# REPORT ON MINING DEVELOPMENT PLAN

# OF

# ISCAYCRUZ (OYON) AREA

# REPUBLIC OF PERU

MARCH 1986

JAPAN INTERNATIONAL COOPERATION AGENCY

METAL MINING AGENCY OF JAPAN

# REPORT ON MINING DEVELOPMENT PLAN

# OF

# ISCAYCRUZ (OYON) AREA

# REPUBLIC OF PERU



MARCH 1986

JAPAN INTERNATIONAL COOPERATION AGENCY

METAL MINING AGENCY OF JAPAN

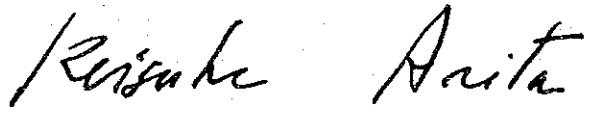
## PREFACE

The Government of Japan, in response to a request by the Government of the Republic of Peru, decided to conduct a preliminary study on the feasibility of the development of the Iscaycruz area located in the northeast part of Lima Department, and entrusted its execution to the Japan International Cooperation Agency (JICA). JICA consigned the project to the Metal Mining Agency of Japan (MMAJ), in that it belongs to a special field involved in mineral resources development.

The study was conducted from October, 1985 to February, 1986, and was completed as scheduled under close cooperation with the Government of the Republic of Peru and its various agencies, especially Instituto Geologico Minero y Metalurgico (INGEMMET), and Ministerio de Energia y Minas.

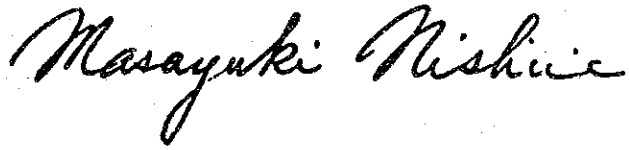
We wish to express our heartfelt gratitude to the Government of the Republic of Peru and the agencies and organizations concerned as well as the Ministry of Foreign Affairs, the Ministry of International Trade and Industry, the Embassy of Japan in Peru and the companies concerned for the cooperation and support extended to the Japanese survey team.

March, 1986



Keisuke Arita

President
Japan International Cooperation Agency



Masayuki Nishiie

President
Metal Mining Agency of Japan

## ACKNOWLEDGEMENTS

This report summarizes the results of the study carried out by the International Development Center of Japan, entrusted by the Metal Mining Agency of Japan.

The objective of the study was to formulate a plan to exploit copper, lead and zinc deposits existing in the Iscarycruz area located in the northeast part of Lima Department in the Republic of Peru, and to analyze its related economic effects.

It is my sincere wish that this study will contribute to the regional development in the area and further the economic development of the Republic of Peru, and that it will also help strengthen the friendly and cooperative relationship between Peru and Japan.

The members and schedule of the survey team are shown on the attached sheet. We would like to express our gratitude to the Government of Peru and its agencies concerned for their positive support and to the Embassy of Japan in Peru for its guidance during our team's stay in Peru. In particular, Instituto Geologico Minero y Metalurgico and Ministerio de Energia y Minas gave valuable advice and cooperation to the team.

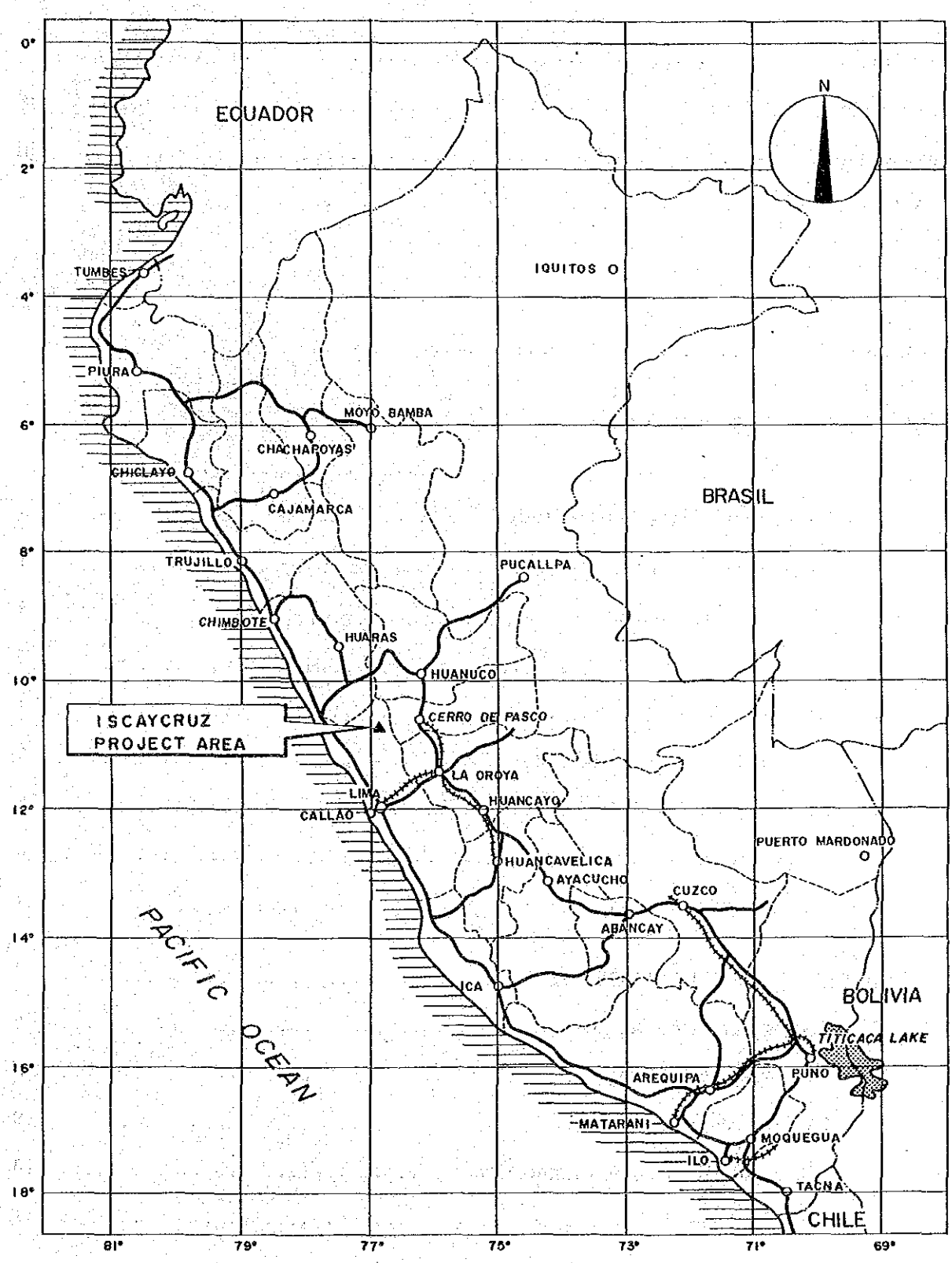
My deep appreciation is also extended to the Ministry of Foreign Affairs, the Ministry of International Trade and Industry, the Japan International Cooperation Agency, and the Metal Mining Agency of Japan for the guidance and support they gave us in performing the study.

March, 1986

Saburo Kawai

President
International Development Center of Japan

# ISCAYCRUZ PROJECT INDEX MAP



## TABLE OF CONTENTS

## LIST OF DRAWINGS

| DRAWING No. | Title of the Drawing |
|---|---|
| 001 | Index Map |
| 002 | Geological Map of the Iscaycruz Area |
| 003 | Mine Site General Layout |
| 004 | Underground Structure Section & Surface |
| 005 | Underground Structure Plan |
| 006 | Underground Structure Plan |
| 007 | Concentrator Basic Flow Diagram |
| 008 | Concentrator Location & Crushing Plant |
| 009 | Concentrator Plan & Section |
| 010 | Tailing Pond |
| 011 | Power Plant General Layout |
| 012 | Electric Power Distribution System |
| 013 | Welfare Facilities Residential Area |

## APPREVIATION USED

| | | | | | |
|---|---|---|---|---|---|
| mm | : | Milimeter | ...°...' | : | Degree, minute (Angle) |
| cm | : | Centimeter | ø | : | Diameter |
| m | : | Meter | ppm | : | Parts per million |
| km | : | Kilometer | HP | : | Horse power |
| ft,...' | : | Foot | A | : | Ampere |
| ..." | : | Inch | V | : | Volt |
| $m^2$ | : | Square meter | kV | : | Kilovolt |
| $,^3$ | : | Cubic meter | W | : | Watt |
| $ft^3$ | : | Cubic feet | kW | : | Kilowatt |
| $yd^3$ | : | Cubic yard | MW | : | Megawatt |
| g | : | Gram | MWh | : | Megawatt hour |
| kg | : | kilogram | Hz | : | Hertz |
| t | : | Metric ton (dry) | MHz | : | Megahertz |
| wt | : | Metric ton (wet) | kVA | : | Kilovolt ampere |
| lb | : | Pound | S/. | : | Soles (Peruvian currency) |
| oz | : | Troy ounce | ¥ | : | Yen (Japanese currency) |
| g/t | : | Gram per metric ton | $ | : | United States dollar |
| $m^3$/sec | : | Cubic meter per second | ¢ | : | United States cent |
| $m^3$/min | : | Cubic meter per minute | | | |
| $m^3$/day | : | Cubic meter per day | | | |
| t/hr | : | Metric ton per hour | | | |
| t/yr | : | Metric ton per year | | | |
| $kg/cm^2$ | : | Kilogram per square centimeter | | | |
| °C | : | Degree Centigrade (Temperature) | | | |

# ABSTRACT

## ABSTRACT

Complying with the Peruvian Government request in 1985, preliminaly survey as well as the subject feasibility study, infrastructure to be related to develop the mine and economic intention for the district was conducted at the Iscaycruz district, which indicated high potentiality of occurrence of copper, lead and zinc deposits under the scheme of "Cooperative Mineral Exploration" since 1979.

The survey was carried out by the feasibility study team which comprised with six specialists from Japan International Cooperation Agency (JICA) and Metal Mining Agency of Japan (MMAJ) as a special participant together with the five Peruvian counter partners of Instituto Geologico Minero y Metalurgico (INGEMMET).


## 1. MINE DEVELOPMENT

Ore reserves: Iscaycruz mineralized zone exist in the area situated geologically in "Sub-Provincia Polimetalica del Altiplano" of "Provincia Metalogenica Andina Occidental". In the Iscaycruz mineralization, two types of deposits are distributed with the zonal arrangement; the massive sulphide deposit associated with copper, lead and zinc metals occurred by contact metasomatism to be characterized with the skarn rocks, and the hydrothermal alternation deposits disseminated of lead and zinc in the siderite layers. At the Limpe district of Iscaycruz zone where the survey was conducted closely by tunnelling and diamond drilling, ore reserves were calculated with applying the polygon method as follows;

| Kind of ore | Ore reserves (1,000 t) | Ag (g/t) | Cu (%) | Pb (%) | Zn (%) |
|---|---|---|---|---|---|
| Pb·Zn ore | 3,257 | 48 | 0.13 | 1.95 | 18.99 |
| Cu ore | 102 | 32 | 2.84 | 0.03 | 0.39 |

Mining: While the operation by the open pit is difficult in order to this district locates in the deep valley where the high mountains of 5,000 m run to E-W, mechanized Cut & Fill mining method will be adopted on this mine operation. Mining will be conducted at four levels with the interval of 40 m (0 m; set at the elevation of present S-adit, +40 m, +80 m and +120 m; set present N-adit of 4,690 m above sea level), and main haulage level to deliver the ore to the concentrator will be established at 0 m level.

Ore mined out is correspondingly delivered to the four main ore passes which are connected to the 0 m haulage level through the trackless incline shafts from the stopes. Waste come from the tunnels and drifts is utilized for the filling materials, and the pebbles and gravels of the talus at the surface are used supplimentary. Two trackless inclines will be provided from the surface during the detail survey and development periods, and prior mining, these inclines will be connected to the main ore passes at each correspondent levels. All underground water are guided to the 0 m haulage level through the trackless inclines by the natural flow, and a fan is installed to boost the natural ventilation. Combination of Mobile jumbo mounted the middle size rock drill with 100 mm piston dia., 3.5 $yd^3$ LHD (Load & haul dump wheel loader) and 8 t trolley locomotive will be engaged on mining operation and tunnelling works. AN-FO explosives is used mainly for blasting.

85% of the extraction factor and 15% of the contamination to waste are expected on the operation.

Concentrator: Based on the test results of the composite samples taken from the adits N and S, streight differencial flotation method will be achieved to the good flotation performance, and following performance is expected on the actual operation.

| | Grade | Recovery |
|---|---|---|
| Pb-concentrate | 65% Pb | 80% of Pb and 15% of Ag |
| Zn-concentrate | 52% Zn | 88% of Zn and 58% of Ag |

The concentrator is in the capacity of max. 825 t/day, and composed of four plants of crushing, grinding, flotation and filtration. Two identical parallel circuits system will be adopted at the grinding and flotation plants. Main equipment used are: a 42" x 30" single toggle crusher, a 5' hydraulic cone crusher, two 9' x 12' ball mills, 16 units of 60 $ft^3$ flotation cells for Pb flotation, 36 units of 60 $ft^3$ flotation cells for Zn flotation and two pressed type filters.
The feed size to the flotation is in 74 micron of passing 80% to applied to the streight differential flotation. Both the concentrates of Pb and Zn are transported by the trucks to the port Callao.

Environmental facilities: Zn flotation tailing will be sent to the tailing pond by gravity through the pipe line, after it was thickened with a 18' callow cone and a 50'ϕ thickener. Sand and slime separate piling method is applied for making the dam, and the clear water separated from solids will be discharged into the Yarahuaino valley. Overflow of the thickener is re-used at the concentrator.
Underground water is guided to the tailing pond and delivered at the pH value of neutral into the Yarahuaino valley, after the slacked lime is added and mixed with clear water of the pond for neutralization.

Other plans: Annual power demand is expected in 15,600 MWh and maximum requirement of 2,500 kW for the mine operation. But, there are no power plants to be purchased in this area. Although some studies for prospectability in this area are progressively carring on by ELECTRO Peru, probably its completion will be in 15 years later at most earlier cases. So that, own mine diesel generators of 2,500 kW are installed to supply the power to the mine operation.
The lake Queliaycocha is used for the source of mine water as much of 1,920 $m^3$/day for both the industrial and domestic requirement. At the concentrator, 30% of total requirement is re-cycled in the plants.
11 km of access road to the mine site are constructed newly and some parts of the public road are necessary to make the detour and innovation although there exsist the road constructed tentatively for the survey but they are too rough and can not afford the mine activity.
For the welfare facilities, company's residential houses are not only provided but communication center, school and clinic, and canteen etc. are also provided for supplying the foods and daily necessary goods. The proposed population will reach to about 1,500 including their families.

Detailed surveys by drilling (4,365 m) and tunneling (1,763 m) are planned to confirm the horizontal and perpendicular shape, elongation and occurrence of ore

deposit, ore reserves and ore grades forcussing the target to the limits above S-adit level (4,570 m/above sea level) of Limpe ore deposit, and declined drillings at S-adit are also planned to grasp the ore potential of the limits below S-adit level.

Production plan: 750 t/day of crude ore will be mined and treated with 300 day-operation an annum having the mineable ore reserves of Pb-Zn existed in Limpe deposit (above the present S-adit). The production plan is as follows, and the mine life is 10 years.

| Item | Tonnage (t) | Ag (g/t) | Cu (%) | Pb (%) | Zn (%) |
|---|---|---|---|---|---|
| Mineable ore | 2,050,000 | 35 | 0.10 | 1.61 | 15.92 |
| Tonnages/annum | 225,000 | 35 | 0.10 | 1.61 | 15.92 |
| Pb-concentrate/ " | 4,458 | 265 | 0.20 | 65.00 | 4.02 |
| Zn-concentrate/ " | 60,618 | 75 | 0.26 | 0.26 | 52.00 |

Manpower: All mine works are performed under the company's administration except the transportation of concentrates. Manpower requirement are 400 at the mine site and 14 in Lima head office, totalling 414. 260 day per man per annum is adopted to estimate the number of requirement.

Development schedule: Five years are scheduled to the completion of works as follows:

Two years : for detail surveying and feasibility study
One year : for detail design and financing
Two years : for construction and development

Investment: The initial investment are estimated as follows: (Based on as of Oct. 1985)

| Item | Amount ($1,000) |
|---|---|
| Production, auxiliary and welfare facilities | 25,211 |
| Construction Management etc. | 1,602 |
| Inventory | 200 |
| Contingency | 1,891 |
| Detailed survey and feasibility study | 3,095 |
| Detailed design etc. | 451 |
| Interest during construction period | 1,734 |
| Working capital | 2,195 |
| Initial Investment Total | 36,379 |

Additional investment and replacement cost: Totaling $2,877,000 of $475,000 for the additional and $2,402,000 for the replacement are estimated based on as of Oct. 1985.

Operation cost: Yearly operation cost is expected as follows: (Based on as of Oct. 1985)

| Item | Amount ($1,000) | $/t ore |
|---|---|---|
| Production (mining & concentration) | 4,090 | 18.18 |
| Maintenance & administration | 1,115 | 4.95 |
| Subtotal | 5,205 | 23.13 |
| Concentrates hauling & ship loading | 1,758 | 7.82 |
| Tax and commission | 353 | 1.57 |
| Total | 7,316 | 32.52 |

## 2. Infrastructure

Transportation: The route to the mine from Lima, the base for procuring and transporting materials and equipment during the mine development and operation, and from Callao, a shipping port used to export concentrates is Lima/Callao - Rio Seco (Pan American Highway) - Sayan - Churin - Oyon (National Road No. 16), totaling 270 km. The busy section from Lima/Callao to Sayan, most of which is asphalt-paved, has no problems. The section of National Road No. 16 from Sayan to Churin along the Huaura river, on the other hand, may be destroyed by floods and cut off traffic completely during the rainy season, especially from January to March. The annual average period of traffic cut-off is 15 - 20 days, with most of them usually occuring in March. The responsibility for the repair work is currently taken by the Ministry of Transportation and Communication and two mines (Raura and Uchuc Chacua) which use the road. When the Iscaycruz mine is developed, however, the mine probably needs to consider participating in the repair work or sharing in the cost.

Since the destruction of the road during the rainy season is quite predictable, it is more important to seek a permanent solution to the problem than to repeat temporary repairs and improvements. National Road No. 16 is one of the few Peruvian east-west arterial roads connecting Huacho on the Pacific coast to Pucallpa, a center of the forest region. The section between Churin and Oyon (30 km long) is as narrow as 3 - 4 m. The section between Oyon and Mishuya, which is a municipal road and in bad condition, will need partial repairs, improvement and reconstruction when developing Iscaycruz.

In this connection, trucks of 25 - 30t capacity can go through from the Pan American Highway to Oyon, and trucks of at least 20t capacity can go through to Mishuya. There is a temporary road used for the mine investigation from Mishuya to Iscaycruz (11 km long), which is passable only by trucks of 6t capacity or less. The mine development will require this road to be reconstructed if it is to serve the mine.

Electric Power: The electric power supply system is not well provided in the vicinity of Iscaycruz except in the Raura and Uchuc Chacua mines now in operation. Although there are small-scale public hydraulic or diesel electric power plants in Churin, Moroc and Oyon, they generate no more than 444 kW of electricity altogether, and the range of distribution is very limited. Raura and Uchuc Chacua mines have their own hydraulic and diesel power plants.

ELECTRO Peru is now conducting an extensive survey on the construction of hydro-electric power plants in the Huaura River basin; the plan is a large-scale one, including the construction of seven plants which generate 393.5 MW in total. In terms of feasibility, however, it is not certain whether any of them can be constructed by 1995. Therefore, these plants cannot be expected to be a source of electricity supply to the mine. It is also extremely difficult to purchase electricity from existing power plants, because the power-transmission line required is too long for a mining company to install and maintain. The mine will have to construct its own power plant.

Water Resources: The greatest use of water in the Huaura river basin is for irrigated agriculture, which has developed in topographically suitable areas in the middle and upper reaches of the Huaura river and along its tributaries. The Raura and Uchuc Chacua mines utilize lakes located in the mountain area in addition to rivers to store the necessary water and generate electric power.

From the hydrological and meteorological point of view, the lower reaches of the Huaura river are basically desert with very little rain, but precipitation increases gradually along the upper reaches, amounting to 1,700 mm annually in the northernmost upper reaches. According to the analysis of existing data, the annual precipitation in the Iscaycruz area is estimated at 1,100 mm, and the annual inflow into Lake Quellaycocha, located within the mining area, is estimated at about 1,000,000 $m^3$, the total of which exceeds the annual demand of about 690,000 $m^3$ by the mine. During the dry season, the lake, whose storage capacity is estimated at about 2.4 million $m^3$, can be utilized to cope with seasonal fluctuations. It is recommended that Lake Quellaycocha should be used as a natural reservoir to supply the water required for mining operation.

Communication: Whereas the Pacific coastal area and main cities are provided with cable telephone lines and microwave circuits, a large part of the mountain areas is not well provided with such services. Communication systems are also poor in the area concerned, where projects for system expansion and improvement have been suspended. Public facilities in the surrounding areas consist of a single cable telephone line connecting Sayan, Churin and Oyon to one another provided by ENTEL Peru, which could not meet the needs of the mine. The mine will need to establish its own system.

The Labor Force and Mine Camp: Data on the numbers of unemployed and underemployed workers in the area concerned is scant, but it is presumed that about 25% of the unskilled workers among the 400 total required personnel, can be locally supplied. There is also a high possibility of recruiting some laborers and employees experienced in mining, from coal and other mines existing in the area.

As candidates for the best site for the mine camp, the mining district itself and communities in nearby areas are possibilities. However, there seems to be no

other choice than set it up in the mine, if we consider the distance from existing communities, road conditions, the scale of the mine, and the examples of neighboring mines (Raura and Uchuc Chacua). The location of the mine camp should preferably be near Lake Quellaycocha, thus separating it from the production quarters to secure better living conditions. Attention should be paid to the layout of the mine camp; two residential areas, one for employees and workers and the other for the staff, should be separate as commonly observed in other Peruvian mines and share social service facilities within an equal distance from each.

### 3. The Overall Evaluation

Financial Evaluation: Expenditure and income were assessed on the assumption that a Special Mining Company would be established under the Peruvian General Mining Law and that all privileges provided by the current law system as of October, 1985 would be given to the company.

The assessment period is ten years, and factors for the assessment are based on prices as of October, 1985, except for quoted metal prices, without consideration of inflation during the mine development and operation period. All produced concentrates (Pb and Zn) are supposed to be exported. It is assumed that silver will be quoted at ¢700/oz, lead at ¢25/lb, and zinc at $900/t.

It is also assumed that about 25% of the investment in the development will be covered by owned capital paid in cash to the Special Mining Company, and the remainder will come from borrowed money at an interest rate of 9%, which is to be repaid in equal ten-year installments after the start of production with a two-year grace period during the development. All the costs of detailed survey, feasibility studies and detailed designs which will be incurred before the start of development works are assumed to be covered by the capital of the company. Accelerated depreciation of 20% per year was applied to the initial and additional investments and replacement costs.

The total profit/loss balance during ten years of operation are estimated as follows:

| | ($1,000) |
|---|---|
| Total revenue | 128,819 |
| Total cost | 124,269 |
| Profit before deduction | 4,550 |
| Deductions | 599 |
| Profit before tax | 3,951 |
| Income tax | 825 |
| Profit after tax | 3,126 |
| Financial internal rate of return (F.IRR) | |
| as against investment | 7.68% |
| as against capital | 3.56% |

Economic Evaluation: The economic benefit of the Iscaycruz mine development from the national economic point of view is the acquisition of foreign currencies by exporting the concentrates produced, and this benefit (on an FOB and dollar basis) represents a direct financial benefit since the financial evaluation is based on prices in dollars. To convert financial costs into economic

costs which are needed to assess national economic benefits, several assumptions were made for taxes, labor costs and foreign exchange rates. On the basis of such assumptions, the costs of startup and operation, additional investments, replacement costs and residual value were converted from financial cost terms into economic cost terms.

The economic internal rate of return (E.IRR) was calculated at 24.99% from the annual series of economic benefit and cost obtained above.

Sensitivity Analysis: According to the financial and economic evaluation, the internal economic rate of return is as high as 29.36%, while the internal financial rate of return for entire investment is at 7.68%. Improvement in the internal financial rate of return would need either to increase income or to reduce expenditure. Although factors for such increase and decrease cannot be easily identified or clarified in terms of their nature and combinations in the present stage of the study, sensitivity analysis was made on the following assumptions.

| | Assumed Cases | Internal Financial Rate of Return (%) |
|---|---|---|
| (1) | Use of the machinery and equipment of currently non-producing domestic mines | 9.9 |
| (2) | Increased grade of Zn at the expense of Zn concentrate recovery | 8.7 |
| (3) | Exemption from import tariffs on machinery and equipment | 8.9 |

Effects on the Local Communities: Although various effects will conceivably be exerted on the neighboring communities by the Iscaycruz mine development, they may be classified into four categories: effects of newly generated income, effects of improvements in infrastructure, effects of an increase in population, and effects of productive activities on natural environment. Newly generated income, among other things, seems to be the most significant and was considered here. One of the improvements in infrastructure would be the participation in construction and improvement of roads near the mining district, and in the repairs of the flood-destroyed sections of National Road No. 16. In particular, the repairs of the national road is important to the area concerned. In this regard, however, a great contribution is not expected from the mine development because the Ministry of Transportation and Communication and the Raura and Uchuc Chacua mines have already largely undertaken repairs and maintenance.

Workers and their families who would migrate from outside the area concerned are estimated at over 1,000, even if a total of only 400 jobs are created by the mine development and part of the workers are locally recruited. Net increase in the total annual income is estimated at about one million dollars, and also capital income will increase. Against the background of these facts, most of the other economic effects on the local communities by the mine development will

come from the consumption of locally produced goods by consumers, such as the camp residents and the mining company. Various uncertain factors, however, make it difficult to quantify the consumption, and therefore, three alternative scenarios --optimistic, pessimistic, and neutral -- were chosen to estimate the amount of money (sales) that might be locally earned through consumption.

($1,000)

| | Optimistic | Pessimistic | Neutral |
|---|---|---|---|
| Agricultural products | 15.1 | 3.3 | 8.0 |
| Livestock products | 41.2 | 9.1 | 20.3 |
| Other | 298.4 | 59.7 | 118.3 |
| Total | 354.7 | 72.1 | 146.6 |

According to these estimates, the amount of money earned is at most $355,000 and at least $72,000 per year. As far as the six items of agricultural and livestock products are concerned, a maximum increase of 27% and a minimum increase of 6% from their respective current outputs is expected. Thus the economic impact through consumption may be large as compared with the current scale of the local economy, though the absolute value of the new gain will not be so large.

From a broad point of view, the mine's participation in the repairs and maintenance of National Road No. 16, as well as increases in employment and income, have major implications for regional and national planning.

## 4. Fact Findings and Recommendation

Fact Findings of the Overall Evaluation: The high internal economic rate of return indicates that investment in this project is feasible from the Peruvian national economic point of view. It is accordingly recommended that the Peruvian government take a positive attitude toward the project to promote the mine development, which also has a major economic effect on the local area.

Policy Recommendations: In consideration of the low internal financial rate of return (despite the high internal economic rate of return), it is recommended that the Peruvian government will adopt such measures as tax incentives, partial payment of infrastructure cost, and low-interest financing.

Technical Recommendations: If the conditions assumed in this report change and as a result the internal financial rate of return rises, it would be recommended that the company, as the executor of the project, carry out the following: precise prospecting; consideration of the possibility of using idle machinery and equipment; study and investigation of the characteristics and quality of Ag, and a method of improving the grade of Zn-concentrate.

Future Outlook: In addition to the Limpe deposits of Iscayeruz, the Limpe south deposits and Chupa deposits which have already been discovered are expected to be exploited (with the main focus on the Limpe deposits) for their favorable influence on the national economy contribution to the development of the local area.

# CHAPTER 1 INTRODUCTION

# CHAPTER 1 INTRODUCTION

## 1. FORWARD

Complying with the request of the Peruvian Government, the Japanese Government commissioned the Japan International Cooperation Agency (JICA) and the Metal Mining Agency of Japan (MMAJ) to perform the survey, "Cooperative Mineral Exploration in the Oyon area" under the scheme of the bilateral technical cooperation, in close cooperation with Instituto Geologico Minero y Metalurgico (INGEMMET). This survey conducted from 1979 to 1981 indicated the Iscaycruz area, the object area of this project, as a potential area of an occurrence of the massive Cu-Pb-Zn deposit.

Subsequently in response to the request, JICA and MMAJ carried out the second survey, "Cooperative Mineral Exploration in the Iscaycruz (Oyon) area" from 1982 to 1984 and this survey confirmed the occurrence of the high-grade irregular massive Cu-Pb-Zn deposit.

The Iscaycruz mineralized zone containing the high-grade Cu-Pb-Zn deposit is situated about 7 km SSW to Oyon at the elevation of 4,700 m above sea level. The zone extends about 12 km in the limestone of Santa formation about 50-100 m thick in the Cretaceous age. The zone is mainly consisted of three kinds of deposit, the contact metasomatic deposit characterized by the Cu-Pb scarn deposit, the massive sulphide deposit containing Cu, Pb, Zn and the hydrothermal deposit characterized by disseminated Pb, Zn in the siderite bed.

At the first survey, "Cooperative Mineral Exploration in the Oyon area", geological survey, geochemical survey, geophysical survey and drilling survey were carried out. At the second survey, "Cooperative Mineral Exploration in the Iscaycruz (Oyon) area", drilling survey and tunnelling survey were carried out. The amount of work in each year is shown in Table 1.1. The outcome of these survey is as described in the following:

(1) The high-grade Cu-Pb-Zn deposit occurs in the Limpe zone, Iscaycruz area.

(2) The dimension of the ore body is supposed to be 300 m long, more than 150 m deep and 10-30 m thick.

(3) The ore reserve is calculated to be about 3,257 thousands tons graded about 20% (Pb, Zn total) by Polygon method

On the basis of these results, JICA and MMAJ concluded the Scope of Work on 28th June 1985 with INGEMMET on the collaborative preliminary investigation for the possible development plan of the mine in the Iscaycruz area including the infrastructure and the regional development.

This collaborative investigation was performed based on the Scope of Work.

Table 1.1 Cooperative Mineral Exploration

The first survey: Oyon area (1979-1981)

| Item | 1979 | 1980 | 1981 | Total |
|---|---|---|---|---|
| Geological survey ($km^2$) | 700 (Reconnaisance) | 160 (Reconn.) | 40 (Detail) | Total area 700 |
| Geochemical survey ($km^2$) | | 40 (Detail) | 2 (Detail) | |
| Geophysical survey | | | | |
| IP method (km) | | 25.4 (8-line) | 10.5 (7-line) | 35.9 (15-line) |
| EM method (km) | | 3.0 (2-line) | 10.0 (8-line) | 13.0 (10-line) |
| Drilling survey (m) | | 564 (3-hole) | 2,086 (9-hole) | 2,650 (12-hole) |
| (Limpe area) | | (157 1-hole) | (697 3-hole) | (854 4-hole) |

The second survey: Iscaycruz (Oyon) area (1982-1984)

| Item | | 1982 | 1983 | 1984 | Total |
|---|---|---|---|---|---|
| Drilling survey (m) | | | | | |
| Limpe | Surface | 1,300 (5-hole) | - | 180 (1-hole) | 1,480 (6-hole) |
| | N-adit | - | 440 (2-hole) | 680 (3-hole) | 1,120 (5-hole) |
| | S-adit | - | 470 (2-hole) | 480 (3-hole) | 950 (5-hole) |
| Limpe S | Surface | | - | 560 (3-hole) | 560 (3-hole) |
| | Total | 1,300 (5-hole) | 910 (4-hole) | 1,900 (10-hole) | 4,110 (19-hole) |
| Tunnelling survey (m) | | | | | |
| N-adit | Approach | 310 | 200 | - | 510 |
| | Cross cut | - | #1 150 | #2 175 | 325 |
| S-adit | Approach | 270 | 330 | 346 | 946 |
| | Cross cut | - | - | #1 141 #2 86 | 227 |
| | Total | 580 | 680 | 748 | 2,008 |

## 2. PURPOSE AND SCOPE OF THE STUDY

### 2.1 PURPOSE OF THE STUDY

This study aimed to formulate the development plan of high-grade Cu-Pb-Zn deposit in the Iscaycruz area, Province of Oyon, Department of Lima under present optimum conditions and to propose the direction of the infrastructure in connection with the development plan. Furthermore, it was to be of use for the regional development by making rational development plan of this area based on the results of this survey.

The main theme is shown in the following three items:

(1) To investigate the possibility of development of high-grade Cu-Pb-Zn deposit in the Iscaycruz area and to evaluate the feasibility of investment by estimating the balance between incomings and outgoings and by planning optimum utilization on the national basis.

(2) To evaluate the investment effects on this whole area containing the Oyon area and the Churin area, which will be caused by the development of the Iscaycruz deposit.

(3) To propose the policy of development by investigating the influence of mine development on the development of the surrounding area and the local residents.

### 2.2 SCOPE OF THE SURVEY

#### 2.2.1 Mine Development

To draw up the development plan by investigating the possibility of the development of the Iscaycruz deposit on the basis of the collected data on the geology and the ore reserve and on the basis of the metallurgical test report.

#### 2.2.2 Infrastructure

Transportation (Roads): To work out a suitable improvement plan for the transportation of the materials and concentrates by investigating the transportation facilities, especially the present conditions of the roads. Not only the mine development but also the effects on the local residents are taken into account in the plan.

Electric power: To plan the source and the optimum method for supplying electric power required for the mine development by investigating the present situation of supply and demand for power in the Iscaycruz area and the supply plan of the Electro Peru S.A. To investigate the possibility of the hydroelectric power plant constructon.

Water supply: To work out the optimum supply plan for industrial and domestic water required for the mine operation by analyzing hydrogic and climatic characteristics and by investigating the present situation of the water source.

Communication: To draw up the optimum communication plan from the mine to other cities and on the mine site by investigating the communication facilities in the whole area containing the Sayan area and the communication methods adopted by the neighboring mines.

The labor force and mine camp: To work out the plan for securing manpower by investigating the working force in the surrounding area, the Oyon area and the Churin area. To select the optimum location for the mine camp construction by investigating the surrounding area and the present situation of the neighboring mines. To make the optimum plan for the allocation of the mine camp facilities by taking into account the intention of the Peruvian Government Agencies and by investigating the general customs of the mines in Peru.

### 2.2.3 The Overall Evaluation

The economic internal rate of return and the financial internal rate of return will be evaluated to determine the feasibility of the mine development on a national economy basis and on a private company basis, respectively. After such evaluation, the scale and timetable of the mine development will be considered to present a plan for the mine development. In addition, its effects on surrounding areas at large (especially in terms of agriculture) will be considered.

## 3. OUTLINE OF THE STUDY

### 3.1 STUDY AREA

Access and Transportation: The Iscaycruz area is situated about 150 km to the north of Lima, in Province of Oyon, Department of Lima. Province of Oyon is mainly composed of six areas, Pachangara, Oyon, Andajes, Caujul, Navan and Cochamarca.

The National Road No. 1 (Pan American Highway) runs from Lima to Rio Seco and runs the National Road No. 16 from Rio Seco to Oyon and the Iscaycruz area is connected with Oyon by the municipal road. From Lima to the Iscaycruz area it takes 7-8 hours by jeep drive over a distance of 270 km. The National Road No. 16 between Sayan and Churin is sometimes closed in wet season by flooding of the Huaura River.

Topography: The study area is situated in the western main range of the Andes, and located 11 km west of the watershed, where the Huaura River rises and flows out as one of the water systems of the Pacific coast. The altitude of the area surrounded by very steep mountains varies from 2,300 m (bottom of gorge) to 5,300 m (mountain tops) above sea level and the relative difference of altitude reaches 3,000 m. The area, from 4,200 m to 4,800 m above sea level in altitude, is comparatively flat plateau called Puna surface. The topographical feature between higher area and lower area from the plateau is much different. The higher area shows glaciated features and in the area higher than 4,800 m above sea level there are steep and rocky peaks. The area lower than the plateau is in the mature stage with deep V-shaped valleys.

The lowest altitude of the Iscaycruz area is 4,600 m above sea level, and in the eastern area, near the watershed, there are snowfalls during the whole year. The area higher than 4,800 m above sea level is covered with glacier.

Climate and Vegetation: The area belongs to the highland cold climate zone. The temperature in the daytime reaches 20°C while in the nighttime it falls below freezing point. It is the dry season from April to November and the wet season from December to March. Judging from the existing data, the annual precipitation in the Iscaycruz area is about 1,100 mm.

Because of highland cold climate, the vegetation is limited to specific herbs called pasto and its distribution is very bare.

Inhabitants: Only a few families settle in the area where the deposit exists. Inhabitants in the survey area, including Oyon area, are almost indios and settle in the basins along valleys and in the mild slopes of mountains. They are mainly engaged in farming and pasturage in primitive methods with small scale. The traffic is only by horses and on-foot connection.

Mines around the area: There are two mines in operation around the Iscaycroz area, Raura mine (Cu, Pb, Zn, operation rate: 1,800 t/day) and Huchuc Chacua mine (Ag, operation rate: 1,000 t/day). About 950 and 500 mine workers are living with their families in the respective mine. These mines, the largest industry in this area, greatly contribute to the social stability.
Some small scale coal mines are in production mainly in Mishuya and its vicinity.

## 3.2 OUTLINE OF STUDY METHOD

The study method and its progress until completion of this report are as follows:

(1) Advance investigation of existing data (in Tokyo)

(2) Dispatch of survey team, composed of 6 experts, to Peru. Consultation with Peruvian counterpart to confirm the principal plan and the allotment of work.

(3) Study in the area and collection of information by survey team and five members of counterpart. Cooperative study and drawing up of draft plan based on the survey results. Both parties confirmed that the final plan would be studied more in detail and drawn up by the survey team in Tokyo.

(4) Arrangement of data, detail calculation and drawing figures by every expert. Meetings were held four times. Investigation on the dressing test's report.

(5) Evaluation

- Financial evaluation for development of Iscaycruz deposit
- Economic evaluation after adjustment and rearrangement of basic figures and analysis of collected data.

Steps for evaluation:

- Drawing up the plan of production and manpower.
- Calculation of initial investment, additional investment and replacement cost.
- Calculation of operating cost.
- Calculation of sales income of concentrates.

(6) In order to analyze the possibility of private company investment, the DCF (Discounted Cash Flow) method was adopted for calculating discount rates or financial internal rates of return so as to offset the current value of expenditure and income during the mine operation. This is based on the assumptions that all preferential treatment would be given to the special mining company and that metal prices would remain at predicted levels. Exchange rates and input prices were based on figures and prices as of October, 1985, and no fluctuations during the mine development and operation were taken into consideration.

(7) In order to analyze the advisability of development from the national point of view, the DCF method was also used, and taxes, wages paid to unskilled workers, and exchange rates were adjusted, so that the discount rate or economic internal rate of return was calculated by means of conversion from financial cost to economic cost.

## 4. MEMBERS AND SCHEDULE

### 4.1 MEMBERS

#### 4.1.1 Members Engaged in Negotation for Study Plan

| Japanese Member | | Peruvian Member | |
|---|---|---|---|
| Makoto Ishida | (MMAJ) | Francisco Sotillo P. | (INGEMMET) |
| Sumihiro Fure | ( " ) | Juan Zegarra W. | ( " ) |
| Takashi Kamiki | ( " ) | Gregorio Flores N. | ( " ) |
| | | Erick Soriano B. | ( " ) |
| | | Carlos Guevara R. | ( " ) |
| | | Carlos Sotomayor G. | ( " ) |
| | | Yorry Elena C. | ( " ) |

#### 4.1.2 Survey Team

Japanese Team;

| Work responsibilities | Name | |
|---|---|---|
| Leader | Takeharu Yamaguchi | (IDCJ) |
| Mining | Kenji Tsurumi | ( " ) |
| Concentration, Water supply | Hisamitsu Oki | ( " ) |
| Power supply, Communication | Takashi Saito | ( " ) |
| Welfare, Infrastructure | Masahiro Nakashima | ( " ) |
| Evaluation | Yutaka Inoue | ( " ) |

Peruvian Counterparts;

| Work responsibilities | Name | |
|---|---|---|
| Leader | Antonio Bararezo | (INGEMMET) |
| Mining | Alejandro Ladera | ( " ) |
| Concentration | Aquiles Figueroa | ( " ) |
| Welfare, Infrastructure | Eli Hernendez | ( " ) |
| Evaluation | Alejandra Dias | ( " ) |

Notes; MMAJ: Metal Mining Agency of Japan
IDCJ: International Development Center of Japan
INGEMMET: Instituto Geologio Minero y Metalurgico

## 4.2 SCHEDULE OF SURVEY TEAM

| Date | Journey , Visit | Object of Visit, Others |
|---|---|---|
| Oct. 7 Mon. | Lv. Norita | Overnight |
| 8 Tue. | Ar. Lima | |
| 9 wed. | Japanese Embassy JICA Lima Office, MMAJ Lima Office, INGEMMET | Courtesy Call |
| 10 Thu. | Ministry of Energy and Mines | Courtesy Call to the Minister and the Director General of Mines |
| | INGEMMET | Consultation of the Principal Plan of Survey |
| 11 Fri. | | Openning of Survey Team Office |
| | INGEMMET | Consultation in general |
| 12 Sat. | | Prepartion for Survey |
| 13 Sun. | Lima - Churin | All Members (including counterpart) |
| 14 Mon. | | Survey (in three groups) |
| 15 Tue. | | Survey (in three groups) |
| 16 Wed. | Churin - Lima | |
| 17 Thu. | | Collection and Arrangement of Information |
| | Japanese Embassy, JICA Lima Office, MMAJ, Lima Office, | |
| 18 Fri. | Mitsui Mining & Smelting Sucursal del Peru, Mitsui del Peru S.A., Nippon Electric Co., Lima, | Ditto. |
| 19 Sat. | Ministry of Energy and Mines, Ministry of Transport and | Ditto. |
| 20 Sun. | Communication, Ministry of Labour and Social | Ditto. |
| 21 Mon. | Promotion SENAMHI, | Ditto. |

| Date | Journey , Visit | Object of Visit, Others |
|---|---|---|
| Oct. 22 Tue. | Ministry of Agriculture,<br>Electro Peru,<br>Callao Custom House,<br>Mining Society, | Collection and Arrangement of Information |
| 23 Wed. | Cia. Minera Santa Luisa,<br>Cia. Minera Buenaventura,<br>Cia. Minera Raura,<br>CENTROMIN, | Ditto. |
| 24 Thu. | Huanzala Mine,<br>Makers of Machinery and Electrical Machinery Appliances | Ditto. |
| 25 Fri. | | Plenary Meeting (Survey Team, Counterpart) |
| 26 Sat. | | Analysis of information and Data, Calculation and Drawing Figures, Collection of Information |
| 27 Sun. | | Ditto. |
| 28 Mon. | | Ditto. |
| 29 Tue. | | Ditto. |
| 30 Wed. | | Ditto. |
| 31 Thu. | | Ditto. |
| Nov. 1 Fri. | | Making out Drafts of Development Plan by every expert in charge (Survey Team, Connecterpart) |
| 2 Sat. | | Ditto. |
| 3 Sun. | | Ditto. |
| 4 Mon. | | Ditto. |
| 5 Tue. | | Ditto. |
| 6 Wed. | | Ditto. |
| 7 Thu. | | Plenary Meeting (MMAJ, Survey Team, INGEMMET) |
| 8 Fri. | Japanese Embassy, JICA | Greeting and Report |
| 9 Sat. | | Preparations for return home |
| 10 Sun. | Lv. Lima | Overnight |
| 11 Mon. | Ar. Narita | |

# CHAPTER 2 MINE DEVELOPMENT

# CHAPTER 2 MINE DEVELOPMENT

## 1. GEOLOGY AND ORE DEPOSIT

### 1.1 GENERAL GEOLOGY

The Iscaycruz district belongs stratigraphically to the zone of Cretaceous Sedimentary basin, classified by Cobbing (1973), and thick Cretaceous sedimentary rocks are distributed widely. The clastic rocks are composed of siliceous sandstone and shale in the lower part, limestones with marl and shale in the upper part, and red formation in the uppermost. The lower part of clastic rocks are divided into Oyon, Chimu, Santa, Carhuaz and Farrat formations in ascending order, and the calcareous rocks consisting of the upper part are divided into Pariahuanca, Chulec, Pariatambo, Jumasha and Celendin formations in ascending order and the uppermost is Casapalca red formation.

The Cretaceous sedimentary rocks are uncomformably overlain by Tertiary CALIPUY volcanic rocks and intruded by tonalite, dacite, granite-porphyry and others. The cretaceous sedimentary rocks were subjected to intense structural movement by Andean Orogeny to form composite folded structure of fold axis trending NNW-SSE, and the overthrusts which are parralel to the axis are observed.

Santa formation which is composed well stratified dark gray limestone as thick as 50 m - 100 m exists between Chimu formation composed of quartzite and siliceous sandstone and Carhuaz formation which is alternating beds of shale and sandstone and distributed in elongate forming the country rock of the Iscaycruz mineralized zone.

Santa formation is situated on the wings of the folded structure and dips vertically owing to remarkable intrafolial fold. Overturned structures are observed in the Limpe district where located the central part of the project area and the Limpe South (Tinyag).

### 1.2 ORE DEPOSIT

Iscaycruz district is located geologically in "Sub-Provincia Polimetalica del Altiplano" belonging to "Provincia Metalogenica Andina Occidental" by Dr. Bellido et al. (1969) and the Iscaycruz mineralized zone and Chupa ore deposit were found in this district.

In the vicinity of this district, there are many middle scaled lead, zinc and silver mines on operation such as Raura (Pb. Zn), Uchuc Chacua (Ag), Atacocha (Pb. Zn & Ag), Cerro de Pasco (Pb. Zn & Ag) Huaron (Pb. Zn & Ag) and Santander (Cu & Zn). These deposits, distributed in the vecinity of Iscaycruz district, classified based on the kinds of ore, shape and genesis as follows;

- Copper-lead-zinc contact metasomatic ore deposits in Cretaceous limestones — Raura deposit, Chupa deposit and part of the Iscaycruz mineralized zone.
- Lead-zinc-pyrite massive hydrothermal metasomatic ore deposits in Cretaceous limestones, found in the Iscaycruz mineralized zone.
- Silver-lead-zinc fissure filling deposits in Cretaceous limestones — Uchuc Chacua deposit and part of Raura deposit.

- Silver-lead-zinc fissure filling deposits in Tertiary Volcanic rocks and intrusives — Chanca deposit and part of Raura deposit.

## 1.3 MINERALIZATION AND ALTERATION

### 1.3.1 Iscaycruz Mineralized Zone

Iscaycruz mineralized zone is formed in limestone of Santa formation, and is distributed inter-mittently in a distance of about 12 km from the northern part of Canaypata to the southern part of Antapampa. Dark colored gossan bearing Pb-Zn, massive pyrite ore bodies associated with galena and sphalerite, skarn massive ore with chalcopyrite and sphalerite, hematite masses with chalcopyrite and sphalerite, and siderite masses with galena and sphalerite are found as the mineralization.

The composite minerals on dark colored gossan which is exposed widely on the surface are mainly goethite, quartz and kaolinite associated with manganese oxides and siderite. Most of the minerals in the gossan are considered to be oxides such as franklinite and smithsonite. And dark colored gossan would be the oxidation products of manganiferous siderite. Massive pyrite deposit consist mainly of pyrite associated with pyrrhotite and marcasite, is occasionally enriched with galena, sphalerite and chalcopyrite. These occur a lot of druses in pyrite orebody and hematite in marginal zones. Dotted grains of chalcopyrite are commonly contained in sphalerite. The mineralized zone in the Iscaycruz district is characterized with the existence of both the contact metasomatizm at the later stage of magma and hydrothermal alteration at the hydrothermal stage and skarnization under the condition of the high temperature is influenced by retrogressive alteration.

Main skarn minerals are tremolite, garnet, epidote and quartz and ore minerals are mainly chalcopyrite, sphalerite and magnetite. Silicification, sericitization, argillization, sideritization, dolomitization and brecciation are observed remarkably in the host rocks of ore deposits. Igneous rocks related to mineralization are acidic intrusive rocks observed in Oyon and Chimu formations distributed near Cunsha Punta ridge.

Features of concentration of ore minerals in the Iscaycruz mineralized zone are variable and intermittent. Generally, skarn ore deposits containing copper and zinc are recognized in Limpe South district where is located nearest to the activity center of acidic intrusive rocks. Besides, massive sulphide ore deposits with lead and zinc are found in the Limpe district and Cumsha Punta district. And, in the mostouter zones of Iscaycruz ridge district and Antapampa district, dissemination type ore deposits of lead and zinc in the siderite layers including manganese are recognized. It is observed that these ore deposits of various type are distributed as a zonal arrengement centered in acidic igneous rocks, and they are considered to have been formed a series of mineralization as a whole.

### 1.3.2 Chupa Ore Deposit

Chupa deposit where exists in 600 m west of skarn outcrops in the Limpe South district is skarn type ore deposit replaced of a part of limestones belonging to Pariahuanca formation and contains zinc and copper minerals mainly. The ore deposit has been prospected in past by two adits and high grade ore was

encountered in both levels. Pariahuanca formation consisting of the host rocks of ore deposit is composed of massive limestones with about 100 m in thickness, and forms the reverse structure. Mineralization of this district is controlled by fault systems of ENE-WSW and E-W directions strongly.

Skarn minerals are mainly composed of tremolite, hedenbergite, quartz, siderite and small amount of chlorite, sericite, epidote and lievrite. Ore minerals are mainly sphalerite, pyrite and magnetite with minor amount of chalcopyrite, pyrrhotite and bismuthinite. The generation of ore deposit assumes due to the acidic igneous activity brought the same mineralization as Iscaycruz district, but igneous rocks are not appeared in this area.

## 1.4 ORE RESERVES

### 1.4.1 Calculation Method

Exploration in Limpe district has been done concentrically by drilling and tunnelling and the existence of the high grade copper, lead and zinc ores are confirmed (Limpe deposit).

Ore bodies occur as a irregular shaped massive ore deposits formed by the replacement of limestones, and it seems that the shapes of ore bodies vary widely and the ore grade might be distributed inhomogeneously althrough ores are found in both parts of the lower and upper of Santa formation in Limpe district and grade of the lower shows higher than upper. The informations are not enough to be lined the boundary of ore body even roughly and to be calculated ore reserves precisely, because only four cross cuts and diamond borings with the interval of 100 m have been conducted against the total length of 1,400 m along the strike direction of mineralization, although more than ten of high grade lodes have been confirmed.

However, it is assumed that they are related intimately to the pyritization and brecciation, and it is estimated that they have continuity to some extent being controlled by the structure of limestones. Therefore, tentative estimation of ore reserves estimation was conducted to know the rough assumption of ore reserves and ore grade. The polygon method was adopted for calculation of them, which is the most simple and objective method of ore reserves estimation.

### 1.4.2 Procedure and Basis of Calculation

(1) More than 2 m thick in actual thickness and having grade of more than 10% of Pb + Zn, but in case of copper ore, more than 2% of Cu. However, any indications which are composed of only one sample, even if satisfy the above conditions, have been excluded.

(2) The centeral point of ore encountered was projected on the profile section, which is established parallel to the extension of the mineralization zone (N 20°W - S 20°E).

(3) After real thickness of ore encountered was obtained according to the inclination angles of ore boundary, ore and structural plane of country rock for directions of drillings, then this length was converted to the horizontal length considering the inferred inclination of orebody and rocks.

(4) Area blocked out in both sides strike and vertical direction, which was taken within 5 times of the horizontal length from the center of ore encountered, but maximum 50 m.

(5) Ore existed within 30 m from surface was ommitted due to possibility as oxidized and leached zone.

(6) Polygon was established with centerring at the point of the indication and the boundary lines of polygon were positioned at the equal distance from each adjacent centers, when ore body was regarded to be on a single ore body such as i) the distance between any two center points of the indication was within 5 times of total horizontal length ii) continuity of mineralization was expected geologically.

(7) The polygon was established in the area where ore body was not found to eliminate the unmineralized zone, and tetragon was assigned for orebody which was captured in only one point.

(8) Ore reserves and their grade were summarized after calculation based on each by area and volume of polygon. The specific gravity is decided to 3.4, considering average value of 3.83 of 26 samples measured and the amount of 12% of porosity.

(9) A safety factor of 95% was adopted for ore grade calculation.

### 1.4.3 Results

Ore reserves were summarized for three ore bodies, such as Pb-Zn ore body existed in upper horizon of Santa formation (upper ore body), Pb-Zn ore body existed in lower (lower ore body) and Cu ore body. The results of each deposit by block and the location of ore blocks are shown in Fig. 2-1, Fig. 2-2 and Fig. 2-3.

Summarized ore reserves is as follows;

| Kind of ore | Ore reserves (1,000 t) | Ag (g/t) | Cu (%) | Pb (%) | Zn (%) |
|---|---|---|---|---|---|
| Pb · Zn Ore | 3,257 | 48 | 0.13 | 1.95 | 18.99 |
| Copper Ore | 102 | 32 | 2.84 | 0.03 | 0.39 |

Table 2.1 Table for Ore Reserves Calculation

| Zone | Body | Tonnage (t) | Grade | | | | Metal content | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Ag (g/t) | Cu (%) | Pb (%) | Zn (%) | Ag (kg) | Cu (t) | Pb (t) | Zn (t) |
| Pb·Zn Ore: | | | | | | | | | | |
| Lower H. | $D_1$ | 66,300 | 15 | 0.32 | 0.02 | 21.59 | 994 | 212 | 13 | 14,314 |
| | $D_2$ | 453,000 | 38 | 0.04 | 3.16 | 22.69 | 17,214 | 181 | 14,314 | 102,785 |
| | $D_{3-4}$ | 509,300 | 20 | 0.11 | 2.01 | 15.36 | 10.186 | 560 | 10,236 | 78,228 |
| | $D_5$ | 948,100 | 78 | 0.19 | 2.61 | 24.08 | 73,951 | 1,801 | 24,745 | 228,302 |
| | $D_{6-7}$ | 250,500 | 172 | 0.15 | 3.36 | 28.62 | 43,086 | 375 | 8,416 | 71,693 |
| | Subtotal | 2,227,200 | 65 | 0.14 | 2.59 | 22.24 | 145,431 | 3,129 | 57,724 | 495,322 |
| Upper H. | $U_1$ | 1,500 | 89 | 0.03 | 6.74 | 14.17 | 133 | 0 | 101 | 212 |
| | $U_2$ | 161,500 | 13 | 0.07 | 0.04 | 14.49 | 2,099 | 113 | 64 | 23,401 |
| | $U_3$ | 304,900 | 8 | 0.10 | 0.07 | 17.13 | 2,439 | 304 | 213 | 52,229 |
| | $U_4$ | 156,400 | 25 | 0.06 | 4.53 | 9.39 | 3,910 | 93 | 7,084 | 14,685 |
| | $U_5$ | 5,500 | 35 | 1,10 | 2.89 | 15.22 | 192 | 60 | 158 | 837 |
| | $U_6$ | 36,700 | 26 | 0.08 | 2.63 | 11.75 | 954 | 29 | 965 | 4,312 |
| | $U_7$ | 251,300 | 32 | 0.18 | 0.13 | 16.78 | 8,041 | 452 | 326 | 42,168 |
| | $U_8$ | 111,900 | 22 | 0.18 | 0.20 | 16.04 | 2,461 | 201 | 223 | 17,948 |
| | Subtotal | 1,029,700 | 19 | 0.12 | 0.89 | 15.15 | 20,229 | 1,252 | 9,134 | 156,036 |
| Total | | 3,256,900 | 51 | 0.13 | 2.05 | 19.99 | 165,660 | 4,381 | 66,858 | 651,114 |
| Adjusted Total*) | | 3,256,900 | 48 | 0.13 | 1.95 | 18.99 | 157,377 | 4,161 | 63,515 | 618,558 |
| Cu Ore: | $C_1$ | 41,600 | 23 | 2.48 | 0.02 | 0.46 | 956 | 1,031 | 8 | 191 |
| | $C_2$ | 1,900 | 5 | 7.10 | 0.22 | 0.48 | 9 | 134 | 4 | 9 |
| | $C_3$ | 47,700 | 46 | 3.43 | 0.03 | 0.43 | 2,194 | 1,636 | 14 | 205 |
| | $C_4$ | 4,800 | 32 | 2.20 | 0.02 | 0.29 | 153 | 105 | 0 | 13 |
| | $C_5$ | 5,900 | 23 | 2.43 | 0.11 | 0.11 | 135 | 143 | 6 | 6 |
| Total | | 101,900 | 34 | 2.99 | 0.03 | 0.42 | 3,447 | 3,049 | 32 | 424 |
| Adjusted Total*) | | 101,900 | 32 | 2.84 | 0.03 | 0.39 | 3,274 | 2,896 | 30 | 402 |

Note: *) Safety factor of ore grade is 0.95

Fig. 2.1 Perspective Section for Ore Reserve Calculation (Lower Horizon)

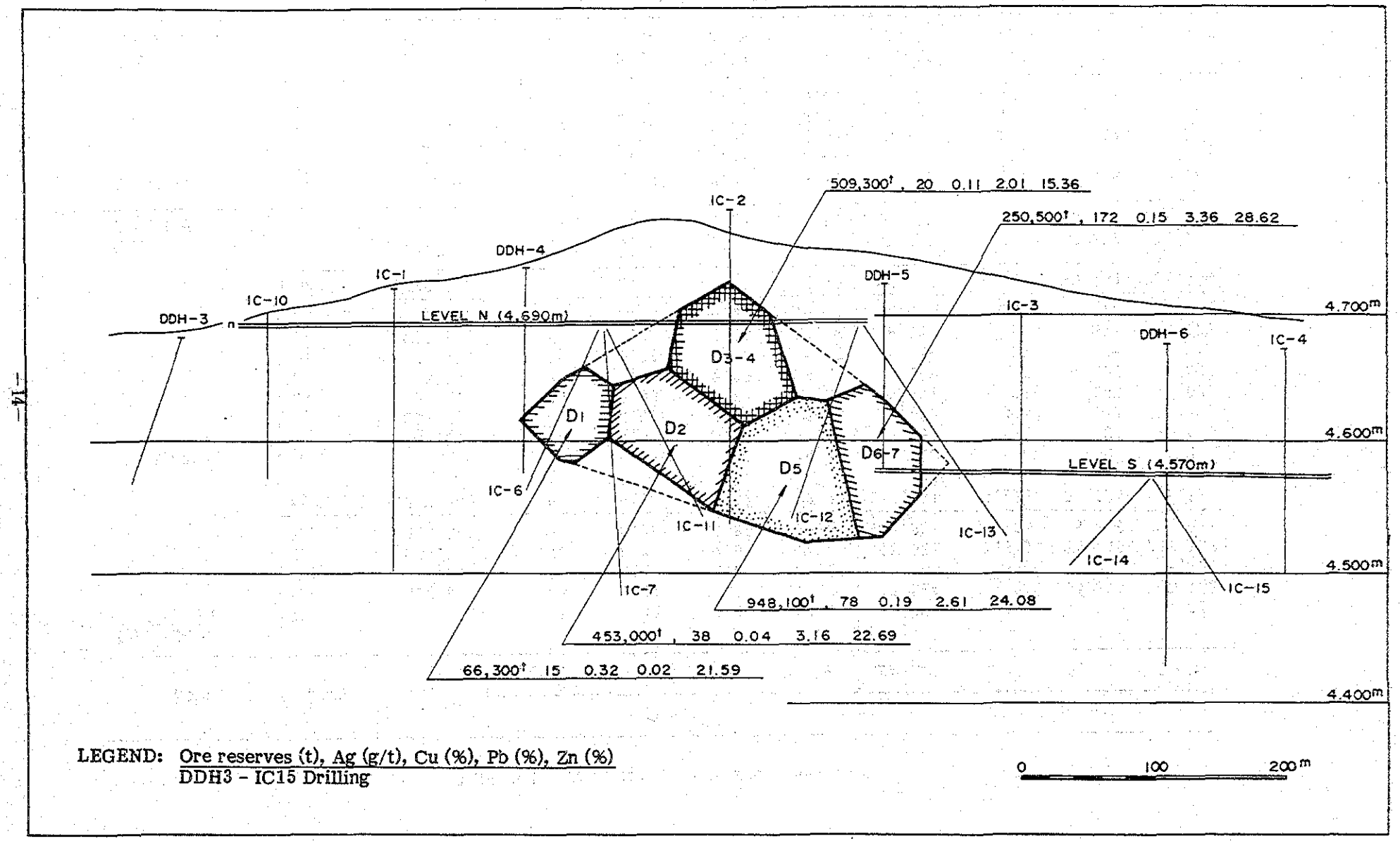
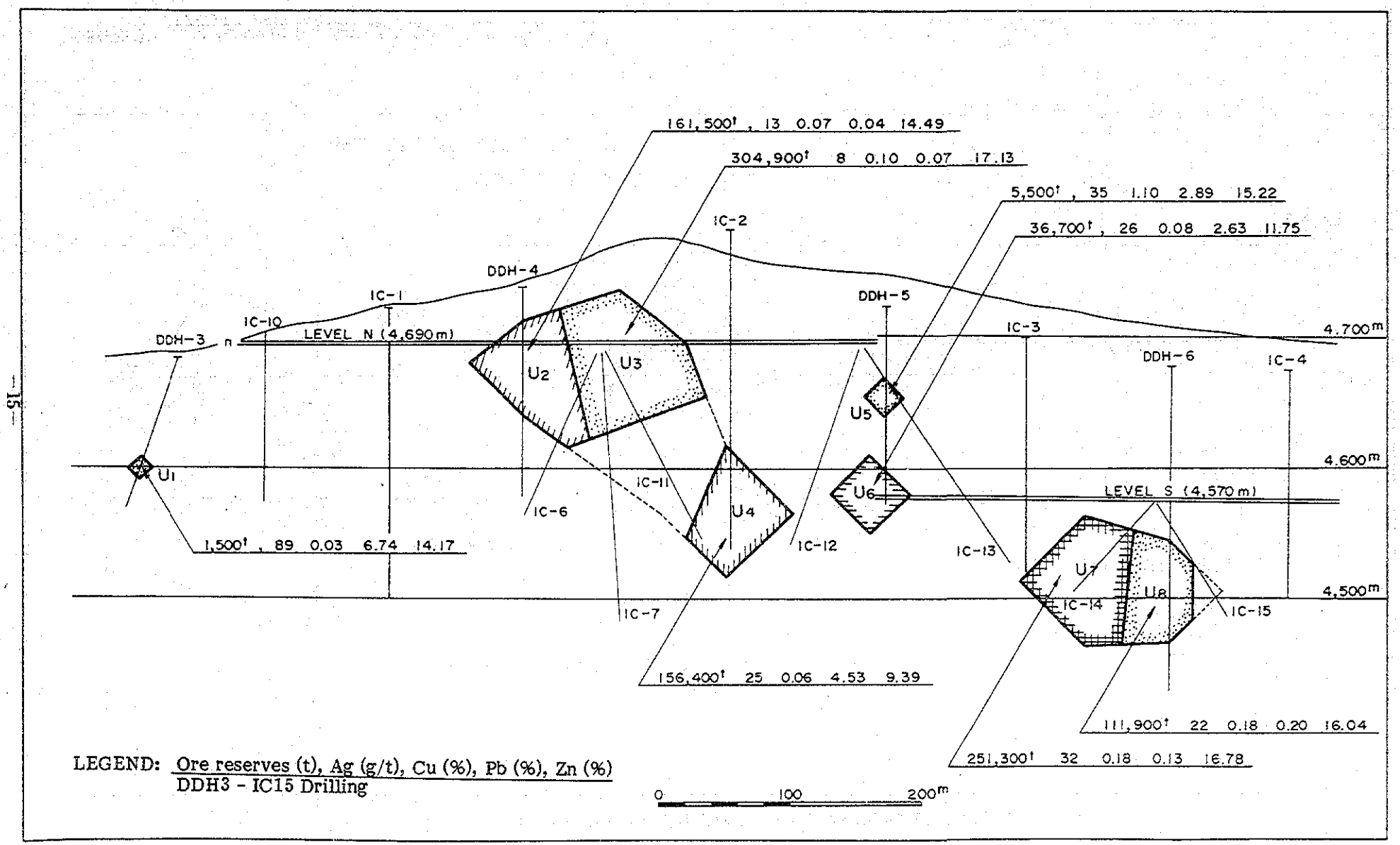
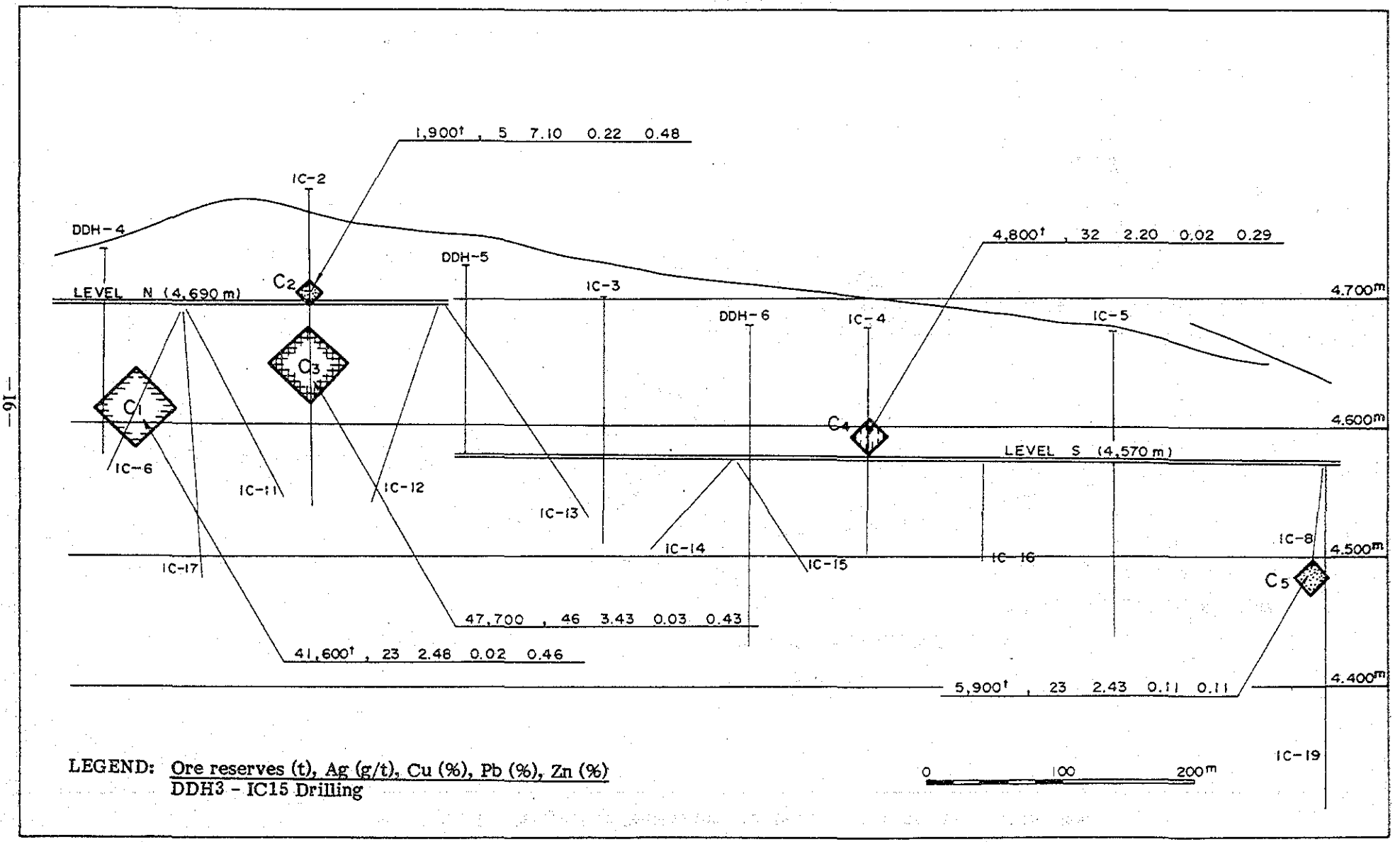


Fig. 2.2 Perspective Section for Ore Reserve Calculation (Upper Horizon)




LEGEND: Ore reserves (t), Ag (g/t), Cu (%), Pb (%), Zn (%)
DDH3 - IC15 Drilling

Fig. 2.3 Perspective Section for Ore Reserve Calculation (Cu Ore)



## 2. MINING

### 2.1 GENERAL

#### 2.1.1 Selection of mining method

What mining methods are applied on this mine, surface or underground, have been studied under the consideration of the regional, topographic and economical conditions involved prior to make a decision of mining methods. Supposing open-pit is applied with the final pit slope of 60° as well, a stripping ratio goes up to more than 30, and the depth of pit reaches over more than 200 m, because of Iscayoruz district where ore body exists is located in the Alps mountains site and is formed the valley to be extended to the high mountains of 5,000 m so far. Therefore, surface mining is not easy to maintain satisfactory a economic and technical factor involved.

Mechanized Cut & Fill method was selected to meet on this mine the most favorable one for the following reasons:

(1) Development and preparation works to be performed before operation starts are relatively less compared to other mining method applied.

(2) It has so wide flexibility on operation that it can cope with less information on prospecting.

(3) High extraction factor and less contamination will be expected for this type ore body.

(4) It can be coped to expand and shrink of ore body existed.

(5) High efficiency on operation will be obtained together with the mechanization.

(6) Filling materials can afford easily from the talus of surface.

(7) This method has much of achievement in Peru.

#### 2.1.2 Basic criteria of plan

The proposed mining area is above the present S-adit (4,570 m above sea level) and the basic criteria of plan is as follows:

| | |
|---|---|
| Mineable ore reserves (t) | 2,050,300 |
| Extraction factor (%) | 85 |
| Contamination of waste (%) | 15 |
| Production, per annum (t) | 225,000 |
| Tonnage to be mined per day (t) | 750 |
| Operation days per annum (day) | 300 |
| Shifts employed per day | 2 |
| Working days per man per annum (day) | 260 |

### 2.1.3 Skelton of underground (Refer to Drawing 004, 005 & 006)

Based on distribution of ore body existed, some surplus stopes will be necessary to maintain the daily production of 750 t, so that four levels of 0 m (present S-adit, 4,570 m above sea level), +40 m, +80 m and +120 m (present N-adit, 4,690 m above sea level) are opened with the interval of 40 m, and three to four access roads to stopes are driven with 100 m apart from each level.

The inclined trackless shaft which is connected correspondingly to the main level with main ore pass and waste chute will be developed into Santa formation. Also, waste chutes which are utilized for a part of ventilation system will be provided apart from ore body. A trackless incline to +120 m level will be developed during the detail surveying period and a trackless incline to +40 m will be provided during the development period from surface respectively. These inclines will be not only used for the purposes of service and ventilation but delivering ore and supplying waste when necessary.

## 2.2 DEVELOPMENT PLAN

### 2.2.1 Main level

Main levels will be set at 0 m, +40 m, +80 m and +120 m as mentioned above. 0 m main level will be utilized for the haulage level to deliver ore to the concentrator and for the inlet of fresh air and the outlet of underground water. Therefore, S-adit presented is improved in such as way the places where passed weak and narrow zone will be made a detour and extended during the development period. Finally, the main level will be innovated to the size of 3.0 m x 3.0 m with the drainage canal of 50 cm x 50 cm.

Development works will be performed with either using the rail-loader (2.6 m x 2.5 m in size) or LHD - Load & haul dump wheel loader (4.0 m x 2.8 m), depend upon the situation of ventilation and treatment of waste occurred. After drive, tunnel is enlarged up to standard size by the brest cut at the place where was advanced by the rail-loader.

### 2.2.2 Chutes

Main ore passes: Three ore passes (OR-1, 2 and 3) will be provided into Santa formation apart 30 m from ore body with the interval of about 100 m and these are served for mining of lower ore body (ore body existed in the foot wall). And for the same purpose, a ore pass (OR-4) will be also provided into Santa formation for upper ore body (ore body located in the roof-wall).

Three ore passes of OR-1, OR-2 and OR-3 which have 2.1 m in dia. and inclination of 80° each will be developed by the raise-borer and depth of them assume as 120 m for OR-1 and OR-2 and 80 m for OR-3. OR-4 which has demension of 1.8 m x 1.5 m and 90 m in depth will be developed by the conventional method.

These four ore passes will be connected to the trackless incline and main level at each level correspondingly, and the ore bin with about 200 t capacity each on the main haulage level will be provided.

Waste chute and ventilation raise: Chutes will be developed in about 100 m interval near ore body and connected to the corresponding stopes to supply filling materials during the operation period. They will convert to the part of ventilation system after mined out.

Service raise: One service raise will be provided from +120 m level up to 0 m level for laying the pipes of compressed air and industrial water and the cable line for low voltage power. Waste chutes and service raise with 1.8 m x 1.5 m in dimension will be driven by the conventional method.

### 2.2.3 Trackless inclined shafts

Three trackless inclines, correspondence to OR-1, OR-2 and OR-3, will be developed for mining a lower ore body at the places where are between the main ore passes and footwall of ore bodies. A trackless incline which will be developed during the detail survey period may be utilized for mining the upper ore body, but additional trackless incline and ore passes might be required depend upon the results of the precise study. Standard dimension of the trackless incline will be 4.0 m wide x 2.8 m high, inclination of $9^{\circ}30'$ (about 1/6) and inner curvature of 10 m.

Only one trackless incline will be driven during the development period from 0 m level to +120 m level and others will be developed correspondingly to the progress of stopes with the twin shafts method during the operatoin period. Procedure of connection between trackless incline and stope are as follows:

(1) The access to the trackless incline is driven from the stope with inclination of +1/5.

(2) The roof of the access will be blasted slicely with relation of rising up of the stope to be maintained the connection to the trackless incline until the access reaches to inclination of -1/5.

(3) The access to the trackless incline will be driven and repeated procedure (1) before previous access reaches to inclination of -1/5.

### 2.2.4 Opening of stopes

The range to be mined will consider tentatively as follows;

| | |
|---|---|
| For the lower ore body: | Above 0 m level<br>4 main levels of 0 m, +40 m, +80 m and 120 m will be provided. |
| For the upper ore body: | Above +80 m but it may have a enough size at even below +80 m level for mining.<br>Tentatively, 2 main levels of +80 m and +120 m will be provided. |

When operation starts, area where ore exists will be expanded and roof-blasted with 3 m a slice at each levels. However, the vertical pillar may established conventionally at the places of loosen and weaken ground or wider ore body.

## 2.3 OPERATION PLAN

### 2.3.1 Exploration and opening stopes

Continuously, prospecting tunnels and opening of stopes will be conducted following the plan and schedule. Length of prospecting tunnel to be conducted per annum is about 2,000 m (equiv. 9 m per 1,000 t mined out.).

### 2.3.2 Extraction of ore

Mechanized Cut & Fill method will be adopted for extraction ore using the same machines which were conducted during the development period. Combination of diesel drive mobile jumbo with 50 Hp class and 40 kg class leg-drill for drilling and LHD of 3.5 $yd^3$ capacity for transportation will be adopted.

Regarding to the process for ore extraction, area where ore exists will be expanded at the ground level and its roof will be blasted with 3 m a slice for opening the stope but 2 m a slice for mining and the open space where broken ore was extracted will be filled 2 m thick with filling materials such as waste occurred by tunnellings. A cycle of mining, so called, consists of a series of works of drilling toward to up, charging explosives into drilled holes, blasting, mucking and filling. When the ground conditions are unfavourable to be followed the standard procedure, method will be modified such as stope will be filled up till underneath of the roof to eliminate the exposed area of both roof and foot walls and drilled in horizontal direction and blasted and so on. Max. 3 m high will be regulated when adopted horizontal drilling although the height of open space to be exposed during ore extraction period reaches to 5 m. The ilastration of both methods shows on fig. 2·4.

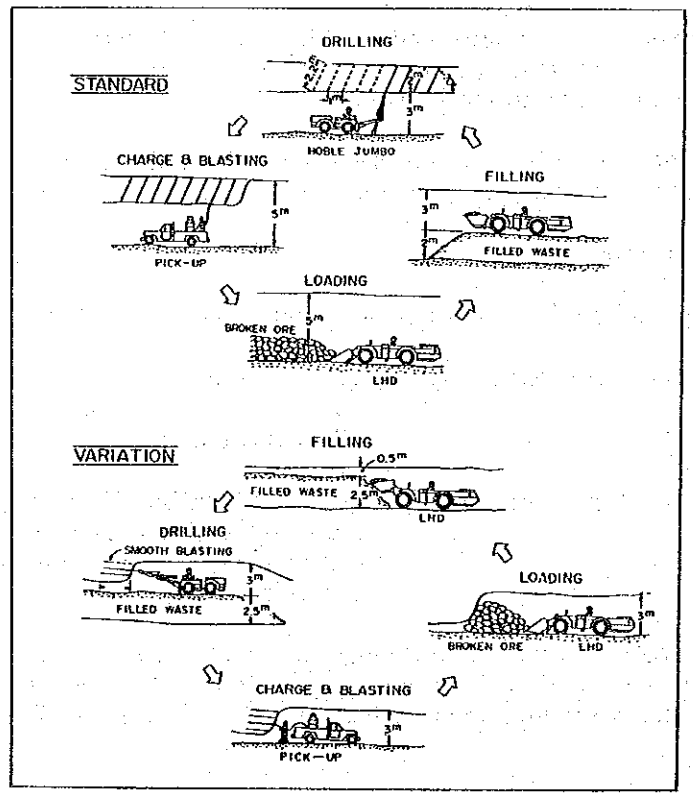



Fig. 2·4 Extraction Method

Extraction factor: About 5 m thick horizontal pillar will be remained between the upper stopes (equivalent to 10% of ore reserves) and some stopes will reach more than 30 m long, so that the vertical pillars may be necessary on a view of safety at stopes where are assigned in weaken and soft ground. 85% of extraction factor was used for the calculation purpose with consideration of losses occurred by the horizontal and vertical pillars and unmined by the contamination to wastes at stopes.

Contamination of waste: The most of contamination will come from waste of filling materials. Assuming that broken ore (having 1.6 of loosened specific gravity), which was blasted with a slice of 2.0 m, will be scooped into the bucket of LHD together with filling materials of 20 cm depth, contamination of waste will calculate as follows:

$$\frac{0.2\ \text{m} \times 1/1.6}{2.0\ \text{m} + (0.2\ \text{m} \times 1/1.6)} \times 100 = 5.9\%$$

It believes that the all over contamination factor reaches up to max. 15% while there will be expected on the actual operation due to the reasons such as contamination at mining boundary even if the pillar remains, overstoping and avoidable contamination mentioned above, and the record of other mines adopted trackless mining.

### 2.3.3 Drilling and blasting

Drilling: The diesel drive two booms mobile jumbo, mounted the pneumatic rock drills, will be engaged together with the leg-drills of 40 kg class supplimentally for both mining and tunnelling. Drilling pattern for mining is 1 m of both spacing and burden with 70° of up grade and 2.2 m deep. Smooth blasting with 50 cm of spacing will be adopted at tunnelling and horizontal drilling at stopes to prevent the growth of loosened rocks.

Blasting: The blasting crew will be taken care of all blasting works using the special truck (pick-up diesel) equipped AN-FO charger. AN-FO explosives mainly and No. 12 non-electric milli-second cap (no requied booster dynamite) with detonator will be used.

### 2.3.4 Transportation

3.5 $yd^3$ LHD which is commonly used in Peru will be signed for both ore and waste hauling at mining and tunnelling works. Ore, which is delivered to main ore passes (OR-1 ~ OR-4) through trackless incline from stope, will be drawn out through ore chutes and loaded on 5 t capacity gramby cars at 0 m main haulage level. A train composed of 10 gramby cars will be transported with a 8 t trolley electric-locomotive to the receiving ore bin of concentrator. In case of emergency, ore will be transported directly up to the portal of the trackless incline from stope by LHD and relayed to the dump truck to deliver it to the concentrator. A hydraulic breaker will be equipped on head of the receiving ore bin, and ore which is larger size than screen of 50 cm x 50 cm installed will be broken by it.

### 2.3.5 Filling and supporting

Waste come from prospecting tunnels and drifts in the operation period are used for filling materials, and when lacking, the broken freshed siliceous pebbles which yield at the talus on surface will be supplement. LHD will work for transportation from the waste chutes to stopes. Regarding the applisal of sand-slime filling, it seems it is not recommendable that the particle of tailing will be too fine to be dewatered. But it is still kept pending at a present stage. Further study will be necessary after operation starts.

Support: Smooth blasting will be adopted in principle at the loosen and weaken ground and roof-bolting will be added when necessary. Iron and wooden framing also are adopted at the breccia zone and fructured ground.

## 2.4 MINING EQUIPMENT AND INSTALLATION PLAN

### 2.4.1 Compressed air

The requirement of compressed air will be estimated to 109 $m^3$/min for boring machine, mobile jumbo, leg drill & stoper, rail loader, and certain amount of leackage and blow. Three units of the compressor with each 55 $m^3$/min capacity included the spare unit will be installed.

12" pipe will be lain in 400 m long from the compressor room up to the head of the service shaft at +120 m level through the trackless incline, and 8" pipe in the service shaft and 4" pipe at the main levels.

### 2.4.2 Ventilation system

Careful attention should be necessary on this mine not only for exhaust gas come from the diesel engine but for backgas and dust. Studied to the natural ventilation, a fan will be installed in the portal of the present N-adit at +120 m level for the reinforcement of the natural head obtained because only 120 m of the elevation difference will not give a enough head to be required as described belows: (5 mm $H_2O$ column will be gained by 10°C of temperature difference between surface and underground). 0.117 Weisbach of the overall ventilation resistance has computed when assuming as the fresh air will enter from 0 m main haulage level and exhaust at +120 m present N-adit, and 2,200 $m^3$/min of fresh air will be required. And when 2,200 $m^3$/min of fresh air flows through the route mentioned above, its head loss becomes as follows:

$$h = RQ^2 = 0.117 \times \left(\frac{2,200}{60}\right)^2 = 157 \text{ mm column } H_2O$$

In this case, the high head fan will be necessary. If the trackless incline which goes down to +40 m level will be opened from the surface, overall ventilation resistance will sharply decrease to the value of 0.0426 Weisbach and required head becomes only 57 mm column $H_2O$.

Specification of the fan to be equipped on the portal of present +120 m level N-adit under the consideration of the reverse action of natural ventilation, additional and extension of the incline toward to below 0 m level and other head losses is decided as follows:

| | |
|---|---|
| Capacity: | 2,200 $m^3$/min |
| Head: | 80 mm column $H_2O$ |
| Motor: | 75 kW |

The local fan of 450 $m^3$/min, with 65 mm head and 11 kW class will be co-operated at the extrime places and branches.

The ventilation system to be adopted on operation shows on Fig. 2·5.

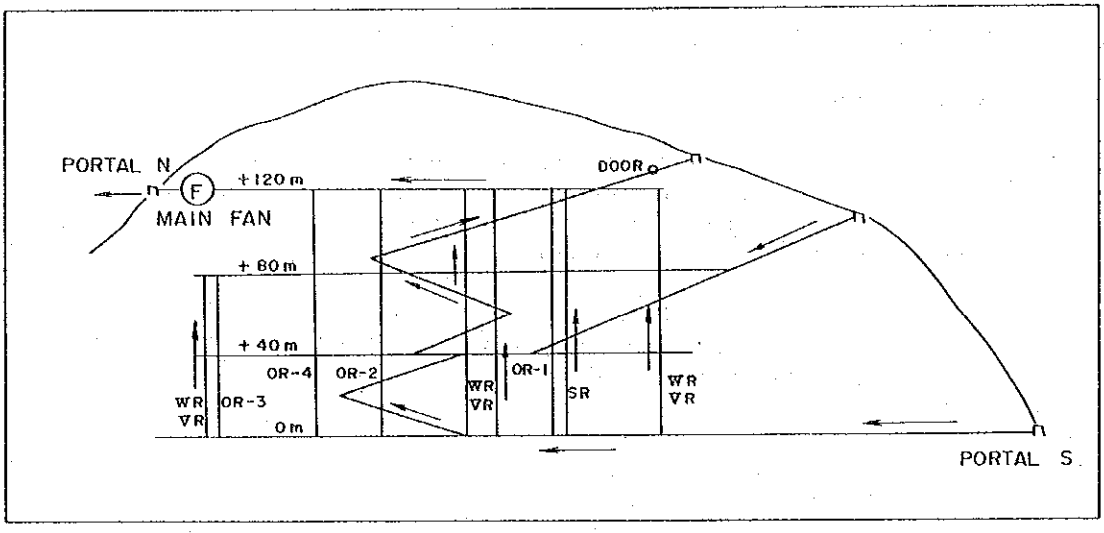



Fig. 2·5 Ventilation System

### 2.4.3 Water supply and drainage

Water used for the rock drills will be supplied from the water tank located in the concentator with 3" pipe up to the portal of the trackless incline going down to +120 m level, 2" pipe for the inside service shaft and 2" or 1" pipes at the main levels.

Underground water of each levels will be collected to the main haulage level through the trackless inclines by gravity and they flow naturally out through the canal, 50 cm x 50 cm, digged at the corner of the main haulage level.

### 2.4.4 Other facilities

A mine office, assign work office, warehouse, repair shop and compressor room will be built concentrately beside the portal of +120 m level trackless incline. The magazine will be provided in underground by adit. And repair house with pit for mine cars and locomotive will be built at the portal of 0 m main haulage level.

## 2.5 MAIN EQUIPMENT AND CONSUMPTION OF SUPPLY AND MATERIAL

### 2.5.1 Main equipment

| Machine and equipment | Unit | Specification |
|---|---|---|
| Diesel drive mobile jumbo | 6 | Mounted 100 ϕmm class drills, 2 booms. |
| Load Haul and Dump | 4 | 3.5 $yd^3$ class, 185 HP |
| Leg-rock drill | 12 | 40 kg class |
| Stoper | 6 | 40 kg class |
| Compressor | 3 | 55 $m^3$/min capacity, 265 kW |
| Main fan | 1 | 2,200 $m^3$/min capacity, 75 kW |
| Local fan | 3 | 450 $m^3$/min capacity, 11 kW |
| Electric locomotive | 2 | Trolley, 8 t capacity |
| Mine car | 15 | Gramby type, 5 t capacity |

### 2.5.2 Proposed consumption of supply and materials

| Item | Unit | Consumption, annum | Consumption, t per mined |
|---|---|---|---|
| AN-FO | kg | 46,700 | 0.208 |
| Dynamite | kg | 78,400 | 0.348 |
| Cap | pc | 82,700 | 0.37 |
| Fuse | m | 97,600 | 0.43 |
| Diesel oil | ℓ | 576,000 | 2.6 |

## 3. CONCENTRATION

### 3.1 METALLURGICAL TEST

**3.1.1** Laboratory test were conducted for the ore samples, which was collected from the underground tunnel, from Oct. to Dec. 1985 to examine basic conditions for a concentrator design and to estimate the performance on operation.

**3.1.2 Test samples**

Composite of sample: Test samples were taken from the wall at each cross cuts of totaling 3 places as 2 places of S-adit and 1 place of N-adit. However, grade of these samples was so high compared to the proposed grade of the crude ore (Ag 35 g/t, Cu 0.1% Pb 1.61%, and Zn 15.92%), that it seems that these samples will not give a true picture. So that, low grade ore which existed near the boundary of ore body were mixed to make one composited test sample.

Grade: The results of complete analysis of the prepared sample are shown in Table 2.2.

Table 2.2 Complete assy results

| | | | |
|---|---|---|---|
| Ag (g/t) | 80.0 | Hg (g/t) | < 0.5 |
| Cu (%) | 0.08 | Ga (%) | 0.004 |
| Pb ( " ) | 1.3 | Mn ( " ) | 0.12 |
| Zn ( " ) | 20.5 | T-S ( " ) | 30.8 |
| Cd ( " ) | 0.03 | $SiO_2$ ( " ) | 13.6 |
| Sn ( " ) | < 0.005 | $Al_2O_3$ ( " ) | 2.0 |
| Fe ( " ) | 20.2 | CaO ( " ) | 4.2 |
| Sb ( " ) | < 0.001 | MgO ( " ) | 2.1 |
| As ( " ) | 0.04 | LOI ( " ) | 5.8 |
| Bi ( " ) | < 0.001 | | |

**3.1.3 Characteristic of ore**

Mineral composition: Summarized the results conducted by the observation under the Microscope, X-ray diffraction and EPMA as follows:

(1) Major zinc mineral are sphalerite and is in the coarse grain.

(2) Major lead mineral are galena. There were two types, one is the coarse grain, other includes with the veinlets form in part of pyrite.
Size of galena intrusive into pyrite is in order of 10 micron, and it seems probably concentrate will be yielded with the middling form because of their separation will be difficult.

(3) Chalcopyrite, bonite, covelline, enargite, stannite and others were observed for copper minerals but major ore is chalcopyrite which is disseminated in sphalerite with the size of fine grain and dotted forms. So that, copper will aggregate in the Zn-concentrate due to the difficult separation.

(4) Silver minerals are argentite and canfieldite. Canfieldite exists in sphalerite with the size of 2-10 micron and both canfieldite and argentite are in pyrite with the size of 2 - 20 micron. These silver minerals will move together with sphalerite and pyrite in flotation process while they are too fine and so difficult to separate. Silver will be recovered with two kinds of forms, one is occluded in galena, other is associated in sphalerite with the form of canfieldite.

(5) Iron minerals are pyrite mainly, arseno-pyrite, hamatite and pyrrhotite.

(6) Gangue rocks are mainly quartz, calcite and dolomite, and sericite, chlorite and talc for clay minerals.

Specific gravity and Work index (Wi): 3.8 of specific gravity was measured by the pycnometer for the composite sample and 11.0 kWh/t of Wi expects from the results measured by Hardgrove method.

### 3.1.4 Flotation test

Selection of flotation methods: Two flotation methods, bulk differential flotation and streight differential flotation, were conducted. Regarding the rougher concentrate, serious difference was not recognized on the recovery of Pb and Zn between both methods. But, recovery of Pb final in Pb-concentrate was very much low at bulk differential flotation compared to streight differential flotation because it will be thought that the flotability of galena is interfered extremely by slaked lime to be added to control pyrite into the cleaner at the bulk differential flotation method, although the recovery of Zn final in the Zn-concentrate shows almost the same value.

Based on the test results, the streight differential flotation method will be favourable for the apprisal on this ore treatment. It will be notice that 60% of silver were recovered together with Zn-concentrate, adopted whichever methods.

Comparison results between both methods are as follows:

| | Bulk diff. f. | Streight diff. f. |
|---|---|---|
| Pb recovery in rougher (%) | 94.0 | 90.8 |
| Zn recovery in rougher ( " ) | 90.8 | 91.6 |
| Pb recovery of Pb-concentrate ( " ) | 44.9 | 71.6 |
| Zn recovery of Zn-concentrate ( " ) | 83.4 | 86.8 |
| Pb grade in Pb-concentrate ( " ) | 59.9 | 63.0 |
| Zn grade in Zn-concentrate ( " ) | 54.4 | 55.5 |

Flotation conditions: Based on the results conducted through a series of the test, the optimum streight differential flotation conditions are expected to be;

Grinding size - 200 mesh with 80% pass

| | Pb flotation | Zn flotation |
|---|---|---|
| Roughing time (min.) | 5 | 10 |
| Stages of cleaning | 5 | 3 |
| Consumption of reagents (g/t): | | |
| Slaked lime | 250 | 1,400 |
| Sodium cyanide | 85 | - |
| Copper sulphate | - | 300 |
| KAX | 70 | 70 |
| Frother | 40 | 60 |
| pH value in roughing | 8.0 - 8.3 | 11.0 - 11.3 |

Operation performance: From the results of the batch test, the expected operational performance is as follows:

| Concentrate | Grade | Recovery |
|---|---|---|
| Pb-concentrate (% Pb) | 65 | 80 |
| Zn-concentrate (% Zn) | 52 | 88 |

The average recoveries of silver are 15% in Pb-concentrate and 58% in Zn-concentrate respectively.

Characteristic of the concentrate: The results of the complete analysis of Pb-concentrate, Zn-concentrate and tailings obtained from the composite sample is shown on Table 2.3, and assay of waste water delivered from the concentrator is shown on Table 2.4.

Table 2.3 Complete analysis of concentrate

| | Pb-conc. | Zn-conc. | tail. | | Pb-conc. | Zn-conc. | tail. |
|---|---|---|---|---|---|---|---|
| Ag (%) | 770 | 159 | 17 | Hg (ppm) | < 0.5 | < 0.5 | < 0.5 |
| Cu (%) | 0.15 | 0.22 | 0.02 | Ga (%) | < 0.001 | 0.017 | < 0.001 |
| Pb (%) | 70.8 | 0.16 | 0.10 | T-S | 17.6 | 33.1 | 33.0 |
| Zn (%) | 3.6 | 55.8 | 0.74 | Mn (%) | 0.02 | 0.05 | 0.13 |
| Cd (%) | < 0.01 | 0.10 | < 0.01 | $SiO_2$ (%) | 1.0 | 1.4 | 18.9 |
| Sn (%) | 0.06 | < 0.005 | < 0.005 | $Al_2O_3$ (%) | 0.30 | 0.11 | 2.5 |
| Fe (%) | 4.6 | 7.7 | 28.6 | CaO (%) | 0.58 | 0.04 | 5.6 |
| Sb (%) | 0.043 | < 0.001 | < 0.001 | MgO (%) | 0.25 | 0.03 | 2.5 |
| As (%) | 0.05 | 0.02 | 0.08 | LOI (%) | -2.3 | 0.14 | 5.0 |
| Bi (%) | 0.005 | < 0.001 | < 0.001 | | | | |

Table 2.4 Assay of waste water

| | | | | | |
|---|---|---|---|---|---|
| pH | 10.5 | Zn (ppm) | 0.02 | As (ppm) | < 0.02 |
| Fe (ppm) | < 0.05 | Pb ( " ) | < 0.02 | CN ( " ) | 0.04 |
| Cu ( " ) | 2.0 | Cd ( " ) | < 0.01 | $SO_4$ ( " ) | 745 |

### 3.1.5 Findings

A series of laboratory test indicated that the good flotation performance will be achieved on Limpe's ore body without any complex treatment system or especially high technology although ore has characteristic to be produced with the middling forms in both lead and zinc. However, it is desirable to be conducted bach tests for different kinds of ore and continuous tests by a medium test facility in order to grade up the precision of the basic data, to design a full-scale concentrator, to select the optimum flotation conditions, and to estimate the operational performance because of the existence of characteristic of yielding the middlings might be influenced on the floatation performance, specially on Pb floatation.

## 3.2 CONCENTRATOR

### 3.2.1 Outline

Concentrator treats 225,000 t annum with 300 operation days an annum and produces Pb-concentrate and Zn-concentrate adopted with the streight differential flotation method. The daily average capacity of the plant is theoritically 750 t, but to compensate a fluctuation of the crude ore to be delivered from the mine and for the interruption by repairs, the treatment tonnages will be put on 825 t/day at the maximum capacity. The operation of ore receiving and crushing plant will be in two shifts per day to co-operate the mining and three shifts per day for the down-stream sections after crushing. The ore adjustment will be controlled by the fine ore bins.

The location of the concentrator will be about 800 m south away from the present S-adit portal considering the location of the portal, topography and foundation, and the tailing disposal. The concentrator will be divided to two, one is crushing plant and other is down stream's plant, with consideration of the relation between elevation of the main haulage level and the final elevation of tailing dam, and both plants are connected with the belt conveyor.

The construction of plants are the semi-buried horizontal type for the crushing plant and the inclined type for grinding, flotation and filtration plants agreed with the topography.

### 3.2.2 Design parameters

Basic conditions: Judging from the metallurgical test results, crude ore is considered to be easily concentrated without any special technique and treatment system, and the streight differential flotation is better than the bulk differential flotation. Basis designs of plant for reducing the initial investment and operation cost are as follows:

(1) Process should be standarlized and simplified as much as possible.

(2) Two rows of grinding and flotation will be adopted.

(3) No high instrumentation should be equipped and only a few members of major sections will be automatized.

(4) Washing facility is not provided since a little amount of clay are expected in the crude ore.

(5) The construction of the buildings will be simple and special attention of equipment's layout should be paid to obtain high efficiency and easy operation.

(6) Number of pumps will be eliminated to be adapted a incline plant.

(7) Recycled water should be used as much as possible to reduce the water cost.

| | | |
|---|---|---|
| Ore treated : | Average Grade (%) | Cu 0.10, Pb 1.16, Zn 15.92 |
| | Average Grade (g/t) | Ag 35 |
| | Specific gravity | 3.8 |
| | Average water content (%) | 5.0 |
| | Grinding work index (kWh/t) | 11.0 |
| Crushing : | Crushing process | Two stage closed circuit |
| | Max. feed size (mm) | 500 |
| | Receiving ore bin capacity (t) | 200 |
| | Max. hourly capacity (t) | 90 |
| | Final product 80% size (mm) | 12 |
| Grinding : | Grinding process | Ball mill - Classifier closed circuit. |
| | Fine ore bin capacity (t) | 800 |
| | Max. hourly capacity (t) | 34.4 |
| | Circulating load (%) | 250 |
| | Classifier o'flow density (%) | 40 |
| | Final product 80% size (micron) | 74 |

| Pb Flotation : | | Density (%) | Time (min) |
|---|---|---|---|
| | Conditioning | 40 | 2 |
| | Roughing | 40 | 10 |
| | Cleaning | 20 | 9 |
| | Stage of cleaning | 5 | |
| | pH value in roughing | 9 | |
| | Grade of concentrate (% Pb) | 65 | |
| | Pb recovery (%) | 80 | |

| Zn Flotation : | | Density (%) | Time (min) |
|---|---|---|---|
| | Conditioning | 35 | 2 |
| | Roughing | 35 | 15 |
| | Cleaning | 25 | 7 |
| | Stage of cleaning | 3 | |
| | pH value in roughing | 11 | |
| | Grade of concentrate (% Zn) | 52 | |
| | Zn recovery (%) | 88 | |

| | | |
|---|---|---|
| Regrinding : | Feed | Zn cleaner tailing and scavenger froth |
| | Regrinding process | Ball mill - cyclone closed circuit. |
| | Feed size, 80% pass (micron) | 147 |
| | Product, 80% pass (micron) | 74 |

Filtration :

| | Pb-conc. | Zn-conc. |
|---|---|---|
| Thicknener spigot density (%) | 45 | 45 |
| Size of conc. (-200 mesh %) | 90 | 85 |
| Apparent specific gravity of conc. | 3.1 | 2.0 |

Tailing thickening :

| | |
|---|---|
| Method treated | Callow cone- thickener, 2 stages |
| Density of Zn-flotation tailing (%) | 25 |
| Density of thickener feed (%) | 22 |
| Density of callow cone spigot (%) | 45 |
| Density of thickener spigot (%) | 40 |
| Precipitation speed of tailing (mm/min) | 9.8 |

**3.2.3 Concentration process** (Refer to Drawing 007, 008 & 009)

Receiving crude ore: Ore mined out is transported by a train composed to a 8 t trolley locomotive and ten 5 t gramby cars. A receiving ore bin, which is made of concrete with reinforced iron bar and 200 t capacity, is installed to adjust the operation hours and tonnages. A 50 cm x 50 cm screen on the top of the bin will be provided to control the oversize, and oversize is broken by a hydro-breaker installed beside the screen.

Crushing: Crushing plant consists of a series with two stages closed circuit and major equipment are a primary crusher, a secondary crusher and a vibrating screen copped a closed circuit with the secondary crusher. Ore stored in the receiving ore bin is drawn by a 40" apron feeder and fed to a 42" x 30" single toggle type crusher, and after crushed, fed to a 6' x 14' double deck vibrating screen (40 mm opening in upper screen, 15 mm opening in lower screen) and screened. Oversize are crushed by a 5' hydraulic cone crusher and fed again to the vibrating screen. Under of the vibrating screen are conveyed with a 24" belt conveyor to the fine ore bins

This storage bin consists of two 400 t capacity each made by the round shaped corrugate iron plates, and a 24" wide shuttle conveyor installed on the storage conveys ore to each ore bin.

Grinding: Grinding plant comparises two identical parallel circuits, each equipped with a 9' x 12' ball mill and a 72"ϕ spiral classifier co-operated with a closed circuit. Ore are drawn by a 20" belt feeder equipped the speed changeable motor.

Flotation: The flotation will be conducted in the streight differential flotation method, and the plant is divided to two of Pb flotation and Zn flotation sections. Two rows of 8 cells x 60 $ft^3$ for roughing and a row of 10 cells x 21 $ft^3$ for cleaning will be provided in the Pb flotation section. And Zn flotation section will be composed of two rows 18 cells x 60 $ft^3$ for roughing and two rows of 9 cells x 36 $ft^3$ for cleaning.

Cleaning of the rougher froth is done in 5 stages arrenged in 3-3-2-1-1 at Pb flotation section and in 3 stages of 4-3-2 at Zn flotation section. Pb cleaner tailing will be returned to the grinding circuit, because much amount of

middlings composed of galena and pyrite may be existed in tailing. While both cleaner tailing and scavenger froth at the Zn flotation section may be composed of the middlings which is matrixed finely with sphalerite and pyrite, and fine grained chacopyrite stopped into sphalerite, they will be reground.

Regrinding: The plant consists of a 6' x 6' ball mill and a 6"ϕ cyclone copped with the closed circuit, and grinds the cleaner tailing and the froth of scavenger. Overflow of cyclone is returned to the Zn rougher system.

Filtration: After the froth of final Pb cleaner is thickened with a 20'ϕ thickener, it is dewatered with a 17 $ft^2$ x 6 cambers pressed type filter. The filter cake is stored in a Pb-concentrate yard of 600 t capacity after weighed with the belt scale. The froth of Zn final cleaner is thickened with a 30'ϕ and dewatered by a 17 $ft^2$ x 14 chambers pressed type filter and stored in a Zn-concentrate yard at 5,000 t capacity after measured by the belt scale.

The thickener overflow is recycled and reused in the concentrator, and concentrates loaded on a truck with a shovel loader from the yard is shipped after weighed with a truck scale.

### 3.2.4 Auxiliary facilities

Reagents: All reagents to be used at both Pb and Zn flotation sections are transported to the each distribution rooms after dissolved and adjusted in a regent room located in beside fine ore bin. They will be supplied to each necessary places after adjusted by the cap feeder or the flowmeter at the distribution room. Slaked lime will be used for pH value control.

Instrumentation: Instrumentation in the plant is conducted at the necessary points for indicating and monitoring. The following are installed;
Weightometer will be at fine ore bin, feed conveyors to ball mills, and each Pb and Zn-concentrate conveyors. pH meter will be installed at the outlet of each Pb and Zn conditioners.

Samplers: Wet type samplers will be provided at feed of Pb flotation, each Pb and Zn flotation tailings, and a dry type sampler is on each conveyor of Pb and Zn-concentrate.

### 3.2.5. Principal unit consumption

| Items | | Consumption |
|---|---|---|
| Supply and material (g/t) | | |
| Ball for ball mill | | 1,200 |
| Slaked lime | | 4,000 |
| Sodium cyanide | | 80 |
| Potassium amyl xanthate | | 140 |
| Copper sulphate | | 300 |
| Frother | | 145 |
| Frocculante reagent | | 5 |
| Power (kWh/t) | | 37.3 |
| Water ($m^3$/t) | Fresh | 2.41 |
| | Recycle | 1.03 |
| | Total | 3.44 |

# 4. ENVIRONMENTAL FACILITIES

## 4.1 TAILING DISPOSAL

### 4.1.1 Outline

The tailing disposal facilities conform from the thickening equipment for Zn flotation tailing, a series of pipe line and a tailing pond. Overflow separated from solids at tailing thickener is reused in the concentrator. Tailing thickened is send to the tailing pond through pipe line, and overflow from the pond is discharged into Yarahuaino valley.

### 4.1.2 Thickening and transportation system

Tailing of Zn flotation having 25% solid of pulp density is thickened to 40% with two stages of 18'Φcallow-cone and 50'Φthickener. Thickener overflow separated from solids is pumped up to be used at Zn flotation section.

Both underflow come from the callow-cone and thickener are mixed and delivered to the reservior of 8 $m^3$ made of concrete. Then, from there it is fed to a 10"Φcyclones installed at the embankment creast. Natural flow by gravity will be adopted during seven years after operation starts, although the proposed tailing pond locates in 400 m apart from the concentrator and 25 m difference in elevation. But, operation by pump will be required after seven years due to rising of the embankment.

### 4.1.3 Piling

Slurry transported from the reservior is classified to two parts, sand and slime, with two 10"Φcyclones, and sand is used for banking materials and then slime is deposited separately behind sand. Proposed ratio between sand and slime will be 50% to 50%. Clear water separated from solids are collected at the upper stream of the pond and delivered to outside of the pond and discharged into Yarahuaino valley through the dicant towers and underlaing culvert.

### 4.1.4 Tailing pond

Selection of site: Two site, Pachangara valley and yarahuaino valley, were surveyed for comparision purpose. Consequently, the latter was selected for the following reasons:

(1) The area locates nearer to concentrator and it exists lower elevation than concentrator, so that transportation of slurry is easier.

(2) Area able to be seen a glance over from concentrator, as a result, good communication and closed attention on operation will be obtained.

(3) A spare area will be available to be expanded in the future.

(4) There is no big domestic residents in the down stream.

(5) Suitable construction materials can be obtained in the neighbourhood.

Topography: This area is surrounded by two hills, northern side (right bank) to the ridge of 5,000 m and southern side (left bank) to be extended to the ridge of 5,200 m. This valley is formed U-shape to the glacial movement bounded at 4,400 m and expanded widely to the upper stream. The back side is cliffed with wall running to N-S direction of 5,000 m high, and the lake Tinyag lies underneath of it.

At the down stream bounded 4,400 m, hard rocks are exposed in both banks and forms the sharp V-type nallow valley. In the left bank of the valley where is bounded to the U-shape valley, there are the large scale and many numbers of talus which starts from 4,800 m in elevation and ends at the valley bottom. Therefore, the pond will be constructed at elevation of 4,485 m to avoid the talus, while the end of down stream side should be above level of talus.

Type of tailing pond and its capacity: Sand and slime separate type dam will be adapted. Slurry is separated to sand and slime before piling, and slime (overflow of cyclone) is discharged toward to upper stream from the bank creast and clear water is delivered to the outside of the pond through the underlaing culvert. The pond capacity is in totalling 2,140,000 $m^3$ with about 878,000 $m^3$ of sand and 1,262,000 $m^3$ of slime, which is sufficient through the planned operation period.

Dam: A sand banking dam which is utilized only sand separated by the cyclones will be adopted. The dams constructed by stones will be built at both the upper site and lower site of proposed dam, and connected with under drain between both dams. The dam should be prevented from rising the water table of the embankment. Inside dam slope will be one to five during the construction period, but 5 meters wide of the step in every 10 m high will be maintained with the progress of the dam and a cut off will be done into the dam foundation to prevent the growth of water leakage for keeping the stability of the dam.

Drainage facilities: There are 7.4 $km^2$ of the catchment area but 2/3 of them are occupaied by the catchment of the lake Tinyag. As the catchment area is rather small and the surrounding hills are gently sloped with grass, no diversion channel is constructed. The rain-fall water in area will be discharged to the outside together with clear water of the pond through the drainage facilities. The demension of the culvert made by concrete is to 800 mm$\phi$ and the decant tower will be provided every 1 2 m for removing clear water.

The design parameter for the drainage facilities are as follows:

| | |
|---|---|
| Rainfall (mm/day) | 48.2 |
| Catchment area ($km^2$) | 7.4 |
| Run-off coefficiency | 0.8 |
| Clear water separated from slurry ($m^3$/sec) | 0.020 |
| Waste water ($m^3$/sec) | 0.067 |
| Rain-fall water ($m^3$/sec) | 3.290 |
| Maximum cuvert capacity ($m^3$/sec) | 3.377 |

Construction schedule: The construction works which has enough capacity for six years operation will be carried out during the construction period and the remains will be again progressed at the time when five years operation passed.

## 4.2 TREATMENT FOR THE UNDERGROUND WATER

### 4.2.1 Nature of underground water

Water encountered at each levels flows through the canal on the trackless inclines by gravity and gathers at 0 m main haulage level, and delivers to surface through the canal of 50 cm x 50 cm by natural flows. Volume will vary by seasons, but the treatment should be conducted before discharge into the river due to pollution occurred by passing-through pyrite zone and stopes, such as low value of pH and contamination of slime and muds. Determination of water volumes and its nature is difficult due to lack of information, but based on the tunnel and boring carried out, volume will be suspected to 0.5 $m^3$/min in the dry season and 4.0 $m^3$/min in the wet season with average 1.5 - 2.0 $m^3$/min in annum, and pH value will be 2 - 3 through a year although varied slightly higher in the wet season.

### 4.2.2 Treatment

Underground water is guided up to the tailing pond by the canal constructed along the surface main haulage track. It treats to mixing together with the clear water of the pond having 11.0 of pH value as the same as value of Zn flotation tailing. Besides, slaked lime will be added to rise pH value at the canal on the way to go to tailing pond with the form of milk which is adjusted at the concentrator reagent room and delivered through pipe line. Proposed lime requirement for treatment expects to 1.5 t per day. Underground water adjusted on the normal value with mixing clear water and adding the lime will be discharged to the outside through the dicant tower and culvert. Also, suspension materials containing underground water are precipitated into the slime pond.

## 5. OTHER PLANS

### 5.1 POWER SUPPY

#### 5.1.1 Mine power plant

Power supply for Iscaycruz mine can not espect to purchase from Electro Peru or other company because there is still on project finding or planning stages to be constructed the electric plants in this district. Own diesel generators of maximum output 2,500 kW will be provided to supply power on mine operation after consideration with comparison of three alternatives; construction of hydraulic plant, own diesel generator and purchase of power transmitted from far away.

#### 5.1.2 Power requirement and voltage used

Power requirement: Maximum power requirement for the production and welfare facilities will be about 2,500 kW (average about 2,000 kW) and total annual requirement will be about 14,557 MWh which are distributed by department as follows:

| Department | Max. power requirement (kW) | Average requirement (kW) | Power consumption annum (kWh) |
|---|---|---|---|
| Mining | 620 | 414 | 2,981 |
| Concentrator | 1,460 | 1,167 | 8,402 |
| Water supply | 70 | 58 | 418 |
| Auxiliary facilities | 90 | 32 | 230 |
| Welfare facilities | 300 | 240 | 2,102 |
| Subtotal | 2,540 | 1,911 | 14,133 |
| Max. resultant power | 2,420 | | |
| Loss | 70 | 57 | 424 |
| Total | 2,490 | 1,968 | 14,557 |

Voltage: Efficiency of the insulation will be deteriorated corresponding to rising of the elevation depend on the air insulation applied on the electrical apparatus and the same tendency will be on temperature limit. Therefore, rated voltage selected for each of these load facilities are listed below, while correlation factor of the insulation on the electrical apparatus is in about 53% for about 4,600 m elevation of mine site.

High voltage motor : Out put 110 kW or more, 3-phase, 2,200 V, 60 Hz
Low voltage motor : Out put 110 kW or less, 3-phase, 220 V, 60 Hz
Lighting/heating : Single phase, 220/110 V, 60 Hz

However, rated voltage for machinaries used is standardized as 600 V for low voltage, 7,200 V for high voltage.

### 5.1.3 Power plant (Refer to Drawing 011)

Diesel Generator: Correlation for output will be necessary since it will be installed in the elevation of 4,600 m. Based on British Standard of 649 "Output will be decreased of 2.5% for every 300 m high between from 150 m to 2,500 m in elevation when generator is installed in over 150 m in elevation.", 37.1% of correlation factor for the output will be calculated at 4,600 m elevation if applied proportionally over 2,500 m.

Therefore, capacity of the generator to be installed at mine site for matching the demand of mine operation is as follows:

$$2{,}500 \text{ kW} \div (1\text{-}0.371) \fallingdotseq 4{,}000 \text{ kW}$$

Five units of each average capacity 820 kW with the super charger and 1,200 rpm will be provided.

But, spare unit will not consider to eliminate the initial investment, and the lack of power occurred during overhaul of them and repair is adjusted by load factor. Generators of two 175 kW and a 75 kW used during the construction period are installed in the power house and utilized for the spare and emergency use.

Comparison among power supplying methods: Results studied among construction of hydraulic plant, diesel generator and purchase of power are as follows:

(1) Possible site to be constructed the hydraulic plant are chosen at two places: one is at Oyon, used the currents of Rio Paton and Rio Pachangara, other is at Viroc used the current of Rio Huaura.

These specification are as follows:

| | Oyon | Viroc |
|---|---|---|
| Elevation of intake (m above sea level) | 3,450 | 3,140 |
| Elevation of plant ( " ) | 3,180 | 3,000 |
| Length of canal (m) | 4,200 | 1,300 |
| Hight difference (m) | 255 | 135 |
| Min. water volume to be used ($m^3$/min) | 2 | 3.2 |
| Minimum out-put (kW) | 4,000 | 3,400 |

(2) Comparison of present value between hydraulic plant and generator

Comparison of present value between hydraulic plant at Viroc and diesel generator at mine site are estimated as follows:

Assuming 10 years of mine life (n) and discount factor of 9% per annum (i),

$$\text{Present value} = \text{Initial investment} + \left\{\text{Annual operation cost} \times \frac{(1+i)^n - 1}{i\,(1+i)^n}\right\}$$

| | Hydraulic | Diesel generator |
|---|---|---|
| Initial investment ($1,000) | 10,145 | 3,769 |
| Operation cost ( " ) | 88 | 1,450 |
| Present value ( " ) | 10,710 | 13,075 |

Hydraulic plant seems available than diesel generator but, diesel generator method was decided on this report because of lower investment and shorter time compared to construction of hydraulic plant and the mine life is assumed on 10 years.

(3) Purchasing power

There are two sources to be transmitted power, one is from Hidro Andina S.A. and other is from CENTROMIN. The further will be favourable on the view of the commercial bases. In this case, the nearest hydraulic plant of Hidro Andina S.A. locates in Cahua, about 65 km far from the mine site in direct, but length of transmission line required will be over 100 km with voltage of 60 kV. However, the private mine company can not afford to construct the such long transmission line and to keep the good condition them always. Therefore, it is impossible to purchase power from the outsides.

### 5.1.4 Power distribution (Refer to Drawing 012)

Four substations will be provided and connection to the generator is performed at the main station. The stations and distribution line laying are as follows:

Main substation and concentrator substation: The combination substations of the main station and concentrator station will be built at the most upper level of concentator having the biggest demand. The main substation will consist of the receiving boards from the generator and transmitting boards with three lines to transmit to mining, water pump, auxiliary and welfare substations. At the concentrator substation, receiving panels, starter panels for high voltage motors, transformer of 2,200V/220V, distribution panels for low voltage motors to be connected to the each blocks (crushing, milling, flotation, filtration and others) and condesner for compensate the efficiency will be installed.

Mining substation: Substation will be provided near mine portal of 4,715 m elevation. Power will be supplied through 2,200 V transmission line from the main substation. Starter panels for compressor, transformer 2,200V/220V, and panels for low voltage motors will be installed. Also, substation which is branched from the line laying from the main substation to mining substation will be built near the portal of the main haulage track and transformer for low voltage power, panels for low voltage power and direct current panels for the locomotive are installed.

Water pumping substation: The substation will be provided near the pump station located in the south end of lake Quellaycocha and receives with 2,200 V from the main substation through the transmission line. The cubicle type station which consists of the transformer of 2,200V/220V, panels for low voltage and control panels for pumps is installed.

Auxiliary and welfare facilities station: These area will be also supplied with 2,200 V feeder line from the main substation. One transformer on platform will be provided auxiliary zone for supply low voltage power to the central office, warehouse, mess and others. The special attention of power shut-on-out will be provided to adjust the load requirement at the auxiliary and welfare facilities with off-on siwtches acted automatically when emergency happens. Other three platform will be provided to supply power with low voltage at the residential area.

Others: The transmission lines, except the line of the main substation to concentrator, pass through the western side of lake Tinyag and Quellaycocha and are supported together with the same supporters.

## 5.2 COMMUNICATION

### 5.2.1 Outline

The wire telephone system is sufficient at the districts along Pacific ocean coast but not enough at the mountain districts. Only one line was operated by ENTEL-Peru between Sayan - Churin - Oyon, so that it can not service for the mine needs. Therefore, to provide the own communication system will be necessary.

### 5.2.2 Radio communication system

The radio station that is the same system applied generally at the mines in Peru will be installed at the mine and Lima head office for inter communication. The opertion frequency will be 150 or 400 MHz band, and emergency power sources will be provided at the mine station.

### 5.2.3 Wire telephone system

Automatic crossbar 96-line switch board which will be able to connect to a public line in future at the Churin station, will be provided in the central office and the telephone sets will be positioned as listed below:

| Item | Unit | Remarks |
|---|---|---|
| Mining | 12 | Surface facility and main levels at underground |
| Concentrator | 5 | Includes assay, labo, and tailing Pond. |
| Water pumping station | 2 | Includes purification plant. |
| Power plant | 2 | |
| Auxiliary facilities | 14 | Central office, repair shop and warehouse and others. |
| Welfare facilities | 15 | Camp houses, quarters, club and canteen |
| Total | 50 | |

## 5.3 WATER SUPPLY FACILITIES

### 5.3.1 Requirement

Total water requirement will in amount of 909,000 $m^3$ an annum. However, used water will be re-cycled in concentrator as much as possible, so that freshed water requirement will be amount of 685,500 $m^3$ an annum.

Industrial water: About 96% of industrial water will be used in concentrator alone. In order to reduce the water cost, about 30% of total needs will be recycled. Detail are as follows:

($m^3$/day)

| | Fresh water | Recycled water | Total |
|---|---|---|---|
| Concentrator | 1,800 | 780 | 2,580 |
| Mining | 100 | - | 100 |
| Repair shop, others | 20 | - | 20 |
| Total | 1,920 | 780 | 2,700 |

Domestic water: The required amount is 109,500$m^3$ (300$m^3$/day) will be consumed at the welfare facilities. The population of the residential area will be estiamted to reach 1,500 including the family, and maximum consumption for person per day will estimate to 200 liters.

### 5.3.2 Suppling method and facilities

Selection of water source: There are no river in mine area excluding some creeks which flow little in the wet season. Rio Pampahuay or its branch will be in source when water pumps up from the river. In this case, it is in distance of 8 km from the proposed point to mine site, and 700 - 800 m high ridge locates on the way. It seems it is not recommendable in economics to establish this system consisted of pumping equipments and apparatus, power line for them and pipe line and others, and it is too difficult to maintain the such system.

Therefore, the lake Quellaycocha, in 800 m long, 300 m wide and 10 m deep, located in 3.5 km north of the concentrator is selected as the source of industrial and domestic water. 1,080,000 $m^3$ of flow-in to the lake an annum will be expected and it enough meet to the mine requirement, based on the observation records such as the isohyet chart at Rio Huaura area and rain-fall in mines conducted by SENAMHI and the operated mines (Raura, Paton, and Uchuc Chacua).

Intake facilities and delivering system: Water of lake delivered from the pontoon, which is equipped a turbine pump and is copped with the water level varing in seasons, will be pumped up till the pump station situated in beside the lake. Each two turbine pumps, including the spare, of 1.5 $m^3$/min for industrial and 0.3 $m^3$/min for domestic will be provided in the station.

Industrial water is pumped up by 6"$\phi$ x 1,500 m pipe line to the reservoir tank (170 $m^3$) situated at near the ridge of 4,800 m high and delivered to concentrator, mining and repair shop and others by 6"$\phi$ and 3"$\phi$ pipe lines by gravity.

Domestic water will be pumped up to the filtration tank through 4"$\phi$ x 1,000 m pipe line, and after filtrated water is sterilized with sodium hypochlorite, treated water will be distributed to the each houses through pipe lines by gravity.

## 5.4 AUXILIARY FACILITIES

### 5.4.1 Outline

This works are composed of the construction of main access road to the mine, inside mine road, buildings such as central office, repair shop, warehouse and others, and purchase of the common vehicles used during the operation period.

It is an important factor for mine activity there is the road which is connected to the outside and maintained well. However, there is only a road which was constructed for the prospecting purpose on survey by Cooperative Mineral Exploration and probably it is available 6 t class truck will pass on it. So that new road construction will be necessary. In addition, improvement and construction of the detour on public roads between Oyon and Mishuya will be necessary.
Central office, warehouse, repair shop and others will be accommodated in the production zone to keep a good communication and administrative control.
Vehicles for the common use such as administratives, concentrates loading, road maintenance, supply material and so on and bus to be operated on schedule are purchased.

### 5.4.2 Road construction

Standard of road is : 4 m wide, max. inclination of 6%, single lain and sand and gravel pavement. The canal will be provided in mountain side but without special treatment, and some concrete culvert will be underlain to be drained into the valley accross the road. The sidetrack will be also provided when necessary. Fig. 2.6 shows the location to be improved and newly constructed.

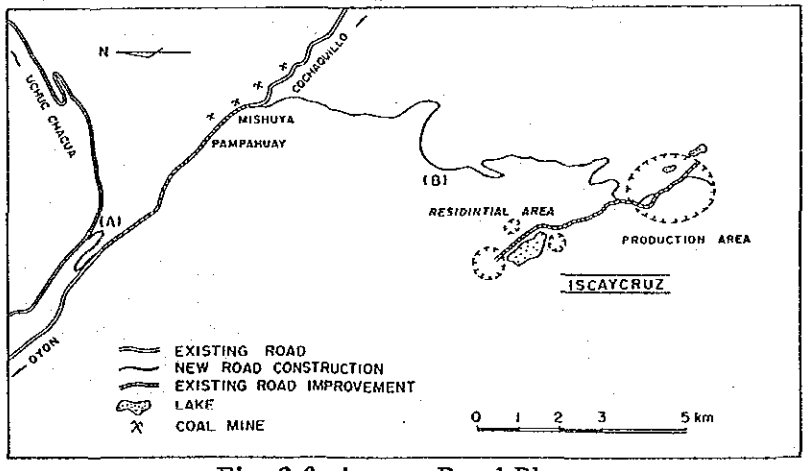



Fig. 2.6 Access Road Plan

Road construction (A): To avoid from passing the present route, new detour road of 1.5 km to be connected to Uchuc Chacua from the suburb of Oyon will be constructed because of the parts of road at the suburb of Oyon is stopped traffic by the soft ground and landslides occurred frequently during the wet season.

Improvement: Improvement works of 7 km long will be conducted to the road between the newly constructed detour road and Mishuya.

Road construction (B): 11.0 km of road between Mishuya to Iscaycruz will be constructed. The present road was tentatively constructed for the survey by Cooperative Mineral Exploration, so that it can not cope with the mining activities due to it has a many steep points of average 1/10, and its curvature was too small and besides, surface was not good.

Improvement of inside mine road: 4 km of improvement and new road of 4 km to be connected closely between the buildings will be provided at the production and residential areas.

### 5.4.3 Building and related construction

Central office: A one-story building made of concrete blocks, with a total floor area 150 $m^2$ will be constructed as the mine management center which will accommodate the mine manager, assistant mine manager and office staffs.

Repair shop: All mechanical and electrical machinaries and apparatus except them of mining department and common used vehicles will be repaired. It will be located in adjacent to the concentrator highly utilized, and equipped with lathe, drilling machine, shaper, grinders, welding machines and others.

Central warehouse: Divided into the mechanical-electrical parts storage and general storage. A one-story building with the steel frame; floor area of 600 $m^2$.

Mess: A one-story building made of concrete blocks with 150 $m^2$ in floor area will be built ajacent to the central office and serves foods during the working hours, and the seating capacity is 70 at a time.

Others: Parking for concentrates transportation trucks, weighing room with 30 t capacity of truck scale and guard houses and others will be provided.

### 5.4.4 Purchase of vehicles for common use

| Item | Specification | Unit | Remarks |
|---|---|---|---|
| Pickup | 400 kg | 3 | General use |
| Jeep (large type) | | 2 | General and clinic |
| Bus | 45 persons | 1 | General |
| Bulldozer | 14.0 t class | 1 | Road maintenance |
| Shovel loader | 1.2 $m^3$ | 1 | Concentrate loading |
| Forklift | 1.5 t | 1 | Repair shop and warehouse |
| Truck | 8.0 t | 1 | General cargo |

## 5.5 WELFARE FACILITIES

### 5.5.1 Residential population

Total of mine employees and workers including expatriates are 403. The pupulation that is the factor of the residential and various facility plan will be estimated as follows. The ratio of the single to the married will be go down following the progress of the operation although the single will be remarkably higher than the married in starting time of operation. Ratio of the single to the married is assumed to be 30% to 70% both the employees and workers and the number of a family of each married person will be assumed to be four in total, composed with wife and three children. All staffs are in married but out of 30% will be resident in mine site and 70% will be stay in mine site separated from the family, and all expatriates will be alone.

The detail of the population are as follows:

| | Single | Married | Family | Total |
|---|---|---|---|---|
| Expatriate | 3 | - | - | 3 |
| Staff | 21 | 9 | 36 | 66 |
| Employee | 20 | 46 | 184 | 250 |
| Worker | 91 | 213 | 852 | 1,156 |
| Total | 135 | 268 | 1,072 | 1,475 |

### 5.5.2 Location and layout of welfare facilities (Refer to Drawing 013)

The site is selected near the lake Quellaycocha apart completely from the production area. There will two residential site separate; one for staffs and other for employees and workers. Necessary services for their daily needs such as school, medical, recreation and shopping, and social service facilities will provided at the area between both the residential areas.

### 5.5.3 Residential houses and others

For employee and worker: 44 of three-stories building made of concrete blocks will be constructed for the married employees and workers. One story consists of two houses of 80 $m^2$ composed of a living and dining room, 3 bed rooms, bath-shower room, kitchen. A quarter made of concrete blocks with one-story with 20 rooms will be built for the bachelor employees, and each room of 15 $m^2$ is occupied by one parson. The bath and shower facilities will be provided one for every two rooms. Also, two quarters with 16 rooms of one-story will be built for the bachelor workers, and one room with 24 $m^2$ is occupied with three persons and a bath and shower facilities will be provided for every two rooms.

For staff: Five buildings of one-story made of concrete blocks will be constructed which consists of two houses of 90 $m^2$ with the same arrangement as the employee and worker house. For bachelor, two quarters having 12 rooms and 10 rooms, respectively, will be provided and one room with 20 $m^2$ is occupied by one person and prepared a bath and shower room for every two rooms. For

expatriate, they will accomodate in the club house, which is constructed at the staff residential area.

Other: Furniture will be completely prepared for the staff house but no furnished for employee and worker house except electrical heating facilities.

### 5.5.4 Social service facilities

School and kindergarten: A elementary school with the capacity of 540 children will be constructed as the two stories building made of concrete blocks with the floor area of 1,200 $m^2$, which will be divided into 20 rooms of 15 rooms for the class room, 3 rooms for the special room and 2 rooms for the teachers.

A kindergarten with the capacity of 100 children will be constructed as one story building made of concrete blocks with the floor area of 250 $m^2$.

Medical facilities: A one story clinic with 10 beds and consultation, dental, operation, X-ray, phermacy and waiting room will be built with the floor area of 720 $m^2$, and two doctors, one phermacist, one midwife and two nurses will be stationed fully.

Canteen: A one story canteen of 400 $m^2$ will be constructed for supplying the foods, clothes and daily goods and it will be divided to two of sales-corner and storage.

Club houses: A one story club house with the floor area of 420 $m^2$ will be built and it has 7 rooms for the welcome reception and overnight stay of visitors and expatriates at the staff residential area. And other a one story club house with 200 $m^2$ will be provided without any facility of overnight stay at the employee and worker residential area.

Recreation and others: One tennis court will be at staff residential area and one soccer court will be prepared at the employee and worker residential area. A guard house will be built at the entrance of each residential areas, and the security man will always be stationed. And, social service office will be associated to the clinic building.

### 5.5.5 Domestic water supply and sewage disposal

The domestic water is fed from a water tank, located in 4,720 m high between the staff and employee & worker residential areas, through the pipe lines to each houses and facilities by gravity.

The sewage from the houses will be collected through underground sewage pipes which are constructed at the staff and employee & worker residential areas, separately, and made harmless before discharge into the river.

The rubbish come from houses will be collected and burried in an favorable place of unused area.

## 5.6 Detailed Survey

### 5.6.1 General

The collaborative mineral explorations to be carried out up to the present in the Iscaycruz (Oyon) district are as follows:

1979-1981 (Phase I): Geological Survey, Geochemical Survey, Geophysical Survey, Drilling
1982-1984 (Phase II): Drilling, Tunneling

However, further advanced survey should be done to delineate the mine development concretely and precisely, because some subjects to be known more detailed still remain. Namely, by the survey results obtained till now, the mineral occurrences of ore deposits which is one of some important preconditions to design the development planning are grasped roughly, but the calculated results of ore reserves and ore grades are not so high in accuracy. Therefore, it is assumed that subsequently detailed survey should be carried out to clarify in detail for the above mentioned matter and to study characteristics of ore, lithologic character and flotability of mineral, and regular development planning must be designed and discussed based on data got additionally

### 5.6.2 Contents of Detailed Surveys

In the first place, detailed surveys by drilling and tunneling are planned to confirm the horizontal and perpendicular shape, elongation and occurrence of ore deposit, ore reserves and ore grades forcussing the target to the limits above S-adit level (4,570 m/above sea level) of Limpe ore deposit, and in addition, declined drillings at S-adit are also planned to grasp the ore potential of the limits below S-adit level. Contents of planning are shown in Table 2.5 and Table 2.6.

Table 2.5 Tunneling

| | Level | Quantities (m) | |
|---|---|---|---|
| Tunnel | 4,690 m (N-adit level) | 320 | drifting in upper ore body |
| | 4,637 m | 380 | drifting in lower ore body |
| | 4,570 m (S-adit level) | 460 | drifting in upper ore body |
| Trackless inclined shaft | | 383 | surface ~ N-adit level, N-adit level ~ 4,637 m level |
| Raise etc. | | 220 | 4,637 m level ~ N-adit level, S-adit level ~ 4,637 m level |
| Total | | 1,763 | |

Note; be executed in (-5) (-4) years, a period is 18 months

Table 2.6 Drilling

| Level | Numbers (holes) | Quantities (m) | Remarks |
|---|---|---|---|
| N-adit (4,960 m) | 22 | 1,080 | |
| 4,637 m | 27 | 1,280 | |
| S-adit (4,570 m) | 29 | 1,295 | |
| " | 7 | 710 | for the limits below S-adit level |
| Total | | 4,365 | |

Note; be executed in (-5) (-4) years, a period is 24 months

# 6. SUMMARY

## 6.1 PRODUCTION PLAN

Mining will be started from the ore existed above the present S-adit surveyed closely. Parameters of the production plan are listed below:

### 6.1.1 Ore Reserves and Mineable Ore Reserves

| Location | Kind of ore | Tonnage (1,000t) | Ag (g/t) | Cu (%) | Pb (%) | Zn (%) |
|---|---|---|---|---|---|---|
| Ore reserves in full area | | | | | | |
| Limpe | Pb·Zn | 3,257 | 48 | 0.13 | 1.95 | 18.99 |
| Limpe | Cu | 102 | 32 | 2.84 | 0.03 | 0.39 |
| Limpe-S*1) | - | 1,461 | 10 | 1.85 | 0.01 | 19.59 |
| Above present S-adit | | | | | | |
| Ore reserves | | | | | | |
| Limpe | Pb·Zn | 2,050 | 42 | 0.11 | 1.89 | 18.72 |
| Mineable ore*2) | | | | | | |
| Limpe | Pb·Zn | 2,050 | 35 | 0.10 | 1.61 | 15.92 |

Remarks: *1) Limpe south

*2) Assumes 85% of mining extraction factor
15% of contamination of waste

### 6.1.2 Production per Annum and Mine Life

Production per annum : 225,000 t (750 t x 300 days)

Period to be mined : 9.1 yrs (But, 10.0 yrs of mine life was made on the assumption since ore reserves will be increased due to the further prospecting.)

### 6.1.3 Production of Concentrates (Process of Concentrator)

| | Tonnage (t) | Grade | | | | Recovery (%) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Ag (g/t) | Cu (%) | Pb (%) | Zn (%) | Ag | Cu | Pb | Zn |
| Crude ore | 225,000 | 35 | 0.10 | 1.61 | 15.92 | 100.0 | 100.0 | 100.0 | 100.0 |
| Pb-concentrate | 4,458 | 265 | 0.20 | 65.00 | 4.02 | 15.0 | 4.0 | 80.0 | 0.5 |
| Zn-concentrate | 60,618 | 75 | 0.26 | 0.26 | 52.00 | 58.0 | 70.5 | 4.3 | 88.0 |
| Tailing | 159,924 | 13 | 0.03 | 0.36 | 2.58 | 27.0 | 25.5 | 15.7 | 11.5 |

## 6.2 MANPOWER REQUIREMENT

The all production activities excluding concentrate transportation will be directly under the administration of the company management, and working days per man-year are 260 days. In the estimation of manpower requirement, this condition is considered to arrive at the total requirement. For work requiring 3-shift operation, a schedule of off- day will be formulated and implemented.

### 6.2.1 Organization Chart in the Mine

| Department | S | E | W | Total | Department | S | E | W | Total |
|---|---|---|---|---|---|---|---|---|---|
| Mining: | | | | | Administration: | | | | |
| Underground | 6 | 8 | 120 | 134 | Secretariate | 2 | 1 | | 3 |
| Surface | 2 | 2 | 44 | 48 | Accounting | 1 | 3 | | 4 |
| Safety | 1 | 1 | 5 | 7 | Purchasing | 1 | 2 | 5 | 8 |
| Total | 9 | 11 | 169 | 189 | Transportation | | 1 | 7 | 8 |
| | | | | | Total | 4 | 7 | 12 | 23 |
| Geology: | 3 | 4 | 20 | 27 | Personnel & Welfare: | | | | |
| Concentration: | | | | | Personnel | 2 | 2 | | 4 |
| Concentrator | 4 | 12 | 30 | 46 | Social security | 1 | 1 | | 2 |
| Assy & labo. | 1 | 1 | 7 | 9 | Canteen | | 1 | 5 | 6 |
| Total | 5 | 13 | 37 | 55 | Mess, quarters | | 1 | 8 | 9 |
| | | | | | Guard etc. | | 2 | 10 | 12 |
| Power plant: | 1 | 4 | 9 | 14 | Total | 3 | 7 | 23 | 33 |
| Maintenance: | | | | | Others: | | | | |
| Machine | 1 | 2 | 15 | 18 | Clinic | 3 | 3 | 2 | 8 |
| Electric | | 1 | 5 | 6 | School etc. | | 12 | 2 | 14 |
| Civil | 1 | 2 | 10 | 13 | | | | | |
| Total | 2 | 5 | 30 | 37 | Grand Total | 30 | 66 | 304 | 400 |

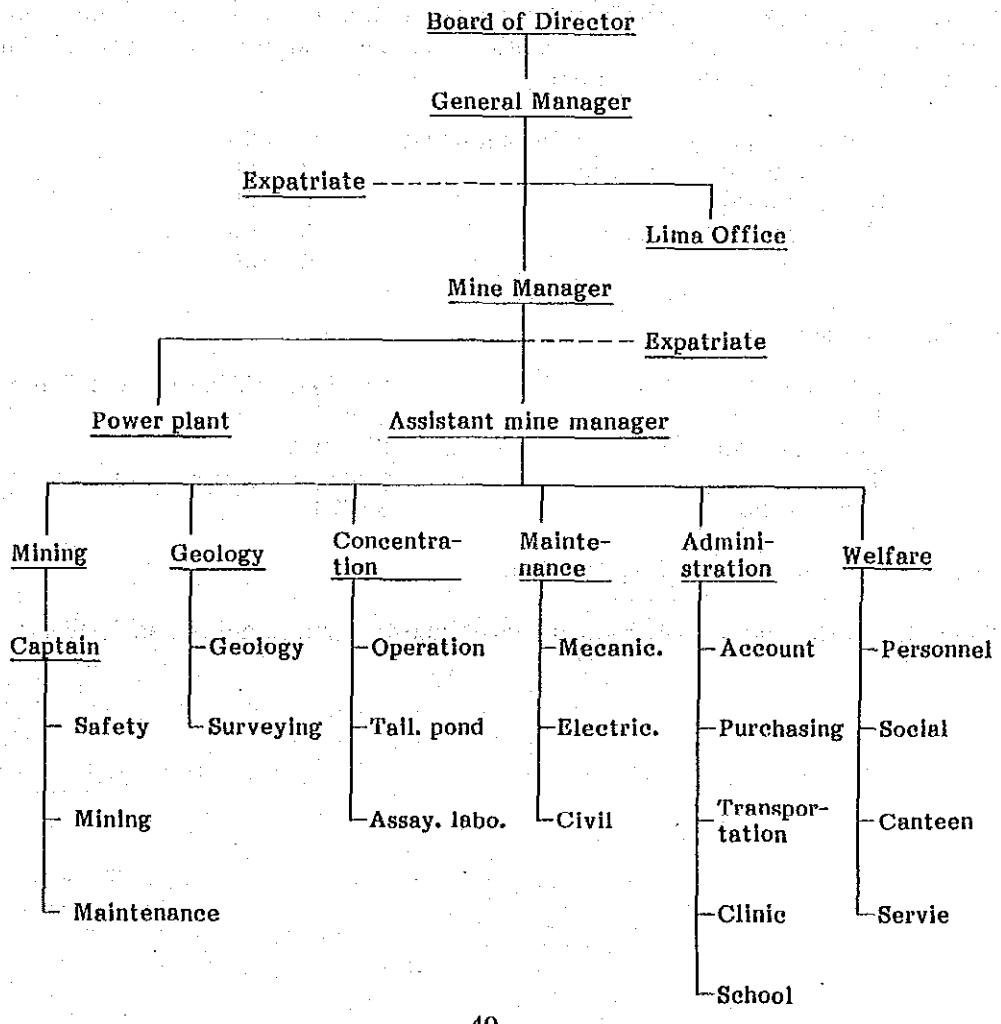
### 6.2.2 Organization Chart in Lima Head Office

| Department | S | E | W | Total |
|---|---|---|---|---|
| Board: | 2 | | | 2 |
| Administration: | | | | |
| Legal, account. | 1 | 2 | | 3 |
| Purchasing | 1 | 2 | 2 | 5 |
| Services | | 1 | 3 | 4 |
| Total | 4 | 5 | 5 | 14 |

Remarks:
S : Staff (Include boards, Mine manager and Asst. mine manager)
E : Employee
W : Worker

But included the following personnels, 3 expatriates in the mine site, and an expariate in Lima office. Also, one attorney and accountant will be in Lima at part timers basis.

### 6.2.3 Organization Chart



## 6.3 CAPITAL, OPERATION COST AND ADDITIONAL INVESTMENT AND REPLACEMENT COST

### 6.3.1 Basis for Estimate

All applicable laws, working conditions, salaries, wages and equipment cost, commodities prices and unit price of construction are as of Oct. 1985 and not considered the escalation through construction and operation period.

Period of constructions: Construction and development period is expected five years, as two years for the detail Survey and feasibility study, one year for detailed design and financing and two years for construction.

Currency and interest: The following rate of exchange are used $1.00 =s/.14,000, $1.00=¥210 and interest for 9% per annum.

Material and expendable and machine parts etc.: Machines, electric equipment, steel pipes, electric wires, steel for buildings, vehicles necessary for operation will be imported from the abroad except equipment and commodities purchased in Peru and price in Peru are standardized with expectation of special favour of customs duty which will be deteriorated with the package purchases as follows:

FOB value (foreign ports) = Minesite value x 1.6

Salaries and wages: Their basic pays are established to which social security, paied vacation, overtime work, bonus etc. are added to obtain the following monthly pays used in the estimate.

| | |
|---|---|
| General manager and mine manager | $2,000 |
| Assistant mine manager | $1,000 |
| Staff and doctor | $ 500 |
| Employee and teacher | $ 200 |
| Worker | $ 150 |

Concentrates hauling:

| | |
|---|---|
| Hauling cost by truck | $18.0/wt (Mine to port Callao) |
| Handling loss | 1.0% |
| Loading expenses | $7.2/wt |
| Tax | 2.0% of total revenue |
| Commission | $1.5/t |

### 6.3.2 Summary of Estimate of Capital Cost

Table 2.7 shows the detailed capital cost and it is summarized as follows.

| Item | Total amount | ($1,000) $ | ($1,000) S/. |
|---|---|---|---|
| (1) Production, auxiliary and welfare etc. | 25,211 | 7,825 | 17,386 |
| (2) Construction Management etc. | 1,602 | 817 | 785 |
| (3) Inventory | 200 | 21 | 179 |
| (4) Contingency | 1,891 | 606 | 1,285 |
| Total (1-4) | 28,904 | 9,269 | 19,635 |
| (5) Detailed survey and feasibility study | 3,095 | 175 | 2,920 |
| (6) Detailed design etc. | 451 | 451 | - |
| (7) Interest during construction period | 1,734 | 1,734 | - |
| Grand Total (1-7) | 34,184 | 11,629 | 22,555 |
| (8) Working capital | 2,195 | 2,195 | - |
| Total Investment | 36,379 | 13,824 | 22,555 |

### 6.3.3 Summary of Operation Cost

The operation cost is divided into production cost, concentrates hauling cost and ship loading. Table 2.8 shows the detailed operation cost and it is summarized as follow:

| Item | Yearly cost ($1,000) | $/t ore |
|---|---|---|
| Mining | 2,154 | 9.57 |
| Concentration | 1,936 | 8.61 |
| Maintenance | 172 | 0.76 |
| Administration | 943 | 4.19 |
| Direct cost total | 5,205 | 23.13 |
| Concentrates hauling | 1,259 | 5.60 |
| Ship loading | 499 | 2.22 |
| Tax and commission | 353 | 1.57 |
| Total | 7,316 | 32.52 |

### 6.3.4 Additional and Replacement Cost

During eight years after operation starts, $475,000 of additional investment for the second stages construction work of tailing pond and $2,402,000 of the replacement cost such as mining equipments, vehicles and common use vehicles are needed, making the total of $2,877,000. Table 2.9 shows the corresponding yearly expenditure.

Table 2.7 Summary of Investment Cost

($1,000)

| | Item | Total | | | Year (-5 ~ -3) | | | Year (-2) | | | Year (-1) | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | $ | S/. | Total | $ | S/. | Total | $ | S/. | Total | $ | S/. | |
| 1 | Mining | 8,540 | 2,137 | 6,403 | - | - | - | 3,332 | 454 | 2,878 | 5,208 | 1,683 | 3,525 | Mechanized Cut & Fill Method, 750 t/day |
| 2 | Concentrator | 5,993 | 2,409 | 3,584 | - | - | - | 572 | - | 572 | 5,421 | 2,409 | 3,012 | Capacity 825 t/day, Pb-Zn stright differencial flotation |
| 3 | Tailing pond | 1,241 | - | 1,241 | - | - | - | 124 | - | 124 | 1,117 | - | 1,117 | Capacity 2,140,000 $m^3$, sand & slime piling separated. |
| 4 | Power plant | 3,769 | 2,321 | 1,448 | - | - | - | 121 | - | 121 | 3,648 | 2,321 | 1,327 | Diesel generator, max output 2,500 kW, 5 units |
| 5 | Power distribution | 643 | 329 | 314 | - | - | - | - | - | - | 643 | 329 | 314 | Transmission voltage 2,200 V, voltage used 2,200V/220V |
| 6 | Communication | 183 | 77 | 106 | - | - | - | 20 | - | 20 | 163 | 77 | 86 | 50 Wire telephones, radio 150-400MHz |
| 7 | Water supply | 317 | 178 | 139 | - | - | - | - | - | - | 317 | 178 | 139 | Pumped up from lake Quellaycocha, industrial 1,920 $m^3$/day, domestic 300 $m^3$/day |
| 8 | Repair shop | 247 | 133 | 114 | - | - | - | 247 | 133 | 114 | - | - | - | Mechanical & electrical shop |
| 9 | Auxiliary facilities | 1,275 | 241 | 1,034 | - | - | - | 1,047 | 96 | 951 | 228 | 145 | 83 | Road construction & repair 27.5 km, office, warehouse, mess, vechicles, etc. |
| 10 | Welfare facilities | 2,845 | - | 2,845 | - | - | - | 903 | - | 903 | 1,942 | - | 1,942 | Residential houses 274, quarters, clubs, shool, clinic, canteen, etc. |
| 11 | Lima head office | 59 | - | 59 | - | - | - | 59 | - | 59 | - | - | - | Office rental 250 $m^2$, vechicles, etc. |
| 12 | Construction facilities | 99 | - | 99 | - | - | - | 99 | - | 99 | - | - | - | Camp during construction 550 $m^2$, 75 kW diesel generator, etc. |
| | Subtotal (1-12) | 25,211 | 7,825 | 17,386 | - | - | - | 6,524 | 683 | 5,841 | 18,687 | 7,142 | 11,545 | |
| 13 | Construction management | 904 | 357 | 547 | - | - | - | 394 | 157 | 237 | 510 | 200 | 310 | Work management and supervision, Operation of 175 kW diesel generators (2) etc. |
| 14 | Lima head office | 339 | 101 | 238 | - | - | - | 156 | 52 | 104 | 183 | 49 | 134 | General administration, procurement, etc. |
| 15 | Oversea's commission | 359 | 359 | - | - | - | - | 159 | 159 | - | 200 | 200 | - | Oversea's expenses for financing and purchasing |
| | Subtotal (13-15) | 1,602 | 817 | 785 | - | - | - | 709 | 368 | 341 | 893 | 449 | 444 | |
| 16 | Inventory | 200 | 21 | 179 | - | - | - | - | - | - | 200 | 21 | 179 | 2-month supply for mining and concentrator |
| 17 | Contingency | 1,891 | 606 | 1,285 | - | - | - | 506 | 73 | 433 | 1,385 | 533 | 852 | 7% of total (1-16) |
| | Direct cost total (1-17) | 28,904 | 9,269 | 19,635 | - | - | - | 7,739 | 1,124 | 6,615 | 21,165 | 8,145 | 13,020 | |
| 18 | Detailed survey | 3,095 | 175 | 2,920 | 3,095 | 175 | 2,920 | - | - | - | - | - | - | Conducted at -5 & -4 yrs; tunnel 1,763 m, boring 4,365 m & feasibility study |
| 19 | Detailed design etc. | 451 | 451 | - | 451 | 451 | - | - | - | - | - | - | - | 12 months x 10 persons, 20 day at site, conducted at -3 yrs |
| 20 | Interest | 1,734 | 1,734 | - | - | - | - | 303 | 303 | - | 1,431 | 1,431 | - | Interest 9% an annum. Capital = 1/4 investment required. |
| | Investment total (1-20) | 34,184 | 11,629 | 22,555 | 3,546 | 626 | 2,920 | 8,042 | 1,427 | 6,615 | 22,596 | 9,576 | 13,020 | |
| 21 | Working capital | 2,195 | 2,195 | - | - | - | - | - | - | - | 2,195 | 2,195 | - | For year (1), 30% of operation cost (excluding interest and depreciation cost) |
| | Initial investment total (1-21) | 36,379 | 13,824 | 22,555 | 3,546 | 626 | 2,920 | 8,042 | 1,427 | 6,615 | 24,791 | 11,771 | 13,020 | |

Note: 1) Expenditure required by year was summed up on occurrence.
2) Detail survey and detailed design will be done by capital.

## Table 2.8 Summary of Yearly Operation Cost

($1,000)

| Item | Total | | | Labor cost | | | Material Cost | | | Expenses | | | $/t ore |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | $ | S/. | Total | $ | S/. | Total | $ | S/. | Total | $ | S/. | |
| 1. Mining | | | | | | | | | | | | | |
| Mining | 2,005.8 | 197.1 | 1,808.7 | 384.6 | - | 384.6 | 1,055.1 | 197.1 | 858.0 | 566.1 | - | 566.1 | 8.91 |
| Geology | 148.6 | - | 148.6 | 63.6 | - | 63.6 | 35.0 | - | 35.0 | 50.0 | - | 50.0 | 0.66 |
| Subtotal | 2,154.4 | 197.1 | 1,957.3 | 448.2 | - | 448.2 | 1,090.1 | 197.1 | 893.0 | 616.1 | - | 616.1 | 9.57 |
| 2. Concentration | 1,936.2 | 321.5 | 1,614.7 | 127.8 | - | 127.8 | 944.2 | 321.5 | 622.7 | 864.2 | - | 864.2 | 8.61 |
| 3. Power plant | (1,449.5 | 54.4 | 1,395.1) | ... Allocated to each department. | | | | | | | | | |
| 4. Maintenance | 171.9 | - | 171.9 | 66.0 | - | 66.0 | 31.0 | - | 31.0 | 74.9 | - | 74.9 | 0.76 |
| 5. Administration | | | | | | | | | | | | | |
| Central office | 350.1 | 156.6 | 193.5 | 234.0 | 147.6 | 86.4 | 20.2 | - | 20.2 | 95.9 | 9.0 | 86.9 | 1.56 |
| Welfare | 396.6 | - | 396.6 | 137.4 | - | 137.4 | 43.0 | - | 43.0 | 216.2 | - | 216.2 | 1.76 |
| Lima head office | 196.0 | 52.2 | 143.8 | 102.0 | 49.2 | 52.8 | 17.0 | - | 17.0 | 77.0 | 3.0 | 74.0 | 0.87 |
| Subtotal | 942.7 | 208.8 | 733.9 | 473.4 | 196.8 | 276.6 | 80.2 | - | 80.2 | 389.1 | 12.0 | 377.1 | 4.19 |
| Total | 5,205.2 | 727.4 | 4,477.8 | 1,115.4 | 196.8 | 918.6 | 2,145.5 | 518.6 | 1,626.9 | 1,944.3 | 12.0 | 1,932.3 | 23.13 |
| 6. Concentrate hauling | 1,259.5 | - | 1,259.5 | - | - | - | - | - | - | 1,259.5 | - | 1,259.5 | 5.60 |
| 7. Ship loading | 498.7 | - | 498.7 | - | - | - | - | - | - | 498.7 | - | 498.7 | 2.22 |
| 8. Tax. commission | 352.8 | - | 352.8 | - | - | - | - | - | - | 352.8 | - | 352.8 | 1.57 |
| Grand total | 7,316.2 | 727.4 | 6,588.8 | 1,115.4 | 196.8 | 918.6 | 2,145.5 | 518.6 | 1,626.9 | 4,055.3 | 12.0 | 4,043.3 | 32.52 |

Table 2.9 Summary of Additional Investment and Replacement Cost

($1,000)

| Year | Additional invest. | Replacement cost | | | Grand total |
|---|---|---|---|---|---|
| | | Mining equipment | Common vehicle | Total | |
| 1 | - | - | - | - | - |
| 2 | - | 20 | - | 20 | 20 |
| 3 | - | - | 19 | 19 | 19 |
| 4 | - | 173 | 20 | 193 | 193 |
| 5 | 150 | 498 | 255 | 753 | 903 |
| 6 | 150 | 648 | 100 | 748 | 898 |
| 7 | 175 | 591 | 19 | 610 | 785 |
| 8 | - | 39 | 20 | 59 | 59 |
| 9 | - | - | - | - | - |
| 10 | - | - | - | - | - |
| Total | 475 | 1,969 | 433 | 2,402 | 2,877 |

# CHAPTER 3 INFRASTRUCTURE

# CHAPTER 3 INFRASTRUCTURE

In this chapter, the problems and current state of the infrastructure in the vicinity of Iscaycruz and related areas will be described for the purposes of planning the utilization and improvement of facilities for transportation, electric power, water supply, communications, labor supply, and a mining camp.

## 1. TRANSPORTATION (ROAD SYSTEM)

### 1.1 DEMAND FOR TRANSPORTATION

Demands for transportation which will arise in connection with the development and operation of the mine are summarized as follows:

(1) Transportation of construction materials from the places of supply to the mine to be developed.

(2) Transportation of various kinds of machinery and equipment from Callao Port (for imported goods) and from the places of supply (domestic goods) to the mine to be developed.

(3) Transportation of materials, equipment and fuels for mine operation from Callao Port or from the places of supply to the mine to be developed.

(4) Transportation of foods and other daily necessities for the residents of the mining camp from the places of supply to the mine to be developed.

(5) Transportation of Pb and Zn concentrates from the mines to Callao Port.

(6) Transportation of residents from the mine camp to other places (Lima, Churin, etc.) for the purposes of economic and social exchange with other people outside the area.

Of these demands, the transportation of concentrates produced is the greatest by volume. Materials, equipment and fuels necessary for mine operation, and daily necessities can be transported economically by use of the returning concentrate transport vehicles. For residents in the mine camp to get to other places, the mining company may be required to provide busses for the time being, in order to take them to Oyon where regular bus services are provided.

### 1.2 ROAD CONDITIONS

The route for transporting goods from Lima, which will serve as the base for the procurement and transportation of materials and equipment during the development work and mine operation, and from Callao, which is the concentrate exporting port, to the mine is shown in Fig. 3.1, and lengths and altitudes of each stage of this route are as shown in Fig. 3.2.

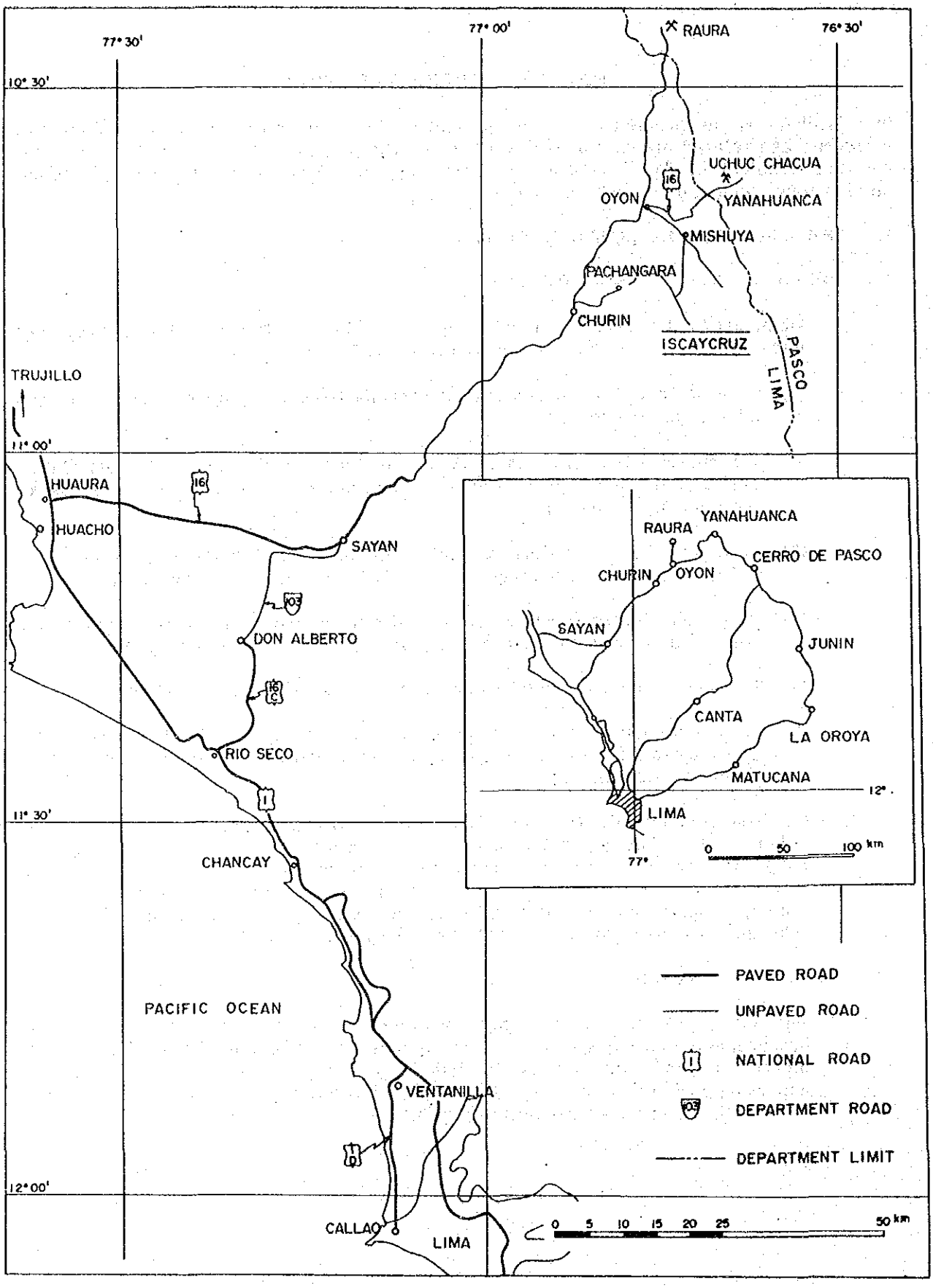



Fig. 3.1 Transportation Route

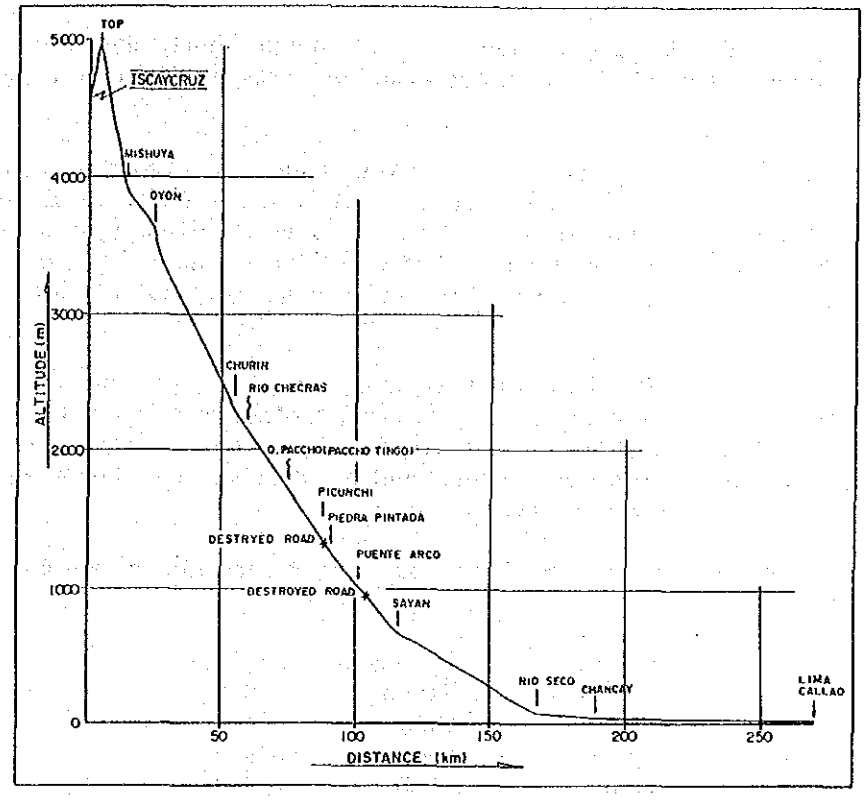



Fig. 3.2 Distance and Altitude of the Transportation Route

The section of the Pan American Highway (National Road No. 1) between Lima and Rio Seco is asphalt-surfaced, consisting for the most past of two lanes in both directions. To the north of Rio Seco, where only one lane is provided in either direction, the expansion to two lanes is now under way.

National Road No. 16-C running from Rio Seco northwards to Sayan is paved only as far as Don Alberto, and unpaved in the section from Don Alberto to Sayan, where it is known as Prefectural Road No. 103.

National Road No. 16 running along the Huaura River from Sayan to Churin is paved only as far as Puente Arco, 15 km to the northeast of Sayan, and unpaved ahead of this point. A section of about 700m located 12 km from Sayan on the way to Puente Arco has been destroyed by flooding of the Huaura River, and vehicles are forced to drive along the broad riverbed there. At Picunchi, 29 km from Sayan, vehicles are likewise forced to run along the riverbed of the Huaura River for a section of about 500 m, where the reconstruction of the road is, however, under way (as mentioned below), and will be completed soon.

At these points of road damage, vehicles may be unable to pass through owing to the flooding of the Huaura River in the rainy season, especially from January to March. The period of traffic stoppage is on average 15-20 days annually, mostly in March.

At Paccho Tingo, 43 km from sayan, the junction of the Paccho River and the Huaura River, where a large amount of earth and sand sediment carried by the Paccho River may block the road in the rainy season, improvement work is now under way to prevent blockage, and is about 80% complete.

A tunnel located 2 km from Paccho Tingo, though short, should be taken into account when planning the transportation of large-sized machinery for mine development.

The section of National Road No. 16 between Churin and Oyon is unpaved and as narrow as 3-4 m. From Oyon to Iscaycruz, it is necessary to leave the national road and take a municipal road at Oyon leading to Mishuya, the center of a number of small-scale coal mines. Trucks of 25-30t capacity can reach Oyon from the Pan American Highway and trucks of at least 20t capacity can reach Mishuya.

On the road from Mishuya to Iscaycruz, which was constructed for the Cooperative Mineral Exploration already conducted, and which has an average gradient of 1:10 in parts, trucks of more than 6t capacity cannot pass through at present. The construction and reconstruction of roads will therefore be needed in this section when developing the mine.

The distances between stages of the route mentioned above are summarized as follows:

| | | | |
|---|---|---|---|
| Callao | - | Rio Seco | 102 km |
| Rio Seco | - | Sayan | 52 " |
| Sayan | - | Churin | 61 " |
| Churin | - | Oyon | 30 " |
| Oyon | - | Mishuya | 10 " |
| Mishuya | - | Iscaycruz | 15 " |
| | | Total | 270 " |

## 1.3 ALTERNATIVE ROUTES

As already mentioned, the road may be partially blocked by the flooding of the Huaura River along the section between Sayan and Churin in the rainy season, and every year during this time it is probable that vehicles are unable to pass through, though for a short period. As an alternative route during such traffic stoppage, it is possible to go from Oyon to Lima and Callao via National Road No. 16 and Yanahuanca--Cerro de Pasco--Canta. In fact, Raura Mine and Uchuc Chacua Mine near Iscaycruz use this route in case of emergency.

From Iscaycruz to Churin, it is possible to take a route via Pachangara avoiding Oyon. The existing road between Churin and Pachangara is so narrow that a jeep can barely get through. With a gradient of 1:10 on average, this road is in a similar condition to that of the section between Mishuya and Iscaycruz. Improvement work will be required on both the gradient and width of the road, if it is to be used as a part of the alternative route. Between Pachangara and Iscaycruz, where no road suitable for vehicles exists, a new road may have to be newly constructed. Its length will be 15 km, if the road is constructed with a gradient of 1:15, due to an altitude difference of about 1000 m.

Further study is needed as to the selection of the route.

## 1.4 MAINTENANCE OF ROADS

The greatest problem for the development and operation of a mine in Iscaycruz would be the maintenance of the two short stretches on the road between Sayan and Churin, which are likely to be destroyed by the flooding of the river in the rainy season. They are located 12 km and 29 km to the northeast of Sayan, extending 700 m and 500 m, respectively. As part of National Road No. 16, they are under the control of the Ministry of Transportation and Communication; the latter stretch is under reconstruction, so that a 3 km diversion is scheduled to be completed by the end of 1985; there has been, however, no plan for improving the former. In addition to these two, there are many other places which need bank protection works and the elevation of the road surface to protect it from the Huaura River between Sayan and Churin. The riverbed of the Huaura River has risen remarkably over this section of the route due to sediment (earth and sand) flowing out of the Checras River, a tributary of the Huaura River, and the buried remains of the old national road can be seen at several points.

It is obvious from these observations that, in this section, the road has been repeatedly blocked by floods at points where earth and sand tend to accumulate because of the small difference in altitude between the riverbed and the road, and the gentle gradient of the riverbed and the widening of its course. Such a phenomenon is naturally likely to occur again, and therefore, efforts should be made to seek a permanent solution, instead of merely remedial works following the occurrence of damages.

In the section between Oyon and Iscaycruz traffic may be stopped by landslides in the rainy season. This is so because unstable piles of sand exist at many points. Landslides, however, do not cause so serious disturbance to traffic as the flooding of the river does, and the repair work is relatively easy.

In Peru, although public roads such as national and provincial ones are maintained by the public agencies concerned, the users of roads often share in the cost of restoration or repairs. In the case of the restoration of the road between Sayan and Oyon, Raura Mine and Uchuc Chacua Mine have supplied civil engineering machinery and workers. To budget for this, Raura Mine allots U.S. $40,000-50,000 every year. Therefore, it will be necessary that the Iscaycruz mine considers participating in repair work or sharing in the cost according to its production scale.

## 1.5 CURRENT TRANSPORTATION CONDITIONS

At present, products from Raura Mine, Uchuc Chacua Mine and many other small-scale coal mines in the neighborhood of Iscaycruz are carried by truck to Callao, Lima, Chimbote and other ports via National Road No. 16. From Raura Mine to Callao (a distance of 285 km), trucks of 30 or 20t capacity are used, taking about 18 hours and 12 hours, respectively. Between Oyon and Lima, there is a regular bus service operating twice a day; and from Raura Mine to Lima, a bus service is operated twice a day exclusively for mine workers.

National Road No. 16, which is an extremely important route for local industry and residents, has a daily traffic of 120 vehicles between Churin and Raura, and 140 vehicles between Sayan and Churin; moreover, the traffic amounts to about 1200 vehicles daily in the section from Sayan to Rio Seco, Huaura, and Huacho, which is one of the leading agricultural zones in Peru.

## 2. ELECTRIC POWER

### 2.1 THE CURRENT SITUATION IN THE REGION

The system of power supply in the vicinity of Iscaycruz is not extensive, except to supply mines in operation.

As for public power plants, only small-scale hydro-electric or diesel power stations exist in Churin, Moroc, and Oyon including those under construction, and the range of power distribution is extremely limited. Two mines in operation, namely Uchuc Chacua (Ag mine, output 1,000 t/day) and Raura (Cu, Pb, and Zn mine, output 1,800 t/day) have their own power plants for mining operation, supplying power for production and residential uses.

The Paton hydro-electric power plant, at Uchuc Chacua Mine, is scheduled to supply a part of the generated power to Oyon, and the construction of power transmission lines is now under way. According to the plan, a maximum of 100 kW will be supplied.

The current situation of power plants and power transmission lines is as shown in Fig. 3.3 and Table 3.1.

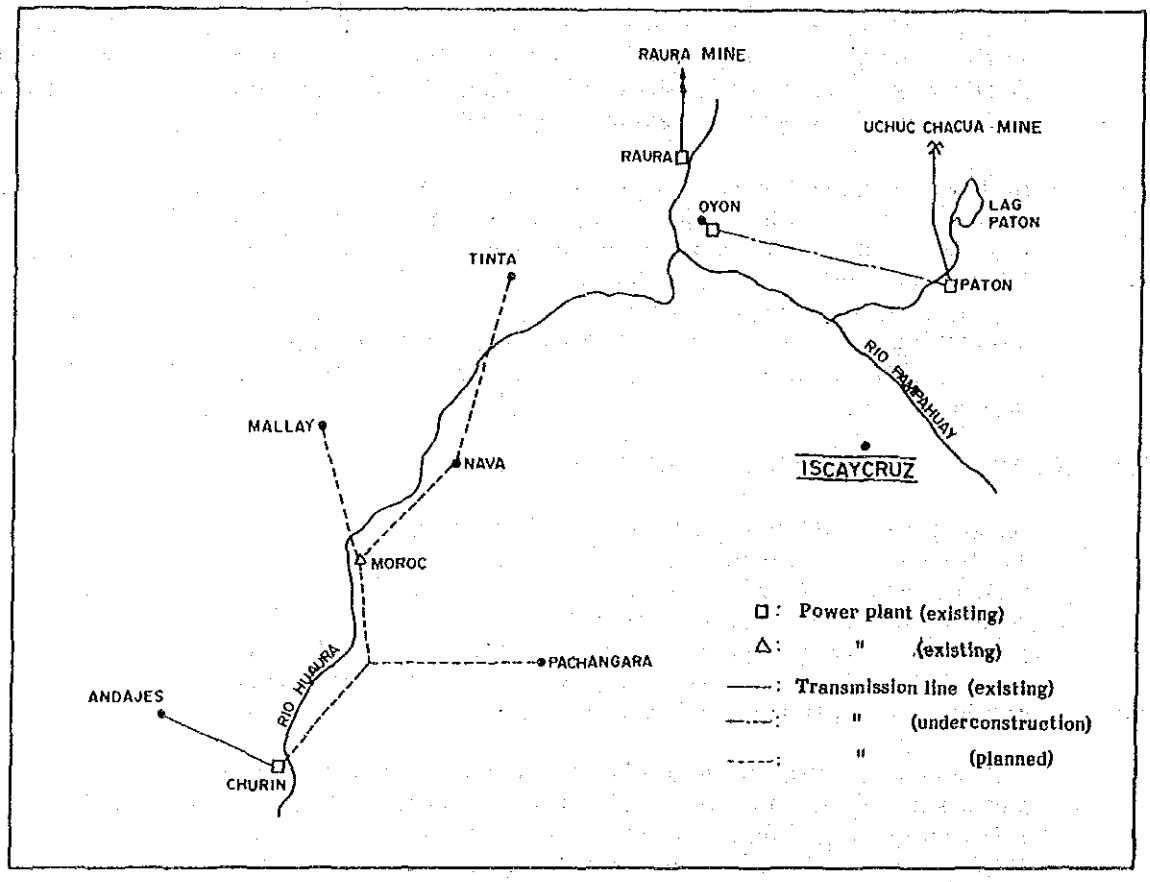



Fig. 3.3 Power Plants and Transmission Lines

Table 3.1 Power Plants

| Power Plant | Generator | | Remark |
|---|---|---|---|
| | Hydraulic | Diesel | |
| Churin | 72kW x 1 | 72kW x 1 | Operated 8:00 - 24:00 |
| Moroc | 250kW x 1 | | Under construction |
| " | 250kW x 1 | | Planned |
| Oyon | | 50kW x 1 | |
| Paton | 2,164kW x 1 | 1,100kW x 1 | For Uchuc Chacua mine's exclusive use |
| " | 500kW x 1 | 800kW x 2 | " |
| " | 800kW x 1 | | " |
| Raura | 1,000kW x 4 | 1,200kW x 1 | For Raura mine's exclusive use |
| " | | 750kW x 1 | " |

## 2.2 DEVELOPMENT PROJECTS

An extensive survey in the basin of the Huaura River is being conducted by ELECTRO Peru, in order to plan the construction of several hydro-electric power plants. If they are actually constructed, Iscaycruz will be able to utilize them as sources of electric power; the possibility of this, however, is very remote, and it is not certain whether even one of them will have been constructed by 1995. For this reason, the mine development will involve the construction of a power plant exclusively for mining operations.

The outline of projects for hydro-electric power stations which are now under study is as shown in Table 3.2 and Fig. 3.4.

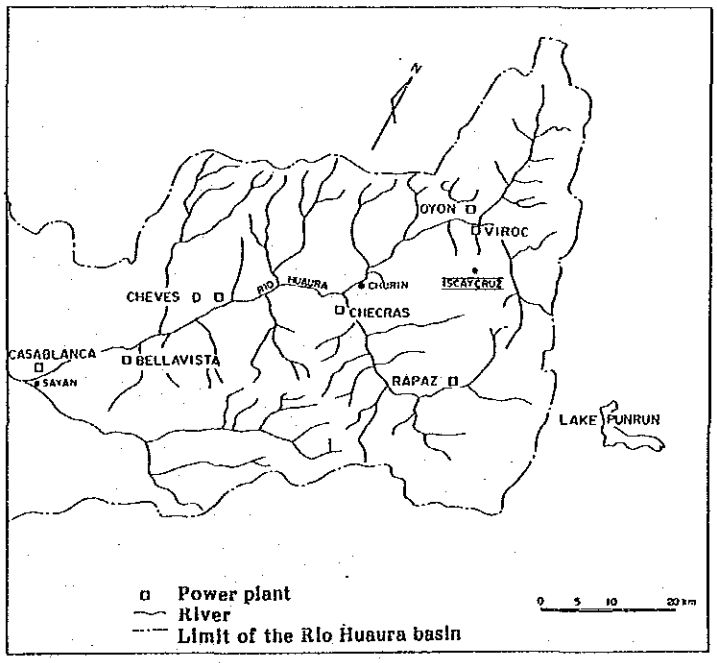



Fig. 3.4 Location of Hydro-electric Plants

Table 3.2 Hydro-electric Projects

| | Plant site | Channel (km) | Flow Volume ($m^3$/sec) | Head (m) | Capacity (MW) | Annual Generation (GWh) Without use of Lake Punrun | | With use of Lake Punrun | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Total | | Total |
| XVII | Casablanca | 13.7 | 22.48 | 238 | 45.5 | 175 | 325 | 374 | 395 |
| XII | Bellavista | 18.1 | 20.96 | 360 | 64.1 | 243 | 453 | 541 | 564 |
| X | Cheves D | 28.8 | 20.96 | 677 | 121.0 | 462 | 858 | 1,017 | 1,059 |
| VI | Checras | 45.6 | 13.50 | 1,075 | 123.0 | 473 | 879 | 1,081 | 1,081 |
| II | Oyon | 18.4 | 2.91 | 761 | 18.8 | 72 | 134 | - | - |
| III | Viroc | 9.3 | 1.73 | 563 | 8.3 | 32 | 59 | - | - |
| IX | Rapaz | 29.0 | 1.59 | 946 | 12.8 | 49 | 91 | - | - |

## 3. WATER SUPPLY

### 3.1 WATER UTILIZATION IN THE HUAURA RIVER BASIN

Most of the water in the Huaura River basin is utilized for irrigation. The main area irrigated is a zone extending from Sayan to Huaura and Huacho along the river, and to Don Alberto to the southwest of Sayan.

This zone along the Huaura River is one of the major areas for sugar cane production in Peru, and some of the areas in the middle and upper reaches of the river and along its tributaries are suitable for irrigated agriculture. As mentioned below, the arid land on the Pacific coast side needs irrigation for agricultue; there are many channels to convey water from the mountains to the coastal area.

Water utilization for mining is also important in connection with water catchment and drainage. Mines in the neighborhood of Iscaycruz utilize many lakes located in this mountainous area in order to store water for industrial and domestic use and to generate hydro-electric power. In the mountainous area, precipitation is very low in the dry season; for example, the average rainfall from May through July at Uchuc Chacua Mine is no more than 10 - 20 mm. Natural lakes play a major role in compensating for the shortage of river water during the dry season.

Small-scale hydro-electric power generation to supply electric power to local communities, as well as power generation exclusive for mines, is one of the important uses of water resources in this region. ELECTRO Peru is now conducting an extensive study in the Huaura River basin in order to construct several hydraulic power plants.

Communities located in the middle and upper reaches of the Huaura River are generally small, with populations numbering several thousands. Larger communities have water supply facilities equipped with chlorination equipment to supply water for domestic uses. There are, however, no public sewer facilities to treat waste water discharged from households.

Waste water from the Iscaycruz mine flows into the Pachangara River downwards and joins the Huaura River near Churin. On the other hand, the supernatant water discharged from the tailing pond of Iscayruz Mine flows into the Yanahuaino River, flows down close to Cuary, becomes the Cayash River, joins the Checras River, flows downwards near Lagusaura, and joins the Huaura River below Churin.

Thus, on the way to the Huaura River, waste water discharged from mines passes through several communities which conduct irrigated agriculture. This is why adequate attention should be paid to the control of waste water.

### 3.2 HYDROLOGICAL AND METEOROLOGICAL CHARACTERISTICS OF THE HUAURA RIVER

Hydrological and meteorological data in Peru are collected and compiled by the Meteorological and Hydrological Agency (SENAMHI), and the isohyet chart for the basin of the Huaura River prepared by SENAMHI is shown in Fig. 3.5.

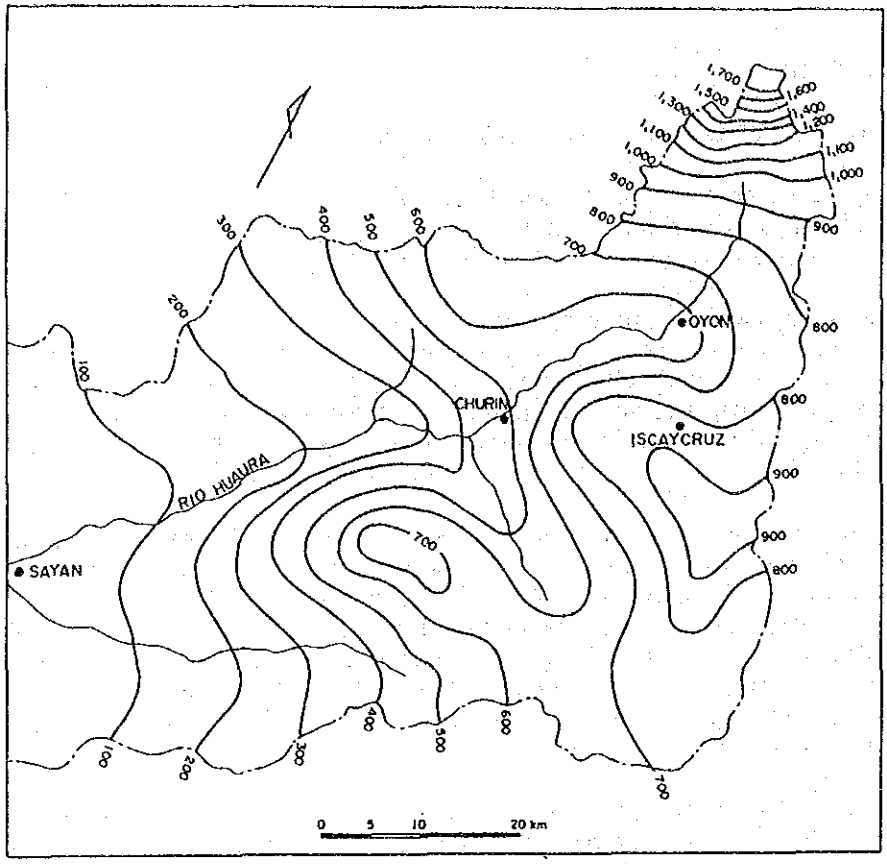



Fig. 3.5 Isohyet Chart (unit: mm)

As seen in the chart, the Pacific coastal area below the Huaura River has extremely little rain, less than 100 mm throughout the year, and is a desert area. This is so because temperature in the upper air is so low, owing to the Humbolt Cold Current flowing northwards off the coast of Peru, that the atmosphere cannot contain a large amount of water vapor. If the air mass flows towards the continent, its temperature rises and its humidity falls, resulting in low rainfall.

Whereas in the lower reaches of the Huaura River, rainfall is very little, in the middle and upper reaches, as the altitude rises, a rising air current occurs and rainfall gradually increases, as can be seen from the chart. For example, annual precipitation is 100 mm near Sayan, 500 mm in Churin, and 600 mm in Oyon. While the annual precipitation is 1,700 mm in the northernmost of the upper reaches of the river, it is 800 mm in the southernmost of them at 5,000 m above sea level; thus there is no sharp increase in precipitation.

The land area of the Huaura River Basin is 5,700 $km^2$, and its altitude ranges from 0 m to 5,685 m; the basin area higher than 3,000 m above sea level accounts for 45% of the total area, and the basin area higher than 4,000 m above sea level accounts for 31%. Because the majority of the basin is at high altitude, the amount of water flowing in the Huaura River is kept constant.

According to data from the hydrological analysis by SENAMHI, the monthly average water flow of the Huaura River along the section Sayan - Casa Blanca - Alco is minimal or 11.5 $m^3$/sec in August, and maximal or 64.6 $m^3$/sec in March; and the annual average is 27.6 $m^3$/sec. The ratio of the annual runoff to the annual rainfall, or runoff coefficient, ranges from 0.43 to 0.58 (1970 - 1976). The specific discharge in liter/sec/$km^2$, or the amount of water flowing per unit area of the basin, is 4.2 in August, 23.9 in March, and 10.2 on annual average. From these data, runoff is estimated at 320,000 $m^3/km^2$ throughout the year.

The above mentioned hydrological characteristics of the Huaura River Basin may possibly provide an index for considering water demands in Iscaycruz.

## 3.3 WATER DEMANDS IN ISCAYCRUZ

To consider water demands in Iscaycruz, the potential supply must be evaluated on the basis of the basin area, precipitation, runoff coefficient and storage of Quellaycocha Lake, and compared with the required amount for mine operation.

The basin of Quellaycocha Lake, which lies partly to the southwest of the lake, extends mainly to the north-east with a total area of 1.39 $km^2$. Although recorded data on precipitation in the basin are not available, the annual rainfall is 800 mm according to the above-mentioned chart. Values based on isophyet are macroscopic, however, and it is preferable to refer to precipitation data collected at observatories in the neighborhood. The annual average precipitation observed by neighborhood observatories is shown in Table 3.3 which was compiled from data collected by SENAMHI.

Table 3.3 Average Annual Precipitation at Adjacent Observatories

| | Raura | Pachangara | Paton | Tablades | Uchu Cha. |
|---|---|---|---|---|---|
| Altutude above sea level (m) | 4,900 | 3,600 | 4,150 | 4,700 | 4,500 |
| Year | 1970-76 | 1965-82 | 1971-75 | 1971 | 1971-80 |
| Maximum (mm) | 1,894 | 1,294 | 976 | - | 1,231 |
| Minimum (mm) | 733 | 458 | 761 | - | 868 |
| Average (mm) | 1,327 | 740 | 804 | 763 | 1,035 |

As seen in this table, there is a tendency for precipitation to increase as altitude rises, excluding the case of Tablades where data are only available for one year. Since the basin of Quellaycocha Lake extends in altitude from 4,600 m to 4,900 m, the annual rainfall in the basin may be greater than the value based on isohyet, that is 800 mm, and is estimated as possibly around 1,100 mm.

As already mentioned, the runoff coefficient was calculated as 0.5 based on the amount of water flowing in the Huaura River near Sayan. At Iscaycruz, however, the coefficient may be higher than this value because of relatively higher precipitation and lower temperature, and is estimated as possibly about 0.7, combining surface runoff with underground runoff.

Based on these estimates, the annual amount of water flowing into the lake is calculated at 1,080,000 $m^3$ by the following formula:

$$\frac{1{,}100 \text{ mm/year}}{1{,}000 \text{ mm/m}} \times 1.4 \text{ km}^2 \times (1{,}000 \text{ m/km})^2 \times 0.7 = 1{,}080{,}000 \text{ m}^3\text{/year}$$

The extra annual amount of water required for mine operation is 576,000 $m^3$ for industrial use and 109,500 $m^3$ for domestic use, totaling 685,500 $m^3$. Thus, the annual supply of water exceeds the demand, and it may be safe to say that there will be no problems in water supply to mine operation in terms of the annual total amount available.

The yearly and seasonal fluctuations of precipitation should be taken into account, however. It is highly probable that the annual rainfall may amount no more than 500 mm once every ten years in this region. In this case, the annual amount of water flowing into Quellaycocha Lake would be reduced to 490,000 $m^3$, resulting in a shortage of 195,500 $m^3$ below demand. This shortage, however, may possibly be offset in a drought year by the storage of the lake. The area of the lake is about 0.24 $km^2$, and the average depth is estimated at 10 m; accordingly, the storage is estimated at 2,400,000 $m^3$.

According to the data from SENAMHI, the monthly precipitation observed by neighborhood observatories is as shown in Table 3.4, showing a sharp difference between the dry season (April through November) and the rainy season (December through March), being especially low from June through August. During the dry season, therefore, storage must be utilized. For this reason, it is essential to catch and store flowing water in the lake as much as possible during the rainy season, to cope with these seasonal fluctuations.

Table 3.4 Monthly Precipitation

(unit: mm)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Paura | 198.5 | 175.4 | 195.7 | 130.5 | 33.7 | 37.1 | 21.0 | 47.7 | 84.9 | 132.0 | 80.1 | 157.8 |
| Pachangara | 139.1 | 132.4 | 156.1 | 57.0 | 13.1 | 1.1 | 7.2 | 5.0 | 20.8 | 56.9 | 62.8 | 101.8 |
| Paton | 130.0 | 121.3 | 153.4 | 75.5 | 24.8 | 6.0 | 4.9 | 27.1 | 41.6 | 72.3 | 58.6 | 88.5 |
| Uchuc chacua | 166.8 | 219.2 | 225.1 | 121.5 | 35.3 | 11.3 | 3.5 | 10.0 | 33.5 | 52.3 | 62.6 | 121.6 |

Utilizing the lake as a reservoir to compensate for seasonal fluctuations as mentioned above may requie efforts to be made so that the current maximum level of water in the lake may rise further during the rainy season. In connection with this, it should be noted that a considerable amount of water currently flows out of the lake into the Pachangara River in the rainy season.

To control the storage and level of Quellaycocha Lake, further study must be carried out, to record precipitation in the basin, and to make a survey of the depth of the lake together with a detailed topographical survey of the vicinity of the lake, in order to investigate the correlation between water level and storage quantity.

## 4. COMMUNICATIONS

In Peru at the present time, while cable telephones and microwave circuits are extensively installed in the Pacific coastal area and between the main cities, communications are still poor in most parts of the mountainous area. Public communication facilities in the region concerned are also inadequate, and projects for expanding and improving such facilities are now suspended as mentioned below.

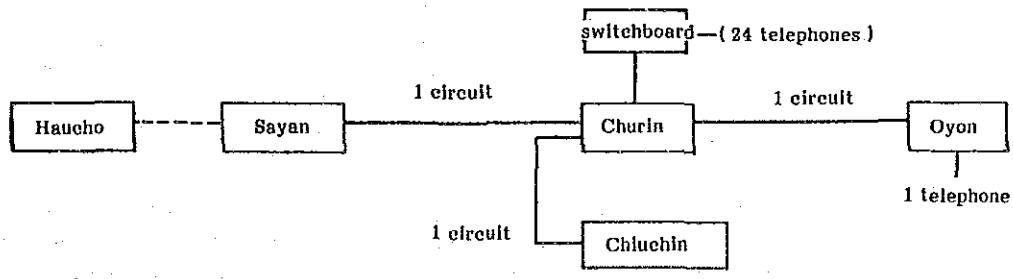
Churin: There is a telephone office connecting with 24 exchanges in the town. The office is equipped with a manual switchboard having a capacity of 50 circuits. The Public Telegram and Telephone Corporation (ENTEL Peru) cannot provide adequate service between Sayan and Oyon in many cases, because it has only one circuit which is so poorly installed that the line is often dead, and is only open for limited hours (from 9:00 to 21:00).

Chiuchin: There is only one circuit via the Churin Telephone Office.

Oyon: Only one circuit is installed via the Churin Telephone Office, and there are no public or private switchboards or telephone equipment except one telephone installed in the town office.

Raura and Uchuc Chacua Mines: There are cable telephone facilities within the mining area, but they have no connection with ENTEL - Peru's communication networks. To contact the outside (Lima), a special radio telephone is used.

ENTEL Peru's Communication Network in the Region:



## 5. THE LABOR FORCE AND MINE CAMP

### 5.1 LABOR FORCE

To develop a mine, the existence of potential labor force in the neighborhood should first be established.

The region concerned belonged formerly to Cajatambo Province, Lima Department, but some districts in the basin of the Huaura River separated from the province and formed Oyon Province in October, 1985. Oyon Province is principally divided into six districts, namely Pachangara (with its center in Churin), Oyon, Andajes, Caujul, Navan, and Cochamarca. Of them, Pachangara and Oyon are considered to have close relations with Iscaycruz. Population in these districts is shown in Table 3.5 and 3.6 based on the results of the census carried out in June, 1981.

Table 3.5 Population

| | Population | | | Urban | | | Rural | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | Male | Female | Total | Male | Female | Total | Male | Female |
| Pachangara | 3,339 | 1,659 | 1,680 | 1,766 | 867 | 899 | 1,573 | 792 | 781 |
| Oyon | 8,354 | 4,098 | 4,256 | 6,304 | 3,101 | 3,203 | 2,050 | 997 | 1,053 |

Table 3.6 Working Population

| | Working Population (Age 6-15) | | | Employed | | | Unemployed | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | Male | Female | Total | Male | Female | Total | Male | Female |
| Pachangara | 1,022 | 798 | 224 | 1,003 | 785 | 218 | 19 | 13 | 6 |
| Oyon | 2,449 | 2,010 | 439 | 2,304 | 1,920 | 381 | 145 | 90 | 55 |

Although these tables include no data on unemployed persons over 15 years of age, the unemployment rate in this category is estimated at 3.7%, almost the same as that for men aged 15 or less, according to our interviews with local officials. Information obtained at the Oyon Town Office indicates that there are about 100 men between 18 and 40 years of age seeking work in Oyon District.

The personnel required for mine operation is estimated at: 30 staffs, 66 employees, and 304 laborers, totaling 400. Of the (unskilled) laborers required, about 25% may be probably recruited within the region. Regarding the remaining laborers and employees, who are required to have working experience in mining, a further detailed survey has to be carried out to establish the potential supply. Oyon District, where two non-ferrous metal mines, that is, Raura and Uchuc Chacua, and many small-scale coal mines are located, offers good potential for supplying experienced mine workers.

## 5.2 MINE CAMP

### 5.2.1 The Location of the Mine Camp

For the site of the mine camp, three places, namely, Iscaycruz Mine, Pachangara and Oyon, are conceivable candidates. Of them, Pachangara and Oyon have already-established communities with service facilities such as schools and clinics; moreover, both of them, located at about 3,600 m above sea level, are more suitable than Iscaycruz (which is about 4,700 m above sea level) in terms of oxygen density and temperature, critical factors for human life.

Nevertheless, if the mine camp is constructed in either of these existing communities, workers will have to travel to the mine using a bus service, taking more than an hour one way. Judging from the scale of the mine to be developed, it would be extremely difficult and unrealistic to transport 400 mine workers everyday by bus. The mining camp should preferably be constructed as near the site of production as possible, because mine operation will be carried out at two or three locations. If Pachangara is selected for the camp site, it will involve the problem of constructing a road about 15 km long for the bus service to Iscaycruz.

At Raura Mine near Iscaycruz, about 950 mine workers and their families live at an altitude of 5,000 m; likewise at Uchu Chacua Mine, about 500 mine workers and their families live at an altitude of 4,500 m. Thus, though disadvantaged by its high altitude, Iscaycruz is still a possible site for the mine camp, if no other candidate is more suitable.

For the site of the mine camp, it would be reasonable to choose the northern area near Quellaycocha Lake, which is separated from the production facilities in the southern part by a 4,800-m ridge. This is so because separating the living quarters from the production site by a natural ridge will secure a good living environment. Distance between the two place is about 3 - 4 km, short enough for workers to commute by foot.

Around the lake there is a suitable stretch of land of 20 ha, comprising a gentle slope and flat ground. This area is large enough to build a mine camp for a total of 1,500 mine workers and their families.

### 5.2.2 The Location of Facilities

The mine camp must have houses and social service facilities for education, medical care, recreation and shopping, for the mine workers and their families. The residential area should preferably be divided into two parts, as commonly observed in Peruvian mines: one for employees and laborers, and the other for the staff. Social service facilities will need to be located at an equal distance from both of the two residential quarters.

If Quellaycocha Lake is to be used as a source of water for domestic use, the two residential areas must be properly chosen so that waste water from the areas does not flow into the lake. Therefore, it is advisable to locate the residential area for employees and laborers (which will be the larger in housing area as well as in population) on the north side of the lake; and to locate the residential area for the staff on the slope to the south of the lake, with drainage properly installed, although this scheme is likely to have some effect on the lake. Since the staff are few in number, there is no extensive construction involved in installing drainage equipment to serve their residential area. Social service facilities should be located to the northeast of the lake.

This disposition of facilities will accomplish the separation of the residential area for employees and laborers from that for the staff, and also give both of them equal access to social service facilities, while minimizing the pollution of the lake water.

# CHAPTER 4 OVERALL EVALUATION

# CHAPTER 4 OVERALL EVALUATION

## 1. FINANCIAL AND ECONOMIC EVALUATION

### 1.1 SIGNIFICANCE AND METHODS

In this section, financial and economic evaluation will be made in terms of the feasibility of exploiting lead and zinc deposits recently discovered in Iscaycruz, Peru. Financial evaluation involves the consideration, from the standpoint of investors, of whether or not investment in the development project will bring about satisfactory returns in the course of continuing operations; and economic evaluation involves consideration, independently of the interests of parties involved in the development, of whether or not such investment may make a greater contribution to the growth of the national economy than other potential investment opportunities.

These two types of evaluation, in adsdition to the assessment of effects on the local communities as described in the next section, are extremely significant in terms of the feasibility study. If the result of financial evaluation is negative, it suggests that the approach to the development should be reconsidered, or that a new assistance policy should be adopted by the Peruvian government. If the result of economic evaluation is negative, it suggests that the government should not promote the development unless political considerations, such as the expansion of employment in the area concerned, are brought to bear.

The financial and economic evaluation is based on the following assumptions besides the estimated costs for development and operation which are presented in Chapter 2.

(1) The concentrates which will be produced and sold as a result of the development are zinc and lead concentrates (containing a small amount of silver), and all of them shall be exported.

(2) The mine shall be managed by a special mining company (Empresa Minera Especial), and its capital accounting for about 25% of investment funds. It is assumed that the remaining 75% of the funds are borrowed over the long term.

(3) Empresa Minera Especial may be given incentives by the government, and the current system is assumed to remain unchanged in the future.

(4) In consideration of currently high inflation rates, the currency employed for analysis shall be the U.S. dollar, and not the Soles, the domestic Peruvian currency. The special mining company is allowed to account in dollars.

(5) The results of financial and economic evaluation shall be represented as a financial internal rate of return and an economic internal rate of return, respectively.

Based on these assumptions, we will first outline the methods of financial and economic evaluation used in this report, and then the various bases for and the results of the calculation of financial and economic internal rates of return will be presented.

### 1.1.1 Financial Evaluation

The procedure for financial evaluation in this report runs thus. First of all, it is assumed that the mining company will succeed in maximizing its profits by taking advantage of incentives as well as by considering the various conditions for future mine development and operation. The future profit and loss, and the income and expenditure of funds under this management are estimated. On the basis of cash flows given by such estimation, the DCF (Discounted Cash Flow) formula is used to calculate an internal rate of return as against the total investment, and an internal rate of return as against equity capital.

In the case of the former, investing entities include not only shareholders but also financing organizations, and it is important that the payment of interest and the repayment of loans, both of which are included as costs in company accounting, are a source of income for the financial organizations. In the case of the latter, on the other hand, the payment of interest and repayment of loans are not included in calculating the cash flows, which consists only of the company's accounting surplus. Dividends to shareholders, which will be covered by the surplus, are not estimated in calculating the income and expenditure of funds in this report, but are merely assumed to be paid out of the surplus. It should be noted that the internal rate of return as against the entire investment when calculated in this way exceeds the rate as against equity capital only when it is higher than the rate of interest at which funds are borrowed.

Financial costs and benefits which constitute cash flow correspond to expenditure and income based on domestic market prices and are included in company accounting, but careful attention should be paid to the fact that some of the items which are included as costs in company accounting do not constitute cash expenditures. To be exact, these are the depreciation and reinvestment allowances. Both are regarded as costs in the calculation of pre-tax profits on the basis of which corporate income tax is imposed, but they are not in fact paid out by companies, so that they do not involve cash expenditure. For this reason, they are not included in financial cost. As already mentioned, the payment of interest and the repayment of loans are not included in such cost, when the entire investment is being considered. In this case, they are cash expenditure on the part of shareholders, while they are cash income for the financing organizations and they offset each other.

The internal rate of return is given by the value of r (the discount rate) which satisfies the following formula:

$$\sum_{t=0}^{T} \frac{(\text{income})_t - (\text{expenditure})_t}{(1+r)^t} = 0$$

Where

t = total number of years since the start of investment,

and T = total years to come until the end of the project.

### 1.1.2 Economic Evaluation

Economic evaluation, which is also called the social cost-benefit analysis, consists of calculating economic benefits and costs based on "shadow prices"

(also called "accounting prices") assessed from the point of view of the national economy, instead of on domestic market prices, in the calculation of cash income and expenditure by the DCF formula. Cost-benefit analysis is usually conducted using the theory of welfare economics, where the total consumer's surplus, which is defined as the aggregate willingness to pay (or individual utility indicator), is maximized. In this report, however, the analysis will be focused on the maximization of national income instead of the consumer's surplus, in accordance with the procedure which is usually followed by international financial organizations such as the World Bank.

An economic benefit of the development project concerned from the national economic point of view is the acquisition of foreign currencies by exporting lead and zinc concentrates. The economic cost of the project, on the other hand, which is called "opportunity cost", represents, a decrease in national income and thus a loss to the Peruvian national economy, as a result of capital and labor input to the project. In this report, economic benefits (on an FOB basis in dollars) are equivalent to financial benefits (see above) because financial evaluation is made in US dollars. Economic cost (opportunity cost), however, differs from financial cost for the following reasons.

The first reason is tax. Tax imposes a cost on companies, while it is a source of revenue or a benefit on the side of the government. However, from the national economic point of view, including both companies and the government, costs and benefits cancel each other out, and therefore the opportunity cost or economic cost related to taxes and any similar payment to government agencies must be assessed at zero.

The second reason is wages. In Peru, mining workers are paid considerably more than the general standard. However, if the development project is not realized, the workers, who, are supposed to be engaged in the project, (except for the skilled staff) will be paid much less. This is so because the opportunity cost (or economic cost) of the labor force involved in the project must be much lower than the wages calculated in the assessment of financial cost, in consideration of the fact that wages for general work are usually fixed at a level related to the value of the marginal product of labor.

The third reason relates to costs assessed on a sol basis but converted into dollars, or in other words, exchange rate consideration. The sol was converted into the dollar at the official exchange rate in assessing financial cost. From the national economic point of view, however, can the people freely purchase US dollars by converting soles at the official exchange rate? If they can, there will be no balance of payments problem in the Peruvian economy; even if trade is liberalized, neither will there be a parallel foreign exchange market where a financial rate other than the official exchange rate is applied. Limited data make it difficult to estimate opportunity cost of soles in dollars (or shadow exchange rate) accurately, but when converting it is necessary to apply the financial exchange rate, if not even lower rates.

In economic evaluation in this report, taxes as a part of financial cost, wages payed to workers except for skilled staff, and costs in soles, were adjusted in order to assess economic costs, for the above-mentioned reasons. The economic internal rate of return was calculated by using the DCF formula and the economic costs and benefits (which are equal to financial benefits) which were assessed as mentioned above for each year of the project life.

## 1.2 THE FINANCIAL INTERNAL RATE OF RETURN

### 1.2.1 Summary

The Iscaycruz mine development under the Peruvian General Mining Law will be carried out by a Special Mining Company whose capital is shared among the Peruvian government agency having a concession for Iscaycruz, a foreign private company and Peruvian private capital.

Accordingly, on the assumption that about a quarter of the investment in the development will be covered by capital, and the remainder will be borrowed over a long term, the annual expenditures, income, and cash flow were assessed, and the financial internal rate of return was evaluated for both the entire investment and for capital.

In the expenditure and income accounting, all preferential treatment and incentives provided by the General Mining Law and the Tax Law applicable to Peruvian mines as of October, 1985 were taken into consideration.

### 1.2.2 Assumptions for Calculation

(1) Annual Amount of Concentrates (For details, see 6.1 Production Plan, Section 6, Chapter 2.):

Pb-concentrate 4,458 t (Grade: Ag 265 g/t, Pb 65%)
Zn-concentrate 60,618 t ( " : Zn 52%)

(2) Mine Life : 10 years

(3) Inflow (Income) : All the produced concentrates shall be exported under the following terms and conditions:

· Selling conditions

| Concentrate | Price | Condition |
|---|---|---|
| Pb | Ag: ¢700/oz<br>Pb: ¢25/lb | 95% or less 50 g, Price x99%<br>95% or less 3 units<br>T/C: $150/t (Base ¢22/lb-Pb)<br>R/C Scale: +$3/¢ |
| Zn | Ag: ¢700/oz<br>Zn: $900/t | 3 oz less x 80%<br>less 8 units or 85%<br>T/C: $150/t (Base $850/t-Zn)<br>R/C Scale: ±$3/¢ |

| | |
|---|---|
| · Handling loss | 1.5% (Inland 1.0%, Ocean 0.5%) |
| · Moisture in concentrate | 7.0% |
| · Ocean freight | $35/wt (from Callao Port to a Japanese port) |
| · Marine insurance | FOB x 0.2695% |

(4) Costs (Expenditures)

- Direct and indirect operation costs (For details, see 6.3, Section 6, Chapter 2)

| | |
|---|---|
| Annual direct operation cost | $5,205,000 |
| Annual indirect operation cost | $2,111,000 |

- Depreciation
  Each of the initial and additional investments and replacement costs shall be depreciated at a maximum rate of 20% per year.
  (For details of the initial and additional investments and replacement costs, see 6.3, Section 6, Chapter 2).

- Interest
  The part of the initial investment not supplied by capital shall be procured through long-term borrowing in consideration of the expenditures during the development period. The working capital for the first year of production (30% of the total cost less depreciation and interest) and annual financial shortfall shall be covered by short-term borrowing.
  Interest accruing during the development period shall be combined with the principal and repaid at the end of the year at a fixed rate for ten years. Annual interest is estimated at 9% (compound interest) including interest tax.

(5) Deductions

- Contribution to the Mining Community: 10% of the profit before deduction
- Contribution to INGEMMET: 1.5% "
- Reinvestment allowance: 40% at most
  (This is not applicable to years in which no additional investments or machine replacements are made)

(6) Income Tax

The following tariff is applicable, and the UIT (unit of taxation) is estimated to be $324.

| Taxable income | | Income tax rate (%) |
|---|---|---|
| Over | Not over | |
| | 150 UIT | 30 |
| 150 UIT | 1,500 UIT | 40 |
| 1,500 UIT | 3,000 UIT | 50 |
| 3,000 UIT | | 60 |

During the investment period and for five years thereafter, one third of the tax assessed from the tariff shall be included in the accounting, and the period of carry-over for tax losses shall be four years.

(7) Capital

The capital is expected to cover about a quarter of the initial investment and the entire cost of detailed survey, the F/S (feasibility study) and detail design. The remainder is used to cover expenditures each year during two years of development work. In the calculation, cost to raise the capital is ignored.

| | | |
|---|---|---|
| (-5) year | (Detailed survey) | $1,889,000 |
| (-4) " | ( " F/R) | $1,206,000 |
| (-3) " | (Detail design, etc.) | $ 451,000 |
| (-2) " | (Development work) | $1,000,000 |
| (-1) " | ( " ) | $3,454,000 |
| Total | | $8,000,000 |

### 1.2.3 Summary

The income statement, the fund flow statement and the annual cash flows as shown in Table 4.1 can be summarized as follows:

| Item | Amount ($1,000) | Remark |
|---|---|---|
| Revenue | 128,819 | |
| Direct & indirect operation costs | 73,160 | |
| Depreciation | 37,061 | The financial internal rate of |
| Interest | 14,048 | return (F IRR): |
| Profit before deductions | 4,550 | as against the investment: |
| Mining Community, INGEMMET | 599 | 7.68% |
| Reinvestment allowance | - | as against the capital: |
| Income before tax | 3,951 | 3.56% |
| Income tax | 825 | |
| Net profit | 3,126 | |

Table 4.1 Income Statement, Fund Flow Statement and Cash Flow

($1,000)

| Item | Total | Year(-5) | (-4) | (-3) | (-2) | (-1) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PRODUCTION | | | | | | | | | | | | | | | | |
| Pb-concentrate (t) | 44,580 | | | | | | 4,458 | 4,458 | 4,458 | 4,458 | 4,458 | 4,458 | 4,458 | 4,458 | 4,458 | 4,458 |
| Zn-concentrate (t) | 606,180 | | | | | | 60,618 | 60,618 | 60,618 | 60,618 | 60,618 | 60,618 | 60,618 | 60,618 | 60,618 | 60,618 |
| INCOME STATEMENT | | | | | | | | | | | | | | | | |
| (1) REVENUE | | | | | | | | | | | | | | | | |
| Pb-concentrate | 10,070 | | | | | | 1,007 | 1,007 | 1,007 | 1,007 | 1,007 | 1,007 | 1,007 | 1,007 | 1,007 | 1,007 |
| Zn-concentrate | 142,820 | | | | | | 14,282 | 14,282 | 14,282 | 14,282 | 14,282 | 14,282 | 14,282 | 14,282 | 14,282 | 14,282 |
| Other revenue | 529 | | | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 529 |
| Ocean freight | 24,250 | | | | | | 2,425 | 2,425 | 2,425 | 2,425 | 2,425 | 2,425 | 2,425 | 2,425 | 2,425 | 2,425 |
| Insurance | 350 | | | | | | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| Revenue total | 128,819 | | | | | | 12,829 | 12,829 | 12,829 | 12,829 | 12,829 | 12,829 | 12,829 | 12,829 | 12,829 | 13,358 |
| (2) COST | | | | | | | | | | | | | | | | |
| Direct operation cost | 52,050 | | | | | | 5,205 | 5,205 | 5,205 | 5,205 | 5,205 | 5,205 | 5,205 | 5,205 | 5,205 | 5,205 |
| Hauling | 12,590 | | | | | | 1,259 | 1,259 | 1,259 | 1,259 | 1,259 | 1,259 | 1,259 | 1,259 | 1,259 | 1,259 |
| Ship loading, charge | 4,990 | | | | | | 499 | 499 | 499 | 499 | 499 | 499 | 499 | 499 | 499 | 499 |
| Tax, commission | 3,530 | | | | | | 353 | 353 | 353 | 353 | 353 | 353 | 353 | 353 | 353 | 353 |
| Subtotal | 73,160 | | | | | | 7,316 | 7,316 | 7,316 | 7,316 | 7,316 | 7,316 | 7,316 | 7,316 | 7,316 | 7,316 |
| Depreciation | 37,061 | | | | | | 3,418 | 3,418 | 3,470 | 3,725 | 3,981 | 4,236 | 4,491 | 4,747 | 3,988 | 1,587 |
| Interest | 14,048 | | | | | | 2,554 | 2,299 | 2,043 | 1,788 | 1,532 | 1,277 | 1,022 | 766 | 511 | 255 |
| Cost total | 124,269 | | | | | | 13,289 | 13,033 | 12,829 | 12,829 | 12,829 | 12,829 | 12,829 | 12,829 | 11,815 | 9,158 |
| (3) PROFIT BEFORE DEDUCTION | 4,550 | | | | | | -460 | -204 | 0 | 0 | 0 | 0 | 0 | 0 | 1,014 | 4,200 |
| (4) DEDUCTIONS | | | | | | | | | | | | | | | | |
| Mining Community | 521 | | | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 101 | 420 |
| INGEMMET | 78 | | | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 63 |
| Reinvestment allowance | 0 | | | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| (5) INCOME BEFORE TAX | 3,951 | | | | | | -460 | -204 | 0 | 0 | 0 | 0 | 0 | 0 | 898 | 3,717 |
| (6) INCOME TAX | 825 | | | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 132 | 693 |
| (7) NET PROFIT | 3,126 | | | | | | -460 | -204 | 0 | 0 | 0 | 0 | 0 | 0 | 766 | 3,024 |
| FUND FLOW STATEMENT | | | | | | | | | | | | | | | | |
| (1) Revenue | 128,819 | 0 | 0 | 0 | 0 | 0 | 12,829 | 12,829 | 12,829 | 12,829 | 12,829 | 12,829 | 12,829 | 12,829 | 12,829 | 13,358 |
| (2) Capital | 8,000 | 1,889 | 1,206 | 451 | 1,000 | 3,454 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| (3) Loan | 26,645 | 0 | 0 | 0 | 6,739 | 19,906 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| (4) In: total | 163,464 | 1,889 | 1,206 | 451 | 7,739 | 23,360 | 12,829 | 12,829 | 12,829 | 12,829 | 12,829 | 12,829 | 12,829 | 12,829 | 12,829 | 13,358 |
| (5) Operation cost (Inc. Mining Community, INGEMMET) | 73,760 | 0 | 0 | 0 | 0 | 0 | 7,316 | 7,316 | 7,316 | 7,316 | 7,316 | 7,316 | 7,316 | 7,316 | 7,433 | 7,799 |
| (6) Interest | 14,048 | 0 | 0 | 0 | 0 | 0 | 2,554 | 2,299 | 2,043 | 1,788 | 1,532 | 1,277 | 1,022 | 766 | 511 | 255 |
| (7) Income tax | 825 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 132 | 693 |
| (8) Investment | 35,327 | 1,889 | 1,206 | 451 | 7,739 | 21,165 | 0 | 20 | 19 | 193 | 903 | 898 | 785 | 59 | 0 | 0 |
| (9) *Working capital* | 0 | 0 | 0 | 0 | 0 | 2,195 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -2,195 |
| (10) Repayment | 28,379 | 0 | 0 | 0 | 0 | 0 | 2,838 | 2,838 | 2,838 | 2,838 | 2,838 | 2,838 | 2,838 | 2,838 | 2,838 | 2,838 |
| (11) Out: total | 152,339 | 1,889 | 1,206 | 451 | 7,739 | 23,360 | 12,708 | 12,473 | 12,216 | 12,135 | 12,589 | 12,329 | 11,961 | 10,979 | 10,914 | 9,390 |
| (12) BALANCE | 11,126 | 0 | 0 | 0 | 0 | 0 | 121 | 356 | 613 | 694 | 240 | 500 | 868 | 1,850 | 1,916 | 3,968 |
| CASH FLOW (Against the investment) | 18,908 | -1,889 | -1,206 | -451 | -7,739 | -23,360 | 5,513 | 5,493 | 5,494 | 5,320 | 4,610 | 4,615 | 4,728 | 5,454 | 5,265 | 7,061 |
| CASH FLOW (Against the capital) | 3,126 | -1,889 | -1,206 | -451 | -1,000 | -3,454 | 121 | 356 | 613 | 694 | 240 | 500 | 868 | 1,850 | 1,916 | 3,968 |

F. IRR (Against the investment) 7.68%
F. IRR (Against the capital) 3.56%

## 1.3 THE ECONOMIC INTERNAL RATE OF RETURN

As stated in the previous paragraph, financial cost estimated in financial evaluation has to be converted to opportunity cost or economic cost to evaluate the project from the national economic point of view. It has already been explained that economic benefits equal financial benefits made from the sales of concentrates at FOB prices in dollars.

### 1.3.1 Conditions for Estimating Economic Cost

(1) Taxes (income tax, export and import taxes, sales tax, etc.), commissions and other payment to the government are zero in terms of opportunity cost from the national economic point of view, and therefore they have a zero value in the economic cost.

(2) Labor costs (monthly) within the conomic cost shall be assessed on the basis of the results of the local survey: it is assumed that in the case of employees and workers, the minimal wages (S/.530,000 per month and S/.20,000 per day) are applied; there are on average 25 working days monthly, and that insurance premiums and other charges amounting to 80% of the minimum wage are paid by the company.

(3) The financial exchange rate of S/.17,500 to a dollar (at the time of the survey), which is available for foreign tourists and others at commercial banks, shall apply to the cost items payable in soles to obtain their economic costs expressed in dollars.

As for the costs of various construction works and unloading concentrates, typical costs shall first be estimated and then 65% of the construction cost and 50% of the transportation cost (both in terms of financial cost) shall be accorded to these respective categories when calculating economic cost. This is so, because some materials used are imported and thus paid for in dollars, and also various kinds of taxes and labor costs are included in the costs of these materials and this makes it difficult to estimate the cost break-down. For transportation element in economic cost, "Costos de Operation Vehicular" by the Peruvian Ministry of Transportation and Communications was referred to.

### 1.3.2 Converting Financial Cost into Economic Cost

Financial cost, consisting of the costs involved in initial investment and operation, additional investment, replacement and salvage value was converted into economic cost using the above-mentioned conditions for estimating economic cost. The results are as shown in Table 4.2, 4.3 and 4.4. As for the costs included economic cost, except for the costs of construction, machinery and goods, and personnel (Peruvian), only the conversion of the exchange rate was applied to items payable in soles, and they were estimated a little higher in terms of economic cost.

### 1.3.3 Result

Economic benefits and costs by year, and internal rate of return drawn from them are shown in Table 4.5. The economic cost of working capital was estimated by applying the conversion factor to the entire operational cost.

The estimated economic internal rate of return was 24.99%, which indicates the high feasibility of this project from the point of view of the Peruvian national economy. The rate indicates the profitability of the project in itself independent of government policies such as taxation, and therefore it is recommended that the Peruvian government should actively promote the project, even to the extent of giving further incentives to the mining company.

## Table 4.2 Summary of Capital Cost

($1,000)

| Item | (-5) Year | | (-4) | | (-3) | | (-2) | | (-1) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $ | S/. | $ | S/. | $ | S/. | $ | S/. | $ | S/. |
| (FINANCIAL COST) | | | | | | | | | | |
| (1) Construction Cost | | | | | | | | | | |
| Detaild survey | - | 1,802 | - | 968 | - | - | - | - | - | - |
| Mining | - | - | - | - | - | - | - | 2,675 | - | 2,429 |
| Concentrator | - | - | - | - | - | - | - | 572 | - | 979 |
| Tailing disposal | - | - | - | - | - | - | - | 124 | - | 1,047 |
| Power plant | - | - | - | - | - | - | - | 121 | - | 287 |
| Power distribution | - | - | - | - | - | - | - | - | - | 110 |
| Communication | - | - | - | - | - | - | - | 8 | - | 51 |
| Water supply | - | - | - | - | - | - | - | - | - | 43 |
| Repair shop | - | - | - | - | - | - | - | 55 | - | - |
| Auxiliary facilities | - | - | - | - | - | - | - | 811 | - | 18 |
| Welfare facilities | - | - | - | - | - | - | - | 903 | - | 1,942 |
| Const.facilities | - | - | - | - | - | - | - | 51 | - | - |
| Subtotal | - | 1,802 | - | 968 | - | - | - | 5,320 | - | 6,906 |
| (2) Equipment Cost | | | | | | | | | | |
| Mining | - | - | - | - | - | - | 454 | 203 | 1,683 | 1,096 |
| Concentrator | - | - | - | - | - | - | - | - | 2,409 | 2,033 |
| Tailing disposal | - | - | - | - | - | - | - | - | - | 70 |
| Power plant | - | - | - | - | - | - | - | - | 2,321 | 1,040 |
| Power distribution | - | - | - | - | - | - | - | - | 329 | 314 |
| Communication | - | - | - | - | - | - | - | 12 | 77 | 35 |
| Water supply | - | - | - | - | - | - | - | - | 178 | 96 |
| Repair shop | - | - | - | - | - | - | 133 | 59 | - | - |
| Auxiliary facilities | - | - | - | - | - | - | 96 | 140 | 145 | 65 |
| Lima head office | - | - | - | - | - | - | - | 49 | - | - |
| Const. facilities | - | - | - | - | - | - | - | 48 | - | - |
| Const.management | - | - | - | - | - | - | - | 140 | - | 143 |
| Lima head office | - | - | - | - | - | - | - | 16 | - | 24 |
| Inventory | - | - | - | - | - | - | - | - | 21 | 91 |
| Subtotal | - | - | - | - | - | - | 683 | 667 | 7,163 | 5,007 |
| (3) Labor Cost | | | | | | | | | | |
| Staff | - | - | - | - | - | - | - | 84 | - | 114 |
| Employee | - | - | - | - | - | - | - | 19 | - | 41 |
| Worker | - | - | - | - | - | - | - | 19 | - | 36 |
| Subtotal | - | - | - | - | - | - | - | 122 | - | 191 |
| (4) Others | 12 | 75 | 163 | 75 | 451 | - | 441 | 628 | 982 | 1,107 |
| Total | 1,889 | | 1,206 | | 451 | | 7,739 | | 21,165 | |
| | | | | | | | | | | |
| (ECONOMIC COST) | | | | | | | | | | |
| Construction cost | 1,171 | | 629 | | - | | 3,458 | | 4,489 | |
| Equipment Cost | - | | - | | - | | 962 | | 8,683 | |
| Labor Cost | - | | - | | - | | 79 | | 115 | |
| Others | 72 | | 223 | | 451 | | 943 | | 1,868 | |
| Total | 1,243 | | 852 | | 451 | | 5,442 | | 15,155 | |

**Table 4.3 Summary of Operation Cost**

($1,000)

| | Item | $ | S/. | Total |
|---|---|---|---|---|
| Financial Cost | Labor cost | | | |
| | Staff | - | 192.0 | |
| | Employee | - | 170.4 | |
| | Worker | - | 556.2 | |
| | Subtotal | - | 918.6 | |
| | Material cost | 518.6 | 1,626.9 | |
| | Conc. hauling | - | 1,259.5 | |
| | Ship loading | - | 498.7 | |
| | Tax, commission | - | 352.8 | |
| | Others | 208.8 | 1,932.3 | |
| | Total | | | 7,316.2 |
| Economic Cost | | | | |
| | Labor cost | | | 390.7 |
| | Material cost | | | 1,536.9 |
| | Conc. hauling | | | 630.0 |
| | Tax. commission | | | 0 |
| | Others | | | 2,153.6 |
| | Total | | | 4,711.2 |

**Table 4.4 Summary of Additional Investment and Replacement Cost**

($1,000)

| | Item | 2 yr | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Financial Cost | Additional investment | - | - | - | 150 | 150 | 175 | - | - |
| | Replace. cost | 20 | 19 | 193 | 753 | 748 | 610 | 59 | - |
| | Total | 20 | 19 | 193 | 903 | 898 | 785 | 59 | - |
| | Residual value | - | - | - | - | - | - | - | 529 |
| Economic Cost | Additional Investment | - | - | - | 98 | 98 | 114 | - | - |
| | Replace. cost | 14 | 14 | 139 | 542 | 539 | 439 | 42 | - |
| | Total | 14 | 14 | 139 | 640 | 637 | 553 | 42 | - |
| | Residual value | - | - | - | - | - | - | - | 388 |

## Table 4.5 Annual Economic Benefits and Costs and Economic Internal Rate of Return

($1,000)

| Item | -5年度 | -4 | -3 | -2 | -1 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Economic Benefits | | | | | | | | | | | | | | | |
| Income | - | - | - | - | - | 12,829 | 12,829 | 12,829 | 12,829 | 12,829 | 12,829 | 12,829 | 12,829 | 12,829 | 12,829 |
| Residual value | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 388 |
| Total | - | - | - | - | - | 12,829 | 12,829 | 12,829 | 12,829 | 12,829 | 12,829 | 12,829 | 12,829 | 12,829 | 13,217 |
| Economic Costs | | | | | | | | | | | | | | | |
| Capital cost | 1,243 | 852 | 451 | 5,442 | 15,155 | - | - | - | - | - | - | - | - | - | - |
| Operation cost | - | - | - | - | - | 4,711 | 4,711 | 4,711 | 4,711 | 4,711 | 4,711 | 4,711 | 4,711 | 4,711 | 4,711 |
| Working capital | - | - | - | - | 1,229 | - | - | - | - | - | - | - | - | - | -1,229 |
| Add., Replace. | - | - | - | - | - | - | 14 | 14 | 139 | 640 | 637 | 553 | 42 | - | - |
| Total | 1,243 | 852 | 451 | 5,442 | 16,384 | 4,711 | 4,725 | 4,725 | 4,850 | 5,351 | 5,348 | 5,264 | 4,753 | 4,711 | 3,482 |
| Net Economic Benefits | -1,243 | -852 | -451 | -5,442 | -16,384 | 8,118 | 8,104 | 8,104 | 7,979 | 7,478 | 7,481 | 7,565 | 8,076 | 8,118 | 9,735 |

E. IRR = 24.99%

## 1.4 SENSITIVITY ANALYSIS

The estimate of the annual profit (loss) and cash flow has been calculated under the consideration of a certain term and condition which are influenced on calculation. However, value of this balance estimation will be varied correspondingly with the terms and conditions to be assumed.

We indicate the economic internal rate of return is as high as 24.99% according to the financial and economic evaluation, although the financial internal rate of return for the entire investment shows at 7.68%. This means that the investment in this project is feasible from the Peruvian national economic point of view and this project is promissible on the economical evaluation.

To be improved the financial internal rate of return would be necessary either to increase the income (such as rising of the metal price, upgrading of concentrates, higher metal recovery and expansion of production and so on.) or to reduce the expenditure (such as investment cost and operation cost and etc.).

Although, there are various factors to be effected on profitability and to be considered together with the combination of them but they will not be easily identified or clarified in terms of their nature and alternatives at the present stage, sensitivity analysis was made under the following assumptions.

(1) Case of reducing the investment cost on the machinery and equipment by the way to be shifted them from the suspended domestic mines.
Assuming the machinery and equipment for mining, concentrator and diesel power plant are available in Peru and they will be purchased with an amount of 50% of the brand new prices including the dismantling, transportation and overhaul costs and as a result $5,500,000 of investment requirement (equivalent to 43% of the purchasing cost on the machinery and equipment) are saved, 7.68% of the financial internal rate of return will be rised to about 9.9%.

(2) Case of increasing the income by upgrading of Zn-concentrate at the sacrifice of Zn recovery.
While 93% of the annual revenue will be born from the income of the Zn-concentrate, more higher Zn-concentrate price at FOB value will be obtained with rising the Zn grade at the sacrifice of Zn recovery and other hand, elimination of the inland transportation and the ocean freight costs will be compensated more than the lost value due to less volume of the concentrate.
Whenever Zn recovery of 85% (lowered by 3% than plan) and Zn grade of 55% (raised by 3% than plan) are maintained, the financial internal rate of return would rise to about 8.7%.

(3) Case of execmption from the import tariffs on machinery and equipment.
Supposed that the import tariffs on the machinery and equipment will be exempted and the price of them will be expected at an amount of 1.2 times of FOB price (foreign ports), the financial internal rate of return would rise to about 8.9%.

## 2. EFFECTS ON THE LOCAL COMMUNITIES

The exploitation of ore deposits at Iscaycruz may have various effects on neighboring communities. These effects, excluding for the moment macro-economic effects, may be classified into the following four categories:

(1) Effects by newly generated income
(2) Effects by improvements in infrastructure
(3) Effects by increases in population
(4) Effects on the natural environment by productive activities

Of these categories, (1) may be the most significant. As for improvements in infrastructure, there will be some road improvement works involved; for example, the improvement of the section between Oyon and Mishuya, repair works done between Mishuya and the mine to be developed, and emergency repair of damaged stretches of National Road No. 16 between Sayan and Churin. Of these improvements, the repair of the national road is the most important for this area; however, the development of the Iscaycruz mine may not contribute much with this respect, because the Ministry of Transportation and Communication, Raura Mine, and Uchuc Chacua Mine have already taken responsibility for its repair and maintenance.
Therefore, in the following paragraphs, we will largely focus on effects by newly generated income. For convenience's sake, (1) and (2) are considered to be economic effects whereas (3) and (4) to be social effects. Neighboring areas of Iscaycruz are divided into two levels: one is called the "immediate zone", representing principally the communities of Oyon, Pachangara and Churin, which will presumably be influenced directly by the mine development; and the other is a wider area along National Road No. 16 between Huacho and Ambo, chosen from a broader viewpoint. These zones are shown in Fig. 4.1.

### 2.1 THE CURRENT STATE OF THE IMMEDIATE ZONE

The immediate zone consists of the Oyon and Pachangara districts (the largest town in the latter, Churin), formerly part of Cajatambo Province, Lima Department; however, in October, 1985, they, along with several other districts in the basin of the Huaura River, separated from Cajatambo Province to form Oyon Province.
Cajatambo Province, before the separation, is divided into eleven districts; Oyon district ranks first in population, and Pachangara third. These districts together constitute the center of population along the upper reaches of the Huaura River.

#### 2.1.1 Population and labor force

Data on general and working population taken from the census in 1981 are shown in Tables 4.6, 4.7 and 4.8. According to local officials there has been no major change in population since then.
In Cajatambo Province, located in the northeast part of Lima Department and in the western part of Andes Mountains, agriculture has not been highly developed because of unfavorable natural conditions such as steep land and severe alpine climate. This fact is reflected in the composition of the population; that is, the urban (and small community) population represents a relatively large proportion (about 52%), and the agricultural population is relatively small (about 35% of the working population over 15 years of age). This tendency is even more marked in Oyon and Pachangara Districts.

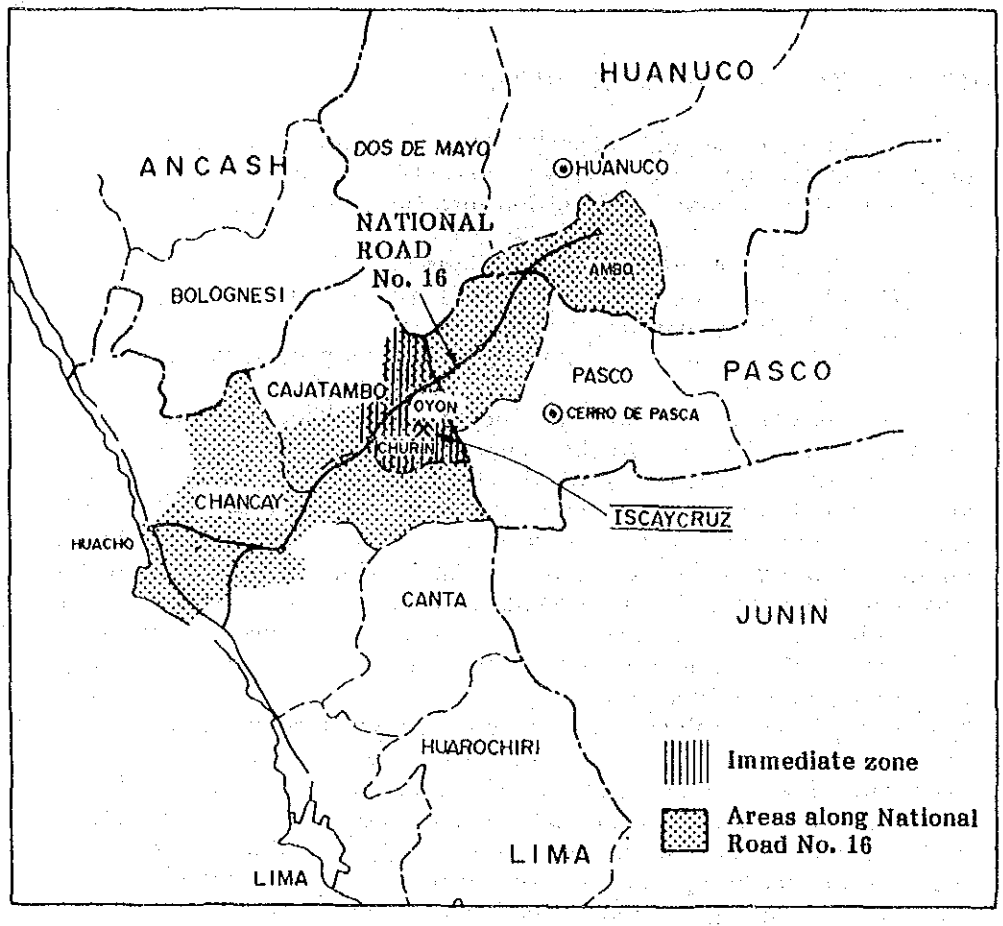



Fig. 4.1 Affected Areas

The unemployment figure for men over 15 years of age (for which data are not available) can be estimated from the results of a local survey to be at almost the same level as the figure for males between 6 and 15 years of age, that is, about 3.0%. According to an official from Oyon Community, there are about 100 people in the age range 18 to 40 seeking work in the district.

Table 4.6 Population

| | Total | Urban | Rural |
|---|---|---|---|
| Oyon | 8,354 | 6,304 | 2,050 |
| Pachangara | 3,339 | 1,766 | 1,573 |
| Subtotal | 11,693 | 8,070 | 3,623 |
| Cajatambo province | 28,555 | 14,417 | 14,138 |

Table 4.7 Working Population, 15 years and older; Cajatambo Province

| | Total | Male | Female | Laborer | Office worker | Self employed | Domestic worker | Other |
|---|---|---|---|---|---|---|---|---|
| Agriculture | 4,927 | 4,153 | 774 | 322 | 27 | 4,014 | 490 | 74 |
| Mining | 1,120 | 1,073 | 47 | 944 | 154 | 10 | 6 | 6 |
| Manufacturing | 245 | 214 | 31 | 73 | 15 | 142 | 8 | 7 |
| Other | 8,473 | 6,808 | 1,665 | 1,830 | 680 | 4,795 | 697 | 471 |
| Total | 14,765 | 12,248 | 2,517 | 3,169 | 876 | 8,961 | 1,201 | 558 |

Table 4.8 Working Population, 6-15 years

| | Total | Male | Female | Employed | Unemployed |
|---|---|---|---|---|---|
| Oyon | 2,449 | 2,010 | 439 | 2,304 | 145 |
| Pachangara | 1,022 | 798 | 224 | 1,003 | 19 |
| Subtotal | 3,471 | 2,808 | 663 | 3,307 | 164 |
| Cajatambo province | 8,640 | 6,916 | 1,724 | 8,378 | 262 |

### 2.1.2 Industry

Agriculture: Subsistence farming using traditional techniques is the principal type of agriculture, producing only a very small surplus for sale. The area under cultivation per farm is extremely small, usually less than 0.5 ha, and an area of 1.0 ha is regarded as rather large. Machinery has hardly been introduced, and fertilization depends mainly on animal compost, with a very small-scale utilization of chemical fertilizers. Potato is the main crop, with other produce such as barley, maize, olluco (a kind of potato) and wheat also being harvested. On the basis of the results of the local survey, the production of the main crops in the area concerned is estimated as shown in Table 4.9.

Table 4.9 Annual Production of Selected Farm Produce

| | Potato | Olluco | Barley | Maiz | Wheat | Fruit | Other |
|---|---|---|---|---|---|---|---|
| Quantity (kg) | | | | | | | |
| Oyon | 30,000 | 1,800 | 2,000 | 600 | 800 | - | 3,000 |
| Pachangara | 15,000 | 1,000 | 1,500 | 500 | 800 | 1,000 | 2,000 |
| Total | 45,000 | 2,800 | 3,500 | 1,100 | 1,600 | 1,000 | 5,000 |
| Price (s/./kg) | 2,000 | 2,000 | 2,000 | 3,000 | 3,000 | 2,000 | 2,000 |
| Sales (s/. million) | 90.0 | 5.6 | 7.0 | 3.3 | 4.8 | 2.0 | 10.0 |

Estimated Total Sales, s/. 122.7 million ($8,800)

Note: Excluding domestic consumption

Livestock farming: Mainly cattle, sheep and pigs are raised, but farms are small scale, under-utilizing natural grassland. The annual livestock production is estimated from the results of the local survey as shown in Table 4.10.

Table 4.10 Annual Production of Livestock

| | Cattle | Sheep | Goat | Swine | Horse | Other |
|---|---|---|---|---|---|---|
| Quantity (head) | | | | | | |
| Oyon | 400 | 300 | 200 | 150 | 100 | 200 |
| Pachangara | 500 | 450 | 150 | 100 | 100 | 180 |
| Total | 900 | 750 | 350 | 350 | 200 | 380 |
| Price (s/. 1,000/head) | 3,000 | 750 | 600 | 500 | 1,000 | 800 |
| Sales (s/. million) | 2,700 | 563 | 210 | 125 | 200 | 304 |

Estimated Total Sales s/. 4,102 million ($293,000)

Note: Excluding domestic consumption

Forestry: The plantation of eucalyptus is carried out on a small scale over a limited area. In Oyon, the forestry cooperative manages a forest of about 6,000 trees, and sells timber mainly to the neighboring metal and coal mines for use as mine props.

Mining: This is the largest modern industry in the area concerned, and Raura Mine (Cu, Pb and Zn; production 1800 t/day; owned by Raura Mining S.A.) and Uchuc Chacua Mine (Ag; production 1000 t/day; owned by Buenaventura Mining S.A.) are in operation to the north and northwest of Oyon, respectively. These two mines employ about 950 workers and 500 workers respectively, who live with their families in their own self-contained mining camps. Thus, they have little linkage to the Oyon Area.

In addition to these mines, there are several coal mines, mainly in Mishuya in Oyon District. Although their production scale is small, they provide an important source of income.

Manufacturing: The region supports no manufacturing or processing except production of dairy products such as butter and cheese on a small scale. Most of the products are locally consumed, but some are distributed to Lima and Huacho.

Commerce: Commercial activities mainly serve the local residents. Clothes, utensils, canned food and so on are supplied mainly from Lima or Huacho. In Churin, there are some souvenir shops for tourists.

Tourism: Churin has busy spas, attracting tourists mostly from Lima. As for accommodation, there are one hotel, thirteen hostels (smaller hotels), and eight tourist homes, which together can accommodate about 550 persons in total.

Infrastructure: Individual sectors such as roads, electric power, water and communications are described in Chapter 3 "Infrastructure". In general, infrastructure in this area has made little improvement, remaining inadequate in many respects.
The current situation of educational and medical facilities is as shown in Table 4.11 based on the local survey. Both Raura and Uchuc Chacua Mines have their own schools and clinics managed by the companies.

Table 4.11 School and Clinic

| | Primary and Secondary school | | Clinic | | | |
|---|---|---|---|---|---|---|
| | Student | Teacher | Number | Doctor | Assistant | Accommodation |
| Churin | 800 | 30 | 1 | 2 | 3 | 4 |
| Oyon | 1,000 | 40 | 1 | 1 | 3 | 10 |

## 2.2 ECONOMIC EFFECTS ON THE IMMEDIATE ZONE

### 2.2.1 The estimation of newly generated income

Labor income: Developing Iscaycruz Mine will create about 400 jobs in total, and some contract laborers may presumably be needed. The resulting annual income is estimated at about $1,080,000 in total.

This income, however, does not necessarily represent gains to the local economy. This is so because, in general, income paid for locally recruited clerks and laborers does not constitute net gain to the local economy; it only shifted its source within the same economy.

In fact, however, a considerable part of the income newly generated by the mine can be expected to add to the total income of the area, since local unemployed and underemployed people may find new employment, and since the wage level at the mine is about three times higher than local average. Assuming that ten employees and one hundred laborers will be recruited from the local area at wages three times higher than usual, and that all the contract laborers will be recruited from among currently unemployed people, net increase in income is estimated at about $1,010,000 (about 94% of the total actually paid). The breakdown is given in Table 4.12.

Table 4.12 Generated Annual Income and Net Increase (estimated)

| Occupation | Generated Annual Income | | | Net Increase ($) | Remark |
|---|---|---|---|---|---|
| | Number | Monthly salary ($) | Annual income ($) | | |
| Mine manager | 1 | 2,000 | 24,000 | 24,000 | |
| Ass. Mine manager | 1 | 1,000 | 12,000 | 12,000 | |
| Staff | 28 | 500 | 168,000 | 168,000 | |
| Employee | 66 | 200 | 158,400 | 150,600 | 10 locally recuited |
| Worker | 304 | 150 | 547,200 | 486,000 | 100 locally recruited |
| Subtotal | 400 | | 909,600 | 840,600 | |
| Expatriate | 3 | 4,100 | 147,600 | 147,600 | |
| Contractor | 15 | 100 | 18,000 | 18,000 | Formerly unemployed |
| Total | | | 1,075,200 | 1,006,200 | |

Capital income: Since most of the capital goods (including intermediate goods) necessary for mining operation will probably be supplied from outside areas such as Lima, the mine development will have little effect of this sort on the immediate zone. Mine props can be supplied locally, however, and the annual income from this source is estimated at about US$30,000 as shown in Table 4.13. The transportation of concentrates from the mine to Callao Port will be contracted out to outside trucking companies, having little effect on the local area. The annual expenses for concentrate transportation are estimated at US$1,260,000.

Table 4.13 Annual Demand for Mine Timber

| | Volume ($m^3$) | Price ($/$m^3$) | Sales ($) |
|---|---|---|---|
| Log (Eucalyptus) | 100 | 90 | 9,000 |
| Board (Eucalyptus) | 115 | 183 | 21,000 |
| Total | 215 | | 30,000 |

### 2.2.2 The estimation of new demand

The incomes estimated in the previous paragraphs do not necessarily mean new gains for the residents in Oyon and Churin districts. The scale of economic effects on the immediate zone depends on what proportion of the labor and capital incomes newly generated by the Iscaycruz mine is spent on goods and services produced in Oyon and Churin districts.
To assess this proportion, we first estimate increases in demand due to the mine development for several major items produced and available in the local area.

Increases in demand for various goods can generally be calculated by the following formula:

$$D = ap + (a - a')p'$$

where

- D ; the increase in demand
- a ; the annual consumption per capita of the population of the new mine
- a' ; the annual consumption per capita in the local area
- p ; the number of mine workers brought in from outside the local area
- p' ; the number of mine workers recruited from inside the local area

That is, net new demand created by the mine is the sum of (1) the entire amount of consumption by workers brought in from outside and (2) the increase in consumption, caused by a higher per-capita consumption level due to higher wages, by workers recruited from inside the local area. On the same assumptions about recruitment as in the previous subsection, the following figures are obtained for p and p':

| | |
|---|---|
| The number of mine workers brought in from outside | P = 1,057 |
| The number of mine workers recruited from inside the local area | P' = 418 |
| Total population of the mine | 1,475 |

Agricultural products: As already mentioned, agricultural products supplied from the neighboring communities are limited in kind and quantity. As an example, using available data on potato and fresh maize, new demands are estimated as shown in Table 4.14, on the assumption that the annual average consumption per capita in the whole of Peru is applicable to the mine population and the population of the local area.

Table 4.14 Estimated Net Demand Increase for Selected Produce

| | National per capita Consumption (kg/year) | Net demand Increase (ton) |
|---|---|---|
| Potato | 83.5 | 88.3 |
| Maiz | 11.0 | 11.6 |

Notes; National total consumption is assumed to be equal to national total production. Potato; 1979-84 average; Maiz; 1982-83 average.

Sources; Institute Nacional de Estadistica, Peru; Compendio Estadistico 1984.
Ministerio de Agricultural, Boletin Estadistico de la Produccion Agricola 1983.

Livestock products: Beef, pork, poultry and egg will be considered under this heading. The annual average per capita consumptions of these products in Peru are 5.4 kg, 3.1 kg, 10.5 kg, and 3.5 kg, respectively. There are, however, two problems in using these figures as the consumption levels of the mine population. One is that these statistics, which do not include imports, are lower than actual levels; the other is that meat consumption by the mine population is expected to be greater than the national average, because their wage and salary levels are set higher than the national average.
In the Lima metropolitan area, the annual average per capita consumptions of beef, pork and poultry including imports are 8.5 kg, 3.1 kg, and 18.0 kg, respectively. In the light of these figures, the annual demand among mine workers for these items is estimated as shown in Table 4.15, on the assumption that the consumption in the local area is the same as the national average, while it is 50% higher among the mine population.

Table 4.15 Estimated Net Demand Increase for Meat and Poultry

| | Annual per Capita Consumption | | | | Net demand increase (ton) |
|---|---|---|---|---|---|
| | National average*1) (kg) | Lima*2) (kg) | Mine camp (kg) | Local (kg) | |
| Beef | 5.4 | 8.3 | 8.1 | 5.4 | 9.7 |
| Pork | 3.1 | 3.1 | 4.7 | 3.1 | 5.6 |
| Chicken | 10.5 | 18.0 | 15.8 | 10.5 | 18.9 |
| Egg | 3.5 | - | 5.3 | 3.5 | 6.4 |

Notes; *1) 1981-84 averages.
*2) 1973-82 averages.

Sources; Institute Nacional de Estadistica, Peru: Compendio Estadistico 1984.
Ministerio de Agricultura, Boletin Estadistico de la Produccion Pecuria Peru: 1982.

Forest products: Mine timber can be supplied locally. The quantity and value of its demand are shown in Table 4.13 above.

Manufactured products: In the local area, only very small amounts of dairy products are produced. Although it is probable that milk, butter and cheese may be supplied to the mining camp, the demand cannot be estimated because production figures are not available.

Services: Since it is expected that the mine development will be followed by an influx of more than 1,000 people to the local area, and by an annual increase of about $1 million in net income, there must be a considerable potential demand for services. Demand for daily goods and clothes, and for the restaurant business will be met in Oyon and Churin Districts to a considerable extent, although new demand for retail foodstuffs is expected to be small, because they will mostly be supplied by a store run by the mine company at the mining camp.
It is difficult to quantify the service activities, but the annual new demands for services are estimated as shown in Table 4.16, on the assumption that the retail margin of commodity sales (except foodstuffs) is generally 10% of household income, and that 4% of income is spent on bar and restaurant expenses.

Table 4.16 Estimated New Demand for Services

| | Demand as portion of income (%) | Income | New demand |
|---|---|---|---|
| Retail | 10 | 1,006,200 | 100,620 |
| Restaurant | 4 | | 40,250 |
| Total | | | 140,870 |

Transportation: The largest demand is for the transportation of concentrates, and the annual expenditure on transportation is estimated at $1,260,000. Of all the cost items, only the labor cost is relevant to the economy of the local area. Assuming that the labor cost accounts for 10% of the transportation expenditure (based on data from the Ministry of Transportation and Communication), a new labor demand worth $126,000 will result.

### 2.2.3 The estimation of local supply and sales

New demands for several sectors have been estimated, but it is difficult to forecast what proportion of the estimated new demand will be met by local supply, and added to the incomes of local producers.
This is so because two uncertainties are involved in such a projection. One is a technical problem: to what extent can production be expanded to meet a considerable increase in demand. The other is a distributional one: if there is no distributive system which can secure constant supply of goods in bulk, demand at the mining camp will be directed to external areas such as Lima, passing over the local producers.

To illustrate the first problem, consider the estimated demand for potatoes, which is about twice the current production. It will also be impossible for local producers immediately to meet the total demand for poultry, which are not being raised at present. However, it is unrealistic to assume that their production will stay at the current levels in the future. To put the case of the second problem, the mining company does not need to purchase daily necessities such as foodstuffs in the local area to save transport costs, because they can be purchased in quantity in Lima and carried by the returning concentrates trucks. In fact, Uchuc Chacua Mine near Iscaycruz obtains its foodstuffs from Lima, except meat which is supplied from Churin District.

It is therefore not very useful to try to specify only one figure for each proportion of local supply, since many uncertainties are involved. Instead, it is preferable to compare several projections based on different assumptions.
The following three scenarios are assumed:

(1) 100% of the demand for each item is locally supplied.

(2) As for foodstuffs, 50% of the local production or local demand, whichever is the smaller, is locally supplied; and for items other than foodstuffs, 20% is locally supplied.

(3) The supply rate of each item is set at a reasonable level with respect to current levels of supply.

Note: It is assumed that in each case supply increase is covered by expanding production.

The local supply and sales estimated for each scenario are shown in Table 4.17. Note, however, that these figures all underestimate the real values since some items which are available from local producers are excluded and multiplier effects are not taken into account.

## Table 4.17 Estimated Local Supplies and Sales

| Item (Unit) | (D) Demand | Local Production | Price ($/unit) | Scenario 1 | | | Scenario 2 | | | Scenario 3 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Local (S) supply | Sales ($1,000) | Local supply ratio S/D (%) | Local (S) supply | Sales ($1,000) | Local supply ratio S/D (%) | Local (S) supply | Sales ($1,000) | Local supply ratio S/D (%) |
| Potato (ton) | 88.3 | 45.0 | 142.9 | 88.3 | 12.6 | 100 | 22.5 | 3.2 | 25 | 53 | 7.6 | 60 |
| Maiz (ton) | 11.6 | 1.1 | 214.3 | 11.6 | 2.5 | 100 | 0.6 | 0.1 | 5 | 1.7 | 0.4 | 15 |
| Subtotal | | | | | 15.1 | | | 3.3 | | | 8.0 | |
| Cattle (head)*1) | 65 | 900 | 214.3 | 65 | 13.9 | 100 | 33 | 7.1 | 50 | 65 | 13.9 | 100 |
| Swine (head)*1) | 111 | 250 | 35.7 | 111 | 4.0 | 100 | 56 | 2.0 | 50 | 111 | 4.0 | 100 |
| Chicken (ton) | 18.9 | 0 | 1,035.7*3) | 18.9 | 19.6 | 100 | 0 | 0 | 0 | 1.9 | 2.0 | 10 |
| Egg (ton) | 6.4 | 0 | 585.7*3) | 6.4 | 3.7 | 100 | 0 | 0 | 0 | 0.6 | 0.4 | 10 |
| Subtotal | | | | | 41.2 | | | 9.1 | | | 20.3 | |
| Timber ($m^3$) | 215 | 1,900*2) | 139.5 | 215 | 30.0 | 100 | 43 | 6.0 | 20 | 215 | 30.0 | 100 |
| Service ($1,000) | 142.5 | - | | 142.5 | 142.5 | 100 | 28.5 | 28.5 | 20 | 63.1 | 63.1 | 44*4) |
| Transport ($1,000) | 125.9 | - | | 125.9 | 125.9 | 100 | 25.2 | 25.2 | 20 | 25.2 | 25.2 | 20 |
| Total | | | | | 354.7 | | | 72.1 | | | 146.6 | |

Notes: *1) Converted from the figures in Table 4.15, using, 0.15 ton/head for the cattle and 0.0506 ton/head for the swine. (Source: Ministerio de Agricultura, Peru: Estadistica Basica de la Actividad Avicola y del Sector Agropeculio 1960-1985.)

*2) Converted using 0.314 $m^3$ per tree (length: 10 m, diameter: 20 cm).

*3) Estimated from 1984 prices in the Lima metropolitan area. (Source: Institute Nacional de Estadistica, Peru: Compendio Estadistico 1984. Consumer price indexes are from ibid p. 120 and Quarterly Economic Review of Peru, Bolivia, no. 3, 1985, Appendix 1.)

*4) Assumed local supply ratios are 30% for Retail and 80% for Bar and Restaurant.

The multiplier effect is induced by the chain-wise relation between income and consumption: part of the household income spent on goods returns to the household through wages paid by the producer, and the cycle is repeated. Since inter-industrial relationships can be ignored here, multiplier effects can be limited to the cycle of increased household income and increased consumption of agricultural and livestock products, and services. The multiplier mechanism here combines the following two components: (1) an increase in local consumers due to rising population or falling outmigration as a result of increasing employment mainly in the service sector; (2) an increase in per-capita consumption as a result of higher income.

Multiplier effects will not be considered in this study, however, because it is difficult to estimate the output elasticity of employment and the income elasticity of consumption that are needed to calculate the multipliers, and also because the scale of economic activities in the immediate zone is so small that multiplier effects as a whole may not be very large, as against the primary effects estimated in the previous paragraphs.

Table 4.18 is a summary of Table 4.17, showing the total new demand and the local supply for each scenario.

Table 4.18 Estimated Total Local Sales

| Scenario | (Y) Net income Increase ($1,000) | (D) Net total New demand ($1,000) | (S) Total Local sales ($1,000) | S/Y (%) | S/D (%) |
|---|---|---|---|---|---|
| 1. Optimistic | | | 354.7 | 35.3 | 100.0 |
| 2. Pessimistic | 1,006.2 | 354.7 | 72.1 | 7.2 | 20.3 |
| 3. Neutral | | | 146.6 | 14.6 | 41.3 |

This table cannot, however, give any clues as to the relative magnitude of the impact of the increase in local supply upon the local economy. To see the magnitude of impact, the total production figures for the selected six items of which production data are available are compared with the current production scales in Table 4.19.

Table 4.19 Sales and Production of Six Food Items

| Scenario | Six food items | | (Q) Total local Agricultural production | S/P (%) | S/Q (%) |
|---|---|---|---|---|---|
| | (S) Local supply ($1,000) | (P) Local production ($1,000) | | | |
| 1. Optimistic | 56.3 | | | 27.0 | 18.7 |
| 2. Pessimistic | 12.4 | 208.5 | 301.8 | 5.9 | 4.1 |
| 3. Neutral | 28.3 | | | 13.6 | 9.4 |

It is possible to draw conclusions from these figures as follows:

(1) Local revenue from sales of goods will be small compared with the newly generated income. The local area in question has a poorly-structured economy to hold such income within it, and the majority of the income may drain into other areas such as Lima.

(2) Nevertheless, new demand will be relatively large compared with the current scale of the local economy. This is the case especially in the livestock sector, which may be substantially affected. The increase in demand for services, especially retail, may also be substantial.

### 2.2.4 Other economic effects

One of the benefits which the local area will receive from the mine development is an increase in tax revenue. This includes the property tax on the mining lot, which is, however, not very large. Large effects cannot be expected from the improvement of infrastructure, either. One possibility is the repair of National Road No. 16 when damaged, but such works have already been carried out by the Ministry of Transportation and Communication, and Raura and Uchuc Chacua Mines. Therefore, the participation of Iscaycruz Mine in such works will not give rise to further economic benefit unless the road is substantially improved.

## 2.3 SOCIAL EFFECTS ON THE IMMEDIATE ZONE

### 2.3.1 Effects of population increase

It is estimated that 1,057 people will move in to the Iscaycruz Mining Camp from outside the local area. Despite this addition to Oyon District's population of about 8400, direct influence is not expected to be very large, because the mining camp will form a self-contained community about 15 km away from Oyon, the center of the district.

### 2.3.2 Environmental effects

From the standpoint of the natural environment, it is the water quality of rivers in the vicinity which will be most affected by mine operation. In the downstream areas of the basin into which discharged waste water from the mine, the tailing dam and households will flow, communities are likely to suffer from pollution of drinking and irrigation water. To avoid this problem, proper measures should be taken on the part of the mining company so that sewage facilities are well designed, maintained and administered.

## 2.4 WIDE-RANGING EFFECTS

### 2.4.1 Increases in employment and income

The effects of the mine development will not be confined to the immediate zone. It is quite predictable that its economic effects will extend to the areas along National Road No. 16, outside Oyon and Pachangara Districts, and also as far as other provinces in terms of employment.
Of the mine employees, all the staffs, the majority of clerks, and about two thirds of the laborers will come from outside Oyon and Pachangara Districts. They will probably include a considerable number of formerly jobless mine workers, and therefore a substantial reduction in unemployment should occur region-wide.
Increases in production and income caused by increased consumption by the new mine population can also be expected to take place outside the immediate zone. Although most of the goods which cannot be supplied from the immediate zone will be procured in Lima, some agricultural products (mainly vegetables, fruit and poultry) are likely to be supplied from the agricultural area around Sayan along National Road No. 16. It is highly possible that an increase in consumption due to the mine population will result in the expansion of agricultural production in the above-mentioned area.

### 2.4.2 Improvements in infrastructure

As previously mentioned, the participation of the mine in the maintenance of National Road No. 16 by sharing the cost of restoration or by supplying machinery and labor will only bring a small benefit to the immediate zone. In the long term, however, its participation in the maintenance as a user of the road can be regarded as significant for the following reasons.

National Road No. 16 is one of the arteries across Peru from east to west. As shown in Fig. 4.2, its route extends from Huacho on the Pacific coast to Pucallpa, a center in Selvas (Forest Region) via Ambo and Huanuco. This route

is significant in two ways. One is that it will provide increased access to the Pacific coast for Yahahuanca Province, Pasco Department, and for Ambo Province, Huanuco Department, which are located on the east side of the Andes range, so that industry in these areas may be encouraged. In addition to many mines, cattle, hogs and sheep are widely raised in the areas, and access to the coast with its large population is an important factor for the producers there.

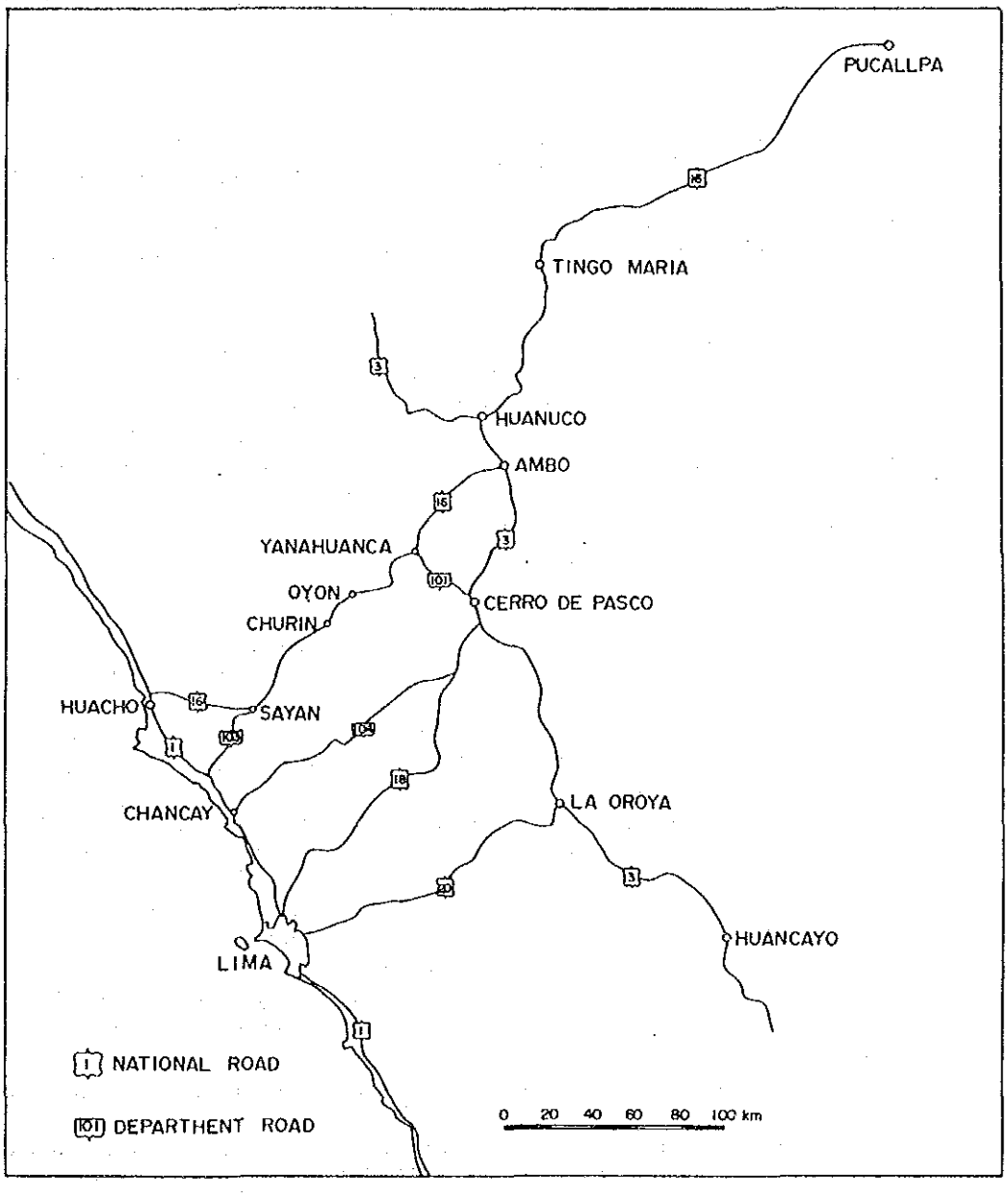



Fig. 4.2 Roads System Around Lima

The second way in which National Road No. 16 is significant is its role in developing the eastern Forest Region. The Peruvian government has given priority to the development of this region, and attaches great importance to the Lima - La Oroya - Cerro de Pasco - Huanuco - Pucallpa route as the basis for the

development. In the future, however, National Road No. 20 from Lima to La Oroya, which is the sole highway connecting the highly-populated central mountain region with Lima, is likely to become so congested as to reach its capacity limit. From the standpoint of the whole national transportation network, National Road No. 16 therefore is a valuable alternative artery for National Road No. 20.
The importance of National Road No. 16 will rise as the mountain and forest regions become increasingly developed, and so will the value of well maintaining the road, viewed from the national economy as a whole.

### 2.4.3 Mine development and agglomeration economies

Developing Iscaycruz Mine may also bring about agglomeration economies among the neighboring mines (both in operation and planned). The area extending from Oyon District to the border between Pasco Department and Huanuco Department to the east of the district is one of the major mining areas in Peru, and coking coal necessary for steel production is domestically produced only in Oyon District.

Developing Iscaycruz Mine in this area may give rise to various agglomeration economies. First of all, there may be a cost reduction by sharing some of the infrastructure. Currently, this is applicable only to the repair and maintenance of National Road No. 16, but electric power generation is another good area where such advantage may be exploited. Second, a greater demand for locally produced inputs may stimulate production in the surrounding areas, reducing the costs of inputs needed for mine operation.

## 2.5 SUMMARY

Some of the effects of the development of Iscaycruz Mine on local communities have been discussed, with the related areas divided into the immediate zone and the area along National Road No. 16.
Most economic effects in the immediate zone are attributable to the consumption of local products by the population of the mining camp and by the mining company.
According to the estimates calculated for the three scenarios, local revenue may total $355,000 per year at the most (which is an optimistic projection) or $72,000 per year at the least (a pessimistic projection). Six categories of agricultural and livestock production as a whole are expected to increase by 27% (optimistic) or 6% (pessimistic), over the current level of production. We can conclude from these estimates that the absolute value of new local income will not be very high (a large part of the newly generated income will be spent outside the local area), but that the impact will nevertheless be large compared to the current scale of the local economy.
With regard to social effects, we have focused on impact upon the natural environment, especially water quality of rivers.
From a broader viewpoint we have noted that the mine's participation in maintaining National Road No. 16 will be significant in terms of economic benefit to the national economy, and also that the mine may benefit other adjacent mines through agglomeration economies.
In conclusion, economic and social effects of developing Iscaycruz Mine on the local communities are by no means small.

# CHAPTER 5 FACT FINDINGS AND RECOMMENDATIONS

# CHAPTER 5 FACT FINDINGS AND RECOMMENDATIONS

## 1. FACT FINDINGS OF THE OVERALL EVALUATION

### 1.1 FEASIBILITY OF INVESTMENT

(1) The economic internal rate of return was estimated at 24.99% on the basis of the assumed metal prices (Ag: ¢700/oz, Pb: ¢25/lb, Zn: $900/t). This means that investment in this project is feasible from the Peruvian national economic point of view, according to the quoted metal prices. It is accordingly recommended that decisions be taken by the Peruvian government in favor of the mine development.

(2) In considering the economic effects of mine development on the local area including Oyon and Churin, it is expected that the local people will benefit, annually at a maximum of $355,000 and a minimum of $72,000, through increased local consumption. Although their absolute value is not very high, it can be concluded that such earnings will have a large impact on the local economy which is currently at low level. From a wider point of view, it is also expected that, in addition to increases in employment and income, a greater contribution will be made to the local and national land development schemes through participation of the Iscaycruz mine in the repairs and maintenance of National Road No. 16.

(3) However, the financial internal rate of return which was estimated at 7.68% on the entire investment basis and at 3.56% on the capital basis, is considerably lower than the assumed interest on borrowing of 9.0%. This indicates that it would be premature for the company to embark upon the project under the conditions assumed in this report (quoted metal prices, ore reserves, production scale, capital and operation, costs etc). The feasibility of the project from the point of view of the company will be dependent on changes in these assumed conditions, such as rises in quoted metal prices, increase in income due to favorable changes in production conditions, and reduced expenditure by cutting investment and direct operational costs.

### 1.2 POLICY RECOMMENDATIONS

(1) The large discrepancy between the financial internal rate of return and the internal economic rate of return is attributable to differences in the assessment of taxes and labor costs, as well as in foreign exchange rates; the assessment of taxes and foreign exchange rates in particular exert a major influence. For this reason, it is proposed that the Peruvian government would consider increasing tax incentives (reduction of, or exemption from, import tariffs and income tax) in favor of the project, in view of the low internal financial rate of return. If import tariffs, for example, are waived, the rate will rise to about 8.9%.

(2) Since expenses on infrastructure facilities and equipment presumably borne by the company (e.g. projected construction of hydroelectric power plant, mine roads and welfare facilities) will bring a considerable public benefit, it is recommended that the central government take measures such as overall or partial payment for these facilities.

(3) Policy support in financing is also important. Low-interest financial assistance from the government and the postponement of repayment and interest payment are proposed. However, for the company as the executor of the project, it is also required to make efforts to borrow funds at as low interest rates as possible.

It is expected that the implementation of these proposals will result in improvements in the financial feasibility of the project. The project depends to a considerable extent on whether or not fiscal (tax system) and financial policies can be flexibly managed.

### 1.3 TECHNICAL RECOMMENDATIONS

If the conditions assumed in the report change in the future so that the internal financial rate of return rises, the project implementing agent (the company) would be advised to:

(1) Conduct a detailed survey (drilling and tunneling) to establish the horizontal and longitudinal scale and form of Limpe deposits, their amount and quality, focused on S-adit level and above. Below S-adit level, declined drillings should be carried out, to define the ore potential of the deposits beneath. If the scale of development can be economically expanded as a result of these drillings, it can be expected that the financial feasibility of the project will be substantially improved.

(2) Investigate the possibility of using machinery and equipment now idle in non-producing domestic mines. According to the calculation made in the sensitivity analysis, it is expected that the internal financial rate of return for such a case would rise to about 9.9%.

(3) Investigate the characteristics and quality of the Ag present in theo re, because the low internal financial rate of return is due partially to the low Ag evaluation. Further study should be conducted to find a means to enhance grade, even at the expense of the concentrate recovery (especially Zn-concentrate), because the cost of transporting concentrates is high. If the recovery of Zn were lowered by 3%, and the grade of Zn in the Zn-concentrate was raised by 3%, the internal financial rate of return would rise to about 8.7%.

(4) Conduct a survey and study on the construction of hydroelectric power stations.

## 2. FUTURE OUTLOOK

As a result of the preliminary study on the development of the Limpe deposits (in which reserves of copper, lead, and zinc were found through an intensive survey in drilling and tunneling, it was ascertained that the development would be feasible from the national economic point of view. On the other hand, it was also made clear that prerequisite conditions had not yet been met for the start of the development from the company's point of view.

However, the project is promising for future development and therefore deserves full consideration by the government, in terms of possible improvements in fiscal

and financial conditions and implementation of a final development feasibility survey including prospecting, in order that this project may pass smoothly into the development stage.

In addition to the Limpe deposits, Limpe south deposits and Chupa deposits which have been located in Iscaycruz area are expected to contribute to the development of the local area as well as the national economy.

# PHOTOGRAPH OF INVESTIGATION

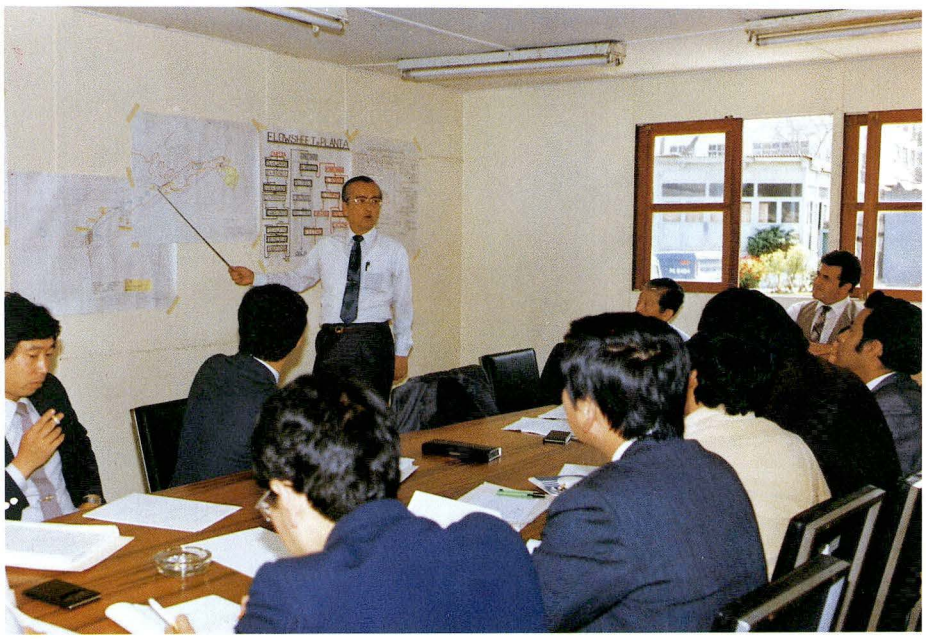
(1) Courtesy call to the Minister of Energy and Mines (in MEM).
From left
Front: Fure (MMAJ), Oki, the Minister Wilfred Huaita, Yamaguchi, Inoue, Kamiki (MMAJ)
Back: Saito, Tsurumi, Nakashima

(2) Courtesy call and consultation with Director General of Mines, Sr. Luis Sanchez.

(3) Meeting with Peruvian counterpart.
(Center: Ing. Balarezo, leader of Peruvian counterpart)

(4) Meeting with staffs of INGEMMET to consult the principal plan of the survey (Oct. 10, '85).
(Center: Manager of Geological Division, Ing. Flores)

(5) Study of concentrator plan (Ing. Figueroa (left) and Ing. Oki)



(6) Plenary meeting of MMAJ, INGEMMET and Survey Team (Nov. 7, '85)
(Right end: Executive Director of INGEMMET, Ing. Zegarra)

(7) Office for survey Team and Counterpart.

(8) Entrance of Sayan.


(9) Street of Churin.

(10) Collapsed point of National Road No. 16 (12 km from Sayan).

(11) Distant view of Oyon.

(12) Road to Iscaycruz from Mishuya.

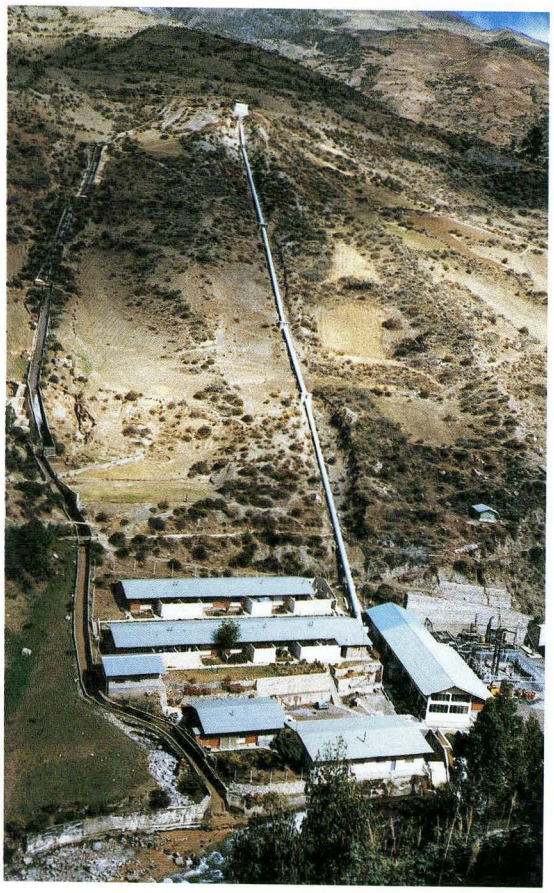
(13) Portal of N-adit (4,690 m above sea level).

(14) Portal of S-adit (4,570 m above sea level).

(15) The expected area for productive facilities.

(16) Road in the above area.

(17) The expected area for welfare facilities.



(18) Hydroelectric power station of Raura Mine.
(1,000 kW x 4)

# APPENDIX – 1

## Breakdowm of Capital Cost

## 1. MINING

($1,000)

| | Item | No. | Specification | Total | | | Year (-2) | | | Year (-1) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Total | $ | S/. | Total | $ | S/. | Total | $ | S/. |
| (1) | Equipment | | | | | | | | | | | |
| | Load & haul dump | 6 | 3.5 $yd^3$ class | 690 | 690 | - | 230 | 230 | - | 460 | 460 | - |
| | Mobile jumbo | 4 | 50 HP class, 2 booms | 380 | 380 | - | - | - | - | 380 | 380 | - |
| | Leg rock drill | 12 | 40 kg class | 24 | 24 | - | - | - | - | 24 | 24 | - |
| | Stoper | 6 | 40 kg class | 12 | 12 | - | - | - | - | 12 | 12 | - |
| | Compressor | 3 | 55 $m^3$/min. 265 kW class | 306 | 306 | - | - | - | - | 306 | 306 | - |
| | Main fan | 1 | 2,200 $m^3$/min. 75 kW class | 45 | 45 | - | - | - | - | 45 | 45 | - |
| | Local fan | 3 | 450 $m^3$/min. 11 kW class | 6 | 6 | - | 6 | 6 | - | - | - | - |
| | Trolley loco. | 2 | 8 t | 146 | 146 | - | - | - | - | 146 | 146 | - |
| | Gramby car | 15 | 5 t | 135 | - | 135 | - | - | - | 135 | - | 135 |
| | Pickup truck | 3 | 110 HP class | 57 | - | 57 | - | - | - | 57 | - | 57 |
| | Large type jeep | 3 | 110 HP class | 30 | 30 | - | 30 | 30 | - | - | - | - |
| | Bulldozer | 1 | 21 t class | 89 | 89 | - | 89 | 89 | - | - | - | - |
| | Dump truck | 1 | 15 t | 134 | - | 134 | - | - | - | 134 | - | 134 |
| | Hydraulic breaker | 1 | 1,200 kg class | 23 | 23 | - | - | - | - | 23 | 23 | - |
| | Shovel loader | 1 | 1.15 $m^3$ class | 54 | 54 | - | - | - | - | 54 | 54 | - |
| | Portable compressor | 1 | 21 $m^3$/min. 146 kW class | 37 | 37 | - | 37 | 37 | - | - | - | - |
| | Other fixture | 1 lot | | 108 | 92 | 16 | 19 | 19 | - | 89 | 73 | 16 |
| | Subtotal | | | 2,276 | 1,934 | 342 | 411 | 411 | - | 1,865 | 1,523 | 342 |
| | Ocean freight etc. | 1 lot | | 203 | 203 | | 43 | 43 | | 160 | 160 | |
| | Import expenses | " | | 957 | | 957 | 203 | | 203 | 754 | | 754 |
| | Equipment total | | | 3,436 | 2,137 | 1,299 | 657 | 454 | 203 | 2,779 | 1,683 | 1,096 |
| (2) | Underground Work | | | | | | | | | | | |
| | Tunnel (by loader) | 1 lot | 2,795 m, 2.6 x 2.5 m | 1,537 | - | 1,537 | 770 | - | 770 | 767 | - | 767 |
| | Tunnel (by loader) | " | 550 m, 3.0 x 3.0 m | 330 | - | 330 | 300 | - | 300 | 30 | - | 30 |
| | Tunnel (by LHD) | " | 755 m, 4.0 x 3.0 m | 529 | - | 529 | 350 | - | 350 | 179 | - | 179 |
| | Tunnel (by LHD) | " | 770 m | 385 | - | 385 | - | - | - | 385 | - | 385 |
| | Raise | " | 490 m, 1.8 x 1.5 m | 245 | - | 245 | 200 | - | 200 | 45 | - | 45 |
| | Raise (by Raise borer) | " | 440 m, 1.8 mφ | 242 | - | 242 | 220 | - | 220 | 22 | - | 22 |
| | Compressor ope. | " | | 439 | - | 439 | 220 | - | 220 | 219 | - | 219 |
| | LHD Operation | " | | 294 | - | 294 | 147 | - | 147 | 147 | - | 147 |
| | Supporting | " | | 296 | - | 296 | 148 | - | 148 | 148 | - | 148 |
| | Underground total | | | 4,297 | - | 4,297 | 2,355 | - | 2,355 | 1,942 | - | 1,942 |
| (3) | Others | | | | | | | | | | | |
| | 0m Level | 1 lot | Rail 2,500 m, Chute 4 | 291 | - | 291 | - | - | - | 291 | - | 291 |
| | Piping | " | Compressed air, water | 57 | - | 57 | - | - | - | 57 | - | 57 |
| | Installation | " | Compressor etc. | 27 | - | 27 | 27 | - | 27 | - | - | - |
| | Building | " | Office, Mess, Magazine etc. | 386 | - | 386 | 270 | - | 270 | 116 | - | 116 |
| | Transportation | " | | 46 | - | 46 | 23 | - | 23 | 23 | - | 23 |
| | Others total | | | 807 | - | 807 | 320 | - | 320 | 487 | - | 487 |
| | MINING TOTAL | | | 8,540 | 2,137 | 6,403 | 3,332 | 454 | 2,878 | 5,208 | 1,683 | 3,525 |

## 2. CONCENTRATOR

($1,000)

| | Item | No. | Specification | Total | | | Year (-2) | | | Year (-1) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Total | $ | S/. | Total | $ | S/. | Total | $ | S/. |
| (1) | Equipment | | | | | | | | | | | |
| | Apron feeder | 1 | 40" x 12' | 17 | - | 17 | - | - | - | 17 | - | 17 |
| | ST Crusher | 1 | 42" x 30" | 83 | 83 | - | - | - | - | 83 | 83 | - |
| | Vibrating screen | 1 | 6' x 14', double deck | 17 | - | 17 | - | - | - | 17 | - | 17 |
| | Cone crusher | 1 | 5½ Hydraulic | 178 | 178 | - | - | - | - | 178 | 178 | - |
| | Belt conveyor | 3 | 24" x 20 m, 15 m, 145 m | 106 | - | 106 | - | - | - | 106 | - | 106 |
| | Others | 1 lot | Weightometer etc. | 15 | 15 | - | - | - | - | 15 | 15 | - |

2. CONCENTRATOR (Cont'd)

($1,000)

| | Item | No. | Specification | Total | | | Year (-2) | | | Year (-1) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Total | $ | S/. | Total | $ | S/. | Total | $ | S/. |
| | Fine ore bin | 2 | Cap. 400 t, corrugate pipe | 34 | 34 | - | - | - | - | 34 | 34 | - |
| | Ball mill | 2 | 9' x 12' | 540 | 540 | - | - | - | - | 540 | 540 | - |
| | Classifier | 2 | 72"Φx 12', Spiral type | 153 | 153 | - | - | - | - | 153 | 153 | - |
| | Ball mill | 1 | 6' x 6' Regrinding | 113 | - | 113 | - | - | - | 113 | - | 113 |
| | Others | 1 lot | Belt feeder, cyclone etc. | 29 | 14 | 15 | - | - | - | 29 | 14 | 15 |
| | Conditioner | 3 | 5'Φx 5'(1), 4' x 4'(2) | 31 | 31 | - | - | - | - | 31 | 31 | - |
| | Flotation cell | 16 | 60 $ft^3$, Pb-roughing | 97 | - | 97 | - | - | - | 97 | - | 97 |
| | " | 10 | 21 $ft^3$, Pb-cleaning | 32 | - | 32 | - | - | - | 32 | - | 32 |
| | " | 36 | 60 $ft^3$, Zn-roughing | 220 | - | 220 | - | - | - | 220 | - | 220 |
| | " | 18 | 38 $ft^3$, Zn-cleaning | 79 | - | 79 | - | - | - | 79 | - | 79 |
| | Blower | 6 | 3 $m^3$/min. | 135 | 135 | - | - | - | - | 135 | 135 | - |
| | Sand pump | 10 | 3"-2" etc. | 16 | 16 | - | - | - | - | 16 | 16 | - |
| | Thickener | 1 | 20'Φx 10', Pb-concentrate | 25 | - | 25 | - | - | - | 25 | - | 25 |
| | " | 1 | 33'Φx 10', Zn- " | 33 | - | 33 | - | - | - | 33 | - | 33 |
| | Press filter | 1 | 17 $ft^2$ x 6 chambers, Pb-conc. | 228 | 228 | - | - | - | - | 228 | 228 | - |
| | Press filter | 1 | 17 $ft^2$ x 14 chambers, Zn-con. | 262 | 262 | - | - | - | - | 262 | 262 | - |
| | Others | 1 lot | Conveyor, weightometer etc. | 41 | 30 | 11 | - | - | - | 41 | 30 | 11 |
| | Thickener | 1 | 50'Φx 10', 18'Φ Callow cone | 88 | 5 | 83 | - | - | - | 88 | 5 | 83 |
| | Reagent equipment | 1 lot | Tank, pump etc. | 7 | 3 | 4 | - | - | - | 7 | 3 | 4 |
| | Mono-rail, etc. | " | 5 t, 3 t | 46 | 46 | - | - | - | - | 46 | 46 | - |
| | Assay apparatus | " | | 142 | 40 | 102 | - | - | - | 142 | 40 | 102 |
| | Electrical equipment | " | Switch board, Instrument | 277 | 277 | - | - | - | - | 277 | 277 | - |
| | Cable wire | " | | 90 | 90 | - | - | - | - | 90 | 90 | - |
| | Subtotal | | | 3,134 | 2,180 | 954 | - | - | - | 3,134 | 2,180 | 954 |
| | Ocean freight etc. | | | 229 | 229 | - | - | - | - | 229 | 229 | - |
| | Import expenses | | | 1,079 | - | 1,079 | - | - | - | 1,079 | - | 1,079 |
| | Equipment total | | | 4,442 | 2,409 | 2,033 | - | - | - | 4,442 | 2,409 | 2,033 |
| (2) | Construction Work | | | | | | | | | | | |
| | Civil work | 1 lot | Excavation, concrete work | 666 | - | 666 | 466 | - | 466 | 200 | - | 200 |
| | Building | " | Steel work, construction | 530 | - | 530 | 106 | - | 106 | 424 | - | 424 |
| | Installation | " | | 355 | - | 355 | - | - | - | 355 | - | 355 |
| | Const. work total | | | 1,551 | - | 1,551 | 572 | - | 572 | 979 | - | 979 |
| | CONCENTRATOR TOTAL | | | 5,993 | 2,409 | 3,584 | 572 | - | 572 | 5,421 | 2,409 | 3,012 |

3. TAILING DISPOSAL (TAILING POND)

($1,000)

| | Item | No. | Specification | Total | | | Year (-2) | | | Year (-1) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Total | $ | S/. | Total | $ | S/. | Total | $ | S/. |
| (1) | Preparation Work | | | | | | | | | | | |
| | Office, apparatus | 1 lot | | 23 | - | 23 | 23 | - | 23 | - | - | - |
| | Vehicles | " | | 25 | - | 25 | 25 | - | 25 | - | - | - |
| | Temporary road | " | 2,000 m | 54 | - | 54 | 54 | - | 54 | - | - | - |
| | Miscellaneous | " | | 22 | - | 22 | 22 | - | 22 | - | - | - |
| | Pre. work total | | | 124 | - | 124 | 124 | - | 124 | - | - | - |
| (2) | Civil work | | | | | | | | | | | |
| | Heel dam | 1 lot | Excavation 22,300 $m^3$, Banking 43,600 $m^3$ | 705 | - | 705 | - | - | - | 705 | - | 705 |
| | Cut-off | " | 18,000 $m^3$ | 47 | - | 47 | - | - | - | 47 | - | 47 |
| | Under curvert | " | 800 mmΦx 480 m, Decant Tower 22 | 212 | - | 212 | - | - | - | 212 | - | 212 |
| | Under drain | " | 220 m | 83 | - | 83 | - | - | - | 83 | - | 83 |
| | Civil work total | | | 1,047 | | 1,047 | | | | 1,047 | | 1,047 |
| (3) | Cyclone, pipe etc. | 1 lot | | 70 | - | 70 | - | - | - | 70 | - | 70 |
| | TAILING POND TOTAL | | | 1,241 | - | 1,241 | 124 | - | 124 | 1,117 | - | 1,117 |

## 4. POWER PLANT

($1,000)

| | Item | No. | Specification | Total | | | Year (-2) | | | Year (-1) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Total | $ | S/. | Total | $ | S/. | Total | $ | S/. |
| (1) | Equipment | | | | | | | | | | | |
| | Generator unit | 5 | 820 kW, 1,200 rpm, 2,200 V, 60 V | 1,970 | 1,970 | - | - | - | - | 1,970 | 1,970 | - |
| | Board, pannel | 1 lot | Direct current | 27 | 27 | - | - | - | - | 27 | 27 | - |
| | Overhead crane | " | | 27 | 27 | - | - | - | - | 27 | 27 | - |
| | Electrical equipment | " | Cable, wire etc. | 54 | 54 | - | - | - | - | 54 | 54 | - |
| | Mechanical equipment | " | Steel product; pipe etc. | 49 | 49 | - | - | - | - | 49 | 49 | - |
| | Subtotal | | | 2,100 | 2,100 | - | - | - | - | 2,100 | 2,100 | - |
| | Ocean freight etc. | 1 lot | | 221 | 221 | - | - | - | - | 221 | 221 | - |
| | Import expenses | " | | 1,040 | | 1,040 | - | - | - | 1,040 | | 1,040 |
| | Equipment total | | | 3,361 | 2,321 | 1,040 | - | - | - | 3,361 | 2,321 | 1,040 |
| (2) | Installation Work | | | | | | | | | | | |
| | Civil, building | 1 lot | | 203 | - | 203 | 121 | - | 121 | 82 | - | 82 |
| | Installation | " | Generator unit etc. | 134 | - | 134 | - | - | - | 134 | - | 134 |
| | Electrical work | " | | 59 | - | 59 | - | - | - | 59 | - | 59 |
| | S/V expenses | " | | 12 | - | 12 | - | - | - | 12 | - | 12 |
| | Inst. work total | | | 408 | - | 408 | 121 | - | 121 | 287 | - | 287 |
| | POWER PLANT TOTAL | | | 3,769 | 2,321 | 1,448 | 121 | - | 121 | 3,648 | 2,321 | 1,327 |

## 5. POWER DISTRIBUTION

($1,000)

| | Item | No. | Specification | Total | | | Year (-2) | | | Year (-1) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Total | $ | S/. | Total | $ | S/. | Total | $ | S/. |
| (1) | Equipment | | | | | | | | | | | |
| | *Main substation* | 1 lot | *Transformer, VCB etc.* | 116 | 116 | - | - | - | - | 116 | 116 | - |
| | Dist. facilities | " | Supporter etc. | 130 | 130 | - | - | - | - | 130 | 130 | - |
| | " | " | Cable, wire etc. (power) | 52 | 52 | - | - | - | - | 52 | 52 | - |
| | " | " | Wire (lighting) etc. | 22 | - | 22 | - | - | - | 22 | - | 22 |
| | Installation material | " | | 34 | - | 34 | - | - | - | 34 | - | 34 |
| | Subtotal | | | 354 | 298 | 56 | - | - | - | 354 | 298 | 56 |
| | Ocean freight etc. | 1 lot | | 31 | 31 | - | - | - | - | 31 | 31 | - |
| | Import expenses | " | | 148 | - | 148 | - | - | - | 148 | - | 148 |
| | Equipment total | | | 533 | 329 | 204 | - | - | - | 533 | 329 | 204 |
| (2) | Installation Work | | | | | | | | | | | |
| | Civil work | 1 lot | | 64 | - | 64 | - | - | - | 64 | - | 64 |
| | Distribution work | " | Main substation - substations | 23 | - | 23 | - | - | - | 23 | - | 23 |
| | " | " | Lighting | 23 | - | 23 | - | - | - | 23 | - | 23 |
| | Inst. work total | | | 110 | - | 110 | - | - | - | 110 | - | 110 |
| | POWER DISTRIBUTION TOTAL | | | 643 | 329 | 314 | - | - | - | 643 | 329 | 314 |

## 6. COMMUNICATION

($1,000)

| Item | No. | Specification | Total | | | Year (-2) | | | Year (-1) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total | $ | S/. | Total | $ | S/. | Total | $ | S/. |
| (1) Equipment | | | | | | | | | | | |
| Radio equipment | 1 lot | 150 - 400 MHz | 12 | - | 12 | 12 | - | 12 | - | - | - |
| Wire telephone | " | Switch board, telephone | 18 | 18 | - | - | - | - | 18 | 18 | - |
| Cable, wire etc. | " | | 52 | 52 | - | - | - | - | 52 | 52 | - |
| Subtotal | | | 82 | 70 | 12 | 12 | - | 12 | 70 | 70 | - |
| Ocean freight etc. | 1 lot | | 7 | 7 | - | - | - | - | 7 | 7 | - |
| Import expenses | " | | 35 | - | 35 | - | - | - | 35 | - | 35 |
| Equipment total | | | 124 | 77 | 47 | 12 | - | 12 | 112 | 77 | 35 |
| (2) Installation Work | | | | | | | | | | | |
| Radio | 1 lot | | 8 | - | 8 | 8 | - | 8 | - | - | - |
| Wire telephone | " | Wiring etc. | 51 | - | 51 | - | - | - | 51 | - | 51 |
| Inst. work total | | | 59 | - | 59 | 8 | - | 8 | 51 | - | 51 |
| COMMUNICATION TOTAL | | | 183 | 77 | 106 | 20 | - | 20 | 163 | 77 | 86 |

## 7. WATER SUPPLY

($1,000)

| Item | No. | Specification | Total | | | Year (-2) | | | Year (-1) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total | $ | S/. | Total | $ | S/. | Total | $ | S/. |
| (1) Equipment | | | | | | | | | | | |
| Turbine pump | 2 | 3 $m^3$/min | 28 | 28 | - | - | - | - | 28 | 28 | - |
| " | 2 | 2 $m^3$/min, Industrial water | 53 | 53 | - | - | - | - | 53 | 53 | - |
| Steel pipe | 1 lot | 6"ϕ x 3,360 m, " | 43 | 43 | - | - | - | - | 43 | 43 | - |
| Turbine pump | 2 | 0.5 $m^3$/min. Domestic water | 24 | 24 | - | - | - | - | 24 | 24 | - |
| Steel pipe | 1 lot | 3"ϕ x 990 m | 6 | 6 | - | - | - | - | 6 | 6 | - |
| Filtration tank | " | | 10 | - | 10 | - | - | - | 10 | - | 10 |
| Pontoon | 1 | | 6 | - | 6 | - | - | - | 6 | - | 6 |
| Electrical equip. | 1 lot | Cubicle type station etc. | 7 | 7 | - | - | - | - | 7 | 7 | - |
| Subtotal | | | 177 | 161 | 16 | - | - | - | 177 | 161 | 16 |
| Ocean freight etc. | 1 lot | | 17 | 17 | - | - | - | - | 17 | 17 | - |
| Import expenses | " | | 80 | - | 80 | - | - | - | 80 | - | 80 |
| Equipment total | | | 274 | 178 | 96 | - | - | - | 274 | 178 | 96 |
| (2) Installation Work | | | | | | | | | | | |
| Water tank | 2 | 170 $m^3$, 100 $m^3$ | 13 | - | 13 | - | - | - | 13 | - | 13 |
| Piping etc. | 1 lot | | 30 | - | 30 | - | - | - | 30 | - | 30 |
| Inst. work total | | | 43 | - | 43 | - | - | - | 43 | - | 43 |
| WATER SUPPLY TOTAL | | | 317 | 178 | 139 | - | - | - | 317 | 178 | 139 |

## 8. REPAIR SHOP

($1,000)

| Item | No. | Specification | Total | | | Year (-2) | | | Year (-1) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total | $ | S/. | Total | $ | S/. | Total | $ | S/. |
| (1) Equipment | | | | | | | | | | | |
| Normal lathe | 1 | 460 x 1,500 | 35 | 35 | - | 35 | 35 | - | - | - | - |
| Drilling machine | 1 | 50ϕ | 6 | 6 | - | 6 | 6 | - | - | - | - |
| Shaper | 1 | 500 x 600 | 18 | 18 | - | 18 | 18 | - | - | - | - |
| Grinder | 2 | | 6 | 6 | - | 6 | 6 | - | - | - | - |
| Welding machine | 3 | A/C | 5 | 5 | - | 5 | 5 | - | - | - | - |
| " | 1 | Engine type | 4 | 4 | - | 4 | 4 | - | - | - | - |
| Dryer | 1 | | 15 | 15 | - | 15 | 15 | - | - | - | - |
| Working table | 1 | | 11 | 11 | - | 11 | 11 | - | - | - | - |
| Tolls, etc. | 1 lot | | 20 | 20 | - | 20 | 20 | - | - | - | - |
| Subtotal | | | 120 | 120 | - | 120 | 120 | - | - | - | - |
| Ocean freight etc. | | | 13 | 13 | - | 13 | 13 | - | - | - | - |
| Import expenses | | | 59 | - | 59 | 59 | - | 59 | - | - | - |
| *Equipment total* | | | *192* | *133* | *59* | *192* | *133* | *59* | - | - | - |
| (2) Construction Work | | | | | | | | | | | |
| Civil & building | 1 lot | 250 $m^2$ | 50 | - | 50 | 50 | - | 50 | - | - | - |
| Installation | " | | 5 | - | 5 | 5 | - | 5 | - | - | - |
| Const. work total | | | 55 | - | 55 | 55 | - | 55 | - | - | - |
| REPAIR SHOP TOTAL | | | 247 | 133 | 114 | 247 | 133 | 114 | - | - | - |

## 9. AUXILIARY FACILITIES

($1,000)

| Item | No. | Specification | Total | | | Year (-2) | | | Year (-1) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total | $ | S/. | Total | $ | S/. | Total | $ | S/. |
| (1) Access Road | | | | | | | | | | | |
| Construction | 1 lot | 1.5 km, By-pass | *90* | - | *90* | *90* | - | *90* | - | - | - |
| Improvement | " | 7.0 km, Public road | 68 | - | 68 | 68 | - | 68 | - | - | - |
| Construction | " | 11.0 km | 441 | - | 441 | 441 | - | 441 | - | - | - |
| Road total | | | 599 | - | 599 | 599 | - | 599 | - | - | - |
| (2) In-mine Road | 1 lot | 8.0 km | 130 | - | 130 | 130 | - | 130 | - | - | - |
| (3) Building | | | | | | | | | | | |
| Central office | 1 | One-story, 150 $m^2$ | 30 | - | 30 | 30 | - | 30 | - | - | - |
| Central warehouse | 1 | " , 600 $m^2$ | 48 | - | 48 | 48 | - | 48 | - | - | - |
| Mess | 1 | " , 150 $m^2$ | 18 | - | 18 | - | - | - | 18 | - | 18 |
| *Others* | *1 lot* | *30 $m^2$, Guard house etc.* | *4* | - | *4* | *4* | - | *4* | - | - | - |
| Building total | | | 100 | | 100 | 82 | | 82 | 18 | | 18 |
| (4) Vehicles Purchase | | | | | | | | | | | |
| Pickup true | 3 | 110 HP class | 57 | - | 57 | 57 | - | 57 | - | - | - |
| Large type jeep | 2 | " | 20 | 20 | - | 20 | 20 | - | - | - | - |
| Bus | 1 | Cap. 45-person | 31 | 31 | - | - | - | - | 31 | 31 | - |
| Bulldozer | 1 | 14 t class | 67 | 67 | - | 67 | 67 | - | - | - | - |
| Shovel loader | 1 | 1.2 $m^3$ | 30 | 30 | - | - | - | - | 30 | 30 | - |

9. AUXILIARY FACILITIES (Cont'd)

($1,000)

| Item | No. | Specification | Total | | | Year (-2) | | | Year (-1) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total | $ | S/. | Total | $ | S/. | Total | $ | S/. |
| Forklift | 1 | 8 t | 10 | 10 | - | - | - | - | 10 | 10 | - |
| Truck | 1 | 1.5 t | 40 | - | 40 | 40 | - | 40 | - | - | - |
| Truck scale | 1 | 30 t | 60 | 60 | - | - | - | - | 60 | 60 | - |
| | | | 315 | 218 | 97 | 184 | 87 | 97 | 131 | 131 | - |
| Ocean freight etc. | | | 23 | 23 | - | 9 | 9 | - | 14 | 14 | - |
| Import expenses | | | 108 | - | 108 | 43 | - | 43 | 65 | - | 65 |
| Vehicles total | | | 446 | 241 | 205 | 236 | 96 | 140 | 210 | 145 | 65 |
| AUXILIARY FACILITIES TOTAL | | | 1,275 | 241 | 1,034 | 1,047 | 98 | 951 | 228 | 145 | 83 |

10. WELFARE FACILITIES

($1,000)

| Item | No. | Specification | Total | | | Year (-2) | | | Year (-1) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total | $ | S/. | Total | $ | S/. | Total | $ | S/. |
| (1) Civil Work | | | | | | | | | | | |
| Site preparation | 1 lot | 6 ha | 18 | - | 18 | 18 | - | 18 | - | - | - |
| Access road | " | 2.0 km | 90 | - | 90 | 27 | - | 27 | 63 | - | 63 |
| Civil work total | | | 108 | - | 108 | 45 | - | 45 | 63 | - | 63 |
| (2) Housing Work | | | | | | | | | | | |
| Family house | 1 lot | Staff, 10-house, one-story | 113 | - | 113 | 57 | - | 57 | 56 | - | 56 |
| Bachelor quarter | " | Staff, 22-room, one-story | 55 | - | 55 | 28 | - | 28 | 27 | - | 27 |
| Family house | " | Employee·Worker, 264-house | 1,901 | - | 1,901 | 432 | - | 432 | 1,469 | - | 1,469 |
| Bachelor quarter | " | Employee, 20-room, 20-bed | 30 | - | 30 | 30 | - | 30 | - | - | - |
| " | " | Worker, 32-room, 96-bed | 86 | - | 86 | 86 | - | 86 | - | - | - |
| Housing work total | | | 2,185 | - | 2,185 | 633 | - | 633 | 1,552 | - | 1,552 |
| (3) Social Facilities | | | | | | | | | | | |
| Elementary school | 1 lot | 1,200 $m^2$ | 96 | - | 96 | - | - | - | 96 | - | 96 |
| Kindergarten | " | 250 $m^2$ | 20 | - | 20 | - | - | - | 20 | - | 20 |
| Clinic | " | 720 $m^2$ | 144 | - | 144 | - | - | - | 144 | - | 144 |
| Canteen | " | 580 $m^2$ | 29 | - | 29 | - | - | - | 29 | - | 29 |
| Club house | " | 420 $m^2$, Staff | 38 | - | 38 | - | - | - | 38 | - | 38 |
| " | " | 200 $m^2$, Employee, worker | 25 | - | 25 | 25 | - | 25 | - | - | - |
| Social faci. total | | | 352 | - | 352 | 25 | - | 25 | 327 | - | 327 |
| (4) Others | | | | | | | | | | | |
| Water supply piping | 1 lot | 6"Φx 600 m, 4"Φx 4,000 m | 67 | - | 67 | 67 | - | 67 | - | - | - |
| Sewage piping | " | 16"Φx 300 m, 14"Φx 2,000 m | 133 | - | 133 | 133 | - | 133 | - | - | - |
| Others total | | | 200 | - | 200 | 200 | - | 200 | - | - | - |
| WELFARE FACILITIES TOTAL | | | 2,845 | - | 2,845 | 903 | - | 903 | 1,942 | - | 1,942 |

## 11. LIMA HEAD OFFICE

($1,000)

| | Item | No. | Specification | Total | | | Year (-2) | | | Year (-1) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Total | $ | S/. | Total | $ | S/. | Total | $ | S/. |
| (1) | Office Rental | 1 lot | 300 $m^2$ | 10 | - | 10 | 10 | - | 10 | - | - | - |
| (2) | Fixtures | 1 lot | | 30 | - | 30 | 30 | - | 30 | - | - | - |
| (3) | Vehicle | 1 | Pickup 110 HP class | 19 | - | 19 | 19 | - | 19 | - | - | - |
| | LIMA HEAD OFFICE TOTAL | | | 59 | - | 59 | 59 | - | 59 | - | - | - |

## 12. CONSTRUCTION FACILITIES

($1,000)

| | Item | No. | Specification | Total | | | Year (-2) | | | Year (-1) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Total | $ | S/. | Total | $ | S/. | Total | $ | S/. |
| (1) | Civil & Bldg. Work | | | | | | | | | | | |
| | Site preparation | 1 lot | | 12 | - | 12 | 12 | - | 12 | - | - | - |
| | Temporary bldg. | " | 250 $m^2$, Office, warehouse | 10 | - | 10 | 10 | - | 10 | - | - | - |
| | " | " | 300 $m^2$, Lodge, mess | 21 | - | 21 | 21 | - | 21 | - | - | - |
| | | | | 8 | - | 8 | 8 | - | 8 | - | - | - |
| | Work total | | | 51 | - | 51 | 51 | - | 51 | - | - | - |
| (2) | Fixtures | | | | | | | | | | | |
| | Power house | 1 | 75 kW Generator | 15 | - | 15 | 15 | - | 15 | - | - | - |
| | Office | 1 lot | | 10 | - | 10 | 10 | - | 10 | - | - | - |
| | Lodge, mess | " | | 23 | - | 23 | 23 | - | 23 | - | - | - |
| | Fixtures total | | | 48 | - | 48 | 48 | - | 48 | - | - | - |
| | CONSTRUCTION FACILITIES TOTAL | | | 99 | - | 99 | 99 | - | 99 | - | - | - |

## 13. CONSTRUCTION MANAGEMENT

($1,000)

| | Item | No. | Specification | Total | | | Year (-2) | | | Year (-1) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Total | $ | S/. | Total | $ | S/. | Total | $ | S/. |
| (1) | Labor Cost | | | | | | | | | | | |
| | Mine manager | 1 lot | 1 man, $2,000/month | 48 | - | 48 | 24 | - | 24 | 24 | - | 24 |
| | Asst. Mine manager | " | 1 " , $1,000 " | 12 | - | 12 | - | - | - | 12 | - | 12 |
| | Staff | " | 4 - 6 men, $500 " | 60 | - | 60 | 24 | - | 24 | 36 | - | 36 |
| | Employee | " | 5 - 12 men, $200 " | 41 | - | 41 | 12 | - | 12 | 29 | - | 29 |
| | Worker | " | 8 - 15 men, $150 " | 41 | - | 41 | 14 | - | 14 | 27 | - | 27 |
| | Expatriate | " | 3 - 4 men, $4,100 " | 345 | 345 | - | 148 | 148 | - | 197 | 197 | - |
| | Labor cost total | | | 547 | 345 | 202 | 222 | 148 | 74 | 325 | 197 | 128 |

13. CONSTRUCTION MANAGEMENT (Cont'd)

($1,000)

| Item | No. | Specification | Total | | | Year (-2) | | | Year (-1) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total | $ | S/. | Total | $ | S/. | Total | $ | S/. |
| (2) Material Cost | | | | | | | | | | | |
| Fuel | 1 lot | | 141 | - | 141 | 47 | - | 47 | 94 | - | 94 |
| Lubricants | " | | 14 | - | 14 | 5 | - | 5 | 9 | - | 9 |
| Gasoline | " | | 23 | - | 23 | 8 | - | 8 | 15 | - | 15 |
| Office supplies | " | | 21 | - | 21 | 9 | - | 9 | 12 | - | 12 |
| Others | " | | 20 | - | 20 | 7 | - | 7 | 13 | - | 13 |
| Material cost total | | | 219 | - | 219 | 76 | - | 76 | 143 | - | 143 |
| (3) Expenses | | | | | | | | | | | |
| Generator purchase | 2 | 175 kW | 64 | - | 64 | 64 | - | 64 | - | - | - |
| Travel expenses | 1 lot | | 48 | 12 | 36 | 21 | 9 | 12 | 27 | 3 | 24 |
| Miscellaneous | " | | 26 | - | 26 | 11 | - | 11 | 15 | - | 15 |
| Expenses total | | | 138 | 12 | 126 | 96 | 9 | 87 | 42 | 3 | 39 |
| CONSTRUCTION MANAGEMENT TOTAL | | | 904 | 357 | 547 | 394 | 157 | 237 | 510 | 200 | 310 |

14. LIMA HEAD OFFICE

($1,000)

| Item | No. | Specification | Total | | | Year (-2) | | | Year (-1) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total | $ | S/. | Total | $ | S/. | Total | $ | S/. |
| (1) Labor Cost | | | | | | | | | | | |
| General manager | 1 lot | 1 man, $2,000/month | 48 | - | 48 | 24 | - | 24 | 24 | - | 24 |
| Staff | " | 2 - 3 men, $500 " | 30 | - | 30 | 12 | - | 12 | 18 | - | 18 |
| Employee | " | 3 - 5 men, $200 " | 19 | - | 19 | 7 | - | 7 | 12 | - | 12 |
| Worker | " | 3 - 5 men, $150 " | 14 | - | 14 | 5 | - | 5 | 9 | - | 9 |
| Expatriate | " | 1 man, $4,100 " | 98 | 98 | - | 49 | 49 | - | 49 | 49 | - |
| Labor cost total | | | 209 | 98 | 111 | 97 | 49 | 48 | 112 | 49 | 63 |
| (2) Material Cost | | | | | | | | | | | |
| Office supplies | 1 lot | | 25 | - | 25 | 10 | - | 10 | 15 | - | 15 |
| Miscellaneous | " | | 15 | - | 15 | 6 | - | 6 | 9 | - | 9 |
| Material cost total | | | 40 | - | 40 | 16 | - | 16 | 24 | - | 24 |
| (3) Expenses | | | | | | | | | | | |
| Rental | 1 lot | 250 $m^2$ x $50/$m^2$ | 26 | - | 26 | 13 | - | 13 | 13 | - | 13 |
| Travel expenses | " | | 12 | 3 | 9 | 6 | 3 | 3 | 6 | - | 6 |
| Communication | " | Telephone, telex | 17 | - | 17 | 7 | - | 7 | 10 | - | 10 |
| Bank charges | " | | 15 | - | 15 | 7 | - | 7 | 8 | - | 8 |
| Remuneration | " | Lawyer, etc. $4,000 x 2 | 8 | - | 8 | 4 | - | 4 | 4 | - | 4 |
| Association | " | $2,000/yr. | 4 | - | 4 | 2 | - | 2 | 2 | - | 2 |
| Others | " | | 8 | - | 8 | 4 | - | 4 | 4 | - | 4 |
| Expenses total | | | 90 | 3 | 87 | 43 | 3 | 40 | 47 | - | 47 |
| LIMA HEAD OFFICE TOTAL | | | 339 | 101 | 238 | 156 | 52 | 104 | 183 | 49 | 134 |

## 15. OVERSEA'S COMMISSION

($1,000)

| | Item | No. | Specification | Total | | | Year (-2) | | | Year (-1) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Total | $ | S/. | Total | $ | S/. | Total | $ | S/. |
| (1) | Labor Cost | | | | | | | | | | | |
| | Salary A | 1 lot | 1 man, $3,500/month | 84 | 84 | - | 42 | 42 | - | 42 | 42 | - |
| | Salary B | " | 1 - 2 men, $3,000 " | 108 | 108 | - | 36 | 36 | - | 72 | 72 | - |
| | Salary C | " | 2 men, $2,500 " | 120 | 120 | - | 60 | 60 | - | 60 | 60 | - |
| | Labor cost total | | | 312 | 312 | - | 138 | 138 | - | 174 | 174 | - |
| (2) | Expenses | 1 lot | 15% | 47 | 47 | - | 21 | 21 | - | 26 | 26 | - |
| | OVERSEA'S COMMISSION TOTAL | | | 359 | 359 | - | 159 | 159 | - | 200 | 200 | - |

## 16. INVENTORY

($1,000)

| | Item | No. | Specification | Total | | | Year (-2) | | | Year (-1) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Total | $ | S/. | Total | $ | S/. | Total | $ | S/. |
| (1) | Mining | | | | | | | | | | | |
| | Explosives | 1 lot | 2.0-month (20.8 t) | 26 | - | 26 | - | - | - | 26 | - | 26 |
| | Cap, detonator etc. | " | " | 13 | - | 13 | - | - | - | 13 | - | 13 |
| | Rod | " | " (202 pcs) | 24 | - | 24 | - | - | - | 24 | - | 24 |
| | Fuel | " | " (96 kl) | 25 | - | 25 | - | - | - | 25 | - | 25 |
| | Mining total | | | 88 | - | 88 | - | - | - | 88 | - | 88 |
| (2) | Concentrator | | | | | | | | | | | |
| | Ball | 1 lot | 2.0-month (45.0 t) | 39 | - | 39 | - | - | - | 39 | - | 39 |
| | Liner | " | " | 14 | - | 14 | - | - | - | 14 | - | 14 |
| | Sodium cyanide | " | " (3.0 t) | 6 | 6 | - | - | - | - | 6 | 6 | - |
| | KAX | " | " (5.3 t) | 12 | - | 12 | - | - | - | 12 | - | 12 |
| | Copper sulphate | " | " (11.3 t) | 6 | - | 6 | - | - | - | 6 | - | 6 |
| | Slacked lime | " | " (150.0 t) | 20 | - | 20 | - | - | - | 20 | - | 20 |
| | Frother | " | " (5.5 t) | 15 | 15 | - | - | - | - | 15 | 15 | - |
| | Concentrator total | | | 112 | 21 | 91 | - | - | - | 112 | 21 | 91 |
| | INVENTORY TOTAL | | | 200 | 21 | 179 | - | - | - | 200 | 21 | 179 |

## 18. DETAILED SURVEY

($1,000)

| | Item | No. | Specification | Total | | | Year (-2) | | | Year (-1) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Total | $ | S/. | Total | $ | S/. | Total | $ | S/. |
| (1) | Tunnel prospecting | 1 lot | 1,763 m (1,233 + 530 m) | 2,099 | - | 2,099 | 1,468 | - | 1,468 | 631 | - | 631 |
| (2) | Additional boring | " | 4,365 m (2,005 + 2,360 m) | 623 | - | 623 | 286 | - | 286 | 337 | - | 337 |
| (3) | Incline shafts | " | Portal making | 48 | - | 48 | 48 | - | 48 | - | - | - |
| (4) | F/S | " | | 325 | 175 | 150 | 87 | 12 | 75 | 238 | 163 | 75 |
| | DETAILED SURVEY TOTAL | | | 3,095 | 175 | 2,920 | 1,889 | 12 | 1,877 | 1,206 | 163 | 1,043 |

## 19. DETAILED DESIGN ETC.

($1,000)

| | Item | No. | Specification | Total | | | Year (-2) | | | Year (-1) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Total | $ | S/. | Total | $ | S/. | Total | $ | S/. |
| (1) | Labor Cost | | | | | | | | | | | |
| | Manager | 1 lot | 1 man, $3,500/month | 42 | 42 | - | - | - | - | 42 | 42 | - |
| | Salary A | " | 2 men, $3,000 " | 72 | 72 | - | - | - | - | 72 | 72 | - |
| | Salary B | " | 3 men, $2,500 " | 90 | 90 | - | - | - | - | 90 | 90 | - |
| | Salary C | " | 2 men, $2,000 " | 48 | 48 | - | - | - | - | 48 | 48 | - |
| | Salary D | " | 2 men, $1,000 " | 24 | 24 | - | - | - | - | 24 | 24 | - |
| | Labor cost total | | | 276 | 276 | - | - | - | - | 276 | 276 | - |
| (2) | Material Cost | 1 lot | $200/man/month | 24 | 24 | - | - | - | - | 24 | 24 | - |
| (3) | Expenses | | | | | | | | | | | |
| | Field survey | 1 lot | | 48 | 48 | - | - | - | - | 48 | 48 | - |
| | Drawing | " | | 50 | 50 | - | - | - | - | 50 | 50 | - |
| | Communication etc. | " | | 12 | 12 | - | - | - | - | 12 | 12 | - |
| | Rental | " | 120 $m^2$, $19/$m^2$/month | 27 | 27 | - | - | - | - | 27 | 27 | - |
| | Miscellaneous | " | 10% | 14 | 14 | - | - | - | - | 14 | 14 | - |
| | Expenses total | | | 151 | 151 | - | - | - | - | 151 | 151 | - |
| | DETAILED DESIGN ETC. TOTAL | | | 451 | 451 | - | - | - | - | 451 | 451 | - |

20. INTEREST

($1,000)

| | | Total | Year (-5 ~ -3) | Year (-2) | Year (-1) | Remarks |
|---|---|---|---|---|---|---|
| (1) | Pre-development | | | | | |
| | Detailed survey | 3,095 | 3,095 | - | - | |
| | Detailed design | 451 | 451 | - | - | |
| | Total | 3,546 | 3,546 | - | - | Down by capital |
| (2) | Direct cost | 28,904 | - | 7,739 | 21,165 | Total (1 - 17) |
| (3) | Capital | 8,000 | 3,546 | 1,000 | 3,454 | |
| (4) | Loans | 24,450 | 0 | 6,739 | 17,711 | |
| (5) | Interest | - | - | 303 | 1,431 | 9% annum |
| | INTEREST TOTAL | 1,734 | 0 | 303 | 1,431 | |

# APPENDIX – 2

## Breakdown of Operation Cost

## 1. MINING

| | Item | Unit | Q'ty | Amount ($1,000) Total | $ | S/. | Remarks |
|---|---|---|---|---|---|---|---|
| (1) | Labor Cost | | | | | | |
| | Staff | man | 9 | 54.0 | - | 54.0 | $500/month |
| | Employee | " | 11 | 26.4 | - | 26.4 | 200 " |
| | Worker | " | 169 | 304.2 | - | 304.2 | 150 " |
| | Labor cost total | | 189 | 384.6 | - | 384.6 | |
| (2) | Material Cost | | | | | | |
| | Explosive | t | 125 | 155.1 | - | 155.1 | 556 g/t, AN-FO, Dinamite |
| | Fuse, detonator | lot | 1 | 76.9 | - | 76.9 | |
| | Rod | pc | 1,211 | 144.2 | - | 144.2 | 7/8" x 1.0 m, 1.6 m, 2.4 m |
| | Fuel | kℓ | 576 | 152.0 | - | 152.0 | 2.6 ℓ/t |
| | Lubricants | lot | 1 | 101.3 | - | 101.3 | |
| | *Equipment parts* | " | 1 | 217.3 | 173.8 | 43.5 | |
| | Tire, tube | " | 1 | 33.3 | 23.3 | 10.0 | |
| | Timber | " | 1 | 10.0 | - | 10.0 | |
| | Pipe, hose etc. | " | 1 | 20.0 | - | 20.0 | Poly.-pipe, rubber hose etc. |
| | Steel products | " | 1 | 30.0 | - | 30.0 | |
| | Steel pipe | " | 1 | 5.0 | - | 5.0 | |
| | Rail etc. | " | 1 | 10.0 | - | 10.0 | |
| | Safety fixtures | " | 1 | 50.0 | - | 50.0 | |
| | Miscellaneous | " | 1 | 50.0 | - | 50.0 | |
| | Material cost total | | | 1,055.1 | 197.1 | 858.0 | |
| (3) | *Expenses* | | | | | | |
| | Power cost | MWh | 2,981 | 298.1 | - | 298.1 | 13.2 kWh/t |
| | Maintenance cost | lot | 1 | 200.0 | - | 200.0 | |
| | Repair cost | " | 1 | 18.0 | - | 18.0 | Outside repair |
| | *Miscellaneous* | " | 1 | *50.0* | - | *50.0* | |
| | Expenses total | | | 566.1 | - | 566.1 | |
| | MINING TOTAL | | | 2,005.8 | 197.1 | 1,808.7 | $8.91/t ore |

## 2. GEOLOGY (Inc. Surveying, Diamond drilling)

| | Item | Unit | Q'ty | Amount ($1,000) Total | $ | S/. | Remarks |
|---|---|---|---|---|---|---|---|
| (1) | Labor Cost | | | | | | |
| | Staff | man | 3 | 18.0 | - | 18.0 | $500/month |
| | Employee | " | 4 | 9.6 | - | 9.6 | 200 " |
| | Worker | " | 20 | 36.0 | - | 36.0 | 150 " |
| | Labor cost total | | 27 | 63.6 | - | 63.6 | |
| (2) | *Material Cost* | | | | | | |
| | Equipment parts | lot | 1 | 20.0 | - | 20.0 | Bit, rod etc. |
| | Others | " | 1 | 15.0 | - | 15.0 | |
| | *Material cost total* | | | 35.0 | - | 35.0 | |
| (3) | Expenses | lot | 1 | 50.0 | - | 50.0 | |
| | GEOLOGY TOTAL | | | 148.6 | - | 148.6 | $0.66/t ore |

### 3. CONCENTRATOR (Inc. Tailing pond, Assay laboratory)

| | Item | Unit | Q'ty | Amount ($1,000) Total | $ | S/. | Remarks |
|---|---|---|---|---|---|---|---|
| (1) | Labor Cost | | | | | | |
| | Staff | man | 5 | 30.0 | - | 30.0 | $500/month |
| | Employee | " | 13 | 31.2 | - | 31.2 | 200 " |
| | Worker | " | 37 | 66.6 | - | 66.6 | 150 " |
| | Labor cost total | | 55 | 127.8 | - | 127.8 | |
| (2) | Material Cost | | | | | | |
| | Ball | t | 270 | 236.8 | - | 236.8 | 3½", 1,200 g/t |
| | Liner | lot | 1 | 65.2 | 45.0 | 20.2 | Rubber, metal liner |
| | Sodium cyanide | t | 18 | 36.0 | 36.0 | - | 80 g/t |
| | KAX | " | 32 | 77.0 | - | 77.0 | 140 " |
| | Copper sulphate | " | 68 | 35.9 | - | 35.9 | 300 " |
| | Slaked lime | " | 900 | 122.4 | - | 122.4 | 4,000 " |
| | Frother | " | 33 | 92.1 | 92.1 | - | 145 |
| | Frocculant | " | 1 | 9.4 | 9.4 | - | 5 " |
| | Lubricants | lot | 1 | 46.8 | - | 46.8 | |
| | Equipment parts | " | 1 | 180.6 | 126.4 | 54.2 | |
| | Others | " | 1 | 42.0 | 12.6 | 29.4 | |
| | Material cost total | | | 944.2 | 321.5 | 622.7 | |
| (3) | Expenses | | | | | | |
| | Power cost | MWh | 8,482 | 840.2 | - | 840.2 | 37.3 kWh/t |
| | Repair cost | lot | 1 | 24.0 | - | 24.0 | Outside repair |
| | Expenses total | | | 864.2 | - | 864.2 | |
| | CONCENTRATOR TOTAL | | | 1,936.2 | 321.5 | 1,614.7 | $8.61/t ore |

### 4. POWER PLANT

| | Item | Unit | Q'ty | Amount ($1,000) Total | $ | S/. | Remarks |
|---|---|---|---|---|---|---|---|
| (1) | Labor Cost | | | | | | |
| | Staff | man | 1 | 6.0 | - | 6.0 | $500/month |
| | Employee | " | 4 | 9.6 | - | 9.6 | 200 " |
| | Worker | " | 9 | 16.2 | - | 16.2 | 150 " |
| | Labor cost total | | 14 | 31.8 | - | 31.8 | |
| (2) | Material Cost | | | | | | |
| | Fuel | kℓ | 4,367 | 1,152.9 | - | 1,152.9 | 0.3 ¢/kWh |
| | Lubricants | lot | 1 | 115.0 | - | 115.0 | |
| | Equipment parts | " | 1 | 78.8 | 54.4 | 24.4 | |
| | Tools etc | " | 1 | 10.0 | - | 10.0 | |
| | Others | " | 1 | 15.0 | - | 15.0 | |
| | Material cost total | | | 1,371.7 | 54.4 | 1,317.3 | |
| (3) | Expenses | | | | | | |
| | Repair cost | lot | 1 | 36.0 | - | 36.0 | $3,000/month, Outside repair |
| | Others | " | 1 | 10.0 | - | 10.0 | |
| | Expenses total | | | 46.0 | - | 46.0 | |
| | POWER PLANT TOTAL | | | 1,449.5 | 54.4 | 1,395.1 | |

Note: 1) Unit power cost $1,449,500 ÷ 14,558 MWh = ¢10/kWh
2) Power plant cost allocated to each department

## 5. MAINTENANCE (Repair shop, Water supply, Power distribution)

| Item | Unit | Q'ty | Amount ($1,000) Total | $ | S/. | Remarks |
|---|---|---|---|---|---|---|
| (1) Labor Cost | | | | | | |
| Staff | man | 2 | 12.0 | - | 12.0 | $500/month |
| Employee | " | 5 | 12.0 | - | 12.0 | 200 " |
| Worker | " | 30 | 54.0 | - | 54.0 | 150 " |
| Labor cost total | | 37 | 66.0 | - | 66.0 | |
| (2) Material Cost | | | | | | |
| Tools | lot | 1 | 3.0 | - | 3.0 | |
| Supplies | " | 1 | 6.5 | - | 6.5 | |
| Lubricants | " | 1 | 9.5 | - | 9.5 | |
| Steel product | " | 1 | 4.0 | - | 4.0 | |
| Equipment parts | " | 1 | 8.0 | - | 8.0 | |
| Material cost total | | | 31.0 | - | 31.0 | |
| (3) Expenses | | | | | | |
| Power cost | MWh | 579 | 57.9 | - | 57.9 | 2.6 kWh/t |
| Repair cost | lot | 1 | 10.0 | - | 10.0 | Outside repair |
| Others | " | 1 | 7.0 | - | 7.0 | 10% |
| Expenses total | | | 74.9 | - | 74.9 | |
| MAINTENANCE TOTAL | | | 171.9 | - | 171.9 | $0.76/t ore |

## 6. CENTRAL OFFICE (Administration)

| Item | Unit | Q'ty | Amount ($1,000) Total | $ | S/. | Remarks |
|---|---|---|---|---|---|---|
| (1) Labor Cost | | | | | | |
| Mine manager | man | 1 | 24.0 | - | 24.0 | $2,000/month |
| Asst. Mine manager | " | 1 | 12.0 | - | 12.0 | 1,000 " |
| Staff | " | 2 | 12.0 | - | 12.0 | 500 " |
| Employee | " | 7 | 16.8 | - | 16.8 | 200 " |
| Worker | " | 12 | 21.6 | - | 21.6 | 150 " |
| Sub total | | 23 | 86.4 | - | 86.4 | |
| Expatriate | man | 3 | 147.6 | 147.6 | - | $4,100/month |
| Labor cost total | | 26 | 234.0 | 147.6 | 86.4 | |
| (2) Material Cost | | | | | | |
| Office supplies | lot | 1 | 5.2 | - | 5.2 | $200/man |
| Fuel, lubricants | " | 1 | 10.0 | - | 10.0 | |
| Others | " | 1 | 5.0 | - | 5.0 | |
| Material cost total | | | 20.2 | - | 20.2 | |
| (3) Expenses | | | | | | |
| Power cost | MWh | 69 | 6.9 | - | 6.9 | 0.3 kWh/t |
| Travel expenses | lot | 1 | 21.0 | 9.0 | 12.0 | Local, overseas |
| Communication | " | 1 | 12.0 | - | 12.0 | $1,000/month |
| Road expense | " | 1 | 40.0 | - | 40.0 | Sayan - Churin |
| Others | | | 16.0 | - | 16.0 | 20% |
| Expenses total | | | 95.9 | 9.0 | 86.9 | |
| CENTRAL OFFICE TOTAL | | | 350.1 | 156.6 | 193.5 | $1.56/t ore |

## 7. WELFARE FACILITIES

| | Item | Unit | Q'ty | Amount ($1,000) Total | $ | S/. | Remarks |
|---|---|---|---|---|---|---|---|
| (1) | Labor Cost | | | | | | |
| | Staff | man | 6 | 36.0 | - | 36.0 | $500/month |
| | Employee | " | 22 | 52.8 | - | 52.8 | 200 " |
| | Worker | " | 27 | 48.6 | - | 48.6 | 150 " |
| | Labor cost total | | 55 | 137.4 | - | 137.4 | |
| (2) | Material Cost | | | | | | |
| | Education mat. | lot | 1 | 11.0 | - | 11.0 | For elementary school |
| | Medicine | " | 1 | 15.0 | - | 15.0 | 1,500 men x $10 |
| | Mis. materials | " | 1 | 10.0 | - | 10.0 | For club, quarters |
| | Others | " | 1 | 7.0 | - | 7.0 | |
| | Material cost total | | | 43.0 | - | 43.0 | |
| (3) | Expenses | | | | | | |
| | Power cost | MWh | 2,102 | 210.2 | - | 210.2 | 9.3 kWh/t |
| | Repair cost | lot | 1 | 6.0 | - | 6.0 | 300 houses x $20 |
| | Expenses total | | | 216.2 | - | 216.2 | |
| | WELFARE FACILITIES TOTAL | | | 396.6 | - | 396.6 | $1.76/t ore |

## 8. LIMA HEAD OFFICE

| | Item | Unit | Q'ty | Amount ($1,000) Total | $ | S/. | Remarks |
|---|---|---|---|---|---|---|---|
| (1) | Labor Cost | | | | | | |
| | General manager | man | 1 | 24.0 | - | 24.0 | $2,000/month |
| | Staff | " | 2 | 12.0 | - | 12.0 | 500 " |
| | Employee | " | 4 | 9.6 | - | 9.6 | 200 " |
| | Worker | " | 4 | 7.2 | - | 7.2 | 150 " |
| | Sub total | " | 11 | 52.8 | - | 52.8 | |
| | Expatriate | man | 1 | 49.2 | 49.2 | - | $4,100/month |
| | Labor cost total | | | 102.0 | 49.2 | 52.8 | |
| (2) | Material Cost | | | | | | |
| | Office supplies | lot | 1 | 12.0 | - | 12.0 | $1,000/man |
| | Fuel etc. | " | 1 | 5.0 | - | 5.0 | |
| | Material cost total | | | 17.0 | - | 17.0 | |
| (3) | Expenses | | | | | | |
| | Office rental | lot | 1 | 15.0 | - | 15.0 | 300 $m^2$ x $50 |
| | Rental | " | 1 | 5.0 | - | 5.0 | Copy machine |
| | Travel expenses | " | 1 | 15.0 | 3.0 | 12.0 | Local, overseas |
| | Communication | " | 1 | 10.0 | - | 10.0 | Telephone, telex |
| | Bank charges | " | 1 | 10.0 | - | 10.0 | |
| | Remuneration | " | 1 | 6.0 | - | 6.0 | $3,000 x 2, Lawyer etc. |
| | Various charges | " | 1 | 12.0 | - | 12.0 | |
| | Miscellaneous | " | 1 | 4.0 | - | 4.0 | 5% |
| | Expenses total | | | 77.0 | 3.0 | 74.0 | |
| | LIMA HEAD OFFICE TOTAL | | | 196.0 | 52.2 | 143.8 | $0.87/t ore |

## 9. CONCENTRATE HAULING

| Item | Unit | Q'ty | Amount ($1,000) | | | Remarks |
|---|---|---|---|---|---|---|
| | | | Total | $ | S/. | |
| (1) Pb-Concentrate | wt | 4,794 | 86.3 | - | 86.3 | Mine - Callao, $18/wt |
| (2) Zn-Concentrate | " | 65,181 | 1,173.2 | - | 1,173.2 | " " |
| HAULING TOTAL | | | 1,259.5 | - | 1,259.5 | $5.60/t ore |

## 10. CONCENTRATE SHIP LOADING

| Item | Unit | Q'ty | Amount ($1,000) | | | Remarks |
|---|---|---|---|---|---|---|
| | | | Total | $ | S/. | |
| (1) Loading Expenses | wt | 69,275 | 464.1 | - | 464.1 | $6.7/wt, Port, Conveyor etc. |
| (2) Storage Expenses | " | 69,275 | 34.6 | - | 34.6 | $0.5/wt |
| SHIP LOADING TOTAL | | | 498.7 | - | 498.7 | $2.22/t ore |

## 11. TAX, COMMISSION

| Item | Unit | Q'ty | Amount ($1,000) | | | Remarks |
|---|---|---|---|---|---|---|
| | | | Total | $ | S/. | |
| (1) Tax | lot | 1 | 256.6 | - | 256.6 | FOB x 2% |
| (2) Commission | t | 64,100 | 96.2 | - | 96.2 | $1.5/t |
| TAX, COMMISSION TOTAL | | | 352.8 | - | 352.8 | $1.57/t ore |

# APPENDIX – 3

## Breakdown of Additional Investment and Replacement Cost

## 1. ADDITIONAL INVESTMENT

($1,000)

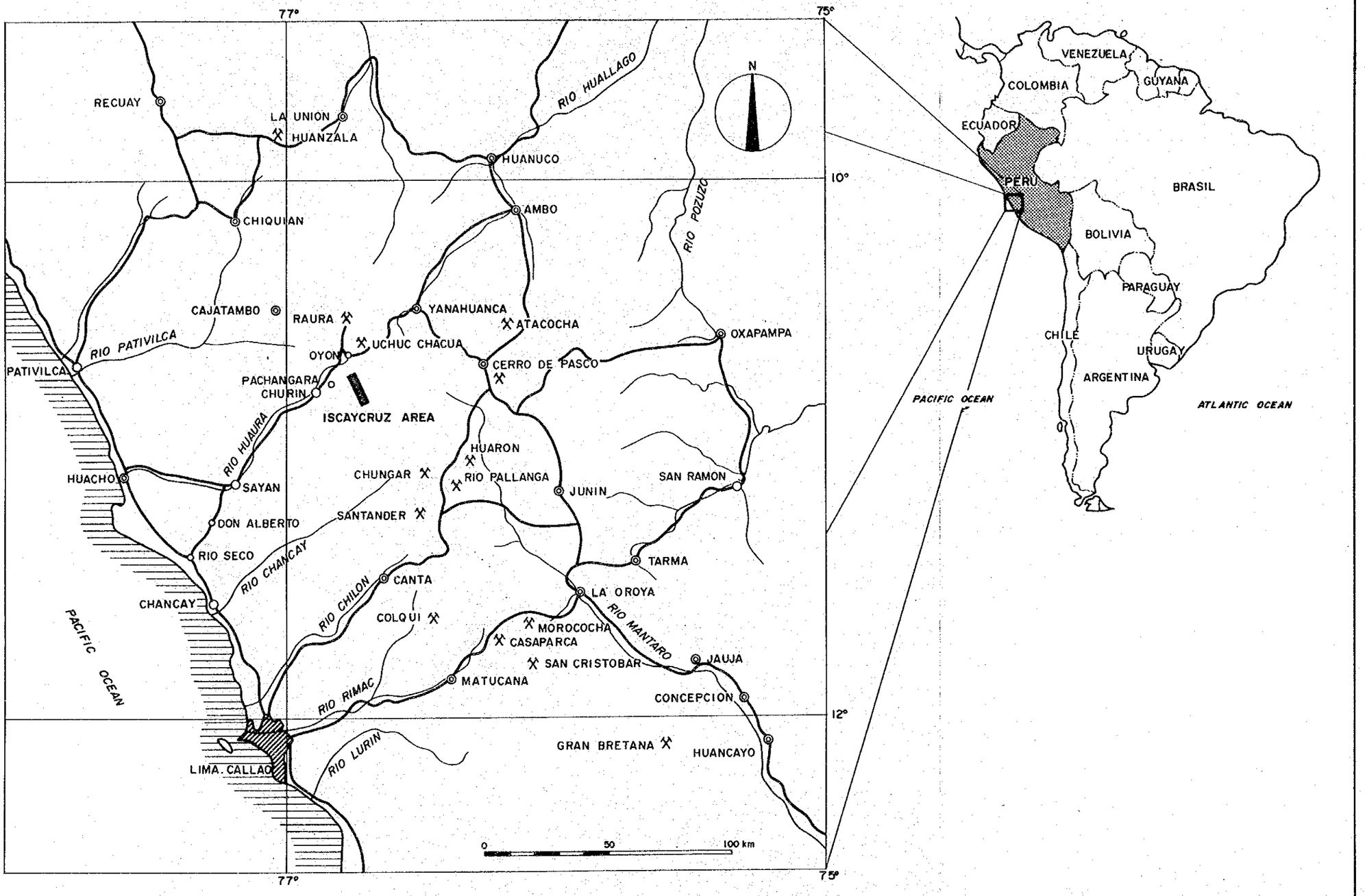
| Item | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Tailing pond: Civil work | – | – | – | 150 | 150 | 160 | – | – | 460 |
| Pump etc. | – | – | – | – | – | 15 | – | – | 15 |
| Total | – | – | – | 150 | 150 | 175 | – | – | 475 |

## 2. REPLACEMENT COST

($1,000)

| Item | | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. Mining Equipment | | | | | | | | | | |
| 3.5 $yd^3$ class LHD | 230 | – | – | – | (1) 230 | (1) 230 | (1) 230 | – | – | 690 |
| Mobile jumbo | 190 | – | – | – | – | (1) 190 | (1) 190 | – | – | 380 |
| Leg rock drill | 4 | – | – | – | – | (6) 24 | (6) 24 | – | – | 48 |
| Stoper | 4 | – | – | – | – | (3) 12 | (3) 12 | – | – | 24 |
| Local fan | 90 | – | – | – | (1) 90 | – | (1) 90 | – | – | 180 |
| Mine car (5t) | 9 | – | – | – | – | (5) 45 | (5) 45 | – | – | 90 |
| Pickup truck | 19 | – | – | (1) 19 | – | (1) 19 | – | (1) 19 | – | 57 |
| Jeep | 20 | (1) 20 | – | (1) 20 | – | (1) 20 | – | (1) 20 | – | 80 |
| Bulldozer (21t) | 178 | – | – | – | (1) 178 | – | – | – | – | 178 |
| Dump truck (15 t) | 134 | – | – | (1) 134 | – | – | – | – | – | 134 |
| Shovel loader | 108 | – | – | – | – | (1) 108 | – | – | – | 108 |
| Subtotal | | 20 | | 173 | 498 | 648 | 591 | 39 | – | 1,969 |
| 2. Common Vehicle | | | | | | | | | | |
| Pickup truck | 19 | – | 19 | – | (1) 19 | – | (1) 19 | – | – | 57 |
| Jeep | 20 | – | – | (1) 20 | – | (1) 20 | – | (1) 20 | – | 60 |
| Bus | 62 | – | – | – | (1) 62 | – | – | – | – | 62 |
| Bulldozer (14t) | 134 | – | – | – | (1) 134 | – | – | – | – | 134 |
| Shovel loader | 60 | – | – | – | – | (1) 60 | – | – | – | 60 |
| Forklift (1.5t) | 20 | – | – | – | – | (1) 20 | – | – | – | 20 |
| Truck (8t) | 40 | – | – | – | (1) 40 | – | – | – | – | 40 |
| Subtotal | | – | 19 | 20 | 255 | 100 | 19 | 20 | – | 433 |
| Total | | 20 | 19 | 193 | 753 | 748 | 610 | 59 | – | 2,402 |

# DRAWINGS




JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

ISCAYCRUZ PROJECT

INDEX MAP

DATE: FEBRUARY, 1986 SCALE:

DWG. NO. 001

Cumbre de Iscaycruz

Black Gossan

DDH-1 DDH-2

Lag. Mancacuta

Black Gossan

Suerococha Camp

Lag. Quellaycocha

Pb Zn Dissemination in Dolostone

Pb Zn Massive Pyrite

DDH-3

Adit-N

IC-1

DDH-4

IC-2

Cumbre de Limpe

DDH-5

IC-3

Cu Pb Zn Hematite Gossan

DDH-6

IC-4

IC-5

Cu Zn Massive Pyrite

Adit-S

Lags. Tinyag

IC-17

Cu Zn Skarn

DDH-7

IC-18

IC-19

Chupa Mine

Cumbre de Cunsha Punta

DDH-8

DDH-9

Pb-Zn Massive Py

DDH-10

LEGEND

- Talus
- Quaternary
- Jumasha Formation
- Pariatambo Formation
- Chulec Formation
- Pariahuanca Formation
- Ferrat Formation
- Carhuaz Formation
- Santa Formation
- Chimu Formation
- Oyan Formation
- Acidic intrusive
- Altered and mineralized zone
- Folding structure
- Fault
- Bedding plane

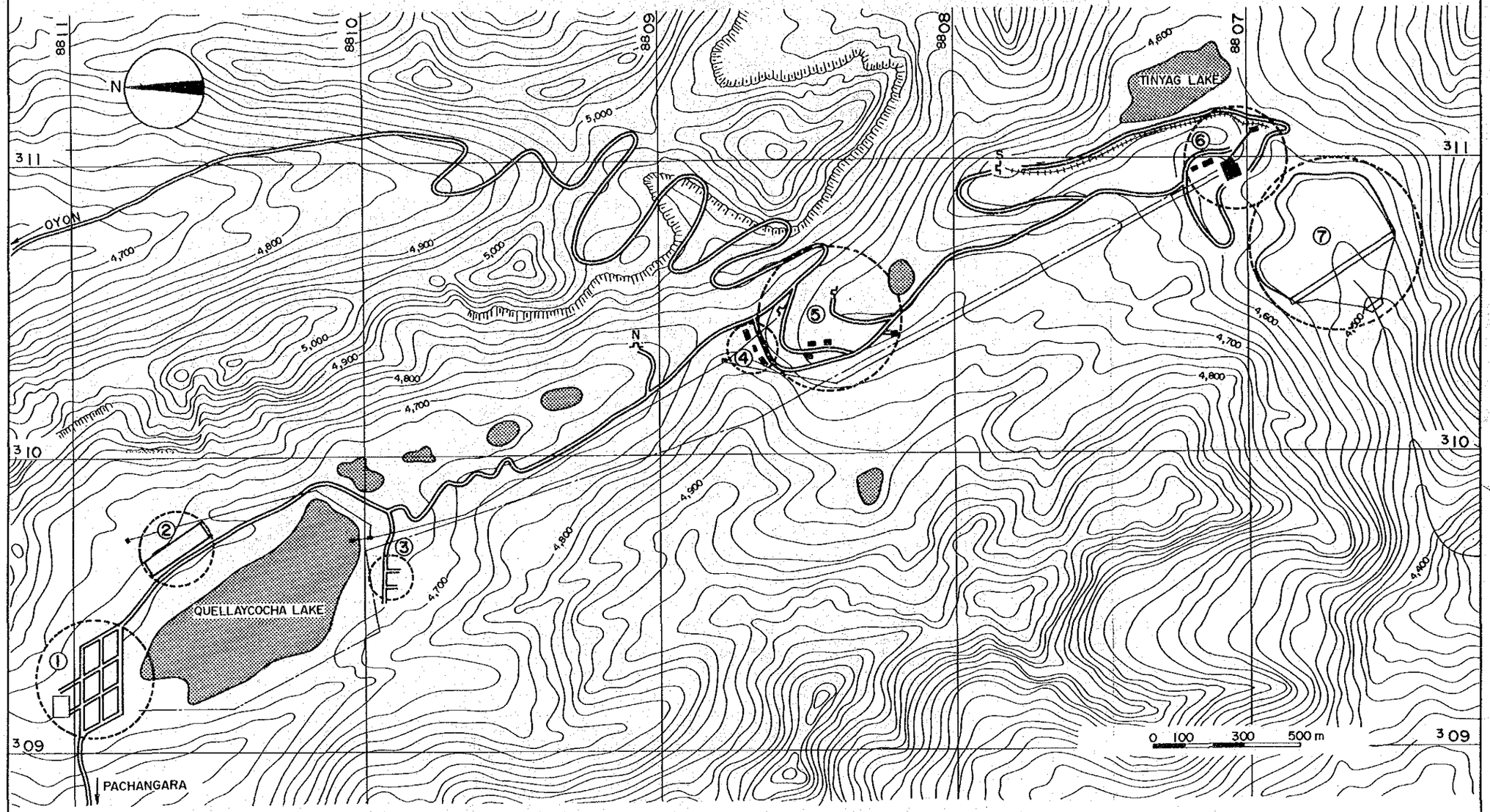
JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

ISCAYCRUZ PROJECT

GEOLOGICAL MAP OF THE ISCAYCRUZ AREA

DATE FEBRUARY 1986 SCALE

DWG. NO. 002




1 WORKER'S RESIDENTIAL AREA
FAMILY HOUSE , BACHELOR QUARTER, CLUB HOUSE , SOCCER COURT ETC.

2 SOCIAL SERVICE AREA
ELEMENTARY SCHOOL , KINDERGARTEN CANTEEN , CLINIC ECT.

3. STAFF'S RESIDENTIAL AREA
FAMILY HOUSE , BACHELOR QUARTER , CLUB HOUSE , TENNIS COURT ETC.

4. ADMINISTRATION AREA
CENTRAL OFFICE , CENTRAL WARENOUSE , MESS , TRUCK SCALE ETC.

5. MINING SECTION AREA
MINE OFFICE , REPAIR SHOP , POWDER MAGAGINE , COMPRESSOR ETC.

6. CONCENTRATOR AREA
CONCENTRATOR , POWER PLANT , MAIN REPAIR SHOP , ASSAY LABORATORY ETC.

7. TAILING POND

8. OTHERS

——— MAIN WATER SUPPLY PIPELINE

——·—— MAIN TRANSMISSION LINE

⊓ PORTAL

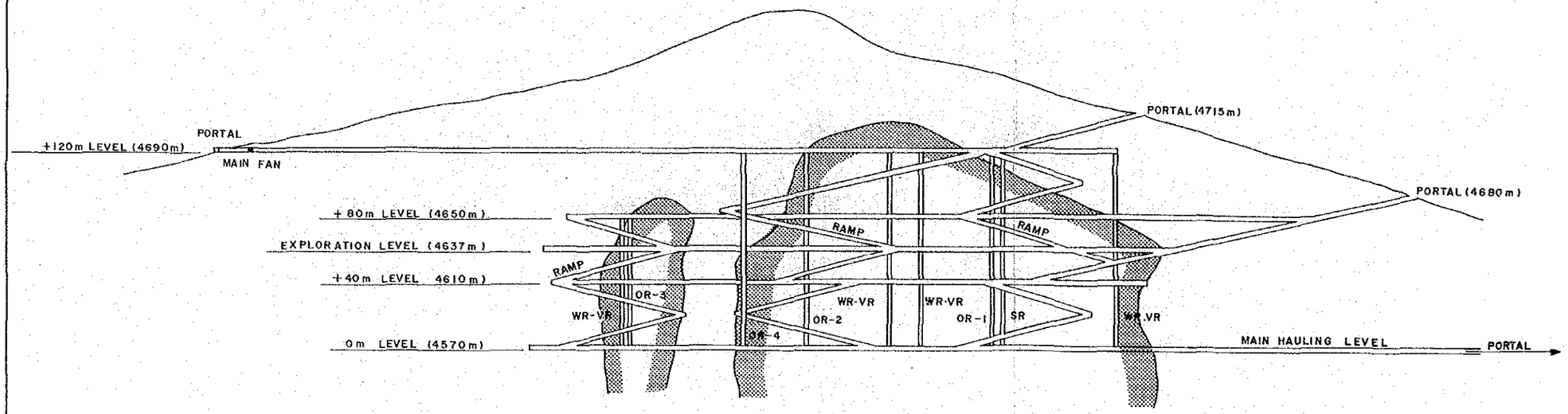
JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

ISCAYCRUZ PROJECT

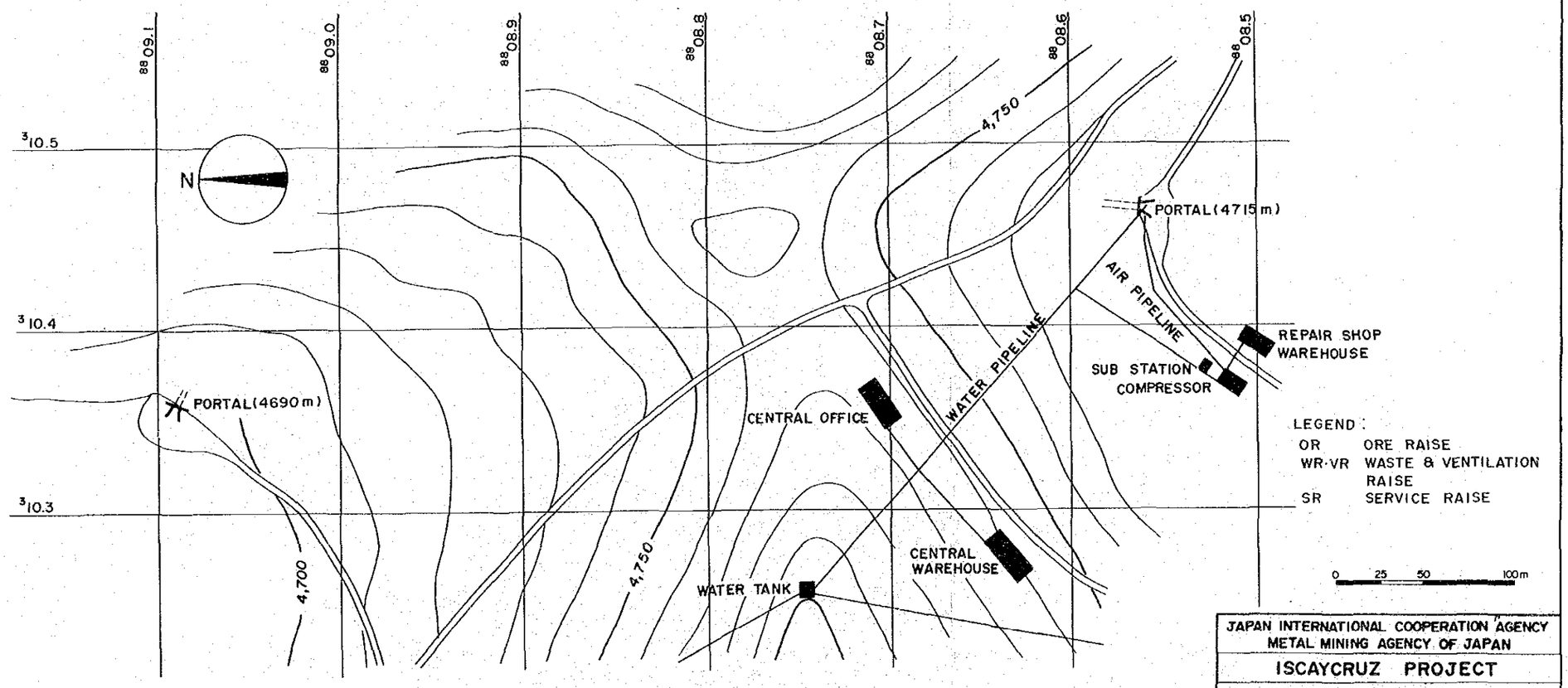
MINE SITE
GENERAL LAYOUT

DATE: FEBRUARY, 1986 SCALE:

DWG. NO.
003




SECTION




SURFACE

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

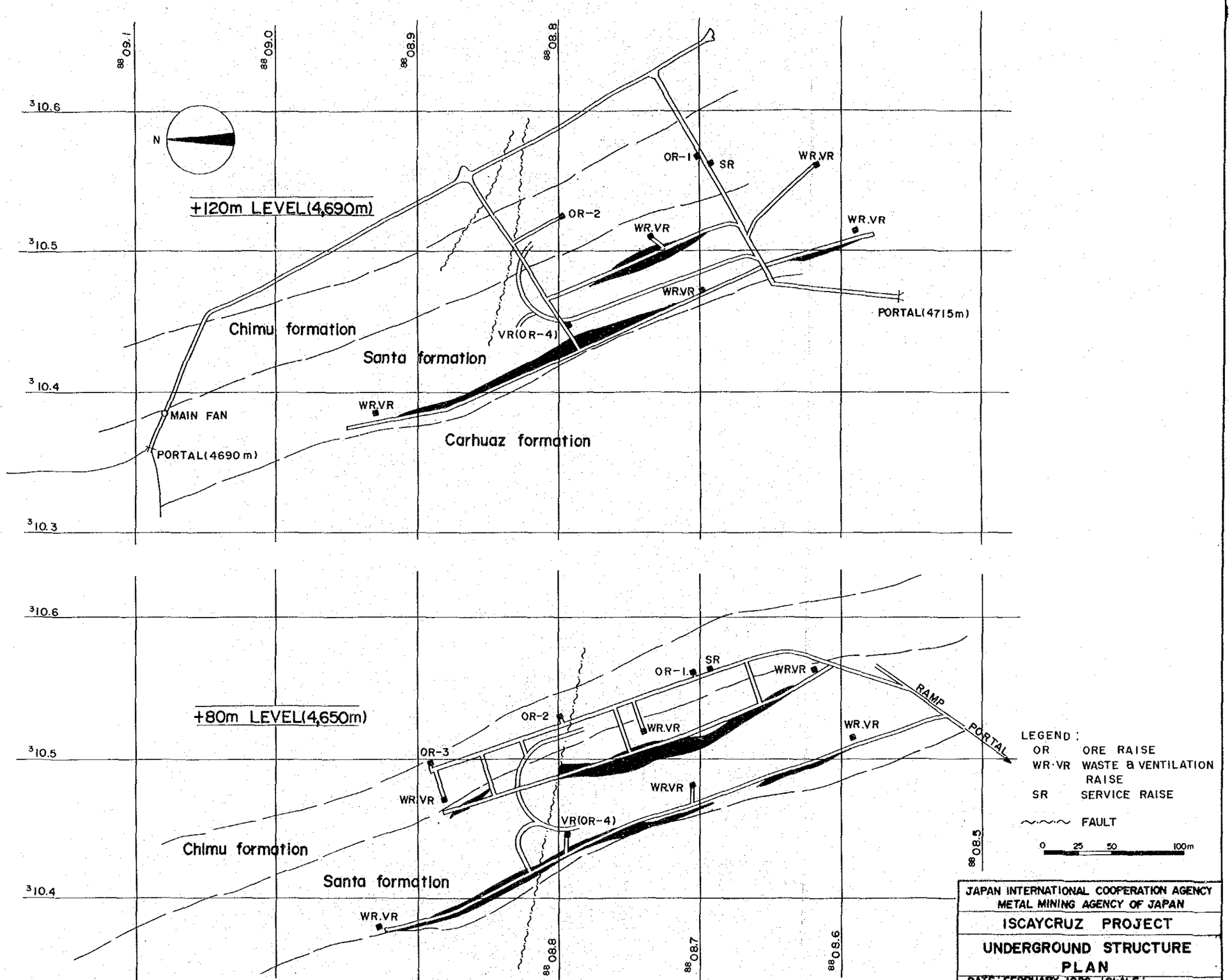
ISCAYCRUZ PROJECT

UNDERGROUND STRUCTURE SECTION & SURFACE

DATE : FEBRUARY, 1986 | SCALE :

DWG. NO.

004



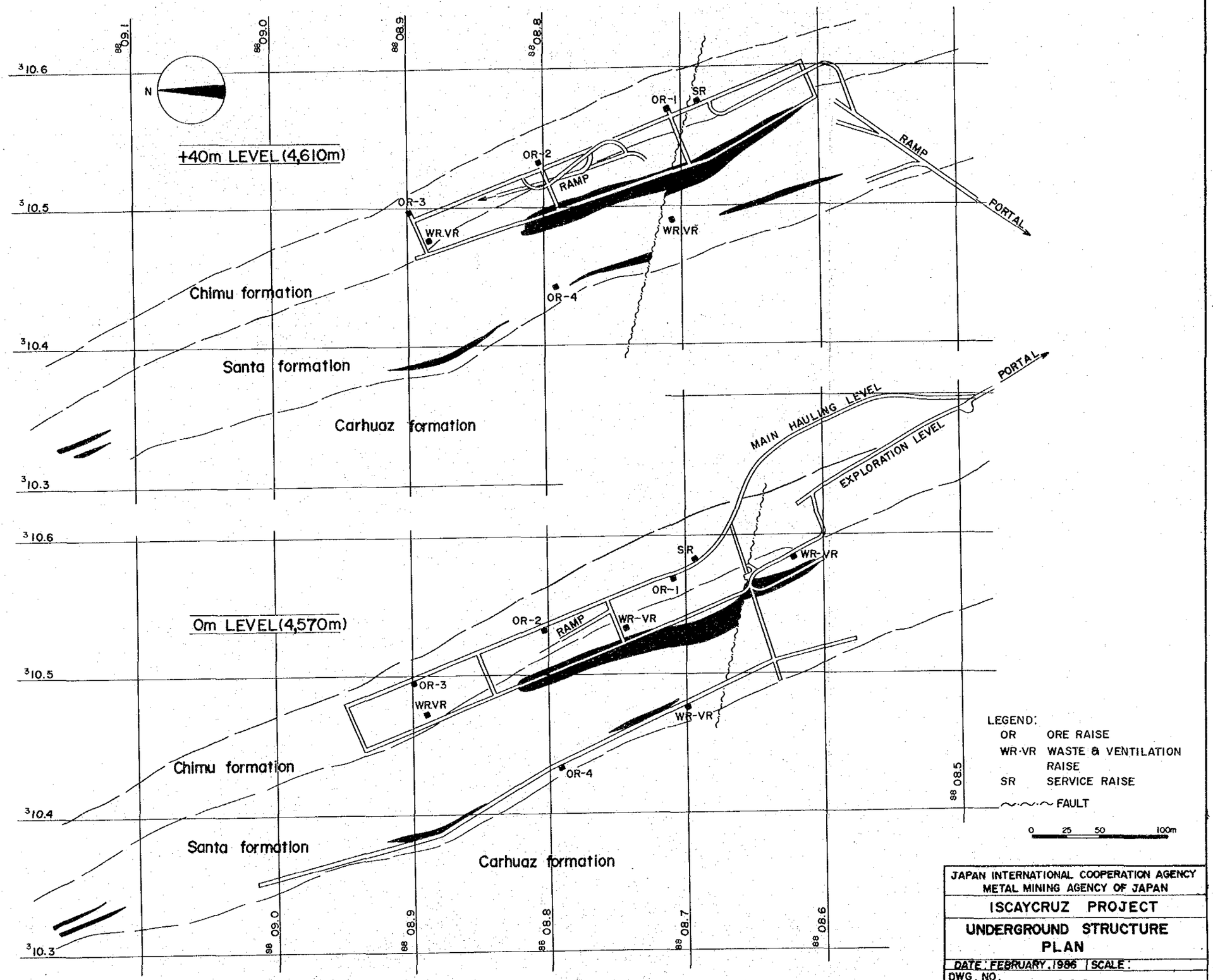

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

ISCAYCRUZ PROJECT

# UNDERGROUND STRUCTURE PLAN

DATE : FEBRUARY, 1986 | SCALE :

DWG. NO. 005



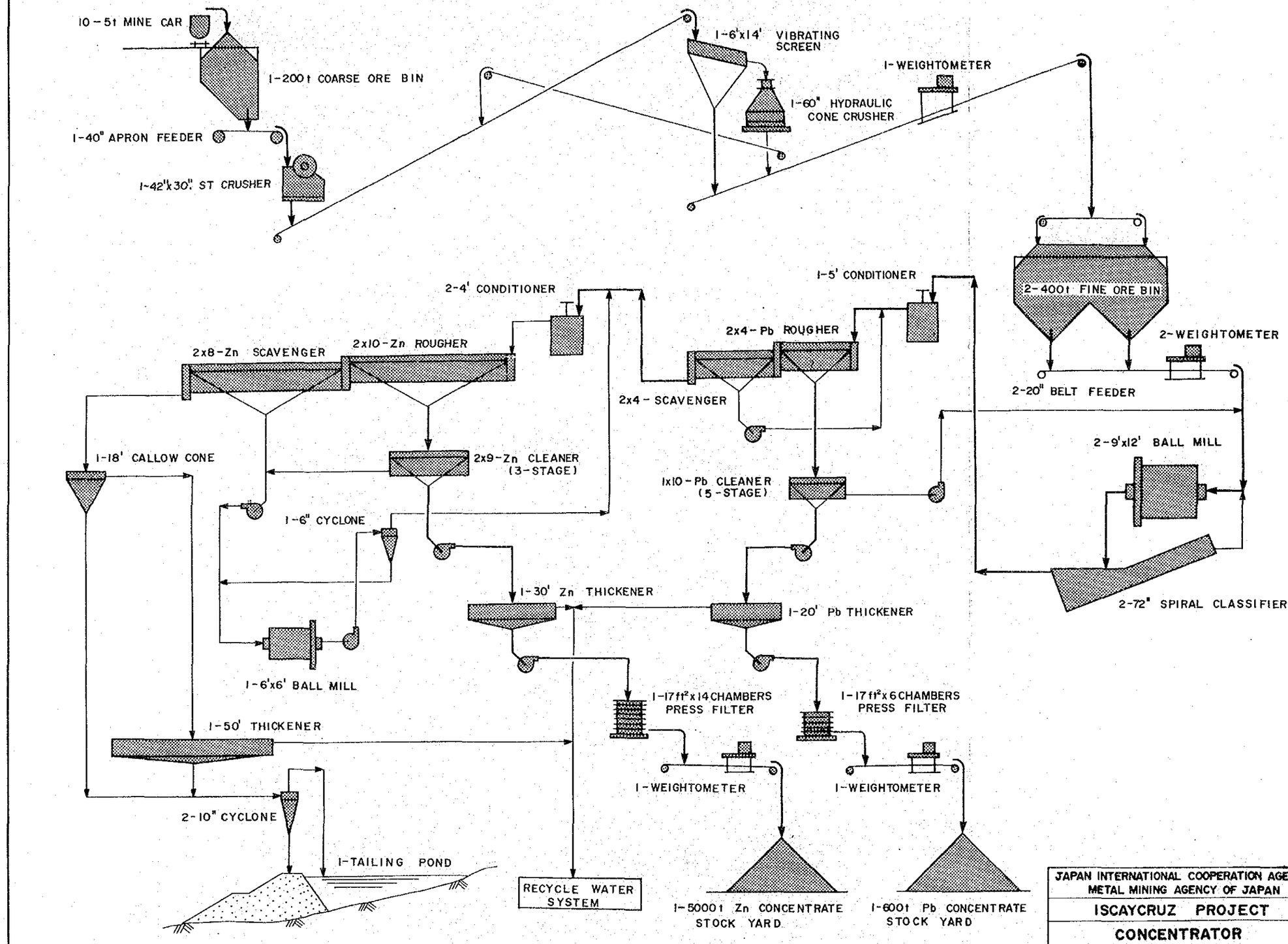

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

# ISCAYCRUZ PROJECT

## UNDERGROUND STRUCTURE PLAN

DATE: FEBRUARY, 1986 | SCALE:

DWG. NO. 006



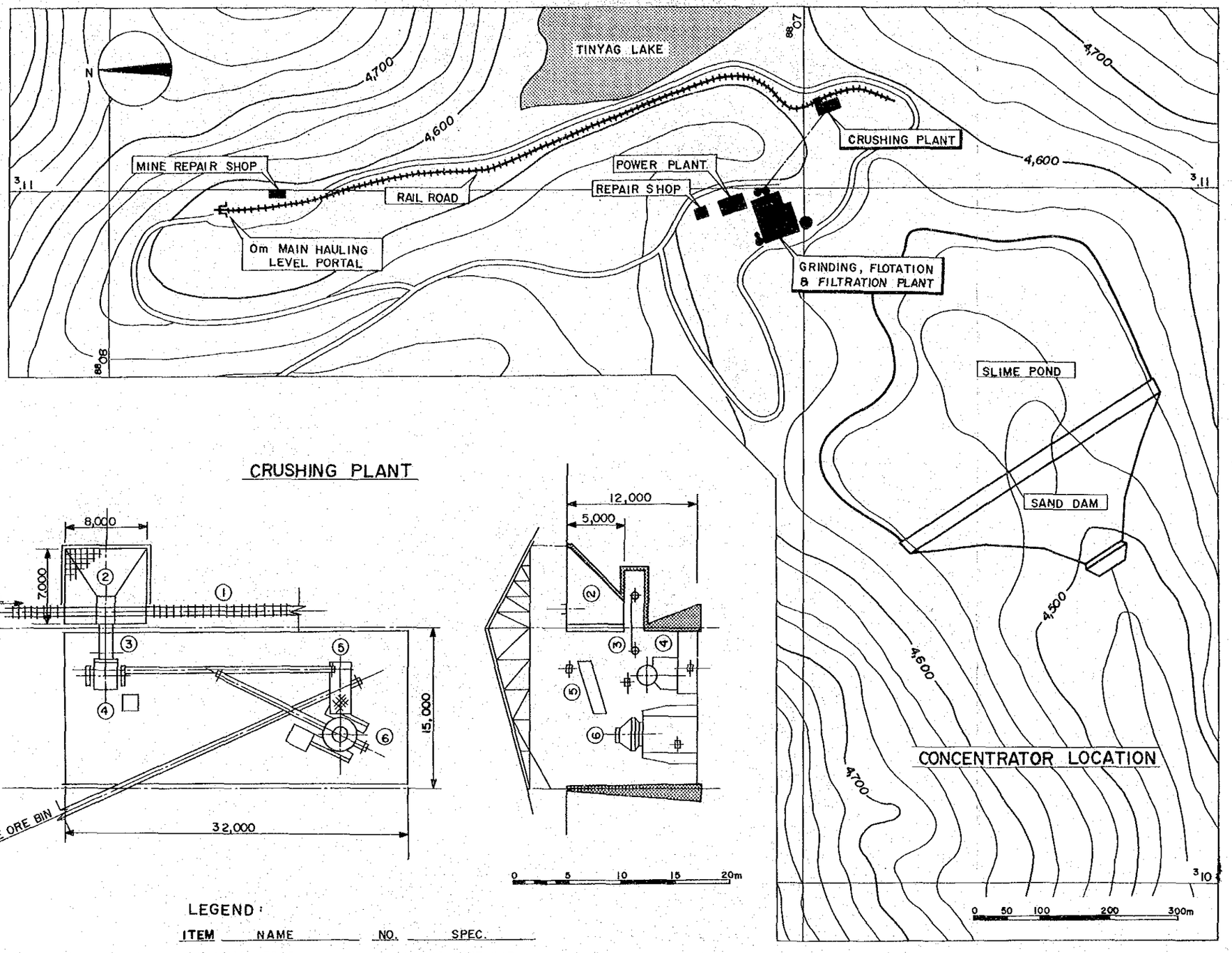

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

ISCAYCRUZ PROJECT

# CONCENTRATOR BASIC FLOW DIAGRAM

DATE: FEBRUARY, 1986 | SCALE:

DWG. NO. 007




## CRUSHING PLANT







LEGEND :

| ITEM | NAME | NO. | SPEC. |
|---|---|---|---|
| 1 | RAIL ROAD | 1 | FOR MINE CAR |
| 2 | COARSE ORE BIN | 1 | Cap. 200t |
| 3 | APRON FEEDER | 1 | 40"x 5m |
| 4 | ST CRUSHER | 1 | 42"x 30" |
| 5 | VIBRATING SCREEN | 1 | 6'x 14' |
| 6 | CONE CRUSHER | 1 | 5'ϕ, HYDRAULIC |

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

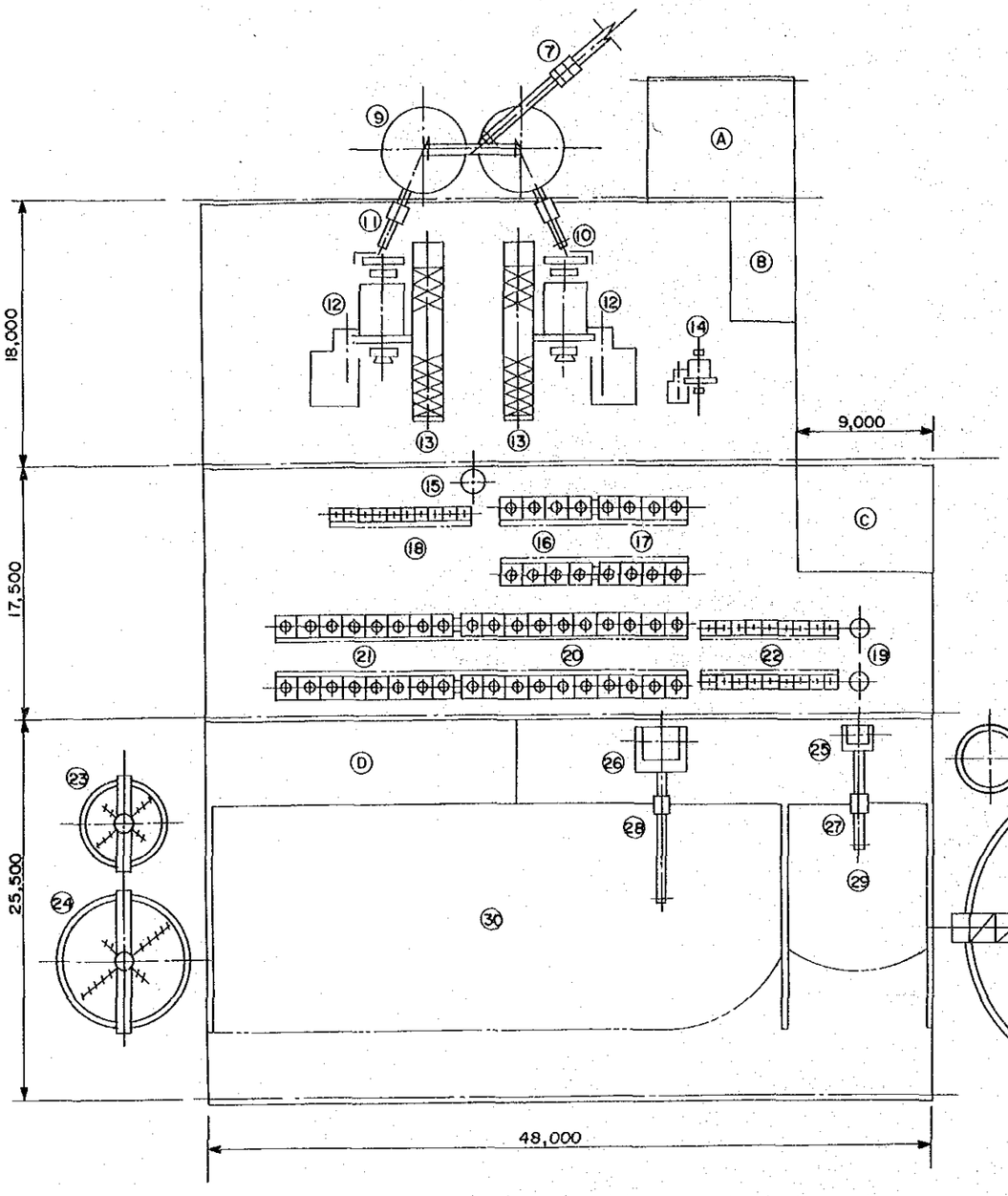
ISCAYCRUZ PROJECT

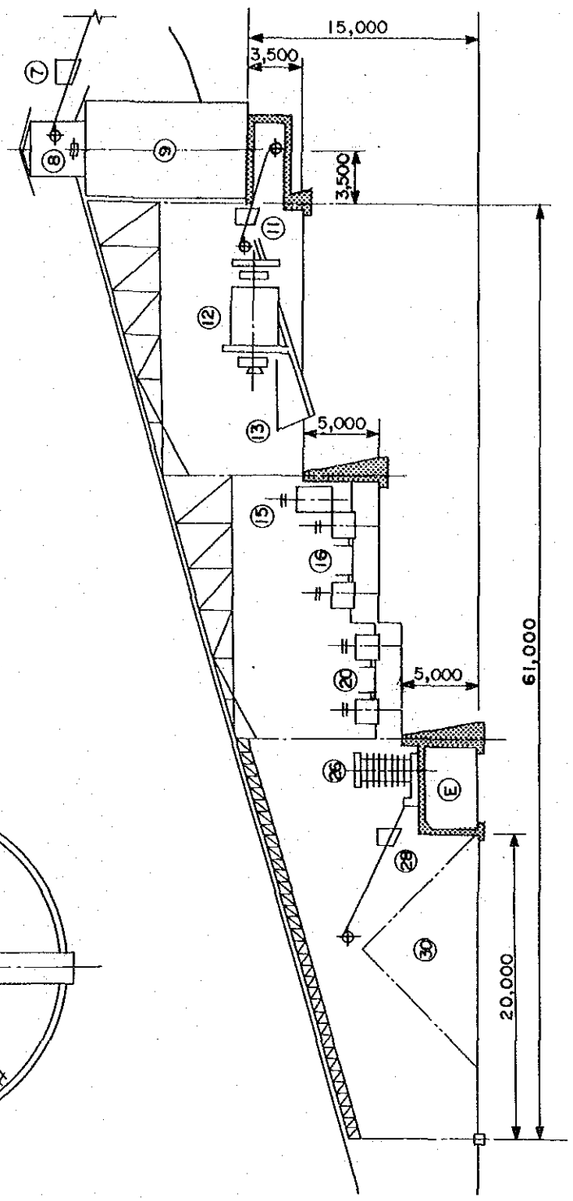
CONCENTRATER LOCATION & CRUSHING PLANT

DATE : FEBRUARY, 1986 | SCALE :

DWG. NO.

008




| ITEM | NAME | NO. | SPEC. |
|---|---|---|---|
| 7 | WEIGHTOMETER | 1 | Cap. 150 t/h |
| 8 | SHUTTLE CONVEYOR | 1 | 24"x 6 m |
| 9 | FINE ORE BIN | 2 | 400 t/each |
| 10 | BELT FEEDER | 2 | 20"x 8 m |
| 11 | WEIGHTOMETER | 2 | Cap. 40 t/h |
| 12 | BALL MILL | 2 | 9' x 12' |
| 13 | SPIRAL CLASSIFIER | 2 | 72" ø |
| 14 | REGRINDING MILL | 1 | 6' x 6' |
| 15 | Pb CONDITIONER | 1 | 5' x 5' |
| 16 | Pb ROUGHER | 4x2 | 60 ft³/cell |
| 17 | Pb SCAVENGER | 4x2 | 60 ft³/cell |

| ITEM | NAME | NO. | SPEC. |
|---|---|---|---|
| 18 | Pb CLEANER | 10 | 21 ft³/cell. |
| 19 | Zn CONDITIONER | 2 | 4' x 4' |
| 20 | Zn ROUGHER | 2 x10 | 60 ft³/cell |
| 21 | Zn SCAVENGER | 2 x 8 | 60 ft³/cell |
| 22 | Zn CLEANER | 2 x 9 | 38 ft³/cell |
| 23 | Pb THICKENER | 1 | 20' ø |
| 24 | Zn THICKENER | 1 | 30' ø |
| 25 | Pb PRESS FILTER | 1 | 17 ft² x 6 ch. |
| 26 | Zn PRESS FILTER | 1 | 17 ft² x 14 ch. |
| 27 | Pb WEIGHTOMETER | 1 | Cap. 2 t/h |
| 28 | Zn WEIGHTOMETER | 1 | Cap. 20 t/h |

| ITEM | NAME | NO. | SPEC. |
|---|---|---|---|
| 29 | Pb STOCK YARD | 1 | Cap 600 t |
| 30 | Zn STOCK YARD | 1 | Cap 5,000 t |
| 31 | CALLOW CONE | 1 | 18 ø |
| 32 | TAILING THICKENER | 1 | 50' ø |
| A | REAGENT ROOM | 1 | |
| B | ELEC. SUB STATION | 1 | |
| C | OFFICE | 1 | |
| D | MAIN STORE HOUSE | 1 | |
| E | PUMP ROOM | 1 | |

0 5 10 15 20m

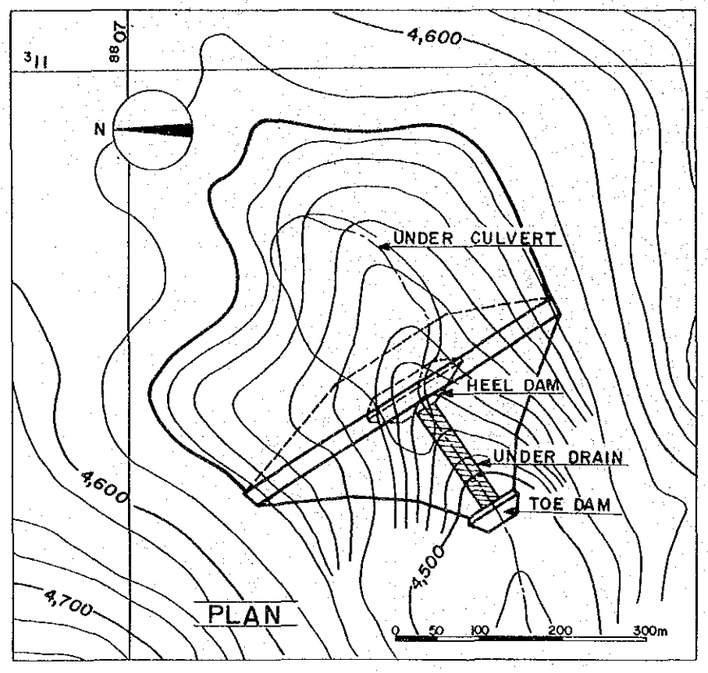
JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

ISCAYCRUZ PROJECT

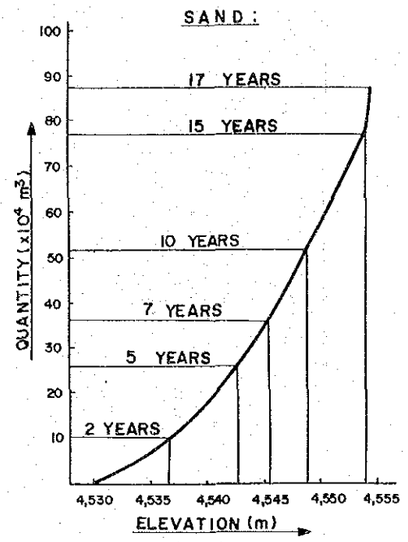
# CONCENTRATOR PLAN & SECTION

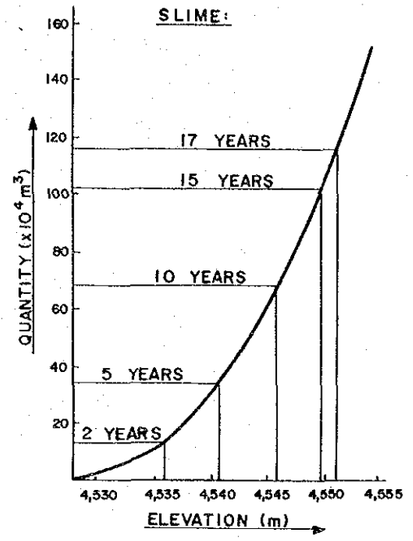
DATE: FEBRUARY, 1986 | SCALE:

DWG. NO. 009

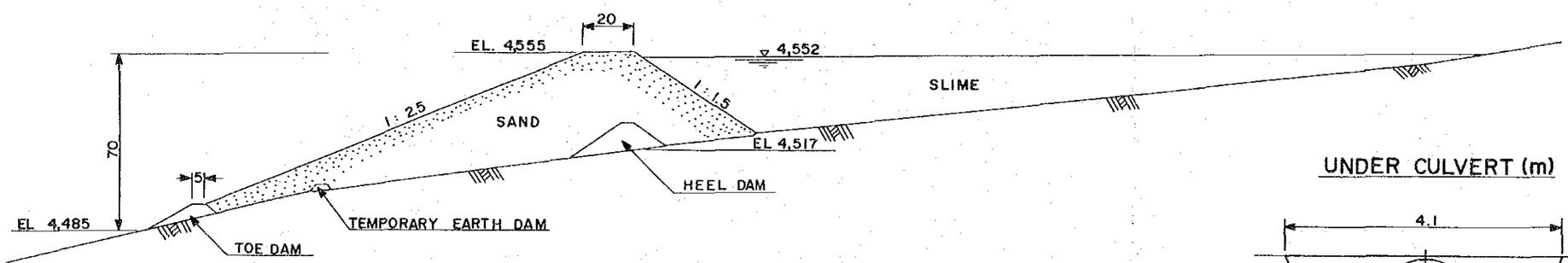



## STAGE-MASS CURVE

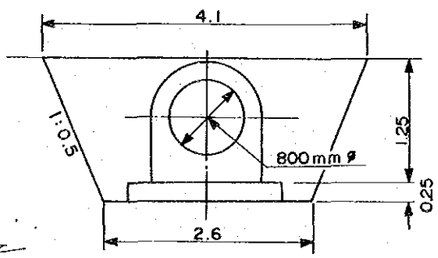


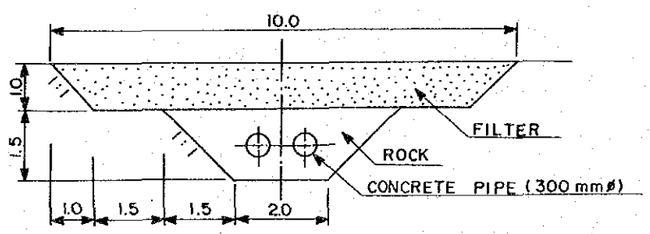

## LONGITUDINAL SECTION (m)



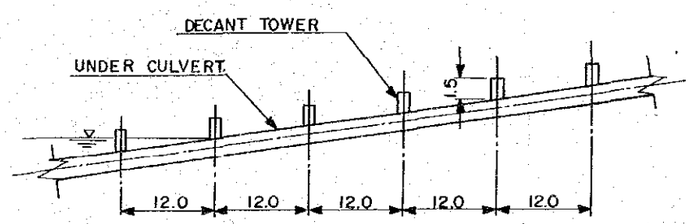

## UNDER CULVERT (m)




## UNDER DRAIN (m)




## DECANT TOWER (m)




JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

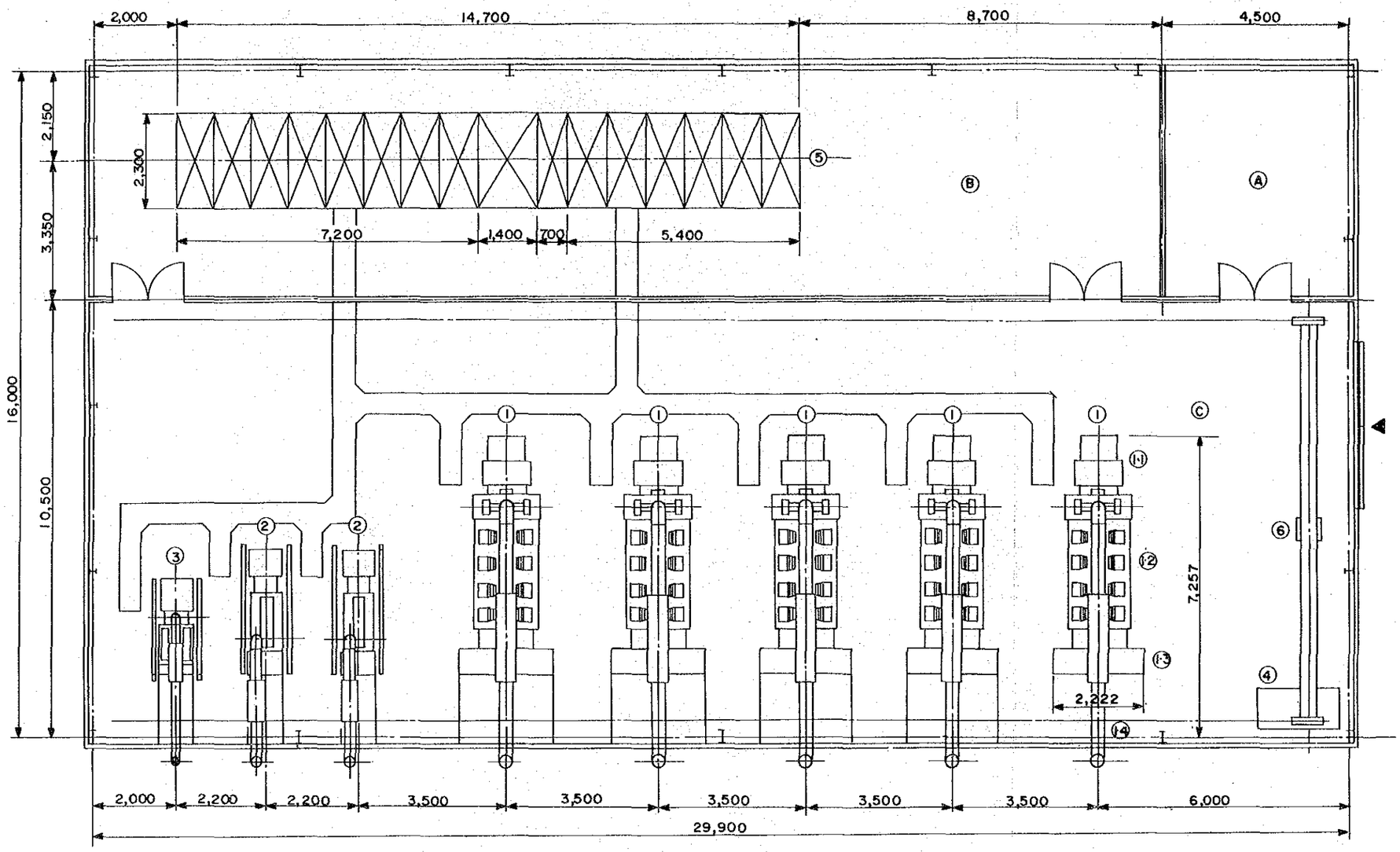
ISCAYCRUZ PROJECT

TAILING POND

DATE: FEBRUARY, 1986 | SCALE:

DWG. NO.

010




LEGEND :

| | | | |
|---|---|---|---|
| 1 | 820KW DIESEL GENERATOR UNIT | 5 | HIGH VORTAGE SWITCHGEARS & CONTROL PANELS |
| 1·1 | GENERATOR | 6 | OVERHEAD CRANE |
| 1·2 | DIESEL ENGINE | | |
| 1·3 | RADIATOR | | |
| 1·4 | EXHAUST DUCT | A | STOCK ROOM |
| 2 | 175 KW DIESEL GENERATOR UNIT. | B | CONTROL ROOM |
| 3 | 75KW DIESEL GENERATOR UNIT. | C | MAINTENANCE SPACE |
| 4 | FUEL OIL TANK | | |

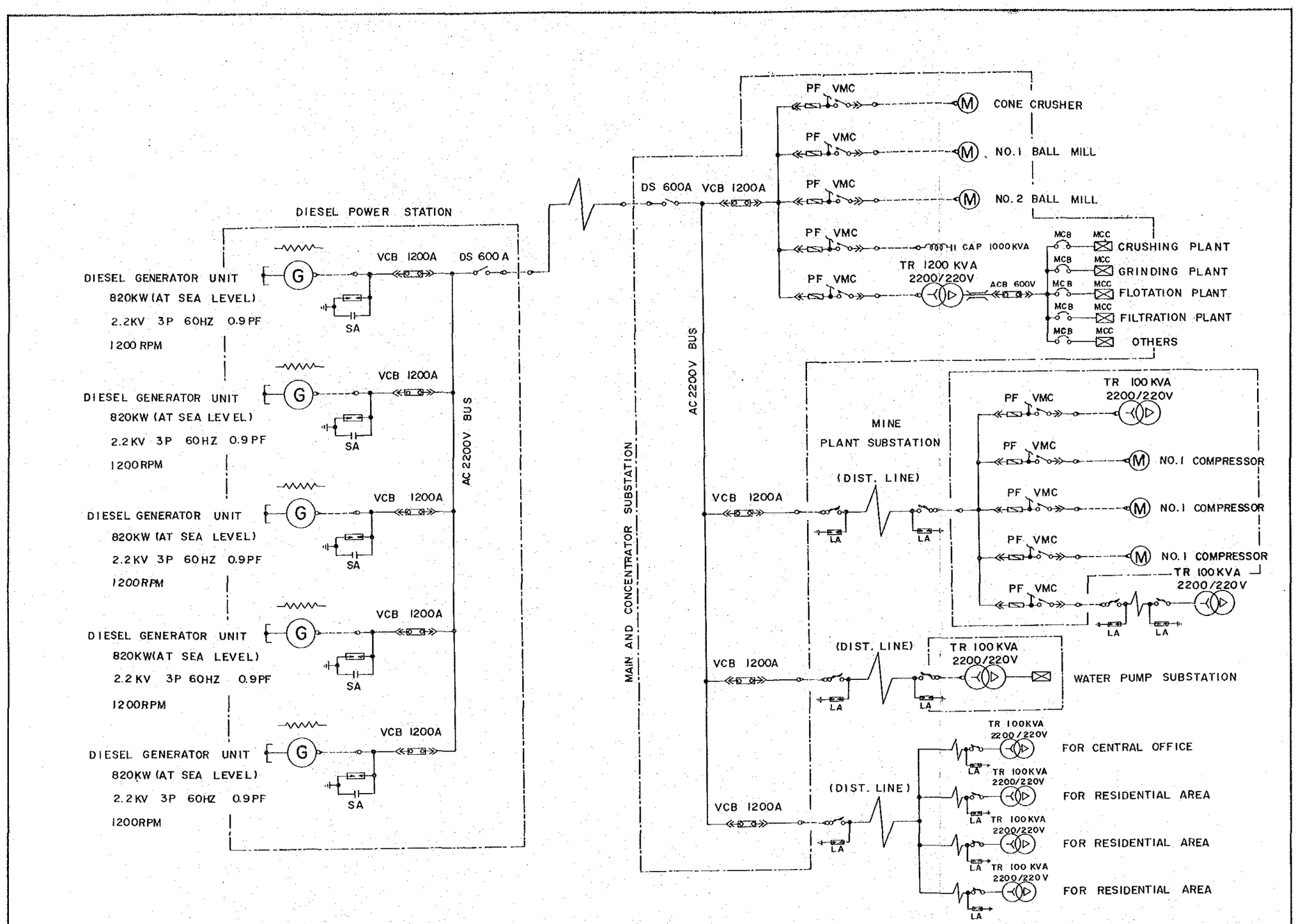
JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

ISCAYCRUZ PROJECT

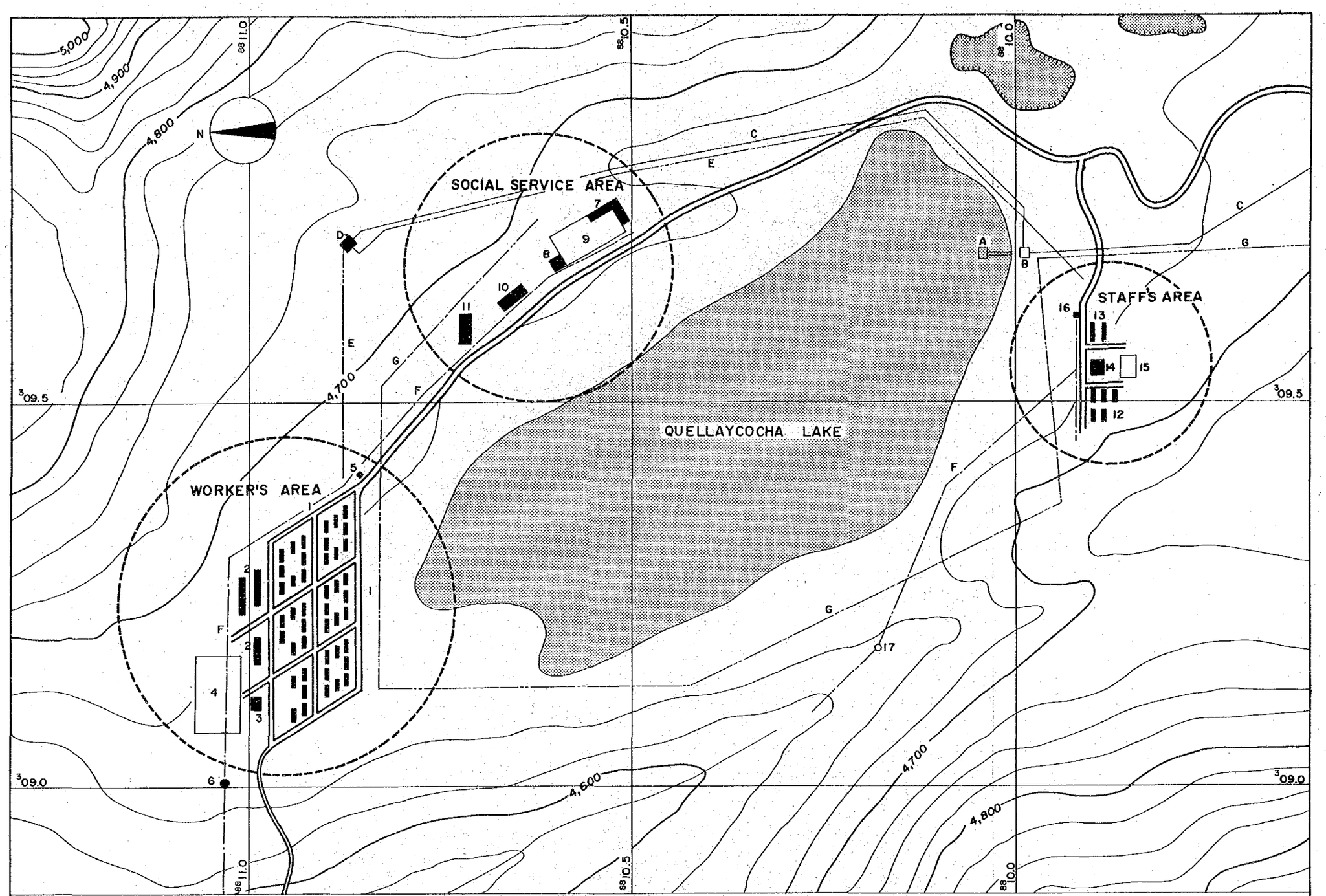
# POWER PLANT GENERAL LAYOUT

DATE: FEBRUARY, 1986 SCALE:

DWG. NO. 011




| | |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY<br>METAL MINING AGENCY OF JAPAN | |
| ISCAYCRUZ PROJECT | |
| ELECTRICAL POWER DISTRIBUTION SYSTEM | |
| DATE: FEBRUARY, 1986 | SCALE: |
| DWG. NO. 012 | |




WORKER'S AREA :

1 FAMILY HOUSE
2. BACHELOR QUARTER
3 CLUB HOUSE
4 SOCCER COURT
5 GUARD HOUSE
6 SEPTIC TANK

SOCIAL SERVICE AREA :

7 ELEMENTARY SCHOOL
8 KINDERGARTEN
9 PLAYGROUND
10 CANTEEN
11 CLINIC

STAFF'S AREA :

12 FAMILY HOUSE
13 BACHELOR QUARTER
14 CLUB HOUSE
15 TENNIS COURT
16 GUARD HOUSE
17 SEPTIC TANK

OTHERS :

A. PUMPING BOAT
B WATER PUMP STATION
C WATER TRANS. PIPELINE
D WATER TANK
E WATER DIST. PIPELINE
F SEWAGE MAIN PIPELINE
G POWER MAIN DIST. LINE

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

# ISCAYCRUZ PROJECT

## WELFARE FACILITIES RESIDENTIAL AREA

DATE : FEBRUARY, 1986 | SCALE :

DWG. NO. 013