of silo (50,000 tons). On the other hand, JUNTA only operated 2.7 times for 367,080 tons capacity of silos. (Table 4-1-2-1, 4-1-2-2)

(FACA)

FACA elevator berth is owned by Federacion Argentina de Cooperativos Argarios. The length of the berth is 130 m and can accommodate a ship of up to 240 m L.O.A. The loading capacity handles at a rate of 1,000 tons/hour and 1,200 tons/hour of received rate of truck. The storage capacity is 19,700 tons.

Table 4-1-2-1 Grain Elevators in Rosario Area

| Name | Length (m) | Depth (m) | Cap./Silo (tons) | Loader (t/hour) | Recep. ton/hour (Truck) | (Train) | Remark |
|---|---|---|---|---|---|---|---|
| FACA | 130 | 9.5 | 19,700 | 1,000 | 1,200 | - | |
| G.GARCIA | 140 | 9.1 | 80,000 | 1,100 | 900 | 500 | |
| UNIT II | 130 | - | 22,800 | 600 | 300 | 300 | No work |
| UNIT III | 80 | 9.0 | 87,500 | 1,000 | 500 | 1,000 | |
| UNIT IV | 145 | 10.7 | 36,280 | 1,000 | 0 | 1,000 | |
| UNIT VI | 250 | 10.4 | 140,500 | 1,500 | 1,200 | 1,200 | |
| UNIT VII | 215 | 9.0 | 80,000 | 1,000 | 0 | 3,200 | uncoplete |
| PLAZOLETA | 150 | 9.0 | - | - | - | - | Open Berth |
| P. ALVEAR | 144 | 10.5 | 70,000 | 1,800 | | | |
| Total | | | 536,780 | 9,000 | | | |

Note: FACA = Federacion Argentina de Cooperativas Agrarias

Table 4-1-2-2 Cargo Volume in Rosario Area ('82-'89)

Unit: $10^3$ ton

| Elvator | '82 | '83 | '84 | '85 | '86 | '87 | '88 | '89 |
|---|---|---|---|---|---|---|---|---|
| UNIT I | - | - | - | - | - | - | - | - |
| F.A.C.A | - | 330 | 520 | 1,167 | 1,073 | 744 | 887 | 175 |
| GENARO GARCIA | - | 824 | 122 | 93 | 324 | 195 | 191 | 62 |
| UNIT II | - | - | - | - | - | - | - | - |
| UNIT III | 887 | 1,211 | 1,131 | 2,134 | 634 | 272 | 246 | 238 |
| UNIT IV | 675 | 451 | 711 | 679 | 323 | - | 303 | 103 |
| UNIT VI | 2,366 | 2,218 | 1,392 | 1,979 | 1,010 | 819 | 960 | 642 |
| PLAZOLETA A.G.P | 2,632 | 2,186 | 2,271 | 2,149 | 1,776 | 914 | 437 | 150 |
| TOTAL | 6,560 | 7,220 | 6,147 | 8,201 | 5,140 | 2,944 | 3,024 | 1,370 |
| PUNTA ALVEAR | - | 934 | 1,448 | 1,903 | 1,981 | 1,185 | 1,494 | 661 |
| G.TOTAL | 6,560 | 8,154 | 7,595 | 10,104 | 7,121 | 4,129 | 4,518 | 2,031 |

(GENARO GARCIA)

The berth is 140 m. The storage capacity is 80,000 tons for grain. The loading rate is 1,100 tons per hour. Part of silo capacity was damaged by fire. The berth can accommodate panamax size ships. The depth alongside is 9.1 m.

(UNIT III)

The berth is 80 m. Loading capacity handles at a rate of 1,000 tons per hour. Shifting is necessary to accommodate the hatches for loading and ship length should not be more than 220 m L.O.A.

(UNIT IV)

The length of the berth is 145 m and consists of 4 concrete dolphins with rubber fenders. The loading capacity handles at a rate of 1,000 tons/hour. The storage capacity is 36,280 tons grain.

(UNIT VI)

The berth is 250 m and the ships lies on 2 dolphins with rubber fenders. Total delivery rate is 1,500 tons per hour. Storage capacity is 140,500 tons grain. The depth alongside is 10.4 m. At the beginning of 1987 a fire in the loading gallery reduced the loading rate by about half.

(UNIT VII)

This wharf is about 215 m. The storage capacity is 80,000 tons grain. Each of the vertical silos has a telescopic shoot installed and will load by gravitation about 1,000 tons/hour.

(PLAZOLETA A)

The berth is about 150 m and has an open yard for the discharge of bulk cargoes and general loading/unloading.

(PUNTA ALVEAR ELEVATOR BERTH)

The berth is privately owned by Products Sud-Americanos and La Emiliana. The ship berth lies on 4 square concrete dolphins and affords a total length of 265 m for mooring. Deliver capacity is up to 1,800 tons of grain or 1,200 by-products per hour. Storage capacity in vertical silos is 55,000 tons and 15,000 tons for horizontal sheds.

(2) San Martin, San Lorenzo

San Martin, situated on the right bank of the river Parana, is 447 km from Buenos Aires; San Lorenzo is 445 km from Buenos Aires. (Figure 4-1-2-2, 4-1-2-3) In these areas, grain elevators handling maize, sun pellets, soybean and sorghum, have been constructed and managed by private companies since the grain law was amended in 1979. There are seven main grain elevators and the silos have a total capacity of 826,500 tons. The grain elevators in San Martin, San Lorenzo had 2.6 times as much grain as Rosario in 1989. (Table 4-1-2-3, 4-1-2-4)

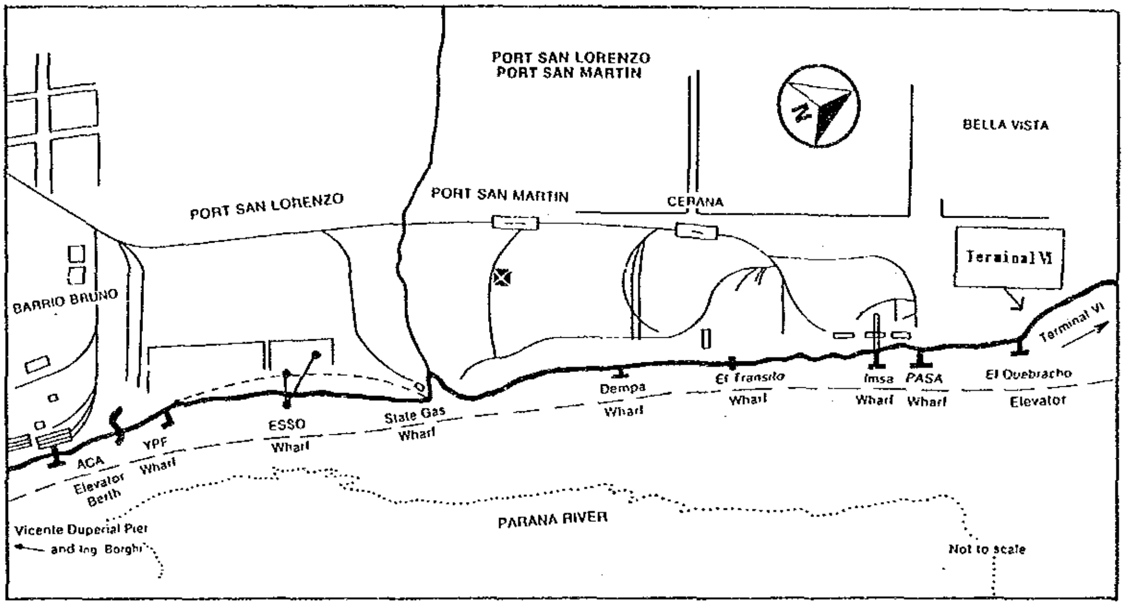


Figure 4-1-2-2 Port of San Martin, San Lorenzo

Table 4-1-2-3 Grain Elevators in San Martin, San Lorenzo

| Name | Length (m) | Depth (m) | Cap./Silo (tons) | Loader (t/hour) | Recep. ton/hour (Truck) | (Train) |
|---|---|---|---|---|---|---|
| TERMINALVI | 180 | 12.0 | 350,000 | 2,000 | 1,800 | 600 |
| CARGILL | 130 | 12.2 | 76,500 | 2,000 | 1,000 | 400 |
| NIDERA | 150 | 10.7 | 130,000 | 1,200 | 1,100 | 500 |
| BUNGE | 140 | 10.7 | 22,000 | 1,600 | 400 | 0 |
| INDO S.A | 100 | 12.2 | 155,000 | 1,000 | 600 | 200 |
| A.C.A. | 184 | 15.2 | 58,000 | 1,800 | 600 | 600 |
| VICENTEN | 180 | 12.2 | 35,000 | 2,400 | 1,600 | 0 |
| Total | | | 826,500 | 12,000 | | |

Table 4-1-2-4 Handling Volume in San Martin, San Lorenzo ('82-'89)

Unit: $10^3$ Tons

| Name | '82 | '83 | '84 | '85 | '86 | '87 | '88 | '89 |
|---|---|---|---|---|---|---|---|---|
| TERMINAL VI | - | - | - | - | - | 411 | 1,520 | 1,793 |
| CARGILL | 1,353 | 1,013 | 941 | 1,327 | 1,331 | 1,154 | 1,195 | 976 |
| BUNGE & BORN | 488 | 653 | 430 | 668 | 518 | 262 | 212 | 174 |
| INDO | 352 | 500 | 325 | 580 | 488 | 536 | 567 | 322 |
| NIDERA (IMSA) | - | 500 | 506 | 1,017 | 1,328 | 817 | 1,041 | 731 |
| A.C.A. | - | - | - | 417 | 1,060 | 807 | 784 | 545 |
| VICENTIN | - | - | - | - | - | 484 | 893 | 650 |
| TOTAL | 2,193 | 2,666 | 2,202 | 4,009 | 4,725 | 4,471 | 6,212 | 5,191 |

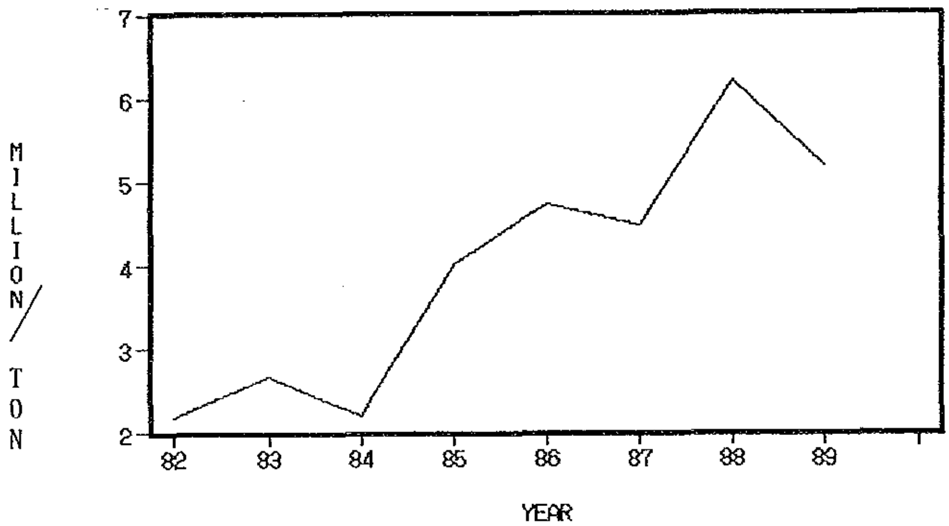


Figure 4-1-2-3 Handling Volume in San Martin, San Lorenzo

(TERMINAL VI)

Terminal VI handled the largest volume, 1,793,000 tons, of grain cargoes in 1989. It is owned jointly by six companies (Oil manifactures) that handle grain and by-products. The purpose of above company is to lower the cost of storage and loading for ocean vessels. This elevator began operating in 1987. The wharf is 180 m long and has 4 mooring dolphins. Delivery rate for grain is 2,000 tons/hour and about 35,000 tons per day. The depth alongside is 12 m.

(CARGILL S.A.)

The berth has 3 dolphins with rubber fenders. The loading rate for grain is 1,200 tons/hour and 750 tons for by-products. The silo capacity is 76,500 tons. The berth can accommodate panamax sized ships. The depth alongside is 12.2 m.

(NIDERA)

The ship berth is situated on 4 concrete dolphins and has an overall length of 150 m. The loading shoot has four and two loading belt conveyers. The rate of delivery for grain is 1,200 tons/hour and 900 tons/hour for by-products. The storage capacity of silos is 130,000 tons. The depth alongside is 10.7 m.

(BUNGE)

There are 3 concrete dolphins and length of berth is 140 m. The storage capacity for grain is 22,000 tons. The delivery capacity handles 1,600 tons per hour. The depth alongside is 10.7 m.

(INDO S.A)

The berth loads grain, by-products and vegetable oil. The berth has 5 dolphins and a length of 100 m. The ship must shift to load hatches due to only one private loading tower with one shoot. Loading capacity is at a rate of 1,000 tons/hour. The storage capacity for grain and by-products is 155,000 tons. The depth of berth is 12.2 m.

(A.C.A.)

The berth is owned by Asociacion de Cooperativas Argentinas. The berth can accommodate ships of any size. The loading rate for grain is 1,800 tons/hour by 2 belt conveyers and 4 shoots. The grain storage capacity is 58,000 tons. The draught is 10.2 m.

(VICENTIN)

There are 4 berthing dolphins. No restriction on the length of ship exists at this berth. The storage capacity is 35,000 tons in horizontal sheds. Grain and by-products are loaded by three shoots that deliver 1,200 tons of grain or 900 tons of by-products.

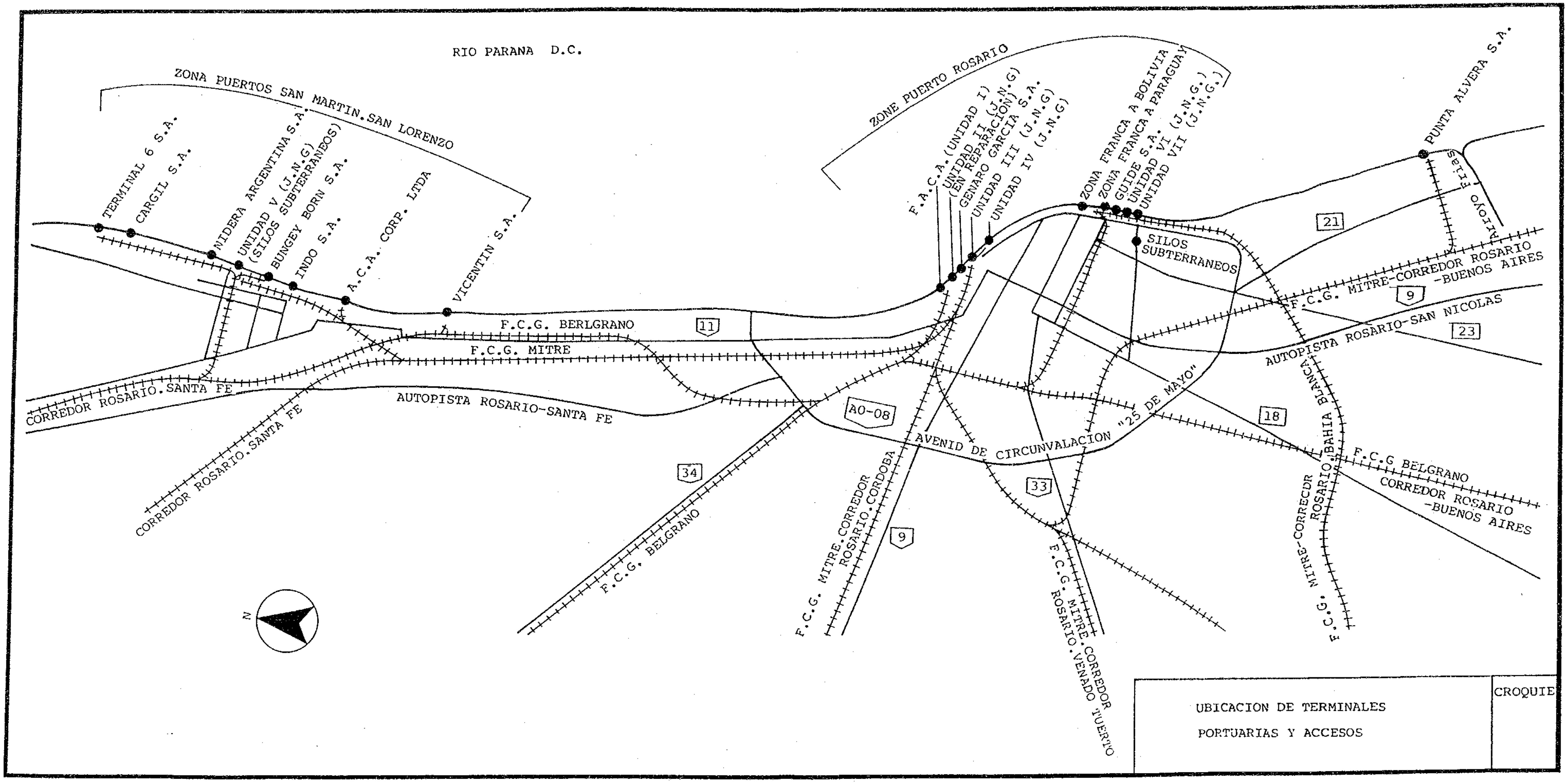


Figure 4-1-2-3 Grain Elevator in Rosario. San Martin and San Lorenzo

(3) Buenos Aires

The port tops off vessels including panamax size loaded until 26 feet at Up-River Ports. But in the port of Buenos Aires, the volume of loading grain cargoes for ocean-going ships is limited from 42,000 tons to 45,000 tons due to navigational safety in the River. (Figure 4-1-2-4)

There are two methods of loading dry bulk cargoes in the port of Buenos Aires. One is operation by JUNTA elevator and the other is performed using several belt conveyers at Public berth. (Table 4-1-2-5)

Table 4-1-2-5 Cargo Handling System in Buenos Aires

| Name | Length (m) | Depth (m) | Cap./Silo (tons) | Loader (t/hour) | Remark |
|---|---|---|---|---|---|
| A.C.A. | 220 | 6.9 | 16,500 | 400 | |
| UNIT I | 750 | 9.0 | 170,000 | 1,000 | |
| PUBLIC | - | 9.0 | - | 4,000/day | Belt Conveyer |

(A.C.A. ELEVATOR)

This elevator was rented by A.C.A. in 1983. Topping-off cannot be expected due to draft of 23 feet. Storage capacity of silos is 16,500 tons and loading rate is 400 tons per hour.

(UNIT 1)

Storage capacity of Unit 1 is 170,000 tons of grain. At berth No.2 of basin D, delivery capacity is 1,000 tons per hour.

(PUBLIC BERTH OF NEW PORT)

Ocean vessels can top-off up to about 28,000 tons because the depth is 30 feet. In this berth, grain cargoes are loaded by four or five of belt conveyers to ocean vessel. The loading capacity of the belt conveyer is approximately 70 tons/hour and from 3,000 tons to 5,000 tons per day.

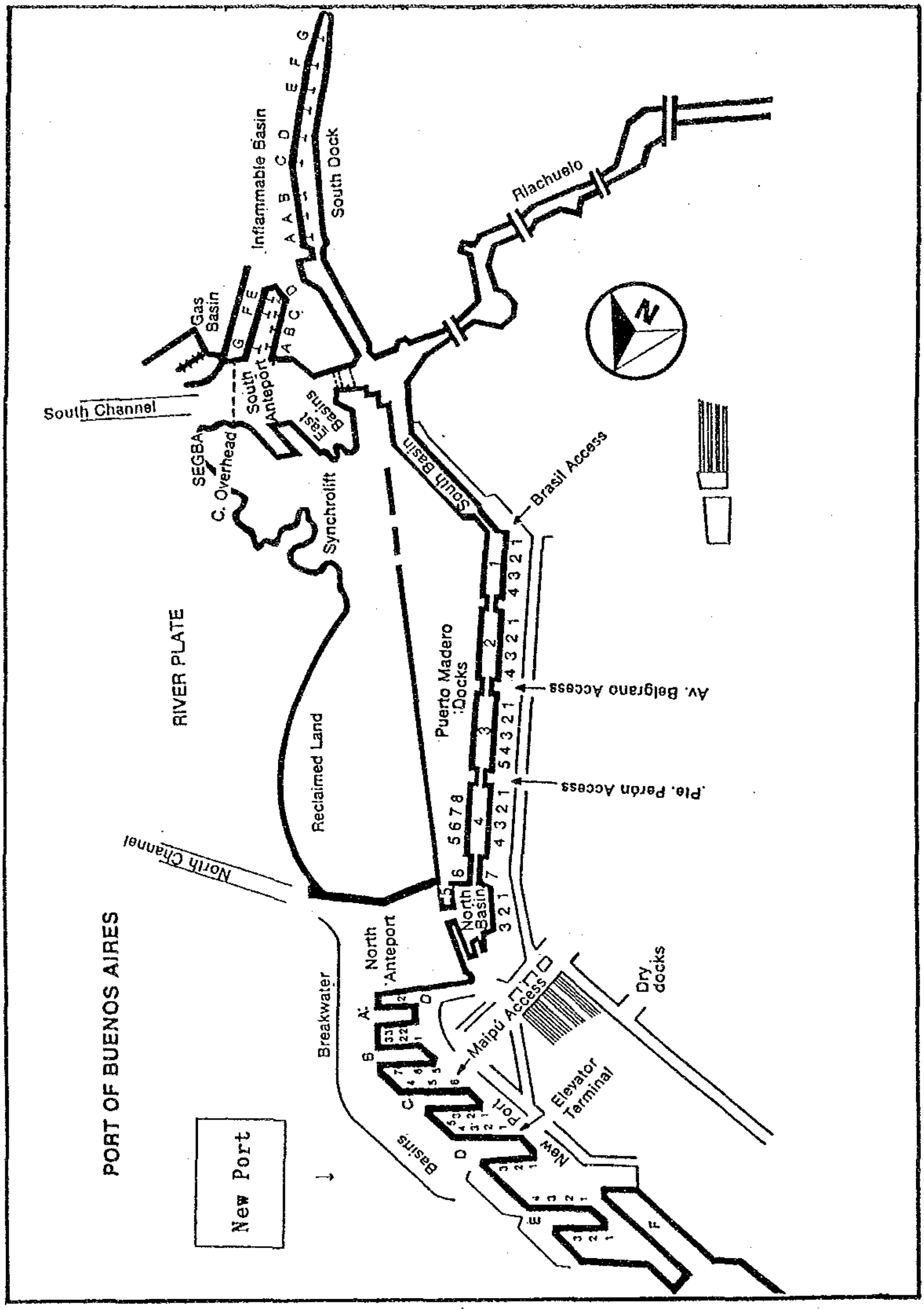


Figure 4-1-2-4 Port of Buenos Aires

(4) Alpha Zone

Alpha Zone is 50 km offshore of Montevideo. The depth is about 12 m. It is usually operated by top-off vessels to top off panamax size vessels. (Figure 4-1-2-5, 4-1-2-6)

There is 3"RIVER PLATE TREATY" of Alpha Zone in which the territorial waters were agreed upon by Uruguay and Argentina in 1976.

Top-off vessels ranging from 60,000 DWT to 70,000 DWT are regarded as big floating elevators with loading facilities. The instruments of operation are only grabs or grabs added to conveyer. The transport of transshipped grain cargoes is carried out in two ways. One is carried out by top-off vessels themselves and another by big barge (37,000 DWT) accompanied with a tug boat from Up-River to Alpha Zone. (Figure 4-1-2-7)

Top-off vessel has no silo function, for example, it lacks quality control, automatic scale, storage of several kinds of grain. Furthermore, this zone is directly influenced by strong winds and rough sea, and for that reason, is inefficient due to frequent delays in loading vessels. (Table 4-1-2-6)

The first scheme of top-off operation is as follows:

| | | | |
|---|---|---|---|
| Loading | (Up-River Port) | 4 | days |
| Navigation | (Alpha Zone - Up-River - Alpha Zone) | 3 | days |
| Loading | (Alpha Zone) | 3 | days |
| Spare days | | 3-4 | days |
| | Total | 13-14 | days |

Thus its operation was planned using two cycles per month. Handling volumes of Alpah zone in 1983 to 1985 are shown in Table 4-1-2-7 and Figure 4-1-2-8.

| | | | |
|---|---|---|---|
| Loading | (Up-River Port) | 6 | days |
| Navigation & Delay | (Alpha Zone - Up-River - Alpha Zone) | 24 | days |
| Loading | (Alpha Zone) | 5 | days |
| | Total | 35 | days |

Table 4-1-2-6 Top-Off Vessels in Alpha Zone

| Name of Company | Name of Ship | Top-off Vessel/Barge/Tug | | | | Cap. Loader Crane | Operation |
|---|---|---|---|---|---|---|---|
| | | L (m) | B (m) | D (m) | DWT/HP (tons) | | |
| Astramar | Vessel | | | | | | |
| | Alianza | 243.84 | 37.79 | 12.66 | 77,220 | 25t×4 Unit | Grab & Conveyer |
| | A.Patricia | 187.45 | 25.76 | 10.10 | 60,000 | 18t×3 Unit | |
| | Barge | | | | | | |
| | Alianza (G1, G2, G3, G4) | 177.21 | 32.00 | 7.32 | 37,532 | | |
| | Tug Boat | | | | | | |
| | A. Rosario | 47.00 | 11.58 | 5.12 | 7,000 | | |
| | A.S.Nicolas | 〃 | 〃 | 〃 | 〃 | | |
| | A.Campana | 〃 | 〃 | 〃 | 〃 | | |
| Ultra Ccean | Zonda 1 | 230.10 | 31.85 | 12.76 | 62,091 | 30t×3 Unit | Grab |
| Del Bene | Karinas | 22.90 | 32.26 | 12.17 | 59,159 | 15t×3 Unit | Grab |

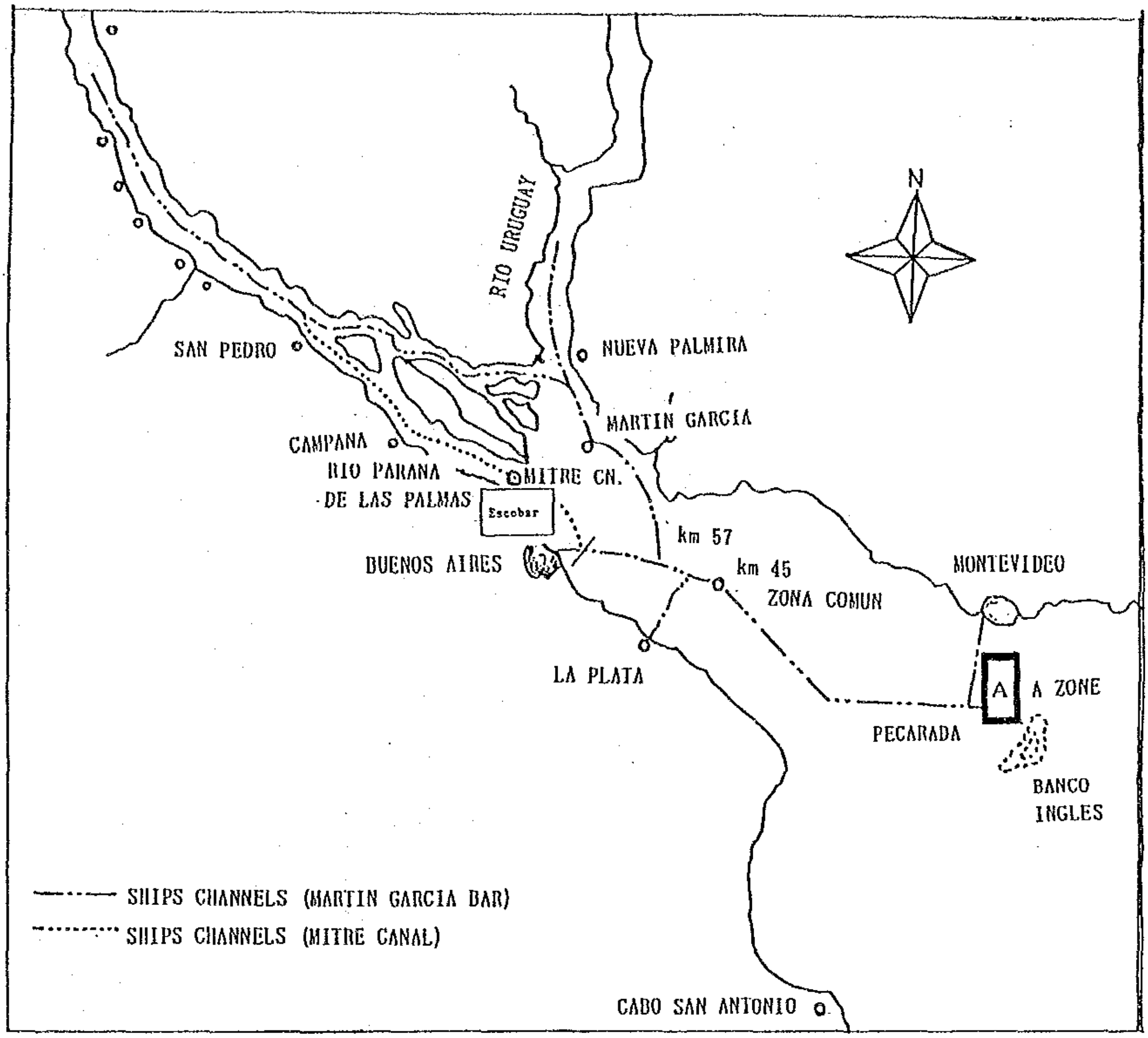


Figure 4-1-2-5 The River Plate

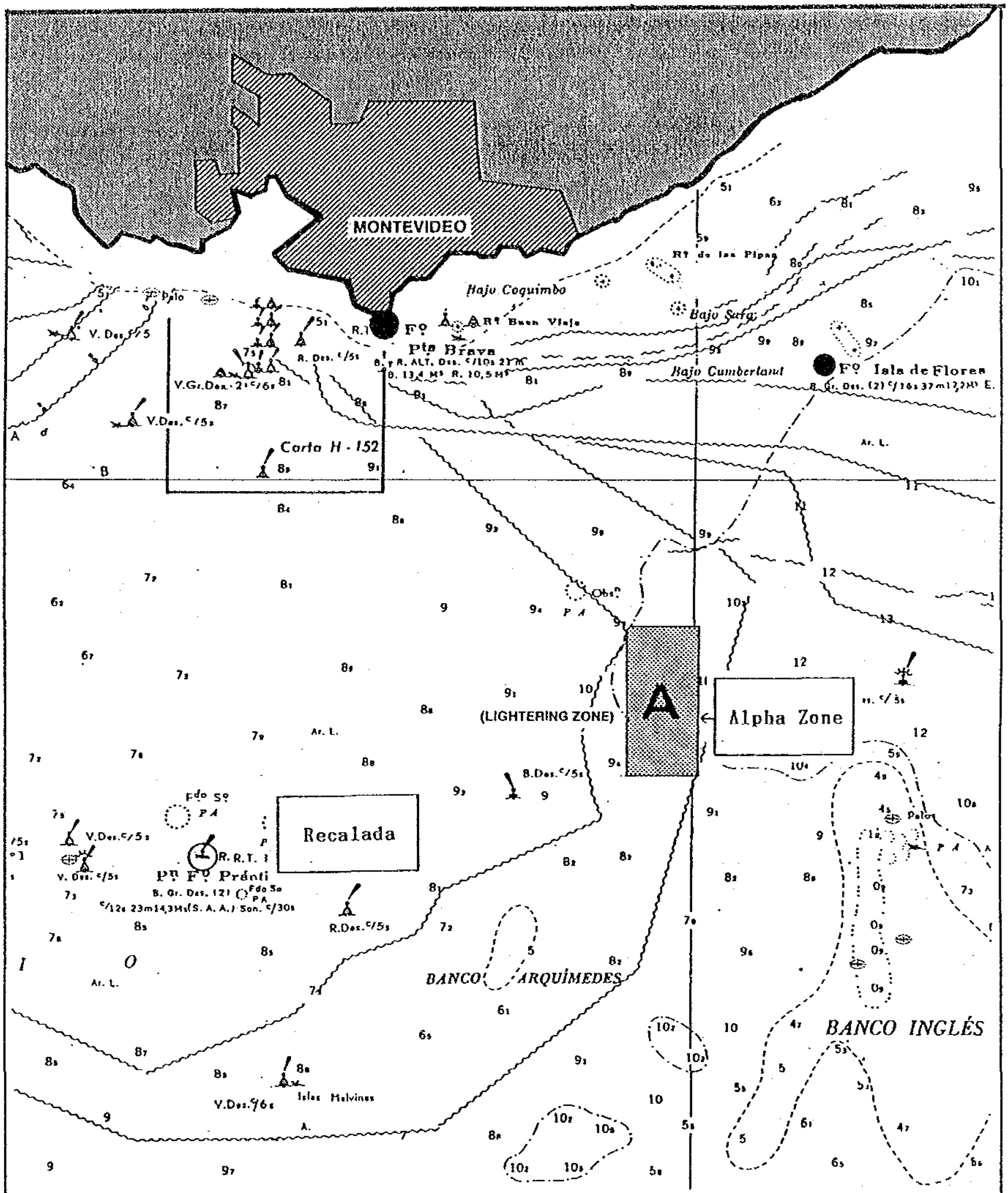


Figure 4-1-2-6 Alpha Zone and Approches

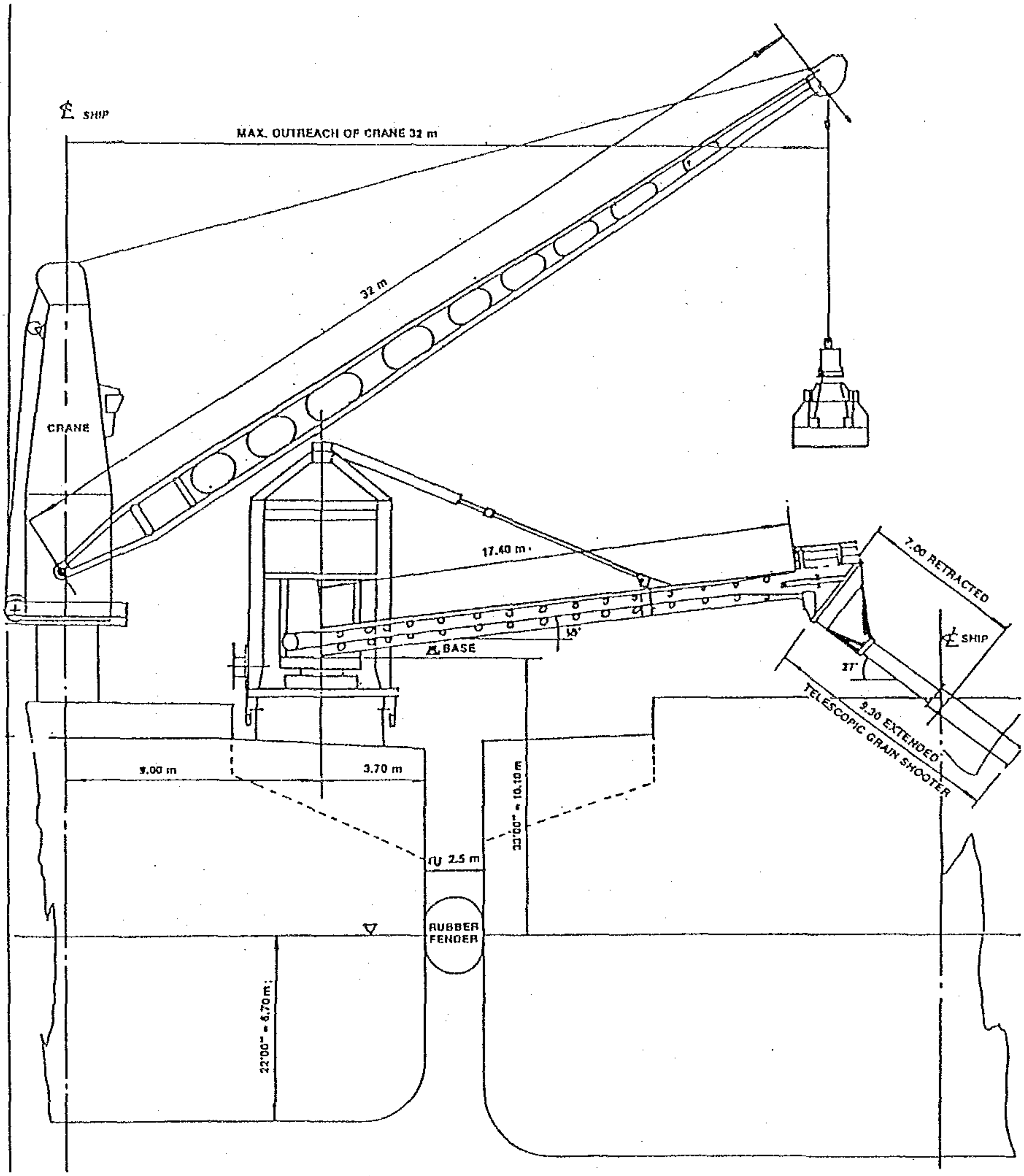


Figure 4-1-2-7 Outline of Top-Off Vessel

Table 4-1-2-7 Handling Volume of Alpha Zone ('83-'85)

Unit:Tons

| | '83 | '84 | '85 |
|---|---|---|---|
| January | 22,500 | 41,135 | 28,100 |
| February | 41,900 | 208,238 | 152,224 |
| March | 36,500 | 104,192 | 202,947 |
| April | 147,027 | 211,164 | 402,479 |
| May | 63,899 | 225,392 | 454,319 |
| June | 90,136 | 236,344 | 201,457 |
| July | 254,781 | 107,524 | 194,797 |
| August | 149,031 | 78,640 | 140,594 |
| September | 94,813 | 24,300 | NO WORK |
| October | 126,505 | NO WORK | NO WORK |
| November | 21,800 | NO WORK | NO WORK |
| December | NO WORK | NO WORK | NO WORK |
| Total | 1,048,892 | 1,236,929 | 1,776,917 |

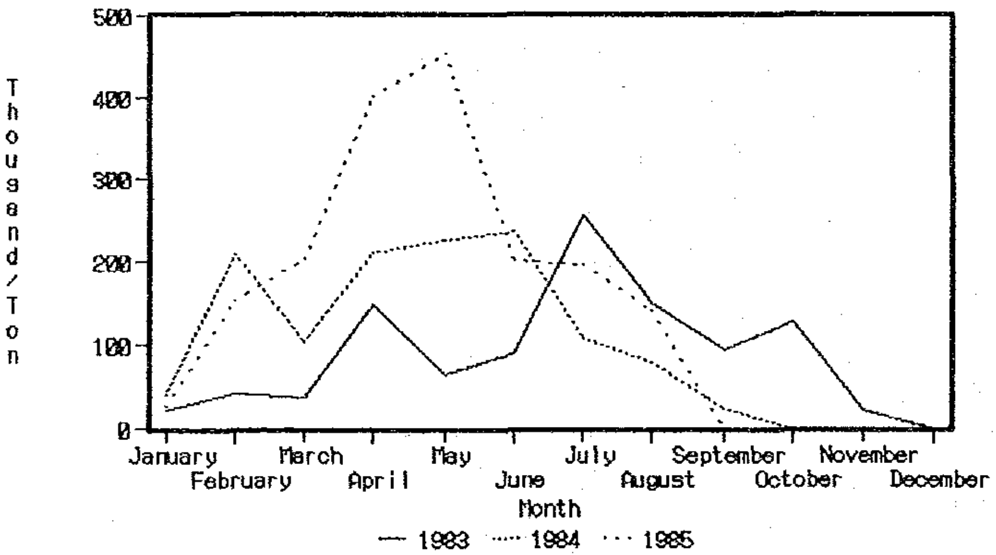


Figure 4-1-2-8 Monthly Handling Volume of Alpha Zone ('83-'85)

(5) Bahia Blanca

Port of Bahia Blanca is about 1,040 km sea-route from Buenos Aires and has developed with the export of grain, especially wheat, sorghum, and by-products. The railway and a network of roads link it to the rest of the country and to bordering countries. Also, the port has greatest water depth in Argentina and top-off service is similarly conducted for vessels not fully loaded at the ports of Rosario, San Martin, Buenos Aires etc.. (Table 4-1-2-8, Figure 4-2-1-9)

The highest volume of grain cargoes (3,280,015 tons, 23.6 %) in Argentina was handled in this area in 1990.

Table 4-1-2-8 Grain Elevators in Bahia Blanca

| Name | Length (m) | Depth (m) | Cap./Silo Tons | Loader T/Hour | Recep. TN/Hour (Truck) | Recep. TN/Hour (Train) | Remark |
|---|---|---|---|---|---|---|---|
| UNIT III | 230,200 | 11.1 | 140,000 | 1,500 | Nil | - | |
| UNIT IV | " | 11.1 | 8,000 | Nil | 200 | Nil | Connect U/III |
| UNIT V | 230 | 11.6 | 60,000 | 2,000 | 1,000 | Nil | |

(UNIT III)

Reception of grain cargoes in this elevator is mainly by railway transportation.

(UNIT IV)

Conveyer system of UNIT IV receiving grain cargoes is linked with UNIT III conveyer, which was constructed underground.

(UNIT V)

Reception condition of this elevator is only from truck and 500 tons per hour/belt. Loading capacity of grain truck in Argentina is total about 35 tons in total, adding 15 tons of body to 20 tons of trailer. Regardingly railway transportation, one unit consists of 30 wagons and can carry about 1,500 tons of grain cargoes.

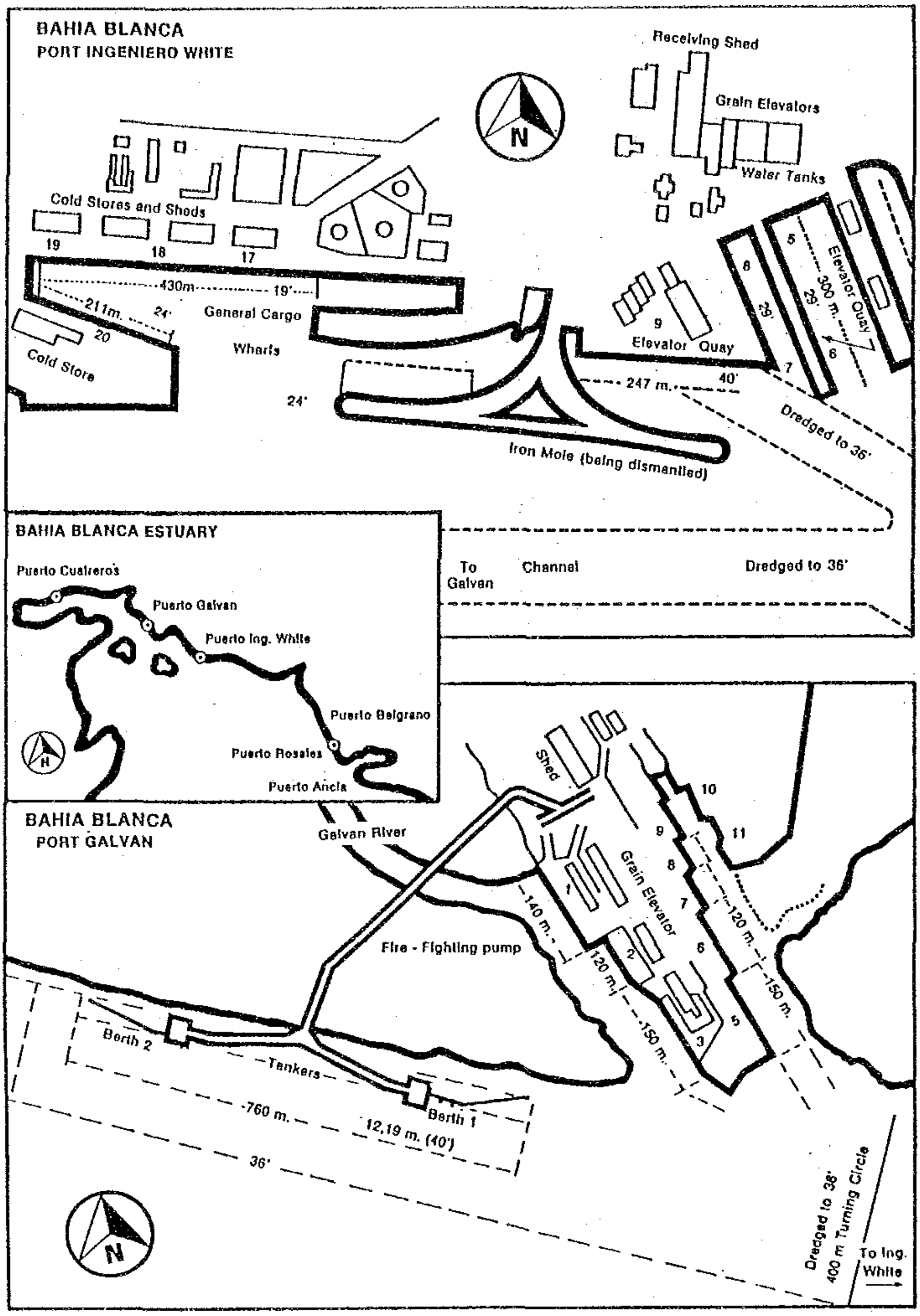


Figure 4-1-2-9 Port of Bahia Blanca

(6) Escobar

The points of anchorage are about 70 km from Buenos Aires. A private company (Del Bene) operates two floating elevator-barges, 1,500 DWT each. The elevators are equipped with 32 m high towers having two pneumatic suction arms which extract the grain from supply barge, weigh it and transfer it to the ocean vessel. The rate of delivery is about 250-300 tons/hour per elevator. (depending on type of by-products and cereal grain) (Figure 4-1-1-1)

It is said that the advantage of Escobar operation, as compared with Buenos Aires port and Bahia Blanca port, is about 1.0 - 1.5 US dollars less in terms of navigation time, port charges and port congestion. Top-off operation in Escobar has a maximum capacity of 8,000 tons, taking into consideration the draft of 28 - 32 feet.

Mitre Channel:

The Mitre Channel begins at 12 km point of the access channel to Buenos Aires and continues to the Parana de las Palnas (48 KM) which from 177 km forms the southern branch of the Parana delta. Normally, it is kept dredged to a depth of 9 m (29.6 feet). A margin of 0.30 m (1 foot) must be left below the keel but for navigation at night (from dusk to dawn) 0.45 m (1.6 feet) clearance is required.

(7) Necochea/Quequen

Necochea port is on the Atlantic coast, 695 km south of Buenos Aires and on the right bank of the river Quequen. Quequen is on the left bank, the center of a rich agricultural area. The port is situated at the mouth of the river and is protected by two breakwaters, south breakwater 1192 m and north 572 m. The entrance between them is 210 m, but the channel has a width of only 90 m. The maximum depth is available in relation to the ship's length. (Table 4-1-2-9) There is no limitation on the ship's beam. There is about 1000 m of berth on the Quequen side. Table 4-1-2-10 shows particulars of each berth and Figure 4-1-2-10 shows the outline of the ports.

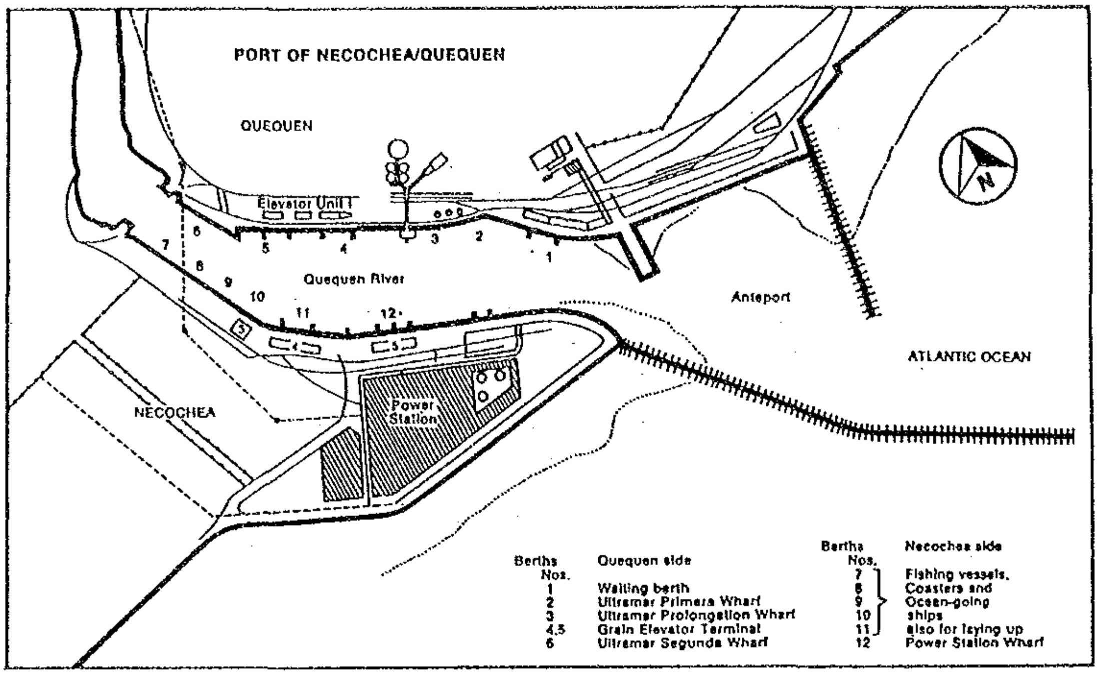


Figure 4-1-2-10 Outline of Necochea and Quequen

(Berth No.6)

The wharf is 120 m long and handles grain and by-products by portable conveyer belts with capacities of 200 tons/hour each. The depth alongside is 9.6 m. The berth can accommodate a ship of 220 m. L.O.A.

(Berth No.4 and 5)

The berth belongs to the National Grain Board. The loading gallery has 8 telescopic tubes served by 4 belts. The delivery capacity is 300-350 tons/hour to a tube, usually only 2 or 3 tubes work at a time.

(Berth No.3)

Berth No.3 is privately owned by two cooperatives, A.C.A. and F.A.C.A. This berth was only recently constructed. The loading gallery has 2 loading belts, each delivering to a telescopic pipe at 600 tons/hour. The storage capacity of grain and by-products is 70,000 tons.

Table 4-1-2-9 Restriction of Ship's Draft in Quequen Port

| Ship's L.O.A. (m) | Max/Depth at Zero (m) |
|---|---|
| Up to 175 | 9.30 |
| Up to 185 | 9.00 |
| Up to 195 | 8.70 |
| Up to 205 | 8.40 |
| Up to 215 | 8.10 |

Table 4-1-2-10 Grain Facilities in Quequen Port

| Berth/No. | Lenght (m) | Depth (m) | Cap./Silo (tons) | Loader (tons/hour) | Remark |
|---|---|---|---|---|---|
| No. 6 | 120 | 9.6 | Nil | 200 | Unit/Conveyer Belt |
| No. 4/5 | 230 | 9.0 | 80,000 | 1,000 | |
| No. 3 | 220 | 9.6 | 70,000 | 1,200 | |

## 4-1-3 Brazil

(1) Paranagua

The port is well equipped for handling grain and by-products, pellets and meal. Below is a diagram of the equipment used for loading grain cargoes.

Ships of up to 120,000 DWT can be accommodated at the export corridor berth which has a depth of 35 feet. There are vertical and horizontal silos with capacities of 210,000 tons for soybeans, 250,000 tons for pellets and 40,000 tons of meal for the loaders at the corridor berth. The capacity of loading machines is 15,000 tons for pellets, 50,000 tons for grain, 7,000 tons for meals per day. The depth alongside is 11.1 m (37 feet). (Figure 4-1-3-1, Table 4-1-3-1)

Paraguayan export grain by land transportation is mainly handled by this grain terminal, which has been owned by Capeco as Free Zone of Paraguay. Storage capacity of the silo is about 180,000 tons for grain.

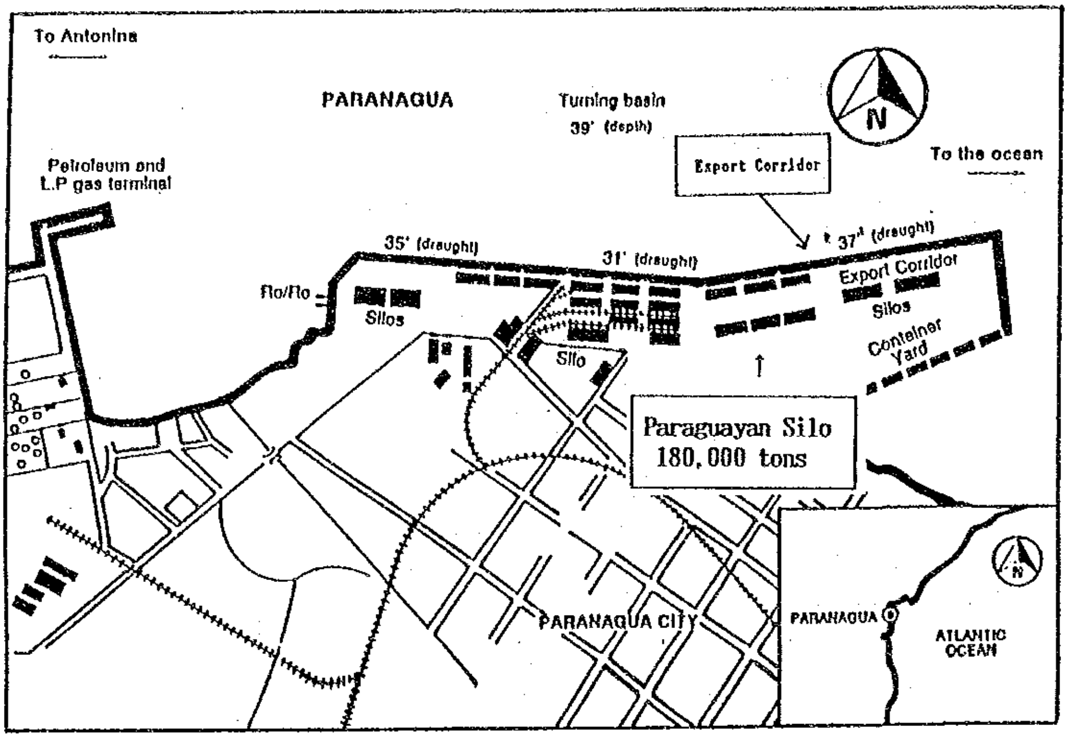


Figure 4-1-3-1 Port of Paranaua

Table 4-1-3-1 Port Facilities of Grain in Paranagua Port

| Name | Length (m) | Depth (m) | Name/ Grain | Capac./Silo Tons | Capac./Loader T /per Day,Max |
|---|---|---|---|---|---|
| CORRIDOR | 500 | 11.1 | Soybeans | 210,000 | 15,000 |
| | | | Pellets | 250,000 | 50,000 |
| | | | Meals | 40,000 | 7,000 |
| | | | Total | 500,000 | |

### 4-1-4 Paraguay

At present, there are mainly three port areas along the Paraguay river that are used for exporting grain by river in Paraguay as shown in Figure 4-1-4-1 (port areas are indicated by shaded circles).

(1) River Ports of Exported Grain

Table 4-1-4-1 shows capacity of grain terminal of Paraguayan river ports.

1) Concepcion (Paraguay River)

The port is situated 1,940 km from Buenos Aires and on the left bank of the Paraguay River. The two private companies of NANAWA, ALGESA handled the greatest volume of grain cargoes (427,307 tons) in 1989, including southwest Brazilian soybeans. However, these firms have poor storage facilities. Therefore, the loading system is almost direct handling from 25 tons trucks. The loading power is 420 tons per hour by three conveyers.

2) San Antonio (Paraguay River)

The distance from Buenos Aires is 1,630 km. The capacity of silos is 75,000 tons in horizontal and 4,000 tons in vertical. Export grain cargoes are loaded to river barges at a rate of 500 tons per hour by two belt conveyers. These grain cargoes are fully inspected at silos when they are carried to the terminal.

3) Villeta (Paraguay River)

The port is 1,593 km from Buenos Aires and quay length is 200 m. At present, the quay is being expanded by 100 m. (The berth is managed by the Port Authority (ANNP).) A private firm, CAPSA, has a horizontal type silo with a capacity of 10,000 tons. The loading capacity of CAPSA is 200 tons per hour and the public berth is 80 tons /hour by a screw conveyer. The development of a container terminal in this area is under consideration by ANNP.

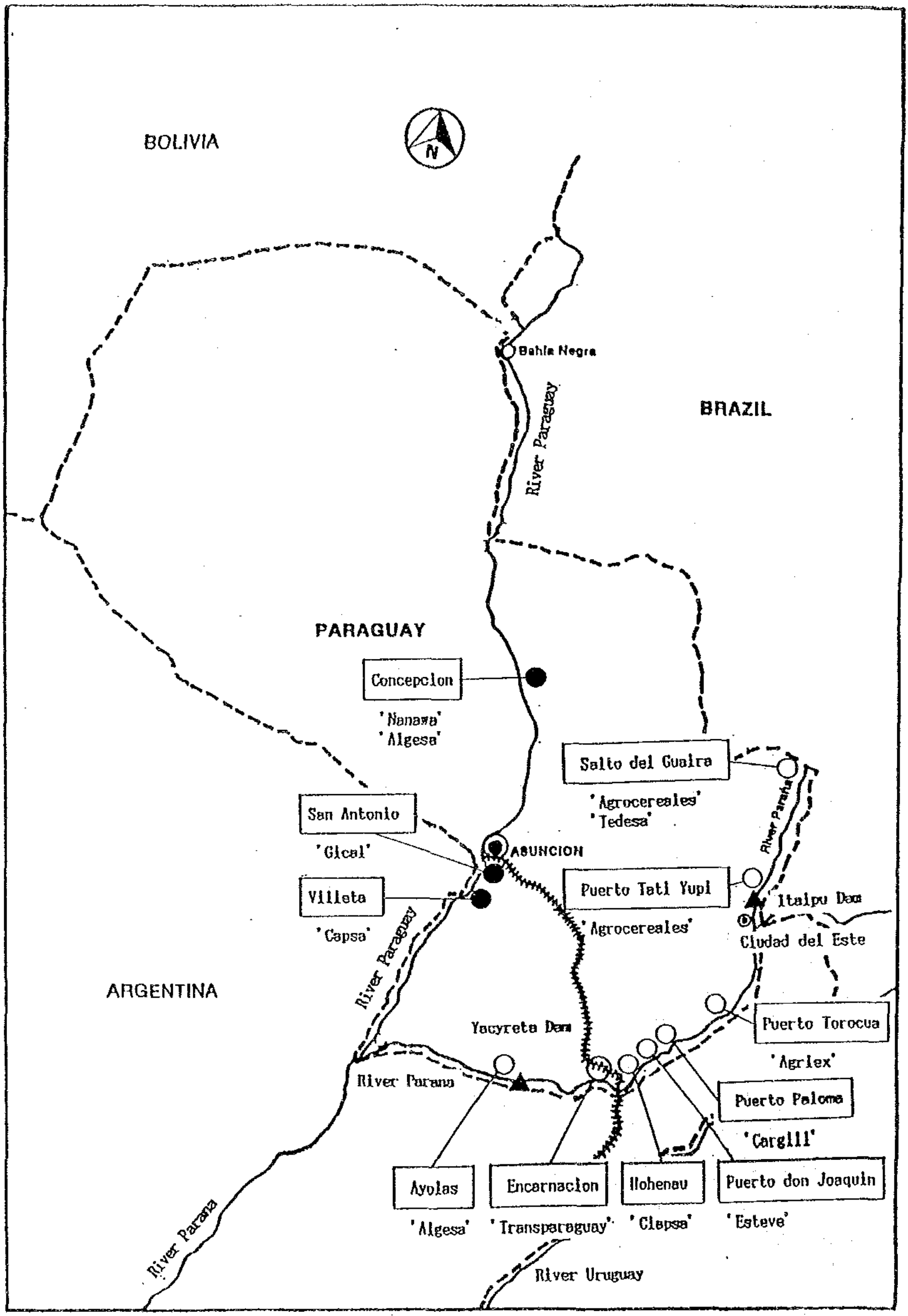


Figure 4-1-4-1 River Ports in Paraguay

4) Encarnacion (Parana River)

Port of Encarnacion is situated on the right bank of the Parana river, 1583 km from Buenos Aires and on the opposite side of Posadas in Argentina. The neighbouring regions including this city produce large quantities of agricultural products, for example, soybeans, wheat and maize.

The floodgate of Yacyreta dam for river transportation was provisionally completed for river cargo barges in 1991. Operation has tentatively begun using a convoy of barges. Currently several grain elevators including Cargill and Agriex of U.S.A. have opened along the Parana river. Considering the low cost of river transportation, in future, these grain elevators will become the main bases for grain exported from Paraguay.

Table 4-1-4-1 Port Facilities for River Barge in Paraguay

| Port/ Company | River | Loader tons/hour | Silo | | Handling Cargo |
|---|---|---|---|---|---|
| | | | Type | Cap./tons | |
| Concepcion<br>Nanawa<br>Algesa | Paraguay | <br>270<br>150 | <br>Ver.<br>Ver. | <br>250<br>4,000 | Soybeans, Pellets<br>Maize & Wheat |
| San Antonio<br>Gical S.A. | " | <br>500 | <br>Ver.<br>Hor. | <br>4,000<br>75,000 | " |
| Villeta<br>Capsa | " | <br>200 | <br>Hor. | <br>10,000 | " |
| Ayolas<br>Algesa | Parana | <br>150 | | <br>Nil | " |
| Encarnacion<br>Transparag. | " | <br>500 | <br>Hor. | <br>60,000 | " |
| Hohenau<br>Ciapsa | " | <br>300 | | <br>Nil | " |
| P.D.Joaquin<br>Esteve | " | <br>500 | <br>Ver. | <br>4,000 | " |
| P. Paloma<br>Cargill | " | <br>500 | <br>Ver. | <br>21,000 | " |
| P. Torocua<br>Agriex | " | <br>300 | <br>Ver. | <br>13,200 | " |
| P. Tati Yupi<br>Agrocereales | " | <br>150 | | <br>Nil | " |
| S.D.Guaira<br>Agrocereales<br>Tedesa | " | <br>120<br>470 | <br>Ver.<br>Ver. | <br>2,000<br>18,000 | " |
| TOTAL | | 4,110 | | 211,450 | |

(2) Present Handling Volume by Each Route

Table 4-1-4-2 gives a breakdown of the three means of transportation used to transport soybeans in 1989. Destinations are also included.

1) By Land

Land transportation accounted for 59 percent of the total in 1989. The transportation volume was 1,015, 569 tons. By destination, 79.4 % was transported to Paranagua Port, 12.8 % to Rio Grande Port, 4.4 % to Santos Port and 3.4 % to others.

2) By River

River transportation accounted for 37 percent of the total in 1989. The transportation volume was 640,763 tons. By destinations, 62 % was transported to Uruguayan Port (55.7 % transported to Nueva Palumira and 6.3 % to Fray Bentos), and 38 % to Argentine Port (21.7 % to Escobar, 14.7 % to Concepcion del Uruguay and 1.6 % to San Martin of Up-River Port).

3) By Railway

Railway transportation accounted for 4 percent of the total in 1989. The transportation volume was 69,014 tons. By destinations, 79.1 % was transported to Fray Bentos and 20.9 % to Argentina.

Table 4-1-4-2 Volume of Soybeans Exported by Each Route in Paraguay ('89)

**Paraguayan Port**

| By Land (59 %) | Volume (tons) | ( % ) |
|---|---|---|
| C.D.Este | 707,380 | (69.7) |
| Encarnacion | 248,339 | (24.5) |
| P.J.Cabajjero | 58,850 | ( 5.8) |
| C.D.Guaira | 1,000 | |
| Sub. Total | 1,015,569 | ( 100) |

| By River (37%) | Volume (tons) | ( % ) |
|---|---|---|
| Concepcion | 427,307 | (66.7) |
| San Antonio | 185,048 | (28.9) |
| Villeta | 27,000 | ( 4.2) |
| Asuncion | 1,408 | ( 0.2) |
| Sub. Total | 640,763 | (100) |

| By Railway (4%) | Volume (tons) | ( % ) |
|---|---|---|
| Encarnacion | 69,014 | |
| Sub. Total | 69,014 | (100) |

| G.TOTAL (100%) | 1,725,346 | (100) |
|---|---|---|

**Destination**

| Port | Volume (tons) | ( % ) |
|---|---|---|
| Brazil | | |
| Paranagua | 806,376 | (79.4) |
| Rio Grande | 130,000 | (12.8) |
| Santos | 44,256 | ( 4.4) |
| Others | 34,937 | ( 3.4) |
| Total | 1,015,569 | ( 100) |

| Port | Volume | ( % ) |
|---|---|---|
| Uruguay | | |
| N.Parumira | 323,386 | (55.7) |
| F. Bentos | 36,433 | ( 6.3) |
| Argentina | | |
| Escobar | 126,292 | (21.7) |
| Con.D. Uru. | 85,523 | (14.7) |
| San Martin | 9,344 | ( 1.6) |
| (1988) Total | 580,978 | ( 100) |

| Port | Volume (tons) | ( % ) |
|---|---|---|
| Fray Bentos | 54,618 | (79.1) |
| Argentina | 14,396 | (20.9) |
| Total | 69,014 | ( 100) |

### 4-1-5 Bolivia

Bolivian soybean exports are carried to up-river ports, San Lorenzo and San Nicolas, by a convoy of barges with a capacity of about 5,000 tons.

(1) Aguirre

The quay is located on the bank of the Tamengo river. The depth alongside is 3.3 m (11 feet) for nine months and 1.8 m (6 feet) for three months. (Figure 4-1-5-1)

The port can handle the grain cargoes of soybeans, pellets and meals. The export volume of soybeans was 44,215 tons in 1988 and 36,433 tons in 1989. (Table 4-1-5-1)

Table 4-1-5-1 Export Volume of Soybean by River System in Bolivia

Unit:Tons

| Name | River | '89 | '90 |
|---|---|---|---|
| Aguirre | Paraguay | 44,215 | 36,433 |

The storage capacity of the private company, Central Aguirre S.A., is 15,000 tons in a horizontal silo and the delivery rate of loader speed is 300 tons per hour. (Table 4-5-1-2)

Table 4-1-5-2 Grain Cargo Facilities in Bolivia

(Aguirre Port)

| Company | Loader | Silo | | Recep. | Scale(Tons) | |
|---|---|---|---|---|---|---|
| | Cap/Tons | Tipe | Cap/Tons | Cap/Tons | Truck | Train |
| Central Aguirre S.A. | 300 | Hor. | 15,000 | 220 | 60 | 120 |

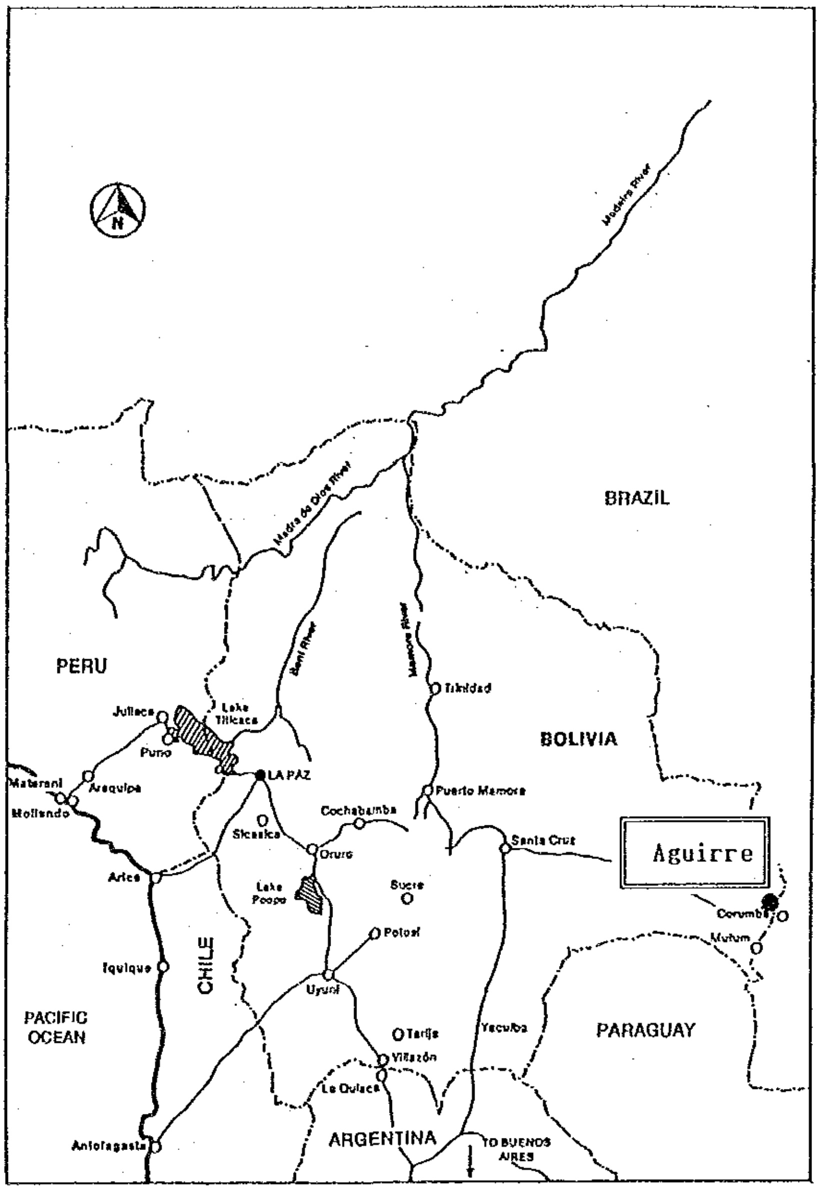


Figure 4-1-5-1 Port of Aguirre

## 4-2 Present Transportation System

### 4-2-1 Present Transport Route

Every country (Argentina, Bolivia, Paraguay and Southwest Brazil) makes use of the river route to carry a lot of grain cargoes for export by river ships or ocean-going vessels as shown in Figure 4-2-1-1.

(1) Argentina

A large quantity of grain products is gathered by trains, trucks and river ships to up-river ports of Rosario, San Martin, San Lorenzo and others. The elevators handling these cargoes have good facilities, for example, equipment from and to grain vessels and storage silos. However, in these areas all ocean-going vessels can be loaded up to about 27,000 tons due to the depth restriction of the Parana River. Accordingly, larger ships (Panamax size type) can't be fully loaded at one berth.

The vessels not fully loaded must be topped-off at another grain terminal, Alpha Zone (Route 5), and Bahia Blanca (Route 5) in Argentina.

It is generally recognized that only one loading for ships larger than 50,000 DWT in one port is the best way to reduce ship costs.

In the near future, it is quite probable that there will be an insufficient berthing capacity for vessels that required topping-off. (Future Route A)

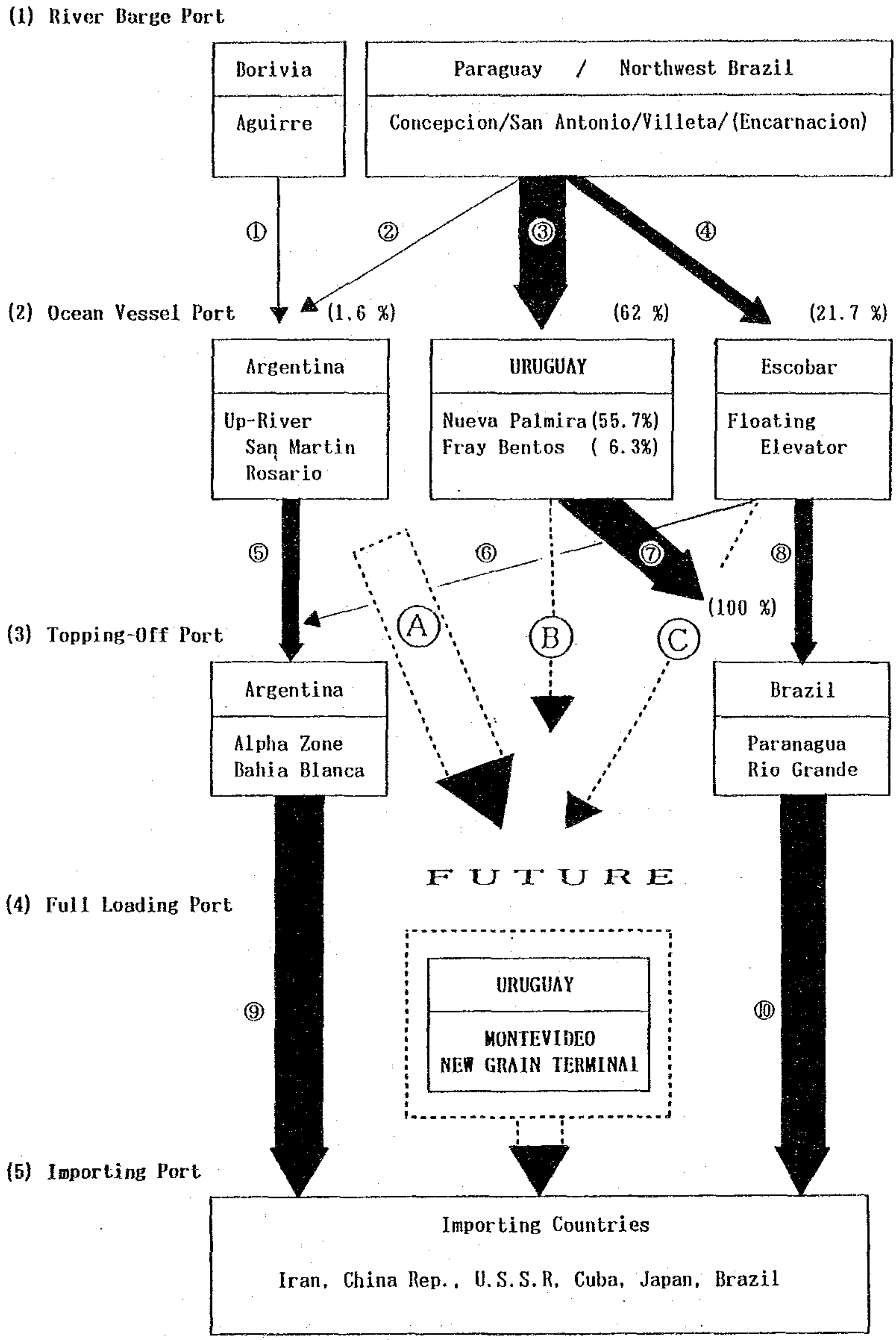


Figure 4-2-1-1 Present Transport Route

Table 4-2-1-1 Distance Table from Montevideo (Uruguay)

| Name | River | Distance (Km) | Country |
|---|---|---|---|
| Montevideo | La Plata | 0 | Uruguay |
| Colonia | : | 177 | : |
| La Paloma | Atrantic | 240 | : |
| Nueva Palmira | Uruguay | 254 | : |
| Fray Bentos | : | 310 | : |
| Paysandu | : | 379 | : |
| Salto | : | 510 | : |

Table 4-2-1-2 Distance Table from Buenos Aires (Argentina)

| Name | River | Distance (Km) | Country |
|---|---|---|---|
| Buenos Aires | Parana | 0 | Argentina |
| Zarate | : | 107 | : |
| San Pedoro | : | 277 | : |
| San Nicolas | : | 352 | : |
| Villa Constitucion | : | 367 | : |
| Rosaria | : | 420 | : |
| San Lorenzo | : | 445 | : |
| San Martin | : | 447 | : |
| Dia Mante | : | 533 | : |
| Santa Fe | : | 590 | : |
| Santa Rosa | : | 649 | : |
| Corrinentes | : | 1208 | : |
| Encarnacion | : | 1583 | Paraguay |
| C.D.Este | : | 1931 | : |
| Formosa | Paraguay | 1448 | Argentina |
| Villeta | : | 1593 | Paraguay |
| San Antonio | : | 1603 | : |
| Asuncion | : | 1630 | : |
| Concepcion | : | 1940 | : |
| Corumba | : | 2770 | Brasil |
| Colonia | La Plata | 50 | Uruguay |
| Nueva Palmira | : | 140 | : |
| Montevideo | : | 196 | : |
| Fray Bentos | Uruguay | 234 | : |
| Paysandu | : | 347 | : |
| Salto | : | 468 | : |
| Bahia Branca | Atrantic | 1040 | Argentina |

(2) Paraguay/Southwest Brazil

There are three ways in which to export domestic grain by a convoy of river barges as follows:

1) To Argentine Ports (Route 2) - Rosario, San Martin, San Lorenzo and other Up-river Ports.

2) To Uruguay Port (Route 3) - Nueva Palmira Port, Fray Bentos Port

3) To Escobar Port (Route 4) - Floating Elevator

(3) Uruguay

The route is the same as Argentina providing the grain cargoes for export will be discharged from the river transport vessels to the silos of grain terminal at Nueva Palmira Port. The large ocean-going vessels required to top-off must be loaded at other ports; almost all have adopted the route to Paranagua port (Route 7), Rio Grande port, and Santos port of Brazil.

In future, the agricultural products, which are expected to increase radically in Paraguay and southwest Brazil, will be probably transported from the private and official (MGAP) grain terminals in the port of Nueva Palmira to Brazilian Ports, mainly Paranagua Port. But part of this transported volume will be transported to the New Grain Terminal in Montevideo port.

(4) Escobar

If topping-off is necessary, the Route 6 and 8 will be adopted for every vessel. However, it will be difficult to handle costly for large ships due to the lack of power of loading machines. Therefore, it does not have the function of storage for grain cargoes. But some of the handling vessels in Escobar might be transported to Montevideo port, if it is necessary to top-off.

### 4-2-2 Present Distribution Cost by Each Means of Transportation

*The present transportation cost of grain cargoes from* Argentina or Paraguay to Montevideo port is considered as follows. (Figure 4-2-2-1)

(1) Argentina

It is assumed that the object grain is produced within a 200 km range of the Up-River port area. The present transportation cost of each means is compared in this chapter. (Table 4-2-2-1)

1) Truck Transportation

Transportation route begins at the production area near Rosario port via national highway 9, next coming into Gualeguaychu by route 155 of Argentina via Zarate, then entering Fray Bentos of Uruguay and finally reaching Grain Terminal of Montevideo port by national highways 2 and 1. It is about a 750 km distance from Rosario port to Montevideo port. One-way transport normally requires three days including customs clearance. National road conditions of both Argentina and Uruguay are paved and very good. The *freight charge is estimated at approximately US 60 dollars by* CATIDU *as the* cargo volume transported from Montevideo port to Rosario port is small.

2) Railway Transportation

This transportation route begins at the production area near Up-River port, next going into Zarate; at this depot, cargo must be transferred to another freight car in order to connect with Montevideo. Then the freight car comes into Salto of Uruguay via Concordia of Argentina, next goes into Paysandu of Uruguay and reaches Montevideo port via Mercedez or Durazno. According to AFE, it is 1,285 km and the transportation period is estimated at seven days, including customs clearance and transit time at Zarate. The railway tariff is US 14.6 dollars/ton from Rosario to Salto, US 1.39 dollars /ton for transit charge at Zarate and US 15.73 dollars/ton from Salto to Montevideo port.

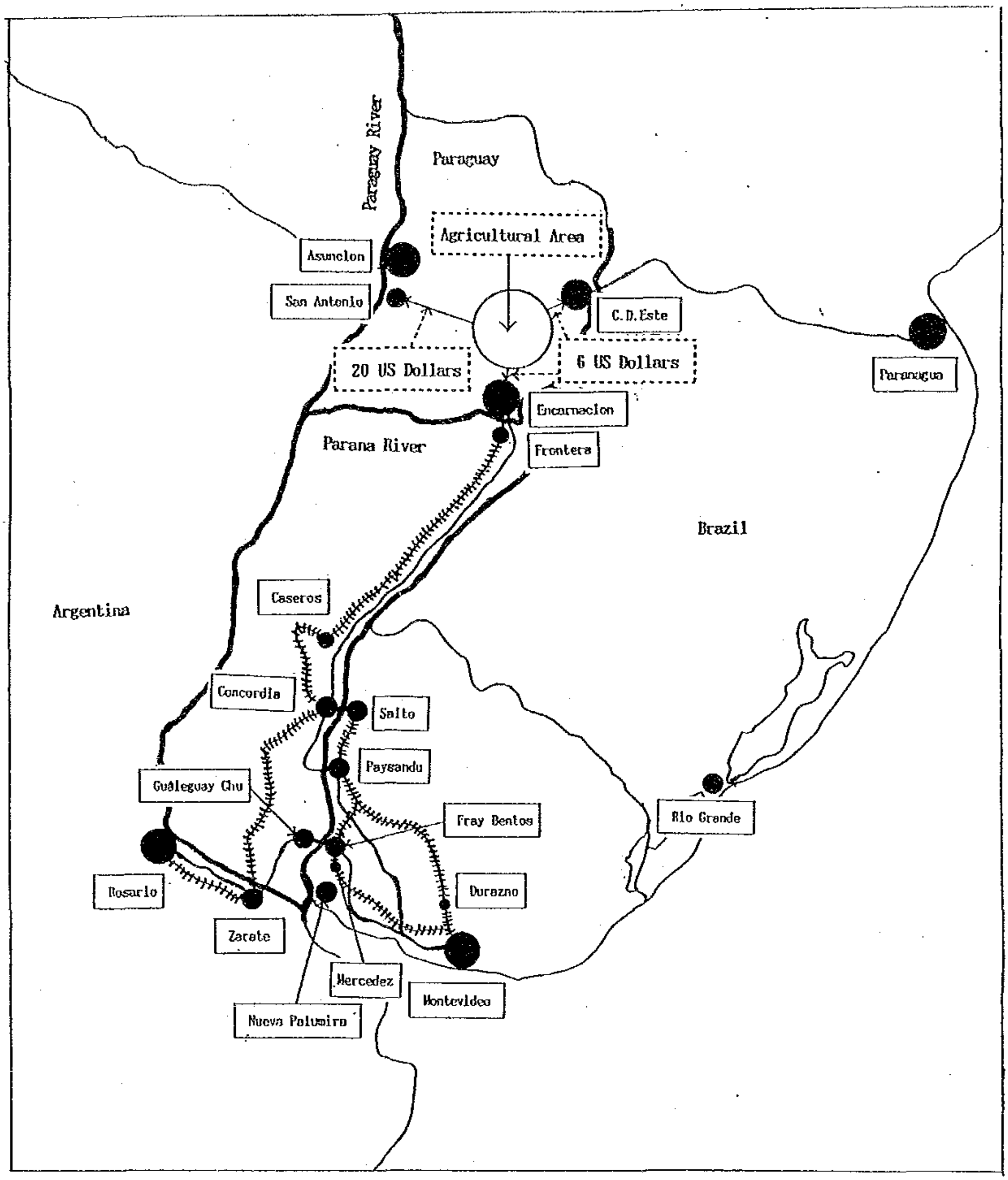


Figure 4-2-2-1 Transportation Route from Argentina or Paraguay

3) River Ship Transportation

This transportation route, at present, does not exist because there is no grain elevator for transit at Montevideo port. But present similar tariff is US 8.5 dollars from Rosario port to Nueva Palmira and US 9.0 dollars from Buenos Aires port to Nueva Palmira. The transportation cost of feeder shuttle vessel is estimated at US 5.57 dollars /ton as shown in Table 2-4-2-3. The total transportation period is estimated at 8 days, taking into account one day which is unworkable because of strong wind and rain and also a delay day.

Table 4-2-2-1 Transportation Tariff from Argentina ('92)

| | Truck | Railway | River Ship |
|---|---|---|---|
| Route | Rosario - Zarate - G. Chu Fray Bentos - Montevideo | Rosario-Zarate - Concordia Salto - Montevideo | Up-River Port (Rosario) - Montevideo |
| Distance (km) | 750 | 1,285 | 600 |
| Period (day) | 3 | 7 | 8 |
| Tariff (US $/ton) | 60 | 31.72 | 5.57 |
| Remark | | a)Rosario - Salto (680km) = 14.60 US $ /ton<br>b)Zarate Transit = 1.39 US $ /ton<br>c)Salto - Montevideo(605km) = 15.73 US $ /ton<br>Total = 31.72 US $ /ton (a+b+c) | a)Rosario - Nueva Palmira = 8.50 US $ /ton<br>b)B. Aires - Nueva Palmira = 9.00 US $ /ton |

SOURCES: AFE (Administracion de Ferrocarriles del Estado)
CATIDU (Camara Autotransporte Terrestre Internacional del Uruguay)

4) Handling Cost at Grain Terminal

The handling cost of grain elevators at up-river port is estimated as follows.

a) receipt and delivery from / to trucks and trains

Grain = 2.5 US $ / ton
By-Products = 2.7 US $ / ton

b) from and to vessels

Escobar Port: from river barges to ocean vessel
= 4 to 5 US $ / ton
Rosario Port: from river barges to ocean vessel
= 4.5 US $ / ton

5) Handling Cost at Alpha Station (Topping-off)

(Loading charge at Alpha Zone and freight)
= 10.0 US $ / ton

(2) Paraguay

It is assumed that object grain is transported from agricultural area of Encarnacion in Paraguay to Montevideo port. (Figure 4-2-2-1, Table 4-2-2-2)

1) Truck Transportation

The transportation route begins at Encarnacion, next going into Posadas of Argentina, running along the Argentine route to the city of Concordia, then coming into Salto and finally reaching Montevideo port by route 3 via Paysandu. It is about 1,046 km and requires three days including customs clearance. According to CATIDU, the transportation cost is influenced by transported cargo volume and period. But freight is estimated at US 1,300 dollars per truck, namely US 52 dollars per ton, because cargo volume that is transported from Montevideo port to Encarnacion is small.

2) Railway Transportation

The transportation route begins at Encarnacion, next coming into Frontera of Argentina; about 22 km from Encarnacion, frieght car is transferred from a Paraguayan railroad engine to an Argentine engine which then travels as far as Salto via Caseres where it is exchanged for a Uruguayan engine, which finally reaches Montevideo port. The total railroad fare is US 34.73 dollars per ton. According to AFE, there is much room for negotiation in this railroad fare if the unit of transportation volume is large.

3) River Ship Transportation

At present, the transportation route does not exist from Encarnacion to Montevideo Port nor it will be connected directly in future, because a convoy of barges must be adopted to pass the shallow draft of the Parana river. For that reason, Nueva Palmira port will be used as before. A convoy of barges is estimated to transport a volume of 10,000 tons per one navigation. It is about 2,194 km in distance. The navigation period is estimated at 15 days in total; 3 days for loading at Paraguay, 7 days for navigation from Encarnacion to Nueva Palmira port, 4 days for unloading and loading at Nueva Palmira port and 1 day for navigation from Nueva Palmira port to Montevideo port. Concerning the transportation period, transport by river ship is the longest. The freight is estimated at US 30 dollars in total ; US 21 dollars from Encarnacion to Nueva Palmira, US 4 dollars for transit charge and US 5 dollars for feeder shuttle vessel cost. However, the river freight can be reduced if the river transportation system is handled efficiently.

Table 4-2-2-2 Transportation Tariff from Paraguay ('92)

| | Truck | Railway | River Ship |
|---|---|---|---|
| Route | Encarnacion - Concordia<br>Salto - Paysandu - MVD. | Encarnacion - F.- Concordia<br>Salto - Paysandu - MVD. | Encarnacion -Nueva Palmira<br>Nueva Palmira - MVD. |
| Distance (km) | 1,046 | 1,238 | 2,194 |
| Period (day) | 3 | 5 | 15 |
| Tariff (US $ /ton) | 52 | 34.73 | 30.00 |
| Remark | 1,300 US $ per Truck | a)Encar.- Frontera (22 km)<br>= 4.40 US $<br>b)Frontera - Salto (611 km)<br>= 14.60 US $<br>c)Salto - MVD (605 km)<br>= 15.73 US $<br><br>Total = 34.73 US $ /ton<br>(a+b+c) | a)Enc.-N. Palmira (1,940 km)<br>= 21 US $<br>b)Tranzit (Nueva Palmira)<br>= 4.00 US $<br>c)N. Palmira - MVD (254 km)<br>= 5.00 US $<br><br>Total = 30 US $ /ton<br>(a+b+c) |

SOURCES: AFE (Administracion de Ferrocarriles del Estado)
CATIDU (Camara Autotransporte Terrestre Internacional del Uruguay)

4) Present export cost from Paraguay

Table 4-2-2-3 shows the comparison between export transportation cost of river ship and that of truck

(a) General Export Cost

This cost, US 38.34 dollars, is required for both transportation means.

(b) Domestic Transportation Cost by Truck

The difference of this cost, namely US 6 dollars to C.D.Este and US 20 dollars to San Antonio, is based on the transportation distance. The former is about 150 km in distance and the latter is about 450 km. However, US 20 dollars by river ship will be reduced at about US 14 dollars because export grain can be loaded from grain elevators along the Parana river to river barges.

(c) Export Transportation Cost by River Ship

*The condition of freight, US 18 dollars, is estimated as the* transportation cost from San Antonio to Nueva Palmira. But the freight from Encarnacion is estimated at about US 21 dollars, even if the transportation distance is the same. The higher cost of this route is attributed to the fact that it has not yet begun to run smoothly.

(d) Export Transportation Cost by Truck

The freight from C.D. Este to Paranagua port is estimated at US 26 dollars on average. The harvest season for soybeans is almost the same in Paraguay and Brazil. The truck fee becomes higher than usual at that time because of the shortage of grain trucks. This item includes the handling charges at Paranagua port; unloading from truck, loading to ocean vessel and storage at silo.

Table 4-2-2-3 Export Cost of Grain Cargo from Paraguay to Each Port ('90)

| | River Ship (US $/ton) | Truck (US $/ton) |
|---|---|---|
| Destination | Nueva Palmira (Uruguay) | Paranagua (Brazil) |
| (a) General Export Cost | | |
| Custom Clearance | 19.44 | 19.44 |
| Silo charge (Production) | 5 | 5 |
| Export Margin | 4 | 4 |
| Silo Charge (Client) | 3 | 3 |
| Financial (30 days x 35 % Anual) | 4.20 | 4.20 |
| Stamp Duty | 2.70 | 2.70 |
| (Sub. Total) | (38.34) | (38.34) |
| (b) Domestic Transportation Cost by Truck | | |
| from Encarnacion to C.D. Este | - | 6 |
| : to San Antonio | 20 | - |
| (Sub. Total) | (20) | (6) |
| (c) Transportation Cost by River Ship | | |
| Handling Cost of San Antonio | 4.5 | |
| Financial (40 days x 14 % Anual) | 3.85 | |
| Others | 2.25 | |
| Freight (to Nueva Palmira) | 18 | |
| Handling Cost of Nueva Palmira | 5 | |
| Different Price (between Paranagua and La Plata) | 7.35 | |
| (Sub. Total) | (39.95) | |
| (d) Transportation Cost by Truck | | |
| Freight (to Paranagua) | | 26 |
| Handling Carge (Paranagua) | | 14.50 |
| Comission Fee | | 2.50 |
| Insurance | | 1.39 |
| Financial (30 days x 14 % Anual) | | 2.56 |
| Others | | 1.63 |
| (Sub. Total) | | (48.58) |
| G. Total | 99.29 | 92.92 |

## 4-3 Present Grain Products in Argentina

### 4-3-1 Grain Production Area

Production area in Argentina for main exports such as grain, wheat, soybeans, maize and sorghum is shown in figure 4-3-1-1 and 4-3-1-2.

(1) Wheat

Wheat is the predominant crop in Argentina. But the productivity is low and drastically fluctuates. One growing area is in the center of the grain belt known as Pampa, which comprises the south of Santa Fe state close to Rosario city, the east of Cordoba state and the north of Buenos Aires State. Soybean or rotated crops of maize are grown here. The other growing area is close to Bahia Blanca, in the southen part of Buenos Aires state.

(2) Soybeans

Soybeans have shown the most growth in Argentine agriculture and have been extended rapidly because of the introduction of the new breed of wheat which is able to yield two crops a year. Growing area of the soybeans is in the southen part of Santa Fe state, the easten part of Cordoba state and the northen part of Buenos Aires state.

(3) Maize

Maize growing area was the same as wheat before soybean growing was introduced in Pampa belt. It is now being grown in the northen part of Buenos Aires state.

(4) Sorghum

50 percent of sorghum products in Argentina are imported by Japan. Sorghum has been grown in the west of Buenos Aires state, the east of La Pampa, the central part of Santa Fe state and the central of Cordoba state because sorghum is the heartiest grain for dry weather.


Figure 4-3-1-1 Location of State in Argentina

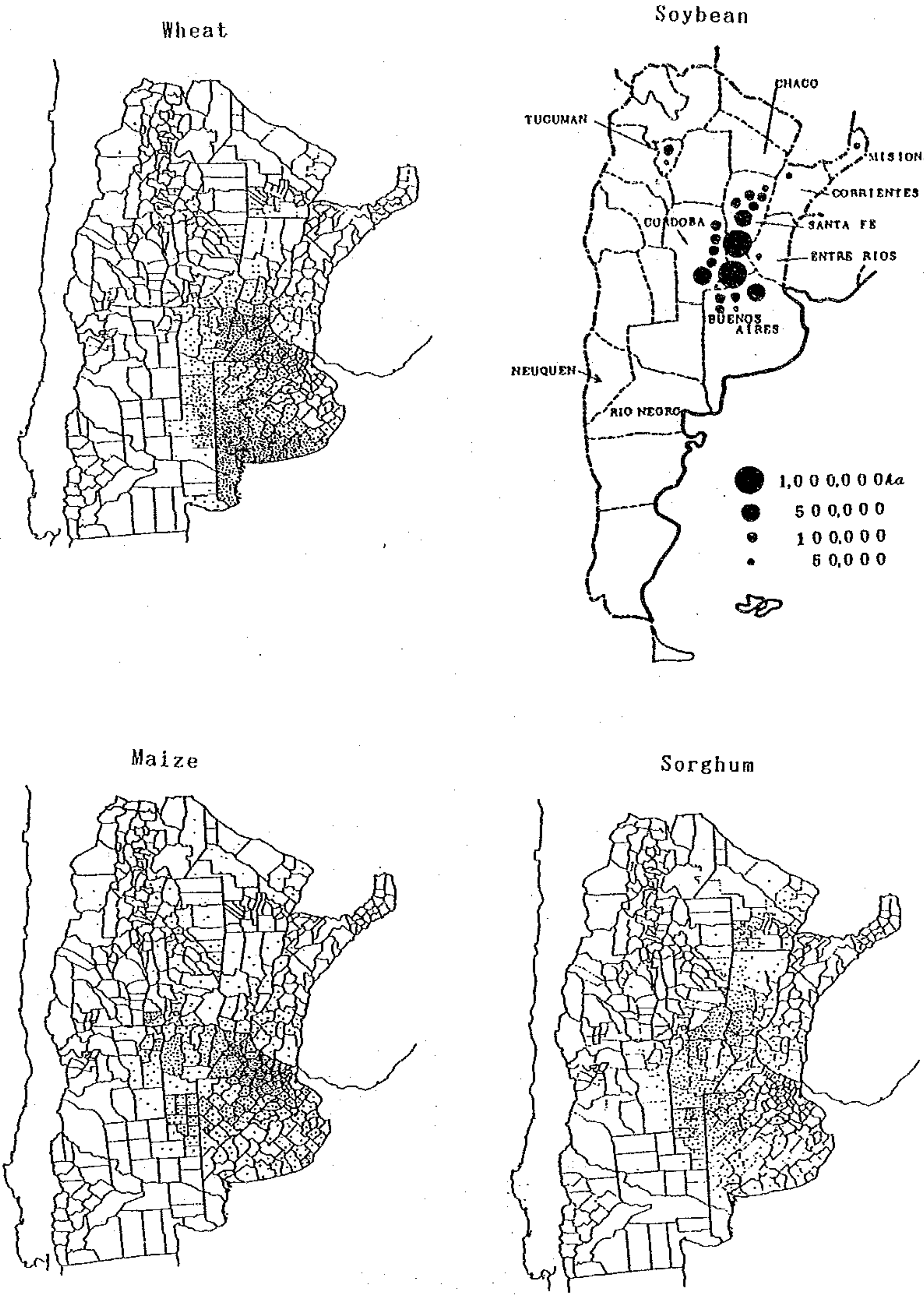


Figure 4-3-1-2 Growing Area of Argentina

### 4-3-2 Handling Volume at Each Port

Table 4-3-2-1 shows the handling volume at each port in Argentina in 1990. Up-River port handled 53.3 percent of the total. This table also implies that Up-River port is very important to export grains. The percentage of handling volume by cargo is 42 % for wheat, 23 % for soybean, 21 % for maize and 8 % for sorghum.

Table 4-3-2-1 Export Ranking of Grain for Each Port in Argentina ('90)

| Port | Quantity/T | % |
|---|---|---|
| Bahia Blanca | 3,280,015 | 23.6 |
| San Martin/San Lorenzo | 2,628,800 | 18.9 |
| Rosario | 2,477,687 | 17.8 |
| Necochea | 2,041,803 | 14.7 |
| Buenos Aires | 1,144,360 | 8.2 |
| San Nicolas | 926,865 | 6.7 |
| V.Constitucion | 732,216 | 5.3 |
| San Pedoro | 336,435 | 2.4 |
| Diamante | 191,650 | 1.4 |
| Santa Fe | 114,935 | 0.8 |
| Mar del Plata | 30,935 | 0.2 |
| Total | 13,905,701 | 100 % |

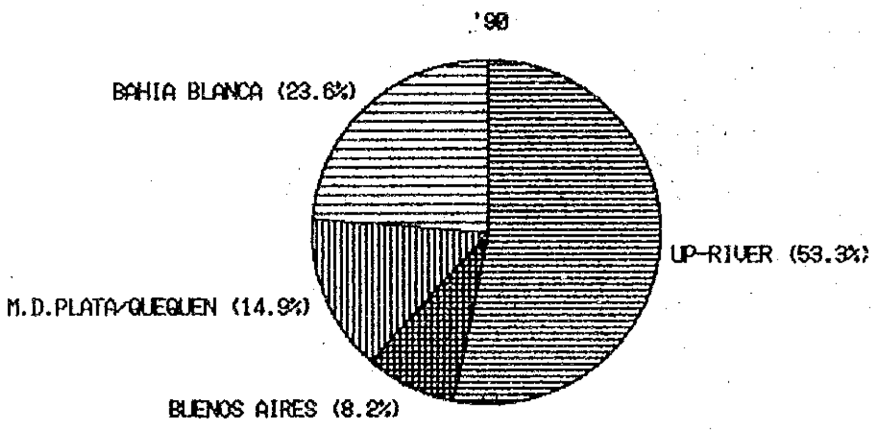


Figure 4-3-2-1 Percentage of Grain Export for Each Port ('90)

Table 4-3-2-2 Grain Export for Each Port in Argentina ('90)

Unit:tons

| Port | Wheat | Maize | Barley | Oats | Bolona | Sorghum | Soybean | Sunflower | Total |
|---|---|---|---|---|---|---|---|---|---|
| Bahia Blanca | 2,594,600 | 277,677 | 52,730 | 74,693 | - | 200,522 | - | 79,793 | 3,280,015 |
| Buenos Aires | 186,336 | 623,730 | 32,481 | 250 | 19,164 | 30,780 | 125,730 | 20,426 | 1,144,160 |
| Diamante | 76,672 | - | - | - | - | 97,660 | 17,114 | - | 191,650 |
| Mar del Plata | 13,794 | 17,141 | - | - | - | - | - | - | 30,935 |
| Necochea | 1,398,808 | 564,679 | - | 53,858 | - | - | - | 24,458 | 2,041,803 |
| Rosario | 542,929 | 378,160 | 6,640 | - | 13,683 | 549,454 | 985,562 | 81,259 | 2,177,187 |
| San Lorenzo | 501,910 | 292,369 | - | - | 12,060 | 151,928 | 1,522,904 | 145,397 | 2,628,800 |
| Santa Fe | 17,761 | - | - | - | - | 97,174 | - | - | 114,935 |
| V.Constitu. | 245,944 | 286,476 | - | - | - | - | 199,796 | - | 732,216 |
| San Nicolas | 236,230 | 383,725 | - | - | - | - | 306,910 | - | 926,865 |
| San Pedro | 47,556 | 97,827 | 10,593 | - | - | - | 184,459 | - | 336,435 |
| Total<br>% s/total | 5,862,540<br>42 | 2,921,784<br>21 | 102,444<br>1 | 128,801<br>1 | 44,907 | 1,127,522<br>8 | 3,258,675<br>23 | 351,333<br>3 | 13,905,701 |

## 4-3-3 Handling Volume in Each Country and Region

Export volume in Argentina in 1990 was 1,305,000 tons to Iran, 1,147,000 to Brazil and 1,127,000 to Republic of China. The export volume to each region was 38.2 % to Latin America, 21.7 % to Europe and 20.4 % to the Middle Near East and 19.7 % to Asia. (Table 4-3-3-1, Figure 4-3-3-1)

Moreover, storage capacity and export volume of each grain are shown in appendix A-4-3-1 to A-4-3-6.

Table 4-3-3-1 Grain Export Volume to Each Region ('89)

Unit: 1,000 tons

| | Wheat | Maize | Sorghum | Soybean | Total |
|---|---|---|---|---|---|
| Latin America | | | | | |
| Brazil | 1,036 | 111 | 0 | 0 | 1,147 |
| Cuba | 50 | 574 | 73 | 0 | 697 |
| Peru | 474 | 45 | 0 | 0 | 519 |
| Venezuela | 111 | 0 | 0 | 0 | 111 |
| Colombia | 99 | 0 | 0 | 0 | 99 |
| Sub. Total (%) | 1,770 | 730 | 73 | 0 | 2,573 (38.2 %) |
| Europe | | | | | |
| U.R.S.S | 624 | 21 | 53 | 0 | 698 |
| Benelux | 0 | 0 | 0 | 269 | 269 |
| West Germany | 0 | 125 | 0 | 34 | 159 |
| Italy | 0 | 66 | 0 | 53 | 119 |
| Belguium | 0 | 90 | 0 | 0 | 90 |
| Greece | 0 | 0 | 0 | 29 | 29 |
| Angola | 0 | 68 | 0 | 0 | 68 |
| Britain | 0 | 25 | 0 | 0 | 25 |
| Spain | 0 | 0 | 0 | 4 | 4 |
| Sub. Total (%) | 624 | 395 | 53 | 389 | 1,461 (21.7 %) |
| Middle N. East | | | | | |
| Iran | 628 | 621 | 56 | 0 | 1,305 |
| Turkey | 73 | 0 | 0 | 0 | 73 |
| Sub. Total (%) | 701 | 621 | 56 | 0 | 1,378 (20.4 %) |
| Asia | | | | | |
| Chaina Rep. | 1,127 | 0 | 0 | 0 | 1,127 |
| Japan | 0 | 1 | 190 | 0 | 191 |
| Indonesia | 1 | 0 | 0 | 6 | 7 |
| Singapore | 0 | 2 | 0 | 0 | 2 |
| Sub. Total (%) | 1,128 | 3 | 190 | 6 | 1,327 (19.7 %) |
| G. Total (%) | 4,223 (62) | 1,749 (26) | 372 (6) | 395 (6) | 6,739 (100 %) |

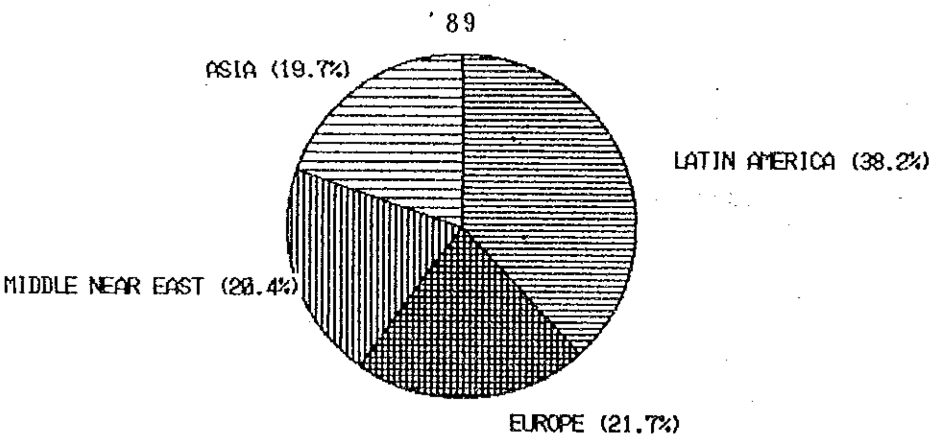


Figure 4-3-3-1 Grain Export to Each Region

# 5 PRESENT CONDITIONS OF NEIGHBORING PORTS

## 5-1 General

ANP administrates Fry Bentos, Nueva Palmira and Colonia etc. in addition to Montevideo Port. There are other big ports such as La Paloma and Piriapolis etc. in Uruguay.

La Paloma and Piriapolis are handling mainly fishery cargo.

Fray Bentos and Nueva Palmira are handling mainly grain cargo.

Colonia is handling mainly passenger and general cargo.

Main facilities of two ports, Fray Bentos and Nueva Palmira, are described in chapter 4.

### 5-1-1 Location of Neighboring Ports

The port of Fray Bentos (capital city of Rio Negro Department), about 300 km north-west of Montevideo, faces the Uruguay river and there are grain zones in the neighborhood.

The port of Nueva Palmira (Department of Colonia), about 250 km north-west of Montevide, is located at the turning point of the Uruguay river and the La Plata river. It faces the Uruguay river.

The port of Colonia (capital city of Colonia Department), about 180 km north-west of Montevideo, is the marine entrance from Argentina and a lot of ferry boats from Argentine call.

Figure 5-1-1-1 shows Location of Neighboring Ports


Figure 5-1-1-1 Location of Neighboring Ports

### 5-1-2 Fray Bentos Port

Table 5-1-2-1 shows cargo handling volume by main commodity at Fray Bentos Port. Almost all handling cargoes are related to agricultural industry, especially grain cargo, which has been increasing steadily. Recently a lot of wheat has been exported from this port.

Table 5-1-2-1 Cargo Handling Volume by Main Commodity at Fray Bentos

Unit:Tons

| Year | Sugar | Beet | Grain | Citrus | Fertilizer | Fodder | Others | Animal | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1985 Export | | | 0 | | 0 | 0 | 28 | | 28 |
| Import | | | 2,779 | | 5,196 | 0 | 11 | | 7,986 |
| 1986 Export | | 9,350 | 17,000 | | 0 | 0 | 0 | | 26,350 |
| Import | | | 7,355 | | 9,745 | 0 | 1,977 | | 19,077 |
| 1987 Export | | 9,200 | 11,532 | | 0 | 150 | 0 | 886 | 20,882 |
| Import | | | 527 | | 4,832 | 0 | 0 | | 5,359 |
| 1988 Export | | 10,531 | 142 | | 0 | 340 | 0 | 1,832 | 11,013 |
| Import | | | 0 | | 0 | 0 | 0 | | 0 |
| 1989 Export | | 7,381 | 12,345 | 1,189 | 0 | 470 | 0 | 5,567 | 21,385 |
| Import | | | 0 | | 10,742 | 0 | 2 | | 10,744 |
| 1990 Export | | 10,090 | 28,650 | | 0 | 0 | 1,842 | | 40,582 |
| Import | | | 0 | | 7,820 | 0 | 0 | | 7,820 |
| 1991 Export | | 7,740 | 44,050 | 4,206 | 0 | 240 | 2,000 | | 58,236 |
| Import | 16,000 | | 0 | | 0 | 0 | 486 | | 16,486 |

Source:ANP
Sugar:Natural Sugar
Beet:Strained Lees of Beet
Grain:Barley, Wheat, Sorgum, Soya, Bran
Fertilizer:Fertilier, Urea, Phosphate
Fodder:Fodder, Alfalfa
Others:Cotton, Timber, Sheep Leather, Malt, Machine
Animal:Live Animal

### 5-1-3 Nueva Palmira Port

Table 5-1-3-1 shows cargo handling volume by main commodity at Nueva Palmira Port. Cargo handling volume was not constant, i.e., 32,883 tons in 1985, 2,499 tons in 1990. In 1986, handling volume was only 92 tons.

In 1990, this port handled only transit cargo.

Table 5-1-3-1 Cargo Handling Volume at Nueva Palmira Port

Unit:ton

| | Veget-able | Food Products | Chemica Products | Leather | Textile | Machinery | Others | Total |
|---|---|---|---|---|---|---|---|---|
| 1985 Export | | 6,400 | | 28 | | | | 6,428 |
| Import | 2,179 | | 3,045 | | | 11 | | 5,235 |
| Transit | | | | | 20,849 | | 371 | 21,220 |
| 1986 Export | | | | | | | | 0 |
| Import | | | | | | | | 0 |
| Transit | | | | | | 92 | | 92 |
| 1987 Export | | 6,347 | | | | | | 6,347 |
| Import | | | | | | | | 0 |
| Transit | 709 | 30 | 3,707 | 339 | | 26 | | 4,811 |
| 1988 Export | | 5,539 | | | | | | 5,539 |
| Import | | | | | | | | 0 |
| Transit | 168 | 19 | 4,219 | | | 345 | 257 | 5,008 |
| 1989 Export | | | | | | | | 0 |
| Import | 190 | | | | | | | 190 |
| Transit | | | | | | | 606 | 606 |
| 1990 Export | | | | | | | | 0 |
| Import | | | | | | | | 0 |
| Transit | | | | | | | 2,499 | 2,499 |

Source:ANP

Unit:ton

| Year | Total Cargo |
|---|---|
| 1985 | 32,883 |
| 1986 | 92 |
| 1987 | 11,158 |
| 1988 | 10,547 |
| 1989 | 796 |
| 1990 | 2,499 |

## 5-1-4 Colonia Port

Port of Colonia is mainly used by ferry boats for passenger from/to Argentine.

Table 5-1-4-1 shows passenger traffic at port of Colonia.

Number of passenger using this port is almost constant.

Table 5-1-4-1 Passenger Traffic at Port of Colonia

| | '85 | | '86 | | '87 | | '88 | | '89 | | '90 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Inter | Leave | Inter | Leave | Inter | Leave | Inter | Leave | Inter | Leave | Inter | Leave |
| Ferry | 379693 | 390279 | 385263 | 396893 | 361242 | 379852 | 391670 | 391928 | 423861 | 450553 | 367390 | 376374 |
| Airplane | 33702 | 32524 | 33201 | 34078 | 17919 | 17744 | 31345 | 32191 | 37365 | 39606 | 43530 | 43560 |
| Yacht | 365 | 0 | 222 | 0 | 246 | 0 | 245 | 0 | 64 | 0 | 0 | 0 |
| Total | 413760 | 422803 | 418706 | 430971 | 379407 | 397596 | 423260 | 424119 | 461290 | 490159 | 410920 | 419934 |
| G.Total | 836563 | | 849677 | | 777003 | | 847379 | | 951449 | | 830854 | |

Sources: ANP

# 6 SEDIMENTATION OF MATERIALS AT THE APPROACH CHANNEL AND THE PORT AREA

## 6-1 General

The Montevideo Port is situated at the mouth of the La Plata River and suffers from huge sedimentation of materials at the approach channel and the port area, conducting constantly maintenance dredging of several million of mud per year using five dredgers. Therefore, Consultant "INTECSA" performed detailed investigation on the sedimentation by means of field hydraulic observation, experimental dredging, hydraulic physical model test and mathematical model calculation, the results of which have been described in the reports of "Master Development Plan", "Approach to the Port Development Alternatives" and "Hydraulic and Sedimentological Studies", in order to make out the future development plan of the Port of Montevideo.

According to the above reports, at first, the method of estimation on the maintenance dredging volume will be reviewed, then its rationality will be checked on the basis of the recent maintenance dredging volume.

## 6-2 Review on the Analysis of the Maintenance Dredging at the Approach Channel

### 6-2-1 Calculation Based on the Data of Experimental Dredging

Assumed that the ratio of shoaling at the channel is proportional to the difference between the channel depth and the natural equilibrium depth of the site where the channel is excavated, the following equation is obtained:

$$dC/dt = -K\ (Ce-C) \qquad (1)$$

Where, C : channel depth (in meters)

Ce : natural equilibrium depth that is equal to the water depth before dredging the channel (in meters)

t : time (in years)

K : proportional coefficient

Deforming the equation (1),

$$dC/(C-Ce) = -K\ dt$$

Integrating with the integral constant B,

$$Ln\ (C - Ce) = -Kt + B$$

Because C = Cd (dredging depth) when t = 0,

$$B = Ln\ (Cd-Ce),$$

Then,

$$Ln(C-Ce)/(Cd-Ce) = -Kt$$

$$(C-Ce)/(Cd-Ce) = e^{-Kt}$$

$$C = Ce + (Cd - Ce)\ e^{-Kt}$$

$$C = Ce - (Ce - Cd)\ e^{-Kt} + Cd - Cd$$

$$C = Cd + (Ce - Cd)\ (1 - e^{-Kt}) \qquad (2)$$

The constant K was determined using the data of experimental dredging at the area which is about 11 Km south and about 5 Km east from Punta Brava along the Approach Channel, whose area was -9 meters in the natural depth. The dredging was carried out during 3 of August to 14 of September 1986 and the depth measurement was conducted 23 and 24 of November 1986 and 13 and 14 of March 1987.

The analyzed result of the above experimental dredging is shown in Figure 6-2-1-1, where C1 is the water depth of 23 and 24 of November 1986 and C2 is that of 13 and 14 of March 1987. Accordingly, C2 - C1 in vertical axis corresponds to the shoaling during this period and C1 and C2 to Cd and C of the equation (2), respectively. By the linear regression analysis, the relation between y = C2 - C1 and x = C1 became as follows:

$$y = -0.137x - 1.392 \quad (3)$$

Because $y = 0$ at $x = Ce$,

$$Ce = -1.392/0.137 = -10.16 \text{ (meters)}$$

The actual equilibrium water depth was -9 meters as mentioned before, but from the above calculation Ce is taken as -10.16 meters.

In order to calculate the value of K, substituting $x = -11$ (meters) in the equation (3),

$$y = -0.137 \times (-11) - 1.392 = 0.115 \text{ (meters)}$$

Substituting $y = C - Cd = 0.115$ (meters), $x = Cd = -11$ (meters), $Ce = -10.16$ (meters) and $t = 110$ (day) $= 0.3$ (year) in the equation (2),

$$0.115 = (-10.16 - (-11))(1 - e^{-0.3K})$$

$$e^{-0.3K} = 0.863095$$

$$K = -Ln(0.863095)/0.3$$

$$= 0.4907(\text{year}^{-1})$$

In the above calculation, t was taken as 0.3 year of the period from 23 of November 1986 to 13 of March 1987.

In Figure 6-2-1-1, Ce and K are -10.14 meters and 0.490 $\text{year}^{-1}$ respectively, but those difference from the above calculation is negligible small.

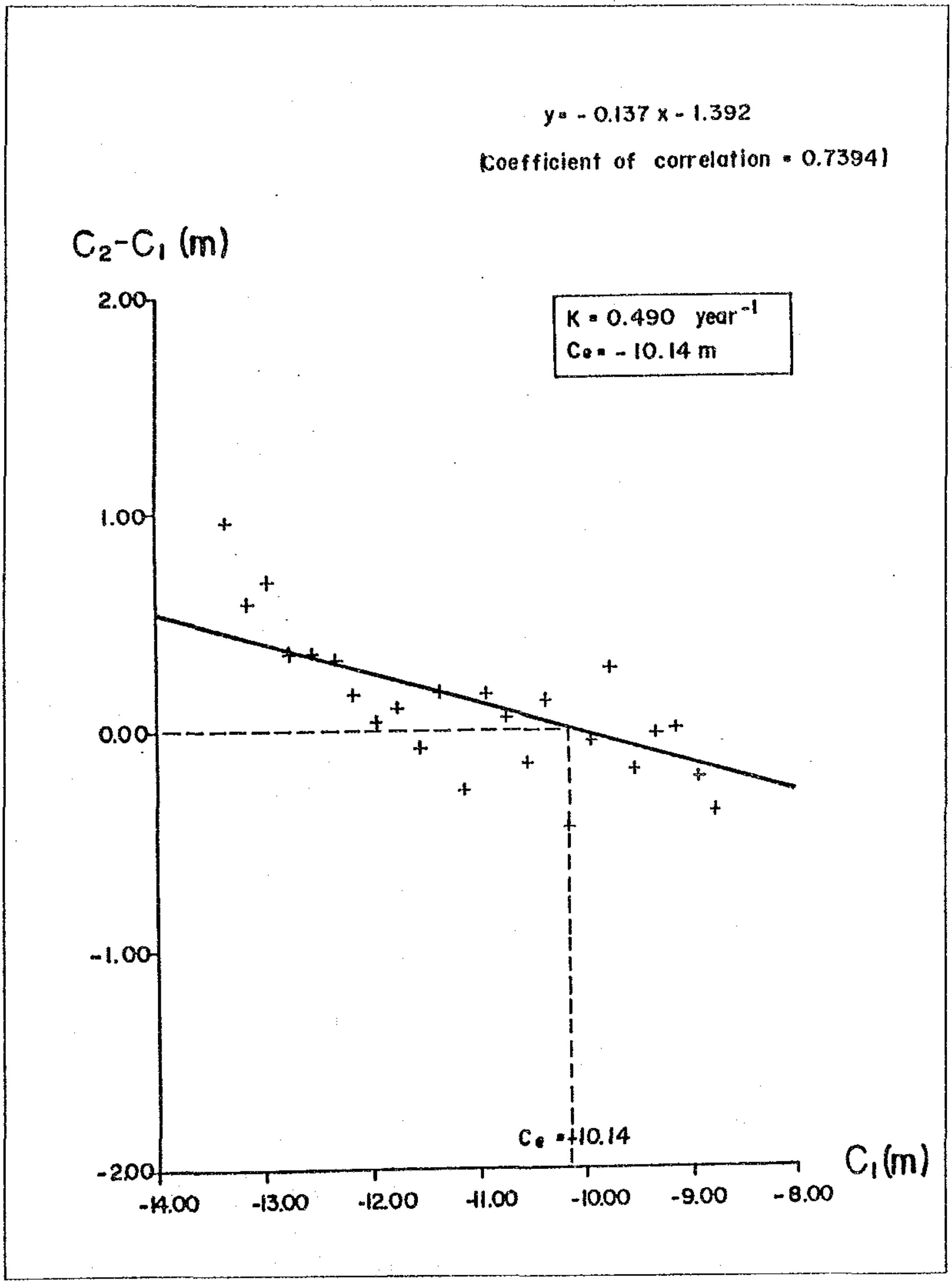


Figure 6-2-1-1 Result of the Experimental Dredging in the Exterior Area Near to the Approach Channel

### 6-2-2 Calculation Based on the Information of Maintenance Dredging

An analysis based on the volume of maintenance dredging during the period from 1979 to 1985 also was carried out on the basis of the information of ANP. The maintenance dredging volume is shown in Table 6-2-2-1 after converting the hopper volume of dredger into the soil volume before dredging through the factor 0.8, together with the dredging area and the dredging depth.

On the other hand, the above mentioned semi-empirical formula (2) was converted as follows:

If the time t is replaced with t2 - t1, the value C - Cd in equation (2) corresponds to the shoaling thickness of the channel during the year t1 to t2, that is:

$$C - Cd = (Ce - Cd)\,(1 - e^{-K(t2-t1)})$$

Accordingly, the shoaling thickness A per year can be expressed as follows:

$$A = (C - Cd)/(t2 - t1)$$

$$A = (Ce - Cd)(1 - e^{-K(t2-t1)})/(t2 - t1) \qquad (4)$$

Next, in order to calculate the value of K in the equation(4), A, Ce, Cd and (t2 - t1) must be known, which are obtained from the column of the Approach Channel of 0 to 6.5 Km in Table 6-2-2-1 as follows:

$$A = \frac{\text{dredged volume}}{\text{dredged area}} = \frac{2{,}710{,}828}{1{,}532{,}143} = 1.77 \text{ (meters)}$$

Cd = -10.5(meters) : average dredging depth

Ce = - 6.0(meters) : equilibrium water depth around the channel.

(t2-t1) = 0.25 (year) : the interval between the maintenance dredging works.

Table 6-2-2-1 Annual Maintenance Dredging Volume
(From the 'Master Development Plan')

| Year | Approach cannel | | | Foreport | | |
|---|---|---|---|---|---|---|
| | Dredging Volume ($m^3$) | Dredging Area ($m^2$) | Dredging Depth (m) | Dredging Volume ($m^3$) | Dredging Area ($m^2$) | Dredging Depth (m) |
| 1979 | 493,630 | 1,300,000 | -10 | 167,873 | 1,350,000 | -10 |
| 1980 | 6,083,289 | 2,100,000 | -7/-11 | 1,678,249 | 1,044,625 | -6/-11 |
| 1981 | 3,678,809 | 2,205,000 | -10/-13 | 2,605,094 | 1,245,625 | -10/-13 |
| 1982 | 2,541,330 | 1,300,000 | -10/-11 | 1,623,687 | 1,350,000 | -10/-11 |
| 1983 | 1,950,152 | 1,260,000 | -10/-12 | 1,988,561 | 1,350,000 | -8/-13 |
| 1984 | 630,623 | 1,260,000 | -10/-11 | 1,185,454 | 1,350,000 | -8/-13 |
| 1985 | 3,597,964 | 1,300,000 | -11 | 1,262,721 | 1,350,000 | -10/-13 |
| Total | 18,975,797 | 10,725,143 | ------ | 10,511,639 | 9,049,250 | ------- |
| Annual Average | 2,710,828 | 1,532,143 | ------ | 1,501,622 | 1,292,750 | ------- |

| Year | Basin 1 | | | Basin 2 | | |
|---|---|---|---|---|---|---|
| | Dredging Volume ($m^3$) | Dredging Area ($m^2$) | Dredging Depth (m) | Dredging Volume ($m^3$) | Dredging Area ($m^2$) | Dredging Depth (m) |
| 1979 | 186,614 | 83,850 | -10/-11 | 165,468 | 57,070 | -10/-11 |
| 1980 | 5,552 | 139,210 | -9/-10 | 65,176 | 150,000 | -7/-10,5 |
| 1981 | 267,725 | 139,210 | -10/-11 | 185,077 | 241,295 | -10 |
| 1982 | 255,439 | 154,810 | -10/-11 | 656,674 | 312,100 | -10/-11 |
| 1983 | 110,322 | 171,360 | -10/-11 | 273,610 | 250,000 | -8/-10 |
| 1984 | 185,790 | 145,860 | -10/-11 | 26,112 | 250,000 | -8/-10 |
| 1985 | 35,005 | 32,200 | -10/-11 | 68,100 | 43,330 | -10/-10.5 |
| Total | 1,046,447 | 866,500 | ------ | 1,440,217 | 1,303,795 | ------- |
| Annual Average | 149,492 | 123,786 | ------ | 205,745 | 186,256 | ------ |

Substituting those values in the equation (4),

$$1.77 = (-6.0 - (-10.5))(1 - e^{-0.25K})/0.25$$

$$e^{-0.25K} = 1 - (1.77 \times 0.25)/(10.5 - 6.0) = 0.90167$$

$$K = -(\mathrm{Ln}0.90167)/0.25$$

$$K = 0.414 \ (\mathrm{year}^{-1})$$

On the other hand, in the report of "Approach to Port Development Alternatives" is described as follows:

Table 6-2-2-2

| | | Shoaling thickness A (m/year) | Maintenance Depth Cd (meter) | Equilibrium Depth Ce (meter) | Coefficient K (year-1) |
|---|---|---|---|---|---|
| Approach | Km 0 - 2 | 2.08 | | -5.5 | |
| Channel | Km 2 - 4 | 1.87 | -10.5 | -6.0 | 0.440 |
| | Km 4 -6.5 | 1.46 | | -7.0 | |
| | Average | 1.77 | | | |

Although the Approach Channel is divided in three parts of 0-2, 2-4 and 4-6.5 Km in the above table, the values of A and Ce against each part can not be obtained from Table 6-2-2-1, and it is not explained from where they were taken. However, the value of K = 0.440 is approximately equal to the above calculated value of 0.414.

### 6-2-3 Estimation of Shoaling Thickness along the Approach Channel by Means of Semi-empirical Formula

The shoaling thickness per year was calculated using the equation (4) for variable natural equilibrium depths Ce and the dredging maintenance depth Cd against the distant area and the nearby area of the Approach Channel.

For the distant area, using K = 0.490 ($year^{-1}$) obtained in the section 6-2-1 the followings were obtained:

Table 6-2-3-1 Estimated Shoaling Thickness A (m/year)

| Cd (meter) | Ce (meter) | | | | | | |
|---|---|---|---|---|---|---|---|
| | -8 | -9 | -10 | -11 | -12 | -13 | -14 |
| - 10 | 0.92 | 0.46 | | | | | |
| - 11 | 1.38 | 0.92 | 0.46 | | | | |
| - 12 | 1.84 | 1.38 | 0.92 | 0.46 | | | |
| - 13 | 2.31 | 1.84 | 1.38 | 0.92 | 0.46 | | |

(K = 0.490 $year^{-1}$, t2 - t1 = 0.25 year)

For the nearby area, using K = 0.440 ($year^{-1}$) obtained in the section 6-2-2, the following shoaling thickness were obtained:

Table 6-2-3-2 Estimated Shoaling Thickness A (m/year)

| Cd (meter) | Ce (meter) | | | | |
|---|---|---|---|---|---|
| | -5 | -6 | -7 | -8 | -9 |
| - 10 | 2.08 | 1.67 | 1.27 | 0.83 | 0.42 |
| - 11 | 2.50 | 2.08 | 1.67 | 1.25 | 0.83 |
| - 12 | 2.91 | 2.50 | 2.08 | 1.67 | 1.25 |
| - 13 | 3.33 | 2.91 | 2.50 | 2.08 | 1.67 |

(K = 0.440 $year^{-1}$, t2 - t1= 0.25 year)

The above distant area and nearby area correspond to the W-E Channel and the N-S Channel, respectively.

### 6-2-4 The Principle of the Sedimentation Forecast by the Overall Method

The rate of bottom erosion was expressed by the following formula.

$$dm/dt = -Mo(J/Jo - 1) \qquad (5)$$

Where m : the thickness of materials eroded from the channel bottom
t : time
J : the bottom friction stress
Jo : the critical friction stress from which erosion begins
Mo : the erosion constant

If the velocity of bottom current is V, J is expressed as follows with the friction coefficient f and the density of sea water $\rho$:

$$J = f \rho V^2$$

Therefore, taking Vo as the critical velocity from which erosion begins,

$$J/Jo = (V/Vo)^2$$

Assumed that the bottom current velocity is sinusoidal with the period T and the amplitude V',

$$V = V' \sin 2\pi t/T$$

Substituting all the above values in the equation (5),

$$dm/dt = -Mo[K(\sin 2\pi t/T)^2 - 1] \qquad (6)$$

where $K = (V'/Vo)^2$, putting $\alpha = 2\pi t/T$, $dt = (T/2\pi) d\alpha$

Therefore the equation (6) changes as follows:

$$dm = -(T/2\pi)Mo[K(\sin\alpha)^2 - 1]d\alpha \qquad (7)$$

If $\alpha$ at the time when V= Vo is $\theta$, as shown in (1) of Figure 6-2-4-1, integrating the equation (7) in the region between $\theta$ and $\pi/2$,

$$m = -(T/2\pi)\int_{\theta}^{\pi/2} Mo[K(\sin\alpha)^2 - 1]d\alpha$$

$$= -(TMo/2\pi)[K(\alpha/2 - (\sin 2\alpha)/4) - \alpha]_{\theta}^{\pi/2}$$

$$= -(T/2\pi)Mo[(K/2 - 1)(\pi/2 - \theta) + (K\sin 2\theta)/4]$$

Because V becomes greater than Vo in four regions during one period as seen in Figure, the materials Me eroded from the channel bottom during one period T is as follows:

$$Me = -(2T/\pi)Mo[(K/2-1)(\pi/2 - \theta) + (K\sin 2\theta)/4] \qquad (8)$$

On the other hand, the rate of deposition of materials was expressed as follows:

$$dm/dt = CW(1 - J/Jo') \qquad (9)$$

Where,

Jo' = the critical friction stress from which deposition begins
C = the concentration of suspended materials
W = the particle falling velocity
m = the height of materials deposited on the channel bottom

Replacing J and Jo' with the velocity V as before,

$$dm/dt = CW[1 - K'(\sin 2\pi/T)^2] \qquad (10)$$

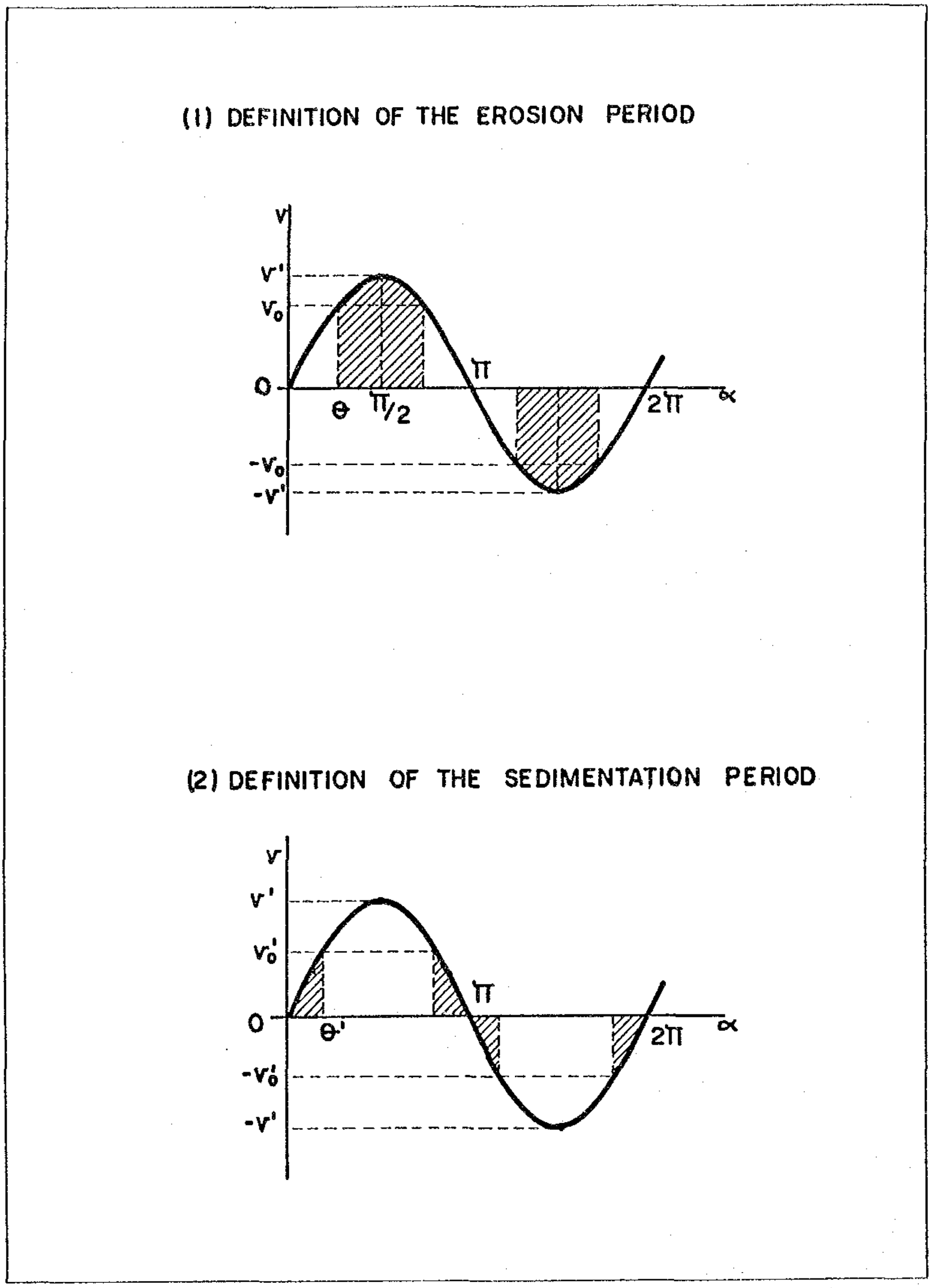


Figure 6-2-4-1 Definition of the Period of Erosion and Sedimentation

Where,

$K' = (V'/Vo')^2$

$Vo'$ = the velocity which produces $Jo'$

Putting $\alpha = 2\pi t/T$ and integrating in the region of $0 \leq \alpha \leq \theta'$, where $\theta'$ is the value of $\alpha$ when the tidal velocity reaches at the value of Vo' as shown in (2) of the figure 6-2-4-1,

$$m = (T/2\pi)CW\int_0^{\theta'}[1- K'\sin\ \alpha^2]d\alpha$$

$$= (T/2\pi)CW[\theta'(1-K'/2) + (K'/4)(\sin 2\theta')]$$

Therefore, the materials Ms deposited in the channel during one period T is obtained as follows:

$$Ms = (2T/\pi)CW[\theta'(1-K'/2) + (K'/4)(\sin 2\theta')] \qquad (11)$$

From the above mentioned, the shoaling the channel during one period T becomes as follows:

$$M = Me + Ms \qquad (12)$$

Then, the followings were supposed for the application of the equation (12) to the actual estimation:

(1) The same tidal current which has 42 m/sec of the amplitude V' continues throughout the year. Owing to that one tide continues during 12.42 hours, the number of tide during one year is as follows:

365 (days) x 24 (hours/day) / 12.42 (hours/each time) = 705 times

Therefore, the annual thickness of sedimentation becomes 705 times as much as the value of M of the equation (12).

(2) The velocity Vo from which erosion begins is 20cm/sec.

(3) The velocity Vo' from which sedimentation begins is 10 cm/sec.

(4) In the area of sea bottom of the coast of Montevideo, 1cm/year of shoaling is found in the natural sea bed without any channel. From this fact and the result of experimental dredging which has been described before, the value of Mo was determined to be $2.43 \times 10^{-8}$ m/sec.

(5) In the North-South Channel, the annual shoaling thickness A were 2.08 meters in the case of the maintenance depth -10.5 meters and the natural equilibrium -5.5 meters as shown in the section 6-2-2.

### 6-2-5 Estimation of Sedimentation by means of the Overall Method.

For the estimation of sedimentation in the channel, the angle between the main direction of tidal current and the direction of the channel should also be taken into account because when the direction of the channel is similar to that of tidal current the current velocity in the channel will be greater than in the reverse case and, consequently, the corresponding sedimentation will decrease.

Figure 6-2-5-1 is the result of the experiment conducted at the Hydraulic Research Center by means of a reduced model, where d1 and d2 are the depth of natural equilibrium sea bottom and of the channel, respectively, and V1 and V2 are the current velocity for the d1 and d2 respectively. is the angle between the direction of tidal current and that of the channel.

Considering the variation of the current velocity in the channel as mentioned above and using the method in the foregoing sections, annual shoaling thickness for the Approach Channel was calculated as shown in Table 6-2-5-1. But the angle between the tidal current and the channel was taken to 90 degrees for until 8.5 meters of Ce which corresponds to the North-South Channel and the curved Channel, and 8.5 degrees for more than 9 meters of Ce which corresponds to the West-East Channel. Moreover, in this table, Ce corresponds to the natural equilibrium depth around the channel and Cd to the maintenance depth of the channel.

The annual maintenance dredging volume is calculated on the basis of Table 6-2-5-1, and the results are shown in Table 6-2-5-2. From this table, the estimated volume of annual maintenance dredging is seen to be 5,272,000 $m^3$ and 7,294,000 $m^3$ for 11 meters and 12 meters of the channel depth respectively, in the case of 160 meters of the channel width. But, the above calculation is based on the assumption that the dredging work is carried out every 3 months.

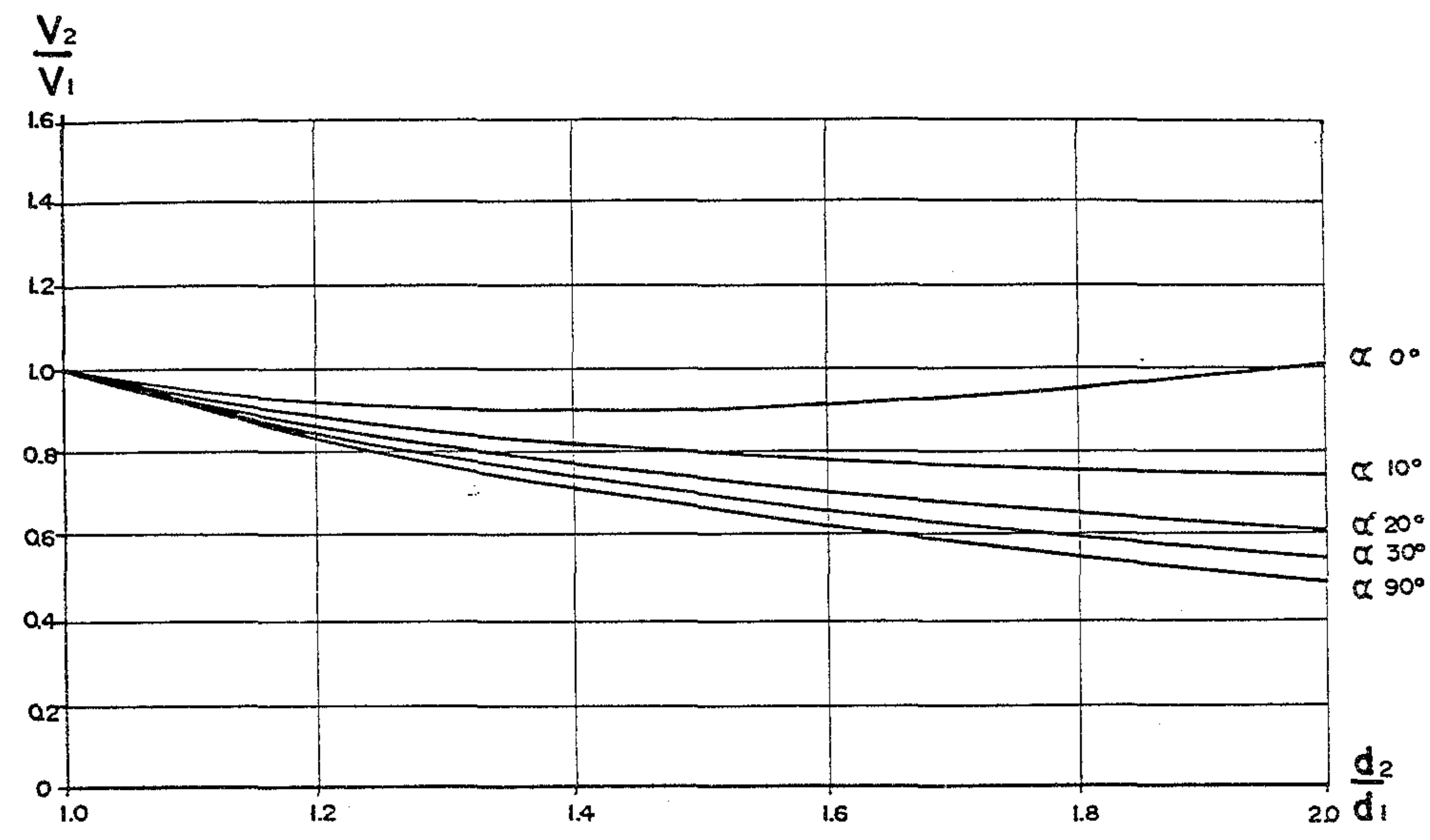


Figure 6-2-5-1 Forecast of the Relative Velocities in Oblique Channel

Table 6-2-5-1 Estimation of the shoaling thickness at the Approach Channel in meters (From the "Master Development Plan")

N-S Channel

| Ce / Cd | 5.50 | 6.00 | 6.50 | 7.00 | 7.50 | 8.00 | 8.50 |
|---|---|---|---|---|---|---|---|
| 5.50 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6.00 | 0.36 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6.50 | 0.66 | 0.33 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7.00 | 0.91 | 0.61 | 0.31 | 0.01 | 0.00 | 0.00 | 0.00 |
| 7.50 | 1.13 | 0.85 | 0.57 | 0.29 | 0.01 | 0.00 | 0.00 |
| 8.00 | 1.32 | 1.06 | 0.80 | 0.54 | 0.27 | 0.01 | 0.00 |
| 8.50 | 1.50 | 1.24 | 0.99 | 0.75 | 0.50 | 0.26 | 0.01 |
| 9.00 | 1.66 | 1.41 | 1.17 | 0.94 | 0.71 | 0.48 | 0.24 |
| 9.50 | 1.81 | 1.56 | 1.33 | 1.11 | 0.89 | 0.67 | 0.45 |
| 10.00 | 1.95 | 1.71 | 1.48 | 1.27 | 1.06 | 0.85 | 0.64 |
| 10.50 | 2.08 | 1.84 | 1.62 | 1.41 | 1.21 | 1.01 | 0.81 |
| 11.00 | 2.20 | 1.97 | 1.75 | 1.54 | 1.34 | 1.15 | 0.96 |
| 11.50 | 2.32 | 2.09 | 1.87 | 1.67 | 1.47 | 1.28 | 1.10 |
| 12.00 | 2.43 | 2.20 | 1.99 | 1.79 | 1.59 | 1.41 | 1.23 |
| 12.50 | 2.53 | 2.31 | 2.10 | 1.90 | 1.71 | 1.53 | 1.35 |
| 13.00 | 2.64 | 2.41 | 2.20 | 2.00 | 1.82 | 1.64 | 1.47 |

W-E Channel

| Ce / Cd | 9.00 | 9.50 | 10.00 | 10.50 | 11.00 | 11.50 | 12.00 | 12.50 | 13.00 |
|---|---|---|---|---|---|---|---|---|---|
| 5.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 9.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 9.50 | 0.16 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 10.00 | 0.28 | 0.15 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 10.50 | 0.39 | 0.27 | 0.14 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 11.00 | 0.48 | 0.38 | 0.26 | 0.14 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| 11.50 | 0.56 | 0.46 | 0.36 | 0.25 | 0.13 | 0.01 | 0.00 | 0.00 | 0.00 |
| 12.00 | 0.62 | 0.54 | 0.45 | 0.35 | 0.24 | 0.13 | 0.01 | 0.00 | 0.00 |
| 12.50 | 0.67 | 0.60 | 0.52 | 0.43 | 0.33 | 0.23 | 0.12 | 0.01 | 0.00 |
| 13.00 | 0.72 | 0.66 | 0.58 | 0.50 | 0.42 | 0.32 | 0.22 | 0.12 | 0.01 |

Table 6-2-5-2 Estimate of the Annual Maintenance Dredging Volume in unit of 1000 $m^3$ (From "Master Development Plan")

| Depth | N-S Channel+Curve | E-W Channel | Total |
|---|---|---|---|
| Channel width: 100m | | | |
| 10.0 | 2,210 | 294 | 2,504 |
| 10.5 | 2,613 | 553 | 3,167 |
| 11.0 | 3,028 | 861 | 3,890 |
| 11.5 | 3,455 | 1,209 | 4,664 |
| 12.0 | 3,890 | 1,596 | 5,486 |
| 12.5 | 4,340 | 2,081 | 6,421 |
| 13.0 | 4,803 | 2,679 | 7,482 |
| Channel width: 150m | | | |
| 10.0 | 2,875 | 420 | 3,296 |
| 10.5 | 3,360 | 778 | 4,138 |
| 11.0 | 3,851 | 1,190 | 5,042 |
| 11.5 | 4,348 | 1,645 | 5,994 |
| 12.0 | 4,849 | 2,143 | 6,993 |
| 12.5 | 5,362 | 2,769 | 8,132 |
| 13.0 | 5,885 | 3,540 | 9,426 |
| Channel width: 160m | | | |
| 10.0 | 3,008 | 446 | 3,454 |
| 10.5 | 3,509 | 823 | 4,333 |
| 11.0 | 4,016 | 1,256 | 5,272 |
| 11.5 | 4,527 | 1,733 | 6,260 |
| 12.0 | 5,041 | 2,253 | 7,294 |
| 12.5 | 5,567 | 2,907 | 8,474 |
| 13.0 | 6,101 | 3,713 | 9,815 |
| Channel width: 260m | | | |
| 10.0 | 4,338 | 699 | 5,038 |
| 10.5 | 5,003 | 1,272 | 6,276 |
| 11.0 | 5,662 | 1,913 | 7,576 |
| 11.5 | 6,315 | 2,606 | 8,922 |
| 12.0 | 6,960 | 3,348 | 10,308 |
| 12.5 | 7,612 | 4,283 | 11,895 |
| 13.0 | 8,266 | 5,435 | 13,702 |

## 6-3 Review on the Analysis of the Maintenance Dredging Volume in the Port Area

### 6-3-1 Calculation based on the Data of Experimental Dredging

The experimental dredging was carried out at the Foreport (Antepuerto) and the Basin 1 (Darsena 1), the situation of which are shown in Figure 6-3-1-1. Dredging monitoring survey was carried out on the following dates:

| | | |
|---|---|---|
| Foreport | Initial survey | October 20 and 23, 1986. |
| | Final survey | March 12 and 15, 1987. |
| Basin 1 | Initial survey | October 25 and 26, 1986. |
| | Final survey | March 11 and 12, 1987. |

Regarding the Foreport, the north part of the experimental dredging area suffered a slope sliding, so that only the result of the south part was thought to be *representative of the Foreport sedimentation process. This result is shown in* Figure 6-3-1-2 with the same definitions of K and Ce etc. as Figure 6-2-1-1 of the section 6-2-1.

That is, the parameters corresponding to this area were obtained as follows:

$K = 0.299\ (\text{year}^{-1})$ and $Ce = -5.23$(meters)

Regarding the experimental dredging at Basin 1, it was not possible to obtain any sufficiently reliable correlation between depth and shoaling thickness.

### 6-3-2 Calculation Based on the Information of Maintenance Dredging

An analysis based on the volume of maintenance dredging for the period 1979 to 1985 also was carried out in the same way as the mentioned in the section 6-2-2. This result is shown in Table 6-3-2-1.

Table 6-3-2-1

| | Shoaling Thickness A (meter/year) | Maintenance Depth Cd (meter) | Equilibrium Depth Ce (meter) | Coefficient K ($year^{-1}$) |
|---|---|---|---|---|
| Foreport | 1.16 | -10.4 | -3.0 to -5.0 | 0.160 to 0.220 |
| BASIN 1 | 1.21 | -10.3 | -3.0 to -4.0 | 0.168 to 0.195 |
| BASIN 2 | 1.10 | - 9.6 | -2.0 to -3.0 | 0.149 to 0.170 |

But in the above calculation it was difficult to evaluate natural equilibrium depths Ce due to the particular location, so that a series of estimated values was used instead of a single value. Moreover, the value of (t2-t1) in the equation (4) was taken as 0.25 $year^{-1}$ as well as in the Approach Channel.

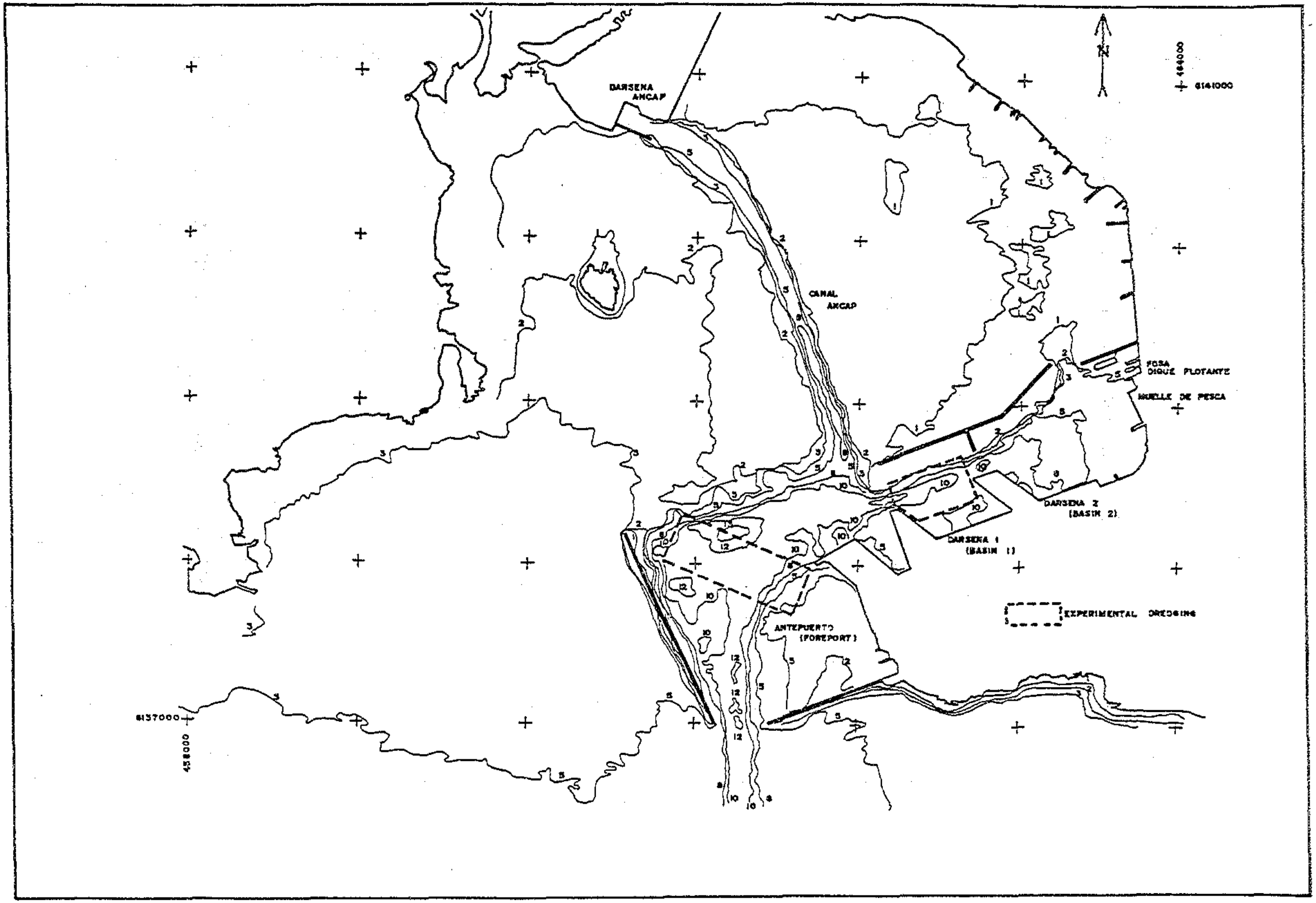


Figure 6-3-1-1 Area of the Experimental Dredging

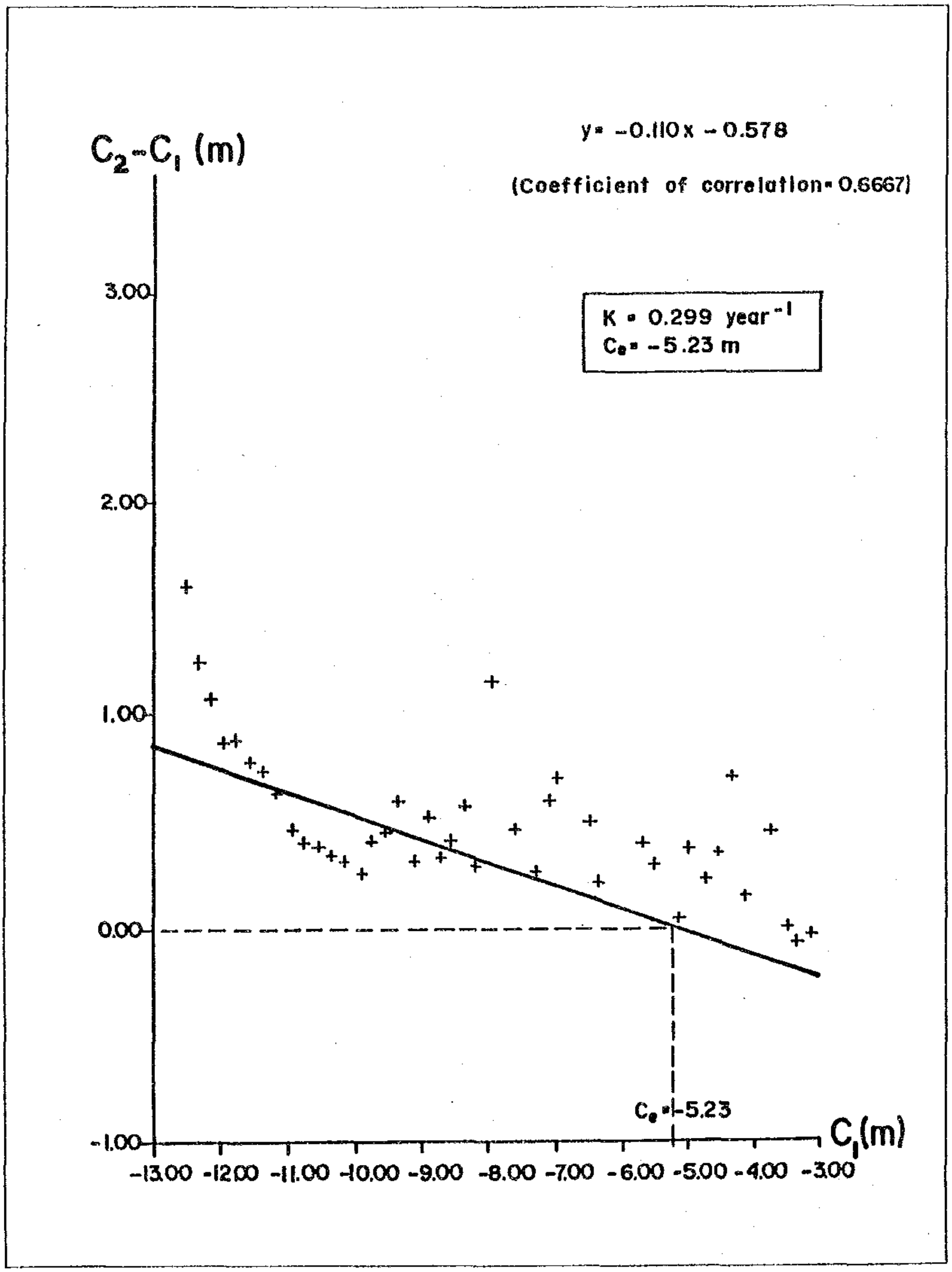


Figure 6-3-1-2 Result of the Experimental Dredging in the Foreport

### 6-3-3 Estimation of Shoaling Height

Once the parameter K and Ce were determined, it was possible to estimate the shoaling for different dredging depths Cd using the equation (4). The result is as follows, where "t2 - t1 = 0.25 year" means that the maintenance dredging is carried out every 3 months.

(1) Foreport

Table 6-3-3-1 Estimated Shoaling Thickness (meter/year)

| Cd (meter) | K = 0.299 Ce = -5.23 meters | K = 0.160 to 0.220 Ce = -3.0 to -5.0 meters |
|---|---|---|
| -10 | 1.38 | 1.10 to 1.07 |
| -11 | 1.67 | 1.25 to 1.28 |
| -12 | 1.96 | 1.41 to 1.50 |
| -13 | 2.23 | 1.57 to 1.71 |

(t2 - t1 = 0.25 year)

The parameters used in the above calculation were obtained from the experimental dredging and the analysis of maintenance dredging.

(2) Basin 1

Table 6-3-3-2 Estimated Shoaling Thickness (meter/year)

| Cd (meter) | K = 0.168 to 0.195 Ce = -3.0 to -4.0 meters |
|---|---|
| -10 | 1.15 to 1.14 |
| -11 | 1.32 to 1.33 |
| -12 | 1.48 to 1.52 |
| -13 | 1.65 to 1.71 |

(t2 - t1 = 0.25 year)

(3) Basin 2

Table 6-3-3-3 Estimated Shoaling Thickness (meter/year)

| Cd (meter) | K = 0.149 to 0.170<br>Ce = -2.0 to -3.0 meters |
|---|---|
| -10 | 1.17 to 1.17 |
| -11 | 1.32 to 1.33 |
| -12 | 1.46 to 1.50 |
| -13 | 1.61 to 1.66 |

(t2 - t1 = 0.25 year)

(4) Fishing Basin

Table 6-3-3-4 Estimated Shoaling Thickness (meter/year)

| Cd (meter) | K = 0.205<br>Ce = -1.5 meters |
|---|---|
| -5 | 0.65 |
| -6 | 0.83 |
| -7 | 1.02 |
| -8 | 1.20 |

(t2 - t1 = 1.0 year)

**6-3-4 Sedimentation Forecasts by Means of Overall Method**

In the sedimentation forecast of the port area were not used such sinusoidal tidal currents as in the Approach Channel, but were used the current velocities measured for the case of 50 cm tidal range in the physical model experiment.

The current velocities obtained in the physical model for the actual layout of the Foreport with 10.5 meters of water depth are shown in Figure 6-3-4-1, where each area is as follows:

Area 1: the entrance area of the Foreport surrounded by the West and Sarandi Breakwqaters.

Area 2: the part of the Foreport situated near to the extreme of the Fluvial Terminal.

Area 3: the area between the beginning of the ANCAP channel and the Roca Sabina.

Accordingly, erosion and sedimentation were calculated with the velocity V of Figure 6-3-4-1 for every five minutes using the following equations and were summed in order to obtain the annual shoaling thickness.

For erosion : $Me = -Mo((V/Vo)^2-1)\Delta t \quad (\Delta t = 5 \text{ minutes})$ (13)

For sedimentation : $Ms = CW(1-(V/Vo')^2)\Delta t \quad (\Delta t = 5 \text{ minutes})$ (14)

In the above calculation, the critical velocities Vo and Vo' were taken as 0.2 m/sec and 0.1 m/sec, respectively, similarly to the case of the Approach Channel.

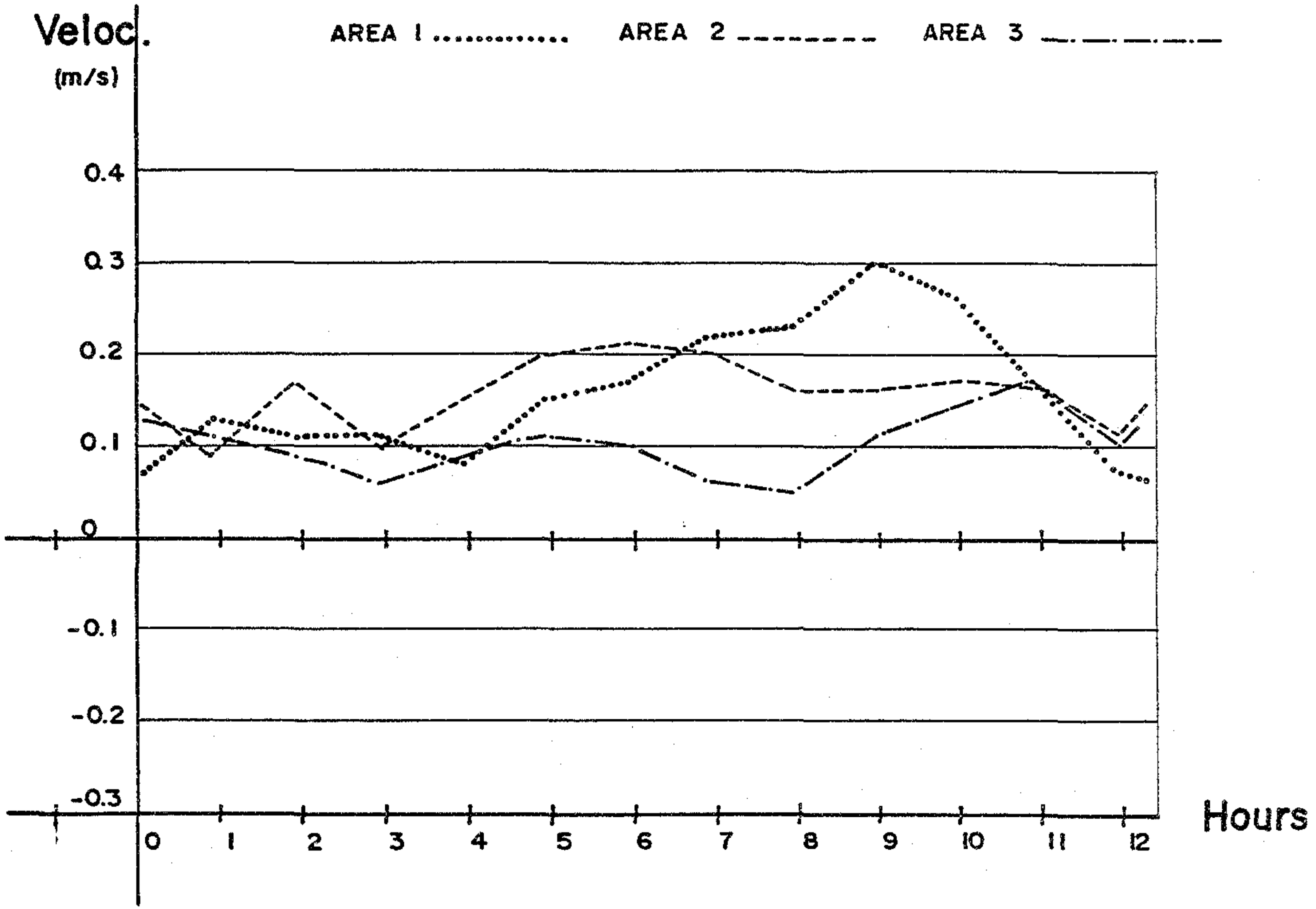


Figure 6-3-4-1 Velocities Measured in the Physical Model Experiment

The parameters in the equations (13) and (14) were determined taking account of the followings:

(1) The annual shoaling thickness at the Foreport is 1.16 meters for the maintenance dredging depth of 10.5 meters as mentioned in the section 6-3-2.

(2) The annual shoaling thickness at the natural equilibrium sea bottom is 1 cm.

Thus, the values of Mo was determined to be 3 x $10^{-8}$m/sec and the ratio of Mo and CW to be 0.14.

The annual shoaling thickness in meters of the actual condition, which was estimated by means of the above mentioned overall method, is shown as follows:

Table 6-3-4-1 Estimated Shoaling Thickness (m/year)

| Section | Cd=-10.5 meters | Cd=-11.5 meters |
|---|---|---|
| Area 1 | 0.73 | (0.99) |
| Area 2 | 1.16 | (1.41) |
| Area 3 | 1.46 | (1.46) |

For the case of - 11.5 meters of maintenance depth in the above table, the model experiment was not carried out, so that the current velocities were assumed to be the value of the velocity in the case of - 10.5 meters multiplied by 10.5/11.5.

Also the same estimations were carried out for the several alternative prolongations of breakwaters, which are shown in Table 6-3-4-2.

## Table 6-3-4-2 Annual Sedimentation Estimates in Meters

| | | 11.5m. DEPTH AT THE FOREPORT | | | 10.5m. DEPTH AT THE FOREPORT | | |
|---|---|---|---|---|---|---|---|
| | | AREA 1 Mouth | AREA 2 Foreport | AREA 3 ANCAP channel 1st stretch | AREA 1 Mouth | AREA 2 Foreport | AREA 3 ANCAP channel 1st stretch |
| Present sit | A0 | (0,99) | (1,41) | (1,46) | (0,73) | (1,16) | (1,46) |
| Short curved dock at West Dock and guide dock | A1 | 0,70 | 0,33 | 0,82 | (0,35) | (0,11) | (0,73) |
| Idem, without guide dock | A'1 | (1,04) | (0,33) | (0,82) | (0,75) | (0,11) | (0,73) |
| Straight dock at West Dock and guide dock | A2 | 0,63 | 0,28 | 0,88 | (0,27) | (0) | (0,74) |
| Idem, without guide dock | A'2 | (1,04) | (0,28) | (0,88) | (0,68) | (0) | (0,74) |
| Long curved dock at West Dock and guide dock | A3 | 0,04 | 0,17 | 0,78 | (-0) | (0) | (0,46) |
| Idem, without guide dock | A4 | 0,80 | 0,29 | 0,78 | (0,48) | (0,03) | (0,46) |
| Present solution plus mouth breakwaters | A5 | 1,71 | 0,63 | 1,46 | (1,47) | (0,35) | (1,29) |

NOTES:
1) It is admitted in solutions A'2 that velocities at the mouth decrease by 10%
2) Values between brackets have been calulated estimatting a velocity increase due to the reduction in depth. The remaining values are based on the model measurements.
3) The -0 values mean that there might be erosion, but it is not taken into account in the evàluation.
4) In all corner areas (where there are no strong currentts) a 0.70 m sedimentation is estimated.

### 6-4 Consideration

The rationality of the estimates of the maintenance dredging volume in the Master Development Plan, which have been briefly reviewed in the foregoing sections, will be checked herewith referring to the recent data of dredging volumes.

### 6-4-1 Estimation of the Maintenance Dredging for the Approach Channel

The maintenance dredging thickness has been estimated by means of thesemiempirical formula on the basis of the data of the experimental dredging in the distant area and the information of maintenance dredging volume in the nearby area as shown in Section 6-2-3. But, it does not seem to be reasonable that the estimated shoaling thickness is larger in the distant area than in the nearby area, against the same values of Ce and Cd.

But, if it is considered that the work of the experimental dredging was done only one time and only during 0.3 years, the above contradiction is not so much important, but the small difference between the both estimated values serves to show that the values of K obtained are not far from the real actual one.

*Regarding the estimate by the overall method, at first, it is necessary to* make clear the meaning of each parameter.

The rates of erosion and sedimentation were expressed as follows:

For the erosion : $dm/dt = -Mo(J/Jo - 1)$

For the sedimentation : $dm/dt = CW(1 - J/J\acute{o})$

If m is taken as the thickness of the mud deposited at the sea bottom, the dimension of Mo become L/T where L is the representative length and T is the representative time. Also if C is taken as the product of the concentration of volume of pure mud suspended in the water and 1/(1 -r), where r is the void ratio of the mud when the mud exists at the bottom, C does not have dimension and CW is of L/T in dimension.

There are suppositions from (1) to (5) in the end of the section 6-2-4 which were used for the calculation of the values in Table 6-2-5-1. But, the value of CW was not shown, so that it will be estimated using the equations (8) and (11) under the supposition (5).

From the supposition (5),

Ce = -5.5 meters, Cd = -10.5 meters and A = 2.08 meters

Thus, in Figure 6-2-5-1, the value of V2/V1 is obtained to be 0.52 for the case of $\alpha$ = 90 degrees and d2/d1 = Cd/Ce = 1.909. Moreover, from the supposition (1), the value of V1 is 0.42 m/sec. Accordingly, taking account of the supposition (2), the values of parameters in the equation (8) become as follows:

$V' = V1 \times 0.52 = 0.42 \times 0.52 = 0.218$ m/sec

From $Vo = V'\sin\theta$

$\theta = \arcsin(Vo/V') = \arcsin(0.2/0.218) = 1.161576$ (radian)

$K = (V'/Vo)^2 = (0.218/0.2)^2 = 1.1881$

Substituting the above values, T = (12.42 x 60 x 60 ≑ 44,700 seconds and Mo = 2.43 x $10^{-8}$ m/sec of the supposition (4) in the equation (8),

$$Me = -(2T/\pi)Mo[(K/2 - 1)(\pi/2 - \theta) + (K/4)\sin 2\theta]$$

$$= -(2 \times 44{,}700 \times 2.43 \times 10^{-8}/\pi)[((1.1881/2)-1)(\pi/2 - 1.161576)$$

$$+ (1.1881/4)\sin(2 \times 1.161576)]$$

$$= -3.507945 \times 10^{-5} \text{ (meters)}$$

Also, taking account of the supposition (3), the values of parameters in the equation (11) become as follows:

$\theta' = \arcsin(Vo'/V') = \arcsin(0.1/0.218) = 0.458716$

$K' = (V'/Vo')^2 = (0.218/0.1)^2 = 4.7524$

Substituting those values in the equation (11),

$Ms = (2T/\pi)CW[\theta'(1 - K'/2)+(K'/4)\sin 2\theta']$

$= (2x44,700/\pi)CW[0.458716(1-4.7524/2)+(4.7524/4)\sin(2x0.458716)]$

$= 8,871.2394$ CW (meters)

Accordingly, taking account of the supposition (1), from the equation (12),

$705\ (-3.507945 \times 10^{-5} + 8,871.2394\ CW) = 2.08$

Therefore,

$CW = 3.4 \times 10^{-7}$ (m/sec)

Now that the value of CW has been determined, the value of shoaling thickness in Table 6-2-5-1 can be checked. For example, in the case of that Ce = -8 meters and Cd= -11 meters in the North-South Channel,

$d2/d1 = 11/8 = 1.375$ and $\alpha = 90$ (degrees)

Then, from Figure 6-2-5-1, $V2/V1 = 0.73$

Therefore, $V' = 0.42 \times 0.73 = 0.307$ (m/sec)

Accordingly, Me and Ms are obtained by the equations (8) and (11) as follows:

$Me = -5.087316 \times 10^{-4}$ meters, $Ms = 2.124145 \times 10^{-3}$ meters

Then, the annual shoaling thickness A becomes as follows:

$A = 705(Me + Ms) = 705(-5.087316 \times 10^{-4} + 2.12415 \times 10^{-3})$

$= 1.14$ meters

This value of A is nearly equal to 1.15 meters for Ce = 8 meters and Cd = -11 meters in Table 6-2-5-1.

Moreover, the case of Ce = -10 meters and Cd = -12 meters in the West-East Channel can be calculated as follows:

With d2/d1 = 12/10 = 1.2 and $\alpha$ = 8.5 degrees, from Figure 6-2-5-1, V2/V1 is obtained to be 0.9. Therefore,

$V' = 0.42 \times 0.9 = 0.307$ (m/sec)

Accordingly, Me and Ms are calculated as follows:

$Me = -1.105269 \times 10^{-3}$ (meters), $Ms = 1.718612 \times 10^{-3}$

Therefore,

$A = 705 \times (-1.105269 + 1.718612) \times 10^{-3}$

$= 0.43$ (meters)

This value of A is nearly equal to 0.45 meters in Table 6-2-5-1.

Next, the annual maintenance dredging volume in Table 6-2-5-2, which was estimated on the basis of the shoaling thickness of Table 6-2-5-1, will be compared with the information of ANP about the actual maintenance dredging volumes in the channel during recent years.

At present, the width of Approach Channel is 200 meters in the N-S Channel and 100 meters in the W-E Channel, and its maintenance depth is approximately 10.5 meters. Therefore, the estimate of the present maintenance dredging volume per year is obtained from Table 6-2-5-2 as follows:

(1) N-S Channel (width = 200 meters, depth = -10.5 meters)

From the values of 160 meters and 260 meters in width

$$[3,509 + \frac{(5,003-3,509)}{(260-160)} \times (200 - 160)] \times 10^3 = 4,107 \times 10^3 \ m^3$$

(2) W-E Channel (width = 100 meters, depth = -10.5 meters)

$553 \times 10^3 \ m^3$

Accordingly, total estimate volume Ve is:

$$Ve = (4,107 + 553) \times 10^3$$

$$= 4,660 \times 10^3 \ m^3$$

This volume becomes $4,660 \times 10^3 / 0.8 = 5,825 \times 10^3 \ m^3$ for the dredging volume of hopperdredgers.

On the other hand, the recent information is shown in Table 6-4-1-1. It is seen that the annual dredged volume is from $6,000 \times 10^3$ to $4000 \times 10^3 \ m^3$ during from 1987 to 1984 and in 1981, though the mean value is less than $5,825 \times 10^3 \ m^3$.

After all, the estimate of annual maintenance dredging volume which has been written in the report of "Master Development Plan" has been confirmed to be very reasonable, although the estimation seems to be a little larger than the actual average dredged volume.

Table 6-4-1-1 Annual dredging volume in the recent years in cubic meters
(From the information of the Oficina Tecnica De Dragado, ANP)

| Year | Approach Channel | Foreport | Basin 1 | Basin 2 | Fishing Basin |
|---|---|---|---|---|---|
| 1990 | 3,726,840 | 630,265 | 110,714 | 553,721 | |
| 1989 | 1,894,145 | 2,304,900 | | 162,000 | |
| 1988 | 2,380,350 | 1,275,812 | 305,440 | 710,103 | |
| 1987 | 5,928,525 | 1,310,700 | 287,954 | 50,747 | |
| 1986 | 4,059,389 | 3,712,579 | 257,650 | | |
| 1985 | 4,497,455 | 2,594,530 | 42,071 | 80,500 | |
| 1984 | 5,325,403 | 1,481,817 | 229,536 | 40,715 | |
| 1983 | 2,437,690 | 2,485,701 | 33,739 | 342,012 | 62,710 |
| 1982 | 3,176,663 | 2,029,609 | 278,742 | 653,842 | 75,814 |
| 1981 | 4,598,511 | 3,256,368 | 334,656 | 231,346 | 12,769 |
| mean | 3,802,497 | 2,108,288 | 188,050 | 282,498 | |

### 6-4-2 Estimation of the Maintenance Dredging Volume for the Foreport

Regarding the Foreport, the maintenance dredging thickness A for the maintenance depth -10.5 meters is calculated by the equation (4) using the parameters obtained by the experimental dredging as follows:

$K = 0.299\ year^{-1}$, $Ce = -5.23$ meters and $Cd = -10.5$ meters

$$A = (Ce-Cd)(1 - e^{-K(t2-t1)})/(t2 - t1)$$

$$A = (-5.23 - (-10.5))(1 - e^{-0.299 \times 0.25})/0.25$$

$$= 1.52 \text{ meters}$$

Moreover, the area of the Foreport is seen to be about $1,300 \times 10^3\ m^2$ from Table 6-2-2-1. Therefore, the annual maintenance dredging volume V can be calculated as follows:

$$V = 1.52 \times 1,300 \times 10^3 = 1,950 \times 10^3\ m^3$$

This volume is converted in $1,950 \times 10^3 / 0.8 = 2,438 \times 10^3\ m^3$ for the dredging volume. It is near to the value of 2,108,288 $m^3$ in Table 6-4-1-1, which is the mean annual volume dredged at the Foreport.

On the other hand, the calculation by the overall method resulted in the following values of A as shown in Section 6-3-4.

For the Area 1 : 0.73m
For the Area 2 : 1.16m

But the extent is not clear for the Area 1 and 2. If the ratio of the extent of the Area 1 against the Area 2 is supposed to be 1/3, the annual maintenance dredging volume V becomes as follows.

$$V = 0.73 \times 1,300 \times 10^3 \times 1/3 + 1.16 \times 1,300 \times 10^3 \times 2/3$$

$$= 1,321,666\ m^3 /year$$

This volume is converted in 1,652 x $10^3$ $m^3$ for the dredging volume, which is also near to the value in Table 6-4-1-1. Therefore, it is reasonable to estimate by the above two methods though the semi-empirical equation(4) give a little larger volume than the actual one and the overall method give a little smaller one.

# 7 BRIEF CONSIDERATION OF FUTURE DEVELOPMENT CONCEPT

## 7-1 Purpose of Consideration

The purpose of the whole study is to conduct a feasibility study of main port facilities (Grain terminal, Fishing terminal) up to the year of 1998. However, it is important to formulate a plan for these facilities based on the long prospect of the development of the Port, analyzing present problems.

It is necessary to confirm the future development concept of the Port to avoid discord between the plan of these main port facilities and the long term development direction of the Port.

There is a Master Plan formulated in 1987. This consideration is conducted briefly, taking account of the development direction shown in the Master Plan.

## 7-2 Items to Be Solved in the Port of Montevideo

It is possible to point out some items to be solved, considering the present situation of the Port.

### 7-2-1 Low Efficiency of Cargo Handling

There are several points explaining the low efficiency of cargo handling. Brief description of them is as follows:

(1) Discord between Ship-side and Land-side Operation

Land-side operation is carried out by ANP, while shipside operation is conducted by ANSE. Since there is a lack of full coordination between them, discrepancies as in the difference of cargo handling speed sometimes arise. As a result, operation of cargo handling is delayed.

(2) Unusually High Berth Occupancy Rate

Table 7-2-1-1 shows the berth occupancy rate of every berth in 1990. There are some possibilities that these data are rather high owing to miscalculation of statistic data. There are many berths where this rate is more than 100%. This means either full occupancy of berth all throughout the year or simultaneous mooring of more than two vessels at the same berth. It is misleading to understand that high berth occupancy rate means long waiting time of the cargo vessels. Rather, it causes fishing vessels to change berth when other vessel enters. Anyway, this high berth occupancy rate is assumed to occur partly because of low efficiency of cargo handling. As cargo volume to be handled in the Port will increase in future, this situation will cause a serious problem for handling main commodities for the Port.

Table 7-2-1-1 Berth Occupancy Rate(1990)

Unit: Hours, %

| Berth | Escala | Maciel | No.1 | No.2 | No.3 | No.4 | No.5 | No.6 | No.7 | No.8 | No.9 | No.10 | No.11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Hour | 17835 | 17702 | 17681 | 12734 | 5659 | 8265 | 5936 | 12833 | 16837 | 18757 | 15087 | 26294 | 101854 |
| Berth Occupancy Rate | 203.6 | 202.1 | 201.8 | 145.4 | 64.6 | 94.3 | 67.8 | 146.5 | 192.2 | 214.1 | 172.2 | 300.2 | 1162.7 |

Source: ANP

(3) Small Volume of Cargo Handled at the Berth

The total cargo volume handled at the Port was 2,067,632 tons in 1990. If it is assumed that all the cargo except for container and liquid bulk was handled at berth from deposit 1 to 11 (Hereinafter, these berths will be referred to as No.1, No.2 etc.), the cargo volume handled per meter is calculated at 471 tons as the volume handled at these berths would be about 852 thousand tons. It is evaluated as low since bulk cargoes are also included in this cargo volume.

(4) Low Rate of Working Hour of Crane

It is understood that a large number of cranes are installed at every berth in this port. However, these cranes are not fully used now, instead, ship's gear is used in many cases. Generally speaking, the working rate of dock side crane is low, resulting in a long waiting time. Table 7-2-1-2 shows rate of working hour of dock side crane during the period from January to March in 1987. According to this table, repairing time is somewhat long, but not so long as to disturb the main work. Main problem to be solved is the low rate of working hours of crane.

Table 7-2-1-2 Rate of Working Hour of Dock Side Crane

Rate of Working Hour of Dock Side Crane

| Make | No. | Working Hour | Repairing Hour | Waiting Hour | Working Hour Rate | Repairing Hour Rate | Waiting Hour Rate |
|---|---|---|---|---|---|---|---|
| Demag | 16 | 1,128.00 | 3,068.00 | 11,196.00 | 7.3% | 19.9% | 72.7% |
| Scoda | 8 | 458.70 | 1,479.00 | 5,758.30 | 6.0% | 19.2% | 74.8% |
| Duro | 14 | 1,617.10 | 2,873.00 | 8,977.90 | 12.0% | 21.3% | 66.7% |
| Takraf | 6 | 570.85 | 492.00 | 4,709.15 | 9.9% | 8.5% | 81.6% |
| Total | 44 | 3,774.65 | 7,849.00 | 30,704.35 | 8.9% | 18.5% | 72.5% |

Note: Working hour rate, repairing hour rate and waiting hour rate are calculated as follows:
Workable hour= working hour+repairing hour+waiting hour
Workable hours per one crane=962 Hrs(72 days x 13 Hrs/day)
ex) Working hour rate = working hours/ 962

(5) Low Utilization of Refrigerating Warehouse

This facility was constructed for promoting export of refrigerated or frozen cargoes, especially meat. At present, however, only small volume of cargo is stored.

### 7-2-2 High Berth Occupation of Fishing Vessels

There are many foreign fishing vessels calling at the Port of Montevideo. The main objective of their visiting at the Port is not only unloading their catch, but also refueling, resting, receiving water and so on. There is a lack of facilities for accommodating fishing vessels in the Port. The high berth occupancy rate is caused by foreign fishing vessels' use of general cargo berth for their mooring. Table 7-2-2-1 shows berth occupancy rate of No.1 to No.9 berths in the duration from July to September in 1991. It is understood that fishing vessels occupy the berth for a long time.

Table 7-2-2-1 Berth Occupation of Fishing Vessels

Unit: %

| | No.1 | No.2 | No.3 | No.4 | No.5 | No.6 | No.7 | No.8 | No.9 |
|---|---|---|---|---|---|---|---|---|---|
| With Fishery Vessel | 134.8 | 108.5 | 76.8 | 60.5 | 74.9 | 75.4 | 213.2 | 108.9 | 163.3 |
| Without Fishery Vessel | 73.0 | 46.1 | 74.3 | 50.8 | 58.3 | 73.1 | 211.3 | 73.4 | 90.3 |

### 7-2-3 Containers Overflowed into All Areas of the Port Other Than Container Terminal

There are many containers stacked in various parts of the port area. It is very important to administrate containers adequately for efficient cargo handling. This item will be solved by the improvement of the container terminal.

### 7-2-4 The Need for a Port Development Strategy

The Port of Montevideo is a port of long history. Many facilities are left in old-fashioned situations and many improvement works have to be carried out. Unfortunately, however, it seems that there is a lack of strategy to guide the improvement of the Port. It is necessary to formulate some strategies to develop this port.

## 7-3 Basic Functional Allotment in the Bay

### 7-3-1 Basic Functions of the Port

Roles expected to be played by the Port of Montevideo are as follows:

(1) Base Port for Import/Export of Cargo in Uruguay

The Port of Montevideo is virtually the only international trading port in Uruguay. This role should be maintained and enhanced.

(2) Transshipment Base Port for Cargo from/to La Plata River Basin

The port is located at the mouth of the River of La Plata. This location provides several advantages from sea transportation point of view. For one thing, it is easier to maintain a sufficient depth than at other ports in La Plata river basin, and for another, it is possible to reduce transportation cost of main vessels by using this port as a transshipment base.

(3) Base Port for Foreign Fishing Vessels Operating in the South Atlantic Ocean

The South Atlantic Ocean is famous for richness of fishing resources. Nowadays there are many foreign fishing vessels operating in this sea area. Some of them use this port for transshipment of cargo, refueling, water receiving and so on.

(4) Base Port for Domestic Fishing Boat

Fishing industry is one of the important industries in Uruguay. Fishing port is a fundamental base of the fishing industry.

(5) Others (ship repairing, passenger traffic and bunkering)

### 7-3-2 Functional Allotment

Although the functional allotment is not specifically described in the Master Plan, it can be assumed from the layout plan of the port facilities as follows:

(1) North east zone

Ship repairing, Basin for ANP ships

(2) East zone

Fishing port

(3) Central zone

Commercial port (Conventional vessels, Cargo-passenger vessels)

(4) Foreport zone

Container terminal, Naval base

Three zones are to be allocated for expansion, i.e., the north-east zone for ship repairing, the east zone for fishing activity and the foreport zone for container terminal. As the Port of Montevideo has a long history, it has a lot of facilities. It is normal to make an effort to use existing facilities more, and also, it is important to gather similar functions or related functions together. Therefore, it is appropriate to consider future functional allotment respecting existing layout of port facilities.

There are some limits for future development within the existing port area. Especially, it is difficult to secure enough space for accommodating large ships within Basin I and Basin II. At the same time, however, there are some areas which are not fully used even in Basin I and Basin II. Therefore, the foreport area is suitable to construct port facilities for accommodating large ships such as container ship. On the other hand, it is possible to develop small port facilities in the basin.

From the above, selection of these three zones for future development is appropriate.

For the further long term development, two areas would be considered, i.e., within the Montevideo Bay and out of the Bay.

(1) Area within the Bay

Since the coastal line of the Bay is not extensively used except for port activity, it is possible to secure enough development space within the Bay. At the same time, however, it is important to coordinate fully with other required spaces such as that for city living activity.

A water depth sufficient to accommodate large vessels is indispensable for future port development. Accordingly, it is necessary to establish countermeasures against sedimentation of the River of La Plata. Fundamental idea of this measure is to construct a breakwater at the mouth of the Bay. However, the construction of the breakwater will bring the closed water area in which water exchange with outer sea area is limited. As a result, water in the Bay will be polluted more than at present, in spite of the positive effects expected against sedimentation from the River of La Plata. Consideration should be given anti-water pollution measures.

(2) Area beyond the Bay

This is an idea whereby future port development is conducted south of Sarandi Breakwater. In this case, it is necessary to construct a breakwater as a countermeasure against both waves and sedimentation. Initial cost for dredging will be cheaper because of short distance to deeper area. This idea also will bring fewer environmental problems because of the small closed area.

## 7-4 Rough Evaluation of Handling Capacity of General Cargo Berth

Commercial port function is divided into two categories: cargo and passenger. Since it is expected that passenger traffic volume will not increase greatly, a study on passenger traffic is not made. Regarding cargo traffic, container cargo handling is not included in this study. Therefore, objective type of cargo is general cargo and dry bulk cargo, including transshipment cargo. These cargoes are assumed to be handled at the berths from deposit 1 to 11. In this section, a very rough evaluation of handling capacity of general cargo berths is carried out.

### 7-4-1 Trend of Export/Import Cargo Volume in Montevideo Port

(1) General

This paragraph describes the future trend of export/import cargo volume at Montevideo port in consideration of long term development concept.

Demand of cargo handling volume in 1998 is estimated at 2,044,000 tons as stated in chapter 1 Part II. Demand in 2010 will be 3,463,000 tons according to same process used to calculate the volume in 1998. Cargo handling volume by cargo type in 2010 is shown in Table 7-4-1-1.

Table 7-4-1-1 Cargo Handling Volume in 2010 at Montevide Port

1,000tons

| | Solid Bulk | General | Container | Total |
|---|---|---|---|---|
| Export | 544 | 259 | 747 | 1,550 |
| Meat & Related products | | 31 | 137 | 168 |
| Fish | | 13 | 57 | 70 |
| Agricultural products | 509 | 86 | 383 | 978 |
| Wool | | 12 | 52 | 64 |
| Chemical products | 35 | | | 35 |
| Wood | | 91 | | 91 |
| Others | | 26 | 118 | 144 |
| Import | 410 | 147 | 218 | 775 |
| Manufacture | 398 | 75 | 112 | 585 |
| Agricultural Products | 12 | 32 | 47 | 99 |
| Others | | 40 | 59 | 99 |
| Transit | 0 | 306 | 832 | 1,138 |
| International | | 306 | 628 | 934 |
| Domestic | | 204 | | 204 |
| Total | 954 | 712 | 1,797 | 3,463 |

(2) Container Cargo

Since the inauguration of international container transportation in 1966 between North American and Europe, the containerization of maritime cargoes has progressed rapidly not only in developed countries but also in developing countries. Container port traffic has increased continuously for 25 years. Montevideo port is no exception to his trend. Therefore, ratio of container will almost reach its maximum level. Transit cargo will also show the same trend.

(3) Grain Cargo from Up River Port

There are some up river ports in Paraguay, Argentina and Bolivia. This study only deals with Argentine grain export through the Montevideo port. However, if production volume of grain could be improved, export volume of grain in Paraguay and Bolivia would also be increased through the Montevideo port. In any case, this grain transportation system depends on transportation and economic condition of Argentina, Paraguay and Bolivia. If the economic condition of these countries takes a turn for the better and MERCOSUR is ratified, there will be a positive effect on Uruguay.

Volume of grain(soybean, soybean meal, sorghum and maize) through the Montevideo port will be more than 3,000,000 tons in 2010.

### 7-4-2 Premises of Calculation

To solve problems mentioned in 7-2, several countermeasures should be taken. Concerning general cargo berth, several kinds of remodeling work are in progress and other countermeasures are planned for the future, following recommendations proposed in the Masterplan study. These countermeasures include the removal of obsolete warehouses, enlargement of apron width, overlaying stone-paved inner port road and so on, all of which are financed by the World Bank. During the construction phase, technical assistance and training for port operation will be given. Meanwhile, all cargo handling will be performed by private sectors in stead of ANSE and ANP after the new port law comes into force.

Therefore, it is expected that cargo handling efficiency will progress by these improvement measures. However, it is a fact that cargo handling efficiency will not improve easily. What percentage of improvement can be expected? It is very difficult to measure the extent of improvement that each measure will bring. Considering the fact that the productivity at the Port of Montevideo, generally speaking, is low, it is not difficult to improve the situation; a rather high rate of improvement would be expected. The following premises are assumed for the rough estimation of handling capacity of general cargo berth in future taking account of the target value of improvement described in the report of the World Bank.

| | Present | Future |
|---|---|---|
| Productivity(t/h) | | |
| General Cargo | 34.5 | 44.85 |
| Dry Bulk | 87.8 | 114.14 |

There are several methods to determine berth capacity. Here, the method using the productivity of berth is applied. According to the report of UNCTAD, it is recommended that berth occupancies for conventional general cargo operations should be set so as not to exceed figures listed below:

| Number of Berth | Recommended Maximum Berth Occupancy |
|---|---|
| 1 | 40 |
| 2 | 50 |
| 3 | 55 |
| 4 | 60 |
| 5 | 65 |
| 6 ~ 10 | 70 |

These figures are used in this examination. Namely, capacity is assumed to be reached at that period when berth occupancy reaches its maximum level.

### 7-4-3 Rough Capacity Calculation

(1) General Cargo Berth

Handling cargo volume per conventional vessel is calculated using data in 1988, the year in which the greatest volume of cargo was handled in the Port. Total general cargo volume is calculated excluding container, liquid bulk and solid bulk cargo. Vessel number is calculated by summing up that of conventional vessels, semicontainer vessels, refrigerating vessels and so on. Accordingly, handling cargo volume per vessel is calculated at 945.5 tons. Annual number of workable days is set at 298 days excluding Sundays and holidays. And also working hours per day is set at 10 hours excluding non-working time. Based on these premises, necessary days for berthing per vessel will be 2.396 days, including non-handling time of 0.2 days at berth. Accordingly, capacity of general cargo berth, which is assumed to be composed of 9 berths excluding No.6, No.7 berth, is calculated at 772,000 tons.

(2) Solid Bulk Cargo Berth

Handling cargo volume per bulk carrier is calculated at 8185.5 tons, using data from 1988. Handling of solid bulk cargo is often done continuously and working hours are normally longer than that of general cargo. Therefore, workable hours are set as 12 hours. Based on these premises, necessary days for berthing per vessel will be 6.176 days. Accordingly, capacity of solid bulk cargo berth(No.6, No.7 berth) is calculated at 395,000 tons.

(3) Allocation of Cargo to be Handled in 2010

Cargo volume to be handled in 2010 is 712,000 tons of general cargo and 433,000 tons of solid bulk cargo. Accordingly, berths No.1 through 11 except No.6 and 7 would be always available for handling general cargo. Since the capacity of these 9 berths is more than estimated cargo volume, foreign fishing vessels sometimes can use these berths. Solid bulk cargo would be handled at No. 6 and 7. Some of solid bulk cargo will be handled at general cargo berths or at the top of wharf B.

## 7-5 Brief Comment on Other Facilities Proposed by Master Plan

### 7-5-1 Petroleum Product Berth

This petroleum product berth is planned for reducing dredging volume for maintaining the depth of ANCAP channel. This volume is not small and it is very important to reduce that volume for securing financial soundness of ANP. Therefore, the petroleum product berth was planned inside the Cintura breakwater where the depth is maintained mainly by the breakwater.

As described in 3-2-1 of Part I, crude oil is transported by pipe line from Jose Ignacio. The existing berth which is located in front of the refinery plant of ANCAP is used mainly for sending off petroleum product to river ports in Uruguay by using small boats. The sizes of vessels being used now are shown in Table 7-5-1-1. Transport operation of product oil to the river port is carried mainly by ANCAP vessel approximately 8 times a month. The draft is very small and enlargement of the vessel size will not be assumed in near future. ANCAP itself does not have any plan to introduce a bigger vessel for achieving the present activity. Though certain vessels, whose maximum drafts are more than 9m, occasionally enter the port (8 times in 1991), their number is not expected to increase.

The place where the berth was planned is a passage for vessels, in a sense. Though the width of it is sufficient at present, it is supposed that a wider area will be required by the activation of port activities.

From these considerations, it can be said that the construction of the berth does not have a high priority and high urgency, though it is necessary. In the case of construction, it is necessary to put this berth close to the breakwater as much as possible so as not to hinder other vessel's passage in front of it.

Table 7-5-1-1 Main Vessels for ANCAP

| Name | GRT (t) | DWT (t) | Length (m) | Draft (m) | Owner |
|---|---|---|---|---|---|
| ANCAP NOVENO | 2516.43 | 3,220 | 104.00 | 4.3 | ANCAP |
| VALIENTE | 69.384 | 1,085 | 52.00 | 5.0 | Agent |
| TRAMACO I | 413.78 | 450 | 43.10 | 3.0 | Agent |
| COPEMAR I | 783.46 | 1,750 | 72.74 | 4.8 | Agent |
| DERTA CRUZ | 226.44 | 280 | 29.00 | 4.6 | Agent |

Source: ANCAP

### 7-5-2 Naval Base

The present naval base is located on the east side of Maciel Wharf. This area was planned to be used for container feeder vessels in the Master Plan and, as a result, the naval base was planned to be moved to the foot of the Sarandi breakwater.

Container cargo volume has grown rapidly and the development of the container terminal is one of the most urgent projects in the Port of Montevideo. Establishment of the feeder berth is assumed to be an important measure for smooth container handling. Therefore, the moving of the naval base is inevitable for the development of the Port.

In the Master Plan study, site selection study for the naval base was conducted among mainly two alternatives, i.e., foot of the Sarandi breakwater and the vicinity of the Uruguayan Navy Base at Punta Lobos. The former site was selected because it requires less initial and maintenance dredging cost. This site is at the mouth of the port and within the foreport. As already examined, the foreport zone is designated as future development zone. Accordingly, it is considered that this area is not good for the construction of the naval base. However, it is a fact that there are not any other areas suitable for the naval base that do not involve substantial construction costs.

Therefore, this area would be selected for the site of the naval base.

### 7-5-3 Ship Repairing Area

According to the Master Plan, three units of floating dock (one of them is possible to accommodate a vessel up to 165 m long) and two platforms (one is for a vessel more than 40m till 90 m, another for less than 40m) were planned at the north-east of the Port which is covered with two breakwaters, Pier F and coastal line.

Private ship repairing company, Tsakos S.A., introduced a new floating dock whose capacity and length are 20,000 ton, 200m in 1989. Accordingly, it means that one part of the Master Plan was already implemented.

Ship of 356,000 tons in total (about 200 ships, one third of them is fishing boat) was repaired in 1991 by Tsakos. The business is in fine condition and the working rate is high. Therefore, it is expected that ship repairing business will expand in future. However, more examination is necessary to confirm the demand for ship repairing facilities proposed by the Master Plan.

As examined briefly before, it is considered appropriate that the north-east part of the port be developed for such kinds of activity. For the development of this area, it is necessary to have sufficiently large basin area for working and water pollution countermeasures such as installation of water way.

# II SHORT TERM DEVELOPMENT PLAN OF MAIN PORT FACILITIES

# 1 DEMAND FORECAST

This chapter describes projection of socioeconomic activity such as GDP and population, and export and import volume up to the year 1998. Also, transit cargo volume and grain cargo volume from La Plata River basin is forecast. Passenger traffic projection is not carried out in accordance with the suggestion of ANP.

## 1-1 Forecast of Socioeconomic Activities

### 1-1-1 Gross Domestic Product

Annual growth rate of gross domestic product is 2.59 % between 1983 and 1990. According to The Oficina de Planeamiento y Presupuesto (OPP), growth rate of gross domestic product will stay around 2.59 % in the near future. Port traffic study by Intecsa and Hidrovia Paraguay-Parana Estudio De Factibilidad Economica also assumed 3 % as the maximum, and 2 % as the minimum value of growth rate of GDP till 2000 and 2010. In this study, assuming that growth rate of GDP is 2.5 %, taking into account the above mentioned results of projections, GDP by sector is calculated by each sector's elastic value to total GDP. GDP in target year (1998 and 2010) is calculated as shown in Table 1-1-1-1. However, GDP of fishery sector is assumed separately. In this study, growth rate of fishery sector is assumed 1 %.

Table 1-1-1-1 GDP Projection

Unit:Million N$

| Class of Economic Activity | 1990 | 1998 | 2010 |
|---|---|---|---|
| Agricultural & Stock | 23,674 | 24,879 | 26,558 |
| Fishery | 257 | 276 | 306 |
| Quarry & Mining | 358 | 370 | 384 |
| Manufacture | 54,750 | 66,621 | 88,609 |
| Electrical, Gas & Water | 7,426 | 9,757 | 14,561 |
| Construction | 6,165 | 8,401 | 13,241 |
| Comerce | 23,961 | 27,378 | 33,133 |
| Transport & Comunication | 14,354 | 20,086 | 32,948 |
| Others | 78,802 | 97,789 | 133,955 |
| Total | 209,747 | 255,556 | 343,695 |

### 1-1-2 Population

DGEC (Direccion General de Estatistica y Censos) conducted forecasts of population for every five year period from 1985 to 2025 in Uruguay. In this projection, population of Uruguay is 3,452,544 in 2010. However, there are some differences between the population value of DGEC and the result of the census in 1985. Therefore, the study team has made some adjustment.

Table 1-1-1-2 shows population projection.

Table 1-1-1-2 Population Projection

| Year | 1985 | 1998 | 2010 |
|---|---|---|---|
| Population | 2,955,200 | 3,181,835 | 3,391,638 |

## 1-2 Export

### 1-2-1 General

The study team forecast export cargo volume by commodity based on classification of N.A.D.E.. Study team divided cargo into seven classes, namely meat and related products, fish, agricultural products, wool, chemical products, wood and "others".

Group of "meat and related products" consists of live animals and related products, food products, hide/leather and related products. Almost all these commodities consist of beef and its related products such as dairy products and corned beef etc..

"Agricultural products" consists of vegetable products and oil (animal and vegetable).

Textile materials will be designated as "wool", because the main commodity of textile material is wool.

"Chemical products" consists of chemical products and plastic materials.

"Wood" consists of wood and coal. Export of "wood" has almost exclusively consisted of eucalyptus in the last three years.

Commodities with very small volumes are grouped together under the heading of "others".

### 1-2-2 Forecast of each group

(1) Meat and Related Products

The share of beef in total "meat and related products" was 50 % based on ANP statistics in 1990. And other commodities included in "meat and related products" are also related to beef. Therefore, forecast of "meat and related products" is carried out based on the production of beef.

The number of cows slaughtered was 1,409,269 and export volume was 80,757 tons in 1988 according to "Annual Statistics in 1989 Uruguay". If 150 kg is the average weight after processing. 1,409,269 heads of cattle were processed into 211,390 tons of meat. Then export volume of beef in Uruguay is calculated as 38 % of total processed meat in 1988.

Projection of live cows and slaughter made by M.G.A.P. is shown in

Table 1-2-2-1. According to M.G.A.P., these numbers will not change in the near future due to limited land space. Concerning export, almost all beef was handled at Montevideo port.

Accordingly, it is assumed that production of beef will be the average between 1992 and 1995 volumes based on projection made by M.G.A.P. and that all beef exports will be handled at Montevideo port in 1998.

As average beef production is calculated at 221,097 tons, export volume of beef will be 83,980 tons using rate of 38 % described above. If the share of beef does not change in 1998, the volume of "meat and related products" will be 168,000 tons in 1998.

Table 1-2-2-1 Projection of Live Cows and Slaughter by M.G.A.P.

| Year | Live Cows | Head of Slaughter | Production of Beef |
|---|---|---|---|
| 1992 | 10,543,000 | 1,498,000 | 224,700 |
| 1993 | 10,272,000 | 1,439,000 | 215,850 |
| 1994 | 10,165,000 | 1,538,000 | 230,700 |
| 1995 | 10,261,000 | 1,422,000 | 213,300 |
| | | Average | 221,097 tons |

221,097X0.38/0.50=168,000 tons

(2) Fish

Almost all fish landed is processed and then most of the processed fish is exported in Uruguay. Uruguay has a common sea area for fishing with Argentine stipulated by law 14. 145 (1973). It is located at the mouth of river Plata. Usually Uruguayan fishing boats catch fish in this area, as well as in their 200 mile zone. The above law regulates the permissible limit of fish catch volume in order to protect fish resources (hake and corvina). The permissible fish catch volume is about 140,000 tons and the volume of fish catch already almost reaches this level now. Uruguay has poor fishing technology, and fish catch volume will not change in the near future. Therefore the study team assumed that export volume of fish is 70,000 tons, the same as at present.

(3) Agricultural Products

M.G.A.P. forecast main grain (consisting of wheat, barley, maize, rice etc.) production from 1990 to 2000. M.G.A.P. suggested that these figures are targets and that it will be very difficult to achieve them. The study team assumed that production volume of grain is 70 % of that projected by M.G.A.P. taking the above into account. Domestic consumption of grain for each head per year is 0.304 tons in Uruguay according to M.G.A.P.. Uruguay exported 52 % of its export volume of grain to Brazil in 1989, and 66 % in 1990. M.T.O.P. and M.G.A.P. said that the majority of export grain is using land transportation. This suggests that 60 % of all export grain is exported by road. Remaining 40 % is exported from Montevideo port. Grain has a 52 % share in "agricultural products" in 1990 based on A.N.P statistics. Export volume of "agricultural products" in 1998 is as follows:

| | | |
|---|---|---|
| Grain production | : 2,055,867 tons | (1) |
| Population | : 3,181,835 persons | (2) |
| Consumption | : 304kg/head/year | (3) |
| Domestic consumption | : (2)X(3)=967,278tons | (4) |
| Export volume of grain | : (1)X70%-(4)=471,829tons | (5) |
| Export volume of grain *through Montevideo* | : (5)X40%=188.732tons | (6) |
| Export volume of "agricultural products" | : (6)/52%=363,000tons | (7) |

Export volume of "agricultural products" is 363,000 tons in 1998.

(4) Wool

Export volume of wool from 1953 to 1989 has fluctuated annually, and no patterns have emerged. However, in a recent five year period, export volume has not changed and average export volume has been 64,000 tons. M.G.A.P. said also that export volume of wool will not change in the near future. This volume is handled in Montevideo port. Export volume of wool is estimated at 64,000 tons in 1998.

(5) Chemical Products

Export volume of "chemical products" is fluctuating annually, and there is no correlation between these figures and any economic index. "Chemical products" is calculated by elastic value of "chemical products" to manufacture sector of GDP. Export volume of "chemical products" is estimated at 21,000 tons in 1998.

(6) Wood

The export volume of "wood" has increased by about 100 times during these ten years. The study team thinks that the government project regarding eucalyptus will continue to bring good results. However, A.N.P has data on export volume for only three years. Therefore, "Wood" is calculated by elastic value of "wood" to agricultural sector of GDP. The study team forecasts that the export volume of "wood" in 1998 will be 75,000 tons.

(7) Others

"Others" shows no tendency, and fluctuate annually. "Others" is calculated by elastic value of "others" to total GDP. Export volume of "others" is estimated at 56,000 tons in 1998. Export volume in 1998 is shown in Table 1-2-2-2.

Table 1-2-2-2 Export Volume in 1998

1,000tons

| | |
|---|---|
| Meat & Related products | 168 |
| Fish | 70 |
| Agricultural Products | 363 |
| Wool | 64 |
| Chemical Products | 21 |
| Wood | 75 |
| Others | 56 |
| Total | 817 |

## 1-3 Import

### 1-3-1 General

The study team forecast import cargo volume by commodity based on classification of N.A.D.I.. Study team divided cargo into four classes, namely, manufacturing, petroleum oil, agricultural products and "others".

"Manufacturing" consists of chemical products, plastic materials, material of fabrication paper, textile material, common metals machine and apparatus and transportation equipment.

Petroleum oil consists of a part of mineral products such as oil made from mineral. Petroleum oil is handled at A.N.C.A.P berth. So, petroleum oil is not forecast this time.

"Agricultural products" consists of live animals and related products, vegetable products, oil, food products, hide/leather and related products and wood.

"Others" consists of commodities other than above mentioned, and main commodities are merchandise products and daily necessities.

### 1-3-2 Forecast of each group

(1) Manufacturing

There are main commodities such as chemical products, metals and machine etc. in "manufacturing" group. The import volume has shown a tendency to increase, though it often fluctuates. "Manufacturing" is calculated by elastic value of "manufacturing" to the manufacture sector in GDP. Import volume of "manufacturing" is expected to be 412,000 tons in 1998.

(2) Agricultural Products

"Agricultural products" has fluctuated annually, however, on average, there has been no tendency to increase or decrease.. This tendency will not change in the near future. Import volume of "agricultural products" in 1998 is expected to be 91,000 tons, the average volume of the last five years.

(3) Others

"Others" has no tendency and fluctuated annually. Import volume of "others" in 1998 is calculated by elastic value of "others" growth rate to manufacture sector of GDP. Import volume of "others" will be 62,000 tons in

1998. Import volume in 1998 is shown in Table 1-3-2-1.

Table 1-3-2-1 Import volume in 1998

1,000tons

| | |
|---|---|
| Manufacturing | 412 |
| Agricultural Products | 91 |
| Others | 62 |
| Total | 565 |

## 1-4 Transit cargo

### 1-4-1 General

Transit cargo consists of international transit cargo and domestic transit cargo. Each transit cargo could be divided into container cargo and general (conventional) cargo.

### 1-4-2 International Transit Cargo

24 % of international transit cargo volume is from/to Paraguay in 1990 according to A.N.P statistics. The other 76 % of international transit cargo is from/to Argentina. Container and general cargo also are divided in the same way, which is perhaps a better way to look at the situation. 24 % for Paraguay and 76 % for Argentina. Projection of international transit cargo is calculated by growth rate of each country's GDP projection value (Argentina:2.3%, Paraguay: 5.6%) in accordance with Hidrovia report.

### 1-4-3 Domestic Transit Cargo

Domestic transit cargo consists of container and general cargo. Almost all general transit cargo is petroleum oil that is handled at the wharf of A.N.C.A.P.. So, study team forecasts only container of domestic transit cargo. Transit cargo of container is calculated by elastic value of growth rate of container export volume to growth rate of GDP total.

## 1-5 Export/Import Volume by Packing Type

### 1-5-1 Export

Cargo can be divided in four types according to its packaging : solid bulk cargo, liquid bulk cargo, general cargo and container. We obtained container cargo volume in general cargo volume by ratio of containerization calculated based on logistic curve. Ratio of containerization will be 59 % for export in 1998. Calculation of ratio of containerization is described in A-1-5 at the end of this chapter.

"Meat and related products", "fish", "wool", "wood" and "others" are general cargoes. These general cargoes can be converted to container cargo except "wood". "Wood" can not be containerized because packing is bundled to accommodate the logs. "Agricultural products" consists of solid bulk cargo and general cargo. Grain is solid bulk cargo. Vegetable and other agricultural products are general cargoes. Share of solid bulk cargo and general cargo of "Agricultural products" is 52 % and 48 % based on ANP statistics in 1990. "Chemical products" consists mainly of fertilizer and material of fertilizer. Therefore, "chemical products" is solid bulk.

### 1-5-2 Import

Import cargoes are divided in the same manner as export cargoes.

Needless to say, "petroleum oil" is liquid bulk. "Manufacturing" consists of 68 % of solid bulk cargo (chemical products and fertilizer), and 32 % of general cargo (steel and machinery) based on ANP statistics in 1990. "Agricultural products" consists of 13 % of solid bulk cargo (grain), and 87 % of general cargo (beans and plants). "Others" is general cargo. Table 1-5-2-1 shows cargo handling volume by packing type in 1998.

Table 1-5-2-1 Cargo Handling Volume by Packing Type in 1998

1,000tons

| | Solid Bulk | General | Container | Total |
|---|---|---|---|---|
| Export | 210 | 294 | 313 | 817 |
| Meat & Related products | | 69 | 99 | 168 |
| Fish | | 29 | 41 | 70 |
| Agricultural Products | 189 | 72 | 102 | 363 |
| Wool | | 26 | 38 | 64 |
| Chemical Products | 21 | | | 21 |
| Wood | | 75 | | 75 |
| Others | | 23 | 33 | 56 |
| | | | | |
| Import | 292 | 111 | 162 | 565 |
| Manufacture | 280 | 54 | 78 | 412 |
| Agricultural Products | 12 | 32 | 47 | 91 |
| Others | | 25 | 37 | 62 |
| | | | | |
| Transit | 0 | 206 | 456 | 662 |
| International | | 206 | 422 | 628 |
| Domestic | | | 34 | 34 |
| | | | | |
| Total | 502 | 611 | 931 | 2,044 |

## 1-6 Projection of Grain Cargo Volume to be Transhipped at Montevideo

### 1-6-1 Bolivia

Bolivia is making efforts to increase out put of agricultural products such as grain, rhizome, vegetable, fruit, fodder grain and industrial materials for agricultural products (sugar cane, soybean and others). With the exception of sugar cane and soybean, production of these products is adequate at best, and sometimes fails to meet domestic demand. Soybean exports are carried to up-river ports. Production of soybean has increased rapidly since 1985. Export volume of soybean was 21,000 tons in 1985 and 66,000 tons in 1988. Export volume of soybean by river system was 44,215 tons in 1989 and 36,433 tons in 1990. Port of Quijarro will export 23,000 tons in 1990, 32,200 tons in 1995, and 39,900 tons in 2000 according to Hidrovia. There are two routes, Quijarro to Nueva Palmira, and Quijarro to Escobar. The study team thinks that these figures are accurate. However, these projection figures are very small.

### 1-6-2 Paraguay

The Paraguayan government commissioned "The Study on The Master Plan of National Transportation" to JICA. According to this study, main results are as follows;

- Grain export volume is estimated at 3,416,000 tons in 1998.
- 785,000 tons of grain, which is 23% of the whole export volume, are assumed to be transported to Brazil by land.
- The grain transported to Paranagua port by land will amount to 31% of all export volume or 1,052,000 tons.
- The remaining portion (1,579,000 tons) of export grain will be transported to La Plata river port by barge via river Parana.

Based on these results, it is possible to assume the following.

- It is assumed that these 1,579,000 tons of Paraguayan grain, which is 46% of total grain export volume, is transshipped at Nueva Palmira. It is impossible to convey grain from Paraguay to Montevideo by barge because of rough wave condition at the mouth of La Plata River.

- Grain transshipped at Nueva Palmira could be divided into two types. One will be exported by handy size ship which will carry 852,000 tons, and the other by panamax size ship which will carry 726,000 tons based on the present proportion.
- There is a 1,200,000 tons of handling capacity for Paraguayan grain at Paranagua port, because Paraguayan government own 180,000 ton class silo at Paranagua port in Brazil. This capacity is larger than loading volume to panamax size ship at Nueva Palmira.

  Generally speaking, the topped off grain is the same as that loaded at the origin port. Therefore, it is normal to assume that the panamax size vessel which is half loaded by Paraguayan grain at Nueva Palmira would be topped off at the port of Paranagua.

  Figure 1-6-2-1 shows flow of Paraguayan grain cargo.

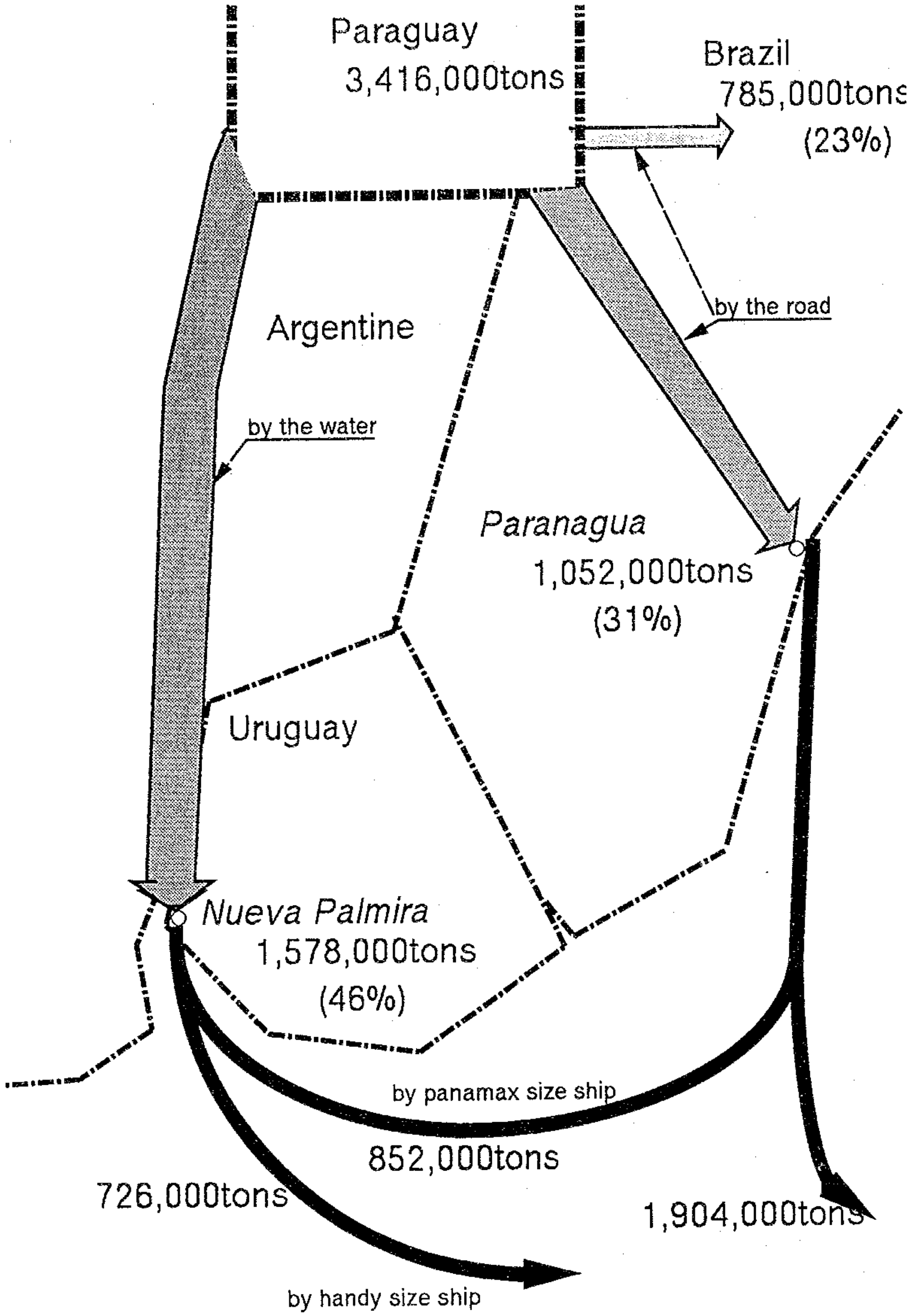


Figure 1-6-2-1 Flow of Paraguayan Grain Cargo

### 1-6-3 Argentina

In 1990, 13,905,701 tons grain were exported by the port in Argentina. About 53 % of this grain volume was handled at up river ports, Rosario, San Martine, San Lorenzo and others. Argentine government has a problem regarding its river transportation system. Panamax size vessels are able to enter the river port, however, when grain is loaded to the vessel, only about half of the vessel loading capacity is utilized. Panamax size vessels are topped off at the deeper ports such as Bahia Blanca and Alpha zone etc.. This transportation system has a high cost and weakens the competitive power of Argentina. If a new transportation system were adopted so as to cut transportation costs, this problem would be eliminated.

Approach channels of port of Buenos Aires and La Plata are 250 km and 200 km respectively. Approach channel of Montevideo port is only 36 km. There is too much sedimentation in the river mouth of river Plata. These approach channel lengths will influence maintenance dredging cost. Therefore, it is desirable that the base of a new transportation system for grain be constructed at Montevideo port.

It is assumed by the study team that cargo handling volume of grain at river port is exported as follows;

(1) Grain loaded on handy size ship (under 55,000 GRT) is exported to foreign country directly.

(2) All grain cargoes except for wheat exported from Bahia Blanca are used for topping off for panamax size ship which is half loaded at river port.

(3) Alpha zone is used for topping off for panamax size ship until handling capacity of alpha zone.

(4) The remainder of exported grain from river port is exported through Montevideo port.

Figure 1-6-3-1 shows flow of Argentine grain cargo.

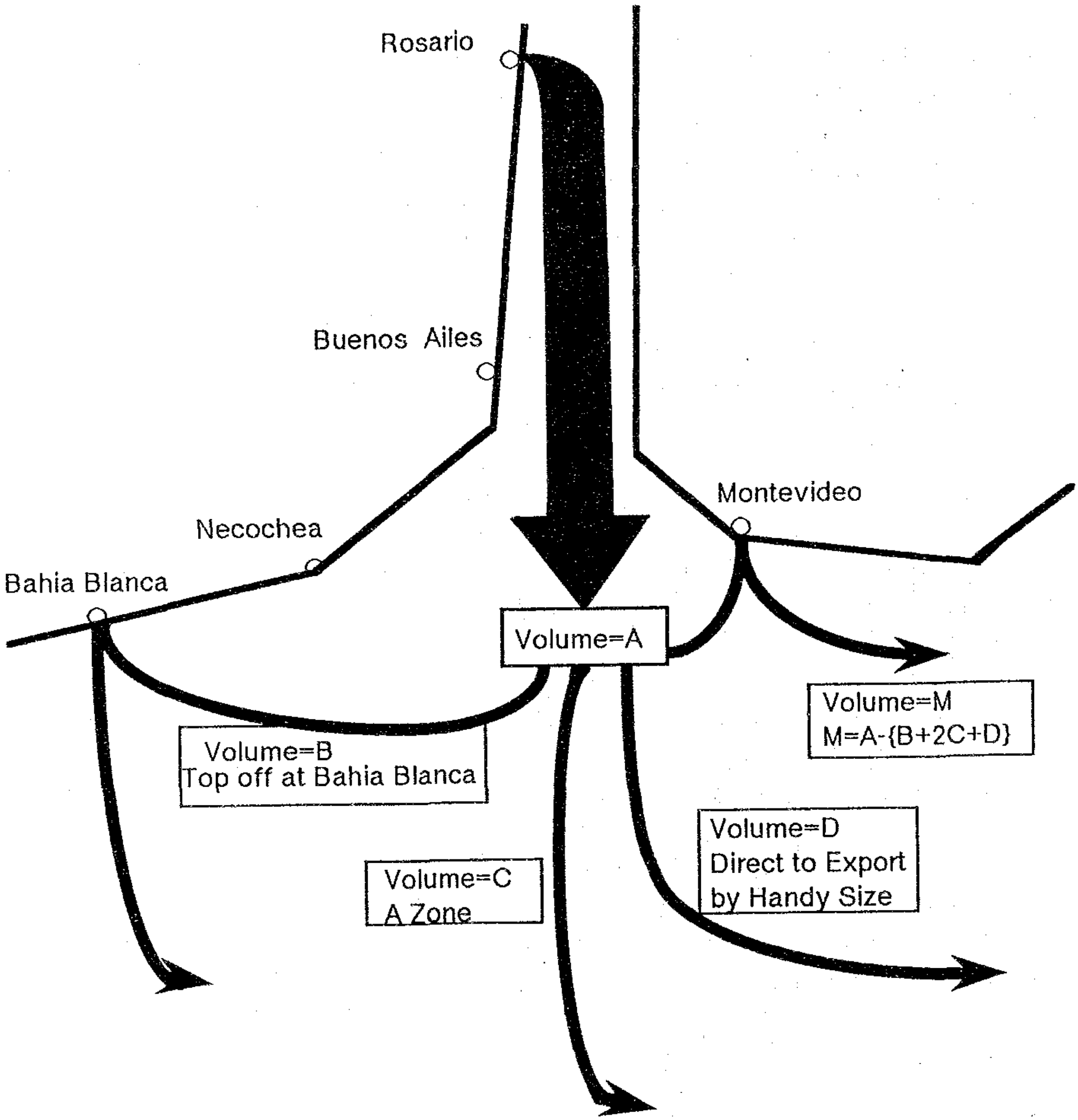


Figure 1-6-3-1 Flow of Argentine Grain Cargo

Export volume of grain from Argentine port is estimated for two cases:

a) the minimum export volume is based on present trend.
b) the maximum is based on growth rate (3.8%) of grain production by "Agriculture: Toward 2000" edited by Food and Agriculture Organization of The United Nations (FAO).

It is assumed that export grains are wheat harvested in November, December and January, Soybean, sorghum and maize, harvested in April, May and June and soybean meal. These are the main grains which are exported from upriver port.

(1) Wheat

It is assumed that growth rate is 0.3 % for minimum, 3.8% for maximum.

(2) Soybean and Soybean Meal

It is assumed that growth rate is 2.2 % for minimum, 3.8 % for maximum.

(3) Sorghum

Sorghum production area has decreased as the soybean production area has increased, and export volume of sorghum has not changed in recent statistics. Therefore, the minimum export volume of sorghum will maintain the status quo, and the maximum growth rate is 3.8 %.

(4) Maize

Minimum export volume of maize held the status quo, the same as sorghum, and growth rate of maximum is 3.8 %.

Table 1-6-3-1 shows export volume of grain from Argentina port and grain volume through the Montevideo port. For grain volume through Montevideo port, wheat is calculated separately from the other grains because wheat has a different growing season.

Table 1-6-3-1 Volume of Grain from Argentina

Grain in 1998 Export Volume of Grain by Port
Lower Limit 1,000tons

| | Export Volume | From Upriver | Buenos Aires | Bahia Blanca | Necochea |
|---|---|---|---|---|---|
| Wheat | 6,007 | 1,682 | | 2,643 | 1,682 |
| Soybean | 3,368 | 3,233 | 135 | | |
| Sorghum | 1,400 | 1,106 | | 294 | |
| Maize | 3,700 | 1,813 | 777 | 333 | 777 |
| Soybean Meal | 6,814 | 6,541 | 273 | | |
| Total | 21,289 | 14,376 | 1,184 | 3,270 | 2,459 |

Grain by Ship Type 1,000tons

| | From Upriver | Panamax Size Ship | Handy Size Ship |
|---|---|---|---|
| Wheat | 1,682 | 774 | 908 |
| Soybean | 3,233 | 1,487 | 1,746 |
| Sorghum | 1,106 | 509 | 597 |
| Maize | 1,813 | 834 | 979 |
| Soybean Meal | 6,541 | 3,009 | 3,532 |
| Total | 14,376 | 6,613 | 7,763 |

Grain Planting in Autumn Which are Exported by Panamax Size Ship
1,000tons

| Upriver Port | Bahia Blanca | Alpha Zone | Montevideo Port |
|---|---|---|---|
| 5,839 | 627 | 3,400 | 1,812 |

Grain in 1998 Export Volume of Grain by Port
Upper Limit 1,000tons

| | Export Volume | From Upriver | Buenos Aires | Bahia Blanca | Necochea |
|---|---|---|---|---|---|
| Wheat | 8,462 | 2,369 | | 3,723 | 2,369 |
| Soybean | 3,825 | 3,672 | 153 | | |
| Sorghum | 1,654 | 1,307 | | 347 | |
| Maize | 4,286 | 2,100 | 900 | 386 | 900 |
| Soybean Meal | 7,832 | 7,519 | 313 | | |
| Total | 26,059 | 16,967 | 1,366 | 4,456 | 3,269 |

Grain by Ship Type 1,000tons

| | From Upriver | Panamax Size Ship | Handy Size Ship |
|---|---|---|---|
| Wheat | 2,369 | 1,090 | 1,279 |
| Soybean | 3,672 | 1,689 | 1,983 |
| Sorghum | 1,307 | 601 | 706 |
| Maize | 2,100 | 966 | 1,134 |
| Soybean Meal | 7,519 | 3,459 | 4,060 |
| Total | 16,967 | 7,805 | 9,162 |

Grain Planting in Autumn Which are Exported by Panamax Size Ship
1,000tons

| Upriver Port | Bahia Blanca | Alpha Zone | Montevideo Port |
|---|---|---|---|
| 6,715 | 733 | 3,400 | 2,582 |

## 1-7 Fishing Vessels

### 1-7-1 Domestic Fishing Boats at Montevideo Port

In 1991, there were 68 fishing boats registered in Montevideo, and 13 of those 68 mainly used La Paloma port. Therefore 55 fishing boats were using Montevideo port in 1991. Almost all these fishing boats catch hake and white croaker, and when fishermen want to register a new fishing boat for hake and white croaker they have to eliminate an existing ship of the same tonnage in accordance with regulation of I.N.A.P.E.. In addition, some of the older fishing boats will be voluntarily abolished, and thus the number of fishing boats will not increase in the near future. A couple of fishing boats for squid and crab will increase at Montevideo port according to interviews with I.N.A.P.E.. However, Uruguayan fishermen do not possess the technique necessary to catch squid and crab. They have to learn fishing technique of squid and crab which is a lengthy process according to interviews with Uruguayan Fishing Industry Chamber.

Economic condition of fishing industry in Uruguay is not good. Some owners of fishing boats have incurred large debts. GDP of fishery sector from 1985 to 1990 has shown a down trend which has caused problems for the fishing industry. In 1989, of the 17 plants which may be considered the most important, three experienced a period of inactivity. Although the industry as a whole is fairly efficient, its heavy debts present a problem, the solution of which is one of the main concerns of the national authorities. However, the sector still has more than 30 markets abroad.

Therefore, the study team considers that the number of fishing boats will increase slightly. The study team assume that 60 fishing boats will be working in Montevideo port.

### 1-7-2 Foreign Fishing Vessel

(1) View Point of FAO

As already described in chapter 5 of part I, foreign fishing vessels' important catch is squid. According to the report of FAO, potential of squid in the South Atlantic Ocean is estimated as follows :

There is good potential for further development of squid fisheries, particularly in the more northerly part of Patagonian shelf which is by no means fully exploited. Quantitatively estimated potential would be "some hundreds thousand tons", while actual catch during five years from 1980 to 84 was 151 thousand tons.

Table 1-7-2-1 Fish Resources: Actual & Potential Catches

Unit: 000 tons

| Species | Main Fishing Countries | Estimated Potential | 1970 -74 | 1975 -79 | 1980 -84 | Current Situation |
|---|---|---|---|---|---|---|
| Hake | Argentina, Brazil, Uruguay | 600 | 153 | 316 | 330 | Moderately Exploited |
| Southern Blue Whiting | Poland, USSR | 300 | - | 11 | 131 | Moderately Exploited |
| Atlantic Croaker | Argentina, Brazil, Uruguay | 100 | 56 | 84 | 79 | Moderately Fully Exploited |
| Weakfish | Argentina, Brazil, Uruguay | 100 | 42 | 58 | 75 | Moderately Fully Exploited |
| Sardinella | Brazil | 200 | 164 | 165 | 226 | Fully Exploited |
| Argentina Anchovy | Argentina, Uruguay | 100 | 32 | 21 | 18 | Almost Unexploited |
| Sprat | Argentina | Some Hundreds | - | - | - | Unexploited |
| Argentina Red Shrimp | Argentina | Unknown | - | - | 11 | ? Fully Exploited |
| Other Shrimp and Prawns | Brazil | 60-80 | 50 | 54 | 53 | Fully Exploited |
| Squid | Argentina, Brazil, Japan, Poland, Uruguay | Some Hundreds | 4 | 43 | 151 | Some Area Fully Exploited |

Source: FAO

Although "some hundreds thousand" is a very vague expression, it generally means two to three hundreds thousand. Based on this estimation, it is possible to assume as follows. Namely, if the capacity of fishing vessels operating in this ocean increases in proportion to the fish catch potential, the capacity will reach twice the level of the period from 1980 to 84. Therefore, potential of squid is around two times the catch between 1980 and 84. Concerning other kinds of fish, their estimated potentials would be twice the level of the period from 1980 to 84 at most. Furthermore, if the number of foreign fishing vessels calling at the port of Montevideo increases in proportion to the capacity described above, the number of foreign fishing vessels will double.

According to the statistics of the ANP, the number of vessels calling at the port of Montevideo has already exceeded the level of 1985 by two or three times.

(2) Recent Trend of Vessel Arrival

Table 3-5-2-2 of Part I shows yearly fluctuation of foreign fishing vessels calling at the Port of Montevideo. According to this table, number of vessels calling in 1989 was 2.82 times that of 1985, while total GRT in 1989 was 2.1 times that of 1985. There was a big increase between 1987 and 1988, but decreased in 1991.

However, it is possible to reach a different conclusion related to recent four years when the situation is looked into in more detail. As described in chapter 3 of Part I, there is a large difference in the number of calling vessels by country. At present, Spain, Korea and Taiwan seem to be in the trend of introducing more vessels, while the participations of Japan, China, USSR and Poland seem to be on the decline. It is assumed that the decline in the number of ships from the USSR and Poland is due to the drastic reforms which have recently taken place in these countries. At the same time, it is possible to assume that Spain, Korea, etc. filled the vacuum made by Japan and China. Therefore, apart from decline made by the USSR and Poland, it can be said that there was not a big fluctuation during recent 4 years as a whole.

(3) Future Forecast

It is very difficult to forecast the number of foreign fishing vessel calls as the available data are very limited. Here, forecast is conducted based on the result of the brief examination described above. The following conclusions are made:

* The number of foreign fishing vessels required to meet the potential estimated by FAO has already been fulfilled.
* Number of calling vessels has remained almost constant for recent 4 years except the decline in the number of ships from the USSR and Poland.

Based on this, it is unlikely that the number of foreign fishing vessels will increase much further. At the same time, it is possible to assume that the number of calling vessels will not substantially decrease. Therefore, about the same number of vessels (500) as in the recent four years is assumed in 1998.

# 2 CONSIDERATION OF NEW GRAIN TRANSPORTATION SYSTEM

## 2-1 General

Basin of the La Plata river is one of the largest grain export centers and is contributing greatly as a source of grain supply in the world. However, it seems that an efficient system to carry grain cargoes and the same contents as mentioned in chapter 4 of Part 1 has not been implemented. At present, it is considered that an efficient transportation system should be organized to facilitate a steady supply of grain world wide. Accordingly, it is expected that the proposed grain transportation system will have a great impact on the port of Montevideo, which is located at the mouth of La Plata river.

But in Uruguay, which is exporting few domestic grain cargoes, the feasibility of constructing a large grain terminal depends on the quantity of products transported from Argentina and Paraguay. For that reason, naturally, Uruguay is rather affected by agricultural policy of those countries and has suffered despite its prime location. Recently, however, these policies have gradually begun to change. As a result, it is necessary to implement a more economically rational transportation system because of the MERCOSUR agreement that will take effect from 1st. January in 1995. The agreement effectively removes every restriction of distribution movement for all cargoes and services among member countries. From this point of view, the outlook for Montevideo port is bright since the agreement eliminates its most serious obstacle.

Consequently, it is considered that with the new transportation system Montevideo port will become center stage for carrying food and feed grain cargoes that are exported from the mouth of La Plata river to every country in the world.

## 2-2 Problem Points of Present Transportation System

As mentioned in chapter 4 of Part I on present condition, most grain cargoes exported from the La Plata river to import countries come from Argentina. The biggest problem in the present transportation system is how to carry agricultural products from Argentine ports. Up-River ports in Argentina including Rosario port, which handles about 60 percent of exported grain, are physically limited in that they are not able to load fully for panamax size vessel due to shallow draught of navigation route. Panamax size ship, in short, which holds capacity of 55,000 tons, can load only up to about 28,000 tons. This system naturally increases the cost of transportation and as a result, the Argentine farmer receives a smaller income from international grain trade.

The port of Argentina lying at the mouth of La Plata river, for example, as well as the ports of Buenos Aires, La Plata and the others, have difficulty in maintaining navigation draft of 12 m and there are no future projects planned. Also from the point of view of Argentina, it is more important to make plans for development of Montevideo port. Port of Montevideo has a favorable location for maintaining navigation draught of 12 m at the mouth of La Plata river even though they must perform maintenance dredging.

At present, the top-off operation system is exclusively used at Bahia Blanca port and Paranagua port of Brazil as seaport or Alpha Zone as specific area. It is considered that top-off operation at these seaports basically consists of grain cargoes which are produced in the neighbouring area. On the other hand, the same operation at Alpha Zone has handled grain which originated in the Up-river area at a great distance from the top-off area.

Top-off operation cost at Alpha Zone includes additional charges as follows:

(1) Freight of top-off barge
(La Plata river - Up-river - Alpha Zone)
(2) Top-off operation cost
(Alpha Zone)

For the above reason, it is a relatively disadvantageous for grain which is produced in Up-river area.

### 2-2-1 Present Operation at Alpha Zone

As mentioned in chapter 4 of Part I, the biggest problem lies in the present transportation system that involves topping-off at Alpha Zone. Consequently, operation of Alpha Zone should be inspected in detail to solve the problem. To that end, it is necessary to analyze the operation date of the private company at Alpha Zone in 1984 because of the lack of recent operation data. Table 2-2-1-1 and 2-2-1-2 show the operations of the private company. It handled 40 vessels and the breakdown was as follows:

| | |
|---|---|
| Panamax size vessel or above | 39 |
| Handy size vessel (35,000 DWT) | 1 |
| Total | 40 |

Table 2-2-1-1 Operation of Private Company at Alpha Zone ('84)

| Quan. /Ship | (1) Loading Volume | | (2) Total Vol. (tons) | (3) Capacity (DWT) | (4) Period (Days) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Operation | | Navi./ Delay | | |
| | Up-River (tons) | Alpha Z. (tons) | | | Up-Riv. | Alpha Zone | Reca. → Up-Riv | Up-Riv → Alpha | Total |
| 40 | 1,030,139 | 1,041,266 | 2,071,405 | 2,427,296 | 254 | 205 | 356 | 607 | 1,422 |
| Ave. | 25,754 | 26,032 | 51,785 | 60,682 | 6 | 5 | 9 | 15 | 35 |

Table 2-2-1-2 Details of (4) in Table 2-2-1-1

| Period (Day) | Operation/times | | Navigation/times | |
|---|---|---|---|---|
| | Up-River | Alpha Z. | Recalada → Up-River | Up-River → Alpha |
| 1 | 0 | 0 | 11 | 1 |
| 2 | 3 | 1 | 6 | 1 |
| 3 | 2 | 8 | 0 | 2 |
| 4 | 10 | 12 | 2 | 3 |
| 5 | 8 | 6 | 1 | 3 |
| 6 | 5 | 4 | 0 | 2 |
| 7 | 1 | 4 | 0 | 1 |
| 8 | 3 | 1 | 0 | 1 |
| 9 | 1 | 2 | 0 | 0 |
| 10 Over. | 7 | 2 | 15 | 26 |
| Uncer. | 0 | 0 | 5 | 0 |
| Total | 254 | 205 | 356 | 607 |

(1) Loading Volume

Total loading volume at Up-river ports was 1,030,139 tons or 25,754 tons per vessel. Maximum volume per vessel was 29,200 tons, being loaded at P. Alvear elevator of Rosario.

Total top-off volume at Alpha Zone was 1,041,266 tons or 26,032 tons per vessel. Maximum volume per vessel was 28,000 tons.

(2) Total Volume

Total loading volume both including Up-river port and Alpha Zone was 2,071,405 tons or 51,785 tons per vessel. 20 vessels were loaded ranging from 54,000 tons to 56,000 tons with a maximum volume of 63,706 tons.

(3) Ship Capacity

Total capacity of handling vessel was 2,427,296 DWT or 60,682 DWT per vessel.

(4) Period

1) Operation

Total loading days for 40 vessels at Up-river ports was 254 days. Also, it took six days for a vessel to load 25,754 tons on average. However, there were 10 cases in which only 4 days were required for loading, and an additional 8 cases in which only 5 days were needed. Total loading days for 40 vessels at Alpha Zone was 205 days or five days per vessel. The average load was 26,032 tons.

2) Navigation

It took 356 days, including delay period, for 40 vessels to navigate from Recalada to Up-river ports. Navigation took nine days per vessel on average.

It took 607 days, including delay period, for 40 vessels to navigate from Up-river ports to Alpha Zone. Navigation took 15 days per vessel on average.

## 2-3 Premise of New Transportation System

### 2-3-1 Grain Bulk Vessel

The type of grain bulk vessel currently used in the world is mainly panamax type, which is able to load about 55,000 tons, the maximum sized vessel able to navigate the Panama Canal. This is because it is desirable that transportation cost be as low as possible due to the low product price of grain cargoes. Panamax size vessel has been becoming larger, 13 m draught, 32.5 m breadth and 230 m length. Panamax size vessel, naturally, requires a high cost per day. But comparing panamax size vessel (55,000 DWT) with handy size (37,000 DWT), a freight per ton is economical, not only over a short distance but also a long distance because there are merits in mass transportation if a large quantity of cargoes are carried. Currently, handy size vessels cannot load fully at Up-river ports.

*Navigation of the La Plata river is restricted, only vessels of about 15,000* DWT at maximum can be fully loaded. But now, small bulk carriers (15,000 DWT) are not being built by shipbuilding companies.

From this point of view, grain bulk carriers at basin of the La Plata river will mostly be of the panamax size instead of the handy size, which ranges from 15,000 DWT to 37,000 DWT and (which are increasingly becoming too old) has been carrying grain such as wheat and by-products. Also, it is considered that grain products will be loaded with three kinds of grain cargoes due to the large-sized vessel; at present, one or two kinds are loaded.

### 2-3-2 Function of Montevideo Port

Grain terminal function of Montevideo port should be adopted to accommodate panamax size vessel in ballast, rather than employing the topping-off system used at Alpha Zone.

In the present system, panamax vessel of high ship cost is not loaded fully, about 26,000 tons in quantity at Up-river ports, and after that, when going back to Alpha Zone, loaded completely, about 26,000 tons. It is considered that the system is not economical for a large grain carrier. A system using a shuttle vessel of about 15,000 DWT, planned with a shallow draft (about 9.0 m) and operating at a low ship cost is required.

Also it is very difficult for a grain carrier, the operation schedule of which is affected by weather, and top-off vessel to be handled jointly without delay period at Alpha Zone. Therefore, a storage facility such as a silo is required to alleviate the problem.

Due to the unknown transportation period, freight will naturally be more expensive and it is more difficult to manage grain stock for grain import countries. New transportation system of Montevideo port must be managed very well both in terms of the transportation system of shuttle vessel and handling operation of cargo of storage facility including loading and unloading.

## 2-4 Comparison of Transportation Cost

### 2-4-1 Cost Factor

Cost factor is estimated to compare the present transportation with the future system.

(1) Ship Cost

Ship cost is determined by market price of freight in the world market at a particular time of the year. As regards this condition, it is calculated at US 11,000 dollars per day for panamax size vessel. Figures ranged from US 9,000 dollars to 14,000. Namely, ship cost of US 11,000 dollars is considered as standard freight. Table 2-4-1-1 shows costs for vessel size.

Table 2-4-1-1 Ship Cost ('92)

| Ship Size (DWT) | Ship Cost (US$/day) | Average Draft (m) | Economy Speed (knot/hour) | Construction Cost (Unit:1,000 US$) |
|---|---|---|---|---|
| 55,000 | 11,000 | 13.0 | 13 | 30,000 |
| 37,000 | 9,000 | 11.0 | 12.5 | 25,000 |
| 25,000 | 8,000 | 10.5 | 12.5 | 19,000 |
| 20,000 | 6,000 | 10.0 | 12 | 15,000 |
| 15,000 | 5,000 | 9.0 | 12 | 13,000 |
| 10,000 | 4,500 | 8.0 | 11 | 10,000 |
| 6,000 | 3,500 | 6.5 | 11 | 7,700 |

(2) Port & Channel Charges

1) Argentine Ports

a) Rosario Port

Table 2-4-1-2 shows all charges of panamax size vessel and handy size remaining for three days at Rosario port. Both panamax and handy size require pilotage six times. Pilotage charge of panamax size is US 14,602