## CHAPTER 3. PLAN FOR TAILING DAM

### 3-1 Position and Construction of Tailing Dam

At first, it was planned that an earth rock dam will be used for the construction of the tailing dam and a search was made for a place suitable for the dam. A ravine at Estancia Chajiluma was thought to be the most suitable place, because there is a large pocket for water and a throat formation suitable for constructing a dam.

On the other hand, the construction cost would be very large, and moreover there is a problem that it will be difficult to transport tailings hydraulically or recover water as there is a valley and a mountain between that rayine and the new concentration plant. Accordingly, this plan was set aside as Plan 2 and a more economical and rational tailing dam plan was studied.

As a result, a dam to deposit earth from outside corresponding to the increase of the quantity of sediments was adopted as the construction of the tailing dam and it was also decided to use a part of tailings transported hydraulically as dam material. The planned site for the dam is a flat place situated on the west of Cerro Sacamarca and south of Colas Arenas. As this plan is superior to Plan 2 in that its construction cost will be lower and the hydraulic transportation of tailings and water recirculation will be easier, etc., this plan was set as Plan 1 and further investigation was carried out concerning it.

The design conditions in the basic design of the tailing dam are as follows.

Quantity of processed ore: 10,000 t/day

Quantity of failings (dry weight): 9,865.8 t/day

Water in tailings: 34,859.0 t/day

Density of tailings transported: P.D. ÷ 22%

Specific gravity of solids in tailings:  $G_S = 2.75$ 

Required quantity of recovered water: approx. 17,000 m<sup>3</sup>/day

Annual number of working days of concentration mill: 300 days

Number of operating years of concentration mill: 10 years

The state of the proposed dam site and the idea of selecting the site are described as follows.

From the western side to the north western side of Cerro Sacamarca, a tailing dam will be constructed. About the materials and method of constructing the dam, as the dam material for the first year sediments of conglomeratic soil around the dam site will be used to build an earth dam, and from the following year on, coarse grains (above 100µ) in tailings separated by classifying at the time of discharging the tailings to the tailing dam will be piled up from outside to increase the height.

The height of crest required will be 3,800 m with a free board of 2 m added to the

sedimentation height. The capacity at the time of completing sedimentation will be 36,256,000 m<sup>3</sup>. The slope of the dam shall be 1:2.0 both on the inside and outside. Before carrying forward practical design, it is required to test earth quality and based on the test data, to examine the plan of slump and then determine the slope of the dam and the crest width. In the case where water intercepting material is required, the surface (inner slope) of the dam will be covered with viscous clay at a place as near as possible from the tailing dam.

Dams will be constructed at the two positions, north and south. The crest heights and shapes of the dams when the sedimentation of tailings will have been finished are shown in the

Height (m) when sedimentation of tailing mill have finished Average size of dam Lòcation Level of Toe of shape Crest of dam Width of crest x height x length Toe of shape sedimentation of inside of outside North. 3.765 3,760 8.0 x 17.5 x 2,400 3,800 South 3 745 3,735 10.0 x 30.0 x 970

Table II-3-1 Shape on Height of Dam

When Sedimentation of Tailing Mill Plant Finished

The required dam size and dam material determined by finding out the quantity of sedimentation and the height of sediments from the sedimentation quantity curve (Fig. II-3-2) are as shown in Table II-3-2.

# 3-2 Quantity of Tailing Sedimentation and Recovered Water

## (1) Quantity of Tailing Sedimentation

By estimating failing density within the failing sedimentation area, the quantity of failing sedimentation and the quantity of supernatant water are determined. Quantity of failing V, transported hydraulically from the concentration mill is,

$$V = \frac{9,865.8}{2.75} + 34,859.0 = 38,466.6 \text{ m}^3/\text{day}$$

The specific gravity (Gr) of tailings when hydraulically transported is,

$$G_{1} = \frac{W}{\gamma_{W}V} = \frac{1}{\gamma_{W}} \times \frac{W_{S} + W_{W}}{V}$$
$$= \frac{1}{1.0} \times \frac{9,865.8 + 34,859.0}{38,466.6} = 1.163$$

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Fig.II-3-1 Tailing Dom Layout

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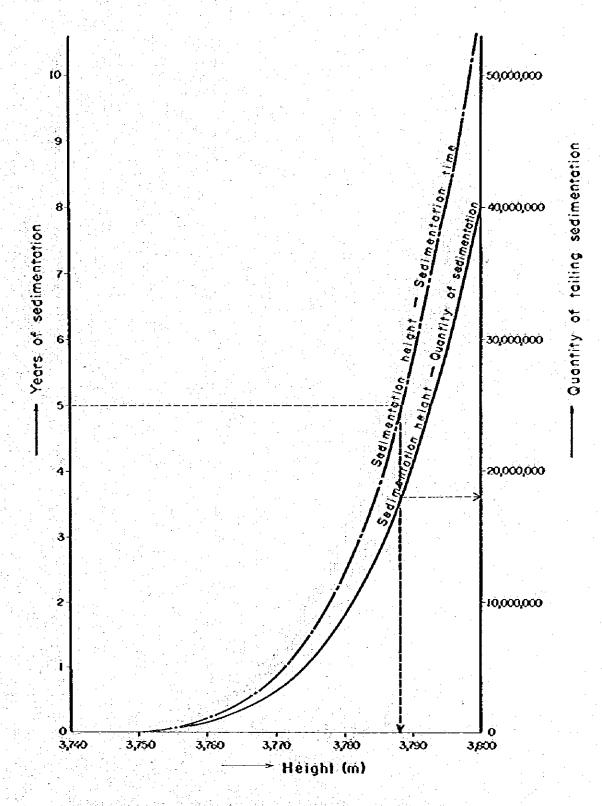


Fig. 11-3-2 Sedimentation Quantity Curve

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그 불만 계기들이는 이 이번 중 하장에 걸 못하는 전기를 하지만 모습니다. 이 사회는 것 없는 처음을 다른	
그 이 이 물론에는 보이는 살이 되었다. 그는 생각에 하는 사람들은 모든 것이 살아보고 있다면 하는데	
그런한 물병들에는 어디도, 한글인터인 사람들들은 사람들에게 이러로 못하는 것 같은 사람들이다.	
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그날 가게 하는 모든 사들을 보는다고하는데 그 바라지면 휴리를 하고 말을 수 있는지를 모르고 하고 했다. 나	
그리는 경우 등은 이 이 선생님, 생님이 있는 사람이 되는 방송에 되는 이 분들은 이 모습으로 밝혀야 있다.	
	- 1 - 12

Table 11-3-2 Annual Quantity of Tailing Sedimentation and Material of Dam

tion		a	Required size of and material		Constru	ction (m³)	
Year of Sedimentation	Quantity of Sedimentation	Height of Sediments	Size of dam (m) Width of crest x Height x Length	Matenal to Construct dam	For One Year	Total	Note
-2.5 J 0					498,000	498,000	Conglomeratic earth
1	3,625,600	3,771.0	N 8.0 x 4.0 x 900 S 8.0 x 16.5 x 650	58,000 440,000 (498,000)	372,000	870,000	Tailing
Ż	7,251,200	3,777.5	8.0 x 7.25 x 1,330 8.5 x 19.75 x 730	217,000 692,000 (909,000)	372,000	1,242,000	
3	10,876,800	3,782.0	8.0 x 9.5 x 1,900 9.0 x 22.0 x 790	487,000 921,000 (1,408,000)	372,000	1,614,000	
4	14,502,400	3,785.5	8.0 x 11.25 x 1,950 9.0 x 23.75 x 830	669,000 1,114,000 (1,783,000)	372,000	1,986,000	
5	18,128,000	3,788.0	8.0 x 12.5 x 1,970 9.5 x 25.0 x 860	813,000 1,279,000 (2,092,000)	372,000	2,358,000	
6	21,753,600	3,790.5	8.0 x 13.75 x 2,080 9.5 x 25.0 x 890	1,015,000 1,448,000 (2,463,000)	372,000	2,730,000	
7	25,379,200	3,792.5	8.0 x 14.75 x 2,160 10.0 x 27.25 x 910	1,195,000 1,599,000 (2,794,000)	372,000	3,102,000	
8	29,004,800	3,794.5	8.0 x 15.75 x 2,240 10.0 x 28.25 x 930	1,394,000 1,747,000 (3,141,000)	372,900	3,474,000	
9	32,630,400	3,796.5	8.0 x 16.75 x 2,320 10.0 x 29.25 x 950	1,613,000 1,903,000 (3,516,000)	369,000	3,843,000	Conglomeratic earth 498,000 Tailing 3,345,000
10	36,256,000	3,798.0	8.0 x 17.5 x 2,400 10.0 x 30.0 x 970	1,806,000 2,037,000 (3,843,000)			

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그리고 있다는 사이트 시작하다는 문에 그는 생활 소설으로 하는 때 그들과 그리를 받고를 만들어 되었다.	
그는 사람들은 이 이 나는 아래를 받는데 하는데 나는데 나는 나는 사람들이 얼마를 받을 때 살을 했다.	
	ar Maria Maria
그는 그는 사람들은 어머니의 회사 전문을 하는 사람들은 회사를 위한 동생은 살로 사실을 한다.	
그는 사람들이 살아 들었다. 학교 기관수의 사진 경험을 받는 학생들에도 기계를 받는 것이 되었다.	
그 이 사람이 함께 되었다. 하는 이 왜 이 전 당시에 가능을 받았다고 하는 때문을 먹는 이와 있다. 유스팅 하는	
이 그는 것이 있다는 것이 하는 사람들이 모델 수는 것으로 함께 한다는 것은 경험을 가는 없는 것이 없었다.	100
그 사람들 그는 사람들이 가는 사람들이 들었다. 그 사람들이 얼마나 사람들이 가장 하는 사람들이 되었다.	
그 마이트 : 이 이 그를 되어 다 하는 것이 그들도 그는 때 이상동이에 힘든 말을 되었다. 함께 다고 됐다.	
그 이 사람들이 되었다. 이번 이 사람들이 아르지 않는 사람들이 가장 그렇게 되었다. 얼마	
그리는 그리다는 경험을 하는 점을 그런 수 있는 하면 하는 수를 지었다면서 사고를 하고 있다고 있다.	
이 얼굴님들이 되는 것들은 독일 아무리는 것 같아 얼굴 보고의 어린다면 살고 있었다면 살을 하면 되었다.	
그는 눈이에 되어 하이 없는 사람들이 하는 사람들은 사람들은 사람들이 얼굴하는 것이 하는 것이다.	
그는 그 항 경우는 이 회사들은 모든 다른 이번에 가장 얼마가 있다면 다음 다음 하는 것이 다른 그렇지만 하지만 생활했다.	
그는 그리는 그는 이번 살이면 되었다는 그리고 있었다. 얼마를 시작을 하는 사일 일시하다 된 학생활동	
그 시민은 어디 아들이, 네 바늘이 되는데 되는데 그는 그들이 이 수록록이고 되었다면 모두 없어. 함	
그 가능한 이번 마음이 되는 바람들이 한 바람이 되었다면 되는 사람들이 얼마를 다 살다.	
그 그 등 사람이 되어야 한 경우 사람들은 학생들이 가는 그들이 가는 바로 하는 바람이 하는 것이다.	
그 사람들은 그리고 있는데 아이트를 가지 않는데 보고를 받는데 그를 하고 있는데 되는데 되는데?	
그 그 보이다는 얼마로 보고 된 어떤 것도 다 나는 아니다. 한 10년 시간 모습니다. 그는 다 없는 것이다.	
이 가능님 아이들은 이 이번을 하는 보면 그 때문에 되면 화가를 모으면 한 살았다. 가고 없어 살라, 다	
그리는 하는 그는 회의회의 아이지 되는 전 시간들이 모임하는 그리고 힘들었다. 그리는 그리는 그림은 그림을 받는다.	
이 보는 그는 사람이 되었다. 그는 일에서 하는 모두 살아 보는 수 있는 사람들은 사람들이 가득하다.	
그러면 되는 그는 이 이 이의에는 이 말이는 한 번 수 있는데 이번 경우를 하실 수 있었다. 경험을 받는데 없다.	
그 하나요. 그렇는데 그렇게 되는 사람들은 이 아름이 없었다면 하다는 사람들이 가는 것이라면 살 들었다. 함께	
그리는 물문 일을 보는 것은 사람들이 가는 이렇게 되었다. 그렇게 들어 가는 하는 것은 하는 사람이 되었다. 그는 것이 없는데	
그 이렇게 되는 사람이 하면 살을 하는 것이 하지 않는 것들이 되었다. 그런 그렇게 되는 것 같습니다.	
그 말을 하는데 집 등에 이모를 하는 사람들이 있는데 이모를 그림을 하는 것이 모르게 들어 되었다.	
그는데 그 이 경우를 있었는데 어떤을 살아왔다면서 아버리는 어디 시대로에 되었다는 중인 전기를 만들었다면	
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그림은 말한 왜 그들의 이 집안의 작가는 것 하는 이렇게 하는 것이 있는 것 같은 말을 하지 않는데 이렇게 되었다.	4 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 -
그는 현생 생님들이 마스트를 가면 하고 하다. 나는 것은 말을 그 살아갔다면 하는 것은 것은 것이다.	
어른 발표가 이 사람들은 살이는 나와 이렇다는데 하나 나는데 나가 되었다. 그리다 수의를 다 돌아왔다.	rita i di Legisia. Legis
그는 말이는 얼마나는 마음과 사람이 되는 사람들이 하셨다면 하는 사람들이 되었다.	
그 그 그들은 이 물 마음에 되었다면 한 물로 한 경험을 걸다는 것 같은 것은 사람이 되었다. 그 생활하였다	
이어 있는 그리는 그 보호를 살 때 하는 사람들은 다른 사람들은 사람들은 것을 보면 그는 그리고 살아왔다. 그는 사람들은	
그들은 학교에 이 전쟁에는 보고하는 전하는 전에 대한 교통을 가지만하게 되는 이 하는 사람들은	
그는 경기를 하는 일 이 살린 기를 하는 것이다. 그런 전기를 가고 하면 하는 것이라는 것이다면 그렇게 돌을 수	
그리는 사람들 말맞는 사람이 말라고 하는 말라면 나와 살고 눈을 하였다. 특히 하는 반에 가능하다.	
	-

The average of dry bulk density ( $\gamma d$ ) in the tailing dam will be at the usual level of 0.8  $t/m^3$ , hence the average density of tailings in the tailing dam is estimated from the above value.

$$\gamma d = \frac{Ws}{V} = \frac{Ws}{Vs + Ww}$$

where Vs: quantity of tailings (volume),

Vw: water contents in tailings

hence,

$$V_{W} = \frac{W_{S}}{0.8} - V_{S}$$

$$= \frac{9,865.8}{0.8} - \frac{9,865.8}{2.75} = 8,744.7 \text{ m}^{3} = 8,744.7^{1} = W_{W}$$

$$P.D. = \frac{W_{S}}{W_{S} + W_{W}} \times 100$$

$$= \frac{9,865.8}{9,865.8 + 8,744.7} \times 100 \div 50\%$$

The quantity of supernatant water (Q) is,

$$Q = 34,859.0 - \frac{9,865.8 \times (100 - 50)}{50} = 24,993.2 \text{ m}^3/\text{day}$$

Therefore, the quantity of tailing sedimentation (QT) is,

$$Q_T = 38,446.6 - 24,993.2 = 13,453.4 \text{ m}^3/\text{day}$$

The quantity of tailing sedimentation in a year becomes,

Wet density (71) and dry density (7d) of sedimented tailings at this time are,

$$\gamma t = \frac{9,865.8 + 9,865.8 \text{ (water 50\%)}}{13,453.4} = 1.467 \text{ t/m}^3$$

$$\gamma d = \frac{9,865.8}{13.453.4} = 0.733 \text{ t/m}^3$$

If the required quantity of failings (in the wet state) is determined when using the failings within the sedimentation area as dam material by assuming that the density of failings after being compacted equals to 1.8 t/m³, the required quantity of dam material is 3,843,000 m³ (See Table 11-3-2) among which 498,000 m³ is the quantity for the first year. For dam material for the first year conglomeratic earth around the failing dams will be used, the quantity of failings required for the dams therefore becomes:

$$3,843,000 - 498,000 = 3,345,000 \text{ m}^3$$

If the density after being compacted is assumed to be 1.8 t/m3, the quantity of tailings in the

wet state is

$$3,345,000 \times \frac{1.8}{1.467} \div 4,104,000 \text{ m}^3$$

Hence, the quantity of tailings which will be sedimented inside the dams in ten years will become:

$$4,036,000 \times 10 \text{ (years)} = 36,256,000 \text{ m}^3$$

## (2) Loss Resulting from Evaporation, etc.

In the computation of evaporation quantity the average value of annual evaporation quantity in  $1964 \sim 1976$ , 1,567 mm/year, is used.

For the inflow of daily rainfall, the average value of annual rainfall in 1934 ~ 1982, 542.63 mm/year, is used for the catchment of the failing dams, 3,448,000 m<sup>2</sup>. The coefficient of run-off in this case is 1.0 inside the overflowing level, and 0.3 outside the overflowing level.

According to the above-mentioned computation of the quantity of tailing sedimentation, the quantity of supernatant water is 24,993.2 m<sup>3</sup>/day, the annual quantity of supernatant water therefore is:

$$24,993.2 \times 300 = 7,497,960 \text{ m}^3/\text{year}$$

If the water filled area corresponding to the quantity of tailing sedimentation and the height of sediments each year (See Table 11-3-8) is determined, and, by determining the difference between evaporation quantity and the inflow of rainfall next, the annual loss is computed, the following table is obtained.

The annual loss will become maximum in the 10th year, and the ratio of loss to the quantity of supernatant water is:

$$1,959,600 \div 7,497,960 \times 100 = 26.1\%$$

By estimating that other loss is 3.9%, total loss is estimated to be 30%.

#### (3) Recovered Water

If the ratio of loss is assumed to be 30% from the result of computation in (2), the quantity of water that can be recovered is:

 $24,993.2 \times (1-0.3) = 17,495 \text{ m}^3/\text{day} > \text{required quantity} + 17,000 \text{ m}^3/\text{day}$ Ratio of recovered water to total water in tailings becomes,

$$17,495 \div 34,859.0 \times 100 = 50.2\%$$

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	<b>u</b> o			Annual water to in	rainfall flow (m³)	
Years of Sedimentation	Feight of Sedimentation (m)	Area of water surface A (m²)	Annual eyapolation quantity A x 1.567 (m³)	Inside of overflowing level: A x 0.54263	Outside of over- flowing-level (3,448,000.A) x 0,54263 x 0,3	Annual loss (m³)
	3,771.0	400,600	627,700	217,400	459,100	- 48,800
2	3,777.5	690,400	1,081,900	374,600	448,900	258,400
3	3,782.0	967,500	1,516,100	\$25,000	403,800	587,300
4	3,785.5	1,257,500	1,970,500	682,400	356,600	931,500
- 5	3,788.0	1,464,700	2,295,200	794,800	322,900	1,177,500
6	3,790.5	1,661,200	2,603,100	901,400	290,900	1,410,800
7	3,792.5	1,784,500	2,796,300	968,300	270,800	1,557,200
8	3,794.5	- 1 <i>,9</i> 07,700	2,989,400	1,035,200	250,700	1,703,500
9	3,796.5	2,031,000	3,182,600	1,102,100	230,700	1,849,800
10	3,798.0	2,123,400	3,327,400	1,152,200	215,600	1,959,600

### 3-3 Drainage Safety Facilities

### (1) Estimation of Rainfall Intensity

Rainfall data obtained in the survey this time are the monthly quantities of rainfall and the annual rainfall quantities in the 48 years from 1934 to 1981 in Catavi, and the daily quantities of rainfall in 13 years from 1970 to 1982 in Catavi, Siglo XX, Miraflores and Lupi-Lupi.

On the other hand, the catchment area of the tailing dams is about 7.6 km<sup>2</sup> and comparatively small, and when considering the outflow of rainwater, daily quantity of rainfall and hourly quantity of rainfall begin to matter, but in the above-mentioned data of the daily quantity of rainfall, there are no records of the duration of continuous rainfall, so it seems impossible to estimate the maximum daily rainfall quantity and the maximum hourly rainfall quantity. Accordingly, we estimated these rainfall quantities concerning the three following cases.

1 By arranging the records of rainfall quantities in 40 years in Catavi in the descending order from the largest annual rainfall quantity, obtaining the arithmetic averages of the first 10 years and the first 20 years, and assuming that the number of rainy days per month is five,

and the duration of continuous rainfall is four hours, the daily quantity of rainfall and the hourly quantity in 100 year probability and 200 year probability were obtained from the maximum value of the average monthly rainfall quantity.

- 2 By arranging the maximum values of the monthly rainfall quantities in each year in the descending order, and from the monthly rainfall quantities of 100 year probability and 200 year probability obtained on a logarithmic probability paper, the daily rainfall quantity and the hourly rainfall quantity in 100 year probability and 200 year probability were obtained by assuming that the number of rainy days in a month is five and the duration of continuous rainfall is four hours.
- By arranging the monthly rainfall quantities of each year in the descending order and obtaining the arithmetic averages of the first 10 years and the first 20 years, the average maximum daily rainfall quantity and the average maximum hourly rainfall quantity were obtained from the maximum value of the average monthly rainfall quantity by assuming that the number of rainy days in a month is five and the duration of continuous rainfall is four hours.

As a result of trial computation with regard to the above three cases, Case 2 gave the maximum value, so we decided to adopt this value, and computation about case 2 is described in the following.

If the maximum values of the monthly rainfall quantities of each year are taken out and arranged in the descending order, the following table is obtained.

Order of Maximum Monthly Rainfall 化分离性性原则 医线线 经营销的 医克克氏管 医皮肤病

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	8	thi of	monthly Fr (mm)	00)**	9	month of	maathly ( ( mm)	. <u>8</u>
	Order (1)	Year, month of	Matemam Ranfall	<b>1.</b> 2. 3. 3.	Janeo	Year, mon	Makimum manthy Kanfall Pr. (mm)	
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	3	19341	243.5	3.75 4.25	22	1942.1 1950.1	157.5 155.9	53.75 56-3
, 20克 克特 斯(多伯克斯	2.0	18593 >	343.0	1.8	2	19343	1593	59.75
	- 5	1939.1	236.9	1125	B	i%Üi	153 0	6135
	- <u>- • .</u>	1901 2 1981 2	2032	11.75	*	1962 13	151.0	03.75
	1	1342	200.8	14.25	29	1969.1	1500	68.25 68.35
	•	1941.1	200.X	hh i	9-14	1965 1	10.5	1,8
The state of the s	×	1349.07	154.5	21.8	30	1963.3	144 9	23.75
	81	1545.1	176.7	3.5	31	11431	143.5	76.2€
	33	2572.3	1952 1910	34.25	32	1353.2	141 6	24.35
	11	1939.8	150	33.75	33	1541	134.7	83.25
เสอส์ขนะเย็น เมืองเลือนสหัญ	,13	1552.9	HJ 0	34.25	- 35	141,2	າຮາ	#3°
	14	19853	BILD.	<b>34.75</b>	36	1136.1	133.2	23,75
· · · · · · · · · · · · · · · · · · ·	11	1973.02	372.0	4125	37	1371.12	1230	91.25
	19	1935.1 1958.1	6313 5	8.8	**	1:431	121.2	9375
医多克氏管 建铁铁铁铁铁铁铁	v	136)?	148 9	45.75	39	1981	117.0	3625
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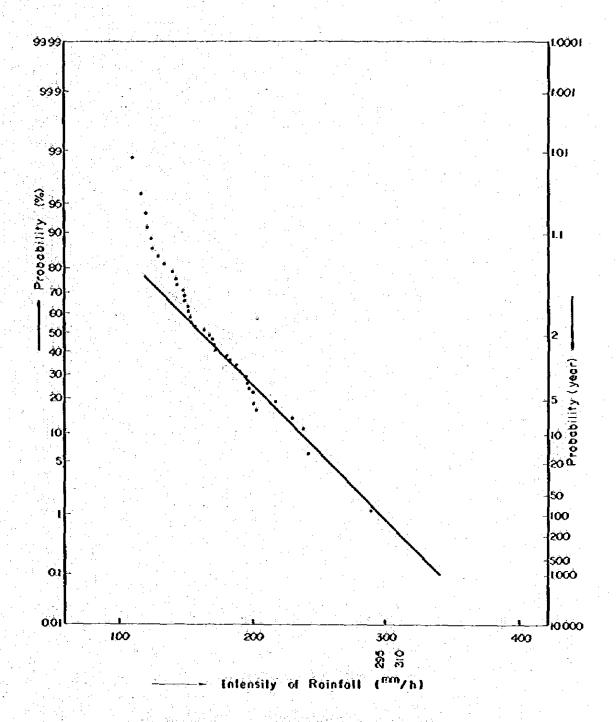


Fig. 11-3-3 Probability of Rainfall

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			18				
	•						
	•						

If  $\gamma$ i and (2i-1)/2N are plotted on a normal probability paper (Fig. II-3-3) to obtain 100 year and 200 year probability rainfall quantities;

100 year probability rainfall quantity: 295 mm/month

200 year probability rainfall quantity: 310 mm/month

If the number of rainy days in a month and the duration of continuous rainfall are respectively assumed to be five days and four hours, the daily rainfall quantities and the monthly rainfall quantities in 100 year probability and 200 year probability become;

100 year probability daily rainfall quantity : 295 ÷ 5 = 59.0 mm/day

100 year probability hourly rainfall quantity: 59.0 ÷ 4 = 14.8 mm/hr

200 year probability daily rainfall quantity : 310 ÷ 5 = 62.0 mm/day

200 year probability hourly rainfall quantity: 62.0 ÷ 4 = 15.5 mm/hr

If rainfall intensity equations are determined from the above data, the 100 year probability rainfall intensity equation is:

and a section of the first one on the sec

$$14.8 = \frac{a}{b + 60}$$

$$\frac{59.0}{24} = 2.46 = \frac{a}{b+1,440} \cdot (2)$$

from equations 1 and 2

$$14.8 b + 888 = a$$

$$2.46 \, \text{b} + 3.540 = a$$

from these equations.

$$b = \frac{3,540 - 888}{14.8 - 2.46} = 214.9$$

Therefore, the 100 year probability rainfall intensity equation is determined as follows.

$$\gamma_{100} = \frac{4,068.5}{1 + 214.9}$$

Next, the 200 year probability rainfall intensity equation is:

$$5.5 = \frac{a}{b + 60}$$

$$\frac{62.0}{24} = 2.58 = \frac{a}{b+1,440}$$

from equation 3 and 4

$$15.5b + 930 = a$$

$$2.58 b + 3,720 = a$$

from these equations, in the continuous vide in the property and the property of the property

$$b = \frac{3,720 - 930}{15.5 - 2.58} = 215.9$$

$$a = 4,277.1$$

Therefore, the 200 year possibility rainfall intensity equation is determined as follows.

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$$\gamma_{200} = \frac{4,277.1}{1+215.9}$$

# (2) Drainage Equipment Design

i) Prerequisites was the end of the property of the contract o

About the drainage equipment, design calculations are carried out based on the following conditions.

- a. In the area of valley including inside area 2,126 km<sup>2</sup>, outside area 5,480 km<sup>2</sup>, rainfall over 4,158 km<sup>2</sup> of the outside area shall be drained by providing waterways on the sides of mountains, and the rainfall quantity over the remaining 1,322 km<sup>2</sup> shall flow into the area.
- b. The mountainside waterways shall have a sufficient sectional area which can drain water inflow according to 100 year probability rainfall into the mountainside waterway safely.
- c. The drainage equipment within the site (underdrain) shall have a sufficient sectional area which can safely drain inflowing water according to the 100 year probability rainfall into the area.
- d. Emergency drainage equipment shall have a sufficient sectional area which can safely drain inflowing water according to the 200 year probability rainfall into the area.
  - e. In the above calculation, the quantity of evaporation is omitted.
  - f. The ratio of outflow shall be 30% for the outside area, and 100% for the inside area.
- g. The quantity of water to be drained is the sum of supernatant water and inflow water according to rainfall, and spring water and valley water shall be neglected.
  - ii) Calculation of outflow quantity

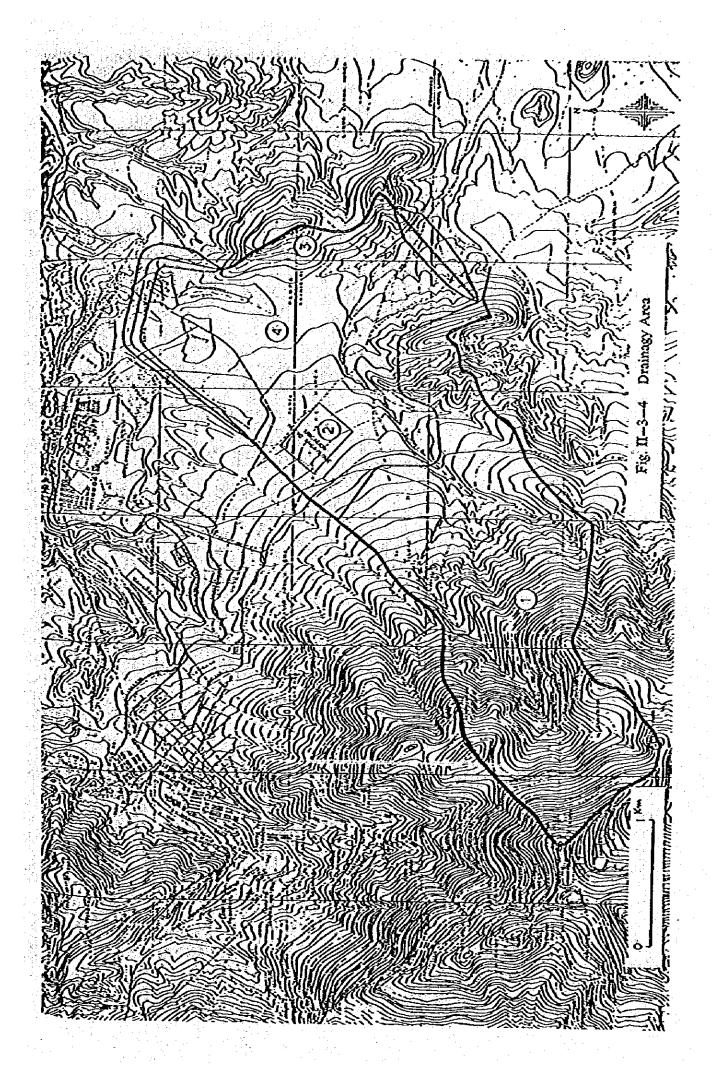
According to the experimental equation by Shirasaka Water Measurement Laboratory, taken for water to reach (t) is,

$$t = 0.33 L^{0.63}$$
 (min)

L: flow passage length from the farthest point of the area of valley to the position where flow quantity is calculated.

Rainfall intensity equations from the above-mentioned are as follows:

100 year probability rainfall intensity ( $\gamma_{100}$ )



그런데 하는 사람들은 그는 사람들은 그리고 사람들이 네트리스 전 경상 그리고 있었다. 그리고 함께 사랑 전 경우 그리고 있었다.	
그는 사람이 아이들은 사람이 나는 이번 가장이 하는 이번 그리고 있는데 나는 사람은 현상을 모든 어디었다.	
	•
그의 기계 생생님은 한 그 이번 것만 이 이상 생겨울이라며 한 활동 그렇게 되는 것은 사람들이 된다.	
그 사이의 아이의 보다 나는 사람들이 되는 사람들이 살려왔다. 그런 사람들은 이 바람들은 사람이 없다.	
그는 이 그는 얼마나도 사람들 살아 있다면 하면 살게 눈살을 받아 있습니다. 이 네이지 않는 사기의	
그는 그는 그 그는 그는 그들에 되지 않는 것이 하셨다. 그는 그렇게 하는 말을 하는 것을 하는 말이 없다.	
그는 그는 이 역 그렇는데 그는 그는 그들에는 그런 그는 그렇게 하는 듯한 돈을 잃었다. 그렇게 얼굴한 이 모든 말을 받는	
그 그는 물에 있는데 그리고 있는데 그는 그를 물러 바라를 살고하게 하고를 살려가지 않는데 되어 하다.	
그는 그는 그리는 사람들은 경기를 가지 않는 사람들은 그들은 사람들은 사람들은 사람들을 받는데 되었다.	
그는 그는 그는 사람이 되는 이번 것 같은 것도 하는 것 같은 것 같은 것을 하는 것이 되었다. 그는 그는 그는 그는 것이 없는 것이 없는 것이다.	
그가 그는 그 집에 가는 이번 사람이 하십시간 사람이 그는 생각을 받는 분들이 들었다면 하면 되었다. 나는 나는 사람이 없는 사람들이 되었다면 하셨다면 하셨다면 하셨다면 하셨다면 하셨다면 하셨다면 다른데 하셨다면 하셨다면 하셨다면 하셨다면 하셨다면 하셨다면 하셨다면 하셨다면	
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그는 사람이 되는 네트리는 사람은 하루 하면 하는 물 회사들을 만들어 왔다. 사람들은 작곡이 불합하다는	
그게 그 그리다는 그리다는데, 현재 그림을 하는 경우를 모르는데 있다는 물이 그리지만 하는 것을 모르는 것이 되었다. 그리고 말하는 것	
그러지 않는데 하는 사람이 하고 아파를 모양한 어떻게 되고 말했다. 그를 하는데 그들이 되었다.	
그는 이 이번 하는 그 사람이 아니 되었는 눈 모임이 되면 되고 있는 일반 하는데 다른데 가지 않는 것 같다.	
그 그리는 경기 그리는 사람들이 생활한 생생들이라고 있다. 그리는 사람들은 그 생활이 모든 사람들은 것 같은 것	
그는 이 모든 이 전문에 되었다. 이 집에 되었다. 그렇게 되었다. 그런 나는 그 사람들이 되었다. 그는 그는 그를 다 되었다.	
그가 가게 하는 이 목소에게 하다. 고급도 마리에 잘 있습니다. 그는 회원 학과 회장 현재의 생각을 들어나는 방	
그는 그는 말하다는 물 하나를 만들었다면 하는데 그들 때문 하는데 하는데 하는데 하는데 하는데 하는데 없는데 다른데 하는데 하는데 없는데 다른데 하는데 하는데 하는데 하는데 하는데 하는데 하는데 하는데 하는데 하는	
그는 그 이상님이 나를 하는 것이 하고 있는 것은 것이 얼마나 되었습니다. 그는 그는 그 사람들이 되었습니다.	
그는 제 이 공고 이 고급이 고급하고 있었습니다. 그리고 말고 말고 하고 말고 그렇게 되었다고 하지만 하지만 하지만 하고 있다. 안 되	
그는 소개 용제 없는 그 가는 사이들은 살아야할 만큼 그들 때에는 중 생기를 하고 있는 것이 없는 것이 하는 것이 없다. 본	
그 이 그 교육 이 어머니는 이 네고 그렇게 한 내었다. 이렇게 함께 되는 이 그리는 어느 이렇게 다른 사람들이 되었다.	
그는 이 이 일면 그는 그 있는 그는 그는 일반에 의하실, 역사들의 회장들에 그 후 하는 사람들이 되면 모든 회원들은	
그는 일본 및 일본 시간 시간 시간 중에 있는 보고를 내려가 하시겠다고 하는 것은 중요한 것이다.	
그 일이 하는 아이는 이 이렇게 하늘만 하는 것 못하는데 가는 것이 되는 사람들이 하는 것이 하는 것이다.	
그 사람들로 하다고 하는 그 하는 소리를 받는 그 별 말 속 독자 목하지만 않는 것이 들어 있는 그를 가지하고 있다. 그는 사람이 지속하	
그는 경기를 하는 것을 가지 않는 경기를 받은 것이 있다는 한 사람들이 하는 것을 하셨다.	
그는 이 이번 살은 사람들은 사이 나를 하나 되었다. 이번 시간 그는 사람이 어디로 바다 가는 사람들이 어디를 가내었다.	
그 사람들은 교회 한 일반에 하는 그리는 모양되었는 역원들의 방향 없었다는 연호한 및 원급보다의 회사 방향로	
그는 이 등장 살이 하는 말이 들어가 하셨다고 하다. 항상을 하는 말을 때 그리고 하는 아니라 하는 것을 수 있다. 그 사람이 없는 것이다.	
그는 회사 생생님 그리고 있는 말로 하면 하고 있으면 하는 이렇게 들어 중인 동네네는 이 회에는 그리고 있었다. 그림	
그 이렇다이라는 살아 나는 나는 아내는 나는 말하다고 가장하고 말했다. 눈물들을 받아 하는 말라면서 이 이번 아니다.	
그는 보장들 수가 할 같이 있다. 이번 이번 가는 아니라 이번 사람들은 사람들은 사람들이 되어 있다. 그리지 나를 가는 것은 것이다.	:
그의 공기에게 되었다. 승규는 그들의 경우는 보다는 병원들이 하면 되었다. 그런 사람들은 이번 모든 그를 다 되었다. 그 그리	
그는 그리고 한 경험을 하고 있다. 그리고 한 경험을 내려왔다는 사람들은 얼굴을 가는 것이 하고 있다. 그리고 있는 것이 없는 것이 없는 것이 없다.	
그는 게 돈 사람들이 하느님이 목가를 만들어야 하는데 내려가 되고 가장하셨다면 하지만 하는데 없다는 것이다.	
그 이 사람들이 있는데 얼마는 얼마는 그리고 하는 사람들은 아내는 경기 되고 눈하고 돌아가는 모든데 되었다.	
그는 그는 그리다는 그리고 있는데 얼마를 하는데 얼마를 보고 있는데 얼마를 하고 하고 하는데 없다는데 없다.	
그는 이번 경기를 잃었다. 경험 열리를 되었다면 얼마를 먹는 동안 회사를 처음했다면 하는 것은 것이다. 그	
그는 말이 되었다면 하는 것이 하는 사람들은 사람들이 보는 사람들이 되었다. 그 아니는 말이 되었다면 하는 것이다.	

$$\gamma_{100} = \frac{4,068.5}{t + 214.9}$$

200 year probability rainfall intensity ( $\gamma_{200}$ )

$$\gamma_{200} = \frac{4,277.1}{1+215.9}$$

The calculation of planned floodover water quantity (Q) is carried out by Rational's formula:

$$Q = \frac{1}{3.6} f \cdot \gamma \cdot A (m^3/sec)$$

f: coefficient of outflow, within mill plant = 1.0, outside mill plant = 0.3

γ: rainfall intensity (mm/hr)

A: area of valley (km²)

The results of carrying out the above calculations by determining the area of valley and the length of current from Fig. 11-3-4, the figures for the valley, are shown in the following table.

Table II-3-5 Water Way 2nd Drainige Equipment

Cast of construction	Name of		of Aziolde 1 L(z) lesia k(kg²)		Coefficient of			Questy of out they		Note
	te basa	Carrest L (21)	Pasa A (ka')	l (sie)	out flow f	7 200	η 200	7 JOO	7 200	
Voce pay in kIride		4,500	4,158	66.1	03	1443		5.017		
Örünge eçsipacal in milyimi	3	1,600 1,500 1,500	1,834 0.198 2,726	39. <u>6</u> 33.1 45.6	03 03 10	15.99 15.41 15.62	Tecas	1511 0227 9224 10592		
Enargemy divings equipment	2	2,006 1,500 2,500	3,134 0,188 2,126	39.6 33.1 45.6	03 03 10	# #	16.74 87.18 16.36	Total	1,582 0,269 9,661 11,512	

#### iii) Hillside waterway design

The hillside waterway shall be an open waterway of reinforced concrete construction.

Design flow velocity (v) and flow quantity (Q) are calculated according to Manning's formula.

$$v = \frac{1}{n} R^{2/3} I^{1/2}$$
 (m/sec)

n; coefficient of roughness of the inner surface of the waterway = 0.015 (concrete)

R: hydraulic radius =  $\frac{A}{P}$  (m)

A: water flow sectional area (m²)

1: waterway gradient = 0.03 (from the figures for the valley)

The section of the hillside waterway shall be as shown in the figure on the right.

A = 1.00 x 1.00 = 1.00 m<sup>2</sup>

P = 1.00 x 3 = 3.00 m

R = 1.00 ÷ 3.00 = 0.333 m

$$v = \frac{1}{0.015} \times 0.333^{2/3} \times 0.03^{1/2} = 5.551 \text{ m/sec}$$

$$Q = 1.00 \times 5.551 = 5.551 \text{ m}^3/\text{sec} > Q_{100}$$

$$= 5.017 \text{ m}^3/\text{sec}$$

Pig. II-3-5 Profile of Water Way

# iv) Design of drainage equipment for water in tailing dam

The drainage equipment for water in the tailing dam shall use underdrains (constructed by litting cover plates to open drains of reinforced concrete) which will be extended corresponding to the increase of the quantity of sediments. As the waterway gradient is as small as 1% on the north side and 3% on the south side, inlet parts in uncovered state can be regarded as dams with very large widths. Accordingly, the flowing capacity of the waterways as underdrains after water has entered can be calculated as follows.

The flow quantity is calculated by Manning's formula:

A = 1.20 x 1.30 = 1.56 m<sup>2</sup>

P = 1.20 + 1.30 x 2 = 3.80 m

R = 1.56 ÷ 3.80 = 0.411 m

I = 0.01 (north side)

$$v = \frac{1}{0.015} \times 0.411 \frac{2}{3} \times 0.01 \frac{1}{2}$$

= 3.685 m/sec

Q = 1.56 x 3.685 = 5.749 m<sup>3</sup>/sec

Pig. II = 3 - 6 B1 ind Ditch in the Bottom

# v) Design of Emergency Drainage Equipment

The emergency drainage equipment (spill way) shall be a canal without timbering made by ditching the base mountain ground at dam and part along the dam, and the entrance of the canal will be required to be raised corresponding to levee raising in the dry season every year.

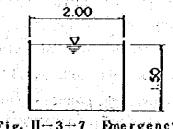
The quantity of flow is calculated by Francis' formula by assuming that contracted flow does not occur at both ends of the dam and there is no approaching relocity. By assuming that the same quantity of water is discharged through the southern and northern emergency drainage canals, we will use a crosssection shown in the figure on the right.

$$Q = 1.84 \text{ bH } 3/2$$

b: bottom width = 2.0 m

H: overflow depth = 1.5 m

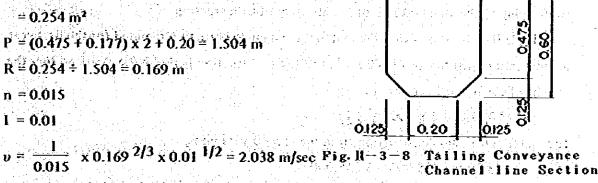
Q = 1.84 x 2.00 x 1.50<sup>3/2</sup> = 6.71 m<sup>3</sup>/sec  
= 
$$\frac{Q_{200}}{2}$$
 =  $\frac{11.512}{2}$  = 5.756 m<sup>3</sup>/sec



## Hydraulic Transportation of Tailings

The waterway for hydraulic transportation of tailings will use an open waterway of plain concrete construction for its 4 km long part from the concentration mill to the head tank and use a plastic pipe for its 500 m long part from the head tank to the cyclone. The quantity of flow can be calculated by Manning's formula. The section of the open waterway is shown by the drawing on the right.

1 = 0.01



$$\therefore$$
 Q = 0.254 x 2.038 = 0.518 m<sup>3</sup>/sec > tailing quantity = 38,446.6 m<sup>3</sup>/day = 0.455 m<sup>3</sup>/sec

Blind waterway section is shown in figure on the right.

$$A = 0.24^{\circ} \times \pi = 0.181 \text{ m}^{\circ}$$

$$P = 0.48 \times \pi = 1.508 \text{ m}$$

$$n = 0.013$$

$$1 = 0.03$$

$$v' = \frac{1}{0.013} \times 0.120^{2/3} \times 0.03^{1/2} = 3.241 \text{ m/sec}$$

$$Q = 0.181 \times 3.241 = 0.587 \text{ m}^3/\text{sec} > \text{tailing quantity} = 0.445 \text{ m}^3/\text{sec}$$

# 3-5 Computation of Approximate Construction Costs

## (1) Prerequisites

Conglomeratic earth used as dam material to secure volume for receiving failing sediments in the first year will be collected within the a radius of 500 m average transporting distance (one way) around the planned site for the dam, and the dam shall be completed in 2.5 years.

For the dam material from the second year on, tailing above 100µ classified and drained in the sedimenting area will be carried to the dam by dump trucks, spread and compacted by buildozers to increase the dam height. To simplify calculation, it is assumed that water is removed from the tailings to make the density of the dam material tailings to be 1.8 ton/m³.

Actual working time of heavy machines in a day shall be 6 hours in the case of dump trucks and 5 hours for other heavy machines. The heavy machines are regarded to be fully depreciated leaving no remaining value. The number of heavy machines to be purchased is required number + reserve number (\$30% x required number), and repair cost to be summed up is purchase price x 85% / 10 years for all the machines. Operation capacity is computed conforming to the standard rate of the Ministry of Construction.

Table II—3–2 shows that the material for dam construction required for the first year sedimentation quantity is  $498,000 \text{ m}^3$ , and the construction period is 2.5 years, so that the volume of earth work per day is:

$$498,000 \div (2.5 \times 300) = 664 \text{ m}^3/\text{day}$$

The material for dam construction from the second year on is,

If this amount of work is performed uniformly in 9 years, annual required amount of dam construction is performed (if the amount is divided by 10 (years), totalled construction amount will become insufficient on the way). If the dam construction from the second year on is completed in 9 years, the volume of earth work per day becomes,

- (2) Computation of Operation Capacity and the Required Number of Heavy Machines
  - i) Bulidozer 32t
    - a) Operation capacity

Volume of excavating and moving earth  $(\hat{V}_B)$ :

$$V_B = \frac{60}{Cm} \times q \times E$$

q : volume of excavating and moving earth per cycle = 4.55 m<sup>3</sup>

B : operation efficiency = 0.55 (conglomeratic earth)

Cm: cycle time =  $\frac{\ell}{V_1} + \frac{\ell}{V_2} + 5$  (min)

V<sub>1</sub>: forward movement speed = 41.6 m/min

V<sub>2</sub>: backward movement speed = 78.6 m/min

t : gear change time = 0.25 min

2 : average distance of excavating and moving earth (including stripping-off of surface soil) = 50 m

hence, 
$$Cm = \frac{50}{41.6} + \frac{50}{78.6} + 0.25 = 2.09 \text{ m}$$

thus, 
$$V_B = \frac{60}{2.09} \times 4.55 \times 0.55 = 71.8 \text{ m}^3/\text{hr} = 359.0 \text{ m}^3/\text{day}$$

Yolume of spreading earth (Q1):

W : effective operation width = 3.8 m (Komatsu D155A)

V : operation speed = 1,700 m/hr

H: thickness of spreading earth = 0.30 m

E : operation efficiency = 0.5

P : times of spreading = 3 times

hency, 
$$Q_1 = \frac{3.8 \times 1700 \times 0.30 \times 0.5}{3} = 323.0 \text{ m}^3/\text{hr}$$

Volume of compacting earth (Q,):

$$Q_2 = \frac{\mathbf{W} \times \mathbf{V} \times \mathbf{D} \times \mathbf{E}}{\mathbf{P}}$$

W: width of effective compacting = 0.8 m

V : operation speed = 4,000 m/hr

D: finished thickness = 0.30m

E : operation efficiency = 0.7

P: times of compacting = 5 times

hence, 
$$Q_2 = \frac{0.8 \times 4000 \times 0.3 \times 0.7}{5} = 134.4 \text{ m}^3/\text{ht}$$

Volume of spreading and compacting earth:

$$Q = \frac{Q_1 \times Q_2}{Q_1 + Q_2} = \frac{323.0 \times 134.4}{323.0 + 134.4} = 94.9 \text{ m}^3/\text{hr} = 474.5 \text{ m}^3/\text{day}$$

b. Required number of bulldozers

Number of bulldozers required for the first year:

Earth excavation and moving : 664 ÷ 359.0 = 2 buildozers

Earth spreading and compacting: 664 ÷ 474.5 = 2 bulldozers

Total 4 buildozers

Number of bulldozers required from the second year onwards:

Spleading and compacting: 1,240 ÷ 474.5 = 3 bulldozers

- ii) Tractor shovel 3.2 m<sup>3</sup>
  - a. Operation capacity

First year:

Volume of excavation and loading (Vt)

$$Vt = \frac{3,600}{Cm} \times q \times E \ (m^3/hr)$$

q : volume of excavation and loading per cycle

= 
$$0.84 \times q_0 - 0.03 = 0.84 \times 3.2 - 0.03 = 2.66 \text{ m}^3$$

schole to school by cepson

R. O. Am Source wife Day 2 and 4.

B : operation efficiency = 0.5

Cm: cycle time = 46 sec

hence,

$$Vt = \frac{3,600}{46} \times 2.66 \times 0.5 = 104.1 \text{ m}^3/\text{hr} = 520.5 \text{ m/day}$$

Second year onwards

$$q = 2.66 \text{ m}^3$$

$$E = 0.6$$

$$Cm = 46 sec$$

hence,

$$Vt = \frac{3,600}{46} \times 2.66 \times 0.6 = 124.9 \text{ m}^3/\text{hr} = 624.5 \text{ m}^3/\text{day}$$

b. Required number of tractor shovels,

First year:  $664 \div 520.5 = 2$ 

Second year onwards: 1,240 ÷ 624.5 ÷ 2

- iii) Dump truck 18t
  - a. Operation capacity

First year:

Volume of earth carried (Vt)

$$Vt = \frac{60}{Cm_T} \times q_T \times E_T (m^3/h_t)$$

qT: capacity of truck (weight of unit volume earth 1.8 t/m3, variation ratio = 1.0

are used) = 
$$18 \div 1.8 = 10.0 \text{ m}^3$$

B : operation efficiency = 0.9

Cm<sub>T</sub>: cycle time =  $\frac{\text{Cms} \cdot n}{60 \text{ Es}} + T_1 + T_2 + t_1 + t_2 \text{ (min.)}$ 

Cms: cycle time of loading machine = 46 sec (tractor shovel)

n ! loading times of loading machine =  $\frac{q_T}{q_s}$  (times)

qs : loading volume per cycle of loading machine = 2.66 m<sup>3</sup>

hence.

$$n = \frac{10.0}{2.66} \div 4 \text{ times}$$

Es : operation efficiency of loading machine = 0.5

 $T_1$ : cycle time of earth haulage =  $\frac{R}{v}$  x 60 (min)

T2 : teturn traveling time (min) = T1

? : one way traveling distance = 1.0 km

v : traveling speed = 15 km/hr

$$T_1 = \frac{1.0}{15} \times 60 = 4.0 \text{ min} = T_2$$

t<sub>1</sub>: unloading time = 1.0 min

t<sub>2</sub>: waiting time, etc. = 0.5 min

thus,

Cmt = 
$$\frac{46 \times 4}{60 \times 0.5}$$
 x 4.0 + 4.0 + 1.0 + 0.5 = 15.63 min

therefore,

$$V_T = \frac{60}{15.63} \times 10.0 \times 0.9 = 34.5 \text{ m}^3/\text{hr} = 207.0 \text{ m}^3/\text{day}$$

From second year onwards :

$$q_T = 10.0 \text{ m}^3$$

$$E_T = 0.9$$

$$E_S = 0.6$$

$$\ell = 1.5 \, \text{km}$$

$$T_1 = \frac{1.5}{15} \times 60 = 6.0 \text{ min} = T_2$$

# (3) Persons Necessary to Operate Heavy Machines (per day)

Table 11-3-6 Persons necessary to operate heavy machines for a day (-2.5 % 0 year)

Machine	Specification		Kerosin		Worker	(person)		1.4	
si scrine	Specification	Vamper	(0)	special operator	operator	assistant	extra	total	Note
Buldozer	32 <sup>1</sup>	4	680	4.0		2.0	0.6	100 100 100 100 100 100 100 100 100 100	Exception 2 Movement of earth 2
Track showvel	3.2 <sup>m³</sup>	2	300	2.0		1.0	0.4	3.4	
Dump track	18 <sup>t</sup>	4	192		4.0	5 of park		4.0	
Total			1,172	6.0	4.0	3.0	1.2	14.2	

Table 11-3-7 Persons necessary to operate heavy machines for a day (0 ~ 9 year)

		er Borer	22-5		Worker	(person)			
Machine	Specification	Number	143	special operator	obsistor	assistant	extra	iólai	Note
Buldozer	32 <sup>E</sup>	3	510	3.0		1.5	0.6	<b>3.1</b>	
Treck showed	3.2 m²	2	300	2.0		1.0	0.4	3.4	
Dump tráck	18 t	8	384		8.0	tien wie de vi		8.0	
Total			1,194	5.0	8.0	2.5	1.0	16.5	

# (4) Cost of Operating Construction Equipment (per day)

Table 11-3-8 Cost of Operating Construction Equipment (-2.5 ∿ 0 year)

Machine Number	Class of construction	Unit	Quantity	Uait cost (\$U\$)	Arsount (SUS)	Note
Buldozes 32 <sup>8</sup> x 4	Kerosin	R	1,172	0.2535	297.1	
	Grease	set	1		59.4	Kerosin x 20%
Track showed 3.2 m x 2	Worker consumption of the	b€isoa	14.2 4	8.0 16.2	113.6 64.8	4,600 = 1,700 ht x 6 ht/day=16.2
Dump track 18 <sup>1</sup> x 4	Regair	set	1		<b>415.3</b>	1,465,700 x 10 x 300 = 415.3
	Total				950.2	

Table II-3-9 Cost of Operating Construction Equipment (0 ~ 9 year)

Machine	Number	Class of construction	Unit	Quantity	Unit cost (\$US)	Amount	Note
Buldozer	32 <sup>t</sup> x 3	Kerosin Gréase	Q set	3.194 1	0.2535	302.7 60.5	
Track Showrel	3.2 <sup>m2</sup> x2	Worker consumption of tire	bettou	16.5 8	8.0 16.2	132.0 129.6	
Dump track	18 <sup>t</sup> x 8	Repair	șei			635.4	(1,465,000 + 777,000) x 0.85 x 10 x 300 = 635.4
		Total				1,260.2	

Table 11-3-10 Heavy Machinery and its Transportation Cost (-2.5 year)

In SU

Item Mark			Buldozes	Track showed	Dumptrack	Note
		<b>k</b>	Komater D155A-1 Komater D955-2 Komater I		Komater HD180-4	
Nu	nba	of Machinery	5	3	<b>5</b>	
We	izhl (	(timechics)	38.4	29.8	16.8	
То	lei w	eight (1)	192.9	89.4	84.0	
	Price		142,300	121,900	77,700	FOB
Pa	ichas	e price	311,500	365,700	388,500	F.O.B Purchase cost Total 1,465,700
43		Freight	36,900	17,200	16,200	Total weight x 192.44
Cost	g	Insurance	5,800	3,000	3,100	(Freight + Purchase cost) x 0.7175%
lon	Marino	Total	42,700	20,200	19,300	
orta	100	Freight	24,800	11,500	10,800	Total weight x 129
Transportation	Inland	Insurance	37,700	19,300	20,400	Marine transportation x 5% cost + Purchase cost
£		Total	62,500	30,800	31,200	
		irsportation st Total	102,300	51,000	59,500	Transportation cost total 206,700
Total	by ci	aces of machin	ne 816,700	416,700	439,000	
	Sai	na Total		1,672,400	·	

	Na sagrana 1988 na sanaharan 1922 na sanaharan 1921 na sanaharan 1921 na sanaharan 1921 na sanaharan 1921 na s
	이번 가는 것이다. 그는 사람들은 그를 가는 하는 것이 되었다. 그는 그를 가는 것이다.
	이는 하는데요 아이들 불다면 본 그 그리고 말하는 점심한 사람이 되었다.
	크는 사람이 고향을 만난만하는 네일 경쟁 사람들 되었다.
	그런 보다를 보는 이 것이 있다면 회의 학생들이 하는 것이다.
	그는 이 나는 나를 들어 있는 것이 생각하는 것이다. 그는 것은
	이 하면 그는 그래요 보이지 않아 뭐야 한 때 하고 있는데 없는
	遺(N) ' ' 전 (18 1일 일 일 일 ) 사고 있는 것 같아.
	그리 일반경기 등록 기회사의 출시하는 지원의 사회들이 되었다. 그렇다
	회사, 그들은 사람들이 되었는데 함께 보는 사람들이 되었다.
	엄마 그렇는 그렇게 살을 하는 사람이 들었다. 그는 이번 하는 것이 없다.
	수 있는 사람들이 하는 기를 발표하는 것을 하는 것이라고 있는 것이다. 사람들은 사람들이 가격한 것이다. 기술에 있는 것이 되었다는 것이다. 그렇게 되었다.
	그들은 마음 아이들은 하고 있는 그 아이들은 아이들은 사람이 없는
	지수야 불만들어 집중 사람들이는 생각을 하지만 하나들는데 보다.
도 기계를 보고 있는 것이다. 그런 목에 다른 것으로 걸 보고 기계를 보고 있는 것이다. 그런 것이다. 그런 것이다.	이 방, 소송의 함, 하루스 스타랑 프로그램 함, 등을 세, 요즘 나는
어느 이번 이번 아들이 아니라 이렇게 하고 있었습니다.	그림이 많은 그는 사람들이 살고 있다. 그들을 것 같아 있는데, 그는데
그는 사람이 많은 얼마나면 그는 지나면 함께 가장했다.	음성이 보면하면 하다 이 때문에는 이렇는 얼을 모든 것이다.
	[본문] 보이 하다고 있으면 되었다. 이 그 보니를 받아 보니는 나는
	일하면 아내는 그런 얼마를 가는 말로 가는 것이다.
	일 주었다. 물리 나이를 보이는데 말을 때 그는 물리를 모르는데 그는데 !
그 두 네트라이다는 얼마 많은 인화 문항였다.	
	원리는 그리고 있다. 문화 보다는 그는 사람들은 보다고 있다.
되고 그리는 의 이 남은 동안 한 호회 양호	
그 이 회 등 전 전에 되어 그는 지를 다듬어야 한다.	그렇게 골인하다 하고 있다면 화소를 보고 하다는데
그 그렇게 그렇게 인일주는 하는 것은 살아 하는데,	된 아이님 공화한 하나 호텔 없는 사라를 보고 하다 보다 했다.
	하는 것이 되었다. 그 학생들은 이 전에 가장 보는 사람들이 되었다. 그는 사람들이 되었다. 그는 사람들이 되었다. 그는 사람들이 되었다. 참 되었다. 하는 것이 되었다. 그는 사람들이 되었다. 그는 사람들이 되었다. 그는 사람들이 되었다. 그는 사람들이 되었다.
	이렇게 되었다면 살으로 보는 사람들은 보는 사람이 되는 것이라고 있다.
	그녀는 이 남이나는 경험에 어떻게 못하는데 아버지는 그리다.
	실하다는 사람들은 대학생은 생기는 이 등 때 하는데 많아 가는데 다.
	소설하다 하루를 어떻게 들어가실 모습을 걸게 살려. 이번 그렇다
	불편하는 경영 및 전투로 프로그램의 등은 경우를 하는 사람들이
	R. 마르막다(100m 120m 120m 120m 120m 120m 120m 120m
	회사 회사 등 사람들이 되는 것이 되는 것이 되는 것이 되었다.
	사람이 발표를 가장 하고 있는 사람들이 되었다. 사람이 있다면 하는 사람들이 사용하는 사람들이 되었다.
	[발생물리다 - 그리고 하고] : 시간 그는 한 경우 그리고 있다.
그의 그들이 그들이 그는 그가 모임 작물을 다시다.	
그는 사용하다 하는데 그가는 이번의 항상으로 됐	다는 동생자 마이에 들어졌다. 알마스 그는 참 하는 그들을 때문다고 했다. 나는 동생 마이트 그들은 사람이 모든 그들은 그는 것이 되었다. 그를 그
그 김 이 생물에 하고 있습니다. 그 작은 사이에 도달하고 있습니다.	그릇 가는 사람들이 가는 사람들이 하다고 하는 것은 하지 않는 것이다.
어떤 경우 살아 보는 바람이 되었다면 되었다. 그는 말은 기사들이 다	
이 없었다는데 이 아이들이 아이지 않는 빛을 다	가지를 보고 있는 것이 가능을 만들어를 보고 있습니다. 그런 전에 제가를 보고 하는 것이다. 근데 전쟁 하지를 보고 있는 것이다.
그리의 일하고 하지 않아 경험되는 이 사람들의 인계들어 점	
이는 계속하는 항상을 받아 되었다. 하면을 모양을 당한다	그렇게 말하는 것이 없다는 얼마는 얼마를 하고 있다. 그 그리고 있는데 없다.
	그렇다 바라이트를 못하는데 살을 잃었다고 있었습니다. 얼마나다.
나는 하는 사람들은 사람들은 유리를 받았다.	
이 보는 보험 시험에 되었다. 그는 사람이 되었다.	현실을 보고 있다면 한 경기를 받는데 보고 있는데 보고 있다. 그런데 그렇게 되었다는데 그런데 
	<u> 등록 본러 문의 화학학자를 한다면 본다면 하다. 은 기호 중인되다.</u>
	연극을 통해가 시민들은 얼마를 가득하는 것만 하다.
	문화 등학 사람들이 얼마를 되었다는 사람들은 학생들은 모양이다.
	보는데 이 영화는 역의 의회자 나를 있는 것 같아 말라다.
	##16 : : : # # # # # # # # # # # # # # # #

Table II-3-11 Heavy Machinery and its Transportation Cost (0 year)

in SUS

<u></u>				<u></u>		131 303
		Item	Buldozer	Track showvel	Dumptrack	Note
	1	Mark			Komatsu HD180-4	
	Numbe	r of Machinery			5	
	Weigh (	(t/machine)			16.8	
1	Total v	weight	-		84.0	
		Price			77,700	
	Porchas	se price			388,500	F.O.B
		Freight			16,200	
	Marine	Insurance			3,100	
Coat	ž	Total			19,300	
		Freight			10,890	
Transportation	Inland	Import fax eic.			20,400	
ranst	7	Toizi			31,200	
H		Transportation Cost Total		- 14 T	50,500	
Tota	d by cl	asses of machine		:	439,090	
		Sum Total		439,000		

アン・アン・アン・アン・アン・アン・カー・アン・アン・アン・オー・アン・アン・アン・アン・アン・アン・アン・アン・アン・アン・アン・アン・アン・	: :
	: .
	. 1
	-
	<b>.</b>
어느 그렇게 되어 되어 있는 나무를 하게 되는 사람이 되었다. 그는 사람들이 얼마를 되었다.	1.4
	- 14 - 14
	12
	4.4
그 그리는 그리는 그는 그 얼마는 사람들이 하는 중요하는 하는 생활이 되었다면 하는 사람들이 되어 가장하다.	·-
그는 그 그리고 그리는 이 아이들이 되는 것이 되는 것 같아 그를 보고 있다면 모양하는 것이 되었다.	`.
는 사용하는 사용하는 이 전 사람들은 현실을 하고 있다. 이 시간 이 사용을 보는 기계를 하고 보고 있다. 그는 이 사용적인 경기를 하게 됩니다. 	1
그는 그는 사람들은 그리는 방마는 사람이 하는 일을 하는 것이 얼룩하지 않아 가는 가능을 받는 것이 하는 것이 없어 없다.	!
그는 그는 이 이 이 그 이 이 이는 말이 되었다. 그는 이 이 이 이 없는 그 사람들은 그 수 있는 것이 되었다. 이	1
그는 사람들은 사람들은 그들은 회사들의 작업이 들어 하는 수 있는 것이 되었다. 그는 사람들은 사람들이 나는 사람들이 되었다.	
그는 사람이 가게 되었다면 되는 사람들이 되는 것은 사람들이 된 경험을 하셨다. 하고 되었습니다 그 사람이	
그런 그는 그런 이 이 사람이 어느는 가는 이는 것이 되는 물리를 만한 회사를 보고 있는데 장말을 받았다. 나는 것이다	1 1
그는 그 하는 어느 어떤 말을 가는 모든 것이 되었다. 그들은 그들은 사람들은 사람들은 사람들은 사람들은 사람들은 사람들은 사람들은 사람	;
	3.
그는 그들은 사람들이 하는 그들은 원인의 그는 그는 그는 사람들이 하지만 말리다는 것 같아. 나는 사람들이 되었다.	
그리지 않는 그리지 하는 그는 그리고 하고 있다. 그는 전화를 전혀 모습 하는데 했다. 이렇지가 별되면 하는데 모든 그	
그는 사람이 가는 사람들은 사람이 있을 때문에 가득하는 사람이 얼마나 하면 다른 사람이 가게 되었다.	- 5-
	.1.
그는 어린 아이를 가게 하고 있는데 이번 사람들이 아니는 사람들이 되었다. 그 사람들이 얼마나 살아 나를 하는데 살아 없다.	S.
그는 사람들이 하는 사람들은 어머니는 사람이 하는 사람이라는 것을 모바다는 말하는 어머니를 먹어 들어갔다. 나는 사람은	
그 일본 다 경기 병에 가지 않는데 그 것 같은 사람은 학교를 받는 경기가 그렇게 되는데 가는 말랑한 모르겠다.	
그리다는 보기에 되게 되는데 이번 그렇게 하다는 그렇게 하셨다면 하고 말통하는데 모양하는 그리고 되었다.	
그 그의 그는 그를 잃어 들는데 티트를 보면 잘했습니? 혹은 생활을 가면 했는데 없을데 그를 받았다.	
그 사람이 이 아이들 때문에는 이번 이번 불어들면서 얼마면 못했다. 이번 그 바다 이번 이번 사람이 되었다. 그는데 그는	1.27
그는 도시한 것은 이렇게 그 그들도 수 없는 눈이 가면 하게 동생 문장을 다고 아니다. 이렇게 함께 들는 그 모든 하게 함께 다	
이 전혀도 하는데 그는 데 다양을 하는 사람들이 그렇게 하는데 하는데 가는데 하나 없는데 하는데 하는데 하는데 하는데 하는데 하는데 하는데 하는데 하는데 하	
그리고 하는 사람이 어느 나는 이외의 역에 가져지고 있어 생각을 된다는 사람들이 가는 것이다.	1 1
이 보고는 하는 사람들은 동안되는 이 없는 그 전실을 나왔다. 하는 이번 것 같은 물건은 중인을 수 없을 수 없다.	
그들은 가는 전에 가장 하는 사람이 가는 살이 가장하는 수 있다면 하는 사람들이 가장 하는 것이다.	 
그리지를 보고 있는데 있다. 아니라 살아 살림을 모습하는 때 모든 사람이 다니라 다른데 하지만 하면 하는데 모습하는 물건 모든	
	15.5
	24.1
그는 그는 사람들에는 물감으로 하는 것이 하고 하다면 살아 다시를 못 하고 사람들은 얼굴하는 하고 모르겠다.	
이 하이 되었는 가능한 학생은 나라면 문에 가지는 하는 것은 사람들은 시험적으로 본 일을 하지 않는 것은	4,734
	-

### (5) Dranage Equipment Construction Cost

Table II-3-12 Drainage Equipment Construction Cost (-2.5 ~ 0 year)

Class of Construction	Specification		Unit	Quantity	Unit price (\$US)	Amount (\$US)	Note	
. Water way in Mill side	Reinforced concrete	1.0 <sup>W</sup> x1.0 <sup>H</sup>	m	3,000	170	\$10,000		
Dramage Equipment	Reinforced concrete open canal	1.2 <sup>W</sup> x1.5 <sup>H</sup>	m	2,400	360	864,000	South North	3,000 m 1,400 m
in Mill Plant	Reinforced concrete box culvat	1.2 <sup>W</sup> x1.5 <sup>H</sup>	m	600	470	282,000	South North	300 m 300 m
Emergency Dramage Equipment	Tonnel water way in rock	20 <sup>W</sup> x 1.5 <sup>H</sup>		900	50	45,000	South North	450 m 450 m
Total		*	1 1 1	<del></del>		3,701,000		

Table 11-3-13 Drainage Equipment Construction Cost (0~9 year)

Class of Construction	Specification		Únit	Quantity	Unit price (\$US)	Amount (SUS)	Note
Drainage Equipment in Hill Plant	Putting on lid reinforced concrete	1.7 <sup>W</sup>	m	2,400	130	312,000	
Emergency Drainage Equipment	Toncel water way	2.9 <sup>W</sup> x1.5 <sup>H</sup>	M	1,800	50	90,000	South 100 x 9 = 900 North 100 x 9 = 900
Tolal						402,000	100 7 9 - 300

# (6) Tailing Transportation Equipment Construction Cost

The construction cost occurres only in construction stage (-2.5 year  $\sim 0$  year).

The dranage canal frome mill plant to head tank, and cycron is included in mineral concentration equipment cost.

Table 11-3-14 Tailing Transportation Equipment Construction Cost

Class of Construction	Specification	Vnit	Quantity	Unit price (SUS)	Amount (SUS)	Note
Tailing Transportation open water way	Concrete open 0.45 Wx0.6H	ED	4,000	90	360,000	<del></del>
	Head Tack		22			
Tailing Transportation	Piping 530 x 200 4 x 2 Une				226,000	
Equipment	Cyclose underflow pump		3			
	Cyclore 20 x 2 pieces		3			<del></del>
Total					586,000	

$$t_1 = 1.0 \, \text{min}$$

$$t_2 = 0.5 \text{ min}$$

thus, 
$$Cm_T = \frac{46 \times 4}{60 \times 0.6} + 6.0 + 6.0 + 1.0 + 1.5 = 18.61 \text{ min}$$

therefore, 
$$V_T = \frac{60}{18.61} \times 10.0 \times 0.9 = 29.0 \text{ m}^3/\text{hr} = 174.0 \text{ m}^3/\text{day}$$

b. Required number of dump trucks

First year : 664 + 207.0 = 4 trucks

Second year onwards: 1,240 ÷ 174.0 = 8 trucks

# (7) Tailing Dam Construction Cost

Construction period is 11.5 years (dam construction period for first year sediments 2.5 years + dam construction period for 2nd ~10th year sediments 9 years), and dam construction cost is summed up as dam raising cost in operation costs.

The construction costs are shown in the following table, but the construction cost of water recovery equipment is not included in this table.

Table II-3-15 Construction Cost of Tailing Dam

The same of the sa

		<u>a a a a a a a a a a a a a a a a a a a </u>	BI 022
Processing ore (t/day)	10,000 <sup>t</sup>	9,000 <sup>t</sup>	8,000 1
Years	2.5	2.5	2.5
Heavy Machine Equip.	1,672,000	1,283,000	1,585,000
Construction of Dam	713,000	518,000	667,000
Drainage Équip. Construction	1,701,000	1,629,000	1,593,000
Tailing Transportation Equipment	586,000	533,000	574,000
Road Construction	60,000	60,000	60,000
Total	4,732	4,023	4,479,000

### CHAPTER 4. Utility Equipment Plan

### 4-1 Water Supply System Plan

In planning the new concentration plant, security of water for concentration must be recokoned as one of the most important subjects, but as the site for the plant is in a dry land area with the average rainfall of the level of  $500 \sim 600$  mm, from where rivers rise, serious difficulty is anticipated in securing the planned quantity of water supply of 32,000 m<sup>3</sup>/day.

In the current state of operation, this mine is suffering from water shortage to some extent, but as there is possibility of securing supplementary water supply from bored wells under way with effort in Centenario area, the quantity of water collection and the quantity of water used will be kept in the present state until the new plant starts its operation. For securing the planned quantity of water supply after starting the operation of the new plant, the drinking water system and the mining water supply system may be kept in the present state, but water supply for concentration, which may be insufficient, has been investigated as follows.

### 4-1-1 Water Collecting Equipment Reviewing

There are mine water sources at present, Sauta, Tomas-Ventilla, dry season, we will estimate it possible to collect 70% of the quantity in average, then the increase of collected water quantity is:

5 m³/min x 60 min/hr x 24 hr/đay x 0.7 = 5,000 m³/day

Since the present water-conveyance equipment will be maintained for supplying drinking water for Catavi area, the following new equipment will be required to send water of 5,000 m<sup>3</sup>/day:

- 1) Debris barrier to be built somewhere upstream of Sauta dam
- (2) Water-conveyance pipe between Sauta dam and pump station
- (3) Pump 380 kw x 1, Reserve pump 1
- 4 Piping between the pump station and the new plant 250 mm/ x 11,000 m(L)
- 2) Ventilla

We heard that a concrete ditch had been buried here to take water in Palino days, but as it has been clogged naturally and become impossible to use, a reservoir of water has been made by excavating the river bed at a position about 100 m upstream of the ditch position to collect surface water and river bed water. Rio Ventilla has comparatively a large basin (87.21 km²) in this district, so that a large quantity of underground water is expected to exist apart from the surface water.

According to the first survey report, the measured quantity of flow was 2,721.6 m3/day

while the quantity of intake water was 1,637,9 m<sup>3</sup>/day, therefore, if the apparent values alone are simply compared, the difference between the two quantities, i.e., 1,083.7 m<sup>3</sup>/day is thought to be a possible increase in the quantity of collected water, but since the abovementioned reservoir occupies only a small part of the river bed, the quantity of water collected now may be negligibly small compared with the quantity of underground water flowing away at present.

The quality of water at the present intake point is acid water of the level of pll=4 and yet contaminated water including much suspended iron compounds. This fact is thought to be one of the factors which clogged the water collecting ditch in Patino days, so the point of collecting water should be transferred upstream.

At a point about 2 km upstream of the present water intake point, spring water is gushing out, which is clear water and its quality is pH  $\geq$  7. Accordingly, we want to set a new water intake point at the junction of Rio Ventilla and Rio Catiri.

According to the records of rainfall observation, average annual rainfall is about \$40 mm, but 83% of the rainfall is concentrated to the rainy season of only four months from December to March. The topographic feature of the area is steep, bold and rocky surface with a large coefficient of outflow, so that most of the rain water is supposed to flow away immediately after rainfall, and, when the quantity of evaporation in the dry season that begins in April is taken into account, it is anticipated that underground water can hardly be reserved and surface water flow will not exist, but actually, surface water existed in the river even at the time of survey (July).

To explain this phenomenon, we suggest the following hypotheses:

- (1) Whether or not the rock formation that seems to scarcely reserve underground water includes much sedimentary rocks such as slate, sandstone, etc., a certain amount of clay is sandwitched between layers and yet fissures have developed, so that the formation may reserve underground water.
- Whether or not the Llallagua formation has features to reserve underground water, e.g. a certain degree of fissures have developed in the formation, when the fact that much mine water exists is taken into account.
- 3 As underground water is reserved at a substantial depth, and apart from the water, underground water which stays near the ground surface are both frozen when oozing out, therefore, whether or not such underground water is hardly affected by evaporation. In fact we observed ice sticking to rock in many places in the shade of the mountainuous area. As the dry season is winter, relation between oozing out quantity and evaporated quantity is not

FIG. 11-4-1 PIPING ROUTE OF WATER SUPPLY

一点,大小大小,大小小小小说:"我们,还是这个大大的,我们也没有的女性,不是这么一样的,你就是一个女人,我不是这么多么。"	
그는 사람은 하는 역으로 함께 여름 사람들은 이번 보고를 잃어가는 살라고를 사용하다는 것을 모습니다.	
그는 그들이 그는 사람들이 많은 사람들이 하는 것이 되는 것이 없는 것이 되는 것이 없는 것이 없는 것이 없는 것이다.	
人名德格尔 医电子切除 化氯化氯 医二氯化氯化物 化氯化 医电震感染 化基础 电影经 医神经炎 医神经炎病	
어른 하는 사람들이 살아 하는 것이다. 그 사람들은 사람들은 사람들은 사람들은 사람들은 사람들은 사람들은 사람들은	
그리다 그는 사람들이 되어 되었다면 이 되는데 되었다면 하시네네. 그는 말을 모르는 모르는데 되었다면 하시네요?	
그는 이 그러는 어린 아는 시간을 받아 되는 것 같은 그들은 것이 되어 있다. 그렇게 모양을 모르는 그로 그렇게 되었다. 그렇게	
그 하는데 된 아이는 어디에 아이들이 하는데 된다면 된 아름답답다고 아이를 받은 모양을 모양되었습니다. 이 분인 어떻게	
그가는 선생님 하다 할 만큼 하는 말도 하는 일을 하는 일을 하는 것은 사람들이 되었다. 학생들은 연극 기업을 받았다.	
그는 하스님은 아이가 되면 하는 것 같아요? 아이는 전 사람들은 이렇게 하는 사람들이 되었다. 그 사람들은 목 하는 것은	
사진 보는 사람은 사용하는 사례를 가면 하는 사람들은 사람들이 많은 생활도 사용하는 것은 사람들이 가득했다.	
그렇게 하는 어느 아름다고 있는데 그는 아이들 이 그리는 하는 그래 말을 가지 않는데 얼굴을 다고 말을 하고 있다.	
그 이 집에 이 것들까? 그러나는 건강이 되었다면서 가는 사람이 모르스트로 가장하게 모르아?	

simple and they are not always linearly proportionate.

By supposing so, the fact that a certain amount of surface water exists in the river even in the dry season, in which rainfall can hardly be expected, can be explained to some extent.

According to Journal of Hydrology, Vol. 53 No. 3/4 (pp. 213 ~ 227, October, 1981), the mean ground water rechargeability in the drainage area in a semi-dry area with an annual rainfall of about 250 mm in the south-western part of Idaho State, USA is estimated to be about 4.6 x 10<sup>-4</sup> cm/min (coefficient of permeability, 0.023 cm/min, average hydraulic gradient 0.02 cm/cm). Although it may be unreasonable to apply this value directly to this area where geological conditions, rainfall conditions, etc., are quite different, if it is assumed that the water rechargeability of that degree exists, as the catchment area of Rio Ventilla is 87.2 km² of which 44.51 km² is occupied by Catiri water system described in article 3), the catchment area of the junction of Rio Ventilla and Rio Catiri becomes 42.7 km², and if it is further assumed that rain water is recharged continuously during the rainy season of four months from December to March, the quantity of underground water reservation is determined as follows:

 $4.6 \times 10^{-4}$  cm/min x 1,440 min/day x 30 days/month x 4 months x 42.7 x 10  $^{10}$  cm<sup>2</sup>

 $= 3.394 \times 10^{13} \text{ cm}^3$ 

 $= 33,941,000 \text{ m}^3$ 

However, it is impossible to collect the entire quantity of this reserved water, but the effective porosity of underground fissures through which water can actually pass matters, and if the porosity is assumed to be about 5%, the quantity of collectable water becomes,

 $33,941,000 \times 0.05 = 1.697,000 \text{ m}^3$ 

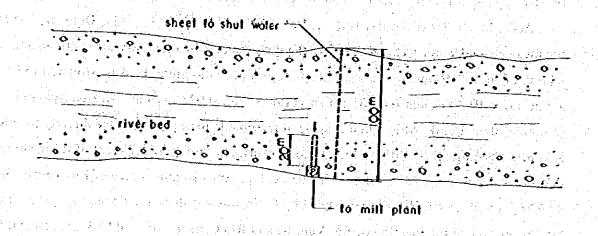
If the quantity of collected water is assumed to be 12,000 m3/day,

1,697,000 ± 12,000 = 140 days = 4.6 months

accordingly, underground water reserve corresponding to the quantity of collected water for 4.6 months can be secured.

During four months in the rainy season, there is abundant surface water and water can be collected through a water collecting pipe installed on the river bed, and during four months in the first half of the dry season, underground water of the river bed and near the bed and a certain amount of surface water will be able to meet the required quantity, so it is only for the four months of the latter half of the dry season during which the above-mentioned underground water reserve must be collected. Accordingly, continuous water collection will be possible.

Equipment required for taking in water of 12,000 m3/day are as follows:



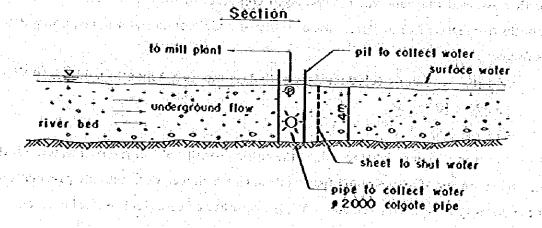


Fig. 11-4-2 Idealized Irustration of Taking Water

As the sheet for shutting off water does not require strength and its main purpose is to reduce the coefficient of permeability of the river bed, water leakage may be allowed to some extent.

1 Equipment to take water: Collecting pipe, 2,000 mmg x 20 m (L) corrugated pipe with holes.

Sheet to shut water: h = 4 m, l = 100 m

Catch pit: 200 m3 x 1 unit

2 Water conveyance equipment :

Pump: 350 kW x 2, Reserve pump 1

Piping: 350 mm x 4,500 m (L)

An underground dam type will be adopted as the method of collecting water, which can be illustrated typically by Fig. II-4-1.

## 3) Catini

Here, water is collected directly from the concrete arch dam of a capacity of 2,500,000 m<sup>3</sup> through a 6" pipe, and in addition, a water collecting dam has been built at a point about 1.5 km upstream of the arch dam to conduct water through an 8" pipe from there. At both intake points, water is reserved once in the intake tanks of pump stations before being pumped up to be supplied as industrial water and drinking water. A noteworthy point about Catiri is the fact that in spite of collecting the above-mentioned quantity, the dam was in a fully filled state (at the time of survey on July 5, 1982), which suggests that this place can also be reckoned as an object of water collection.

The quantity of water intake at present is about 1 m<sup>3</sup>/min including water for concentration, domestic use water, etc., and as the dam is equilibrated in the fully filled state while the above quantity of water is taken, we will assume that 85% of the dam capacity can be taken, then the increase of collected water quantity is:

2,500,000 m<sup>3</sup> x 0.85 = 2,125,000 m<sup>3</sup>

If the number of days in which water can be taken is calculated from the above quantity.

The number of days water can be taken = 2,125,000 ÷ 20,000 = 110.75 days

As the number of working days of the new mill plant is 25 days/month, the above quantity of water can meet the requirement of water for approximately 4.4 months.

On the other hand, about eight months from April to November belong to the dry season here, and especially in four months from April to August, almost no rainfall can be expected. It is supposed that the peak time of the dry season of the river upstream of the dam naturally lags a little from the peak time of the dry season of the district because of the outflow time of rainfall, and as surface water exists at the time of July, a period in which inflow to the dam cannot be expected is thought to be about four months from August to November. Accordingly, these four months can be got through sufficiently with the reserve water of the dam.

To collect the quantity of water of 20,000 m<sup>3</sup>/day at Catiri, the following equipments will be required:

- Water pipe from Catiri dam to pump station.
- (2) Pump: 5 m<sup>3</sup>/min x 270 m(H) x 370 kW x 3, Reserve 1
- 3) Piping from pump station to new mill plant: 450 mm x 3,000 m(L)

The existing water conveyance equipments cannot be diverted for this purpose in relation to their specifications, but as they are used for supplying drinking water, they will be left unchanged.

#### 4) Centenario and Lagua-Lagua

The alluvial fan developed in the east of Uncia town at the foot of Juan del Valle mountain makes us expect intuitively the existence of underground water, but now, water is pumped up from only one deep well, so that it can be said without exaggeration that this place can be regarded a so-called undeveloped virgin soit as water source.

This alluvial fan is said to be an alluvium bed formed by eroding and sedimenting Juan del Valle peak, etc., in the glacial period and is distributed over a range of 7 km from east to south, 5 km from north to south and the maximum depth of 90 m. The geology mainly consists of coarse gravel layers, and when observed through the deep well at Centenario, the layers have been compacted hard, and the well itself is as bored having no timbering.

The depth of the well is 45 m and the water level in the well is 5 m below the ground surface. On the other hand, the erosion of glaciers also carried and sedimented the mineralized zones of Juan del Valle peak, this alluvial fan forms an alluvial deposit of tin and the upper layer has become the mining place of Veneros.

COMIBOL has also noticed this land form and is working on a plan of boring three wells each having a section of 2 m x 2 m and a depth of 30 m. At the time of the last survey, one of them was being bored and hit the underground water level at 13 m below the ground surface and the quantity of water springing out was confirmed to be 2 k/sec. According to the plan, the wells are said to be bored on both sides of Rio Temporal, and apart from the plan, a trench with a section of 5 m x 5 m and a length of about 200 m has been ditched at a position downstream of the well and the water exists about 3 m below the ground surface level, so the water can surely be found by boring a well anywhere around the place. From the wells under boring now, the quantity of water equal to that of the well in operation is supposed to be pumped up at the stage when they are bored to the planned depth of 30 m.

On the other hand, we have heard that COMIBOL authorities have particular concern for Rio Lagua-Lagua and are planning to supply water from the river to Catavi area.

In the flow quantity survey in August, 1981, the quantity of surface water of 11.5 g/sec was confirmed and a pll value of 7.8 was measured. Although the quantity of surface water is not so large, its wide basin area of 150 km<sup>2</sup> is worthy of notice.

The rainfall in this basin entirely flows into Tranque except loss due to evaporation, etc., and is utilized for hydraulic power generation, but as the water is acid water (pH=3), the water is not used in any other way. Tranque is an artificial lake with a capacity of 38,000,000 m³, but as acid water of concentration tailings, No. 2 Kenko Lake effluent, etc., has flowed into the Lake for many years, the lake has become reservoir of chronic acid water, and it is regretable that the water of the lake has not been utilized efficiently in spite of the fact that this lake is a sole abundant source which can be confirmed visually in this area. However, the river through which flow the above mentioned concentration tailings, etc., is Rio Andavilque alone, and the water quality of Rio Lagua-Lagua and Rio Santa is almost neutral, so that everyone will agree that is would be far more advantageous to take the neutral water before flowing into the lake than to neutralize acid water before collection.

Moreover, Centenario area alone, where the quantity of water reserve has been confirmed to a certain extent, has a basin area of 60 km², and the land form of the basin forms a state that the whole quantity of underground water flows into Rio Lagua-Lagua, so that Lagua-Lagua seems to have a considerably large scale of underground water in existence. When compared Rio Lagua Lagua with other rivers in the neighborhood, i.e., Rio Ventilla and Rio Sauta, Rio Lagua-Lagua has a sand river bed formed of materials including much sand, while other rivers have gravel river beds mainly of boulders. Perhaps, this is because Rio Lagua-Lagua has considerably a large basin area and a long river length, and materials flowed by the river stream have been sized down to a larger degree as they flow down. Although these rivers flow into Lago Tranque independently at present, Tranque is essentially a lake made by damming Rio Lague Lagua and Rio Ventilla and Rio Sauta were originally tributaries of Rio Lagua-Lagua, so that the above-mentioned fact is quite natural. Other rivers therefore have steeper gradients than that of Rio Lagua-Lagua and also have larger quantities of surface water. Accordingly, although it may sound paradoxical, as Rio Lagua Lagua has a wide basin area, it is anticipated that the river has a considerably high underground water recharging ability and the seasonal fluctuation of its underground water quantity is far smaller than those of other neighboring rivers. Also for this reason, the collection of underground water here is sufficiently worthy of investigation.

About the possible quantity of water collection, assumptions are made similar to the case of Rio Ventilla.

4.6 x 10<sup>-4</sup> cm/min x 1,440 min/day x 30 days/month x 4 months x 150 x 10 cm<sup>2</sup> x 0.05  $\approx$  5.9616 x 10<sup>1,2</sup> cm<sup>3</sup>  $\approx$  5,961,600 m<sup>3</sup>

If the quantity of water collection is assumed to be 12,000 m<sup>3</sup>/day, 5,961,600 m<sup>3</sup>  $\div$  12,000 m<sup>3</sup>/day  $\Rightarrow$  496.8 days

Accordingly, there will hardly be any problem even if water is collected all through the year.

To take in water, a catch pit will be built on the river bed of Rio Lagua-Lagua, water collected on the left bank and pumped up from there to the new mill plant. Accordingly, the following equipment will be required:

Catch pit: 200 mm/x 20 mL corrugated pipe

Water collecting pit : 200 m3 x 1 years and a property of the collecting pit : 200 m3 x 1 years and the collecting pit : 200 m3 x 1 years are the collecting

Water pump: 4.5 m³/min x 340 mH x 420 kW x 2, Reserve pump 1

Water conveyance piping: 350 mm x 8,500 mL

#### 4-1-2 Determination of Water-Intake Point

As described in 4-1-1, Sauta requires comparatively a large amount of equipment investment compared with the small increase of water collection of only 5,000 m<sup>3</sup>/day. As Ventilla is comparatively near to the new mill plant, construction cost may not be so large, but it has a weak point in securing its ability to secure the sufficient quantity of water. Accordingly, Sauta and Ventilla are omitted from investigation objects, and two points, Catiri and Lagua-Lagua are determined as water-intake points.

र कोर्यन्तर के लेकी के प्रकृत है को पर ने रहिता के लेकिन के उसे होती

As Catiri has a reserve dam and the quantity of water can be confirmed, and it is also at the nearest place to the new plant mill, construction cost will be comparatively low, so that water should be collected here as much as possible. Thus, the quantity of water collection is determined to be 20,000 m<sup>3</sup>/day.

Lagua-Lagua has somewhat unsteady factors in securing water quantity and is also far from the new mill plant, the quantity of water collection is limited as small as possible, i.e., 12,000 m<sup>3</sup>/day. Although there may be such problem, underground water actually exists in Centenario area, so that the remaining problem is the quantity of existing water.

If it is assumed that the water reserving gravel layer here has an area of about 30 km<sup>2</sup>, average depth of 10 m and effective porosity of 15%, the quantity of water that can be collected is estimated to be:

 $30 \times 10^6 \text{ m}^2 \times 10 \text{ m} \times 0.15 = 45,000,000 \text{ m}^3$ 

then,

 $45,000,000 \text{ m}^3 \div 12,000 \text{ m}^3/\text{day} = 3,750 \text{ days}$ 

This means that the existence of the quantity of water reservation corresponding to the quantity of collection for ten years is expected. This expectation can be several times surer than the uncertain computation based on the assumption of underground water rechargeability of Lagua-Lagua described in 4-1-1. As Centenario is an area where such enormous possibility is hidden, we think it indispensable to confirm the quantity of existing underground water. However, the purpose of this survey was not the survey of underground water, we only describe possibility in this report and want to suggest another survey concerning underground water at the earliest possible occasion.

#### 4-1-3 Measures to Get through Water-Shortage Period.

It was described in 4-1-1, 2) that about 83% of the average annual rainfall of 540 mm here is concentrated to the rainy season of four months. In the eight-month dry season, there may be a certain amount of rainfall in four months including April, September, October and November (16% annual rainfall), but in four months from May to August, almost no rainfall can be expected (1% of annual rainfall). In addition to the existence of no rainfall period, it happens about once in three years that annual rainfall falls short of 500 mm, and sometimes there is a year with annual rainfall below 400 mm. In such a year, the dry season tends to last longer, and in Catiri, it may be impossible to collect the required quantity of water. The occurrence of such a state at a place where 55% of required fresh water is to be taken will have a serious impact on production plans, so the best way is to prepare a reserve system of collecting water. From this viewpoint, we suggest to prepare the water collecting equipment described in 4-1-1, 2) in the Ventilla water system as early as possible during the operation period.

#### 4-1-4 Operating System for Water Collecting Equipment

The operating system described so far can be summarized as follows:

The drinking water systems of Saula and Catiri will be left unchanged.

For supplying concentration water, new equipments will be constructed in Catiri and Lagua-Lagua.

Accordingly, the following pump operators will be required (Refer to Primary Report).

Sauta system  $2 \times 3$  shifts = 6 operators

Catiri system 3 x 3 shifts = 9 operators

Lagua-Lagua system 1 x 3 shifts = 3 operators

After the operating system has been prepared, it is desirable to change the drinking water system into a distribution system utilizing natural head by preparing a head tank at a high place or anyhow to avoid keeping pump operators in places other than the water-intake places.

# 4-1-5 Computation of Approximate Construction Costs

Construction costs of water collecting equipment at each water-intake point can be summarized as follows.

Table 11-4-1 Cost of Construction of Water Collecting Equipment (in 1,000 USS)

	Pump	Piping	Electric Construction	Civil engineering construction	Total
Catiri			164	98	
Lagua-lagua			558		
Total	. 743	1,914	722	135	3,534

# 4-2 Plan for Electric Power Source

# 4-2-1 Basic Idea

Catavi Mine has an existing substation (132 KV / 66 KV) with a capacity of 50 MVA, among which 18 MVA is supplied to the surrounding mines, pumps, towns, houses, etc. Accordingly, there is a surplus capacity of 32 MVA at present, so that this capacity will be allotted to the power sources for the increased equipments including the new mill plant and water supply equipments, etc., accompanied by the plant.

In addition, the existing hydraulic power plant should be abolished, and the emergency power source is required only for ventilation in the mining department and for thickness in the concentration department, and the capacity of the existing diesel power generation equipment will be sufficient for the emergency power source, so that the equipment will be diverted for the emergency purposes.

# 4-2-2 Power Transmission to New Concentration Mill

To the afore-mentioned incoming power substation (capacity 25 MVA) to be built within the site of the new concentration mill, overhead wires of a length of transmission of 2.5 km will be newly provided from the secondary busses (three phase three wire system 66 KV) of the above-mentioned main substation.

Power transmission system & transmission voltage: 3-phase 3-wire system, 66 KV 50 Hz I circuit.

Transmission capacity: 30 MVA

Length of transmission: 2.5 km

Kind of supporters: Steel towers of angle steel

Number of steel towers: 11 (average span 230 m)

Transmission wire material: ACSR 160 mm<sup>2</sup>

Aerial ground wire: Twisted wire of galvanized steel

## 4-2-3 Power Transmission to Pump Stations

To Caliri and Lagua-Lagua where pumps will be increased greatly as the result of the afore-mentioned water collecting equipment reviewing, to the former will be supplied power from the Siglo XX substation by changing the thickness of the existing transmission wires (length 3 km) from 45 0 to 100 0 from the Siglo XX substation to the Catiri pump station, and to the latter power will be supplied from the Victoria power substation by newly drawing 6 km long 11 KV transmission wires.

#### 4-2-4 Rough Estimation of Construction Costs

66 KV transmission wires total amount 105 million yen
Substation equipments " 379 "
Substation outer structures " 33 "

Notes: Estimating conditions are the same as those of the concentration mill.

The cost of water supply pump is included in 4-1-5.

#### CHAPTER S. PLAN FOR MAINTENANCE SHOP

## 5-1 Policy of Managing Machine Shop

In Catavi Mine there are large organizations of the department of maintenance and the electrical section historically. The number of total workers in them is, including 370 mm in the department of maintenance and 180 mm in the electrical section, 550. Jobs in which they are engaged cover all the operations and repair work of surface and underground machines and electrical equipment, but for the operation and minor repair work of the equipment of concentration shops, there are in total 138 workers who belong to the departments of concentration of three mills, Siglo XX, Victoria and Kenko. In consequence, 688 workers in total are directly engaged in jobs concerning equipment.

The capacities of equipment, the operation of which is directly administrated by the maintenance section, are roughly shown in the following table.

Division	Equipment	Number	Capacity	Note
	Compressor	:	3,400 KW	
	Weich	13	850	
	Dranige pemp	19	2,100	program
Mense	Fa	21	1,050	egise i eteloji.
	Water pamp	5	69	
	Troßey (Direct current)	1	75	
	i Total		7,555 KW	Saar total
	In loctine, others	13	1,440	€ 11,000 KW
Membergeri	Water pump	23	2.020	
	Total		3,460 KW	aly share has be
	Hydraube generator	8	2,300	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
Electric	Desil generator	5	2,000	
bòser	Siglo XX substation	and the	8,800	66 KV/10KV

Table II-5-1 Equipment that Maintenance Section Administrales

Functions performed by the machine shop cover a casting shop which includes pattern making and mold making, a lathe shop, a welding and plate working shop, automobile repair work, tire repair work, motor rewinding work, maintenance work of bits and drilling machines, etc., in short, all of the maintenance and repair work of various equipment in the mine.

Such a system of the machine shop covering various functions as the above is regarded to be just the same system once possessed also in Japan by most of the large scale mines.

The teason for adopting such a system is that the mining industry itself started its business

activities prior to other general industries, and moreover, different from so-called urban industries, the mining industry usually constructed mining towns in remote and secluded places in the mountains.

To cope with these recent basic problems, exploration for new ore deposits is continued in mines, and if a new ore deposit of considerable scale is found fortunately, the maintenance section will tentatively be very busily occupied by various developmental and starting jobs.

After the construction work of the concentration mill is finished, the maintenance section will be engaged in the maintenance of the equipment. However, compared with the old deteriorated equipment, as various measures for wear resisting, corrosion resisting, etc., are incorporated into new equipments, the quantity and frequency of repair work will normally be reduced to a large extent.

Consequently, the number of workers of the maintenance section naturally will become too large, so some measures will be required to balance the income and expenditure of the maintenance section itself. In short it is suggested as countermeasures to get rid of entrusting the mine only with everything of the section and to develop some outside income sources, or to reduce expenditures by reducing the number of workers of the maintenance section or by transferring them to some other posts, etc.

## \$-2 Maintenance of Equipment after Modernization

We have suggested construction of a large concentration mill with a processing capacity of 10,000 t/day in this modernization plan.

In this article, we want to describe the way of developing PM (production maintenance) for reference of developing the maintenance of equipment by supposing Catavi Mine after completing the new concentration mill.

#### (1) Adoption of PM system

The purpose of PM is to carry out the maintenance of equipment in the most appropriate way.

The purpose of production is to increase earnings and maintenance prevents unexpected suspension of production caused by equipment trouble.

Of course production cannot be performed only by maintenance but can be performed satisfactorily by close cooperation of various sections including engineering, maintenance, operation, management, etc.

PM can at least serve to harmonize maintenance and operation. Accordingly, maintenance work after modernization of the plant will be performed most efficiently by PM system. PM

aims at the increase of earnings by maintenance, but a very careful and rational method is required to attain the aim. However, such a perfect method has not yet been accomplished, although the efforts to make PM approach completeness are always continued.

The way PM is progressing in Japan will be described as follows.

## (2) Preparation for PM

- a. The current status of equipment maintenance is checked carefully. The reference point for measuring future progress is determined.
  - b. Important equipments are selected

Equipment which can increase earnings most effectively by apply PM are selected.

c. Important points are determined

Highly effective points of each important equipment in carrying out PM are determined.

d. The most economical repair limit is determined

The most economical repair limit of each machine is determined by comparing the effect of recovering the functions of the machine when it is deteriorated with the cost required for the repair.

e. Consent is obtained from related persons

The current status of maintenance and improvement expectation are explained to them to obtain their consent.

f. Organization is prepared

The most appropriate organization for obtaining the effect of PM is prepared and persons are arranged.

g. Rules and procedures are established

The most appropriate rules and procedures for obtaining the effect of PM are established.

#### (3) Carrying out PM

a. Equipment which has reached its repair limit is found

Equipments are inspected periodically not to miss the equipment which have reached their repair limit.

b. Proper repair is carried out

Repair which meets requirements most economically is carried out.

c. Appropriate improvement is undertaken

Appropriate improvement is undertaken to increase profit by saving maintenance cost and preventing the deterioration of equipments.

d. Proper renewal is carried out

Proper renewal is carried out by examining the change of conditions of repair limits

resulting from the deterioration of the equipment:

## e. Effects are checked to the transport of the state of t

The results of carrying out the PM are analyzed and investigated to check whether the expected profit has been obtained or not and undesirable points are corrected if there are any.

Profit which can be expected by carrying out PM comes from earnings obtained by production. The profit cannot be gained without production. Even if PM is carried out very well so that earnings may be increased, the valuable PM will give no fruit if there are defects in operation which cancel the effect of PM. Accordingly, proper control of operation must be carried out concurrently with PM.

The concept of PM, requires preparation before carrying out PM things to be done under the PM system have been listed above followed by brief explanation.

In Japan, PM system has been adopted in the procedures briefly explained above and great effect has been obtained, so that it is desirable to adopt this system referring to the Japanese example.

## (4) Proposal

Essentially, the mining equipment has been developed by the combination of various industries. In other words, they can be looked upon as a department store of technology. Accordingly, mining facilities cannot be improved without the improvement of the level of all the engineering fields — which cover mechanical, electrical, civil engineering, building, applied chemistry, metallurgical and industrial material industries, etc. — however hard the maintenance workers may make effort.

Accordingly, excessive demands cannot be placed upon the maintenance workers of Calavi Mine, but we believe it important to adopt the advanced maintenance techniques of developed countries positively from those which can be adopted and put them into practice surely.

Especially for the maintenance of equipment of the new large concentration plant which we suggest and for operation control and maintenance techniques, it is desirable to prepare a factory of wear resisting rubber lining near the mine and to equip sufficient instrumentation devices and further to make workers master the handling and maintenance techniques of various devices as early as possible.

According to the impression of our survey committee members, most of the native workers seem to be very dexterous and have obedient character, so that they will be able to master techniques early, if appropriate training and labor control are carried out.

निर्मात् के कि के के कि के हैं है कि कार और कि विकास कि एक एक कि किया के अन्यत कि है है कि कि का कुछ है।

## CHAPTER 6. ADMINISTRATION DEPARTMENT PLAN

## 6-1 Organization

Based on the results of research carried out last year, conceptual designs for a new mining method and new concentration mill plant together with a production program have been drawn up as a case study. The following organizational setup has been planned so as to provide an appropriate administration department for the execution of the above plan.

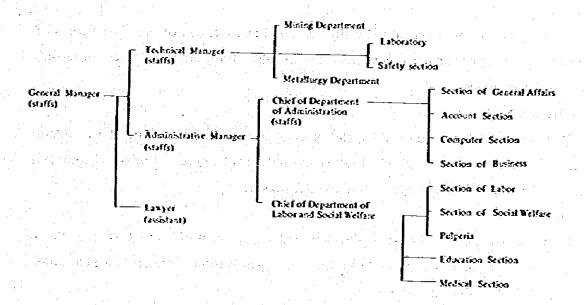


Fig. II-6-1 Organization

In the above plan, the Education and Medical Sections have been prepared taking the circumstances at the site into consideration. An Administrative Manager controls two subordinate departments and their respective sections to reinforce the administrative activities.

The tasks allotted to each section are as follows. General Affairs Section:

Management and control of the receiving and sending of documents, wireless telecommunications, telephone exchange room, data room, club for visitors; management of mining rights, land, land surface rights, water rights, and corporeal fixed assets; cleaning and security of premises; and public relations with the community.

## Accounts Section:

Financing, accounting, cost accounting, budgeting and settling accounts.

## Computer Section:

Calculation of wages, receipts and payments of material supplies, costs, mined quantities and others.

#### **Business Sections:**

Management and control of materials warehouses (purchasing, receipts and payments, and storage) and printing shop; management of one deliveries, transportation of ones, materials and supplies, and vehicle operation; and the loading of concentrates.

#### Labor Section:

Formalities for employment and retirement, and arrangement of personal records of employees; preparations and arrangements for wage calculation; and arrangement of records related to labor unions.

#### Social Welfare Section:

Management, preservation and control of company residences, welfare clubs, athletic facilities, movie theaters, and lighting, heating and water for living; uplifting social consciousness; and planning and executing hygienic countermeasures.

#### Education Section:

Setting up education policies; employment and management of instructors; operation of special classes; purchases, receipts and payments, and preservation of materials for education; and integrated controls over each school.

#### **Medical Section:**

Setting up health policies, and planning and executing countermeasures for health and prevention; management of purchases, receipts and payments for medical instruments and drugs; management of employment etc. of doctors and nurses; management and operation of nurse-training schools.

#### 6-2 Personnel Planning

The personnel have been assigned as follows to ensure that the above organization fulfills its functions effectively.

事 机工程设施设备 人名格特特 医皮肤 网络拉斯尼亚 化二烯酸 计自由 电电流 电电流 医皮肤 医多种异类 医电子 医二

Table 11-6-1 List of Personel of Administration department

	Salaried Worker	Day Labour	Total
Leading members	6 per	per	6 per
General manager, Technical and Administrative manager and staffs	18	je to <b>⇔</b> toj tega otoj	187 / /
General affair section	21	38	59
Account section	11		12
Computer section	8	1	9
Section of Business	26	46	72
Section of Labour	16	6	22
Section of Social Welfare	12	20	32
Pulperia	29	111 <b>12</b> 7 . 11 1 1 1	41
Education section	80	17	97
Medical section	50	18	68
Total	277 pei	159 per	436 per

Note: The 28 personnel for loading concentrates in the Business Section and the 68 personnel in the Medical Section are not included in the operating costs.

## 6-3 Construction Costs

Because the project has been based on the fundamental concept of a case study which can be applied to operational mining, differing from conventional projects which aim to newly develop ore deposits which have not yet been producing, no construction program has been provided for the department since it is thought that existing facilities should be utilized as much as possible. However, the changes in organization described in the previous section require some improvements and repairs to the offices, so that the necessary expenses for this have been appropriated. In addition, according to the plans described above, all of the production sites will come together in Siglo XX area while the major part of the administration department will remain in Catavi area. This will require good communication between the production sites and the administration department, so that an increase of vehicles has been projected to reinforce the communication system. The outlined construction costs for the administration department are as follows. (For a breakdown of the construction costs, refer to "Details of Construction Costs of Administration Department" in the Appendix.)

(1) Vehicles 15 x US\$ 12,000 (average) US\$ 180,00	(1)	Vehicles	15 x US\$	12,000 (average	e)	USS 1	80.00
---	-----	----------	-----------	-----------------	----	-------	-------

(2)	Business machines		1	
	Communication ins	truments	}	US\$ 175,000

(3) Improvem	ents to offices	 1 -1 -	USS	100,000
Total		 	USS	455,000

## CHAPTER 7. ECONOMIC FEASIBILITY OF THE PROJECT

## 7-1 Feasibility Study

Pre-tax incomes were in the black until 1979, but turned into the red after 1980, and the deficit for each of 1981 and 1982 reached about 15 millions dollars.

In this plan, the revenues and expenditures have been calculated on the premise that revenue should be raised by activating the merits of the plan as much as possible, obtainable from the collection of production sites into one area and the enlargement of the production scale with the modernization of various facilities. To put the premise concretely, the treatment capacity for crude ores has been vastly increased from the present 5,000 t/day up to 10,000 t/day, 9,000 t/day or 8,000 t/day.

The calculated results, as seen in Table II—7—4, show that the annual pre-tax revenue can be expected to be 6.4 million dollars with 10,000 t/day capacity, 7.6 million dollars with 9,000 t/day capacity and 5.6 millions dollar with 8,000 t/day capacity, which means some 21 million dollars increase in annual revenue. The incomes per ton of crude ore are 2.123 dollars, 2.799 dollars and 2.335 dollars for 10,000 t/day, 9,000 t/day and 8,000 t/day respectively, provided that the quotation is \$6/lb. The calculation result shows that an income improvement of some 12 dollars per ton of crude ores can be realized with the fundamental concept; i.e. collection of facilities, increase of production, utilizing of tailing and modernization of production management. Details are as follows.

#### (1) Cut-Off Grade

As shown in Table II-7-1, the operating cost calculated in the plan indicates that the cut-off grade is 0.28% tin content in the case of 10,000 ton production when the quotation is \$6/lb. An increment of the operating cost by one dollar per ton of crude ones requires a 0.01% lifting of the cut-off grade.

#### (2) Cut-Off Quotation

Based on the ore grade and the operating cost in the plan, the cut-off quotation is estimated to be \$5.29/lb in the case of 10,000 ton production. An increment of the operating cost by one dollar per ton of crude ores equals a rise of the quotation by 0.25 to 0.37 dollars per pound.

## (3) Construction Costs and Depreciation Expenses

A 10% increase of the construction cost results in a 0.437 dollars rise in the case of 10,000 ton production in depreciation expenses per ton of crude ore. This estimate is based on all funds being raised by loans and the capital being fully repaid within 10 years. When the operating cost for six months is borrowed as working capital, or one percent increase of the interest

necessitates a 0.287 dollars rise in the depreciation cost per ton of crude ore.

## 7-2 Discount Cash Flow (DCF) Calculation

Based on the Calculation of Revenues and Expenditures shown in Table II-7-4, the DCF has been calculated at \$6.0/lb quotation, 6% interest rate, and 35% total tax rate including 30% corporate tax and 5% other taxes which were not estimated in the Calculation of Revenues and Expenditures. The calculated results are listed in Table II-7-1, 2, 3, and the Internal Rate of Return are 10.50% for 10,000 1/day treatment, 10.79% for 9,000 1/day treatment and 9.95% for 8,000 1/day treatment; each of these is around 10%. As a result of a sensitivity analysis, a 10% income increase at 10,000 1/day treatment elevates the Internal Rate of Return from 10.50% to 13.25%. Increases of the operating and construction costs both lower Internal Ratio of Return; for 10,000 1/day treatment, a 10% increase in the operating cost reduces the Internal Ratio of Return by 1.6%, down to 9.31%. As shown above, such factors as a rise of quotation and an upturn in grade improve the Internal Ratio of Return remarkably. This represents the general characteristic of the mining industry, like the proverbial saying: "First if the ore situation, second is the market conditions, and fifth is technology, with nothing in third and fourth place."

# 7-3 Calculation of Revenues and Expenditures

#### 7-3-1 Calculation of Revenues

The calculation of revenues has been based on the whole amount of high-grade concentrates produced under the project being sold to the tin refinery at Vinto, Oruro City, which belongs to the Empresa Nacional de Fundiciones under the present terms of sale. The entire amount of low-grade concentrates is sold to the volatilization plant that is now under construction at Machacamarca by the Corporacion Minera de Bolivia, under the intracompany trade conditions which are being applied to a similar volatilization plant at Palca. The selling expenses are estimated also under conditions corresponding to the above, and the quotation is regarded as \$6/lb. Key results of the calculation of the amount of revenue are shown as follows, and details of the calculation are explained later.

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र निर्माणको व्यवस्थिति । अञ्चलिका विकास विकास में अभिन्न के अधिकार है। असे असे असे असे असे असे स्ट्रेसिका है।

केत्र वर्ति । इतिवादिक विवाद के कि कार्यक्ष के प्रवाद करिए । एक विकास ते विकास कार्यक विवाद विवाद विवाद विवाद

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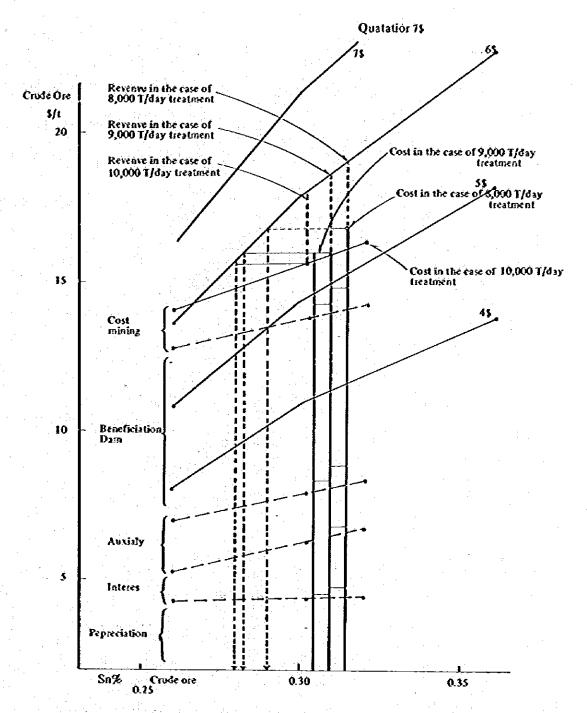


Fig. II-7-1 Net Income for Ton of Crude Ore by Grades Quotation and Cost

Table II-7-1 Profit/Loss Forecast and DCF Calculation (10,000 T/Dav)

		-					10,000 1/000	20					1,000 U.S.S	S.5
You	1	-	3	Þ	\$	9	4	. 8	6	10	11	12	13	Accum.
Processed Ore (1000T)	0	0	O	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	30,000
Sn-Cone H. (T)	•	•	0	10,557	10,557	10,557	10.557	10,557	10,557	10.537	8,310	8,310	8,310	98,830
Sn-Cone L. (T)	0	0	0	11,700	11,700	11,700	11,700	11,700	11,700	11,700	13,950	13,950	13.950	123,750
Not Revenue	0	<u>ہ</u>	0	58,431	58,431	58,431	58,431	58,431	58,431	58,431	41,007	41,007	41,007	832,040
Operating Cost	0	0	0	28,804	28,804	28,804	28.804	28,804	28,804	28.804	26,098	26,098	26,098	279,922
Operating Profit	0	0	0	29,627	29,627	29,627	29.627	29,627	20,627	29.627	14,909	14,909	14,909	252,119
(-) Depreciation	•	•	0	12,478	12,478	12,478	12,478	12,478	12,478	12,478	12,478	12,478	12,478	124,775
(-) Interest (6.00%)	•	3,075	5.375	7,487	7,225	6,0%	606.4	3,683	2,410	1,086	0	0	Ø	32,889
Profit Before Tax	0	0	0	6996	9,925	11,060	12,240	13,466	14,740	16.064	2,432	2,432	2,432	\$6.454
(-) Income Tax (35,00%)	0	0	0	3,382	3,474	1,871	4,284	4,713	5,159	5,622	523	883	\$\$1	33,059
Profit After Tax	0	•	0	6,281	6,451	7,187	7,956	8,753	9.581	10,441	1,581	1,581	1,581	61,395
() Initial Investment	\$1.258	35,251	29,816	0	c	0	0	٥	Ó	0	•	0	0	116,325
(-) Working Capital Change	•	•	•	14.402	0	0	0	0	0	0	-1.353	0	-13.049	٥
(*) Primary Bank Loans	\$1,258	38,326	35,191		0	6	0	0	0	0	0	Ó	0	124,776
(-) Loan Repayment	0	•	•	4,357	18,929	19,667	20,434	21,231	22,059	18,100	•	0	0	124,776
Surplus	•	•	0	_		.:	:			4,819	15,411	14,058	27,107	61,395
Debt Outstanding	51,258	89,584	124,776	120,419	101,490	81,823	61,390	40,159	18,100	Ö	0	0	0	Ó
Before Interest														
Rate of Return 10.50%				:					•					
Not Card Plow	-51,258	-35,251	978'67-	11,843	26,154	25,756	25,343	24,914	24.468	24,003	15.411	14,058	27,107	102,735
Discounted Cash Flow	-51,258	-31,901	8 4.45 -	8,777	17,541	15,633	13,920	12,384	11,007	9,772	2,677	4,687	8,178	0
														_

÷ :

Table II-7-2 Profit/Loss Forecast and DCF Calculation

						( <del>)</del>	(A:000 1/00(A)					Unite	Unit: 1,000 U.S.S	٠.
Year	-	7	: B	4	\$	9		æ	6	. 01	11	12	ន	Accum.
Processed Ore (1000 IT)	0	0	0	2,700	2,700	2,700	2,700	2,700	2,700	2,700	2,700	2,700	3,78	27,000
Sn-Cone If. (T)	0	6	0	9,174	9,174	9114	9,174	9,174	9.174	9.174	9,174	9,174	9.174	91,740
SmCone L. (T)	•	•	0	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	10,170	101,700
Not Revonue	•	٥	0	. 50,773	50,773	50,773	50,773	50,773	\$0,773	50,773	50,773	50,773	\$0,773	\$07,728
(+) Operating Cont	0	٥	•	25,670	25,670	25,670	25,670	25,670	25,670	25,670	25,670	25,670	25,670	236,699
Operating Profit	•	•	0	25,103	25,103	25,103	25,103	25,103	25,103	25,103	25,103	25,103	25,103	251,028
(+) Depreciation	0	•	0	11,595	11,595	11,598	11,595	11,595	11,595	11,595	11,595	11,595	11,595	115,953
() Interest (6.00%)	0	2,862	4,998	6,957	6,776	878'S	4,822	3,788	2,713	1,596	436	•	Ö	32,906
Profit Before Tax	0	0	0	6,550	6,732	2,690	8,685	9,720	10,795	11,911	13,072	13,508	13,508	102,170
(-) Income Tax (35,00%)	<b>-</b>	•	•	2,293	2,386	2,691	3,040	3,042	3,778	4,169	4,575	4,728	4,728	35,759
Profit After Tux	0	0	Ó	4,25%	4,375	4,998	5,646	8.318	7.017	7,742	×,497	8,780	8,780	66,410
() Initial Investment	47,706	32,739	27,647	0	•	0	•	0	Ö	. 0	0	0	0	108,092
(-) Working Capital Change	•	•	0	12,835	0	٥	0	Ó	٥	•	0	0	-12,835	Ö
(+) Primary Bank Loans	47,706	35,601	32,645	0	0	0	0	0	0	0	0	0	0	115,953
(-) Loan Ropaymont	0	0	0	3,018	12,971	16,594	17,241	17,913	18,612	19,338	77,267	0	Ö	115,953
Surplus	0	0	Ó	0	0	0	0	0	0	0	12,825	20,375	33,210	66,410
Debt Outstanding	47,706	83,307	115,953	112,935	96,964	80,370	63,129	45,216	26,604	7,267	•	0	0	0
Before Interest														
Kate of Keturn 10,79%	7	4			: 1									
Not Call Flox	47,706	-32,739	-27,647	9,975	22,747	22,411	22,063	21,701	21,328	20,934	20,528	20,378	33,210	107,177
Discounted Cash Flow	-47,706	-29,551:	-22,524	7,338	15,098	13,427	11,931	10.592	9 395	450.8	7,368	6,601	9.711	7

Table II-7-3 Profit/Loss Forecast and DCF Calculation (8,000 I/Day)

Year	-	"	6	4	× .	9	_	8	٥	2	11	ä	ដ	Accum.
Processed Ore (1000 T)	0	0	0	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2.400	2,400	2,400	24,000
Sn-Cong.K. (T)	0	0	٥	8,283	8,283	8,283	8,283	8,283	8,283	8,283	8283	8,283	8,283	82.830
SP-Cone L. (T)	0	0	•	9,183	9,183	9,183	9,187	9,183	9,183	6,183	9,183	9.183	9.183	91,830
Net Reverve	0	0	0	45.842	45,842	45,842	45,842	45,842	45,842	45,342	45,842	45,842	5,82	458,423
(-) Operation Cost	٥	0	0	23,745	27,12	23,744	23,744	23,74	23,744	23,744	23,744	37,53	23,744	37.440
Operating Profit	٥	٥	0	22,098	35,098	22,098	22,098	22,098	22,098	22,098	8601	22,098	22,098	220,983
(~) Dopreciation	•	0	0	10,914	10,914	10,914	10,914	10,914	10.914	10,914	10,914	10,914	10.914	109,140
(-) Interest (6.00%)	0	2,692	4,70	6,548	6,425	5,585	1,711	3,804	2,861	1,882	***	0	0	32,682
Profit Before Tax	٥	•	0	969'4	4,739	5,600	6,473	7,380	8,323	9,302	10.320	11.184	11,184	79,162
(-) Income Tax (35.00%)	•	0	0	1,623	1,666	1,960	2,266	2,583	2,913	3,256	3,612	3918	3,915	27,707
Profit After Tax	0	0	•	3,013	3,093	3,640	4,207	4,797	5,410	970.9	6.708	7.270	7,270	51,455
(-) Initial Investment	44,870	30,841	26,033	0	0	٥	0	0	0	0		0	•	
(-) Working Capital Change	•	0	0	11,872	0	0	O	0	Ó	0	Ó	•	-11,872	•
(+) Primary Bank Loan	44,870	33,533	30,737	٥	0	0	•	0	0	0	0	•	0	109,140
(-) Loan Ropaymens	٥	٥	•	2,055	14,008	14,554	15,121	15,711	16,324	196'91	14,407	0	٥	109,140
Surplus	0	0	Ġ	•	0	0	÷	0	0	0	3,215	18,184	30,056	\$1,455
Debt Outstanding	44,870	78,403	109,140	107.085	93,077	78,524	63,402	47,691	31,367	14,407	0	٥	0	<b>\$</b> ;
Before Interest											•			
Rated Return 9.95%														
Not Cash Mow	44,870	-30,841	-26,033	8,604	20,433	20,138	19,833	\$15,61	19,185	18,843	18,486	18,184	30,056	91,533
Discounted Cash Flow	44.870	-28,050	-21,534	6,473	13,981	12,532	11,225	10,006	. 286'8	8,023	7,139	6,405	879'6	•

(A) Por 10,000 t/day (1st-7th Year)	(\$1,000/day) 194.8	(\$1,000/year) 58,443	(\$/t of crude ore) 19.48
" (8th-10th Year)	136.7	41,007	13.67
(B) Por 9,000 (/day (10th Year)	169.2	50,779	18.81
(C) For 8,000 t/day (10th Year)	152.8	45,842	19.10

As a reference taking 10,000 t/day treatment as an example, changes in revenues per ton of crude ore by grades, caused by a \$1/lb change in the quotation, are as follows.

(Grade of crude ore)	0.34	0.32	0.30	0.28	0.26
(Change in dollars)	4.13	3.82	3.52	3.13	2.77

Calculation of Revenue (A)

Example A: 10,000 t/day treatment under new operating system

First Term (7 years after operation start): Income per day

1. Lot: Catavi tin concentrates (high-grade)

(1) Weight: 1,034 bags, wet wt. 36.2 t, moisture 2.8%, dry wt. 35.2 t (Sn 17.6 t)

(2) Grade: Sn 50%, Fe 6%, S 1%, As, Sb < 0.15%, Bi < 0.40%

(3) Quotation: US\$ 6.00/lb

(4) Value: US\$ 232,808 (17.6 x 2,204.62 x 6.00)

(5) Refining cost:

Recovery subtraction US\$ 6,984 (35.2 x 0.015 x 2,204.62 x 6.00)

Smelting and refining cost U\$\$28,356 (35.2 x 805.58)

Total US\$35,340

(No penalty condition applicable)

(6) Selling expenses:

(Mining site - Refinery)

Freight rate US\$ 243 (36.2 x 6.70)

Loading change US\$ 109 (36.2 x 3.00)

Bag cost US\$ 827 (1,034 x 0.80)

Insurance bill US\$ 70 (198.000 x 1.10 x 0.00032)

(Subtotal) US\$ 1,249

(Refining - Destination)

Marine transport charges US\$ 2,312 (17.6 x  $\frac{0.485}{0.5}$  x 135.42)

Carriage US\$ 922 ( " x 54.00)

Loading charges US\$ 102 ( " x 6.00)

Calculation of Revenue and Expenditure (Sum of 10 years)

					,000 t/day treatm	ent		
	· ·	A	rticle	First year~ 7th year Total	8th year ~ 10th year Total	Sum Total	9,000 t/day Treatment	8,000 t/day Treatment
ł				0.41%	0.22%	0.38%	0.41%	0.41%
			Mine	3,500t	2,000t	3,0501	2,500t	2,5001
		(per day)	Desmonte	0.27 6,500	0.21 8,000	0.27 6,950	0.27 6,500	0.21 5,500
		ğ		0.32	0.26	0.302	0.309	0.314
	Minim		Total	10,000	10,000	10,000	9.000	8,000
	31			10001	16904	10001	1000t	1000
	٦,		Mine	7,350	1,800	9,150	7,500	7,500
၌ ၂	1	٠.	Desmonte	13,650	7,200	20,850	19,500	16,500
ğ	1	17.		0.32	0.26	0.302	0.309	0.314
Production	4		Total	21,000	9,000	30,000	27,000	24,000
2	ŀ	Crade		50.0	45.05	48.76	50.0	50.0
١.	اي	ر ق	Dry Conc.	73,900t	24,9301	98,830t	91,7401	82,8301
	ĝ [	Sec.	Tin Metal	36,960	11,232	48,192	45,870	41,415
:   }	-		Recos.	55%	48%	53%	55%	55%
	oncentration	Conc.	~ .	4.10	4.40	4.2	4.1	4.1
و ا	ξĮ,	Š	Dry Conc.	81,900t	41,850t	123,750t	101,7001	91,8301
1	1	ž ď	Tin Metal	3,358	1,841	5,199	4,170	3,765
	_ [-	ĭŭ	Recov.	5%	7.9%	5.7%	5%	5%
	-	tatic	Value	6 \$/lb \$33,314. —	" 172,931.–	706,245.—	" 661,917	597,630
N	et	Rev	enue	409.104	123,022.	532,126	507,729	458,424.—
		-						
٠.			velopment	8,204	633	8,837	7,300	7,300
:	20	M	ne	24,535	6,009	30,544	25,430	25,430
2	Mining	De	smonte	3,822	1,953	5,775	5,460	4,830
2	Σ	1.0	hers	6,671	2,445	9,116	8,750	8,750
Operation cost		To	tal	43,232	11,010	54,272	46,940	46,310
Š	٠.	Co	ncentration	119,721	51,309	171,030	154,650	138,640
ដ		D <sub>2</sub>	m	3,346	957	4,303	4,110	3,430
င်			intenance	12,012	5,097	17,109	18,000	16,180
	1		ocratory Safety	2,625	1,089	3,714	3,660	3,540
: 1			ministration	10,843	4,647	15,490	15,490	15,490
			bour, Social	9,819	4,155	14,004	13,850	13,850
	L_	ľo	(a)	201,628	78,294	279,922	256,700	237,440
		D	preciation	01 849	20.263	,,,,,, T		1
			PILETAUOII	91,848	39,363	131,211	122,267	115,084
	<u>.</u>			· · · · · · · · · · · · · · · · · · ·				
	. :	lu l	ment of erests	48,376	8,924	57,300	53,183	49,850
			. D. A. — —				and the second second	
·		Ne	t Profit	67,252	△ 3,559	63,693	75,579	56,050

 Unloading charges
 US\$ 102 (17.6 x  $\frac{0.485}{0.5}$  x 6.00)

 Consular fees
 US\$ 1 ( " x 0.05)

 Commission
 US\$ 222 ( " x 13.00)

 Marine insurance
 US\$ 264 (198.000 x 1.1 x 0.00121)

 (Subtotal)
 US\$3,925

 Total
 US\$5,174

(7) Net income

US\$ 192,294

- 2. Lot: Catavi tin concentrates (low-grade, for volatilization)
  - (1) Weight: 800 bsgs, wet wt. 40 t, moisture 2.5%, dry wt. 39 t (Sn 1.599 t)
  - (2) Grade: Sn 4.1 %
  - (3) Quotation : US\$ 6.00/lb
  - (4) Value: US\$ 21,151 (1.599 x 2,204.62 x 6.00)
  - (5) Smelting and volatilization cost:

US\$ 17,310 [21,15] - (39 x 98.50) ]

Intracompany invoiced prices for

US\$ 6.00 quotation,

Sn 4%: US\$ 94.70/t,

Sn 4.2%: US\$ 102.30/t

(6) Selling expenses

Carriage US\$ 268 (40.0 x 6.70)
Loading charges US\$ 120 (40.0 x 3.00)
Bag costs US\$ 936 (800 x 1.17)
Total US\$1,324

(7) Net income US\$2,517

3. Revenue amount

US\$ 194,811 / day

US\$ 58,443,300 / year

US\$ 409,103,700 / 7 years

USS

19.48 / ton of crude ore

Second Term (8th to 10th year after operation start for three years)

- 1. Lot: Catavi tin concentrates (high-grade)
  - (1) Weight: 827 bags, wet wt. 28.6 t, moisture 3%, dry wt. 27.7 ( (Sn 12.48 t )
  - (2) Grade! Sn 45.05%, Fe 6%, S 1%, As, Sb < 0.15%, Bi < 0.40%
  - (3) Quotation : US\$ 6.00/16

(4) Value: US\$ 165,082 (12.48 x 2,204.62 x 6.00)

# (5) Refining cost:

Recovery subtraction US\$ 5,859 (27.7 x 0.01599 x 2,204.62 x 6.00)

Note: For Sn 50% (-) 1.5% base, add 0.02% (-) for each -1%,

 $\therefore -4.95 \times 0.02\% = -0.099\%$ 

Smelting and refining cost

US\$ 22,315 (27,7 x 805.58)

Total

US\$ 28,174

(No penalty condition applicable)

## (6) Selling cost:

(Mining site - Refinery)

Freight rate	US\$	192	(28.6 x 6.70)
Loading charges	US\$	86	(28.6 x 3.00)
Bag costs	US\$	662	(827 x 0.80)
Insurance bill	taria US\$	48	(137.000 x 1.10 x 0.00032

US\$ 988

(Subtotal)

(Refinery - Destination)	1 - 1 - p.		1. j.		
Marine transport charges	US\$ 1	,630	(12.48 x	0.43451 0.4505	x 135.42)
Carriage	US\$	650	( '	•	x 54.00)
Loading charges	USS	72	(	•	x 6.00)
Unloading charges	USS	72	(	•	x 6.00)
Consular fees	USS	1	,	•	x 0.05)
Commission	USS	156	( .	,	x 13.00)
Marine insurance	USS	182	(137.00	0 x 1.1 x 0	0.00121)
(Subtotal)	US\$2	,763			Tari Tari
Total	1221	751		1	A

(7) Net income

US\$ 133,157

## 2. Lot: Catavi tin concentrates (low-grade, for volatilization)

- (1) Weight: 958 bags, wet wt. 47.9 t, moisture 3%, dry wt. 46.5 t (Sn 2.046 t)
- (2) Grade: Sn 4.4%
- (3) Quotation: US\$ 6.00/lb
- (4) Value: US\$ 27,064 (2.046 x 2,204.62 x 6.00)
- (5) Smelting and volatilization cost: US\$ 21,944 [ 27,064 (46.5 x 110.10) ]

(6) Selling expenses:

Carriage US\$ 321 (47.9 x 6.70)

186 a virtical

Loading charges US\$ 144 (47.9 x 3.00)

Bag costs US\$ 1,121 (958 x 1.17)

Total US\$ 1,586

(7) Net income US\$ 3,534

3. Revenue amount US\$ 136,691 / day

US\$ 41,007,300 / year

US\$123,021,900 / 3 years

US\$ 13.67 / ton of crude ore

(The entire amount for 10 years in Example A reaches US\$ 532,125,600)

Calculation of Revenue (B)

Example B: 9,000 t/day treatment under new operating system.

For whole term (10 years after operation start): Income per day

1. Lot: Catavi tin concentrate (high-grade)

(1) Weight: 899 bags, wet wt. 31.46 t, moisture 2.8%, dry wt. 30.58 t (Sn 15.29 t)

(2) Grade: Sn 50%, Fe 6%, S 1%, As Sb < 0.15%, Bi < 0.40%

(3) Quotation: US\$ 6.00/lb

(4) Value: US\$ 202,252 (15.29 x 2,204.62 x 6.00)

(5) Refinery cost:

Recovery subtraction USS 6.068 (30.58 x 0.015 x 2,204.62 x 6.00)

Smelting and refining cost US\$ 24,635 (30.58 x 805.58)

Total US\$ 30,703

(No penalty condition applicable)

(6) Selling expenses:

(Mining site - Refinery)

Freight rate US\$ 211 (31.46 x 6.70)

Loading charges USS 94 (31.46 x 3.00)

Bag costs US\$ 719 (899 x 0.80)

Insurance bill US\$ 61 (172,000 x 1.1 x 0.00032)

(Subtotal) USS 1,085

(Refinery - Destination)			· · · · · · · · · · · · · · · · · · ·	
Marine transport charges	USS	2,008	(15.29 x	$\frac{0.485}{0.5}$ x 135.42)
Carriage	US\$	801	( , '	x 54.00)
Loading charges	US\$	89	( '	x 6.00)
Unloading charges	US\$	89	•	x 6.00)
Consular fees	US\$	1	. (	x 0.05)
Commission	US\$	193	(	x 13.00)
Marine insurance	US\$	229	(172.000	0 x 1.1 x 0.00121)
(Subtotal)	USS	3,410	, S	
Total	US\$	4,495	•	
Net income	US\$ 1	67,054		
	Marine transport charges  Carriage  Loading charges  Unloading charges  Consular fees  Commission  Marine insurance  (Subtotal)  Total	Marine transport charges USS  Carriage USS  Loading charges USS  Unloading charges USS  Consular fees USS  Commission USS  Marine insurance USS  (Subtotal) USS	Marine transport charges US\$ 2,008  Carriage US\$ 801  Loading charges US\$ 89  Unloading charges US\$ 89  Consular fees US\$ 1  Commission US\$ 193  Marine insurance US\$ 229  (Subtotal) US\$ 3,410  Total	Marine transport charges USS 2,008 (15.29 x)  Carriage USS 801 ( " Loading charges USS 89 ( " Unloading charges USS 89 ( " Consular fees USS 1 ( " Commission USS 193 ( " Marine insurance USS 229 (172.000 (Subtotal) USS 3,410  Total USS 4,495

- Lot: Catavi tin concentrate (low-grade, for volatilization)
  - (1) Weight: 695 bags, wet wt. 34.77 t, moisture 2.5%, dry wt. 33.9 t (Sn 1.39 t)
  - (2) Grade: Sn 4.1%
  - (3) Quotation: US\$ 6.00/lb
  - (4) Value: US\$ 18,387 (1.39 x 2,204.62 x 6.00)
  - (5) Smelting and volatilization cost : US\$ 15,048 [18,387 (33.9  $\times$  98.50)]
  - (6) Selling expenses:

Carriage	US\$	233	(34.77 x 6.70)
Loading charges	US\$	104	(34.77 x 3.00)
Bag costs	USS	813	(695 x 1.17)
Total Test of the grant total	US\$	1,150	
Net income	US\$	2,189	
enue amount US	\$	69,243	/ day
T T		***	<u>.</u> 1

Reve

US\$ 50,772,900 / year

US\$507,729,000 / 10 years

USS 18.805 / ton of crude ore

## Calculation of Revenue (C)

(7)

Example C: 8,000 t/day treatment under new operating system.

For whole term (10 years after operation start): Income per day

- 1. Lot: Catavi tin concentrate (high-grade)
  - (1) Weight: 812 bags, wet wt. 28.41 t, moisture 2.8%, dry wt. 27.61 t (Sn 13.805 t)
  - (2) Grade: Sn 50%, Fe 6%, S 1%, As, Sb < 0.15%, Bi < 0.40%

(3) Quotation: US\$ 6.00/16

(4) Value: US\$ 182,609 (13.805 x 2,204.62 x 6.00)

(5) Refinery cost:

Net yield subtraction US\$ 5,478 (27.61 x 0.015 x 2,204.62 x 6.00)

Smelting and refining cost US\$ 22,242 (27.61 x 805.58)

Total USS 27,720

(No penalty condition applicable)

(6) Selling expenses:

(Mining site - Refinery)

Freight rate	US\$	190 (28.41 x 6.70)
Loading charges	USS	85 (28.41 x 3.00)
Bag costs	USS	650 (812 x 0.80)
Insurance bill	USS	55 (155.000 x 1.1 x 0.00032)
(Subtotal)	US\$	980

(Refinery - Destination)

Marine transport charges	USS	1,813 (	(13.805 x	$\frac{0.485}{0.5} \times 135.42)$
Carriage				x 54.00)
Loading charges	USS	80 (	( "	x 6.00)
Unloading charges	USS	80 (		x 6.00)
Consular fees	USS	9.741		x 0.05)
Commission	USS	174 (		x 13.00)
Marine insurance	USS	206 (	155.000	(1.1 × 0.00121)
(Subtotal)	US\$	3,077		
Total	USS	4,057	•	androne in the Ausgrafia and a

(7) Net income

US\$ 150,832

2. Lot: Calavi tin concentrate (low-grade, for volatilization)

(1) Weight: 628 bags, wet wt. 31.39 t; moisture 2.5%, dry wt. 30.61 t (Sn 1.255 t)

(2) Grade: Sn 4.1%

(3) Quotation: USS 6.00/lb

(4) Value: US\$ 16,601 (1.255 x 2,204.62 x 6.00) 1 diagram of the second of the second

(5) Smelting and volatilization cost: US\$ 13,586 [16,601 - (30.61 x 98.50)]