CHAPTER 8 ECONOMIC AND FINANCIAL ANALYSIS

8.1 Economic Evaluation

8.1.1 Outline of Economic Analysis

The economic analysis is aimed at appraising the economic feasibility of the projects. It is based on the viewpoint of the national economy in the target year for the Key Projects extracted from the Short-term Development Plan. Based on the analysis of economic benefits as well as economic costs arising from the projects, evaluation was undertaken to determine if the project benefits exceed those that could be obtained from other investment opportunities in Lithuania.

In this analysis, the Key Projects are defined and comparative analysis undertaken for the case with project (hereinafter referred to as “With Case”) and the case without project (hereinafter referred to as “Without Case”). All benefits and costs in market prices to determine the difference between “With Case” and “Without Case” are calculated and converted into economic prices.

Feasibility of each project is appraised through a cost-benefit analysis based on the economic internal rate of return (EIRR) and the benefit/cost ratio (B/C ratio).

The procedure for the analysis is shown in Figure 8.1.

8.1.2 Prerequisites for Economic Analysis

(1) Base Year

In this study, the year 2004 has been adopted as the “Base Year”.

(2) Project Life

40 years has been adopted as the “Project Life”.

(3) Foreign Exchange Rate

The foreign exchange rate adopted for this analysis is the same as that used in the cost estimation, namely 1 Euro = 3.44 Litas = 130 Japanese Yen = US$1.238.

(4) “With Case” and “Without Case”

There are two key projects in the Short-term Plan; one is the Outer Port Development Project and the other is the Southern Access Railway Improvement Project.

Items of investment for the two projects are as follows:

1) Outer Port Development Project

[With Case]

- Expansion and construction of breakwaters
- Construction of quay facilities with basins and navigation aid (including revetments)
- Construction of storage facilities with cargo handling equipment (including railway facilities).

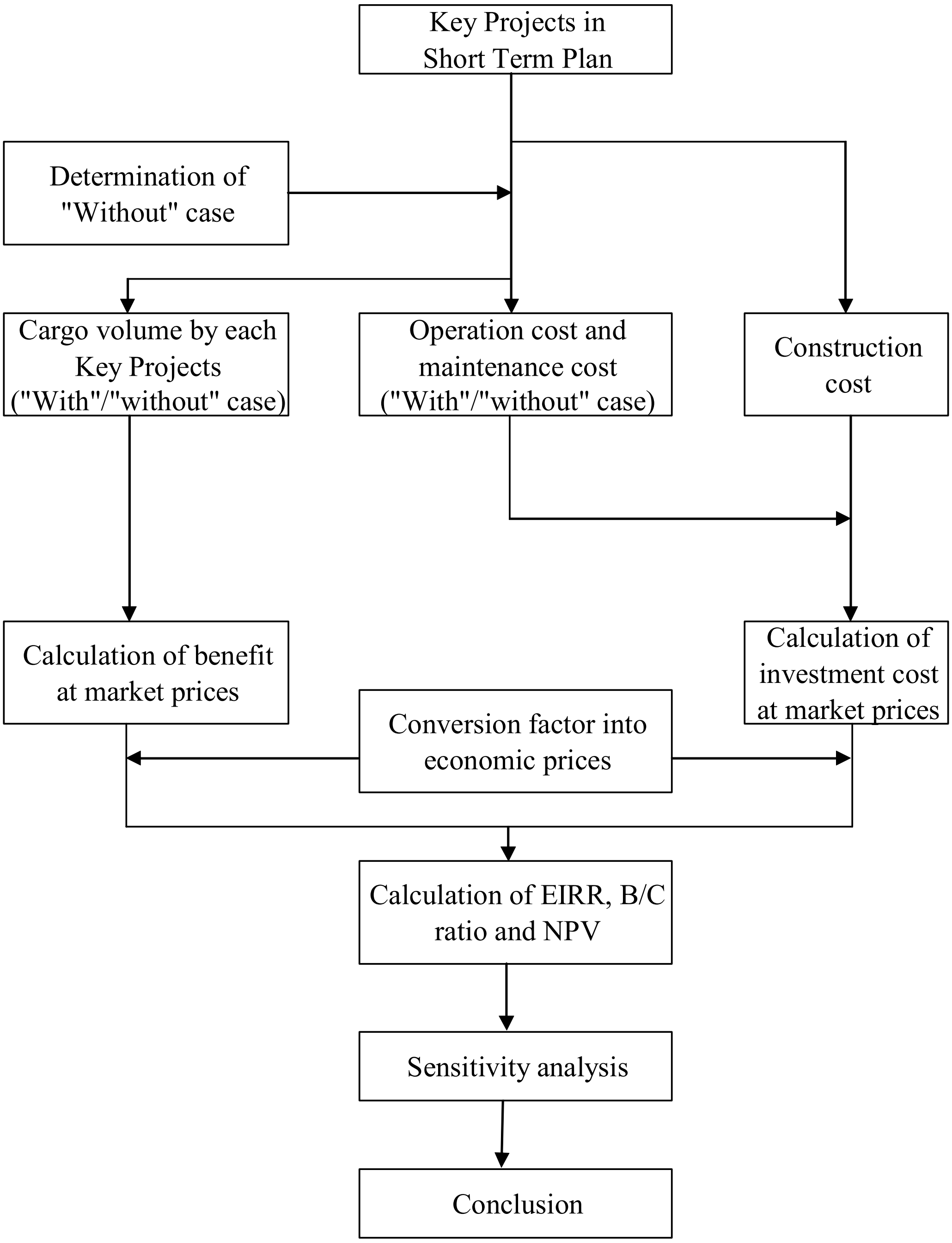


Figure 8.1 Procedure of Economic Analysis

[Without Case]

In the “without case”, no investment will be made for Outer Port Development Project, viz.:

- Breakwaters will not be expanded or constructed
- Quay facilities including revetments with basins and navigation aids will not be constructed

- Storage facilities with cargo handling equipment including railway facilities will not be constructed

2) Southern Access Railway Improvement Project

[With Case]

- Improvement of railway facilities for Southern Access Railway

[Without Case]

- No improvement of railway facilities for Southern Access Railway

8.1.3 Benefits

Items of direct benefits of both projects have been considered as follows:

1) Savings in vessel waiting costs at offshore anchorage

The vessel waiting costs at offshore anchorages are decreased due to construction of the berths in the outer port and the installation of efficient equipment.

2) Savings in sea transportation cost

Ocean freights are decreased by construction of the deep-sea berth in the outer port, which enables visits by large vessels.

3) Savings in land transportation cost

For the import of bulk cargoes to Lithuania, the land transportation cost of those cargo volumes exceeding the present capacity of the Southern Access Railway at Klaipeda Port will be decreased by improving Southern Access Railway and avoiding the roundabout routes currently necessary through ports in neighbouring countries.

4) Growth in port revenues

Port revenues will increase because the transit cargo volumes carried by large-sized bulk carriers will increase following construction of the deep-sea berths in the outer port.

8.1.4 Costs

(1) Construction Cost

The classified construction costs are converted from market prices to economic prices by multiplying the local currency portion by the conversion factor.

(2) Re-investment

The re-investment cost for facilities and equipment after their useful lifetime are considered.

(3) Maintenance Cost

The annual maintenance costs for facilities and machinery are calculated based on the estimated fixed rate for annual maintenance costs vs. their initial investments. In this study, the fixed rates are set as follows: 1% for structures made mainly of concrete and stone, 3% for those made of steel stock and machines, and 5% for transportation machinery.

8.1.5 Evaluation of the Key Projects

(1) EIRR, B/C Ratio and NPV

EIRR, B/C ratio and NPV have been calculated for each key project and are listed in Tables 8.2 and 8.3. EIRR and B/C for the Outer Port Development is 12.57% and 1.32 respectively. EIRR and B/C for the Southern Access Railway Improvement is 25.46% and 4.9 respectively.

(2) Sensitivity Analysis

Sensitivity analysis was performed in order to assess the effects of unexpected changes in cargo volumes, construction costs, benefits, etc. for each project.

In this study, the following three cases were envisioned:

Case 1: Costs increase by 10%

Case 2: Benefits decrease by 10%

Case 3: Costs increase by 10% and benefits decrease by 10%

Table 8.1 shows results of calculations for the sensitivity analysis.

Table 8.1 Results of Calculations for Sensitivity Analysis

Key Project	EIRR		
	Case1	Case2	Case3
Outer Port Development Project	11.65%	11.56%	10.67%
Southern Access Railway Improvement Project	24.28%	24.16%	23.03%

Source: Estimate by the JICA Study Team

(3) Evaluation

A project with an EIRR of more than 10% is generally considered economically feasible when considering the opportunity cost of capital. The B/C ratio and NPV should be higher than 1 and zero, respectively.

The proposed key projects in the Short-term Plan in this study are considered feasible from the viewpoint of the national economy because the results of the calculations for EIRR, B/C ratio and NPV exceed 10%, 1.0 and 0 in each of the key projects, respectively, including the sensitivity analysis cases.

Table 8.2 Cost and Benefit Analysis (Outer Port Project)

EIRR= 12.57%
B / C = 1.32

(Unit : EURO)

	Benefit					Costs				Difference	Net Present Volume(NPV)		
Year	Vessel Waiting Costs at Offshor Anchorag	Saving in Land Transportaion Cost	Growth in Port Revenues	Increasing of Employees	Total	Construction Costs	Maintenance Costs	Re-Investment	Total	Benefit - Cost	Benefit	Cost	Benefit - Cost
2,009					0	3,066,053			3,066,053	-3,066,053	0	3,066,053	-3,066,053
2,010					0	3,041,148			3,041,148	-3,041,148	0	2,764,680	-2,764,680
2,011					0	36,907,107			36,907,107	-36,907,107	0	30,501,741	-30,501,741
2,012					0	76,036,305			76,036,305	-76,036,305	0	57,127,201	-57,127,201
2,013					0	65,754,065			65,754,065	-65,754,065	0	44,910,911	-44,910,911
2,014					0	78,896,131			78,896,131	-78,896,131	0	48,988,290	-48,988,290
2,015	2,285,000	0	0	1,725,610	4,010,610		4,552,431	0	4,552,431	-541,821	2,263,885	2,569,729	-305,844
2,016	8,360,000	0	0	1,725,610	10,085,610		4,552,431	0	4,552,431	5,533,179	5,175,513	2,336,117	2,839,396
2,017	27,645,000	393,800	13,260,150	1,725,610	43,024,560		4,552,431	0	4,552,431	38,472,129	20,071,275	2,123,743	17,947,532
2,018	27,645,000	792,500	14,914,238	1,725,610	45,077,348		4,552,431	0	4,552,431	40,524,917	19,117,196	1,930,675	17,186,521
2,019	27,645,000	1,191,200	16,885,932	1,725,610	47,447,742		4,552,431	173,800	4,726,231	42,721,511	18,293,159	1,822,167	16,470,992
2,020	27,645,000	1,585,930	18,857,624	1,725,610	49,814,164		4,552,431	0	4,552,431	45,261,733	17,459,561	1,595,599	15,863,961
2,021	27,645,000	1,984,630	20,829,318	1,725,610	52,184,558		4,552,431	0	4,552,431	47,632,127	16,627,608	1,450,545	15,177,064
2,022	27,645,000	2,378,430	22,801,009	1,725,610	54,550,049		4,552,431	0	4,552,431	49,997,618	15,801,206	1,318,677	14,482,529
2,023	27,645,000	2,777,130	24,772,701	1,725,610	56,920,441		4,552,431	0	4,552,431	52,368,010	14,988,931	1,198,797	13,790,134
2,024	27,645,000	3,170,930	26,744,395	1,725,610	59,285,935		4,552,431	1,146,083	5,698,514	53,587,421	14,192,581	1,364,179	12,828,403
2,025	27,645,000	4,550,560	28,398,468	1,725,610	62,319,638		4,552,431	0	4,552,431	57,767,207	13,562,569	990,742	12,571,827
2,026	27,645,000	4,550,560	28,398,468	1,725,610	62,319,638		4,552,431	0	4,552,431	57,767,207	12,329,608	900,674	11,428,934
2,027	27,645,000	4,550,560	28,398,468	1,725,610	62,319,638		4,552,431	0	4,552,431	57,767,207	11,208,735	818,795	10,389,940
2,028	27,645,000	4,550,560	28,398,468	1,725,610	62,319,638		4,552,431	0	4,552,431	57,767,207	10,189,759	744,359	9,445,400
2,029	27,645,000	4,550,560	28,398,468	1,725,610	62,319,638		4,552,431	173,800	4,726,231	57,593,407	9,263,417	702,524	8,560,893
2,030	27,645,000	4,550,560	28,398,468	1,725,610	62,319,638		4,552,431	0	4,552,431	57,767,207	8,421,288	615,173	7,806,116
2,031	27,645,000	4,550,560	28,398,468	1,725,610	62,319,638		4,552,431	0	4,552,431	57,767,207	7,655,717	559,248	7,096,469
2,032	27,645,000	4,550,560	28,398,468	1,725,610	62,319,638		4,552,431	0	4,552,431	57,767,207	6,959,742	508,407	6,451,335
2,033	27,645,000	4,550,560	28,398,468	1,725,610	62,319,638		4,552,431	0	4,552,431	57,767,207	6,327,039	462,188	5,864,850
2,034	27,645,000	4,550,560	28,398,468	1,725,610	62,319,638		4,552,431	6,205,371	10,757,802	51,561,836	5,751,853	992,902	4,758,951
2,035	27,645,000	4,550,560	28,398,468	1,725,610	62,319,638		4,552,431	0	4,552,431	57,767,207	5,228,957	381,974	4,846,984
2,036	27,645,000	4,550,560	28,398,468	1,725,610	62,319,638		4,552,431	0	4,552,431	57,767,207	4,753,598	347,249	4,406,349
2,037	27,645,000	4,550,560	28,398,468	1,725,610	62,319,638		4,552,431	0	4,552,431	57,767,207	4,321,452	315,681	4,005,772
2,038	27,645,000	4,550,560	28,398,468	1,725,610	62,319,638		4,552,431	0	4,552,431	57,767,207	3,928,593	286,983	3,641,611
2,039	27,645,000	4,550,560	28,398,468	1,725,610	62,319,638		4,552,431	173,800	4,726,231	57,593,407	3,571,448	270,853	3,300,595
2,040	27,645,000	4,550,560	28,398,468	1,725,610	62,319,638		4,552,431	0	4,552,431	57,767,207	3,246,771	237,176	3,009,596
2,041	27,645,000	4,550,560	28,398,468	1,725,610	62,319,638		4,552,431	0	4,552,431	57,767,207	2,951,610	215,614	2,735,996
2,042	27,645,000	4,550,560	28,398,468	1,725,610	62,319,638		4,552,431	0	4,552,431	57,767,207	2,683,282	196,013	2,487,269
2,043	27,645,000	4,550,560	28,398,468	1,725,610	62,319,638		4,552,431	0	4,552,431	57,767,207	2,439,347	178,194	2,261,154
2,044	27,645,000	4,550,560	28,398,468	1,725,610	62,319,638		4,552,431	1,146,083	5,698,514	56,621,124	2,217,588	202,777	2,014,812
2,045	27,645,000	4,550,560	28,398,468	1,725,610	62,319,638		4,552,431	0	4,552,431	57,767,207	2,015,989	147,267	1,868,722
2,046	27,645,000	4,550,560	28,398,468	1,725,610	62,319,638		4,552,431	0	4,552,431	57,767,207	1,832,718	133,879	1,698,838
2,047	27,645,000	4,550,560	28,398,468	1,725,610	62,319,638		4,552,431	0	4,552,431	57,767,207	1,666,107	121,709	1,544,398
2,048	27,645,000	4,550,560	28,398,468	1,725,610	62,319,638		4,552,431	0	4,552,431	57,767,207	1,514,643	110,644	1,403,999
2,049	27,645,000	4,550,560	28,398,468	1,725,610	62,319,638		4,552,431	173,800	4,726,231	57,593,407	1,376,948	104,426	1,272,522
2,050	27,645,000	4,550,560	28,398,468	1,725,610	62,319,638		4,552,431	0	4,552,431	57,767,207	1,251,771	91,441	1,160,329
2,051	27,645,000	4,550,560	28,398,468	1,725,610	62,319,638		4,552,431	0	4,552,431	57,767,207	1,137,973	83,129	1,054,845
2,052	27,645,000	4,550,560	28,398,468	1,725,610	62,319,638		4,552,431	0	4,552,431	57,767,207	1,034,521	75,571	958,950
2,053	27,645,000	4,550,560	28,398,468	1,725,610	62,319,638		4,552,431	0	4,552,431	57,767,207	940,474	68,701	871,773
2,054	27,645,000	4,550,560	28,398,468	1,725,610	62,319,638		4,552,431	6,205,371	10,757,802	51,561,836	854,976	147,589	707,388
	1,061,155,000.0	150,791,350	1,011,019,407	69,024,400	2,291,990,157	263,700,809	182,097,240	15,398,108	461,196,157	1,830,794,000	284,629,410	216,080,985	68,548,424

Table 8.3 Cost and Benefit Analysis (Southern Access Railway Improvement Project)

EIRR = 25.46%

B / C = 4.90

(Unit : EURO)

Benefit				Costs			Difference	Net Present Volume(NPV)		
Year	Land Transportaion Cost	Growth of Port Revenues	Total	Construction Costs	Maintenance Costs	Total	Benefit - Cost	Benefit	Cost	Benefit - Cost
2,009			0	0		0	0	0	0	0
2,010			0	119,310		119,310	-119,310	0	108,464	-108,464
2,011			0	3,335,568		3,335,568	-3,335,568	0	2,756,668	-2,756,668
2,012			0	0		0	0	0	0	0
2,013			0	0		0	0	0	0	0
2,014			0	0		0	0	0	0	0
2,015	92,208	96,002	188,210		32,560	32,560	155,650	106,240	18,379	87,860
2,016	131,309	944,154	1,075,463		32,560	32,560	1,042,903	551,883	16,709	535,174
2,017	16,763	1,792,306	1,809,069		32,560	32,560	1,776,509	843,944	15,190	828,754
2,018	30,597	1,983,659	2,014,256		32,560	32,560	1,981,696	854,241	13,809	840,432
2,019	42,868	2,175,012	2,217,880		32,560	32,560	2,185,320	855,089	12,553	842,535
2,020	54,226	2,366,365	2,420,591		32,560	32,560	2,388,031	848,402	11,412	836,990
2,021	64,960	2,557,718	2,622,678		32,560	32,560	2,590,118	835,666	10,375	825,291
2,022	75,174	2,749,072	2,824,246		32,560	32,560	2,791,686	818,083	9,432	808,652
2,023	84,933	2,940,425	3,025,358		32,560	32,560	2,992,798	796,671	8,574	788,097
2,024	94,694	3,131,778	3,226,472		32,560	32,560	3,193,912	772,392	7,795	764,597
2,025	103,446	3,323,131	3,426,577		32,560	32,560	3,394,017	745,723	7,086	738,637
2,026	103,446	3,323,131	3,426,577		32,560	32,560	3,394,017	677,930	6,442	671,488
2,027	103,446	3,323,131	3,426,577		32,560	32,560	3,394,017	616,300	5,856	610,444
2,028	103,446	3,323,131	3,426,577		32,560	32,560	3,394,017	560,273	5,324	554,949
2,029	103,446	3,323,131	3,426,577		32,560	32,560	3,394,017	509,339	4,840	504,499
2,030	103,446	3,323,131	3,426,577		32,560	32,560	3,394,017	463,035	4,400	458,635
2,031	103,446	3,323,131	3,426,577		32,560	32,560	3,394,017	420,941	4,000	416,941
2,032	103,446	3,323,131	3,426,577		32,560	32,560	3,394,017	382,674	3,636	379,038
2,033	103,446	3,323,131	3,426,577		32,560	32,560	3,394,017	347,885	3,306	344,580
2,034	103,446	3,323,131	3,426,577		32,560	32,560	3,394,017	316,259	3,005	313,254
2,035	103,446	3,323,131	3,426,577		32,560	32,560	3,394,017	287,508	2,732	284,777
2,036	103,446	3,323,131	3,426,577		32,560	32,560	3,394,017	261,371	2,484	258,888
2,037	103,446	3,323,131	3,426,577		32,560	32,560	3,394,017	237,610	2,258	235,352
2,038	103,446	3,323,131	3,426,577		32,560	32,560	3,394,017	216,009	2,053	213,957
2,039	103,446	3,323,131	3,426,577		32,560	32,560	3,394,017	196,372	1,866	194,506
2,040	103,446	3,323,131	3,426,577		32,560	32,560	3,394,017	178,520	1,696	176,824
2,041	103,446	3,323,131	3,426,577		32,560	32,560	3,394,017	162,291	1,542	160,749
2,042	103,446	3,323,131	3,426,577		32,560	32,560	3,394,017	147,537	1,402	146,135
2,043	103,446	3,323,131	3,426,577		32,560	32,560	3,394,017	134,125	1,274	132,850
2,044	103,446	3,323,131	3,426,577		32,560	32,560	3,394,017	121,932	1,159	120,773
2,045	103,446	3,323,131	3,426,577		32,560	32,560	3,394,017	110,847	1,053	109,794
2,046	103,446	3,323,131	3,426,577		32,560	32,560	3,394,017	100,770	958	99,812
2,047	103,446	3,323,131	3,426,577		32,560	32,560	3,394,017	91,609	870	90,739
2,048	103,446	3,323,131	3,426,577		32,560	32,560	3,394,017	83,281	791	82,490
2,049	103,446	3,323,131	3,426,577		32,560	32,560	3,394,017	75,710	719	74,991
2,050	103,446	3,323,131	3,426,577		32,560	32,560	3,394,017	68,827	654	68,173
2,051	103,446	3,323,131	3,426,577		32,560	32,560	3,394,017	62,570	595	61,976
2,052	103,446	3,323,131	3,426,577		32,560	32,560	3,394,017	56,882	541	56,342
2,053	103,446	3,323,131	3,426,577		32,560	32,560	3,394,017	51,711	491	51,220
2,054	103,446	3,323,131	3,426,577		32,560	32,560	3,394,017	47,010	447	46,563
	3,791,112	120,430,421	124,221,533	3,454,879	1,302,411	4,757,290	119,464,243	15,015,465	3,062,839	11,952,626

8.2 Financial Evaluation

8.2.1 Outline of Financial Analysis

In the FIRR Analysis, the Financial Internal Rate of Return (FIRR) on a gross capital basis has been used as the indicator. Conversely, in the Ratio Analysis, profitability, operational efficiency and long-term solvency have been assessed using the typical financial ratios as indicators as calculated from the financial statements.

In the case of "the Outer Port Development Project", a financially-independent single entity has been envisaged. This entity has been assumed to own the equity capital, construct the new port facilities, and operate the marine terminals, functioning as an investor, administrator and port service provider. The entity is an imaginary entity, not a legal entity, and is further divided into the two legal entity components, viz. the port authority (KSSA) and a potential private terminal operator(s) at the new outer port.

In other words, these entities represent the grantor (the Government (KSSA)) and a lessee(s) (a private terminal operator(s)) in terms of a lease contract. Thus, in the first step, the financial statements were developed based on the above-mentioned imaginary entities, which implicitly include the port authority (KSSA) and the potential private terminal operator(s). In the second step, the financial statements were respectively developed for the grantor and a potential lessee(s) by assuming contract conditions in the marine terminals containing the Grain Terminal behind Berth No.2 of the outer port and Multi-purpose Terminal behind Berth No. 3.of the outer port.

“The Southern Access Railway Improvement Project” will enable KSSA’s revenues from port dues to increase after the estimated saturation year of 2012 in terms of access railway capacity if the project is not implemented. Such incremental revenues from port dues, with the linkage of the operations mainly at BEGA and Smelte terminals, will be generated not only from the access railway project but also from the outer port project where access channel improvement (one of the project components) will contribute to the increase in these revenues.

There is some difficulty in clearly allocating the incremental revenues to the two key projects, viz. “the Outer Port Development Project” and “the Southern Access Railway Improvement Project”. However, as the latter project cost is much smaller in comparison to the former (only 1.4%), the railway project was regarded as one project component of the outer port project in the financial analysis in this study. Nonetheless, the two projects are still identified as two independent projects in terms of project implementation, apart from financial analysis mentioned above.

8.2.2 Prerequisites for the Financial Analysis Common in the Two Key Projects

(1) Base Year

In this analysis, the year 2003 has been adopted as the “Base Year”.

(2) Project Life

30 years has been adopted as the “Project Life”.

(3) Financial Terms of Loans to be Raised for the Project

The current financial terms of loans (as of February 2004) are listed below and have been referred to in the financial analysis:

1) EIB Loans

- Interest Rate: EURIBOR (fixed at a rate of disbursement): 2.24% (the rate as of January 29, 2004 will be used as a substitute)
- Maturity (grace period): 17 years (5 years)
- Amortization: LRP (Level Repayment Principle)

2) IBRD Loans

- Interest Rate: LIBOR (floating: an average rate of proceeding 6 months from a disbursement date and repayment date): 2.29% (the average interest rate as of January 2004 (in the past 6 months) has been used as a substitute)
- +0.55%
- Maturity (grace period): 17 years (5 years)
- Amortization: LRP (Level Repayment Principle)

3) NIB Loans

- Interest Rate: EURIBOR (floating: a rate on a disbursement date and repayment date): 2.24% (the rate as of January 29, 2004 has been used as a substitute)
- +0.6%
- Maturity (grace period): 10 years (5 years)
- Amortization: LRP (Level Repayment Principle)

The above interest rates in the initial investment are in the range of 2.24% to 2.84%.

(4) Evaluation Criteria in FIRR Analysis

The Government of Lithuania that has funded and will continue to fund statutory capital to its state-owned entities including KSSA sets a target financial ratio of 7% in ROI (return on investment) or ROE (return on equity). On the other hand, the maximum interest rate of potential lenders is 2.84%. The two figures have been adopted as criteria of FIRR analysis to judge financial soundness of the proposed projects.

8.2.3 Prerequisites for the Financial Analysis in the Two Key Projects

(1) Outer Port Development Project

1) Cargo handling at the new outer port has been assumed to start in 2015. Yearly cargo throughput from the starting year of port operations through to the expiration of the project has been cited from the results of demand forecasts and cargo allocation between the new outer port and the existing port.

2) The number of calling vessels has been estimated based on the cargo volumes, lot sizes and anticipated vessel sizes.

3) The current tariff level of the Port has been applied to estimate revenues for the Project.

4) Currently, there is no fee specified in the usage of railway infrastructure (hereinafter referred to as “railway infrastructure fee”). The collection of a “railway infrastructure fee” is planned to provide the major revenue sources for its entity, separate from the current LG. KSSA would be eligible in the fee collection.

(2) Southern Access Railway Improvement Project

The number of railway wagons to pass through the proposed access railway lines has been estimated based on the results of the simulation. In this study, the necessity to collect the fee by KSSA has been examined.

8.2.4 Revenues

(1) Outer Port Development Project

Major revenue sources are divided into the following three categories:

a) Port dues from vessels calling at the outer port (to KSSA)

b) Cargo handling charges at the outer port terminals (to a Terminal Operator)

c) Port dues from vessels calling at the inner port (to KSSA)

The incremental revenues of the third category will be generated from the increase in channel capacity through the improvement of the existing sea channel. It would otherwise be curbed at the revenue level in the access channel saturation year of 2010 in terms of adequate capacity.

(2) Southern Access Railway Improvement Project

Revenues of port dues from bulk carriers calling at mainly BEGA or Smelte terminals will be indirectly generated from the increase in railway capacity through the improvement of the southern access railway. This would otherwise be curbed at the revenue level in the access railway saturation year of 2012. As the revenues associated with the access railway project are partly overlapped with the outer port project, the combined project comprising the two projects has been financially assessed as one project, as mentioned previously.

8.2.5 Costs

(1) Outer Port Development Project

1) Initial investment costs are summarized in Chapter 12.

2) Expense items for management/operations and maintenance are listed below:

   * Maintenance dredging cost has been estimated assuming annual dredging of 100,000 cu. m. and unit dredging expenses of 1.9 EURO/cu. m.

   * Maintenance cost for infrastructure has been assumed to be 1% of initial investment expenses of depreciable infrastructure.

   * Maintenance cost for equipment has been assumed to be 4% of initial investment expenses of equipment.

   * Fuel and utilities expense has been assumed to be 4% of initial investment expenses of equipment.

   * Labour expenses at the terminals of the outer port will be expended by the terminal operator(s) as lessees.

* General and administrative expenses will be expended at local office(s) of the terminal operator(s). Main expense items are personnel expenses.

3) Renewal investment costs have been assumed based on actual operational life spans experienced in the leading ports, these ranging from 7 to 25 years.

4) Total project cost comprising initial investment costs, yearly management/operations and maintenance expenses and renewal investment costs for equipment from time to time during the project life are summarized in Table 8.6. Also included are revenues to be generated from the Project and the result of the subsequent FIRR calculations.

(2) Southern Access Railway Improvement Project

1) Initial investment costs are summarized in Chapter 12.

2) Maintenance costs for infrastructure have been assumed to be 1% of initial investment expenses.

8.2.6 Methodology and Results of Evaluation of the Key Projects

(1) FIRR Analysis

1) Calculation of the FIRR (Base Case)

The financial internal rate of return (FIRR) of the Outer Port Development Project, including the Southern Access Railway Project, has been estimated as 7.5%.

2) Sensitivity Analyses

In order to determine if the Project is still financially viable when some factors are varied, the following cases have been tested as sensitivity analyses:

Case A: Total cost (cash outflow) increases by 5% and revenue (cash inflow) decreases by 5%

Case B: Total cost increases by 10% and revenue decreases by 10%

The resulting FIRRs of the Outer Port Development Project in Cases A and B in the above sensitivity analyses are 6.5% and 5.6%, respectively.

3) Evaluation

The resulting FIRR of the Outer Port Development Project is 7.5% and exceeds the evaluation criteria, which is in the range of 2.84% to 7%. In addition, even based on the assumptions in the sensitivity analyses, all cases exceed the maximum interest rate of potential lenders. Thus, the Outer Port Development Project is judged to be financially viable.

(2) Ratio Analysis

Assessment of the financial soundness of the key projects to be evaluated is based on their being implemented by imaginary entities. This has been done by so-called ratio analysis through drafting the financial statements to be supposedly reported by the imaginary entity responsible for administration, management and operations of the new outer port or for administration of the new access railway infrastructure.

1) Profitability

The profitability of the key projects has been assessed by Rate of Return on Assets (ROI) defined as follows:

$$\text{Rate of Return on Assets (ROI)} = \frac{\text{Net Operating Income}}{\text{Net Fixed Assets}}$$

In the Outer Port Development Project, the criterion is that the financial indicator exceeds the maximum interest rate of the potential lenders. This is estimated to be 2.84% from the starting year 2015, and over 7% from the year 2021.

2) Operational Efficiency

The operational efficiency of the key projects has been assessed by two financial indicators. One is Operating Ratio defined as follows:

$$\text{Operating Ratio} = \frac{\text{Operating Expenses}}{\text{Operating Revenues}}$$

The criterion of the above financial indicator is that it be less than 0.70 to 0.75. For the Outer Port Development Project from the starting year 2015, this criterion is satisfied throughout the project life.

The other is Working Ratio defined as follows:

$$\text{Working Ratio} = \frac{\text{Operating Expenses} - \text{Depreciation Expenses}}{\text{Operating Revenues}}$$

The criterion of the above financial indicator is that it be less than 0.50 to 0.60. From the starting year of 2015, this criterion is satisfied throughout the project life.

3) Long-Term Solvency

The long-term solvency (debt repayment capacity) of the port management and operations entity has been assessed by the Debt Service Coverage Ratio defined as follows:

$$\text{Debt Service Coverage Ratio} = \frac{\text{Net Operating Income and Depreciation Expense}}{\text{Repayment Amount of Principal and Interest for Long-Term Debt}}$$

The criterion of the above financial indicator is that it exceeds 1.0. Excluding the first five years from the starting year of 2015, the criterion is satisfied for all remaining years of the project life.

(3) Consideration on Adequate Land Lease Fee in the New Outer Port

It is considered operations at the new outer port will be provided by private terminal operators who will be granted a lease for the use of terminal land from the government (KSSA) according to a lease contract. For the government (KSSA), the lease fee affects the repayment capacity for long-term debt to potential lenders. On the other hand, for the potential private terminal operators, the lease fee also controls the fate of the management of their terminal operations business.

The change from a certain level of land lease fee creates a gain for one party and a loss for the other. In this regard, within the financial framework of the entire port business, sensitivity to this parameter has been tested. The amount of the lease fee has been varied and the respective sets of financial statements of each party have been compared in terms of financial soundness for both the one who gains and the one who loses. It has also been assumed that the land lease fee should cover a portion of investment costs of basic port infrastructure including breakwaters and basins in addition to the costs of land creation that will be prepared by KSSA. The current land lease fee rate of 3.9 Lt. per sq. m per annum has been used in the base case in the above-mentioned sensitivity analysis.

Table 8.4 Sensitivity Analysis of Land Lease Rate Level

Unit' million EURO

Case/Item		-30%	-20%	-10%	Base Case	+10%	+20%	+30%
Total Land Lease Fee		0.26	0.30	0.33	0.37	0.41	0.45	0.48
Retained Earnings (Current Value)	124	124	123	122	121	121	120	119
	458	458	459	460	461	462	463	463
		78.7%	78.9%	79.0%	79.0%	79.3%	79.4%	79.6%
Retained Earnings (Present Value)	TOC	50	50	49	49	48	48	48
	KSSA	188	188	189	189	190	190	191
		79.0%	79.2%	79.3%	79.5%	79.7%	79.8%	80.0%

Note (1): Above retained earnings areis an amount accumulated through the project term.
Note (2): In the base case current land lease rate of 3.9 Lt./sq. m per annum has been used.

As shown in Table 8.4, fluctuation of land lease rate from the current level has minimal affect on the accumulated retained earnings of both KSSA and a potential terminal operator. In terms of the project for KSSA, revenue from a land lease fee is much smaller than from other revenue sources, viz. port dues. On the other hand, in terms of the project for a potential terminal operator (TOC), this expense incurred by TOC is also much smaller than other expenses. Therefore, if KSSA's financial conditions can allow it to proceed with the project, financial viability for both KSSA and TOC in terms of the outer port development project has been verified for the condition of the current lease rate level.

(4) Consideration on the Necessity of Railway Infrastructure Fee

According to the results of the financial analyses mentioned above, the combined project comprising the Outer Port Development Project and Southern Access Railway Improvement Project has been verified to be financially viable without collecting a so-called "Railway Infrastructure Fee" to cover the investment for port access railways for the two key projects. This, however, does not necessarily rule out the right of this fee collection by KSSA. It is advisable to consider the collectability of the fee taking into account the consistency of the railway tariff system covering the overall railway network in Lithuania.

Table 8.5 Summary of FIRR Calculation (Base Case)

Unit:'000EURO

No.	Year	Initial Investment Costs	Management/Operations and Maintenance Expenses						Renewal Investment Costs	Salvage Values	Cost Total (Out)	Revenue Total (In)	In-Out	Net Present Value (NPV)
			Maintenance Dredging	Infra-structure/ buildings	Equipment	Fuel and Utilities	Labor Costs	General and Administrative Costs						
1	2009	3,602									3,602		-3,602	-3,602
2	2010	3,602									3,602		-3,602	-3,352
3	2011	43,477									43,477		-43,477	-37,654
4	2012	90,369									90,369		-90,369	-72,838
5	2013	78,427									78,427		-78,427	-58,828
6	2014	93,263									93,263		-93,263	-65,104
7	2015		190	2,865	364	364	824	613			5,220	21,903	16,682	10,837
8	2016		190	2,865	364	364	824	613			5,220	24,218	18,997	11,485
9	2017		190	2,865	364	364	824	613			5,220	27,453	22,233	12,509
10	2018		190	2,865	364	364	824	613			5,220	29,716	24,495	12,826
11	2019		190	2,865	364	364	824	613			5,220	31,978	26,758	13,039
12	2020		190	2,865	364	364	824	613			5,220	34,240	29,020	13,160
13	2021		190	2,865	364	364	824	613			5,220	36,503	31,282	13,202
14	2022		190	2,865	364	364	824	613	1,107		6,327	38,765	32,437	12,740
15	2023		190	2,865	364	364	824	613			5,220	41,027	35,807	13,088
16	2024		190	2,865	364	364	824	613			5,220	43,289	38,069	12,950
17	2025		190	2,865	364	364	824	613			5,220	43,289	38,069	12,051
18	2026		190	2,865	364	364	824	613			5,220	43,289	38,069	11,215
19	2027		190	2,865	364	364	824	613			5,220	43,289	38,069	10,437
20	2028		190	2,865	364	364	824	613			5,220	43,289	38,069	9,713
21	2029		190	2,865	364	364	824	613	1,107		6,327	43,289	36,962	8,777
22	2030		190	2,865	364	364	824	613			5,220	43,289	38,069	8,413
23	2031		190	2,865	364	364	824	613			5,220	43,289	38,069	7,829
24	2032		190	2,865	364	364	824	613			5,220	43,289	38,069	7,286
25	2033		190	2,865	364	364	824	613			5,220	43,289	38,069	6,781
26	2034		190	2,865	364	364	824	613			5,220	43,289	38,069	6,310
27	2035		190	2,865	364	364	824	613			5,220	43,289	38,069	5,872
28	2036		190	2,865	364	364	824	613	1,107		6,327	43,289	36,962	5,306
29	2037		190	2,865	364	364	824	613			5,220	43,289	38,069	5,086
30	2038		190	2,865	364	364	824	613		-17,120	-11,899	43,289	55,189	6,862
Total		309,138	4,560	68,762	8,748	8,748	19,772	14,701	3,321	-17,120	420,629	935,142	514,513	0

FIRR = 7.5%

Table 8.6 Financial Statements of the Entire Project (EURO'000s)

Income Statement (EURO'000s)

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
REVENUE																															
Port Dues (Vessel, Tonnage and other dues) (for KSSA)							15,193	16,925	19,579	21,258	22,938	24,618	26,298	27,977	29,657	31,337	31,337	31,337	31,337	31,337	31,337	31,337	31,337	31,337	31,337	31,337	31,337	31,337	31,337	31,337	31,337
Cargo Handling Charge (for TOC)							6,710	7,292	7,875	8,457	9,040	9,622	10,205	10,787	11,370	11,952	11,952	11,952	11,952	11,952	11,952	11,952	11,952	11,952	11,952	11,952	11,952	11,952	11,952	11,952	11,952
Land Lease Fee (from TOC)																															
TOTAL REVENUE							21,903	24,218	27,453	29,716	31,978	34,240	36,503	38,765	41,027	43,289	43,289	43,289	43,289	43,289	43,289	43,289	43,289	43,289	43,289	43,289	43,289	43,289	43,289	43,289	43,289
EXPENSE																															
DIRECT EXPENSE																															
Labor (TOC)							-824	-824	-824	-824	-824	-824	-824	-824	-824	-824	-824	-824	-824	-824	-824	-824	-824	-824	-824	-824	-824	-824	-824	-824	-824
Maintenance of equipment (TOC)							-364	-364	-364	-364	-364	-364	-364	-364	-364	-364	-364	-364	-364	-364	-364	-364	-364	-364	-364	-364	-364	-364	-364	-364	-364
Fuel & Utilities (TOC)							-364	-364	-364	-364	-364	-364	-364	-364	-364	-364	-364	-364	-364	-364	-364	-364	-364	-364	-364	-364	-364	-364	-364	-364	-364
Maintenance of Super-structures (TOC)							-391	-391	-391	-391	-391	-391	-391	-391	-391	-391	-391	-391	-391	-391	-391	-391	-391	-391	-391	-391	-391	-391	-391	-391	-391
Maintenance of infrastructures (KSSA)							-2,721	-2,721	-2,721	-2,721	-2,721	-2,721	-2,721	-2,721	-2,721	-2,721	-2,721	-2,721	-2,721	-2,721	-2,721	-2,721	-2,721	-2,721	-2,721	-2,721	-2,721	-2,721	-2,721	-2,721	-2,721
Maintenance dredging (KSSA)							-209	-209	-209	-209	-209	-209	-209	-209	-209	-209	-209	-209	-209	-209	-209	-209	-209	-209	-209	-209	-209	-209	-209	-209	-209
Total Direct Expense							-4,874	-4,874	-4,874	-4,874	-4,874	-4,874	-4,874	-4,874	-4,874	-4,874	-4,874	-4,874	-4,874	-4,874	-4,874	-4,874	-4,874	-4,874	-4,874	-4,874	-4,874	-4,874	-4,874	-4,874	-4,874
INDIRECT EXPENSE																															
Depreciation (Infrastructures) (for KSSA Assets)							-5,416	-5,416	-5,416	-5,416	-5,416	-5,416	-5,416	-5,416	-5,416	-5,416	-5,416	-5,416	-5,416	-5,416	-5,416	-5,416	-5,416	-5,416	-5,416	-5,416	-5,416	-5,416	-5,416	-5,416	-5,416
Depreciation (equipment) (for TOC's Assets))							-478	-478	-478	-478	-478	-478	-478	-478	-478	-478	-478	-478	-478	-478	-478	-478	-478	-478	-478	-478	-478	-478	-478	-478	-478
Depreciation (Super-structures)(for TOC's Assets)							-978	-978	-978	-978	-978	-978	-978	-978	-978	-978	-978	-978	-978	-978	-978	-978	-978	-978	-978	-978	-978	-978	-978	-978	-978
Land Lease Fee (to KSSA)																															
Total Indirect Expense							-6,872	-6,872	-6,872	-6,872	-6,872	-6,872	-6,872	-6,872	-6,872	-6,872	-6,872	-6,872	-6,872	-6,872	-6,872	-6,872	-6,872	-6,872	-6,872	-6,872	-6,872	-6,872	-6,872	-6,872	-6,872
GENERAL & ADMINISTRATIVE																															
Administrative Personnel (TOC)							-438	-438	-438	-438	-438	-438	-438	-438	-438	-438	-438	-438	-438	-438	-438	-438	-438	-438	-438	-438	-438	-438	-438	-438	-438
Others (TOC)							-175	-175	-175	-175	-175	-175	-175	-175	-175	-175	-175	-175	-175	-175	-175	-175	-175	-175	-175	-175	-175	-175	-175	-175	-175
Total General & Administrative							-613	-613	-613	-613	-613	-613	-613	-613	-613	-613	-613	-613	-613	-613	-613	-613	-613	-613	-613	-613	-613	-613	-613	-613	-613
TOTAL EXPENSE							-12,359	-12,359	-12,359	-12,359	-12,359	-12,359	-12,359	-12,359	-12,359	-12,359	-12,359	-12,359	-12,359	-12,359	-12,359	-12,359	-12,359	-12,359	-12,359	-12,359	-12,359	-12,359	-12,359	-12,359	-12,359
OPERATING INCOME							9,544	11,859	15,095	17,357	19,619	21,881	24,144	26,406	28,668	30,931	30,931	30,931	30,931	30,931	30,931	30,931	30,931	30,931	30,931	30,931	30,931	30,931	30,931	30,931	30,931
OTHER INCOME/(EXPENSE)																															
Interest Expense (KSSA)							-6,857	-6,328	-5,760	-5,200	-4,639	-4,079	-3,519	-2,959	-2,399	-1,838	-1,278	-718	-228	0	0	0	0	0	0	0	0	0	0	0	0
Interest Expense (TOC)							-2,385	-2,257	-2,095	-1,933	-1,771	-1,609	-1,447	-1,313	-1,178	-1,013	-851	-689	-527	-365	-231	-115	-47	-39	-32	-24	-17	-38	-57	-47	-39
Interest Expense for Short-term Borrowings (Government)							0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL OTHER							-9,242	-8,585	-7,855	-7,133	-6,410	-5,688	-4,966	-4,272	-3,576	-2,851	-2,129	-1,407	-754	-365	-231	-115	-47	-39	-32	-24	-17	-38	-57	-47	-39
EARNINGS before TAXES							302	3,274	7,240	10,224	13,209	16,193	19,178	22,134	25,092	28,079	28,802	29,524	30,176	30,566	30,700	30,815	30,884	30,891	30,899	30,906	30,914	30,893	30,873	30,884	30,891
(Taxable Earnings)							-14,891	-13,652	-12,339	-11,034	-9,729	-8,424	-7,120	-5,843	-4,565	-3,258	-2,535	-1,813	-1,161	-771	-637	-522	-453	-446	-438	-431	-423	-444	-464	-453	-446
INCOME TAX							0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NET INCOME after tax							302	3,274	7,240	10,224	13,209	16,193	19,178	22,134	25,092	28,079	28,802	29,524	30,176	30,566	30,700	30,815	30,884	30,891	30,899	30,906	30,914	30,893	30,873	30,884	30,891
Retained Eranings							302	3,576	10,815	21,040	34,249	50,442	69,620	91,755	116,846	144,926	173,727	203,251	233,427	263,993	294,693	325,509	356,392	387,283	418,182	449,088	480,002	510,895	541,768	572,652	603,543
Statement of Cash Flows (EURO'000s)																															
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Cash Beginning	0	0	-50	-779	-3,334	-8,124	-20,578	-35,817	-48,099	-56,415	-61,746	-64,093	-63,455	-59,832	-53,253	-43,779	-31,256	-18,010	-4,041	20,442	55,179	90,049	126,261	163,892	201,530	239,175	276,828	314,489	352,129	389,687	427,317
CASH FLOWS FROM OPERATING ACTIVITIES																															
Net Income							302	3,274	7,240	10,224	13,209	16,193	19,178	22,134	25,092	28,079	28,802	29,524	30,176	30,566	30,700	30,815	30,884	30,891	30,899	30,906	30,914	30,893	30,873	30,884	30,891
Noncash Items included in Net Income																															
Depreciation (equipment) (for KSSA Asset)							5,416	5,416	5,416	5,416	5,416	5,416	5,416	5,416	5,416	5,416	5,416	5,416	5,416	5,416	5,416	5,416	5,416	5,416	5,416	5,416	5,416	5,416	5,416	5,416	5,416
Depreciation (equipment) (for TOC's Assets)							478	478	478	478	478	478	478	478	478	478	478	478	478	478	478	478	478	478	478	478	478	478	478	478	478
Depreciation (Super-structures)(for TOC's Assets)							978	978	978	978	978	978	978	978	978	978	978	978	978	978	978	978	978	978	978	978	978	978	978	978	978
Total Noncash Items included in Net Income							6,872	6,872	6,872	6,872	6,872	6,872	6,872	6,872	6,872	6,872	6,872	6,872	6,872	6,872	6,872	6,872	6,872	6,872	6,872	6,872	6,872	6,872	6,872	6,872	6,872
Net Cash Flow From Operating Activities							7,174	10,146	14,112	17,096	20,081	23,065	26,050	29,006	31,964	34,951	35,674	36,396	37,048	37,438	37,572	37,687	37,756	37,763	37,771	37,778	37,786	37,765	37,745	37,756	37,763
CASH FLOWS FROM INVESTING ACTIVITIES																															
Construction in Progress (KSSA)	-3,962	-4,121	-52,352	-99,406	-86,270	-49,542																									
Capitalized Interst (KSSA)	0	-50	-729	-2,555	-4,790	-6,424																									
Assets Acquired (TOC)		0	0	0	0	-51,832	-1,218	0	0	0	0	0	0	-1,107	0	0	0	0	0	0	-1,107	0	0	0	0	0	0	-1,107	0	0	0
Capitalized Interset (TOC)						-1,318																									
Net Cash Used by Investing Activities	-3,962	-4,171	-53,081	-101,961	-91,060	-109,116	-1,218	0	0	0	0	0	0	-1,107	0	0	0	0	0	0	-1,107	0	0	0	0	0	0	-1,107	0	0	0
CASH FLOWS FROM FINANCING ACTIVITIES																															
Proceeds from Long-Term Borrowings (KSSA)	0	3,492	44,366	84,242	73,110	41,985	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paid-in Statutory Capital from the Government to KSSA	3,962	629	7,986	15,164	13,160	7,557																									
Repayment to Long-Term Debt (KSSA)	0	0	0	0	0	0	-19,726	-19,726	-19,726	-19,726	-19,726	-19,726	-19,726	-19,726	-19,726	-19,726	-19,726	-19,726	-9,863	0	0	0	0	0	0	0	0	0	0	0	0
Proceeds from Long-Term Borrowings (TOC)						39,932	938	0	0	0	0	0	0	938	0	0	0	0	0	0	938	0	0	0	0	0	0	938	0	0	0
Paid-in Capital from the Sock Holders (TOC)						7,188	169							169							169							169			
Repayment to Long-Term Debt (TOC)	0	0	0	0	0	0	-2,576	-2,701	-2,701	-2,701	-2,701	-2,701	-2,701	-2,701	-2,764	-2,701	-2,701	-2,701	-2,701	-2,701	-2,701	-1,476	-125	-125	-125	-125	-125	-125	-188	-125	-125
Proceeds from Short-Term Borrowings (KSSA)																															
Repayment Short-Term Borrowings (KSSA)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0															
Net Cash Provided by Financing Activities	3,962	4,121	52,352	99,406	86,270	96,662	-21,195	-22,428	-22,428	-22,428	-22,428	-22,428	-22,428	-21,321	-22,490	-22,428	-22,428	-22,428	-12,564	-2,701	-1,594	-1,476	-125	-125	-125	-125	-125	982	-188	-125	-125
NET INCREASE IN CASH	0	-50	-729	-2,555	-4,790	-12,454	-15,239	-12,282	-8,316	-5,331	-2,347	638	3,623	6,579	9,474	12,524	13,246	13,968	24,484	34,737	34,870	36,212	37,631	37,638	37,646	37,653	37,661	37,640	37,558	37,631	37,638
Cash Ending	0	-50	-779	-3,334	-8,124	-20,578	-35,817	-48,099	-56,415	-61,746	-64,093	-63,455	-59,832	-53,253	-43,779	-31,256	-18,010	-4,041	20,442	55,179	90,049	126,261	163,892	201,530	239,175	276,828	314,489	352,129	389,687	427,317	464,955
Balance Sheet (EURO'000s)																															
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
CURRENT ASSETS	0	-50	-779	-3,334	-8,124	-20,578	-35,817	-48,099	-56,415	-61,746	-64,093	-63,455	-59,832	-53,253	-43,779	-31,256	-18,010	-4,041	20,442	55,179	90,049	126,261	163,892	201,530	239,175	276,828	314,489	352,129	389,687	427,317	464,955
Cash and Cash Equivalent Investments	0	-50	-779	-3,334	-8,124	-20,578	-35,817	-48,099	-56,415	-61,746	-64,093	-63,455	-59,832	-53,253	-43,779	-31,256	-18,010	-4,041	20,442	55,179	90,049	126,261	163,892	201,530	239,175	276,828	314,489	352,129	389,687	427,317	464,955
PROPERTY, PLANT AND EQUIPMENT	3,962	4,171	57,252	159,213	250,273	359,389	353,735	346,863	339,991	333,119	326,247	319,375	312,503	306,738	299,866	292,994	286,122	279,250	272,378	265,506	259,741	252,869	245,997	239,125	232,253	225,381	218,509	212,744	205,872	199,000	192,128
Construction in Progress (KSSA)	3,962	4,171	57,252	159,213	250,273																										
Fixed Assets (KSSA)						306,240	306,240	306,240	306,240	306,240	306,240	306,240	306,240	306,240	306,240	306,240	306,240	306,240	306,240	306,240	306,240	306,240	306,240	306,240	306,240	306,240	306,240	306,240	306,240	306,240	306,240
Fixed Assets (TOC)						53,150	54,367	54,367	54,367	54,367	54,367	54,367	54,367	54,367	54,367	54,367	54,367	54,367	54,367	54,367	54,367	54,367	54,367	54,367	54,367	54,367	54,367	54,367	54,367	54,367	54,367
Accumulated Depreciation (KSSA)							-5,416	-10,832	-16,248	-21,663	-27,079	-32,495	-37,911	-43,327	-48,743	-54,158	-59,574	-64,990	-70,406	-75,822	-81,238	-86,654	-92,069	-97,485	-102,901	-108,317	-113,733	-119,149	-124,565	-129,980	-135,396
Accumulated Depreciation (TOC)							-1,456	-2,912	-4,368	-5,825	-7,281	-8,737	-10,193	-10,542	-11,998	-13,455	-14,911	-16,367	-17,823	-19,279	-19,628	-21,084	-22,541	-23,997	-25,453	-26,909	-28,365	-28,714	-30,171	-31,627	-33,083
TOTAL ASSETS	3,962	4,121	56,473	155,879	242,149	338,812	317,918	298,764	283,576	271,373	262,155	255,920	252,671	253,485	256,087	261,738	268,112	275,209	292,820	320,685	349,790	379,130	409,889	440,655	471,428	502,209	532,998	564,873	595,559	626,317	657,083
CURRENT LIABILITIES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Short-Term Borrowings (KSSA)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LONG-TERM LIABILITIES	0	3,492	47,859	132,101	205,211	287,128	265,764	243,336	220,909	198,481	176,054	153,626	131,199	109,709	87,219	64,792	42,364	19,936	7,316	4,052	2,289	813	688	563	438	313	188	1,001	813	688	563
Long-Term Loans (KSSA)	0	3,492	47,859	132,101	205,211	247,196	227,470	207,744	188,018	168,291	148,565	128,839	109,113	89,387	69,660	49,934	30,208	10,482	562	0	0	0	0	0	0	0	0	0	0	0	0
Long-Term Loans (TOC)	0	0	0	0	0	39,932	38,294	35,593	32,891	30,190	27,489	24,787	22,086	20,323	17,559	14,857	12,156	9,455	6,753	4,052	2,289	813	688	563	438	313	188	1,001	813	688	563
CAPITAL	3,962	629	8,615	23,778	36,938	51,683	52,154	55,428	62,667	72,892	86,101	102,294	121,472	143,775	168,867	196,947	225,748	255,272	285,448	316,014	346,883	377,698	408,582	439,473	470,372	501,278	532,192	563,254	594,127	625,011	655,902
Paid-in Statutory Capital from the Government to KSSA	3,962	629	8,615	23,778	36,938	44,495	44,495	44,495	44,495	44,495	44,495	44,495	44,495	44,495	44,495	44,495	44,495	44,495	44,495	44,495	44,495	44,495	44,495	44,495	44,495	44,495	44,495	44,495	44,495	44,495	44,495
Paid-in Capital from the Sock Holders (TOC)						7,188	7,357	7,357	7,357	7,357	7,357	7,357	7,357	7,526	7,526	7,526	7,526	7,526	7,526	7,526	7,694	7,694	7,694	7,694	7,694	7,694	7,694	7,863	7,863	7,863	7,863
Retained Earnings							302	3,576	10,815	21,040	34,249	50,442	69,620	91,755	116,846	144,926	173,727	203,251	233,427	263,993	294,693	325,509	356,392	387,283	418,182	449,088	480,002	510,895	541,768	572,652	603,543
TOTAL LIABILITIES AND CAPITAL	3,962	4,121	56,473	155,879	242,149	338,811	317,918	298,764	283,576	271,373	262,154	255,920	252,671	253,485	256,086	261,738	268,112	275,209	292,764	320,066	349,172	378,511	409,270	440,036	470,810	501,591	532,379	564,254	594,940	625,699	656,465
Financial Indicators	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
PROFITABILITY																															
Rate of Return on Net Fixed Assets (Criterion: over 7%)							2.7%	3.4%	4.4%	5.2%	6.0%	6.9%	7.7%	8.6%	9.6%	10.6%	10.8%	11.1%	11.4%	11.6%	11.9%	12.2%	12.6%	12.9%	13.3%	13.7%	14.2%	14.5%	15.0%	15.5%	16.1%
OPERATIONAL EFFICIENCY																															
Operating Ratio (Criterion: under 0.7- 0.75)							0.56	0.51	0.45	0.42	0.39	0.36	0.34	0.32	0.30	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
Working Ratio (Criterion: under 0.5- 0.6)							0.25	0.25	0.22	0.20	0.19	0.17	0.16	0.15	0.15	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
LONG-TERM SOLVENCY																															
Debt Service Coverage Ratio (Criterion: over 1.0)							0.52	0.60	0.73	0.82	0.92	1.02	1.13	1.25	1.36	1.50	1.54	1.59	2.84	12.33	12.89	23.76	219.79	229.82	240.81	252.90	266.27	232.47	154.39	219.79	229.82

Source: JICA Study Team

CHAPTER 9 NATURAL CONDITIONS

9.1 Meteorological Condition

Lithuania experiences two climatic patterns, namely maritime and continental. Klaipeda is located in a region subject to maritime weather and has a monthly average mean temperature of 14 to 17 degrees in summer and –3 to 0 degrees in winter.

The monthly average wind velocity is slightly higher in the winter season and varies between 4.0 and 6.0 m/sec throughout the year (see Table 9.1). The prevailing average wind direction is easterly in autumn, westerly to southerly in winter, westerly to northerly in spring, and westerly in summer. The maximum wind velocity of 38 m/sec (in a westerly direction) was observed in December 1999.

Table 9.1 Mean and Maximum of Average Wind Velocity (1993-2002)

(Unit: m/sec)

Year/ Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	5.7	5.9	4.9	4.0	3.7	4.0	3.9	3.7	4.1	5.2	5.3	5.4
Maximum	32	28	28	20	18	23	32	19	25	31	32	38
	WSW	SE, SSW	SW	NW, S	NW, W	WSW	S	SE	S	WSW	WSW	W

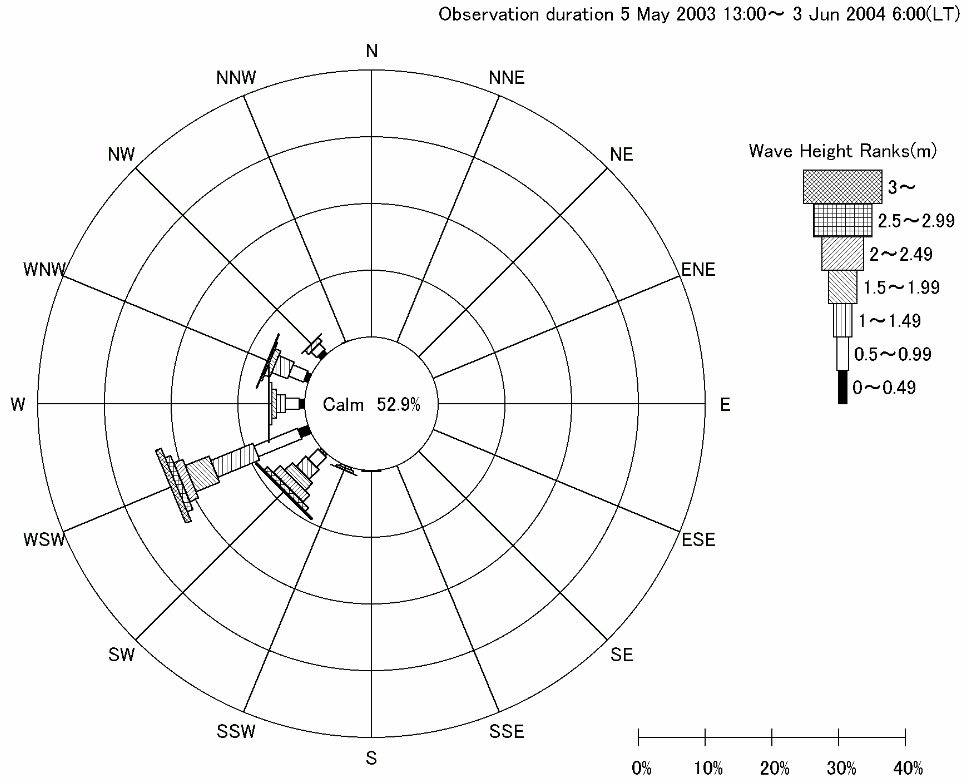
Source: Meteorological Station Centre

The Curonian Lagoon (the Lagoon) freezes in winter, but most of the Port area remains ice-free. In mild winters and when ice begins to thaw in spring, ice blocks drift from the Lagoon into the Klaipeda Strait. January, February, and March experience days with ice, however, it is not too thick to cause problems to ship navigation.

9.2 Oceanographic Condition

(1) Wave

The deepwater wave climate around the Port has been hindcast based on wind data from the British Meteorological Office and was further confirmed through on-site data collected from the wave recorder. The latter was installed by the JICA Study Team at a water depth of 20 m off the existing breakwater. On this basis, a wave pattern in the Klaipeda region has been prepared and is illustrated in Figure 9.1.



Significant wave height in each mean wave direction

Source: JICA Study Team

Figure 9.1 Frequency Distribution for Each Wave Direction

The preliminary assessment of offshore wave characteristics are outlined below:

- Waves less than 1.0 m in height occur some 73% of the time while heights of 1.5 m occur some 87% of the time. Waves higher than 3.0 m occur several times per month.
- Waves from the W-WSW direction have a high frequency, while those from the WSW occur 66% of the time.
- Wave periods with a frequency less than 6.0 seconds occur 90% of the time.

It is reported the entrance area of Klaipeda Port has been subject to long-period waves causing mooring problems for vessels. The wave measurement by the JICA Study Team revealed the average periodicity of long-period waves ranges from 40 to 45 seconds, while the long-period waves account for 5-8% of total wave numbers.

(2) Coastal Currents

The dynamics of water mass in the Baltic Sea are principally determined by the atmospheric processes, which cause annual changes in current velocities. The coastal currents in the Baltic Sea circulate anti-clockwise and flow northwards near Klaipeda. The surface water movements are significantly influenced by the river flows. The fresh water from the Lagoon to the Klaipeda Strait flows in a northerly direction at a speed of less than 0.5 m/s. During the floods in spring, the fresh water spreads some 9-11 miles from the shore at a depth of 5 to 14 m.

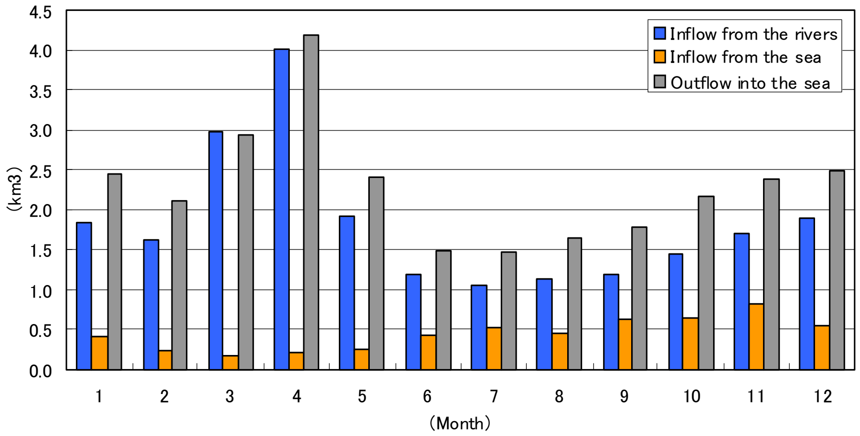
9.3 Hydraulic Condition of Lagoon

(1) Water Flows and Water Levels

Water Flows into/out of the Lagoon

Water flows in the Lagoon were studied in the EIA report on the dredging of the entrance channel (up to -12.5 m) by LEI in 2002. The results of study are summarized below:

- The total catchment area of the rivers flowing into the Lagoon is 100,458 km^2, of which 98% is covered by the Nemunas basin. The average total inflow from the rivers is 22 km^3/year, with a seasonal breakdown of 41.6% in spring, 15.6% in summer, 19.9% in autumn and 22.9% in winter.
- Annually about 26.5 km^3 of water flows out from the Lagoon to the sea. Some 50% flows in spring, 15% in summer and the remaining 35% in autumn and winter.



Source: Lithuanian Energy Institute

Figure 9.2 Water Balance Between Curonian Lagoon and Baltic Sea

Water Levels of the Lagoon

The Baltic Sea Level (BSL) is based on the mean water level in St. Petersburg and is used as the standard sea water level by the coastal countries of the Baltic Sea, including Klaipeda Port.

Figure 9.4 shows the monthly average water levels measured at three points (Pionersk - facing the Baltic Sea, Juodkrante – inside the Lagoon, and Klaipeda Port) during the period from 1955 to 1996. According to this data, the water level in the Baltic Sea changes seasonally, falling approximately 15 cm below BSL in spring and rising approximately 5 cm above BSL in winter. In addition, the water level inside the Lagoon is marginally higher than that of the Baltic Sea.

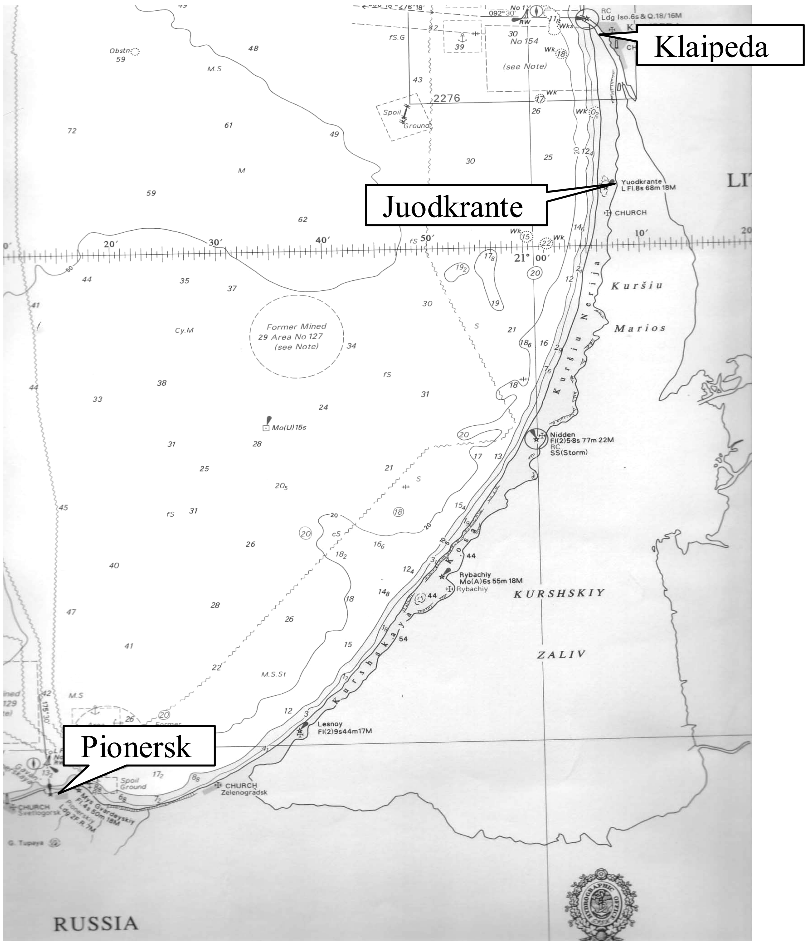
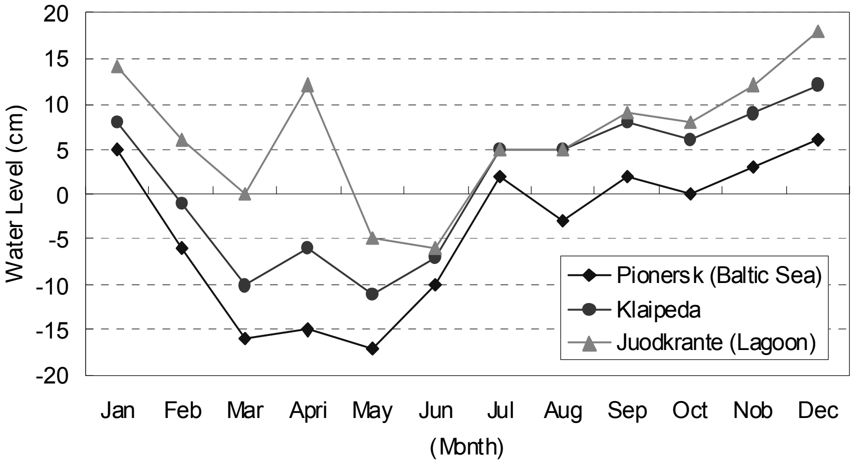


Figure 9.3 Location of Measuring Points of Water Level



Source: Lithuanian Energy Institute

Figure 9.4 Average Water Level in the Project Area (1955-1996)

(2) Current, Salinity and Turbidity

The currents inside the Lagoon are discussed in the Geochemistry of Sediments of the Curonian Lagoon (Institute of Geography, 1998) and are outlined below:

- Currents in the Lagoon are predetermined by river runoff, wind, and the inflow of saline waters. The bottom relief and configuration of the shoreline are stabilized by the effects of the currents.
- A stable water mass movement induced by the Nemunas basin water discharge can be observed in the northern part of the Lagoon. Its main flow moves northwards through a narrow belt extending from the Ventes Ragas Cape to the Klaipeda Strait, sometimes widening to the central part of the Lagoon.
- In the southern part of the Lagoon, the current regime is mainly governed by wind action. The relief of the shallow depression is dominant over a water depth of 4 m to 5.8 m.
- A stable flow towards the entrance of the Port has always been observed in the Klaipeda Strait. Flow velocity approaches 0.4 to 0.5 m/s at several locations. A flow towards the Lagoon appears particularly after strong winds blow west to northerly. Generally, current speed is fast in the upper layer and decreases proportionally with depth.
- The current directions inside the Lagoon have not always been stable. Current velocity and direction have often differed between upper and lower layers. This probably reflects the dependence of flow inside the Lagoon on water discharge and wind conditions.
- According to existing data (e.g. Sedimentary Material in the Transitional Aquasystem, Vilnius, 1997) salinity changes daily. From the measurement results, the characteristics are summarised as follows: 1) Saline water has been located only in the lower layer when it is not eccessively stirred by the wind. As saline water has also been located in the lower layer of the channel, it approaches the ferry terminal at the inner part of the Port; 2) After strong winds, highly saline water has been measured in the upper layer of the inner part of the Port area. Occasionally, it has extended up to a distance of 10 km into the inner areas from the entrance of the Port.

9.4 Topographic and Bathymetric Conditions

(1) Topography and Bathymetry

The Port and Klaipeda City are located in flat and low-lying land rising gradually some 20 to 30 m to the east of the City. These are areas of higher ground bisected by the Dane River and Minija River that flow in a north-south direction. To the west of the Port is the Curonian Spit, which is a narrow sandy peninsula consisting of coastal dunes and forest. The Curonian Spit is an arc-shaped strip of land, 50.8 km long in the territory of Lithuania. Along the coast, the Curonian Spit extends to form a beach some 20 to 55 m wide. Behind the beach, dunes extend 4 to 12 m in height and 30 to 150 m in width.

The water depth of the Lagoon averages 3.8 m, but deepens towards the western bank closer to the Port. The southern half of the Port channel is 8 to10 m deep and is slightly greater in certain areas, including the berths of the International Ferry Terminal. The water depth increases to 12 m to the north of “Bega” jetties, and reaches 14 m at the Nafta and Klasco terminals.

Along the coast, the beach slopes gradually down to the Baltic Sea. The seabed off the port entrance reaches a water depth of 15 m some 2 km offshore and 50 m some 30 km offshore.

9.5 Geological Condition

In the port area, two types of historic deposits exist. Both formed during the Pleistocene and Holocene eras when the Baltic Sea was created. Morainic till was deposited in the ice flows of the Pleistocene era and remains over a 40 m thick belt of loam, containing gravel, pebbles and boulders. Above this lies a 5 to 8 m thick surface layer of younger deposits comprising sand, peat and other organic matter.

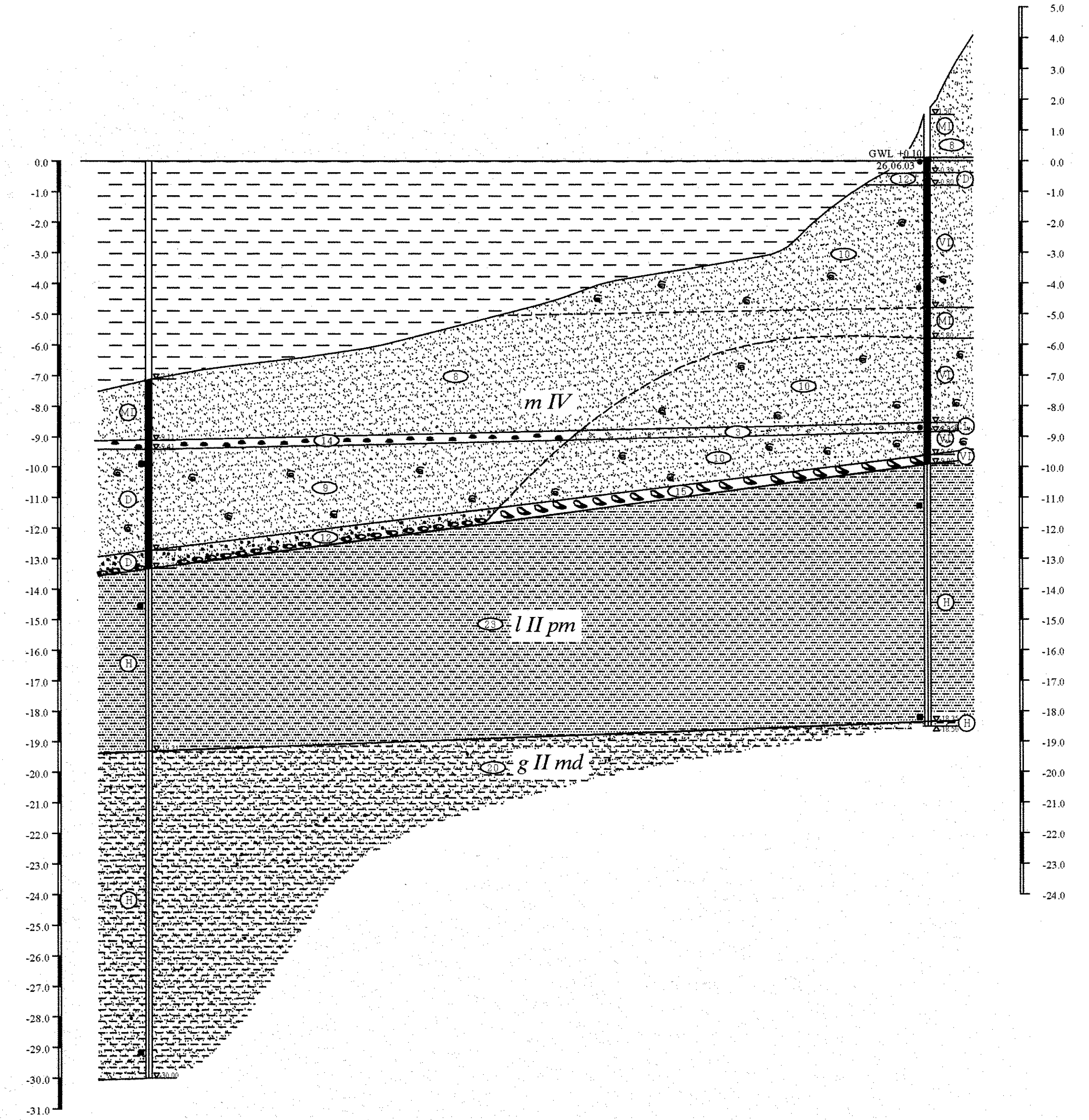
The recent sediments in the Klaipeda Strait consist of unevenly spread materials from the Lagoon and sea. This reflects the sedimentation processes, which are influenced by currents, waves and the activities of man, primarily dredging.

Four deep bores were drilled in the northern part of Klaipeda Port, close to its entrance during the period of the “Rehabilitation Project (1998)”, under the assistance of the World Bank.

Offshore and onshore bores were drilled by the JICA Study Team in the southern and northern parts of the Port area. A cross-section for the outer port zone is shown in Figure 9.5, while a cross-section perpendicular to the shore line in the inner port area is shown in Figure 9.6.

Figure 9.5 shows the borders between the sandy layer and silty clay layer. The sandy layer extends down to -9.0 to -13.0 m BSL and is underlain by the silty clay layer with a downward slope of 5%. This is consistent with the seabed. Gravels and cobbles appear at the bottom of the sandy layer. The sandy clay layer underlies the silty clay layer at elevations from -18.0 to -19.0 m BSL.

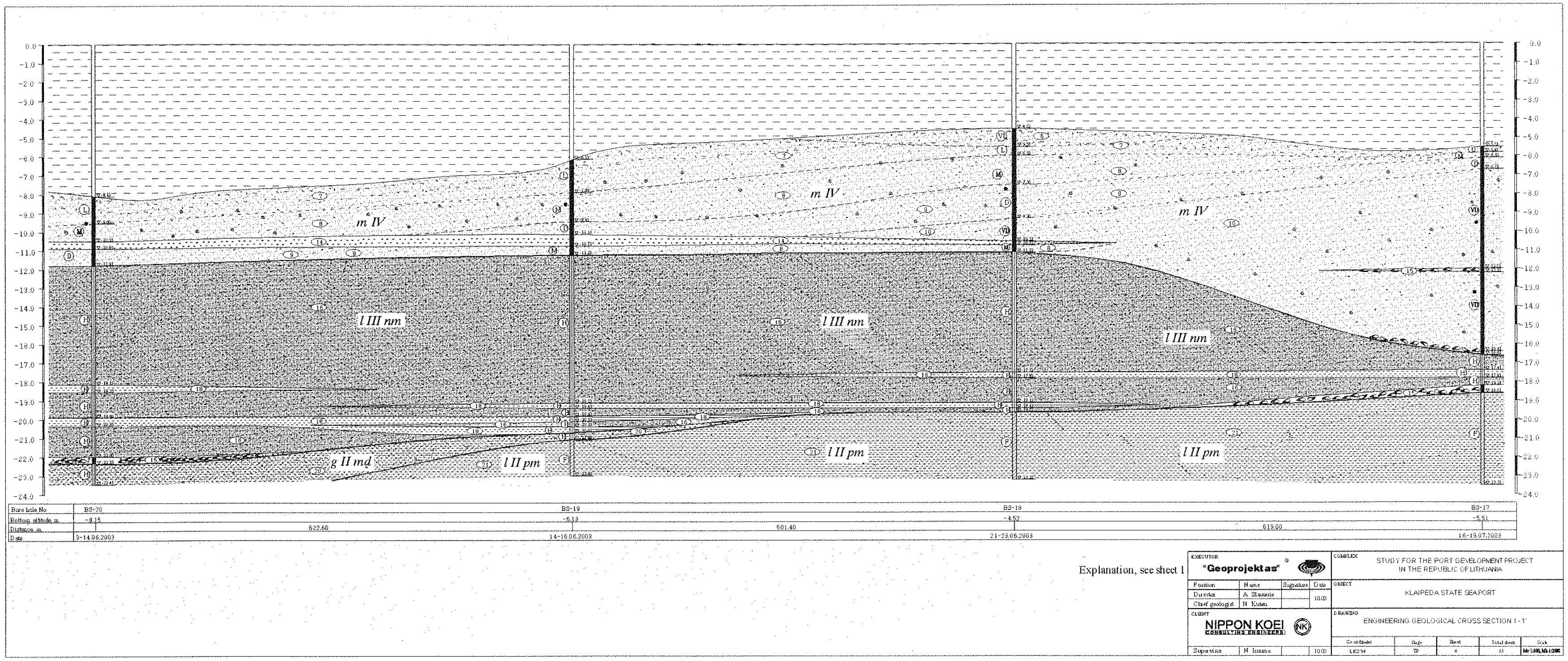
Although the geological profile of Figure 9.6 is almost the same as that in Figure 9.5, some mixed layers also appear, partly in the southern areas. The bottom of the sand layer varies in elevation from -12.0 to -16.0 m BSL, while the silt layer varies between -22 and –19 m BSL.



Bore hole No	BS-2	BL-2
Bottom altitude, m	-7.11	1.50
Distance, m	635.9	
Date	30.07.2003	26-28.06.2003

Source: The JICA Study Team

Figure 9.5 Geological Profile of Outer Port Zone



Source: The JICA Study Team

Figure 9.6 Geological Profile of Inner Port Zone

9.6 Sediment Investigation

Existing Sediment Sampling

The sediment inside the Port area was periodically sampled and tested by KSSA in order to monitor the level of pollution on the seabed. The test items include concentrations of oil products, Cu, Pb, Zn, Ni, Cd, Cr and Hg.

Sediment Analysis by the JICA Study Team

The seabed samples have been taken from both inside and outside the Lagoon, and tested to analyze their physical and chemical characteristics.

The sediment analysis shows that the fine sand is dominant outside the Lagoon, where heavy metals, oil products and organic matter are low in concentration. In the existing inner port area, there is also a low concentration of polluted materials. The seabed profiles, particularly of muddy (silty) layers, have been sounded using an echo-sounder equipped with two frequency bands (200 kHz and 33 kHz). The silt layers were found to be thick in the following areas, which also concurs with the geographical distribution based on the results of KSSA:

- Around the Port entrance
- Around Berth No.2
- Around the mouth of the Dane River
- Around Berth No.69
- Near Mulku Bay

CHAPTER 10 COASTAL ENGINEERING

10.1 Engineering Review of Historical Coastal Records

10.1.1 Littoral Drift and Beach Change in Lithuanian Coast

To determine the overall characteristics of littoral drift along the Lithuanian coast, it is essential to examine the wave characteristics and past records of shore line changes in and around the Port area. As such, the following coastal engineering aspects have been analyzed:

- Characteristics of incident waves
- Configuration of Lithuania and Kaliningrad coast lines
- Shape of beach line around the marine facilities near the Port
- Shape of beach line around the Port

(1) Analysis of incident waves

Based on the historical records of frequency distribution in the deepwater waves, the prevailing wave direction in the Port area is mainly from W-WSW. Consequently, it is assumed the northward flowing littoral drift would be predominant in and around the port areas.

(2) Analysis of the configulation of coast in Lithuania and Kaliningrad

Photo 10.1 was developed from a satellite photo in 2002. Through the interpretation of this photo, the littoral drift in the study area can be characterized as follows:

- The shore line inside the Lagoon, most of which is formed with dunes, is oriented towards the WSW direction. It is reasoned that this orientation has been established by the strong winds from the Baltic Sea, hence the prevailing direction of strong winds would be from WSW. As the waves in the Baltic Sea are generated mainly by the wind, it can be concluded that the prevailing wave direction is also from W to WSW.
- The shore line in the southern part of the Curonian Spit is oriented towards the northeast. As the incident waves (W-WSW) approach the shore line obliquely, this results in the existence of a northward flowing littoral drift. However, the shore line in the northern part of the Curonian Spit faces west. Therefore, the incident waves in this area approach the shore line more frontally and the magnitude of asociated littoral drift would be less than in the southern part.
- The Curonian Spit, which is narrowest in the southernmost portion, gradually widens towards the north, and reaches a maximum width around Nida near the border with Russia. This phenomena can be interpreted as a diminishing of the northward flowing drift closer to Nida, breaking the net accumulating balance towards Nida.

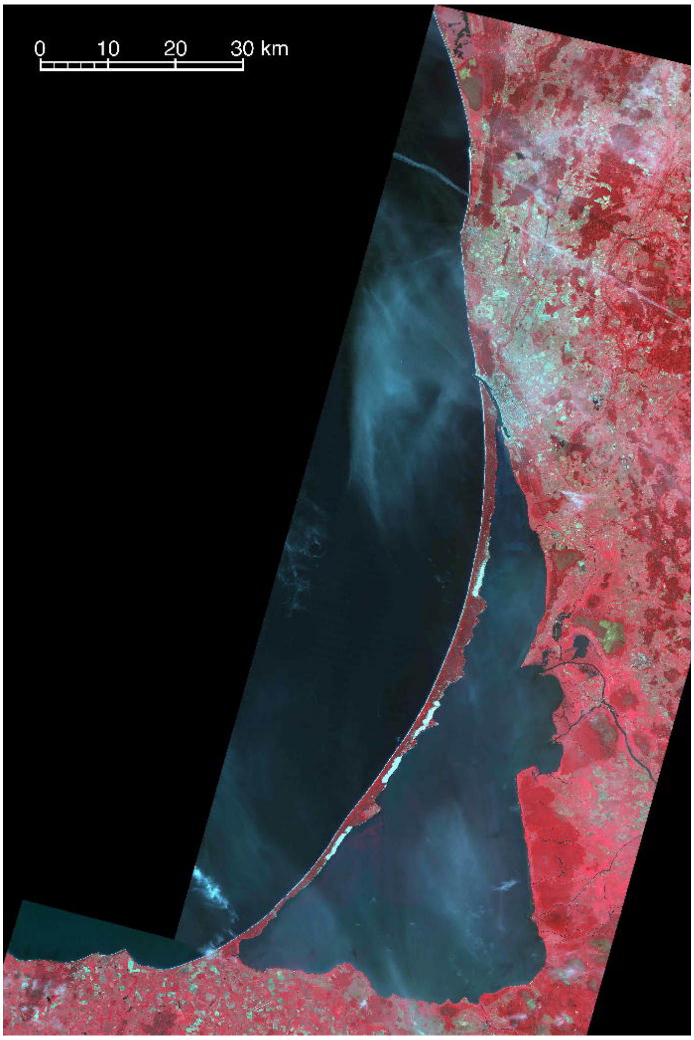


Photo 10.1 Satellite Photo in/around Lithuania

(3) Analysis of the Beach Line around Marine Facilities near the Port

Changes in the shore line frequently occur due to the existence of marine facilities around the Port. To identify these changes, which are induced by local littoral drift, aerial photos have been taken in Palanga and Sventoji using a helicopter. Photo 10.2 and Photo 10.3 show site conditions around Palanga and Sventoji, respectively. The jetty at Palanga seems to have caused few change in the shore line, because its structure is permeable.

There is a rock-mound jetty at Sventoji, which is about 35km north of Klaipeda Port. To the south of the jetty a wide stretch of natural beach extends. To the north, the shore line shows a gentle curvature, and becomes narrower in width. Unlike the shore formation noted at Sventoji, any change in the width of the beach cannot be seen in the vicinity of the port entrance of Klaipeda, where the shore line extends almost perpendicular to the direction of incident waves (W-WSW). This local climate reduces the possibility of inducing littoral drift.

Photo 10.2 Palanga

Photo 10.3 Sventoji

(4) Analysis of the Beach Line around the Port area

The historical changes in beach lines around the Port area have been examined and compared. The data analysed include the following:

- Technical report on long-term shoreline（Zilinskas, 2000）
- Geographical survey data (1953 and 1975)
- Aerial photographs (1991 and 1997)
- Satellite image photograph (2002)
- Shoreline monitoring data (1995 - 1999)

The construction of the breakwater commenced in 1835, and the present configuration was almost established by 1957. Figure 10.1 shows the changes in shoreline around the breakwaters from 1845 to 1993. The long-term shoreline changes around the breakwater can be examined by overlapping the past topographic maps and the results of shoreline measurements (Zilinskas, 2000).

It is understood the shore line advanced for 43 years from 1835, when the first breakwater was constructed, until 1878 when both breakwaters were completed. The retreat on the northern side is more remarkable than that on the south with the shoreline on the northern side appearing to have advanced around 1 km further.

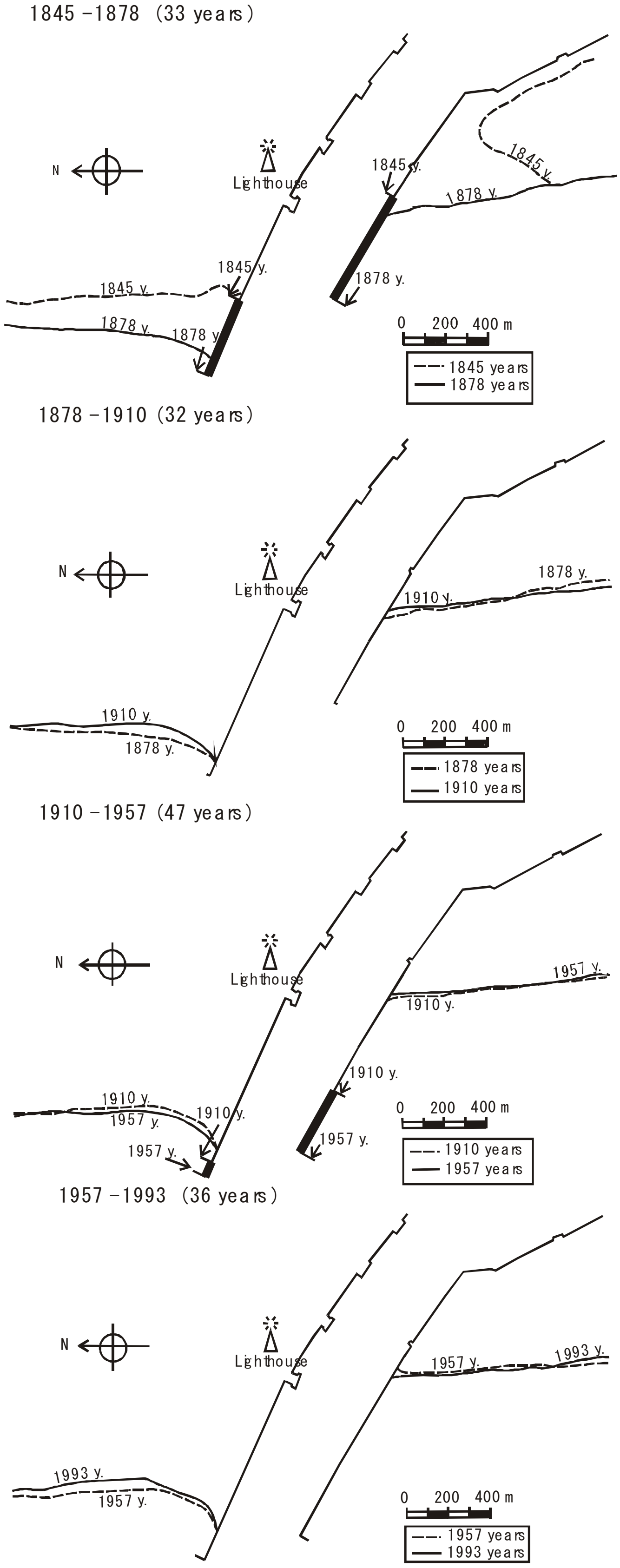


Figure 10.1 Long-Term Shoreline Change for Last 150 Years (Zilinskas, 2000)

This could be interpreted as implying the existence of a local south-bound littoral drift. Nevertheless, it can also be suggested the shoreline on the northern side was signficantly advanced prior to construction of the breakwaters. The shoreline on both sides advanced at the beginning of construction of the breakwaters and the recent appearance of a tendency of retreating northern shoreline is also apparent. From these facts, it is suggested a northward littoral drift has appeared, at least in recent years.

10.1.2 Sedimentation in the Port Area

(1) Balance of Suspended Load in the Lagoon (Review of Previous Study)

The balance of suspended load in the Lagoon (including port area) is discussed in the study on "The Only Lithuanian Seaport and Its Environment, 2003". The major points described in these documents are outlined below:

- The total amount of annual suspended load in the Lagoon is about 1,340,000 tons, with about 30% from the Nemunas River and 70% from the Lagoon. Some 60% of the total suspended load from the Nemunas River is a lithogenous product and 40% is a bioproduct. The suspended load from the Lagoon is mainly bioproduct.
- Most course-grained matter transported from the Nemunas River does not reach Klaipeda Port and remains in the Nemunas delta and delta front.
- The total annual amount of suspended load flowing into the Baltic Sea from the Lagoon is around 550,000 tons. The load flowing into the Lagoon from the Baltic Sea is around 33,000 tons.
- It is not clear what percentage of the total suspended load settles on the bottom. The sedimentation rate for suspended load in the Lagoon was assumed to be 25% in the previous 2003 study mentioned above. Using this figure, about 400,000 tons of sedimentation occurs annually in the Lagoon.
- Both suspended load and sedimentation increase greatly in the spring and summer seasons.
- In the port area, sediment sand exists at the port entrance to Berth No.5. This was transported from the Baltic Sea. In the other parts of the port area, silt and mud transported from the Lagoon or produced in the port area are dominant. The thickness of silt and mud is remarkable, particularly in the deeper part of the channel and stagnant areas (in terms of currents) in the port area.

(2) Sedimentation Analysis from Records of Dredging Volumes in the Port Area

To analyse sedimentation, the records of dredging volumes have been obtained from KSSA. In estimating sediment volume, the maintenance dredging data are invaluable. Based on the dredging data between 1960 and 2002, the annual average maintenance dredging volume is estimated at around 400,000 m^3, although the average dredging volumes over the last eight years have increased to about 480,000 m^3/yr. Figure 10.2 shows the annual average maintenance dredging volume for the period from 1994 to 2002 in each port area.

The following important points are noted:

- A large volume of maintenance dredging was executed in the vicinity of the port entrance and BAR (sea channel) areas totalling about 110,000 m^3 and 160,000 m^3, respectively.

- The annual maintenance volume in the central part of the port area is about 8,000 to 50,000 m^3.
- About 70,000 m^3 of maintenance dredging was executed in the vicinity of the international ferry terminal located in the deep inner part of the Port.

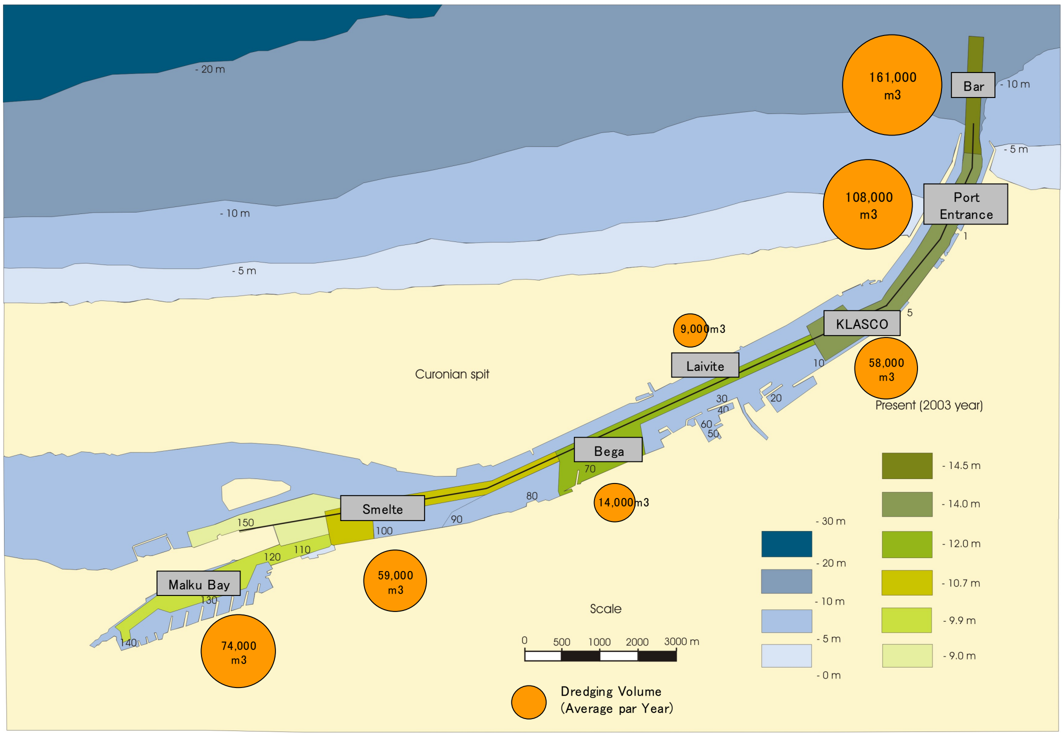


Figure 10.2 Dredging Volume in the Port Area (Annual Average)

10.2 Wave Analysis for Outer Port Basin

The wave analysis should be performed for both extreme and ambient conditions. The former are used mainly for the design of marine structures, and the latter in evaluating the port protection by the proposed breakwaters. In addition to this wave analysis, the long-period waves have also been studied, as the Port occasionally experiences such waves.

10.2.1 Deep Water Wave Analysis

The extreme statistics analysis has been performed in order to estimate offshore design waves. This was based on offshore wave data obtained from long-term wind observations. Table 10.1 shows the predicted offshore wave height and associated periodicity for a range of return periods. The wave height with a 50 year return period has been adopted as the appropriate offshore design wave height for structual design.

Table 10.1 Offshore Waves with Associated Return Period

Direction / Return Period	SW		WSW		W		WNW		NW	
	H0(m)	T0(s)	H0(m)	T0(s)	H0(m)	T0(s)	H0(m)	T0(s)	H0(m)	T0(s)
1 Year	3.8	6.5	4.3	6.5	4.9	8.0	3.6	6.5	3.1	6.5
2 Year	4.1	7.5	4.6	6.5	5.3	8.5	4.0	7.0	3.5	6.5
3 Year	4.3	7.5	4.8	8.0	5.6	8.5	4.2	7.5	3.7	6.5
5 Year	4.6	7.5	5.0	8.0	5.9	8.5	4.5	7.5	3.9	7.5
10 Year	4.9	7.5	5.3	8.5	6.3	9.0	4.8	7.5	4.2	7.5
20 Year	5.2	8.0	5.6	8.5	6.8	9.0	5.2	8.0	4.5	7.5
50 Year	5.6	8.5	5.9	8.5	7.3	9.0	5.6	8.5	4.9	7.5
100 Year	5.9	8.5	6.1	9.0	7.7	9.5	5.9	8.5	5.2	7.5

T0 is calculated by using the formula 2.8^{*}sqrt(H0)<TO<4.3^{*}sqrt(H0)
Source: British Meteorological Office

10.2.2 Nearshore Wave Analysis

The offshore waves have been transformed into nearshore waves to obtain design waves at representative points in the outer port. The nearshore wave heights have been computed using a parabolic approximate model of the Mild-Slope Equation, which can be applied to wave refraction and diffraction in an open wave field. The design waves at a point of -20 m depth for each offshore wave direction are listed in Table 10.2.

Table 10.2 Design Wave Characteristics (at -20m Depth)

Item	Offshore Wave Direction (degrees)	SW (225)	WSW (247.5)	W (270)	WNW (292.5)	NW (315)
Offshore	H_0 (m)	5.6	5.9	7.3	5.6	4.9
	T_0 (m)	8.5	8.5	9.0	8.5	7.5
-20m Depth	$H_{1/3}$ (m)	5.2	5.5	6.7	5.1	4.4
	Hmax(m)	9.3	9.8	12.1	9.1	7.8
	$T_{1/3}$ (s)	8.5	8.5	9.0	8.5	7.5
	θ(deg)	227	247	268	289	310

Source: Estimate by the JICA Study Team

10.2.3 Estimation of Calmness in Outer Port Basin

In order to achieve the optimum layout of breakwaters for the outer port development, the calmness inside the basin has been examined for ambient waves intruding into the port (Figure 10.3). In order to evaluate the calmness, six points have been selected as representative areas of the basin.

The desirable levels of calmness have been set up in consideration of ship/cargo handling patterns expected in the basin and quayside. The required calmness varies depending on ship characteristics. Generally, it needs to be less than 0.7 m for bulk carriers and 0.5 m for container ships. In the study, it has been determined that an occurence ratio of wave height less than 0.7 m should be obtained more than 95% of the time throughout the year.

Table 10.2 lists wave occurences of less than 0.7 m at each point of the outer port basin. The table also presents the occurence of waves less than 0.5 m for reference. The major points identified in the computation are summarised below:

- The occurence of waves less than 0.7 m is obtained for more than the target value of 95% in most areas of the outer port basin apart from areas “I” (Berth No.1) and “II”, which are located nearest to the port entrance.
- A high degree of wave calmness (almost 100%) is achieved in areas “IV” to “VI”.

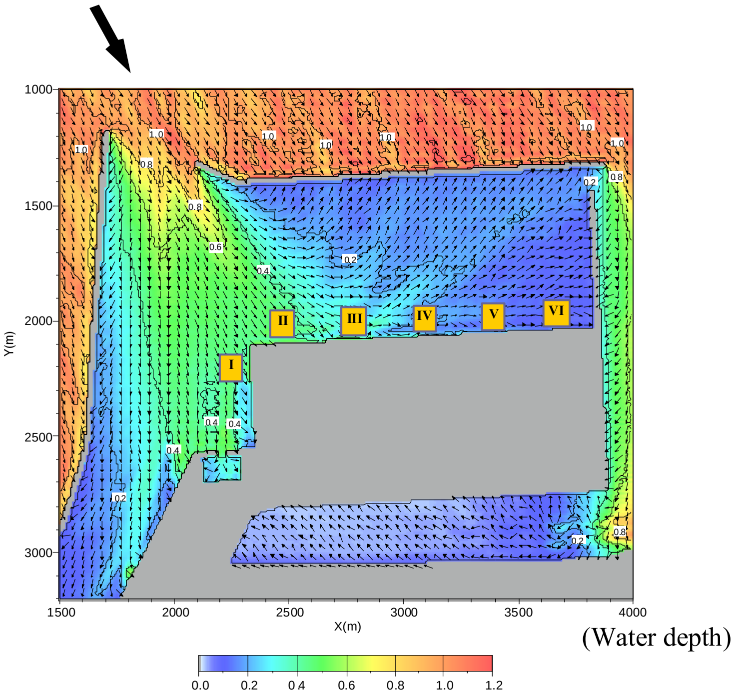


Figure 10.3 Example of Computational Result of Calmness (Incident Direction WNW)

Table 10.3 Wave Calmness for Each Point

Appearance Rate of Calmness (%)	Estimation Point					
	I	II	III	IV	V	VI
$H_{1/3} < 0.7$m	94	88	96	100	100	100
$H_{1/3} < 0.5$m	85	77	92	97	97	100

Source: Estimate by the JICA Study Team

10.2.4 Influence of Long-Period Waves

Ship motion is normally generated as a result of long-period waves. These are generally defined as those with a period of more than 20 to 30 seconds and the magnitude of ship motion depends on the size of each ship. Based on the example of field investigations for waves and ship motion for a coal carrier (36000 GT, L=225 m) moored at Tomakomai Port in Japan, ship motion increases in proportion to the growth of long-period waves. These data indicate long-period waves with a height of 0.15 m to 0.2 m are critical to secure safe cargo handling. Furthermore, a Delft Hydraulics (1995) Report indicates vessels larger than 15,000 DWT mooring in the existing oil berth of the Port have long been affected by long-period waves greater than 0.25 m in height.

Of the waves approaching the Port, the long-period wave component accounts for 5% to 8%. In this section, the influence of long-period waves on movement of ships mooring in the existing port entrance and outer port has been assessed by considering the effects of removing the existing northern breakwater. This was based on numerical computation for long-period wave propagation.

Point-1: *How far the removal of the existing northern breakwater and newly aligned outer breakwater will affect efficient berth operation.*

The relative wave height at the point of the existing oil berth (x = 800 m) is very small and approximately 0.15 for both cases of with and without the existing northern breakwater (Figure 10.4). For example, even if an offshore wave with a height of 4 m is propagating, the height of long-period waves is less than 10 cm. From this, it is understood the removal of the existing northern breakwater will have no negative impact on the characteristics of long-period wave propagation. Figure 10.5 shows the relative wave height for both cases of present and outer port development. The relative wave height for the outer port development plan at the point of the existing oil berth is approximately 0.1, less than that for the present case. Based on this, the outer port development plan is effective in reducing the long-period wave height at the position of the existing oil berth.

Point-2: *How far the intrusion of long-period waves will influence the cargo handling operation in the new oil berth.*

The relative wave height at the position of the new oil berth (I) is estimated to be between 0.3 and 0.4. This value is greater than that at the location of the existing oil berth. As a result, there is a possibility the long-period waves with the same degree or greater will intrude into the new port basin when compared to conditions for the existing port area. If the offshore wave height is assumed to be 4 m as previously, the long-period wave height at the new oil berth location is estimated to be approximately 10 cm. This value is less than the critical wave height for cargo handling. (For detailed discussion of the influence of long-period waves it is necessary to accumulate further data for waves and cargo handling conditions.)

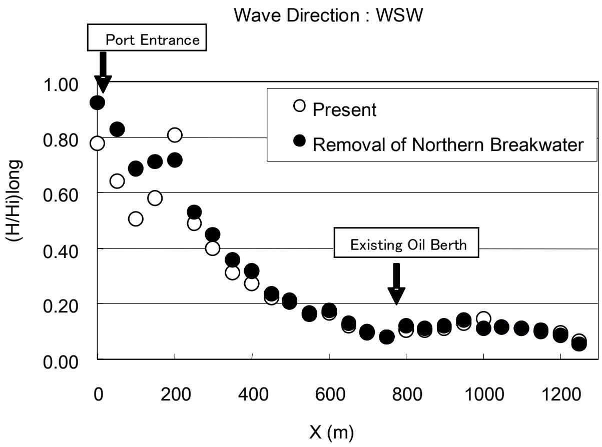


Figure 10.4 Distribution of Relative Wave Height for Long-Period Waves in Existing Channel (Comparison With and Without Existing Northern Breakwater)

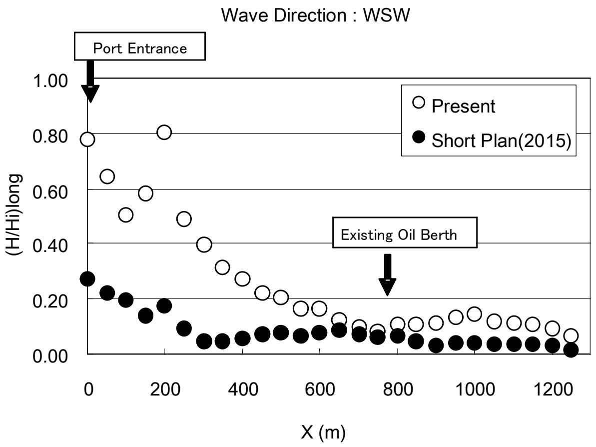


Fig.10.5 Distribution of Relative Wave Height for Long-Period Waves in Existing Channel (Comparison of Present and Outer Port Plans)

10.3 Sedimentation Analysis for Inner Channel

In Chapter 4, “Master Plan of Klaipeda Port”, the possibility of developing the inner port expansion has been studied. As part of the study, the change in the sedimentation rate in the expanded and deepened inner channel was raised as one of the technical study points. Therefore, the extent and magnitude of likely sedimentation associated with the inner port expansion has been examined based on numerical computation using the Mud Transportation model.

Based on the computations, measured sedimentation in the port area was accurately simulated, with low sedimentation rate around the Kiaules Nugara Island and near the port entrance (due to accelerating the current velocity), and high sedimentation rate around the International Ferry Terminal, Malku Bay, and Inner Port (where the fresh water is stagnant).

Numerical computations for cases representing present conditions and those after construction were then undertaken. Figure 10.6 shows the comparison of sedimentation rates for each port area.

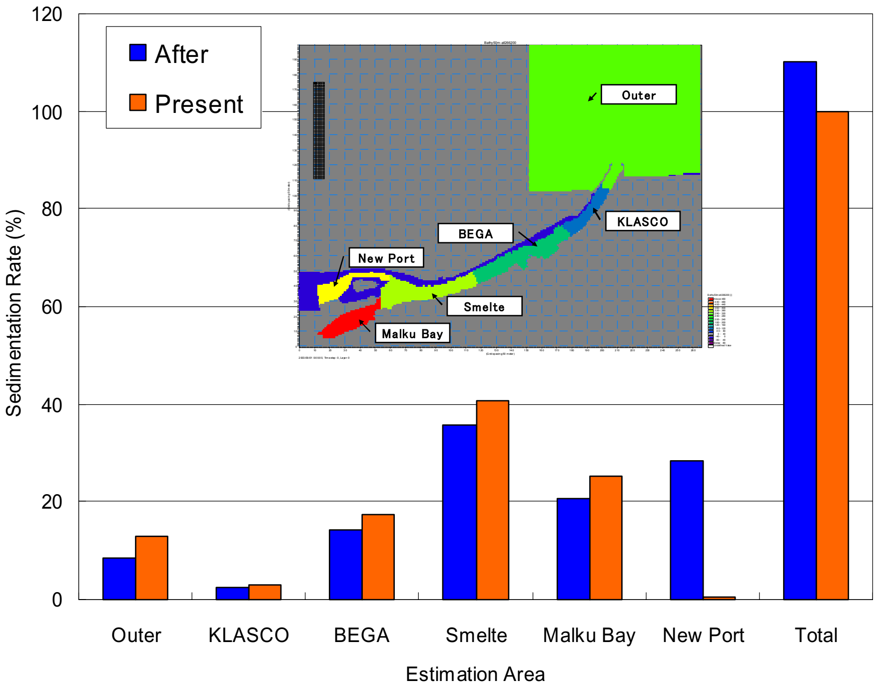


Figure 10.6 Comparison of Sedimentation Rate Before and After Construction

- Sedimentation volume in the planned inner port area is almost the same as that at the Smelte berths and Malku bay. As the maintenance dredging volume is 50,000 to 70,000 m^3/year at the Smelte berths and the Malku bay, there is a possibility similar sedimentation will occur in the planned inner port area after construction.

10.4 Analysis on Salinity Intrusion

The Port is located close to the Baltic Sea and is associated with a salinity intrusion zone in the Lagoon. The area inshore of the existing port zone is, however, marginally affected by salinity intusion. Salinity is a very sensitive factor to the ecological system in the Lagoon. The water-intake canals exist near the proposed inner port zone to tap city water. Any change in salinity in these areas due to the inner port expansion would be critical. This section deals with salinity intrusion in the port area.

10.4.1 Salinity Characteristics in the Port

The field observations undertaken by the JICA Study Team confirmed that the vertical distribution of salinity in the port area was greatly influenced by wind and wave conditions. When calm, the saline water stagnates only near the bottom of the dredged navigation channel, while the remaining seabed is covered by fresh water. Conversely, when strong winds blow the salinity concentration extends from the bottom to the surface. The salinity concentration is less, however, in the surface areas compared to the bottom layers.

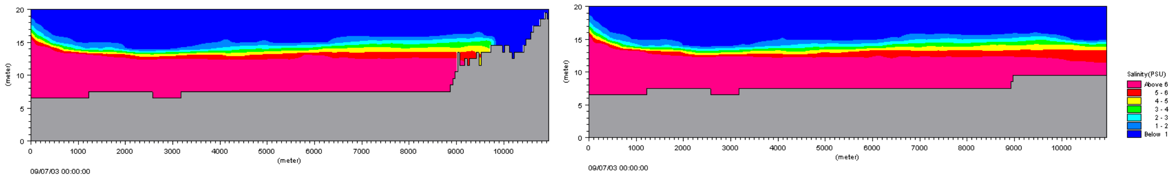
10.4.2 Influence of Salinity Intrusion on Inner Port Plan

The influence of salinity intrusion on the inner port development has been examined by using a three-dimensional numerical computation model of salinity diffusion (Figure 10.7).

The expected influence of salinity after construction of the inner port is outlined below:

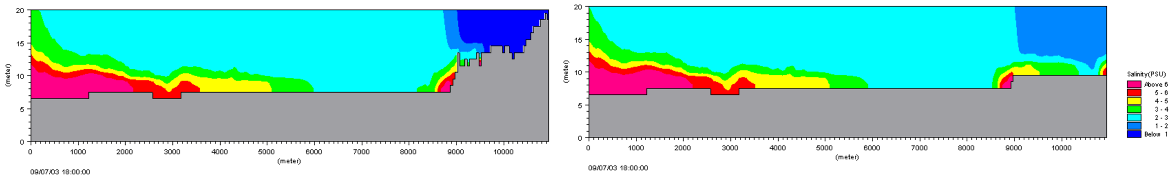
- Under calm conditions, stratification (a saline water / fresh water interface) is formed and saline water doesn't appear at the inner port area (shallow water region). On the other hand, after construction of the inner port, saline water always stagnates in the vicinity of the bottom layer due to an increase in water depth resulting from channel dredging.
- When strong winds blow, water area is disturbed and the stratification is destroyed. As a result, saline water can be detected throughout the port area due to vertical mixing of the saline water from the bottom of the existing channel and by accelerating sea water intrusion from the port entrance. Salinity will increase in comparison to the present condition after construction of the inner port.

After 6days (No Wind, Steady Condition)



(1) Calm Condition (No Wind)

After 18hours from starting strong wind



(2) Storm Condition (Strong Wind)

Figure 10.7 Vertical Distribution of Salinity in Existing Channel
(Left Side: Present, Right Side: After Inner Port Development)

10.5 Sedimentation Analysis for Outer Channel

10.5.1 General

The mechanism of sedimentation on the sea channel is different from that inside the port area. The influence of sand drift on the outer port, including its channel portion, has been examined based on the following two methods:

- Estimation based on the critical water depth for sediment transport
- Estimation based on the actual sediment situation in the existing sea channel

In addition, the influence of the suspended load from the Lagoon has been examined using the numerical Mud Transportation model.

10.5.2 Estimation of Critical Water Depth for Sediment Transport

The water depth of the port entrance should be greater than the critical water depth that causes sediment transport. In order to assess the critical water depth, several methods have been applied as outlined below.

(1) Analysis from the shape of contour line around the existing outer channel

Figure 10.8 shows the water depth contour lines around the existing outer channel. The contour lines deeper than –13 m bend with acute angles, and are almost at right angles. On the other hand, contour lines shallower than –12 m curb with rounded shapes. It can be inferred that this change in shape from acute to obtuse angles is attributable to the existence of substantial sediment movements around the shoulder portion of the channel slope. Based on this fact, it can be assumed the critical water depth for sediment transport is about 12 m to 13 m.

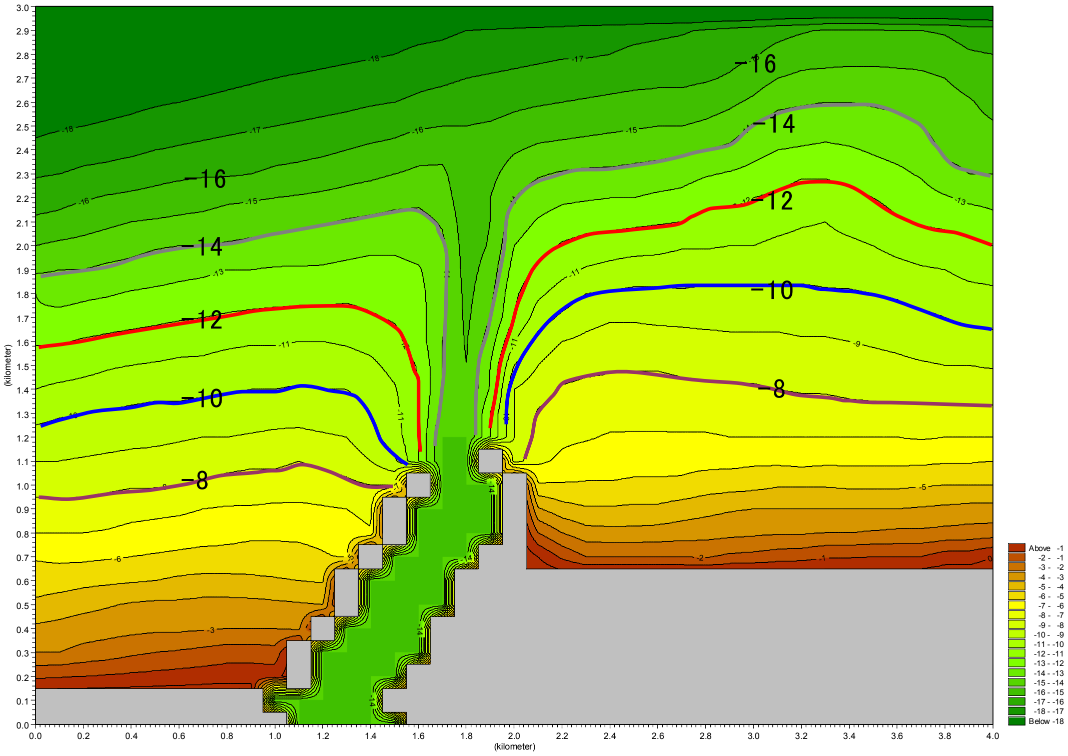


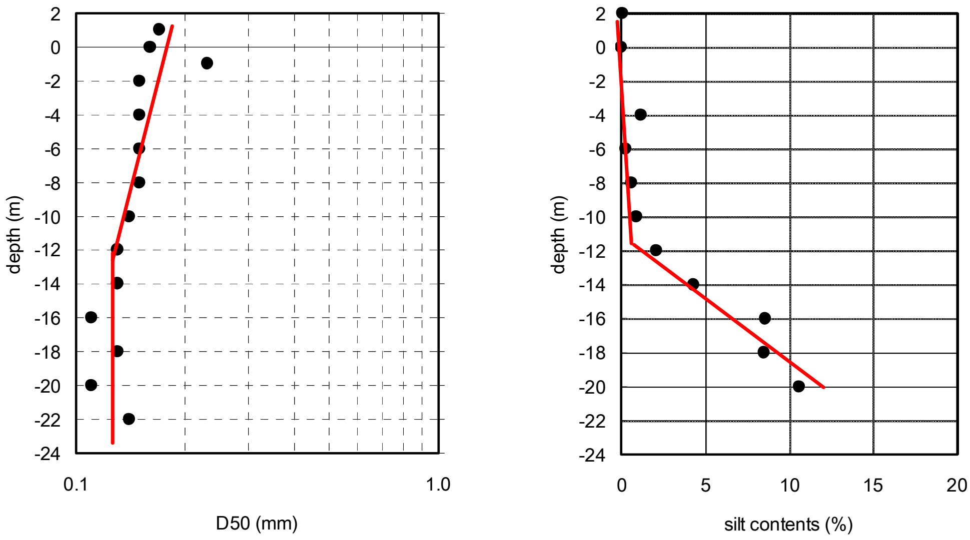
Figure 10.8 Contour Line Around Existing Outer Channel

(2) Analysis using the calculation formula with offshore wave condition and mean grain size

A calculation formula incorporating the offshore wave condition and mean grain size has been used in estimating critical depth of sedimentation, as proposed by Dr. Sato and Dr. Tanaka. As the critical depth of sedimentation is calculated for each wave condition, it is difficult to set up the offshore wave condition in this calculation. It is, however, known that a substantial part of the sediment transport is generated by a stormy climate with high-wave energy, but low appearance. Therefore, peak wave heights during storms that appear about once a month have been extracted from the wave observation results. These show the existence of wave heights of 2.7 to 2.8 m. As such, the average wave of $H_{1/3}$ = 2.75 m has been selected as the representative wave height. The mean grain size (D_{50}) in this area is distributed between 0.12 to 0.2 mm. Applying this wave condition and the D_{50} value, the critical water depth for inducing sedimentation can be calculated as 12 m.

(3) Analysis from grain size distribution in on-offshore direction

According to experimental theory by Dr. Uda in Japan, the mean grain sizes become constant regardless of an increase in water depth and the silt content increases towards the deep water area from the critical water depth. Figure 10.9 shows the distribution of the mean grain size and silt content obtained by the on-offshore line (Line II) on the northern side of the port entrance (as shown in Figure 10.8). A plotted line of both mean grain size distribution and silt content bend at the point of about –12 m, as shown in Figure 10.9. Therefore, it has been assumed a water depth of about –12 m is the critical depth for sedimentation. (The same analysis has been examined for Line I on the south side of the port entrance, however, this expected tendency could not be seen. This area is most likely to be affected by the local sediment regime, which is governed by dominant northerly flows from the Lagoon.)



(1) Mean Grain Size(D_{50}) **(2) Silt Content**

Figure 10.9 Distribution of Mean Grain Size (D_{50}) and Silt Content for Each Depth in Line II

10.5.3 Sedimentation Analysis for Outer Channel Based on Existing Dredging Record

Figure 10.10 shows the average sedimentation thickness during eight months in 1999-2000 including the winter season. Distance "0" indicates the position of the port entrance. The right side of "0" indicates the offshore direction and the left side of the port area.

The proposed position of the entrance in the outer port is shown with an arrow. The sedimentation peaks in the vicinity of the port entrance and decreases seaward. The deposition diminishes to a thickness of 0.1 m in water depths greater than –13 m. The new entrance of the outer port will be located in this depth. Therefore, it is anticipated sediment transport now observed in the vicinity of the port entrance will significantly decrease.

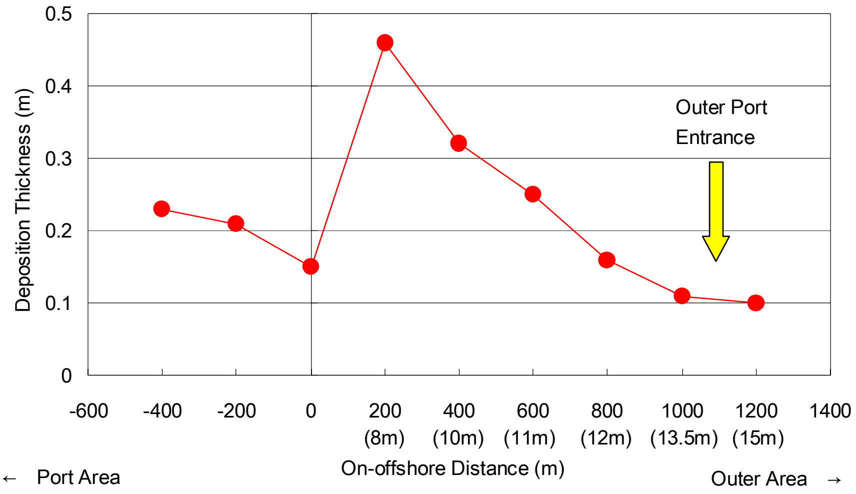


Figure 10.10 Sedimentation Thickness for Outer Channel

10.5.4 Sedimentation in Outer Port by Suspended Load from Lagoon

The following outlines the present understanding on the sediment regime based on numerical computational analysis using the Mud Transportation model:

- The suspended load from the Lagoon, at present, diffuses outside the port area and expands widely to the open sea.
- After construction of the outer port, most of the suspended load will remain in the new port basin (a calm region), where it will settle and accumulate due to stagnation of flow. This will cause substantial sedimentation in the port basin.
- As a result, 70% to 80% of the total sediment volume will accumulate in the new outer port basin. From the previous study this volume is estimated to be about 80,000m^3.

10.6 Influence of Outer Port Development on Surrounding Coastal Areas

With the development of the outer port, it is likely the coastal areas surrounding the Port will experience geographical changes, particularly in the northern part. One of the concerns is beach erosion with the interception of littoral drift due to the construction of the new breakwaters. Another concern would be the shoreline change with the formation of a region sheltered from nearshore waves after construction of new offshore breakwaters.

10.6.1 Influence on the coast line due to intercept of littoral drift

The characteristics of the northward littoral drift in the Lithuanian coastal area is reported in III Section 2.1 This littoral drift is likely to cause beach erosion on the northern side of the port area and accumulation on the southern side.

There is a possibility of a change in shoreline formation due to the dredging work of -14.5 m and the recent extension of breakwaters at the port entrance. The monitoring survey of the shoreline around Klaipeda Port started a few years ago, but the data has not been well recorded to date. As a result, high resolution aerial photography (AGI in 1997) and aerial photographs taken by the JICA Study Team from a helicopter in 2003 have been compared and analysed to evaluate the historical changes in shoreline.

Figure 10.11 shows these shoreline changes between 1997 and 2003. Figure 10.13 shows the cumulative change in area on the southern and northern sides of the port entrance. No remarkable change could be found on the southern coast line. On the northern coast, some retreats about 1 to 2 km long can be noticed in the vicinity of the northern breakwater, while there is almost no change from the point 0 up to the point some 6 to 7 km from the port entrance (Melnrage to Giruliu). Photo 10.4 shows the satellite photo indicating the geomorphology of the shoreline around the port entrance. The orientation of the beach line from Melnrage to Karkle is different from that on the northern side of Karkle, and is almost perpendicular to the incident wave (WSW direction). This means a lower degree of sedimentation will occur. A sea cliff of glacial till extends about 1 km along the shore line of Karkle, where some boulders are observed in the glacial till layer (Photo 10.5). These facts may imply the sea cliff at Karkle has functioned as the boundary for the movement of the northward littoral drift, and leads to the local difference of beach line and maintaining the balance of beach at the north part of the port entrance.

From these facts, it is concluded there will be no remarkable influence on the northern coast line due to the interception of the northward littoral drift by the construction of the outer port. It seems the sea cliff at Karkle is under a process of erosion (see Photo 10.5). However, it has not been identified whether this erosion has accelerated in recent years as there are insufficient past data on shoreline monitoring. To clarify these phenomena, a long-term monitoring survey is required.

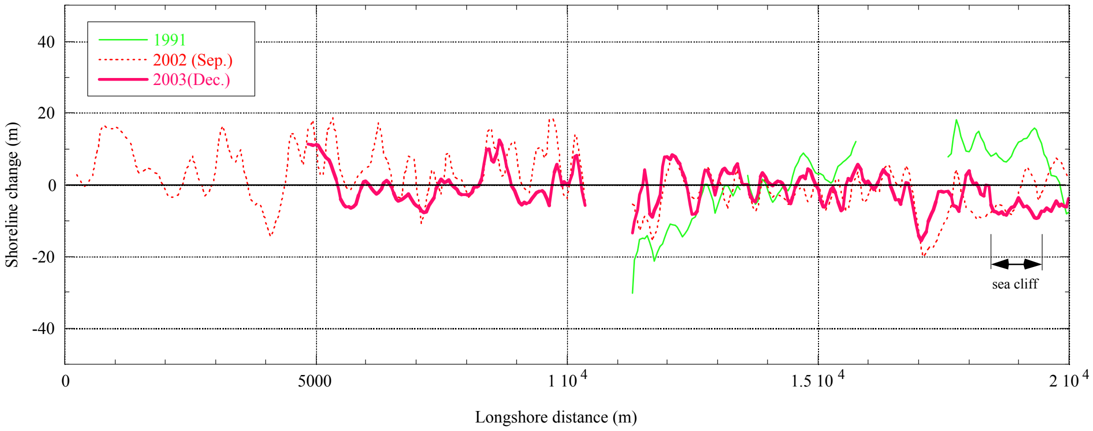


Figure 10.11 Shoreline Change (based on 1997)

10.6.2 Change in Shoreline by Forming Shadow Region of Waves

When a breakwater is constructed, a shadow region is created by the breakwater. The local sediment regime induces longshore currents, which allow the adjacent sand to move into this shadow region from external regimes. As a result, topographic changes in the shore line take place, with likely erosion outside the shadow region and accretion inside. The incident waves from W–WSW are predominant in the port area, therefore a shadow region of waves will be formed on the northern side of the new north breakwater as shown in Figure 10.12.

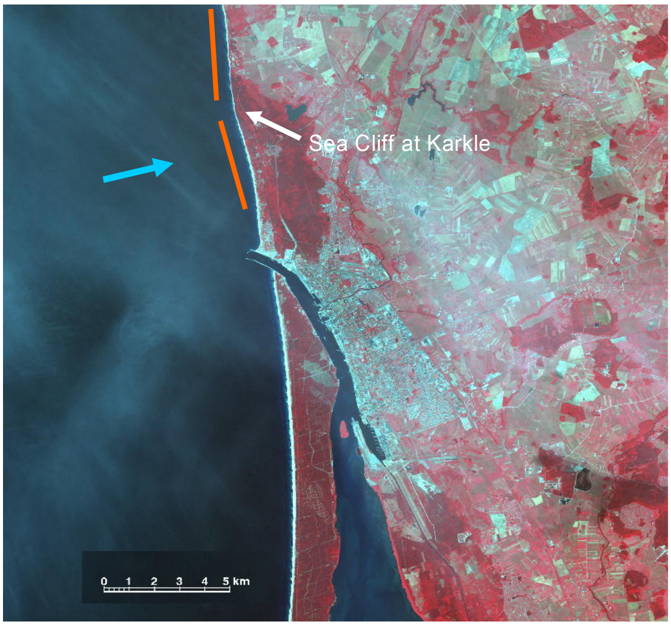
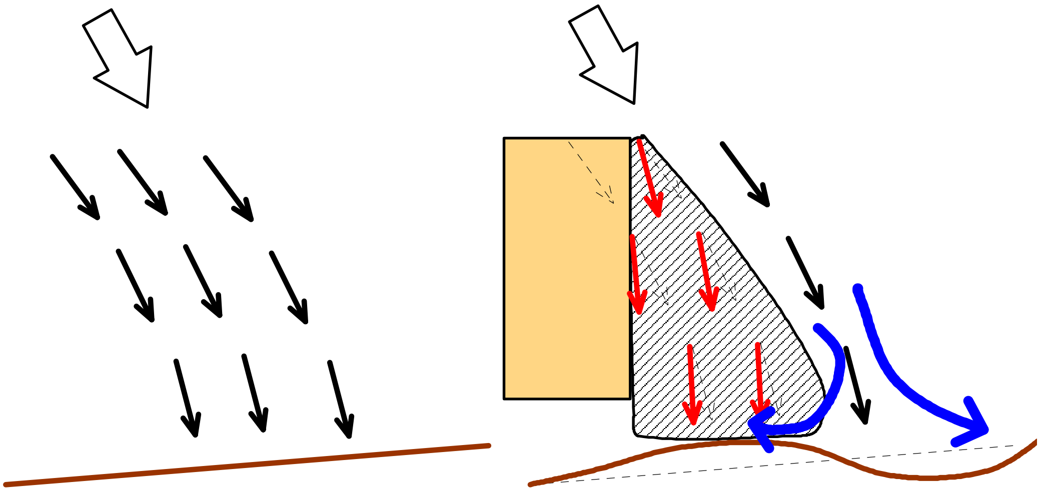


Photo 10.4 Geomorphologic Shape of Shoreline

Photo 10.5 Sea Cliff at Karkle

The wave direction will also change due to wave diffraction and circulation in this area. The changes in the fields of waves and currents cause the shoreline change. The range is rather limited and from experience the shoreline influenced on the downdrift side is known to be about three times larger than the distance of the breakwater extending from the shore to the offshore end.

It is difficult to predict such shoreline change quantitatively. Two studies were therefore performed. One predicted the outline of a stable beach line using a mathematical formula based on many experimental results of beach lines located behind capes and offshore breakwaters, as proposed by Dr. Hsu. The other was a case study based on assessing the actual beach line change for an island-type port with similar scale, layout and some clearance between shoreline and port area as proposed for the outer port plan. The results obtained are outlined below (Figure 10.13).



(1)Present Condition **(2)Predictive Condition**

Figure 10.12 Shoreline Change Caused by Forming Shadow Area of Waves

- The accumulation area in the shadow region results within a reach about 1.0 to 1.5 km on the north side of the northern breakwater. The advance of beach width is expected to be about 150 to 200 m based on the results of the two alternative study approaches.
- A sediment budget analysis suggests a possibility that the shoreline may retreat by about 50 m up to the vicinity of Karkle where sea cliffs exist.
- Several countermeasures can be proposed for decreasing the change of shoreline and for maintenance of sandy beaches, as shown in Figure10.14:

1) Decreasing of the shadow region for waves (for example, change of shape at the north part of the offshore breakwater from straight shape to a curvature, adjustment of clearance, distance between shoreline and port area, etc).

2) Beach nourishment together with construction of additional coastal protection facilities such as groins or headlands to decrease the retreat of shoreline.

3) Decreasing sand movement from northern side to southern accumulation area by filling up the sand in advance.

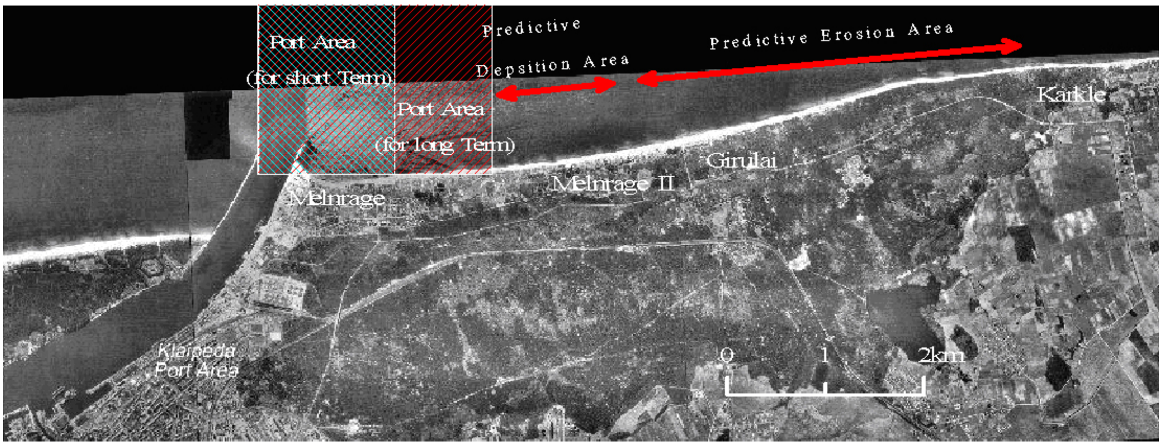


Figure 10.13 Location of Predicted Shoreline Change on Northern Side

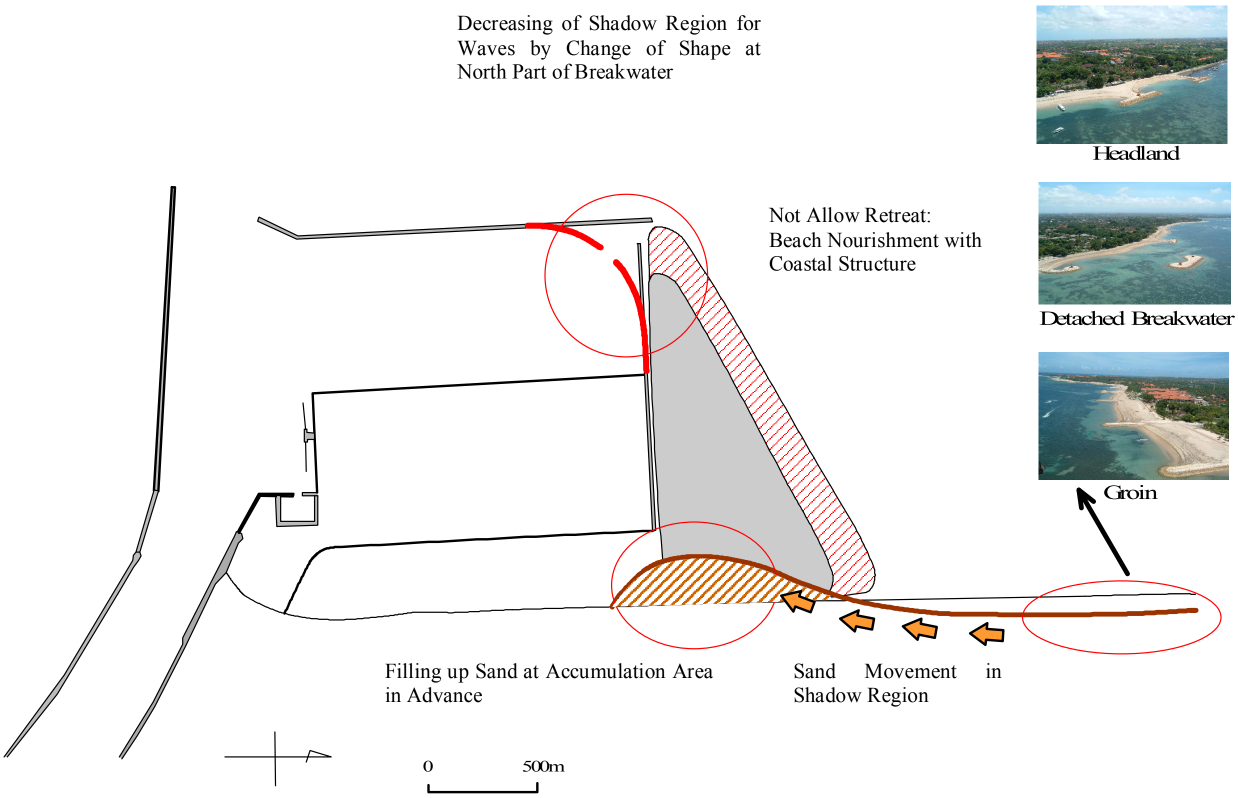


Figure 10.14 Proposed Countermeasure