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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
MINISTRY OF PUBLIC WORKS
REPUBLIC OF CHILE

THE FEASIBILITY STUDY ON THE NEW BIOBIO BRIDGE IN THE REPUBLIC OF CHILE

Final Report (Summary)

October 1994

Chodai Co.,Ltd.
Nippon Koei Co.,Ltd.

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Note

Following exchange rates are applied in this report :

US$ 1.00 = Ch$ 431 = Yen 105

Ch$ 1.0 = Yen 0.243

(As of December 1993)

Ch$: Chilean Peso

Preface

In response to a request from the Government of the Republic of Chile, the Government of Japan decided to conduct a feasibility study on the New Biobio Bridge and entrusted the study to the Japan International Cooperation Agency(JICA).

JICA sent a study team to Chile two times between October 1993 and July 1994. The study team was headed by Mr Junji Yasui and composed of members of Chodai Co.,Ltd and Nippon Koei Co.,Ltd.

The team held discussions with the officials concerned of the Government of Chile, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Chile for their close cooperation extended to the team.

October 1994

Kimio Fujita
President
Japan International Cooperation Agency

OUTLINE OF THE STUDY

(1) Background

Improvement of the road transportation networks connecting production centers with shipping points or consumption centers, is currently in progress in the Republic of Chile. Development of the regional economy and promotion of exports heavily rely on road transport networks.

The bridges located along these roads are however becoming obsolete. The effects of earthquakes, river bed scour caused by the rapid flow of rivers from steep mountain slopes, the increase in transportation volume, as well as overloading, contribute to the deterioration of bridges, and create an acute need for bridge construction and maintenance.

Concepcion is one of the most important commercial and industrial areas in Chile, and the central city of Chile's south region. Concepcion is divided into south and north areas by the Biobio River. Passage of traffic between the north and south areas of the city is funneled through two bridges; the Juan Pablo II Bridge, constructed in 1960, and the Biobio Antiguo Bridge, constructed in the thirties.

The Biobio Antiguo Bridge has been in place since the thirties, and the traffic crossing the bridge (25,000 vehicles per day) has reached its design capacity. The bridge subsided two times in the past due to the obsolescence and deterioration of structure, and has undergone repairs, and maintenance. Because of structural deficiencies, the MOP has restricted the maximum load on the bridge to 8 tons.

(2) Objectives of the Study

Objective of the study is to determine the feasibility of constructing a New Biobio Bridge. The study includes examination of the existing two bridges and analysis of the traffic volume on each bridge. The study include the selection of the best alternative route for the new bridge.

(3) Outline of the Study

The result of the study of traffic volume makes it clear that the new bridge must be a four-lane bridge. Four alternative route for the new bridge were investigated, and the optimal alternative route was determined to be that connecting Concepcion and San pedro along the alignment of extension of Los Carrera Street. Based on the study of river condition, a geographical survey and construction techniques in Chile, the study team proposed continuous post tensioned concrete hollow slab spans, each 35 m in length, as the optimal type of bridge. The bridge specification is listed in the Table-1

Table-1 Specification of the New Bridge over the Biobio River

Total Bridge Length	6 x 8 x 35 m + 5 x 35 m = 1,855 m
Width	2 x 3.5 m + 2 x 8.2 m + 1.0 m = 24.4 m
Type of Superstructure	Post tensioned Concrete Hollow Slab
Type of Substructure	Solid Shaft Pier, Reverse T Abutment
Type of Foundation	Caisson Foundation
Design Load	AASHTO HS20-44 or Equivalent
Seismic Coefficient	Kh = 0.15
Number of Spans and Span Length	Continuous Eight Spans, 35 m each

(4) Project Cost

The estimated project cost is shown in Table 2

Table-2 Project Cost

Cost Item	Foreign Currency 1000 Us$	Local Currency 1000 Ch$	Total (x 1000) in Us$	in Ch.$
1. New Biobio Bridge	8,699.5	8,868,173.5	29,275.3	12,617,650.3
2. Access to Concepcion	872.4	1,488,820.7	4,233.9	1,824,818.2
3. Access to San Pedro	823.8	1,387,953.6	4,044.2	1,743,032.7
4. Direct Cost Total	10,359.7	11,704,947.8	37,553.4	16,185,501.2
5. General Expense	2,079.7	2,340,989.6	7,510.7	3,237,100.2
6. Construction Cost	12,474.9	14,045,937.4	45,064.0	19,422,601.5
7. Engineering Cost	998.0	1,123,675.0	3,605.1	1,553,808.1
8. Contingency	1,247.5	1,404,593.7	4,506.4	1,942,260.1
9. IVA	2,679.7	2,983,357.1	9,571.6	4,125,360.6
10. Land Acquisition	0.0	1,432,288.0	3,323.2	1,432,288.0
11. Total construction C	17,370.0	20,989,851.2	66,070.3	28,476,318.3

(5) Evaluation

1. Economic Evaluation

Base case is the evaluation under the network conditions :

a. Old Biobio bridge is closed before the new bridge is completed 1999 in order to avoid possible disasters.
b. Costanera Avenue is constructed in this century.
c. Widening of Los Carrera Street and Prat Street are completed prior to 1999.
d. Other road conditions remain the same as at present.

Based on these conditions, traffic was assigned by type of vehicles, peak and off-peak times, and "with project" and "without project" conditions for 1999 and 2010 to determine the probable project benefits in those years. When calculating NPV and B/C, a discount rate of 12 % was applied. The rate is commonly used to evaluate a project in Chile.

The internal rate of return (IRR) implied in the project is as high as 20.8 %, B/C is 2.04 and NPV amounts to Ch.$ 19,573 million. All of these factors assure high economic returns will be derived by the implementation of the new Biobio bridge project.

2. Environmental Impact Statement

Implementation of this project will have some impact in the areas of residential relocation, air pollution, noise, and vibration. However, air pollution, noise and vibration will increase even without the project because of the expected increase of traffic through economic development in the study area.

It is considered that the effects on the environment of the "without project" case will be worse for the environment than the "with project" case. Air pollution, noise from traffic jams, and traffic detours are considered to be worse in the area if the project is not implemented.

However, when over 60,000 vehicles are concentrated into the city, local environment problem can be expected. It will be necessary to disperse the traffic entering the central area of the city by implementing the "Biobio River North Dike Area Recovery Project" and the " Costanera Road Project"

(6) Recommendation

(1) Since the year 1996 is estimated as the optimal year to start the construction of the new Biobio bridge from the economic point of view, this project should be started as soon as possible.

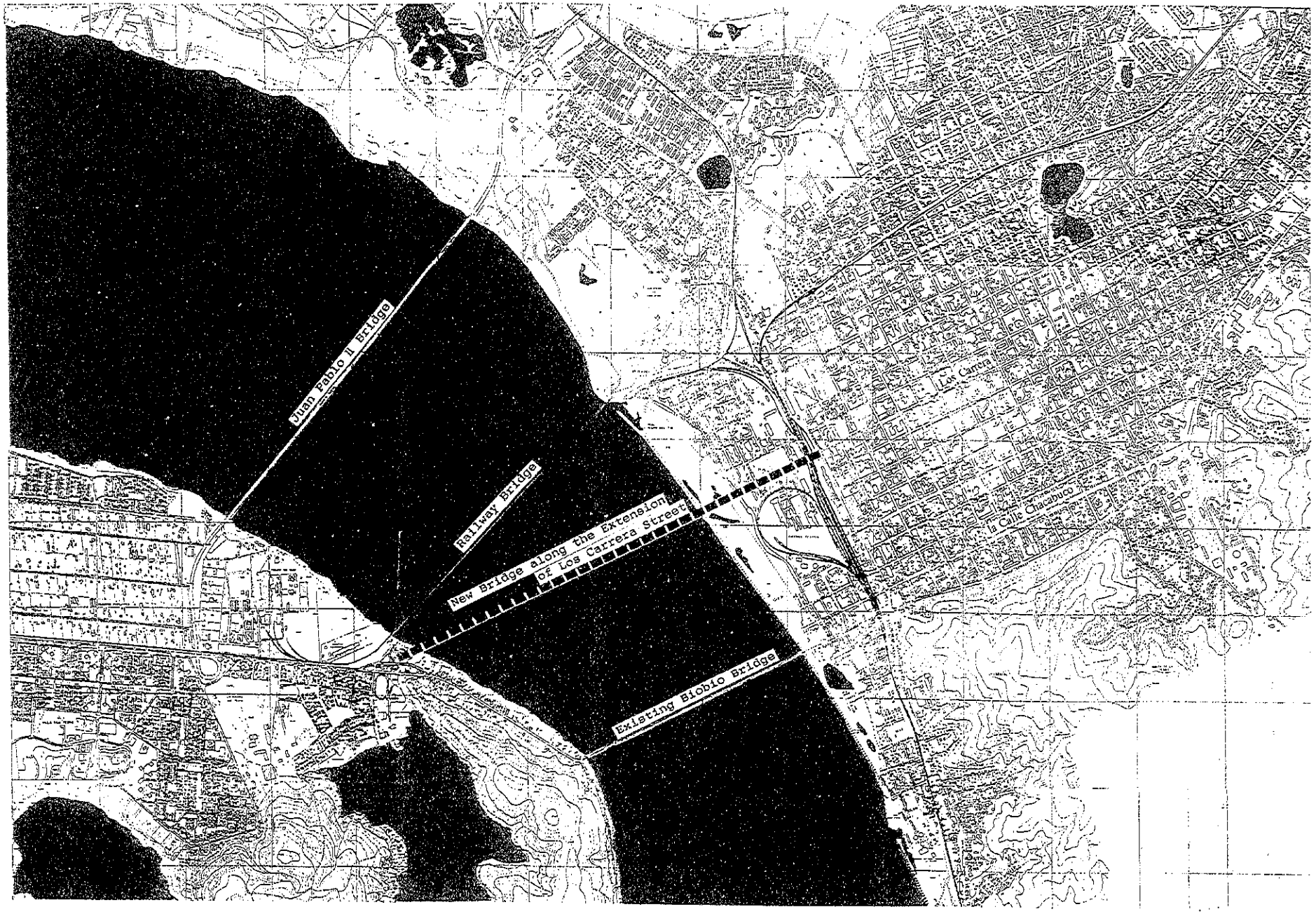
(2) The Biobio Antiguo Bridge has reached the end of its service life and should be closed. However, certain maintenance works should be instituted, and traffic should be limited to passenger cars and emergency vehicles until the new bridge is constructed,

(3) From an engineering and economic point of view, it is not feasible to upgrade the Biobio Antiguo Bridge.

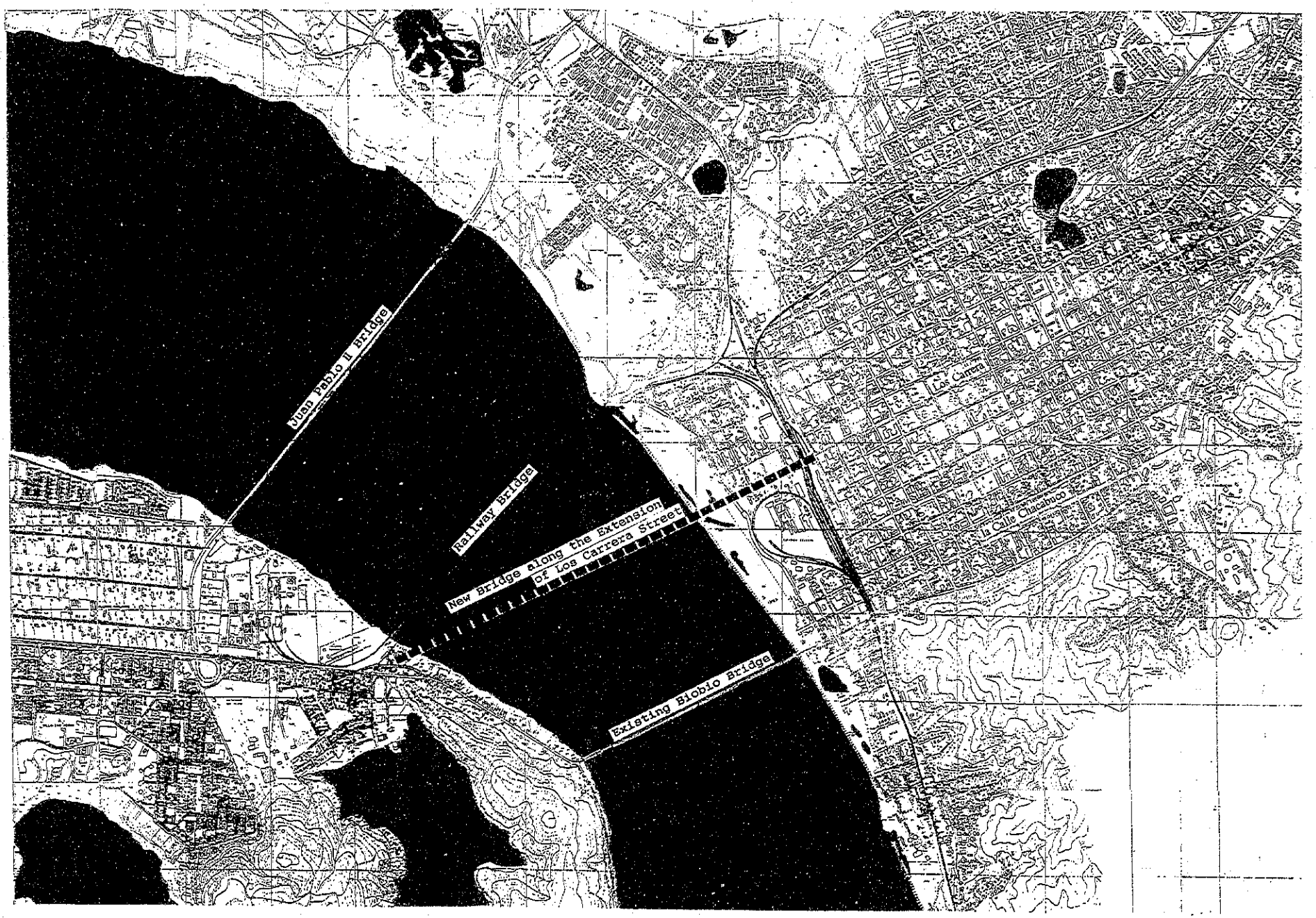
(4) The improvement of road network related to this bridge should be continued. Especially, the improvement of Los Carrera Street, construction of the New Costanera Avenue, and development of a road network connecting the old city center in relation to the "Biobio River North-dike Area Recovery Project" should be undertaken.

(5) To disperse traffic concentrate into the central area of the city, construction of Costanera Road should be implemented.

(6) The peak hour traffic volume on the new bridge will exceed its design capacity in 2010. A study to evaluate the need for another new bridge is recommended, by means of the evaluation of the traffic volume and trends, shortly after the opening of the New Biobio Bridge.



Location of New Biobio Bridge



Location of New Biobio Bridge

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CHAPTER 1 BACKGROUND AND OBJECTIVES OF THE STUDY

1.1 Background

Improvement of road transportation networks connecting production centers with shipping points or consumption centers, is currently in progress in the Republic of Chile. Development of the regional economy and promotion of exports heavily rely on road transport networks.

The bridges located along these roads are however becoming obsolete. The effects of earthquakes, river bed scour caused by the rapid flow of rivers from steep mountain slopes, the increase in transportation volume, as well as overloading, contribute to the deterioration of bridges, and create an acute need for bridge construction and maintenance.

Concepcion is one of the most important commercial and industrial areas in Chile. It is directly connected with the capital city of Santiago. Concepcion is divided into south and north by the Biobio River. The flow of traffic in the north-south direction is dependent on two bridges, the Juan Pablo II Bridge constructed in 1960, and the Biobio Antiguo Bridge constructed in the thirties.

A bridge, referred to as the Biobio Antiguo Bridge has been in existence since the thirties. This bridge has suffered serious deterioration over the years, and has undergone repairs, and maintenance. Due to the deficiencies, the MOP restricted the maximum load on the bridge to 8 tons. In the report " The Study on the Rehabilitation and Conservation Program of Bridges in The Republic of Chile" prepared by Japan International Cooperation Agency (JICA) in March 1993, this bridge was a candidate for a thorough evaluation as to its load carrying capacity, and has potential need for a replacement.

In response to the request from the Government of Chile, the Government of Japan decided to implement the Feasibility Study of the New Biobio Bridge, in accordance with the Agreement on Technical Cooperation between the Government of Chile and the Government of Japan signed on July 28, 1978.

Accordingly, the JICA, the official agency responsible for the implementation of the technical cooperation programs of the Government of Japan, was tasked to undertake the Study, in close cooperation with the authorities concerned of the Government of Chile.

Refer to Figure 1-1 for Map of the Study Area

1.2 Objectives of the Study

Objective of the study is to determine the feasibility of constructing a New Biobio Bridge. The study includes examination of the existing two bridges and analysis of the traffic volume on each bridge. The study include the selection of the best alternative route for the new bridge.

Region VIII is divided south and north by the Biobio river. Because there are few bridges across the river, the whole area of Region VIII will be influenced by construction of a new bridge. Figure 1-1 delineates the study area which covers all of Region VIII. The Study includes the following items:

- Investigation of socio-economic frame of the study area.
- Study of current situations of traffic and forecast of transportation demand.
- Detailed investigation of existing bridges.
- Study of natural conditions.
- Environmental impact assessment.
- Selection of optimum bridge construction location and road improvement plan.
- Preliminary design, estimation of construction cost and economic evaluation for the optimum alternative plan, and implementation program.

Technology transfer related to design and planning of bridges will be done for the benefit of the counterparts of the Republic of Chile through the implementation of the study.

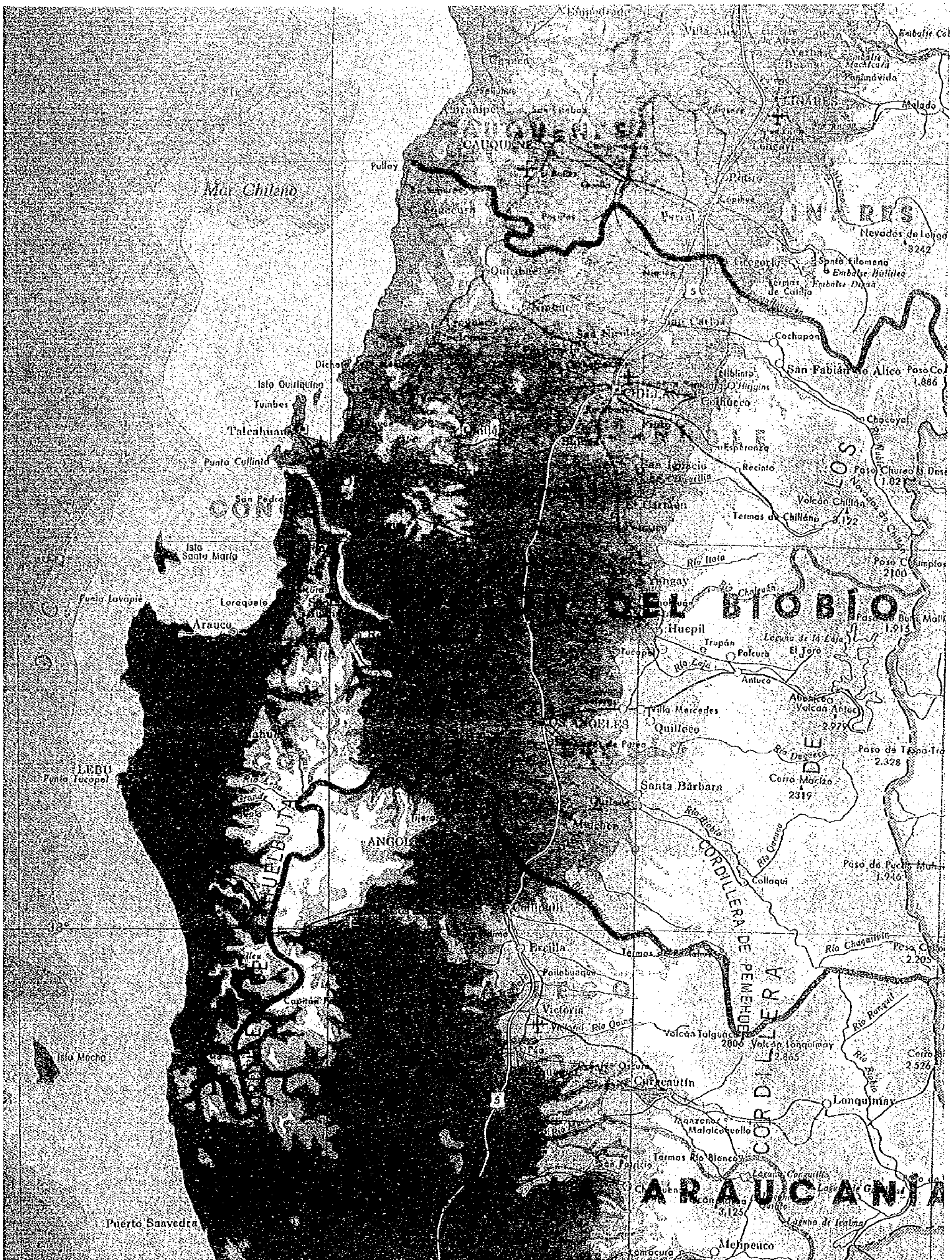

Figure 1-1 Map of the Study Area

Figure 1-1 Map of the Study Area

CHAPTER 2 SOCIO-ECONOMIC SITUATION OF THE STUDY AREA

2.1 Urban Structure and Socio-economic Conditions in Concepcion

(1) Administrative Division and Concepcion Area

The Study Area (Concepcion Province) belongs to Region VIII and consists of 9 municipalities; Concepcion, Talcahuano, Penco, Tome, Florida, Hualqui, Santa Juana, Lota and Coronel. The Metropolitan Concepcion, as used in the statistics of the INE (Instituto Nacional de Estadisticas), encompasses seven (7) urbanized coastal municipalities, excluding Florida and Santa Juana (see Fig. 2-1).

(2) Zone Division

For the purpose of traffic demand projections, it is necessary to divide the Study Area to several small zones. Since the project under the Study is a new bridge over the Biobio River within the jurisdiction of the Municipality of Concepcion, Concepcion should be divided to zones of appropriate size considering the directions of traffic flow which crosses over the River. Other municipalities can be aggregated depending on their locations.

Concepcion Province is divided into 21 zones, of which 15 zones belong to Concepcion. Penco and Tome as well as Lota and Coronel are aggregated to 1 zone. Zone numbers and corresponding administrative units are given Fig. 2-2 and Fig 2-3.

(3) Population of the Study Area

The population of the study area is 870.1 thousand. The municipality of Concepcion has a population of 342.7 thousand. Population densities by zone in Concepcion Province are shown in Table 2-1.

(4) Household Income

Average monthly household incomes are estimated at Ch.$ 52,800 (as of 1993, at 1989 prices) in the urban areas of Metropolitan Concepcion. Table 2-2 shows the zone-wise results.

(5) Vehicle Ownership

In Concepcion Province there were 40,200 passenger cars, 18,200 pickups and 5,400 trucks, in 1993, representing 57 % of the Region's total. The Municipality of Concepcion issued permits for 37,467 vehicles in 1993, which represents 59 % of the total number of vehicles in the Province.

Comparing the per capita number of vehicles with Chile as a whole, which is 0.086 vehicles per person in 1992, it is 0.061 in Region VIII, 0.071 in Concepcion Province and 0.103 in Concepcion. The average number of vehicles per household in the urban areas of Metropolitan Concepcion is estimated at 0.239, and considerably higher in the Municipality of Concepcion, 0.335.

Table 2-1 Area, Population(mid-year) and Population Density by Zone in Concepcion Province, 1993

Number and Name of Zona	(1) Area (ha)	(2) Population	(2)/(1) Population Density (psns/ha)
1 Centro Sur	183.9	20,000	108.8
2 Centro Norte	240.3	29,500	122.8
3 Costanera	230.4	12,500	54.3
4 Pedro de Valdivia	185.9	7,800	42.0
5 Chillancito	230.4	21,100	91.6
6 Lorenzo Arenas	547.2	30,200	55.2
7 Barrio Norte	851.2	41,400	48.6
8 Puchacay	130.7	1,600	12.2
9 Observ./A.Potable	5,080.0	25,000	4.9
10 Chiguayante	3,720.0	58,000	15.6
11 Larenas	1,710.0	14,000	8.2
12 Palomares	2,870.0	4,700	1.6
13 R.Gde/Chai./Ulloas	12,810.0	3,200	0.2
18 San Pedro	7,250.0	71,400	9.8
19 Pinares	4,030.0	2,300	0.6
Municipality of Concepcion	40,070.0	342,700	8.6
14 Talcahuano	14,820.0	258,000	17.4
15 Penco/Tome	59,870.0	92,300	1.5
16 Florida	61,320.0	10,400	0.2
17 Hualqui	53,460.0	16,600	0.3
20 Lota/Coronel	41,470.0	137,800	3.3
21 Santa Juana	73,440.0	12,300	0.2
Province of Concepcion	344,450.0	870,100	2.5

Source: (1) Estimated by the Study Team for municipality of Concepcion, anad data of INE for other municipalities.
(2) Estimated by the Study Team based on 1992 census and data of INE.

Table 2-2 Average Monthly Household Income by Zone, Urban Area of Metropolitan Concepcion, 1993
(Ch.$ at 1989 price)

Number and Name of Zona	Average Monthly Household Income	Differential
1 Centro Sur	158,800	3.01
2 Centro Norte	76,600	1.45
3 Costanera	41,800	0.79
4 Pedro de Valdivia	37,700	0.71
5 Chillancito	47,000	0.89
6 Lorenzo Arenas	56,400	1.07
7 Barrio Norte	46,900	0.89
8 Puchacay	109,600	2.08
9 Observatorio/Agua Potable	90,000	1.70
10 Chiguayante	47,900	0.91
11 Larenas	31,100	0.59
18 San Pedro	.56,200	1.06
19 Pinares	173,200	3.28
Municipality of Concepcion	64,800	1.23
14 Talcahuano	52,400	0.99
15 Penco/Tome	37,400	0.71
17 Hualqui	37,800	0.72
20 Lota/Coronel	33,700	0.64
Metropolitan Area of Concepcion	52,800	1.00

Source: Estimation by the Study Team based on from SECTRA data

2.2 Development Trend of Concepcion Area

(1) Population Increase

Population of Concepcion Province is increasing at an annual rate of 1.62 %. As the capital city, Concepcion is growing at a higher rate of 1.96 %, but a population decrease is occurring in the central district.

(2) Development Plans and Projects

There are two land-use regulation plans for the Concepcion area. One is "Plan Regulador Metropolitano de Concepcion", which is an inter-municipal plan for the urban areas of Concepcion, Talcahuano, Penco and Hualgui. The other is "Plan Regulador de la Comuna de Concepcion" for the Municipality of Concepcion. The inter-municipal plan covers general land use, where the municipal plan intends to control land use through more detailed quantitative regulations for each use. These plans were prepared and enforced at the beginning of the 80s and are still in force today. A new regulation plan, however, will be made public during 1994.

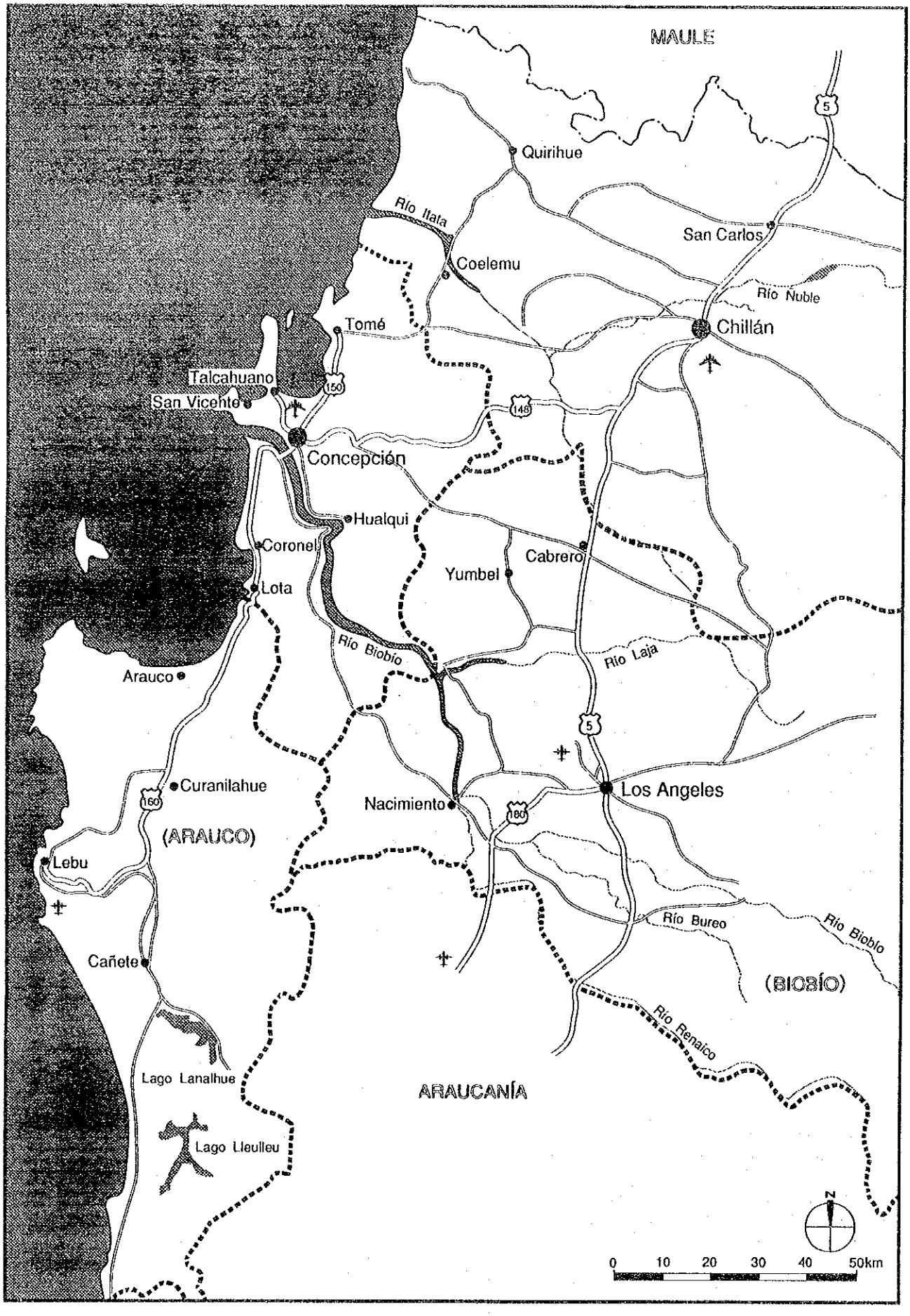

Figure 2-1 Location and Composition of the Study Area

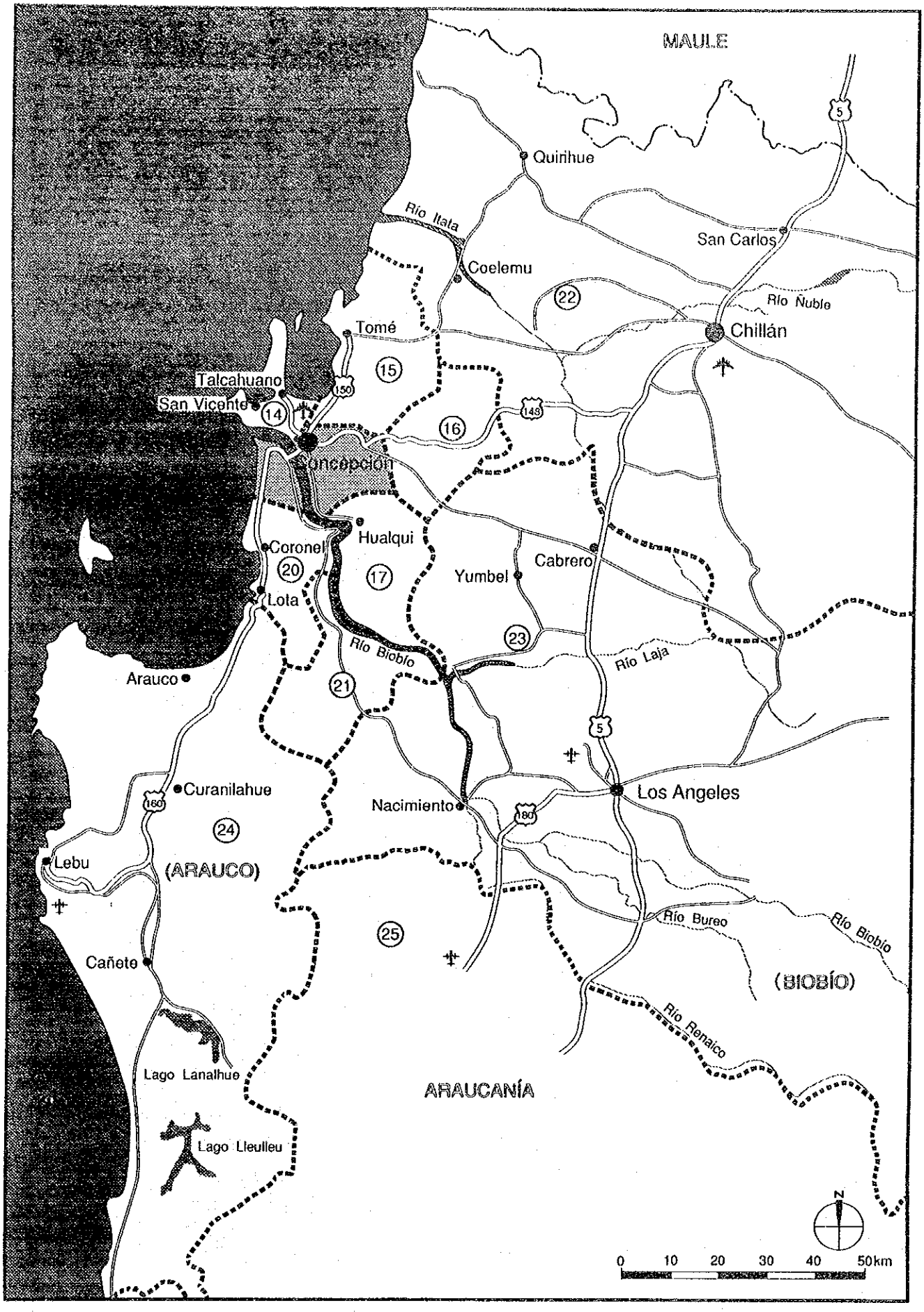

Figure 2-2 Zone Division (1)

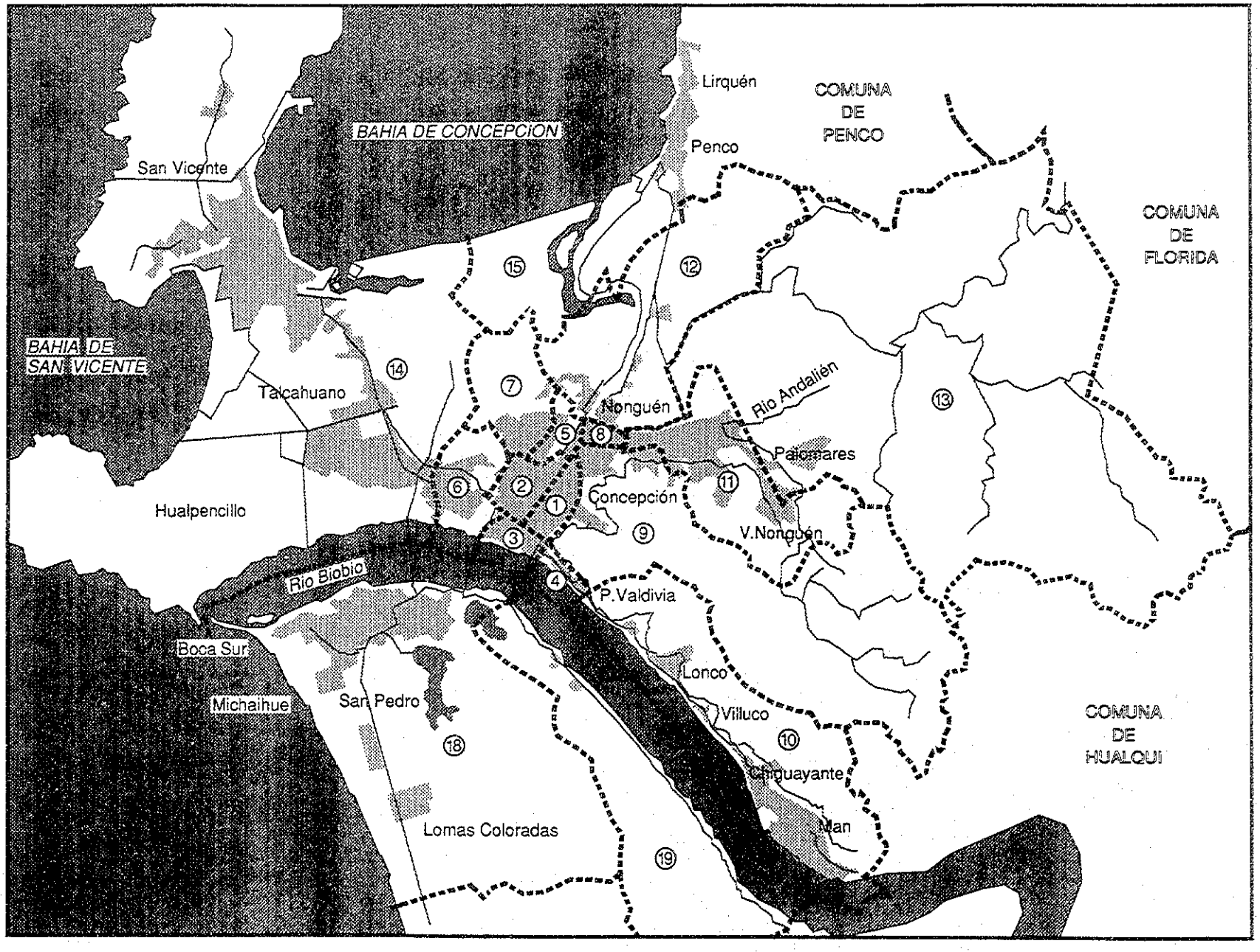

Figure 2-3 Zone Division (2)

There are not so many development projects, which will have a great impact on the urban structure of Concepcion. Excluding transport related projects, the following should be taken into consideration:

1. A redevelopment project along the north bank of the Biobio River.
2. Rebuilding of the Central Public Market.
3. A shopping mall development at the clover leaf interchange of J. Alessandri Avenue with "Autopista a Talcahueno".
4. Real estate development projects near Laguna Grande and Laguna Chica in San Pedro.
5. An industrial zone developed along the road to Cabrero.

The redevelopment of the north bank of the River is gradually being realized. A committee composed of regional offices of related Ministries, the Regional Government and the Municipality of Concepcion started to work for making an implementation plan focused on sections 3 and 4. The plan includes an improvement of residential area with infrastructures and a formation of new governmental and commercial center. (See Fig.2-4).

The rebuilding of the Central Public Market is now at the stage of negotiations between the Municipality and stall users.

The shopping mall is now under construction, According to the plan it will have a total floor area of 40,000 m^2 in two levels, developed on a vast site of 150,000 m^2. There would be two department stores, 120 specialty shop of national and international brands, 16 first-class restaurants and a supermarket. The inauguration is scheduled for April 1995.

The development projects in San Pedro are middle- to high-class residential areas planned around Laguna Grande and Laguna Chica. A part of the first project is already completed and lots are sold out. The other projects will start after 1995, and the total number of planned housing units is 6,820.

The industrial zone is at present partially occupied, but is expected eventually to be fully used, since the location is good and there are not so many other places where industries can locate.

PROGRAMA GESTION URBANA 1993

COMISION COORDINADORA DEL PROYECTO DE RECUPERACION DE LA RIBERA NORTE DEL RIO BIO BIO CONCEPCION

PROYECTO DE SANEAMIENTO URBANO CON COOPERACION EXTERNA

AREA FUTURO PARQUE COSTANERA

AREAS DE EQUIPAMIENTO

AREA OCUPADA BENEFICIADA POR PROGRAMA DE MACROINFRAESTRUCTURA

AREA DESOCUPADA BENEFICIADA POR PROGRAMA DE MACROINFRAESTRUCTURA

AREA RECUPERADA AL RIO DE PROPIEDAD FISCAL

AREA DE INTERES PARA EJECUTAR RELLENOS

AREA FUTURO PARQUE EN SECTOR RECUPERADO AL RIO

++++ LIMITE AREA PROGRAMA

VIALIDAD ESTRUCTURANTE

COLECTORES

PLANTA ELEVADORA

ALTERNATIVAS FUTURO PUENTE

Figere 2-4 Development Plans and Projects in the North Bank of Biobio River

CHAPTER 3. ROAD NETWORK AND TRANSPORT DEMAND CHARACTERISTICS

3.1 Transportation Network

(1) Interurban Road Network

The main roads connecting Concepcion city with its surrounding core cities consist of Route 148 which is a gate from the East, Route 150 linking Penco /Tome in the North, Route 154 an access to the harbor area of Talcahuano in the West and Route 160 running along the seashore connecting with Coronel/Lota in the South.

Fig.3-1 indicates the locations of the main access roads to/from Concepcion city with its daily traffic volume in 1990. Among those roads, Route 154 handled about 25,000 vehicles a day in 1990 because it functions as a trunk road linking the harbor area with Concepcion city.

(2) Road Network in Concepcion City

The road network in Concepcion city is a grid type as illustrated in Fig.3-2. The number of lanes of main streets are shown in Fig.3-2 as well. The Los Carrera street and the Chacabuco street running through the West to East have 6 lanes. the A.Prat Avenue and the Paicavi Street play important roles as North-South axes in the city and have 4 lanes each.

3.2 Traffic Crossing Over the BioBio River

(1) Traffic Volume on Each Bridge

According to the results of traffic survey conducted by the Study Team in December 1993, 24-hour traffic volume on each bridge is as summarized below

Table 3-1 Present Traffic Volume over the Existing Bridge

(Vehicles/day)

Vehicle Type	Biobio Bridge	Juan Pablo Bridge
Car,Wagon	14,729	8,746
Taxibus	3,199	2,346
Pickup	5,016	4,512
Bus	-	307
Truck(2 axles)	-	1,718
Truck(3 axles)	-	504
Trailers	-	1,329
Total(2-way)	22,944	19,462

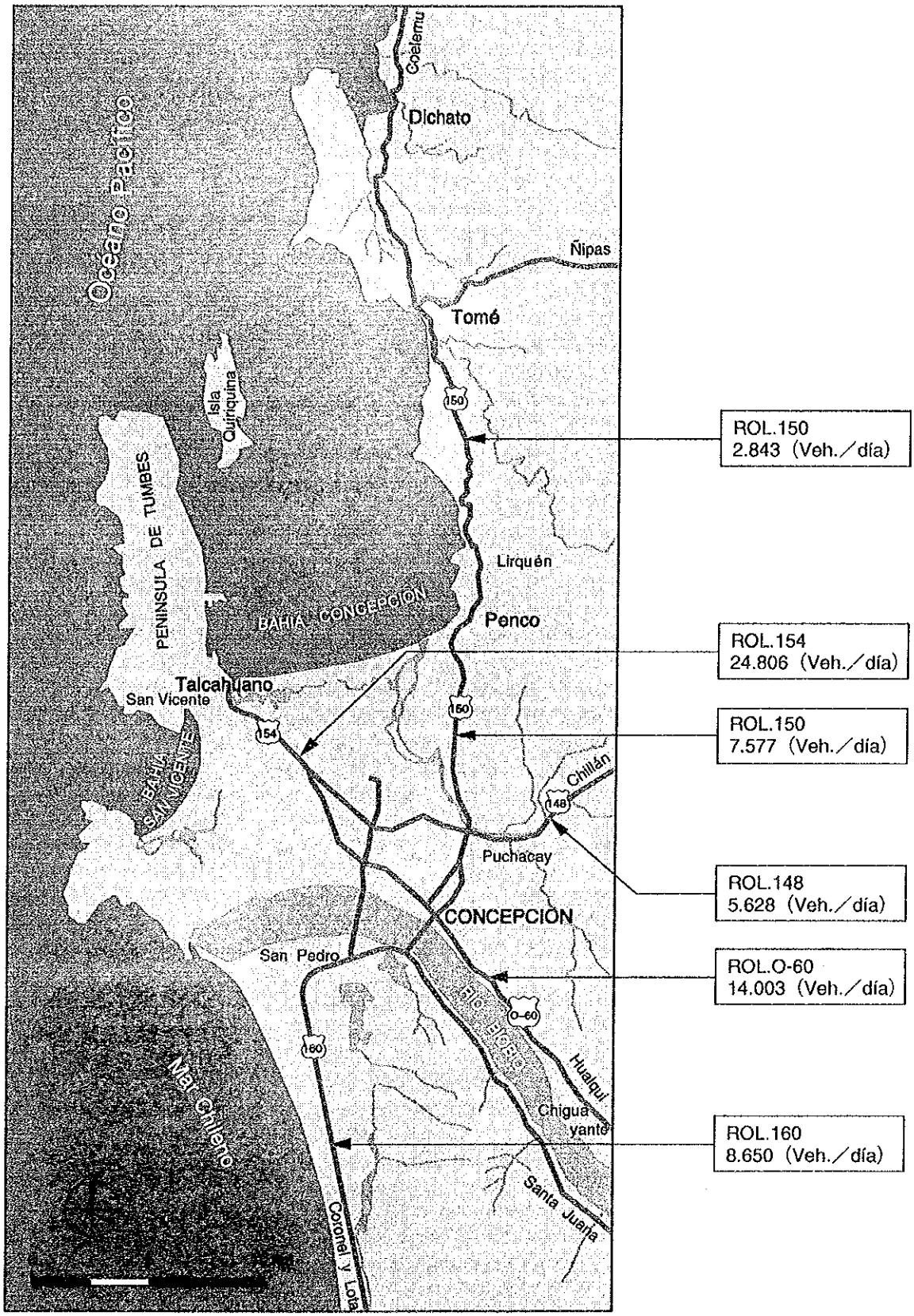

Figure 3-1 Interurban Road Network

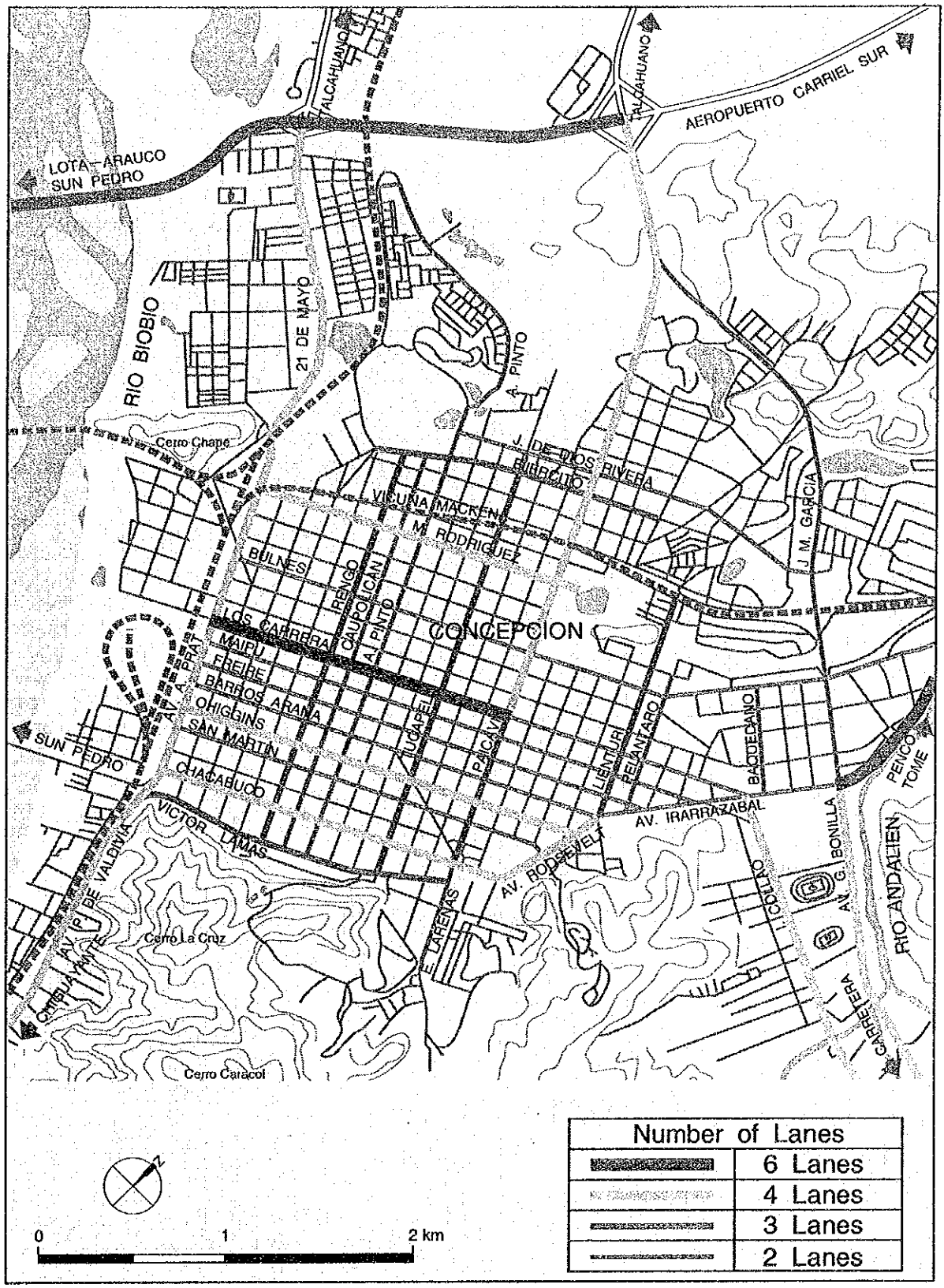

Figure 3-2 Road Network and Number of Lanes

CHAPTER 4. FUTURE SOCIO-ECONOMIC FRAME OF THE STUDY AREA

4.1 Trend of Economic Growth in Chile and Region VIII

Chilean economy experienced a drastic fall of -14.1% in 1982, followed by -0.7% in 1983. Since 1984, however, the Chilean economy has been attaining a continuous growth (See Table 4-1).

Table 4-1 Economic Growth Trend of Chile

Year	Gross Domestic Product (Million Ch.$ at 1977 prices)	Annual Growth Rate(%)
1980	363,446	-
1981	383,551	5.5
1982	329,523	-14.1
1983	327,180	-0.7
1984	347,926	6.3
1985	356,447	2.4
1986	376,627	5.7
1097	398,230	5.7
1988	427,530	7.4
1989	470,243	10.0
1990	480,323	2.1
1991	509,153	6.0
1992	562,254	10.4

Source: Central Bank of Chile

The Gross Regional Domestic Product (GRDP) is estimated and published by the Central Bank of Chile. At present the figures until 1986 are available. The GRDP of Region VIII for 1986 is shown in Table 4-2.

Table 4-2 GRDP by Sector of Region VIII in 1986

Economic Activity	GRDP (Millon Ch.$ at 1977 prices)	Percentage Distribution Region (%)	Share in Chile (%)
Agriculture and fishery	5,911	16.3	15.9
Mining	836	2.3	2.7
Manufacturing	11,936	32.8	15.2
Construction	1,585	4.4	7.6
Electricity,gas and water	1,865	5.1	19.2
Transport and communication	2,127	5.8	9.9
Commercial	4,392	12.1	7.0
Others	7,740	21.2	6.8
Primary sector	5,911	16.3	15.9
Secondary sector	14,357	39.5	11.0
Tertiary sector	16,126	44.2	7.7
Total	36,394	100.0	9.7

4.2 Future GDP and GRDP of Region VIII

(1) Future GDP

The Chilean economy enjoyed a "Decade of Growth" (1982-1992), with an annual growth during that period of 5.5 %. The Instituto Nacional de Estadisticas (INE) estimated that Chile's economy grew at a rate of 5.7 % in 1993.

The pace of economic growth in Chile, however, is considered to slow down a little in the future. One technical institute states that the economic growth in 1994 will fall between 3 and 4 %. Government organizations have put the target for the growth rate in 1994 at 4 to 5 %.

Considering the macro-economic structure of Chile, and the recovery trends of the international economy, a 4.5 % annual average economic growth is assumed for the period of 1992-2010 and a 4.0 % for 2010-2020.

(2) Future GRDP of Region VIII

For the projection of future GRDP of Region VIII, GRDP in 1992 is estimated by using the region-wise employment data which have been published yearly from INE. Then, sectoral elasticities of growth rates of Region VIII to the nation as a whole are calculated for the period from 1986 to 1992. It is assumed that the Region's economic development will follow the national trend at a rate proportional to that determined for the period 1986-1992.

GRDP per capita will rise from Ch.$ 819.1 thousand in 1992 at 1992 prices (US$ 2,260 at the exchange rate of US$ 1.00 = Ch.$ 362.576 in that year) to Ch.$ 1,548.6 thousand in 2010, which is equivalent to US$ 4,270.

4.3 Future Population

In mid 1993, the population of Region VIII is estimated at 1,788,800. It is assumed that the future population of Region VIII will increase along the course projected by INE and will reach 2,133,800 in mid/2010.

In order to determine the future population by province, the estimated population at the Region level is distributed to each province based on the past tendency of increase. The results are shown in Table 4-3.

Table 4-3 Future Population by Province in Region VIII

Province	Population (Thousand Persons)				Annual Increase Rate (%)		
	1993	2000	2010	2020	93/00	00/10	10/20
Concepcion	870.1	960.1	1,076.9	1,187.2	1.4	1.2	1.0
Nuble	430.6	454.3	482.2	507.4	0.8	0.6	0.5
Biobio	333.4	356.5	385.5	411.9	1.0	0.8	0.7
Arauco	154.6	169.4	188.5	206.5	1.3	1.1	0.9
Region VIII	1,788.8	1,940.3	2,133.8	2,313.0	1.2	1.0	0.8

4.4 Future Vehicle Ownership

(1) Passenger Car and Pickup

Most passenger cars and pickups are owned by households. In the urban areas of Metropolitan Concepcion, the number of vehicles per household will rise from 0.239 in 1993 to 0.459 in 2010. Applying this future vehicle ownership to the estimated future number of households, 106,440 vehicles for household use will exist. Adding the number of vehicles owned by establishments for business use, and assuming that the percentage of passenger cars is 75%, the future numbers of passenger cars and pickups are projected for the urban areas of Metropolitan Concepcion as shown in Table 4-4.

Table 4-4 Future Number of Passenger Cars and Pickup in the Metropolitan Concepcion

Type of Vehicle	Number of Vehicle		Ratio
	1993	2010	1993/2010
Passenger Car	37,530	96,770	2.56
Pickup	16,630	32,250	1.94
Total	54,160	129,020	2.38
Vehicle Ownership (Veh./household)	0.239	0.459	1.92

The number of passenger cars and pickups in areas outside the urban areas of Metropolitan Concepcion within Region VIII are estimated as the total of household-owned and establishment-owned. It is assumed that the ratio of the number of vehicles to that of households will increase in the future at the same pace as in the urban areas of Metropolitan Concepcion. The percentage of passenger cars is assumed at 60% according to the past trend.

Table 4-5 Future Number of Passenger Cars and Pickups in the Other Area of Region VIII

Type of Vehicle	Number of Vehicle		Ratio
	1993	2010	1993/2010
Passenger Car	25,870	60,870	2.35
Pickup	19,970	40,580	2.03
Total	45,840	101,450	2.21

(2) Truck

The future number of trucks in Region VIII is estimated by using an elasticity of the rate of increase of trucks to the growth of the regional economy. Since the number of trucks increased at an annual rate of 4.1 % from 1982 to 1992 and the GRDP expanded at an annual rate of 6.2 % during the same period, the elasticity was calculated to be 0.66. Applying the elasticity to the projected annual 4.7 % growth rate of the regional economy till 2010, a 3.1 % annual rate of increase for trucks is adopted. The estimated results are indicated in Table 4-6.

Table 4-6 Future Number of Trucks by Province in Region VIII

Province	Number of Vehicles		Ratio
	1993	2010	1993/2010
Concepcion	5,400	9,250	1.71
Nuble	3,100	5,000	1.61
Biobio	3,000	4,990	1.66
Arauco	1,200	2,100	1.75
Region VIII	12,700	21,340	1.68

CHAPTER 5. ROOD DEVELOPMENT PLAN OF MOP

5.1 Investment Plan Upto 2010

MOP prepared the 17-year investment plan targeting for the year 2010. The total investment amount during the period is envisaged at US$ 33,360 million. The amount of US$ 24,427 million, representing 73% of the total program, is allotted to the road sector, of which US$ 7,370 million US$ is allocated to the urban road sector. Out of the last amount, the assignment to the South Central Region (Regions VII and VIII) is US$ 1,251 million (Table 5-1).

Table 5-1 Investment Plan of MOP for 1994-2010
(Million US$ at 1993 price)

Sector	Planned Investment (Mill.US$)			Investment per Capita(US$)		
	A Region VII & VIII	B National Total	A/B (%)	C Region VII & VIII	D National Total	C/D
Population	2,563	13,232	19.4	-	-	-
Inter-City Road	3,467	17,057	20.3	1,353	1,289	1.05
Urban Road	1,251	7,370	17.0	488	557	0.88
Port and Fishery Port	166	726	22.9	65	55	1.18
Airport	16	213	7.5	6	16	0.39
Drainage	535	1,361	39.3	209	103	2.03
Water Supply	112	1,042	10.7	44	79	0.55
Sewage	172	2,217	7.8	67	168	0.40
Rain Water	30	52	57.7	12	4	2.98
River Control	28	107	26.2	11	8	1.35
Public Building	350	1,381	25.3	137	104	1.31
Subway	-	1,232	0.0	0	93	0.00
Railway	-	501	0.0	0	38	0.00
Total	6,126	33,260	18.4	2,390	2,514	0.95

Source: El Mercurio, 29 of January, 1994
Note: The investment amount for Region VIII is officially published combined with the amount for Region VII, but not individually.

5.2 Road Projects on-going or planned in the Study Area

MOP and the local authorities the following road projects in the Study Area, of which (1)-2,(1)-4 and (3) will greatly affect the demand and the feasibility of the new Biobio bridge projects.

(1) Road Improvement Project in Concepcion
(Over US$ 2.0 million)

1. Av. Pedro de Valdivia
2. Av. Prat - St.21 de Mayo
3. Av. Collao - St Gral. Novoa
4. Av. Los Carrera
5. Av. P. Aguirre Cerda
6. Av. Roosevelt - Av. Irarrazaval
7. Interconnection St. Concepcion - Chiguayante
8. Interconnection St. Concepcion - Paicavi
9. Trunk Road O'Higgins

(2) Acceso Norte (North Access)

There are two routes connecting Concepcion and Route 5; National route 148 and 0-50, both of which have poor alignment and surface conditions. The construction of the third route is planned to the north of Route 148, using funds from the private sector. Acceso Norte starts from Penco, and continues east and reaches Route 5 at about 13 km south of Chillan. The total length is about 65 km. Two branch roads are also planned to be constructed to connect with Quillon and Rafael. These roads are designed as access-controlled expressways with four lanes. The toll system has not yet been determined.

(3) Costanera (Riverside Road)

The Costanera project is a river-side road construction of 35 km, starting from Hualqui which is regarded as the southern limit of urbanization and extending to the mouth of the Biobio river. This is one of the main components of a large-scale urban development project named "the Biobio River North-Dike Area Recovery Project "which aims at land and urban development, economic activation,creation of urban amenity and relief of squatters in the river-side areas.

(4) Camino de la Madera (Timber Road)

This project, to be financed by the private sector, aims at improvement and maintenance of 113 km road between San Pedro - Caihue via Santa Juana and Nacimiento. Timbers produced in the catchment area of the Biobio river are transported mainly though this route to the ports of Talcahuano, San Vicente and Lirquen. Total investment is estimated to be Ch.$ 14,328 million.

CHAPTER 6. FORECASTING OF FUTURE TRAFFIC DEMAND

6.1 Present River Crossing Traffic Volume

Total daily traffic volume in the Study Area is estimated to be 170,000 trips in 1993, of which 72% are trips of passenger cars, 19% of taxibuses, 4% of buses and 5% of trucks. Out of the total, traffic crossing the river Biobio is 43,000 trips, 25% of the total (Table 6-1).

Table 6-1 Present River Crossing Traffic Volume

	Car,Wagon,Pickup	Taxibus,Bus	Truck	Total
Total of River Crossing Traffic (AADT)	33,646	6,074	3,258	42,978
Peak hours (6 hours)	12,722	2,302	1,327	16,351
Off peak hours	20,924	3,772	1,931	26,627

Note: Total traffic volume in this table is larger than the volume stated in Chapter 3, by 1.3 %. This discrepancy accrued by rounding of each OD traffic volume estimated when zones in urbanized area are sub-divided.

6.2 Forecasting Future Traffic

Total traffic volume in the Study Area will increase to 350,000 trips per day in 2010, 2.1 times of the present. Passenger cars will raise its share to 80% of the total. River crossing traffic will reach to 112,000 trips which is about 2.6 times of 1993 volume (Table 6-2).

Table 6-2 Future River Crossing Traffic Volume

Vehicle Type	River Crossing Traffic (Vehicles/day)			Annual Growth Rate (%) 1993 - 2010	2010/1993
	1993	1999	2010		
Car, Wagon, Pickup	33,646	51,000	90,500	6.0	2.69
Taxibus,Bus	6,074	7,700	12,900	4.5	2.12
Truck	3,258	5,000	8,700	5.9	2.67
Total	42,978	63,700	112,100	5.8	2.61

CHAPTER 7. NATURAL ENVIRONMENT OF THE STUDY AREA.

7.1 General

Engineering survey consisted of meteorological Survey, hydrological survey, geological investigation including soil investigation, seismic survey and topographical survey.

7.2 River Condition

The Biobio's catchment area is 24,420 km2 at the river-mouth, between the 36°45' and 38°52' south parallels. It discharges at the west into the Pacific Ocean, and extends to the east up to the ranges of the LOS ANDES at the national frontier with Argentina.

The Biobio flows from southeast to northwest for 356 km until the sea, where the latitude of river mouth is at 36°50' south, south of the HUALPEN Peninsula and north of ARAUCO Gulf. The river begins in the LOS ANDES Ranges at ICALMA and GALLETUE lakes, less than 1,500 m above sea level.

7.3 Geological Characteristic at Bridge Site

(1) General Characteristic of soils

Most soils are fine granular, dense or very dense, silty sands (SP or SM). Occasionally, some layers of sandy silt hard to very hard consistency are encountered. Rarely thin layers of gravel,were found. In accordance with generally accepted correlations the Biobio sediments, below 6 m depth, have good bearing capacity.

(2) General Comment for the soil mechanism

Geological profiles confirmed by boring results making relevant the following issues :

1. Superficial sediment shows low density. From the surface to 4-6 m depth, soils correspond to recent deposits after periodic changes in this zone during floods.

2. Wave velocity reduction in front of Laguna Chica de San Pedro shows the existence an ancient interconnection between the pond and the river.

3. High wave velocity reduction in the area of Costanera on Av. Los Carrera, confirmed the presence of thick stratums of hard consistency silts. This measurement shows the existence of a natural canal that connected Andalien and Biobio rivers during flood in the past century.

CHAPTER 8 OLD BIOBIO BRIDGE

8.1 The Old Biobio Bridge Condition

It is noted that a critical condition is currently prevailing. Under the 8 ton loading, the fiber stress in the steel of the main girder due to dead load alone (1,885 Kg/cm2) is higher than the allowable stress of 1,320. Furthermore, under the same 8 ton load, the combined dead and live load stress in the steel girder substantially exceed the permissible unit stress of 1,320 Kg/cm2.

It appears that the stability is generated by the combined action of the girders and the deck slab, and as a result the long range service of the bridge is dependent on the progress of the deterioration, particularly the cracks in the deck slab.

All bridge codes as well as other structural codes have limitations regarding the depth of the structural supports. These restrictions are made to control deflections as well as to reduce vibrations.

The limitations of the AASHTO Specifications are 1/25 when the combined depths of the girder and slab are used, and 1/30 when the girder depth is taken alone. These two parameters for the existing bridge are 1/25.08 and 1/34.77 respectively.

According to the "Manual for Inspection and Maintenance of Bridges, AASHTO 1978, a bridge shall require traffic control such as weight or speed limitations of vehicles if RF is below 1.0. The bridge, however shall be closed to traffic in the event the load carrying capacity is below 3 tons. The load carrying capacity of this bridge is below 3 tons, suggesting the need for the MOP to take countermeasures related to safety.

8.2 Maintenance of the Old Biobio Bridge

Some maintenance works shall be carried out if the present conditions are kept as they are until the completion of the new bridge. Deck slab repairs shall be carried out if the cracks will progress. Additionally, widening of the existing pier caps shall be undertaken to avoid the dropping of spans which can be caused from the horizontal displacements caused by earthquake forces.

Maintenance works shall be continued on a routine basis. Periodic observation of bridge conditions shall be carried out especially in regard to the deck slab cracks and settlement of the foundations. Expansion joints shall be repaired and pile caps shall be reinforced as necessary.

8.3 Upgrading Works

The stability of the bridge is substantially doubtful, and most of the components of the bridge may not be suitable for upgrading due to many reasons. Existing components of the bridge will, however be utilized to reduce the cost for construction of a new bridge by using them as temporary facilities such as scaffolding, staging and a temporary bridge for construction work.

It is concluded that the upgrading of the bridge is not a practical solution, is not economical, and is therefore not recommended.

8.4 Recommendations Regarding the Bridge

Based on the above findings, particularly with regard to the over-stress in the structural steel girders, and the over-stress in the steel reinforcement in the deck, the Study Team has reached the following conclusions:

1. Due to the excessive over-stress of the structural components, this bridge should be closed to traffic.

2. The MOP may however, decide to carry out the above recommendation in two stages. a) By restricting the traffic to passenger and emergency vehicles only, and b) Complete closure of the bridge.

3. It is not recommended to upgrade the bridge.

4. The MOP should make arrangements for replacement of this bridge as soon as possible.

CHAPTER 9 STUDY OF ALTERNATIVE ROUTE PLANS FOR THE NEW BRIDGE

9.1 Basic Policy for the Study

The total volume of trips crossing the river will reach 112,000 vehicles a day in the target year(2010). This means the volume of traffic will reach the capacity of the new four lane bridge. The Study Team, there, does not consider it advisable to recommend an ultimate situation where a 2-lane, 20 ton bridge is constructed adjacent to a 2-lane, 8-ton bridge (the current load restriction on the existing bridge), as the ultimate solution under this Study. Such condition will severely restrict the routing of the Public Transport which is a critical element of this Study, creating the following situations:

1. If the existing (8 ton) 2-lane bridge is located side by side with a new (20 ton) 2-lane bridge and both lanes of each bridge are restricted to one-way traffic, with the new bridge carrying the buses and trucks, etc.the traffic would have to be routed for the return trip via Juan Pablo II Bridge.

2. If the existing (8 ton) 2-lane bridge is located side by side with a new (20 ton) 2-lane bridge and both bridges are used for 2-way traffic, then the buses and trucks will be restricted to use only the new bridge, creating a serious traffic management problem, in addition to not meeting the traffic demand for 2010.

The useful life of this bridge is limited and the load-carrying capacity of the bridge is estimated below 3 tons. However, the MOP may consider maintaining limited use of the existing bridge in lieu of its demolition, since this bridge is needed as a detour during the construction of the new bridge. Thus, for the route selection for the new bridge, old bridge is assumed to be closed before the opening of the new one.

The Study Team's recommendations regarding the existing bridge are as follows.

1. That the new bridge must have a standard capacity for truck loading, HS20-44, and should be a 4-lane bridge.

2. The demolition of the old bridge should not be considered in the costing for the new bridge.

For the above reasons, investigation of the alternative plans described in the following section is recommended.

9.2 Alternative Plans for the Study

In studying the various alternatives, the extent of the study is shown on Fig.9-1. Following alternatives are investigated.

1. Alternative 1.

   Construction of a new 4-lane bridge, parallel to the existing bridge, but slightly upstream.

2. Alternative 2.

   Construction of a new 4-lane bridge, along the alignment of the extension of Chacabuco Street.

3. Alternative 3.

   Construction of a new 4-lane bridge, connecting the end of Av. Los Carrera and Av. Pedro A. Cerda at San Pedro with the shortest bridge length.

4. Alternative 4.

   Construction of a new 4-lane bridge, along the alignment of extension of Los Carrera Street.

9.3 Evaluation and Selection of Alternatives

Four alternative routes are evaluated from the economic viewpoint, based on the traffic assignment results and estimated project costs. Several plausible conditions are assumed to simplify the problems. They are:

1. The new Biobio bridge will open at the beginning of 1999. The construction of Costanera road and widening of Av. Los Carrera and St. Prat are completed, and old bridge will have been closed before 1999.

2. Construction of the bridge will take three years and 20% of the total cost will be invested in the first year of 1996 and 40% in each of 1997 and 1998.

3. Social cost of the project is assumed to be 75% of the total financial cost in terms of market price. This assumption seems reasonable, because in Chile the value added tax (IVA) is 18% and import duties of 11% is widely adopted. In addition, the shadow wage rate of unskilled labor is estimated at 60% by MIDIPLAN.

4. Economic benefit accruing by savings in travel time and vehicle operating cost will be counted for the twenty years after opening (1999-2019).

5. Residual values in 2020 of the bridge and roads constructed by the project is regarded to be 50% of the initial investment amount.

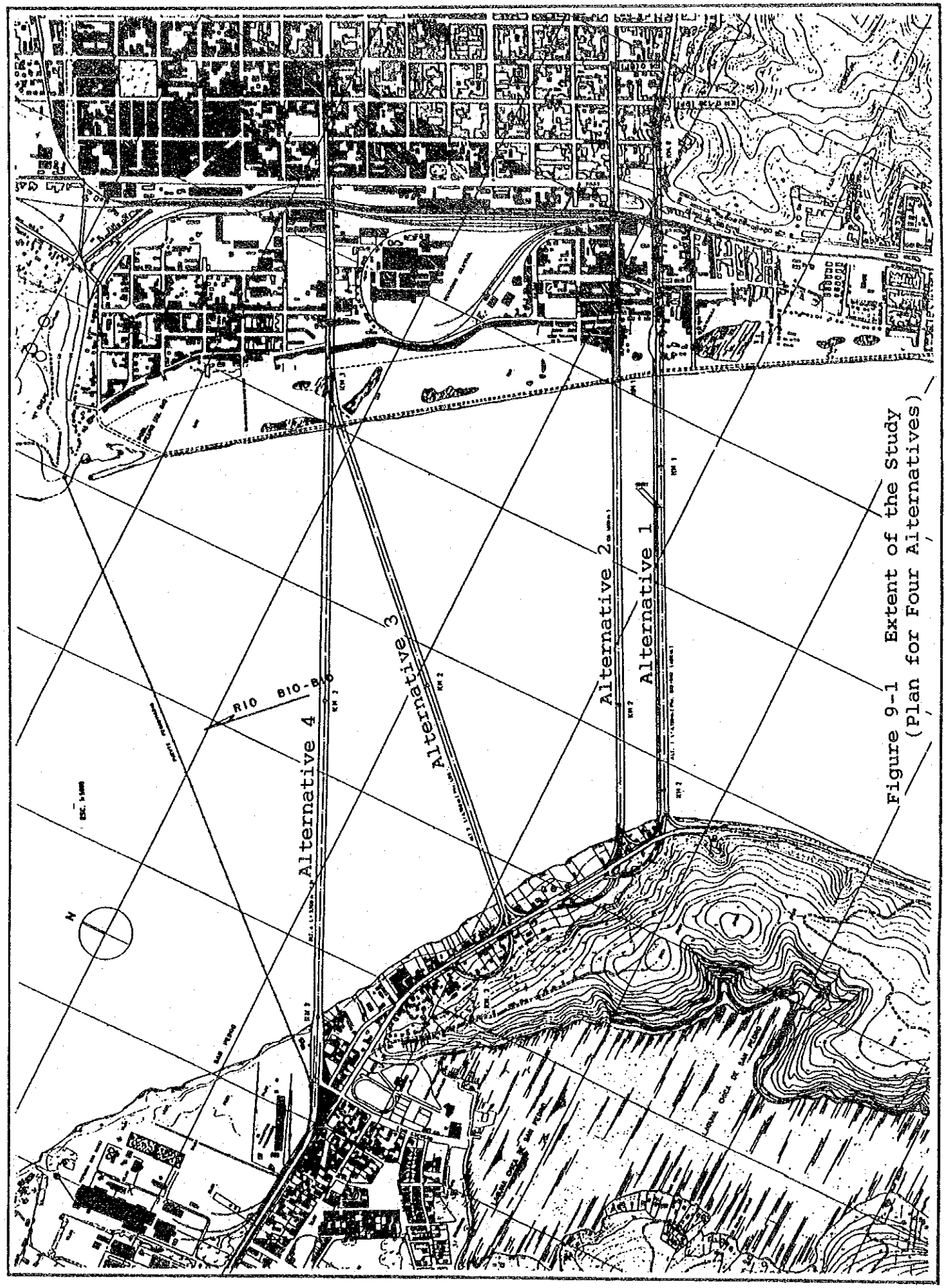

Figure 9-1 Extent of the Study
(Plan for Four Alternatives)

6. Maintenance costs of the new bridge is disregarded at this stage. They may be negligibly small (less than 1% of the initial investment) and will not affect the order of priority.

9.4 Evaluation Results

(1) Traffic Assignment Results

Table 9-1 shows the summary of traffic assignment results of "without project" case and of each alternative case. If the new bridge is not constructed, daily traffic volume in the Study Area will increase 1.8 times from 1,480,000 pcu-km in 1999 to 2,670,000 pcu-km in 2010. As the result of traffic increase, average travel speed will fall from 41 km/hr to 25 km/hr during this period.

On the other hand , with the construction of the new bridge, traffic burden will be mitigated much even in 1999, by 9% t 12% in terms of pcu-km and by 8% to 12% in terms of pcu-hour. In the year 2010, this traffic mitigation will be more significant, by about 15% of pcu-km and 30% of pcu-hour. This will allow average travel speed to be maintained over 30 km/hour in 2010.

Comparing these saving effects by four Alternatives, No.4 has the largest savings both in PCU-km and PCU-hour, followed by No.3 and the other Alternatives No.2 and 1 are almost at the same level.

Table 9-1 Savings of PCU-Km and PCU-Hour by each Route Alternative

(1000 PCU-Km, 1000 PCU-Hr per day)

Route Alternative	Year	Daily Traffic		Savings	
		PCU-km	PCU-Hour	PCU-km	PCU-Hour
Without Project	1999 2010	1,480.53 2,672.04	35.71 108.00	- -	- -
1	1999 2010	1,303.43 2,298.04	32.91 73.45	177.10 374.00	2.80 34.55
2	1999 2010	1,350.70 2,298.69	32.73 73.46	129.83 373.35	2.98 34.54
3	1999 2010	1,342.71 2,294.75	32.51 73.60	137.82 377.29	3.20 34.40
4	1999 2010	1,312.49 2,255.81	31.37 71.09	168.04 416.23	4.34 36.91

Note: PCU represents "Passenger Car Unit"

(2) Economic Evaluation

Savings in travel time and distance are converted into the money term economic benefits and compared to the construction cost of each Alternative. The following points are to be noted:

1) Economic benefit from travel time savings, stands at about one half of total benefit both in 1999 and 2010.

2) All the Alternatives are judged to be highly feasible (IRR values are far over 12 % which is regarded as the rate of capital opportunity in Chile).

3) Alternative No.4 implies the largest economic return, followed by No.3, No.2 and No.1, in this order. Net present value (NPV) of No.4 is 1.7 times larger than that of No.1.

Table 9-2 Economic Evaluation Indicators of Route Alternatives

Items		Alt.1	Alt.2	Alt.3	Alt.4
1. Project Cost (Mill Ch$)					
	Financial Cost	26,518	26,262	25,659	29,089
	Economic Cost	19,889	19,697	19,244	21,817
	Residual Value	9,944	9.848	9,622	10,908
2. Annual Benefit (Mill Ch$)					
1999	Time Saving	1,133.68	1,185.29	1,298.57	1,672.92
	Fuel Saving	146.56	179.07	206.43	296.78
	Other Benefit	571.60	753.42	861.35	1,289.71
	Total	1,851.84	2,117.78	2,366.35	3,259.41
2010	Time Saving	3,084.07	3,091.74	3,238.47	4,215.38
	Fuel Saving	623.19	626.39	639.70	828.45
	Other Benefit	2,729.11	2,719.29	2,757.15	3,640.83
	Total	6,436.37	6,437.42	6,635.32	8,684.67
3. Evaluation Indicators					
	IRR (%)	17.09	17.61	18.62	20.00
	NPV (Mill Ch$)	9,952	10,818	12,525	16,985
	B/C	1.57	1.63	1.74	1.89

Note: Other benefits are savings in vehicle operation cost other than fuel cost, which consists of lubricantcost, tire cost, repair cost, crew cost, depreciationcostandcata opotunity cost.

9.5 Impact of Costanera Avenue and Old Biobio Bridge

Among the assumptions and preconditions stated in 9.3, most influential ones may be construction of Costanera Avenue and closure of the old Biobio bridge. Hence, their influences on the priority order of the Alternatives are to be studied by assuming that those conditions are not satisfied.

1. Costanera Avenue

If Costanera Avenue is not constructed along the Concepcion bank, economic return of the new Biobio bridge would be much more larger, 1.6 to 1.8 times in IRR and 3 to 4 times in NPV comparing to the case with Costanera Avenue (Table 9-4).

In this case, the old bridge is already closed. Therefore, if the new bridge is not constructed, all the traffic from San Pedro will be forced to pass the Juan Pedro II bridge and flow into Concepcion together with traffic from Talcahuano. Consequently, in "without Av. Costanera Project" case, 21 de Mayo st., J. Alesandri st., Paicavi st., and J. M. Garcia st. will be deadly congested. By this reason, to diversify traffic to Concepcion by construction of the new bridge will generate economic benefit more significantly than in "with Av. Costanera Project" case. This does not necessarily deny the importance of An Costanera Project. Because, without the Av. Costanera Project, the service level of road traffic can hardly keep the tolerable level in the future.

Table 9-3 Economic Evaluation Indicators
("without Costanera" Case)

Items	Alt. 1	Alt. 2	Alt. 3	Alt.4
IRR	30.50	31.33	32.85	33.57
NPV(Mill Ch$)	41,610	43,301	46,171	52,910
B/C	3.39	3.51	3.74	3.77

2. Old Biobio Bridge

On the contrary, if the old Biobio bridge is maintained open, economic return of the new Biobio bridge will fall down significantly as shown in Table 9-4.

Table 9-4 Economic Evaluation Indicator
("with Old Biobio Bridge" Case)

Items	Alt. 1	Alt. 2	Alt. 3	Alt. 4
IRR	5.08	5.73	7.95	12.05
NPV(Mill Ch$)	-9,748	-8,583	-5,567	3,699
B/C	0.44	0.50	0.67	1.19

9.6 Selection of Alternatives

As shown in Table 9-2 and 9-3, Alternative No.4 is the most favorable from economic viewpoint, although its cost is the highest. Alternative 4 is finally selected for the further study, not only from the economic reason, but also from other advantages as follows:

1. Alternative No.3 and No.4 which connect with Los Carrera St. will apparently contribute most to the urban development in the riverside area (refer to "Region-wide Major Activity Center in Chapter 13) and also in the area along Los Carrera Avenue.

2. Alternative No.4 will need the least land acquisition and demolition of existing buildings and structures, while Alternative No.3 and No.2 will require more and Alternative No.1, most.

3. In case of Alternative No.1 and No.2, heavy traffic passing the river will come into Concepcion in the morning peak time, taking Victor Lamas St. or Chacabuco St. which are located in the southmost of downtown. Therefore, every vehicle from San Pedro side is forced to make left turn in order to enter the downtown. This will cause severe traffic congestion in the future.