MSc Thesis

- Master plan Porto Romano Bay, Albania -

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PREFACE

This study is the final report of my Master Thesis 'Master plan Porto Romano Bay, Albania'. It has been conducted as the graduation project of my study in the section Hydraulic Engineering in the Chair of Ports and Waterways of the Civil Engineering Department of the Technical University in Delft.

In order to achieve a more realistic approach, I exploited the knowledge and the experience of engineers and managers from Witteveen+Bos. These people provided me with a special insight in port planning and design.

I would like to thank Prof. Ir. H. Ligteringen from the Chair of Ports and Waterways who communicated a part of his knowledge and experience to me. I would also like to thank Ir. H. J. Verhagen from the Hydraulic Engineering section as well as Ir. F.A.M. Soons from the section Design an Construction Processes. Special thanks also to Ir. P. Quist from Witteveen+Bos, my daily supervisor who suggested the subject of the project and showed special interest in my Thesis as well as John D.M. Koppies, managing director of Koppies&Stevens BV, Michiel Nijdam, transport, port and regional economist at the Erasmus University, Marco Duijnisveld from TNO and Attie Kuiken, consultant at MTBS who provided me with valuable information.

Marco Kersten
Delft, June 2010

SUMMARY

PART A. INTRODUCTION AND GENERAL INFORMATION

Albania has the following major sea ports: Durrës, Vlora, Sarandë and Shëngjin. Investments in sea transport have been concentrated mainly in the ports of Durrës and Vlora as main entrances of Corridor VIII, a strategic road segment linking Albania with Macedonia and Bulgaria. The port of Durrës has the biggest share in the volume of import/export in Albania, nearly 75%.

Due to current development rates, limited possibilities for expansion and pollution in the city because of its vicinity to the port, projects are identified to construct a new port which will better meet increasing needs and demands.

Oil products and LPG have been imported into Albania through and stored in the Port of Durrës. The tank farms presently in use are in such condition that safety for the surrounding densely populated area cannot be guaranteed.

The Albanian Government designated an area 10 km north of Durrës (Romano Port) to be the new location for the storage of oil products and LPG. The Albanian company Romano-Port Sh.a. obtained from the Albanian Government a BOT license to develop storage facilities and operate these for 30 years. In December 2004 Romano-Port completed a LPG and oil storage facility at the designated location. In 2008/2009 Romano-Port completed the civil/structural part of the port facilities required for loading and unloading LPG and oil.

As described above in the present situation the Port of Durrës is overcrowded. This gives a reason to do research on the possibilities of constructing port facilities at an alternative location. This new ‘port’ is designed in the Durrës area due to the following reasons:

1. The Tirana/Durrës area is a gateway region of Albania with regard to the European Union;
2. The Tirana/Durrës area forms a Metropolitan area with its own strong development momentum and the highest estimated growth rate. In this region 35% of Albanian enterprises are located and 60% of foreign investments are made. The location of the region in the centre of Albania is – in general terms- very favourable for development.
3. As a result plans are made for constructing energetic and industrial parks just above the city of Durrës. This gives a very good opportunity to build the port nearby;
4. The already built facilities for LPG and oil at Romano Port can be seen as a first step in the development of this bay.

PART B. TRADE AND TRAFFIC

To design a new port, information is needed about future trade and traffic anticipated in the future. Such a forecast comprises a separate report on their own since the parameters that affect them are numerous. Moreover an effort was made to make some forecasts in order to render this report more realistic. The produced forecasts are bases on a combination of past data extrapolation, trade and traffic trends as well as insight in the situation of Albania and hinterland connections.

For an even more realistic approach of the future conditions, the master plan duration, which will be 25 years (2010-2035), is divided into three periods for each scenario: two periods of ten years (2010-2020 and 2020-2030) and one period of five years (2030-2035). Three different growth scenarios were taken into account. This report has been based on the medium growth scenario (4.3%, 3.8% and 3.1 % increase in the total trade of Albania in tons for the three time periods respectively) while at the same time the final alternatives for the port layout are characterized by a certain level of flexibility in order to cope with potential deviation from the forecasted growth rates.

The forecast up to 2035 showed a significant decrease in the dry bulk sector and general cargo, falling to a percentage of 20% and 10% respectively (34% and 16% in 2008). The liquid bulk sector and the container sector are increasing to a percentage of 20% and 50% respectively (14% and 36% in 2008). Assuming a medium growth scenario 1,807,000 tons of dry bulk will be handled in Porto Romano in 2035, 774,000 tons liquid bulk, 1,033,000 tons general cargo and 215,111 TEUs.

In general small vessels with an average Dead Weight of about 4,000 tons are calling the port of Durrës. Containership dimensions increase especially in the Mediterranean region up to vessels with TEU capacities of 12,500 up to 14,000. Albania with its small economic trade doesn't attract the larger vessels even not in future. It is unknown which type of vessels will enter in future the container port of Vlora, but for the Romano Port, the maximum is set on 45,000 dwt. For 2020, 2030 and 2035, the maximum ship size is the same because this type of vessel enters the Mediterranean area frequently. Therefore, when Romano Port starts functioning, it is immediately able to accommodate container vessels up to 45,000 dwt. For dry bulk it is assumed that the port should be able to accommodate vessels up to 40,000 dwt.

The General Cargo vessels which currently enter the port of Durrës have an average size of 4,000 dwt. Although in general the size of General Cargo vessels remains relative small the average ship is expected to increase up to 10,000 dwt in 2035, with a maximum of 15,000 dwt. The throughput handled per call is expected to be approximately 65% of the dwt.

The liquid bulk terminal which is already constructed in Romano Port, will accommodate cargo ships with liquid gas capacity of 9,000 tons and oil cargo ships with a capacity of 20,000 tons. The maximum ship size is assumed at 25,000 dwt. Because this terminal is in operation for one year now, no big future expansions are expected.

PART C. MASTER PLAN DEVELOPMENT

Taking into account the above forecasts, the future needs concerning terminal areas, berths and equipment were depicted. The container terminal will require a storage area of 440,000 m^2 and a berth length of 466 meter. Dry bulk needs an area of 62,000 m^2 and a berth length of 240 meter. General cargo will require a storage area of 84,000 m^2 and a berth length of 543 meter. For the liquid bulk terminal, no additional berth is required.

Ten alternatives were generated based on the future needs above. Three of them were discussed in more detail. Several affecting parameters were taken into account like extensibility, tranquillity, manoeuvrability etc. The comparison among these alternatives was conducted with the help of a multi criteria analyses. The objectivity of this method was verified by doing several sensitivity checks. Finally it leads to a final optimum port layout.

At the end of this master plan two short chapters are written about the breakwater and quay wall. After an analysis, where several breakwater types were discussed and a comparison between a caisson type and rubble mound breakwater was made, the rubble mound breakwater appeared to be the preferred solution. The breakwater armour layer is designed using a single layer of Accropode ll cubes. A concrete unit is selected because the required weight of the armour units is substantially larger than the available 2 ton rock in the quarry nearby. For the quay wall, an open pile construction has been selected.

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PART B. TRADE AND TRAFFIC

PART C. MASTER PLAN DEVELOPMENT

FIGURE LIST

PART A. INTRODUCTION AND GENERAL INFORMATION

1. GENERAL INFORMATION

1.1 Albania

Albania is a small country of 28,748 km^2 situated in south-eastern Europe at the western part of the Balkan Peninsula. It is bounded to the northwest by Montenegro, to the northeast by Kosovo, to the east by Macedonia and to the southeast and south by Greece (see figure 1.1). With a climate ranging from Mediterranean to alpine, precipitation is abundant (1,430 mm annually), and much of the country's electricity output is generated by hydropower. Around 36% of the land is covered by forest, 24% is arable, and 15% is meadows and pastures; the remainder is infertile or in non-farm use. Albania is rich in mineral resources, particularly in high-quality chromium ores. Other resources present are oil, natural gas, copper, nickel, coal, iron ore and phosphates.

Albania is a parliamentary democracy. The government is a coalition led by the centre-right Democratic Party of Albania (DPA), which was returned to power in 2005.

The government is pursuing a policy of Euro-Atlantic integration. It signed a stabilisation and association agreement (SAA) with the EU in 2006 and was invited to join NATO in 2008 [ECONOMIST INTELLIGENCE UNIT, 2009].

FIGURE 1.1 - SOUTHEAST EUROPE

Albania has the following major sea ports: Durrës, Vlora, Sarandë and Shëngjin, see figure 1.2. Investments in sea transport have been concentrated mainly in the ports of Durrës and Vlora as main entrances of Corridor VIII, a strategic road segment linking Albania with Macedonia and Bulgaria. The port of Durrës has the biggest share in the volume of import/export, nearly 75%. Two other ports, which both have contracts for processing oil, gas and their by-products are located in Porto Romano (near Durrës), and Petroliferous Park (Vlora) and were operational in the beginning of year 2009.

1.2 The port of Durrës

Durrës is the principal port of Albania, formed by two breakwaters which protect 11 berths, with about 2,200m of quay length. Access to the port is via a buoyed channel with a depth of 10.2m. The port handles all kinds of goods including general cargo, dry bulk, break-bulk, containers, liquid bulk and dangerous cargo. There are regular passenger/cargo ferry services to Bari, Ancona and Trieste located in Italy.
The main imports are construction materials, construction steel, coal, wheat, cement. The main exports are oil, bitumen, chrome ore, nickel-iron ore, textiles and marble.

FIGURE 1.2 – THE PORTS OF ALBANIA

1.3 The Durrës area

The geo-strategic location of Albania is generally valued as one of Balkans bridges of communication between East and West and vice versa. And, for sure, Durrës Region represents its essence. It is part of the biggest Albanian Metropolis, Tirana-Durrës area, where approximately 1 million inhabitants live and work. With 'Mother Teresa' airport in its territory, Durrës Region is just the crossroad of all land, railway and maritime roads that enable its connection with all other parts of the country, neighbouring countries, and the rest of the world.

FIGURE 1.3 – DURRËS-TIRANA AREA

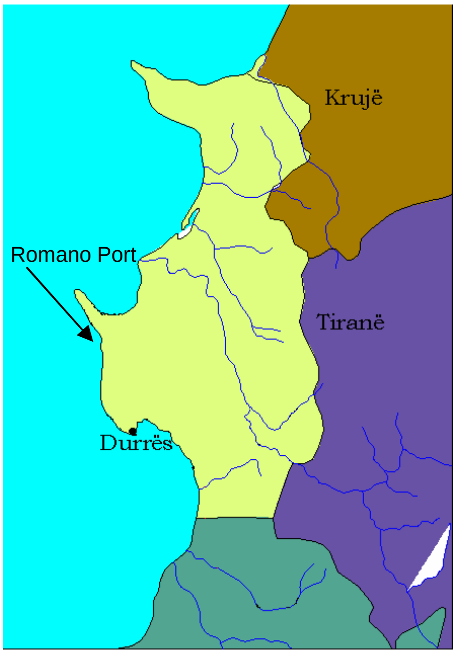


FIGURE 1.4 –DURRËS AREA (YELLOW PART)

2 BACKGROUND TO THE PROJECT

Albania inherited a very poor infrastructure from the former communist regime which was a serious obstacle to the development of the country and attraction of foreign investors. For 20 years now the government has been trying to overcome this major problem by investing in the road, sea, railroad and air transport sector.

Over this last decade, investments made in infrastructure have boosted the development of the infrastructure sector, playing an increasingly important role in fostering the economic development and intensifying the economic ties among various areas of Albania. The main priority for Albania 's government has been the construction of a road network capable of being integrated in regional networks and creating facilities not only for domestic but also for international transporters.

Investments in sea transport have mainly been concentrated in the ports of Durrës and Vlora, which are the main entrances of Corridor VIII. The port of Durrës has the biggest share of imports/exports in Albania, almost 75%.

Port of Durrës will be subject to potential concessions for cereal and cement storehouses as well as for other port activities. The port of Durrës is considering the possibility to grant concession for the entire activity or for different services in the Port of Durrës, which would increase competition and potentials to attract not one but several well-known international companies to this port. [ALBINVEST, 2009] Due to current development rates, limited possibilities for expansion and pollution in the city because of its vicinity to the port, projects are identified to construct a new port which will better meet increasing needs and demands.

Oil products and LPG have been imported into Albania through and stored in the Port of Durrës. The tank farms presently in use are in such condition that safety for the surrounding densely populated area cannot be guaranteed.

FIGURE 1.5 – OIL PLANT ROMANO-PORT

In 2001 the World Bank executed a study and recommended to develop a new tank farm at a safer place. This plan has been triggered by two developments: firstly oil imports in Albania are rapidly increasing, secondly the anticipated termination of the present oil imports and storage at the Durrës port. The government took the latter decision particularly because of the hazard invoked for the Durrës town dwellings directly bordering this port and the planned trespassing North-South motorway. The Albanian Government designated an area 10 km north of Durrës (Romano Port) to be the new location for the storage of oil products and LPG, see figure 1.4 and 1.5.

The Albanian company Romano-Port Sh.a. (hereafter called Romano Port) obtained from the Albanian Government a BOT license to develop storage facilities and operate these for 30 years. In December 2004 Romano-Port completed a LPG and oil storage facility at the designated location. In 2008/2009 Romano-Port completed the civil/structural part of the port facilities required for loading and unloading LPG and oil.

FIGURE 1.6 – ROMANO PORT

As described above in the present situation the Port of Durrës is overcrowded. This gives a reason to do research on the possibilities of constructing port facilities at an alternative location. This new 'port' should be designed in the Durrës area (figure 1.3 and 1.4) due to the following reasons:

1. The Tirana/Durrës area is a gateway region of Albania with regard to the European Union;
2. The Tirana/Durrës area forms a Metropolitan area with its own strong development momentum and the highest estimated growth rate. In this region 35% of Albanian enterprises are located and 60% of foreign investments are made. The location of the region in the centre of Albania is – in general terms- very favourable for development.
3. As a result plans are made for constructing energetic and industrial parks just above the city of Durrës. This gives a very good opportunity to build the port nearby;
4. The already built facilities for LPG and oil at Romano Port can be seen as a first step in the development of this bay.

Therefore it is recommended to develop a new port master plan for this nearly undeveloped area.

3 INFRASTRUCTURE ALBANIA

Although the state of the physical infrastructure in Albania has improved significantly in recent years, it remains underdeveloped by European standards. Most of the recent investment has been concentrated on roads, whereas the railway network has received little funding. Freight and passengers are nearly doubled in 4 years, except the rail passengers. They are decreased from 2.1 million in 2003 to 1.1 million in 2007 (table 3.1) due to the poor network condition.

TABLE 3.1 – TRANSPORT STATISTICS

	2003	*2004*	*2005*	*2006*	*2007*
Rail					
Passengers (m)	2.1	1.8	1.4	1.7	1.1
Freight (m tonne-km)	31	32	26	36	53
Road (no.)					
Passenger cars	174,782	190,004	195,125	225,114	237,932
Total vehicles	263,901	274,652	284,655	320,347	349,626
Air					
Passengers (.000)	561	650	672	906	1,107
Freight (tonnes)	1,623	1,558	1,842	2,109	3,499

Source: Institute of Statistics.

3.1 Road network

The road network in Albania is far below the standards of other European countries, including most of its neighbours. Only around 20% of the 18,000-km network is paved, and the secondary and tertiary networks are in especially bad shape, making it hard for villagers to transport agricultural products to urban centres. In recent years governments have completed parts of national motorway corridors running east-west and north-south.

Currently the major cities of the country are linked with first class national roads. There is a four lane highway connecting the city of Durrës with Tirana and the city of Durrës with the city of Lushnje. Albania is partaking in the construction of what it sees as three major corridors of transportation.

The **major priority** as of present is the construction of the four lane Durrës-Pristine highway which will link Kosovo with Albania's Adriatic coast, see figure 3.1. The portion of the highway which links Albania's north east border with Kosovo (Morin) was completed in June 2009, as a result, cutting the time it takes to get from Kosovo to Durrës from six hours to two. The Durrës-Morin Road, will considerably augment the economic exchanges between Albania and Kosovo, particularly tourism and commercial ones. This road, connected in future with Corridor 10 in Nish (Serbia), opens a new opportunity even for transit of goods to and from Romania and Bulgaria.

The **second priority** is the construction of European Corridor 8 linking Albania with the Republic of Macedonia, Bulgaria and Greece. ‘Corridor 8’ passing through Durrës Port, offer the best alternative for Macedonia to transit people and goods to and from Western Europe. ‘Corridor 8’, which will be completed in 2028, links the Adriatic-Ionian regions with the Balkan regions and Black Sea countries. It is a multi-modal transport system along the East-West axis comprising of sea and river ports,

FIGURE 3.1 – CORRIDOR 7

airports, road and railways, for a total extension of 1270 kilometres of railways and 960 kilometres of roads. Its main route follows the Bari – Brindisi – Durrës – Tirana – Skopje – Burgas – Varna axis (There are also branches leading to Greece and, through Corridor 4, to Turkey). Nowadays, an existing road in good conditions connects Durrës with Skopje.

FIGURE 3.2 - CORRIDOR 8 BARI-VARNA

The **third priority** for the government is the construction of the north-south axis of the country; it is sometimes referred to as the Adriatic–Ionian motorway as it is part of a larger regional highway connecting Croatia with Greece along the Adriatic and Ionian coasts. The Albanian North-South corridor, at length 405 km from Hani I Hotit to Kakavija, passes through Durrës. It certainly links its port with regions of Greece, Montenegro and other countries of East-Central Europe.

By the end of the next decade it is expected that the majority of the sections of these three corridors have been built. When all three corridors are completed Albania will have an estimated 759 kilometres of highway linking it with its neighbours.

Transport is and will be dominated by road in the foreseeable future. However, the Albanian Government is fully aware that a better equilibrium between the various transport modes is necessary to optimize development [LOUIS BERGER S.A., 2004]. Combined transport could represent a first step towards the development of a more integrated transport system in the country.

FIGURE 3.3 - NORTH-SOUTH AXIS

3.2 Rail network

The Albania's Central Railway station is placed near Durrës Port and has a direct connection with it. Continuing from the Port, the rail reaches Montenegro and from there the European Rail Network. Except the rail link between the ports of Durrës and Vlora, it is another branch that traverses the space between Durrës and Skopje. There is only a still missing link of about 30 km length on the Macedonian side to complete the rail connection between these two cities. However, the economic and financial viability for completing the missing railway link between Albania and Macedonia hinges much on the volume of traffic to and from Bulgaria. As the distance table indicates, Durrës Port has good chances to capture an increasing share of Kosovo and Macedonia markets exchanging with Europe, in the competition between three nearest ports to both these countries.

TABLE 3.2 – DISTANCE BETWEEN PORTS AND MARKETS

Port	***Skopje***	***Pristina***
Durrës	120 km by rail 200 km by road	no direct rail 230 km by road
Thessaloniki	225 by rail	310 by rail
Bar	715 by rail	630 by rail

Albania has 447 km of single track railway (and 230 km of secondary tracks) serving Tirana, Durrës and several larger towns. A link to Montenegro was completed in 2004, providing access to the European rail network. The national rail network is in poor condition, reflecting a lack of investment since the communist era. Because of the poor condition of the network, and the growth of minibus services, the number of rail passengers has almost halved in the past five years, see table 3.1.

The physical infrastructure of the railways is in very poor condition aggravated mostly in the mountainous areas by soil instability: train crossing points out of use, major crossings without communication links, derelict condition of the permanent way across the whole system, continuous safety hazard, severe lack of maintenance and bad drainage of bridges or viaducts, ineffectual track drainage systems, etc [UNITED NATIONS DEVELOPMENT PROGRAMME, 2009]. This has lead to speed restrictions, causing extended journey times and reducing the attraction of rail travel. Plans, currently awaiting for finance, exist for track rehabilitation on the Pogradec and Shkoder routes. The sections most requiring early attention are between Plaza and Rrogozhine, and between Elbasan and Pogradec (see figure 3.4).

The following map shows the main routes taken by international railway transportation of goods at the present time. The blue lines represent a Single Non-Electrified railway, the red ones a Single Electrified line. The highways are marked in green.

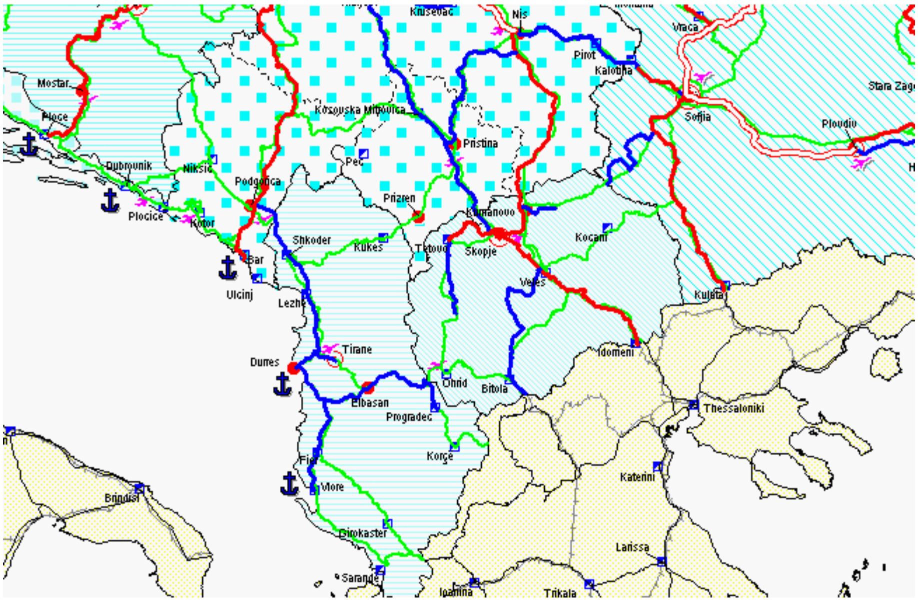


FIGURE 3.4 – PRESENT RAIL NETWORK

The total quantity of freight transported by rail is small (517,000 tons a year, or 31.2 million ton-km in 2003) and the average haul is extremely short (60.1 km in 2003). It is generally considered that a railroad generally breaks even financially if it transports one million of tons a year and that rail transport is generally cheaper than road transport for distances exceeding 500 km.

Freight Services: Freight activity is currently at a low level, and only some five daily services are being operated regularly. Unit trains are operated from origin to destination, the major goods being Cement Clinker, Phosphate/Fertiliser, Chrome and Ferro Chrome, Fuel Oil and Coal/Coke. International traffic via the Montenegro link from Podgorica is developing rapidly [LOUIS BERGER S.A., 2004]. This traffic consists of general consumer goods from Central Europe to Tirana.

3.3 Inland Waterways

In Albania transport of passengers and transport of goods is possible on the waterway system on the River Drin above Komani to Firza and Kukes. A waterway from the Adriatic Sea to Lake Shkoder used to be operational as an inland waterway but has become silted up and is no longer operational.
Two services operate: Koman – Fierze and Fierze – Kukes, mainly passengers ferry services. With the continuing improvement in the national highway system, land travel times are very much shorter and road traffic allows for greater convenience. It appears that there is very little benefit, economically or in time, to encourage national coastal services for transport of goods or passengers.

3.4 Seaports

In section 7.7 the biggest ports in the Mediterranean area are shown, but in table 3.3 and 3.4 key data of seven more or less identical ports in the region are shown, including Rijeka, Split, Dubrovnik and Ploce in Croatia; Bar in Montenegro; and Durrës and Vlore in Albania. All ports – except Dubrovnik which is purely passenger port – are multipurpose, whilst Rijeka is the only port that presently acts as a transhipment centre [SEETO, 2008].

TABLE 3.3 – DATA SEAPORTS IN REGION OF DURRËS 2007

Port	***Rijeka***	***Split***	***Ploce***	***Dubrovnik***	***Bar***	***Durrës***	**Vlore**
Port Area (ha)	2,000	666	238	100	2,000	138	53
Container terminal	Yes	Yes	No	No	Yes	Yes	No
Ro-Ro facilities	Yes	Yes	Yes	Yes	Yes	No	No
Transhipment centre	Yes	No	No	No	No	No	No
Berths (number)	16	28	16	7	20	11	3
Max. draught (m)	18.5	11.8	13.5	11.5	14	11.5	7.5
Min. draught (m)	5.5	1.9	4.5	7.5	6	6.6	3
Condition	Good	Good	Good	Good	Medium	Very Poor	Very Poor

Source: SEETIS 2 (2008)

TABLE 3.4 – DATA SEAPORTS IN REGION OF DURRËS

Port	Rijeka		Split		Ploce		Dubrovnik		Bar		Durrës		Vlore	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Number of vessels	2,542	-	17,130	-	618	-	-	-	1,120	1,198	1,127	2,811	237	268
Passengers ('000pass)	223	213	3540	3660	120	128	900	657	80	85	701	770	137	75
Loaded (mil. tons)	-	3.13	1.21	1.30	0.95	1.26	-	-	1.06	0.7	0.32	0.58	0.09	0.18
Unloaded (mil. tons)	-	10.39	1.80	1.43	2.23	2.95	-	-	1.15	1.42	2.58	2.22	0.04	0.34
Total	10.88	13.52	3.01	2.73	3.18	4.21	-	-	2.21	2.18	2.90	2.81	0.13	0.51

Source: SEETIS 2 (2008)

The ports and terminals in Albania are located in Shengjin, Durrës, Vlora and Saranda. The main seaports (Durrës and Vlora) are being upgraded. The privatisation of the Durrës Port Authority has helped to improve services. Durrës accounts for around 80% of the total volume of international trade processed in Albanian ports. The port handled 794,000 passengers in 2008, equivalent to 3% growth year on year. The number of tons loaded and unloaded in the port of Durrës, as given in table 2B is inaccurate. More precise information is shown in table 7.5, where the number of tons is in accordance with the statistical information of the Durrës port authority. But for a comparison between the ports, table 2B is good enough to see the differences. In the next section more information is given about the ports in Albania.

Ferry lines

There are four ferry lines linking Durrës Port with ports of Bari, Ancon, Trieste (Italy) and Koper (Slovenia). They transit trucks, containers, cars and people, from and to Albania, and cover a considerable part of total traffic through the Port. Other lines are expected to be opened in the near future, connecting the Port with Brindisi (Italy), Istanbul (Turkey), Rijeka (Croatia), Bar (Montenegro) and some others.

3.5 Air transport

Mother Teresa Airport in Rinas, outside Tirana, is the country's only international airport. In 2008 Rinas handled almost 1.3m passengers, up from 561,000 in 2003. The Rinas concession, under which Tirana Airport Partners, a German-US consortium, will manage the airport until 2025, stipulates that Albania may not have another international airport for the duration of the contract. Plans to upgrade regional domestic airports have made little progress, owing to lack of investor interest [ECONOMIST INTELLIGENCE UNIT, 2009].

4 PORT DESCRIPTION

The ports and terminals are located in Shengjin, Durrës, Vlora and Saranda, see figure 4.1. A short description of each port will be given below except the port of Durrës which will be described in more detail.

FIGURE 4.1 – THE PORTS IN ALBANIA

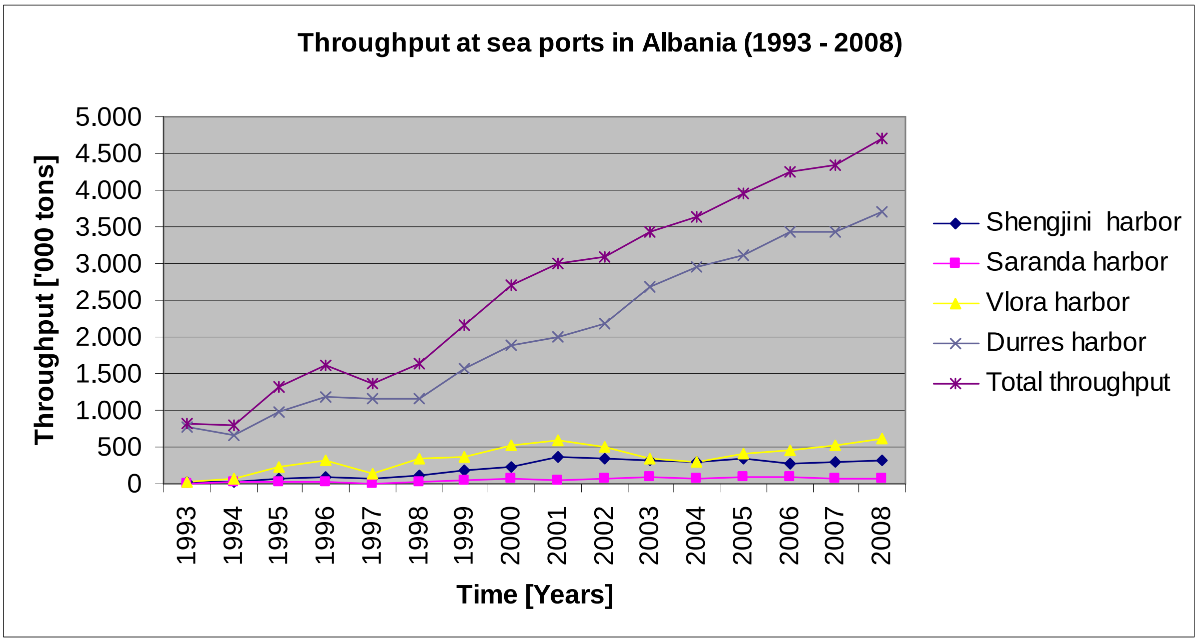


FIGURE 4.2 – THROUGHTPUT ALBANIAN SEAPORTS

4.1 Port of Durrës

At the western end of the Pan-European Transport Corridor VIII, the Albanian port of Durrës has an essential role to play in the economic development of the country and the Western Balkan region. Durrës is considered as one of the important ports in the Adriatic Sea, as it could play a significant transit role in passengers and goods transportation to other European countries. According to official data, the passenger volume was 704,000 during 2005 being increased more than 21,000 passengers year-on-year [LOUIS BERGER S.A., 2004].

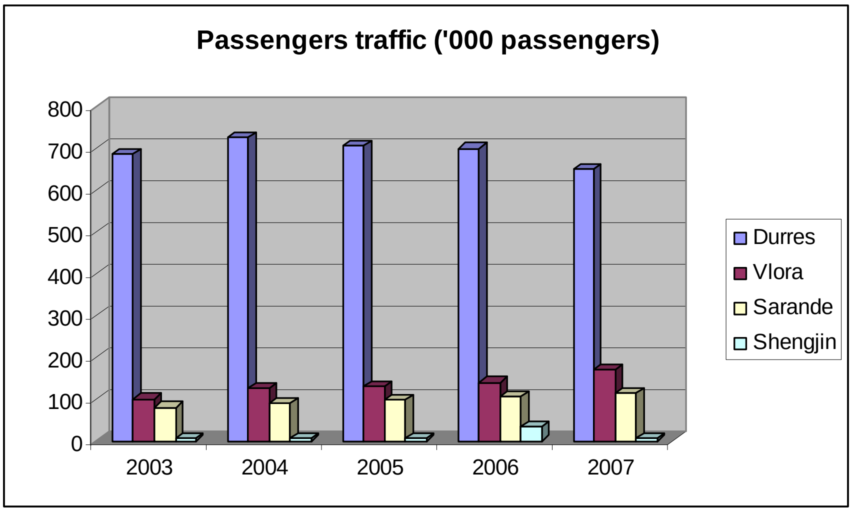


FIGURE 4.3 – ALBANIA'S PASSENGERS TRAFFIC www.osce.org

Commodities

The port handles all kinds of goods including general cargo, dry bulk, break-bulk, containers, liquid bulk and dangerous cargo. There are regular passenger/cargo ferry services to Bari, Ancona and Trieste located in Italy.
The main imports are construction materials, construction steel, coal, wheat, cement. The main exports are oil, bitumen, chrome ore, iron-nickel ore, textiles and marble.

Port layout

In figure 4.4 the layout of the port of Durrës is shown. The deck elevation is at + 2.0m above MSL (Mean Sea Level). The entrance channel was originally dredged to 11m deep, 100m wide and 4.6km long. The port land area covers approximately 80 hectares of land and a basin of 70 hectares. The 80 hectares of land, of which about 12,500m² are covered storage area. The Ferry Terminal covers 36,300m² (4.6%), berth aprons and usable back areas respectively 66,685m² (8.46%), and 213,565m² (27.08%) are used for roads, rail, parking, general open storage, etc.

FIGURE 4.4 – LAYOUT PORT OF DURRËS

TABLE 4.1 – BERTHS INFORMATION

Berths	*Length [m]*	*Depth [m]*	*Use*
1	186	7.3	Oil and benzene
2	292	6.5	Oil and benzene
2/3/4	444	7/8	General Cargo, high speed ferry
5	236	9/9.5	Grain 1500t silo
6	274	-	Containers, yard of 40,000 m2
7/8	406	9.5	General Cargo, dry bulk (mainly minerals), Containers, yard of 70,000m2
9	180	8.5	RO-RO Terminal
10/11	422	10.5/11	Bulk cement discharge

Source: www.portguide.com

Hinterland connection
Access by road is by a modern East-West 4-lane dual carriageway highway to Tirana. This highway gives a connection to the TEN Corridor VIII to Macedonia, and to the eastern Balkans. There is also access to the north south highway that in turn goes to Montenegro and Greece as well as to the planned road which will link with Kosovo.

4.2 Port of Saranda

The Port of Saranda has a total throughput of only 2% of the national cargo. No export cargoes are recorded. The port also handles a small amount of passenger traffic, principally tourists from the Island of Corfu visiting Saranda and the Roman remains at Butrinti, plus the cruise ships that make this a port of call.

The port facilities are not in a good state of repair. The facilities comprise a 52m long and 4m wide jetty in 4m of water and a quay 58m long with an alongside water depth of 4.5m. The structural condition of the quay is not good and suffers from lack of repairs and maintenance over the years. The access to the berth is along a channel 800m long by 50m wide with depths in the range of 6.0 to 7.0m. There is approximately 800m² open storage and 3,050m² warehousing available [LOUIS BERGER S.A., 2004].

4.3 Port of Shengjin

The port is situated 85km north of Durrës, some 41 km to the south of Shkoder and 7 km by road from Lezha. The condition of this road is poor. There is no railway access to the port. Access from the sea is through a buoyed access channel which had a design depth of 7.5m, now reduced to 4.5m. Some of the buoys are now missing. The port serves its local hinterland with the major towns of Shkoder, Lezha and Kukes as well as being the nearest port to Kosovo.

Some 10% of the country’s import and 4% of country’s export tonnage pass through the port, a total of 9% of Albania’s traffic. Cargo traffic is quite unbalanced between imports equal to over 97% of total throughput and exports at 3% of total throughputs.

Construction materials have formed a large proportion of the volume of imports of which cement has been a large component. With the increase of Albanian manufactured cement it is probable that this particular import will be reduced. Other volume imports are foodstuffs. Major exports include fish and fish products [LOUIS BERGER S.A., 2004].

4.4 Port of Vlora

4.4.1 Description present situation

The Port of Vlora is Albania’s second port with some 8% of the country’s import and 11% of country’s export tonnage passing through the port, a total of 10% of Albania’s traffic. Similarly to the Port of Durrës cargo traffic is quite unbalanced between imports equal to 94% of total throughput and exports at 6% of total throughputs. Moreover, Vlora has recently been declared a Free Trade Zone.

Access by road is by an improved existing road, which links the port with the planned highway connecting Vlora with Rrogozhina (TEN Corridor VIII to Macedonia, and to the eastern Balkans), and with the North-South Corridor. There is no rail operation from the quay aprons to the inland rail system [LOUIS BERGER S.A., 2004].

4.4.2 Future developments

Container terminal

Albania awarded on January 2009, a 35-year concession to the British-Swiss Zumax AG group for a €1.18 billion container terminal for ships in south-western Albania including a free-trade zone. Zumax AG will build the terminal at the Vlora port, 140 kilometres southwest of the capital Tirana, which will be capable of handling more than three-million TEU annually [ALBINVEST, 2009] [ALBANIA DAILY NEWS, 2009]. Given that the current annual container throughput in Albania is less than 0.1 million TEU these figures may be questioned. The realistic throughput will be much less. Its construction has been started in summer 2009 and will be completed in four years. They expect more than 4,000 companies in the free-trade zone. Vlora will function in future as a major international gateway for trade between the Mediterranean, Central Europe and the Black Sea. Again, the note should be made that this expectation is like an utopia, probably the real situation will differ.
Vlora, the only harbour on the Adriatic coast with deepwater access within 250 metres of the shore, would replace Durrës as Albania's main gateway for trade. Durrës is closer to the capital

Tirana but needs constant dredging to serve the needs of ocean-going ships. The small northern port of Shengjin caters only for vessels up to 6,000 tonnes. The terminal would serve local traffic, transit traffic to central and eastern Europe and also provide trans-shipment facilities. The free zone would serve manufacturers and suppliers for the Balkan region, providing facilities for storage, re-packing, assembling, customising and repair. Vlora has a single track rail link with Tirana, which goes north to Montenegro, while the road link is being upgraded to serve increasing commercial and tourist traffic.

AMBO pipeline project

AMBO pipeline is a planned oil pipeline from the Bulgarian Black Sea port of Burgas via the Republic of Macedonia to the Albanian Adriatic port of Vlora, see figure 4.5. The aim of the 912-kilometre long pipeline is to bypass Turkish Straits in transportation of Russian and Caspian oil. The pipeline is expected to cost about US$1.5 billion and it will have a capacity of 750,000 barrels per day (119,000 m3/d). There will be four pump stations, two in Bulgaria and one each in the Republic of Macedonia and Albania, constructed along the route. The pipeline is expected to be operational by 2011.

FIGURE 4.5 – AMBO PIPELINE PROJECT

Storage terminal and industrial park

The Vlora region is important for industrial development, and in particular will be the site of a deep water port for containers, oil and gas transhipment.

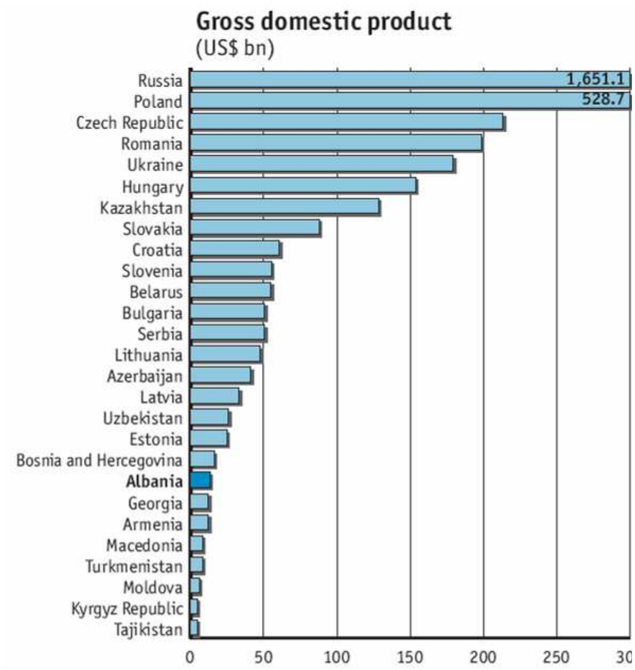
A site plan for a hydrocarbons terminal adjacent to the southern Albanian harbour town of Vlora was conceived by the Albanian government in 2001. The project was approved in 2003, and a year later a concession agreement with an Italian investor – La Petrolifera Italo Rumena – was signed. The project consists of a storage terminal for LPG, oil and its by-products with a capacity of around 60,000 tons/year LPG and 400,000 tons/year diesel/oil/gasoline and related marine infrastructure (the jetty and breakwaters). The terminal is to be located inside the industry park near a thermo-power plant which has already received lending support. However, the key problem was the lack of a Strategic Environmental Assessment to evaluate the complex industrial and energy developments in the Vlora region and their impacts on the environment. Up to now the Vlora terminal has provoked strong local opposition. There is a lack of local and national monitoring to cope with this high risk terminal. It is likely that the terminal will cause serious damage to the local community including reducing tourism industry.

In part due to ongoing public protests and political deliberations, the government requested that the National Council of Territorial Adjustment review its decision and restrict the status of the Vlora park to an industrial one in May 2007. Although some of the park's energy components have been moved to a new energy park in Porto Romano in the city of Durrës, Vlora will host a thermal power plant and a hydrocarbons terminal. The construction on both projects is ongoing [CEE BANKWATCH NETWORK, 2008]. (www.bankwatch.org)

5 TRADE AND ECONOMY

5.1 Economic growth Albania

Under the harsh communist regime, the private sector was repressed and foreign trade was strictly controlled by the state. As a result, Albania began its transition in 1991 as the least developed post-communist economy in Europe, and despite strong GDP growth since then, it remains one of the poorest countries in Europe, as shown in figure 5.1. The GDP fell sharply during the chaotic transition from communist-era to a market economy in 1991-92, and again in 1997 during the unrest that followed the collapse of several 'pyramid' schemes. Since 1998 annual real GDP growth has averaged around 6%, see figure 15.2 and 15.3.



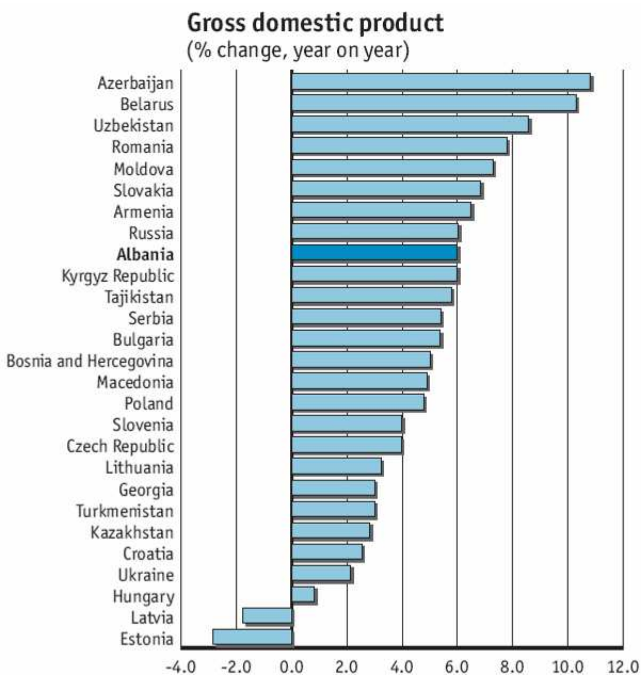


FIGURE 5.1 – GDP LEVEL 2008

FIGURE 5.2 – GDP GROWTH RATE 2008

Source: Economist Intelligence Unit

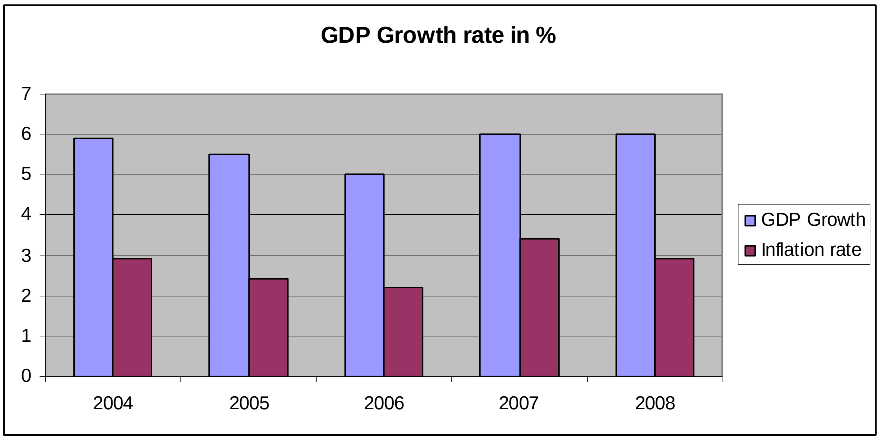


FIGURE 5.3 - GDP GROWTH RATE

Albania is widely credited with achieving one of the fastest transformations among transition economies. As figure 5.4 shows, Albania has outperformed in terms of GDP growth all Central and Eastern Europe countries since 1992, including those countries that have become European Union members in recent years [REPUBLIC OF ALBANIA COUNCIL OF MINISTERS, 2007].

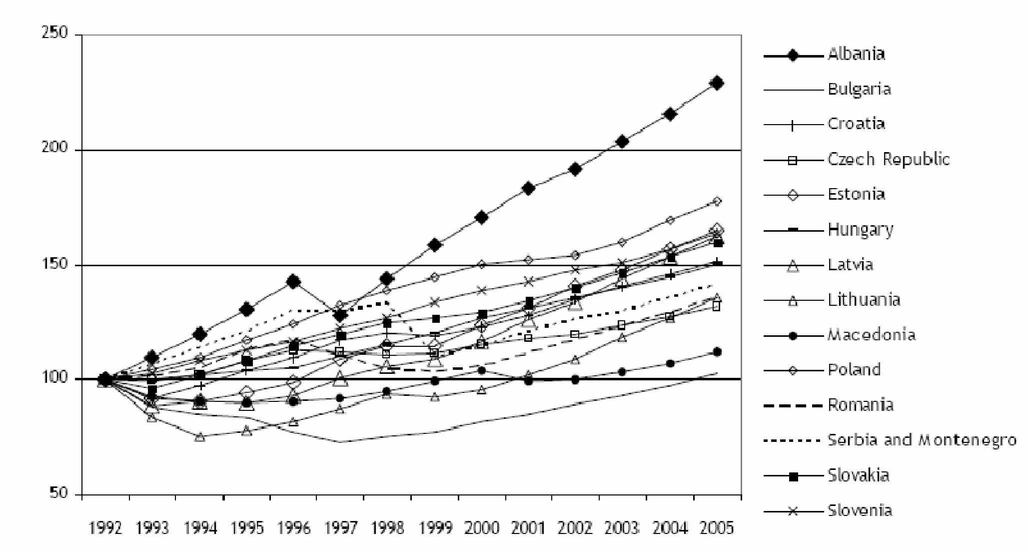


FIGURE 5.4 – GROWTH IN CENTRAL AND EASTERN EUROPEAN COUNTRIES 1992 = 100
Source: World Economic Outlook Database

Unemployment is a serious problem, although there has been a marked reduction in the unemployment rate, from 16.4% in 2001 to 12.5% in 2008. However, a very high proportion of the working-age population is employed abroad.

Greece and Italy are the mainstays of the Albanian economy, providing employment for hundreds of thousands of Albanians as well as being Albania's main trade partners.

Foreign direct investment (FDI) has grown in recent years, but the total amount invested in Albania remains among the lowest in the Balkans.

5.2 GDP by sector

TABLE 5.1 – REAL GDP BY SECTOR

% of GDP	*1986*	*1996*	*2004*	*2005*	*2006*	*2007*	*2008*
Agriculture	34	33	23.5	22.8	22.4	21.2	20.6
Industry	44.2	20.2	21.2	21.5	20.9	20.5	19.9
Services	21.8	46.8	55.3	55.7	56.7	58.3	59.5

Source: Economist Intelligence Unit

5.2.1 Agriculture

Privatisation has left land ownership highly fragmented, with the average farm little more than 1 ha in size. The sector is hindered by poor infrastructure: produce often cannot be transported further than the nearest city. Agriculture has picked up, despite the fragmentation of land holding, and accounts for 21% However, productivity remains low and Albanian farmers are unable to compete with subsidised imports from neighbouring Greece, an EU member.

5.2.2 Industry

Industry was badly disrupted by the post communist transition, and its share of GDP has more than halved, to 20%. This shift, which is shown in table 5.1, reflects the reduced importance of the mining and manufacturing sectors since the communist period, when the authorities pursued a policy of aggressive industrialisation. Textiles and footwear are Albania's principal exports, and generate about 43% of total export revenue. Food-processing remains an important branch of manufacturing, although technology levels remain well below those in Italy and Greece [ECONOMIST INTELLIGENCE UNIT, 2009].

Mining
Albania is rich in mineral resources, especially chromium, copper and nickel, and before 1990 it was the world's third-largest chromium producer. However, mineral production collapsed during the early 1990s, and its revival was slow until recent years, when higher prices in international markets led to a doubling of export volumes of chromium, iron, copper and related products in 2005-2008, with China accounting for the bulk of the growth in demand.

Energy
Hydroelectricity supplies 98% of the power generated in Albania. The sector's capacity of 1,668 mw (and the small thermal capacity of 224 mw) was installed about 30 years ago with Chinese technology. Albania periodically suffers from severe energy shortages, owing to lack of investment in new generating capacity, rapid increase in demand, droughts, and traditionally low levels of bill collection. The sale of the distribution arm is expected to improve efficiency. Planned new power plants should lessen Albania's dependence on electricity imports.

TABLE 5.2 – NATIONAL ENERGY STATISTICS, STATE SECTOR PRODUCTION

	2003	***2004***	***2005***	**2006**	**2007**
Crude oil (.000 tonnes)	359	386	349	316	281
Natural gas (m cu metres)	12	12	11	11	10
Petrol (.000 tonnes)	21	21	20	32	23
Diesel (.000 tonnes)	102	98	94	99	81
Electrical energy (m khw)	4,904	5,493	5,451	5,454	2,974

Source: Institute of Statistics

Oil has been extracted in Albania since 1918, but the domestically produced diesel is of low quality and meets only a fraction of domestic demand. A number of foreign oil companies operate in Albania both in exploration and in production.

5.2.3 Services

Services account for 59% of GDP, although the tourism sector remains relatively underdeveloped. The services sector is a smaller part of the economy than in most other post-communist countries in eastern Europe.

The retail sector is dominated by small shops and open markets for farm produce and handicrafts. Imported consumer goods became available when barriers to trade were removed in the early 1990s. Modern and well-supplied shops exist mainly in large cities, and the number of supermarkets and out-of-town shopping centres is growing. The presence of international retailers is expanding.

Tourism has a great potential because of the coastline along the Adriatic and Ionian seas, as well as the scenic mountains. However, poor infrastructure has held up development. Now tourism is expanding rapidly, with numbers of foreign holidaymakers rising by 31% in 2007, to reach 912,000, most of them are from neighbouring countries.

5.3 Future economic development prospects

A consensus exists within the Government and Albania's external partners (EU, IMF, the World Bank) that the country's medium term development prospects indicate continued strong economic growth [LOUIS BERGER S.A., 2004]. Provided however that macroeconomic stability continues and that aggressive policy reform leads to increased private sector investment. Albania has large fiscal and external imbalances which will need to be reduced to underpin sustainable growth. This will require strong measures to reduce structural weaknesses. Enterprise privatization and public sector reform need to continue, to address weak governance. Investment climate also needs to improve to widen the narrow export base (about 1/3 of import).

FIGURE 5.5 – ESTIMATED GROWTH RATE AREAS

By [LOUIS BERGER S.A., 2004] regional development conditions and prospects have been analyzed at the level of the 13 prefectures and 36 districts. It appears that the country may be divided into three broad areas in respect to future development prospects: the Tirana/Durrës area forms a Metropolitan area with its own strong development momentum and the highest estimated growth rate; the second area (southern and northern coastal districts and Elbasan district bordering Tirana) has a strong agricultural base which could be developed further, but also a strong potential for tourism development in the coastal zones and an industrial one in the Elbasan zone, and the third area (north- and south- eastern inland areas) represents areas with poor development prospects unless concerted action is taken (see figure 5.5).

Because the Tirana/Durrës region forms the study area for new port facilities, in the next chapter specified information about this region will be given.

6 TIRANA - DURRËS REGION

The study area for the Tirana - Durrës Region covers a corridor of about 35 km in length along and mainly between the two major road connections between Tirana and Durrës. In this region, 35% of Albanian enterprises are located and 60% of foreign investments are made. The location of the region in the centre of Albania is - in general terms - very favourable for development. Tirana and Durrës forms the country's largest markets. Durrës is Albania's biggest seaport, covering 85% of maritime trade. The main national roads which connect Tirana and Durrës as well as Rinas international airport are located in the region. This chapter gives attention to the Tirana - Durrës region because it's mostly, especially for container transport, the economic trade centre for the Romano port. Countries like Macedonia and Bulgaria will mainly be served by the port of Vlora, as described in section 4.4.2.

6.1 The Tirana - Durrës Region in a European context

Albania forms an integral part of Europe. It is aiming to become an accession state of the European Union in a medium term perspective. This requires that the Albanian regions pay special attention to the European context while promoting their development. Albania is also effected by the pan-European transport corridors, because corridor no. VIII runs form Durrës via Skopje to Sofia and Varna.

6.2 The vision

The vision of this region is a wise growth and a sustainable development facilitating the Tirana-Durrës Region to become an integrated city-region in the core of Albania as well as a part and a partner of Europe [GTZ, IOER, 2002].

In more detail, this means:

- In the Tirana-Durrës Region, growth shall continue
- In the Tirana-Durrës Region, sustainable development shall be the main overall guideline for development.
- The Tirana-Durrës Region is not only located in the core of Albania but also plays the decisive role in the overall economic and social development of the whole country.
- The Tirana-Durrës Region is a gateway region of Albania with regard to the European Union. The integration of the region into the overall European development shall be fostered. This requires that the central government and the responsible actors of the region undertake intensive efforts to make the region an integral part of the European space.

6.3 Economic structure

The economic development in the Tirana - Durrës Region is booming although in international terms it is still very weak. Regarding the economic structure, the existing industrial cores in the northern part of the Tirana - Durrës Region, e.g. food production and construction businesses, commerce and repair garages are major strengths. Building materials - mostly sand and gravel - are extracted on the banks of the river Erzen.

The most important economic sectors in terms of employment are trade and industry. Construction and agriculture are the least important formal employment sectors in the region.

6.4 The economic activity in Durrës area

Durrës, with a population over 200 thousand inhabitants, is the centre of the region with the same name, which is extended on a surface of 740 km^2, where live and work about 400 thousand inhabitants. It creates an operation space for nearly 10,000 private enterprises [DURRËS CHAMBER

OF COMMERCE AND INDUSTRY, 2008]. But also for industrial and tourist constructions, industrial and agro-alimentary production, the fishery with the biggest fleet in the country and other services. Durrës Region, with a favourable business climate for anyone, gives over 10% of all country's GDP.

The region comprehends two districts, Durrës and Kruja. Their structures contain 6 municipalities which are cities or inhabited centres, and 10 communes, which are union of nearby villages. The following figure and table of district Durrës may help to create an idea about territorial and human resources.

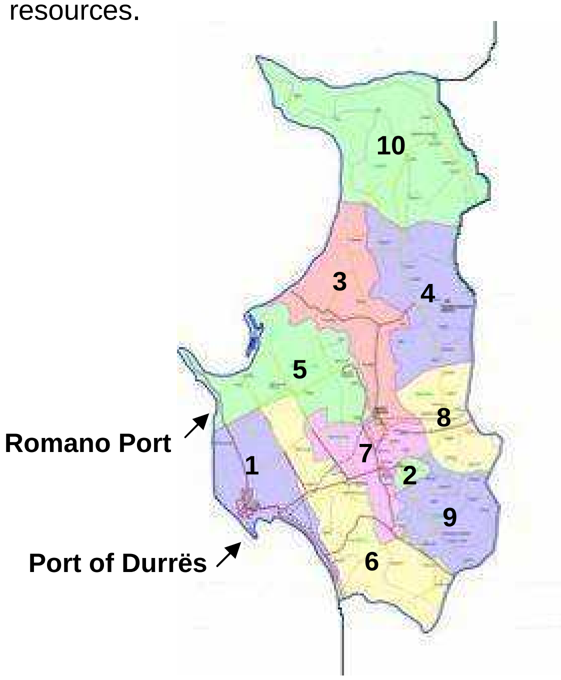


FIGURE 6.1 – DURRËS DISTRICT

TABLE 6.1 – SURFACE AND POPULATION OF DURRËS DISTRICT

Nr.	*Division Municipality*	*Surface [km2]*	Population	*Special features*
1	Durrës	45.1	197.699	
2	Shijak	1.9	12.840	
3	Sukth	51.9	24.598	Well drained land
4	Manze	44.9	10.757	Massive olive grove
	Commune			
5	Katund i Ri	50	15.488	Fertile land
6	Rrashbull	56.1	26.099	
7	Xhalzotaj	27.6	16.387	Poultries and piggy farming
8	Maminas	29	6.698	Agricultural inputs
9	Gjepalaj	34	5.849	
10	Ishem	92.9	8.201	
	Durrës District	**433.4**	**324.616**	

Source: Durrës Chamber of Commerce and Industry www.ccidr.al

The natural resources has served as starting bases for local economies responding to new open market after '90. The fertile land and the balanced climate with long warm summer alternated my mild winter have determined most of people living in communes to operate agriculture and farming activities.

New other developments are in rapid progress in communes like Rrashbull, Xhafzotaj, Maminas. Their areas along the highway and the old road that connect Tirana with Durrës has favoured the foster of many new establishment dedicated to manufacture or service.

Nowadays, all companies everywhere in European countries need to increase their competitiveness. Exporting the technology and a part of their value added by labour to a developing country will give benefits to both countries. Durrës Region is a good opportunity to do so.

The private sector constitutes the economic engine of the Durrës region. There is a high trend of new established businesses and entrepreneurship development in this area. During 2007 and 2006 there is a growth of start-up companies, respectively 1,568 and 2,083 companies.

Durrës was the second region in the country by the number of operating enterprises in its territory in 2007, see table below.

TABLE 6.2 – ENTERPRISES IN ALBANIA

No.	***Region***	***Enterprises***	**%**
1	Tirana	34,131	39.1
2	**Durrës**	**10,624**	**12.1**
3	Fier	8,321	9.5
4	Korce	6,875	7.9
5	**Vlora**	**6,826**	**7.8**
6	Elbasan	5,971	6.8
7	Shkoder	4,323	4.9
8	Berat	3,554	4.1
9	Gjirokaster	2,493	2.8
10	Lezhe	2,207	2.5
11	Diber	1,395	1.6
12	Kukes	764	0.9
	Albania	**87,484**	**100**

Source: Durrës Chamber of Commerce and Industry www.ccidr.al

Since 1991, the structure of the enterprises has been changing and adapting to the open market economy. In 2007 it had a view similar to many other developing countries entering the global market. In table 8 the total number of enterprises in the Durrës region is split in different sectors.

TABLE 6.3 – ENTERPRISES OF DIFFERENT SECTORS IN DURRËS AREA

Sector	***Enterprises***	**%**
Production	1,955	18.4
- Agriculture & Fishing	161	1.5
- Industry	1,096	10.3
- Construction	698	6.6
Services	8.669	81.6
- Commerce	4,732	44.5
- Hotel, restaurant, etc	1,732	16.3
- Transport & Comm.	1,111	10.5
- Other services	1.094	10.3
Durrës Region	**10,624**	**100**

Source: Durrës Chamber of Commerce and Industry www.ccidr.al

Due to geographical position close to major regional and European markets, and also by good access to Adriatic and Mediterranean seas, the enterprises in Durrës Region has paid much attention to international trade. They occupied the 2e place for the Albanian exports in 2007, fig 6.2.

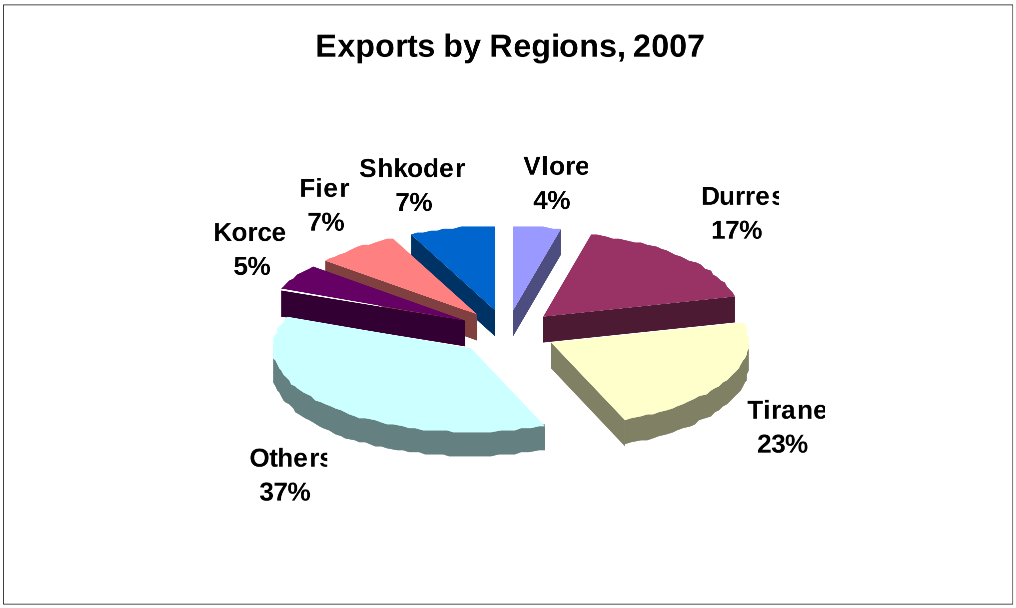


FIGURE 6.2 – EXPORTS BY REGIONS, 2007

6.5 The new developments in northern Durrës

New and ambitious developments have been projected in Northern Durrës [DURRËS CHAMBER OF COMMERCE AND INDUSTRY, 2008]:

- The Terminal of petroleum products, suitable for tankers up to 20.000 tons, with annual capacity of 140.000m^3 petroleum products and 14.000m^3 liquid gases. The construction ended last year.

- Energetic Park, approved by the Government, on a surface of 550 ha, where thermal power plants will be established, as well as plants processing petroleum products.

- Industrial Park, approved by the Government, on a surface of 850 ha, where industrial, commercial and logistic activities will be developed.

Beneath more details will be given of these developments.

6.5.1 The Terminal of petroleum products

Taking the respective concession of the form 'BOT' since two years ago, the company 'Romano Port' has constructed a wharf for delivering petroleum products (gas oil, gasoline, coal-oil, combustibles) and of liquid gas. This investment, approximately 25 million euros, has entered in function in the beginning of year 2009. Its annual capacity goes around 140.000m^3 of petroleum products and 14.000m^3 liquid gas. It is situated in the northern area of Durrës, called Porto-Romano, extending on a surface of 2 ha.

In a square with a surface of 54ha deposits are placed with an overall capacity of 140.000m^3 petroleum products and 14.000m^3 liquid gas. They occupy a surface of 26ha, which together with the free surfaces between them, fill all the foreseen territory. By main pipe managed by the

Terminal, liquid hydrocarbons arrive in the Central Collector, whereof braches, at the responsibility of collector companies, supply each of the deposits [www.romanoport.com.al]

6.5.2 Energetic Park (EP)

By [MINISTER'S COUNCIL DEGREE NO. 703, DATE 23.4.2008] has been approved the raising of an EP in the northern area of Durrës. EP will occupy a surface around 550ha, exactly the marsh land reclaimed form the former Durrës Swamp, situated between Porto Romano and Bishti i Palles. Aiming EP to supply a good part of the country demand for energy, in the study approved by MCD are foreseen investment like:

- The terminal of gross petroleum, an investment of 10 million Euro, on a surface of 9 ha.
- Refinery 3-5 million ton/year, an investment of 700 million Euro, on a surface of 45 ha.
- Two TEC, each 800 MW, of combined cycle technology, each an investment of 1.2 billion Euro, on a surface of 40 ha
- The park of storehouses of chemical substances and oils, an investment of 15 million Euro, on a surface of 15 ha.
- The plant of bio combustibles elaboration, an investment of 45 million Euro, on a surface of 15 ha.
- The plant of gasification of liquid gas, an investment of 100 million Euro, on a surface of 15 ha.
- The plant of cleaning and security of the area, an investment of 60 million Euro, on a surface of 18ha.

6.5.3 Industrial Park (IP)

Also by MCD, date 21-2-2008, is declared an economic zone, with status of 'Industrial Park' the territory with a surface of 850ha. In this area will develop economic activities, like:

- Production: industrial and agro processing
- Commercial
- Services

Building a new port in this zone opens quite new perspectives even for container transport, and also the creation of free quays for sailing and pleasure boats in the existing port.

The new opportunities revealing in Durrës North, with its Industrial and Energy Park, and the new Port, will certainly attract many other foreign investors, interested in manufacturing, trade, transport or other services.

7 TRADE FORECASTING

7.1 Introduction

Forecasting the demand for a port's service is usually the first step in the planning of a new port. Planning of a new port (or an improvement in an existing port) in a country with more than one port involves two major tasks. The demand for port services is a derived demand, i.e., it is derived from the demand for a country's exports and imports. Therefore, the first task is to forecast the future volume of total waterborne imports and exports of the country and its origins/ destinations. In countries with more than one existing port, shippers and receivers have an option to route their cargo through different ports. The second task, therefore, is to allocate the predicted total volume of imports and exports among the country's ports. Since Durrës currently has the biggest share of waterborne transport and the port of Vlora will be upgraded to be his competitor in future, these are the essential ports in forecasting trade volumes in Albania.

The cost to the shipper/receiver of sending those goods through one port rather than another depends on the cost of inland transport to/from the port, which in turn depends on the shipper's/receiver's location relative to available ports, the cargo handling and other costs in the port, and the cost of sea transport. These costs depend on the type of cargo and the state of the inland transport system. The transport costs for bulk cargo such as grain, iron ore, coal, etc. are usually high relative to the value of commodities. These so called 'tied' cargoes, therefore, will typically move through the closest port.
The 'footloose' cargo consists primarily of containerized cargo, break bulk general cargoes. These cargoes have a more diffused pattern of origins and destinations which increases the importance of inland transport costs.

The first task is to forecast the country's total foreign trade volume. For this task one may use historical data and regress the country's imports and exports on some aggregate measure of economic activity such as GDP and then use the independent forecasts of the GDP to predict future volume of the country's imports and exports. Alternatively, one may disaggregate total imports and exports by major commodities, generate forecasts for each commodity separately and the aggregate individual commodity forecasts to obtain the total country's imports and exports. However, the second approach requires availability of more detailed data. Due to the lack of this data the second approach is not used.

Once the total volume of foreign trade is predicted, the next task is to divide the country into a number of origin/destination zones (demand centres), and to estimate the volume of waterborne export and import traffic associated with each zone.

7.2 Investigation current trade conditions

7.2.1 Commodities

Albania's main exports are metals and minerals, textiles and footwear, and building materials. Growing re-exports of textiles and footwear have been a feature of the transition period, and there is also a potential for Albania to become competitive in early-season fruit and vegetables, particularly for the EU market. Machinery and equipment is the largest single category of imports, and electricity imports are also significant, owing to chronic power shortages. In appendix A, the commodities are described in a more detailed level.

TABLE 7.1 – EXPORT BY H.S. SECTIONS [TONS]

HS	Section	2005	2006	2007	2008
01	Live animals and animals products	1.489	1.600	3.456	5.841
02	Vegetable products	21.384	24.528	28.454	25.869
03	Edible oils	257	638	769	159
04	Prepared foodstuffs, beverages, tobacco	20.126	17.590	4.437	8.588
05	Mineral products	366.721	596.748	227.752	184.587
06	Products of chemical industries	3.353	2.479	2.944	3.864
07	Plastics, rubber and their articles	2.807	2.879	3.340	5.527
08	Leather and their articles	5.497	5.133	4.916	5.163
09	Wood and articles of wood	36.502	34.728	31.098	40.717
10	Paper and their articles	10.130	11.647	18.933	20.705
11	Textiles and textile articles	19.769	20.484	22.558	21.466
12	Footwear	16.562	17.960	17.987	17.136
13	Articles of stone, ceramic products, glass	33.839	52.730	77.480	110.557
14	Pearls, precious stones and metals etc.	72	98	99	127
15	Base metals and articles of base metal	116.703	150.402	141.350	209.338
16	Machinery, appl. and electric materials	7.350	7.813	11.981	13.791
17	Transport means	564	402	998	2.534
18	Optical, photographic, musical instrum.	105	93	66	53
19	Arms and ammunition	520	2.044	2.870	126
20	Miscellaneous manufactured articles	9.184	10.071	11.752	11.735
21	Work of art, collections etc.	6	6	12	0
	Total	**672.941**	**960.072**	**1.633.250**	**1.687.884**

Source: www.dogana.gov.al

TABLE 7.2 – IMPORT BY H.S. SECTIONS [TONS]

HS	Section	2005	2006	2007	2008
01	Live animals and animals products	62.297	73.406	76.210	79.852
02	Vegetable products	609.065	629.568	614.901	561.461
03	Edible oils	41.931	49.576	45.269	42.923
04	Prepared foodstuffs, beverages, tobacco	231.732	244.362	271.112	295.324
05	Mineral products	2.199.043	2.218.149	1.795.068	1.885.461
06	Products of chemical industries	176.494	211.793	233.132	224.634
07	Plastics, rubber and their articles	63.746	64.592	71.956	78.463
08	Leather and their articles	4.811	5.438	7.472	6.380
09	Wood and articles of wood	119.382	140.565	153.300	151.848
10	Paper and their articles	40.538	47.723	52.200	56.380
11	Textiles and textile articles	61.244	63.930	66.961	63.049
12	Footwear	10.406	11.484	10.386	9.647
13	Articles of stone, ceramic products, glass	588.967	532.402	542.173	508.847
14	Pearls, precious stones and metals etc.	103	118	174	163
15	Base metals and articles of base metal	440.072	491.695	580.646	474.898
16	Machinery, appl. and electric materials	105.576	84.185	97.797	117.304

17	Transport means	54.343	61.982	71.939	71.543
18	Optical, photographic, musical instrum.	2.078	2.332	2.604	2.615
19	Arms and ammunition	365	208	122	222
20	Miscellaneous manufactured articles	26.548	26.042	32.434	30.114
21	Work of art, collections etc.	15	20	17	17
	Total	**4.838.756**	**4.959.570**	**4.725.873**	**4.661.142**

Source: *www.dogana.gov.al*

7.2.2 Foreign trade

Since the end of the communist-era, Albania's foreign trade has expanded rapidly. The EU buys about 80% of the country's exports, and about 60% of Albania's imports come from the EU.

TABLE 7.3 – VOLUME OF EXPORTS BY COUNTRY OF DESTINATION

Countries	***2005 Ton***	***2005 %***	***2006 Ton***	***2006 %***	***2007 Ton***	***2007 %***	***2008 Ton***	***2008 %***
Italy	165,505	24.6	243,707	25.4	415,657	25.4	464,309	27.5
Macedonia	130,268	19.4	175,330	18.3	273,900	16.8	386,481	22.9
Greece	128,576	19.1	178,114	18.6	220,162	13.5	228,129	13.5
Kosovo	72,206	10.7	70,961	7.4	175,818	10.8	153,432	9.1
China	31,467	4.7	114,977	12.0	224,381	13.7	122,455	7.3
Sweden	50,069	7.4	69,048	7.2	85,336	5.2	19,284	1.1
Turkey	38,803	5.8	30,610	3.2	62,125	3.8	33,596	2.0
Russia	6,075	0.9	3,341	0.3	15,407	0.9	41,381	2.5
Others	49,972	7.4	73,983	7.7	160,462	9.8	238,817	14.1
Total	**672,941**	**100**	**960,072**	**100**	**1,633,250**	**100**	**1,687,884**	**100**

Source: *www.dogana.gov.al*

TABLE 7.4 – VOLUME OF IMPORTS BY COUNTRY OF ORIGIN

Countries	***2005 Ton***	***2005 %***	***2006 Ton***	***2006 %***	***2007 Ton***	***2007 %***	***2008 Ton***	***2008 %***
Greece	1,255,750	26.0	1,119,808	22.6	1,234,421	26.1	1,263,051	27.1
Italy	1,121,346	23.2	1,082,385	21.8	945,852	20.0	1,043,455	22.4
Russia	407,042	8.4	384,950	7.8	481,041	10.2	403,376	8.7
Turkey	638,624	13.2	582,736	11.7	375,019	7.9	209,406	4.5
Macedonia	93,735	1.9	117,459	2.4	184,088	3.9	221,812	4.8
Ukraine	248,480	5.1	372,363	7.5	259,549	5.5	134,653	2.9
Spain	136,226	2.8	121,109	2.4	121,654	2.6	138,468	3.0
Brazil	21,844	0.5	31,057	0.6	71,962	1.5	111,013	2.4
China	92,524	1.9	100,429	2.0	140,363	3.0	156,492	3.4
Kosovo	45,058	0.9	77,918	1.6	109,060	2.3	136,158	2.9
Bulgaria	118,678	2.5	112,899	2.3	60,018	1.3	84,163	1.8
Others	659,450	13.6	856,456	17.3	742,846	15.7	759,094	16.3
Total	**4,838,756**	**100**	**4,959,570**	**100**	**4,725,873**	**100**	**4,661,142**	**100**

Source: *www.dogana.gov.al*

7.2.3 Seaborne trade

Albania has four major sea ports: Durrës, Vlora, Saranda and Shëngjin, see figure 1.2. The port of Durrës has the biggest share in the volume of waterborne import/export, in average 77%, see table 7.5.

TABLE 7.5 – VOLUME OF LOADING AND UNLOADING AT SEA PORTS (1993-2008) [‘000 TONS]

Year	*Durrës*	*[%] of total*	*Vlora*	*Saranda*	*Shengjini*	*Total*
1993	774	0.94	15	11	28	828
1994	662	0.83	78	20	33	793
1995	988	0.75	235	30	58	1,311
1996	1,174	0.72	313	26	96	1,609
1997	1,151	0.85	144	9	59	1,362
1998	1,168	0.71	339	22	117	1,646
1999	1,558	0.72	367	42	183	2,150
2000	1,883	0.70	527	60	232	2,702
2001	1,989	0.66	592	52	362	2,995
2002	2,181	0.71	503	61	347	3,092
2003	2,673	0.78	352	82	316	3,423
2004	2,960	0.82	301	73	294	3,628
2005	3,112	0.79	404	97	344	3,957
2006	3,422	0.80	457	99	282	4,260
2007	3,442	0.79	520	77	293	4,332
2008	3,704	0.79	609	72	319	4,708

Comparing throughput data at the sea ports with the total trade volume in Albania gives a result of about 72% in waterborne transport, see table 7.6.

TABLE 7.6 – SEATRANSPORT IN RELATION TO TOTAL TRADE VOLUME [* = FORECAST]

Year	*Total trade volume [tons]*	*Sea trade volume [tons]*	*Percentage*
2000	3,297	2,338	71%
2005	5,512	3,957	72%
2006	5,920	4,260	72%
2007	6,359	4,332	68%
2008	6,349	4,708	74%
2020*	9,378	6,898	74%

7.2.4 GDP as indicator

It is generally accepted that the trade level that occurs between trading partners is closely related to global economic activity (GDP). Most international merchandise transport is carried out via seaborne routes due to lower associated costs. Hence, it is no surprise that the world gross domestic product (GDP) and seaborne trade are strongly correlated. The global GDP is therefore often used as an indicator in forecasting international trade. Similarly a country’s GDP is often used as an indicator for its trade.

A transport multiplier method is utilized in the country level forecasting. With this method, a multiplier is found by looking at historic levels of foreign trade volume and Albania’s GDP, see table 7.8. Forecast GDP levels are then multiplied with this multiplier to arrive at a forecast throughput level.

TABLE 7.7 – HISTORIC GDP GROWTH LEVELS

GDP growth [%]	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*
World	4.2	1.5	1.9	2.7	4.0	3.4	3.9	3.7	2.7
Europe	4.0	2.1	1.3	1.5	2.7	2.0	3.1	-	-
Developed countries	3.7	1.2	1.3	2.0	3.3	2.6	2.9	-	-
Developing countries	5.6	2.8	2.8	5.2	7.3	6.4	4.5	-	-
Low income countries	4.0	4.7	3.5	6.9	7.4	8.0	7.4	-	-
Albania	**7.3**	**7.0**	**2.9**	**5.7**	**5.9**	**5.5**	**5.0**	**6.0**	**6.0**
Italy	3.6	1.8	0.3	0.0	1.2	0.1	1.9	-	-
Greece	4.5	4.5	3.9	4.9	4.7	3.7	4.3	-	-
Macedonia	4.5	-4.5	0.9	2.8	4.1	4.1	3.0	-	-

Source: http://earthtrends.wri.org/text/economics-business/variable-227.html

TABLE 16 – RELATION GDP AND FOREIGN TRADE

	2000	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*Average*
Import + export [tons]	3,296,503[1]	3,489,000[2]	3,826,000[2]	4,689,000[2]	5,192,000[2]	5,511,697	5,919,642	6,359,123	6,349,026	-
Annual growth trade [%]		5.8	9.7	22.6	10.7	6.2	7.4	7.4	-0.2	8.7
GDP growth [%]	7.3	7.0	2.9	5.7	5.9	5.5	5.0	6.0	6.0	5.7
Multiplication factor		0.8	3.3	4.0	1.8	1.1	1.5	1.2	0.03	1.7

[1] = Following ‘Trans-Tools’ the import + export in 2000 is 2,637,202 tons. Because ‘Trans-Tools’ has used only trade data with EU-countries a higher value is given based on the assumption that Albanian foreign trade is dominated by the EU by 80% of total flows.

[2] = These quantities aren’t historical data, but they are estimated based on the throughput of the Port of Durrës which is in average 57% of all trade volumes in Albania.

7.3 Forecasting total foreign trade up to 2035

7.3.1 Introduction

Market demand for sea transportation is an indirect demand, which depends on economic activity and international trade. Demand drivers are current market conditions (international, country specific and regional economic activity), seaborne commodity trade volumes, market choice and other factors like political events, security of transport etc.

The nature and number of potential demand drivers to be considered and the lack of reliable data make forecasting difficult.

7.3.2 Methods

There are many ways of forecasting demand at ports.

A simple method of forecasting is to extrapolate throughput data of the last years to predict the future volumes which would be handled in the port. In fact this is not precise enough due to different outcomes when using different timescales. Further, this method assume that changing in economy wouldn't occur. It is only an allowable prediction method for forecasting at small timescales. Therefore, this method is not used.

An alternative method is forecasting with the help of a transport model. For this master plan, Trans-Tools is used as control system to analyse and verify the results of the handmade calculation. More information about Trans-Tools is given in chapter 7.3.5.

A more simplified approach has been sought whereby only the most important aspects and variables that influence the port demand were modelled. The first step is to understand the current market conditions to determine potential key drivers. Once the key drivers are known the model (by hand calculations) can be verified by the output of Trans-Tools, see chapter 7.3.6.

7.3.3 Procedure

The global calculation procedure from statistical information up to a forecast for 2035 will be described in several steps.

1. A calculation is performed with the help of Trans-Tools. Trans-Tools uses statistical trade information of the base year 2000 and predict flows up to 2020. These flows contain Albania's total road, rail and sea transport. For more information of Trans-Tools, see section 7.3.5.
2. The output data of Trans-Tools for 2020 is analysed in section 7.3.5 and 7.3.6. Next, an estimation of Albania's total trade flows is made for 2035 by hand calculations using GDP curves. (section 7.2.4 and 7.3.6)
3. In section 7.4 the import / export ratio is shown and some trend assumptions up to 2035 are carried out.
4. For the Master plan of Romano port, information is needed which part of Albania's total trade will be transported by sea. In section 7.5 a future trend is depictured.
5. Trans-Tools uses the NSTR classification of commodities. For the Master plan and forecasting port throughputs, the sectors dry bulk, liquid bulk, general cargo and containers become important. In section 7.6 the NSTR classification is converted in the sectors mentioned above.
6. Subsequently some further investigations are made with respect to evolutions of the four sectors; dry bulk, liquid bulk, general cargo and containers. At the end in section 7.6.3. the expected percentages of seaborne throughput in sectors are shown at three points in time, respectively 2020, 2030 and 2035.

7. Finally, in section 7.7 the share in sea trade which will be handled in Romano Port with respect to other ports is described and a throughput estimation is performed.

7.3.4 Time series

The division of the forecasts into three scenarios is a wide-used tactic which encloses the limits of future growth. For an even more realistic approach of the future conditions, the master plan duration, which will be 25 years (2010-2035), will be divided into three periods for each scenario: two periods of ten years (2010-2020 and 2020-2030) and one period of five years (2030-2035). The time frame of 25 years is in line with the general practise of master plans.

7.3.5 Trans-Tools (forecast up to 2020)

Traffic and transport models are an essential tool for policy makers to identify and asses trends and counter-measures. In addition to the needs of market player, transport models give a quantitative insight in trends in the traffic and transport market, the usage of infrastructure, and the impact of environment.

Trans-Tools is an European transport network model that has been developed in collaborative projects funded by the European Commission and DG TREN. It is covering both passengers and freight, as well as intermodal transport. The model developed is based on the most recent European strategic reference database on transport demand, services, infrastructure networks and impact related information, namely the ETIS Reference database of the ETIS-BASE project [CHEN, T.M., *ET AL*. 2005].

Freight demand model

For the scope of this project, the freight demand model is important. A generation and attraction pattern of the trade flows in the chosen basis year is a starting point for building a trade model in general. Especially for the Trans-Tools trade model, the ETIS freight transport matrix will be used. The ETIS matrix describes the generation and attraction of physical flows of goods between the trading countries given the economical determinants of the year 2000. The output of the Trans-Tools trade model is a forecast matrix for freight including origin region, destination, commodity group and tonnes. Within the model there are four modes of transport available (road, rail, inland waterway, sea). In Trans-Tools Albania isn't divided in several provinces but is seen as one destination/ origin point.

Input/data needed for trade transport model

The input for the trade model consists of:

A) Transport components (Origin, destination, commodity group, tonnes)

B) Socio-economic component, consisting of the following 2 components:

1. Data on economical/political granulation of the world
2. Economic data set by country (GDP, population, etc.)

These variables are needed for the base year 2000. For running the model the average growth rates between the base year and the forecast year are needed for these variables.

TNO has performed a calculation for Albania with the base year 2000 and has set the forecast year on 2020. The results have been analysed and the summary is shown below in tables 7.9 and 7.10.

In Trans-Tools data are gathered and calculations are made with respect to trade in EU-context. Because Albania's foreign trade is dominated by the EU (80% of total flows), the outcome of Trans-Tools is multiplied by 1.25 to compensate for this limitation, see table 7.9 and 7.10. The prognosis is that the 80% EU trade will remain stable, Italy and Greece are Albania's main trade partners, even in future.

TABLE 7.9 – FOREIGN TRADE ALBANIA IN 2000

	2000 EU [tons]			*2000 World [tons]*					
	Import	*Export*	*Total*	*Import*	*[%]*	*Export*	*[%]*	*Total*	*[%]*
Sea	1,740,163	129,897	1,870,060	2,175,204	71	162,371	66	2,337,575	71
Road	671,059	64,663	735,722	838,824	28	80,829	33	919,653	28
Rail	29,963	1,457	31,420	37,454	1	1,821	1	39,275	1
Total	2,441,185	196,017	2,637,202	3,051,481	100	245,021	100	3,296,503	100

TABLE 7.10 – FOREIGN TRADE ALBANIA IN 2020 [FORECAST]

	2020 EU [tons]			*2020 World [tons]*					
	Import	*Export*	*Total*	*Import*	*[%]*	*Export*	*[%]*	*Total*	*[%]*
Sea	4,872,114	646,059	5,518,173	6,090,143	73	807,574	76	6,897,716	73
Road	1,433,651	189,115	1,622,766	1,792,064	22	236,394	22	2,028,458	22
Rail	347,462	14,001	361,463	434,328	5	17,501	2	451,829	5
Total	6,653,227	849,175	7,502,402	8,316,534	100	1,061,469	100	9,378,003	100

TABLE 7.11 – VOLUME OF SEABORNE EXPORTS BY COUNTRY OF DESTINATION (TRANS-TOOLS)

Countries	***2000 Ton***	***2000 %***	***2020 Ton***	***2020 %***
Italy	95,732	74	382,746	59
Greece	4,946	4	96,649	15
The Netherlands	9,024	7	67,986	11
Slovenia	4,845	4	28,608	4
France	6,738	5	26,444	4
Yugoslavia	4,150	3	16,657	3
Croatia	2,384	2	15,668	2
Belgium	1,273	1	4,564	1
Denmark	42	0	4,553	1
Bulgaria	529	0	1,580	0
Germany	209	0	458	0
Turkey	23	0	139	0
Total	**129,897**	**100**	**646,059**	**100**

TABLE 7.12 – VOLUME OF SEABORNE IMPORTS BY COUNTRY OF ORIGIN (TRANS-TOOLS)

Countries	***2000 Ton***	***2000 %***	***2020 Ton***	***2020 %***
Italy	936,085	54	2,285,990	47
Greece	619,655	36	2,103,636	43
Spain	59,849	3	174,102	4
France	43,999	3	89,036	2
Slovenia	17,827	1	68,669	1
Yugoslavia	15,969	1	37,773	1
Croatia	12,386	1	32,830	1
The Netherlands	9,813	1	21,608	1
Belgium	14,394	1	16,614	0
Germany	5,469	0	14,644	0
Romania	0	0	11,752	0
Bulgaria	1,205	0	7,934	0
Denmark	2,155	0	4,503	0
Total	**1,740,163**	**100**	**4,872,114**	**100**

7.3.6 Forecast up to 2035

7.3.6.1 GDP Growth

In table 7.13 the GDP growth forecast is given of relevant countries which have a trade relation with Albania. In figure 7.1 more GDP-data of Balkan countries is given and from this list Albania is the country with the highest expected GDP growth rate.

TABLE 7.13 – GDP GROWTH 2000-2030 [FORECAST]

	GDP yearly growth rate 2000 – 2020 [%]	***GDP yearly growth rate 2005 – 2030 [%]***
Greece		2.6
Italy		1.2
Albania	7.2	
Macedonia	4.7	
Russia	3.0	
Turkey	4.7	

Source: DG TREN (2005) and PRIMES

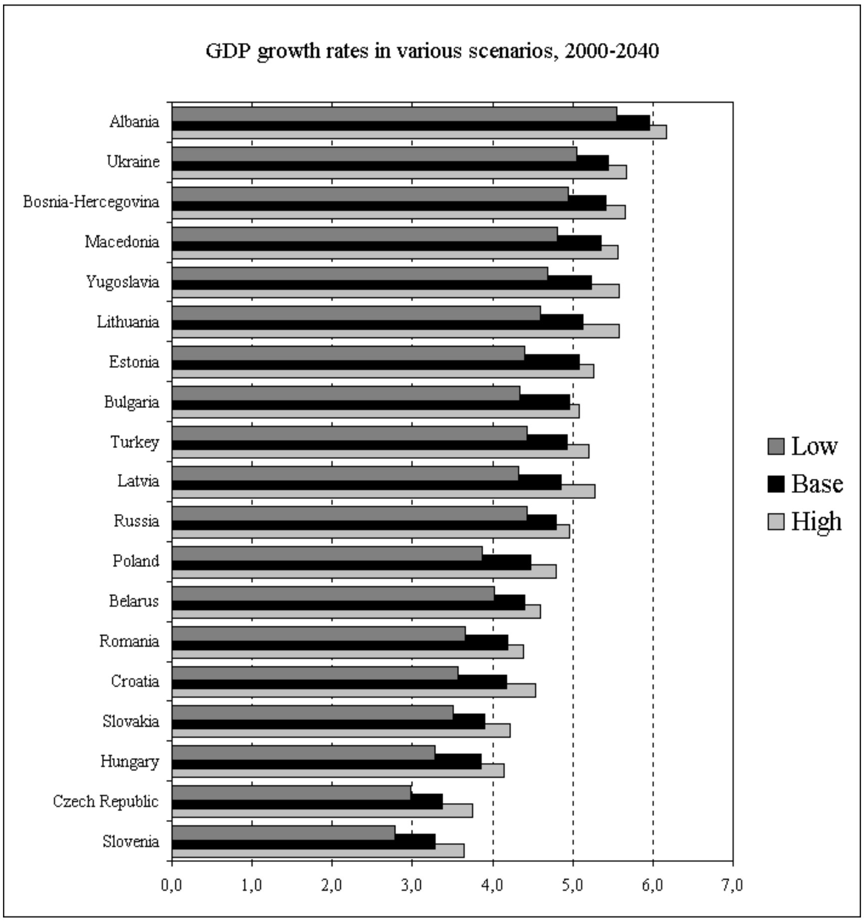


FIGURE 7.1 – GDP GROWTH RATES IN VARIOUS SCENARIOS, SOURCE: WWW.NOBE.PL

Development scenarios

Three growth scenarios have been retained for the long term regional development:

- A base growth scenario
- A low growth scenario
- A high growth scenario

The base growth scenario represents an average reasonable scheme. The low growth scenario can be considered as the pessimistic scenario with little economic growth. The high growth scenario is the optimistic scenario, envisioning a rather high economic growth. The construction of the three scenarios is presented by table 7.14 [NOBE, 2002].

TABLE 7.14 – GDP SCENARIOS [FORECAST]

Growth of GDP Albania	*2010-2020*	*2020-2030*	*2030-2040*
Low scenario	6.6	6.1	4.9
Base scenario	7.2	6.4	5.2
High scenario	7.7	6.5	5.1

Source: www.nobe.pl

As mentioned before in chapter 7.2.4 transport multipliers are used in the country level forecasting. With this method, a multiplier is found by looking at historic levels of foreign trade volume and Albania's GDP, see table 7.8. However, the average transport multiplier of the last eight years is 1.7 and multiplying forecast GDP levels with this factor gives a huge forecast throughput level in 2035 which is unreliable. The output of Trans-Tools for the total trade volume in 2020 is 9.5 million tons. This value will certainly be underestimated due to old data. With this background information a transport multiplier is chosen with a value of 0.6, such that in the base scenario the total trade volume in 2020 will exceed the result of Trans-Tools with 10%. The final forecast calculation for 2035 will end up in a total trade volume of about 18 million tons.

TABLE 7.15 – TOTAL THROUGHPUT LEVELS [FORECAST]

	2010-2020	*2020-2030*	*2030-2035*
GDP growth [%] Low Scenario	6.6	6.1	4.9
Multiplication factor	0.6	0.6	0.6
Annual trade growth [%]	4.0	3.7	2.9
Import + export 2020/2030/2035 [tons]	10,118,179	14,494,873	16,754,645
GDP growth [%] Base Scenario	7.2	6.4	5.2
Multiplication factor	0.6	0.6	0.6
Annual trade growth [%]	4.3	3.8	3.1
Import + export 2020/2030/2035 [tons]	**10,546,735**	**15,373,220**	**17,925,834**
GDP growth [%] High Scenario	7.7	6.5	5.1
Multiplication factor	0.6	0.6	0.6
Annual trade growth [%]	4.6	3.9	3.1
Import + export 2020/2030/2035 [tons]	10,916,507	16,004,392	18,607,579

7.4 Relation import / export

An important parameter is the ratio between import and export. The respective ratio from the previous years will be presented in order to estimate the future one. The period of data collection is short but will be certainly long enough to see a trend depiction instead of a periodical phenomenon. In order to proceed though, some values will have to be chosen based on the ratio of the years 2000 up to 2008, see table 7.16. After 2008, this ratio is assumed to decrease from 73%/27% to 63%/37% in 2035 because of the expected growth of the hinterland demand and increasing productivity in Albania. This is an arbitrary assumption and it has to be checked with the actual values in the future.

TABLE 7.16 – RELATION IMPORT / EXPORT [* = FORECAST]

	2000	*2005*	*2006*	*2007*	*2008*	*2020 (T-T)**	*2020**	*2030**	*2035**
Import [%]	93	88	84	74	73	89	70	65	63
Export [%]	7	12	16	26	27	11	30	35	37
Total [%]	100	100	100	100	100	100	100	100	100

Another aspect that makes this national trend plausible is the import/export ratio of several years of the Port of Durrës which is exactly the same, see figure 7.2.

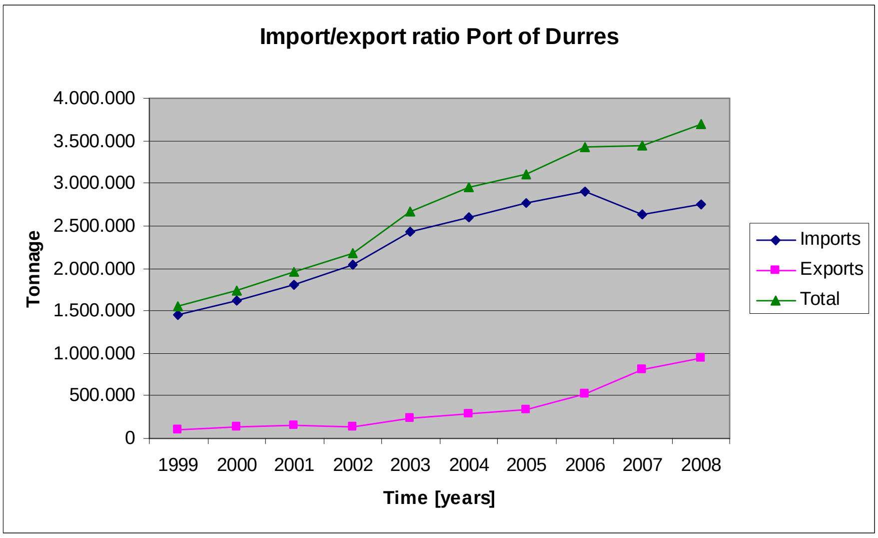


FIGURE 7.2 – IMPORT / EXPORT RELATION PORT OF DURRËS

7.5 Seaborne transport

The relation between seaborne transport and the total trade volume in Albania is constant in time from 2000 up to now and therefore supposed to be stable in future at 72%.

TABLE 7.17 – SEABORNE TRANSPORT [* = FORECAST]

('000 tons)	*2000*	*2008*	*2020(T-T)**	*2020**	*2030**	*2035**
Total trade volume	3,297	6,349	9,378	10,547	15,373	17,926
Import	3,051	4,661	8,317	7,383	9,992	11,114
Export	245	1,669	1,061	3,164	5,381	6,812
Seaborne transport	2,338	4,708	6,897	7,594	11,069	12,907
Import	2,175	3,617	6,090	5,316	7,195	8,390
Export	162	1,091	808	2,278	3,874	4,517

7.6 Market Sector Split of Sea transport

The NSTR classification of commodities has been retained for trade statistics analysis and this classification on the digit-1 level has the following commodity categories:

0) Agricultural product and life animals
1) Foodstuff and animal fodder
2) Solid mineral fuels
4) Ores and metal waste
5) Metal products
6) Crude and manufactured minerals, building materials
7) Fertilizers
8) Chemicals
9) Machinery, transport equipment, manufactured articles and miscellaneous articles
10) Petroleum products

In table 7.18 and 7.19 the import/export data is given at year 2000 and a forecast of 2020 made by Trans-Tools.

TABLE 7.18 - TRANS-TOOLS SEA IMPORTS [* = FORECAST]

Nstr		*2000 [tons]*	*2020* [tons]*
0	Agricultural Products and Live Animals	95,056	228,298
1	Foodstuffs and Animal Fodder	149,726	330,557
2	Solid Mineral Fuels	5,646	9,641
4	Ores and Metal Waste	81	203
5	Metal Products	36,843	178,815
6	Crude and Manufactured Minerals, Building Materials	1,170,268	3,285,374
7	Fertilizers	3,475	5,573
8	Chemicals	35,509	174,543
9	Machinery, Transport Equipment, Manufactured Articles and Miscellaneous Articles	117,458	352,061
10	Petroleum products	126,099	307,049
	Total	1,740,163	4,872,114

TABLE 7.19 – TRANS-TOOLS SEA EXPORTS [* = FORECAST]

Nstr		*2000 [tons]*	*2020* [tons]*
0	Agricultural Products and Live Animals	12,500	27,437
1	Foodstuffs and Animal Fodder	5,266	8,865
2	Solid Mineral Fuels	0	0
4	Ores and Metal Waste	17,255	21,776
5	Metal Products	35,808	280,935
6	Crude and Manufactured Minerals, Building Materials	1,860	3,330
7	Fertilizers	0	0
8	Chemicals	2,422	17,915
9	Machinery, Transport Equipment, Manufactured Articles and Miscellaneous Articles	44,618	224,399
10	Petroleum products	10,170	61,403
	Total	129,897	646,059

Forecasting port throughputs, the sectors dry bulk, liquid bulk, general cargo and containers become important. In table 7.20 the commodities divided in sectors are shown. This information is gained from appendix A where the commodities are described in a more detailed level.

TABLE 7.20 – SEA IMPORT COMMODITIES DIVIDED IN SECTORS

Nstr		*Dry bulk [%]*	*Liquid bulk [%]*	*General Cargo [%]*	*Containers [%]*
0	Agricultural Products and Live Animals	61		35	4
1	Foodstuffs and Animal Fodder		11	72	17
2	Solid Mineral Fuels	100			
4	Ores and Metal Waste	100			
5	Metal Products			100	
6	Crude and Manufactured Minerals, Building Materials	74		22	4
7	Fertilizers		100		
8	Chemicals		40		60
9	Machinery, Transport Equipment, Manufactured Articles and Miscellaneous Articles			39	61
10	Petroleum products		100		

TABLE 7.21 – SEA EXPORT COMMODITIES DIVIDED IN SECTORS

Nstr		*Dry bulk [%]*	*Liquid bulk [%]*	*General Cargo [%]*	*Containers [%]*
0	Agricultural Products and Live Animals			85	15
1	Foodstuffs and Animal Fodder		1	93	6
2	Solid Mineral Fuels	100			
4	Ores and Metal Waste	100			
5	Metal Products			99	1
6	Crude and Manufactured Minerals, Building Materials	74		6	20
7	Fertilizers		100		
8	Chemicals		34		66
9	Machinery, Transport Equipment, Manufactured Articles and Miscellaneous Articles			31	69
10	Petroleum products		100		

Further aggregation may lead to only four key categories:

- Agriculture products (aggregation of above categories 0, 1 and 7)
- Industry products (aggregation of above categories 2, 4, 5 and 8)
- Miscellaneous products (aggregation of above categories 6 and 9)
- Petroleum products (category 10)

The rationale behind this further aggregation is that, in terms of growth, agricultural products or commodities are heavily linked to the overall level of the agricultural production of a given country, the industry products or commodities are linked to the level of the industrial production and finally, the miscellaneous products and the petroleum products are linked to the GDP level. In table 7.22 seaborne throughput is shown splitting up in the three main categories. A further investigation is made of the categories into the sectors, dry bulk, liquid bulk, containers and general cargo, the result is represented in table 7.23. One have to keep in mind that containerisation is not included.

TABLE 7.22 – RELATION SEABORNE THROUGHPUT WITH THREE CATEGORIES

	Linked to GDP level	*Linked to agriculture level*	*Linked to industry level*
Seaborne throughput 2000	79%	14%	7%
GDP yearly growth rate [2000-2035]	7.2%	3.3%	9.9%
Seaborne throughput 2035	65%	4%	31%

Source of GDP yearly growth rate: Primes

TABLE 7.23 – INVESTIGATION SECTORS [* = FORECAST]

	Sectors linked to GDP level	*Sectors linked to agriculture level*	*Sectors linked to industry level*	*Total 2000*	*Total 2035**
Dry bulk	59%	22%	13%	51%	42%
Liquid bulk	10%	7%	16%	9%	9%
General Cargo	22%	59%	54%	29%	36%
Containers	9%	12%	17%	11%	13%
Total	100%	100%	100%	100%	100%

From historic data the evolution of the market sector split of the various sectors (Dry bulk, Liquids etc) for Albania will be reviewed to determine the typical market share of each sector. Graph 7.3 shows that there are in some cases in the port of Durrës (77% of waterborne trade) quite some yearly variations and sometimes the markets share for a sector appears relatively stable. Beneath the movement of these sectors will be explained for each sector separately. Outside this categories it is assumed that no discontinuities in trends will occur.

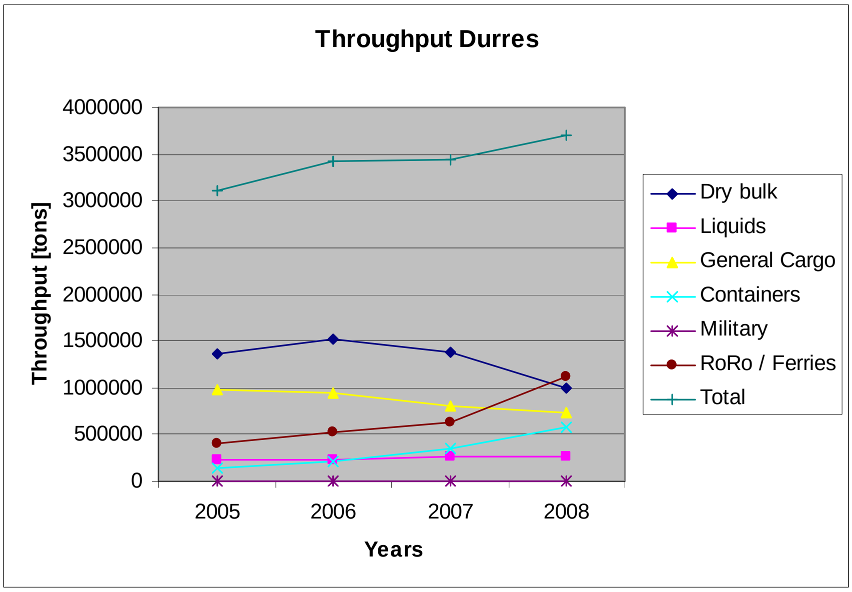


FIGURE 7.3 – THROUGHPUT PORT OF DURRËS

7.6.1 Containerisation / General Cargo

Avoiding overestimated general cargo and underestimated container traffic one have to care witch the phenomena that there is a general trend to containerize goods and reduce general cargo. In many countries this trend had been going on for some considerable time already, but Albania is a country where this trend is just started.

Global container transport has been booming during the last decades [ESCAP/UNDP,MPPM, 2001]. Figure 7.4 shows worldwide growth in maritime and container trade volumes over the period 1987 up to 2006. Total international maritime trade volumes grew at an average of 4.1% per annum over the period, with the result that by 2006 total seaborne trade was almost double 1990 volumes. Containerized cargoes by contrast have grown at an annual average rate of 9.5% over that same period, resulting in a five-fold increase in container movements.

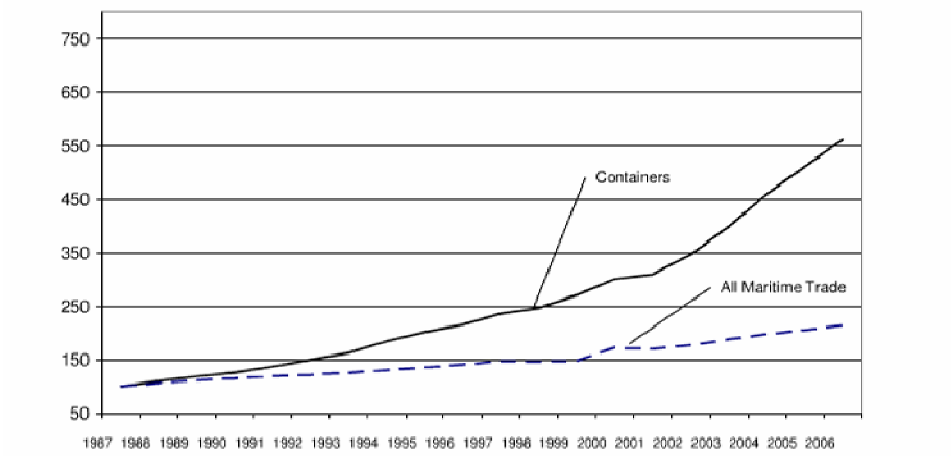


FIGURE 7.4 – WORLDWIDE GROWTH OF MARITIME AND CONTAINER TRADE (1987 = 100)
Source: Drewry shipping consultants, UNCTAD 2007

The main growth areas for ports in the Mediterranean in recent years have been containers and oil. Calls by containerships at Mediterranean ports have increased 71% since 1997. Consequently, most Mediterranean ports' development plans for the next 10 to 15 years include scope for expanding container handling or developing new container terminals, like Vlora. The Eastern Mediterranean will attract an increasing share of larger vessels due to its proximity to emerging Adriatic and Black Sea markets [EU-FUNDED MEDA REGIONAL PROJECT MED, 2008].

The main determinants of container port growth are the port preferences of container lines and economic growth in the hinterland served by a gateway port. The expectation will be that Albania's containerized traffic will increase significantly due to the start up of a container terminal in Vlora, the containerisation trend which is coming up in Albania and the expected improvement of the hinterland connections to landlocked countries. Automatically this will result in a slow decrease of the general cargo throughput. But one have to keep in mind that some goods cannot be containerized due to their inherent nature i.e. weight or size.

In [LOUIS BERGER S.A., 2004] the consultant has carried out a market analysis of the main commodities which will be described below. The analyses are done in 2003 and projected over a 20 year period, until 2023.

Iron and steel

Iron and steel are mainly used for residential construction and for road structure works. In 2003 total imports amounted 341,000 tons plus a local production (Elbasan) of 96,000 tons whereas the domestic market of construction iron and steel was estimated at 235,000 tons. The balance includes scrap, some for other purposes than construction and re-exports to Kossovo estimated to reach 90,000 tons, which do not appear in the official statistics. The consultant considers the growth in steel domestic demand will have the same pattern as the one for cement (section 7.6.2. dry bulk) bringing the Albania domestic market for iron and steel to 1.1 million tons in 2023, and due to an upgraded local production, the needs for imports will be limited to 586,000 tons.

Beverages
Beverages (beer, wine, soft drinks and mineral water) represent a significant market for road transport in Albania. The total consumption of manufactured beverages in Albania reached 174,000 tons in 2003, it is projected to reach 811,000 tons in 2023.

Sugar
Sugar is consumed both in Albanian households and for the production of soft drinks, jam and other fruit products. The total amount used in the country increased slightly from 65,000 tons in 1999 to 70,000 tons in 2003 (an average annual growth of 1.9%). The consultant assumed that the present growth of the sugar consumption in Albania will continue until 2023 to reach 102,000 tons. He also assumed that the amount of re-exports to Kossovo will grow at the same rate to reach 35,000 tons in 2023.

Vegetables and fruit
Albania has very good climatic conditions for the cultivation of vegetables (tomatoes, cucumbers, watermelons, legumes, carrots and eggplants) and fruits (apples, pears, peaches, apricots and cherries), mainly grown in the low lands of the coastal region. Imports of fruits and vegetables come through the port of Durrës. Exports are to the neighbouring countries (mainly Kossovo and Macedonia) and are transported by road. The consultant believes that the fruit production will grow at an average rate of 5% a year for the next 10 years and of 1 % a year (the same rate as the population growth) afterwards, and the vegetable production will only grow at a rate of 2.4 % for 5 years and at a rate of 1 % afterwards. The total local production of fruits and vegetables will then reach 1.265 million tons in 2023. The level of exports is therefore projected to increase to 55,000 tons in 2023.

7.6.2 Dry Bulk

Bulk ports and terminals in the Mediterranean have not experienced the same high levels of growth as their container counterparts. Worldwide the break bulk cargoes are rapidly declining, therefore the focus is mainly on containerized traffic [MIKLIUS, WALTER AND WU, YOUNGER, 1988]. In the bulk sector, Adriatic ports are a natural gateway for Central and Eastern European traffic. They are well placed and take advantage of any hinterland infrastructure improvements to attract cargo currently routed via Northern European ports. In this event maritime traffic through the Strait of Otranto (connection between Ionian and Adriatic Sea) and into the Northern Adriatic is likely to increase [EU-FUNDED MEDA REGIONAL PROJECT MED, 2005].

In contrast with other commodities which are directly correlated with the evolution of the economy, and may be accordingly forecasted from the perspectives of GDP, the transport of industrial or mining products (or inputs) have to be analysed branch by branch and sometimes even company by company.
Albania, Montenegro and Macedonia are countries where the future pattern of industrial and mining activities is still unclear. [LOUIS BERGER S.A., 2002]

Cement
Subsequently to the construction sector's boom the cement consumption has been rapidly increasing to reach 1,584 million tons in 2003. The consultant considers that this trend will continue for a few years and then will progressively slow down to grow only at a 5% annual rate until 2013 and at 2% until 2023, resulting then in a forecasted 4 million ton cement annual demand. In order to respond to this domestic demand, one million tons of cement were imported as well as 300 000 tons of clinker. Imports mainly come from Italy (44%), Greece (33%) and Turkey (22%), and arrive at the ports of Durrës (62%), Shengjin (21%), Vlora (11%), and Saranda (6%).

On the other hand, a new cement plant near Durrës is being constructed and is forecasted reducing the imports from the port of Durrës. The cement plant will be supplied with (solid) fuel and raw materials imported from overseas and part of the cement produced at the plant will be exported by means of vessels. It is foreseen that the production capacity of the plant is such that it will exceed the demand of the local construction market. Therefore, a sea transhipment terminal is required [WITTEVEEN+BOS, 2005]. The import for this plant will concern coal (also referred to as ´solid fuel´) and raw materials for the production of the different types of cement. These raw materials will comprise amongst others pozzolana and gypsum in the form of crushed stone. Furthermore, minor quantities of pyrite ashes, (wet) fly ash, etc. will arrive in the port.

Bricks and tiles

Bricks and tiles production and imports have increased dramatically in recent years with the expansion of the construction industry and the privatization of the brick plants. There are a total of 22 brick plants in Albania with an annual production of 725,000 tons in 2003. The consultant considers the growth in bricks and tiles demand will have the same pattern as the one for cement, bringing the bricks and tiles market in 2023 to 2.3 millions tons with imports limited to 428,000 tons in 2023.

Grain and flour

Albania has in recent years become increasingly dependent on imported grain and flour. Wheat is used to produce flour for human consumption which represents in 2003, 448,000 tons of which 69,000 tons are imported. Maize, mainly used to feed animals, is the second most important cereal in Albania with a production of 207,000 tons and an import volume of 31,000 tons in 2003. About 90% of grain imports come through the port of Durrës, the balance come from Greece by road. About 50% of flour is imported from the port of Durrës and the balance also comes from Greece by road. Finally, it is anticipated that the combination of the continuous decrease in rural population with the increase in yields, which results from better cultivation techniques, the production will more or less stabilise in the future at the present levels.

Fertilizer

Fertilizer needs are supplied entirely by imports, which amounted to 100,000 tons in 2003. A large part of these (84,000 tons) were imported through the Durrës Port, while small amounts in the range of about 5,000 tons were imported from Greece. Most of the imports of phosphates and nitrates are from Russia, Egypt and Tunisia, the rest comes from Greece, Italy and Germany. Given the low prospects for the development of agriculture in Albania, the Consultant estimated that the growth in fertiliser consumption will be limited to 2% a year. On this basis, the imports of fertilisers in 2023 would reach 150,000 tons.

7.6.3 Liquid Bulk

The pattern and volume of crude oil, products and LNG throughput at ports is also changing. Exports from Caspian oil producers via Black Sea ports are increasing. The Bosporus forms the boundary between the Black and Mediterranean Seas and is the only maritime access route between the two. All crude oil shipped by sea out of the Black Sea consequently has to pass through the Bosporus. Tankers up to 165,000 DWT currently transit the Bosporus. The increase in shipping, particularly large tankers, using the Bosporus in recent years has given rise to safety concerns on the part of the Turkish authorities. During poor weather conditions at certain times of the year navigational restrictions are already imposed for safety reasons. This, coupled with the increased volume of shipping using the Bosporus, has resulted in congestion and delays of up to three weeks for vessels leaving the Black Sea [EU-FUNDED MEDA REGIONAL PROJECT MED, 2008].

The future development of new export routes for crude oil from the Caspian region, the development of new pipelines bypassing the Bosporus (for AMBO project, see 4.4.2) and the expansion of current pipeline capacity is likely to result in a significant increase in the density of tanker deployment in the eastern Mediterranean. Exports of crude oil from Black Sea ports averaging at over 100 million tonnes a year are expected to continue to rise, resulting in continued seaborne transits via the Bosporus and increased use of eastern Mediterranean ports linked to new pipelines intended to bypass the Bosporus. The port of Vlora will be one of them in future.

It is assumed that the local production of petroleum products will stabilise at its current level of about 300,000 tons a year (Ballsh refinery) for the next 10 years and will grow at a rate of 5 % per annum afterwards to reach 490,000 tons in 2023. Further assumptions lead to an estimate total demand for petroleum products of 2.77 millions tons in 2023. [Albania National Transport Plan]

7.6.4 Estimated percentages of cargo types

The percentages of 2000 and 2008 are real figures and will be used as a starting point for trade forecasting. It can be noted that the Trans-Tools forecast for 2020 differs from logical expectations due to containerisation, the general decrease in break bulk and the increase in liquid cargo as a result of the planned AMBO pipeline to the port of Vlora. In table 7.24 the expected percentages of throughput in sectors are shown at three points in time, respectively 2020, 2030 and 2035.

TABLE 7.24 – ALBANIA'S SEABORNE THROUGHPUT IN SECTORS [* = FORECAST]

[%]	***2000***	***2008***	***2020 (T-T)****	***2020****	***2030****	***2035****
Dry bulk	51%	34%	47%	27%	23%	20%
Liquid bulk	9%	14%	9%	17%	19%	20%
General Cargo	29%	16%	32%	14%	11%	10%
Containers	11%	36%	12%	42%	47%	50%

7.7 Market Choice

In the Mediterranean area there are a lot of existing ports that have the potential to compete with the planned new port.

7.7.1 Ports in south east Europe

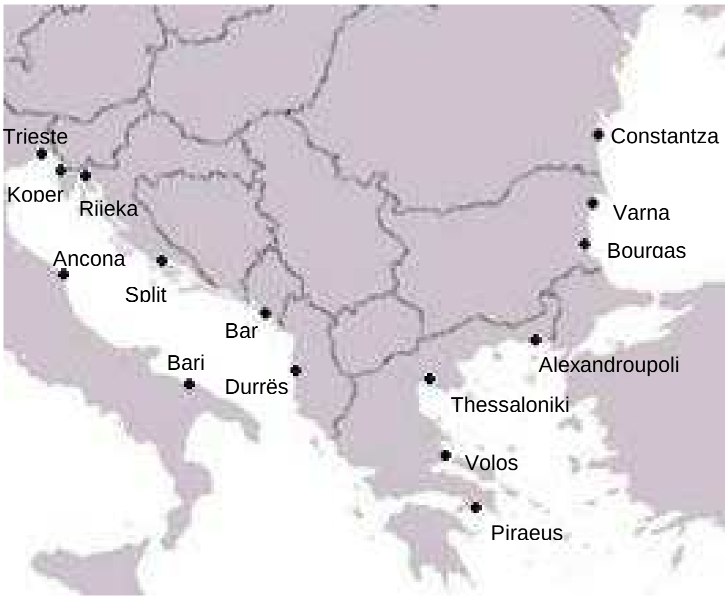


FIGURE 7.5 – PORTS IN SOUTH EAST EUROPE

Transhipment is the transport of goods from one vessel to another for re-transport to another region. A transhipment port has the property of being in the proximity of a number of intersecting trade routes. Durrës doesn't act as a transhipment port due to the more strategic location of other neighbouring ports, for example Piraeus, which easily can serve final destinations by sea or inland waterways, see figure 7.6. Therefore, Romano Port, which is situated just 10 km above the Port of Durrës, will not be able to compete for transhipment but will focus on serving its own hinterland only.

Romano Port is the only one which can serve the area nearby in Albania and ports that may compete with the Romano Port just for serving the hinterland like Kosovo, Macedonia and Bulgaria are Bar, Thessaloniki, Alexandropoulos, Bourgas and Varna.

The competitiveness of this Albania's transport system as a transit route, which is called gateway traffic, will ultimately depend on the cost, speed and quality of service as compared with some other alternative. One scenario, which would make a trans-Balkan transit route (EU Corridor VIII) attractive, would be restrictions imposed on shipping through the Bosporus, due to environmental and other hazards resulting from congested sea lanes. However, the economic and financial viability for completing the missing railway link between Albania and Macedonia hinges much on the volume of traffic to and from Bulgaria.

FIGURE 7.6 – ALBANIA SERVED BY GREECE

FIGURE 7.7 – THESSALONIKI, A COMPETITOR OF DURRËS

7.7.2 Ports in Albania

In section 7.2.3 the throughput is given of all ports in Albania. Durrës' share of total sea trade (average of 16 years) is 77% and there is no increasing or decreasing trend. The throughput data of the last 4 years are shown in table 7.25 and 7.26. It is expected that the ports of Shengjin and Saranda will not develop significantly. Different is the situation of the port of Vlora, which future developments are described in section 4.4.2. The planned container terminal, the AMBO pipe line project and the industrial park in Vlora will result in a different distribution of the sea throughput. An estimation is made in table 7.27 where Romano Port mainly have to deal with dry bulk and general cargo, respectively 70 and 80%. The port of Vlora isn't specialised in these sectors, even other ports in Albania haven't master plans to handle these increasing cargo flows. This justifies to count with a high percentage of dry bulk and general cargo flows in Romano Port.

Liquids and Containers are mostly handled in Vlora, but dependent on commodity and timescale, a part of about 20 to 40% of liquids and containers will be handled in Romano Port. The assumption is made that in 2035 the port of Durrës is converted in a 'city' port, mainly for ferry-pleasure boats.

TABLE 7.25 – IMPORTS DURRËS IN TONS

Item	*2005*	*2006*	*2007*	*2008*
Dry Bulk	1,197,750	1,238,733	883,541	743,046
Liquids	234,299	225,166	270,447	263,383
General	969,099	929,847	781,783	714,467
Containers	130,471	188,178	287,751	424,942
Military	2,968	0	0	2,430
Ferries	240,380	314,750	404,372	608,898
Total	**2,774,967**	**2,896,674**	**2,627,894**	**2,757,166**

TABLE 7.26 – EXPORTS DURRËS IN TONS

Item	2005	2006	2007	2008
Dry Bulk	156,280	272,309	493,336	249.931
General	7,688	20,924	25,136	20,273
Containers	16,970	26,443	69,423	157,185
Military	1,095	240	0	3,580
Ferries	155,458	206,044	225,760	516,018
Total	**337,491**	**525,960**	**813,655**	**946,987**

The traffic forecast for the port of Durrës should be handled with some precautions because of the uncertainty which prevails on some major factors like the level and pace of privatisation of the operation of the terminals, the competition between container and Roll on – Roll off (ferries) traffic in Durrës, the schedule of the AMBO pipe line project, and eventually, the investment and marketing policy of the competing ports in the region (Bar in Montenegro, Thessaloniki and Igoumenitsa in Greece).

TABLE 7.27 –THROUGHPUT PER PORT IN SECTORS IN '000 TONS [FORECAST]

	2020		2030		2035	
Dry bulk	2,050		2,546		2,581	
- Porto Romano		1,435		1,782		1,807
- Others		615		764		774
Liquid bulk	1,291		2,103		2,581	
- Porto Romano		387		631		774
- Vlora		904		1,472		1,807
General Cargo	1,063		1,218		1,291	
- Porto Romano		850		974		1,033
- Vlora		213		244		258
Containers	3,189		5,202		6,454	
- Porto Romano		1,276		1,561		1,936
- Vlora		1,913		3,641		4,518
Total	7,594		11,069		12,907	

TABLE 7.28 –THROUGHPUT ROMANO PORT IN SECTORS IN '000 TONS [FORECAST]

	2020	2030	2035
Dry bulk	1,435	1,782	1,807
Liquid bulk	387	631	774
General Cargo	850	974	1,033
Containers	1,276	1,561	1,936
Total	**3,948**	**4,948**	**5,550**

8 VESSEL FORECAST

In order to estimate the number and lengths of berths the number of calls per terminal has to be known. In table 8.1 vessel statistics of the last four years of the port of Durrës are given. In general small vessels with an average Dead Weight of about 4,000 tons are calling the port of Durrës.

TABLE 8.1 – VESSEL INFORMATION 2005-2008

Year	*Type of ships*	*Tonnage*	*Nr. of ships*	*Tons per call*	*Average ship size*		
					NRT	*GRT*	*DWT*
2005	General	976,787	463	2,110	1,108	2,026	3,025
	Dry bulk	1,354,030	602	2,249	784	1,727	2,564
	Tankers	234,299	120	1,952	726	1,514	2,331
	Containerships	147,441	164	899	1,037	2,255	2,995
	Ferries	395,838	1,582	250	4,050	-	-
2006	General	950,771	605	1,572	791	1,129	2,145
	Dry bulk	1,511,042	455	3,320	1,229	2,593	3,954
	Tankers	225,166	125	1,801	677	1,348	2,143
	Containerships	214,621	160	1,341	2,013	4,269	5,294
	Ferries	520,794	1,422	366	4,504	-	-
2007	General	806,919	557	1,449	848	1,862	2,305
	Dry bulk	1,376,877	280	4,917	1,914	4,002	5,989
	Tankers	270,447	160	1,690	632	1,264	1,977
	Containerships	357,174	301	1,186	1,941	4,021	4,799
	Ferries	630,132	1,635	385	4,401	-	-
2008	General	734,740	397	1,851	1,197	2,308	3,090
	Dry bulk	992,976	330	3,009	1,229	2,591	3,775
	Tankers	263,383	140	1,881	738	1,398	2,293
	Containerships	582,127	313	1,860	2,407	5,128	5,961
	Ferries	1,124,916	1,684	668	4,400	-	-

Source: Port Authority Romano Port

It can be noted that dry bulk carriers and tankers load or unload their total cargo because the tons per call amounts in average 84% of the Dead Weight Tonnage of the average vessel. For general cargo ships this percentage is a little lower (67%), meaning that not all cargo is (un)loaded. For container transport this value is 28%, indicating that in average a small part of the containers of one vessel is (un)loaded in the port of Durrës.

Due to vessel statistics of only four years, a trend in vessel dimensions can't be observed. Therefore the global trend and the expected future vessel dimensions will be described below.

8.1 Containers

The average size of a containership that enters the port of Durrës in the last four years is 5,000 dwt. Containership dimensions increases especially in the Mediterranean region up to vessels with TEU capacities of 12,500 up to 14,000. Albania with its small economic trade doesn't attract the larger vessels even not in future. It is unknown which type of vessels will enter in future the container port of Vlora, but for the Romano Port, the maximum is set on 45,000 dwt. For 2020, 2030 and 2035, the maximum ship size is the same because this type of vessel enters the Mediterranean area frequently. Therefore, when the port starts functioning, it is immediately able to accommodate container vessels up to 45,000 dwt. The average throughput per call is estimated at 40% of the maximum TEU capacity of a vessel.

TABLE 8.2 – VESSEL FORECAST CONTAINERS

	2020	***2030***	***2035***
Total throughput (TEU)	116,000	156,100	215,111
Number of ship calls	322	325	336
Call size (TEU)	360	480	640
Average ship dimensions			
- Capacity (dwt)	14,000	20,000	25,000
- Capacity (TEU)	1,000	1,400	1,800
- LOA (m)	160	180	190
- Beam (m)	24	27.1	29
- Draught (m)	9	9.9	10.7
Maximum ship dimensions			
- Capacity (dwt)	45,000	45,000	45,000
- Capacity (TEU)	3,300	3,300	3,300
- LOA (m)	260	260	260
- Beam (m)	32	32	32
- Draught (m)	12.5	12.5	12.5

8.2 Dry bulk

Although the number of dry bulk vessels is decreasing in time, their dimensions are increasing (table 8.1). Taking into account the large increase in dry bulk throughput up to 2035, the dimensions of the respective vessels is estimated to grow significantly. It is assumed that the port should be able to accommodate vessels up to 40,000 dwt.

This maximum capacity is mainly the result of the requirements of a big cement plant that is being constructed in the vicinity Fushë-Krujë which is located inland northeast of the city of Durrës. They expect 10,000 DWT dry bulk carriers when the material originates from e.g. Russia and about 40,000 DWT dry bulk carriers in case the coal comes from e.g. the Caribbean region or South Africa; the smaller vessel will visit the port about once a month, the larger about once in two months [WITTEVEEN+BOS, 2005].

As indicated in table 8.1, the average ship size is small, and the number of port calls is pretty high. In table 8.3 forecast vessel dimensions are estimated considering that the average ship size is steadily growing, which indicates that the number of ship calls is decreasing.

TABLE 8.3 – VESSEL FORECAST DRY BULK

	2020	***2030***	***2035***
Total throughput (tons)	1,435,000	1,782,000	1,807,000
Number of ship calls	221	178	145
Call size (tons)	6,500	10,000	12,500
Average ship dimensions			

- Capacity (dwt)	8,000	12,000	15,000
- LOA (m)	125	145	165
- Beam (m)	18	21.5	21
- Draught (m)	7.2	8.5	9.5
Maximum ship dimensions			
- Capacity (dwt)	40,000	40,000	40,000
- LOA (m)	210	210	210
- Beam (m)	30	30	30
- Draught (m)	11	11	11

8.3 General Cargo

The General Cargo vessels which currently enter the port of Durrës have an average size of 4,000 dwt. Although in general the size of General Cargo vessels remains relative small the average ship is expected to increase up to 10,000 dwt in 2035, with a maximum of 15,000 dwt. The throughput handled per call is expected to be approximately 65% of the dwt.

TABLE 8.4 – VESSEL FORECAST GENERAL CARGO

	2020	***2030***	***2035***
Total throughput (tons)	850,000	974,000	1,033,000
Number of ship calls	213	177	148
Call size (tons)	4,000	5,500	7,000
Average ship dimensions			
- Capacity (dwt)	6,000	8,000	10,000
- LOA (m)	125	135	145
- Beam (m)	16.5	18	20
- Draught (m)	7.5	8	8.5
Maximum ship dimensions			
- Capacity (dwt)	15,000	15,000	15,000
- LOA (m)	165	165	165
- Beam (m)	21.5	21.5	21.5
- Draught (m)	9.5	9.5	9.5

8.4 Liquid Bulk

The liquid bulk terminal which is already constructed in Romano Port, will accommodate cargo ships with liquid gas capacity of 9,000 tons and oil cargo ships with a capacity of 20,000 tons [WWW.ROMANOPORT.COM.AL]. The maximum ship size is assumed at 25,000 dwt. Because this terminal is in operation for one year now, no big future expansions are expected.

TABLE 8.5 – VESSEL FORECAST LIQUID BULK

	2020	***2030***	***2035***
Total throughput (tons)	387,000	631,000	774,000
Number of ship calls	92	94	92
Call size (tons)	4,200	6,700	8,400
Average ship dimensions			
- Capacity (dwt)	5,000	8,000	10,000
- LOA (m)	106	120	130
- Beam (m)	17.0	19.0	20.5
- Draught (m)	7.4	9.0	9.5
Maximum ship dimensions			
- Capacity (dwt)	25,000	25,000	25,000
- LOA (m)	180	180	180
- Beam (m)	26.0	26.0	26.0
- Draught (m)	11.0	11.0	11.0

8.5 Conclusion

In table 8.6 a summary is shown of the expected number of port calls. In 2008 the number of ship calls, excepting ferries, amounted 1,180. As indicated the number of ship calls decreases in time while the throughput enhances. This is a result of the increase in ship sizes.

TABLE 8.6 – NUMBER OF PORT CALLS PER YEAR

	2020	***2030***	***2035***
Containers	290	284	307
Dry bulk	221	178	145
General Cargo	213	177	148
Liquid bulk	92	94	92
Total	**816**	**733**	**692**

TABLE 8.7 – MAXIMUM VESSEL DRAUGHT

	2020	***2030***	***2035***
Containers	12.5	12.5	12.5
Dry bulk	11	11	11
General Cargo	9.5	9.5	9.5
Liquid bulk	11	11	11

PART C. MASTER PLAN DEVELOPMENT

9 TERMINALS

9.1 Container terminal

The quantity of container throughput is generally expressed in TEU (Twenty feet Equivalent Unit). The throughput in container transport up to 2035 is forecasted in tons, but have to be converted in TEU. In table 9.1 the ratio is given between throughput (in tons) and TEU of the last four years. This ratio is increasing significantly. This trend can be explained by the reason that the number of empty containers with respect to the total number is slightly decreasing from 10 to 7%. The ratio between empty and loaded containers is changing only in the export of the port of Durrës, see figure 9.1 and 9.2. Because in future a broadening of the narrow export base is expected, the number of empty containers is decreasing.

TABLE 9.1 – TEU AND TONNAGE (PORT OF DURRËS)

Year	*Tonnage*	*TEU*	*Ratio (Ton / TEU)*
2005	147,441	15,286	9.65
2006	214,621	21,879	9.81
2007	357,174	33,127	10.78
2008	582,127	46,798	12.44

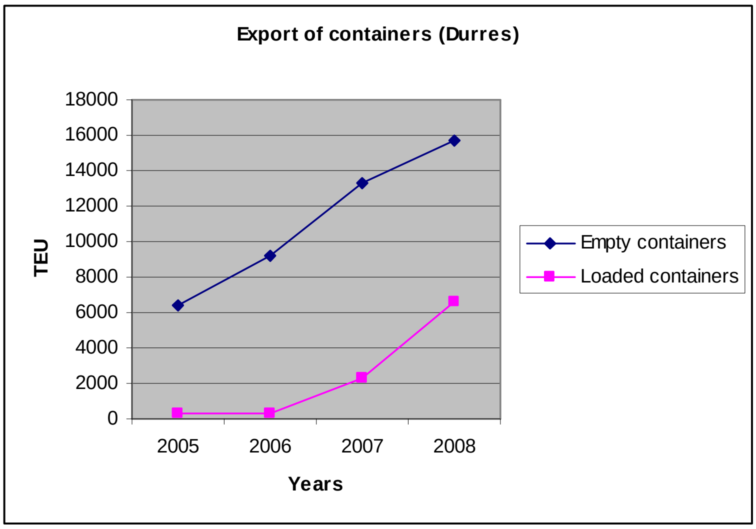


FIGURE 9.1 – EXPORT OF CONTAINERS (PORT OF DURRËS)

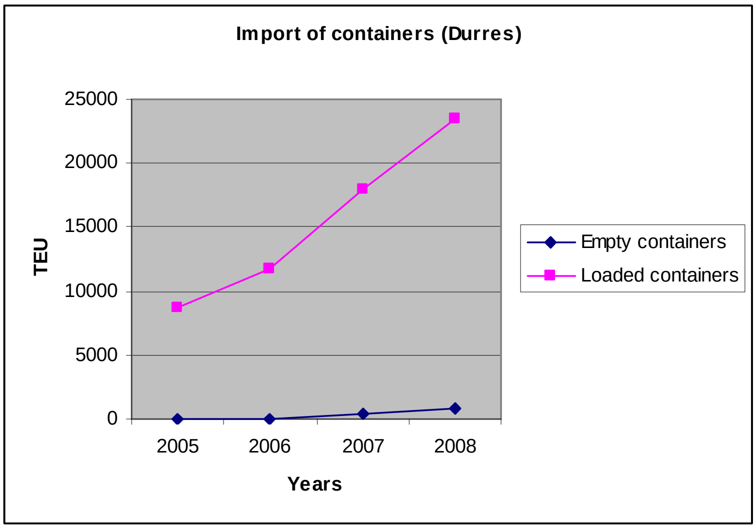


FIGURE 9.2 – IMPORT OF CONTAINERS (PORT OF DURRËS)

The most calculations will be carried out in TEU, except for the capacity of the storage yard, where the division between 20 ft and 40 ft containers has to be known. This division is given by the TEU-factor: $f = \frac{N_{20'} + 2 \cdot N_{40'}}{N_{tot}}$

Because statistical data of the TEU-factor isn't available for the port of Durrës this factor should be estimated. In developing countries a large percentage of goods is transported in 20 ft containers [LIGTERINGEN, H., 2007], however there is a shift towards 40 ft containers over the years, which is expected to continue for some time. The TEU-factor is estimated for 2009 at 1.2 and to reach 1.6 in 2035. To avoid risks the ratio (ton/TEU) will be reduced in 2035. That's realistic because when a country develops, in general the ratio (ton/TEU) decreases. In table 9.2 these factors are given and the number of TEU is calculated.

TABLE 9.2 – FORECAST FOR THE NUMBER OF CONTAINERS IN TEU

	2008	***2020***	***2030***	***2035***
Tonnage	582,127	1,276,000	1,561,000	1,936,000
TEU-factor	1.2	1.4	1.5	1.6
Ratio (table 1)	12,44	11	10	9
TEU	46,798	116,000	156,100	215,111

A first approximation of the number of berths is made on the basis of an estimated berth productivity in appendix B. The result is that two berths are needed. A more detailed calculation, using the queuing theory, is carried out in section 9.5.

TABLE 9.3 – FORECASTED NUMBER OF CONTAINERS

	2020	***2030***	***2035***
TEU	116,000	156,100	215,111
TEU-factor	1.4	1.5	1.6
Number of 20 ft containers	49,714	52.034	53,778
Number of 40 ft containers	33,143	52.033	80,666
Total number of containers	82,857	104,067	134,444

In table 9.4 the number of TEU is divided in sectors. The percentage of empty containers is diminishing form 30% in 2020 to 15% in 2035. The reason for this choice is that a broadening of the narrow export base is expected, which results in a decrease of empty containers.

TABLE 9.4 – TEU DIVIDED IN SECTORS

	2020	***2030***	***2035***
TEU total	116,000	156,100	215,111
TEU empty (percentage of TEU)	34,800 (30%)	31,220 (20%)	32,267 (15%)
TEU import	70,000	101,465	135,520
TEU export	11,200	23,415	47,324
TEU CFS	20,000	30,000	35,000

Storage areas

The areas needed for container storage of the different stacks (import, export, empties) can be calculated as follows:

$$O = \frac{C_i \cdot t_d \cdot \bar{F}}{r \cdot 365 \cdot m_i}$$

C_i represents the number of container movements per year in TEU (see table 9.4).

Dwell time

T_d is the average dwell time in days, which is considered separately for empty, import, export and for the Container Freight Station (CFS), respectively 20, 10, 7 and 5 days. De dwell time for empty containers is much higher than the others, caused by no quick demand and supply requirements.

Equipment between quay and storage yard

The factor F in the formula depends on the handling system and the nominal stacking height. For transport between quay and storage yard use will be made of a Reach Stacker, resulting in a factor F of 27 m^2 / TEU.

A Reach Stacker is one of the most flexible handling solutions whether to operate a small terminal or a medium sized port. Reach stackers are able to transport a container in short distances very quickly and pile them in various rows depending on its access. Reach stackers have gained ground in container handling in most markets because of their flexibility and high stacking and storage capacity. Using reach stackers, container blocks can be kept 4-deep due to the second row access, see figure 9.3.

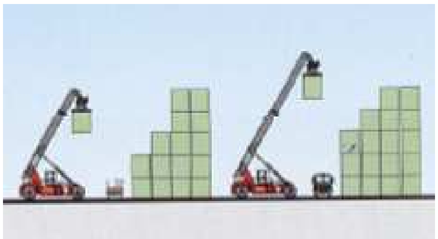


FIGURE 9.3 – REACH STACKER

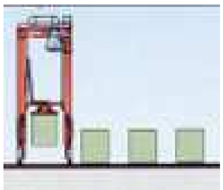


FIGURE 9.4 – STRADDLE CARRIER

An other kind of container equipment that could be used in this case is the straddle carrier, see figure 9.4. For this Straddle Carriers, the stack consist of rows of containers, separated by lanes wide enough for the legs and tyres of the SC. But normally they are used by medium to big container terminals.

Factor 'r'

The factor 'r' reflects the fact that the sequence in which the containers will leave the stack, is partly unknown (mostly so for import stack) and that extensive intermediate re-positioning of containers is expensive. For empty containers a value of 0.9 will be chosen, a relative high value, but for empty container there is no need for re-positioning. The 'r' value for export and import is set on respectively 0.8 and 0.6.

Occupancy rate 'm'

The factor 'm' has to be introduced because the pattern of arrivals and departures of containers differs. For the storage yard for empty containers an occupancy rate of 0.8 is used. For import and export a lower value of 0.7 is chosen.

TABLE 9.5 – DIMENSIONS CONTAINER YARD

	2020	*2030*	*2035*
Storage yard for empty containers	71,507 m^2	64,151 m^2	66,302 m^2
Storage yard for import containers	123,288 m^2	178,705 m^2	238,684 m^2
Storage yard for export containers	10,356 m^2	21,651 m^2	43,758 m^2
Storage yard for CFS	6,723 m^2	10,084 m^2	11,765 m^2
Offices / roads / etc. (25%)	50,000 m^2	65,000 m^2	80,000 m^2
Total:	261,874 m^2	339,591 m^2	440,509 m^2

Storage area Container Freight Station (CFS)

One finds a Container Freight Station (CFS) for the cargo, when cargo is imported in one container, but has different destinations (“stripping”), or when freight comes from different origins and is loaded into one container for export (“stuffing”). The surface area of the CFS does not follow the original equation but is calculated as follows:

$$O_{CFS} = \frac{C_i \cdot V \cdot t_d \cdot f_1 \cdot f_2}{h_a \cdot m_i \cdot 365}$$

C_i = number of TEU moved thought CFS, see table 9.4.
V = contents of 1 TEU container = 29 m^3
T_d = dwell time of 5 days
F_1 = gross area / net area =1.4
F_2 = bulking factor = 1.1
h_a = average height of cargo in the CFS = 2.6
m_i = acceptable occupancy rate = 0.7

Berth Length

For multiple berths in a straight continuous quay front, the quay length is based on the average vessel length, as follows:

Lq = 1.1 x n x (Ls + 15) + 15 = 1.1 x 2 x (190 + 15) + 15 = 466 meter

9.2 Dry bulk terminal

TABLE 9.6 – FORECAST FOR THE DRY BULK SECTOR

	2020	**2030**	**2035**
Throughput	1,435,000 ton	1,782,000 ton	1,807,000 ton

A first approximation of the number of berths is made on the basis of an estimated berth productivity in appendix B. The result is that one berth is enough. A more detailed calculation, using the queuing theory, is carried out in section 9.5.

Storage area

The area needed for the storage yard can be calculated as follows:

$$O = \frac{C \cdot t_d \cdot f}{h_a \cdot m_i \cdot 365}$$

C = 1,807,000 tons
T_d = 10 days
F = 1.2
H_a = 2 m
M_i = 0.7

TABLE 9.7 – AREA NEEDED FOR STORAGE DRY BULK

	2020	**2030**	**2035**
Throughput	1,435,000 ton	1,782,000 ton	1,807,000 ton
Number of berths	1	1	1
Storage yard	34,000 m^2	43,000 m^2	44,000 m^2
Offices / roads / etc. (40%)	14,000 m^2	17,000 m^2	18,000 m^2
Total area needed	48,000 m^2	60,000 m^2	62,000 m^2

The area will be divided approximately in half open storage, half sheds, depending on the specific transport materials.

Berth Length

For a single berth the quay length is determined by the length of the largest vessel frequently calling at the port, increases with 15 meter extra length fore and after for the mooring lines.
Lq = 210 + 15 + 15 = 240 meter

9.3 General cargo terminal

TABLE 9.8 – FORECAST FOR THE GENERAL CARGO SECTOR

	2020	***2030***	***2035***
Throughput	850,000 ton	974,000 ton	1,033,000 ton

A first approximation of the number of berths is made on the basis of an estimated berth productivity in appendix B. The result is that two berths are needed. A more detailed calculation, using the queuing theory, is carried out in section 9.5.

Storage area

The area needed for the storage yard can be calculated as follows:

$$O_{ts} = \frac{f_1 \cdot f_2 \cdot C_{ts} \cdot \bar{t}_d}{m_{ts} \cdot h \cdot \rho \cdot 365}$$

C = 1,033,000
F_1 = 1.5 F_2 = 1.2
t_d = 10 days
M_{ts} = 0.7
H = 2 m
Rho = 0.6

TABLE 9.9 – AREA NEEDED FOR STORAGE GENERAL CARGO

	2020	***2030***	***2035***
Throughput	850,000 ton	974,000 ton	1,033,000 ton
Number of berths	2	2	2
Storage yard	49,902 m^2	57,182 m^2	60,646 m^2
Offices / roads / etc. (40%)	20,000 m^2	23,000 m^2	24,000 m^2
Total area needed	69,902 m^2	80,182 m^2	84,646 m^2

The area will be divided approximately in half open storage, half sheds, depending on the specific transport materials.

Berth Length

For multiple berths in a straight continuous quay front, the quay length is based on the average vessel length, as follows:

Lq = 1.1 x n x (Ls + 15) + 15 = 1.1 x 3 x (145 + 15) + 15 = 543 meter

9.4 Liquid bulk terminal

TABLE 9.10 – FORECAST FOR THE GENERAL CARGO SECTOR

	2020	***2030***	***2035***
Throughput	387,000	631,000	774,000

A first approximation of the number of berths is made on the basis of an estimated berth productivity in appendix B. The result is that the present berth is enough, no additional berth is required. A more detailed calculation, using the queuing theory, is carried out in section 9.5.

9.5 Queuing theory

The queuing theory will be used to check the number of berths. In order to define a queuing theory, three elements have to be known:
a) the inter arrival time distribution of the vessels;
b) the distribution of service times;
c) the number of berths in the system

A three-part code system consisting of a letter/letter/number combination is used to specify which system has been chosen. The first letter specifies the inter arrival time distribution. The second letter specifies the service time distribution and the number defines the number of berths. [GROENVELD, R., 2001]

For the inter arrival time use has made of the Negative exponential distribution (M value) whereby arrivals are independent of each other. This distribution is very suitable when the arrive pattern is irregular, which is most probably in the case.

For the service time a distinction is made between General Cargo and Containers/Dry Bulk/Liquid bulk, where respectively a Negative exponential and a Erlang-2 distribution is used. The reason of this distinction is that General Cargo implies a big variation in goods, resulting in a significant spread of service time.

$$u = utilisation = \frac{\lambda}{\mu \cdot n}$$

$$\lambda = arrival\ rate = \frac{tons\ or\ TEU\ handled\ per\ year}{tons\ or\ TEU\ handled\ per\ call}$$

$$\mu = service\ rate = \frac{operational\ hours\ per\ year}{service\ time}$$

De service time consist of time for mooring, unloading, loading and unmooring. It is assumed that berthing takes one hour and departure one hour again. The time needed for loading and loading a vessel is determined by the number of tons/TEU handled per call and the capacity of the container cranes. In formula:

$$Service\ time = 1 + 1 + \frac{tons\ or\ TEU\ handled\ per\ call}{handling\ rate\ per\ berth \times (TEU\ factor)}$$

After the utilisation is known, the average waiting time in units of the average service time is determined using [GROENVELD, R., 2001].

9.5.1Containers

Kendall notation: M / E2 / n

TABLE 9.11 – ESTIMATES FOR FUTURE (CONTAINER TERMINAL)

	2020	*2030*	*2035*
n = number of berths	2	2	2
TEU handled per year	116,000	156,100	215,111
TEU handled per call	360	480	640
λ = arrival rate	322	325	336
Operational hours per year	8400	8400	8400
Cranes per berth	2	2	2
Handling rate per crane	15 TEU / hour	15 TEU / hour	15 TEU / hour
TEU-factor	1.4	1.5	1.6
Service time	10.6	12.7	15.3
μ = service rate	795	663	548
u = utilisation	0.20	0.25	0.31
W.T. in units of S.T.	0.03	0.05	0.08
W.T. in hours	0.3	0.6	1.2

In general for container terminals a waiting time of 10% of the service time is acceptable. Therefore, the maximum average waiting time of 1.2 hours is considered as an acceptable value, which results in 2 berths.

9.5.2 Dry bulk

Kendall notation: M / E2 / n

TABLE 9.12 – ESTIMATES FOR FUTURE (DRY BULK TERMINAL)

	2020	*2030*	*2035*
n = number of berths	1	1	1
tons handled per year	1,435,000	1,782,000	1,807,000
tons handled per call	6,500	10,000	12,500
λ = arrival rate	221	178	145
Operational hours per year	8400	8400	8400
Cranes per berth	2	2	2
Handling rate per crane	900 tons / hour	900 tons / hour	900 tons / hour
Service time	5,6	7.6	8.9
μ = service rate	1497	1112	939
u = utilisation	0.15	0.16	0.15
W.T. in units of S.T.	0.13	0.14	0.13
W.T. in hours	0.7	1.1	1.2

In general for dry bulk terminals a waiting time of 10 - 15% of the service time is acceptable. Therefore, the maximum average waiting time of 1.2 hours is considered as an acceptable value for dry bulk vessels, which results in 1 berth.

9.5.3 General Cargo

Kendall notation: M / M / n

TABLE 9.13 – ESTIMATES FOR FUTURE (GENERAL CARGO TERMINAL)

	2020	2030	2035
n = number of berths	3	3	3
tons handled per year	850,000	974,000	1,033,000
tons handled per call	4,000	5,500	7,000
λ = arrival rate	213	177	148
Number of gangs per ship	2.5	2.5	2.5
Number of shifts per day	2	2	2
Operational hours per year	4800	4800	4800
Productivity per gang	80 tons / hour	80 tons / hour	80 tons / hour
Service time	22	29.5	37
μ = service rate	218	163	130
u = utilisation	0.32	0.36	0.38
W.T. in units of S.T.	0.04	0.06	0.07
W.T. in hours	0.9	1.8	2.6

In general for general cargo terminals a waiting time of 10 - 15% of the service time is acceptable. Therefore, the maximum average waiting time of 2.6 hours is considered as an acceptable value for general cargo vessels, which results in 3 berths. This is in contrast with the first approximation of the number of berths in section 9.3 where 2 berths would be enough to handle the number of tons. In this case the waiting time is normative to determine the number of berths.

9.5.4 Liquid bulk

Kendall notation: M / E2 / n

TABLE 9.14 – ESTIMATES FOR FUTURE (LIQUID BULK TERMINAL)

	2020	2030	2035
n = number of berths	1	1	1
tons handled per year	387,000	631,000	774,000
tons handled per call	4,200	6,700	8,400
λ = arrival rate	92	94	92
Operational hours per year	8400	8400	8400
Productivity per hour	375 ton	500 ton	650 ton
Service time	13.2	15.4	14.9
μ = service rate	636	546	563
u = utilisation	0.14	0.17	0.16
W.T. in units of S.T.	0.12	0.15	0.14
W.T. in hours	1.6	2.3	2.1

In general for liquid bulk terminals a waiting time of 10 - 15% of the service time is acceptable. Therefore, the maximum average waiting time of 2.3 hours is considered as an acceptable value for liquid bulk vessels, which results that no additional berth is required. However, it means that the present discharge capacity of 375 tons / hour at the liquid bulk terminal in Romano Port should be increased up to 500 and 650 tons / hour respectively for 2030 and 2035. That shouldn't be a problem because normally the liquid bulk pump capacities are in the order of 10% of the Dead Weight Tonnage of a vessel and in the forecast in table 9.14, the pump capacities are still below this level.

10 PHYSICAL BOUNDARY CONDITIONS

10.1 Data collection
The information given in this chapter is retrieved from W+B's Porto Romano archives. Only information which is deemed relevant for the present study is presented.

10.1.1 Vertical reference system
All elevations mentioned in this report and the related drawings are relative to Low Water Spring (LWS).

10.1.2 Bathymetry
The coastline is characterized by some cliffs, situated north and south of the site. The seabed at Porto Romano is generally smooth close to the shore line. Some outcrops are shown in the bathymetric survey around the already built LPG/oil jetty. The outcrops consist of hard clays and possibly bedrock formations and reach some 3 to 4 meters above the surrounding seabed.
In September 2005 a under water video survey has been executed. The video was executed for a 200 m long strip in the planned axis of the causeway to the LPG/oil jetty. The video shows a lot of big stones and a number of caves. This explains the big differences in water depth at short distances from each other. In figure 10.1 a rough bathymetry of the Adriatic Sea is shown.

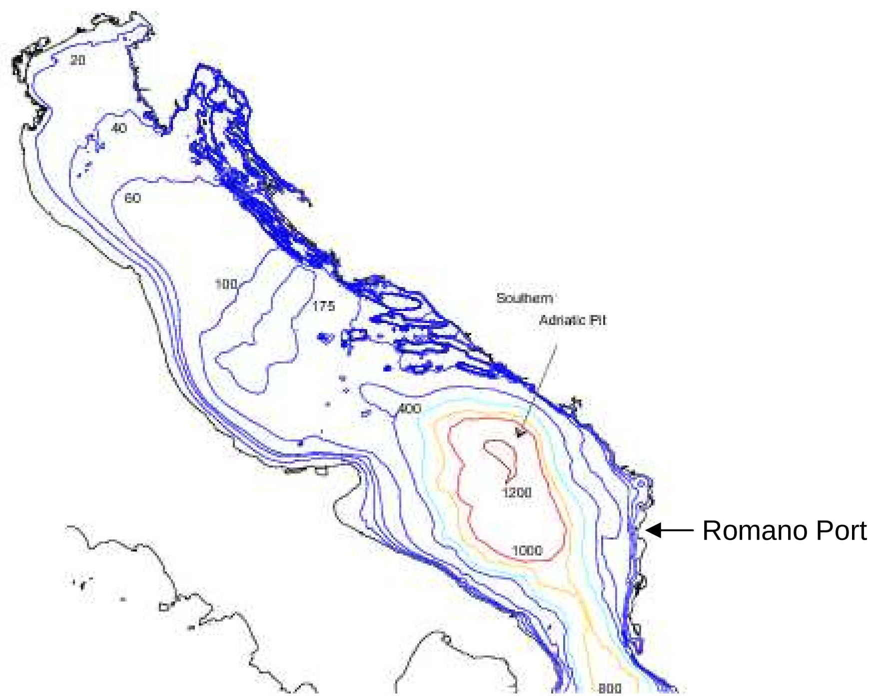


FIGURE 10.1 – ROUGH BATHYMETRY ADRIATIC SEA

10.1.3 Water level fluctuations
During the 24-hour period the sea levels are influenced by the semi diurnal tide oscillation. Two high levels during the high tide and two low levels during the low tide. Water level fluctuations do hardly occur in the Adriatic Sea. Tidal levels referred to Datum of Sounding on the Admiralty Chart are presented in the following table.

TABLE 10.1 – TIDAL LEVELS

Place	***Heights in meters above datum***			
	HWS	HWN	LWN	LWS
Durrës	0.3	0.2	0.1	0.0

10.1.4 Wind

Local harbour authorities state that summer winds are mostly from the north and northwest. A north-westerly sea breeze regime is established on most days from June through August and on a few days in early September, but is normally not strong enough to have impact on small boat operations.
The northwest sea breeze, locally called Maestro, starts about 11 am local time and lasts until approximately 4 pm to 5 pm. During July, the Maestro is commonly 4 to 6 kt (2 to 3 m/s), increasing to 8 to 11 kt (4 to 5.5 m/s) during the afternoon. During evening hours the wind speed decreases to 4 to 8 kt (2 to 4 m/s). Local authorities state that the maximum sea breeze wind speeds are approximately 16 to 19 kt (8 to 10 m/s). Light land breezes of 2 to 4 kt (1 to 2 m/s) are prevailing during night and early morning hours. These light land breezes can be relevant for the port design, due to their constant speed and direction which results in little waves near shore. The strongest wind speed recorded during the four-month summer season over a 19-year period of record is 45 kt (22 m/s). The strongest wind speed recorded during October over a 19-year period of record is 37 kt (19 m/s).

While relatively strong and gusty winds may be observed, the exceptionally strong Bora winds common over the northern Adriatic coasts near Trieste and Koper do not occur at Durrës. According to the Hydro meteorological Institute in Tirana, Albania, southerly (locally called Scirocco) and south-westerly (locally called Garbi) wind directions predominate during the November through February period. When Scirocco winds occur, they last for an average of 2 to 3 days. The strongest wind speed recorded during the four-month winter season over a 19-year period of record is 49 kt (25 m/s).

The current anchorage in the bay of Porto Romano is affected mostly be winds and waves from southwest through west. Waves reach 13.1 ft (4 m) in the anchorage, and 19.7 ft (6 m) in exposed waters west of the anchorage. Currently, when waves make the anchorage hazardous, ships are advised to move to the bay of Rodonit, approximately 15 nautical miles north of Durrës. The anchorage in the bay of Rodonit is sufficiently deep to accommodate deep-drafting vessels.

The wind speeds shown in the following table have been gathered and used for the designs and studies in relation to the LPG/oil terminal in Porto Romano.

TABLE 10.2 – DIRECTIONAL EXTREME WIND SPEEDS

Wind speed [m/s]	***Wind direction (°N)***						
	180°	210°	240°	270°	300°	330°	0°
1 year return period	18.9	15.3	N.A.	18.8	14.0	13.4	19.7
10 year return period	21.3	17.5	N.A.	22.9	17.5	15.6	24.7
100 year return period	23.2	19.3	N.A.	26.5	20.6	17.6	29.0

10.1.5 Waves

The period with the wave height H=0.0-0.2 m represents about 80% of the general cases in an average year, while the height H= 0.2-4.0 m represents about 20%.

The fetch lengths on the sea free surface to its main direction are presented in table 10.3.

TABLE 10.3 – FETCH LENGTHS

Direction	***N***	***NE***	***E***	***SE***	***S***	***SW***	***W***	***NW***
Distance [km]	300	5	7	120	1350	1200	450	800

Waves frequency (in %) according to their main directions and their corresponding average heights are presented in table 10.4.

TABLE 10.4 – FREQUENCY TO WAVES ACCORDING TO DIRECTIONS

	N	*NE*	*E*	*SE*	*S*	*SW*	*W*	*NW*
Frequency [%]	15.8	5.6	5.9	15.5	12.0	11.1	20.1	14.0
Average height [m]	0.15	0.18	0.66	1.29	1.19	1.28	1.20	1.10

10.1.6 Earthquakes

The area where the Romano-Port facilities are planned is subject to seismic activity due to the presence of an active tectonic fault. The nearby town of Durrës is often hit by strong earthquakes with epicentre in or near it. The earthquakes that can be generated by the fault will have a moment magnitude M = 6.8 as a maximum.

10.1.7 Geotechnical data

For the marine structures of the LPG/oil project of Romano-Port eleven boreholes have been performed. Based on the samples, the laboratory tests and the analyses for the Rira and Inter Gas onshore investigation, the physical and mechanical features of the soil are determined as mentioned further in this report.

The local geology is characterised by the presence of sedimentary clay, silty sands, siltstone and a large fault, located 300 m offshore. The zone toward the shore is showing subsidence, while the zone opposite shows uplifting. The basin in the subsiding area has been filled with Holocene sediments, which consists largely of clay and silty sands. The rock near shore and onshore consists of clay-siltstone and sandstone, whilst further offshore it consist of bedrock of siltstone and clay-siltstone.

A first estimate of the soil conditions is derived from the soil investigation performed for the design of the oil/LPG jetty [KONONI, N., HYSENI, A. AND HOXHA, P., 2004]. Additional soil investigations on relevant locations shall be executed to establish soil layers with corresponding parameters in more detail. In figure 10.2 the bathymetric profile of the pier tracing of the existing oil/LPG jetty is shown.

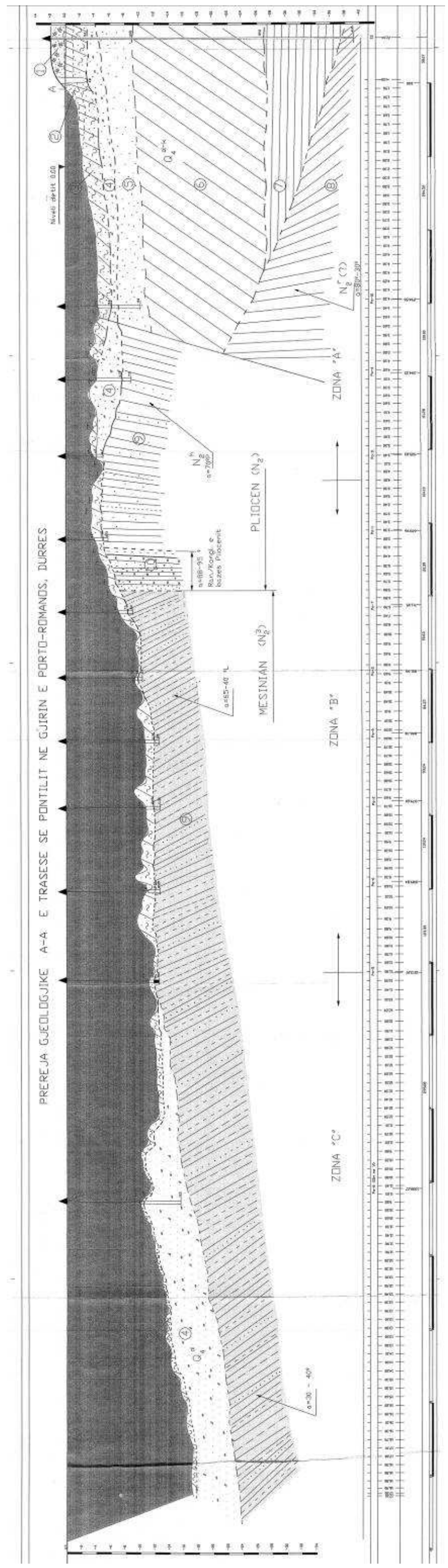


FIGURE 10.2 – BATHYMETRIC PROFILE OF THE PIER TRACING

From onshore to approximately 1400 meters offshore, the subsoil consists of Holocene sediments, which consists of poorly graded sand with gravel in the first 1 – 2 meters from the seabed level. Below this layer a very stiff clay layer is found. In table 10.5, the physical features are given of this layer consisting of siltstone and clay-siltstone. This layer is very solid and as a result, it may be difficult for dredging and installing piles. (With a tumb nail it was possible to indent a sample but by thumb it was not possible to indent the sample.) Between 1400 and 2000 meters offshore, the sand layer becomes thicker, approximately 6 à 7 meters. After 2000 meters offshore, soil information isn't available. Attention is drawn to the fact that soil information is available in line with the axis of the already built causeway. So the local thickness of sand and rock layers should be obtained from locally executed boreholes.

TABLE 10.5 – PHYSICAL AND MECHANICAL FEATURES OF THE SILTSTONE LAYER

Description	***Value***	***Unit***
Sandy fraction (0.075 – 4.75 mm)	17.4	%
Silty + clayey fraction (< 0.075 mm)	82.6	%
Water content	17.4	%
Liquid plasticity (Wl)	39.2 - 47.6	%
Plasticity limit (Wp)	26.4 – 30.7	%
Index of plasticity (Ip)	11.8 – 16.8	%
Bulk gravity (γ)	2.06	gr/cm^3
Dry density (δ)	1.76	gr/cm^3
Specific gravity (Δ)	2.70	gr/cm^3
Porosity (n)	34.9	%
Index of porosity (e)	0.54	-
Module of compression (E)	200 – 220	kg/cm^2
Angle of internal friction	26	^{o}
Cohesion	0.40	kg/cm^2
PP	8 - 10	-

Stability with respect to earthquakes
As a result of the study of prof. Dr. Aliaj on seismic activity, two layers in the construction area are identified as susceptible to liquefaction, the sandy layers 3 and 4 (on top of the siltstone). Liquefaction during an earthquake will result in instability of the slope of breakwaters. To prevent or to decrease the risk of liquefaction in case of an earthquake one can install drainage, condense the loose layers or excavating the concerned layers. In case of the breakwaters, excavating the loose layers is preferred because the thickness of the concerned layers is relatively small, 0.5 to a maximum of 3 meters.

10.2 Determination of design conditions

The information given hereinafter is also retrieved from W+B’s Porto Romano archives. For the structural design of the port facilities with a planned lifetime of 50 year, it is advised to use the 100 year design water level. This means that this water level has a probability of occurrence of 39% in the planned lifetime of 50 years. This 39% is a quite high value, but is accepted because the risk involved when structures fails is relatively low. Moreover the lifetime of 50 years is relatively high. To deal with this issue one have to use the Poisson Distribution, where probability of occurrence can be calculated by the following formula:

$$P = 1 - \exp(-fT)$$

P is the probability of occurrence, T is considered in years and f is the average frequency of the event per year.
The values for the return period of 1 year can be used for operational purposes, where the equation shows that the probability that this level/load in one year is reached or exceeded is 63%.

10.2.1 Water levels

Table 10.6 shows the derivation of the design water level. The values have been derived from the Final Design report for the oil/LPG jetty for Romano Port.

TABLE 10.6 – DESIGN WATER LEVEL

Components	***Design water level (100 years RP)***	***Low water level for toe (100 years RP)***	**Operational water level used for down time analysis**
Mean sea level	+0.12	+0.12	+0.12
Seasonal effects	+0.07	-0.03	+0.07
Tide	+0.17	-0.11	+0.17
Long term sea level rise	+0.22	0.0	+0.22
Atmospheric pressure drop	+0.33	0.0	0.0
Wind set up + seiches	+0.17	0.0	0.0
Design water level	**+1.1 LWS**	**-0.0 LWS**	**+0.6 LWS**

10.2.2 Waves at extreme conditions

The extreme design wave conditions on the 10 m depth contour are directly available from a report of April 2005 prepared by GEOSAT Group. GEOSAT provide global wind speeds and significant wave heights derived from radar altimeters.
Only the relevant wind directions for Porto Romano are shown.

TABLE 10.7 – DESIGN WAVE CONDITIONS PER WIND DIRECTION AT 10 M DEPTH

Wave conditions at 10 m depth contour		***Wind direction [°N]***						
		165 – 195	195 – 225	225 – 255	255 - 285	285 – 315	315 – 345	345 – 15
1year return period	Wave height	2.5	2.6	2.6	3.3	2.9	2.4	1.8
	Peak period	9.7	8.7	6.4	8.3	8.9	9.1	7.9
	Wave direction	231°	237°	248°	267°	281°	289°	302°
10year return period	Wave height	3.1	3.2	3.4	4.7	3.7	2.9	2.2
	Peak period	10.9	9.7	7.4	9.9	9.7	9.9	8.6
	Wave direction	234°	239°	250°	267°	280°	287°	299°
100year return period	Wave height	3.6	3.7	4.0	5.4	4.4	3.4	2.6
	Peak period	11.8	10.4	8.1	11.4	10.4	10.5	9.2
	Wave direction	237°	241°	251°	267°	278°	285°	298°

10.2.3 Waves at operational conditions

For the determination of the downtime, operational wave conditions will be used. The joint probability of occurrence (%) of the waves classified by height and direction are summarised in table 10.8.

TABLE 10.8 – JOINT PROBABILITY OF OCCURRENCE (%) OF WAVES AT 10 METER DEPTH CONTOUR (ALL YEAR)

Hs (m)		Wave direction (°N)												
Lower	Upper	-15 to 15	15 to 45	45 to 75	75 to 105	105 to 135	135 to 165	165 to 195	195 to 225	225 to 255	255 to 285	285 to 315	315 to 345	Total
<	0.25	1.75	1.81	1.77	1.56	1.47	1.58	7.48	4.85	0.99	1.41	6.13	14.58	45.38
0.25	0.75	-	-	-	-	-	-	0.02	12.43	2.3	2.28	9.92	6.16	33.11
0.75	1.25	-	-	-	-	-	-	-	4.65	2.21	1.14	5.68	-	13.68
1.25	1.75	-	-	-	-	-	-	-	0.85	1.54	0.61	2.03	-	5.03
1.75	2.25	-	-	-	-	-	-	-	-	0.84	0.47	0.48	-	1.8
2.25	2.75	-	-	-	-	-	-	-	-	0.28	0.21	0.13	-	0.62
2.75	3.25	-	-	-	-	-	-	-	-	0.07	0.15	0.05	-	0.26
3.25	4.25	-	-	-	-	-	-	-	-	0.01	0.08	0.01	-	0.1
4.25	5.25	-	-	-	-	-	-	-	-	-	0	0.01	-	0.01
5.25	6.25	-	-	-	-	-	-	-	-	-	0	-	-	0
6.25	7.25	-	-	-	-	-	-	-	-	-	0.01	-	-	0.01
7.25	8.25	-	-	-	-	-	-	-	-	-	0.01	-	-	0.01
8.25	9.25	-	-	-	-	-	-	-	-	-	-	-	-	-
9.25	10.25	-	-	-	-	-	-	-	-	-	-	-	-	-
10.25	11.25	-	-	-	-	-	-	-	-	-	-	-	-	-
11.25	12.25	-	-	-	-	-	-	-	-	-	-	-	-	-
12.25	13.25	-	-	-	-	-	-	-	-	-	-	-	-	-
Total		1.75	1.81	1.77	1.56	1.47	1.58	7.5	22.78	8.23	6.38	24.43	20.74	100

10.2.4 Flow velocities

Operational flow velocities have been obtained from a hydrodynamic model. The model only predicts the wind-driven flow, so tidal influence was separately added to the model predictions. For the tidal influence a value of 0.30 m/s was estimated on the basis of the measurements in August 2003.

Tables 29A and 29B presents the flow velocities based on analysis of a 10 year model run based on NCEP global climate database wind input with hourly output from the model.

TABLE 29A – CURRENTS [M/S] PER DIRECTION ANS SPEED (PERCENTAGE OF TIME)

Flow conditions per direction	***Flow direction (°N)***					
	345- 15	15 - 45	45 – 75	75 – 105	105 - 135	135 - 165
<0.35	10.1 %	3.4 %	1.2 %	0.9 %	1.4 %	4.3 %
0.35-0.45	14.5 %	0.6 %	0.0 %	0.0 %	0.0 %	0.5 %
0.45-0.55	2.5 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %
0.55-0.65	0.3 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %
0.65-0.75	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %
>0.75	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %
Total	27.4 %	4.0 %	1.2 %	0.9 %	1.4 %	4.8 %

TABLE 29B – CURRENTS [M/S] PER DIRECTION ANS SPEED (PERCENTAGE OF TIME)

Flow conditions per direction	***Flow direction (°N)***						
	165 - 195	195 - 225	225– 255	255– 285	285 - 315	315 - 345	total
<0.35	13.0 %	2.0 %	0.5 %	0.4 %	0.6 %	1.7 %	39.3 %
0.35-0.45	29.6 %	0.2 %	0.0 %	0.0 %	0.0 %	0.0 %	45.5 %
0.45-0.55	9.2 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	11.7 %
0.55-0.65	2.4 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	2.7 %
0.65-0.75	0.6 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.7 %
>0.75	0.2 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.2 %
Total	55.1 %	2.2 %	0.5 %	0.4 %	0.6 %	1.7 %	100 %

Two main flow directions can be distinguished, namely 345-15° (27 % of the time) and 165–195° (55 % of the time). Flow velocities are mostly caused by the tide (fixed value of 0.3 m/s) but wind surge can add significantly. The maximum flow velocity in the 10 year model run equals 0.98 m/s.

11 LAYOUT ALTERNATIVES

In order to depict the future layout of the port, first a set of alternatives will be presented following some basic notions. A further screening of the 3 best alternatives with the help of a MCA will result in a final layout of the port.

11.1 Basic notions for the generation of alternatives

11.1.1 Cut and Fill

The optimum position of the berths and terminals depends upon several factors. The required depth of the berthing basin shall be about 120% (see 11.1.2) of the draft of the biggest ship. There are two ways to meet this requirement:

1. position the berths far enough offshore in deep water;
2. position the berths in less deep water and provide access for ships by dredging.

The optimum is to have a balance between ‘cut’ and ‘fill’ concerning land. In case of Romano Port, a good balance between ‘cut’ and ‘fill’ means a very large amount of dredge work. Dredging is an expensive operation, especially if the subsoil is hard, like in Romano Port; thus it should be minimized, which means subsequently positioning the berths as far as possible in deep water (for more information about the subsoil, see section 10.1.7).

11.1.2 Dimensions access channel and turning basin

The design of an access channel is based on the following dimensions of the design vessel:

Length:	260 meter
Beam:	32 meter
Draught:	12.5 meter
Capacity:	45,000 dwt

If the current velocity outside the port is too big or the waves are too high vessels have to sail in a sheltered access channel surrounded by breakwaters to get enough time for tying up tugboats and decelerate subsequently.

By small waves and small current velocities tugboats already can make fast outside the port entrance. This, of course, very much reduces the manoeuvring space required within the port.

Tugboats can’t make fast at ship speeds of 5-6 knots and a wave height of more than 1.5 meter. This means that exceeding these numbers vessels can’t enter the port when a sheltered access channel wouldn’t be applied.

The first requirement can be met, because the maximum flow velocity is about 1 m/s (see section 10.2.4), which allows vessels to enter the port slowly. The second requirement can also be met, because the period with the wave height H=0.0-1.5 m represents about 95% of the general cases of them for the average year. This implies that nearly the whole year, vessels can enter the port mouth without any hindrance, without a sheltered access channel surrounded by breakwaters.

Of course, an access channel is needed, because water depth is decreasing near to the coast. Therefore a channel will be dredged to guide the largest ships from deep sea to their destination in the port and vice versa.

Depth of channel and basin

The depth of the access channel and also the turning basin depends on a number of factors, in formula:

$$d = D - T + s_{max} + r + m$$ [LIGTERINGEN, H. 2007]

d	= guaranteed depth
D_1	= draught design container vessel = 12.5 meter
D_2	= draught design dry bulk vessel = 11 meter
T	= tidal elevation in case of a tidal window. This is not taken into account due to the little tidal variation in the Adriatic Sea.
s_{max}	= maximum sinkage due to squat and trim = 0.5 meter
r_1	= vertical motion due to wave response for approach channel (=H_s/2=2/2=1 meter).
r_2	= vertical motion due to wave response for basin (=H_s/2=0.5/2=0.25 meter).
m	= remaining safety margin or net under keel clearance. For hard soil of rock this value will be 1.0 meter.

Depth in approach channel
d = D – T + s_{max} + r + m = 12.5 + 0.5 + 1.0 + 1.0 =15.0 meter (below MLWS)

Depth in basin for container vessels
d = D – T + r + m = 12.5 + 0.25 + 1.0 =13.8 meter (below MLWS)

Depth in basin for other vessels
d = D – T + r + m = 11 + 0.25 + 1.0 =12.3 meter (below MLWS)

Channel width
For determining the channel width the PIANC Working Group has developed a method for concept design. For straight sections for a one-way channel (for two vessels per day in 2035 an one-way channel is sufficient) the width is described by the following equation:

$$W = W_{BM} + \sum W_i + 2W_B$$

W_{BM} = Basic width (1.25 D < d < 1.5 D)	1.6B
W_i = Additional width	
- Prevailing cross winds (15 – 33 kn)	0.4B
- Prevailing cross current (0.5 – 1.5 kn)	0.7B
- Prevailing long current (1.5 – 3 kn)	0.1B
- Prevailing wave height (1-3 m)	1.0B
- Aids to navigation (good)	0.1B
- Seabed characteristic (hard)	0.2B
- Cargo Hazard (medium)	0.5B
- W_B = Bank clearance (sloping edge)	0.5B

$$W = 1.6B + \sum(0.4B + 0.7B + 0.1B + 1.0B + 0.1B + 0.2B + 0.5B) + 2\cdot 0.5B = 5.6B = 5.6\cdot 32 = 180m$$

The underwater slope of the channel is assumed to be 1:4.

Dimensions turning basin
The inner channel ends in a turning circle, from where vessels, whether small or big, are towed by tugboats to their respective quays. Assumed that tugboats are available, the diameter of the turning circle should be bigger than 2 times the maximum ship length, resulting in 520 meters.

11.1.3 Littoral Transport (Scour and sedimentation)

Coastal erosion is a great problem in the northern and central coastal regions particular north of the city of Durrës. Sediment discharges from rivers are relatively large, which explains the very dynamic nature of the deltaic development of the coast, resulting in the rapid development of new coastal features, such as spits and lagoons. There are four main causes of this coastal erosion:
a) sediment input, mainly brought by rivers, into the coastal zone;
b) the reduction in the amount of sand in the coastal zone due to anthropogenic activities (sand extraction from the beaches and bottom of the sea although this is prohibited by law);
c) the changing location of river mouths in deltaic systems, as a result of natural causes or anthropogenic effects; and
d) the alteration of the usual pattern of coastal currents and the associated sediment transport along and across the shoreline, due to man-made structures built along the coast. [ECAT TIRANA, June 2007]

There is a large counter clockwise current gyre in the centre of the Adriatic Sea. The large gyre sometimes breaks into two smaller gyres. In both scenarios, the general current flow is northward along the eastern coast of the Adriatic Sea and southward along the western shores. From this current direction and the dominant South-West to West wave and wind direction, it can be concluded that sediments will be transported along the coast from south to north.

The coastline near the project site at Porto-Romano is rather straight, without major obstructions in the coastline or offshore (such as islands). The contour lines of the seabed are more or less parallel to the coastline and show no strong variations. At the project location it can be observed that a severe scour has taken place during the last decades. Bunkers, from the communistic regime, constructed on shore are nowadays 30 meters positioned in sea, see figure 11.1 and 11.2. The road along the coast seems to be constructed as a dike to protect the land inward situated area. The elevation of this road is about 1 meter higher than the access bridge to the LPG plant (figure 11.1). Between the LPG plant and the road a channel exists. A pumping station south of the LPG plant drains this channel. Between the road and the channel a low-levelled strip is situated.

FIGURE 11.1 – BUNKERS IN SEA

FIGURE 11.2 – BUNKERS IN SEA

At the project site no sedimentation takes place. Scour will be the prevailing situation. But although sedimentation does not take place, it doesn't mean that sediment is not moving along the coast from south to north. The already constructed causeway will initiate a stronger sedimentation at the south side of this dam and a stronger scour direct northerly of the causeway. The beginning of this process can already be observed, as shown in figure 11.1. The causeway will catch sediments, and doing so the sedimentation north of the causeway will be reduced. How strong this effect will be, cannot be predicted without a detailed study.

11.1.4 Drainage sluice

The main parts of the land behind the oil / LPG jetty consist of old sea-bottom (lagoon), turned into saline-brackish swamp (the Durrës Marsh) by natural processes, and finally drained during the communist area into mainly grassland for stockbreeding.
The areas are characterized by a network of drainage channels, with the main channels leading to the pumping stations running in the western part of the area. The main altitude of the areas is LWS +1.4 m with some parts even under sea level down to LWS -0.8 m. The area is loosing elevation over sea level at a rate of about 1 cm/year. This calls for both effective drainage systems and for land profiling.

In hydro-geological terms, the area of investigation has scarce water resources and there are no permanent flowing rivers. The current lowlands used to be a marsh with temporary transgressions of the Adriatic Sea. After the construction of the road from Porto Romano to Bishti e Palles, the Durrës marsh was cut off from maritime influence due to the damming effect of the road. The natural interchange between the marsh and the Adriatic Sea could no longer take place and the natural balance was interrupted.

The current lowlands were reclaimed in 1980's when an artificial drainage channel and a network of secondary drainage channels were constructed to lead the seasonal rain water (and waste water) from Durrës to the sea. The flow in the secondary drainage channels and main channel is driven by the Pumping station south of Porto Romano with 2 very voluminous pumps, see figure 11.1 and 11.3. A measured flow velocity during the centre part of the main channel was around 0.2 m/s. [LANDELL MILLS, 2008] Making a design for the port, one has to keep in mind that the flushing volume of water can be significant and can have impacts on the vessel movements.

FIGURE 11.3 – DRAINAGE SLUICE

The central part of the Durrës plain nowadays is flooded during heavy rains, and in particular, when the Porto Romano pumping station accidentally stops pumping. The area of interest is characterized by frequent presence of stagnant water, probably linked with backwater phenomenon of rain water and/or run-off of surface water from the outside areas, and the malfunctioning of pumping activity of the pumping station at Lalzet bay (a pumping station some kilometres north of Porto Romano), caused by general bad maintenance of the pumping stations, and by power breaks.

11.1.5 Archaeology

In the hilly area near the area in question are several archaeological monuments (Illyrian-Roman), but it is anticipated that the actual constructions will not affect these.

11.1.6 Future extension

The proposed expansion in this Master plan of Porto Romano Bay is based on a rough estimation of future trade and transport. Thus it should be kept in mind that any extension should be formed in a way that they can be the base for some further extensions after the year 2035, or maybe earlier.

11.1.7 Rectangular areas

The global trend of terminal shapes is towards large rectangular areas. Although this is valid especially for the container terminals, dry bulk and general cargo terminals should also be formed like this. Bends and irregularities in berths hinder manoeuvring and makes the handling operations difficult.

11.1.8 Breakwaters

Among the most expensive parts of a port expansion are the breakwaters. Thus one should opt for no breakwaters or at least a minimum length of them. To extend Romano Port without breakwaters is no option because significant hindrance occurs at berths for loading an unloading vessels due to the present wave climate. More information about the breakwaters is given in chapter 12.

11.1.9 Dust, Noise and Light pollution

Except the pollution caused by the emissions of the ships (either in air of in water), other types of pollution have to be minimised like dust, noise and light pollution. Dust is dominant in the dry bulk, noise is dominant in the Container en General Cargo terminal while light pollution can be traced in all of the terminals; the latter has an enhanced presence in the Container and Dry Bulk terminal due to the continuous twenty four hour operation. All three should be decisive factors in the port expansion. Regulations in Albania about this topic are unknown and it is recommended to perform a study about this.

The city of Durrës hasn't any significant hindrance of the pollution of Romano Port as a result of sufficient distance between them of about 7 kilometres. But south of Romano Port there is a inhabited area, which indicated that expansion of the port to the north is preferred with respect to dust, noise and light pollution.

11.1.10 Wind direction – wave attack

The prevailing wind in the area of the port has a north and a west origin; thus avoiding an orientation of the quays perpendicular to these directions isn't really possible. It should be noted that for the wind coming from the north the fetch length is negligible. For western winds the fetch length is significant and therefore a breakwater is needed to reduce wave attack and provide tranquillity. For more information about wind and waves, see chapter 10.

11.1.11 Relocation of oil/LPG jetty

It is assumed that the newly built oil/LPG jetty remains in place. It is an expensive operation to relocate the jetty and additional facilities and it is supposed that this would be a very undesirable situation because the jetty has just been built. In a Greenfield project the oil/LPG jetty has got a more strategic location regarding the other terminals, but in this master plan, the location of the jetty acts as an boundary condition or design requirement.

11.2 Existing situation

In figure 11.4 the existing situation of Romano Port is drawn. Depth contours are included as well as the drainage sluice and already built oil and LPG storage areas. South of Romano Port the coast exists of cliffs up to a height of 187 meters. The structure of the hilly system extends for 7 kilometres and begins from the port of Durrës, in the south. At its northern margin, at Porto Romano, the hilly relief dips deeply towards the sea from a height of 50/60 meter. The crest chain becomes gradually lower northwards from the elevation of 187 meters in south that is the highest elevation, to 83 meters near the interruption at Porto Romano. At the area of Porto Romano the width of the hills diminish sharply, from 2000 to 400 meters. In appendix C the depth contours are visible as a result of a Photoshop session of a ‘Google Earth’ shot. The depth contours of this photo and the dept contours obtained from Romano Port archives are quite similar.

From the reclamation area, a connecting road and pipe bridge is needed to the jetty. The first part from the reclamation area up to about 500 meter is constructed as a causeway. The width of the top of the causeway is 7 meter. The slope protection consists of an armour layer, one filter layer of rock and a geotextile. The next 500 meter is executed as a trestle of 7 meter wide to allow for a 3 meter wide precast roadway plus a pipe-track. The piping is placed in one level for construction and maintenance reasons. The width of the pipe track is 3 meter. On the causeway there is an access road to the loading and unloading platform just for small trucks for minor maintenance and inspection purposes. Major maintenance will have to be executed using floating equipment. The trestle is founded upon steel piles.

The complete jetty system consists of six mooring dolphins, five breasting dolphins, an unloading platform and a trestle to the shore. Interconnecting walkways are provided between the dolphins and platform.

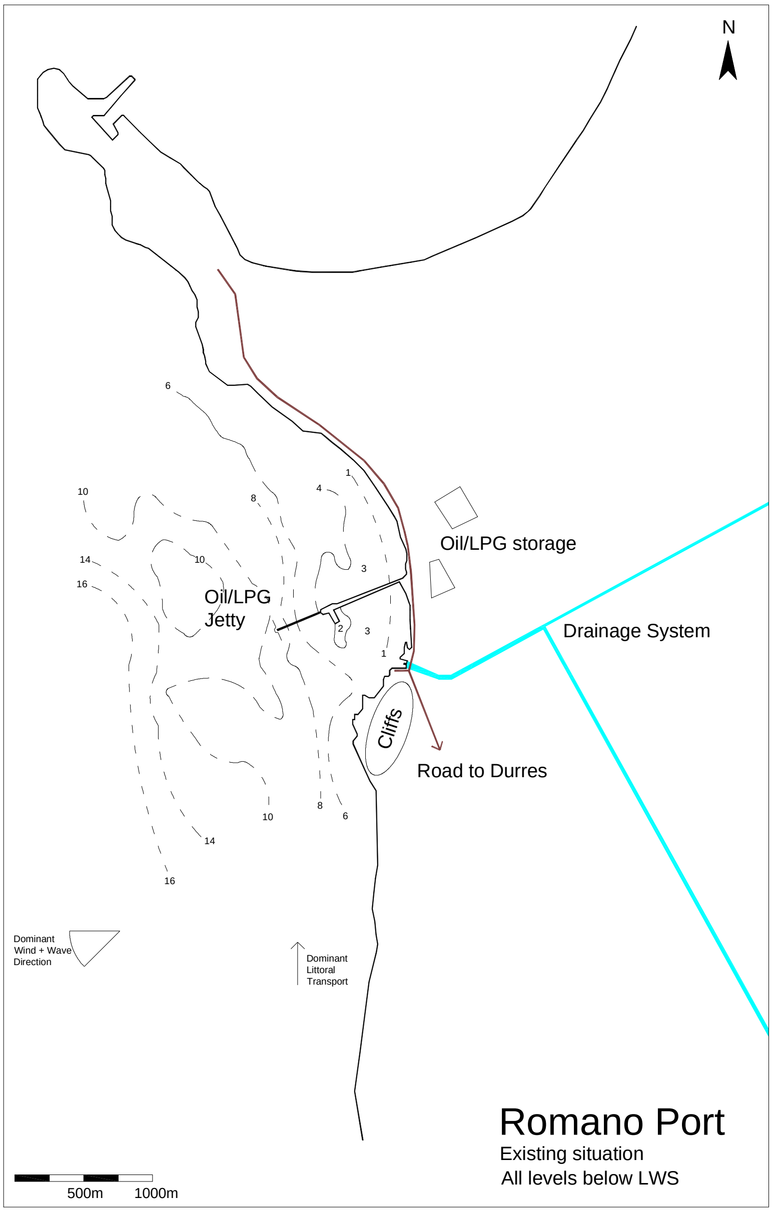


FIGURE 11.4 – EXISTING SITUATION

11.3 Alternatives

In appendix D ten layout alternatives for Porto Romano are presented. In this chapter the three most promising alternatives are worked out in more detail. Below a short description and sketch is given per alternative and in appendix E the detailed drawings are shown per alternative.

11.3.1 Alternative 1

The basic idea of this alternative is to keep the planned terminals away from the existing LPG and oil Terminal regarding safety considerations and manoeuvring space. Two breakwaters are needed, one attached and the other detached. At the lee site of the attached breakwater the terminals are situated. Drainage water of the sluice will have enough freedom to flow anywhere, which results likely in no hinder for vessels which enter of leave the port or for loading and unloading operations. Future expansions are possible between the existing causeway and the newly build Container terminal. If littoral transport or wave hindrance will dominate in future a closure of the southern breakwater is possible.

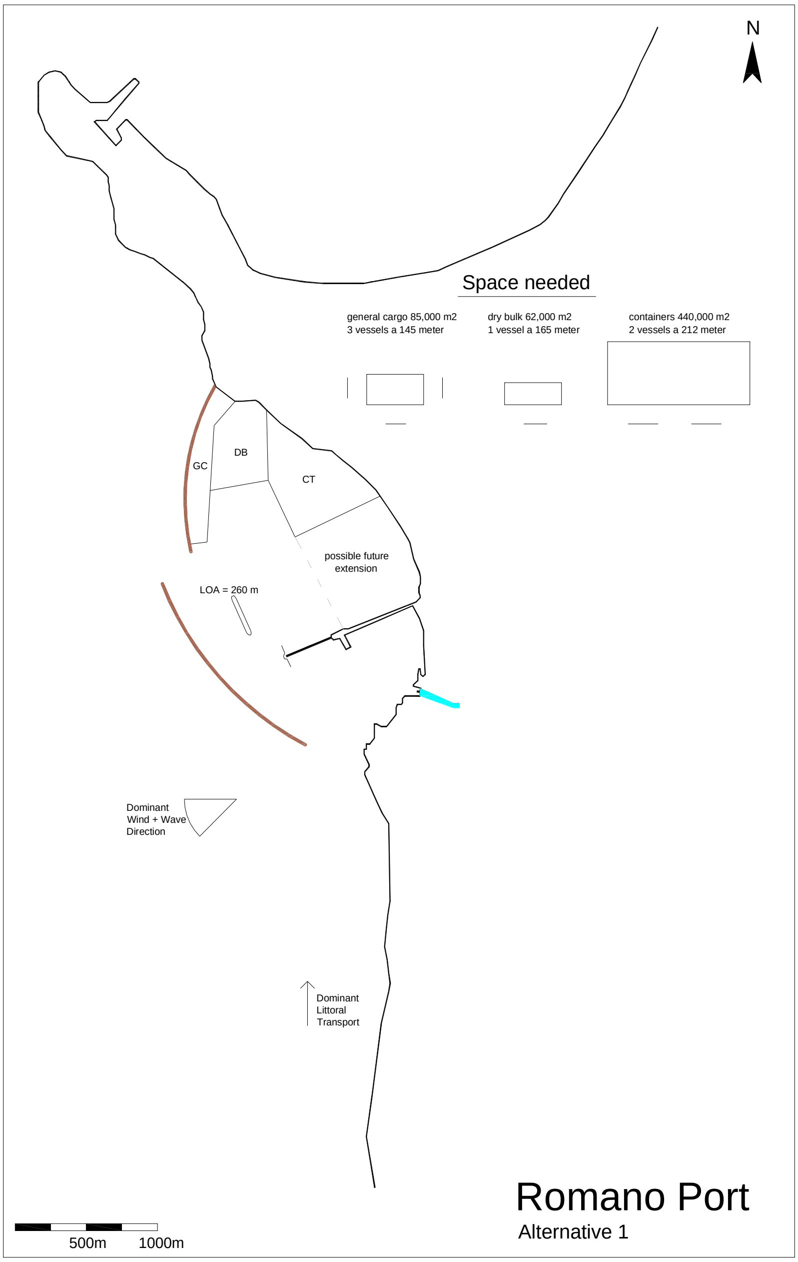


FIGURE 11.5 – ALTERNATIVE 1

11.3.2 Alternative 2

The principle of alternative 2 is to keep all port facilities around the already constructed oil and LPG jetty, to use the available space efficiently. The port consists of one large breakwater which starts at the cliffs south of Romano Port and ends after a curve of 2240 meter. Future expansion is possible northwards of the Container terminal.

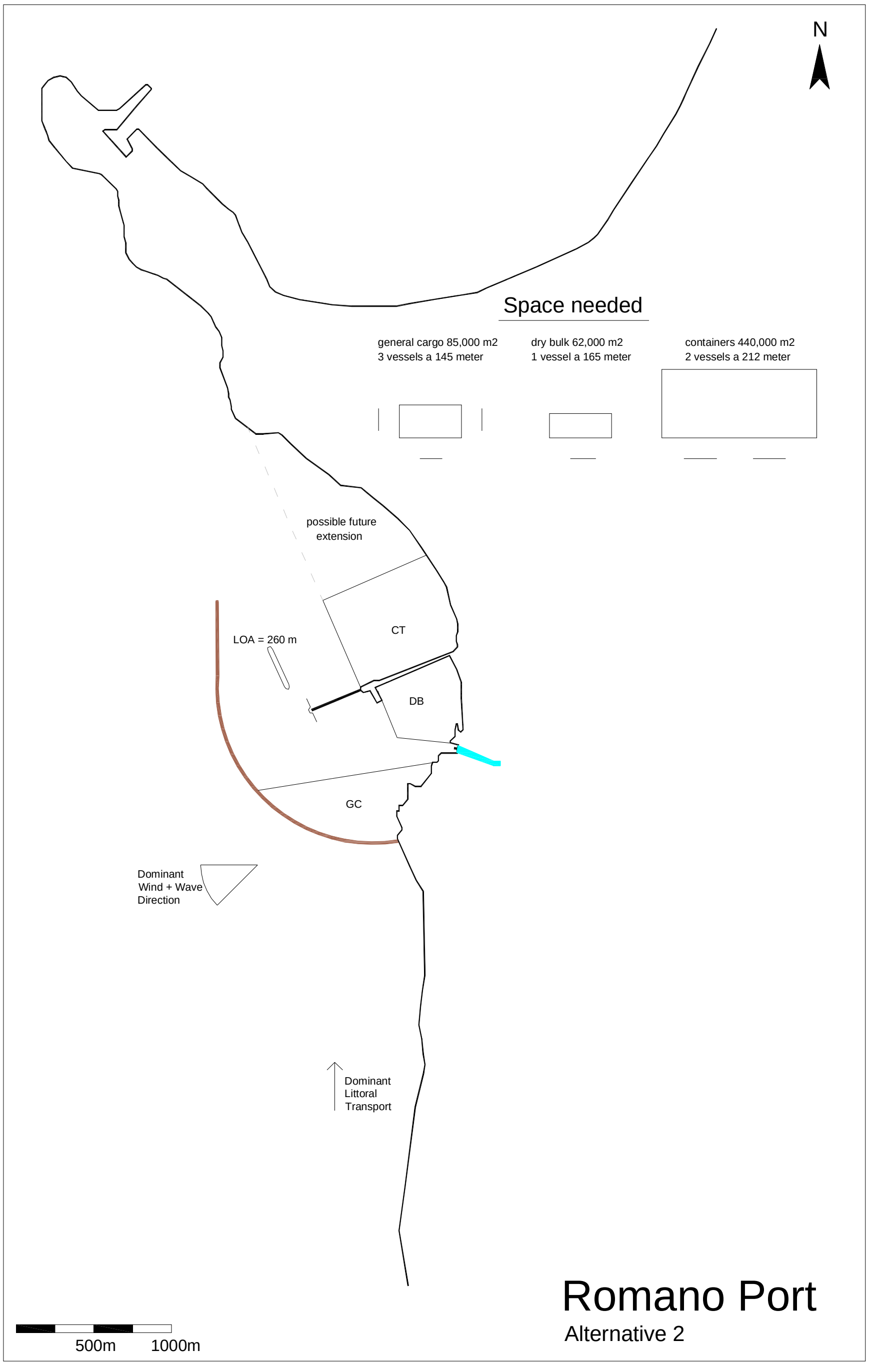


FIGURE 11.6 – ALTERNATIVE 2

11.3.3 Alternative 3

The basic idea of alternative 3 is to keep it simple. One straight detached breakwater in front of the terminals aims tranquillity for loading and unloading operations. The container terminal, dry bulk terminal and the general cargo terminal are aggregated in one terminal area north of the existing oil/LPG jetty to reduce quay length and make use of the existing causeway as border of the terminal area. Basically there are two vessel entrances, but to reduce dredging costs only the north entrance of the breakwater will be used.

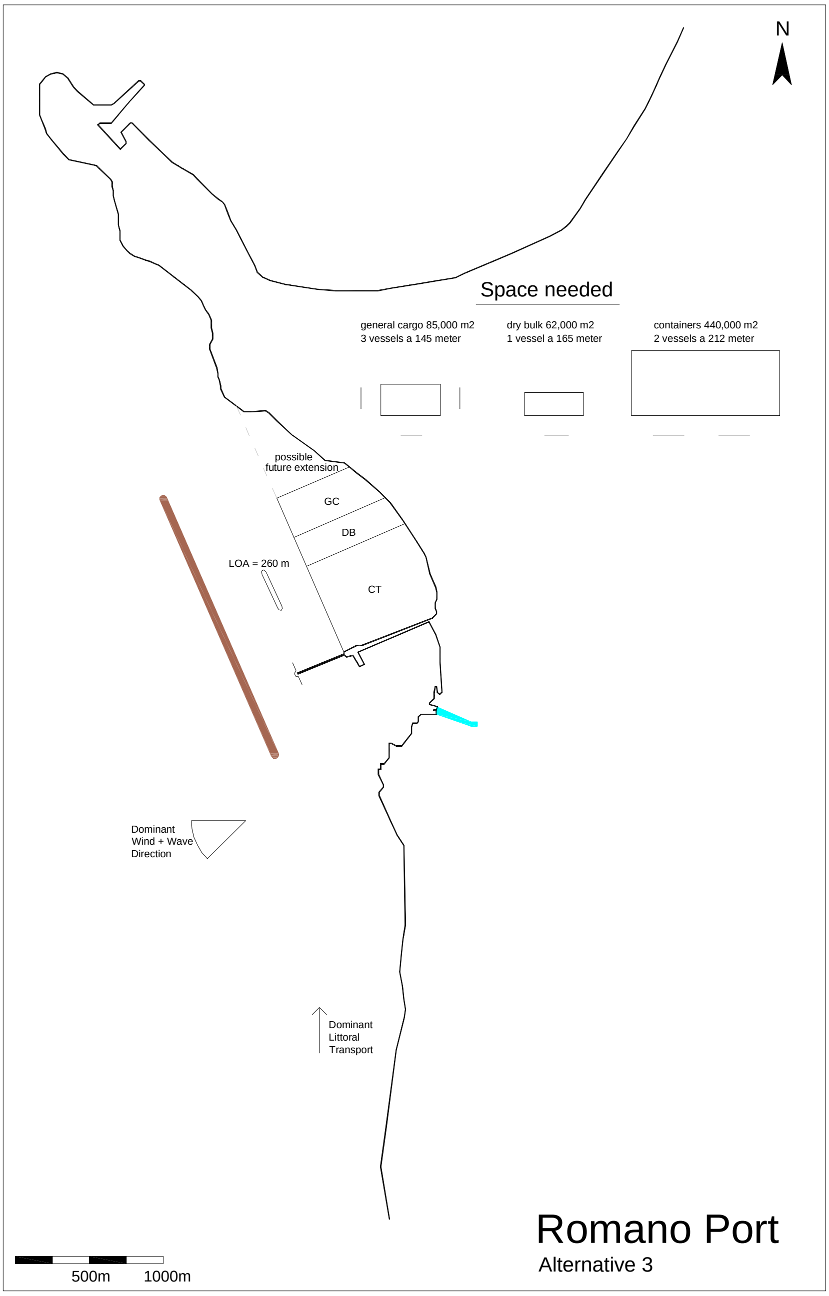


FIGURE 11.7 – ALTERNATIVE 3

11.4 Comparison of the alternatives

The alternatives for a port layout entail a lot of parameters that should be taken into account when deciding for the optimum. In order to deal with all these affecting parameters an MCA (Multi-Criteria Analyses) will be applied.

First, the mentioned decisive parameters will be presented and next a certain weighing factor, ranging between 1 to 10 will be applied to each parameter. A mark of 1 to 5 will be further given in order to judge the alternatives. The value ‘1’ designates the worst alternative while the value ‘5’ shows the best alternative.

Due to the great subjectivity of the MCA, a sensitivity check will be made in order to validate the results.

It should be stated that the environmental aspects (except dust, noise and light pollution) will not be included in the MCA. These investigations should be worked out in a Environmental Impact Assessment (EIA) which would deviate from the scope of this report. Moreover, if there would be some impact, this would be almost the same for each alternative, so is doesn’t affect the final results.

11.4.1 Affecting parameters and multiplying coefficients

Seven major parameters have been chosen for the MCA of this report: extensibility, tranquillity, manoeuvrability, maintenance dredging, dust/noise and light pollution, hindrance of draining sluice and safety distance to oil/LPG jetty. The multiplying coefficients for each one are presented below. The meaning of the parameters are described in section 11.4.4. It should be noted that the parameters ‘pollution’ and ‘hindrance of drainage sluice’ are subjective parameters and can’t be measured precisely. But because they are less important with respect to the other parameters any deviation in weighting is negligible. Because the trade forecasts are conducted until 2035 and the design is bases on a medium growth scenario the output should be treated carefully. For this reason the parameter extensibility has the highest weight factor ‘10’. Because one of the main functions of Romano Port is to acquire a quite wave climate for loading and unloading vessels, tranquility gets a weight factor of ‘8’. Manoeuvrability and maintenance dredging are of moderate importance.

TABLE 11.1 – MULTIPLYING COEFFIENT PER PARAMETER

Parameters	***MCA weight factor***
Extensibility	10
Tranquility	8
Manoeuvrability	6
Maintenance dredging	5
Hindrance of drainage sluice	3
Dust, noise and light pollution	2
Separation LPG versus other cargoes	2

11.4.2 Ranking

TABLE 11.2 – MCA RESULTS

Parameter	***Multiplier***	***Layout 1***	***Layout 2***	***Layout 3***
Extensibility	10	3	5	4
Tranquility	8	5	5	3
Manoeuvrability	6	4	3	5
Maintenance dredging	5	4	5	2
Hindrance of drainage sluice	3	5	3	4
Dust, noise and light pollution	2	5	3	4
Separation LPG versus other cargoes	2	5	2	4
		149	**152**	**132**

Layout alternative 2 seems to be the most promising one with the highest score. Layout 1 follows with a lower score of 182 and layout 3 demonstrates the lowest score. However the differences are very small.

11.4.4 Sensitivity check

The MCA is a method which takes into account several parameters by attributing to them the respective weight. Its major disadvantage is that it is described by a rather great subjectivity not only by giving weights but also by deciding which criteria will be included.

In order to cope with this problem, a sensitivity check was applied. More specifically, the MCA will be repeated with different weights and sometimes even with the exclusion of some of the parameters. The previous MCA will be used as a base scheme.

1st Sensitivity check

In this check, the last three parameters (hindrance of the drainage sluice, dust/noise and light pollution and safety distance to oil/LPG jetty) are left out, resulting in five factors which all have a relatively high weight. Layout 2 is again the most promising and layout 3 acquired again the third position.

TABLE 11.3 – 1ST SENSITIVITY CHECK

Parameter	***Multiplier***	***Layout 1***	***Layout 2***	***Layout 3***
Extensibility	10	3	5	4
Tranquility	8	5	5	3
Manoeuvrability	6	4	3	5
Maintenance dredging	5	4	5	2
		114	**133**	**104**

2st Sensitivity check

This check was made in order to stress the tranquillity aspect; thus the multiplier is increased from a ‘eight’ to a ‘ten’. Layout 2 has the highest score again.

TABLE 11.4 – 2ST SENSITIVITY CHECK

Parameter	***Multiplier***	***Layout 1***	***Layout 2***	***Layout 3***
Extensibility	10	3	5	4
Tranquility	**10**	5	5	3
Manoeuvrability	6	4	3	5
Maintenance dredging	5	4	5	2
Hindrance of drainage sluice	3	5	3	4
Dust, noise and light pollution	2	5	3	4
Separation LPG versus other cargoes	2	5	2	4

		159	**162**	**138**

3st Sensitivity check
In this check, the value of the four originally most important parameters are levelled to ‘eight’, which means an equal scale of importance. This sensitivity check results in no difference between layout 1 and 2.

TABLE 11.5 – 3ST SENSITIVITY CHECK

Parameter	***Multiplier***	***Layout 1***	***Layout 2***	***Layout 3***
Extensibility	8	3	5	4
Tranquility	8	5	5	3
Manoeuvrability	8	4	3	5
Maintenance dredging	8	4	5	2
Hindrance of drainage sluice	3	5	3	4
Dust, noise and light pollution	2	5	3	4
Separation LPG versus other cargoes	2	5	2	4
		163	**163**	**140**

Conclusion
The above sensitivity check procedure, demonstrates the validity of the initial MCA. Layout 2 seems to be the most promising one. Layout 1 comes next and layout 3 acquired the third position. Layout 3 has the worst score.

Since layout 2 is not the best on all parameters, a presentation will follow of the major advantages and disadvantages per parameter.

Extensibility
The proposed expansion in this Master plan of Porto Romano Bay is based on a rough estimation of future trade and transport. Thus it should be kept in mind that any extension should be formed in a way that they can be the base for some further extensions after the year 2035, or maybe earlier. Layout 2 has the best opportunity to expand. The terminals are designed in the south of Romano Port and eventual expansion is possible northwards without drastic changes in the existing layout.

Tranquility
The breakwater in layout 2, which is needed to reduce wave attack and provide tranquility, protects nearly the entire port. To the north the port is sheltered by a spit. Diffraction and transmission will be calculated, for more information about this topic, see chapter 12.

Manoeuvrability
Regarding the manoeuvrability layout 2 gets the lowest mark. The oil/LPG jetty is projected in the middle of the harbour basin, with the result that the dry bulk and general cargo vessels have to pass the oil/LPG jetty, resulting in some extra vessel movements compared with layout 1 and 3.

Maintenance dredging
The meaning of this topic is the question if dredged areas remain at depth in time or that due to littoral transport sedimentation will take place which results in maintenance dredging. The degree of estimated maintenance dredge work will determine the mark in the MCA. Layout 3 gets a low mark due to the fact that there is no protection at all to sedimentation. Littoral transport will carry on without any form of interference which possibly results in sedimentation and a decrease of the water depth in front of the berths. Layout 2 is by far the best. From south the inner part of the port is protected against sedimentation. From north no sand transport will reach the port entrance due to the sheltered location of the port entrance behind the spit. In front of the southern breakwater in layout 2, accretion will occur, filling up the triangle between the original coastline and the breakwater, after which littoral transport continues. How strong this effect will be, cannot be

predicted without a detailed study. If the effect is strong it will cause siltation in the approach channel. It this shoal grows, the access of the largest ships would be blocked, which is clearly not acceptable, meaning still maintenance dredging. But the head of the breakwater is positioned in such a way that by-passing sand is not drawn in the port.

Hindrance of drainage sluice
In layout 1 and 3 vessels haven't significant hindrance of the flow of the drainage sluice. In layout 2 there can be some hindrance and impact on vessel movements dependant on the magnitude of the flushing volume. This parameter is an disadvantage of layout 2. In case of heavy rains, vessels at the dry bulk terminal and general cargo terminal should be warned about these currents.

Dust, noise and light pollution
It is expected that the city of Durrës hasn't any significant hindrance of the pollution of Romano Port as written before as a result of the sufficient distance between them of about 7 kilometres. But south of Romano Port there is a inhabited area, which indicate that expansion of the port to the north is preferred with respect to dust, noise and light pollution. This results in the highest mark for layout 1 and the lowest for layout 2. Regulations in Albania about this topic are unknown and it is recommended to perform a study about this.

Separation LPG versus other cargoes
Minimum safety distances are applied in all alternatives but there is a significant difference between the three layouts concerning vessels movements in the vicinity of the oil/LPG jetty. In layout 1 the liquid bulk activities are carried out at a great distance of the other port activities. The probability that a vessel collision will occur is quite low. In layout 3 the mentioned distance becomes smaller and in layout 2 there is no separation between the mentioned cargo types, resulting in the lowest score.

11.4.3 Design characteristics and cost comparison of the alternatives

For a global estimate of the construction costs the main design characteristics are determined for the three layout alternatives.

TABLE 11.6 – DESIGN CHARACTERISTICS

		Layout 1	***Layout 2***	***Layout 3***
Breakwater length	[m]	2735	2240	1700
- Detached	[m]	1370	0	1700
- Attached	[m]	1365	2240	0
Quay length	[m]	1359	1290	1277
Bank protection	[m]	750	1450	300
Dredging works	[m3]	3.3 mil	5.2 mil	4.3 mil
- Rock	[m3]	- 1.5 mil	- 2.8 mil	- 2.3 mil
- Sand	[m3]	- 1.8 mil	- 2.5 mil	- 2.0 mil
Land filling	[m3]	5.6 mil	5.1 mil	4.7 mil

On the basis of the design characteristics a global estimate of the construction costs is made in table 11.7. In this report only some costs related to the previously mentioned technical data will be given, assuming that the prices remain constant during time. The reason for this simplification is that the purpose of this report is not to present a complete financial analysis but to provide some indicative values.

TABLE 11.7 – GLOBAL ESTIMATE OF THE CONSTRUCTION COSTS

	unit rate	Layout 1	Layout 2	Layout 3
Breakwater		205 mil	112 mil	170 mil
- Detached	€100.000/m^1	137 mil	-	170 mil
- Attached	€50.000/m^1	68 mil	112 mil	-
Quay (concrete + steel piles)	€25.000/m^1	34 mil	32 mil	32 mil
Bank protection (slopes)	€5.000/m^1	4 mil	7 mil	2 mil
Dredging works		56 mil	99 mil	81 mil
- Rock	€30/m^3	45 mil	84 mil	69 mil
- Sand	€6/m^3	11 mil	15 mil	12 mil
Land filling	€5/$m^{3\ new}$	21 mil	12 mil	12 mil
	€2.5/$m^{3\ fill\ only}$	4 mil	7 mil	6 mil
TOTAL CAPITAL INVESTMENTS		€325 mil	€269 mil	€303 mil

Dredging works and the breakwater construction determine substantially the value of the construction costs. The quantity of dredging work in layout 2 is significant due to the large area needed for vessel manoeuvres. However, by contrast, the construction costs for the breakwater in layout 2 will be the lowest of all three alternatives due to the attached type instead of detached. This means that use can be made of land-based equipment which is far cheaper than waterborne equipment that has to be used in case of a detached breakwater. However, there is no significant difference between the three alternatives. Layout 2 will be probably the cheapest, however the differences in this global estimate is too small to make a realistic choice with respect to construction costs.

Despite some disadvantages of layout 2 and the rather subjective method (MCA), layout 2 has proven to be the best alternative. The sensitivity check that was implemented verified the validity of the results. In the next chapter, this final layout will presented in a more detailed way, with the emphasis on the breakwater and quay design.

12 BREAKWATER DESIGN

Based on an analysis in appendix F, where several breakwater types were discussed and a comparison between a caisson type and rubble mound breakwater was made, the rubble mound breakwater appeared to be the preferred solution.

12.1 Design requirements

General

The design requirements for the breakwater are specified below:
- the main function of the breakwater is to reduce the downtime of the port operations at the quays/jetties. The estimated downtime shall be approximately 20 days per year (5%);
- the design life time of the breakwater will be 50 years;
- the breakwater is designed to withstand a 100 years Return Period storm. During this storm damage is allowed, but structures may not fail;
- the breakwater will be not accessible;
- the crest level of the breakwater will only be determined by wave transmission requirements.

Construction materials

For the already built causeway at Romano Port use has been made of a quarry near Krüje, north of Tirana about 50 km from the site. For the construction of the shore protection as well as for the armour layer big stones are needed. However, the quarry can produce stone with a mass up to 2000 kg. Therefore, the armour layer will be designed using concrete blocks. It is recommended to make sure the capacity of the quarry is sufficient for the construction of other rock layers.
The following assumptions about the construction materials are made:
- the stone density is assumed at 2650 kg/m^3 - the concrete density is 2400 kg/m^3.

Water depth

The water depth at the breakwater location is taken from the depth contour lines. The sea bed level varies from place to place but is taken as LWS -10m from 640m offshore.

Allowable wave heights

Maximum wave heights for ships at berths and for loading and unloading operations are given respectively in table 12.1 and 12.2. The limiting operational conditions for container vessels (which is normative) is 0,5 meter for waves at the head or stern and an estimated value of 0.3 meter for waves at the beam. In the layout of Romano Port container vessels have to deal with waves at the beam, which results in a limiting wave height of 0.3 meter.

TABLE 12.1 – MAXIMUM WAVE HEIGHTS FOR SHIPS AT BERTH

Type of vessel	*Maximum Hs at berth [m]*
General cargo (<30,000 dwt)	1.00 - 1.25
Dry bulk (<30,000 dwt)	1.00 - 1.25
Dry bulk (up to 100,000 dwt)	1.50
Oil tankers (<30,000 dwt)	1.00 - 1.25

Source: PIANC bulletin 1987, principles of integrated port planning

TABLE 12.2 – MAXIMUM WAVE HEIGHTS FOR LOADING AND UNLOADING OPERATIONS

Type of vessel	*Maximum Hs for loading and unloading [m]*	
	0° (head or stern)	45° - 90° (beam)
General Cargo	1.0	0.8
Container	0.5	
Dry bulk (30,000 - 100,000 dwt); loading	1.5	1.0
Dry bulk (30,000 - 100,000 dwt); unloading	1.0	0.8 - 1.0
Tankers (< 30,000 dwt)	1.5	

Source: PIANC bulletin 1987, principles of integrated port planning

12.2 Block type

For the construction of the shore protection as well as for the armour layer big stones are needed. However, the quarry can produce stones with a mass up to 2000 kg.

In such case, the use of artificial blocks made of concrete becomes an interesting alternative distinguished in three approaches:
- Block resistance mainly by weight;
- Block resistance mainly by interlocking;
- Block resistance mainly by friction.

The last group consists of pattern placed concrete blocks and columns, mainly used in block revetments.

Blocks mainly functioning due to their weight consist of randomly placed cubes. These elements are always placed in double layers.

The main advantages of single layer armour units are:
- Economically: Reduced number of armour units – thus savings in concrete, fabrication and placement costs;
- Technically: Less rocking than in a double layer armour and therefore a lower risk of impact loads and breakage (Sogreah, 1985).

The breakwater armour layer is designed using a single layer of Accropode II, see figure 12.1.
The strong points of Accropode armour units are single layer placement and large structural stability (compared with the Core-Loc).

FIGURE 12.1 – ACCROPODE II

The Accropode can be placed in one layer. And because of the interlock, the units themselves can be made lighter and more slender. This means less mass per running meter, and is therefore more economic.

The original Accropode was the first element that could be placed in a single layer. The unit proved to be very successful. However, because of the two flat sides of the block, careful placing is required. And therefore placing costs are quite high. Both Sogreah as well as Delta Marine Consultants were looking for a unit which did not have that disadvantage. More or less simultaneously both the Accropode II and the Xbloc were presented. Because these elements do not have a flat side, placing is easier and therefore placing goes much faster. [VERHAGEN H.J., ET AL.,2009]

12.3 Hydraulic design

12.3.1 Design philosophy

Three conditions will be checked. A first operational condition, where only diffraction is decisive. A second operational condition where diffraction and transmission determine the wave heights at the berths. And finally, extreme wave conditions will be used for the design of the required breakwater armour and filter layer dimensions.

The approach adopted for the design is to keep the crest of the breakwater as low as possible and the crest width as small as possible to minimise the construction costs of the breakwater.

Operational condition 1
The breakwater alignment is determined using the downtime criteria as main design parameter. The limiting operational wave condition for a container vessel as written before is 0.3 meter for waves acting on the beam and 0.5 meter for waves at the head or stern. Therefore, the breakwater is designed reducing the wave height at the container terminal (which is decisive) to the aforementioned values accounting for a downtime of 5%.

Operational condition 2
The breakwater crest height and crest width were determined using the criteria that vessels are berthing but they perform no loading and unloading operations. The limiting operational wave conditions for vessels as written before is between 1 and 1.25 meter. Therefore, the breakwater is designed reducing the wave height at the container terminal (which is decisive) to the aforementioned maximum value of 1.25 meter. The design wave is characterised by a wave height of about H_s = 4.7 meter and a wave period of T_p= 9.9 meter. This is a wave with a return period of 10 years. In case of bigger waves, vessels are advised to move to the bay of Rodonit, approximately 15 nautical miles north of Durrës. The anchorage in the bay of Rodonit is sufficiently deep to accommodate deep-drafting vessels.

Extreme conditions
The breakwater armour layer is designed to withstand the extreme 100 years return period wave conditions. The 100 years design wave conditions at the 10 meter depth contour are again presented in table 12.3.

TABLE 12.3 – EXTREME WAVE CONDITIONS AT 10 M WATER DEPTH

Sector	***165º-195º***		***195º-225º***		***225º-255º***		***255º-285º***		***285º-315º***		***315º-345º***		***345º-15º***	
Return Period	H_s [m]	T_p [s]	H_s [m]	T_p [s]	H_s [m]	T_p [s]	H_s [m]	T_p [s]	H_s [m]	T_p [s]	H_s [m]	T_p [s]	H_s [m]	T_p [s]
100	3.6	11.8	3.7	10.4	4.0	8.1	5.4	11.4	4.4	10.4	3.4	10.5	2.6	9.2

12.3.2 Breakwater alignment

The harbour area should be designed so that:

- The least amount of wave energy penetrates into the harbour area;
- Wave disturbance at the berths is minimised to avoid downtime;
- The approaches, entrance and inner basins are navigable.

The breakwater alignment is determined using the downtime criteria as main design parameter. The limiting operational wave condition for a container vessel as written before is 0.3 meter for waves acting on the beam and 0.5 meter for waves at the head or stern. Therefore, the breakwater is designed reducing the wave height at the container terminal (which is decisive) to the aforementioned values accounting for a downtime of 5%. For this requirement, diffraction is the only decisive parameter that should be taken into account, because the corresponding design wave is so small compared with the crest height of the breakwater that transmission can be neglected. The diffraction calculation is given in appendix G.

It can be concluded that the breakwater alignment as drawn in appendix E meets the tranquillity requirements as given above.

12.3.3 Crest height and crest width

The breakwater crest height and crest width were determined using the criteria that vessels are berthing but they perform no loading and unloading operations. The limiting operational wave conditions for vessels as written before is between 1 and 1.25 meter. Therefore, the breakwater is designed reducing the wave height at the container terminal (which is decisive) to the aforementioned maximum value of 1.25 meter.

These calculations are given in appendix H.

The calculations showed that the tranquillity requirements at the container terminal were not met by waves with a return period of 10 years. This is caused by relative high diffraction, due to the breakwater alignment. Therefore container vessels should move to the Rodonit Bay earlier. A second calculation is carried out with respect to the oil / LPG jetty (which is decisive in the second place).

With the breakwater alignment as drawn in appendix E, a crest width of 10 meter and a crest height of 4.2 meter, the requirement of about 1 meter wave height at the LPG / oil jetty is met.

12.3.4 Armour

Van der Meer tested Accropodes and found that storm duration and wave period have no influence on the hydraulic stability. It was found that the *no damage* and *failure criteria* for Accropodes are very close. Tests were performed with non-breaking wave conditions on a slope of 1:1.33, but a similar behaviour is expected for a 1:1.5 slope. Stability for Accropode layers can therefore be described by a simple formula (start of damage, non breaking waves and a safety factor included):

$$\frac{H_s}{\Delta d_n} = 2.7$$

[CIRIA, CUR, CETMEF, 2007]

Density water	= 1025 kg/ m^3
Density concrete	= 2400 kg/m^3
Δ	= 1.34
H_s	= 5.4 m (100 year RP)

Substituting these values in the design formula above, yields a d_n of 1.5 meter.

Note that d_n is the nominal diameter of the unit. For Accropodes this leads to a layer thicknes of 1.95 meter.

Underlayer

Concrete armour units always require an underlayer to be of a specific size to ensure a proper transfer of loads, to obtain sufficient permeability and to resist outward movement of fines. As for rock armouring, a relatively narrow graded rock material should be used for the underlayer in view of permeability. Since a reduced permeability often leads to a lower stability of the armour it is important that the underlayer material is not too small and the grading is not too wide. As rules of thumb the following is applicable:

- The median armourstone mass of the underlayer, M_{50} (kg), should be about 1/10 of the armour unit mass;
- For Accropodes (and others), the nominal limits of the armourstone mass of the underlayer should be between 7 percent and 14 percent of the armour unit mass.

The required filter grading is 300 – 1000 kg.

Core

One have to use material in the core that can be situated directly under the first under-layer. The finer fractions of the quarry yield curve will be used for the core within the weight ratio of 1/10 and 1/25 between the first under-layer and the core. Therefore, the stone gradation will be 40-200 kg.

Filter / Toe

Under the seaward toe, large pressure gradients may exist that can wash out material of the structure. Loose of material is a large threat tot the stability of the armour layer. Therefore a geometrically impermeable filter should be placed under the seaward part of the breakwater. The bearing capacity of the 'mud' layer of 1-3 meter under the breakwater is insufficient to create a safe foundation for the heavy load presented by the breakwater. Therefore, it is good to apply soil improvement. Placing the toe in the dredged trench creates the intended soil improvement. For the filter layer a stone gradation of 10-100 kg is used.

The toe detail for concrete armour units do not differ significantly from those for natural armourstone. An important feature of highly interlocking single-layer armour units is that the armour layer is much more stable at the centre than at the edges and especially at the toe. Two solutions are possible. The first one is to support the armour layer by a toe of rock armour stones as shown in figure 12.2.

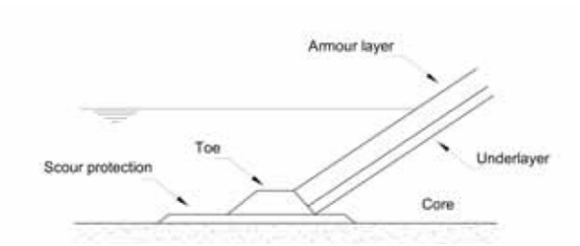


FIGURE 12.2 – TRADITIONAL TOE CONSTRUCTION

For calculating the toe stone size the following equation can be used:

$$\frac{H_s}{\Delta d_{n50}} = \left(6.2\left(\frac{h_t}{h}\right)^{2.7} + 2\right) N_{od}^{0.15}$$ [CIRIA, CUR, CETMEF, 2007]

For the design of the toe, it is anticipated that no damage to the toe may occur during design conditions, resulting in a N_{od}=0.5.

H_s = significant wave height = 5.4 meter
Δ = relative density = 1.59
d_{n50} = required nominal stone diameter
h_t = water depth on the toe berm = 7 meter
h = water depth in front of the toe = 10 meter
N_{od} = number of displaced units = 0.5

Substituting these values in the design formula above, yields in a d_n of 0.86 meter.

Because the nearest quarry can produce stone with a mass up to 2000 kg, is would be cheaper using concrete blocks (second solution). Otherwise, the armour stones have to transported from another quarry resulting in extra transport costs.

The construction of this second solution is to place the first two rows flat on the bottom of the sea on the first under layer as shown in figure 12.3. The toe width should be at least 3 Accropode II elements. The shoulder width at the sea side is 2 meter.

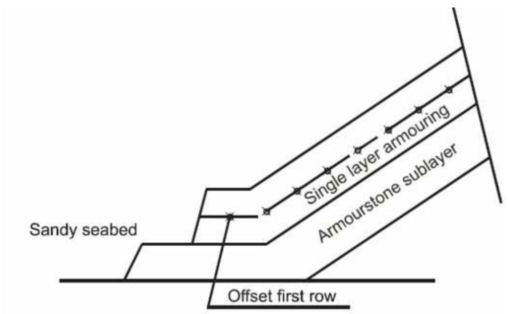


FIGURE 12.3 – TOE OF ARMOUR LAYER

Attention should be made on the fact that the overall subsoil conditions are unknown. The design of the toe is based on the soil investigation performed for the design of the oil/LPG jetty. Additional soil investigations on relevant locations would be executed to establish soil layers with corresponding parameters in more detail.

Roundhead

The breakwater roundhead involve a special physical process, as wave breaking over roundheads yields large velocities and wave forces. The area of exposed high wave attack is around still water level, about 120-150° from the wave direction and thus on the lee side of the roundhead. To obtain the same stability as for the trunk section two options are available:
- to increase the mass of the armourstone (by larger units and/or higher density)
- to make the side slope of the roundhead less steep

Because Accropode elements obtain their resistance mainly by interlocking, reducing the slope is no option, because a more gentle slope means a lower stability.

Stability for Accropode layers on roundheads can be described by the following formulae:

$$\frac{H_s}{\Delta d_n} = 2.5$$ [CIRIA, CUR, CETMEF, 2007]

To meet this requirement, two options are possible:
- In case of using the same concrete with a density of 2400 kg/m^3 the nominal diameter would be 1.61 meter, 0.11 meter bigger as the armour units at the trunk.
- To keep the nominal diameter of the roundhead units the same as for the trunk units, the concrete density has to be increased up to 2500 kg/m^3.

Increasing the nominal diameter of the Accropodes means that another mold should be made and that a transition occurs between the two different sizes of armouring which should be avoided as much as possible.
Using a higher density might be achieved by extra heavy aggregates.

The choice has been made for increasing the density, because it is expected that using a higher concrete density would be cheaper than increasing the nominal diameter of the Accropode blocks.

The Accropode II units are placed on a grid to guarantee interlocking. However at the breakwater head the placement pattern will deviate significantly from a regular grid. The placement at the head is characterised by varying distances by neighbouring armour units.

The radius of the Accropode II units, measured at design water level, should not be less than three times the design wave height, in order to prevent a significant reduction of interlocking. This results in a radius of 3 x 5.4 = 16.2 meter

13 BERTH STRUCTURE

13.1 Type of berth structure

The purpose of the berth structure is to provide a vertical front where ships can berth safely. The berth fronts can be constructed according to one of the following two main principles.
- solid berth structure (gravity wall structure or sheet pile wall structure);
- open berth structure.

The choice has been made for an open pile construction. Open pile construction is an economic means of building simple berths. The main reason to apply this system is that the seabed consists of siltstone (see section 10.1.7). Vertical piles are less expensive to drive, but these are more susceptible to loads, so low reaction fenders are specified. The fenders will be installed onto the concrete deck. A schematisation is shown in figure 13.1. Moreover, the open berth structure is favourable with respect to the reflection of incoming waves against the berth front. At an open structure the waves will be damped to a great extent against the rough rubble-covered slope beneath the berth structure. The damage due to an earthquake in case of an gravity wall can be more significant than in case of an open pile construction. Both options are likely to suffer damage when a strong earthquake occur. However, the damage to a open pile construction is probably far more easy to repair.

Because an open berth structure is less resistant to loadings than the solid berth structures, both vertically and horizontally, it is not permitted to store large quantities of materials/containers (depends on the kind of terminal) in the first 35 meter from the front wall. All vertical loads are transmitted by piles to the sub-soil.

13.2 Top elevation of the berth slab

The top elevation of the berth structure is determined by the following factors:

(a) the elevation of the area behind the terminal;
The main altitude of the area behind the terminals is LWS +1.4meter with some parts even under sea level down to LWS -0.8 meter. The existing elevation of the road along the coast (which is constructed as a dike to protect the land inward situated area) is about 2.2 meter.

(b) the water levels;
The maximum water level with a return period of 100 years is LWS +1.1 meter.
The minimum water level with a return period of 100 years is LWS 0.0 meter.
The maximum operational water level is LWS +0.6 meter.

(c) the wave action in the harbour basin;
The transmitted and diffracted wave height with a return period of 100 years is 2.5 meter.
The transmitted and diffracted wave height with a return period of 10 years is 1.5 meter.

(d) the type of ships using the berths.
The type of vessels varies from about 2,000 dwt up to 40,000 dwt.

Given the mentioned value, the berth elevation is set to LWS +2.5 meter.
- In case of low water (100 years RP) with no waves the elevation of the berth is 2.5 meter above the water level.
- In case of high water (100 years RP) with Hs= 2.5 meter (100 years RP) the elevation of the berth is 0.15 meter above the wave top. However, this is a situation where vessels are advised to move to the bay of Rodonit, approximately 15 nautical miles north of Durrës.
- In case of the situation where vessels remain berthed (10 years RP), the elevation of the berth is 1.25 meter above the wave top.
- Al these situations gives acceptable ‘freeboard’ values. The berth elevation will remain at LWS +2.5 meter.

13.3 Fender

A fender has to be able to absorb the kinetic energy of the berthing ship. When the berthing energy is known, a selection of a fender type can be made. The concrete deck behind the fender will act as a massive construction, so the fender has to absorb the complete kinetic energy. In table 13.1, the berthing energy per vessel type is given. The detailed calculation is given in appendix I.

TABLE 13.1 – BERTHING ENERGY PER VESSEL TYPE

Vessel type	***Berthing energy [kNm]***
Container vessel	338
Dry bulk vessel	238
General cargo vessel	151

Fender

Use will be made of Super Cone Fenders as shown in figure 13.1. Super Cones are the latest generation of 'cell' fender combining excellent energy capacity with low reaction force to give the most efficient performance of any fender type. The conical shape keeps the body stable under all combinations of axial, shear and angular loading. They are robust, long lasting and easy to install. A big advantage of this fender construction is that all kind of vessels can moor along them. The fender panel will be designed in such a way that the smallest vessels can moor safely.

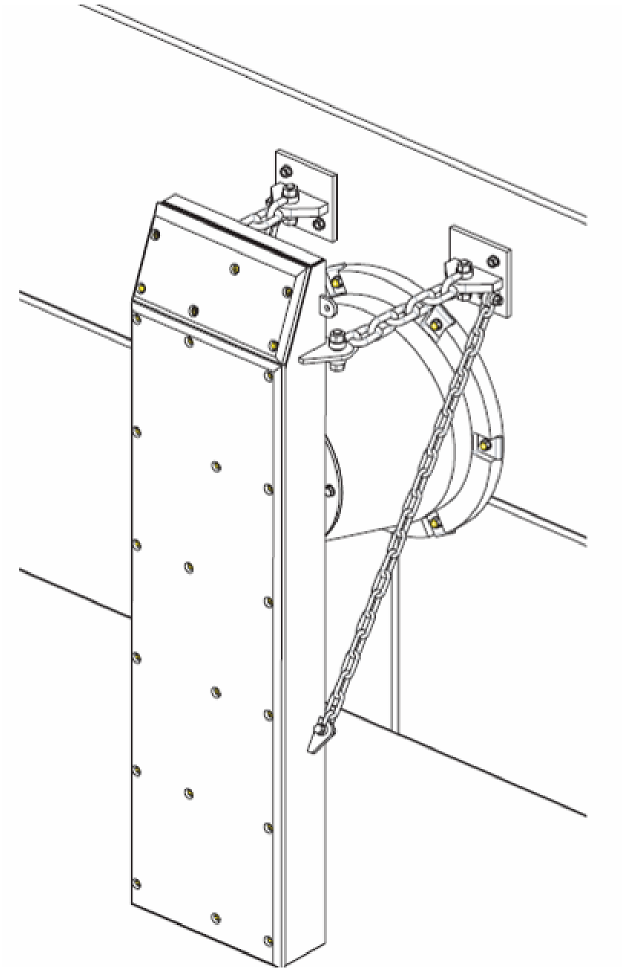


FIGURE 13.1 – SUPER CONE FENDER

The fenders which have the ability to deal with the specific berthing energy are given in table 13.2. It should be noted that a manufacturing tolerance (10%) of a fender should be taken into account.

TABLE 13.2 – FENDER TYPE PER TERMINAL

Vessel type	*Berthing energy*	*+10% tolerance*	*Fender type*	*Energy absorption*	*Reaction force*
Container	338 kNm	372 kNm	SCN 1000 (E1.0)	375 kNm	725 kN
Dry bulk	238 kNm	262 kNm	SCN 900 (E1.0)	275 kNm	585 kN
General cargo	151 kNm	166 kNm	SCN 800 (E1.0)	190 kNm	465 kN

In figure 13.2 and table 13.3 the dimensions are shown of the different fenders.

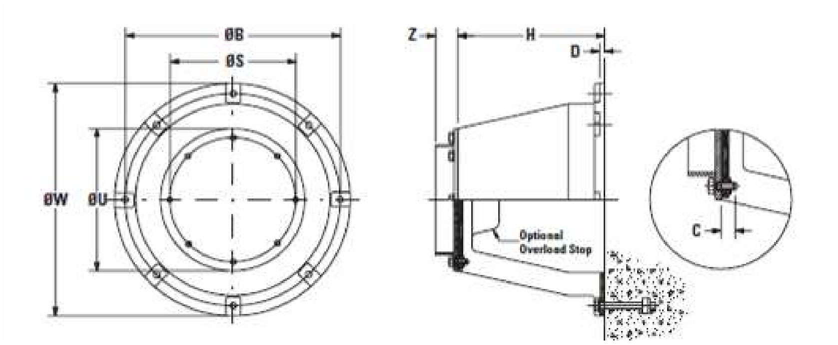


FIGURE 13.2 – DIMENSIONS OF A SCN FENDER

TABLE 13.3 – MAIN FENDER DIMENSIONS

Main dimensions	*SCN 1000 (E1.0)*	*SCN 900 (E1.0)*	*SCN 800 (E1.0)*
H	1000 mm	900 mm	800 mm
ØB	1460 mm	1313 mm	1165 mm
ØS	855 mm	770 mm	685 mm
ØU	980 mm	885 mm	785 mm
ØW	1600 mm	1440 mm	1280 mm

While absorbing the berthing energy of a vessel the fender will give a reaction force (table 13.4) to both the vessel and waterfront structure. Under normal conditions no plastic deformation of the ship's hull should take place. Vessels are becoming larger and larger, side plate thickness is becoming smaller and smaller and the distance between web frames is increasing. The permissible hull pressures given by ship-owners are decreasing. The maximum hull pressure are shown in table 13.4. To prevent that the maximum hull pressure of a ship is exceeded, the fender panel would have sufficient dimensions.

TABLE 13.4 – FENDER PANEL DIMENSIONS

Vessel type	**Max hull pressure**	**Reaction force fender**	**Required area fender panel**	**Height fender panel**	**Width fender panel**
Container	300 kN/m^2	725 kN	2.4 m^2	2.1 m	1.2 m
Dry bulk	200 kN/m^2	585 kN	2.9 m^2	2.1 m	1.4 m
General cargo	400 kN/m^2	465 kN	1.2 m^2	2.1 m	0.8 m

The bottom level of the fender panels is designed 0.4 meter above LWS to ensure that all kinds of vessels will be able to moor along the berths. The top of the fender panels are equal with height of the capping beam.

Fender spacing

If fenders are spaced too far apart, it is possible for ships with small bow radii to contact the structure when berthing at an angle to the quay face. To calculate the maximum fender spacing, the bow radius (R_B), fender projection (P_U) and deflection (δ_F) should first be determined.

The bow radius can be estimated with the following formula, based on the design container vessel of 45,000 dwt, a dry bulk vessel of 40,000 dwt and a general cargo vessel of 15,000 dwt:

$$R_B \approx \frac{1}{2}\left[\left(\frac{B}{2}\right) + \frac{L_{OA}{}^2}{8B}\right] \approx 140m$$

The maximum centre tot centre spacing of fenders is:

$$S \leq 2 \cdot \sqrt{R_B{}^2 - \left(R_B - P_U + \delta_F + C\right)^2} \leq 14.5m$$ [FENTEK, 2001]

PU = Uncompressed fender projection including rubber, panel etc = 1,45 meter
δ_F = Fender deflection = 0.72 x 1.45 = 1.04 meter
C = Clearance distance = 15% of the uncompressed fender projection = 0.22 meter

TABLE 13.5 – FENDER PANEL DIMENSIONS

Vessel type	***Design vessel***	***Bow radius R_B***	***Centre to centre space S***
Container	45,000 dwt	140 m	14.5 m
Dry bulk	40,000 dwt	100 m	12.2 m
General cargo	15,000 dwt	85 m	11.3 m

It should be noted that smaller ships usually have a smaller bow radius, but have a lower berthing energy as well, so will not compress the fenders as much.

In the absence of adequate information about the ships, fender centres should not be less than 15% of the overall length of the smallest ships. Due to this reason the centre to centre spacing of fenders will be kept on 14.5 / 12.2 and 11.3 meter which belongs to the expected smallest vessel that will enter the port of respectively 100, 80 and 75 meter.

14 CONCLUSION AND RECOMMENDATIONS

The planned capacity of Romano Port has a total cargo throughput of 5.5 million tons in 2035. This amount of cargo consists of dry bulk, containers, liquid bulk and general cargo. Other cargo will be handled in the existing port of Durres as well as passenger traffic that would be the basic activity of the port of Durres in future. Furthermore, building Romano Port opens quite new perspectives for the creation of free quays for sailing and pleasure boats in Durres port.

Based on the cargo throughput of 5.5 million tons in 2035, terminal areas, berths and equipment were depicted. Next, several layout alternatives are made and with the help of a MCA one layout is chosen. The principle of this layout is to keep all port facilities around the already constructed oil and LPG jetty, to use the available space efficiently. Tranquility in the port basin is guaranteed by one breakwater. This breakwater starts at the cliffs south of Romano Port and ends after a curve of 2240 meter. Future expansion is possible northwards of the container terminal.

The breakwater armour layer is designed using a single layer of Accropode II elements. A concrete unit is selected because the required armour units are substantially larger than the available rock in the quarry nearby. The choice for the berth structure has been made for an open pile construction.

Several subjects have been described superficially and other, more detailed technical parts of the master plan have been paid more attention to.

In order to define the future needs, forecasts were conducted until 2035. These forecasts should be treated very carefully. One reason is that the duration of 25 years is a very long period to make predictions. Another reason is that each commodity would require a detailed separate investigation. In order to cope with the mentioned deficiencies, the forecasts will require regular update and will have to be constantly checked with the actual throughput handled at the port. This updating and checking procedure is considered to be crucial because otherwise this Master plan will not respond to reality.

The final port layout has been chosen among several alternatives through an MCA. Although this method was verified by five sensitivity checks, changing each time different multiplying coefficients, it is still considered to be quite subjective. The authority will have to go over the parameters that were taken into account, re-evaluate them if needed and define which are the priorities for them.

The breakwater armour layer is designed using Accropode II. As an alternative to the Accropode ll, the Xbloc, of Delta Marine Consultants, is possible to apply. The calculations will be carried out using a Accropode ll block, but in the detailed design process, the choice can be made to use X-blocks because of the same characteristics.

This study provides a framework for developing Romano Port. The structure of the approach has general validity. The basic data contains many assumptions, which require changes when more detailed knowledge is available. In addition certain choices have been made on limited data and a more detailed analysis would be recommended to validate the outcome.
Therefore it is recommended that at the following subjects more research is done:

- More detailed information on Albania's future plans;
- Future design ships for the terminals;
- More basic data for the Environmental Impact Assessment;
- Morphology research (and about drainage sluice);
- Extensive soil data collection of the coast line.

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Appendices

A. COMMODITIES

TABLE A.1 – TOTAL IMPORT VOLUME IN COMMODITIES [TONS]

Nr.	Chapters	2005	2006	2007	2008
01	Live animals	7.334	14.079	4.992	18.313
02	Meat and edible meat offal	40.068	40.150	42.066	42.874
03	Fish and crustaceans, molluscs	3.971	6.270	5.817	6.739
04	Dairy products, birds, eggs	10.850	12.691	13.089	11.558
05	Products of animal origin	74	216	246	368
06	Live trees and other plants	3.943	3.228	4.664	7.170
07	Edible vegetables and certain roots	40.761	44.420	40.436	44.275
08	Edible fruit and nuts	114.417	110.209	95.559	79.602
09	Coffee, tea, mate and spices	4.002	6.009	6.638	6.779
10	Cereals	392.035	419.678	418.216	385.416
11	Products of the milling industry	50.226	43.700	47.497	37.085
12	Oil seeds and oleaginous fruits	3.658	2.295	1.843	1.101
13	Lac, ac, gums, resins and other vegetable saps and extracts	17	21	32	32
14	Vegetable plaiting materials & products	6	8	15	2
15	Animal or vegetable fats and oils	41.931	49.576	45.269	42.923
16	Preparation of meat / fish / crustaceans	7.754	6.002	6.851	7.451
17	Sugar and sugar confectionery	74.934	74.675	65.282	91.534
18	Cocoa and cocoa preparation	2.427	2.788	2.605	2.536
19	Preparation of cereals/flour/starch/milk	34.978	33.491	35.737	30.476
20	Preparation of vegetables, fruit nuts	22.818	21.653	24.673	19.938
21	Miscellaneous edible preparations	7.824	9.009	10.804	12.294
22	Beverages, spirits and vinegar	54.399	65.295	83.901	88.388
23	Residues and waste from food industries	22.601	27.217	37.791	38.317
24	Tobacco and manufactured substitutes	3.998	4.233	3.470	4.390
25	Salt, sulphur, earths, stone, lime, cement	1.771.011	1.712.501	1.178.409	1.218.040
26	Ores, slag and ash	0	461	3.308	4.413
27	Mineral fuels,oils & products of distillation	428.031	505.187	613.351	663.008
28	Inorganic chemicals	24.719	30.535	31.956	29.417
29	Organic chemicals	1.963	2.009	2.072	1.850
30	Pharmaceutical products	3.158	3.638	4.504	3.571
31	Fertilisers	81.428	84.988	94.221	74.626
32	Tanning or dyeing extracts	14.579	20.235	25.622	25.629
33	Essential oils, parfumery, cosmetic	4.608	5.145	5.900	6.235
34	Soap, washing preparations	31.319	37.114	37.706	36.461
35	Aluminoidal substances, enzymes	1.333	1.636	1.763	1.465
36	Explosives, pyrotechnic prdts, matches	1.334	1.482	2.289	3.021
37	Photographic or cinematographic goods	411	385	352	293
38	Miscellaneous chemical products	11.641	24.628	26.748	42.068
39	Plastics and articles thereof	54.349	54.913	61.680	66.924
40	Rubber and articles thereof	9.397	9.679	10.277	11.539
41	Raw hides and skins and leather	4.154	4.664	6.516	5.534
42	Articles of leather	646	765	943	833
43	Furskins and artificial fur	10	10	12	13
44	Wood and articles of wood	119.317	140.515	153.209	151.785
45	Cork and articles of cork	19	12	19	9
46	Manufactures of straw of esparto or other plaiting materials	47	37	72	53
47	Pulp of wood or of other fibrous cellulosic materials	76	194	101	543
48	Paper and paperboard	39.030	46.181	50.204	53.687

49	Printed books, newspapers, pictures	1.432	1.349	1.895	2.150
50	Silk	3	5	3	7
51	Wool fine or coarse animal hair	178	270	393	540
52	Cotton	3.775	3.818	4.678	3.779
53	Other vegetable textile fibres, paper yarn and woven	78	46	19	36
54	Man made filaments	3.130	3.479	4.243	4.113
55	Man-made staple fibres	3.207	3.622	3.722	3.004
56	Wadding, felt&nonwovens, special yarns	6.237	5.016	4.595	4.236
57	Carpets and oyjer textile floor coverings	3.070	3.290	3.629	3.449
58	Special woven fabrics	1.305	1.001	1.014	823
59	Impregnated coated covered or laminated textile fabrics	2.033	1.575	1.833	2.026
60	Knitted or crocheted fabrics	507	569	772	1.739
61	Articles of apparel and clothing accessories	10.709	11.645	11.888	11.579
62	Articles of apparel and clothing accessories not knitted	9.312	10.062	10.500	9.490
63	Other made up textile articles, sets, worn clothing	17.700	19.532	19.671	18.229
64	Footwear, gaiters, parts of such art.	9.466	10.440	9.493	8.740
65	Headgear and parts thereof	80	114	121	89
66	Umbrellas, sun umbrellas, walking-sticks, seat sticks	682	734	522	608
67	Prepared feathers and down and articles made of feathers	177	196	250	209
68	Articles of stone, plaster, cement, asbestos, mica	49.690	58.988	68.196	79.950
69	Ceramic products	498.541	434.906	428.706	385.940
70	Glass and glassware	40.737	38.508	45.272	42.958
71	Natural or cultured pearls	103	118	174	163
72	Iron and steel	355.300	401.407	481.561	344.240
73	Articles of iron or steel	50.066	52.933	55.987	87.824
74	Copper and articles thereof	894	943	982	827
75	Nickel and articles thereof	9	10	1	17
76	Aluminium and articles thereof	20.504	21.244	24.767	25.775
78	Lead and articles thereof	46	114	39	50
79	Zinc and articles thereof	575	641	976	892
80	Tin and articles thereof	5	6	7	8
81	Other base metals, cermets, articles thereof	3	11	9	1
82	Tools, implements, cultery, spoons and forks of base metal	2.432	2.036	2.527	2.140
83	Miscellaneous articles of base metal	10.239	12.349	13.791	13.122
84	Nuclear reactors, boilers, machinery and mechanical appliances	72.584	54.771	66.674	82.387
85	Electrical machinery and equipment and parts thereof	32.992	29.415	31.124	34.917
86	Railway or tramway locomotives	481	430	652	1.878
87	Vehicles other than railway or tramway rolling-stock	52.047	57.074	69.119	66.616
88	Aircraft, spacecraft and parts thereof	17	4	19	60
89	Ships, boats and floating structures	1.797	4.474	2.150	2.988
90	Optical, photographical, cinematographic instruments	1.905	2.153	2.420	2.431

91	Clocks and watches and parts thereof	116	129	121	131
92	Musical instruments	57	51	64	52
93	Arms and ammunition, parts and their accessories	365	208	122	222
94	Furniture, bedding mattresses, mattress supports	21.904	21.485	27.153	25.040
95	Toys, games and sport requisites	2.736	2.692	3.500	3.499
96	Miscellaneous manufactured articles	1.907	1.864	1.781	1.574
97	Works of collectors' pieces and antiques	15	20	17	17
	Total	**4.838.756**	**4.959.570**	**4.725.873**	**4.661.142**

TABLE A.2 – TOTAL EXPORT VOLUME IN COMMODITIES [TONS]

Nr.	***Chapters***	***2005***	***2006***	***2007***	***2008***
01	Live animals	143	176	111	82
02	Meat and edible meat offal	117	579	71	29
03	Fish and crustaceans, molluscs	544	618	718	1.137
04	Dairy products, birds, eggs	656	156	2.308	3.307
05	Products of animal origin	29	71	248	1.286
06	Live trees and other plants	727	1.127	1.378	1.435
07	Edible vegetables and certain roots	1.124	1.772	1.614	4.446
08	Edible fruit and nuts	10.502	12.319	13.731	9.257
09	Coffee, tea, mate and spices	690	611	745	603
10	Cereals	1	20	636	104
11	Products of the milling industry	45	113	985	28
12	Oil seeds and oleaginous fruits	8.248	8.526	9.315	9.957
13	Lac, ac, gums, resins and other vegetable saps and extracts	5	11	30	3
14	Vegetable plaiting materials & products	42	29	20	37
15	Animal or vegetable fats and oils	257	638	769	159
16	Preparation of meat / fish / crustaceans	2.331	2.352	2.351	2.161
17	Sugar and sugar confectionery	7	54	49	40
18	Cocoa and cocoa preparation	43	34	5	42
19	Preparation of cereals/flour/starch/milk	85	78	91	181
20	Preparation of vegetables, fruit nuts	1.327	659	1.126	1.447
21	Miscellaneous edible preparations	9	4	49	70
22	Beverages, spirits and vinegar	12.594	13.168	15.934	2.161
23	Residues and waste from food industries	1.995	23	2.771	1.450
24	Tobacco and manufactured substitutes	1.735	1.219	2.061	1.037
25	Salt, sulphur, earths, stone, lime, cement	82.218	102.725	296.624	397.646
26	Ores, slag and ash	205.384	355.374	670.849	510.090
27	Mineral fuels,oils & products of distillation	79.119	138.649	260.278	276.851
28	Inorganic chemicals	1.580	936	1.137	806
29	Organic chemicals	26	17	4	11
30	Pharmaceutical products	35	34	58	64
31	Fertilisers	509	215	-	85
32	Tanning or dyeing extracts	515	598	889	2.163
33	Essential oils, parfumery, cosmetic	13	10	37	42
34	Soap, washing preparations	288	182	223	188
35	Aluminoidal substances, enzymes	72	30	41	77
36	Explosives, pyrotechnic prdts, matches	160	40	474	209
37	Photographic or cinematographic goods	0	17	6	0
38	Miscellaneous chemical products	155	400	74	219
39	Plastics and articles thereof	2.576	2.750	3.136	5.305
40	Rubber and articles thereof	231	129	204	221

41	Raw hides and skins and leather	5.436	5.011	4.755	5.048
42	Articles of leather	60	118	158	114
43	Furskins and artificial fur	2	4	3	1
44	Wood and articles of wood	36.447	34.727	31.094	40.717
45	Cork and articles of cork	25	-	3	-
46	Manufactures of straw of esparto or other plaiting materials	31	1	1	0
47	Pulp of wood or of other fibrous cellulosic materials	1.015	358	4.577	5.339
48	Paper and paperboard	9.042	11.187	14.236	15.312
49	Printed books, newspapers, pictures	73	102	119	54
50	Silk	13	25	14	-
51	Wool fine or coarse animal hair	344	194	147	312
52	Cotton	2	31	23	32
53	Other vegetable textile fibres, paper yarn and woven		0	1	-
54	Man made filaments	80	5	1	10
55	Man-made staple fibres	0	8	2	82
56	Wadding, felt&nonwovens, special yarns	33	178	85	93
57	Carpets and oyjer textile floor coverings	0	0	5	6
58	Special woven fabrics	2	0	1	2
59	Impregnated coated covered or laminated textile fabrics	3	12	21	12
60	Knitted or crocheted fabrics	8	11	12	13
61	Articles of apparel and clothing accessories	7.465	8.333	10.118	9.262
62	Articles of apparel and clothing accessories not knitted	11.219	10.825	11.206	10.540
63	Other made up textile articles, sets, worn clothing	601	862	922	1.102
64	Footwear, gaiters, parts of such art.	16.522	17.914	17.942	17.087
65	Headgear and parts thereof	32	41	40	42
66	Umbrellas, sun umbrellas, walking-sticks, seat sticks	8	6	4	7
67	Prepared feathers and down and articles made of feathers		-	1	0
68	Articles of stone, plaster, cement, asbestos, mica	28.437	40.346	62.253	73.528
69	Ceramic products	4.944	12.063	14.961	36.516
70	Glass and glassware	457	322	266	513
71	Natural or cultured pearls	72	98	99	127
72	Iron and steel	94.673	124.255	110.534	178.879
73	Articles of iron or steel	2.382	2.139	2.650	4.164
74	Copper and articles thereof	4.369	5.807	6.940	4.867
75	Nickel and articles thereof	7	-	0	14
76	Aluminium and articles thereof	8.107	9.464	10.292	10.216
78	Lead and articles thereof	922	1.294	2.165	2.816
79	Zinc and articles thereof	155	173	226	64
80	Tin and articles thereof	26	-	-	-
81	Other base metals, cermets, articles thereof	0	-	-	-
82	Tools, implements, cultery, spoons and forks of base metal	41	31	32	87
83	Miscellaneous articles of base metal	6.021	7.239	8.511	8.232
84	Nuclear reactors, boilers, machinery and	1.074	1.047	1.892	1.566

	mechanical appliances				
85	Electrical machinery and equipment and parts thereof	6.276	6.766	10.089	12.224
86	Railway or tramway locomotives	88	19	20	42
87	Vehicles other than railway or tramway rolling-stock	443	378	911	988
88	Aircraft, spacecraft and parts thereof	2	2	4	17
89	Ships, boats and floating structures	31	4	64	1.487
90	Optical, photographical, cinematographic instruments	104	93	65	53
91	Clocks and watches and parts thereof		-	0	0
92	Musical instruments	0	-	1	-
93	Arms and ammunition, parts and their accessories	520	2.044	2.870	126
94	Furniture, bedding mattresses, mattress supports	7.806	8.683	10.159	9.919
95	Toys, games and sport requisites	1.279	1.328	1.582	1.796
96	Miscellaneous manufactured articles	99	60	10	20
97	Works of collectors' pieces and antiques	6	6	12	0
	Total	**672.941**	**960.072**	**1.633.250**	**1.687.884**

B. FIRST APPROXIMATION OF THE NUMBER OF BERTHS

B.1 Container terminal

TABLE B.1 – FORECAST FOR THE NUMBER OF CONTAINERS IN TEU

	2020	2030	2035
TEU	116,000	156,100	215,111

Number of berths

A first approximation of the number of berths is made on the basis of an estimated berth productivity. Such an estimate is made as follows:

$$c_b = p \cdot f \cdot N_b \cdot t_n \cdot m_b$$

In the calculation beneath 2035 is used as a starting point. A more detailed calculation, using the queuing theory, is carried out in section 9.5.

p = 15 moves per hour (normal crane)
f = 1.6
Berth length = 220 m
N_b = 2
t_n = 96% of a year = 50 weeks per year x 7 days x 24 hours = 8400 hour / year
m_b = 40%

c_b = 161,280 TEU / Year

Result: two berths needed

B.2 Dry bulk terminal

TABLE B.2 – FORECAST FOR THE DRY BULK SECTOR

	2020	2030	2035
Throughput	1,435,000 ton	1,782,000 ton	1,807,000 ton

Number of berths

A first approximation of the number of berths is made on the basis of an estimated berth productivity. Such an estimate is made as follows:

$$c_b = p \cdot N_b \cdot t_n \cdot m_b$$

In the calculation beneath 2035 is used as a starting point. A more detailed calculation, using the queuing theory, is carried out in section 9.5.

p = 900 tons per hour
Berth length = 250 m
N_b = 2
t_n = 96% of a year = 50 weeks per year x 7 days x 24 hours = 8400 hour / year
m_b = 45%

c_b = 2,268,000 tons / year

result: one berth is enough

B.3 General cargo terminal

TABLE B.3 – FORECAST FOR THE GENERAL CARGO SECTOR

	2020	2030	2035
Throughput	850,000 ton	974,000 ton	1,033,000 ton

Number of berths

A first approximation of the number of berths is made on the basis of an estimated berth productivity. Such an estimate is made as follows:

$$c_b = p \cdot N_b \cdot t_n \cdot m_b$$

In the calculation beneath 2035 is used as a starting point. A more detailed calculation, using the queuing theory, is carried out in section 9.5.

p = 80 tons per hour
Berth length = 250 m
N_b = 2,5
t_n = 55% of a year = 2 shifts per day, 6 days per week, 50 weeks per year = 4800 hour / year
m_b = 70%

c_b = 672,000 tons / year

result: 2 berths needed

B.4 Liquid bulk terminal

TABLE B.4 – FORECAST FOR THE GENERAL CARGO SECTOR

	2020	2030	2035
Throughput	387,000	631,000	774,000

Number of berths

A first approximation of the number of berths is made on the basis of an estimated berth productivity. Such an estimate is made as follows:

$$c_b = p \cdot t_n \cdot m_b$$

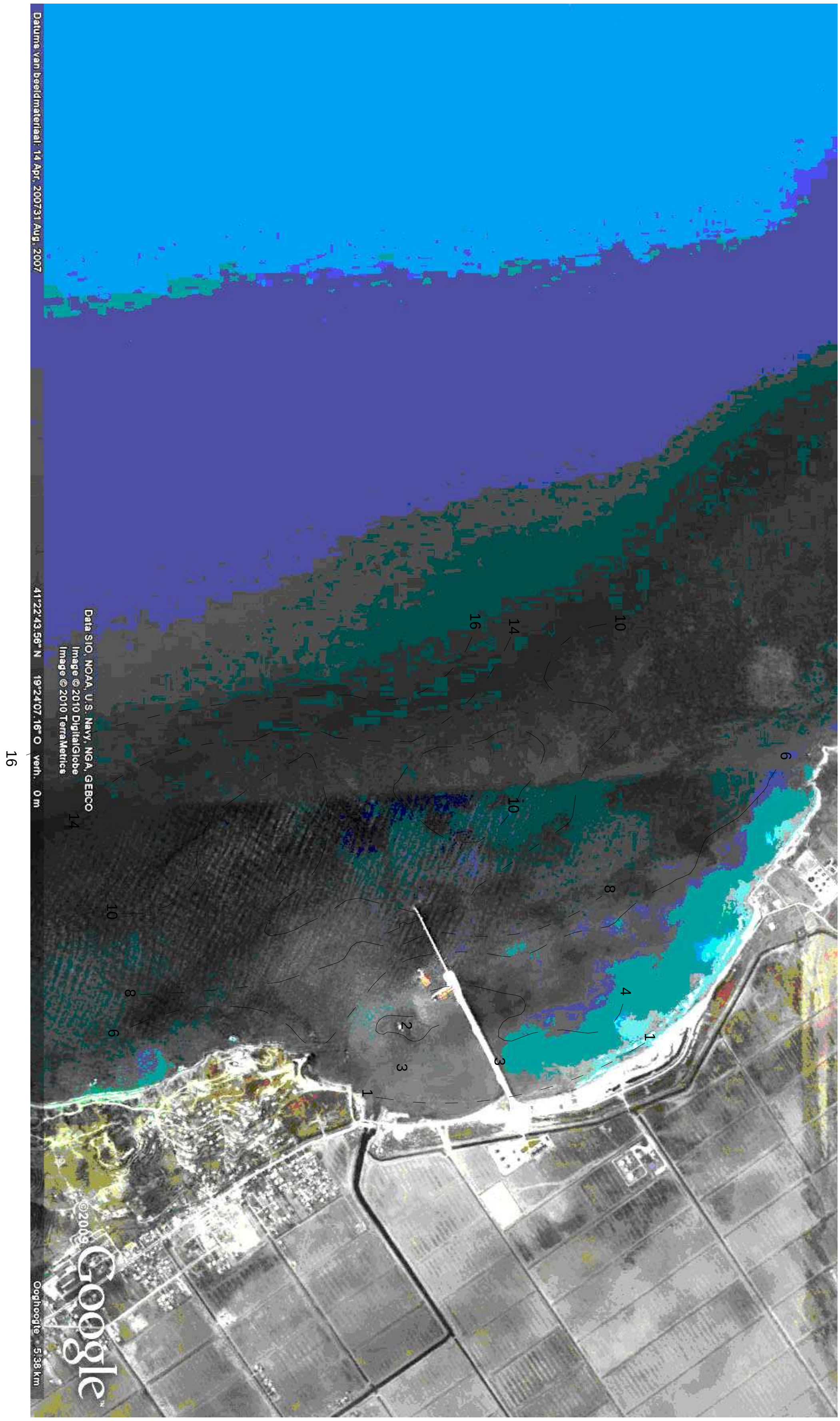
In the calculation beneath 2035 is used as a starting point. A more detailed calculation, using the queuing theory, is carried out in section 9.5.

p = 375 tons per hour (present discharge capacity in Romano Port of equipment for transport of oil (gasoline))
Berth length = 250 m
t_n = 96% of a year = 50 weeks per year x 7 days x 24 hours = 8400 hour / year
m_b = 40%

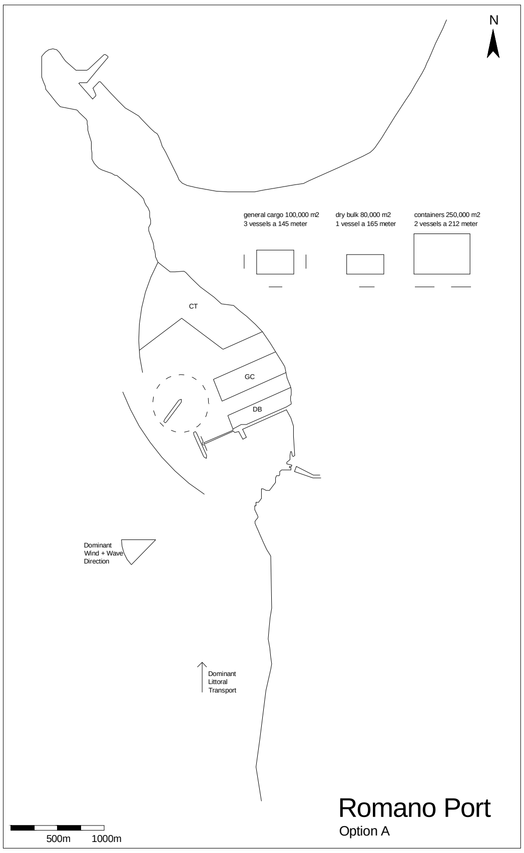
c_b = 1,260,000 tons / year

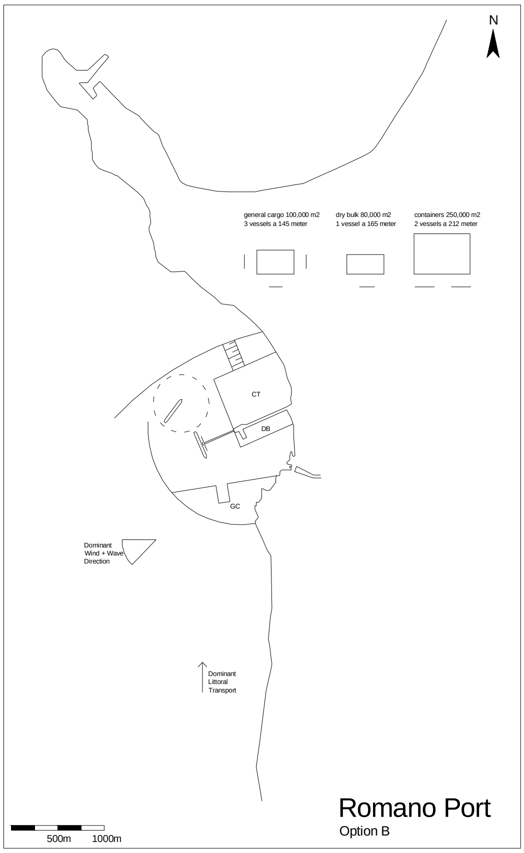
result: the present berth is enough, no additional berth is required.

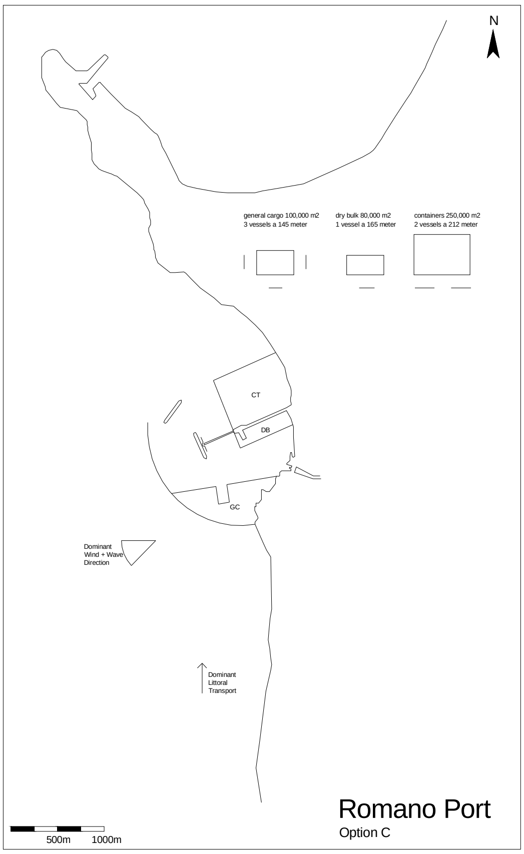
C. GOOGLE EARTH MAP OF PORTO ROMANO

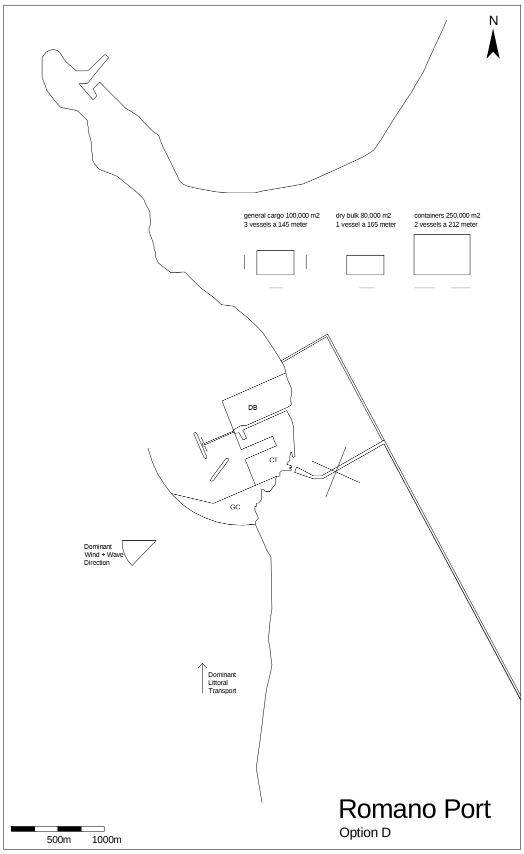


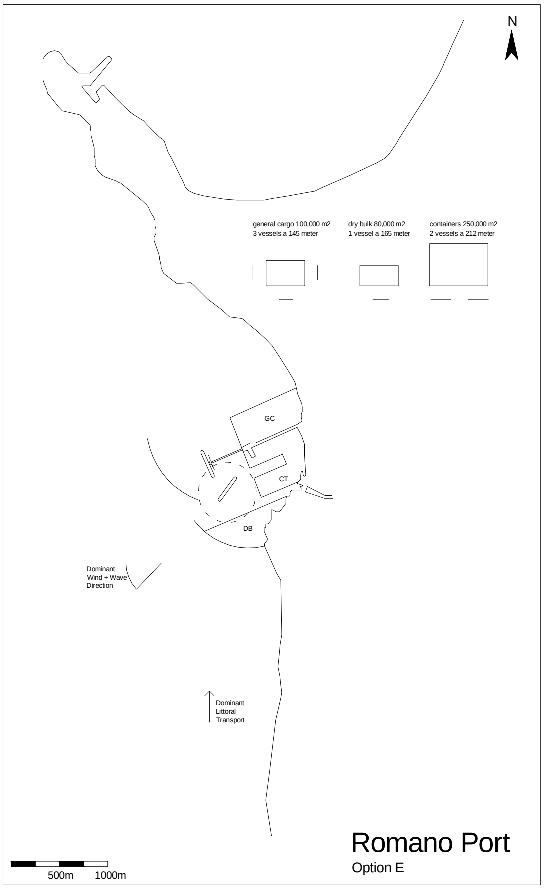
D. TEN LAYOUT ALTERNATIVES

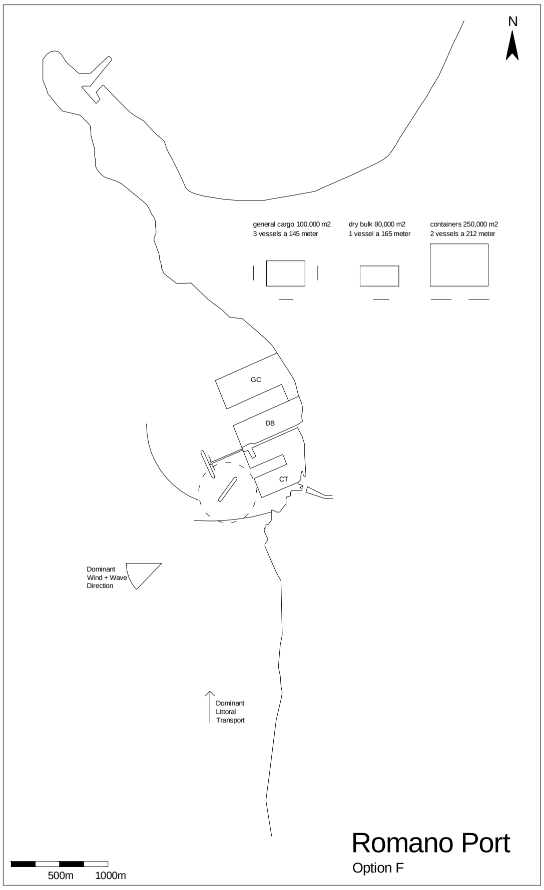


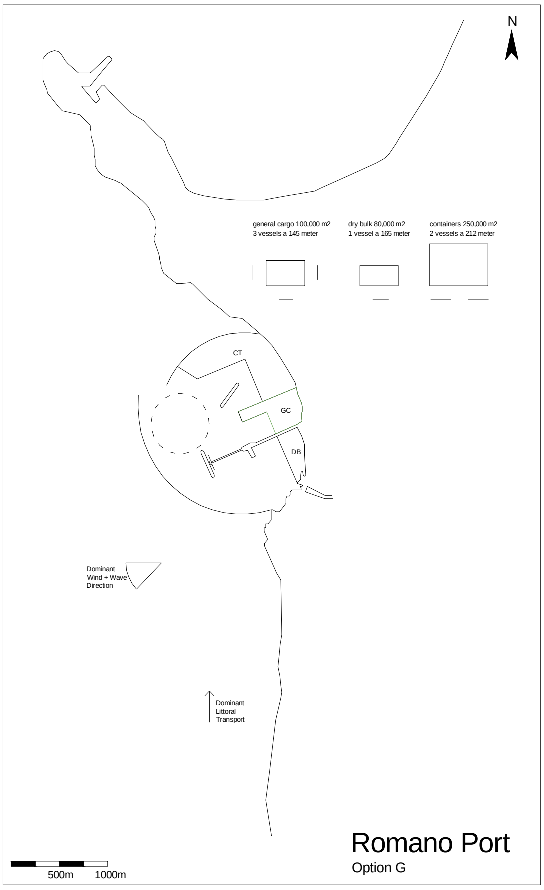


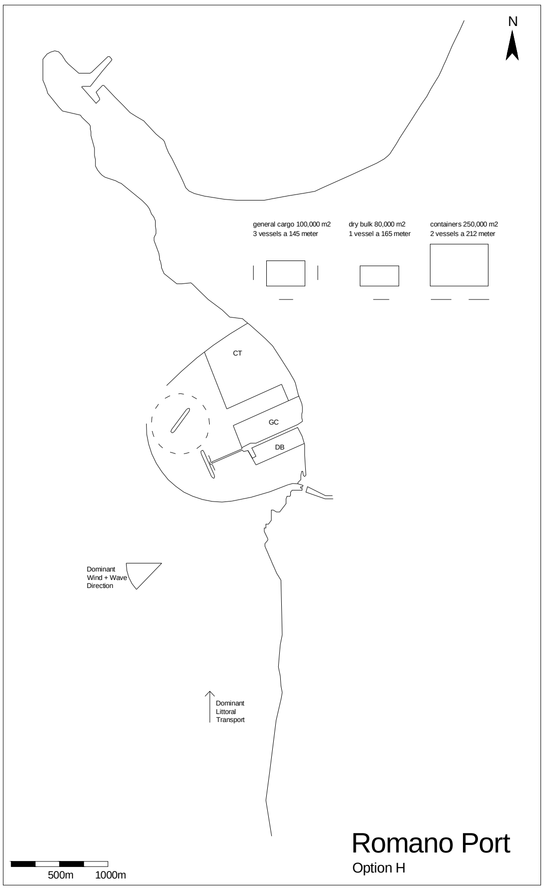


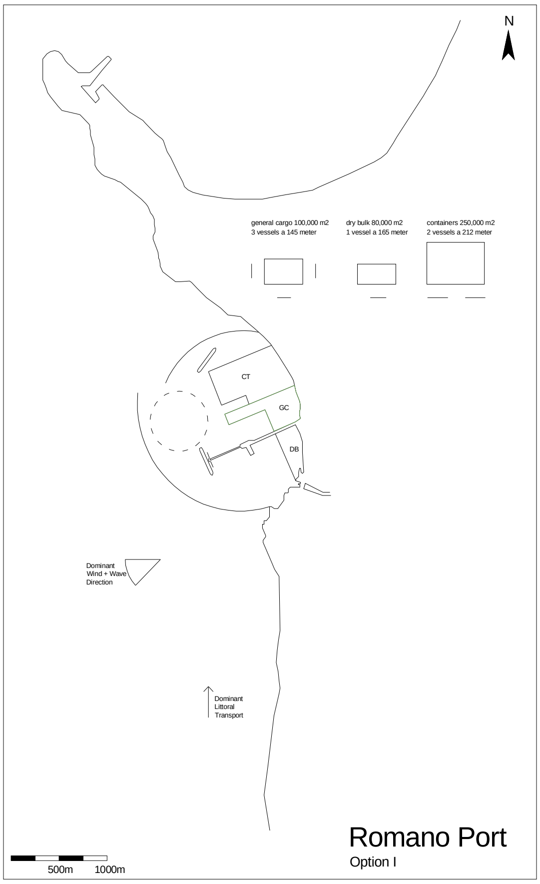


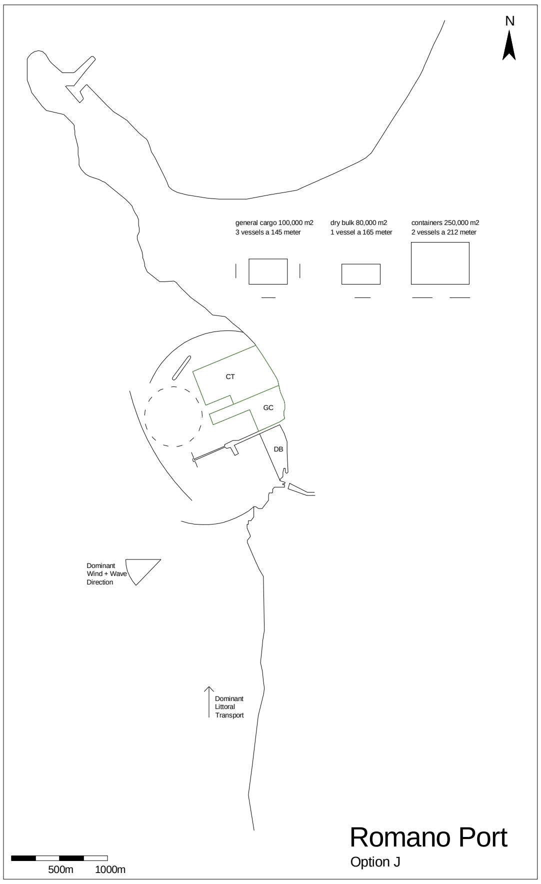

N
general cargo 100,000 m2
3 vessels a 145 meter
dry bulk 80,000 m2
1 vessel a 165 meter
containers 250,000 m2
2 vessels a 212 meter
GC
CT
DB
Dominant
Wind + Wave
Direction
Dominant
Littoral
Transport
500m
1000m
Romano Port
Option E


N
general cargo 100,000 m2
3 vessels a 145 meter
dry bulk 80,000 m2
1 vessel a 165 meter
containers 250,000 m2
2 vessels a 212 meter
GC
DB
CT
Dominant
Wind + Wave
Direction
Dominant
Littoral
Transport
500m
1000m
Romano Port
Option F


N
general cargo 100,000 m2
3 vessels a 145 meter
dry bulk 80,000 m2
1 vessel a 165 meter
containers 250,000 m2
2 vessels a 212 meter
CT
GC
DB
Dominant
Wind + Wave
Direction
Dominant
Littoral
Transport
500m
1000m
Romano Port
Option G

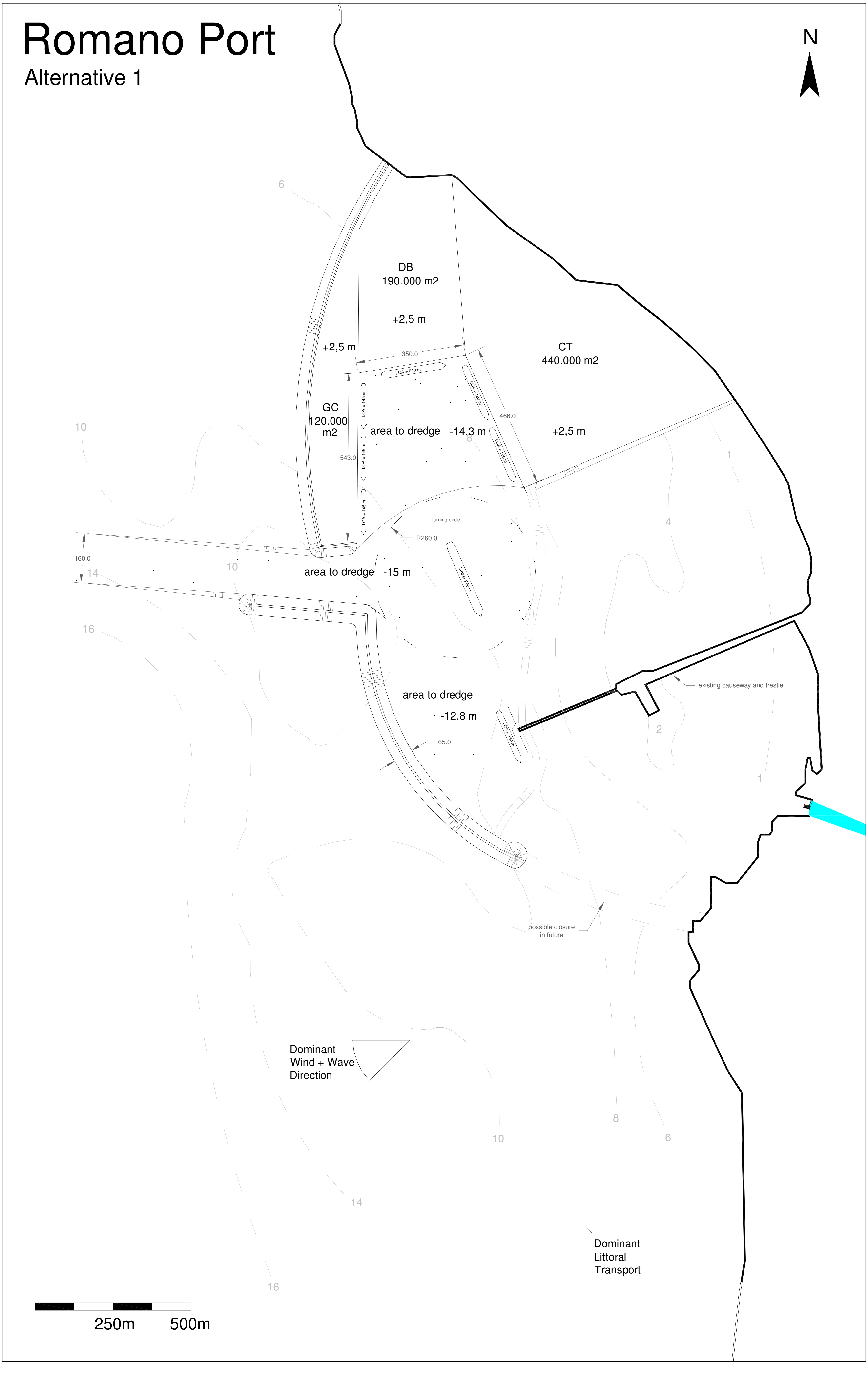

N
general cargo 100,000 m2
3 vessels a 145 meter
dry bulk 80,000 m2
1 vessel a 165 meter
containers 250,000 m2
2 vessels a 212 meter
CT
GC
DB
Dominant
Wind + Wave
Direction
Dominant
Littoral
Transport
500m
1000m
Romano Port
Option H


N
general cargo 100,000 m2
3 vessels a 145 meter
dry bulk 80,000 m2
1 vessel a 165 meter
containers 250,000 m2
2 vessels a 212 meter
CT
GC
DB
Dominant
Wind + Wave
Direction
Dominant
Littoral
Transport
Romano Port
Option I
500m
1000m


N
general cargo 100,000 m2
3 vessels a 145 meter
dry bulk 80,000 m2
1 vessel a 165 meter
containers 250,000 m2
2 vessels a 212 meter
CT
GC
DB
Dominant
Wind + Wave
Direction
Dominant
Littoral
Transport
Romano Port
Option J
500m
1000m

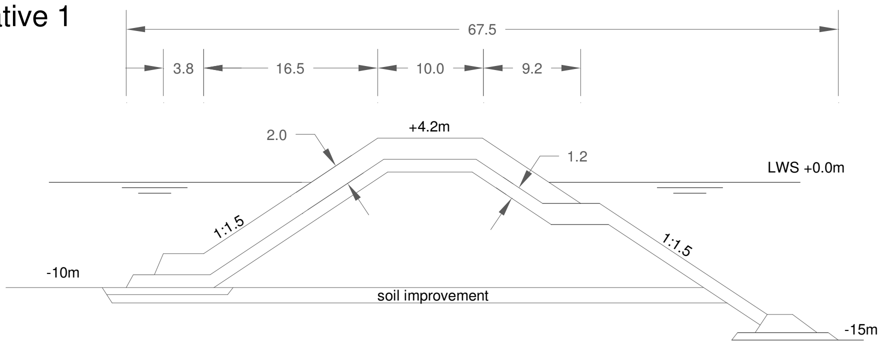
E. DETAILED DRAWINGS OF THREE ALTERNATIVES

Romano Port
Alternative 1

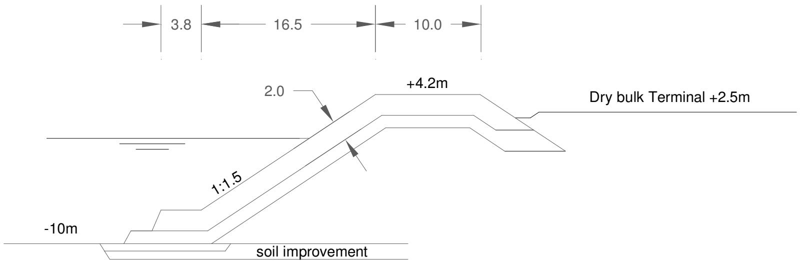


Romano Port

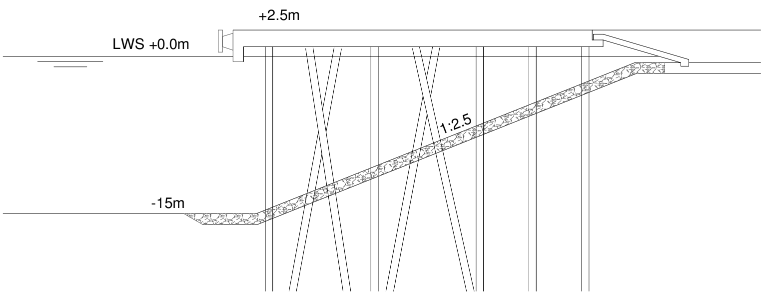
Alternative 1



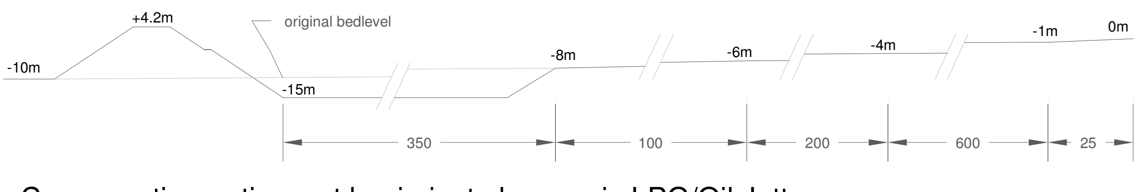
Cross section southern breakwater



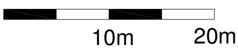
Cross section northern breakwater



Cross section berth

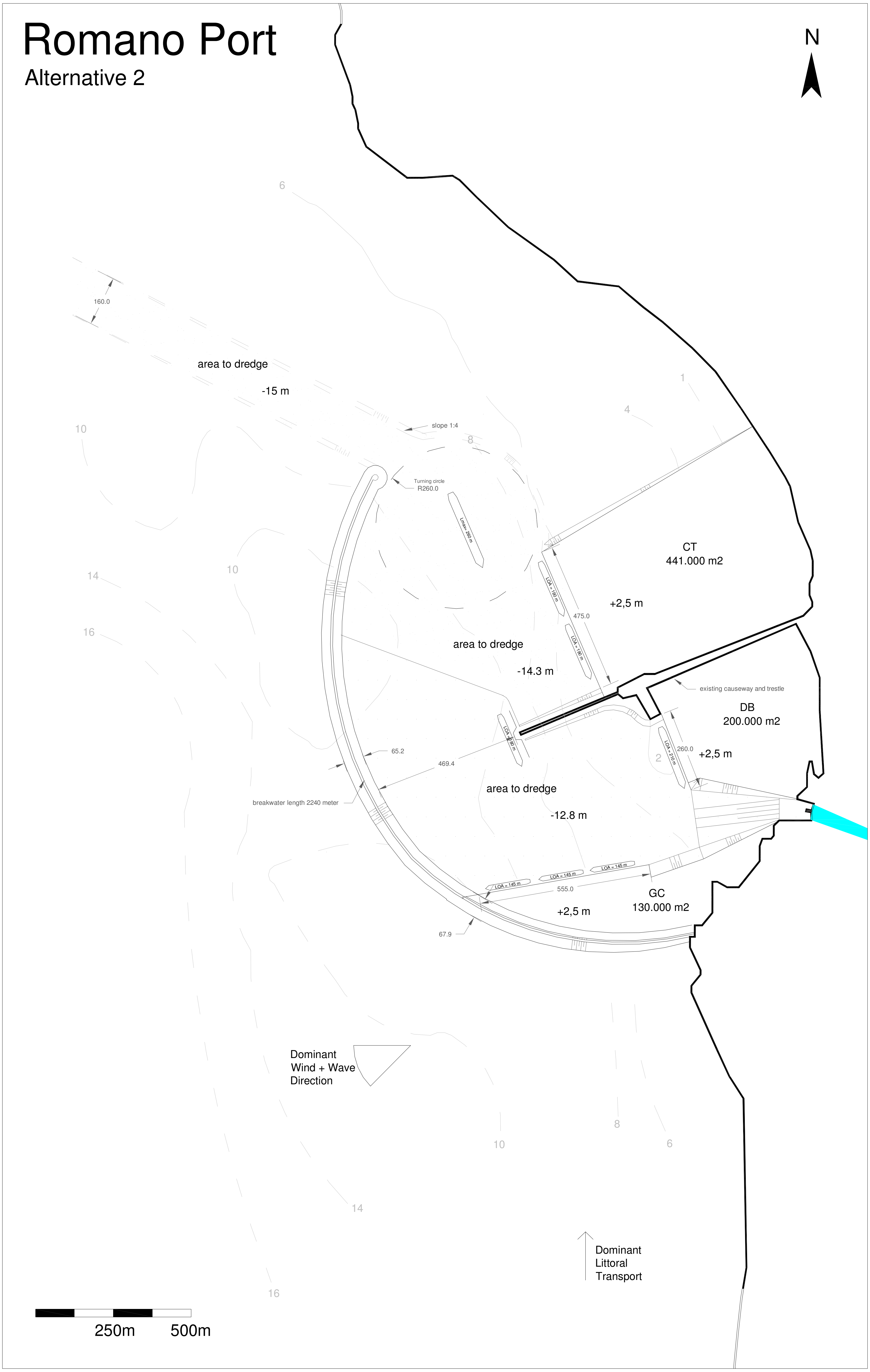


Cross section entire port basin just above axis LPG/Oil Jetty



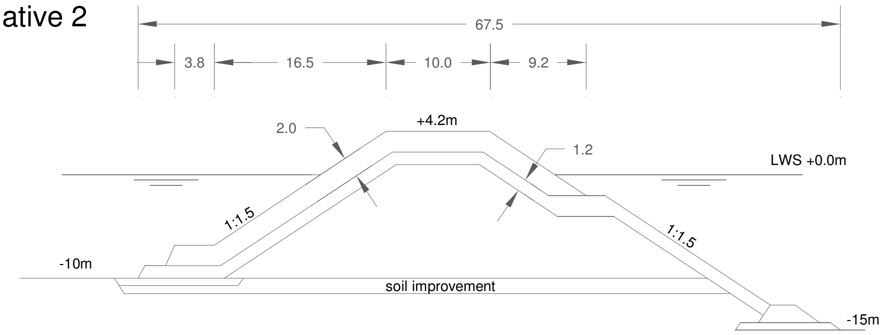
Romano Port

Alternative 2

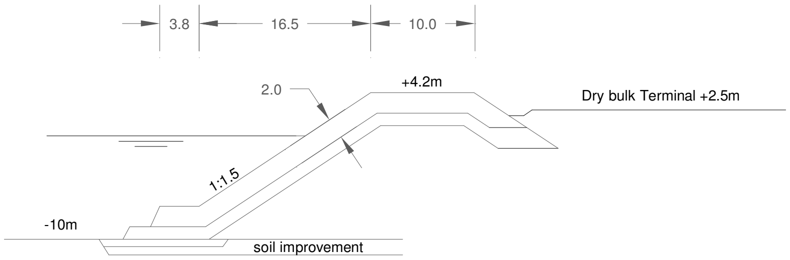


Romano Port

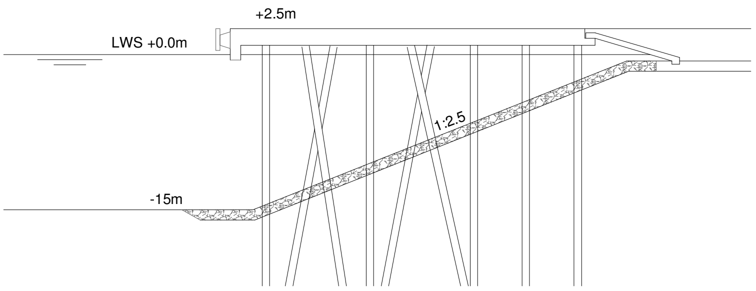
Alternative 2



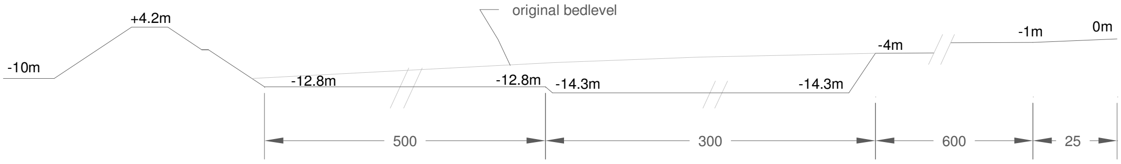
Cross section northern breakwater



Cross section southern breakwater



Cross section berth

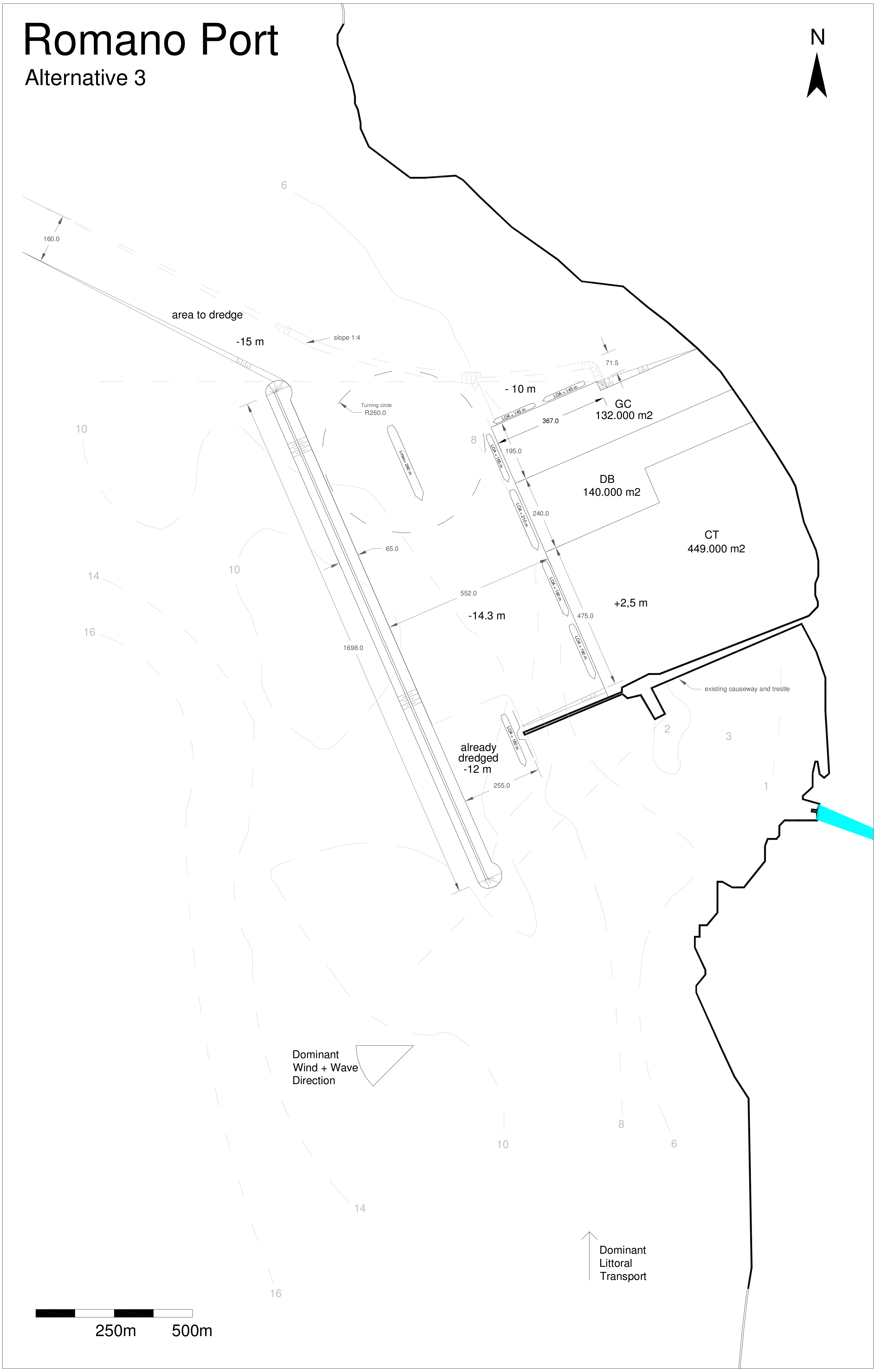


Cross section entire port basin just above axis LPG/Oil Jetty

10m 20m

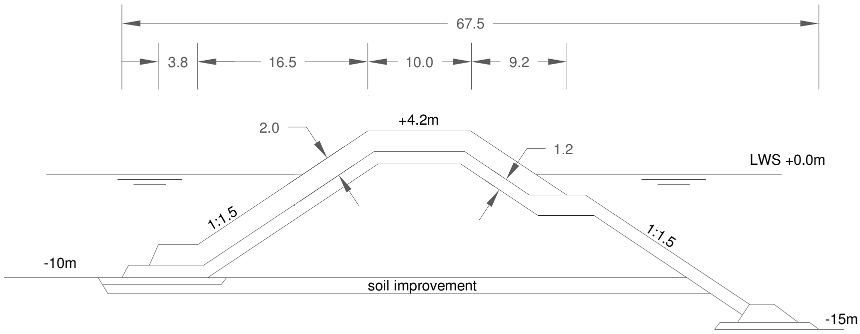
Romano Port

Alternative 3

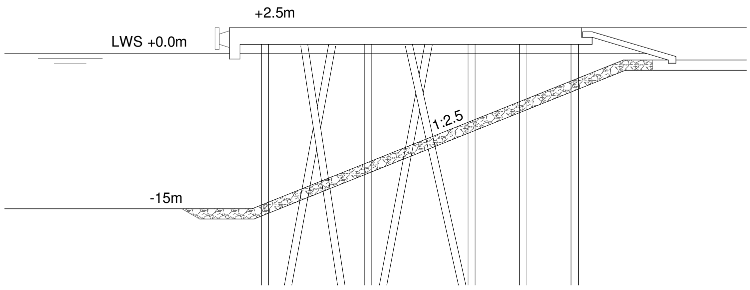


Romano Port

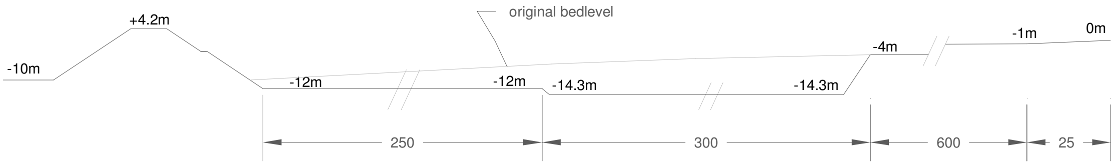
Alternative 3



Cross section breakwater



Cross section berth



Cross section entire port basin just above axis LPG/Oil Jetty

10m 20m

F. BREAKWATER TYPE

F.1 Different types of breakwaters

The following types of rubble mound breakwater will be discussed in this section (see figure F.1).

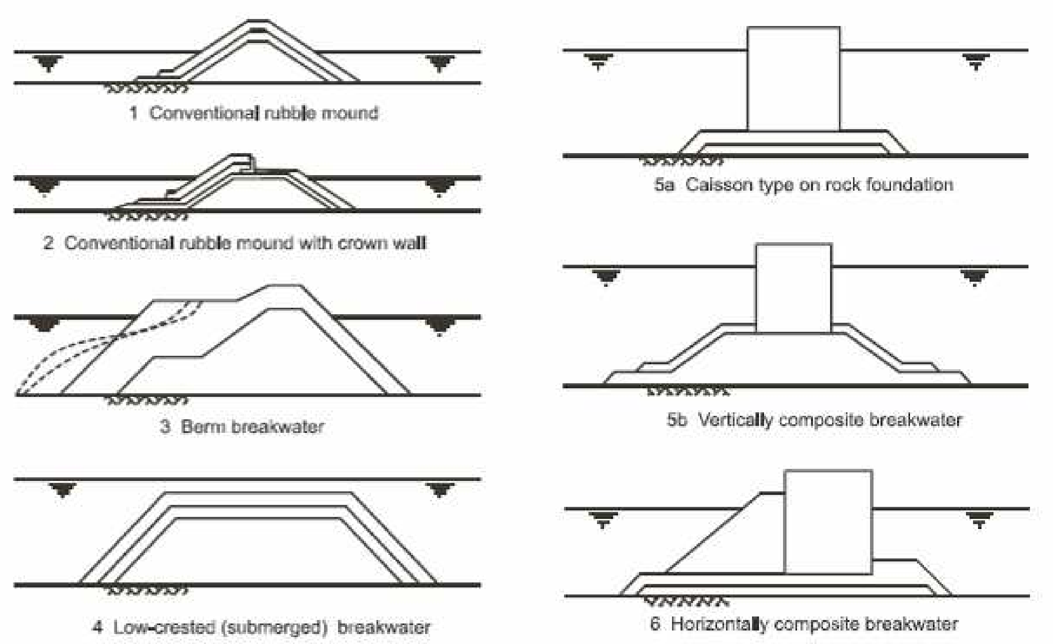


FIGURE F.1 – TYPICAL CROSS-SECTIONS OF VARIOUS TYPES OF RUBBLE MOUND BREAKWATER

1. **Conventional rubble mound**
   This commonly used form of structure has a simply trapezoid cross-section. The armour layer may cover the crest and part of the lee slope as well as the front face. The purpose of such a simple cross-section is generally to provide shelter to other structures, such as jetties or berths.
2. **Conventional rubble mound with crown wall**
   These structures are mainly used for port structures. The crown wall which often incorporates a road, allows access along the breakwater. This is essential where the lee side of the breakwater is used for port operations, such as ship mooring (quay) or storage (platform). In port design 1 and 2, this type of breakwater may be a suitable option along the General Cargo terminal.
3. **Berm breakwater**
   In this case, armourstone is placed in a berm on the seaward slope. One can distinguish three types, non-reshaping statically stable breakwater, reshaped statically stable berm breakwater and a dynamically stable reshaping berm breakwater.
4. **Low-crested breakwater**
   Low-crested structures may be used for protection in areas where wave conditions need to be modified but overtopping is acceptable or where horizontal visibility is a requirement. These structures allow significant wave overtopping and may be partially emergent above the surface or fully submerged. These structures generally only limit wave heights effectively for a narrow variation in water levels so they tend to be used mainly for low tidal range conditions as present in the Adriatic Sea.
5. **Caisson-type or vertically composite breakwater**
   This is a combination of a rubble mound with a caisson, where the caisson is placed on top of the mound. This type of breakwater is mainly used as a port protection structure.
6. **Horizontally composite breakwater**

This is another combination of a rubble mound with a caisson, where the caisson is placed behind a rubble mound-type seaward protection made of armour stone or artificial units that are of sufficient size to be hydraulically stable.

Outside the traditional types, many other methods can be used, such as floating breakwaters, pneumatic/hydraulic breakwaters, pile and horizontal plate breakwaters. However, floating and pneumatic/hydraulic breakwaters are usually only economic in case of relative small waves in very deep water. Pile breakwaters and horizontal plate breakwaters require very high structural strength to survive wave loads under extreme conditions. In case of the Romano Port, the soil is very hard and as a result, installing piles will be very difficult.

Below a selection is made between the rubble mound breakwater and the caisson breakwater (or a combination). Berm breakwaters are not considered because the available stone sizes are not large enough. Submerged breakwaters will not function either in Romano Port, because the down time for port operations would be too high.

F.2 Caisson breakwater versus Rubble mound breakwater

Factors affecting the selection of a preferred breakwater type include costs, construction time, local availability of materials, maintenance, sensitivity to earthquakes and constructability.

Construction costs
The construction costs of both breakwater types are not determined, but it can be noted that caisson breakwaters are often preferred in deep water, as the quarried rock quantities for a rubble mound increase significantly with increasing depth. There is a general preference for caisson breakwaters, including vertically composite caissons placed on a rubble mound, where the water depth is 15 meters or more. It can be further noted that the construction depth varies from 2 to 10 meters where the caisson type breakwater is likely the most expensive option.

Construction time
With regard to construction time the rubble mound breakwater is probably the best solution, when looking to the issues controlled placement versus dumping, land based equipment versus waterborne operations and the construction method sensitivity to weather conditions.

Availability of materials
With regard to the local availability of materials, no significant difference exist. For using rock, there is a quarry near Krüje, north of Tirana about 50 km from the site. On the other hand, a new cement plant near Durrës is being constructed which can be used when selecting the caisson breakwater (or using concrete blocks in the rubble mound breakwater).

Maintenance
In terms of maintenance costs no clear difference for both breakwater types is expected. The rubble mound breakwater probably has a larger structural deterioration, while the caisson type breakwater has larger costs related to repair of the caisson.

Sensitivity to earthquakes
The damage due to an earthquake in case of the caisson breakwater can be more significant than in case of a rubble mound breakwater. Both options are likely to suffer damage when a stronger earthquake occurs and in both cases settlements and displacements of rock or armour units are to be expected. However, the damage to the rubble mound breakwater is probably far more easy to repair and will require input of relatively common equipment. It is foreseen that it will require a substantially greater effort to re-align displaced caissons, if such will be possible at all and damage to the caissons can be repaired at all. Of course, also a possible crown wall of the rubble mound breakwater may be subject to displacements during an earthquake, but the wall is

less sensitive to such settlements compared to the caissons and less heave, so easier to re-install.

Constructability

An important factor for the choice of the breakwater type is the availability of equipment to construct, to transport and to place the structural elements. For the rubble mound breakwater large amounts of material (core of the breakwater) can be dumped and only the filter and armour layer should be constructed using controlled placement. The controlled placement can be done using either land based or waterborne equipment. The caisson type breakwater requires special equipment for the transportation and placement of the caissons.

Other properties

Where the breakwater will also serve a purpose within a port such as providing a quay wall or storage (in layout 1 and 2), a rubble mound structure will require a concrete crest. A caisson option may be preferred in this instance, as vessels will be able to berth alongside. But this is not the case.

Finally rubble mound breakwaters have better energy dissipation properties than vertical breakwaters and so may be preferred to reduce wave reflections.

Based on the analysis above, in which a caisson type and rubble mound breakwater was compared, the rubble mound breakwater appeared to be the preferred solution.

Conventional rubble mound with crown wall

Integrating a concrete wall (like an L-type wall) in the breakwater is one option to reduce for example the width of the breakwater. However, probably the introduction of a concrete wall did not result in a cost reduction because construction and installation of such elements is more complicated. And, finally, the concrete walls are more sensitive to settlements and a breakwater with concrete elements is more vulnerable to damage in case of an earthquake.

G. WAVE DIFFRACTION FOR OPERATIONAL CONDITION

The wave diffraction is determined using the diffraction diagrams for a semi-infinite breakwater for random wind waves (s_{max} = 10) of normal incidence [CIRIA, CUR, CETMEF, 2007].

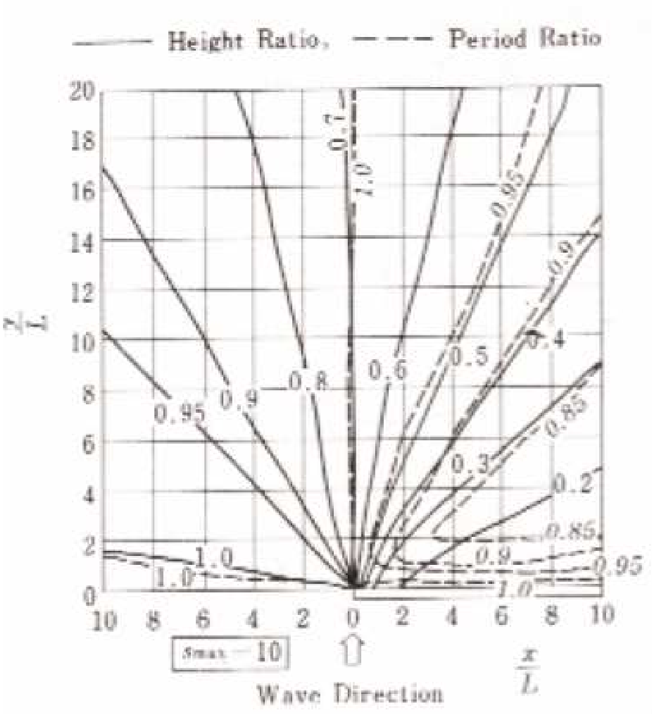


FIGURE G.1 – DIFFRACTION DIAGRAM FOR A SEMI-INFINITE BREAKWATER

The wave diffraction is determined from the position of the head of the breakwater with respect to the container terminal (see layout 2 in appendix E). The resulting wave heights due to diffraction are given per wave direction in table G.2.

For the determination of diffraction, operational wave conditions will be used. For determination of the operational design wave height per wave direction again the joint probability of occurrence (%) is given in table G.1. The 5% of the waves that haven't to be included in diffraction calculations are blueprinted. This results in the operational design wave heights as given in table G.2.

TABLE G.1 – JOINT PROBABILITY OF OCCURRENCE (%) OF WAVES AT 10 METER DEPTH CONTOUR (ALL YEAR)

Hs (m)		Wave direction (°N)												
Lower	Upper	-15 to 15	15 to 45	45 to 75	75 to 105	105 to 135	135 to 165	165 to 195	195 to 225	225 to 255	255 to 285	285 to 315	315 to 345	Total
<	0.25	1.75	1.81	1.77	1.56	1.47	1.58	7.48	4.85	0.99	1.41	6.13	14.58	45.38
0.25	0.75	-	-	-	-	-	-	0.02	12.43	2.3	2.28	9.92	6.16	33.11
0.75	1.25	-	-	-	-	-	-	-	4.65	2.21	1.14	5.68	-	13.68
1.25	1.75	-	-	-	-	-	-	-	0.85	1.54	0.61	2.03	-	5.03
1.75	2.25	-	-	-	-	-	-	-	-	0.84	0.47	0.48	-	1.8
2.25	2.75	-	-	-	-	-	-	-	-	0.28	0.21	0.13	-	0.62
2.75	3.25	-	-	-	-	-	-	-	-	0.07	0.15	0.05	-	0.26
3.25	4.25	-	-	-	-	-	-	-	-	0.01	0.08	0.01	-	0.1
4.25	5.25	-	-	-	-	-	-	-	-	-	0	0.01	-	0.01
5.25	6.25	-	-	-	-	-	-	-	-	-	0	-	-	0
6.25	7.25	-	-	-	-	-	-	-	-	-	0.01	-	-	0.01
7.25	8.25	-	-	-	-	-	-	-	-	-	0.01	-	-	0.01

8.25	9.25	-	-	-	-	-	-	-	-	-	-	-	-	-
9.25	10.25	-	-	-	-	-	-	-	-	-	-	-	-	-
10.25	11.25	-	-	-	-	-	-	-	-	-	-	-	-	-
11.25	12.25	-	-	-	-	-	-	-	-	-	-	-	-	-
12.25	13.25	-	-	-	-	-	-	-	-	-	-	-	-	-
Total		1.75	1.81	1.77	1.56	1.47	1.58	7.5	22.78	8.23	6.38	24.43	20.74	100

TABLE G.2 – DIFFRACTED WAVE HEIGHT

Wave sector (°N)	***165-195***	***195-225***	***225-255***	***255-285***	***285-315***	***315-345***
Angle of approach (°N) [1]	±235	±240	±250	±267	±280	±287
Operational design wave height at sea [m]	0.75	1.75	1.75	1.25	1.25	0.75
y/L	3.1	3.9	5.1	7.2	7.8	8.0
x/L	6.8	7.2	6.4	4.1	2.9	2.0
Diffraction factor [-]	0.20	0.27	0.34	0.44	0.53	0.60
Diffracted wave height [m]	0.15	0.39	0.47	0.53	0.62	0.43

[1] *see table 10.7*

It can be concluded that the breakwater alignment as drawn in layout 2 (appendix E) meets the tranquillity requirements as given above.

H. CALCULATION CREST HEIGHT AND CREST WIDTH

The design wave is characterised by a wave height of about H_s = 4.7 meter and a wave period of T_p= 9.9 meter. This is a wave with a return period of 10 years. In case of bigger waves, vessels are advised to move to the bay of Rodonit, approximately 15 nautical miles north of Durrës. The anchorage in the bay of Rodonit is sufficiently deep to accommodate deep-drafting vessels.

The wave conditions at the container terminal where determined by a superposition of wave energy transmitted through and over the breakwater and wave energy diffracted around the structure according to the following formula:

$$H_{s;containerterminal} = \sqrt{H^2_{s;transmitted} + H^2_{s;diffracted}}$$

Wave diffraction

The wave diffraction is determined using the diffraction diagrams for a semi-infinite breakwater for random wind waves (s_{max} = 10) of normal incidence [CIRIA, CUR, CETMEF, 2007].

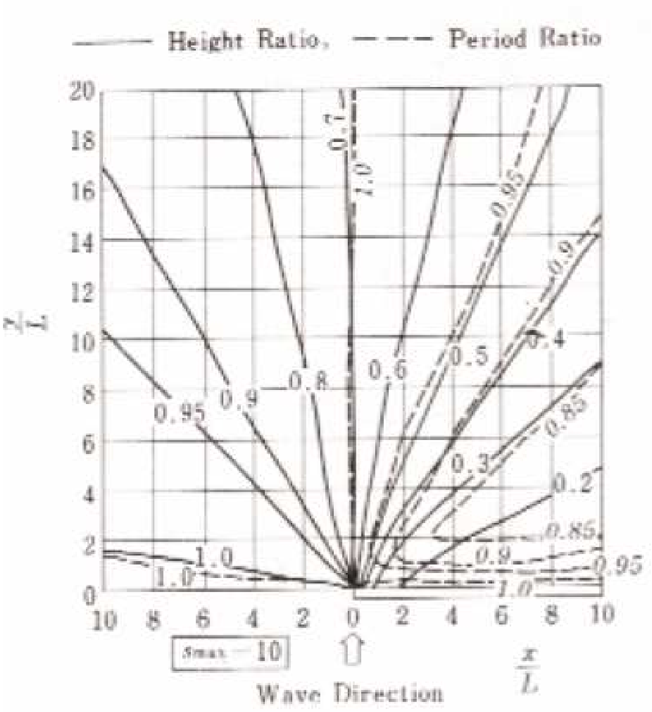


FIGURE H.1 – DIFFRACTION DIAGRAM FOR A SEMI-INFINITE BREAKWATER

The wave diffraction is determined from the position of the head of the breakwater with respect to the container terminal (see layout 2 in appendix E). The resulting wave heights due to diffraction are given per wave direction in table H.1.

TABLE H.1 – DIFFRACTED WAVE HEIGHT

Wave sector (°N)	***165-195***	***195-225***	***225-255***	***255-285***	***285-315***	***315-345***
Angle of approach (°N) [1]	±234°	±239°	±250°	±267°	±280°	±287°
Operational design wave height at sea [m]	3.1	3.2	3.4	4.7	3.7	2.9
y/L	3.1	3.9	5.1	7.2	7.8	8.0
x/L	6.8	7.2	6.4	4.1	2.9	2.0
Diffraction factor [-]	0.2	0.22	0.34	0.44	0.53	0.60
Diffracted wave height [m]	0.6	0.7	1.2	2.1	2.0	1.7

[1] *see table 10.7*

The diffracted wave heights do not satisfy the requirement of 1.25 meter. Container vessels should move to the Rodonit Bay earlier. In the next table the diffracted wave heights are calculated with respect to the oil / LPG terminal which is decisive in the second place.

TABLE H.2 – DIFFRACTED WAVE HEIGHT AT OIL / LPG TERMINAL

Wave sector (°N)	***165-195***	***195-225***	***225-255***	***255-285***	***285-315***	***315-345***
Angle of approach (°N) [1]	±234°	±239°	±250°	±267°	±280°	±287°
Operational design wave height at sea [m]	3.1	3.2	3.4	4.7	3.7	2.9
y/L	-	-	1.0	3.8	5.3	5.7
x/L	-	-	8.7	7.8	6.9	6.5
Diffraction factor [-]	-	-	0.1	0.2	0.25	0.29
Diffracted wave height [m]	0	0	0.3	0.9	0.9	0.8

[1] *see table 10.7*

Wave transmission

The wave transmission is determined using the formula for narrow rubble mound low-crested structures ($B_c/H_s < 10$) by Briganti et. al. [CIRIA, CUR, CETMEF, 2007]:

$$H_{s;transmitted} = C_T \times H_s$$

With:

$$C_T = -0.4\frac{R_c}{H_s} + 0.64\left(\frac{B}{H_s}\right)^{-0.31}\left(1-\exp\left(-0.5\xi_p\right)\right)$$

B = crest width [m]
C_T = transmission coefficient [-]
H_s = significant wave height at the seaward side of the breakwater [m]
R_c = crest freeboard [m]
ξ_p = surf similarity parameter [m]

The purpose of the breakwater is to reduce the incoming waves with H_s = 4.7 meter to $H_{s;\ oil\ /\ LPG\ terminal}$ = 1.00 meter in operational conditions. The maximum water level for the operational situation is LWS +0.6m.

Crest width

The crest width should be sufficient to permit at least three artificial units to be placed on the crest. This is a particularly important requirement if significant overtopping is expected to occur. Given a Accropode layer coefficient of 1.29, the crest of the armour layer should be at least 3x1.29x1.5 = 6 meter.
The crest width also depends on the core crest width, because the core is built out with dump trucks. The core width should be sufficient for practical execution of the works. Dump trucks should be able to pass cranes and other trucks and to tip and turn. This implies a minimal core width of 8 meter. This core width is measured 1 meter above HWS. This automatically implies a crest width of 10 meter.

Given a crest width of 10 meter, a crest freeboard of 3.6 meter and a surf similarity parameter of 3.8 meter results in a transmission coefficient of 0.12, meaning a transmitted wave height of 0.58 meter.

The occurring wave height at the container terminal is a combination of wave diffraction around the breakwater bead and wave transmission. The combined wave height is shown in table H.3.

TABLE H.3 – COMBINED WAVE HEIGHT AT OIL / LPG JETTY

Wave sector	***165-195***	***195-225***	***225-255***	***255-285***	***285-315***	***315-345***
Angle of approach	±234°	±239°	±250°	±267°	±280°	±287°
Diffracted wave height	0	0	0.3	0.9	0.9	0.8
Transmitted wave height	0.6	0.6	0.6	0.6	0.6	0.6
Combined wave height	**0.6**	**0.6**	**0.7**	**1.1**	**1.1**	**1.0**

With these breakwater alignment and dimensions (a crest width of 10 meter, a crest height of 4.2 meter) the requirement of about 1 meter wave height at the LPG / oil jetty is met.

I. CALCULATION OF BERTHING ENERGY

Beneath the kinetic energy will be calculated in detail for a container vessel. The results for dry bulk and general cargo vessels will be given in short afterwards.

I.1 Berthing energy of container vessels

The 'normal' kinetic berthing energy of the ship (side berthing) can be calculated as follows:

$$E_n = 0.5 M_D (V_B)^2 C_M C_E C_S C_C$$

E_n = Normal Berthing Energy [KNm]
M_d = Vessel displacement = 61,000 tons
V_B = Berthing velocity [m/s]
C_M = Added Mass Coefficient [-]
C_E = Eccentricity Coefficient [-]
C_S = Softness Coefficient [-]
C_C = Berth Configuration Coefficient [-]

Berthing velocity
The berthing velocity will depend upon the ease of difficulty of the approach, expose of the berth and the size of the vessel. Conditions are divided into five categories:
a) Easy berthing, sheltered
b) Difficult berthing, sheltered
c) Easy berthing, exposed
d) Good berthing, exposed
e) Difficult berthing, exposed

For the decisive situation, the berthing energy is calculated using the easy berthing, and sheltered condition (c), resulting in the following berthing velocity:

$$V_B = 599.1 \cdot M_D^{-0.4423} = 0.05 m/s$$ [FENTEK, 2001]

However, in PIANC guidelines for the Design of fenders systems, the approach velocity which belongs to a favourable condition can not be less than 0.08 m/s. [PIANC, 2002] It is assumed that this velocity of 0.08 m/s is a reliable value.

Added Mass Coefficient
The Added Mass Coefficient allows for the body of water carried along with ship as it moves sideways through the water. These coefficient is calculated via the Vasco Costa method, which is most widely used by design codes for ship to shore berthing, usually where under keel clearance is more than 10% of the vessel draft and when berthing velocity exceed 80mm/s.

$$C_M = 1 + \frac{2D}{B} = 1.78$$

D = draught = 12.5 meter
B = beam = 32 meter

Eccentricity Coefficient
The Eccentricity Coefficient allows for the energy dissipated in rotation of the ship when the point of impact is not opposite the centre of mass of the vessel. To determine the Eccentricity

Coefficient, first the radius of gyration (K), the distance from the vessels centre of mass to point of impact (R) and the velocity vector angle (γ) should be calculated using the following formulae:

$$K = [(0.19 \cdot C_B) + 0.11] \cdot L_{BP} = 55$$

L_{BP} = Length between perpendiculars = 245 meter

C_B = Block coefficient = $\dfrac{M_D}{L_{BP} \cdot B \cdot D \cdot \rho_{SW}} = 0.60$

$$R = \sqrt{\left[\frac{L_{BP}}{2} - x\right]^2 + \left[\frac{B}{2}\right]^2} = 44m$$

x = Distance from bow to point of impact. Assuming a third-point berthing gives 82m

$$\gamma = 90° - \alpha - \arcsin\left[\frac{B}{2 \cdot R}\right] = 59°$$

α = Berthing angle, assuming 10 degrees

The Eccentricity Coefficient is calculated using the following formula:

$$C_E = \frac{K^2 + (R^2 \cdot \cos^2(\gamma))}{K^2 + R^2} = 0.72$$

Softness Coefficient
The Softness Coefficient allows for the energy absorbed by elastic deformation of the ship hull or by its rubber belting. Using a 'soft' fender, the Softness Coefficient is ignored.

Berth Configuration Coefficient
The Berth Configuration Coefficient allows for the cushioning effect of water trapped between the vessel and the berth. For a semi-closed structure with keel clearance (Kc) / Draught (D) < 0.5, the Berth Configuration Coefficient is 0.9

All criteria and coefficients have been established. The formula can be used to calculate the 'normal' kinetic energy of the ship.

$$E_n = 0.5 M_D (V_B)^2 C_M C_E C_S C_C = 225 KNm$$

Abnormal Berthing Energy (EA)
Abnormal impacts may occur for many reasons - engine failure, breakage of towing lines, sudden weather changes or human failure. PIANC suggests abnormal impact safety factors be applied to the design (normal) energy according to the table below:

TABLE I.1 – FENDER SAFETY FACTORS

Type of Berth	Vessel	Safety Factor
Tankers and Bulk Cargo	Largest	1.25
	Smallest	1.75
Container	Largest	1.5
	Smallest	2.0

General Cargo	1.75
RoRo and Ferries	2.0 or higher
Tugs, Workboats etc	2.0

For the maximum size container vessels a safety factor of 1.5 will be applied, which results in a Berthing Energy of 1.5 x 225 = 338 KNm.

I.2 Berthing energy of dry bulk vessels

The ‘normal’ kinetic berthing energy of the ship (side berthing) can be calculated as follows:

$$E_n = 0.5 M_D (V_B)^2 C_M C_E C_S C_C$$

E_n = Normal Berthing Energy [KNm]
M_d = Vessel displacement = 50,000 tons
V_B = Berthing velocity [m/s]
C_M = Added Mass Coefficient [-]
C_E = Eccentricity Coefficient [-]
C_S = Softness Coefficient [-]
C_C = Berth Configuration Coefficient [-]

Berthing velocity
The berthing velocity will be kept the same, 0.08 m/s. [PIANC, 2002]

Added Mass Coefficient

$$C_M = 1 + \frac{2D}{B} = 1.73$$

D = draught = 11 meter
B = beam = 30 meter

Eccentricity Coefficient

$$K = [(0.19 \cdot C_B) + 0.11] \cdot L_{BP} = 50$$

L_{BP} = Length between perpendiculars = 200 meter

C_B = Block coefficient = $\dfrac{M_D}{L_{BP} \cdot B \cdot D \cdot \rho_{SW}} = 0.74$

$$R = \sqrt{\left[\frac{L_{BP}}{2} - x\right]^2 + \left[\frac{B}{2}\right]^2} = 37m$$

x = Distance from bow to point of impact. Assuming a third-point berthing gives 67

$$\gamma = 90° - \alpha - \arcsin\left[\frac{B}{2 \cdot R}\right] = 55°$$

α = Berthing angle, assuming 10 degrees

The Eccentricity Coefficient is calculated using the following formula:

$$C_E = \frac{K^2 + \left(R^2 \cdot \cos^2(\gamma)\right)}{K^2 + R^2} = 0.76$$

Softness Coefficient
The Softness Coefficient allows for the energy absorbed by elastic deformation of the ship hull or by its rubber belting. Using a ‘soft’ fender, the Softness Coefficient is ignored.

Berth Configuration Coefficient
The Berth Configuration Coefficient allows for the cushioning effect of water trapped between the vessel and the berth. For a semi-closed structure with keel clearance (Kc) / Draught (D) < 0.5, the Berth Configuration Coefficient is 0.9

All criteria and coefficients have been established. The formula can be used to calculate the 'normal' kinetic energy of the ship.

$$E_n = 0.5 M_D (V_B)^2 C_M C_E C_S C_C = 190 KNm$$

Abnormal Berthing Energy (EA)
Abnormal impacts may occur for many reasons - engine failure, breakage of towing lines, sudden weather changes or human failure. PIANC suggests abnormal impact safety factors be applied to the design (normal) energy according to the table below:

TABLE I.2 – FENDER SAFETY FACTORS

Type of Berth	Vessel	Safety Factor
Tankers and Bulk Cargo	Largest	1.25
	Smallest	1.75
Container	Largest	1.5
	Smallest	2.0
General Cargo		1.75
RoRo and Ferries		2.0 or higher
Tugs, Workboats etc		2.0

For the maximum size dry bulk vessel a safety factor of 1.25 will be applied, which results in a Berthing Energy of 1.25 x 190 = 238 kNm.

I.3 Berthing energy of general cargo vessels

The ‘normal’ kinetic berthing energy of the ship (side berthing) can be calculated as follows:

$$E_n = 0.5 M_D (V_B)^2 C_M C_E C_S C_C$$

E_n = Normal Berthing Energy [KNm]
M_d = Vessel displacement = 21,500 tons
V_B = Berthing velocity [m/s]
C_M = Added Mass Coefficient [-]
C_E = Eccentricity Coefficient [-]
C_S = Softness Coefficient [-]
C_C = Berth Configuration Coefficient [-]

Berthing velocity
The berthing velocity will be kept the same, 0.08 m/s. [PIANC, 2002]

Added Mass Coefficient

$$C_M = 1 + \frac{2D}{B} = 1.88$$

D = draught = 9.5 meter
B = beam = 21.5 meter

Eccentricity Coefficient

$$K = [(0.19 \cdot C_B) + 0.11] \cdot L_{BP} = 37$$

L_{BP} = Length between perpendiculars = 2155 meter

C_B = Block coefficient = $\frac{M_D}{L_{BP} \cdot B \cdot D \cdot \rho_{SW}} = 0.66$

$$R = \sqrt{\left[\frac{L_{BP}}{2} - x\right]^2 + \left[\frac{B}{2}\right]^2} = 28m$$

x = Distance from bow to point of impact. Assuming a third-point berthing gives 52

$$\gamma = 90° - \alpha - \arcsin\left[\frac{B}{2 \cdot R}\right] = 57°$$

α = Berthing angle, assuming 10 degrees

The Eccentricity Coefficient is calculated using the following formula:

$$C_E = \frac{K^2 + (R^2 \cdot \cos^2(\gamma))}{K^2 + R^2} = 0.74$$

Softness Coefficient
The Softness Coefficient allows for the energy absorbed by elastic deformation of the ship hull or by its rubber belting. Using a ‘soft’ fender, the Softness Coefficient is ignored.

Berth Configuration Coefficient

The Berth Configuration Coefficient allows for the cushioning effect of water trapped between the vessel and the berth. For a semi-closed structure with keel clearance (Kc) / Draught (D) < 0.5, the Berth Configuration Coefficient is 0.9

All criteria and coefficients have been established. The formula can be used to calculate the ‘normal’ kinetic energy of the ship.

$$E_n = 0.5 M_D (V_B)^2 C_M C_E C_S C_C = 86 KNm$$

Abnormal Berthing Energy (EA)

Abnormal impacts may occur for many reasons - engine failure, breakage of towing lines, sudden weather changes or human failure. PIANC suggests abnormal impact safety factors be applied to the design (normal) energy according to the table below:

TABLE I.3 – FENDER SAFETY FACTORS

Type of Berth	Vessel	Safety Factor
Tankers and Bulk Cargo	Largest	1.25
	Smallest	1.75
Container	Largest	1.5
	Smallest	2.0
General Cargo		1.75
RoRo and Ferries		2.0 or higher
Tugs, Workboats etc		2.0

For the maximum size general cargo vessel a safety factor of 1.75 will be applied, which results in a Berthing Energy of 1.75 x 86 = 151 kNm.