CHAPTER IV PLANNING FOR POWER TRANSMISSION LINES

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1. POWER TRANSMISSION PLAN

1-1 Demand Forecast

1) Power Demand of Copper Mine

According to the Research Report for Regional Development of the Republic of Panama, May, 1977 (Metal Mining Agency of Japan), the demand of Petaquilla Mine is estimated as shown in the table below.

Crude ore handling capacity	12,000 ton/day	20,000 ton/day
Max. demand	16,000 KW	26,000 KW
Mining and concentrator	11,500 KW	20,000 KW
Others	3,700 KW	5,000 KW
Mining town	800 KW	1,000 KW
Annual energy consumption	105,120 MWh	170,820 MWh

Source: Metal Mining Agency of Japan

On the other hand, the Petaquilla Mine First Development Plan, Sept., 1977, (Panama Mineral Resources Development Co., Ltd.) estimated the power demand of mine as follows.

Crude ore handling capacity	18,000 ton/day	
Max. demand	19,000 KW	
Annual energy consumption	126,000 MWh	100%
Mining	9,400 MWh	7%
Ore concentrator	109,000 MWh	87%
Others	7,600 MWh	6%

Source: Panama Mineral Resources

Evidently, the ore concentrator consumes most of energy.

Power demand of copper mines varies substantially depending on the mining method, volume of spring water, size of mines, etc. Here several mines, which are strip mines same as Petaquilla Mine, are selected, and the energy consumption and installed capacity are extracted from the respective development and production increase plan. Table IV-1-1 and Fig. IV-1-1 show these data. As is evident, installed capacity can be closely correlated to the copper ore production in the case of strip mines: the correlation coefficient actually runs up to as high as 97%.

In general, there are available various methods to forecast the demand: the analytical method in which the aggregate of capacities of mine equipment is multiplied by utilization factor, load factor, and diversity factor as well as the method based on the energy consumption per unit product. In addition to these microscopic and macroscopic methods, the actual records of similar mines may also be used for the demand forecast. Judging from the distribution of actual values (copper ore production and max. facility demand) along a straight regression curve, forecasted values of

Crude ore handling capacity	18,000 ton/day
Max. demand	19,000 KW
Annual energy consumption	126,000 MWh

are not at all unrealistic.

Table IV-1-1 Installed Capacity of Strip Mines (Abstract from Development and Production Increase Plan)

Name of mine	Country	Ore production		Installed capacity		Energy consumption		
		10^3 ton/year	t/day	KW	KW/t/day	MWh/year	KWh/t	Ore dressing only
Petaquilla	Paname	6,300	18,000	19,000	1.056	126,000	20.0	17.3
Mamut -	Malaysia	5,250	15,000	15,000	1.000	108,620	20.69	19.9
Lornex -	Canada	12,410	34,473	34,764	1.008	275,844	22.22	-
Bougen Ville-	Papua	29,393	71,400	65,000	0.910	-	-	-
Cuajone -	Peru	13,063	36,300	33,333	0.918	-	-	-
Michiquillay-	Peru	14,000	40,000	38,000	0.950	270,065	19.29	16.7
Sitalay -	Philippines	9,000	25,000	25,000	1.000	-	-	-

Source: Panama Mineral Resources Development Co., Ltd.

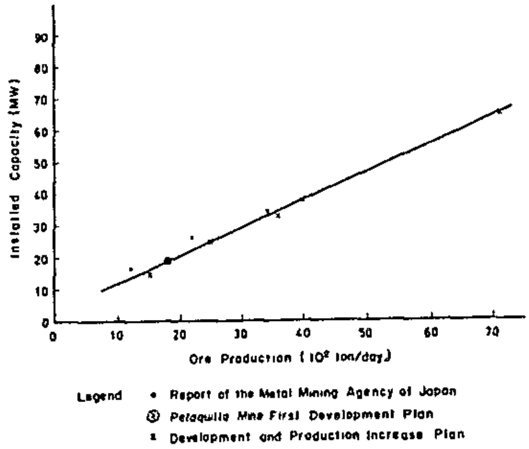


Fig. IV-1-1 Installed Capacity of Strip Mines

2) Power of Mine Town

The report of Metal Mining Agency of Japan proposes Petaquilla, Coclesito, Cascaja, La Pintada, and Penonome as locations of mining town for Petaquilla and makes analysis by comparison from various aspects. The report concludes that the optimum location is Coclesito, forecasting its population at 6500 - 8800 persons.

The annual report (1978) of IRHE says that the energy sold in 1978 amounts to:

413,131 x 10^3KWh	Domestic
1,167 KWh/year	Annual energy consumption per household
97 KWh/month/household	Unit consumption.

Assuming that the energy consumption of mining town has reached the average of the Republic of Panama in 1978, the demand may be forecasted as follows.

With the population of town being 8,800,

the number of households	1,700,	and
Electrification factor	100%,	

the annual energy consumption	2054 MWh
Max. annual demand	430 KW (load factor 55%)
Unit consumption	100 KWh/month/household

If the demand increases at annual compound rate of 10%, the demand of Petaquilla Mine in the year of commisioning (1978) becomes as follows:

Annual energy consumption	5,330 MWh
Max. annual demand	1,100 KW

This demand is nearly equivalent to the max. annual record 1,320 KW of Penonomé in the year 1979.

3) Power Demand of Coclesito Collective Farm

According to the site investigation, the population of Coclesito Collective Farm is about 800 as of the end of 1979, of which about 50% is occupied by infants. Most of inhabitants are occupied with agriculture and stock farming. Average cultivated area is about 5 hectare. Corns, rice, banana, and coffee are in cultivation and beef cattles are grazed.

Demand of Coclesito is roughly estimated as follows. With the population estimated at 814, number of households (6-person household) 140, and electrification factor 100%, and the annual energy consumption per customer 3.30 KWh, the annual energy consumption of Coclesito is 46,200 KWh. With the load factor 30%, the max. annual demand is 18 KW.

If the demand from lumbering, street lighting, and public agencies is added, the max. annual demand of Coclesito is at most 30 KW. It may safely be expected that the demand never exceeds the capacity (30 KW) of existing diesel generator. Assuming that the demand increases at annual compound rate of 10% (IRHE long-term plan value), the demands at the mine operation start period and peak period are:

About 80 KW	1987 (mine operation start)
About 200 KW	1997 (peak period)

As long as Coclesito develops as a collective farm, the local hydraulic power plants 125 KW x 2 now under construction can well meet the demand.

4) Demand of Districts around Penonomé

At present, the Pononomé District receives energy from the Pocri Substation in the vicinity of Aguadulce via the 34.5 KW distribution line. IRHE plan proposes the construction of new 115/34.5 KV 42 MVA substation in Penonomé in 1987. IRHE estimates the max. annual demand of 6,000 KW at the commissioning of the substation. Fig. IV-1-2 shows the service area, and Fig. IV-1-3 and Tables IV-1-2 and IV-1-3 show the demand forecast (IRHE estimate) of Penonomé.

IRHE plans six 34.5/13.8 KV distribution substations in Penonomé, La Pintada, Anton, Rio Hato, Farallon, and Santa Clara after the commissioning of Petaquilla Substation. Five substations are located on the Pacific coast and only the La Pintada Substation is situated nearer to the mountain from Penonomé. According to the forecast of IRHE, the demand of La Pintada remains as low as 200 KW in 1987. This means that IRHE does not expect any demand growth in the district around the mountain ridge and that the Petaquilla Mine Line gives only a very limited impact on the regional development.

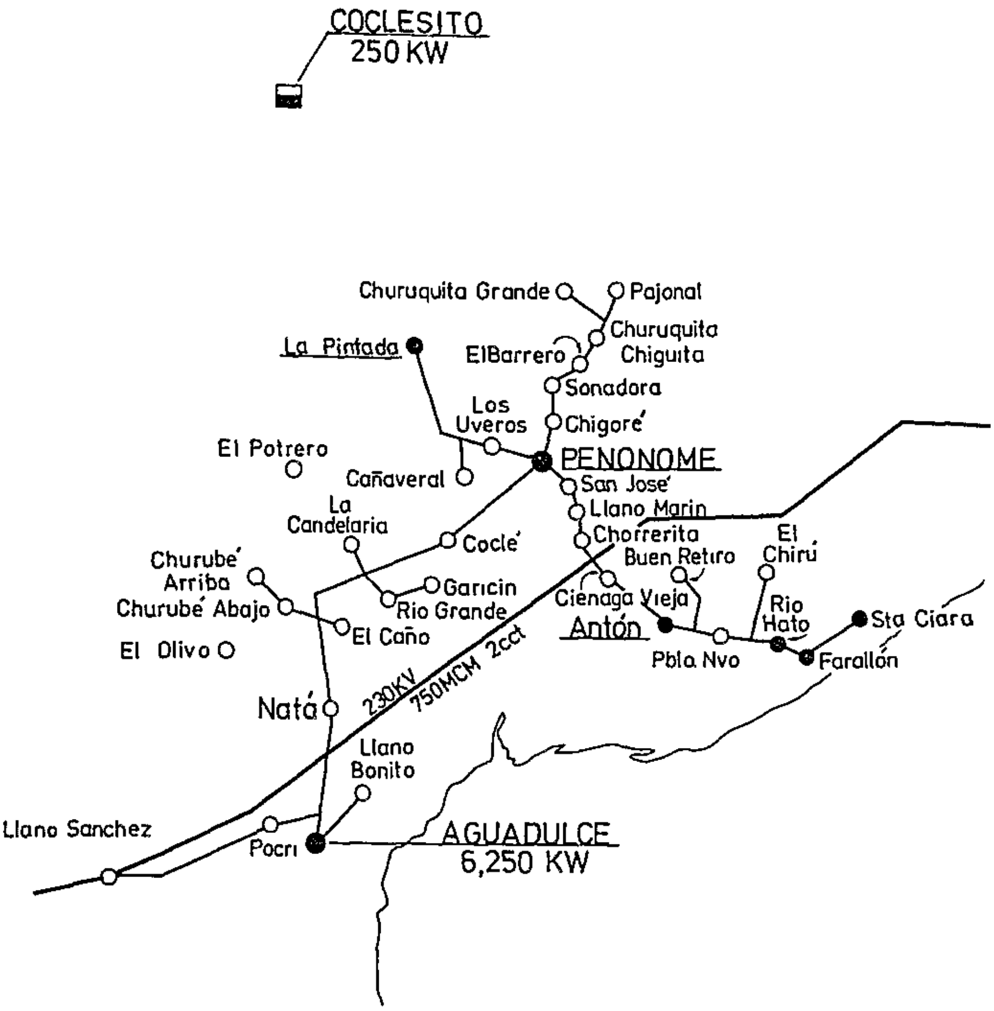


Fig. IV-1-2 IRHE Service Area (Penonomé)

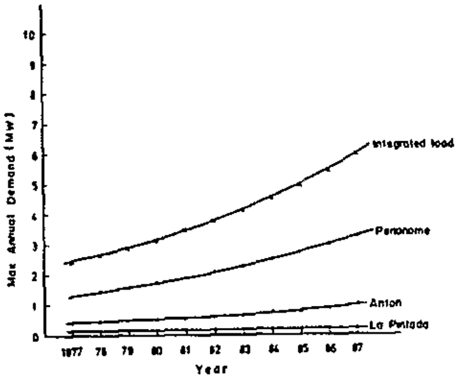


Fig. IV-1-3 Load Forecasr in Penonomé District

Table IV-1-2 Demand Forecast in Penonomé District (MW)

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
PENONOME SUBSTATION	2.401	2.631	2.884	3.164	3.464	3.797	4.161	4.560	4.998	5.478	6.004
PONONOMÉ	1.321	1.448	1.587	1.789	1.906	2.089	2.290	2.509	2.750	3.014	3.304
LA PINTADA	0.084	0.092	0.100	0.110	0.121	0.132	0.145	0.159	0.174	0.191	0.209
ANTON	0.390	0.427	0.468	0.513	0.563	0.617	0.676	0.741	0.812	0.890	0.975
RIO HATO	0.190	0.209	0.229	0.251	0.275	0.301	0.330	0.362	0.396	0.434	0.476
FARALLON	0.191	0.210	0.230	0.252	0.276	0.302	0.331	0.363	0.398	0.436	0.478
SANIA CLARA	0.225	0.240	0.270	0.296	0.324	0.355	0.389	0.427	0.468	0.513	0.562

Table IV-1-3 Demand Forecast in Penonomé District (MWh)

AREA	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
PONONOMÉ	4821	5284	5741	6347	6957	7625	8357	9159	10038	11002	12058
LA PIMIADA	305	334	366	461	440	482	528	579	635	605	762
RIO GRANDE	228	249	273	300	328	360	395	433	474	520	570
ANTON	1423	1559	1709	1873	2053	2250	2466	2703	2962	3247	3558
RIO HATO	695	761	834	914	1002	1099	1204	1320	1446	1585	1738
FARALLON	698	765	838	918	1007	1103	1209	1325	1453	1592	1745
SANTA CLARA	820	898	984	1079	1183	1296	1421	1557	1707	1871	2050
SUB-TOTAL	8990	9850	10795	11832	12970	14215	15580	17076	18715	20512	22481

Source: IRHE

1-2 Service Power and Transmission System

1) Service Power

The plan is established on the assumption that the energy consumed by Petaquilla Mine is supplied by the national integrated power system.

IRHE power plant has an sanctioned output of 481 MW with hydraulic-thermal ratio of about 40 : 60 as of Dec. 31, 1978. IRHE power plant includes steam power plant, hydraulic power plant, and diesel power plant. Diesel power plants are mostly small and outdated, with low thermal efficiency.
Major power plants currently operating are as follows.

Power plant	Location	Output MW	Type
Las Minas	Colon	40 MW x 3	Steam
ditto	ditto	22 MW x 1	ditto
Bayano	Panama	75 MW x 2	Hydraulic
La Estrella	Chiriqui	21 MW x 2	ditto
Los Valles	ditto	24 MW x 2	ditto
Total		382	

Source: IRHE

Flow rate of IRHE hydraulic plants fluctuates substantially between dry and wet seasons. In the case of run-off-river type power plant such as in La Estrella and in Los Valles, the flow in dry season drops to about 1/3 of max. discharge. Table IV-1-4 shows the record of drop in generated output of typical IRHE hydraulic power plants during the period of minimum flow except ten days.

Table IV-1-4 Drop of Output of Hydraulic Power Plant during the Period of Minimum Flow

Power plant	Type	Sanctioned output (MW)	Generated output (GWh/year)	Generated output during the period of minimum flow		Drop ratio during the period of minimum flow	
				(MW)	(GWh/month)	Power (%)	Energy(%)
Bayano	Reservoir	150	603	145	32.6	97	65
La Estrella Los Valles	Run-off river type	90	530	31	22.4	34	50

Source: IRHE

The listed values are the generated output averaged over several years, thus the output for the years of extraordinary flow shortage becomes further lower. Accordingly, sufficient service surplus must be secured as the hydraulic power generation prevails with the thermal power generation taking a secondary role.

On the otherhand, the IRHE hydraulic power plant has the unit capacity far larger than the reasonable ratio (max. 10%) to the system capacity. Reportedly, IRHE plans the unit capacity limit at 100 MW for the period up to 1983 and 150 MW for the period after 1984. This plan is intended to achieve reduction in construction cost by large capacity ("scale merit"): the present max. unit capacity is 75 MW of Bayano Power Plant, which amounts to about 1/4 of existing system capacity. If this plan falls off due to failure of equipment, the power system is disturbed, possibly leading to the power outage over the entire system. To avoid this, IRHE normally has 20 - 30% surplus capacity as standby, which is assigned to hydraulic and thermal power plants. Large unit capacity is advantageous in terms of economy, but the system reliability deteriorates correspondingly. In the case of the Republic of Panama, where the industrialization and automatization remains low, the above system reliability may be considered enough.

IRHE is providing the computerized automatic frequency control, with satisfactory frequency deviation of ±0.05 Hz. IRHE is also promoting positively the development of hydraulic power sources, and the Fortuna power Plant (275 MW 1250 GWh/year) is planned to start operation in 1983.

It may be concluded that IRHE has sufficient service capacity and the power resource development plan need not be modified even by the Power demand of Petaquilla Mine.

2) Transmission System

On September, 1979, IRHE completed its national integrated power system of 230 KV transmission line. This system enables the integrated operation of power service system in the Metropolitan Area around Panama and the hydraulic power source district in Chiriqui under the command from the Panama Load Dispatching Office. In this manner, the advantageous effects of system netwrok (reduction of service surplus, saving of fuel cost in thermal power generation, and imposed service reliability) are fully realized.

This plan is made on the assumption that the Petaquilla Mine Line receives supply from the Penonomé Substation. However, only a 34.5 KV distribution line (60 km) is constructed between Penonomé and Aguadulce at present and no 115 KV transmission line is yet constructed in Penonomé. The IRHE long-term plan proposes the installation of 115 KV ACSR 160 mm^2 transmission line (1 circuit) and the construction of 115/34.5 KV 42 MW Penonomé Substation in 1987. Accordingly, we have planned to take the Petaquilla Mine Line from this Penonomé Substation with the approval of IRHE. Note that the Petaquilla Mine Line and its demand are not contained in IRHE long-term plan.

Fig. IV-1-4 shows the transmission system at the end of 1979.

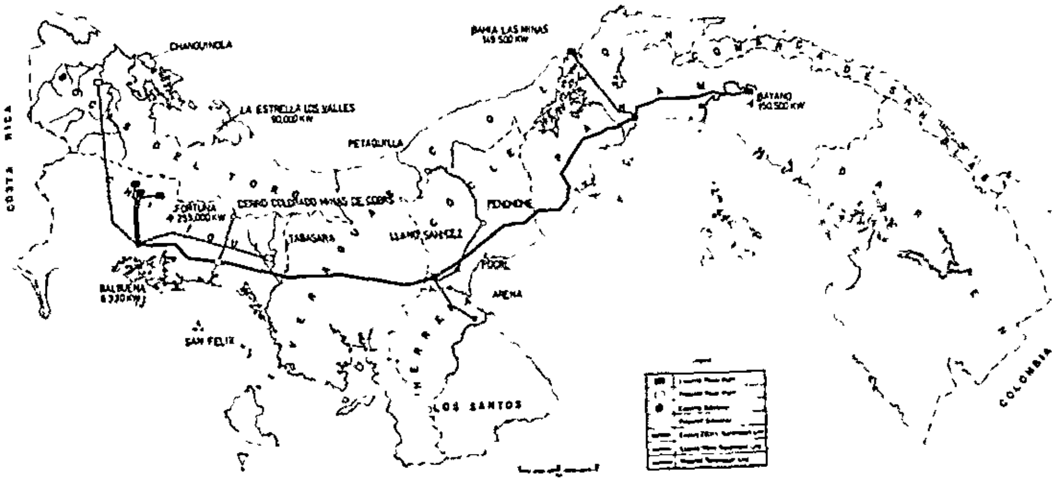


Fig. IV-1-4 Transmission System (as of end of 1979)

1-3 Facilities Investigated

The report of Metal Mining Agency of Japan covers not only the transmission line, but also the substation for the Mine, power service system for Coclesito Mining Town, and the collective farm, and the use of power line carrier system for maintenance as a public telephone service.
In line with this report, our investigation was made while stressing the total utilization of related facilities.
As a result of site investigation, we have decided to limit the facilities to be inspected to the exclusive mine line and to exclude other related facilities (substation for mine, service system for the mine town, and service and communication systems for Coclesito Collective Farm) from the plan this time.

1) Facilities Investigated This Time

Overall specification of facilities

*115 KV transmission line, steel tower (wooden pole)
1 circuit
ACSR 266.8 KCM 63 km
(Communication for maintemance and data transmission circuit included)

*115 KV one circuit outgoing point at Pononomé Substation
(Complete set of distribution board and switchgear)

Reason for the exclusion of mine substation, service system for the mining town, and other related facilities is described in the following.

2) Substation for Petaquilla Mine

Whether the substation should be constructed by the mine authority or by IRHE must be determined on the mutual agreement. Considering that the electric power company generally has service code for large customers, we have checked the intention of IRHE. IRHE code stipulates that the receiving substation of large customer must, as a rule, be constructed by the customer and that its property limit is at a line side terminal of 115 KV line side disconnecting switch in the receiving substation. If the customer so requests, however, the substation exclusive for mine may be constructed and maintained by IRHE. In the latter case, IRHE takes charge of design and construction of substation as well as maintenance, control, and operation of completed substation. Needless to say, the power rate is determined with due consideration on the depreciation and operating cost, resulting in relatively higher power rate than in the case of receiving 115 KV service. Operation and control of this substation are made under direct supervisory remote control from the Panama Load Disptaching Office. Maintenance and administration (patrolling and inspection) are made by the IRHE work gang stationed in Aguadulce. Needless to say, the maintenance and control costs go to the electric power company.

The Petaquilla Mine First Development Plan inlcudes the construction cost for exclusive substation under the item of start-up cost as shown below:

* Main-transformer	3-phase, 60 Hz 115/34.5/6.6 KV 25/9/2.5 MVA	1 set
* Switchgear of distibution board		
	120KV 1200A gas circuit breaker	1
	120KV 1200A disconnecting switch	1
	Measuring and protective relay system	1
	6.6 KV closed distribution board	8
	34.5 KV distribution board switchgear (For Botija Mine)	1

In addition to the above, the budget is made for the electric facilities of Petaquilla Mine:

* Diesel generator for emergency (400 KW)	3 sets
* 6 KV distribution line	
* Other electric facilities in the premises	

And the plan also contains the arrangement of engineers and workers for the operation and maintenance of these facilities. Also the Panama Mine Resources Development Corporation appears to be of the intention to construct the receiving substation with its own fund.

We excluded the mine substation from the scope of investigation this time.

3) Power Service to Coclesito Mining Town

According to the report of Metal Mining Agency of Japan, the Coclesito Mining Town will have the population of 6500 - 8800, which is nearly equivalent to that of Penonomé City. Since no other mining town plan is available, the scale and location of town are still not determined.

Petaquill Mine First Development Plan says that the Panama Government is of the intention to avoid the mining town under control of any specific company. Accordingly, the Government will make the final decision of town location and the authorities concerned will take charge of constructions including miners dwelling houses. And the power service system to the mining town must be accompanied with the total construction plan covering not only the receiving substation, but also the high- and low-tension distribution lines and service drop wires. In this view, we judged the planning should naturally be made by IRHE. Consequently, the facilities related to Petaquilla Mine development need not be taken into consideration this time and thus are excluded. Construction cost of 115/34.5 KV 1000 KVA receiving substation and the alternative service plan in the above report were also referred to and studied. We came to the conclusion that the substation of original plan is of special design and thus expensive and that the power servicing via the 34.5 KV distribution line (15 km) from the Petaquilla Mine is economically feasible.
(For details, refer to Appendix 1, "Power Service to Coclesito Mining Town".)

4) Service Facilities to Coclesito Collective Farm

As is above described, the demand for Coclesito Collective Farm is estimated at 80 KW in 1987 and about 200 KW in 1997, with electrification ratio at 100%. IRHE is supplying the power by 30 KW diesel generator at present.

Additionally, IRHE is constructing two 125 KW hydraulic power platns, which will soon be put into operation. These plants were planned in line with the long-term rural electrification project. Since their max. discharge is rated at a level during dry season, they will be less affected by the shortage of water. Coclesito can be well supplied with power by these hydraulic power plants for the coming ten to twenty years. Consequently, the power servicing to the Coclesito Collective Farm from the transmission line is excluded from this plan.

5) Communication System in the Mine and the Mining Town

According to the report of Mineral Mining Agency of Japan and Petaquilla Mine First Development Plan, the power line carrier telephony circuit of Petaquilla Mine Line is to be used for communication between the mine and the Panama Main Office and loading port and as public telephone circuit for inhabitants of the mining town. This power line carrier tepehony circuit is connected to the INTEL micro wave circuit in Penonomé. Number of subscribers is shown in the table below.

Location	Number of subscribers	
	Report of Metal Mining Agency of Japan	Development plan
Petaquilla Mine	40	100
Coclesito Mining Town	40	(*)200 - 300

Source: Metal Mining Agency of Japan

(*) Record of Penonomé City (as of 1978)

The number of main lines to cover above subscribers is calculated at 20 - 30 circuits. (Refer to Appendix 2, "How to Determine the Number of Main Lines")

To ensure the optimum service quality, six channels are the limit in the power line carrier telephony. Since IRHE specification for power line carrier telephony sets forth five channels, the micro wave circuit will be empolyed to cover excessive channels. As shown in Fig. IV-2-3, one channel is used for maintenance communication cirucit and four channels for supervisory remote control. Accordingly, there remains no availability to utilize the maintenance communication circuit for public telephony service. In this view, we propose the use of INTEL public telephone circuit for the communication in the mine and the mining town. And the power line carrier telephony circuit in power line will not be used for the public telephone service. Fig.IV-1-5 shows the communication system after the start of mine operation.

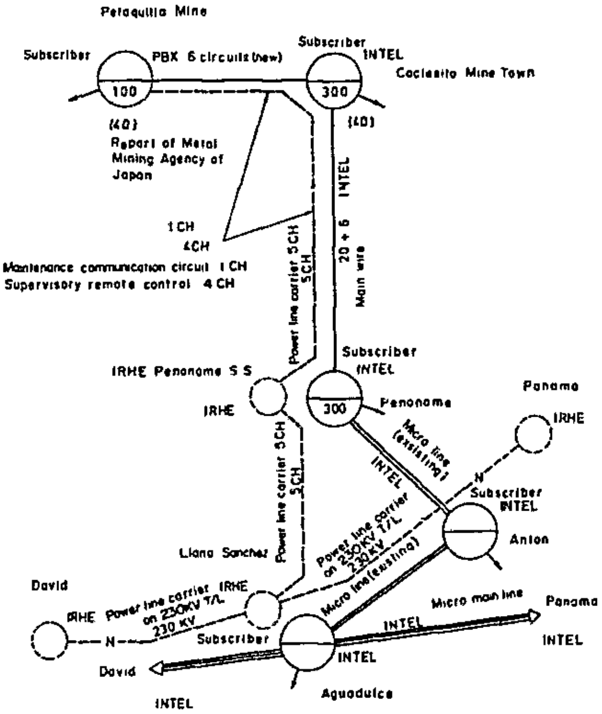


Fig. IV-1-5 Communication System Diagram

1-4 Policy of Transmission Project Planning

1) Selection of Transmission Voltage

Power standard of IRHE is said to be based on ANSI (American National Standard Institute) standard. ANSI specifies four standard voltages of 69, 115, 138, and 230 KV for the high voltage system. IRHE standard, on the other hand, specifies only three standard voltages of 34.5, 115, and 230 KV for the transmission line.

To meet the demand of the Petaquilla Mine (19,000 KW), the transmission line of about 60 km and with voltage drop at ±5% is enough.

For this transmission capacity, the 69 KV transmission line is generally used. Actually, Japan and U.S.A. use this type of line mostly. However, if the 66 KV line which is not covered by IRHE standard is to be used in Panama, a new 115/66 KV substation will have to be constructed. This type of line is not feasible in terms of maintenance, or interchangeability of spares and repair materials. Besides, if the transmission line is used exclusively for the mine, the transmission line whose construction work is assigned to IRHE is constructed according to IRHE standard and becomes the property of IRHE.

In this view, it is advisable to follow the IRHE standard. Consequently, the transmission voltage is set at 115 KV as IRHE standard specifies.

2) Determination of Conductor Size

Conductor size of transmission line is generally determined from various factors including electrical characteristics (allowable current, corona voltage), transmission loss, economical aspects (construction cost, etc.), and mechanical strength of line. In the case of Petaquilla Mine Line having extremely large transmission capacity for the load, the max. section is obtained from the corona

voltage and mechanical strength.
IRHE exsiting transmission line (115 KV) for general purpose (excluding main line) is found to be designed with the conductor size to be the minimum sectional area.

Investigation on the power source side transmission line in Petaquilla Mine Line shows that ACSR 266.8 KCM conductor is used between Divisa and Aguadulce (19 km) and between Divisa and Chitre (48 km). For the Aguadulce - Penonomé section (60 km) to be completed in 1987, IRHE plans the use of ACRS 266.8 KCM.

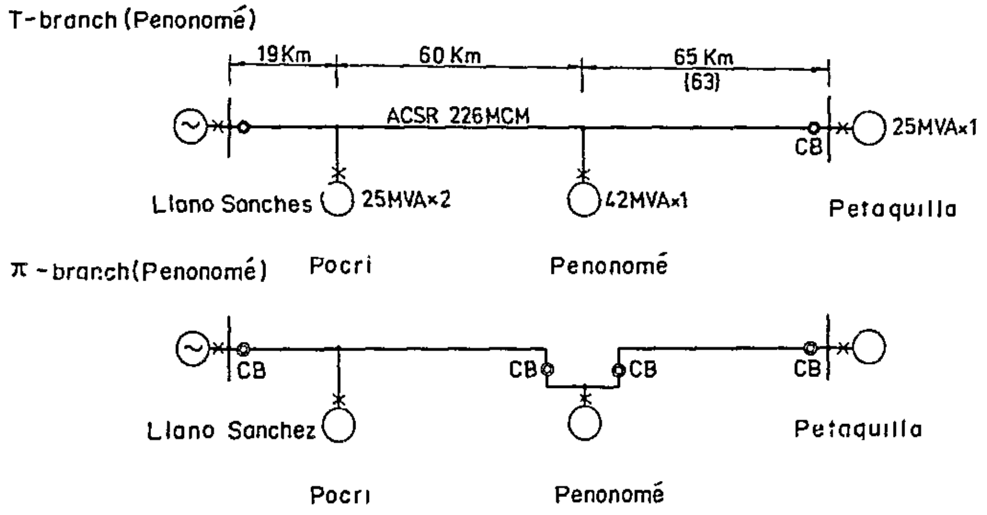
These examples indicate the necessity of using ACSR 266.8 KCM (115 KV transmission line with minimum sectional area) for Petaquilla Mine line. In spite of substantial allowance in transmission capacity, it is advanteous to uniform the conductor size to ACSR 266.8 KCM from the maintenance aspect. Consequently, we propose the use of ACSR 266.8 KCM for Petaquilla Mine Line to uniform the wire size with relevant transmission lines.

3) System Configuration

To service the power to Petaquilla Mine, the power is received from the IRHE 230 KV national integrated power system, stepped down to 115 KV at the Llano Sachez Substation, and transmitted to Pocri, Penonomé, and Petaquilla. Now the 115 KV transmission line between Llano Sanchez and Pocri is in operation. For the 60 km section from Pocri to Penonomé, IRHE is planning the construction of transmission line by 1987. Acordingly, the problem concerning the system configuration consists in whether the Petaquilla Mine Line should be T-branched or π-branched at Penonomé. In the case of T-branch, it is impossible to cut off faulty circuit selectively: trouble in any part of 140 km section between Llano Sanchez and Petaquilla may cause power outage in Aguadulce, Penonome, and Petaquilla. However, this branching method is economically advantageous because the expensive line-side breaker can be neglected. On the other hand, π-branch is advantageous in that its selective cut-off capacity can prevent the power outage in Penonomé and Aguadulce even when the failure occurs in Petaquilla Mine Line. However, the line side breaker is necessary.

Since Petaquilla Mine is located at the end of tree-branch type line system of uni-directional power supply, the electricity failure occurs, regardless of T-bracnh or π-branch, when the failure occurs in this line system. Selection of either type concerns solely with the supply reliability to Petaquilla and Aguadulce. Calculation on reliability proves that π-branch ensures supply reliability to both districts higher by 3 times than that of T-bracnh. Pononomé and Aguadulce are important cities and IRHE is of the intention to minimize the power outage. In this view, we propose the π-branching of Petaquilla Mine Line.

Comparison of outage between T-branch and π-branch



District Branch type	Outage for each district			
	Peta-quilla	Penonomé	Pocri	Average for Penonomé and Pocri
Penonomé T-bracnh	209x10^{-2}	209x10^{-2}	209x10^{-2}	209x10^{-2}
Penonomé π-branch	209x10^{-2}	79x10^{-2}	79x10^{-2}	79x10^{-2}

Source: Survey Mission

Note: Outage of 115 KV transmission line was assumed as follows:

a) Penonomé - Petaquilla 2 x 10^{-2} times/km/year
(The line runs over mountain edges through tropical zone, rain forest area, and is exposed to lightning.)

b) Other sections 2 x 10^{-2} times/km/year

1-5 Description of Plan

1) Selection of Transmission Line Route

a) Location of substation

In compliance with the agreement with IRHE, 115 KV bus bar of IRHE Penonomé Substation (115/34.5 43 MVA, commitioning planned for in 1987) is determined to be an outgoing line to Petaquilla Mine Line.

The location of Penonomé Substation is not determined yet. In this planning, the substation location is temporarily assumed by the Pan American Highway at the sourthern end of Penonomé City in view of transportation of heavy equipment (main-transformers, circuit breaker) and principal equipment. (Refer to Fig. IV-1-7)

The location of the mine substation is assumed at the southern end of ore concentrator as shown in the attached drawing of Petaquilla Mine First Development Plan. Location of Petaquilla Substation is shown in Fig. IV-1-6.

b) Supporting structure

As the supporting structure of transmission line, both the steel tower and the wooden pole are proposed.

Line route is determined with the standard span 300 m for steel tower and 200 m for wooden pole. From the macroscopic view, there is no difference between the route using steel towers and that using wooden poles, and the route is assumed the same for both cases at a present stage. In the case of using wooden poles, the standard span is shorter and the route becomes mostly curved depending on the geographical features. In this view, the plan this time takes the possibility of increase in distance by about 5% into consideration.

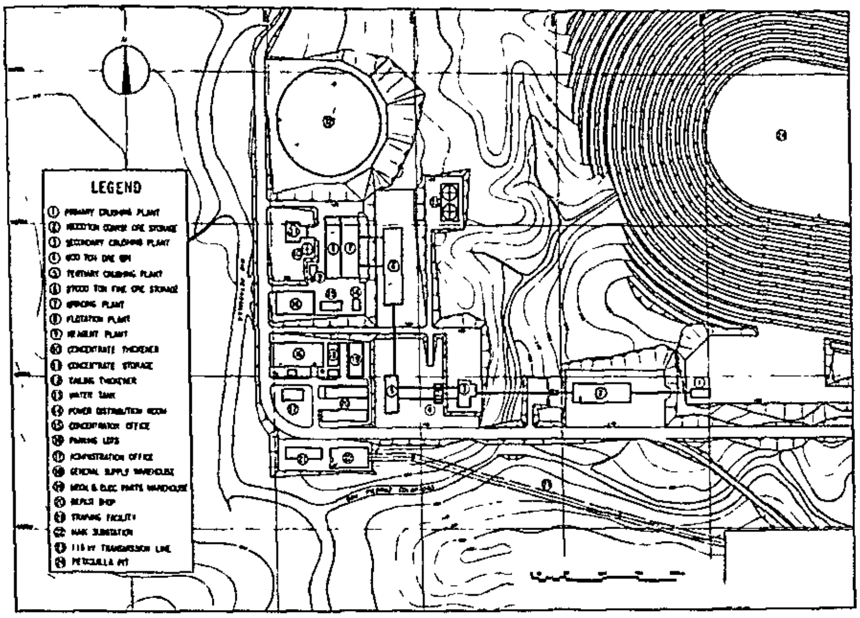


Fig. IV-1-6 General Plan of Petaquilla Mines

c) Investigation and selection of route

Basically, the 115 KV Petaquilla Mine Line is constructed alongside the ore transportation road. This route is chosen because of its advantages for the construction work (transportation of construction material, workers) as well as for the maintenance (patrolling and inspection after the completion). Investigation proved that the above planned coincided approximately with that of the report of Metal Mining Agency of Japan. This may be the result naturally concluded since the route investigation was made according to the generally approved procedure.

Fig. IV-1-7 shows the comparison of above two routes. In the investigation this time, the route was determined so as not to present obstruction to the take-off and landing of light planes in Coclesito airfield. Accordingly, the transmission line route changes its direction at a point 5 km before Coclesito and runs toward the junction of Rio Sanjuan and Rio Botija. This is the noticeable difference from the previous investigation.

Penonomé - Llano Grande section of the route runs on the flat land, comprising cultivated field, grassland, and wasteland. This district covers wide land used for slash-and-burn agriculture, and thus trees are scarce. Transmission route will be easy to secure.

Llano Grande - Coclesito section covers complexed geographical features with intricate swamps. In this district, the lands used or having been used for slash-and-burn agriculture are sporadically found along the road and the vegetation is scarce, making the route determination relatively easy. However, the map of this district is not available and the selection was made this time using air photos. It is advisable to obtain the map at the ealiest possible time and to increase the accuracy of investigation.

Typical tropical, rain forest area covers the section

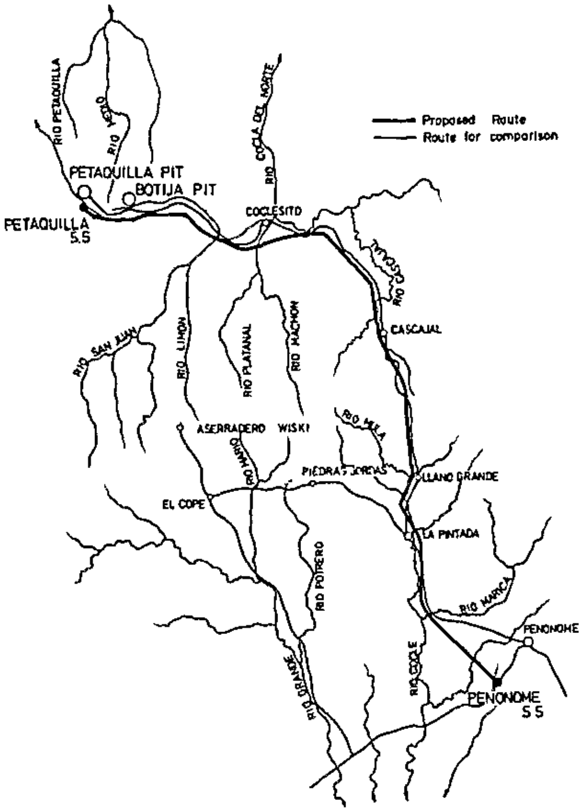


Fig. IV-1-7 Rough Petaquilla Mine Line Route Map

between Coclesito and Petaquilla, and considerable amount of trees will have to be cut down for the construction of transmission line. By the time the construction is started, the ore transportation road will have been completed, facilitating the transportation of material, construction machines, etc. Consequently, the construction work may be completed relatively easily.

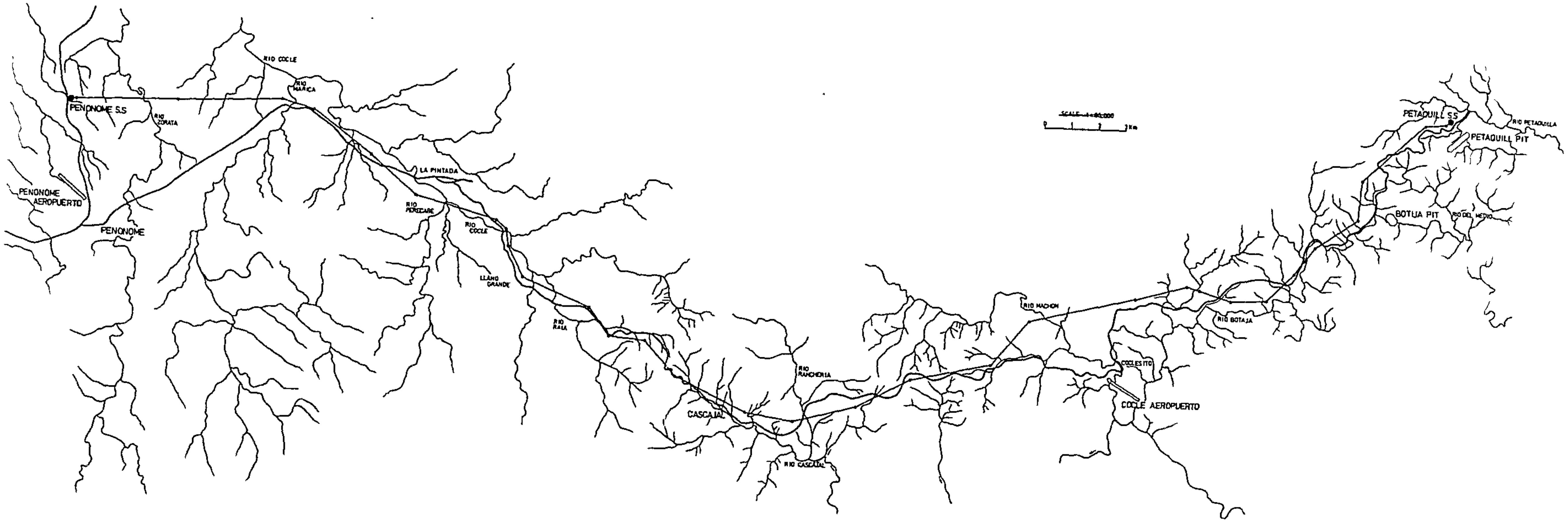


Fig. IV-1-8 shows the 115 KV Petaquilla Mine Line route map (Scale 1/125,000).

2) Outline of Transmission Line Facilities

(a) Specification

Section	From Penonomé Substation to Petaquilla Substation
Distance	63 km
Nominal voltage	115 KV
Number of circuits	1 circuit
Transmission system	3-phase and 3-wire, 60 Hz
Ground neutral system	Direct grounding
Supporting structure	Steel tower
Conductor	ACSR 226.8 KCM (equivalent)
Overhead ground wire	Aluminum sheathed steel stranded wire AWG No.# 5 x 3
Insulator	250 mm suspension insulator 8 insulators in string
Conductor arrangement	Triangular arrangement - Steel tower Horizontal arrangement - Wooden pole

3) Operation and Maintenance setup for Transmission Line facilities

a) Operation of transmission line facilities

IRHE takes charge of the operation of Petaquilla Mine Line. The circuit breaker on the outgoing side of Penonomé Substation is either operated manually under command by the load dispatching office or controlled directly by the supervisory remote control by the Panama Load Disptaching Office.

Receiving circuit breaker in Petaquilla Mine Substation is operated by the electrical engineer of the mine under the command from load dispatcher of IRHE. Details will be modified according to the supply agreement in the future. Strict interlock is provided to prevent the emergency power source from being parallel to the IRHE system.

b) Maintenance setup

IRHE electrical engineers (about 20 persons) are stationed in Aguadulce: 6 engineers and 14 workers, divided into four gangs. Maintenance and control of electrical equipment in the central four Provinces (Aguadulce, Penonomé, etc.) are executed by these maintenance men. For the Petaquilla Mine Substation, the mine electrical engineers are to carry out maintenance and inspection. If so requested by the customer, IRHE may often takes charge of operation, maintenance, and control of customer's substation.

c) Measures in case of line fault

When the fault occurs in the transmission line, the countermeasure is taken according to the following procedure.

* Protective relay of transmission line is activated, determining the faulty section and performing selective breaking.
* Within a certain period (several seconds - one minute) after the breaking, the circuit breaker is automatically closed. This is called "reclosing". When the faulty is not existing after the reclosing, the power transmission is to be continued. This is called "successful reclosing." Rate of successful reclosing is generally 80 - 90%, and 80 - 90% of transmission faulty can be removed automatically by this.
* When the faulty sustains after the reclosing, the protective relay is activated again, stopping the transmission. Transmission engineers stationed in Aguadulce receive the order from dispatcher, and workers patrol along the line route for the detection of fault and removal.
* In Japan, the power transmission line fault locator is used, enabling quick detection of a fault point. Installation of this device was not proposed this time since IRHE does not emply it for 230 KV transmission line.

d) Daily maintenance

Daily maintenance of transmission line is made up from the patrolling, inspection, and repair. These maintenance activities are executed by IRHE workers stationed in Aguadulce according to the predetermined annual work schedule.

In addition to the patrolling over the entire line once or twice a year, the preventive patrolling before wet season and special patrolling for landstrip section are made according to the feature of district. These are made in accordance with the safety code of IRHE.

Inspections of steel towers, insulators, and conductors are also made once for several years according to the predetermined schedule.

2. DESIGN OF TRANSMISSION LINE

2-1 Design Conditions

Transmission line is designed basically according to the IRHE Standard. When IRHE standard is not available, Japanese standards and codes are applied.

a) Climate conditions

Altitude	60 - 420 m (above sea level)	
Ambient temperature	Max.	32°C
	Min.	23°C
	Mean	27°C

b) Safety factor

The followings are adopted according to the IRHE standards:

Conductor (ACSR)	4.0
Insulator	4.0
Steel tower	2.5
Wooden pole	4.0
Foundation	2.0

c) Conductor temperature

Max. working temperature of conductor
120°F (48.9°C)

Allowable temperature of conductor
90°C

d) Assumed wind load

Max. wind velocity	26.6 m/sec.	
Wind load	Overhead line	45 kg/m^2
	Steel tower	75 kg/m^2
	Wooden pole	63 kg/m^2

e) Clearance of overhead line from ground surface

The clearance of line is determined according to IRHE standard (no wind at conductor temperature 48.9°C).

Item		
Roadway	Crossing	7.0 m
	Others	7.0 m

Pavement	Crossing	7.0 m
	Others	7.0 m
Above telecommunication wire		2.6 m

2-2 Design of Overhead Transmission Line

1) Design standard

In designing the 115 KV Petaquills Mine Line, necessary considerations are given to the following basic items as well as harmony and coodination with IRHE's existing facilities.

a) To ensure stable supply of good quality electricity to the mine
b) To avoid deterioration of reliability of existing service system
c) To ensure economical feasibility

As the mine effective life is 20 years, an alternative plan of using the wooden pole is proposed in addition to the plan using steel tower from the viewpoint of economy.

2) Design of Transmission Line

Transmission line using steel towers is designed according to IRHE standards. For the line using wooden poles, IRHE has not design stadnard and Japanese standards are applied.

a) Improvement of service reliability

* For the ground fault, which occupies most of transmission fault, the reclosing function is provided, ensuring higher service reliability.

* Since the foundation of IRHE, only twice faults due to contaminated insulator have been reported.

115 KV transmission line: In the vicinity of cement plant in Panama City
34.5 KV distribution line: In the vicinity of salt works in Las Tabalas

Petaquilla Mine Line runs through a high-rain area and existing lines use standard insulators. In this view, the anti-contamination measure is not taken.

* Overhead ground wire is incorporated in the transmission

line to prevent lightning fault.

Number of overhead ground wire	Steel tower	1-wire
	Wooden pole	2-wire
Shielding angle:	0 - 30°C	

* To prevent the conductor breakage due to vibration in a breeze, following measures are taken:
* Armor rod is provided to the suspension insulator.
  Damper is provided for the long span exceeding 300 m.
  To prevent the loosening of steel tower, anti-loosening lock nuts are provided.
* As the transmission line passes a high-rain area, driving anchors are used as stay anchors for wooden pole to stabilize the soil around anchors.

b) Insulation strength

Insulation of overhead transmission line must be able to withstand not only the normal voltage, but also the switching surge in the system and short-term commercial frequency over-voltage. Flash-over is allowed to a certain extent. No anti-salt measure is taken.

* Kind of insulator 250 mm suspension insulator
* Number of insulators in string
  Suspension insulator string 8 pcs
  Strain insulator string 9 pcs

  Number of insulators in string is determined according to IRHE standard. Theoretically, 7 pcs is enough. Here one to two spares are added (8 pcs for suspension insulator and 9 pcs for strain insulator) to facilitate the replacement of faulty insulator. Fig. IV-3-1, a and b show the insulator structure.
* Standard insulation distance: 110 cm
* Min. insulation distance: 70 cm
* Lateral oscillation angle: Determined according to IRHE standard
  Max. lateral oscillation angle: 50°
  Normal lateral oscillation angle (No wind) 30°

* Horizontal spacing

The horizontal spacing is determined as following by taking the result of examination of clearance diagram and lateral oscillation of wire into consideration.

Wooden pole, horizontally arranged	4.20 m
Steel tower, triangularly arranged	5.30 m

c) Standard span

Based on the study on the relationship between standard span and construction cost for steel tower and wooden pole, the most economical span is determined as follows:

Supporting structure	Standard span
Steel tower	300 m
Wooden pole	200 m

Relationship between the standard span and the weight of steel tower/material of pole is as shown in the table below.

Relationship between standard span and weight of steel tower

Standard span (m)	200	250	300	350
Steel tower weight per 1 km (ton)	7.95	7.40	7.20	7.50

Relationship between Standard Span and Material of Wooden Pole

(Pole length: 55 ft (16.8 m)

Standard span	180	190	200	210	220	230	240
Volume per km (m^3/km)	15.0	14.2	13.5	12.9	12.3	11.8	11.3
Allowance for sag	1.5	1.3	1.0	0.8	0.5	0.2	-0.1

From the above analysis, the standard span is determined as 300 m (smallest weight) for steel tower and 200 m (including allowance for sag) for wooden pole.

d) Supporting structure

* Steel tower

Tower for 115 KV one-circuit	Square
Conductor arrangement	Triangular
Foundation	Steel foundation (soil foundation)

Steel tower is designed according to IRHE standard for existing steel towers. Foundation is also designed according to IRHE standard: soil foundation is employed to reduce costs and construction period. Outline of standard steel tower adopted this time is shown in Fig. IV-2-1 and IV-2-2.

* Wooden pole

Wooden pole for 115 KV one-circuit	H-pole (Creosote impregnated)
Conductor arrangement	Horizontal
Cross arm	

Outline of standard wooden pole adopted this time is shown in Fig. IV-2-3 and IV-2-4.

e) Conductor

In conjunction with existing IRHE transmission line, the conductor specified below is used. Size of this conductor is similar to that of Llano Sanchez - Pocri Line (115 KV, one circuit) on the power source side of Petaquill Mine Line and has sufficient transmission capacity. To facilitate easy maintenance and inspection in futire, the conductor, conductor accessories, and repair materials same as those for existing 115 KV transmission line in this area are used.

Aluminum cable steel reinforced	266.8 KCM
Wire configuration	Al. 26x2.57 mm/ st. 7x2.00mm

f) Ground wire

Direct ground system is used for IRHE 115 KV transmission line. Therefore, extremely large current flows within a very short time in the case of abnormality. Its induction disturbance to communication line is more critical than in the case of resistance grounded neutral system. To reduce the resistance in the overhead ground wire, the conductor as specified below is used.

Aluminum sheathed steel standard wire	3x#5 AWG
Wire configuration	3x4.62 mm

g) Insulator for 115 KV Petaquilla Mine Line is shown in Fig. IV-2-5 and IV-2-6.

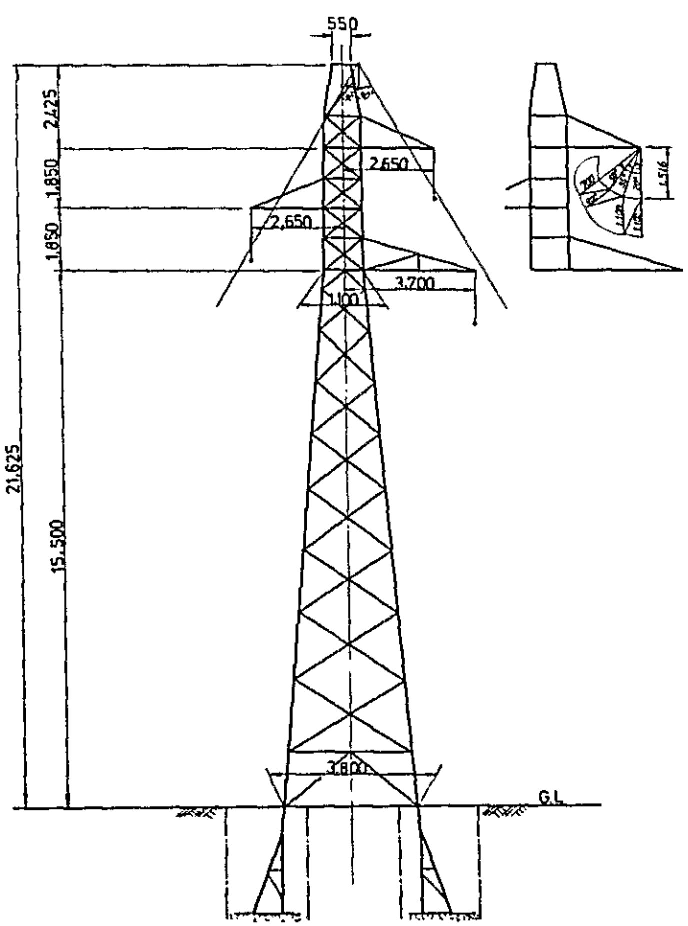


Fig. IV-2-1 Outline of Straight Line Suspension Tower for 115 KV Petaquilla Mine Line

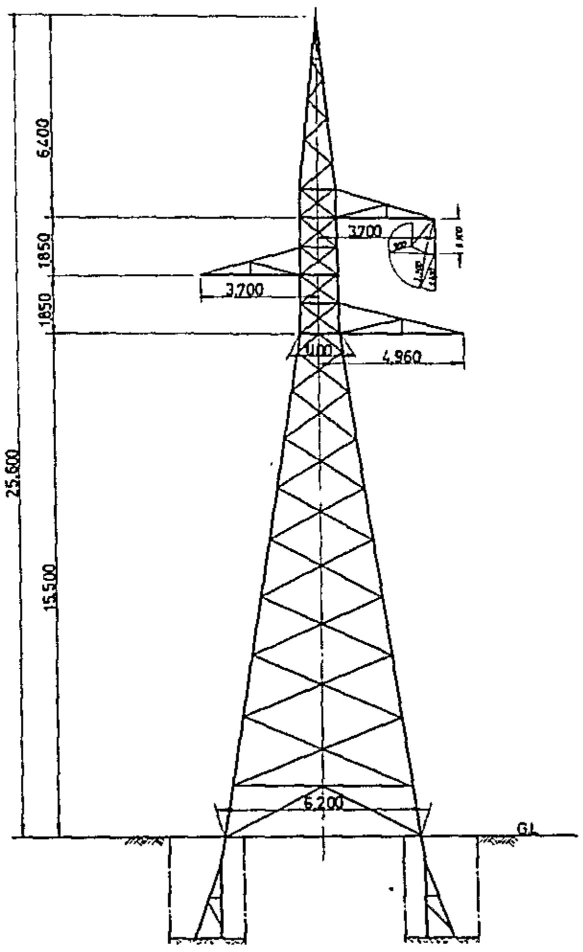


Fig. IV-2-2 Outline of Angle Tower for 115 KV Petaquilla Mine Line

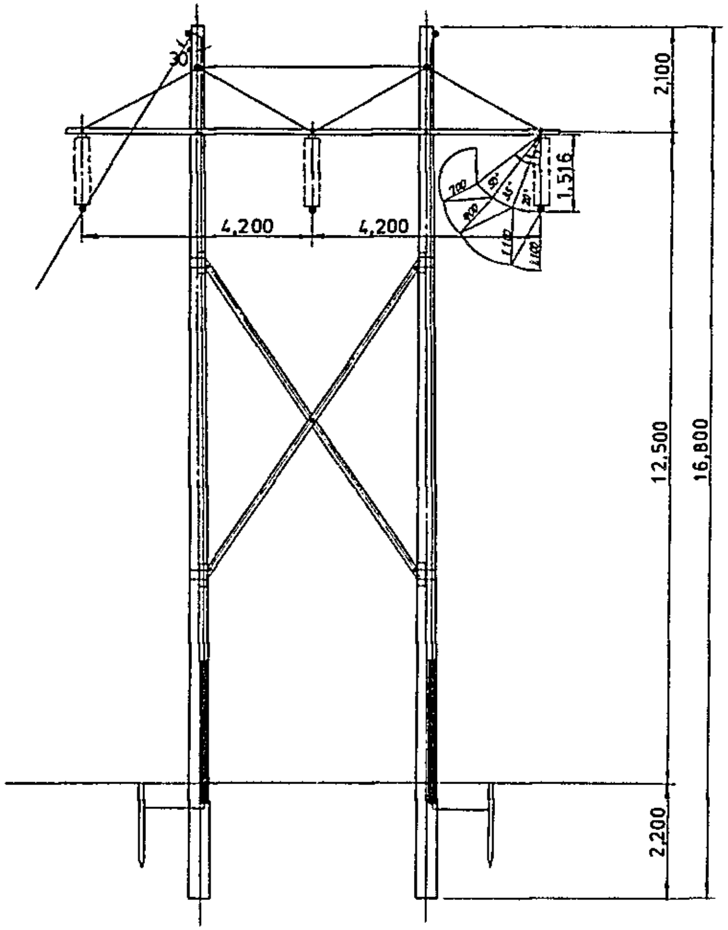


Fig. IV-2-3 Outline of Straight Line Suspension Pole for 115 KV Petaquilla Mine Line

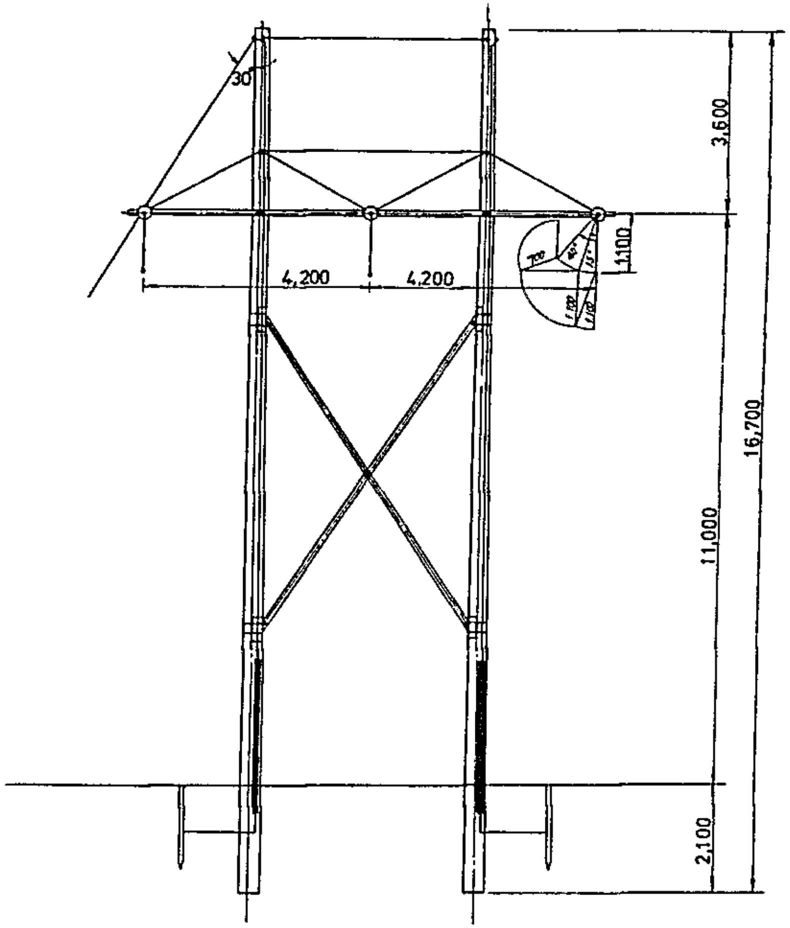


Fig. IV-2-4 Outline of Angle Pole for 115 KV Petaquilla Mine Line

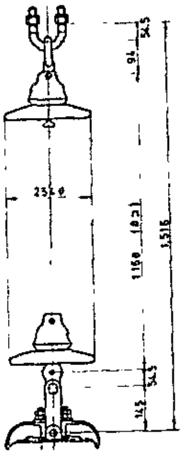


Fig. IV-2-5 Insulator (suspension) for Petaquilla Mine Line

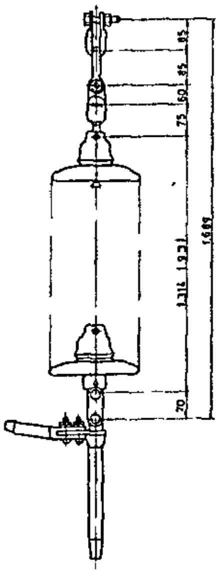


Fig. IV-2-6 Insulator (strain) for Petaquilla Mine Line

3) Specification of principal material

a) Steel tower — 115 KV one-circuit steel tower

Type	Square
Material	Galvanized structural steel
Type of tower	Straight line suspension tower Angle tower (light angle, heavy angle) Dead-end tower

b) Wooden pole (American Standard Association, Class 1 or equivalent)

Material	Pine (creosote impregnated)	
	55ft.	60ft.
Length	16.8 m	18.3 m (Fiber stress 7400lbs/m^2)
Tip end	0.218 m	0.218 m
Bottom end	0.404 m	0.420 m

c) Conductor

Aluminum cable steel reinforced	ACSR 266.8 KCM "Partridge"
Equivalent copper sectional area	85.01 mm^2
Aluminum sectional area	135.2 mm^2
Steel sectional area	22.0 mm^2
Total sectional area	157.2 mm^2
Conductor configuration	Aℓ 26x2.57 mm/st 7x2.00 mm
Outside dia.	16.28 mm
Cable weight	545.4 kg/km
Tensile strength	5100 kg

d) Earth wire

Aluminum sheathed steel stranded wire	3x#5AWG
Wire configuation	3x4.62 mm
Outer dia.	9.957 mm
Sectional area	50.317 mm^2
Wire weight	334.052 kg/km
Tensile strength	5546 kg

e) Insulator

Suspension insulator	(254 mm x 146 mm)
Wet withstand voltage	50 KV
50% flashshover voltage, power-frequency, dry	125 KV
Oil immersed dielectric breakdown voltage, power frequency	110 KV
Electro-mechanical failing load	6804 kg
Weight	4.99 kg

2-3 Design of Outgoing of Transmission Line

1) Specification of Principal Equipment

Gas circuit breaker	120 KV 800A 12.5 KV 1 set
Disconnecting switch	120 KV, 800A Manual operation (with earthing device)

Disconnecting switch	120 KV 800A Manual operation 1 set
Distribution board (Instrument panel, protective relay panel)	2
Outdoor steel structure	(5 ton)

Note: Supervisory remote control, DC power supply (battery and charging device), lighting and power panel, distribution board room are excluded from the plan this time, assuming that those equipment in Penonomé Substation are available.

2) Design of Maintenance Communication circuit

* Power line carrier system	Shown in Fig. IV-2-7.
Transmission system	Single side-band transmission (SSB)
Number of channels	3 CH
Band width of speech frequency	300 - 2300 Hz
Signalling method	FS with two frequency outside of speech band
Standard input level of carrier	0 dB/CH
Standard output level of carrier	+27 dB/CH
Standard input level of voice	-8 dB
Standard output level of voice	0 dB
Input/output impedance of device	High frequency 75Ω Voice frequency 600Ω
Automatic gain control	Compression ratio 20% at +10 - minus 10 dB
* Coupling capacitor for power line carrier	
Rated voltage	110/√3 KV
Insulation class	120
Electrostatic capacity	0.02 μF
Rated frequency	60 Hz
* Blocking coil	115 KV 400 A
* Constant voltage constant frequency power supply (CVCF)	
Type	Static type of thyristor and

	silicon rectifier
Cooling method	Forced air cooling
Circuit type	AC → DC → AC conversion
Power rectification	3-phase full wave rectification
Power inversion	Multiple inversion
DC switch-over method	DC switching

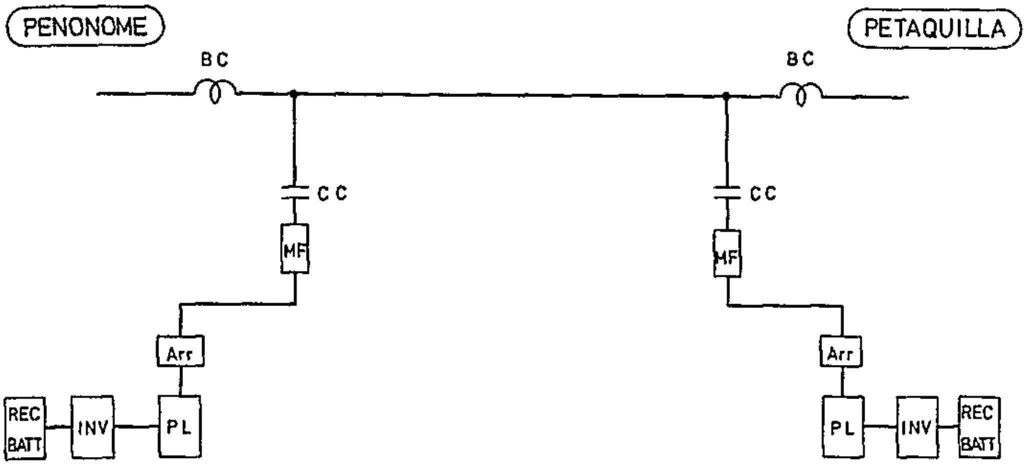


Fig. IV-2-7 Power Line Carrier System of Petaquilla Mine Line

3. CONSTRUCTION WORKS AND COSTS

3-1 Quantity of Materials

1) Transmission Line

For the Petaquilla Mine Line from the Penonomé Substation to Petaquilla Mine, the transmission line using steel towers and the alternative plan using wooden poles are proposed. Quantity of material to be used is as shown in the table below.

Item	Steel tower line	Wooden pole line (alternative)
Voltage	115 KV	
Number of circuit	1 circuit	
Conductor	ACSR 266.8 KCM	
Overhead ground wire	1	2
Supporting structure	Steel tower	Wooden pole (H type)
Arrangement	Triangular	Horizontal
Standard span	300 m	200 m
Distance	63 km	65 km

2) Outgoing of 115 KV transmission line (at Penonomé Substation) For one circuit

3) Maintenance communication system (3/6 ch) superposed on 115 KV transmission line 1 set
(For Penonomé and Petaquilla terminal stations)

3-2 Trnasportation and Custody of Materials

1) Packing and weight

a) Steel tower line

Main material	Quantity	Weight (ton)	Packed condition
Steel tower	210	756	Bound with steel belt
Conductor	195 km	106	Drum
Insulator	6560 pcs	33	Wooden frame
Ground wire	65 km	22	Drum
Line hardware	1 set	6	Wood box
Others	1 set	50	
Total		973	

b) Wooden pole line

Main material	Quantity	Weight (ton)	Packed condition
Wooden pole	650	880	Bulk
Conductor	201 km	110	Drum
Insulator	10300 pcs	52	Wooden frame
Line hardware		12	Wooden box
Arm, brace		190	Bound with steel belt
Others		60	
Total		1304	

Steel tower materials, arms and braces are bound with steel belt to prevent from getting loose during transportation. Conductors and earth wires are wound on the drum specified for export and insulators are packed in the wood frame (six insulators in one frame).

2) Transportation of materials

After the disembarkation, materials are transported on land by the trucks.

From Panama and Colon Port to Penonomé City, Pan American Highway runs, ensuring problems-free transportation of heavy materials. For the route from Penonomé to Llano Grande, it is assumed that the road has already been improved to a certain extend for the purpose of mine development.

It is also assumed that the road from Llano Grande through Coclesito to Petaquilla has been newly constructed and repaired for the mine development.

3) Custody of materials and storehouse

Construction work is divided into several sections, and these construction sections are executed simultaneously. Since these sections are distributed at a long distance, one stockyard will be provided for each section.

The stockyard is fenced, and the storehouse functioning also as a site office is constructed to store and control small size materials and construction vehicles and tools. The yard is constructed in Penonomé and Coclesito, where the access road and yard site are easy to obtain. Outline of the yard is shown in the table below.

Location	Site area	Storehouse area
Penonomé	1400 m^2	50 m^2
Coclesito	1400 m^2	50 m^2

3-3 Working Plan

1) Construction method and managing formation

Construction of transmission line is planned principally on the man-power base. This method ensures utilization of regional labor power as much as possible. Besides, introduction of large size construction machines is not always economical for this small work and their transportation is difficult. For the survey, design, and stringing work, which require high technology and skillness, foreign engineers will have to be introduced.

Type and details of each work, gang formation, and number of workers are shown in Table IV-3-1.

* Foundation work for steel tower: Steel foundation is adopted, thus only the excavation, installation, and back filling are necessary. Because of work amount thus reduced as compared with the concrete foundation, use of construc-

tion machine is not planned.

- * Erection work of steel tower: Because of lightweight, the steel tower can be assembled by using a gin pole.
- * Stringing work: Tentioner, stringing car, and common bundle blocks are used.
- * Erection work of wooden pole: Since long poles are used, stepped excavation is made to erect the pole. For the erection, "gin pole" is used. For the transfer from the road up to the site, the use of livestock and engine winch is planned.

Table IV-3-1 Number of Staffs

Steel tower transmission line (man-day)

Job	Number of gangs	Total
Measurement and investigation	4	3,969
Foundation	10	21,420
Erection	6	5,260
Stringing	4	9,040
Outgoing point of transmission line	1	500
Total		40,189

Wooden pole transmission line (man-day)

Job	Number of gangs	Total
Measurement and investigation	4	3,275
Supporting structure	12	13,530
Stringing	4	10,848
Outgoing point of transmission line	1	500
Total		28,153

2) Construction schedule

a) Steel tower transmission line

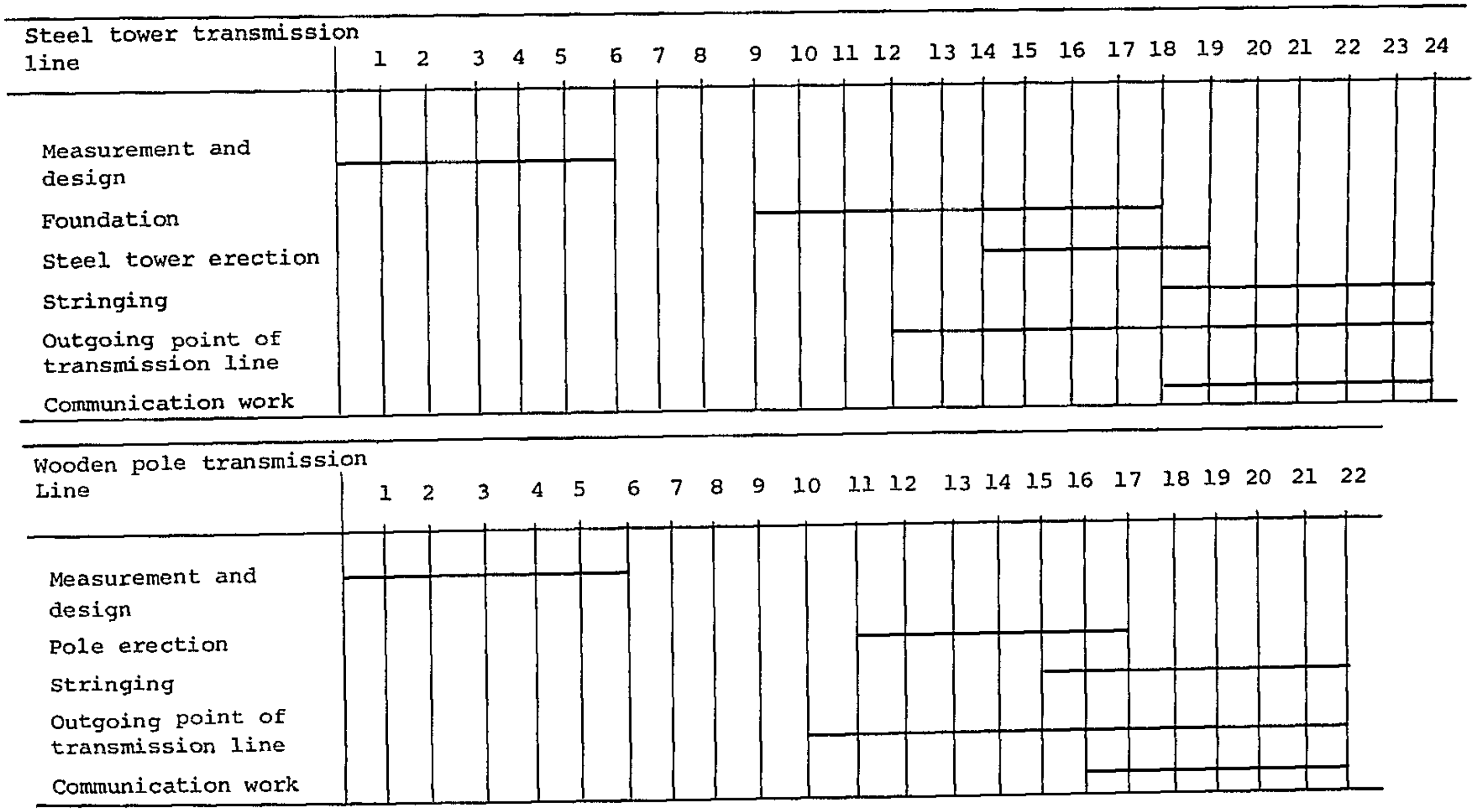
Period from the completion of survey and design up to the delivery of tower substructure members to site is estimated at 3 months. Foundation work is considered completed by the time the stringing work is started.

b) Wooden pole transmission line

Period from the completetion of survey and design up to the start of construction work is estimated at 5 months. It is also estimated that the delivery of wooden poles requires about 5 months at least. As regards a large number of materials required for the erection of poles, it would take longer period than 5 months to prepare them in full quantity. Consequently, it would often be necessary to specify the supplier at early period.

Table IV-3-2 shows the schedule of construction of transmission line.

Table IV-3-2 Rough schedule of construction



3-4 Construction Cost

First the standard construction cost per 1 km of transmission line is calculated, which is further multiplied by the distance of transmission line to obtain the total construction cost. Table IV-3-3 and IV-3-4 show the standard construction cost per 1 km of transmission line (with steel tower and wooden pole). Construction cost is also calculated for the outgoing point (one-circuit) according to the IRHE specification and on two terminal stations in Pononomé and Petaquilla for the maintenance communication line. Transmission outgoing point construction cost and the maintenance communication equipment installation cost per terminal station are shown respectively in Table IV-3-5 and IV-3-6. On the basis of IRHE budget plan, the contingency cost, engineering fee, and administrative cost, each equivalent to 10% of direct cost, are included in the construction cost for the transmission outgoing point and the maintenance communication circuits.

1) Premise on computation of construction cost

Major construction cost items (material and equipment cost, labor cost, inland transportation cost) are calculated on the condition detailed below.

* Material cost

Cost is calculated on the basis of CIF price as of the end of 1979. Import duties are not included. In the calculation of this cost, IRHE's record (1978) and the manufacturer's rough quotation were referred to.

* Labor cost

Cost is calculated on the basis of actual record in the construction of David - Santa Maria 230 KV Transmission Line while taking the escalation rate up to the now. In the calculation of material and equipment cost and Labor cost, the Panama construction price list (Camara Panameña de la Construcciõn, Lista Deprecios de Materiales de Construccioñ) was referred to.

* Inland transportation cost

10% of CIF price of construction material

* Spare parts

0.4% of construction material cost

* Contingency cost

10% of direct cost for both foreign and domestic portions

* Engineering fee and administrative cost

Respectively 10% of direct cost

Table IV-3-3 Construction Cost of Petaquilla Mine Line
(per km, steel tower)

	$
Material cost	23,984
Conductor	2,432
Insulator	609
Steel tower	20,110
Others	833
Labor cost	16,593
Inland transportation cost (Material cost x 10%)	2,398
Temporary construction cost (Labor cost x 10%)	1,659
Measurement and design	4,170
Spare parts	100
Total	48,904
Contingency cost	4,890
Engineering fee	4,890
Administrative cost	4,890
Grand total	63,574

Source: Survey Mission

Table IV-3-4 Construction Cost of Petaquilla Mine Line
(per km, wooden pole)

	$
Material cost	17,626
Conductor	2,431
Insulator	955
Wooden pole	4,903
Others	9,336
Labor cost	13,248
Inland transportation cost (Material cost x 15%)	2,606

Temporary construction cost (Labor cost x 10%)	1,325
Measurement and design	3,750
Spare parts	80
Total	38,635
Contingency cost	3,864
Engineering fee	3,864
Administration cost	3,864
Grand total	50,227

Source: Survey Mission

Table 4-3-5 Construction Cost of Outgoing Point of Petaquilla Mine Line (115 KV one circuit)

$\$10^3$

Material cost		167
Gas circuit breaker	1 set	64
Disconnecting switch 120 KV 800 A, manual operation with earthing device)	1 set	21
Disconnecting switch 120 KV 800 A, manual operation	1 set	18
Outdoor steel structure	1 set	6
Distribution board (instrument panel)	1 panel	10
Distribution board (protective relay panel)	1 panel	16
Pipe bus bar, others	1 set	15
Spare parts, small materials and others	1 set	17
Contract work cost	1 set	96
Labor cost	1 set	63
Transportation cost		25
Temporary work cost		8
Total		263
Contingency cost	1 set	26
Engineering fee	1 set	26
Administrative cost	1 set	26
Grand total		341

Source: Survey Mission

Table IV-3-6 Construction Cost of Power Line Carrier Telephony of Petaquilla Mine Line (for one terminal station) $\$10^3$

Material cost		46
Power line carrier telephony terminal equipment	1 set	15
Constant voltage constant frequency power supply (CVCF) 1 KVA (including rectifier and battery)	1 set	20
Coupling capacitor 115 KV 0.02 μF	1 set	6
Blocking coil 300 A	1 set	2
Coupling filter	1 set	2
Coaxial cable and small materials	1 set	1
Contract work cost		6
Installation of power line carrier telephony terminal equipment	1 set	1
Installation of coupling capacitor	1 set	5
Total		52
Contingency cost	1 set	5
Engineering fee	1 set	5
Administrative cost	1 set	5
Grand total		67

Source: Suvey Mission

2) Foreign portion and domestic portion

The scope of foreign portion and domestic portion of the construction cost is as follows.

a) Foreign portion

* Materials and equipment, steel tower, insulator, conductor, wooden pole, etc.

* Measurement and design

* Engineering fee

* Spare parts

* Part of temporary work cost

b) Domestic portion

* Labor cost (all except for stringing cost)

* Inland transportation cost

* Most of temporary work cost

* Contingency cost and administrative cost

Table IV-3-7 shows the foreign and domestic portions for each equipment.

Table IV-3-7 Construction Cost of Petaquilla Mine Line (foreign and domestic portions)

$10³

Item	Total	Foreign portion	Domestic portion
Steel tower			
Transportation line	4,004	2,505	1,499
Outgoing point of trnas-mission line	341	225	116
Maintenance communication system	134	92	42
Total	4,479	2,822	1,657
Wooden pole			
Transmission line	3,315	2,196	1,119
Outgoing point of transmission line	341	225	116
Maintenance communication system	134	92	42
Total	3,790	2,513	1,277

Source: Survey Mission

3) Construction cost by year

Assuming that two years are necessary from the measurement and design up to the completion, the construction cost (total by equipment) by year is as shown in Table IV-4-6.

Table IV-3-8 Construction Cost by Year of Petaquilla Mine Line

$10³

Item	Total	- 1 Year	Year of commissioning
Steel tower			
Transmission line	4,004	1,275	2,729
Outgoing point of transmission line	341	225	116
Maintenance communication circuit	134	-	134
Total	4,479	1,500	2,979
Wooden pole			
Transmission line	3,315	1,961	1,354
Outgoing point of transmission line	341	225	116

Maintenance communication circuit	134		134
Total	3,790	2,186	1,604

Source: Survey Mission Refer to Appendix 4.

4) Total construction cost

Total construction cost for steel tower and wooden pole is as shown in the table below.

$\$10^3$

Kind of work	Steel tower	Wooden pole
Total construction cost	4,479	3,790
Transmission line	4,004	3,315
Outgoing point of line	341	341
Maintenance communication circuit	134	134

Source: Survey Mission

APPENDIX 1

Power Supply to Coclesito Mining Town

Following three plans may be considered for the power supply to Coclesito Mining Town.

1) Plan to T-branch the 115 KV Petaquilla Mine Line at Coclesito and to construct a 115/13.5 KV, 2000 KVA substation there
2) Plan to construct the 34.5 KV 1/0 AWG distribution line (35 km) from La Pintada near Penonomé
3) Plan to increase the capacity of Petaquilla Mine Substation by 2500 KVA to 27,000 KVA and to construct 34.5 KV 1/0 AWG line (15 km) from its tertiary side to Coclesito.

Table 1-1 shows the rough estimation of construction cost for each plan. (For the construction cost used in economical comparison, the estimates and IRHE records in 1979 are used.)

Comparison result shows that the construction cost is lowest in Case 3 and no particular difference is observed between Case 1 and Case 2. In Case 3, however, the power is taken from the tertiary side of main transformer of a large customer and thus the particular agreement must be concluded between the mine and IRHE.

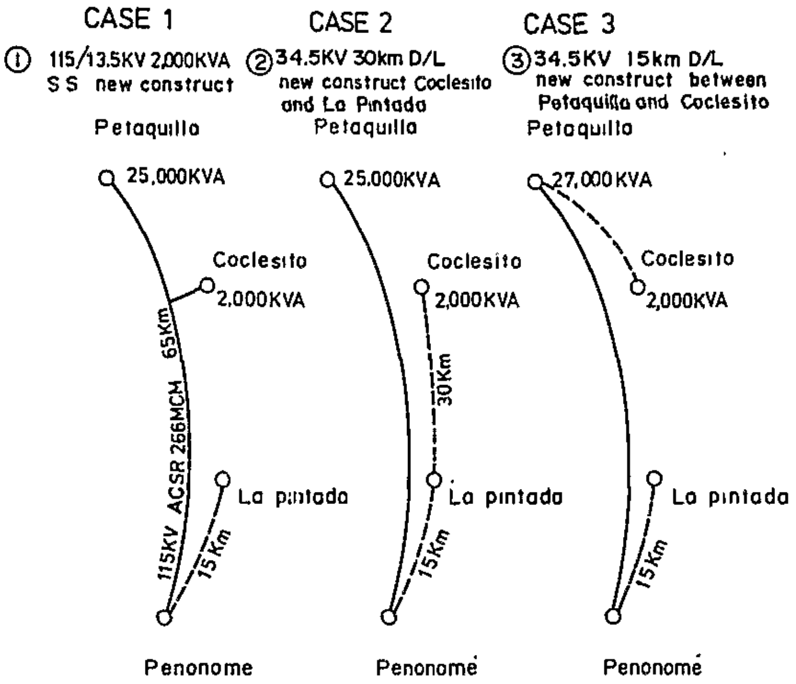


Table 1-1 Construction Cost (10^6 Yen)

Facilities	Case 1	Case 2	Case 3
115/13.5 KV 2000 KVA substation	145	-	-
34.5 KV 1/0 AWG distribution line	-	116	50
34.5/13.5 KV 2000 KVA substation	-	24	24
Petaquilla substation (capacity increment)	-	-	11
Total	145	140	85

Source: Survey Mission

In case 1, the primary side voltage is very high for the substation capacity. Consequently, the protective devices (circuit breaker, protective relay) become extremely expensive as compared with the price of main transformer in the substation. Table 1-2 shows the typical value of Case 1.

Table 1-2 Ratio of Construction Cost

Substation	Voltage	Capacity	Main transformer	Others	Remarks
Petaquilla	115/34.5KV	20,000KVA	30%	70%	Development plant
Coclesito	115/34.5KV	1,000	2	98	Metal Mining Agency of Japan
ditto	115/13.5KV	2,000	10	90	Trial calculation this time
ditto	34.5/13.5KV	2,000	40	60	ditto

Source: Survey Mission

In the case of substation of primary voltage 115 KV and 1000 - 2000 KVA capacity, the price of main transformer (main component) occupies only 2 - 10% of total construction cost and the ratio occupied by protective devices and attached devices appears to be found very high. As compared with this, the substation of primary voltage 34.5 KV and 2000 KVA capacity ensures well-balanced design: ratio between the main transformer price and other equipment price is 40 : 60.

If the 115 KV and 1000 - 2000 KVA substation is to have the same economical feasibility as the 34.5 KVA substation, the protective relay and circuit breaker must be omitted. This in turn causes low service reliability, possibly resulting in the deterioration of reliability of system as a whole. As far as the situation permits, any electric enterprise tends to avoid the high-voltage small-capacity substation.

From the viewpoint of manufacturing the transformer, the transformer of extremely high voltage and small capacity or that of low voltage and extremely large capacity is not economically advantageous.

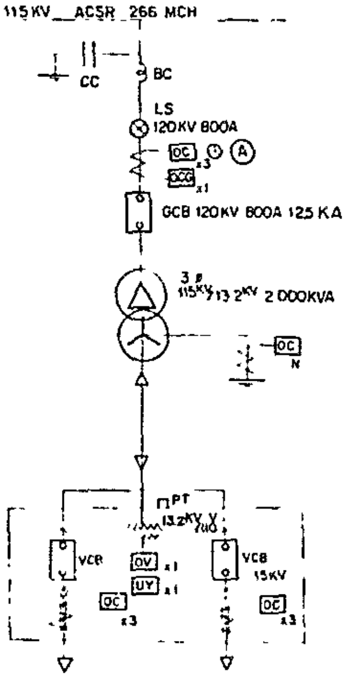
Standard transformer currently manufactured has the relationship between the high-tension side voltage and capacity as shown below.

High-tension voltage (KV)	Transformer capacity (KVA)
6	5 - 2,000
11.22 and 33	750 - 5,000
66 and 77	3,000 - 30,000

Source: Electrical Engineering Hand Book (JIEE, 1979)

It may be concluded that the construction of 115/13.5KV, 1000 - 2000 KVA substation is expensive and disadvantageous in terms of manufacturing, protective devices and service reliability.

Single Line Connection Diagram of Coclesito Substation



Construction Cost of Coclesito Substation $\$10^3$

Material cost		
Main transformer 3-phase 115KV/13.2KV, 2000KVA	1	15,000
Gas circuit breaker 120 KV 12.5 KA 800A	1	16,000
Disconnecting switch 120 KV 800A, manual operation, with earthing device	1	5,250
Current transformer 100/5A	3	11,500
11.5 KV cubicle, 2 stage for two circuits	1	5,200
Distribution board (for transformer line)	1	4,000
Distribution board (for main transformer)	1	4,000
Battery 48 V 100 Ah	1	500
Charging device	1	1,000
Blocking coil	1	500
Coupling capacitor	1	2,500
Dead-end steel structure	1 set	900
Power line carrier equipment	1	8,000
Remote control system (two ways)	1	45,000
Others		5,650
Total		125,000
Contract work cost		20,000
Grand total		145,000

Source: Survey Mission

APPENDIX 2

How to determine the number of main wires of private branch-exchange (PBX).

According to the standard of Nippon Telegraph and Telephone Public Corporation, the number of main wires of private branch-exchange (PBX) must be above the values in table 2-2 in correspondence to the bothway basic number of calls.

Note: Bothway basic number of calls means the traffic by taking the average of number of calls for 30 days (from annual max. number of calls to 30th of them), or its estimated number of calls. The number of calls applies to the continuous ten hours of a day when the annual average is the largest.

In the recent Japan, the average number of calls for office is about 0.15 Erlag, with the width of 0.13 - 0.17 Erlang. In the case of office, the traffic concentrates to a specific time period, with sharp peak in the busiest time. Contrary to this, the local telephone line covers many and unspecified subsribers and the diversity produces nearly uniform peak. On the basis of the case of Japanese offices, the number of main wires may be calculated at 20 wires for the 100 extension lines.

However, this result cannot be applied to the mines in Panama. Average number of calls in Panama (in the mine particularly) was not available, and here the number of main wire is estimated by using the actual average number of calls of Japanese electric power company (as of 1965).

Number of extension subsribers 100

By referring to the number of calls in Table 2-1, the outgoing traffic and terminating traffic of main wire is 0.5 HCS per subscriber. Accordingly, the traffic in the case of 100 extension subsribers, 0.5 HCS outgoing traffic and 0.5 HCS terminating traffic is

(0.5 + 0.5) x 100 = 100 H.C.S.
100 HCS/36 = 2.78 Erlang

From Table 2-2, the number of main wires which is nearest and above 2.78 is determined at 6 main wires.

Table 2-1 Reference Traffic

		Between extensions	Outgoing from private line	Terminating to private line	Outgoing from exchange line	Terminating to exchange line	Private line tandem	Total
Subscriber	Main office	1.0	2.0	1.5	0.5	0.5	1.0	6.5
	Branch office	1.0	1.5	1.5	0.5	0.5	1.0	6.0
	Business office	0.5	1.5	1.5	0.5	0.5	0.5	5.0
	Power plant & substation	0.2	0.9	0.9	-	-	-	2.0
Mean holding time		100	200	200	100	100	200	-

Source: Tohoku Electric Power Co., Ltd.
Note: Private line includes connected subsriber line.

Table 2-2 Calculation Chart for Number of Main Wires

Number of main wires	Traffic	Number of main wires	Traffic	Number of main wires	Traffic	Number of main wires	Traffic
1	0.11	5	2.43	9	5.43	13	8.26
2	0.53	6	3.15	10	6.22	14	8.96
3	1.10	7	3.90	11	6.88	15	9.69
4	1.75	8	4.66	12	7.56	16	10.40

Source: Nippon Telegraph and Telephone Public Corporation

Note: 1) Traffic is expressed in Erlang.

2) When the traffic exceeds 10.40 Erlang, the number of main wire is calculated as follows:

$$N = \frac{a}{0.65}$$

Here, a: Traffic (Erlang)
N: Required number of main wires

APPENDIX 3

Breakdown of transmission construction cost for foreign portion and domestic portion (Wooden pole)

$\$10^3$

Item	Total	Foreign portion	Domestic portion
Material cost	1,164	1,164	
Conductor	161	161	
Insulator	63	63	
Wooden pole	324	324	
Others	616	616	
Labor cost	874	524	350
Transportation cost	172		172
Temporary work cost	87		87
Measurement and design	248	248	
Spare parts	5	5	
Total	2,550	1,941	609
Contingency cost	255		255
Engineering fee	255	255	
Administrative cost	255		255
Grand total	3,315	2,196	1,119

Source: Survey Mission

Breakdown of transmission construction cost for foreign portion and domestic portion (steel tower)

$\$10^3$

Item	Total	Foreign portion	Domestic portion
Material cost	1,510	1,510	
Conductor	153	153	
Insulator	38	38	
Steel tower	1,267	1,267	
Others 1)	52	52	
Labor cost	1,045	2) 418	627
Transportation cost	151		151
Temporary work cost	105		105
Measurement and design	263	263	
Spare parts	6	6	
Total	3,080	2,197	883

Continued

Contingency cost	308		308
Engineering fee	308	308	
Administrative cost	308		
Grand total	4,004	2,505	1,499

Source Survey Mission

Note: 1) Line hardware, accessories, overhead ground wire
2) Only stringing is included in foreign portion (40%)

Breakdown of outgoing point construction cost for foreign portion and domestic portion

$\$10^3$

Item	Total	Foreign portion	Domestic portion
Material cost	167	167	
Contract work cost	63	30	33
Transportation cost	25		25
Temporary work cost	8	6	2
Total	263	199	64
Contingency cost	26		26
Engineering fee	26	26	
Administrative cost	26		26
Total	341	225	116

Source: Survey Mission

Breakdown of maintenance communication facilities construction cost for foreign portion and domestic portion

$\$10^3$

Item	Total	Foreign portion	Domestic portion
Material cost	92	92	
Contract work cost	12		12
Administrative cost	10		10
Transportation cost	10		10
Contingency cost	10		10
Total	134	92	42

Source: Survey Mission

APPENDIX 4

Breakdown of construction cost per year (steel tower) $\$10^3$

Item	Total	-1 year	Year of commissioning
Measurement and design	263	263	
Labor cost	1,045	157	888
Foundation	470	157	313
Steel tower erection	167		167
Stringing	408		408
Material cost	1,510	422	1,088
Conductor	153		153
Insulator	38		38
Steel tower	1,267	422	845
Others	52		52
Transportation cost	151	75	76
Temporary work cost	105	50	55
Spare parts	6		6
Total	3,080	967	2,113
Contingency cost	308		308
Engineering fee	308	154	154
Administrative cost	308	154	154
Grand total	4,004	1,275	2,729

Source: Survey Mission

Breakdown of constructive cost by year (wooden pole) $\$10^3$

Item	Total	-1 year	Year of commissionig
Measuring and design	248	248	
Labor cost	874		
Supporting structure	353	86	272
Stringing	516		516
Material cost	1,164	1,164	
Conductor	161	161	
Insulator	63	63	
Wooden pole	324	324	
Others	616	616	

Continued

Transportation cost	172	80	92
Temporary work cost	87		87
Spare parts	5		5
Total	2,550	1,578	972
Contingency cost	255	127	128
Engineering fee	255	127	128
Administrative cost	255	129	126
Grand total	3,315	1,961	1,354

Source: Survey Mission

Breakdown of outgoing point construction cost by year $\$10^3$

Item	Total	-1 year	Year of com-missioning
Material cost	167	80	87
Contract work cost	63	30	33
Transportation cost	25	12	13
Temporary work cost	6	3	3
Contingency cost	2		2
Total	263	125	138
Contingency cost	26	13	13
Engineering fee	26	13	13
Administrative cost	26	13	13
Grand total	341	164	177

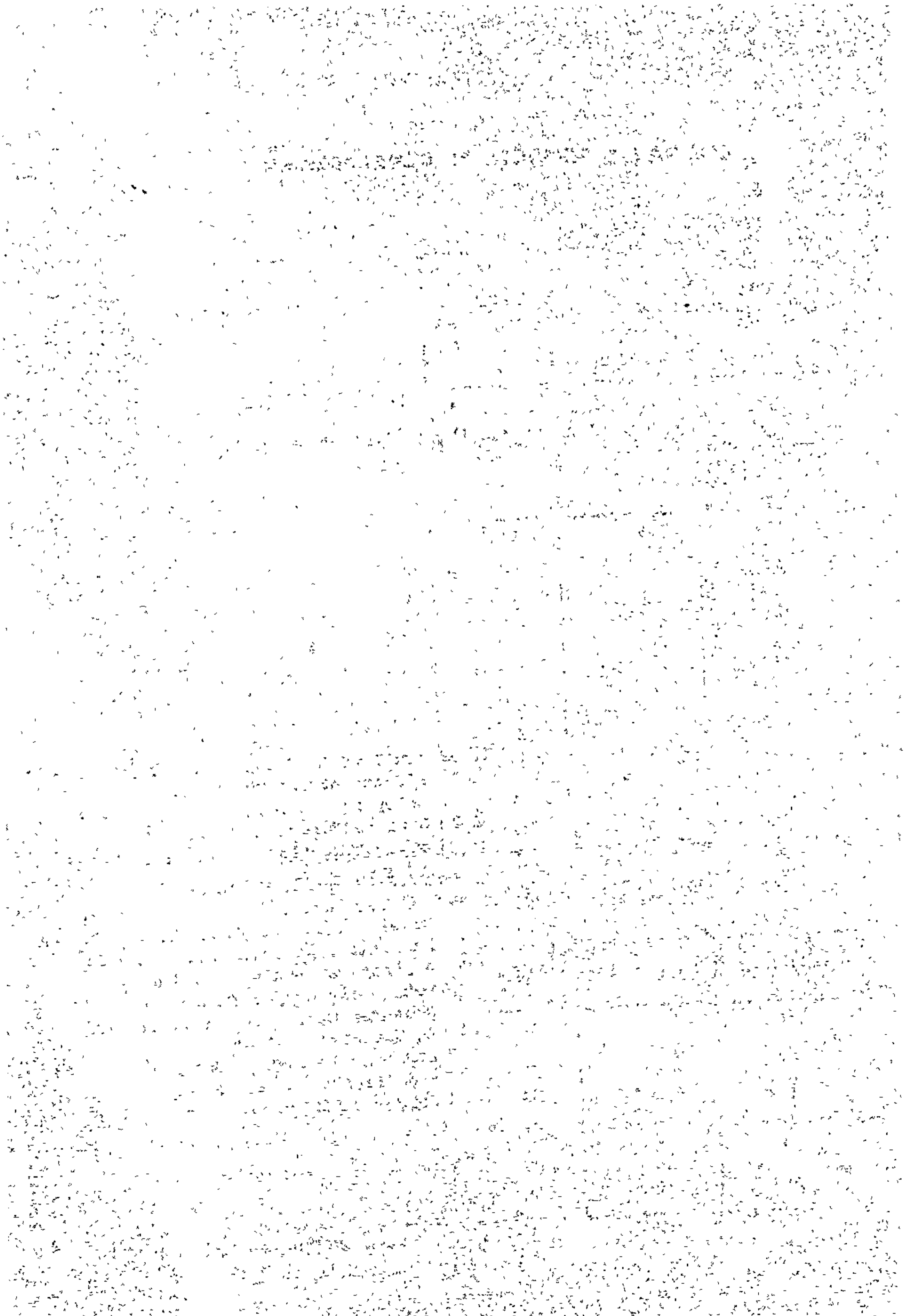
Source: Survey Mission

Breakdown of manitenance comminication facility construction cost by year $\$10^3$

Item	Total	-1 year	Year of com-missioning
Material cost	92		92
Contract work cost	12		12
Administrative cost	10		10
Transportation cost	10		10
Contingency cost	10		10
Grand total	134	0	134

Source: Survey Mission

CHAPTER V EFFECTS OF DEVELOPMENT



CHAPTER V

EFFECTS OF DEVELOPMENT

1. REGIONAL EFFECTS

1-1 Effects during the Period of Operation

1) The Effects on Regional Government Finances

According to "Laws of Panama" (Univ. of Panama School of Law and Political Science, 1974), the regional taxation system in the Republic of Panama takes the form described below:

a) Sales taxes on imported goods

b) Taxation on automobiles and automobile registration

c) Other taxes (e.g. business taxes on barber shops, cinema taxes, dog taxes)

The Petaquilla copper mining development, therefore, will not be a major factor in enriching regional finances.

2) Effects in the Form of Stimuli to Regional Economies

According to Panama Mineral Resources Development Co., Ltd., expenditure inside Panama during the period of operation, averaged over 20 years, will be as follows (1977 prices):

Table V-1-1 Expenditure inside Panama during the Period of Operation

Wages and salaries	4,980 x $\$10^3$
Fuel, oil	2,485 x "
Slaked lime	1,027 x "
Other commodities	672 x "
Electricity	5,298 x "
Other costs	877 x "
Sub-total	15,399 x "
Transportation of concentrate	1,544 x "
Shipping expenses	724 x "
Replacement or additional investment	1,444 x "
Total	19,051 x "

Source: Panama Mineral Resources Development Co., Ltd.

Of this expenditure, it is "wages and salaries", "other commodities", "other costs" and "transportation of concentrate" which will have a direct impact on regional economies. According to a field survey in Canada, the multiplier effect on the per household income of mine-workers is 1.79. Although the way of life of Canadians is hardly the same as that of Panamanians, the survey was carried out in Nova Scotia, and the fact that this is an outlying and geographically isolated region of Canada suggests that there would not be a major difference in the multiplier effect. The regional impact from wages and salaries, therefore, would come to $\$4,980 \times 1.79 \times 10^3$ or $8,914.2 \times 10^3$. The expenditure on transportation of concentrates also includes wages and salaries, but since it is not possible to separate these here, the multiplier effect will be disregarded.

Also, it is assumed that the contribution to the regions in the form of added value on expenditure other than wages and salaries will be 20% for "other commodities",

30% for "other costs" and 40% for "transportation of concentrate". On the basis of these suppositions, the contribution to the regional GDP may be calculated as follows:
$(4,980 \times 1.79 + 672 \times 0.2 + 877 \times 0.34 + 1,544 \times 0.4) \times 10^3$
$= \$9,929.3 \times 10^3$

Provincial GDP, which is an indicator of economic activity in the regions concerned, is as set out in Table V-1-2. However, since it was not possible to obtain the overall GDPs of the various provinces, the ratios of provincial to national figures for per capita GDP were obtained from MIPPE (op. cit.), and on the assumption that these ratios have not changed drastically in recent years, GDPs were computed using national GDP, overall population and provincial GDP figures. This assumption is supported by the fact that the percentage of gross domestic product occupied by primary production has remained stable at around 16% since 1970.

Table V-1-2 Estimated Provincial GDP ('77)

	GDP ($\$10^3$)	Pop.	Per Capita GDP ($)
Coclé	39,336	141,150	279
Herrera	22,708	82,060	277
Los Santos	23,213	73,790	315
Total	85,257	297,000	287

Sources: MIPPE (op. cit.)
Contraloria General de la Republica, Panama en Cifras, Años 1974 a 1978, Noviembre de 1979.

Compared to an estimated GDP('77) of $\$39,336 \times 10^3$ for Coclé Province (Donoso County in Coclé Province has mines, but since its GDP can be disregarded because of its isolation, it will not be included), the estimated overall impact will be $\$9.929 \times 10^3$, or $\$8,074 \times 10^3$ when converted to 1977 prices (according to IMF, International Financial Statistics 1980, Vol XXXIII, No.1, and Panama wholesale price indices). The gross product of the region will thus be multiplied by a factor of (39,336 + 8,074) ÷ 39,336, i.e. 1.205 times as a result of the Petaquilla copper mining development. The impact will be especially strong in Coclesito, while Penonomé's involvement will probably take the form of substituting functions which cannot be carried out in Coclesito.

3) Effect on Employment

According to the F/R of Panama Mineral Resources Development Co., Ltd., the average number of workers employed during operations at Petaquilla will be as shown in Table V-1-3.

Table V-1-3 Personnel Program

			Japanese	Staff	Workers	Total
Department	Production	Mining	8	39	217	264
		Concentration	5	15	68	88
		Maintenance	8	35	288	331
		Total	21	89	573	683
	Administration		11	64	108	183
	Total		32	153	681	866
Area	At mines		28	131	657	816
	Azuelo Port		0	4	20	24
	Panama City		4	18	4	26
	Total		32	153	681	866

Source: Panama Mineral Resources Development Co., Ltd.

Another factor directly affecting employment will be the requirement for workers in the trucking of concentrates. According to the F/R, this sector of the work is to be contracted to out side operators. The average volume transported per day will be 400-480 tons, over a distance of 187 km between the mines and the port of Azuero.

Ten ton trucks will be used, and assuming that average speeds will be 30 km/h loaded and 45 km/h unloaded, that the combined period of time required for loading and unloading will be 1 hour and allowing for a lunch break of 1 hour, 12.4 hours will be required for each return trip. The daily capacity for each truck, therefore, given a loading ratio of 0.8, may be regarded as being 8 tons. With the mines requiring a daily transportation capacity of 480 tons, therefore, 60 trucks would be used exclusively. The number of drivers would be 1.3 times the number of trucks required, with a similar number of assistants. When 10 maintenance and clerical personnel are taken into account, the number of people employed in transportation comes to 166 (fractions rounded upwards).

The number of people involved in mining, excluding Japanese staff and employees at the headquarters in Panama City and at the port of Azuero and including those employed in transportation, will be 954. According to forecasts quoted in MIPPE (op. cit.) as being estimates by Augustjne Garcia, the population of Coclé Province will be 153,942 in 1980 and 172,985 in 1990. According to En Cifras, the working population comprises 55.8% of the total population over the age of 15. On the other hand, according to "Contraloria General, Estimacion de Indícadores Demograficos de la Repulbíca de Panama para el Periodo 1950-1970 y Proyecciones de Poblacion pov Sexo y Grupos de Ecades, Anõs 1960 al 2000", the ratio of the population over the age of 15 to the total population will be 0.5754 in 1980 and 0.5669 in 1990 on the basis of maximum population growth. These figures overestimate the working population, or, in other words, underestimate the effect of mining development on employment, and thus represent a hypothesis with a wide margin for error. On this basis, the number of people requiring employment throughout Coclé Province will be 88,579 in 1980 and 98,066 in 1990. The increase over this ten-year period, therefore, will be 9,487.

The number of employment opportunities provided directly by mining will be 954. However, this number will be increased greatly by the addition of indirect employment opportunities such as those provided by the development of commerce, mainly in Coclesito, by the transportation activities required to support this and by the demand for domestic help. No survey has ever been made of the total pervasive effect in the formal and informal sectors resulting from the employment of one unit in the formal sector. We will therefore use the results of the survey carried out in Nova Scotia, which yielded an indirect employment coefficient of 1.92 for each unit of direct employment. On the basis of this supposition, the number of people finding direct or indirect employment opportunities through mining activities will be 1,832.

Thus, of the 9,487 job opportunities which will needed in Coclé by 1990, mining will provide 954 direct opportunities (10.1%), or 1,832 (19.3%) with the inclusion of indirect opportunities.

4). Effects on Regional Development

The effect on regional developments can be broadly divided into growth in the area around Coclesito and development along the La Pintada - Coclesito road.

a) Growth in the Area around Coclesito

As already described elsewhere, Coclesito is a community of about 850 people and was planned and settled as a collective ranch. At present, while work continues on the conversion of forests into pasture, cattle are being grazed on pasture already formed. Work has only just begun on the development of pasture for the collective ranch, so there are only a few scattered fields of cassava and maize (mainly in the valleys) for home consumption. With regard to the siting of housing for the workers needed for the mining development, it is the basic policy of the present

Panamanian Government that the Government will choose the site and prepare and sell the housing. Judging from this policy, it is reasonable to assume, considering such factors as the circumstances surrounding the construction of Coclesito, its distance from the mines, and local conditions, that the housing will be sited around Coclesito.

We discuss the changes that are expected to take place in Coclesito in the event that housing for mineworkers is built there. We make two assumptions in this connection: the first is that since the people currently living in Coclesito are all restricted to working for the collective ranch, the personnel required for the mining operations may be regarded in calculations as a net increase to the population; the second is that since temporary quarters will be built on site for the preparatory work, the effect on Coclesito will be negligible.

As stated earlier, the average number of workers (including Japanese) at the mines will be 816. The addition of 166 employees of transportation operators gives a total of 982 people employed directly in mining acitivities. The overall number of those employed directly and indirectly will be 982 multiplied by 1.92, i.e. 1,886. Assuming that each family consists of 5 members and that the ratio of single-person households is 20%, the net increase in population resulting from the mining activities will be 7,922.

The impact on the regional economy resulting from 7,922 net consumers arriving to settle there will be extremely big. It is difficult to discuss this question in a few words since the region has hinterlands. However, the number of shops in central Penonomé, which has a population of 9,000, is about 100. However, when the fact that the 9,000 population does not consist entirely of net consumer household and the fact that the inhabitants of the hinterlands are self-sufficient peasants are taken into account, one would expect a shopping center of only half or two thirds the size of that in Penonomé.

Seen in this light, it is obvious that the sudden appearance in uninhabited fields of Panama's 12th population concentration in excess of 5,000, and its commercial scale, will create an extremely big market, especially for agriculture - the main industry in the area in question.

Of course, this will have major effects on the operation of Coclesito's collective ranch. On the positive side, a market will be created in close proximity for the ranch's products and it will be possible to obtain daily necessities and investment for ranch activities more cheaply, quickly and easily than in the past. Also, even the vegetables which the ranch families grow in their gardens for home consumption will become cash crops, enhancing the economic self-sufficiency of these families. And there will be rapid improvements to the social infrastructure, including hospitals, schools, electrification, communications and roads.

Negative influences, on the other hand, include the fact that wage differences between the collective ranch families and the mine workers will weaken the motivation of these families towards participation in the ranch. Also, the location of a group of net consumers in the heart of the collective ranch, which is basically a self-sufficient economy, will give rise to a number of problems in relation to the operation of the ranch. These problems include the way in which the meat produced will be distributed to the participating families and the Coclesito market, and there is a danger that differences in management policies will lead to basic confrontations. Another negative influence will be the fact that if the participating families are able to obtain sufficient income by supplying home-grown produce to the market, their motivation to work for the collective ranch will diminish, making it impossible to carry out improvement work according to schedule.

In addition, we must also consider the effects that the influx and settlement of a new type of people will have on the Coclesito community. Needless to say, this community consists only of homogeneous elements, i.e. those involved in the collective ranch. An educated class, including foreigners, will establish itself in this context and introduce a sophisticated consumer life-style. To meet the needs of these high-income earners, a variety of facilities will be built and various commodities will go on sale. This urbanization phenomenon will accelerate divergences among the people involved in the collective ranch.

The most important point when considering the expansion of Coclesito is that unless it is government policy simply to develop it as a mining town and then abandon it when it is no longer needed, the economic activities made possible by the mining operations must be used to build Coclesito into a full-scale urban center for the collection and distribution of agricultural produce. By this we mean that Coclesito should be developed from a merchant's town simply serving the collective ranch and the mine accommodations, into a more complex urban center.

b) Development along the La Pintada-Coclesito Road

To ascertain the effects road development would have on the region we travelled by 4-wheel drive vehicle, covering all the drivable roads in the northern part of Coclé Province, along the coast of Coclé Province, and along the shore of Lake Gatun. The results are set out in Table V-1-4 while the roads covered are as shown in Figure V-1-1. In particular, data pertaining to the roads between La Pintada and Coclesito has been consolidated in Table V-1-5 and Figure V-1-2.

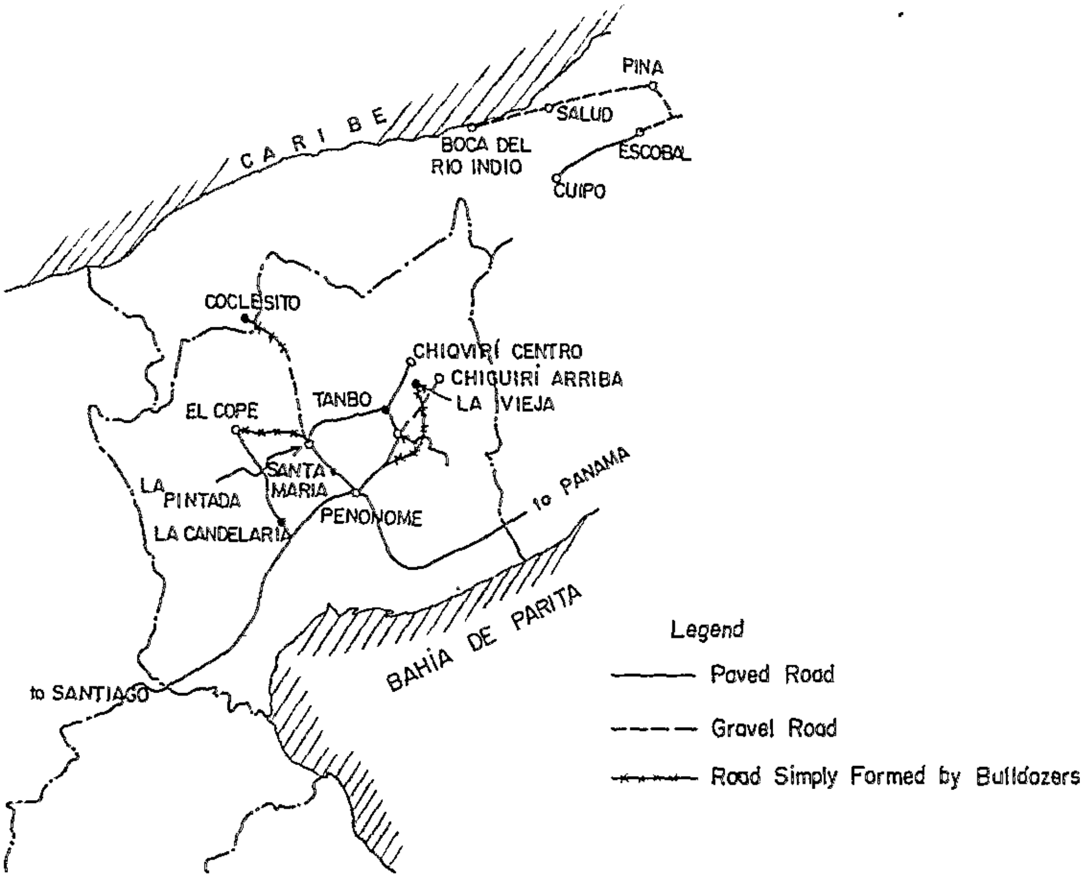


Figure V-1-1 *Roads Surveyed*

Table V-1-4 The State of Development along the Various Roads

Section	Road conditions	Development in adjacent areas
Pina → Boca del Rio Indio	Good gravelled road	∘Indios are living along the coast between Pina and Salud, and settlement of poor peasants is difficult. ∘Ranches are scattered here and there. Grass growth is clearly better (between Pina and Salud) than around Penonomé. ∘The area between Salud and Boca del Rio Indio is a region of oil palms.
Escobal ↕ Cuipo	The section between Gatun Lock and Escobal consists of good gravelled roads, and the contingent section from Escobal to Cuipo is sealed asphalt and concrete road.	∘The road as far as Escobal is reserved for the Canal Zone. ∘Although the road is still new, ranch development is already complete. ∘Gently sloping, grass conditions are very good for pasture. ∘Escobal and Cuipo are towns of a size consistent with their role as transportation centers.
Churuquita Grande ↕ Chiquiri Arriba	Asphalt for a certain distance from Churuquita Grande, then gravel road just passable by truck.	∘There are a large number of ranches along the asphalt section. ∘It is extremely rare to see a ranch once one enters the gravelled section. There are a few scattered subsistence farms using the slash-and-burn method. ∘There is a large amount of citrus cultivation, especially along the gravelled road. ∘Where the gravelled road begins the land becomes steep and hilly. Nevertheless, on flat areas, however small, primitive peasant households are established.

(Table V-1-4 cont'd)

Section	Road conditions	Development in adjacent areas
Penonomé ↕ Tambo ↕ La Pintada loop road	Sealed road	○There is some farmland scattered around villages but ranchland has been developed mainly along the road. ○A new road was recently opened between Taobré and Llano Grande (part of the Tambo-La Pintada section) but there are still few ranches established in the vicinity.
La Candelaria vicinity ↕ Penonomé	Sealed road (part of the Pan-American Highway)	○Ranches and farms are mingled together. At the time of the survey (January - the beginning of the dry season), sugar cane and solgum were under cultivation and there were also a large number of harvested maize fields.
La Pintada ↕ El Copé	Extremely bad. The road is 4-6 m wide and there are many steep grades. The road has not been maintained since its construction 12-13 years ago and is strewn with boulders. The section between La Pintada and Piedras Gordas is just passable by small truck, but the Piedras Gordas-El Copé section is impassable.	○There is little flat land. Yuca, corn, coffee, rice, sugar cane and oranges etc. are grown (mainly for home consumption) on impoverished farms with small acreages. ○People obtain cash income by going to work near La Pintada or Penonomé. ○The topography is harsh and there is almost no possibility of development.
El Copé ↕ Pan-American Highway crossroads (near La Candelaria)	Well-maintained road sealed with asphalt and concrete. (The terminal is at El Copé.)	○Ranchland has been developed alongside the road on a fairly large scale. ○Needless to say, the ranches become larger in the lowlands. ○However, we did not see particularly large numbers of cattle.

(Table V-1-4 cont'd)

Section	Road conditions	Development in adjacent areas
Churuquita Chiquita ↕ La Vieja	∘The approximately 2 km between Churuquita Chiquita and Pajonal Abajo consists of gravel road or blacktopped road and is passable to all vehicles. ∘The road becomes extremely bad from the village of Pajonal Abajo onwards and is only passable by tracked vehicle. ∘We left the jeep and went on on foot, but the road continued to be boulerstrewn.	∘There are ranches here and there until Pajonal Abajo. ∘There are a few scattered fields of maize, apparently for home consumption, but these are extremely wretched.
Tambo ↕ Chiquiri Centro	∘The road is gravelled for about 1 km out of Tambo and then becomes dirt road, only passable by 4-wheel drive vehicles in the dry season. Dusk fell as we approached the Rio Atré ford and we called a halt to the road survey. ∘According to the map, the distance from Tambo to Rio Atré ford is	∘The land is comparatively flat for about 1 km out of Tambo so the ranches actually have cattle. The ranches further on seemed to be in the process of being established and the only work being done was the erection of fences. ∘On the flat land there were orange orchards and pineapple plantations in the lowland areas, but these were on a small scale, and would be more accurately described as garden cultivation. ∘Housing varied from mud-walled houses thatched with palm leaves to mortar or stone houses roofed with corrugated iron.

(Table V-1-4 cont'd)

Section	Road conditions	Development in adjacent areas
	4 km as the crow flies - about half the distance to Chiquiri Centro.	

Table V-1-5 The State of Development along the La Pintada-Coclesito Road

Section	Road conditions	Development in adjacent areas
La Pintada ↕ Llano Grande	The 1:250,000 Geographic Survey map shows a place named "Llano Grande", both on the road from La Pintada to Toabré and on the road from La Pintada to Coclesito. For our purposes, "Llano Grande" refers to the place shown on the latter road.	○The land is flat and is being used for ranches. ○There are a few scattered estates.
Llano Grande ↕ Sabaneta de Llano Grande	Gravel road (in excellent condition)	○Cassava is relatively abundant on both sides of the road. There are settlers in the vicinity, and it seems that they secure their food supply initially with Cassava and change their crop later. ○There are scattered ranches.
Sabaneta de Llano Grande ↕ The highest point	The excellent gravel road continues until it crosses the ridged mountain range at an altitude of about 900m above sea level.	○There are ranches on land which is suitable, but such land is scarce since the topography is continuously complex right up to the ridgeline. ○There is little possibility of development.
The highest point ↕ Casacajal	Gravel road interspersed with red clay. The clay road is poor but passable by 4-wheel drive vehicle.	○As this is a mountainous region, there are only a few scattered slash-and-burn fields. ○There is hardly any land fit for ranching.

(Table V-1-5 cont'd)

Section	Road conditions	Development in adjacent areas
Cascajal vicinity	Gravel road	◦The topography is fairly open. ◦Ranches spread to the foot of the mountains. ◦There is little land for development.
Cascajal ↕ Rio Rancheria ford	The road is poor - passable only by 4-wheel drive vehicle.	The mountains are not very steep and there is more land fit for ranching, but development has not progressed very far.
Cascajal ↕ Rio Cutevilla ford (just before Coclesito)	We were frequently unable to go forward though we were in a 4-wheel drive vehicle in low gear.	◦Mountainous. There are no ranches or farms whatsoever. In just one place we saw fences being erected for use as pens on the site of a planned ranch. ◦There is one lumber mill.

The road survey described in Tables V-1-4 and V-1-5 was carried out over a three-day period in early January, 1980, using a Toyota Landcruiser. It is said that Panama's dry season normally begins in mid-December, but the rainy season this year was long and there had been heavy rain a week before the survey. On roads where the surface had been churned into mud we drove with our tyres continuously submerged to a depth of 40 cm in sludge. Although the record of our trip was better than it would have been in the rainy season, therefore, it was not made under dry season road conditions.

To add depth to the results of the survey from-the-point-of-view of the extent of development, we tried flying by helicopter over all the roads we had travelled, with the exception of those in Colon Province. However, we were unable to approach the mountain regions because of strong winds, and were only just able to survey the Penonomé ↔ Churuquita Grande and Penonomé ↔ Santa Maria sections. In other words, we did no more than examine the plain areas to the north of Penonomé City. Our observations on the lateral expansion of land usage as seen from the helicopter are set out below:

i) Isolated houses located in the plain areas are linked by natural paths which have developed as offshoots of main roads, and there is almost total utilization of the land.

ii) Most land utilization takes the form of ranches, but we saw quite large fields of maize here and there in low and marshy areas.

iii) These facts were not apparent when we travelled by car and there may be wider development in the mountainous areas than the road survey led us to believe.

As is apparent from the above tables, the state of road maintenance, and particularly the question of whether or not the road is sealed, has a major effect on development in the adjacent areas.

As can be seen from Table V-1-5, the La Pintada - Coclesito road is gravelled for half of its length while on the Coclesito side it is a clay road only passable by 4-wheel drive vehicles in the dry season (for details, see Chapter III of the section on road design). There is no doubt that the sealing of these roads would facilitate and enliven development in the adjacent areas. (For information concerning road improvement schemes, see Chapter III.)

The areas adjacent to roads are at present almost entirely scheduled for ranching, but the proportion in use as ranches is small.

It is known from the 1970 census that Panama has about 1 head of breeding livestock per hectare. If we regard the area of land along the 27 km of the road between Grande and Coclesito as having a width of 5 km on each side of the road, its area is 27 x 5 x 2 km^2. If half of this land is suitable for ranching, it has the potential to carry 13,500 head of breeding cattle. This represents 1% of the Republic of Panama's total number of breeding cattle (1,395,000) for the year 1978, and 15% of Coclé Province's 92,300 head.

The opening of an all-weather road between Llano Grande and Coclesito has the potential to make a major impact on the region, not so much through changing patterns of land usage as in stimulating them. As stated above, there are many examples of changes taking place in regions where road improvements have been carried out. Considering this fact, the abovementioned potentialities of all-weather roads seem to have a very high probability.

1-2 Effects during the Period of Construction

The conceivable effects during the period of construction are the effect on employment from the hiring of construction workers and the economic stimulus resulting from the procurement of materials locally. The effects during the period of construction, according to estimates by Panama Mineral Resources Development Co., Ltd. and the survey team, are summarized in Table V-1-6.

The majority of employees included in the employment effect will be laborers. Hence, the effect will take place locally, i.e. in Coclé Province. It is clear that the impact will be considerable when figures of 1,000 in the third year, 1,807 in the second year and 2,226 (if pylons are used for power transmission lines) in the first year before completion are compared to the 1970 unemployment figures for Coclé Province. (According to Contraloria General, Census Nacionales de 1970, Compendio General de Poblacion Volumen III.)

Over half of the effect of material purchases will be made up of wages and salaries. Gravel for concrete, and fuel etc. will be procured locally. There is, however, a strong possibility that some materials such as cement, and machinery etc. will be procured in Panama City. Also, it is not certain what percentage of the expenditure on work to be contracted locally will be used in the Penonomé economic zone. If roughly 70% of the total figure goes to the Penonomé economic zone, this will amount to $30 million in the third year, $22.188 million in the second year and $23.605 million (if pylons are used) in the first year before completion. By comparison, the 77/78 figure for rice production in Coclé (at 1978 producers' prices) was $6.136 million and the figure for maize production was $0.919 million. These facts show that the impact of the mining development on the local area (i.e. Coclé) will already be extremely big at the time of construction.

Table V-1-6 Effects during the Period of Construction

	Employment effect (No. employed/year)			Effect of material purchasing (for local portion only) ($\$10^3$)							
	Years before completion			Years before completion			Expenditure breakdown				
	3rd year	2nd year	1st year	3rd year	2nd year	1st year	Machinery	Materials	Construction	Wages & salaries	Other expenditure
The mine itself	1000	1200	1500	35321	26465	26664	1.7		76.2	4.1	18.0
Roads											
Asphalt		575	650	7540	5232	5442	40.0	30.0		30.0	
Power-transmission lines											
Pylons		32	76		1615 2)				3.5	66.2	30.3
Poles		6	58		1235 2)				4.9	52.0	43.1
Total 3)	1000	1807 (1781)	2226 (2208)	42851	31697	33721 (33341)					

Note: 1) Refers to expenditure on contracted work. Expenditure on temporary works and transportation is included under "other expenditure".

2) Purchases to be spread over the second and first years before completion.

3) The amounts referred to in note 2 have been included in the total for the first year before completion. Figures inbrackets represent expenditure in the event that wooden power poles are used.

Sources: Survey Mission
Panama Mineral Resources Development Co., Ltd.