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LIST OF ABBREVIATIONS AND ACRONYMS

Abbreviation	Explanation
µg/kg	Micrograms per kilogram
As	Arsenic
BOD	Biological Oxygen Demand
BS	British Standard
c.	Circa
CD	Chart datum
Cd	Cadmium
CEA	Cumulative Effects Assessment
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CIRIA	Construction Industry Research and Information Association
COD	Chemical Oxygen Demand
Cr	Chromium
Cu	Copper
EAP	Environmental Action Plan
EIA	Environmental and Social Impact Assessment
EMP	Environmental Management Plan
EMS	Environmental Management System
EU	European Union
FMEnv	Nigerian Federal Ministry of Environment
FUF	Fuel Unloading Facility
GHG	Green House Gases
GPS	Global Positioning System
ha	Hectare
HAT	Highest astronomical tide
HGV	Heavy Goods Vehicle
HSE	Health, Safety and Environment
IDSA	International Dark Sky Association
IFC	International Finance Cooperation
IRP	Incident Response Plan
ISO	International Organisation for Standardisation
ISQG	Interim Sediment Quality Guidance
Km	Kilometre
LASMOE	Lagos State Ministry of Environment

Abbreviation	Explanation
LAT	Lowest astronomical tide
LOD	Limit of detection
m	Metre
M&E	Mechanical and Electrical
mg/kg	Milligrams per kilogram
mg/l	Milligrams per litre
ND	Not detected
Ni	Nickel
NIOMR	Nigerian Institute for Oceanography and Marine Research
NO2	Nitrogen Dioxide
NRMM	Non Road Mobile Machinery
OEMP	Operational Environmental Management Plan
PAHs	Polycyclic aromatic hydrocarbons
Pb	Lead
PEL	Probable Effect Level
PM10	Particulate Matter (10 microns and less)
PPM	Parts Per Million
PSA	Particle size analysis
SENL	South Energyx Nigeria Ltd.
SES	Site Environmental Standards
SO2	Sulphur Dioxide
SSC	Suspended sediment concentrations
TEL	Threshold Effect Level
TOC	Total organic carbon
TPH	Total petroleum hydrocarbons
TSHD	Trailing Suction Hopper Dredger
UK	United Kingdom
USEPA	United States Environmental Protection Agency
WHO	World Health Organisation
Zn	Zinc

ENVIRONMENTAL IMPACT ASSESSMENT AUTHORS AND CONTRIBUTORS

Name	Task
Dirk Heijboer	Project Director
Ruud Platenburg	Project Manager
Chris Adnitt	Technical Director (Ecology)
Claire Bryant	EIA Coordinator and Author
Greg Shaw	EIA and Survey Specialist
Kim Cartwright	Social Expert
Trevor Morrish-Hale	Project Engineering
Franco Cheng	Project Engineering
Claartje Hoyng	Coastal Engineer
Martijn Lips	Coastal Engineer
Joost Lansen	Coastal Processes Expert
Zaman Sarker	Wave Modelling Expert
Alice Mclean	Air Quality Expert
Pete Websdell	Noise Expert
Duncan Russel	Groundwater Expert
Local experts	
Felix Olawore	Environmental Expert
Oladimeji Bodude	Socioeconomic Expert
For environmental baseline surveys:	
Abubakar Abdul-Mumin	Environmental Specialist
Egbeh Fredrick	Environmental Specialist
Ladigbolu Ismail	Environmental Research Scientist
Dotun Bolaji	Environmental Specialist
Itunu Ogundepo	Environmental Specialist
Okun-omo	Environmental Specialist
Uzoma Ejimadu	Ecology & Biology Expert

ACKNOWLEDGEMENTS

The Eko Atlantic Environmental and Social Impact Assessment (EIA) team wishes to acknowledge and thank South Energyx Nigeria Ltd (SENL), for their continued support throughout this Project.

We also wish to thank the Project engineers for providing the technical and Project planning information necessary to produce this comprehensive EIA for the proposed Eko Atlantic Shoreline Protection and Reclamation Project.

Furthermore, we were fortunate to receive constructive contributions and comments from several organisations and we offer our appreciation to these organizations and in particular to the Federal Ministry of Environment (FMEnv) and Lagos State Ministry of Environment (LASMOE).

Our appreciation also extends to all organisations and individuals who contributed to the EIA study including our Project consultants and survey experts.

EXECUTIVE SUMMARY

I. South Energyx Nigeria Ltd (SENL)

South Energyx Nigeria Ltd (SENL) is a company specifically created to undertake the development of the Eko Atlantic Project. Key elements of the management structure of SENL have a distinguished track record in Nigeria for the successful completion of major construction and engineering works.

SENL plans to develop the Eko Atlantic Shoreline Protection Reclamation Project (The Project). This Project will provide approximately 900 hectares (ha) of high quality land for development within the heart of Lagos, Nigeria and will offer a long term solution to the shoreline erosion problems at Victoria Island, Lagos.

The Project is located offshore of Victoria Island, Lagos State, Nigeria. The Project site is located in the marine waters adjacent to Bar Beach, at Victoria Island, Lagos, within the Eti-Osa Local Government Area.

This document forms the executive (non-technical) summary of the Environmental Impact Assessment (EIA) for Phase I of this Project. It covers the planned shoreline protection and reclamation activities be carried out by SENL.

Royal Haskoning is the consultant employed by SENL to complete the EIA Study.

II. The Need for the Eko Atlantic Project

The shoreline of Victoria Island has retreated significantly in the past century. The main reason for this erosion is the blocking of the coastal sediment transport by the construction of the Lagos Harbour Moles (between 1908 and 1912). Coastal protection schemes have been put in place over time, in order to reduce the erosion threat to Victoria Island, including several nourishment schemes. However, these appear to have only temporarily mitigated the erosion and there have continued to be regular coastal flooding incidents in this region. The erosion culminated in 2006, when the protective beach disappeared with resultant flood damage to the road infrastructure at Bar Beach. With no action, highly valued areas of residential and commercial property would continue to be threatened by intrusion of sea water.

This type of flooding can cause destruction of properties, loss of income and lives. As such, following the 2006 incident, the coastline was protected by a sea revetment consisting of concrete X-bloc armour units. However, a permanent and more extensive solution is considered necessary to address the persistent erosion problem, which is predicted to be exacerbated by climate change and increased likelihood of storm events.

With an increasing population and aspirations for greater economic development, there is a strong need to provide additional, strategically planned urban areas within Lagos. However, space for this within the central areas of Lagos is heavily restricted. In response to the need for land for future development and the necessity for a long term solution to the erosion problems of Victoria Island, SENL developed the Project proposal to protect Victoria Island through the development of a new sea defence in combination with land reclamation of the area previously eroded.

The Project is anticipated to bring significant economic benefits to the region through direct investment in the local economy, knowledge sharing and publicity for the City of Lagos.

III. The Need for Environmental and Social impact Assessment

The Eko Atlantic Project is subject to an Environmental Impact Assessment (EIA), as required under the Nigerian Environmental Impact Assessment (EIA) Act No. 86 of 1992. The EIA has been carried out in accordance with these regulations.

This study report is the EIA report of phase 1 of the proposed Eko Atlantic Project and covers the shoreline protection and reclamation activities. Future development of the land will require independent EIA in order to comply with the requirements of FMEnv and Nigerian Legislation.

IV. Project Description

The reclamation works will form approximately 900 ha of land which will be for the future development of a modern city. The new land will be realised using approximately 90 million m^3 of sand, dredged offshore from the coast of Lagos State from the sea bed of the Atlantic Ocean.

The main reclaimed area will be approximately 6 km long, with a width of 1.5 km on the western end, tapering to 0.5 km on the eastern end. The outer edge of the reclaimed area will be protected from the sea by an approximately 7 km long rock revetment to provide shoreline protection to the new land and to Victoria Island.

The reclamation activities and associated works include the following tasks, which are further described below:
1. Dredging of sand for reclamation from offshore borrow areas;
2. Pre-construction - strengthening of the East Mole by quarry materials to enable use of the mole as an access road;
3. Construction – construction of the sea defence, using several grades of quarry materials, geotextile fabrics and pre-cast concrete armour units; and
4. Construction - sand placement for reclamation.

1. Dredging works

The proposed dredging activities occur during the construction phase and consist of:
- Dredging of approximately 90 million m^3 medium to coarse sand from offshore borrow areas;
- Vessel navigation from borrow areas to the reclamation area; and
- Operation of tugs to assist the berthing of the dredging vessel on the East Mole.

Geotechnical and environmental studies have identified three potential offshore borrow areas for this Project. Although all three have been determined to be suitable, it is planned to take main part of the materials from Borrow Area A. Area A is the most economically viable option in terms of dredging depth, sailing time to the dredging site and furthermore, this area avoids interference with Lagos Port shipping activities. All areas have been considered in this assessment, to allow for changes in dredging plans in future years.

The main type of vessel to be used for the dredging is a Trailing Suction Hopper Dredger (TSHD). It is planned to use one or more vessels similar to the Pearl River, the Rotterdam or the Volvox Terranova, all of which are TSHDs.

2. Strengthening of the East Mole:

The East Mole is the existing breakwater located on the eastern side of the Commodore Channel, the entrance to Lagos Port. This breakwater is able to provide a suitable area for an access road to the Eko Atlantic site for the trucks delivering rock for the sea defence. The access road will be temporary, and will be in place for the duration of the reclamation. The side slopes of the East Mole are excessively steep due to deterioration in time and lack of maintenance. The integrity and stability of the mole could reduce if no action is taken. Therefore the East Mole will be stabilized by the addition of rock and re-profiling of the side slopes. Monitoring will take place continuously during operations. Further, when the reclamation area along the East Mole is sufficiently in place, the temporary access road on the East Mole will be abandoned gradually and transport will shift to new roads on the reclamation area.

3. Construction of the sea defence

The sea defence has been designed with a core of rock with a grading (size) of 1-1000 kg. This core is protected by several layers of armour rock (500 – 2000 kg) and concrete armour blocks (5t Accropodes™) to protect the structure from the ocean waves. The sea defence is designed for extreme wave conditions, such as a 1/100 year storm event and when completed, the crest of the sea defence will rise 6m above sea level (above Chart Datum) with a concrete wall on top of it up to approximately 7m. The sea defence has been physically tested on a scale of 1:30 on stability and overtopping at the Danish Hydraulic Institute (DHI) model testing basins in Denmark. DHI is world renowned for testing coastal structures and is considered a high class facility for testing of this type.

Rock for the sea defence will be supplied by four quarries located between approximately 100 km and 150 km from the Project area. The concrete armour blocks will be produced initially at the Hi-Tech yard at the entrance to the Eko Atlantic site. The equipment at the Hi-Tech yard consists of bulldozers, trucks and plant to mix and cast the concrete armour blocks. The main materials used are rocks, cement, water, aggregates and sand. Following completion of part of the reclamation works, the concrete batching yard will be relocated adjacent to the new sea defence to reduce the amount of transportation and logistics required.

4. Sand placement for reclamation

Construction of the sea defence will be the primary activity in the early stages of the Project. The presence of the sea defence will shelter the waters behind, enabling safe and efficient filling of the area to be reclaimed. Several methods for reclamation will be used, which are dependent on the location at which sand will be deposited. The main methods will be pumping of dredged sand by 1) Sand pumping into the reclamation area from the Commodore Channel over the East Mole or 2) Sand pumping from behind the sea defence into the reclamation area or 3) in some instances, rainbowing directly from the dredger onto the reclaimed land may also be used. 4) Sand dumping by dredgers with bottom doors.

- *Sand pumping into the reclamation area from the Commodore Channel over the East Mole.*
  Following dredging at the offshore borrow areas, the loaded TSHD will moor in the Commodore Channel and pump its load via a pipeline over the East Mole and into the reclamation area.

- *Sand pumping from behind the sea defence into the reclamation area.*
  This option involves the use of two dredgers. Dredger 1 will be stationed behind the sea defence after partial completion and Dredger 2 will be used for dredging at the offshore borrow area. Following dredging offshore, the Dredger 2 will place collected sand next to the first dredger, behind the sea defence. Dredger 1 will then pump the sand to the reclamation area via a pipeline.

- *Sand placement through rainbowing.*
  At sites where pumping is not possible, for instance due to pipeline distance or the use of a smaller dredging vessel, the dredged sand will be deposited using the rainbow technique. During rainbowing the sand is pumped from the hopper directly into the reclamation area. This will be done only in areas protected by the sea defence to maximise reclamation efficiency and minimise environmental effects on water quality.

- *Sand placement by dredgers using bottom doors.*
  Following dredging at the borrow area, the fully loaded TSHD will travel to the reclamation site. The dredger will open the bottom of the hopper doors, placing the dredged material directly onto the reclamation area. This will only take place where water depths allow safe navigation of vessels and is not expected to be the main method of placement.

- *Programme*
  Dredging and reclamation works will be carried out under the supervision of Haskoning Nigeria Engineering Consulting Ltd. The dredging activities are planned to be carried out until May 2016, on a 24/7 work basis (based on the use of a single dredger).

V. Consideration of alternatives

The main alternative for this project was for no project to take place. In this case Victoria Island would continue to be exposed to wave action and erosion, with the associated risks of land loss, damage to coastal infrastructure and flooding. As shoreline protection is a critical need requiring urgent attention, the no-project alternative was not considered.

Alternative locations were not suitable for this project, given the fact that the shoreline protection is needed at Victoria Island and moving the project would remove the planned protection from this area.

At the early stages of the project, a number of design options were considered to address the erosion problem. These included the use of offshore breakwaters and creation of pocket beaches using groyne structures. The alternatives were analysed by coastal specialists and for technical reasons and in order to obtain the most sustainable and secure coastal defense, the sea defense concept was adopted.

Later on in the project design, coastal modeling was undertaken to assess the effects of different project designs. This modeling has led to the recommendation for an S-Shaped design, to help reinstate the natural shape of the coastal and maximise long shore transport

A number of alternative dredging locations have been considered for this project. In order to ensure correct selection, potential locations for the dredging of sand (borrow areas) were determined according to the following criteria:
- Suitability of sand for reclamation purpose;
- Ensure stability of the reclaimed area;
- Within a 20km radius from the reclamation area (for economic feasibility);
- Cause no damage to existing cables and pipelines;
- Minimise conflicts with other sea users;
- Induce no erosion (or no additional erosion) to coastal environment; and
- Avoid marine areas where ecology may be particularly sensitive to dredging activity.

VI. Description of the Environment

Extensive baseline studies have been completed to collect relevant information for the EIA. In line with Nigerian and International EIA best practice, the study area has encompassed all areas within the potential impact footprint of the Project. The study area comprises the area of reclamation (directly adjacent to Bar Beach and the East Mole on Victoria Island, Lagos) and, the borrow pit areas located offshore of Victoria Island, and the areas in between.

Based on the Project location and activities, the following environmental and social parameters have been investigated:
- Meteorology;
- Coastal and sediment processes;
- Water and sediment quality;
- Groundwater;
- Air quality;
- Noise environment;
- Marine ecology;

- Terrestrial ecology;
- Socio-economic environment;
- Navigation;
- Fisheries;
- Cultural heritage;
- Religious worship;
- Landscape character;
- Urban development;
- Public health; and
- Socio-economic environment.

The baseline studies comprised desk based literature research on the above parameters and where data gaps were identified, field studies have been commissioned. This process has helped to ensure that a comprehensive baseline environment could be established and used to inform the EIA process. The studies included:

- Marine and lagoon sediment quality;
- Marine and lagoon water quality;
- Marine and lagoon benthic ecology;
- Marine and lagoon plankton ecology;
- Terrestrial ecology;
- Social (local communities) studies;
- Social (economics) studies.

A summary of the main features of the baseline environment at the Project site are described in the following text. A full description of the investigative studies undertaken and the baseline environment is provided in the main report.

1. Land Environment

Victoria Island is a heavily urbanised and developed area, supporting both residential and commercial areas. The only onshore area directly utilised for construction activities would consist of a small coastal strip of land running eastwards from the East Mole to the Hi Tech Yard, Victoria Island. This land would be used for the storage of concrete blocks for the breakwater and as an access way to the East Mole. This area is currently heavily affected by human activity and is not of ecological importance.

Observations show that the coastline from Lekki Beach to Bar Beach is highly impacted by urban development and disturbed, and unlikely to be of significant ecological importance

2. Coastal Environment

The coastline near Lagos is oriented in an east-west direction and is characterised by a complex system of interconnected lagoons, inland lakes, rivers, creeks, wetlands and channels. The bathymetry offshore from Lagos is characterised by a reasonably gentle and constant bottom slope. The 30m depth contour is located at about 8km from the shore, the 50m depth contours at 17km offshore. The continental shelf extends approximately 30km from the coast.

The morphology of the lagoon complex of Lagos has largely been determined by local coastal dynamics and drainage. Bar Beach is exposed to persistent southerly to south-westerly swells resulting in a persistent long-shore sediment transport, directed from west to east. Bar Beach at Lagos is the fastest eroding beach in Nigeria with average erosion rates of 20-30 m annually, recorded over a period of 100 years. This high rate of erosion has been linked to the construction of the moles that were built to stop the silting up of the entrance to Lagos harbour.

3. Sediments (Lagoons and Marine)

The marine sediment at the Project site generally consists of sandy sediments typical of the barrier beaches along this part of the Atlantic Coast of Africa. It is noted however that fine and very fine sands predominate at the surface, rather than medium to coarse grained sands that are typical of the barrier-lagoon geomorphic complex, an indication that the surface sediments in the area may have been altered by anthropogenic activities.

In general, the analysis of sediments showed the majority of marine sediment samples collected do not contain high concentrations of pollutants. However, some evidence of sediment pollution from heavy metals was recorded in patches, perhaps related to runoff from the industrial activities in Lagos, or pollution from ships, wrecks or discharges.

Higher concentrations of pollutants were identified in the Lagoon sediments. This is likely to be related to the discharge of sewage and other wastes into this water body.

4. Water Environment (Lagoons and Marine)

Surveys of the offshore marine and lagoon environment in the Project area studied the physical, chemical and biological nature at offshore and lagoon sample sites. Evidence of pollution was identified in the survey although it was found that Kuramo Waters and sampled sections of the Lagos lagoon have a higher level of water and sediment pollution than recorded in the marine environment.

The ecological survey found a total of 34 different types of organisms living in the seafloor within the marine study area. No ecological communities of conservation value were identified and the species recorded are not usual for the Nigerian environment and Gulf of Guinea in general.

A total of 15 different types of organisms were found living within the sediments of the Lagos Lagoon and Kuramo Waters. Annelids and insect larvae were the most abundant in these lagoons and the results of the analysis indicated that Kuramo waters are polluted.

Thirty-three species of zooplankton were found in the sampled marine environment. The population and species richness are good when compared to similar areas in the Nigerian gulf of Guinea.

A total of fifty-four species of phytoplankton and twenty-two species of zooplankton were recorded in Lagos Lagoon and Kuramo waters during the baseline surveys.

Species diversity was generally higher in Lagos Lagoon, an indication that this section of the lagoon system is of better water quality.

Overall, the results identified a marine environment that is typical of the Nigerian coastline. No species or habitats of specific conservation importance were identified that are likely to be regular users of the Project area. There is some evidence of pollution in the marine environment, mostly in the surface sediments, where fine particles are present in patches. The lagoon environment is typical of a disturbed system, with evidence of water and sediment pollution. The ecological communities identified in the lagoon also represent a disturbed environment.

5. Air Quality and Noise

The key existing sources of air pollution in the vicinity of the Project site include road transport, port activities (in particular marine vessels waiting to enter Lagos Port), the airport and its flight path. In addition, the use of generators (common in households) will also contribute to local air pollution. The main pollutants of concern from these emission sources are likely to be those relating to fuel combustion and other direct industrial releases, such as Nitrogen Dioxide, Sulphur Dioxide and particulate matter.

The background noise environment on Victoria Island near the reclamation site is dominated by noise from road traffic, industrial activity and construction. Many of the urban express ways are close to residential buildings and schools, thus these are currently exposed to road traffic noise. The roads on Victoria Island are subject to very high levels of traffic. The Bar Beach road runs along the shore immediately adjacent to the reclamation area and therefore thus the properties closest to the site are likely to be used to relatively high levels of noise.

6. Social Environment

Lagos is Nigeria's largest city with an official population of 8 million and unofficially between 15 and 18 million expanding rapidly. Spread over several large islands on a vast lagoon and mainland near the Gulf of Guinea, Lagos is Nigeria's principal port and its commercial and cultural centre. The city continues to grow and the conurbation, including Ikeja and Agege, extends 40 kilometers northwest of Lagos Island. Victoria Island and Lekki are situated to the south of Lagos Island. Along with Ikoyi, they are suburbs of Lagos, home to several large commercial and shopping districts, and the city's beaches. Victoria Island is one of Nigeria's busiest centres of banking and commerce, with most major Nigerian and international corporations headquartered on the Island.

7. Navigation

The project area is located adjacent to the Commodore Channel, the entrance to the Port of Lagos. Vessel traffic into the Lagos Ports in 2009 was approximately 3, 500 vessels. The project area is not within the designated shipping channels or anchorage areas and is not used for recreational navigation or water sports vessels.

8. Fisheries

The main fishing areas in the project area are the Lagos Lagoon, Kuramo Water and the open sea. The fishermen consulted generally fish only at daytime and sail up to about 40 kilometers out to sea. The impact of the Project on their fishing is determined to be negligible.

9. Cultural heritage
Due to the intensive land use in the area, it is very unlikely that there is cultural heritage or an archaeological site of interest in the project area. The beach may contain homemade shrines to the Yoruba pantheon of gods, but these shrines are not thought to hold much intrinsic value beyond the immediate family group nor are they of any archaeological or cultural importance. No chance findings were discovered at the project site.

10. Urban development
Shoreline protection and land reclamation addresses several of the Lagos city's urban development issues. It will boost the real estate values in the financial district of Victoria Island, particularly those businesses and governmental office buildings located near the coastline and at high risk of flooding. Associated projects, including the building of the Eko Atlantic City, will reduce the traffic bottlenecks in downtown Lagos and make it more pedestrian friendly, through the building of public walkways, creation of parks and removal of squatter communities.

11. Public health
The health sector in Nigeria is characterised by wide regional disparities in status, service delivery and resource availability. More health services are provided in the southern states than in the northern states. The current priorities in the health sector are in the area of childhood immunisation and HIV/AIDS prevention. Land clearance at the beach will improve the low level of public health in the city through the destruction of inferior sanitary grounds and dumping areas.

12. Socio-Economic
The Project is situated near a large number of beachfront businesses and small long-standing communities. In first instance consultations took place with communities at Lighthouse Creek, Middle Creek and Badagry Creek and with businesses situated in near proximity to the reclamation area. In second instance also the communities Apese, Igbosere, Itirin, Inupa, Olukotun, Okokuku and Ilabare (within Eti-Osa LGA and Eti-Osa LCDA of Lagos State) have been visited and consulted. It has been determined that the communities will encounter no impacts as a result of the Project. Any inconveniences to the businesses rendered by the reclamation, such as noise, air and visual impacts are considered to be minor. The overall impact of the Project on businesses will be highly positive, both in terms of the shoreline protection the development will offer and the amenities brought about by urban renewal (and associated projects sponsored by Lagos State), such as an improved highway with more orderly traffic, less congestion and noise, trees and parks lining the highway, and the public subway.

VII. Impact Assessment and Mitigation

A comprehensive impact assessment has been undertaken by qualified international specialists using standard methods and techniques. Significance levels have been assigned to each impact in order to provide a consistent framework for considering and evaluating impacts.

Where potentially significant adverse impacts were identified mitigation measures have been considered and are described, either as part of the design or as a measure implemented during construction or operation. Mitigation measures help to avoid or reduce potential significant impacts to acceptable levels. In addition, good practice measures are discussed where relevant and will be undertaken throughout the project.

Impacts on the following environmental parameters have been assessed, with mitigation and monitoring requirements included where necessary:

- Meteorology;
- Coastal and sediment processes;
- Water and sediment quality;
- Groundwater;
- Air quality;
- Noise environment;
- Marine ecology;
- Terrestrial ecology;
- Socio-economic environment;
- Navigation;
- Fisheries;
- Cultural heritage;
- Landscape character.

The sections below provide further information on the key points of interest for this Project.

Based on this study it has been predicted that the Project will have minimal adverse environmental effects on the majority of receptors. Analyses of project-level design and planning of engineering and procedural mitigation measures have resulted in the minimisation and avoidance of potential negative impacts over the lifetime of the Project. Section 7 presents a summary of the predicted residual impacts which are of minor significance or smaller. The impact significance ratings provided in this table assume the implementation of the mitigation measures recommended in this document are executed (Refer to Table 7.1 for more details). As the table illustrates, following mitigation, there are no impacts greater than minor adverse significance are predicted. As per the definition of significances provided in Section 6, the majority of adverse impacts are expected to be small scale and of little concern, being undesirable but acceptable. A number of beneficial impacts have also been identified, including some major beneficial impacts which are defined as being large scale and providing a significant positive gain to the environment.

Coastal morphology and sediment processes

An assessment of the impact of the Project on hydrodynamics and geomorphology looked at the changes that the reclamation could have on the local waves, currents and sediment transport regime. The Project will provide a long term solution to the coastal erosion at Victoria Island. However, the analysis predicts that the pressure of coastal erosion currently experienced at Victoria Island may be shifted to the land eastward of Eko Atlantic. In order to minimise this potential effect, the shape of the sea defence has been designed to maximise the long shore coastal transport of sediment. In addition, a monitoring and mitigation strategy has been recommended to monitor the potential erosion zone and instruct coastal protection management actions to be implemented if required. It should be noted that the coastal regions of Nigeria are considered to be naturally eroding. The study identified that overall a highly significant beneficial effect is predicted for Victoria Island.

Socio-economics

The Project has the potential to generate positive economic effects, which given the total Project investment of several billion dollars is considered to be a beneficial impact to the local and national economy. Positive effects would arise from employment and via the supply chain. In addition, the sharing of international knowledge and expertise with local workers is considered a positive effect of the Project. The luxury hotels and offices on Adetokumbo Ademola Street and the businesses on Ahmadu Bello Way are predicted to benefit significantly from the reclamation activity in the operation phase as the real estate value of their properties will increase.

Landscape and Visual Character

The landscape is defined in this Project as views from the land out to sea. Given the scale and extent of the Project, it is inevitable that effects upon the surrounding landscape would be incurred. The visual effects arising from the presence of the new land would be greatest for the coastal properties of Victoria Island. Overall, the likely landscape and visual effects arising from the Project varies from property to property. However impacts of this nature should be considered in reference to the coastal protection value afforded to these properties by the Project and the relatively low value of landscape character in Lagos.

Cumulative Effects

In order to assess the cumulative effects of the Project on the environment, all other relevant Projects within the Project area were identified and reported. Those Projects which would potentially impact upon the same receptors as the Eko Atlantic Project within the same time frame were selected for review. The overall conclusion of the cumulative effects assessment was that the Project would not significantly contribute to in-combination effects within the Study Area.

VIII. Environmental Management and Monitoring Plan

A comprehensive Environment Management and Monitoring Plan (EMMP) have been established. The purpose of the EMMP is to:

- Establish a comprehensive framework for environmental management during all Project phases;
- Describe roles and responsibilities of the various individuals and organisations involved in environmental management;
- Provide an implementation process for the mitigation measures;
- Provide a system for reporting and management of environmental data;

- Specify strategies to promote sustainable development, waste management, pollution control and reuse, recovery and recycling;
- Enable compliance with legislative requirements.

As part of the EMMP, monitoring programmes have been described where necessary, which would take place either during or post construction, in order to verify predicted impacts and enable management actions where necessary.

IX. Summary

The proposal by SENL to construct the Eko Atlantic shoreline protection and reclamation Project represents a significant investment in infrastructure development in a region that is considered, based on most of the economic and social indicators, one of the least developed in the world.

SENL will provide high quality land for future development in an area of economic importance. This land will be protected from the forces of the sea, and in doing so will also protect the valuable land and properties of Victoria Island, which have been at risk due to extensive coastal erosion issues along this stretch of coast. Lagos will see economic benefits and infusion of funds into the local economy throughout the construction of the development.

A full and comprehensive EIA has been completed for the Project which has been supported by numerous specialist studies including studies in coastal morphological modelling; wave modelling, geotechnical investigations, stakeholder engagement and social and environmental baseline surveys.

Based on this study it has been predicted that the Project will have minimal adverse environmental effects. Analyses of Project-level design and planning of engineering and procedural mitigation measures have resulted in the minimisation and avoidance of potential negative impacts over the lifetime of the Project.

The key area of interest from the study relates to coastal erosion. The Project has been designed to provide a long term solution to the significant coastal erosion problem of Victoria Island and this will undoubtedly provide a major beneficial impact to this area, protecting high value land behind the Eko Atlantic site.

For each aspect of the Project, SENL has developed and committed itself to mitigation measures for the limited number of potential negative impacts identified. An Environmental Management and Monitoring Plan has also been developed to ensure the recommended measures are implemented and environmental effects monitored and managed accordingly.

X. Conclusion

Overall, given the successful implementation of the stated mitigation measures as committed to by SENL, this assessment indicates that the Eko Atlantic Shoreline Protection and Reclamation Project would not have any long term unacceptable impacts. The Project would, however, provide long term coastal protection of Victoria Island and a significant contribution to the local economy.

To sustain proper implementation of mitigation measures SENL has established an environmental management system (EMS). The EMS will ensure proper implementation of the environmental management plan including regular consultations and environmental monitoring. The EIA for phase 2 of the Eko Atlantic project has been initiated.

1 INTRODUCTION

1.1 General

This document reports on the Environmental Impact Assessment (EIA) for the Eko Atlantic City Development Project - Phase 1; Reclamation and Shoreline Protection, also referred to as 'the Project', planned to take place in the Lagos State, Nigeria.

South Energyx Nigeria Ltd. (SENL), the developer, has commissioned Haskoning Engineering Consultants Nigeria Ltd (HKNG), a company of Royal Haskoning, to carry out the EIA for the Reclamation and Shoreline Protection Phase of this Project (Phase 1). Phase II of the works will consist the development of Infrastructure on the reclaimed land and an additional EIA will be done separately for this phase, in line with the relevant legislation.

The present Phase I study is intended to contribute to the identification, assessment and management of the potential environmental and social impacts the Eko Atlantic Reclamation and Shoreline Protection Project and to adequately inform the appraisal process of the Project by the regulating authorities.

For this Project, the regulating authority is the Federal Ministry of Environment (FMEnv). The Lagos State Ministry of Environment (LASMOE) has also been involved in ensuring the proper steps are taken to assess the Project in line with Nigerian Law.

1.2 This report

The remainder of the report is build up as follows:

Appendix E	Social Questionnaire
Appendix F	HSE Documents
Appendix G	Consultation Documents
Appendix H	Coastal Modelling Study
Appendix I	Dredging Erosion Effects Study
Appendix J	3D Physical Model Study (design tests)
Appendix K	Slope Stability Report – East Mole
Appendix L	Geotechnical investigations (sand search)
Appendix M	Air quality informations
Appendix N	Additional socio-economic study
Appendix O	Initial geo-technical monitoring data

1.3 The Project

The EKO Atlantic Reclamation and Shoreline Protection Project comprises land reclamation along the shoreline of the City of Lagos, east of the Lagos port entrance and in front of Bar Beach. The following works are included within the Project scope:

- Coastal protection works;
- Transport of rocks from licensed quarries;
- Dredging (borrowing) and transport of sand by vessel; and
- Reclamation works.

The outcome of the tasks above will be to offer long term shoreline protection to Victoria Island and also provide valuable space for future development in Lagos. It will also replace land that was lost due to severe coastal erosion.

The project is described in all its details in chapter 4.

1.4 Project Location and Study Area

The project is located offshore of Victoria Island, Lagos State, Nigeria and is located in the marine waters adjacent to Bar Beach, at Victoria Island, Lagos **(Figure 1.1 and 1.2).** The project is within the Eti-Osa Local Government Area (**Figure 1.3**). The coastal strip in this area houses residential and commercial properties, and also the Kuramo Lagoon (**Plate 1.1**).

It is important to define the study area as the area in which impacts from the project activities will be considered. This area should be large enough to include all valued environmental and social resources that might be significantly affected by the Project.

Following this criterion, the study area for this project comprises those areas whose physical proximity is likely to be affected directly or indirectly by the land reclamation and dredging activities

Figure 1.2 presents the overall study area from within which impacts have been assessed. Compared to the Eko Atlantic site itself the whole area is large. It should be noted, however, that as impact magnitudes are dependent on individual parameters, the study area for the analysis of each impact varies according to the parameter in question. For example, the study area for noise has been restricted to the areas immediately surrounding the Project reclamation site and traffic route, as the impact would not extend beyond these sites. However, for coastal processes, the study area is larger, covering several kilometers of coastline, as the impacts are potentially over a large scale. In addition, in some instances (*e.g.* the lagoon survey), sites outside the main study area have been selected for the collection of control samples, which by definition must be outside the area of project influence.

a. Western Kuramo – view from Eko Hotel

b. Western Kuramo with shanties

c. Eastern Kuramo

Plate 1.1 Kuramo Lagoon (western and eastern end), January 2010

Key:

Project Area

Projection: Datum Minna UTM Zone 31N

Note: map or data should not to be used for navigation purposes

Title:
Location of Eko Atlantic Project Site

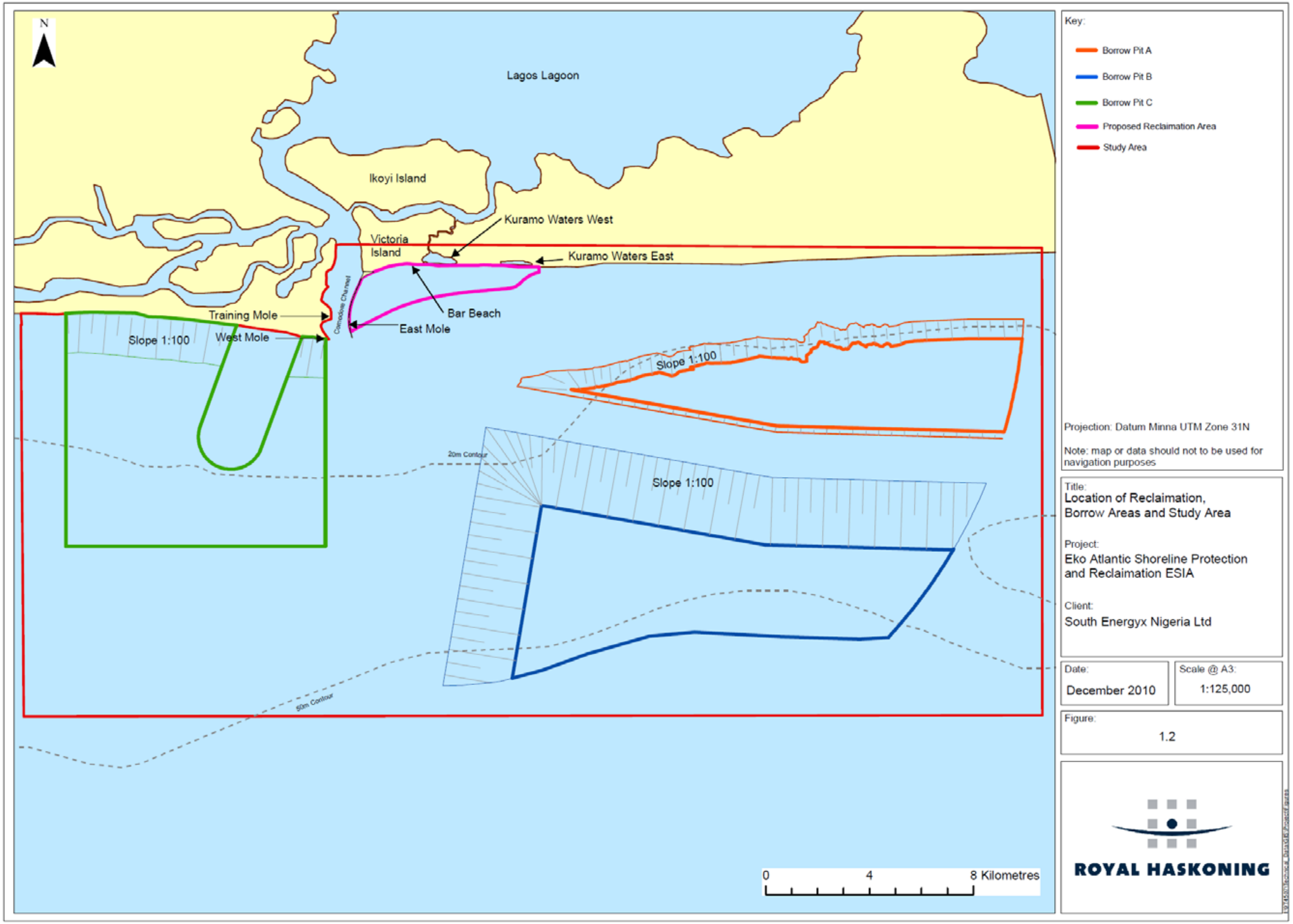
Project:
Eko Atlantic Shoreline Protection and Reclaimation ESIA

Client:
South Energyx Nigeria Ltd

Date:	Scale @ A3:
December 2010	1:4,000,000

Figure:
1.1

ROYAL HASKONING



N
Lagos Lagoon
Ikoyi Island
Victoria Island
Kuramo Waters West
Kuramo Waters East
Training Mole
West Mole
East Mole
Bar Beach
Slope 1:100
Slope 1:100
Slope 1:100
20m Contour
50m Contour
0
4
8 Kilometres
Key:
Borrow Pit A
Borrow Pit B
Borrow Pit C
Proposed Reclamation Area
Study Area
Projection: Datum Minna UTM Zone 31N
Note: map or data should not to be used for navigation purposes
Title:
Location of Reclaimation, Borrow Areas and Study Area
Project:
Eko Atlantic Shoreline Protection and Reclamation ESIA
Client:
South Energyx Nigeria Ltd
Date:
December 2010
Scale @ A3:
1:125,000
Figure:
1.2
ROYAL HASKONING

Figure 1.3 Lagos Local Governments

1.5 The project proponent

South Energyx Nigeria Ltd (SENL), a subsidiary of the Chagoury Group, is a company specifically created to undertake the planning and development of the Eko Atlantic Project.

Key elements of the management structure of SENL have a distinguished track record in Nigeria for the successful completion of major construction and engineering works.

SENL is based in Lagos, Nigeria.

2 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

2.1 Nigerian Administrative Framework

2.1.1 Introduction: Nigeria Administrative Framework

In Nigeria, there are several legislative and regulatory requirements controlling dredging for developments related to industry (dredging for infrastructure, reclamation, and dredging associated with aquaculture). These regulations include local laws as well as some international treaties, acts and conventions. In this section, an overview of the laws that relate to the dredging for development project (dredging for infrastructure and reclamation) are presented below.

Local regulations for dredging for infrastructure and reclamation project fall under the jurisdiction of two main government agencies: The Federal Ministry of Environment (FMEnv), and State Environment laws. These following regulations are of relevance:

- Federal Environmental Protection Agency (FEPA), (now Federal Ministry of Environment - FMEnv) Environmental Guidelines and Standards, including the EIA Act No. 86 of 1992;
- The Nigerian Minerals and Mining Act 2007 ("the Act") was passed into law on March 16, 2007 to repeal the Minerals and Mining Act, No. 34 of 1999 for the purposes of regulating the exploration and exploitation of solid materials in Nigeria;
- The Lagos State Environmental Pollution Control Law Cap 46 of 1989. Lagos State has also enacted the Environmental Pollution Control Law, to provide for the control of pollution and protection of the environment from abuse due to poor waste management hence the creation of charges by the provisions of section 25(1) with the punishment of a fine;
- The Lagos State Waterfront Infrastructure Development Law 2009 (“the LAWID Law”).

2.1.2 National Legislations: National Regulatory Requirements

The Federal Environmental Protection Agency (FEPA) was established in 1988 (with the modifications of the enabling law in 1992 and later in 1999). The Agency was charged with the responsibility of overseeing sustainable development through environmental protection and conservation of natural resources. The Agency was upgraded to become a ministry and in 1999, the Federal Ministry of Environment (FMEnv) was established by the civilian administration to implement laws related to the environment and sustainable development. FMEnv brought under one roof all the federal government’s agencies and departments whose activities related to environment, with FEPA as the nucleus.

The primary mandate of FMEnv is to achieve environmental objectives as expressed in Chapter II Section 20 of the 1999 Constitution of the Federal Republic of Nigeria, whose basic premise is “to protect and improve water, air, land, forest, and wildlife of Nigeria”. Most activities of FMEnv involve policy formulation, project implementation and compliance monitoring. The Ministry is responsible for ensuring the formulation and compliance monitoring of environmental standards. The Ministry has very wide powers covering all the major economic industries.

2.1.3 National Environmental Standards and Regulations Enforcement Agency (NESREA) Act

In order to achieve effective enforcement of environmental laws, standards and regulations in the country, the National Environmental Standards and Regulations Enforcement Agency (NESREA) was established as a parastatal of the Federal Ministry of Environment. The NESREA Act was accented to by Mr. President on the 30^{th} July 2007. By the NESREA Act, the FEPA Act Cap F10 LFN 2004 has been repealed.

NESREA is charged with the responsibility of enforcing all environmental laws, guidelines, policies, standards and regulations in Nigeria, with the exception of oil and gas. It also has the responsibility to enforce compliance with provisions of international agreements, protocols, conventions and treaties on the environment (for more details on NESREA relevant to the project, see http://www.nesrea.org/about.php).

Some of the responsibilities of NESREA include the following:

1. Enforce compliance with laws, guidelines, policies and standards on environmental matters;
2. Liaise with, stakeholders, within and outside Nigeria on matters of environmental standards, regulations and enforcement;
3. Enforce compliance with the provisions of international agreements, protocols, conventions and treaties on the environment including climate change, biodiversity conservation, desertification, forestry, oil and gas, chemicals, hazardous wastes, ozone depletion, marine and wild life, pollution, sanitation and such other environmental agreements as may from time to time come into force;
4. Enforce compliance with policies, standards, legislation and guidelines on the following:

    i. water quality, Environmental Health and Sanitation, including pollution abatement;
    ii. sustainable management of the ecosystem, biodiversity conservation and the development of Nigeria’s natural resources;
    iii. sound chemical management, safe use of pesticides and disposal of spent packages thereof; and
    iv. regulations on the importation, exportation, production, distribution, storage, sale, use, handling and disposal of hazardous chemicals and waste, other than in the oil and gas sector;

5. Enforce through compliance monitoring, the environmental regulations and standards on noise, air, land, seas, oceans and other water bodies other than in the oil and gas sector;
6. Ensure that environmental projects funded by donor organizations and external support agencies adhere to regulations in environmental safety and protection;
7. Enforce environmental control measures through registration, licensing and permitting Systems other than in the oil and gas sector;
8. Conduct environmental audit and establish data bank on regulatory and enforcement mechanisms of environmental standards other than in the oil and gas sector;
9. Create public awareness and provide environmental education on sustainable environmental management, promote private sector compliance with environmental regulations other than in the oil and gas sector and publish general scientific or other data resulting from the performance of its functions; and
10. Carry out such activities as are necessary or expedient for the performance of its functions.

2.1.4 State Legislations: States Environmental Protection Edicts

The responsibility for environmental management in Nigeria is shared between the three tiers of government as enshrined in Chapter II Section 20 of the 1999 Constitution under the fundamental objectives and directive principles of state policy. It stipulates: “States shall protect and improve the environment and safeguard the water, air and land, forest and wild life of Nigeria”. This section of the Constitution refers to Nigeria as a Sovereign State and empowered federating states to legislate on environmental issues. As a result of the law, many State governments in Nigeria have established their Ministries of Environment; in some states as a separate ministry and in others as a part of the Ministry of Water Resources or Agriculture. Almost all of the 36 States (and the Federal Capital Territory, Abuja) have in addition created a State Environmental Protection Agency (SEPAs) whose duty is to implement state environmental policies with particular attention to solid waste removal and industrial pollution control.

Furthermore, in accordance with Section 24 of the Federal Environmental Protection Agency (FEPA) Act, Chapter 131 of the Federal Republic of Nigeria, 1990, (as amended) by Decree No. 59. of 1992, the State Environmental Protection Edicts were enacted. The Edicts empower the State Ministry of Environment to establish such environmental criteria, guidelines/specifications or standards for the protection of the state’s air, lands and waters as deemed necessary to protect the health and welfare of the people.

2.1.5 Nigeria’s National Policy on the Environment (1989, Revised 1999)

The National Policy on Environment, 1989, identified the key sectors in which environmental concerns were to be integrated with sustainable development. It presented specific guidelines for achieving sustainable development in the following fourteen sectors of Nigeria’s economy: Human Population; Land Use and Soil

Conservation; Water Resources Management; Forestry, Wildlife and Protected Natural Areas; Marine and Coastal Area Resources; Sanitation and Waste Management; Toxic and Hazardous Substances; Mining and Mineral Resources; Agricultural Chemicals; Energy Production; Air Pollution; Noise in the Working Environment; Settlements; Recreational Space, Green Belts, Monuments; and Cultural Property.

This Policy defines guidelines and strategies for achieving the policy goal of sustainable development in Nigeria, and, in particular to:

i. Secure a quality of environment adequate for good health and well-being;
ii. Conserve and use the environment and natural resources for the benefit of present and future generations;
iii. Restore, maintain and enhance the ecosystems and ecological processes essential for the functioning of the biosphere to preserve biological diversity and the principle of optimum sustainable yield in the use of living natural resources and ecosystems;
iv. Raise public awareness and promote understanding of the essential linkages between the environment, resources and development, and encourage individual and community participation in environmental improvement efforts; and
v. Co-operate in good faith with other countries, international organizations and agencies to achieve optimal use of transboundary natural resources and effective prevention or abatement of transboundary environmental degradation.

Main Points of the Provisions:

The National Policy on the Environment is a programme of actions rooted in a conceptual framework within which the linkages between environmental problems and their causes, effects, and solutions can be discussed. This is achieved in the policy document through five major policy initiatives:

i. Preventive activities directed at the social, economic, and political origins of the environmental problems;
ii. Abatement, remedial, and restorative activities directed at the specific problems arising from industrial production processes, problem caused by rapid population growth and the attendant excessive pressure of the population on the land and other resources, and problems due to rapid growth of urban centres;
iii. Designs and application of broad strategies for sustainable environmental protection and management at systematic or sub-systematic levels;
iv. Enactment of necessary legal instruments designed to strengthen the activities and strategies recommended by this policy; and
v. Establishment/ placement of management organs, institutions and structures designed to achieve the policy objectives (Article 3.0).

2.1.6 National Guidelines and Standards for Environmental Pollution Control in Nigeria

Based on the 1989 National Policy on Environment, the National Guidelines and Standards for Environmental Pollution Control in Nigeria were enacted in March 1991 to serve as a basic instrument for monitoring and controlling industrial and urban pollution. These guidelines and standards were put in place to ensure the sustainability of Nigeria's industrial and agricultural practices. Sent to plant managers and operators to help them improve their operations, they relate to six key areas of environmental regulation:

i. Effluent limitations;
ii. Water quality for industrial water uses at point of intake;
iii. Industrial emission limitations;
iv. Noise exposure limitations;
v. Management of solid and hazardous wastes; and
vi. Pollution abatement in industries.

The Ministry of Environment (local and Federal) enforces the provisions to ensure compliance.

2.2 Nigerian Regulatory Framework

2.2.1 National EIA Procedures

The EIA procedure of Nigeria is outlined below. The State Environmental Authority works together with FMEnv to ensure the execution on sustainable EIA studies. An overview of the FMEnv EIA Procedural Guidelines has been attached in **Appendix B**.

There is an Environmental Regulation Framework in Nigeria (for EIA and environmental pollution and protection). The requirement for compliance with EIA in all parts of Nigeria derives from the following general laws and enactments that stipulate and mandate project proponents to abide by the standard requirements for sustainable development.

Owing to the dynamic nature of the legal system and the changes that often occur in response to local demands, some of these general laws (applicable to this type of project) are included below however the list is not exhaustive:

Environmental Impact Assessment (EIA) Act No. 86 of 1992

This is the core legislation that governs EIA in respect of proposed projects in Nigeria and flows directly from the provisions of Principle 17 of the Rio Declaration:

"Environmental Impact Assessment as a national instrument shall be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority" (31 I.L.M. 874 (1992): Adoption of Agreement on Environment and Development; the Rio Declaration on Environment and Development).

The Nigerian EIA Act No. 86 of 1992 -Section (1(a) makes it mandatory that before the final decision is taken or approval given for any activity likely to significantly affect the environment, the effect of such activity shall first be taken into account. This is very important because this stresses the need to have an environmental assessment of a project in such a way that the action will be environmental friendly and will not cause serious hazards to the people and the ecosystem.

Federal Environmental Protection Agency, Act 1988, (1988 No. 58), National Guidelines And Standards For Industrial Effluents, Gaseous Emissions And Hazardous Waste Management In Nigeria states that Environmental Auditing of existing industries EIA of new industries and major developmental projects shall be mandatory.

The FMEnv administers and enforces environmental laws in Nigeria. It took over this function in 1999 from the Federal Environmental Protection Agency (FEPA). FEPA was absorbed and its functions taken over by the FMEnv in 1999. A vital role played by FMEnv relates to the approval of EIA. New projects require the EIA to be approved by the Ministry before any construction can commence. In addition, there is a public hearing which is an innovation to the approval process. Members of the wider community, particularly those potentially affected by the project have a forum to modify the way potential impacts are mitigated by project sponsors.

The Nigerian E.I.A. procedure recognized and classified the Eko Atlantic City Development Project (Phase 1) as a category 1 project, that is, it requires a full E.I.A. process and a public review. This is because the scope of the project and the fact that it involves reclamation of a large size of a water body that is considered as an Environmental Sensitive Area (ESA), thus requiring the involvement of the Federal Ministry of the Environment (FMEnv).

The State Environmental Protection Agencies (SEPAs) have enabling instruments which permit them roles and responsibilities in the conduct of EIA. This means that different States within Nigeria also have the power to make laws to protect the environment within their respective jurisdiction. In Lagos State there is the Environmental Protection Agency Law Cap L23 and Laws of Lagos State of Nigeria, 2003. However, the States instruments are subject to Federal enactments and also they are to monitor the process for and on behalf of FMEnv.

Apart from publishing the National Policy on the Environment (NPE) in 1989, with the policy goal of achieving sustainable development, FEPA (now FMEnv) published other sectoral regulations including the National Environmental Protection (Pollution Abatement in Industries and Facilities Generating Wastes) Regulation 1991 wherein an EIA was made obligatory only when so required by FEPA (FMEnv) and compliance must be within 90 days of such demand.

Regulation 11 of the National Environment Protection (Pollution Abatement in Industries and Facilities Generating Wastes) Regulations provides that the collection, treatment, transportation and final disposal of waste shall be the responsibility of the industry or facility generating the waste. The ultimate responsibility lies with the producer, because under Nigerian law, the "polluter pays" principle applies.

2.3 Nigerian Environmental Legislations

A list of Nigerian national legislative frameworks and international regulations relevant to the Eko Atlantic City Development Project and its EIA are presented below and in **Table 2.1**. This EIA study is based on them. A summary discussion of these regulations (both local and international) is presented in the subsequent sections of this chapter. The relevant national and international guidelines in Table 2.1 are treaties and conventions that Nigeria as a country has ratified.

Furthermore, some international treaties relevant to the Eko Atlantic dredging activities are;

i. Convention on Biological Diversity (CBD);
ii. Convention on the Conservation of Migratory Species of Wild Animals (also known as CMS or Bonn Convention);
iii. United Nations Convention on the Law of the Sea (UNCLOS), and
iv. International Convention on the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 (Marine Pollution Convention (MARPOL) 1973/1978).

Some of the above treaties are also cited among the World Bank's list of key international agreements on environment and natural resources (Environmental Assessment Sourcebook- update 10 of the World Bank).

2.3.1 Some of the National/ Local regulatory laws relevant to the Project are:

1. *Environmental Impact Assessment Act No. 86 of 1992 (EIA Act);*

2. *National Policy on Environment;*

3. Harmful Wastes (Special Criminal Provisions etc.) Act of 1988 (Harmful Wastes Act);

4. *Federal Ministry of Environment (FMEnv) Statutory Instrument (S.I.8) National Environmental Protection (Effluent Limitations) Regulation of 1991;*
   i. Section 1 – No industry or facility shall release hazardous or toxic substances into the air, water or land of Nigerian's ecosystem beyond limits approved by the Agency;
   ii. Section 17 – An industry of a facility which is likely to release gaseous, particulate, liquid or solid untreated discharges shall install into its system appropriate abatement equipment in such manner as may be determined by the Agency;

5. *National Environmental Protection (Pollution Abatement in Industries and Facilities Generating Wastes) Regulations of 1991.*

Regulation 10 of National Environment Protection (Pollution Abatement in Industries and Facilities Generating Wastes) provides that no person shall be engaged in the storage, treatment or transportation of harmful toxic waste without a permit issued by FEPA. Therefore where harmful toxic waste is produced on-site, it may only be stored or disposed on-site where a permit has been issued to the producer of such waste. Where it is environmentally safe to do so, solid waste may be stored or disposed of on-site, subject to the issuance of the requisite permit as prescribed by Regulation 16.

Producers of waste may retain residual liability, particularly where a transferee or person engaged to dispose of the same absconds. If the regulator is able to trace the waste back to the producer, he would be liable for clean-up.

6. *The Endangered Species Act 11, 1985.*
   The Act makes general provision for the protection of flora and fauna.

7. *Water Resources Act CAP W.2 Laws of the Federation of Nigeria (LFN) 2004.*
   The Water Resources Act is targeted at developing and improving the quantity and quality of water resources. The following sections are pertinent:

   Section 2 – made provisions for the rights to take and use water generally in Nigeria.
   i. Section 3- provides for acquisition of rights to use or take water in any part of the country.
   ii. Section 5 and 6 provides authority to make pollution prevention plans and regulations for the protection of fisheries, flora and fauna.

8. *Nigerian Ports Authority Act No 38 of 1999*
   The Nigerian Ports Authority (NPA) is a federal government agency that governs and operates the ports of Nigeria. NPA was established in 1955 by the Port Act Cap 155 Laws of the Federation of Nigeria and Lagos as a corporate body with perpetual succession. The enabling statutes have been amended several times. The successor law is the Nigerian Ports Authority Act No 38 of 1999. By Act No. 38 of 1999, Nigerian Ports Authority owns the ports and controls all public and private tasks.

   Under Section 7 of the NPA Act No. 38 of 1999, the functions of the Authority in summary are too:
   i. Provide and operate port facilities and services;
   ii. Maintain, improve and regulate the use of the ports;
   iii. Ensure efficient management of port operations; and
   iv. Control pollution arising from oil or any other from ships using the port limits or their approaches.

   Section 8 of the Act gives the Authority very wide powers. These include power to:
   i. Build and develop port docks, harbours, piers, wharves, canals, jetties, embankment and water courses;
   ii. Invest the funds of the Authority;

iii. Act as consultants in relation to port and port operations in Nigeria or any part of the world;
iv. Act as carrier by land or sea, stevedore, wharfinger, wharehouseman or lighterman
v. Appoint, license and manage pilots of vessels;
vi. Reclaim, excavate, enclose, raise or develop any of the lands acquired by or vested in the authority; and
vii. Win sand from the ports and their approaches for such purposes as it may deem fit.

9. *National Inland Water Ways (NIWA) Act No. 13 of 1997*

NIWA was established in 1997 (Act No. 13 of 1997) as a Parastatal from the erstwhile (old Marine) Inland Waterways Department (IWD) of the Federal Ministry of Transport, which itself was established in 1956. Some of the key functions of NIWA include:

i. Improve and develop inland waterways for navigation;
ii. provide an alternative mode of transportation for the evacuation of economic goods and persons;
iii. Execute the objectives of the national transport policy as they concern inland waterways; and
iv. Subject to the provisions of the EIA Act, carry out environmental impact assessment of navigation and other dredging activities within the inland water and its right-of-ways.

10. *Sea Fisheries Act, CAP S4, LFN 2004.*

The Sea Fisheries Act makes it illegal to take or harm fishes within Nigerian waters by use of explosives, poisonous or noxious substances. Relevant sections include the following:

i. Section 1 prohibits any unlicensed operation of motor fishing boats within Nigerian waters;
ii. Section 14 (2) provides authority to make for the protection and conservation of sea fishes.

11. *Inland Fisheries Act, CAP I10, LFN 2004.*

The Inland Fisheries Act focused on the protection of the water habitat and its species, the following sections are useful:

i. Section 1 prohibits unlicensed operations of motor fishing boats within the inland waters of Nigeria;
ii. Section 6 prohibits the taking or destruction of fish by harmful means.

12. *Nigerian Maritime Administration and Safety Agency (NIMASA) Act. 2007*

The Nigerian Maritime Administration and Safety Agency, NIMASA, focal areas include effective Maritime Safety Administration, Maritime Labour Regulation, Marine Pollution Prevention and Control, Search and Rescue, Cabotage enforcement, Shipping Development and Ship Registration, Training and Certification of Seafarers, and Maritime Capacity Development.

In summary, some relevant functions of the Agency are to:

i. Pursue the development of shipping and regulate matters relating to merchant shipping and seafarers;
ii. Administering the registration and licensing of ships;
iii. Regulate and administer the certification of seafarers;
iv. Regulate the safety of shipping as regards the construction of ships and navigation;
v. Provide directions and ensure compliance with vessel security measures;
vi. Carry out air and coastal surveillances;
vii. Control and prevent maritime pollution
viii. Enforce and administer the provisions of the Cabotage Act 2003;
ix. Receive and remove wrecks; and
x. Provide National Maritime Search, Rescue Services and Maritime Security.

13. *Land Use Act No.6 of 1978*

The Land Use Act of 1978 vested all Land situated in the territory of each State (except land vested in the Federal Government or its agencies) solely in the Governor of the State, who would hold such Land in trust for the people and would henceforth be responsible for allocation of land in all urban areas to individuals resident in the State and to organisations for residential, agriculture, commercial and other purposes. Similar powers will with respect to non-urban areas are conferred on Local Governments. The Law commenced from 27th March 1978.

14. *The Nigerian Minerals and Mining Act 2007 ("the Act")*

The Act was passed into law on March 16, 2007 to repeal the Minerals and Mining Act, No. 34 of 1999 for the purposes of regulating the exploration and exploitation of solid materials in Nigeria. The Act vests control of all properties and minerals in Nigeria (in, under, or upon any land in Nigeria, its contiguous continental shelf and all rivers, streams and water courses throughout Nigeria, any area covered by its territorial waters or constituency and the exclusive economic zone) in the State and prohibits unauthorized exploration or exploitation of minerals.

Mineral Resources Section 1(1) states that all lands in which minerals have been found in commercial quantities shall from the commencement of the Act be acquired by the Federal Government in accordance with the Land Use Act. Mineral Resources Section 1(3)-Property in mineral resources shall pass from the Government to the person by whom the mineral resources are lawfully won, upon their recovery in accordance with provisions of the Act.

The Act further provides that the use of land for mining operations shall have a priority over other uses of land and be considered (for the purposes of access, use and occupation of land for mining operations) as constituting an overriding public interest within the meaning of the Land Use Act. In the event that a mining lease, a small scale mining lease or a quarry lease is granted over land subject to an existing and valid statutory or customary right of occupancy, the Governor of the state within which such rights are granted shall within sixty days of such grant or declaration revoke such right of occupancy in accordance with the provisions of section 28 of the Land Use Act.

15. *Lagos State Environmental Pollution Control Law Cap 46 of 1989*
Lagos State has also enacted the Environmental Pollution Control Law to provide for the control of pollution and protection of the environment from abuse due to poor waste management. In Section 25(1) transgressors were subject to pay a fine. The law also prohibits the discharge of Gamalin 20 or any herbicide or insecticide or other chemicals to kill or whatever purpose in rivers, lakes, or streams within the State, without first obtaining written approval from the Ministry of Environment and Physical Planning.

Section 15(i) of the Edict prohibits the discharge into the air of any inadequately filtered and purified gaseous waste containing substances injurious to life and property whilst subsection 2 provides that persons not burn any type of refuse, bush, weed, grass, tyres, and cables on the Lagos Metropolis without obtaining a written permission from the State Ministry of Environment.

Environmental Pollution Control Law Section 12 of this law under the Laws of Lagos State makes it an offence to cause or permit a discharge of raw untreated human waste into any public drain, water course, or onto any land mass or water body. This offence is punishable with a fine not exceeding N100, 000 (One hundred thousand naira) and in the case of a company, a fine not exceeding N500, 000.

16. *The Lagos State Waterfront Infrastructure Development Law 2009 ("the LAWID Law")*
The Lagos State House of Assembly passed a bill in 2008 for a law to provide for the regulation of waterfront infrastructure development, sand dealing and dredging operations in the state. The LAWID Law empowered Lagos State Ministry of Waterfront Infrastructure Development (MWID) to regulate sand dredging in two (2) distinct areas.

MWID is empowered to grant permit for sand dredging or dealing within, around and on waterfronts and embankments according to Sections 3(e), 4 and 1(2) of the LAWID Law. Waterfront is defined as land at the edge of a stream, creek, lagoon, coastal area, shoreline, harbour, wharf, dock, bar beach and other beaches within Lagos State – section 23 of the LAWID Law Embankment simply means bank of wall of waterways.

Sections 3, 4 and 1(2) of the LAWID law empower MWID to grant permit for sand dealing or sand dredging around waterfronts. MWID is statutorily empowered to regulate not only the transportation of granite, laterite etc. but also those who buy and sell it. Sand stockpiles fall into the category of those who buy and sell sand.

2.4 Regional and International Agreements and Conventions

Apart from the National Laws, Acts and Regulations, Nigeria is a signatory or party to many International Environmental Conventions and Treaties and has participated in many related conferences. A list of some of the relevant International Environmental Conventions and Treaties ratified by the Government of the Federal Republic of Nigeria are presented below.

Table 2.1 Summary of Relevant Regional and International Agreements and Conventions

Regulations	Year Adopted
Gulf of Guinea Large Marine Ecosystem Project (GOG-LME)	1999
Convention on Biological Diversity (CBD)	1994
United Nations Framework Convention on Climate Change (FCCC)	1992
Convention on Fisheries Cooperation among African States Bordering the Atlantic Ocean	1991
World Bank Operational Directive 4.01: Environmental Assessment, which classifies projects according to the nature and extent of their environmental impacts.	1991
Convention on Oil Pollution Preparedness, Response, and Co-operation	1990
Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal	1989
Convention on the Conservation of Migratory Species of Wild Animals (CMS or Bonn Convention) (Signatory only)	1988
Montreal Protocol on Substance that Deplete the Ozone Layer	1987
Vienna Convention on the Ozone Layer	1985
United Nation Convention on the Law of the Sea	1982
Convention on Co-operation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Regions (Abidjan Convention)	1981
Protocol Concerning Cooperation in Combating Pollution in Cases of Emergency in the West and Central African Region	1981
Convention on Conservation of Migratory Species of Wild Animals	1979
International Convention on Standards of training Certification and Watch-Keeping for Seafarer	1978
Convention on the Protection of the World Cultural and Natural Heritage (world Heritage Convention), Paris	1975
International Convention for the Safety of Life at Sea	1974
Convention to Regulate international trade in Endangered species of Fauna and Flora (CITES)	1973
International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) (this supersedes OILPOL, 1954)	1973
Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter (the convention was amended in 1992)	1972

Convention on the International Regulations for Preventing Collisions at Sea	1972
African Convention on the Conservation of Nature and Nature Resource	1968
Convention on the Territorial Sea and Contiguous Zone	1958
Convention on the Continental Shelf	1958
Convention on the High Seas, Geneva	1958

2.5 Terms of Reference for the EIA

In January 2010, the Terms of Reference (ToR) for the EIA for this project were approved by FMEnv. It was agreed that the principal aim of the EIA process for the Eko Atlantic Project Phase 1 was to determine any potential environmental impacts and to provide guidance to minimise or avoid any adverse impacts upon the environment (from baseline to construction and during operation), through appropriate mitigation and management recommendations. The preparation of an Environmental Management Plan (EMP) would ensure proper implementation of mitigation and monitoring measures.

In addition, the EIA aims to inform decision making and to promote environmentally sound and sustainable development. The methodology is described in the text below and a copy of the full Terms of Reference (scope of works) document and approval letter from FMEnv are provided in **Appendix A** to this report.

It should be noted that this EIA does not include the operational phase of the development as this will be subject to a separate EIA of Phase 2 of the Eko Atlantic Project. It also does not cover the areas identified for land based sources of materials *i.e.* the quarries which are subject to independent assessment and licensing procedures.

2.6 ToR Methodology for EIA

EIA process

EIA is a tool for systematically examining and assessing the impact and effects of development on the environment. A summarised illustration of the EIA Process for this project is provided in **Figure 2.1**. During this process, there will be regular interaction with the design team.

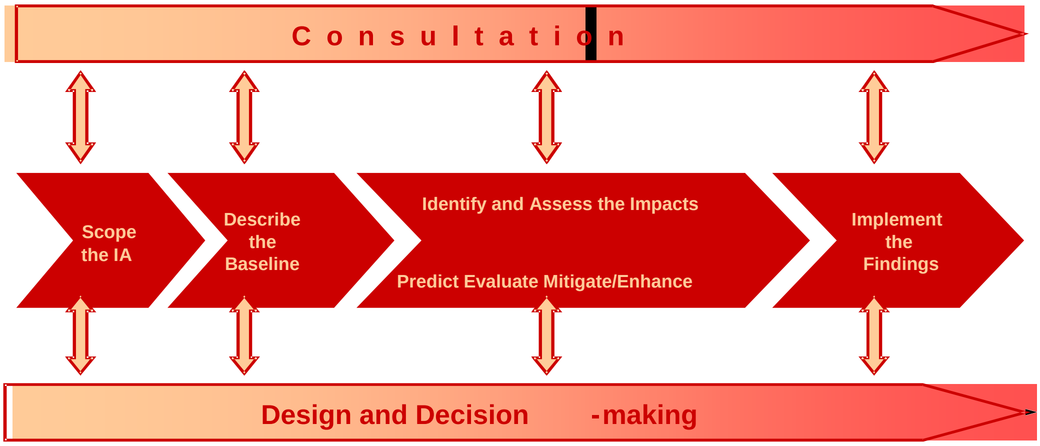


Figure 2.1 Schematic presentation of the general methodology for the EIA

The issues to be addressed in the EIA study shall include the following as a minimum:

1. A full description of the proposed project;
2. A statement of the objectives of the proposed project;
3. Evaluation of alternatives;
4. A description of the existing environment likely to be affected;
5. Identification of the potential impacts resulting from proposed project on the environment (both positive and negative);
6. Mitigation measures to help minimise or avoid any identified significant impacts;
7. Commitments to formulate environmental management and monitoring plan, taking into consideration any information gaps.

The following text provides more detailed information on the approach to EIA:

Baseline Environment

The description of the baseline to be included in the EIA Report for this project will include relevant available information from literature and data available from previous studies in the region. In addition, the baseline description will be supplemented with observations, special studies, existing information etc.

The description of the baseline environment will include the following information:

- Physical environment: hydrodynamics, coastal morphology, sediment quality, water quality, air quality and noise;
- Biological environment: terrestrial, coastal and marine ecology, including a description of the marine habitats; and
- Human environment: socio-economic/cultural issues.

Impact Assessment

The EIA will assess the potential environmental impacts of both the construction and operational phases of the proposed project using the following:

- Observations on site;
- A review of existing environmental data;
- A review of impacts associated with other similar schemes;
- A review of literature and expert judgement on the sensitivity of environmental parameters to the predicted impacts.

Potential impacts will be determined based on the characteristics of the existing environment and the alteration of any physical, chemical, biological or perceived characteristic (including social and cultural) of or on that environment. The parameters that will be assessed in the EIA are summarised as follows:

Table 2.2 Parameters to be assessed

Biological environment	Human environment
> Coastal ecology > Marine ecology	> Socio-cultural > Navigation > Traffic and transportation > Archaeology > Visual amenity > Health and Safety
Physical environment	
> Coastal Processes and Hydrodynamics > Sediment quality > Water quality > Groundwater > Noise > Air quality	

Statement of impact

For each parameter, a description of the impact will be provided followed by a characterisation of the impact in terms of its nature and magnitude, or physical extent. The magnitude or physical extent of impacts will be quantified wherever possible.

Where an impact cannot be quantified because of the nature or complexity of the impact, a subjective scale will be used to determine its significance.

Defining significance

For the purposes of the EIA process, a significant change (or effect) will be determined as one where the predicted net impact of the activity or process would exceed the normal variation in baseline conditions without the activity.

The definition of significance will involve consideration of the sensitivity of the receiving parameter and the magnitude of the impact (which is dependent on the frequency, extent and timescale of the impact). Therefore, to calculate the level of significance, the following formula will be used:

Significance of Effect = Magnitude of Impact x Sensitivity of the Receptor

This formula shows that as the sensitivity of the environment and the magnitude of the effect increases, so the significance of the effect also increases. This relationship is illustrated in **Table 2.3.**

Table 2.3 Derivation of significance criteria

Magnitude of Effects	Receptor Sensitivity / Value of Feature				
	Very High / International / National	High/ Regional	Medium / District	Low / Local	Very Low / Site - Specific
High	Major	Major	Major	Moderate	Minor
Medium	Major	Major or Moderate	Moderate	Minor	Negligible
Low	Moderate	Moderate or Minor	Minor	Negligible	None

Development of Mitigation Measures

As part of the EIA process, Royal Haskoning will provide recommendations for measures that may be required to avoid, minimise or reduce adverse impacts on the environment. It is preferable that Royal Haskoning select practical and economically feasible options which hold up to scrutiny. Costs of construction and operation will be taken into account in the selection process.

Mitigation measures will be described mainly in a qualitative manner, and will also be assessed against relevant national or local policies and best practices to determine which mitigation measures are the most appropriate for the given situation. The box below provides details on the mitigation hierarchy which will be applied.

Information box 2.1 Mitigation hierarchy

Avoid at Source/Reduce at Source
Avoiding or reducing at source is essentially modifying the Project so that a feature causing an impact is designed out (*e.g.* spoil disposal location) or altered (*e.g.* reduced working width).

Abate on Site
This involves adding something to the basic design to abate the impact – pollution controls (*e.g.* dredging screen) fall within this category.

Abate at Receptor
If an impact cannot be abated on-site then measures can be implemented off-site or at the receptor.

Repair or Remedy
Some impacts involve unavoidable damage to a resource. Repair essentially involves restoration and reinstatement type measures.

Compensate in Kind
Where other mitigation approaches are not possible or fully effective, then compensation, in some measure, for loss, damage and general intrusion might be

appropriate. This could be “in kind”, such as recreating a new wetland habitat elsewhere to replace what has been lost.

Residual Impacts

Following the development of mitigation measures, the significance of the impact will be reassessed. In determining the residual impact rating in the reassessment process, it is assumed that the proposed mitigation measure(s) is successfully implemented.

Development of Monitoring Requirements

Finally, the TOR stated that the EIA process will also detail the requirements for the monitoring of parameters that are adversely affected to a significant extent. The monitoring aims to record the actual changes to the baseline environment and the success of the mitigation measures recommended reducing the significance of the impact. The monitoring should be reviewed regularly and further mitigation measures are recommended where the significance of any effect is not reduced to acceptable levels.

2.7 Overall schedule of EIA implementation

At the completion of the final remarks into the EIA report, the implementation of the EIA process had the following schedule:

Table 2.3 EIA implementation schedule

Nr	EIA component	Period	Remark
1.	Initial environmental studies	2008-2009	Preliminary EIA
2.	Terms of reference FMEnv	Jan 2010	Approved March 2010
3.	Draft EIA preparation	April 2010 – June 2011	Completed and submitted
4.	Public forum / expert panel	Nov 2011	Completed
5.	Preliminary EIA Certificate	Jan 2012	Received
6.	Follow up actions (EMS and EMP)	Feb – May 2012	Completed
7.	1st Impact Mitigation Monitoring (IMM) meeting	September 2012	Completed
8.	Final EIA preparation	June - October 2012	
9.	Final EIA Certificate	To be issued	

3 PROJECT JUSTIFICATION

3.1 Introduction

In this section of the report, we provide a justification for the proposed project based on the need, the benefits and the value of the Project. In addition, we provide an analysis of the different alternatives for the Project, in line with the Nigerian EIA Guidance.

3.2 Statement of Need

3.2.1 National Context

In 2007, the population of Nigeria was estimated at nearly 150 Million people, with the largest urban agglomeration being Lagos (United Nations Statistics Division, 2010). With an urban population growth rate of 3.8% per annum, there is continued need for urban development to provide housing and business facilities.

The proportion of the Nigerian population living in urban centres has increased phenomenally over the years. While only 7% of Nigerians lived in urban centres in the 1930s, and 10% in 1950s, by 1970, 1980 and 1990, 20%, 27% and 35% lived in the cities respectively (Okupe, 2002). The incidence of this population in urban centres has created severe housing problems, resulting in overcrowding in inadequate dwellings (FGN, 2004).

It should be acknowledged that private sector developers account for the majority of urban housing (FOS, 1983). The production of housing in Nigeria is primarily the function of the private market; approximately 90% of urban housing is produced by private developers (Kabir and Bustani, 2009).

Nigeria's housing deficit to date is 17 million housing units for a total population of nearly 150 million. The demand for housing is therefore huge, including in Lagos. Housing investment is a key component of economic development, as housing is a social need and private home ownership is often an important source of capital for entrepreneurship (The Netherlands Development Finance Company (FMO, 2010).

3.2.2 Local Context

Land for development

Lagos State is a state of Nigeria, located in the south-western part of the country. The smallest of Nigeria's states (representing 0.4% of the entire geographical area of the Country), Lagos State is the most populous state and a highly economically important state of the country. In a UN study of 1999, the city of Lagos was expected to hit the 24.5 million population mark by the year 2015 and thus be among the ten most populous cities in the world.

Lagos is a Commercial city-state with sound economic base, strategic location and socio-political importance which has induced a high rate of rural-urban immigration from other parts of the Country. One of the key economic features of Lagos is the presence of its port, which is the main hub for ship transport in Nigeria. Lagos urban facts are summarised below (Lagos State Government, 2008).

- Geographical Area – 3,577sq. km (0.4% of the Nation);
- Population Estimate – 16.86m (27.4% of Country Urban/UN);
- Population Density – 4,193 persons/sq.km;
- Population Growth Rate – Between 6-8% (Nigeria 2.9%);
- Rural Population Growth – 600,000;
- Projected Population – 20.19m (2010) 24.5m (2015);
- 20 Local Government Authorities and 37 Local Council Development Areas (LCDA)
- Number of Communities – 2,600.

The rate of population growth in Lagos is about 600,000 per annum with a population density of about 4,193 persons per sq. km. In the built-up areas of Metropolitan Lagos, the average density is over 20,000 persons per sq. km (Lagos State, 2010).

At present, planned urban development in Lagos is limited, with large parts of the city having low/middle class housing. With an increasing population and aspirations for greater economic development, there is a strong need to provide additional, strategically planned urban areas within Lagos. However, space for this within the central areas of Lagos is heavily restricted.

Coastal Erosion and Flooding

Coastal and marine erosion and land subsidence have been recorded in the coastal areas of Nigeria including in Lagos, Ogun, Ondo, Delta, Rivers, Bayelsa, Akwa Ibom and Cross River states and, as a result of which, oceanic surging has resulted. Urban flooding is now a common experience in Nigeria. Identified areas of major erosion and flood potential along the Nigerian coastal zone are Victoria beach, Awoye/Molume, Escravos/Ugborodo, Forcados, Brass, Bonny, IbenoEket, IkotAbasi (United Nations, 2001). Flood and erosion can remove top soil, destroy roads, affect fresh water resources and threaten lives and properties.

As the population has been increasing, certain areas of Lagos have been retreating. The shoreline of Victoria Island has retreated significantly in the past century. The main reason for this erosion is the blocking of the coastal sediment transport by the construction of the Lagos Harbour Moles (between 1908 and 1912). Coastal protection schemes have been put in place over time, in order to reduce the erosion threat to Victoria Island, including several nourishment schemes. However, these appear to have only temporarily mitigated the erosion and there have continued to be regular coastal flooding incidents in this region. The erosion culminated in 2006, when the protective beach disappeared with resultant flood damage to the road infrastructure at Bar Beach. The images presented in **Plate 3.1 to 3.6** illustrate the situation in 2006. With no action, highly valued areas of residential and commercial property would continue to be threatened by intrusion of sea water.

This type of flooding can cause destruction of properties, loss of income and lives. As such, following the 2006 incident, the coastline was protected by a sea revetment consisting of concrete X-bloc armour units. However, a permanent and more extensive solution is considered necessary to address the persistent erosion problem, which is predicted to be exacerbated by climate change and increased likelihood of storm events.

With accelerated rise in sea level, the potential for flooding and erosion of certain key infrastructures on low lying coastlines is predicted to increase leading to a degeneration or interruption of social and economic services and possible destruction of nearby residences and businesses.

In response to the need for land for future development and the necessity for a long term solution to the erosion problems of Victoria Island, SENL developed the Project proposal to protect Victoria Island through the development of a new sea defence in combination with land reclamation of the area previously eroded.

Plate 3.1 Erosion at Bar Beach c. 2006

Plate 3.2 Erosion at Bar Beach c. 2006

Plate 3.3 Erosion at Bar Beach c. 2006

Plate 3.4 Erosion at Bar Beach c. 2006

Plate 3.5 Erosion at Bar Beach c. 2006

Plate 3.6 Present Shoreline Protection at Bar Beach

3.3 Benefits of the Project

There are several significant benefits to gain from the construction of the shoreline protection and the reclamation of land adjacent to Victoria Island. The beneficiaries include the Project proponent (SENL), the State and Federal Governments, the local community and importantly the local economy.

International standard design and construction methods will be used in the development of the Project. With many local companies and individuals employed by the Project, the development of Eko Atlantic will introduce new design and technology concepts and skills to the local workforce.

Even before construction, the Project has attracted a large amount of international interest, helping to raise the profile of Lagos, and Nigeria as a whole as an important development centre. This interest will grow and the Project will attract high profile local and international investment.

In summary the main benefits of the development include:

- Protection of the valued land on Victoria Island from further erosion;
- Provision of high value land for future development;
- Creation of employment opportunities for skilled and unskilled personnel;
- Raising of the profile of Lagos;
- Preparation of the development of the Eko City Development Project and its corresponding benefits, such as reduced traffic and better public amenities; and

- Introduction of state of the art design, technologies and construction methods to the local setting.

3.4 Value of the Project

The total investment required for the marine works for this project is in the magnitude of several billion Euros. Of this value, 75% is expected to be invested in the local economy, with the remainder as costs for international companies, such as the dredging contractor. In addition, other associated investments including preservation of land (from erosion) and knowledge and technology transfer will be made.

The project will be financed through local and international banks and private sector investors.

3.5 Project Sustainability

This sub-section examines the environmental sustainability of the proposed project. Economic sustainability becomes applicable in the City Development phase of the Project.

3.5.1 Environmental Sustainability

The shoreline protection and reclamation project is planned to adopt best practice technologies which will minimise effects on the local environment. This comes through the following sources:

Project Design

The shape of the reclamation area has been carefully studied and designed by international experts in coastal processes, using modern computerised coastal modelling programmes and physical scale modelling. The final design provides maximum space for future development, whilst providing a sustainable and durable structure which prevents future erosion at the valuable areas in Lagos (Victoria Island), whilst minimising effects on neighbouring coastlines.

The shape of the reclamation is considered to be an essential parameter in minimising possible new erosive tendencies at the seaward face and east of the reclamation. Initial qualitative results from modelling using computerised coastal modelling programmes show that by smoothing the plan shape of the reclamation gradually to the present coastline increases the volume of sediment bypassing the coastal inlet. As a result, the shoreline at the seaward face and east of the reclamation is expected to be less vulnerable to erosion.

In case undesired effects on the shoreline along the first 10km on the eastern side of the reclamation area will occur, mitigation measures shall be considered such as a soft solution, sand nourishment, or a hard solution using rocks and/or concrete blocks.

Selection of best dredging methods.

The dredging contractor is Dredging International (part of the DEME-Group) and their policy is that concern for safety, environment and the maintenance of the strictest quality standards contribute to better performance and higher efficiency. Operational and environmental risks are evaluated for every project they work on and preventive measures are included in every Method Statement, Construction Manual or Control Plan. Project-specific requirements include a risk assessment and checking activities against local regulations (Dredging International, 2010). The standard of Quality, safety and environmental awareness in the DEME-Group is demonstrated by the ever-growing list of ISO/VCAB/OHSAS/ISM and ISPS certificates:

- ISO 9001 for the execution of quality assurance;
- ISO 14001 for the execution of environmental protection;
- VCA & OHSAS for the execution of occupational health and safety.
- ISM for the execution of safety at sea and marine-environmental protection;
- ISPS for the execution of security on vessels.

Selection of best construction materials and methods

The construction methods for the sea defence and reclamation aim to minimise effects on the environment. This includes the phasing of the Project. Best practice in reclamation requires that a protective bund (or in this case the sea defence) is developed prior to reclamation filling. In this way, during the filling process, sand pumped from the dredger does not disperse as far into the water, and is contained as far as possible making for a more efficient and environmentally sound reclamation process.

In addition to the above, where possible local materials are selected in order to minimise effects on the environment through international transport of resources and maximise input to the local economy. This includes the large amount of rock required for the sea defence, which are sourced at Nigerian quarries and the concrete armour units which are produced locally.

3.6 Alternatives Analysis

There are usually several alternatives to a project design and in this sub section, a number of alternatives are considered. In assessing alternatives, there are often many influencing factors including economic feasibility, level of political support for the Project (in line with Government policies) and social-environmental feasibility and sustainability

3.6.1 No Project

In this option, no project would take place and the area for Eko Atlantic would not be reclaimed. In this case Victoria Island would continue to be exposed to wave action and erosion, with the associated risks of land loss, damage to coastal infrastructure and flooding. As shoreline protection is considered a priority need to Government,

businesses, and residents, essential at the Project site, the no project alternative has been disregarded.
Furthermore, without the shoreline protection scheme, the planned investment for the Eko Atlantic City Development would not occur and the anticipated economic benefits would not be seen. The space for future development at the heart of Lagos would not be created. In addition, no dredging and reclamation would occur offshore, which would avoid the potential environmental impacts on the marine environment as a result of the Project. However, the avoidance of any environmental impacts accrues much smaller benefits than the direct and indirect benefits of shoreline protection. Furthermore, as a result of the EIA process, any significant adverse environmental impacts will be mitigated to acceptable levels if not reduced altogether.

3.6.2 Delayed Project

In this option the Project is delayed, for example due to political position, public opinion and/or availability of funding. The two direct outcomes of a significant delay or delays in the project are escalating project costs which could jeopardize the financial feasibility of the Project and increased exposure of the shoreline to additional flooding.

In addition, the development will take a number of years (approximately 6 to complete reclamation) and therefore any delays to the Project extend this already lengthy period.

3.6.3 Alternative Reclamation Location

In this option, a different location would be selected for the Project. This alternative is not suitable given the fact that the shoreline protection is needed at Victoria Island and moving the Project would remove the planned protection from this area.

3.6.4 Alternative Project Design

At the early stages of the Project, a number of design options were considered to address the erosion problem. These included the use of offshore breakwaters and creation of pocket beaches using groyne structures. The alternatives were analysed by coastal specialists and for technical reasons and in order to obtain the most sustainable and secure coastal defense, the sea defense concept was adopted.

Later on in the Project design, coastal modelling was undertaken to assess the effects of different project designs. This modelling has led to the recommendation for an S-Shaped design, to help reinstate the natural shape of the coastal and maximise long shore transport (See **Chapter 5 and 6** Coastal Processes Sections).

3.6.5 Potential Dredging Locations

The selection of dredging locations (to acquire sand for reclamation) has been considered. Potential locations for the dredging of sand (borrow areas) have been determined according to the following criteria:

- Suitability of sand for reclamation purpose;
- Ensure stability of the reclaimed area;
- Remaining within a 20km radius from the reclamation area (for economic feasibility);
- Avoiding and causing no damage to existing cables and pipelines;
- Minimise conflicts with other sea users;
- Induce no erosion (or no additional erosion) to coastal environment;
- Avoid marine areas where ecology may be particularly sensitive to dredging activity.

Based on the above, which have been studied through field investigations (**see Chapter 5**), the dredging areas were geospatially mapped to provide the areas identified in **Figure 4.5** This figure illustrates the constraints developed using the criteria above *e.g.* cable areas, anchorage areas, shipping channels, etc. In light of these considerations, the choice of the selected location for the Project is the most suitable in the country. Any alternative location would compromise the twofold aims of the Project to protect the already eroding coastline and to develop it for further commercial purposes.

4 PROJECT DESCRIPTION

4.1 Introduction

This section provides a description of the pre-construction and construction activities. The operational activity is not described, as the outcome of the Project will form new land, which has no operating activities. The Project comprises land reclamation along the shoreline of the City of Lagos entailing:

- Shoreline protection works (sea defence);
- Dredging (borrowing) and transport of sand by vessel; and
- Reclamation works.

The reclamation works will form approximately 900 hectares (ha) of land which will be for the future development of a modern city. The new land will be realised using approximately 90 million m^3 of sand, dredged offshore the coast of Lagos State from the sea bed of the Atlantic Ocean **(Figure 1.1**).

The main reclaimed area will be approximately 6km long, with a width of 1.5 km on the western end, tapering to 0.5 km on the eastern end. The shape of the reclamation is presented **Figure 1.2**. The outer edge of the reclaimed area will be protected from the sea by a 7 km long rock sea defence to provide shoreline protection to the new land and to Victoria Island.

4.2 Description of Project Activities

The reclamation activities and steps include the following tasks, which are further described below:

1. Dredging of sand for reclamation from offshore borrow areas;
2. Pre-construction - strengthening of the East Mole by quarry materials to enable the use of the mole as an access road;
3. Construction – construction of the sea defence, using several grades of quarry materials, geotextile fabrics and pre-cast concrete armour units; and
4. Construction - sand placement for reclamation.

The sequence of reclamation is presented in **Figure 4.2**. It is expected that the reclamation area will be completed in a phased manner, which is subject to the urban development program as well. The most western phases will be reclaimed by pumping sand from the dredging vessel moored in the Commodore Channel. The method of reclamation of the most eastern phases depends on the method statement the Contractor prefers.

The sea defence provides shelter to the reclaimed sand-fill and therefore she should protrude towards the east ahead of the sand-fill progress.

Figure 4.2. indicates that the reclamation works are planned to be carried out between the years 2010 (start first phase) and 2016 (last phase).

4.2.1 Dredging works

The proposed dredging activities occur during the construction phase and consist of:

- Dredging of approximately 90 million m3 medium to coarse sand from offshore borrow areas;
- Vessel navigation from borrow areas to the reclamation area; and
- Operation of tugs to assist the berthing of the dredging vessel on the East Mole.

Geotechnical and environmental studies have identified three potential offshore borrow areas for this project. The borrow areas have been labelled A, B and C and the locations of these are presented in **Table 4.1.**

All areas are considered suitable for dredging. It is up to the decision of the Contractor to choose or identify alternative dredging locations, which should comply with the criteria as stipulated here above. The suitability of a dredging area does highly depend on the characteristics of the dredging vessel, such as sailing speed, pumping capacity, length of suction pipe etc.

Best estimates characteristics of the borrow areas are presented in the **Table 4.1**

Table 4.1 Borrow area characteristics

Borrow area	Average bottom depth from CD	Max allowable dredge depth from CD	Dredge thickness	Sand type	Dredge volume
A	15m – 20m	22m	7m	Medium to coarse sand	294Mm^3
B	20m - 35 m	45 m	10m	Medium to coarse sand	640Mm^3
C	10 - 20m	15m	10m	Sand layer below silt	300Mm^3

The main type of vessel to be used for the dredging is a Trailing Suction Hopper Dredger (TSHD). It is planned to use one or more vessels similar to the Pearl River, the Rotterdam or the Volvox Terranova, all of which are TSHDs. The vessels will be fuelled by marine diesel fuel which is bunkered to the vessel via pipeline at the high sea. The fuel operations will be subject to monitoring by the Consultants' dredging supervisors. The type of vessel to be used for the dredging activities and the transportation of sand is shown in **Plate 4.1** and the specification is provided in **Table 4.2**.

The sand harvested from the borrow areas (to be used in the reclamation area) will be tested for suitability for use in the planned reclamation works. Details of the sand search are provided in **Appendix D** (Hak Marine Report, 2008)

Plate 4.1 Dredging vessel The Pearl River (Dredging International, 2010), as example of type of vessel used for the Project

Table 4.2 Pearl River Specifications (Dredging International, 2010), as example of type of vessel used for the Project

construction year // 1994 - 2002 - 2006				
dimensions	length o.a.		182.22	m
	breadth o.a.		28.00	m
	moulded depth		11.90	m
	draught maximum		10.30/10.60	m
dredging depth			30.00/60.00/120.00	m
suction pipe Ø			2 x 1,200	mm
suction pipe deep dredging Ø			1,200/1,100	mm
discharge pipe Ø			1,000	mm
hopper capacity			24,130	m^3
loading capacity			30,140	t
maximum speed loaded			15.00	knots
power	total installed with D.R.A.C.U.L.A.®		21,293	kW
	total installed		19,061	kW
	on pumps	sb (dredging)	3,000	kW
		ps (dredging)	3,000	kW
		shore delivery	8,400/12,160	kW
	propulsion	sailing	17,280	kW
		trailing	10,200	kW

4.2.2 Strengthening of the East Mole

The East Mole is the existing breakwater located on the eastern side of the Commodore Channel, the entrance to Lagos Port. This breakwater is able to provide a suitable area for an access road to the Eko Atlantic site for the trucks delivering rock for the sea defence. The access road will be temporary. The side slopes of the East Mole are locally excessively steep due to deterioration in time and lack of maintenance. The integrity and stability of the mole could reduce if no action is taken. Therefore the East Mole will be stabilized by the addition of hydraulically stable rock on and re-profiling of the side slopes from the road down to the toe in the Commodore Channel using an excavator. Full details of the stabilisation plans are provided in **Appendix K**.

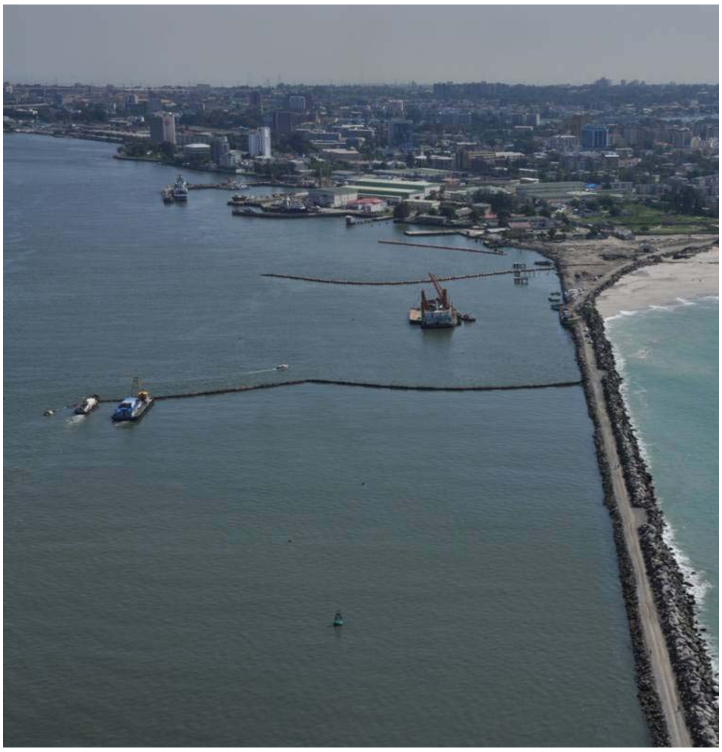


Plate 4.2 Commodore Channel and the part of the East Mole

4.2.3 Construction of the sea defence

The sea defence has two functions; to protect the reclamation for erosion by the waves and currents and to limit wave overtopping volumes. It is necessary to limit overtopping to reduce the risk of injury and drowning to users of the promenade, damage to any buildings and assets on the promenade and flooding of the development.

Physical model tests to assess the performance the sea defence design were undertaken at DHI's laboratories in Horsholm, Denmark in August 2010. All tests were witnessed by Royal Haskoning staff and also recorded on video. The set-up of the model is illustrated in **Figure 4.1**. The modelling studies demonstrated that the sea defence can meet its requirements to limit overtopping, at a design level of +9.2m CD. A full copy of the physical model reports and results is provided in Appendix.

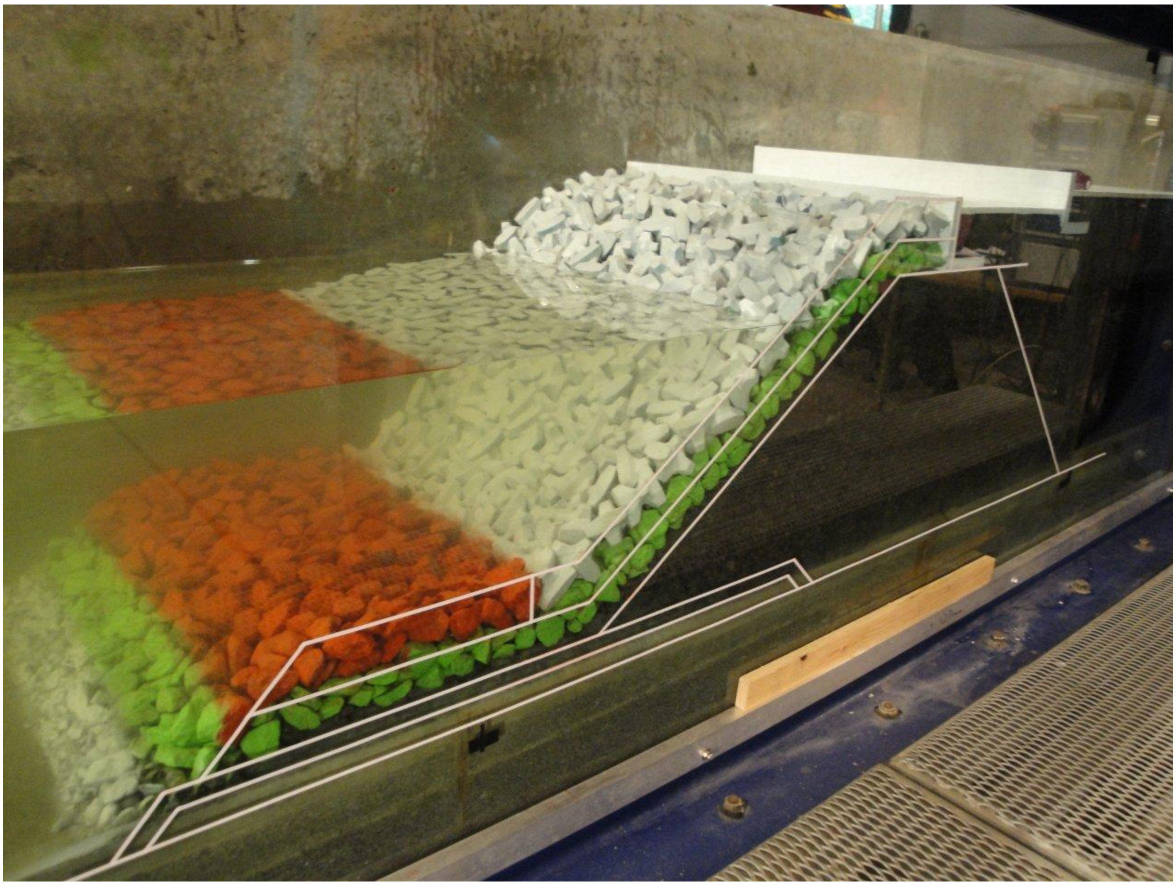


Figure 4.1 Model Set-Up

The sea defence has been designed with a core of rock with a grading (size) of 1-1000 kg. This core is protected by several layers of armour rock (500 – 2000 kg) and concrete armour blocks (5t Accropodes^{TM}) to protect the structure from the ocean waves. The sea defence is designed for extreme wave conditions, such as a 1/100 year storm event and when completed, the crest of the sea defence will rise 6m above sea level (above Chart Datum) with a concrete wall on top of it up to approximately 7m. The sea defence has been physically tested on a scale of 1:30 on stability and overtopping at the Danish Hydraulic Institute (DHI) model testing basins in Denmark. DHI is world renowned for testing coastal structures and is considered a high class facility for testing of this type.

Rock for the sea defence will be supplied by four quarries located between approximately 100 km and 150 km from the Project area. The concrete armour blocks will be produced initially at the existing Hi-Tech yard at the entrance to the Eko Atlantic site. The equipment at the Hi-Tech yard consists of bulldozers, trucks and plant to mix and cast the concrete armour blocks. The main materials used are rocks, cement, water, aggregates and sand. Following completion of part of the reclamation works, a separate concrete batching yard will be relocated next to the site offices and close to the new sea defence to reduce on transportation and logistics. The Contractor will determine the optimum location during construction of the entire scheme. The construction is to be completed in 4 phases (running concurrently) as follows:

Phase 1 – temporary works; placement of Filter material, Core material and Rock Underlayer to +3.0mCD to form sea defence. Equipment - Excavator (CAT 345), Excavator (CAT385), Trailers, 2 Dumpers, 1 Tipper, 1 Wheel loader

Phase 2 – permanent works (toe construction); placement of Filter material, Core material and Rock Underlayer to form scour protection toe. Equipment - Excavator (CAT385), Trailers, 2 Dumpers, 1 Tipper, 1 Wheel loader

Phase 3 – placement of Accropodes™; lifting and placement of Accropodes™ to the slope with sling wire. Equipment - Excavator (CAT 345), Excavator (CAT385), 3 Tippers.

Phase 4 – geotextile placement; excavate the landward slope, trim the slope to shape and place geotextile by rolling it down the slope, cover up and protect with sand. Equipment - Excavator (CAT 345), Excavator (385), 1 wheel loader, 2 dumpers, diving equipment.

The designs for this type of sea defence are presented in **Figures 4.3** and **4.4.** The materials required for the sea defence are described in **Table 4.3.**

Table 4.3 Materials and quantities required for Eko Atlantic sea defence

Item No	Description	Unit	Quantity
	Rock		
A	Quarry run 1- 1000kg		
B	Underlayer Rock, 500 – 2000kg	m^3	2,956,340
C	Toe Rock, 2t	m^3	519,090
D	Bedding layer, 5-75mm	m^3	169,830
		m^3	116,625
	Accropodes™		
E	Accropodes™ block, 5t		
		m^3	201,430
	Geotextile Materials		
F	Geotextile fabric		
		m^2	245,070
	Rock Armour Additional (Groyne Only)		
G	Quarry run 1- 500kg		
H	Rock armour, 2.0t to 5.0t and 2.20m thick	m^3	1,000
I	Rock armour, 0.5t to 2.0t and 1.50m thick	m^3	42,400
J	Selected rock 5.0t and 1.2m thick	m^3	3,500
K	Rock underlayer, 60 – 300kg	m^3	1,000
		m^3	19,700

Sea level rise in Lagos is expected to be in the region of 35 to 50cm over a 100 year period, however there is no agreed forecast. The design of the breakwater has accounted for extreme wave conditions and extreme water levels. The physical testing of the breakwater design used the highest high water levels and therefore takes a precautionary approach to design.

Future sea level rise will result in larger waves attacking the revetment which will reduce the stability of the primary armour and increase the overtopping under extreme design conditions by approximately 50%. The impact of sea level rise will need to be considered into the future upgrade/maintenance of the revetment (as part of the overall coastal defense). However, it is expected that sea level rise of 35-50cm over a 100 year period will not negatively affect the stability or integrity of the sea defence. Some increased overtopping of waves may be experienced during very extreme wave conditions.

4.2.4 Sand placement for reclamation

Construction of the sea defence will be the primary activity in the early stages of the Project. The presence of the sea defence will shelter the waters behind, enabling safe and efficient filling of the area to be reclaimed. Several methods for reclamation will be used, dependant on the location at which sand should be deposited. The main methods will be pumping of dredged sand by 1) Sand pumping into the reclamation area from the Commodore Channel over the East Mole or 2) Sand pumping from behind the sea defence into the reclamation area or 3) in some instances, rainbowing directly from the dredger onto the reclaimed land may also be used, or 4) Sand placement by dredgers using bottom doors.

Sand pumping into the reclamation area from the Commodore Channel over the East Mole.

Following dredging at the borrow areas, the loaded TSHD will moor in the Commodore Channel and pump its load via a pipeline over the East Mole and into the reclamation area (**Plate 4.3**)

Sand pumping from behind the sea defence into the reclamation area.

A Cutter Head Dredger will be positioned behind the sea defence after partial completion. The sea defence will be used as a shelter from the wave conditions. Following dredging, the TSHD will place the sand next to the Cutter Head Dredger. The Cutter Head Dredger will then pump the sand to the reclamation area via a pipeline.

Plate 4.3 Example of sand pumping operations

Sand placement through rainbowing.

At sites where pumping is not possible due to pipeline distance, the dredged sand will be deposited by a TSHD, using the rainbow technique (**Plate 4.4**). During rainbowing the sand is pumped from the hopper directly into the reclamation area. This will be done only in areas protected by the sea defence to maximise reclamation efficiency and minimise environmental effects on water quality.

Plate 4.4 Sand placement via pipe (left) and rainbowing from dredging vessel (right)

Sand placement by dredgers using bottom doors.

Following dredging at the borrow area, the fully loaded TSHD will travel to the reclamation site. The dredger will open the bottom of the hopper doors, placing the dredged material directly onto the reclamation area. This will only take place where water depths allow safe navigation of vessels and is not expected to be the main method of placement.

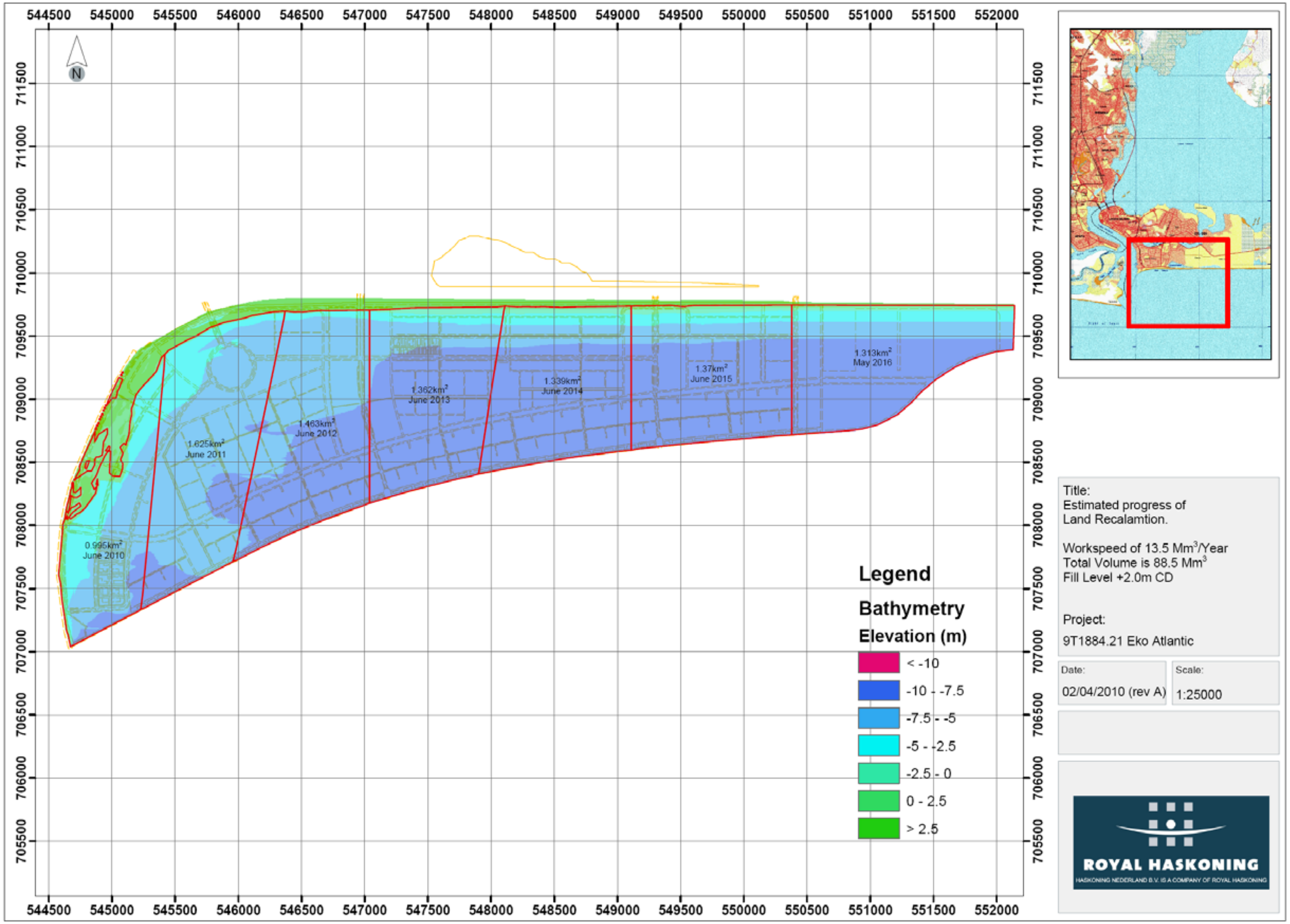


Figure 4.2 Estimated progress of land reclamation

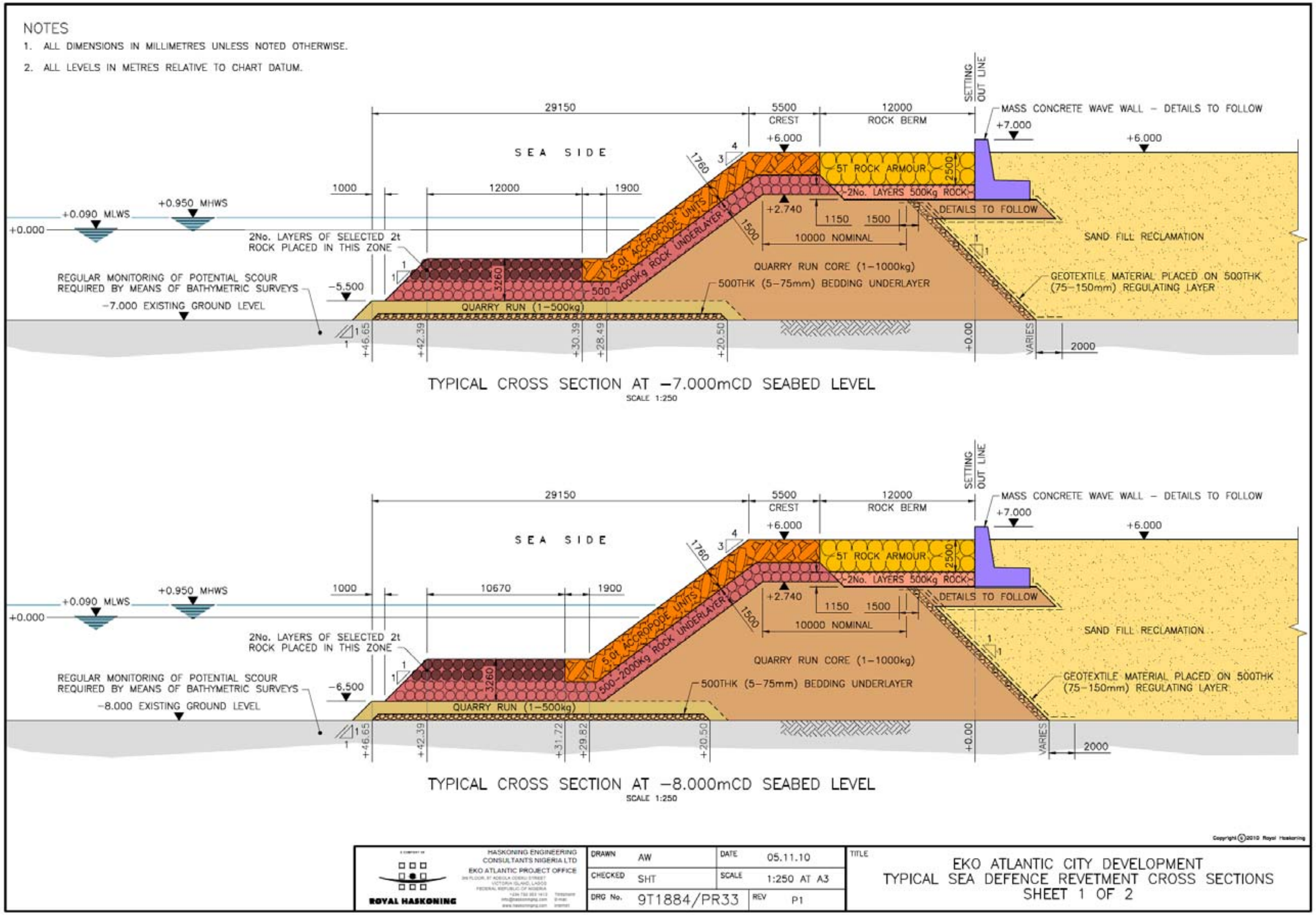


Figure 4.3 Cross section of sea defence Part I

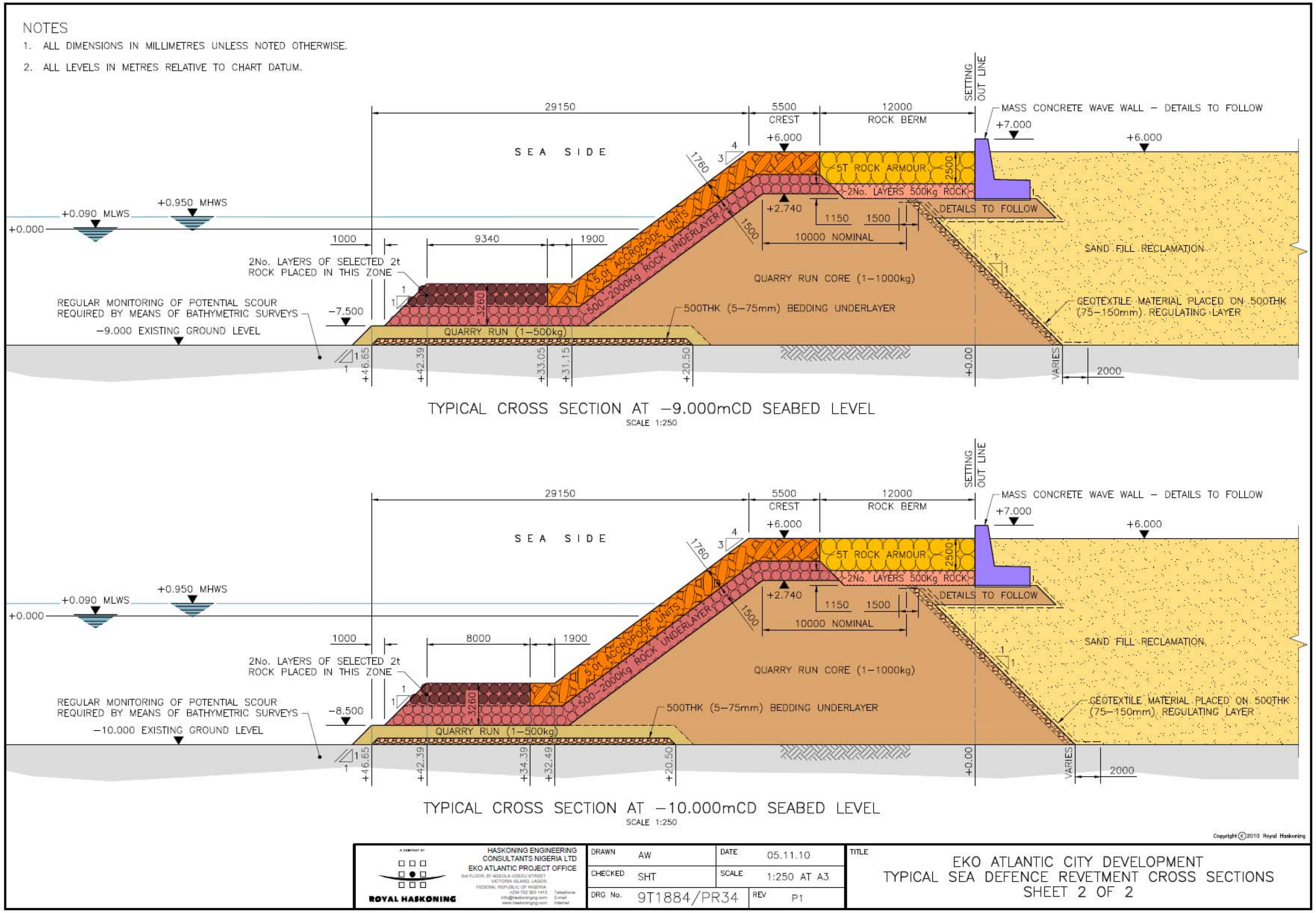
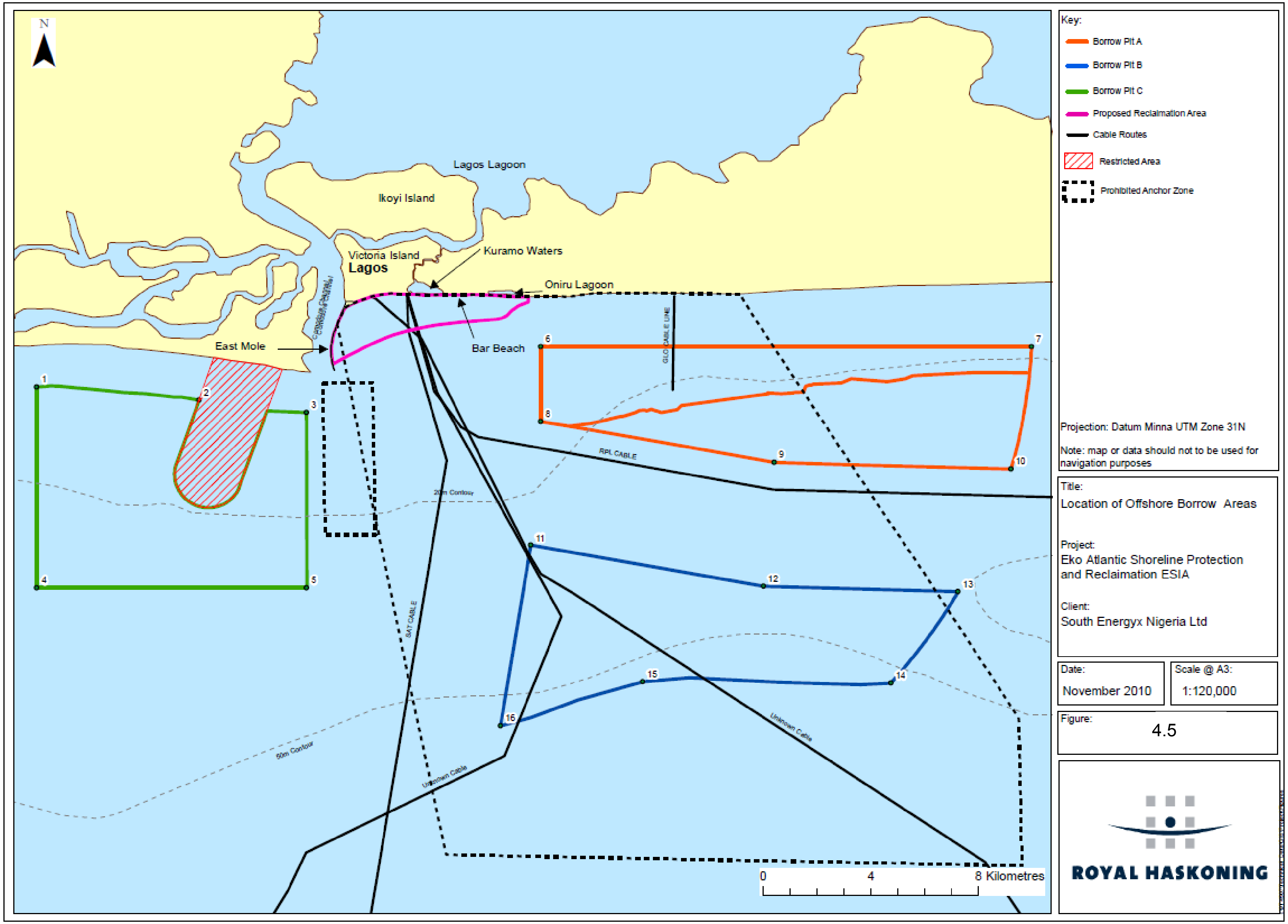


Figure 4.4 Cross section of sea defence Part II


N
Lagos Lagoon
Ikoyi Island
Victoria Island
Lagos
Kuramo Waters
Oniru Lagoon
Bar Beach
East Mole
RPL CABLE
SAT CABLE
20m Contour
50m Contour
Unknown Cable
0
4
8 Kilometres
Key:
Borrow Pit A
Borrow Pit B
Borrow Pit C
Proposed Reclamation Area
Cable Routes
Restricted Area
Prohibited Anchor Zone
Projection: Datum Minna UTM Zone 31N
Note: map or data should not to be used for navigation purposes
Title:
Location of Offshore Borrow Areas
Project:
Eko Atlantic Shoreline Protection and Reclamation ESIA
Client:
South Energyx Nigeria Ltd
Date:
November 2010
Scale @ A3:
1:120,000
Figure:
4.5
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5 DESCRIPTION OF THE PROPOSED PROJECT ENVIRONMENT

5.1 Introduction

This section covers the existing biophysical and social environmental conditions in the study area in order to determine the impacts of the scheme. The area of reclamation is directly adjacent to Bar Beach and the East Mole on Victoria Island, Lagos; with the offshore description incorporating the area offshore of Victoria Island, Lagos as shown on **Figure 1.2**. The information collected has been collated from various sources, including literature review (published/unpublished), consultation with local and national organisations, field data gathering, in-field/laboratory analysis, and contributions from various experts on the environment and inherent impacts.

The key environmental aspects considered for the proposed project EIA baseline studies were:

- Abiotic environment:
  - Hydrodynamics and sediment processes;
  - Water quality;
  - Sediment quality;
  - Groundwater;
  - Air quality;
  - Noise levels.

- Biotic environment:
  - Marine and coastal ecology (including ornithology);
  - Terrestrial ecology

- Socio-economic environment:
  - Demographic data and housing;
  - Livelihood and economic activities (including fisheries activity);
  - Transport infrastructure (land);
  - Services;
  - Navigation (marine);
  - Tourism and recreation;
  - Cultural heritage;
  - Land ownership and existing land use;
  - Public health.

5.2 Data Collection and Sources of Information

This Environmental Impact Assessment (EIA) report has been established based on extensive desk and field based studies, consultation, numerical modelling and expert judgement. Where existing data has been used, this has been appropriately referenced in the text. The remainder of this section focuses on the main studies commissioned specifically for the Project, which are:

- Oceanographic measurements to inform the Modelling Studies;
- Wet and Dry Season Marine and Lagoon Baseline Environment Study (incorporating physical, chemical and biological data);
- Geotechnical Investigations; and
- Socio-Economic Baseline Environment Study.

In addition, this section provides information on the data and methods for the Air, noise and vibration assessments

5.3 Oceanographic measurement campaign to inform coastal modelling

The performance of the computerised coastal modelling program can be considerably improved by calibration with measurements (this enables adjustment of aspects such as the imposed boundary conditions, friction coefficients and even water depths to obtain better correlation). Furthermore, after harmonic analysis a residue remains which may be associated with meteorological effects and in particular with river run-off. This will enable the relationship between flow velocity and the river-runoff to be established.

A measurement campaign was set-up in May 2008 (**Figure 5.13**). The measurements were planned for a continuous period to cover a normal, a spring and neap tide. Furthermore, any additional available local data was gathered in this period.

The campaign was performed with the co-operation of Nigerian Port Authority and DEEP as the contractor. DEEP provided the equipment and arranged local labour to deploy and recover the current meters. In addition, topographic foreshore surveys have been carried out on March 28, 2008 by Engee Surveys Ltd. Beach profiling has been undertaken over a stretch of 22 km to the east of the eastern harbour mole at intervals of about 250m.

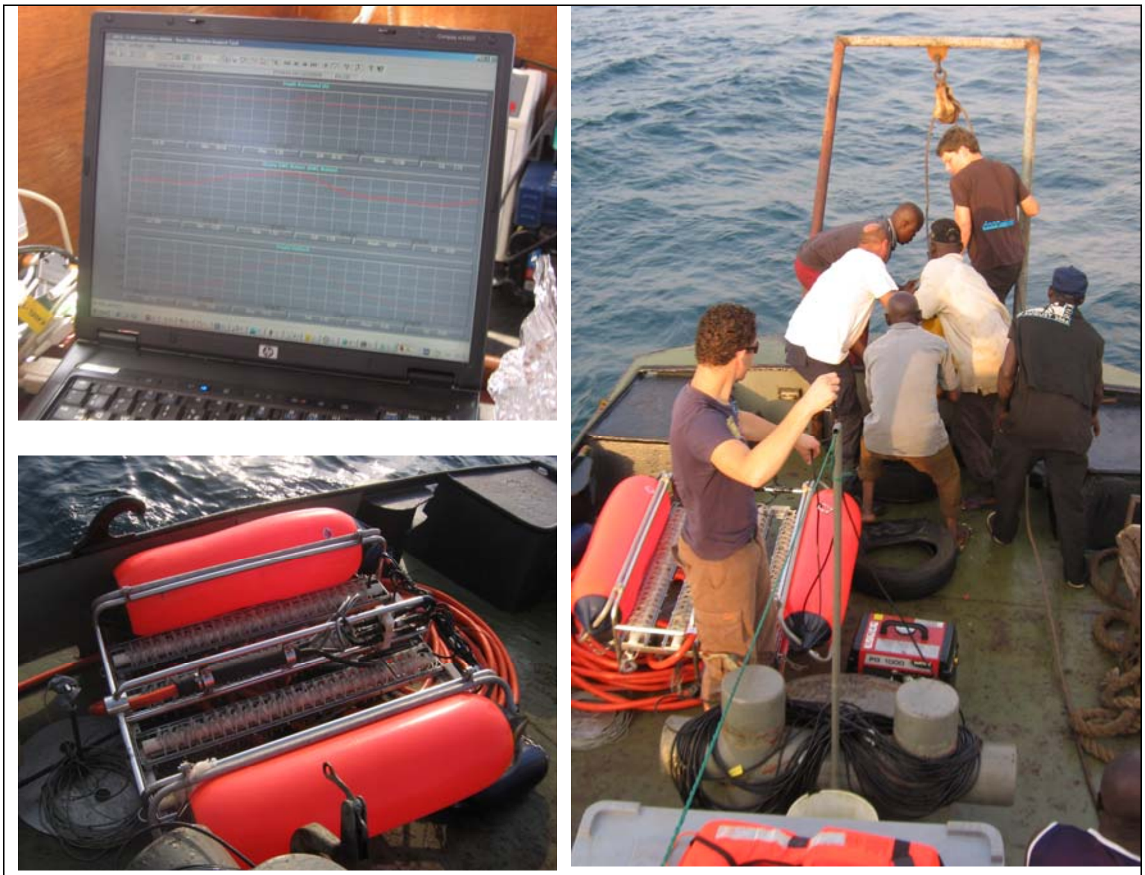


Figure 5.1 Oceanographic Survey, May 2008

Three current meters and water level recorders were deployed during the survey. A Royal Haskoning qualified surveyor supervised the execution of the measurements considering the local topography, geometry and layout of the area and the specific requirements for modelling. Local experts provided support to the Consultants engineer during the collation of additional data.

The following measurements were taken offshore:

- Three continuous flow measurements using ADCP current meters;
- Three continuous water level recorders at the same locations.

The meters were kept operational for a period of 15 days. They were activated on the 5th May 2008 and dropped by a local surveyor. The meters were lifted on the 20th May 2008. The visits of the surveyor to Nigeria additionally resulted in the collation of further data that was gathered with the help of Nigerian Port Authority (NPA).

5.4 Wet Season Marine and Lagoon Baseline Environment Study

Wet Season

In June 2008, Fugro collected sediment samples from 8 sites within 3 areas within and adjacent to the Project site as well as at the primary borrow area (**Figure 5.2**). The sediments were analysed for a range of physical-chemical parameters including:

- Heavy Metals;
- Sediment Hydrocarbons;
- Polychlorinated Biphenyls (PCBs); and
- Other Compounds and Testing Parameters

The results of analysis revealed Total Petroleum Hydrocarbon presence in the sediment of the sampled area at consistent levels across the stations sampled. The heavy metals and Total Organic Carbon analysed were within their background limits obtainable in an uncontaminated environment. As such it was concluded that there was little or no sediment pollution in the area surveyed. No additional monitoring was recommended. The full results of the analysis and copies of relevant reports by Fugro are provided in **Appendix D**.

It was agreed with FMEnv that it would be acceptable to utilise existing wet season data from other local studies for water quality and ecology, followed by a full dry season baseline study. Please, refer to **Appendix D** to review the correspondence and justification for this decision. Given the location of the Project data from the following reports / studies was available to supplement the wet season baseline information:

- Lekki Port EIA (Global Environmental Technology Ltd 2008) ;
- Physical-chemical and macro benthic faunal characteristics of Karamu Water, Lagos, southern Nigeria (Edokpayi et al., 2001).

5.5 Dry Season Marine and Lagoon Baseline Environment Study

In March 2010 extensive field surveys of marine and lagoon system sediment, water quality, benthic ecology and plankton and subsequent laboratory analyses were carried out by Environmental Resources Managers Limited (ERML) in order to provide further baseline data to inform the EIA, as required by Nigerian Legislation. The analyses were carried out to local and international standards. The specific baseline studies' field work and laboratory analyses' approaches were designed to conform to the Nigerian impact assessment legislation and international best practice procedures.

Table 5.1 and **Table 5.2**, respectively show the total number of samples, collected from the study area in the marine environment and the Lagos lagoon system. Sampling maps are shown in **Figure 5.2** and **Figure 5.3,** which show an even distribution across the target study areas. The full dry season baseline survey report can be found in **Appendix C.**

Table 5.1 Total number of samples from the offshore environment.

Sample Type	Number Of Samples
Water	22
Sediment	22
Benthic	51
Plankton	5

Table 5.2 Total number of samples from the Lagos Lagoon system.

Sample Type	Number Of Samples
Water	13
Benthic	13
Sediment	13
Plankton	2

A marine going vessel, MV Brone Explorer was used for sampling activities in the offshore environment, while a smaller boat was deployed for the sampling in Kuramo Waters. The field team comprised personnel from the FMEnv, LASMOE, Royal Haskoning Nigeria Limited and ERML.

5.5.1 Sediment and Benthic Ecology Sampling

Sediment samples were collected at each designated station using a 0.1m^2 Van-Veen grab. A portion of the top 1-2cm of the first haul was preserved for physical, chemical and other analyses in labelled polythene bags and stored in the deep freezer. Another portion for organic analysis was stored in Aluminium foil and frozen prior to analysis. The portion for studies on benthic community structure was washed with sea water through a 0.5mm mesh size sieve. The sieved contents were preserved in 4% formalin in labelled jars for further analysis in the laboratory. Samples for microbial determinations were aseptically collected from sediments grab hauls, stored in sterile screw capped bottles and transported chilled to the laboratory for microbial analysis.

5.5.2 Water Sampling

Water samples were collected using a Niskin water sampler. In-situ measurements of dissolved oxygen (DO), temperature, pH, total dissolved solids (TDS), salinity and conductivity were also taken using a Hanna water quality meter. The samples for physicochemical and microbiological analyses were obtained mostly at the surface, but also at mid and bottom depth at some locations offshore.

At each sampling station, water samples were taken and stored in previously washed 2L plastic containers for evaluation of physical-chemistry parameters. Samples for heavy metals analysis were stored in 1L white plastic containers and pre-treated using 1ml HNO_3 as suggested by Batley and Gardener (1977), while samples for oil and grease were sampled using glass bottles and pre-treated with 1ml conc. H_2SO_4 and cooled at $4^{\circ}C$. The water samples for microbiological analysis were stored in sterilized 50ml Universal bottles and refrigerated, pending laboratory analyses, while those for biological oxygen demand were stored in amber 250ml stopper reagent glass bottles.

5.5.3 Phytoplankton and Zooplankton Sampling

Plankton was collected from horizontal hauls using 55μm mesh size standard plankton net. Each 10 minute tow was made by tying the plankton net onto the ship and filtering the water at low speed (<4knots). Each haul was concentrated into an attached bottle and transferred into a labelled 750ml plastic container with screw cap. Preservation was done by adding 5ml of 4% unbuffered formalin and each bottle secured in a box for transportation to the laboratory after proper labelling to reflect appropriate details

5.5.4 Laboratory Methods

Standard methods approved by the Nigerian regulators were used for laboratory analyses of water and sediment samples. **Table 5.3** summarises the reference methods used.

Table 5.3 Summary of Laboratory analytical methods used for Water / Sediment Analysis

Parameters	Unit	Method
pH (H2O)		ASTM D 4972
Turbidity	(NTU)	APHA 214
Salinity	$^{0}/_{00}$	API-RP 45
Total Dissolved Solids	(mg/L)	APHA 209C
Total Solids	(mg/L)	APHA 209D
TSS	(mg/L)	APHA 209D
Electrical conductivity	(μS/cm)	APHA 209
Bicarbonate	(mg/L)	API-RP 45
Alkalinity	(mg/L)	APHA 2320-ALKALINITY-B
Acidity	(mg/L)	APHA 2310 B
Ammoniac nitrogen	(mg/L)	EPA 350.2
THC	(mg/L)	APR – RP 45
Nitrite	(mg/L)	EPA 354.1

Parameters	Unit	Method
Chloride	(mg/L)	APHA 4500Cl- B
Sulphate	(mg/L)	EPA 375.4
Total Phosphorous	(ppm)	APHA 4500 P0 43-
Calcium	(ppm)	APHA 3111
Magnesium	(ppm)	APHA 3111/ASTM D 3561
Potassium	(ppm)	APHA 3111/ASTM D 3561
Cadmium	(ppm)	APHA3111
Chromium	(ppm)	APHA3111
Lead	(ppm)	APHA 3111
Manganese	(ppm)	APHA 3111
Iron	(ppm)	APHA 3111
Copper	(ppm)	APHA 3111
Zinc	(ppm)	APHA 3111
PCB	(ppb)	EPA method 625

Benthic Macrofauna Analysis

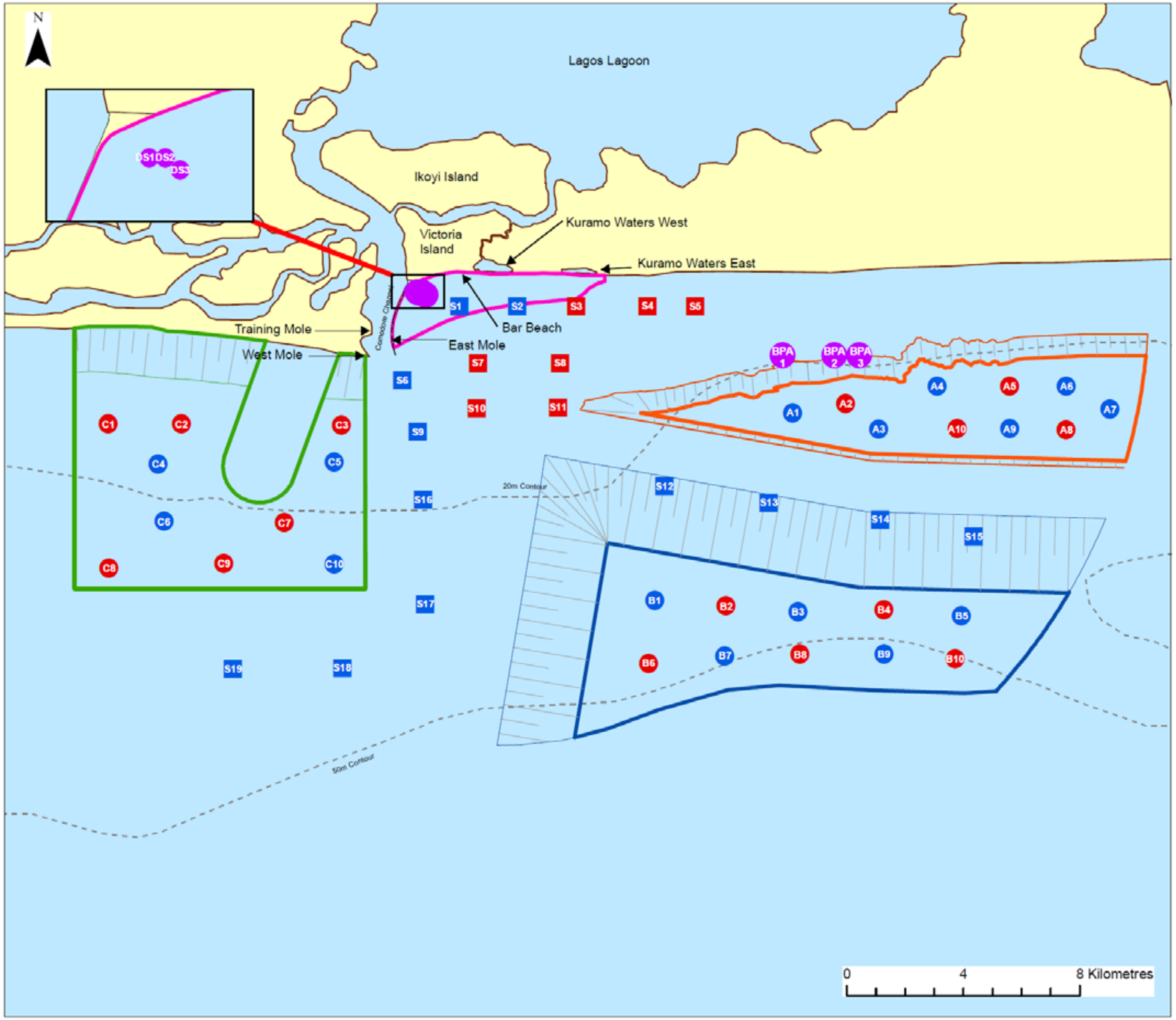
In the laboratory, the preserved fauna samples collected from each station were washed through a 0.5mm sieve to remove the preservative and any remaining fine sediments. The samples were sorted under a x40 magnification binocular dissecting microscope. The macrofauna were identified to species level where possible, with the aid of relevant literature (*e.g.*, Day, 1967; Edmunds, 1978; Gosner, 1971), and subsequently counted. Juvenile macrobenthic animals which because of their size could not be identified to species level were recorded on higher taxonomic levels, usually the genus level. Where fragmented animals were found, only those fragments with heads and identifiable body parts were counted. Statistical analysis involving Margalef's (d) Index, Shannon and Weaver Information Function, Equitability Measure and Cluster Analysis were applied to evaluate species density and diversity.

Plankton Analysis

Representative plankton specimens were identified under X40-100 magnification. Identification was done using relevant literature (*e.g.*, Wickstead, 1965; Kadiri, 1987; Opute, 2000; Onwudinjo, 1990; Wiafe and Frid, 2001, Imoobe, 2007). Individuals of each identified species were later enumerated from each of the quantitative samples. The number of organisms was expressed per cubic meters of water filtered.

5.5.5 Quality Assurance /Quality Control

The collection, analyses and reporting for the Environmental Baseline Study (EBS) were subject to recommended quality assurance standards in accordance with the stipulated regulatory bodies in Nigeria. The FMEnv, Lagos State Ministry of Environment and Royal Haskoning personnel were on-board the vessel during the field activities to ensure compliance to guidelines and standards. They also witnessed selected laboratory analyses from April 27 to April 29, 2010.



Key:

2008 Survey

- Sample Points

2010 Survey

- Control Site - Benthic Only
- Control Site - Water Sediment & Benthic
- Benthic Only
- Water Sediment & Benthic
- Borrow Pit A
- Borrow Pit B
- Borrow Pit C
- Proposed Reclamation Area

Projection: Datum Minna UTM Zone 31N

Note: map or data should not to be used for navigation purposes

Title:
Location of Wet (2008) and Dry (2010) Marine Baseline Survey Locations

Project:
Eko Atlantic Shoreline Protection and Reclamation ESIA

Client:
South Energyx Nigeria Ltd

Date:	Scale @ A3:
December 2010	1:125,000

Figure:
5.2

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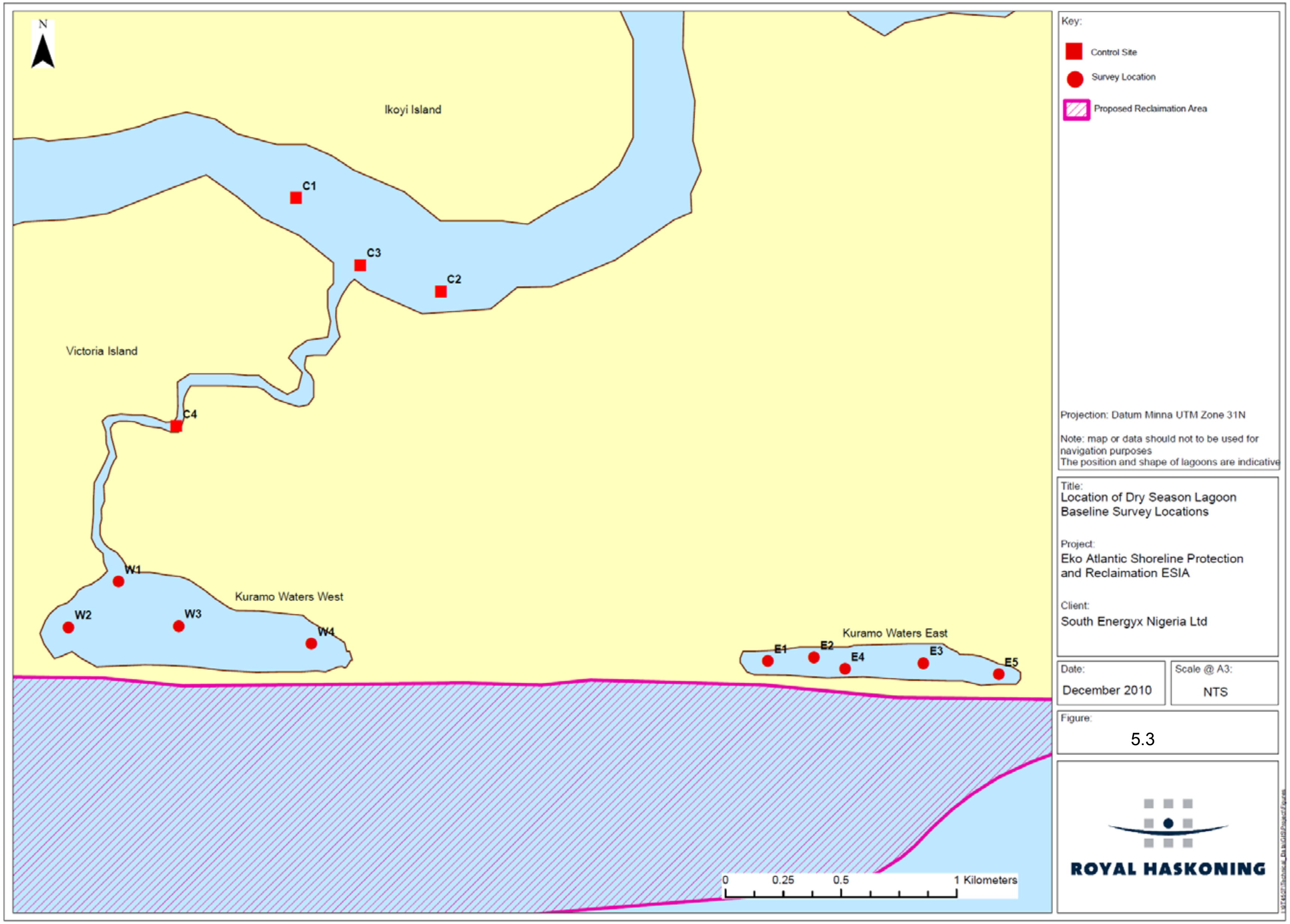
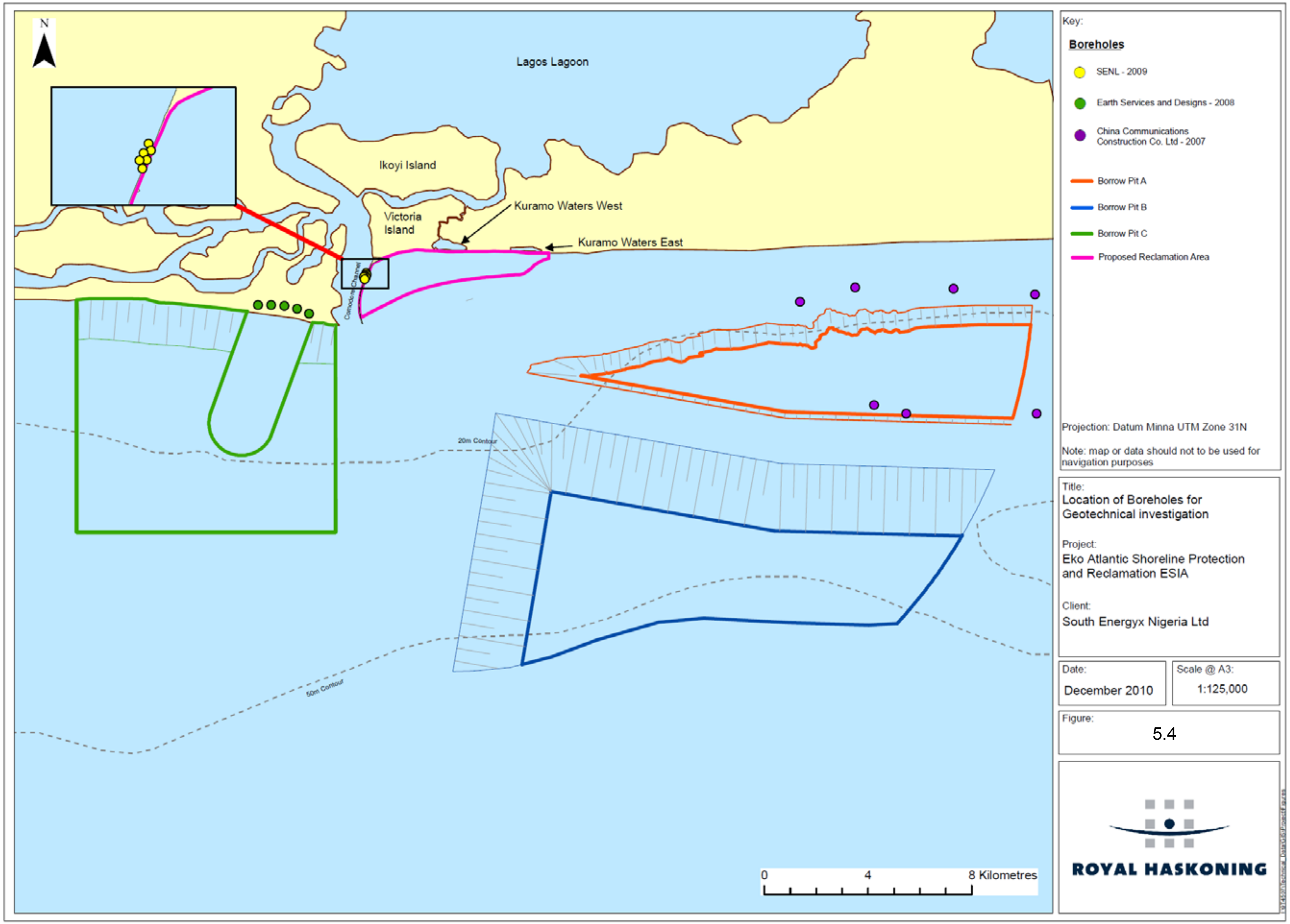

N
Ikoyi Island
Victoria Island
C1
C2
C3
C4
W1
W2
W3
W4
Kuramo Waters West
Kuramo Waters East
E1
E2
E3
E4
E5
0 0.25 0.5 1 Kilometers
Key:
Control Site
Survey Location
Proposed Reclamation Area
Projection: Datum Minna UTM Zone 31N
Note: map or data should not to be used for navigation purposes
The position and shape of lagoons are indicative
Title:
Location of Dry Season Lagoon Baseline Survey Locations
Project:
Eko Atlantic Shoreline Protection and Reclamation ESIA
Client:
South Energyx Nigeria Ltd
Date:
December 2010
Scale @ A3:
NTS
Figure:
5.3
ROYAL HASKONING


N
Lagos Lagoon
Ikoyi Island
Victoria Island
Kuramo Waters West
Kuramo Waters East
20m Contour
50m Contour
0
4
8 Kilometres
Key:
Boreholes
SENL - 2009
Earth Services and Designs - 2008
China Communications Construction Co. Ltd - 2007
Borrow Pit A
Borrow Pit B
Borrow Pit C
Proposed Reclamation Area
Projection: Datum Minna UTM Zone 31N
Note: map or data should not to be used for navigation purposes
Title:
Location of Boreholes for Geotechnical investigation
Project:
Eko Atlantic Shoreline Protection and Reclamation ESIA
Client:
South Energyx Nigeria Ltd
Date:
December 2010
Scale @ A3:
1:125,000
Figure:
5.4
ROYAL HASKONING

5.6 Geotechnical Studies

In order to inform the engineering, borrow area selection and EIA, a number of geotechnical investigations have been undertaken. These are listed below and full copies of the geotechnical reports are provided in **Appendix L**. **Figure 5.4** presents the location of the boreholes.

In summary, the studies have identified that there is an abundant amount of reasonable quality sand present. In the western areas (*e.g.* Borrow Area C) some shallower areas have a silty clay layer.

It should be noted that additional geotechnical studies are planned in order to check the stability of both the sea defence and the reclamation. Details of these are presented in **Table 8.1**.

5.6.1 Survey 1 - Sand Resource Survey Report, 2007 China Communications Construction Co. Ltd.

This initial sand survey for preliminary investigations was undertaken in May 2007. The study found suitable material for dredging and reclamation in the studied area, within 15km of the Project site. This study helped to outline the potential borrow areas.

5.6.2 Sand-search Lighthouse beach, 2008, done by Earth Surveys and Designs

The study (in the summer of 2008) found that to 25m depth into the sediments of the studied area, there is an extensive sand deposit. This subsoil may be divided into three generalized zones based primarily on the material encountered. The upper third up to 14m (18m in some cases) are fine medium to coarse sands. Underlying this sand deposits are clayey silty sands, sandy clays and silty clays to about 21m depth. Below this, fine medium to coarse sands with gravels were found to the end of boring at 25m, except in one case, where the borehole terminated in clays. Groundwater was between 0.35m and 3.4m depth at the time of the investigation. The marked variation appears to be due to tidal conditions. It was concluded that considerable volume of material may be quarried from this site and the sands generally have medium grading, with the sand deposit generally reaching 18m depth.

5.6.3 SENL / Fugro Geotechnical Investigation for Financial District Reclamation Area, 2010.

The objective of this geotechnical investigation was to determine the geotechnical characteristics of the Financial City Zone within the proposed Eko Atlantic City in Lagos State. In order to achieve the set objective, six boreholes were drilled to a depth of 60m below the existing ground level. The fieldwork was carried out between the 1st and 18th November 2009.

The boreholes generally revealed the soil strata showing about 10.95m of sand underlain by alternating layers of clay and sand to a depth of 60m. The groundwater level observed in boreholes during the field investigation varies between 0.5m and 2.2m below the existing ground levels.

Laboratory analysis showed that the undrained shear strength of the clay varies between 16 and 161kPa, while the co-efficient of volume compressibility ranges between 0.089 and 0.11 m2/MN indicating clay of low to medium compressibility. Based on the soil conditions encountered in these boreholes and the loading parameters (600Kpa) as provided by the client, deep foundations are recommended for the 30/40 store buildings. Please refer to **Appendix L** for more information on the geotechnical studies.

5.7 Socio-Economic Baseline Environment Study

5.7.1 Stakeholder Consultation Process

Various consultations have taken place to inform the primary and secondary stakeholders about the Eko Atlantic Project and to gather information to inform the socio-economic impact assessment. They range from media communications to the public at large to group and face-to-face consultations with stakeholders. **Table 5.4** below summarises the consultation activities undertaken (see **Appendix G** for supporting documents). The findings of the Public Forum, carried out in January 2011, are detailed in Section 5.6.2.

The consultee list was developed by SENL and LASMOE. It has been agreed in a meeting of 1 December 2010, by these two parties, that illegal communities and businesses should not be consulted on this project or considered in the impact assessment phase, and that this is compliant with Nigerian Law.

Table 5.4 Register of consultations for Eko Atlantic Phase I EIA

Date	Place	Stakeholders	Purpose of meeting
November 20 2009	Haskoning office, Lagos	Lagos State Commissioner for Environment Lagos State Commissioner for Waterfront Infrastructure Development	To discuss progress of the EIA study
January 27 2009	Riverine villages	Lighthouse Creek Village, Middle Creek Village, Ilase Village and Ituagan Village	To investigating the likely impacts of the reclamation works on the surrounding ecosystem.
December 12 to 18 2009	Royal Haskoning office, Netherlands	Representatives of Lagos State Ministry of Environment	In depth discussion of the EIA study between Lagos State Ministry of Environment and Royal Haskoning teams.
December 10 2009	Project Site & Haskoning Office	Representatives of Federal Ministry of Environment, Lagos State Ministry of Environment & Royal Haskoning	Site verification
January 27 2010	Federal Ministry of Environment (EIA Division) office, Abuja	Representatives of Federal Ministry of Environment office & Royal Haskoning	To discuss progress of the EIA study
January 28 2010	Nigerian Ports Authority (HSE Department)	Representatives of Nigerian Ports Authority	Ensure that Stakeholders understand the Project and its benefits.
January 29 2010	Nigerian Institute for Oceanography & Marine Research	Nigerian Institute for Oceanography & Marine Research	Ensure that Stakeholders understand the Project and its benefits.
January 27 2010	Federal Ministry of Environment (EIA Division) office, Abuja	Representatives of Federal Ministry of Environment office & Royal Haskoning	To discuss progress of the EIA study
August 29 2010	Riverine village	Lighthouse Village	To investigating the likely impacts of the reclamation and dredging works on the community.

Date	Place	Stakeholders	Purpose of meeting
August 30 2010	Lagos State Ministry of Land	Acting Permanent Secretary of the Lands Bureau Director and Head of the Directorate of Land Regularisation.	To discuss the Social Impact Assessment (SIA) aspect of the Project and the impact of the Project on the land policy administration of Lagos State and the Federal Government of Nigeria.
August 31 2010	Lagos State Ministry of Waterfront Infrastructure Development	Lagos State Commissioner for Waterfront Infrastructure Development & other Representatives of the Ministry	The meeting discussed the Social Impact Assessment (SIA) of the Project
Sept 1 2010	Beach coastline	Beach communities	Identify communities
Sept 27- 30 2010	Beach coastline	Beach communities	Identify communities
December 1 2010	Haskoning office, Lagos	Lagos State Commissioner for Environment Lagos State Commissioner for Waterfront Infrastructure Development	Discussed and update stakeholders on the progress and plans for the EIA for Phase I. Also, discussed the draft EIA and the next steps.
December 13 2010	Federal School of Fisheries and Marine Technology	Federal School of Fisheries and Marine Technology	To discuss project
December 13 2010	Eko Hotel and Suites	Eko Hotel and Suites	Ensure that Stakeholders understand the Project and are aware of the progress of the EIA. To take on board stakeholder comments.
December 13 2010	Cash and Carry HQ, Lagos Island	Cash and Carry	Ensure that Stakeholders understand the Project and are aware of the progress of the EIA. To take on board stakeholder comments
December 13 2010	Eko Hotel and Suites	Ocean View Restaurant	Ensure that Stakeholders understand the Project and are aware of the progress of the EIA. To take on board stakeholder comments
December 13 2010	Avenue Suites	Avenue Suites	Eko Hotel and Suites
December 14 2010	Skye Bank	Skye Bank	Ensure that Stakeholders understand the Project and are aware of the progress of the EIA. To take on board stakeholder comments

Date	Place	Stakeholders	Purpose of meeting
December 14 2010	Royal Haskoning Office, VI	Nigerian Environmental Society	Ensure that Stakeholders understand the Project and are aware of the progress of the EIA. To take on board stakeholder comments
July 18 – 15 August 2011	1. Lagos State Ministry of Environment, Secretariat Alausa, Ikeja Lagos 2. Headquarters Eti-Osa Local Government Area, Victoria Island, Lagos State 3. Federal Ministry of Environment, Game Village Surulere, Lagos State 4. Federal Ministry of Environment, Conservation (Green) Building, Plot 444 Aguiyi, Ironsi, Maitama Abuja F.C.T.	The public and all relevant stakeholders	Public display and Public notice for information and comments on the draft EIA report submitted.
October 11 – 14, 2011	Ocean View Restaurant meeting hall, Victoria Island, Lagos	The public and all relevant stakeholders including representatives of Federal Ministry of Environment, Lagos State Ministry of Environment, Lagos State Commissioner for Waterfront Infrastructure Development , Eti-Osa Local Government Area, Nigerian Ports Authority, Nigerian Institute for Oceanography & Marine Research, villages and communities in the neighbourhood of the project area, Nigerian Environmental Society, Nigerian Society of Engineers, NGOs, etc.	Panel review meeting of the draft EIA report submitted.
April 24 – May 15, 2012	Six communities within Eti-Osa LGA of Lagos State: Apese, Igbosere, Itirin,	The Baales, opinion leaders and Representatives of the various communities.	To consult the surrounding communities regarding the project and collect additional socio-economic information.

Date	Place	Stakeholders	Purpose of meeting
	Inupa, Olukotun, Okokuku and Ilabare.		
May 28 2012	Eko Atlantic Sales Office, Victoria Island, Lagos	Press representatives, Government Officials and members of the public	Press briefing to acquaint stakeholders on recent developments in Eko Atlantic City Development Project.

5.7.2 Public Forum

As part of the stakeholders and public consultation process within the EIA, a Public Meeting was held on 21 January 2011 at 1100 hours at Eko Hotel & Suites, Adetokunbo Ademola Street, Victoria Island, Lagos.

The meeting was chaired by Prince Adesegun Oniru- the Honourable Commissioner Lagos State Ministry of Waterfront Infrastructure Development (MWFID), who informed participants of the purpose and agenda and also introduced the members of the head table and resource persons. He informed participants that the Public Forum was organized as part of the EIA public consultation process in order to obtain their comments and concerns and to try to address them, as much as possible, in the EIA. It was noted that the consultation would be a continuous process with follow-ups through the EIA and by the relevant authorities. Therefore, any additional comments were to be sent to the Environmental Consultants - Royal Haskoning (none were received).

Mr. O.A Obanewa (Chief Environmental Scientist) - Federal Ministry of Environment, Abuja, and Dr. (Mrs.) Titi Anibaba (Permanent Secretary) - Lagos State Ministry of Environment gave opening remarks.

Thereafter, Mr. David Frame (Managing Director) - South Energyx Nigeria Limited, the project proponent introduced the project to the participants. He explained that the Eko Atlantic city is a planned district of Lagos, Nigeria adjacent to Victoria Island. It will be a dynamic new city that will be constructed on land being reclaimed from the Atlantic Ocean. Eko Atlantic City will become home to at least 250,000 residents and the workplace for another 150,000 commuters. Planned to be around nine square kilometers in size, the city will have a state-of-the-art high-tech infrastructure in line with modern and environmental standards that will propel the status of Lagos as the financial centre of Africa.

Mr. Brent Sadler a former news reporter of Cable News Network (CNN) International in his remark gave a summary on the international prospect of the project. He explained that the project is a laudable project that should be supported by everybody. He made mention of the local and international awards the project has received since inception. He explained further that the project has put Lagos State and Nigeria in general on the world map through adherence of the project to international best practices.

There were two scheduled presentations: (i) project overview and (ii) presentation on the process, findings and status of the Environmental Impact Assessment (EIA) Study by the Environmental Consultants (Royal Haskoning). The Environmental Consultants presented key findings of the EIA. These were followed by an open floor discussion session. There were approximately 50 participants from Federal and State Government Ministries/Agencies, Local Governments, the private sector, Banks, ENGOs/NGOs, and fishing communities, Tarkwa-Bay Community, and Press men.

Table 5.5 provides a summary of the comments, concerns, and an indication of the section in the EIA where concerns were addressed. (See Appendix G for list of participants and agenda of the Public Forum).

Table 5.5 Public Forum - Summary of Comments, Concerns, Responses and related sections within EIA document.

Participant/Group	Summary of Comment/Concerns	Summary of response given/related sections in EIA document
Dr. (Mrs.) Titi Anibaba Permanent Secretary - Lagos State Ministry of Environment	-What method of sand placement is being used? What types of sand are being dredged and are they suitable for reclamation? What method of sand compaction is being used? - What are the environmental implications of the dredging method on the boring areas? - What will be the present and future effects of the sediments on the dredging areas?	- Hydraulic fill method is being used. - The dredged sand type is medium to coarse sand. - The method of sand compaction that is being used is hydraulic compaction during fill. - No serious environmental implication revealed by the study. - The studies carried out have shown that the dredging method to be used wouldn't have any serious implications on the sediments. Also, it wouldn't cause any erosion in the future.
Mr. Brent Sadler Former news reporter of Cable News Network (CNN) International	- Unlike developed countries, it is not common in Nigeria to see EIA reports on the internet (websites). Would the final EIA report of Eko Atlantic City going to be displaced on the internet (website)?	- Yes, the final EIA report will be available on the internet as soon as approval is obtained from the Federal Ministry of Environment, Abuja. EIA document will be made accessible to the public after its approval.
Pastor Abraham Naikon Community coordinator of Tarkwa-Bay Community	- What will be the impacts of the dredging activities on Tarkwa-Bay island, fishing and tourism? If any, how would the negative effects be addressed? - What kind of work have you done	Concerns voiced by the participant have been addressed already in the EIA and by the relevant authorities for the proposed project. - Concerns voiced by the

Participant/Group	Summary of Comment/Concerns	Summary of response given/related sections in EIA document
	so far with regards to fishing knowing that lots of fishermen fish in the high sea close to the reclamation areas?	participant have been addressed already in the EIA.
Mr. E.A. Edozie NPA	- What are the mitigation measures put in place? -Is provision made for maintenance dredging permanent?	- Dredging equipment minimise increase in turbidity. No dredging closer than -15m contour to avoid impact on the shoreline. - Maintenance dredging is not relevant. There will be no need for maintenance dredging related.
Mr. O.S. Savage Lagos State Ministry of Environment	- I will advise you that the EIA for the 2nd phase of the project should commence immediately so that there wouldn't be any overlapped.	- The Proponent and the Consultants will look into the suggestion and try to commence the EIA for the 2nd phase of the project as soon as possible.
Mr. Success C. Ikpe Nigerian Environment Society	- I have checked the list of your relevant key stakeholders; I want to know whether you have also contacted Nigerian Maritime Administration and Safety Agency (NIMASA) and National Inland Waterways Authority (NIWA). I am of the opinion that they are also good key stakeholders and they should be able to make useful contributions to the EIA.	- We are yet to contact them. We will make efforts in seeking for their contributions.
Engr. R.A. Kumolu Nigerian Society of Engineers	- The issue of settlements cannot be overemphasised. Therefore, have the study find out the level of settlements before any reclamation/construction on site?	- Settlement plates are being monitored. All buildings will be built on appropriate foundations such as piles to good ground. Hydraulic compaction is sufficient for low ground bearing infrastructures such as roads, drainages, etc. .

Participant/Group	Summary of Comment/Concerns	Summary of response given/related sections in EIA document
Mr. K.S.A. Lasisi Lagos State Ministry of Environment	- From the presentation made, no archaeology studies were mentioned. I will suggest that archaeology studies should be considered in the study. - I want to suggest that sedimentation study should commence now.	- Concerns voiced by the participant will be look into and incorporated in the EIA study. - maintaining of sediments will form part of the ongoing monitoring plan.
Mr. Babajide Adeoye Lagos State Ministry of Environment	- I commend the Consultants and the Proponent of the project for the EIA study and public forum. I will like to suggest that the social economic of the EIA should be strengthen. - There is a need to further widen the scope of the EIA study.	- The suggestion made by the participant will be look into and incorporated in the EIA study. - The suggestion made by the participant will be look into and incorporated in the EIA study.
Mr. H. Shittu Federal Ministry of Environment, Abuja	- Applaud effort of the public forum and would like to know why the project have to take off before issuance of EIA permit from FMEnv. - What efforts have been made or are being made to correct this abnormality?	- Concerns voiced by the participant have been addressed already in the EIA and by FMEnv. for the proposed project. - Concerns voiced by the participant have been addressed already in the EIA and by FMEnv. for the proposed project.

5.8 Air, Noise and Vibration Assessment Methodologies

5.8.1 Air Quality Assessment methodology

The Nigerian Federal Ministry of Environment (FMEnv) has an overall mandate to "to protect and improve water, air, land, forest and wildlife of Nigeria", and is responsible for ensuring the formulation and compliance monitoring of Environmental Standards. The recently established National Environmental Standards and Regulations Enforcement Agency (NESREA) is responsible for enforcing all environmental laws, guidelines, policies, standards and regulations in Nigeria, including those relating to air quality. Ambient Air Quality Standards have not been set in Nigeria; therefore European Union (EU) Limit Values[1] and World Health Organisation Air quality Guidelines (WHO)[2] are presented in **Table 5.6**.

Table 5.6 International Air Quality Standards (µg.m^3)

Pollutant	Averaging Period	EU	WHO
Sulphur Dioxide (SO_2)	10 minutes		500
	15 minutes	266	
	hourly	350	-
	daily	125	20[3]
	annual		-
Nitrogen Dioxide (NO_2)	hourly	200[4]	200
	daily	-	-
	annual	40	40
Particulate Matter (PM_{10})	hourly	-	-
	daily	50[5]	50
	annual	40[6]	20
Carbon [7]Monoxide (CO)	15 minute		100,000
	30 minute		60,000
	hourly		30,000
	8 hourly	10,000	10,000

Air quality monitoring surveys specific to Phase 1 works were not undertaken and the assessment presented here is based upon a desktop study.

[1] European directive limit values (96/62/EC, 99/30/EC, 200/69/EC, 2002/3/EC) *http://ec.europa.eu/environment/air/ambient.htm.*

[2] WHO (2006) Air Quality Guidelines for Particulate Matter, Ozone Nitrogen Dioxide and Sulphur Dioxide Global Update 2005.

[3] WHO also proposes interim targets of 125 µg.m^{-3}, which is equal to the former WHO guidelines (WHO, 2000), and 50 µg.m$^{-3,}$ which is viewed as a feasible and achievable goal that would lead to significant health improvements.

[4] 18 hourly exceedances per year allowed

[5] 35 daily exceedances per year allowed

[6] UK Annual Mean Air Quality Objective

[7] WHO Guidelines from: WHO (2000) Air Quality Guidelines for Europe 2nd Edition

The significance of impacts is considered in the context of the World Health Organisation's Air Quality Guidelines and EU Limit Values, existing conditions and the sensitivity of the receptors potentially affected by any changes.

5.8.2 Noise and Vibration Assessment methodology

Nigerian legislation

The Nigerian Federal Ministry of Environment (FMEnv) has an overall mandate to "to protect and improve water, air, land, forest and wildlife of Nigeria", and is responsible for ensuring the formulation and compliance monitoring of Environmental Standards. The recently established National Environmental Standards and Regulations Enforcement Agency (NESREA) is responsible for enforcing all environmental laws, guidelines, policies, standards and regulations in Nigeria, including those relating to noise. Draft legislation relating to environmental noise is currently being produced by NESREA but there are as yet no guidelines relating to the assessment of noise impact or acceptable environmental noise criteria or levels.

A strategy document for the future noise legislation listed the following as key objectives:

- *set up noise standards including acoustic guarantees;*
- *prescribe guidelines for the control of neighbourhood noise especially with respect to construction sites, markets, meeting places and places of worship;*
- *prescribe permissible noise levels in noise-prone industries and construction sites and ensure the installation of noise dampers on noisy equipment;*
- *set up quiet zones especially within game parks, reserves and recreational centres;*
- *provide guidelines for the control of aircraft noise by prescribing acceptable or permissible noise levels within the vicinity of airports;*
- *ensure compliance with stipulated standards by conducting periodic audit checks*.

The FMEnv has published noise regulations relating to occupational (workplace) noise exposure levels. These occupational limits recommend a permissible noise exposure limit of 90 dB(A) for an 8-hour working day. This limit level is based upon a threshold intended to minimise hearing loss and adverse health effects in the workplace, and does not relate directly to environmental noise.

International legislation

The World Health organization (WHO) document *Guidelines for community noise*[8] provides general guidance on the effects of environmental noise on communities and recommends limits for noise levels within residential areas. The noise level limits are presented in **Table 5.7**:

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[8] Berglund *et al*, 1999. Guidelines for Community Noise. Geneva, World Health Organisation (WHO)

Table 5.7 WHO guidelines for ambient noise levels in residential areas

Time of day	Limit type	Limit level
Day	Average level	50 to 55 dB $L_{Aeq,16h}$
Night	Average level	45 dB $L_{Aeq,8h}$
Night	Maximum level	60 dB L_{Amax}

British Standard (BS) 5228[9] provides guidance and advice on the creation and control of noise from construction and open sites. The Standard includes calculation methods for predicting noise at sensitive receptors from construction works and a database of source noise levels for a wide variety of construction plant. The Standard also provides advice on methods of determining the significance of noise from construction works.

Two relevant approaches to assessing the significance of construction noise are proposed. The first method utilises fixed noise limits and provides the following advice:

Noise levels, between say 07.00 and 19.00 hours, outside the nearest window of the occupied room closest to the site boundary should not exceed:

- *70 decibels (dBA) in rural, suburban and urban areas away from main road traffic and industrial noise;*
- *75 decibels (dBA) in urban areas near main roads in heavy industrial areas.*

The second method, referred to as the ABC method, provides varying noise threshold levels dependant on the existing noise climate in the vicinity of the construction works. **Table 5.8**, reproduced from BS 5228 below, presents these noise threshold levels.

Table 5.8 Example construction noise threshold levels from BS 5228

Assessment category and threshold value period (L_{Aeq})	Threshold value, in decibels (dB)		
	Category A [A)]	Category B [B)]	Category C [C)]
Night time (23.00 to 07.00)	45	50	55
Evening and weekends [D)]	55	60	65
Daytime (07.00 – 19.00) and Saturdays (07.00 - 13.00)	65	70	75
[A)] Category A: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are less than these values.			
[B)] Category B: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are the same as category A values.			
[C)] Category C: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are higher than category A values.			
[D)] 19.00–23.00 weekdays, 13.00–23.00 Saturdays and 07.00–23.00 Sundays.			

[9] British Standards Institution, 2009. BS 5228-1: 2009 Code of practice for noise and vibration control on construction and open sites – Part 1: Noise. London, BSI.

Significance Criteria

Criteria for assessing the significance of construction noise impacts are presented in **Table 5.9.** The criteria are based on the WHO guideline noise levels and guidance from BS 5228, from which the upper criteria (category C) were chosen, to reflect the generally elevated existing noise environment on Victoria Island.

Table 5.9 Criteria for assessment of construction noise

Impact significance	**Construction noise level (dB L_{Aeq})**		
	Day (07:00 – 19:00)	**Evening (19:00 – 23:00)**	**Night (23:00 – 07:00)**
No impact	< 55	< 55	< 45
Negligible	55 – 75	55 – 65	45 – 55
Minor	75 – 80	65 – 70	55 – 60
Moderate	80 – 85	70 – 75	60 – 65
Major	> 85	> 75	> 65

ABIOTIC ENVIRONMENT BASELINE DESCRIPTION

This section describes the abiotic environment of the Project study area, including the coastal processes, sediment and water quality. Information presented here is based on existing data sources (*e.g.* previous EIAs or published scientific studies) and the survey work completed for the Project in March 2010 (refer to **Section 5.5.1** for methodologies and sample locations and **Appendix C** for full results). In addition to this, the EIA from Lekki Port project and environmental studies of the Kuramo Lagoon have been used to supplement baseline data for the wet season. Relevant raw data from the Lekki Port study is provided in **Appendix C**

5.9 Coastal Morphology and Sediment Processes

5.9.1 Coastal geology

The Nigerian continental shelf is located on a relatively localised protrusion into the Gulf of Guinea basin and is underlain by Tertiary sediments that thicken seaward to a maximum of about 12,000 m. According to Allen (1965), the Tertiary sediments are overlain by two series of Quaternary sediments. The older series comprises sheet-like sand bodies which can be traced over most of the continental shelf, deposited during late Pleistocene to early Holocene sea-level rise (transgression of the sea). The surface of the sand sheet is formed into terraces and ridges parallel to the shore and crossed locally by shallow valleys. The ridges have been interpreted as drowned barrier beaches and island complexes.

The younger series locally buries the older sands across the continental shelf. They comprise sands near shore, silts in moderate depths and clays in deep water, and have been deposited during the seaward growth of the modern Niger Delta. River mouth bars and inshore terraces are the principal morphological features of the modern continental shelf underlain by the younger series. Allen and Wells (1962) and Awosika (1990) described a system of relict Holocene coral banks in some parts of the middle and outer continental shelf (**Figure 5.5**). The coral banks are aligned parallel to the coastline in 80 - 100 metres of water and attain heights of about 7 m in some places, especially along the western shelf.

5.9.2 Coastal bathymetry

The Nigerian continental shelf is narrow in the west and ranges in width from 28 - 33 km (**Figure 5.5**). The width increases to 63 km off Cape Formoso at the nose of the Niger Delta, increasing eastwards to about 75 km off the coast of Calabar.

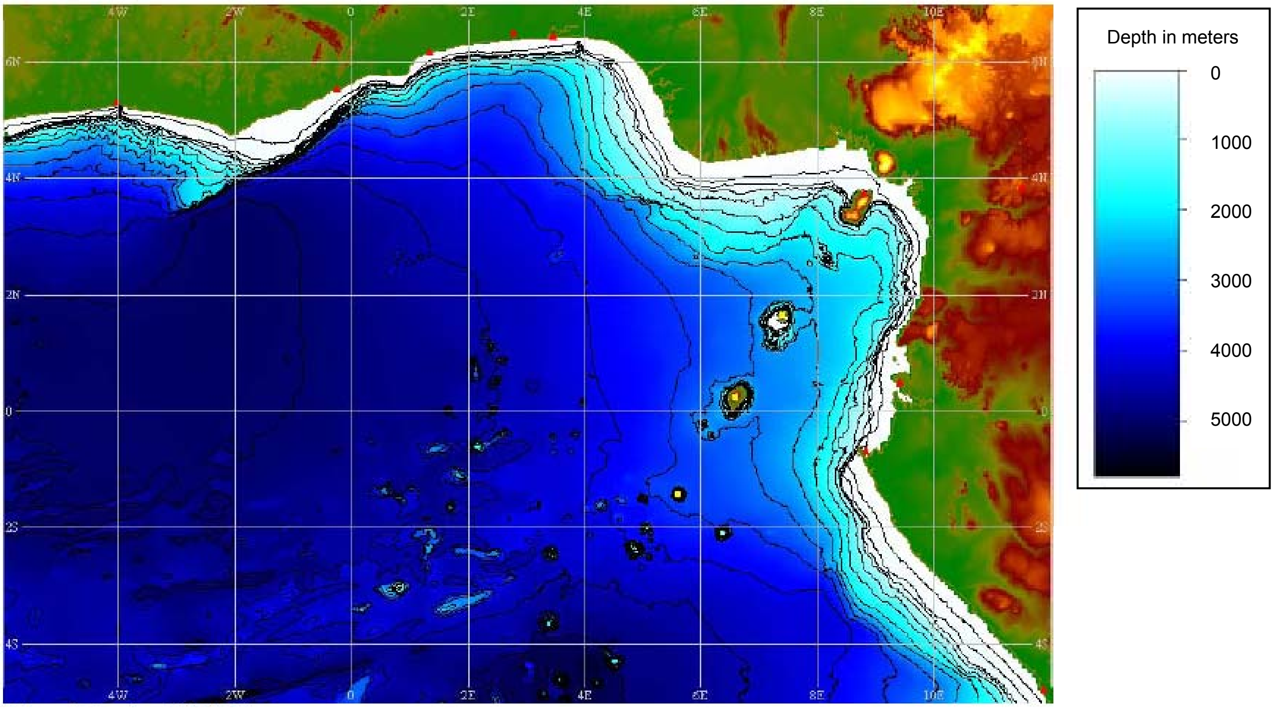


Figure 5.5 Nigerian Continental shelf

Three major submarine canyons; Avon, Mahin and Calabar deeply groove the Nigerian continental shelf and slope. The Avon Canyon (approx. 06°10'N, 03°55'E) is about 15 km wide and 730 metres deep with its head at about 3 - 5 km off the Lagos coast in water depths less than 18 m. The Mahin Canyon is located off the Mahin Mud Coast. It is smaller than Avon Canyon and begins further from the coast in 55 m of water. This canyon is approximately 1.6 km wide and 180 - 900 m deep. The Calabar Canyon is located eastwards off the coast of Calabar. This canyon cuts the shelf for a length of about 8 km; the width is about 3 km and the depth varies from 180 - 450 m.

These canyons serve as conduits for channelling sand into offshore submarine fans located on the continental slope. The overall nature of the Nigerian continental shelf is mainly depositional as compared to adjacent parts of the continental shelf along the Gulf of Guinea where rocks appear close to the coast.

5.9.3 Coastal geomorphology

Nigeria’s coastline is about 853 km long stretching between its western and eastern borders with the Republic of Benin and Cameroun, respectively. It lies generally between 4°10' and 6°20'N latitudes and 2°45' and 8°35'E longitudes adjacent to the Gulf of Guinea. Geomorphologically, the Nigerian coastline can be divided into four main zones. From west to east, the following coastal types can be distinguished: the Barrier-Lagoon Complex, the Transgressive Mud beach or the Mahin Mud coast, the Niger Delta and the Strand Coast (Okada) (Ibe, 1988) (**Figure 5.6**).

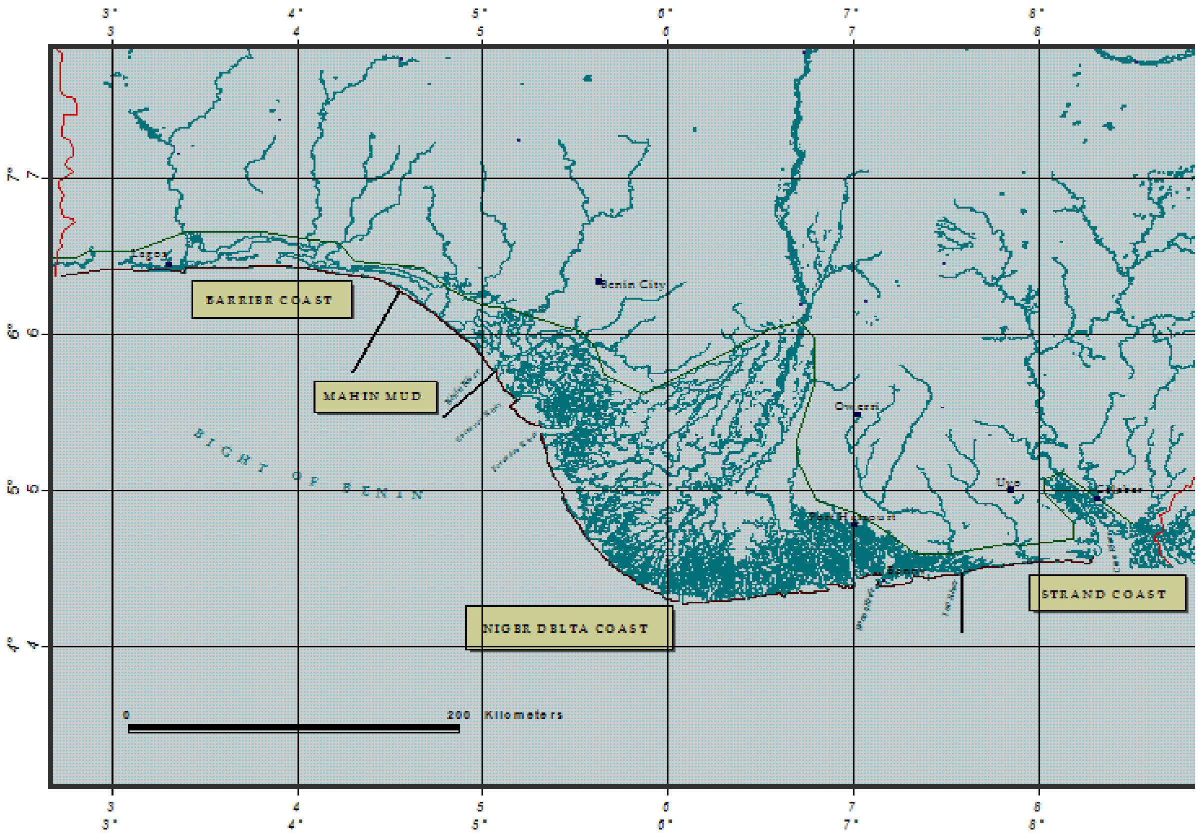


Figure 5.6 Map showing the different geomorphological zones along the Nigerian coast. (Awosika et. al, 2002)

5.9.4 Lagos coastal system

The Eko Atlantic project is located along Bar Beach at Victoria Island, Lagos, along the Barrier-Lagoon Complex, which lies between Badagry and Ajumo, east of Lekki town and extends for about 200 km (**Figure 5.7**). Some geomorphic features have evolved over millennia dating from the Tertiary whereas others are more recently developed features resulting from the interaction with physical processes. These processes are in addition to human related activities such as the damming of rivers, dredging activities, sand mining, deforestation of coastal vegetation, urbanization and industrialization.

The coastline near Lagos is oriented in an east-west direction and is characterised by a complex system of interconnected lagoons, inland lakes, rivers, creeks, wetlands and channels. The morphology of the Barrier-Lagoon complex of Lagos has largely been determined by coastal dynamics and drainage. Bar Beach is exposed to persistent southerly to south-westerly swells resulting in a persistent longshore sediment transport, directed from west to east. Although various rivers discharge in this area, it is unknown how much water flows into and out of this system.

5.9.5 Historic development of Victoria Island and Bar Beach

The configuration of the Lagos coastal system before construction of the West Mole is shown in **Figure 5.7**. It comprises an easterly growing spit forming Lighthouse Beach in the west separated by a tidal inlet from Bar Beach in the east. The tidal inlet allows exchange of water between Lagos Lagoon and the

Gulf. Both Lighthouse Beach and Bar Beach were formed by westerly-directed longshore sediment transport. The deposition started where the coast changes direction further west. This resulted in a narrow spit of sand, attached to the mainland and an inlet at the other end of the spit. In a dynamic coastal environment, the location of the inlet is likely to change over time. Since the construction of the Lagos Harbour Moles in 1912, the inlet of Lagos Lagoon has been fixed.

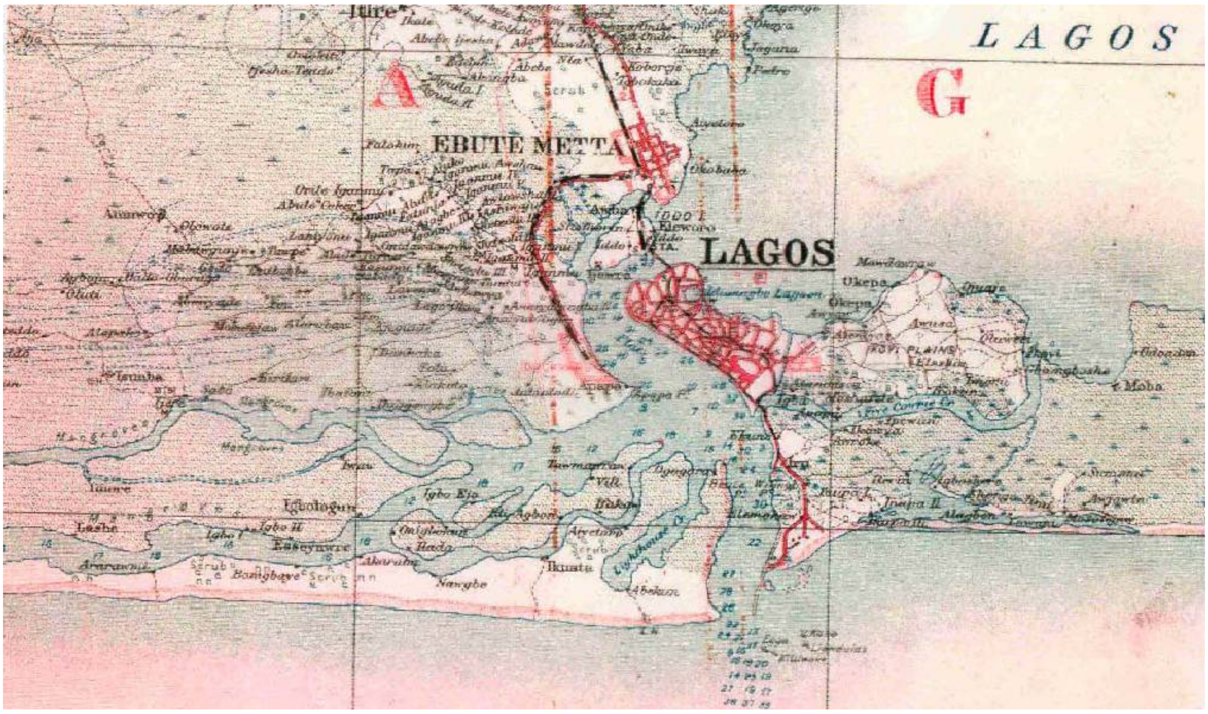


Figure 5.7 Coastal area around Lagos before construction of the west mole

Before construction of the Lagos Harbour Moles, the morphology within the tidal inlet of Lagos Lagoon was very dynamic. Because of the dynamic environment around the inlet, the entrance channel to Lagos Lagoon was difficult and dangerous to navigate. Hence, in 1892, Sir John Coode proposed to dredge the entrance channel to Lagos Lagoon and construct two breakwaters (moles) to prevent the entrance from siltation.

Due to the construction of the harbour moles, the physical processes around the inlet changed considerably. The western mole is a barrier to sediment transport from the west supplying Bar Beach to the east. Consequently, sand is accumulating and accretion is occurring along the western side of the mole. Since the construction of the moles, Bar Beach has suffered from severe erosion (Pugh, 1954; Webb, 1960). Due to the reduced sand supply from the west, NIOMR report average erosion rates of 20-30 m annually at Bar Beach. Between 1900 and 1959, Bar Beach retreated by over 1 km near the eastern mole, with erosion decreasing to around 400m some 3 km east of the mole in the area of the Kuramo waters. Lighthouse Beach near the western breakwater accreted over 500m within the same period. Comparing early maps of the Lagos coast with the present configuration shows that the shoreline at Bar Beach has receded about 1-2 km, since the erection of the moles at the mouth of Lagos Harbour.

The erosion along the coastline of Nigeria is reported in various sources (**Table 5.10**Error! Reference source not found.). The 6 km section of Bar Beach on Victoria Island has the highest erosion rates in Nigeria, averaging 25-30 m per year. Awosika *et al*. (1991) found the highest erosion rates close to the moles, averaging 66 m during a survey carried out over a 14 month period between 1990 and 1991. This amounted to a mean monthly erosion rate of 4.71 m.

Table 5.10 Erosion along the Nigerian Coastline (Oyegun, 1990)

Erosion Rates along Nigeria's Coastline

Locations	*Rate of erosion/yr*
Badagry Beach (Lagos State)	2–6 m
Victoria Beach (Lagos State)	25–30 m
Awoye/Molume (Ondo State)	20–30 m
Ogborodo/Escravos (Bendel State)	18–24 m
Forcados (Bendel State)	16·8–22 m
Brass (Rivers State)	16–19 m
Ibeno-Eket (Akwa Ibom State)	10–13 m

In Okude and Ademiluyi (2006) showed that the Lagos area has eroded between 1986 and 2002. From **Table 5.11**, it is seen that the varying annual erosion rate (between 1.53 and 22.29 m) was derived from the analysis. While the highest annual rate of 22.29 m was recorded for the 1986-1990 period; the smallest annual erosion rate of 1.53 m was associated with the 1990-1995 period. This sharp contrast may be connected with periods of beach nourishment along the coast. The annual erosion rate has not yet reached a stable value in **Table 5.11**.

Table 5.11 Estimated erosion pattern for the Lagos area, Okude and Ademiluyi (2006)

Periods	Net change [m^3/m]#	Annual erosion rate [m]
1986-1990	-4814.74	22.29
1986-1995	-5325.18	10.56
1986-2002	-5942.33	6.63
1990-1995	-414.41	1.53
1990-2002	-1113.55	1.72
1995-2002	-632.08	1.61

The cited reference does not mention what this figure means exactly, but it is assumed that it is the erosion in a transect perpendicular to the coastline

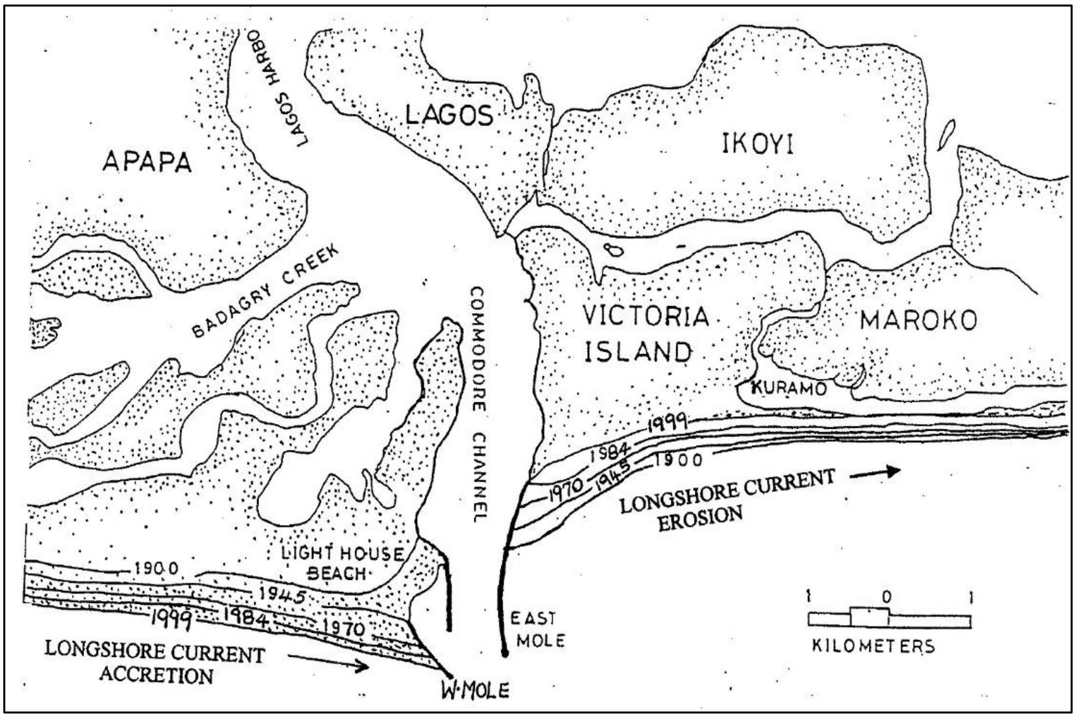


Figure 5.8 Historical coastal erosion since construction of the east mole

5.9.6 Erosion control near Bar Beach

The very high rates of erosion of the Lagos coast have been of serious concern both to the Federal Government of Nigeria and the Lagos State Government. The concern results from the very important position of Lagos as a former Federal Capital City and as the Capital of Lagos State, as well as its importance as the economic, industrial and commercial nerve centre of Nigeria. This is in addition to its position providing a residential base for about 15 million people.

Between 1912 and 1960, no mitigation measures were implemented to combat the on-going erosion. In 1960, large quantities of sand were pumped onto the beach. Studies undertaken by the Nigerian Institute of Oceanography and Marine Research show, that about 0.6 – 1.0 million m^3 of sand per year would be required at Bar Beach to keep the beach in a stable condition. Stein and Eichweber (1984) showed that since 1924, Lighthouse Beach has been accreting at a rate of 0.46 million m^3/year and the areas east of the East Mole show a loss at a rate of 0.7 million m^3/year during past 60 years.

To avoid a possible flooding of the city of Lagos by the incursion of the sea through shoreline erosion and the accompanying flooding of adjacent lands, several mitigation measures have been, and continue to be applied at Bar Beach (**Table 5.12**).

Table 5.12 Erosion control measures applied from 1958 to 2003 to Bar Beach

Period	Mitigation measure applied
1958	Construction of a groyne at the foot of the eastern breakwater to avoid undermining of the breakwater.
1958-1960	Dumping of sediment dredged from the Commodore Channel of the extremity of eastern breakwater, for dispersal along the beach by waves.
1960-1968	Permanent pumping station built on the eastern breakwater, supplying an average of 0.66 Million m3 per annum of sediment from the Commodore Channel.
1969-1974	Some artificial sand replenishment (but reliable records of quantities or frequencies are not available)
1974-1975	3 million m^3 of sand dumped and spread on the beach.
1981	2 million m^3 of sand dumped and spread on the beach.
1964	A zigzag timber breakwater running parallel to the shoreline was driven about 26m from the shoreline.
1985-1986	3 million m^3 of sand dumped on the beach (before the work commenced, the Culvert to the main boulevard parallel to the shoreline was already being undermined at some points by wave action).
1990-1991	5 million m^3 of sand was dumped on the beach. Before the work started in August 1990, the entire sand dumped on the beach between 1985 -1986 has been washed away in most places. The Lagos State Tourism fence along the main boulevard, as well as the main boulevard, Ahmadu Bello drive was already being undermined.
1995-1997	6 million m^3 (2 million m^3 per year) was dumped.
1998	A groyne was constructed at the back of the Federal School of Fisheries.
1999	2 million m^3 of sand were dumped and spread on the beach using a dredger.
2002-2003	Dredging of more than 2 million m^3 of sand refurbishment of Ahmadu Bello Way.
[Source: Awosika *et al*, 1991; Odofin, 2004]	

In December 2006, a temporary shoreline protection project was completed to protect Victoria Island from further erosion and water intrusion. Just eastward of the East mole, 1 km of shore protection works has been built using 1.5m^3 X-blocs (**Plate 5.1**). The shore protection consists of 4800 concrete units. After installation of the shore line protection works, no significant erosion has been observed. However, considering the historic trends and the dynamics of the system, it cannot be concluded that erosion has been completely halted by installation of the shore protection works.

Plate 5.1 Recent Bar Beach shore protection works

5.9.7 Analysis of coastal process drivers of erosion at Bar Beach

As along many other coasts, the drivers of shoreline erosion along the Nigerian coast are a combination of various interrelated factors that create the conditions for erosion. These factors can be grouped into natural and human-induced causes. In particular, the following contributing causes of erosion have been identified for the Lagos coastline.

1. **Severe wave climate:** A fundamental naturally-induced cause of shoreline erosion in Lagos is from the incidence of the long ocean waves (swells) that initiate the coastal erosion process along the Lagos coast. The dominant oblique direction of approach to the shoreline enhances its effect on the erosion.

2. **Storm surges:** A fundamental cause of coastal erosion in Nigeria, particularly in the Lagos coastal area, is the incidence of storm surges which generate powerful waves whose impact on the sandy formations prove destructive. The storm surges are frequent during the rainy season at Bar Beach. Hence, the highest beach recession occurs during the rainy season months and the least during the dry season months, when some accretion takes place. Erosion seems to be closely related to the incidence of storm surges. An increase in the number and severity of storms due to climate change means increase in the rate of beach recession.
3. **Sediment supply:** The main contributory factor of coastal erosion is the lack of adequate sediment supply from the west. Where sand supply is adequate there is potential for beaches to adapt their shape to the incoming wave climate without damage.
4. **Construction of Harbour Moles:** Human activity is regarded as a dominating factor behind the erosion of the Lagos coastline. Tilmans *et al* (1991) describes the human intervention on the development on the West African coast. “Taking a historical jump, it may be correct to assume that the first real intervention by man in the large-scale coastal processes was the building of the Lagos Inlet breakwaters in the period 1908-1912. The subsequent immediate effects were dramatic. However, it was not till 1958 that effective coastal mitigating measures were brought into force.
5. **Human activities onshore:** As well as the erosive processes of the sea, processes from the landside have also enhanced the vulnerability of Bar Beach. NIOMR (1992) described sand mining at places along the beach. They also reported lowering of the beach berm crest of recently nourished beaches by religious sects for praying grounds. The occasional removal of dunes along the coastline also reduces the sediment budget in the coastal system.
6. **Human activities offshore:** Another human-induced enhancement of erosive processes along Bar Beach is the dredging of borrow pits located offshore. NIOMR concluded that “Future beach nourishment must include reducing the gradients of the foreshore and surf-zone as well as the location of borrow pits farther offshore.”

The construction of the moles at the mouth of the Lagos harbour is a major human construction activity that has had a profound influence on the coastal erosion process along the Lagos coast.

Figure 5.9 shows a generic picture of erosion and accretion due to the construction of a structure protruding into the sea. For the Lagos case, incident waves approach from southwest and hence erosion is expected on the east side of the structures, whereas accretion is expected on the west side. Before the construction of the breakwaters, the active Bar Beach at Victoria Island was almost in line with the Lighthouse Beach to the west of the inlet, both forming a barrier bar system and having a consistent west-east transport of sand. The presently observed more northern disposition of Victoria Island is attributed to the disruption of the west-east longshore sand transport by the moles.

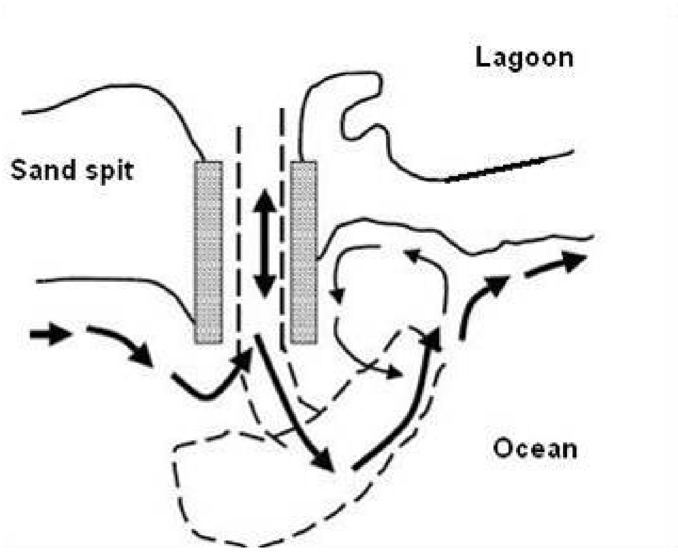


Figure 5.9 Schematic figure of sedimentation and erosion process near coastal inlets fixated by constructions, with sediment bypass, taken from Coastal engineering Manual, USACE (2002) V-6-11, Figure V-6-6.

Long swell waves are approach the Lagos coast continuously. At the steep nearshore, these waves start to break in 3m water depths or shallower, creating turbulence and release of sand into suspension. It is believed that, because of the steep slope, small breaker zone and large wave impact, the beach sand is also transported outside the breaker zone by offshore directed bottom currents (undertow). Once the sand is in suspension, there are two types of wave induced current which are able of transporting the sediment (HYDRODYNAMICS BV, 1997):

a) The interrupted east-directed wave induced longshore sediment transport restarts again approx. 1 km east of Kuramo Waters. Because there is no supply of sand from the west, sand has to be withdrawn from Bar Beach. So, in this area, sand brought in suspension by the swell waves is transported in east direction. More to the east, supply and discharge parallel to the coast line are in equilibrium again. This explains why not much beach erosion has been reported from Kuramo Waters to the east. The project development will move this point of reattachment of the longshore transport further to the east.
b) The predominant wave direction is south-west. Therefore, the incoming waves are diffracted around the East Mole, causing a lower wave height behind the mole. At about the middle of the Bar Beach the wave height is ‘normal’ again, because the diffraction influence has faded away. The difference in wave set-up between the middle of Bar Beach and the lee area near the East Mole causes a local current in western direction. Therefore sand brought in suspension by swell waves can be transported in direction of the East Mole.

   The above explains why prior to the construction of the revetment of Xbloc units the erosion (1) is concentrated at the middle part of Bar Beach, (2) in east direction the erosion rate decreases and no erosion is reported east of Kuramo Waters and (3) the near shore immediately east of the East Mole is not as steep as the beach a little more to the east.

At present, less erosion has been observed at Bar Beach after the temporary coastal protection works using X-Blocs, which accounts for the area more East of the construction works as well.

5.9.8 Conclusions Coastline Development Bar Beach

The observed increased erosion rate at Bar Beach over the past 100 years can be attributed to the construction of the Harbour Moles. Before construction of the Harbour Moles, sand was bypassing over an offshore bar, which made navigation of the entrance channel difficult. By constructing these moles, bypassing of sediment was reduced and sediment accreted on the west side. In addition, the sand bar in front of the inlet was removed and hence bypassing was made difficult. The observed erosion trends along Bar Beach are related to the construction of these structures. However, also other factors will be contributors, such as sand mining, nearshore dredging and dune erosion. ENTEC and CSIR (2006) reported that over the last century, up to 35 million m^3 might have been dredged from nearshore off Bar Beach. The following can be concluded:

- The influence of human intervention is today so large that natural erosion trends are masked. There is however evidence (from old records and adjacent shorelines) for the view that coasts in the region were in dynamic equilibrium prior to the human works, and that natural erosion trends would be attributed mainly to the global rise in sea level. Based on this, it could be concluded that, there is an overall trend of coastal erosion along the Bight of Benin and along the Victoria Coastline and thus Bar Beach as well;
- Significant erosion has taken place along Bar Beach after the construction of the Lagos Harbour Moles in the early 1900’s; related to this, accretion has taken place at Lighthouse Beach. The bulk of the littoral sediment transport is blocked by the Lagos Harbour Moles, in particular the West Mole;
- The littoral transport of sand, driven by the dominant ocean waves and their oblique direction of approach from the southwest, is clearly oriented from west to east; literature, computer models and studies from nearby ports (Cotonou, Olakola), show that an annual sand transport of the order of 800,000 m^3/yr is taking place along the shoreline;
- Since the late 1900’s, repetitive beach nourishment has taken place along Bar Beach that temporarily mitigated the coastline retreat;
- Most of the transported sand originating from the west has been deposited on Lighthouse Beach. However, the sand-trap created by the West Mole has been filled and sediments are now bypassing the tip of the West Mole and depositing in the Commodore Channel Entrance and/or bypassing to the area east of the less protruding East Mole;
- In 2006, a temporary solution to erosion at Bar Beach was implemented by construction of a so-called X-bloc revetment. This construction appears to work efficiently; apparently no further progressive erosion has been observed, although it was expected to happen east of the scheme at Kuramo Waters and further down the transport pathway. The absence of further significant erosion could be due to the West Mole not being able to trap all the transported sediment from the west. Another possibility is that

the sea bed in front of the X-blocs was deepened and was feeding the areas further to the east.

5.10 Metocean data

5.10.1 Introduction

This chapter provides an overview of the metocean characteristics of the Project site based on available data. Data collected during a field campaign in April and May 2008 is reported in **Section 5.3**. Data have been made available to the Project from various publications, previous studies and field surveys carried out before or during the course of this project.

5.10.2 Bathymetry and shoreline

The bathymetry near Lagos (**Figure 5.10**) is characterised by a reasonably gentle and constant bottom slope. The 30m depth contour is located at about 8km from the shore and the 50m depth contour at 17 km offshore. The continental shelf extends to about 30 km from the coast. The area east of the tidal inlet is shallower than the area to the west. Furthermore, Lagos has a port entrance channel which is connected to a large outer ebb-tidal delta.

5.10.3 Beach profiles

Topographic foreshore surveys have been carried out in March 2008 by Engee Surveys Ltd. Beach profiling has been undertaken over a 22 km stretch of Bar Beach east of the eastern harbour mole at about 250m intervals. The nearshore profiles have a steepness ranging from 1/20 to 1/50 underwater to about 1/5 to 1/10 above the water line.

5.10.4 Air temperature

Temperatures in Lagos are high to very high throughout the year. During the wet season, when the Lagos area is under the influence of the maritime air mass, mean daily maximum temperatures are usually between 28^{o}C and 30^{o}C, whereas the mean daily temperature is about 24^{o}C. During the dry season, when Lagos is mostly dominated by the dry north-east trade winds (Harmattan), temperatures are hot and dry with mean daily temperatures rising as high as 34^{o}C, whereas the minimum temperature experienced is about 30^{o}C.

5.10.5 Rainfall

Due to its location in the equatorial zone, the climate of Lagos is mostly under the influence of warm wet tropical maritime air masses. The city experiences two periods of rainfall; the first season begins between April and May and ends in July, while the second starts late August and ends in early October. Total annual rainfall in Lagos exceeds 1,750 mm. Monthly average rainfall of more than 600 mm characterises the peak period of the first wet season, whereas the second wet season is characterised by about 300 mm of rain during its peak period.

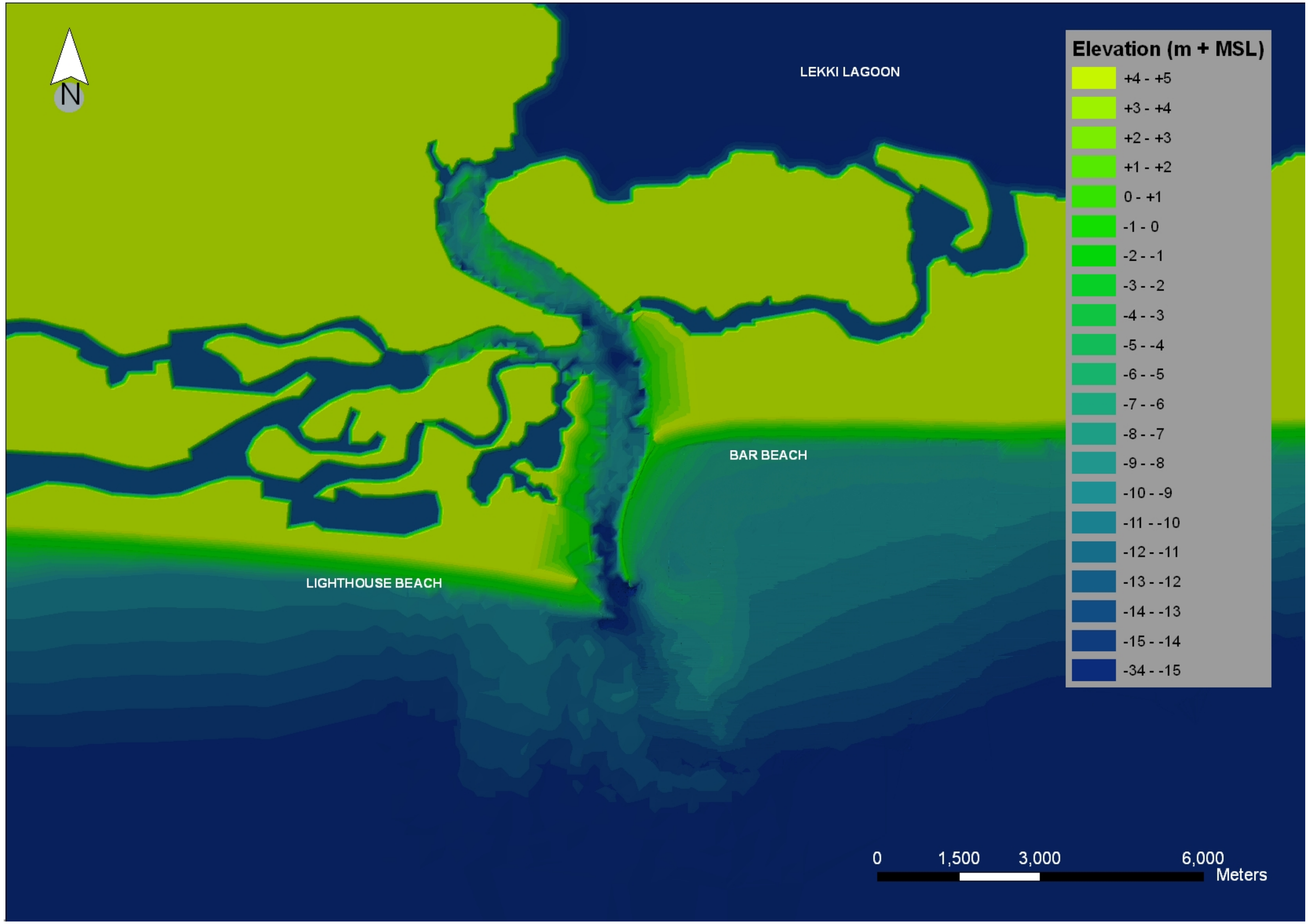


Figure 5.10 Bathymetry around Lagos

5.10.6 Wind

Wind data are required for the purposes of predicting the locally generated wave energy, and was available from two wave-hindcast models:

- NOAA at 3-hourly intervals from January 1997 until February 2008 for offshore location 3o45'00'' E; 6o00'00'' N. In total, 32,152 records of wind speed and direction were available. Annual and seasonal wind roses derived from these data are presented in **Figure 5.11**. The annual dominant wind direction is west-south-west with typical wind speeds from 4-6 m/s. Above average wind speeds are observed during the wet season from June to September. Lower wind speeds are observed in the dry season from November to March;
- Wavewatch III: hindcast data of wind, sea and swell and frequency spectra. The data consist of 3-hourly records from 1 January 1992 to 31 December 2007, in total 46,752 records. The data were extracted for location 3o45'00'' E; 5o00'00'' N.

Squalls

A type of wind that is not properly included in the available data are squalls; high winds from the east. Squalls are not properly expressed in the data sets because they are of very short duration. They may nevertheless be relevant for wave generation for more sheltered locations because of the associated high wind speeds. These winds can have gust speeds well over 30 m/s, but because they are so short they do not show up in the hourly-averaged statistics. Within the scope of this study, it is considered acceptable to leave the squalls out of the wave analysis.

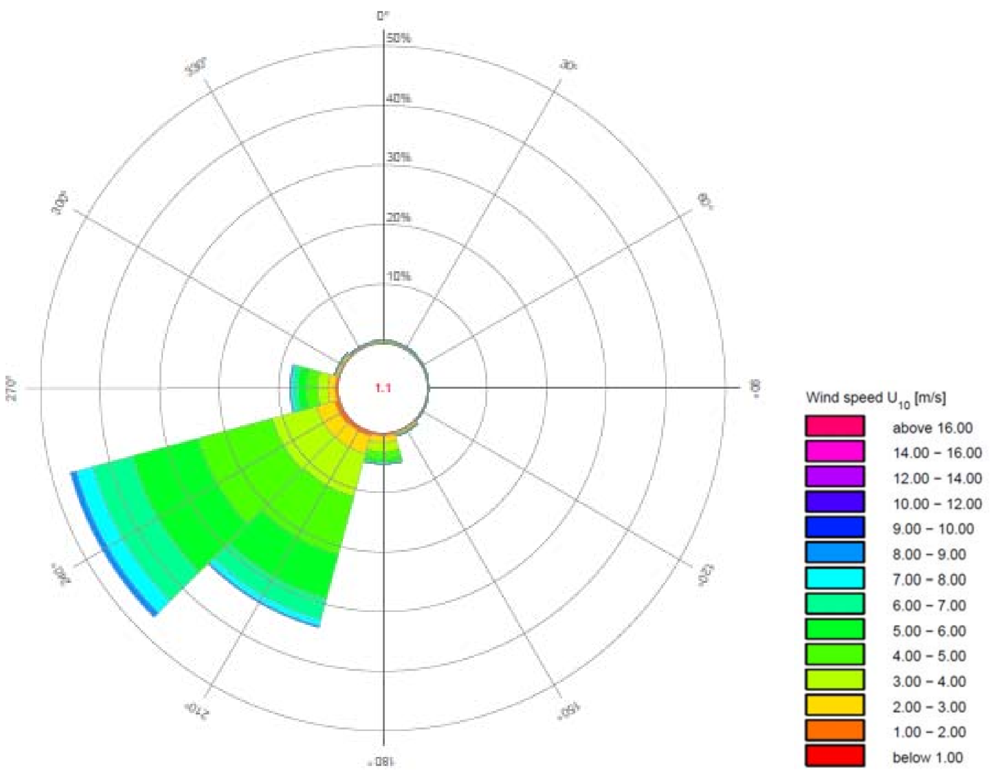


Figure 5.11 All year wind climate based on NOAA hindcast data

5.10.7 Waves

Offshore wave data are available from two wave-hindcast models:

- NOAA at 3 hourly intervals from January 1997 until February 2008 for offshore location 3°45'00'' E; 6°00'00'' N. In total 32,152 records of wave height, period and direction were available. Annual and seasonal wave roses are presented in **Figure 5.12**. The annual dominant wave directional sector is very narrow, highly dominated by waves from 195°-225° N. Significant wave heights are typically between 1 and 2m with typical wave periods of 10-12 s;
- Wavewatch III: hindcast data of wind, sea and swell and frequency spectra. The data consists of 3-hourly records from 1 January 1992 to 31 December 2007, in total 46,752 records. The data was extracted for location 3°45'00'' E; 5°00'00'' N.

The Wavewatch-III hindcast data was considered to be more accurate. Also, the Wavewatch-III record is longer. However, both data sets provide useful information.

The wind climate is considered mild. This means that the local wave climate is mainly determined by swells generated further south in the Atlantic. Most of the time the waves approach from a narrow directional sector generating a strong easterly-directed longshore sediment transport.

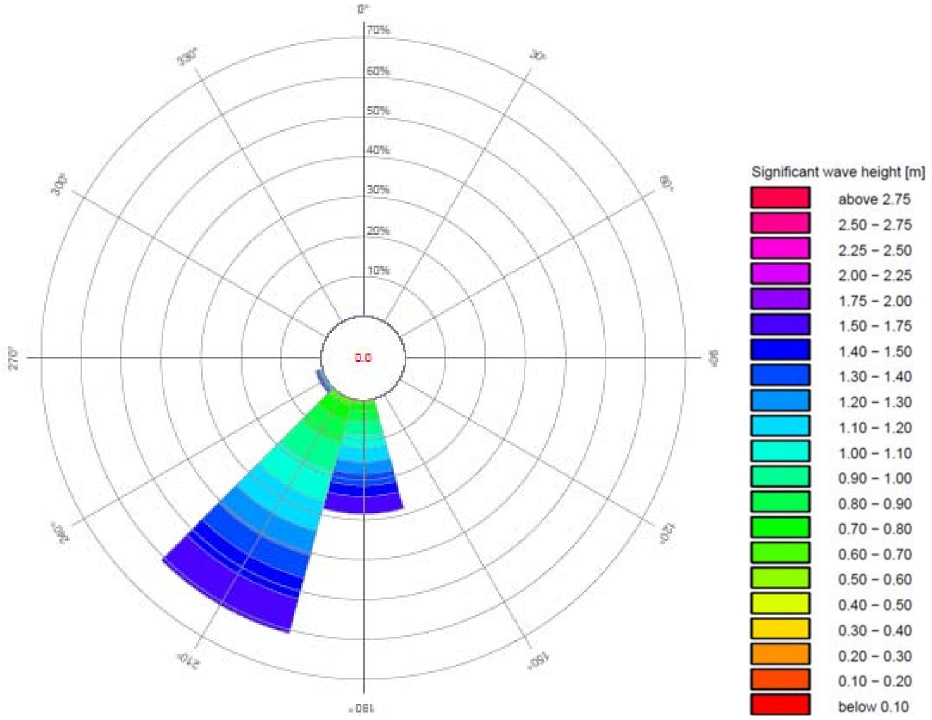


Figure 5.12 All year wave climate based on NOAA hindcast data

5.10.8 Water levels

Tidal information for 14 offshore harmonic components was derived from satellite altimeter data as no reliable recent local measurements are available. In addition, detailed water level records were obtained from LCM, Lagos for three stations in Lagos harbour. **Table 5.13** presents water levels in Lagos Harbour.

Table 5.13 Characteristic tidal water levels at Lagos from Nigerian Navy Tide Tables

Water level		Level [mCD]
MHWS	Mean High Water Spring	0.945
MHWN	Mean High Water Neap	0.701
MSL	Mean Sea Level	0.457
MLWN	Mean Low Water Neap	0.213
MLWS	Mean Low Water Spring	0.091

Tides along the Nigerian Coast are semi-diurnal with significant diurnal inequalities. The mean tidal range is about 1m, increasing to 1.5m during extreme spring tides. A monthly variation in the mean sea level was reported to be 0.2m.

At the start of the study, no long time series of measured water levels were available for the area of interest near Lagos. However, during the course of the study, for a period of three years, continuous readings of waves, water levels and weather became available for three locations inside the port of Lagos (See **Figure 5.13**).

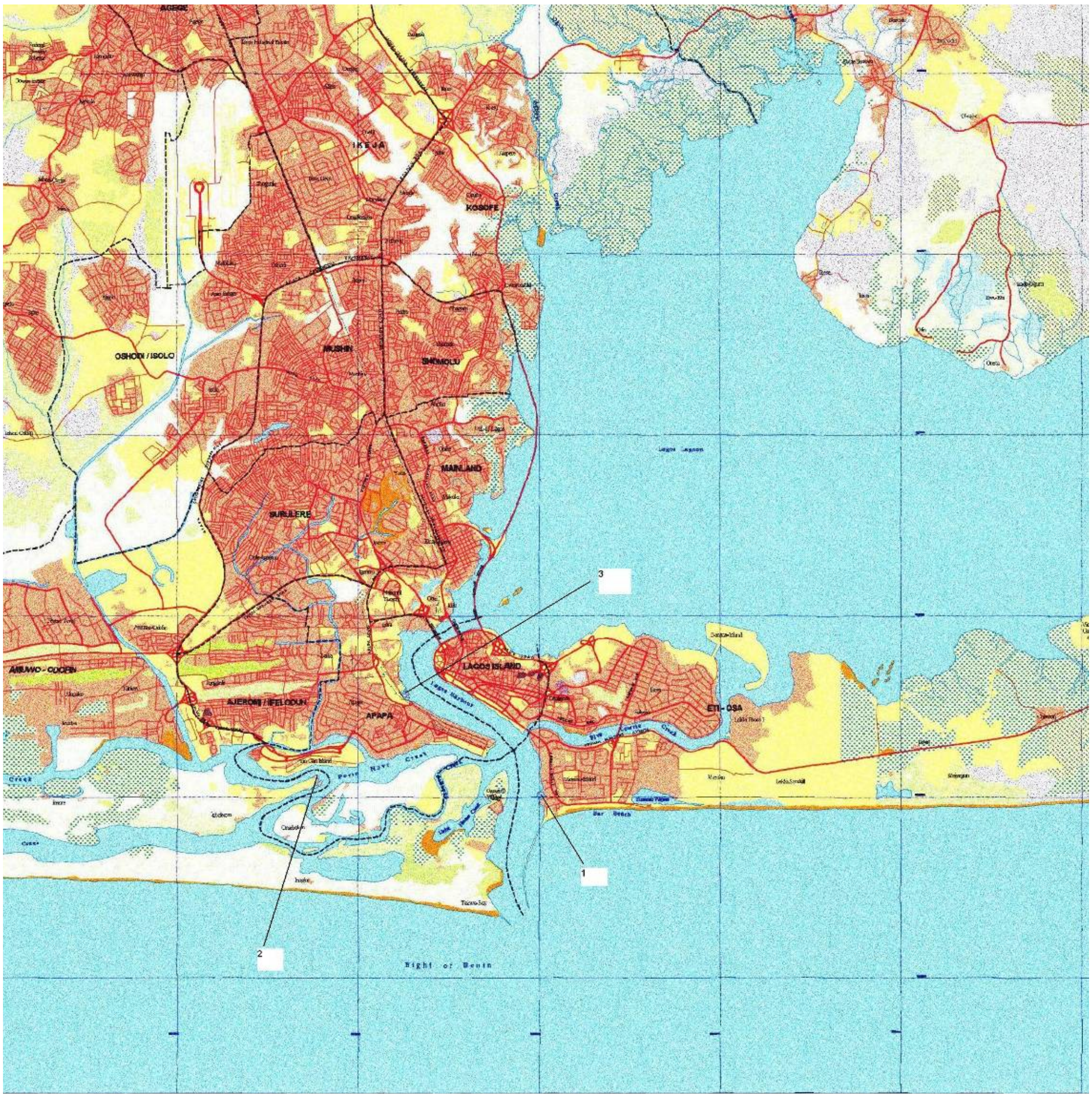


Figure 5.13 Measurement positions of LCM data

5.10.9 Currents

Local currents can be generated by tides, wind-waves, wind, density gradients and river discharges. In the hydraulic model that was used, local currents are simulated by taking into account wave-driven currents, tidal processes and the river discharges. Wind-driven currents and currents induced by density differences are not likely to have a significant effect on the flow pattern in the Lagos bar area. Furthermore, at a larger scale ocean currents play a role. These large scale currents are not taken into account in the model.

Ocean Currents

The coastal waters of Nigeria are located at the edge of the Atlantic Ocean, within the Gulf of Guinea, which starts at Cape Palmas, near Harper. The surface waters of the Gulf of Guinea are warm (temperatures above 24°C) and have salinities below $35°/_{000}$ as a result of heavy rainfall and high river discharge during the wet season. These surface waters circulate in a counter clockwise direction along the West African coasts from Senegal to Nigeria. Two currents supply water to the Guinea Current (GC); the Equatorial Counter Current (ECC) moving eastward, and the Canary Current (CC) (**Figure 5.15**). The ocean system does not cause any coastal upwelling in the Nigerian region, which results in very low productivity. The Guinea Current creates a dominant offshore flow in a south easterly direction, contrary to the predominant nearshore longshore sediment transport direction.

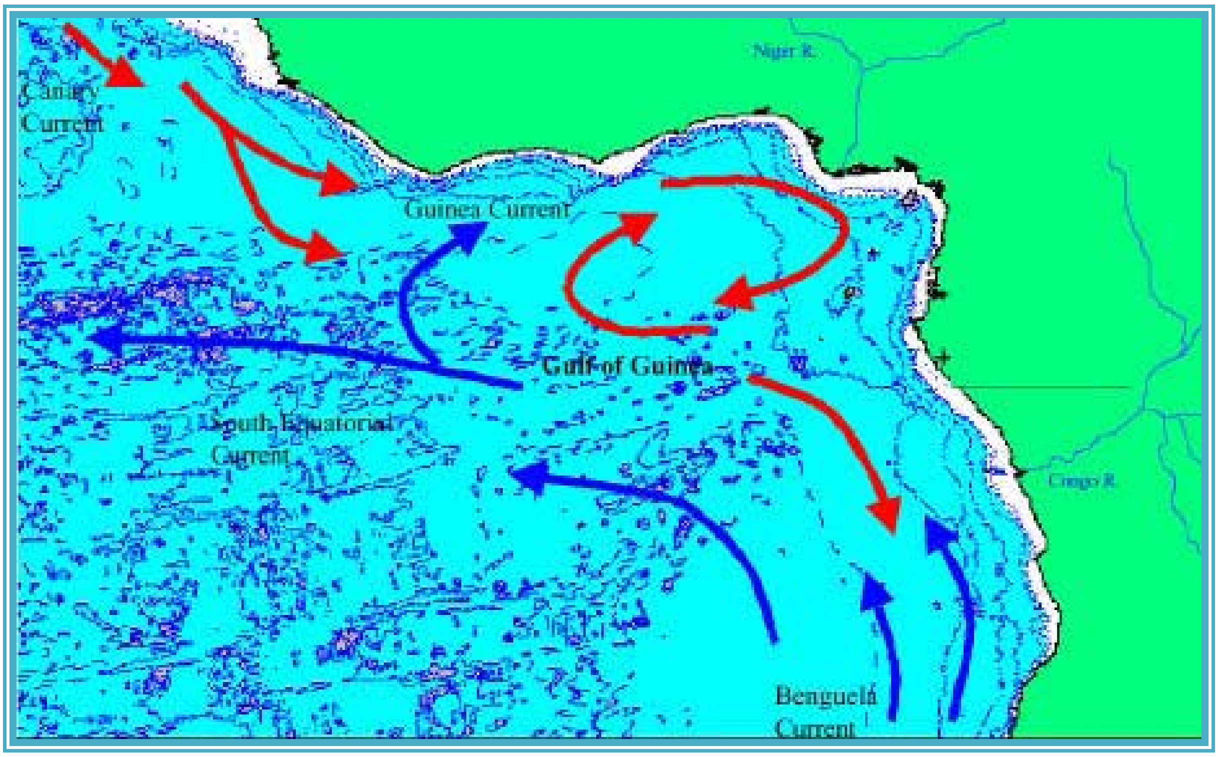


Figure 5.14 Main ocean currents in the region of Nigeria (Source: FAO)

The Guinea Current attains speeds of 0.3 m/sec with some reversals. This current reversal seems to occur most frequently at the beginning and end of the rainy season (Longhurst, 1964). The Guinea Current flows above an undercurrent which is thought to be a westward flowing extension of the northern branch of the Equatorial Undercurrent which splits into two branches after impinging upon the African continent at Sao Tome Island. The other relevant surface current in the Gulf of Guinea is the South Equatorial Current (SEC).

Wind driven currents

The wind driven currents are insignificant compared to other mechanisms of current formation, because the wind climate near Lagos is very mild during all seasons.

Wave driven currents

Wave driven currents have a significant effect in shallow waters where wave breaking processes are dominant (like beaches). Waves are predominantly south westerly due to the dominant south westerly winds. Due to the orientation of the coast, waves arrive at the coast at oblique angles of between 10 and 15 degrees. As a result of waves breaking at oblique angles to the coast, longshore currents are generated which move predominantly in an easterly direction. Longshore currents attain speeds averaging 0.2 to 0.4m/s along the coastline.

As wave breaking occurs in this situation, its effect on the currents in the Lagos area are considered of importance, especially related to sediment transport and the morphological development of the area where they are the driving mechanism for sediment transport. Because the wave action is predominantly from south to south-west, there is a continuous longshore current, less than 1 m/s, along the coast in an eastern direction. The wave driven currents are calculated with the nearshore wave model and used as input in the flow model and the morphological model.

Tidal currents

Only very limited current measurements were available for the Project area at the start of the Project. Hence, a measurement campaign was undertaken.

Tidal currents consist of flood currents which arrive from the south west and attain average speeds of 0.2m/s. Ebb currents are stronger and attain speeds of 0.4m/s. The ebb-tidal currents are stronger due to the addition of river discharges.

Tidal currents and water levels were measured at three locations in the port of Lagos. This information was required to get an idea of how much water flows to and from the estuarine area formed by the various lagoons and to derive a relationship between currents and water levels. This relationship is determined by the immensely complex system of interconnected lagoons, creeks and rivers that characterize the Nigerian coast. Current velocities are typically up to 1m/s in the port entrance. More details on the measurement campaign are reported in **Appendix H**.

Density driven currents

Density differences are considered insignificant, because the river discharge is small compared to the tidal storage capacity of the Lagos Lagoon, which means that the Lagos Lagoon is dominantly saline.

5.10.10 River run-off

The combined river runoff through the port entrance is small compared to the tidal storage capacity of the connecting lagoons (such as Lagos Lagoon). The flood volume of the estuary is estimated to be in the order of 300-500 x 10^6 m^3 with maximum discharge through the entrance in the order of 1,000 m^3/s during maximum ebb and maximum flood. There are no estimates of the average yearly run-off of the rivers and the distribution of the river run-off over the various branches is unknown.

The river discharge varies through the year as a consequence of the monsoon. During the wet season, high river discharges occur near Lagos. Although this period is not necessarily the “monsoon season”, this period is (in this report) treated as the “wet season”. The remaining months will be termed the “dry season”.

5.10.11 Sea-level rise

The entire Nigerian coastline, which is low-lying, will be adversely affected by sea-level rise due to climate change. The impacts of sea-level rise on the Nigerian coastal area were well articulated in a Vulnerability Assessment case study (Awosika *et al*., 1991, French and Awosika *et al*., 1995). The Niger Delta is predicted to lose 2,846 km^2 of land with a 0.2m sea-level rise while a rise of 2.0m is expected to result in the loss of about 18,398 km^2 of land. This could lead to the displacement of up to half a million people

The study, "The Potential Effect of Global Warming and Sea Level Rise in Victoria Island and Lekki," conducted by the Nigerian Institute for Oceanography and Marine Research suggests that, besides the possible loss of property, the land mass of Victoria Island and nearby Lekki could reduce in area by as much as 595 km^2 due to coastal erosion and rising sea level.

It is evident that sea-level rise coupled with storm surges can be a serious threat to the Lagos area. Hence, continuous collection and analysis of tidal data are important for the future management of Nigerian coastal areas.

5.11 Marine Water Quality

5.11.1 Introduction

This Section presents the water quality baseline environmental conditions based on previous wet season studies (2001) undertaken in nearby marine waters and the extensive dry season baseline marine survey undertaken in March 2010 (refer to **Sections 5.4** and **5.5** for more information on method of survey). The data collected showed similar results to other areas of Nigeria (particularly Lekki Port) and it is expected that wet season data had it been required would also be very similar. It was noted that there was increased riverine flow to the lagoon and shallow marine waters during the wet season and this may cause minor seasonal variation in results. Through consultation with FMEnv it was considered that through the dry season survey undertaken and existing local data from previous surveys there was sufficient data to complete baseline water and sediment quality reports. As much as possible, measured values from the field studies are compared to national and international regulatory standards (**Table 5.14**). Where there are no standards or guidelines that are appropriate, results are compared to data from other studies carried out in Nigerian marine waters or the Lagos coastal environment. It should be noted that it is difficult to use standards from other parts of the world, due to environmental differences, and therefore the standards have only been used as an indication.

Table 5.14 Relevant National and International Water Quality Standards (mg/l unless stated otherwise)

Parameter	Standard for Aquatic Life (FMEnv, 1999)	Standard for Recreation (FMEnv, 1999)	Canadian Water Quality Standard, (2007)	State of Louisiana, (USA),Water Quality Standard (2007)

			Lagoon/ Estuarine	Marine	Lagoon/ Estuarine	Marine
pH	6.0-9.0	5.0-9.0	6.5-9.0	7-8.-9	6.5-8.5	6.5-9.0
Temperature	20-33°C	20-33 °C	NS		33 °C	
Total Suspended Solid	NS	<5.0	NS			
Dissolved Oxygen (DO)mg/l	6.8	>5.0	>8(8000 µg/l)		5.0	
Biochemical Oxygen Demand (BOD)	4.0	2.0	NS			
Foaming agents	NS	NS	NS			
Oil and Grease	NS	NS	NS			
Phosphate	NS	NS	NS		NS	NS
Aluminium	0.005-1[a]	NS	5-100 µg/l	NS	NS	NS
Antimony	0.6	NS	NS		NS	NS
Arsenic	0.5	NS	5.0 µg/l	12.5µg/l	36-69µg/l	36-69µg/l
Beryllium	NS	NS	NS		NS	NS
Cadmium (µg/l)	0.2-1.8[a]	NS	0.12			10-45.35µg/l
Chlorine (Total residual Chlorine µg/l)	2.0	NS	1.5		NS	NS
Chromium	0.02c-2.0[d]	NS	1 µg/l	1.5 µg/l	11-16 µg/l	50 µg/l
Copper (µg/l)	2-4[b]	NS	2-4 µg/l	NS	NS	3.63
Cyanide (free CN-) (µg/l)	5.0	NS	5 µg/l		1 µg/l	1 µg/l
Iron	1.0	NS	300 µg/l	NS	NS	NS
Lead (µg/l)	1.7[b]	NS	1-7 µg/l	NS	NS	8.08/209 µg/l(Chronic/Acute)
Mercury	1.0	NS	0.026	0.016	0.012-2	0.025-2

(µg/l)			µg/l	µg/l	µg/l(Chronic/Acute	µg/l(Chronic/Acute
Nickel (µg/l)	25-150[b]	NS	NS		NS	8.2-74 µg/l (Chronic/ Acute
Ammonia (Total)	2.2-1,37[a]	NS	15.2 ammonia nitrogen/ litre (temperature and pH dependant)	NS	19 µg/l	NS
Nitrite	0.06	NS	197 nitrite nitrogen/ litre	NS	NS	NS
Nitrate	NS	NS	2900 µg nitrate nitrogen/ litre	3600 µg nitrate nitrogen/litre	NS	NS
Nitrosamines	NS	NS	NS		NS	NS
Potassium	NS	NS	NS	NS	NS	NS
Selenium (µg/l)	1.0	NS	1.0	NS	NS	NS
Silver (µg/l)	1.0	NS	0.1 µg/l	NS	NS	NS
Thallium		N/A	0.8 µg/l	NS	N/A	NS
Zinc	0.03	NS	NS	NS	NS	81 µg/l /90 µg/l(Acute/Chronic)
Acrolein		NS	NS	NS	NS	NS
Aldrin/dieldrin (µg/l)	4	NS	NS	NS	1.3/{0..19-0.2374 µg/l(Acute/ Chronic)	1.3 µg/l/{0.0019/0.71 µg/l(Acute/Chronic)}
Benzene	0.3	NS	110		1125/2249(Chronic /Acute)	1350/2700(Chronic /Acute)
Vanadium	0.1	NS	NS	NS		1125-2249(Chr

						onic/ Acute)
PCB	NS	NS				0.03ppb (chronic) 10.00ppb (acute)
NS = Not stated a-PH dependent b-Hardness dependent c-To protect fish d-To protect aquatic life including plankton						

5.11.2 Marine Waters – Physical - Chemical Parameters

Table 5.15 presents the physical -chemical characteristics of marine waters in the study area based on the laboratory analysis. In situ measurements were also taken and these are described in the text where appropriate and are detailed in **Appendix C**. The following sections describe the baseline water quality environment in greater detail.

Table 5.15 Physical-Chemical Characteristics of Marine Waters of the Eko Atlantic Study Area, March 2010.

	pH	Electrical Conductivity(Us/Cm)	Salinity (‰)	TDS (Mg/L)	TSS (Mg/L)	Turbidity (NTU)
MIN	7.93	48305.00	31.70	25476.70	1.00	1.00
MAX	8.38	52605.00	34.50	27747.15	10.00	13.00
MEAN	8.28	49283.18	32.22	25993.19	4.07	4.69

* for aquatic life (1999)

Water Temperature

The entire Gulf of Guinea is highly stratified with a thin surface layer of warm fresh tropical water (25°C - 29°C, 33 – 34‰), overlying cooler, high salinity subtropical water (19°C - 28°C, 35 - 36.5‰) (Dublin-Green *et al*., 1997). The upper limit of the thermocline along the Nigerian coast is generally shallow at about (12 - 14 m). The depth of the thermocline tends to increase with increasing distance offshore at least over the continental shelf. The thickness of the mixed zone varies between 30 - 40 m (Dublin-Green *et al*., 1997). The surface water off the Nigerian coast is basically warm with temperatures generally greater than 24°C. The surface water is typical oceanic surface water of the Gulf of Guinea with salinity generally less than 35‰.

Within the study area for this project, the water temperature values in the marine environment range from 28.02 to 30.55 °C, with a mean of 30.04 °C. At 28.8 °C, the mean air temperature is however slightly cooler.

pH

The pH of the waters in the sampled marine environment ranges from 7.93 to 8.38 with a mean of 8.28. The highest values generally occur in the surface thus displaying an alkaline nature. The alkaline nature of the seawater is very important in the buffering capacity of the seawater. Measured pH values are within Nigerian regulatory guidelines and standards for aquatic life (FMEnv, 1999) and considered normal for the sampled environment. Previous studies undertaken for the Lekki Port EIA found wet and dry season pH values of approximately 7.5, slightly lower than in our project area. However, from this data it is apparent that there is no significant variation in pH between the two seasons (Global Environmental Technology Ltd, 2008).

Salinity

Salinity is a measure of the total amount of dissolved salts in the seawater. The primary dissolved elemental components of seawater are chloride, sodium, sulphate, magnesium, calcium and potassium. Natural salinity for open seas in the tropical regions is usually between 33 parts per thousand (ppt) and 35ppt, but could be as high as 37ppt where rainfall is low and evaporation is high. The value can be low if large rivers enter the sea thereby adding fresh water to the system (King, 1975). The laboratory determined salinity of the water column in the study area ranges from 31.70‰–34.50‰ with a mean value of 32.22‰. Field salinity measurements had a mean of 31.72‰, which compares well with the laboratory data. Measured salinity values are very typical of the marine environment offshore of Nigeria during the dry and wet season.

Total Suspended Solid

Dry season total suspended solid (TSS) values in marine waters range from 1.00 mg/L to 10.00 mg/L with an average value of 4.07 mg/L, although some samples were below detection limit. Values obtained compare well with results from other studies in marine waters offshore of sandy sections of the Nigerian coastline. For instance the Environmental Impact Assessment carried out in the Bonny Island East Area Project, (ExxonMobil, 2004) reported TSS values of 2mg/l to 10mg/l for marine waters offshore of the eastern section of Nigeria's coast. However , wet and dry season studies for the Lekki Port EIA found lower values with seawater having TSS ranging from <0.1 mg/L up to 2 mg/l (Global Environmental Technology Ltd, 2008). This indicates that the Eko Atlantic Project area has a much higher TSS than to the east at the Lekki Port area, probably associated with the discharge of suspended sediments. However, this is not an unusual level of TSS for an area adjacent to a river discharge (**Figure 5.15**). It is likely that the higher levels seen at the Eko Atlantic site will be due to higher level of mixing from material within the Commodore Channel (which could be from riverine or storm events influencing sediment re-suspension and run off). There is also likely to be some interaction with mobile sediments due to the shallower depths seen at the Eko Atlantic site. It is expected that slightly higher TSS values would be recorded during the wet season, if there is increased riverine run-off.

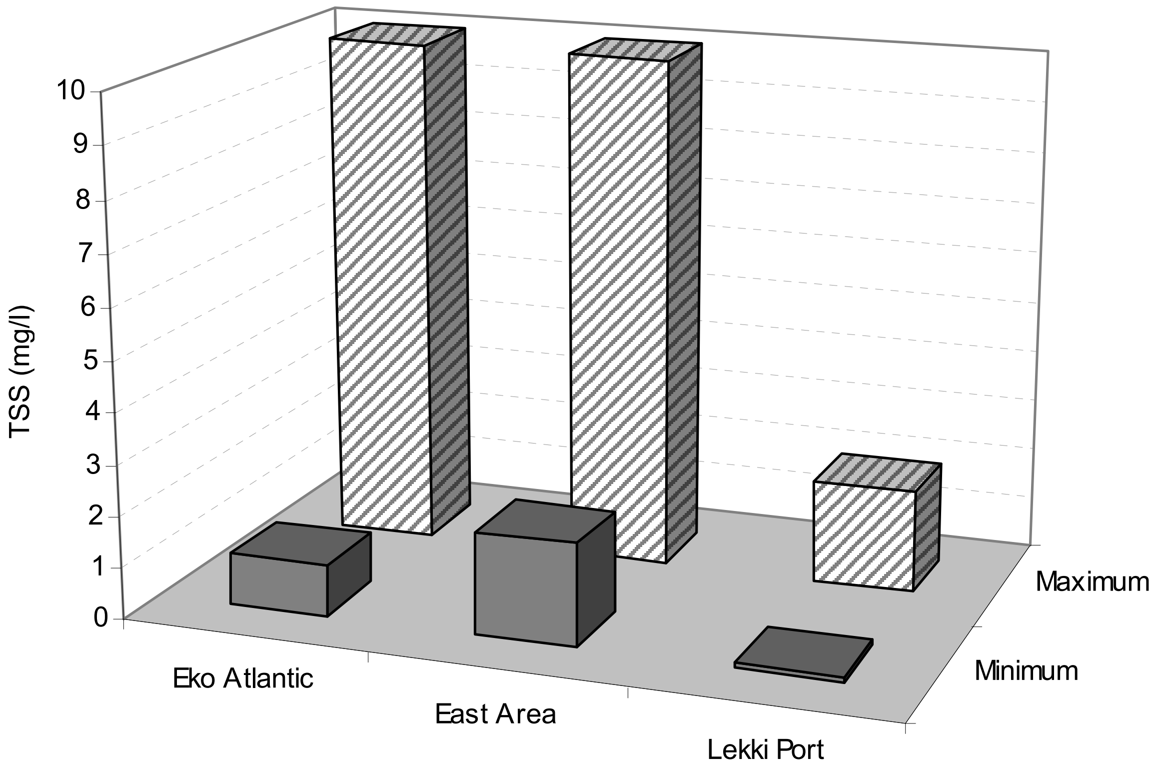


Figure 5.15 Comparison of maximum and minimum TSS (mg/l) at three locations along the Nigerian Coastline, including the Eko Atlantic Project site.

Turbidity

The dry season survey found turbidity values ranging from 1.00 Nephelometric Turbidity Unit (NTU) to 13.00 NTU and an average value of 4.69NTU. This result suggests that the waters are visible to an appreciable depth. As with some of the earlier discussed marine water parameters, turbidity values obtained are not unusual for the Project area and the Nigerian marine environment in general. As with TSS, the turbidity vales are higher at the Eko Atlantic site than recorded in the wet and dry season to the east of the Project site at Lekki Port, where there was insignificant seasonal variation (values between 1.0 and 4.5 Formazin Turbidity Units (FTU, which is more or less comparable to NTU)) (Global Environmental Technology Ltd, 2008). The type of sediment found at the Eko Atlantic site contains a higher content of clay and silt than that found within the Lekki Port site, which is likely to increase reflection of light and therefore increase turbidity.

5.11.3 Marine Waters – Chemical Parameters

The general chemical characteristics of sampled marine waters are discussed below and summarised in **Table 5.16.**

Table 5.16 Chemical Characteristics of Marine Waters of the Eko Atlantic Study Area

	HCO3 (mg/L)	Cl- (mg/L)	S04 (mg/L)	Reactive Silica (mg/L)	NH3 -N (mg/L)	NO2 - N (mg/L)	NO3 - N (mg/L)	Avail.Phosphorous (mg/L)	Total.Phosphorous (mg/L)	O &G (ppm)	COD (mg/L)
MIN	98.82	15391	1345	0.01	0.10	0.00	0.05	0.01	0.13	2.87	30.35
MAX	136.64	16997	2500	0.18	1.42	0.02	0.08	1.01	2.07	0.06	10.60
MEAN	121.16	15940	1959	0.05	1.00	0.01	0.06	0.11	0.28	0.64	60.50

Chemical Oxygen Demand (COD)

Chemical oxygen demand (COD) is the amount of oxygen that is required to chemically stabilize the organic matter contained in a solution under aerobic conditions. The chemical oxygen demand (COD) test is commonly used to indirectly measure the amount of organic compounds in water. A value over 50 mg/l is usually indicative of polluted waters. The COD levels in the sampled marine waters range from 10.6mg/l to 60.5mg/l with a mean value of 30.35mg/l. Measured values are slightly higher than results obtained from other studies in the Nigerian marine environment, *e.g.* Lekki Port project area recorded wet and dry season values of between 12 mg/l and 17 mg/l (Global Environmental Technology Ltd, 2008). The higher COD may be connected to significant marine vessel activity around the sampling area and is likely to reflect both the current and historical practice of direct discharge and flushing of wastes. Within this sampling area there is also likely to be higher levels of anthropogenic chemicals which have been flushed out from the Commodore Channel and the industrial areas adjacent to this.

Nutrient Content

Nutrients are essential chemical substances required by living organisms for growth and life. They can also be seen as substances used in an organism's metabolism which must be taken in from their environment. Marine animals thus depend on water to supply their nutrients. However, if these nutrients are present in high concentration, they could become detrimental to the organisms. The major nutrients analysed in marine water are chlorides, sulphates, phosphates, nitrates and carbonates. Other nutrients present include exchangeable cations such as sodium and potassium.

Available phosphorus accounted for 10% to 50% of total phosphorus, which ranges from 0.011mg/l to 1.007mg/l. The measured chloride, sulphate and phosphorus values are considered normal for the sampled environment and are comparable with the wet and dry season values measured at the Lekki Port Project area to the east (Global Environmental Technology Ltd, 2008). Previous results from the Lekki development showed available phosphate figures of 0.4-2.13 mg/l during the dry season and 0.95-2.55 mg/l during the wet season from recent surveys.

Nitrate levels are between 0.05 mg/l and 0.08 mg/l with a mean value of 0.06 mg/l while the nitrites are present in minute concentrations ranging from 0.00 mg/l to 0.02 mg/l with a mean value of 0.01 mg/l. The generally low levels of nitrite are indicative of the absence of pollution from nitrites. Wet and dry season measurements at the Lekki Port Project area show no seasonal variation and are similar in result (Global Environmental Technology Ltd, 2008) Results at Lekki ranged between 0.43 and 2.1mg/l during the dry season and 0.41 and 2.21 mg/l during the wet season for nitrates, which may reflect the higher volume of agriculture on the Lekki site.

Bicarbonates on the other hand are present in higher concentrations and range from 98.82mg/l to 136.64mg/l with a mean value of 121.16mg/l indicating fairly weak acidity and the presence of essential nutrients for plant life.

Exchangeable Cations

Sodium and Potassium are abundant natural elements and are important in ensuring primary and secondary productivity of the marine ecosystem. Potassium, sodium and calcium have mean concentrations of 338.682mg/l, 6439.859mg/l and 495.725mg/l respectively. These values suggest that the sampled marine environment is rich in minerals, although the measured values are consistent with data obtained from other studies on the Nigerian marine environment.

Dissolved oxygen (DO)

Dissolved oxygen is the amount of gaseous oxygen (O^2) dissolved in an aqueous solution. Oxygen gets into water by diffusion from the surrounding air, by aeration (rapid movement), and as a waste product of photosynthesis. Oxygen is a necessary element to all forms of life and natural stream purification processes require adequate oxygen levels in order to provide for aerobic life forms. As DO levels in water drop below 5.0 mg/l (approximately 70% saturation at 24°c), aquatic life is put under stress. The lower the concentration of oxygen, the greater the stress will be. Oxygen levels that remain below 1 - 2 mg/l (approximately 15-25% saturation at 24°c) for a few hours can result in large fish kills (Francis-Floyd, 2003). Hence, adequate dissolved oxygen is necessary for good water quality.

The DO of water in the marine waters ranges from 2.52mg/l to 6.2mg/l (approximately 35-80% saturation) with a mean value of 4.1 mg/l. Oxygen follows a similar trend with temperature as it decreases slightly with depth. Values obtained for the current study are generally in agreement with data from other studies although mostly fall below the Nigerian regulatory standards for aquatic life which is 6.8mg/l (FMEnv, 1999).

5.11.4 Hydrocarbons in Marine Waters

Oil and Grease

Oil and grease measured in sampled water bodies was generally low. Values ranged between 0.06 and 2.87ppm with a mean of 0.64ppm. Although there are no regulatory standards for oil and grease in aquatic waters, these values are generally low and do not suggest pollution of the marine environment.

Petroleum Hydrocarbons

Total Petroleum Hydrocarbons (TPH) are chemical substances that can enter the environment through natural or man-made activities resulting from accidents, industrial releases, by-products from commercial/private uses or may have been released directly into the water body through spills. The summary of hydrocarbons detected in the marine water study area is presented in **Table 5.17**.

In general the TPH concentrations are very low suggesting minimal (if at all) petroleum hydrocarbon pollution in the sampled marine waters.

Table 5.17 Petroleum Hydrocarbon in Marine Waters

S/No	Parameter	Minimum Level Detected (mg/l)	Maximum Level Detected (mg/l)	Average Level Detected (mg/l)
1.	**Aliphatic Hydrocarbon**	0.000	0.032	0.016
2.	**Polyaromatic Hydrocarbon**	0.000	0.006	0.003
3.	**Total Petroleum Hydrocarbon**	0.000	0.038	0.019

5.11.5 Heavy Metals in Marine Waters

The investigated heavy metals in marine water samples are generally very high in concentration (**Table 5.18**). All recorded heavy metals were above guidance exceedence levels for marine waters, with the exception of Zinc and Iron. Notable metals included mercury which had exceptionally high readings, this is considered acutely toxic to marine invertebrate species at values ranging from 1-10 µg/l. Full results are shown in **Appendix C**.

Table 5.18 Heavy Metal Content in Marine Waters (µg/l)

Field Code	Cu	Hg	Zn	Cr	Mn	Ni	Co	Fe	Cd	Pb
MIN	30	60	15	10	70	260	70	110	0.00	450
MAX	70	60	20	19	1830	440	690	990	90	790
MEAN	53	60	80	78	675	364	368	381	29	642

The levels of contaminants found within the marine waters relate to the discharge and industrial processes taking place along this area of coastline and the values shown from the water sampling are typical for this area of coast. Previous surveys at Lekki Port during both wet and dry season provided similar results with certain heavy metals having very high readings, Mercury which varied between 20 and 50µg/l for the Lekki Port development (wet season) and 10-20µg/l (dry).

5.11.6 PCBs in Marine Waters

PCBs are persistent and toxic organic compounds with 1 to 10 chlorine atoms attached to biphenyl, which is a molecule composed of two benzene rings. PCB congeners are formed by electrophilic chlorination of biphenyl with chlorine gas.

PCB sources include dielectric fluids in transformers, capacitors, and coolants. They have been banned in a number of countries due to their toxicity and persistence in the environment.

Table 5.19 provides a summary of total PCB congeners detected in sampled marine waters. Concentrations range between 0.001ppb and 0.052ppb with a mean of 0.018ppb. Although there are no national standards for PCBs, values obtained are generally less than international standards for harmful concentrations in marine waters although seven out of the 24 samples are on the threshold of chronic effects which is 0.03ppb (*e.g.* Louisiana standards for marine water quality, 2007).

Table 5.19 Concentration of PCB Congeners in Sampled Marine Waters

PCB Congeners	C2	C3	C7	C8	C9	A2	A5	A8	A10	B2	B4	B6
Total(µg/l)ppb	0.002	0.044	0.050	0.006	0.041	0.022	0.007	0.001	0.005	0.037	0.009	0.011
	B8	**B10**	**S1**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S10**	**S11**	**S19**
Total(µg/l)ppb	0.023	0.009	0.012	0.029	0.052	0.016	0.003	0.042	0.011	0.000	0.009	0.035

5.11.7 Microbiology in Marine Waters

The summary results of the microbiology analysis of the sampled marine waters are given in **Table 5.20**. The results show that the surface waters have higher microbial counts compared to the bottom water samples. This can be clearly observed in Appendix 1.6 of the full report (**Appendix C**).

There are no national regulatory standards for bacteria numbers in aquatic waters for aquatic life however, some of the measured values are slightly higher than results obtained from other marine areas in offshore Nigeria and exceed national standards for recreational waters. Additionally, coliforms were detected, which are an indication of pollution from domestic waste sources, although their values are less than international standards and international levels.

Table 5.20 Microbial Population in Marine Waters

	(THB)* $X10^4$CFU/ml	(THF)* $X10^3$CFU/ml	(HUB)* $X10^3$CFU/ml	(HUF)* $X10^2$CFU/ml	(SRB)* $X10^3$CFU/ml	Coliform Count MPN/100 ml*
MAX	1.68	0.13	1.13	0.13	2.07	32.00
MIN	0.30	0.02	0.38	0.02	0.10	2.00
MEAN	0.73	0.07	0.74	0.05	0.27	12.0

*THB Total heterotrophic bacteria; HUF Hydrocarbon utilizing fungi; HUB Hydrocarbon utilizing bacteria; THF Total heterotrophic fungi; MPN Most-probable-number; SRB sulphate reducing bacteria

5.12 Lagoon Water Quality

5.12.1 Introduction

This Chapter presents the water quality baseline environment based on previous studies and the extensive baseline survey undertaken in March 2010 (See **Section 5.5**). One significant study of this area was undertaken by Edokpayi *et al*., in 2001 during the wet season. This data is used to inform the description of the baseline environment and a map of the 2001 sample locations are presented in **Figure 5.17.** As much as possible, measured values from the field studies are compared to national or international regulatory standards and guidelines (**Table 5.14**). In addition, where applicable, values have been compared against the New Zealand Guidance for Estuarine Waters (**Table 5.21**). Where there are no standards or guidelines, results are compared to data collected for the Lekki Port development approximately 10km along the coast.

Table 5.21 Guidelines and standards used to assess estuarine water quality for ecological health, for contact recreation and for shellfish-gathering (New Zealand Regional Council, 2010).

Water quality variable (units)	Relevance	Categories		
		Excellent	Satisfactory	Unsatisfactory
Ecological health				
Dissolved oxygen (% of saturation)(figure also provided in approximately mg/l at 24°c)	Oxygen for aquatic animals to breathe	>90(approximately 7mg/l)	80 – 90(approximately 6.2-7mg/l)	<80(<6.2mg/l)
pH	Can affect plants and fish	7.5 – 8	7 – 7.5 or 8 – 8.5	<7 or >8.5
Turbidity (NTU)	Can restrict plant growth	<2	2 - 10	>10
Total ammonia (g N/m3)	Toxic to fish	<0.1	0.1 - 0.91	>0.91
Nitrate (g N/m3)	Causes nuisance plant growth	<0.005	0.005 – 0.015	>0.015
Total phosphorus (g/m3)	Causes nuisance plant growth	<0.01	0.01 – 0.03	<0.03
Chlorophyll a (g/m3)	Algal blooms	<0.002	0.002 – 0.004	>0.004
Contact recreation				

Enterococci, single sample (no./100 mL)	Human health	<28	28 – 280	>280
Shellfish-gathering				
Faecal coliforms, median (no./100 mL)	Human health	<2	2 – 14	>14
Faecal coliforms, 90 percentile (no./100 mL)	Human health	<6	6 - 43	>43

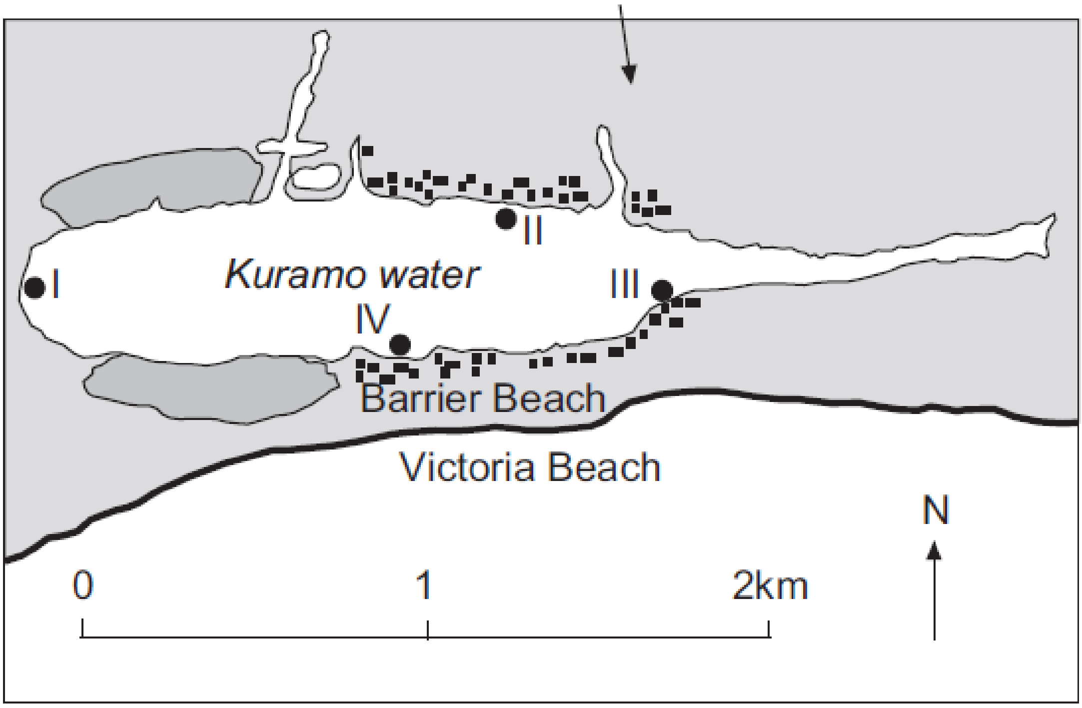


Figure 5.16 Sample locations of 2001 wet season study of Kuramo Waters (Edokpayi *et al*., 2004).

5.12.2 Physical characteristics of Lagoon Waters

During the 2010 survey undertaken in the dry season, a total of 13 water samples were collected from the lagoon areas near the Project site. The areas are Kuramo Waters (samples W1-W4 and E1 to E5) and the Lagos Lagoon (sampling stations C1-C4) (Refer to **Figure 5.3** for a map of the sample locations). Both water bodies are part of the Lagos Lagoon system. **Table 5.22** gives the *in-situ* water quality measurements from these areas while **Table 5.23** provides a summary of laboratory measurements of physical-chemical characteristics. These results are discussed in the following text. The full report prepared by ERML can be found in **Appendix C.**

Kuramo Water is about 1.5km long with an average depth of 2.96m. The water is green in colour, characterised by floating debris, and is used as a receptor for human waste, notably by a hotel, commercial and residential buildings along the northern boundary of the lagoon and the littoral shanty settlements scattered along the barrier beach separating the lagoon from Victoria Beach (Edokpayi *et al*., 2004). Other non-point sources of human and domestic wastes discharge occur along the banks of Kuramo Water (Edokpayi *et al*., 2004).

Table 5.22 *In-situ* Measurements for Lagos Lagoon and Kuramo Waters

Station ID	Water Depth (m)	Air Temp (^{0}C)	Water Temp (^{0}C)	pH	Salinity (ppt)	DO (ppm)
C2	5.7	33.33	30.82	7.94	21.11	3.26
C3	6.2	33.5	30.64	8.91	19.44	3.97
C1	6.7	31.24	30.53	8.83	18.99	3.28
C4	1.2	30.53	35.23	8.22	0.52	3.15
W2	1.3	32.68	30.33	9.54	1.04	4.16
W1	4.0	30.19	30.71	9.75	1.03	6.01
W3	3.8	28.23	30.98	10.33	1.03	4.16
W4	3.3	28.51	29	9.15	3.15	3.99
E1	3.1	28.21	30.37	10.23	1.63	5.58
E2	3.16	27.83	31.01	11.4	1.03	4.88
E3	5.2	28.29	33.37	7.77	11.73	3.77
E4	2.3	28.42	33.26	7.97	23.3	3.04
E5	1.3	27.98	34.27	7.93	20.21	3.4
MAX		**33.5**	**35.23**	**11.4**	**23.3**	**6.01**
MIN		**27.83**	**29**	**7.77**	**0.52**	**3.04**
MEAN		**29.92**	**31.56**	**9.07**	**9.55**	**4.05**

Table 5.23 Physical-chemical characteristics of Lagos Lagoon and Kuramo Waters from laboratory measurements

	Electrical Conductivity (uS/cm)	Salinity (‰)	TSS (mg/L)	Turbidity (NTU)	HCO_3 (mg/L)
MIN	1744.00	0.90	1.00	1.00	69.54
MAX	43300.00	27.20	5.00	10.00	123.22
MEAN	20716.43	12.71	2.67	5.30	92.63
	Avail. Phosphorous (mg/L)	**Total Phosphorous (mg/L)**	**THC (mg/L)**	**TDS***	**NO3 - N (mg/L)**
MIN	0.02	0.15	0.06	891.80	0.02
MAX	0.36	0.75	1.95	23815.6	0.21
MEAN	0.18	0.45	0.24	11191.06	0.06

* Unreliable measure as waters partially saline.

Temperature

The dry season water temperature from the lagoon and Kuramo waters ranges from 29°C to 35.2°C, with a mean of 31.56°C. This is slightly higher than the range of 26.7°C to 28.8°C recorded in the wet season study of Kuramo Waters by Edokpayi *et al*. in 2001.

pH

The hydrogen ion concentration (pH) of water samples from the two sampled areas is slightly alkaline as is observed for the marine area. The pH values range from 7.77 to 11.4 with a mean value of 9.07. The values indicate an alkaline environment. However pH values in Kuramo waters are generally higher than national standards and guidelines for aquatic waters (FMEnv 2007). The dry season values are comparable to the wet season values recorded by Edokpayi *et al*. in 2001, which range from pH 8 to 10.2. The reason for the higher pH is likely to be due to effluent discharges within Kuramo.

Salinity

The salinity of the sampled lagoon waters in dry season ranges between 0.52‰ and 23.3‰ with a mean value of 9.55‰ and can be categorized as mesohaline and polyhaline. The salinity of the western part of Kuramo Waters is much lower (1.03-3.15‰) than the Lagos Lagoon (18.99–21.11‰). However, there is an increasing salinity gradient towards the eastern part of Kuramo waters with station E3 having a salinity of 11.73‰ and stations E4 and E5 having a salinity of 23.3 and 20,21 respectively, which is comparable to that of the Lagos Lagoon sites. Previous sampling of the western part of Kuramo waters in the wet season 2001 also indicates a very low salinity of between 0.95‰ and 1.98‰.

The data suggests the western end of Kuramo Waters receives more freshwater inputs and less marine water overflows compared to the eastern section. The observed salinity of the Lagos Lagoon section is indicative of its direct link to the sea. It also indicates that there is not a significant difference in salinity between wet and dry seasons.

Total Suspended Solids and Turbidity

Total suspended solid (TSS) values for lagoon waters in the wet season range from 1.00 mg/L to 5.00 mg/L with an average value of 2.07 mg/L (**Figure 5.17**). The western part of Kuramo Waters and one of the Lagos Lagoon stations had the highest values, potentially due to the discharge of untreated waste into this area. Previous dry season studies found slightly higher levels of TSS ranging between 8.5 mg/L and 13.5 mg/L (Edokpayi *et al*., 2001).

Turbidity values range from 1.00 NTU to 10.00 NTU with an average value of 5.30 NTU and followed a similar spatial pattern to that recorded for TSS. In the absence of National Standards for turbidity, these values are considered satisfactory in terms of ecological health of estuarine waters in accordance with the New Zealand Guidance and are representative of a site of this nature and current industrial/commercial use.

Dissolved Oxygen

Dissolved oxygen (DO) in the lagoon waters during wet season range from 3.04 to 6.01 mg/l (approximately 50-90% DO saturation at 31.5°c), with a mean of 4.05 mg/l (approximately 65% DO saturation) (**Figure 5.18**). The majority of the recorded values are considered below the Nigerian Standards advised for aquatic life and recreational use of the waters. However, this low level of DO is unlikely to be a new occurrence as in 2001 similar values of between 3 mg/l (approximately 51% DO saturation) and 6.5 mg/l (approximately 97% DO saturation) were recorded in Kuramo Waters (Edokpayi *et al*., 2001). This indicates that in some areas water quality within the lagoon system is poor. This is likely to be due to the effluent and run off being discharged into the lagoon and reflects the results of analysis for levels of ammonia, nitrates and phosphates.

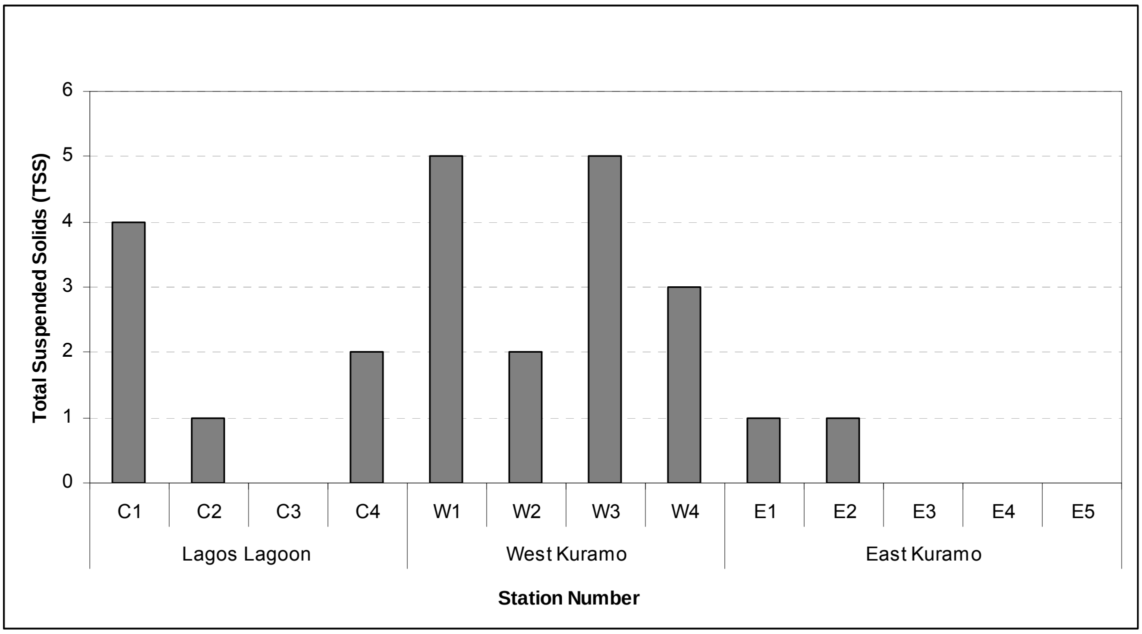


Figure 5.17 Total Suspended Solids in Lagoon Waters, 2010.

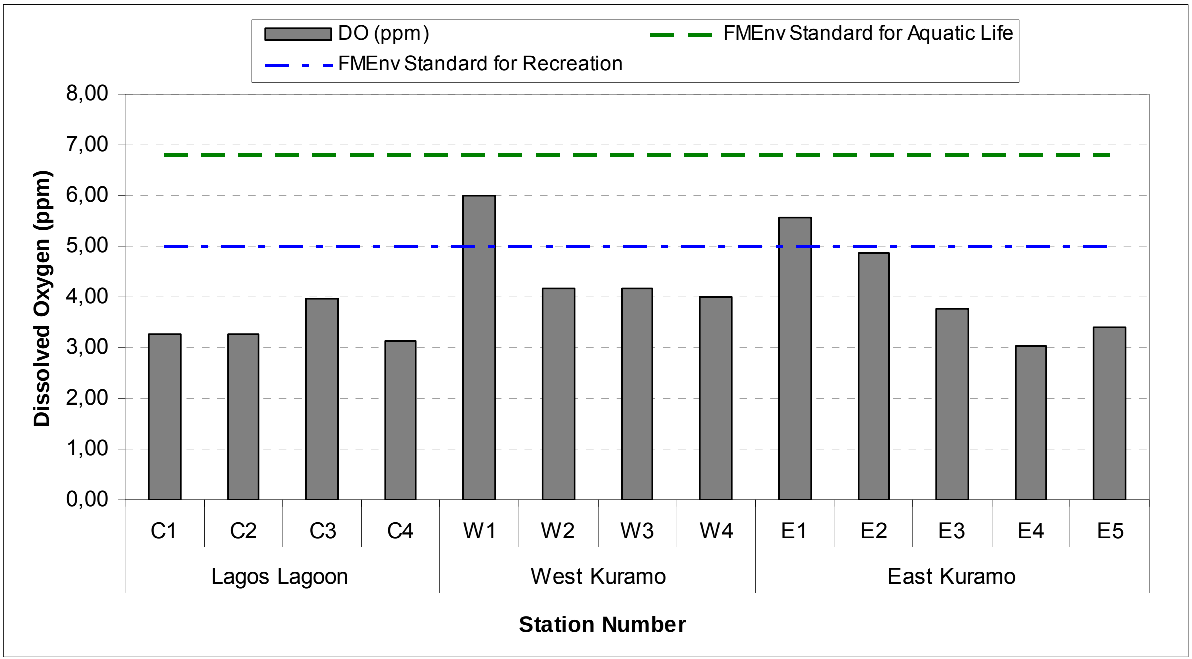


Figure 5.18 Dissolved Oxygen in Lagoon Waters, 2010.

5.12.3 Chemical Characteristics of Lagos Lagoon and Kuramo Waters

Results of general chemical characteristics of water samples from the sampled lagoon and Kuramo waters are given in Table 5.24 and discussed in the following sections.

Table 5.24 Chemical Characteristics of Water Samples from Lagoon and Kuramo Waters

	HCO3 (mg/L)	Cl- (mg/L)	S04 (mg/L)	NH_3 (mg/L)	NO_2 (mg/L)	NO_3 (mg/L)	Avail. Phosphorous (mg/l)	Total Phosphorous (mg/l)	Oil and Grease (ppm)	COD (mg/L)
MIN	69.5	260	100	0.14	0.016	0.02	0.02	0.15	0.06	20.60
MAX	123.2	26989	4820	1.33	0.303	0.21	0.36	0.75	1.95	66.40
MEAN	92.6	8796	1282	0.59	0.090	0.06	0.18	0.45	0.24	38.81

Chemical Oxygen Demand (COD)

The COD levels in the lagoon waters during dry season are between 20.60mg/l to 66.40mg/l with a mean value of 38.81mg/l (**Figure 5.19**). This is slightly lower than previously recorded in the wet season of 2001 where values ranging from 60 mg/l to 75 mg/l were recorded in Kuramo Waters (Edokpayi *et al*., 2001). This is likely to be due to reduced flow into the lagoon during the dry season with lower volumes of chemical nutrients introduced.

There are no national standards and guidelines for COD in aquatic waters; however, the FMEnv (1999) specifies a maximum limit of 75mg/l for effluent discharges for end of pipe water quality for some industries and all recorded values are below this level. Levels of 50mg/l are considered to represent polluted waters. Samples C1 – C3 (and C4 where levels are very close) could therefore be described as taken from polluted water areas.

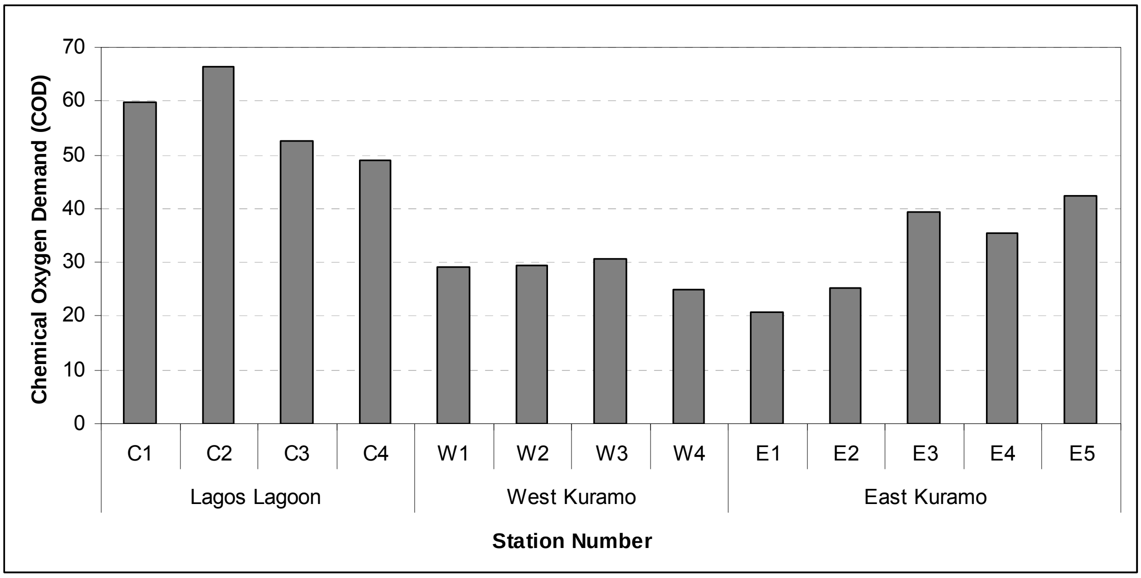


Figure 5.19 Chemical Oxygen Demand in Lagoon Waters, 2010.

Nutrients and Anions

The concentration of nutrients and anions in inland waters can vary widely due to both natural (such as rock/sediment type) and anthropogenic influences (such as effluent discharge). Measurements of chlorides within the lagoon system range from 260mg/l to 26989.46mg/l while the sulphates are present in lower concentrations between 100mg/l and 4820.00mg/l. Their mean values are 8796.05mg/l and 1284.46mg/l respectively. These values are similar to those obtained from other studies in the Lagos Lagoon (*e.g.*, ENRON, 2001).

The abundance of inorganic nitrogen compounds in the water samples occur in the ranking order of Nitrate (NO_3)> Nitrite (NO_2) > Ammonia (NH_3). Ammonia is present in concentrations ranging from 0.14 mg/l to 1.33 mg/l with a mean value of 0.59 mg/l. The nitrate levels are between 0.02 mg/l and 0.21mg/l with a mean value of 0.06 mg/l while the nitrites are present in concentrations ranging from 0.016 mg/l to 0.303 mg/l with a mean value of 0.09 mg/l.

Nitrate is considered a key indicator of ecological health for water quality, and previous studies of Kuramo Waters in the wet season 2001 indicate levels of between 1.62 and 4.5 mg/l, which is higher than the 2010 dry season results. There is no national standard for nitrates; however, the maximum standard for nitrites (FMEnv, 2007) is 0.06mg/l, which is exceeded in the sampled waters. Furthermore, the nitrate values far exceed the New Zealand water quality guidance levels which state that a value exceeding 0.015 mg/l is unsatisfactory for ecological health of estuarine waters (**Figure 5.20**).

Bicarbonate ions range from 69.54mg/l to 123.22mg/l with a mean value of 92.63mg/l while available phosphorus is present in percentages ranging from 0.02% to 0.36% with a mean percentage of 0.1%. The concentration of total phosphorus present in these inland waters ranges from 0.15 mg/l to 0.75mg/l with a mean concentration of 0.45mg/l. There is no National guidance for Total

Phosphorus, but these values far exceed the New Zealand Guidance Value of 0.03 mg/l for healthy waters (**Figure 5.21**).

High levels of phosphorus and nitrates as identified in the lagoon waters can lead to significant eutrophication and knock on effects for the ecology of the water body.

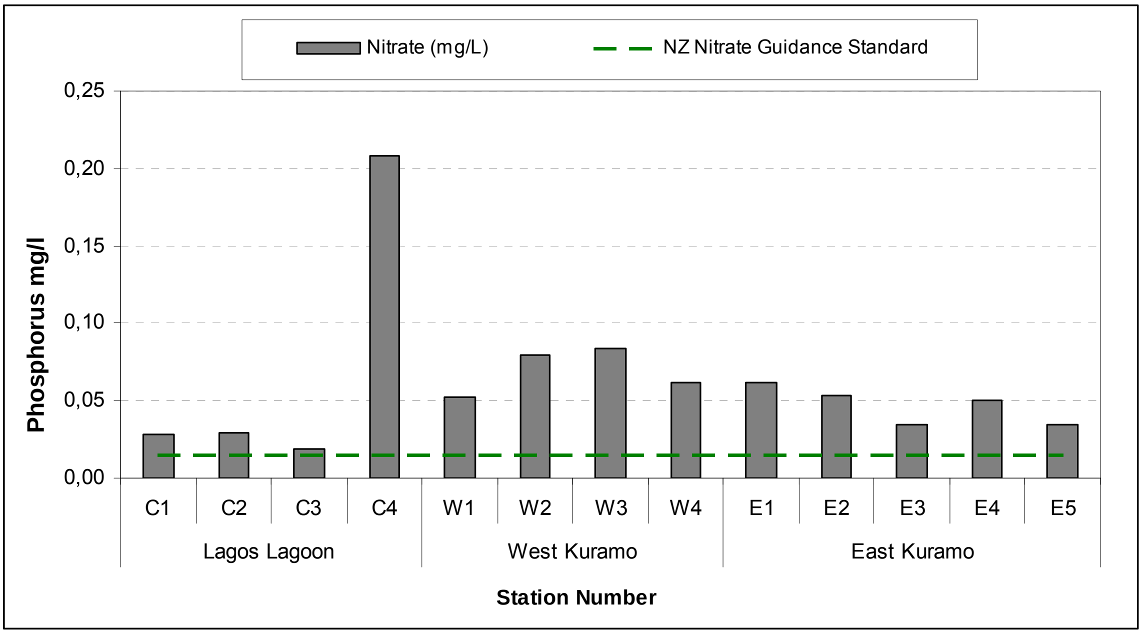


Figure 5.20 Nitrate in Lagoon Waters, 2010.

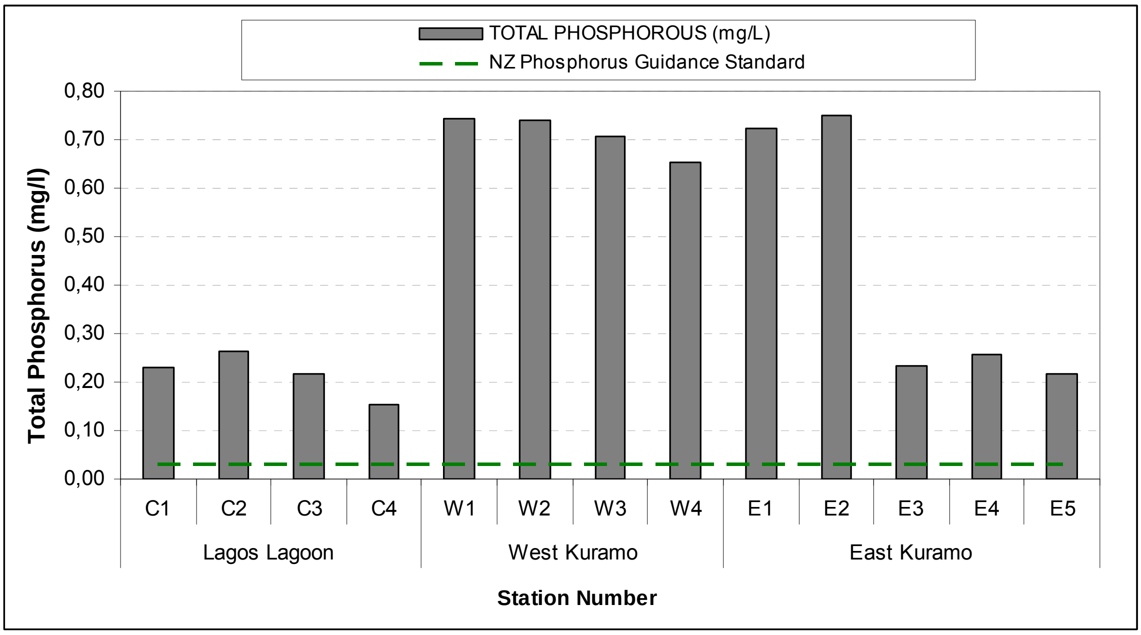


Figure 5.21 Total Phosphorus in Lagoon Waters, 2010.

Exchangeable Cations

The observed concentrations of sodium and potassium in the lagoon and Kuramo water samples are summarized in **Table 5.25**. As is observed in sampled marine waters, sodium in water occurs in higher concentrations than potassium and calcium. Their respective mean concentrations are 2196.342mg/l 141.395mg/l and 219.150mg/l. When compared to the marine environment, these cations occur in lower concentrations (P<0.05), which indicates the influence of freshwater in the coastal inland waters.

Table 5.25 Exchangeable Cations in Lagoon and Kuramo Waters

Field Code	Na (mg/L)	K (mg/L)	Ca (mg/L)
MIN	273.146	30.264	17.263
MAX	4740.526	298.277	429.004
MEAN	2196.342	141.395	219.150

5.12.4 Oil and Grease and Petroleum Hydrocarbons in Lagoon Waters

Oil and Grease

Oil and grease values in lagoon waters are also low as in the marine waters. Values range between 0.06ppm and 1.95 with a mean concentration of 0.24ppm. The values are considered low and within background concentrations.

Petroleum Hydrocarbons

Table 5.26 gives results of aliphatic and aromatic hydrocarbons in the sampled coastal inland waters. The total aliphatic hydrocarbons range from 0.00mg/l to 0.007mg/l while the PAH occur in much lower concentrations, ranging from 0.00mg/l to 0.001mg/l. Their respective average values are 0.0035mg/l and 0.0005mg/l. Results obtained for petroleum hydrocarbons show that the sampled sections of the Lagos lagoon and Kuramo waters are not polluted by petroleum hydrocarbons.

Table 5.26 Petroleum Hydrocarbon Content in the Lagoon Waters

S/No	Parameter	Minimum Level Detected (mg/l)	Maximum Level Detected (mg/l)	Average Level Detected (mg/l)
1.	**Aliphatic Hydrocarbon**	0.000	0.007	0.0035
2.	**Polynuclear Aromatic Hydrocarbon**	0.000	0.001	0.0005
3.	**Total Petroleum Hydrocarbon**	0.000	0.008	0.0040

5.12.5 Heavy Metals in Lagoon Waters

The heavy metals detected in the lagoon waters were found to be well above guidance exceeding concentration levels outlined by international standards and are summarised in **Table 5.27**. It is likely that industrial effluent discharge alongside dumping (ships and industrial waste) may contribute to the levels seen within the lagoon. The exception to these results was Mercury and Manganese which showed negligible concentrations in samples taken.

Table 5.27 Heavy Metal Content in the Water Samples in Lagos Lagoon and Kuramo Waters

Field Code	Cu (µg/l)	Zn (µg/l)	Hg (µg/l)	Ni (µg/l)	Cr (µg/l)	Mn (µg/l)	Co (µg/l)	Cd (µg/l)	Fe (µg/l)	Pb (µg/l)
MIN	3	6	0	15	68	0	0	47	46	104
MAX	46	152	0	290	166	0	813	101	1355	799
MEAN	28	61	0	184	111	0	572	73	548	416

When compared to sampling completed along the coast, the results within the Lagoon were significantly higher than those found at Lekki port site. This can be attributed to dilution taking place as the Lekki site is coastal and not estuarine where contaminants are more likely to be trapped within the Lagoon system.

5.12.6 PCBs in Lagoon Waters

The concentration of investigated PCB congeners in Lagoon waters ranges from non-detection to 0.054 ppb with a mean of 0.0219 ppb (**Table 5.28**). The measured values of PCB in the coastal inland waters are generally lower than global standards for intervention levels.

Table 5.28 Concentration of PCB Congeners in Lagoon Waters

Sample Site	**C1**	**C2**	**C3**	**C4**	**E3**	**E4**	**E5**	
Total(µg/l) ppb	0.010	0.009	0.031	0.000	0.043	0.017	0.000	
Sample Site	**W1**	**W2**	**W3**	**W4**	**W5**	**MAX**	**MIN**	**MEAN**
Total(µg/l) ppb	0.000	0.041	0.054	0.030	0.027	0.054	0	0.0218

5.12.7 Microbiology in Lagoon Waters

The summary of microbiology results and their population densities in the 13 Lagoon water samples taken during the dry season is shown in **Table 5.29**.

Total coliforms were high ranging from 39mpn/100ml to 260mpn/100ml with a mean of 138.23mpn/100ml. The recorded coliform values indicate faecal pollution in the sampled waters. Kuramo Waters contain higher numbers of bacteria, particularly coliforms, than the sampled sections of Lagos Lagoon.

While there is no national standard for aquatic coliform numbers at some sites the values far exceed the New Zealand Standards for shellfish gathering (>43) and ANZECC General water quality standards (>150). Some of the values obtained are similar to those recorded for the Apapa Canal, which is a polluted water body linked to the Lagos Lagoon system (ERML, 2006).

Table 5.29 Microbial Population in Lagoon and Kuramo Waters

	(THB) X10^{5}CFU/ ml	(THF) X10^{2}CFU/ ml	(HUB) X10^{3}CFU/ ml	(HUF) X10^{2}CFU/ ml	(SRB) X10^{3}CFU/ ml	Coliform Count MPN/100 ML
MAX	2.00	0.13	0.60	0.07	1.00	260
MIN	0.65	0.04	0.13	0.02	0.10	39
MEAN	1.02	0.07	0.30	0.05	0.25	138.23

5.13 Marine Sediment Quality

5.13.1 Introduction

This chapter presents baseline sediment quality data and focuses on both data collected in the wet season 2008 (June) by Fugro alongside data collected during the dry season in March 2010 (refer to **Sections 5.4** and **5.5** for more information). As much as possible, measured values from the field studies are compared to international regulatory standards and guidelines. Where there are no standards or guidelines, results are compared to data from other studies carried out in the Nigerian marine sediments in the Lagos coastal environment.

5.13.2 Sediment Quality Guidelines

There are currently no published sediment guidelines in Nigeria to assess the quality of marine sediments against. However, in the absence of Nigerian guidelines, there are a number of international guidelines which can be used (**Table 5.30**). To assess the baseline sediment quality data from the marine samples collected for the Eko Atlantic project, the Canadian Interim Marine Sediment Quality Guidelines (CISQG) issued by Canadian Council of Ministers of the Environment (CCME) are used. In addition to the CISQG values, Australian and New Zealand Environment and Conservation Council (ANZECC) Interim Sediment Quality Guidelines are incorporated in the study where supplementary guidance levels are required.

The CISQGs and ANZECC Guidelines can be used to assess whether organisms are at risk from high concentrations of toxic substances present in the sediment. The CISQGs include threshold effect levels (TELs) and probable effect levels (PELs). The lower value, TEL, represents the concentration below which adverse biological effects are expected to occur rarely. The upper value, PEL, defines the level above which adverse effects are expected to occur frequently.

The ANZECC guidelines for the assessment of sediments outline methods for sediment sampling and analysis, sediment quality assessment and biological testing. The guidelines identify lower and upper values, referred to as screening and maximum levels respectively.

Table 5.30 Relevant International Sediment Quality Standards

Applicable standards	ANZECC ISQG Low(updated 2009)	ANZECC ISQG High(updated 2009)	Canadian (TEL) (2002)	Canadian (PEL) (2002)
METALS (mg/kg)(DRY WEIGHT)				
Antimony	2	25	n/a	n/a
Barium	n/s	n/s	n/s	n/s
Cadmium	1.5	10	07	4.2
Chromium	80	370	52.3	160
Cobalt	n/s	n/s	n/s	n/s
Copper	65	270	18.7	108
Mercury	0.15	1	0.13	0.7
Manganese	n/s	n/s	n/s	n/s
Lead	50	220	30.2	112
Iron	n/s	n/s	n/s	n/s
Silver	1	3.7	n/a	n/a
Vanadium	n/s	n/s	n/s	n/s
Molybdenum	n/a	n/a	n/a	n/a
Nickel	21	52	15.9	42.8
Zinc	n/s	n/s	124	271
Arsenic	20	70	72	416
NUTRIENTS AND MICROBIOLOGY				
Faecal coliforms*	150 / 100 ml			
Chlorophyll a µg L-1	0.7			
Total phosphorus µg L-1	15			
Reactive phosphorus µg L-1	5			
Total nitrogen µg L-1	100			
Ammonium µg L-1	1-10			
POLYCYCLIC AROMATIC HYDROCARBONS (ug/kg)				
Acenaphthylene	n/s	n/s	5,87	123
Acenaphthene	n/s	n/s	6,71	88,9
Naphthalene	160	2100	34,6	391
2-methylnaphthalene	n/s	n/s	n/s	n/s
Phenanthrene	240	1500	86.7	544
Anthracene	85	1100	46.9	254
Fluorine	19	540	21.2	144
Fluoranthene	600	5100	113	1494
benzo (a)anthracene	261	1600	74.8	693
dibenzo (a,h)anthracene	6.22	135	n/s	n/s
Chrysene	384	2800	108	846
Pyrene	665	2600	153	1398
Lindane	0.32	1	n/s	n/s
benzo (B)fluoranthene	n/s	n/s	n/s	n/s
benzo (k)fluoranthene	n/s	n/s	n/s	n/s

Applicable standards	ANZECC ISQG Low(updated 2009)	ANZECC ISQG High(updated 2009)	Canadian (TEL) (2002)	Canadian (PEL) (2002)
benzo (a)pyrene	430	1600	88.8	763
benzo (ghi)perylene	n/s	n/s	n/s	n/s
indeno (1,2,3-cd)pyrene	n/s	n/s	n/s	n/s
high molucular weight PAHs	1700	9600	n/s	n/s
sum 10 PAH	552	3160	n/s	n/s
total PAH	4000	45000	n/s	n/s
CHLOROBENZENES				
hexachlorobenzene (µg/kgdm)	n/s	n/s	n/s	n/s
POLYCHLORINATED BIPHENYLS (µg/kg)				
PCB 28 (µg/kgdm)	n/s	n/s	n/s	n/s
PCB 52 (µg/kgdm)	n/s	n/s	n/s	n/s
PCB 101 (µg/kgdm)	n/s	n/s	n/s	n/s
PCB 118 (µg/kgdm)	n/s	n/s	n/s	n/s
PCB 138 (µg/kgdm)	n/s	n/s	n/s	n/s
PCB 153 (µg/kgdm)	n/s	n/s	n/s	n/s
PCB 180 (µg/kgdm)	n/s	n/s	n/s	n/s
total PCB (7) (µg/kgdm)	23	n/s	n/s	n/s
CHLOROPESTICIDES (µg/kg)				
total DDT (µg/kgdm)	1.6	46	n/s	n/s
o,p-DDT (µg/kgdm)	n/s	n/s	n/s	n/s
p,p-DDT (µg/kgdm)	n/s	n/s	n/s	n/s
total DDD (µg/kgdm)	2	20	n/s	n/s
o,p-DDD (µg/kgdm)	n/s	n/s	n/s	n/s
p,p-DDD (µg/kgdm)	n/s	n/s	n/s	n/s
total DDE (µg/kgdm)	n/s	n/s	n/s	n/s
o,p-DDE (µg/kgdm)	n/s	n/s	n/s	n/s
p,p-DDE (µg/kgdm)	2.2	27	n/s	n/s
total DDT, DDE, DDD (µg/kgdm)	n/s	n/s	n/s	n/s
aldrin (µg/kgdm)	n/s	n/s	n/s	n/s
dieldrin (µg/kgdm)	0.02	8	0.71	7
endrin (µg/kgdm)	0.02	8	n/s	n/s
sum chlordane (µg/kgdm)	0.5	6	n/s	n/s
quintozene (µg/kgdm)	n/s	n/s	n/s	n/s

*n/s = Not Stated

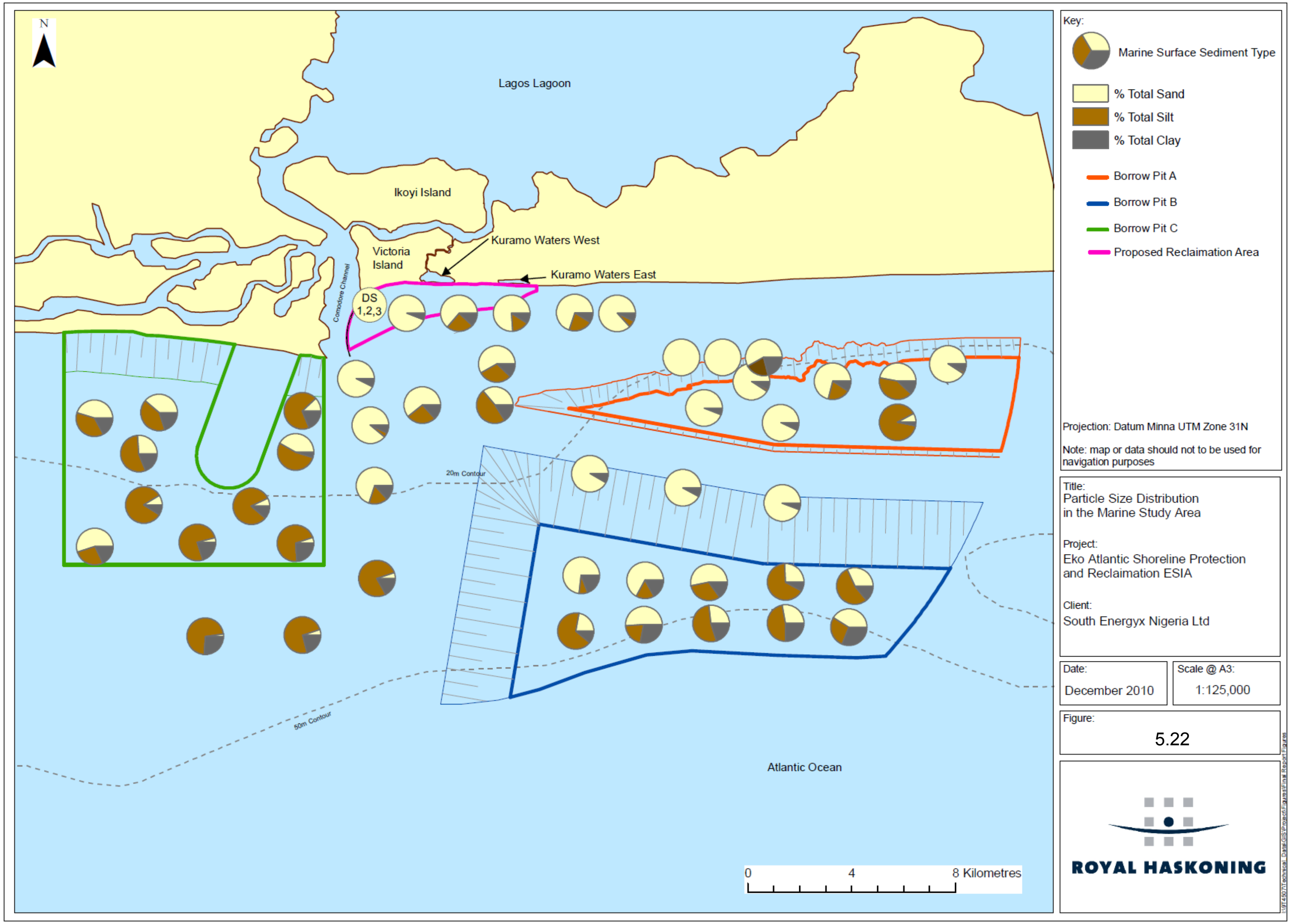
5.13.3 Physical Characteristics of Marine Sediments

The marine sediments at the Project site generally consist of sandy sediments characteristic of the barrier beaches common along this part of the Atlantic Coast of Africa. The survey found that the sediment type varies from sandy loam, sand, silt-loam, clay-loam to silt. The particle size distribution has an average sand, silt and clay content of 50.9%, 35.4% and 13.6% respectively. **Table 5.31** presents the summary of the findings. There is some variation in the sediment composition across the study area. Sediments from Borrow Area A are mostly sandy, whilst those from Areas B and C are slightly higher in silt content,

The tests undertaken for this study indicate that the electrical conductivity of the marine sediments is very high with a range of 6470µS/cm to 63600µS/cm and a mean value of 26806.82µS/cm. The pH of the sediment samples ranged from 7.65 to 8.53 with a mean of 8.23. These values are normal for what should be expected in a saline environment.

Table 5.31 Summary of Physical Sediment Characteristics Marine Area

	Total Sand %	**Total Silt %**	**Total Clay %**	**pH**	**Electrical Conductivity (µS/cm)**
MIN	2	0	3	7.65	6470
MAX	94	89	31	8.53	63600
MEAN	51	35	14	8.23	26806


N
Lagos Lagoon
Ikoyi Island
Victoria
Island
Kuramo Waters West
Kuramo Waters East
Comodore Channel
DS
1,2,3
20m Contour
50m Contour
Atlantic Ocean
0
4
8 Kilometres
Key:
Marine Surface Sediment Type
% Total Sand
% Total Silt
% Total Clay
Borrow Pit A
Borrow Pit B
Borrow Pit C
Proposed Reclaimation Area
Projection: Datum Minna UTM Zone 31N
Note: map or data should not to be used for navigation purposes
Title:
Particle Size Distribution
in the Marine Study Area
Project:
Eko Atlantic Shoreline Protection
and Reclaimation ESIA
Client:
South Energyx Nigeria Ltd
Date:
December 2010
Scale @ A3:
1:125,000
Figure:
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5.13.4 Chemical Characteristics of Marine Sediments

The results of the dry season survey chemical analysis of marine sediments from the study area are summarized in **Table 5.32**.

Table 5.32 Summary of Chemical Sediment Characteristics in Marine Area (ERML, 2010).

	SO_4^{2-} (ppm)	TOC %	CL^- (ppm)	Total Nitrogen %	NO_3 - N (ppm)	NH4 - N (ppm)	Total Phosphorous %	Exchangeable Acidity Cmol/kg	Oil and Grease ppm
MIN	1652.36	0.27	1072.50	0.10	0.44	0.12	0.05	0.22	0.26
MAX	12850.37	3.28	13056.25	0.18	0.79	0.22	0.13	0.55	3.14
MEAN	6015.52	1.19	5059.733	0.13	0.57	0.16	0.07	0.36	1.21

Total Organic Carbon

The Total Organic Carbon (TOC) measured in the sediments was generally within typical ranges for fine-grained, coastal marine sediments (1% to 2%) and comparable to average TOC concentrations found in comparable zones (Lekki Port). Results from the marine samples at the Eko Atlantic sites ranged from 0.016 mg/kg to 0.16mg/kg in comparison to <0.001mg/kg and 0.212mg/kg at Lekki Port.

The maximum levels found were above typical marine sediments (3.28%) but these were considered hotspots where there are likely to be anthropogenic sources of carbon and increased runoff with high clay and silt content. Of the sites sampled two (BPA 1 and BPA 2) were above baseline TOC guidance levels these were concentrated on borrow site C where sediments were fined grained silts with increased likelihood of organics adsorbing onto grains.

Nutrients and Anions

The Chloride (Cl-) ions are present in the marine sediment samples in concentrations ranging from 1072.50ppm to 13056.25 ppm with a mean value of 5059.73ppm.

Total Nitrogen available ranges from 0.1% to 0.18% with a mean percentage of 0.13%. The abundance of inorganic nitrogen compounds in the water samples occur in the ranking order of NO3-N >NH3-N.

Ammonia Nitrogen concentration ranges from 0.12ppm to 0.22ppm with a mean value of 0.16ppm. The nitrate nitrogen levels range from 0.44ppm to 0.79 ppm with a mean value of 0.57 ppm.

Sulphate (SO_4^{2-}) ions are also present in quantities ranging from 1652.36 ppm to 12850.37 ppm with a mean concentration of 6015.52 ppm. The total phosphorus available is between 0.05% and 0.13% with a mean value of 0.07%. The mean value for exchangeable acidity detected in the sediments is 0.22Cmol/kg with quantities ranging from 0.55 Cmol/kg to 0.36 Cmol/kg.

The measured values for these nutrients and anions in the marine sediments are considered within the normal range of concentrations for the sampled marine environment when compared with the FMEnv guidelines.

5.13.5 Oil, Grease and Petroleum Hydrocarbons in Marine Sediments

The concentration of oil and grease in the marine sediments is within the range of 0.43ppm to 4.84ppm with a mean value of 3.25ppm. These values are within background concentrations of oil and grease values for sediments from coastal inland waters (ERML, 2010).

A summary of results of measured petroleum hydrocarbons detected in the marine sediment samples is presented in **Table 5.33**. The Total Petroleum Hydrocarbons were present in the sediment samples in trace amounts with values ranging from 0.00mg/kg to 0.031mg/kg for the Total Aliphatic Hydrocarbons and 0.00mg/kg to 0.015mg/kg for the Polyaromatic Hydrocarbons. Their respective average values were 0.015mg/kg and 0.007mg/kg. The concentration in the sediment samples is slightly higher than in the water samples. However, although these measured values indicate inputs from petroleum sources, concentrations do not portend pollution of the sampled waters (ERML, 2010).

Table 5.33 Petroleum Hydrocarbon in sampled marine sediments

Parameter	Minimum Level Detected (mg/kg)	Maximum Level Detected (mg/kg)	Average Level Detected (mg/kg)
Aliphatic Hydrocarbon	0.000	0.031	0.015
Polycyclic Aromatic Hydrocarbon (PAH)	0.000	0.015	0.007
Total Petroleum Hydrocarbon (TPH)	0.000	0.046	0.022

5.13.6 Heavy Metals in Marine Sediments

In general, the analysis of sediments showed the majority of sediment samples collected did not indicate high concentrations of heavy metals. Certain samples showed high concentrations of Iron (Fe) with Lead (Pb), Nickel (Ni) and Mercury (Hg) found to have maximum values substantially above the PEL. The reasons for specific high concentrations are likely to be areas where point source pollution has occurred. .A summary of the results is presented in **Table 5.34**. The results of the analysis of the marine sediments show hotspots of heavy metals which reflect the industrial nature of land use surrounding the port area of Lagos and the heavy industry along the banks of the Commodore Channel. There is also a historical record of dumping and ship disposal in this area. It is likely that material containing high levels of heavy metals will flush seaward down the Commodore Channel and sink to the seabed between the 20 and 50m Ordnance Datum (OD) contours. This will then become adsorbed on fine grained material found on the seabed within this area. The samples collected particularly from borrow site C showed the highest concentration of heavy metals which is consistent with the sediment containing the highest percentage of silt and fine grained material.

The results of the 2008 wet season survey indicated that the majority of sediment heavy metal concentrations measured are below the CISQG Threshold Effect Level (TEL), with the exception of Arsenic, which was recorded at 10.60 mg/kg and 8.56 mg/kg at locations BPA1 and BPA2, within borrow pit A site. These levels are above the TEL (7.2mg/kg), but considerably below the PEL (41.6mg/kg). It is likely that these readings maybe a result of historical industrial discharge and dumping offshore of Lagos and are not specific to the wet season.

Table 5.34 Heavy Metal Contents in the Sediment Samples in Marine Area, 2010 (mg/kg)

	Cu	Zn	Hg	Cr	Mn	Ni	Co	Cd	Fe	Pb
MIN	0.001	0	0	0.003	0.307	23.9	0	0.01	1784	19
MAX	50.2	34.8	183	0.03	11.13	80.2	0	0.25	41303	422
MEAN	5.69	1.4	42.6	0.02	4.89	50.2	0.00	0.06	14184	189

5.13.7 PCBs in Marine Sediments

Polychlorinated biphenyls (PCBs) are mixtures of aromatic chemicals, manufactured by the chlorination of biphenyl in the presence of a suitable catalyst (JNCC, 2008a). PCBs were widely used as coolants and lubricants in electrical equipment, cabling, gaskets, and insulation items (including ship parts), paint and old hydraulic oils. As with PAHs in the aquatic environment, PCBs are usually found in much higher concentrations in sediments than in the overlying water. The main concern over PCBs is their high bioaccumulation capacity, resulting in chronic effects rather than direct toxicity (JNCC, 2008a).

Table 5.35 provides a summary of PCB congeners detected in sampled marine sediments. While congeners were identified in most samples, their values were generally low. Measured concentrations range from 0.001ppb(ug/kg) to 0.1494ppb with a mean value of 0.0573ppb. Values obtained for sediments are generally but only slightly higher than in marine waters. The measured concentrations of PCBs in sediments are significantly less than most global standards for intervention levels for PCB pollution *e.g.*, ANZECC Guidance for PCBs is 23ug/kg.

Table 5.35 Concentration of PCB Congeners in Marine Sediments

	A2	A5	A8	A10	B2	B4	B6	B8	B10	C1	C2
Total ppb (µg/kg)	0.004	0.033	0.053	0.003	0.000	0.010	0.031	0.056	0.096	0.071	0.092
	C3	**C7**	**C8**	**C9**	**S3**	**S4**	**S5**	**S8**	**S10**	**S11**	**S7**
Total ppb (µg/kg)	0.037	0.108	0.132	0.046	0.055	0.041	0.149	0.021	0.051	0.099	0.072

5.14 Lagoon Sediment Quality

5.14.1 Introduction

This Chapter presents sediment quality data collected within the lagoon of Kuramo Waters during the dry season marine survey undertaken in March 2010 (**Appendix C**). Where appropriate, values collected from field studies are compared to international regulatory standards and guidelines. Comparison has been made where appropriate to previous surveys completed within the region, in particular recent survey work carried out at the Port Lekki complex.

There are currently no published sediment guidelines in Nigeria to assess the quality of lagoon sediments. In order to provide adequate comparison against suitable environmental parameters CISQGs and ANZECC marine sediment quality guidelines can be used for comparison in this study. For an outline of these sediment quality standards please see **Section 5.13.2.**

5.14.2 Physical Characteristics of Lagoon Sediments

The lagoon sediment data collected from the study area indicates that the sediment type varies from sandy loam, sand, silt-loam; silt-loam to loam. The particle size distribution of the sediment samples has an average sand, silt and clay content of 45.33%, 41.00% and 13.67% respectively. The eastern area of Kuramo waters has the highest percentage of silt in the sediments. Samples from the Lagos Lagoon sections have the highest percentage of sand.

The results of analysis of physical-chemical characteristics of sediments from the lagoon study area are summarised in **Figure 5.24** and **Table 5.36**.

Table 5.36 Summary of Sediment Characteristics in Lagoon Area

	pH	Electrical Conductivity (µS/cm)	SO_4^{2-} (ppm)	TOC °/o	CL^- (ppm)	Total Nitrogen °/o	NO_3 - N (ppm)	NH4 - N (ppm)	Total Phosphorous °/o	Exchangeable Acidity Cmol/kg	O&G ppm
MIN	5.41	1998	406	0.47	407	0.1 1	0.49	0.13	0.05	0.40	0.43
MAX	8.13	65800	1329 6	5.58	13506	0.1 6	0.71	0.20	0.14	1.16	4.84
MEAN	6.95	16911	3629	3.35	3312	0.1 3	0.59	0.16	0.09	0.71	3.25

pH

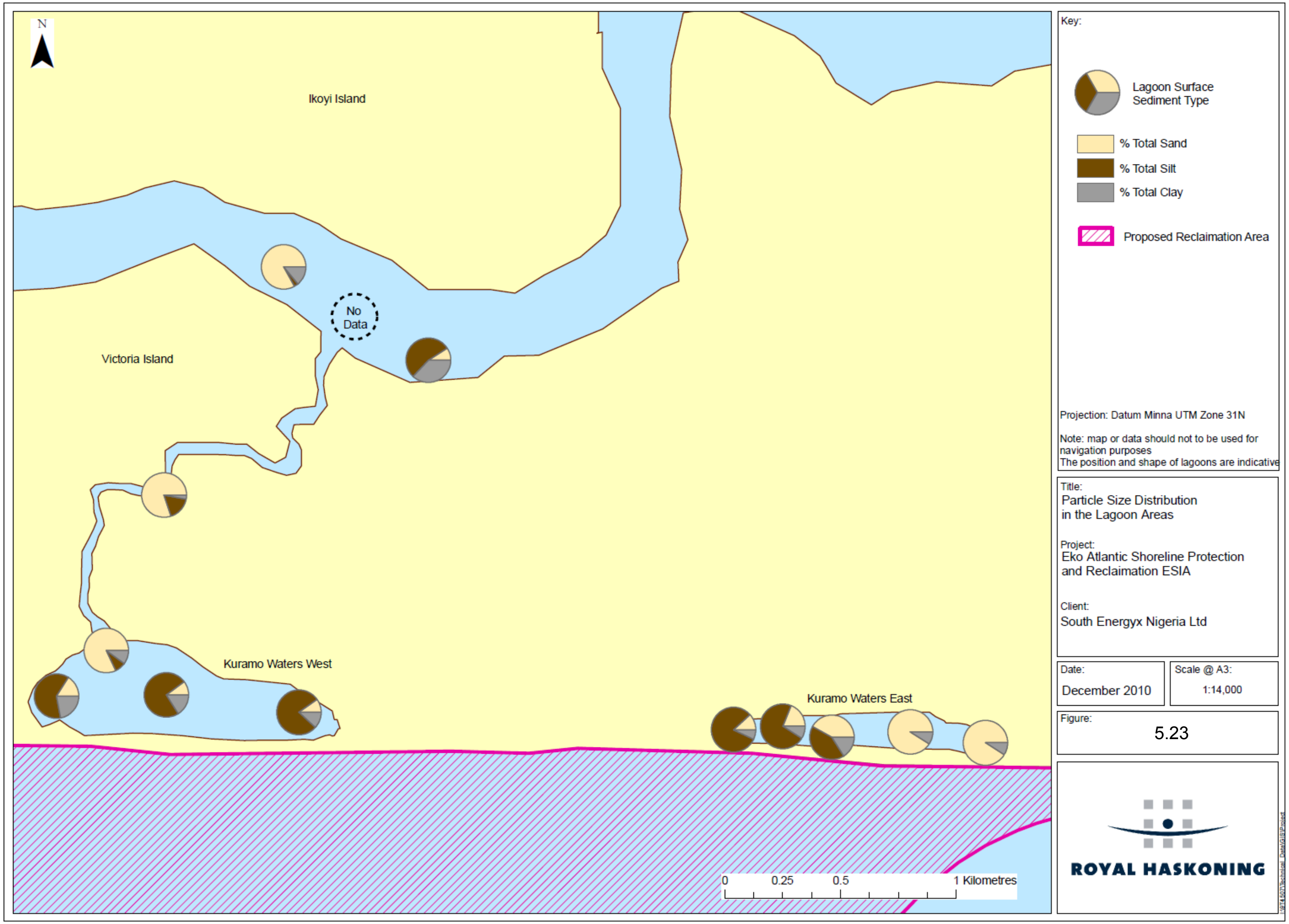
The pH of the sediment samples from the lagoon and Kuramo waters range from 5.41 to 8.31 with sediments in the Kuramo waters generally measuring in the neutral range (6.6 – 7.3) while those from the lagoon are more alkaline. Acidity in the sediments could be attributed to organic matter decay and iron content oxidization. The iron content is likely to reflect historical dumping of industrial waste and ships along this coastline along with discharge of industrial waste.

Electrical Conductivity

Electrical conductivity of sediment within the study area ranges from 1998.00µS/cm to 65800.00µS/cm with a mean value of 16910.67µS/cm. This result is much lower than the value obtained in the marine area, indicating brackish water.

Total Organic Carbon

The total organic carbon content (TOC) of the sampled lagoon sediments varies from 0.47% to 5.58% with an average of 3.35%. This shows that the sediments are very high in organic matter. Values are significantly higher ($P<0.05$) than the marine sediments. These results indicate that these inland waters receive significant organic inputs which are consistent with untreated waste and effluent being discharged directly into the lagoon.


N
Ikoyi Island
Victoria Island
No Data
Kuramo Waters West
Kuramo Waters East
0 0.25 0.5 1 Kilometres
Key:
Lagoon Surface Sediment Type
% Total Sand
% Total Silt
% Total Clay
Proposed Reclamation Area
Projection: Datum Minna UTM Zone 31N
Note: map or data should not to be used for navigation purposes
The position and shape of lagoons are indicative
Title:
Particle Size Distribution in the Lagoon Areas
Project:
Eko Atlantic Shoreline Protection and Reclamation ESIA
Client:
South Energyx Nigeria Ltd
Date:
December 2010
Scale @ A3:
1:14,000
Figure:
5.23
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Nutrients and Anions

The Chloride (Cl^-) ions are present in the sediment samples in concentrations ranging from 407.20mg/kg to 13506.25 mg/kg with a mean value of 3311.68 mg/kg. The total available Nitrogen ranges from 0.11% to 0.16% with a mean value of 0.13%.

Nitrogen is present in concentrations ranging from 0.13 mg/kg to 0.20 mg/kg with a mean value of 0.16 mg/kg. The nitrate nitrogen levels are between 0.49 mg/kg and 0.71 mg/kg with a mean value of 0.59 mg/kg.

Sulphate (SO_4^{2-}) ions are present in the lagoon sediments in quantities ranging from 405.72mg/kg to 13296.15mg/kg with a mean concentration of 3629.34mg/kg. The Total phosphorus available ranges from 0.05% through to 0.14% with a mean value of 0.09%. The mean value for exchangeable acidity in sediments is 0.71Cmol/kg with quantities ranging from 0.4 Cmol/kg to 1.16 Cmol/kg.

The measured values of ammonia nitrogen, nitrate nitrogen, sulphate and phosphorus are all within ranges recorded from international values (ERML, 2010).

Sodium, Potassium and Calcium are abundant natural elements and are important in ensuring primary and secondary productivity of the marine ecosystem. Sodium, potassium and calcium have mean concentrations of 3249.43mg/l, 199.02mg/l and 448.24mg/l respectively in these inland waters. These values suggest that the sampled sediment environment is rich in minerals.

5.14.3 Heavy Metals in Lagoon Sediments

In the lagoon sediments, iron occurs abundantly compared to all the other metals while zinc and copper are also found in appreciable concentrations. These values do not differ significantly from data obtained from other studies on the Lagos lagoon system (ERML, 2010), however at some stations, the levels exceeded the CISGQ TEL, indicating slight pollution of these sediments. None of the PEL levels were exceeded. A summary of the results is presented in **Table 5.37** and graphs indicating zinc and copper levels in sediments are presented in **Figure 5.25 and Figure 5.26.**

Table 5.37 Heavy Metal Contents in the Sediment Samples in Lagoon Area (mg/kg)

	Cu	Zn	Hg	Cr	Mn	Ni	Co	Cd	Pb
MIN	1.90	0.14	0	0.000	0.18	20	0.000	0.01	19
MAX	50.20	0.43	0	0.000	4.14	67	0.000	0.25	422
MEAN	14.40	0.25	0	<0.001	3.15	44	<0.001	0.07	221

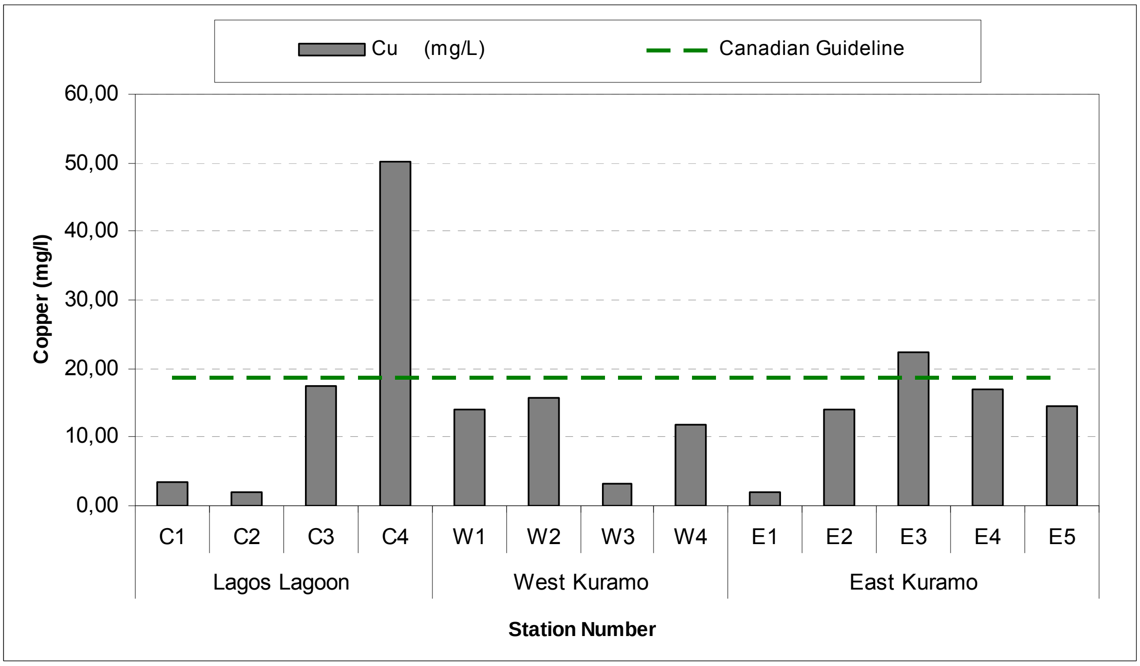

Figure 5.24 Summary of Copper (Cu) Content in Lagoon Area (Indicating Canadian Threshold Effect Level Guideline Value)

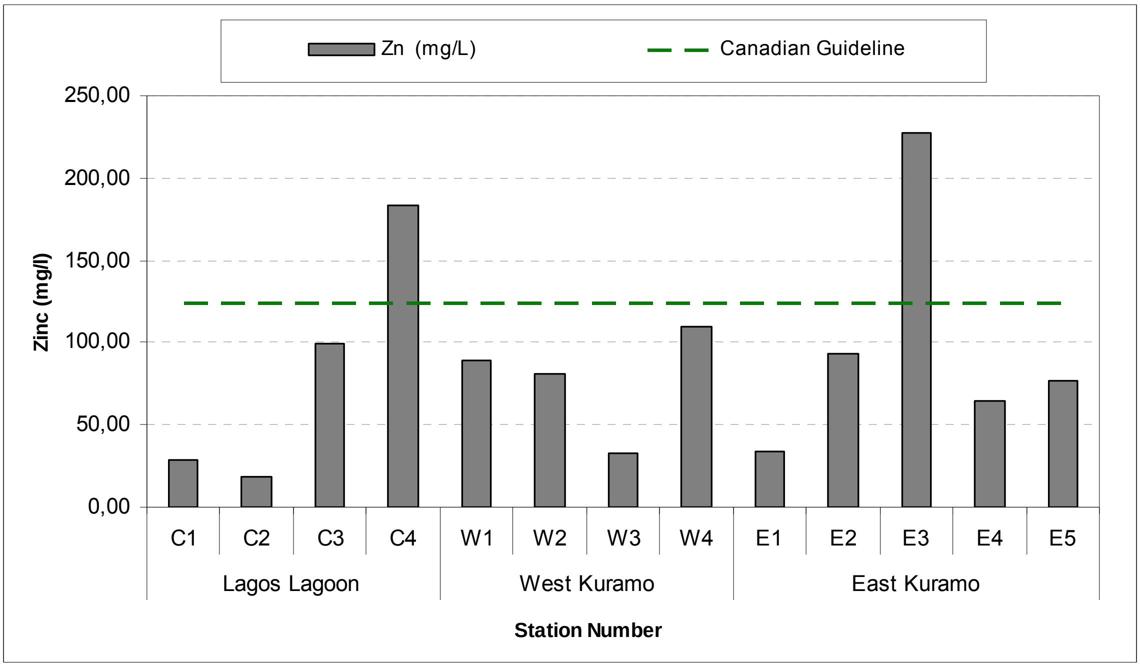

Figure 5.25 Summary of Zinc (Zn) Content in Lagoon Area (Indicating Canadian Threshold Effect Level Guideline Value)

5.14.4 Oil, Grease and Petroleum Hydrocarbons in Lagoon Sediments

The concentration of oil and grease in sediments from the lagoon and Kuramo waters ranges between 0.43 and 4.84ppm. These oil and grease values are slightly higher than measured values in the water column and suggest slight hydrocarbon pollution of the sediments. Highest oil and grease values are found in the Kuramo waters.

The summary of hydrocarbons detected in the sediments from the lagoon and Kuramo waters is presented in **Table 5.38**. The Total Petroleum Hydrocarbons (TPH) are present in the sediment samples in trace amounts with values ranging from 0.00mg/kg to 0.027mg/kg for the Total Aliphatic Hydrocarbons and 0.00mg/kg to 0.016mg/kg for the Polyaromatic Hydrocarbons. Their respective mean values are 0.013mg/kg and 0.008mg/kg. Results do not indicate existing petroleum hydrocarbon pollution in the sampled areas.

Table 5.38 Petroleum Hydrocarbons in the Sediment Samples in Lagoon Areas

S/No	Parameter	Minimum Level Detected (mg/l)	Maximum Level Detected (mg/l)	Average Level Detected (mg/l)
1.	**Aliphatic Hydrocarbon**	0.000	0.027	0.013
2.	**Polynuclear Aromatic Hydrocarbon**	0.000	0.016	0.008
3.	**Total Petroleum Hydrocarbon**	0.000	0.043	0.021

5.15 Groundwater

As with surface water flows, groundwater flows generally follow a topographic pattern from inland out towards the coast. Given the position of Victoria Island within a channelised low lying estuarine environment, shallow groundwater resources in the development area and its immediate surroundings are hydraulically separated from the mainland and will therefore be of very limited areal extent indeed.

Deeper fluxes of fresh groundwater (say greater than 50 m) may be present, as fresh groundwater originating from many hundreds of kilometres inland makes its way south, down gradient, to rise above the more dense saline groundwater, nearer the coast and beneath the seabed. These deeper fluxes, where present, will be driven by immense pressures derived from groundwater recharge processes many hundreds of kilometres inland and as such will, in geological terms, not be impacted by the relatively small scale of this development. Where present, such deep groundwater fluxes typically rise on foreshores and shallow marine environments as freshwater springs

5.16 Air Quality

5.16.1 Local Air Quality

The Lagos State Ministry of Environment (LASMOE) monitors air quality using a variety of methods at 47 sites across the State. Sampling is carried out once every two months for the following pollutants:

- Sulphur dioxide (SO_2);
- Nitrogen dioxide (NO_2);
- Carbon monoxide (CO);
- Carbon dioxide (CO_2);
- Hydrogen sulphide (H_2S);
- Hydrogen chloride (HCl);
- Ozone (O_3); and
- Total hydrocarbons (THC)

The nearest of the monitoring sites to the Eko Atlantic development are located on Lagos and Victoria Islands as presented in **Figure 5.26**, where monitoring commenced in January 2010.

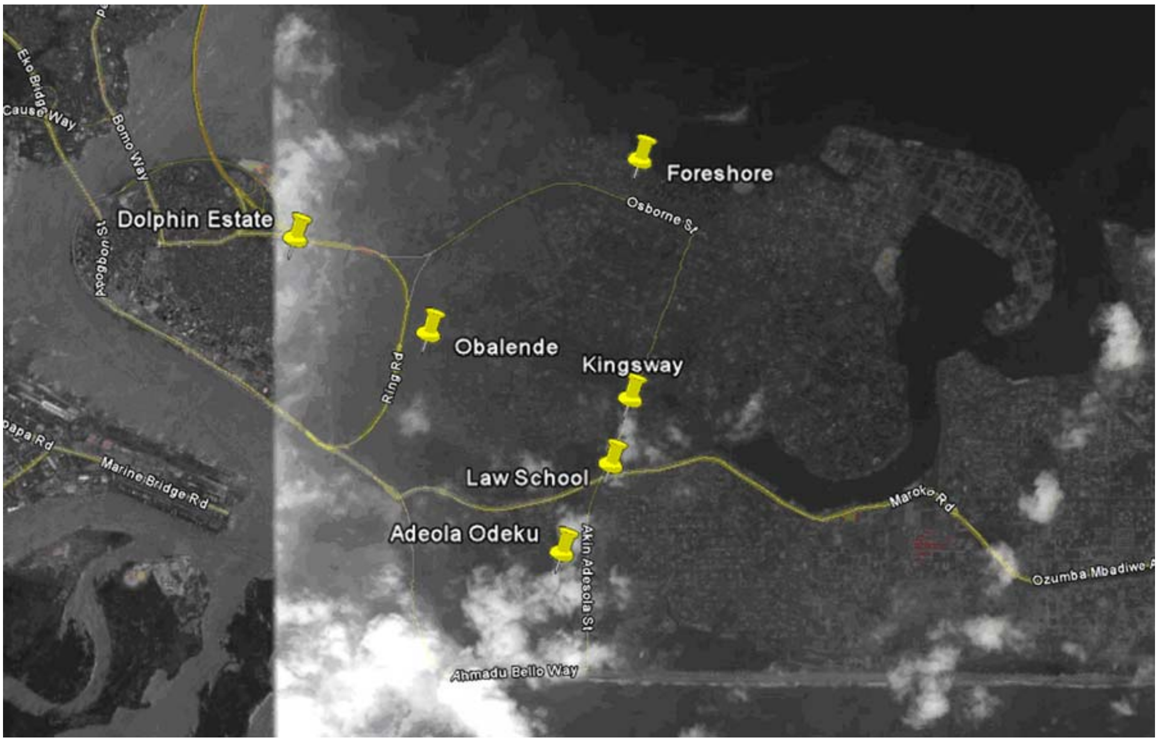

Figure 5.26 LASMOE Monitoring sites on Lagos and Victoria Islands

The main pollutants of concern associated with this development are carbon monoxide (CO) nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and particulate matter (normally assessed as the fraction of airborne particles with an average aerodynamic diameter less than ten micrometers, or 'PM_{10}'). To inform the assessment of existing air quality in the locality of the development, available monitoring data for the sites in **Figure 5.26** were obtained from LASMOE (February, April, and June 2010). These data show concentrations of NO_2 and SO_2 as '*ND-not detected*' at all sites, however monitoring results for PM_{10} and limited results for CO were recorded and results are presented in **Table 5.39** and **Table 5.40**.

Table 5.39 LASMOE PM10 monitoring results, Lagos and Victoria Islands 2010 µg.m3

Site	Residential/Secretariat Area			High Traffic Area			
	Dolphin Est	Adeola-Odeku	Fore Shore Est	C.M .S	Law School	Obale nde	Kings way
Febru ary	73	124	26	75	61	32	-
April	65	111	45	45	101	71	41
June	68	21	2	113	47	67	67
Mean	**69**	**85**	**24**	**78**	**70**	**57**	**54**

The period mean monitoring results in **Table 5.39** show elevated concentrations of PM_{10} at the majority of sites, with a range of measured concentrations between 85 µg.m^3 (at Adeola-Odeku) and 24 µg.m^3 (Fore Shore Est). These monitoring data cannot be used to determine compliance with the WHO air quality Guidelines as they do not represent average hourly or daily objectives, but maximum concentrations recorded. However, the daily WHO air quality guideline of 50 µg.m^3 would be exceeded at all sites, with the exception of Fore Shore Est, if these concentrations were to be recorded over a full 12 month period.

Table 5.40 LASMOE CO monitoring results, Lagos and Victoria Islands 2010 µg.m^3

Site	Residential/Secretariat Area			High Traffic Area			
	Dolphin Est	Adeola-Odeku	Fore Shore Est	C.M. S	Law School	Obalen de	Kings way
Febru ary	ND	ND	ND	10,00 0	2,000	2,000	-
April	1,000	ND	ND	ND	ND	ND	ND
June	ND	ND	ND	ND	ND	ND	ND

Monitoring results for CO are limited; however, those which are available (**Table 5.40**) indicate elevated concentrations at relevant monitoring sites.

Monitoring data are not available for NO_2 and SO_2, however, it is likely that existing concentrations of these pollutants are elevated on Lagos and Victoria Islands, at roadside and urban centre locations, due to existing high levels of road traffic (approximately 1 to 5 million people per day commute to Victoria Island for employment).

5.16.2 Existing sources of atmospheric pollution

The key existing sources of air pollution in the vicinity of the reclamation site include road transport, port activities (in particular marine vessels waiting to enter Lagos Port), the airport groundside activities and landing/take-off emissions. In addition, the use of generators (common in households in Nigeria due to the uncertainty in energy supply) will also contribute to local air pollution. The main pollutants of concern from these emission sources are likely to be those relating to fuel combustion and other direct industrial releases, such as NO_2, SO_2, CO and PM_{10}.

The majority of larger particulate and dust in the study area is thought to be formed through mechanical generation for example, from sea-salt particles, friction from wear of vehicle tyres and brakes, and re-suspension of settled materials due to road transport.

5.16.3 Public Exposure

The air quality assessment (described in Chapter 6) focuses on those locations where members of the public are likely to be regularly present and are likely to be exposed for a period of time appropriate to the averaging period of the air quality objective/standard. In consideration of long-term (annual mean) exposures, locations which generally do *not* meet these criteria include:

- Building façades of offices or other places of work where members of the public do not have regular access;
- Hotels, unless people live there as their permanent residence;
- Gardens of residential properties; and
- Kerbside sites (as opposed to locations at the building façade), or any other location where public exposure is expected to be short term.

Locations in the vicinity of the reclamation area where members of the public (sensitive receptors) are likely to be regularly present are described in **Table 5.41**.

Table 5.41 Sensitive receptors in the vicinity of Eko Atlantic reclamation area

Location	Sensitive Receptors	Approximate distance to reclamation area
1. Along Ambodu Bello Way 2. Onijefi beach (Mawa beach) near Goshen Estate 3. Goshen Estate 4. Lekki beach	Residents of domestic properties	500m
5. Kuramo village upward 6. Akpese village 7. Oniru lagoon/beach	Residents of shanties	500m

Members of the public are also likely to be regularly present along the routes from the quarries to reclamation area.

5.17 Noise and Vibration

The ambient noise environment on Victoria Island near the reclamation site is dominated by noise from road traffic, industrial activity and construction. Many of the urban express ways are close to residential buildings and schools, thus these receptors are currently exposed to road traffic noise. The roads on Victoria Island are subject to very high levels of traffic. The Bar Beach road, a multi-lane highway, runs along the shore immediately adjacent to the reclamation area, thus the receptors closest to the site are likely to be subject to relatively high levels of noise from this road. Currently there is no heavy industry within Victoria Island.

Baseline noise studies were not undertaken as part of this assessment, therefore a desk based assessment of the baseline noise situation was undertaken. Results from a noise survey on Lagos Island in 2007 show, that noise levels ranged from 53.0 dB to 77.5 dB across seven locations (Geosystems, 2008). Noise levels were noted to remain relatively stable during the daytime; however noise levels measured during the late night and early morning tended to be lower. The study concluded that noise levels in most residential areas were almost fully determined by road traffic noise and local noise sources, such as domestic air conditioning units.

The levels reported in the study are typical of noise levels in large cities, which generally vary between day and night to a lesser degree than in suburban or rural areas. The data also concur with the typical noise levels presented in **Table 5.42**, which was collated from two different reference sources[10,11]. It would be expected that close to roads, daytime noise levels would be in the range of 60dB to 70dB and 50dB to 60dB in quieter areas, decreasing by 10dB to 20dB during the night.

Table 5.42 Typical noise levels

Source of noise	Typical noise level (dB(A))
Discotheque, Live band	110 – 120
Jet fly-by at 300 metres	100 – 110
Power mower / cockpit of light aircraft	90 – 100
Side of a busy highway	80 – 90
Source of noise	**Typical noise level (dB(A))**
Street corner in city / Car 60mph at 7.6 metres / washing machine / TV audio	70 – 80
Light traffic at 30 metres / typical office	50 – 60
Quiet residential area – daytime	40 – 50
Quiet residential area – night time	30 – 50
Wilderness area	20 – 30

[10] Casella USA, date unknown. Training information: Typical noise levels. [online] Available at: <http://www.casellausa.com/en/docs/apps/cel/typical_noise_levels.pdf> [Accessed 10/10/2009]

[11] Kinsler, L. Frey, A. Coppens, B. Sanders, J. 2000. Fundamentals of Acoustics 4th ed. Hoboken: Wiley.

BIOTIC ENVIRONMENT BASELINE DESCRIPTION

This section describes the biotic environment of the Project study area. Information presented here is based on existing data sources (*e.g.* previous EIAs or published scientific studies) and the survey work completed for the Project in March 2010 (refer to **Section 5.5.1** for methodologies and sample locations and **Appendix C** and **D** for full results). In addition to this, the EIA from Lekki Port project and environmental studies of the Kuramo Lagoon have been used to supplement baseline data for the wet season. Relevant raw data from the Lekki Port study is provided in **Appendix D.**

5.18 Marine Ecology

5.18.1 Introduction

Lagos is located in an area known as the Guinea Current Large Marine Ecosystem (GCLME). This area extends from Bissagos Island (Guinea Bissau) in the north to Cape Lopez (Gabon) and Angola in the south. The GCLME is considered to be one of the world's most productive marine areas, rich in fishery resources, important for petroleum production, and an important global region of marine biological diversity which supports the livelihood of many communities, especially those living around the coast (Ukwe, 2004). There are no known marine or coastal protected areas in Nigeria (Ukwe *et al*., 2006)

The following sections detail the marine ecology of the Project area in terms of the marine benthic ecology, fish resource and marine mammal presence.

5.18.2 Marine Benthic Macrofauna

The term macrobenthos is used to describe those organisms that are larger than half a millimeter (the size of a pencil dot) living on or in the bottom of a water mass or closely related to it. This includes, not only the whole range of invertebrate species but also, the bottom dwelling (demersal) fish like flatfish, gadoids and gobies. The benthic system is characterized by its direct relationship to the type of substrate

The benthos detected in the marine sediment samples taken during the dry season survey in March 2010 includes a diverse assemblage of animals. A total of 34 taxa from the groups Mollusca, Polychaeta, Crustacea, Echinodermata, Nemertea, Sipuncula and Echiura were identified from all the samples collected (**Table 5.43**).

Table 5.43 Summary of Diversity Indices and Relative Abundance of Major Taxonomic Groups of Macrobenthic Invertebrates in Marine Sediments

Parameter	Sampling Stations			
	C1-10	A1-10	B1-10	S1-19
Diversity				
Taxa Number (S)	25	27	29	34
Range of Taxa Number	2 - 7	2 – 9	3 – 7	3 – 10

Parameter	Sampling Stations			
Taxa Richness Index (D)	5.8859	6.2754	6.5686	6.4403
Shannon Wiener's Index (H')	2.9788	3.1691	3.1941	3.3684
Evenness Index (E)	0.9254	0.9615	0.9486	0.9552
Number of individuals /m^2 (Species Number in Parenthesis)				
Crustacea	14 (7)	16 (6)	13 (6)	45 (8)
Polychaeta	12 (7)	15 (6)	10 (7)	53 (8)
Mollusca	27 (7)	24 (10)	42 (12)	58 (12)
Echinodermata	3 (2)	3 (2)	4 (2)	3 (3)
Echiura	0 (0)	2 (1)	1 (1)	3 (1)
Nemertea	2 (1)	1 (1)	0 (0)	1 (1)
Sipuncula	1 (1)	2 (1)	1 (1)	5 (1)
Total (counts ml^{-1})	59 (25)	63 (27)	71 (29)	168 (4)

The population of the benthic community is dominated by the Molluscs (41.8%), followed by the polychaetes (24.93%) and crustaceans (24.4%), while echinoderms represented by 3.6% of the population; the other fauna groups were occasionally encountered. Molluscs, Polychaeta, Crustacea, and Echinodermata also show higher taxa richness (**Figure 5.27**). Most of the sampling stations have low population density and there is no significant spatial variation ($P > 0.05$) among all the stations (**Figure 5.28**). The number of individuals is more or less equally distributed among the species found at every station, so Evenness index is high; Margalef and Shannon-Wiener diversity are also high in the area.

The near uniformity in the macrofauna composition and their pattern of distribution in the sediment, suggest that the sediment characteristic across the study area may be similar. The species recorded are typical for the Nigerian environment and Gulf of Guinea in general. The macrofauna indicates that the water quality is good. The presence of macro invertebrates sensitive to oil pollution were found at the majority of sites for example, *Alpheus normani and Gammarus oceanicus*. This is indicative of an ecosystem that is ecologically balanced and healthy.

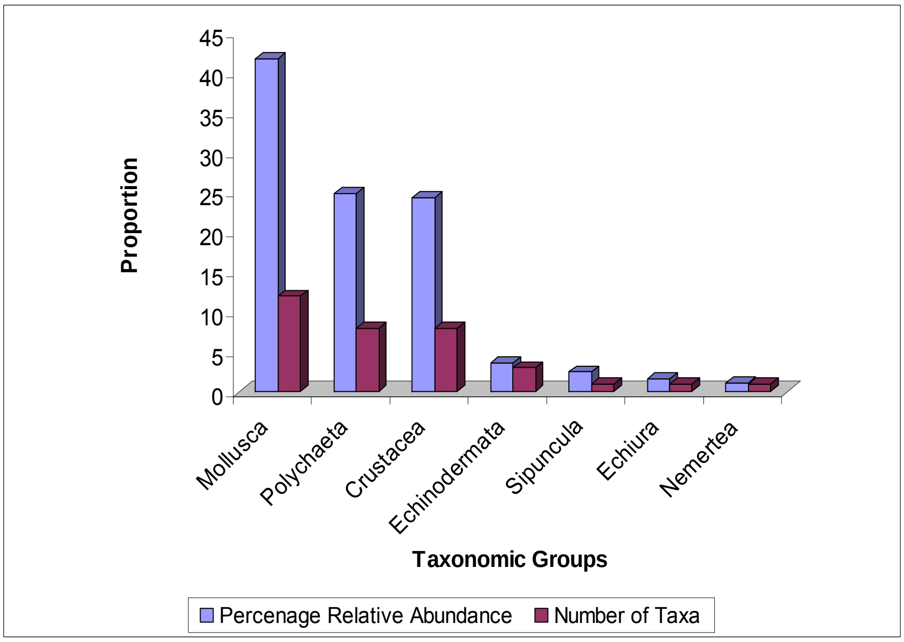

Figure 5.27 Relative Abundance and Taxa Richness of Major Benthic fauna Groups in Marine Sediments for all stations

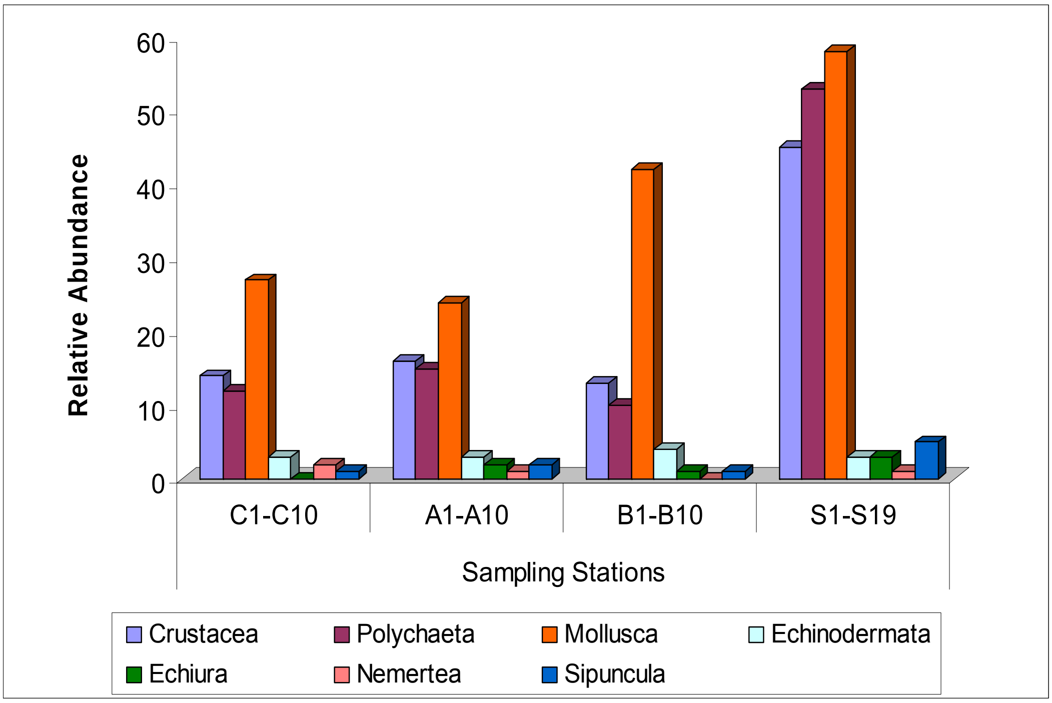

Figure 5.28 Spatial Variation in the Relative Abundance of Major Benthic Fauna Groups in Marine Sediments

The intertidal area in Lagos is limited and in the Project area it consists mostly of sandy sediment habitats, exposed to rough wave conditions most of the year (**Plate 5.2**). As such, these communities are likely to be very resilient to disturbance within the range of prevailing environmental conditions.

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Plate 5.2 Sandy beach intertidal habitat at project area

5.18.3 Plankton in Marine Waters

The term plankton is used to refer to those pelagic organisms which are carried about by the movement of the water rather than by their own ability to swim. Some plankton can only float passively and are unable to swim at all. Others are quite active swimmers but are so small that swimming does not move them far compared to the distance they are carried by the water. The ability to swim serves chiefly to keep them afloat, alter their levels, obtain food and avoid capture. The phytoplankton community occupies the regions of light penetration namely on the surface layer of the pelagic zone.

The planktonic plants are called phytoplankton and planktonic animals are called zooplankton. Phytoplankton species are predominantly autotrophic or holophytic organisms (they build organic matter from inorganic materials present in their environment). Marine phytoplankton is the most important producer of organic substances and the rate at which energy is stored up by these tiny organisms determines the basic primary productivity of the ecosystem. All other living forms of higher trophic levels are directly or indirectly dependant on phytoplankton for energy supply and therefore, performing vital functions. Marine phytoplankton is made up of small plants, mostly microscopic in size and unicellular.

Three divisions of phytoplankton (**Table 5.44**), namely, Bacillariophyceae (diatoms), Chlorophyceae (green algae) and Dinophyceae (dinoflagellates) represented by 28, 1 and 8 taxa respectively were sampled in the Project area during the survey. In terms of relative abundance, the Bacillariophyceae dominate the flora followed by Dinophyceae (dinoflagellates) and Chlorophyceae (green algae) in that order (**Figure 5.29**). The bulk of the algae population across the sampling stations is made up of diatoms particularly *Coscinodiscus excentricus*, which was the dominant species at all the stations (Appendix 1.7). All the Stations show very high similarity in taxa composition and population density (**Figure 5.31**), such that there was no significant ($p > 0.05$) spatial variation.

Table 5.44 Summary of taxa composition, relative abundance and spatial distribution of Phytoplankton in Marine Waters.

Taxonomic List	Sampling Station					Summary	
	A5	B2	B10	C3	S10	Total	%
Division Bacillariophyta	1447	1402	1488	1444	1444	7225	75.3
Division Chlorophyta	2	4	6	2	0	14	0.1
Division Dinophyta	463	511	427	480	470	2351	24.5
Abundance (N)	1912	1917	1921	1926	1914	9590	
Taxa number (S)	37	37	36	36	35	37	

S = Taxa richness; N = Abundance (Nm^{-3}).

Diversity and abundance across the Stations are relatively even and high when compared with other studies from Nigerian shallow marine waters (*e.g.*, AFREN, 2007). Recorded taxa are between 35 or 37 taxa while the flora abundance is within a range of 1912 and 1926 individuals/ m3. Comparatively, population density, taxa richness and diversity are generally high and similar throughout the sampling stations. Species diversity is generally high in terms of Margalef species richness (D), Shannon (H1) and Evenness (E1) (**Table 5.45**) an indication that the sampled marine waters are of good quality. Additionally, there are no species found that cause toxic algal blooms.

The clear dominance of diatoms in the water, both in abundance and diversity suggests the presence of a relatively clean environment and rules out any significant level of pollution from a petroleum source. This is in agreement with the findings of Dorgham *et al*. (1987) who reported a higher percentage of diatoms than dinoflagellates in plankton from areas in the Gulf of Guinea comparatively free from oil pollution.

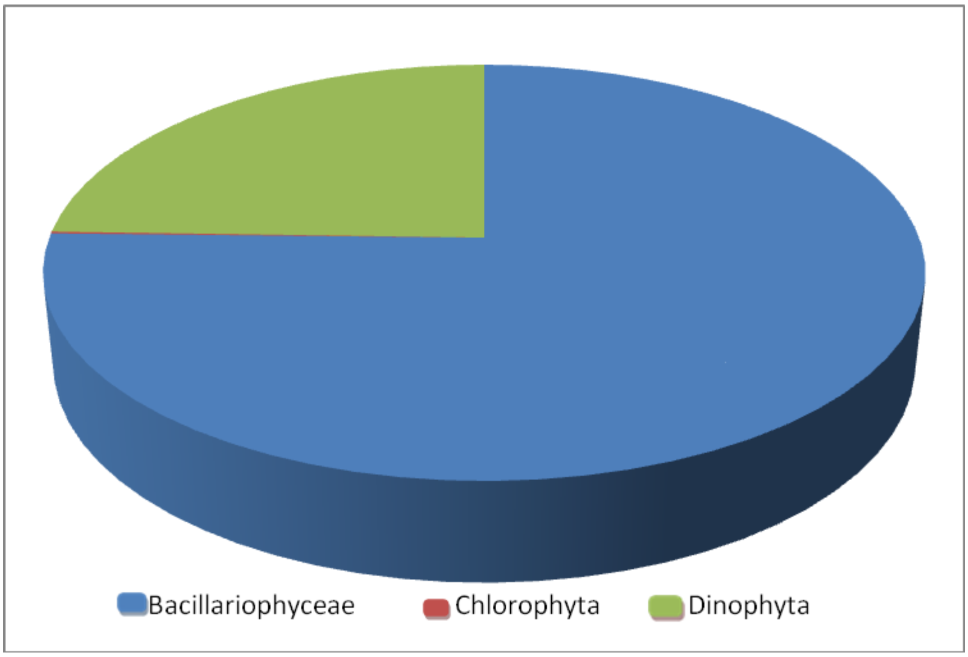

Figure 5.29 Relative Proportion of Phytoplankton in Marine Waters

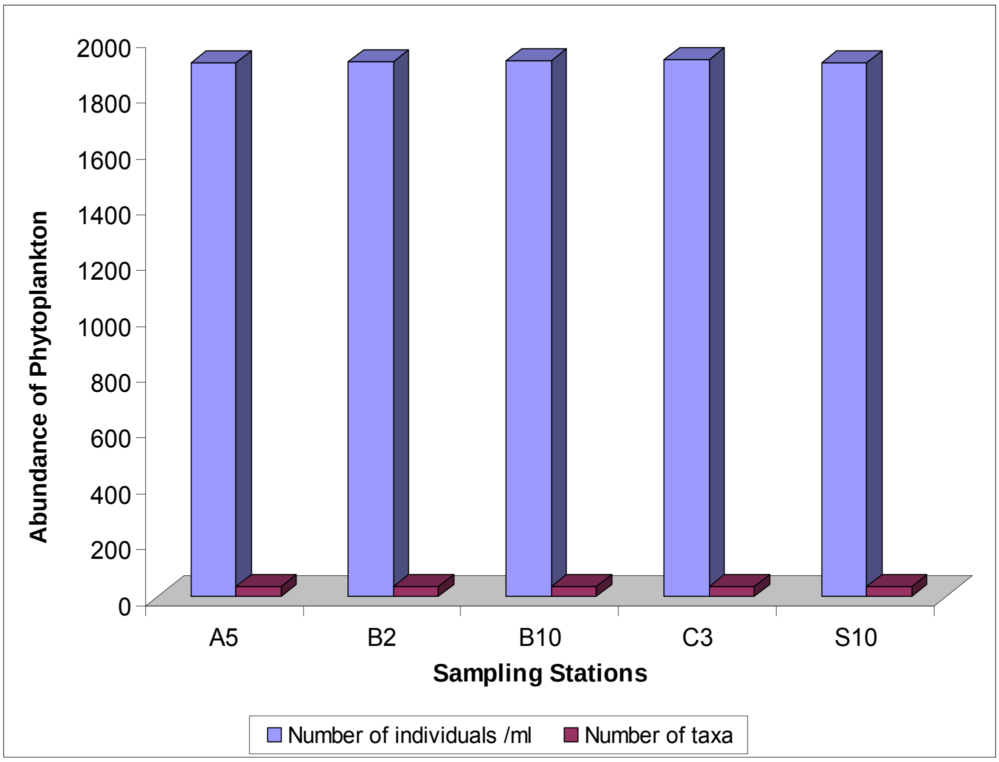

Figure 5.30 Spatial Variation of Phytoplankton in Marine Waters

Table 5.45 Diversity Indices and Relative Abundance of Major Taxonomic Groups of Phytoplankton

Diversity	Value
Taxa Number (S)	37
Range of taxa Richness	35 – 37
Taxa Richness Index (D)	3.9265
Shannon Wiener's Index (H')	3.1846
Evenness Indes (E)	0.8819
Number of individuals /m^3 (Species Number in Parenthesis)	
Bacillariophyceae	7225 (28)
Dinophyceae	2351 (8)
Chlorophyceae	14 (1)

5.18.4 Zooplankton

In the marine environment, animals making up the zooplankton are taxonomically and structurally diverse. Among the zooplankton, two major groups can be distinguished: the holoplankton forms that spend their entire life cycle in the plankton; and the meroplankton forms that spend only part of their life cycle in the plankton, usually larval forms of benthic or nektonic adults. Most zooplankton occupies the second or third trophic level of the food web. As such, these herbivores and small carnivores play an exceptionally important role in food webs.

Thirty-three (33) permanent zooplankton (Zooplankton) in seven major groups and ten different larval stages of animals (Meroplankton) are found in the marine environment within the study area. The most abundant and frequently encountered are the Crustaceans. This group consisting of copepods, cladocerans, mysids, decapods, amphipods and ostracods constitute 60% of the zooplankton population. This is followed by the larvae form (Meroplankton) (23.6%). The chaetognaths (arrow worms) and urochordates make up 9.01% and 4.9% respectively of the zooplankton while polychaetes constitute the remaining 2.39%.

Taxa richness is highest among the Crustacea with 25 taxa, followed by the Chaetognatha (**Table 5.46** and **Table 5.47**). The population density in the sampled stations was relatively even and no significant difference ($p > 0.05$) is observed among the Stations (**Figure 5.31**). The population density, taxa richness and diversity are generally high and similar throughout the sampling stations. Species diversity is also generally high in terms of Margalef species richness (D), Shannon (H1) and Evenness (E1) (Table 3-10) an indication that the water was of good quality. The population and species richness are good when compared to similar environments in the Nigerian gulf of Guinea.

Table 5.46 Summary of Diversity Indices and Relative Abundance of Major Taxonomic Groups of Zooplankton from Marine Waters

Diversity	Value
Taxa Number (S)	33
Range of taxa Richness	31 – 32
Taxa Richness Index (D)	4.661
Shannon Wiener's Index (H')	3.464
Evenness Index (E)	0.9906
Number of individuals /m^3 (Species Number in Parenthesis)	
Chaetognata	113 (4)
Polychaeta	30 (2)
Copepoda (Calanoida)	365(11)
Copepoda (Cyclopoida)	191 (7)
Copepoda (Harpacticoida)	42 (2)
Cladocera	31 (1)
Mysidacea	28 (1)
Ostracoda	29 (1)
Decapoda	35 (1)
Amphipoda	32 (1)
Urochordata	62 (2)
Meroplankton	296 (0)

Table 5.47 Summary of Taxa Composition, Relative Abundance and Spatial Distribution of Zooplankton in Sampled Marine Waters

	Sampling Station					Summary	
Taxonomic List	A5	B2	B10	C3	S10	TOTAL	%
Chaetognatha	23	26	28	18	18	113	9.01%
Polychaeta	4	11	5	1	9	30	2.39%
Copepoda (Calanoida)	81	69	61	72	82	365	29.11%
Copepoda (Cyclopoida)	35	33	41	41	41	191	15.23%
Copepoda (Harpacticoida)	6	8	13	10	5	42	3.35%
Cladocera	7	5	6	8	5	31	2.47%
Mysidacea	8	5	3	7	5	28	2.23%
Ostracoda	8	8	5	8	0	29	2.31%
Decapoda	9	7	8	5	6	35	2.79%
Amphipoda	5	7	8	5	7	32	2.55%
Urochordata	13	14	10	10	15	62	4.94%
Meroplankton	67	58	55	53	63	296	23.60%
Number of individuals /ml	**266**	**251**	**243**	**238**	**256**	**1254**	**100%**
Number of taxa	**32**	**31**	31	**32**	**31**		

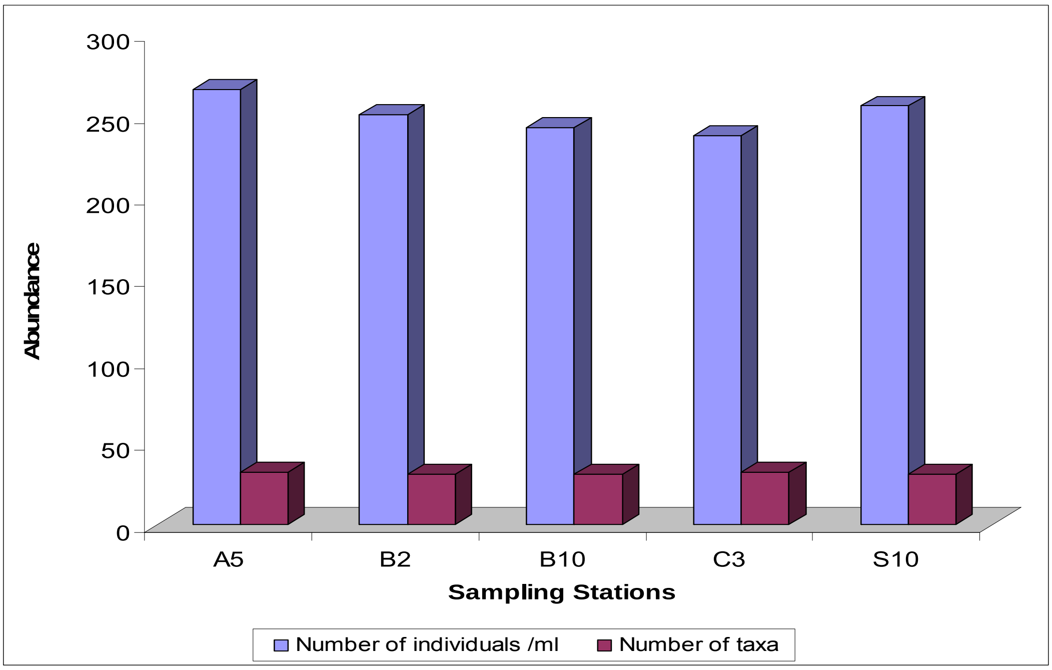

Figure 5.31 Spatial Variation in the Relative Abundance of Zooplankton in Marine Waters

5.18.5 Fish, Shellfish and Cephalopods

Fishery resources in the GCLME include over 300 species of finfish, 17 species of cephalopods, 25 species of crustaceans and 3 species of turtles (FAO, 2004). In Nigeria, the extensive estuarine interface constitutes the spawning and nursery grounds for many marine, brackish and fresh water species.

The demersal target species exploited by artisanal fishing units in Nigeria are croakers (*Pseudotolithus*), threadfins (*Galeoides, Pentanemus* and *Polydactylus*), soles (*Cynoglossidae*), marine catfish (*Arius*), brackish water catfish (*Chrisichthys*), snapper (*Lutjanus*), grunters (*Pomadasyidae*), groupers (*Epinephelus*), and the estuarine white shrimp (*Palaemon*) (Ukwe, 2004). Offshore pelagic resources also include tuna and tuna-like fishes such as the skip jack, yellow fin tuna, frigate tuna and sword fishes which have remained largely unexplored and unexploited (Solarin, 2010).

Shrimps are found in abundance off shore of the Badagry - Lagos - Lekki lagoon system (Dublin-Green *et al*., 1997). Among important species is the pink shrimp (*Penaeus notialis*), which dominates in 10-50m depth. This specie occurs abundantly off Lagos and Benin River to Pennington River and from Bonny River estuary to Cross River estuary. Other shrimp species occurring include the Guinea shrimp (*Parapenaeopsis atlantica*), which occurs in coastal shallow waters between 0-20m depth; the royal shrimp (*Parapenaeus longirostris*), which occurs abundantly in deep waters 60-120m deep; and *Nematopalaemon hastatus*, an estuarine shrimp, found in coastal waters to a depth of 50m (Dublin-Green *et al*., 1997).

The spiny lobster (*Palinuridae*) and locus lobster (*cyllarodae*) occur in Nigerian coastal waters. Only one species *Panulirus regius*, the royal spiny lobster is common and prefers rocky substrate in depths of 5 - 15m (Dublin-Green *et al*., 1997).

In Nigeria, cephalopods (squids, cuttlefish and octopus) occur commonly in offshore depths of 90-250 m (Dublin-Green *et al*., 1997).

Some of the exploited fish species, *e.g.*, bonga, croakers, sardinella, snappers, threadfins, pink shrimp and barracuda make seasonal migrations from the sea into the creeks and back to sea. The mechanism and timing of migrations and their significance to the coastal inshore fisheries has still to be evaluated.

Trawl fishing is the dominant form of industrial fishing in Nigeria (Moore *et al*., 2010). Currently the industrial fleet is made up essentially of shrimp trawlers for targeting demersal fin fish and shrimps in the inshore coastal waters mainly between 10 and 50m depth. About 156 vessels were registered in 2009 mainly for targeting shrimps with a large volume of fish as by-catch. The by-catch mainly constituted a very large percentage of small size juvenile fish which is an indication of over-fishing (Solarin, *et al*., 2010). Furthermore fish abundance is likely to be affected by waste on the sea floor. During a trawl survey of the coastal waters (<10mm depth) conducted by the NIOMR, Lagos, Nigeria, very high volumes of solid waste/debris including non-biodegradable nylon and plastic products and household items was recorded (Solarin et. al 2010).

No information on spawning or nursery ground in the area was available for this study.

5.18.6 Marine Mammals and Sea Turtles

Marine mammals that inhabit the waters of the Gulf of Guinea are restricted to the cetaceans

(whales and dolphins) and sirenians (manatees) with the Atlantic Humpbacked dolphin (*Sousa teuszii*) and the African manatee (*Trichecus senegalensis*) being of special importance. Both species appear on the IUCN Red List of endangered species; the West African manatee is classified as vulnerable and the humpbacked dolphin is classified as highly endangered under CITES. Other species which occur in West African waters include (but are not limited to):

- Bottlenose dolphin, *Tursiops truncates;*
- Long-snouted common dolphin, *Delphinus capensis;*
- Short-snouted common dolphin, *Delphinus delphis; and*
- Atlantic spotted dolphin, *Stenella frontalis.*

According to Solarin (2010), whales and dolphins are frequently sighted by small scale artisanal and industrial fishermen, marine mammals observers (MMO) and other scientists from their various crafts or platforms (canoes or vessels) in the near shore coastal waters or deep sea (>2500m). In one of the few quantitative reports, 277 sightings were recorded between November 2007 and December 2009 and comprised of 187 (68%) whales and 88 (32%) dolphins. The herds included both adult and young calves. Whales occurred mainly between June/July and December, while dolphins occurred throughout the year (Solarin, 2010).

In recent studies conducted into fishing of marine mammals (Moore *et al*, 2010) there was no record of directed or intentional capture targeted at the cetaceans by either the artisanal small scale or industrial fishermen. It was observed that the cetaceans were rarely caught or entangled in the fishing nets or gear of the artisanal or industrial fishermen. The artisanal fishermen maintained that it was a dangerous venture to capture whales which could result in capsizing of the canoe together with damage to the nets. The dolphins were observed to avoid the nets (Solarin, 2010).

West and Central Africa contain a variety of habitats suitable for manatees ranging from large and small rivers, coastal estuaries, freshwater and saltwater lagoons, shallow quiet coastal bays, lakes and reservoirs. **Figure 5.32** shows the distribution of the West African manatee. The West African manatee, *Trichechus senegalensis* inhabits practically every accessible habitat. They have been observed or recorded from coastal areas, estuarine lagoons, large rivers that range from brackish to fresh water, freshwater lakes and the extreme upper reaches of rivers above cataracts. In general, their habitat requirements seem to require sheltered water with access to food and freshwater. They may use areas of unsheltered coast, but they are usually rare in these areas (Powell, 2008). It is estimated that there are fewer than 10,000 manatees in West Africa. A population decline of at least 10% is anticipated based on continuing and increasing anthropogenic threats (Powell, 2008).

Manatees are found in shallow waters of the Nigerian coastal brackish waters as well as inland lakes and rivers and they are commonly seen in the Lagos lagoon further inland (Nigerian Conservation Foundation, 2008)

In general, little information is available on the abundance and distribution of marine mammals in Nigerian waters. However, sea turtles have been found to occur in small numbers in Nigerian waters (Dublin-Green *et al*., 1997) and anecdotal information from fishermen indicates the rare presence of whales, dolphins and turtles within the Project area. Unconfirmed reports indicate that 4 species of turtle (leatherback, loggerhead, hawksbill and green) and the West African Manatee have been caught in Nigerian waters (either intentionally or accidentally) (Moore *et al*., 2010). It is not expected that turtles would be nesting on the beaches at the Project site, due to the high level of human activity in this area. In addition, consultations did not identify any known turtle nesting beaches at the project site.

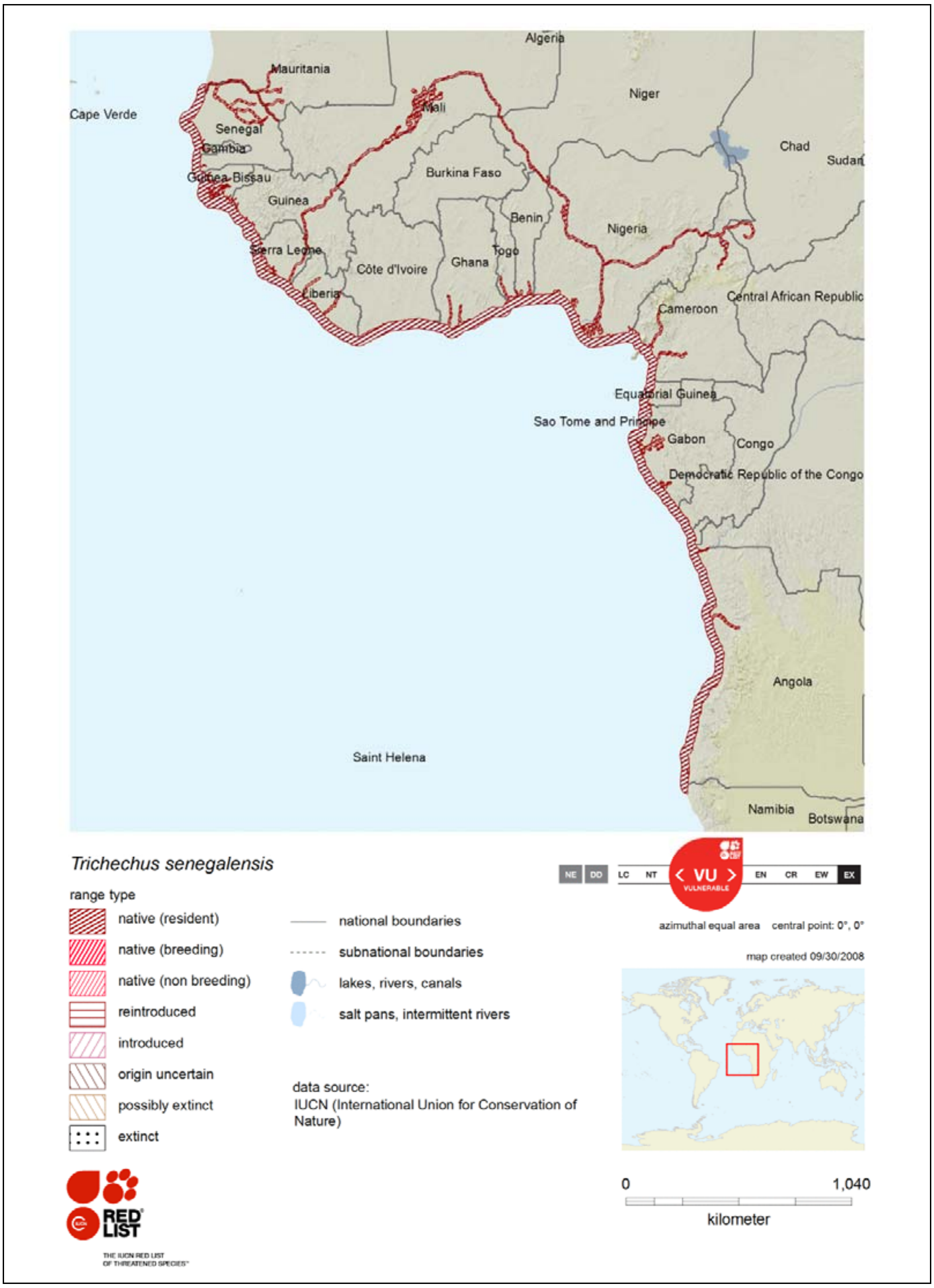

Figure 5.32 Distribution of the West African Manatee (Powell, 2008)

5.19 Lagoon Ecology

5.19.1 Introduction

Nine lagoons are known in South-western Nigeria: the Yewa, Badagry, Ologe, Iyagbe, Lagos, Kuramo, Epe, Lekki and Mahin lagoons. The eastern part of Kuramo is also known as the Apese Lagoon (Onyema, 2009). Within the study area, there are two lagoons of interest namely Lagos and Kuramo (east and west). The east and west parts of Kuramo probably originate from one lagoon that has been separated over time through sediment transport and anthropogenic modifications (Onyema, 2009).

Lagos lagoon is open to the sea through approximately 7km of channel ending in the Commodore Channel. The west Kuramo Waters is a semi closed lagoon, open only in the wet season via the Kuramo creek into the Five Cowrie creek to the Lagos Lagoon. The eastern part of Kuramo Lagoon is closed and it is thought to be the only closed lagoon in the region (Onyema, 2009).

Although none of the lagoons are within the direct footprint of the reclamation or shoreline protection, it was considered important that further detailed information be gathered on Kuramo Waters as part of the main environmental survey as the reclamation will extend along the shoreline, seaward of these lagoons. This lagoon was selected for focus due to its close proximity to the Project site. In addition, samples were taken from Lagos Lagoon to obtain additional comparison data (Please refer to **Sections 5.4** and **5.5** for further details).

5.19.2 Benthic Macrofauna in Lagos Lagoon and Kuramo Waters

The benthic macro invertebrate taxa found in the Lagos Lagoon and Kuramo Waters sample sites during the dry season survey are listed in **Appendix D**. A total of 15 taxa, including 5 each of insects (*e.g.* larvae), annelids and molluscs were obtained during the survey. The highest number of taxa (13) is recorded in the Kuramo waters, although the difference between this and the number detected in the Lagos lagoon (11 taxa) did not indicate a significant spatial variation in the taxon richness or composition.

An average of 25 individuals m^{-2} are found in the Lagos lagoon (locations C1 to C4), this is significantly different ($p < 0.05$) from the Kuramo waters which had an average of 96 individuals m^{-2} due principally to the large numbers of annelids found there. The overall assessment of the relative contributions of the major groups of the benthic macro invertebrates (**Figure 5.33**) shows that annelids and insect larvae are the most abundant, accounting for 56% and 23% respectively of the total individuals recorded throughout the study. Numbers are highest in the Kuramo waters, where Branchiodrilus *sp, Eiseniella tetrahedral and Tubifex tubifex* constitute the dominant annelids, an indication that the water body is polluted.

The results of the dry season survey compare well with data presented in a wet season survey of 2001 (**Table 5.49**). This survey analysed benthic macrofauna of the root biotope (waters edge) of Kuramo Lagoon (Edokpayi *et al*., 2001). A total of 16 taxa and 691 macrobenthic individuals belonging to 11 families were recorded at the four study sites across the lagoon. Annelid worms and dipteran (insect) larvae were dominant at all four sites.

The diversity indices for the wet and dry season are summarised in **Table 5.48**. Lagos lagoon had the highest diversity in terms of Margalef species richness (D) and Evenness (E^1) an indication that this section of the lagoon system was of better water quality. The data presented also indicated that the benthic community of Kuramo Waters has become more diverse since 2001, however this could also be a function of the sample location in 2001 being located near to the shore or to higher pollution levels in 2001, or due to seasonal variation.

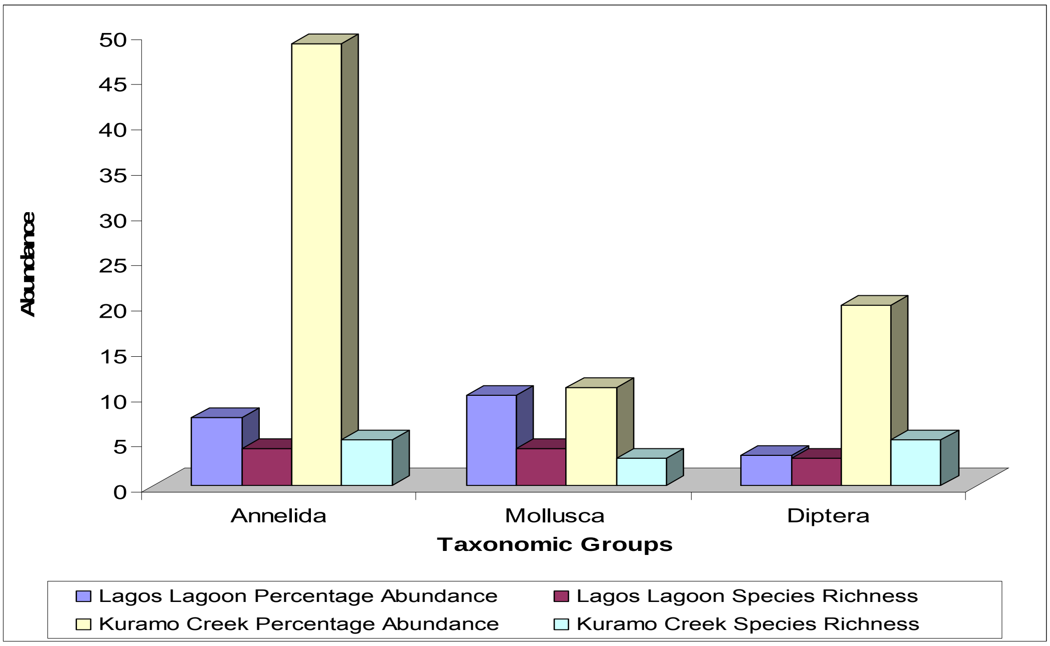

Figure 5.33 Relative Abundance and Species Richness of Macrobenthic Invertebrates in the Lagos Lagoon and Kuramo Waters

Table 5.48 Summary of Diversity indices and Relative Abundance of Major Taxonomic Groups of Macrobenthic Invertebrates in the Lagoon and Kuramo Waters.

Parameter	Dry Season 2010		Wet Season 2001
	Lagos Lagoon	Kuramo	Kuramo
Taxa Number (S)	11	13	9.75
Taxa Richness Index (D)	3.1067	2.6291	3.9
Shannon Wiener's Index (H')	2.2106	2.3272	0.55
Evenness Index (E)	0.9219	0.9073	0.63
Number of individuals /m^{-2} (Species Number in brackets)			
Annelida	9 (4)	59 (5)	See Table 5.49
Mollusca	12 (4)	13 (3)	
Diptera	4 (3)	24 (5)	
Total (counts m^{-2})	25	96	

Table 5.49 Composition and distribution of macrobenthic invertebrates at Kuramo waters study Station June – Oct, 2001 (Edokpayi *et al*., 2004).

	STATION I		STATION II		STATION III		STATION IV		ALL SITES	
	No. of Taxa	No. of individuals	No of Taxa	No. of individuals	No. of Taxa	No. of individuals	No. of Taxa	No. of individuals	No. of Taxa	No. of individuals
ANNELIDA										
Oligochaeta										
Naididae	2	68[a]	2	71[a]	2	56[b]	2	60[a]	2	255
Tubificidae	–	–	1	6	–	–	–	–	1	6
Polychaeta										
Nereidae	–	–	1	3	–	–	–	–	1	3
INSECTA										
Coleoptera										
Dysticidae	1	1	1	3	1	4	–	–	1	8
Elmidae	–	–	–	–	1	1	–	–	1	1
Odonata										
Zygoptera	1	1	1	29	1	10	1	9	1	49
Plecoptera										
Nemouridae	–	–	1	2	2	3	–	–	2	5
Hemiptera										
Nepidae	–	–	–	–	1	1	–	–	1	1
Diptera										
Culicidae	–	–	–	–	2	4	1	24	2	28
Chironomidae	2	78[a]	1	52[b]	2	46[b]	2	82[a]	2	258
GASTROPODA										
Prosobranchiata										
Viviparidae	1	3[c]	1	39[a]	1	11[b]	1	6[b]	1	59
NEMATODA	1	9	1	8	–	–	1	13	1	30
Total	8	160	10	213	13	136	8	194	16	703

[a, b, c] – means indicated with same letters are not significantly different (P > 0.05); Kruskal-Wallis test

5.19.3 Phytoplankton in Lagoon and Kuramo Waters

The relative abundance and diversity of phytoplankton in the sampled lagoon systems are summarised in **Table 5.50**. A total of fifty-four species of phytoplankton were recorded, 46 were found in the Lagos Lagoon while 43 were recorded in Kuramo waters. Phytoplankton abundance ranged between 576 counts/m^3 (Lagos Lagoon) and 2364 counts/m^3 (Kuramo). Species richness is generally higher in Lagos Lagoon in terms of Margalef species richness (D), Shannon (H1) and Evenness (E1) an indication that this section of the lagoon system is of better water quality than that of Kuramo Waters.

Table 5.50 Relative Abundance and Diversity of Phytoplankton in Lagos Lagoon and Kuramo Waters

Parameter	Lagos Lagoon	Kuramo
Taxa Number (S)	46	43
Taxa Richness Index (D)	7.0798	5.4067
Shannon Wiener's Index (H')	3.6908	2.6126
Evenness Index (E)	0.964	0.6946
Total (counts m^3)	576	2364

The recorded phytoplankton in the Kuramo waters belong to five taxa namely: Bacillariophyceae (diatoms), Cyanophyceae (blue-green algae), Euglenophyceae (euglenid), Chlorophyceae (green algae) and Dinophyceae (dinoflagellates). In terms of relative abundance, the Euglenophyceae dominate the flora followed by

Cyanophyceae (blue-green algae), Bacillariophyceae (diatoms), Chlorophyceae (green algae) and Dinophyceae (dinoflagellates) in that order (**Figure 5.35**).

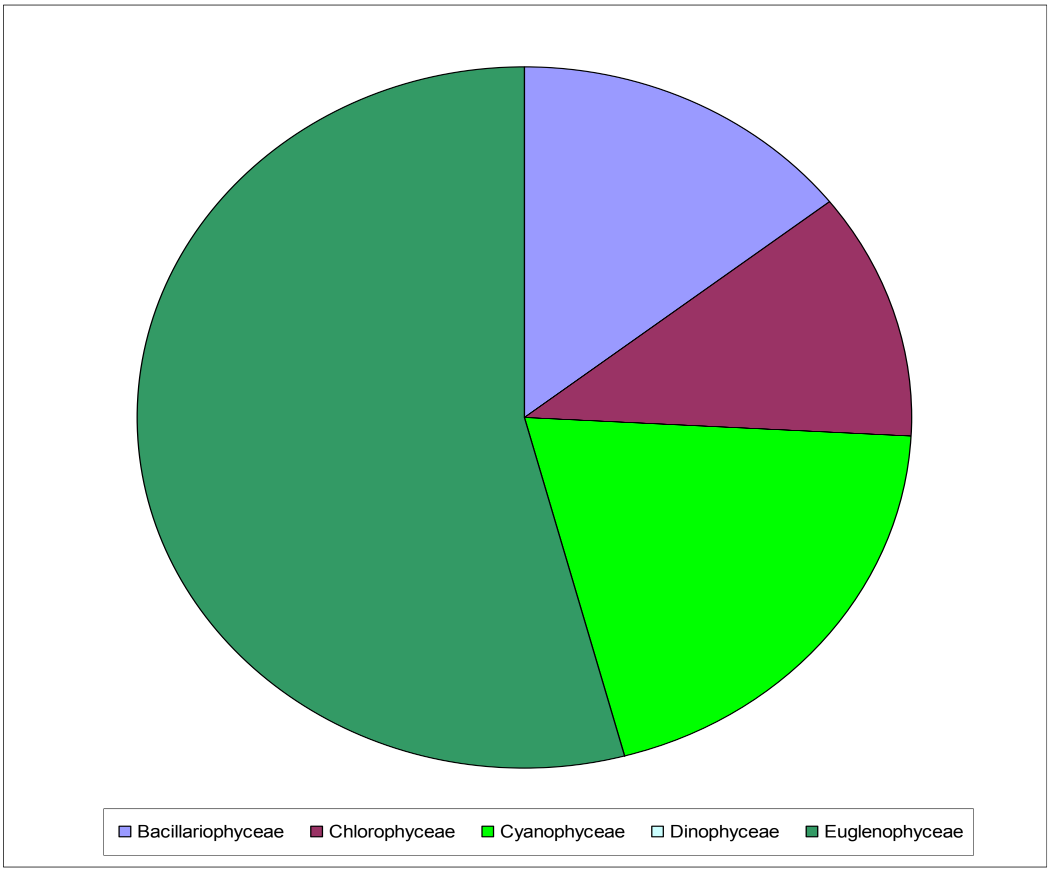

Figure 5.34 Relative Proportion of Phytoplankton in Lagoon and Kuramo Waters

A total of 24 species of diatoms are observed in the study stations, 21 of these are found in the Lagos lagoon while 15 occur in Kuramo waters. The number of blue green algae species range between 11 species (Lagos Lagoon) and 13 species (Kuramo). They constitute the second largest group of the algae population (20%) being more predominant in the Kuramo waters with 15.07% (**Figure 5.34**).

The maximum number of species of Euglenid (5 species) is found in Kuramo waters and the minimum (3 species) in Lagos Lagoon respectively. *Euglena acus* (556 counts/m3, 18.91%) is the most abundant Euglenid. Generally, Euglena species have the highest abundance of the Euglenophyceae. The number of green algae ranges from 8 species (Kuramo) to 9 species (Lagos Lagoon). *Spirogyra angolensis* (60 counts/m^3) is the most abundant species (Appendix 1.22). Dinoflagellates are absent in Kuramo waters and only 2 species are recorded in the Lagos Lagoon (**Figure 5.36**).

The high phytoplankton abundance recorded for the Kuramo waters may be attributed to the high quantities of anthropogenic wastes (domestic) such as raw human and animal faeces received from its surroundings. These wastes increase the nutrient concentrations of this creek. The dominance of Euglenophyceae and blue-green algae indicate that the Lagos lagoon system particularly Kuramo waters is polluted. Ruivo (1972) states that natural unpolluted environments are characterized by balanced biological conditions and contains a great diversity of plants and animals life with no one species dominating.

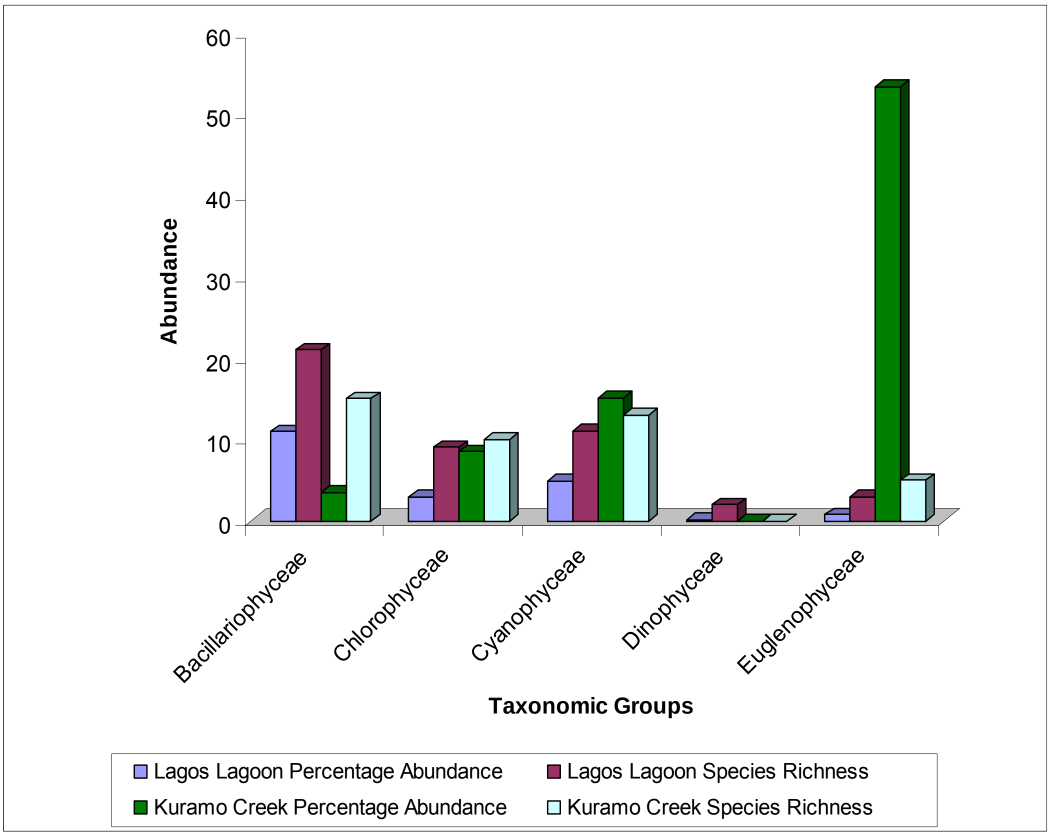

Figure 5.36 Relative Abundance and Species Richness of Phytoplankton Lagoon and Kuramo Waters

5.19.4 Zooplankton in Lagoon and Kuramo Waters

The zooplankton community in the Lagos Lagoon system is composed of 9 species of rotifers, 8 species of copepods, 4 species of cladocerans and 1 ostracod (Appendix 1.23). All rotifers, except *Filinia longiseta*, were found in Kuramo Creek (Appendix 1.23). *Brachionus angularis*, *Brachionus plicatilis, Conochilus dossuarius* and *Synchaeta oblonga* were absent from the Lagos lagoon. Among the copepods, only *Eucyclops serrulatus* and *Mesocyclops leuckarti* were present in Kuramo Creek. The nauplius stage and all copepod species recorded occur in the Lagos lagoon (Appendix 1.23). The only species of Cladocera that is found across the lagoon system is *Bosmina longirostris.* Other cladocerans are restricted to either Kuramo Creek or Lagos lagoon. The only species of ostracod present in the system, *Cyclocypris globosa* is found in Kuramo waters.

Regarding relative abundance, rotifers are dominant in Kuramo waters, while copepods, show higher abundance in Lagos lagoon which is a brackish water environment (**Figure 5.35**).

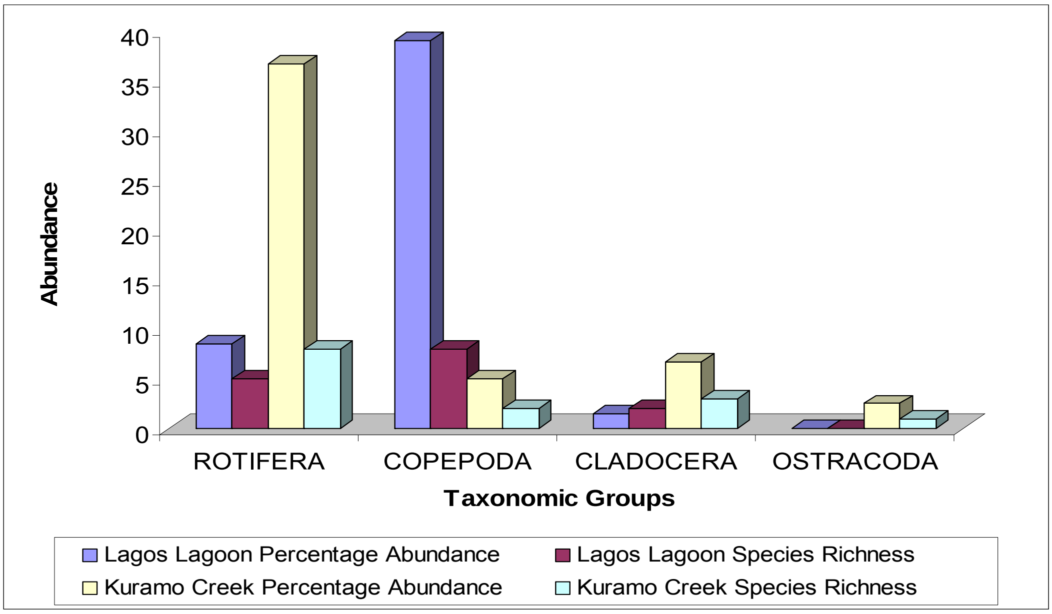

Figure 5.35 Relative Abundance and Species Richness of Zooplankton in Lagoon and Kuramo Waters

Of the twenty-two species of zooplankton recorded, 15 of them are found in Lagos Lagoon while 14 occur in the Kuramo waters. Zooplankton abundance range between 293 counts m-3 (Lagos Lagoon) and 304 counts m-3 (Kuramo waters). Species richness is generally higher in Lagos Lagoon in terms of Margalef species richness (D) (**Table 5.51**) an indication that this section of the lagoon system is of better water quality.

Table 5.51 Summary of Diversity Indices and Relative Abundance of the Major Taxonomic Groups of Zooplankton in the Lagoon and Kuramo Waters

Parameter	Lagos Lagoon	Kuramo
Diversity		
Taxa Number (S)	15	14
Taxa Richness Index (D)	2.483	2.2739
Shannon Wiener's Index (H')	2.4489	2.4533
Evenness Index (E)	0.9043	0.9296
Number of individuals /m^3 (Species Number in Parenthesis)		
Rotifera	51 (5)	219 (8)
Copepoda	233 (8)	30 (2)
Cladocera	9 (2)	40 (3)
Ostracoda	0 (0)	15 (1)
Total (counts ml^{-1})	293	304

In natural environments, high abundance of rotifers is generally related to eutrophic conditions, with only few species recorded as bio-indicators of oligotrophic environments (Gannon & Stemberger, 1978). In the present study 9 rotifer species were recorded, most of which are known for eutrophic environments. The Brachionids and *Synchaeta oblonga* are the most abundant in

Kuramo waters. The high abundance recorded for the Kuramo Creek might be attributed to the high nutrients status (phosphate, nitrate and sulphate). According to Sládecek (1983), the species of Brachionus found in this study show a wide range of tolerance to pollutants and are abundant in eutrophic environments.

Copepods are organisms broadly represented in aquatic ecosystems and constitute an important portion of the biomass in the zooplankton community of freshwater and marine environments (Margalef, 1983; Wetzel, 2001) hence there relatively higher proportion in the brackish Lagos lagoon.

5.19.5 Fish, Shellfish and Cephalopods in Lagoon Waters

Species directly collected, observed and recorded at the shore and shallow parts of the lagoon include *Ocypoda cursor* and *O. africana, Tilapia* spp., *Callinectes latimanus, Cadmium* sp. A good number of schools of juvenile fish are commonly seen.

5.20 Ornithology

Table 5.52 presents the globally threatened species of birds in Nigeria, as defined by Birdlife International (2010). The table also summarises the habitat and foraging preference of the listed species. Based on this information, and the habitats available at the Project site, it is considered that the Project site holds no significant importance for any of the threatened species. Furthermore, there are no identified important bird areas near the Project site, the closest being located at the IITA Forest Reserve, Ibadan and the Omo Forest Reserve, both over 120km away inland (Birdlife International, 2010).

It is understood that some coastal habitats at Lagos do support populations of other (unthreatened) species such as immature Black Terns and Royal Terns, which breed only in northwest Africa. Adults of the Lesser Black-backed Gulls and Damara Terns may also reach Lagos (from breeding grounds almost two continents apart) (Wallace, 1972). However, it is expected that these species are not regular visitors to the Project area.

Table 5.52 Globally threatened species in Nigeria (Birdlife International, 2010)

Species	Category	Habitat preference	Foraging preference
Marbled Teal *Marmaronetta angustirostris*	Vulnerable	It is adapted to temporary, unpredictable, Mediterranean-type wetlands and breeds in fairly dry, steppe-like areas on shallow freshwater, brackish or alkaline ponds with well vegetated shorelines14, and rich emergent and submergent vegetation	Diptera are an important component of the diet along with small seeds.
Cape Gannet *Morus capensis*	Vulnerable	Marine species, not breeding in Nigeria,	Within 120km of shore on shoaling

Species	Category	Habitat preference	Foraging preference
		although some juveniles may travel there outside of breeding season.	pelagic fish.
Lesser Kestrel *Falco naumanni*	Vulnerable	Habitat typically in grassland areas, so unlikely to be present in project area.	It forages in steppe-like habitats, natural and managed grasslands, and non-intensive cultivation.
Egyptian Vulture *Neophron percnopterus*	Endangered	Typically inland species.	Forages in lowland and montane regions over open, often arid, country.
White-headed Vulture *Trigonoceps occipitalis*	Vulnerable	Prefers mixed, dry woodland at low altitudes and generally avoids human habitation.	
Beaudouin's Snake-eagle *Circaetus beaudouini*	Vulnerable	Inhabits dry savannah / grassland.	
Black Crowned-crane *Balearica pavonina*	Vulnerable	This species breeds in wet and dry open habitats, but prefers freshwater marshes, wet grasslands, and the peripheries of water-bodies. Rarely associated with deep, open water. Nests are built on the ground in densely vegetated wetlands.	Forages on dry ground with short grass. Primary food source is small grain crops, with small plants, small invertebrates and small vertebrates also featuring in the diet. Often forages near herds of domestic livestock.
Green-breasted Bush-shrike *Malaconotus gladiator*	Vulnerable	It is found in montane forest, both primary and old secondary forest	It feeds mainly on invertebrates
Grey-necked Picathartes *Picathartes oreas*	Vulnerable	It inhabits closed-canopy, primary rainforest	It feeds mainly on invertebrates
White-throated Mountain-babbler *Kupeornis gilberti*	Endangered	Dependent on primary montane forest with high rainfall in areas between 950-2,130 m	It feeds mainly on invertebrates

Species	Category	Habitat preference	Foraging preference
Bannerman's Weaver *Ploceus bannermani*	Vulnerable	It occurs at 1,100-2,900 m, occupying forest edge and dense, shrubby habitat	
Ibadan Malimbe *Malimbus ibadanensis*	Endangered	It inhabits forest patches, forest edge and secondary woodland	
Anambra Waxbill *Estrilda poliopareia*	Vulnerable	It occurs in long grass along rivers, lagoon sandbanks, swamps and within or on the edges of open deciduous forest. restricted to a few localities in central southern Nigeria (not Lagos)	feeds principally on grass seeds taken from seedheads

5.21 Terrestrial Ecology

Typical of an urban beach area, the majority of the coastal land cover in the study area comprises bare sand interspersed with areas for concrete drainage structures, commercial and residential buildings and piles of scrap and waste materials.

A site walkover was held to check whether any valuable ecological features could be observed. Flora was mainly observed mostly towards the east of the project site (**Plate 5.3**). There it consists of small palm trees and ground running opportunistic plants. Some reed plants also survive at the waters edge in the eastern parts of Kuramo Waters. The ecological value of the observed flora is low.

A variety of small mammals such as rodents and small reptilian species are present in the terrestrial areas adjacent to the Project site. Observations show that the coastline from Lekki Beach to Bar Beach is highly impacted by urban development and disturbed, and therefore no species of significant ecological importance have been observed.

Considering these observations, the beach area has low to very low ecological potential. The findings of these observations have been confirmed during consultation with the local communities.

Plate 5.3 Pictures of the coastal terrestrial habitat within and to the east of the Project area

It can be concluded that flora and fauna are heavily determined by the anthropological interventions along the coast. Therefore, this part of the baseline has been limited to a general description of the environment. For the same reasons also interactions between flora and fauna are considered not important from an ecological point of view.

5.22 Navigation

The project area is not within the designated shipping channels or anchorage areas and is not used for recreational navigation or water sports vessels.

Lagos is the principle port of Nigeria situated on the Gulf of Guinea. The Nigerian Ports Authority (NPA) owns and operates the Nigerian ports, including the one at Lagos. Lagos Port Complex (port of Lagos) is located at the Apapa area of Lagos, South West Nigeria. Apapa Port occupies a total land area of over 120 Hectares (NPA, 2010).

The Commodore Channel, which runs directly to the west of the Project site, is the access route to Lagos Port. This stretch of water is also under the jurisdiction of the NPA.

A large number (>50) of commercial vessels (cargo, container etc.) are regularly moored in the waters immediately offshore of Lagos, awaiting entry to the port. These vessels tend to be anchored in an anchorage area to the south and west of the Commodore Channel, and not close to the reclamation project area, nor the main operations of the dredger (*i.e.* within Borrow Area A).

Fishing vessels are likely to be active in all areas offshore of Lagos. Recreational use of the marine area is not a popular activity in the Project area with limited recreational navigation.

SOCIO-ECONOMIC BASELINE DESCRIPTION

5.23 Fishing Grounds

The main fishing areas for the primary stakeholders are the lagoon west of Kuramo Water, Kuramo Water, and the open sea. The secondary stakeholders, such as communities living at Lighthouse Creek, Badagry Creek and Middle Creek fish in the Lagos Lagoon and in the open sea.

5.24 Cultural Heritage / Archaeology

Due to the intensive land use in the area, it is very unlikely that there is cultural heritage or an archaeological site of interest in the Project area. The beach contains home-made shrines to the Yoruba panthenon of gods, but these shrines do not hold much intrinsic value beyond the immediate family group nor are they of any archaeological or cultural importance. No chance findings were discovered in the Project area.

5.25 Religious Worship

Religious practices amongst the communities on the beach can be characterised as being a local version of “juju” (colloquially known as “jazz”). This is a fusion of elements of both Christian and Muslim traditions with animistic traditions. There is an established church born out of the Anglican church community among the Yoruba people, called, “The Eternal Sacred Order of the Cherubim and Seraphim.” Worshipers wear white gowns, refer to themselves as Cherabums and Seraphims, wear crosses, speak in tongues, and claim to cure physical ailments through prayer and herbal remedies. The belief in the power of ‘juju’ is widespread whether Christian or Muslim and it is often attributed to the death of a child, husband or wife, or other misfortunes. Traditional beliefs and various taboos are also common, none of which are relevant to this Project.

5.26 Landscape Character

Over the last twenty-five years there has been considerable business and residential development in Victoria Island. This had led to a landscape (or cityscape) comprising densely packed buildings and roads. Buildings range from one and two store residential properties to skyscraper hotels and businesses. To the east of Victoria Island, there are some patches of open land, but these are mostly already owned as designated for development of private properties. For many hours of the day, the roads are incredibly busy, which adds to the bustling character of the area.

On the shoreline, views of the sea are possible from many beach front properties. A mixture of building types is seen on the beach, ranging from expensive hotels at the high end to make-shift shanty villages at the low end.

5.27 Characteristics of Metropolitan Lagos

Lagos is Nigeria's largest city with an official population of 8 million. Spread over several large islands on a vast lagoon and mainland near the Gulf of Guinea, Lagos is Nigeria's principal port and its commercial and cultural centre. The city continues to grow and the conurbation, including Ikeja and Agege, extends 40 kilometers northwest of Lagos Island. There are 57 local governments in Lagos.

The former capital grew to prominence when it was discovered by the Portuguese in the late 1400s and became a central trading post for the area, also serving as a major hub of the slave trade. When the British annexed the city in 1861, they put a stop to the slave trade, but took control of the trade and industry of the area. Once Nigeria gained independence in 1960, Lagos experienced a boom, which swelled the city's population and today, Lagos is the seventh fastest growing city in the world and is home to 250 ethnic groups. From 1914 to 1991, Lagos was the capital of Nigeria and then it was replaced by Abuja.

Of the Local Government Areas in Lagos State, 16 are located in metropolitan Lagos. All together they cover nearly 1,000 square meters of land with a total official population of 8 million. Until 1976, Lagos was a municipality comprising Lagos Island, Ikoya, Victoria Island, and some mainland territory. Today, Lagos refers to the metropolitan area, which includes both the island of the former municipality and the mainland suburbs.

Although the 2006 National Population Census credited the metropolitan area with 8 million, this figure is at variance with projections from the United Nations and other population agencies worldwide. The figure given for Lagos State is disputed as being set too low; unofficial state and UN estimates go up to over 15 million – with roughly 88% living in Lagos Metropolitan Area. Lagos Metropolitan Area has an estimated growth rate of 8% compared to the national average of 4%. Given the unresolved issue of the population figure, a conservative estimate for Victoria Island, the focus of the EIA, has been set at 280,000 with an annual growth rate of 2.8% (Central Bank of Nigeria).

Most of the population lives in the four districts on the mainland: Ebute-Meta, Surulere, Yaba and Ikeja. Greater Lagos includes Mushin, Maryland, Somolu, Oshodi, Oworonsoki, Isolo, Ikotun, Agege, Iju Ishaga, Egbeda, Ketu, Bariga, Ipaja and Ejigbo. The three major urban islands of Lagos in Lagos Lagoon are Lagos Island, Ikoyi and Victoria Island. These islands are separated from each other by creeks of varying sizes and are connected to Lagos Island by three bridges. They are the Carter Bridge, the Eko Bridge and the Third Mainland Bridge. Eko Bridge and Carter Bridge start from Iddo Island whereas the Third Mainland Bridge passes through the lagoon and the surrounding densely populated suburbs.

Lagos Island contains many of the largest markets in Lagos; its central business district, the central mosque, and the Oba's palace. Tinubu Square on Lagos Island is a site of major historical importance as it was there that the Amalgamation ceremony that united the North with the South took place in 1914 (**Plate 5.4**).

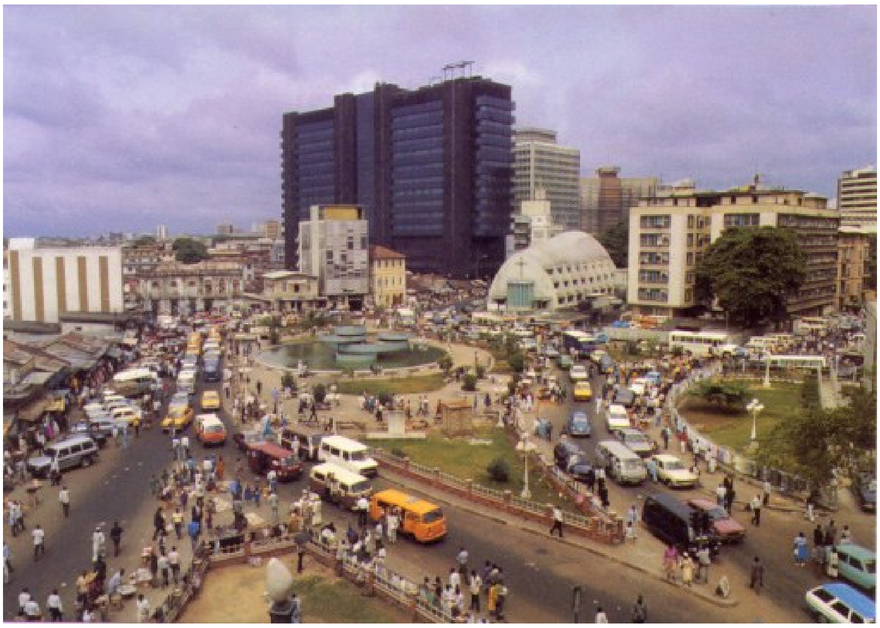

Plate 5.4 Tinubu Square

Ikoyi is situated on the eastern half of Lagos Island. It houses the headquarters of the federal government and all the other government buildings. It also has many hotels, and one of Africa's largest golf courses. Originally a middle class neighbourhood, Ikoyi has become fashionable in recent years and is popular among the wealthier contingents of Lagos society.

Victoria Island and Lekki are situated to the south of Lagos Island. Along with Ikoyi, they are suburbs of Lagos, home to several large commercial and shopping districts, and the city's popular beaches.

5.28 Victoria Island

Victoria Island was originally entirely surrounded by water - bordered by the Atlantic Ocean on the south, the mouth of the Lagos Lagoon on the West, the Five Cowrie Creek to the North and swamps on the East. The colonial government began the process of filling in the eastern swamps to reduce mosquito-breeding areas. This created a bridge between Victoria Island and Lekki Peninsula and hence ended Victoria Island's existence as a true island. After independence, successive state governments expanded this development, culminating in the construction of a highway connecting Victoria Island to Epe. This activity, along with the rapid commercialisation of Victoria Island, served to stimulate residential development along the Lekki-Epe corridor, starting with Lekki Phase 1.

The area of the land bridge, composed of the former swampland (which was called Maroko) became a large slum, which housed many of the new migrants to Lagos State. Residents of the Island complained about this problem, leading the then military Governor of the State – Raji Rasaki – to forcibly remove these squatters. This area – called Victoria Island Annex – was then cleared and sold to residential buyers. Subsequent reclamation has expanded this area to the extent that it is now connected to the Lekki Peninsula. This new, enlarged area is referred to as "Oniru Estate" after the ruling family of the area.

Originally designated an upscale residential area, failing infrastructure and overcrowding in the old business district on Lagos Island and poor zoning enforcement in Victoria Island has led to a mass migration of businesses over the last twenty-five years. Today, Victoria Island is one of Nigeria's busiest centres of banking and commerce, with most major Nigerian and international corporations headquarters on the Island. Unsurprisingly, Victoria Island is one of the most exclusive and expensive areas to live in Nigeria (**Plate 5.5**). The cost of renting an apartment with various luxurious amenities ranges from $10,000 to $48,000 per year. Due to the array of world-class restaurants, shopping malls, hotels, bars, night clubs, movie theatres, schools and businesses located in Victoria Island, investing in property is a lucrative business. However the influx of banks and other commercial ventures has changed the formerly serene atmosphere of the Island. Long-time residents complain about the increase in traffic and influx of street traders.

Plate 5.5 A view of the housing available on Victoria Island

5.29 History of Lagos

According to Benin, oral traditions and written evidence from Andreas Ulsheimer, a German surgeon aboard a Dutch merchant ship in 1603, Lagos was one of the towns under the suzerainty of Benin in the 16th century. These accounts assert that Oba Orhogbua of Benin (c. 1550-1578) conquered the island of Lagos and set up a military camp to take advantage of the flourishing trade taking place. Lagos Lagoon was known to European traders by 1485, when it first appeared on the maps, but the town of Lagos was not included, suggesting that it had either not been discovered or considered to be of little importance until the end of the 16th century (Adefuyi, Ade, Babatunde A. Agiri & J. Osuntokun, A History of the Peoples of Lagos State, 1987). The Portuguese and Dutch merchants trading in the area with the Ijebu in cloth, ivory and slaves also did not mention the town of Lagos, even though the Portuguese established a trading post for themselves farther away in the Ijada quarter of Ijebu-Ode around 1519. Hence, little is known about Lagos prior to 1603. Oral traditions assert that when Benin conquered Lagos there were already pre-existing settlements on Lagos and the nearby Ido Islands. Nothing is known about the size of these settlements or their inhabitants and their way of life.

Benin forces settled on the northwest tip of Lagos Island where they could overlook Lagos Lagoon, which narrowed at that point between Lagos and Ido Island. It is believed that Benin wanted to take Ido Island because it was the most populated place in the Lagos area and served as a gateway to the mainland. Benin was especially interested in towns, especially settlements along the Ogun River, such as Isheri and Ota, as the Ogun River was an important waterway leading to inland trade. For unknown reasons, however, they never occupied Idos Island until much later when refugees founded the settlement known today as Eti-Osa. Instead, the Benin established a stronghold across the lagoon on Lagos Island as well as a large number of colonies throughout the Ogun Basin, west from Lagos to Badagry, and north from the coast to latter day Ilaro Division boundaries.

What is currently known about Lagos is rooted in folklore about Ido Island, the centre of indigenous local activity. It is said that a leader by the name of Olofin dominated the group of villages on the Island prior to the Benin conquest. He had Awori Yoruba ancestry. He divided the Island into shares for his sons (either blood-related or loyal supporters) to rule. Over time, Olofin's sons became known as Idejo, land-owning chiefs. Twelve of the families are recognised by government today, one of whom is Prince Oniru.

5.30 Urban Development

At the end of colonial rule in the 1960s, Lagos underwent a process of rapid modernisation that has led to a multiplicity of problems involving mass transit, open space, inadequate housing and infrastructure, slums and squatter settlements. The influx of rural, less educated people into Lagos led to rising rates of urban poverty and its "villagization", characterised by illegally built clusters of ramshackle huts in the open spaces (E.C. Emordi & O.M. Osiki, December 2008, p. 100). This phenomenon occurred throughout Africa.

A consequence of urbanisation was felt in pockets of Lagos. Statistics indicate severe overcrowding in Isale Eko, where as many as 22 people inhabited one room (Emordi & Osiki, p. 101). The Ije Slum emerged in the Obalende area of Lagos Island and the Maroko settlement also degenerated into a slum. Other non-urban and unplanned areas such as Ajegunle, Iwaya and Iponri worsened. By the time of the preparation of the Lagos Metropolitan Master Plan in 1980, 42 slum areas were identified.

The Lagos-based NGO, Socio-Economic Rights Initiative, SRI, characterises the slum areas, as follows:

> *The houses are drab, dirty and reeking with unclean and decaying refuse. Water is scarce and must therefore, be rationed; excreta disposal is inadequate with litters of human waste being a common sight in a neighbourhood…. there are also inadequate drainage facilities with waste water forming mini puddles within the compound where mosquitoes and insect vectors exercise their reproductive potentials. The degree of environmental pollution emanating from such high level of squalor can be imagined by realizing that the epidemic of cholera, typhoid fever and dysentery are frequent occurrence (Vanguard, September 18, 2006, p. 42, cited from Emordi & Osiki, p.101).*

The large number of slum areas in Lagos is not legally recognized by the governmental authorities and therefore absent of basic municipal services, such as clean water, electricity, solid waste disposal, and health clinics. Slum dwellers are not eligible to receive governmental social supports and loan schemes with which they could improve their conditions.

Slum dwellers tend to view their living surroundings as temporary because they are under constant threat of eviction. Squatters are forced out whenever an area in the city is under development. Without city plans in place to deal with slum dwellers, a bi-product of urban renewal in Lagos is the emergence of new slums as the slum dwellers get pushed out to make way for the better-off. Between 1983 and 1985, the Ije slum in Obalende was abolished to develop Dolphin Estate. Maroko became a slum in the process of developing Ikoyi and was subsequently abolished in July 1990 under the military administration of Raji Rasaki.

Evicted slum dwellers have been known to move into uncompleted buildings in nice housing estates leading to their demise. This happened in Satelite Town, Gowon Estate, Ikota Housing Estate, the Sure-lere Housing Estate and the Gowon Housing Estate. In the 1970s, the Gowon Housing Estate in Ipaja was purportedly highly sought after but by the mid-1990s it was just another slum. These areas are no longer inhabitable, characterised by very low levels of hygiene and general squalor.

The lack of good public space has contributed to traffic gridlock, with the high preponderance of illegal trading and make-shift markets taking place on the bridges and motorways of Lagos. One-fifth of the Lagos workforce commutes to work by car on roads which had not been built to accommodate such heavy traffic. A fast deteriorating road is the Ibadan Express Way, the only road linking Lagos with Ibadan and Abuja, going directly North from Lagos.

The recent building of the toll gates at Lekki-Epe expressway has been a subject of controversy for commuters. This six-lane highway, traversing 49.5 kilometers, will have three toll gates each priced at N100 to N250. Residents of Eti-Osa East and West Local Councils in Lagos State are opposed to the tolls because they believe it will hurt them financially as well as dampen demand for business activities between Lekki and central Lagos. They have staged several protests in the summer of 2010, blocking the road for hours. On July 20, 2010, at a meeting with the Eti-Osa community, Governor Fashola agreed that an alternative, toll-free route would be made available. Upon learning however that this route, the anticipated Coastal Highway, would also be tolled, the protesters took to the streets on August 19th. There are two minor roads linking Lagos to Lekke, one at the Oniru side and another around Jakande, but the road surface is so poor, covered by potholes and stagnant pools of water, that they are not viable alternatives.

The Lekki-Epe expressway and the Coastal Highway at Lagos-Epe Expressway are managed by the Lekki Concession Company (LCC) (**Plate 5.6**). In April 2006, Lagos State signed an agreement with LCC under the Build, Operate and Transfer (BOT) Scheme, which allows LCC to upgrade and expand the Lekki-Epe expressway for 30 years (Gbenro Adeoye, Next, August 20, 2010). The Lekki-Epe expressway is a critical access route into the newly planned Lekki Free Trade Zone. In 2008, Oniru Royal Family commissioned LCC to build the Coastal Highway (Office of the Governor, Lagos State website, March 18, 2008). This highway would be the primary access route into Eko Atlantic City. The construction of the Coastal Highway is being developed under a separate project than the Eko Atlantic Shoreline Protection and Reclamation Project.

Plate 5.6 Photograph of the Lekki-Epe Expressway near Caverton (October 8, 2010, 2 pm)

5.31 Public Health

Modern day public health in Lagos dates back to 1841 when an expedition of Europeans traveling up the Niger River were infected with malaria and one third of the passengers died (Savage, “Health in Lagos State”, 16 July 2010, worldwide web) In 1901, in an attempt to lower dysentery rates, quality improvements were made to the water supply including chemical analysis of impurities and the removal of dumping from wells. In 1920 and in 1946 respectively, the Yellow

Fever Research Institute and the Malaria Control Service were established. In 1956, Nigeria became a member of the World Health Organisation.

In response to the high population growth rate, the Federal Government launched the National Policy on Population for Sustainable Development in 2005. The policy recognises that population factors, social and economic development, and environmental issues are interconnected and are critical to the achievement of sustainable development in Nigeria. To guide policy and the planning of programs and their implementation, the following targets were set:

- Reduce the national population growth rate to 2 percent or lower by 2015;
- Reduce the total fertility rate by at least 0.6 children every five years by encouraging child spacing through the use of family planning;
- Increase the contraceptive prevalence rate for modern methods by at least two percentage points per year through family planning;
- Reduce the infant mortality rate to 35 per 1,000 live births by 2015;
- Reduce the child mortality rate to 45 per 1,000 live births by 2010.
- Reduce the maternal mortality ratio to 125 per 100,000 live births by 2010 and to 75 by 2015;
- Achieve sustainable universal basic education as soon as possible before 2015;
- Eliminate the gap between males and females in school enrolment at all levels and in vocational and technical education by 2015;
- Eliminate illiteracy by 2020; and
- Achieve at least a 25 percent reduction in HIV/AIDS adult prevalence every five years.

The Federal Government's Revised National Health Policy of 2004 regards primary health care as the framework to achieve improved health for the population. Primary health services include health education; adequate nutrition; safe water and sanitation; reproductive health; immunisation again major infectious diseases; the provision of essential drugs; and disease control. The policy requires that a comprehensive health care system be delivered through the primary health centres.

The health sector in Nigeria is characterised by wide regional disparities in status, service delivery and resource availability. More health services are provided in the southern states than in the northern states. The current priorities in the health sector are in the area of childhood immunisation and HIV/AIDS prevention.

5.32 Socio-economic situation

5.32.1 General

The immediate Project surroundings are located in a densely urban environment whose commercial profile includes expensive hotels and office buildings at the top end and dilapidated buildings housing illegal squatters at the bottom end. Several long-standing communities, the Creek communities, reside east of the development near the East Mole. See Figure 6.14 for a bird's eye view of the location of the businesses and Creek communities vis-à-vis the Project area. Other surrounding communities identified on the Public Forum concern Apese, Igbosere, Itirin, Inupa, Olukotun, Okokuku and Ilabare.

Project stakeholders comprise 4 main groups:
- Government;
- Business;
- Communities;
- Citizens posting comments about the Project on the web-based Nairaland Forum.

5.32.2 Government

Key governmental authorities have been individually consulted to inform them about the Project, to understand their concerns, and to learn about any regulations to be followed in the course of the Project. These key governmental stakeholders also attended a public forum hosted by the Project developer in Lagos on 16 January 2011 representing government, business, and housing and community associations.
The Project's key governmental stakeholders are:

- Federal Ministry of the Environment;
- Lagos State Ministry of the Environment;
- Lagos State Ministry of Waterfront Infrastructure Development;
- Nigerian Ports Authority; and
- Lagos State Ministry of Land.

Several governmental institutes were also consulted, including:

- Nigerian Institute for Oceanography and Marine Research; and
- Federal School of Fisheries and Marine Technology.

5.32.3 Businesses

Businesses thought to be impacted, either directly or indirectly, by the Project were consulted and invited to the public forum. These businesses include:

- Business Cabins at Kuramo Water;
- Business and Office Buildings on Ahmadu Bello Way; and
- Businesses on and near Adetokumbo Ademola Street.

A consultative meeting with the Nigerian Society of Engineers also took place in January 2011.

Business Cabins at Kuramo Water

Extending from Kuramo Water to Bar Beach for 500 meters are 104 business cabins housing approximately 2,840 people (**Plate 5.7**). The cabins are more or less uniform with one or two kiosks at the front and 8 to 10 private rooms in the back. Each room has enough space to sleep 2 to 4 people. Some of the cabins are for residential use only, but the majority rent rooms by the night and for extended stays. One of the inhabitants reported that he pays 400 naira a day in rent and he and his family has occupied for the past two months. He originates from outside Lagos but came to Lagos searching for low skilled work.

Almost all the cabins have a kiosk or bar with indoor and/or outdoor seating. Some serve food, and the more established cabins have games rooms with one or more televisions which broadcast sporting events. Nearer to Bar Beach are large restaurants and bars with beach front seating serving as many as 100 to 200 patrons on the weekends. The owner of one of the larger restaurants reported that the business cabins all belong to an association of businesses which pays rent and taxes to the agent of the Lagos State and Federal authorities. A complete listing of the business cabins is presented in Annex 1.

Plate 5.7 A view of the business cabins and kiosks at Bar Beach

Businesses and Government Buildings on Ahmadu Bello Way

Ahmadu Bello Way is a two lane highway that runs parallel to the coastline. There are 26 office and government buildings situated in directly across the Project site, between Darico Digital Studio (No. 1220) and the Ocean View Hotel (intersection of Ahmadu Bello Way and Adetokumobo Ademola Street). Many of the buildings are in a dilapidated state with about only half in actual operation. The other half were abandoned and sit empty. In May 2009, waves coming onto Bar Beach flooded the businesses on Ahmadu Bello Way, which contributed to their high vacancy rates and deterioration.

Businesses on and near Adetokumbo Ademola Street

A second group of businesses with a view of the Atlantic Ocean situated on Adetokumbo Ademola Street and on the smaller side streets off Adetokumbo

Ademola Street and north of Kuramo Waters. These include: Ajose Adeogun Street, Molade Okoya Street, Sinari Daranijo Street, AJ Marinho Drive and Dr. Akin Oguniewe Street (**Figure 5.36**). Notable businesses on these streets include: The Eko Hotel and Suites, The Protea Hotel, and Zenith Bank. These businesses are farther away from the ocean than those on Ahmadu Bello Way, which are 200 meters from the ocean front. The Eko Hotel, for instance, is over three times the distance and is buffered by Kuramo Water and the ribbon of shanties along the coastline. The Protea Hotel (indicated by the blue balloon in the map below) is about 400 meters from the ocean.

Figure 5.36 Streets where the high end hotels and businesses are located

Plate 5.8 shows the view of the shanties from the side courtyard of the Ocean View Hotel, similar to the view from the Eko Hotel.

Plate 5.8 View of the shanties from the Ocean View Hotel

5.32.4 Creek Communities

Long standing village communities located near the Project were consulted from early on in the Project. These villages include:

- Lighthouse Creek;
- Middle Creek; and
- Badagry Creek.

Site visits were also made to Ilase Village and Ituagan Village on 29 January 2009.

Located close to the Port of Lagos and west of the Commodore Channel are the Lighthouse Creek, Middle Creek and Badagry Creek communities. These communities were visited on 27 January 2009 and a second visit to Lighthouse Creek village was made on 2 September 2010. The Nigerian Port Authority (NPA) has jurisdiction over the land inhabited by these communities. Fishing is common to all three communities. In 2009, a team from University of Lagos linked declining fish productivity and poor health (e.g. asthma and respiratory diseases) with the discharge of effluents into Lagos Lagoon. The Lagoon has been subject to oil spills and the dumping of used parts of machines, even abandoned shipping vessels. (September 24, 2009, Next). See **Figure 5.37** for the location of these three Creek communities.

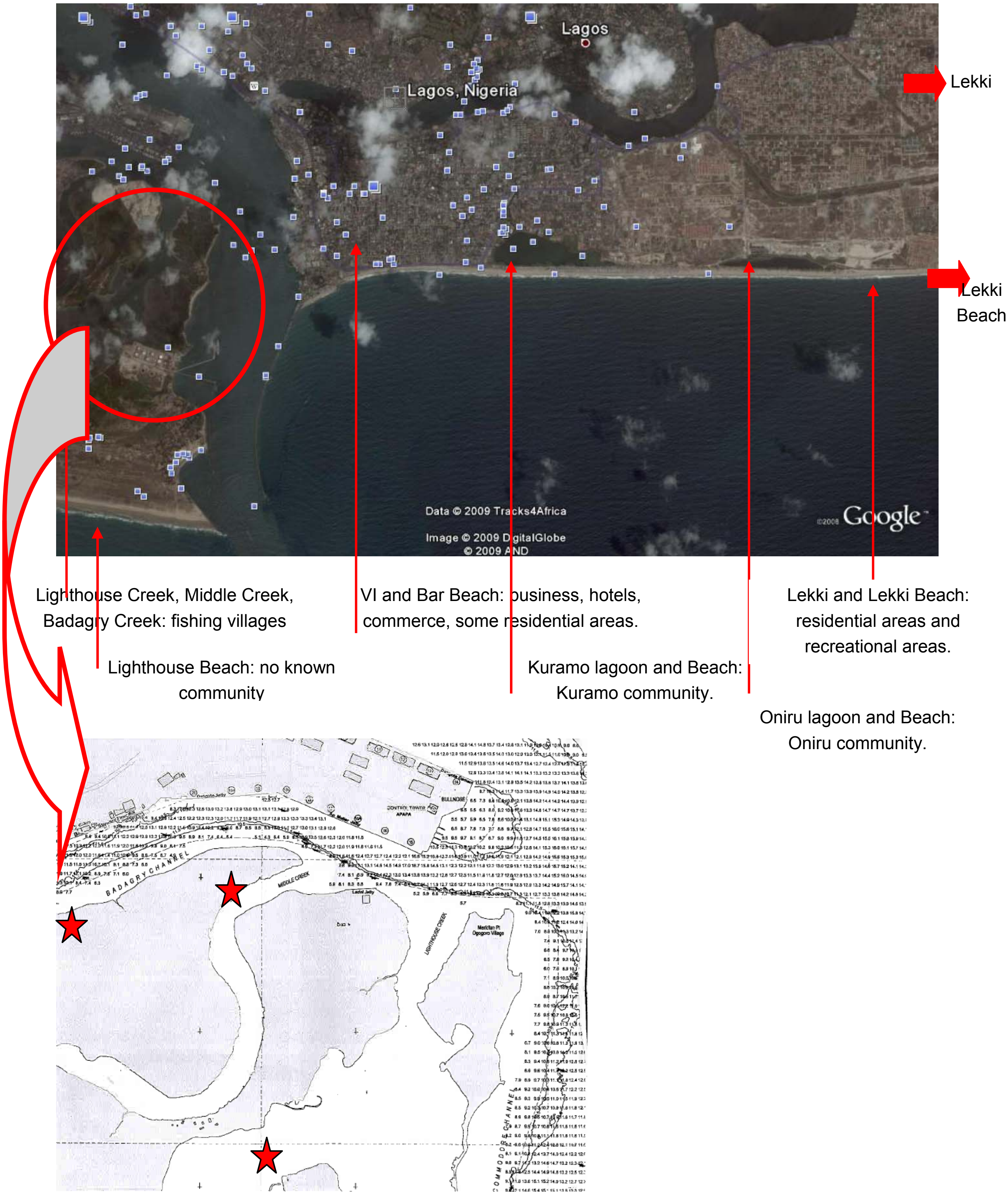

Figure 5.37 Location of the three Creek communities vis-à-vis the Project area

Lighthouse Community at Tarkwa-Bay

The local name for Lighthouse Creek village is Ebute Oko Village. Photographs of the community are provided in **Plate 5.9.** Ebute Oko Village came into existence in 1918 and currently has a population of approximately 6,500 residents. The village is well-established with a community center, church, hospital and primary school. The houses are made from wood and mud. Chief John Owoeye of Tarkwa-Bay, the traditional ruler and head of the community, lives in the heart of the village; he has been Baale for nine years. According to residents, 10 percent of village inhabitants engage in artisanal and commercial fishing for their livelihoods and the remaining 90 percent farm and/or work for wages in Lagos. The fishermen are engaged in fishing at Lighthouse Creek and in the high sea, approximately 10 miles out in the Atlantic Ocean. Fishing activities take place all year round except for high sea fishing, which is limited to the dry season when the waves are calmer. The high sea fisherman row to their fishing grounds in wooden canoe-like boats and use hooks, fishing lines and five- and ten-finger nets to catch the fish, primarily barracudas, pala, red snapper, small sharks and occasionally, turtles.

The high sea fishing route and grounds are outside the boundaries of the Eko Atlantic Project. A thin rock barrier stretching out into the canal was built by NPA in conjunction with a Chinese dredging company for a project connected with the West Mole Development. According to residents, this barrier bars the high seas fishermen access to their fishing grounds and they have to travel around it. They also claim they have to fish farther out because the fish are disturbed by the dredging. The Baale feels disgruntled that the Chinese dredging company has not visited the village once to consult with them about the West Mole Development.

None of the communities in the vicinity would be affected as they are located behind the training mole and the west mole.

Plate 5.9 Pictures of Lighthouse Creek Community

a. Preparing to fish

b. A Catholic Church at Lighthouse Creek

c. A house at Lighthouse Creek

d. Chief J. Owoeye of Tarkwa-Bay and villagers

e. A view of the rock barrier in the distance at the left near the West Mole

Middle Creek Community

The local name for Middle Creek is Ilu ti omi yika. The fishermen living in Middle Creek travel with their boats outside Lagos State and later come back to the village. They travel to Epe, Ijebu of Ogun State, and occasionally, the Lagos State suburbs. Like their ancestors, they follow the migrations of the fish.

The fishermen fish only at daytime and since they must travel far, they depart as early as 3.00 a.m. to 7.00 a.m. They sail up to 20 nautical miles. Their boats were the largest and looked the most solid of the three Creek communities visited (see picture). Nets are of 1, 1.5 and 2 inches.

Most of the houses are built with cement and corrugated sheets and are typical of old Yoruba houses. About 60 percent of the population in this community are fishermen. Most of the fishermen are Egun (from Togo and Cotonou) and Ghanaians. Few Nigerians among these fishermen are the indigenous Yorubas. According to the history of this community, the Egun (from Togo and Cotonou) and the Ghanaians in this community have been living here for many years.

Middle Creek itself has a variety of fish. They include: barracuda, red snapper, sole fish and most importantly, shawa fish. In Ogun State, the main fish they catch are bonga and aboro. Occasionally they come across small shark. The peak fishing period is from January to March and the low fishing period is from June to September.

Plate 5.10 Pictures of boats from the Middle Creek community

Badagry Creek Community

Badagry Creek village, known locally as Itu-Agan Village, belongs to the Amwo Odofin Local Government Area. Itun-Agan, a coastal community of approximately 5,000 inhabitants, is situated along the shores of the Lagos Lagoon in Apapa, opposite the Port of Lagos. There are another 5,000 inhabitants in the neighbouring communities of Ilu Titun, Naty Village, Igbo Alaso and Oko Ata. It is a 15 minute journey to Itu-Agan by speed boat on the Lagos Lagoon, yet it lacks basic services such as electricity and health facilities. Recently, the Community Development Association established two schools in the Village – Itun-Agan Community Nursery/Primary School and Itun-Agan Community High School, which are now under the tutelage of Lagos State Government. The schools have no infrastructure. The buildings are makeshift structures and there are no benches, table or chairs, or toilets. Three hundred pupils attend the primary school. Previously the children travelled by boat to Apapa and Ajegunle to attend school.

The population is almost entirely in the fishing business. One inhabitant reports that 85 percent are fishermen. Many of them are migrant Ilaje from fishing families in Ondo State. Fishing takes place near shore, outside the Village and in Epe and Ijebu, and in the high sea. The fishermen travel 8 miles to different locations on the high sea where there is a high concentration of fish. Common fish found in the high seas include: barracuda, shinino, bone fish, shawa fish, mackerel, small shark, and turtle. Crayfish, shrimp and croaker are caught near shore.

Fishing in the high sea by these fishermen is usually conducted throughout the whole year (January to December 15). The crayfish and shrimp are usually found in large numbers during the raining season (April to August and sometimes March to December). Early morning fishing (4.30 am) is the ideal starting time to catch shrimp. Late evenings (7.00 pm upward) are usually used for catching Shava fish. Shava fish are usually caught in large quantity from February to April. However, the peak period for catching Shawa fish is between January to November. Riverine fish is difficult to catch in the dry season and many families go hungry unless they catch fish in the sea. Fish are sold to fish merchants serving different markets in Lagos. A basket of fish is sold for 7,000 naira in the rainy season and 13,000 naira in the dry season.

a. Equipment to catch crayfish

b. Net used for other types of fish (a boat of the Port of Lagos in the background), c. Women selling fish

d. Types of boat used by the community (Port of Lagos in the background)

e. Boats and housing types in the background

Plate 5.11 Pictures at Itu-Agan Village, Badagry Creek

5.32.5 Communities east of the project area

General

Other communities within Eti-Osa Local Government Area and Eti-Osa Local Council Development Area of Lagos State are Apese, Igbosere, Itirin, Inupa, Olukotun, Okokuku and Ilabare. An additional socio-economic study was carried out to collect main socio-economic characteristics of these communities. This would facilitate strengthening the impact assessment.

This inventory was conducted in May 2012 and by distribution of tailor made questionnaires. A high number of questionnaires have been filled out in the local communities (see **Table 5.53**). The full study has been attached as **Appendix N**.

Table 5.53 Pattern of questionnaire administration

No	Community	Number of questionnaire	Number retrieved
1.	Apese	40	31
2.	Igbosere	20	15
3	Itirin	20	17
4	Inupa	20	14
5	Olukotun	20	15
6	Okokuku	20	13
7	Ilabare	20	18
	Total	**160**	**123**

Historical background

All of the communities in the proposed Eko Atlantic City project area have a common ancestry. Their oral history shows that their common ancestor is from the Oniru family of Lagos. Interactions with the Baale of Itirin community revealed that Itirin community is one of the domains of Oba Oniru. Itirin ancestors migrated from Isale eko (Iga Ologun –Ide otherwise known as Ägole Elepin”). Their major occupation is fishing, they fish along the Marina, Eyingbeti up to Mekunwen before they finally settle down at Itirin village, (where Eko Le Meriden Hotel is located today) under the permission of Chief Orunbe Oniru in the year 1821. As a matter of development Itirin village requested for Baaleship status from Chief Orunbe Oniru and approval was given after due consultation The first baale was installed in 1825. In 1958, Itirin village was moved to the riverine area because of their occupation. The government at that time reached an agreement with Chief Abiodun Onirun to resettle Itirin village and other villages for 25 years as temporary settlement before government would finally settle them in a permanent site. In 1961, Itirin village was moved together with other villages to the Old Maroko by the Government as a temporary site, while in 1990, the Lagos State Military Government announced the demolition exercise of the old Maroko in general on the 7th July, 1990. During, the Tinubu’s administration, in April 2004, they are now located at Lekki Scheme Two (Ikota Resettlement).

The Igbosere people are also fishermen who fish around the kuramo waters. There is a tree called ”Osere” then in the community, after a hard day job, fishermen gathered under the tree for relaxation. After sometime they started building houses and bringing their wives also some of them were farmers, they started planting coconut along the coastline. The first settlers are members of the Oniru family.

The Olukotun community migrated from Abeokuta, they came to Oba Oniru to ask for land from him, he granted their request and they settle there and started building houses. They are farmers; they are involved in oil palm production. At the end of the year they pay royalty to then Oniru. Olukotun was also moved with other villages.

Inupa an ancient village was established bin the 18th century, the people migrated from Apa in Lagos state, they were fishermen, they fished to Lagos Island where they met the then Oba Oniru who gave them land and they settled there. Inupa means a village besides the water; Inupa was also moved alongside other villages to Maroko and finally to Lekki stream two.

Okokuku also known as Okun Alansia was founded by Baba Okun Agba. The people are also under the domain of Oniru, they were hunters and herbalist and they migrated from Togo in the 18th century.

In terms of settlement pattern, they all conform to one basic settlement pattern: nucleated settlement pattern were linearly situated along the coastline area.

Plate 5.12 Settlement pattern along the coastline of the project Area

Population size and age

Eti-Osa LGA has total population of 287,785 consisting of 160,396 male and 127,389 female. The field survey revealed that more than 50% of the population is younger than 20 years while its structure is made up of 55% male and 45% female. The population distribution according to age is visualised in **Figure 5.38**.

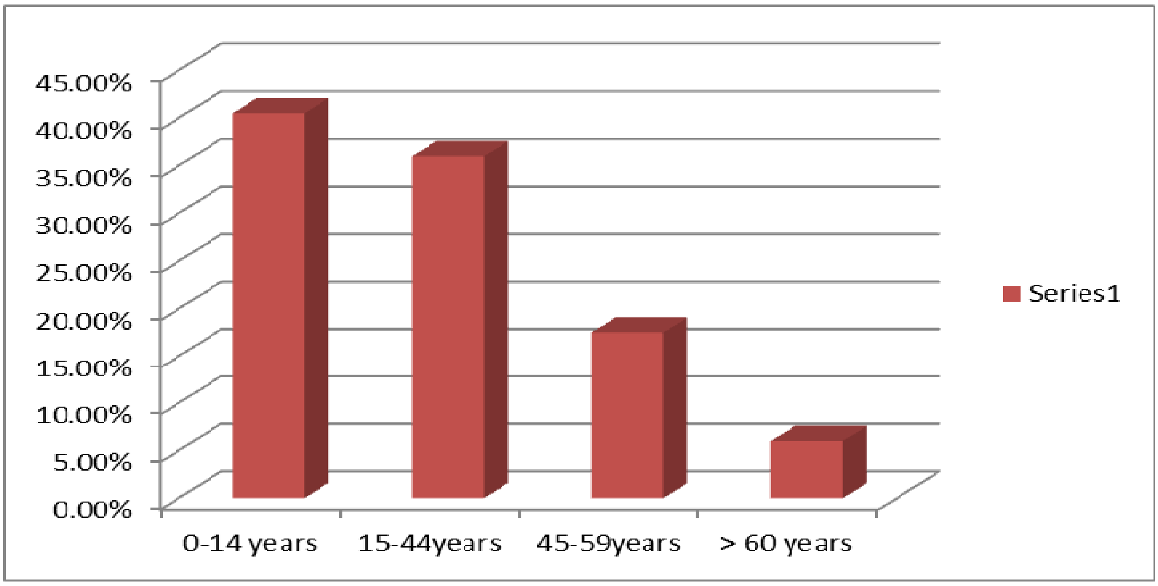

Figure 5.38 Age Distribution of Respondents in the Project area.

Education

The 2004 Nigeria DHS EdData Survey (NDES) reported that sixty percent of the children age 6-11 (64 percent of males and 57 percent of females) attend primary school. School-age children in urban areas are more likely than those in rural areas to attend primary (70 percent versus 56 percent). In addition, there are notable regional differences in the percentage of school-age children attending primary. In the North-West, 42 percent of the children attend, compared with 83% in the South-West and 82% in the South- South.

The above survey results correspond to an earlier report. According to a policy document titled Education For all In Nigeria: Development Partners Perspective, authored in July, 2003, an FME school census (carried out in March 2002) estimated that in 2001, there were almost 19.4 million children in 49,300 primary schools (all public and majority of the private schools) throughout the country, with 460,406 teachers. Estimates were that about 30% of the 6-11 years old were not in primary school, but with wide variations between states. The combination of poor educational quality at all levels, lack of curriculum relevance, and high unemployment of tertiary graduates (at 22%) has eroded the confidence of the students and the parents in the education system. For many of the poor, children do not attend school, because of the direct and indirect costs associated with schooling.

The majority of the people who are actually resident in the project environment and who make decisions on land and development matters are or were barely literate. This constraint notwithstanding (i.e. the proportion of the population who can read and write among the older age cohort was high), the resident population possess a high level of awareness of issues relating to livelihoods. At the household level, most of the children of school age attend primary and secondary schools, while many household/parents also have sons and daughters who are educated but live in the urban areas.

Occupation, income generating activities and employment

Generally, the economic life of the communities around the project environment mainly takes place around water especially fishing. Virtually all the indigenous people are engaged in fishing for a living, using both dugout canoes and engine-enhanced fibre boats that go to deep waters. Coastal and riverine resources such as fish and other pelagic resources such as crayfish are harvested.

Besides fishing (60%), other occupations of the inhabitants of the communities include trading activities engaging (25%), while artisans engages 8% , motorcyclists 5% and civil servants 2% of the population (see **Figure 5.39**). Community participants during the FGD session unanimously confirmed these predominant income generating activities in the study area.

Fishing is conducted all year round and mostly by men, while the women buy, process (smoking/drying) and sell the fishes to buyers, either within the town or are taken to nearby market for sale. Some of the women in the village are also engaged in the collection of pelagic organisms, primarily crayfish and periwinkle.

Plate 5.13 Canoe used for fishing activities

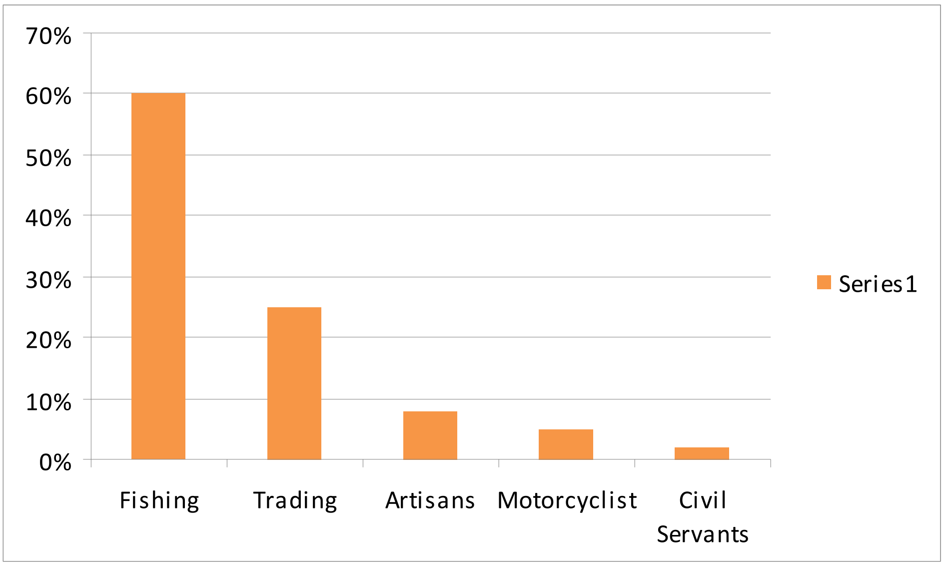

Figure 5.39 Occupation Distribution of Respondents in the project Area

Personal Income

The average income per adult in the project area is fair (compared to national average income), estimated at N40000 per year. The dominance of informal sector jobs (fishing, trading, artisanship, motorcyclists, etc) which account for

98% of the employment, explains the fair income level of the inhabitants of the area as the sector is characterised by low productivity and income. The income distribution is presented in **Figure 5.40.**

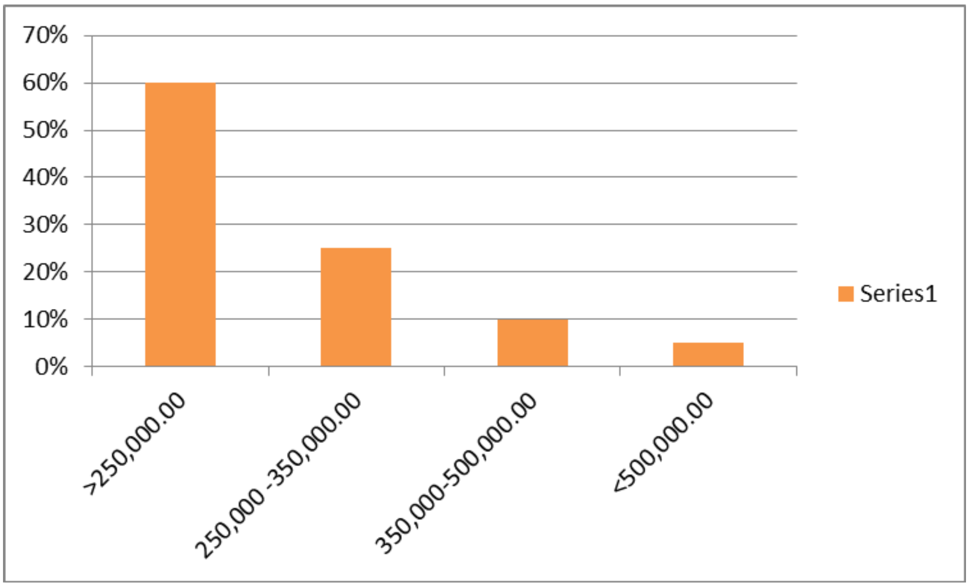

Figure 5.40 Income of Respondent in the Project Area

Social infrastructures

The level of infrastructure and amenities available and functional in any area or community has direct implications on the quality of life in that area. The field observations in the vicinity of the Eko Atlantic Project show very poor availability of basic social infrastructures...

(a) Educational Facilities

The socio-economic survey shows no school in the community; children of school age go to schools in the neighbourhood.

(b) Electricity

The communities are not connected to the national grid of the Power Holding Company of Nigeria (PHCN), but there is electricity in the neighbouring Victoria Island and the Oniru estate.

(c) Transportation and Communication

Both primary and secondary roads run from Lagos Island to Victoria Island. The population is served by a mix of transportation modes, cars, trucks and buses, motorcycles, bicycles. As coastal villages, the use of boats for transportation and communication is also common. Transport of the variety of goods takes place especially on market days. The new mode of telephony, the GSM, which has made telecommunications much easier across most communities in Nigeria, has full utility in the project area (all the networks are available).

d) Water Supply

Accessibility to safe water is vital to reducing the frequency of associated water-borne diseases and can be used to assess the state of human health. Therefore, this indicator has crucial influence on human health and sustainable development. The resident population has no access to modern potable water facilities. Residents buy water from vendors around.

Plate 5.14 Hand Dug Well in One of the Communities in the Study Area

e) Housing and Housing Quality

The provision of good housing is an important aspect of environmental health. It represents a significant part of man's environment; shelter from the elements; workshop (the kitchen for the housewife, the playroom for the children and tool-shed for the adult males); and home (the residence of the family, where this social institution carries out some of its major functions. The housing stock in the outlying fringes of the community is of shanty type.

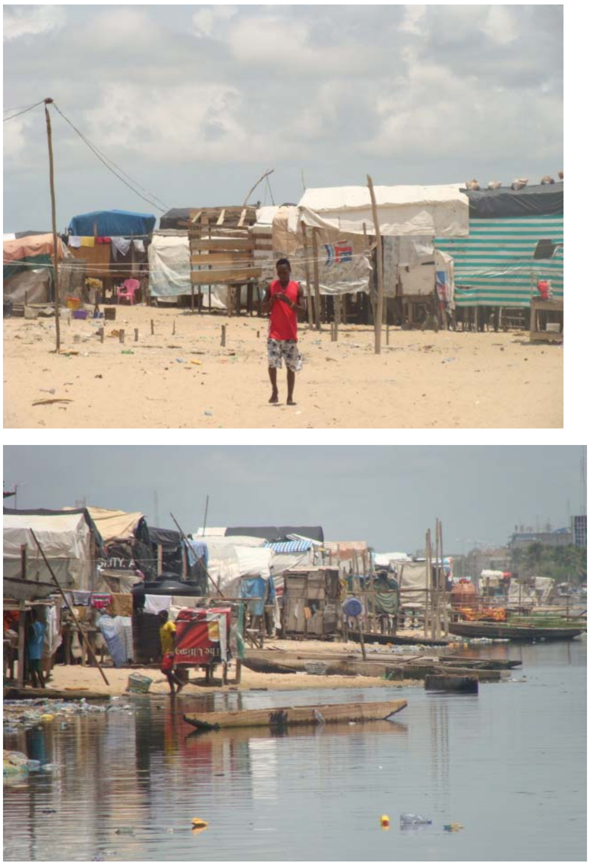

Plate 5.15 Housing Type in One of The Communities in The study Area

6 POTENTIAL AND ASSOCIATED IMPACTS

6.1 Introduction

The purpose of this chapter is to identify, predict and evaluate the significance of the potential environmental and social impacts that may occur as a result of the proposed project. **Section 6.2** provides a description of the methodology used for the impact assessment and **Sections 6.3** to **6.16** present the impact assessment for the parameters which may be affected by the Project, either positively or negatively. Finally, **Section 6.18** details the cumulative effects assessment for this project.

All stages of the Project are considered in the impact assessment: The potential impacts have been grouped into construction (site preparation, reclamation, dredging etc.) and operation (presence of the reclamation site within the environment, following construction). Decommissioning of the Project is not considered relevant in this impact assessment, as the structure will be permanent. As such, this aspect is not analysed further in this report.

As defined in the Terms of Reference, the following aspects of the environment are considered in the Impact Assessment:

- Coastal Morphology, Sediment Processes and Meteorology
- Water and Sediment Quality
- Groundwater
- Air Quality
- Noise and Vibration
- Marine and Coastal Ecology
- Lagoon Ecology
- Ornithology
- Terrestrial Ecology
- Socio-economic Impacts
- Navigation
- Landscape and visual quality
- Recreation
- Cultural heritage
- Health and Safety
- Cumulative Effects Assessment

6.2 Impact Evaluation Methodology

6.2.1 Statement of impact

For each parameter assessed in this EIA, a textual description of the impact is provided in the following sections, followed by a characterisation of the impact in terms of its nature and magnitude or physical extent. The magnitude or physical extent of impacts has been quantified wherever possible. In line with Nigerian Legislation, the nature of predicted impacts has been identified, as appropriate, in consideration of the following potential project specific effects:

- Beneficial or adverse.

- Direct or indirect.
- Short-, medium- or long-term.
- Permanent or temporary.
- Secondary.
- Reversible or irreversible.
- Cumulative.

Where an impact is quantified, thresholds are applied to determine the level of significance of an impact, unless otherwise stated. Where an impact cannot be quantified because of the nature or complexity of the impact, a subjective scale has been used to determine its significance.

6.2.2 Definition of Impact Significance

The potential impact of the proposed works on environmental parameters and interests has been assessed using a technique which considers the significance of the impact as being built up from a number of individual, but interrelated, components. For the purposes of the EIA process, a significant change (or effect) has been determined as one where the predicted net impact of the activity or process would exceed the normal variation in baseline conditions without the scheme.

The definition of significance involves consideration, through data analysis, consultation and experience, of a number of aspects relating to the potential impact. These are listed and explained below.

<u>Sensitivity of the receiving parameter</u>
This is a measure of the adaptability and resilience of an environmental parameter to an identified impact:

- ***High*** – The environmental parameter is fragile and an impact is likely to leave it in an altered state from which recovery would be difficult or impossible.
- ***Medium*** – The parameter has a degree of adaptability and resilience and is likely to cope with the changes caused by an impact, although there may be some residual modification as a result.
- ***Low*** – The parameter is adaptable and is resilient to change.

<u>Magnitude of the impact</u>
This is the scale of change which the impact may cause compared to the baseline and how this change relates to accepted thresholds and standards.

- ***High*** – A large change compared to variations in the baseline. Potentially a clear breach of accepted limits.
- ***Medium –*** Change which may be noticeable and may breach accepted limits.
- ***Low*** – When compared with the baseline, change which may only just be noticeable. Existing thresholds would not be exceeded.

<u>Frequency of the impact</u>
This is the duration of the impact compared to the activity causing it.

- ***Continuous*** – The impact persists over the life of the activity causing it.
- ***Frequent –*** The impact is likely to occur for a period of greater than 5% of the life of the activity, or will be intermittent.

- ***Infrequent*** – The impact is likely to occur for a period of less than 5% of the life of the activity.

<u>Extent of the impact</u>
This relates to the geographical area that the impact may affect.

- ***Local/immediate*** – The impact is likely to affect interests at district level or for a limited area around the scheme.
- ***Regional*** – The impact is likely to affect sub-national concerns such as regional and county level interests.
- ***International*** **–** The impact is likely to affect an interest of supra-regional concern.

Unless otherwise explained in the accompanying text it is considered that all identified impacts are local in extent although interest features of potential regional and/or international significance may be affected.

<u>Timescale of the impact</u>
This is the duration of the impact irrespective of the activity causing it.

- ***Short-term*** – The period over which the impact is experienced is temporary and lasts for the period of construction or less.
- ***Medium-term*** **–** The impact occurs for longer than the full period of construction.
- ***Long-term*** – The impact remains for a substantial time, perhaps permanently after construction.

6.2.3 Calculating Significance

Following on from the above, and to better portray the identified significance of a project on specified parameters and receptors, a consistent set of significance levels have been applied to impacts throughout this EIS. The levels of significance applied are shown in **Table 6.1**.

Table 6.1 Definition of significance

Significance	Definition
Major Adverse	The impact is large scale, giving rise to great concern. It may be considered unacceptable.
Moderate Adverse	The impact gives rise to some concern, but it is likely to be tolerable in the short-term.
Minor Adverse	The impact is small scale and of little concern, being undesirable but acceptable.
Negligible	The impact is so small that it is barely noticeable and is of no concern.
Minor Beneficial	The impact is small scale and of slight significance, providing some benefit to the environment.
Beneficial	The impact provides positive gain to the environment.
Major Beneficial	The benefit is large scale, providing a significant positive gain to the environment.

The criteria for definition of impact significance can be used to ‘score’ the level of significance of a particular impact, using the formula below:

Significance of impact = Magnitude of effect x Value and sensitivity of Receptor

This formula provides us with a better appreciation of the fact that as the sensitivity of the environment and the magnitude of the effect (accounting for impact frequency, extent and timescale) increases, so the significance of the effect increases. This is illustrated in **Table 6.2**.

Table 6.2 Dependence of significance on magnitude and sensitivity

		VALUE & SENSITIVITY		
		Low	Medium	High
MAGNITUDE	High	Moderate	Moderate/Major	Major
	Medium	Minor/Moderate	Moderate	Moderate/Major
	Low	Minor	Moderate	Moderate
	Negligible	No Impact	Minor/Moderate	Minor/Moderate

6.2.4 Cumulative Effects Assessment Methodology

A cumulative impact arises when impacts from several developments, which individually might be insignificant, coincide together and potentially produce a significant cumulative impact and there is a legal requirement to consider such impacts.

The cumulative impacts process occurs over time and over space from the local to the regional level (Council on Environmental Quality, 1997). For the purposes of the cumulative impacts assessment the environmental effects of any other development that is already built and operational is effectively included within the environmental baseline of the EIA, so is excluded from the cumulative impact assessment. Developments that are included may have been built in the recent past but are not yet operational, be under development or will be undertaken in the reasonably foreseeable future.

To be considered within the cumulative impact assessment other development schemes must meet the following criteria:

- generate their own residual impacts of at least minor significance;
- be likely to be constructed or operate over similar time periods;
- be spatially linked (similar geographic area / receptor over which impacts may occur)
- be either consented (but not operational) or be the subject of applications with the statutory authority in the area or be the subject of another statutory procedure.

The CEA is provided in Section **6.18**.

6.3 Coastal Morphology, Sediment Processes and Meteorology

This section provides a description of the impact assessment for coastal morphology and sediment processes. This section also provides a summary description of the modelling assessment methods undertaken to inform the assessment. No impacts on meteorology are expected as a result of this project and as such this is not covered further in this section.

6.3.1 Assessment Methodology: Coastal Modelling

A comprehensive morphological modelling study was undertaken by Royal Haskoning (**Appendix H**) to investigate potential coastal erosion at and adjacent to the Project site resulting from the proposed scheme. The coastal modelling had the following objectives:

- To provide a clear picture of the coastal processes around Lagos and in the vicinity of the reclamation area for the existing situation (baseline scenario);
- To assess the impact of the Eko Atlantic project on the coastline (evolution) and other users; and
- To provide information for design and optimisation of coastal mitigation works.

These objectives were met by assessing the flow patterns, the nearshore wave conditions and the sediment transport conditions in the vicinity of the reclamation area for the existing and proposed coastal configurations. The methods for the study are summarised below, and full details can be found in **Appendix H**.

During the study, an extensive literature search was carried out to gather as much information as possible to address the relevant issues. Several studies of coastline erosion near Lagos have been carried out in the past, in particular, Okude and Taiwo (2006) and Ibe and Intia (1983). Useful information was also provided in ENTECH & CSIR (2001). In addition to the literature review, an extensive data collection campaign was undertaken to obtain sound background information. Following this, the data was interpreted to obtain an initial level of understanding of the problem and to establish a reliable and consistent data set that was used for all modelling studies.

The morphological effects of the Eko Atlantic project have been investigated using a detailed (coupled) sediment transport model that consists of current flows, waves and sediment transport characteristics. In order to assess various design options and before and after scenarios, the following three scenarios were examined in the study:

- Present situation;
- Eko Atlantic project layout I; and
- Eko Atlantic project layout II, with a characteristic S-shape at the eastern end.

For all modelling activities, state of the art marine modelling software packages MIKE21 and LITPACK from Delft Hydraulics Limited (DHL) have been used.

The approach involved the following tasks:

- estimate the potential annual longshore transport along the coast of Lagos;
- simulate the present coastline development around Lagos;
- predict the long-term coastal impacts of Eko Atlantic on longshore sediment transport; and
- study the most effective mitigation strategy for a worst case scenario.

The MIKE-LITPACK coastal modelling package was used for this work. The LITDRIFT package was applied to calculate longshore transport rates and LITLINE was used to predict coastline development, changes based on the calculated longshore transport and the evaluation of mitigation schemes.

MIKE21-ST was also used in this detailed study, which is a module in the MIKE21 application suite for calculation of non-cohesive sediment (sand) transport rates. Both waves and currents can be taken into account. In addition to the sand transport rates (longshore and cross-shore), a simulation gives insight into the instantaneous rates of bed level changes. This enables identification of potential areas of erosion or deposition. The MIKE21-ST model which is applied in typically 2D situations was run in coupled mode with MIKE21-HD (flow module) and MIKE21-SW (spectral wave module). The modules exchange information about wave radiation stresses (caused by breaking waves) and water levels. More details about the **Appendix H**.

6.3.2 Assessment Methodology: Wave Disturbance Modelling

The wave modelling study was designed to determine the difference in wave conditions following the construction of the Eko Atlantic sea defence. The full wave modelling report can be found in **Appendix H** and the text below provides a summary of the method. The wave data obtained in previous studies by Royal Haskoning has been used to determine typical operational and extreme wave heights, periods and directions (**Table 6.3**).

Table 6.3 Selected typical operational and extreme wave conditions

Conditions	Hs (m)	Tp (s)	Direction (ºN)
Operational	1.0	10 to 20	170 to 210
	2.0	15	170 to 210
Extreme	4.0	20	170 to 210

The MIKE 21 BW model was selected for the modelling work (DHI, 2010a). The MIKE21 BW model incorporates the latest development of the enhanced Boussinesq equations which include nonlinearity as well as frequency dispersion making the model more suitable for simulation of the propagation of directional wave trains travelling from deep water to shallow water. Details of the MIKE21 BW model are provided in **Appendix H**. **Figure 6.1** shows the model area. The southern boundary was extended offshore so that there is enough distance for waves to stabilise before they interact with the breakwaters. The east and west boundaries were at distance from the breakwaters to include local effects into the wave climate. The northern boundary was set in such a way to include the Commodore Channel fully. The overall model domain measured 6250m×6500m.

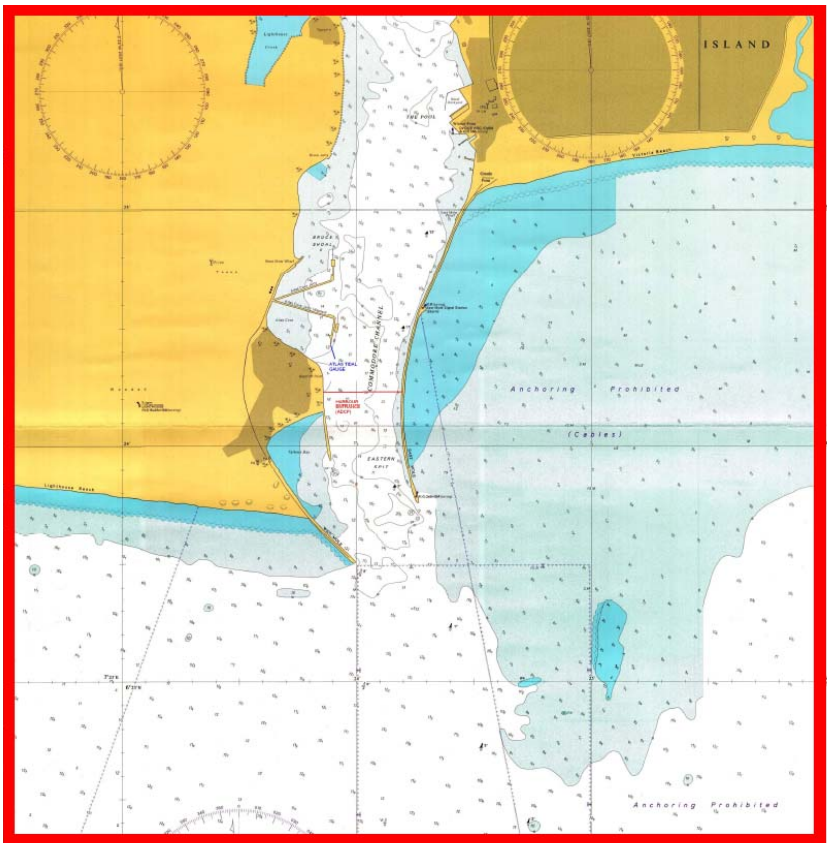

Figure 6.1 Model area (Admiralty Chart No. 2812, 5th edition, 4th October 2007)

Breakwaters and Revetments Configurations

a) Existing condition

The existing condition of the East and West Moles were included within the model. Topographic survey data from 2008 was used to locate these moles. The recently repaired Training Mole and the X-Block revetment at Bar Beach were also included in the model.

b) Eko Atlantic condition

The model setup for the existing condition was used with addition of the Eko Atlantic City revetment. The western 3.2km of the revetment was included in the model. The remaining (eastern part) of the revetment was not included as it will not affect the wave conditions at the harbour entrance and inside the Commodore Channel.

Model Grid

A rectilinear grid was used in the model. A square grid (5m×5m) was used to provide high resolution in areas where changes to physical processes take place rapidly and over short distances. This high resolution grid size was also used for the remaining areas of the model. **Figure 6.2** shows model grids near the West Mole (shown in red).

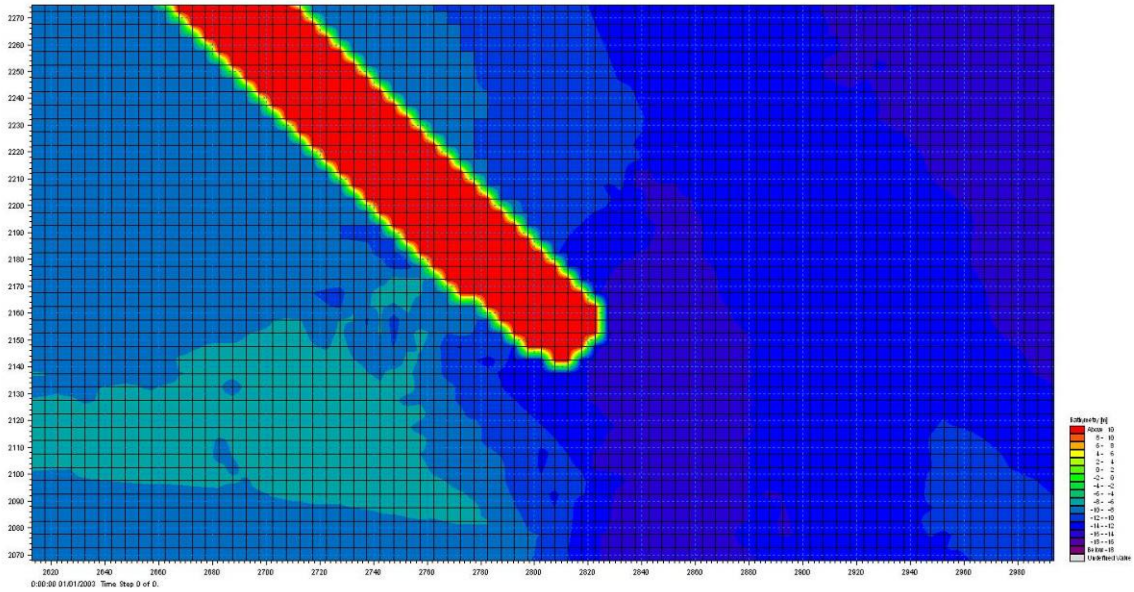

Figure 6.2 Model grid (west mole in red)

Model Bathymetry

The MIKE21 BW model requires an accurate bathymetry to acquire reliable results. The CMap (2010) bathymetry data was combined with the recent survey data available for the Commodore Channel (Deep, 2010) and the Eko Atlantic City (Deep, 2008). CMap data is a digital form of the Admiralty bathymetry supplied under licence for use specifically in coastal models. The accuracy of this data is the same as if extracted directly from Admiralty Chart data at the various scales available. The combined bathymetry for the entire model area is shown in **Figure 6.3** (without the Eko Atlantic revetment). The bathymetry file was then modified to include the Eko Atlantic revetment (**Figure 6.4**).

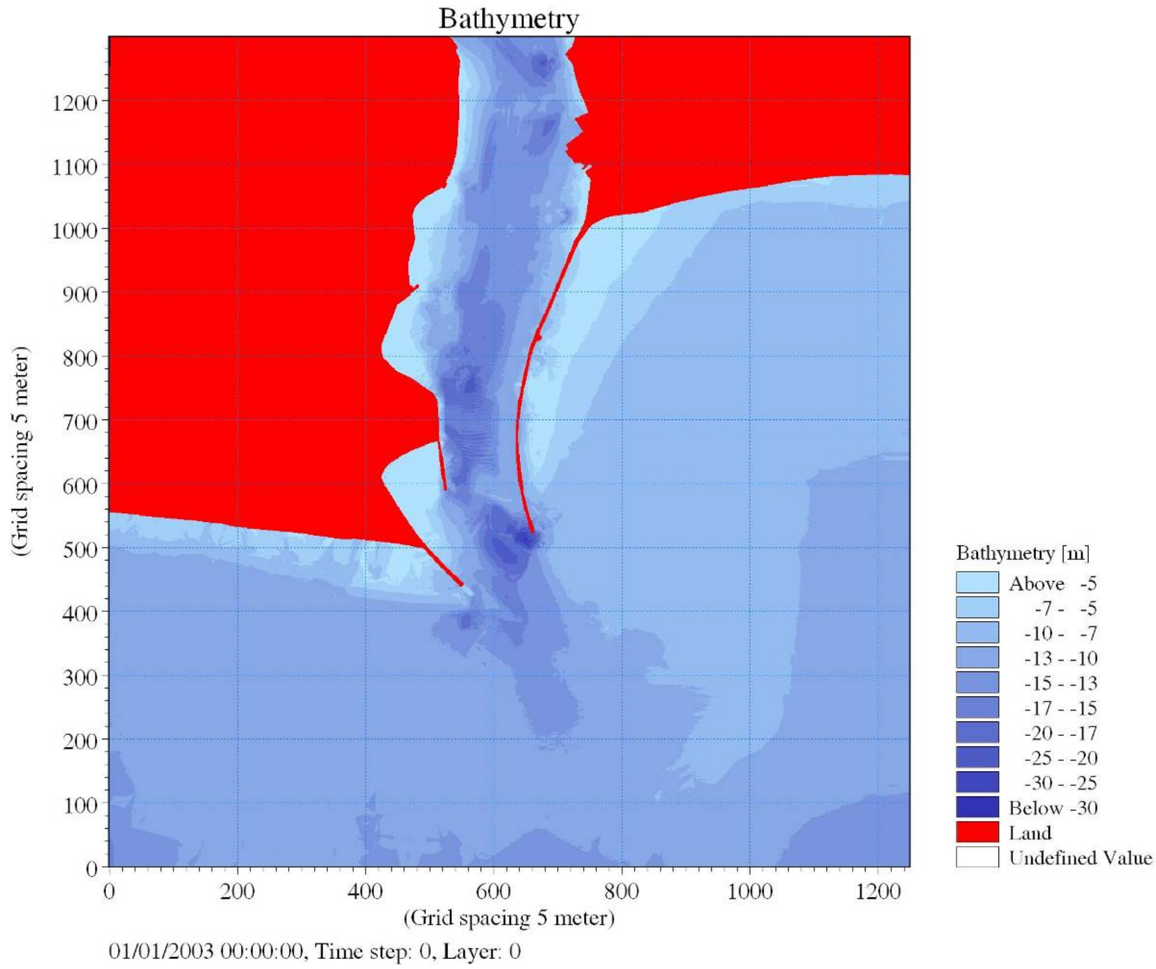

Figure 6.3 Model bathymetry [without the Eko Atlantic revetment]

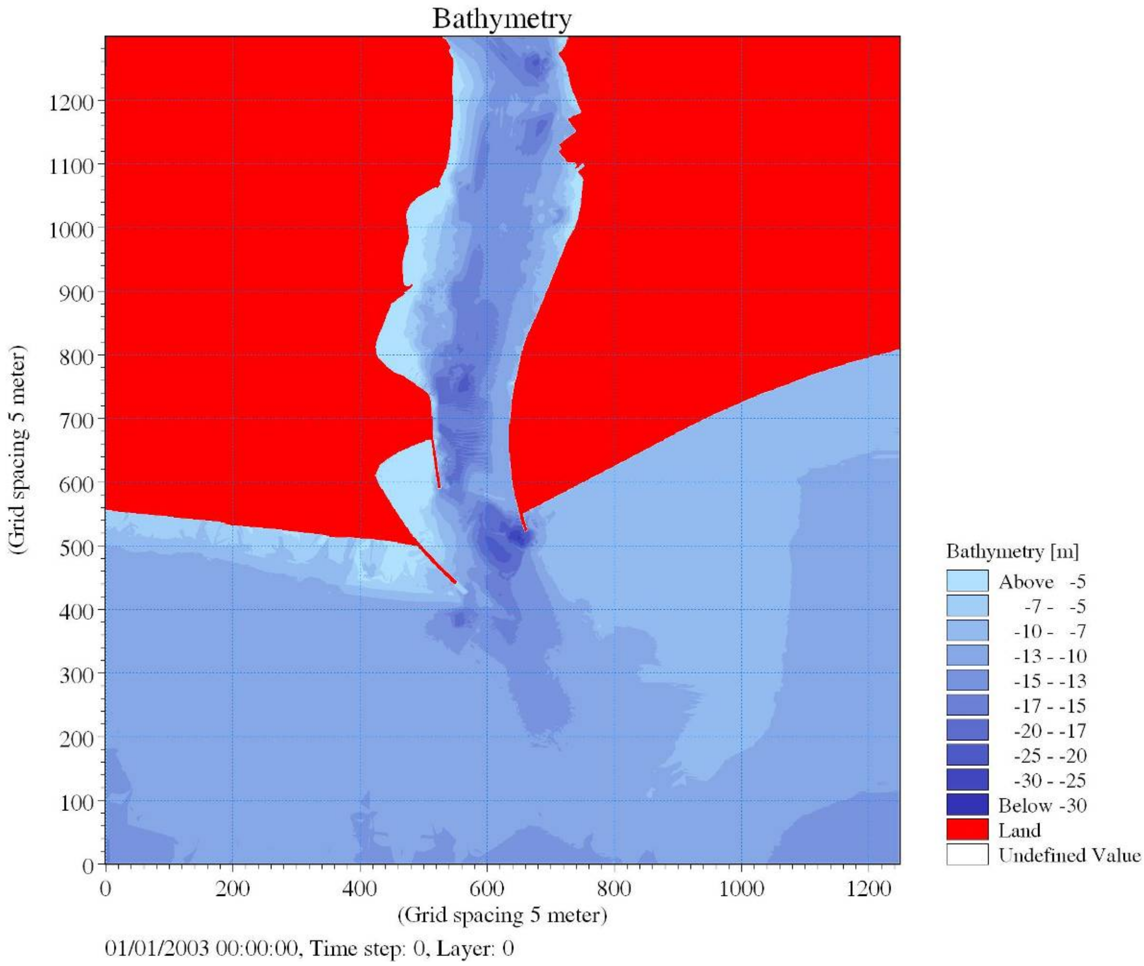

Figure 6.4 Model bathymetry [with the Eko Atlantic revetment]

Wave Reflection

The MIKE21 BW model considers wave reflection from various edges. The percentage of wave energy reflected from the principal types of construction used within the harbour was as follows:

- Solid vertical wall (north-east boundary) 90%
- Slope armour with rock or concrete units (breakwaters) 45%
- Bar Beach X-block revetment 45%
- Eko Atlantic revetment 60%
- Sandy beach 10%

The reflection percentage of the Eko Atlantic revetment was based on physical model tests recently carried out at DHI (2010b).

Water levels

The water levels given in **Table 6.4** have been used to assign typical operational and extreme conditions.

Table 6.4 Typical operational and extreme water levels

Conditions	Water levels (mCD)
Operational	0.15 (mean low water)
	0.82 (mean high water)
Extreme	2.0 (1 in 100 year)

6.3.3 Potential Impact during Construction

Impact of dredging and reclamation activity on coastal morphology

During construction, no significant negative impact on coastal processes and hydrodynamics are predicted, as the majority of effects from the development on this receptor will occur in the longer term, following the dredging and during the ''operation'' phase of the reclaimed island. However, during the long construction phase, the reclamation activities will have a positive impact on coastline, as the beach areas of Victoria Island will be nourished thereby increasing the beach width and the natural shoreline protection. It is considered that this activity will help prevent further erosion of the foreshore at Bar Beach (in stages) and therefore will have a **major beneficial impact** on the local environment at Victoria Island during the construction process.

Impact Box 6.1 Impact of dredging reclamation activity on coastal morphology

Description of Impact	Impact of dredging reclamation activity on coastal morphology
Receptor(s)	Coastline of Lagos
Investigation/reference	Study including modelling; Section 5.9; Appendix H, I, J
Features of Impact	Long term
Significance of Impact	**Major beneficial Impact**
Mitigation advice	None required
Residual Impact	**Major beneficial Impact**

6.3.4 Potential Impact during Operation

Impacts of Eko Atlantic reclamation on coastal erosion and accretion

The impacts presented in this section have been assessed by a thorough desk based analysis of the coastal processes during the last century. In addition, the knowledge and data gathered have been applied in comprehensive modelling programs to obtain a better understanding of the coastal processes. Such modelling studies help to estimate the rate of erosion and/or accretion that could be expected following the development of the Eko Atlantic Project. The accuracy of the results is mainly governed by the quality of model input parameters (hydraulics, sediments etc.) and the quality of the computer algorithms (Refer to **Appendix H** for complete modelling reports).

Desk based assessment

The analysis identified that there is longshore sediment transport from west to east in the project region, which is driven by the dominant oblique ocean waves from the southwest. Since the construction of the Lagos Harbour Moles in the early 1900's, there has been considerable erosion along Bar Beach. Analyses of historical records on coastline retreat at Bar Beach indicate that a significant volume of the sediment transported west to east along Lighthouse Beach has been blocked by the Lagos Harbour Moles, in particular the protruding West Mole. This is supported by observed accretion along Lighthouse Beach over the same period as the erosion has been observed at Bar Beach. The area to the west of the West Mole has effectively been operating as a sand trap.

Following years of accretion, the sand at Lighthouse Beach has extended to reach the tip of the West Mole (**Figure 6.5**). It can therefore be expected that the west to east sediment transport has been partially re-established as sand can more easily bypass the tip of the mole. This hypothesis is supported by the observations recorded following the placement of an X-Bloc revetment at Bar Beach in 2006, as a temporary solution to the erosion problem at the Beach. Prior to the placement, it was predicted that greater erosion would be experienced to the east of the revetment at Kuramo Waters and further eastwards. However no further progressive erosion at these locations was observed after completion of the scheme, over a period of 4 years to date. The absence of further significant erosion could be explained by the fact that the West Mole was no longer trapping the littoral transport of sand. Another possibility is that the sea bed in front of the X-blocs was deepened and erosion was still on-going.

At the same time as the Eko Atlantic marine works are planned, NPA will rehabilitate the West Mole head of the Lagos Harbour Moles. This means that the West Mole will be built up to its original length, which implies that the head of the West mole currently far below water level will be elevated to a height of +5m CD over a length of approximately 100m. This in turn may result in increased sand trapping. As such, it could be predicted that the amount of sand bypassing the Moles will be reduced for a certain period of time until the trap is full again.

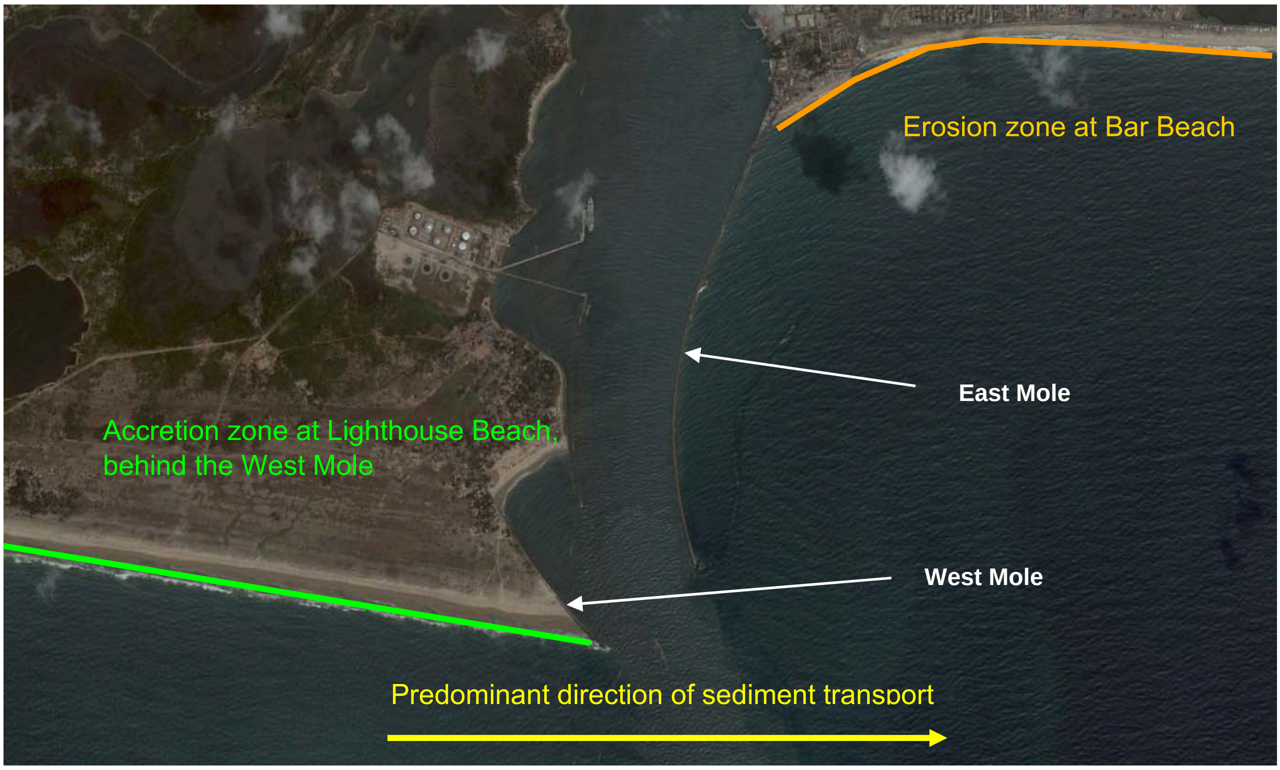

Figure 6.5 Schematic to indicate erosion and accretion patterns around the Project site.

Given the information presented above, it is predicted that once the Eko Atlantic sea defence is in place (*i.e.* during the operation phase of the reclaimed land), erosion to the east of Eko Atlantic may occur. This erosion could be expected to continue until the sand trap at Lighthouse Beach is full and sand can once again bypass the West Mole.

The degree to which Eko Atlantic will affect the erosion to the east is mainly governed by the sand bypassing performance of the Lagos Harbour Moles and the time that is needed to re-instate a dynamic equilibrium on the coastal processes at the Lagos Harbour Moles tips and in front of the Eko Atlantic sea revetment.

Modelling Study:

The LITPACK modelling (1D) program has been used to support the desk based assessment of the erosion and accretion effects described above. LITPACK is a state of the art modelling tool; however, as with all modelling programs, expert judgement must be used with regard to determining accuracy and interpretation. The interpretation of the results of the model runs can only be made by qualified professionals, who have appropriate project experience of the models. The results of the LITPACK modelling (1D) program are intended for use in the qualitative comparison of the performance of design alternatives and the resulting figures should be interpreted carefully.

The LITPACK analysis considered two scenarios; (1) the baseline situation (*i.e.* with no project) and (2) that with the Eko Atlantic Reclamation present. The analysis indicates that in the baseline situation erosion of 50m is predicted over a period of 10 years within the model boundaries (an area extending to 5km east of the project). In the worst case scenario after construction of EKO Atlantic, with only limited sand bypassing the West Mole, the erosion is estimated to be maximum of 120 m over a period of 10 years. The model indicates a maximum of 70m increased erosion over a 10 year period. **Figure 6.6** and **Figure 6.7** illustrate the results of this modelling.

It should be noted that the Commodore Channel has been schematised as a functional source and sink of sediment in the model. This means that it is assumed that very little sediment will bypass the West Mole and be able to transport east. However, the amount of sediment that will bypass is not known. An accurate assessment of the volume of sediment bypassing is difficult to ascertain and would demand many years of sampling and monitoring. As highlighted above, the erosion estimation is conservative and it is considered likely that more sediment will bypass the West Mole than is assumed in the model. In the case that more sediment can bypass, it will significantly reduce the erosion effects to the east.

At a more detailed level, localised erosion impacts at the east end of the Eko Atlantic scheme are predicted to arise due to effects at the eastern end of the reclamation and initial littoral sand-deficits. However, this effect has been partially mitigated by the smoother S-shape of the sea revetment along the Public Services Island extension of Eko Atlantic. This design improvement is supported by the modelling results presented in **Appendix H**.

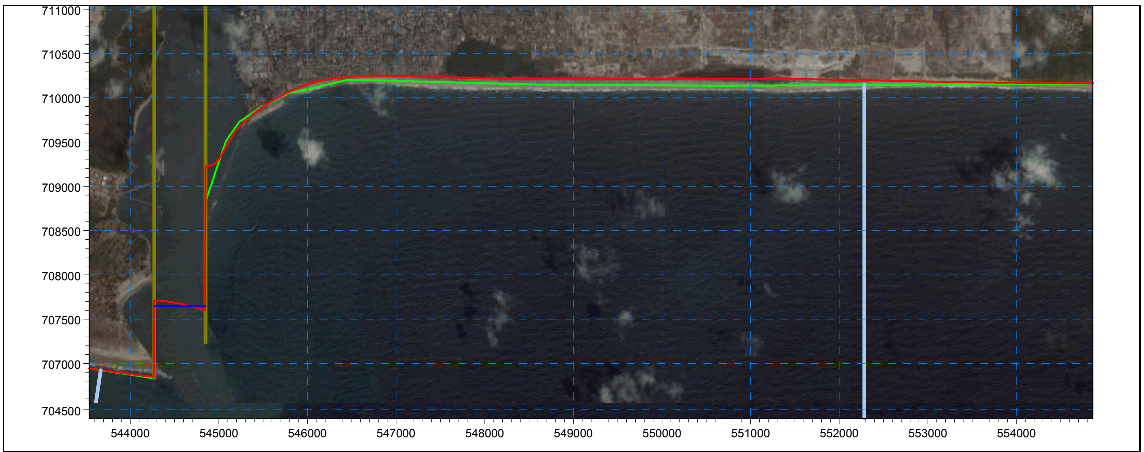

Figure 6.6 Shoreline development of the Baseline condition after 10 years.

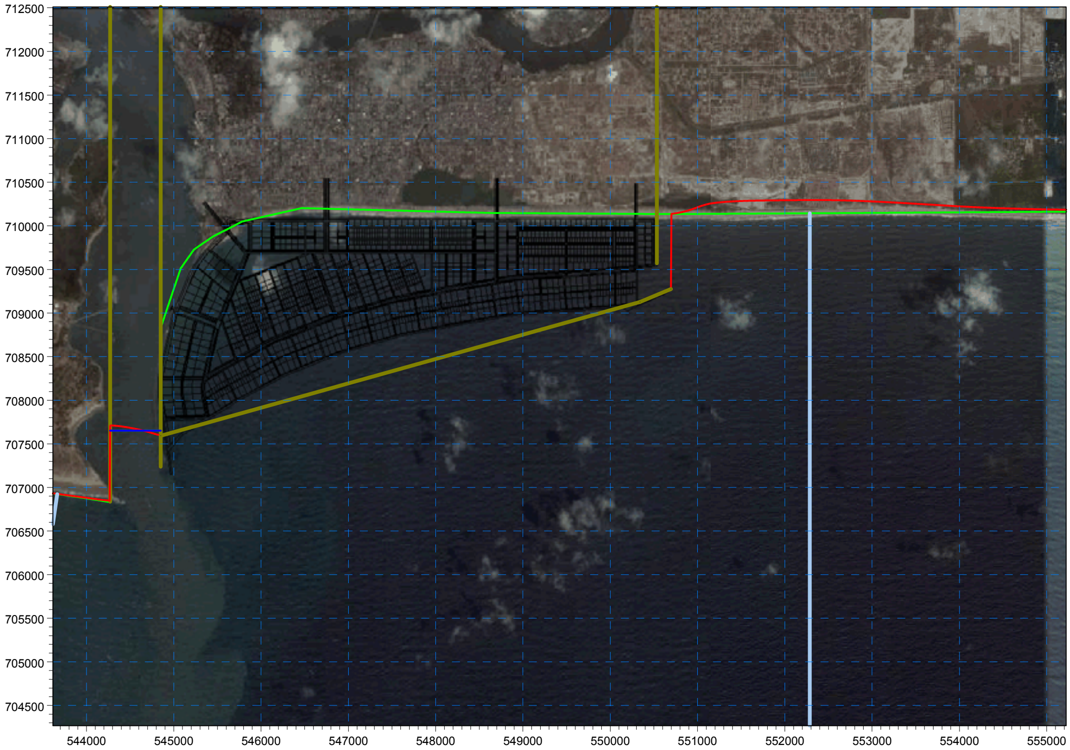

Figure 6.7 Litline schematization for EKO Atlantic City scenario

In summary, the presence of the Eko Atlantic land reclamation and shoreline protection will shift the erosion of Bar Beach eastwards. The project is therefore predicted to have a **major adverse** significance over a length of 3km to the east of the project and **moderate adverse** significance up to 10km to the east of the project. The selection of the chosen layout with an s-shape would help to minimise the effects on erosion through creating a more natural shape and improving sand bypassing the commodore Channel. However, monitoring and mitigation measures are required in order to reduce the level of this impact to acceptable levels. An adaptive coastal erosion mitigation scheme is required. Such an adaptive approach is widely adopted as an approved measure to mitigate coastline retreat (see Paragraph 8.6). With these in place, an impact of **minor adverse** significance is predicted compared to the autonomous coastline development.

Impact Box 6.2 Impacts of Eko Atlantic reclamation on coastal erosion and accretion

Description of Impact	Impacts of Eko Atlantic reclamation on coastal erosion and accretion
Receptor(s)	Coastal communities, habitats and infrastructure to the east of the project site.
Investigation/reference	Study including modelling; Section 5.9; Appendix H, I, J
Features of Impact	Long term
Significance of Impact	**Moderate to Major adverse impact**
Mitigation advice	• Selection of the layout with the addition of an S-shaped extension on the east side of the project area. • Implementation of adaptive coastal erosion mitigation

	scheme (See Table 8.1)
Residual Impact	**Minor adverse impact**

Impacts of dredging on longshore sediment transport at the coast

Sediment to fill the Eko Atlantic reclamation is to be dredged from an offshore borrow pit to the east of the proposed city. Removal of sediment from the seabed will take place in water deeper than 15m from Borrow Area A. One-dimensional modelling (using the LITDRIFT module of the DHI Litpack model) was carried out along three representative cross-shore profiles across the proposed borrow area and adjacent coastline. Dredging at -10m, -15m and -20m CD were input to the model to predict impacts on longshore sediment transport. The results showed that for wave heights less than 2.25m combined with periods less than 12s, impacts on longshore sediment transport were very small for borrow pits at all water depths. However, for higher and longer period waves, sediment transport rates increased by 10-20% for a borrow pit at -10m, whereas at borrow pit depths of -15m and -20m the impacts remained very small. Based on the one-dimensional modelling results alone, there is **no impact** on sediment transport at the coast of a dredged borrow pit in water depths greater than 15m.

An empirical formula was used to assess the impacts of dredging on the cross-shore profile. The results showed that the profile is unaffected by borrow pits in water depths greater than 15m, but could potentially be drawn-down if dredging takes place in water depths less than 10m. However, the formula is only appropriate where the closure depth is in water depths greater than the depth of the borrow pit. In this case, the closure depth is considered to be less than 10m and hence the empirical formula may not apply.

It should be emphasised that the longshore sediment transport results are based on a one-dimensional model, which only simulates the situation in one dimension (in this case alongshore) and assumes that the other dimensions do not vary. This provides a quick and simple method to determine whether additional modelling may be required. The LITDRIFT module does not consider the two-dimensional effects of bathymetric change including refraction, cross-shore sediment transport, and potential changes to the closure depth. Dredging and its impacts are two-dimensional processes and a two-dimensional sediment transport model (for example MIKE21-ST) would provide greater confidence in the coastal erosion impact predictions.

Impact Box 6.3 Impacts of dredging on longshore sediment transport at the coast

Description of Impact	Impacts of dredging a borrow pit on longshore sediment transport at the coast (based on one-dimensional modelling only)
Receptor(s)	Users of the beach
Investigation/reference	Study including modelling; Section 5.9; Appendix H, I
Features of Impact	Long term
Significance of Impact	**No Impact**
Mitigation advice	Ensure that dredging is only undertaken in depths greater than the 15m depth contour.

	Implementation of adaptive coastal erosion mitigation scheme (See Table 8.1)
Residual Impact	**No Impact**

Impacts on sediment transport to the Commodore Channel

In the Commodore Channel dredging is carried out frequently. It is predicted that as a result of the Eko Atlantic Project, this dredging requirement will decrease locally around the Commodore Channel, due to changing flow patterns around the East Mole. From modelling results, it can be estimated that the total sediment load entering the Commodore Channel may decrease by as much as 30-50% due to the construction of the project site. This can be explained by the fact that the long-shore current does not "bend" behind the east mole, since the project area is located there. The close shore turbulent eddy is shifted a bit more seawards which allows more sand transport to bypass the Commodore Channel (**Figure 6.8**). Both layouts for the Eko Atlantic project reduce the annual sediment transport into the Commodore channel, the S-shaped layout reduces the amount of sediment that flows into the channel the most. This result is considered a **minor beneficial** impact, as it should reduce the dredging requirement for the Commodore Channel.

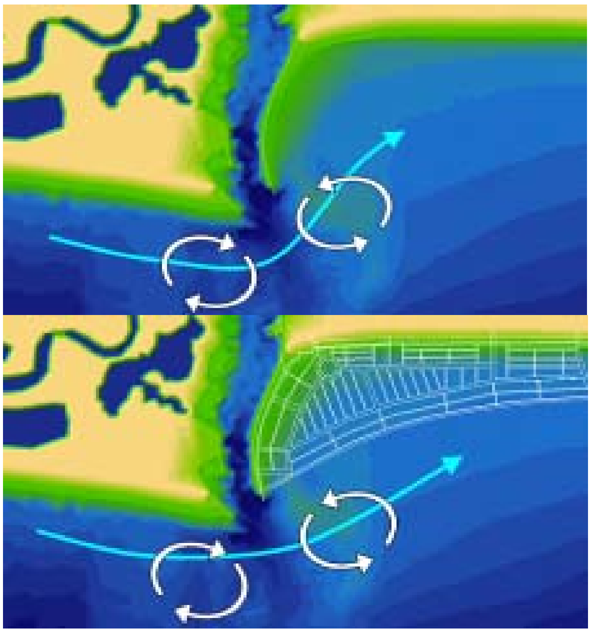

Figure 6.8 Impression of longshore current and eddies near the inlet to the Commodore Channel

Impact Box 6.4 Impacts on sediment transport to the Commodore Channel

Description of Impact	Impacts on sediment transport to the Commodore Channel
Receptor(s)	Users of the Commodore Chanel
Investigation/reference	Study including modelling; Section 5.9; Appendix J, K
Features of Impact	Long term
Significance of Impact	**Minor beneficial impact**
Mitigation advice	None required
Residual Impact	**Minor beneficial impact**

Impacts of sea defence on wave disturbance at the harbour entrance and within the Commodore Channel

The wave disturbance modelling, with MIKE - Boussinesq Wave model, was carried out for two scenarios; without and with the Eko Atlantic revetment. Both typical and extreme wave conditions were considered. Model simulations were carried out for all dominant directions and with a range of peak wave periods.

The model results show that there are negligible changes in wave heights and directions at the harbour entrance and in the Commodore Channel due to the presence of the Eko Atlantic revetment. The reflected waves from the Eko Atlantic revetment do not reach the harbour entrance or the Commodore Channel as these areas are too far away from the reflective zone. Furthermore, the orientation of the Eko Atlantic revetment reflects waves away from the harbour entrance. A higher wave reflection due to the Eko Atlantic revetment was found for waves from 170ºN, as expected.

As a worst case, a fully reflective Eko Atlantic revetment was also considered (Run 13). The increased wave reflection from the revetment was found to have no influence on wave conditions at the harbour entrance and within the Commodore Channel. On this basis **no impact** is predicted on wave conditions at the harbour entrance and within Commodore Channel as a result of the sea defence.

Impact Box 6.5 Impacts of sea defence on wave disturbance at the harbour entrance and within the Commodore Channel

Description of Impact	Impacts of sea defence on wave disturbance at the harbour entrance and within the Commodore Channel
Receptor(s)	Users of the Commodore Chanel
Investigation/reference	Study including modelling; Section 5.9; Appendix J, K
Features of Impact	Long term
Significance of Impact	**No Impact**
Mitigation advice	None required
Residual Impact	**No Impact**

6.4 Water and Sediment Quality

6.4.1 Potential Impacts during Construction

The dredging and reclamation activities associated with the development have the potential to impact on water quality, the main environmental risks being associated with:

- Increased total suspended solid concentrations from dredging and reclamation;
- Pollution from accidental spillage or leaks of fuel or oil during construction works; and
- Suspension of sediment contaminants into the water column.

Impacts of Increased Suspended Solids in Marine Waters

Suspended solids are particulate matter present in the water column and can include inorganic solids such as clay, silt, sand, etc. as well as organic solids such as algae, zooplankton and detritus. The dredging works for Eko Atlantic would mobilise suspended sediments throughout dredging operations (due to overflow and direct disturbance of the seabed), resulting in the formation of sediment plumes.

The water from the dredger's overflow (when using TSHD) will contain suspended sediments. The larger particles (coarse sands which form the bulk of the material) would sink in the immediate vicinity of the dredging. It is the silt (smaller than 63 micrometres) and very fine sand particles (up to 125 micrometres) that have the potential to drift in the water column.

The sediment measurements to date show that of the samples within and close to Borrow Area A, the majority of the samples contain sand. As such, limited plume formation would be expected from the sandy areas as the sand will settle in the hopper. In the areas where silts and clays are in higher quantities (such as Borrow sites B and C) there will be a greater chance of plume formation occurring through the overflow water. However the dredger system to be used has an overflow system that discharges below the keel. This minimises the plume effect from the fines in the overflow water.

Table 6.5 Levels of Total Suspended Solids (TSS) and Turbidity recorded within marine waters (March 2010).

	TSS (mg/L)	Turbidity (NTU)
MIN	1.00	1.00
MAX	10.00	13.00
MEAN	4.07	4.69

Although the surrounding waters are relatively clear, a continuous outflow of sediment particles out of the Commodore Channel is observed very clearly in most satellite images. Satellite images indicate that the dispersion of sediments nearshore is rather limited, as can be seen from the outflow plume of Commodore Channel. This also means that a sediment plume is not alien to the local natural coastal system and that some sediment is in suspension naturally around the channel. Furthermore, as it is a high energy coast, it is likely that there is some material in suspension on a regular basis. Plume dispersion is affected by currents which will transport and disperse the sediment particles, and by waves which mix the upper part of the water column. In general sediments to be dredged are relatively coarse, so it can be expected that the plume will be small, localised and therefore have limited capability for plume dispersion. Any silt in the sediments would remain in suspension longer, and therefore, the dredging should target areas of coarse sand as far as possible.

Increases in suspended sediments have the potential to affect water quality through various mechanisms such as reductions in oxygen levels within the water (if material has high organic content), a change of pH, and increases in turbidity (reduction in the depth/length of light penetration through the water column).

Reclamation activities can also be associated with increased levels of suspended sediments, related to the dewatering process (as water drains from the site) and increases of suspended sediments from this source could be expected at the reclamation sites. However, sediments will be placed directly behind the new breakwater, therefore minimising the spread of sediments.

The magnitude of dredging and reclamation for Eko Atlantic is considered to be large and it is likely that impacts on water quality from increased suspended sediment during the dredge and reclamation phase would be significant on a district scale, particularly as the baseline survey (**Section 5.11**) indicates that the waters of the Project area are relatively clear. However the activities are temporary (*i.e.* only during the construction phase) and although this is planned to be for 6 years it will not be a permanent feature and the effects on water quality within any one area of activity would recede once the dredger/reclamation ceased in that location. Furthermore, the dredger is targeting those areas with coarser sand, which will drop out of the water column more rapidly than finer sediments, thereby limiting the effects of a turbidity plume. Where appropriate, turbidity monitoring should be undertaken in consultation with local regulators to ensure that dredging works do not create turbidity levels of concern (refer to **Chapter 8, Table 8.1**). This should ensure that turbidity from the dredge arisings does not exceed turbidity levels already seen over the coastal zone and ensure that any increases in dredge arisings do not remain within the water column for prolonged periods of time.

On this basis, and assuming implementation of the mitigation measures, an impact of **minor adverse** significance on marine water quality resulting from increased levels of suspended sediments is expected during this phase of the works. It is not expected during this phase that there would be any effect on the lagoon waters in relation to suspended sediments.

Impact Box 6.6 Impacts of Increased Suspended Solids on Water Quality

Description of Impact	Impacts of Increased Suspended Solids on Water Quality
Receptor(s)	Marine Water Quality
Investigation/reference	Surveys and analyses; Section 5.11; Appendix C, D
Features of Impact	Temporary
Significance of Impact	**Moderate adverse impact**
Mitigation advice	• Reclamation activities to be conducted to minimise spillage and loss of material from the reclamation site *e.g.* creation of breakwater early in project to create sheltered reclamation site. • Sediments to be dredged should be selected with the lowest percentage of fine material available in order to reduce potential for fines to be dispersed during dredging and placement activities. • Ensure that overflow is released below the keel of the vessel to minimise the plume effect; • Where discharges are necessary strict control on

	the physical and chemical parameters of the discharge should be maintained. • Turbidity monitoring should occur as described in Table 8.1. • Avoid rainbowing of sand fill into reclamation area where possible and favour direct pumping.
Residual Impact	**Minor adverse impact**

Impacts of Pollution Incidents from Activities during Dredging and Reclamation

Works near water pose a threat to water quality due to potential spillage of hazardous materials such as concrete and cement, (which are alkaline or contain fine grained sediments). There is also the risk of releases of fuels, hydraulic oils, lubricants and coatings into the water environment from the construction site or vessels, either due to accidental spillage or through surface water run-off (*e.g.* from fuel tanks). The use of vessels during this phase of the works also poses some risk to the environment in terms of accidental pollution (*e.g.* litter, fuel spillages) and discharge of waste water, bilge water, etc. **Table 6.6** outlines example sources of accidental pollution. These sources can be minimised through the use of good practices by the construction contractors.

Table 6.6 Example sources of accidental pollution

Pollutant	Effect	Example sources
Concrete and cement	Cement is a highly alkaline and corrosive material and can have a significant impact on groundwater and surface waters.	Spillage during transport or construction activities involving concrete
Fuels (diesel and oil)	Hydrocarbons are generally toxic and persistent in the environment	Construction machinery, vessels, fuel storage areas, refuelling areas (especially over or near water).
Paints, solvents and cleaners	These materials can typically contain toxic and persistent organic pollutants	Leakage from storage areas.
Construction debris and litter	Can lead to loss of amenity and a threat to ecological receptors.	All construction activities, especially around stockpiles and during transportation of materials.

The results of the water quality survey (**Section 5.13**) indicate that the general marine water quality in the Project area is not currently contaminated. Given this factor and the dynamic nature of the Atlantic ocean (enabling mixing), the sensitivity of the receiving environment to direct spills or contaminated surface water run-off is considered to be medium.

It is recommended that the developer (alongside the dredging company) develop relevant protocols to be followed by all vessels operating during construction. The protocol should be in line with the relevant international legislation (*e.g.* Marpol) and should include relevant environmental management systems to control dredge material alongside chemical spill response plans in the event of an incident. The implementation of this protocol and associated environmental management initiatives will help to limit the risk of pollution and thereby impacts from his source should be **negligible.**

Although the risk of pollution should be minimised through the incorporation of the recommended mitigation measures, the actual impact (should an accidental spill occur) could potentially still create significant adverse effects. The impact would be dependent on the size and type of the spill and the speed with which the Contractor instigates clean-up operations, if necessary. Given the risk of a spillage or incident, contract supervision and management of mitigation measures must be stringent at all times. If a polluting incident does occur, the relevant authorities must be contacted.

Impact Box 6.7 Impacts of Pollution Incidents from Activities during Dredging and Reclamation

Description of Impact	Impacts of Pollution Incidents from Activities during Dredging and Reclamation
Receptor(s)	Marine Water Quality
Investigation/reference	Surveys and analyses; Sections 4.2; 5.11; Appendix C, D, F, P
Features of Impact	Temporary
Significance of Impact	**Minor Adverse**
Mitigation advice	• Where discharges to water are necessary strict control on the physical and chemical parameters of the discharge should be maintained. Discharges should be in line with the FMEnv Guidelines on Water Quality. • Close supervision of all plant refuelling to minimise spillage. • Fill portable fuel tanks and containers away from water and never overfill. • Maintain plant regularly and using drip trays. • No washing of tools or plant in water. • Prevention of dust or litter being blown into water. • Keep the site and access roads free from excessive build-up of materials. • Prevent washout from concrete mixing draining into the ground. • Ensure the works are secure from vandals and thieves. • Supervise the delivery of any hazardous materials. • Adequately bund all storage areas and tanks for oil and chemicals. • Carry out all refuelling of plant in a designated area. • Emergency response recommendations as

	outlined in Chapter 7 of the EMP must be followed. • It is also recommended that the dredging contractor provide measures to ensure compliance with MARPOL agreements including: – Management of Bilge Waste Water; – Management of Ballast Water; – Non-Hazardous Waste Management and Sewage; – Storage of Hazardous Materials and Chemicals and disposal of in accordance with regulations; – Vessel Cleaning; and – Metal Works / Equipment Maintenance.
Residual Impact	**Negligible**

Impact on Water Quality from Mobilisation of Sediment Contaminants.

Dredging work has the potential to cause the re-suspension and subsequent redistribution of contaminated sediments in areas within and adjacent to the dredge footprint and could transfer contaminants to the reclamation area. Significant sediment transport in the region already exists due to strong wave and tidal currents, therefore the potential impact at the dredge location will be reduced by rapid mixing, which will quickly dilute any potential contaminants. In addition the sediment is thought to consist of sand in the majority of the borrow areas. Sand is not considered to be a high risk medium for contaminants as the contaminants do not bind with such a high affinity as they do in finer grained sediment areas. The sediment quality analysis undertaken on the samples taken has shown that the levels of contaminants analysed in the samples from Borrow site A does not exceed the threshold effect levels outlined within CISQGs (2002).

Table 6.7 Heavy Metal Contents in the Sediment Samples in Marine Area (All sites), 2010

	Cu	Zn	Hg	Cr	Mn	Ni	Co	Cd	Fe	Pb
MIN	0.001	0	0	0.003	0.307	23.9	0	0.01	1784	19.1
MAX	50.2	34.8	183	0.03	11.139	80.2	0	0.25	41303	422.5
MEAN	5.69	1.42	42.59	0.02	4.89	50.23	0.00	0.06	14184	189.86

The baseline samples included surface grab samples within Borrow Area A, B and C and surrounding sediments. In the borrow areas tested a range of contaminants were recorded, however the majority of these were also below TEL and PEL's outlined. Presently, it is anticipated that sediment will be taken from Borrow Area A, as it is anticipated this area contains enough source material (sand). Where there is sediment with significant levels of contaminated material (particularly heavy metals) then it is likely that these areas would be avoided for dredging works (Southern sites in Borrow Area C). As long as sediment is extracted from such areas, the impact can be reduced to **minor adverse** or **negligible**.

Impact Box 6.8 Impact on Water Quality from Mobilisation of Sediment Contaminants.

Description of Impact	Impact on Water Quality from Mobilisation of Sediment Contaminants.
Receptor(s)	Marine Water Quality
Investigation/reference	Surveys and analyses; Section 5.11; 5.13; Appendix C
Features of Impact	Temporary
Significance of Impact	**Moderate Adverse**
Mitigation advice	• Select borrow areas with medium to coarse sand to minimise distribution of silt, and any potential associated contaminants • Select borrow Area A and B as primary dredge areas • Test sediment quality on board dredger (See Table 8.1)
Residual Impact	**Minor adverse or Negligible**

Impact of Eko Atlantic on Lagoon Water Quality
The Kuramo Lagoon is located immediately landward of the new Eko Atlantic site. The extent of saline water exchange between the ocean and the lagoons is not known. However, both the eastern and western ends of the lagoon are partially saline. Western Kuramo is linked to the Lagos Lagoon through a small channel, but Eastern Kuramo is not, indicating there is likely to be some other exchange system, such as through groundwater or overtopping of the beach during storms. The current water quality of the lagoon system is highly variable (as shown by the results of the baseline survey in **Appendix C)** and reflects both the evolving nature of a highly dynamic coastline such as found within this area of Nigeria alongside the anthropogenic pressure being placed on the lagoon system for discharge and effluent disposal. The newly reclaimed land would potentially affect the exchange of saline water (either through overtopping or groundwater exchange) between the ocean and the lagoons system which could affect the salinity of the lagoon. However, lagoons systems are not static and the salinity of the Kuramo waters is expected to vary naturally with fluctuations in sediment transport along this area of coast (which would affect the width of the Beach and alter current water exchange processes).

The likelihood of occurrence and potential significance of this change are difficult to establish, but it could be expected that a **minor impact** on water quality could be experienced as a result of the land reclamation. This takes into account the fact that the lagoons are already degraded by anthropogenic activity. This effect is less likely to occur if a salt water channel is maintained between the existing shoreline and the new land and as such, a **negligible** to **minor adverse** effect may be expected.

Impact Box 6.9 Impact of Eko Atlantic on Lagoon Water Quality

Description of Impact	Impact of Eko Atlantic on Lagoon Water Quality
Receptor(s)	Lagoon Water Quality
Investigation/reference	Surveys and analyses; Section 5.12; Appendix C
Features of Impact	Long term

Significance of Impact	**Minor Adverse**
Mitigation advice	• Implement monitoring system for lagoon water quality (See Table 8.1). • Salt water channel(s) in and around newly reclaimed land have positive effect; this will be reviewed in phase 2.
Residual Impact	**Negligible to Minor**

6.4.2 Potential Impacts during Operation

Impact of contaminant and TSS leaching from reclaimed land

The compaction of the sediments prior to construction to remove water has the potential to impact on water quality through the leaching of contaminants or fine sediments into the surrounding water. However, for this project the sediments being used are coarse sand and are not anticipated to hold significant levels of contamination or fines which could leach from the reclamation site. As such the predicted impact is therefore considered to be of **negligible** significance.

Impact Box 6.10 Impact of contaminant and TSS leaching from reclaimed land

Description of Impact	Impact of contaminant and TSS leaching from reclaimed land
Receptor(s)	Marine Water Quality
Investigation/reference	Surveys and analyses; Section 5.11; Appendix C, O
Features of Impact	Medium term
Significance of Impact	**Negligible**
Mitigation advice	• No mitigation required at this stage, but monitoring of water quality during construction and sediment quality of the hoppers will be implemented to ensure the impacts are as predicted (Table 8.1).
Residual Impact	**Negligible**

6.5 Groundwater

6.5.1 Potential Impacts during Construction

Impact on groundwater

It is possible that the Hitech Yard Borehole on Victoria Island, from which fresh water is pumped for use in mixing concrete, and which is understood to be 250-300 m deep, may well intercept deep fresh groundwater resources. Given the provenance of such waters, the positive pressures likely to be present at such depths, and the relatively small quantities of water likely to be drawn, then it is most unlikely that the Eko Atlantic development will have any impact on the groundwater and also the supply of fresh water to the Hitech Yard Borehole.

There is a freshwater lagoon present on the southern edge of Victoria Island called Kuramo Waters. It is not known whether this is fed by groundwater or surface water or a combination of both. In any event the hydraulic boundary conditions sustaining water flows towards the lagoon are not expected to be altered by the proposed development and so the freshwater flows towards the lagoons, and the associated water levels, will be maintained as well. It is understood that a canal oriented parallel to the existing coastline may be a proposed as an amenity feature within the development. It will be important to protect this feature in its entirety from pollution risks arising from the development, as discussed below.

Assuming the Kuramo Waters Lagoon is sustained by groundwater then the potential impacts during construction are that levels within the lagoon are drawn down by a breach of the existing water level control structures and/or by pollution of the groundwater by hazardous materials used during construction. Typically such materials include fuels, oils and suspended sediments.

Overall it is predicted that **no impact** on groundwater would occur, particularly if mitigation is implemented.

Impact Box 6.11 Impact on groundwater

Description of Impact	Impact on groundwater
Receptor(s)	Groundwater
Investigation/reference	Desk study; Section 5.15
Features of Impact	Short Term, Temporary
Significance of Impact	**Negligible**
Mitigation advice	• Risks to ambient water features on construction sites are not uncommon and mitigation measures to deal with these are described in Impact Box 6.6.
Residual Impact	**No Impact**

6.5.2 Potential Impacts during Operation

No impact on groundwater during operation is anticipated. However, it should be noted that immediately following reclamation, the quality of the groundwater will be influenced by the quality of the sediments used for reclamation (refer to **Section 6.5**)

6.6 Air Quality

Dredging Vessel Engine Exhaust Emissions

An inventory of dredging vessels likely to be used for Eko Atlantic Phase 1 dredging works was compiled following best practice guidance in preparing port emission inventories[12]. Emission rates from these vessels were calculated using information such as hours of operation, percentage time in operational modes (excavating, transportation and disposal), vessel characteristics, number, type and horsepower of main and auxiliary engine(s), and qualitative information

[12] United States Environmental Protection Agency, April 2009, Current Methodologies and Best Practices in Preparing Port Emission Inventories.

regarding how the vessels are used in service. All model parameters are described in **Appendix M**.

The dispersion model Screen View (an interface for the U.S. EPA model, SCREEN3), was used to calculate the contribution of engine exhaust emissions from marine vessels involved in Phase 1 dredging works to ground level pollutant concentrations. The flow chart in **Figure 6.9** summarises the steps taken to estimate the majority of emissions.

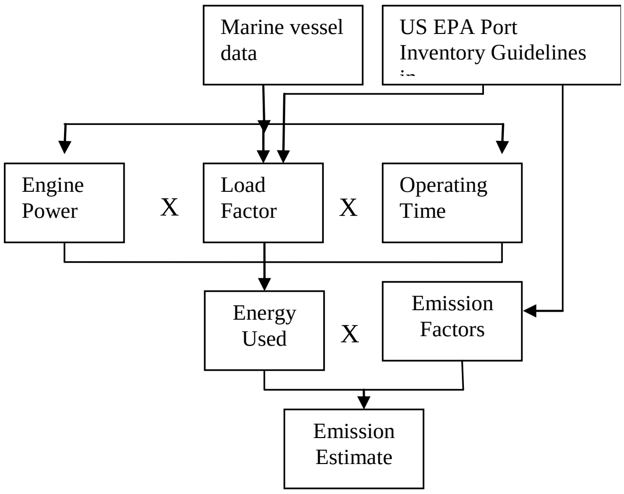

Figure 6.9 Marine vessel emission estimation flow chart

Odour

Potential impacts from odour were assessed qualitatively with reference to the location of reclamation activities, distance from such activities to sensitive receptor locations, and results of marine sediment analysis undertaken for this scheme (**Chapter 5**).

Other Engine Exhaust Emissions - On road vehicles

Potential contributions to ambient concentrations of Nitrogen dioxides and Particulate Matter (NO_2 and PM_{10}) from trucks transporting rock from quarries to the reclamation site were calculated using the Design Manual for Roads and Bridges (DMRB) road vehicle emissions dispersion model, published by the UK Highways Agency[13]. Concentrations were predicted with vehicles travelling at average speeds of 48kph (30mph), at a nominal receptor located 6m from the centre of a rural/minor road.

The magnitude of change in annual mean NO_2 and PM_{10} concentrations from on road vehicles was defined as described in **Table 6.8**.

[13] Highways Agency (2007). Design Manual for Roads and Bridges Screening Method: Assessment of Local Air Quality. Version 1.03c, July 2007.

Table 6.8 Definition of impact magnitude for changes in Annual Mean NO_2 and PM_{10} concentration.

Magnitude of Change	Changes in Annual Mean PM_{10} and NO_2 Concentration
Large	Increase/decrease >4 μg.m^3
Medium	Increase/decrease 2 - 4 μg.m^3
Small	Increase/decrease 0.4 - 2 μg.m^3
Imperceptible	Increase/decrease <0.4 μg.m^3

Other Engine Exhaust Emissions - Non road Mobile Machinery (NRMM)

Potential impacts on local air quality from NRMM engine exhaust emissions involved in Phase 1 works were assessed qualitatively with reference to the construction schedule for the scheme, and distance from such activities to sensitive receptor locations.

Fugitive dust emissions

The effect of fugitive dust emissions is difficult to quantify accurately as it depends on a number of factors including the activity taking place, the type of dust emitted, the location and nature of sensitive receptors and meteorological conditions. This issue was therefore dealt with qualitatively by establishing the fugitive dust risk for the development as presented in **Table 6.9**, identifying distance to sensitive receptors, and determining the likely impact using the Impact Assessment Matrix presented in **Table 6.10**.

Table 6.9 Fugitive Risk dust classification[14]

Risk categories	Criteria
Low Risk Site	Development of up to 1,000 m^2 of land; or Potential for emissions and dust to have an infrequent impact on sensitive receptors.
Medium Risk Site	Development between 1,000 and 15,000 m^2 of land; or Potential for emissions and dust to have an intermittent or likely impact on sensitive receptors.
High Risk Site	Development of greater than 15,000 m^2 of land; or Major Development as defined by the LPA; or Potential for emissions and dust to have a significant or likely impact on sensitive receptors.

[14] Greater London Authority and London Councils (GLA&LC) (2006). *The control of dust and emissions from construction and demolition - Best Practice Guidance (2006).*

Table 6.10 Impact Assessment Matrix

		Risk from development		
		Low	Medium	High
Distance to receptors (m)	100-200	Negligible	Negligible	Minor
	50-100	Minor	Moderate	Moderate
	0-50	Minor	Moderate	Major

The 200 metre distance to receptor criterion is based on UK Department of Environment, food and rural affairs (DEFRA) guidance[15] as the distance beyond which there is no need to proceed with further assessment of fugitive emissions (as receptors beyond 200m are not located 'near' to the source of dust emissions). The 100 metre distance to receptor criterion is based on guidance which assumes that the majority of dust is deposited within 100 metres of the emissions sources[16]. The 50 metre criterion allows the identification of properties which are close to the source and therefore likely to receive greater impacts during construction activities.

6.6.1 Potential Impacts during Construction

Air Quality Impact from Dredging Vessel Engine Exhaust Emissions

The Phase 1 reclamation works will use a variety of marine vessels which will operate for different periods throughout the six year construction programme (2008-2014). It is anticipated that one dredger, several sand barges, and auxiliary boats (tugboat, multicat and survey vessel) will be operating on site at any one time.

Emission rates from dredgers likely to be used for the reclamation works are shown in **Table 6.11**. Predicted emission rates are higher during dredging operations than during reclamation works due to the increased engine loading.

Emission factors used to derive these emission rates were based on the following assumptions:

1. All propulsion engines on dredgers are slow speed diesel engines operating on residual oil (intermediate fuel oil 380 or similar specification with average sulphur content of 2.7%), with a maximum engine speed of less than 130 rpm.

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[15] DEFRA (2009) *Local Air Quality Management Technical Guidance TG(09)*

[16] Office of the Deputy Prime Minister (ODPM) (2005) *Minerals Policy Statement 2: Controlling and Mitigating the Effects of Mineral Extraction in England – Annex 1: Dust (2005).*

2. All auxiliary engines (dredging engines) on dredgers are medium speed diesel engines operating on residual oil (intermediate fuel oil 300 or similar specification with average sulphur content of 2.7%); with a maximum engine speed greater than 130 rpm and typically over 400 rpm.
3. All SO_x releases were assumed to be converted to SO_2

Table 6.11 Emission rates g/s/m^2 from dredging and propulsion engines of one dredger

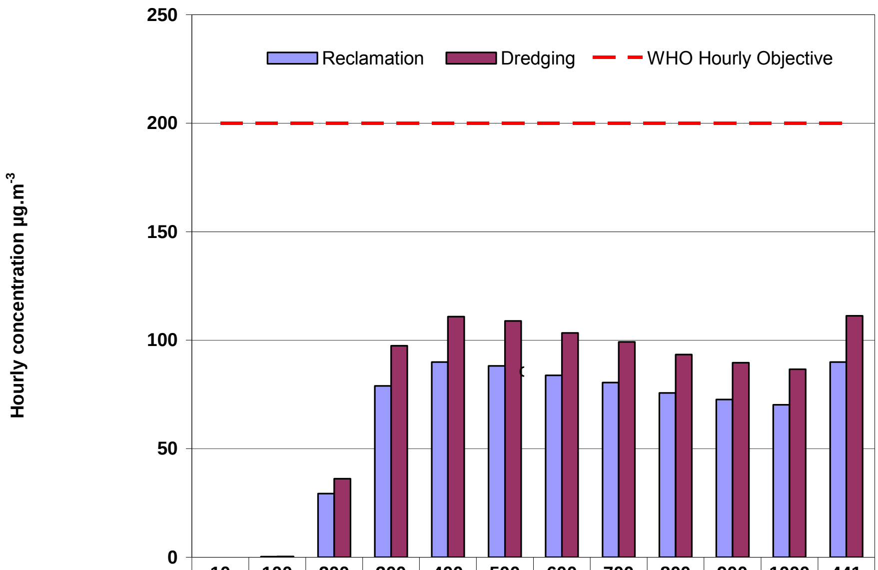
Emission Source	Assumed Operation	NO_x	CO	PM_{10}	SO_2
Dredgers during excavating/dredging works	Operating 7hrs in 24hrs using 85% capacity of propulsion engines and 100% of dredging engines.	34.6	2.6	3.0	23.0
Dredgers during disposal/reclamation works	Operating 10hrs in 24hrs using 25% capacity of propulsion engines and 100% of dredging engines.	28.0	2.1	2.6	20.7
Dredgers during transportation	Operating 7hrs in 24hrs using 85% capacity of propulsion engines and 0% of dredging engines.	21.2	1.6	1.7	12.1
Tugboat during operation	Operating 16hrs in 24hrs	0.97	0.15	0.03	0.13

Nitrogen Dioxide (NO2)

The UK Environment Agency Air Quality Modelling and Assessment Unit advises that the percentage of modelled NO_x emitted as NO_2 for combustion processes is likely to be 35% for hourly concentrations. In this study it has been assumed that 35% of modelled hourly NO_x concentrations are emitted as NO_2.

The estimated contribution of engine exhaust emissions from dredgers to hourly ground level concentrations (glc) of NO_2 during dredging and reclamation activities are presented in **Figure 6.10,** with concentrations predicted up to 1000m from the source (vessel flue).

Engine exhaust emissions from dredgers during reclamation and dredging activities are predicted to contribute a maximum of 90µg/m^3 and 111µg/m^3 respectively to hourly glc NO_2 concentrations at a distance of 441m from the source. These values are well below the WHO Air Quality Objective of 200µg/m^3, with concentrations predicted to decrease with increasing distance from the source.



	10	100	200	300	400	500	600	700	800	900	1000	441
Reclamation	0	0	29	79	90	88	84	80	76	73	70	90
Dredging	0	0	36	97	111	109	103	99	93	90	87	111
WHO Hourly Objective	200	200	200	200	200	200	200	200	200	200	200	200

Distance from source m

Figure 6.10 Calculated contribution of engine exhaust emissions from dredgers to Hourly Ground Level Concentrations NO2 (µg.m-3)

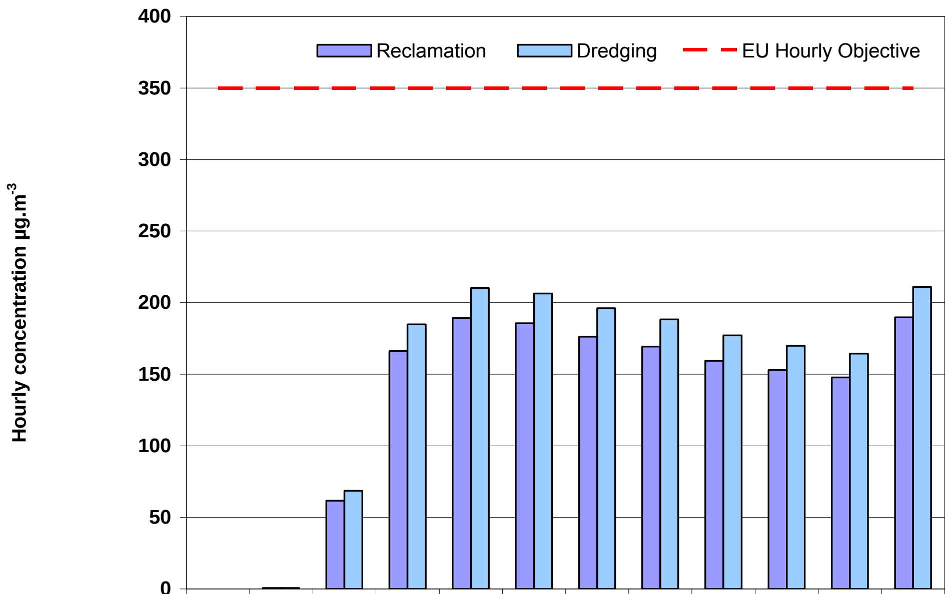
Sulphur Dioxide (SO2)

The estimated contribution of engine exhaust emissions from dredgers to hourly ground level concentrations (glc) of SO_2 during dredging and reclamation activities are presented in **Figure 6.11**, with concentrations predicted up to 1000m from the source (vessel flue).

Engine exhaust emissions from dredgers during reclamation and dredging activities are predicted to contribute a maximum of 190µg/m^3 and 211µg/m^3 respectively to hourly glc SO_2 concentrations at a distance of 441m from the source. These values are below the EU Air Quality Objective of 350µg/m^3, with concentrations predicted to decrease with increasing distance from the source.

Particulate Matter (PM10)

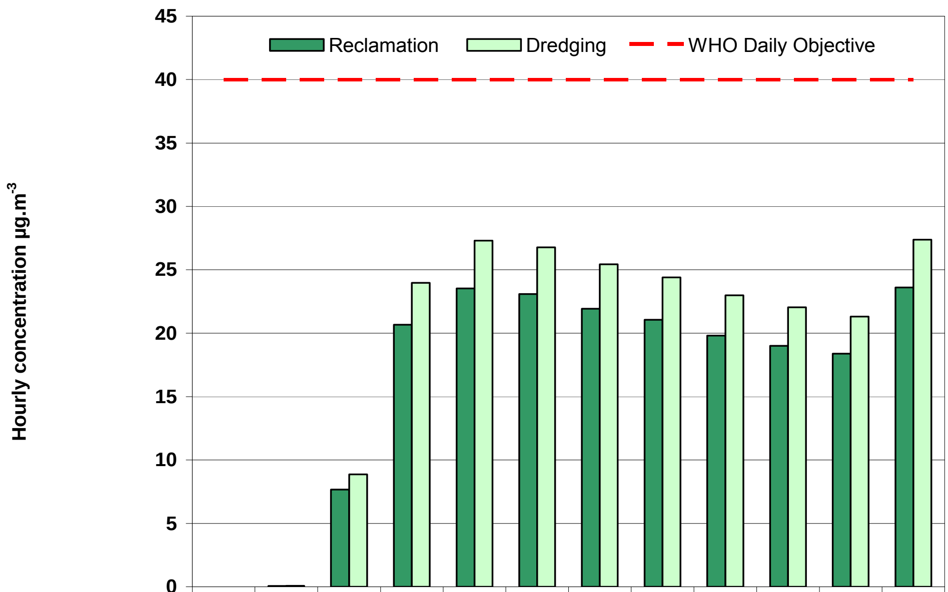
The estimated contribution of engine exhaust emissions from dredgers to hourly ground level concentrations (glc) of PM_{10} during dredging and reclamation activities are presented in **Figure 6.12**, with concentrations predicted up to 1000m from the source (vessel flue). Engine exhaust emissions from dredgers during reclamation and dredging activities are predicted to contribute a maximum of 24µg/m^3 and 27µg/m^3 respectively to hourly glc PM_{10} concentrations at a distance of 441m from the source (vessel flue). There is no WHO hourly PM_{10} guideline; the daily guideline and EU Limit Value is 50µg/m^3.



	10	100	200	300	400	500	600	700	800	900	1000	441
Reclamation	0	1	62	166	189	186	176	169	159	153	148	190
Dredging	0	1	69	185	210	206	196	188	177	170	164	211
EU Hourly Objective	350	350	350	350	350	350	350	350	350	350	350	350

Distance from source m

Figure 6.11 **Calculated contribution of engine exhaust emissions from dredgers to Hourly Ground Level Concentrations SO2 (µg.m-3)**



	10	100	200	300	400	500	600	700	800	900	1000	441
Reclamation	0	0	8	21	24	23	22	21	20	19	18	24
Dredging	0	0	9	24	27	27	25	24	23	22	21	27
WHO Daily Objective	40	40	40	40	40	40	40	40	40	40	40	40

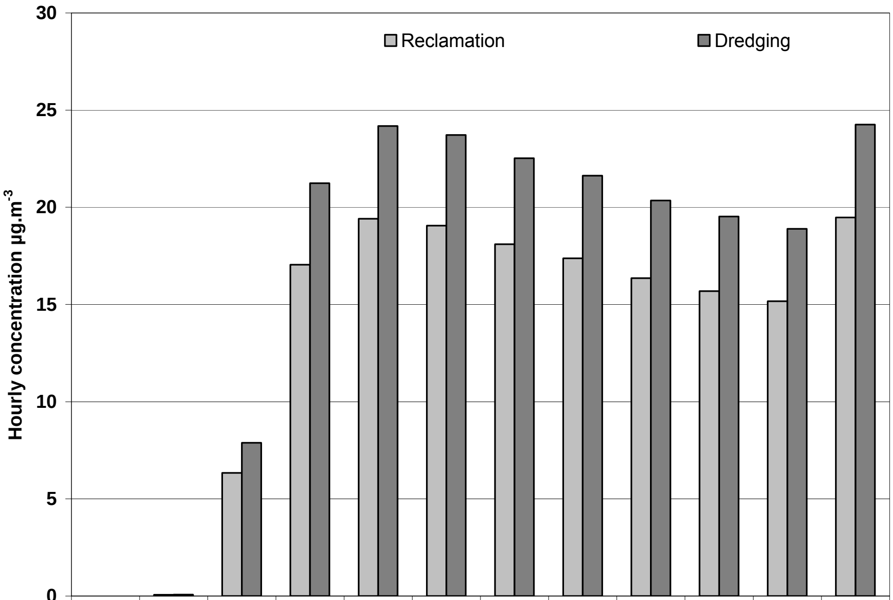
Distance from source m

Figure 6.12 **Calculated contribution of engine exhaust emissions from dredgers to Hourly Ground Level Concentrations PM10 (µg.m-^{3})**

Carbon Monoxide (CO)

The estimated contribution of engine exhaust emissions from dredgers to hourly ground level concentrations (glc) of CO during dredging and reclamation activities are presented in **Figure 6.13**, with concentrations predicted up to 1000m from the source (vessel flue).

Engine exhaust emissions from dredgers during reclamation and dredging activities are predicted to contribute a maximum of 19μg/m^3 and 24μg/m^3 respectively to hourly glc CO concentrations at a distance of 441m from the source. These values are well below the hourly WHO Air Quality Guideline of 30,000μg/m^3, (not indicated on the plot) with concentrations predicted to decrease with increasing distance from the source.



	10	100	200	300	400	500	600	700	800	900	1000	441
Reclamation	0	0	6	17	19	19	18	17	16	16	15	19
Dredging	0	0	8	21	24	24	23	22	20	20	19	24

Distance from source m

Figure 6.13 Calculated contribution of engine exhaust emissions from dredgers to Hourly Ground Level Concentrations CO (μg.m-^{3})

Summary of Assessment - Engine exhaust emissions from dredgers

It is likely that existing concentrations of NO_2, SO_2, PM_{10} and CO are elevated in the vicinity of the study area due to the high numbers of vessels operating in the vicinity. The additional engine exhaust emissions from dredgers will contribute to local air pollution but is likely to only be a small percentage. The relative impact of such emissions cannot be quantified without existing baseline validated hourly and annual mean air quality data, which is currently not available. Sensitive receptors are most likely to be affected by engine exhaust emissions from dredgers during reclamation works which will occur in close proximity to the shore – the nearest receptors are located approximately 500m away (see Table 5). The majority of dredging is anticipated to take place well away from any potentially sensitive receptors, in borrow area A, located approximately 10km from the mainland. At such distances, the predicted dispersion of relevant exhaust emissions as indicated above would not be expected to significantly impact upon local air quality in the residential areas in closest proximity to the works. As such, a **negligible** impact from this source is predicted.

Impact Box 6.12 Air Quality Impact from Engine exhaust emissions from dredgers

Description of Impact	Air Quality Impact from Engine exhaust emissions from dredgers
Receptor(s)	Shoreline residential and business properties, businesses at rear of Kuramo Lagoon
Investigation/reference	Data inventory and analyses; Section 4.2; 5.16; Appendix F, M
Features of Impact	Temporary, reversible, short term
Significance of Impact	**Negligible**
Mitigation advice	• The source of the predicted pollutant effects at land based receptors is the combustion of fuel on marine vessels; therefore the approach to reduction of air quality impacts should be to consider the quality of fuel used, and ensuring engines are properly serviced and maintained. • Monitoring recommended (See Chapter 8)
Residual Impact	**Negligible**

Air Quality impact from Odour

Results from a sediment survey undertaken in 2008 within and adjacent to the development site indicate that sediments are unlikely to contain odorous compounds (**Chapter 5**). Although small pockets of potentially odorous substances may be disturbed, the potential for odorous emissions from bulk dredged material to affect residential areas is therefore predicted to be **negligible.**

Impact Box 6.13 Air Quality Impacts from Engine Exhaust Emissions – vehicles

Description of Impact	Air Quality Impacts from Engine Exhaust Emissions – vehicles
Receptor(s)	Shoreline residential and business properties, businesses at rear of Kuramo Lagoon
Investigation/reference	Data inventory and analyses; Section 4.2; 5.16; Appendix P
Features of Impact	Temporary, reversible, short term
Significance of Impact	**Negligible**
Mitigation advice	Each dredging location should be qualitatively assessed and documented to determine the risk of odorous emissions. Should excavated material produce odorous emissions it should not be deposited in close proximity to the mainland and should be monitored to ensure no significant effect.
Residual Impact	**Negligible**

Air Quality Impacts from Engine Exhaust Emissions – on road vehicles

It is anticipated that approximately 98 trucks (heavy goods vehicles, HGVs) will be used per day to transport rock from the four quarries (located in Ibadan, Oyo State (2), and Ogberre, Ogun State (2)) to the reclamation site (that is, 196 daily vehicle journeys). Deliveries will occur between 08.00h and 19.00h, with peak deliveries between 11.00h and 18.00h.

Existing traffic flows along the haul routes from the quarries to the site are not known. Therefore a comparison between the contribution of existing vehicles along the haul routes (*existing baseline*), and HGVs associated the scheme (*existing traffic + HGVs transporting rocks*) to concentrations of NO_2 and PM_{10} cannot be made. However, the estimated contribution to 2010 ambient concentrations of NO_2 and PM_{10} from HGVs exhaust emissions associated with transporting rock is shown in **Table 6.12**.

The screen modelling was undertaken for nominal roadside receptors at 6m from the road centreline. At these worst-case locations, estimated contribution from daily HGVs movements associated with the scheme to annual mean PM_{10} and NO_2 concentrations are 'imperceptible' and 'small' respectively.

Table 6.12 Estimated contributions to 2010 annual mean NO_2 and PM_{10} concentrations from HGVs transporting rock from quarries

Annual Average Daily Traffic (AADT)	Contribution to annual mean NO_2 $\mu g/m^3$	Contribution to annual mean PM_{10} $\mu g/m^3$
196 HGVs	1.0	0.15

Emissions of NO_x and PM_{10} are strongly related to vehicle speeds, with highest vehicle emission rates occurring at very slow speeds and lowest emission rates occurring in free flowing traffic. Trucks delivering rocks to the site will change the traffic volume and composition on haul roads to and from the quarries, potentially resulting in local traffic congestion in urban areas along the route. Vehicle emissions of NO_x and PM_{10} will increase should such congestion occur.

It is not known whether these pollutants currently exceed WHO air quality Guidelines along the haul route. However, the contribution of HGV exhaust releases to annual mean PM_{10} and NO_2 concentrations are predicted to be 'imperceptible' and 'small' respectively,. Due to the long duration of Phase 1 construction works (maximum 6 years), potential for increased congestion in urban areas associated with HGVs for the scheme, and the potential for existing elevated concentrations of PM_{10} and NO_2 in urban areas, HGVs transporting rocks are predicted to have a **minor adverse** impact on air quality.

Impact Box 6.14 Air Quality Impacts from Engine Exhaust Emissions – vehicles

Description of Impact	Air Quality Impacts from Engine Exhaust Emissions – vehicles
Receptor(s)	Shoreline residential and business properties, businesses at rear of Kuramo Lagoon

Investigation/reference	Data inventory and analyses; Section 4.2; 5.16; Appendix P
Features of Impact	Temporary, reversible, medium term
Significance of Impact	**Minor adverse**
Mitigation advice	On-road vehicles Fuel quality and engine exhaust standards should be specified for vehicles in the contractor's fleet. Such controls may be based for example on European Emission Standards.
Residual Impact	**Minor adverse**

Air Quality Impacts from Engine Exhaust Emissions – NRMM

It is anticipated that the following NRMM will be used during construction of the sea defence structure:

- Excavators x 2
- Trailers x 1
- Dumper truck x 2
- Tipper truck x 1
- Wheel loader x 1

Although emissions from NRMM operating on the reclamation site may affect air quality in close proximity to the activities, the impact will be local and only when such plant and machinery are being operated. In the absence of mitigation, emissions from NRMM used during construction are predicted to have a **minor adverse** impact on local air quality.

Impact Box 6.15 Air Quality Impacts from Engine Exhaust Emissions – NRMM

Description of Impact	Air Quality Impacts from Other Engine Exhaust Emissions – NRMM
Receptor(s)	Shoreline residential and business properties, businesses at rear of Kuramo Lagoon
Investigation/reference	Data inventory and analyses; Section 4.2; 5.16; Appendix F, P
Features of Impact	Temporary, reversible, short term
Significance of Impact	**Minor adverse**
Mitigation advice	Off-road vehicles: Both static and mobile non-road mobile machinery (NRMM) and plant should be well maintained. If any emissions of dark smoke occur then the relevant machinery should stop immediately and any problem should be rectified. The following controls are applied to non-road mobile machinery for large scale developments in the EU and these or equivalent standards should be considered for the Eko Atlantic project: • All NRMM should use fuel equivalent to ultra low sulphur diesel (fuel meeting the specification within EN590:2004);

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All NRMM shall comply with either the current or previous EU Directive Staged Emission Standards (97/68/EC, 2002/88/EC, 2004/26/EC). As new emission standards are introduced the acceptable standards will be updated to the previous and most current standard;
All NRMM shall be fitted with Diesel Particulate Filters (DPF) conforming to a defined and demonstrated filtration efficiency (load/duty cycle permitting);
The ongoing conformity of plant retrofitted with DPF, to a defined performance standard, shall be ensured through a programme of on-site checks; and

Implementation of energy conservation measures including throttle down or switch off idle construction equipment, switch off the engines of trucks while they are waiting to access the site and while they are being loaded or unloaded, ensure equipment is properly maintained to ensure efficient energy consumption.

In addition to the emission standards and controls specified for off road vehicles, the following control measures should be implemented:

Plant or equipment must not emit dark smoke except during start-up;
Engines and exhaust systems need to be regularly serviced according to manufacturer’s recommendations maintained to meet statutory limits/opacity tests;
All vehicles including off-road vehicles must hold current certification where required;
Vehicle exhausts must be directed away from the ground and positioned so they are not directed at site entrances;
Where practicable plant and equipment should not be operated near to residential areas or sensitive receptors near to the site boundary;
Control of queuing/ stationary vehicles outside the site is required, both during and before the site opens;
Avoid use of diesel or petrol powered generators by using mains electricity or battery powered equipment where available; and
Encourage the use of consolidation centres to manage site deliveries. This will help reduce the number of vehicles entering the site.

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<td>Residual Impact</td>
<td>Negligible</td>
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Air Quality Impacts from Fugitive Dust Emissions

Following the methodology presented in **Chapter 5**, there is a high risk of fugitive dust emissions from onshore and offshore construction (due to the geographical extent of the development). The potential for sensitive locations to be affected by dust emissions will vary depending on the duration and location of dust-raising activity taking place on the site; however due to the size and location of the development, it is likely that sensitive receptors will be more than 200m away from dust raising activities. In the absence of mitigation, dust emissions from construction activities are predicted to have a **minor adverse** nuisance impact at sensitive receptor locations.

Impact Box 6.16 Impact from Fugitive Dust Emissions

Description of Impact	Air Quality Impacts from Fugitive Dust Emissions
Receptor(s)	Shoreline residential and business properties, businesses at rear of Kuramo Lagoon
Investigation/reference	Desk study; Section 4.2; 5.16; Appendix P
Features of Impact	Temporary, reversible, short term
Significance of Impact	**Minor adverse**
Mitigation advice	Dust control equipment should be readily available on site from the commencement of works. Construction materials • Material transported by road should be dampened prior to its handling and placement; • Covers should be used on trailer units to minimise dust blow from lorries; • Emplacement of fill material should be avoided during strong winds; and • Washing/cleaning of stone prior to leaving the quarry should be considered. Site Haul Roads • Where possible all major haul roads should be paved and laid to camber to prevent water accumulation; and • Haul roads should be inspected for integrity and repair.
Residual Impact	**Negligible**

6.7 Noise and Vibration

6.7.1 Potential Impacts during Construction

On-site reclamation noise impacts

On-site reclamation activities are defined as activities occurring within or adjacent to the reclamation area, such as the operation of non-road mobile machinery (NRMM) and dredging vessels. For the purposes of the noise assessment these are distinguished from off-site construction related traffic on roads away from the reclamation area, which are assessed separately.

The assessment of noise from on-site reclamation works comprised the prediction of noise levels from the operation of associated machinery, vehicles and vessels at potentially noise sensitive receptors close to the reclamation area. Calculations were performed to predict the noise level from the reclamation works on adjacent receptors, using the calculation methodology provided in British Standard 5528 (BS 5228), which provides guidance and advice on the creation and control of noise from construction and open sites. This calculation methodology adopts a standard hemi-spherical noise propagation model to account for attenuation due to the distance between the activity and receptor, but also accounts for various additional factors including: the operating time of the equipment as a percentage of the assessment period (on-time), the ground type between the equipment and the receptor and attenuation by barriers or topography. It should be noted that the effect of screening or ground attenuation were not taken into account in the assessment.

Table 6.13 presents a list of equipment associated with various aspects of the reclamation works, including the source noise level assumed on-time for the equipment.

Table 6.13 Construction equipment

Group	Equipment	Number	Sound power level (dB L_{WA})	On-time (%)
Main dredging vessel	TSHD dredger discharging	1	110	28
	Dredger to/from borrow area	1	110	25
	TSHD dredging	1	110	30
Ancillary dredging vessels	Tug Boat	1	110	25
	Multicat	1	110	25
	Survey vessel	1	110	25
Movement / levelling of reclaimed earth	Dozer	2	106	50
	Tracked excavator (Cat 385)	1	107	50
Placement of rock armour	Tracked excavator (Cat 385)	2	107	50

(daytime only)	Tracked excavator (Cat 345)	2	104	50
	Dumper	1	109	50
	Tipper	2	104	50
	Wheeled loader	1	108	50
	Tipper (Haul route)	14[B]	108[A]	100
Concrete Accropode construction (daytime only)	Concrete truck & pump	3	108	25
	Tracked excavator (Cat 385)	1	107	40

[A] *Maximum drive-by noise level (L_{Amax})*
[B] *Hourly vehicle movements*

Source noise levels for the various activities were primarily obtained from the noise database contained within Annex C of BS 5228, however noise levels from trailing suction hopper dredger (TSHD) and other vessels was obtained from measurements taken as part of the Port of Melbourne Channel Deepening Project (PoMC)[17].

The PoMC report provides measured sound power levels (L_{WA}) for two TSHD dredgers, with hopper volumes of 23,145m^3 and 8,000m^3, which were 105 dB and 110 dB respectively. The higher value of 110 dB was used for this noise assessment, to represent a conservative approach. The on-time for the operation of the TSHD dredger activity, collecting material at the borrow area and depositing the material at the reclamation area, were derived from average values of dredging vessels that will contribute to the reclamation works.

Due to the very large size of the reclamation area, there are potentially a large number of receptors that may be affected by noise from the works. The noise assessment therefore took into account a number of generic receptor locations along the existing shoreline immediately adjacent to the reclamation area. It was not intended to represent each individual receptor, but rather groups of receptors in various locations with comparable characteristics along the existing shore line. The various receptors at which reclamation noise impacts were predicted are presented in **Table 6.14** and **Figure 6.14**. Although noise from the reclamation may affect receptors further inland, the assessment has been conducted on the basis that the closest receptors to the site will be the worst affected and thus assessment at this location will provide the most conservative assessment of potential impact.

[17] PoMC, 2007. Channel Deepening Project. Supplementary Environmental Effects Statement. Port of Melbourne Corporation. Appendix 63.

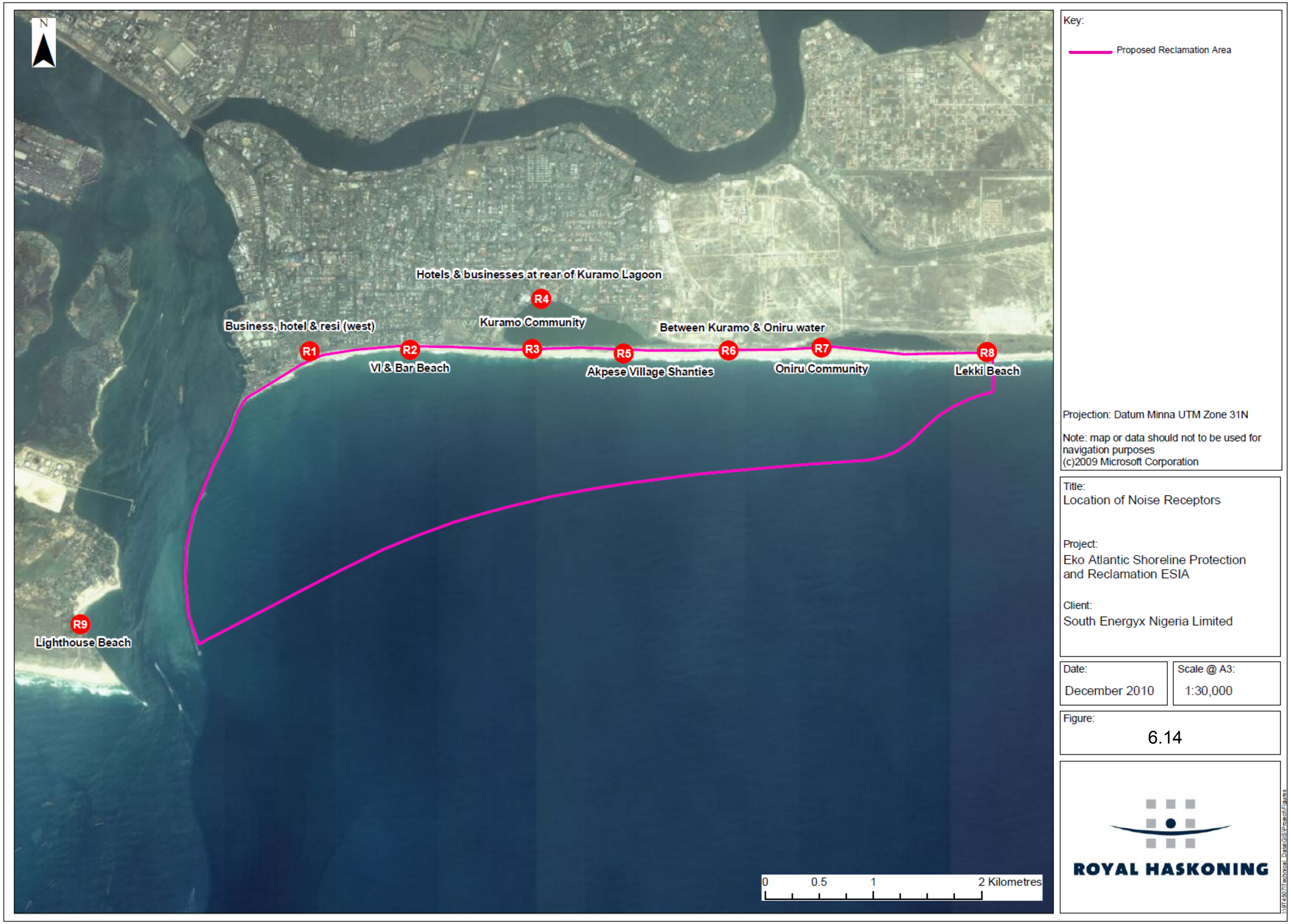

N
Hotels & businesses at rear of Kuramo Lagoon
R4
Kuramo Community
Business, hotel & resi (west)
Between Kuramo & Oniru water
R1
R2
R3
R5
R6
R7
R8
VI & Bar Beach
Akpese Village Shanties
Oniru Community
Lekki Beach
R9
Lighthouse Beach
0
0.5
1
2 Kilometres
Key:
Proposed Reclamation Area
Projection: Datum Minna UTM Zone 31N
Note: map or data should not to be used for navigation purposes
(c)2009 Microsoft Corporation
Title:
Location of Noise Receptors
Project:
Eko Atlantic Shoreline Protection and Reclamation ESIA
Client:
South Energyx Nigeria Limited
Date:
December 2010
Scale @ A3:
1:30,000
Figure:
6.14
ROYAL HASKONING

Table 6.14 Receptors adjacent to the reclamation area

ID	Description
R1	Businesses, hotel and residences on Ahmadu Bello Way
R2	VI & Bar Beach
R3	Kuramo Waters Properties
R4	Hotels & businesses at rear of Kuramo Lagoon
R5	Apese Village
R6	Area between Kuramo & Oniru
R7	Oniru Community
R8	Lekki Beach
R9	Lighthouse Beach

The very large geographical scope of the reclamation area means that, at different locations, noise from the works will vary significantly over the reclamation period. In order to assess the potential for impact, a conservative scenario was assumed, which assumed that all plant was operating at its closest likely proximity to each receptor location. The results of the construction noise calculations therefore represent an estimate of the maximum day-average noise levels that would be expected to occur at the relevant location at any time in the Project construction period.

The calculated noise levels from reclamation works and associated impacts, for day, evening and night periods, are presented in the **Table 6.15** below.

Table 6.15 Calculated Construction noise level and impact

Receptor		Construction noise level (dB L_{Aeq})		Significance of impact		
		Day	Night & Evening	Day	Evening	Night
R1	Businesses, hotel and residences on Ahmadu Bello Way	59.8	59.6	Negligible	Negligible	Minor
R2	VI & Bar Beach	59.6	59.6	Negligible	Negligible	Minor
R3	Kuramo Properties	59.6	59.6	Negligible	Negligible	Minor
R4	Hotels & businesses at rear of Kuramo Lagoon	46.1	45.4	Negligible	Negligible	Negligible
R5	Apese Village	59.7	59.6	Negligible	Negligible	Minor

Receptor		Construction noise level (dB L_{Aeq})		Significance of impact		
		Day	Night & Evening	Day	Evening	Night
R6	Area between Kuramo & Oniru	59.8	59.5	Negligible	Negligible	Minor
R7	Oniru Community	78.4	59.6	Minor	Negligible	Minor
R8	Lekki Beach	43.7	41.1	Negligible	Negligible	Negligible
R9	Lighthouse Beach	50.8	46.3	Negligible	Negligible	Negligible

Table 6.15 shows that, during the daytime, evening and night-time periods, reclamation activity was predicted to result in negligible to minor adverse impact. The reduction in impact from day to evening at receptor R7 is due to the daytime only operation of the sea defence construction activity.

As the levels are all below the Nigerian National Standard of 90 dB, it is deemed that specific mitigation is not required in order to reduce the quantitative impacts determined in **Table 6.15**, however generic noise control measures in the form of good site management practices should be employed and are shown in **Impact Box 6.17**.

Impact Box 6.17 On-site construction traffic noise impacts

Description of Impact	On-site construction traffic noise impacts
Receptor(s)	Shoreline residential and business properties, businesses at rear of Kuramo Lagoon
Investigation/reference	Surveys and analyses; Section 4.2; 5.17; Appendix P
Features of Impact	Temporary, reversible, short term
Significance of Impact	**Minor adverse**
Mitigation advice	• Locate plant in use as far away from noise sensitive receptors as is feasible for the particular activity • Maintain all equipment, machinery and vehicles in good working condition at all times. • Fit all equipment, machinery and vehicles with silencers. • Operators of equipment should avoid unnecessary idling, revving or inappropriate use of equipment. • Ensure that covers and hatches on equipment are properly secured and there are no loose fixings causing rattling. • Acoustic covers on all machine engines that generate excessive noise levels are to remain closed at all times. • Imposition of vehicle speed limits for heavy goods vehicle traffic travelling on access roads close to receptors and ensuring that vehicles do not park or

	queue for long periods outside noise sensitive properties with engines running unnecessarily. • Where possible, limit construction/reclamation activities to daytime hours. • Ensure, where practicable, that access routes are in good condition with no pot-holes or other significant surface irregularities. • Maintain good public relations with local residents/businesses that may be affected by noise from the construction works. An effective public relations campaign should be put in place, keeping local residents informed of the type and timing of works involved, paying particular attention to potential evening and night time works and activities which may occur in close proximity to receptors. Leaflet drops, posters and public meetings or exhibitions are effective methods of keeping local residents informed. • Provision of 24-hour contact details for a site representative in the event that disturbance due to noise or vibration from the construction works occurs; ensuring that any complaints are dealt with pro-actively and that subsequent resolutions are communicated to the complainant.
Residual Impact	**Negligible to minor adverse**

Off-site construction traffic noise impacts

In addition to the works within and in the vicinity of the reclamation area, potential impacts may arise from the transport of materials to the site for the rock revetment which surrounds the reclamation area. Rock for the revetment will be delivered from four quarries outside Lagos.

Approximately 98 truck-loads of rock will be delivered per day, which equates to 196 2-way vehicle trips. The rock deliveries currently take place typically between the hours of 07:00 to 19:00. Details of the specific delivery routes used to deliver the rock, and therefore details of the areas and receptors surrounding the routes are not currently available. The assessment therefore comprised the calculation of noise from the heavy vehicles at various distances from the route.

Noise levels from the vehicles were predicted using the ‘haul route’ method defined in BS 5228. In order to study the worst case scenario, it was assumed that all of the vehicles would use the same delivery route.

The noise levels associated with the transport of rock for the sea defences were predicted, and are presented in **Table 6.16**.

Table 6.16 Calculated delivery vehicle noise levels

Distance from road edge (m)	Delivery vehicle noise level ($L_{Aeq,12h}$)
5	63
10	59
20	56
50	52
100	49

The above results indicate that noise from the delivery of rock for the sea defence will not result in a significant impact. The predicted noise level of 63 dB $L_{Aeq,12h}$ is below the UK guidance daytime construction noise threshold of 75 dB $L_{Aeq,12h}$. It is also below the national Nigerian standard of 90dB and is in the range of noise levels that might be expected from a road with moderate traffic flow. The delivery of rock for the construction of the sea defence is therefore judged to result in a **negligible** noise impact.

Impact Box 6.18 Off-site construction traffic noise impacts

Description of Impact	Off-site construction traffic noise impacts
Receptor(s)	Shoreline residential and business properties, businesses at rear of Kuramo Lagoon
Investigation/reference	Surveys and analyses; Section 5.17; Appendix P
Features of Impact	Temporary and local
Significance of Impact	**Negligible**
Mitigation advice	Ensure drivers are properly qualified follow standard road safety procedures
Residual Impact	**Negligible**

6.8 Marine and Coastal Ecology

6.8.1 Impact on Marine and Coastal Ecology during Construction

Impact on Marine Ecology from Increased Suspended Sediments

The project involves the dredging of large areas and placement of the dredged material on the area to be reclaimed. Sediment mobilisation and subsequent deposition is likely to arise through both the dredging and reclamation activities. It is likely therefore that this could result in a fine layer of sediment over wider areas with the potential to impact benthic organisms through the smothering of feeding/respiratory organs and the restriction of light for photosynthesis. Mobile fauna (*e.g.* fish) and epifauna (*e.g.* crabs) and active burrowers in the area are least likely to be affected by smothering, with sessile organisms being vulnerable and more sensitive.

The increase in suspended sediment within the water column arising from the proposed dredging and reclamation works also has the potential to affect the physiology of fish. Although adult fish are often able to move away from an area of increased suspended sediment, fish eggs, larval stages and juveniles may be unable to move away and avoid such areas and can be impacted though smothering, the ingestion of sediment or blockage of gills. Therefore, shellfish species or species of fish which deposit eggs on the sea floor are most likely to be affected by this source.

Increased turbidity resulting from elevated levels of suspended sediments may also result in a reduction in photosynthetic activity of marine flora due to decreased light penetration.

It is probable that organisms present within the area of impact would be used to some level of naturally turbid water, due to the presence of the commodore channel which provides a source of riverine sediment to the nearshore zone and from the action of waves causing disturbance to the seabed.

The species present in the area (as identified during the baseline survey work) showed that the species were widespread in distribution and no species highly sensitive to smothering or increase in suspended sediment were identified. As such it is expected that there would be high levels of tolerance and quick recovery from adjacent species. As such, although the impacts from dredging and reclamation are on a large scale, the receptor sensitivities are considered to be medium to low. Therefore, it is predicted that the suspended sediments resulting from dredging and reclamation activities would result in an impact of **moderate adverse** significance upon marine ecology. If mitigation measures are implemented to help reduce the suspended sediments it is expected that a residual impact of **minor adverse** significance would occur from this effect.

Impact Box 6.19 Impact on Marine Ecology from Increased Suspended Sediments

Description of Impact	Impact on Marine Ecology from Increased Suspended Sediments
Receptor(s)	Marine Ecology
Investigation/reference	Surveys and analyses; Section 5.18; Appendix C, F
Features of Impact	Long term
Significance of Impact	**Moderate adverse**
Mitigation advice	• Reclamation activities to be conducted to minimise spillage and loss of material from the reclamation site *e.g.* creation of breakwater early in project to create sheltered reclamation site. • Sediments to be dredged should be selected with the lowest percentage of fine material available in order to reduce potential for fines to be dispersed during dredging and placement activities.
Residual Impact	**Minor adverse**

Impact on Marine Ecology from Habitat Loss and Direct Damage or Removal

During all dredging operations, the removal of material from the seabed also removes the benthic habitat and the animals living on and in the sediments (benthic animals). With the exception of some deep burrowing animals or mobile surface animals that may survive a dredging event through avoidance, dredging may initially result in the complete removal of animals from the excavation site (JNCC, 2008b).

The expected significance of this impact on marine ecology is dependent on the community type which is removed, changes to bathymetry and their resultant effects on marine organisms, any changes in sediment/benthic substrate composition as a result of dredging and the ability of marine organisms to re-colonise following disturbance either through migration or spawning from adjacent areas.

Given the nature of the sediments within the borrow areas (sandy), it is likely that there would be recovery following dredging, as the remaining sediment would remain as sandy habitat and could therefore be colonised by similar species from adjacent areas, although the community is not likely to be identical to that which was affected due to the potential for changed environmental conditions within the new area (*i.e.* mobility of sediment and size distribution).

Reclamation activities would have a significant impact for those communities located within the reclamation footprint. Smothering of the seafloor would be fatal for the majority of organisms inhabiting the area, however no unusual species were recorded during the baseline surveys and areas adjacent to the borrow areas support similar benthic communities. The proximity of similar species would facilitate re-colonisation of the borrow areas.

The impacts on benthic communities from removal via dredging would be highly significant for those species within the footprint of the dredge. However, the benthic communities identified in the marine survey are not considered to be of conservation importance and similar habitats are likely to be found along the remainder of the Nigerian coastline. In addition, the species found are widely distributed within the adjacent area.

The significance of the effect on marine ecology would vary dependant on the location. Effects would be long term for the reclamation area due to habitat loss and temporary in dredged areas, as it is expected that the benthic communities would recover over a period of 1 to 3 years if undisturbed. Although the scale of the activities are large, the value of the receptor is considered to be limited, and therefore it is predicted that the dredging and reclamation activities would result in an overall impact of **minor adverse** significance for the marine ecology of the area, as a result of direct damage and removal.

Impact Box 6.20 Impact on Marine Ecology from Habitat Loss and Direct Damage or Removal

Description of Impact	Impact on Marine Ecology from Habitat Loss and Direct Damage or Removal
Receptor(s)	Marine Ecology
Investigation/reference	Surveys and analyses; Section 4.2; 5.18; Appendix F, L, O
Features of Impact	Long term
Significance of Impact	**Minor adverse**
Mitigation advice	Where possible, marine habitat should remain in a state that facilitates re-colonisation of marine flora and fauna post dredging and post reclamation.
Residual Impact	**Minor adverse**

Impact on Coastal Ecology from Habitat Loss

Potential erosion may occur to the east of the new reclamation area (refer to **Section 6.3**) and therefore there is potential for loss of the coastal habitats. However, coastal habitats in the potential erosion area are limited, and where they do occur they are of low ecological value and / or are heavily urbanised or polluted. As such, a **negligible** impact on coastal habitats is predicted. In the case that the coastal erosion mitigation strategy is implemented, then **no impact** on coastal habitat is predicted.

Impact Box 6.21 Impact on Coastal Ecology from Habitat Loss

Description of Impact	Impact on Coastal Ecology from Habitat Loss
Receptor(s)	Marine Ecology
Investigation/reference	Site observations, analyses; Section 5.9; 5.21; Appendix H, O
Features of Impact	N/A
Significance of Impact	**Negligible**
Mitigation advice	Refer to Table 8.1 for information on the coastal monitoring and mitigation strategy
Residual Impact	**No Impact**

Release of Sediment Contaminants into Marine Environment

The dredging and reclamation operations would cause the re-suspension and subsequent redistribution of sediments within the area of activity. If there were any sediment contaminants within the mobilised sediments, these may also be suspended and redistributed. Such contaminants can be toxic to marine organisms.

The sediment survey, albeit limited, found low levels of contaminants in the sediment at selected sites in the borrow area and reclamation area (See **Section 5.11**). The sediment quality in Borrow Area A does not exceed CISQG standards and as such dredging within this area should not have an adverse effect on marine biota.

Impact Box 6.22 Release of Sediment Contaminants into Marine Environment

Description of Impact	Release of Sediment Contaminants into Marine Environment
Receptor(s)	Marine Ecology
Investigation/reference	Surveys and analyses; Section 5.11; 5.13; Appendix C, D, F, P
Features of Impact	Long term
Significance of Impact	**Minor adverse**
Mitigation advice	Control and mitigation of spillages of fuels/oils etc. during construction and operational phases Maintain water quality (application of mitigation measures for water and sediment quality will help to mitigate impacts on marine ecology) Dredging in areas with clean sands only
Residual Impact	**Negligible**

Impacts on marine ecology due to disturbance effects

Marine mammals and turtles can be sensitive to disturbance from underwater noise and large noise disturbances have the potential to cause shifts in behaviour and under extreme conditions, physiological damage and increased risk of mortality. However, Lagos is a large shipping hub on the African coast and as such, the noise and vibration associated with the dredging and reclamation activities is anticipated to be limited against existing background noise of the shipping operating in the area. On this basis, the impacts from underwater noise are considered to be of **negligible adverse** significance.

Impact Box 6.23 Impacts on marine ecology due to disturbance effects

Description of Impact	Impacts on marine ecology due to disturbance effects
Receptor(s)	Marine Ecology
Investigation/reference	Surveys and analyses; Section 5.11; 5.18; Appendix C
Features of Impact	Long term
Significance of Impact	**Negligible**
Mitigation advice	In general, vessels operating in the area should maintain a constant speed and direction as far as possible to minimise the risk of disturbance. Minimise lighting at night
Residual Impact	**Negligible**

Risks to Marine Mammals and Reptiles due to Vessel Traffic and Collision Risk

Other than the dredger proposed for use in this project, it is not anticipated that significant increases in vessel numbers and movements would occur compared with normal operation of the area, and therefore a very low risk of collision with marine mammals would be associated with the Project. Furthermore, the risk of collision is also a function of the likely frequency of presence of marine mammals in the vicinity of the works. Given that marine mammals do not frequently visit the Project in large numbers, therefore the risks of collision are considered **negligible**.

Impact Box 6.24 Risks to Marine Mammals and Reptiles due to Vessel Traffic and Collision Risk

Description of Impact	Risks to Marine Mammals and Reptiles due to Vessel Traffic and Collision Risk
Receptor(s)	Marine Ecology
Investigation/reference	Surveys and analyses; Section 5.18; 5.22; Appendix C
Features of Impact	Long term
Significance of Impact	**Negligible**
Mitigation advice	In general, vessels operating in the area should maintain a constant speed and direction as far as possible to minimise the risk of collision. Should there be periods where marine mammals occur in the area and are affected then additional mitigation measures should be investigated.

Residual Impact	Negligible

Impacts to Marine Mammals and Reptiles due to Decreased Prey Availability

Noise and vibration associated with construction activities may cause temporary displacement of the prey species of marine mammals away from the source of disturbance. However, as previously stated, the area is not considered to be an important foraging area for marine mammals and, as such, the number of individuals potentially affected would be low.

Indirect impacts on l fish and shellfish from sediment plumes

The increase in suspended sediment within the water column arising from the proposed dredging and piling works has the potential to affect the physiology of fish. Although adult fish are often able to move away from an area of increased suspended sediment, fish eggs, larval stages and juveniles may be unable to move away and avoid such areas and can be impacted though smothering, the ingestion of sediment or blockage of gills. Therefore, shellfish species or species of fish which deposit eggs on the sea floor are most likely to be affected by this source.

Assuming the selection of coarser sand for dredging, it is expected that increased suspended sediments would only be noticeably increased above background during dredging operations and that the effects would be seen only within the immediate vicinity of the dredging. If silts or clays were dredged, then the effects of the sediment plume would be wider.

Given the strong wave climate of the Project area and the localised level of increased turbidity and deposition predicted to arise from the dredging, the impacts on fish and shellfish resource from sedimentation are considered to be of **minor adverse** significance. Any such effects from sedimentation would be short-term, localised and reversible.

Impact Box 6.25 Indirect impacts on commercial fish and shellfish from sediment plumes

Description of Impact	Indirect impacts on commercial fish and shellfish from sediment plumes
Receptor(s)	Fish and shellfish
Investigation/reference	Desk study; Section 4.2; 5.23; Appendix C, F
Features of Impact	Short-term, localised and reversible.
Significance of Impact	Minor adverse
Mitigation advice	Refer to water quality mitigation for suspended sediments
Residual Impact	Minor adverse

Impacts on commercial fish and shellfish resource from direct extraction of species

The proposed dredging would result in the direct extraction of the seabed sediments and benthic organisms within the footprint of the dredging works. This may result in impacts on fish and shellfish in the dredge footprint from direct extraction into the dredge hopper. However, the impacts on the overall fish and shellfish resource are not considered significant based on the low rate of dredging and relatively the low levels of shellfish species which would be extracted in any one period. It is therefore predicted that the impacts on the fish and shellfish resource from the direct extraction of species would be **negligible**.

Impact Box 6.26 Impacts on commercial fish and shellfish from direct extraction of species

Description of Impact	Impacts on commercial fish and shellfish from direct extraction of species
Receptor(s)	Fish and shellfish
Investigation/reference	Desk-study; Section 4.2; 5.23; Appendix C, F
Features of Impact	Local, short-term and reversible
Significance of Impact	**Negligible**
Mitigation advice	None required
Residual Impact	**Negligible**

Impact on fish from loss of food resource

The proposed dredging would directly remove benthic invertebrates and would temporarily reduce the abundance of benthic organisms in the immediate vicinity of the dredge and reclamation works and by affecting the benthic food resource in the area, there is a potential to impact the fish. However, the benthic communities in this area are expected to constitute a minor proportion of the feeding resource for fish species and due nature of the baseline environment at the Project site and the low rate of dredging, the predicted impact on benthic communities is low. As such, it is unlikely that the loss of food resource or would be significant and it is predicted that the impacts on fish from this source would be **negligible**.

Impact Box 6.27 Impact on fish from loss of food resource

Description of Impact	Impact on fish from loss of food resource
Receptor(s)	Fish
Investigation/reference	Desk-study; Section 5.8; 5.18; 5.23; Appendix C
Features of Impact	Short-term, local and reversible.
Significance of Impact	**Negligible**
Mitigation advice	None required
Residual Impact	**Negligible**

6.8.2 Impact on Marine and Coastal Ecology during Operation

Impact of new breakwater on marine ecology

Eko Atlantic will represent a new environment created artificially by reclamation activities. The new breakwater structure will provide substrate suitable for ecological colonisation and therefore, it is predicted that in time the structure will support subtidal rock communities.

The breakwaters are considered the key area of potential for environmental enhancement. The long shallow areas consisting of rock substrate should provide a suitable habitat for the colonisation of algae and associated fish and invertebrate communities.

In terms of defining the significance of the impact, difficulty arises as it is hard to demonstrate whether the artificial habitat will increase fish production, or just attract fish from surrounding areas. However it is hoped that by providing appropriate environmental conditions (substrate, water quality *etc.*), communities will develop on the breakwaters, which would not be able to colonise the sand sediments previously there, and therefore, a **minor beneficial impact** on marine ecology is predicted from this source.

Impact Box 6.28 Impact of new breakwater on marine ecology

Description of Impact	Impact of new breakwater on marine ecology
Receptor(s)	Marine Ecology
Investigation/reference	Surveys and analyses; Section 4.2; 5.18; Appendix P
Features of Impact	Long term
Significance of Impact	**Minor adverse**
Mitigation advice	Ensure good water quality around the reclamation is maintained. Refer to **Section 5.4** for more information on the required mitigation measures for water quality.
Residual Impact	**Minor adverse**

No other impacts on marine ecology are predicted during operation.

6.9 Lagoon Ecology

6.9.1 Impact on Lagoon Ecology during Construction

No impacts are predicted in the lagoon ecology during construction.

6.9.2 Impact on Lagoon Ecology during Operation

Impact of Eko Atlantic on Lagoon Water Quality

The newly reclaimed land could potentially affect the exchange of saline water (either through overtopping or groundwater exchange) between the ocean and the lagoons system at Kuramo Waters, which could affect the salinity of the lagoon.

Although the likelihood of occurrence and potential significance of this change are difficult to establish, a small effect may be expected on water quality (salinity). In the case the salinity of the lagoon was to change, a shift in the ecology could also be expected from those species which are tolerant of more saline conditions to those of freshwater preference. A change in salinity would potentially cause an adverse impact on the lagoon ecology. The level of significance of the change is dependent on the existing level of input of seawater and how this is affected by the scheme. The Species in the lagoon are not considered to be of conservation value and are already strongly impacted by deteriorating water quality (see **Section 5.12**).

However there could be a change in species composition which affects overall biodiversity of the area. Due to the level of uncertainty, it is considered that the potential effect should be monitored through water quality testing of the lagoon. Change in salinity would potentially cause a **negligible** to **minor adverse impact** on the lagoon ecology. However, it is considered that the potential effect should be monitored through regular water quality testing of the lagoon.

Impact Box 6.29 Impact of Eko Atlantic on Lagoon Ecology

Description of Impact	Impact of Eko Atlantic on Lagoon Water Ecology
Receptor(s)	Lagoon Ecology
Investigation/reference	Surveys and analyses; Section 5.12; 5.19; Appendix C
Features of Impact	Long term
Significance of Impact	**Minor adverse impact**
Mitigation advice	• Implement monitoring system for lagoon water quality (See Table 8.1) • (Salt) water channels in or besides newly reclaimed land might slightly positively influence the interaction with the Lagoon waters. The final design of the city development includes such channels (phase 2).
Residual Impact	**Negligible to Minor adverse impact**

6.10 Ornithology

6.10.1 Impact on Birds during construction and operation

Dredging and reclamation projects can affect bird populations through noise disturbance from construction and by impacting marine feeding areas. The placement of the reclamation removes an area of ocean that may be used by foraging birds. However the reclamation area is small in relation to the areas of undisturbed coastline to the east and west of the Project area. Furthermore, the Project site is not thought to support significant numbers of bird species and dredging is not predicted to have significant effects on marine ecology of the area. On this basis, it is predicted that there would be a negligible impact on bird populations during construction and operation.

Impact Box 6.30 Impact of Eko Atlantic on Bird Populations

Description of Impact	Impact of Eko Atlantic on Bird Populations
Receptor(s)	Bird Populations
Investigation/reference	Desk study; Section 5.20; Appendix F, P
Features of Impact	Long term
Significance of Impact	**Negligible**
Mitigation advice	None required
Residual Impact	**Negligible**

6.11 Terrestrial Ecology

6.11.1 Impact on Terrestrial Ecology during Construction

Impacts on terrestrial ecology during construction

The majority of construction activity would be restricted to the marine environment and therefore the potential for impact upon the terrestrial environment would be limited. However, the potential exists for impacts on terrestrial habitats and species to occur as a result of land based construction traffic and construction noise.

The routes which would be utilised by construction traffic are currently in use and the level of increase in traffic on these routes is not considered to be of an adverse nature for terrestrial ecology in the area. Given that traffic would be limited to clearly marked roads and impacts would be restricted to the construction period it is considered that there would be **a negligible impact** on terrestrial ecology.

Impact Box 6.31 Impact on terrestrial ecology during construction

Description of Impact	Impacts on terrestrial ecology during construction
Receptor(s)	Terrestrial habitats and species
Investigation/reference	Site observation and analyses; Section 5.21; 5.30; Appendix N, P
Features of Impact	Short-term, local and reversible
Significance of Impact	**Negligible**
Mitigation advice	All construction traffic should be directed to the site using clear signage to avoid any unnecessary damage to terrestrial habitats. Should any damage occur to habitats through the presence of a construction yard or movements of vehicles, the habitat should be restored at the end of the construction period to the state that it was originally found.
Residual Impact	**No impact**

6.11.2 Impact on Terrestrial Ecology during Operation

Impacts on terrestrial ecology during operation

The presence of the reclaimed land during operation should have **no impact** on terrestrial ecology. However the enhancement of habitats should be considered during Phase II of the development during the construction of the infrastructure.

Impact Box 6.32 Impact on terrestrial ecology during operation

Description of Impact	Impacts on terrestrial ecology during operation
Receptor(s)	Terrestrial habitats and species
Investigation/reference	Site observation and analyses; Section 5.21; 5.30; Appendix N
Features of Impact	None
Significance of Impact	**No Impact**
Mitigation advice	N/A
Residual Impact	**No Impact**

HUMAN ENVIRONMENT

6.12 Socio-economic Impacts

6.12.1 Potential Impacts during construction

Impact of reclamation activity on Businesses and Government Buildings on Ahmadu Bello Way

In the construction phase, predicted impacts to these stakeholders range from negligible to **moderate beneficial** significance. Shrewd business owners, recognizing that their properties will increase in value as a result of the shoreline defence construction, will begin to renovate the buildings for future use or sale in the early stages of construction. The noise and dust impacts, as currently evidenced, have no impact on these properties, because half of them are empty and they are located far enough away from the reclamation works. All of the businesses have benefited from the sea defence construction as they are no longer at risk of flooding.

Impact Box 6.33 Impact of reclamation activity on Businesses and Government Buildings on Ahmadu Bello Way

Description of Impact	Impact of reclamation activity on Businesses and Government Buildings on Ahmadu Bello Way
Receptor(s)	Established hotels and office buildings
Investigation/reference	Consultations and analyses; Section 5.32; Appendix E, N
Features of Impact	Long term
Significance of Impact	**Moderate Beneficial impact**
Mitigation advice	None.
Residual Impact	**Moderate Beneficial impact**

Impact of reclamation activity on businesses on and near Adetokumbo Ademola Street

These businesses are located far enough away so that any noise emitted from the construction will be negligible during the day and only a minor disturbance at night (and hence, inaudible inside the building). Office employees and hotel guests residing on the upper floors of buildings will have their view of the ocean obstructed by the reclamation activities, but this will be temporary. As a result, an impact of **minor adverse** significance is predicted for these businesses.

Impact Box 6.34 Impact of reclamation activity on businesses on and near Adetokumbo Ademola Street

Description of Impact	Impact of reclamation activity on businesses on and near Adetokumbo Ademola Street
Receptor(s)	Businesses – legal
Investigation/reference	Consultations and analyses; Section 5.32; Appendix E, N
Features of Impact	Short term
Significance of Impact	**Minor adverse impact**
Mitigation advice	Maintain good communication with all users of the

	area, through regular communications
Residual Impact	**Minor adverse impact**

Impact of reclamation activity on Lighthouse Creek, Middle Creek, and Badagry Creek

All communities have been described in the baseline chapter of this EIA report. The Creek communities are far away from the Eko Atlantic area, while various other communities are situated to the east. No direct impacts are therefore expected.

However, as many of these communities depend on fishing activities, there is an indirect potential that the dredging and reclamation activities have an impact on their movements and fish catch. This potential has been dealt with in the sections on fisheries in chapter 5 and 6. The potential impacts are summarized in the **Impact boxes 6.25, 6.26 and 6.27**. These impacts on fisheries are predicted as negligible to locally minor. Therefore, the impacts for the communities in the region are considered of **negligible** significance.

Impact Box 6.35 Impacts on Creek and eastern communities

Description of Impact	Impact of reclamation activity on businesses on or near Adetokumbo Ademola Street
Receptor(s)	Established hotels and office buildings
Investigation/reference	Consultations and analyses; Section 5.32; Appendix E, N
Features of Impact	Long term
Significance of Impact	**Negligible significance**
Mitigation advice	Maintain communication and inform the about the various project phases
Residual Impact	**Negligible to No Impact**

6.12.2 Potential Impacts during Operation

Impact of reclamation activity on Kuramo Business Cabins

Assuming the cabins are not required to move, it is predicted that the reclamation activity will have a **moderate beneficial** impact on the Kuramo Business Cabins in the operational period, provided they are allowed to stay in their current locations and tourist access to the Cabins is not restricted. The impact is predicted to be positive because there should be a large number of tourists patronizing these businesses as a result of the land fill. This is already happening at Bar Beach.

Impact Box 6.36 Impact of reclamation activity on Businesses and Government Buildings on Ahmadu Bello Way

Description of Impact	Impact of reclamation activity on Businesses and Government Buildings on Ahmadu Bello Way
Receptor(s)	Established hotels and office buildings
Investigation/reference	Consultations and analyses; Section 5.32; Appendix E, N

Features of Impact	Long term
Significance of Impact	**Moderate Beneficial impact**
Mitigation advice	None.
Residual Impact	**Moderate Beneficial impact**

Impact of reclamation activity on Businesses and Government Buildings on Ahmadu Bello Way

Potential impacts to these office buildings will be highly beneficial. These buildings will be safe from flooding and surrounded by modern amenities, such as new parks and green areas. The real estate value of these properties will increase dramatically. The predicted impact level is **major beneficial** significance.

Impact Box 6.37 Impact of reclamation activity on Businesses and Government Buildings on Ahmadu Bello Way

Description of Impact	Impact of reclamation activity on Businesses and Government Buildings on Ahmadu Bello Way
Receptor(s)	Established hotels and office buildings
Investigation/reference	Consultations and analyses; Section 5.32; Appendix E, N
Features of Impact	Long term
Significance of Impact	**Major Beneficial impact**
Mitigation advice	None.
Residual Impact	**Major Beneficial impact**

Impact of reclamation activity on businesses on and near Adetokumbo Ademola Street

These hotels and offices are predicated to benefit enormously from the increase in real estate prices in anticipation of the Eko City Atlantic Development. This benefit outweighs any negative arising from the loss of the sea view.

Impact Box 6.38 Impacts on the hotels and offices on or near Adetokumbo Ademola Street

Description of Impact	Impact of reclamation activity on businesses on or near Adetokumbo Ademola Street
Receptor(s)	Established hotels and office buildings
Investigation/reference	Consultations and analyses; Section 5.32; Appendix E, N
Features of Impact	Long term
Significance of Impact	**Major Beneficial impact**
Mitigation advice	None.
Residual Impact	**Major Beneficial impact**

Impact of reclamation activity on Lighthouse Creek, Middle Creek, and Badagry Creek as well as other communities east of the study area

In the operation phase, impacts to these stakeholders are expected to be **negligible** as the reclamation area is located at a considerable distance.

6.13 Navigation

6.13.1 Impact on Navigation during Construction

Impact from Dredging Vessels Navigation on Existing Commercial Navigation

During dredging and reclamation operations, there will dredging vessels and associated survey vessels utilising the waters around the Commodore Channel. The dredging vessel will also be stationed at frequent intervals within the Commodore Channel, adjacent to the East Mole, in order to pump sand to the placement site. As such, there will be a slight increase in the potential navigational safety risks.

However, the intensity of traffic navigating in and out Lagos Port is relatively low, and is tightly controlled by the Nigerian Port Authority (NPA). The project developer and engineers have been in liaison with the NPA regarding safety and arrangements for navigation in these waters and the NPA have agreed to the presence of the dredger in the channel. The movement of the Project vessels will be carefully managed to minimise risks and therefore the impact on commercial navigation is predicted to be of **no impact.**

Impact Box 6.39 Impact from Dredging Vessels Navigation on Existing Commercial Navigation

Description of Impact	Impact from Dredging Vessels Navigation on Existing Commercial Navigation
Receptor(s)	Other vessels
Investigation/reference	Desk study; Section 5.9; 5.22; 6.3; Appendix F, H
Features of Impact	None
Significance of Impact	**Negligible significance**
Mitigation advice	Maintain good communication with all users of the area, through regular communications with NPA. Follow instructions provided by NPA regarding navigational safety
Residual Impact	**No Impact**

6.13.2 Impact on Navigation during Operation

Impact from operation on Existing Commercial Navigation

The wave disturbance modelling study has concluded that there will be no impact on wave conditions at the harbour to the entrance or the Commodore Channel (**Section 6.3**) and therefore **no impact** is predicted on commercial navigation during operation due to altered wave heights.

Impact Box 6.40 Impact from operation on Existing Commercial Navigation

Description of Impact	Impact from operation on Existing Commercial Navigation
Receptor(s)	Other vessels
Investigation/reference	Desk-study; Section 5.9; 5.22; 6.3; Appendix H
Features of Impact	None
Significance of Impact	**No Impact**
Mitigation advice	Maintain good communication with all users of the area, through regular communications with NPA
Residual Impact	**No Impact**

6.14 Landscape and visual quality

6.14.1 Impacts on landscape during Construction and Operation

Impacts on landscape from reclamation

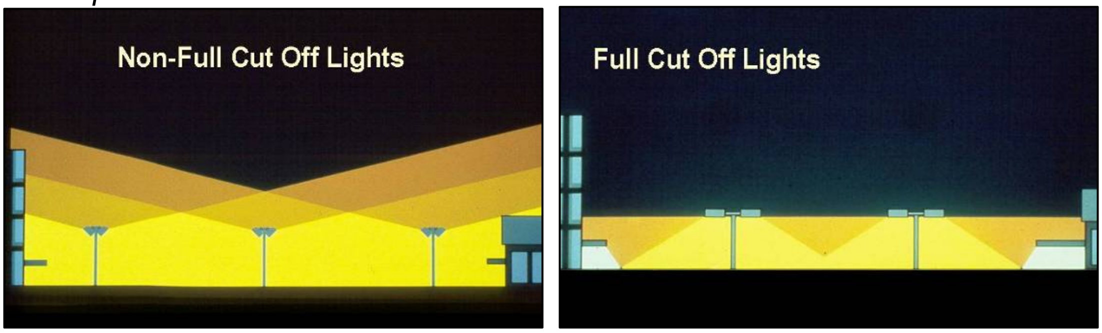
The presence of construction plant, machinery and marine operations would create a visual intrusion on the landscape during construction. The main receptors affected by this would be the residents of hotels and beach front properties. Such effects could include impacts from lighting, construction areas and construction debris. The presence of the reclaimed area will change the character of the coastline. The change in visual appearance will be from a beach area to a hard defence coastline backed by land. The beach area has however been subject to considerable erosion over the last few decades in certain areas. Under a ‘do nothing’ option the beach would continue to erode, thereby affecting the landscape adversely. Once completed the land reclamation should enhance the landscape behind the sea defences.

This is a permanent impact and therefore the overall impact significance is expected to be of **moderate adverse** significance. No mitigation measures are possible for this effect, however it is expected that beneficial effects for coastal commercial businesses would be seen in Phase II of the Project.

To help minimise the effects, where absolutely required light sources should be pointed inland and directed downwards in an attempt to minimise lighting impacts further-a-field. This can be achieved by using cut off lights, which only reflect the light towards the ground. Studies have shown that these fixtures generally have an upward flux of between 0.2 – 1.5%, leading to an average reduction in light pollution of around 85% and a reduction in energy consumption of between 40 – 60% (Dıaz-Castro, 1998). **Figure 6.15** shows the difference between non-full cut off lights and cut-off lights (from International Dark Sky Association (IDSA), 2007).

Where lighting is not essential, it should not be used; high levels of lighting wastes energy and money. If required for security purposes, site lighting should be kept to the minimum brightness necessary. The use of energy efficient light sources (*e.g.* fluorescent and halogen bulbs instead of incandescent bulbs) is also recommended.

Impact significance to be reviewed following consultations with local potentially affects parties



(Source: IDSA, 2007).

Figure 6.15 Non-full and full cut-off lights

Impact Box 6.41 Impacts on landscape from reclamation

Description of Impact	Impacts on landscape from reclamation
Receptor(s)	Coastal human receptors such as hotels and beach front properties.
Investigation/reference	Desk study; Section 5.26; Appendix F, P
Features of Impact	None
Significance of Impact	**Moderate adverse**
Mitigation advice	A tidy site scheme should be implemented at all times. The scheme should include best practices such as: • Supply temporary washroom and toilet facilities with sewage storage and/or treatment to be emptied at regular intervals to avoid overflow. • Ensure correct rubbish disposal and regular collection from the Site to avoid distribution of rubbish around the Site and the attention of carrion seeking birds. • Reduce office waste, (reduce, re-use, re-cycle). Refer to **Section 7.3 and appendices F and P** If lighting is necessary, a number of measures can be taken to ensure a greater degree of sustainability: • Select the correct light source. High pressure sodium is recommended unless the light is motion sensor activated, in which case incandescent or instant start compact fluorescent bulbs can be used. Metal halide light sources are discouraged and mercury vapour bulbs are generally prohibited; • Ensure that lights are correctly adjusted so that they only illuminate the surface intended and do not throw light onto adjacent areas; • Security lights should be correctly adjusted so that they only pick up the movement of persons in the area intended and not beyond; • Use "shut off" controls such as sensors, timers and motion detectors. Install automatic controls or turn

	off lights when not needed. • In order to reduce the effects of glare, beam angles should be below 70 degrees. If up-lighting has to be used then install shields or baffles above the lamp to reduce the amount of wasted upward light; and • Do not install equipment which spreads light above the horizontal.
Residual Impact	**Moderate adverse**

6.15 Recreation

6.15.1 Impacts on recreation during Construction

Impact on recreation from construction activities

During construction, the beach area at Bar Beach will be extended, as sediments are pumped for reclamation and drift along the shore. Without the reclamation activities, the beach would erode away. This nourishment is therefore predicted to have a **major beneficial impact** on the local area for people wishing to use the beach for recreation for the duration of the construction period, assuming that access is maintained to the beach area.

Impact Box 6.42 Impact on recreation from construction activities

Description of Impact	Impact on recreation from construction activities
Receptor(s)	General public
Investigation/reference	Consultations and analyses; Section 5.32; Appendix E, N
Features of Impact	None
Significance of Impact	**Major Beneficial**
Mitigation advice	None required
Residual Impact	**Major Beneficial**

6.15.2 Impacts on recreation during Operation

Impact on recreation from operation

Once complete and assuming access is maintained to the ocean, the presence of the reclamation will make travel distances to the ocean longer by 500m to 2 km. This will stop some people using this area of beach and it is expected these people will travel to an alternative stretch of beach to either the east or west of the development. This is considered to be a **minor adverse impact** to the users the beach area due to inconvenience.

Impact Box 6.43 Impact on recreation from operation

Description of Impact	Impact on recreation from operation
Receptor(s)	General public
Investigation/reference	Consultations and analyses; Section 5.32; Appendix E, N

Features of Impact	None
Significance of Impact	**Minor adverse**
Mitigation advice	None required
Residual Impact	**Minor adverse**

6.16 Cultural heritage

6.16.1 Impacts on recreation during Construction and Operation

Impact on cultural heritage from construction and operation

No Impact on cultural heritage is expected as a result of the Project, as no facilities for this would be affected in the Project area.

Impact Box 6.44 Impact on cultural heritage from construction and operation

Description of Impact	Impact on cultural heritage from construction and operation
Receptor(s)	General public
Investigation/reference	Desk-study; Section 5.24; Appendix N
Features of Impact	None
Significance of Impact	**No Impact**
Mitigation advice	None required
Residual Impact	**No Impact**

6.17 Health and Safety

6.17.1 Impacts on landscape during Construction and Operation

Impacts to public health and safety

No information is known on the current situation regarding public health. However, it is unlikely that the Project will have any negative impacts on public health, especially as most of the workers are accommodated on ships. There will be increased road traffic as a result of the Project, but this is not expected to increase current public road safety risks. The Hi-Tech yard and construction areas are closed to the public and therefore risks to health and safety as a result of the Project are expected to be **negligible.**

Impact Box 6.45 Impacts to public health and safety

Description of Impact	Impacts to public health and safety
Receptor(s)	General public in vicinity of project site
Investigation/reference	Desk-study; Section 4.2; 5.31; Appendix F, P
Features of Impact	None
Significance of Impact	**Negligible**
Mitigation advice	• Contractor to develop and implement public health and safety plans. • Ensure construction areas are closed to public access • Ensure drivers are properly qualified follow standard road safety procedures

Residual Impact	Negligible

Impacts on Occupational Health and Safety

Occupational Health and Safety is the responsibility of the contractor on site. A potential **moderate adverse** impact could occur as a result of accidents associated with the construction work and use of heavy machinery and materials. However, these impacts will be mitigated through Health and Safety Management systems of the Contractors. Assuming implementation of proper Health and Safety systems, the predicted impact is of **minor** significance, as it is considered that not all risks can be removed in a construction project. For information HSE documents from the contractor have been provided in **Appendix F**.

Impact Box 6.46 Impacts on occupational health and safety

Description of Impact	Impacts on occupational health and safety
Receptor(s)	Workers
Investigation/reference	Desk-study; Section 4.2; 5.31; Appendix F, P
Features of Impact	None
Significance of Impact	**Moderate adverse**
Mitigation advice	• Contractor to develop and implement occupational health and safety plans.
Residual Impact	**Negligible**

6.18 Cumulative Effects Assessment

6.18.1 Introduction

The proposed Eko Atlantic Shoreline Protection and Reclamation Project has undergone EIA to identify the environmental impacts associated with the proposed works. The findings of this assessment process are document in this report.

The EIA identified the potential environmental impacts of the proposal in isolation. However, there are several activities within Lagos which in-combination with the Eko Atlantic Project, have the potential to impact on the environment. Consideration of sustainability principles and the assessment of impacts from multiple developments on sensitive estuarine and coastal environments are emerging factors in the planning of coastal infrastructure (Conlan and Rudd, 2000). This chapter assesses the residual impact of the proposed project cumulatively with the residual impacts of other major developments within the vicinity of the proposed development.

A cumulative impact arises when impacts from several developments, which individually might be insignificant, coincide together and potentially produce a significant cumulative impact.

6.18.2 Assessment Methodology

The cumulative impacts process occurs over time and over space from the local to the regional level (Council on Environmental Quality, 1997). For the purposes of this assessment the environmental effects of any other development that is already built and operational is effectively included within the environmental baseline of the EIA, so is excluded from the cumulative impact assessment. The developments that are included may have been built in the recent past but are not yet operational, be under development, or will be undertaken in the reasonably foreseeable future.

To be considered within the cumulative impact assessment other development schemes must meet the following criteria:

- Generate their own residual impacts of at least minor significance;
- Be likely to be constructed or operate over similar time periods;
- Be spatially linked to the proposed development (for example using the same local road network); and
- Be either consented (but not operational) or be the subject of applications with the statutory authority in the area or be the subject of another statutory procedure.

Identification of Projects

Based on the above criteria and through consultation with FMEnv, LASMOE, and other contacts in Lagos, a list of relevant activities and projects in the area was compiled. This assessment was undertaken in September 2010 and therefore only projects known of at this date could be included.

Following compilation of the Project list, those activities and projects that may overlap in space or time and interact with each other were selected for inclusion within the assessment. Selection was also limited to those for which sufficient information exists to allow consideration of the potential for cumulative effects to arise, as in the absence of publicly available information, proper consideration may be overly subjective (*i.e.* assumptions may be speculative or contentious).

Based on this process, the Projects identified in **Table 6.17** have been considered within the Cumulative Effects Assessment (CEA).

Table 6.17 Identified projects in Lagos Area and potential for spatial or temporal overlap with the Eko Atlantic project Phase I

Project Name	Status (where information known)	Distance from Eko project	Potential for spatial or temporal overlap of impacts
Lekki Port and Harbour Facilities Project	Planned, EIA complete	60-70km	Limited potential for cumulative effects due to distance
Lekki Epe expressway	Ongoing	8km – 10km	No, considered too far away
Rehabilitation of the Lagos Moles	Ongoing to 2012	1km – 2km	Yes
Atlas Cove Tanker Jetty Rehabilitation	Proposed project, not yet awarded	5km – 7km	No, considered too far away and would affect

			difference receptors
Lekki Airport and development	Planned, not yet awarded	70km - 80km	Not enough information available
NPA Port Master plan and extension	Planned, not yet awarded		Not enough information available
Rehabilitation of Bullnose Jetty	Planned , not yet awarded	2km – 3km	Not enough information available
General building/hotels development in Victoria Island	Ongoing and planned	Opposite the Project area, along Ahmadu Bello way and its environs	No, unlikely to impact similar receptors
The proposed Lagos coastal road construction	Planned	Along Lagos atlantic coastline	Not enough information available, but this project should consider Eko Atlantic effects within its own EIA.

Description of projects with potential cumulative effects

Based on the identification, initial analysis and available data, it is considered that only one may have potential cumulative effects in combination with the Eko Atlantic shoreline protection and reclamation project. This is the Rehabilitation of the Lagos moles.

The Rehabilitation of the Lagos Moles is being undertaken to repair and improve the moles, as significant damage has occurred to the rock armour protection along the moles in previous years. The project is under the initiative of the Nigerian Ports Authority and involves works to approximately 150m of the East Mole, 500m of the Training Mole and 250m of the West Mole needed to be repaired. The project began in 2000 and is planned to continue until 2012. Construction activities consist of the placement of rock and concrete armour on the West and East Mole by both land and water based equipment. The rehabilitation of the Training Mole has been completed. In the future, the trunks of the moles, which have also been damaged, might require rehabilitation. The projects were not expected to cause any significant environmental impact as they involved rehabilitation of existing works and as such no EIA was required for this project.

It is considered that the Rehabilitation of the Lagos Moles may affect the sediment movement in a west-east direction. There is therefore a potential for in-combination effects to arise in conjunction with the Eko Atlantic project. This combined impact is considered in the coastal impact section (**Section 6.3**), where following mitigation, it is predicted to result in a **minor adverse effect** on coastal process.

It should be noted that the Lagos area is heavily disturbed by Human activity and the Eko Atlantic project is predicted to only have minor adverse effects on the environment, assuming the mitigation is implemented. As such, and by limiting the project effects in this way, it also reduces the likelihood of in combination effects to arise.

7 MITIGATION MEASURES

7.1 Introduction

Mitigation measures to reduce the significance of impacts or to avoid impacts have been recommended throughout the impact assessment section of this report (**Chapter 6**), in order that the residual (after mitigation) impact could be clearly presented.

This Section of the report summarises the predicted environmental impacts and associated mitigation measures to reduce or prevent them **(Table 7.1**). The measures are categorised by relevant impact parameter, potential impact, and affected receptor. The residual impact is also provided in this table.

In addition, **Section 7.2** and **Section 7.3** of this report provide additional guidance on best practice procedures for protection of the environment in relation to emergency response and waste management, which should be adopted by the contractor.

In determining these recommendations, the following factors have been taken into consideration:

- Feasibility;
- Local suitability;
- Training requirements; and
- Cost (capital and operating).

These measures are taken forward in the Environmental Management Plan in **Section 8** of this report.

Table 7.1 Summary of predicted impacts and associated mitigation measures

Description of Impact	Receptor(s)	Phase of project	Features of Impact	Significance of Impact	Mitigation measure	Residual Impact
Impact of dredging reclamation activity on coastal morphology	Coastline of Lagos	Operation	Long term	Major beneficial impact	None required	Major beneficial impact
Impacts of Eko Atlantic reclamation on coastal erosion and accretion	Coastal communities, habitats and infrastructure to the east of the Project site.	Operation	Long term	Moderate to Major adverse impact	• Selection of Layout with the addition of an S-shaped extension on the east side of the Project area. • Implementation of adaptive coastal erosion mitigation scheme (See Chapter 8)	Minor adverse impact
Impacts of dredging a borrow pit on longshore sediment transport at the coast	Coastal communities, habitats and infrastructure to the east of the Project site.	Operation	Long term	No Impact	To avoid the impact the following measures are required: • Ensure that dredging is only undertaken in depths greater than the 15m depth contour. • Implementation of adaptive coastal erosion mitigation scheme (See Table 8.1)	No Impact
Impacts on sediment transport to the Commodore	Users of the Commodore Chanel	Operation	Long term	Minor beneficial impact	None required	Minor beneficial impact

Description of Impact	Receptor(s)	Phase of project	Features of Impact	Significance of Impact	Mitigation measure	Residual Impact
Channel						
Impacts of sea defence on wave disturbance at the harbour entrance and within the Commodore Channel	Users of the Commodore Chanel	Operation	Long term	No Impact	None required	No Impact
Impacts of Increased Suspended Solids on Water Quality	Marine Water Quality	Construction	Long term	Moderate adverse impact	• Reclamation activities to be conducted to minimise spillage and loss of material from the reclamation site *e.g.* creation of breakwater early in project to create sheltered reclamation site. • Sediments to be dredged should be selected with the lowest percentage of fine material available in order to reduce potential for fines to be dispersed during dredging and placement activities. • Turbidity monitoring should occur as described in Table 8.1. • Ensure that overflow is	Minor adverse impact

Description of Impact	Receptor(s)	Phase of project	Features of Impact	Significance of Impact	Mitigation measure	Residual Impact
					released below the keel of the vessel to minimise the plume effect; • Where discharges are necessary strict control on the physical and chemical parameters of the discharge should be maintained. • Avoid rainbowing of sand fill into reclamation area where possible and favour direct pumping.	
Impacts of Pollution Incidents from Activities during Dredging and Reclamation	Marine Water Quality	Construction	Temporary	Minor adverse impact	• Where discharges to water are necessary strict control on the physical and chemical parameters of the discharge should be maintained. Discharges should be in line with the FMEnv Guidelines on Water Quality. • Close supervision of all plant refueling to minimise spillage. • Fill portable fuel tanks and containers away from water and never overfill. • Maintain plant regularly and using drip trays.	Negligible impact

Description of Impact	Receptor(s)	Phase of project	Features of Impact	Significance of Impact	Mitigation measure	Residual Impact
					• No washing of tools or plant in water. • Prevention of dust or litter being blown into water. • Keep the site and access roads free from excessive buildup of materials. • Prevent washout from concrete mixing draining into the ground. • Ensure the works are secure from vandals and thieves. • Supervise the delivery of any hazardous materials. • Adequately bund all storage areas and tanks for oil and chemicals. • Carry out all refueling of plant in a designated area. • Emergency response recommendations as outlined in Section 8.3 of the EMP must be followed. • It is also recommended that the dredging contractor provide measures to ensure compliance with MARPOL agreements including:	

Description of Impact	Receptor(s)	Phase of project	Features of Impact	Significance of Impact	Mitigation measure	Residual Impact
					• Management of Bilge Waste Water; • Management of Ballast Water; • Non-Hazardous Waste Management and Sewage; • Storage of Hazardous Materials and Chemicals and disposal of in accordance with regulations; • Vessel Cleaning; and • Metal Works / Equipment Maintenance.	
Impact on Water Quality from Mobilisation of Sediment Contaminants.	Marine Water Quality	Construction	Temporary	Moderate adverse impact	• Select borrow areas with medium to coarse sand to minimise distribution of silt, and any potential associated contaminants • Select borrow Area A and B as primary dredge areas • Test sediment quality on board dredger (See Chapter 8)	Minor to Negligible impact
Impact of Eko Atlantic on Lagoon Water Quality	Lagoon Water Quality	Construction	Long term	Minor adverse	• Salt water channel(s) around / inside newly reclaimed land part of phase 2 EIA. • Implement monitoring system	Negligible to Minor impact

Description of Impact	Receptor(s)	Phase of project	Features of Impact	Significance of Impact	Mitigation measure	Residual Impact
					for lagoon water quality (See Chapter 8).	
Impact of contaminant and TSS leaching from reclaimed land	Marine Water Quality	Operation	Medium term	Negligible impact	• No mitigation required at this stage, but monitoring of water quality during construction and sediment quality of the hoppers will be implemented to ensure the impacts are as predicted (Chapter 8).	Negligible impact
Impact on groundwater	Groundwater quality	Construction	Short Term, Temporary	Negligible	• Risks to ambient water features on construction sites are not uncommon and mitigation measures to deal with these are described in Impact Box 6.6.	No Impact
Impact on groundwater	Groundwater quality	Operation	N/A	No Impact	None required	No Impact
Air Quality Impact from Engine exhaust emissions from dredgers	Shoreline residential and business properties, businesses at rear of Kuramo Lagoon	Construction	Temporary, reversible, short term	**Negligible**	• The source of the predicted pollutant effects at land based receptors is the combustion of fuel on marine vessels; therefore the approach to reduction of air quality impacts should be to consider the quality of fuel used, and ensuring engines	**Negligible**

Description of Impact	Receptor(s)	Phase of project	Features of Impact	Significance of Impact	Mitigation measure	Residual Impact
					are properly serviced and maintained. • Monitoring recommended (See Chapter 8)	
Air Quality Impacts from Engine Exhaust Emissions – vehicles	Shoreline residential and business properties, businesses at rear of Kuramo Lagoon	Construction	Temporary, reversible, short term	**Negligible**	• Each dredging location should be qualitatively assessed and documented to determine the risk of odorous emissions. Should excavated material produce odorous emissions it should not be deposited in close proximity to the mainland.	**Negligible**
Air Quality Impacts from Engine Exhaust Emissions – vehicles	Shoreline residential and business properties, businesses at rear of Kuramo Lagoon	Construction	Temporary, reversible, short term	**Minor adverse**	On-road vehicles: Fuel quality and engine exhaust standards should be specified for vehicles in the contractor's fleet. Such controls may be based for example on European Emission Standards.	**Minor adverse**
Air Quality Impacts from Other Engine Exhaust Emissions – NRMM	Shoreline residential and business properties, businesses at rear of Kuramo Lagoon	Construction	Temporary, reversible, short term	**Minor adverse**	In addition to the emission standards and controls specified for off road vehicles, the following control measures should be implemented: • Plant or equipment must not	**Negligible**

Description of Impact	Receptor(s)	Phase of project	Features of Impact	Significance of Impact	Mitigation measure	Residual Impact
					emit dark smoke except during start-up; • Engines and exhaust systems need to be regularly serviced according to manufacturer's recommendations maintained to meet statutory limits/opacity tests; • All vehicles including off-road vehicles must hold current certification where required; • Vehicle exhausts must be directed away from the ground and positioned so they are not directed at site entrances; • Where practicable plant and equipment should not be operated near to residential areas or sensitive receptors near to the site boundary; • Control of queuing/ stationary vehicles outside the site is required, both during and before the site opens; • Avoid use of diesel or petrol powered generators by using	

Description of Impact	Receptor(s)	Phase of project	Features of Impact	Significance of Impact	Mitigation measure	Residual Impact
					mains electricity or battery powered equipment where available; and • Encourage the use of consolidation centres to manage site deliveries. This will help reduce the number of vehicles entering the site.	
Air Quality Impacts from Fugitive Dust Emissions	Shoreline residential and business properties, businesses at rear of Kuramo Lagoon	Temporary, reversible, short term	Construction	**Minor adverse**	• Dust control equipment should be readily available on site from the commencement of works. Construction materials • Material transported by road should be dampened prior to its handling and placement; • Covers should be used on trailer units to minimise dust blow from lorries; • Emplacement of fill material should be avoided during strong winds; and • Washing/cleaning of stone prior to leaving the quarry should be considered. Site Haul Roads	**Negligible**

Description of Impact	Receptor(s)	Phase of project	Features of Impact	Significance of Impact	Mitigation measure	Residual Impact
					• Where possible all major haul roads should be watered down; and • Haul roads should be inspected for integrity and repair.	
On-site construction traffic noise impacts	Shoreline residential and business properties, businesses at rear of Kuramo Lagoon	Construction	Temporary, reversible, short term	**Minor adverse**	• Locate plant in use as far away from noise sensitive receptors as is feasible for the particular activity • Maintain all equipment, machinery and vehicles in good working condition at all times. • Fit all equipment, machinery and vehicles with silencers. • Operators of equipment should avoid unnecessary idling, revving or inappropriate use of equipment. • Ensure that covers and hatches on equipment are properly secured and there are no loose fixings causing rattling. • Acoustic covers on all machine engines that	**Negligible to minor adverse**

Description of Impact	Receptor(s)	Phase of project	Features of Impact	Significance of Impact	Mitigation measure	Residual Impact
					generate excessive noise levels are to remain closed at all times. • Imposition of vehicle speed limits for heavy goods vehicle traffic travelling on access roads close to receptors and ensuring that vehicles do not park or queue for long periods outside noise sensitive properties with engines running unnecessarily. • Where possible, limit construction/reclamation activities to daytime hours. • Ensure, where practicable, that access routes are in good condition with no pot-holes or other significant surface irregularities. • Maintain good public relations with local residents/businesses that may be affected by noise from the construction works. An effective public relations campaign should be put in place, keeping local	

Description of Impact	Receptor(s)	Phase of project	Features of Impact	Significance of Impact	Mitigation measure	Residual Impact
					residents informed of the type and timing of works involved, paying particular attention to potential evening and night time works and activities which may occur in close proximity to receptors. Leaflet drops, posters and public meetings or exhibitions are an effective method of keeping local residents informed. • Provision of 24-hour contact details for a site representative in the event that disturbance due to noise or vibration from the construction works occurs; ensuring that any complaints are dealt with pro-actively and that subsequent resolutions are communicated to the complainant.	
Off-site construction traffic noise impacts	Shoreline residential and business properties,	Construction	Temporary and local	**Negligible**	• Ensure drivers are properly qualified follow standard road safety procedures	**Negligible**

Description of Impact	Receptor(s)	Phase of project	Features of Impact	Significance of Impact	Mitigation measure	Residual Impact
	businesses at rear of Kuramo Lagoon					
Impact on Marine Ecology from Increased Suspended Sediments	Marine Ecology	Construction	Long term	Moderate adverse impact	• Reclamation activities to be conducted to minimise spillage and loss of material from the reclamation site *e.g.* creation of breakwater early in project to create sheltered reclamation site. • Sediments to be dredged should be selected with the lowest percentage of fine material available in order to reduce potential for fines to be dispersed during dredging and placement activities.	Minor adverse impact
Impact on Marine Ecology from Habitat Loss and Direct Damage or Removal	Marine Ecology	Construction	Long term	Minor adverse impact	• Where possible, marine habitat should remain in a state that facilitates re-colonisation of marine flora and fauna post dredging and post reclamation.	Minor adverse impact
Impact on Coastal Ecology from	Marine Ecology	Construction	N/A	Negligible impact	Please refer to Chapter 8 for information on the coastal mitigation strategy	No impact

Description of Impact	Receptor(s)	Phase of project	Features of Impact	Significance of Impact	Mitigation measure	Residual Impact
Habitat Loss						
Release of Sediment Contaminants into Marine Environment	Marine Ecology	Construction	Long term	Minor adverse impact	• Control and mitigation of spillages of fuels/oils etc. during construction and operational phases • Maintain water quality (application of mitigation measures for water and sediment quality will help to mitigate impacts on marine ecology)	Negligible impact
Impacts on marine ecology due to disturbance effects	Marine Ecology	Construction	Long term	Negligible impact	• In general, vessels operating in the area should maintain a constant speed and direction as far as possible to minimise the risk of disturbance. • Minimise lighting at night	Negligible impact
Risks to Marine Mammals and Reptiles due to Vessel Traffic and Collision Risk	Marine Ecology	Construction	Long term	Negligible impact	• In general, vessels operating in the area should maintain a constant speed and direction as far as possible to minimise the risk of collision • Should there be periods where marine mammals occur in the area and are affected then additional	Negligible impact

Description of Impact	Receptor(s)	Phase of project	Features of Impact	Significance of Impact	Mitigation measure	Residual Impact
					mitigation measures should be investigated.	
Indirect impacts on commercial fish and shellfish from sediment plumes	Fish and shellfish	Desk-study	Short-term, localised and reversible.	Minor adverse	• Refer to water quality mitigation for suspended sediments	Minor adverse
Impacts on commercial fish and shellfish from direct extraction of species	Fish and shellfish	Desk-study	Short-term, localised and reversible.	Negligible	None required	Negligible
Impact on fish from loss of food resource	Fish	Desk-study	Short-term, localised and reversible.	Negligible	None required	Negligible
Impact of new breakwater on marine ecology	Marine Ecology	Operation	Long term	Minor adverse impact	• Ensure good water quality around the reclamation is maintained. Refer to Impact Box 6.6 for more information on the required mitigation measures for water quality.	Minor adverse impact
Impact of Eko Atlantic on Lagoon Water	Lagoon Ecology	Operation	Long term	Minor adverse impact	• (Salt water) channels in / besides newly reclaimed land part of phase 2.	Negligible to Minor adverse

Description of Impact	Receptor(s)	Phase of project	Features of Impact	Significance of Impact	Mitigation measure	Residual Impact
Ecology					• Implement monitoring system for lagoon water quality (See Chapter 8).	impact
Impacts on terrestrial ecology during construction	Terrestrial habitats and species	Construction	Short-term, local and reversible	Negligible impact	• All construction traffic should be directed to the site using clear signage to avoid any unnecessary damage to terrestrial habitats. • Should any damage occur to habitats through the presence of a construction yard or movements of vehicles, the habitat should be restored at the end of the construction period to the state that it was originally found.	No impact
Impact of Eko Atlantic on Bird Populations	Bird Populations	Construction and Operation	n/a	Negligible impact	None	Negligible impact
Impacts on terrestrial ecology during construction	Terrestrial habitats and species	Operation	None	No impact	None	No impact
Impact of reclamation activity on	Established hotels and office	Construction	Long term	Moderate beneficial	None	Moderate beneficial

Description of Impact	Receptor(s)	Phase of project	Features of Impact	Significance of Impact	Mitigation measure	Residual Impact
Businesses and Government Buildings on Ahmadu Bello Way	buildings					
Impact of reclamation activity on businesses on and near Adetokumbo Ademola Street	Businesses – legal	Construction	Short term	Minor adverse	Maintain good communication with all users of the area, through regular communications	Minor adverse
Impact to other communities notably related to fisheries	Creek communities and east communities	Construction	Short term	Negligible impact	Maintain good communication with all communities and inform them on various project phases	Negligible to no impact
Impact of reclamation activity on Businesses and Government Buildings on Ahmadu Bello Way	Established hotels and office buildings	Operation	Long term	Moderate beneficial	None	Moderate beneficial

Description of Impact	Receptor(s)	Phase of project	Features of Impact	Significance of Impact	Mitigation measure	Residual Impact
Impact of reclamation activity on Businesses and Government Buildings on Ahmadu Bello Way	Businesses – legal	Operation	Long term	Major beneficial	None	Major beneficial
Impact of reclamation activity on businesses on or near Adetokumbo Ademola Street	Established hotels and office buildings	Operation	Long term	Major beneficial	None	Major beneficial
Impact from Dredging Vessels Navigation on Existing Commercial Navigation	Terrestrial habitats and species	Construction	None	No Impact	Maintain good communication with all users of the area, through regular communications with NPA Follow instructions provided by NPA regarding navigational safety	No Impact
Impact from operation on Existing	Terrestrial habitats and species	Operation	None	No Impact	Maintain good communication with all users of the area, through regular	No Impact

Description of Impact	Receptor(s)	Phase of project	Features of Impact	Significance of Impact	Mitigation measure	Residual Impact
Commercial Navigation					communications with NPA	
Impacts on landscape from reclamation	Coastal human receptors such as hotels and beach front properties.	Construction & Operation	None	Moderate adverse impact	A tidy site scheme should be implemented at all times. The scheme should include best practices such as: • Supply temporary washroom and toilet facilities with sewage storage and/or treatment to be emptied at regular intervals to avoid overflow. • Ensure correct rubbish disposal and regular collection from the Site to avoid distribution of rubbish around the Site and the attention of carrion seeking birds. • Reduce office waste, (reduce, re-use, re-cycle) If lighting is necessary, a number of measures can be taken to ensure a greater degree of sustainability: • Select the correct light source. High pressure	Minor adverse

Description of Impact	Receptor(s)	Phase of project	Features of Impact	Significance of Impact	Mitigation measure	Residual Impact
					sodium is recommended unless the light is motion sensor activated, in which case incandescent or instant start compact fluorescent bulbs can be used. Metal halide light sources are discouraged and mercury vapour bulbs are generally prohibited; • Ensure that lights are correctly adjusted so that they only illuminate the surface intended and do not throw light onto adjacent areas; • Security lights should be correctly adjusted so that they only pick up the movement of persons in the area intended and not beyond; • Use "shut off" controls such as sensors, timers and motion detectors. Install automatic controls or turn off lights when not needed. • In order to reduce the effects	

Description of Impact	Receptor(s)	Phase of project	Features of Impact	Significance of Impact	Mitigation measure	Residual Impact
					of glare, beam angles should be below 70 degrees. If up-lighting has to be used then install shields or baffles above the lamp to reduce the amount of wasted upward light; and • Do not install equipment which spreads light above the horizontal.	
Impact on recreation from construction activities	General public	Construction	None	Major Beneficial	None required	Major Beneficial
Impact on recreation from operation	General public	Operation	None	Minor adverse	None required	Minor adverse
Impact on cultural heritage from construction and operation	General public	Construction & Operation	None	No Impact	None required	No Impact
Impacts to public health and safety	General public in vicinity of project site	Construction & Operation	None	Negligible impact	• Contractor to develop and implement public health and safety plans. • Ensure construction areas are closed to public access • Ensure drivers are properly	Negligible impact

Description of Impact	Receptor(s)	Phase of project	Features of Impact	Significance of Impact	Mitigation measure	Residual Impact
					qualified follow standard road safety procedures	
Impacts on occupational health and safety	Workers	Construction & Operation	None	Moderate adverse	• Contractor to develop and implement occupational health and safety plans.	Negligible

7.2 Emergency response mitigation

Once a pollutant enters the sea it is extremely difficult to remove or control. Consequently, it is vital that appropriate steps are taken to prevent water pollution during both the construction and operation phases.

Contingency plans and guidelines for pollution control must be established by the contractors from the outset of dredging and reclamation, to be implemented in the event of spillages into the marine environment. An effective emergency response plan (ERP) is based on:

- Suitable emergency equipment and associated staff training;
- Good definition and allocation of responsibilities;
- Readily visible and accessible contact numbers for the regulators; and
- Training in implementation of the plan, environmental management and monitoring.

Table 7.2 and **Table 7.3** identify good practice with regard to pollution avoidance and monitoring and mitigation equipment.

Table 7.2 Preventing spills during construction

Checklist – Spills during Construction
• Close supervision of all plant refuelling.
• Filling portable fuel tanks and containers away from water and never overfill.
• Maintaining plant regularly and using drip trays.
• No washing of tools or plant in water.
• Spillage control – ensure that all liquids are appropriately stored to prevent spillage.
• Prevention of dust or litter being blown into water.
• Keep the site and access roads free from excessive build-up of silt and materials.
• Preventing washout from concrete mixing draining into the ground.
• Ensuring the works are secure from vandals and thieves.
• Supervising the delivery of any hazardous materials.
• Adequately bunding all storage tanks for oil and chemicals.
• Carrying out all refuelling of plant in a designated area.
Although the risk of pollution should be minimised through the incorporation of the measures detailed above, the actual impact (should an accidental spill occur) could potentially still create significant adverse effects. The impact would be dependent on the size and type of the spill and the speed with which the Contractor instigates clean-up operations, if necessary. Given the risk of a spillage or incident, contract supervision and management of mitigation measures must be stringent at all times. If a polluting incident does occur, the relevant authorities must be contacted.

Table 7.3 Emergency actions and remediation

Checklist – Pollution Avoidance & Monitoring / Mitigation Equipment

- Oil spill kits should be available on site, these should include (at least), shovels, containers, sand for barriers, absorbent materials, rakes booms *etc.*

- Each vessel must maintain an inventory of absorbent material to contain small spills.

- Spill kits, and other emergency ‘first aid’ kit, should be kept in an easily accessed location and checked on a daily basis.

- Relevant trained staff should know of its location and how to use the equipment.

- Formulate a simple but effective ERP, including:
  - Assess the risk of tackling the spill, if safe to do so.
  - Inform relevant company official and the relevant authority of the IRP.
  - Try to identify the potential sources of pollution and stop the flow immediately.
- Try to contain the spill or prevent it spreading.
- Divert from drains to the sea.
- Dam the flow with earth/sand/polythene.
- Maintain a position upwind, if possible, since fume or vapours could be harmful.
- Eliminate ignition sources. Vapours may travel to an ignition source and flashback.
- Do not touch or walk through the spill since the product may be toxic and/or corrosive.

On water:

- Install containment booms; install recovery equipment recommended by specialists (*e.g.* mop, rotating disc or other skimmer); attempt to recover as much of the spill as possible.
- Provide personnel with appropriate personal protective equipment (*e.g.* boots, gloves, eye goggles *etc.*).
- If wildlife (*e.g.* turtles, dolphins) is in close proximity, attempt to keep them away from the site during pollution events.
- Recovered material and clean-up supplies to be placed in 6mm polyethylene bags.

On land:

- Do not wash down the spillage and do not use detergents; Use absorbent pads or sand to mop it up; and make sure that materials used are easily recoverable; Shovel contaminated sand/earth/granules into ‘double bags’.
- Attempt to contain spill by making a dike, deploying sorbent material *etc.*
- Dispose of clean-up/waste materials correctly.

- The boundaries of the spill area should be marked for future monitoring and clean-up if deemed required by the relevant government body.

7.3 Waste management

7.3.1 Waste Management and Minimisation

Waste management during construction should comply with the relevant local and national legislation. It should also follow the common principles under the Integrated solid waste management hierarchy by managing the waste in the preferred (descending) order of “eliminate” waste, “reduce” waste, “re-use” waste, “recycle” waste, “treat” waste and eventually to “dispose” of waste to a controlled landfill or incinerator only if no other options are available. The contractor needs to think of waste as a recoverable resource and not simply of a by-product that needs removing, the waste management hierarchy is shown in **Figure 7.1**.

Through re-use of materials, precious natural resource extraction can be reduced, which will have a positive impact on reducing greenhouse gas emissions. The diversion of waste from landfill or incinerator will also be reflected in the amount of traffic required to transfer it, but also on landfill life. In general, minimising the generation of waste will reduce waste disposal costs and will give the contractor and developer the reputation as companies that strive to protect the environment.

Figure 7.1 The waste hierarchy

To manage wastes effectively, contractors should focus their strategies for construction on:

- Effective procurement strategy to avoid product wastage.
- The amount of materials that are wasted.
- The way in which wastes are handled and stored.
- The amount of wastes that can be reclaimed, re-used or recycled.
- The method of disposal of wastes and the location of appropriate recycling, treatment or disposal facilities.

The contractor should allocate responsibility for these issues to nominated individuals.

It will be the responsibility of the contractor to develop waste management and minimisation strategies. Within these strategies, the following waste management methods are encouraged.

Information Box 7.1 Waste management and minimisation guidance

Checklist – Mitigation measures during construction	
General Mitigation Measures	
Prevention	• Always try to prevent waste as much as possible
Collection	• Always follow the local legal requirements and the client demands
	• Make agreements with the waste collecting company
	• Make agreements with vessel(s) involved in the Project
	• Make agreements with suppliers and subcontractors
	• Sort waste products as much as possible. Put your waste in the appropriate container(s)
	• Keep the workplace clean: remove waste as soon as possible from the workplace
	• Always identify the waste recipients
	• In order to achieve a smooth separation of waste flows, smaller recipients can be provided at various locations on site in order to separately collect different types of waste • These can be emptied manually into the respective containers on site
	• Measures should always be taken to prevent litter *e.g.* by covering recipients
	• Storage of oil and other liquid waste products preferably in leak-proof recipients and on a drip-tray (at least 25% of maximum quantity of waste products stored above it) underneath a shelter or on a drip-tray in a container
	• Wastewater: if possible, always connect sanitary fittings to the sewer system and/or use chemical toilets. If not feasible: discharge waste water in a watercourse or in the soil, if legally allowed. At least follow legal requirements with regard to discharges, if need be, provide mobile water purification (bio rotor, sedimentation pits, etc.)
New waste flows	• New on-site waste flows must be reported to the Project QHSE Engineer, who shall provide an appropriate collection recipient
Administration	• Keep records of waste administration (*e.g.*: invoices of waste collectors)
Surveillance	• Waste incineration is forbidden
	• Check frequently if separate waste collection is done

Checklist – Mitigation measures during construction	
Purchase	
•	Purchase materials that have the least amount of packaging, to minimize packaging being thrown out.
•	Return excess packaging to the supplier where appropriate.
•	Purchase durable products.
•	Purchase materials in the quantity required for the Project only, to minimize unused left-over.
•	Purchase products when they are needed to avoid excess storage.
•	Encourage recycling or re-use of materials such as plastic, paper & cardboard, glass, aluminium cans & products, steel, organic food waste etc.
Transport and treatment	
•	Ensure proper schedule for the collection of waste every time there is one full load of waste generated for removal.
•	Transport, recycle or dispose of environmentally hazardous waste in compliance with local regulations.
•	Follow the proximity principle – re-use, recycle or dispose of the waste as near as practicable to its place of production.
•	Keep a record of waste disposal activities, including location of bins, stockpiles, name of removal contractor, waste volumes and disposal receipts.
•	Maintain a record of waste leaving the site (description and volume), including who it was transferred to and what authorisation they has to accept it.
•	The waste carrier may need to be authorised and licensed to carry the type of waste for disposal.
•	It may be useful to undertake a small number of 'spot checks' on waste carriers to ensure hazardous materials are taken to authorised landfill sites.

7.3.2 Storage of Waste

All wastes should be stored in designated areas that are isolated from surface water drains, open water and are bunded to contain any spillage. **Information Box 7.2** provides guidance on how to safely store and deal with waste.

Information Box 7.2 Waste storage and handling guidance

Checklist – Waste storage and handling guidance	
Storage of waste	
•	Segregate different types of waste as they are generated. Incompatible wastes must be separated by an appropriate barrier.

•	Mark waste clearly with their intended contents – (and consider colour coding *e.g.* as advised by the ICE in the UK www.wasteawareconstruction.org.uk).
•	Use containers suitable for their contents - check their condition.
•	Minimise the risk of accidental spillage or leaks – containers should be placed in impervious bunded areas and spill kits should be made available.
•	Ensure that wastes cannot be blown or washed away - containers must be securely covered.
•	Place waste disposal containers in a designated area for the different waste streams and remove from site when the container is full.
•	The waste should be protected against unauthorised access by people or animals.
•	Adequate bunding of liquid waste, fuel and chemical storage areas.
•	Spill kits should be readily available near the storage of liquids and staff should be trained in how to use them.
•	Good labelling of tanks and drums with secure storage.
Dealing with Waste	
•	Prevent damage and loss of material during unloading.
•	Only accept deliveries with correct specifications and quantities.

7.3.3 Recognising Issues and Taking Action

The contractor's site manager should arrange for reviews where appropriate of waste management procedures with specific regard to:

- The amount of raw material wastage.
- The storing and handling of waste.
- The amount of waste going to landfill/incinerators.
- The waste minimisation strategy and its success.
- Following local regulation/guidance on waste transport and disposal.

If issues are discovered, the site manager should be responsible for ensuring that corrective action is taken.

8 ENVIRONMENTAL MANAGEMENT PLAN

8.1 Introduction

This Section forms the **Environmental Management Plan** (EMP), a Section of the EIA as required by Nigerian Legislation. The EMP provides the framework required to implement the environmental commitments (mitigation measures) and presents the monitoring proposals for the Project. Its purpose is to reduce the risk any potential adverse impacts resulting from the Project on environmental resources, and to minimise disturbance to receptors.

Due to the long time span for this project, it is intended that this report is a document which can be updated and reviewed as appropriate, based on any significant changes to the national and international legislative requirements. In addition, the document should be updated if any significant changes to the construction methodology occur.

8.2 Environmental Organisation and Programme

8.2.1 Roles and Responsibilities

South Energyx Nigeria Ltd

It is the responsibility of the Project proponent, South Energyx Nigeria Ltd (SENL), to ensure that the contractor does their utmost to meet the environmental management standards established in these guidelines and in all cases to satisfy compliance requirements associated with the local and national regulations and guidance.

Contractors

Contractors are instructed to do their utmost to meet the standards established in these guidelines and in all cases to satisfy any compliance requirements associated with local and national laws and regulations.

In order to manage and monitor the implementation of these guidelines, it is recommended that the checklists and mitigations measures outlined within this document are used to develop an Environmental Action Plan (EAP). The EAP should be completed by the appointed contractor and approved by SENL and the supervising engineers prior to construction activities commencing.

The EAP is a document which translates the mitigation measures into actions on the construction site and which can be clearly followed by all contractor staff. The purpose of this approach is that a contractor may use various methods and locations during the course of a project and therefore they should develop and update the EAP based on these variations.

The following table provides a summary checklist of roles and responsibilities to ensure proper environmental control throughout the construction phase of the Project. The tasks identified in this table are expanded upon in the later sections of this report.

Information Box 8.1 Summary roles and responsibilities

SENL roles and responsibilities

Before start up

- Appoint Project Environmental Manager.
- Review and approve Contractors Environmental Action Plan
- Review and approve Monitoring Program.
- Perform start up audit:
  - Review auditing system.
  - Review contractor training systems.
  - Review contractor emergency response procedure.
  - Review permits and approvals.

During construction

- Enforce compliance with commitments made in the EMMP
- Conduct scheduled and un-scheduled inspections of contractor performance.
- Enforce reduction of non-conformances.
- Review emergency response procedures
- Review monitoring results and propose corrective actions if required.

Post construction

- Close out audit.
- Review monitoring results.

Contractor roles and responsibilities

Before start up

- Develop Environmental Action Plan
- Appoint Environmental Project Officer
- Develop reporting for non-conformance and pollution incidents.
- Develop training/information program to implement Environmental Action Plan
- Develop/Review emergency response plan.

- Implement Environmental Action Plan
- Implement reporting for non-conformance and pollution incidents.
- Implement training/information program to implement Environmental Action Plan / emergency response plans
- Implement / Review emergency response plan as appropriate.
- Ensure compliance with EMP and provide evidence to support this (quarterly reporting)

8.3 Control of dredging and reclamation processes

8.3.1 Environmental Awareness and Competence

The raising of environmental awareness is a crucial element in the implementation of the mitigation measures. As a consequence all staff (including any staff brought in during the Project) will require a pre-start induction which will include details of the environmental aspects of the site. Managers and supervisors must ensure that all personnel engaged in activities that may have an impact on the environment are competent to carry out their duties or, where necessary, provide suitable training.

8.3.2 Supervision of Dredging and Reclamation Activities

All project activities, including those carried out by subcontractors, will be supervised by SENL (or their nominated consultants) to ensure that requirements are properly implemented. The frequency of this supervision will be dependent upon the competency displayed by the workforce and the level of risk to the environment.

Environmental commitments will be subject to inspections by Royal Haskoning. These inspections would seek to confirm that:

- Agreed protection and mitigation measures are in place prior to or during the commencement of dredging and reclamation activities.
- Dredging and reclamation works have been completed in accordance with the design and the commitments made during the statutory process.

Appointed environmental representatives at Royal Haskoning will carry out regular inspections to verify that the required methods and mitigation measures are being implemented effectively.

8.3.3 Environmental Inspection and Reporting

The project consultant will report on the project's environmental performance based upon site inspections. This will be carried out on a quarterly basis. An assessment of the performance over the month will be made and quantified, where possible. The report should detail inspections completed, audits undertaken and a register of incidents and corrective measures.

8.4 Mitigation Measures

The measures required to mitigate the predicted impacts are summarised in Section 7. These measures should be detailed within the EAP with regard to the responsibility for implementation and the review procedure for their monitoring and review. Within the EAP, the threshold for action should be detailed and actions to be taken should there is a requirement for further measures.

Best practice measures have also been included in the mitigation summary but it is assumed that best practice will be followed for all activities during the construction and operation phases of the scheme.

8.5 Monitoring

8.5.1 Introduction

The EIA for the proposed Eko Atlantic shoreline Protection and reclamation activities has identified potential adverse impacts on a number of receptors and, therefore, environmental control measures have been recommended to mitigate those potential impacts (**Chapter 7**). However, the impacts identified in the EIA are *predictions* based on current knowledge and the actual effects may vary from those predicted.

Monitoring can help to establish whether the impact predictions made in the EIA are correct, through comparison of the baseline and the post impact environment. The monitoring can also determine the success of the mitigation measures in reducing the scale of effect. Monitoring should target those receptors which are likely to be impacted by the activity and requires the availability of suitable baseline data.

This section gives guidance on the monitoring required for this project.

8.5.2 Overview of monitoring requirements

For this project, monitoring is not considered necessary for the majority of sensitivities as the impact predictions are low. However, dredging, reclamation and shoreline protection works have the potential to significantly impact upon coastal processes, marine sediment and water quality and the subtidal and intertidal ecology. As such, it is required that the following monitoring is carried out.

Information Box 8.2 Monitoring to be undertaken during the Project activities

Checklist – Monitoring
Monitoring during construction
• Bathymetric surveys of near shore coastal environment
• Marine and lagoon water quality monitoring
• Air quality monitoring at selected locations (also to provide baseline for any future EIA for Infrastructure)
• Noise monitoring if required due to complaints received
Monitoring post-construction
• Bathymetric surveys of near shore coastal environment
• Marine and lagoon water quality monitoring
• Monitoring of status of lagoon ecology

Further recommended details regarding these monitoring requirements are provided in **Table 8.1**. Based on these initial recommendations the monitoring programme should be designed in detail, in which effectiveness and efficiency are important criteria. Regular evaluation of the monitoring programme is recommended, also in view of phasing out those parts of the programme for which impacts are stable or no impacts are expected anymore.

It is recommended that the results of the monitoring and its evaluation are published to enable the stakeholders (Government and public) to recognise the environmental sustainability of the shoreline protection and reclamation phase of the development and to use the data for future work. The studies will also provide good baseline data for the SENL to use if additional works and supporting applications are required on site.

8.5.3 Monitoring by SENL

SENL as the Project owner will be responsible for ensuring that the monitoring within its jurisdiction is undertaken. If monitoring requirements are passed on to a second party (*e.g.* contractor), SENL should take steps (*e.g.* audits) to ensure the contractor meets their obligations.

Initial monitoring results including its methods of acquirement have been included in **Appendix O**. The geo-technical data provide initial indications that the levels for revetment and reclamation are stable.

8.5.4 Reporting

Quarterly progress reporting during the construction phase is initially required to summarise all observations of the period. This report should be submitted to FMEnv and LASMOE.

If any concerns, such as pollution incidents, are identified during the construction or operation period of the land reclamation, these should be reported immediately in a specific report pertaining to the event. A review should be undertaken to establish the cause of the pollution and if the cause relates to the activities of the Eko Atlantic project, then new mitigation measures should be put in place to reduce or avoid the problem.

Table 8.1 Recommended monitoring measures for during and post construction

Monitoring Parameter	Objective	Location	Method	Frequency	Management Action	Responsible by
Coastal Processes	Detect any change in the rate of erosion to east of development as a result of Eko Atlantic (10 km east of project)	Beach surveys and fore shore surveys 18 km of beach starting at the east mole.	Bathymetric and land survey along beach stretch of 18km.	Every 3 to 6 months and after a large storm event at start of east revetment construction. Frequency to be optimised based on any observed changes	Surveys to be reviewed and erosion rate to be determined. Mitigation strategy to be consulted and evaluated.	To be agreed between SENL and LASMOE
Stability of Sea Defence and Reclamation	Determine settlement of sea defence to ensure structural integrity.	Regular intervals along the sea defence, to be determined by the supervising engineer.	Level survey of primary armour Accropode™ units and of rock berm.	Initially weekly reducing to monthly after initial settlement period. Frequency to be further optimised based on any observed changes	Surveys to be reviewed and settlement rate to be determined. Mitigation strategy to be consulted and evaluated.	SENL
Stability of Sea Defence	Determine stability of sea defence to ensure structural integrity.	Along full length of revetment structure.	Side scan sonar and bathymetric survey under water; visual inspection of sections above	Post construction and then initially at 6 monthly intervals	Surveys to be reviewed and integrity of the revetment to be determined.	SENL

Monitoring Parameter	Objective	Location	Method	Frequency	Management Action	Responsible by
			water level.	reducing to annually; and after large storm events.	Mitigation strategy to be consulted and evaluated.	
	Determine erosion at toe of sea defence to ensure structural integrity.	Along full length of revetment structure.	Side scan sonar and bathymetric survey under water.	Post construction and then initially at 6 monthly intervals reducing to annually; and after large storm events.	Surveys to be reviewed and integrity of the revetment to be determined. Mitigation strategy to be consulted and evaluated.	SENL
Stability of Reclamation	Determine settlement of reclamation area to check for sand loss through the revetment and East mole and ensure integrity of reclaimed area.	Regular grid across the reclamation site, behind the revetment and East mole, to be determined by the supervising engineer.	Level survey of settlement beacons.	Initially weekly reducing to monthly after initial settlement period. Frequency to be further optimised based on any observed changes	Surveys to be reviewed and settlement rate to be determined. Mitigation strategy to be consulted and evaluated.	SENL
	Determine settlement of reclamation area to ensure integrity of reclaimed area and bearing capacity.	Regular grid across the reclamation site and behind the revetment, to be	Boreholes and Cone Penetration Tests (CPT).	Post construction.	Surveys to be reviewed and ground conditions to be determined. Mitigation strategy	SENL

Monitoring Parameter	Objective	Location	Method	Frequency	Management Action	Responsible by
		determined by the supervising engineer.			to be consulted and evaluated.	
Marine Water Quality	Confirm impact t assessment predictions To detect any breaches of quality standards or turbidity levels above background for prolonged periods of time.	Baseline sites S3, S7, S8, S10, S11, A2, A10, A8, B2 and B4. Sites should be added in Borrow Area C, if used.	*in situ* probe to measure basic physical parameters including temperature, salinity, pH, dissolved oxygen, turbidity and chlorophyll.	Monthly	Mitigation measures to be reviewed, thresholds for action agreed and new measures identified as appropriate and implemented if pollution above agreed threshold.	SENL
			laboratory analysis should include the following parameters: - Nitrate. -Total phosphorus. - TPH - TSS	Every three to six months		
Lagoon Water Quality	Confirm impact assessment predictions and ensure no significant changes to lagoon environment	6 monitoring sites to be established. 2 each in east Kuramo, east Kuramo and the Lagos Lagoon	*in situ* probe to measure basic physical parameters including temperature, salinity, pH,	Every six months	Further investigation and potentially mitigation / enhancement measures to be	SENL

Monitoring Parameter	Objective	Location	Method	Frequency	Management Action	Responsible by
		control area. Recommend to use baseline sites C1, C2, W1, W3, E1 and E3.	dissolved oxygen, turbidity and chlorophyll.		developed in the case that effects are observed *e.g.* significant changes in salinity.	
			laboratory analysis of the following parameters: - Nitrate. - Total phosphorus. - Total coliforms - Heavy metals	Every year		
Sediment Quality	To monitor quality of sediment used in reclamation	Hopper of dredger	laboratory analysis of the following parameters: - Particle size analysis - Heavy metals - Total petroleum hydrocarbons - Polyaromatic Hydrocarbons	Once per month	Dredge location selection to be reviewed, with potential to relocate elsewhere in borrow area if pollution in sediments significant.	SENL / DI
Sediment Quality	To detect any breaches of quality standards	To be determined by environmental specialist dependant on	laboratory analysis of the following parameters:	Only in the case of a pollution incident recorded	Mitigation measures to be reviewed, new identified as	SENL

Monitoring Parameter	Objective	Location	Method	Frequency	Management Action	Responsible by
		water quality result. Sites should be selected at same locations as water quality sampling.	- Particle size analysis - Heavy metals - Total petroleum hydrocarbons - Polyaromatic Hydrocarbons	through water quality monitoring or if moving into areas known from the sediment quality data to contain samples which exceed standards.	appropriate and implemented if pollution above background recorded.	
Noise	To monitor noise levels if required due to complaints from locals.	6 sites: 4 along the shoreline of Victoria Island and 2 on the reclamation area	Hand held noise meter	As required dependent on noisy activity.	None	SENL
Coastal Processes	Establish increase in rate of erosion to east of development as a result of Eko Atlantic (10 km east of project)	Beach surveys and fore shore surveys 18 km of beach starting at the east mole.	Bathymetric and land survey along beach stretch of 18km.	Every 3 to 6 months and after a large storm event. Frequency to be optimised based on any observed changes	Surveys to be reviewed and erosion rate to be determined. Mitigation strategy to be consulted and evaluated.	To be agreed between SENL and LASMOE
Marine Water Quality	Confirm impact assessment predictions	Baseline sites S3, S7, S8, S10 and S11.	*in situ* probe to measure basic physical parameters	Every three to six months for 3 years	Mitigation measures to be reviewed, new	SENL

Monitoring Parameter	Objective	Location	Method	Frequency	Management Action	Responsible by
	To detect any breaches of quality standards		including temperature, salinity, pH, dissolved oxygen, turbidity and chlorophyll.		identified as appropriate and implemented if pollution above background recorded.	
Lagoon Water Quality	Confirm impact assessment predictions and ensure no significant changes to lagoon environment	Same monitoring sites as during construction	*in situ* probe to measure basic physical parameters including temperature, salinity, pH, dissolved oxygen, turbidity and chlorophyll.	Every year for 3 years	Further investigation and potentially mitigation / enhancement measures to be developed in the case that effects are observed *e.g.* significant changes in salinity.	SENL
Lagoon Ecology	Determine if any effect due to presence of reclamation affecting salinity levels in lagoon and affecting biodiversity.	Baseline sites within the lagoon complex	Grab samples and laboratory analysis of species and abundance.	Six, 12 and 24 months following completion of reclamation.	None	SENL

8.6 Adaptive coastal erosion mitigation scheme

As a result of 1) the dynamic nature of the coastal system near Lagos and 2) the observations in the modelling & the historic observations and recent observations, a robust and phased adaptive coastal impact mitigation approach is advised. This mitigation approach should be able to adapt to any future developments of the coastline adjacent to the Eko Atlantic Project. The mitigation can be executed in phases.

By doing so, a fit to purpose protection is obtained, which is economically advantageous. An adaptive management approach involves a sequential re-assessment and evaluation of system states (*i.e.* shoreline position, foreshore development etc.) and dynamic relationships should be an integral part of a well-designed monitoring program.

For this project a three phase monitoring and mitigation program has been designed (**Figure 8.1**):

Phase 1: A campaign to monitor shoreline development and coastal processes during construction and after completion of the land reclamation;

Phase 2: If monitoring indicates increased erosion, beach nourishment should be undertaken as an initial mitigation measure. This nourished beach would initially create a buffer for shoreline retreat occurring during the first phase of construction. This should account for the coastline retreat over the first few years.

Phase 3: If erosion becomes problematic, hard coastal structures are to be considered. Structures could either be a revetment (similarly to Bar Beach), groynes, detached breakwaters, or a combination of the concepts. The optimal scheme can be selected according to the newly formed coastal situation. Also, coastal structures can then be engineered accurately, as newly derived data can be taken into account.

The main advantages of such a flexible and adaptive scheme in phases are:

- Preservation of the natural sandy coastline as far as possible;
- If erosion proves to be limited, no hard structures are needed;
- Any coastal mitigation structure, if needed, can be tailored and engineered more accurately as more information becomes available on the new coastal situation; and
- Any nourishment is a so-called “no-regret” option. If beach nourishment proves to be needed, or is initially undertaken, the sediment brought into the system will benefit the down-drift coastline.

Such an adaptive approach is widely adopted as an approved measure to mitigate coastline retreat.

Monitoring should start as soon as construction starts, but in particular, before construction of the eastside of the revetment. This will ensure that any negative impacts of the Project on coastal erosion are carefully observed and monitored immediately, and management steps can be taken accordingly. It will be advantageous to monitor both the down-drift and the up-drift side of the Eko

Atlantic project area, as the up-drift side is the main source of sediment in the system.

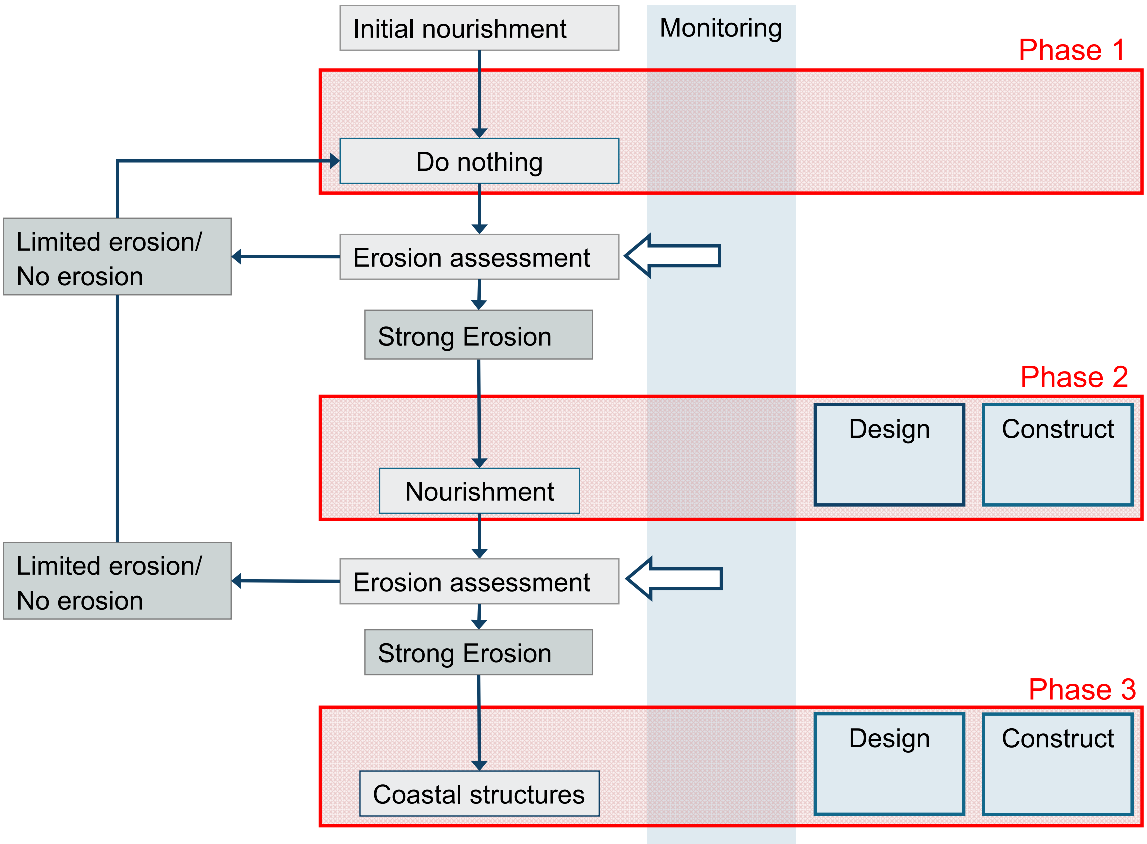


Figure 8.1 Schematic adaptive coastal erosion mitigation scheme

Any erosion east of Eko Atlantic Development Project that may be observed during and after reclamation, is considered remaining erosion that would also have occurred in case of no project. If this erosion is observed, the proponent will contact the Government authorities to take action in this.

9 CONCLUSIONS

The proposal by SENL to construct the Eko Atlantic shoreline protection and reclamation project represents a significant investment in infrastructure development in a region that is considered, based on most economic and social indicators, one of the least developed in the world.

SENL will provide high quality land for future development in an area of economic importance. This land will be protected from the forces of the sea, and in doing so will also protect the valuable land and properties of Victoria Island, which have been at risk due to extensive coastal erosion issues along this stretch of coast.

Lagos will see economic benefits and infusion of funds into the local economy throughout the construction of the development.

This EIA has been completed for the Project which has been supported by numerous specialist studies including studies in coastal morphological modelling, wave modelling, geotechnical investigations, stakeholder engagement and social and environmental baseline surveys.

Based on this study it has been predicted that the Project will have minimal adverse environmental effects on the majority of receptors. Analyses of project-level design and planning of engineering and procedural mitigation measures have resulted in the minimisation and avoidance of potential negative impacts over the lifetime of the Project (Refer to **Table 7.1** for more details). As the table illustrates, following mitigation, there are no impacts greater than minor adverse significance are predicted. As per the definition of significances used, in the majority of adverse impacts are expected to be small scale and of little concern, being undesirable but acceptable. A number of beneficial impacts have also been identified, including some major beneficial impacts which are defined as being large scale and providing a significant positive gain to the environment.

The key area of interest from the study relates to coastal erosion. The project has been designed to provide a long term solution to the significant coastal erosion problem of Victoria Island and this will undoubtedly provide a major beneficial impact to this area, protecting high value land behind the Eko Atlantic site. As is expected in a dynamic coast such as experienced at Lagos, the analysis of the coastal morphology of this region predicts that the pressure of coastal erosion may be shifted to the east side of Eko Atlantic. The shape of the sea defence has been designed to minimise the erosion effect by maximising the long shore coastal transport of sediment. In addition, a monitoring and mitigation strategy has been recommended to monitor this effect and instruct coastal protection management actions to be implemented if required.

For each aspect of the Project, SENL has developed and committed itself to mitigation measures and monitoring for the potential negative impacts identified. An Environmental Management and Monitoring Plan has been developed to ensure the recommended measures are implemented and environmental effects monitored and managed accordingly.

It is recommended that SENL ensure compliance with all of the mitigation and monitoring requirements provided in this EIA Report.

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