

**Appendix 7 :  
Related Tables for Economic  
and Financial Evaluations**



**Table A7.1.1 Unit Benefit in Scenario 1**

Zone	River Transport		Paved Road		Unpaved Road		With Cost	Without Cost	Unit Benefit (per ton)
	Distance	Cost	Distance	Cost	Distance	Cost			
Down ward									
St. Filomena ~ Floriano	585	0.0281	543	0.067	140	0.081	16.4385	47.721	31.2825
R. Goncalves ~ Floriano	310	0.0281	74	0.067	264	0.081	8.711	26.342	17.631
R. Goncalves ~ Teresina	555	0.0281	308	0.067	264	0.081	15.5955	42.02	26.4245
Urcui ~ Teresina	455	0.0281	308	0.067	153	0.081	12.7855	33.029	20.2435
Guadalupe ~ Teresina	315	0.0281	308	0.067	48	0.081	8.8515	24.524	15.6725
Amarante ~ Teresina	170	0.0281	145	0.067	0	0.081	4.777	9.715	4.938
Palmeiras ~ Teresina	120	0.0281	116	0.067	0	0.081	3.372	7.772	4.4
		0.0281		0.067		0.081			
Urcui ~ Floriano	210	0.0281	74	0.067	153	0.081	5.901	17.351	11.45
Guadalupe ~ Floriano	70	0.0281	74	0.067	48	0.081	1.967	8.846	6.879
		0.0281		0.067		0.081			
St. Filomena ~ Urcui	375	0.0281	275	0.067	303	0.081	10.5375	42.968	32.4305
R. Gocalves ~ Urcui	100	0.0281	0	0.067	129	0.081	2.81	10.449	7.639
		0.0281		0.067		0.081			
Floriano ~ Teresina	245	0.0281	234	0.067	0	0.081	6.8845	15.678	8.7935
		0.0281		0.067		0.081			
Amarante ~ Teresina	170	0.0281	145	0.067	0	0.081	4.777	9.715	4.938
Palmeiras ~ Teresina	120	0.0281	116	0.067	0	0.081	3.372	7.772	4.4
		0.0281		0.067		0.081			
Miguelalves ~ Parnaiba	250	0.0281	139	0.067	192	0.081	7.025	24.865	17.84
Porto ~ Parnaiba	205	0.0281	60	0.067	169	0.081	5.7605	17.709	11.9485
Luzilandia ~ Parnaiba	120	0.0281	45	0.067	102	0.081	3.372	11.277	7.905
		0.0281		0.067		0.081			
Up Ward		0.0281		0.067		0.081			
Uniao ~ Floriano	315	0.0281	290	0.067	0	0.081	8.8515	19.43	10.5785
Teresian ~ Floriano	245	0.0281	234	0.067	0	0.081	6.8845	15.678	8.7935
Palmeiras ~ Floriano	125	0.0281	93	0.067	45	0.081	3.5125	9.876	6.3635
Amalante ~ Floriano	75	0.0281	93	0.067	0	0.081	2.1075	6.231	4.1235
		0.0281		0.067		0.081			
Floriano ~ Urcui	210	0.0281	74	0.067	153	0.081	5.901	17.351	11.45
Floriano ~ R. Goncalves	310	0.0281	74	0.067	264	0.081	8.711	26.342	17.631
Miguel Alves ~ Teresin.	135	0.0281	110	0.067	0	0.081	3.7935	7.37	3.5765
Uniao ~ Teresina	70	0.0281	56	0.067	0	0.081	1.967	3.752	1.785
		0.0281		0.067		0.081			
Teresina ~ St. Filomena	830	0.0281	777	0.067	140	0.081	23.323	63.399	40.076
Teresina ~ Goncalves	555	0.0281	308	0.067	264	0.081	15.5955	42.02	26.4245
Teresina ~ Urcui	455	0.0281	308	0.067	153	0.081	12.7855	33.029	20.2435
Teresina ~ Guadalupe	315	0.0281	308	0.067	48	0.081	8.8515	24.524	15.6725
Teresina ~ Floriano	245	0.0281	234	0.067	0	0.081	6.8845	15.678	8.7935
		0.0281		0.067		0.081			
Floriano ~ St. Filomena	585	0.0281	543	0.067	140	0.081	16.4385	47.721	31.2825
Floriano ~ R. Goncalves	310	0.0281	74	0.067	264	0.081	8.711	26.342	17.631
Floriano ~ Urcui	210	0.0281	74	0.067	153	0.081	5.901	17.351	11.45
Floriano ~ Guadalupe	70	0.0281	74	0.067	48	0.081	1.967	8.846	6.879
		0.0281		0.067		0.081			
Uniao ~ Floriano	315	0.0281	290	0.067	0	0.081	8.8515	19.43	10.5785
Miguelalves ~ Teresin.	135	0.0281	110	0.067	0	0.081	3.7935	7.37	3.5765
Uniao ~ Teresina	70	0.0281	56	0.067	0	0.081	1.967	3.752	1.785
		0.0281		0.067		0.081			
Parnaiba ~ Porto	205	0.0281	60	0.067	169	0.081	5.7605	17.709	11.9485
Parunaiba ~ Miguelalve	250	0.0281	139	0.067	192	0.081	7.025	24.865	17.84
Parunaiba ~ Uniao	315	0.0281	169	0.067	127	0.081	8.8515	21.61	12.7585

**Table A7.1.2 Transport Benefit in Scenario 1 in 2003**

Zone	Unit Benefit (US\$)	Transport Volume (t)	Transport Benefit (US\$)
<b>Down ward</b>			
St. Filomena ~ Floriano	31.2825	33,500	1,047,964
R. Goncalves ~ Floriano	17.631	57,220	1,008,846
R. Goncalves ~ Teresina	26.4245	104,050	2,749,469
Urcui ~ Floriano	11.45	12,380	141,751
Urcui ~ Teresina	20.2435	159,270	3,224,182
Guadalupe ~ Floriano	6.879	16,800	115,567
Guadalupe ~ Teresina	15.6725	43,200	677,052
Floriano ~ Teresina	8.7935	900	7,914
Amarante ~ Teresina	4.938	16,800	82,958
Palmeiras ~ Teresina	4.4	18,000	79,200
Miguelalves ~ Parnaiba	17.84	12,800	228,352
Porto ~ Parnaiba	11.9485	11,600	138,603
Luzilandia ~ Parnaiba	7.905	49,100	388,136
		sub total	9,889,994
<b>Up Ward</b>			
Floriano ~ St. Filomena	31.2825	5,790	181,126
Floriano ~ R. Goncalves	17.631	36,120	636,832
Floriano ~ Urcui	11.45	32,160	368,232
Floriano ~ Guadalupe	6.879	13,440	92,454
Amarante ~ Floriano		0	0
Palmeiras ~ Floriano	6.3635	2,400	15,272
Teresina ~ St. Filomena	40.076	890	35,668
Teresian ~ R. Goncalves	26.4245	17,520	462,957
Teresian ~ Urcui	20.2435	30,820	623,905
Teresina ~ Guadalupe	15.6725	960	15,046
Teresina ~ Floriano	8.7935	16,230	142,719
Uniao ~ Floriano	10.5785	3,000	31,736
Miguelalvves ~ Teresina	3.5765	14,200	50,786
Uniao ~ Teresina	1.785	14,800	26,418
	0		
Parnaiba ~ Porto	11.9485	430	5,138
Parunaiba ~ Miguelalves	17.84	920	16,413
Parunaiba ~ Uniao	12.7585	1,230	15,693
		sub total	2,720,393
		Total	12,610,387

**Table A7.1.3 Transport Benefit in Scenario 1 in 2010**

Zone	Unit Benefit (US\$)	Transport Volume (t)	Transport Benefit (US\$)
<b>Down ward</b>			
St. Filomena ~ Floriano	31.2825	72,500	2,267,981
R. Goncalves ~ Floriano	17.631	83,650	1,474,833
R. Goncalves ~ Teresina	26.4245	275,050	7,268,059
Urcui ~ Floriano	11.45	15,750	180,338
Urcui ~ Teresina	20.2435	243,550	4,930,304
Guadalupe ~ Floriano	6.879	19,000	130,701
Guadalupe ~ Teresina	15.6725	28,000	438,830
Floriano ~ Teresina	8.7935	1,600	14,070
Amarante ~ Teresina	4.938	36,900	182,212
Palmeiras ~ Teresina	4.4	35,000	154,000
St. Filomena ~ Urcui	32.4305	450	14,594
R. Goncalves ~ Urcui	7.639	4,300	32,848
Miguelalves ~ Parnaiba	17.84	26,900	479,896
Porto ~ Parnaiba	11.9485	24,800	296,323
Luzilandia ~ Parnaiba	7.905	114,300	903,542
		sub total	18,768,530
<b>Up Ward</b>			
Floriano ~ St. Filomena	31.2825	11,600	362,877
Floriano ~ R. Goncalves	17.631	54,000	952,074
Floriano ~ Urcui	11.45	42,100	482,045
Floriano ~ Guadalupe	6.879	9,000	61,911
Amarante ~ Floriano			
Palmeiras ~ Floriano			
Teresina ~ St. Filomena	40.076	1,100	44,084
Teresian ~ R. Goncalves	26.4245	2,000	52,849
Teresian ~ Urcui	20.2435	49,800	1,008,126
Teresina ~ Guadalupe	15.6725	29,200	457,637
Teresina ~ Floriano	8.7935	500	4,397
Uniao ~ Floriano	10.5785	6,700	70,876
Miguelalvves ~ Teresina	3.5765	25,000	89,413
Uniao ~ Teresina	1.785	25,000	44,625
	0		
Parnaiba ~ Porto	11.9485	500	5,974
Parunaiba ~ Miguelalves	17.84	1,000	17,840
Parunaiba ~ Uniao	12.7585	1500	19,138
		sub total	3,673,865
		<b>Total</b>	<b>22,442,395</b>

**Table A7.2.1 Unit Benefit in Scenario 2**

Zone	River Transport		Paved Road		Unpaved Road		With Cost	Without Cost	Unit Benefit (per ton)
	Distance	Cost	Distance	Cost	Distance	Cost			
Down ward									
St. Filomena ~ Floriano	585	0.0249	543	0.067	140	0.081	14.5665	47.721	33.1545
R. Goncalves ~ Floriano	310	0.0249	74	0.067	264	0.081	7.719	26.342	18.623
R. Goncalves ~ Teresina	555	0.0249	308	0.067	264	0.081	13.8195	42.02	28.2005
Urcui ~ Teresina	455	0.0249	308	0.067	153	0.081	11.3295	33.029	21.6995
Guadalupe ~ Teresina	315	0.0249	308	0.067	48	0.081	7.8435	24.524	16.6805
Amarante ~ Teresina	170	0.0249	145	0.067	0	0.081	4.233	9.715	5.482
Palmeiras ~ Teresina	120	0.0249	116	0.067	0	0.081	2.988	7.772	4.784
				0.067		0.081			
Urcui ~ Floriano	210	0.0249	74	0.067	153	0.081	5.229	17.351	12.122
Guadalupe ~ Floriano	70	0.0249	74	0.067	48	0.081	1.743	8.846	7.103
				0.067		0.081			
St. Filomena ~ Urcui	375	0.0249	275	0.067	303	0.081	9.3375	42.968	33.6305
R. Goncalves ~ Urcui	100	0.0249	0	0.067	129	0.081	2.49	10.449	7.959
				0.067		0.081			
Floriano ~ Teresina	245	0.0249	234	0.067	0	0.081	6.1005	15.678	9.5775
				0.067		0.081			
Amarante ~ Teresina	170	0.0249	145	0.067	0	0.081	4.233	9.715	5.482
Palmeiras ~ Teresina	120	0.0249	116	0.067	0	0.081	2.988	7.772	4.784
				0.067		0.081			
Up Ward									
Uniao ~ Floriano	315	0.0249	290	0.067	0	0.081	7.8435	19.43	11.5865
Teresina ~ Floriano	245	0.0249	234	0.067	0	0.081	6.1005	15.678	9.5775
Palmeiras ~ Floriano	125	0.0249	93	0.067	45	0.081	3.1125	9.876	6.7635
Amalante ~ Floriano	75	0.0249	93	0.067	0	0.081	1.8675	6.231	4.3635
				0.067		0.081			
Floriano ~ Urcui	210	0.0249	74	0.067	153	0.081	5.229	17.351	12.122
Floriano ~ R. Goncalves	310	0.0249	74	0.067	264	0.081	7.719	26.342	18.623
Miguel Alves ~ Teresina	135	0.0249	110	0.067	0	0.081	3.3615	7.37	4.0085
Uniao ~ Teresina	70	0.0249	56	0.067	0	0.081	1.743	3.752	2.009
				0.067		0.081			
Teresina ~ St. Filomena	830	0.0249	777	0.067	140	0.081	20.667	63.399	42.732
Teresina ~ Goncalves	555	0.0249	308	0.067	264	0.081	13.8195	42.02	28.2005
Teresina ~ Urcui	455	0.0249	308	0.067	153	0.081	11.3295	33.029	21.6995
Teresina ~ Guadalupe	315	0.0249	308	0.067	48	0.081	7.8435	24.524	16.6805
Teresina ~ Floriano	245	0.0249	234	0.067	0	0.081	6.1005	15.678	9.5775
				0.067		0.081			
Floriano ~ St. Filomena	585	0.0249	543	0.067	140	0.081	14.5665	47.721	33.1545
Floriano ~ R. Goncalves	310	0.0249	74	0.067	264	0.081	7.719	26.342	18.623
Floriano ~ Urcui	210	0.0249	74	0.067	153	0.081	5.229	17.351	12.122
Floriano ~ Guadalupe	70	0.0249	74	0.067	48	0.081	1.743	8.846	7.103

**Table A7.2.2 Transport Benefit in Scenario 2 in 2003**

Zone	Unit Benefit (US\$)	Transport Volume (t)	Transport Benefit (US\$)
<b>Down ward</b>			
St. Filomena ~ Floriano	33.1545	33,500	1,110,676
R. Goncalves ~ Floriano	18.623	57,220	1,065,608
R. Goncalves ~ Teresina	28.2005	104,050	2,934,262
Urcui ~ Floriano	12.122	12,380	150,070
Urcui ~ Teresina	21.6995	159,270	3,456,079
Guadalupe ~ Floriano	7.103	16,800	119,330
Guadalupe ~ Teresina	16.6805	43,200	720,598
Floriano ~ Teresina	9.5775	900	8,620
Amarante ~ Teresina	5.482	16,800	92,098
Palmeiras ~ Teresina	4.784	18,000	86,112
		sub total	9,743,453
<b>Up Ward</b>			
Floriano ~ St. Filomena	33.1545	5,790	191,965
Floriano ~ R. Goncalves	18.623	36,120	672,663
Floriano ~ Urcui	12.122	32,160	389,844
Floriano ~ Guadalupe	7.103	13,440	95,464
Amarante ~ Floriano		0	0
Palmeiras ~ Floriano	6.7635	2,400	16,232
Teresina ~ St. Filomena	42.732	890	38,031
Teresian ~ R. Goncalves	28.2005	17,520	494,073
Teresian ~ Urcui	21.6995	30,820	668,779
Teresina ~ Guadalupe	16.6805	960	16,013
Teresina ~ Floriano	9.5775	16,230	155,443
		sub total	2,738,506
		Total	12,481,959

**Table A7.2.3 Transport Benefit in Scenario 2 in 2010**

Zone	Unit Benefit (US\$)	Transport Volume (t)	Transport Benefit (US\$)
<b>Down ward</b>			
St. Filomena ~ Floriano	33.1545	72,500	2,403,701
R. Goncalves ~ Floriano	18.623	83,650	1,557,814
R. Goncalves ~ Teresina	28.2005	275,050	7,756,548
Urcui ~ Floriano	12.122	15,750	190,922
Urcui ~ Teresina	21.6995	243,550	5,284,913
Guadalupe ~ Floriano	7.103	19,000	134,957
Guadalupe ~ Teresina	16.6805	28,000	467,054
Floriano ~ Teresina	9.5775	1,600	15,324
Amarante ~ Teresina	5.482	36,900	202,286
Palmeiras ~ Teresina	4.784	35,000	167,440
St. Filomena ~ Urcui	33.6305	450	15,134
R. Goncalves ~ Urcui	7.959	4,300	34,224
		sub total	18,230,316
<b>Up Ward</b>			
Floriano ~ St. Filomena	33.1545	11,600	384,592
Floriano ~ R. Goncalves	18.623	54,000	1,005,642
Floriano ~ Urcui	12.122	42,100	510,336
Floriano ~ Guadalupe	7.103	9,000	63,927
Amarante ~ Floriano			
Palmeiras ~ Floriano			
Teresina ~ St. Filomena	42.732	1,100	47,005
Teresian ~ R. Goncalves	28.2005	2,000	56,401
Teresian ~ Urcui	21.6995	49,800	1,080,635
Teresina ~ Guadalupe	16.6805	29,200	487,071
Teresina ~ Floriano	9.5775	500	4,789
		sub total	3,640,398
		Total	21,870,714



**Table A7.3.1 Unit Benefit in Scenario 3**

Zone	River Transport		Paved Road		Unpaved Road		With Cost	Without Cost	Unit Benefit (per ton)
	Distance	Cost	Distance	Cost	Distance	Cost			
<b>Down ward</b>									
St. Filomena ~ Floriano	585	0.0168	543	0.067	140	0.081	9.828	47.721	37.893
R. Goncalves ~ Floriano	310	0.0168	74	0.067	264	0.081	5.208	26.342	21.134
Urcui ~ Floriano	210	0.0168	74	0.067	153	0.081	3.528	17.351	13.823
Guadalupe ~ Floriano	70	0.0168	74	0.067	48	0.081	1.176	8.846	7.67
<b>Up Ward</b>									
Floriano ~ St. Filomena	585	0.0168	543	0.067	140	0.081	9.828	47.721	37.893
Floriano ~ R. Goncalves	310	0.0168	74	0.067	264	0.081	5.208	26.342	21.134
Floriano ~ Urcui	210	0.0168	74	0.067	153	0.081	3.528	17.351	13.823
Floriano ~ Guadalupe	70	0.0168	74	0.067	48	0.081	1.176	8.846	7.67

**Table A7.3.2 Transport Benefit in Scenario 3 in 2003**

Zone	Unit Benefit (US\$)	Transport Volume (t)	Transport Benefit (US\$)
<b>Down ward</b>			
St. Filomena ~ Floriano	37.893	38,000	1,439,934
R. Goncalves ~ Floriano	21.134	183,000	3,867,522
Urcui ~ Floriano	13.823	196,000	2,709,308
Guadalupe ~ Floriano	7.67	67,500	517,725
		sub total	8,534,489
<b>Up Ward</b>			
Floriano ~ St. Filomena	37.893	9,700	367,562
Floriano ~ R. Goncalves	21.134	39,500	834,793
Floriano ~ Urcui	13.823	63,300	874,996
Floriano ~ Guadalupe	7.67	24,800	190,216
		sub total	2,267,567
		<b>Total</b>	<b>10,802,056</b>

**Table A7.3.3 Transport Benefit in Scenario 3 in 2010**

Zone	Unit Benefit (US\$)	Transport Volume (t)	Transport Benefit (US\$)
(US\$)			
Down ward			
St. Filomena ~ Floriano	37.893	72,950	2,764,294
R. Goncalves ~ Floriano	21.134	363,000	7,671,642
Urcui ~ Floriano	13.823	410,700	5,677,106
Guadalupe ~ Floriano	7.67	132,650	1,017,426
		sub total	17,130,468
Up Ward			
Floriano ~ St. Filomena	37.893	12,700	481,241
Floriano ~ R. Goncalves	21.134	58,000	1,225,772
Floriano ~ Urcui	13.823	99,900	1,380,918
Floriano ~ Guadalupe	7.67	38,200	292,994
		sub total	3,380,925
		Total	20,511,393

**Table A7.4.1 Unit Benefit in Scenario 4**

Zone	River Transport		Paved Road		Unpaved Road		With Cost	Without Cost	Unit Benefit (per ton)
	Distance	Cost	Distance	Cost	Distance	Cost			
<b>Down ward</b>									
St. Filomena ~ Floriano	585	0.0182	543	0.067	140	0.081	10.647	47.721	37.074
R. Goncalves ~ Floriano	310	0.0182	74	0.067	264	0.081	5.642	26.342	20.7
R. Goncalves ~ Teresina	555	0.0182	308	0.067	264	0.081	10.101	42.02	31.919
Urcui ~ Teresina	455	0.0182	308	0.067	153	0.081	8.281	33.029	24.748
Guadalupe ~ Teresina	315	0.0182	308	0.067	48	0.081	5.733	24.524	18.791
Amarante ~ Teresina	170	0.0182	145	0.067	0	0.081	3.094	9.715	6.621
Palmeiras ~ Teresina	120	0.0182	116	0.067	0	0.081	2.184	7.772	5.588
Urcui ~ Floriano	210	0.0182	74	0.067	153	0.081	3.822	17.351	13.529
Guadalupe ~ Floriano	70	0.0182	74	0.067	48	0.081	1.274	8.846	7.572
St. Filomena ~ Urcui	375	0.0182	275	0.067	303	0.081	6.825	42.968	36.143
R. Gocalves ~ Urcui	100	0.0182	0	0.067	129	0.081	1.82	10.449	8.629
Floriano ~ Teresina	245	0.0182	234	0.067	0	0.081	4.459	15.678	11.219
Amarante ~ Teresina	170	0.0182	145	0.067	0	0.081	3.094	9.715	6.621
Palmeiras ~ Teresina	120	0.0182	116	0.067	0	0.081	2.184	7.772	5.588
<b>Up Ward</b>									
Uniao ~ Floriano	315	0.0182	290	0.067	0	0.081	5.733	19.43	13.697
Teresian ~ Floriano	245	0.0182	234	0.067	0	0.081	4.459	15.678	11.219
Palmeiras ~ Floriano	125	0.0182	93	0.067	45	0.081	2.275	9.876	7.601
Amalante ~ Floriano	75	0.0182	93	0.067	0	0.081	1.365	6.231	4.866
Floriano ~ Urcui	210	0.0182	74	0.067	153	0.081	3.822	17.351	13.529
Floriano ~ R. Goncalves	310	0.0182	74	0.067	264	0.081	5.642	26.342	20.7
Miguel Alves ~ Teresina	135	0.0182	110	0.067	0	0.081	2.457	7.37	4.913
Uniao ~ Teresina	70	0.0182	56	0.067	0	0.081	1.274	3.752	2.478
Teresina ~ St. Filomena	830	0.0182	777	0.067	140	0.081	15.106	63.399	48.293
Teresina ~ Goncalves	555	0.0182	308	0.067	264	0.081	10.101	42.02	31.919
Teresina ~ Urcui	455	0.0182	308	0.067	153	0.081	8.281	33.029	24.748
Teresina ~ Guadalupe	315	0.0182	308	0.067	48	0.081	5.733	24.524	18.791
Teresina ~ Floriano	245	0.0182	234	0.067	0	0.081	4.459	15.678	11.219
Floriano ~ St. Filomena	585	0.0182	543	0.067	140	0.081	10.647	47.721	37.074
Floriano ~ R. Goncalves	310	0.0182	74	0.067	264	0.081	5.642	26.342	20.7
Floriano ~ Urcui	210	0.0182	74	0.067	153	0.081	3.822	17.351	13.529
Floriano ~ Guadalupe	70	0.0182	74	0.067	48	0.081	1.274	8.846	7.572

**Table A7.4.2 Transport Benefit in Scenario 4 in 2003**

Zone	Unit Benefit (US\$)	Transport Volume (t)	Transport Benefit (US\$)
<b>Down ward</b>			
St. Filomena ~ Floriano	37.074	33,500	1,241,979
R. Goncalves ~ Floriano	20.7	57,220	1,184,454
R. Goncalves ~ Teresina	31.919	104,050	3,321,172
Urcui ~ Floriano	13.529	12,380	167,489
Urcui ~ Teresina	24.748	159,270	3,941,614
Guadalupe ~ Floriano	7.572	16,800	127,210
Guadalupe ~ Teresina	18.791	43,200	811,771
Floriano ~ Teresina	11.219	900	10,097
Amarante ~ Teresina	6.621	16,800	111,233
Palmeiras ~ Teresina	5.588	18,000	100,584
		sub total	11,017,603
<b>Up Ward</b>			
Floriano ~ St. Filomena	37.074	3,400	126,052
Floriano ~ R. Goncalves	20.7	31,620	654,534
Floriano ~ Urcui	13.529	21,560	291,685
Floriano ~ Guadalupe	7.572	4,440	33,620
Amarante ~ Floriano	4.866	10,240	49,828
Palmeiras ~ Floriano	7.601	2,440	18,546
Teresina ~ St. Filomena	48.293	3,190	154,055
Teresian ~ R. Goncalves	31.919	6,220	198,536
Teresian ~ Urcui	24.748	36,820	911,221
Teresina ~ Guadalupe	18.791	19,960	375,068
Teresina ~ Floriano	11.219	16,230	182,084
		sub total	2,995,230
		Total	14,012,832

**Table A7.4.3 Transport Benefit in Scenario 4 in 2005**

Zone	Unit Benefit (US\$)	Transport Volume (t)	Transport Benefit (US\$)	(US\$)
<b>Down ward</b>				
St. Filomena ~ Floriano	37.074	40,420	1,498,531	
R. Goncalves ~ Floriano	20.7	67,700	1,401,390	
R. Goncalves ~ Teresina	31.919	81,300	2,595,015	
Urcui ~ Floriano	13.529	15,170	205,235	
Urcui ~ Teresina	24.748	202,580	5,013,450	
Guadalupe ~ Floriano	7.572	20,630	156,210	
Guadalupe ~ Teresina	18.791	53,000	995,923	
Floriano ~ Teresina	11.219	1,100	12,341	
Amarante ~ Teresina	6.621	22,550	149,304	
Palmeiras ~ Teresina	5.588	22,700	126,848	
		sub total	12,154,246	
<b>Up Ward</b>				
Floriano ~ St. Filomena	37.074	7,550	279,909	
Floriano ~ R. Goncalves	20.7	35,550	735,885	
Floriano ~ Urcui	13.529	24,200	327,402	
Floriano ~ Guadalupe	7.572	4,400	33,317	
Amarante ~ Floriano	4.866	12,400	60,338	
Palmeiras ~ Floriano	7.601	3,000	22,803	
Teresina ~ St. Filomena	48.293	3,450	166,611	
Teresian ~ R. Goncalves	31.919	6,850	218,645	
Teresian ~ Urcui	24.748	43,200	1,069,114	
Teresina ~ Guadalupe	18.791	23,600	443,468	
Teresina ~ Floriano	11.219	19,650	220,453	
		sub total	3,577,944	
		Total	15,732,190	

**Table A7.4.4 Transport Benefit in Scenario 4 in 2010**

Zone	Unit Benefit (US\$)	Transport Volume (t)	Transport Benefit (US\$)
<b>Down ward</b>			
St. Filomena ~ Floriano	37.074	72,500	2,687,865
R. Goncalves ~ Floriano	20.7	257,000	5,319,900
R. Goncalves ~ Teresina	31.919	101,700	3,246,162
Urcui ~ Floriano	13.529	36,450	493,132
Urcui ~ Teresina	24.748	222,850	5,515,092
Guadalupe ~ Floriano	7.572	24,950	188,921
Guadalupe ~ Teresina	18.791	22,050	414,342
Floriano ~ Teresina	11.219	1,600	17,950
Amarante ~ Teresina	11.219	15,000	168,285
Palmeiras ~ Teresina	5.588	15,000	83,820
St. Filomena ~ Urcui	36.143	450	16,264
R. Goncalves ~ Urcui	8.629	4,300	37,105
		sub total	18,188,839
<b>Up Ward</b>			
Floriano ~ St. Filomena	37.074	8,900	329,959
Floriano ~ R. Goncalves	20.7	48,200	997,740
Floriano ~ Urcui	13.529	34,300	464,045
Floriano ~ Guadalupe	18.791	4,900	92,076
Amarante ~ Floriano	4.866	22,500	109,485
Palmeiras ~ Floriano	7.601	5,000	38,005
Teresina ~ St. Filomena	48.293	3,800	183,513
Teresian ~ R. Goncalves	31.919	7,800	248,968
Teresian ~ Urcui	24.748	57,600	1,425,485
Teresina ~ Guadalupe	18.791	33,300	625,740
Teresina ~ Floriano	11.219	34,000	381,446
		sub total	4,896,462
		Total	23,085,300

Table A7.5.1 Economical Project and O&M Cost in Scenario 1

		Unit : US\$ Allocations of the Project Cost													
Project	Unit	Unit Cost	Qty	Cost	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
<b>A. Construction and Procurement Cost</b>															
1 Lock Rehabilitation			1	13,865,730	4,159,719	4,159,719	5,546,292								
2 Port Construction	LS		1	45,704,000	21,450,000	35,680,000									
3 Vessel Procurement	Vessel	859,500	53	45,555,500	4,555,350	4,555,350	4,555,350	4,555,350	4,555,350	4,555,350	4,555,350	4,555,350	4,555,350	4,555,350	4,555,350
4 Navigation Aids	LS	1	1	830,000		830,000									
sub-total				105,943,230	30,165,069	46,611,642	4,555,350	4,555,350	4,555,350	4,555,350	4,555,350	4,555,350	4,555,350	4,555,350	4,555,350
B. Engineering Fee	%		10%	9,530,391	9,530,391										
C. Physical Contingency	%		5%	4,216,379	1,264,914	1,686,552									
Total				119,700,000	19,510,373	31,429,983	48,298,194	4,555,350	4,555,350	4,555,350	4,555,350	4,555,350	4,555,350	4,555,350	4,555,350
<b>Operation Cost</b>															
1 Ship Operation Cost	資本費込						11,799,200	12,600,800	13,402,400	14,204,000	15,005,600	15,807,200	16,608,800	17,410,400	18,212,000
	資本費除						7,322,200	8,503,200	9,684,200	10,865,200	12,046,200	13,227,200	14,408,200	15,589,200	16,770,200
2 Ship Operation Office							2,521,800	2,521,800	2,521,800	2,521,800	2,521,800	2,521,800	2,521,800	2,521,800	2,521,800
3 Port Operatic Office							3,305,280	3,305,280	3,305,280	3,305,280	3,305,280	3,305,280	3,305,280	3,305,280	3,305,280
4 River Management Office							2,369,280	2,369,280	2,369,280	2,369,280	2,369,280	2,369,280	2,369,280	2,369,280	2,369,280
Total	資本費込						19,985,060	21,801,160	23,617,260	25,433,360	27,249,460	29,065,560	30,881,660	32,697,760	34,513,860
	資本費除						15,518,560	16,699,560	17,880,560	19,061,560	20,242,560	21,423,560	22,604,560	23,785,560	24,966,560





**Table A7.5.3 Economical Project and O&M Cost in Scenario 3**

Unit : US\$ Allocations of the Project Cost

Project	Unit	Unit Cost	Qty	Cost	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
<b>A. Construction and Procurement Cost</b>															
1 Lock Rehabilitation			1	13,863,750	4,159,719	4,159,719	5,546,292								
2 Port Construction	LS		1	27,136,000		16,960,000	16,960,000								
3 Vessel Procurement	Vessel	859,300	31	26,644,500	2,664,450	2,664,450	2,664,450	2,664,450	2,664,450	2,664,450	2,664,450	2,664,450	2,664,450	2,664,450	2,664,450
4 Navigation Aids	LS	1	1	200,000			200,000								
sub-total				67,846,230	6,824,169	23,784,169	25,370,742	2,664,450	2,664,450	2,664,450	2,664,450	2,664,450	2,664,450	2,664,450	2,664,450
B. Engineering Fee	%		10%	6,102,561	6,102,561										
C. Physical Contingency	%		5%	3,451,210	1,035,363	1,035,363	1,380,484								
Total				77,400,000	13,962,093	24,819,532	26,751,226	2,664,450	2,664,450	2,664,450	2,664,450	2,664,450	2,664,450	2,664,450	2,664,450
<b>Operation Cost</b>															
1 Ship Operation Cost	資本費込							5,115,600	5,846,400	6,577,200	7,308,000	8,038,800	9,133,000	10,231,200	11,327,400
	資本費除<							3,098,200	3,540,800	3,983,400	4,426,000	4,868,600	5,532,500	6,196,400	6,860,300
2 Ship Operation Office								1,033,560	1,033,560	1,033,560	1,033,560	1,033,560	1,033,560	1,033,560	1,033,560
3 Port Operation Office								1,456,320	1,456,320	1,456,320	1,456,320	1,456,320	1,456,320	1,456,320	1,456,320
4 River Management Office								1,259,520	1,259,520	1,259,520	1,259,520	1,259,520	1,259,520	1,259,520	1,259,520
Total	資本費込							8,865,000	9,595,800	10,326,600	11,057,400	11,788,200	12,884,400	13,980,600	15,076,800
	資本費除<							6,847,600	7,290,200	7,732,800	8,175,400	8,618,000	9,281,900	9,945,800	10,609,700

**Table A7.5.4 Economical Project and O&M Cost in Scenario 4**

Unit : US\$ Allocations of the Project Cost															
Project	Unit	Unit Cost	Qty	Cost	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
<b>A. Construction and Procurement Cost</b>															
1 Lock Rehabilitation			1	13,865,730	4,159,719	4,159,719	5,546,292								
2 Port Construction	LS		1	36,960,000		21,430,000	24,750,000								
3 Vessel Procurement	Vessel	859,300	40	34,380,000	3,438,000	3,438,000	3,438,000	3,438,000	3,438,000	3,438,000	3,438,000	3,438,000	3,438,000	3,438,000	3,438,000
4 Navigation Aids	LS	1	1	360,000			360,000								
sub-total				85,565,730	7,597,719	29,047,719	34,094,292	3,438,000	3,438,000	3,438,000	3,438,000	3,438,000	3,438,000	3,438,000	3,438,000
B. Engineering Fee	%		10%	7,695,516	7,695,516										
C. Physical Contingency	%		5%	3,438,754	1,031,626	1,031,626	1,375,502								
Total				96,700,000	16,324,861	30,079,345	35,469,794	3,438,000	3,438,000	3,438,000	3,438,000	3,438,000	3,438,000	3,438,000	3,438,000
<b>Operation Cost</b>															
1 Ship Operation Cost	資本費込							6,201,600	6,854,400	7,833,600	8,486,400	9,465,600	10,444,800	11,750,400	13,056,000
	資本費除							3,463,700	3,828,500	4,375,200	4,739,800	5,286,700	5,833,600	6,562,800	7,292,000
2 Ship Operation Office								1,430,280	1,430,280	1,430,280	1,430,280	1,430,280	1,430,280	1,430,280	1,430,280
3 Port Operatio Office								1,966,400	1,966,400	1,966,400	1,966,400	1,966,400	1,966,400	1,966,400	1,966,400
4 River Management Office								1,345,920	1,345,920	1,345,920	1,345,920	1,345,920	1,345,920	1,345,920	1,345,920
Total	資本費込							10,944,200	11,597,000	12,576,200	13,229,000	14,208,200	15,187,400	16,493,000	17,798,600
	資本費除							8,206,300	8,570,900	9,117,800	9,482,400	10,029,300	10,576,200	11,305,400	12,034,600

Table A7.6.1 Project Cash Flow in Scenario 1

Year	Project Cash Flow				Benefit			Benefit - Cost
	Cost		Operation	Total	Running	Products	Total	
	Investment	Operation						
1 2000	19,510,373			19,510,373				-19,510,373
2 2001	31,429,983			31,429,983				-31,429,983
3 2002	48,298,194			48,298,194				-48,298,194
4 2003	4,555,350	15,518,560		20,073,910	12,610,387	1,477,354	14,087,741	-5,986,169
5 2004	4,555,350	16,699,560		21,254,910	13,692,772	1,723,794	15,416,566	-5,838,344
6 2005	4,555,350	17,880,560		22,435,910	14,868,061	2,011,342	16,879,403	-5,556,507
7 2006	4,555,350	19,061,560		23,616,910	16,144,229	2,346,857	18,491,086	-5,125,824
8 2007	4,555,350	20,714,960		25,270,310	17,529,934	2,738,339	20,268,273	-5,002,037
9 2008	4,555,350	20,714,960		25,270,310	19,034,578	3,195,126	22,229,704	-3,040,606
10 2009	4,555,350	20,714,960		25,270,310	20,668,370	3,728,109	24,396,479	-873,831
11 2010		20,714,960		20,714,960	22,442,395	4,350,000	26,792,395	6,077,435
12 2011		20,714,960		20,714,960	22,442,395	4,350,000	26,792,395	6,077,435
13 2012		20,714,960		20,714,960	22,442,395	4,350,000	26,792,395	6,077,435
14 2013		20,714,960		20,714,960	22,442,395	4,350,000	26,792,395	6,077,435
15 2014		20,714,960		20,714,960	22,442,395	4,350,000	26,792,395	6,077,435
16 2015		20,714,960		20,714,960	22,442,395	4,350,000	26,792,395	6,077,435
17 2016		20,714,960		20,714,960	22,442,395	4,350,000	26,792,395	6,077,435
18 2017		20,714,960		20,714,960	22,442,395	4,350,000	26,792,395	6,077,435
19 2018		20,714,960		20,714,960	22,442,395	4,350,000	26,792,395	6,077,435
20 2019		20,714,960		20,714,960	22,442,395	4,350,000	26,792,395	6,077,435
21 2020		20,714,960		20,714,960	22,442,395	4,350,000	26,792,395	6,077,435
22 2021		20,714,960		20,714,960	22,442,395	4,350,000	26,792,395	6,077,435
23 2022		20,714,960		20,714,960	22,442,395	4,350,000	26,792,395	6,077,435
24 2023		20,714,960		20,714,960	22,442,395	4,350,000	26,792,395	6,077,435
25 2024		20,714,960		20,714,960	22,442,395	4,350,000	26,792,395	6,077,435
26 2025		20,714,960		20,714,960	22,442,395	4,350,000	26,792,395	6,077,435
27 2026		20,714,960		20,714,960	22,442,395	4,350,000	26,792,395	6,077,435
28 2027		20,714,960		20,714,960	22,442,395	4,350,000	26,792,395	6,077,435
29 2028		20,714,960		20,714,960	22,442,395	4,350,000	26,792,395	6,077,435
30 2029	-11,970,000	20,714,960		8,744,960	22,442,395	4,350,000	26,792,395	18,047,435
Total	119,156,000	545,604,320		664,760,320	563,396,231	104,220,921	667,617,152	2,856,832

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**Table A7.6.2 Project Cash Flow in Scenario 2**

Year	Project Cash Flow				Benefit				Benefit - Cost
	Cost		Benefit		Running	Products	Total	Total	
	Investment	Operation	Total	Running					
1 2000	17,358,352		17,358,352					-17,358,352	
2 2001	30,648,706		30,648,706					-30,648,706	
3 2002	36,057,042		36,057,042					-36,057,042	
4 2003	3,953,700	10,550,400	14,504,100	12,481,959	1,477,354	13,959,313		-544,787	
5 2004	3,953,700	10,993,000	14,946,700	13,523,214	1,723,794	15,247,008		300,308	
6 2005	3,953,700	11,656,900	15,610,600	14,651,331	2,011,342	16,662,673		1,052,073	
7 2006	3,953,700	12,320,800	16,274,500	15,873,557	2,346,857	18,220,414		1,945,914	
8 2007	3,953,700	12,984,700	16,938,400	17,197,742	2,738,339	19,936,081		2,997,681	
9 2008	3,953,700	13,648,600	17,602,300	18,632,392	3,195,126	21,827,518		4,225,218	
10 2009	3,953,700	14,533,800	18,487,500	20,186,721	3,728,109	23,914,830		5,427,330	
11 2010		15,419,000	15,419,000	21,870,714	4,350,000	26,220,714		10,801,714	
12 2011		15,419,000	15,419,000	21,870,714	4,350,000	26,220,714		10,801,714	
13 2012		15,419,000	15,419,000	21,870,714	4,350,000	26,220,714		10,801,714	
14 2013		15,419,000	15,419,000	21,870,714	4,350,000	26,220,714		10,801,714	
15 2014		15,419,000	15,419,000	21,870,714	4,350,000	26,220,714		10,801,714	
16 2015		15,419,000	15,419,000	21,870,714	4,350,000	26,220,714		10,801,714	
17 2016		15,419,000	15,419,000	21,870,714	4,350,000	26,220,714		10,801,714	
18 2017		15,419,000	15,419,000	21,870,714	4,350,000	26,220,714		10,801,714	
19 2018		15,419,000	15,419,000	21,870,714	4,350,000	26,220,714		10,801,714	
20 2019		15,419,000	15,419,000	21,870,714	4,350,000	26,220,714		10,801,714	
21 2020		15,419,000	15,419,000	21,870,714	4,350,000	26,220,714		10,801,714	
22 2021		15,419,000	15,419,000	21,870,714	4,350,000	26,220,714		10,801,714	
23 2022		15,419,000	15,419,000	21,870,714	4,350,000	26,220,714		10,801,714	
24 2023		15,419,000	15,419,000	21,870,714	4,350,000	26,220,714		10,801,714	
25 2024		15,419,000	15,419,000	21,870,714	4,350,000	26,220,714		10,801,714	
26 2025		15,419,000	15,419,000	21,870,714	4,350,000	26,220,714		10,801,714	
27 2026		15,419,000	15,419,000	21,870,714	4,350,000	26,220,714		10,801,714	
28 2027		15,419,000	15,419,000	21,870,714	4,350,000	26,220,714		10,801,714	
29 2028		15,419,000	15,419,000	21,870,714	4,350,000	26,220,714		10,801,714	
30 2029	-10,250,000	15,419,000	5,169,000	21,870,714	4,350,000	26,220,714		21,051,714	
Total	101,490,000	395,068,200	496,558,200	549,961,196	4,350,000	654,182,117		157,623,917	

6.56%

Table A7.6.3 Project Cash Flow in Scenario 3

Year	Project Cash Flow			Benefit			Benefit - Cost
	Cost	Operation	Total	Running	Products	Total	
1	2000	13,962,093	13,962,093				-13,962,093
2	2001	24,819,532	24,819,532				-24,819,532
3	2002	26,751,226	26,751,226				-26,751,226
4	2003	2,664,450	6,847,600	9,512,050	10,802,056	10,802,056	1,290,006
5	2004	2,664,450	7,290,200	9,954,650	11,838,332	11,838,332	1,883,682
6	2005	2,664,450	7,732,800	10,397,250	12,974,022	12,974,022	2,576,772
7	2006	2,664,450	8,175,400	10,839,850	14,218,662	14,218,662	3,378,812
8	2007	2,664,450	8,618,000	11,282,450	15,582,704	15,582,704	4,300,254
9	2008	2,664,450	9,281,900	11,946,350	17,077,604	17,077,604	5,131,254
10	2009	2,664,450	9,945,800	12,610,250	18,715,914	18,715,914	6,105,664
11	2010		10,609,700	10,609,700	20,511,393	20,511,393	9,901,693
12	2011		10,609,700	10,609,700	20,511,393	20,511,393	9,901,693
13	2012		10,609,700	10,609,700	20,511,393	20,511,393	9,901,693
14	2013		10,609,700	10,609,700	20,511,393	20,511,393	9,901,693
15	2014		10,609,700	10,609,700	20,511,393	20,511,393	9,901,693
16	2015		10,609,700	10,609,700	20,511,393	20,511,393	9,901,693
17	2016		10,609,700	10,609,700	20,511,393	20,511,393	9,901,693
18	2017		10,609,700	10,609,700	20,511,393	20,511,393	9,901,693
19	2018		10,609,700	10,609,700	20,511,393	20,511,393	9,901,693
20	2019		10,609,700	10,609,700	20,511,393	20,511,393	9,901,693
21	2020		10,609,700	10,609,700	20,511,393	20,511,393	9,901,693
22	2021		10,609,700	10,609,700	20,511,393	20,511,393	9,901,693
23	2022		10,609,700	10,609,700	20,511,393	20,511,393	9,901,693
24	2023		10,609,700	10,609,700	20,511,393	20,511,393	9,901,693
25	2024		10,609,700	10,609,700	20,511,393	20,511,393	9,901,693
26	2025		10,609,700	10,609,700	20,511,393	20,511,393	9,901,693
27	2026		10,609,700	10,609,700	20,511,393	20,511,393	9,901,693
28	2027		10,609,700	10,609,700	20,511,393	20,511,393	9,901,693
29	2028		10,609,700	10,609,700	20,511,393	20,511,393	9,901,693
30	2029	-7,740,000	10,609,700	2,869,700	20,511,393	20,511,393	17,641,693
Total		76,444,001	270,085,700	346,529,701	511,437,154	0	164,907,453

8.54%

**Table A7.6.4 Project Cash Flow in Scenario 4**

Year	Cost			Benefit			Benefit - Cost
	Investment	Operation	Total	Running	Products	Total	
1	16,324,861		16,324,861			0	-16,324,861
2	30,079,345		30,079,345			0	-30,079,345
3	35,469,794		35,469,794			0	-35,469,794
4	3,438,000	8,206,300	11,644,300	14,012,832	1,477,354	15,490,186	3,845,886
5	3,438,000	8,570,900	12,008,900	14,872,511	1,723,794	16,596,305	4,587,405
6	3,438,000	9,117,800	12,555,800	15,732,190	2,011,342	17,743,532	5,187,732
7	3,438,000	9,482,400	12,920,400	16,986,286	2,346,857	19,333,143	6,412,743
8	3,438,000	10,029,300	13,467,300	18,340,354	2,738,339	21,078,693	7,611,393
9	3,438,000	10,576,200	14,014,200	19,802,361	3,195,126	22,997,487	8,983,287
10	3,438,000	11,305,400	14,743,400	21,380,913	3,728,109	25,109,022	10,365,622
11		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300	15,400,700
12		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300	15,400,700
13		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300	15,400,700
14		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300	15,400,700
15		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300	15,400,700
16		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300	15,400,700
17		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300	15,400,700
18		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300	15,400,700
19		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300	15,400,700
20		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300	15,400,700
21		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300	15,400,700
22		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300	15,400,700
23		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300	15,400,700
24		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300	15,400,700
25		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300	15,400,700
26		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300	15,400,700
27		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300	15,400,700
28		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300	15,400,700
29		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300	15,400,700
30	-9,670,000	12,034,600	2,364,600	23,085,300	4,350,000	27,435,300	25,070,700
Total	96,270,000	307,980,300	404,250,300	582,833,447	104,220,921	687,054,368	282,804,068

EIRR: 11.02%  
 NPV(discounted 10%): 7,807,152  
 B/C Ratio(discounted 10%): 1.05

Table A7.6.5 Project Cash Flow in Scenario 4 (construction cost : 5% cut)

Year		Cost			Benefit			Benefit - Cost	
		Investment	Operation	Total	Running	Products	Total		
1	2000	15,508,618		15,508,618			0		-15,508,618
2	2001	28,575,378		28,575,378			0		-28,575,378
3	2002	33,696,304		33,696,304			0		-33,696,304
4	2003	3,266,100	8,206,300	11,472,400	14,012,832	1,477,354	15,490,186		4,017,786
5	2004	3,266,100	8,570,900	11,837,000	14,872,511	1,723,794	16,596,305		4,759,305
6	2005	3,266,100	9,117,800	12,383,900	15,732,190	2,011,342	17,743,532		5,359,632
7	2006	3,266,100	9,482,400	12,748,500	16,986,286	2,346,857	19,333,143		6,584,643
8	2007	3,266,100	10,029,300	13,295,400	18,340,354	2,738,339	21,078,693		7,783,293
9	2008	3,266,100	10,576,200	13,842,300	19,802,361	3,195,126	22,997,487		9,155,187
10	2009	3,266,100	11,305,400	14,571,500	21,380,913	3,728,109	25,109,022		10,537,522
11	2010		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300		15,400,700
12	2011		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300		15,400,700
13	2012		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300		15,400,700
14	2013		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300		15,400,700
15	2014		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300		15,400,700
16	2015		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300		15,400,700
17	2016		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300		15,400,700
18	2017		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300		15,400,700
19	2018		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300		15,400,700
20	2019		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300		15,400,700
21	2020		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300		15,400,700
22	2021		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300		15,400,700
23	2022		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300		15,400,700
24	2023		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300		15,400,700
25	2024		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300		15,400,700
26	2025		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300		15,400,700
27	2026		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300		15,400,700
28	2027		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300		15,400,700
29	2028		12,034,600	12,034,600	23,085,300	4,350,000	27,435,300		15,400,700
30	2029	-9,186,500	12,034,600	2,848,100	23,085,300	4,350,000	27,435,300		24,587,200
Total		91,456,500	307,980,300	399,436,800	582,833,447	104,220,921	687,054,368		287,617,568

EIRR:

11.59%

NPV(discounted 10%):

11,725,641

B/C Ratio(discounted 10%):

1.08



Table A7.7.1 Project Cash Flow in Scenario 4 (original case)

Project Cash Flow										Benefit - Cost	
Year	Cost			Revenue			Total		Total	Benefit - Cost	
	Investment	Operation	Total	Transport Tariff	Total	Total	Total				
1 2000	21,584,000		21,584,000							-21,584,000	
2 2001	32,274,000		32,274,000							-32,274,000	
3 2002	38,022,000		38,022,000							-38,022,000	
4 2003	4,560,000	9,440,300	14,000,300	6,449,759			6,449,759		6,449,759	-7,550,541	
5 2004	4,560,000	9,830,900	14,390,900	6,847,701			6,847,701		6,847,701	-7,543,200	
6 2005	4,560,000	10,416,800	14,976,800	7,245,642			7,245,642		7,245,642	-7,731,158	
7 2006	4,560,000	10,807,400	15,367,400	7,775,580			7,775,580		7,775,580	-7,591,820	
8 2007	4,560,000	11,393,300	15,953,300	8,344,279			8,344,279		8,344,279	-7,609,021	
9 2008	4,560,000	11,979,200	16,539,200	8,954,571			8,954,571		8,954,571	-7,584,629	
10 2009	4,560,000	12,760,400	17,320,400	9,609,499			9,609,499		9,609,499	-7,710,901	
11 2010		13,541,600	13,541,600	10,312,329			10,312,329		10,312,329	-3,229,271	
12 2011		13,541,600	13,541,600	10,312,329			10,312,329		10,312,329	-3,229,271	
13 2012		13,541,600	13,541,600	10,312,329			10,312,329		10,312,329	-3,229,271	
14 2013		13,541,600	13,541,600	10,312,329			10,312,329		10,312,329	-3,229,271	
15 2014		13,541,600	13,541,600	10,312,329			10,312,329		10,312,329	-3,229,271	
16 2015		13,541,600	13,541,600	10,312,329			10,312,329		10,312,329	-3,229,271	
17 2016		13,541,600	13,541,600	10,312,329			10,312,329		10,312,329	-3,229,271	
18 2017		13,541,600	13,541,600	10,312,329			10,312,329		10,312,329	-3,229,271	
19 2018		13,541,600	13,541,600	10,312,329			10,312,329		10,312,329	-3,229,271	
20 2019		13,541,600	13,541,600	10,312,329			10,312,329		10,312,329	-3,229,271	
21 2020		13,541,600	13,541,600	10,312,329			10,312,329		10,312,329	-3,229,271	
22 2021		13,541,600	13,541,600	10,312,329			10,312,329		10,312,329	-3,229,271	
23 2022		13,541,600	13,541,600	10,312,329			10,312,329		10,312,329	-3,229,271	
24 2023		13,541,600	13,541,600	10,312,329			10,312,329		10,312,329	-3,229,271	
25 2024		13,541,600	13,541,600	10,312,329			10,312,329		10,312,329	-3,229,271	
26 2025		13,541,600	13,541,600	10,312,329			10,312,329		10,312,329	-3,229,271	
27 2026		13,541,600	13,541,600	10,312,329			10,312,329		10,312,329	-3,229,271	
28 2027		13,541,600	13,541,600	10,312,329			10,312,329		10,312,329	-3,229,271	
29 2028		13,541,600	13,541,600	10,312,329			10,312,329		10,312,329	-3,229,271	
30 2029		13,541,600	13,541,600	10,312,329			10,312,329		10,312,329	-3,229,271	
Total	123,800,000	347,460,300	471,260,300	261,473,611			261,473,611	0	261,473,611	-209,786,690	

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Table A7.7.2 Project Cash Flow in Scenario 4 (Case 1)

Project Cash Flow							Benefit - Cost	
Year	Cost			Revenue			Total	Total
	Investment	Operation	Total	Transport Tariff	Total	Total		
1	2000	21,584,000		21,584,000				-21,584,000
2	2001	32,274,000		32,274,000				-32,274,000
3	2002	38,022,000		38,022,000				-38,022,000
4	2003	4,560,000	9,440,300	14,000,300	19,349,277		19,349,277	5,348,977
5	2004	4,560,000	9,830,900	14,390,900	20,543,102		20,543,102	6,152,202
6	2005	4,560,000	10,416,800	14,976,800	21,736,926		21,736,926	6,760,126
7	2006	4,560,000	10,807,400	15,367,400	23,326,740		23,326,740	7,959,340
8	2007	4,560,000	11,393,300	15,953,300	25,032,837		25,032,837	9,079,537
9	2008	4,560,000	11,979,200	16,539,200	26,863,713		26,863,713	10,324,513
10	2009	4,560,000	12,760,400	17,320,400	28,828,497		28,828,497	11,508,097
11	2010		13,541,600	13,541,600	30,936,987		30,936,987	17,395,387
12	2011		13,541,600	13,541,600	30,936,987		30,936,987	17,395,387
13	2012		13,541,600	13,541,600	30,936,987		30,936,987	17,395,387
14	2013		13,541,600	13,541,600	30,936,987		30,936,987	17,395,387
15	2014		13,541,600	13,541,600	30,936,987		30,936,987	17,395,387
16	2015		13,541,600	13,541,600	30,936,987		30,936,987	17,395,387
17	2016		13,541,600	13,541,600	30,936,987		30,936,987	17,395,387
18	2017		13,541,600	13,541,600	30,936,987		30,936,987	17,395,387
19	2018		13,541,600	13,541,600	30,936,987		30,936,987	17,395,387
20	2019		13,541,600	13,541,600	30,936,987		30,936,987	17,395,387
21	2020		13,541,600	13,541,600	30,936,987		30,936,987	17,395,387
22	2021		13,541,600	13,541,600	30,936,987		30,936,987	17,395,387
23	2022		13,541,600	13,541,600	30,936,987		30,936,987	17,395,387
24	2023		13,541,600	13,541,600	30,936,987		30,936,987	17,395,387
25	2024		13,541,600	13,541,600	30,936,987		30,936,987	17,395,387
26	2025		13,541,600	13,541,600	30,936,987		30,936,987	17,395,387
27	2026		13,541,600	13,541,600	30,936,987		30,936,987	17,395,387
28	2027		13,541,600	13,541,600	30,936,987		30,936,987	17,395,387
29	2028		13,541,600	13,541,600	30,936,987		30,936,987	17,395,387
30	2029		13,541,600	13,541,600	30,936,987		30,936,987	17,395,387
Total		123,800,000	347,460,300	471,260,300	784,420,832	0	784,420,832	313,160,532

11.26%

Table A7.7.3 Project Cash Flow in Scenario 4 (Case 2)

Year	Project Cash Flow				Revenue		Benefit - Cost
	Cost		Operation		Transport	Tariff	
	Investment	Total	Operation	Total			
1 2000	9,116,000	9,116,000					-9,116,000
2 2001	4,560,000	4,560,000					-4,560,000
3 2002	4,560,000	4,560,000					-4,560,000
4 2003	4,560,000	8,270,700	3,710,700		6,449,759	6,449,759	-1,820,941
5 2004	4,560,000	8,661,300	4,101,300		6,847,701	6,847,701	-1,813,600
6 2005	4,560,000	9,247,200	4,687,200		7,245,642	7,245,642	-2,001,558
7 2006	4,560,000	9,637,800	5,077,800		7,775,580	7,775,580	-1,862,220
8 2007	4,560,000	10,223,700	5,663,700		8,344,279	8,344,279	-1,879,421
9 2008	4,560,000	10,809,600	6,249,600		8,954,571	8,954,571	-1,855,029
10 2009	4,560,000	11,590,800	7,030,800		9,609,499	9,609,499	-1,981,301
11 2010		7,812,000	7,812,000		10,312,329	10,312,329	2,500,329
12 2011		7,812,000	7,812,000		10,312,329	10,312,329	2,500,329
13 2012		7,812,000	7,812,000		10,312,329	10,312,329	2,500,329
14 2013		7,812,000	7,812,000		10,312,329	10,312,329	2,500,329
15 2014		7,812,000	7,812,000		10,312,329	10,312,329	2,500,329
16 2015		7,812,000	7,812,000		10,312,329	10,312,329	2,500,329
17 2016		7,812,000	7,812,000		10,312,329	10,312,329	2,500,329
18 2017		7,812,000	7,812,000		10,312,329	10,312,329	2,500,329
19 2018		7,812,000	7,812,000		10,312,329	10,312,329	2,500,329
20 2019		7,812,000	7,812,000		10,312,329	10,312,329	2,500,329
21 2020		7,812,000	7,812,000		10,312,329	10,312,329	2,500,329
22 2021		7,812,000	7,812,000		10,312,329	10,312,329	2,500,329
23 2022		7,812,000	7,812,000		10,312,329	10,312,329	2,500,329
24 2023		7,812,000	7,812,000		10,312,329	10,312,329	2,500,329
25 2024		7,812,000	7,812,000		10,312,329	10,312,329	2,500,329
26 2025		7,812,000	7,812,000		10,312,329	10,312,329	2,500,329
27 2026		7,812,000	7,812,000		10,312,329	10,312,329	2,500,329
28 2027		7,812,000	7,812,000		10,312,329	10,312,329	2,500,329
29 2028		7,812,000	7,812,000		10,312,329	10,312,329	2,500,329
30 2029		7,812,000	7,812,000		10,312,329	10,312,329	2,500,329
Total	50,156,000	242,917,100	192,761,100		261,473,611	0	18,556,511

2.91%

**Table A7.7.4 Project Cash Flow in Scenario 4 (Case 3)**

Project Cash Flow									
Year	Cost			Revenue			Benefit - Cost		
	Investment	Operation	Total	Transport Tariff	Total	Total	Total		
1 2000	9,116,000		9,116,000				-9,116,000		
2 2001	4,560,000		4,560,000				-4,560,000		
3 2002	4,560,000		4,560,000				-4,560,000		
4 2003	4,560,000	3,710,700	8,270,700	8,384,687	8,384,687	8,384,687	113,987		
5 2004	4,560,000	4,101,300	8,661,300	8,902,011	8,902,011	8,902,011	240,711		
6 2005	4,560,000	4,687,200	9,247,200	9,419,335	9,419,335	9,419,335	172,135		
7 2006	4,560,000	5,077,800	9,637,800	10,108,254	10,108,254	10,108,254	470,454		
8 2007	4,560,000	5,663,700	10,223,700	10,847,563	10,847,563	10,847,563	623,863		
9 2008	4,560,000	6,249,600	10,809,600	11,640,942	11,640,942	11,640,942	831,342		
10 2009	4,560,000	7,030,800	11,590,800	12,492,349	12,492,349	12,492,349	901,549		
11 2010		7,812,000	7,812,000	13,406,028	13,406,028	13,406,028	5,594,028		
12 2011		7,812,000	7,812,000	13,406,028	13,406,028	13,406,028	5,594,028		
13 2012		7,812,000	7,812,000	13,406,028	13,406,028	13,406,028	5,594,028		
14 2013		7,812,000	7,812,000	13,406,028	13,406,028	13,406,028	5,594,028		
15 2014		7,812,000	7,812,000	13,406,028	13,406,028	13,406,028	5,594,028		
16 2015		7,812,000	7,812,000	13,406,028	13,406,028	13,406,028	5,594,028		
17 2016		7,812,000	7,812,000	13,406,028	13,406,028	13,406,028	5,594,028		
18 2017		7,812,000	7,812,000	13,406,028	13,406,028	13,406,028	5,594,028		
19 2018		7,812,000	7,812,000	13,406,028	13,406,028	13,406,028	5,594,028		
20 2019		7,812,000	7,812,000	13,406,028	13,406,028	13,406,028	5,594,028		
21 2020		7,812,000	7,812,000	13,406,028	13,406,028	13,406,028	5,594,028		
22 2021		7,812,000	7,812,000	13,406,028	13,406,028	13,406,028	5,594,028		
23 2022		7,812,000	7,812,000	13,406,028	13,406,028	13,406,028	5,594,028		
24 2023		7,812,000	7,812,000	13,406,028	13,406,028	13,406,028	5,594,028		
25 2024		7,812,000	7,812,000	13,406,028	13,406,028	13,406,028	5,594,028		
26 2025		7,812,000	7,812,000	13,406,028	13,406,028	13,406,028	5,594,028		
27 2026		7,812,000	7,812,000	13,406,028	13,406,028	13,406,028	5,594,028		
28 2027		7,812,000	7,812,000	13,406,028	13,406,028	13,406,028	5,594,028		
29 2028		7,812,000	7,812,000	13,406,028	13,406,028	13,406,028	5,594,028		
30 2029		7,812,000	7,812,000	13,406,028	13,406,028	13,406,028	5,594,028		
Total	50,156,000	192,761,100	242,917,100	339,915,694	0	339,915,694	96,998,594		

11.89%

Table A7.7.5 Project Cash Flow in Scenario 4 (Case 4)

Project Cash Flow		Cost			Revenue			Benefit - Cost
Year	Investment	Operation	Total	Transport Tariff	Total			
1 2000	4,558,000		4,558,000				-4,558,000	
2 2001	2,280,000		2,280,000				-2,280,000	
3 2002	2,280,000		2,280,000				-2,280,000	
4 2003	2,280,000	3,710,700	5,990,700	6,449,759	6,449,759	6,449,759	459,059	
5 2004	2,280,000	4,101,300	6,381,300	6,847,701	6,847,701	6,847,701	466,401	
6 2005	2,280,000	4,687,200	6,967,200	7,245,642	7,245,642	7,245,642	278,442	
7 2006	2,280,000	5,077,800	7,357,800	7,775,580	7,775,580	7,775,580	417,780	
8 2007	2,280,000	5,663,700	7,943,700	8,344,279	8,344,279	8,344,279	400,579	
9 2008	2,280,000	6,249,600	8,529,600	8,954,571	8,954,571	8,954,571	424,971	
10 2009	2,280,000	7,030,800	9,310,800	9,609,499	9,609,499	9,609,499	298,699	
11 2010		7,812,000	7,812,000	10,312,329	10,312,329	10,312,329	2,500,329	
12 2011		7,812,000	7,812,000	10,312,329	10,312,329	10,312,329	2,500,329	
13 2012		7,812,000	7,812,000	10,312,329	10,312,329	10,312,329	2,500,329	
14 2013		7,812,000	7,812,000	10,312,329	10,312,329	10,312,329	2,500,329	
15 2014		7,812,000	7,812,000	10,312,329	10,312,329	10,312,329	2,500,329	
16 2015		7,812,000	7,812,000	10,312,329	10,312,329	10,312,329	2,500,329	
17 2016		7,812,000	7,812,000	10,312,329	10,312,329	10,312,329	2,500,329	
18 2017		7,812,000	7,812,000	10,312,329	10,312,329	10,312,329	2,500,329	
19 2018		7,812,000	7,812,000	10,312,329	10,312,329	10,312,329	2,500,329	
20 2019		7,812,000	7,812,000	10,312,329	10,312,329	10,312,329	2,500,329	
21 2020		7,812,000	7,812,000	10,312,329	10,312,329	10,312,329	2,500,329	
22 2021		7,812,000	7,812,000	10,312,329	10,312,329	10,312,329	2,500,329	
23 2022		7,812,000	7,812,000	10,312,329	10,312,329	10,312,329	2,500,329	
24 2023		7,812,000	7,812,000	10,312,329	10,312,329	10,312,329	2,500,329	
25 2024		7,812,000	7,812,000	10,312,329	10,312,329	10,312,329	2,500,329	
26 2025		7,812,000	7,812,000	10,312,329	10,312,329	10,312,329	2,500,329	
27 2026		7,812,000	7,812,000	10,312,329	10,312,329	10,312,329	2,500,329	
28 2027		7,812,000	7,812,000	10,312,329	10,312,329	10,312,329	2,500,329	
29 2028		7,812,000	7,812,000	10,312,329	10,312,329	10,312,329	2,500,329	
30 2029		7,812,000	7,812,000	10,312,329	10,312,329	10,312,329	2,500,329	
Total	25,078,000	192,761,100	217,839,100	261,473,611	261,473,611	0	43,634,511	

11.78%

**Table A7.8.1 Transport Revenue in 2003**

Zone	Unit Tariff (US\$)	Traffic Volume (t)	Distance (km)	Revenue (US\$)
<b>Down Ward</b>				
St. Floriano ~ Floriano	0.0272	33,500	585	533,052
R.Goncalves ~ Floriano	0.0272	57,220	310	482,479
R.Goncalves ~ Teresina	0.0272	104,050	555	1,570,739
Urucui ~ Floriano	0.0272	12,380	210	70,715
Urucui ~ Teresina	0.0272	159,270	455	1,971,126
Guadalupe ~ Floriano	0.0272	16,800	70	31,987
Guadalupe ~ Teresina	0.0272	43,200	315	370,138
Floriano ~ Teresina	0.0272	900	245	5,998
Amarante ~ Teresina	0.0272	16,800	170	77,683
Palmeiras ~ Teresina	0.0272	18,000	120	58,752
Sub total				5,172,668
<b>Up Ward</b>				
Floriano ~ St. Filomena	0.0272	5,790	585	92,130
Floriano ~ R. Goncalves	0.0272	36,120	310	304,564
Floriano ~ Urucui	0.0272	27,560	210	157,423
Floriano ~ Guadalupe	0.0272	7,640	70	14,547
Amarante ~ Floriano	0.0272	10,240	75	20,890
Palmeiras ~ Floriano	0.0272	2,440	125	8,296
Teresina ~ St. Filomena	0.0272	890	830	20,093
Teresina ~ R.Goncalves	0.0272	1,720	555	25,965
Teresina ~ Urucui	0.0272	30,820	455	381,428
Teresina ~ Guadalupe	0.0272	16,760	315	143,600
Teresina ~ Floriano	0.0272	16,230	245	108,157
Sub total				1,277,092
Total				6,449,759

**Table A7.8.2 Transport Revenue in 2005**

Zone	Unit Tariff (US\$)	Traffic Volume ( t )	Distance (km)	Revenue (US\$)
<b>Down Ward</b>				
St. Floriano ~ Floriano	0.0272	40,420	585	643,163
R.Goncalves ~ Floriano	0.0272	67,700	310	570,846
R.Goncalves ~ Teresina	0.0272	81,300	555	1,227,305
Urucui ~ Floriano	0.0272	15,170	210	86,651
Urucui ~ Teresina	0.0272	202,580	455	2,507,130
Guadalupe ~ Floriano	0.0272	20,630	70	39,280
Guadalupe ~ Teresina	0.0272	53,000	315	454,104
Floriano ~ Teresina	0.0272	1,100	245	7,330
Amarante ~ Teresina	0.0272	22,550	170	104,271
Palmeiras ~ Teresina	0.0272	22,700	120	74,093
Sub total				5,714,173
<b>Up Ward</b>				
Floriano ~ St. Filomena	0.0272	10,050	585	159,916
Floriano ~ R. Goncalves	0.0272	40,600	310	342,339
Floriano ~ Urucui	0.0272	31,000	210	177,072
Floriano ~ Guadalupe	0.0272	8,000	70	15,232
Amarante ~ Floriano	0.0272	12,400	75	25,296
Palmeiras ~ Floriano	0.0272	3,000	125	10,200
Teresina ~ St. Filomena	0.0272	950	830	21,447
Teresina ~ R.Goncalves	0.0272	1,800	555	27,173
Teresina ~ Urucui	0.0272	36,400	455	450,486
Teresina ~ Guadalupe	0.0272	20,000	315	171,360
Teresina ~ Floriano	0.0272	19,650	245	130,948
Sub total				1,531,469
<b>Total</b>				<b>7,245,642</b>

**Table A7.8.3 Transport Revenue in 2010**

Zone	Unit Tariff (US\$)	Traffic Volume ( t )	Distance (km)	Revenue (US\$)
<b>Down Ward</b>				
St. Floriano ~ Floriano	0.0272	72,500	585	1,153,620
R.Goncalves ~ Floriano	0.0272	257,000	310	2,167,024
R.Goncalves ~ Teresina	0.0272	101,700	555	1,535,263
Urucui ~ Floriano	0.0272	36,450	210	208,202
Urucui ~ Teresina	0.0272	222,850	455	2,757,992
Guadalupe ~ Floriano	0.0272	24,950	70	47,505
Guadalupe ~ Teresina	0.0272	22,050	315	188,924
Floriano ~ Teresina	0.0272	1,600	245	10,662
Amarante ~ Teresina	0.0272	15,000	170	69,360
Palmeiras ~ Teresina	0.0272	15,000	120	48,960
St.Filomena ~ Urucui	0.0272	450	375	4,590
R.Goncalves ~ Urucui	0.0272	4,300	100	11,696
Sub total				8,203,799
<b>Up Ward</b>				
Floriano ~ St. Filomena	0.0272	11,600	585	184,579
Floriano ~ R. Goncalves	0.0272	54,000	310	455,328
Floriano ~ Urucui	0.0272	42,100	210	240,475
Floriano ~ Guadalupe	0.0272	9,000	70	17,136
Amarante ~ Floriano	0.0272	22,500	75	45,900
Palmeiras ~ Floriano	0.0272	5,000	125	17,000
Teresina ~ St. Filomena	0.0272	1,100	830	24,834
Teresina ~ R.Goncalves	0.0272	2,000	555	30,192
Teresina ~ Urucui	0.0272	49,800	455	616,325
Teresina ~ Guadalupe	0.0272	29,200	315	250,186
Teresina ~ Floriano	0.0272	34,000	245	226,576
Sub total				2,108,530
Total				10,312,329



**Table A7.9.1 Financial Project and O&M Costs in Scenario 4 (total)**

Unit : US\$ Allocations of the Project Cost

Project	Unit	Unit Cost	Qty	Cost	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
<b>A. Construction and Procurement Cost</b>															
1 Lock Rehabilitation			1	15,480,000	4,644,000	4,644,000	6,192,000								
2 Port Construction	LS		1	46,200,000		21,450,000	24,750,000								
3 Vessel Procurement	Vessel	1,140,000	40	45,600,000	4,560,000	4,560,000	4,560,000	4,560,000	4,560,000	4,560,000	4,560,000	4,560,000	4,560,000	4,560,000	4,560,000
4 Navigation Aids	LS	1	1	360,000			360,000								
sub-total				107,640,000	9,204,000	30,654,000	35,862,000	4,560,000	4,560,000	4,560,000	4,560,000	4,560,000	4,560,000	4,560,000	4,560,000
B. Engineering Fee	%		10%	10,760,000	10,760,000										
C. Physical Contingency	%		5%	5,400,000	1,620,000	1,620,000	2,160,000								
Total				123,800,000	21,584,000	32,274,000	38,022,000	4,560,000	4,560,000	4,560,000	4,560,000	4,560,000	4,560,000	4,560,000	4,560,000
<b>Operation Cost</b>															
1 Ship Operation Cost	資本費込							5,551,800	6,136,200	7,012,800	7,597,200	8,473,800	9,350,400	10,519,200	11,688,000
	資本費除							3,710,700	4,101,300	4,687,200	5,077,800	5,663,700	6,249,600	7,030,800	7,812,000
2 Ship Operation Office								1,589,200	1,589,200	1,589,200	1,589,200	1,589,200	1,589,200	1,589,200	1,589,200
3 Port Operatio Office								2,458,000	2,458,000	2,458,000	2,458,000	2,458,000	2,458,000	2,458,000	2,458,000
4 River Management Office								1,682,400	1,682,400	1,682,400	1,682,400	1,682,400	1,682,400	1,682,400	1,682,400
Total	資本費込							11,281,400	11,865,800	12,742,400	13,326,800	14,203,400	15,080,000	16,248,800	17,417,600
	資本費除							9,440,300	9,830,900	10,416,800	10,807,400	11,393,300	11,979,200	12,760,400	13,541,600



**Appendix 8 :  
Necessity of Luiz Correia Port**



**A.8 Necessity of Luiz Correia Port**

There is no sea port facing the ocean in Piauí Province at present. A construction of port at Luiz Correia in the mouth of the Igaracu River was planned and its construction works commenced in the past. However, its construction works has suspended in 1989 due to a stagnation of Brazilian economy and its fiscal problems as prescribed in the previous chapter.

From the standing point of the Provincial Government of Piauí, it is quite understandable the contention of restarting the construction of Luiz Correia Port in view of economic development for the future, however, it would require a sufficient study with regard to effective utilization of both national and provincial budget and analyses on co-relation among existing ports located near-by from the view point of capital opportunity cost on national level to determine appropriate timing to restart its construction works.

Under such circumstances, in this sub-chapter, an examination on the necessity of Luiz Correia Port within the target year (year 2010) of study period from the above mentioned view point of capital opportunity cost in accordance with forecasting and analyses of transport/transfer cargo volume in Piauí Province on macro level at the present and the future time frame.

**A8.1 Present Situation of Transport and Transfer Cargo in Piauí Province**

1. The study results derived from the report of "Cargo transportation in the State of Piauí" is reviewed and compiled. The result of such analyses on items of cargo and their relevant cargo transport volume through the ports between Piauí Province and the over as well as other provinces in the country is shown in below table.

**(1) Transport/Transfer Out-bound Cargo**

Leather	3,000 t	via Fortaleza
Carnauba Wax	800 t	via Fortaleza
Iron Sorap	2,400 t	via Fortaleza
Ceramic	3,260 t	via Sao Luiz
Total	9,460 t	

**(2) Transport/Transfer in-bound Cargo**

Petroleum Products	180,000 t	via Fortaleza
Fuel Oil	23,000 t	via Fortaleza
Wheat Flour	90,000 t	via Fortaleza and Itaquí
LPG	53,000 t	
Fertilizer	115,000 t	via Fortaleza and Itaquí
Cement	40,000 t	via Fortaleza
General Cargo	10,000 t	via Fortaleza
Total	551,000 t	

2. The items of cargoes and their respective volumes which transferred, in and out bound between other provinces in the country by road transport is estimated as follow:

(1) Out-bound Cargo

Rice	44,000 t
Nuts	22,000 t
Carnauba Wax and Powder	7,500 t
Ceramics	195,000 t
Clothing	3,800 t
Vegetable Oil	79,000 t
Babasu, Charcoal & Oil	16,000 t
Vermiculite	59,000 t
Total	534,800 t

(2) In-bound Cargo

Petroleum Products	190,000 t
Sugar	86,000 t
Cement	34,000 t
Salt	22,000 t
Limestone	413,000 t
Cotton	5,400 t
Malt	24,000 t
General Cargo	600,000 t
Total	1,374,400 t

3. The items and their respective volume of cargoes which will be transferred from the volume of cargo transported between other provinces by road transport to the volume of cargo handled at port assuming that Luiz Correia Port is in operation taking account of origin-destination for their in and out bounds and respective characters relevant to each cargo items.

(1) Out-bound Cargo

Nuts	22,000 t
Carnauba Wax and Powder	7,500 t
Babassu, Charcoal & Oil	10,000 t
Total	39,500 t

(2) In-bound Cargo

Petroleum Products	80,000 t
Cement	20,000 t
Total	100,000 t

4. A collective handling cargo volume of the Luiz Correia Port on macro level based on the assumption that this port exists and the condition of access among other regions in the province are operative is as follow under the prescribe hypothesis.

Transport/Transfer Out-bound Cargo Volume	49,000 t
Transport/Transfer In-bound Cargo Volume	611,000 t
Total	660,000 t

#### **A8.2 Transport/Transfer, in and Out-bound Cargo Volume handled at the Ports in Piauí Province in the future (Year 2010).**

##### **1. Macro Forecasting Method**

Following Increasing rates by cargo items were adopted to conduct cargo handling volume forecast up to year 2010 on macro basis assuming that the Luiz Correia Port is in operative.

- (1) The volume of cargo of which items can be categorized as a daily consumer goods is assumed to grow in parallel with the average annual population growth ratio for the period 1980 - 1990 in Piauí Province (2.14%), therefore, it will grow 1.43 times:

$$(1 + 0.0214)^{17} = 1.43$$

- (2) The volume of cargo of which items can be categorized as an agricultural products is assume to grow double in consideration of growing productivity per cultivating area and expansion of clopping area.

- (3) The volume of cargo of which items can be categorized as an industrial products is assumed to grow gradually in consideration of recent statistics showing the growth of GDP in Brazil as appeared in the below Table A8.2.1, therefore, it will grow 1.29 times.

$$(1 + 0.015)^{17} = 1.29$$

- (4) The volume of other cargo of which items can be categorized as general cargo is assumed to grow at the rate of 3% per annum and therefore it will grow 1.65 times.

$$(1 + 0.03)^{17} = 1.65$$

**Table A8.2.1 Gross Domestic Products and Resident Population - 1986-90**

Years	Gross Domestic Products				Resident Population (1,000 psns)
	Current Prices		Real Products Index		
	Total value (Cr\$mill)	Per capita value (Cr\$1.00)	Total value	Per capita	
1986	3,326	26,440	113.8	99.4	138,493
1987	11,537	81,558	117.7	110.9	141,452
1988	86,197	596,820	117.8	98.7	144,428
1989	1,266,348	8,591,004	121.4	99.9	147,404
1990	32,353,477	215,161,981	116.5	94.0	150,368

Source: IBGE.

**2. Transport/Transfer Out-bound Port Handling Cargo Demand Volume  
(at Year 2010)**

The port handling cargo demand volume at year 2010 in accordance with previous method of forecasting is estimated as follow:

Transport/Transfer Out-bound Cargo Demand Volume:	85,800 t
Transport/Transfer In-bound Cargo Demand Volume:	914,000 t
<b>Total</b>	<b>999,800 t = 1 million</b>

The production volume of soybeans in Piauí Province in year 2010 is estimated to be 470,000 tons and major part of its will be exported, however, 130,000 ton will be transported by land to the Itaquí Port by Caralás Railway via Imperatriz for export: and remaining 340,000 tons will be transported by water to the Itaquí Port via Teresina either by rail or road for export.

The handling capacity of the Luiz Correia Port for soybean is to be designed from 800,000 tons to 1 million tons by one port in consideration of character associated with soybean export: and transport system connecting with the port is to be completely provided so as to transport designated goods smoothly.

The loading facility necessary for loading of soybean for export has already been existing at the Itaquí Port. In consideration of maximum navigable volume by water transport from Teresina to the Luiz Correia River and present situation of rail and road transport system between Teresina and Luiz Correia which have not been completed, it is suggested that soybean export operation should depend on the Itaquí on the Itaquí Port until year 2010, thus, its volume was disregarded for the estimation of total transport/transfer our-bound cargo volume in year 2010 at the Luiz Correia Port discussed in the above paragraph.



### **A8.3 Necessity of the Luiz Correia Port and Recommendation on the Timing of Construction of the Port**

1. Following table show the result of study on relevancy between the future estimated volume of transport/transfer, in and out bound cargo volume in Piauí Province: and present cargo handling volume at the neighbor ports (Fortaleza and Itaqui Ports).

(1) Future estimated transport/transfer, in-out bound cargo volume in year 2010 in Piauí Province (Prescribed)

Transport/Transfer, out-bound Cargo Volume:	85,800 t
Transport/Transfer, in-bound Cargo Volume:	914,000 t
Total	999,800 t

(2) Present cargo handling volume at the Fortaleza Port in 1992

Transport/Transfer, out-bound Cargo Volume:	244,305 t
Transport/Transfer, in-bound Cargo Volume:	1,944,478 t
Total	2,188,783 t

The cargo handling capacity of the Fortaleza Port is expected to increase sharply in the future, because even at present, this port has a sufficient surplus cargo handling capacity due to enough length of berth, warehouse capacity and a number of appurtenant facilities such as flour mill, liquid pipe lines etc. exist: and a plan to construct a container berth is underway.

(3) Present cargo handling volume at the Sao Luiz Port (Itaqui Port, P/Madeira Port, Alma Port) in 1993

Transport/Transfer, out-bound Cargo Volume:	35,731,535 t
Transport/Transfer, in-bound Cargo Volume:	3,957,280 t
Total	39,688,815 t

The Sao Luiz Bay has a natural condition capable of entering vis-a vis going-out large size vessels and the Sao Luiz Port was constructed to be the biggest trade port in the northern part of Brazil. Iron ore from Caralás Mine which is export cargo is handled at the P. Madeira Port and the other cargo for export and import are handled at the Itaqui Port and the Almar Port. A new berth (500m length x 20m width) capable to berth 150,000 DWT large size ocean going vessel is under construction at the Almer Port. And the connection between this port and P. Madeira Port by belt conveyor is also going on. Such investment envisage and increased cargo handling volume of other than iron ore in the future. In addition to these facilities a special facilities for soybean export has been under preparation at present.

In consideration of relevancy between the transport/transfer. In and out-bound cargo volume from the sea in Piauí Province in year 2010 described in the above chapter and the present and future cargo handling capability at neighboring ports such as the Fortaleza and Sao Luiz Ports discussed in sub-chapter (2) and (3), it can be judged that transport/transfer, in and out-bound cargo to and from Piauí Province can be handled

sufficiently by both Fortaleza and Sao Luiz (Itaqui) Ports until the year 2010 which is the target year of this study without touching present transport system. This fact expresses that as the Fortaleza and Sao Luiz Ports have a sufficient cargo handling capability, the execution of the construction of the Luiz Correia Port as schedule would mean uneconomic matter from the capital utilization view point at national economic level.

## **2. Premises for Development of the Luis Correia Port**

The transport system in Piauí Province is as discussed before that the east - west direction centering Teresina is dense by road and railways system, however, the south - north direction has not effective transport system yet.

With regard to the water transport system along the Parnaíba River as a transport system consisting the south - north direction which is one of the objectives of this study, it became clear that especially the down-stream area from Teresina has a certain limitation of annual transport capability and its seasonal fluctuation is quite large as analyzed in the previous chapter seven.

Under such consideration, the provision of the south - north land transport line consisting with road and railways should be an avoidable premises to effectively utilize the performance of Luiz Correia Port planned to be constructed in the future.

In addition to this, the construction of relating facilities at surrounding area of the port such as flour mill, warehouse, pipe line, storage, etc. is thought to be a premises for the construction of the port.

It is to be noted that a considerable amount of initial capital investment is needed to satisfy with the above mentioned premises to provide a ground for the construction of the ports designated and to carry out the construction works of the ports themselves.

## **3. Necessity of the Luiz Correia Port and Recommended Development Timing**

It can be judged that the necessity for development of the Luiz Correia Port would be strongly recognized in the future as this port is required to accelerate economic development of Piauí Province and rectify a regional economic differential in the east-northern part of Brazil as analyzed above. However, as it is difficult to verify appropriateness of development timing of the project by year 2010 which is the target year of this study, it can be judged that the time of development of the subject port will be beyond year 2010 as an opportunity cost from national economic point of view.

In summing up, it is recommended to attach the best priority on the development of transport system, mainly road system, within the province until year 2010. Future more, it is recommended to commence the development of the Luiz Correia Port from any year during the period of year 2010 - 2020, as during this period the industrial development of the province will reach the stage of which total volume of transport/transfer, out-bound cargo volume including soybean exceeds 800,000 ton/year. (Note: The total volume of the same in the year 2010 is estimated to be around 450,000 ton/year)

**Appendix 9  
Environmental Study  
Report**



**JAPAN INTERNATIONAL COOPERATION AGENCY  
(JICA)**

**PACIFIC CONSULTANTS INTERNATIONAL**

***THE FEASIBILITY STUDY ON THE NAVIGATION OF THE  
PARNAÍBA RIVER BASIN***

**PARNAÍBA RIVER BASIN ENVIRONMENTAL STUDIES**

**FINAL REPORT**

---

November, 1993

## THE TEAM:

- Mr. Sylvio Lopes da Rosa  
*Civil Engineer, Project Manager and Technical Coordinator.*
- Mr. Ivo Sadao Massunari  
*Civil Engineer*
- Mr. Raul de Carvalho  
*Economist*
- Mr. Luiz Dino Vizotto, Ph.D.  
*Biologist, Zoologist (UNESP), responsible for fauna studies*
- Mr. Waldir Mantovani, Ph.D.  
*Agronomist, Ecologist, Botanicist (USP), responsible for flora studies.*
- Mrs. Luciana Fonseca Cersósimo, M.Sc.  
*Biologist (USP), support in flora studies*
- Mrs. Takako Sakamoto, R.S.A. (Cambridge University)  
*Support in translations and final revision*
- Mr. Alcides Takakura  
*Technician*
- Mr. Moacir José Gonçalves  
*Draftsman*
- Mrs. Valéria Cristina Cutrim  
*Typist*

---

USP: São Paulo University

UNESP: Estado de São Paulo University

**OCTA**  
**Consultoria e Planejamento S/C Ltda**  
Rua Humberto I, nº 598, cj. 8º  
Vila Maria  
04018-031 São Paulo, SP  
BRAS  
☎ (011) 572-13  
☎ (011) 570-64

# PARNAÍBA RIVER BASIN ENVIRONMENTAL STUDIES

## FINAL REPORT

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## 1. INTRODUCTION

OCTA Consultoria e Planejamento, as a contractor of PACIFIC CONSULTANTS INTERNATIONAL (PCI), was in charge of developing brief environmental studies, as stated in the scope of work of the "Terms of Reference for Environmental Impact Survey on the Navigation of the Parnaíba River Basin".

Contract signature happened on September 22nd, 1993 in São Paulo, SP, Brazil in a meeting between Japan International Cooperation Agency (JICA) Study Team leader, Mr. Makoto TANAKA, representative of PCI, and Mr. Sylvio Lopes da Rosa, representative of OCTA. In this event, OCTA submitted a report on the method and sequence of works to be performed under this contract, whose scope of work included:

1. Data collection and bibliographic research.
2. Study on existing reports.
3. Field trip for inspection, exploring and reconnaissance survey.
4. Analysis and evaluations.

As stated in that paper, the works should be reported in a document showing survey results, containing at least the following items:

- a. Method of analysis;
- b. Field trip survey results, together with predictions of the possible problems on the fauna, flora, fisheries and wildlife that may arise from the development of the navigation and construction of river training works and, as well as with an assessment of the benefits due to the plans;
- c. Evaluations of the present and predictable environmental problems of the region and its consequences on the river channel (sedimentation aspects) and evaluation of impacts due to the navigational plan;
- d. Recommendations of the countermeasures;
- e. List of data and information.

Studies were conducted in accordance to scope and plan of work. Data collection and bibliographical researches were performed in advance, because of evaluations previously done which showed difficulties that could arise due to distances involved and time consuming field trips in a region well known by OCTA for its social problems, lack of infra-structure and information systems.

The studies performed made important conclusions available, as for the environmental problems that were foreseen during work planning for the study, but were not well understood. There are good chances now for a better knowledge of the intrinsic problems that will certainly arise from the decisions of developing the navigation on the Parnaíba Basin. But for the purposes of the study, information and data obtained were enough to permit a correct impact analysis and evaluation, in which important conclusions and recommendations were produced in view of immediate actions.

It is important to note that the work shows that Parnaíba River Basin should claim for attention to various and serious problems that can arise from any environmental analysis of the region, which ought to be foreseen in association to the big social and economic problems due mainly to the characteristic lack of infrastructure, intense annual droughts and sub development.



Chapter 2 is a brief summary of the studies, with the main conclusions and the most significant recommendations. It is intended for those who want to have only a brief approach of the Parnaíba River Basin environmental main aspects. It contains an overview of the basin, discussions on important environmental problems, considerations on impact survey, and a resume of the conclusions and recommendations.

Chapter 3 presents the methodological approach used along the studies and discuss methods of data collection, bibliographical researches, data analysis, field trip and office work. It presents comments on specific methodological aspects concerning fauna and flora and on socioeconomic chief problems that were foreseen in the initial discussions. Methods for impact assessment and evaluation are pointed out in order to demonstrate that they were the most suitable in face of available time for the study and the deadline previously established under contract conditions.

Peculiarities of the region of study begin to appear in Chapter 4, in which detailed descriptions of field trip are presented together with comments on relevant aspects. It is worth mentioning that for fauna aspects the field trip represented a continuation of researches, since local University (Teresina) researchers counted with support of one of the OCTA's experts in works done in the past for specific purposes.

It may be noticed that the team adopted methods of work, which were fit to available time and to the characteristic lack of systematic information about the region. Then, results obtained during field researches and contacts made on Teresina are adequate to the purposes of the study.

Chapter 5 presents a brief diagnosis of Parnaíba River Basin environmental and socioeconomic main characteristics, which were pointed out in order to allow a better understanding of the main problems that will arise from the regional present situation of poverty and lack of development. The discussions are illustrated with tables, photos and maps that come along with the Report as its Annex.

Chapter 6 contains discussions on the environmental problems that can be associated to present conditions of land usage and general deforestation practises. They are based on field researches and in discussions held among the whole team in OCTA's office. This chapter may be considered as a brief introduction to the impact evaluation, which is discussed in details in Chapters 7 and 8.

Chapter 9 contains the proposals of countermeasures and recommendations of actions that must be followed by the proponents of the Navigation Plan, together with recommendations that should be followed by State authorities in order to keep environment under adequate control.

This is important to mention, since study shows that the Parnaíba River Basin presently has serious problems correlated to land usage and agricultural practises beyond those that arise from underdevelopment and lack of education. Besides, there are indications about the legal aspects that must be observed in further actions on the Navigation Plan. For this purpose, a summary of the Brazilian legislation concerning environment is presented in Chapter 10.

This Final Report is complemented by an Annex containing a detailed list of data available and existing reports and studies, with indications of their availability, followed by tables, general information, photos and maps.

## 2. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

### 2.1. An overview of the Parnaíba River Basin

The geographic situation of the Parnaíba Basin turns it into a frontier between two regions that have significant climatic differences. The main stream source lies in the highland "Chapada das Mangabeiras" south of Piauí, at 800 m above mean sea level and flows into the northeast until it reaches the city of Floriano then runs into the north to the Atlantic Ocean.

The main tributaries from the left side are permanent rivers as the Balsas river is a good example. From the right most of the tributaries are non permanent rivers, due to poor and low water tables and semi-arid climate.

Four stretches from upstream to downstream may divide the waterway, as was stated by a 1980 SUDENE (a governmental development agency) study:

- From Santa Filomena to upper extremity of Boa Esperança Reservoir (355 km);
- Boa Esperança Reservoir (155 km);
- Boa Esperança Dam to city of Floriano (76 km);
- Floriano to the mouth in the Atlantic Ocean (596 km)

The Balsas River is a tributary of the Boa Esperança Reservoir and has 225 km navigable length, with a 24,700 km<sup>2</sup> catchment area.

The Parnaíba Delta represents a vast and complex flatland area which in turn benefits the navigation due to its rich quantity of canals, streams and sea level amplitudes of variation. In this region lies the city of Parnaíba harbor facilities (State of Piauí), which make it the most important city in the region.

Nowadays, due to road maintenance troubles in the Maranhão side of the River, the production from the fisheries of the city of Tutóia is traded in Parnaíba. That means tax and income losses to the State of Maranhão. This last statement introduces to the grave and serious problems of the whole region of the Parnaíba River Basin due to absence of adequate road network, climatic droughts to the South and alarming indexes of poverty of most of the population, which in turn has high rates of growth and infant mortality.

The Basin environmental characteristics are mostly typical of Northeastern Brazil, with severe droughts to the south, inadequate land usage due to lack of modern agricultural technology and very low income rates most of the population.

As proposed in the SUDENE study, construction of various dams in the main river and in the Balsas River would increase the potentialities for navigation in the Basin in a whole year basis.

This in turn would introduce tremendous changes in the aquatic environment and induce new technologies and forms of appropriation of the economic resources of the whole region, thus introducing important modifications in the economy, new forms of land usage and reclamation and new agricultural techniques. All this will bring great social and economic benefits to a vast population, together with important changes in the relations among men and the natural environment and will probably induce new social problems.

But, this is not the case, in order that the Navigation Development Plan envisaged by JICA is a much simpler one and fit to the present reality and socioeconomic conditions of the country. Thus, the aquatic environment will not suffer any relevant changes due to navigation activities or to river works. However, socioeconomic development will occur due to navigation, which in turn will induce the above mentioned modifications and problems, then requiring attention to future environmental problems.

## 2.2. Important environmental problems

Since the second half of last century, Parnaíba River Basin has suffered aggressions in its various ecosystems, resulting, as a consequence, in hazards sometimes irremediable to the flora and fauna, erosion process acceleration and consequent siltation of the rivers in general and the total debris obstruction in some specific areas.

Besides, there are water pollution problems which although they do not achieve alarming proportions as in other Brazilian regions, they are of such a magnitude that require urgent measures, as in the cities of Teresina, Floriano and Parnaíba.

This means that apart from the present Brazilian legislation requirements, as regards the discipline towards the use of water and environmental resources, there should be an awareness that for big scale projects, which directly or indirectly interfere in the environment and mobilize significant portion of human, technical and financial resources, operations should not be limited to a specific purpose.

On the contrary, these projects should be analyzed in different ways, in order that decisions can be made aiming at better using the resources to be mobilized, and promoting socioeconomic development without the serious risks of deteriorating the natural resources.

This study pointed out several problems correlated to bad land and soil usage and agricultural and livestock practises, which can impose future problems to the region, even if they are not directly linked to the navigation development, but could be worsened as a consequence of a disorganized development, as it is later discussed in this report.

In view of the Navigation Development Plan for the Parnaíba River Basin, the impact survey clearly showed that the impacts and problems that will arise directly from the waterway implementation and eventually its operation, will be — *in general* — temporary, of small magnitude and spatial very small coverage, mainly those ones resulting from specific construction actions.

From the discussions and analyses for this study, a generic scenario can be outlined for the Parnaíba River Basin, as stated below:

- The biggest effects of the waterway operation, specially those that will result from the probable intensification of economic exploitation of extensive areas along the main riverbanks, will be of great magnitude and coverage, basically due to extremely out of date socioeconomic, political and cultural patterns still predominant in all the region.
- The navigation development will be able to extend the human occupation along the marginal areas of Parnaíba and Balsas Rivers valleys, as well as in the plateaus of Southwest Piauí and Southeast Maranhão, with acceleration and

amplification of deforestation processes and consequent deterioration and environmental weakening of marginal areas along river valleys, borders and steep areas.

- Construction of new roads for production flow may affect hydraulic conditions of minor drainage systems due to obstructions, landslides along river banks, etc., with increasing erosion processes, which will be intensified by burning practises, thus affecting greater areas than today's. As a consequence, obstruction of river beds will be intensified, thus bringing problems for the future waterway traffic.

### 2.3. Impact description and general considerations

The most relevant environmental impacts pointed out in the discussions are described and commented in detail in Chapter 7 of this report. Impact survey was conducted under the "matrix-step" method, usually adopted by OCTA in environmental studies, in which direct cause-effect relationships are analyzed.

From the matrix examination, it may be observed that most impacts will affect surface water quality, but in general with temporary effects, which will last as long as the causing actions last. However, other environmental factors are also important, as the matrix shows, which are likely to be changed and cannot be disregarded.

On the other hand, the study also points out the presence of significant impacts over socioeconomic factors. This shows that the navigation plan could originate important changes of the region in general, not only affecting the natural resources. Moreover, the study also shows that the future consequences of the Navigation Development Plan will be closely related to the type of occupation and economic activities that may be developed in the region, which in turn could be conditioned in higher or lower degree by development of navigation.

The present practises of intensive agriculture become highly questionable, considering that:

- a. The bad use of soils ends up with their infiltration capacity, making them prone to intensive erosive process;
- b. An increase of water pollution is observed, due to excessive use of pesticides and fertilizers;
- c. The incorrect use of irrigation in the plateaus together with swamp drainage, associated to the destruction of riparian forests can, in a long run, jeopardize the regional water balance;
- d. The uncontrolled deforestation, linked to the excessive use of pesticides and monoculture implantation provokes ecological unbalances, with consequent increase of plague incidence;
- e. Land use along river banks for agriculture, specially in areas with quartzous sands, together with the increasing occurrence of ravines, has turned these areas inappropriate for productive use;
- f. The intensification of burning frequency, mainly at the end of drought periods, leads to loss of soil protection, which is highly susceptible to erosion, thus diminishing its potential for production.



Consequently, it is important to consider that new management practises in the savanna areas should be established, but, prior to this, it is necessary to know in details the peculiarities of the environment so that it can be provided to the society, without destroying its natural inheritance.

## 2.4. Conclusions and recommendations

Thus, the analysis of environmental impact, in the present stage of knowledge and information about the waterway shows that certain precautions are necessary as regards a region *with a high degree of environmental fragility*.

Also, the development actions which will bring new inhabitants and new economic activities to Piauí, could be responsible to worsen the present conditions of environmental deterioration, which may jeopardize the integrity of the waterway itself.

However, these considerations bear in mind a longer period than a more immediate planning view, being only a warning for the future. The study does not reveal more serious problems other than the ones that can be predicted in the light of current socio-environmental conditions of Piauí today.

For the detected problems in the impact analysis, discussions are presented in two levels. Chapter 7 presents the impact survey in a more direct level, that is to say, those that may occur immediately from construction actions. Chapter 8 analyses problems that may arise from future developments. For both levels there are solutions and recommendations, summed up in Chapter 9 of this report.

Studies show that there are not animal or vegetal endangered species that *could* be affected by the necessary actions for implementation of the plan. Thus, one can conclude that the plan will not jeopardize the natural environment. However, the proponent must be acquainted of the fact that, at least for the regional vegetation, it is not secure to make any conclusions about rare or endangered species due to the small amount of available studies and information.

As for legal aspects, attention must be given to Brazilian laws concerning environment (see Chapter 10 for details), in order that any project or action that may affect the environment must be submitted to the appreciation of State authorities as for licensing purposes, as well as to some other institutions in specific cases, such as wood procurement, hunting, fishing, etc.

In the view of the characteristics of the Navigation Development Plan and the actions that are actually to be taken at this stage of planning, licensing for wood procurement or cutting for the spur dikes is necessary, and IBAMA should be contacted by the contractors and sponsors of the project. For further actions including those that may alter river beds or banks, such as road construction, dredging, port construction, borrowing areas, etc., attention should be paid to determinations of CONAMA's resolution n° 01/86 and so, contacts with environment management official institutions of both Maranhão and Piauí States should be made.

### 3. METHODOLOGICAL APPROACH

#### 3.1. General Considerations

The methodological approach can be summarized as follows, with description of the sequence of works done, in a series of previously planned activities, part of which was presented by OCTA to PCI in contract signature:

- Data collection and bibliographic research
- Preliminary data analysis and workshop
- Field trip
- Office works and seminars
- Specific methodological aspects
  - Fauna and fisheries
  - Flora
  - Socioeconomic studies
  - Impact assessment

The general methodological approach adopted in the study can be summarized in the flowchart presented at the end of this chapter, in which a much more complex scheme of studies is shown to demonstrate the complexities of the environmental problems that must be analyzed in the future if the navigational development plan becomes a reality. Line boundaries in the chart show the scope of work performed by OCTA under contract with PCI.

#### 3.2. Data collection and bibliographic research

Researches were done in order to obtain general information about the environmental main characteristics of the Parnaíba River Basin, including socioeconomic, physical and biological aspects, data on flora, fauna and fisheries, project and planning for the region including the whole territory of Piauí State and part of the Maranhão State.

For this, contacts were made prior to contract signature in order to obtain useful information from or in São Paulo. The following institutions were visited or contacted by phone calls during the period of 15 and 22 of September:

- AIINOR\*<sup>1</sup>, São Luís, MA;
- Fundação IBGE São Paulo main branch and library;
- FUFPI, Departamento de Biologia, Teresina, PI;
- IBILCE, Departamento de Zoologia, UNESP, São José do Rio Preto, SP;
- Instituto Botânico da SMA, São Paulo, SP;
- Instituto de Geografia e História da USP, São Paulo, SP;
- Instituto de Ecologia da USP, São Paulo, SP;
- Instituto de Pesquisas Tecnológicas da USP São Paulo, SP;
- Secretaria de Agricultura do Estado do Maranhão\*, São Luís, MA;
- SINFRA\*, São Luís, MA;
- SUDENE\*, Recife, PE;

\* Only by phone calls

<sup>1</sup> See Annex.

It is important to note that previously knowledge of the Parnaíba River Basin was available to the whole team in a general basis, since OCTA has recently developed field researches in the State of Maranhão for a damming program. On the other hand, the specialists in flora and fauna have experiences in researches in Piauí since 10 years ago, when they gave support to the students of local university, as it is commented elsewhere in this chapter.

### **3.3. Preliminary data analysis and workshop**

According to time schedule presented to PCI in the Report nº 1, secondary data were collected in the institutions above mentioned during the first week of job, although bibliographic research was done in anticipation of contract signature, as OCTA was concerned with the great amount of information that should be examined. Data obtained at this first stage of researches were presented to PCI in the Report nº 1, as its annex nº 1. Material (data and bibliography) collected is listed in the Annex A of this Final Report.

Analysis of information was made during the first job week on existing reports, technical and scientific papers, magazines and books listed in Annex A. At the same time, work plan presented in Report nº 1 was discussed with the team in a workshop held at OCTA office on September 23.

In this event, field trip program and strategies were reviewed and decisions were made on the most relevant aspects that should be researched. Thus, original plan of researching the environmental main aspects of upper Parnaíba Basin was reinforced, since the bibliographical research showed that the peculiarities of this region represent important tips to the comprehension of the physical processes that may affect the main stream in correlation with siltation and sedimentation processes.

The workshop pointed out that a team of 4 should go to Piauí for field trip and data collection at local institutions and a group of 3 technicians should remain in São Paulo for data analysis termination and study on existing reports and other contacts with institutions.

### **3.4. Field trip**

Field trip was planned in advance, because it was known that no sufficient data could be obtained in or from São Paulo. The strategy of work included flights and land incursions to the north and south portions of the Parnaíba Basin, mainly to the upper stretches of the Parnaíba River and the Gurguéia valley. Because of knowledge on the characteristics of the latter, efforts should be concentrated on the south.

Due to requirements of the impact survey, work would be done in a simple reconnaissance level and the team concluded that only flight observations on vegetation, land usage and socioeconomic aspects would be sufficient for the purposes being sought of as information and data on the most relevant geographic aspects are available in the bibliography.

On the other hand, the flight should save precious time, mainly if one thinks about the poor road infra-structure available. So, decision was taken by the team, with the approval of the backing team in São Paulo, and a single flight was designed and done, with two landing points (Guadalupe and in the highlands near the Uruçuí Preto River).

The western portion of the Basin in State of Maranhão territory wasn't investigated during field trips due to information available from another OCTA study developed in late 1992 under contract with SINFRA, whose subject was the general damming plan of the whole State of Maranhão for water supply purposes in rural areas. In this study, OCTA made extensive field researches on socioeconomic and general environmental problems.

Two informal workshops were held by the team during this period, one of which with PCI representatives, in order to exchange ideas and impressions of the main problems. Daily phone calls were made to São Paulo, in order to keep the backing team informed on job evolution and to exchange ideas and discuss strategies for the following days.

This was of great value, as information flowed among the whole team and this made possible the necessary integration with such different subjects as Biology in general, Sociology, Economics and Engineering for environmental analysis.

### **3.5. Office works and seminars**

Just at the end of field trip, the whole team gathered again in OCTA office to evaluate the results and quality of information obtained, in an internal seminar held on October 5, 1993. In this occasion, plans were established in order to adapt the original time schedule to the needs of fixing the methodological approach for impact assessment based on a more consistent analysis of new available data and information.

Another seminar was held on October 13, when the possible impacts of the navigation plan were discussed and the assessment was consolidated, thus permitting discussions of the proposed counter measures.

Drafts of field trip report with main conclusions were discussed and photographic documentation was analyzed and selection was made to as to provide appropriate illustration to the final report.

### **3.6. Specific methodological aspects**

#### **3.6.1. Vegetation**

Secondary available data were researched in scientific publication about geological, geomorphological, pedological and climatic aspects of the regional vegetation, land usage and occupation, principally in the libraries of Instituto de Botânica of SMA, of Instituto de Biociências of USP and UFPI.

The vegetal formations were identified in the field, through the over flight in the central and southern region of the Parnaíba River Basin and terrestrial incursions covering the Northern portions. Most relevant aspects of field trip are commented elsewhere. Details of vegetal formations are presented in Chapter 5 and in Annex B.

#### **3.6.2. Fauna and fisheries**

It has to be mentioned that the works done on fauna for the State of Piauí and the Parnaíba River Basin are based on researches done 12 years ago by the specialist in fauna for other purposes than the environmental studies for the navigation plan of the river, and on specific bibliographic researches and field trip done for this particular study related on this report.

The survey and identification of the kinds of animals from various regions of State of Piauí were accomplished in two stages: the first, through 10 field trips, lasting 10 days each on average, from March 8th, 79 to July 25th, 81, *all sponsored by FUFPI-CNPq*, with an excellent result and with quite a significance to FUFPI Department of Biology Museum of Natural Sciences Center (DBM), which started its collection from this first stage.

The second stage, *under the sponsorship of Pacific Consultants International Ltd., and OCTA in the scope of work defined by JICA*, held from September 26th to October 2nd, 93, aiming at updating the previously obtained data, mainly concerning the birds, surveyed and identified at DBM by Dr. Fernando C. Novaes, from Goeldi Museum. (Belém)

During first stage, two trips were taken along the Parnaíba River, using 13 motorboats piloted by the Military Police Fire Brigade of the State of Piauí. The first trip, from Teresina to Parnaíba town was held from June 12th to June 21st, 1981, in which fauna and flora as well as Parnaíba River ecological conditions were observed and studied, at the most important spots for the team.

The second trip took place from July 11th to 25th, 1981, from the sources of Curupá River in Tabatinga Hills to Ribeiro Gonçalves municipality, with studies not only on flora and fauna but also on the ecological conditions of the Parnaíba River headwaters and the conservation study of its banks.

As regards the Parnaíba River and its tributaries, the survey was intensified in Uruçuí-Una Ecological Station, in Ribeiro Gonçalves municipality, between the Uruçuí-Preto and Riozinho Rivers, in the valleys of which "*riparian forests*" can be found as well as savanna in their neighborhood. Also, the survey was made along the Parnaíba River, in the municipalities of Santa Filomena, Uruçuí, Antonio Almeida, Boa Esperança Dam, Floriano, Palmeiras, Teresina, União, Porto, Matias Olímpio, Luzilândia and Parnaíba, next to the Delta.

It is worth mentioning the survey and the studies carried out on Caju Island, on Maranhão Coast, near Parnaíba River Delta, for being the most preserved of delta islands, and for this reason, the most representative as regards natural resources of flora and fauna, perhaps one of the fewest examples of peaceful coexistence between economic exploration (cattle breeding and agriculture) and the preservation of natural inheritance. Also, flora and fauna studies were performed on the Delta Islands: Poções Island, Ilha Grande de Santa Isabel, on Piauí Coast and Canárias Island and Ilha Grande do Paulinho, offshore Maranhão.

The Vertebrate groups have been identified either in the survey carried out in the various regions of the State or in the field studies, through binoculars or yet by means of sound manifestations, typical of many species, mainly of birds and anurous, during day and night periods, in several spots in which other vertebrates were surveyed.

The Crustaceans, Mollusks, Fish, Anurous and Reptiles were pinned up in formaldehyde at 10% and placed in plastic containers after having the metrical characters taken. The birds and mammals were taxidermized with the standard measures and incorporated to the collection of FUFPI DBM. Details of fauna and fisheries are presented in Chapter 5. One should note, however, that bibliography and lists of species are methodological means, which are presented in Annex C.

### 3.6.3. Socioeconomic aspects

Important considerations have to be made on socioeconomic aspects and the methodological approach, since the reclamation of the Parnaíba River waterway and the implementation of the navigation plan will arise lots of problems and questions that ought to be examined in a regional basis, as well as in local basis if predictions of future environmental situation are to be made.

For these reasons, bibliographical researches were made in advance, secondary data collection in São Paulo (mainly in universities) and in Teresina. It was known in advance that an overflight along the Basin, together with land incursions to specific sites would be necessary and of great value.

The initial investigations, together with OCTA's previous knowledge of the western portion of the Parnaíba River Basin, showed that it would be necessary to determine the possible area of influence of the waterway, with limits that extrapolate watershed boundaries and state borders.

Although there is a poor state information system and lack of basic statistical information and data, it was possible to point out the main characteristics of the area of influence of the future waterway, which could be analyzed aiming at the environmental problem, as stated below:

- a. Delimitation of the potential area of influence of the future waterway (considering the Parnaíba and Balsas Rivers);
- b. Present socioeconomic situation of this area of influence in comparison to economic evolution of the State of Piauí and the southeastern part of the State of Maranhão;
- c. Economic occupation and land usage along the Parnaíba River valley and its main tributaries, as well as fishing activities;

Based on such assumptions, it was possible to delineate the main social, economic and political aspects and characteristics of this area of influence, thus permitting further discussions about the influence of these aspects on the environment and a simple impact assessment was delineated in a preliminary basis. The following themes were envisaged:

- a. Direct and indirect effects on the environment that may arise from actions planned for navigation implementation;
- b. Potential direct and indirect effects that may be caused by waterway navigation operation and facilities, including construction of water and river training works and new harbors;
- c. Present and predictable effects of economic activities along river valleys and possible amplification of these effects due to navigation development.

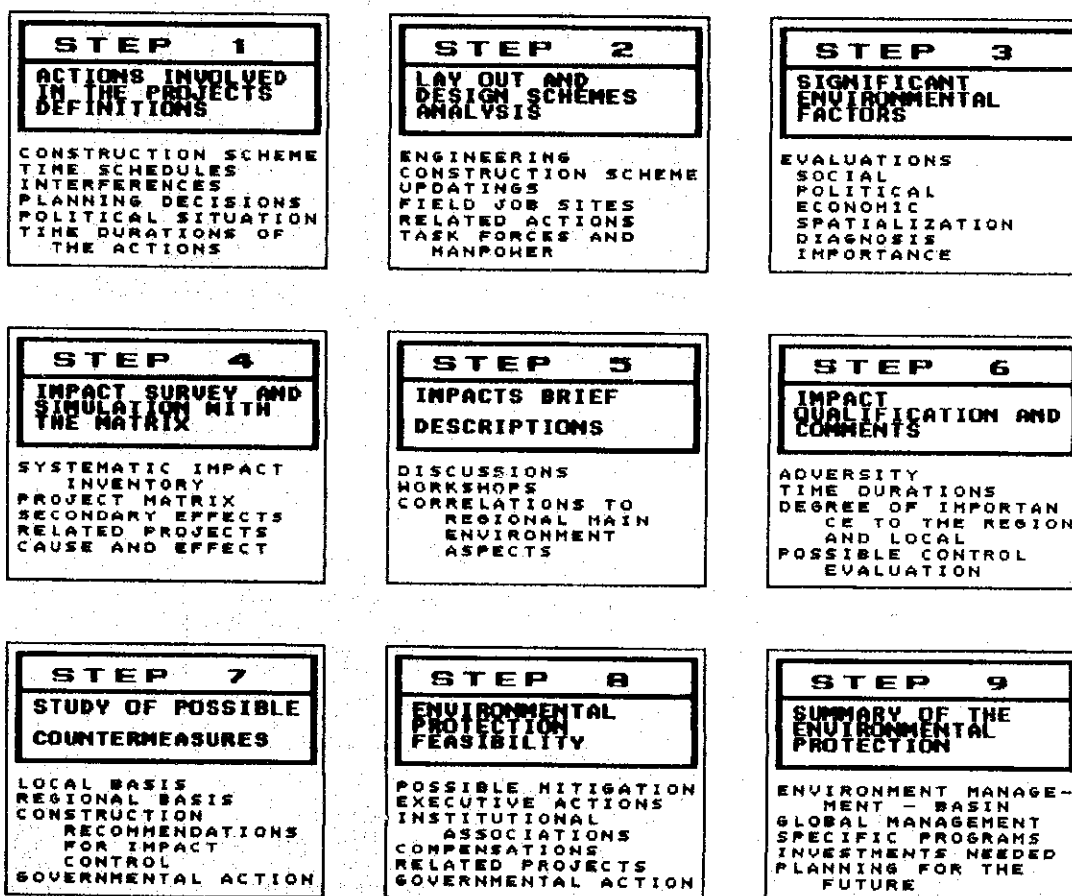
### 3.6.4. Impact assessment

Impact survey and assessment were done in two levels, both based upon the traditional matrix method, in which the actions that *can* generate impacts are determined from knowledge of the project being analyzed. The actions are those needed to implement the project, correlated with studies, construction and further on associated operation of the project as a whole.

One must know the main reasons which can be responsible for impact generation, but it is also very important to know in advance the possible problems that may arise from such a development and the problems that environment can impose to the waterway. Thus this justifies the so-called "matrix-step" method of study, commonly used by OCTA in other studies, mainly those correlated to hydraulic resources engineering and power generation plants and reservoirs, in which the team is obliged to be acquainted with the characteristics of the whole project and its area of influence, instead of only looking to local and present situation.

The method following the steps stated below is based on specific bibliography<sup>2</sup>. It was used as a reference for discussions among the team, and the matrix wasn't actually drawn up because it was unnecessary as the initial discussions showed a much simpler assessment than it was foreseen before. Thus the 9 steps shown below actually translates the schedule of work adopted by the team to check conclusions and propose recommendations.

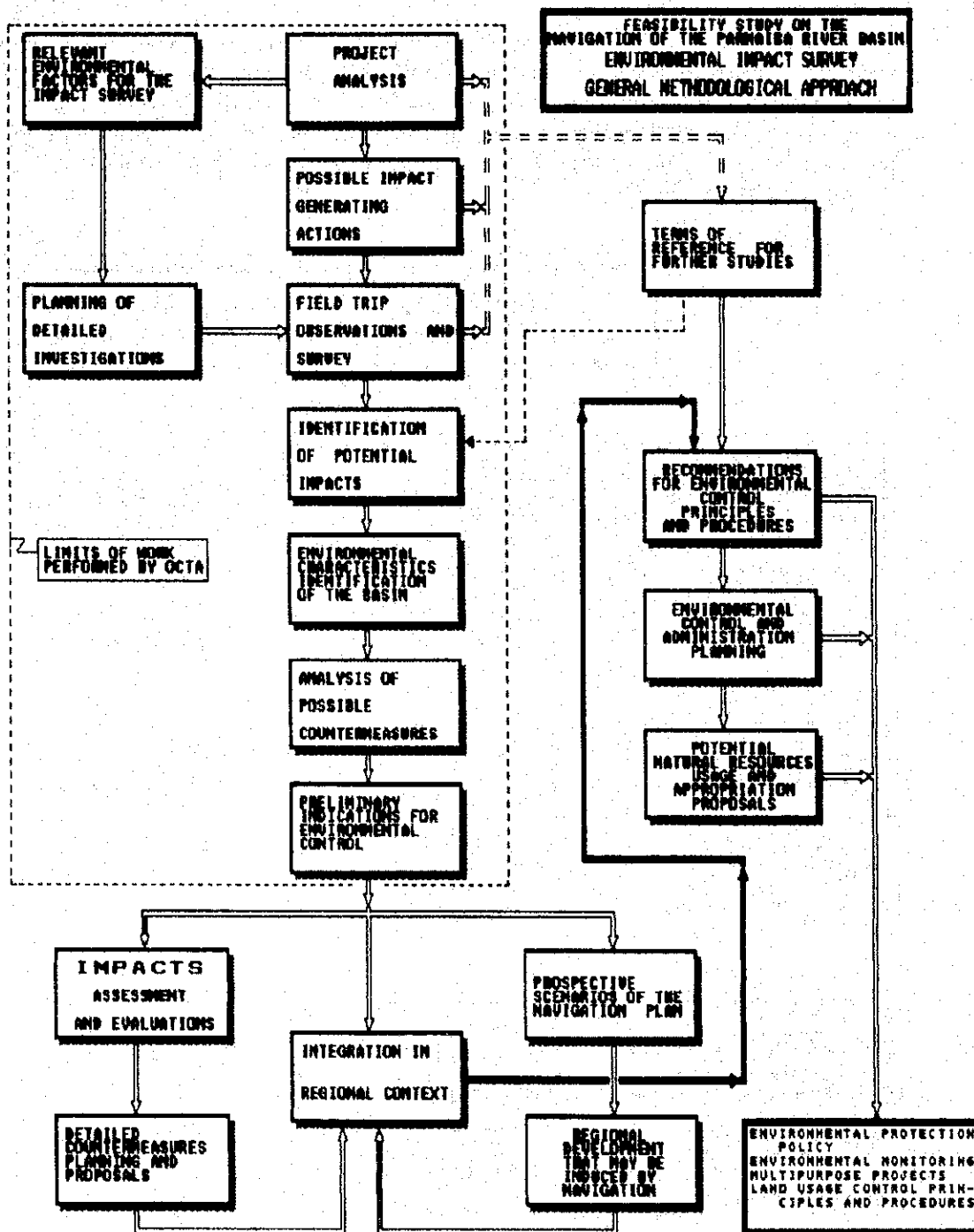
## PARNAIBA RIVER BASIN ENVIRONMENTAL ANALYSIS



<sup>2</sup> See references in Chapter 11.

With such steps it was possible for the team to evaluate the importance and significance of the problems that can be associated to the navigation plan. The analysis was conducted in a seminar held on October 13, in which these steps were discussed by the whole team. As shown elsewhere in this report, a very much simplified matrix was examined and thus presented as a way of fixing ideas and driving discussions.

Methodological approach as referred to in item 3.1:





## 4. FIELD TRIP: OBSERVATIONS, RESULTS AND COMMENTS

### 4.1. Summary

Field trip started on September 26, 1993 and was concluded on October 2, 1993. Team was composed by Mr. Ivo Sadao Massunari, Mr. Raul de Carvalho, Professor Luiz Dino Vizotto, Ph. D. and Professor Waldir Mantovani, Ph. D. Support team in São Paulo was composed by Mr. Alcides Takakura, Mr. Moacir José Gonçalves and Mr. Sylvio Lopes da Rosa.

### 4.2. Time and journey schedule

Team held various contacts with Piauí State institutions in Teresina, mainly with SEPLAN. Fauna and flora researches and data collection were continued with the FUFPI Biology Department support. Socioeconomic studies were based on analysis of data obtained in interviews with local authorities and data collection in local institutions.

Due to lack of information and data, time spent on contacts in Teresina took longer than originally planned and additional work had to be done since there is not an adequate State information system.

Time and journey schedule may be summarized as follows:

Date	Event
September 26, 1993	Flight from São Paulo to Teresina
September 27, 1993	Contacts in Teresina and data collection
September 28, 1993	Flight to upper Parnaíba River Basin.
September 29, 1993	Contacts in Teresina and data collection. Meeting with PCI representatives, during which discussions on the Parnaíba River navigation problems were held. Also, first impressions of the flight were discussed.
September 30, 1993	Land expedition to the north, along the River valley.
October 01, 1993	Contacts with JICA and PCI personnel and document examination in SEPLAN. Conclusion of visits and contacts in Teresina
October 02, 1993	Flight back to São Paulo

### 4.3. Field observations

A flight to the south (upper Parnaíba Basin) was programmed to start at 08:00 a.m. of September 28, with a flight duration of 7 hours, with a previously planned route which would permit the reconnaissance of the region main environmental characteristics, including land usage, agricultural projects, deforestation, geomorphological aspects, and an overview of the Gurguéia River watershed, which shows specific aspects concerning the siltation problems of the Parnaíba River.

During the flight, photos were taken in order to record the aspects observed. Two landing points were chosen so as to permit land observations of relevant aspects, which are commented elsewhere in this report. See documentation at the end of this report.

Land incursions were made in the outskirts of Teresina, and a land trip to the north (lower Parnaíba Basin) was made on September 30, with the team reaching the Delta

region. Specific observations on fauna were made in the *Batalha* region, located about 100 km north of Teresina: there, field observations on bats were done in the Urubu falls<sup>3</sup>.

Details of land and flight routes are illustrated in Figure 01.

#### 4.4. Contacts with local agencies and institutions

Contacts were made with the following institutions<sup>4</sup>

- AGESPISA.
- Associação de Pescadores da Represa de Boa Esperança em Guadalupe.
- CEPRO
- CHESF:
  - Teresina headquarters;
  - Boa Esperança Power Plant offices.
- CONDEPI.
- DER/PI.
- DMA.
- DNOCS.
- FUFPI:
  - Departamento de Biologia;
  - Centro de Pesquisas sobre Desertificação (DESERT);
  - Departamento de Economia.
- SEAAB-PI:
  - Departamento de Hidrometeorologia;
  - Departamento de Planejamento.
- Secretaria do Meio Ambiente da Prefeitura do Município de Teresina.
- SEPLAN.
- SUDEX.

#### 4.4. General aspects

Both in the over flight and land incursions, evident signs of environmental deterioration were observed in practically all the Basin, but principally along the main river course. This had also been noted by OCTA in 1992 in the Balsas Basin region.

#### 4.5. Aspects related to vegetation

As regards the natural aspects in general, the over flight made it possible to observe and register the different vegetation features and formations, as well as evaluate the degree of natural conditions preservation. On the other hand, it was also noted that the overview was enough to make visual evaluations of low degree of soil protection provided by vegetation which, together with the observation regarding the relief made it possible to infer about the region environmental fragility, mainly in the area of Gurguéia River Basin.

<sup>3</sup> It should be noted that the observations on fauna have a complementary character to researches done 10 years ago in Piauí by Professor Vizotto, Ph. D. and his colleagues of the FUFPI in the project of Piauí Natural Resources Researches and Experimentation Program, with the support of CNPq.

<sup>4</sup> See list of names at end of report

It was also noted the conditions of vegetation conservation compared with the type of occupation of the region. To sum up, the field work made the observation possible as regards the vegetation: that the herbaceous extraction is quite sparse and that bush and arboreal extraction are open and therefore do not offer appropriate protection to the soils. Also, these are in general sandy, which means that areas of intense liberation of sediments in the upper stretches of the basins can be expected, mainly in the region of Gurguéia and the High Parnaíba, despite this phenomenon apparently being common in all Piauí territory, confirming the information and references previously available in the bibliography listed in this study.

It is also important to point out this last aspect, considering a possible intensification of erosive processes generally in the Parnaíba River, caused by the inadequate occupation and land usage to the regional environmental characteristics, which could affect the proposed navigation plan, as it happened in the past.

#### 4.6. Aspects related to fauna, wildlife and fisheries

The aspects of fauna, wildlife and fisheries were observed only in land incursions. However, during the over flight, the observation of the present situation of environmental deterioration, principally along the main river, indicated deep changes in the environment.

Aquatic fauna is hardly observed along the Parnaíba River and its tributaries, except near the Delta. In the Delta region, particularly on Caju Island, the environment is still well preserved, with expressive kinds of regional fauna and flora.

As far as fisheries are concerned, practically 95% of commercialized fresh-water fishes in Teresina come from other states, principally Pará, Maranhão and Bahia, showing evidence of little if any importance of the fisheries in the Parnaíba River Basin as well as a significant reduction of the quantities and qualities of the river species, which may be attributed to the environmental changes.

Fishing along the Parnaíba River Basin is essentially amateurish, on a subsistence level and of little significance. Fishing in the marginal lakes is common practice in the lower Parnaíba. *The most important fishery in Piauí is essentially marine.* It is necessary to emphasize this important aspect, in order to show that navigation won't affect fishing activities along Parnaíba River.

#### 4.7. Socioeconomic aspects

As for the socioeconomic aspects, the field survey was very important due to lack of updated secondary data available, mainly as regards the southern part of the Parnaíba Basin, as well as the partial and even contradictory character of the conveyed information.

Therefore, special attention was given to the observation of the borderline occupation of both banks of the Parnaíba River, from the mouth to Santa Filomena and to the plateau between the latter and Uruçuí. It was also given emphasis to the observation of the fluvial fishing activity, particularly in Boa Esperança Reservoir and the central northern segment, focusing on Teresina-Timon, Miguel Alves, Porto and Luzilândia.

Two differentiated structures of occupation and productive potential in the borderline territorial segments of Parnaíba River Basin were noted. The northern part

proportionally presents a high degree of occupation, with predominance of big landowners, devoted to extensive butchering cattle. This activity, with low use of labor force, is done together with a great number of establishments — small tenants, partners, small owners and occupants — which practice agriculture of subsistence (rice, corn, maize, manioc, beans, cotton and goatish) and with small negotiable surplus, besides the extraction of *carnaúba*<sup>5</sup> and *babassupalm tree* oil, with little significance nowadays.

This numerous population presents a high degree of poverty in extremely backward cattle breeding, agricultural and environmentally predatory practices. The fragmentation and exhaustion of the soil lead to constant opening of new areas, deforestation and land burning. The biggest areas with potential for irrigated agriculture are situated in the Northern part (lower Parnaíba), with the presence of numerous public and private projects.

A very contradictory situation was noted: the largest public areas (Federal Government and State) are still in the implantation phase and its work is semi-paralyzed or in slow rhythm of implementation due to the lack of budget. In the oldest perimeters, the functioning irrigated areas are reduced, observing also low productivity and production.

Out of private projects, implanted with the public incentives and subsidies, it was found out that the second biggest, the SULANOR, which was known as a model of a high technology agroindustrial plant, is out of operation. Another big private project, Cia. Agroindustrial do Vale do Parnaíba, specialized in alcohol production, was fully operating with plans of expanding its irrigated areas. The other projects of irrigation are smaller and devoted to grain and fruit production and extend as far as Teresina and neighborhood, where also the pisciculture projects are located.

Thus, from a more than 200,000 ha of potential irrigable lands already studied and identified (considering Longá and Piracuruca River Basins), little more than 10,000 ha are implanted and even less is in effective operation. Therefore, the traditional agriculture of drought (without irrigation) widely predominates, subordinated to the extensive cattle breeding.

From Teresina southbound, occupation along the Parnaíba River banks are shown to be increasingly scattered with the presence of only small colonies with similar characteristics to the Northern part, deforestation and burning being constantly observed.

Further to the south, there are great borderline areas along the Parnaíba River, which are fit to agriculture and irrigation but with low degree of occupation. These areas belong to the Municipalities of Guadalupe — where the Plateau of Guadalupe project is located —, Uruçuí, Ribeiro Gonçalves, Tasso Fragoso, Santa Filomena (Piauí) and Benedito Leite, São Feliz, Balsas, and Alto Parnaíba (Maranhão). In these areas (specially Piauí's side), there is a great potential for the production of grain and butchering cattle, which can eventually benefit from the navigation plan.

Piauí Southeast Plateaus, between Uruçuí and Parnaíba Rivers, present similar characteristics, due to their potentialities and to the kind of recent occupation by big agricultural, cattle breeding and reforestation enterprises but presently only sparsely occupied.

<sup>5</sup> Plant scientific designation is presented in Chapter 5.

To the south (upper stretches of Parnaíba, Balsas and Gurguéia Rivers), there is a great potential for grain production, cattle breeding and reforestation in very extensive areas. Field surveys and the study show that these territories, due to geographic situation and lack of road infra-structure, could be strongly benefited by the waterway.

There are different factors to be noted, which characterize the regional environment: the low natural fertility of the soils, semi arid climate, considerable lack of infra-structure and long distances to trading and processing centers. They inhibit and delay the land occupational process. It is worth mentioning that the fiscal incentives are still on the basis of current process of occupation and that the decrease of its flow due to the budget difficulty of the Federal Government can strongly reduce present appealing factors.

As for fresh water fisheries, field researches showed that fishing efforts are extremely reduced, and imperfectly practiced with activities concentrated on Boa Esperança Reservoir, next to Teresina and in a less scale to the north.

#### 4.8. The Parnaíba River valley landscape

From field observations and data analysis, it may be described the general landscape in terms of its environment, from the upper stretches of the river to its mouth in the Atlantic Ocean. For this purpose, the main river is divided in three stretches, which are better defined in Chapter 5.

*Upper Parnaíba* region lies in the *savanna* (known in Brazil as *cerrado*) dominion and in a transition zone between typical savanna formations and seasonal subdeciduous forests<sup>6</sup>. The vegetation is of medium height, sparsely distributed over flat and plain relief. Grassy herbaceous extract predominates, but in some places it is replaced by trunkless palms of the *Attalea* gender.

Riparian forest along the main river and its tributaries are a good means of natural protection of river banks. Upstream Ribeiro Gonçalves city they are very dense and exuberant. Presence of palm trees (*babassupalm*, *carnaúba* and *buriti*) is limited to more humid areas, where they form dense bushes or compose more complex formations of riparian woods.

The whole landscape is characterized by remaining isolated elevations and slope areas that border the high tables and highlands forming various canyons along the main river and some tributaries.

This region, from the Boa Esperança Reservoir to upstream there are deforestation activities for agricultural purposes. Along the main river clearances are intense near the cities and villages. Along Boa Esperança Reservoir there are remnants of the original vegetation which was not removed before reservoir impounding. Along the shorelines, the environment thus became modified, with eutrophication in some small bays and increasing presence of palm trees forests.

Along *Medium Parnaíba*, savanna formation predominates and may be found upstream from Guadalupe, PI up to Amarante, MA. Between Guadalupe and Teresina

<sup>6</sup> See details of vegetation in Chapter 5.

seasonal sub-deciduous forest with babassupalm is found, but with an increasing predominance of babassupalm tree woods.

This region is distinguished by spreading of human occupation, with deforested lands along river banks and roads along the rivers in both sides of the main stream. It is worth mentioning the presence of rice cultures that predominate in the flat and low lands alongside the watercourses, together with unprotected sandy riverbanks and unprotected soils.

The *Lower Parnaíba* is marked by the presence of the dominion of seasonal subdeciduous forests with palm trees, and by various contact areas of forest/savanna and forest/thorn steppe (in Brazil, steppe stands for *caatinga*). Babassupalm trees predominate along the stretch between Teresina and Porto. From this place onwards (to the north), there is an increasing importance of *carnaúba* up to Parnaíba town, where it predominates. This region is also distinguished by economic activities correlated to vegetal exploitation, mainly for babassupalm tree oil and *carnaúba* wax production.

Mango, cashew and orange production is also present as permanent cultures, together with temporary crops of rice, bean, maize, potatoes, sweet potatoes, sugar-cane and grass for cattle breeding. Primitive practices of alongside watercourse cultures is common, but there are also great agricultural modern projects, such as irrigated sugar-cane cultures at União and a big project of irrigated rice crops near *Miguel Alves*, where low lands were reclaimed due to dike construction along river banks, conforming a big "polder".

