Along the main and branch streams forming consequent valleys, the natural ground is eroded conspicuously with resultant failure and slide of land as observed everywhere. Slope failure and talus are developed especially on the stream base-rack side (soil surface being sloped toward the valley). The damaged conditions are as shown in Fig. 3.3.3. This section, as compared with the others, is suffered from more damages from slope failure on a large scale, still being highly endangered by reoccurrence of similar damages. Furthermore, because of remarkable debris outflow from branch valleys, this causes the track to be buried and the bridge to be washed out. In spite of the attempts to remove soil deposit and excavate the bed to depth, the track still remains as being exposed to high danger of causing similar damages again by sliding of the slope surface after soil removal or by burying of the excavated stream bed.

Within this section, the following two sub-sections draw special attention to the possible danger of causing such damages:

- Near the bridge crossing the Rio Changolla

  The bridge is in danger of being washed out because of insufficient clear head as the result of remarkable uprise of the river bed.

- 105 km ~ 110 km subsection

  Outflow of debris from branch valleys may cause the track to be buried or the previously damaged slope surface to fall into further failure and slide.

As the result of review as aforestated, the following two alternative may be taken up for comparative study to select the optimum rehabilitation plan for this section.

Alternative-A:	To improve the existing railway route partly at and from Point 103 km and to lift up the track formation level
Alternative-B:	To construct a new detour line on the opposite bank from Point 103 km with relatively stabilized soil foundation and to relocate Changolla Station to the side of Oruro under this proposed plan
Alternative-C:	To construct a new track line on the opposite bank side from Point 101 km and, under this proposed plan, to relocate Changolla Station to the side of Oruro

3-3-3 113 km + 000 m ~ 116 km + 000 m

The existing railway line in this section is also suffered from damages as frequently as is the case of the preceding section 3-3-2. The particular problem exists near the point of 114 km + 500 m, where the track was buried when the main stream was blocked up with large quantity of debris outflown from the Rio Pichacani.

Although the main stream was improved after such damage, it is anticipated with fear that there will be possibility of causing again buring of the track or destruction of the embankment over a pretty long length, because of remarkable lift of the bed, if avalanche of debris reoccurs.

For the reason as mentioned above, the rehabilitation plan is such that the track level will be lifted equally to the formation level from 112km + 500m to 116km + 500m as accorded to allow for the estimated future possible rise of the river bed.

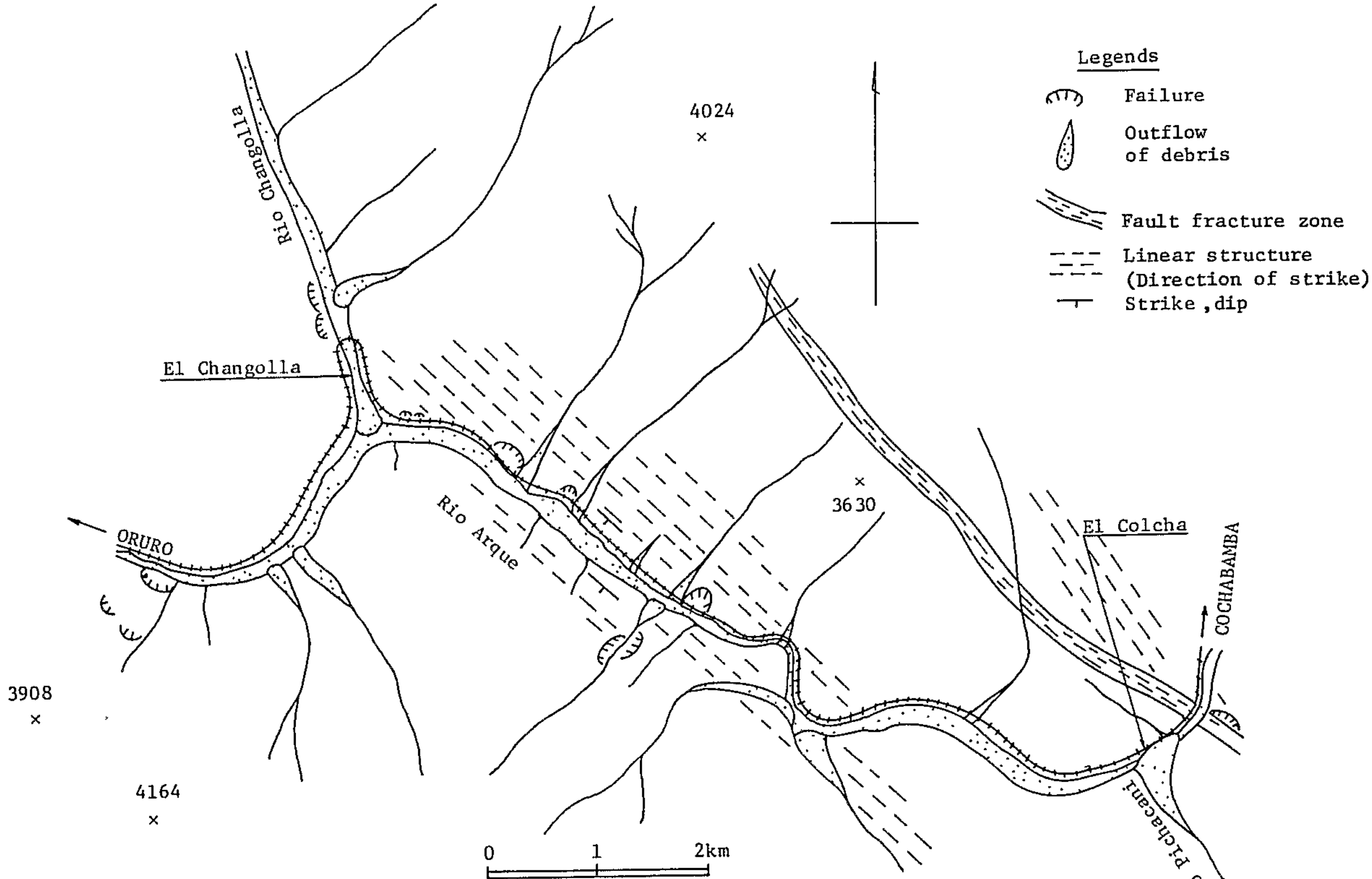


Fig. 3.3.3 Damaged Conditions

3-3-4 Bill of Quantities for Work

Bill of quantities for work are as shown in Table 3.3.1.

Table 3.3.1 Bill of Quantities for Work

Km post on conventional line		Section 48km+000m ~ 57km+650m	Section 101km+000m ~ 110km+000m			Section 112km+500m ~ 116km+500m
			Alternative -A	Alternative -B	Alternative -C	
Planned route extension	m	3,215	6,550	5,100	7,050	4,000
Nature of work	Unit					
Earthwork	m^3	53,500	1,559,000	413,500	974,400	384,000
Pipe culvert ϕ2.0m	No.	1	4	-	2	6
Open channel	No.	-	-	2	1	-
Revetment wall	m	-	-	800	1,100	4,000
Protection against falling stone	m	-	300	-	-	-
Bridge	m	-	490	780	1,140	105
Tunnel	m	1,250	-	-	-	-
Track laying	m	3,215	6,550	5,900	7,850	4,000
Security system	unit	1	1	1	1	-

3-3-5 Construction Plan

(1) Tunnel

The internal open space section of the tunnel is determined from the track clearance, to which the ENFE's designed section should apply (Fig. 3.2.3).

The lining thickness is determined generally at 40 cm. However, geological survey must be carried out at the detailed-design stage, so that safe and economic thickness can be determined accordingly.

Temporary supports will be provided for the portions of unstabilized rock foundation near the entrance of tunnel.

1) Tunnel construction plan

In order to excavate the tunnel in a safe and efficient manner, it is necessary to adopt such construction method as may be able to give quick response to the unforeseeable change of geology.

Therefore, the construction plan is to be based upon the following methods as the applicable standards:

- "Bottom Heading Pilot Drift Upper Half Section Method" for the relatively unstabilized section near the entrance (Fig. 3.3.4)
- "Full Section Tunneling Method" for all the intermediate section except both ends (Fig. 3.3.5)

Shape, size and spanning of erection for supports are determined as may be required by earth pressure of the natural ground. Prior to erection of temporary supports, they will be provided with adequate blocking so as to enable each member to receive sufficient arch action.

Concrete lining work will be carried out normally by use of the concrete-mixing plant installed at the tunnel entrance.

Since the construction site is situated at around 4,000 m in altitude, it is most necessary to make full review of all construction, plants and working efficiency.

2) Construction work schedule

Preparatory work will include installation of various constructional plants and concrete-mixing plants and construction of the material stock yard and the workers' domitory near the tunnel entrance.

The necessary period for preparatory work is estimated at about one (1) year. The average speed of excavation work progress in the main tunnel is rated at 100 m per month.

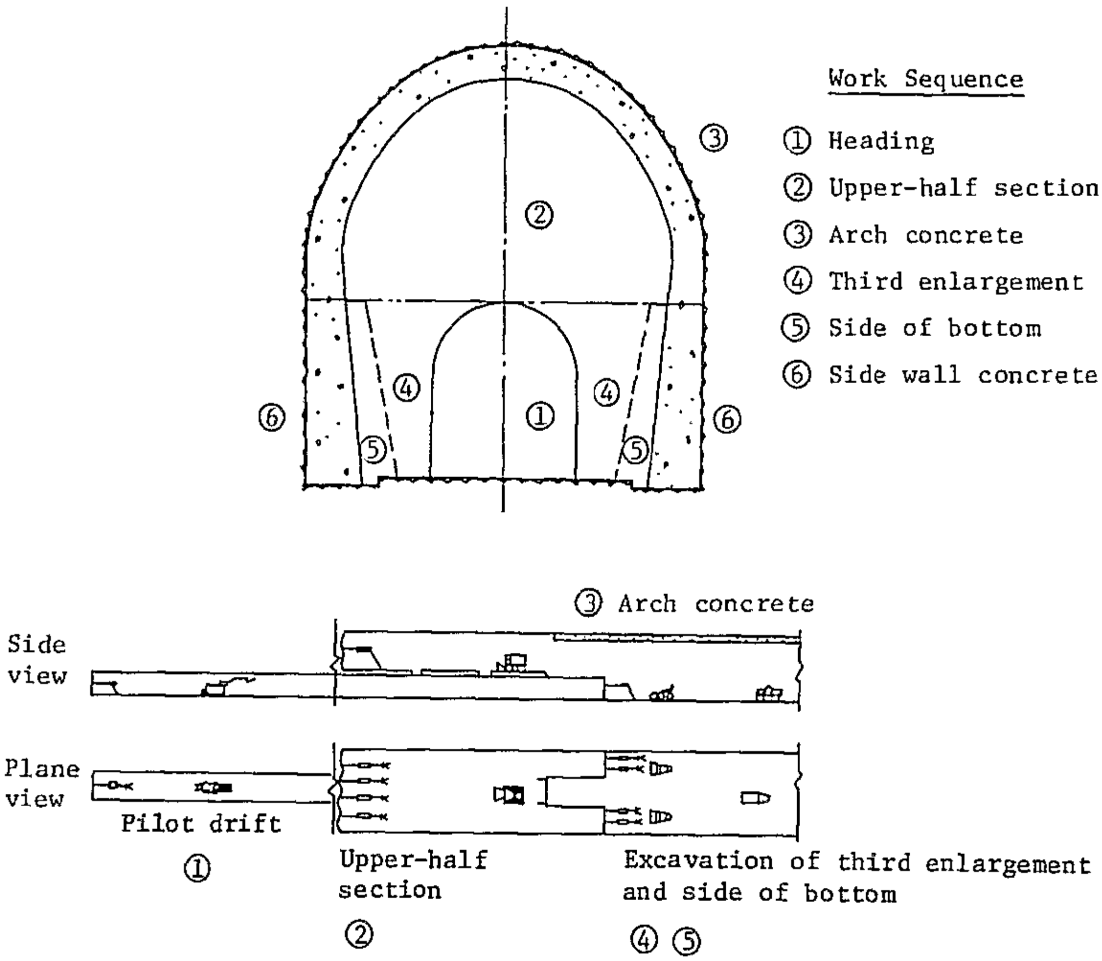
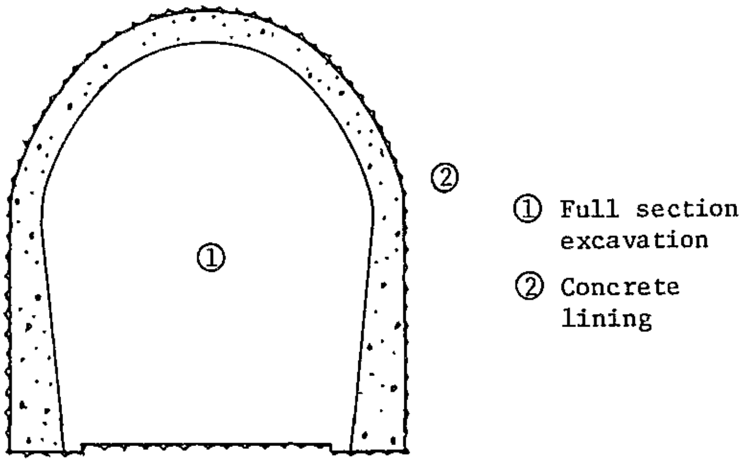


Fig. 3.3.4 Bottom Heading Pilot Drift Upper Half Section Method



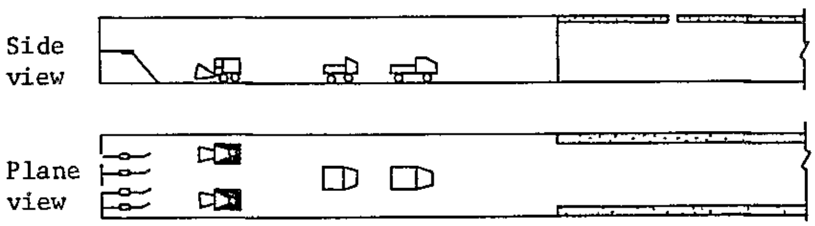


Fig. 3.3.5 Full Section Tunneling Method

(2) Earthwork (Fig. 3.3.6)

Earthwork will be executed by a mechanized method.

Waste soil produced after excavation will be used as material for embankment of the railway line or disposed into the spoilbank existing in the vicinity.

Grade of the slope surface will be determined from geological condition and slope surface length.

Cutting of slope will be executed by use of either rock breaker or dynamite in anticipation of rock excavation.

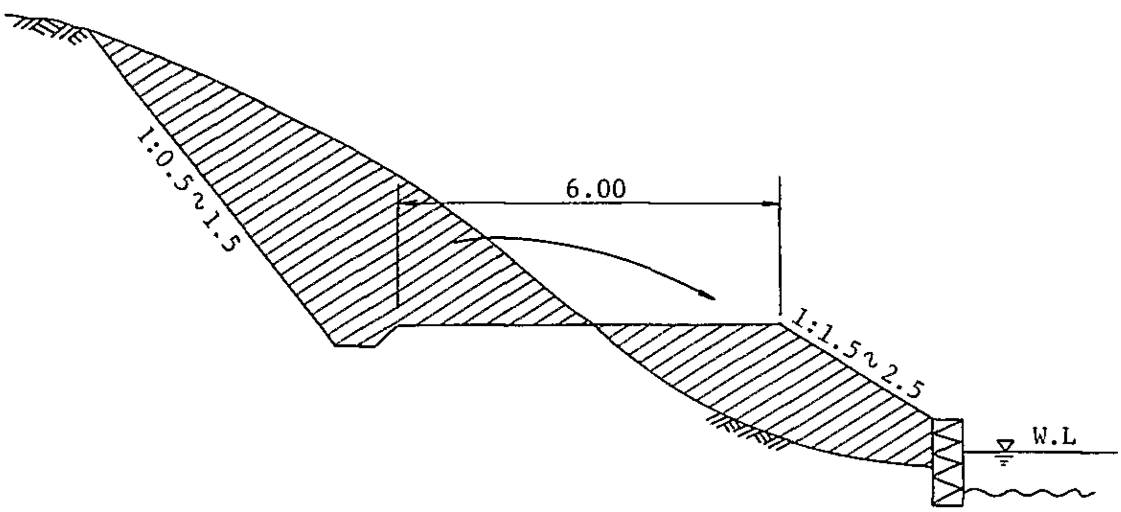


Fig. 3.3.6 Schematic Illustration of Earthwork

(3) Concrete work

Designed strength of the concrete structure is determined from the executing method and control such as quality of cement or aggregate, mixing and placing of concrete and curing.

Designed strength has been determined as follows in this work plan.

Reinforced concrete	210 kg/cm^2
Plain concrete	180 kg/cm^2
Plain concrete	160 kg/cm^2
Boulder concrete	110 kg/cm^2

Concrete will be mixed mechanically by the concrete mixer installed at the job site.

Prior to procurement of cement study must be made on its availability including the method of supply, so that the work can be progressed without suspension due to lack of supply.

(4) Reinforcing bar and steel member

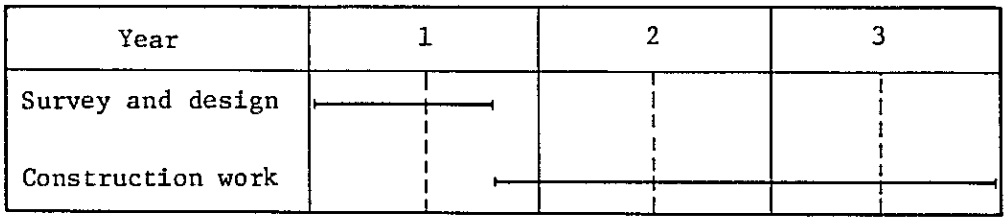
Reinforcing bar for the concrete work and steel member for bridge construction will be off-shore purchased.

(5) Material for track construction

Ballast and timber tie will be procured in Bolivia while rail-spacer and track spike will be purchased from abroad.

(6) Time schedule

The time schedule by phasing of the project is as shown in the following chart:



3-3-6 Project Cost

The project cost is estimated by inclusion of costs for detailed design and construction work (including supervisory service cost) and contingency.

Since the construction work cost accounts for the greater majority of the project cost, it has been estimated by investigation and review of the domestic railway construction record in the past and the basic data on road construction.

All those construction unit costs are estimated at the price level as of July, 1979.

(1) Detailed design service

- Preparation of topographic map on a scale reduced to 1/5,000 of 1.0 km in total width, 0.5 km each on both sides from the center line of the proposed route and surveying of both control and leveling points related to map preparation
- Surveying of center-line and profile leveling and setting of center-line piles
- Geological survey
  Survey for banking soil, study on slope surface grade and tamping and examination of earth stress and bearing power for bridge substructural construction
- Detailed design of planned structure
- Preparation of tender documents including bill of quantities, technical specifications and others as may be required for construction work

(2) Construction cost

The estimate for construction cost may be broken down by civil engineering work, track construction, station facilities and safety securing system.

Field supervision cost is estimated at 5 per cent of the total construction cost.

(3) Contingency

Contingency is allowed for at 5 per cent a year for variation in quantities and also at 5 per cent a year for price escalation.

The project cost is estimated as follows:

(1) 48 km + 000 m ~ 57 km + 650 m

Tunnel construction	236,104,000$b

(2) 101 km + 000 m ~ 110 mm + 000m

Alternative-A	294,276,000$b
Partial improvement of existing line route by lifting up of subgrade formation	
Alternative-B	251,010,000$b
New detour line on opposite bank side (103 km + 000 m ~ 110 km + 000 m)	
Alternative-C	378,398,000$b
New detour line on opposite bank side (101 km + 000 m ~ 110 km + 000 m)	

(3) 112 km + 500 m ~ 116 km + 500 m

Lifting-up of track level on conventional line	123,560,000$b

Economic and financial analyses are made hereunder from the foregoing results. With regard to the proceding Item (2) covering the 101 km + 000 m ~ 110 km + 000 m section, it is intended to adopt a plan of new detour line construction on the opposite bank side with relatively stabilized soil foundation. The result of comparative study on the two alternatives (B and C) of the plan is as follows.

	Alternative-B Relocation between 103∿110 km	Alternative-C Relocation between 101∿110 km
Track construction length	5.1 km	7.1 km
Bridge extension	780 m	1,140 m
Construction cost	251,000 $b	378,000 $b
Conditional comparison in the 101∿103 km section		
Geology	Subsoil condition consists of bed rock with growth of cracks and talus covering such base rock.	Same as the condition in Alternative-B.
Debris outflow	No serious problem involved in damage from debris outflow because of no deep gorge and small limited basin area.	Two (2) big branch valleys exist as potential sources of debris outflow. Brisk activity of erosion is still anticipated toward future.
Slope surface failure and sliding	Land failure and slide on a small scale may possibly occur in the future but may not grow to big collapse.	Same as the condition in Alternative-B.
Coastal erosion	Coastal erosion may be anticipated in the area where debris deposit is observed. However, since at present the river bank protection is being improved, any future erosion problem may be solved by such protective measures.	Same as is the case of Alternative-B, it is anticipated that coastal erosion may take place in the vicinity of the debris-deposited area.
Flexibility for future improvement	New line has come up to its maximum possible track level formation with longitudinal grade of 30 ‰. However, it is still possible to relocate the conventional line of 101∿103 km section on a plane level.	Same as the condition of Alternative-B.

As noted from the foregoing comparative study, it is most probable that the present condition in the 101 km∿103 km section would not be improved even by relocation of the existing route to the opposite bank side at a sacrifice of vast construction cost and that the new line, even though relocated, would be fallen again into the similar condition which the existing track line is confronted with.

With regard to the problem of coastal erosion to be anticipated for the existing track line between 101 km and 103 km, it can be fully protected, for the time being, by the protective work and other necessary measures as have so far been taken on a step-by-step basis. If necessary in the future, it would be possible to relocate the existing track line to the mountain side.

All those things considered, therefore, Economic and Financial study will be made on the basis of Alternative-B while the result of study on Alternative-C is stated in the Appendix-2.

Table 3.3.2 (a) Project Cost Breakdown

(a) 48 km + 000 m ~ 57 km + 650 m
Tunnel construction project cost

Nature of Work	Unit	Quantity	Unit Cost	Amount
			($b)	(1,000$b)
1. Civil engineering work				168,191
Earthwork	m^3	53,500	57	3,050
Pipe culvert ϕ2.0 m	No.	1	141,000	141
Tunnel	m	1,250	132,000	165,000
2. Track construction	m	3,215	1,670	5,369
3. Safety security installation	unit	1		187
4. Supervision	%	5	173,747	8,687
5. Sub total ① ~ ④				182,434
6. 1/5,000 topographic map preparation, center-line surveying and geological survey	km	3.2	290,000	928
7. Detailed design and tender documents	mm	65	225,000	14,625
8. Sub total ① ~ ⑦				197,987
9. Contingency (variation in quantity)	%	5	182,434	9,122
10. Contingency (price escalation)	%	14	207,109	28,995
11. Total ① ~ ⑩				236,104

Table 3.3.2 (b) Project Cost Breakdown

(b) 103 km + 000 m ~ 109 km + 400 m
Project cost for partial improvement of existing route and lifting-up of subgrade formation (Alternative-A)

Nature of Work	Unit	Quantity	Unit Cost	Amount
			($b)	(1,000$b)
1. Civil engineering work				205,667
Earthwork	m^3	1,559,000	57	88,863
Pipe culvert ϕ2.0 m	No.	4	141,000	564
Bridge	m	490	176,000	86,240
Protection against falling stone	m	300	100,000	30,000
2. Track construction	m	6,550	1,670	10,939
3. Safety security installation	unit	1		489
4. Supervision	%	5	217,095	10,855
5. Sub total ① ~ ④				227,950
6. 1/5,000 topographic map preparation, center-line surveying and geological survey	km	6.6	290,000	1,914
7. Detailed design and tender documents	mm	75	225,000	16,875
8. Sub total ① ~ ⑦				246,739
9. Contingency (variation in quantity)	%	5	227,950	11,398
10. Contingency (price escalation)	%	14	258,137	36,139
11. Total ① ~ ⑩				294,276

Table 3.3.2 (c) Project Cost Breakdown

(c) 103 km + 000 m ~ 110 km + 000 m
Project cost for new detour line construction on opposite bank side (Alternative-B)

Nature of Work	Unit	Quantity	Unit Cost ($b)	Amount (1,000$b)
1. Civil engineering work				171,233
Earthwork	m^3	451,000	57	25,707
Open channel	No.	2	2,860	6
Revetment wall	m	800	10,300	8,240
Bridge	m	780	176,000	137,280
2. Track construction	m	5,900	1,670	9,853
3. Station facilities and safety securities installation	unit	1		1,980
4. Supervision	%	5	183,066	9,153
5. Sub total ① ~ ④				189,099
6. 1/5,000 topographic map preparation, center-line surveying and geological survey	km	5.1	290,000	192,219
7. Detailed design and tender documents	mm	75	225,000	16,875
8. Sub total ① ~ ⑦				210,573
9. Contingency (variation in quantity)	%	5	192,219	9,611
10. Contingency (price escalation)	%	14	220,184	30,826
11. Total ① ~ ⑩				251,010

Table 3.3.2 (d) Project Cost Breakdown

(d) 101 km + 000 m ~ 110 km + 000 m
Project cost for new detour line construction on opposite bank side (Alternative-C)

Nature of Work	Unit	Quantity	Unit Cost	Amount
			($b)	(1,000$b)
1. Civil enginheering work				267,796
Earthwork	m^3	974,400	57	55,541
Open channel	No.	1	2,860	3
Corrugated pipe	No.	2	141,000	282
Revetment wall	m	1,100	10,300	11,330
Bridge	m	1,140	176,000	200,640
2. Track construction	m	7,850	1,670	13,110
3. Station facilities and safety securities installation	unit	1		1,980
4. Supervision	%	5	282,886	14,145
5. Sub total ① ~ ④				297,031
6. 1/5,000 topographic map preparation, center-line surveying and geological survey	km	7.05	290,000	2,045
7. Detailed design and tender documents	mm	80	225,000	18,000
8. Sub total ① ~ ⑦				317,076
9. Contingency (variation in quantity)	%	5	297,031	14,852
10. Contingency (price escalation)	%	14	331,928	46,470
11. Total ① ~ ⑩				378,398

Table 3.3.2 (e) Project Cost Breakdown

(e) 112 km + 500 m ~ 116 km + 500 m
Project cost for lifting-up of conventional line track level

Nature of Work	Unit	Quantity	Unit Cost	Amount
			($b)	(1,000$b)
1. Civil engineering work				82,414
Earthwork	m^3	384,000	57	21,888
Revetment wall	m	4,000	10,300	41,200
Pipe culvert ϕ2.0 m	No.	6	141,000	846
Bridge	m	105	176,000	18,480
2. Track construction	m	4,000	1,670	6,680
3. Supervision	%	5	89,094	4,455
4. Sub total ① ~ ③				93,549
5. 1/5,000 topographic map preparation, center-line surveying and geological survey	km	4	290,000	1,160
6. Detailed design and tender documents	mm	40	225,000	9,000
7. Sub total ① ~ ⑥				103,709
8. Contingency (variation in quantity)	%	5	93,549	4,677
9. Contingency (price escalation)	%	14	108,386	15,174
10. Total ① ~ ⑨				123,560

CHAPTER 4 TRAFFIC DEMAND FORECAST

4-1 General Description

The Cochabamba branch line serves for transport of passengers and freights as the connection line to the State of Cochabamba nearly centered in the territory of Bolivia, being branched off at Oruro Station in the Oruro state which is situated nearly in the middle of the La Paz - Rio Mulato Line being operated as one of the trunk lines forming the railway network in the western part of the country. Figure 4.1.1 shows the existing network of railways and roads.

4-1-1 General Status of Oruro State

The State of Oruro is situated in the central west of Bolivia, covering a total land area of 53,588 sq.km with a population of 311,245 as given by the census in 1976. This population accounts for 6.7 per cent of the nation's total and its annual growth rate is averaged at 1.9 per cent. The State reserves mineral resources of mainly tin and some others in abundance which become a vital input to the economic activity of the whole state. By the way, production in the mining sector alone accounts for as much as 25.0 per cent of the nation's total. However, since the greater portion of the State's territory covers and central plateau featured by impoverished land and scarce rainfall, very little is produced from agricultural and stock farming. Such being the circumstance, the State depends upon any other producing States for supply of daily living necessaries. Production in the industrial sector accounts for 8.2 per cent of the nation's total. As shown in Table 4.1.1, the public investment in this state alone takes a share of 36.0 per cent. Special effort is being concentrated at industrial development mainly for metal, machine and cement.

4-1-2 General Status of Cochabamba State

The State of Cochabamba has a population of 730,358 as confirmed by the concensus in 1976. This accounts for 15.7 per cent of the nation's total.

The increase rate of population in this State is 1.86 per cent at annual average, down below the whole nation's increase rate of 2.1 per cent. The reason for this is said to be because the potential unemployed labor force engaged in the agricultural and stock farming is transfered into the Santa Cruz State and the northern Argentine, where many job opportunities can be sought. The total potential workable population from 15 up to 60 of age accounts for 51.1 per cent of the State's total population, out of which the actual working population is estimated at no more than 55.3 per cent, thus still holding sufficiency for future labor availability.

The State Government is exerting an active effort toward industrial development under the scheme formulated by the Andes Treaty Organization. A new turning point in the State's industry can be observed from the changing trend in the composition by industrial sectors during the 1975 ~ 1977 period; from 32.0 to 22.0 per cent in the agricultural and stock farming sector, from 17.0 to 19.8 per cent in the manufacturing sector, from 6.3 to 18.0 per cent in the construction sector, from 8.6 to 20.0 per cent in the transportation sector and from 9.7 to 18.0 per cent in the service sector. As noted from such changing trend the working population appears to be moving from its conventional stronghold in the primary industry toward either manufacturing or service industry. In the future prospect, therefore, it may be possible for the potential unemployed now in the primary sector of the State's industry to get new jobs in the secondary and tertial industries, as the result of which outflow of the population from this State will mark a gradual decrease.

The State's share of production in the nation's gross domestic product is pretty high, or 17.0 per cent ranking the third after 31.4 per cent in La Paz State and 18.6 per cent in Santa Cruz. As shown in Table 4.1.1, the public investment in 1978 also accounts for 30 per cent of the nation's total. Those figures predict much potentiality for future economic growth of this State.

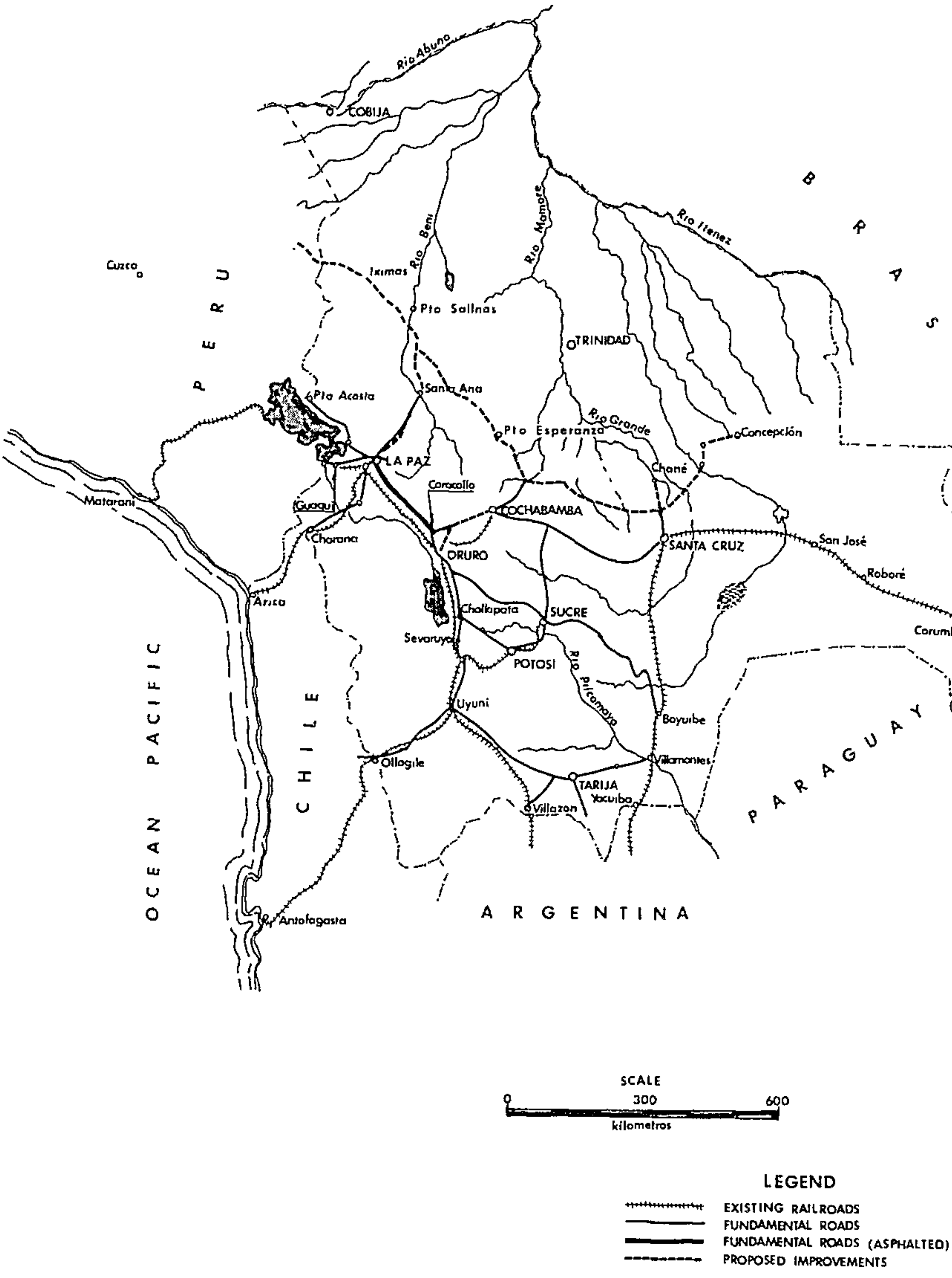


Fig. 4.1.1 Network of Railways and Roads

Table 4.1.1 Breakdown of Public Investment by States and Sectors (1978)

Unit: 1,000$b

Sectors \ State	La Paz	Cochabamba	Santa Cruz	Oruro	Potosi	Chuguisaca	Tarija	Beni	Pando	Total	Composition Ratio (%)
Agriculture & stock farming	151,863.3	741,048.6	189,327.7	2,434.5	9,062.8	64,968.4	43,192.4	43,894.5	11,043.3	1,256,835.5	16.9
Mining	113,565.6	8,999.5	12,907.0	30,017.0	56,311.2	4,675.0	848.0	5,358.0	605.0	233,286.3	3.1
Hydro carbon	9,663.0	353,084.1	1,244,213.4	-	3,179.0	29,817.0	106,208.6	3,201.0	4,286.0	1,753,652.1	23.6
Industrialization & tourist	15,737.5	173,360.0	258,253.1	296,441.0	17,836.2	38,000.0	17,146.0	1,764.0	6,293.2	824,831.0	11.1
Energy	93,724.0	413,780.0	58,588.0	103,657.0	51,740.0	62,195.0	51,807.0	12,532.0	1,500.0	849,523.0	11.4
Water resources	-	10,180.0	7,375.0	140.0	-	-	4,400.0	-	-	22,095.0	0.3
Transportation & communication	622,687.9	421,340.7	78,483.9	6,051.1	127,025.7	65,355.5	217,630.3	46,204.4	19,444.8	1,604,224.3	21.6
Commerce & finance	3,615.7	-	10,396.0	-	-	-	300.0	-	-	14,311.7	0.2
Education & culture	34,602.6	12,624.8	17,832.0	500.0	-	166.6	166.6	-	1,500.0	67,392.6	0.9
Welfare & social insurance	19,418.7	6,000.0	22,618.9	2,837.3	2,837.3	6,000.0	805.0	-	-	60,517.2	0.8
Urban development & housing	82,014.0	70,255.0	84,381.5	93,626.0	49,275.0	24,032.0	33,154.0	45,033.7	41,496.3	523,267.5	7.0
Water supply & sewerage	94,680.0	16,140.0	37,061.0	1,670.0	52,309.1	1,448.0	3,872.0	12,061.2	3,247.0	222,488.3	3.0
Others	500.0	1,500.0	4,562.0	1,705.0	-	-	250.0	500.0	-	9,017.0	0.1
Total	1,242,072.3	2,228,312.7	2,025,999.5	539,078.9	369,576.3	296,657.5	479,779.9	170,548.8	89,415.6	7,441,441.5	100.0
%	16.7	30.0	27.2	7.2	5.0	4.0	6.4	2.3	1.2	100.0	

Source: Ministerio de Planeamiento y Coordinacion

4-2 General Status of Transport Facilities

The State of Cochabamba is situated nearly at a center of Bolivia, playing its vital role as the traffic relaying pivot between both eastern and western parts of the country. It is connected with the State of Santa Cruz via the road and also with the State of Oruro via the road and the railway as shown in Fig. 4.2.1

4-2-1 Road Transportation

The liaison road between Oruro and Cochabamba is 224 km in total length. In the section between Parotani and Cochabamba with heavy traffic volume the road is asphalt-paved with second lanes each on its up and down sides while the road between Oruro and Parotani is graveled. The road is aligned in a bad shape, since it passes through the mountainous zone. At present, the project is under way for improvement of the existing road toward the completion target in 1982, as the result of feasibility study conducted in 1972. When it will be completed, the total length of the existing road will be shortened by about 20 km as shown in Table 4.2.1.

Table 4.2.1 Comparative Length of New and Existing Roads

	Oruro ~ Caihuasi	Caihuasi ~ Parotani	Parotani ~ Quillacollo	Quillacollo ~ Cochabamba	Total
Existing road Source 1	41 km	143 km	26 km	14 km	224 km
Improved road Source 2	35	129	26	14	205

Source 1 Boletin de Transportes Primer Semestre 1977
Source 2 Carretera Quillacollo-Oruro Feasibility Report 1972

The vehicle traffic volume between Oruro and Cochabamba shows an ever-increasing tendency, as shown by kinds of vehicle in Table 4.2.2, at an annual average rate of 16 per cent. It is expected that this tendency will further continue in the future as well as at present.

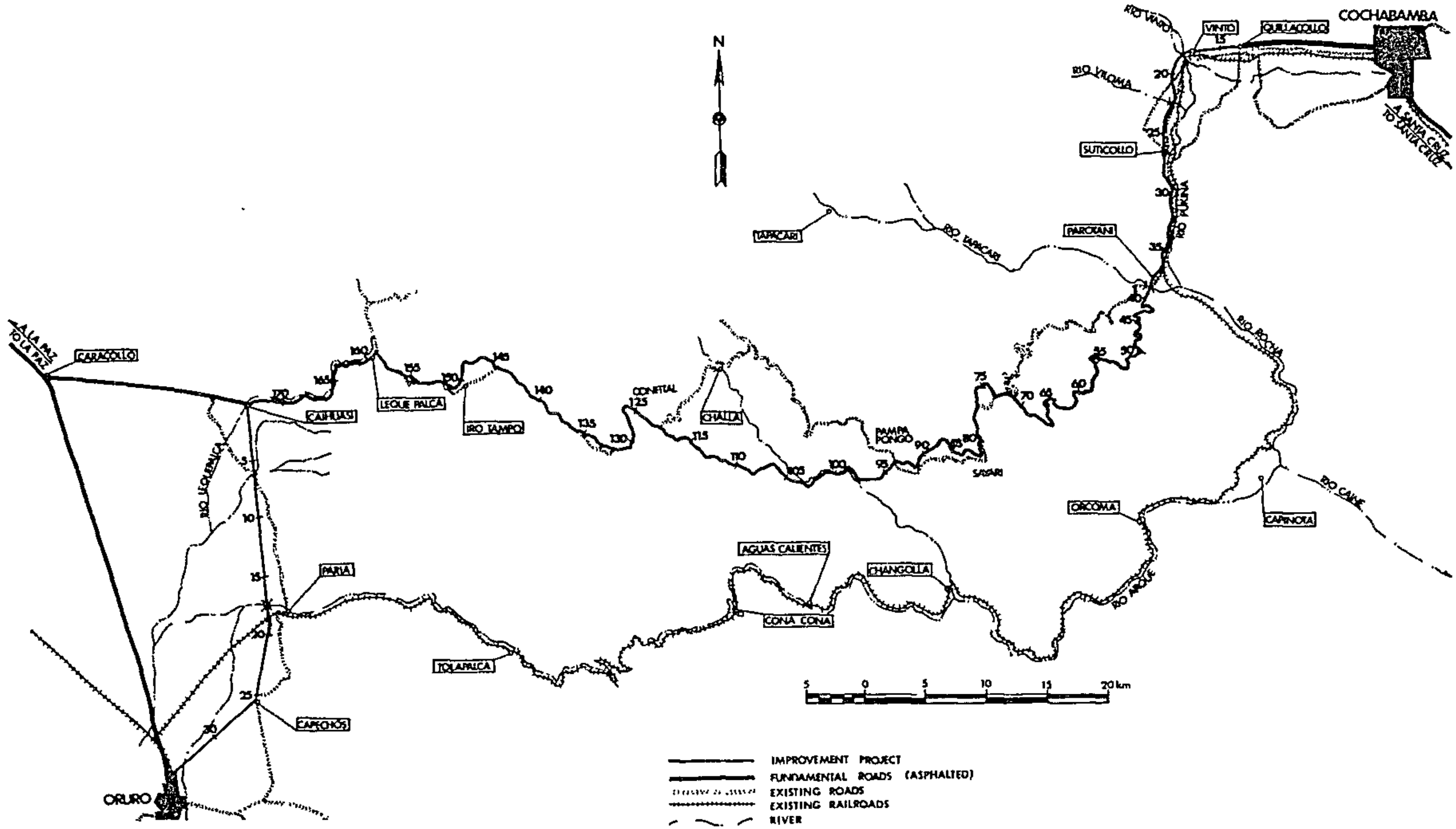


Fig. 4.2.1 Map of Transport Network Between Oruro and Cochabamba

Table 4.2.2 Trend of the Vehicle Traffic Volume of Types

Unit: Average annual daily traffic

	Bus (1)	Truck (2)	Others	Total
1974	56	179	25	260
75	48	204	54	306
76	32	197	123	352
77	58	282	60	400
78	69	336	72	477

Note (1) The seating capacity of each bus within a range of 30 to 36 persons.

(2) The allowable loading capacity of each truck within a limit of 8 to 10 tons.

Source: Data available from ENFE's local office in Oruro

Because of no available statistic data on total passengers by bus and freight tonnage by truck, those totals are summed up, as shown in Table 4.2.3, by quessing from the average volume of transport per each unit vehicle.

Table 4.2.3 Estimated Volume of Transport by Bus and Truck

	Bus Transport (1)		Truck Transport (2)	
	Person/Day	Person/year	Ton/Day	Ton/Year
1974	1,568	572,000	1,146	418,000
75	1,344	491,000	1,306	477,000
76	896	327,000	1,261	460,000
77	1,624	593,000	1,805	659,000
78	1,932	705,000	2,150	785,000

Note (1) Total number of bus passengers are calculated on the basis of 28 persons per each vehicle at average, as indicated by the data available from ENFE's local office in Oruro, by multiplying with the total number of bus actually operated.

(2) Total volume of freight is calculated on the basis of 6.4 tons per each vehicle at average, as indicated by the data available from ENFE's local office in Oruro, by multiplying with the total number of trucks actually operated.

4-2-2 Railway Transport

The actual record of transport by the branch line of Cochabamba shows 312,225 persons per year and 167,750 in freight tonnage in 1978. In terms of the passenger transport, the said branch line is the highest in the utilization rate among all the railway divisions.

(1) Yearly trend of transport volume

The changing trend of passenger and freight transport in past years is as shown in Table 4.2.4. The total freight transport in 1978 is shared by export at 22 per cent, import at 56 per cent and domestic distribution at 22 per cent. As compared with the transport in 1971, export and import are increased by 11.0 times and 2.8 times respectively but domestic transport is rather decreased to 0.6 time. Such decrease in domestic transport may be because the means of transport has been shifted from railway to truck and other vehicles as the freight transport is limited to a relatively short distance.

Table 4.2.4 Trend of Passenger and Freight Transport

Year	Passenger Transport (Person/Year)			Freight Transport (Ton/Year)			
	Ordinary Train	Ferro Bus	Total	Export	Import	Domestic	Total
1971	-	-	-	3,396	33,708	59,060	96,164
72	-	-	-	1,477	51,767	66,460	119,704
73	-	-	-	50,244	48,194	63,664	162,102
74	-	-	-	8,766	38,617	47,280	94,663
75	-	-	-	12,748	81,071	56,871	150,690
76	171,094	105,322	276,416	31,487	63,514	43,131	138,132
77	171,783	145,054	316,837	26,673	94,548	41,884	163,105
78	178,895	133,330	312,225	37,389	92,955	37,406	167,750

Source: Anuario Estadistico Ferroviario

(2) General status of Cochabamba branch line

The branch line of Cochabamba runs in parallel with the road only for the two sections between Oruro and Paria and between Parotani and Cochabamba. However, since the railway line is disconnected away from the road in all the other operating sections, the said branch line is the sole important means of transport not only for convenience between large cities but also for the local inhabitant in any wayside areas.

According to the data available from ENFE, the wayside population is estimated at 19,600 in Vinto, 2,600 in Ucuchi, 1,200 in Irpa Irpa, 1,000 in Higuerani, 600 in Arque, 500 in Changolla and 100 ~ 200 in each of other stations. Most of them are engaged in the agricultural and stock farming.

Figure 4.2.2 deals with the flows of passenger and freight from station to station as of June 1978. The operating condition of trains in the month of June 1978 seems to have been almost normal with suspension of service, though there remains a record indicating 11.50 hours as time length required for restoration from the derailed accident.

The average flow of transport between Oruro and Cochabamba in June 1972 is 20,448 persons per return trip for passengers and 16,756 tons per return trip for freights. The flowing conditions of both passenger and freight can be broken down as shown in Table 4.2.5, when divided into the intra-regional flow between Oruro and Cochabamba and the inter-regional flow.

Table 4.2.5 Condition of Passenger and Freight Transport (June 1978)

	Freight (Ton/Month)			Passenger (Person/Month)
	Import	Export	Domestic	
Intra-regional flow	-	-	2,039.6 (6%)	17,547 (44%)
Inter-regional flow	18,129.0 (57%)	5,627.6 (18%)	5,873.4 (19%)	21,985 (56%)

Note: Percentage in ( ) denotes the ratio to the total.

Freight transport accounts for 75 per cent of the total flow in both export and import, which means a high share of transport over a long distance. Contrary to that, in case of passenger transport the share of the intra-regional flow between Oruro and Cochabamba accounts for 44 per cent, reflecting high frequency of railway utilization by the wayside inhabitants.

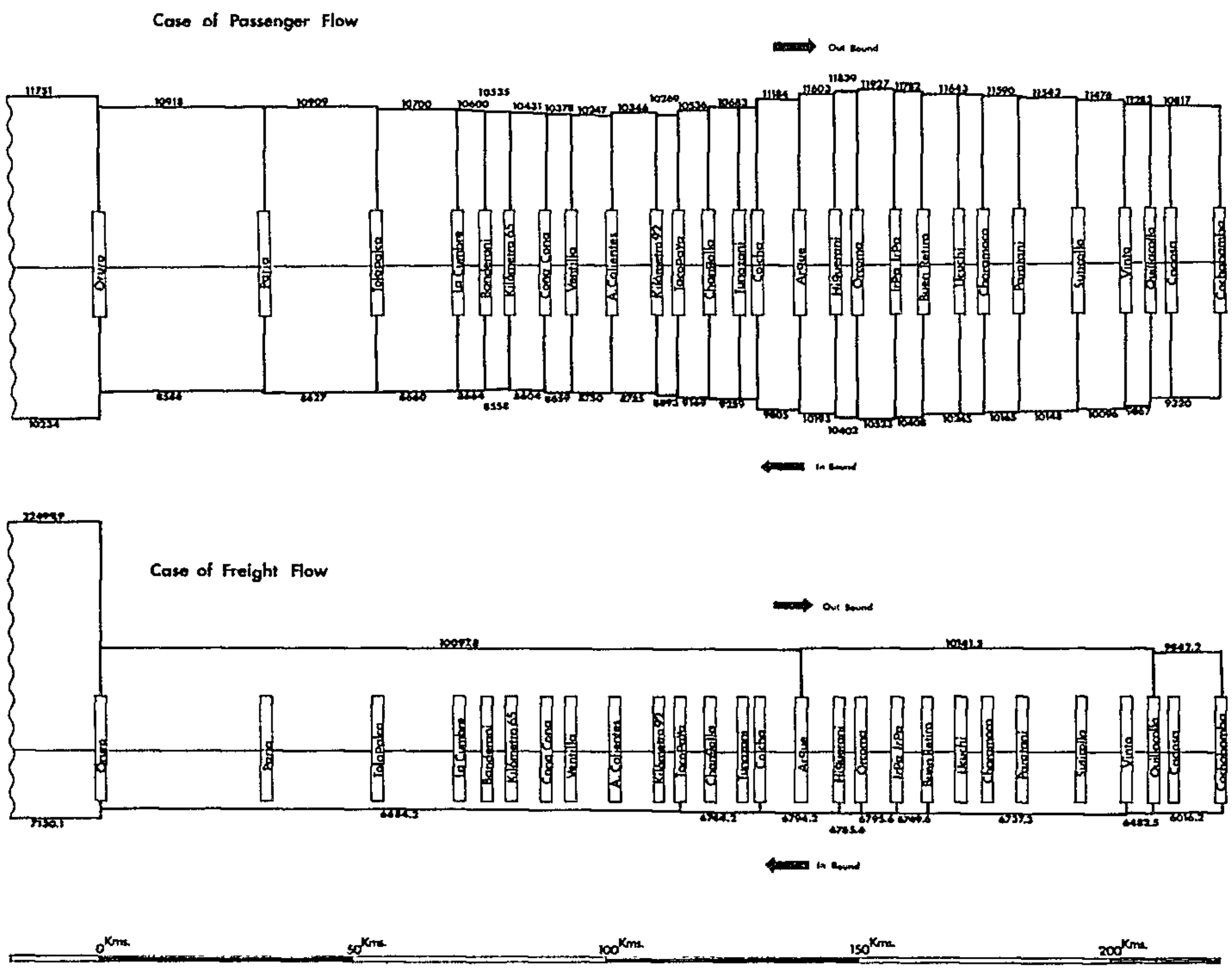


Fig. 4.2.2 Flow of Passenger and Freight Between Stations (June 1978)

4-3 Traffic Demand Forecast

The transport route between Oruro State and Cochabamba State can be divided into the road, railway and air line.

The road and the railway as the main ground transport facilities are paralleled close to each other in the sections between Oruro and Paria and between Parotani and Cochabamba, but they are not interconnected in any other sections. However, in view of the present condition that the majority of total passengers and freight reach Cochabamba via Oruro by way of the La Paz - Rio Mulato line, it can be said that the road is completing with the railway as the most popular means of transport.

The road for liaison between Oruro and Cochabamba is now being improved and the completion is scheduled for 1982. As the road condition for vehicle driving is expected to be improved with completion of the present improvement work, there seems to be a probability of causing transfer of passenger and freight transport from the conventional railway into the improved road.

Future demand forecast is made herein on the estimated railway transport volume between Oruro and Cochabamba, in consideration of the competitive relation between the road and the railway in some sections.

4-3-1 Method of Traffic Demand Estimation

There are several alternative methods developed for estimation of future traffic demand. As an approach to this project the railway traffic demand has been estimated by such flow chart as shown in Fig. 4.3.1.

- To calculate the ratio of traffic volume between railway and road from the past transport records
- To set the resistance factor' for the traffic share model corresponding to the shared ratio
- To set the traffic share model with a revised road traffic resistance factor, in anticipation of the improved vehicle driving condition upon completion of the road improvement work
- To estimate future railway traffic volume by tracing back the past trend of railway traffic volume
- To revise estimated railway traffic volume by use of the traffic share model adjusted by inclusion of the improved road factor

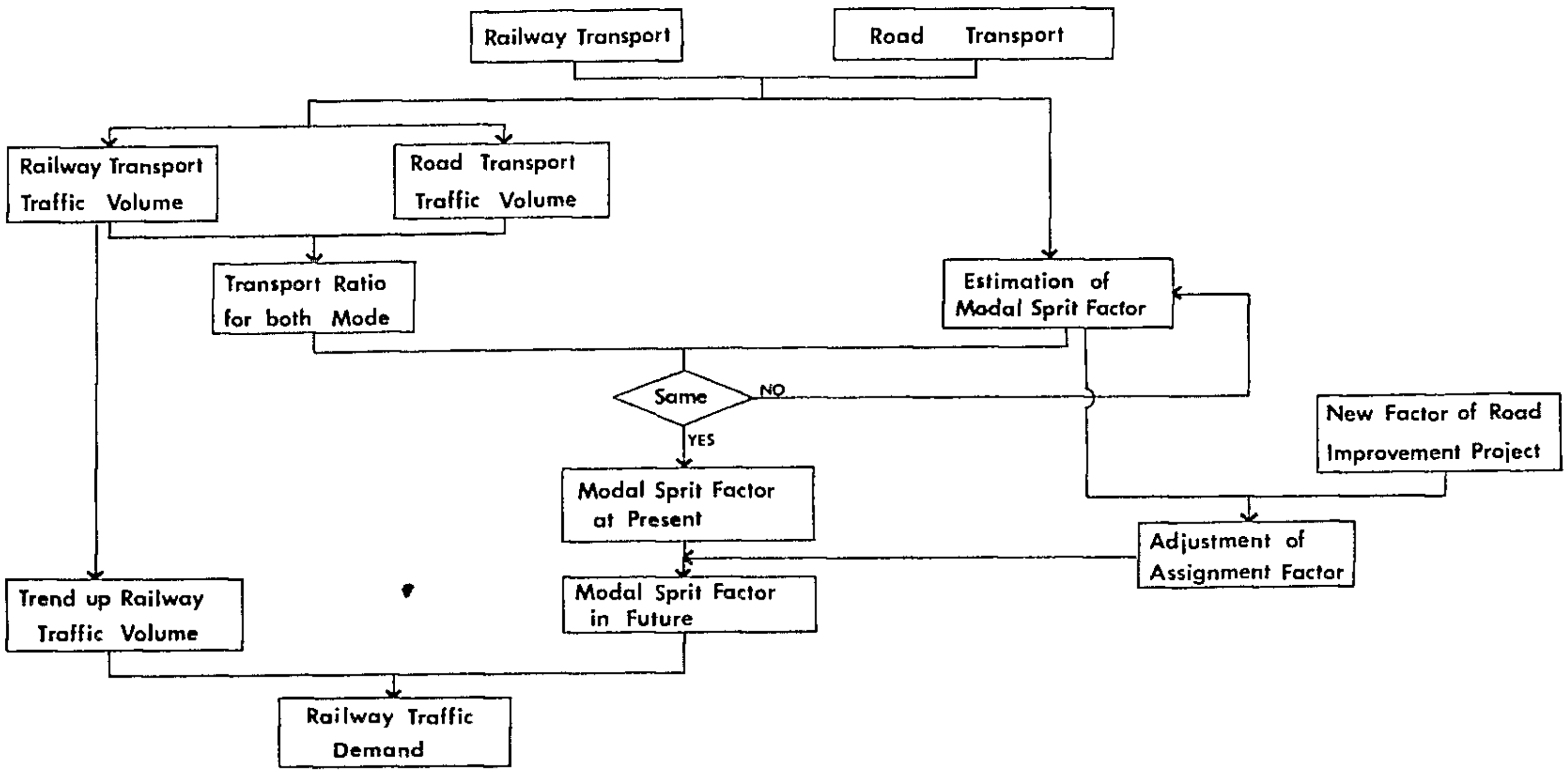


Fig. 4.3.1 Flow Chart for Estimation of Traffic Demand

4-3-2 Review of Traffic Share Model

The traffic share model is used to seek the traffic ratio of each transportation route, if there exist more than two routes of transport in competition by a combined pattern of "road versus road" or "road versus railway".

The following formula has been used to attain the traffic share model:

$$Frij = \frac{Trij^{-n}}{\sum_{r=1}^{m} Trij^{-n}}$$

Where, Frij: Traffic share ratio of root r between zones i and j
Trij: Traffic resistance factor of each route
n : Constant to be fixed by condition of each route
m : Number of routes

The value Frij may be variable depending upon the traffic resistance factor of each route. For initial conversion of the present traffic condition into a model it is necessary first to seek the traffic share of the road versus the railway between Oruro and Cochabamba and then to set such traffic resistance factor as may enable the value A Frij to be equalized to the traffic share as obtained.

The traffic share of the road versus the railway between Oruro and Cochabamba has been obtained, as shown in Table 4.3.1, from the past record of traffic volume on a year-to-year basis.

Table 4.3.1 Traffic Share of the Road Versus the Railway

Year	Passenger (Person/Year)		Freight (Ton/Year)				
				Railway			
	Road	Railway	Road	Export	Import	Domestic	Total
1974	-	-	418,000	8,766	38,617	47,280	94,663
75	-	-	477,000	12,748	81,071	56,871	150,690
76	327,000	276,416	460,000	31,487	63,514	43,131	138,132
77	393,000	316,837	659,000	26,673	94,548	41,884	163,105
78	705,000	312,225	785,000	37,389	92,955	37,406	167,750
Average traffic volume	541,670	301,830	559,800	23,400	74,200	45,300	142,900
Utilization rate	64%	36%	80%	3%	11%	6%	20%

The traffic resistance factor used to seek the value Frij is a quantitative conversion from the traffic characteristic of each transport route. Major factors can be compared, as shown in Table 4.3.2 between the road and the railway.

Table 4.3.2 Comparison of Traffic Resistance Factor

Item	Passenger		Freight	
	Bus	Railway	Truck	Railway
Required running time	8.0 hour	Ferro bus 4.7 hour Passenger-freight mixed-run 8.5 hour	8.0 hour	7.7 hour
Fare rate	45$b	Ferro bus 1st class 76$b 2nd class 65$b Passenger-freight mixed-run 1st class 63$b 2nd class 37$b	240~300$b/ton	about 200$b/ton
Distance	224 km	211 km	224 km	211 km
Operation interval	28~35 return trip /day	Ferro bus 2 return trip /day Passenger-freight mixed-run 2.6 return trip/day		2 return trip /day (Note)

Note: Not including any passenger-freight mixed-run train.

As the operating distance between Oruro and Cochabamba will be reduced from 224 km at present to 205 km upon completion of the improvement work, 'required running time' and 'distance' will be taken up as the influential factors to be considered for the traffic resistance factor. ('Fare rate' is not regarded appropriate as the resistance factor, because it may be varied occasionally by any other external factors.)

In selecting the means of transport, such choice is normally made by the passenger or by the consigner after taking into consideration various traffic requirements. Therefore, it is conceivable that the vehicle driving condition to be improved after completion of the present road improvement work would not affect the railway traffic so significantly. In terms of the freight transport, however, comparative study has been made on sharing of the traffic volume by train and truck between Oruro and Cochabamba, since such share should give large influence to the cost-benefit calculation for the economic analysis.

Comparative study has been made by the following assumptions:

- Those freights for export and import now being transported by railway would still be carried by the same means of transport as at present, since they need long-distance transportation. For this reason, the object to be affected by the improved road has been limited only to the domestic flow of freight.
- The railway transport needs some extra time for collection and delivery of the cargo as compared with the truck transport available from door to door. Such extra time is assumed to be 3 hours respectively for collection and delivery.

On the basis as assumed above, the present traffic condition may be expressed as follows by the share model:

Truck share rate by model — Present share

$$F_1ij = \frac{8.0^{-4.7}}{8.0^{-4.7} + 13.7^{-4.7}} = 0.926$$ 559,800 tons (92.5%)

Railway share rate by model — Present share

$$F_2ij = \frac{13.7^{-4.7}}{8.0^{-4.7} + 13.7^{-4.7}} = 0.074$$ 45,300 tons (7.5%)

The average running speed of truck traffic at present is 224 km/8 hours = 28 km per hour.

Assuming that the speed could be increased by 10 per cent after improvement of plane and profile alignments, then

204.9/30.8 = 6.65 hours

The transport share after road improvement can be calculated as follows by reference to the required time of running in this section.

Share in case of truck transport

$$F_1ij = \frac{6.65^{-4.7}}{6.65^{-4.7} + 13.7^{-4.7}} = 0.968$$

Share in case of train transport

$$F_2ij = \frac{13.7^{-4.7}}{6.65^{-4.7} + 13.7^{-4.7}} = 0.032$$

After full review of the probable effect from the road improvement upon the future railway traffic demand, it is concluded that there would be no remarkable effect to be expected from improvement of the road in case of the passenger traffic where the preferred choice rather depends upon the other influential factors such as the fare rate and the operating time interval of trains. In case of the freight transport, however, it is anticipated that 4.2 per cent of the domestic transport volume would be shifted from railway to road, because the running time can be reduced by about 1.35 hour as the result of road improvement.

4-3-3 Estimation of Traffic Demand

For future traffic demand the railway transport volume is estimated for the Oruro - Cochabamba section being included in the scope of the rehabilitation project.

Since this project planned for rehabilitation purpose alone does not create any new traffic demand, unlike the development of a general pattern, it is assumed that there would be no difference in the predicted value for future traffic demand between the two alternative cases 'with project' and 'without project'.

(1) Passenger traffic demand

Passenger traffic demand has been estimated from the population growth rate in Cochabamba, because of deficiency of past records on passenger traffic.

The growth rate of population in the State of Cochabamba is 1.86 per cent, below the nationwide growth rate of 2.1 per cent in Bolivia. This is because many of the potential unemployed in the field of agricultural and stock farming in this State are gone out into the other states where they think they can find more job opportunities. However, with astonishing growth of both manufacturing and service industries in recent years the rate of population outflow from the State of Cochabamba will be slowed down because of local job availability in those industrial sectors.

All those conditions considered, it is estimated that the future passenger demand will continue further increase at annual average rate of 1.86 per cent within a decade and 2.1 per cent beyond that period thereafter.

The result of forecast is as shown in Table 4.3.3.

(2) Freight traffic demand

Future traffic demand of freight has been estimated by the curve regression analysis method from the general traffic trend in the past, because the original unit for future generation of the freight traffic in Cochabamba remains unknown.

Notwithstanding the fact that the demand has so far been on a general increase for the 1971 ~ 1978 period, future forecast can not be made so accurately by straight-forward application of the past increasing trend because the past trend line is varied, year by year, with large undulation. For this reason, forecast is herein based upon two alternative cases with a relatively high increase rate and with a relatively low increase rate, within the range of which the predicted value of demand is assumed to exist.

The following is the regression formula showing the result of relatively small increase as against the actual increase in the past. The comparison between the actual trend of demand and the estimated demand as sought from the regression formula is as shown in Table 4.3.3.

Curve regression formula: $y = 96{,}076 + 79{,}366 \log x \quad x=1\ (1971)$

Table 4.3.3 Comparison Between Actual Demand and Estimated Demand

Unit: Ton

Year	Actual Demand	Estimated Demand
1971	96,164	96,076
72	119,704	119,967
73	162,102	133,943
74	94,663	143,859
75	150,690	151,550
76	138,132	157,834
77	163,105	163,148
78	167,750	167,750

Although the estimated demand seems to have been increasing at a nearly equal rate to the actual trend, the long-range projection prodicts a rather discouraging prospect that the future demand by 2,000 would reach 213,309 tons but it would only be no more than 27 per cent in the rate of increase as compared with the present demand level (in 1978).

As an alternative case to the above, it is expected that the flow of freight to and from the State of Cochabamba will increase briskly in the future as well as in the past, since active effort is being paid to the industiral development in the Cochabamba State under the Andes Treaty Organization.

In this case, therefore, the estimated traffic demand as sought from the following regression formula reflecting a relatively high rate of increase can be compared with the actual trend of demand as shown in Table 4.3.4.

Curve regression formula:

$$y = 117,022 + 6,213x + 0.016x^2 \qquad x=1 \text{ (1971)}$$

Table 4.3.4 Comparison Between Actual Demand and Estimated Demand

Unit: Ton

Year	Actual Demand	Estimated Demand
1971	96,164	123,251
72	119,704	129,512
73	162,102	135,805
74	94,663	142,130
75	150,690	148,487
76	138,132	154,876
77	163,105	161,297
78	167,750	167,750

The long-range forecast of demand predicts that it would reach 317,812 tons by 2,000 or 89 per cent increase above the present level (1978).

After analysis by the regression method on the two alternative cases, the intermediate figure to be obtained between the two as forecasted by the regression method has been adopted for this project, on assumption that adequate sum of investment would be promoted and the future freight traffic demand could be located within the range of forecast as obtained from the two regression formulas, as shown in Fig. 4.3.2.

The freight transport in 1978 is shared by 22 per cent for export, 56 per cent for import and 22 per cent for domestic. In view of the latest declining trend in the domestic share of freight transport, the future share is assumed to trace a certain fixed trend of 25 per cent for export, 55 per cent for import and 20 per cent for domestic. Then, as the result of model sharing, the future freight transport by railway can be estimated as shown in Table 4.3.5, on assumption that 4.2 per cent of the domestic transport volume would be shifted to the improved road traffic.

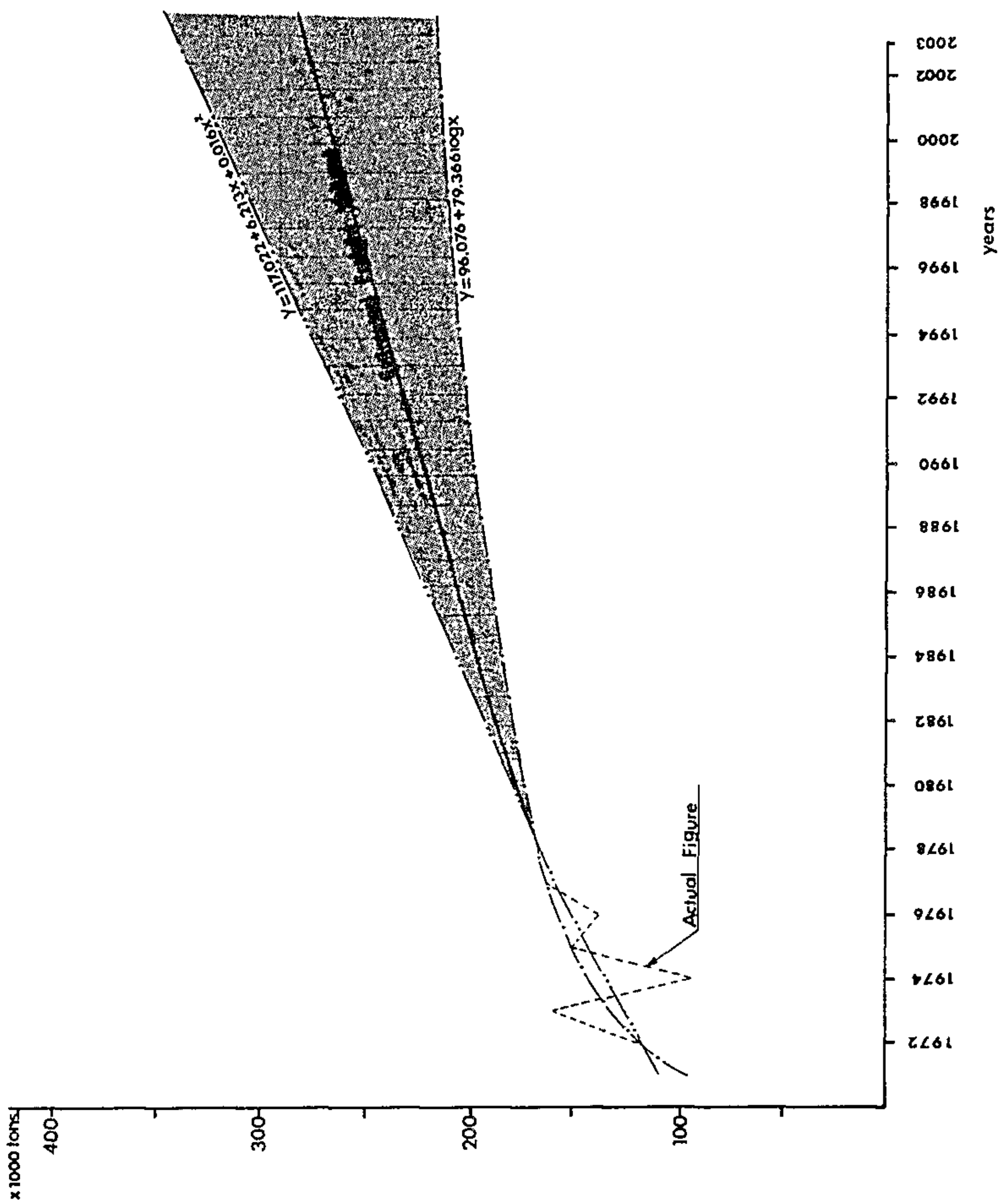


Fig. 4.3.2 Future Freight Traffic Demand

Table 4.3.5 Passenger & Freight Traffic Demand (Natural Increase)

Year	Passenger (Person)	Freight (Ton)				
		Intermediate Value	Except the Partial Volume Shifted to Road Traffic			
			Export (25%)	Import (55%)	Domestic (19.16%)*	Total
1980	323,900	178,100	44,500	98,000	34,100	176,600
81	330,000	183,000	45,800	100,700	35,100	181,600
82	336,100	187,800	47,000	103,300	36,000	186,300
83	342,400	192,500	48,100	105,900	36,900	190,900
84	348,700	197,100	49,300	108,400	37,800	195,500
85	355,200	201,600	50,400	110,900	38,600	199,900
86	361,800	206,100	51,500	113,400	39,500	204,400
87	368,600	210,500	52,600	115,800	40,300	208,700
88	375,400	214,900	53,700	118,200	41,200	213,100
89	382,400	219,200	54,800	120,600	42,000	217,400
1990	390,400	223,500	55,900	122,900	42,800	221,600
91	398,600	227,800	57,000	125,300	43,600	225,900
92	407,000	232,000	58,000	127,600	44,500	230,100
93	415,500	236,300	59,100	130,000	45,300	234,400
94	424,300	240,500	60,100	132,300	46,100	238,500
95	433,200	244,700	61,200	134,600	46,900	242,700
96	442,300	248,900	62,200	136,900	47,700	246,800
97	451,600	253,100	63,300	139,200	48,500	251,000
98	461,000	257,200	64,300	141,500	49,300	255,100
99	470,700	261,400	65,400	143,800	50,100	259,300
2000	480,600	265,600	66,400	146,100	50,900	263,400
01	490,700	269,700	67,400	148,300	51,700	267,400
02	501,000	273,900	68,500	150,600	52,500	271,600
03	511,500	278,000	69,500	152,900	53,300	275,700

* (1.00-0.042)×20%=19.16%

CHAPTER 5 ECONOMIC ANALYSIS

5.1 The Method of Economic Analysis

The purpose of economic analysis herein taken up for review is to make a study of whether or not it is significant, in the light of the national economy, to execute the improvement project as proposed after technical feasibility study; in short, it is to study to see if the project is economically feasible.

5-1-1 Basic Conception

With regard to the improvement plan for the Cochabamba branch line, the proposals selected as being technically feasible are to construct a new tunnel in the 48 km + 000 m to 57 km + 650 m section, to construct a detour route on the opposite bank side for the 103 km + 000 m to 110 km + 000 m section and to lifting-up the track level in the 112 km + 500 m to 116 km + 500 m section.

Those two sections, where construction of a detour line and lifting-up of the track level are proposed, are conspicuous by high frequency of disastrous damage occurrence on a large scale, as compared with any other damaged sections, thus causing problems in the daily train operation. For this reason, an approach to economic analysis of this project is made on assumption that the improvement work for each of those two sections in question would be carried out simultaneously at the same time, and thus measurement is made on the benefits to be produced from such improvement. Apart from those two rehabilitation projects, the new tunnel construction project between 48 km + 000 m and 57 km + 650 m is evaluated separately, since the said project aims at saving of the maintenance cost. Presented in Appendix-2 are the results of economic analysis by combining two improvement plans; one (Alternative C) for a section from 101 km + 000 m to 110 km + 000 m and the other for a section from 112 km + 500 m to 116 km + 500 m.

Although the road and the railway exist as the available means of transport between Oruro and Cochabamba, any alternative method of evaluation to choose either railway or road is not taken up in this report as an approach to economic analysis of the project, mainly because of the following conditions to be considered in mind.

- The two transport routes, road and railway, are paralleled close to each other only in the sections between Oruro and Paria and between Parotani and Cochabamba but are not interconnected in all the rest. Therefore, suppose if the railway traffic should be abolished, those local wayside inhabitants would lose their only means of transport at the result.
- The existing railway division between Oruro and Aiquile via Cochabamba is already incorporated into the construction plan as a part of the new transcontinental railway to interconnect Port Santos in Brazil and Port Arica in Chile. Therefore, it is not conceivable at the present time that the railway will be abolished for replacement by the road traffic in the future.

Figure 5.1.1 shows an example of the procedural steps for economic analysis. In case of 'without project', the case study is given such condition that there would further occur, as a repeated cycling pattern, disastrous damages and needs for restoration from them after suspension of train operation on the existing railway line restored from the previous damage. On such assumed basis, calculation has been made to seek the economic loss to be incurred by the passenger or the freight in case of suspension of the train operation service and also the required cost for restoration from the damage, thus evaluating its total cost by comparison with the cost to be estimated in case of 'with project'.

Calculation for the economic analysis has been based upon the following conditions:

(1) Normally, the economic durable service life of a new earth structure is fixed at 30 years. However, a shorter project life of 20 years is assumed herein for the sections of 103 km + 000 m to 110 km + 000 m planned for a new detour line on the other bank side and 112 km + 500 m to 116 km + 500 m proposed for lifting-up of the existing track level, since the maximum possible length for the track to be enabled to maintain its function is limited to 20 years by assumption in anticipation of any possible future change in local geology. Meanwhile, the project life for new tunnel construction between 48 km + 000 m and 57 km + 650 m is assumed as 60 years.

(2) The official exchange rate of currency in Bolivia is set at US$1.00 =$b20.00. No 'shadow price' against foreign currency is taken into account.

(3) The wage level for unskilled workers is estimated at 20 per cent lower than the prevailing wage level in the labor market.

(4) It is understood that all the materials to be imported for this project will be exempted from any duties and taxes in accordance with the governmental policy in Bolivia. The taxable rate for the materials to be locally procured is estimated at 5 per cent as being applied by ENFE at present.

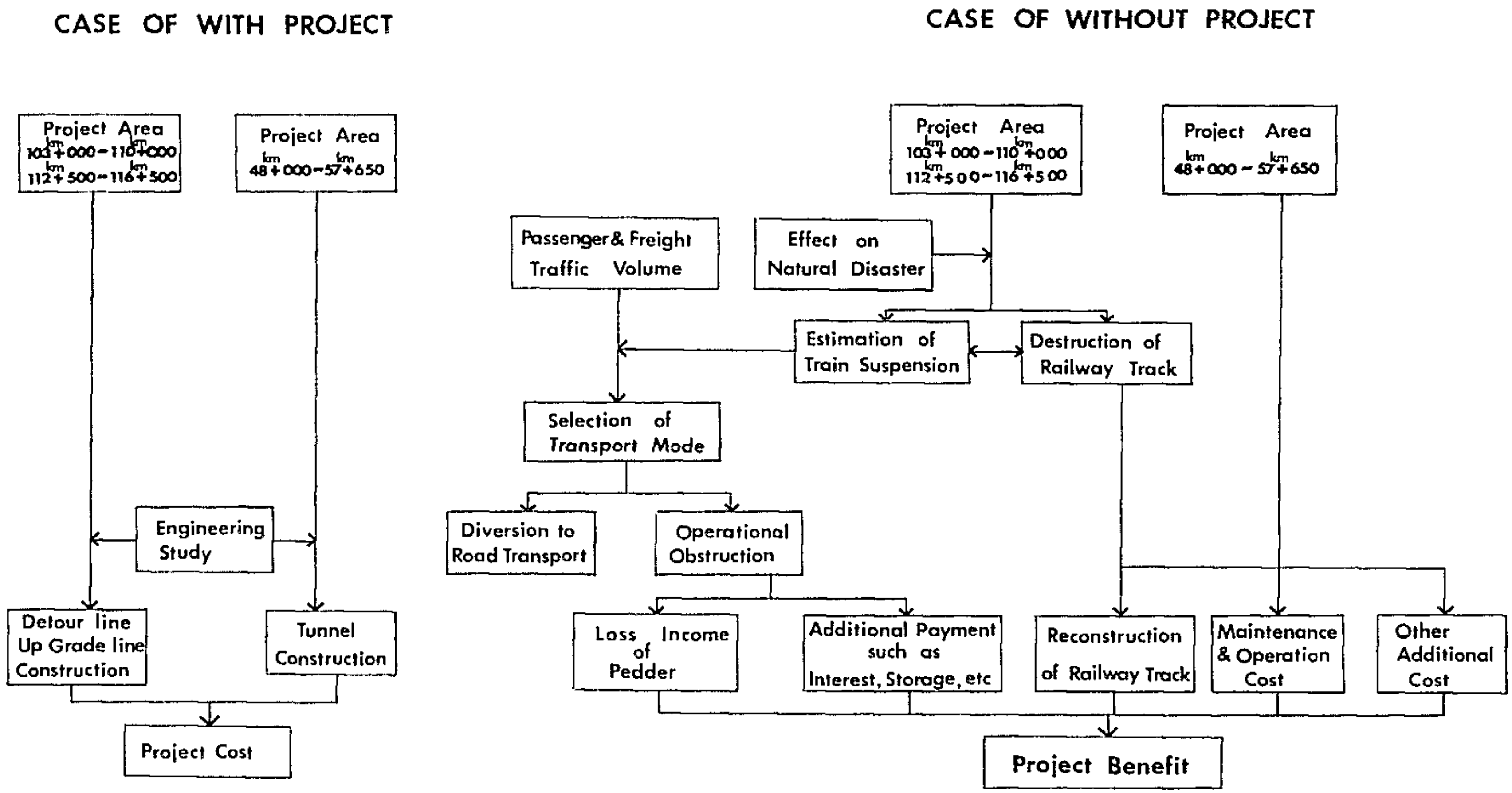


Fig. 5.1.1 Work Flow of Economic Analysis

5-1-2 Assumption on Service Suspension Period

The total number of probable suspension days in train operation are estimated for economic analysis in order to calculate the benefit in terms of the estimated amount of social loss to be incurred by the passengers, freights and wayside inhabitants due to suspension of service.

In case of the Cochabamba branch line, any shuttle service would not be available from the damaged point back to the original starting point, once the track line gets into damage or collapse by natural disaster. If it happens, the operating service of trains between Oruro and Cochabamba would be suspended completely. As shown in Table 5.1.1, the total number of days in suspension of train operation, as calculated from the time length required for restoration from disastrous damages or operational accidents for the past 5 years, amount to 58 days for reason of natural damages alone and 71 days including the other accidental cases such as derailment of trains.

Table 5.1.1 Transport Service Suspension Period

Year	Suspension Days Due to Natural Disaster	Restoration of Train Damages		Service Suspension Days
		Hours	Days	
1975	59	117.45	5	64
1976	52	415.55	17	69
1977	38	409.56	17	55
1978	42	338.07	14	57
1979*	100	236.32	10	110
Average	58	303.39	13	71

Note* The figure includes only January - June records, excluding records in July and henceafter.

Data source: VIA Y OBRAS, ENFE

Since it is expected that there would occur no suspension of train operation due to damages in the improved section, if the rehabilitation project is executed as planned, the total number of days in suspension in the said section to be improved have been estimated from the proportional removal rate of sediment for this section out of the total removal over the whole damaged section.

Table 5.1.2 shows comparison of sediment in removed volume between the whole branch line of Cochabamba and the section planned for rehabilitation. The proportional rate of removal in the improvement section as against the whole line is being swelled from about 51 per cent in 1974 to 73 per cent in 1978, as the result of ever-increasing tendency in occurrence of disastrous damages year after year.

Table 5.1.2 Ratio of Sediment Removal in Volume for Rehabilitation Section in the Whole Track Line

Unit: m^3

Year	Sediment in Volume in the Whole Track Line	Sediment in Volume in the Section Planned for Improvement			Ratio of the Planned Section in the Whole Track Line
		89km.0 ~ 96km.0 *	103km.0 ~ 110km.0 112km.5 ~ 116km.5	Sub-Total	
1974	38,176	8,595	10,779	19,374	51%
1975	-	-	-	-	-
1976	15,944	3,720	4,196	7,916	50%
1977	19,672	2,379	9,911	12,289	62%
1978	33,736	4,342	20,299	24,641	73%

* This section is included in the table because the improvement construction is now under way.

Data source: Planeamiente, ENFE

Although the ratio of sediment removal in volume from the section planned for improvement is expected to continue its further growth, the total number of suspension days in this section is estimated at 46 days at a '79's level, as can be sought from the annual average of 58 days in suspension to be obtained from the past actual record and also from the assumed ratio to be set at 80 per cent for the volume of sediment removal from the said section.

Number of suspension days from damages per month are as shown in Table 5.1.3, apparently being concentrated in the rainy season from January to April. Such number of suspension days each month have been sought from the proportional distribution of the annual total suspension, or 46 days as assumed for the section planned for improvement, by application of the monthly frequency rate of occurrence as calculated from the past record of suspension in operation.

Table 5.1.3 Number of Monthly Suspension Days of Operation Service

Year / Month	1975	1976	1977	1978	1979*	Average	Frequency Rate	Number of Suspension Days of Operation Service
	hours	hours	hours	hours	hours	hours	%	days
1		160.35	17.00	116.45	415.50	141.85	17	8
2		164.15	182.30	119.40	422.10	177.59	21	10
3		265.00	149.40	67.50	744.00	245.18	30	14
4	9.30	8.00		205.00	520.00	148.46	18	8
5	41.00		12.35		2.40	11.15	1	-
6	4.30		72.50		0.30	15.42	2	1
7			2.30			0.46	-	-
8	16.40		0.20	1.45				
9	16.40	0.40	6.30			4.62	1	1
10			16.25	2.35		3.72	1	
11	20.30	9.10	88.31	58.65		35.27	4	2
12	46.30	18.00	68.15	80.76		42.64	5	2
Total	154.00	625.00	615.06	651.56	2,104.30	826.36	100	46

Note * The 1979 figures show only January - June records, excluding those in July and thereafter.

Data source: VIA Y OBRAS, ENFE

In the meantime, the time required for restoration from the operational accident of trains is computed as 13 days as the annual average, as shown in Table 5.1.1, by daily conversion from the past record on restoration. The greater majority of accidents experienced fall upon the category of derailment attributable to insufficiency of track maintenance. It is therefore believed that the frequency of train accidents could be reduced if the improvement work is executed for the section.

Table 5.1.4 includes frequency of operational accidents in the said section as compared with that in the whole track line. According to the most up-to-date record, it can be said that about 30 per cent, 4 days of equivalent daily conversion, of the total operational accidents take place in this limited span of section.

Although such operational accident has no direct bearing with the disastrous damage, the length of 4 days as converted from total frequency of operational accidents in this section may possibly be reduced to far less, if the improvement work is completed.

Table 5.1.4 Frequency of Operational Accidents in the Improvement Section as Compared with the Whole Track Line

Year	Frequency of Operational Accidents in the Whole Track Line	Frequency of Operational Accidents in the Improvement Section			Ratio of Improvement Section Compared in the Whole Track Line
		89km.0 ~ 96km.0 *	103km.0 ~ 110km.0 112km.5 ~ 116km.5	Sub-total	
1974	51	1	6	7	14%
1975	97	6	14	20	19
1976	65	8	19	27	42
1977	155	17	28	45	29
1978	247	50	32	82	33

Note * This section is included because the improvement works are now under way.

Data source: VIA Y OBRAS, ENFE

Services are suspended whenever the disastrous damage takes place on the branch line of Cochabamba. After review of the data on the service suspension of trains, it is forecasted that the annual total number of days in suspension would be reduced from 58 days to 12 days and the total even including accidental suspension would be decreased from 71 days to 21 days. However, in case of the operational accident it may sometimes be possible that such accident can be restored in a very short time. With this in mind, therefore, the effect from any accident will be checked by sensitivity analysis.

5-1-3 Concept of Freight Evaluation

In this economic analysis, the freight cost has been evaluated by measurement of the interest accuring from the goods remaining undelivered as the additional cost to the capital goods to the account of the owner or the consigner, same as the assessing method applied to the rehabilitation project for the Santa Cruz - Corumba section of the Eastern Line. The commercial value of the goods as the basis for calculation of the interest accrual has been sought, after deduction of export and import taxes and sales taxes regarded as transfer costs, by investigation of market prices on an item-to-item basis with regard to all kinds of freight handled by railway transport between Oruro and Cochabamba.

Table 5.1.5 is a summary list of the total sales sums of freight by export, import and domestic transportations in 1978, thereby indicating the average sales amount of 10,333$b per ton for export, 25,833$b per ton for import and 14,082$b per ton for domestic transport.

Table 5.1.5 Commercial Sales Amount by Commodity

Goods	Export		Import		Domestic		Key goods
	No. of tons handled (ton)	Sales sum (1,000$b)	No. of tons handled (ton)	Sales sum (1,000$b)	No. of tons handled (ton)	Sales sum (1,000&b)	
Agriculture & sea products	18,556	131,678	42,909	767,959	5,677	60,780	Wheat, fruits, cotton, beaf, mule, etc.
Forest products	893	6,251	1,967	9,543	11,416	44,734	Lumbers, cross-ties, etc.
Mining products	3,584	100,095	3,784	50,434	9,374	141,187	Lime, marble, gypsum, iron ore, etc.
Metal & machinery	0	0	6,245	426,515	1,362	185,230	Train, electric generator, automobile, agricultural machinery
Chemical products	0	0	19,519	449,893	7,723	39,492	Alcohol, chemical fibres, oil synthetic rubber, etc.
Light indus-trial products	0	0	498	26,086	22	176	Glass wares, textile, beers, papers, etc.
Industrial merchandise	6	30	1,835	149,622	277	19,048	Home furniture, china-wares, TV's music instruments, etc.
Special products	0	0	401	28,070	0	0	Animal feed
Others	0	0	746	102,066	213	14,222	Tabacco
Total goods	23,039	238,054	77,904	2,010,188	35,851	504,869	
$b/ton	16.9%	10,333	56.9%	25,803	26.2%	14,082	

(Note) The sales sum by goods are calculated to subtract various taxes from the survey results in cooperation with the exporters and importers.

5-2 Benefits Incidental to the Project Execution

5-2-1 Benefit to Be Expected from Rehabilitation Project

(1) Evaluation of non-transport passenger

a) Railway passengers

The branch line of Cochabamba is noted for its heaviest passenger traffic volume in all the existing railway divisions.

According to the traffic record in 1978, the total railway passengers can be shared by 43 per cent for Ferro-bus and 57 per cent for ordinary train, as shown in Table 5.2.1. It is said that the ferro-bus is generally utilized by tourists traveling in and out of the country and the passengers traveling on business of rather high grade, while about 40 per cent of those passengers utilizing the orindary train service are the peddlers selling vegitables and other farm products.

Table 5.2.1 Passenger Train Use Pattern by Mode of Transportation (1978)

Mode of Transportation	No. of Passengers	Ratio to Total Passenger	Passenger - km	Average Traveling Distance *
	(Persons)	(%)	(×1,000)	(km)
Ordinary Train	178,895	57	22,191	124
Ferro-bus	133,330	43	28,068	211
Total	312,225	100	50,259	-

Note * Because of inflow or outflow of passengers from sections other than the Oruro - Cochabamba section, the average traveling distance is longer than computed.

Although the benefit to be produced by implementation of the project may be estimable for all the passengers utilizing ordinary train and ferro-bus, those ferro-bus travelers are regarded herein as being influenced by neither cost nor benefit, on the judgement that they would be relatively free in their optional choice of any other alternative facilities, such as planes or passenger-cars, utilizable so as to minimize their own sacrifice of cost, even if the train service is suspended.

Of all the passengers utilizing ordinary trains the general travelers account for 60 per cent. In assessing the time value for those general travelers, it is assumed that there would be no time value worthy of assessment on their travel in consideration of the fact that the said passengers belong to the low income stratum. Therefore, assessment is made on the sales of farm products to be carried by peddlers.

a) Peddlers to be affected by train service suspension

Since it is said that peddlers sell farm products by use of railway traffic after purchased in the city of Cochabamba, the number of peddlers getting on and off the Cochabamba station are estimated on the basis of the O.D. Table on passengers as of June 1978, on assumption that the pattern in that O.D. Table would further continue in the future.

Although the sphere of sales activities by the peddlers remains unknown, it is assumed that the range of their traveling would cover the wayside area between Oruro and Cochabamba. With regard to railway utilization on the Cochabamba branch line. The O.D. Table in June 1978 indicates that the number of passengers traveling within the said section amount to 44 per cent of 17,547 persons out of the total 39,532 persons utilizing the railway service (Table 4.2.5). The passengers getting on or off at the Cochabamba station are shared by 71 per cent of 12,391 persons in the total number of passengers traveling within the said section.

Therefore, the estimated number of peddlers who will get on or off the Cochabamba station in 1984, the year of producing the benefit from the project upon completion of the planned rehabilitation would be:

$$348{,}700 \times 0.44 \times 0.71 \times 0.57 \times 0.40 \times 1/2 = 12{,}418 \text{ persons per year}$$

Therefore, the number of passengers to be affected for the suspension period of train service would be:

$$12{,}418 \times 46/365 = 1{,}565 \text{ persons}$$

b) Estimated loss to be incurred by peddlers

On the assumed basis that the range of peddlers' sales activity would cover the wayside area between Oruro and Cochabamba, the average traveling distance for each passenger getting on or off the Cochabamba station can be estimated at 108 km as calculated from the O.D. Table in June 1978.

Since the average sales of peddlers utilizing the railway traffic are estimated at 500\$b per each at average, the net loss can be computed as follows after deduction of the railway fare paid and other expenses:

$$500 \times 0.90 - 34 \times 2 = 382\$b$$

Where, the railway fare is counted as 34\$b on a single way and the expenses are estimated roughly at 10 per cent of total sales.

Then, by use of the number of days in suspension of railway service as per-determined the total loss in 1984 may be computed as follows:

$$1{,}565 \text{ persons} \times 382\$b = 598{,}000\$b$$

2) Estimated loss to be incurred by wayside inhabitants

Most of the wayside inhabitants alongside the branch line of Cochabamba are engaged in the agricultural and stock farms, while a part of them earn their daily bread as venders of food and drink to the train passengers. Since their income would undoubtedly be decreased as the result of train service suspension, their estimated loss must be computed.

Because the number of such venders to be gathered at one station are unknown, estimation is made herein for 17 station (except Oruro station) with a local population over 1,000, on assumption that each one of ten venders at average could earn about 50$b per each a day. It is also assumed that the future sales would grow in proportion to possible increase in the total number of passengers.

Hence, the loss in their earnings may be computed as follows in 1984:

17 stations × 10 persons × 50$b × 348,700/318,000 × 46 days
= 430,000$b

Incidentally, the estimated total of 318,000 for passengers in 1979 is obtained from the actually recorded figure in 1978 multiplied by 1.38 per cent as an applicable increase rate.

From the result above, the estimated total loss by 2003, the year in which the project life will come to end, may be computed as shown in Table 5.2.2.

Table 5.2.2 Loss Amount Incurred by Non-transport Passengers

Year	Estimated Loss of Railway Passengers ×1,000$b	Estimated Loss of Wayside Inhabitants		Total Loss ×1,000$b
		Sales Amount $b	Loss Amount ×1,000$b	
1984	598	55	430	1,028
1985	609	56	438	1,047
1986	620	57	446	1,066
1987	632	58	454	1,086
1988	644	59	461	1,105
1989	656	60	469	1,125
1990	669	61	477	1,146
1991	683	63	493	1,176
1992	698	64	500	1,198
1993	712	65	508	1,220
1994	727	67	524	1,251
1995	743	68	532	1,275
1996	758	70	547	1,305
1997	774	71	555	1,329
1998	790	72	563	1,353
1999	807	74	579	1,386
2000	824	76	594	1,418
2001	841	77	602	1,443
2002	859	79	618	1,477
2003	877	80	626	1,503

(2) Non-transport freight evaluation

On the Cochabamba branch line, the train operation service apts to be suspended by disastrous damages incurred every year and economic loss is estimated hereunder in case of such service suspension in freight transport.

1) Measures taken against train service suspension

Table 5.2.3 shows the emergency measures set up, for domestic transport, export and import of freight in the case of train service suspension, by reference to the previous patterns of handling.

Table 5.2.3 Transport Measures against Service Suspension

	Railway Transport			Alternative Transport	Total
	Warehouse	Open Stock Pile	Sub Total		
	%	%	%	%	%
Domestic					
Oruro → Cochabamba	68.0	17.0	85.0	15.0	100.0
Cochabamba → Oruro	42.5	42.5	85.0	15.0	100.0
Export					
Cochabamba → Oruro	45.0	45.0	90.0	10.0	100.0
Import					
Oruro → Cochabamba	100.0	-	100.0	-	100.0

a) Warehouse and open stock-pile

This pattern of freight handling applies to the cargoes in stock ready for resumption of the railway operation. Since the freight, except those left on the ground, would be kept in the warehouse (including the freight vehicle body), total economic loss incurred on those freight kept idle in stock or on ground until resumption of operation is assessed at an interest rate (12 per cent per annum) to the warehouse cost rated at 4$b per ton being applied to the case of ENFE.

b) Alternative transport

In the previous instance of freight handling in case of service suspension, about 10 to 15 per cent of the total freight carried by railway is said to be handled by truck or other means of road transport as the alternative to the railway in suspension. Therefore, this pattern applied to assessment of the alternative means in this project. The freight to be carried by such alternative means is assumed herein to produce neither benefit nor loss in the economic cost analysis, on the judgement that the owner or the consigner would have chosen the other alternative means with an intension to minimize his own sacrifice of cost.

2) Estimated amount of loss

The amount of loss to be incurred incidental to the suspension of train running can be assessed by the custody cost and interest accrual to be incurred until resumption of the operation. The estimated freight transport for the year 1984 may be computed as follows.

a) Domestic freight

In case of domestic freight transport, it is relatively easy to choose the other alternative means to the railway when it has been suspended. Therefore, the alternative means of transport is estimated herein at a share of 15 per cent. The share by directions to destinations has been estimated at 42 per cent in the direction from Oruro to Cochabamba and at 58 per cent in its reversed direction. The majority of the freight moving in the direction from Oruro to Cochabamba is carried by freight trains up to the Oruro station. Then, the share of freight in stock has been estimated at a ratio of 80 per cent for warehouse and remaining 20 per cent for open stock-pile in that direction. In the reversed direction from Cochabamba to Oruro the total freight in stock is estimated to be halved exactly by warehouse and open stock-pile.

b) Exporting goods

Prior to shifting of the transport means of exporting and importing goods from railway, because of its service suspension, to truck or any other available means, it is necessary to acquire the approval from the Ministry of Finance by submission of the notice in writing of change of the destination. In the judgement of the fact that it would normally take 7 or 8 days at least from application for governmental approval until procurement of trucks or any other transport service, it is scarcely conceivable that any other means of transport would be utilized as the substitute for the railway in the said section where the length of each suspension period can be limited only a few days. However, since there seems to be a possibility of utilizing trucks or any other services available for such exporting goods as being ready for loading on the train at Cochabamba stations or wherever else up to the destination of the Oruro station, a share of such alternative means is estimated herein at 10 per cent.

c) Importing goods

As far as the importing goods are concerned, it is assumed that no other alternative means of transport would be utilized even though the train operation service may be suspended, in the judgement of the number of days to be required for acquisition of the approval on the change of destination in relation to the normal period of train service suspension.

On the basis of the assumed conditions as aforementioned, the estimated total loss of the freight out of the railway transport service due to its suspension can be calculated as shown in Table 5.2.4. The calculating method is shown in Appendix 3.

Table 5.2.4 Loss of Non-transport Freight

Unit: 1,000$b

Year	Domesric Freight		Exporting Goods		Importing Goods		Total
	Warehouse	Interest	Warehouse	Interest	Warehouse	Interest	
1984	466	862	514	874	2,513	5,337	10,566
85	476	881	526	893	2,572	5,460	10,808
86	487	901	537	913	2,630	5,583	11,051
87	497	919	549	932	2,685	5,702	11,284
88	508	940	560	952	2,741	5,820	11,521
89	518	958	572	971	2,797	5,938	11,754
90	528	976	583	991	2,850	6,051	11,979
91	538	995	595	1,010	2,906	6,169	12,213
92	549	1,015	605	1,028	2,959	6,283	12,439
93	559	1,033	617	1,048	3,015	6,401	12,673
94	569	1,052	627	1,065	3,068	6,514	12,895
95	579	1,070	639	1,085	3,121	6,627	13,121
96	589	1,088	649	1,102	3,175	6,740	13,343
97	598	1,106	661	1,122	3,228	6,854	13,569
98	608	1,125	671	1,140	3,281	6,967	13,792
99	618	1,143	682	1,159	3,335	7,080	14,017
2000	628	1,161	693	1,177	3,388	7,193	14,240
01	638	1,179	703	1,195	3,439	7,302	14,456
02	648	1,198	715	1,214	3,492	7,415	14,682
03	658	1,216	725	1,232	3,546	7,528	14,905

(3) Estimation of emergency restoration cost

The sections of 103 km + 000 m ~ 110 km + 000 m and 112 km + 500 m ~ 116 km + 500 m under the proposed rehabilitation project are conspicuous by highest frequency of being suffered from damages as compared with any other damaged sections and marked by damages on large scale. Under such circumstance, there have been repeated needs of maintenance and repair every year in the past.

Therefore, since annual expenses would be required for maintenance and repair each year if the rehabilitation project is not implemented, the cost estimate is made on the basis of the actual record in the 1974 ~ 1978 period.

1) Expenses required for restoration by damage occurrence

The expenses required in the two sections under the proposed rehabilitation project may be broken down largely into the cost for immediate measures of restoration and the cost for repair and maintenance in the dry season.

a) Emergency restoration cost

The actual spending for the emergency restoration in the past is as shown in Table 5.2.5. The average cost per annum may be attained at 5,510,000$b of price conversion into the level in 1979.

b) Repair cost for dry season

The annual trend of the repair cost in dry season is as shown in Table 5.2.6. Though the past trend shows considerable fluctuation year by year, the cost for the said two sections accounts for as much as 40 per cent of the total spending in the division of Parotani.

The repair cost for the '75 ~ '79 period is averaged at 6,963,000$b.

Table 5.2.5 Emergency Restoration Cost

Unit: 1,000$b

Year	Expenses			Index (%)	Sum of 1979 Conversion
	101km ~ 110km	113km ~ 116km	Total		
1974	2,976	874	3,850	62.7	6,140
75	3,492	455	3,947	69.7	5,663
76	5,007	395	5,402	74.5	7,251
77	2,012	395	2,407	82.1	2,932
78	5,402	1,810	7,212	89.4	8,067
79				100.0	
Average	-	-	-		6,011

Note: Although the data covers 12 km in total length between 101 to 110 km and between 113 to 116 km, the rehabilitation plan is proposed for 11.0 km out of the above total length. Therefore, the average cost for the planned section length has been adjusted as follows:

$$6,011,000 \times \frac{11.0\text{km}}{12.0\text{km}} = 5,510,000\$b$$

Table 5.2.6 Repair Cost for Dry Season

Unit: 1,000$b

Year	Expenses				①/② (%)	Index (%)	Sum of 1979 Conver-sion
	103.0km ~110.0km	112.5km ~116.5km	① Sub total	② Parotani			
1975	3,238	1,762	5,000	12,494	40.0	69.7	7,174
76	3,523	2,058	5,581	13,968	40.0	74.5	7,491
77	36	-	36	323	11.1	82.1	44
78	2,615	1,011	3,626	8,474	42.8	89.4	4,056
79		-		22,325			
1979 Im-proved			9,131(2)	22,325	40.9	100.0	9,131
Average					(1) 40.9		(1) 6,963

Note (1) The average does not include the cost in 1977.
(2) Though the recorded data for 1979 is not available, estimate is made by assumption that the average rate of 40.9% of the budget allocated for dry season in the division of Parotani would be spent.

c) Cost to be incurred for recovery from future damages

The average costs of recovery from damages, as obtained from the most up-to-date actual record of spending, amount to 5,510,000$b for immediate repair and maintenance and 6,963,000$b for anti-drought measures, the total sum of which reaches 12,473,000$b, or 11,719,000$b reflecting shadow prices at economic cost.

Suppose if the existing line would be suffered from damages in the rainy season every year and immediate measures would be taken for recovery from such damages each time they occur, it is anticipated that the costs would further continue their ever-increasing tendency year after year. According to the past trend on cost increases, the costs trend to increase by 131 per cent (6.3 per cent at annual average) for the '74 to '78 period for immediate measures and by 127 per cent (5.4 per cent at annual average) for the '75 to '79 period for anti-drought measures.

All those things considered, it is estimated that the future annual spending for restoration of damages will increase at an annual average rate of 6 per cent or so.

2) Other effects from execution of the rehabilitation project

In the case that the rehabilitation project will be executed for the two sections involved, it is expected that the maintenance cost will be reducible as the result of shortening of the track length and renewal of the track structure.

The past trend of spending for maintenance in the division of Parotani is as shown in Table 5.2.7. The cost required for maintenance in the said sections, because of frequent outbreak of damages, is considerably higher as compared with any other sections. The maintenance cost in the division of Parotani, as computed by conversion into the price level in 1979, amounts to 22,255,000$b, or 142,000$b per km. On assumption that the track maintenance cost in those sections could be reduced to the nearly equal level to that in the other sections after renewal of the track structure (37,000$b per km at 1979's price level for the other sections), the reducible portion of the maintenance cost may be obtained from the computation as follows (Appendix 4):

$$142{,}000\$b \times 11.0\ km - 37{,}000\$b \times 9.1\ km = 1{,}225{,}000\$b$$

Then, the economic cost reflecting shadow prices would amount to 1,151,000$b.

Table 5.2.7 Maintenance Cost in the Division of Parotani

Unit: 1,000$b

Year	① Cost Total	Ratio		① × ② Normal Maintenance Cost	Index (%)	Cost of 1979 Price Conversion
		Emergency	② Normal			
1974	24,532	0.390	0.610	14.965	62.7	23,868
75	24,175	0.375	0.625	15.109	69.7	21,677
76	26,085	0.400	0.600	15.651	74.5	21,008
77	31,480	0.420	0.580	18.258	82.1	22,239
78	36,285	0.446	0.554	20.101	89.4	22,484
79					100.0	
Average						22,255

5-2-2 Benefit to Be Expected from Tunnel Construction

The section between 48 km + 000 m and 57 km + 650 m starting from Oruro is conditioned adversely in both plane and profile alignments with an average grade of 21/1,000 and with a minimum curve radius of 95.67 m. Because of difficulty in track maintenance, the annual maintenance cost of the track structure exceeds conspicuously that in any other existing sections. Therefore, the benefit is estimated herein from possible saving of both track maintenance cost and operating expense after completion of tunnel construction in the said section.

(1) Maintenance cost saving

The maintenance cost per km in the proposed section for tunnel construction amounts to 10,632$b at monthly average in 1978. This figure is revised to 174,000$b, as shown in Table 5.2.8, when converted into the cost at a 1979's price level by adjustment of a part of the overhead cost as addition.

Table 5.2.8 Maintenance Cost per km a Month

Unit: $b

	Parotani Division (1976)	48km ~ 60km (1978)	48km ~ 60km (1979 Conversion)	
			Adjustment by Price Fluctuation	Adjusted Cost
Payroll cost	4,109	2,575	*4,109 × 1.34	5,506
Material cost	1,485	6,803	6,803 × 1.12	7,619
Traveling expense	138	125	125 × 1.12	140
Temporary allowance	929	521	521 × 1.12	584
Subcontract	4,140	608	608 × 1.12	681
Monthly total	10,801	10,632	-	14,530
Annual conversion	-	-	-	174,000

Note * The payroll cost including the overhead cost for the whole Parotani area is used for estimation, because the payroll cost does not a part of overhead.

The maintenance cost after improvement of both curve and grade by tunnel construction may possibly be reduced down to a level of 37,000$b per km at average on the whole track line of ENFE as computed by estimation of the required cost for restoration. Then, the possible saving of cost, including the merit by shortening of the running length, can be estimated at 1,560,000$b, as shown in Table 5.2.9, or 1,465,000$b reflecting shadow prices in the economic cost.

Table 5.2.9 Maintenance Cost Saving by Tunnel Construction

	Existing Railway Line (A)	After Tunnel Construction (B)	(A) - (B)
Length	9,650 m	3,215 m	6,435 m
Maintenance cost per km	174,000$b/km	37,000$b/km	-
Total maintenance cost in proposed section	1,679,000$b	119,000$b	1,560,000$b

Since the track maintenance cost increases in proportion to the increased total tonnage of trains in passage and the tonnage also increases, in turn, in escalation to the increased traffic volume.

The track maintenance cost may be broken into both fixed and variable costs. Then, as the variable cost increases in proportion to the increased traffic volume, the variable portion should account for 80 per cent as computed from the maintenance cost of '79 price level conversion, as shown in Table 5.2.8, on the assumed basis that the fixed cost portion would be equivalent to half of the payroll cost. Then, the possible saving in the maintenance cost as sought from the future probable increase of the traffic volume is as shown in Table 5.2.12.

$$(14{,}530 - 5{,}506 \times 1/2)/14{,}530 \fallingdotseq 0.80$$

(2) Operating cost saving

Because of improvement in plane and profile alignments after construction of the tunnel, the possible economic benefit is expected from saving of fuel consumption and shortening of running time. Table 5.2.10 shows a comparison of operating expenses, in view of plane and profile alignments and operating performance of trains, with regard to the existing line and the future improvement plan by tunnel construction. In case of tunnel construction as planned, it is estimated that fuel consumption can be saved by 160 liters per each train and the running time can be reduced by 14.3 minutes.

Table 5.2.10 Saving of Operating Expenses

	Fuel Consumption (ℓ)			Running Time (Minute)		
	Existing Line (A)	Tunnel (B)	(A) - (B)	Existing Line (C)	Tunnel (D)	(C) - (D)
Cochabamba → Oruro	143	11	132	22.5	7.3	15.2
Oruro → Cochabamba	243	55	188	21.7	8.4	13.3
Average	193	66	160	22.1	7.8	14.3

Note: The following locomotive has been used for calculation above.

Type of locomotive: MTV 12V (2000 HP)
Weight in haulage : 600 + (Locomotive inclusive)

Although the benefit from tunnel construction covers both saving of fuel consumption and shortening of running time, the latter is not included in the calculated benefit, because the savable time of train running is limited only to 14.3 minutes per each train, which seems to be too short to help boosting-up of productivity in the other sectors, even though ime could be saved as calculated.

Future saving of fuel consumption is calculated herein on the basis of frequency of train operation in 1979, on assumption that possible increase in saving of fuel consumption could be of approximate quantity to increase in traffic volume. Table 5.2.11 shows frequency of daily train operation at average in 1979.

Table 5.2.11 Frequency of Train Operation per Day (1979)

	No. of Trains in Weekly Operation	Daily Average	Conversion into Train
Freight train	7	1.0	1.0
Mixed train	9	1.3	1.3
Ferro-bus	14	2.0	0.2*
Total	30	5.3	2.5

Note * Fuel consumption for a ferro-bus is estimated at 10 per cent of that for a freight train.

Therefore, daily fuel consumption in 1979 is calculated as $2.5 \times 2 \times 160\ell = 800\ell$.

Then, the annual total saving can be computed as $800\ell \times 365$ days $\times$ 2.5\$b = 730,000\$b at the assumed oil price of 2.5\$b per liter (however, shadow price does not apply to light oil because it is deemed as import item). Thus, the possible saving of operating expenses as sought from the future increase of traffic volume is as shown in Table 5.2.12.

Table 5.2.12 Benefit from Tunnel Construction

Unit: 1,000$b

Year	Traffic Volume	Maintenance Cost Saving	Operating Cost Saving	Total
	(ton)			
1984	195,500	1,617	825	2,442
85	199,900	1,653	847	2,500
86	204,400	1,676	861	2,537
87	208,700	1,711	883	2,594
88	213,100	1,735	898	2,633
89	217,400	1,770	920	2,690
90	221,600	1,793	934	2,727
91	225,900	1,828	956	2,784
92	230,100	1,857	971	2,828
93	234,400	1,875	986	2,861
94	238,500	1,910	1,007	2,917
95	242,700	1,934	1,022	2,956
96	246,800	1,964	1,044	3,008
97	251,000	1,992	1,059	3,051
98	255,100	2,016	1,073	3,089
99	259,300	2,051	1,095	3,146
2000	263,400	2,074	1,110	3,184
01	267,400	2,110	1,132	3,242
02	271,600	2,133	1,146	3,279
03	275,700	2,156	1,161	3,317
↓	↓	↓	↓	↓
2043	275,700	2,156	1,161	3,317

Note: Traffic volume is assumed to continue its increase until 2003 and to be stabilized thereafter.

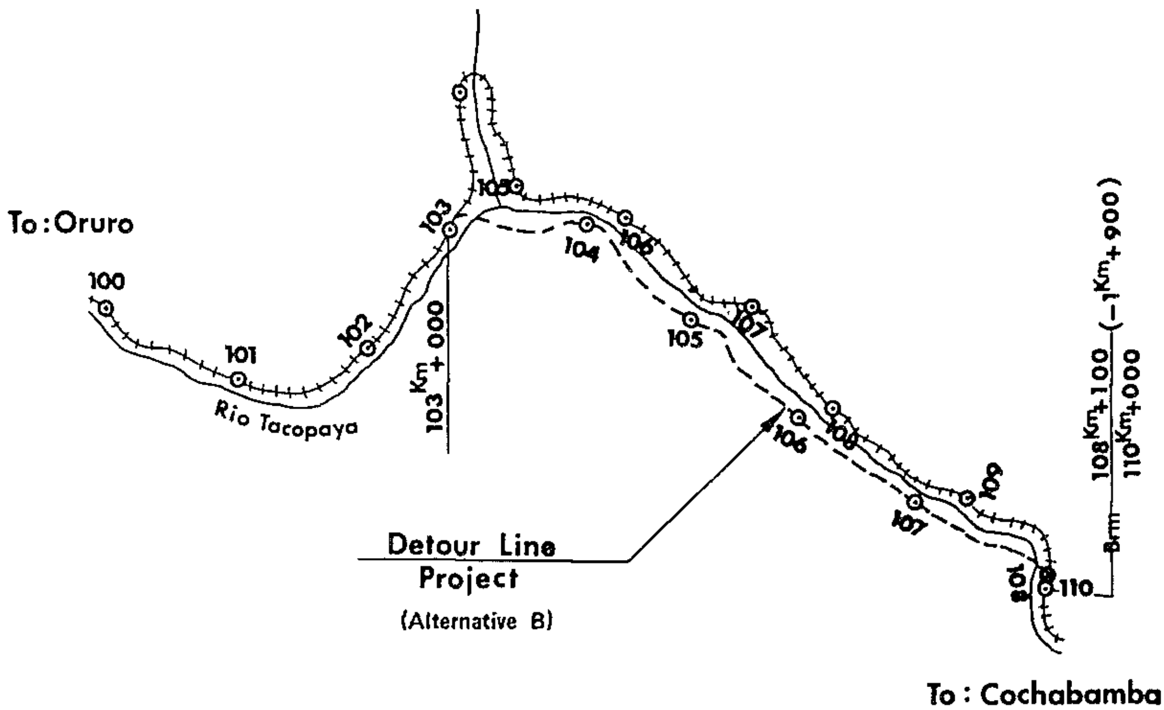
5-3 Costs for Implementation of the Project

After technical review and evaluation on the improvement plan for the branch line of Cochabamba, the following three (3) proposals have been selected as being technically feasible, that is, tunnel construction plan between 48 km + 000 m and 57 km + 650 m, a detour route construction plan on the opposite side between 103 km + 000 m ~ 110 km + 000 m and lifting up of track formation between 112 km + 500 m ~ 116 km + 500 m.
Those improvement plans are outlined as follows:

5-3-1 Rehabilitation Project

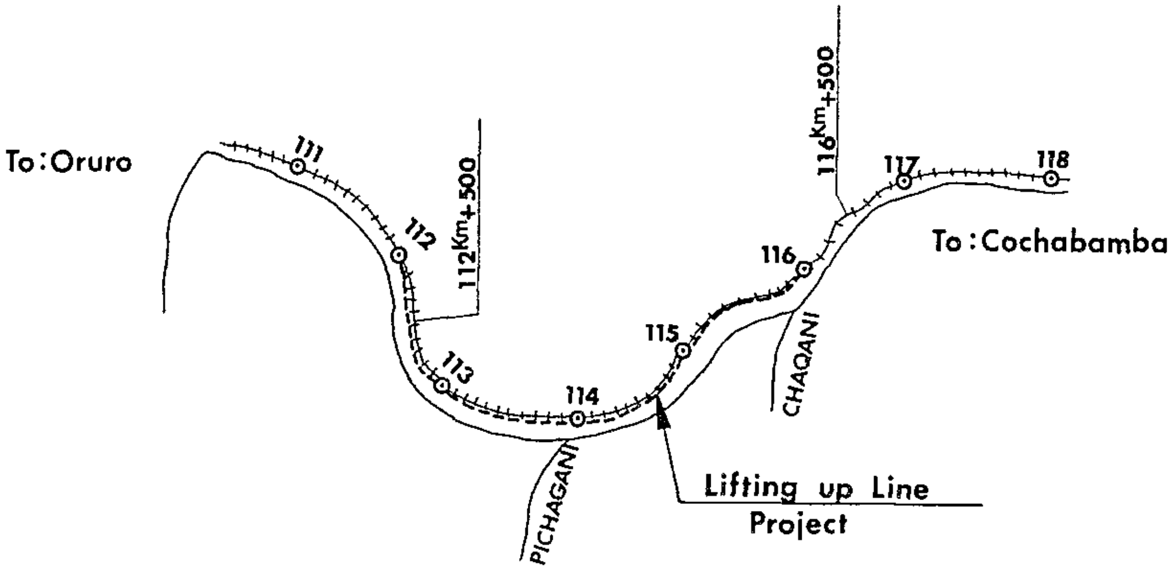
(1) Detour route selected on the opposite bank side (103 km + 000 m ~ 110 km + 000 m)

Because the track in this section runs alongside the valley stream, it is very often suffered from damages such as erosion of the subgrade due to the current flow of the river and burying of the track under a graat deal of sediment flown from many tributaries. Therefore, a new route has been selected on the opposite side bank with relatively stabilized geology.



(2) Lifting-up of track formation (112 km + 500 m ~ 116 km + 500 m)

In this section the track formation level is nearly at an equal elevation to the water surface level as the result of uprising of the river bed formation. The plan is therefore to lifting-up the present level of track formation allowing for any further rise of the river bed.



The construction cost for implementation of the rehabilitation plans, as calculated in Chapter 3, can be converted into the economic costs, as shown in Table 5.3.1 ~ 2, by application of shadow prices to the local currency cost and the unskilled labor cost.

Table 5.3.1 Construction Cost for Proposed Detour Line on the Opposite Side Bank (103 km + 000 m ~ 110 km + 000 m)

Unit: 1,000$b

Type of Work	Material Cost			Labor Cost			Total
	Local Currency	Foreign Currency	Sub Total	Skilled	Un-skilled	Sub Total	
Earthwork	6,478	15,681	22,159	514	1,851	2,365	24,524
Open channel	3	2	5	-	1	1	6
Revetment	2,522	3,131	5,653	330	1,582	1,912	7,565
Bridge	21,004	93,350	114,354	2,746	14,277	17,023	131,377
Track	1,064	6,897	7,961	296	1,182	1,478	9,439
Station·safety securities	303	1,346	1,649	40	206	246	1,895
Sub total ①	31,374	120,407	151,781	3,926	19,099	23,025	174,806
Field supervision ②	1,561	6,041	7,602	183	952	1,135	8,737
Contingency ③	1,643	6,343	7,986	192	1,000	1,192	9,178
Sub total ①~③	34,578	132,791	167,369	4.301	21,051	25,352	192,721
Surveying, designing, etc. ④	-	18,354	18,354	-	-	-	18,354
Total ①~④	34,578	151,145	185,723	4,301	21,051	25,352	211,075

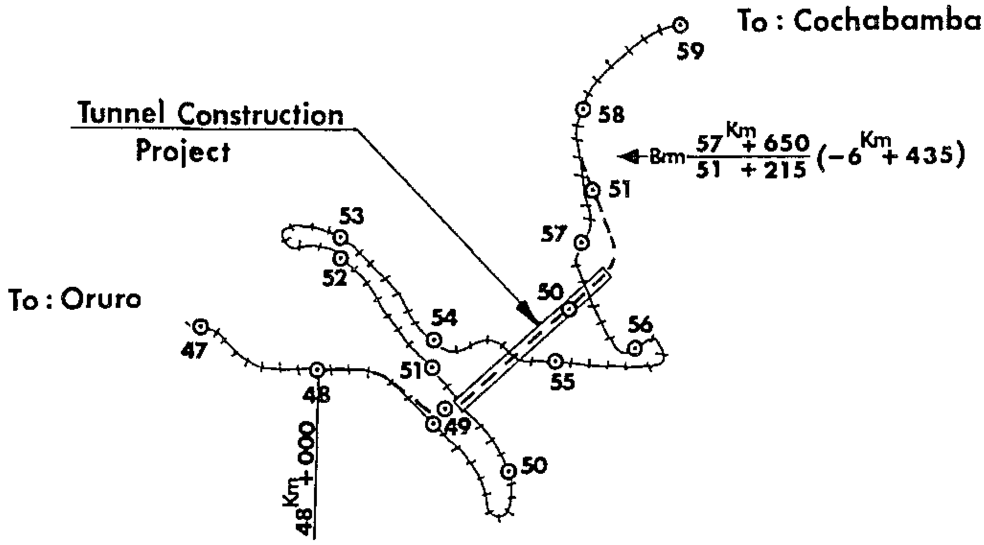
Table 5.3.2 Construction Cost of Lifting-up of Track Formation
(112 km + 500 m ~ 116 km + 500 m)

Unit: 1,000$b

Type of Work	Material Cost			Labor Cost			Total
	Local Currency	Foreign Currency	Sub Total	Skilled	Un-skilled	Sub Total	
Earthwork	5,822	13,352	19,174	438	1,576	2,014	21,188
Revetment	13,308	15,656	28,964	1,648	7,910	9,558	38,522
Pipe culvert ϕ2.0m	169	601	770	8	47	55	825
Bridge	2,985	12,566	15,551	370	1,922	2,292	17,843
Track	762	4,676	5,438	200	802	1,002	6,440
Sub total ①	23,046	46,851	69,897	2,664	12,257	14,921	84,818
Field supervision ②	1,143	2,361	3,504	134	606	740	4,244
Contingency ③	1,200	2,479	3,679	140	636	776	4,455
Sub total ①-③	25,389	51,691	77,080	2,938	13,499	16,437	93,517
Surveying, designing, etc. ④	-	10,160	10,160	-	-	-	10,160
Total ① ~ ④	25,389	61,851	87,240	2,938	13,499	16,437	103,677

5-3-2 Tunnel Construction Project (48 km + 000 m ~ 57 km + 650 m)

Because of unfavorable conditions in both plane and profile alignment of the track line, track maintenance care is required to a great extent in this section. For this reason a short-cut route will be provided by construction of a tunnel.



The construction cost for implementation of the improvement plans, as calculated in Chapter 3, can be converted into the economic costs, as shown in Table 5.3.3, by application of shadow prices to the local currency costs and the unskilled labor cost.

Table 5.3.3 Other Costs Related to Tunnel Construction

Unit: 1,000$b

Type of Work	Material Cost			Labor Cost			Total
	Local Currency	Foreign Currency	Sub Total	Skilled	Un-skilled	Sub Total	
Earthwork	811	1,860	2,671	61	220	281	2,952
Pipe culvert	29	100	129	1	8	9	138
Tunnel	20,378	102,300	122,678	8,250	26,400	34,650	157,328
Track	612	3,758	4,370	161	645	806	5,176
Safety securities	30	127	157	4	19	23	180
Sub total ①	21,860	108,145	130,005	8,477	27,292	35,769	165,774
Field supervision ②	960	5,386	6,346	434	1,390	1,824	8,170
Contingency ③	1,008	5,656	6,664	456	1,459	1,915	8,579
Sub total ①-③	23,828	119,187	143,015	9,367	30,141	39,508	182,523
Surveying, designing, etc. ④	-	15,553	15,553	-	-	-	15,553
Total ①~④	23,828	134,740	158,568	17,844	30,141	39,508	198,076

5-4 Economic Analysis

5-4-1 Benefit Cost Analysis

The branch line of Cochabamba may result in remarkable increase, as compared with the other lines, in regard to repair maintenance and operating costs, because the train runs through the steep hillside and the section featured by frequent happenings of disastrous damage.

Various studies are made herein, within a possible scope of quantitative analysis, to clarify to what extent the benefit will be brought by implementation of the improvement project. Then, analysis can be made as follows for the economic effect from the project.

(1) Rehabilitation project in the section featured by frequent happenings of damage

The rehabilitation project for prevention of the natural disaster aims at such benefits as the economic effect upon passenger and freight transports from the reducible number of days in service suspension and the possible saving of expenses for restoration from damages. The annual cash flow of cost and benefit is as shown in Table 5.4.1. The economic internal rate of return (the discount rate equalizing both cost and benefit) as computed from that Table is as follows:

I.R.R. = 10.28%

Then, the result reveals that the project is economically feasible. Still more, this analysis does not reflect any influence upon the train operation service on the La Paz - Mulato line from probable suspension of service on the branch line of Cochabamba and any induced effect from the reduced number of days in service suspension. Therefore, it is conceivable that higher economic effect can be obtained if those two factors are taken into account.

(2) Tunnel construction

The plan proposes construction of a tunnel in the section between 48 km + 000 m and 57 km + 650 m aiming at such benefits as the savable cost of maintenance and operation. The annual cash flow of cost and benefit is as shown in Table 5.4.2.

Since the benefit to be produced from construction of the tunnel is influenced largely by tonnage of the passing train traffic, the project is far from its economic feasibility with such traffic volume as estimated for the project at present. It is rather advisable to make further review of the economy if the situation becomes encouraging in the future with prospect for large increase in the traffic volume.

5-4-2 Sensibility Analysis

Economic analysis has been made by full review of collected data and information to the possible extent. However, it may be possible that the predicted result should give rise to some uncertainty, since analysis of the benefit is projected over a long range in the future. Therefore, the economic soundness of the project has been reviewed with due consideration to the variable factors affecting the predicted result.

(1) Rehabilitation project in the section featured by frequent happenings of damage

The rehabilitation project aims at the benefit covering the number of suspension days and the expenses required for rehabilitation. Study has been made herein to clarify the extent of influence to be exerted by changes in the number of suspension days.

1) In case of no increase in the number of suspension days

This project is based upon assumption that the annual total number of service suspension days would be estimated at 27 days at a 1979's level with an annual increase rate of 2 per cent to continue thereafter. Then, assuming that the number of suspension days would continue each year at a rate of about 27 days or so until termination of the project life, it is estimated that the internal rate of return would be:

I.R.R. = 9.53%

2) In case of inclusion of restoration time from train accident in the improvement section

The time length to be required for restoration from train accident is estimated at 4 days of daily conversion only in the improvement section as calculated from the past record. If such number of days required for restoration are added to the number of days in train service suspension from disastrous damages, the economic internal rate of reutrn would be

I.R.R. = 10.92%

Table 5.4.1 Cash Flow of Rehabilitation Project

Unit: 1,000$b

Year	Cost	Benefit				
		Passenger	Freight	Rehabilitation Cost		Total
				Emergency Rehabilitation Cost Saving	Maintenance Cost Saving	
1981	28,514					
82	114,495					
83	171,743					
84		1,028	10,566	15,683	1,151	28,428
85		1,047	10,808	16,624	1,151	29,630
86		1,066	11,051	17,621	1,151	30,889
87		1,086	11,284	18,678	1,151	32,199
88		1,105	11,521	19,799	1,151	33,576
89		1,125	11,754	20,987	1,151	35,017
90		1,146	11,979	22,246	1,151	36,522
91		1,176	12,213	23,581	1,151	38,121
92		1,198	12,439	24,996	1,151	39,784
93		1,220	12,673	26,496	1,151	41,540
94		1,251	12,895	28,085	1,151	43,382
95		1,275	13,121	29,770	1,151	45,317
96		1,305	13,343	31,557	1,151	47,356
97		1,329	13,569	33,450	1,151	49,499
98		1,353	13,792	35,457	1,151	51,753
99		1,386	14,017	37,584	1,151	54,138
2000		1,418	14,240	39,839	1,151	56,648
01		1,443	14,456	42,230	1,151	59,280
02		1,477	14,682	44,764	1,151	62,074
03	-82,071	1,503	14,905	47,449	1,151	65,008

Table 5.4.2 Cash Flow of Tunnel Construction

Unit: 1,000$b

Year	Cost	Benefit		
		Saving of Maintenance Cost	Saving of Operating Cost	Total
1981	15,553			
82	73,009			
83	109,514			
84		1,617	825	2,442
85		1,653	847	2,500
86		1,676	861	2,537
87		1,711	883	2,594
88		1,735	898	2,633
89		1,770	920	2,690
90		1,793	934	2,727
91		1,828	956	2,784
92		1,857	971	2,828
93		1,875	986	2,861
94		1,910	1,007	2,917
95		1,934	1,022	2,956
96		1,964	1,044	3,008
97		1,992	1,059	3,051
98		2,016	1,073	3,089
99		2,051	1,095	3,146
2000		2,074	1,110	3,184
01		2,110	1,132	3,242
02		2,133	1,146	3,279
03		2,156	1,161	3,317
↓		↓	↓	↓
2043	-18.30	2,156	1,161	3,317

CHAPTER 6 FINANCIAL ANALYSIS

6-1 Purpose of the Analysis

The purpose of this financial analysis is to compare and assess, on behalf of the enterprise for which an independent profit system is required, the cost to arise from execution of the project and the expense to be incurred otherwise due to non-execution of the project.

This imporvement project is featured by the fact that it would not bring about any increase of income even though it has been executed as proposed, because it is entirely of different nature from the development project of an ordinary pattern which could generate the traffic volume of both passengers and freight or stimulate transfer of such passengers and freight from any other means of transport after completion of the project.

After technical studies, however, it has been revealed that if the existing track condition remains unimproved there would be a specific section (for a rehabilitation project) to be suffered from damages on the track whenever it rains heavily and a section (for a tunnel construction project) to cost remarkably higher expenses for track maintenance than any other existing sections. Therefore, if the projects remain undone, it is estimated that certain amount of expenses should be required every year for restoration from damages, maintenance care and transport of congested freight. Hence, the profitability of the project is reviewed by comparison between the investment sum as the cost for the improvement project in case of 'with project' and the amount of expenses in case of 'without project'.

6-2 Expenditures in Case of Project Execution

The expenditure for project execution has been estimated by comparative study of the following assumed conditions.

(1) Organization

On assumption that the project could be fulfiled by the present work force in the organization of ENFE, any possible increase of the overhead cost is not taken into account.

(2) Subsidy

It has been assumed that the local currency portion of the capital investment cost would be financed by grant of the governmental subsidy at no interest rate. Repayment to the loan fund of the capital investment cost would commence at the future time when the profit will have been yielded at a later year.

(3) Annual operating expenses

The annual operating expenses may include the required costs for vehicles, track, train operation and repair. They are assumed herein to be disbursed on nearly equal conditions, regardless of whether the project will be executed or not.

(4) Capital expenditure

The capital expenditure for construction is estimated on the basis of the plan selected as being most suitable for the improvement project as the result of technical feasibility study. This cost is broken down into both foreign and domestic currency portions as shown in Tables 6.2.1 ~ 6.2.3.

Table 6.2.1 Detour Line Construction Plan on Opposite Bank Side (103 km + 000 ~ 110 km + 000)

Nature of Work	× 1,000$B			× 1,000US$		
	Local Currency	Foreign Currency	Total	Local Currency	Foreign Currency	Total
Earthwork	10,026	15,681	25,707	501	784	1,285
Open channel	4	2	6	-	-	-
Revetment	5,109	3,131	8,240	255	157	412
Bridge	43,930	93,350	137,280	2,197	4,667	6,864
Track	2,956	6,897	9,853	148	345	493
Station · Safety securities	634	1,346	1,980	32	67	99
Sub total ①	62,659	120,407	183,066	3,133	6,020	9,153
Field supervision ②	3,112	6,041	9,153	156	302	458
Contingency ③	3,268	6,343	9,611	163	317	480
Sub total ① ~ ③	69,039	132,791	201,830	3,452	6,639	10,091
Surveying, designing, etc. ④	-	18,354	18,354	-	918	918
Sub total ① ~ ④	69,039	151,145	220,184	3,452	7,557	11,009
Price escalation ⑤	9,556	21,270	30,826	478	1,064	1,542
Total ① ~ ⑤	78,595	172,415	251,010	3,930	8,621	12,551

Table 6.2.2 Plan for Lifting-up of Track Formation Level
(112 km + 500 ~ 116 km + 500)

Nature of Work	×1,000$b			×1,000US$		
	Local Currency	Foreign Currency	Total	Local Currency	Foreign Currency	Total
Earthwork	8,536	13,352	21,888	427	667	1,094
Revetment	25,544	15,656	41,200	1,277	783	2,060
Pipe culvert ϕ2.0 m	245	601	846	12	30	42
Bridge	5,914	12,566	18,480	296	628	924
Track	2,004	4,676	6,680	100	234	334
Sub total ①	42,243	46,851	89,094	2,112	2,342	4,454
Field supervision ②	2,094	2,361	4,455	105	118	223
Contingency ③	2,198	2,479	4,677	110	124	234
Sub total ①~③	46,535	51,691	98,226	2,327	2,584	4,911
Designing, surveying, etc. ④	-	10,160	10,160	-	508	508
Sub total ①~④	46,535	61,851	108,386	2,327	3,092	5,419
Price escalation ⑤	6,525	8,649	15,174	326	433	759
Total ①~⑤	53,060	70,500	123,560	2,653	3,525	6,178

Table 6.2.3 Tunnel Construction Plan
(48 km + 000 ~ 57 km + 650)

Nature of Work	× 1,000$b			× 1,000US$		
	Local Currency	Foreign Currency	Total	Local Currency	Foreign Currenct	Total
Earthwork	1,190	1,860	3,050	60	93	153
Pipe culvert	41	100	141	2	5	7
Tunnel	62,700	102,300	165,000	3,135	5,115	8,250
Track	1,611	3,758	5,369	80	188	268
Safety securities	60	127	187	3	6	9
Sub total ①	65,602	108,145	173,747	3,280	5,407	8,687
Field supervision ②	3,301	5,386	8,687	165	269	434
Contingency ③	3,466	5,656	9,122	173	283	456
Sub total ①~③	72,369	119,187	191,556	3,618	5,959	9,577
Surveying designing, etc. ④	-	15,553	15,553	-	778	778
Sub total ①~④	72,369	134,740	207,109	3,618	6,737	10,355
Price escalation ⑤	10,148	18,847	28,995	508	942	1,450
Total ①~⑤	82,517	153,587	236,104	4,126	7,679	11,805

6-3 Expenditure and Revenue Reduction in Case of Execution of Project

6-3-1 Influences upon the Section Proposed for Rehabilitation

If the section being suffered from frequent occurrences of damages still remains unimproved by execution of the rehabilitation project, it is anticipated that the income to yield from the passenger or freight fare will be decreased and the extra expenses will have to be disbursed for restoration due to suspension of the train service, because the damage is supposed to take place each year the rainy seasons comes.

(1) Passenger fare income reduction

On assumption that all the travelers between Oruro and Cochabamba would be deprived of train service during its suspension, estimate is made for the possible decrease in the total income from the passenger fare of railway for the corresponding period.

The average traveling distance by each train passenger and the share of passengers utilizing train service by classes have been sought from the actual operating record in 1978, the results of which are assumed to further ocntinue in the future. On this basis, the income decrease is calculated for the year 1984, for example, as shown in Table 6.3.1. The calculated result for each year on a long-range projection is as shown in Table 6.3.3.

Table 6.3.1 Decrease in Incomes from Passenger Fare

	Ordinary Train		Ferro-bus		Total
	1st Class	2nd Class	1st Class	2nd Class	
Train passengers	198,800 person (57%)		149,900 person (43%)		348,700 person
Passengers by car classes	66,300 person (2/6)	132,500 person (4/6)	74,950 person (1/2)	74,950 person (1/2)	348,700 person
Ifnluence from service suspension (46/365)	8,400 person	16,700 person	9,450 person	9,450 person	44,000 person
Average traveling length	124 km		210 km		-
Fare (Note)	288,900$b	334,000$b	638,700$b	540,400$b	1,802,000$b

Note: Fares are calculated at a share ratio of adult for 80% and children for 20% in total passengers, to which each rate applies respectively.

(2) Freight fare income reduction

The possible decrease in incomes may be caused by a part of domestic and export freights which would be handled by any other alternative transport during the train service suspension.

The average transport distance of freight has been sought from the actual operating record in 1978, the result of which is assumed to further continue in the future. Although the fare rate of transport may be varied by items of goods to be handled, calculation has been made on a basis of the current average freight rate, or 0.9$b per ton-km. Thus, the income decrease is calculated for the year 1984, for example, as shown in Table 6.3.2 and its long-range forecast by years is as shown in Table 6.3.3.

Table 6.3.2 Decrease in Income from Freight Rate

	Domestic	Export	Import	Total
Traffic volume	37,800 ton	49,300 ton	108,400 ton	195,500 ton
Freight volume by other substitutive means by transport during suspension of service	714 ton	621 ton	-	1,335 ton
Average transport length	181 km	202 km	-	-
Freight fare	116,000$b	113,000$b	-	229,000$b

(3) Expenses for emergency restoration cost

The restoration work is done every year in the section proposed for the rehabilitation project, because of its high frequency of damage occurrence and large scale of damage. Therefore, if the project is not executed as proposed, disbursement of extra expenses is anticipated for restoration from damage as estimated in the preceding item 5-2-1 dealing with the cost and benefit in regard to restoration. The long-range projection on the restoration expenses by years is as shown in Table 6.3.3.

Table 6.3.3 Influences in the Section Proposed for Rehabilitation Project

Unit: 1,000$b

Year	Decrease in Income from Passenger Fare		Decrease in Income from Freightage		Cost of Restoration from Damage	Maintenance Cost	Total
	Ordinary Train	Ferro-bus	Domestic	Export			
1984	623	1,179	116	113	16,692	1,225	19,948
85	634	1,201	119	115	17,693	1,225	20,987
86	646	1,223	122	118	18,755	1,225	22,089
87	658	1,246	124	121	19,880	1,225	23,254
88	670	1,269	127	123	21,073	1,225	24,487
89	683	1,293	129	126	22,337	1,225	25,793
90	697	1,320	132	128	23,677	1,225	27,179
91	712	1,348	134	131	25,098	1,225	28,648
92	727	1,376	137	133	26,604	1,225	30,202
93	742	1,405	140	135	28,200	1,225	31,847
94	758	1,435	142	138	29,892	1,225	33,590
95	774	1,465	144	140	31,686	1,225	35,434
96	790	1,496	147	143	33,587	1,225	37,388
97	807	1,527	149	145	35,602	1,225	39,455
98	823	1,559	152	147	37,738	1,225	41,644
99	841	1,592	154	150	40,003	1,225	43,965
2000	859	1,625	157	152	42,403	1,225	46,421
01	877	1,659	159	154	44,967	1,225	49,041
02	895	1,694	161	157	47,643	1,225	51,775
03	914	1,730	164	159	50,502	1,225	54,694

6-3-2 Influence upon the Section Proposed for Tunnel Construction

This section requires conspicuously higher expenses for track maintenance, when compared with any other sections, because of difficulty in maintenance of the track being laid under the adverse conditions of plane and profile alignments. If the tunnel is constructed in this section, the track alignment can be improved with resultant shortening of the running distance. Then, as estimated in the preceding item 5-2-2, the possible annual saving can be estimated at 1,560,000$b for the track maintenance cost and 730,000$b for the operating expenses. Those savings in cost may increase in escalation to possible increases in the total volume of freight transportation.

6-4 Financial Assessment

6-4-1 Financial Internal Rate of Return

On assumption that the total fund requirement for execution of the improvement project could be financed to a certain extent through a foreign aid loan, instead of total financing from the ENFE's own fund, an estimate is made to see to what extent ENFE can sustain the interest rate.

The construction cost used for this calculation is based upon the market prices. The calculated income includes extra expenses for restoration and increased costs for maintenance and operation which would otherwise be incurred in case of 'without project'.

	Rehabilitation project
Internal rate of return	7.14%

In case of the rehabilitation project, it may be said financially feasible (financially viable), if the foreign loan fund of low interest rate can be introduced to the project.

On the other hand, however, the tunnel construction project lacks its financial soundness, same as calculated by economic analysis. It is therefore advisable to make further review of the project, if the situation becomes encouraging in the future with prospect for large increase in the traffic volume.

Since there may be something unforeseeable to happen before the project is executed, the financial analysis should also need, same as in the case of economic analysis, careful examination to see if this project is financially feasible enough to cope with any risk or uncertainty. Herein, calculation is made to seek the possible extent of cost impact to the financial internal rate of return, in the case where the probable future price increase is incorporated into the construction cost estimated on a 1979's price basis. In calculating this price escalation, the World Bank calculation formula has been used on the two assumed cases of price increases, 7 per cent and 10 per cent annually.

		Rehabilitation project
Internal rate of return	7%	5.46%
	10%	4.80%

The calculated result reveals that the rehabilitation project would become financially feasible only if the loan fund at an interest rate of 4.80 per cent becomes available, on the assumed condition that a price increase rate of 10 per cent would be incorporated into the construction cost. It is therefore expected that the project will be financially feasible by fare rate increase and also by effective use of the low-interest loan fund available from the source abroad.

6-4-2 Financing and Repayment

Financial arrangements for the project and formulation and decision of the repayment plan and schedule can only be made by cooperation of the financing institution affiliated with the government of Bolivia.

For financing arrangements and repayment calculations it has been assumed that the government would bear the capital cost for the local currency portion and the interest accrusal from the foreign currency loan.

(1) Foreign currency

It is assumed that all the foreign currency portions for the construction cost would be financed by the foreign currency loan fund at an annual interest rate of 7.5 per cent. The method of payment would be conditioned on a 25-year instalment basis with a grace period of 7 years.

(2) Local currency

It is also assumed that all the domestic currency portions would be provided from the governmental budgetary fund at no interest rate. This would cover not only the capital cost but also the subsidies to interest payment.

With regard to the financing arrangements and repayment plan, review has been made also in the case where the price increase rate would be incorporated into the construction cost estimated on a 1979's price basis.

In either case of review as above, it is safely predictable that the invested capital would be recoverable by payments. By the year 2014 when payment of the foreign currency loan may terminate, the sum of return to the government would be as shown in Tables 6.4.1 ~ 6.4.3.

• In case no price increase is incorporated into project cost

Unit: 1,000$b

	Rehabilitation project
Sum of return	659,491
Share ratio to governmental investment	5.64

• In case 7% price increase is incorporated into project cost

Unit: 1,000$b

	Rehabilitation project
Sum of return	520,381
Share ratio to governmental investment	3.60

• In case 10% price increase is incorporated into project cost

Unit: 1,000$b

	Rehabilitation project
Sum of return	454,283
Share ratio to governmental investment	2.88

Table 6.4.1 Rehabilitation Project

Unit: 1,000$b

	Foreign Currency Portion					Expenditure			Income	
Year	Investment on Forign Currency	Payment of Loan Capital	Payment of Loan Interest	Total Payment in Foreign Currency	Balance of Loan Outstanding	Total Payment in Foreign Currency	Investment on Local Currency	Total Expenditure	Operational Saved Loss Transferred	Total Annual Govorment Expenditure
1981	28.514				28.514					0.000
1982	73,213		2.139	2,139	101.727	2.139	46.809	48.948		-48,948
1983	109,321		7,630	7.630	211.548	7,630	70.213	77,843		-77.843
1984			15.866	15,866	211.548	15.866		15.866	19,948	4.082
1985			15.866	15,866	211.548	15,866		15.866	20.987	5.121
1986			15.866	15,866	211.548	15,866		15,866	22.089	6.223
1987			15.866	15,866	211.548	15.866		15,866	23.254	7,388
1988		1,154	15.866	17.020	210.394	17,020		17,020	24,487	7.467
1989		4,081	15.780	19.861	206.313	19.861		19,861	25.793	5.932
1990		8.481	15.473	23.954	197.832	23.954		23.954	27.179	3.225
1991		8,460	14.837	23.297	189,372	23.297		23,297	28.648	5.351
1992		8,460	14,203	22.663	180.912	22.663		22,663	30.202	7.539
1993		8,460	13.563	22,028	172,452	22,028		22.028	31.847	9.819
1994		8.460	12.934	21.394	163,992	21.394		21,394	33,590	12.196
1995		8.460	12.299	20.759	155,532	20.759		20,759	35.434	14.675
1996		8,460	11.665	20,125	147.072	20,125		20.125	37.388	17.263
1997		8,460	11,030	19,490	135.612	19.490		19,490	39,455	19,965
1998		8,460	10,396	18,856	130.152	18.856		18,856	41.644	22.788
1999		8,460	9,761	18.221	121.692	18,221		18,221	43,965	25.744
2000		8,460	9,127	17.587	113,232	17.587		17.587	46.421	28.834
2001		8,460	8,492	16,952	104.772	16,952		16,952	49,041	32,089
2002		8,460	7.654	16,318	96.312	16,318		16.318	51,775	35,457
2003		8,460	7.223	15,683	87,852	15,683		15,683	54,694	39,011
2004		8,460	6.589	15,049	79,392	15,049		15.049	54,694	39,645
2005		8,460	5.954	14,414	70.932	14,414		14,414	54,694	40,280
2006		8,460	5,320	13,780	62.472	13,780		13,780	54,694	40.914
2007		8,460	4,685	13,145	54,012	13.145		13,145	54,694	41.549
2008		8,460	4,051	12,511	45.552	12.511		12.511	54.694	42,183
2009		8,460	3.416	11,876	37.092	11.876		11,876	54,694	42.818
2010		8,460	2.782	11.242	28.632	11,242		11,242	54,694	43.452
2011		8,460	2.147	10,607	20.172	10,607		10,607	54,694	44,087
2012		8.460	1,513	9,973	11,712	9,973		9,973	54,694	44,721
2013		7,320	0.878	8,198	4.392	8,198		8,198	54,694	46,496
2014		4,392	0.329	4,721	0,000	4,721		4,721	54,694	49,973
TOTAL	211,548	211,548	301,411	512,958	4018,833	512,958	117,022	629,979	1289,472	659,491

Table 6.4.2 Rehabilitation Project (Inflation rate: 7%)

Unit: 1,000$b

	Foreign Currency Portion					Expenditure			Income	
Year	Investment on Forign Currency	Payment of Loan Capital	Payment of Loan Interest	Total Payment in Foreign Currency	Balance of Loan Outstanding	Total Payment in Foreign Currency	Investment on Local Currency	Total Expenditure	Operational Saved Loss Transferred	Total Annual Govorment Expenditure
1981	31.578				31,578					0,000
1982	86.755		2.368	2,368	118,334	2.368	55,467	57.835		-57,835
1983	139,244		8,875	8,875	257,578	8.875	89,025	97.900		-97,900
1984			19.318	19.318	257,578	19,318		19,318	19.948	0.630
1985			19.318	19,318	257,578	19.318		19.318	20.987	1.669
1986			19,318	19,318	257,578	19,318		19,318	22,089	2.771
1987			19,318	19.318	257.578	19.318		19,318	23,254	3.936
1988		1,266	19.318	20.584	256.312	20.584		20.584	24,487	3.903
1989		4.739	19,223	23,962	251.573	23.962		23.962	25,793	1,831
1990		10,321	18,868	29,189	241.252	29.189		29,189	27,179	-2.010
1991		10,302	18,094	28,396	230.950	28,396		28,396	28.648	0,252
1992		10.302	17,321	27,623	220.648	27.623		27,623	30,202	2,579
1993		10,302	16,549	26,851	210.346	26,851		26,851	31.847	4,996
1994		10,302	15.776	26,078	200.044	26.078		26.078	33.590	7.512
1995		10.302	15,003	25,305	189.742	25.305		25,305	35,434	10,129
1996		10.302	14,231	24,533	179.440	24.533		24,533	37,388	12.855
1997		10,302	13.458	23,760	169,138	23.760		23.760	39,455	15.695
1998		10.302	12.685	22.987	158.836	22.987		22,987	41.644	18,657
1999		10.302	11.913	22,215	148.534	22.215		22.215	43,965	21,750
2000		10.302	11,140	21,442	138.232	21.442		21.442	46,421	24,979
2001		10.302	10.367	20.669	127,930	20.669		20,669	49,041	28,372
2002		10,302	9.595	19,897	117,628	19.897		19.897	51.775	31,878
2003		10.302	8.822	19,124	107.326	19.124		19,124	54,694	35.570
2004		10.302	8,049	18,351	97,024	18,351		18.351	54,694	36,343
2005		10.302	7.277	17,579	86.722	17,579		17.579	54.694	37.115
2006		10,302	6,504	16,806	76,420	16,806		16.806	54,694	37,888
2007		10,302	5.732	16.034	66.118	16,034		16,034	54,694	38.660
2008		10,302	4,959	15,261	55.816	15,261		15,261	54.694	39.433
2009		10,302	4,186	14,488	45.514	14.488		14,488	54,694	40,206
2010		10,302	3,414	13,716	35.212	13.716		13,716	54,694	40.978
2011		10.302	2.641	12.943	24.910	12,943		12,943	54,694	41.751
2012		10,302	1,868	12,170	14,608	12.170		12.170	54,694	42.524
2013		9.039	1,096	10.135	5.569	10.135		10.135	54.694	44.559
2014		5,569	0,418	5,987	0,000	5,987		5.987	54,694	48,707
TOTAL	257.578	257,578	367,021	624,599	4893.621	624,599	144.492	769,090	1289.472	520.381

Table 6.4.3 Rehabilitation Project (Inflation rate: 10%)

Unit: 1,000$b

	Foreign Currency Portion					Expenditure			Income	
Year	Investment on Forign Currency	Payment of Loan Capital	Payment of Loan Interest	Total Payment in Foreign Currency	Balance of Loan Outstanding	Total Payment in Foreign Currency	Investment on Local Currency	Total Expenditure	Operational Saved Loss Transferred	Total Annual Govorment Expenditure
1981	32,934				32,934					0.000
1982	93,018		2,470	2.470	125,952	2,470	59,470	61,940		-61,940
1983	153,440		9,446	9,446	279,432	9,446	98,127	107,573		-107,573
1984			20,957	20,957	279,432	20,957		20,957	19,948	-1,009
1985			20,957	20,957	279,432	20,957		20,957	20,987	0,030
1986			20,957	20,957	279,432	20,957		20,957	22,089	1,132
1987			20,957	20,957	279,432	20,957		20,957	23,254	2,297
1988		1,326	20,957	22,283	278,106	22,283		22,283	24,487	2,204
1989		5,055	20,858	25,913	273,051	25,913		25,913	25,793	-0,120
1990		11,181	20,479	31,660	261,870	31,660		31,660	27,179	-4,481
1991		11,176	19,640	30,816	250,694	30,816		30,816	28,648	-2,168
1992		11,176	18,802	29,978	239,518	29,978		29,978	30,202	0,224
1993		11,176	17,964	29,140	228,342	29,140		29,140	31,847	2,707
1994		11,176	17,126	28,302	217,166	28,302		28,302	33,590	5,288
1995		11,176	16,287	27,463	205,990	27,463		27,463	35,434	7,971
1996		11,176	15,449	26,625	194,814	26,625		26,625	37,388	10,763
1997		11,176	14,611	25,787	183,638	25,787		25,787	39,455	13,668
1998		11,176	13,773	24,949	172,462	24,949		24,949	41,644	16,695
1999		11,176	12,935	24,111	161,286	24,111		24,111	43,965	19,854
2000		11,176	12,096	23,272	150,110	23,272		23,272	46,421	23,149
2001		11,176	11,258	22,434	138,934	22,434		22,434	49,041	26,607
2002		11,176	10,420	21,596	127,758	21,596		21,596	51,775	30,179
2003		11,176	9,582	20,758	116,582	20,758		20,758	54,694	33,936
2004		11,176	8,744	19,920	105,406	19,920		19,920	54,694	34,774
2005		11,176	7,905	19,081	94,230	19,081		19,081	54,694	35,613
2006		11,176	7,067	18,243	83,054	18,243		18,243	54,694	36,451
2007		11,176	6,229	17,405	71,878	17,405		17,405	54,694	37,289
2008		11,176	5,391	16,567	60,702	16,567		16,567	54,694	38,127
2009		11,176	4,553	15,729	49,526	15,729		15,729	54,694	38,965
2010		11,176	3,714	14,890	38,350	14,890		14,890	54,694	39,804
2011		11,176	2,876	14,052	27,174	14,052		14,052	54,694	40,642
2012		11,176	2,038	13,214	15,998	13,214		13,214	54,694	41,480
2013		9,859	1,200	11,059	6,139	11,059		11,059	54,694	43,635
2014		6,139	0,460	6,599	0,000	6,599		6,599	54,694	48,095
TOTAL	279,432	279,432	398,160	677,591	5308,601	677,591	157,597	835,188	1289,472	454,283

APPENDIX

APPENDIX-1 MONTHLY PRECIPITATION OF EACH STATION

CONA CONA STN.

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL AMOUNT
1970	227.0	82.1	74.4	15.8	0	0	0	0	0	0	23.0	186.0	608.3
1971	141.6	119.5	29.5	25.0	0	4.0	0	11.0	0	30.0	75.0	44.0	479.6
1972	200.0	209.0	99.0	57.0	0	0	0	0	0	14.0	13.0	115.0	707.0
1973	197.0	150.0	124.0	0	0	0	0	0	0	24.0	21.0	92.0	608.0
1974	-	-	-	-	-	-	-	-	-	-	-	-	-
1975	-	-	-	-	-	-	-	-	-	-	-	-	-
1976	340.0	55.0	150.0	6.0	0	0	7.0	6.0	47.0	0	23.0	70.0	704.0
1977	72.0	151.0	167.0	22.0	23.0	0	0	0	51.0	69.0	147.0	244.0	946.0
1978	210.0	200.0	82.0	60.0	0	0	0	0	0	33.0	180.0	377.0	1,142.0
1979	697.0	146.0	198.0	20.0	-	-	-	-	-	-	-	-	-
MONTHLY AVERAGE	198.2	138.1	103.7	26.5	3.3	0.6	1.0	2.4	14.0	24.3	68.9	161.1	

AGUAS CALIENTES STN.

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL AMOUNT
1970	351.6	148.1	156.8	28.9	0	0	0	0	0	0	15.0	170.9	871.3
1971	155.5	196.1	43.5	32.0	0	3.4	0	9.3	0	38.0	67.0	62.5	607.3
1972	254.0	230.0	115.0	58.0	0	0	0	0	0	9.0	37.0	177.0	880.0
1973	231.0	110.0	124.0	0	0	0	0	0	0	28.0	62.0	96.0	651.0
1974	-	-	-	-	-	-	-	-	-	-	-	-	-
1975	-	-	-	-	-	-	-	-	-	-	-	-	-
1976	331.0	48.0	122.0	7.0	0	0	9.0	4.0	61.0	0	48.0	45.0	675.0
1977	71.0	174.0	160.0	26.0	23.0	0	0	0	75.0	73.0	124.0	253.0	979.0
1978	231.0	174.0	141.0	84.0	0	0	0	0	0	22.0	154.0	218.0	1,024.0
1979	559.0	136.0	167.0	30.0	-	-	-	-	-	-	-	-	-
MONTHLY AVERAGE	232.2	154.3	123.2	33.7	3.3	0.5	1.3	1.9	19.4	24.3	72.4	146.1	

CHANGOLLA STN.

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL AMOUNT
1970	245.4	145.9	159.7	28.8	0	0	0	0	0	15.0	15.0	138.7	748.5
1971	114.5	301.0	41.0	26.5	0	3.0	0	8.5	0	49.0	50.0	73.5	667.0
1972	269.0	200.0	87.0	7.0	0	0	0	0	0	5.0	32.0	114.0	714.0
1973	224.0	182.0	113.0	0	0	0	0	0	0	20.0	55.0	95.0	689.0
1974	-	-	-	-	-	-	-	-	-	-	-	-	-
1975	-	-	-	-	-	-	-	-	-	-	-	-	-
1976	250.0	58.0	99.0	0	0	0	4.0	0	19.0	0	29.0	58.0	517.0
1977	76.0	186.0	169.0	21.0	19.0	0	0	0	73.0	74.0	153.0	200.0	971.0
1978	179.0	130.0	64.0	67.0	0	0	0	0	0	11.0	213.0	382.0	1,046.0
1979	741.0	88.0	252.0	62.0	-	-	-	-	-	-	-	-	-
MONTHLY AVERAGE	194.0	171.8	104.7	21.5	2.7	0.4	0.6	1.2	13.1	24.9	78.1	151.6	

ARQUE STN.

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL AMOUNT
1970	532.4	170.6	145.4	45.8	0	0	0	0	0	17.6	18.0	242.4	1,172.2
1971	61.5	182.4	46.0	40.5	0	5.0	0	27.0	0	27.0	41.5	93.0	523.9
1972	222.0	187.0	60.0	6.0	0	0	0	0	0	7.0	29.0	193.0	704.0
1973	201.0	142.0	172.0	0	0	0	0	0	0	3.0	36.0	170.5	724.5
1974	-	-	-	-	-	-	-	-	-	-	-	-	-
1975	-	-	-	-	-	-	-	-	-	-	-	-	-
1976	276.0	47.0	104.0	0	0	0	0	0	0	0	29.0	41.0	497.0
1977	116.0	222.0	247.0	10.0	0	0	0	0	48.0	0	75.0	202.0	920.0
1978	230.0	231.0	183.0	45.0	0	0	0	0	0	12.0	61.0	150.0	912.0
1979	548.0	51.0	181.0	39.0	-	-	-	-	-	-	-	-	-
MONTHLY AVERAGE	234.1	168.9	136.8	21.0	0	0.7	0	3.9	6.9	9.5	41.4	156.0	

ORCOMA STN.

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL AMOUNT
1970	239.1	168.9	239.1	64.1	4.5	0	0	0	0	56.0	84.0	94.0	949.7
1971	61.5	182.4	46.0	40.5	0	5.0	0	27.0	0	27.0	41.5	93.0	523.9
1972	272.0	120.0	50.0	16.0	0	0	0	0	0	18.0	35.0	146.0	657.0
1973	151.0	138.0	81.0	0	0	0	0	0	0	51.0	41.0	118.0	580.0
1974	-	-	-	-	-	-	-	-	-	-	-	-	-
1975	-	-	-	-	-	-	-	-	-	-	-	-	-
1976	213.0	33.0	94.0	4.0	0	0	0	0	8.0	0	50.0	57.0	459.0
1977	88.0	202.0	190.0	9.0	0	0	0	0	30.0	2.0	118.0	129.0	768.0
1978	155.0	141.0	185.0	95.0	0	0	0	0	0	1.0	64.0	144.0	785.0
1979	257.0	52.0	135.0	34.0	-	-	-	-	-	-	-	-	-
MONTHLY AVERAGE	168.5	140.8	126.4	32.7	0.6	0.7	0	3.9	5.4	22.1	61.9	111.6	

BUEN RETIRO STN.

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL AMOUNT
1970	292.1	144.9	56.3	30.7	0	0	0	0	0	6.0	6.0	32.5	568.5
1971	40.0	159.5	41.5	23.5	0	7.0	0	10.0	0	36.0	23.5	46.5	387.5
1972	226.0	84.0	51.0	11.0	0	0	0	0	0	8.0	19.0	216.0	615.0
1973	144.0	90.0	128.0	0	0	0	0	0	0	25.0	31.0	102.5	520.5
1974	-	-	-	-	-	-	-	-	-	-	-	-	-
1975	-	-	-	-	-	-	-	-	-	-	-	-	-
1976	218.0	24.0	41.0	4.0	0	0	0	0	0	0	45.0	65.0	397.0
1977	106.0	257.0	178.0	0	0	0	0	0	3.0	0	121.0	150.0	815.0
1978	157.0	126.0	153.0	55.0	0	0	0	0	0	5.0	87.0	260.0	843.0
1979	324.0	46.0	160.0	32.0	-	-	-	-	-	-	-	-	-
MONTHLY AVERAGE	169.0	126.5	92.7	17.7	0	1.0	0	1.4	0.4	11.4	47.5	124.6	

PAROTANI STN.

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL AMOUNT
1970	212.4	93.6	103.6	20.0	15.7	0	0	0	3.6	12.5	60.5	53.0	574.9
1971	52.5	202.5	21.0	0.6	0	16.0	0	9.0	0	8.0	72.5	58.5	440.6
1972	242.8	96.5	0	0	0	0	0	0	0	0	0	125.6	464.9
1973	116.0	175.0	69.0	0	0	0	0	0	0	26.0	54.0	72.5	512.5
1974	-	-	-	-	-	-	-	-	-	-	-	-	-
1975	-	-	-	-	-	-	-	-	-	-	-	-	-
1976	196.0	118.0	58.0	3.0	7.0	0	2.0	2.0	61.5	5.0	63.5	69.5	585.5
1977	59.0	144.0	107.0	6.0	9.5	0	0	4.0	25.0	17.0	100.0	116.0	587.5
1978	139.5	80.0	90.0	32.0	0	0	0	0	0	1.0	112.0	158.0	612.5
1979	157.0	88.0	82.0	5.0	-	-	-	-	-	-	-	-	-
MONTHLY AVERAGE	145.5	129.9	64.1	8.8	4.6	2.3	0.3	2.1	12.9	9.9	66.1	93.3	

APPENDIX-2 Economic Evaluation in the Case of Alternative C

1. Estimation on train service suspension

The probable length of train service suspension for the improvement project section has been estimated from the total earth volume to be removed out of the damaged section. On this basis, the earth volume for the total project section including that of Alternative C can be estimated as shown in Table 2.1.

Table 2.1 Earth Volume Estimated for the Improvement Project Section

Unit: m^3

Year	Total Earth Volume for Whole Section	Earth Volume for Project Section			Ratio of Volume in Project Section for Whole Section
		89km.0 ~ 96km.0	101km.0 ~ 110km.0 112km.5 ~ 116km.5	Sub-total	
1974	38,176	8,595	11,609	20,204	53%
1975	-	-	-	-	-
1976	15,944	3,720	4,621	8,341	50%
1977	19,672	2,378	9,968	12,346	62%
1978	33,736	4,342	20,637	24,979	73%

Although it is expected that the earth volume for the project section will continue further increase in the future as well as in the past, it is assumed herein that such earth volume would account for 80 percent of the total in the said section, same as is in the case of any other alternative plan. Therefore, the total number of days of train service suspension in the project section are estimated at 46 days when 58 days estimated as average number of days of suspension for the Oruro-Cochabamba section are multiplied by 80 percent. Then, the result turns out to be the same number of days as obtained from the comparative study made in the content of the Report.

2. Benefit to gain from the Project execution

(1) Evaluation of non-transport passengers

The result of evaluation for passengers deprived of railway traffic facilities may be same as shown in Table 5.2.2 in the Report because the number of suspension days turn out to be equal to the result of comparative study made in the content of the Report.

(2) Evaluation of non-transport freight

The result of evaluation for freight deprived of transport facilities may be same as shown in Table 5.2.4 of the Report because the number of suspension days turn out to be equal to the result of comparative study made in the content of the Report.

(3) Cost estimate for rehabilitation

Required cost for rehabilitation of the improvement project section including Alternative C is estimated for each of the two categories of cost comprised of cost for emergency restoration and cost for maintenance and repair in the dry season.

a) Cost for emergency restoration

The cost for emergency restoration in the project section can be estimated as follows from the calculated result of conversion on a 1979's basis as shown in Table 5.2.5:

$$6{,}011{,}000\$b \times \frac{13.0\text{km}}{12.0\text{km}} = 6{,}512{,}000\$b$$

b) Cost for maintenance in dry season

The maintenance cost estimated for the project section in the dry season is, as shown in Table 2.2, averaged at 8,277,000$b on a 1979's conversion basis.

Table 2.2 Estimated Maintenance Costs for Dry Season

Unit: 1,000$b

Year	Maintenance Cost in Dry Season				①/②	Index	'79 Conversion from Figures in ①
	101km.0 ~ 110km.0	112km.5 ~ 116km.5	① Sub-total	② Parotani			
1975	4,163 [1]	1,762	5,925	12,494	47.4	69.7	8,501
1976	4,530 [1]	2,058	6,588	13,968	47.2	74.5	8,843
1977	46 [1]	-	46	323	14.2	82.1	56
1978	3,362 [1]	1,011	4,373	8,474	51.6	89.4	4,891
1979		-		22,325			
1979 as revised		-	[3] 10,872	22,325	48.7	100.0	10,872
Average					[2] 48.7		[2] 8,277

Note) 1) The maintenance cost for planned section is calculated based on the proportional allotment in consideration of the average cost of Alternative B.

2) Average figure not including that in 1977.

3) Though the actual figure in 1979 is not yet available, cost estimate is based upon assumption that the average ratio of 48.7% in the total budget granted for Protani Area would be spent for maintenance.

c) Cost estimate for recovery from future damage

The estimated costs for recovery from damage and for maintenance in the dry season amount to 6,512,000$b and 8,277,000$b respectively, the total of which reaches 14,789,000$b. The economic cost reflecting the shadow price is then estimated at 13,894,000$b.

Inasmuch as those costs are expected to trace the ever-increasing tendency year after year, it can be estimated that same as in the case of Alternative B the cost for immediate recovery would increase by 131 percent for the 1974 ~ 1978 period (at annual average increase of 6.3%) and the cost for maintenance in the dry season would increase by 127 percent for the 1975 ~ 1979 period (at annual average increase of 5.4%). It is therefore predictable that the annual cost for recovery in the future should continue its increase at a rate of 6 percent or so.

(4) Expectancy of other effects from execution of Project

If the rehabilitation project is executed as planned, it is expected that the track maintenance cost would be reducible because of shortening of route length and renewal of track, same as is the case of any other alternative plan.

The required cost for maintenance of the Parotani Section is estimated at 22,255,000$b on a '79 conversion basis, or 142,000$b per km (refer to Table 5.2.7). Then, on the assumed basis that the track maintenance cost after renewal of track could be reduced down to the equal level to the cost in the other sections (37,000$b per km of 1979 conversion), the possible reduction of the maintenance cost would be calculated as follows:

142,000$b × 13km.00 - 37,000$b × 11km.05 = 1,437,000$b

On the basis above, the economic cost reflecting the shadow price would be estimated at 1,350,000$b.

3. Project costs

In reference to the construction cost for the rehabilitation project section including Alternative C as calculated in Chapter 3 of the Report, the economic costs of the Project are calculated as shown in Table 2.3 and 2.4 respectively by application of the shadow price to domestic currency and unskilled labor force.

Table 2.3 Construction Costs in Case of Alternative C (101 km + 000 m ~ 110 km + 000 m)

Unit: 1,000$b

Nature of Work	Material Cost			Labor Cost			Total
	Domestic Currency	Foreign Currency	Sub-total	Skilled	Un-skilled	Sub-total	
Earthwork	14,773	33,880	48,653	1,111	3,999	5,110	53,763
Open Channel	1	1	2	0	1	1	3
Corrugate Pipe	56	200	256	3	16	19	275
Revetment	3,659	4,306	7,965	453	2,175	2,628	10,593
Bridge	32,404	136,435	168,839	4,013	20,866	24,879	193,718
Track Construction	1,494	9,177	10,671	393	1,574	1,967	12,638
Station Building & Security Installation	320	1,346	1,666	40	206	246	1,912
Sub-total ①	52,707	185,345	238,052	6,013	28,837	34,850	272,902
Field Supervision ②	2,688	9,194	11,882	283	1,471	1,754	13,636
Contingency ③	2,822	9,654	12,476	297	1,545	1,842	14,318
Sub-total ①~③	58,217	204,193	262,410	6,593	31,853	38,446	300,856
Surveying & Designing, etc. ④	-	20,045	20,045	-	-	-	20,045
Total	58,217	224,238	282,455	6,593	31,853	38,446	320,901

Table 2.4 Construction Costs for Track-raising Plan (112 km + 500 m ~ 116 km + 500 m)

Unit: 1,000$b

Nature of Work	Material Cost			Labor Cost			Total
	Domestic Currency	Foreign Currency	Sub-total	Skilled	Un-skilled	Sub-total	
Earthwork	5,822	13,352	19,174	438	1,576	2,014	21,188
Revetment	13,308	15,656	28,964	1,648	7,910	9,558	38,522
Pipe Culvert φ2.0m	169	601	770	8	47	55	825
Bridge	2,985	12,566	15,551	370	1,922	2,292	17,843
Track Construction	762	4,676	5,438	200	802	1,002	6,440
Sub-total ①	23,046	46,851	69,897	2,664	12,257	14,921	84,818
Field Supervision ②	1,143	2,361	3,504	134	606	740	4,244
Contingency ③	1,200	2,479	3,679	140	636	776	4,455
Sub-total ①~③	25,389	51,691	77,080	2,938	13,499	16,437	93,517
Surveying & Designing, etc. ④	-	10,160	10,160	-	-	-	10,160
Total ①~④	25,389	61,851	87,240	2,938	13,499	16,437	103,677

4. Economic analysis

In reference to the calculated cost and benefit with expectancy from the improvement project for the selected sections of 101 km + 000 m ~ 110 km + 000 m (Alternative C) and 112 km + 500 m ~ 116 km + 500 m (Track-raising plan), the economic effect from execution of the Project is evaluated as hereunder mentioned.

The future trend of cost and benefit to be annually developed for the improvement project is as shown in Table 2.5. The result of analysis reveals that the economic internal rate of return from the project, in the case of 46 days estimated for train service suspension, would be 8.43 percent (10.28 percent in combination with Alternative B), the encouraging figure to verify economic feasibility of the project.

Although preferrable choice on either Alternative B or Alternative C for the improvement project may be left to the final decision after further detailed survey and the strategic policy of ENFE, it is advisable that Alternative B should be adopted with preference over the other because of its advantage in construction cost, in view of general judgement that neither of the two alternatives can be of any use as the permanent measures against the remarkably varied and undulated ground surface in the proposed section for the project.

Table 2.5 Cash Flow Estimation for the Rehabilitation Project

Unit: 1,000$b

Year	Cost	Benefits				
		Passenger	Freight	Recovery Cost from Damage	Mainte-nance Cost	Total
1981	30,205					
1982	157,749					
1983	236,624					
1984		1,028	10,566	18,593	1,350	31,537
1985		1,047	10,808	19,709	1,350	32,914
1986		1,066	11,051	20,891	1,350	34,358
1987		1,086	11,284	22,145	1,350	35,865
1988		1,105	11,521	23,474	1,350	37,450
1989		1,125	11,754	24,882	1,350	39,111
1990		1,146	11,979	26,375	1,350	40,850
1991		1,176	12,213	27,957	1,350	42,696
1992		1,198	12,439	29,635	1,350	44,622
1993		1,220	12,673	31,413	1,350	46,656
1994		1,251	12,895	33,298	1,350	48,794
1995		1,275	13,121	35,296	1,350	51,042
1996		1,305	13,343	37,413	1,350	53,411
1997		1,329	13,569	39,658	1,350	55,906
1998		1,353	13,792	42,038	1,350	58,533
1999		1,386	14,017	44,560	1,350	61,313
2000		1,418	14,240	47,234	1,350	64,242
2001		1,443	14,456	50,068	1,350	67,317
2002		1,447	16,682	53,072	1,350	72,551
2003	-116,359	1,503	14,905	56,256	1,350	74,014

APPENDIX-3 Calculation Method of Freight Loss (1984)

1. Alternative measures of transport at train service suspension

	Railway Traffic			Alternative Transport	Total
	Warehouse	Open Field Stock	Sub Total		
	%	%	%	%	%
Domestic					
(Oruro→Cochabamba)	68.0	17.0	85.0	15.0	100.0
(Cochabamba→Oruro)	42.5	42.5	85.0	15.0	100.0
Export					
(Cochabamba→Oruro)	45.0	45.0	90.0	10.0	100.0
Import					
(Oruro→Cochabamba)	100.0	-	100.0	-	100.0

2. Freight volume to be affected during service suspension

(1) Domestic transport

Oruro → Cochabamba

Freight volume for warehouse stock

37,800 ton × 1/365 × 46 days × 0.42 × 0.68 = 1,361 ton

Freight volume for interest accrual

37,800 ton × 1/365 × 46 days × 0.42 × 0.85 = 1,701 ton

Cochabamba → Oruro

Freight volume for warehouse stock

37,800 ton × 1/365 × 46 days × 0.58 × 0.425 = 1,174 ton

Freight volume for interest accrual

37,800 ton × 1/365 × 46 days × 0.58 × 0.85 = 2,349 ton

(2) Export

Freight volume for warehouse stock

49,300 ton × 1/365 × 46 days × 0.45 = 2,796 ton

Freight volume for interest accrual

49,300 ton × 1/365 × 46 days × 0.90 = 5,592 ton

(3) Import

Freight volume for warehouse stock

108,400 ton × 1/365 × 46 days = 13,661 ton

Freight volume for interest accrual

108,400 ton × 1/365 × 46 days = 13,661 ton

3. Loss during service suspension

(1) Domestic

Warehouse charge

(1,361 ton + 1,171 ton) × 46 days × 4$b = 466,000$b

Interest

(1,701 ton + 2,349 ton) × 46 days × 14,082$b × 0.12 × 1/365 = 862,000$b

(2) Export

Warehouse charge

2,796 ton × 46 days × 4$b = 514,000$b

Interest

5,592 ton × 46 days × 10,333$b × 0.12 × 1/365 = 874,000$b

(3) Import

Warehouse charge

13,661 ton × 46 days × 4$b = 2,513,000$b

Interest

13,661 ton × 46 days × 25,833$b × 0.12 × 1/365 = 5,337,000$b

APPENDIX-4 Track Maintenance Cost

ESTUDIO SOBRE COSTOS POR KM/VIA DE LOS DISTRITOS DE VIA Y OBRAS

Distrito Parotani R.C. Enero - Junio 1976

	Enero	Febrero	Marzo	Abril	Mayo	Junio	TOTAL
Jefatura	42.337,75	43.172,00	45.065,00	43.539,00	43.430,00	47.203,00	264.746
Talleres y Cdllas.Varios	18.332,52	20.879,60	20.229,20	17.933,20	17.907,69	19.629,60	114.629
Secc.Parotani-Km.48 a 205	542.070,77	621.954,14	657.438,62	632.736,32	520.198,64	516.511,59	3.490.910
	602.741,04	686.005,74	722.732,82	694.208,52	581.536,33	583.344,19	3.870.568

Total		Meses		PROMED. MENSUAL	Km.		Costo M.de O. por Km. del Distrito
3.870.568,64	÷	6	=	645.094,00	157	=	4.109,00 $b/Km.

Secc. Parotani - Km. 48 al 205

						%
Promedio Mensual M. de O.	645.094	+	157	=	4.109,00 $b/Km.	37
Promedio Mensual Materiales	233.234	+	157	=	1.485,00 $b/Km.	14
Promedio Mensual Viáticos	21.620	+	157	=	138,00 $b/Km.	1
Promedio Aguinaldo-Navidad Patriotico y Prima	145.836	+	157	=	929,00 $b/Km.	8
Promedio trabajos a Contrato	650.000	+	157	=	4.140,00 $b/Km.	38
					10.801,00 $b/Km.	98
Proporción Jefatura Via y Obras Or.	27.874	+	157	=	177,00 $b/Km.	2
					10.978,00 $b/Km.	100

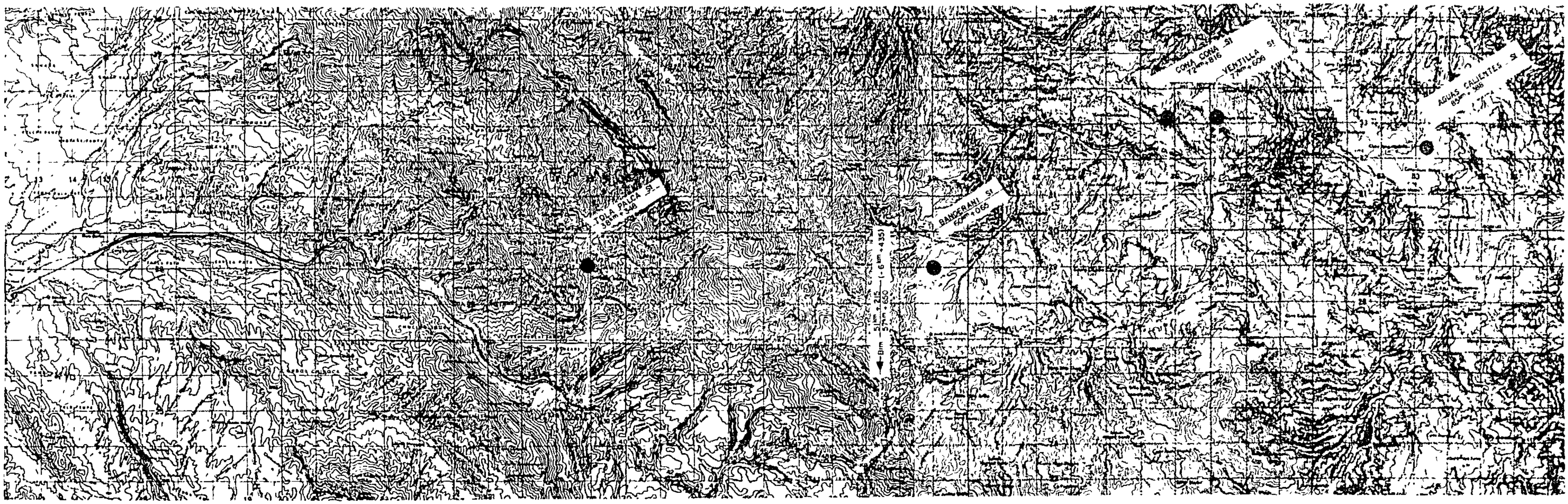
Oruro, Septiembre de 1.976

	T O T A L E S		P R O M E D I O % 12 Kms.	
	Anual $b.	Mensual $b.	Anual $b.	Mensual $b.
Mano de Obras	370.771,20	30.897,60	30.897,60 $b/Km.	2.574,80 $b/Km.
Materiales	979.670,04	81.639,17	81.639,17 $b/Km.	6.803,26 $b/Km.
Viáticos	17.963,40	1.496,95	1.496,95 $b/Km.	124,75 $b/Km.
Aguinaldo y Prima	45.564,04	3.797,00	3.797,00 $b/Km.	316,42 $b/Km.
Bono Patriótico	29.407,48	2.450,62	2.450,62 $b/Km.	204,22 $b/Km.
Personal transitorio 15 eventuales 4 meses al año	87.600,00	7.300,00	7.300,00 $b/Km.	608,33 $b/Km.
T O T A L E S.-	1.530.976,16	127.581,34	127.581,34 $b/Km.	10.631,78 $b/Km.

NOTA.- Los datos para establecer estos costos son reales, sin tomar en cuenta las Cargas Sociales, que tiene ENFE. per pagos de Aportes Patronales a Ferrocaja, Caja Complementaria, Pulperia Subvencionada etc. Tampoco se considera los gastos que ocasionanon los accidentes en los Kms. 51/52 en 1.977 y Kms. 51/52 en 1.968.-

Oruro, 19 de Julie de 1.979

DRAWINGS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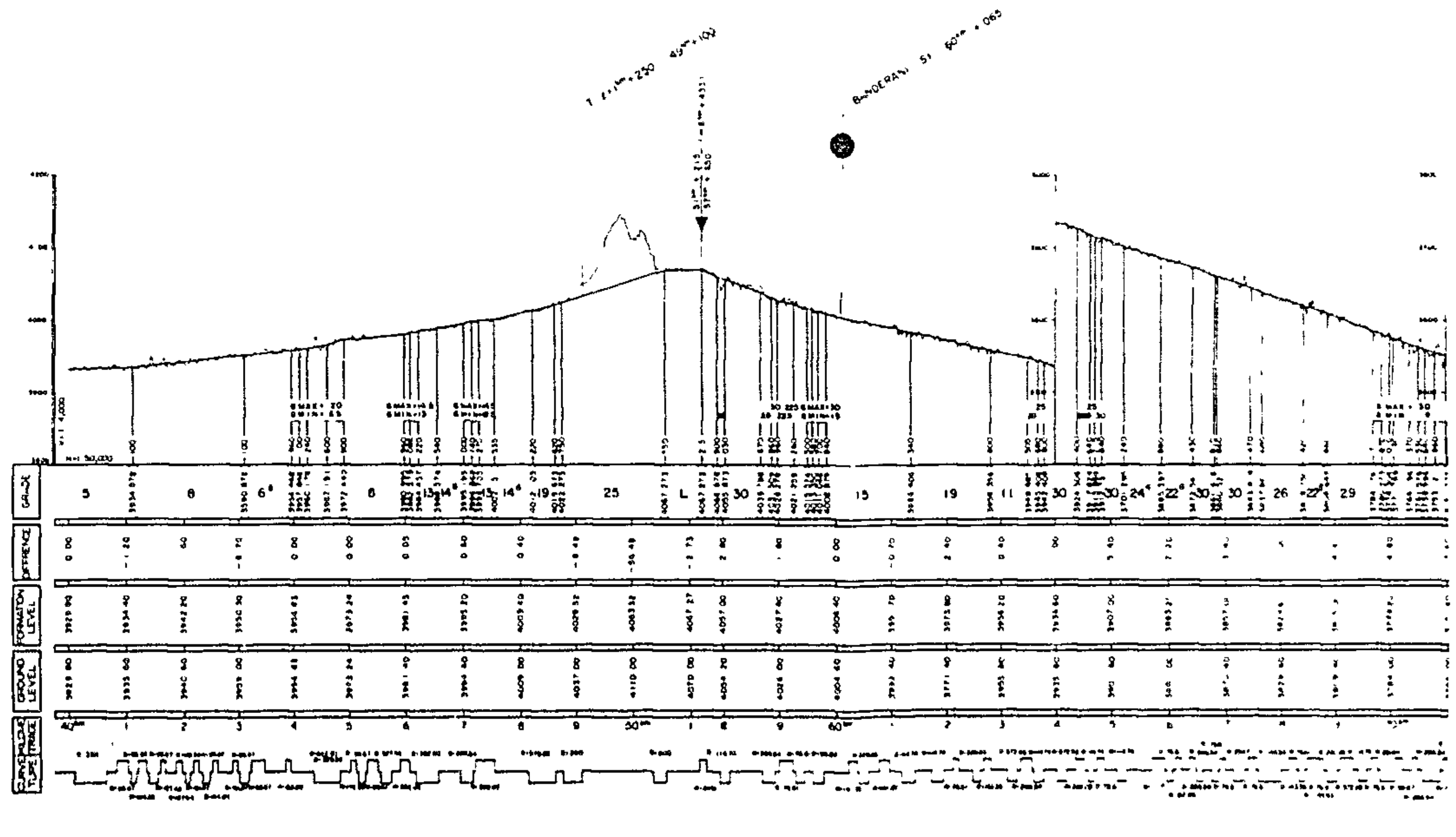
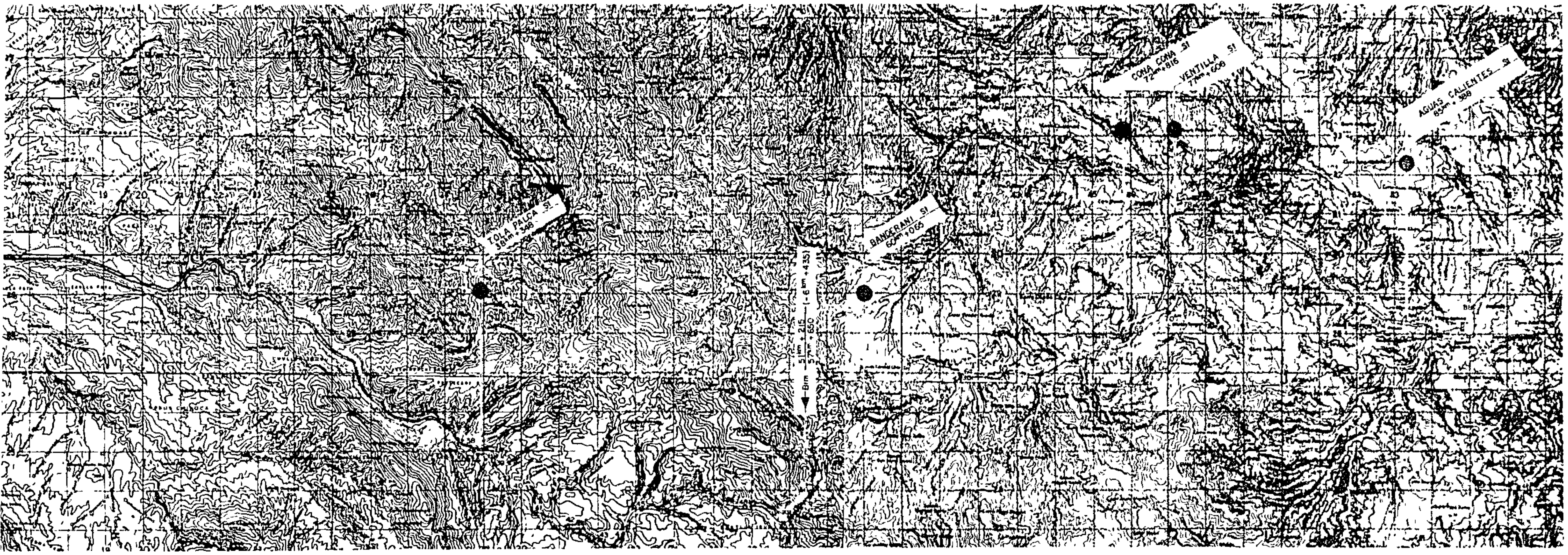
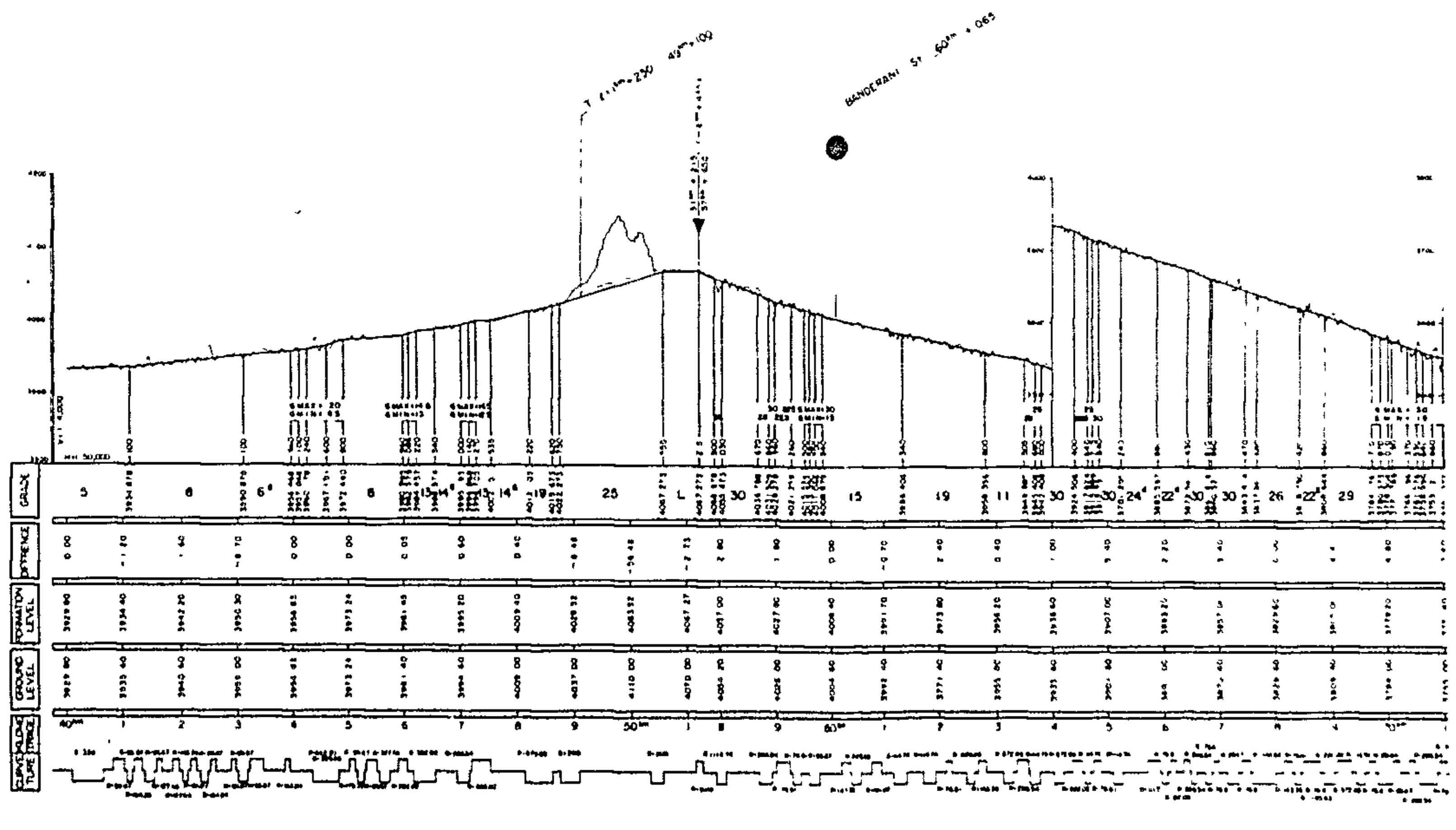




Drawing - 1

Plan of Tunnel Construction (48 km + 000 m ~ 57 km + 650 m)

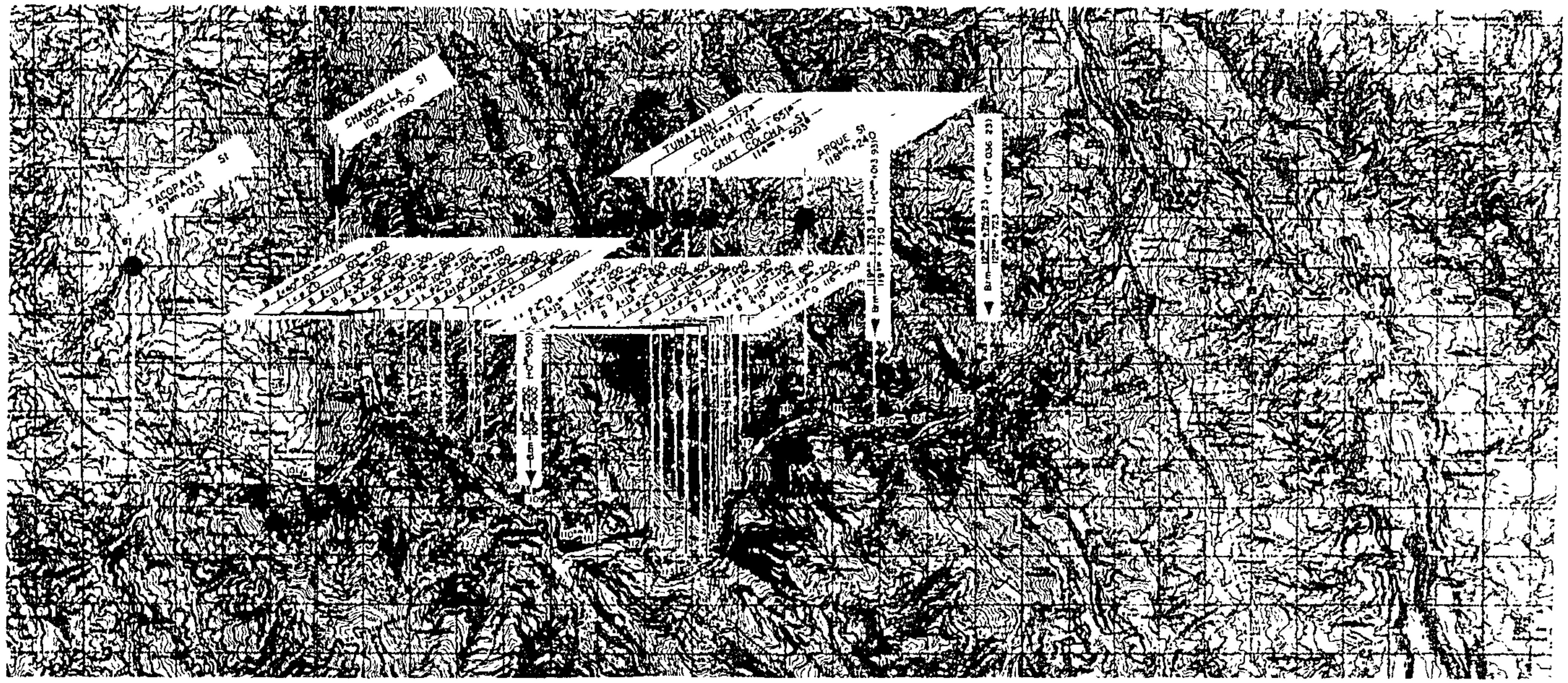
(scale 1/50,000)



Drawing - 2

Longitudinal Profile of Tunnel Construction (48 km + 000 m ~ 57 km + 650 m)

(scale 1/50,000, 1/4000)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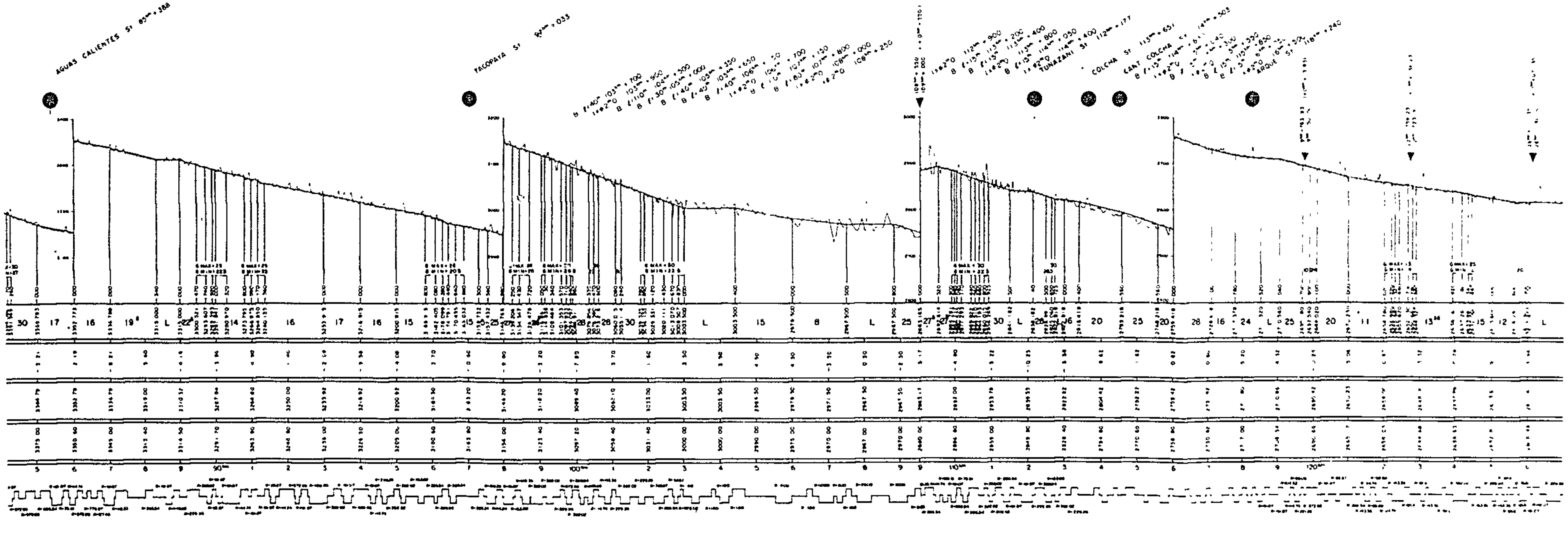
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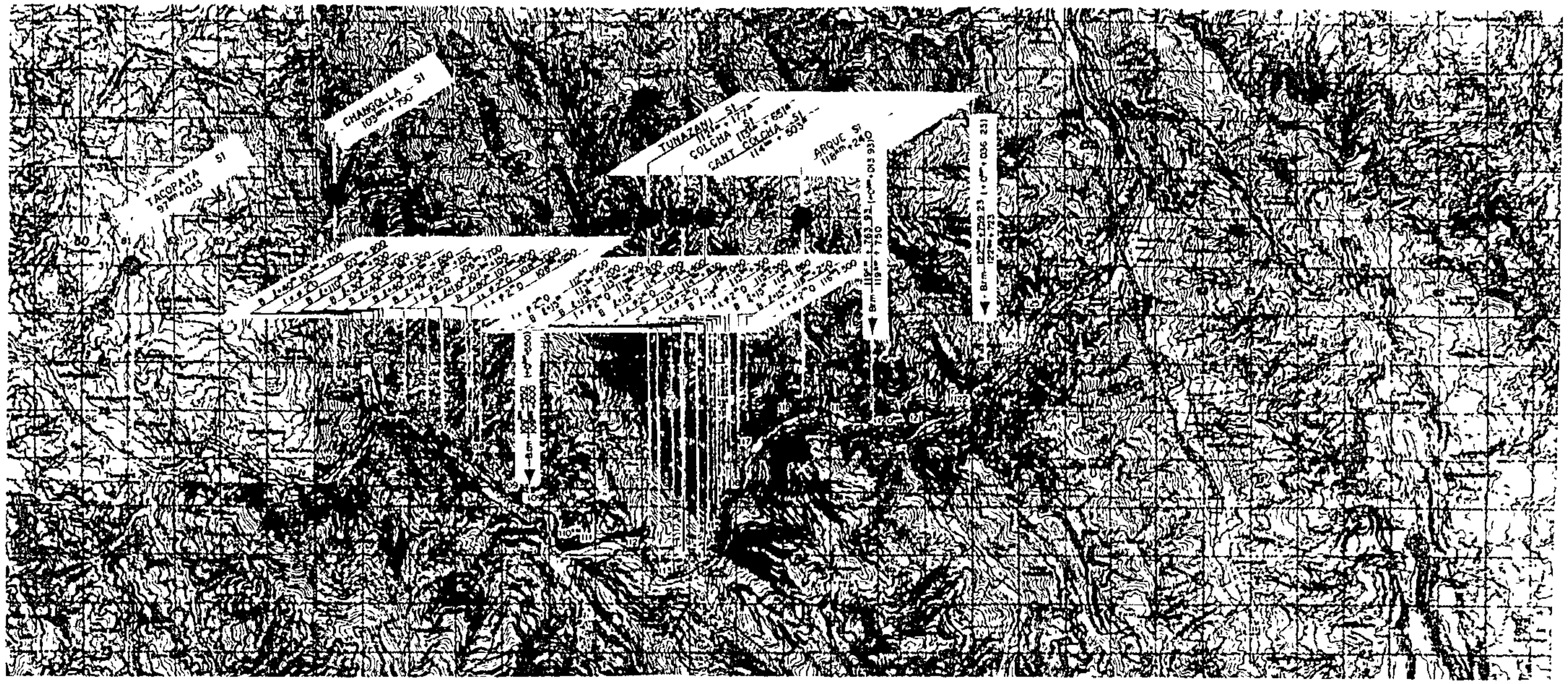
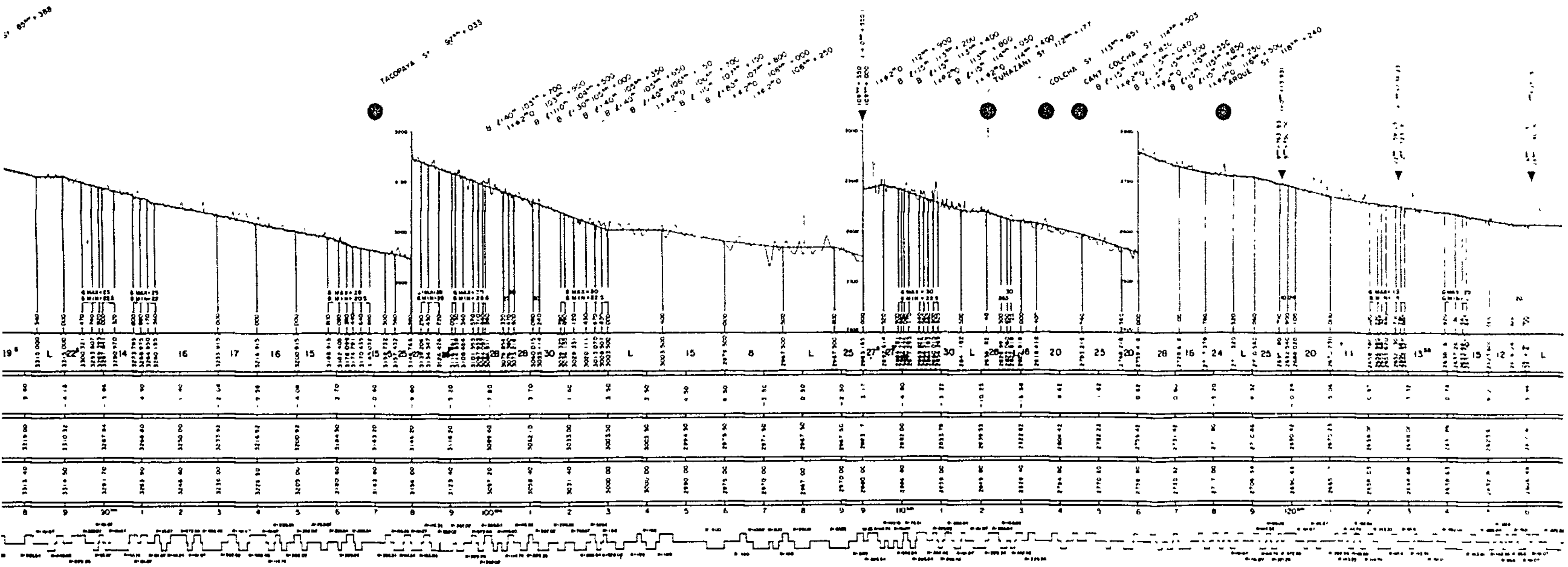


Drawing - 3

Plan of Existing Line Improvement (Alternative A, 103km + 000m ~ 109km + 400m) and Lifting-up of track level (112km + 500m ~ 116km + 500m)

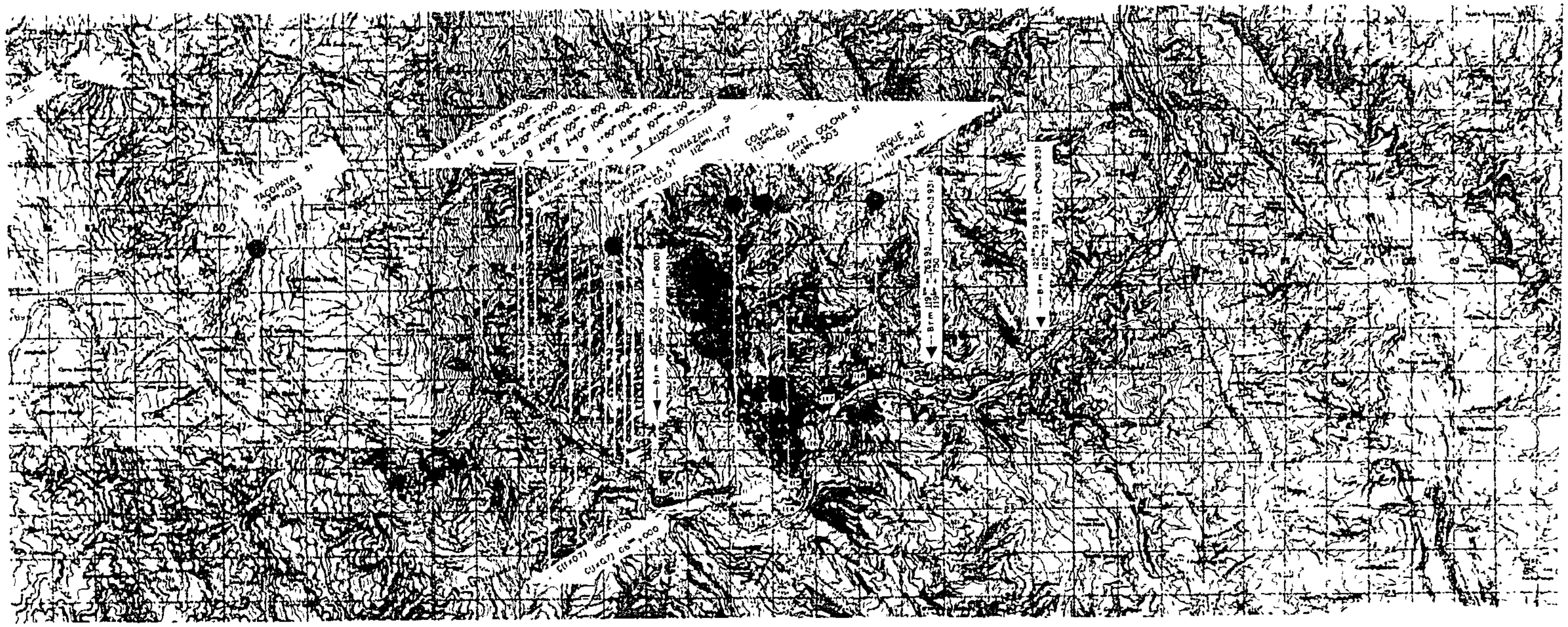
(scale 1/50,000)



Drawing - 4

Longitudinal Profile of Existing Line Improvement (Alternative A, 103km + 000m 109km + 400m) and Lifting-up track level (112km + 500m ~ 116km + 500m)

(scale 1/50,000, 1/4,000)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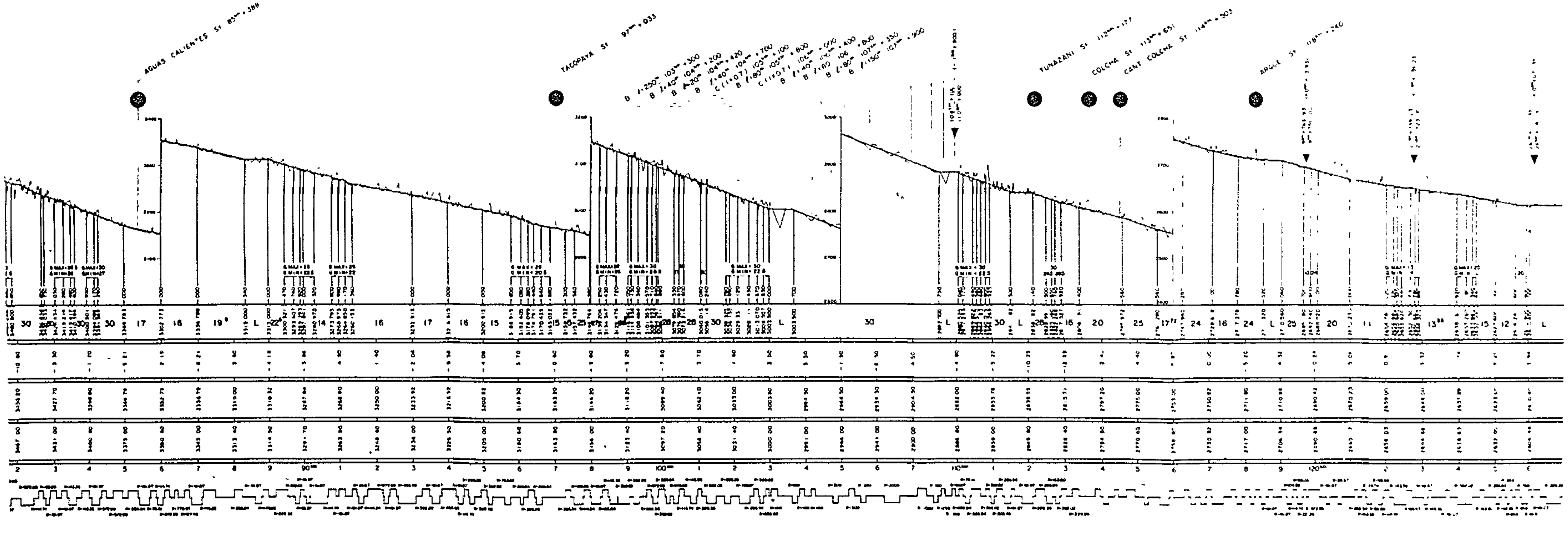
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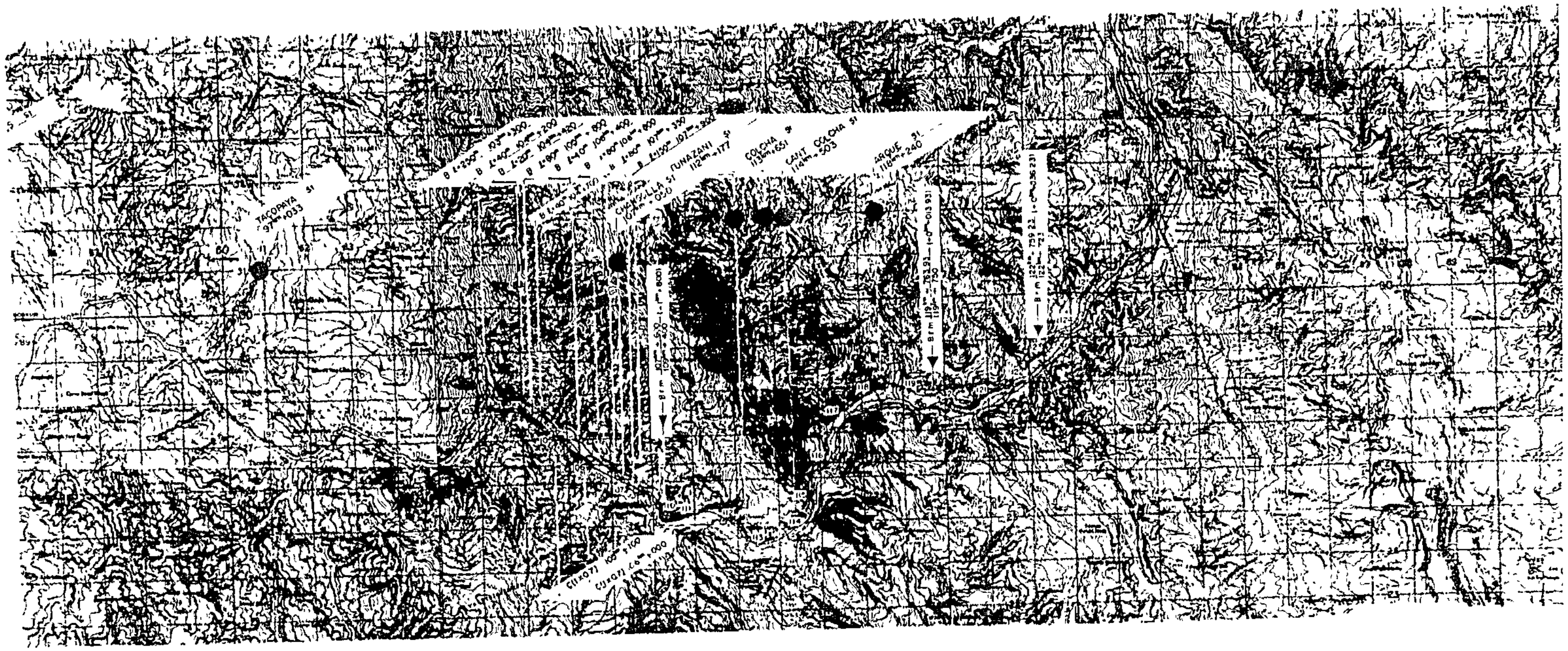
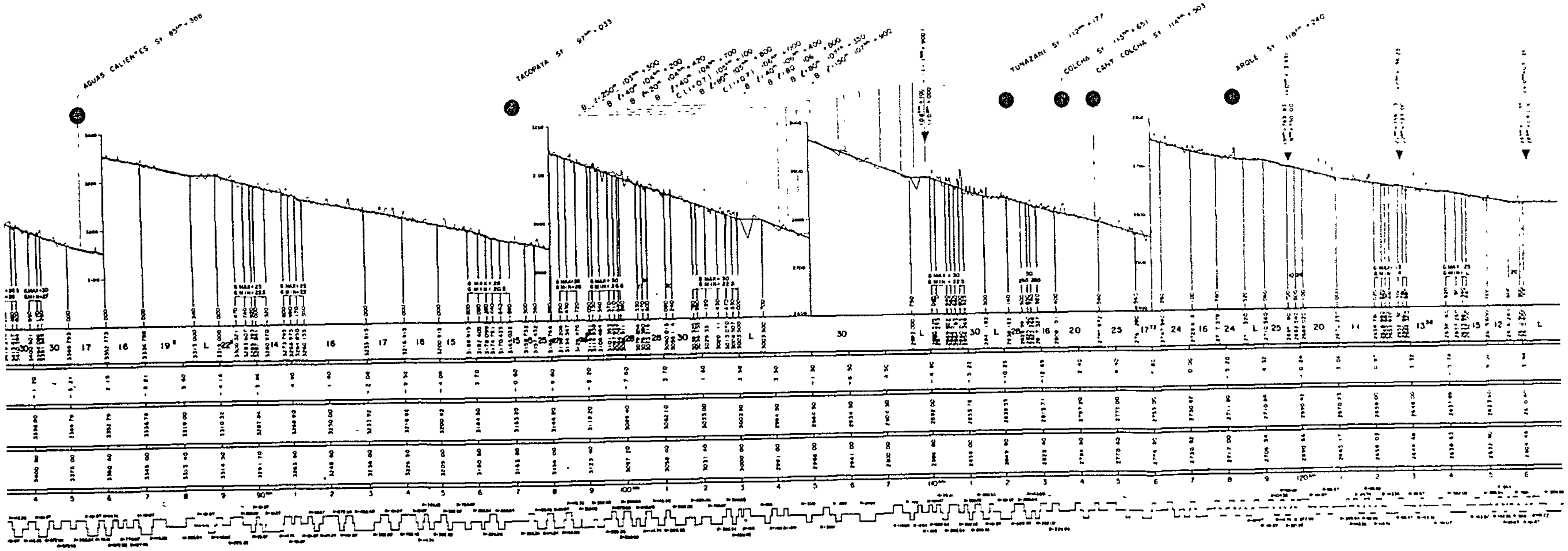


Drawing - 5

Plan of New Detour Line
(Alternative B, 103km + 000m - 110km + 000m)

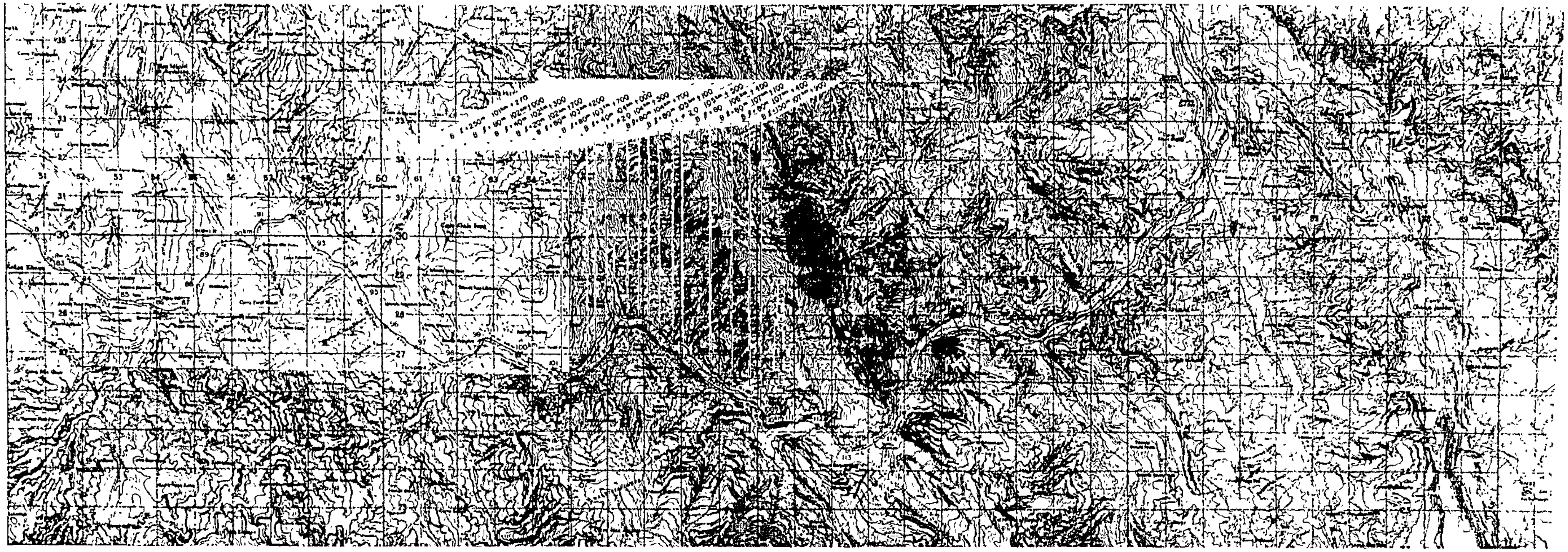
(scale 1/50,000)



Drawing - 6

Longitudinal Profile of New Detour Line
(Alternative B. 103km + 000m ~ 110km + 000m)

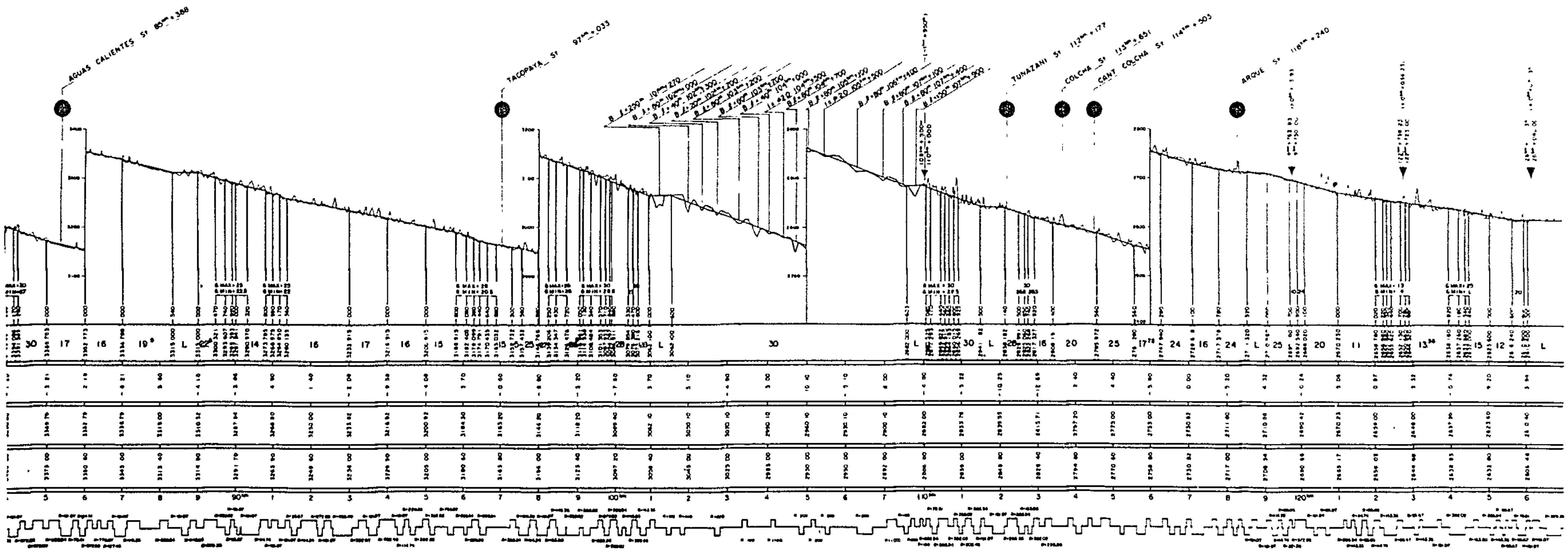
(scale 1/50,000, 1/4,000)



Drawing - 7

Plan of New Detour Line
(Alternative C, 101km+000

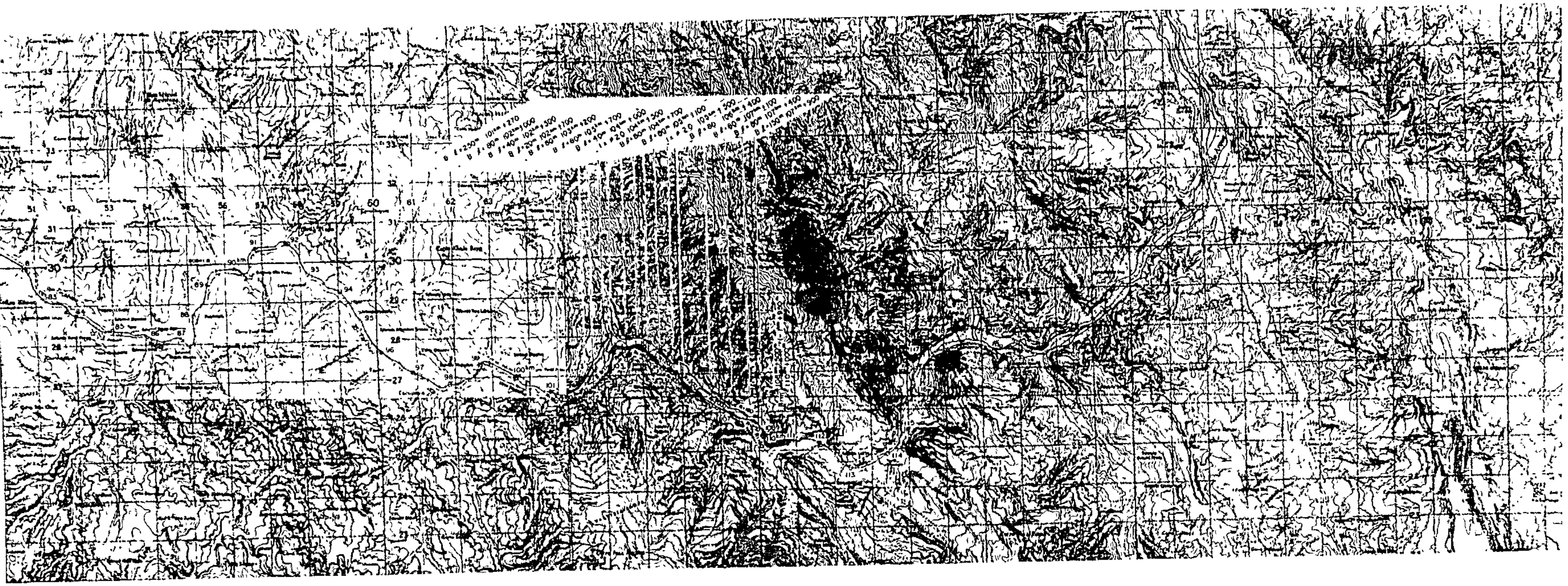
(scale 1/50,000)



Drawing - 8

Longitudinal Profile of New
(Alternative C, 101km+000m-

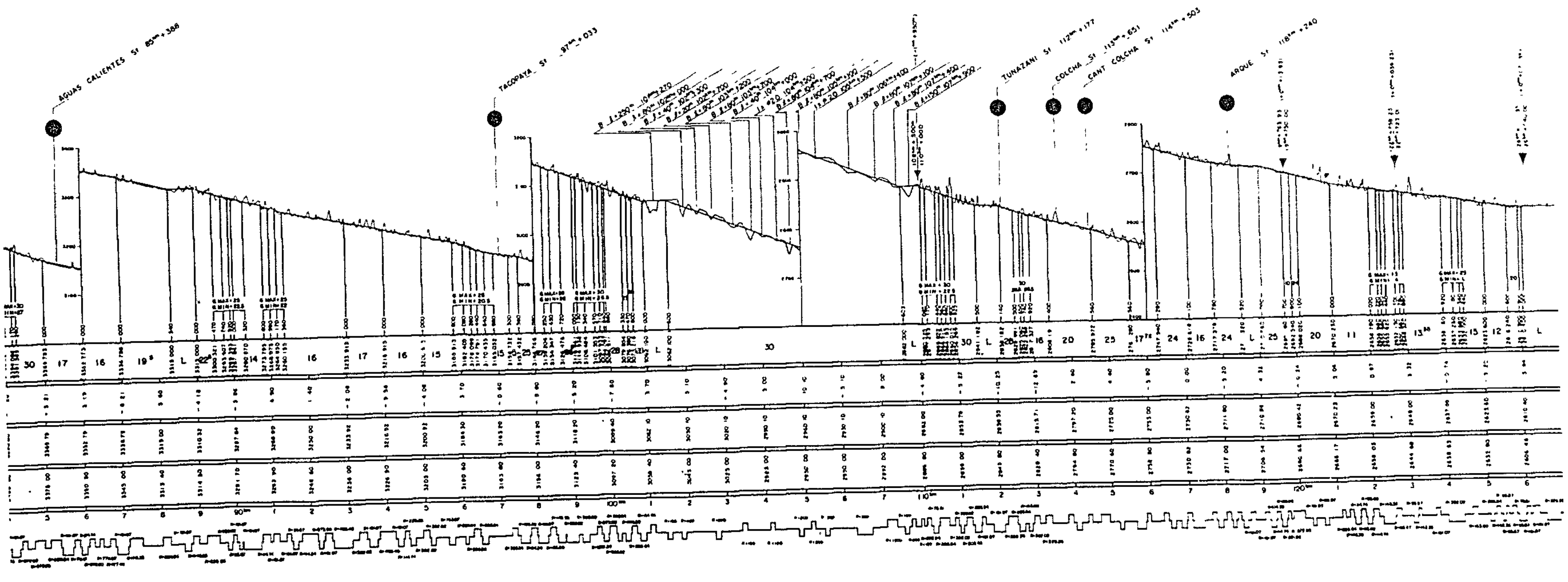
(scale 1/50,000, 1/4,000)



Drawing - 7

Plan of New Detour Line
(Alternative C, 101km+000m ~ 110km+000m)

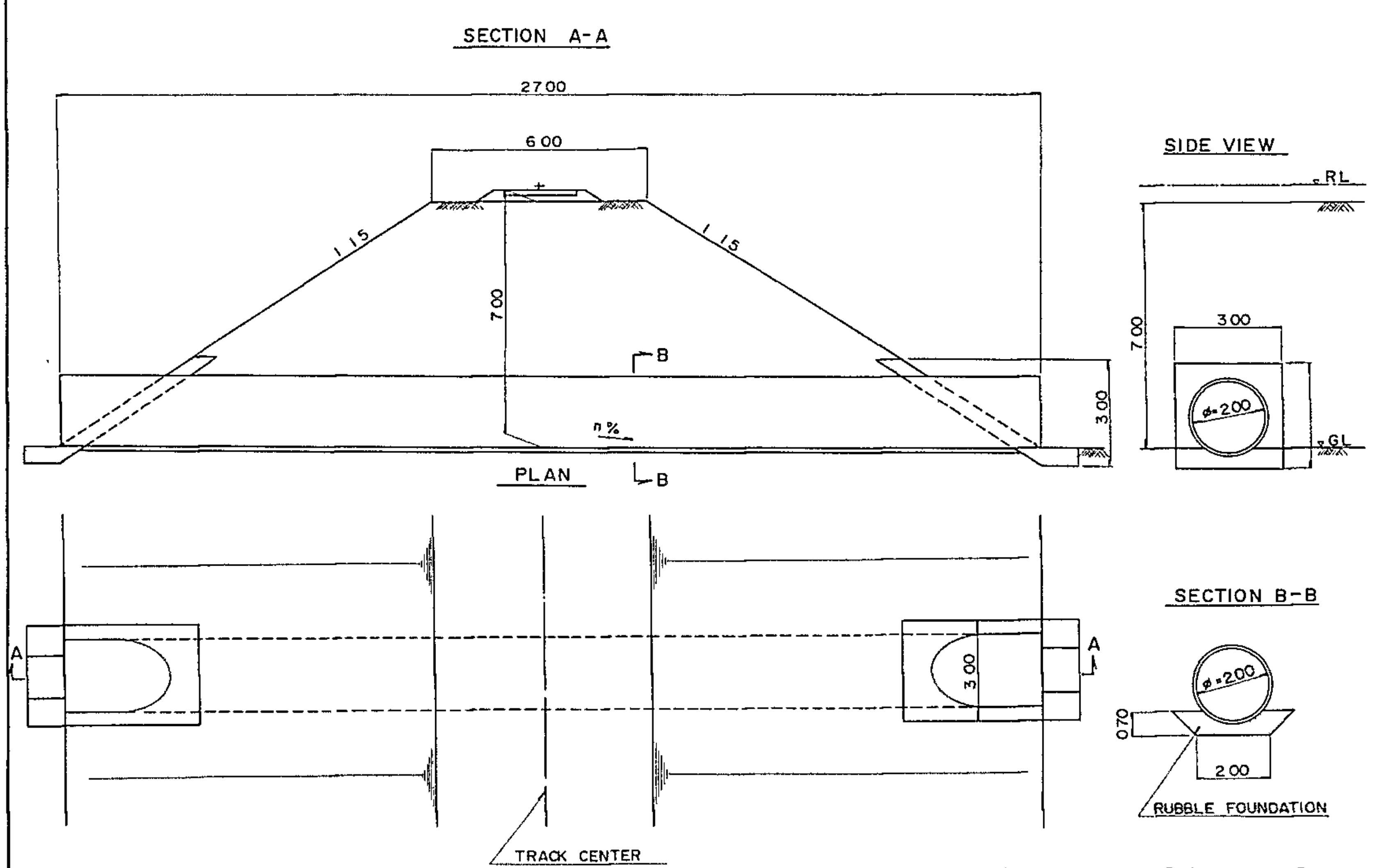
(scale 1/50,000)



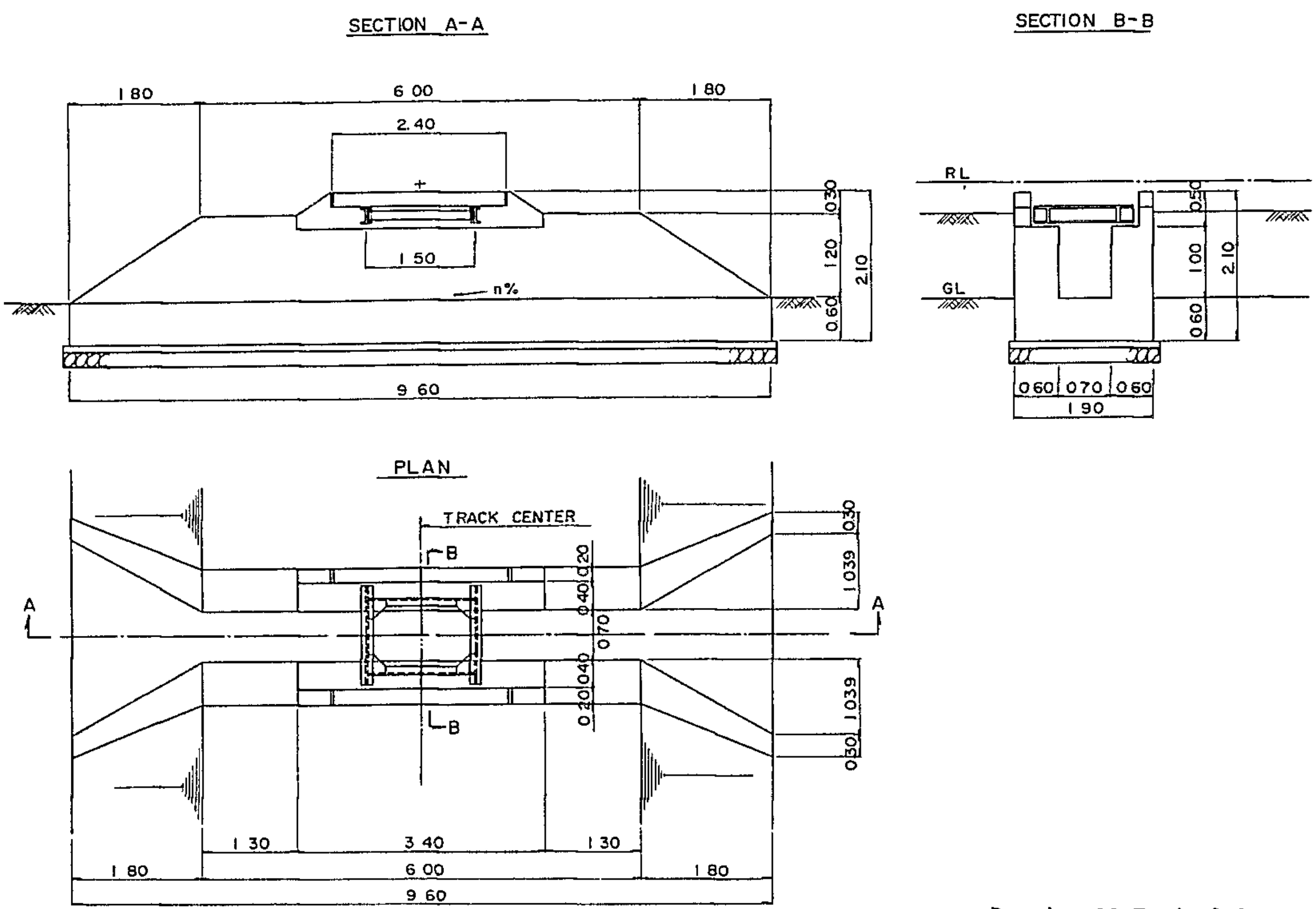
Drawing - 8

Longitudinal Profile of New Detour Line
(Alternative C, 101km+000m ~ 110km+000m)

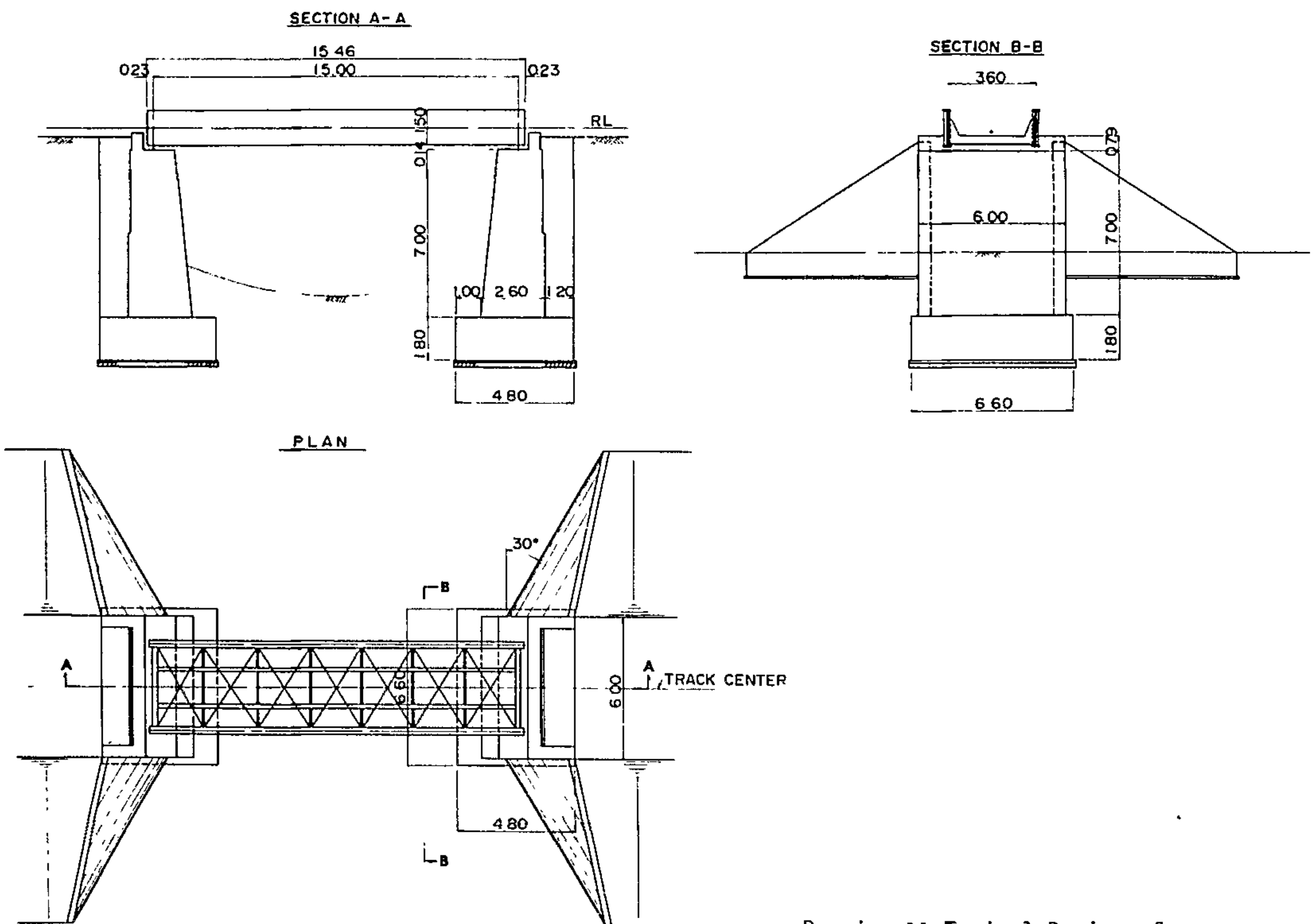
(scale 1/50,000, 1/4,000)



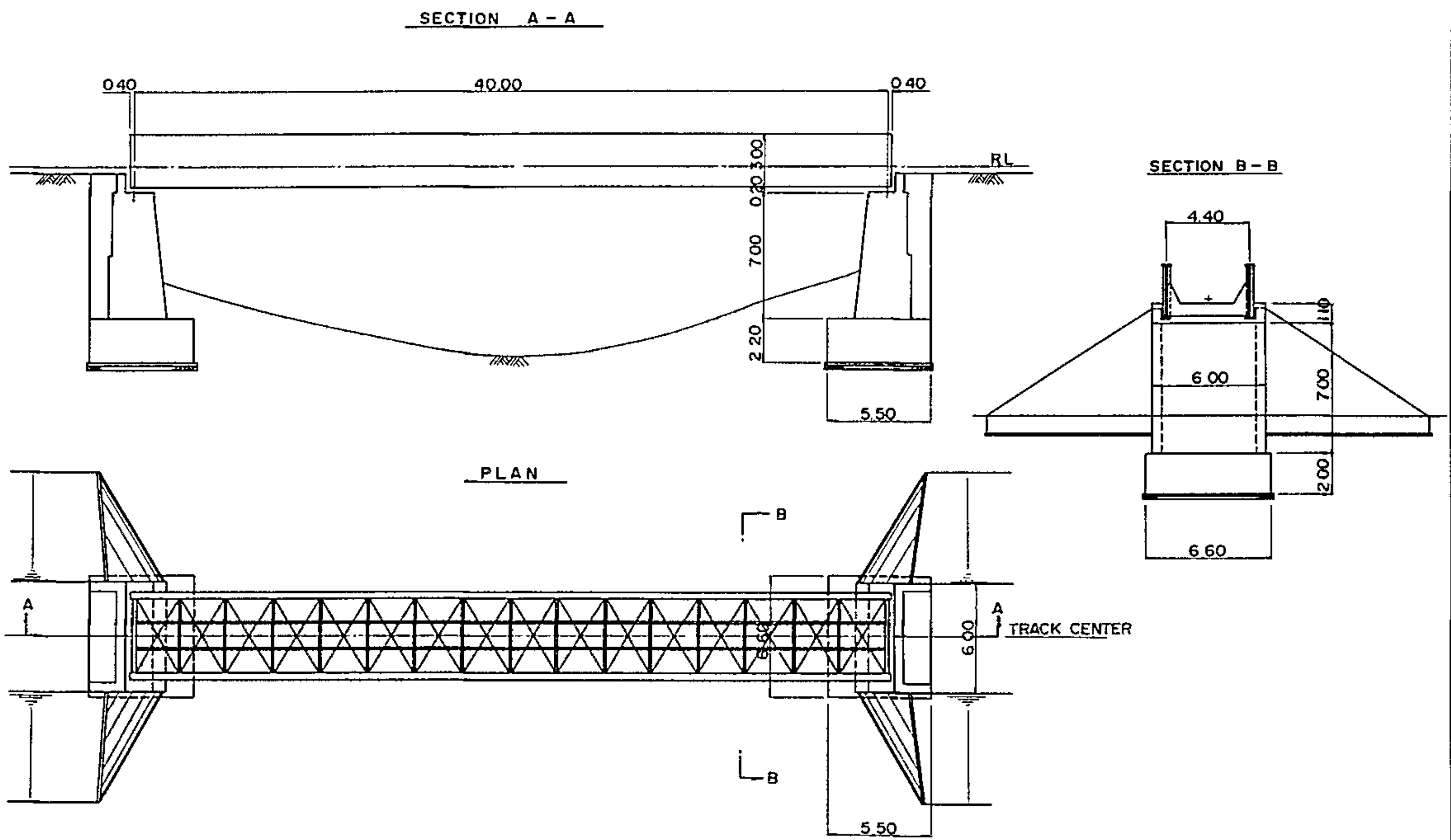
Drawing-9 Typical Design of Corrugated Steel Pipe



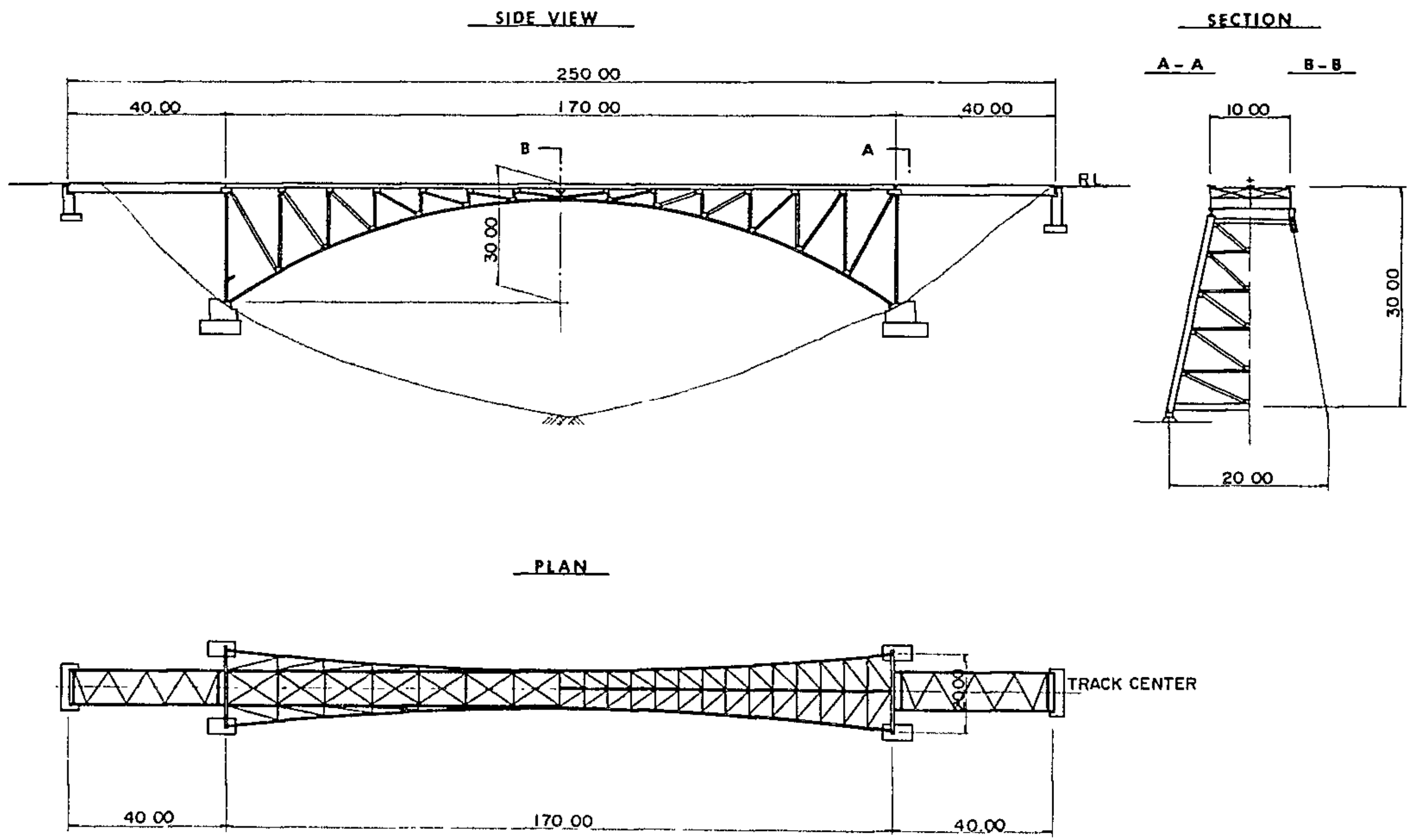
Drawing-10 Typical Design of Open Culvert



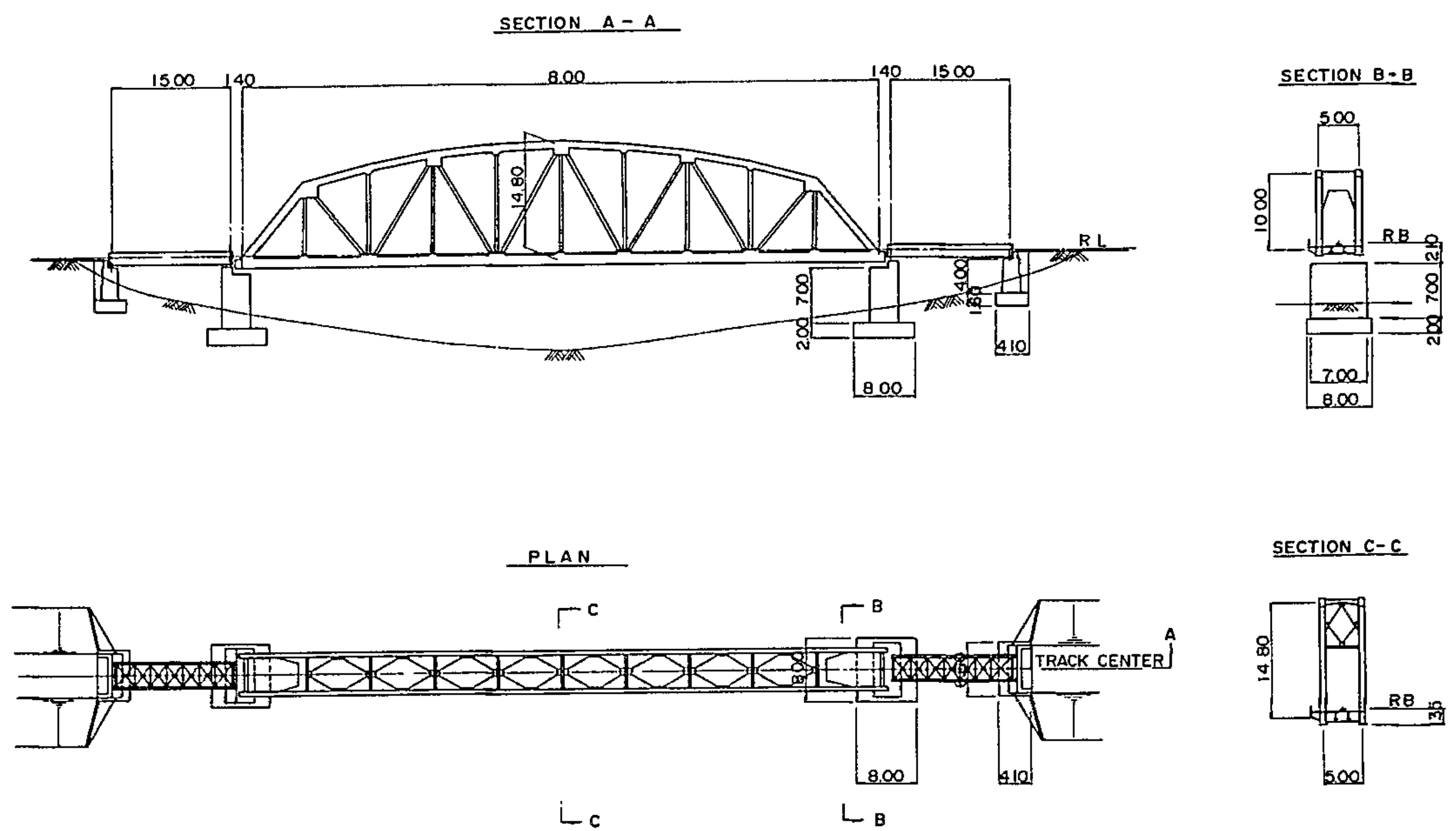
Drawing-11 Typical Design of Through Girder Bridge ($\ell=15^{m}0$)



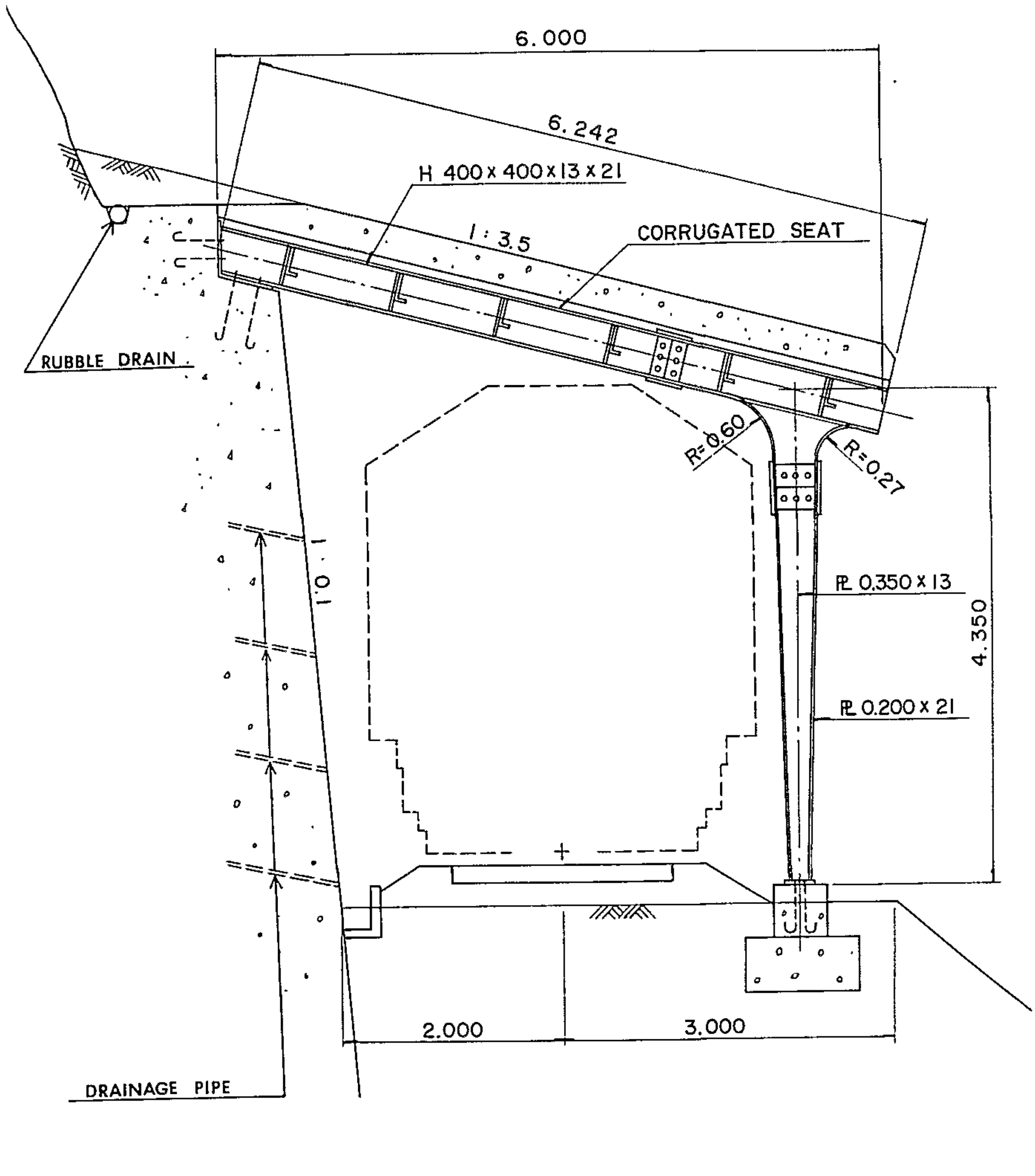
Drawing-12 Typical Design of Through Girder Bridge (ℓ=40^{m}0)



Drawing-13 Typical Design of
Arch Bridge



Drawing-14 Typical Design of Through Truss Bridge



DRAWING-15 Design of Rock Fall Shed

SCALE 1/50

JICA