,205
Project NPV @1[illegible]			4,911,746											
Project IRR			18.45%											
Net Cash Flow to Venture Partners				1,772,447	954,047	1,350,047	1,777,727	2,243,423	2,754,739	3,320,797	3,952,547	4,663,127	5,968,302	28,757,205
S&S NCF	51%			903,948	486,564	688,524	906,641	1,144,146	1,404,917	1,693,606	2,015,799	2,378,195	3,043,834	14,666,174
Pierce NCF (inc. Royalty)	49%			1,206,102	805,086	999,126	1,208,689	1,436,880	1,687,424	1,964,793	2,274,350	2,622,535	3,262,071	17,467,055

Cash Flow Analysis Case: 2
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			1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
Production Tonnes/year mill feed				360,000	360,000	360,000	1,080,100	1,080,100	1,080,100	1,080,100	1,080,100	1,080,100	1,080,100	1,080,100	1,080,100	1,080,100	11,581,300
S Grade %				20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%
Au Grade g/t				0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Waste at Strip Ratio of 0.16 :1				57,600	57,600	57,600	172,816	172,816	172,816	172,816	172,816	172,816	172,816	172,816	172,816	172,816	1,900,960
Total mined material				417,600	417,600	417,600	1,252,916	1,252,916	1,252,916	1,252,916	1,252,916	1,252,916	1,252,916	1,252,916	1,252,916	1,252,916	13,781,960
Tonnes mined per day				2,320	2,320	2,320	6,961	6,961	6,961	6,961	6,961	6,961	6,961	6,961	6,961	6,961	5,030
Mill Recovery S %				83.30%	83.30%	83.30%	83.30%	83.30%	83.30%	83.30%	83.30%	83.30%	83.30%	83.30%	83.30%	83.30%	83.30%
Mill Recovery Au %				80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%
S Conc. Produced Tonnes				70,560	70,560	70,560	211,700	211,700	211,700	211,700	211,700	211,700	211,700	211,700	211,700	211,700	2,328,676
Contained S Produced Tonnes				59,976	59,976	59,976	179,945	179,945	179,945	179,945	179,945	179,945	179,945	179,945	179,945	179,945	1,979,375
Au ounces payable				6,945	6,945	6,945	20,836	20,836	20,836	20,836	20,836	20,836	20,836	20,836	20,836	20,836	229,193
Acid Produced				179,928	179,928	179,928	539,834	539,834	539,834	539,834	539,834	539,834	539,834	539,834	539,834	539,834	5,938,124
Acid Produced tonnes per day				500	500	500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	
Acid Revenue @	50			8,996,400	8,996,400	8,996,400	26,991,699	26,991,699	26,991,699	26,991,699	26,991,699	26,991,699	26,991,699	26,991,699	26,991,699	26,991,699	296,906,191
Gold Revenue @	325			2,257,017	2,257,017	2,257,017	6,771,678	6,771,678	6,771,678	6,771,678	6,771,678	6,771,678	6,771,678	6,771,678	6,771,678	6,771,678	74,487,931
Interest Income Balance			5,000,000	6,000,000	7,200,000	8,640,000	10,368,000	12,441,600	14,929,920	17,915,904	21,499,085	25,798,902	30,958,682	37,150,419	44,580,502	53,496,603	
Interest Income on $5 million	20%			1,000,000	1,200,000	1,440,000	1,728,000	2,073,600	2,488,320	2,985,984	3,583,181	4,299,817	5,159,780	6,191,736	7,430,084	8,916,100	48,456,603
Total Revenue				12,253,417	12,453,417	12,693,417	35,491,377	35,836,977	36,251,697	36,749,381	37,346,558	38,063,194	38,923,157	39,956,113	41,193,461	42,679,477	419,890,623
Operating costs	$/tonne																
Contract Mining																	
Mining cost (5 mo mining period)	1.25			522,000	522,000	522,000	1,566,145	1,566,145	1,566,145	1,566,145	1,566,145	1,566,145	1,566,145	1,566,145	1,566,145	1,566,145	17,227,450
Process Plant																	
Processing	7.00			2,520,000	2,520,000	2,520,000	7,560,700	7,560,700	7,560,700	7,560,700	7,560,700	7,560,700	7,560,700	7,560,700	7,560,700	7,560,700	83,167,000
Contract Hauling																	
Short truck & Rail Haul to Acid Plant ($/tm)	0.04	434.4		1,226,051	1,226,051	1,226,051	3,678,492	3,678,492	3,678,492	3,678,492	3,678,492	3,678,492	3,678,492	3,678,492	3,678,492	3,678,492	40,463,074
Acid Plant																	
Acid Plant	3.23			234,965	234,965	234,965	704,960	704,960	704,960	704,960	704,960	704,960	704,960	704,960	704,960	704,960	7,754,491
Total G & A																	
G&A Mine, Process, Acid Plant, Corp				1,200,000	1,200,000	1,200,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	18,600,000
Total Operating cost				5,703,015	5,703,015	5,703,015	15,010,297	15,010,297	15,010,297	15,010,297	15,010,297	15,010,297	15,010,297	15,010,297	15,010,297	15,010,297	167,212,015
$/tonne sulfur				95.09	95.09	95.09	83.42	83.42	83.42	83.42	83.42	83.42	83.42	83.42	83.42	83.42	86.11
$/tonne acid				31.70	31.70	31.70	27.81	27.81	27.81	27.81	27.81	27.81	27.81	27.81	27.81	27.81	28.70
Indirect costs																	
Principal Repayment				1,500,000	1,500,000	1,500,000	4,100,000	4,100,000	4,100,000	4,100,000	4,100,000	4,100,000	4,100,000	4,100,000	4,100,000	3,600,000	45,000,000
Principal Balance				15,000,000	13,500,000	12,000,000	37,900,000	33,800,000	29,700,000	25,600,000	21,500,000	17,400,000	13,300,000	9,200,000	5,100,000	1,500,000	
Interest on Principal	24%			1,800,000	3,240,000	2,880,000	9,096,000	8,112,000	7,128,000	6,144,000	5,160,000	4,176,000	3,192,000	2,208,000	1,224,000	360,000	54,720,000
Owner Royalty				337,603	337,603	337,603	1,012,901	1,012,901	1,012,901	1,012,901	1,012,901	1,012,901	1,012,901	1,012,901	1,012,901	1,012,901	11,141,921
Before Tax Income				2,912,799	1,672,799	2,272,799	6,272,179	7,601,779	9,000,499	10,482,163	12,063,360	13,763,996	15,607,959	17,623,915	19,846,262	22,656,279	141,816,769
Corporate Income Tax	0.34			990,352	568,752	772,752	2,132,541	2,584,605	3,060,170	3,563,935	4,101,542	4,679,759	5,306,706	5,992,131	6,747,729	7,718,735	48,217,709
Subtotal Indirect Costs				4,627,954	5,646,354	5,490,354	16,341,442	15,809,506	15,301,071	14,820,837	14,374,444	13,958,680	13,611,607	13,313,032	13,084,631	12,689,838	159,079,529
Return Before Capital				1,922,447	1,104,047	1,500,047	4,139,638	5,017,174	5,940,329	6,918,227	7,961,817	9,084,237	10,301,253	11,631,784	13,098,533	14,379,544	93,599,080
Capital Expenditures																	
Development/Construction			9,500,000			29,000,000											38,500,000
Ongoing Capital				150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	1,950,000
Working Capital Change			500,000			1,000,000										(1,500,000)	0
Total Capital			10,000,000	150,000	150,000	30,150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	(1,350,000)	40,450,000
Net Cash Flow			(10,000,000)	1,772,447	954,047	(28,649,953)	3,989,638	4,867,174	5,790,329	6,768,227	7,811,817	8,934,237	10,151,253	11,481,784	12,948,533	16,329,544	52,149,080
Project NPV @10%			8,000,556														
Project IRR			13.86%														
Net Cash Flow to Venture Partners				1,772,447	954,047	1,350,047	3,989,638	4,867,174	5,790,329	6,768,227	7,611,817	8,924,237	10,151,253	11,481,784	12,948,533	16,329,544	93,149,080
S&S NCF	51%			903,948	486,564	688,524	2,004,715	2,482,259	2,953,068	3,451,796	3,884,027	4,556,461	5,177,139	5,856,710	6,603,752	8,328,068	47,506,031
Pierce NCF (inc. Royalty)	49%			1,206,102	875,086	999,126	2,987,824	3,397,817	3,950,163	4,329,333	4,840,692	5,390,678	5,987,015	6,638,975	7,357,683	9,014,378	56,784,870

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