INTEGRATED COASTAL POLICY

VIA

BUILDING WITH NATURE®

R.E. WATERMAN

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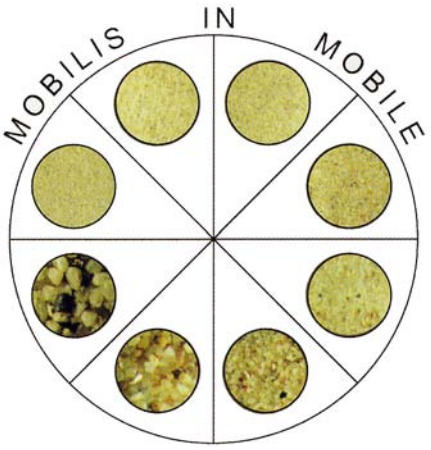
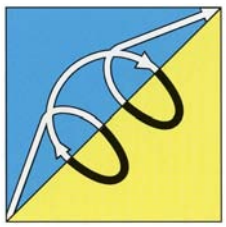
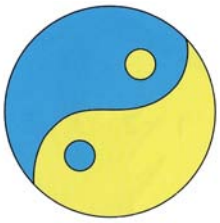




Towards an *Integrated Coastal Policy* via *Building with Nature*, using forces and materials present in Nature.



Achieving a Dynamic Equilibrium Coast. Flexible integration of land in water and of water in land.

Integrated Coastal Policy via Building with Nature ®

PROEFSCHRIFT

ter verkrijging van de graad van doctor,
aan de Technische Universiteit Delft,
op gezag van de Rector Magnificus prof.ir. K.C.A.M. Luyben,
voorzitter van het College voor Promoties
in het openbaar te verdedigen
op dinsdag 21 december 2010 om 15.00 uur

door

Ronald Eduard WATERMAN
geboren te Delft.

Dit proefschrift is goedgekeurd door de promotoren
prof.dr.ir. M.J.F. Stive
prof.drs.ir. J.K. Vrijling

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ABSTRACT

The thesis which appears here is excerpted from the book Integrated Coastal Zone Development via Building with Nature® (Waterman 2008a, 2008b). Although this approach was first applied in the Netherlands, it has gradually been recognized worldwide as a harmonious means of creating land areas for living, working, tourism & recreation, and infrastructure, whilst ensuring the preservation or expansion of valuable environmental resources, nature and landscape. In addition, climate change resulting in sea-level rise, more frequent and intense storm-surges are taken in to account, as well as land subsidence and salt water intrusion.

The most extensive applications are found in the Netherlands, but remarkable examples also exist or are in progress bordering densely populated coastal and delta areas elsewhere in Europe, Africa, the Middle East, Far East, the Americas, Australia, as well as numerous waterfront developments on lakes, rivers and canals.

With approximately 80 percent of the largest population centres in the world situated on coasts and deltas, the need for sound, integrated coastal zone development via building with nature" is urgent and appropriate. The flexible integration of land-in-water and of water-in-land, using materials and forces & interactions present in nature is an environmentally friendly and economically advantageous system which is gaining more and more acceptance worldwide. In implementing this method a new flexible dynamic equilibrium coastline is created using sand from the sea, consisting of a new primary range of dunes with a new beach in front and with a minimum of solid sea-wall elements. The emphasis is no longer on inflexible solid bulwarks against the sea, like dams & dykes, but instead on flexible soft structures in harmony with the sea, like dunes & beaches.

INTRODUCTION

Implementing Integrated Coastal Policy by adhering to the principle of Building with Nature ®, using the soft solution of dunes & beaches with a minimum of "hard" elements such as rocks and jetties, or dykes & dams, about 1050 hectare of land have been reclaimed along the coastline of the Netherlands. In the coastal zones stretching from Hoek van Holland to Scheveningen, the extension of the Port of Rotterdam, and near the extension to the ports of IJmuiden/Amsterdam, integrated coastal projects have been successfully completed. And more are planned. In addition, the principle has also been applied, albeit to a lesser degree, on most other continents including Asia, Africa and the Americas. Even in the thinly populated Australia, the principle has gained popularity because it not only addresses the issue of local shortage of space for urban, industrial, residential and recreational development, but Integrated Coastal Policy and Building with Nature also represent long-term, environmentally and economically sustainable solutions.

SUSTAINABLE COASTAL ZONE DEVELOPMENT

Many civilisations originated and were developed in the border zone of land - water in coastal and delta regions. These border zones were and still are very attractive for living, working, tourism & recreation, transport, water resources and food supply. They are also attractive for the development of valuable nature areas, because of the presence of gradients from wet to dry, from high to low salt, calcium compound and other mineral concentrations, differences in height & micro-climate. These gradients are often guarantees for a large variety of species.

With this in mind, it is not a surprise that at the beginning of the 21st century, around 80 percent of the largest population centres in the world are found in coastal areas. Striking examples of coastal urbanisation can be found on nearly all continents (Figure 1).

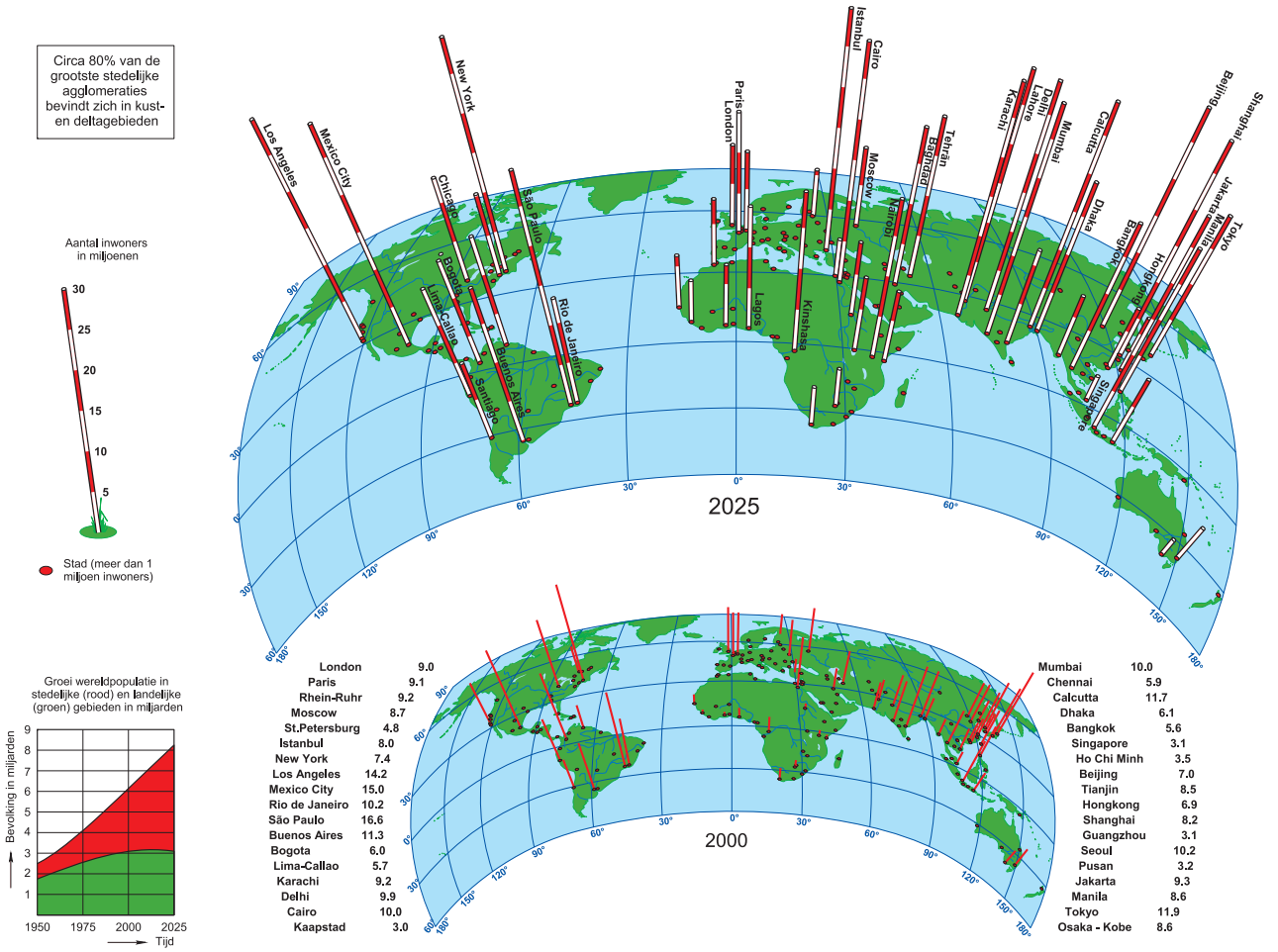


Figure 1: Development of major cities in the world: eighty percent of major cities in the world are situated on coastal or delta areas. For instance, Tokyo-Kawasaki-Yokohama, Osaka-Kobe, Seoul-Inchon, Pusan, Shanghai, Hong Kong, Guangzhou, Taipei, Kaohsiung, Manila, Jakarta, Mumbai, Calcutta, Chennai, Karachi, Dhaka, Bangkok, Singapore, Sydney, Rio de Janeiro, Buenos Aires, Caracas, Lima-Callao, Montevideo, New York, Los Angeles-Long Beach, San Francisco, Vancouver, Alexandria-Cairo, Lagos, Cape Town, Istanbul, Saint Petersburg, London, Randstad Holland.

In these densely populated coastal areas there are many existing and future problems in need of solutions, but they also present challenging opportunities to create added value.

The Netherlands is a good example of this situation. The Netherlands have a high population density, as well as a high motorcar density, a high waste production and a high energy usage per capita. The need for new building sites for living, working, recreation & tourism, for an adequate infrastructure, for a continued town renovation process is clear; at the same time the need for preservation and expansion of valuable environment, nature and landscape are present. In short, limited space is available for living, working, transport and recreation, while at the same time the need to preserve or even enlarge natural coastal and delta habitats is growing. This lack of space is specifically apparent in Randstad Holland or "Rim-City Holland", a rim of cities in the western part of the Netherlands, which includes Amsterdam, The Hague, Rotterdam, Utrecht and Almere. A Blue-Green Heart on the landward inner side, and the Coast on the other side border this so-called "Polycentric Network Delta-Metropolis".

Apart from the necessity of population stabilisation in due time, in principle three spatial solutions exist to cope with this scarcity of space:

- Making better use of the 3rd dimension (sky-scraping & underground development) and the 4th dimension (recycling of functions) and multifunctional use within the present available space;
- Using space in the existing hinterland;
- The seaward option with flexible integration of land in water (sea, estuary, lake and/or river) and of water into the new and old land (estuaries, tidal lagoons, lakes, harbour basins, canals, waterways and/or fresh water lenses under dunes), making use of materials and forces & interactions present in nature, with special attention to the intensive relation water-land.

Worldwide, all these options are applied solely, or in combination. In this publication the emphasis is put on the seaward option, while taking into account the other options.

The seaward option gives unique possibilities for the application of multi-functional use. Sustainable coastal zone development is therefore an important multi-faceted instrument to find an adequate answer to the scarcity of space, while it offers at the same time unique opportunities for an improved water resources system.
In addition, given the present concern for climate change, which results in rising sea levels and increased frequency and intensity of storm surges, this method provides an essential instrument for improving coastal safety. All the more so, because land subsidence and salt water intrusion are additional factors to be reckoned with.

The seaward option is based on two important principles:

'Integrated Coastal Policy' and *'Building with Nature'* ®.

1. INTEGRATED COASTAL POLICY

Integrated Coastal Policy answers the questions: “When considering coastal and delta regions, how can the multitude of existing and future problems be solved in relation to each other and in relation to the hinterland on the interior and the bordering sea on the other, while creating added value?”

A sustainable, integrated approach is of vital importance for many coastal and delta regions worldwide, and to achieve this, many functions, using many different disciplines, have to be considered carefully. The final development should be such that the overall economy is strengthened and the environment is improved. The many specific functions in the coastal zone which are of great importance can be seen in Figure 2 and Figure 3.

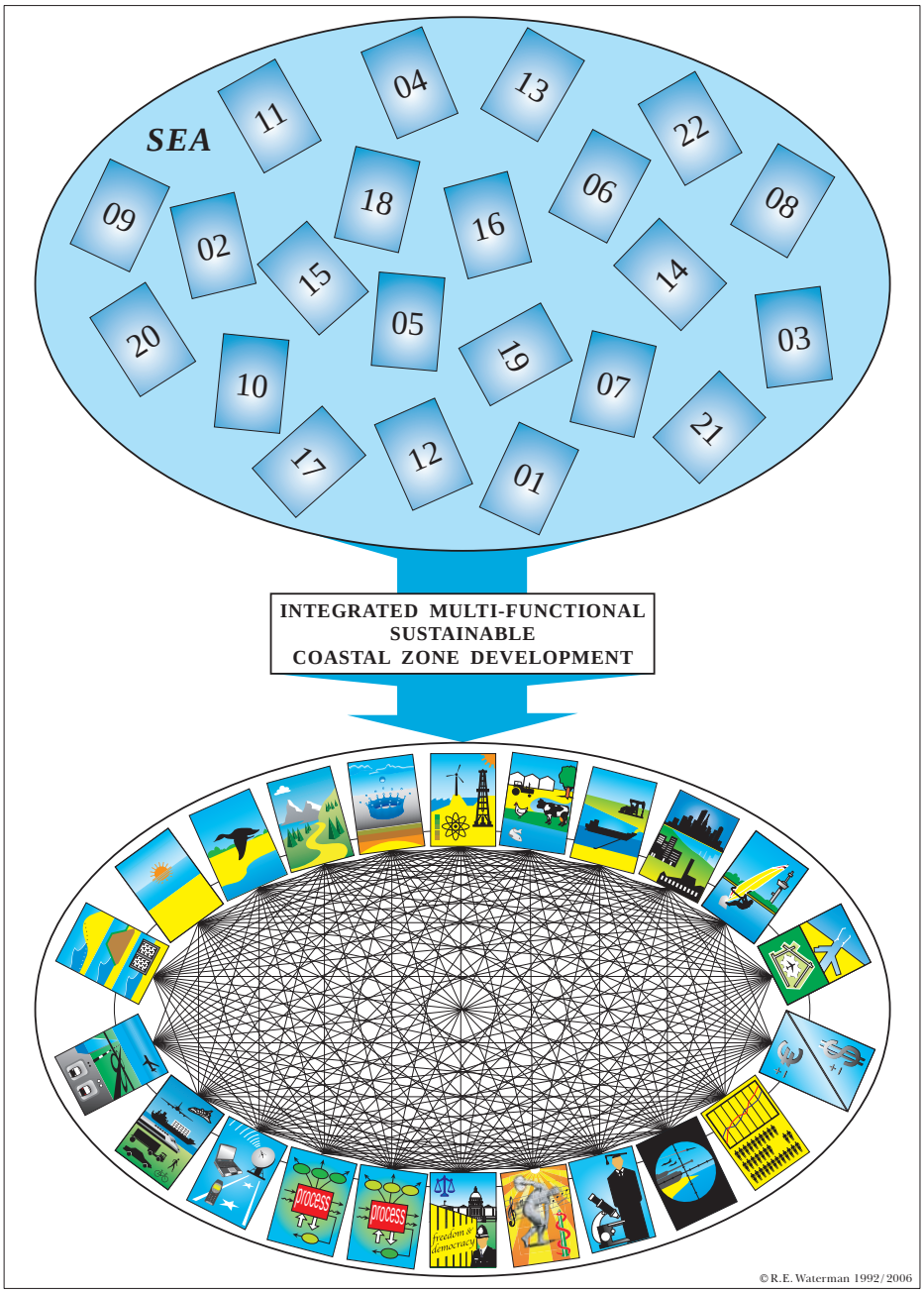


Figure 2:
Integrated multifunctional sustainable coastalzone development: The numbers in the “Sea” relate to the specific functions in the coastal zone which are listed in the text.

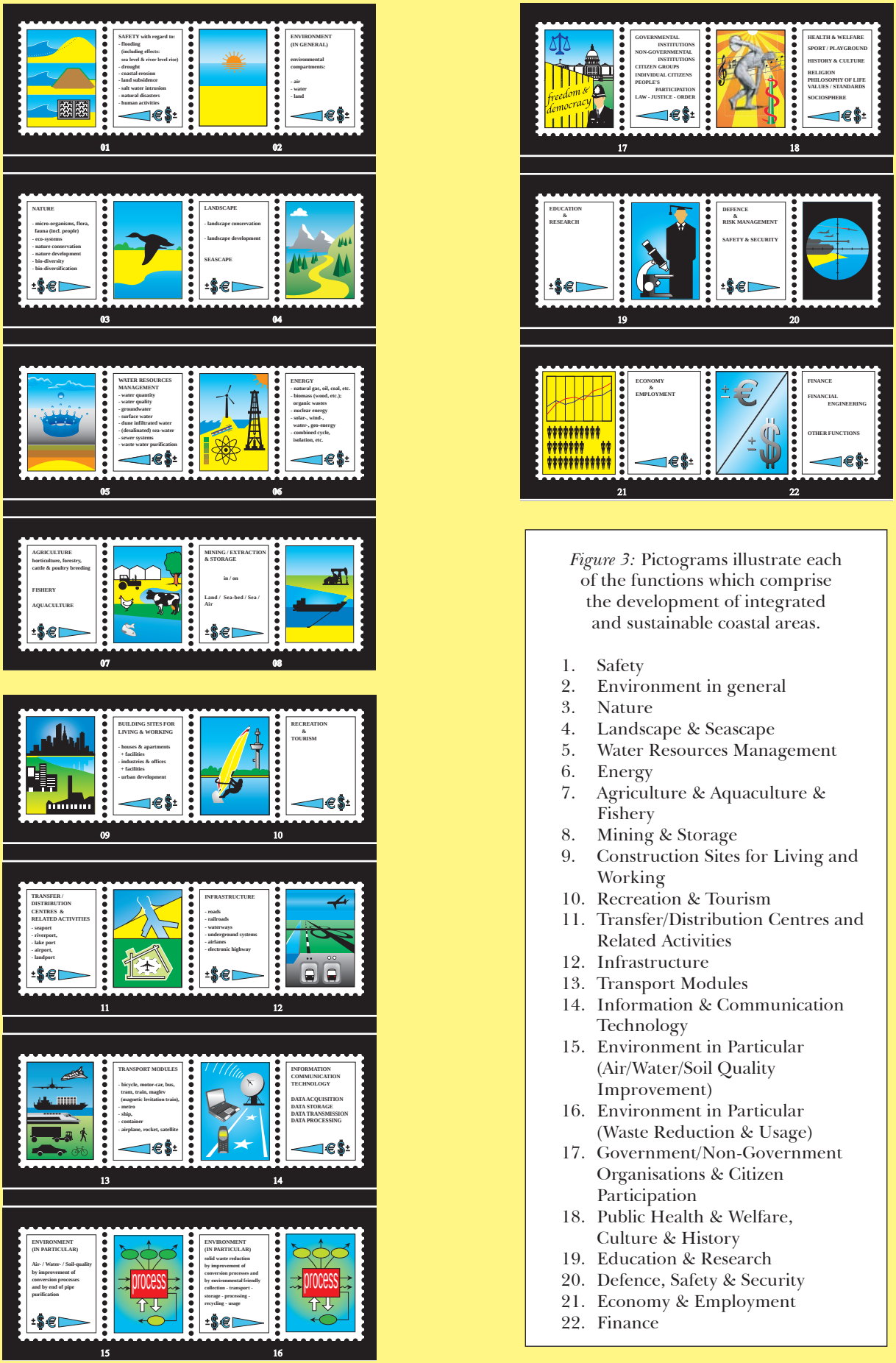


Figure 3: Pictograms illustrate each of the functions which comprise the development of integrated and sustainable coastal areas.

1. Safety
2. Environment in general
3. Nature
4. Landscape & Seascape
5. Water Resources Management
6. Energy
7. Agriculture & Aquaculture & Fishery
8. Mining & Storage
9. Construction Sites for Living and Working
10. Recreation & Tourism
11. Transfer/Distribution Centres and Related Activities
12. Infrastructure
13. Transport Modules
14. Information & Communication Technology
15. Environment in Particular (Air/Water/Soil Quality Improvement)
16. Environment in Particular (Waste Reduction & Usage)
17. Government/Non-Government Organisations & Citizen Participation
18. Public Health & Welfare, Culture & History
19. Education & Research
20. Defence, Safety & Security
21. Economy & Employment
22. Finance

2. BUILDING WITH NATURE ®

The second basic principle in the seaward option, in addition to *Integrated Coastal Policy*, is *Building with Nature*®. Where nature allows it, the principle of Building with Nature should be applied as much as possible in the realisation of new land. The essence of this principle is: flexible integration of land-in-sea and of water-in-the-new-land, making use of materials, and forces & interactions present in nature, taking into account existing and potential nature values, and the bio-geomorphology & geo-hydrology of the coast and seabed.

Materials

These include: Loose mobile material sand and silt (varying in size, structure and composition) and the forces & interactions to which they are exposed.

Forces & Interactions occurring are:

01. Tidal action (ebb & flood);
02. Wave action (specifically in the breaker zone) and swell action;
03. Sea currents other than tidal currents;
04. River outflow (as force and as supplier of freshwater and sediment);
05. Gravity;
06. Wind;
07. Rain;
08. Solar radiation;
09. Interaction dunes-vegetation (root systems of the vegetation hold together sand and silt); interaction coastal zone-mangroves;
10. Complex interaction marine organisms – sand/silt/coral.

Bio-geomorphology & Geo-hydrology of coast and seabed

Regarding the land reclamation application, the method of Building with Nature should be emphasized, both from the viewpoint of nature as from a viewpoint of cost-effectiveness. Human activities should be incorporated as much as possible in the system of natural cycles. The emphasis is on sustainable development in densely populated coastal and delta areas. In this method a new flexible, dynamic equilibrium coastline is created using sand from the sea, consisting of a new primary range of dunes with a new beach in front and with a minimum of solid sea-wall elements.

The emphasis is no longer on inflexible solid bulwarks against the sea, like dams & dykes, but instead on flexible soft structures in harmony with the sea, like dunes & beaches.

In the new flexible dynamic equilibrium coastline accretion and erosion are more or less balancing each other, with a limited maintenance factor through periodic beach nourishment. Only in those places where erosion strongly dominates accretion solid seawall elements are applied. The overall principle is applicable in many of the world's coastal regions and has been applied with success, adapted to local situations.

The method takes into account all the forces and interactions acting on the loose mobile material sand and silt, being the action of tides, waves (specifically in the breaking zone), swell, river outflow (as force and as a source of fresh water and sediment), estuarine and ocean currents, gravity, wind, rain and solar radiation, seeing to it that the net resulting force acting on the sand/silt – averaged in time – is relatively small. Use is also made of the interaction vegetation-sand. Another factor to be considered is the complex interaction between marine organisms and sand/silt/clay particles in beach and near shore. In all cases the bio-geomorphology & geo-hydrology of the region, referring to coast and seabed have to be considered.

Building with Nature also takes into account the present geomorphology and the historic development of these coastal and delta areas, soil & subsoil characteristics, land subsidence, plate tectonics, marine/river & terrestrial environment, monera & protista, flora & fauna, ecosystems, climate & climate change with all its implications like sea-level rise, higher frequency and intensity of storm surges and rainfall, as well as periods of drought.

A low maintenance factor of the new coastline is taken into account, through periodic beach nourishment. Only in those cases where erosion is clearly and strongly dominating accretion, solid seawall elements are to be preferred, but only then. In those cases a marriage between soft and tough coastal defence can be realised, leading to a concave coastline between an existing soft coast and a solid seawall element or a concave coastline between two solid seawall elements.

Coastal Zone Development & Sustainability

In all cases of integrating land in water and of water in land through Building with Nature, of and above a certain scale, multifunctional master concepts are developed in such a way that nature reserve areas are included and that net nature gain is achieved and that careful zoning regarding all functions is applied. These coastal zone developments can be carried out phase after phase, segment after segment, all fitting in a flexible master plan, leading not only to cost-effectiveness and flexibility but also to environmental improvement.

The environment, including nature, has four important basic functions:

1. *Carrier Function*, providing space and habitat/substrate for all living organisms and other organic as well as inorganic matter, landscape & seascape, energy systems and all human and non-human induced processes.
2. *Production Function*, through exploration, exploitation, harvesting of inorganic & organic materials in the environmental compartments air-water-soil and by the conversion and use of all forms of energy.
3. *Regulatory Function*, maintaining essential eco-systems as well as other systems and processes, including the bio-geochemical cycle, the climate & hydrological cycle, the carbon & sulphur & nitrogen & phosphor cycle.
4. *Information Function*, providing information in many forms for many known and unknown purposes. Some of the known purposes are science; research & development; education; culture & history; recreation & experience; insight; inspiration.

Triple-C approach

Strengthening the economy and improving the environment are achieved through the application of the method of Building with Nature, the creation of new nature reserve areas, careful zoning of the various functions and the introduction of a Triple-C approach: Clean Technology, Clean Products, and Cleaning-up Technology.

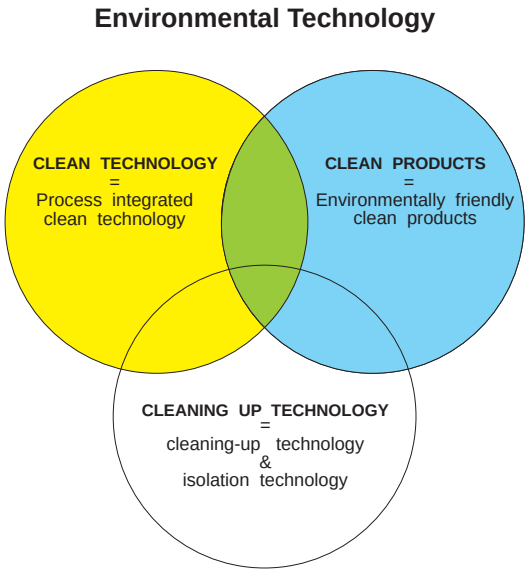
With regard to the first, Clean Technology, it must be realised that in each coastal zone there are always existing and newly human-induced conversion processes in the field of industry, in power stations for energy-supply, in agriculture & aquaculture, in transport & distribution, in the services sector, as well as in the domestic sector. In the direct future, those conversion processes should be developed and implemented, so that with fewer raw materials and with less energy, products at a higher yield are produced, with less hazardous emissions to air, water and soil, and with fewer waste products.

Clean Products should be relatively environment-friendly during their lifetime and thereafter. In case waste products are formed, they should be recycled or converted to environment-friendly products, or, when this is not possible, be safely stored.

Cleaning-up Technology should be applied in order to improve or remove existing situations that are harmful to the environment.

Clean Technology (process-integrated clean technology), Clean Products (useful products that during their lifetime and thereafter are relatively environment-friendly) and Cleaning-up Technology, embodied in the Triple-C approach, are useful instruments to achieve – in due time – sustainable development.

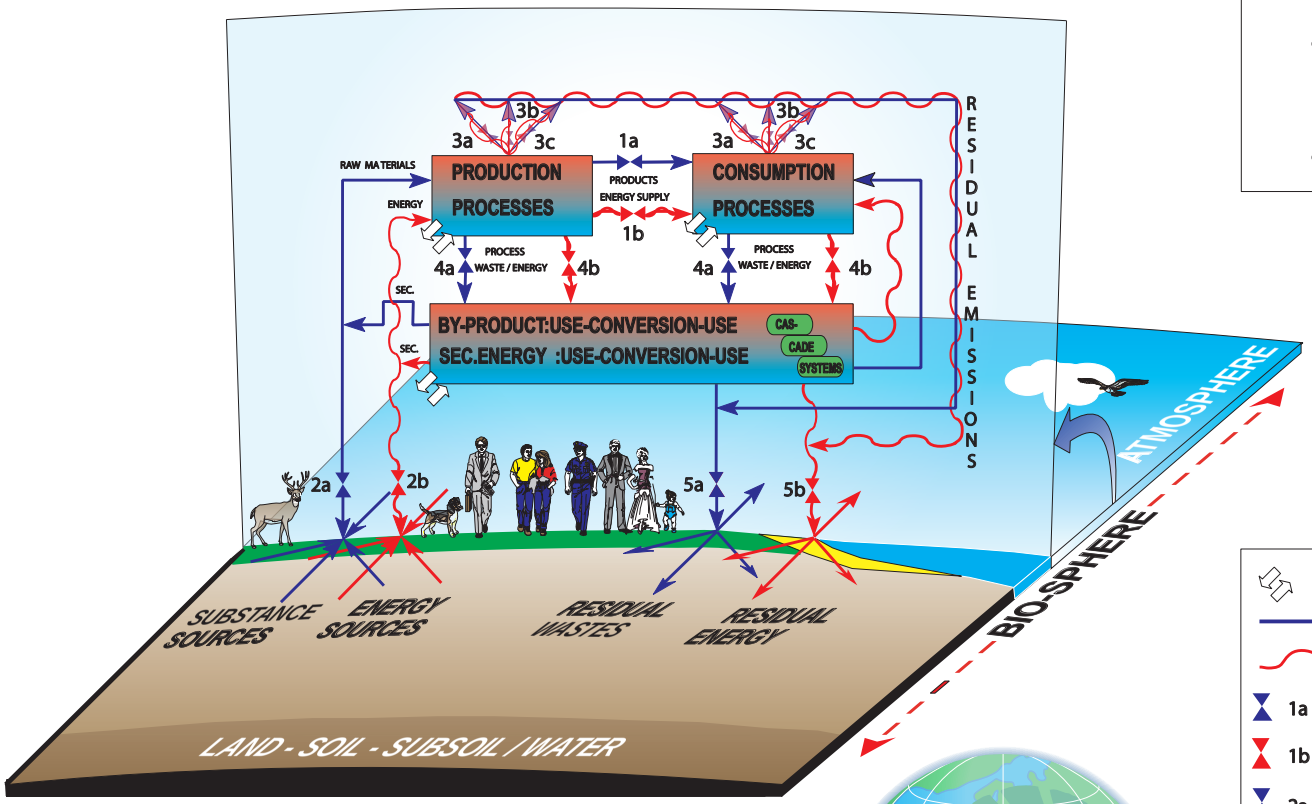
Harmonious co-operation with all the relevant authorities at the various government levels and with non-governmental organisations and citizen groups is an essential prerequisite to achieve integrated multi-functional and sustainable coastal zone development. Detailed, illustrated examples of sustainable coastal zone development will be given, which are applicable worldwide and can be adapted to local circumstances.



Triple - C approach

TOWARDS A (CLOSED) MASS / ENERGY - CYCLE IN A SUSTAINABLE SOCIETY

(in which up- and downgrading occurs)



ENVIRONMENTAL FOOT IMPRINT (IN HA)

=

FUNCTION (POPULATION, LIFESTYLE, TECHNOLOGY)

- The conversion processes take place in the environment. They are often initiated, developed and managed by people.
- Those processes should be developed whereby with less raw materials and less energy, valuable products can be produced at a higher yield, with less hazardous emissions to air/water/soil.
- In so far by-products are produced, these should be transformed into environmentally friendly products. If this is not feasible these by-products should be safely stored in order to protect the environment.
- Space- and time-factors should also be taken into account.

BIO-SPHERE :

- ENVIRONMENTAL COMPARTMENTS, AIR - WATER - SOIL
- MICRO-ORGANISMS, FLORA, FAUNA (INCL. PEOPLE)
- ECO - SYSTEMS
- ALL MATERIAL EXPRESSIONS OF HUMAN ACTIVITIES
- MASS SOURCES, ENERGY SOURCES } VIA EXPLORATIONS, EXPLOITATION, MINING, CULTIVATION, HARVEST, ETC.
- RESIDUAL WASTES, RESIDUAL ENERGY } IMMOBILISATION / DIFFUSION & DISSIPATION

	INFORMATION IN / OUT
	MASS - TRANSPORT
	ENERGY - TRANSPORT
1a	CONTROL VALVE PRODUCT (QUALITY & QUANTITY)
1b	CONTROL VALVE ENERRGY SUPPLY (QUALITY & QUANTITY)
2a	CONTROL VALVE RAW MATERIALS (QUALITY & QUANTITY)
2b	CONTROL PRIMARY ENERGY FROM VARIOUS SOURCES (QUALITY & QUANTITY)
3a,b,c	CONTROL VALVE EMISSION REDUCTION (OF HARMFUL COMPONENTS TO AIR - WATER - SOIL
4a, 5a	CONTROL VALVE FOR BY-PRODUCTS & RESIDUAL WASTES (USE - CONVERSION - USE, IMMOBILISATION, DIFFUSION
4b, 5b	CONTROL VALVE FOR SEDCUNDARY & RESIDUAL ENERGY (USE - STORAGE, DIFFUSION & DISSIPATION)

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3. BUILDING WITH NATURE® IN THE NETHERLANDS

The Netherlands has three coastal types: the Wadden Island coast in the North; the segmented dune coast from Den Helder to Hoek van Holland, and the estuarine coast in a transition state lying between Hoek van Holland and Belgium. From a coast morphological viewpoint a number of interesting developments and plans for reclamation are in progress. The satellite photo (Figure 4) gives an overview of these coastal zones and of the development plans. Figure 5 shows the historical coastlines of Holland where restoration of 1150 ha have already been realised.

Figure 4: The Netherlands has three coastal types:

- Wadden Island coast in the North;
- Segmented dune coast from Den Helder to Hoek van Holland;
- Estuarine coast in transition state between Hoek van Holland and Belgium.

From a coast morphological viewpoint there are a number of interesting developments in progress:

1. Coastal zone Scheveningen – Hoek van Holland;
2. Coastal zone Rotterdam/Maas Plain – Westvoorne;
3. Coastal zone near IJmuiden;
4. Island Noorderhaaks in relation to Texel;
5. Coastal zone between panhandle peninsulas of Goeree and Schouwen-Duiveland;
6. Coastal zone Katwijk – Noordwijk;
7. Island Neeltje Jans in Storm Surge Barrier Zeeland;
8. Western Scheldt Container Terminal.

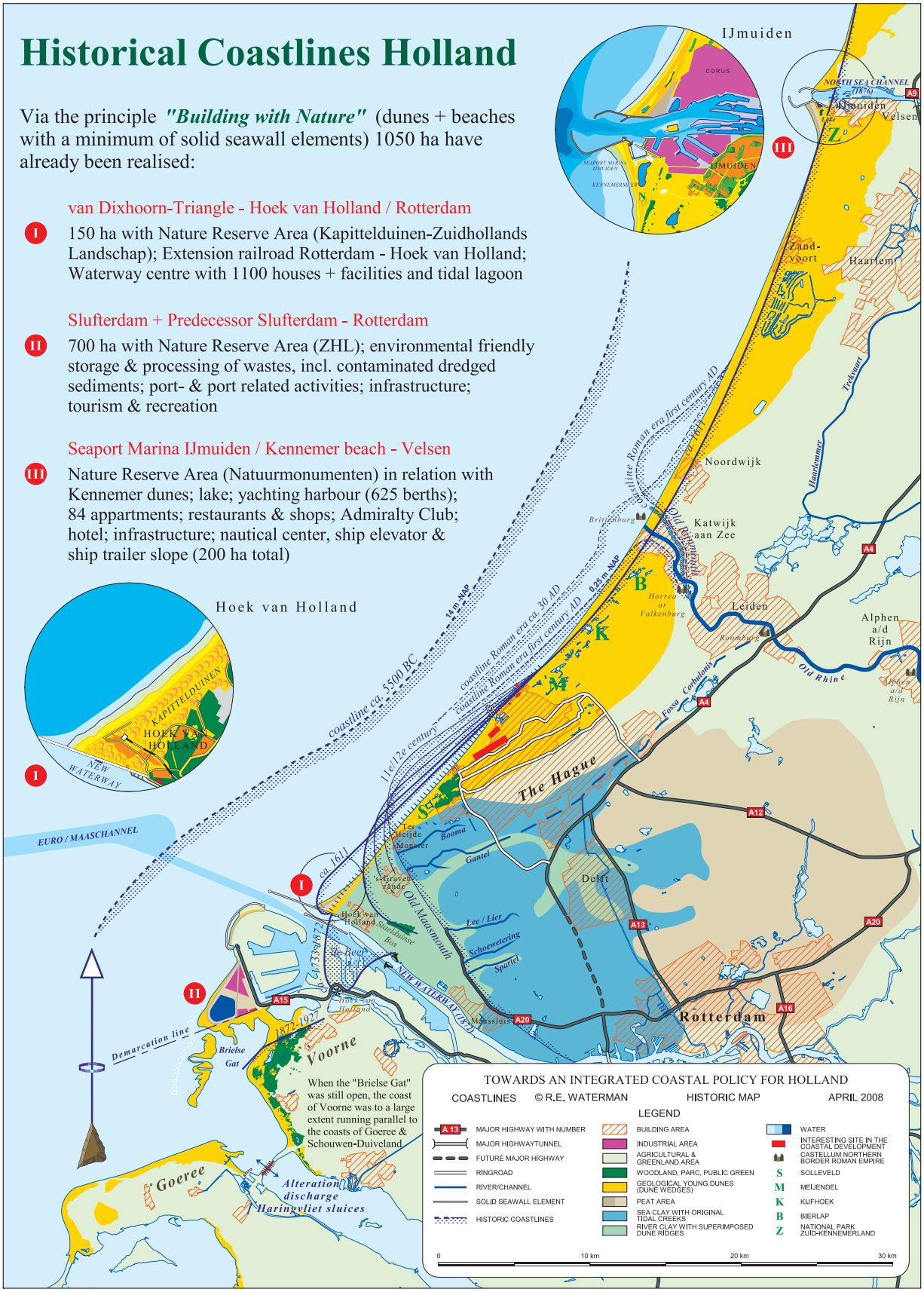


Figure 5:
The historic coastlines of North and South Holland, including the van Dixhoorn Triangle (I), Slufterdam (II) and Seaport Marina IJmuiden / Velsen (III)

Plan 1

Plan 1 is a wedge-shaped land reclamation between North Scheveningen (coastal area of The Hague) and Hoek van Holland, circa 21 km in length and its width is gradually increasing from a few metres near North Scheveningen to approximately 4 km near Hoek van Holland (see Figure 6).

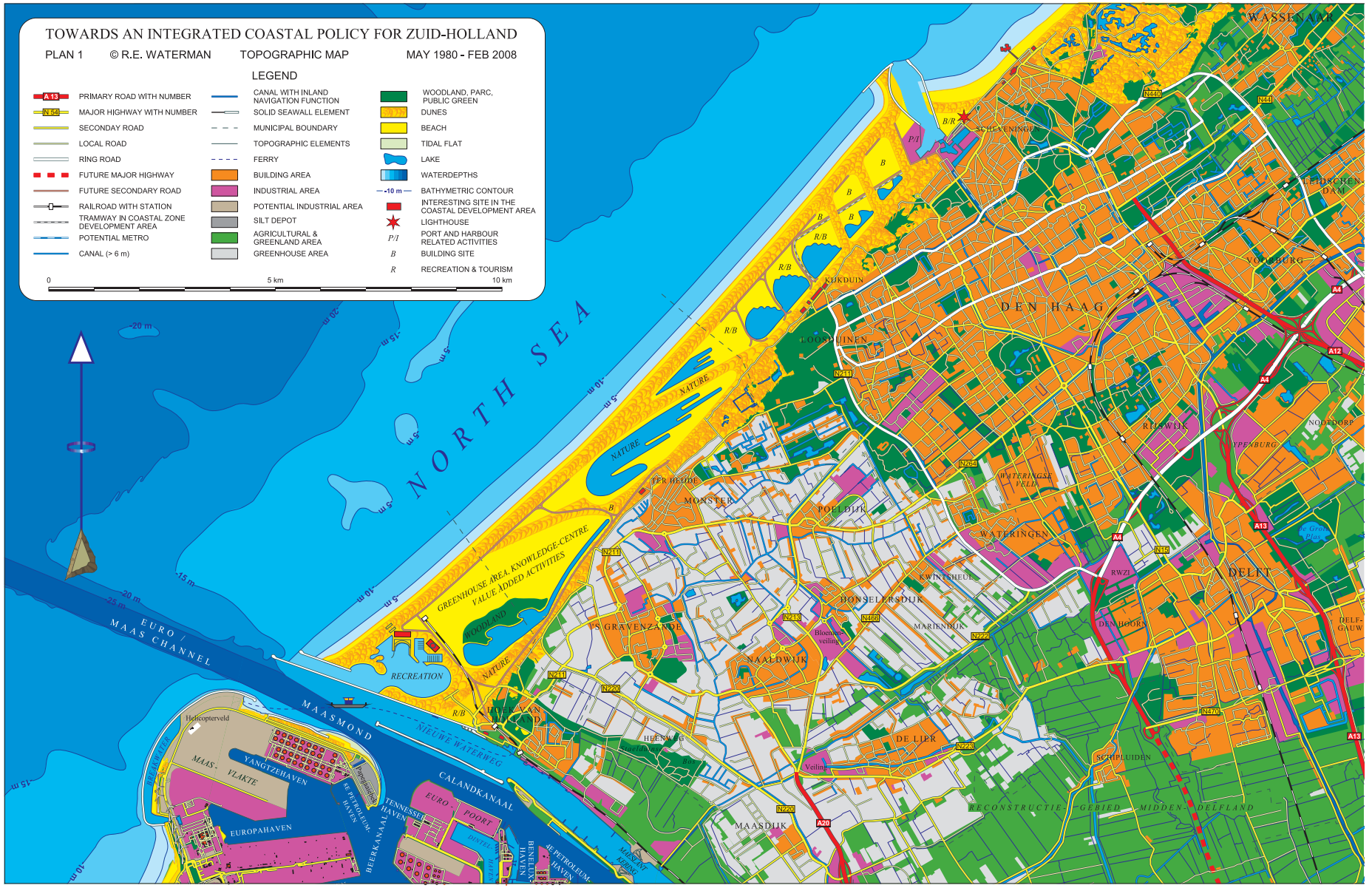
This area is known as the Delfland coast. The new land has an area of circa 3,250 hectares and the volume of sand required, amounts to approximately 360 million m^3. This amount of sand can be obtained by widening and deepening the Euro-Maas Channel and by dredging from the seabed of the North Sea beyond the 20 m – MSL depth line, thereby keeping intact the coastal seabed foundation up to this 20 m – MSL line. This land reclamation has two parts: a smaller part with a short new hollow coastline from North Scheveningen to the extended northern harbour mole of Scheveningen, and a much larger part with a new hollow arched coastline between the extended southern harbour mole of Scheveningen and the adapted existing northern harbour mole of Hoek van Holland.

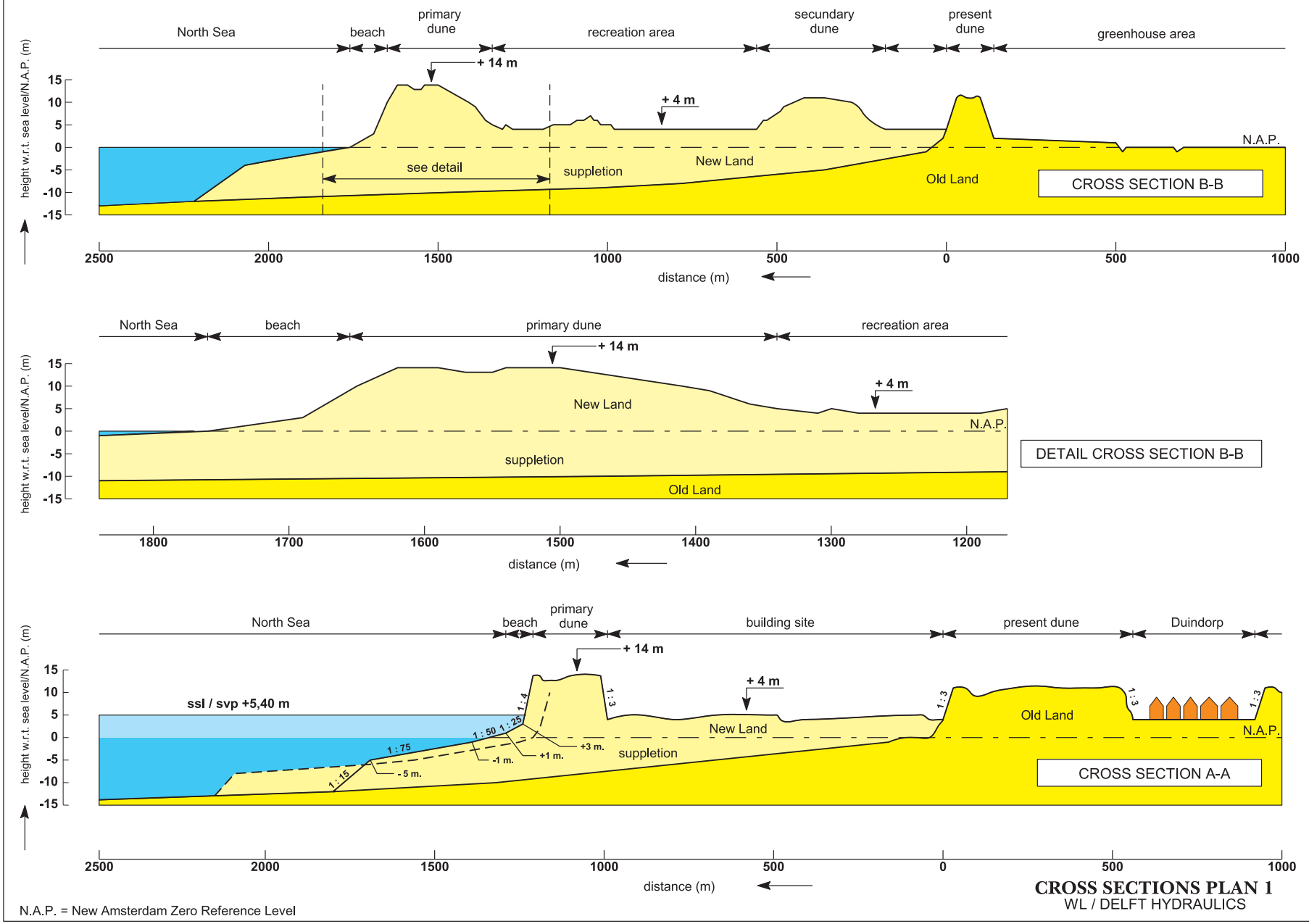
The plan includes a primary range of dunes with a new beach in front, parallel to the new coastline, and secondary ranges of dunes at an angle to the coast, as it were, extensions of historical dune ridges which can still be recognised in the basic street pattern of The Hague.

These secondary dune ranges are not only of interest for reasons of history and landscape, but they also offer the opportunity to create the plan in phases, segment after segment. For this, trailer suction hopper dredgers are used to start the construction of the land reclamation from the existing land going in a seaward direction. In addition and in concert, phasing is possible through the three-coastline concept. The essence of this is to establish first of all the primary range of dunes with the new beach in front and behind it while maintaining the existing beach. The new dune territory is sown in and planted with marram grass (amophila arenaria) and pioneer plants. After nature has taken root, the old coast can be connected to the new coast wherever desirable. The new dune territory can therefore be established from existing land to sea or the reverse, while combinations are also possible. The choice depends on the local situation and the future functions of the area. Special attention is needed for properly linking the soft Building with Nature solution to the hard solid seawall elements, which means the linkage of the soft dune / beach arch to the existing / extended or adapted harbour moles of Scheveningen and Hoek van Holland (Figures 6 and 8).

Maintenance of this new Delfland coast is provided for through periodical beach nourishment. Groynes are no longer necessary (Figure 7).

Figure 6: Plan 1 is for a wedge-shaped land reclamation between North Scheveningen and Hoek van Holland, circa 21 km in length and its width is gradually increasing from a few metres near North Scheveningen to approximately 4 km near Hoek van Holland.


TOWARDS AN INTEGRATED COASTAL POLICY FOR ZUID-HOLLAND
PLAN 1 © R.E. WATERMAN TOPOGRAPHIC MAP MAY 1980 - FEB 2008
LEGEND
PRIMARY ROAD WITH NUMBER
MAJOR HIGHWAY WITH NUMBER
SECONDAY ROAD
LOCAL ROAD
RING ROAD
FUTURE MAJOR HIGHWAY
FUTURE SECONDARY ROAD
RAILROAD WITH STATION
TRAMWAY IN COASTAL ZONE DEVELOPMENT AREA
POTENTIAL METRO
CANAL (> 6 m)
CANAL WITH INLAND NAVIGATION FUNCTION
SOLID SEAWALL ELEMENT
MUNICIPAL BOUNDARY
TOPOGRAPHIC ELEMENTS
FERRY
BUILDING AREA
INDUSTRIAL AREA
POTENTIAL INDUSTRIAL AREA
SILT DEPOT
AGRICULTURAL & GREENLAND AREA
GREENHOUSE AREA
WOODLAND, PARC, PUBLIC GREEN
DUNES
BEACH
TIDAL FLAT
LAKE
WATERDEPTHS
BATHYMETRIC CONTOUR
INTERESTING SITE IN THE COASTAL DEVELOPMENT AREA
LIGHTHOUSE
PORT AND HARBOUR RELATED ACTIVITIES
BUILDING SITE
RECREATION & TOURISM
0 5 km 10 km
NORTH SEA
EURO / MAAS CHANNEL
MAASMOND
NIEUWE WATERWEG
CALANDKANAAL
GREENHOUSE AREA, KNOWLEDGE-CENTRE VALUE ADDED ACTIVITIES
NATURE
RECREATION
WOODLAND
WASSENAAR
SCHEVENINGEN
KIJKDUIN
DEN HAAG
LOOSDUINEN
VOORBURG
RIJSWIJK
NOORDORP
WATERINGSE VELD
MONSTER
POELDIJK
WATERINGEN
DELFT
RWZI
KWINTSHEUL
HONSELERSDIJK
'S GRAVENZANDE
MARIENDIJK
NAALDWIJK
DE LIER
MAASDIJK
DE HOEF
SCHIPLUIDEN
RECONSTRUCTIE-GEBIED MIDDEN-DELFLAND
Helicopterveld
MAAS-VLAKTE
YANGTZEHAVEN
EUROPAHAVEN
BEERKANAAL
TENNESSEEHAVEN
EURO-POORT
BEREHAVEN
SE PETROLEUMHAVEN
MAASVLAKTE
HOEKSCHE KRING
-20 m
-15 m
-10 m
-5 m



CROSS SECTIONS PLAN 1
WL / DELFT HYDRAULICS

N.A.P. = New Amsterdam Zero Reference Level

Because of the newly acquired land including the new primary range of dunes, a much safer situation with regard to the sea is created, while at the same time a much larger fresh water lens is realised under the wider dune area. This again improves the protection of the low-lying westland district with its large greenhouse area and important horticultural activities against salty seawater intrusion.

Considering the cross section of the present land, going from the existing hinterland in the direction of the North Sea we come across polders, ditches and canals – partly below and partly above sea level – present sea-defence dune and primary dune, the new beach and the new seabed, up to the point where the new seabed meets the old (toe-line). In other words, the plan continues under water and the slope of the foreshore is also related to the grain size of the sand that is used. This sand is extracted from the seabed in the North Sea, not too close to the coast because that would negatively influence the slope of the foreshore, and not too far away because then the transport costs are too high. The so-called coastal foundation up to the 20 m – MSL line, is kept intact. Consequently, the required sand is extracted mainly from the North Sea seabed outside the 20 m – MSL line and also from widening and deepening the Euro-Maas Channel.

Plan 1 fulfils an important role in the coastal defence of the Delfland coast. This coast has several dangerously weak coastal stretches, where the dune range is too narrow. The new primary sea-defence dune complies with the strictest standards of height and width and is taking into account further sea level rise. Furthermore the total dune area is considerably enlarged, leading to a further increase in safety.

The height – with a certain width – of the new primary dune is approximately 14 m + MSL and complies with the new Delta standard. The ongoing sea level rise in the future is taken into account. It is not allowed to build on the new primary sea-defence dune for reasons of safety and nature. An important advantage of this is that – in case of continued sea level rise – this dune can be widened and heightened without destruction of capital. The inner area between the present dune and the new primary range of dune has an average height of 4 m + MSL, but varies from around 5 m + MSL to 0 m MSL; the water level of the water surfaces within the newly acquired land is around sea level and depends on the location and type of the water volumes (fresh water lake, tidal lagoon, waterway, et cetera). The groundwater level in the newly acquired area is related to the surface level. Rain falling in the area percolates through the sand resulting in a gradual formation of a fresh water lens, which in due time will be an instrument in fighting salt water intrusion into the Westland District. In addition, it is possible to regulate the groundwater level in certain areas – both in the old and in new land – through the creation of waterways and through pumping. The total volume of required sand will be approximately 360 million cubic metres, which is transported by trailing suction hopper dredgers.

Figure 7: The groynes at Delfland Water Board: basalt groynes were built perpendicular to the coast to prevent the natural transport of sand along the coast. However, they have a negative impact because they initiate rip tides which transport sand away from the beach. Sand plumes result and literally and figuratively the coast is hollowed out.

Figure 8: The first realised segment of Plan 1 from Hoek van Holland to Scheveningen, the so-called Van Dixhoorn Triangle, completed with a primary protective dune running parallel to a major thoroughfare in the Hague, the Laan van Meerdervoort. The coast orientation is good and 11 of the 68 Delfland groynes have disappeared under the sand.
This is a land reclamation of ca. 150 ha with a splendid natural reserve, the Kapittel Dunes. South of this the train route Rotterdam to the Hoek van Holland will be lenghtened and further roadways will be constructed, as well as 1100 homes and facilities. In the next phase a tidal lagoon will be realised for a yacht harbour and hotel conference centre, together with the already existing passenger-ship connection to the UK.

Plan 2

Plan 2 is a multi-functional peninsula attached to the Europort-Maasvlakte as an extension of the world-famous Port of Rotterdam (see Figure 4). Its panhandle shape resembles the panhandles of the islands Goeree and Schouwen and its southern axis was purposely designed to run exactly parallel to the coast of Goeree thus conforming to the natural coastal system. Originally two earlier designs were made in 1980 and 1982; one with the longitudinal axis parallel to the coast of Voorne and a second plan with a longitudinal axis parallel to the coast of Goeree. Later on in the period 1990 – 2004, the final Plan 2 was developed incorporating the advantages of the two earlier plans.

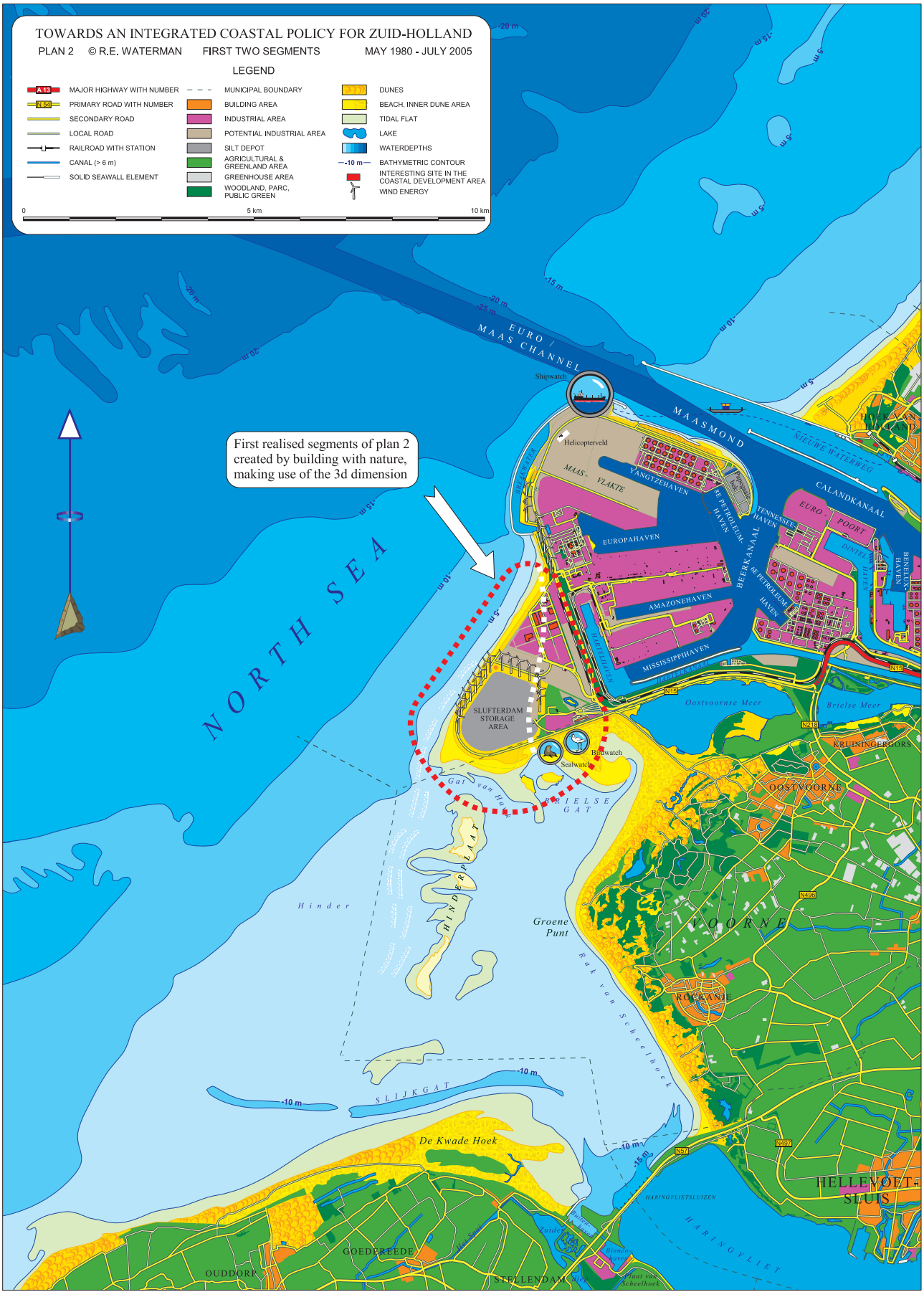
In the final Plan 2, the preferred southern longitudinal axis parallel to the coast of Goeree was designed as a demarcation line and as an inter-municipal boundary. this boundary defines on the north side an area designated for port and port-related activities developed in abidance with environmental standards, under the jurisdiction of the municipality of Rotterdam. This includes a container handling area, chemical factories, roll-on-roll-off, bulk storage and distribution area, absolutely environment-friendly storage and processing facilities for all types of waste, including contaminated sediments, pipeline, railway and road systems, cranes, quay walls and harbour basins.

In developing Plan 2, at first consideration was given to creating a new port entrance for this area. this proved not to be necessary as the present entrance is capable of handling 60,000 sea-going vessels per year, while at present only 30,000 are entering and leaving the port. Therefore Plan 2 utilises the existing entrance of the Port of Rotterdam since it is already able to double its present capacity.

To the south, the area is a triptych of newly designed and existing nature reserves under the jurisdiction of the municipality of West Voorne. Directly along the inter-municipal boundary is a new, narrow elongated nature reserve for terrestrial flora and fauna. Adjacent is a developing seascape, the so-called “Slufter”, which is an excellent mating, breeding and nursery habitat for marine organisms and birdlife. Next to this is an existing valuable nature reserve with over 700 species of higher vegetation, varying from the pioneer vegetation near the shore to the climax vegetation in the wooded inland area.

In both areas, in Rotterdam and West Voorne, provisions have been made for tourism and recreation facilities.

Figure 9: Plan 2, with segments 1 and 2 realized


TOWARDS AN INTEGRATED COASTAL POLICY FOR ZUID-HOLLAND
PLAN 2 © R.E. WATERMAN FIRST TWO SEGMENTS MAY 1980 - JULY 2005
LEGEND
MAJOR HIGHWAY WITH NUMBER
PRIMARY ROAD WITH NUMBER
SECONDARY ROAD
LOCAL ROAD
RAILROAD WITH STATION
CANAL (> 6 m)
SOLID SEAWALL ELEMENT
MUNICIPAL BOUNDARY
BUILDING AREA
INDUSTRIAL AREA
POTENTIAL INDUSTRIAL AREA
SILT DEPOT
AGRICULTURAL & GREENLAND AREA
GREENHOUSE AREA
WOODLAND, PARC, PUBLIC GREEN
DUNES
BEACH, INNER DUNE AREA
TIDAL FLAT
LAKE
WATERDEPTHS
BATHYMETRIC CONTOUR
INTERESTING SITE IN THE COASTAL DEVELOPMENT AREA
WIND ENERGY
0
5 km
10 km
First realised segments of plan 2 created by building with nature, making use of the 3d dimension
NORTH SEA
EURO / MAAS CHANNEL
MAASMOND
Shipwatch
Helicopterveld
MAAS-VLAKTE
YANGTZEHAVEN
EUROPAHAVEN
AMAZONEHAVEN
MISSISSIPPIHAVEN
BEERKANAAL
CALANDKANAAL
NIEUWE WATERWEG
EURO POORT
SLUFTERDAM STORAGE AREA
Birdwatch
Sealwatch
Oostvoornse Meer
Brielse Meer
KRUININGERGORS
OOSTVOORNE
BRIELSE GAT
HINDER PLAAT
Hinder
Groene Punt
ROCKANJE
SLIJKGAT
De Kwade Hoek
HELLEVOETSLUIS
HARINGVLIETSLUIZEN
HARINGVLIET
GOEDEREEDE
OUDDORP
STELLENDAM

Aeral picture of the finished Slufterdam project. First 2 segments of plan 2a and plan 2b, entrance World Port Rotterdam with New Waterway & Caland Channel, Europoort/Maas plan, Hook of Holland, Voorne, Primary Dam, Lake Oostvoorne, Hinderplaat, Haringvliet Dam with sluices and Goeree.

© R.E. Waterman

figure 10

Plan 2 started with the creation of the first two segments (See Figures 9 and 10). Sand needed for the realisation of these to segments was obtained by widening and deepening the Euro-Maas Channel and through internal dredging of 35 million m^3 within the second segment by the creation of a storage basin with an internal depth of 28 m – MSL and a surrounding dune with a height of 24 m + MSL. The storage basin within the Slufterdam has an internal storage capacity of 90 million m^3 for contaminated sediments (Figure 11).

The second segment was created from May 1986 to September 1987. Using the method of Building with Nature, a dune-beach perimeter as a natural sea defence was created, as was segment 1 earlier. Figure 12 shows an artist's rendering of the whole Plan 2 with terrestrial and marine nature reserve areas West Voorne.

The third segment within Plan 2 will be the so-called Rhine Plain or Second Maasvlakte. This segment covers 2000 ha (1000 ha land area & 1000 ha harbour basin area) and requires approximately 350 million m^3 sand, which is transported by trailing suction hopper dredgers (Figure 13).

A fourth segment is already being considered (Figure 14).

Figure 11: In the distance at the top of the photograph, the hollow Rhineland coastline – without any solid seawalls – can be seen. This coast has shown slight accretion since 1611. Where the hollow Rhineland coast meets the slightly convex attacked Delfland coast, the range of 68 Delfland Groynes commences. At the constructed Van Dixhoorn Triangle, north of Hoek van Holland 11 of these groynes are buried under sand and they are totally unnecessary. Below in front of and west of the motorway A15 the first 2 segments of Plan 2 are visible, with dunes and beach protecting them according to the principle of Building with Nature.

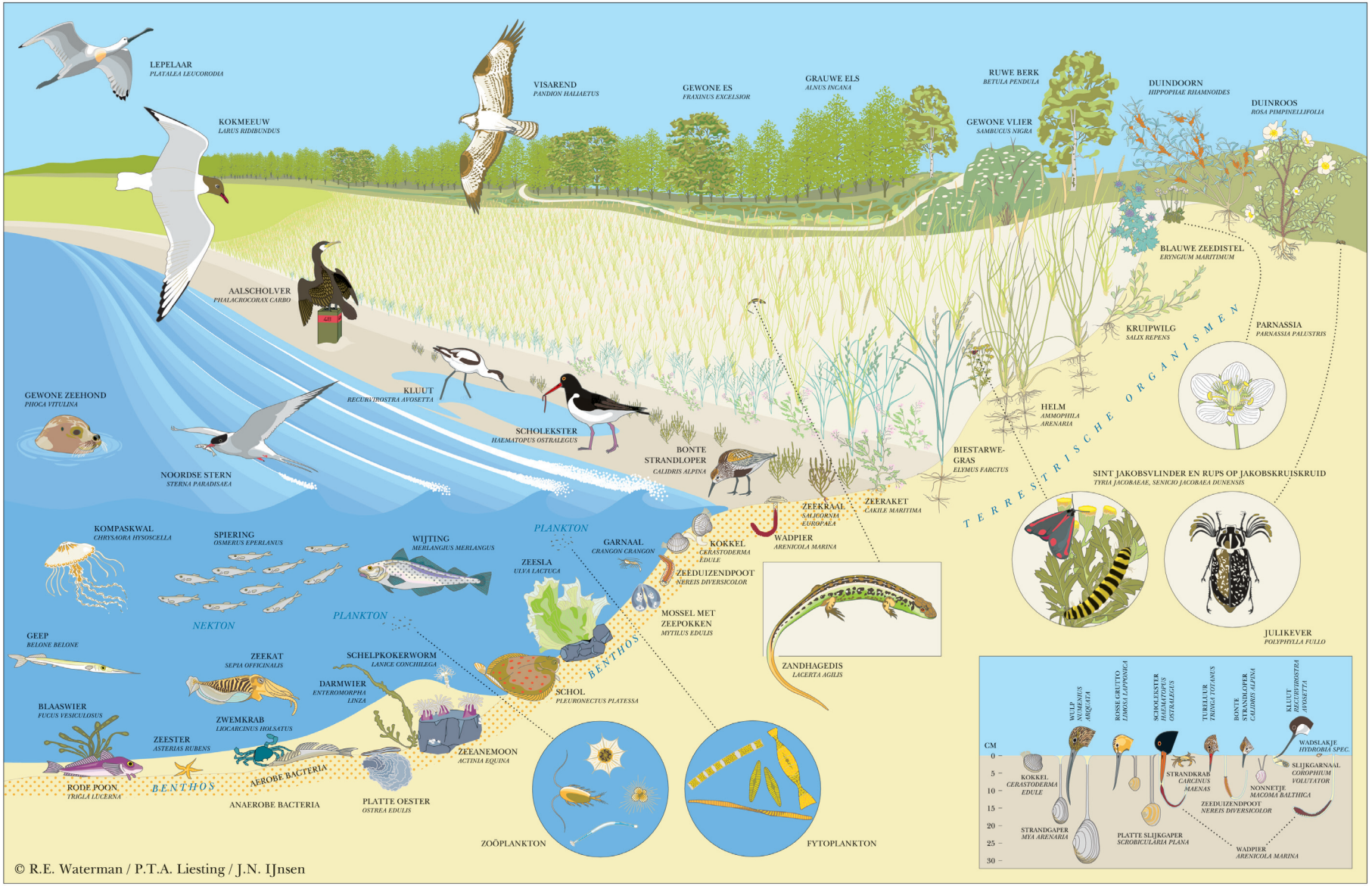


Figure 12: Artist ‘s rendering of Plan 2: The terrestrial and marine nature reserve areas Westvoorne, with flora and fauna.

PARNASSIA

photo P. Zonderwijk

LACERTA AGILIS JUVENILE WITH TYPICAL EYE SPOTS ON THE SIDE

photo T. Velthorst

Figure 13: Plan 2, Segments 1, 2 and 3.

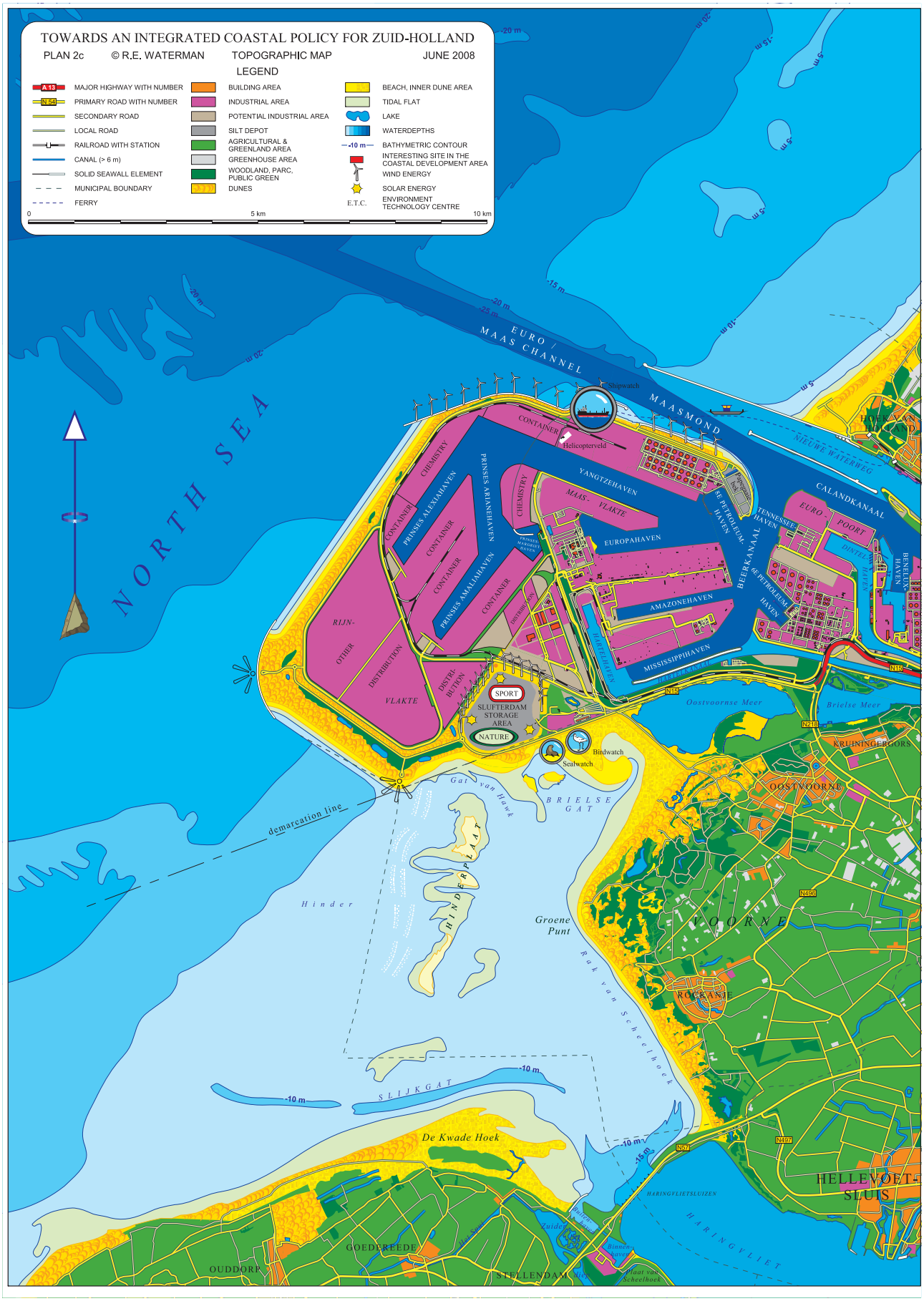


Figure 14: Plan 2, Segments 1, 2, 3 and 4.

Plan 3

Plan 3 is a multifunctional land reclamation in IJmuiden, on both sides of the entrance channel of the Port of Amsterdam, situated in the angle between the extended southern harbour mole of IJmuiden and the coast south of it (Plan 3a), and situated in the angle between the extended northern harbour mole of IJmuiden and the coast north of it (Plan 3b) (Figures 15, 16 and 17.)

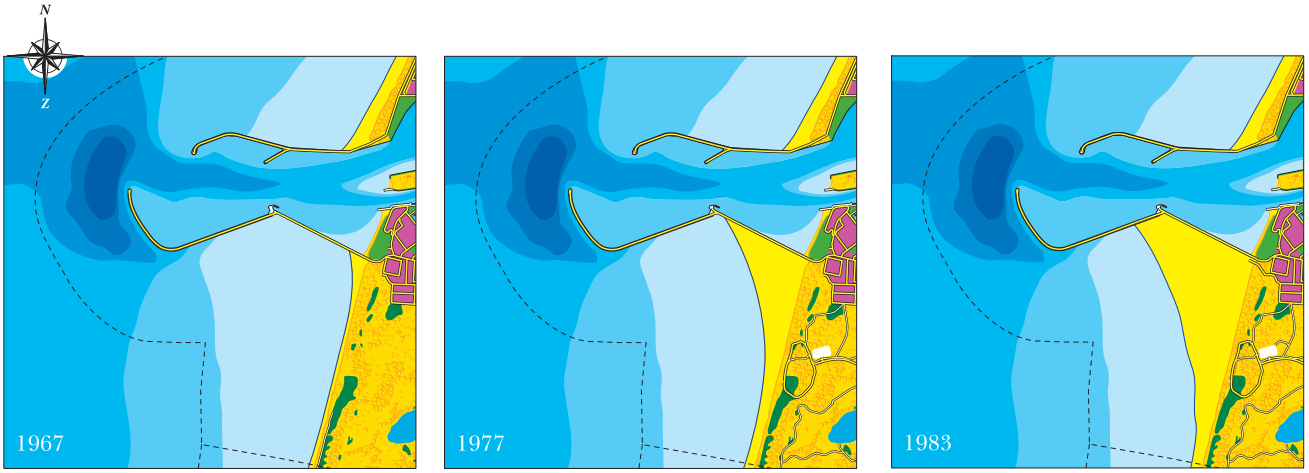


Figure 15: Seaport Marina IJmuiden / Kennemer Beach, Plan 3a. Nature already developed a new area south of the existing southern harbour mole of IJmuiden, owing to littoral sand transport in a northern direction along the coast from the Province of South Holland to the Province of North Holland. The process was quickened by human induced action – dredging external and internal waters.

Plan 3a has been completely realised and shows a perfect combination of Building through Nature and Building with Nature. It was primarily caused by a long shore net sand transport in northern direction. This sand was blocked and caught by the extended southern harbour mole of IJmuiden. In this way the plan started to come into being and Building through Nature found its expression. This process was quickened by the actions of people by using special dredging equipment and then in a later stage people completely took over and started to construct a marina, a double boulevard, a nautical centre, apartments, restaurants & shops, hotel capacity and an artificial lake.

In addition, following the methods of Building with Nature, conditions were created for the establishment of a new nature reserve area linked to an existing nature reserve area. After these conditions were created, Building through Nature once again took over.

At the inner side of the old southern harbour mole was projected a third harbour for IJmuiden with port related activities and a new perched beach with two rows of beach recreation dwellings. Plan 3a which started in 1983 has now been fully realised (Figures 16 and 17).

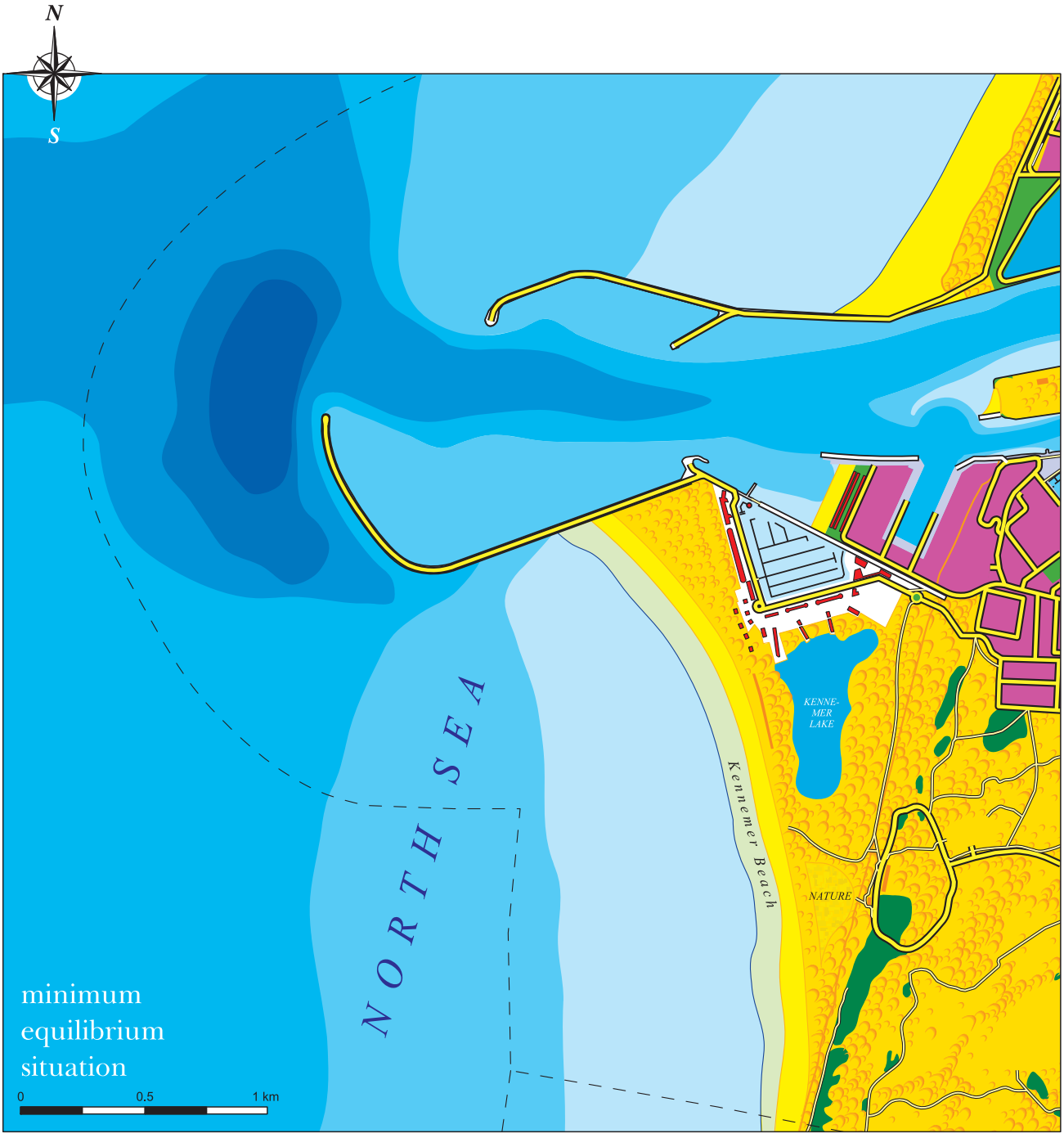


Figure 16: Plan 3A is triangle-shaped and consists of a primary range of dunes with a marina, double boulevard, apartments, restaurants and shops, hotel capacity, infrastructure, intensive recreation and tourism; transition zone with a lake (Kennemer Lake) ; a nature reserve area linked to an existing nature reserve area (Kennemer Dunes).
The developments are continuing. Nature extented itself on three sides of the lake, resulting in a larger nature reserve area in connection with the national park South Kennemer Land. A footbridge will be constructed at the entrance of the marina, while a new nautical centre will be situated at the eastern corner of the marina.
Along the West-Boulevard, at it's northern tip, a complex of high-rise apartment buildings will be realised. The total number of apartments will then reach 500. Attractive bicycle and footpaths will be provided for and of course adequate transport facilities together with 3300 parking places. In locations for police and rescue aid is foreseen and in space for five beach pavilions. In conjunction with a South-Boulevard an entrance square and a central square for leisure activities will be realised.

Figure 17: Birds'eye view of Plan 3a: Seaport Marina IJmuiden / Kennemer Lake / Kennemer Beach.

Conclusions: Plan 1, 2 and 3

It is interesting that all plans 1, 2 and 3 were created using the method of Building with Nature. They all have a dune-beach outer perimeter as coastal defence. They all include one or more nature reserves. They all have economic functions in harmony with the nature reserves, realized by carefully considered zoning and overall spatial planning.

And they all encompass a flexible master plan that was implemented in stages, segment after segment. Instead of using solid seawall elements as bulwarks against the sea, these dunes and beaches are realised in harmony with the sea, with a minimum of solid seawall elements and a low maintenance factor by beach nourishment.

Building with Nature leads to sustainability in harmony with the natural environment and has the advantages of an inherent flexibility, adaptability and coast effectiveness.

4. COASTAL ZONE DEVELOPMENT WORLDWIDE

As previously mentioned, approximately 80 percent of the largest population centres in the world are situated along coasts and in deltas with limited space available for living, working, tourism & recreation, for infrastructure and coastal defence. Therefore it is not surprising that forms of land reclamation can be found in the direct vicinity of these population centres all over the world. Remarkable examples are present on nearly all continents, in Europe as well as in Asia, in Africa and America, and even in Australia with its very thinly populated hinterland. There is such an abundance of examples, that only a select few can receive attention here.

More and more the focus is on well-balanced combinations of spatial functions, in which values related to environment, nature and landscape play an increasingly important role, and rightly so. Furthermore the importance of attractive new, extended and improved waterfronts comes prominently to the fore.

With regard to safety, here too the emphasis is no longer on the application of bulwarks against the sea in the form of solid seawall elements, but instead the emphasis is directed towards the creation of a flexible, dynamic, equilibrium coast consisting of dunes and beaches in harmony with the sea. Insofar as solid seawall elements are being applied, they are increasingly designed in such a way that they form an attractive substratum and habitat for marine organisms.

Environment-friendly dredging techniques are increasingly used. Integrated water resources management is introduced, including special attention to gradients from salt water to brackish and fresh water.

The importance of the development of both new terrestrial and marine nature reserve areas, in which net environmental gain is achieved, is being recognized and applied. In short, to some degree, both the concepts – Integrated Coastal Policy and Building with Nature – are gaining increasing acceptance worldwide.

In the following pages, a few examples of coastal extensions and waterfront developments in various parts of the world are presented in which these principles are beginning to be applied.

Waterfront Development Copenhagen in Harmony with Nature:

Amager Beach Park

A typical example of sustainable coastal zone development in harmony with nature is the Amager Beach Park Project near Copenhagen in Denmark.
The original coastline of around 2 km was more than tripled by creating an island in front of the original coast connected by three bridges and terminal structures on both ends to the north and south, complete with a tidal lagoon. The main wave directions at the site are northeast and southeast, which have been utilized to make two sections of outer beaches separated by a headland, one facing towards northeast and one facing towards southeast. In this way two outer beaches are created facing the Øresund Sound, the strait between Denmark and Sweden. The northern section has a natural beach environment with winding

paths, broad sandy beaches and low dunes. The southern section offers a so-called city beach with a broad promenade and park like grounds for ball play and picnicking. There are also a small marina and parking facilities at the southern end. On the inner side a lagoon is created with the original transformed beach and the new inner shore line. Various types of shore line perimeters were applicated,varying from beaches to quay walls and cobble stones protected shore lines. In the Øresund Sound there is water exchange between the Baltic and the North Sea and measures are taken to provide good flushing of the lagoon. The volume of sand necessary to create the island was for a large part excavated from the lagoon to a depth of between 2 and 4m -MSL and partly gained by extraction of outside marine sediments. Attention was paid to the type of available sand and to the grain size and grain size distribution of the sand. Careful attention was also paid to the beach profiles.

The Amager Beach Park, designed by DHI, Hasløv and Kjoersgaard and Niras, has been very well received by the inhabitants of Copenhagen and it has in an opinion poll been nominated as the best beach park in the Copenhagen area. It has also received a reward from the "Society for the Beautification of the Capital", and people are enjoying all the facilities in the park.
The plan was created from May 2004 to August 2005 by application of the method "Building with Nature". The island is 2 km long and the lagoon is 400 m at its widest point. The island is bisected, so that in the north you encounter a landscape of sand dunes and more park-like grounds in the south. Beach stations with facilities are situated in the middle of the island. These beach stations also act as lookout and vantage points, providing a fantastic view of large vessels plying the Øresund Sound and the planes preparing to land at Kastrup Airport. Provisions are present for wind and kite surfing, sea kayaking, beach volleyball, rowing, swimming, diving, sunbathing and festivals.
Copenhagen as capital of Denmark with a population of over 1 million inhabitants has in this way improved its coastal zone quality considerably through coastal zone development via Building with Nature.

Amager Beach Park, Copenhagen

General endorsed conclusions

For a succesful design of beach and lagoon elements in waterfront development it is essential that the hydraulic, coastal and environmental aspects are included in the planning from the earliest stage. The design of these elements has to follow the " rules of nature", which imposes certain restrictions with regard to the design. The main issues to be observed are:

Artificial Beaches:

- Good quality recreational beaches should be moderately exposed to waves; they should be oriented towards the direction of the prevailing waves to be stable and terminal structures should in serveral cases be constructed to prevent loss.
- Artificial beaches should be constructed by good quality beach sand:
  medium, i.e. 0.25 mm < d_{50} < 0.5 mm.
- Coastal structures adjacent to beaches should be designed so that no dangerous currents are generated.

Artificial Lagoons:

- High water quality standards should be ensured in recreational lagoons;
  the "flushing time" should be sufficient.
- The lagoon mouths should be stable and free of sedimentation.
- Water depths should be between 2 and 4 m.
- There must be no discharge of pollutants to the lagoon, such as sewage, storm water, brine, cooling water, pesticides & nutrients.

Waterfront developments in general:

- A thoroughly planned location and layout of the urban elements integrating recreational demands with the natural dynamics of artificial beaches is necessary.
- Coastal structures should also have recreational functions.

Reference: Carsten Mangor, Ida Brøker, Dan Hasløv, Waterfront Developments in Harmony with Nature, Terra et Aqua, number 111, June 2008.

Artificial Islands: Dubai, United Arab Emirates

The design and execution of a series of spectacular artificial islands in front of the coast of Dubai, based on the vision of H.H. General Sheikh Mohammed bin Rashid al Maktoum, Crown Prince of Dubai and UAE Defence Minister has marked a major achievement in the beginning of the 21st century.

Palm Island Jumeirah

The Palm Island Jumeirah can be considered as one of the most spectacular examples of land reclamation in the world. It was inspired by nature through the vision of a date palm tree projected in the sea and linked to the coast. The date palm tree is a symbol for valuable food production and for other-life-giving essentials in the emirate of Dubai, where the desert meets the sea (Figure 18).

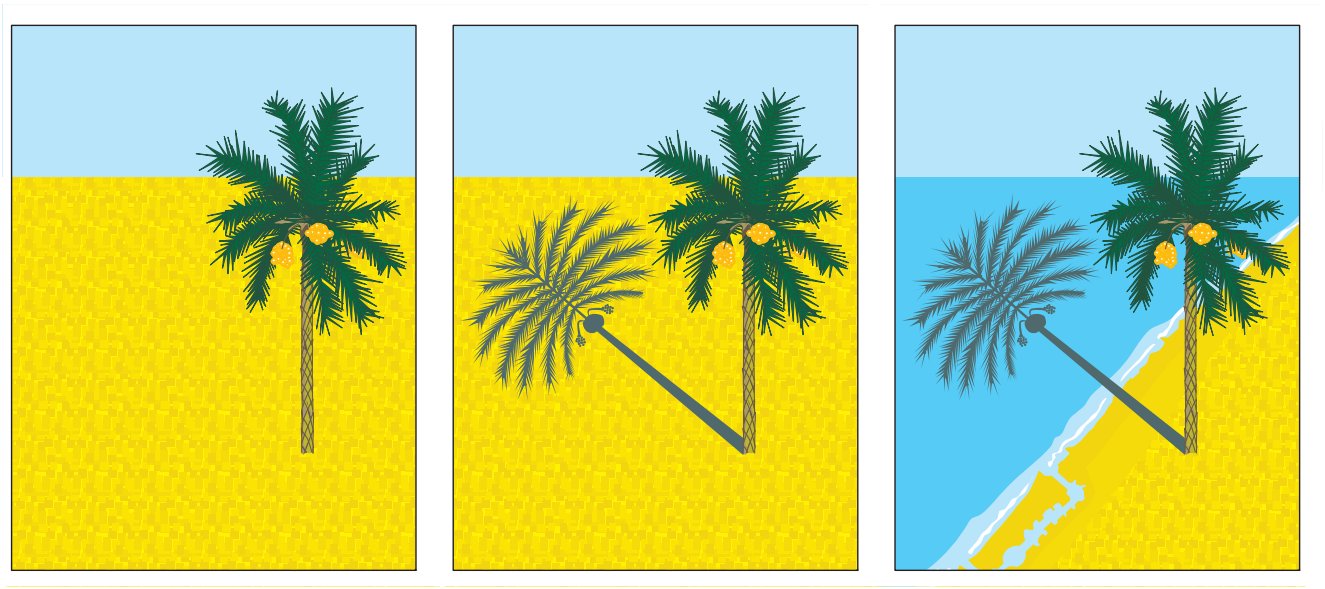
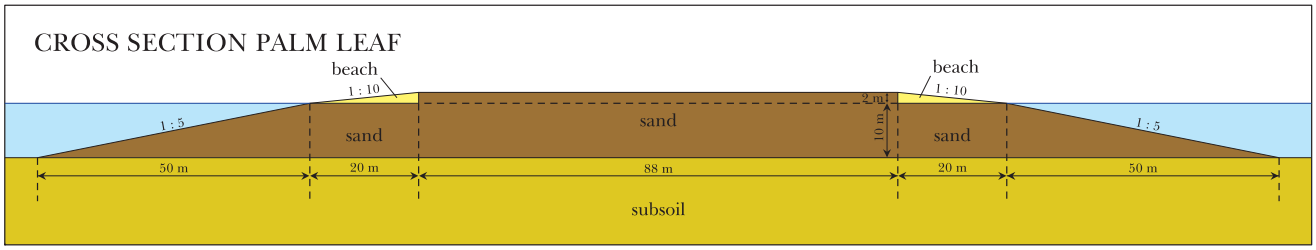


Figure 18: Overview Date Tree and its Shadow, the inspiration of the Palm Islands, Dubai.

The Palm Island is connected by a causeway and a bridge to the original coast. The trunk of the palm tree is 2 km long and 450 m wide and contains a stately palm lined motor parkway, a central 50 m wide canal, a pedestrian promenade, a high quality hotel and a theme park with ponds and lagoons. There are also shopping arcades with exclusive shops and boutiques, art galleries, restaurants, a gourmet supermarket, a panoramic tower with a rotating top restaurant, as well as utilities for energy and fresh water supply, ICT provisions, sewer system and waste-water purification units (Figure 19).

Figure 19: Palm Island Jumeirah can be considered as one of the most spectacular examples of land reclamation in the world.


Persian Gulf
N
S
Burj Al Arab Hotel
Palm Island, Jumeirah
Dubai
Abu Dhabi
PALM ISLAND, JUMEIRAH
Land reclamation project
Housing purposes
Industry
Parks and woods
Sea wall
Beach
Dessert
Diving site / Golf
0
400
800
1200
1600
2000 m


CROSS SECTION PALM LEAF
beach
1 : 10
beach
1 : 10
2 m
1 : 5
sand
sand
10 m
sand
1 : 5
50 m
20 m
88 m
20 m
50 m
subsoil

There are 17 palm-leaf-shaped peninsulas, each with a central access road flanked by architecturally designed villas with private beaches, swimming pools and docking facilities. The length of the beaches around the palm leaves along the 1,000 single-family villas adds to a 60 km of coastline, whereas the width of the original coast leading to the causeway of the island is less than 80 m.

A crescent-shaped barrier reef (berm breakwater) 13 km in length, acts as a protection for the Palm Island by creating a relatively calm sea around the island. The cross-section of the crescent is specially designed in width and height with an outside armouring by rocks to ensure stability and to minimize overtopping of waves. In the 200 m wide crescent, there are two openings of 100 m each to ensure water quality by adequate water flow around the Palm Island and to ensure waterway access.

The inner side of the crescent consists of sandy beaches. On the crescent there are 10 -15 theme resort hotels, a spa and health facilities. In the vicinity of the crescent, artificial coral reefs are provided, including shipwrecks, plane wrecks and replicas of archaeological objects. This series of artificial coral reefs were specifically designed by marine biologists. A special diving centre was built with provisions for diving activities, from which these reefs and marine organisms can be observed and studied.

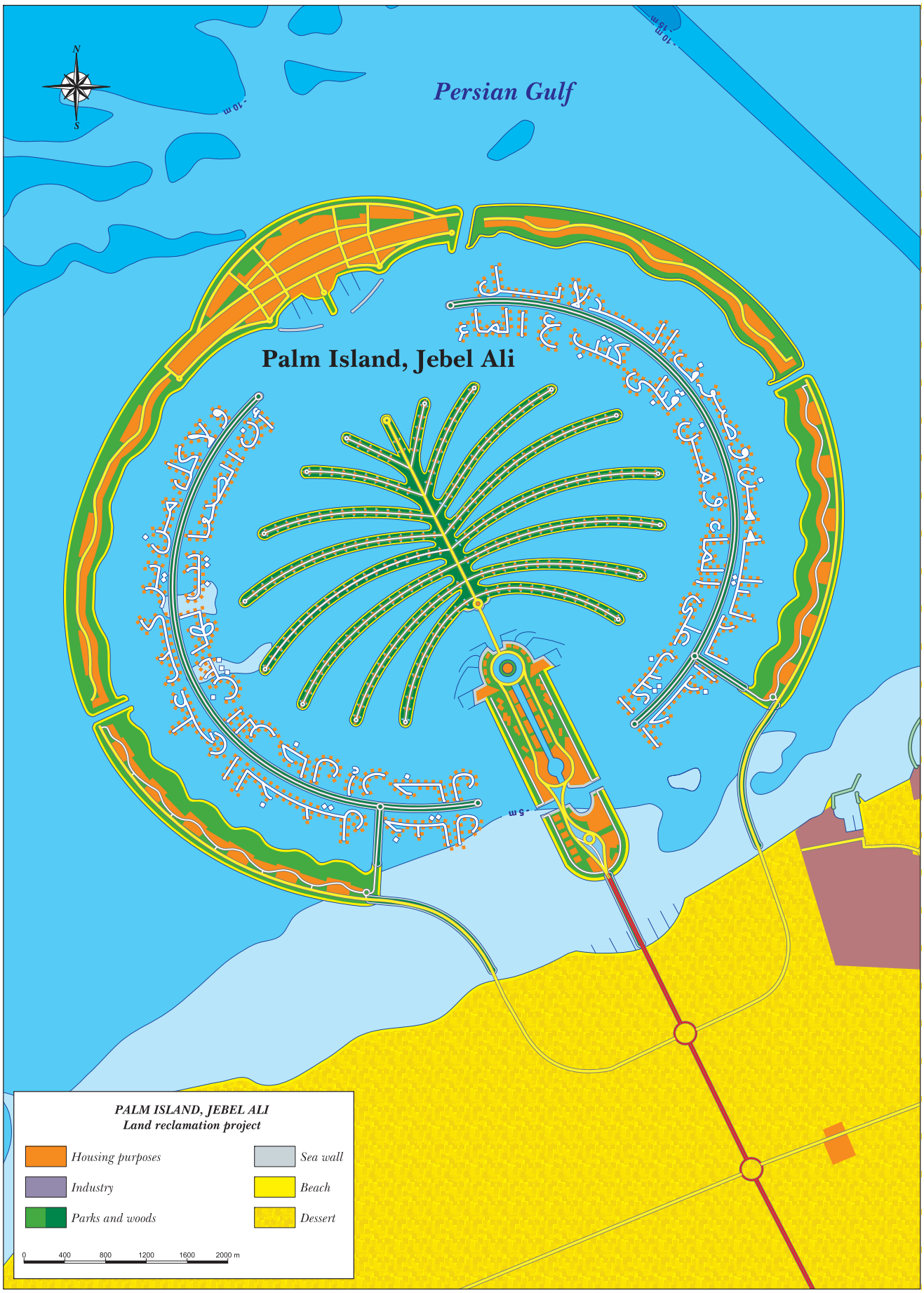
There is a Central Marina Village with two marinas, one on each side of the trunk, symbolising the clusters of dates in the palm tree. In addition, two islands on each side of the base of the trunk were created in the shape of the logo of the developing company and its mirror image. Each of these two 14 ha large private islands is equipped with berths and facilities for a large-scale yacht. The Sheik's own yacht measures 160 m in length; quay length is 200 m.

The construction of the palm leaves was executed using the method of Building with Nature. The total surface area of Palm Island Jumeirah is 650 ha. The amount of sand needed to create this project was 110 million m^3 and was obtained from the seabed by trailing suction hopper dredgers. To realize the berm breakwater along the outer side of the crescent, 9 million tones of rocky material were used. This rocky material was obtained from 16 quarries in the hinterland. Construction started October 2001 and was completed in 2003. Preceding this ambitious project was the design and construction of a small delta-shaped island connected by a bridge with the mainland. On this island the very luxurious seven-star 321 m high Burj al-Arab Hotel was built. The shape of this landmark hotel was inspired by a billowing sail of an Arab dhow (Figure 19).

Palm Island Jebel Ali

After the first Palm Island Jumeirah, a second, 50 percent larger Palm Island Jebel Ali was designed. This island is situated at a distance of 22 km from the first island, and like the first island is connected to the coast. Similar to the Palm Jumeirah, the shape of this second island is also based on a palm tree with a trunk, 17 palm leaves and a 15,5 km long outer crescent also acting as a protective breakwater (Figure 20).

Figure 20: The second Palm Island, Jebel Ali, is 50 percent larger than Palm Island Jumeirah (which is 650 ha).


Persian Gulf
Palm Island, Jebel Ali
PALM ISLAND, JEBEL ALI
Land reclamation project
Housing purposes
Industry
Parks and woods
Sea wall
Beach
Dessert
0
400
800
1200
1600
2000 m

A Sea Village will feature on the trunk, which measures 2.4 km in length and 450 m in width, with hotels, apartments, shops, restaurants, marinas and a sea aquarium.

The Palm Island Jebel Ali has an inner crescent with attached shapes in the form of Arab characters, which together compose the verse of an Arabic poem, which translates as

"Take wisdom from wise people – Not everyone who rides a horse is a jockey.
Great men rise to great challenges. It takes a man of vision to write on water".

On top of these Arab characters, 1,060 Water Homes are built on concrete stilts with wooden structures on top. Each of these Water Homes has attractive waterfronts. The depth of the water below the homes is approximately 8 to 10 m, and each home covers a built up area of 360 m^2. Each Water Home has boardwalk access to a common parking area and private moorings for personal yachts. In addition, the outer crescent can accommodate a series of functions for recreation and living. Another modification in comparison to the first palm island, are the "fingers" on both ends of the Palm Island Jebel Ali outer crescent where luxury apartment blocks are located. In total, there will be approximately 2,000 Signature Villas, Garden Homes and Town Homes together with luxury apartment buildings in addition to the aforementioned Water Homes.

The island will be 7.5 km in width and 7 km in length. The Palm Island Jebel Ali will be connected to the mainland via three bridges, one linking the trunk and one at either side leading to the end of the crescents.

After years of designing and planning, the construction of each Palm Island takes approximately two years to raise the island from the sea and another three years to complete the infrastructure and the buildings.

The project started in 2002, completion was expected in 2007. For the realization 140 million m^3 sand is needed and many millions m^3 of rocky material for the construction of the berm breakwater at the outer side of the crescent. This berm breakwater acts also as a substrate and has niches which are both attractive for marine organisms and birdlife.

The World

Another artificial island project "The World" is designed in the shape of an ellipse of 6 by 9 km and is situated at a depth of 15 to 20 m – MSL (Figure 21).

"The World" is located at a distance of approximately 5 km from the coast. Access to each island will be by marine transport, since there will be no road access. "The World" has a protective outer breakwater of 25 km – the longest breakwater ever built – with on the inner side approximately 300 islands. Together these give a visual representation of the six continents of the world. The surface area of these islands within the Island Archipelago varies from circa 2.5 to 8.5 ha. The distance between the individual islands varies from 50 – 100 m. The islands are divided into four categories, for private homes, for estates, for so-called dream resorts, and for communal use. In itself it is an attractive thought that it is possible to sail around "The World" in three hours. For the creation of "The World" 325 million m^3 sand and 32 million tonnes of rocky material are required. The project commenced in 2004 and completion was expected by the end of 2007.

Figure 21: Another extensive artificial island project, "The World".


N
S
Persian Gulf
-15 m
The World
Persian Gulf
-10 m
-5 m
Dubai
THE WORLD
Land reclamation project
Housing purposes
Parks and woods
Sea wall
Beach
0
400
800
1200
1600
2000 m
Artificial Reef "The World" Cross section berm breakwater
+4.00
rock
sea
quarry run
sand
-0.50M
caprock / sandstone
18260

Palm Island Deira

A third Palm Island exceeds the other preceding islands in size, surface are, coastal length and required amounts of sand and rocky material. The design has not been finalized yet, but will likely have 41 palm fronds with central veins in the form of roads, with villas on both sides and private beaches. Again, a protective outer crescent with a length of 21 km in the form of a berm breakwater has been included. The overall length from trunk base to the central tip of the outer crescent is 16.5 km, whereas the overall width is 9 km. The total surface area is around 80 km^2. In the direct vicinity of the trunk base from left to right the so-called Deira Corniche is under construction (Figure 22).

Figure 22: Palm Island Deira, the third Palm Island, exceeds the other preceding islands in size, surface area, coastal length and required amounts of sand and rocky material.

The construction of Palm Island Deira, together with the Deira Corniche, results in increasing the local coastal length to almost 400 km. The sea depth of the construction area varies from 6 to 22 m – MSL. The quantities needed for the construction are a staggering 1,300 million m^3 of sand and 42 million tonnes of rock. The construction of Palm Deira is therefore the largest reclamation project in volume of replaced material ever undertaken.

Palm Island Deira will include facilities for leisure, recreation and tourism, more than 7000 villas, a large number of luxurious hotels, several large marinas, restaurants, shopping malls, art galleries, sports facilities, cinemas, and so on. The crescent is divided into 12 segments to ensure shipping accessibility as well. Each segment contains a number of finger shaped peninsulas in order to lengthen the waterfronts and their beaches. Each frond has at its tip a park for communal use.

A road infrastructure has been provided for, complete with fly-overs, bridges and tunnels, sewer systems, wastewater purification, a storm water drainage system, irrigation, drinking water supply, natural gas supply, telecommunication, electricity supply, cooling water provision, marinas, port facilities, fire fighting systems, safety precaution measures, separate waste collection, recycling & processing, navigation channels, landscape and waterscape architecture and integrated water management. Special attention is paid to parks and greenery.

The vast dredging and construction works have commenced in 2005 and the duration will be around 8 years.

However, Palm Island Deira is far too ambitious. It requires a vast amount of 1,300 million m^3 sand, to be extracted from the seabed of the Persian Gulf with serious environmental consequences. The extraction causes interruption of the groundwater flow from mountainous Iran to the Emirates. Fresh groundwater is lost in the Persian Gulf. Furthermore there are also negative influences on the ecosystem of the seabed. Palm Island Deira in its original design has a poor ratio of new surface area versus volume of sand required, with consequently prohibitive costs and an overall negative cost-benefit analysis. Therefore, the final plan will be considerably downsized and several mitigating measures have to be taken to safeguard the environment.


Persian Gulf
The Palm, Deira
Dubay
The Creek
PALM ISLAND, DEIRA
Land reclamation project
Housing purposes
Harbor, industry
Parks and woods
Sea wall
Beach
Dessert
0 400 800 1200 1600 2000 m

Dubai Waterfront Project

This fifth, ambitious project is located both in the Arabian Gulf and in the mainland of Dubai. It involves integration of land into the sea and of water into the new and the old land. As far as the latter is concerned a 75 km long canal, the so-called Arabian Canal, will be dug as well as a series of water courses connected to this canal. This will be combined with a number of impressive developments on the existing land and on the new land in the sea, making use of all the newly created waterfronts (Figure 23).

The project comprises a substantial crescent shaped development around the western side of Palm Island Jebel Ali.

The nucleus structure of this development has the shape of a waxing moon (first quarter). This crescent has twelve districts, partly situated in the old land and partly situated in the new land.

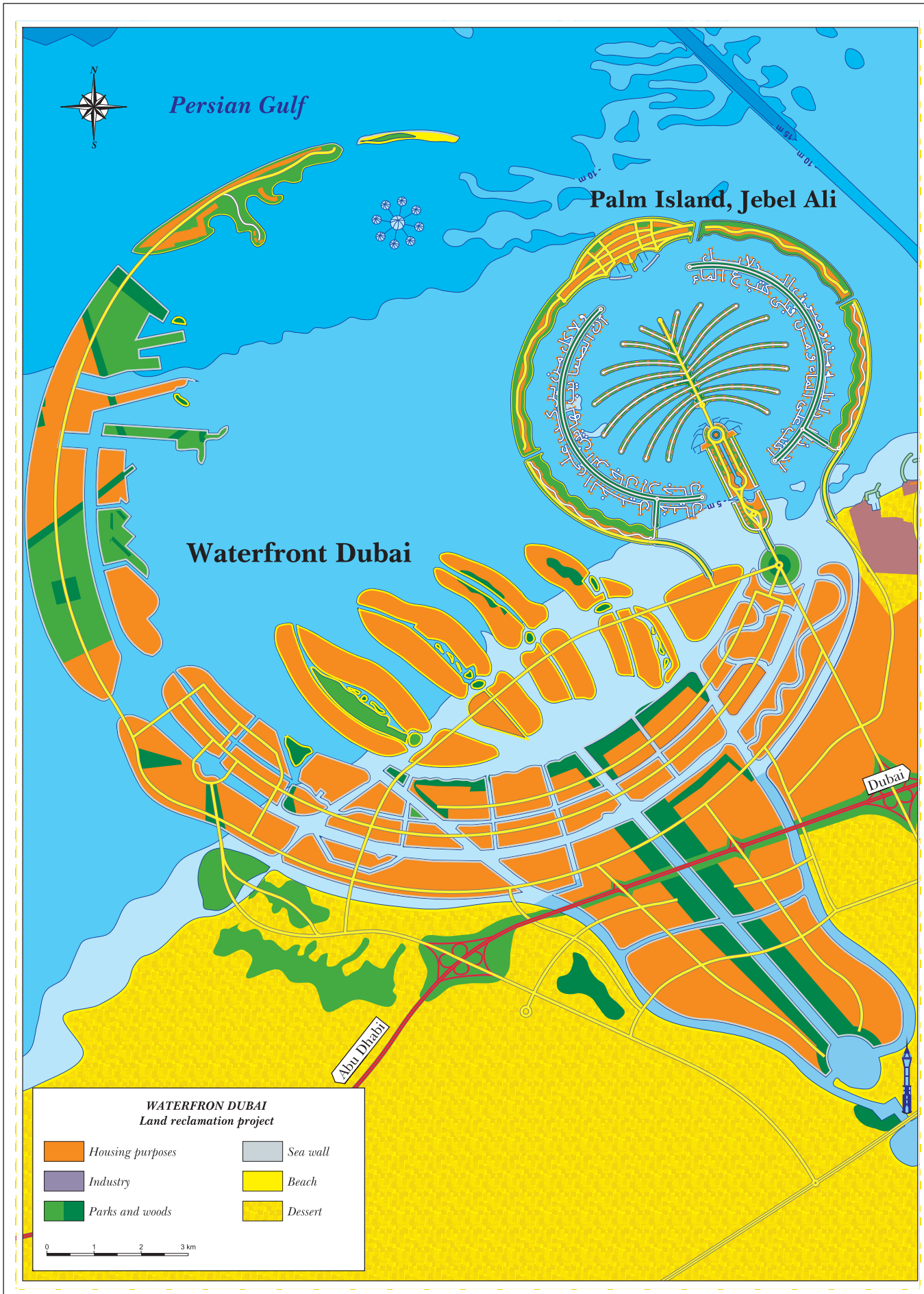
They are: Al Ras, Outer Corniche, Inner Corniche, The Riviera, The Promenade, Al Mina, The Peninsula, The Palm Boulevard, Madinat al-Arab, Downtown, Boulevard and The Exchange. In the vicinity there are Jumeirah Lake Towers, Jumeirah Islands, The Gardens Shopping Mall, and the existing Jebel Ali Harbour.

The project comprises 8,100 ha of waterfront related area for mixed uses. This includes living and working space for 400,000-750,000 people divided over 250 communities. Realisation of this project will imply lengthening the original coastline by around 800 km. In addition 5 km^2 of coral reef will also be constructed.

Reflections

The dimensions of the five projects are such that – as the Dubai promotion team points out – they can be observed from the moon. This was also the objective. In this way, Dubai puts itself on the world map literally and figuratively (Figure 24).

Figure 23: Dubai Waterfront Project


Persian Gulf
Palm Island, Jebel Ali
Waterfront Dubai
Dubai
Abu Dhabi
WATERFRON DUBAI
Land reclamation project
Housing purposes
Industry
Parks and woods
Sea wall
Beach
Dessert
0
1
2
3 km

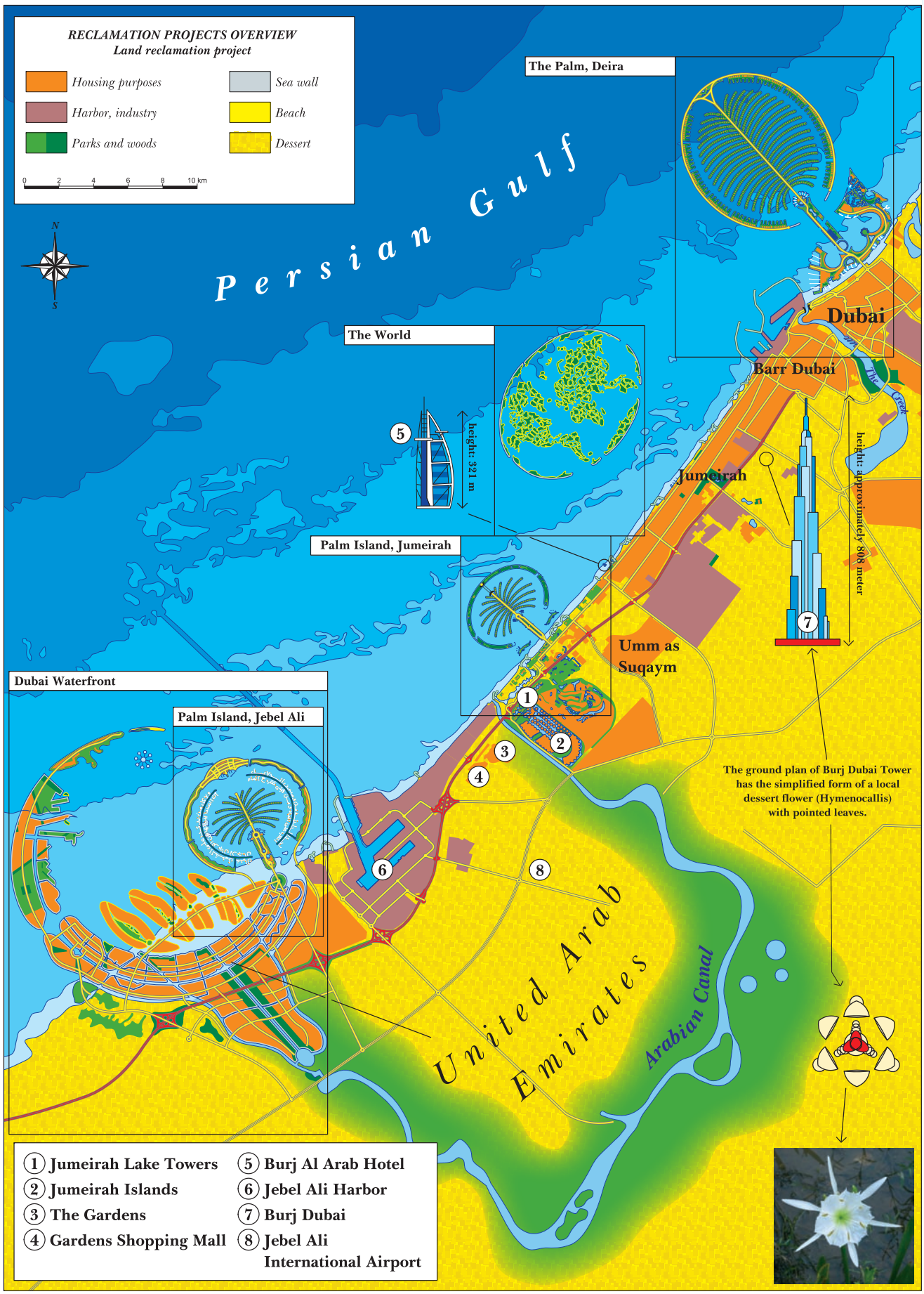

RECLAMATION PROJECTS OVERVIEW
Land reclamation project
Housing purposes
Harbor, industry
Parks and woods
Sea wall
Beach
Dessert
0 2 4 6 8 10 km
N
S
Persian Gulf
The Palm, Deira
The World
Palm Island, Jumeirah
Palm Island, Jebel Ali
Dubai Waterfront
Dubai
Barr Dubai
Jumeirah
Umm as Suqaym
height: 321 m
height: approximately 808 meter
The ground plan of Burj Dubai Tower has the simplified form of a local dessert flower (Hymenocallis) with pointed leaves.
United Arab Emirates
Arabian Canal
1 Jumeirah Lake Towers
2 Jumeirah Islands
3 The Gardens
4 Gardens Shopping Mall
5 Burj Al Arab Hotel
6 Jebel Ali Harbor
7 Burj Dubai
8 Jebel Ali International Airport

Figure 24. Overview of all the Dubai Land Reclamation Projects.
The coast in its totality, including the Arabian Canal.
Right the world's tallest skyscraper, the Burj Dubai with a height of 808 m.
The base of the building is in the form of a common desert flower blossom.

The strategic position of the United Arab Emirates, bordering the Arabian/Persian Gulf and the Straits of Hormuz, their enduring merchant spirit, the vicinity of fossil fuels, together enable the UAE, including Dubai, to develop themselves into a very prosperous federation. With modern ports and airports, Dubai has become an important logistics, distribution and trade centre between Europe and Asia.

The fascinating aspect of these developments is that they include both a seaward expansion as well as land inward development, with special attention to existing and newly created waterfronts. Furthermore, they are not limited to only two dimensions as the concept comprises also a third dimension, upward into the air and downward into the sea. There are manifold examples of this concept. These include the construction of the tallest skyscraper in the world, the realization of a complete underwater hotel and diving centre, and also the creation of a Snow & Ice Sports Centre in the middle of the desert.

Bear in mind that the original inspiration was taken from nature, that is, an island resembling the shadow of a date palm. Furthermore, during the execution of the various land reclamations more and more attention was paid to the principles related to Building with Nature. This refers to both the methods of dredging and creating the new land as well as to establishing conditions for marine and terrestrial nature development. This also has involved carrying out mitigating and compensation measures there where existing nature has been affected.

Hydraulic engineering construction of the series of islands, Palm Island Jumeirah, Palm Island Jebel Ali, The World, Palm Island Deira and Dubai Waterfront, influences the wave and flow pattern in the Arabian/Persian Gulf. The beaches in the sphere of influence shall adapt themselves causing local erosion and accretion. These influences will be considered before the execution of these projects through model studies. The results are being used for the Total Development Plan of the coastal zone, including all the aforementioned islands. This has led to adaptation of the detailed designs of these islands.

As mentioned before, attention has been paid to the marine environment, including the realization of artificial reefs and the creation in general of favourable conditions for marine organisms and birdlife. Marine biologists and other specialists were and are involved in this process. Experience gained in earlier projects has been used. Although execution of the aforementioned projects has led to initial disturbance of the environment, provisions are made for net environmental gain in due time. Of the utmost importance are not only the implementation of environment-friendly dredging methods and the thoughtful designed construction of breakwaters, but also the ensuing careful urban development, landscaping, waterscaping and the final operation and maintenance of the newly created territories.

Similar spectacular coastal zone developments can also be found in other parts of the Arabian Peninsula along the coasts of the other emirates, Saudi Arabia, Qatar, Bahrain and Oman.

Municipalidad de la Costa, Argentina

República Argentina covers 2,780,000 km^2 and is thereby the eighth largest country in the world. It has a coastline of almost 5,000 km along the Rio de la Plata and the Atlantic Ocean. Its capital Buenos Aires has approximately 12 million inhabitants and is situated at the Rio de la Plata, whereas the total number of inhabitants of the country is over 40 million (2007).

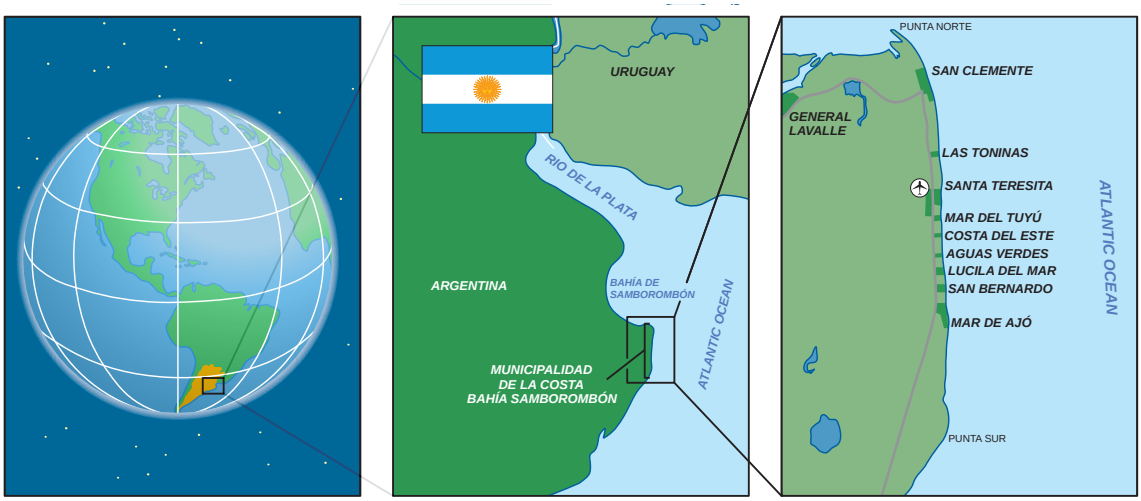
The most spectacular land reclamation plan Aeroisla concerns an artificial island in the Rio de la Plata with an airport complete with other functions. In the future, a bridge and tunnel connection between Buenos Aires and Colonia del Sacramento (Uruguay) is considered. At this time however, these very ambitious plans are far from being realised.

Expansion step-by-step of the most important harbours is taking place, coupled with dredging wherever necessary for the approach channels and harbour basins. Applying the principle of "making work with work" coupling dredging with land reclamation plays a role in this process. Attention should be given to the coastal stretch south of the Bahia de Somborombón from Punta Rasa to Punta Médanos. This coastal stretch of 65 km facing the full expanse of the Atlantic Ocean are the Municipalidad de la Costa consisting of San Clemente del Tuyú, Las Toninas, Santa Teresita, Mar del Tuyú, Costa del Este, Aguas Verdes, La Lucila del Mar, San Bernardo and Mar de Ajó.

This coastal stretch has a very important function for tourism & recreation, especially for the population of the greater metropolitan area of Buenos Aires. There are many hotels, restaurants and their facilities along a seaside boulevard, which was originally protected by a primary range of dunes, with a beach in front. However, over a stretch of 25 km, comprising all the Municipalidad de la Costa, with the exception of San Clemente del Tuyú, a terrible mistake was made by levelling parts of the primary range of dunes, followed by building hotels and seaside pavilions there, resulting in severe coastal erosion. The results were indeed dramatic, as hotels collapsed and the seaside boulevard was attacked.

Incorrect advice led to the construction of solid seawall elements, which only aggravated the problem. Reflected waves caused scouring. The concrete walls were undermined, broke and caused havoc.

Having carefully studied the problem the ideal solution is to recreate a primary range of dunes with a new beach in front by supplying sand from the seabed using trailer suction hopper dredgers. In this way, a resilient coast is created, whereby the primary range of dunes must be restored and maintained without building any artificial structure on it and in it (Figure 25).



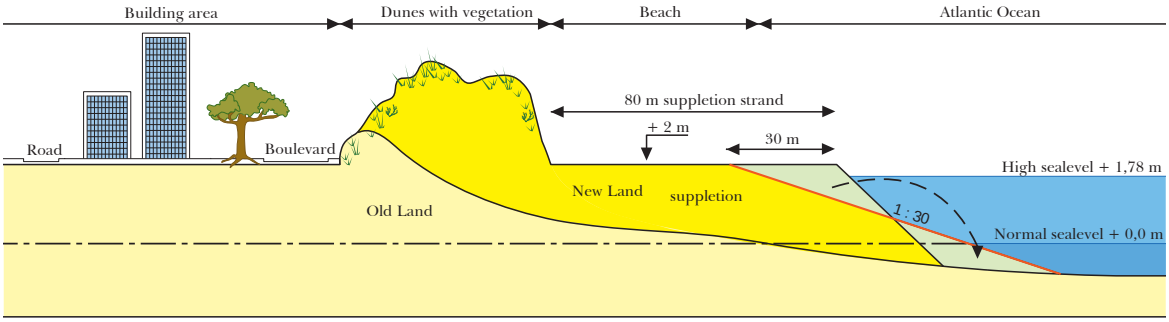
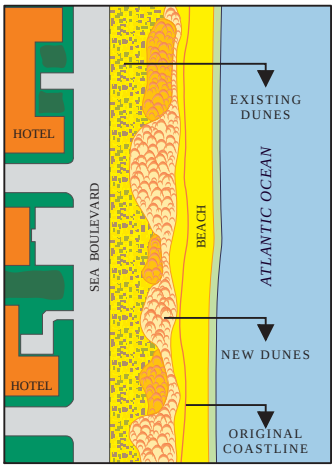
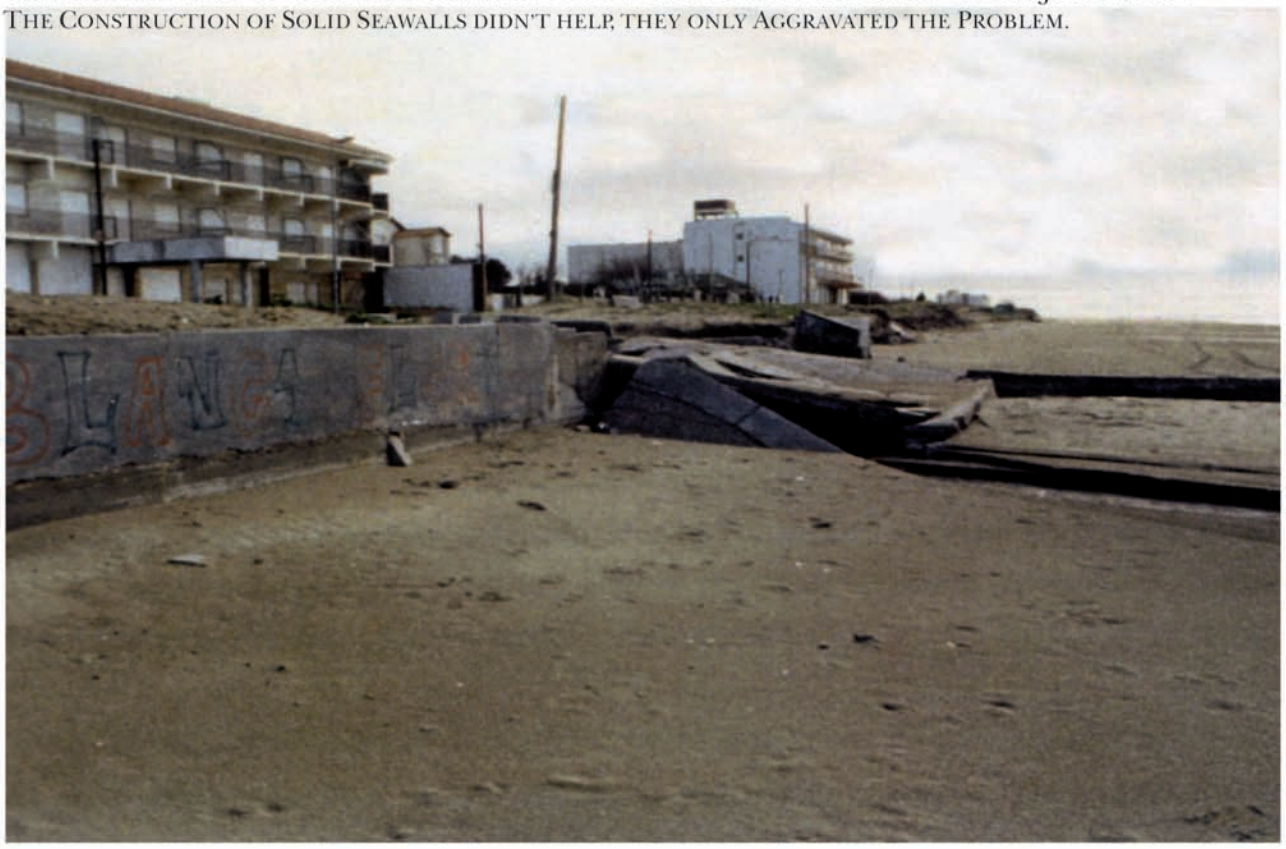


Figure 25: General overview of the beaches of Argentina on the Atlantic Coast, with the cross section of the old and new land, showing location of dune widening and the new beach.



DISASTROUS SITUATION MUNICIPALIDAD DE LA COSTA: 1 x MAR DE AJO & 4 x MAR DEL TUYU
THE PRIMARY RANGE OF DUNES WAS LEVELLED FOR HOTELS & SEASIDE PAVILIONS. WRONG JUDGEMENT !!
THE CONSTRUCTION OF SOLID SEAWALLS DIDN'T HELP, THEY ONLY AGGRAVATED THE PROBLEM.



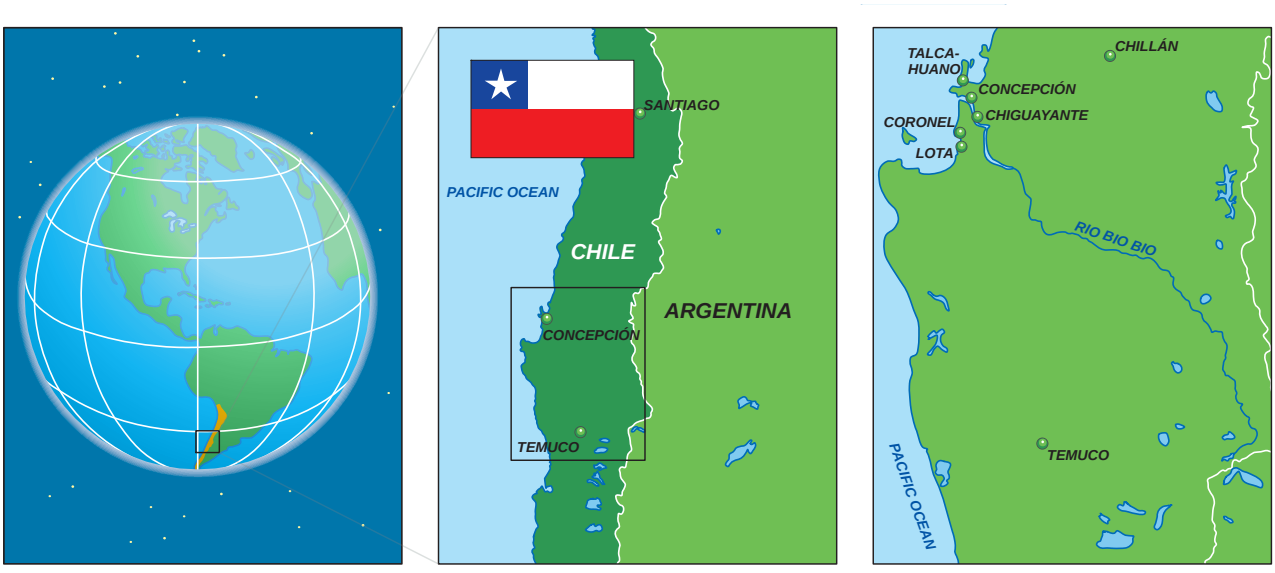
SAN CLEMENTE DEL TUYÚ
FAVOURABLE SITUATION, IN WHICH THE ORIGINAL SEA DEFENCE COASTAL DUNE IS LARGELY LEFT INTACT.

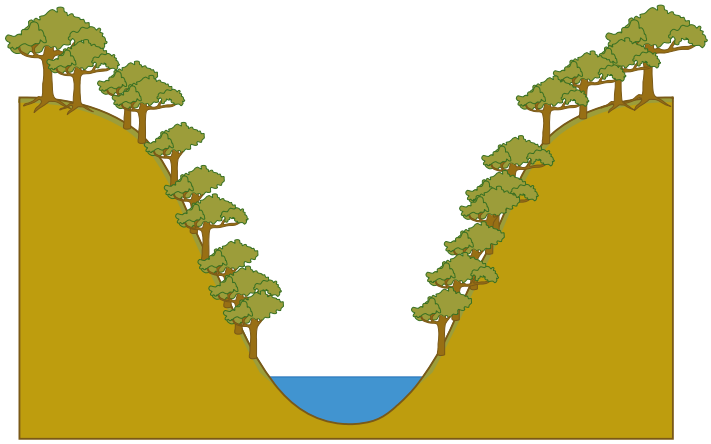
Rio Bio Bio restauration – Chile

República de Chile, facing the Pacific Ocean and bordering Bolivia, Peru and Argentina along the Andes mountain range, has a surface area of approximately 757,000 km^2 and a population of approximately 17 million inhabitants (2010). Due to its extraordinary elongated shape with limited width, varying between 90 and 380 km, and a length of 4,274 km it has a coastline of 6,435 km. Along its coastline circa 70 ports are located. The main ports from north to south are Arica, Iquique, Antofagasta, Coquimbo, Valparaíso, San Antonio, Talcahuano, Concepción, Puerto Montt and Punta Arenas. Several of these existing ports and a few new ports are further developed, to some limited extent by land reclamation on the one hand and by the creation of harbour basins within the existing land on the other hand.

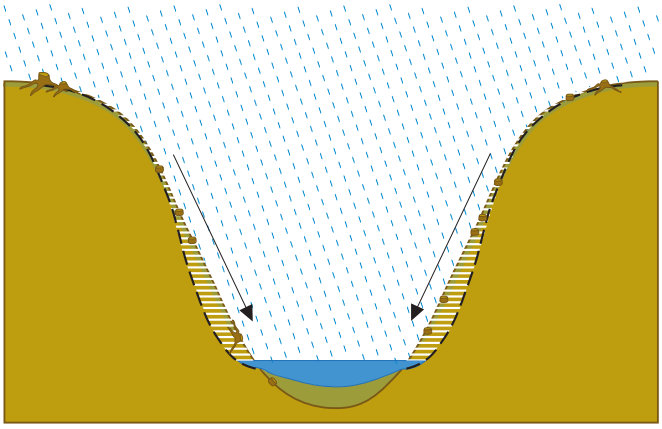
Leaving these port developments aside for the moment, we will turn our attention to a very special project involving the longest river of Chile, the Rio Bio Bio. The Rio Bio Bio has its origin in the Andes and flows through steep and narrow gorges and forests of araucaria pine and passes through agricultural lands and cities, until it reaches the Pacific Ocean, 380 km from its source. Over one million people use the resources of the Rio Bio Bio for drinking and irrigation water, recreation and fisheries. Construction of six hydro-electric dams in the upper Rio Bio Bio is being considered.
The lower Rio Bio Bio was once navigable for around 100 km. However, because of the extensive logging of trees for timber, erosion of the river slopes occurred. This human-induced erosion created a wider, but shallower riverbed, which in turn caused reduced navigability and the reduction of fertile land.
Nowadays, by planting trees and shrubs on the slopes, erosion has been stopped and the riverbanks have been restored. In addition, by planting tree saplings in the river itself, local sedimentation and land reclamation in the river takes place, which in turn forces the river into a narrower and deeper riverbed, thereby restoring the original river depth and hence its navigability.

In its entirety, this Rio Bio Bio restoration project is a beautiful example of Building with Nature.

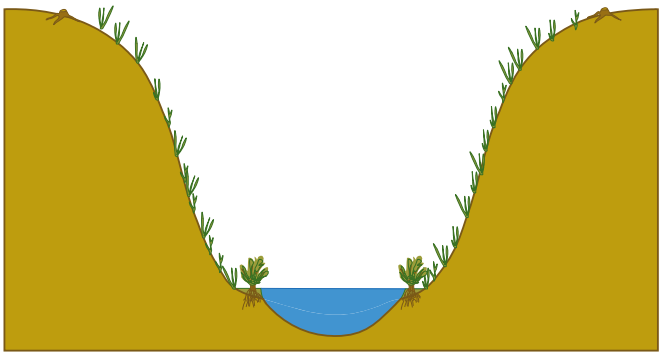




Cross section with man-induced erosion by tree logging leading to a wider but less deep riverbed which in turn causes reduced navigatebility and reduction of fertile land.



Cross section with river bank restoration by tree planting and planting of tree saplings in the river causing local sedimentation and land reclamation, which in turn forces the river in a narrower and deeper riverbed, thereby restoring the original river depth.



Curaçao – the Caribbean

Curaçao, Aruba, Bonaire, St. Eustatius, St. Maarten and Saba belong to the Lesser Antilles and are situated in the Caribbean. Curaçao, like Aruba and Bonaire, is located off the coast of Venezuela at a distance of approximately 70 km. Curaçao has a surface area of 444 km^2 and has a population of 150,000. The length of the islands is 61 km and its width varies from 5 to 14 km.
The total coastal length is around 200 km. The island has an interesting geological history that finds its expression in the landscape and in the morphology of the coast. The capital Willemstad is beautifully positioned along the Saint Anna Bay, with its famous "Pontjesbrug" (Pontoon Bridge), and the larger "Schottegat" (Bay). The old partially restored city with Fort Amsterdam, Water Fort and Rif Fort, has been declared a World Heritage Site. The various nature parks, the historic plantations with their mansions, the manifold tourist attractions along the varied coast, the previously mentioned beautiful bay with its numerous shipping activities, other port-related activities and the still active oil refinery complex, are all worth mentioning.

The focus here is on a special coastal zone development project in which land into sea and water into the old and into the new land are integrated. The principle of Building with Nature and Integrated Coastal Policy were both applied in this project.

The project concerns a transformation of a coastal segment on the south western side of Curaçao, east of Willemstad with a length of approximately 1 km.
This coastal stretch used to be a severely neglected area with a garbage dump and adjacent polluted partially swampy area. The cleaning-up and transformation plan was designed by Adrian "Dutch" Schrier and executed for a large part under his own supervision. Advice was given by Professor Dr. J.F. Agema.

The project is known under the name of Curaçao Sea Aquarium. It comprises parks, artificial beaches, specially designed coast parallel breakwaters, lagoons, a marina, an ocean resort, hotel and condominiums, disco, bar, restaurants, fitness centre, dive shop, a public sea aquarium, a maritime museum and educational centre, gift shop, footpaths and roads and parking facilities. The lagoons encompass a dolphin therapy lagoon, an animal encounter lagoon, a dolphin swim lagoon and a sea lion lagoon (Figures 26 and 27).

Special attention has been paid to well thought-out greenery provisions with regard to the various sections of the project. These greenery provisions fulfil three purposes: to provide an attractive environment for the visitors; to create a modest but attractive habitat for flora and fauna, including birds; and to fixate sand and silt through the root systems of the plants, shrubs and trees.

Figure 26: Map of the plan of Curaçao Sea Aquarium land reclamation project, with inserts of rock boulder profiles and the exact location on the map of Curaçao.

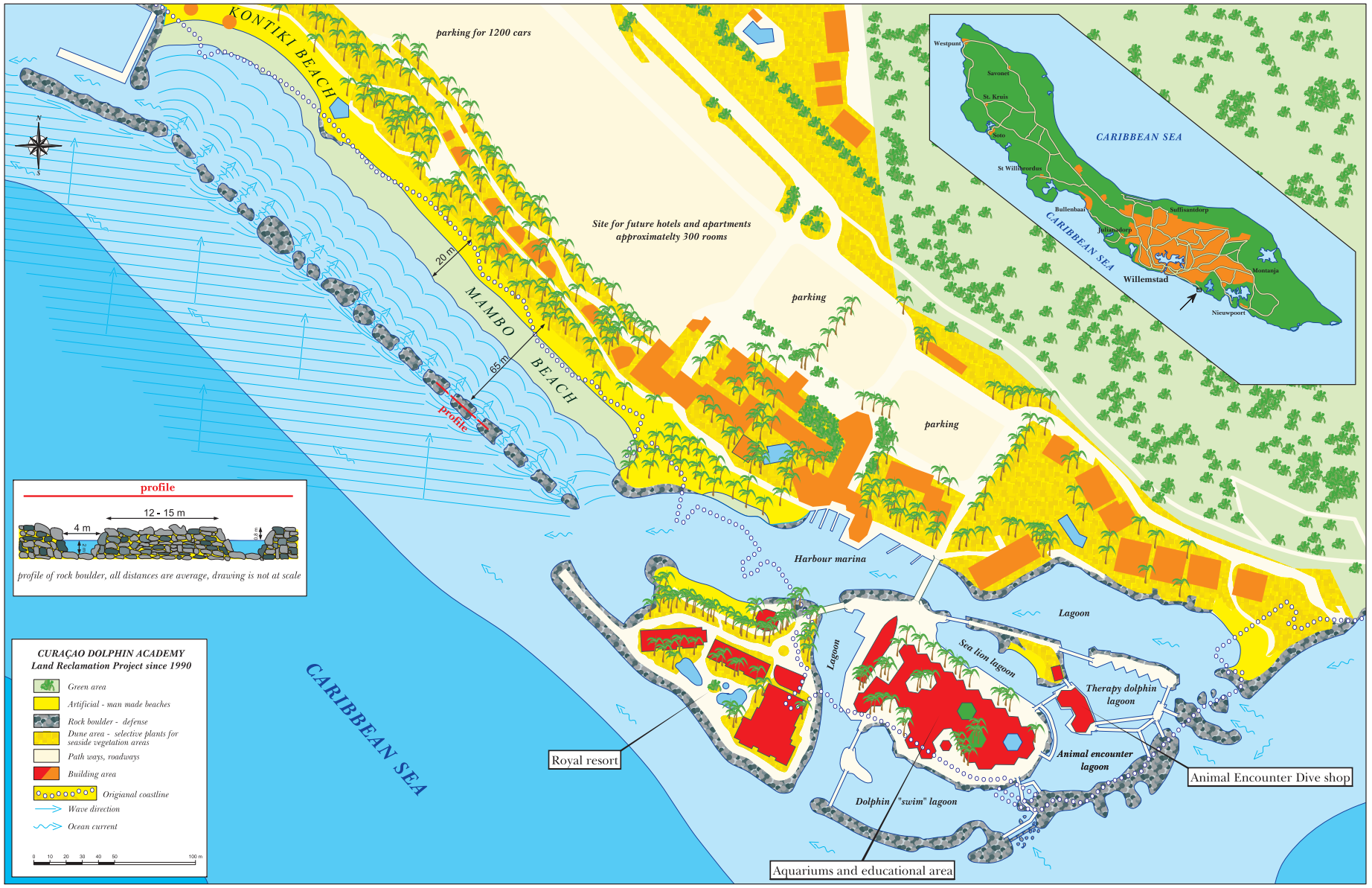

KONTIKI BEACH
parking for 1200 cars
Site for future hotels and apartments
approximatelty 300 rooms
parking
parking
parking
MAMBO BEACH
20 m
65 m
profile
profile
12 - 15 m
4 m
profile of rock boulder, all distances are average, drawing is not at scale
CARIBBEAN SEA
CARIBBEAN SEA
CARIBBEAN SEA
Westpunt
Savonet
St. Kruis
Soto
St Willibrordus
Bullenbaai
Suffisanidorp
Julianadorp
Willemstad
Montanja
Nieuwpoort
Harbour marina
Lagoon
Lagoon
Sea lion lagoon
Therapy dolphin lagoon
Animal encounter lagoon
Dolphin "swim" lagoon
Royal resort
Animal Encounter Dive shop
Aquariums and educational area
CURAÇAO DOLPHIN ACADEMY
Land Reclamation Project since 1990
Green area
Artificial - man made beaches
Rock boulder - defense
Dune area - selective plants for seaside vegetation areas
Path ways, roadways
Building area
Origianal coastline
Wave direction
Ocean current
0 10 20 30 40 50 100 m

Figure 27: Aerial photo of the area of the Curaçao Sea Aquarium land reclamation project including the Dolphin Academy, hotels and houses.

The project started in 1990. Sixty to eighty thousand cubic metres of limestone boulders were quarried in the hinterland of Curaçao. The construction occurred from the landside using earth and rock moving equipment and trucks.

The construction originally caused a serious disturbance of the environment in the offshore area. However, after several years the coast parallel breakwaters and their niches acted as an attractive substratum for marine organisms, while the coral reefs in front of the artificial reefs were thriving.

The required amount of sand for the artificial beaches was gained from a depth of 45 m – MSL on the northern side of Curaçao by using a trailer suction hopper dredger. This sand was applied in the designated area beyond the newly created coast parallel breakwaters. A series of round trips, each time carrying 6,000 m^3 of sand, were executed until a total of 80,000 m^3 for the new beach was reached. The new beach and the coast parallel breakwaters are separated by a lagoon with inlets and outlets.

The majority of the special saltwater lagoons, including the large lagoon in front of the new beach, were excavated in the old land in order to remove the original sand, silt and peat. This system of lagoons with their inlets and outlets was designed in such a way that ocean currents, waves and wind energy guarantee a constant supply of clean ocean water. An underwater nature reserve park was established, bordering the Curaçao Sea Aquarium with extensions at the lefthand and righthand sides, up to a total length of 20 km and of a certain width in the direction of deeper waters. This protected nature reserve park allows eco-tourism with certain restrictions (Figure 28).

Figure 28 : The land reclamation created an attractive habitat for birdlife and wildlife including frigate birds, pelicans, flamingos, and turtles.

Various trees, shrubs and plants were selected for the greenery provisions with regard to the separate sections of the project. On and in the direct vicinity of the artificial beach, coconut palms were planted because of their ability to thrive in a more or less saline environment. Date palms were also planted at a somewhat larger distance from the beach with their root systems above and partially in the brackish and salt water. To stimulate their growth, expansion granules (Terrasorb / Terracotton) were applied around the base of each palm tree. These granules can absorb water up to a hundred times their own volume and will last up to 10 years. In this way, around 850 coconut palms were planted.

Some of the other plants which were used are the cocoloba unifera and the mangrove type conocarpus erectus, as well as aloe vera and a variety of grasses and other plants and flowers. Drip irrigation and special sprinkler systems are also introduced. Partially computer controlled and partially manually operated. Special attention has been paid to the foundations of the various buildings and constructions. A sewer system is installed linked to an existing wastewater purification unit. There are provisions for the drinking water supply as well as for the energy supply.

The Dolphin Therapy for handicapped children and their immediate family is applied with great success. At the moment six inshore bottlenose dolphins (tursiops truncatis) with their current offspring are used for this therapy (Figure 29).

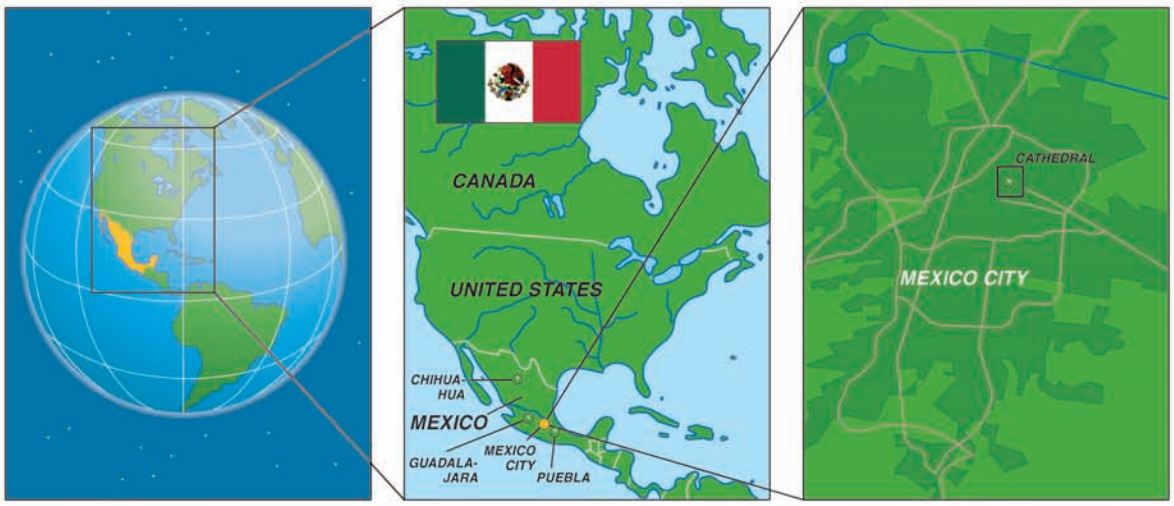
Figure 29: At the Curaçao Sea Aquarium, doing therapy with a handicapped child at the Dolphin Academy.

What makes this project so extraordinary is that it is a perfect example of good entrepreneurship based on a clear vision coupled to an understanding and knowledge of sea currents, waves, tidal action, climate and of border zones water-land. Where necessary, this was complemented by additional scientific advice in the field of civil engineering and biological engineering. All together, this has resulted in a remarkable project, which has around 300 personnel, including physicians, therapists and animal specialists.

5. THE SIGNIFICANCE OF WATERFRONTS

In general the discussion here has been limited to a sampling of land reclamations and water-land transformations in the vicinity of densely populated coastal and delta areas. The majority of examples are indeed found in the vicinity of 80 percent of the largest population centres in the world in coastal and delta areas. It follows that 20 percent of population centres are not along coasts or deltas.

Figure 30: Historical map of Mexico City shows its original location, in a lake which for 80 percent has disappeared. Today the mayor of Mexico City is planning to create waterfronts with four beaches in this land-locked capital city situated on a high plateau. The first beach was opened a few months ago.


CANADA
UNITED STATES
CHIHUA-
HUA
MEXICO
GUADALA-
JARA
MEXICO
CITY
PUEBLA
CATHEDRAL
MEXICO CITY


Mexico.
MEXICO, REGIA
ET CELEBRIS
HISPANIÆ NO-
VÆ CIVITAS.
Cum Privilegio.

Tenochtitlan as predecessor of Mexico City used to be the capital of the Aztecs. The city found its origin on an island in a lake connected to the lakeshores by a series of dams with satellite settlements along the shores. The myth tells us that Tenochtitlan was founded on this island after sighting of an eagle perched on a cactus with a snake in its beak. As the coat of arms, this symbol can be found on the central white band of the Mexican green-white-red flag.

Mexico City is the most prominent example. However, Mexico City was once a city in the middle of a lake, connected by dams to the lake shores where satellite towns were located. The original lake fell dry for a large part because of water extraction, causing Mexico City gradually to sink into a basin. Originally, Mexico City had a clear relationship with water. It is fascinating to note that nowadays action is taken to restore, this historic relationship, be it to a limited extent. As far as possible, dilapidated industrial sites are converted into lakes and waterways with parks, recreational and other facilities, complete with cultural-historical elements (Figure 30).

Many other of those 20 percent largest inland-situated cities have a strong historical and present relationship with water, even though they are not located near a coast or in a delta. Take Chicago for instance, with is location along Lake Michigan, or Saint Louis at the confluence of the Missouri and the Mississippi. But also in the case of land-locked cities like Moscow and Berlin, there is a strong relationship with water. Moscow as capital of the Russian Federation is positioned along the locally wide Moskva River.

The other example is Berlin as capital of Germany, with five rivers flowing through it, being Spree, Havel, Panke, Dahme and Wuhle, as well as several canals. Berlin is also situated along 13 lakes, including the Wannsee and the Grosser Müggelsee. Berlin has 60 km^2 open water surface (6.5% of the total urban area) with 500 km shore length. These waterfonts are nowadays developed as part of a well thought-out urban planning policy, while waterway connections for transportation of both people and freight receive special attention. The same applies to the establishment of blue-green arteries acting as an ecological network, serving both nature as well as urban beautification.

The significance of waterfronts does not only limit itself to the historically grown large urban areas in coastal or delta positions. Even cities that were not organically developed along existing waterways, coasts or in deltas, but which were artificially created on land without natural waterfronts, artificially-made water surfaces were deliberately created.
An example is Canberra, the capital of Australia. When Australia became a federation, Sydney and Melbourne vied to become the capital of Australia. A decision was made to create a new capital city approximately halfway between these two cities. Thus Canberra came into existence, designed from the start along the shores of a central large artificial lake, Lake Burley Griffin (Figure 32).

Figure 31: The capital of Brasil, Brasilia, was designed and is built on an artificially created body of water, Lago do Paranoá.

Another parallel example is Brasilia, the likewise artificially created capital of Brazil. Brasilia is situated in the inland at a distance of 1,000 km from the original capital Rio de Janeiro on a plateau 1,200 m above sea level. Like Canberra, this capital is located around an artificial lake, Lago do Paranoá.
Yet another example is the desert town of Las Vegas in the USA, a well-known booming tourist destination. To enhance the attraction of the town, it has been furnished with many artificial water surfaces and fountains.

Figure 32: The capital of Australia, Canberra, was designed and is built on an artificially created body of water, Lake Burley Griffin.

From all possible angles, the relationship water-town remains fascinating. Take another two examples, Venice and St. Petersburg. Looking down from the atmosphere, Venice manifests itself as two hands locked and separated from each other by the S-shaped Canal Grande. One hand is connected to the mainland by a long dam. Both hands are situated in the Venice Lagoon. In this lagoon a number of small islands are located in the vicinity and are also part of Venice (Figure 33).

Figure 33: Venice manifests itself as two interlocking hands, separated by the S-shaped Canal Grande.

The Lagoon is separated from the Adriatic Sea by several barrier islands, including Lido. In the opening between these islands, hinged water barriers are constructed in order to protect Venice against flooding. Both hands of this unique city contain a network of secondary canals. The historic city is by its shape, its location and its history a World Heritage Monument in its entirety, while its individual components like bridges and buildings, are monuments in their own right.

St. Petersburg, Russia can in many ways be considered as the vision set in marble, stone and granite of Tsar Peter the Great and his successors, especially Catharine the Great. This city of Tsars, master builders, poets and other inhabitants has risen from the swampy area in the delta of the Neva River.
This Neva Delta consists of many islands with a height of 1 to 2 metres above sea level. Partly because of strategic maritime considerations, Tsar Peter the Great decided in 1703 to establish a city in the mouth of the Neva bordering the Gulf of Finland. He decided to create a city of allure as window onto the Western World and as capital of Russia. His Peter and Paul Fortification bordering the Neva was inspired by the Dutch way of building fortifications. From the Admiralty Building the city develops in a radial fashion along a number of straight boulevards intersected by more or less concentric canals with stone embankments. These canals are connected on both ends to the Neva River. The layout is inspired by the city of Amsterdam along the IJ with its concentric canals (Figure 34).

Figure 34: Two models of St. Petersburg, Russia, with its historic waterfronts along the Neva.

Ports & Cities

The relation between port and city requires special attention. Often city and port do not develop harmoniously in relation to each other. Autonomous development of the city on the one hand and of the port on the other hand, often leads to a back-to-back position. Gradually one realizes that an integrated development of port and city is absolutely required, including special attention to waterfronts. After all, there is a dire need for town renovation, for transformation of out-dated industrial estates and out-dated port basins.

New port developments with port related activities as well as urban renewal are simultaneously urgently required in conjunction with each other, to serve a strengthened economy & employment and an improved environment and social climate. To obtain this goal, it is necessary to establish a special authority with public-private partnerships. Thus, ambitious plans can be developed in stages in order to achieve the harmonious development of port and city in tandem. In this process a large number of issues and stakeholders are involved.

These issues are:

- New port basins with port related activities to be constructed;
- Urban renewal by demolition followed by attractive housing developments including houses, apartments and their facilities. Reconstruction of out-dated port basins and port-estates;
- Facilities for education, sport and playgrounds;
- New and renovated industrial estates for, among others, production industry, transport, distribution and logistics sector;
- Service sector including financial sector, hotel, restaurant and catering sector, ICT and creative sector. All these coupled to a conscientious mixture of living and working;
- Community centres and shopping malls;
- Differentiated housing for all categories;
- Museums and culture-historical elements;
- Landmarks;
- Public utilities, including drinking water, energy, sewer systems, wastewater purification, separate collection, recycling, processing and storage of waste materials;
- Infrastructure including all transport modes;
- Attention to safety, security, law & order, social cohesion;
- Pursuit of environmental quality with regard to the environmental compartments air, water and soil;
- Green-blue arteries, parks, reserves and public gardens;
- Recreational and tourist facilities;
- Organisation of important events as stimulus for developments and to promote the city and its harbour;

In all these, combined urban and port developments waterfronts play an essential role. These waterfronts provide unique possibilities for living, working, infrastructure and recreation. Prominent examples in Europe of the in harmony development of city-port combinations are:

- London with Docklands;
- Glasgow with Clyde Waterfront & Clyde Gateway;
- Rotterdam with Kop van Zuid and Stadshavens;
- Barcelona with Port Vell, Port Olympic and Forum 2004;
- Dublin with Dublin Docklands;
- Genoa with Porto Antico;
- Lisbon with Parque das Nações;
- Copenhagen with Sydhavn, Havnstad, Nordhavn, Ørestad, Amager project;
- Antwerp with 't Eilandje;
- Hamburg with Hafen City;
- Amsterdam with IJ-shores;

Also in the USA, city-port waterfront development has taken place in New York/New Jersey, Baltimore and Miami to name a few. In the Far East as well, Singapore, Hong Kong and Shanghai are good examples of this principle of harmonious development (fig 35).

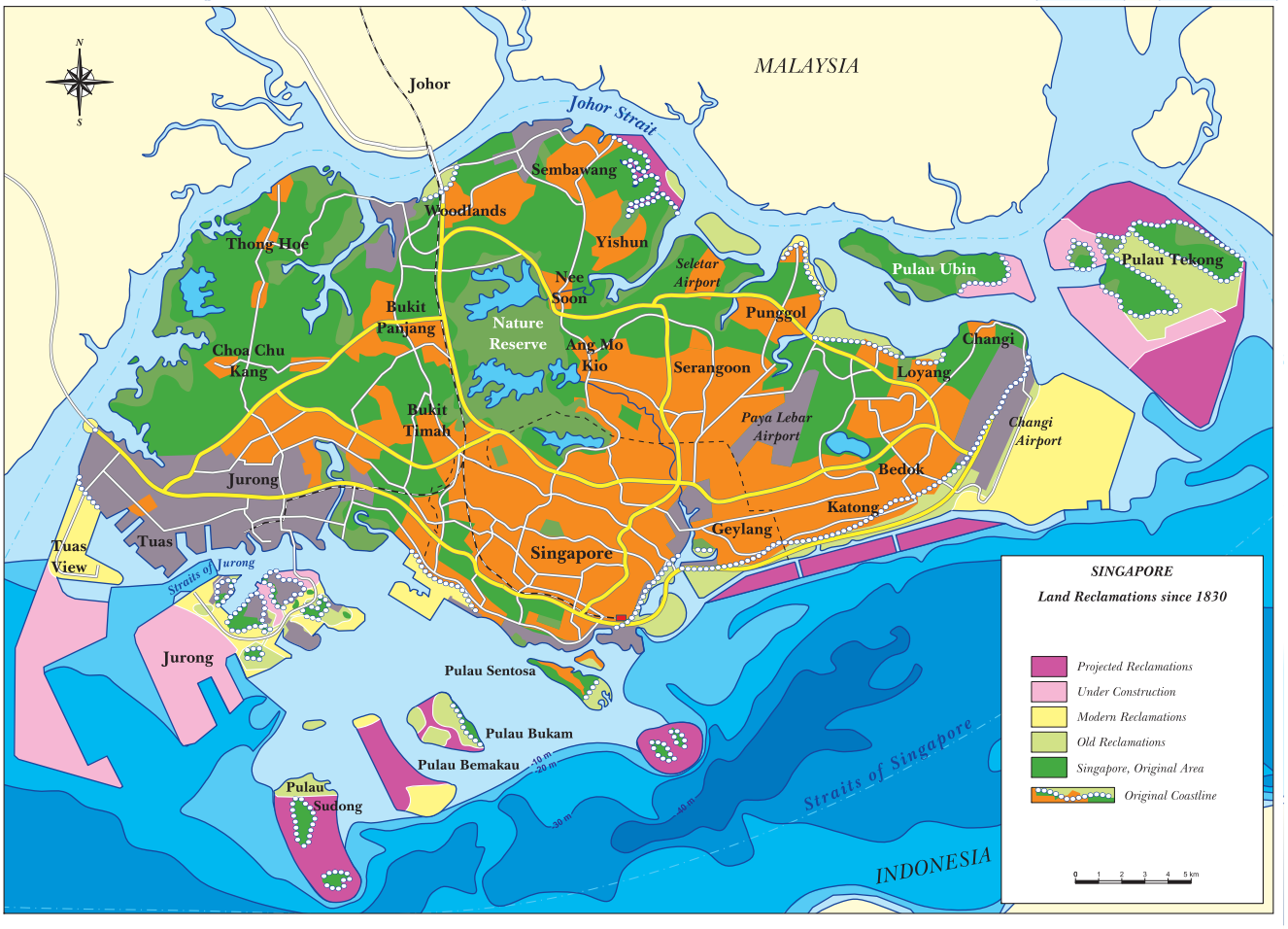


Figure 35: Waterfront development around Singapore is an important addition to the airport, the harbour, industrial areas, as well as to the living & leisure space in the overcrowded city.

Rivers & Lakes & Canals linking Cities

Apart from the relation city-port and in parts overlapping, there is the relation city-river and the relation city-lake. In all these relations, waterfronts are of great importance. Considering the great rivers like Nile (6,695 km), Amazon (6,515 km), Chan Jiang (6,380 km) and Missouri / Mississippi (6,019 km), or intermediate rivers like Saint Lawrence, Parana, Orinoco, Indus, Ganges / Brahmaputra, Mekong, Congo, Euphrates, Volga, Danube, Rhine and Elbe, or relatively short rivers like Thames, Hudson, Seine, Rhone and Loire, and their connected cities with their urban developments, one immediately realizes the importance of their waterfronts. That also applies to the cities bordering the Great Lakes and many other lakes elsewhere in the world.

Canals fulfil an important role in urban developments as well. Originally canals were often constructed as important waterways for trade, a role they still fulfil as such. In conjunction they are increasingly in use for tourism and recreation, transport of persons and various types of freight, raw materials and waste products, while at the same time they fulfil an important role in urban redevelopment. Not only do canals connect cities but also rivers, lakes and seas, of which there are numerous examples, like Panama Canal, Suez Canal and the Rhine-Main-Danube Canal.

A historic and contemporary example of the former is the Grand Canal in China, which connects the cities of Hangzhou, Suzhou, Shanghai, Yangzhou, Tijanjin and Beijing. With its total length of 1,789 km this is the longest canal in the world.

Conclusions / Afterword

Looking back over a period of over 30 years and at the same time looking forward, a few observations can be made. Good plans have their roots in the past and are pointing to the future. Using the achievements of the past, we are able to meet the challenges of the future.

Taking into consideration Towards an Integrated Coastal Policy via Building with Nature our concern has been, not only with plans – based on relatively simple and clear principles – but also with processes. Each case involves an integrated design, followed by its execution fully based on the environment, using the most advanced well thought-out techniques, whilst applying the lessons that the environment – including nature – teach us.

It is noteworthy that the overall investments and maintenance cost of the method based on these principles are significantly lower than those of methods that neither use an integrated approach nor use the environment as a basis. Furthermore, the proposed method improves the environment and simultaneously strengthens the economy as well.

Building with Nature, in addition to conservation of Nature, will become even more significant in the future. It will not only be absolutely necessary for solving existing and future problems but it will also create added value and help regain lost values. The environment – including nature – constitutes the foundation and support for present and future existence.

Over the course of years, the necessity of an Integrated Coastal Policy via Building with Nature has become more apparent not only in Europe but also elsewhere in the world. Remarkable, but not surprising, is that in this period of time broad support for these principles at a global level has been gained. The developed concept has proven to be applicable in a large number of countries in coastal and delta areas.

Even in areas far removed from coasts and deltas, these concepts are applicable for natural as well as artificial waterfront developments, and methods similar to Integrated Coastal Policy via Building with Nature are being implemented.

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The extensive list of literature can be found in the aforementioned books

Curriculum Vitae

Born 28-09-1934 in Delft as son of prof.dr.ir. H.I. Waterman and M.J. Waterman-Prins. After a brief period primary school, went to Grotius College HBS-B and finished as no.1 of that secondary school in 1952 and entered Delft University of Technology to study chemical engineering; later followed by environmental engineering and civil engineering at a.o. M.I.T., Illinois Institute of Technology. During his studies he did research at Delft University of Technology and at Leiden University.
After a short period at the Dept. of Justice (Netherlands Forensic Institute) and the Gaubius Institute of Leiden University to get acquainted with several micro-analytical methods he became in 1960 director of the laboratory of micro-analysis of organic compounds at Delft University of Technology. In 1967 deputy-director of the Laboratory of Centrafarm for introducing new methods for the analysis of pharmaceuticals and for laboratory personnel instruction. Introduction of gas chromatography, atomic absorption, thin layer chromatography combined with electro-photography.

In 1968 founder/director of Data Transmissie for e.g. data transmission processes in chemical engineering. In 1969 this company was taken over for 80% by Woods Research & Development Corporation in Oklahoma City. In 1970 Data Transmissie became fully independent again. From 1978 onwards career in civil engineering. In 1979 designer of a multi-purpose canal in South-Holland for fresh water supply, transport, tourism and recreation with special attention to waterfront developments, water quantity and quality & navigational safety. Absolute environmental-friendly storage and processing of contaminated sediments and other types of wastes. Introduction of characteristic environmental parameters as a management instrument From 1980 onwards designer/co-designer of a series of plans based on integrated sustainable multi-functional coastal zone development via Building with Nature: plan Scheveningen-Hoek van Holland; Slufterdam; Maasvlakte 2 (Rhine Plain); Seaport Marina IJmuiden/Kennemer Lake & Beach; Katwijk Seaport with dune-beach widening on each side of the port for coastal protection and net nature gain.

From 1978 onwards eight times elected Member of Government/Parliament Province of South-Holland. In the period 1985, ‘86 and ‘87 also governor of the board of Technion Institute of Technology. Before, during and after that period member of the Advisory Board of Nethconsult and later of Nedeco.
From 1982 onwards senior advisor to the Ministry of Transport, Public Works and Water Management, the Ministry of Economic Affairs and the Ministry of Housing, Planning and the Environment, Port of Rotterdam, Deltares, TNO Netherlands Institute of Applied Geoscience, Netherlands Water Partnership. All in the field of Multifunctional Sustainable Land Reclamations based on Building with Nature.

From 2006 onwards also deputy director of the Association Region Water. In that position actively involved in the European Waterways Forward Project for the period 2010-2013 and from 2009 onwards director of Foundation Building with Nature®.Ronald Waterman has given lectures all over the world and has held and holds several positions in various universities, scientific institutions and in various industries.
Contributions to several international congresses in the field of large and small scale land reclamations based on the principles of Building with Nature & Integrated Coastal Policy.

Several publications (scientific journals and books) in the field of chemical engineering (micro-analytical chemistry, inorganic chemistry, polymer chemistry, process characterization, thermodynamics and environmental engineering) and in civil engineering (land reclamation via Building with Nature, Integrated Multifunctional sustainable Coastal zone development, environmental-friendly storage and processing of contaminated sediments and other types of wastes, water resources management, energy supply, plan development management systems, relation environment-economy-space; absolute necessity of an adequate infrastructure for all modes of transport). Specialist with 30 years of worldwide experience in the field of integrated multifunctional sustainable coastal zone development and management, using methods that at the same time strengthen the economy and improve the environment, while ensuring an optimal use of the available space.

Was awarded e.g.:

- The prize for "Future oriented thinking for the benefit of mankind" from the Society of Dutch Consulting Engineers (ONRI / NL Ingenieurs) – 1982, together with J.N. Svašek;
- Medal for his contribution to Dutch water-land engineering in general and coastal zone development including land reclamation in particular – 1992
- Medal Universitá Maritima de Chile for integrated coastal zone development – Vina del Mar – 1994;
- Plaque of appreciation for extending advance training and cognition in the field of land reclamation and coastal management in the Philippines – 1994 & 2001;
- Special recognition for land reclamation design in the Bay of Jakarta – 1996;
- Award for design & realization of various large and small scale projects in the field of integrated multi-functional sustainable coastal zone development – Bouwend Nederland – 1996;
- Chosen as best member of regional Dutch parliaments – 2007;
- Gouden Lis Medal of the Province of South-Holland – 2008;
- Knight in the Order of the Dutch lion since 1993.

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SAMENVATTING

Integraal Kustbeleid via Bouwen met de Natuur betreft de nieuwste fase in de Nederlandse Waterbouw. Er is sprake van innovatie passend in een typisch Nederlandse traditie met betrekking tot het werken op het grensvlak water-land.

Integraal Kust- & Deltabeleid geeft een antwoord op de vraag hoe wij tal van bestaande en komende problemen in onderlinge samenhang, in relatie tot het bestaande achterland enerzijds en in relatie tot de aangrenzende zee anderzijds, tot een gewogen oplossing kunnen brengen onder het creëren van meerwaarde. Vele functies worden in onderlinge samenhang in beschouwing genomen, onder gebruikmaking van vele disciplines. Zo leidt gebundelde α-, β- en γ-kennis op termijn tot duurzame kust- en deltagebieden.

Bouwen met de Natuur betreft het flexibel integreren van land in zee en omgekeerd van water in het nieuwe en het oude land met gebruikmaking van de in de natuur aanwezige anorganische (zand) en organische materialen (vegetatie) en van de krachten/interacties, die daarop werken. Daarbij worden tevens de biogeomorfologie en de geohydrologie van kust en zeebodem in beschouwing genomen.
Er wordt gestreefd naar een flexibele, dynamische evenwichtskustlijn, waarvoor bij benadering geldt dat aangroei en afslag elkaar redelijkerwijs in evenwicht houden met een kleine onderhoudsfactor in de vorm van een periodieke zandsuppletie en met een minimum aan harde zeewerende elementen. Niet langer dominant dammen en dijken als bolwerken tégen de zee, maar in plaats daarvan duinen en stranden in harmonie met de zee. Speciale aandacht wordt daarbij gegeven aan de betekenis van waterfronten.
Interessant daarbij is, dat de uiteindelijke investerings- en onderhoudskosten bij toepassing van dergelijke methoden beduidend lager liggen dan van methoden, die milieu en natuur niet als uitgangspunt nemen. Tevens is het langs deze weg mogelijk om tegelijkertijd het milieu te verbeteren en de economie te versterken. Naast behoud van de natuur zal *Bouwen met de Natuur* in de toekomst in betekenis toenemen, niet alleen om bestaande en komende problemen op te lossen, maar ook om meerwaarde te creëren en om verloren gegane waarden terug te winnen. Het milieu en de daarin aanwezige natuur vormen de grondslag en het draagvlak van ons voortbestaan.

De aangegeven gecombineerde methode, aangepast aan lokale omstandigheden, is vooral van toepassing op veelal laaggelegen dichtbevolkte kust- & deltagebieden. Immers, juist daar is er een gebrek aan ruimte om te wonen, te werken, te recreëren en voor infrastructuur, terwijl er tevens de noodzaak is voor het instandhouden, zo mogelijk uitbreiden van milieu-, natuur- & landschapswaarden. Tegelijkertijd wordt men geconfronteerd met factoren als zeespiegelstijging, hogere frequentie en intensiteit van stormvloeden en zoutwaterindringing. Tevens heeft men in het achterland te maken met bodemdaling, een hogere frequentie & intensiteit van regenval, afgewisseld door perioden van droogte, een hoger percentage verhard oppervlak met een versnelde afstroming naar de rivieren. Water als vriend, maar ook water als vijand, zowel van zeezijde als van rivierzijde. Voor al die aspecten moeten oplossingen gevonden worden onder het creëren van meerwaarde, waar de vermelde methode een antwoord op geeft.
Verder is er een volstrekte analogie tussen: Ruimte voor de Kust - Levende Kusten; Ruimte voor de Rivier - Levende Rivieren; Ruimte in & om het Meer - Levende Meren.

Integraal Kust- & Deltabeleid via Bouwen met de Natuur leidt tot een scala van mondiale toepassingsmogelijkheden, waarbij tegelijkertijd het milieu wordt verbeterd en de economie wordt versterkt. Opmerkelijk, maar niet verrassend, is het brede draagvlak op mondiaal niveau, dat voor deze principes is ontstaan.

STELLINGEN

behorende bij het proefschrift

Integrated Coastal Policy via Building with Nature®

van

Ronald E. Waterman

Delft, 21 december 2010

1 De principes '*Bouwen met de Natuur*' en '*Integrale Multifuctionele Duurzame Kustontwikkeling*' tezamen bieden unieke mogelijkheden voor export en import van kennis en uitvoering van werken voor kennisinstituten, ingenieursbureaus, consultants en contractors, vooral gericht op laaggelegen, dichtbevolkte kust- en deltagebieden.

2 Drie pregnante, gerealiseerde voorbeelden in Nederland van zeewaartse kustverbreding volgens het principe '*Bouwen met de Natuur*' gekoppeld aan *Integraal Kustbeleid* – a) Van Dixhoorndriehoek, als opmaat voor het Plan Scheveningen-Hoek van Holland; b) Slufterdam, als opmaat voor Maasvlakte 2 (Rijnvlakte); c) Seaport Marina IJmuiden/Kennemermeer en -strand – tonen aan dat het zeer wel mogelijk is zeewaartse kustontwikkelingen te realiseren met:
1) Een zachte (duin-strand) begrenzing in harmonie met de zee;
2) Een gewaarborgde kustveiligheid, uitgaande van overeengekomen veiligheidsnormen;
3) Netto-natuurwinst;
4) Economische functies in harmonie met natuurontwikkeling met in achtneming van een zonering;
5) Faseringsmogelijkheden passend binnen een flexibel masterplan.

3 Voor het ontwerpen van landaanwinningen is het gebruik en ontwikkelen van hoogwaardige zee(bodem)- en landkaarten een eerste vereiste. Daarnaast dient optimaal gebruik te worden gemaakt van historische land- en zeekaarten.

4 Bij het ontwerpen van landaanwinningen langs bestaande kusten dienen de wordingsgeschiedenis (biogeomorfologie) en de geohydrologie van kust- en zeebodem ter dege in beschouwing te worden genomen.

5 Bij kustzone-ontwikkeling gaat het niet alleen om het integreren van land in zee, maar ook om de integratie van water in het nieuwe en oude land, in de vorm van estuaria, lagunes, meren, watergangen, zoetwaterlenzen en havenbekkens.

6 De bij het ontwerp van de Slufterdam ingevoerde demarkatielijn parallel aan de kust van Goeree als intergemeentelijke grens tussen Westvoorne en Rotterdam – met ten noorden ervan haven en havengerelateerde activiteiten op grondgebied van Rotterdam, gebonden aan milieuhygienische randvoorwaarden, en ten zuiden ervan een terrestrisch natuurgebied op grondgebied van Westvoorne als sluitstuk van een drieluik natuurgebieden – is een succes gebleken dat navolging verdient. Dat succes betreft zowel kustveiligheid als natuurontwikkeling, naast andere functies en last but not least het gebruikmaken van kustmorfologische inzichten.

7 Wereldwijde toepassing en verdere ontwikkeling van milieuvriendelijke baggermethoden en baggermaterieel bij kustzone- en deltaontwikkeling zijn in toenemende mate van beduidend grote toegevoegde waarde.

8 De door de auteur beschreven 'Interactive Plan Ontwikkeling' is een uitstekend instrument om de uiteindelijke realisatie van uiteraard wetenschappelijk goedgefundeerde kustontwikkelingsplannen te bereiken.

9 Invoering van een 6-lagensysteem in de Ruimtelijke Ordening betekent een aanmerkelijke verbetering ten opzichte van een 3-lagensysteem dat nog steeds door vele centrale en regionale overheden bij ruimtelijke plannen wordt toegepast.

10 In de Ruimtelijke Ordening dient meer dan voorheen rekening te worden gehouden met de 3e en 4e dimensie in streek- & structuurplannen en ruimtelijke structuurvisies.

11 De eminente betekenis van de overgangen water-land voor leven, werken, recreëren, infrastructuur en biodiversiteit wordt nog steeds niet volledig op waarde geschat.

12 Natura 2000-gebieden hebben een sterk conserverend karakter met als primaire doelstelling natuurbehoud. Zij houden echter te weinig rekening met de natuurlijke dynamiek, waardoor zij remmend kunnen werken op het creëren van condities voor natuurontwikkeling ten dienste van biodiversificatie.

13 De inzichten en aanbevelingen van R.S. de Groot (1990) dat het milieu en de daarin aanwezige natuur een viertal basisfuncties heeft (met daarvan weer afgeleide functies), zijnde: (a) Draagfunctie; (b) Productiefunctie; (c) Regulerende functie en (d) Informatiefunctie, verdienen toegepast te worden in een betere bepaling dan wel wijziging van het zogenaamde Bruto Nationaal Product in de vorm van bv. een 'Index for Sustainable Economic Welfare' (Herman Daly and John B. Cobb, 1989) of een 'Green National Product'.

14 Er is de absolute noodzaak voor een adequate infrastructuur voor het transport van personen, goederen/massa, energie en informatie. De problematiek verbonden aan mobiliteit kan alleen opgelost worden met een én-én-én-én-beleid met aandacht voor alle vervoersmodaliteiten, separaat en in onderlinge samenhang, en met de transportmodules die daarvan gebruik maken, naast flankerend beleid.

15 Tegenover een veelal snel groeiend gemeentelijk wegennet gedurende een lange reeks van jaren staat een volstrekt achterblijvende basiscapaciteit van het rijks- en provinciale wegennet. De notie dat bij het op orde brengen van die basiscapaciteit 'heel Nederland wordt geasfalteerd' is volstrekt onjuist.

16 Optimale benutting van de regionale vaarwegen is gewenst, mede ter bevordering van de vrijetijds-economie, en wel zódanig dat:
1) de nautische veiligheid met betrekking tot de drie gebruikersgroepen (commerciële binnenvaart, recreatie- en toervaart, watersport w.o. roeiers) en voor speciale evenementen gewaarborgd wordt;
2) de waterkwaliteit wordt verbeterd via hoog-gekwalificeerde ligplaatsen met afvalwaterinzameling, drinkwatervoorziening, sanitaire voorzieningen en walstroom;
de waterkwantiteit en het waterpeil worden beheerst en gereguleerd;
3) de milieukwaliteit en leefomgeving in algemene zin worden verbeterd door een verdergaande ontwikkeling van energiezuinige en geluidsarme vaartuigen met de nodige voorzieningen aan boord, waarbij gestreefd wordt naar minder schadelijke emissies naar water, lucht en bodem en de biodiversiteit wordt bevorderd;
4) de waterfronten (wandel-, fiets- en trekpaden, laad/losplaatsen, parkeervoorzieningen, horecavoorzieningen, winkels, musea, bedrijven, onroerend goed) tegelijkertijd en in samenhang verder ontwikkeld worden; ook dienen milieuvriendelijke oevers en ecozones ontwikkeld te worden; oevererosie wordt tegengegaan;
5) cultuur-historische waarden worden gerespecteerd - waar nodig gerestaureerd - en benut; promotie van regiospecifieke producten en diensten;
6) waar nodig 'aquapunctuur' wordt toegepast (vaarwegbreedte en -diepgang, baggerregiem, waterpeilregulering, brughoogte & brugbediening, sluiscapaciteit en sluisbediening, aquaducten, laad- en loswallen);
7) speciale aandacht wordt gegeven aan de relatie water-energie, zoutwaterindringing, zout/zoetovergangen, vispassages, terugdringing eutrofiering; beheersing waterplantengroei en tegengaan van indringing uitheemse flora en fauna;
8) toereikende maatregelen worden genomen met betrekking tot klimaatverandering door o.a. (a) ruimte voor de waterweg; (b) calamiteitenberging; (c) retentiebekkens; (d) drainage- en pompsystemen voor waterpeilregulering; (e) aanpassingen in het water-landgebruik en ruimtelijke ordening; (f) terpen, landophoging; (g) ontwerp van overstromingsveilige multifunctionele stedelijke waterfronten; (h) dijkversterking & kadeverbetering; (i) duin/strand verbreding & verhoging; (j) stormvloedkeringen;
Een goed beleid wordt verzekerd op basis van documenten, communicatie en coöperatie tussen de publieke en private stakeholders. Een en ander mede op basis van water-& milieuwetgeving, richtlijnen en normen. Maatschappelijke kosten-batenanalyses zijn tevens noodzakelijk.

17 Een van de grootste uitdagingen van de 21e eeuw is het ontwikkelen en implementeren van methoden, die tegelijkertijd de economie versterken èn het milieu verbeteren, op weg naar duurzaamheid. Biotechnologie – in brede zin – is een van de belangrijke instrumenten om dat doel te bereiken, naast stabilisatie van de wereldbevolking en aanpassing levensstijl.

18 Door mensen in de geosfeer geïnitieerde of gepropageerde conversieprocessen dienen zó ontwikkeld te worden dat zij met minder grondstoffen en minder energie, en met minder schadelijke emissies naar lucht, water en bodem verlopen, maar wel met een hoger rendement. De ontstane producten dienen tijdens hun levensfase of daarna zo milieuvriendelijk mogelijk te zijn en reststoffen dienen gescheiden te worden ingezameld, gerecycled of omgezet in relatief milieuvriendeljke producten, of, indien dat niet mogelijk is, milieubeheersbaar te worden geborgen. Restenergie dient benut te worden.

19 De mogelijkheid van het bestaan van een heelal met een dominante aanwezigheid van anti-materie, mede op basis van beschouwingen van Nobelprijswinnaar Hannes Alfven, kan niet op voorhand worden uitgesloten.

Deze stellingen worden verdedigbaar geacht en zijn als zodanig goedgekeurd door de promotoren Prof. dr. ir. M.J.F. Stive en Prof. drs. ir. J.K. Vrijling.

PROPOSITIONS

pertaining to the thesis

Integrated Coastal Policy via Building with Nature®

by

Ronald E. Waterman

Delft, December 21, 2010

1 The principles of '*Building with Nature*' and '*Integrated Multi-Functional Sustainable Coastal Zone Development*' together offer unique opportunities for export and import of knowledge and realisation of projects for institutes, consulting engineers and contractors, mainly directed at vulnerable, densely populated coastal and deltaic areas.

2 Three typical examples in The Netherlands based on the combined principles of "*Building with Nature*" and "*Integrated Coastal Policy*": (a) Van Dixhoorn-Triangle, as predecessor of the Plan Scheveningen - Hoek van Holland; (b) Slufterdam as predecessor of the second Maasvlakte (Rhine - Plain); (c) Seaport Marina IJmuiden / Kennemer Lake and Beach, each demonstrating clearly that seaward coastal extensions can be realised with:
1. A new soft dune - beach shoreline in harmony with the sea.
2. A guaranteed coastal safety, protecting the hinterland, based on well defined safety standards.
3. Net nature gain.
4. Enlargement of a fresh water lens in due time under the dunes.
5. Economic functions in harmony with nature development, with zoning for the various functions.
6. Phasing, segment after segment, within a flexible masterplan.

3 For the design of land reclamations the use and development of high quality land and sea charts are essential. In addition use should be made of historic land and sea charts.

4 In the design of land reclamations along existing coasts the biogeomorphology and geohydrology of coast & seabed should be fully taken into account.

5 Coastal zone development is not only focused on the integration of land in sea but also on the integration of water in the newly created land and in the already existing hinterland, in the form of estuaries, lagoons, lakes, waterways, fresh water lenses & harbour basins.

6 Within the 'Slufterdam' land reclamation design a demarcation line was introduced as intermunicipal boundary between the municipalities of Rotterdam and Westvoorne. The purpose of this 'landmarking' of two territories was: to the North an area for high standard port & port related activities; to the South a triplet of nature reserve areas – partly new, partly existing – on the territory of Westvoorne.
The result was all-round a complete success, based on coast morphological insights and a combination of coastal safety, nature development and various other functions, an example worth following elsewhere in the world.

7 Worldwide application and further development of environmentally friendly dredging methods and dredging equipment for coastal & delta zone development are becoming increasingly important and are leading to considerable added value.

8 'Interactive Plan Development' as introduced by the author is an excellent instrument to achieve realisation of scientifically well founded coastal zone development plans.

9 Introduction of a 6-layer system in spatial planning can be considered as a substantial improvement over the 3-layer system presently in use by national and regional governments.

10 For the development of high quality regional spatial plans a stronger emphasis on the significance of the 3rd and 4th dimensions should be taken into account.

11 The significance of border zones water/land for living, working, recreation, infrastructure and biodiversity is still underestimated and should be given far more active attention.

12 Nature-2000 areas have as their main objective nature conservation. However, they do not sufficiently take into account the dynamics of nature. Consequently in many cases, they act as an obstacle in creating conditions for nature development and biodiversification.

13 The perceptions and recommendations of R.S. de Groot (1990) that the environment, including nature, is the basis for the economy with its 4 fundamental functions: (a) Carrier function; (b) Production function; (c) Regulatory function; (d) Information function, deserve to be applied to an improved Gross National Product in the form of e.g. an 'Index for Sustainable Economic Welfare' (Herman Daly and John B. Cobb, 1989) or a 'Green National Product'.

14 There is an absolute necessity for an adequate infrastructure for the transport of people, products, mass/energy and information. The problems inherent to mobility can only be solved using a policy which addresses itself to all modes of transport, separately and in conjunction, and with all the various transport modules using the infrastructure. In addition, flanking measures can be applied.

15 Considering the continuous fast growing municipal road network, the base capacity of the provincial and national road networks is far from up-to-date. The popular idea that by expanding the base capacity of the provincial and national road grid, a large part of the Netherlands will be covered with asphalt is a complete misconception.

16 Optimal sustainable use of inland waterways should be promoted to strengthen regional socio-economic development, in such a way that:
1) Nautical safety is ensured for the three main user groups (commercial traffic, leisure traffic, water-sport: rowing, angling, fishing, canoeing, rafting, boating, waterskying) and for special events;
2) Water quality is improved through introduction of berths with adequate facilities, such as intake and purification of waste water, drinking water supply, sanitary provisions, electrical current supply; Water quantity and water levels are regulated and controlled;
3) Provisions on board of the various ships are present to ensure an adequate water quality; in general striving for reduction of harmful emissions to air, water and soil; pollution prevention;
4) Waterfronts are developed in conjunction with infrastructural connections for walking, cycling & towing, parking, loading/unloading platforms, real estate development, musea, hotels & restaurants, shops & water related companies; environmentally friendly shore and bank development and erosion prevention; eco-zones;
5) Heritage values are respected - restored where necessary - and used; promotion of region specific products & services;
6) Aquapuncture is applied to improve the waterways (waterway width, depth, dredging regime, height under the bridges above water level, water level regulation, sluice/shiplock capacity, bridge/sluice/shiplock servicing, aquaducts, quay wall construction, berths & bollards for mooring);
7) Special attention is given to the relation water-energy, salt water intrusion, fresh water - salt water gradients, fish passages, eutrofication prevention, aquatic plant control, controlling invasive species;
8) Adequate measures are taken in relation to climate change through e.g. (a) room for the waterway; (b) calamity storage; (c) retention basins; (d) adequate drainage & pumping systems for water level regulation; (e) adaptation of water-land use, spatial planning; (f) artificial high grounds; (g) multifunctional flood proof urban waterfronts; (h) dike strengthening & quay wall improvement; (i) dune-beach widening & heightening; (j) storm-surge barriers;

Good governance is ensured on the basis of documents, communication and cooperation between public & private stakeholders. European and national water & environmental laws, directives, regulations and standards have to be taken into account. Cost-benefit analyses are also required.

17 One of the great challenges of the 21st century is the development and implementation of methods that simultaneously improve the environment and strengthen the economy, on the way to sustainability. Biotechnology - in a broad sense - is one of the important instruments to achieve this goal, in addition to stabilisation of the world population and adaptation of lifestyles.

18 Mankind initiated or propagated conversion processes in the geosphere should be developed in such a way that useful products are made with less raw materials and less energy and with a higher yield, with less hazardous emissions to air, water and soil, and with less by-products. The product specification must be chosen in such a way that these products during and after their lifecycle are relatively environmentally friendly. The byproducts must be processed and applied and, if that is not possible, safely stored. Residual energy should be used.

19 The possibility of the existence of an universe with a dominating presence of anti-matter, also on the basis of considerations of Nobel Prize Winner Hannes Alfven, can not be completely ruled out.

These propositions are considered opposable and defendable and as such have been approved by the supervisors Prof.dr.ir. M.J.F. Stive and Prof.drs.ir. J.K. Vrijling.