9.2 Operation Planning

This study was made to estimate the necessary number of ships to be used for the cargo transportation on the Parnaiba river, considering the maximum transport capacity restricted by the Boa Esperanca Lock, the depth of the river, ship's speed, capacity of cargo work, and other necessary factors.

9.2.1 Scenario of Operation

To estimate the necessary number of ships, two scenarios were studied under the following conditions.

(1) Conditions

- Maximum navigable cargo volume are used.
- Soy Beans shall be transported between February and May.
- Monthly cargo volume passing the locks shall be within the maximum transport capacity in the case of 18 hours of lock operation in Table 7.3.6.
- Daytime navigation.

(2) Alternatives

Alternative 1 : Cargo Average

Cargoes other than soybeans and cargoes passing the locks shall be transported on an average through the year considering the demand of the consumer.

Alternative 2 : Ship Average

Some cargoes shall be adjusted so that number of ships shall become almost even through the year. Since scenario 1 shall require a large number of ships at the peak, this scenario has been studied.

9.2.2 Cargo to be Transported

Monthly cargo volume to be transported by each alternative is as per Table 9.2.1 and 9.2.2.

9.2.3 Ship's Speed

Average river flow	: about 2.0 knots (see Table 3.1.6)
Ship's speed without current	: 8.0 knots
Downward Navigation	: 8.0 + 2.0 = 10.0 knots (18.5 km/h)
Upward Navigation	: 8.0 - 2.0 = 6.0 knots (11.1 km/h)

9.2.4 Navigation Hours

Table 9.2.3 shows the estimated distance and navigation hours between major ports along the Parnaiba river. It is estimated that it takes about 70 hours from Santa Filomena to Parnaiba for downward navigation and about 109 hours from Parnaiba to Santa Filomena for upward

Table 9.2.1 2010 year Monthly cargo volume to be transported. Alternative-1 (Cargo Average)

Unit:Tons

	Port \ Month	104160 JAN	104160 FEB	104160 MAR	104160 APR	48720 MAY	26880 JUN	26880 JUL	26880 AUG	26880 SEP	33600 OCT	62160 NOV	68880 DEC	737520 TOTAL
DOWNWARD	S.F → URC	40	40	40	40	40	40	35	35	35	35	35	35	450
	S.F → FLR	14200	6160	6160	6160	2720	3700	3700	3700	3700	4500	8500	9300	72500
	R.G → URC	360	360	360	360	360	350	350	360	360	360	360	360	4300
	R.G → FLR	23100	0	0	0	0	6000	6000	6000	6000	7400	13900	15250	83650
	R.G → TRS	48300	28800	28800	28800	13600	12600	12600	12500	12600	15500	29000	31850	275050
	URC → FLR	4400	0	0	0	0	1100	1100	1100	1100	1400	2600	2950	15750
	URC → TRS	6500	63400	63400	63400	29800	1700	1700	1700	1700	2100	3900	4250	243550
	GUD → FLR	5460	0	0	0	0	1180	1180	1180	1180	2000	2960	3860	19000
	GUD → TRS	2200	5800	5800	5800	2600	600	600	600	600	700	1300	1400	28000
	FLR → TRS	140	140	140	140	130	130	130	130	130	130	130	130	1600
	AMR → TRS	3100	3100	3100	3100	3100	3100	3050	3050	3050	3050	3050	3050	36900
	PAL → TRS	3000	3000	2900	2900	2900	2900	2900	2900	2900	2900	2900	2900	35000
	SUB TTL①	110800	110800	110700	110700	55250	33400	33345	33355	33355	40075	68635	75335	815750
	MAL → PNB	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2200	2200	26900
	PRT → PNB	2150	2150	2150	2150	2150	2150	2150	2150	2150	2150	2150	2150	25800
	LZL → PNB	9500	9500	9500	9500	9500	9500	9550	9550	9550	9550	9550	9550	114300
	SUB TTL③	13900	13900	13900	13900	13900	13900	13950	13950	13950	13950	13900	13900	167000
	TOTAL	124700	124700	124600	124600	69150	47300	47295	47305	47305	54025	82535	89235	982750
UPWARD	S.F ← FLR	1000	1000	1000	1000	950	950	950	950	950	950	950	950	11500
	R.G ← FLR	4700	4700	4700	4700	4700	4700	4700	4700	4600	4600	4600	4600	56000
	URC ← FLR	4150	4150	4150	4150	4150	4150	4200	4200	4200	4200	4200	4200	50100
	GUD ← FLR	750	750	750	750	750	750	750	750	750	750	750	750	9000
	FLR ← AMR	1850	1850	1850	1850	1850	1850	1900	1900	1900	1900	1900	1900	22500
	FLR ← PAL	400	400	400	400	400	400	400	400	450	450	450	450	5000
	S.F ← TRS	100	100	90	90	90	90	90	90	90	90	90	90	1100
	R.G ← TRS	150	150	150	150	150	150	150	150	200	200	200	200	2000
	URC ← TRS	4150	4150	4150	4150	4150	4150	4150	4150	4150	4150	4150	4150	49800
	GUD ← TRS	2400	2400	2400	2400	2400	2400	2400	2400	2500	2500	2500	2500	29200
	FLR ← TRS	2900	2900	2900	2900	2800	2800	2800	2800	2800	2800	2800	2800	34000
	FLR ← UNA	550	550	550	550	550	550	550	550	550	550	600	600	6700
	SUB TTL①'	23100	23100	23090	23090	22940	22940	23040	23040	23140	23140	23190	23190	277000
	TRS ← UNA	2100	2100	2100	2100	2100	2100	2100	2100	2050	2050	2050	2050	25000
	TRS ← MAL	2100	2100	2100	2100	2100	2100	2100	2100	2050	2050	2050	2050	25000
	SUB TTL②'	4200	4200	4200	4200	4200	4200	4200	4200	4100	4100	4100	4100	50000
	UNA ← PNB	125	125	125	125	125	125	125	125	125	125	125	125	1500
	MAL ← PNB	80	80	80	80	80	80	80	80	90	90	90	90	1000
	PRT ← PNB	40	40	40	40	40	40	40	40	40	40	50	50	500
	SUB TTL③'	245	245	245	245	245	245	245	245	255	255	265	265	3000
	TOTAL	27545	27545	27535	27535	27385	27385	27485	27485	27495	27495	27555	27555	330000
	GRAND TOTAL	152245	152245	152135	152135	96535	74685	74780	74790	74800	81520	110090	116790	1312750

lock d-ward	104160	104160	104160	104160	48720	26880	26880	26880	26880	33600	62160	68860	737500

Table 9.2.2 2010 year Monthly cargo volume to be transported. Alternative–2 (Ship Average)

Unit:Tons

	Port \ Month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
	Max Load	104160	104160	104160	104160	48720	26880	26880	26880	26880	33600	62160	68880	737520
DOWNWARD	S.F → URC	40	40	40	40	40	40	35	35	35	35	35	35	450
	S.F → FLR	14200	6160	6160	6160	2720	3700	3700	3700	3700	4500	8500	9300	72500
	R.G → URC	360	360	360	360	360	350	350	360	360	360	360	360	4300
	R.G → FLR	23100	0	0	0	0	6000	6000	6000	6000	7400	13900	15250	83650
	R.G → TRS	48300	28800	28800	28800	13600	12600	12600	12600	12600	15500	29000	31850	275050
	URC → FLR	4400	0	0	0	0	1100	1100	1100	1100	1400	2600	2950	15750
	URC → TRS	6500	63400	63400	63400	29800	1700	1700	1700	1700	2100	3900	4250	243550
	GUD → FLR	5460	0	0	0	0	1180	1180	1180	1180	2000	2960	3860	19000
	GUD → TRS	2200	5800	5800	5800	2600	600	600	600	600	700	1300	1400	28000
	FLR → TRS	140	140	140	140	130	130	130	130	130	130	130	130	1600
	AMR → TRS	0	0	0	0	3100	3100	6100	6100	6300	6100	3050	3050	36900
	PAL → TRS	0	0	0	0	2900	2900	5900	5900	5800	5800	2900	2900	35000
	SUB TTL①	104700	104700	104700	104700	55250	33400	39395	39405	39505	46025	68635	75335	815750
	MAL → PNB	3800	3800	3800	3800	3400	2100	1000	500	500	900	1100	2200	26900
	PRT → PNB	3600	3600	3600	3600	3400	2100	950	500	500	850	900	2200	25800
	LZL → PNB	16100	16100	16100	16100	15000	8500	4200	2000	2000	4200	5000	9000	114300
	SUB TTL③	23500	23500	23500	23500	21800	12700	6150	3000	3000	5950	7000	13400	167000
	TOTAL	128200	128200	128200	128200	77050	46100	45545	42405	42505	51975	75635	88735	982750
UPWARD	S.F ← FLR	250	250	250	250	475	1665	1425	1425	1470	1190	1190	1760	11600
	R.G ← FLR	1175	1175	1175	1175	2350	8230	7050	7050	5750	5750	5750	9370	56000
	URC ← FLR	1035	1035	1035	1035	2075	7265	6300	6300	5250	5250	5250	8270	50100
	GUD ← FLR	185	185	185	185	375	1310	1125	1125	935	935	935	1520	9000
	FLR ← AMR	460	460	460	460	925	3240	2850	2850	2375	2375	2375	3670	22500
	FLR ← PAL	100	100	100	100	200	700	600	600	560	560	560	820	5000
	S.F ← TRS	25	25	20	20	45	160	135	135	115	115	115	190	1100
	R.G ← TRS	40	40	40	40	75	260	225	225	250	250	250	305	2000
	URC ← TRS	1040	1040	1040	1040	2075	7260	6225	6225	5190	5190	5190	8285	49800
	GUD ← TRS	600	600	600	600	1200	4200	3600	3600	3125	3125	3125	4825	29200
	FLR ← TRS	730	730	725	725	1400	4900	4200	4200	3500	3500	3500	5890	34000
	FLR ← UNA	140	140	140	140	275	965	825	825	685	685	750	1130	6700
	SUB TTL①'	5780	5780	5770	5770	11470	40155	34560	34560	29205	28925	28990	46035	277000
	TRS ← UNA	3000	3000	3000	3000	1700	1300	1300	1300	1300	1700	2100	2300	25000
	TRS ← MAL	3000	3000	3000	3000	1700	1300	1300	1300	1300	1700	2100	2300	25000
	SUB TTL②'	6000	6000	6000	6000	3400	2600	2600	2600	2600	3400	4200	4600	50000
	UNA ← PNB	200	200	200	200	100	50	50	50	50	50	150	200	1500
	MAL ← PNB	150	150	150	150	50	50	50	50	50	50	50	50	1000
	PRT ← PNB	70	70	70	70	20	20	20	20	20	20	50	50	500
	SUB TTL③'	420	420	420	420	170	120	120	120	120	120	250	300	3000
	TOTAL	12200	12200	12190	12190	15040	42875	37280	37280	31925	32445	33440	50935	330000
	GRAND TOTAL	140400	140400	140390	140390	92090	88975	82825	79685	74430	84420	109075	139670	1312750

lock d-ward	104160	104160	104160	104160	48720	26880	26880	26880	26880	33600	62160	68860	737500

navigation. It means that in the case of daytime navigation, it takes about 6 days from Santa Filomena to Parnaiba and 9 days from Parnaiba to Santa Filomena.

Table 9.2.4 Distance and Navigation Hours (Main Ports)

Port to Port	Distance (km)	Navigation Hours			
		Downward		Upward	
		Hours	Days	Hour	Days
Santa Filomena to Floriano	585	36.0	3.0	52.0	4.3
Santa Filomena to Teresina	830	49.2	4.1	74.0	6.2
Santa Filomena to Parnaiba	1,215	70.0	5.8	108.7	9.1
Floriano to Teresina	245	13.2	1.1	22.0	1.8
Floriano to Parnaiba	630	34.0	2.8	56.7	4.7
Teresina to Parnaiba	385	20.8	1.7	34.6	2.9

Source: JICA Study Team

Note : Distance was obtained by map of 1:200,000 scale.

9.2.5 Capacity of Cargo Work

(1) General Cargo

Considering the effective ship's turn round, a ship is recommended to install a crane with the capacity of about 1 ton which shall be possible to turn 20 times per hour. It means that the capacity of cargo work is 20 tons per hour for general cargo.

(2) Bulk Cargo

The following capacities are to be used for the estimation of the required number of ships which are scheduled to be installed under Scenario 1.

Table 9.2.5 Capacity of Cargo Work of Bulk Cargo

Port	Loader/Unloader Capacity (ton/h)		
	Nminal	Loading	Unloading
Parnaiba	200	100	140
Luzilandia	100	50	70
Porto	100	50	70
Miguel Alves	100	50	70
Uniao	100	50	70
Teresina	700	350	490
Palmeiras	100	50	70
Amarante	100	50	70
Floriano	200	100	140
Guadalupe	100	50	70
Urucui	200	100	140
Ribeiro Goncalves	300	150	210
Santa Filomena	100	50	70

Source : JICA Study Team

Table 9.2.3 Distance and Navigation Hours

Distance

Unit : Km

	S.Filomena	R.Goncalves	Urcui	Guadalupe	Floriano	Amarante	Palmeirais	Teresina	Uniao	M.Alves	Porto	Luzilandia	Parnaiba
S.Filomena		275	375	515	585	660	710	830	900	965	1010	1095	1215
R.Goncalves	275		100	240	310	385	435	555	625	690	735	820	940
Urucui	375	100		140	210	285	335	455	525	590	635	720	840
Guadalupe	515	240	140		70	145	195	315	385	450	495	580	700
Floriano	585	310	210	70		75	125	245	315	380	425	510	630
Amarante	660	385	285	145	75		50	170	240	305	350	435	555
Palmeirais	710	435	335	195	125	50		120	190	255	300	385	505
Teresina	830	555	455	315	245	170	120		70	135	180	265	385
Uniao	900	625	525	385	315	240	190	70		65	110	195	315
M.Alves	965	690	590	450	380	305	255	135	65		45	130	250
Porto	1010	735	635	495	425	350	300	180	110	45		85	205
Luzilandia	1095	820	720	580	510	435	385	265	195	130	85		120
Parnaiba	1215	940	840	700	630	555	505	385	315	250	205	120	

Navigation Hours

Ship's Speed : 8.0 knots, Flow : 2.0 knots, Lock : 2.5 hrs

Unit : Hours(Days basis 12 hours/day)

	S.Filomena	R.Goncalves	Urcui	Guadalupe	Floriano	Amarante	Palmeirais	Teresina	Uniao	M.Alves	Porto	Luzilandia	Parnaiba
S.Filomena		14.8 (1.2)	20.2 (1.7)	29.7 (2.5)	36.0 (3.0)	40.0 (3.3)	42.8 (3.6)	49.2 (4.1)	53.0 (4.4)	56.5 (4.7)	58.9 (4.9)	63.5 (5.3)	70.0 (5.8)
R.Goncalves	24.7 (2.1)		5.4 (0.4)	14.8 (1.2)	21.1 (1.8)	25.2 (2.1)	27.9 (2.3)	34.4 (2.9)	38.1 (3.2)	41.6 (3.5)	44.1 (3.7)	48.7 (4.1)	55.1 (4.6)
Urucui	33.7 (2.8)	9.0 (0.7)		9.4 (0.8)	15.7 (0.8)	19.8 (1.6)	22.5 (1.9)	29.0 (2.4)	32.7 (2.7)	36.2 (3.0)	38.7 (3.2)	43.3 (3.6)	49.7 (4.1)
Guadalupe	43.2 (3.6)	18.4 (1.5)	9.4 (0.8)		6.3 (0.5)	10.3 (0.9)	13.0 (1.1)	19.5 (1.6)	23.3 (1.9)	26.8 (2.2)	29.2 (2.4)	33.8 (2.8)	40.3 (3.4)
Floriano	52.0 (4.3)	27.2 (2.3)	18.2 (1.5)	8.8 (0.7)		4.0 (0.3)	6.8 (0.6)	13.2 (1.1)	17.0 (1.4)	20.5 (1.7)	22.9 (1.9)	27.5 (2.3)	34.0 (2.8)
Amarante	58.7 (4.9)	34.0 (2.8)	25.0 (2.1)	15.5 (1.3)	6.7 (0.6)		2.7 (0.2)	9.2 (0.8)	13.0 (1.1)	16.5 (1.4)	18.9 (1.6)	23.5 (2.0)	30.0 (2.5)
Palmeirais	63.2 (5.3)	38.5 (3.2)	29.5 (2.5)	20.0 (1.7)	11.2 (0.9)	4.5 (0.4)		6.5 (0.5)	19.5 (1.6)	23.0 (1.9)	25.4 (2.1)	30.0 (2.5)	36.5 (3.0)
Teresina	74.0 (6.2)	49.3 (3.4)	40.3 (3.4)	30.8 (2.6)	22.0 (1.8)	15.3 (1.3)	10.8 (0.9)		3.8 (0.3)	7.3 (0.6)	9.7 (0.8)	14.3 (1.2)	20.8 (1.7)
Uniao	80.3 (6.7)	55.6 (4.6)	46.6 (3.9)	37.1 (3.1)	28.3 (2.4)	21.6 (1.8)	17.1 (1.4)	6.3 (0.5)		3.5 (0.3)	5.9 (0.5)	10.5 (0.9)	17.0 (1.4)
M.Alves	86.2 (7.2)	61.4 (5.1)	52.4 (4.4)	43.0 (3.6)	34.2 (2.8)	27.4 (2.3)	23.0 (1.9)	12.1 (1.0)	5.8 (0.5)		2.4 (0.2)	7.0 (0.6)	13.5 (1.1)
Porto	90.2 (7.5)	65.5 (5.5)	56.5 (4.7)	47.0 (3.9)	38.2 (3.2)	31.5 (2.6)	27.0 (2.3)	16.2 (1.3)	9.9 (0.8)	4.0 (0.3)		4.6 (0.4)	11.1 (0.9)
Luzilandia	97.9 (8.2)	73.1 (6.1)	64.1 (5.3)	54.7 (4.6)	45.9 (3.8)	39.1 (3.3)	34.7 (2.9)	23.8 (2.0)	17.5 (1.5)	11.7 (1.0)	7.6 (0.6)		6.5 (0.5)
Parnaiba	108.7 (9.1)	83.9 (7.0)	74.9 (6.2)	65.5 (5.5)	56.7 (4.7)	49.9 (4.2)	45.5 (3.8)	34.6 (2.9)	28.3 (2.4)	22.5 (1.9)	18.4 (1.5)	10.8 (0.9)	

Source : JICA Study Team

9.2.6 Days in Port

The days in port were obtained by dividing the port to port cargo volume by the loader/unloader capacity on the basis of 12 hours per day of which a sample calculation is shown as per Table 9.2.6.

A 80 percent of port operation rate is used considering berthing/unberthing time,the cargo documentation and the maintenance of port facilities etc.

9.2.7 Number of Ships Required

To estimate the number of ships required for cargo transportation on a monthly basis, the following measures were applied of which the calculation is shown hereunder and in Table 9.2.7 (Alternative 1) and Table 9.2.8 (Alternative 2) attached as a sample calculation.

1) The number of ships was estimated separately for upstream and downstream of Teresina.

2) Separate the cargo movements into Downward and Upward.

3) The use of the larger number of sub total of navigation days out of Downward and Upward because cargo of smaller navigation days shall be considered to be carried as ballastl of larger ones.

4) A 90 percent of ship's operation rate is used when considering the following items.
   - Repair and inspection of the ship.
   - Hours awaiting passage in a narrow channel or lock.
   - Hours to move to another shipment without cargo.

5) The calculation for the number of ships required for monthly cargo transportation is made from;

   a.: The larger number of sub total of navigation days out of Downward and Upward.
   b.: Total days in port for Downward movement
   c.: Total days in port for Upward movement

Case-1 : Daytime navigation and Daytime cargo work
$(a+b+c)/30/0.9$ = Number of ships on a monthly basis

In addition, the following case study was conducted

Case-2 : Daytime navigation and Halfnight cargo work
$(a+(b+c)/1.5)/30/0.9$ = Number of ships on a monthly basis

Case-3 : Daytime navigation and Overnight cargo work
$(a+(b+c)/2)/30/0.9$ = Number of ships on a monthly basis

Case-4 : Day and night navigation and Daytime cargo work
$(a/2+b+c)/30/0.9$ = Number of ships on amonthly basis

Table 9.2.7 Number of Ship Required Month : Sep. Year : 2010 Cargo Average (Alternartive–1)

	PORT	CARGO Q'TY (Ton)	LOADABLE Q'TY (Ton)	VOYAGE NUNBER	DIST (Km)	NAVIGATION DAYS DOWN WARD (Hrs)	UP WARD (Hrs)	LOCK PASS (Hrs)	TOTAL (Hrs)	DAYS	TOTAL DAYS	DAYS IN PORT
DOWNWARD	S.F → URC	35	370	0.1	375	20.3	33.8	0.0	54.1	4.6	0.5	
	S.F → FLR	3700	370	10.0	585	31.7	52.8	5.0	89.5	7.5	75.0	
	R.G → URC	360	370	1.0	100	5.5	9.1	0.0	14.6	1.3	1.3	
	R.G → FLR	6000	370	16.3	310	16.8	28.0	5.0	49.8	4.2	68.5	
	R.G → TRS	12600	160	78.8	555	30.0	50.0	5.0	85.0	7.1	559.5	
	URC → FLR	1100	370	3.0	210	11.4	19.0	5.0	35.4	3.0	9.0	
	URC → TRS	1700	160	10.7	455	24.6	41.0	5.0	70.6	5.9	63.2	
	GUD → FLR	1180	620	2.0	70	3.8	6.4	5.0	15.2	1.3	2.6	
	GUD → TRS	600	160	3.8	315	17.1	28.4	5.0	50.5	4.3	16.4	
	FLR → TRS	130	160	0.9	245	13.3	22.1	0.0	35.4	3.0	2.7	
	AMR → TRS	3050	160	19.1	170	9.2	15.4	0.0	24.6	2.1	40.2	
	PAL → TRS	2900	160	18.2	120	6.5	10.9	0.0	17.4	1.5	27.3	
	SUB TTL①	33355									① 866.2	④ 57.5
	MAL → PNB	2250	50	45.0	250	13.6	22.6	0.0	36.2	3.1	139.5	
	PRT → PNB	2150	50	43.0	205	11.1	18.5	0.0	29.6	2.5	107.5	
	LZL → PNB	9550	50	191.0	120	6.5	10.9	0.0	17.4	1.5	286.5	
	SUB TTL③	13950									③ 533.5	⑤ 39.4
	TOTAL	47305									******	
UPWARD	S.F ← FLR	950	370	2.6	585	31.7	52.8	5.0	89.5	7.5	19.5	
	R.G ← FLR	4600	370	12.5	310	16.8	28.0	5.0	49.8	4.2	52.5	
	URC ← FLR	4200	370	11.4	210	11.4	19.0	5.0	35.4	3.0	34.2	
	GUD ← FLR	750	620	1.3	70	3.8	6.4	5.0	15.2	1.3	1.7	
	FLR ← AMR	1900	330	5.8	75	4.1	6.8	0.0	10.9	1.0	5.8	
	FLR ← PAL	450	330	1.4	125	6.8	11.3	0.0	18.1	1.6	2.3	
	S.F ← TRS	90	160	0.6	830	44.9	74.8	5.0	124.7	10.4	6.3	
	R.G ← TRS	200	160	1.3	555	30.0	50.0	5.0	85.0	7.1	9.3	
	URC ← TRS	4150	160	26.0	455	24.6	41.0	5.0	70.6	5.9	153.4	
	GUD ← TRS	2500	160	15.7	315	17.1	28.4	5.0	50.5	4.3	67.6	
	FLR ← TRS	2800	160	17.5	245	13.3	22.1	0.0	35.4	3.0	52.5	
	FLR ← UNA	550	160	3.5	315	17.1	28.4	0.0	45.5	3.8	13.3	
	SUB TTL①'	23140									①' 418.4	⑥ 185.7
	TRS ← UNA	2050	450	4.6	70	3.8	6.4	0.0	10.2	0.9	4.2	
	TRS ← MAL	2050	240	8.6	135	7.3	12.2	0.0	19.5	1.7	14.7	
	SUB TTL②'	4100									②' 18.9	⑦ 9.4
	UNA ← PNB	125	50	2.5	315	17.1	28.4	0.0	45.5	3.8	9.5	
	MAL ← PNB	90	50	1.8	250	13.6	22.6	0.0	36.2	3.1	5.6	
	PRT ← PNB	40	50	0.8	205	11.1	18.5	0.0	29.6	2.5	2.0	
	SUB TTL③'	255									③' 17.1	⑧ 2.7
	TOTAL	27495									454.4	
	GRAND TOTAL	74800									1854	294.7

REMARKS

Case-1:Navigation 12 Hours & Cargo Work 12 Hours
Upstream (①or①' +④ +⑥) /30/0.9 = 42.0
Downstream (②' + ③or③' +⑤+⑦+⑧) /30/0.9 = 23.0
Total Upstream + Downstream = 65.0

Case-2:Navigation 12 Hours & Cargo Work 18 Hours
Upstream { ①or①' + (④ +⑥) /1.5} /30/0.9 = 39.0
Downstream { ②' + ③or③' + (⑤+⑦+⑧) /1.5} /30/0.9 = 22.0
Total Upstream + Downstream = 61.0

Case-3:Navigation 12 Hours & Cargo Work 24 Hours
Upstream { ①or①' + (④ +⑥) /2} /30/0.9 = 37.0
Downstream { ②' + ③or③' + (⑤+⑦+⑧) /2} /30/0.9 = 22.0
Total Upstream + Downstream = 59.0

Case-4:Navigation 24 Hours & Cargo Work 12 hours
Upstream = 26.0
Downstream = 13.0
Total = 39.0

Case-5:Navigation 24 Hours & Cargo Work 18 hours
Upstream = 23.0
Downstream = 12.0
Total = 35.0

Case-6:Navigation 24 Hours & Cargo Work 24 hours
Upstream = 21.0
Downstream = 12.0
Total = 33.0

Speed Downward : 18.5 Km/h
Upward : 11.1 km/h

Ship Operation Rate : 90 %

Source: JICA Study Team

Table 9.2.8 Number of Ship Required Month : Jan. Year : 2010 Ship Average (Alternartive–2)

	PORT	CARGO Q'TY(Ton)	LOADABLE Q'TY(Ton)	VOYAGE NUMBER	DIST (Km)	NAVIGATION DAYS: DOWN WARD(Hrs)	UP WARD(Hrs)	LOCK PASS(Hrs)	TOTAL (Hrs)	DAYS	TOTAL DAYS	DAYS IN PORT
DOWNWARD	S.F → URC	40	930	0.1	375	20.3	33.8	0.0	54.1	4.6	0.5	
	S.F → FLR	14200	620	23.0	585	31.7	52.8	5.0	89.5	7.5	172.5	
	R.G → URC	360	930	0.4	100	5.5	9.1	0.0	14.6	1.3	0.6	
	R.G → FLR	23100	620	37.3	310	16.8	28.0	5.0	49.8	4.2	156.7	
	R.G → TRS	48300	620	78.0	555	30.0	50.0	5.0	85.0	7.1	553.8	
	URC → FLR	4400	620	7.1	210	11.4	19.0	5.0	35.4	3.0	21.3	
	URC → TRS	6500	620	10.5	455	24.6	41.0	5.0	70.6	5.9	62.0	
	GUD → FLR	5460	620	8.9	70	3.8	6.4	5.0	15.2	1.3	11.6	
	GUD → TRS	2200	620	3.6	315	17.1	28.4	5.0	50.5	4.3	15.5	
	FLR → TRS	140	710	0.2	245	13.3	22.1	0.0	35.4	3.0	0.7	
	AMR → TRS	0	710	0.0	170	9.2	15.4	0.0	24.6	2.1	0.0	
	PAL → TRS	0	710	0.0	120	6.5	10.9	0.0	17.4	1.5	0.0	
	SUB TTL①	104700									① 995.2	④158.3
	MAL → PNB	3800	660	5.8	250	13.6	22.6	0.0	36.2	3.1	18.0	
	PRT → PNB	3600	660	5.5	205	11.1	18.5	0.0	29.6	2.5	13.8	
	LZL → PNB	16100	660	24.4	120	6.5	10.9	0.0	17.4	1.5	36.6	
	SUB TTL③	23500									③ 68.4	⑤ 67.3
	TOTAL	128200									******	
UPWARD	S.F ← FLR	250	620	0.5	585	31.7	52.8	5.0	89.5	7.5	3.8	
	R.G ← FLR	1175	620	1.9	310	16.8	28.0	5.0	49.8	4.2	8.0	
	URC ← FLR	1035	620	1.7	210	11.4	19.0	5.0	35.4	3.0	5.1	
	GUD ← FLR	185	620	0.3	70	3.8	6.4	5.0	15.2	1.3	0.4	
	FLR ← AMR	460	930	0.5	75	4.1	6.8	0.0	10.9	1.0	0.5	
	FLR ← PAL	100	930	0.2	125	6.8	11.3	0.0	18.1	1.6	0.4	
	S.F ← TRS	25	620	0.1	830	44.9	74.8	5.0	124.7	10.4	1.1	
	R.G ← TRS	40	620	0.1	555	30.0	50.0	5.0	85.0	7.1	0.8	
	URC ← TRS	1040	620	1.7	455	24.6	41.0	5.0	70.6	5.9	10.1	
	GUD ← TRS	600	620	1.0	315	17.1	28.4	5.0	50.5	4.3	4.3	
	FLR ← TRS	730	710	1.1	245	13.3	22.1	0.0	35.4	3.0	3.3	
	FLR ← UNA	140	710	0.2	315	17.1	28.4	0.0	45.5	3.8	0.8	
	SUB TTL①'	5780									①' 38.6	⑥ 46.3
	TRS ← UNA	3000	930	3.3	70	3.8	6.4	0.0	10.2	0.9	3.0	
	TRS ← MAL	3000	800	3.8	135	7.3	12.2	0.0	19.5	1.7	6.5	
	SUB TTL②'	6000									②' 9.5	⑦ 13.8
	UNA ← PNB	200	660	0.4	315	17.1	28.4	0.0	45.5	3.8	1.6	
	MAL ← PNB	150	660	0.3	250	13.6	22.6	0.0	36.2	3.1	1.0	
	PRT ← PNB	70	660	0.2	205	11.1	18.5	0.0	29.6	2.5	0.5	
	SUB TTL③'	420									③' 3.1	⑧ 4.4
	TOTAL	12200									51.2	
	GRAND TOTAL	140400									1115	290.0

Source: JICA Study Team

REMARKS

Case-1:Navigation 12 Hours & Cargo Work 12 Hours
Upstream (①or①' +④ +⑥) /30/0.9 = 45.0
Downstream (②' + ③or③' +⑤+⑦+⑧) /30/0.9 = 7.0
Total Upstream + Downstream = 52.0

Case-2:Navigation 12 Hours & Cargo Work 18 Hours
Upstream { ①or①' + (④ +⑥) /1.5} /30/0.9 = 42.0
Downstream { ②' + ③or③' + (⑤+⑦+⑧) /1.5} /30/0.9 = 5.0
Total Upstream + Downstream = 47.0

Case-3:Navigation 12 Hours & Cargo Work 24 Hours
Upstream { ①or①' + (④ +⑥) /2} /30/0.9 = 41.0
Downstream { ②' + ③or③' + (⑤+⑦+⑧) /2} /30/0.9 = 5.0
Total Upstream + Downstream = 46.0

Case-4:Navigation 24 Hours & Cargo Work 12 hours
Upstream = 27.0
Downstream = 5.0
Total = 32.0

Case-5:Navigation 24 Hours & Cargo Work 18 hours
Upstream = 24.0
Downstream = 4.0
Total = 28.0

Case-6:Navigation 24 Hours & Cargo Work 24 hours
Upstream = 23.0
Downstream = 4.0
Total = 27.0

Speed Downward : 18.5 Km/h
Upward : 11.1 km/h

Ship Operation Rate : 90 %

Table 9.2.6 Days in Port

Month : Jan. Year : 20 Year : 2010 Ship Average

	Port	CARGO VOLUME (tons)		CARGO WORK CAPACITY (T/Hr)				DAYS IN PORT
				BULK		GENERAL CARGO		
		BULK (A)	G.C. (B)	LOAD (C)	UNLOAD (D)	LOAD (E)	UNLOAD (F)	
DOWNWARD	S.F → URC	40	0	50	140	20	20	0.1
	S.F → FLR	14,200	0	50	140	20	20	40.1
	R.G → URC	360	0	150	140	20	20	0.5
	R.G → FLR	23,010	90	150	140	20	20	34.0
	R.G → TRS	48,300	0	150	490	20	20	43.8
	URC → FLR	4,330	70	100	140	20	20	8.5
	URC → TRS	6,370	130	100	490	20	20	9.3
	GUD → FLR	5,460	0	50	140	20	20	15.4
	GUD → TRS	2,050	150	50	490	20	20	6.3
	FLR → TRS	140	0	100	490	20	20	0.2
	AMR → TRS	0	0	50	490	20	20	0.0
	PAL → TRS	0	0	50	490	20	20	0.0
	SUB TTL①	104,260	440	-	-	-	-	158.3
	MAL → PNB	3,800	0	50	140	20	20	10.7
	PRT → PNB	3,600	0	50	140	20	20	10.2
	LZL → PNB	16,100	0	50	140	20	20	45.5
	SUB TTL③	23,500	0	-	-	-	-	66.4
	TOTAL	127,760	440	-	-	-	-	224.8
UPWARD	S.F ← FLR	0	250	100	70	20	20	2.6
	R.G ← FLR	45	1,130	100	210	20	20	11.8
	URC ← FLR	175	860	100	140	20	20	9.3
	GUD ← FLR	0	185	100	70	20	20	1.9
	FLR ← AMR	460	0	50	140	20	20	1.3
	FLR ← PAL	100	0	50	140	20	20	0.3
	S.F ← TRS	0	25	350	70	20	20	0.3
	R.G ← TRS	0	40	350	210	20	20	0.4
	URC ← TRS	0	1,040	350	140	20	20	10.8
	GUD ← TRS	0	600	350	70	20	20	6.3
	FLR ← TRS	715	15	350	140	20	20	0.9
	FLR ← UNA	140	0	50	140	20	20	0.4
	SUB TTL①'	1.635	4.145	-	-	-	-	46.3
	TRS ← UNA	3.000	0	50	490	20	20	6.9
	TRS ← MAL	3.000	0	50	490	20	20	6.9
	SUB TTL②'	6.000	0	-	-	-	-	13.8
	UNA ← PNB	0	200	100	70	20	20	2.1
	MAL ← PNB	0	150	100	70	20	20	1.6
	PRT ← PNB	0	70	100	70	20	20	0.7
	SUB TTL③'	0	420	-	-	-	-	4.4
	TOTAL	7.635	4.565	-	-	-	-	64.4
	GRAND TOTAL	135.395	5.005	-	-	-	-	289.2

REMARKS

Operation Rate: 80% (Taking into account berthing / unberthing time and time for documentation etc...)

Operation hour: 12 hours / day

Days in port = (A/C+A/D+B/E+B/F)/0.8/12

Source: JICA Study Team

Case-5 : Day and night navigation and Halfnight cargo work
(a/2+(b+c)/1.5)/30/0.9 = Number of ships on a monthly basis

Case-6 : Day and night navigation and Overnight cargo work
(a+b+c)/2/30/0.9 = Number of ships on a monthly basis

A summary of the above calculations is shown in Table 9.2.9. A maximum of 65 vessels are required to be operated along the Parnaiba river in a same day for Alternative 1 and 54 vessels for Alternative 2.

Table 9.2.9 Number of Ships Required

	Alternative 1						Alternative 2					
Case	1	2	3	4	5	6	1	2	3	4	5	6
Jan	55	51	48	35	31	29	52	47	46	32	28	27
Feb	56	51	49	36	32	29	52	49	48	32	28	27
Mar	56	51	49	36	30	28	52	49	47	32	28	27
Apr	56	51	49	36	31	28	52	49	47	32	28	27
May	54	50	48	34	29	28	53	50	48	31	28	27
Jun	48	44	42	30	27	25	52	46	44	35	29	27
Jul	55	51	49	33	30	29	54	49	47	34	30	28
Aug	64	60	59	38	34	33	54	49	47	34	29	27
Sep	65	61	59	39	35	33	53	49	47	32	28	27
Oct	56	52	50	34	31	29	53	48	46	33	29	27
Nov	55	51	49	35	30	28	52	48	46	34	29	27
Dec	46	41	39	30	25	23	53	46	43	37	30	27

Source : JICA Study Team

9.2.8 Evaluation of Each Alternative

From a view point of operation costs, safety of navigation, maintenance of ship etc., each alternative shall be evaluated as follows;

Table 9.2.10 Evaluation of Transportation Alternative

	Alternative - 1	Alternative - 2
Operation Cost	About 65 ships are required at the peak. 2	About 53 ships are required through the year. 1
Safety of Navigation	Concentration of ship is expected. 2	Safer. 1
Maitenance of Ships	About 15 ships must be maintained without working at the bottom. 2	No maintenance without working. 1
Port Operationrt	Congestion is expected at the peak. 2	Not so much congestion is expected. 1

Note : 1: Recommendable 2: Not Recommendable

9.3 Required Ship Number and Navigational Cost

(1) Required Ship Number

Referring to chapter 8 and the view of the above Table 9.2.10, for ship operations on the Parnaíba river it is recommendable to adopt Alternative 2 which means " ship average". The daytime navigation should be adopted for the sake of safe navigation. Table 9.3.1 shows the number of ships required in 2000 and 2010 for each scenario, calculated under the conditions of 12 hours navigation and 12 hours of cargo work.

Table 9.3.1 Number of Ship Required in 2000 and 2010

Year	2000				2010			
Scenario	1	2	3	4	1	2	3	4
Jan	21	19	12	15	52	45	31	40
Feb	20	18	12	15	52	46	29	40
Mar	20	18	12	15	52	46	29	40
Apr	20	18	12	15	52	46	29	40
May	20	19	7	7	53	46	29	29
Jun	19	18	9	9	52	45	30	30
Jul	19	17	9	9	54	47	32	32
Aug	21	18	9	9	54	48	32	32
Sep	20	17	9	9	53	47	31	31
Oct	20	17	9	9	53	46	33	33
Nov	20	17	9	9	52	46	31	31
Dec	19	16	11	9	53	45	31	31
Average	21	18	10	11	53	46	31	34

Source : JICA Study Team

(2) Ship Operation Cost

Based on the above required number of ships, ship operation costs are estimated. Table 9.3.2 shows the ship operation costs in 2010 for each scenario. In Scenario 1, 53 ships are required which contains 46 ships in the section from the upper region to Teresina and 7 ships from Teresina to Parnaíba. The cost of Scenario 1 is the most expensive of all the Scenario because passing downstream is so inefficient owing to shallow basin.

In Scenario 2, 46 ships are required, the same as upstream in Scenario 1. This is not planned to operate downstream from Teresina.

In Scenario 3, to minimize the ship's operation costs for Scenario 1 and 2, the cargo unloading at Teresina in Scenario 1 and 2 is transferred to unload at Floriano, and therefore, soybean should be transported by truck. Restriction of draft is eased so that transportation cargo is increased slightly. Scenario 4 means the improvement of Scenario 3 so carrying soybean to Teresina during rainy season is possible.

Table 9.3.2 Ship Operation Cost in 2010

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Operation Section	Upper region - Parnaíba	Upper region - Teresina	Upper region - Floriano	Upper region - Floriano & Teresina
Number of Ship Required	53	46	31	40
Cargo Volume (ton.km/ship)	8,874,000	9,417,000	13,930,000	10,749,000
Operation Cost including capital cost (US$/ton.km)	0.0429	0.0388	0.0262	0.0272
Operation Cost excluding capital cost (US$/ton.km)	0.0281	0.0249	0.0168	0.0182

9.4 Comments on the Vessel Fabrication and Operation

Remarkable points for the accomplishment of vessel fabrication and operation are as follows :

- To prepare a suitable assistance and rescue system for accidents such as groundings, collisions and engine trouble.
- To provide emergency repair facilities and staff for the above accidents and machineries trouble.
- To improve especially narrow channels and sharp curves where it seems very difficult for a ship's safe navigation.
- To give ship's crew training for manoeuvring.
- To provide suitable and adequate navigation aids throughout the river.
- To conduct a survey of the depth, width and flow rate of the navigable waters throughout the Parnaíba river before commencement of the river navigation.
- To prepare maps of the waterway showing the positions of the buoys, under water obstructions and other necessary information.
- To establish the waiting areas for daytime navigation at the both sides (upstream and downstream) of the locks.
- To maintain the width of the river for straight channels as follows ;
  Min. 30 m for one-way traffic
  Min. 50 m for two-way traffic
- To keep the suitable overhead clearance for electric cables depending on the possibility of a dangerous electrical discharge between the cable and a ship passing underneath.

10. PLANNING OF RESUMPTION OF BOA ESPERANÇA LOCKS

10. PLANNING OF RESUMPTION OF THE BOA ESPERANÇA LOCKS

10.1 Present Circumstances of the Boa Esperança Lock

Construction of the Boa Esperança Dam was started for hydraulic power generation by the Hydro Electric Company of Sao Francisco (CHESF) in 1962, and completed in 1965. The completed reservoir is 155 km in length and 352 km2 in its deposit area.

Ship navigation became impossible because of the construction of the Boa Esperança Dam, and so to enable ship navigation past the dam, construction planning for a lock system was established. The lock system was planned to be located in the right bank area of the Boa Esperança Dam, latitudinally southward 6°45' and longitudinally eastward 43°34', in the neighboring town of Guadalupe.

The water level difference between the reservoir and the downstream Parnaíba river is 47m at the maximum. To overcome this water level difference, the lock is designed to be a double lock chamber system, namely an upstream lock chamber, and a downstream lock chamber connected by an intermediate reservoir.

Construction of the system started in 1974, and concreting work was completed in 1982, but the work stopped for financial reasons. Presently, due to the existence of no mechanical equipment such as gate structures and control equipment, the lock system does not work. A sectional arrangement of the Boa Esperança Lock System is shown in Fig. 10.1.1. Specifications of the lock system are as follows :

(1) Upstream Lock Chamber

Useful Length	: 50m
Width	: 12m
Upstream Water Level	: H.W.L.304.0m-L.W.L.294.0m
Downstream Water Level	: L.W.L.280.5m
Bottom Elevation	: 278.0m
Minimum Water Depth	: 2.5m
Water Level Difference	: 23.5m(Maximum)

(2) Downstream Lock Chamber

Useful Length	: 50m
Width	: 12m
Upstream Water Level	: 280.5m(Maximum)
Downstream Water Level	: H.W.L.269.0m-L.W.L.257.0m
Bottom Elevation	: 254.5m
Minimum Water Depth	: 2.5m
Water Level Difference	: 23.5m(Maximum)

(3) Intermediate Reservoir

Water Level	: 280.5m(Average)
Embankment Crest Elevation	: 282.5m
Accumulated Volume	: 675,000m3

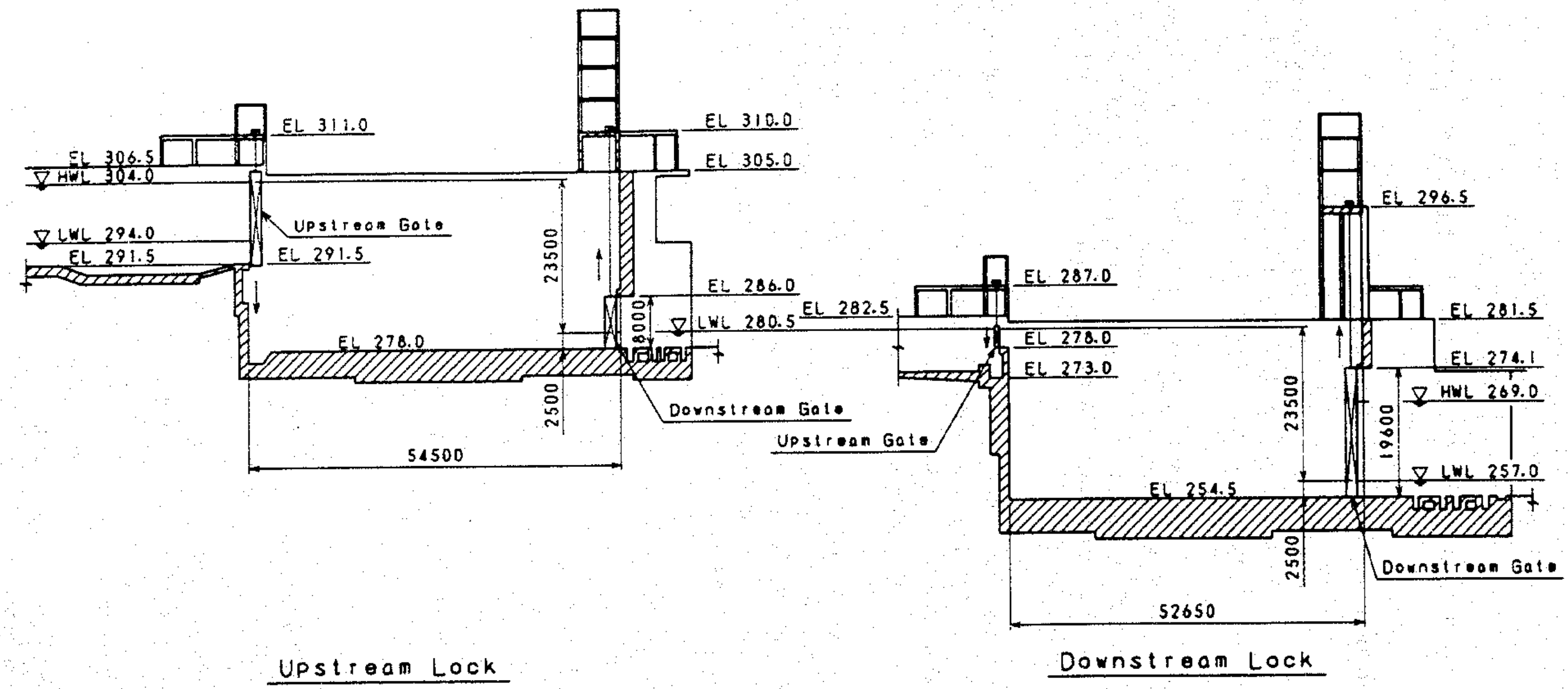


Fig.10.1.1 Sectional Arrangement of the Boa Esperanca Lock

Area of Basin	: 124,000m2
Control of Water Level	: Discharge by Bottom Outlet

(4) Access and Restitution Channels

Access to Upstream Chamber	
Width	: Variable
Bottom Elevation	: 291.5m
Upstream Chamber Restitution	
Width	: 12.0m
Bottom Elevation	: 278.0m
Access to Downstream Chamber	
Width	: 12.0m
Bottom Elevation	: 278.0m
Downstream Chamber Restitution	
Width	: 12.0m
Bottom Elevation	: 254.5m

In order to enable ship navigation between the Boa Esperança Dam and the downstream Parnaiba river, the presently suspended lock system must be continued and completed, or otherwise, the new construction of another type of navigation system must be made in lieu of the lock system.

10.2 Comparison of Navigation Systems

From the Boa Esperança Dam to the Parnaiba river, the water level difference reaches 47m. To overcome this water level difference and enable the navigation of ships between the Boa Esperança Dam and the Parnaiba river, the following systems are to be considered.

- Lock System
- Vertical Lift System
- Inclined Lift System

Sectional arrangements of respective systems are shown in Fig. 10.2.1, and explanations for the three systems are made as follows.

(1) Lock System

This system is generally composed of a lock chamber wherein the upstream and downstream closing gates are contained, along with filling and emptying facilities.

After the intrusion of the ship and closing of the entrance gate, the up and down movement of the ship can be made through the filling and discharging of the chamber water.

For the Boa Esperança Lock System, where a 47m water level difference exists, two lock systems are designed upstream and downstream of the Dam.

(2) Vertical Lift System

This system is composed of a huge vessel to enclose the ship and water, two towers to raise and lower the vessel, and an approach flume to access the towers from the upstream end. A schematic arrangement of the vertical lift system is shown in Fig. 10.2.2.

After the balancing of water level in the vessel, a ship intrudes into the vessel and by closure of the entrance gate enables the segregation from the flume, whereby up and down movement can be made by the operation of the lift equipment, suspended vertically from the two towers.

From the suspension devices at the two respective towers, a vessel is connected by wire-ropes to the counter weight through a huge sheave, and is balanced with a counter weight.

Operation of the up and down movement of the vessel is performed by the turning of a nut around a spindle which is fixed vertically along the tower.

(3) Inclined System

This system is formed by a carriage supporting a vessel which encloses the ship together with the water. There is an inclined rail path and a control tower with the driving equipment. A schematic arrangement of the Inclined Lift System is shown in Fig. 10.2.3.

The vessel wherein ship and water are enclosed is loaded on to carriage, and then the carriage runs up and down on the inclined rail by the operation of driving equipment located in the control tower.

The carriage with the vessel is connected by wire-ropes to a counterweight through a sheave which is located at the control tower.

The counter weight and carriage balance each other and run on the lined rail, but in the reverse direction to the operation of the driving equipment.

(4) Comparison of the Systems

Comparison of the three systems, namely the lock system, the vertical lift system and the inclined lift system is made and summarized as shown in Table 10.2.1.

For the comparison of the three systems, the specifications of the navigating ship are defined as follows:

Overall length	: 47.0 m
Breadth	: 11.0 m
Depth	: 3.5 m
Operation draft	: 2.3 m
Dead weight	: 620 tons

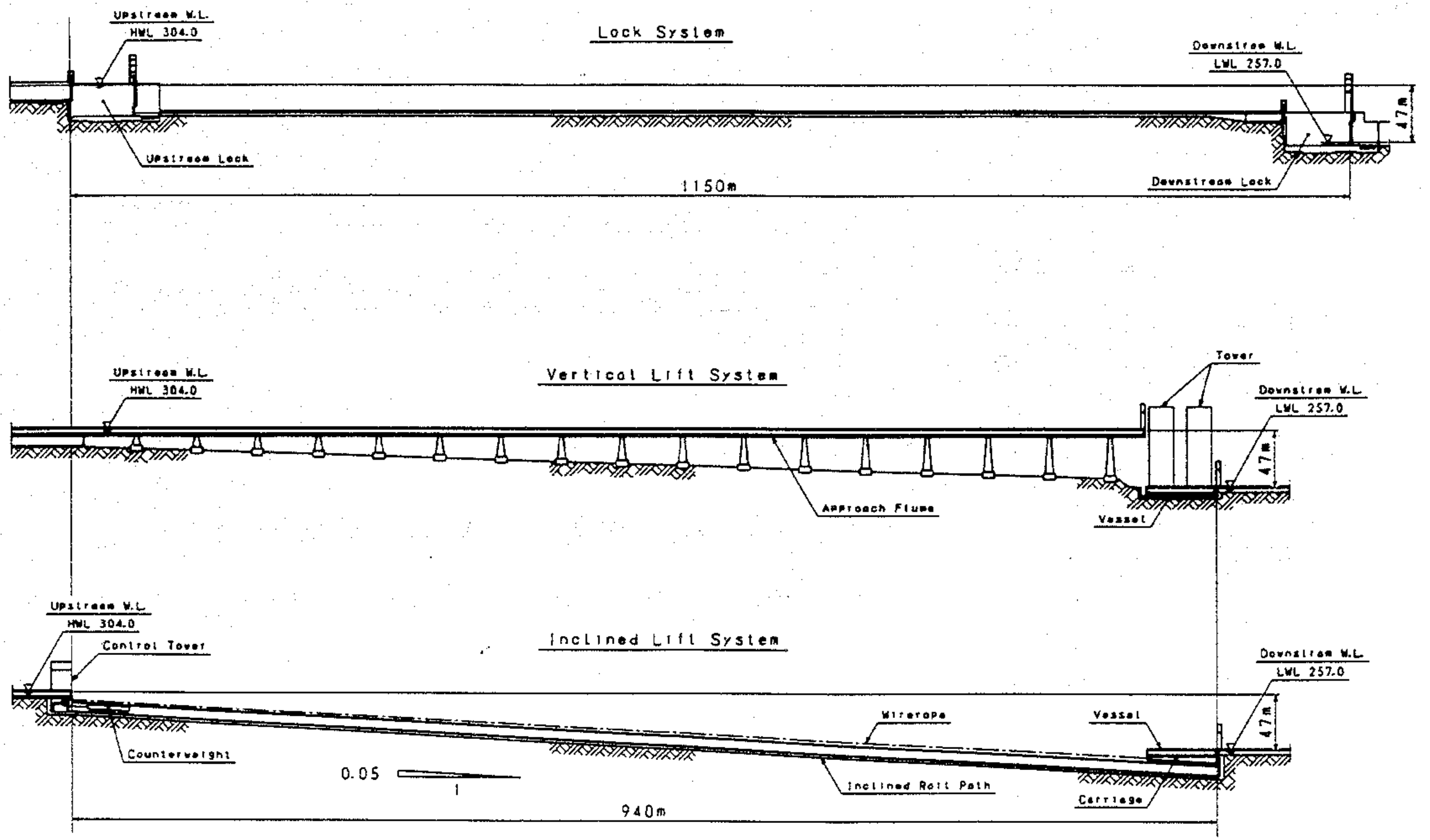


Fig.10.2.1 Sectional Arrangements of the Lock System, Vertical Lift System and Inclined Lift System

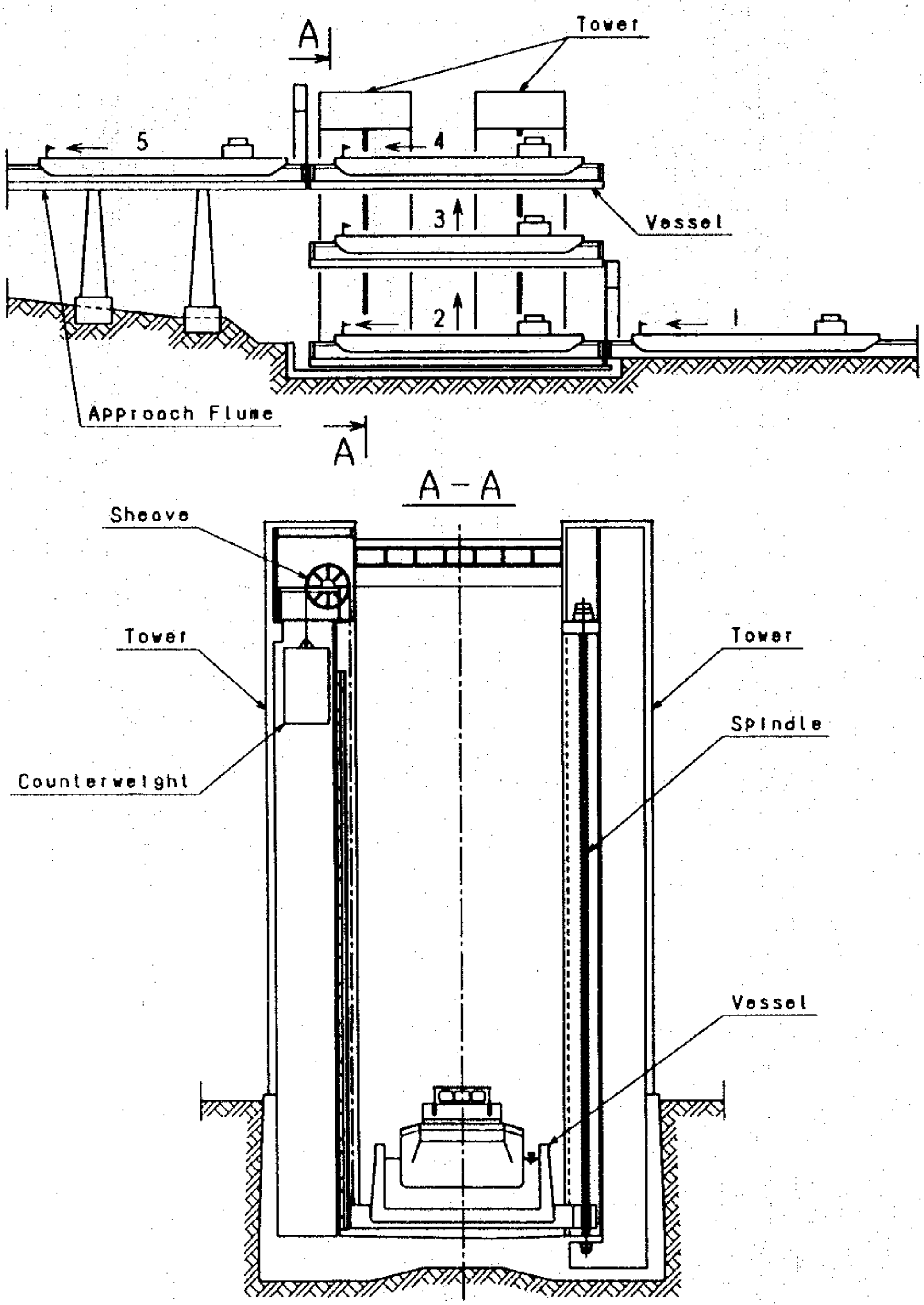


Fig.10.2.2 Schematic Arrangement of the Vertical Lift System

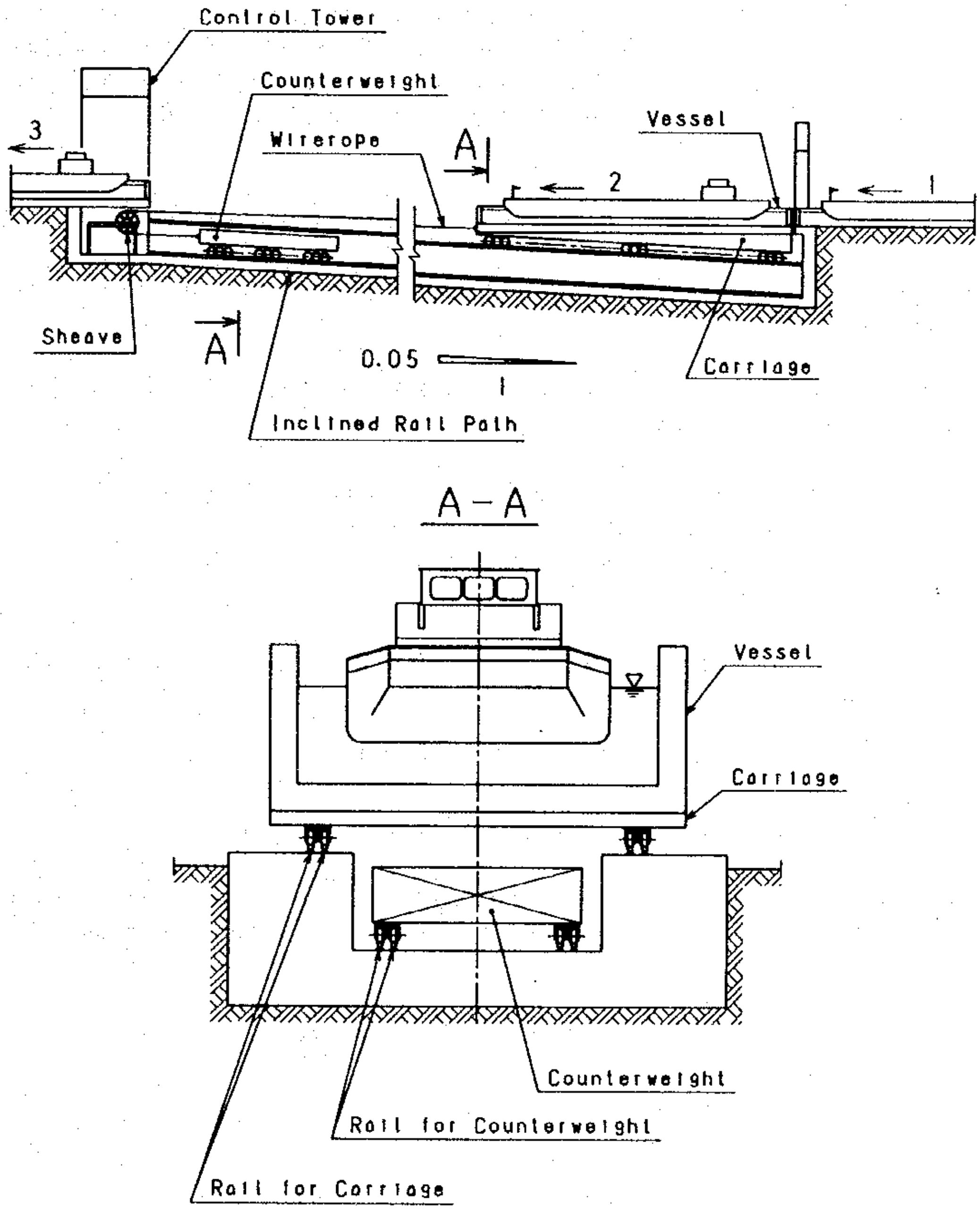


Fig.10.2.3 Schematic Arrangement of the Inclined Lift System

(5) Results

The significant characteristic of the locational arrangement of navigation system is the fluctuation of water level. The maximum water difference between the Boa Esperança Dam and the Parnaíba river reaches 47m, and the maximum fluctuation of the surface water level at the upstream Boa Esperança Dam is 10m, and is similarly 12m at the downstream Parnaíba river.

For the satisfactory overcoming of such a big water level difference and fluctuation of surface water levels, the planning of a vertical lift system or an inclined lift system needs fairly big initial investments, and must solve difficult problems of locational selection and technical difficulties.

On the other hand, a lock system has no substantial problems with the water level difference and is also advantageous because of the followings points:

- Existing civil structures including lock chambers are applicable.
- Economically excellent
- Construction period is comparatively short
- No existence of technical anxieties

For the result, as summarized in the Table 10.2.1, a lock system is definitely recommendable and conclusive.

10.3 Planning of Resumption of Boa Esperança Locks

10.3.1 Necessary Equipment to Complete the Lock System

The Boa Esperança Lock was suspended after the completion of the concrete works. In order to complete the lock system, the following remaining works must be accomplished:

- Gate equipment for lock chamber
- Filling and emptying equipment for lock chamber
- Stoplogs
- Control equipment
- Ancillary equipment

(1) Gate Equipment for Lock Chamber

1) Gates for upstream lock chamber

The arrangement of the gates for the upstream lock chamber is shown in Fig. 10.3.1, and specification of the gates is as follows.

Type	:Vertical Lift Gate
Clear Width	: 12.0m
Clear Height	: Upstream Gate 14.0 m
	: Downstream Gate 8.0 m

Table 10.2.1 Comparison of Navigation System

Item \ Type of System	Lock System	Vertical Lift System	Inclined Lift System
Major Composition	- Upstream chamber - Downstream chamber - Gates in the chamber - Filling & discharging facilities	- Vessel - Tower lift - Approach flume - Gates for vessel & approach flume	- Carriage with vessel - Inclined rail path - Control tower - Gates for vessel & Flume
Civil Work	Upstream and downstream lock chambers had been almost completed, except slight civil work remains.	Construction of towers and approach flume are needed. For the foundation of the tower, firstly a geological investigation must be made to find the most suitable foundation to support the heavily concentrated load for the system.	Construction of inclined rail path and control tower are needed. By reason that the heavy load acts along the inclined rail path, a geological investigation must be made to find out a suitable foundation to support the load
Structural Construction Work	Construction of lock gates, and filling & discharge facilities has been experienced in the Brazil, and no technical difficulties exist.	Vessel to contain ship and also towers with driving equipment are very complicated. Accordingly manufacturing and construction needs advanced techniques.	Carriage with vessel to contain ship and driving equipment are extraordinary large structures and manufacturing and construction needs advanced techniques and is difficult.
Control of Water Level	Control of water level is possible by the matured technique applying with filling and discharging facilities, and no difficulty exist.	To comply with the fluctuation of surface water level in the Parnaiba River i.e."12m", height of vessel exceed 15m. For the approach flume of the system, height of flume wall exceed 13m to suit the fluctuation of surface water level of the dam. Both structures are extraordinary large.	To comply with the fluctuation of surface water level in the Parnaiba River i.e. "12m", height of vessel exceed 15m.
Navigability of Ship	Upstream chamber and downstream chamber are independent to each other, and accordingly, ship navigation becomes effective through the stand-by period at the intermediate reservoir.	Ship navigation become possible just after the navigation of former ship.	Identical to the description of vertical lift system.
Maintenance	Maintenance work is considered to be the same as for ordinary gate equipment.	A lot of maintenance works are needed for the driving equipment and in the towers. In addition there is the vessel and complicated operation mechanisms of the gate facilities.	Not only for the maintenance of the huge carriage with vessel and driving equipment, but also difficult maintenance must be made for the rail and wire rope of more than 1000m length.
Work Period	Remaining civil work is not so much, and work period for the steel structures can be shortened through the parallel performance of manufacturing and installation.	In addition to the civil works as well as the steel structural works, investigation and design work needs a long period.	Identical to the vertical lift system.
Work Experience	Work experiences commonly exist in Brazil.	Work experience do not exist in the Brazil and techniques must be transferred from foreign countries.	Identical to the vertical lift system
Weight ratio of the steel structures	1	6	7
Concrete volume	negligible	30,000m3 (excluding approach flume)	60,000m^3
Construction Cost	Approx. US $ 16 million	Approx. US $ 100 million (excluding approach flume)	Approx. US $ 120 million
Total evaluation	Recommendable	———	———

Note : Construction cost of this table is prepared for the comparison purpose.

Design Water Level	: Upstream Gate 304.0 m + 1.5 m (wave height by wind)
	:Downstream Gate 304.0 m + 0.25m(wave height by wind)
Sill Elevation	: Upstream Gate 291.5 m
	:Downstream Gate 278.0 m
Operating Head	:Balanced Water Level
Operating System	:Chain Hoist Combined with Counter weight
Operating Speed	:2.0m/min.
Lifting Height	: Upstream Gate 14.1 m
	: Downstream Gate 8.1 m

2) Gates for downstream lock chamber

The arrangement of the gates for the downstream lock chamber is shown in Fig. 10.3.2, and specification of the gates is as follows.

Type	:Vertical Lift Gate
Clear Width	:12.0m
Clear Height	:Upstream Gate 3.4m
	:Downstream Gate 19.6m
Design Water Level	:Upstream Gate 280.5m + 0.5 m (wave height by wind)
	:Downstream Gate 280.5 m + 0.25m(wave height by wind)
Sill Elevation	:Upstream Gate 278.0m
	:Downstream Gate 254.5m
Operating Head	:Balanced Water Level
Operating System	:Chain Hoist Combined with Counter Weight
Operating Speed	:2.0m/min.
Lifting Height	: Upstream Gate 3.5 m
	: Downstream Gate 19.7 m

(2) Filling and Emptying Equipment for Lock Chamber

The arrangement of the filling and emptying gates is shown in Fig. 10.3.3. Specifications for the filling and emptying gates, and trashrack at the culvert inlet are as follows:

1) Filling and emptying gates

Type	:Reversal Tainter Gate
Quantity	:8 sets
Conduit Width	:2.0m
Conduit Height	:1.2m
Design Water Level	:Upstream chamber 304.0m + 1.5m (wave height by wind)
	:Downstream chamber 280.5m+0.5m(wave height by wind)
Sill Elevation	:Upstream chamber 276.05m
	:Downstream chamber 252.55m
Operating System	: Hydraulic cylinder
Operating Speed	:1.2m/min.
Lifting Height	: 1.25 m

2) Trashrack

Type	:Removable bar-screen type

Quantity	:Upstream chamber 2 sets
	:Downstream chamber 2 sets
Width	:Upstream chamber 5.76m
	:Downstream chamber 5.49m
Height	:3.0m
Bar Pitch	:0.1m
Sill Elevation	:Upstream chamber 290.0m
	:Downstream chamber 274.0m

(3) Stoplogs

1) Stoplogs for lock chambers

Type	:Multiple slide gate
Quantity	:2 sets
Clear Width	:12.0m
Height	:15.0m(height for one block : 1.5m)
Design Head	: 15.0m
Operating system	: Monorail Hoist

2) Stoplogs for filling and emptying gates

Type	:Roller gate
Quantity	:4 sets
Conduit Width	:2.0m
Conduit Height	:1.2m
Design Head	: 24.45m
Operating system	: Monorail Hoist

(4) Control Equipment

1) Control panel

The arrangement of the control panels is shown in Fig. 10.3.4, and their purpose and function are shown in the Table 10.3.1.

Table 10.3.1 Purpose and Function of Control Panel

Purpose	Qty	Function
Local Control Panel for Lock Gate	4	Local control of respective gates for lock chamber
Local Control Panel for Filling and Emptying Gates	8	Local control of respective filling and emptying gates
Remote Control Panel	2	Remote control of gates for lock chamber, filling and emptying gates from the control room of upstream and downstream locks.
Remote Control Panel for Emergency	1	Remote control of overall gates from the remote control room of upstream lock.

2) Other Equipment

Following equipment is needed for the purpose of a ship's safe navigation :

- ITV Monitoring Equipment
- Traffic Signals
- Announcement Equipment
- Water Level Indicator
- Lighting Equipment

(5) Ancillary Equipment

Following ancillary equipment is necessary

- Elevator for the control room
- Floating bollards in the lock chamber
- Monorail hoist for the maintenance purpose of operating equipment
- Handrails on the lock chamber deck and staircase
- Ladders for the lock chamber and pit
- Pit cover in the hoisting room
- Mooring wharf in the reservoir

10.3.2 Relevant Civil Works

Following civil works are needed additionally.

- Jetty on the right bank in the intermediate reservoir and access road
- Walls for hoisting room and control room
- Storage facility for stoplogs
- Removing of plants and bushes on the navigation line in the intermediate reservoir
- Removing of a concrete bulkhead in the upstream flume for the upstream lock chamber
- Removing of gravel and rocks which are interrupting the ship's navigation in the downstream flume and the Parnaíba river

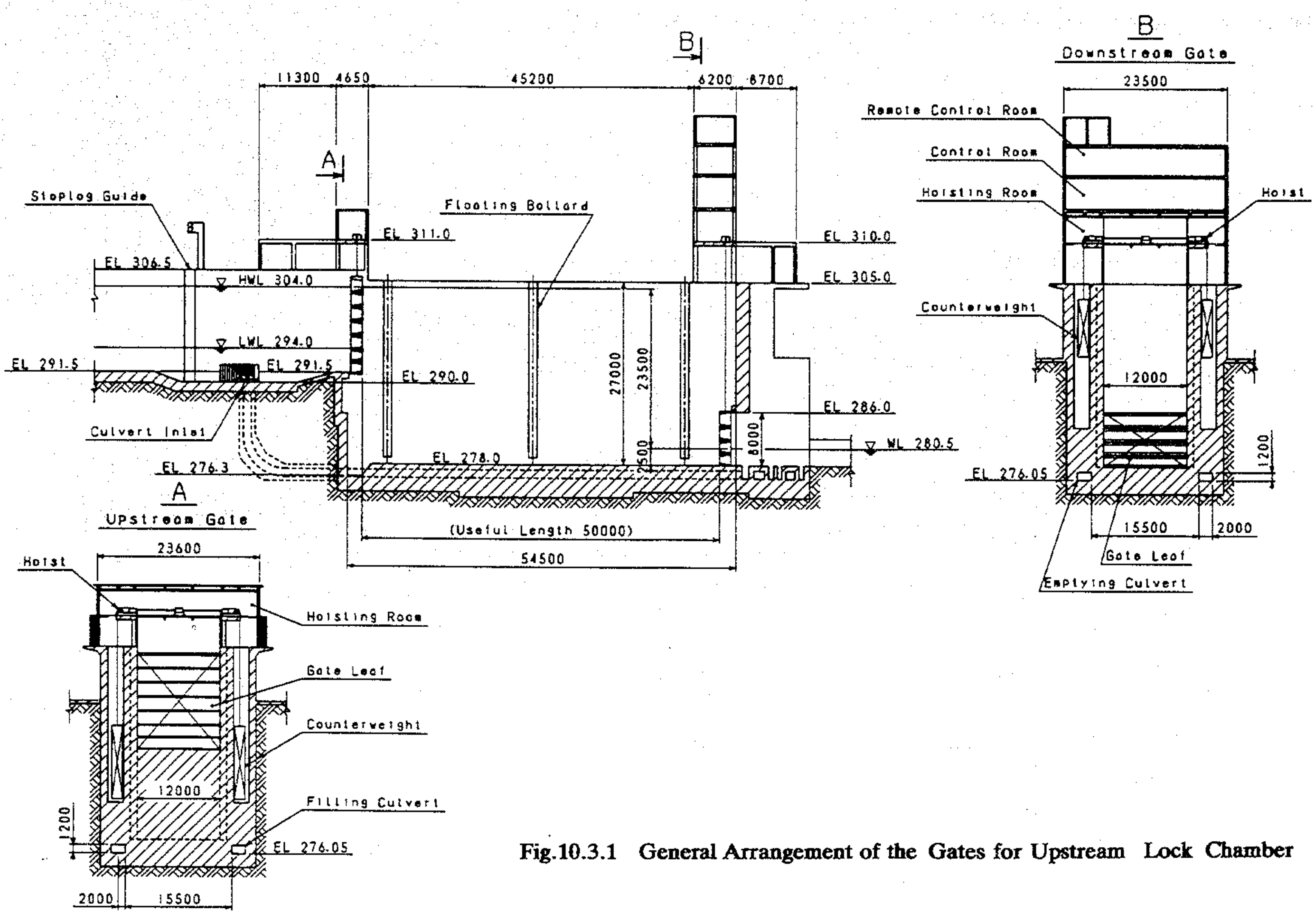


Fig.10.3.1 General Arrangement of the Gates for Upstream Lock Chamber

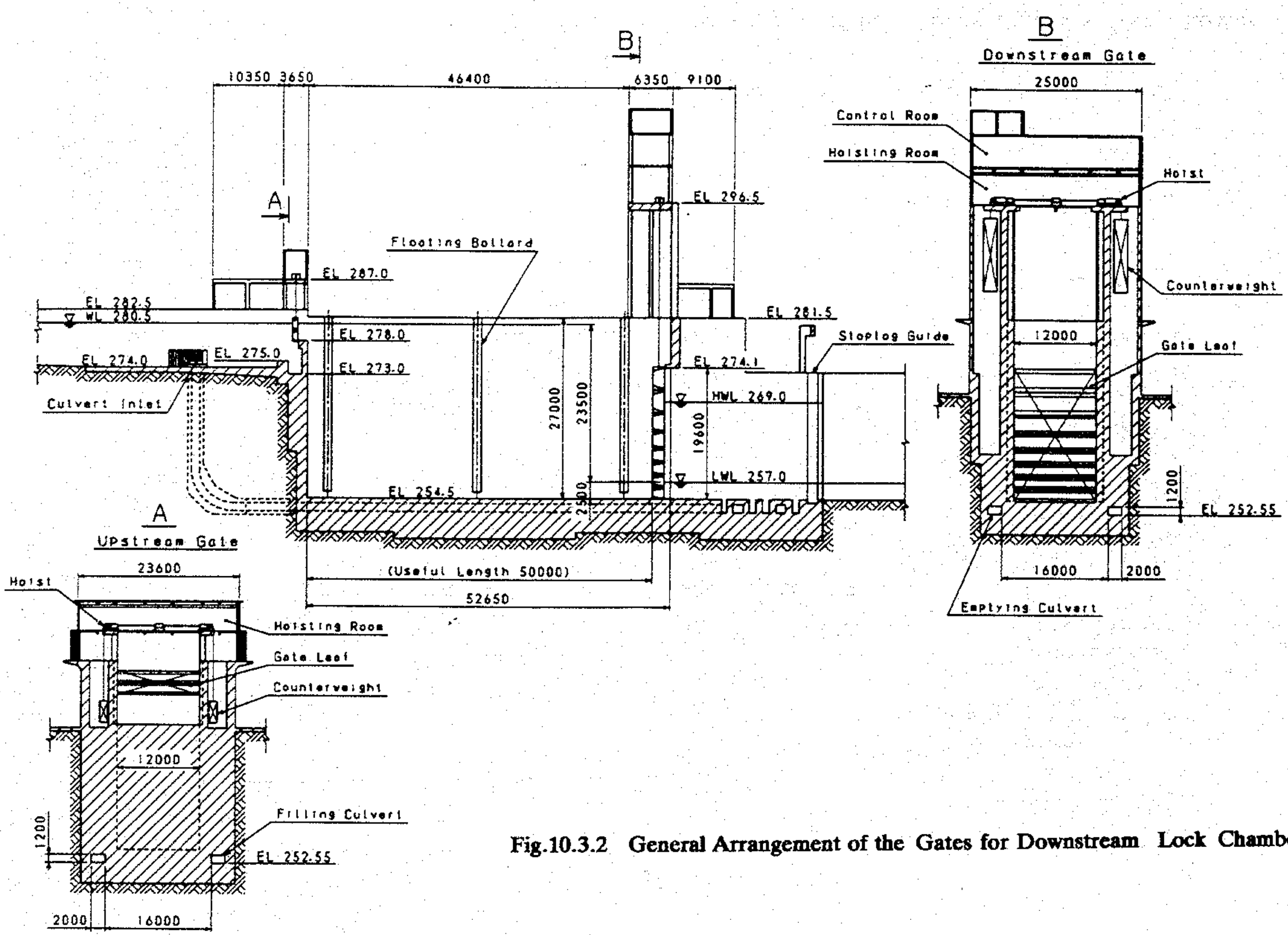


Fig.10.3.2 General Arrangement of the Gates for Downstream Lock Chamber

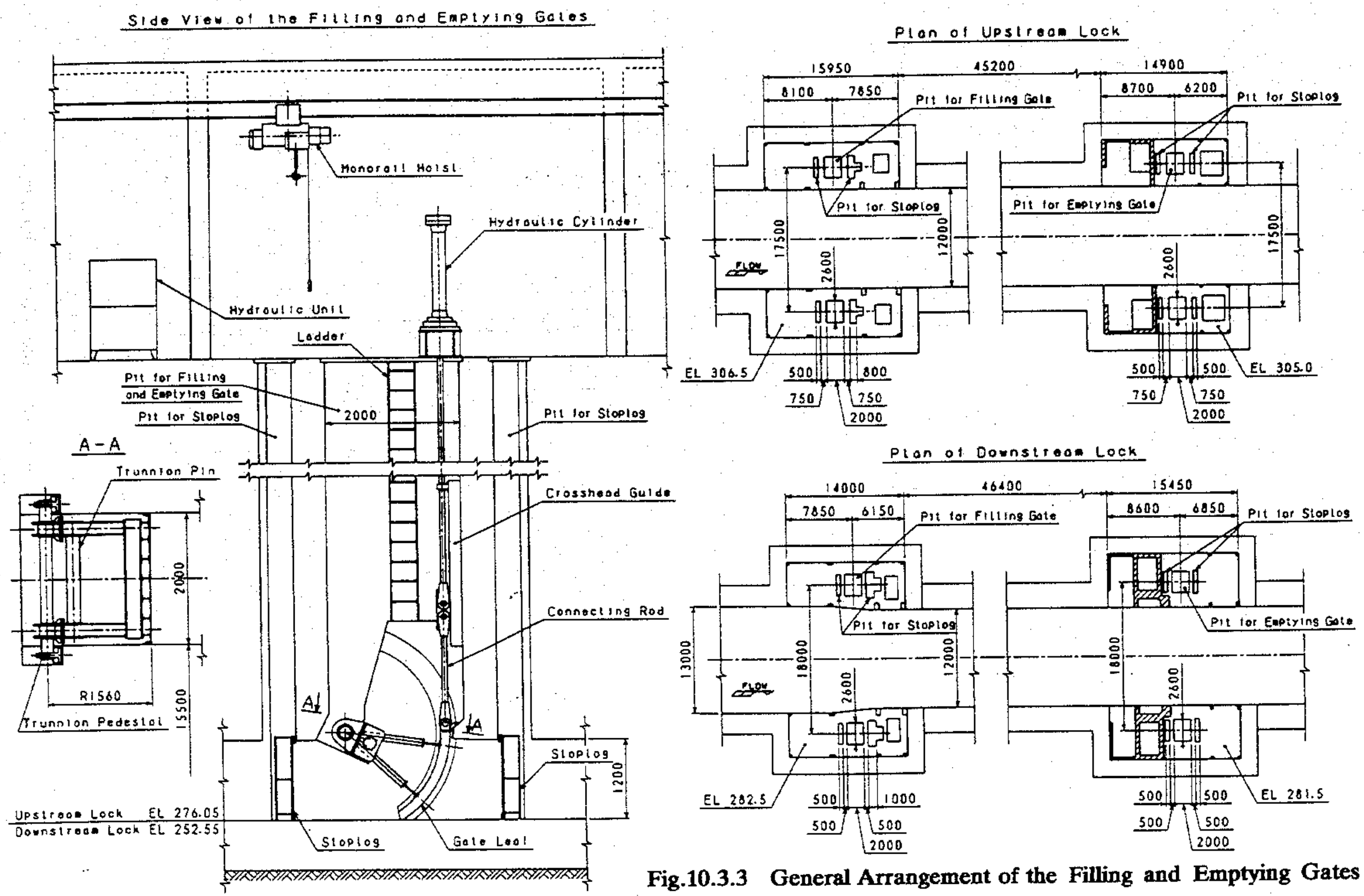


Fig.10.3.3 General Arrangement of the Filling and Emptying Gates

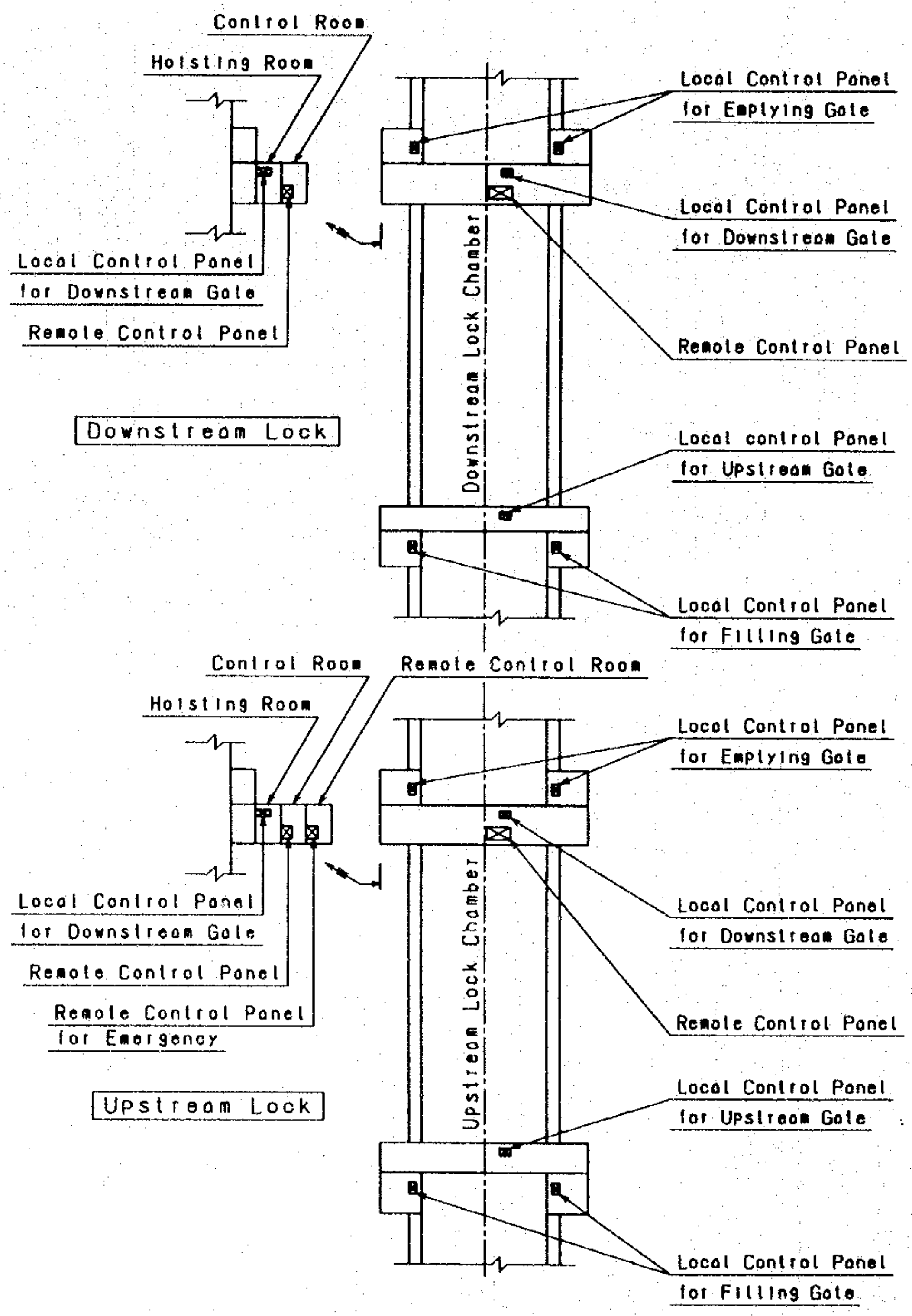


Fig.10.3.4 Arrangement of the Control Panels

10.3.3 Control System

Control system for the locks is shown in Fig. 10.3.5, and the specification of control equipments is shown in Table 10.3.2.

Table 10.3.2 Specification of the Control Equipments

Item	Specification	Quantity
Local Control Panel for Lock Gate	Type : Outdoor type Size : 800w x 600d x 2000h	4
Local Control Panel for Filling and Emptying Gate	Type : Outdoor type Size : 800w x 600d x 2000h	8
Remote Control Panel	Type : Indoor type Size : 3000w x 1000d x 1500h	3
ITV Monitoring Equipment	Type : Outdoor type Camera and Controller	6
Traffic Signal	Type : Outdoor type	8
Water Level Indicator	Pressure Detective type	5
Announcement Equipment	Microphone : 2 Speaker : 4 Amplifier : 2	1 set
Lighting Equipment	Mercury Vapor Lamp	16
Elevator for upstream Locks	Lifting Load : 200kg Lifting Height : 21m	1
Elevator for Downstream Lock	Lifting Load : 200kg Lifting Height : 15m	1

The operation of lock gates, filling and emptying gates could be made generally from the remote control panel in the control room, which is located independently to each upstream and downstream lock. An operator who is always stays in the control room can operate the lock gates, filling and emptying gates, watching the ship by ITV monitoring equipment. In case of emergency, the operation at the remote control panel enables gate equipment of the upstream and downstream locks to be functioned.

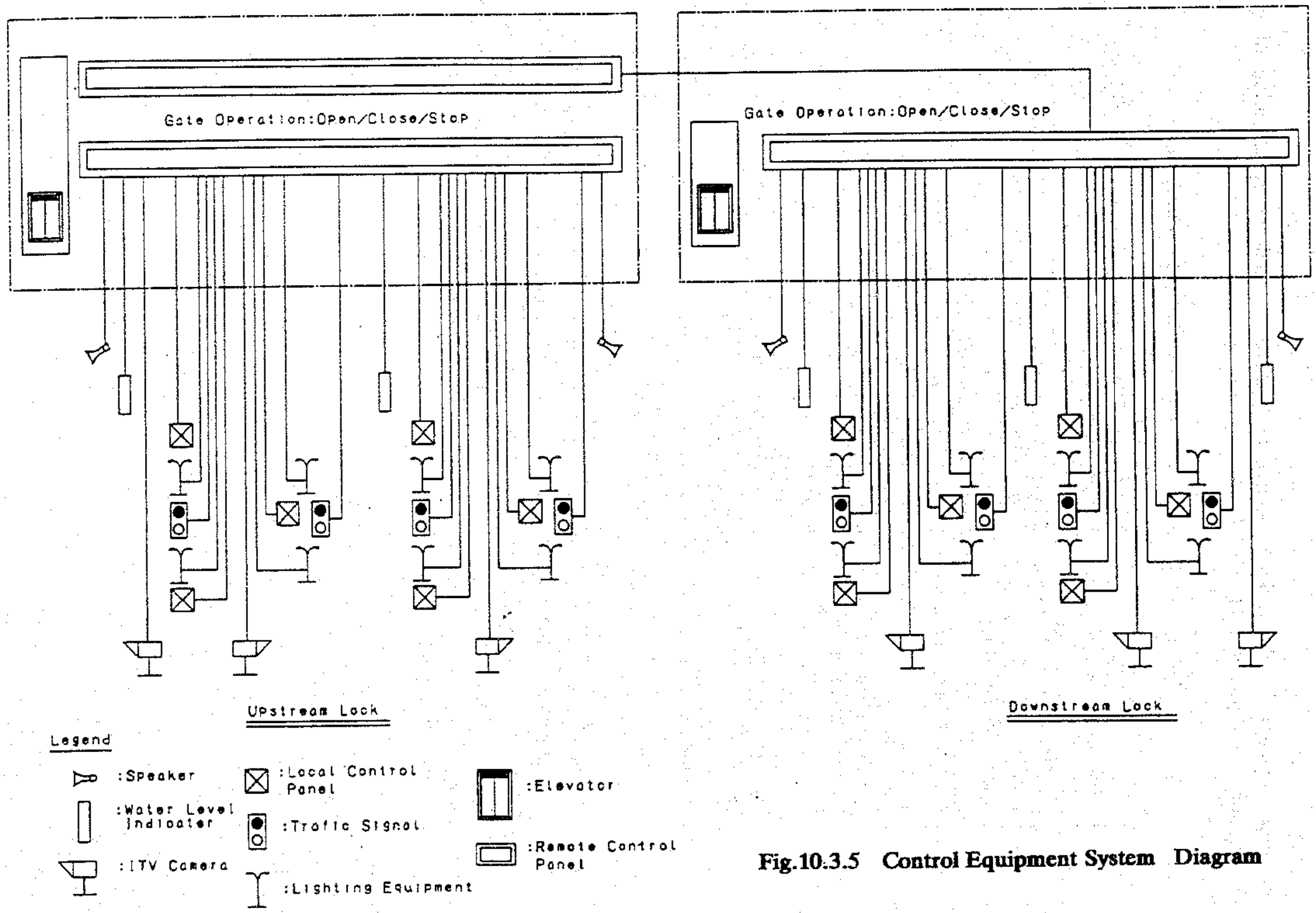
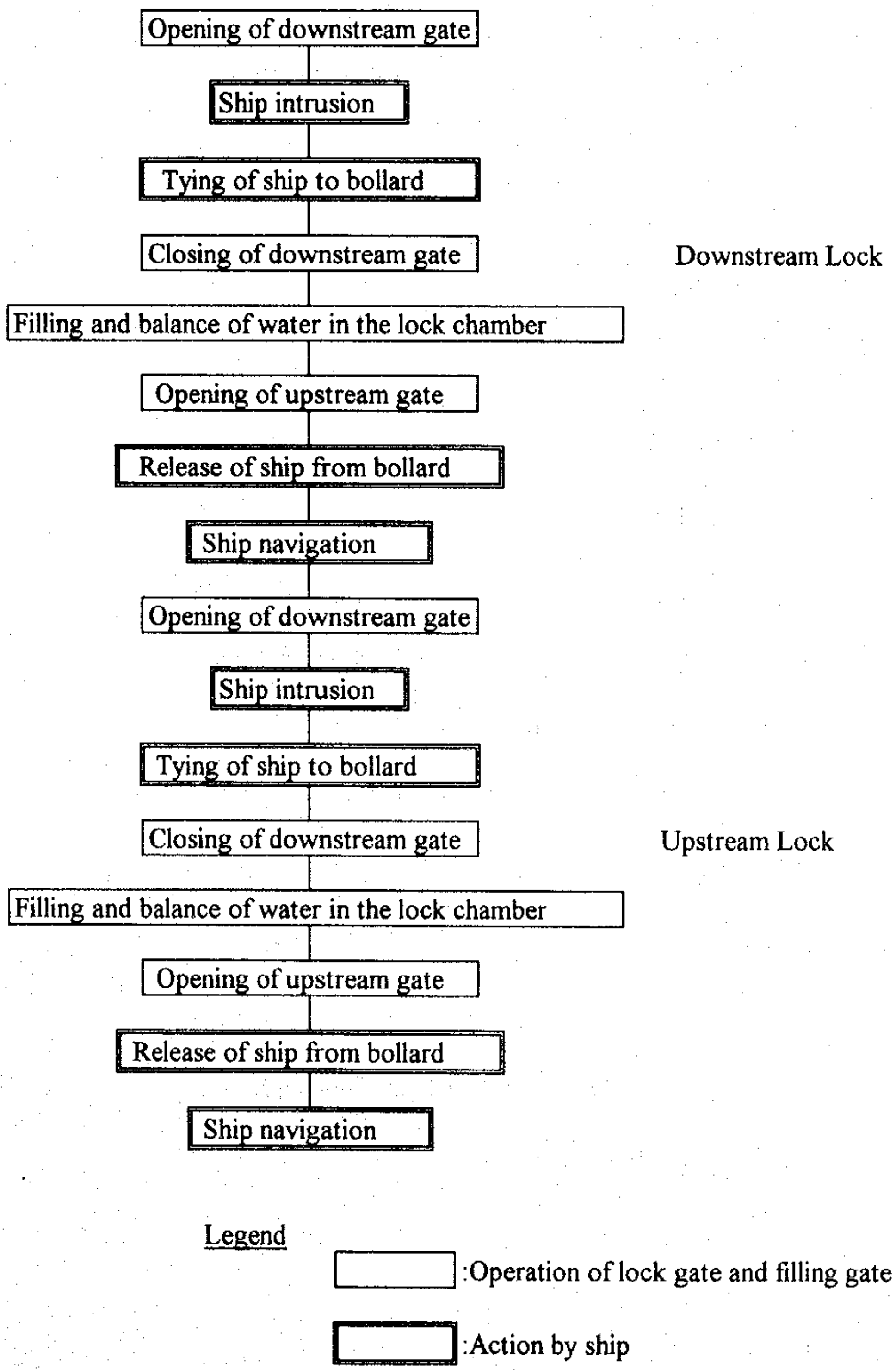


Fig.10.3.5 Control Equipment System Diagram

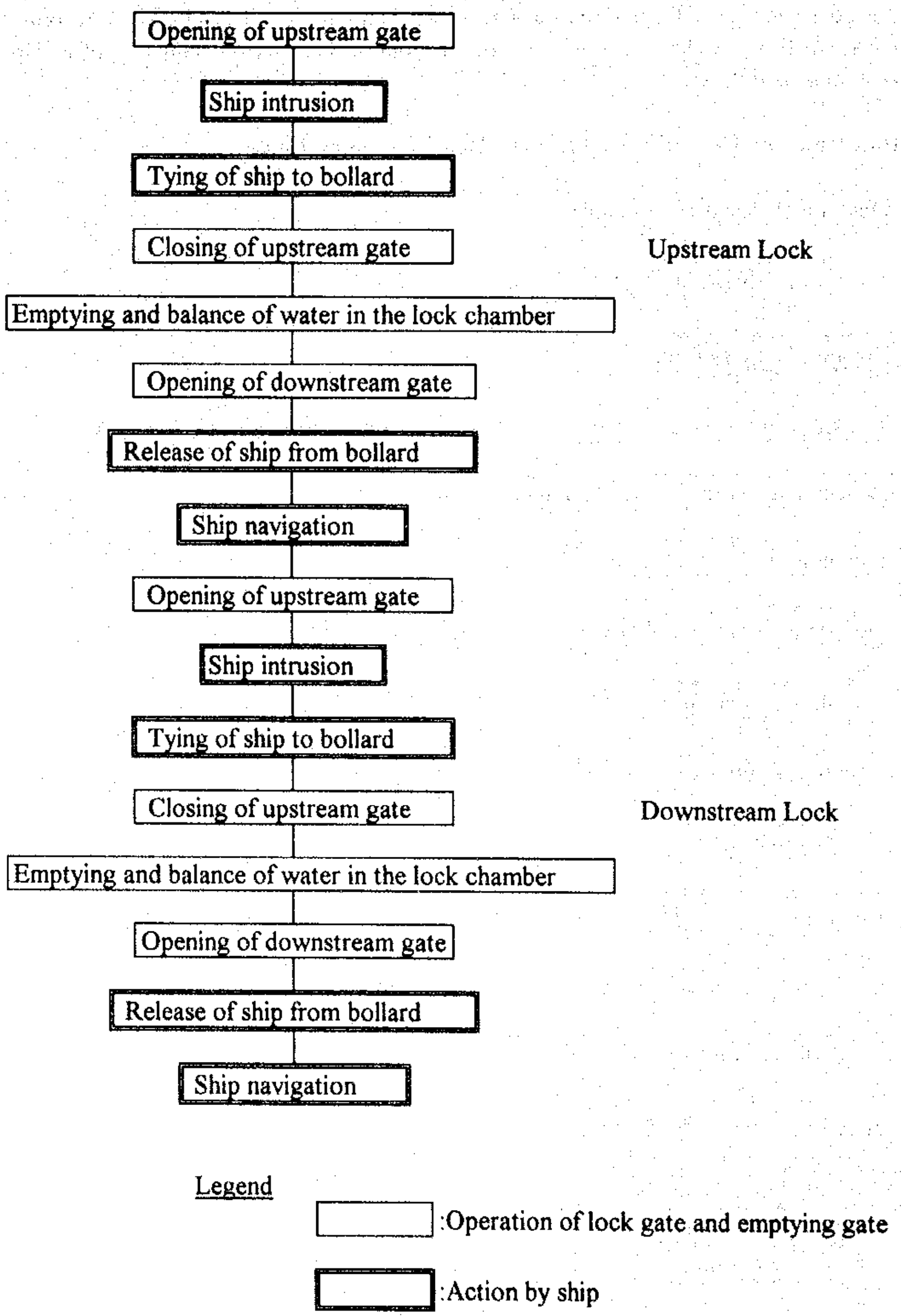
10.3.4. Navigation Sequence of Lock System

Necessary period to navigate from the Boa Eaperanca Dam to the Parnaiba river through upstream and downstream locks is 2.5 hours at the maximum. Navigation sequence of a ship in the lock system is as follows:

(1) Navigation from the Parnaiba River to the Boa Esperanca Lock



(2) Navigation from the Boa Esperanca Dam to the Parnaiba River



10.4 Comments on the Resumption of the Boa Esperança Lock

(1) Design of Steel Structures and Control Equipment

The detailed design work for the steel structures and control equipment was made once about 20 years ago. However present techniques for the design and manufacturing, and characteristics of the material and articles have been developed greatly. Accordingly, resumption work is recommended to start a new design and not to use the performance based on the previous design so as to achieve the advantages of new functions and economy.

(2) Investigation of the Existing Structures

Due to the elapse of a long period after the completion, the existing structure is recommended to be investigated for deterioration and damage, and as a result the inappropriate portion must be corrected, where necessary.

(3) Check of Existing Concrete Structure for the Practical Loads

Especially for the emplacement of hoist equipment in the hoisting room, the floor with beams need to be checked against the practical loads, after a review of the allowable loads given by the previous design, and structural modifications provided, where necessary.

11. PLANNING OF THE PORT FACILITIES

11. PLANNING OF THE PORT FACILITIES

11.1 Cargo Handling Volume in the River Ports

From Tables 11.1.1 to 11.1.4 show the annual loading and unloading cargo volumes in each scenario along the Parnaíba river basin obtained by the cargo transportation planning. (see Tables A4.1 in Appendix 4 for forecasted cargo volume by agricultural products and commodities in 2010, respectively).

Table 11.1.1 Loading and Unloading Cargo Volumes in Scenario 1

Unit : Tons/year

Location	Agricultural Products		Necessary Goods		Total
	Loading	Unloading	Loading	Unloading	
1. Parnaíba	-	167,000	3,000	-	170,000
2. Luzilandia	114,300	-	-	-	114,300
3. Porto	25,800	-	-	500	26,300
4. Miguel Alves	51,900	-	-	1,000	52,900
5. Uniao	31,700	-	-	1,500	33,200
6. Teresina	33,500	670,100	82,600	-	786,200
7. Palmeiras	40,000	-	-	-	40,000
8. Amarante	59,400	-	-	-	59,400
9. Floriano	11,600	258,600	116,700	500	387,400
10. Guadalupe	47,000	-	-	38,200	85,200
11. Urucui	259,300	12,750	-	91,900	363,950
12. Ribeiro Goncalves	363,000	2,000	-	56,000	421,000
13. Santa Filomena	72,950	-	-	12,700	85,650
Total	1,110,450	1,110,450	202,300	202,300	2,625,500

Source : JICA Study Team

Table 11.1.2 Loading and Unloading Cargo Volumes in Scenario 2

Unit : Tons/year

Location	Agricultural Products		Necessary Goods		Total
	Loading	Unloading	Loading	Unloading	
1. Parnaíba	-	-	-	-	-
2. Luzilandia	-	-	-	-	-
3. Porto	-	-	-	-	-
4. Miguel Alves	-	-	-	-	-
5. Uniao	-	-	-	-	-
6. Teresina	33,500	620,100	82,600	-	736,200
7. Palmeiras	40,000	-	-	-	40,000
8. Amarante	59,400	-	-	-	59,400
9. Floriano	11,600	258,600	116,700	500	380,700
10. Guadalupe	47,000	-	-	38,200	85,200
11. Urucui	259,300	12,750	-	91,900	363,950
12. Ribeiro Goncalves	363,000	2,000	-	56,000	421,000
13. Santa Filomena	72,950	-	-	12,700	85,650
Total	886,750	886,750	199,300	199,300	2,172,100

Source : JICA Study Team

Table 11.1.3 Loading and Unloading Cargo Volumes in Scenario 3

Unit : Tons/year

Location	Agricultural Products		Necessary Goods		Total
	Loading	Unloading	Loading	Unloading	
1. Parnaíba	-	-	-	-	-
2. Luzilandia	-	-	-	-	-
3. Porto	-	-	-	-	-
4. Miguel Alves	-	-	-	-	-
5. Uniao	-	-	-	-	-
6. Teresina	-	-	-	-	-
7. Palmeiras	-	-	-	-	-
8. Amarante	-	-	-	-	-
9. Floriano	10,000	979,300	198,800	-	1,188,100
10. Guadalupe	132,650	-	-	38,200	170,850
11. Urucui	410,700	8,000	-	91,900	510,600
12. Ribeiro Goncalves	363,000	2,000	-	56,000	421,000
13. Santa Filomena	72,950	-	-	12,700	85,650
Total	989,300	989,300	198,800	198,800	2,376,200

Source : JICA Study Team

Table 11.1.4 Loading and Unloading Cargo Volumes in Scenario 4

Unit : Tons/year

Location	Agricultural Products		Necessary Goods		Total
	Loading	Unloading	Loading	Unloading	
1. Parnaíba	-	-	-	-	-
2. Luzilandia	-	-	-	-	-
3. Porto	-	-	-	-	-
4. Miguel Alves	-	-	-	-	-
5. Uniao	-	-	-	-	-
6. Teresina	33,500	378,200	103,000	-	514,700
7. Palmeiras	20,000	-	-	-	20,000
8. Amarante	37,500	-	-	-	37,500
9. Floriano	11,600	451,900	96,300	500	560,300
10. Guadalupe	47,000	-	-	38,200	85,200
11. Urucui	259,300	12,750	-	91,900	363,950
12. Ribeiro Goncalves	363,000	2,000	-	56,000	421,000
13. Santa Filomena	72,950	-	-	12,700	85,650
Total	844,850	844,850	199,300	199,300	2,088,300

Source : JICA Study Team

11.2 Port Locations

A total 13 river ports are planned along the Parnaíba river basin based on the forecasted cargo volume under Scenario 1 (see Fig. 11.2.1 for the location of the river ports under Scenario 1). Table 11.2.1 shows the required river ports locations in other scenarios.

No definite sites, however are decided yet since no topographic and hydrographic survey map for the selection of the sites along the Parnaíba river is available. Only the cities are selected for the river port location. The following matters should be considered for the site selection of the definite river ports.

1) Access to the road and rail road.

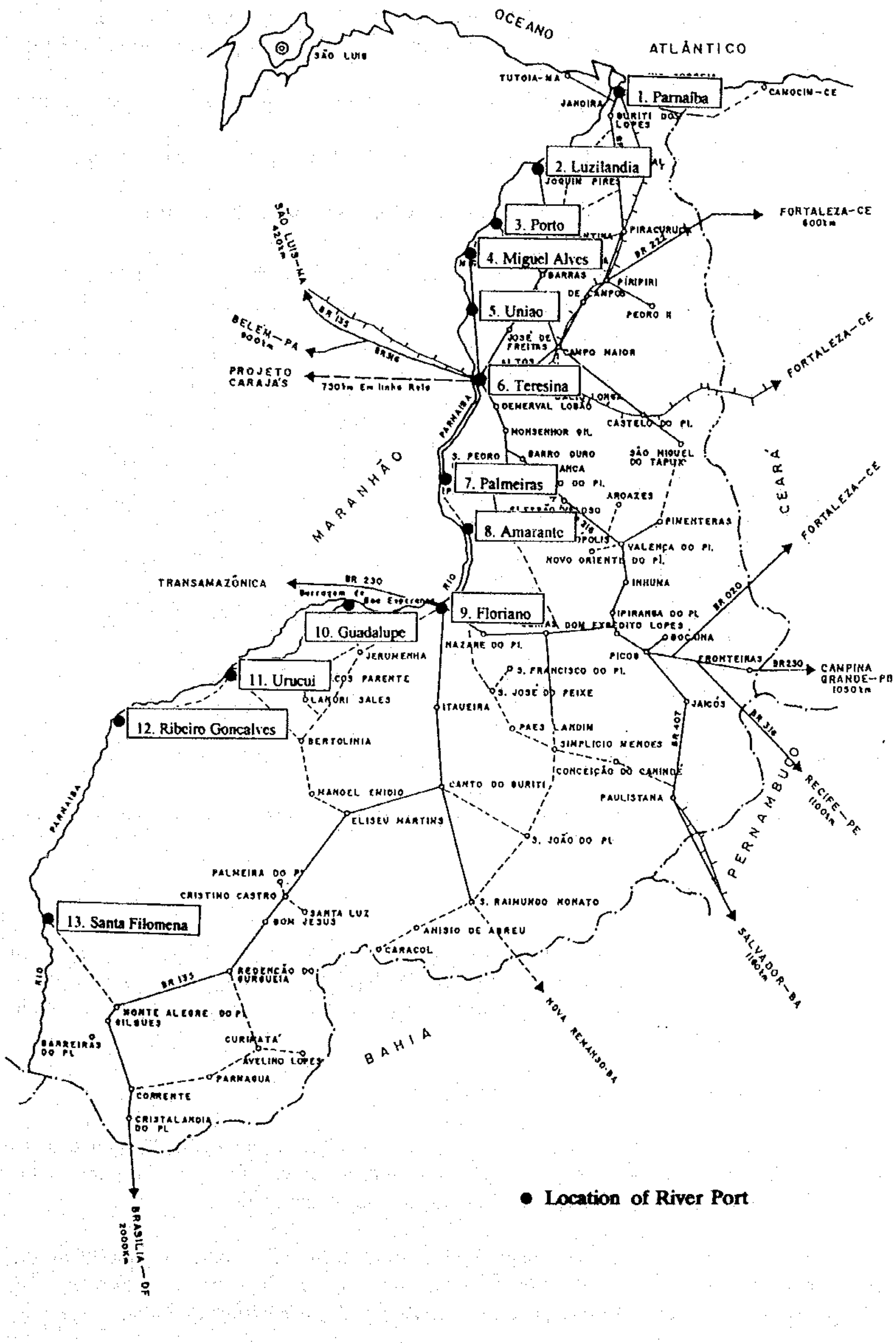


Fig. 11.2.1 **Proposed Location of River Ports**

2) Access to the agricultural products center for Teresina, Floriano, and Parnaíba.
3) Access to the farmhouses for Santa Filomena, Ribeiro Goncalves, Amarante, Palmeiras, Miguel Alves, Porto and Luzilandia.
4) Wide enough land area especially for Teresina, Floriano, Guadalupe, Ribeiro Goncalves, and Urucui.
5) Wide enough water area for Teresina, Parnaíba, Floriano, Urucui, and Guadalupe.

Table 11.2.1 Required River Ports Location in Each Scenario

Location	Scenario 1	Scenario 2	Scenario 3	Scenario 4
1. Parnaiba	x	-	-	-
2. Luzilandia	x	-	-	-
3. Porto	x	-	-	-
4. Miguel Alves	x	-	-	-
5. Uniao	x	-	-	-
6. Teresina	x	x	-	x
7. Palmeiras	x	x	-	x
8. Amarante	x	x	-	x
9. Floriano	x	x	x	x
10. Guadalupe	x	x	x	x
11. Urucui	x	x	x	x
12. Ribeiro Goncalves	x	x	x	x
13. Santa Filomena	x	x	x	x
Total	13	8	5	8

Source : JICA Study Team
Note : x : Required ,
- : Not required

11.3 Required Port Facilities

The study of the required port facilities at each river port is carried out in Scenario 1 since Scenario 1 includes all river ports.

(1) Cargo Flow

The cargo flow of each river port in Scenario 1 is presented in Fig. A4.1 in Appendix 4. In these figures, you can easily understand the relationship between the cargo volume and the port facilities. Cargo flows in other scenarios are basically the same. Only the cargo handling volume is the different.

(2) Type of Packing and Handling Facilities

Viewing the prospect of transportation in 2010, large quantities of agricultural products leads to packing by bulk except general goods and fruits in order to ease the cargo handling. Table 11.3.1 shows the type of packing and handling facilities by commodities.

Basically, the cago for which the packing type is other than bulk should be handled by the ship's crane. There will need to be a loader or unloader in the case of total cargo other than bulk in excess of 240 tons/day/berth, and also for 30 tons/day/berth for forklifts.

Table 11.3.1 Type of Packing and Handling Facilities by Commoditiy

Commodity	Package	Loader	Unloader	Hopper	Belt Conveyor	Hand	Forklift	Truck	Shed	Silo
1. Rice	Bulk	xx	xx	xx	xx	-	-	-	-	x
2. Corn	Bulk	xx	xx	xx	xx	-	-	-	-	x
3. Fejon	Bulk	xx	xx	xx	xx	-	-	-	-	x
4. Soy Beans	Bulk	xx	xx	xx	xx	-	-	-	-	x
5. Fruit	Case	Over 240	Over 240	-	x	x	Over 30	x	x	-
6. Nuts	Bulk	xx	xx	xx	xx	-	-	-	-	x
7. Babassu	Bulk	xx	xx	xx	xx	-	-	-	-	x
8. Salt	Sack	Over 240	Over 240	-	x	x	Over 30	x	x	-
9. Fertilizer	Sack	Over 240	Over 240	-	x	x	Over 30	x	x	-
10. Sugar	Sack	Over 240	Over 240	-	x	x	Over 30	x	x	-
11. Flour	Sack	Over 240	Over 240	-	x	x	Over 30	x	x	-
12. Petroleum	Drum	-	-	-	-	-	Over 30	x	x	-
LPG	Bomb	-	-	-	-	x	Over 30	x	x	-
13. Cement	Sack	Over 240	Over 240	-	x	x	Over 30	x	x	-

Source : JICA Study Team

xx : Always necessary
x : Applicable
- : Not applicable
Unit : ton/day/berth
Over 240 : Need equipment more than 240 ton/day/berth
Over 30 : Need equipment more than 30 ton/day/berth

(3) Required Port Facilities

Table 11.3.2 shows the required port facilities based on the above cargo flow, type of packing and handling facilities in Scenario 1 (see Tables A4.2.1 in Appendix 4 for the required port facilities in other scenarios).

Table 11.3.2 Required Port Facilities at Each River Port in Scenario 1

	Mooring Basin	Berthing Facilities	Loading Equipment	Unloading Equipment	Silo	Shed or Warehouse
1. Parnaíba	x	x	x	x	x	x
2. Luzilandia	-	x	x	-	x	-
3. Porto	-	x	x	x	x	x
4. Miguel Alves	-	x	x	x	x	x
5. Uniao	-	x	x	x	x	x
6. Teresina	x	x	x	x	x	x
7. Palmeiras	-	x	x	-	x	-
8. Amarante	-	x	x	-	x	-
9. Floriano	x	x	x	x	x	x
10. Guadalupe	x	x	x	x	x	x
11. Urucui	x	x	x	x	x	x
12. Riberio Goncalves	x	x	x	x	x	x
13. Santa Filomena	-	x	x	x	x	x

Source : JICA Study Team
Note : x : Required
- : Not required

11.4 Requirements of the River Ports

(1) Berth Requirements

Berthing facilities are the most important infrastructure at the port. Therefore, berth requirements at each river port are estimated based on the forecasted cargo volume and cargo handling system with the following assumptions. Tables 11.4.2 and 11.4.3 show the results of the estimation for bulk berth and general cargo berth in Scenario 1, respectively.

- Annual cargo volume	: see Tables 11.1.2 to 11.1.3
- Fraction of time	: 0.5
- Working hours per day	: 12 hr
- Number of working days	: 350 days
- Maximum loading and unloading capacities	: 20 ton/hr for general cargo berth
	: min. 100 ton/hr for bulk berth
- Berth occupancy ratio (BOR)	: 50 - 70 %

Therefore, the number of berths and type of berth at each river port in Scenario 1 are summarized as follows :

Table 11.4.1 Number and Type of Berth at Each River Port

River Ports	Number of Berth	Type of Berth
1. Parnaíba	1	Bulk with general cago berth
2. Luzilandia	1	Bulk berth
3. Porto	1	Bulk with general cago berth
4. Miguel Alves	1	Bulk with general cago berth
5. Uniao	1	Bulk with general cago berth
6. Teresina	3	One bulk and two general cargo berths
7. Palmeiras	1	Bulk berth
8. Amarante	1	Bulk berth
9. Floriano	3	One bulk and two general cargo berth
10. Guadalupe	2	One bulk and one general cargo berth
11. Urucui	3	One bulk and two general cargo berth
12. Ribeiro Goncalves	2	One bulk and one general cargo berth
13. Santa Filomena	2	One bulk and one general cargo berth

Source : JICA Study Team

Table 11.4.2 Annual Berth Day Requirement and Utilization for Bulk Berth

Location	Loading/Unloading Cargo Volume (ton)	Loader/Unloader Capacity (ton/hr)	Average Cargo Volume per Ship (ton)	Average Berth Time per Ship (hr)	Annual Berth Day Requirement (days)	Berth Utilization
1. Parnaiba	167,000	200	380	7.4	136	0.39
2. Luzilandia	114,300	100	380	17.2	216	0.62
3. Porto	25,800	100	380	17.2	49	0.14
4. Miguel Alves	51,900	100	360	16.4	99	0.28
5. Uniao	31,700	100	380	17.2	60	0.17
6. Teresina	703,600	700	390	3.9	290	0.83
7. Palmeiras	40,000	100	420	18.8	75	0.21
8. Amarante	59,400	100	420	18.8	111	0.32
9. Floriano	270,200	200	540	11.0	229	0.66
10. Guadalupe	47,000	100	650	28.0	84	0.24
11. Urucui	272,050	200	650	15.0	261	0.75
12. Ribeiro Goncalves	365,000	300	600	10.0	254	0.72
13. Santa Filomena	72,950	100	600	26.0	132	0.38

Note : Working hour per day : 12 hours
Working days per year : 350 days
Loader and unloader productivity rate : Loader : 0.5, Unloader : 0.7

Table 11.4.3 Annual Berth Day Requirement and Number of Berth Requirement for General Cargo Berth

Location	Loading/Unloading Cago Volume (ton)	Cargo Handling Capacity (ton/hr)	Berth Occupancy Rate (%)	Annual Berth Day Requirement (days)	Number of Berth Requirement	Type of Berth
1. Parnaiba	3,000	10t x 1	50	25.0	0.14	Bulk & GC
2. Luzilandia	-	-	-		-	Bulk Only
3. Porto	500	10t x 1	50	4.1	0.02	Bulk & GC
4. Miguel Alves	1,000	10t x 1	50	8.3	0.05	Bulk & GC
5. Uniao	1,500	10t x 1	50	12.5	0.07	Bulk & GC
6. Teresina	82,600	10t x 2	70	344.0	1.4	Bulk + 2GC
7. Palmeiras	-	-	-	-	-	Bulk Only
8. Amarante	-	-	-	-	-	Bulk Only
9. Floriano	117,200	10t x 2	70	488.0	1.99	Bulk + 2GC
10. Guadalupe	38,200	10t x 2	70	159.0	0.65	Bulk + GC
11. Urucui	91,900	10t x 2	70	383.0	1.56	Bulk + 2GC
12. Ribeiro Goncalves	56,000	10t x 2	70	233.0	0.95	Bulk + GC
13. Santa Filomena	12,700	10t x 1	70	106.0	0.43	Bulk + GC

(2) Shed Requirements

Required capacity of the Sheds at each river port was estimated based on the general cargo volume handled in the ports. Table 11.4.4 shows the results of the estimation (see Table A4.3 in Appendix 4 for the detailed estimation).

Table 11.4.4 Shed Requirements of Each River Port in Scenario 1

River Ports	Number of Sheds	Minimum Capacity (m2)
1. Parnaiba	1	300
2. Luzilandia	-	-
3. Porto	1	50
4. Miguel Alves	1	100
5. Uniao	1	150
6. Teresina	2	2,400
7. Palmeiras	-	-
8. Amarante	-	-
9. Floriano	2	2,400
10. Guadalupe	1	1,200
11. Urucui	2	2,400
12. Ribeiro Goncalves	1	1,200
13. Santa Filomena	1	1,200

(3) Silo Requirements

Required capacity of the Silos at each river port was estimated based on the cargo volume of agricultural products excluding fruits since the type of packing for fruits is assumed as in cases. Table 11.4.5 shows the results of the estimation.

Table 11.4.5 Required Capacity of the Silos at Each River Port in Scenario 1

	Cargo Volumes			Required Silo Capacity	
Location	Loading	Unloading	Total	Capacity (ton)	Dia (dia : m)
1. Parnaiba	-	167,000	167,000	6,000 x 1 unit	25.5 m
2. Luzilandia	114,300	-	114,300	5,000 x 1	23.5
3. Porto	25,800	-	25,800	1,000 x 1	16.5
4. Miguel Alves	51,900	-	51,900	2,000 x 1	23.0
5. Uniao	31,700	-	31,700	2,000 x 1	23.0
6. Teresina	33,500	667,900	701,400	6,000 x 5	25.5 / unit
7. Palmeiras	40,000	-	40,000	2,000 x 1	23.0
8. Amarante	59,400	-	59,400	3,000 x 1	28.0
9. Floriano	11,600	257,350	268,950	5,000 x 2	23.5 / unit
10. Guadalupe	45,850	-	45,850	2,000 x 1	23.0
11. Urucui	257,700	12,750	270,450	5,000 x 2	23.5 /unit
12. R. Goncalves	362,300	2,000	364,300	5,000 x 3	23.5 /unit
13. S. Filomena	72,950	-	72,950	3,000 x 1	28.0

Note (1) Storage factor : 52 cu.ft/Lt
(2) Rotation rate : 25 times per year
(3) The height of silo : 10 m for less than 3,000 capacity
20 m for more than 3,000 capacity

11.5 River Port Plan

(1) Port Layout

Based on the above requirements, four types of port layout are established, Type 1 for a bulk berth, Type 2 for a bulk with general cargo berth, Type 3 for a bulk and one general cargo berth, and Type 4 for a bulk and two general cargo berths. Figs. 11.5.1 to 11.5.4 show each type of port layout. Table 11.5.1 shows the type of each river port in Scenario 1.

Table 11.5.1 Type of Each River Port

Type	Berth Type	River Ports
1	Bulk berth	Luzilandia, Palmeiras, Amarante
2	Bulk with general cargo berth	Parnaíba, Porto, Miguel Alves, Uniao
3	Bulk and general cargo berth	Guadalupe, Ribeiro Goncalves, Santa Filomena
4	Bulk and two general cargo berths	Teresina, Floriano, Urucui

(2) Cargo Handling Facilities

Table 11.5.2 shows the required cargo handling facilities.

Table 11.5.2 Required Cargo Handling Facilities at Each River Port

Location	Loader	Unloader	Belt Conveyor	Hopper	Fork lift	Silo
1. Parnaiba	-	200 x 1 u/t	x	x	-	6000t x 1
2. Luzilandia	100 x 1 u/t	-	x	-	-	5000t x 1
3. Porto	100 x 1 u/t	-	x	-	-	1000t x 1
4. Miguel Alves	100 x 1 u/t	-	x	-	-	2000t x 1
5. Uniao	100 x 1 u/t	-	x	-	-	2000t x 1
6. Teresina	100 x 1 u/t	400 x 1 u/t 200 x 1 u/t	x x	x x	3 u/t	6000t x 5
7. Palmeirais	100 x 1 u/t	-	x	-	-	2000t x 1
8. Amarante	100 x 1 u/t	-	x	-	-	3000t x 1
9. Floriano	use Unloader	200 x 1 u/t	x	x	4 u/t	5000t x 2
10. Guadalupe	100 x 1 u/t	-	x	-	1 u/t	2000t x 1
11. Urucui	200 x 1 u/t	use Loader	x	x	3 u/t	5000t x 2
12. R. Goncalves	300 x 1 u/t	use Loader	x	x	2 u/t	5000t x 3
13. S. Filomena	100 x 1 u/t	-	x	-	1 u/t	3000t x 1
Total	11	4			14	21

Source : JICA Study Team
x : Necessary
- : Not available

(3) Structural Type of the Port Facilities

Table 11.5.3 shows the structural type of the basic port facilities.

Table 11.5.3 Structural Type of the Basic Port Facilities

Facilities	Structural Type	Size
1. Platform	Concrete deck supported with foundation piles, and -3.5 m depth with fender system and mooring bit.	- 10 m width x 15 m length for Type 1 - 10 m width x 25 m length for Type 2 - 10 m width x 50 m length for Type 3 - 10 m width x 100 m length for Type 4
2. Bresting Dolphin	Pile type dolphin with fender system and mooring bit, Depth : -3.5 m.	2.5 m x 2.5 m deck size
3. Mooring Dolphin	Concrete base with mooring bit supported with foundation piles.	2.0 m x 2.0 m
4. Revetment	Stone with concrete with 10 m slope length	App. 80 m for Type 1 and Type 2. App. 150 m for Type 3 App. 200 m for Type 4
5. Shed	Steel frame structure	- 300 m2 x 1 unit for Type 2 - 1,200 m2 x 1 unit for Type 3 - 1,200 m2 x 2 units for Type 4

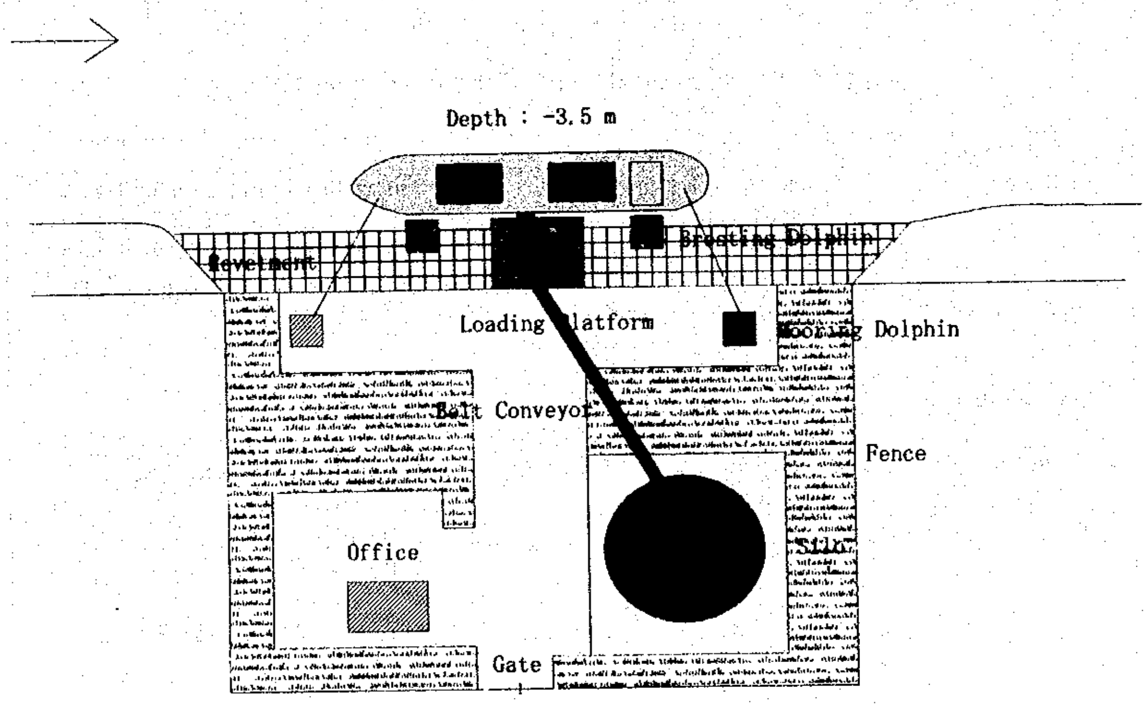


Fig. 11.5.1 River Port Layout - Type 1

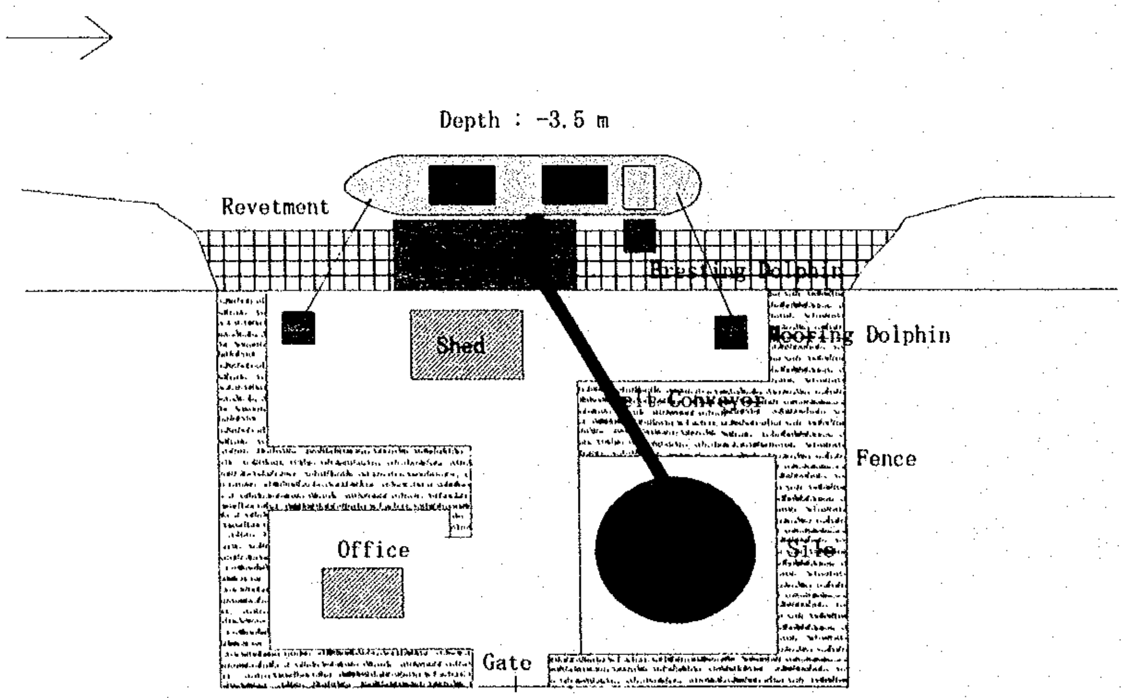


Fig. 11.5.2 River Port Layout - Type 2

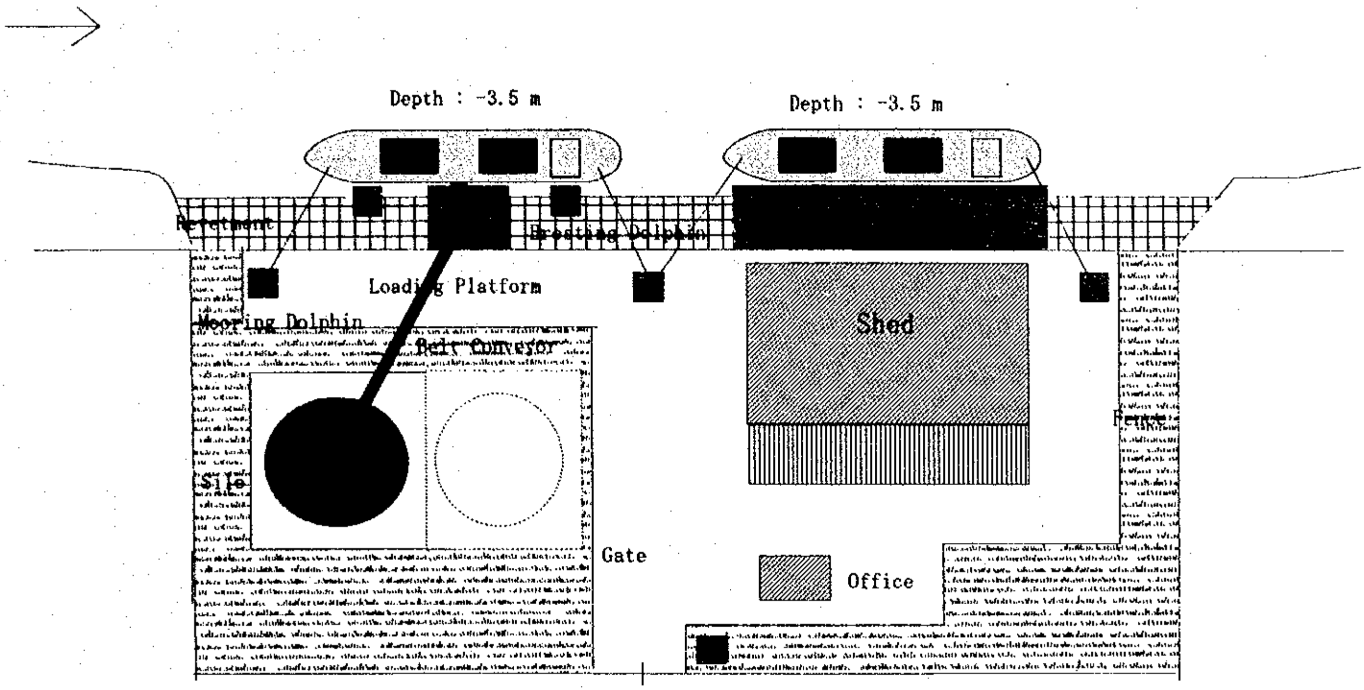


Fig. 11.5.3 River Port Layout - Type 3

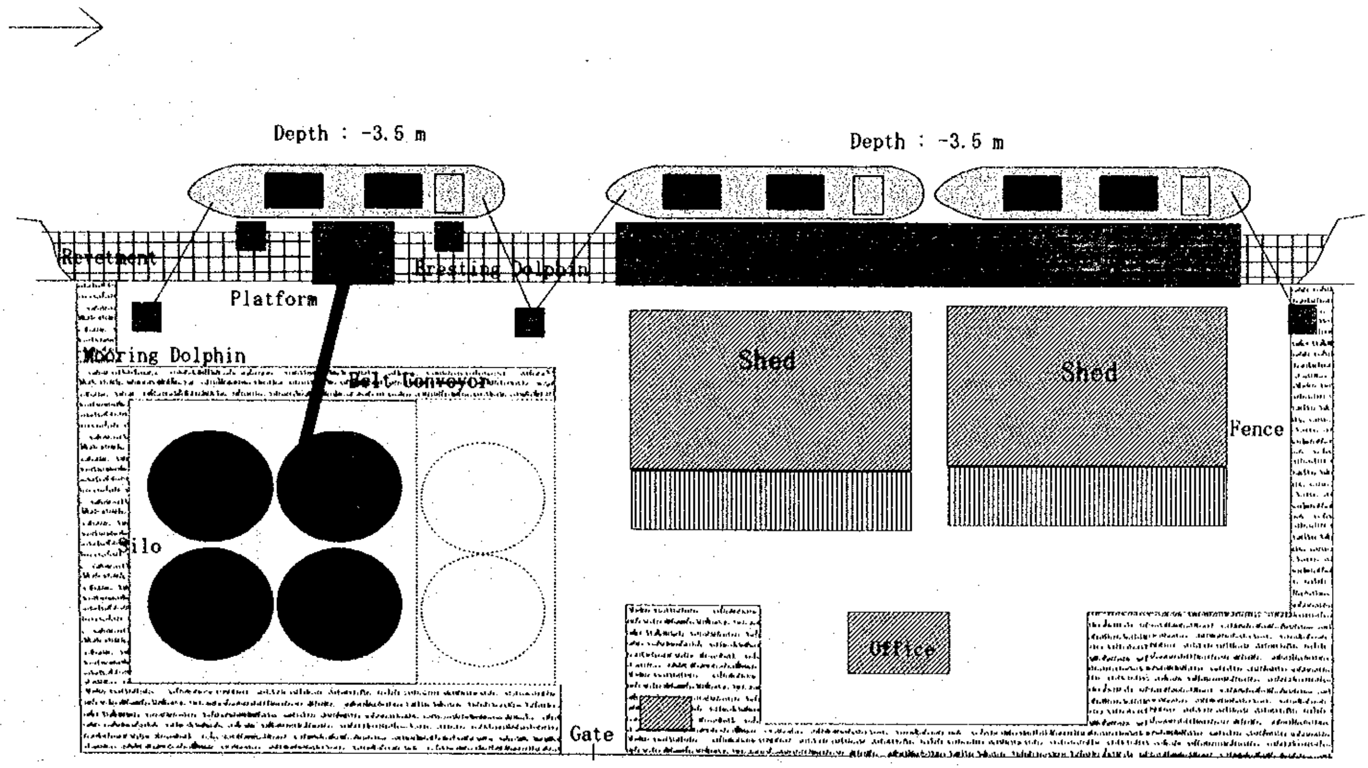


Fig. 11.5.4 River Port Layout - Type 4

12. NAVIGATION AIDS PLANNING

12. NAVIGATION AIDS PLANNING

The basic functions attributed to aids to navigation are divided into improvement in traffic efficiency for a ships navigation from one point to another so as to reach the destination in the most economical way, and safety of navigation providing forewarnings to mariners on navigation dangers such as shoals, sunken rocks, sand bars etc.

12.1 Present Condition of Navigation Aids

At present, in the Parnaíba river basin, no navigation aids are installed except for the navigation aids for the "Spur Dike" installed by the JICA Study Team to indicate the channel-width-limit.

12.2 Navigation Aids for the River Basin in Brasil

The navigation aids for rivers in Brazil are installed in accordance with the regulations of "Permanent International Association of Navigation Conference (PIANC)". The signalling indicative symbols are shown in Fig. 12.1.1.

12.3 Proposal of Navigation Aids

A suitable navigation aids system shall be established indicating the shallow sandbank areas, the isolated danger areas and the safe position under bridges including the safe area of channel.

According to the aforesaid, the vessel navigation is limited to daylight time. Navigation aids are indicated by a signal board of beacon colour and shape in accordance with the regulations.

A general arrangement of beacons is shown in Fig.12.3.1. Table 12.3.1 shows the required number of navigation aids in each scenario (see Table 12.3.2 for the required number of navigation aids along the Parnaíba river basin in each area). The required number of the navigation aids in the tables is estimated based on the aerial photography taken by the JICA Study team and topographic maps.

Table 12.3.1 Required Number of Navigation Aids

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Required Number of Navigation Aids	475	213	109	213

The installation of beacons shall be done before the operation of vessels. Navigation aid beacons shall be installed on a concrete base fixed with anchor bolts on the bank of river. Trees around each beacons shall be cut to keep visibility.

Fig.12.3.2 shows an example of the installation of navigation aids. The actual location of the navigation aids shall be decided based on the local conditions of the river.

Table 12.3.2 Required Number of Navigation Aids

Port	Distance (km)	Number of Sand Bar	Navigation Aids		Kind of Navigation Aids		
			Quantity	Average Distance (km)	Navigation	Obstruction	Bridge
S.FILOMENA							
	275		60	4.6		60	
R.GONCALVES							
	100		25	4.0		25	
URCUI							
	140		0				
GUADALUPE							
	70		24	3.5		20	1 (4)
FLORIANO							
	75		5	15.0		5	
AMARANTE							
	50	1	5	10.0		5	
PALMEIRAIS							
	120	27	94	1.3	90		1 (4)
TERESINA							
	70	70	64	1.2	60		1 (4)
UNIAO							
	65	40	40	1.6	40		
M.ALVES							
	45	30	35	1.3	35		
PORTO							
	85	60	55	1.6	53	2	
LUZILANDIA							
	120	80	68	2.0	60		2 (8)
PARNAIBA							
TOTAL	1,215	308	475	2.7	338	117	5 (20)

Source : Topographical Map (Sata Filomena - Urcui)
Aerial Photography (Guadalupe - Parnaiba)

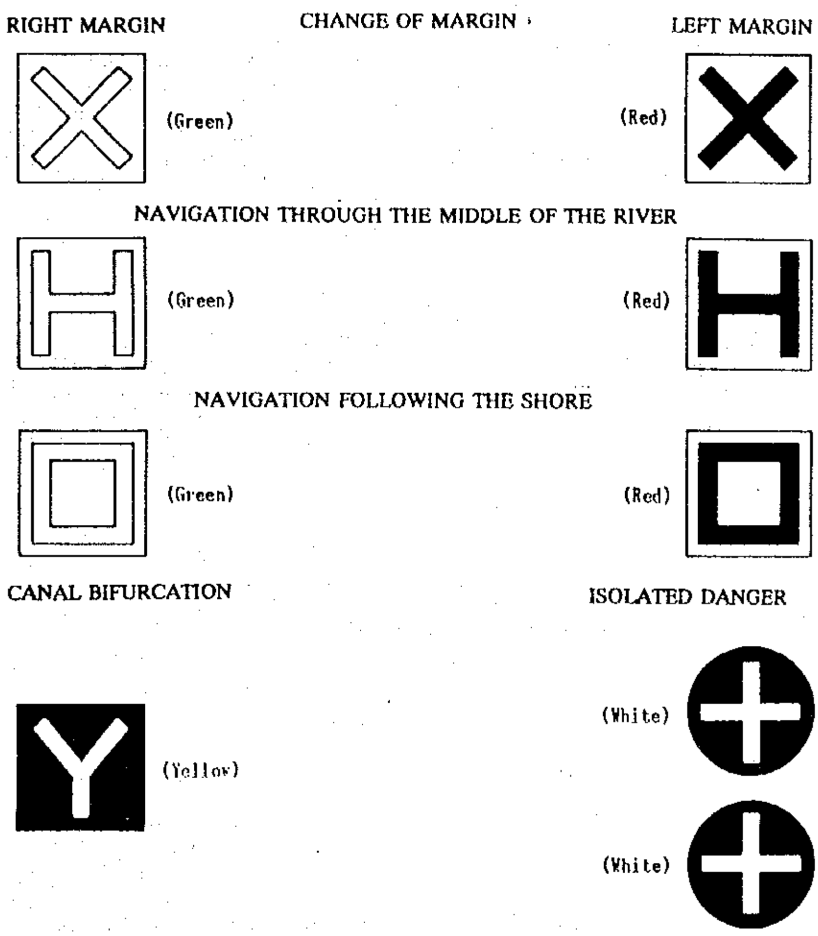
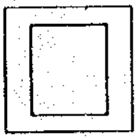


Fig. 12.1.1 Complementary Signalling Indicative Symbols, Approved for Diurnal and Nocturnal Fluvial Navigation (1)

XVI (Folheto nº 14/92)

BRIDGES


(Green)

WHITE PLATE WITH A GREEN RECTANGLE IN THE CENTER - BRIDGE PILLAR BY THE LARBOARD OF WHO GOES UP OR BY THE STARBOARD OF WHO GOES DOWN THE RIVER.


(Red)

WHITE PLATE WITH A RED TRIANGLE IN THE CENTER - BRIDGE PILLAR BY THE STARBOARD OF WHO GOES UP OR LARBOARD OF WHO GOES DOWN THE RIVER.

Fig. 12.1.2 Complementary Signalling Indicative Symbols, Approved for Diurnal and Nocturnal Fluvial Navigation (2)

Note : The first three signals are placed by the navigable margin and the last two ones in proper places.

The symbols are painted in the beacon plates with retro-reflective material (paint or adhesive tape) of the type used in highway signalling to allow also the nocturnal identification, through the spotlight utilization.

The beacons also have kilometer measurement plates which are a very important help to the position knowledge and to the navigation. The numbers indicating the kilometers are painted with retro-reflective material.

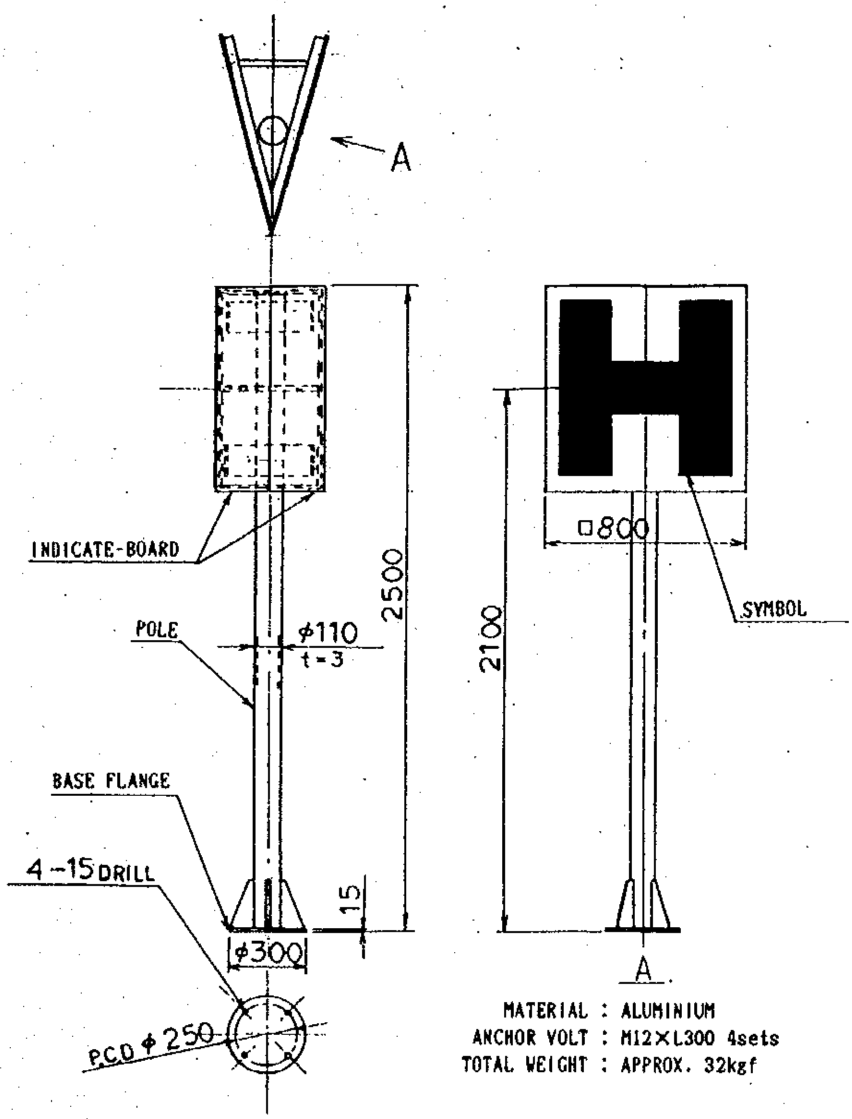
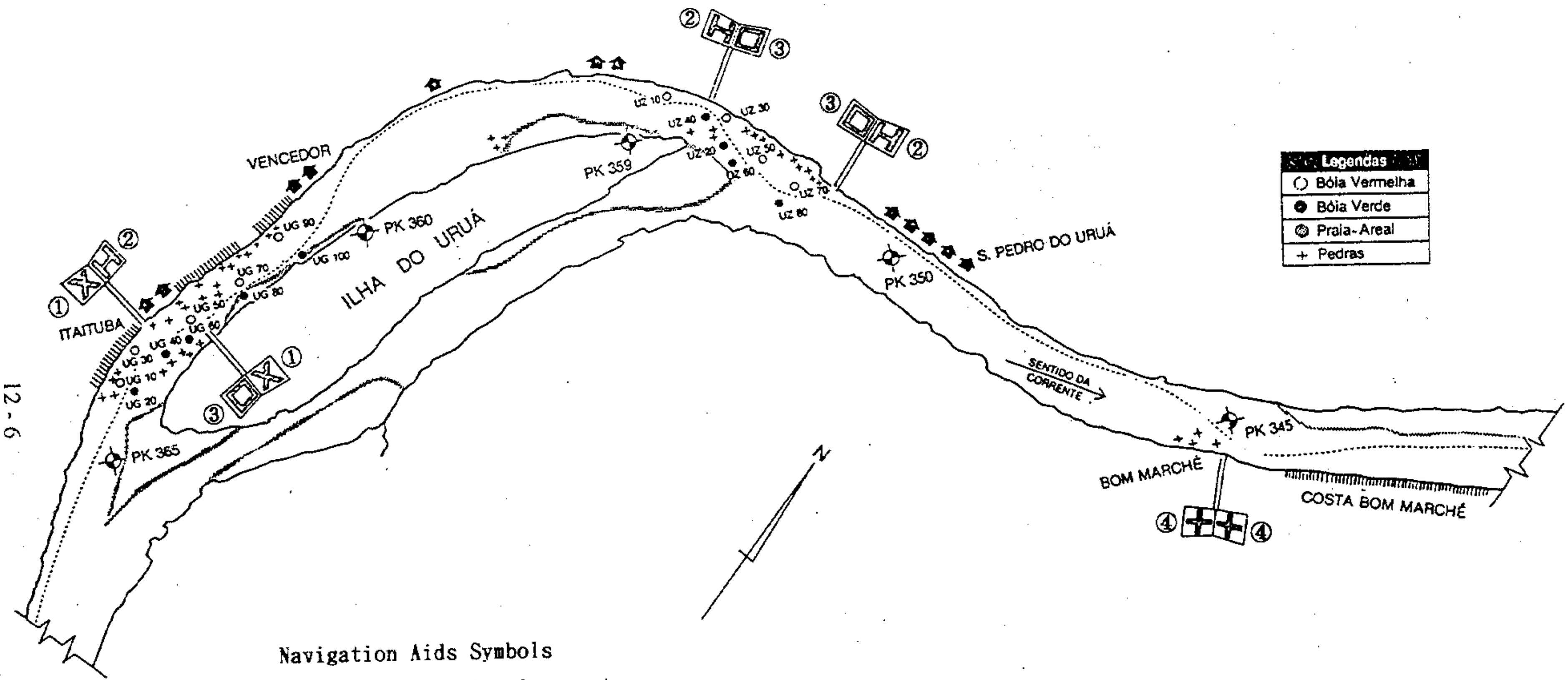


Fig. 12.3.1 General Arrangement of Beacon



Navigation Aids Symbols

① Change of navigation route

② Navigation through the middle of the river

③ Navigation following the shore

④ Isolated danger

Source : RIO MADEIRA, GUIA DE NAVEGACAO
AHIMOC, PORTOBRAS, Ministerio dos Transportes

Fig. 12.3.2 Example of the Installation of the Navigation Aids

13. OPERATION AND MAINTENANCE PLANNING

13. OPERATION AND MAINTENANCE PLANNING

13.1 Present Situation of the Operation and Maintenance

In Brazil, rivers crossing either the National border or state border are under the control of the Federal government. The Parnaíba river is under the Federal government, for it passes across the state boundary to Maranhão State and therefore falls into the above category.

The actual operation and maintenance program of the channel is administered by the north-east channel authority at Sao Luis city, abbreviated as AHINOR, and is responsible for provision of any structures installed in the channel, including navigation aids and groins, etc.. Vessels maneuvering in the Parnaíba river and in the surrounding sea area are registered at the Port Authority of Parnaíba city, abbreviated as CPPI. The authority organizes the overall administration of vessels utilizing the channel with the help of their patrolling boats.

On the other hand, CHESF, possesses seven field stations for the observation of the water depth along the Parnaíba river. These stations warn of possible rises in the high water levels to the nearby towns/villages in the case of discharging water during reservoir operations. They are responsible for safety precautions in the channel resulting from the operation/maintenance of Boa Esperança Dam.

13.2 Organization for the Maintenance, Administration and Operation

The action plan to achieve a practical transport network in the Parnaíba river should consist of the following three phases:

- Study Phase,
- Construction Phase and
- Operation phase.

At the first stage, organization of the committee composed of various concerned firms should be established towards the implementation of the plan. The organization shall conduct the survey, investigation and design of the facilities such as locks, ports, etc., to be constructed in the project. They will be preferably be based around the State of Piauí and will be responsible for the works/studies on the status quo of the transport, the design of the facilities, tendering and construction programming/management as well as the financial arrangement.

At the same time, other organizations shall be arranged so as to continue the project smoothly. One shall be responsible for the construction and operation phase and the other for maintenance/administration/operation phase covering the facilities such as locks, ports, vessels and control/utilization of the river.

The schematic structure of the organization is shown in Table 13.2.1. In the operation stage, the department of operation and administration of transport in the Parnaíba river, tentatively named here, shall be established in the State of Piauí. The department will function as an authority organizing and managing the overall activities on transport in the channel. The establishment is expected to contribute to the flexible transport provision.

Table 13.2.1 General Structure of the Organization

Responsibility	Construction Phase	Operation Phase	Maintenance/Administration Phase
1 Vessels	Private Firms	Private Firms	Private Firms
2 Locks	State government of Piauí or the Ministry	CHESF	CHESF
3 Ports in the Channel	State government of Piauí	Concerned City/Towns	Concerned Towns/Villages
4 Navigational Aiding Markers	State government of Piauí or of the Federal	-	Government of the Federal (AHINOR)
5 Management of the Channel	-	-	AHINOR (existing)

13.2.1 Vessels

(1) Organization

The operation and management of the vessels shall be carried out by private firms. It is recommended to arrange basic key spots of the above firms for marketing and management of operating vessels at Parnaiba, Teresina, Floriano and Ulucui. The related branch offices should be set for other ports where required.

(2) Function

The following functions shall be assigned :

- Marketing and operational management of vessels,
- Managing the safety precautions and crew allocation, and
- Supervision on shipbuilding and maintenance.

(3) Staffing

Proposed allocation of staff members in Scenario 1 is shown in Table 13.2.2. The other scenarios' cases are presented in Tables A5.1 in Appendix 5.

Table 13.2.2 Staff Allocation of Each Vessel Office in Scenario 1

Liaison Offices	Staff Members			
	Manager	Office Supporting Staff	Technicians	Total
1 Parnaíba	1	3	2	6
2 Luzilandia	1	2	-	3
3 Porto	1	-	-	1
4 Miguel Alves	1	-	-	1
5 Uniao	1	-	-	1
6 Teresina	1	6	2	9
7 Palmeiras	1	-	-	1
8 Amarante	1	-	-	1
9 Floriano	1	4	2	7
10 Guadalupe	1	2	-	3
11 Urucui	1	3	2	6
12 Libeiro Goncalves	1	3	-	4
13 Santa Filomena	1	-	-	1
Total	13	23	8	44

13.2.2 Locks

(1) Organization

Matters on operation, maintenance and management of the locks shall be carried out by CHESF, who owns the Boa Esperança Dam. Consequent activities at the power station shall be arranged by a division of CHESF to be organized at the site as their branch office.

(2) Function

The following functions shall be assigned to the above division :

- Operation, maintenance and management of locks,
- Recording and storing the operational statistics of the locks and
- Coordination and arrangement with the private shipping firms.

(3) Staffing

In general, the locks should be operated in daytime for providing safe navigation/maneuvering of vessels in the river channel. Night time operation should be avoided. The operators should be assigned one for each lock either upstream or downstream, forming a shifting working system of two teams. The staffing may be as follows.

- Manager : 1
- Operators : 5, including a reserved substitution personnel.