Provision of Consultancy Services for Engineering and Safeguards Assessment of Proposed Interventions in the coastal areas of the Monrovia Metropolitan Area (MMA) in Liberia

Annex 2.C: Engineering Sub-assessment

18 October 2019

for

UNDP in Liberia
Environmental Protection Agency
Government of Liberia

Provision of Consultancy Services for Engineering and Safeguards Assessment of Proposed Interventions in the coastal areas of the Monrovia Metropolitan Area (MMA) in Liberia

Annex 2.C: Engineering Sub-assessment

18 October 2019

for

UNDP in Liberia
Environmental Protection Agency
Government of Liberia

Document	: PART II – Feasibility Report
Status	: Final
Code	: B1804-07-LBR-UNDP-R003
Revision	: 3.0
Date	: October 18th, 2019

Rev.	Description	Prepared	Approved	Date
1.0	Draft	Staff CDR	D. Heijboer	May 3rd, 2019
2.0	Final	Staff CDR	D. Heijboer	June 27th 2019
3.0	Final	Staff CDR	D. Heijboer	October 18th 2019

CDR International BV
Koningin Wilhelminalaan 43
3818HN Amersfoort
Netherlands
Telephone: +31 8 5301 0885
E-Mail: info@cdr-international.nl
Web: www.cdr-international.nl
CoC/Kvk: 56270127

TABLE OF CONTENTS

0. EXECUTIVE SUMMARY

Coastal communities and infrastructure in Monrovia are vulnerable to climate change induced coastal hazards. Up to 2018 over 670 households are reported to have been displaced due to coastal retreat, which is the main identified coastal hazard. The vulnerability to climate change of the Monrovia coastal zone has been discussed extensively in the Vulnerability Report (PART 1) of this Study, estimating that a significantly growing share of the coastal communities and infrastructure will be impacted in the coming decades if no measures are taken.

This report (PART II) describes the proposed climate resilient strategies, interventions that have emerged from the studies and stakeholder consultations, including its technical and economic feasibility, and should be read in conjunction with the Vulnerability Report (PART I) as well as with the Environmental and Social Assessment Report (PART III). The latter provides a detailed appraisal of the risks associated with the project, and the ways in which they can be addressed; they are to be avoided through project design wherever possible, and mitigated through an Environmental and Social Mitigation and Monitoring Matrix where avoidance cannot be assured.

The key strategic objectives of a climate resilient strategy for Monrovia are:

- Minimise contribution to the drivers of climate change;
- Reduce vulnerability and make society resilient to events caused by climate change;
- Protect and enhance livelihoods;
- Safeguard food security;
- Enhance ecosystems.

The project has a twofold approach to addressing climate change in fulfilment of the strategic objectives listed above.

(i) **Adaptative Measures:** measures to help minimise the drivers as well as the impacts of climate change and prepare awareness and capacities for implementation of the protective measures. These exploit opportunities to safeguard currently sustainable livelihoods that are low consumers of carbon energy, and which consequently promise to give Liberia “green” living approaches for both the current and future generations. The project focuses on the inshore artisanal fishery of Monrovia, which contributes significantly to the city’s food security with very low carbon emissions. However, a number of interventions are required to ensure that the environment supporting this will continue to sustain it as climatic conditions change, and impacts increase as a result of higher sea levels and stronger storms.

(ii) **Protective Measures:** measures to help mitigate the impacts of climate change. These are mostly engineered interventions such as the construction of revetments, groynes and beaches to protect against rising sea level and the damaging effects of waves from higher-energy storm events. Some aspects are preventative, such as the development of alternative sand sources to stop mining of the natural beaches, and the promotion of measures to improve infrastructure resilience.

The synergy between both type of measures is of importance. The adaptive measures are important conditions for the effectiveness and sustainability of the protective measures, but they also provide synergies within the strategy. This is illustrated in Figure 0-1. The intention is that both types of measures must go hand in hand with each other.

Underlying rationale

The rationale for this adaptive-protective strategy emerged during project development. Monrovia has outgrown the secure terrain on which it was founded in the early nineteenth century, expanding mostly inland. However, several communities of fisherfolk have established themselves on the beaches below the city, and in turn the city has become dependent on them for its food security, specifically in their provision of protein through low energy artisanal catch methods. However, the presence of these communities is now threatened by climate change. The initial view that it might be better to translocate them elsewhere is stymied by the lack of alternative landing sites and the fact that a wholesale move inland would fundamentally damage the societies and the conditions underlying their livelihoods.

An opportunity is therefore presented of ensuring that Monrovia retains its food security through an industry that is remarkably low in carbon emissions. This allows the project to contribute to a minimisation of the causes of climate change. Hence the importance of the adaptive measures: they will, among other things, ensure that Liberia becomes more capable of managing changing coastal conditions, and therefore more resilient to the effects of climate change; and at the same time, it improves the safeguarding of the natural resources, of which fisheries is a key resource. Coupled with this is the need to protect the low-lying land around Monrovia against coastal retreat so that the communities are physically able to continue to live and pursue their livelihoods with access to the resource close on one side and the market close on the other side. But protection alone would not give a successful and sustainable scheme.

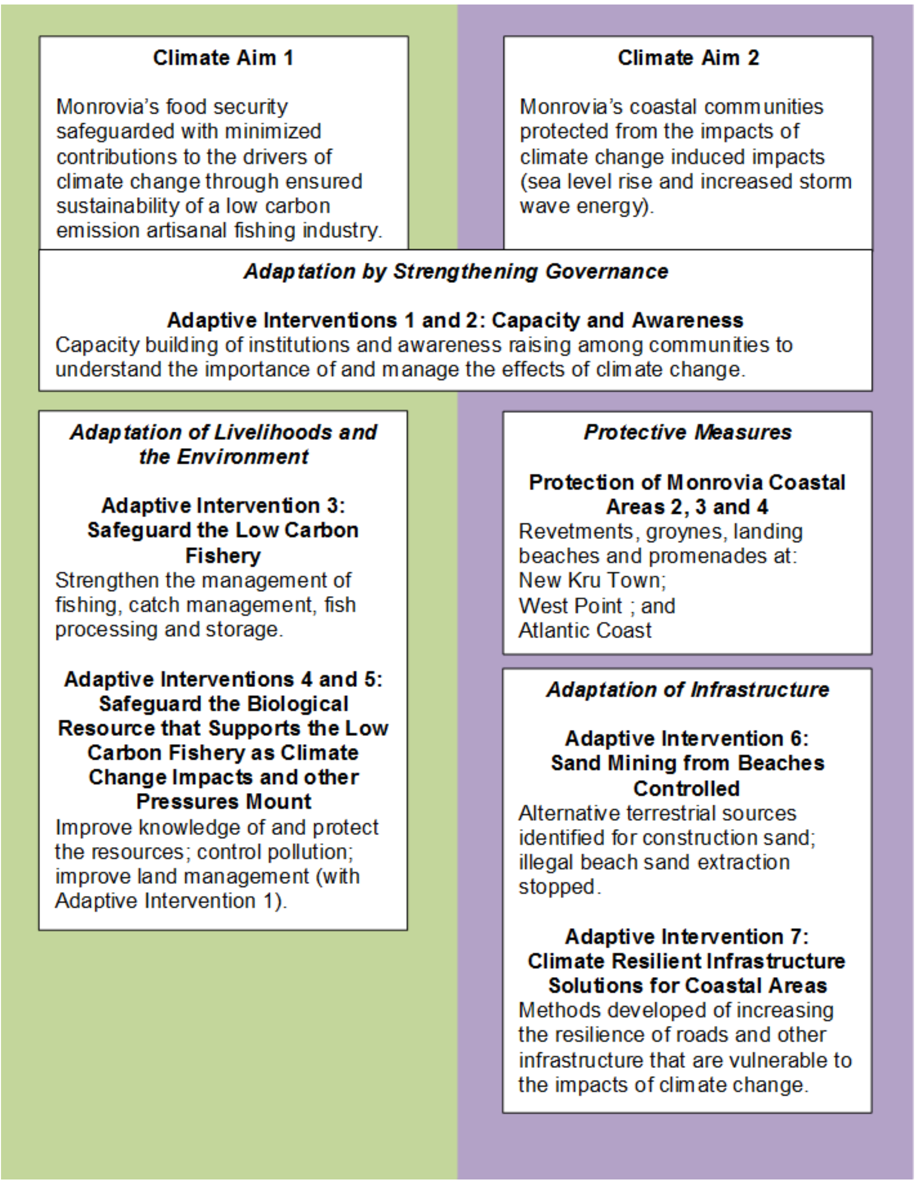


Figure 0-1: Overview of climate resilient strategies and the link between adaptation and protective measures

Adaptation Measures
The proposed adaptation measures are summarized as follows. The linkages with climate change are summarised in Figure 0-1.

1. Capacity building to develop and maintain a sustainable coast in Liberia by sound coastal zone management policies and land planning. This will improve the capacity of and co-ordination between the relevant institutions responsible for Integrated Coastal Zone Management in Liberia.
2. Awareness raising to strengthen community resilience for climate change. This will create awareness of coastal zone vulnerability (coastal retreat due to erosion and climate change) and environmental issues for communities.
3. Improved fishery management to ensure that the current low energy artisanal fishery can continue to function, using low carbon emission methods to supply affordable protein to the local urban market.
4. Research and strategy development to help sustain the low energy fishery through protected marine and mangrove areas, by establishing the linkages and biological values between habitats and fish exploitation.
5. Research and strategy development for effective urban pollution control and waste management in coastal waters, to prevent damage to and sustain the low energy fishery.
6. Sand mining of beaches stopped by identifying and establishing environmentally sound terrestrial sources of construction sand and equipping government to enforce the ban on sand extraction from present-day beaches.
7. Strategies developed to enhance the resilience of road infrastructure and to improve the capacity of relevant authorities to respond promptly in an emergency

Protective Measures:
Based on the extensive assessment part of the Vulnerability Report (PART I) the following alternatives for protective measures have been selected (the linkages with climate change are summarised in Figure 0-1):

1. At New Kru Town, construction of a revetment wall and promenade, with additional measures to ensure fish landing beaches. This will protect the residential and artisanal industrial area of New Kru Town from coastal retreat and allow the fishery to continue from this base. The promenade will sustain recreation and access for pedestrians to enjoy the ocean view. By planting (palm) trees along the promenade the aesthetic value is enhanced. Landing sites are required to accommodate for the fishing canoes and direct access to the ocean. A small beach is therefore required which need to be protected by hard structures to prevent further erosion and serious overtopping.
2. At West Point two alternatives proposed: either construction of a revetment wall and promenade, with additional measures to ensure fish landing beaches (Alternative A); or construction of a groyne with widening of the beach through nourishment (Alternative B). Both measures would protect the densely populated residential and artisanal industrial area of West Point from coastal erosion and allow the fishery to continue from this base. The first option was strongly supported by stakeholders during project preparation. The second is reliant on periodic re-nourishment of the beach, however will sustain the aesthetic value of the beach, urban recreation and landing of fishing canoes. The beach widening serves also as a buffer for the accommodation of additional storm erosion. A groyne is required to enclose the beach replenishment and prevention of structural coastal retreat.
3. On the Atlantic coast east of the American Embassy at Mamba Point, construction of a groyne combined with widening of the beach through nourishment. This will protect the communities living along this shore from the effects of coastal retreat, and provide the important social spaces offered by the beach as a key urban recreational facility. Moreover, here the beach widening

serves also as a buffer for the accommodation of additional storm erosion and a groyne is required to enclose the beach replenishment and prevention of structural coastal retreat.

The coastal protection measures include both soft and hard structural components that have specific functional and design requirements. The reason for protective measures is to mitigate and reduce the vulnerability of the coastal hazard. From the vulnerability analysis it is clear that the major threat is mainly coastal retreat, hence the above protective measures are proposed. Their main function is therefore to prevent structural and climate change induced coastal retreat.

Figure 0-2 shows an artist impression of the revetment solution, including promenade at New Kru Town. Figure 0-3 shows an artist impression of the groyne solution with a beach widening at West Point (Alternative B).

Figure 0-2: Artist impression New Kru Town

Figure 0-3: Artist impression West Point (Alternative B)

The preliminary design of the coastal protection is in accordance with common practice standards and guidelines. For all the rock works a design life **of 50 years** has been selected, which is common practice for maritime structures and coastal protection works. It should be noted that the design life is not necessarily the same as the return period of the design condition and both parameters should be selected with care. A design condition with a **return period of 100 years** with a design life of 50 years implies a probability of exceedance of 40% of the design condition during its design life, which is considered acceptable for these type of structures. It is noted that a design needs to be made such that the structure can sufficiently withstand the design conditions of the selected return period.
Since the boundary conditions are expected to worsen during the design life due to climate change, multiple design criteria are defined for different projection years, i.e. more damage is allowed at the end of the design life compared to the start.

Another aspect of the design is the allowable overtopping of the structure. Large overtopping can have significant impact on the hinterland leading to serious damage and threat to people's safety. Based on the guidelines, it is considered that an overtopping rate of more than 10 l/s/m will result in significant impact on the access, mobility, safety for pedestrians and potential damage to pavements (if significant more and depending on type of pavement).

The soft character of a beach replenishment will inevitably require an adaptive and resilient design, since it is progressively changing to its environment. Natural variability makes it hard to predict the exact development and therefore robustness is required in the design. Due to these reasons the design life of the beach replenishment is considered shorter than for rock works and is set to **20 years**.

For the beach replenishments/widening the design requirements are related to the functional requirement of creating a buffer zone for additional storm erosion and sea level rise.
It is considered that the minimum beach width (in case of no revetment) should at least be based on:

- Expected additional storm erosion with a return period of 100 years in 2050 plus;
- Expected retreat due to sea level rise between 2020 and 2050.

The minimum beach width is in this case defined as the distance between the shoreline (MSL) and the settlement boundary. It is emphasized that the function of this minimum beach width is merely to create a buffer zone and therefore it is strongly noted that no housing or property is allowed on at least this buffer.

In the above design requirements, it is considered that the applicable relevant climate change scenario should be the worst-case scenario, which is RCP 8.5 (worst case scenario climate change).

The design conditions are related to the design requirements and are determined for each section separately. Further details regarding the design conditions are presented in section 3.4.
It is noted that the preliminary design need to be followed by a detailed design phase. During the detailed design phase the detailing (e.g. of transitions) of the design and full verification of the design criteria, by means of for example physical model testing, will be performed.

Cost estimation

The cost estimations are presented separately for the adaptation and protective measures. The estimated costs for the adaption measures are presented in Table 0-1.

Table 0-1: Cost estimation Adaptation measures

Adaptation measure		Cost Estimation
1	Capacity building of national and metropolitan institutions in ICZM and land use planning	About 3-4 million USD
2	Strengthening of community awareness and management of coastal zone risks and solutions	About 2 million USD
3	Sustainable fisheries management	About 2 million USD
4	Management of the biological resources.	About 2.75 million USD
5	Management of urban pollution in coastal areas.	About 0.8 million USD
6	Sustainable sand extraction.	About 0.8 million USD
7	Climate resilient community roads and other critical infrastructures	About 2.5 million USD
Total		**About 14.3 million USD**

The basis for the cost estimation of the protective measures is the Bill of Quantities (BoQ) of materials to be used for the project or materials to be removed from the project. A unit rate has been used for the specific material items in order to calculate the costs. These costs form the basis for the estimation for the Capital Expenditure (CAPEX) costs. A range for the unit rates is used to obtain a bandwidth in the cost estimation. The total Capital Expenditure (CAPEX) costs are estimated by the BoQ costs, including contingency (10-15%), mobilization/demobilization (5-10%), design (4-6%) and supervision (4-6%). Table 0-2 and Table 0-3 show the estimated CAPEX costs for both alternatives.

Table 0-2: Total cost estimate for Alternative A (West Point Revetment option)

	Low estimate	*Average*	*High Estimate*
New Kru Town Revetment	$ 20,833,000.00	**$ 26,374,000.00**	$ 31,915,000.00
West Point Revetment	$ 14,420,000.00	**$ 18,252,000.00**	$ 22,084,000.00
American Embassy Groyne	$ 9,743,000.00	**$ 13,380,500.00**	$ 17,018,000.00
Total	**$ 44,996,000.00**	**$ 58,007,000.00**	**$ 71,017,000.00**

Table 0-3: Total cost estimate for Alternative B (West Point Groyne option)

	Low estimate	*Average*	*High Estimate*
New Kru Town Revetment	$ 20,833,000.00	**$ 26,374,000.00**	$ 31,915,000.00
West Point Groyne	$ 8,922,000.00	**$ 12,147,500.00**	$ 15,373,000.00
American Embassy Groyne	$ 9,743,000.00	**$ 13,380,500.00**	$ 17,018,000.00
Total	**$ 39,498,000.00**	**$ 51,902,000.00**	**$ 64,306,000.00**

The Operational Expenditure (OPEX) are estimated by a percentage (yearly) of the BoQ costs (including contingency). Also the OPEX costs are estimated for the high and low estimates which can subsequently be used as bandwidth. OPEX costs are mainly related to required maintenance of the coastal protection work, which depends on the type of structure. Table 0-4 shows the applied OPEX estimates.

Table 0-4: Summary OPEX estimates for each type of structure

Return period (yr)	**1**	**10**	**15**
Revetment works	0-0.5%	-	-
Groyne works	0-0.5%	-	-
Beach replenishment	-	-	100%
Promenade+Drainage	1%	10%	-

Cost Benefit Analysis

A cost-benefit analysis has been undertaken assessing the economic feasibility of the protective and adaptive measures. Starting point for the cost-benefit analysis is the vulnerability analysis and damage estimation in the do-nothing scenario (presented in Part I). As was shown in the vulnerability analysis, damages in the coastal sections due to coastal retreat and storm hazards will increase substantially over time. In below figure, damage costs in the do-nothing scenario are presented for the period 2030-2100 (for low and high climate change-economic scenarios). As can be seen the total cumulative damage due to coastal retreat (for all five sections) is already 26 million USD in 2030. This damage increases in the high scenario with a factor 17 to 450 million USD (factor 11 in the lower climate change-economic scenario to 260 million USD).

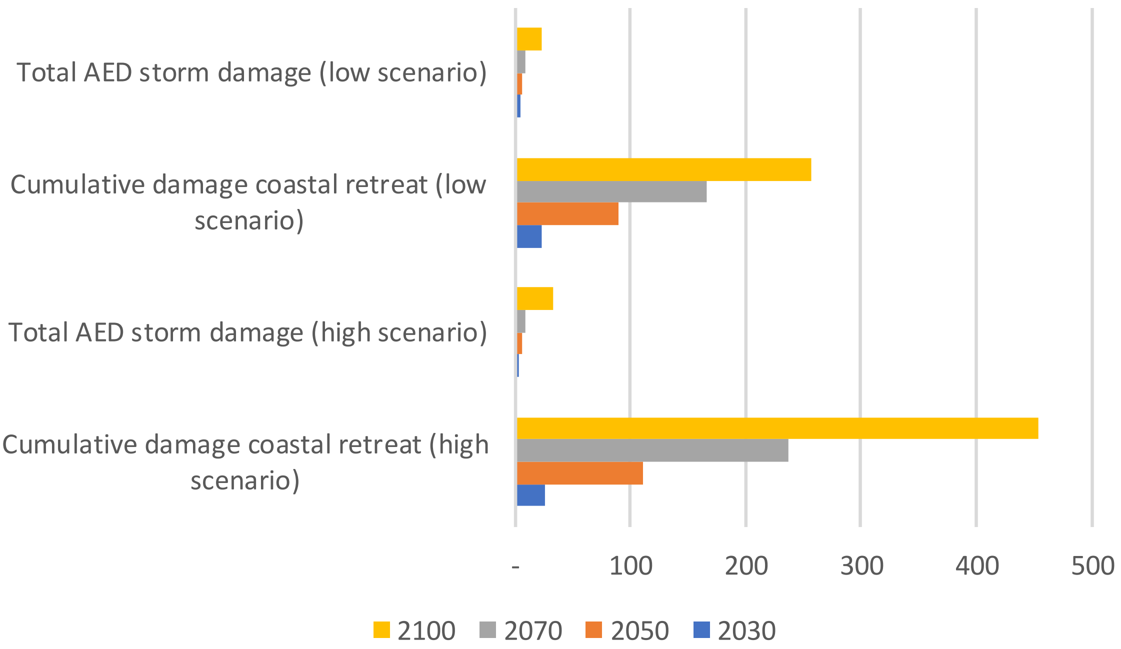


Figure 0-4: Total damage costs (all five sections) in the do-nothing scenario, two climate change-economic scenarios, 2030-2100 (million USD) Note: Total erosion damage is cumulative damage of coastal retreat until the relevant year.

The benefits of the adaptive measures are qualitatively discussed, because for most of these benefits, these are not easy to quantify due to inherent complexity of these 'softer' impacts and lack of data. In table below an overview of the benefits are shown.

Table 0-5: Overview benefits of protective and adaptive measures

Section	Alternative	Key benefits & intangible benefits
Protective alternatives		
2	Revetment New Kru town	Damage reduction (coastal retreat & storms) Safety (higher land / real estate prices) *Intangible benefits* Preservation of livelihoods and culture for fishery communities; Avoidance of relocation costs for communities, such as fisheries, market sellers etc.
3	West Point Option A Revetment	Damage reduction (coastal retreat & storms) Safety (higher land / real estate prices) *Intangible benefits*

Section	Alternative	Key benefits & intangible benefits
		Preservation of livelihoods and culture for fishery communities; Avoidance of relocation costs for communities, such as fisheries, market sellers etc
3	West Point Option B Groynes & nourishment	Damage reduction (coastal retreat & storms) Beautification and safety (land / real estate prices) *Intangible benefits* Preservation of livelihoods and culture for fishery communities; Preservation of beach recreation & cultural values Avoidance of relocation costs for communities, such as fisheries, market sellers etc
4	American Embassy Groyne & nourishment	Damage reduction (coastal retreat & storms) Beautification and safety (real estate prices) *Intangible benefits* Preservation of beach recreation & cultural values Potential for urban development (real estate, leisure)
Adaptive alternatives		
All sections	Strengthening governance	-Better policies, regulations and land management -Improved capacity of relevant institutions -Increased safety in coastal areas in Liberia
All sections	Adaptation of livelihoods and the environment	-Improved biodiversity - More sustainable fisheries - Mitigation of climate change drivers
Idem	More climate resilient infrastructure in coastal areas	-Reduction in economic and social costs due to failure of infrastructure

The tangible benefits (reductions in direct and indirect damage costs for buildings, infrastructure and livelihoods) are reflected in below figure of benefit-cost ratios. As can be seen all measures are economically feasible (show benefit-cost ratios larger than 1).

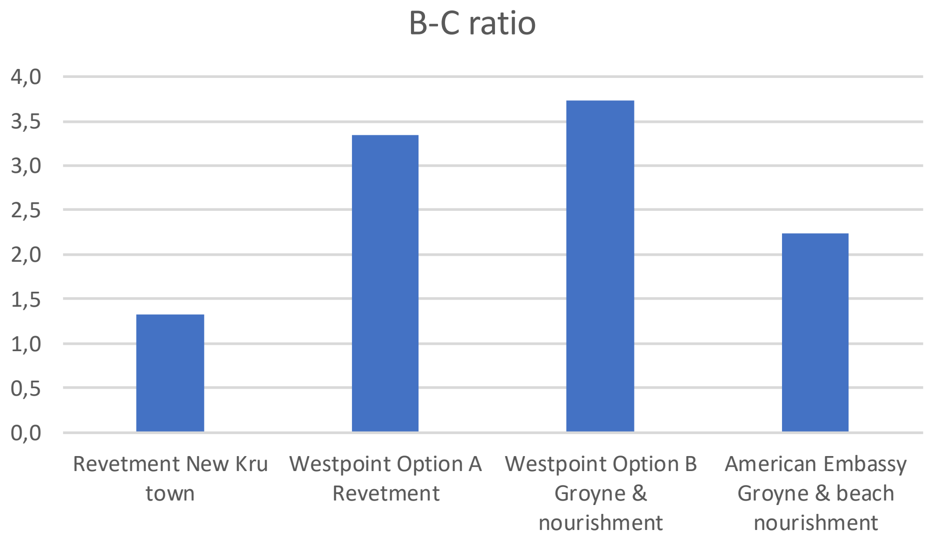


Figure 0-5: Benefit Cost (B-C) ratios of protective measures, high climate change economic scenario

The figure shows that all protective measures have benefit-cost ratio's larger than one (discounted benefits are larger than discounted costs for society). Apart from high damage reduction benefits, protective measures with beach nourishment and promenade have beautification impacts and intangible benefits. Especially, the protective measures in sections New Kru town and West Point serve to protect the livelihood of the fishery and market communities. For West Point, the groyne & nourishment option performs economically better compared to the revetment option, mainly due to lower investment costs of this alternative (B). However, participants in the stakeholder consultation workshop of January 2019 rated alternative A (revetment) higher due to risks a number of stakeholders perceived regarding sustainability of beach nourishment and maintenance.

A sensitivity analysis also shows that with more pessimistic assumptions (regarding costs, discount rate, climate change and economic scenario) the benefits still outweigh the costs for most of the measures (except for the revetment in New Kru town). However, some intangible benefits have not been included in the B-C ratios and the operation and maintenance costs for the revetment in New Kru town are quite pessimistically estimated. Moreover, this measure includes a promenade and two landing sites for fisheries. Further cost optimization seems possible for this alternative.

Implementation

The institutional setting for the implementation of the project is extensively discussed in detail in section 6.1.

It is anticipated that the adaptive interventions will be implemented by specialist service providers through a series of contracts. Most of these will be consultancy companies, but in some cases suitably qualified non-governmental organisations or civil society organisations might also be considered. In most cases, the skills and expertise are new to Liberia, and so consortia of local and international consultants will be needed.

For the protective measures two types of approaches (contracts) are discussed:

- **Design and construct**
  This type of contract minimises the administration for the client organisation, and means that the contractor takes a greater share of the risk. Design and construct is being applied more and more by employers that have the capability to review and monitor the process themselves. This approach is suitable when employer is open to new alternatives as well as optimisations of design and costs. It is strongly advised to apply FIDIC yellow book.
- **Construct only**
  Construct only is preferred when employer is not open to alternatives, and wants a design to be constructed straightforwardly according to design and specifications. Construct only preferable when design is to be constructed by local and/or less experienced/capable contractors. It is strongly advised to apply FIDIC red book.

Complexity, viz. amount of interfaces between different type of infrastructures, buildings and functions and conditions to be handled can determine what type of contract arrangement is more suitable, particularly in relation to whether national or international contractors are considered.

Conclusions

Based on the results of this project it is concluded that the defined and designed adaptation and protective measures are considered technically and economically feasible. It is concluded that both type of measures are only considered sustainable in case they are implemented together. This emphasizes the synergy between the both.

The following additional conclusions and recommendations are made regarding the protective measures:

- In principle the revetment solution is technically more robust compared to the beach replenishment. The rock works are able to withstand extreme events and will fix the coastline with minimal maintenance required. Beach replenishments inherently will have higher maintenance and a shorter design life compared to rock works. The maintenance is however minimized by implementation of the groyne. This means that the revetment solution can be considered a more sustainable solution.
- Beach replenishments will however preserve the typical character of the present shoreline. Both the present recreation, fishery and ocean view can remain as it is and the environmental impact and impact on aesthetic value is limited. The inclusion of the promenade in the revetment design enables accommodation for recreation but will change the present landscape.
- The soft character of the beach replenishment and the associated uncertainty in terms of durability, ultimately leads to a slightly conservative design. Although much effort has been put into the design of the alternatives, optimization of the design, especially the beach and groyne layout is recommended.
- Since the designs are preliminary, it is recommended to further detail the designs, especially the interfacing, transitions, drainage, promenade pavements and beautification.
- For West Point two alternatives are proposed: Revetment including promenade (Alternative A) and a beach replenishment with a groyne (Alternative B). Alternative B scores well regarding economic feasibility, preservation of beaches and recreational values, investment costs and environmental considerations. Alternative A has lower needs for repeated maintenance (with less risks for sustainability of the solution). It was the latter which resulted in a higher acceptance for alternative A of the communities.

It is recommended that the Government of Liberia and the United Nations Development Programme now undertake the following key steps:

- Review the reporting and accompanying documents, and seek clarification from the project preparation consultants where necessary;
- Discuss the proposed adaptive measures with relevant stakeholders/institutions and detail these further;
- Develop the proposed strategy into a funding proposal for the Green Climate Fund.
- Start arrangements with the relevant Ministries in order to discuss and ensure the national co-financing as required for the funding proposal for the Green Climate Fund;
- Establish the institutional structure for implementing the project, including the recruitment of the key implementation staff;
- Investigate most appropriate procurement strategy;
- Expand the stakeholder consultations with the affected communities, the appropriate elements of civil society, and the relevant metropolitan and national institutions.

1. CLIMATE RESILIENT STRATEGIES

1.1 Rationale and synergy

In Part I – Vulnerabilty Reporting, the key strategic objectives of a climate resilient strategy for Monrovia were described: These were:

- Minimise contributing to the drivers of climate change;
- Reduce vulnerability and make society climate resilient;
- Protect and enhance livelihoods;
- Safeguard food security;
- Enhance ecosystems.

In order to contribute to these objectives effectively, the strategy we have proposed consists of a variety of measures split over two main themes. The first set of interventions consists of the protective measures: these are combinations of soft engineering solutions with green elements to protect the most vulnerable coastal sections from erosion and storm hazards. The second series of actions consists of adaptive measures: actions to develop climate resiliency of the communities and relevant institutions, nature and assets. To help achieve this, some of the adaptive measures aim to generate awareness and capacity in the communities and institutions, that will enable and support the implementation and maintenance of both other adaptive measures and the protective measures, which is necessary for their sustainability: without knowledge, understanding and support from society and the institutions that administer it, the success of the project is at risk of being negated by competing interests that give low value to the threats posed by climate change.

The intention is therefore that the activities of the adaptive interventions must go hand in hand with each other, and with the protective measures. The protection of the fishery community is justified in this project because it provides opportunities to develop a more sustainable low carbon fishery sector while safeguarding the environment in the face of climate change-induced impacts. In this sense the adaptive measures are important conditions for the effectiveness and sustainability of the protective measures, but they also provide synergies within the strategy. This is illustrated in Figure 1-1.

The project has a twofold approach to addressing climate change.

(i) **Adaptation Measures: :** measures to help minimise the drivers as well as the impacts of climate change and prepare awareness and capacities for implementation of the protective measures. These exploit opportunities to safeguard currently sustainable livelihoods that are low consumers of carbon energy, and which consequently promise to give Liberia "green" living approaches for both the current and future generations. The project focuses on the inshore artisanal fishery of Monrovia, which contributes significantly to the city's food security with very low carbon emissions; however, a number of interventions are required to ensure that the environment supporting this will continue to sustain it as climatic conditions change, and impacts increase as a result of higher sea levels and stronger storms.

(ii) **Protective Measures:** measures to help mitigate the impacts of climate change. These are mostly engineered interventions such as the construction of revetments, groynes and beaches to protect against rising sea level and the damaging effects of waves from higher-energy storm events. Some aspects are preventative, such as the development of alternative sand sources to stop mining of the natural beaches, and the promotion of measures to improve infrastructure resilience.

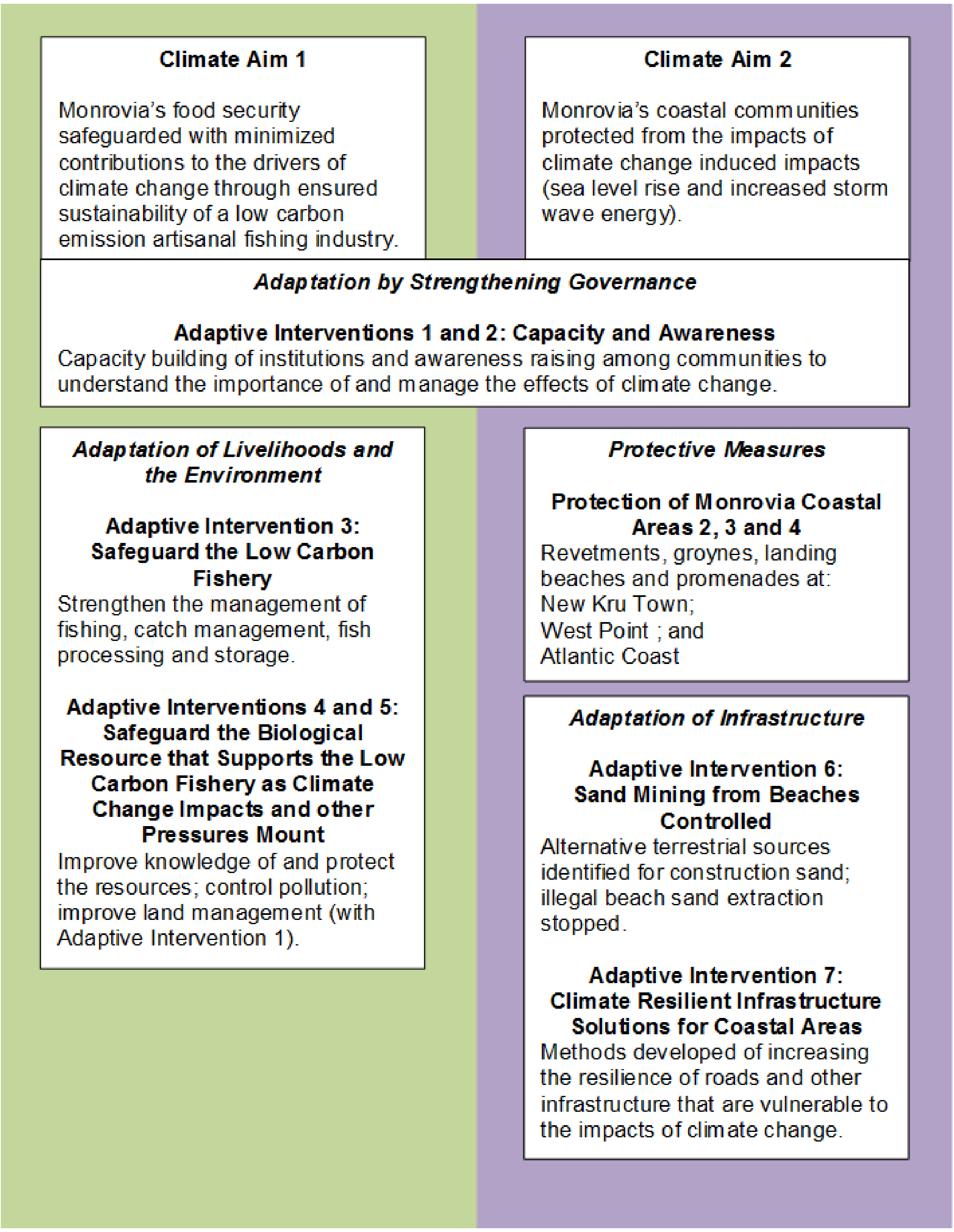


Figure 1-1: Relation between strategic objectives, adaptive measures and protective measures

1.2 Reading guide

The defined climate resilient strategies comprises adaptation and protective measures. These are treated separately in chapter 2 and chapter 3, for the adaptation and protective measures respectively. Chapter 4 shows the cost estimation of both types of measures. Chapter 5 shows the financial and economic feasibility of the proposed alternatives. This is followed by a brief description of the implementation of the project in chapter 6. Finally chapter 7 shows the main conclusions and recommendations of the feasibility study.

2. ADAPTATION MEASURES

The adaptive measures that are proposed have been grouped under three headings: i) strengthening governance; ii) adaptation of livelihoods and the environment; and iii) adaptation of infrastructure. In the next sections, the adaptive measures are described and detailed under these headings with the help of a logical framework. Subsequently, detailed project Concept Notes can be found, which can serve as a basis for further development of the interventions during the project implementation stage (including for tender documents and terms of reference).

2.1 Strengthening Governance

Good governance – a broad term we use here for sound overall management, coordination, awareness and capacity for integrated coastal zone management – is an important condition for sustainable implementation of the proposed strategy. For this reason, we have proposed and detailed a number of measures aiming to strengthen governance by relevant institutions and awareness in the local communities.

2.1.1 Rationale and relation with climate change

The awareness, understanding, capacity and coordination between all relevant institutions regarding risks for the coastal zone and potential integrated solutions are poor in Liberia. The expected climate change – sea level rise, more extreme rainfall and storm events – will worsen the situation of the coastal areas and can endanger assets and communities in Monrovia and along the shores elsewhere in Liberia. Communities living in the areas and institutions in Monrovia still have a limited awareness of potential hazards and risks, and lack experience, funding mechanisms and tools regarding integrated coastal zone management policies and international practices. Coordination between the authorities responsible for the different assets and policy areas relevant for coastal zone management (mainly the EPA, various ministries and authorities, and metropolitan organisations) needs to improve to address these problems. Moreover, a sustainable national funding mechanism will need to be established to create sufficient funding for long term investments and maintenance of the coastal areas (including beaches, mangroves etc.), and avoid dependency on donor funding for the long term.

The two approaches are as follows.

- Adaptive Intervention 1: Increase the capacity of the institutions responsible for integrated coastal zone management.
- Adaptive Intervention 2: Increase awareness of the importance of addressing climate change issues among the affected society.

2.1.2 Proposed measures

Table 2-1 provides an outline of the two proposed measures to strengthen governance. The full Concept Notes with more detailed information can be found in Appendix A.

Table 2-1: Outline of Adaptive measures aiming to strengthen governance

Adaptive intervention	Activities	Implementation agency and modality	Budget
Adaptive Intervention 1. Capacity building of national and metropolitan institutions in ICZM and land use planning **Aims**: to develop and maintain a sustainable coast in Liberia by sound coastal zone management policies and land planning. The project purpose is to improve the capacity of and co-ordination between the relevant institutions responsible for Integrated Coastal Zone Management in Liberia. **Climate relationship rationale**: To ensure that the institutions all understand the climate-related benefits of the project: (i) reducing the drivers of climate change; and (ii) mitigating the impacts of climate change.	The measure has three components. *Component 1.1: Capacity building ICZM* • Trainings, workshops and (international) study and site visits • Support to ICZM policies, regulations, funding mechanisms and project development; • Establishing structures • Development of ICZM tools *Component 1.2: Strengthening coordination between institutions* • Establishing an Inter-agency ICZM working group & defining roles and responsibilities; • Organizing awareness and learning and discussion workshops *Component 1.3: Improvement of land use planning and enforcement* • Support to developing regulations, land registry systems and enforcement policies; • Training and on the job support to enforcement implementation to stop illegal activities; • Dispute resolution support & training	Environmental Protection Agency (EPA) The component activities will be procured as service contracts to consultancies or knowledge institutes (or combinations thereof)	About 3-4 million USD
Adaptive Intervention 2. Strengthening of community awareness and management of coastal zone risks and solutions **Aims**: to strengthen community resilience for climate change. Project purpose: to create awareness of coastal zone vulnerability (coastal retreat due to erosion and climate change) and environmental issues for communities. **Climate relationship rationale**: To ensure that the target and beneficiary communities and wider	*Component 2.1: Investigations* • Identifying and selecting the most vulnerable coastal zones in Liberia (next to these in Monrovia); • Identification of the specific target groups in the selected coastal areas. • Development of awareness and information strategy (including information materials and methods); • Development of awareness and capacity building programme and materials *Component 2.2: Implementation*	National Fisheries and Aquaculture Authority could steer the project together with the Liberian Artisanal Fishermen's Association service contract with communication consultancies or NGOs having experience working with local communities/ civil society	About 2 million USD

Adaptive intervention	Activities	Implementation agency and modality	Budget
interests all understand the climate-related benefits of the project: (i) reducing the drivers of climate change; and (ii) mitigating the impacts of climate change.	• Implementation of the awareness and capacity building strategy and programme • Evaluation, lessons learned and follow-up recommendations		

2.2 Adaptation of Livelihoods and the Environment

There are three adaptation interventions in this category. These all relate to the ensuring that the Monrovia artisanal fishery remains productive and sustainable, so that in turn it ensures a major contribution to the city's food security in a low carbon manner.

2.2.1 Rationale and link with climate change

These measures are all required to ensure that the fishery can be sustained indefinitely, at a time of increasing pressure of population for cheap food sources, while the resources required to provide this are threatened by the impacts of climate change. These interventions not only address those impacts, but also ensure that this industry remains one that is minimal in terms of contributing to the drivers of climate change.

The three approaches are as follows.

- Adaptive Intervention 3: Address the management of fishing, catches, and fish processing and storage.
- Adaptive Intervention 4: Understand the biological resource and ensure its protection as necessary to sustain catch volumes.
- Adaptive Intervention 5: Understand and manage the pollution that threatens the biological resource in the urban proximity.

While these fishery and environmental management measures appear indirect to a project seeking to ensure climate resilience, they are in fact closely related to the hub of the issue. An inshore fishery close to an urban centre offers exceptional benefits for low carbon emission food production, but it must be managed holistically if it is to be sustained. Failure to do this would lead to Monrovia shifting to food sources that require much greater inputs of carbon-based energy, and would cause the city to increase its contributions to the drivers of climate change.

Climate change and its effect on mangroves in the Mesurado basin is discussed in Appendix C.

2.2.2 Proposed measures

Table 2-2 provides an outline of the three proposed measures to strengthen livelihoods and the environment. The full Concept Notes with more detailed information can be found in Appendix A..

Table 2-2: Outline of adaptive measures for livelihoods and the environment

Adaptive intervention	Activities	Implementing agency and modality	Budget
Adaptive Intervention 3. Sustainable fisheries management **Aims**: to ensure that the current low energy artisanal fishery can continue to function, using low carbon emission methods to supply affordable protein to the local urban market. **Climate relationship rationale**: To ensure that the Monrovia artisanal fishery continues sustainably as a low carbon emission industry that minimises contributing to the drivers of climate change while providing for urban food security in a major way.	Component 3.1: Investigations • Study of catch volumes and species targeted by Kru, Fanti and Popoh fishermen. • Survey of the marine biological resources and assessment of their sustainable offtake capacity. • Study of low energy options for improvement of fish processing and storage facilities. Component 3.2: Implementation • Institutional development and capacity building support to the Liberian Artisanal Fishermen's Association. • Institutional development and capacity building support to branches of the Monrovia Fishmongers' Association. • Inshore 6 nautical mile zone enforced for artisanal fishing and sustainable offtake monitored.	National Fisheries and Aquaculture Authority could steer the intervention together with the Liberian Artisanal Fishermen's Association Service contracts will be necessary with specialist consultancies.	About 2 million USD
Adaptive Intervention 4. Management of the biological resources. **Aims**: to sustain the low energy fishery through protected marine and mangrove areas. **Climate relationship rationale**: To ensure that the biological resource remains intact to support the Monrovia artisanal fishery in continuing to function sustainably as a low carbon emission industry that minimises contributing to the drivers of climate change while providing for urban food security in a major way.	Component 4.1: Investigations • Study of the marine and estuarine biological environment, Component 4.2: Implementation • Determination of areas where protected area status is justified. • Consultation on the proposed protected areas; local and national agreements; preparation of management plans. • Support to the Forestry Development Authority or another agency to draft the appropriate legal instruments to designate defined marine or estuarine areas as protected areas • Support to the start-up of the management of the protected areas.	EPA should manage this intervention with support from FDA and other agencies as required. Service contracts will be necessary with specialist consultancies.	About 2.75 million USD
Adaptive Intervention 5. Management of urban pollution in coastal areas. **Aims**: to sustain the low energy fishery through effective urban	Component 5.1: Investigations • Survey of water quality in the creeks, estuaries and nearshore ocean that might affect mangroves and other sensitive habitats.	EPA should manage this intervention with support from municipal and	About 0.8 million USD.

Adaptive intervention	Activities	Implementing agency and modality	Budget
pollution control and waste management in coastal waters **Climate relationship rationale**: To ensure that the biological resource remains intact to support the Monrovia artisanal fishery in continuing to function sustainably as a low carbon emission industry that minimises contributing to the drivers of climate change while providing for urban food security in a major way.	• Survey of housing areas and sewerage systems within 1 km of tidal water. • Survey of businesses and industries within 1 km of tidal waters. • Review of the urban waste management system. Component 5.2: Implementation • Development of improved strategies for the waste management and pollution control agencies, including capacity development. • Design of major waste management or pollution control interventions, if required, for separate financing by government. • Monitoring of the effectiveness of the improved waste management or pollution control systems in terms of reducing damage to ecosystems and habitats in tidal waters.	other agencies as required. Service contracts will be necessary with specialist consultancies.	

2.3 Adaptation of Infrastructure

Infrastructure (roads, energy, water facilities etc.) are key for the functioning of communities and the economy. Climate change, more specifically coastal erosion worsened by sea level rise, storm hazards and extreme rainfall (flash floods) can cause infrastructure to be damaged or to stop working. Therefore, the measures described below aim to develop more climate resilient infrastructure in the coastal areas.

2.3.1 Rationale and relation with climate change

The key problem to be solved by these measures is related to climate change related hazards in the form of sea level rise, exacerbated by storm surges, extreme rainfall and the inundation of critical infrastructure in selected vulnerable coastal areas. One intervention relates to the control of sand mining to alleviate the pressure of erosion of the natural sea defences. The other intervention will investigate solutions to coastal erosion and retreat of the shoreline, mainly in the form of advice on the relocation or heightening of primary roads. The problem of inundated roads during the rainy season or during storm surges causes problems for transportation of people and goods, and can isolate communities for weeks or more. In order to avoid these bottlenecks, more climate resilient roads or other assets or relocation of roads could overcome these problems.

The two interventions are as follows.

- Adaptive Intervention 6: Alternative sources of construction sand.
- Adaptive Intervention 7: Options for climate-resilient infrastructure in coastal areas.

2.3.2 Proposed measures

Table 2-3 gives an outline of the proposed measures. The full Concept Notes of the measures with more detailed information can be found in Appendix A.

Table 2-3: Outline of adaptive measures: adaptation of infrastructure

Adaptive intervention	Activities	Implementation agency and modality	Budget
Adaptive Intervention 6. Sustainable sand extraction. **Aims**: to establish environmentally sound terrestrial sources of construction sand and to stop sand extraction from present-day beaches. **Climate relationship rationale**: To ensure that the illegal but widespread extraction of sand from active beaches is stopped, to help mitigate the impacts of climate change.	**Component 6.1: Investigations** • Prospecting of potential inland sources of sand within a 2-hour haulage distance from central Monrovia. • Review of the impacts on livelihoods in poor coastal communities of the strict enforcement of a ban on sand extraction from present-day active beaches. • Review of the formal and informal construction industries, and the economic consequences of sand extraction from only inland sources. **Component 6.2: Implementation** • Preparation of a strategy on inland sourcing of construction sand. • Development of a planning framework within which inland construction sand will be permitted from designated areas. • Support to government agencies to uphold strict enforcement of a ban on the extraction of sand from present-day active beaches.	EPA should manage this intervention in close collaboration with the MLME. Service contracts will be necessary with specialist consultancies.	About 0.7 million USD.
Adaptive Intervention 7. Climate resilient community roads and other critical infrastructures **Aims**: (a) to enhance the resilience of road infrastructure (b) to improve the capacity of relevant authorities to respond promptly in an emergency	**Component 7.1**: **Developing knowledge on the vulnerability and potential resiliency options for infrastructure** • Vulnerability assessment of infra/roads in selected coastal areas; • Conducting a feasibility study / plan • Providing recommendations **Component 7.2: Capacity building in resilient road infrastructure for relevant authorities.** • Developing a climate resilient policy mainstreaming framework; • Preparing a training curriculum; • On the job support to relevant staff in implementing agencies • Organizing trainings, workshops and field and study visits on climate resiliency of roads and waste, water and energy facilities.	Ministry of Public Works. Project could be procured as a service contract to consortium of consultancy / engineering firms	About 2,5 million USD

3. PROTECTIVE MEASURES

This chapter describes the preliminary design of the protective measures part of the climate resilient strategies. The following sections describe the functional requirements, design requirements and design conditions. This is followed by the preliminary design of each component for each section separately: New Kru Town, West Point and the American Embassy.

3.1 Introduction

Based on the extensive assessment part of the Vulnerabilitiy Reporting (PART I) the following alternatives for protective measures have been selected:

Section	Alternative A	Alternative B
2 – New Kru Town	Revetment including promenade and fish landing sites	Same as alternative A
3 – West Point	Revetment including promenade and fish landing sites	Groyne including beach widening
4 – American Embassy	Groyne including beach widening	Same as alternative A

The coastal protection measures include both soft and hard structural components that have specific functional and design requirements, which are treated in the sections below. The preliminary designs of each section and alternative are treated in the following sections.

3.2 Functional requirements

The reason for protective measures is to mitigate and reduce the vulnerability of the coastal hazard. From the vulnerability analysis it is clear that the major threat is mainly coastal retreat, hence the above protective measures are proposed. Their main function is therefore to prevent structural and climate change induced coastal retreat.

By doing so the protective measures need to:

- Prevent loss of land and damage to property;
- Protect livelihood and property of coastal communities;

It is thereby preferred that they:

- Sustain and possibly enhance fishery and food security;
- Sustain and possibly increase attractiveness for recreation at the ocean front

It is considered that the protection needs to rigid, robust and sufficiently stable for future extreme conditions to counter structural coastal erosion and damage to the structures.

For each type of structure additional specific functional requirements are specified.

- Revetment including promenade and fish landing sites:
  - Fixing the coastline position and prevention of coastal retreat;
  - Remain stable during its design life under extreme conditions;
  - Limit overtopping;
  - Increase attractiveness of the ocean front;
  - Allow access to the ocean with fishing canoes;
- Groyne:
  - Block longshore sediment transport and thereby enclose beach replenishments
- Beach widening/replenishments
  - Prevention of loss of land and damage to property by:
  - Creating a buffer zone for potential storm erosion and coastal retreat by sea level rise (Bruun effect).
  - Sustain and increase attractiveness for recreation at the ocean front

3.3 Design requirements

In this section the design requirements for the coastal protection are stated. It includes the applied design guidelines, design life and corresponding return period in relation to the functional requirements.

3.3.1 Design Guidelines Coastal Protection

The preliminary design of the coastal protection is in accordance with common practice standards and guidelines, including but not limited to:

- The Rock Manual (Ref [1]);
- Coastal Engineering Manual (Ref [2]);
- EurOtop 2016 Manual (Ref [3]);
- Latest editions of British Standard/Eurocode codes and standards on coastal engineering and structural aspects.

3.3.2 Design life and return period

The design life and design conditions are interrelated. The design life of a structure can be taken as the specified period for which a structure is to be used for its intended purpose with planned maintenance. A design working life of the order of 50 years is common practice for maritime structures such as quay walls, jetties, docks and coastal protection works. The selected design life depends on the type of structure, financial and technical considerations, e.g. the possibility to adjust the design later for a longer design life and the difference in costs. In reality, rock works are a durable solution, relatively easy adaptable and low in maintenance and most likely the design life can be quite easily extended. For all the rock works a design life **of 50 years** has been selected.

It should be noted that the design life is not necessarily the same as the return period of the design condition and both parameters should be selected with care. The probability that the design condition will occur or exceeded during the design life can be calculated with the following expression:

$$P = 1 - \left(1 - \frac{1}{RP}\right)^N$$

In which *RP* is the return period of the design conditions and *N* the design life in years. This expression is visualized in Figure 3-1.

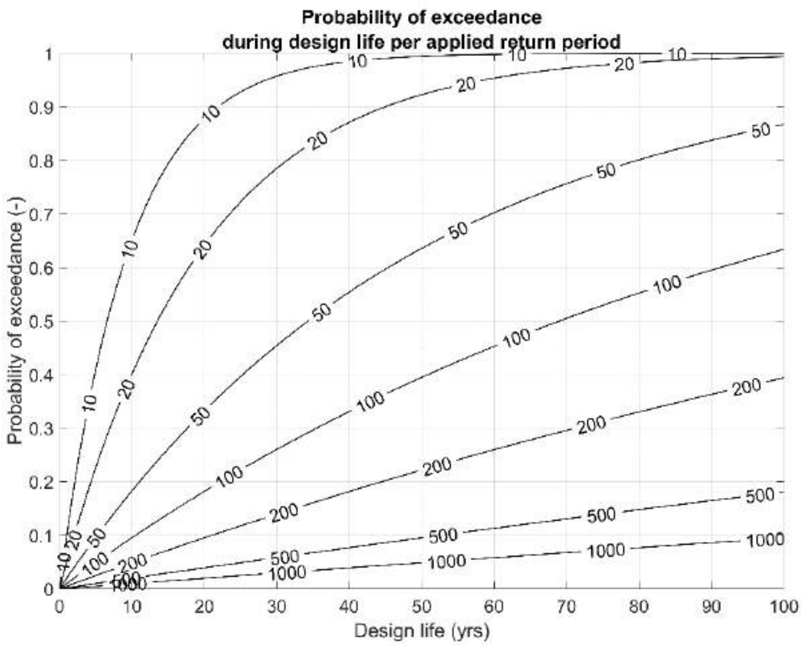


Figure 3-1: Probability of exceedance of design condition with specific return period during design life

From the figure it becomes clear that applying a design condition with a return period of 50 year with 50 year design life the probability of exceedance during the design life will be approx. 64%. A return period of 100 years with a design life of 50 years implies a probability of exceedance of 40%, which is considered acceptable for these type of structures. It is noted that a design needs to be made such that the structure can sufficiently withstand the design conditions of the selected return period.

Note that the above probability of exceedance does not equal the probability of failure of the structure. That depends on the allowable damage corresponding to the design condition and the safety margin included in the design. Moreover, the damage development and the subsequent definition of failure is of importance. For the revetment it is considered that failure of the structure is when (part of) the structure has collapsed and hence its function, e.g. protection of the coast, is lost. The function of the groyne is, however, to block the longshore sediment transport. Hence, the allowable damage can be higher than for the revetment: even if some rocks have been moved/rolled it is still able to capture the sand and its function will not be lost. Therefore additional requirements for allowable damage (e.g. allowable displaced armour rock) has been defined for each type of structure separately.

Since the boundary conditions are expected to worsen during the design life due to climate change, multiple design criteria are defined for different projection years. Due to this continuous worsening of the boundary conditions the most extreme condition is expected at the end of the design life. However, the probability that this most extreme event occurs at the last part of its design life is very low, see Figure 3-1. Also with respect to maintenance, it is considered that more damage is allowed at the end of the design life compared to the start.
A design life of 50 years and assuming a start of design life at approx. 2020 means that the end of design life will be approx. 2070. Table 3-1 shows the defined damage levels for the two applied structures in this project for the design conditions with return period of 100 years at the start and end of the design life (including the impact of climate change).

Table 3-1: Allowable damage with design condition with return period = 100 years (Sd = damage parameter)

Type	2020 (start)	2070 (end)
Revetment	Sd = 2	Sd = 3
Groyne	Sd = 3	Sd = 4

Another aspect of the design is the allowable overtopping of the structure. Large overtopping can have significant impact on the hinterland leading to serious damage and threat to people's safety. The critical overtopping rate is extensively discussed in the Overtopping Manual of 2016 and the Rock Manual.

Based on these guidelines, it is considered that an overtopping rate of more than 10 l/s/m will result in significant impact on the road access, mobility, safety for pedestrians and potential damage to pavements (if significant more and depending on type of pavement). The probability that such an event occurs should therefore be limited. Overtopping will increase over time due to worsening of the wave conditions by climate change and sea level rise. It is also considered that a (slight) lower overtopping rate should not occur frequently as hinder should be limited. Therefore, an additional overtopping criterion is applied for more frequent conditions.

Table 3-2: Applied critical overtopping rates

Year	Return period	Critical overtopping
2020	1 year	$q < 1$ l/s/m
2070	100 years	$q < 10$ l/s/m

For the beach replenishments/widening the design requirements are related to the functional requirement of creating a buffer zone for storm erosion and sea level rise. Since the beach replenishments are always implemented together with a groyne the structural loss of sand in the beach cell due to longshore sediment transport is limited. A buffer therefore is only required for the potential storm erosion and the inevitable retreat due to sea level rise (‘Bruun effect’).

There is no specific guideline for the design life of a beach replenishment. The soft character of a beach replenishment will inevitably require an adaptive and resilient design, since it is progressively changing to its environment. Natural variability makes it hard to predict the exact development and therefore robustness is required in the design. Maintenance is therefore an important component of beach replenishment design. Due to these reasons the design life of the beach replenishment is considered shorter than for rock works and is set to 20 years. That is the lifetime in which it the probability for maintenance needs to be considerably low. The additional storm erosion that needs to be accounted for is considered to be with a return period of 100 years. To be slightly conservative the expected retreat due to sea level rise and storm erosion are used for the projection year of 2050.

That means that in summary the minimum beach width (in case of no revetment) should at least be based on:

- Expected additional storm erosion with a return period of 100 years in 2050 plus;
- Expected retreat due to sea level rise between 2020 and 2050.

The minimum beach width is in this case defined as the distance between the shoreline (MSL) and the settlement boundary. It is emphasized that the function of this minimum beach width is merely to create a buffer zone and therefore it is strongly noted that no housing or property is allowed on the beach.

In the above design requirements it is considered that the applied climate change scenario should be the worst case scenario, which is RCP 8.5.

3.4 Design conditions

The design conditions presented here are related to the design requirements and are determined for each section separately. The main design requirements and hence design conditions are related to water levels, wave conditions and expected coastal retreat (storm erosion and sea level rise). For the overall site conditions (e.g. bathymetry and topography) reference is made to the Vulnerability Reporting. Specific design parameters for each section are treated in the next section.

Water levels

The local water level conditions are mainly affected by tide, surge and sea level rise. A detailed description of each component is described in the Vulnerability Reporting. The following water levels are the design water levels for specific return periods and projection years. All levels are referred to Mean Sea Level (MSL) in the year 2000. The adopted sea level rise is for RCP 8.5

Table 3-3: Design water levels (m+MSL2000)

Return period (yr) Projection year	1	10	100
2000	0.72	0.84	0.85
2020	0.80	0.92	0.93
2050	0.98	1.10	1.11
2070	1.14	1.26	1.27
2100	1.46	1.58	1.59

Wave conditions

The extreme nearshore wave conditions stem from the nearshore wave modelling exercise as described in the Vulnerability reporting. The wave conditions are averaged over the relevant output locations along the -5 m+MSL depth contour for New Kru Town and West Point and the -10 m+MSL depth contour for the American Embassy, i.e. near the toe of the structures, and for the relevant projection years. The wave conditions below are all for climate scenario RCP 8.5. These conditions are both used for the stability and overtopping design and verification.

Table 3-4: Design wave conditions

Section	Return Period (yr)	Projection year	Hs (m)	Tp (s)	Depth (m+MSL)
New Kru Town	1	2020	1.70	14.3	5
New Kru Town	100	2020	2.20	16.6	5
New Kru Town	100	2070	2.30	17.0	5
West Point	1	2020	1.38	14.3	5
West Point	100	2020	2.07	15.9	5
West Point	100	2070	2.15	16.1	5
American Embassy	100	2020	3.89	15.9	10
American Embassy	100	2070	4.06	16.5	10

Coastal Retreat

The expected coastal retreat as used for design is merely the coastal retreat due to storm erosion and sea level rise to determine the minimum required beach width. For section West Point and American Embassy the coastal retreat due to SLR and the additional storm erosion with return period of 100 year in 2050 is required for the design.

Table 3-5: Expected coastal retreat and potential additional storm erosion in 2050

Section	Bruun effect (Coastal retreat SLR) [m]	Additional Storm Erosion (RP=100yr) [m]	Sum [m]
West Point	4.8	23	28
American Embassy	4.1	28	32

3.5 Preliminary design protective measures

This section describes the preliminary design of the protective measures for each section separately. The difference between alternative A and B is merely the difference in type of structure for the section West Point. Therefore only for West Point two different alternatives are described.

It is noted that the preliminary design needs to be detailed further during the detailed design phase before construction can commence.

3.5.1 New Kru Town

The New Kru Town coastline is approx. 2.5 km long and stretches from the St. Paul river mouth towards the northern port breakwater. Figure 3-2 provides an overview of the coastline of New Kru Town and the proposed protective measures. All the major design components for New Kru Town are summarized in Table 3-6. The most southern section indicates the port area which is considered outside the scope of the project.

Table 3-6: Design components New Kru Town

Chainage	Structure
0-650 m	Revetment light
650-1950 m	Revetment
1240-1350 m	Fishing landing site North
1950-2100 m	Fishing landing site South

The below sections describe each design component separately.

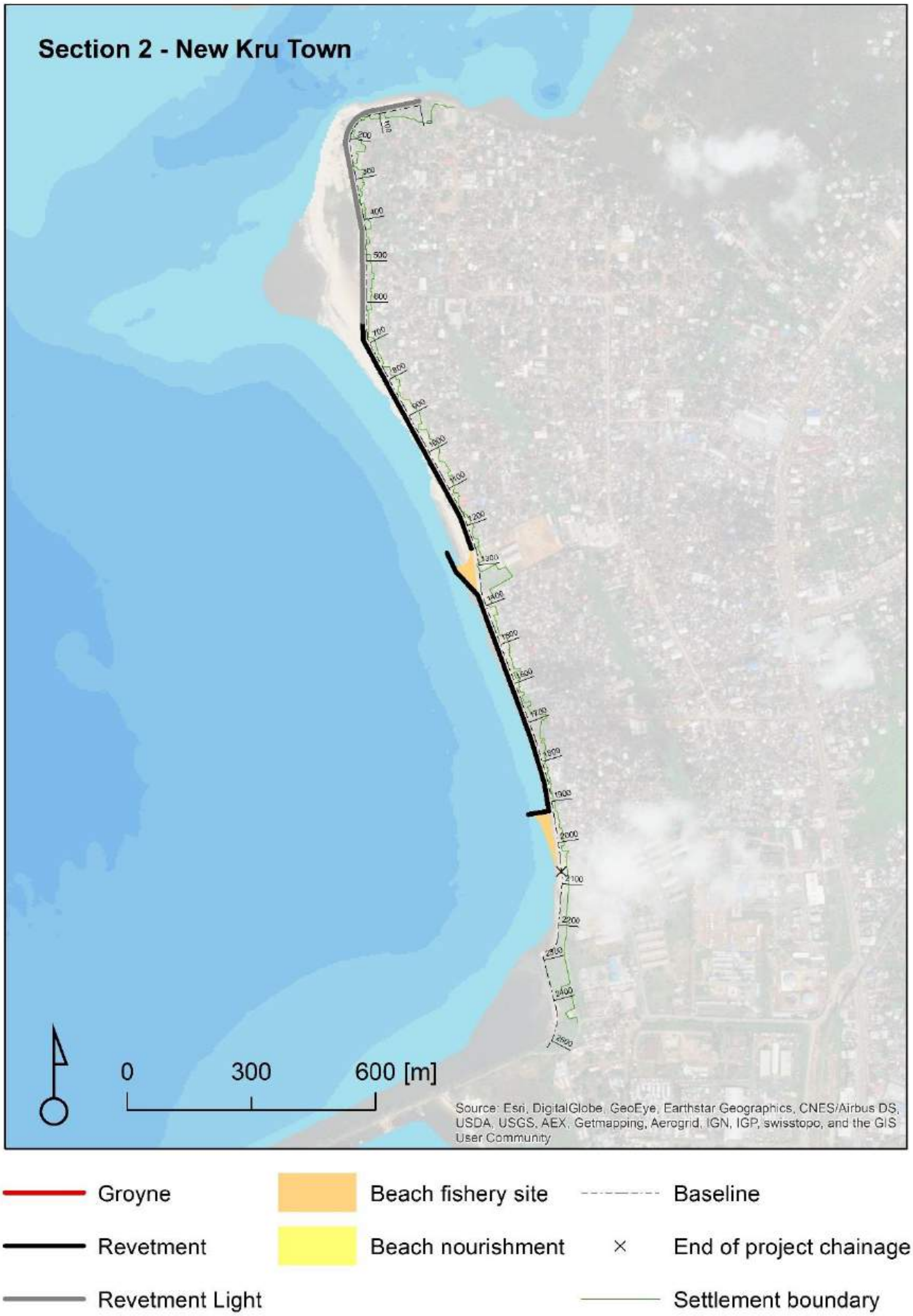


Figure 3-2: Overview of protective measures New Kru Town

Revetment
Along the major part of the coastline a revetment is proposed that will fix the coastline position and thereby protect the coastline against coastal retreat. The revetment should be stable enough to withstand extreme scenarios as specified in the design requirements and conditions. The beach will be more or the less kept as it is, as the excavated sand (for the revetment) will be placed at the beach location. However, in the future the beach will retreat further and eventually disappear. This means that the depth in front of the revetment will increase till an equilibrium is found.

It is noted that in the present situation already a revetment has been constructed which construction is still ongoing at the moment of writing of this report. The existing revetment lies approx. between **chainage 900-1750m**. The existing revetment is not considered sustainable to mitigate coastal retreat as it is not designed for the expected future (extreme) conditions and is therefore placed as a temporary solution only. The existing structure has been taken into account in this design. It is noted that the exact present situation (levels dimensions and inner part) is not known as the construction is still ongoing without any (control) measurement instruments nor detailed design drawings available. Based on site visits, drone and satellite images an estimation of the dimensions of the present situation is made.

A rubble mound revetment has been selected as protection for which the dimensions and rock gradings are based on the applicable formulae following the Rock Manual. The relevant design parameters for the revetment are shown in Table 3-7. The design conditions are described in section 3.4.

Table 3-7: Design parameters New Kru Town Revetment

Parameter	Value
Sea water density	1025 kg/m^3
Rock density	2650 kg/m^3
Storm duration	6 – 12 hours (applying low estimate Tp for short storm duration and best estimate Tp for longer storm duration)
Slope	1:2
Notional Permeability factor	0.2 (combination of geotextile in the lower part and rock core (rip-rap) in the upper part)

With the applied allowable damage values as depicted in section 3.3.2 the required stone mass (M_{50}) for the armour layer has been calculated for the different sets of conditions and shown in Table 3-8, with in bold the normative values.

Table 3-8: Calculated required stone mass for revetment New Kru Town

Year	Return period (yr)	H_s (m)	T_p (s)	Storm Duration (hr)	S_D	M_{50}(tonnes)
2020	100	2.2	13.5	6	2	3.33
2070	100	2.3	14.0	6	3	2.92
2020	**100**	**2.2**	**16.6**	**12**	**2**	**3.40**
2070	100	2.3	17.0	12	3	3.02

This has led to the required gradings for the different layers in the design as presented in Table 3-9. The different layers comply with the filter rules as presented in the Rock Manual.

Table 3-9: Required gradings for New Kru Town revetment

Layer	Grading
Armour	2 -5 t
Underlayer	60 – 300 kg
Core	Quarry Run (1-500 kg)

The required crest level has been determined based on the allowable overtopping rates. The '*design and assessment approach*' of EurOtop 2016 has been applied to calculate the overtopping rates. The following correction factors have been applied in the formulas:

- γb = 1.0;
- γβ = 1.0;
- γf = 0.5 (*in between permeable and impermeable core)*

After iteration it seems that applying a crest level of +4.6 m MSL_{2000} the overtopping criteria are met. The resulting overtopping rates are shown in Table 3-10. The overtopping criteria are shown in the design requirements (section 3.3.2)

Table 3-10: Calculated overtopping rates for New Kru Town revetment for crest level of 4.6 m MSL

Year	Return Period (yr)	Hs [m]	Tp [s]	WL [m+MSL]	Overtopping [l/m/s]
2020	1	1.7	14.3	0.93	0.19
2020	100	2.2	16.6	0.93	3.41
2070	100	2.3	17	1.27	9.65

Figure 3-3 shows the principle cross-section for the revetment along the coastline of New Kru Town where no existing structure is present, which is applicable for the chainage 650-900m and 1750-1950m. The toe of the structure is buried into the existing beach to a level of -5mMSL to account for the expected future deepening of the foreshore.

A bund of Quarry run is included in the design with on top a pavement for the accommodation of a promenade. A total width of 6 m for the promenade is accounted for which is sufficient for recreation and access for pedestrians to enjoy the ocean view. The promenade pavement has to be detailed in the detailed design phase. A pavement consisting of concrete slabs or big tiles is deemed sufficient and aesthetically attractive. By planting (palm) trees along the promenade the aesthetic value is enhanced even further.

Figure 3-4 and Figure 3-5 show two principle cross-sections for the revetment at New Kru Town for the locations where the existing structure is located (chainage 900-1750). The difference is mainly the distance from the baseline and the (estimated) dimensions of the existing structure. The existing structure is implemented in the design as much as possible and the promenade is included in the design.

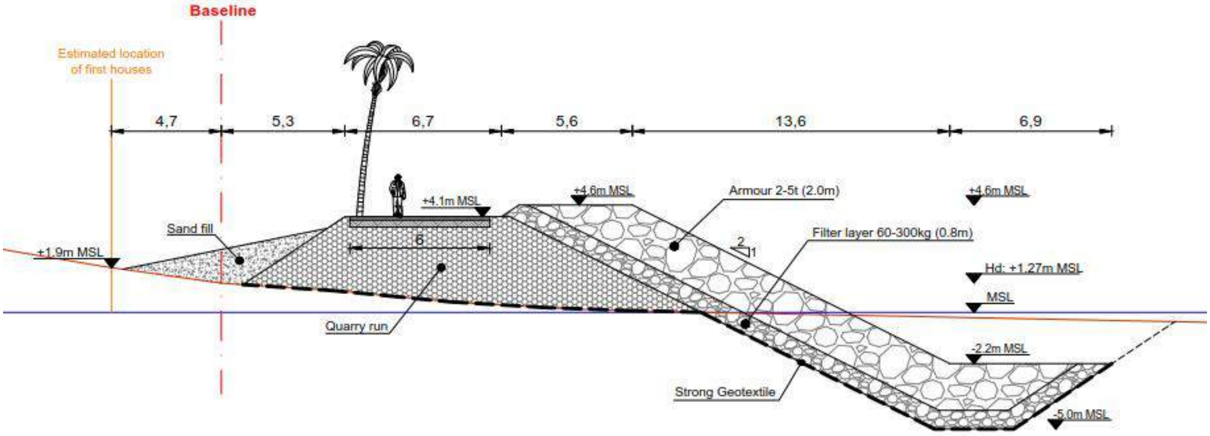


Figure 3-3: Principle cross-section Revetment New Kru Town – without existing structure – Chainage 850

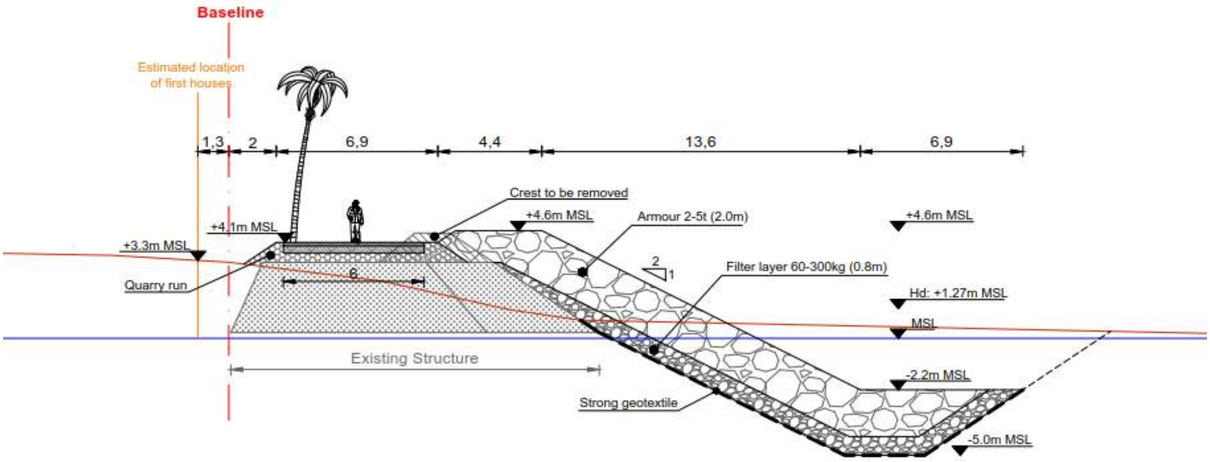


Figure 3-4: Principle cross-section Revetment New Kru Town - with existing structure – Chainage 1150

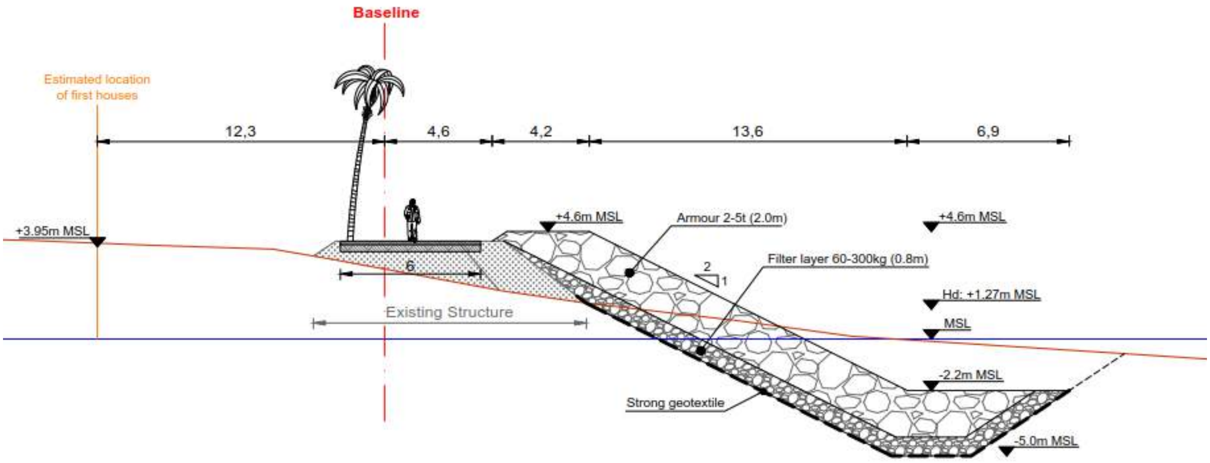


Figure 3-5: Principle cross-section Revetment New Kru Town - with existing structure – Chainage 1550

Revetment light
At the northern part of New Kru Town, at the river mouth of the St. Paul river it is expected that erosion will also gradually continue, which will threaten the local community. To prevent scour development at the northern part of the revetment (as presented above) and potential backwashing a (lighter) revetment running towards the North is included in the design. Since this part is mostly covered in sand in the present situation and in case of further erosion the wave action is drastically lower at that part a (significant) lighter revetment suffices at these locations. Even if the river mouth of St. Paul is completely eroded and waves are able to attack this revetment the waves will arrive at much larger angle compared to the other parts, which will eventually decrease the net wave attack at the structure.

Figure 3-6 shows the principle cross-section for the revetment light which is applicable for the chainage 0-600 m. The grading of the armour layer is defined as 300-1000 kg on top of an underlayer of 60-300 kg. The exact future wave conditions at these locations are unknown, however such an revetment is theoretically stable for wave conditions with a significant wave height of 1 to 1.5 m with strong oblique incoming waves. This is deemed sufficient for this location. The toe is also constructed less deep compared to the larger revetment as the complete structure needs to be buried in the existing beach.

Also here the promenade is included in the design to ensure a continuous access with ocean view along the complete coastline of New Kru Town.

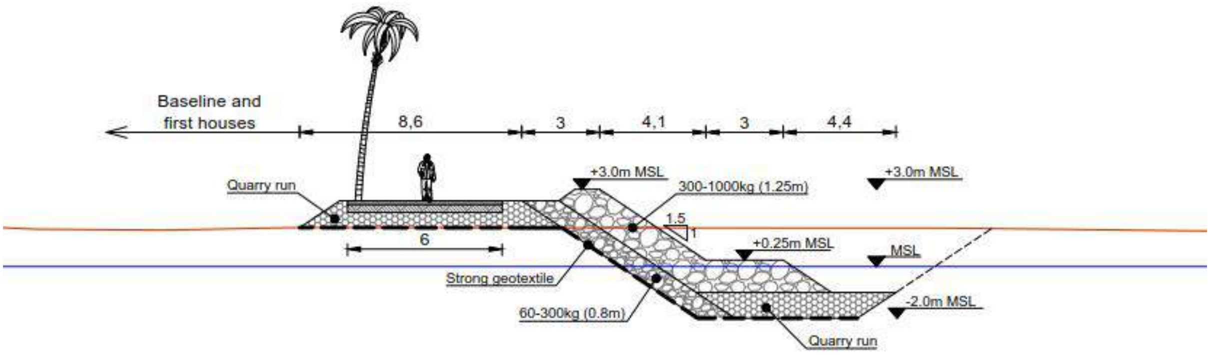


Figure 3-6: Principle cross-section revetment light - New Kru Town - Chainage 0 - 600m

Fishing landing sites
At two locations potential fishing landing sites are envisaged. These landing sites are required to accommodate for the fishing canoes and direct access to the ocean. A small beach is therefore needed which need to be protected by hard structures to prevent further erosion and serious overtopping.

At the northern part of the revetment, close to the school, an existing bend in the coastline is observed (chainage 1300), which is probably naturally formed due to lee side erosion just north of the constructed revetment that was only finished up to the school last year. This bend is a very suitable location for a fishing landing site as it minimizes the need for large amounts of rock.

By extending part of the southern revetment into sea, like a parallel groyne, a small bay is formed which can be used to create a small beach and accommodation for the fishing canoes. Figure 3-7 shows a principle overview of the fishing landing site at the northern part of the revetment. The parallel groyne will be approx. 80 m long. The same design principles and parameters as used for the revetment are applicable for the design here. Figure 3-8 shows a principle cross-section at the landing site showing the small groyne and continued revetment. The transitions need to be detailed during the detailed design phase.

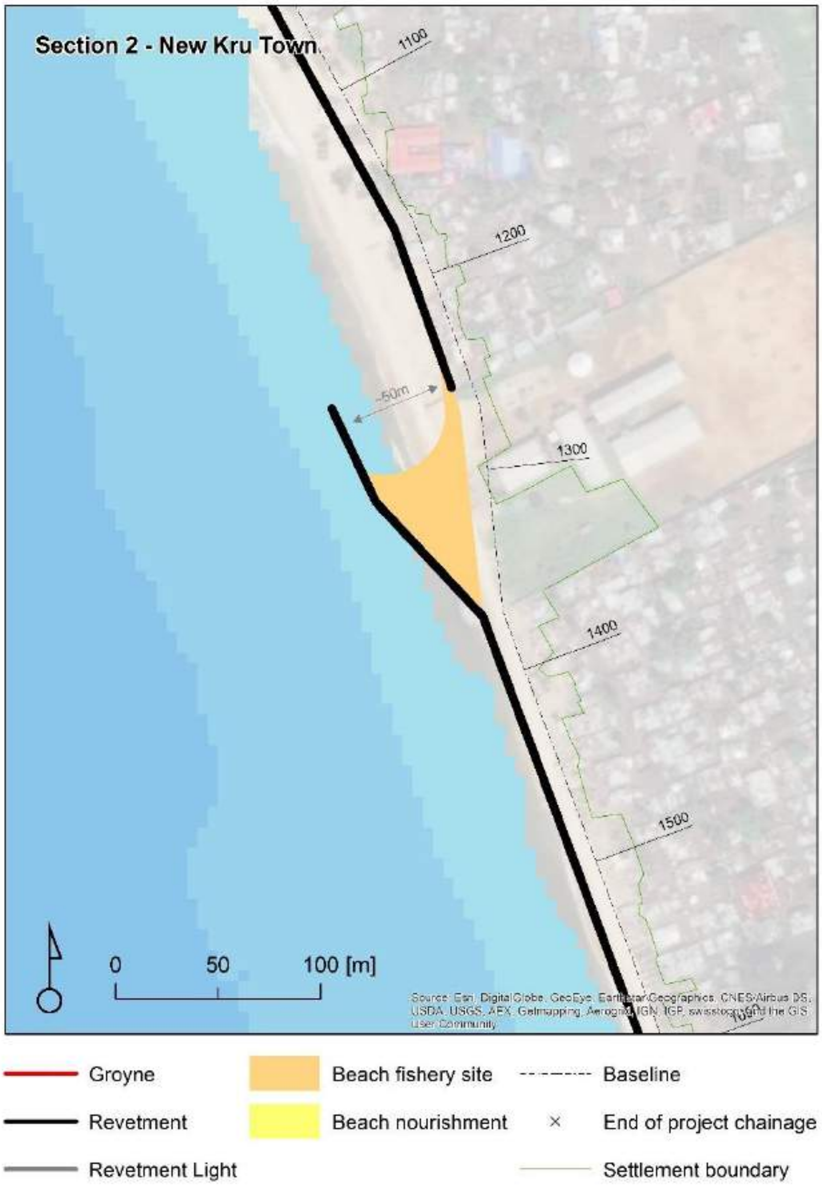


Figure 3-7: Principle of fishing landing site northern part New Kru Town (Chainage 1350)

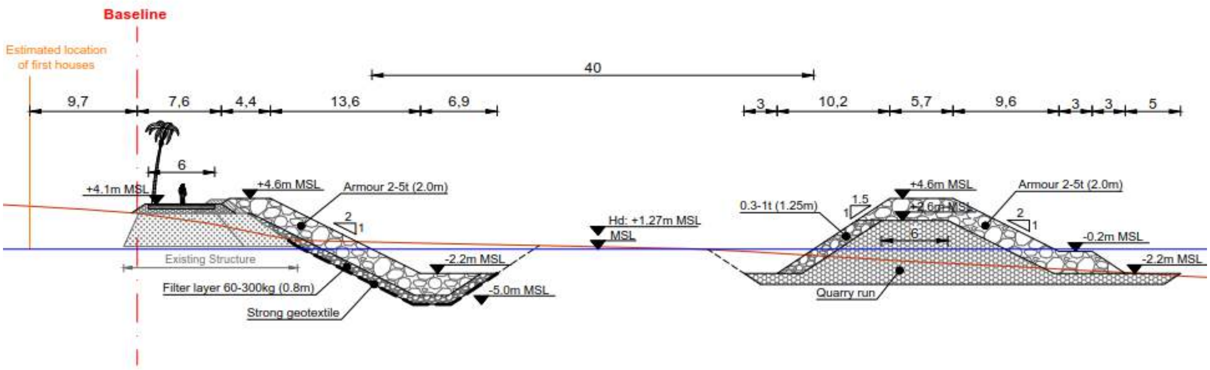


Figure 3-8: Principle cross-section fishing landing site northern part New Kru Town revetment (at dashed red line in Figure 3-7)

At the most southern part of New Kru Town the wave action is lower compared to the northern part of New Kru Town, due to the sheltering by the port breakwaters. This is potentially a good location for a fishing landing site. In the design a small beach is accounted for a the most southern part (chainage 1950-2100m) of 150 m in length. A principle cross-section of the beach design is shown in Figure 3-9. A small groyne (extension of revetment into sea) at the northern part of this small beach (chainage 1950) is applied to enclose the small formed bay. The dimensions of this groyne are similar to the groyne shown in Figure 3-8.

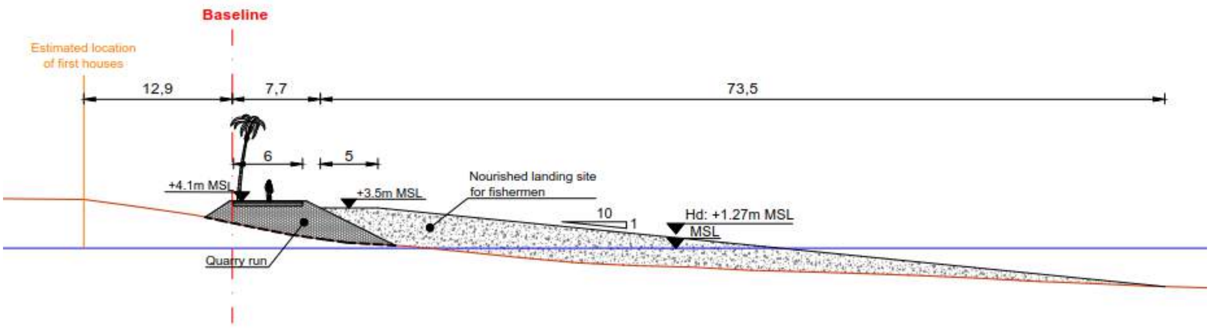


Figure 3-9: Principle cross-section fishing landing site southern part New Kru Town (chainage 1950-2100m)

Drainage

All the structures at New Kru Town require sufficient drainage capacity to discharge excess stormwater from the promenade to the sea. This has been accounted for In the Bill of Quantities (BoQ). The existing drainage from the hinterland should be sustained and not worsened. It is expected that the existing beach does not serve as an open water drain for the hinterland. However small scale trenches may exist that drain excess water from the hinterland to sea. In the detailed design phase any existing drainage capacity should be accounted for in the design of the revetment, by either including culverts or open water drains in the design. In no case the revetment should act as a barrier that lead to stagnant water at the barrier side. On the other hand no additional water should enter the hinterland through the revetment in case of high waters.

Figure 3-10 and Figure 3-11 show two artist impressions and provide an overview how the New Kru Town coastline will look with the applied proposed protective measures. It is noted that the potential fishing landing site at the northern part of New Kru Town has not yet been included in the artist impressions.

Figure 3-10: Artist impression New Kru Town Northern Part (excluding fishing landing site)

Figure 3-11: Artist impression New Kru Town southern part (including fishing landing site at the south)

3.5.2 West Point

The West Point coastline is approx. 1.2 km long and stretches from the Mesurado river mouth towards cape Mamba point. Two alternatives are presented for the protective measures of West Point:

- Alternative A: Revetment
- Alternative B: Groyne, including beach replenishment.

Alternative A

Figure 3-12 provides an overview of the coastline of West Point and the proposed protective measures for Alternative A (revetment). The green dots show the chainages along the coastline every 50 m and represents the Baseline for the design. All the major design components for the Revetment option at West Point are summarized in Table 3-6.

Table 3-11: Design components West Point – Alternative A

Chainage	Structure
0-200 m	Revetment light
200-1050 m	Revetment
690-730 m	Fishing landing site North
1050-1180 m	Fishing landing site South

The below sections describe each design component separately.

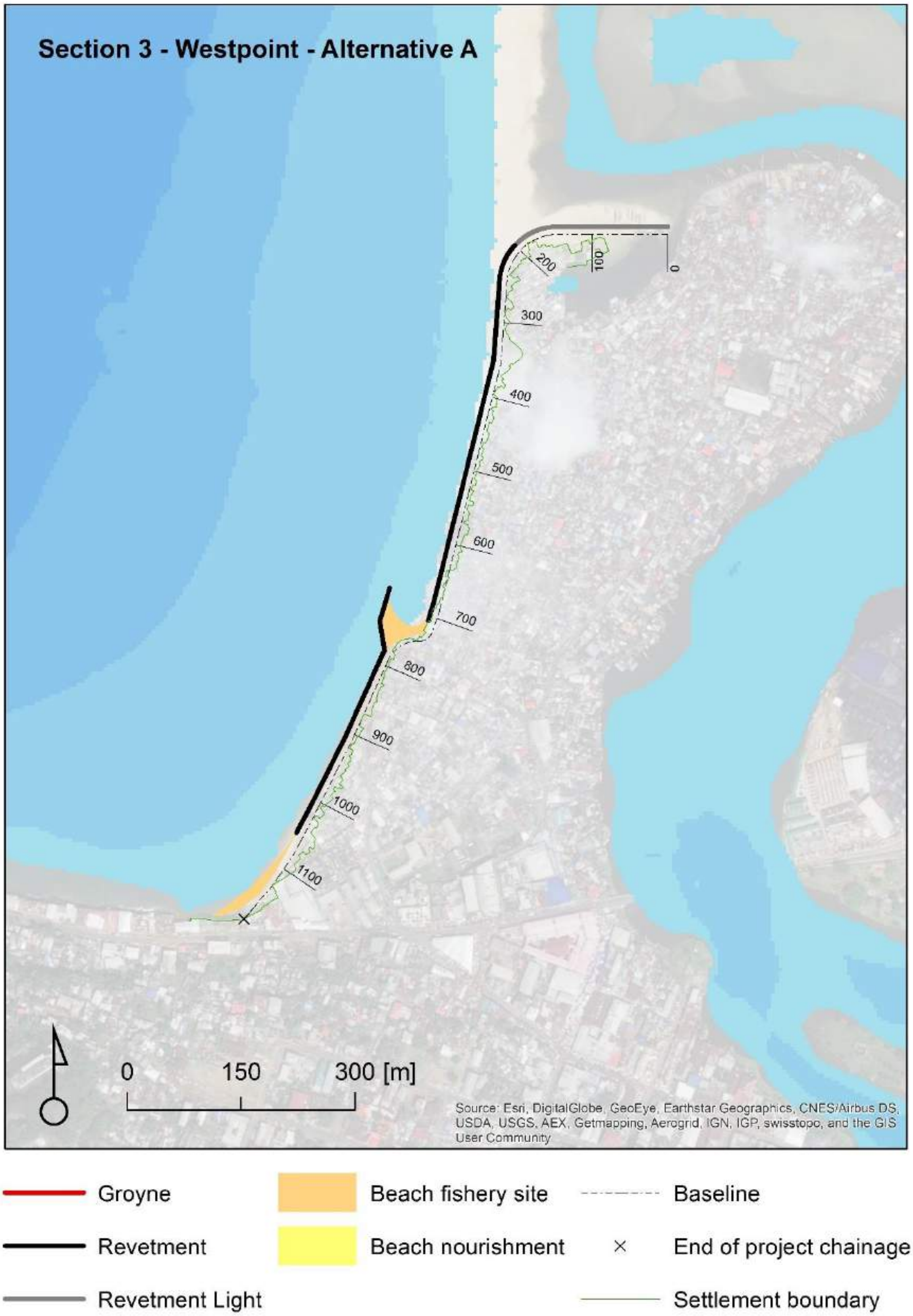


Figure 3-12: Overview of protective measures West Point – Alternative A (revetment)

Revetment
Along the major part of the coastline a revetment is proposed that will fix the coastline position and thereby protect the coastline against coastal retreat. The revetment should be stable enough to withstand extreme scenarios as specified in the design requirements and conditions. The beach will be more or the less kept as it is, as the excavated sand (for the revetment) will be placed at the beach location. However, in the future the beach will retreat further and eventually disappear. This means that the depth in front of the revetment will increase till an equilibrium is found.

A rubble mound revetment has been selected as protection for which the dimensions and rock gradings are based on the applicable formulae following the Rock Manual. The relevant design parameters for the revetment are shown in Table 3-12. The design conditions are described in section 3.4. It is noted that the design wave condition is relevant for the northern, more exposed part. Towards the south the design wave heights decrease, therefore in detailed design lighter armour may be applied here. This will however not significantly affect the BoQ.

Table 3-12: Design parameters West Point – Alternative A, Revetment

Parameter	Value
Sea water density	1025 kg/m^3
Rock density	2650 kg/m^3
Storm duration	6 – 12 hours (applying low estimate Tp for short storm duration and best estimate Tp for longer storm duration)
Slope	1:2
Notional Permeability factor	0.15 (combination of geotextile in the lower part and (small) rock core in the upper part)

With the applied allowable damage values as depicted in section 3.3.2 the required stone mass (M_{50}) for the armour layer has been calculated for the different sets of conditions and shown inTable 3-13, with in bold the normative values.

Table 3-13: Calculated required stone mass for revetment West Point

Year	Return period (yr)	H_s (m)	T_p (s)	Storm Duration (hr)	S_D	M_{50}(tonnes)
2020	100	2.07	13.0	6	2	3.18
2070	100	2.15	13.0	6	3	2.81
2020	**100**	**2.07**	**15.9**	**12**	**2**	**3.36**
2070	100	2.15	16.1	12	3	2.95

This has led to the required gradings for the different layers in the design as presented in Table 3-14. The different layers comply with the filter rules as presented in the Rock Manual.

Table 3-14: Required gradings for West Point Alternative A revetment

Layer	Grading
Armour	2 -5 t
Underlayer	60 – 300 kg
Core	Quarry Run (1-500 kg)

The required crest level has been determined based on the allowable overtopping rates. The '*design and assessment approach*' of EurOtop 2016 has been applied to calculate the overtopping rates. The following correction factors have been applied in the formulas:

- $\gamma_b = 1.0$;
- $\gamma_\beta = 1.0$;
- $\gamma_f = 0.5$ (*in between permeable and impermeable core)*

After iteration it seems that applying a crest level of +4.3 m MSL_{2000} the overtopping criteria are met. The resulting overtopping rates are shown in Table 3-15. The overtopping criteria are shown in the design requirements (section 3.3.2)

Table 3-15: Calculated overtopping rates for New Kru Town revetment for crest level of 4.3 m MSL

Year	Return Period (yr)	Hs [m]	Tp [s]	WL [m+MSL]	Overtopping [l/m/s]
2020	1	1.38	14.3	0.93	0.11
2020	100	2.07	15.9	0.93	3.39
2070	100	2.15	16.1	1.27	9.07

Figure 3-13 and Figure 3-14 show two principle cross-sections for the revetment along the coastline of West Point, which are applicable for the chainage 200-1050m. The toe of the structure is buried into the existing beach to a level of -5mMSL to account for the expected future deepening of the foreshore. The quarry run core is placed directly on the beach and will first function as (temporary) construction road. Afterwards these bund is used as base for the promenade pavement.

A total width of 6 m for the promenade is accounted for which is sufficient for recreation and access for pedestrians to enjoy the ocean view. The promenade pavement has to be detailed in the detailed design phase. A pavement consisting of concrete slabs or big tiles is deemed sufficient and aesthetically attractive. By planting (palm) trees along the promenade the aesthetic value is enhanced even further.

Figure 3-4 and Figure 3-5 show two principle cross-sections for the revetment at New Kru Town for the locations where the existing structure is located (chainage 900-1750). The difference is mainly the distance from the baseline and the (estimated) dimensions of the existing structure. The existing structure is implemented in the design as much as possible and the promenade is included in the design.

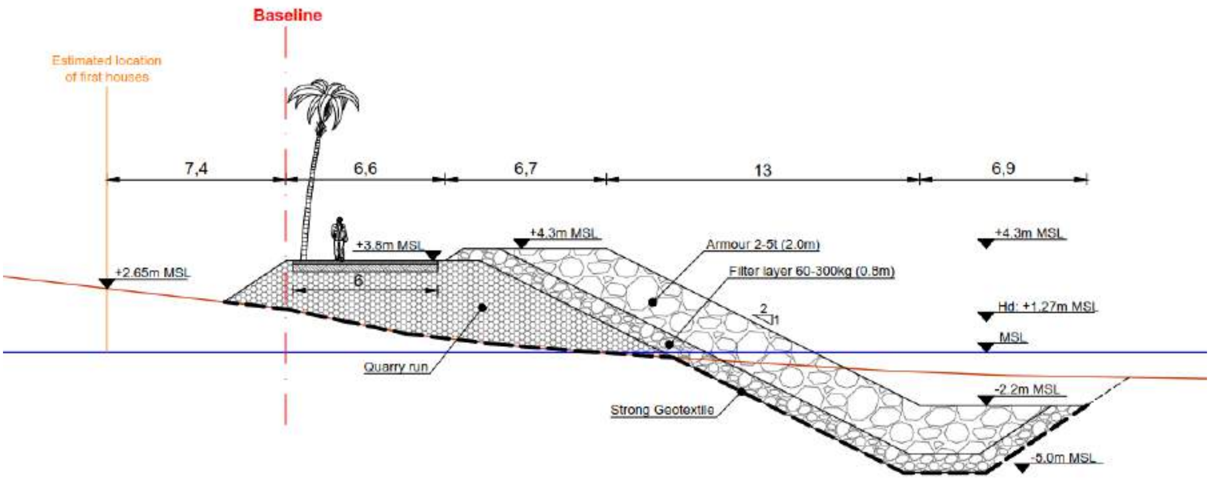


Figure 3-13: Principle cross-section Revetment West Point - Revetment Chainage 450

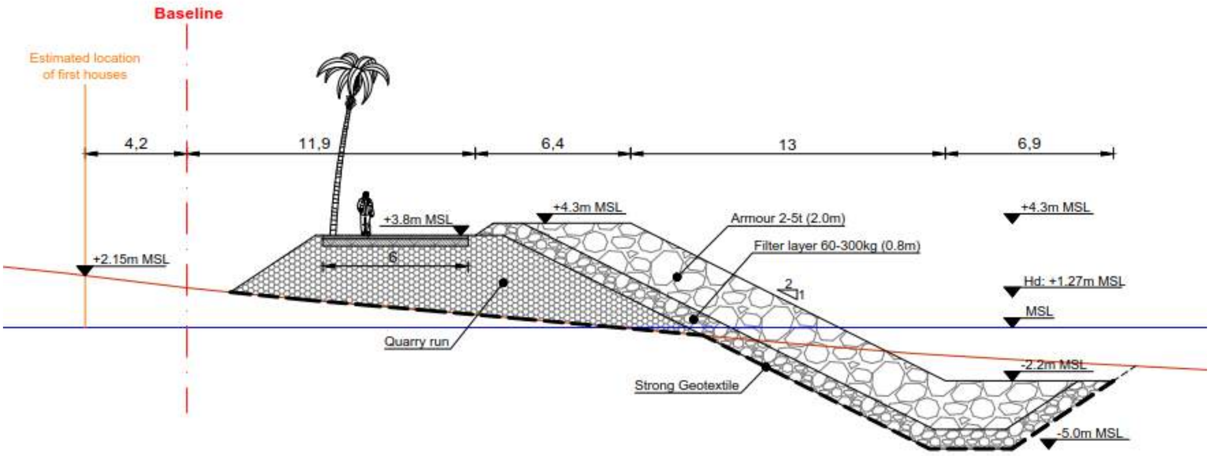


Figure 3-14: Principle cross-section Revetment West Point - Revetment Chainage 900

Revetment light
At the northern part of West Point, at the river mouth of the Mesurado river it is expected that erosion will also gradually continue, which will threaten the local community. To prevent scour development at the northern part of the revetment (as presented above) and potential backwashing a (lighter) revetment running towards the North is included in the design. Since this part is mostly covered in sand in the present situation and in case of further erosion the wave action is drastically lower at that part a (significant) lighter revetment suffices at these locations. Even if the river mouth of Mesurado river is completely eroded and waves are able to attack this revetment the waves will arrive at much larger angle compared to the other parts, which will eventually decrease the net wave attack at the structure.

Figure 3-15 shows the principle cross-section for the revetment light which is applicable for the chainage 0-600 m. The grading of the armour layer is defined as 300-1000 kg on top of an underlayer of 60-300 kg. The exact future wave conditions at these locations are unknown, however such an revetment is theoretically stable for wave conditions with a significant wave height of 1 to 1.5 m with strong oblique incoming waves. This is deemed sufficient for this location. The toe is also constructed less deep compared to the larger revetment as the complete structure needs to be buried in the existing beach.

Also here the promenade is included in the design to ensure a continuous access with ocean view along the complete coastline of West Point.

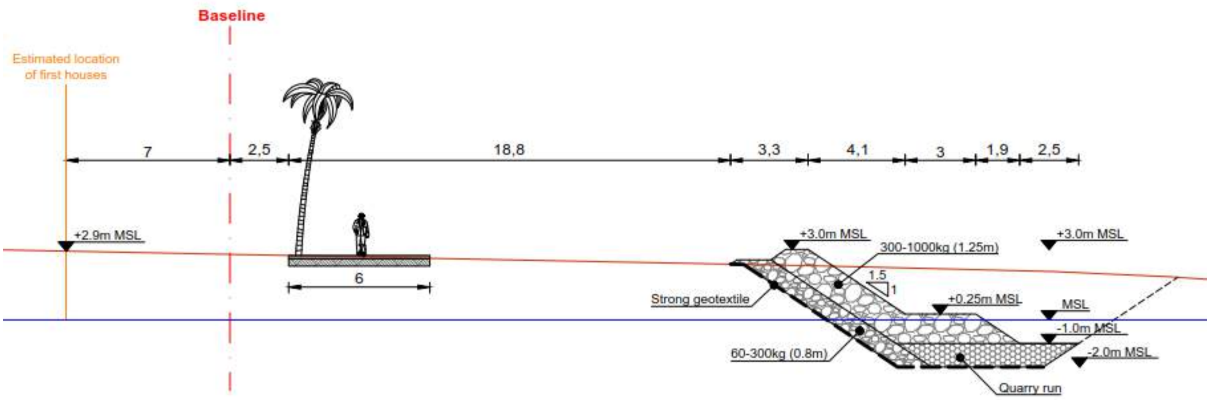


Figure 3-15: Principle cross-section revetment light – West Point (Alternative A) - Chainage 100 m

Fishing landing sites

At two locations potential fishing landing sites are envisaged. These landing sites are required to accommodate for the fishing canoes and direct access to the ocean. A small beach is therefore needed which need to be protected by hard structures to prevent further erosion and serious overtopping.

At the middle part of the revetment an existing bend in the coastline is observed (chainage 700m), which is probably naturally formed due to lee side erosion just north of the small constructed revetment. This bend is a very suitable location for a fishing landing site as it minimizes the need for large amounts of rock.

By extending part of the southern revetment into sea, like a parallel groyne, a small bay is formed which can be used to create a small beach and accommodation for the fishing canoes. Figure 3-17. shows a principle overview of the fishing landing site at the northern part of the revetment. The parallel groyne will be approx. 40 m long. The same design principles and parameters as used for the revetment are applicable for the design here. Figure 3-17 shows a principle cross-section at the landing site showing the small groyne and continued revetment. The transitions need to be detailed during the detailed design phase.

The parallel groyne provides calm waters at the beach of the fishery site and ensures a safe accommodation and landing for the fishermen.

Figure 3-16: Principle of fishing landing site middle part West Point (Chainage 700m)

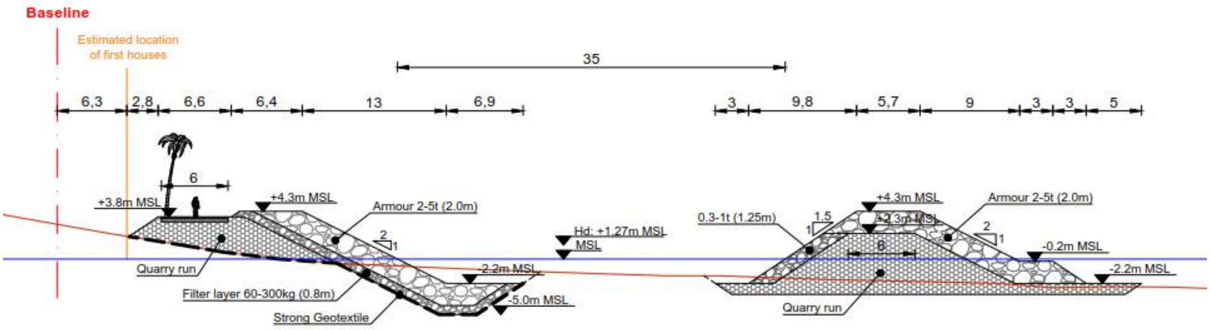


Figure 3-17: Principle cross-section fishing landing site middle part West Point revetment (Alternative A)

At the most southern part of West Point the wave action is lower compared to the northern part of West Point, due to the sheltering by cape Mamba Point. This is therefore potentially a good location for a fishing landing site. In the design a small beach is accounted for a the most southern part (chainage 1050-1180 m) of 130 m in length. A principle cross-section of the beach design is shown in Figure 3-9. A small groyne (extension of revetment into sea) at the northern part of this small beach (chainage 1950) is applied to enclose the small formed bay. The dimensions of this groyne are similar to the groyne shown in Figure 3-18.

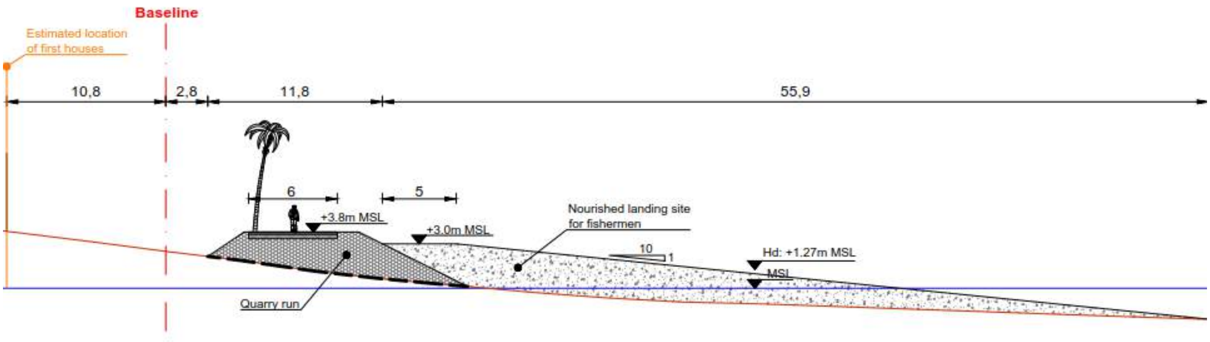


Figure 3-18: Principle cross-section fishing landing site southern part West Point (chainage 1050-1180m)

It is noted that due to the abundance of excavation material from the construction of the revetment there is no need to import any additional sand material for the beach(es) of the landing sites.

Drainage

All the structures at West Point require sufficient drainage capacity to discharge excess stormwater from the promenade to the sea. This has been accounted for In the Bill of Quantities (BoQ). The existing drainage from the hinterland should be sustained and not worsened. It is expected that the existing beach does not serve as an open water drain for the hinterland. However small scale trenches may exist that drain excess water from the hinterland to sea. In the detailed design phase any existing drainage capacity should be accounted for in the design of the revetment, by either including culverts or open water drains in the design. In no case the revetment should act as a barrier that lead to stagnant water at the barrier side. On the other hand no additional water should enter the hinterland through the revetment in case of high waters.

Figure 3-19 shows an artist impressions and provides an overview how the West Point coastline will look with the applied proposed protective measures for alternative A. It is noted that the fishing landing site at the middle part has not yet been included in the artist impressions.


Figure 3-19: Artist impression New Kru Town Northern Part (excluding fishing landing site at middle part)

Alternative B – Groyne West Point

Figure 3-12 provides an overview of the coastline of West Point and the proposed protective measures for Alternative B (groyne including beach widening). The green dots show the chainages along the coastline every 50 m and represents the Baseline for the design. All the major design components for West Point are summarized in Table 3-6.

Table 3-16: Design components West Point – Alternative B

Chainage	Structure
0-200 m	Revetment light
200m	Groyne (350m length)
200-1180	Beach widening/ replenishments

The below sections describe each design component separately.

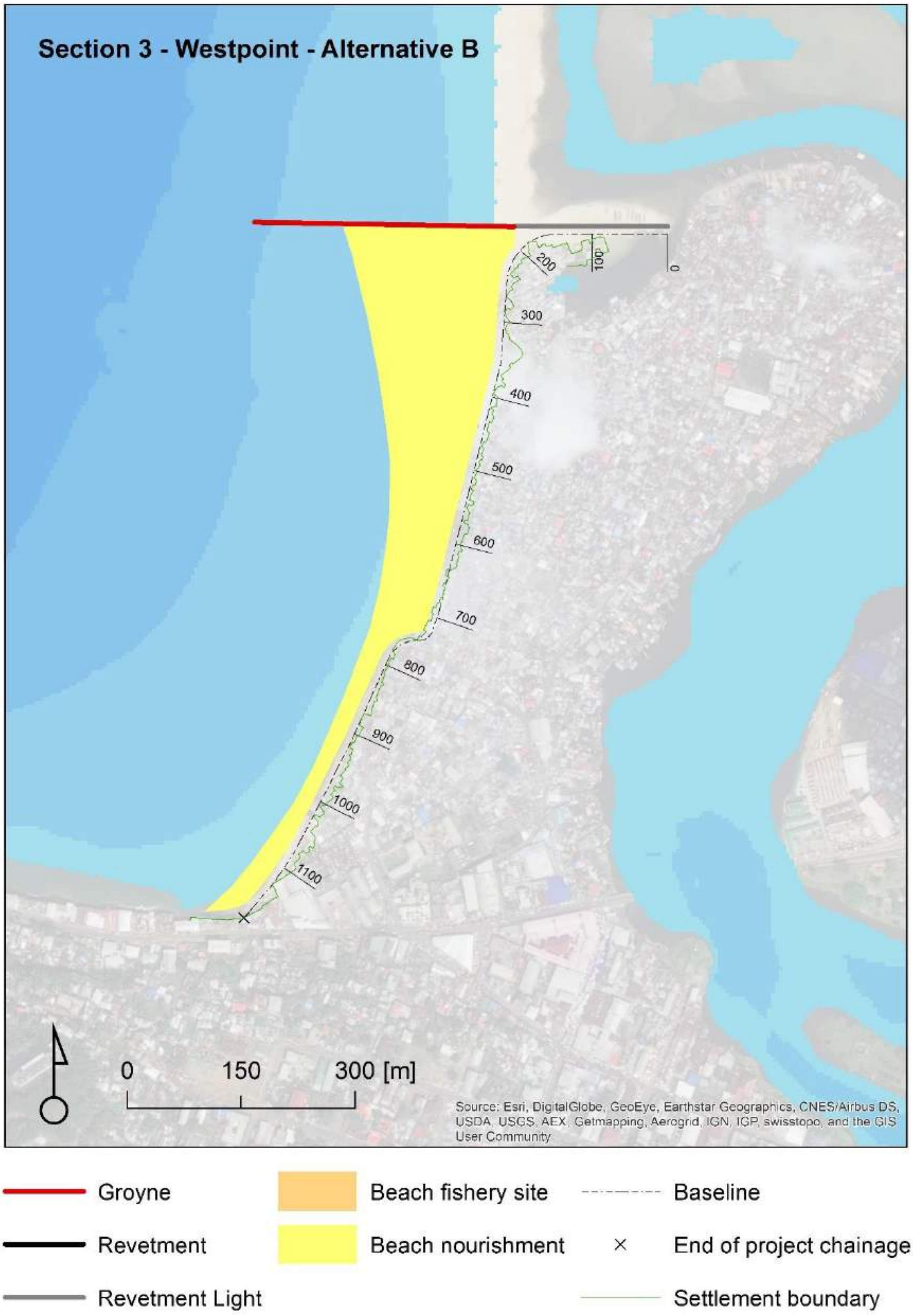


Figure 3-20: Overview Protective measures West Point - Alternative B

Beach replenishments

A beach replenishment is included in the design to ensure a sustainable beach for the accommodation of both landing of fishing canoes and recreation. The design of the beach is based on the minimum required beach width and the expected shoreline development over time. It is noted that the proposed design life is 20 years. However due to its soft character it is almost impossible to guarantee a maintenance free design. By applying a minimum beach width and taking the expected shoreline development over time, including the implementation of the groyne, the expected maintenance is minimized. The minimum beach width is defined as the distance between the shoreline (MSL) and the settlement boundary. The minimum required beach width at West Point is based on the design requirements (section 3.3) and needs to be at least **28 m** (see Table 3-5). A safety margin of 25% has been applied which leads to a total minimum width of approx. **35 m** along the coastline of West Point to accommodate for coastal retreat due to sea level rise and additional storm erosion.

It is noted that the most southern part of West Point is sheltered by cape Mamba Point. Hence at the southern part significant less potential additional storm erosion is expected. Figure 3-21 shows the wave field of a storm condition of return period of 100 years in 2100 (RCP 8.5) around West Point. From the wave field it is visible that the wave height at the southern part is 25% to 50% lower in the south. It is therefore considered that at the southern part (i.e. from chainage 800-1150) the additional storm erosion can be diminished with 25% as well[1]. This leads to a total minimum beach width at these locations of **30m.**

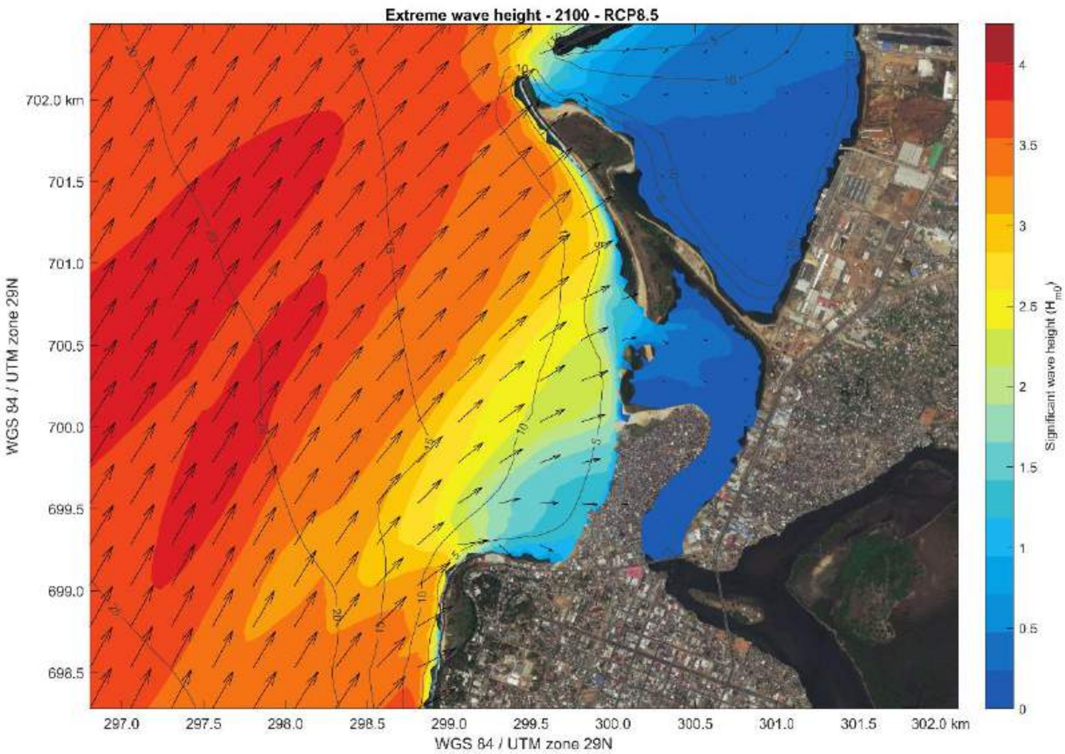


Figure 3-21: Example of wave field at West Point with storm condition of Return period of 100 years in 2100

The most optimal beach design, i.e. layout of the shoreline, has been based on extensive numerical modelling. The numerical shoreline model ShorelineS has been used to assess the expected shoreline development over time. With use of this model the most optimal shoreline, while taking the expected groyne into account and ensuring the minimum beach width requirements. The model has successfully

[1] Storm erosion is approximately proportional with wave energy (~H^2), a linear relationship is therefore conservative.

been calibrated by means of observed historical coastline developments. Appendix C describes the modelling in more detail.

From the modeling exercise the following shoreline layout has been deemed most optimal which suffices the design requirements. The layout has been designed as such that it follows the expected final equilibrium coastline. Hence marginal additional coastline development is expected in case such layout is applied.

The required nourishment volume has been estimated by multiplying the required area (i.e. the difference between present coastline and the coastline design) with the active height. The active height is equal to the active depth (also known as the closure depth) plus the beach height. In this case the closure depth at West Point is calculated to be approx. 3.5 m (see PART I, Vulnerability Reporting). A beach height of approx. 3 m has been assumed which leads to a total active height of 7 m (rounded). It is herewith assumed that the beach replenishment eventually will move towards the present equilibrium shoreface profile.

This leads to the required nourishment volumes as shown in Table 3-17.

Table 3-17: Required nourishment dimensions West Point Alternative B

Parameter	Value
Required Area	70,000 m^2
Active height	7 m
Required sand volume	490,000 m^3
Average initial beach widening	~72 m
Average volume per m	500 m^3/m

It is noted that this minimum required beach width of 35 m needs to remain clear from property during its design life as this part is merely used as buffer zone to accommodate expected shoreline retreat due to sea level rise and additional storm erosion.

It is considered that the nourishments needs to consist of the same material as the present beach. Based on the sediment samples that have been taken and the sieve analysis (see PART I, Vulnerability Reporting) it is considered that the minimum grainsize of the replenishment material needs to be D_{50}=400μm. The material needs to be non-contaminated as it is used for recreation.

Groyne

The function of the groyne at West Point is to enclose the beach (replenishment) by blocking the alongshore transport. Its length is based on the beach design, expected shoreline development over time and the effective blocking length.

Length

The length of the groyne needs to sufficient to effectively block the longshore sediment transport and ensure the minimum beach width is maintained. Any bypassing of sediment is not allowed to ensure that the sand is enclosed the created beach cell. An effective blocking length is therefore based on the depth of closure, which is the maximum depth to which morphological activity is expected. The depth of closure has been determined and described in the Vulnerability reporting and is calculated to be 3.5 m at West Point.

This means that the tip of the groyne (i.e. toe of the groyne structure) needs to extend at least to 3.5 m of water depth in the expected *future* situation (i.e. equilibrium or end of design life). Therefore the final coastline position at the groyne is of importance to determine the required groyne length.

Based on the beach layout design (which is based on numerical modelling, see above) the final coastline position at the groyne has been determined. Assuming that the coastal profile remains the same the length towards the -3.5 mMSL contour can be determined.

The has led to a total required groyne length of 350 m, from the present MSL position to the toe of the groyne. This means that the toe of the groyne will reach at a depth of approx. 5 mMSL in the *present* situation.

Stability

A rubble mound groyne has been selected for which the dimensions and rock gradings are based on the applicable formulae by Van der Meer for deep water, following the Rock Manual. The relevant design parameters for the revetment are shown in Table 3-18. The design conditions are described in section 3.4.

Table 3-18: Design parameters West Point – Alternative B, Groyne

Parameter	Value
Sea water density	1025 kg/m^3
Rock density	2650 kg/m^3
Storm duration	6 – 12 hours (applying low estimate Tp for short storm duration and best estimate Tp for longer storm duration)
Slope	1:1.5
Notional Permeability factor	0.5 (armour placed directly on the Core)

<u>Groyne Trunk</u>

The groyne orientation is in principle perpendicular to the coastline orientation. Due to the sheltered location of Wespoint the waves generally arrive from WSW directions, having a large angle of incidence with the trunk of the groyne. For this reason, the reduction factor as determined by van Gent et all. (2014) is applied in the calculation for the rock weight using an incident wave angle of 60°. With the applied allowable damage values as depicted in section 3.3.2 the required stone mass (M_{50}) for the armour layer has been calculated for the different sets of conditions and shown in Table 3-19, with in bold the normative values.

Table 3-19: Calculated required stone mass for West Point – Groyne: trunk section

Year	Return period (yr)	H_s (m)	T_p (s)	Storm Duration (hr)	S_D	M_{50}(tonnes)
2020	**100**	**2.07**	**13.0**	**6**	**2**	**0.51**
2070	100	2.15	13.0	6	3	0.46
2020	100	2.07	15.9	12	2	0.44
2070	100	2.15	16.1	12	3	0.4

This has led to a required armour grading of 300-1000kg (standard grading). This should be placed on top of Quarry Run material of 1-500kg or 1-1000kg; this is summarized in Table 3-20.

Table 3-20: Required gradings for West Point Alternative B: groyne trunk section

Layer	Grading
Armour	300-1000kg
Core	Quarry Run (1-500 or 1-1000kg)

The crest level has been set at +1.75m MSL (MHWS + monthly wave condition) with a width of 6m to ensure a sufficiently wide and safe construction platform for practical construction of the groyne. Figure 3-22 and Figure 3-23 show the principle cross-sections for the groyne trunk structure.

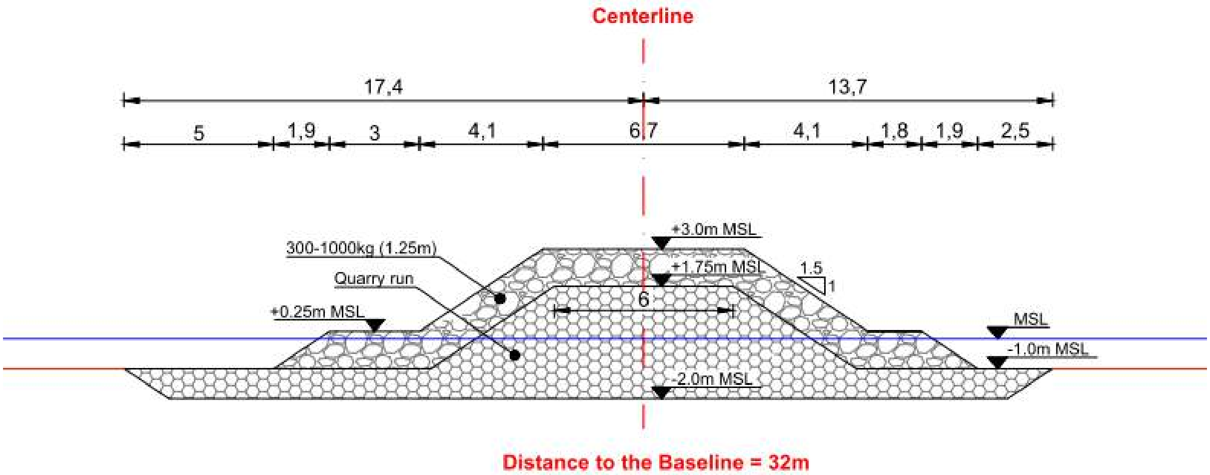


Figure 3-22: Principle cross-section West Point - groyne trunk B-B (Alternative B)

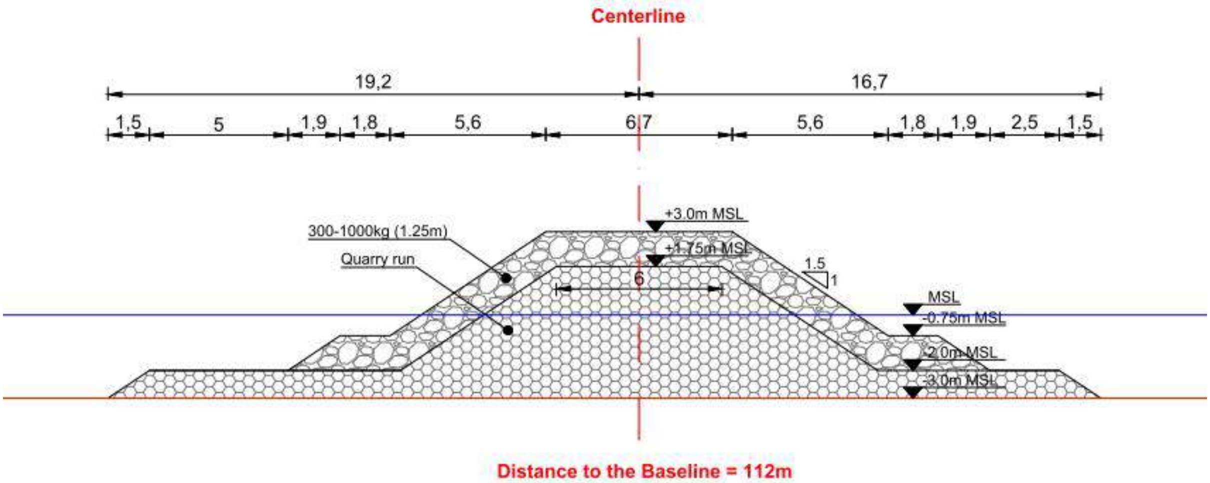


Figure 3-23: Principle cross-section West Point - groyne trunk D-D (Alternative B)

Groyne Roundhead

The head of the groyne structure is under direct wave attack and waves do arrive perpendicular to the structure here. Moreover, waves breaking over the head structure involves a special physical process due to the 3D curvature of the roundhead. No specific design rules are available for the roundhead, in most case a gentler slope or increase of the armour mass is applied for roundhead structures. For preliminary design, a mass increase of 50% is applied on the computed required stone mass. With the applied allowable damage values as depicted in section 3.3.2 the required stone mass (M_{50}) for the armour on the roundhead has been calculated for the different sets of conditions and shown in Table 3-21, with in bold the normative values.

Table 3-21: Calculated required stone mass for West Point – Groyne: roundhead section

Year	Return period (yr)	H_s (m)	T_p (s)	Storm Duration (hr)	S_D	M_{50}(tonnes)
2020	**100**	**2.07**	**13.0**	**6**	**2**	**1t + 50% = 1.5t**
2070	100	2.15	13.0	6	3	0.9t + 50% = 1.35t
2020	100	2.07	15.9	12	2	0.9t + 50% = 1.35t

2070	100	2.15	16.1	12	3	0.8t + 50% = 1.2t

This has led to a required armour grading of 1-3t (standard grading) or 500-2000kg (non-standard grading). This should be placed on top of Quarry Run material of 1-500kg or 1-1000kg; this is summarized in Table 3-22. Figure 3-24 shows the principle cross-sections for the groyne head.

Table 3-22: Required gradings for West Point - groyne head (Alternative B)

Layer	Grading
Armour	1-3t (*or 500-2000kg)*
Core	Quarry Run (1-500 or 1-1000kg)

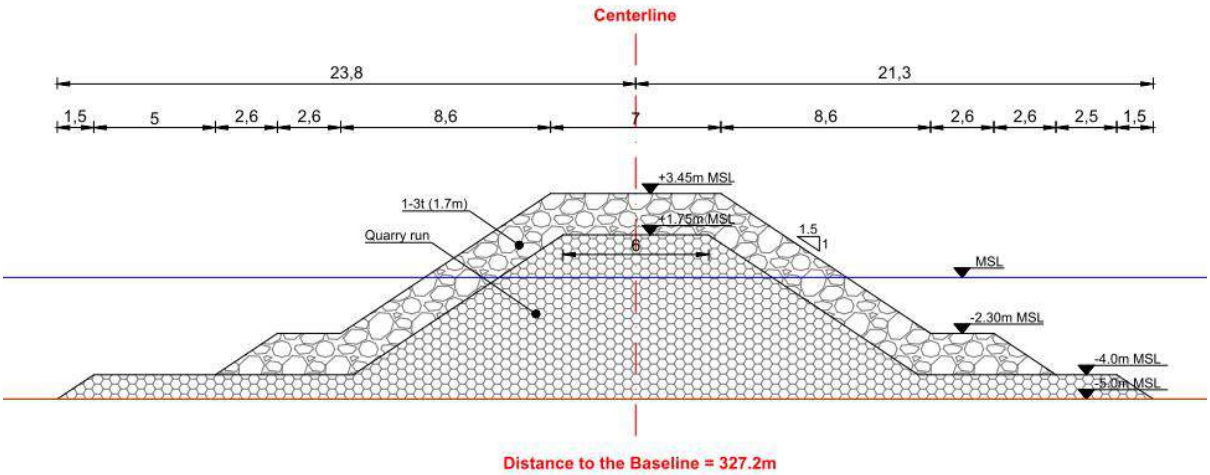


Figure 3-24: Principle cross-section West Point - groyne head (Alternative B)

Revetment light

At the northern part of West Point, at the river mouth of the Mesurado river it is expected that erosion will gradually continue, which will threaten the local community. To prevent scour development east of the groyne (as presented in Figure 3-20) and potential backwashing, a light revetment running towards the east is included in the design. Since this part is mostly covered in sand in the present situation and in case of further erosion the wave action is drastically lower (due to sheltering of the groyne) a light revetment can be applied here. Moreover, even if the river mouth of Mesurado river is completely eroded the waves will arrive at a large angle, decreasing the net wave attack at the structure.

Figure 3-25 shows the principle cross-section for the revetment light which is applicable for the chainage 0-200 m. The grading of the armour layer is defined as 300-1000 kg on top of an underlayer of 60-300 kg. The exact future wave conditions at these locations are unknown, however such an revetment is theoretically stable for wave conditions with a significant wave height of 1 to 1.5 m with strong oblique incoming waves. This is deemed sufficient for this location.

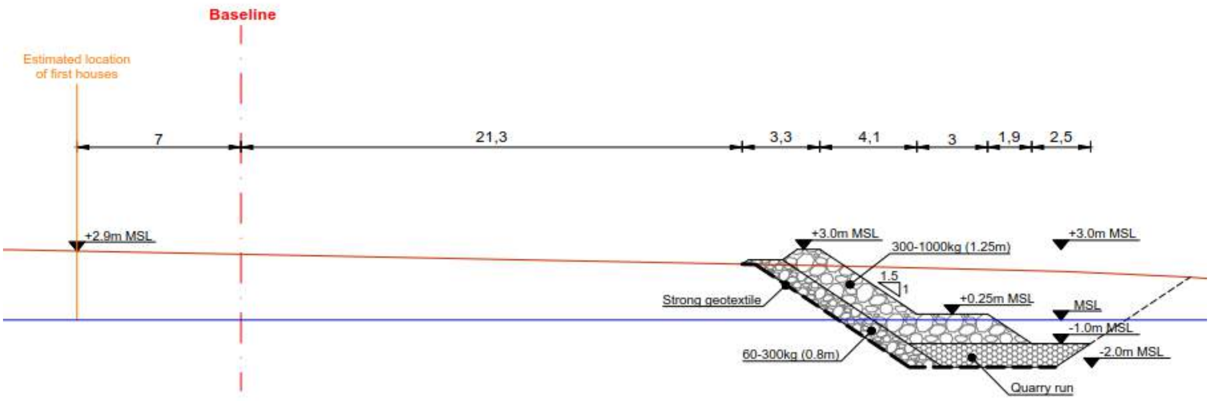


Figure 3-25: Principle cross-section revetment light – West Point (Alternative B) - Chainage 100 m

Figure 3-26 shows an artist impression and provides an overview how the West Point coastline will look with the applied proposed protective measures for alternative B.

Figure 3-26: Artist impression West Point Alternative B - Groyne option

Leeside effects coastal protection West Point

Due to the increasing sediment hunger of the Mesurado Basin, caused by increase of accommodation space, which in turn is caused by sea level rise, will eventually lead to erosion of the inlet, irrespective of any protective measures that may be implemented.

With and without construction of the groyne or revetment the inlet will disappear over time. Possibly slowly due to existing vegetation on top of the beach. With a groyne or revetment the potential sediment coming from the present southern beach is blocked, which may mean that erosion of the inlet is accelerated.

This means that the natural formed beach in front of the harbour breakwater disappears. However, based on site visits and satellite imagery it is clear that the breakwater has been built prior to forming of the beach. Buried rocks can be found and inside the inlet the same protection has been applied as offshore. This may imply that the breakwater has been designed to accommodate for deeper waters and heavier wave attack, i.e. in case the natural formed beaches and sand patches of the inlet disappear.

By a widening of the inlet the tidal prism (the volume of water coming in and out during one tide) won't be affected, since this is only dependent on the surface area of the basin and the tidal range. The tidal prism might be affected by sea level rise, however it is assumed that the tidal flat levels will follow sea level rise due to the sediment import and hence the tidal prism is likely to remain unchanged. The latter might even suggest that the flow velocities even decrease in the inlet due to the larger cross-sectional width and constant tidal prism.

Sea level rise may affect the saline intrusion, which is however considered already significant, due to the relatively low fresh water inflow. Any of the proposed interventions won't affect this.

3.5.3 American Embassy

The American Embassy (Section 4) coastline is approx. 2.4 km long and stretches from cape Mamba point towards Capitol Hill. Figure 3-27 provides an overview of the coastline of American Embassy and the proposed protective measures. The green dots show the chainages along the coastline every 50 m and represents the Baseline for the design. All the major design components for the section American Embassy are summarized in Table 3-23.

Table 3-23: Design components American Embassy

Chainage	Structure
200-2200 m	Beach widening/replenishments
200 m	Groyne (190m length)

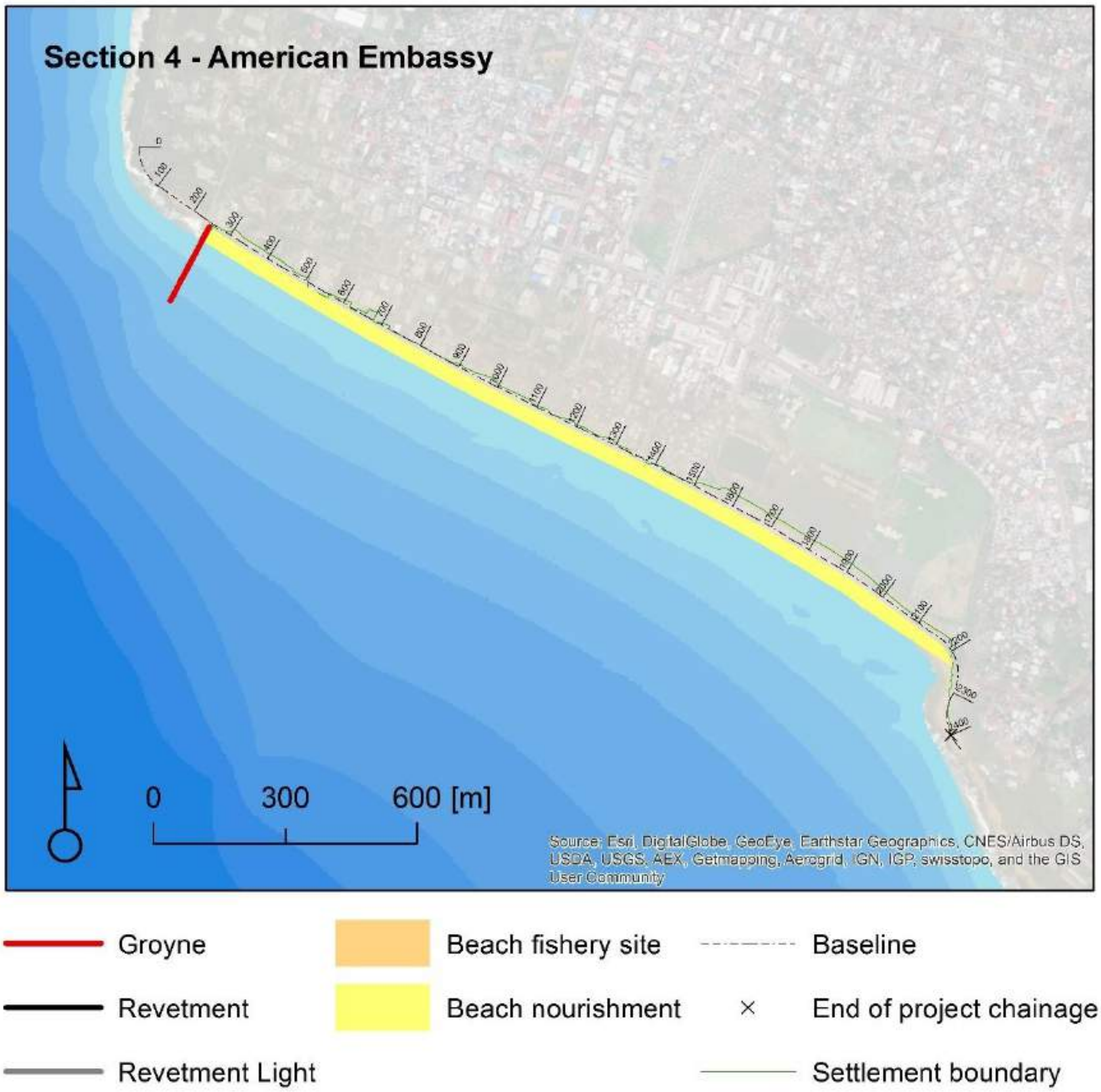


Figure 3-27: Overview protective measures American Embassy

Beach replenishments

A beach replenishment is included in the design to ensure a sustainable beach for the accommodation of both landing of fishing canoes and recreation. The design of the beach is based on the minimum required beach width and the expected shoreline development over time. It is noted that the proposed design life is 20 years. However due to its soft character it is almost impossible to guarantee a maintenance free design. By applying a minimum beach width and taking the expected shoreline development over time, including the implementation of the groyne, the expected maintenance is minimized.

The minimum required beach width at the American Embassy is based on the design requirements (section 3.3) and needs to be at least **32 m** (see Table 3-5). A safety margin of 25% has been applied which leads to a total minimum width of approx. **40 m** along the coastline of American Embassy to accommodate for coastal retreat due to sea level rise and additional storm erosion.

The most optimal beach design, i.e. layout of the shoreline, has been based on extensive numerical modelling. The numerical shoreline model ShorelineS has been used to assess the expected shoreline development over time. With use of this model the most optimal shoreline, while taking the expected groyne into account and ensuring the minimum beach width requirements. The model has successfully been calibrated by means of observed historical coastline developments. Appendix C describes the modelling in more detail.

From the modeling exercise the following shoreline layout has been deemed most optimal which suffices the design requirements. The layout has been designed as such that it follows the expected final equilibrium coastline. Hence marginal additional coastline development is expected in case such layout is applied.

The required nourishment volume has been estimated by multiplying the required area (i.e. the difference between present coastline and the coastline design) with the active height. The active height is equal to the active depth (also known as the closure depth) plus the beach height. In this case the closure depth at American Embassy is calculated to be approx. 6 m (see PART I, Vulnerability Reporting). A beach height of approx. 2 m has been assumed which leads to a total active height of 8 m. It is herewith assumed that the beach replenishment eventually will move towards the present equilibrium shoreface profile.

This leads to the required nourishment volumes as shown in Table 3-24.

Table 3-24: Required nourishment dimensions at the American Embassy

Parameter	Value
Required Area	80,000 m^2
Active height	8 m
Required sand volume	640,000 m^3
Average initial beach widening	~40 m
Average volume per m	320 m^3/m

It is noted that this minimum required beach width of 40 m needs to remain clear from property during its design life as this part is merely used as buffer zone to accommodate expected shoreline retreat due to sea level rise and additional storm erosion.

It is considered that the nourishments needs to consist of the same material as the present beach. Based on the sediment samples that have been taken and the sieve analysis (see PART I, Vulnerability Reporting) it is considered that the minimum grainsize of the replenishment material needs to be D_{50}=400μm. The material needs to be non-contaminated as it is used for recreation.

Groyne
The function of the groyne at the American Embassy is to enclose the beach (replenishment) by blocking the alongshore transport. Its length is based on the beach design, expected shoreline development over time and the effective blocking length.

Length
The length of the groyne needs to be sufficient to effectively block the longshore sediment transport and to ensure that the minimum beach width is maintained. Any bypassing of sediment is not allowed to ensure that the sand is enclosed in the created beach cell. An effective blocking length is therefore based on the depth of closure, which is the maximum depth to which morphological activity is expected. The depth of closure has been determined and described in the Vulnerability reporting and is calculated to be 6 m at the American Embassy.

This means that the tip of the groyne (i.e. toe of the groyne structure) needs to extend at least to 6 m of water depth in the expected *future* situation (i.e. equilibrium or end of design life). Therefore the final coastline position at the groyne is of importance to determine the required groyne length.

Based on the beach layout design (which is based on numerical modelling, see above) the final coastline position at the groyne has been determined. Assuming that the coastal profile remains the same the length towards the -6 mMSL contour is determined. The has led to a total required groyne length of 190 m, from the present MSL position to the toe of the groyne. This means that the toe of the groyne will reach a level of approx. -7 mMSL in the *present* situation.

Stability
A rubble mound groyne has been selected for which the dimensions and rock gradings are based on the applicable formulae by Van der Meer for deep water, following the Rock Manual. The relevant design parameters for the revetment are shown in Table 3-25. The design conditions are described in section 3.4.

Table 3-25: Design parameters American Embassy – Groyne

Parameter	Value
Sea water density	1025 kg/m^3
Rock density	2650 kg/m^3
Storm duration	6 – 12 hours (applying low estimate Tp for short storm duration and best estimate Tp for longer storm duration)
Slope	1:2
Notional Permeability factor	0.5 (armour placed directly on the Core)

With the applied allowable damage values as depicted in section 3.3.2 the required stone mass (M_{50}) for the armour layer has been calculated for the different sets of conditions and shown inTable 3-13, with in bold the normative values.

<u>*Groyne Trunk*</u>
The groyne orientation is in principle perpendicular to the (equilibrium) coastline orientation. Because of this, design waves arrive nearly parallel to the structure; having a large angle of incidence with the trunk of the groyne. For this reason, the reduction factor as determined by van Gent et all. (2014) is applied in the calculation for the rock weight using an incident wave angle of 65°. With the applied allowable damage values as depicted in section 3.3.2 the required stone mass (M_{50}) for the armour

layer has been calculated for the different sets of conditions and shown in Table 3-26, with in bold the normative values.

Table 3-26: Calculated required stone mass for the American Embassy – Groyne: trunk section

Year	Return period (yr)	H_s (m)	T_p (s)	Storm Duration (hr)	S_D	M_{50}(tonnes)
2020	**100**	**3.89**	**13.0**	**6**	**3**	**3.6**
2070	100	4.06	13.5	6	4	3.5
2020	100	3.89	16.0	12	3	3.3
2070	100	4.06	16.5	12	4	3.1

This has led to a required armour grading of 2-5t. This should be placed on top of Quarry Run material of 1-500kg or 1-1000kg; this is summarized in Table 3-27Table 3-20. During detail design, specifications should be determined for this Quarry Run material to comply with the filter requirements.

Table 3-27: Required gradings for the American Embassy – Groyne trunk section

Layer	Grading
Armour	2-5t
Core	Quarry Run (1-500 or 1-1000kg)

The crest level has been set at +2.0m MSL (MHWS + monthly wave condition) with a width of 6m to ensure a sufficiently wide and safe construction platform for practical construction of the groyne. Figure 3-28 to Figure 3-30 show the principle cross-sections for the American Embassy groyne trunk section.

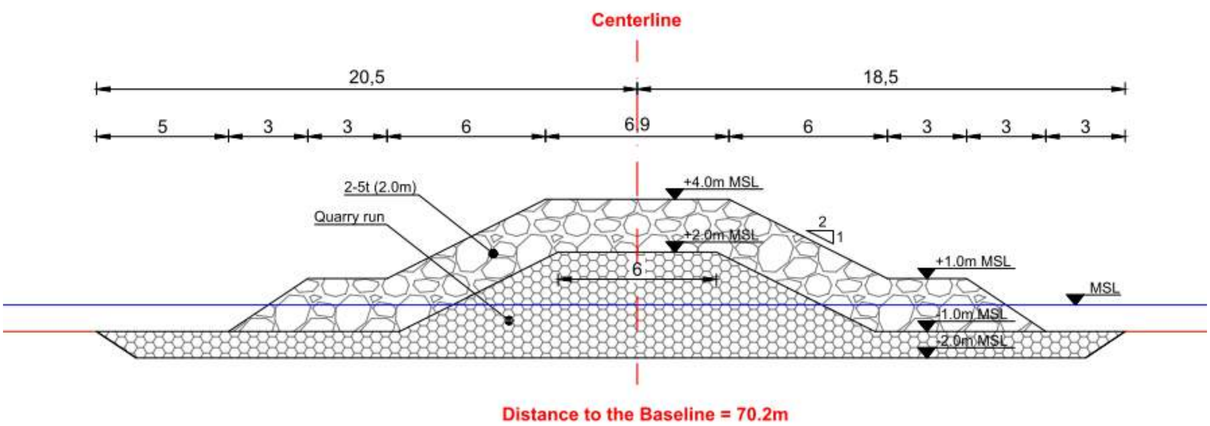


Figure 3-28: Principle cross-section American Embassy groyne – A-A

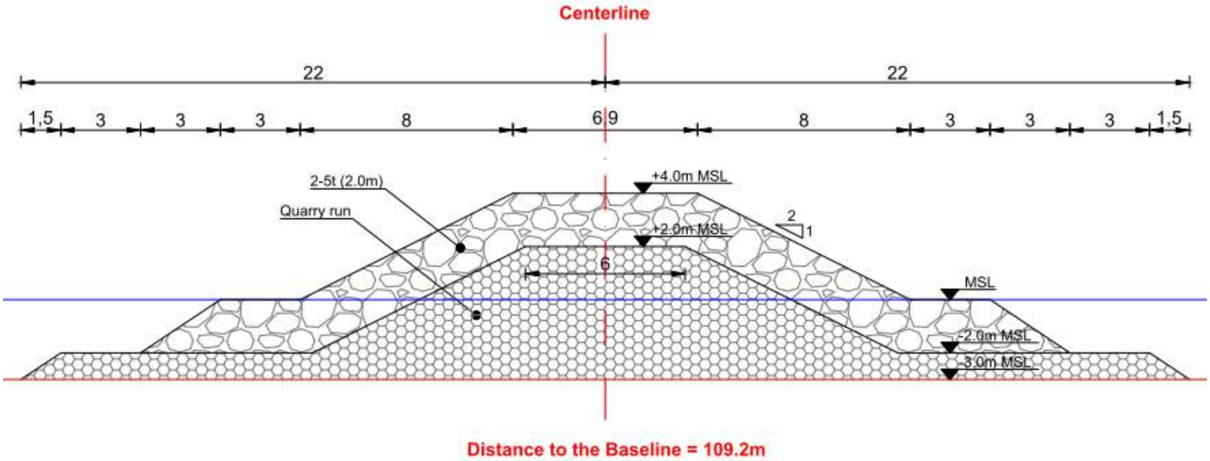


Figure 3-29: Principle cross-section American Embassy groyne – C-C

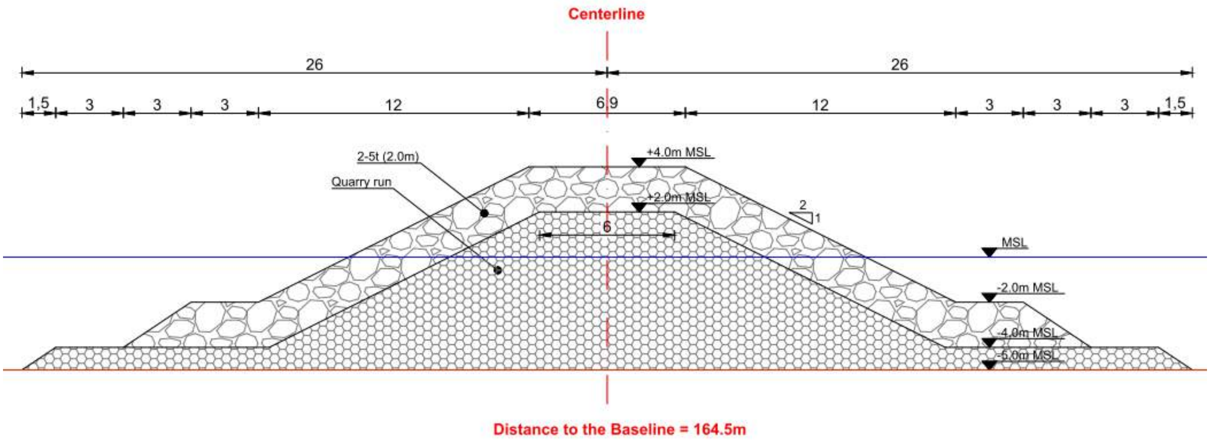


Figure 3-30: Principle cross-section American Embassy groyne – E-E

Groyne Roundhead

The head of the groyne structure is under direct wave attack and waves do arrive perpendicular to the structure here. Moreover, waves breaking over the head structure involves a special physical process due to the 3D curvature of the roundhead. No specific design rules are available for the roundhead, in most cases a gentler slope or increase of the armour mass is applied for roundhead structures. For preliminary design, a weight increase of 50% is applied on the computed required armour weight.

Because of the high design wave conditions no practical / easy to construct design is feasible for the head of the groyne. Therefore, two alternatives are proposed:

1) using concrete interlocking elements (e.g. Accropode 1 or 2, X-blocs, Core-loc), and
2) using rock material up to 10 tonnes (this is considered the maximum weight to be transported using standard trucks).

For the concrete interlocking units a concrete density of 2400 kg/m^3 is used and a stability number of N_s = 2.7 (i.e. applicable for the Accropode 1&2, X-blocs and Core-loc units). As the required weight only depends on the wave height and relative buoyant density, this has led to a required armour weight for concrete interlocking units of 3.47t + 50% = ±5 tonnes units. Underneath the armour an underlayer must be placing having an M_{50} of approximately 1/10th of the armour, therefore 300-1000kg is selected. For the toe the same material as the trunk is used, i.e. 2-5t rock material. This is in line with computed results using the Van der Meer formulae for toe design as included in the Rock

Manual; it is however noted that these formulae are at the boundary of their validity and the stability of the 2-5t toe material should therefore be verified in detailed design.

With the applied allowable damage values as depicted in section 3.3.2 and selected armour mass of 5-10t (as 10t is the maximum rock weight to be used in the works from a practical point of view), a slope of 1:3 is computed using the rock stability formulae. Between the 1-500kg Quarry Run core and 5-10t armour an underlayer should be used, where 300-1000kg is selected in line with the filter guidelines as included in the Rock Manual.

Figure 3-31 and Figure 3-32 show the principle cross-sections for the different alternatives for the American Embassy groyne head section.

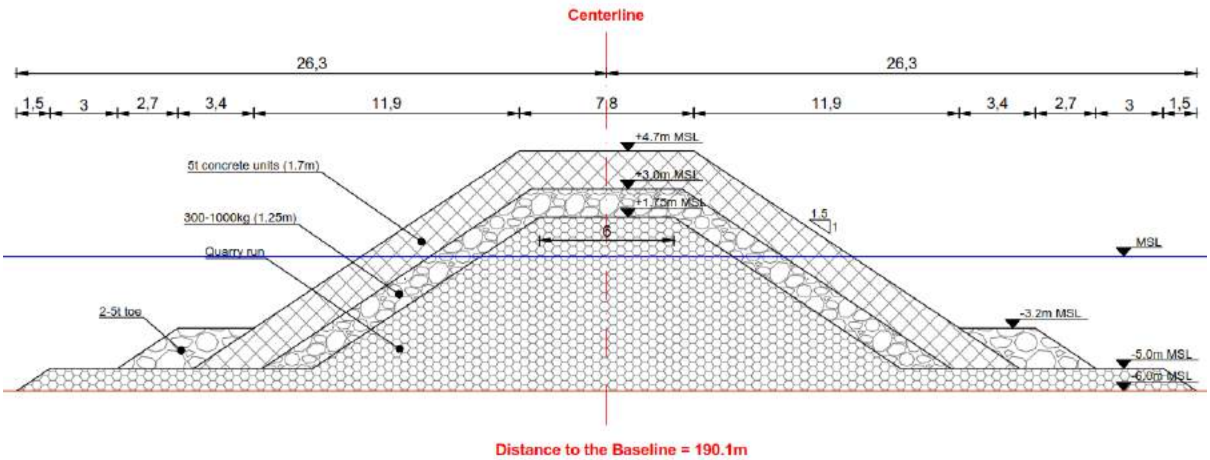


Figure 3-31: Principle cross-section groyne head American Embassy (concrete units)

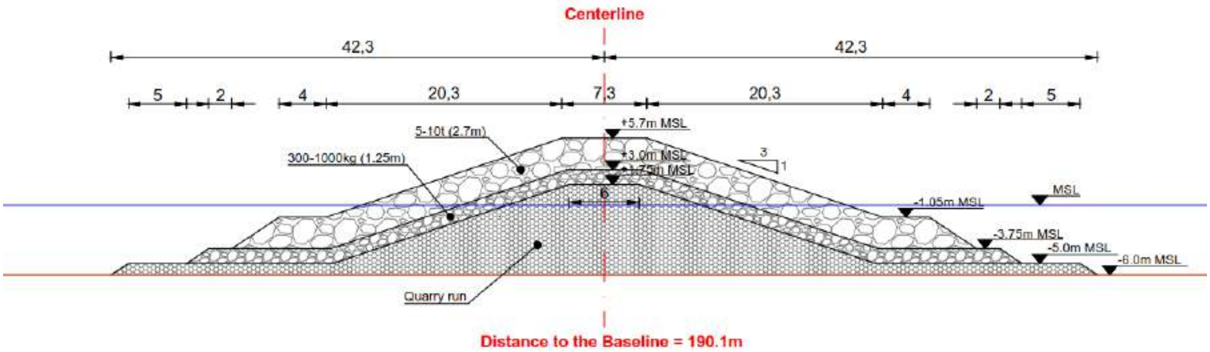


Figure 3-32: Principle cross-section groyne head American Embassy (rock)

Figure 3-33 shows an artist impressions and provides an overview how the American Embassy coastline will look with the applied proposed protective measures in place.


Figure 3-33: Artist impression American Embassy - Groyne

4. COST ESTIMATION

4.1 Adaptation measures

The cost estimation for the adaptation measures are based on the extensive description in chapter 2 and the concept notes in Appendix A.Table 4-1 shows the cost estimations for the defined 7 adaptive interventions. The cost justification is described in the concept notes in Appendix A and a breakdown of the costs per associated activity is shown in Appendix B.

Table 4-1: Cost Estimation Adaptation measures

Adaptation measure		Cost Estimation
1	Capacity building of national and metropolitan institutions in ICZM and land use planning	About 3-4 million USD
2	Strengthening of community awareness and management of coastal zone risks and solutions	About 2 million USD
3	Sustainable fisheries management	About 2 million USD
4	Management of the biological resources.	About 2.75 million USD
5	Management of urban pollution in coastal areas.	About 0.8 million USD
6	Sustainable sand extraction.	About 0.8 million USD
7	Climate resilient community roads and other critical infrastructures	About 2.5 million USD
Total		About 14.3 million USD

4.2 Protective measures

The basis for the cost estimation is the Bill of Quantities (BoQ) of materials to be used for the project or materials to be removed from the project. A unit rate will be used for the specific material items in order to calculate the costs. These costs form the basis for the estimation for the Capital Expenditure (CAPEX) costs. The basis of the cost estimation for the protective measures is the preliminary design as described in chapter 3 and shown in the drawings of Appendix 0. The quantity and cost estimation of the protective measures has been based on the chainage along the coastline of each section separately. The Operational Expenditure (OPEX) is based on the CAPEX costs and is treated separately.

The following sections describe the BoQ, unit rates and subsequently the CAPEX and OPEX estimation.

4.2.1 Bill of Quantities

The Bill of Quantities shows the estimated quantities for each type of construction material. The quantities are estimated along each 50m chainage along the coastline of each section and the drawings presented in Appendix 0. The full Bill of Quantities per chainage is shown in Appendix 0. Here a summary is provided of the quantities for each construction item for each section. Note that the presentation of the bandwidth and uncertainty is performed under the unit rates and cost estimation.

New Kru Town

Table 4-2 shows the estimated required quantities for each design component of the preliminary design of the protective measures for New Kru Town, as described in section 3.5.1.

Table 4-2: Summary Bill of Quantities New Kru Town

Item	Unit	Revetment light	Revetment	Fishing Landing sites	Total
Quarry run	m^3	8,164	22,962	13,831	**44,957**
Armour 2-5 t	m^3	-	50,699	7,152	**57,851**
Armour 300-1000kg	m^3	8,125	-	864	**8,989**
Underlayer 60-300 kg	m^3	4,290	23,056	1,424	**28,770**
Geotextile	m^2	14,950	33,200	4,270	**52,420**
Excavation	m^3	26,000	74,926	13,864	**114,790**
Backfill	m^3	12,545	3,192	-	**15,737**
Promenade pavement	m^2	3,900	6,960	1,560	**12,420**
Landscaping	№ trees	26	46	10	**83**
Drainage	m	650	1,160	260	**2,070**
Sand (nourished)	m^3	-	-	22,800	**22,800**

West Point
For West Point two alternatives are presented: Revetment option (Alternative A) and Groyne including beach widening option (Alternative B).

Alternative A – Revetment
Table 4-3 shows the estimated required quantities for each design component of the preliminary design of the protective measures for West Point (Alternative A), as described in section 3.5.1.

Table 4-3: Summary Bill of Quantities West Point – Alternative A (Revetment)

Item	Unit	Revetment light	Revetment	Fishing Landing sites	Total
Quarry run	m^3	1,260	32,316	9,393	**42,969**
Armour 2-5 t	m^3	-	34,020	3,004	**37,024**
Armour 300-1000kg	m^3	2,500	-	408	**2,908**
Underlayer 60-300 kg	m^3	1,320	17,952	666	**19,938**
Geotextile	m^2	3,000	30,930	3,480	**37,410**
Excavation	m^3	10,300	36,015	4,069	**50,384**
Backfill	m^3	5,500	-	-	**5,500**
Promenade pavement	m^2	1,200	4,860	1,020	**7,080**
Landscaping	№ trees	8	32	7	**47**
Drainage	m	200	810	170	**1,180**
Sand (nourished)	m^3	-	-	12,205	**12,205**

Alternative B – Groyne
Table 4-4 shows the estimated required quantities for each design component of the preliminary design of the protective measures for West Point (Alternative B), as described in section 3.5.2. The full BoQ is shown in Appendix 0. Note that the estimation for the quantities of the groyne a separate BoQ has been drafted with different chainages along the groyne, to account for the depth changes and subsequent different cross-sections along the groyne.

Table 4-4: Summary Bill of Quantities West Point – Alternative B (Groyne)

Item	Unit	Beach Replenishment	Revetment light	Groyne	Total
Quarry run	m^3	-	1,260	33,128	**34,388**
Armour 1-3 t	m^3	-	-	2,563	**2,563**
Armour 300-1000kg	m^3	-	2,500	10,897	**13,397**
Underlayer 60-300 kg	m^3	-	1,320	-	**1,320**
Geotextile	m^2	-	3,000	-	**3,000**
Excavation	m^3	-	10,300	2,242	**12,542**
Backfill	m^3	-	5,500	-	**5,500**
Sand (nourished)	m^3	490,000	-	-	**490,000**

American Embassy

Table 4-5 shows the estimated required quantities for each design component of the preliminary design of the protective measures for American Embassy section, as described in section 3.5.3. This table shows the quantities for the groyne option where concrete units are applied.

Table 4-5: Summary Bill of Quantities American Embassy (Concrete Units)

Item	Unit	Beach Replenishment	Groyne	Total
Quarry run	m^3	-	25,574	**25,574**
5t units[2]	№ units	-	457[2]	**457**
Armour 2-5 t	m^3	-	11,934	**11,934**
Underlayer 300-1000kg	m^3	-	1,846	**1,846**
Toe 2-5 t	m^2	-	551	**551**
Excavation	m^3	-	4,240	**4,240**
Sand (nourished)	m^3	624,000	-	**624,000**

In case it is considered that the application of concrete units is troublesome (i.e. difficult in terms transport, production etc.) an alternative for the head of the groyne is proposed where large rock has been applied as armour. Table 4-6 shows the estimated required quantities for each design component of the preliminary design of the protective measures for American Embassy section in case a rock armour groyne head is applied, as described in section 3.5.3.

Table 4-6: Summary Bill of Quantities American Embassy (Rock armour)

Item	Unit	Beach Replenishment	Groyne	Total
Quarry run	m^3	-	30,068	**30,068**
Armour 5-10 t	m^3	-	7,506	**7,506**
Armour 2-5 t	m^3	-	11,934	**11,934**
Underlayer 300-1000kg	m^3	-	4,033	**4,033**
Excavation	m^3	-	4,240	**4,240**
Sand (nourished)	m^3	624,000	-	**624,000**

[2] The number of concrete units has been estimated by assuming a packing density of 0.406 units/m^2, based on the Accropode[tm] design table for equivalent 5 tonnes units and the estimated surface area of the head of the groyne

4.2.2 Unit rates

Table 4-7 shows the applied unit rates for each construction material/type. Note that the both a high and a low estimate for the unit rates have been provided. The unit rates include the cost of the material, transport to site and the placement/construction of the material.

Table 4-7: Applied Unit Rates per construction material, including high and low estimates

	Unit rate (USD)			Alternative unit rate (USD)		
Item	**Unit**	**Low estimate**	**High estimate**	**Unit**	**Low estimate**	**High estimate**
Quarry run	m^3	$95.00	$133.00	tonnes	$50.00	$70.00
5t units	units	$1,200.00	$1,600.00			
Armour 1-3 t	m^3	$108.00	$144.00	tonnes	$60.00	$80.00
Armour 2-5 t	m^3	$108.00	$144.00	tonnes	$60.00	$80.00
Armour 5-10 t	m^3	$108.00	$144.00	tonnes	$60.00	$80.00
Armour/underlayer 300-1000kg	m^3	$108.00	$144.00	tonnes	$60.00	$80.00
Underlayer 60-300 kg	m^3	$114.00	$152.00	tonnes	$60.00	$80.00
Excavation	m^3	$8.00	$12.00			
Sand (nourished)	m^3	$4.00	$8.00			
Backfill	m^3	$4.00	$6.00			
Geotextile	m^2	$10.00	$15.00			
Promenade pavement	m^2	$30.00	$50.00			
Landscaping (trees)	trees	$400.00	$600.00			
Drainage	m	$80.00	$100.00			

The following notes are made with regard to the unit rates:

1. The estimated bandwidth of the unit rates are based on reference projects and expert judgment. The local context (e.g. available rock in Liberia) has been taking into account in the estimation.
2. Normally the unit rates for rock works are estimated per tonne. Therefore for these items an alternative unit rate has been presented in tonnes. The ratio between tonnes and m^3 is different depending on the size of the material. In this project the ratio factor for tonnes to m^3 is considered to be 1.9 for Quarry run and Underlayer 60-300 kg and 1.8 for the armour layers (>300 kg).
3. Because large rock is more difficult to handle the unit rates for larger rock is higher compared to quarry run.
4. The largest bandwidth in unit rates is found for the nourished sand. Nourishment of sand and the corresponding unit rates, heavily depend on the methodology (e.g. rainbowing, pumping ashore) and the contractor.
5. The unit prices for drainage is estimated in meter length along one side of the promenade pavement and includes (small scale) drainage works.

4.2.3 Cost estimates CAPEX

The BoQ and unit rates together form the basis for the cost estimates (CAPEX) of the protective measures. Besides the BoQ costs the following additional costs are included in the CAPEX estimation:

a) **Mobilization and Demobilization**
Mobilization and demobilization costs do significantly depend on the selected contractor, the type of contract, the available resources and the expected construction period. For this project,some equipment will likely to be imported (temporary or permanent) for rock quarrying and transport, for the rock works (for example a long-boom excavator) and potentially equipment for the casting and preparation of concrete units. A range between 5% and 10% of the BoQ costs is estimated for the Mobilization and Demobilization.

b) **Contingency**
A contingency is included as common practice to ensure that there a buffer during execution the project and includes unforeseen costs for items / aspects that are not foreseen in this stage of the project or that were underestimated. Furthermore, costs will depend on how the project will be implemented. In this project, the reliability margin of the costs is not only influenced by the level of detail of the design, but also by the specific conditions of implementing a relative large project in Liberia. A range of 10% to 15% is estimated for contingency.

c) **Design**
Costs for detailed design are added. It shall be noted that the detailed design of the coastal protection works can be a substantial task. These costs depend on the level of detail that will be required or whether certain detailed engineering aspects are left for the contractor. In this estimate are range of 4% to 6% are included. If the detailed design is prepared via a separate budget, these costs may be reduced or deleted from the total costs.

d) **Supervision**
Cost for supervision will strongly depend on: type of contract, duration of construction period and number of international members involved. In this estimate, costs of 4% to 6% included

Table 4-8 to Table 4-11 show the cost estimations for each section separately including the additional cost items as described above. It is noted that the cost estimate for American Embassy includes the cost estimate for the head with concrete units, which is the preferred option. An additional cost estimation has been done with a groyne head of rock armour.

The tables include both a high and low estimate for the BoQ costs and the additional items. The average cost estimates are calculated based on both estimates. After adding all costs a rounded number has been included. The percentages shows the relative difference compared to the average and represent the bandwidth of the associated estimate.

Table 4-8: Cost estimation (CAPEX) Protective measures - New Kru Town

			Low estimate	*Average*	*High estimate*
		Location	***New Kru Town***		
		BoQ costs	**$ 16,937,403.00**	**$ 20,116,483.00**	**$ 23,295,563.00**
			-16%		*+16%*
Additional items	*Low estimate*	*High estimate*	*Low estimate*	*Average*	*High estimate*
Mob/DeMob	5%	10%	$ 846,870.15	**$ 1,588,213.23**	$ 2,329,556.30
Contingency	10%	15%	$ 1,693,740.30	**$ 2,594,037.38**	$ 3,494,334.45
Design	4%	6%	$ 677,496.12	**$ 1,037,614.95**	$ 1,397,733.78
Supervision	4%	6%	$ 677,496.12	**$ 1,037,614.95**	$ 1,397,733.78
Total additional			$ 3,895,602.69	**$ 6,257,480.50**	$ 8,619,358.31
Total			**$ 20,833,005.69**	**$ 26,373,963.50**	**$ 31,914,921.31**
			-21%		*+21%*
Total round			**$ 20,833,000.00**	**$ 26,374,000.00**	**$ 31,915,000.00**

Table 4-9: Cost estimation (CAPEX) Protective measures – West Point (Alternative A – Revetment)

			Low estimate	*Average*	*High estimate*
		Location	***Westpoint***		
		BoQ costs	**$ 11,723,820.00**	**$ 13,921,833.00**	**$ 16,119,846.00**
			-16%		*+16%*
Additional items	*Low estimate*	*High estimate*	*Low estimate*	*Average*	*High estimate*
Mob/DeMob	5%	10%	$ 586,191.00	**$ 1,099,087.80**	$ 1,611,984.60
Contingency	10%	15%	$ 1,172,382.00	**$ 1,795,179.45**	$ 2,417,976.90
Design	4%	6%	$ 468,952.80	**$ 718,071.78**	$ 967,190.76
Supervision	4%	6%	$ 468,952.80	**$ 718,071.78**	$ 967,190.76
Total additional			$ 2,696,478.60	**$ 4,330,410.81**	$ 5,964,343.02
Total			**$ 14,420,298.60**	**$ 18,252,243.81**	**$ 22,084,189.02**
			-21%		*+21%*
Total round			**$ 14,420,000.00**	**$ 18,252,000.00**	**$ 22,084,000.00**

Table 4-10: Cost estimation (CAPEX) Protective measures - West Point (Alternative B – Groyne)

			Low estimate	*Average*	*High estimate*
		Location	***Westpoint***		
		BoQ costs	**$ 7,253,305.15**	**$ 9,237,113.32**	**$ 11,220,921.49**
			-21%		*+21%*
	Low estimate	*High estimate*	*Low estimate*	*Average*	*High estimate*
Mob/DeMob	5%	10%	$ 362,665.26	**$ 742,378.70**	$ 1,122,092.15
Contingency	10%	15%	$ 725,330.52	**$ 1,204,234.37**	$ 1,683,138.22
Design	4%	6%	$ 290,132.21	**$ 481,693.75**	$ 673,255.29
Supervision	4%	6%	$ 290,132.21	**$ 481,693.75**	$ 673,255.29
Total additional			$ 1,668,260.18	**$ 2,910,000.57**	$ 4,151,740.95
Total			**$ 8,921,565.34**	**$ 12,147,113.89**	**$ 15,372,662.45**
			-27%		*27%*
Total round			**$ 8,922,000.00**	**$ 12,147,500.00**	**$ 15,373,000.00**

Table 4-11: Cost estimation (CAPEX) Protective measures - American Embassy

			Low estimate	*Average*	*High estimate*
		Location	***American Embassy (Concrete)***		
		BoQ costs	**$ 7,056,564.04**	**$ 9,148,467.39**	**$ 11,240,370.75**
			-23%		*+23%*
Additional items	*Low estimate*	*High estimate*	*Low estimate*	*Average*	*High estimate*
Mob/DeMob	5%	10%	$ 352,828.20	**$ 738,432.64**	$ 1,124,037.07
Contingency	10%	15%	$ 705,656.40	**$ 1,195,856.01**	$ 1,686,055.61
Design	4%	6%	$ 282,262.56	**$ 478,342.40**	$ 674,422.24
Supervision	4%	6%	$ 282,262.56	**$ 478,342.40**	$ 674,422.24
Total additional			$ 1,623,009.73	**$ 2,890,973.45**	$ 4,158,937.18
Total			**$ 8,679,573.76**	**$ 12,039,440.84**	**$ 15,399,307.92**
			-28%		*+28%*
Total round			**$ 8,680,000.00**	**$ 12,039,500.00**	**$ 15,399,000.00**

As described in section 3.5.3 an alternative for the groyne head has been proposed with large rock, in case the construction or import of concrete units is troublesome. Table 4-12 shows the cost estimate for this alternative groyne head.

Table 4-12: Cost estimation (CAPEX) Protective measures - American Embassy (Alternative with Rock Head)

			Low estimate	*Average*	*High estimate*
		Location	***American Embassy (Rock)***		
		BoQ costs	**$ 7,921,422.15**	**$ 10,171,700.92**	**$ 12,421,979.70**
			-22%		*+22%*
Additional items	*Low estimate*	*High estimate*	*Low estimate*	*Average*	*High estimate*
Mob/DeMob	5%	10%	$ 396,071.11	**$ 819,134.54**	$ 1,242,197.97
Contingency	10%	15%	$ 792,142.21	**$ 1,327,719.58**	$ 1,863,296.95
Design	4%	6%	$ 316,856.89	**$ 531,087.83**	$ 745,318.78
Supervision	4%	6%	$ 316,856.89	**$ 531,087.83**	$ 745,318.78
Total additional			$ 1,821,927.09	**$ 3,209,029.79**	$ 4,596,132.49
Total			**$ 9,743,349.24**	**$ 13,380,730.71**	**$ 17,018,112.19**
			-27%		*+27%*
Total round			**$ 9,743,000.00**	**$ 13,380,500.00**	**$ 17,018,000.00**

Total cost estimate

This leads to the total CAPEX cost estimates as presented in Table 4-13 and Table 4-14 for alternatives A and B respectively. Note that this includes the groyne head with concrete units for American Embassy.

Table 4-13: Total cost estimate for Alternative A (West Point Revetment option)

	Low estimate	*Average*	*High Estimate*
New Kru Town Revetment	$ 20,833,000.00	**$ 26,374,000.00**	$ 31,915,000.00
West Point Revetment	$ 14,420,000.00	**$ 18,252,000.00**	$ 22,084,000.00
American Embassy Groyne	$ 8,680,000.00	**$ 12,039,500.00**	$ 15,399,000.00
Total	**$ 43,933,000.00**	**$ 56,666,000.00**	**$ 69,398,000.00**

Table 4-14: Total cost estimate for Alternative B (West Point Groyne option)

	Low estimate	*Average*	*High Estimate*
New Kru Town Revetment	$ 20,833,000.00	**$ 26,374,000.00**	$ 31,915,000.00
West Point Groyne	$ 8,922,000.00	**$ 12,147,500.00**	$ 15,373,000.00
American Embassy Groyne	$ 8,680,000.00	**$ 12,039,500.00**	$ 15,399,000.00
Total	**$ 38,435,000.00**	**$ 50,561,000.00**	**$ 62,687,000.00**

Total cost estimate – Alternative with Rock Groyne head at American Embassy

A separate total cost estimate has been shown in where the rock is applied as groyne head armour instead of concrete elements. It is clear that the alternatives are more expensive compared to the alternatives with concrete elements.

Table 4-15: Total cost estimate for Alternative A (West Point Revetment option) – Rock groyne head American Embassy

	Low estimate	*Average*	*High Estimate*
New Kru Town Revetment	$ 20,833,000.00	**$ 26,374,000.00**	$ 31,915,000.00
West Point Revetment	$ 14,420,000.00	**$ 18,252,000.00**	$ 22,084,000.00
American Embassy Groyne	$ 9,743,000.00	**$ 13,380,500.00**	$ 17,018,000.00
Total	**$ 44,996,000.00**	**$ 58,007,000.00**	**$ 71,017,000.00**

Table 4-16: Total cost estimate for Alternative B (West Point Groyne option) – Rock groyne head American Embassy

	Low estimate	*Average*	*High Estimate*
New Kru Town Revetment	$ 20,833,000.00	**$ 26,374,000.00**	$ 31,915,000.00
West Point Groyne	$ 8,922,000.00	**$ 12,147,500.00**	$ 15,373,000.00
American Embassy Groyne	$ 9,743,000.00	**$ 13,380,500.00**	$ 17,018,000.00
Total	**$ 39,498,000.00**	**$ 51,902,000.00**	**$ 64,306,000.00**

4.2.4 Cost estimates OPEX

The Operational Expenditure (OPEX) are estimated by a percentage (yearly) of the BoQ costs (including contingency). Also the OPEX costs are estimated for the high and low estimates which can subsequently be used as bandwidth. OPEX costs are mainly related to required maintenance of the coastal protection works. The required maintenance depends on the type of structure, hence the BoQ costs are separated for each type of structure. Table 4-17 to Table 4-20 show the low and high estimates of the BoQ costs, including contingency, so without other additional costs, for both alternatives. Note that the BoQ costs for American Embassy include the option for concrete units for the groyne head.

Table 4-17: Low estimate BoQ costs (including contingency) for Alternative A (West Point Revetment)

Item	New Kru town	Westpoint	American Embassy	Sum
Revetment works	$ 17,902,371.30	$ 12,505,042.00	$ -	$ 30,407,413.30
Groyne works	$ -	$ -	$ 5,016,620.44	$ 5,016,620.44
Sand	$ 100,320.00	$ 42,020.00	$ 2,745,600.00	$ 2,887,940.00
Promenade+Drainage	$ 628,452.00	$ 349,140.00	$ -	$ 977,592.00
Total	$ 18,631,143.30	$ 12,896,202.00	$ 7,762,220.44	$ 39,289,565.74

Table 4-18: Low estimate BoQ costs (including contingency) for Alternative B (West Point Groyne)

Item	New Kru town	Westpoint	American Embassy	Sum
Revetment works	$ 17,902,371.30	$ 742,038.00	$ -	$ 18,644,409.30
Groyne works	$ -	$ 5,080,597.67	$ 5,016,620.44	$ 10,097,218.11
Sand	$ 100,320.00	$ 2,156,000.00	$ 2,745,600.00	$ 5,001,920.00
Promenade+Drainage	$ 628,452.00	$ -	$ -	$ 628,452.00
Total	$ 18,631,143.30	$ 7,978,635.67	$ 7,762,220.44	$ 34,371,999.41

Table 4-19: High estimate BoQ costs (including contingency) for Alternative A (West Point Revetment)

Item	New Kru town	Westpoint	American Embassy	Sum
Revetment works	$ 25,570,805.45	$ 17,889,222.90	$ -	$ 43,460,028.35
Groyne works	$ -	$ -	$ 7,185,626.36	$ 7,185,626.36
Sand	$ 209,760.00	$ 87,860.00	$ 5,740,800.00	$ 6,038,420.00
Promenade+Drainage	$ 1,009,332.00	$ 560,740.00	$ -	$ 1,570,072.00
Total	$ 26,789,897.45	$ 18,537,822.90	$ 12,926,426.36	$ 58,254,146.71

Table 4-20: High estimate BoQ costs (including contingency) for Alternative B (West Point Groyne)

Item	New Kru town	Westpoint	American Embassy	Sum
Revetment works	$ 25,570,805.45	$ 1,069,293.00	$ -	$ 26,640,098.45
Groyne works	$ -	$ 7,326,766.72	$ 7,185,626.36	$ 14,512,393.08
Sand	$ 209,760.00	$ 4,508,000.00	$ 5,740,800.00	$ 10,458,560.00
Promenade+Drainage	$ 1,009,332.00	$ -	$ -	$ 1,009,332.00
Total	$ 26,789,897.45	$ 12,904,059.72	$ 12,926,426.36	$ 52,620,383.53

The following OPEX estimates are included, which are partly based on literature (Ref [7] and [8]) and expert judgment.

Revetment and Groyne works
For coastal protection OPEX costs are in general very low as maintenance would be difficult and costly and thus the design (based on design conditions and design life) is such that maintenance for the parts built-up of rock (revetment, groyne) is only due to very extreme situations. Therefore a low expected maintenance is estimated between 0% and 0.5% per year for the rock works

Beach replenishments
The design life of the beach replenishments/widening has been set to 20 years. It is expected that during that period the maintenance is low. However to be conservative it is herewith assumed that the beach needs full recovery after 15 years (5 earlier than design life). Which means that the estimated OPEX costs are 100% each 15 years for all the beach replenishments.

Promenade and Drainage
The OPEX costs for the promenade are mainly influenced by the estimated frequency for replacing the surface layer. Generally the surface layer is replaced between 8-15 years, this is dependent of traffic conditions. As the purpose of the promenade is mostly access for pedestrians an extended lifetime of the surface layer can be expected. However some traffic has been taken into account. Minor interventions cover small maintenance and repairs of landscape and drainage. Based on this, the estimated maintenance costs are as follows:

- 1% per year for minor interventions
- 10% every 10 years

Table 4-21: Summary OPEX estimates for each type of structure

Return period (yr)	1	10	15
Revetment works	0-0.5%	-	-
Groyne works	0-0.5%	-	-
Beach replenishment	-	-	100%
Promenade+Drainage	1%	10%	-

This leads to the following OPEX cost estimates for the different return periods and the low and high estimates for the OPEX costs per year. Table 4-22 to Table 4-25 show the low (green) and high (red) estimates for the OPEX costs per return period and average per year.

Table 4-22: Low (green) and high (red) OPEX estimates per return period and average per year for New Kru Town

New Kru Town	Return Period (year)			
Item	1	10	15	Avg per year
Revetment works	$ -	$ -	$ -	$ -
Groyne works	$ -	$ -	$ -	$ -
Sand	$ -	$ -	$ 100,320.00	$ 6,688.00
Promenade+Drainage	$ 6,284.52	$ 62,845.20	$ -	$ 12,569.04
Total	**$ 6,284.52**	**$ 62,845.20**	**$ 100,320.00**	**$ 19,257.04**

New Kru Town	Return Period (year)			
Item	1	10	15	Avg per year
Revetment works	$ 127,854.03	$ -	$ -	$ 127,854.03
Groyne works	$ -	$ -	$ -	$ -
Sand	$ -	$ -	$ 209,760.00	$ 13,984.00
Promenade+Drainage	$ 10,093.32	$ 100,933.20	$ -	$ 20,186.64
Total	**$ 137,947.35**	**$ 100,933.20**	**$ 209,760.00**	**$ 162,024.67**

Table 4-23 Low (green) and high (red) OPEX estimates per return period and average per year for West Point (Alternative A – Revetment)

Westpoint (Revetment)	**Return Period (year)**			
Item	**1**	**10**	**15**	**Avg per year**
Revetment works	$ -	$ -	$ -	$ -
Groyne works	$ -	$ -	$ -	$ -
Sand	$ -	$ -	$ 42,020.00	$ 2,801.33
Promenade+Drainage	$ 3,491.40	$ 34,914.00	$ -	$ 6,982.80
Total	**$ 3,491.40**	**$ 34,914.00**	**$ 42,020.00**	**$ 9,784.13**

Westpoint (Revetment)	**Return Period (year)**			
Item	**1**	**10**	**15**	**Avg per year**
Revetment works	$ 89,446.11	$ -	$ -	$ 89,446.11
Groyne works	$ -	$ -	$ -	$ -
Sand	$ -	$ -	$ 87,860.00	$ 5,857.33
Promenade+Drainage	$ 5,607.40	$ 56,074.00	$ -	$ 11,214.80
Total	**$ 95,053.51**	**$ 56,074.00**	**$ 87,860.00**	**$ 106,518.25**

Table 4-24: Low (green) and high (red) OPEX estimates per return period and average per year for West Point (Alternative B – Groyne)

Westpoint (Groyne)	**Return Period (year)**			
Item	**1**	**10**	**15**	**Avg per year**
Revetment works	$ -	$ -	$ -	$ -
Groyne works	$ -	$ -	$ -	$ -
Sand	$ -	$ -	$ 2,156,000.00	$ 143,733.33
Promenade+Drainage	$ -	$ -	$ -	$ -
Total	**$ -**	**$ -**	**$ 2,156,000.00**	**$ 143,733.33**

Westpoint (Groyne)	**Return Period (year)**			
Item	**1**	**10**	**15**	**Avg per year**
Revetment works	$ 5,346.47	$ -	$ -	$ 5,346.47
Groyne works	$ 36,633.83	$ -	$ -	$ 36,633.83
Sand	$ -	$ -	$ 4,508,000.00	$ 300,533.33
Promenade+Drainage	$ -	$ -	$ -	$ -
Total	**$ 41,980.30**	**$ -**	**$ 4,508,000.00**	**$ 342,513.63**

Table 4-25: Low (green) and high (red) OPEX estimates per return period and average per year for American Embassy

American Embassy	**Return Period (year)**			
Item	**1**	**10**	**15**	**Avg per year**
Revetment works	$ -	$ -	$ -	$ -
Groyne works	$ -	$ -	$ -	$ -
Sand	$ -	$ -	$ 2,745,600.00	$ 183,040.00
Promenade+Drainage	$ -	$ -	$ -	$ -
Total	**$ -**	**$ -**	**$ 2,745,600.00**	**$ 183,040.00**

American Embassy	**Return Period (year)**			
Item	**1**	**10**	**15**	**Avg per year**
Revetment works	$ -	$ -	$ -	$ -
Groyne works	$ 35,928.13	$ -	$ -	$ 35,928.13
Sand	$ -	$ -	$ 5,740,800.00	$ 382,720.00
Promenade+Drainage	$ -	$ -	$ -	$ -
Total	**$ 35,928.13**	**$ -**	**$ 5,740,800.00**	**$ 418,648.13**

This leads to the following average OPEX estimate for each section, which is subsequently used in the financial and economic feasibility.

Table 4-26: Average OPEX estimates per return period and average per year for New Kru Town

New Kru Town	**Return Period (year)**			
Item	**1**	**10**	**15**	**Avg per year**
Revetment works	$ 63,927.01	$ -	$ -	$ 63,927.01
Groyne works	$ -	$ -	$ -	$ -
Sand	$ -	$ -	$ 155,040.00	$ 10,336.00
Promenade+Drainage	$ 8,188.92	$ 81,889.20	$ -	$ 16,377.84
Total	**$ 72,115.93**	**$ 81,889.20**	**$ 155,040.00**	**$ 90,640.85**

Table 4-27: Average OPEX estimates per return period and average per year for West Point (Alternative A – Revetment)

Westpoint (Revetment)	**Return Period (year)**			
Item	**1**	**10**	**15**	**Avg per year**
Revetment works	$ 44,723.06	$ -	$ -	$ 44,723.06
Groyne works	$ -	$ -	$ -	$ -
Sand	$ -	$ -	$ 64,940.00	$ 4,329.33
Promenade+Drainage	$ 4,549.40	$ 45,494.00	$ -	$ 9,098.80
Total	**$ 49,272.46**	**$ 45,494.00**	**$ 64,940.00**	**$ 58,151.19**

Table 4-28: Average OPEX estimates per return period and average per year for West Point (Alternative B - Groyne)

Westpoint (Groyne)	**Return Period (year)**			
Item	**1**	**10**	**15**	**Avg per year**
Revetment works	$ 2,673.23	$ -	$ -	$ 2,673.23
Groyne works	$ 18,316.92	$ -	$ -	$ 18,316.92
Sand	$ -	$ -	$ 3,332,000.00	$ 222,133.33
Promenade+Drainage	$ -	$ -	$ -	$ -
Total	**$ 20,990.15**	**$ -**	**$ 3,332,000.00**	**$ 243,123.48**

Table 4-29: Average OPEX estimates per return period and average per year for American Embassy

American Embassy	**Return Period (year)**			
Item	**1**	**10**	**15**	**Avg per year**
Revetment works	$ -	$ -	$ -	$ -
Groyne works	$ 17,964.07	$ -	$ -	$ 17,964.07
Sand	$ -	$ -	$ 4,243,200.00	$ 282,880.00
Promenade+Drainage	$ -	$ -	$ -	$ -
Total	**$ 17,964.07**	**$ -**	**$ 4,243,200.00**	**$ 300,844.07**

5. FINANCIAL AND ECONOMIC FEASIBILITY

5.1 Methodology and assumptions

The objective of an economic cost-benefit analysis (CBA) is to estimate the (likely) costs and benefits of proposed measures to avoid coastal retreat and storm hazards and therefore increase safety levels in greater Monrovia. The CBA's aim is to provide insight in the advantages and disadvantages of the proposed protective and adaptive measures for people, business and the environment.

In economic CBAs, costs and benefits of alternatives are analysed from a broad welfare perspective. Not only direct costs and (financial) revenues are taken into account, but also all other possible positive and negative impacts on society are included in the impacts. In CBAs, the impacts of investment projects to society are quantified, and also presented in monetary values (in this case USD). Nonetheless, for some impacts it is not well possible to express these in monetary values due to lack of data, inherent complexity or ethical reasons. In this study this is the case for the intangible safety effects (accidents or life lost), biodiversity impacts, and recreational & cultural impacts of measures (such as safeguarding beach recreational life by beach nourishment). These impacts could not be quantified due to inherent complexity and lack of data for Liberia. For these reasons, these impacts are assessed in a more qualitative manner.

The key ingredients and steps in CBA are summarized in Figure 5-1.

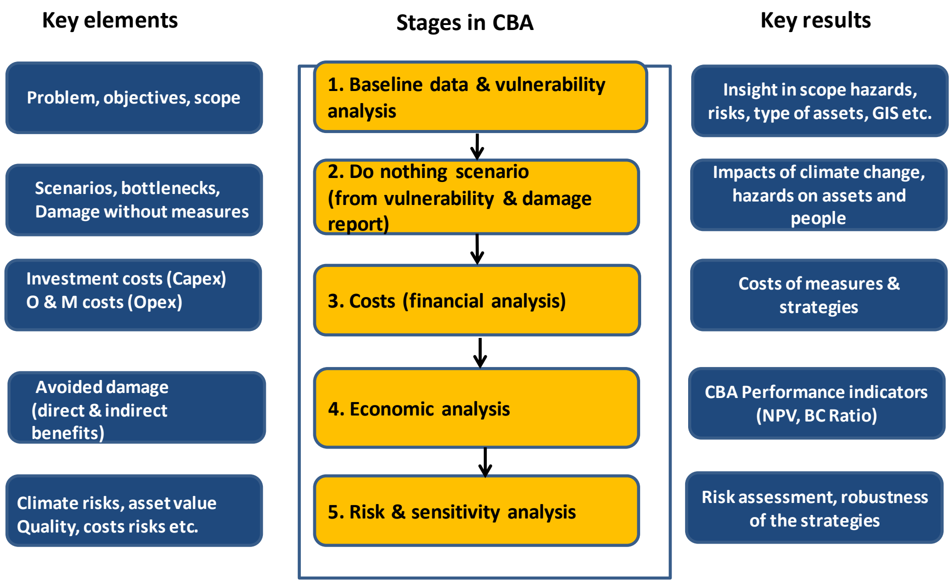


Figure 5-1: Key elements and steps CBA

Comparing measures with a baseline (do nothing scenario)

In the CBA approach effects are defined as changes (incremental costs or benefits) that may be attributed to a project. CBA is conducted on the basis of incremental analysis, whereby effects are determined by investigating the difference between the future scenario, both "with" and "without" implementing measures (do nothing scenario). For this study a damage model was developed for the five coastal zones estimating the damage caused by the hazards (erosion, storm erosion) without any protection measures (the so - called damage in the do- nothing scenario).

Key assumptions CBA
During the development of the CBA, a number of assumptions have been made which are described below:

Time horizon
Coastal Zone management infrastructure often has a lifetime of 30 to 100 years and climate change is a long-term phenomenon. In this study, the protective measures have been designed for a technical lifetime of 50 years. We have assumed that about 2,5 years will be necessary for the preparatory activities such as agreement on funding, detailed technical design, procurement and contracting of works (2020-2023). For these reasons the implementation could start in 2023 and operation would start in 2024. Given a technical lifespan of 50 years, this implies 2074 is the time horizon in the CBA. In this chapter we will also provide estimates of yearly damages in 2030, 2050 and 2070. Regarding the Net Present Values all discounted values will be presented for the year 2019.

Project area
This CBA focusses on Monrovia and the identified coastal sections, but estimates impacts (benefits & costs) for Liberian society.

Social discount rate
Because people tend to value current payment or benefits higher than an equal payment in the future, a discount factor is used in CBA's to discount future values to todays value. The discount rate also reflects the opportunity costs of undertaking investments in protective measures (what would be the real return on any other alternative investment). We estimated a potential discount rate based upon four different sources/methods from literature for estimating a discount rate:

1. The opportunity cost of capital method based upon returns on alternative investments (for example bonds or loans). The real interest in Liberia is about 5-6%. In 2017 the yield on government bonds was 3,4% (Source Central bank of Liberia), while inflation was minus 2,2% in 2017, which would imply a real discount rate of about 5%. In terms of market interest rate (about 12% in 2018) and long -term inflation of 3%, the real market interest rate would be about 9% (including risk premium). Corrected for risks the risk-free real interest rate would be about 6%.
2. The view of climate economists: they derive real discount rates for climate policies of 2,7% (until negative or declining in time) based upon time preferences for consumption and inter-generational considerations (see for example Stern, 2007 and Fleurbaey, 2010);
3. Social time preference method based upon long term GDP growth (see DG Regio, 2014)[3]. The real GDP growth rate was 2,5% in 2017 and 5% over the longer period 1990-2017 (source World Development Report, World Bank). This results in a possible average discount rate for Liberia for 2020-2100 of approximately **3-5%** based upon the long-term GDP growth scenarios as formulated in this study;
4. A study of the World Bank on Economics of adaptation to climate change used a real discount rate of **5%**. IUCN uses for a CBA forest in Ghana a discount rate of **5**%, while HKV (2018) assumes a discount rate of 7% in a World Bank study for flood protection strategies in Ghana.

It is also good to have in mind that while some donors (such as World Bank) use real discount rates up to 8 or 12% for assessing infrastructure in African countries, that such high discount rates imply that

[3] In the Guide of the European Commission DG Regio, 2014 an extensive discussion of discount rates is described in Annex II of that guide. The social time preference method is explained in that section.

future generations have zero to very little weight in the CBA. We regard this as inter-generational unbalanced for climate change mitigation and adaptation policies, which are often meant to protect both current and future generations. Moreover, Recent CBA guides in the Netherlands advise different discount rates for different types of costs and benefits, suggesting lowest discount rates for externalities (higher discount rates for market related impacts). Therefore, based on the above range between 2,7% and 7% we recommend assuming a real discount rate of **6%** in this CBA, as this rate is most comparable to the results of different methods and sources and still gives weight to impacts for future generations. In sensitivity analysis we will show results with higher and lower assumptions regarding the discount rate.

Average population and income growth rates

A real growth of GDP has been assumed for the period 2019-2030 between of 3,5% (pessimistic scenario) and 4,8% (optimistic scenario) per year. After 2030 the growth rates are slightly declining over time until 2100 (see Appendix G of PART I – Vulnerability Report, Socio-economic scenarios). An annual population growth rate has been assumed of 3,4% (pessimistic scenario) and 3,9% (optimistic scenario) for the period 2020-2030 for Monrovia. The implied real economic growth per capita rate (real income growth of 1-1,4% per year) affects the real growth of assets (buildings etc.) and content (quality improvement over time) in the damage and CBA models.

5.2 Alternatives, timing and costs

In the CBA the focus is on the protective measures for most vulnerable sections 2,3 and 4 as described in Part I – Vulnerability Reporting. The adaptive measures will be discussed, but in less detail because the costs are substantially lower and benefits of the adaptive measures are often difficult to quantify or monetize (intangible benefits). In table below a summary overview is provided of the protective measure options and the potential timing of implementation.

Table 5-1: Overview protective measures & potential timing of implementation

Section	Alternative	Key objectives & benefits	Timing
2	**Revetment New Kru town**	Protection of coastal retreat and storm floods for communities in section 2	2023
3	**West Point option A Revetment**	Protection of coastal retreat and storm floods for communities in section 3	2023
3	**West Point option B Groyne and nourishment**	Protection of coastal retreat and storm floods for communities in section 3	2023
4	**American Embassy Groyne & beach nourishment**	Protection of coastal retreat and storm floods for communities in section 4	2023
All sections	**Strengthening governance**	Strengthening capacities and awareness of stakeholders, better policies, planning and regulation	2022-2025
All sections	**Adaptation of livelihoods and the environment**	More resilient communities and fisheries, better protected ecosystems Income and environmental benefits	2022-2026
All sections	**More climate resilient infrastructure in coastal areas**	Reduction of damages and economic losses by developing more resilient infrastructure in coastal areas	2022-2023

Timing

The timing merely depends on the time needed for the necessary preparatory studies and funding requirements and decisions. At this stage it is foreseeable that GCF application and funding process will take place in 2019 and 2020, and that detailed design and tender document preparation studies would take place in 2020 and 2021. (International) tendering of the protective measures could take place in 2021 and 2022. This implies implementation (construction) of these alternatives could start in the year 2023. For most construction measures the construction time is less than a year, which would imply operation of these facilities could start in 2024. The funding process would also apply for the adaptive measures and these need to be developed in some further detail. Moreover, tender documents will need to be drafted and the services tender procedure will need at least half a year. This process could take place in 2020 and 2021, resulting in start of implementation in 2022. Most adaptive projects will take 2-3 years, finalizing around 2024 (and for some 2026) (see above table).

Costs

The costs of the protection measures consist of investment costs (capex) and yearly operating & maintenance costs (OPEX). Regarding investment costs, the following components are included:

- Construction costs (based upon the Bill of Quantities (BoQ) as presented in Part II section 4.2.1), a high, low and average estimation is presented based upon the uncertainties in units and prices). In the CBA base case we have used the average estimation for Capex.
- Temporary construction costs (for transport of sand or rocks to the sites etc.);
- Indirect costs of studies, management, supervision (a range has been assumed of 13-22% of construction costs based upon the uncertainty);
- Contingencies (10-15% of construction costs).

Indirect taxes such as VAT are not included in the cost estimations (these are regarded as transfers in CBA literature).

Operating & maintenance (O&M) costs are separately estimated by assessing necessary activities for maintenance and return periods (see section 4.2.4). The annual maintenance costs for revetments are low compared to the alternatives with include beach nourishment with sand, which needs to be repeated at minimum every 15 years. In table below the annual O&M (OPEX) costs are shown based upon the average estimation of Bill of Quantities and OPEX.

The table below provides an overview of the nominal investment costs (prices 2019) and annual O&M costs for each of the alternative measures.

Table 5-2: Costs of alternatives 1 (million USD, prices 2019, average base case)

Section	Alternative	Investment costs (Capex, prices 2019)	O&M costs (annual OPEX)
Protective measures			
2	Revetment New Kru town	26,374	0,090
3	West Point option A Revetment	18,252	0,058
3	West Point option B Groyne & nourishment	13,567	0,243
4	American Embassy Groyne & nourishment	12,038	0,301
	Total protective measures (West Point Option A included)	**56,664**	**0,449**
	Total protective measures (West Point Option B included)	**51,979**	**0,634**
Adaptive Interventions		**Costs of implementation**	
All	Strengthening governance	5-6	
All	Livelihoods and the environment	6	
All	Adaptation of infrastructure	2,5	
All	**Total adaptive interventions**	**13-14,5**	

Note: Costs estimations for protective measures are based upon BoQ and OPEX (average estimations) as described in Part II Chapter 4 and for the adaptive measures on Chapter 2 (Adaptation Measures). Costs are excluding VAT, including indirect costs.

For inclusion in the economic analysis the above financial costs have been corrected to the economic costs based upon the Standard Conversion Factor (SCF). A conversion of financial to economic costs is based upon many CBA Guides (see for example DG Regio, 2014). Some costs, such as Liberian unskilled labour inputs in construction, are not regarded as economic costs due to market failures (unemployment and benefits related to employment, shadow price of labour). As the construction of the protective measures will be most likely be implemented by a consortium of international and local firms, the Social Conversion Factor will not be as low as 0,90, because some international skilled workers will also be needed. For this reason, we have applied a mid- range conversion factor on the financial costs of 0,95.

Benefits of protective measures

The main benefits considered in the CBA are direct and indirect benefits of the protective measures *compared to the do-nothing scenario*. The direct benefits consist of ***asset damage reduction*** (based upon the damage model from vulnerability analysis) by reducing coastal retreat and storm hazards by the protective measures. For the assets (buildings, roads, fishery sites etc) and damages considered in the do-nothing scenario we refer to Part I Chapter 3 (Vulnerability Analysis) and the Appendix on the damage model.

Indirect benefits are all other damage reduced based upon asset damage reduction, such as ***loss of livelihoods for fisheries and market sellers***, business interruption effects due to storms etc. These are estimated as mark-ups (about 20%) on the direct asset damages in the damage model.

Do nothing scenario

Firstly, the do-nothing scenario is presented. Assets (including content values) at risk will increase over time due to volume and quality changes. The volume of the assets in some of the sections will increase due to population growth and growth of economic activities over time (period 2019-2100). The quality of the assets and content will improve over time due to income per capita growth. For economic or income growth we have assumed two scenarios, an optimistic scenario with an average annual real growth of GDP of about 4% and a pessimistic scenario with average GDP growth of 2,75% per year[4].

Overall, this implies for the do-nothing scenario that the potential damage of coastal retreat will increase over time between 2030 and 2100 with a factor 17 in the high climate change- optimistic socio-economic scenario and with a factor 11 in the lower scenario. This is a result of both climate change and erosion processes and future urban development and the expected quality improvement of the housing stock due to income growth. For storm surge the expected annual damage increases with a factor 10 between 2030 and 2100 in the high scenario (factor 6 in the pessimistic scenario).

This is illustrated in below table for the high climate change (RCP 8.5), optimistic socio-economic scenario.

Table 5-3: Cumulative damage of coastal retreat and average annual expected damage (AED) of storms in USD, 2030-2100- RCP 8.5.

Section 1	2030	2050	2070	2100
Cumulative erosion damage	**18.902**	**94.213**	**269.144**	**2.103.634**
Expected annual storm damage	**67.404**	**128.443**	**1.195.243**	**5.644.610**
Section 2				
Cumulative erosion damage	**5.088.195**	**22.466.653**	**60.495.550**	**204.521.381**
Expected annual storm damage	**1.214.525**	**1.513.759**	**1.874.403**	**3.474.056**
Section 3				
Cumulative erosion damage	**19.641.704**	**85.095.280**	**154.939.075**	**154.939.075**
Expected annual storm damage	**751.537**	**1.740.455**	**-**	**-**
Section 4				
Cumulative erosion damage	**1.106.710**	**1.675.326**	**18.793.620**	**80.070.501**
Expected annual storm damage	**1.272.495**	**2.828.236**	**5.990.126**	**23.675.460**
Section 5				
Cumulative erosion damage	**206.258**	**2.137.388**	**3.203.413**	**12.387.876**
Expected annual storm damage	**6.617**	**12.869**	**23.889**	**69.298**
Total cumulative erosion damage	**26.061.769**	**111.468.860**	**237.700.802**	**454.022.468**
Total AED storm damage	**3.312.579**	**6.223.762**	**9.083.662**	**32.863.425**

Note: In Appendix H of PART I – Vulnerability Report the damage figures are presented for the moderate climate change (RCP 4.5), pessimistic socio-economic scenario.

Reduced direct and indirect damage

All protective measures reduce the direct and indirect damages caused by coastal retreat (erosion) and storm erosion. For example, the revetment options for New Kru town are designed in such a way that they still protect at the extreme storm surges (t=100). By protecting the areas, also the indirect damages such as loss of livelihoods or temporary business interruption during storms, are reduced.

In below table the damage reduction benefits are presented in terms of present values of all yearly avoided damages over the period 2019-2100.

[4] See Appendix G of PART I – Vulnerability Report on Socio-economic scenarios for all growth rates per period assumed between 2019 and 2100.

Table 5-4: Direct and indirect damage reduction benefits (USD) of alternatives, high climate change & socio-economic scenario, 2019-2100

Alternative	Present value damage reduction coastal retreat	Present value damage reduction storms	Present value total damage reduction
New Kru town Revetment	9.498.197	13.865.772	23.363.969
West Point option A Revetment	29.881.251	12.546.332	42.427.584
West Point Option B Groyne	29.881.251	12.546.332	42.427.584
American Embassy Groyne & beach nourishment	2.627.799	17.099.500	19.727.299

Beautification and safety impacts on asset prices

A number of the protective alternatives either safeguard the existence of beaches in Monrovia, while some revetment options also add green elements (boulevard with trees etc.) and therefore improve the quality of the public space. These we call here 'beautification benefits. Those measures which safeguard beaches and improve the quality of public space raise the quality of life for the people residing and working in the coastal areas. One way to capture these impacts in CBA is through the effects on real estate prices. There is quite a substantial literature on the effects of green areas and waterfronts on real estate prices (see for example for an overview Crompton, 2001 – Ref [9]). These studies show effects of around 20% of green or water on the houses or buildings adjacent to the park of beachfront. For the wider area effects of about 10% are found. For this reason, we have assumed that measures protecting the beaches and adding green or spatial qualities will result 10% higher real estate prices in the section compared to the do-nothing scenario. This effect is relevant for both current existing assets (buildings) and future assets (as the volume of buildings will grow in some sections due to population and economic growth).

Below table presents which alternatives will preserve and add spatial quality and the impacts on real estate prices.

Table 5-5: Beautification & safety benefits of alternatives (USD, prices 2019)

Alternative	Effect included?	PV of benefits 2019-2100 (in 2019)
Spatial quality (beautification) effects	Preservation of beaches and adding spatial quality	
New Kru town Revetment	Adding green promenade	1.231.435
West Point option A Revetment	Adding green promenade	1.539.576
West Point Option B Groyne & nourishment	Yes (beaches preserved)	1.539.576
American Embassy Groyne & beach nourishment	Yes (beaches preserved)	3.521.220
Safety effect on real estate prices	***Safety effect on prices***	
New Kru town Revetment	Yes	3.267.369

Alternative	Effect included?	PV of benefits 2019-2100 (in 2019)
West Point option A Revetment	Yes	4.330.057
West Point Option B Groyne & nourishment	Yes	4.330.057
American Embassy Groyne & beach nourishment	Yes	4.951.715

All protective alternatives will increase the long-term safety of the communities. Safety will also be reflected in higher prices of assets (real estate). We have assumed 15% higher real estate prices due to the long-term safety benefits for sections 2 and 3 (7,5% for section 4, due to the lower hazard exposure in section 4).

Other benefits

Apart from the quantified benefits, there are a number of more intangible benefits, which were not possible to quantify and monetize. These are:

- *Preservation of livelihoods and culture* for fishery communities (sections 2 and 3). The protective measures in sections Nu Kru town and West point will enable the fishermen to stay in the area and maintain their landing sites and boats in the beach areas. Next to prevention a loss of income from fisheries to the community (for those who cannot relocate, which is captured under the quantified indirect damage benefits), this will also preserve the fishing culture in these areas.
- *Recreation & cultural values*: the preservation of beaches by the protective alternatives in sections 2 and 4 will safeguard the social & recreational functions of the seafront area not only for the communities living and working in the coastal sections, but also for other inhabitants and visitors in Monrovia. The beaches ae used for social gatherings, playing sports such as football and are part of the lifestyle of some groups (rasta, fishermen) etc. This benefit is difficult to quantify (although partly captured in the real estate prices effect), but potentially substantial for the inhabitants of Monrovia.
- *Avoidance of relocation costs* for communities, such as fisheries, markets etc. In the do-nothing scenario some groups would need to relocate to other areas in Monrovia (if possible!) to maintain their livelihoods. This would imply costs for these groups, such as moving costs, rebuilding fishery landing sites in other (safer) areas, longer transport costs of fishermen to the fishery catch sites in the ocean etc. Due to lack of data, if was not possible to quantify this benefit (reduction of relocation costs compared to the do-nothing scenario).
- *Reduction of intangible damage*: avoidance of health problems and accidents (due to inundation & sanitation issues) during storm surge events. During storm surges the coastal areas (especially 2 and 3) will be flooded in inland directions. This could cause accidents (especially for vulnerable groups such as the elderly, children, disabled etc.) and - in case of longer duration of inundation - to water quality problems and effects on diseases such as diarrhea etc.
- *Potential for urban and leisure development*. Especially in section 4 (partly in section 2), the measures create safety and preserve a long stretch of beaches. This will create opportunities for development of real estate and leisure, such as beach clubs, restaurants, hotels etc. The additional development of these functions -although likely- is not easy to forecast, especially for a long period up until 2100. The impacts of more safety on prices and development

opportunities for real estate can generate distributional impacts. Some areas, which are without protective measures are currently not interesting for development, but these areas will become more interesting for developers after protective measures are in place. This might be the case at the most interesting spots in the sections 2 and 4. Although this real estate development can bring economic gains to the city and for the developers or current land owners, it might crowd out some low-income people in the most attractive places.

Benefits of adaptive measures

The adaptive measures will also result in number of benefits which are not easy to quantify due to inherent complexity of these 'softer' impacts and lack of data. These benefits are:

- Better policies, regulations and land management for coastal zone management: which eventually could result in more safety and avoidance of damages in coastal areas in Liberia;
- Improved capacity of relevant institutions dealing with Coastal Zone Management. This could eventually also lead to better implementation of policies, stronger coordination between institutions and therefore more safety in coastal zone areas in Liberia;
- Stronger awareness of communities in coastal areas for climate change hazards and options for self- adaptation. Eventually this could create more resilient communities for climate change hazards, such as storm surges or flash floods cause by extreme rainfall.
- More resilient infrastructure in coastal areas: which would avoid loss of infrastructure due to coastal retreat and isolation of communities or blockage of transport corridors during storm surges or extreme rainfall. This would reduce economic damage due to failure of infrastructures.

Table 5-6: Overview benefits of protective and adaptive measures

Section	Alternative	Key benefits & intangible benefits
Protective alternatives		
2	Revetment New Kru town	Damage reduction (coastal retreat & storms) Safety (real estate prices) Intangible benefits (PM)
3	West Point Option A Revetment	Damage reduction (coastal retreat & storms) Safety (real estate prices) Intangible benefits (PM)
3	West Point Option B Groynes	Damage reduction (coastal retreat & storms) Beautification and safety (real estate prices) Intangible benefits (PM)
4	American Embassy Groyne & beach nourishment	Damage reduction (coastal retreat & storms) Beautification and safety (real estate prices) Intangible benefits (PM)
Adaptive alternatives		
All sections	Adaptation of livelihoods and the environment	-Improved biodiversity - More sustainable fisheries - Mitigation of climate change impacts
Idem	Strengthening governance	-Better policies, regulations and land management -Improved capacity of relevant institutions -Increased safety in coastal areas in Liberia
Idem	More climate resilient infrastructure in coastal areas	-Reduction in economic and social costs due to failure of infrastructure

Key result indicators in Cost-Benefit Analysis (CBA)
The most well-known CBA result indicators and decision criteria are net present value (NPV), internal rate of return (IRR) and benefit-cost ratio (BCR).

Net Present Value (NPV) is the present value of the sum of all future benefits and cost (aggregated). Benefits in the future cannot be valued the same as todays benefits, as people have a time preference (you will prefer to receive an income now as opposed to 10 years later). This is why all costs and benefits are discounted to the values of 2019 in a CBA. The NPV is basically the difference between the absolute (discounted) damage benefits minus the absolute value of all discounted costs.

The *Internal Rate of Return (IRR)* gives the rate of return of a project at which the NPV is equal to zero (and is used to compare against the opportunity costs of the investments, what could be the return on any other public investment, in this case assumed at 5%). So, if the IRR of the measure is higher than 5%, this implies investing in the proposed measure provides additional well-being for society.

The *Benefit – Cost ratio* (BCR) is basically equal to the present value of the sum of benefits divided by present value of all costs. If BCR is larger than 1, this implies the benefits of the proposed measure are large larger than the costs to society (implying the measure improves net welfare, if BCR is less than 1 net welfare is reduced)

We propose to use the Benefit Cost ratio's as the main indicator for the CBA assessment. The NPV has the disadvantage that when comparing alternatives, the absolute scale of the measure plays a role. For these reasons, we propose to focus on the BCR in the CBA study (but we will also present the NPVs as this indicator provides information on the absolute reduction of damage against costs).

5.3 CBA Results

The table below shows the discounted total costs, and discounted benefits (risk reduced) by an alternative compared to the do-nothing scenario (for the high climate change-economic scenario). The two right end columns illustrate the NPV and BC ratio for each alternative compared to the do-nothing scenario.

Table 5-7: Overview costs and benefits of measures (USD, Present values 2019), high climate change (RCP 8.5) and optimistic socio-economic scenario

Alternative	Discounted costs	Discounted benefits	NPV	Benefit-cost ratio	E-IRR
	USD	USD	USD	-	%
Revetment New Kru town	20.924.695	27.843.891	6.919.196	1,3	8%
West Point Option A Revetment	14.426.380	48.332.387	33.906.008	3,4	23%
West Point Option B Groyne & nourishment	12.964.441	48.323.085	35.358.644	3,7	32%
American Embassy Groyne & beach nourishment	12.638.256	28.223.431	15.585.176	2,2	26%

Implementation of the proposed protective measures have positive net welfare effects for Liberian society (discounted benefits are larger than the discounted costs) in the high climate change, optimistic socio-economic scenario. Gains are especially high in West Point due to the large coastal retreat damage reduction impacts in that area. It can also be concluded that West Point option B is the most economically feasible intervention. Option B shows a slightly better benefit-cost ratio performance compared to option A due to lower Capex and beautification & recreational benefits of the beach preservation under A, even though OPEX of option B are higher than A. However, the sustainability of option A might be lower due to the need for repeated beach nourishment. Option A was the higher rated option in the stakeholder's consultation in January 2019.

In the next section we will test how robust these results are in light of some different assumptions regarding for example climate change scenario, economic growth and discount rate.

5.4 Risk and sensitivity analysis

Risk analysis

A full risk analysis would identify and assess all risks relevant for the project: environmental, institutional, legal, social, technical, financial, economic etc. This section does not contain a full risk assessment for the strategy, but briefly discusses potentially important risks and focuses on those risks relevant for the outcomes of the cost benefit analysis (CBA). In below table we highlight some important risks and also provide some risk management options.

Table 5-8: Risk assessment

Risk	Risk management option	Relevancy
Environmental		
Higher climate change scenario	Establish monitoring system: monitoring sea level rise and coastal retreat in Liberia (protective measures are designed for RCP 8.5)	Very relevant

Risk	Risk management option	Relevancy
Pollution (ocean, fish breeding areas etc.)	Improving mangroves, etc.	Relevant
Institutional		
Lack of capacity for implementation & maintenance (undermining effectiveness & sustainability of projects, such as beach nourishment)	Capacity building of relevant institutions, see adaptive measures	Very relevant
Legal		
Lack of enforcement (Illegal sand mining continues)	Improving land management and enforcement policies (see adaptive measures)	Very relevant
Social		
Lack of involvement, awareness and collaboration of communities	Involving communities, adaptive measure on awareness	Highly relevant
Technical		
Poor quality of construction and maintenance	Sound and transparent requirements, procurement process and documents, sound and transparent selection of contractor	Highly relevant
Financial-economic		
Higher or lower population and economic growth in the coastal sections	Protective measures sufficient for higher growth scenario	Medium (discussed in sensitivity analysis)
Higher investment costs (capex)	Reserve funding for high Capex scenario, assess robustness of CBA (see below)	Medium (see below)
Limited funding for maintenance (especially risk for sustainability of beach nourishment)	Developing long term funding instrument (see adaptive measures)	Highly relevant

Especially, the identified social, technical and institutional risks are highly relevant for the effectiveness and sustainability of the protective measures. This is why the adaptive measures play an important role in mitigating these risks. In regard of the cost-benefit analysis especially the financial - economic risks are important to consider. In the next section a sensitivity analysis is presented focusing on some of these risks.

Sensitivity analysis

There are a number of future uncertainties regarding key (input) assumptions and future developments relevant for the costs and benefits. This is especially relevant here given the long-time horizon (2019-2100). For this CBA several factors are uncertain and important for the results of the CBA. These are:

1. The rate of *climate change*. There is no consensus yet on what level of climate change is to be expected. This is why IPPC has constructed a number of climate change scenarios. In this study we have used RCP 8.5 (high climate change) and RCP 4.5 (limited climate change). In above table results were presented for the high climate change (RCP 8.5) and optimistic socio-economic scenario. Below, we will show the CBA results with the low climate change, and pessimistic socio-economic scenario, illustrating the low side of the bandwidth of potential benefits.
2. The (future) *population and economic growth* rates (income growth) (as one of the determining factors of the future size of the assets (at risk) and resulting damage reduction benefits; This is why we have developed two scenarios for population and economic growth. Below, we will show the CBA results with the low climate change, and

pessimistic socio-economic growth scenario to also illustrate the lower side of the bandwidth of potential benefits.

3. *Investment costs*: the BoQ estimates are based upon preliminary design and materials estimations. These still have a range of uncertainty at this stage of the feasibility study. In the base-case CBA we have used the average Capex estimations. Also, estimations have been made based upon lower and higher units and unit prices (BoQ +/ - 20%) and different contingency and indirect cost assumptions (35-55% in investment costs). Therefore, we show below the CBA results (BC-ratio's) at higher and lower investment costs (capex -20%, +20% compared to the average estimate);
4. The *discount rate* (6% has been assumed based upon various methods and sources as described in the first section in this chapter). We will also use the results at other reasonable levels of the discount rate (Stern rate / low rate of 3%) and a high discount rate of 9% (the latter implies that climate change impacts after 2050 and for next generations have a very low weight in the present value of all benefits);

In below table we provide an overview for the protective alternatives of the changes in Benefit Costs (BC) ratio's due to the changes in key assumptions.

Table 5-9: Sensitivity analysis of CBA results, compared to base case CBA.

	Benefit- cost ratio					
Alternative	**Base case CBA**	**Pessimistic scenario**	**Low capex**	**High capex**	**3% discount rate**	**9% discount rate**
Revetment New Kru town	1,3	1,3	1,7	1,1	2,2	0,9
West Point Groyne option A Revetment	3,4	3,2	4,2	2,8	9,7	1,7
West Point Option B Groyne	3,7	3,5	4,7	3,1	9,7	2,0
American Embassy Groyne & nourishment	2,2	1,8	2,8	1,9	3,4	1,7

Note: a B-C ratio higher than 1 implies discounted benefits are higher than discounted costs. Below 1 implies discounted costs are higher than the benefits.

As can be seen in the table the overall benefit costs indicators results are not very sensitive to changes in the assumptions. For most alternatives the BC-ratio stays above 1 (benefits outweigh costs) under different more pessimistic assumptions. There is one exemption regarding the revetment in New Kru town. The B-C ratio falls below 1 in case of a higher discount rate (9%). However, such a high discount rate for climate change impacts is not theoretically justifiable as future generations would have zero weight in the discounting of benefits (see also the first paragraph of this chapter). Moreover, apart from the quantified benefits there are a number of intangible benefits which were not included in the BC-ratio.

5.5 Conclusions

A number of conclusions emerge from the cost-benefit analysis.

Firstly, the damages of coastal retreat and storms are substantial and increasing in the period 2020-2100. Especially, for the sections 2, 3 and 4 damage costs of coastal retreat and storms in the do-nothing scenario are already millions of US dollars in 2030 and increase by a factor 17 to 2100. No action would risk a serious loss of assets (buildings, infrastructures), but also loss of beaches with important livelihood values for fishermen and social and recreational values for the communities.

Secondly, the cost-benefit analysis shows that for all alternatives the benefits outweigh the costs for society. Apart from high damage reduction benefits, protective measures with beach nourishment and promenade have beautification impacts and intangible benefits. Especially, the protective measures in sections 2 and 3 serve to protect the livelihood of the fishery and market communities. For West Point, the groyne & nourishment option performs better compared to the revetment option, both due to lower investment costs and due to beautification benefits of preserving the beach. However, participants in the stakeholder consultation workshop of January 2019 rated option A (revetment) higher due to risks a number of stakeholders perceived regarding sustainability of beach nourishment and maintenance.

Important risks are related to the institutional and funding capacity of relevant authorities for implementation and maintenance of the protective structures. It is for this reason that the adaptive measure on ICZM capacity building is important as risk mitigation. Sensitivity analysis shows that also with more pessimistic assumptions most alternatives perform well in terms of benefit-cost ratios.

6. IMPLEMENTATION

6.1 Organisation

The project will be implemented over a period of 7 years according to UNDP's National Implementation Modality (NIM).

National implementation is the norm for UNDP programme activities, taking into account the capacities of programme countries and the nature of UNDP programme activities. It applies where: (a) there is a government entity directly concerned with the project's activities and results; (b) there is a government entity whose intended role is to sustain project results; and (c) the relevant government entity has adequate capacity and is committed to carrying out the project as determined by a capacity assessment.

Under this system, the following definitions are used.

- Execution is the overall ownership and responsibility for UNDP programme activities at the country level;
- Implementation is the management and delivery of programme activities to achieve specified results including the procurement and delivery of UNDP programme activity, inputs and their use in producing outputs, as set forth in a signed document between UNDP and the implementing partner.

Responsibility	Entity term	Organisation
Execution – ownership of results	Government Co-ordinating Agency	Project Board
Implementation – management and mobilisation of resources	National Implementing Partner	Environmental Protection Agency
"Contractual" – provision of goods and services	Responsible Party	Contractors and service suppliers

The National Implementing Partner is accountable to UNDP and the Government Co-ordinating Agency for the reporting on progress towards the achievement of results.

The National Implementing Partner is accountable to UNDP for the documenting of the prudent and proper use of resources.

Organisational arrangements

The organisational arrangements are summarised as follows and shown graphically in the organisation chart shown in Figure 6-1.

1. UNDP will have responsibility for overseeing the implementation of the project.
2. A Project Board will be established to provide guidance and support for the smooth implementation of the project as the **Government Co-ordinating Agency**.
3. The Environmental Protection Agency (EPA) will be the **National Implementing Partner** in this project, with UNDP Country Office support.
4. The project implementing partner, EPA, will have full responsibility under the NIM arrangements to ensure accountability, transparency, timely implementation, management and achievement of results.
5. The EPA will appoint a full-time National Project Director (NPD) to oversee the coordination of project activities through different line Ministries.

6. The EPA will also hire a Project Manager (PM) to oversee actual implementation and the operational aspects of the project.
7. The day-to-day management of the project will be entrusted to a Project Management Unit (PMU) which will be accountable to the National Project Director and Board for the performance of the project. The PMU will be based in Monrovia.
8. The PMU will be manned by the PM, a Project Finance and Administration Assistant, and a Technical Advisor financed from the GCF grant. The PM is accountable to the National Project Director for the quality, timeliness and effectiveness of the activities carried out, as well as for the use of funds.
9. The PMU will arrange the contracting of service providers as the **Responsible Parties** to deliver the various activities, components and interventions.
10. Project interventions will be supported by the relevant government executing agencies including the Ministries of Public Works (MPW), of Lands, Mines and Energy (MLME), of Transport (MOT), the National Fisheries and Aquaculture Authority (NAFAA), the Liberian Land Authority (LLA), and others.
11. The representatives of MPW, MLME, MOT, NAFAA, LLA etc. shall form the Project Implementation Technical Support Team (PITST) in order to provide technical advice and guidance to the PMU.
12. The PITST will be supported by experts (both national and international) who will be contracted to perform specific tasks as required by the project.
13. The NPD will ensure a continued cohesion between the project and the government development plan and programmes, and provide additional linkages and interactions with high level policy components within the government. Through this arrangement, the EPA will be in a good position to assume responsibility and follow up on, supervise and coordinate the contributions from stakeholders.

Planning and reporting

The PMU will produce Annual Project Performance Reports (PPR) and Budget and Work Plans (ABWP), to be approved by the Project Board at the end or beginning of each year. These reports and plans will be submitted to the GCF Secretariat after having passed all the UNDP clearance steps.

Project Board organisation and responsibilities

The Project Board will be chaired by the Executive Director of the EPA, and will comprise UNDP, a senior representative of the Government of Liberia (expected to be from the Ministry of Finance and Development Planning), and a senior representative of the Monrovia City Corporation (MCC). Representatives of other stakeholder groups may be included in the Project Board, as considered appropriate and necessary.

The Project Board will meet at least twice per annum (or more often if required).

The Project Board is to approve the project annual work plan (AWP), and authorise any major deviation from the agreed work plan. It will arbitrate on any conflicts within the project or negotiate a solution to any problems between the project and external bodies. In addition, it will approve the appointment and responsibilities of the Project Manager and any delegation of its Project Assurance responsibilities.

The Project Board's constitution will be reviewed and recommended for approval during the Local Project Appraisal Committee (LPAC) meeting (a UNDP procedural and minuted meeting which allows the Resident Representative to sign off on a Project Document).

Specific Roles of the Project Board include:

a) The Board shall set strategic direction, reinforce government leadership of the programme and coordinate all interventions;
b) Provide guidance and agree on possible countermeasures or management actions to address specific risks;
c) Agree on the Project Manager's tolerances in the Annual Work Plan (prior to approval by UNDP) and quarterly plans when required;
d) Conduct regular meetings to review the project progress, and provide direction and recommendations to ensure that the agreed deliverables are produced satisfactorily according to the approved Annual Work Plan;
e) Provide ad-hoc direction and advice for exceptional situations when the Project Manager's tolerances are exceeded;
f) Review and approve all activities that are supported by the programme, based on the agreed objectives, work plan and availability of funding;
g) Provide technical advice to create synergy and uniformity between programme-supported activities and policy;
h) Guide and support programme delivery at sectoral level;
i) Provide support in resource mobilisation to support programme funding gaps;
j) Undertake monitoring and evaluation of programme activities through periodic meetings and occasional site visits;
k) Receive reports on all activities supported by the programme to serve as an additional basis to assess and monitor performance and delivery.

Project assurance

The UNDP (Country Office and Regional Support unit) will provide oversight of the project's implementation to ensure the proper use of GCF resources and the project's progress towards achieving the expected outputs, outcome and development objective outcomes.

As requested by the Government of Liberia, the UNDP Country Office will provide the following support services for the implementation of this project, and recover the actual direct and indirect costs incurred by the Country Office in delivering such services as stipulated in the Letter of Agreement (LOA) between the Government of Liberia and UNDP and following the Universal Prices List:

- Payments, disbursements and other financial transactions;
- Recruitment of staff, project personnel, and consultants;
- Procurement of services and equipment, including disposals;
- Organisation of training activities, conferences, and workshops, including fellowships;
- Travel authorisation, government clearances ticketing, and travel arrangements;
- Shipment, customs clearance, and vehicle registration.

Procurement responsibilities

- Ownership of project equipment: UNDP unless there was a transfer of title on purchase.
- Disposal of project equipment: UNDP in close consultation with IP
- Preparation of terms of reference and specifications: Implementing Partner in close consultation with end user and UNDP.

Funding arrangements

UNDP's National Implementation Modality has the following funding responsibilities.

Cash Transfer Modality	Procurement / Obligation	Disbursement
Direct cash transfer	Implementing Partner	Implementing Partner
Direct payment	Implementing Partner	UNDP
Reimbursement	Implementing Partner	Implementing Partner

Direct payments to vendors

- Implementing Partner requests UNDP to pay
- Implementing Partner fills Direct Request Form

Direct Cash Transfer/NEX Advance to Implementing Partner

- Reporting period – Quarterly
- Tool – Funding Authorisation and Certificate of Expenditure – FACE

Signing of Combined Delivery Report (Financial Report) produced by UNDP

- Implementing Partner and UNDP

Project audits

- Government Audit Office or Private Auditors engaged by UNDP in consultation with GCA and GAC
- UNDP prepares Audit Plan in consultation with GCA
- UNDP shares Audit Plan with the Implementing Partner

Organisation Chart

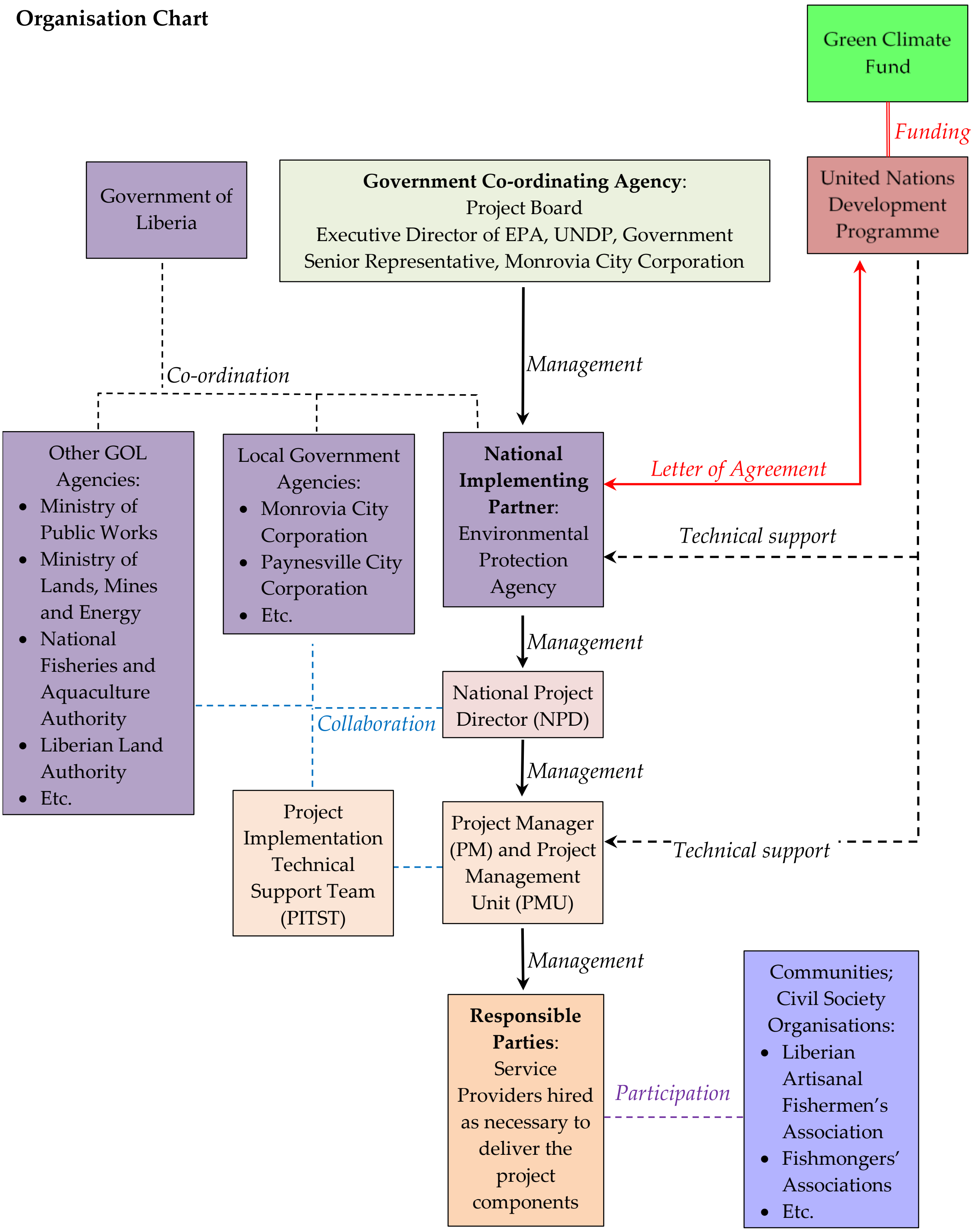


Figure 6-1: Organization Chart

6.2 Procurement

Adaptive interventions

It is anticipated that the adaptive interventions will be implemented by specialist service providers through a series of contracts. Most of these will be consultancy companies, but in some cases suitably qualified non-governmental organisations or civil society organisations might also be considered. In most cases, the skills and expertise are new to Liberia, and so consortia of local and international consultants will be needed.

The terms of reference for the various measures should be prepared by the PMU with the assistance of UNDP. This activity might be outsourced to the project's detailed design consultant (see below). Contracting of services would then follow a standard pattern, with appropriate delivery milestones built in against the payment schedule, and sufficient quality assurance processes in place.

Table 6-1 shows the summary of the potential implementation schedule for the Adaptation measures. The detailed implementation schedule can be found in Appendix B.

Table 6-1: Summary implementation schedule Adaptation measures

Activities	2020				2021				2022				2023				2024				2025				2026			
	Year 1				Year 2				Year 3				Year 4				Year 5				Year 6				Year 7			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Typical Adaptive Intervention																												
Prepare terms of reference																												
Tender and procure service providers																												
Mapping, survey, etc.																												
Identify vulnerable target groups																												
Develop intervention first component																												
Implement intervention first component																												
Implement intervention second component																												
Evaluate effectiveness and follow up																												

Protective measures

Procurement for the protective measures can be done using one of several options. The main approaches considered are as follows.

- **Design and Construct**
  Under this arrangement, each major construction project is tendered to a company that will undertake the detailed design and then construct it. This minimises the administration for the client organisation, and means that the contractor takes a greater share of the risk. Design and construct is being applied more and more by employers that have the capability to review and monitor the process themselves. This approach is suitable when employer is open to new alternatives as well as optimisations of design and costs. The contractor may choose to alter the design from the original specifications, which can lead to additional consultations with stakeholders and a different post-construction maintenance regime. Hence, the functional requirements are important and need to be specified in detail. Ensuring a high standard of build quality can also be hard, since the contractor tends to be dominant in this more hands-off approach. The preparation of tender documents that will ensure the desired outcome is complicated for a design and build contract, and itself often requires a consultant to assist. Design and Construct is being applied more and more in coastal/marine construction projects. It is strongly advised to apply FIDIC yellow book.[5]

- **Construct only**
  This is an arrangement whereby the implementing organisation either undertakes the detailed design itself or commissions it through an engineering consultant. This consultant

[5] http://fidic.org/

would typically also prepare the contract documents for construction, assist in contractor procurement and supervise the actual building of the project. Construct only is preferred when employer is not open to alternatives, and wants a design to be constructed straightforwardly according to design and specifications. Construct only preferable when design is to be constructed by local and/or less experienced/capable contractors. It is strongly advised to apply FIDIC red book.[5]

Complexity, viz. amount of interfaces between different type of infrastructures, buildings and functions and conditions to be handled can determine what type of contract arrangement is more suitable, particularly in relation to whether national or international contractors are considered.

7. CONCLUSIONS AND RECOMMENDATIONS

Vulnerability

Coastal communities and infrastructure in Monrovia are vulnerable to climate change induced coastal hazards. Up to 2018 over 670 households are reported to have been displaced due to coastal retreat, which is the main identified coastal hazard.

From the vulnerability assessment (PART I – Vulnerability Report) it can be concluded that the Liberian coastline is very dynamic, with open exposure to the high-energy oceanic environment. The low-lying areas of the coast around Monrovia have been threatened by significant coastal retreat, which has led to loss of valuable land and assets.

Monrovia has outgrown the secure terrain on which it was founded in the early nineteenth century, expanding mostly inland. However, several communities of fisherfolk have established themselves on the beaches below the city, and in turn the city has become dependent on them for its food security, specifically in their provision of protein through low energy artisanal catch methods. However, the presence of these communities is now threatened by coastal retreat. It is hard to translocate them elsewhere because of the lack of alternative landing sites and the fact that a wholesale move inland would fundamentally damage the societies and the conditions underlying their livelihoods.

The impacts of climate change in this part of the West African coast are expected to be sea level rise and increased impacts from waves. This has resulted, and very likely will result, in an amplification of the expected coastal retreat and the inundation of the low-lying beaches and land immediately behind them. These are the locations of a number of urban areas, including the densely populated communities of West Point and New Kru Town. The beaches themselves are the launching and landing sites for the artisanal fishing boats, as well as the recreational open spaces required by every urban society.

Based on the vulnerability mapping it is concluded that the sections New Kru Town (2), West Point (3) and American Embassy (4) are the most vulnerable sections which require protective measures to reduce its vulnerability (and potential future damage) considerably.

Climate resilient strategies

Climate resilient strategies are developed, which comprises a synergy between adaption and protective measures. Adaptation measures help to minimise the drivers of climate change, while protective measures help to mitigate the impacts of climate change.

The key conclusion is that the proposed project must address the complex climate change issues facing society and the environment through a broad range of technical and non-technical measures, combined in climate resilient strategies. The intention is that both types of measures must go hand in hand with each other.

Adaptative measures

The adaptative measures exploit opportunities to safeguard currently sustainable livelihoods that are low consumers of carbon energy, and which consequently promise to give Liberia “green” living approaches for both the current and future generations. The project focuses on the inshore artisanal fishery of Monrovia, which contributes significantly to the city’s food security with very low carbon emissions. Moreover, a number of adaptive measure prepare the capacities and awareness among relevant stakeholders for effective and sustainable implementation of the protective measures. However, a number of interventions are required to ensure that the environment supporting this will continue to sustain it as climatic conditions change, and impacts increase as a result of higher sea levels and stronger storms

Protective measures
There is no opportunity to use totally soft coastal protection measures on the Monrovia beaches, such as the establishment of fringing mangroves, because the wave energy is too high and the beach profile too steep. Any protection of the coastline against sea level rise and greater storm wave energy must be robust. The measures designed are relatively soft, using beach nourishment and vegetation where possible. But the high energy coast means that strong physical protection in the form of groynes and revetment walls cannot be avoided if structures are to be successful in protection of the communities and assets in the coastal sections.

Basically, two types of protective measures are proposed:

A. Revetment including promenade and fishing landing sites
B. Beach replenishment, including groyne

The first type has been proposed for New Kru Town and West Point and the second type for American Embassy and as second alternative for West Point. It is concluded that both types of protective measures are technically feasible at the proposed locations. The preliminary designs are made based on specified functional requirements and design criteria.

The following additional conclusions and recommendations are made regarding the protective measures:

- In principle the revetment solution is technically more robust compared to the beach replenishment. The rock works are able to withstand extreme events and will fix the coastline with minimal maintenance required. Beach replenishments inherently will need higher maintenance and have a shorter design life compared to rock works. The maintenance is however minimized by implementation of the groyne. This means that the revetment solution can be considered a more sustainable solution.
- Beach replenishments will however preserve the typical character of the present shoreline. Both the present recreation, fishery and ocean view can remain as it is and the environmental impact and impact on aesthetic value is limited. The inclusion of the promenade in the revetment design enables accommodation for recreation but will change the present landscape (existing beaches will disappear over time).
- The soft character of the beach replenishment and the associated uncertainty in terms of durability, ultimately leads to a slightly conservative design. Although much effort has been put into the design of the alternatives, optimization of the design, especially the beach and groyne layout, is recommended.
- The CAPEX costs are in general higher for the revetment solution compared the beach replenishment solution. The OPEX costs are however significantly higher for the beach replenishment alternative compared to the revetment solution.
- Based on the MCA workshop it became apparent that the revetment solution was considered mostly socially acceptable. The aspect of (political) sustainability was considered a heavily weighted criterion after the workshop.
- Since the designs are preliminary, it is recommended to further detail the designs, especially the interfacing, transitions, drainage, promenade pavements and beautification.
- It is emphasized that the protective measures are considered not sustainable without implementation of the proposed adaptative measures. Especially capacity building to develop and maintain a sustainable coast in Liberia by sound coastal zone management policies and land planning is an important aspect. By raising awareness to strengthen community resilience for climate change a broader support for the project needs to be assured.

Financial and Economic Feasibility
The cost-benefit analysis shows that for all alternatives the benefits outweigh the costs for society. Apart from high damage reduction benefits, protective measures with beach nourishment and promenade have beautification impacts and intangible benefits.

For West Point, the groyne & nourishment option performs economically better compared to the revetment option, mainly due to lower investment costs. However, participants in the stakeholder consultation workshop of January 2019 rated option A for West Point (the revetment) higher due to risks a number of stakeholders perceived regarding the (political) sustainability of beach nourishment and maintenance.

Important risks are related to the institutional and funding capacity of relevant authorities for implementation and maintenance of the protective structures (especially regarding beach nourishment which should be repeated after 15-20 years). It is for this reason that the adaptive measure on Integrated Coastal Zone Management capacity building (including developing of a funding instrument) is important as risk mitigation.

It is recommended to optimize further the cost for the revetment and promenade in New Kru Town and discuss the designs for promenade and fishery landing sites with the fisheries community. In that sense acceptability and costs can be (further) optimized. Furthermore, we recommend to start with discussion and further development of the project regarding capacity building of national and metropolitan institutions in Integrated Coastal Zone Management in order to mitigate capacity and funding risks for co-finance and maintenance.

Preferred alternatives
In principal for all coastal sections three main protective alternatives are possible (see also Part I: Vulnerability Report). These are:

- Develop safety zoning, resettle and retreat (no investments, accept coastal retreat in the do-nothing scenario);
- Revetments;
- Groynes and beach nourishment.

These three alternatives have been extensively discussed in a consultation (MCA) workshop with stakeholders (including from the communities) in January 2019. From this workshop it also became clear that most stakeholders regarded the first option as not acceptable by the communities and not sustainable. The option was regarded as not sustainable due to experiences in the past with a lack of enforcement. The vulnerability analysis showed that sections 1 and sections 5 are not significantly affected by coastal retreat (limited damage due to coastal retreat expected in these sections). This implies that the benefits of investments would likely not outweigh investments in sections 1 and 5.

The conclusion was that only the alternatives (i) revetments and (ii) groynes combined with beach nourishment are relevant options for sections 2,3 and 4. For section 2 (New Kru town) the ongoing construction of a revetment created a precondition for further revetment construction in that section. For section 4 the large beach area with extensive use for social gatherings, recreation and fisheries favoured the beach widening and groyne as preferred alternative. Therefore, only for section 3 (West Point) the two alternatives remained possible from a technical and safety perspective.

In below table the pros and cons for these two alternatives for West Point are assessed (including the outcomes of the economic feasibility analysis/ CBA).

Table 7-1: Pros and Cons of Alternatives A and B for West Point

Alternative A: Revetment including promenade and fish landing sites		Alternative B: Groynes including beach widening & nourishment	
Pros	**Cons**	**Pros**	**Cons**
Robustness for more extreme hazards	Higher Investment costs	Lower investment costs	Less robust for more extreme hazards
Lower OPEX	Less potential for urban development	More potential for urban development	Higher OPEX
More sustainable/ less maintenance needed		Less sustainable, more maintenance needed	
Higher social acceptability by community			Lower social acceptability by community
	No preservation of beaches & recreational values	Preservation of beaches & recreational values	
	Negative environmental impacts	Limited negative environmental impacts	
Economically feasible	Less economically feasible than Option B	Economically feasible, more feasible than A	

In conclusion, Alternative B (beach replenishment and groyne) scores well regarding economic feasibility, preservation of beaches and recreational values, Investment costs and environmental considerations. Alternative A (revetment) has lower Operation and Maintenance costs and much lower needs for repeated maintenance (with less risks for sustainability of the solution). It was the latter which resulted in a higher acceptance for alternative A of the communities.

This report gives details of the interventions that have emerged from the studies and stakeholder consultations that led to its preparation. It is supported by a number of documents that provide the technical and economic analyses on which the proposed measures are based. An Environmental and Social Assessment Report provides a detailed appraisal of the risks associated with the project, and the ways in which they can be addressed; they are to be avoided through project design wherever possible, and mitigated through an Environmental and Social Mitigation and Monitoring Matrix where avoidance cannot be assured.

It is recommended that the Government of Liberia and the United Nations Development Programme now undertake the following key steps:

- Review the reporting and accompanying documents, and seek clarification from the project preparation consultants where necessary;.
- Discuss the proposed adaptive measures with relevant stakeholders/institutions and detail these further;
- Develop the proposed strategy into a funding proposal for the Green Climate Fund.
- Start arrangements with the relevant Ministries in order to discuss and ensure the national co-financing as required for the funding proposal for the Green Climate Fund;
- Establish the institutional structure for implementing the project, including the recruitment of the key implementation staff;
- Investigate most appropriate procurement strategy;
- Expand the stakeholder consultations with the affected communities, the appropriate elements of civil society, and the relevant metropolitan and national institutions.

8. REFERENCES

[1] Construction Industry Research, Information Association, Civieltechnisch Centrum Uitvoering Research en Regelgeving (Netherlands) and Centre d'études maritimes et fluviales (France), 2007. The Rock Manual: The use of rock in hydraulic engineering (Vol. 683). Ciria.

[2] Coastal Engineering Manual. Washington, D.C.: U.S. Army Corps of Engineers, 2006.

[3] Van der Meer, J.W., Allsop, N.W.H., Bruce, T., De Rouck, J., Kortenhaus, A., Pullen, T., Schüttrumpf, H., Troch, P. and Zanuttigh, B., 2016. EurOtop, 2016. Manual on wave overtopping of sea defences and related structures. An overtopping manual largely based on European research, but for worldwide application.

[4] D. Roelvink, B. Huisman and A. Elghandour, “Efficient modelling of complex coastal evolution at monthly to century time scales,” in Sixth International Conference on Estuaries and Coasts (ICEC-2018), August 20-23, 2018, Caen, France, 2018.

[5] Shore Protection Manual, 1984. U.S. Army Corps of Engineers, Coastal Engineering Research Center, U.S. Government Printing Office, Washington, D.C.

[6] Benedet, L., Dobrochinski, J.P.F., Walstra, D.J.R., Klein, A.H.F. and Ranasinghe, R.W.M.R.J., 2016. A morphological modeling study to compare different methods of wave climate schematization and evaluate strategies to reduce erosion losses from a beach nourishment project. Coastal engineering, 112, pp.69-86.

[7] Cost estimation for coastal protection – summary of evidence; Report SC080039/R7; Environment Agency, March 2015

[8] Global Investment Costs for Coastal Defence Through the 21st Century, Fifth GGKP Annual Conference on Sustainable Infrastructure(Global Climate Forum, Berlin, Germany); Robert J. Nicholls (University of Southampton, Southampton, UK), Daniel Lincke, Jochen Hinkel, Thomas van der Pol

[9] Crompton, 2001, “The Impact of Parks on Property Values: A Review of the Empirical Evidence”.

[10] McIvor, A.L., Spencer, T., Möller, I. and Spalding, M., 2013. The response of mangrove soil surface elevation to sea level rise. Natural Coastal Protection Series: Report 3. Cambridge Coastal Research Unit Working Paper 42. ISSN 2050-7941.

[11] Langley, J.A., McKee, K.L., Cahoon, D.R., Cherry, J.A. and Megonigal, J.P., 2009. Elevated CO2 stimulates marsh elevation gain, counterbalancing sea-level rise. Proceedings of the National Academy of Sciences, 106(15), pp.6182-6186.

[12] Cahoon, D.R., Day, J.W., Reed, D.J., 1999. The influence of surface and shallow subsurface soil processes on wetland elevation, a synthesis. Curr. Topics Wetland Biogeochem. 3, 72–88

[13] Morris, J.T., Sundareshwar, P.V., Nietch, C.T., Kjerfve, B. and Cahoon, D.R., 2002. Responses of coastal wetlands to rising sea level. Ecology, 83(10), pp.2869-2877.

A. CONCEPT NOTES ADAPTATION MEASURES

CONCEPT NOTE 1: CAPACITY BUILDING IN INTEGRATED COASTAL ZONE MANAGEMENT

Coastal area: entire coastal area of Liberia	
Measure title: Capacity Building of National and Metropolitan Institutions in ICZM and Land Use Planning	

Measure description – Adaptive Intervention 1	
Measure type: • **Construction** • **Knowledge & awareness** • **Institutional & capacity building**	Institutional & capacity building Knowledge & awareness
Timing:	Capacity building and strengthening co-ordination in project years 1 to 3. Supporting enforcement in project years 2 to 4.
Location of the Project (and specific area concerned):	All coastal zones of Liberia
Rationale of the measure	**BACKGROUND** The coastal zone of Liberia suffers from a number of hazards, such as erosion of the coastline, disappearance of mangroves and storm events with flooding of coastal areas. The pressure on the coastal zone is increasing due to population growth and the need for urban expansion, economic and infrastructural development activities etc. Climate change will worsen the coastal retreat due to sea level rise and due to more extreme storms and flooding. The protection of the coastal shoreline and urban development need to be coordinated between various institutions. **PROBLEM STATEMENT** The awareness, understanding, capacity and co-ordination between the relevant institutions regarding risks for the coastal zone and potential integrated solutions is still limited. The expected climate change, sea level rise and more extreme rainfall and storm events will worsen the situation of the coastal areas and can endanger assets and communities in Monrovia particularly, but also elsewhere along the Liberian coast. Institutions in Monrovia still have limited awareness and inadequate understanding of potential hazards and risks. They also have a lack of experience, funding mechanisms and tools regarding integrated coastal zone management policies and (international) practices. Co-ordination between the relevant authorities (particularly EPA, ministries and metropolitan organisations) must be improved to address these problems. Moreover, a sustainable national funding mechanism will need to be established to create sufficient funding for long term investments and for the maintenance of the coastal areas (including

	beaches, mangroves etc), and to avoid dependency on donor funding for the long term.
Objectives	**Overall (wider) objective:** The overall objective of this measure is to develop and maintain a sustainable coast in Liberia by sound coastal zone management policies and land planning. **Project purpose** The project purpose is to improve the capacity of and co-ordination between the relevant institutions responsible for Integrated Coastal Zone Management in Liberia. Specific objectives are to: • Strengthen integrated coastal zone management (ICZM) knowledge, skills and processes and tools in the relevant institutions; • Support the development of Coastal Zone protection plans and projects for Monrovia and other coastal areas in Liberia for donor funding (including Green Climate Fund applications); • Support co-ordination of ICZM policies and regulations between relevant ministries (Ministry of Public Works, Transport etc.), EPA and local authorities. • Strengthen land use planning; • Improve dispute settlement.
Target group(s)	The target group consists of operational staff involved in policies and projects along the coastal shoreline: • Environmental Protection Agency, • Ministries: Ministry of Public Works, Ministry of Transport, Ministry of Finance and Development and the Ministry of Lands, Mines and Energy • National Fisheries and Aquaculture Authority • Liberia Land Authority • Liberian Artisanal Fishermen's Association • Monrovia City Corporation • Paynesville City Corporation A detailed discussion with all of the institutions is essential to get more information regarding the needs, relevant departments and staff to involve.
Measure description & activities	The measure aims to improve the institutional capacity of the targeted institutions in relevant aspects of Integrated Coastal Zone Management: vulnerability analysis of coastal areas, and monitoring and forecasting tools for coastal retreat and hazards, planning of policies, measures and land use, development of coastal zone protection and adaptation projects, appraisal and funding of measures, implementation, monitoring and evaluation of coastal zone projects. The measure has three components: Component 1.1: Capacity building in ICZM Component 1.2: Strengthening coordination between institutions Component 1.3: Improvement of land use planning and enforcement **Component 1.1: Capacity Building in ICZM** Activity 1.11

	Trainings, workshops and (international) study and site visits regarding all phases and practices of ICZM for staff. Training of trainers and collaboration with local knowledge institutes for sustainability. Activity 1.12 Support to ICZM policies, regulations, funding mechanisms and project development (also for donors such as GCF) and on the job coaching. Activity 1.13 Establishing structures (inter-organisational and within organisations) for ICZM. Activity 1.14 Development of ICZM tools (vulnerability, forecasting & warning systems, data collection, monitoring etc.). **Component 1.2: Strengthening co-ordination** Activity 1.21 Establishing an Inter-agency ICZM working group, and defining roles and responsibilities. Activity 1.22 Organizing awareness and learning and discussion workshops on specific ICZM topics with the stakeholders. **Component 1.3: Capacity building for land management and enforcement** Activity 1.31 Support to the development of regulations, land registry systems and enforcement policies. Activity 1.32 Training and on the job support to enforcement implementation to stop illegal activities (sand mining etc.) Activity 1.33 Dispute resolution support & training. *Note: this component will work particularly to support components in interventions 3 and 6.*
Outputs (what is achieved after activity implementation in which year)	By the end of year 2, the following outputs should be achieved: • Policy and regulatory document on ICZM developed; • A funding policy or instrument (Fund) for sustainable funding of ICZM projects and maintenance established; • At least 2 planning and forecasting tools developed; • At least 50 people trained on all aspects of ICZM and land use planning and enforcement; • 2 study visits organized around ICZM practices to other relevant countries; • Inter-organizational ICZM working group established and active.
Budget (costs)	In USD (including indirect costs and VAT, specify separately any running / operational costs) About 3-4 million USD
Implementation modality	The project will be procured as a service contract to consultancies or knowledge institutes (or combinations thereof).
Responsible Implementing Agency	Environmental Protection Agency (EPA) would steer this part of the project.

Risks	Insufficient interest of some institutions. Lack of participation in trainings and workshops. Insufficient quality of service provider.
Risk mitigation actions advised	Create incentives for interest and participation by involvement of the institutions from the start, handing out diplomas, making workshops highly relevant and interesting etc. Select strong consultancies or consortia with a proven strong track record in ICZM (international and Africa) and capacity building (with experience in Africa) and with local partners (knowledge institutes or consultants) from Liberia.
Information or studies needed for further detailing	Discussions with the key stakeholders regarding the intervention concepts, and the participating institutions' needs and capacity gaps. Detailed terms of reference need to be devised for the various implementing consultancies. These are expected to be devised by the Project Management Unit with support from the participating line agencies.

CONCEPT NOTE 2: STRENGTHENING COMMUNITY AWARENESS AND MANAGEMENT OF COASTAL ZONE RISKS

Coastal area: Selected most vulnerable coastal areas in Liberia (including Monrovia coastal areas 2,3 and 4)	
Measure title: Strengthening of Community Awareness and Management of Coastal Zone Risks and Solutions	

Measure description – Adaptive Intervention 2	
Measure type: • **Construction** • **Knowledge & awareness** • **Institutional & capacity building**	• Knowledge and awareness • Institutional and capacity building
Timing:	Consultations and the preparation of materials will be undertaken in the first two years of the project. Awareness raising will be undertaken over an eighteen-month period in years 2 and 3, with evaluation and follow up in years 4 and 5.
Location of the Project (and specific area concerned):	Communities in the most vulnerable coastal zones in Liberia (including areas 2, 3 and 4 in Monrovia and selected areas at risk outside Monrovia).
Rationale of the measure	**BACKGROUND** Coastal erosion and climate change will impose risks to a number of communities along the coast of Liberia. Coastal retreat in combination with sea level rise and hazards such as storms imply possible loss of the beaches and areas along the coast in the period 2020-2050. This can affect the livelihoods of the communities living near the shoreline where people's incomes depend on activities related to the coastal zone, such as fisheries, recreation, markets etc. Up until now no systematic information and knowledge regarding these threats and potential solutions have been provided to the affected communities by the government or donors. **PROBLEM STATEMENT** The overall problem is that climate change will intensify coastal erosion processes because of sea level rise and increased storm events. This will result in retreat of coastal areas with a potential loss of beaches and assets (buildings, infrastructures etc.) and livelihoods as a result. However, many communities in the coastal areas in Liberia are not aware of these threats and are not knowledgeable of potential ways the communities could adapt or the government could protect the vulnerable areas.
Objectives	**Overall (wider) objective** To strengthen community resilience for climate change in coastal areas by reducing their vulnerability to coastal retreat and other climate related hazards (flooding caused by storms, extreme rainfall etc.).

	Project purpose (specific objective to be achieved for target group): To create awareness of coastal zone vulnerability (coastal retreat due to erosion and climate change) and environmental issues for communities. To strengthen the knowledge of communities' needs and potential solutions: adaptive and protective strategies by the communities themselves or protection measures by the government.
Target group(s)	Communities from the identified at-risk coastal areas in Monrovia and some selected most vulnerable coastal areas outside Monrovia. • Local inhabitants of vulnerable areas • Chiefs • Fishermen and fishermen's associations • Owners of beach clubs / restaurants/ recreational or tourism facilities • Others, to be determined
Measure description & activities	The measure will consist of the following components and activities. **Component 2.1: Investigations** Activity 2.11 Identifying and selecting the most vulnerable coastal zones in Liberia (in addition to these in Monrovia). Mapping of the most vulnerable coastal areas for climate hazards in Liberia is necessary in order to define the communities at risk. This mapping will be based on literature study, and the study of past coastal retreat based on maps and Google Earth images. Activity 2.12 Identification of the specific target groups in the selected coastal areas. Under this activity the specific target groups will be identified, such as local residents of houses at risk, local chiefs, fishermen or fishermen's associations, asset owners etc. The communities will be visited and representatives of the groups will be identified. Activity 2.13. Development of awareness and information strategy (including information materials and methods). Under this activity an awareness and capacity building strategy will be formulated. The strategy will include the communication methods with the target groups (workshops, movies, apps and other tools), topics of the information campaigns, information materials etc. Activity 2.14 Development of an awareness and capacity building programme and materials. The necessary awareness and capacity building products and materials will be developed, such as information brochures, presentations, interactive learning sessions, examples of protection and adaptive strategies of communities from elsewhere, apps etc. **Component 2.2: Implementation** Activity 2.21 Implementation of the awareness and capacity building strategy and programme. This activity includes the organisation of events (workshops, trainings), spreading brochures, etc. Workshops will be organized on the following topics: • Impacts of climate change on the coastal areas and communities; • Needs of the communities and ways the communities could become more climate resilient (what actions can communities do themselves, versus for which actions support from the government is needed);

	• Environmental issues: which environmental problems might arise and what would be solutions; • Gender issues: how will women be affected, and what are potential solutions. Activity 2.22 Evaluation, lessons learned and follow-up recommendations. Finally, the project should evaluate the programme with the stakeholders and target groups, and derive lessons learned and any needs for follow-up. This will all be documented in a final report and discussed in a finalization workshop with the relevant stakeholders.
Outputs (what is achieved after activity implementation in which year)	Project years 1 and 2: • Climate risks awareness and capacity building strategy for vulnerable coastal communities; • Awareness and capacity building programme (agenda) and information training materials and tools (brochures, workshop ppt presentations, apps, other). Project years 2 and 3: • At least 8 workshops & trainings organized; • At least 100 community representatives or members participated in the programme and are aware; • Community needs and potential community adaptation actions identified (reported and communicated). Project years 4 and 5: • Final report with evaluation of the awareness campaign, promising adaption actions, lessons learned and follow-up recommendations (and disseminated through workshop with key stakeholders).
Budget (costs)	In USD (including indirect costs and VAT, specify separately any running / operational costs) About 2 million USD
Implementation modality	The project will be procured as a service contract to communication consultancies or NGOs having experience of working with local communities and civil society.
Responsible Implementing Agency	National Fisheries and Aquaculture Authority could steer this intervention, together with the Liberian Artisanal Fishermen's Association.
Risks	1. Limited quality of the communication and capacity building strategy. 2. Lack of interest or participation from communities or certain target groups.
Risk mitigation actions advised	1. The quality of the strategy should be ensured by proper tendering and selection of the service provider. This should preferably be a consortium with experience in communication, working with local communities in Liberia and knowledge of climate change, coastal retreat and flooding, and adaptation or flood management measures. A combination of a local communication NGO or consultancy with international knowledge and skills as a training provider in climate adaptation seems preferable. 2. The strategy, programme and materials should be designed in such a way as to maximize community interest and participation. This implies involvement of community representatives from the start of strategy formulation and designing attractive, easy to communicate materials and attractive workshop settings.

Information or studies needed for further detailing	Detailed terms of reference need to be devised for the various implementing consultancies. These are expected to be devised by the Project Management Unit with support from the participating line agencies

CONCEPT NOTE 3: SUSTAINABLE FISHERIES MANAGEMENT

Coastal area:	Entire coastal area around Monrovia
Measure title:	**Management of Monrovia's Inshore Fisheries to Ensure Sustainability**

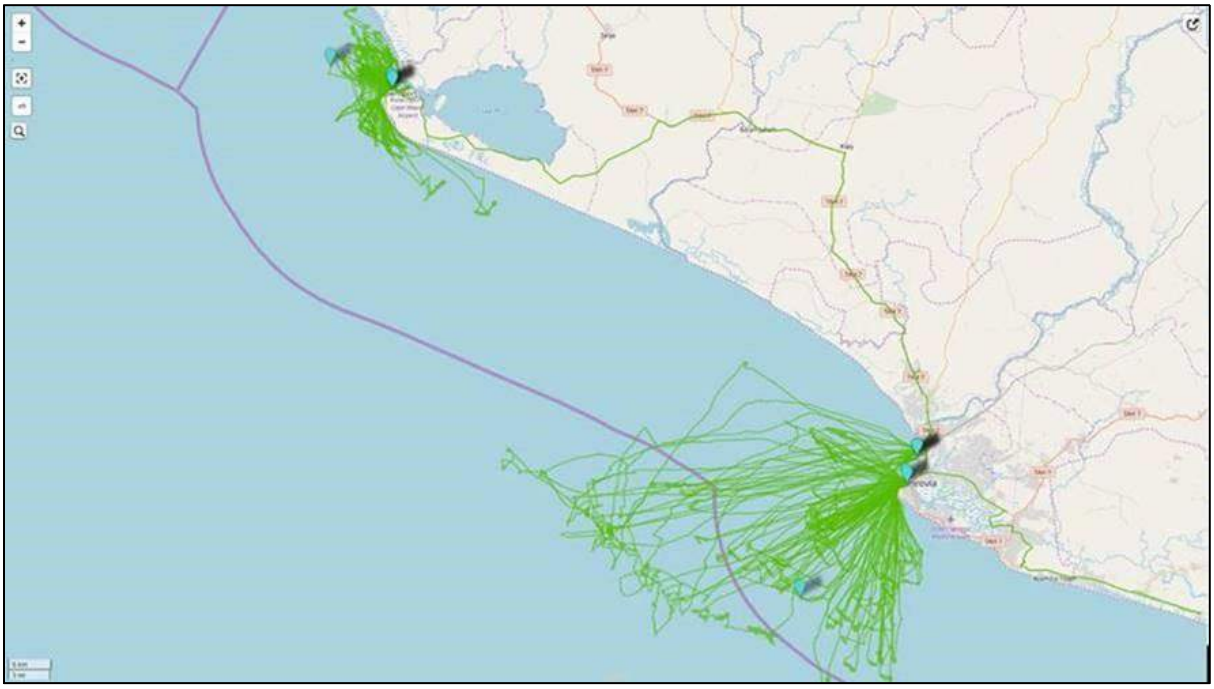
Measure description – Adaptive Intervention 3	
Measure type: • **Knowledge & awareness** • **Climate-smart planning**	This adaptation measure is to ensure the sustainability of low-energy, low carbon emissions artisanal fisheries in the inshore zone around Monrovia. This will help to safeguard the food security of Monrovia, while supporting the livelihoods of a large number of households in the poorer parts of the city. It will do this while helping to minimise the drivers of climate change.
Timing:	Years 1 to 4 of the project. Monitoring will continue throughout years 4 to 7.
Location of the Project (and specific area concerned):	The fishing communities are predominantly in New Kru Town (Coastal Area 2) and West Point (Coastal Area 3). The fishing map given after this concept note shows the inshore areas where the fishermen from these areas mainly travel for fishing. This is in an area with a radius of about 15 km from Monrovia, and is mostly within the inshore zone of 6 nautical miles. Fish processing takes place mainly within the same two communities and fish are mostly marketed in the city itself.
Rationale of the measure	**BACKGROUND** The Monrovia artisanal fisheries are based on two main landing beaches, at West Point and New Kru Town. The two main groups are the Kru, with small non-motorised canoes, and the Fanti, with larger canoes powered by outboard motors; there is a third, smaller group, the Popoh. These three peoples operate a sustainable fishery on a significant scale right in the heart of Liberia's capital city. Fish caught from the small wooden vessels are brought ashore within easy walking distance of the markets. This contributes to Monrovia's food security as well as providing the livelihoods of large communities. **PROBLEM STATEMENT** • Although the fisheries appear to have been sustainable up to now, details of catches and the sustainable offtake from the marine biological resource have not been established. The fisheries are poorly regulated and could go into decline if they are not better managed in the long term. • In most parts of the world, productive artisanal fishing is usually replaced by semi-industrial and fully industrial fishing methods once the local economy reaches a critical point of investment potential. This type of fishing requires high carbon-based energy, and is usually a driver of climate change. This transformation has not yet occurred in Monrovia, but it is likely to do so unless the existing fishing systems are strengthened to ensure their competitiveness. • Fish processing is mainly undertaken by the women in the communities of West Point and New Kru Town. With limited access to reliable electricity supplies, the main technique of fish preservation is smoking; this is frequently done using wood from mangrove trees, which are accessible using the fishermen's boats. In turn, this has led to a decline in the condition

	of the mangrove forests and the tidal habitat they provide. The low technology of smoking systems used means that the process is inefficient (in terms of wood consumption) and unhealthy for the smokers. • While the industry itself, with its low energy consumption, has a limited impact in terms of driving climate change, it is very vulnerable to the impacts of climate change. If it is to continue as a low energy industry, the launching of boats, and the landing, processing and selling of catches must all take place very close to the homes of both the fishermen and the urban consumers. This means it must take place on the city's more sheltered beaches, which are themselves due to be inundated and eroded as a result of rising sea level and increased storm waves. • Ensuring the sustainability of an industry in ways that limit the drivers of climate change is the subject of this intervention; stabilising the land in which it happens because of the impacts of climate change is the subject of the project's protective interventions.
Objectives	**Overall (wider) objective:** Maintenance of a low carbon industry to safeguard the livelihoods of poor communities and the food security of Monrovia without increasing the drivers of climate change. **Project purpose (specific objective to be achieved for target group):** To ensure that the current low energy artisanal fishery can continue to function, using low carbon emission methods to supply affordable protein to the local urban market.
Target group(s) and beneficiaries	The target group is the Monrovia artisanal fishing industry, which is split between fishermen (almost exclusively male), and fishmongers and sellers (the majority of whom are female). The beneficiaries are the individuals in the target group, the wider communities in which they live, and the large number of people living in Monrovia who rely on the fisheries to provide affordable protein.
Measure description & activities	This intervention involves a number of activities that are parallel or sequential within two sequential components. **Component 3.1: Investigations** Three concurrent activities. Activity 3.11 Study of catch volumes and species targeted by Kru, Fanti and Popoh fishermen, aimed at establishing the economic value of fishermen's livelihoods and assessing the industry's sustainability. Activity 3.12 Survey of the marine biological resources and assessment of their sustainable offtake capacity in the context of evolving climate change impacts, as a basis for a system of sustainable quotas. *Note: this activity will be combined with the survey of habitats required for Activity 4.11.* Activity 3.13 Study of low energy options for improvement of fish processing and storage facilities that removes the risk of mangrove forest degradation. Examples of the potential measures to be investigated include sustainable sources of wood for smoking and the use of solar and other renewable energies for refrigeration. **Component 3.2: Implementation**

	Three mainly concurrent activities. Activity 3.21 Institutional development and capacity building support to the Liberian Artisanal Fishermen's Association branches in the target communities, aimed at improving acceptance of and compliance with fishing rules and quotas at levels which will sustain a reasonable livelihood within the resource limits as affected by climate change impacts. Activity 3.22 Institutional development and capacity building support to branches of the Monrovia Fishmongers' Association, aimed at assisting the improvement of fish processing and storage systems (e.g. clean smoking technologies and refrigeration driven by solar power). Activity 3.23 Inshore 6 nautical mile zone enforced for artisanal fishing and sustainable offtake monitored. *Note: capacity development in support of this activity will be provided through Activity 1.32.*
Outputs (what is achieved after activity implementation in which year)	Year 1: • Report on options for low energy fish processing. Year 2: • Report and recommendations on the marine biological resources and offtake capacity. • Report and recommendations on catch volumes and species – effectively a potential sustainable quota system. Year 3: • Improvements in the management of catches through the fishermen themselves. • Improvements in fish processing and storage implemented at West Point and New Kru Town. Year 4 onwards: • Increased capacity among LAFA and relevant agencies to manage catches sustainably. • Monitoring and refinement of fishing rules and quotas to demonstrate a sustainable, low carbon emission industry.
Budget (costs)	In USD (including indirect costs and VAT, specify separately any running / operational costs) Studies and surveys: estimated 1.0 million USD. Implementation and monitoring: estimated 0.5 million USD. Support for low carbon emission fish processing and storage facilities: estimated 0.5 million USD. **Cost justification** The risk to society posed by what should be a readily preventable hazard that reduces food security – the over-exploitation of the resources behind the low carbon emission fisheries – has significant consequences both for the environment and society, as well as being intended to sustain the low emission industry that avoids contributing to the drivers of climate change.
Implementation modality	A number of specialist consultancies are expected to be required.

	• Study of marine biological resources, offtake capacity, fishery activities and catch volumes, with recommendations (a team of different specialists required, including marine biologists, sociologists and economists). • Study of fish processing and storage, with recommendations. • Development and capacity building implementation consultants for fishing. • Development and capacity building implementation consultants for fish processing.
Responsible Implementing Agency	This intervention will be managed by the Project Management Unit created and directed by the EPA with support from the UNDP. Participating line agencies are expected to be the EPA (on biological resources), NAFAA and LAFA (on fisheries) and the fish mongers' associations.
Risks	1. The pressure on the fishery is too great for a sustainable quota system to be designed. 2. Suitable sustainable wood sources for fish smoking cannot be identified as alternatives to mangrove wood.
Risk mitigation actions advised	1. Capacity building and awareness raising (adaptive interventions 5 and 6) will help to overcome individual and community inertia in encouraging adaptations to ensure the industry remains sustainable. 2. A broad view of sustainable and low energy fish processing and storage options need to be investigated.
Information or studies needed for further detailing	Detailed terms of reference need to be devised for the various implementing consultancies. These are expected to be devised by the Project Management Unit with support from the participating line agencies.

Adaptive Intervention 1. Map of recorded artisanal fishing areas. The green lines show tracks taken by fishing canoes. The lower cluster are fishermen based at West Point and New Kru Town. The upper cluster show fishing around Robertsport. The purple line shows the 6 nautical mile boundary within which fishing is reserved for artisanal boats. The longer routes going outside the reserved zone are Fanti drift netters in their larger, motorised canoes.



Source. http://www.macalister-elliott.com/news/electronic-data-collection-project-in-liberia-fishing-communities/ Accessed 29 March 2019.

CONCEPT NOTE 4: PROTECTED MARINE AND MANGROVE HABITATS

Coastal area:	**Entire coastal area around Monrovia**
Measure title:	**Protection of the Marine and Mangrove Habitats that Support Monrovia's Inshore Fishery**

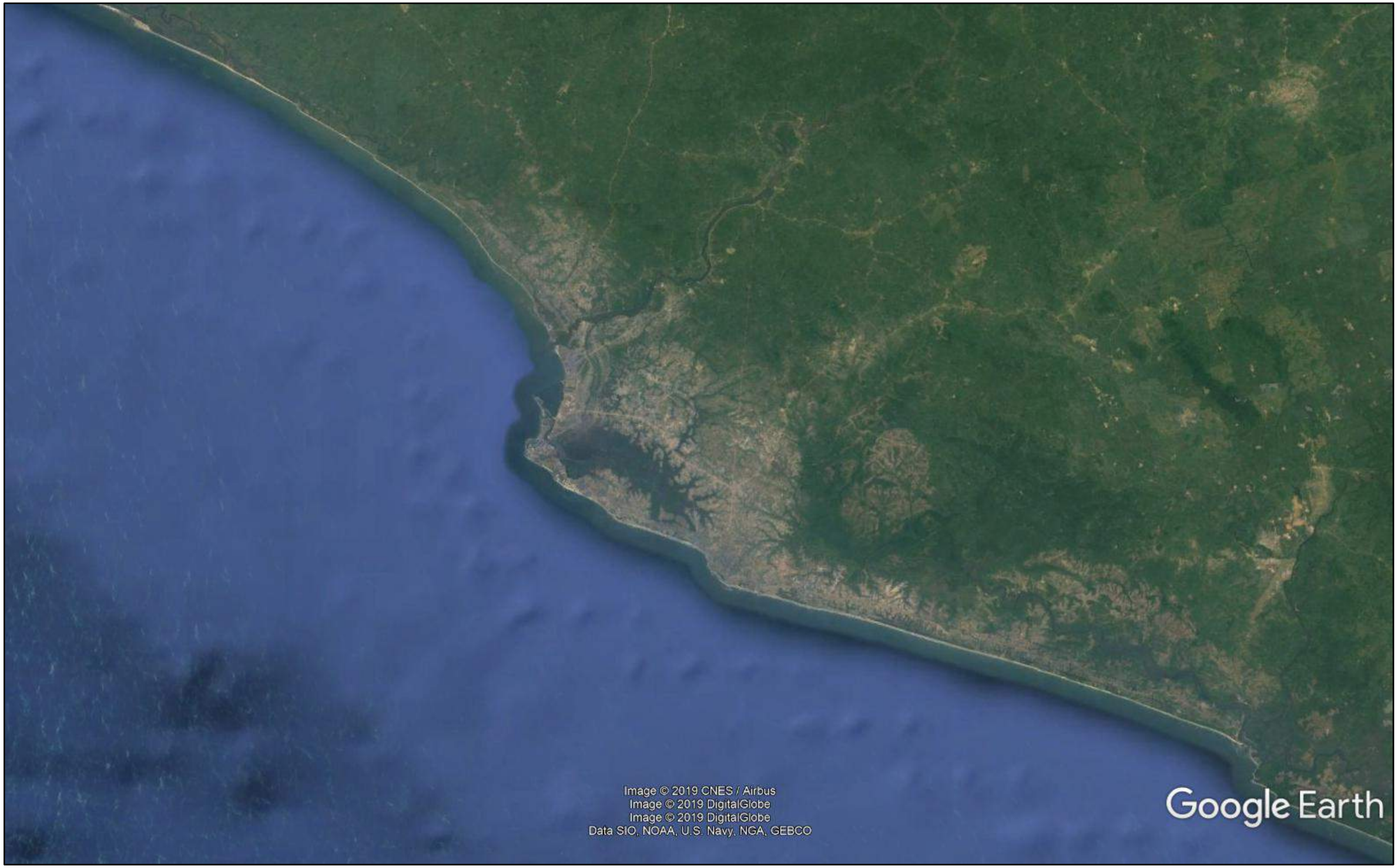
Measure description – Adaptive Intervention 4	
Measure type: • **Knowledge & awareness** • **Climate-smart planning**	This adaptation measure is to help ensure the sustainability of low-energy and low carbon emission artisanal fisheries in the inshore zone around Monrovia. This will help to safeguard the natural environment on this section of the coast, while sustaining food security and supporting the livelihoods of a large number of households in the poorer parts of Monrovia. It will do this while helping to minimise the drivers of climate change.
Timing:	The surveys required to move this intervention forward would happen over an 18-month period in years 1 and 2 of the project. If there is a justification to develop protected areas, then it would be undertaken in years 2 to 5 of the project. Support to the establishment of a protected area would occur from year 5 onwards.
Location of the Project (and specific area concerned):	Investigations should be focussed on the coast for at least 25 km on either side of Monrovia, and out to a depth of at least 50 metres. Particular attention needs to be paid to any areas where seagrass beds or coral are found, though neither are known of in this area. Otherwise the main areas of investigations must be the mangrove swamps in the many inlets, estuaries and lagoons along the coast.
Rationale of the measure	**BACKGROUND** The coastal waters of Liberia appear to be quite pristine, probably due to the relatively low population density and low level of development in the area. The estuarine mangroves are key breeding habitats for many of the marine species that form the fishery or sources of food for the species targeted by the fishermen. However, the marine biology of this area has not been surveyed in detail and its sensitivity to over-fishing, as well as to pollution and the impacts of climate change, all remain unknown. **PROBLEM STATEMENT** • The coast of Liberia faces the open mid-Atlantic Ocean. The warm tropical water supports a wide range of sedentary and roaming species of crustaceans, fish, reptiles and mammals. Many of these depend for at least part of their life cycles on the sandy beaches and the mangrove habitats in the tidal swamps in lagoons behind sand bars, as well as in inlets and estuaries. • Apart from a number of urban centres, of which Monrovia is the largest, the population along the Liberian coast has remained relatively low. Development has been slow to make progress, with the result that the marine fishery is still worked as an artisanal industry. This means that it has apparently remained sustainable on account of the high inherent natural fecundity and the absence of a large offtake using industrial fishing measures.

	• Development on land has led to extensive deforestation for habitation, agriculture and economic activities such as mining. In the urban zones of greater Monrovia, increasing pressure for land has led to encroachment towards the upper parts of the mangroves. In particular, the basin of the Mesurado River has been surrounded by urban development. Other mangroves are smaller in area, but have not been affected to the same extent. The sediment patterns of rivers have changed. • The effect of climate change to Mangrove areas is discussed in detail in Appendix C. • Exactly how intact the estuarine and marine ecosystems remain, is currently unknown. As a result, the vulnerability of the fishery to a decline in its underlying biological resource is also unknown. Even if the resource is still intact, it may not remain so indefinitely without positive action. If it cannot sustain the fishery in the long term, then the fishery itself will decline; and with it will decline the low-energy supply of protein to the city of Monrovia. • This intervention seeks to understand the biological resources supporting the fishery, determine whether legal protection is justified for some areas of marine or estuarine habitat, and support the people and government of Liberia in setting up that protection using existing national laws or international conventions.
Objectives	**Overall (wider) objective:** Determination of the ecological value of the marine and estuarine habitats in order to support the designation of protected area status if this is justifiable. **Project purpose (specific objective to be achieved for target group):** To ensure that the current low energy artisanal fishery can continue to function, using low carbon emission methods to supply affordable protein to the local urban market that is derived from sources made more sustainable by the protection of key supporting habitats.
Target group(s) and beneficiaries	The target of this intervention is the natural environment and not directly any human group. The beneficiaries are the artisanal fishing communities, the wider communities in which they live, and the large number of people living in Monrovia who rely on the marine and mangrove resources to support the fisheries that provide affordable protein.
Measure description & activities	This intervention involves a number of activities that are parallel or sequential within two sequential components. **Component 4.1: Investigations** One key activity. Activity 4.11 Study of the marine and estuarine biological environment, to determine the diversity and density of the biological resources related to the fisheries. *This will be combined with the study for Activity 3.02.* **Component 4.2: Implementation** Four mainly concurrent activities. Activity 4.21 Determination of areas where protected area status is justified. Activity 4.22 Consultation on the proposed protected areas; local and national agreements; preparation of management plans.

	Activity 4.23 Support to the Forestry Development Authority or another agency to draft the appropriate legal instruments to designate defined marine or estuarine areas as protected areas under either the Establishment of a Protected Forest Areas Network Act 2003, the Ramsar Convention or another national law or international convention. Activity 4.24 Support to the start-up of the management of the protected areas.
Outputs (what is achieved after activity implementation in which year)	Year 2: • Report and recommendations on the marine biological resources and its sensitivity. The outcome of this report will determine whether this intervention is then stopped or continued. • Possibly – a list of areas where legal protection is justifiable. Year 3: • Detailed determination of the case for legal protection of identified areas of valuable marine and estuarine habitat. Year 4 onwards: • Consultations with stakeholders and the development of management plans for potential protected areas. • Legal instruments developed for protected areas. • Management established and running for the selected protected areas.
Budget (costs)	In USD (including indirect costs and VAT, specify separately any running / operational costs) Biological surveys: estimated 0.5 million USD (shared with Adaptive Intervention 1) Protected area provision development: estimated 0.25 million USD Support to the start-up of protection: estimated 2.0 million USD **Cost justification** The risk to society posed by what should be a readily preventable hazard that reduces food security – the lack of protection of the biological resources behind the low carbon emission fisheries – has significant consequences both for the environment and society, as well as being intended to sustain the low emission industry that avoids contributing to the drivers of climate change.
Implementation modality	A number of specialist consultancies are expected to be required. • Study of marine biological resources and their sensitivity, with recommendations (a team of different specialists required, mainly marine biologists). • Consultations and the preparation of plans for protected areas, with recommendations (a team of biological protected areas specialists). • Preparation and enactment of the legal instruments to create protected areas (mainly legal activities). • Development and capacity building implementation consultants for the starting up of protected areas.
Responsible Implementing Agency	This intervention will be managed by the Project Management Unit created and directed by the EPA with support from the UNDP. Participating line agencies are expected to be the EPA (on biological resources), the FDA (on the management of protected areas), the Ministry of Justice and the communities with interests in the potential protected areas.

Risks	1. Existing biological resources may not be sufficiently valuable to justify protected area status.
Risk mitigation actions advised	1. Stop this part of the project after the investigation component, and conduct no further work towards the development of protected areas.
Information or studies needed for further detailing	Detailed terms of reference need to be devised for the various implementing consultancies. These are expected to be devised by the Project Management Unit with support from the participating line agencies.

Adaptive Intervention 2. Satellite image of the Monrovia coastal area. Some of the estuarine mangroves are visible as dark grey dendritic areas amongst the khaki-coloured areas of urban development. Relatively undisturbed beaches extend towards the north-west.



CONCEPT NOTE 5: CONTROL OF POLLUTION AND WASTE

Coastal area:	Estuarine and coastal areas around Monrovia
Measure title:	**Improved Control of Pollution and Waste Management in Areas Affecting Tidal Waters**

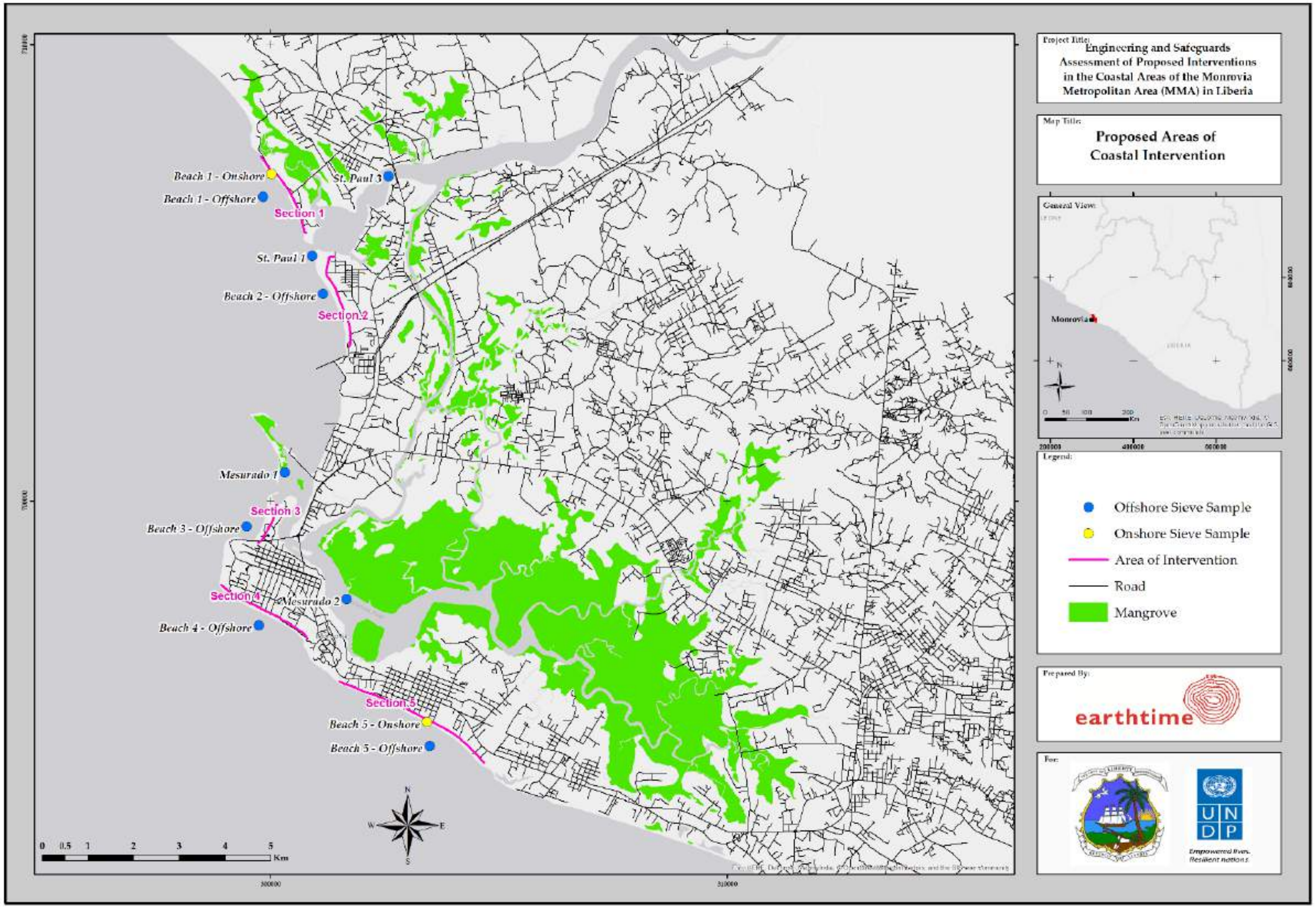
Measure description – Adaptive Intervention 5	
Measure type: • **Knowledge & awareness** • **Climate-smart planning**	This adaptation measure is to help ensure the sustainability of low-energy artisanal fisheries in the inshore zone around Monrovia. This will help to safeguard the food security of Monrovia, while supporting the livelihoods of a large number of households in the poorer parts of the city. It will do this while helping to minimise the drivers of climate change. This is an indirect measure to address the climate change issue: the sustainability of the fishery is threatened by pollution; if significant damage is caused to fish stocks, then the fishery could be completely jeopardised; this would mean that this key component of Monrovia's food supply could not be maintained as a low carbon industry.
Timing:	Detailed investigations would be undertaken in the first year of the project. Implementation actions would be undertaken in years 2 to 4 of the project. Monitoring of actions would be undertaken from year 4 to year 7.
Location of the Project (and specific area concerned):	Most of the urban area of greater Monrovia. The map given after this concept note shows the extent of mangroves, which are a useful indicator of estuarine tidal waters with value for saline habitat. This part of the project will work in all areas of land from which there is a pollution vector – usually water flows – into tidal waters, whether estuarine or the open ocean.
Rationale of the measure	**BACKGROUND** The coastal waters of Liberia appear to be quite pristine, probably due to the relatively low population density and low level of development in the area. However, the estuarine mangroves are key breeding habitats for many of the marine species that form the fishery or sources of food for the species targeted by the fishermen. The mangroves exist in a complex estuarine topography, around which the city of Monrovia has developed. This development became rapid as Liberia prospered in the presidencies of Tubman and Tolbert (1944 to 1980), and continued, though with less order, through the years of civil war (1980 to 2003) and beyond. Rapid expansion of housing stock, combined with frequently informal commercial and small-scale industrial activities, out-stripped the provision of infrastructure and services. The result is that waste management and pollution control have not always been well planned and implemented. **PROBLEM STATEMENT** • The expansion of the city of Monrovia has led to dense population occupying the land around the estuarine mangroves of the Mesurado River and other inlets. • Lack of good infrastructure means that there is a high risk of sewage and other forms of waste being washed into tidal waters, possibly from some distance away via creeks. • Limited options for mainly poor households and lack of awareness of the dangers posed by waste and pollution mean that they are widespread threats to the environment.

	• A dense and growing urban population is a difficult setting in which agencies with limited resources and capacity must enforce controls. • The mangroves and nearshore marine habitats are sensitive ecological receptors critical to the sustainability of the fishery, as the breeding grounds and refuges for many species. • Damage to the tidal habitats from pollution can therefore have a direct impact on the health of the fishery; a decline in the fishery will lead to greater reliance on food sources with much higher carbon emissions.
Objectives	**Overall (wider) objective:** Development of a society that understands the importance of pollution control and abides by strict regulations to protect sensitive ecosystems. **Project purpose (specific objective to be achieved for target group):** To reduce the pollution of tidal waters to sustainable levels.
Target group(s) and beneficiaries	The target groups are the residents, businesses and industries in the greater Monrovia area, which are the potential sources of waste streams and pollution in the catchments discharging into the estuaries that host mangroves, or directly into the ocean. The beneficiaries are the fishermen, fish handlers and fish consumers: this last group being the large number of people living in Monrovia who rely on the fisheries to provide affordable protein. Many of the target groups are also the beneficiaries, since this intervention effectively aims to prevent society from inadvertently damaging the environment that is so important for its food source.
Measure description & activities	This intervention involves a number of activities that are parallel or sequential within two sequential components. **Component 5.1: Investigations** Four concurrent activities. Activity 5.11 Survey of water quality in the creeks, estuaries and nearshore ocean that might affect mangroves and other sensitive habitats, to identify key sources and hotspots of sewage and other waste. Activity 5.12 Survey of housing areas and sewerage systems within 1 km of tidal waters, to identify areas requiring targeted measures to reduce waterborne pollution. Activity 5.13 Survey of businesses and industries within 1 km of tidal waters, to identify potential sources of hazardous waste or pollution. Activity 5.14 Review of the urban waste management system, to identify weaknesses that are leading to waste or pollution entering tidal waters. *Note: it is expected that Activities 5.12, 5.13 and 5.14 will be undertaken through a single contract.* **Component 5.2: Implementation** Three mainly concurrent activities. Activity 5.21 Development of improved strategies for the waste management and pollution control agencies, including capacity development for effective implementation and enforcement. Activity 5.22

	Design of major waste management or pollution control interventions, if required, for separate financing by government to tackle the sources of environmentally damaging substances. Activity 5.23 Monitoring of the effectiveness of the improved waste management or pollution control systems in terms of reducing damage to ecosystems and habitats in tidal waters.
Outputs (what is achieved after activity implementation in which year)	Year 1: • Detailed year-round survey of water quality in the tidal waters around Monrovia. • Surveys of housing and sewerage provision, potential and actual pollution sources from residential, commercial and industrial land uses, and of the urban waste management systems near tidal waters. Year 2: • Strategy developed for improved waste management and pollution control in the areas of Monrovia affecting tidal waters. Year 4 onwards: • Agreed improved arrangements for better waste management and pollution control in the areas of Monrovia affecting tidal waters. • Undertaking by the city corporations to undertake the agreed strategy. • Reductions in tidal water pollution shown in regular monitoring.
Budget (costs)	In USD (including indirect costs and VAT, specify separately any running / operational costs) Survey of tidal water quality: estimated 0.25 million USD Surveys of waste and pollution: estimated 0.1 million USD Strategy development etc.: estimated 0.2 million USD Monitoring of effectiveness: estimated 0.25 million USD **Cost justification** The risk to society posed by what should be a readily preventable hazard that does not threaten the sustainability of the low carbon emission fishery that underlies Monrovia's food security – the pollution of the tidal waters through careless disposal of waste streams – is enormous compared to the cost of finding ways to manage the problem.
Implementation modality	A number of specialist consultancies are expected to be required. • Study of water quality in the tidal waters around Monrovia (a team of tidal hydrology specialists and chemists required). • Reviews of housing and sewerage, sources of potential and actual pollution, and urban waste management (a team of environmental engineers and waste management specialists required). • Preparation of the action plan for improved waste management by the city corporations (mainly environmental engineers and waste management specialists required). • Monitoring of the changes in tidal water pollution a team of tidal hydrology specialists and chemists required).
Responsible Implementing Agency	This intervention will be managed by the EPA with support by the Project Implementation Consultant. Participating line agencies are expected to be the Monrovia City Corporation and the Paynesville City Corporation. The EPA will be the main agency responsible for long term monitoring.

Risks	1. The scale of waste management and pollution control in the city of Monrovia may be so great that it takes many years to resolve. 2. The solutions determined by the project may not be wholeheartedly implemented by the Monrovia and Paynesville City Corporations.
Risk mitigation actions advised	1. The project must ensure the full co-operation of all relevant agencies to help find as rapid and effective solutions as possible. 2. A full dialogue and involvement of the city corporations must be undertaken throughout the execution of this intervention.
Information or studies needed for further detailing	Detailed terms of reference need to be devised for the various implementing consultancies. These are expected to be devised by the Project Management Unit with support from the participating line agencies.

Adaptive Intervention 3. Map of the layout of mangroves in the greater Monrovia area. This intervention will target all of the land from where there are vectors (usually water flows) leading from residential and commercial properties into the tidal waters.



CONCEPT NOTE 6: CONSTRUCTION SAND SOURCES

Coastal area:	Entire coastal area around Monrovia
Measure title:	**Development of Alternative Sources for Construction Sand in the Monrovia Metropolitan Area**

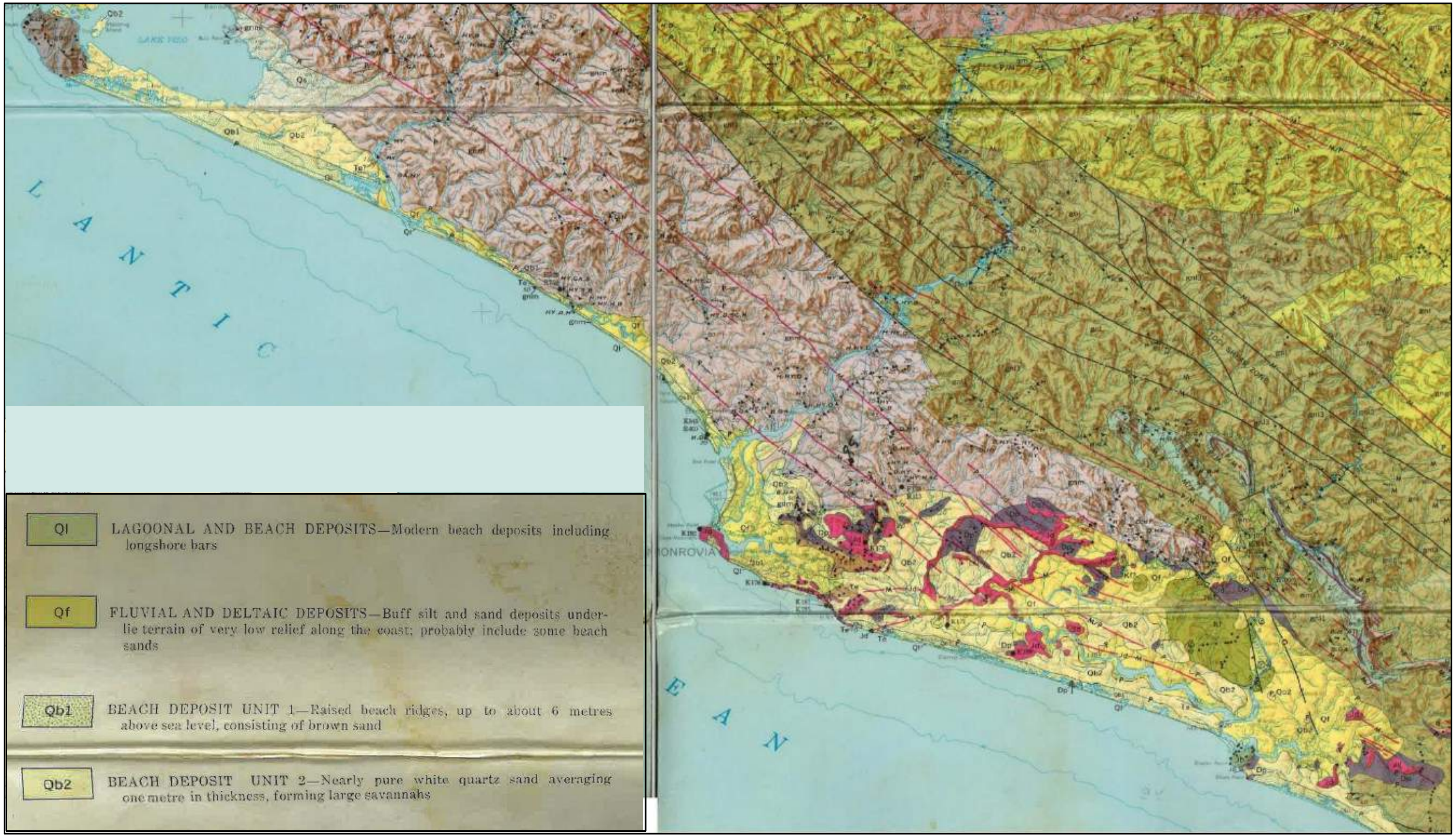
Measure description – Adaptive Intervention 6	
Measure type: • **Knowledge & awareness** • **Climate-smart planning**	This adaptation measure is to reduce dependency on construction sand extracted from active beaches, a practice which increases vulnerability to coastal erosion. To achieve this requires the prospecting of alternative sources, introduction of appropriate planning and permitting provisions, and the raising of awareness of the issue and enforcement of a change of sourcing. It seeks to help minimise the impacts of climate change.
Timing:	Detailed investigations would be undertaken in the first year of the project. Implementation actions would be undertaken in years 2 and 3 of the project. Enforcement would be supported from year 4 to year 7.
Location of the Project (and specific area concerned):	The geological map given after this concept note shows the layout of Quaternary deposits along the coastal plain. Four units are recognised. Ql: Lagoonal and beach deposits – modern beach deposits including longshore bars. Qf: Fluvial and deltaic deposits – buff silt and sand deposits underlie terrain of very low relief along the coast; probably include some beach sands. Qb1: Beach deposit Unit 1 – raised beach ridges, up to about 6 metres above sea level, consisting of brown sand. Qb2: Beach deposit Unit 2 – nearly pure white quartz sand averaging one metre in thickness, forming large savannahs. Of these, Unit Ql is the current source of much of the construction sand used in Monrovia, but this is detrimental to coastal protection. Unit Qf is mostly in low-lying swampy land, and largely composed of silt. Unit Qb1 is mostly limited in area (though more prevalent to the north-west of the St Paul River mouth) but may form part of the higher storm beach and therefore an essential coastal protection resource as sea level rises. Unit Qb2, which is thinner but much more extensive, should be the main prospecting target for this component of the project.
Rationale of the measure	**BACKGROUND** A considerable amount of sand for construction in Monrovia is derived from the active beaches. This is easy to collect and provides material for both small scale enterprises through digging by hand and, at times, larger scale sources using machines. This depletion of the sand resource adds to the natural removal of sand by geomorphological processes. This adaptation measure will provide alternative sources of sand from inland to allow the authorities to stop beach sand extraction effectively. **PROBLEM STATEMENT** • Construction sand is a low value bulk commodity in high demand in Monrovia. The abundant, freely available material on the active beaches mean that these have been used as the main sources up to now. With sea level rise expected, along with greater wave energy during storms, beach

	sand extraction will have increasingly serious consequences on a coast that is already eroding. • Although there are abundant deposits of sand inland on the coastal plain, derived from ancient beach deposits, these are at a greater distance for haulage (and therefore more expensive to consumers). • The savannahs that lie on the sandy areas of the coastal plain are not valuable for agriculture and have limited biodiversity value since they support only scrubby vegetation and not high forest. However, the expansion of Monrovia since the end of the second civil war in 2003 means that these slightly higher areas in the landscape have become valuable for housing and other urban development. • Some of the sand extraction from the present-day active beaches is dug by hand by poor members of communities in the beach-side townships. These groups have limited short-term livelihoods options, and may suffer as a result of the banning of their practices. • In some parts of the Liberian hinterland, construction sand is obtained from rivers. This has a number of environmental disadvantages in that it affects sediment fluxes, flood discharges and water quality, in turn affecting downstream aquatic ecology and water users. It also affects the sediment supply in the nearshore marine environment, which in turn affects coastal geomorphology. For these reasons, river sand sources must not be utilised in place of beach sand.
Objectives	**Overall (wider) objective:** Reduction of vulnerability to the effects of climate change on the active beaches along the Monrovia coast by the removal of a human-induced hazard. **Project purpose (specific objective to be achieved for target group):** To establish environmentally sound terrestrial sources of construction sand and to stop sand extraction from present-day beaches.
Target group(s) and beneficiaries	The target group is the construction industry, both formal and informal, that utilises sand for building works in Monrovia, and by extension the consumers of this commodity. The beneficiaries are the communities living beside or using the present-day active beaches or the land immediately behind them.
Measure description & activities	This intervention involves a number of activities that are parallel or sequential within sequential components. **Component 6.1: Investigations** Three concurrent activities. Activity 6.11 Prospecting of potential inland sources of sand within a 2-hour haulage distance from central Monrovia. Mapping of technically suitable sand deposits in relation to current land uses and road networks. Activity 6.12 Review of the impacts on livelihoods in poor coastal communities of the strict enforcement of a ban on sand extraction from present-day active beaches. Activity 6.13 Review of the formal and informal construction industries, and the economic consequences of sand extraction from only inland sources. **Component 6.2: Implementation**

	Three mainly sequential activities. Activity 6.21 Preparation of a strategy on inland sourcing of construction sand, the establishment of cross-institutional agreement on it and the creation of a roadmap for its implementation. Activity 6.22 Development of a planning framework within which inland construction sand will be permitted from designated areas, and its roll-out to the construction sector. Activity 6.23 Support to government agencies to uphold strict enforcement of a ban on the extraction of sand from present-day active beaches.
Outputs (what is achieved after activity implementation in which year)	Year 1: • Detailed report on alternative sources of construction sand on the coastal plain within 2 hours' haulage of Monrovia. • Detailed report on the potential socio-economic impacts of banning the extraction of sand from the present-day active beaches around Monrovia. • Detailed report on the economic impacts likely to be incurred by enforcing the extraction of construction sand only from inland sources. Year 2: • Established strategy and roadmap for inland construction sand sourcing. Year 3 onwards: • Development and agreement of the cross-institutional planning framework for the supply of inland construction sand. • Implementation of the planning framework. • Support for enforcement of the ban on sand extraction from the present-day active beaches.
Budget (costs)	In USD (including indirect costs and VAT, specify separately any running / operational costs) Survey of terrestrial sand sources: estimated 0.15 million USD Surveys of potential impacts on informal and formal sand extraction industries: estimated 0.1 million USD Strategy development etc.: estimated 0.2 million USD Support for enforcement: estimated 0.25 million USD **Cost justification** The risk to society posed by what should be a readily preventable hazard that exacerbates coastal vulnerability – the reduction of beaches for construction sand – is enormous compared to the cost of developing alternatives. The volume of sand extracted for construction relative to that removed by coastal erosion is not known, but could be a significant contributor to coastal erosion.
Implementation modality	A number of specialist consultancy contracts are expected to be required. • Prospecting survey of the drift geology of the coastal plains, mainly targeting Unit Qb2. • Research on the potential impacts on poor communities in Monrovia of the cessation of beach sand extraction. • Research on the potential impacts on the Monrovia construction industry of the cessation of beach sand extraction. • Development of a strategy, roadmap, and a planning and permitting framework, for terrestrial sand sources.

	• Support for the enforcement of a ban on the use of active beaches for sand extraction.
Responsible Implementing Agency	This intervention will be managed by the EPA with support by the Project Implementation Consultant. The Ministry of Lands, Mines and Energy (MLME) will be responsible for the prospecting, testing and mapping of potential inland sand sources. The EPA will be responsible for commissioning the other Year 1 reviews (coastal community livelihoods and construction industry economic impacts). The EPA will be responsible for drawing the strategy together, assisted by the Project Implementation Consultant, and with the collaboration of the MLME and the Liberia Land Authority. The EPA will be responsible for enforcing the ban on sand extraction from active beaches, assisted by the Liberian National Police.
Risks	1. Adequate accessible sources of sand may be difficult to find within an economically viable haulage distance of Monrovia. 2. Market forces may make it hard to stop the illegal extraction of sand from active beaches.
Risk mitigation actions advised	1. If the extent of surficial sand deposits will not support the demand from Monrovia, then alternatives must be investigated, such as the use of crushed rock from terrestrial quarries. 2. Support for enforcement must include "soft" measures such as information and awareness campaigns to ensure that society's opinions support the authorities in stopping sand mining on active beaches.
Information or studies needed for further detailing	Detailed terms of reference need to be devised for the various implementing consultancies. These are expected to be devised by the Project Management Unit with support from the participating line agencies.

Adaptive Intervention 4. Geological map, showing the coastal plain to the north-west and south-east of Monrovia. Unit Qb2 appears to offer the best prospects as sources of construction sand.



Source. Geologic Map of the Monrovia Quadrangle, Liberia, by C.H. Thorman (1977). Mapped at 1:250,000 scale. Department of the Interior, United States Geological Survey and Ministry of Lands and Mines, Liberian Geological Survey.

CONCEPT NOTE 7: CLIMATE RESILIENT INFRASTRUCTURE IN COASTAL ZONES

Coastal area: Vulnerable areas in Monrovia and selected vulnerable areas in Montserrado county, Greenville and Buchanan	
Measure title: Climate Resilient Infrastructure in Coastal Zones	

Measure description – Adaptive Intervention 7	
Measure type: • **Construction** • **Knowledge & awareness** • **Institutional & capacity building**	• Knowledge (vulnerability & feasibility studies, workshops) • Institutional & capacity building
Timing:	This intervention is expected to be undertaken within the first two years of the project.
Location of the Project (and specific area concerned):	Selected coastal areas in Liberia, based on vulnerability mapping for climate hazards (coastal areas 2, 3 and 4 in Monrovia, and areas in Buchanan, Cestos City, other parts of River Cess, and Greenville).
Rationale of the measure	**BACKGROUND** Climate change will affect the coastal areas of Liberia in several ways. Firstly, sea level rise is likely to accelerate the present catastrophic situation of coastal erosion. According to the NAPA (2008), the areas along the coast where erosion is most severe are Montserrado County coastlines, (West Point, New Kru Town, River Cess, Cestos cities) and Buchanan. The expected sea level rise will result in continuous and more severe coastal shore retreat of tens to hundreds of meters in the period 2020-2050. Basically, this implies a loss of assets (buildings, critical infrastructure such as roads, energy stations, schools) in these areas. Complete loss of assets and roads can only be avoided by protective measures and/or relocating or heightening roads in these areas. However, other hazards such as storm surges and extreme rainfall can also cause inundation of more inland roads and other infrastructures in these coastal areas. This implies that - especially in the wet season in spring – the roads are blocked and cannot be used with serious implications for economic activities and people. **PROBLEM STATEMENT** The key problem to be solved by this project is related to climate change related hazards storm surges and extreme rainfall and the inundation of critical infrastructure (roads, other) in selected vulnerable coastal areas in Montserrado and Buchanan. The project is to a lesser extent able to provide solutions to coastal erosion and retreat of the coastal shoreline (complete loss of roads to the ocean), except advice on relocation or heightening of primary roads. The problem of inundated roads during the rainy season or during storm surges causes problems for transportation for people and goods and can isolate communities for weeks or more. In order to avoid these bottlenecks, more climate resilient roads or other assets or relocation of roads could overcome these problems.
Objectives	**Overall (wider) objective:**

	The objectives of the Climate Resilient Infrastructure Project for Liberia are: (a) to enhance the resilience of road infrastructure in coastal areas against climate hazards (storm surges, extreme rainfall and the related inundation); and (b) to improve the capacity of relevant authorities to respond promptly and effectively in an emergency event such as storm surge or flash flood. **Project purpose (specific objective to be achieved for target group):** The project purpose is to enhance the capacity of relevant authorities to prepare and respond to climate events (extreme rainfall, storm surges). This will be done by developing knowledge on the vulnerability of infrastructure (mainly roads) in (climate vulnerable) coastal areas in Montserrado county and the feasibility of potential measures to strengthen the resiliency of roads (and other critical infrastructures) in these coastal areas.
Target group(s)	
Measure description & activities	The project will have two components. **Component 7.1: Developing knowledge** This component aims to reduce physical vulnerability of critical infrastructure through the identification of infrastructure at risk, developing strategies for the retrofitting and rehabilitation of existing infrastructure within the primary and secondary road network. Actions will include associated drainage and flood mitigation systems in order to strengthen resilience to the natural hazards and the anticipated impacts of climate variability. Under this component, the following activities are foreseen. Activity 7.11 Vulnerability assessment of infrastructure and roads in selected coastal areas. Activity 7.12 Feasibility study for adapting, strengthening or relocating infrastructure at risk. This study should identify options to create climate resilient infrastructure in these areas, estimate the costs and benefits of these options, identify funding possibilities and establish institutional recommendations. **Component 7.2: Capacity building** This technical assistance intervention for improved climate resilience management of infrastructure, mainly roads, will strengthen the capacity of the Ministry of Public Works to mainstream climate resilience considerations into core physical and investment planning, and asset maintenance. The anticipated activities to support the implementing agencies under this component are as follows. Activity 7.21 Assist government to develop a climate resilient policy mainstreaming framework. This would be supported by procedures and plans for government actions during emergencies (storm surges, flash floods etc.) to alleviate problems on critical infrastructures, such as warnings, road diversions, evacuation plans, shelters, pumping etc.). Activity 7.22 Prepare a training curriculum; and organize trainings, workshops and field and study visits on the climate resiliency of roads and waste, water and energy facilities; provide on-the-job support to relevant staff in implementing agencies (responsible for road and other asset construction procurement, supervision and maintenance).
Outputs (what is achieved after activity implementation in which year)	Project year 1 • Vulnerability assessment of infrastructure in selected coastal areas. • Feasibility study of resiliency options and preferred measures. Year 2 • Policy framework document and plans.

	• Trainings, workshops, visits organized.
Budget (costs)	In USD (including indirect costs and VAT, specify separately any running / operational costs) About 2,5 million USD
Implementation modality	
Responsible Implementing Agency	Ministry of Public Works (MPW).
Risks	Lack of capacity in MPW to implement and follow-up the advised projects.
Risk mitigation actions advised	Support to the MPW is envisaged under this intervention and could also be foreseen for any follow-up.
Information or studies needed for further detailing	• Vulnerability for climate change of coastal areas in Liberia, selection of most vulnerable areas in Liberia (see also UNDP project "Enhancing Resilience of Liberia Montserrado County Vulnerable Coastal Areas to Climate Change Risks II" and David Wiles (2005), "Coastal zone vulnerability and adaptation to climate change in Liberia". • Discussion on capacity building needs with Ministry of Public Works and possibly other relevant implementing agencies.

B. IMPLEMENTATION SCHEDULE AND BREAKDOWN ADAPTATION MEASURES

Ref.	Interventions	Ref.	Activities	2020	2021	2022	2023	2024	2025	2026	Approach	Est. cost ('000 US$)
1	**Coastal Zone Management Capacity Developed**											
1.0	Preparation	1.01	Prepare terms of reference								Consultant team	25
		1.02	Tender and procure service providers								Consultant team	25
1.1	Component 1.1: Capacity building	1.11	Training in integrated coastal zone management (ICZM)								Contracted service provider	300
		1.12	Support to ICZM policies and strategic activities								Contracted service provider	500
		1.13	Establish ICZM support structures between agencies etc.								Contracted service provider	50
		1.14	Develop information and management tools to support ICZM								Contracted service provider	400
1.2	Component 1.2: Strengthening co-ordination	1.21	Establish an inter-agency ICZM working group								Contracted service provider	50
		1.22	Awareness of ICZM issues with stakeholders								Contracted service provider	500
1.3	Component 1.3: Building enforcement	1.31	Support for policies and regulations for land management								Contracted service provider	400
		1.32	Support and training in enforcement activities								Contracted service provider	500
		1.33	Dispute resolution training and support								Contracted service provider	400
1	***Estimated cost***											**3,150**
2	**Community Awareness and Management Strengthened**											
2.0	Preparation	2.01	Prepare terms of reference								Consultant team	25
		2.02	Tender and procure service providers								Consultant team	25
2.1	Component 2.1: Investigations	2.11	Map other vulnerable coastal zones								Contracted service provider	500
		2.12	Identify vulnerable target groups								Contracted service provider	50
		2.13	Develop awareness and information strategy								Contracted service provider	150
		2.14	Develop awareness and information materials								Contracted service provider	300
2.2	Component 2.2: Implementation	2.21	Implement the awareness-raising strategy								Contracted service provider	500
		2.22	Evaluate effectiveness and follow up								Contracted service provider	200
2	***Estimated cost***											**1,750**
3	**Monrovia's Fisheries Sustainably Managed**											
3.0	Preparation	3.01	Prepare terms of reference								Consultant team	25
		3.02	Tender and procure service providers								Consultant team	25
3.1	Component 3.1: Investigations	3.11	Study of catch volumes and species								Contracted service provider	150
		3.12/4.11	Survey of marine biological resources and offtake capacity								Contracted service provider	500
		3.13	Study of options for low energy processing improvements								Contracted service provider	100
3.2	Component 3.2: Implementation	3.21	Development via LAFA to improve fishermen's compliance								Contracted service provider	400
		3.22	Development of fishmongers' processing and storage								Contracted service provider	400
		3.23/1.31	Capacity building to enforce fishing rules and quotas								Contracted service provider	250
		3.24	Monitoring and refinement of fishing rules and quotas								Contracted service provider	250
3	***Estimated cost***											**2,100**

Ref.	Interventions	Ref.	Activities	2020	2021	2022	2023	2024	2025	2026	Approach	Est. cost ('000 US$)
4	**Marine and Mangrove Habitats Protected**											
4.0	Preparation	4.01	Prepare terms of reference								Consultant team	25
		4.02	Tender and procure service providers								Consultant team	25
4.1	Component 4.1: Investigations	4.11/3.12	Survey of marine and mangrove biological resources								Contracted service provider	500
4.2	Component 4.2: Implementation	4.21	Determination of protected area justification								Contracted service provider	300
		4.22	Consultation and preparation of management plans								Contracted service provider	200
		4.23	Development of legal instruments and enactment								Contracted service provider	200
		4.24	Support the start-up of protected areas								Contracted service provider	1,000
4	***Estimated cost***											**2,250**
5	**Pollution and Waste Controlled**											
5.0	Preparation	5.01	Prepare terms of reference								Consultant team	25
		5.02	Tender and procure service providers								Consultant team	25
5.1	Component 5.1: Investigations	5.11	Survey of water quality in tidal waters								Contracted service provider	200
		5.12	Survey of housing and sewerage near tidal waters								Contracted service provider	50
		5.13	Survey of potential and actual pollution sources								Contracted service provider	50
		5.14	Review of urban waste management near tidal waters								Contracted service provider	50
5.2	Component 5.2: Implementation	5.21	Strategy for improved waste and pollution control								Contracted service provider	100
		5.22	Design of improved waste and pollution control systems								Contracted service provider	400
		5.23	Monitoring of the effectiveness of the improved systems								Contracted service provider	200
5	***Estimated cost***											**1,100**
6	**Construction Sand Sources Improved**											
6.0	Preparation	6.01	Prepare terms of reference								Consultant team	25
		6.02	Tender and procure service providers								Consultant team	25
6.1	Component 6.1: Investigations	6.11	Identification of inland sand sources								Contracted service provider	100
		6.12	Review of impacts on smallscale sand miners' livelihoods								Contracted service provider	100
		6.13	Review of economic impact on construction industry								Contracted service provider	50
6.2	Component 6.2: Implementation	6.21	Strategy and roadmap for implementation								Contracted service provider	100
		6.22	Development of a planning and permitting framework								Contracted service provider	200
		6.23	Enforcement of a ban on beach sand extraction								Contracted service provider	400
6	***Estimated cost***											**1,000**
7	**Resilience of Coastal Zone Infrastructure Increased**											
7.0	Preparation	7.01	Prepare terms of reference								Consultant team	25
		7.02	Tender and procure service providers								Consultant team	25
7.1	Component 7.1: Developing knowledge	7.11	Vulnerability assessment of infrastructure in coastal areas								Contracted service provider	200
		7.12	Feasibility study of making infrastructure resilient								Contracted service provider	200
7.2	Component 7.2: Capacity building	7.21	Assist government to develop strategies, plans, etc.								Contracted service provider	400
		7.22	Prepare and provide trainings on infrastructure resiliency								Contracted service provider	400
7	***Estimated cost***											**1,250**

C. CLIMATE CHANGE IMPACT MANGROVES

In an unconstrained natural setting, a rise in sea level on a low-relief coast might typically lead to an inland migration of mangroves as tidal waters push inland and the coastline itself also retreats. However, around the inlets near Monrovia, there is considerable housing and other infrastructure that limit the availability of land for this to happen. There is also the question of changed dynamics in the flows of water and sediment as sea level rise alters the physical environment of the marine and estuarine zones along the coastal fringe. This has particular implications for the main mangrove swamps in the area, in the tidal but largely land-locked basin of the Mesurado estuary.

Quantification of the change in the sediment balance in the Mesurado basin is shown in the top right graph of Figure 4-16 of PART I. Here, unlike the other rivers, the sediment flux is negative, indicating an accumulation rather than a loss: this is a 'sediment hunger' equals expected sedimentation, as the volume of the basin increases with rising water levels. The sediment will be drawn in from the marine environment with incoming tides, and will accumulate gradually in the calm water of the basin. It is uncertain as to whether this accumulation will keep up with the rise of sea level, not least because of the uncertainty over the rate of sea level rise itself. In addition, other activities along the coast will affect the supply of sediment. Nevertheless, it is clear that there will always be a significant amount of sediment in suspension in the marine environment, and some of this will accumulate in the Mesurado basin.

Studies have shown that vertical accretion of sediment can allow mangroves to keep pace with sea-level rise and continue providing important ecosystem services, including defence against rising seas and storms. *"Mangroves are within the inter-tidal zone and are thus highly sensitive to rising sea level, but the community may adapt to rising sea level if the rate of vertical accretion of the soil surface of the forest equals or exceeds the rate of sea level rise (Cahoon et al. 1999 (Ref [12]), Morris et al. 2002(Ref [13])). This can be achieved, for example, if the higher photosynthesis rates observed under increased CO2 conditions result in increased carbon allocation to roots, increasing the soil root volume and thus soil elevation (Langley et al. 2009 – Ref [11])"*

"Mangroves contribute to an increase in soil volume by capturing riverine or coastal sediments that pass through, as well as adding their own organic matter in the form of roots, leaves and woody material. The fine mangrove roots also help to trap and bind the particles. Due to a lack of oxygen in the waterlogged soil, organic matter is not broken down by soil organisms. This allows the organic matter to build up over time, producing the deep peaty soils that underlie mangroves in some areas. Mangrove root growth also pushes the soil upward, resulting in a higher soil level. These processes can allow mangroves to keep pace with rising sea levels. Some mangroves sit on top of deep layers of mangrove peat that may be 6 meters deep or more, that were built up over thousands of years as sea levels rose. These mangrove soils grew vertically at rates of up to 10 mm per year in sites from Australia to Belize, suggesting that mangroves may be able to keep up with similar rates of sea level rise into the future, where local conditions allow. While not all mangroves may be able to fully "keep up" with rising seas, even a small increase in soil surface height over time may help to reduce the impact of sea level rise on coastal areas."

Also, as McIvor et al. (2013 – Ref [10]) have also stated: "Historical evidence suggests that mangrove surface elevations have kept pace with sea level rise over thousands of years in some places, such as Twin Cays, Belize. Rates of surface elevation increase ranged between 1 mm/yr and 10 mm/yr in different locations and settings."

The question is whether, in the particular situation of Monrovia, this accretion and rise of the soil surface keeps up with the pace of SLR and how much these mangrove communities have the capacity to adapt to the actual rate of sea level rise.

Three general scenarios may be distinguished:

1. In areas with very high rates of sedimentation, mangrove soil surfaces may rise at a rate which exceeds the local rate of sea level rise, such that terrestrial species invade landward areas, and progradation occurs (i.e. new land is formed seaward of the current mangrove area, which mangroves then colonise); this is likely to occur around the deltas of large rivers that bring high volumes of sediment to the coast.
2. Sea level rise rates may be matched by a rise in mangrove soil surface elevation, allowing mangroves to remain in the same location, possibly also colonising more landward areas if such areas have suitable substrate and topography.
3. Mangrove soils may be unable to rise as fast as the local rate of sea level rise, resulting in the death of trees in the lower areas and at the seaward edge of the mangrove area. Mangroves are likely to invade landward areas which now fall within the tidal frame, providing suitable substrate and topography are present there.

Given the relatively low outflow and additional sediment from upstream it is suggested that in the Mesurado basin either scenario 2 or 3 would be likely to happen. But which of these two is more likely is hard to predict and is dependent on many complex processes and feedback loops within the system, as described by McIvor et al. (2013). Recent evidence based on measurements using the Surface-Elevation Table - Marker Horizon methodology (from studies published between 2006 and 2011) suggest that mangrove surfaces are rising at similar rates to sea level in a number of locations. This suggests that is very much possible that indeed the soil surface rise might be in pace with the sea level rise projection, and that therefore the main areas of mangroves will remain where they are, rising gradually with the levels of sediment and water.

Horizontal expansion of mangroves inland is undesirable from a social perspective due to the associated need for resettlement of the properties occupying the land in which this would occur. But the rising sea level will be very likely cause a number of people to be displaced as their houses are flooded on every high tide. This will happen with or without the project. Hence the project does not need to deal with resettlement per se, although there will be enforced movement because of the impacts of climate change. It is not suggested therefore that the project should get involved in resettlement, but that the government will require a policy on this topic at some point, if not need to take action. This in itself should help to reduce the pressure on the mangroves and help to improve their overall health (thereby incidentally strengthening local fisheries through improved habitat).

D. COASTLINE DEVELOPMENT MODELLING

The new free-form coastline model Shoreline Simulation model (ShorelineS, Ref [4]) is used to predict coastline development at Section 3 and 4 for the implementation of beach replenishments. The model is capable to describe drastic coastal transformations based on relatively simple principles.

Its description of coastlines is of strings of grid points that can move around, expand and shrink freely. The model can have multiple sections which may be closed (islands, lagoons). This allows for a rich behaviour including shoreline undulations and formation of spits, migrating islands, merging of coastal shapes, salient and tombolos.

The coastline changes in the model are driven by wave-driven longshore transport, which is computed using the CERC formulation (Ref [5]). Wave input conditions can either be applied as constant parameters, time series or as a representative wave climate.

Wave input conditions
Simulations will be performed on a long-term timescale and thus the computational effort becomes too large if a long-term time series is used. Hence wave input reduction is necessary to avoid excessive computation time. The aim of setting up a representative wave climate is to represent natural variability with a minimum number of wave conditions. The reduced number of wave conditions should represent approximately the same wave energy flux as the actual climate would.

Along multiple locations of the 10 m contour line the wave climate has been schematized in 50 wave conditions (25 direction bins and 2 wave height bins) using the ‘equal energy flux‘ method (Ref [6]). The nearshore wave climate has been schematised for several time-slices (i.e. 2000-2020 and 2020-2040). See an example of this binning method in the figure below.

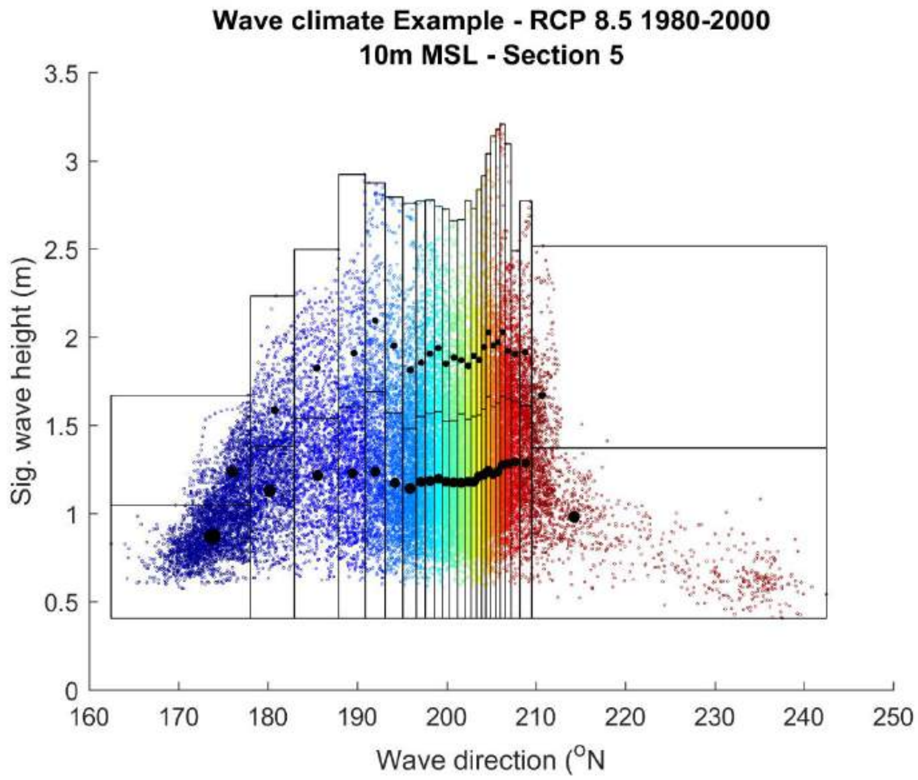


Figure 8-1: Example of morphological wave climate, using energy flux binning method. The boxes show the bins with equal energy flux and the black dots represent the representative conditions, where the size of the dots show the associated probability.

At both Section 3 and 4, one representative location is selected from which the schematised wave climates are used. At both locations the conditions are sequenced randomly with a time step of 3 days according to their probability of occurrence. This has been done for the time-slice of 2000-2020 as well as 2020-2040 (including the effect of climate change for scenario RCP 8.5).

Wave refraction around the Cape of Monrovia plays an important role at Section 3. It changes the nearshore wave height and direction, which in turn affects the magnitude and direction of longshore sediment transport. Therefore, a fast implicit refraction model has been implemented in ShorelineS, which propagates the offshore waves over a relatively coarse 2D grid and creates a lookup table. For each condition in the above-mentioned schematised wave climates, the corresponding refracted wave field is obtained and local wave conditions are interpolated along the coast. Figure 8-2 shows a simulation result in which a representative wave field refracts around the Cape of Monrovia.

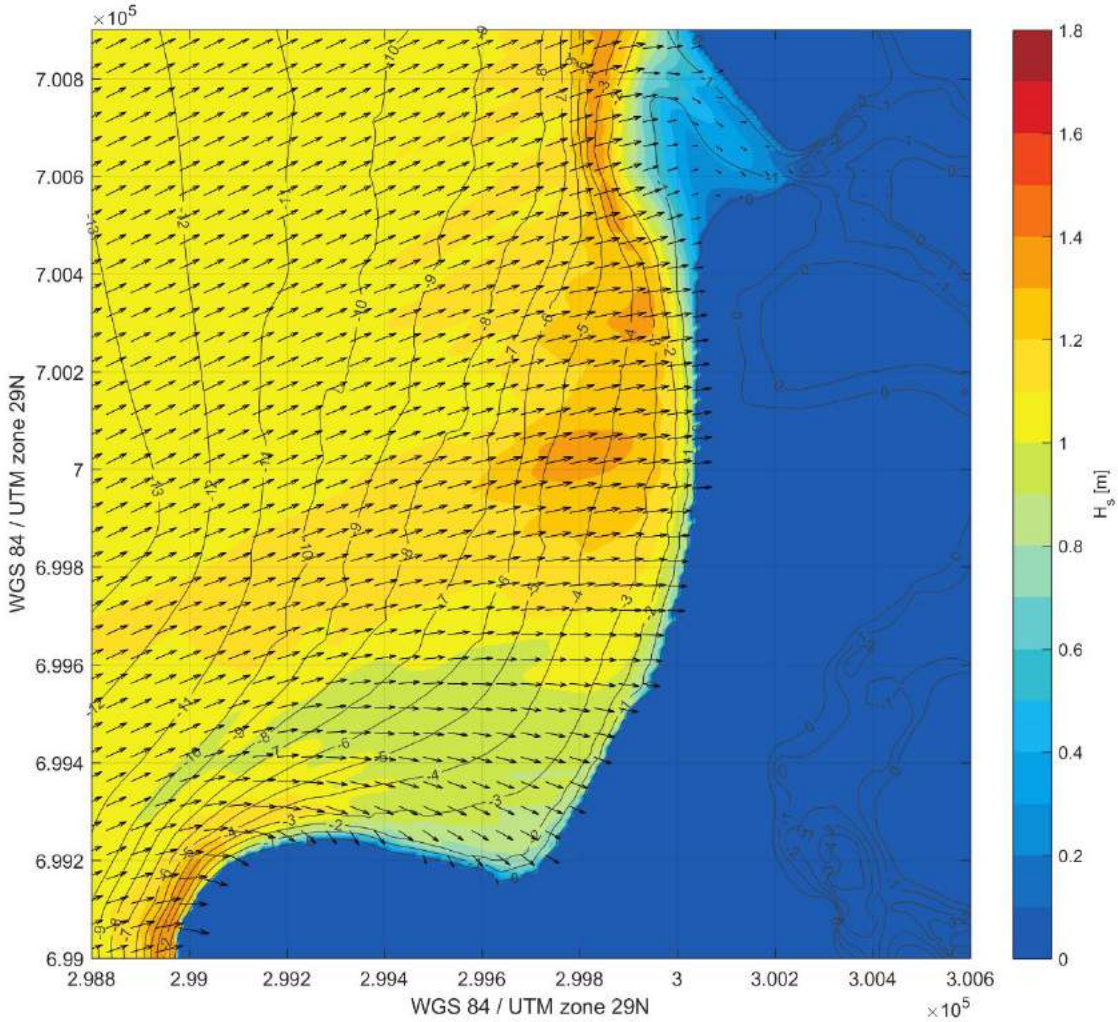


Figure 8-2: Example of propagated wave field around the Cape of Monrovia at Section 3

Calibration

Figure 8-3 shows the observed coastline changes at Section 3 from January 2008 (left, red) to December 2018 (right, blue). This coastline development over a period of 10 years is used to calibrate the ShorelineS model. The coastline of 2008 serves as input for the calibration runs, after which the simulated coastline should represent the observed coastline of 2018 as accurately as possible.

Figure 8-3: Observed coastal retreat at West Point, showing the coastline in 2008 (red) and 2018 (blue)

The model is calibrated by adjusting the transport calibration coefficient, surf width and spit width in order to match the local transport rates and final coastline orientation. It is noted that the effects caused by dynamic (tide dominated) processes in the Mesurado estuary (i.e. increasing sediment demand) are not included in the model. This is justified for the populated part of the coastline as this part is dominated by alongshore processes on a shorter time scale.

Figure 8-4 shows the coastline evolution after calibration of the model. The net longshore transport is directed northward, which corresponds to observations at Section 3. Wave refraction and the resulting coastline orientation are clearly visible in the results. Furthermore, the formation of the spit is very well represented by the model. The size of the spit is however overestimated, which can be explained by the existing and increasing sediment demand of the Mesurado estuary (see PART I – Vulnerability reporting). Moreover, some sand has been transported across the river mouth which has settled at the port breakwater, which has also been observed by the coastline advance in the Figure above. This effect causes sediment transport into the estuary which is not included in the model.

It is concluded that the model is calibrated adequately, and it predicts the coastline evolution well. Hence it will be used to assess the effect of the proposed beach replenishment on coastline development.

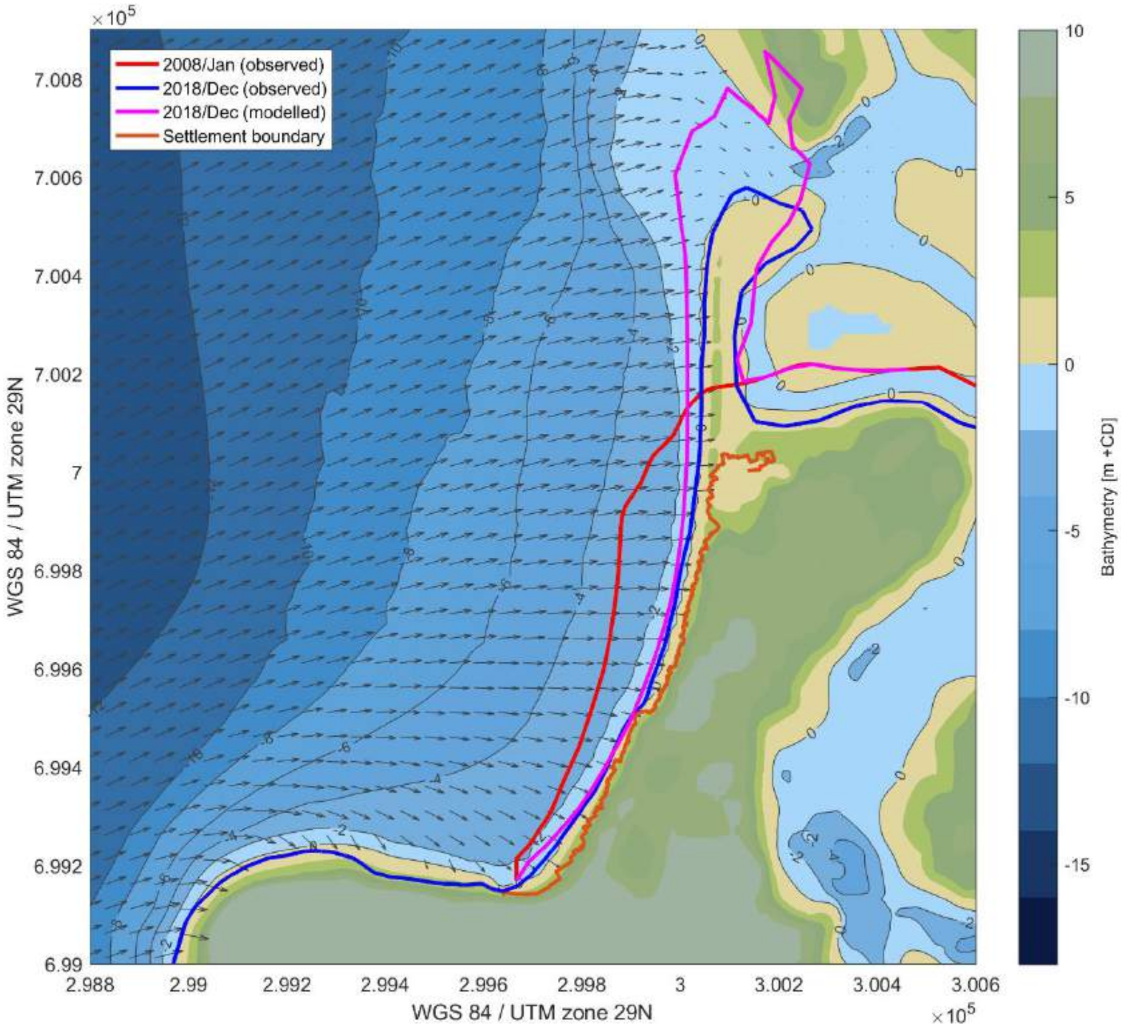


Figure 8-4: Modelled coastal retreat at Section 3, showing the coastline in 2008 and 2018 and a typical wave field for an offshore wave direction of 240 °N

Section 3: West Point

The proposed protective measure at Section 3 for Alternative B consists of a groyne and a beach replenishment. In order to assess the effect of the groyne on the new coastline position, the representative climate from 2020 to 2040 is applied, including the effect of climate change for scenario RCP 8.5. The refraction model is used to obtain local wave conditions along the coast.

An initial simulation run is carried out for a uniform nourishment with a width of approximately 70m over the full length of Section 3. The coastline evolution after 20 years is shown in magenta in Figure 8-5. It is observed that the groyne blocks the northward directed net longshore sediment transport. As a result, the sand is trapped, and the coastline tends to develop perpendicular to the direction of wave incidence. This results in a curved shape of the coastline. From the results it is clear that the minimum beach width requirement is met (i.e. 35 m distance between coastline and settlement boundary).

The coastline orientation is to be designed in such a way that the expected coastline development is minimized to ensure a stable profile. Therefore, the final coastline position of the initial simulation is used to design the new nourishment layout as presented in red in Figure 8-6. The simulated coastline orientation after 20 years is presented in magenta and shows only limited reshaping of the coast. Hence the coastline is considered stable and the final nourishment design should follow this shape. This layout is subsequently used in the design and to estimate the required nourishment volume and the required groyne length to ensure a stable coastline and the design requirements are met.

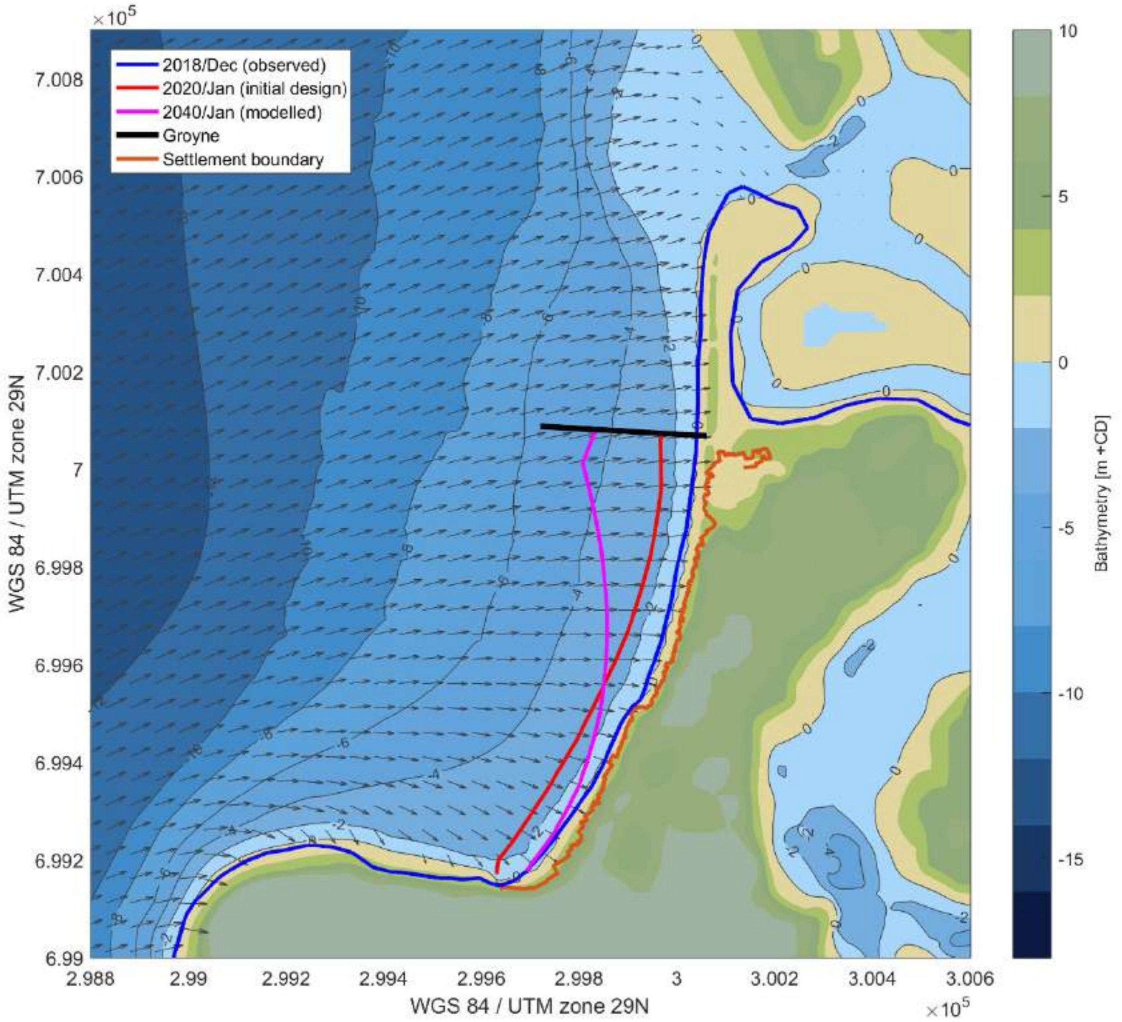


Figure 8-5: Modelled coastal retreat at Section 3, showing the initial design in 2020 and modelled coastline in 2040 and a typical wave field for an offshore wave direction of 240 °N

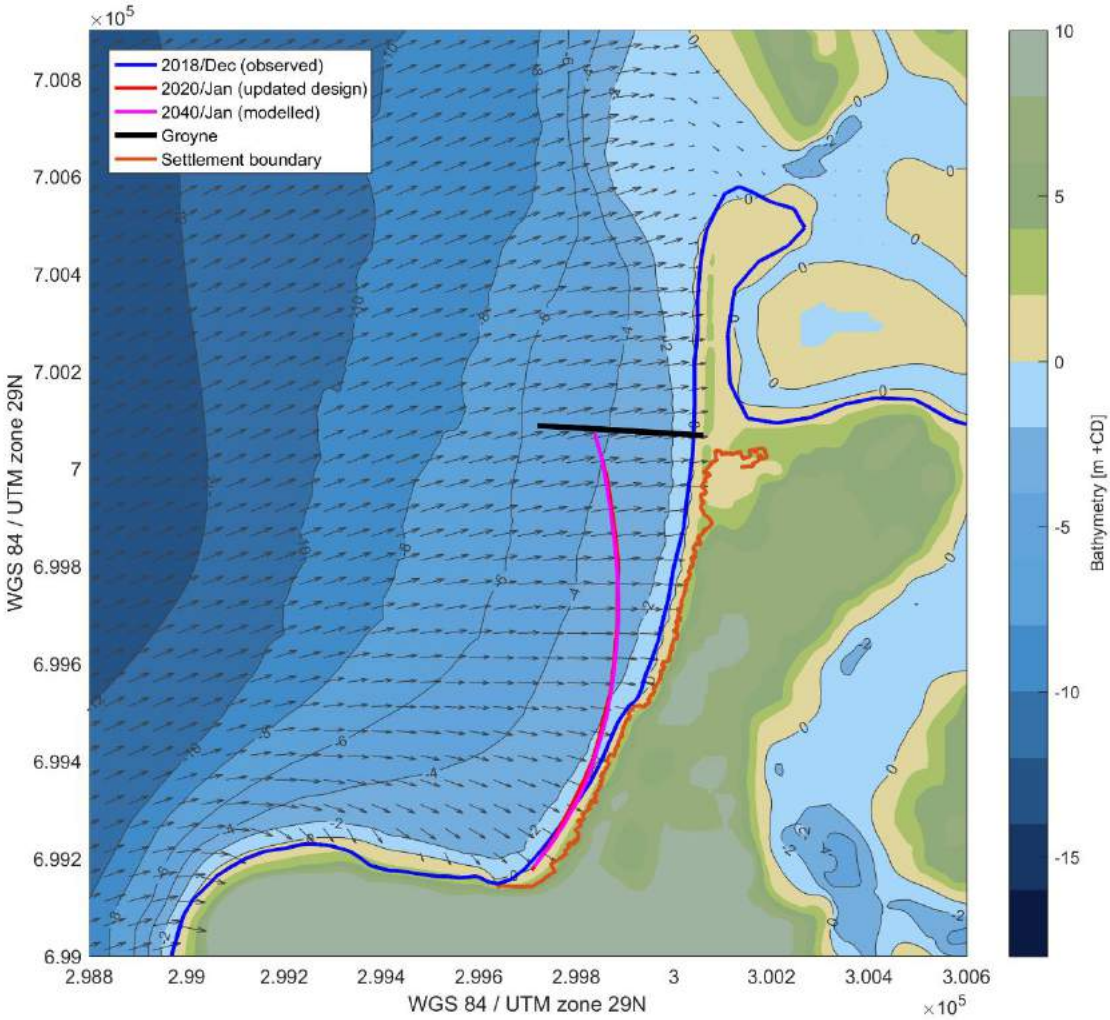


Figure 8-6: Modelled coastal retreat at Section 3, showing the updated design in 2020 and modelled coastline in 2040 and a typical wave field for an offshore wave direction of 240 °N

Section 4: American embassy to Barclay training center

Also at Section 4 a representative wave climate of 50 offshore conditions is used for the period from 2020 to 2040. The coast at Section 4 is relatively uniform and refraction doesn't play an important role. Therefore, to minimize the model errors and computational effort, the wave climate has been applied uniformly along the coast, which is justified in this case.

An initial nourishment design at Section 4 is shown in red in Figure 8-7. After 20 years' time, the coastline has changed towards an orientation perpendicular to the dominant wave angle (±208 °N). This orientation corresponds to the existing coastline orientation as indicated in blue in the Figure below. Hence it is concluded that the nourishment design should follow the original coastline in order to be stable in longshore direction over a longer period of time.

An updated nourishment design of approximately 35m wide is shown in Figure 8-8. This coastline design is straight and follows the original coastline orientation as much as possible. Hardly any changes occur after 20 years of simulation time and hence it can be concluded that this coastline orientation is stable. Moreover, the nourishment is trapped between the outcrop in the east and the groyne in the west. Therefore, no sediment is able to move out the coastal cell by any gross sediment transport.

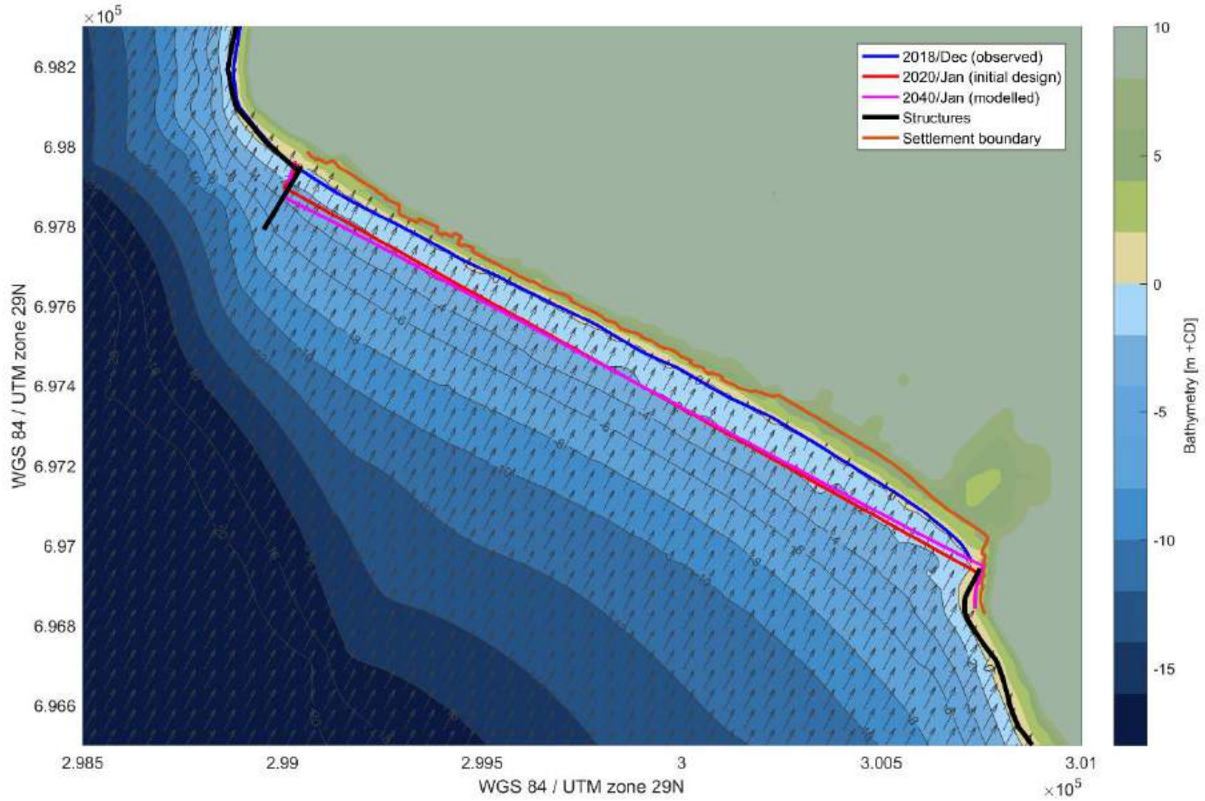


Figure 8-7: Modelled coastal retreat at Section 4, showing the initial design in 2020 and modelled coastline in 2040 and a typical uniform wave field for a wave direction of 208 °N

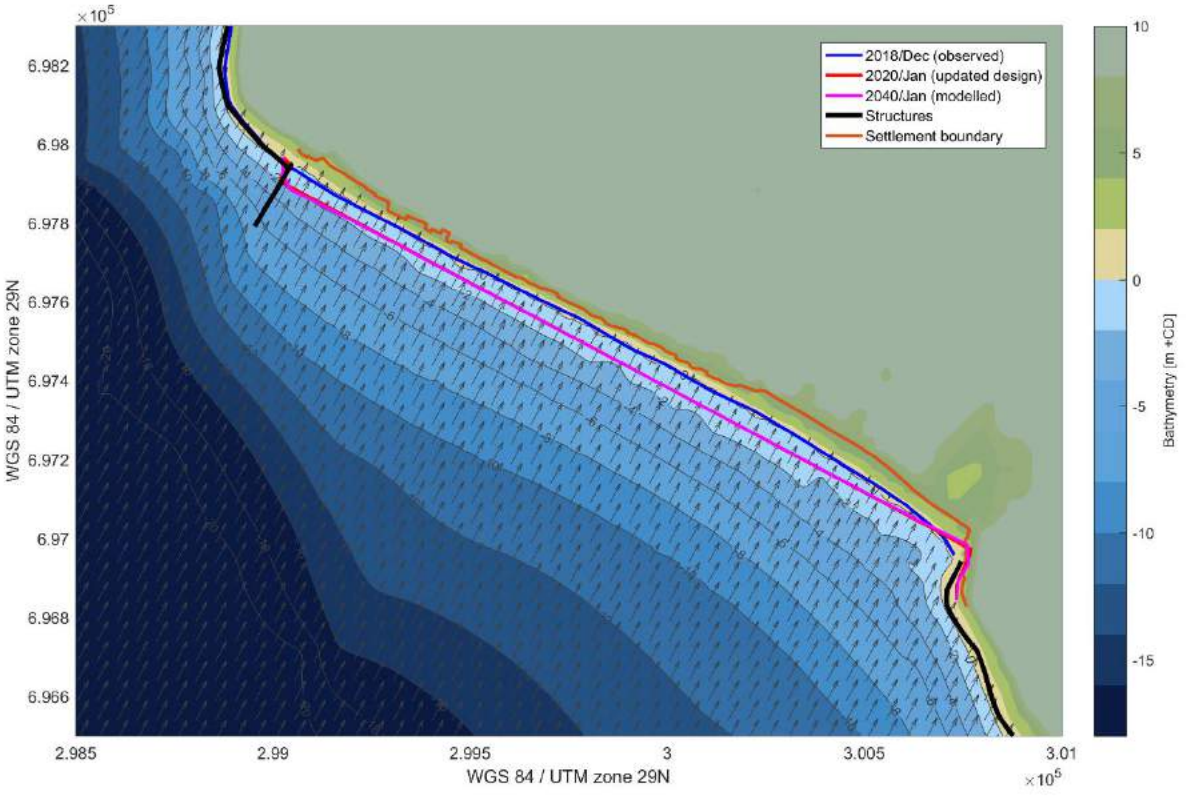
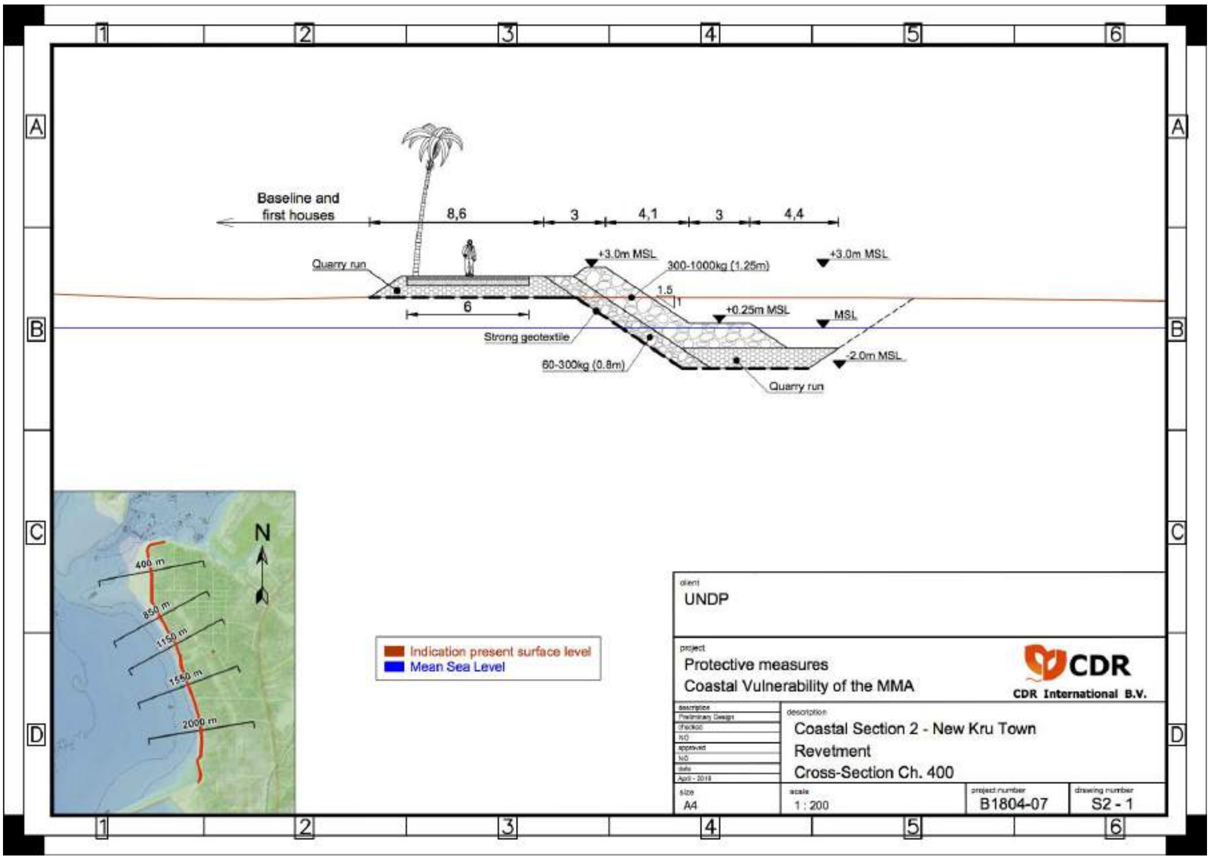
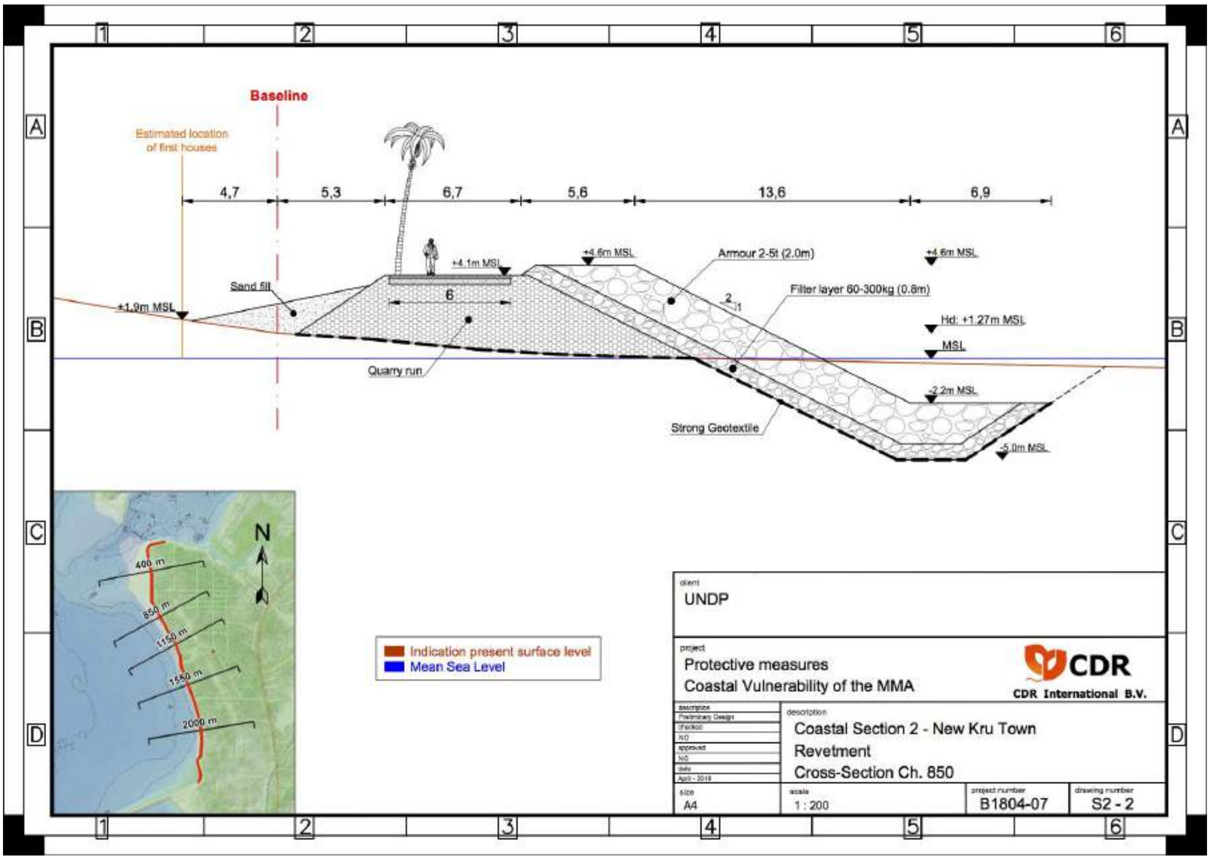
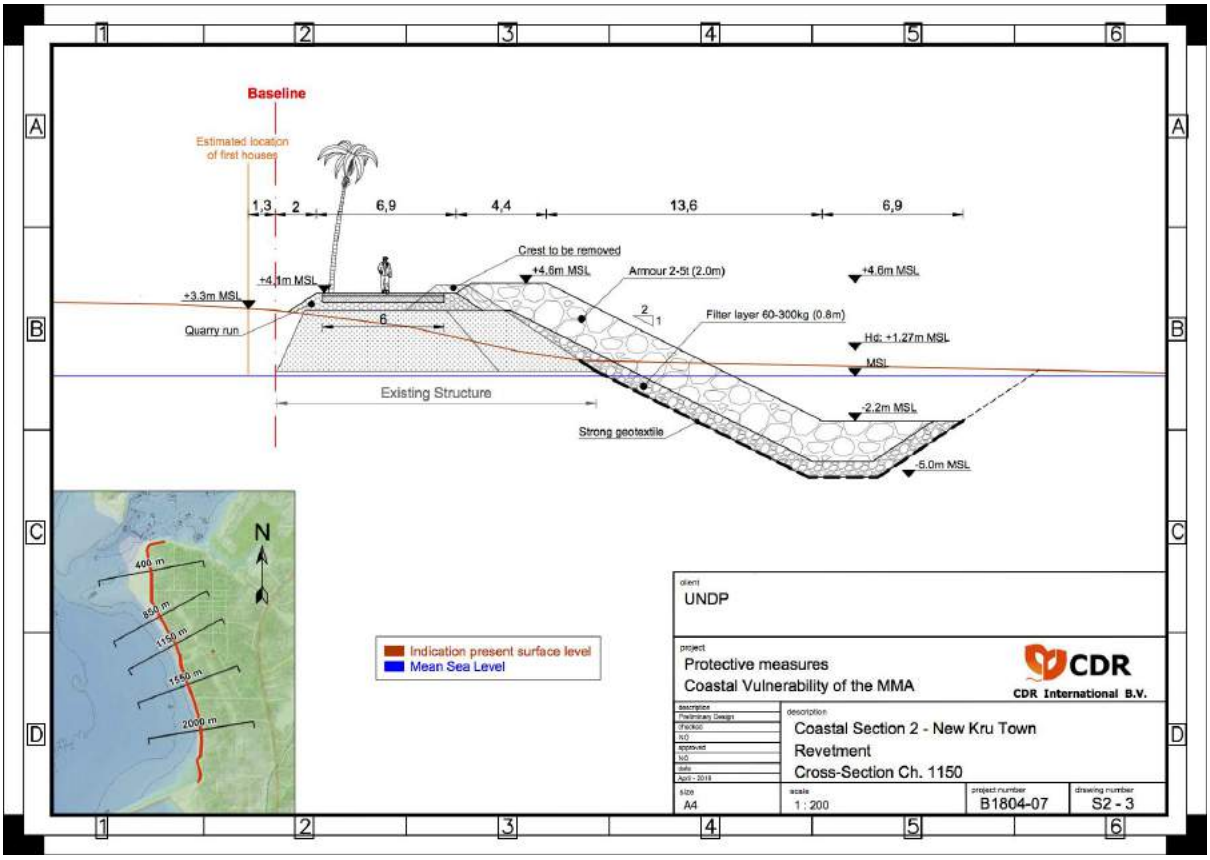


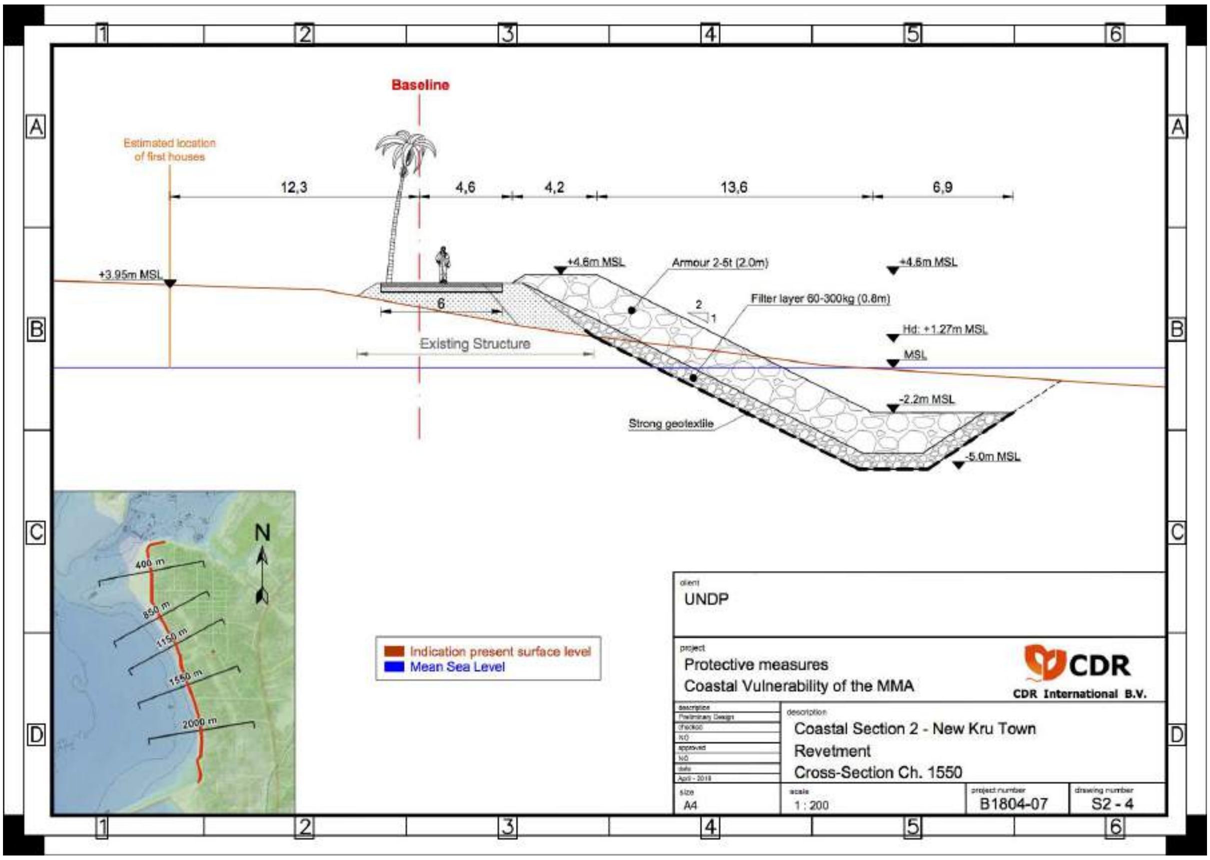
Figure 8-8: Modelled coastal retreat at Section 4, showing the updated design in 2020 and modelled coastline in 2040 and a typical uniform wave field for a wave direction of 208 deg N

E. PRELIMINARY DESIGN DRAWINGS

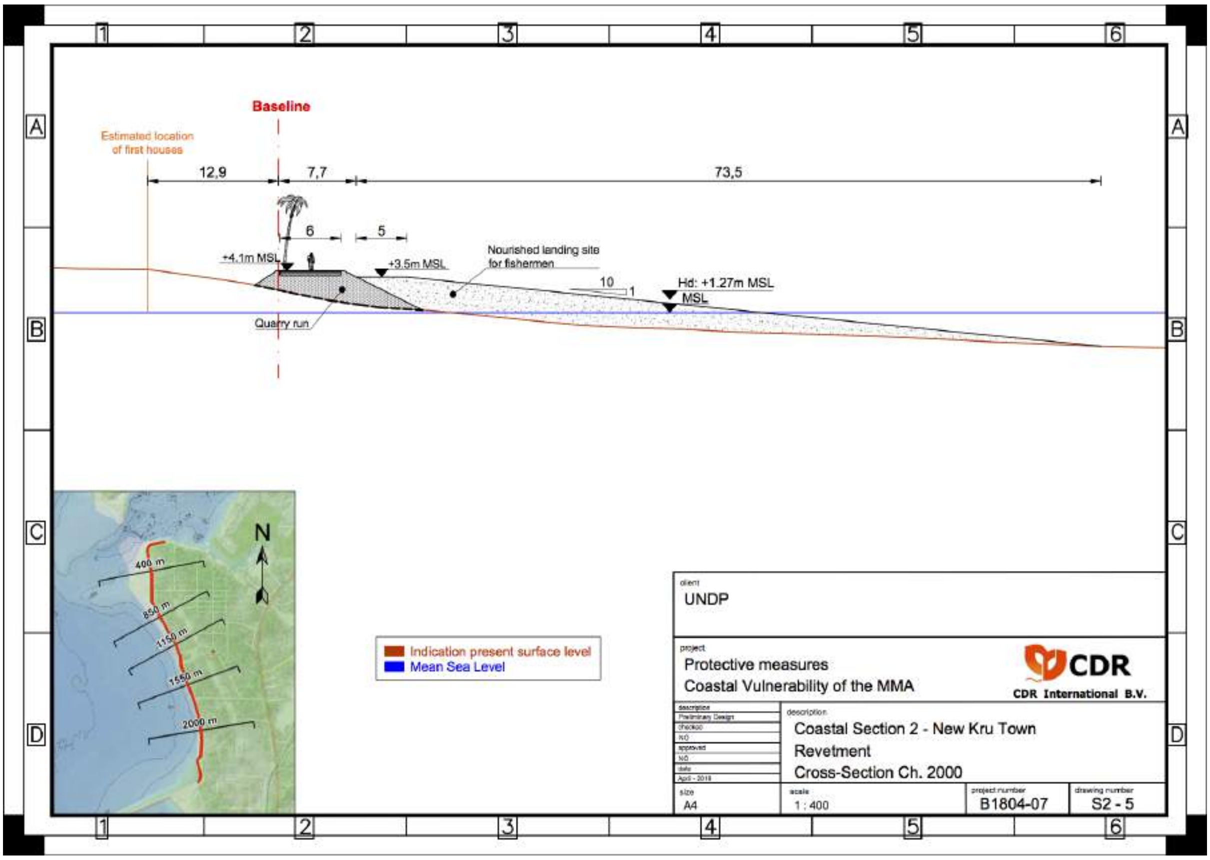



Baseline
Estimated location of first houses
4,7
5,3
6,7
5,6
13,6
6,9
+4.1m MSL
+4.6m MSL
Armour 2-5t (2.0m)
+4.6m MSL
Sand fill
6
Filter layer 60-300kg (0.8m)
+1.9m MSL
Hd: +1.27m MSL
MSL
Quarry run
-2.2m MSL
Strong Geotextile
-5.0m MSL
Indication present surface level
Mean Sea Level
client
UNDP
project
Protective measures
Coastal Vulnerability of the MMA
CDR
CDR International B.V.
description
Coastal Section 2 - New Kru Town
Revetment
Cross-Section Ch. 850
size
A4
scale
1 : 200
project number
B1804-07
drawing number
S2 - 2

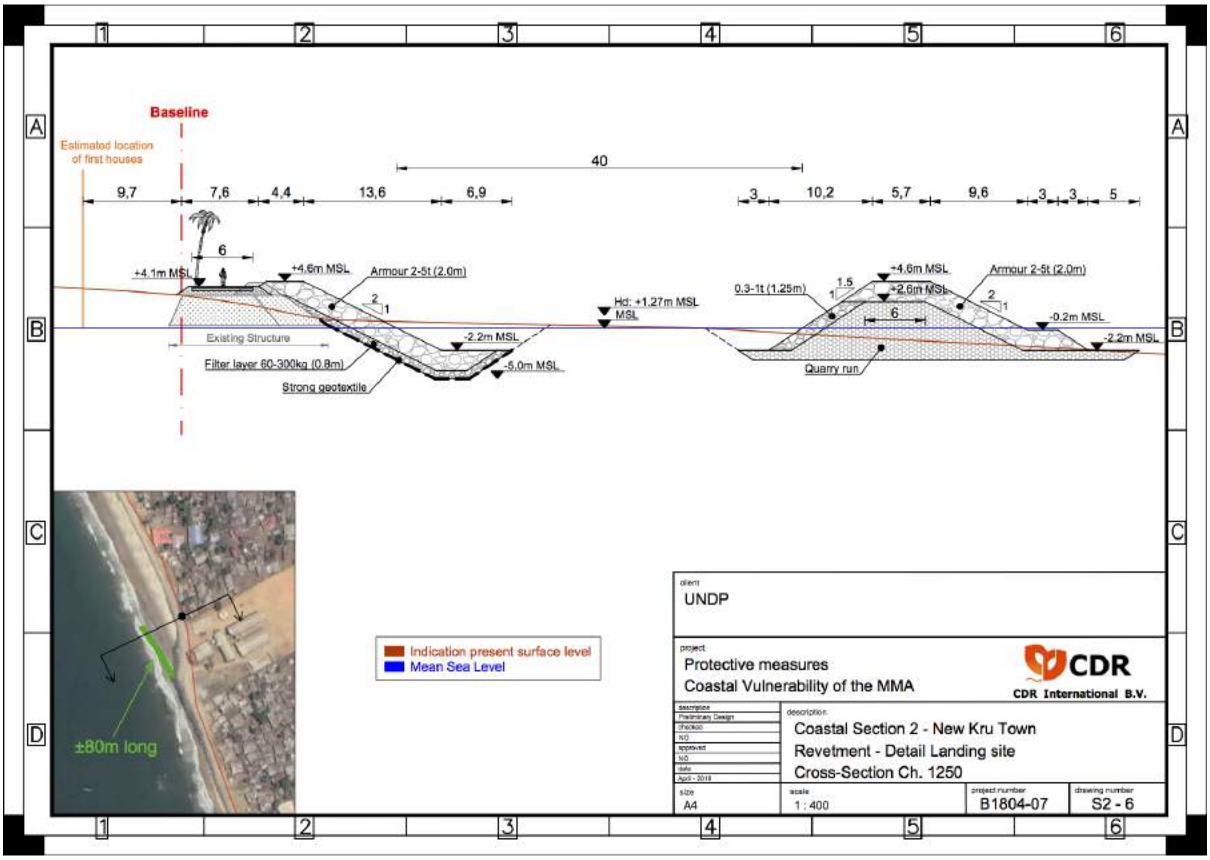

Baseline
Estimated location of first houses
1,3
2
6,9
4,4
13,6
6,9
Crest to be removed
+4.6m MSL
Armour 2-5t (2.0m)
+4.6m MSL
+4.1m MSL
+3.3m MSL
6
Filter layer 60-300kg (0.8m)
Quarry run
Hd: +1.27m MSL
MSL
Existing Structure
-2.2m MSL
Strong geotextile
-5.0m MSL
Indication present surface level
Mean Sea Level
client
UNDP
project
Protective measures
Coastal Vulnerability of the MMA
CDR
CDR International B.V.
description
Coastal Section 2 - New Kru Town
Revetment
Cross-Section Ch. 1150
size
A4
scale
1 : 200
project number
B1804-07
drawing number
S2 - 3



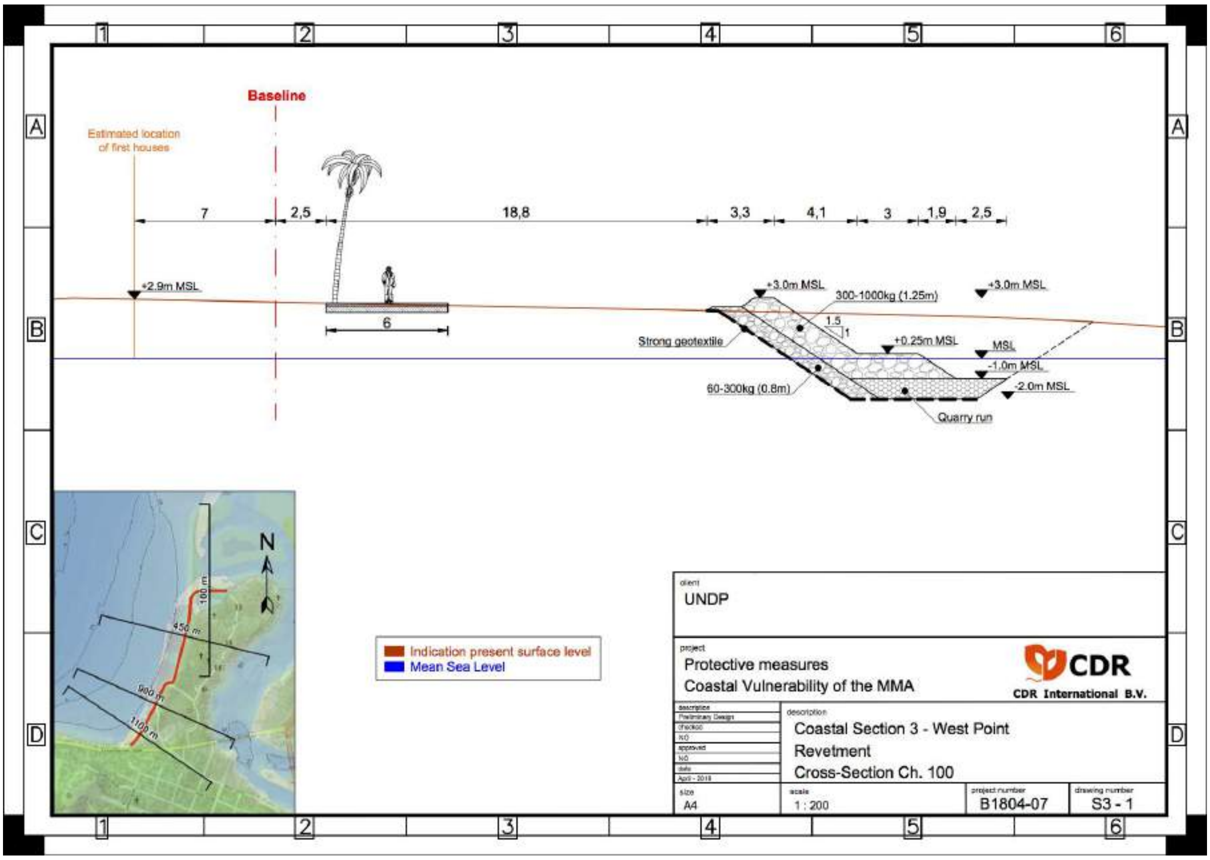
Baseline
Estimated location of first houses
12,3
4,6
4,2
13,6
6,9
+3.95m MSL
+4.6m MSL
Armour 2-5t (2.0m)
+4.6m MSL
6
Filter layer 60-300kg (0.8m)
2
1
Hd: +1.27m MSL
MSL
Existing Structure
-2.2m MSL
Strong geotextile
-5.0m MSL
N
400 m
850 m
1150 m
1550 m
2000 m
Indication present surface level
Mean Sea Level
client
UNDP
project
Protective measures
Coastal Vulnerability of the MMA
CDR
CDR International B.V.
description
Coastal Section 2 - New Kru Town
Revetment
Cross-Section Ch. 1550
size
A4
scale
1 : 200
project number
B1804-07
drawing number
S2 - 4



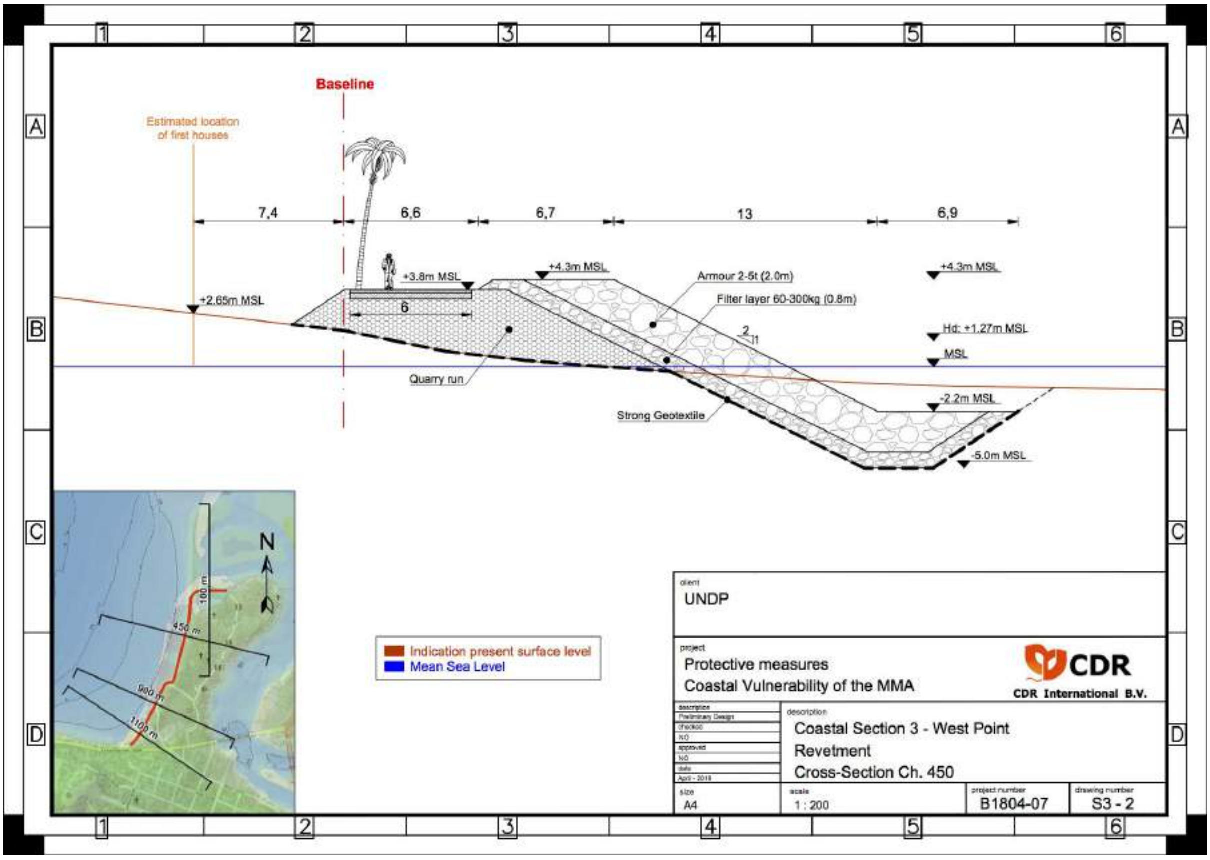
Baseline
Estimated location of first houses
12,9
7,7
73,5
6
5
+4.1m MSL
+3.5m MSL
Nourished landing site for fishermen
10
1
Hd: +1.27m MSL
MSL
Quarry run
N
400 m
850 m
1150 m
1550 m
2000 m
Indication present surface level
Mean Sea Level
client
UNDP
project
Protective measures
Coastal Vulnerability of the MMA
CDR
CDR International B.V.
description
Coastal Section 2 - New Kru Town
Revetment
Cross-Section Ch. 2000
size
A4
scale
1 : 400
project number
B1804-07
drawing number
S2 - 5

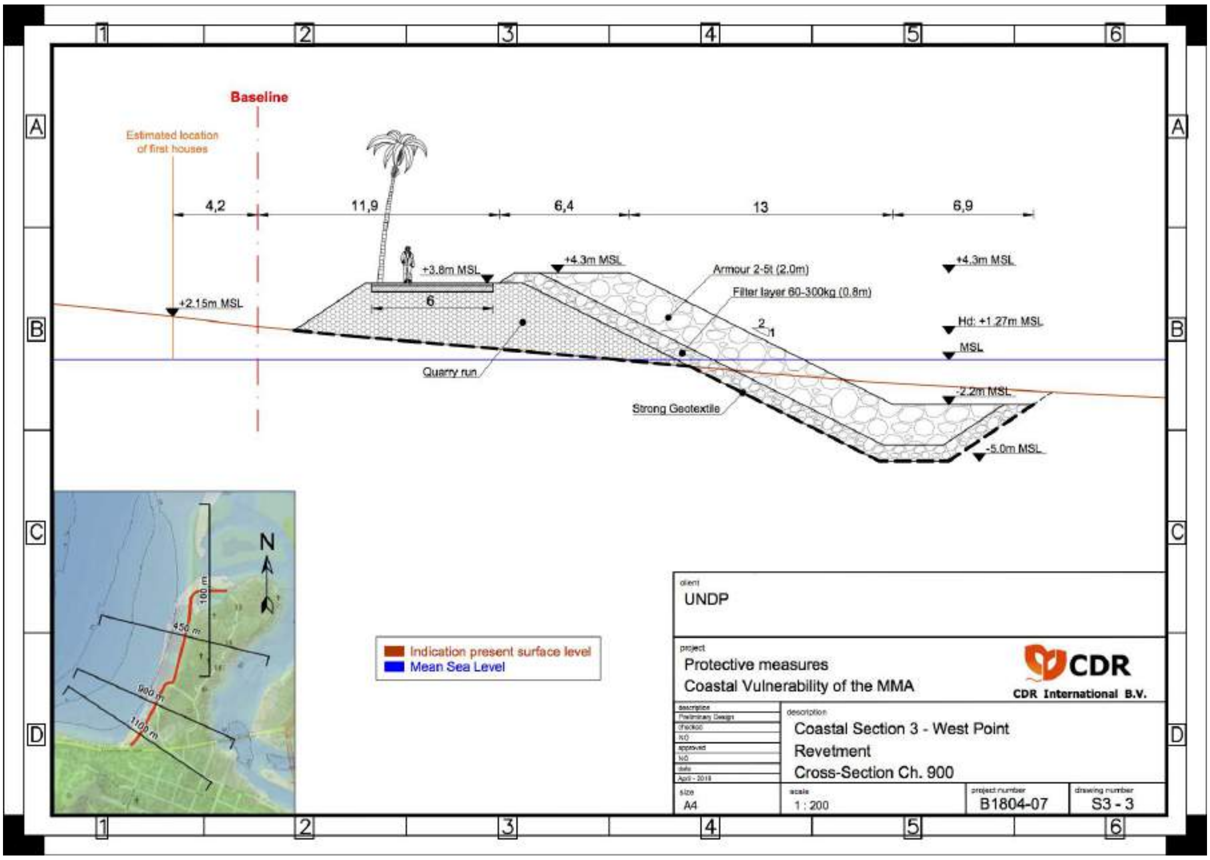


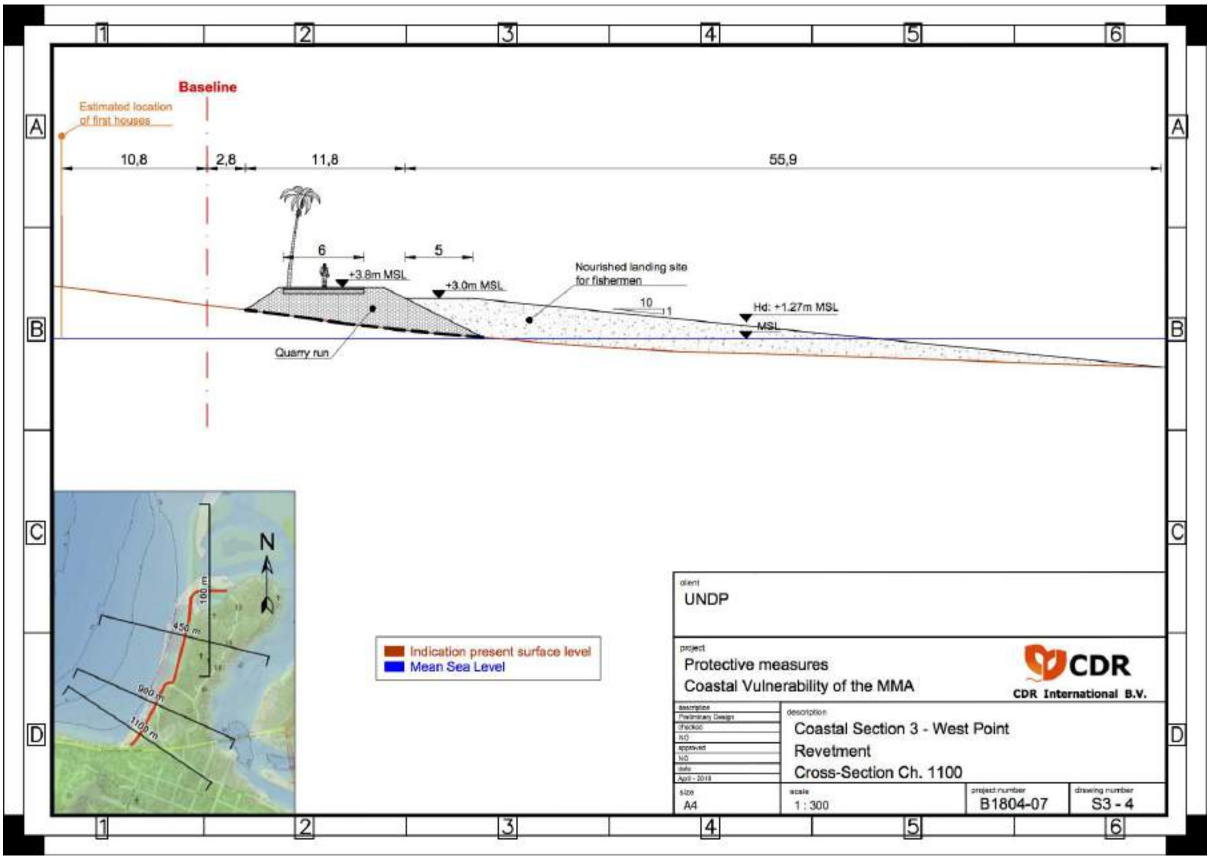
Baseline
Estimated location of first houses
40
9,7
7,6
4,4
13,6
6,9
3
10,2
5,7
9,6
3
3
5
6
+4.1m MSL
+4.6m MSL
Armour 2-5t (2.0m)
Hd: +1.27m MSL
0.3-1t (1.25m)
+4.6m MSL
+2.6m MSL
Armour 2-5t (2.0m)
-0.2m MSL
-2.2m MSL
Existing Structure
-2.2m MSL
Filter layer 60-300kg (0.8m)
-5.0m MSL
Strong geotextile
Quarry run
±80m long
Indication present surface level
Mean Sea Level
client
UNDP
project
Protective measures
Coastal Vulnerability of the MMA
CDR
CDR International B.V.
description
Coastal Section 2 - New Kru Town
Revetment - Detail Landing site
Cross-Section Ch. 1250
size
A4
scale
1 : 400
project number
B1804-07
drawing number
S2 - 6

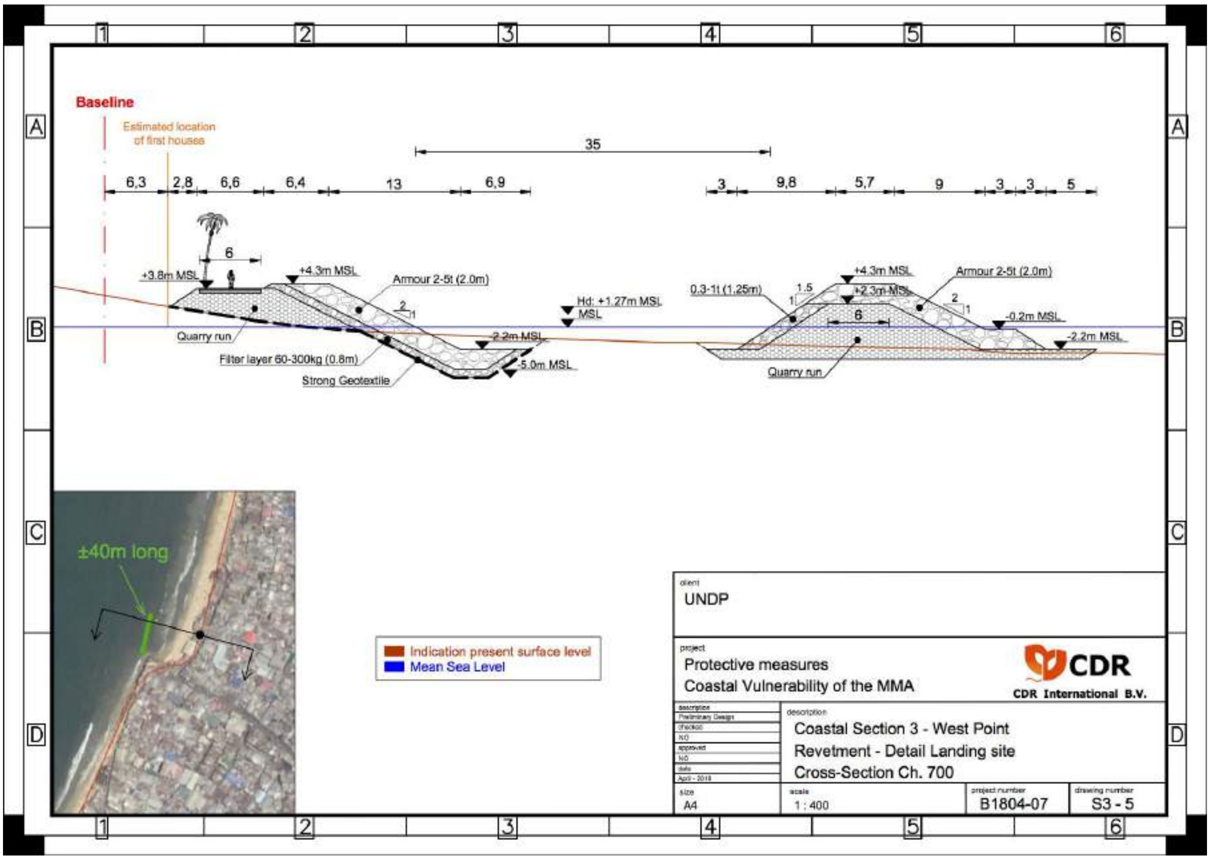


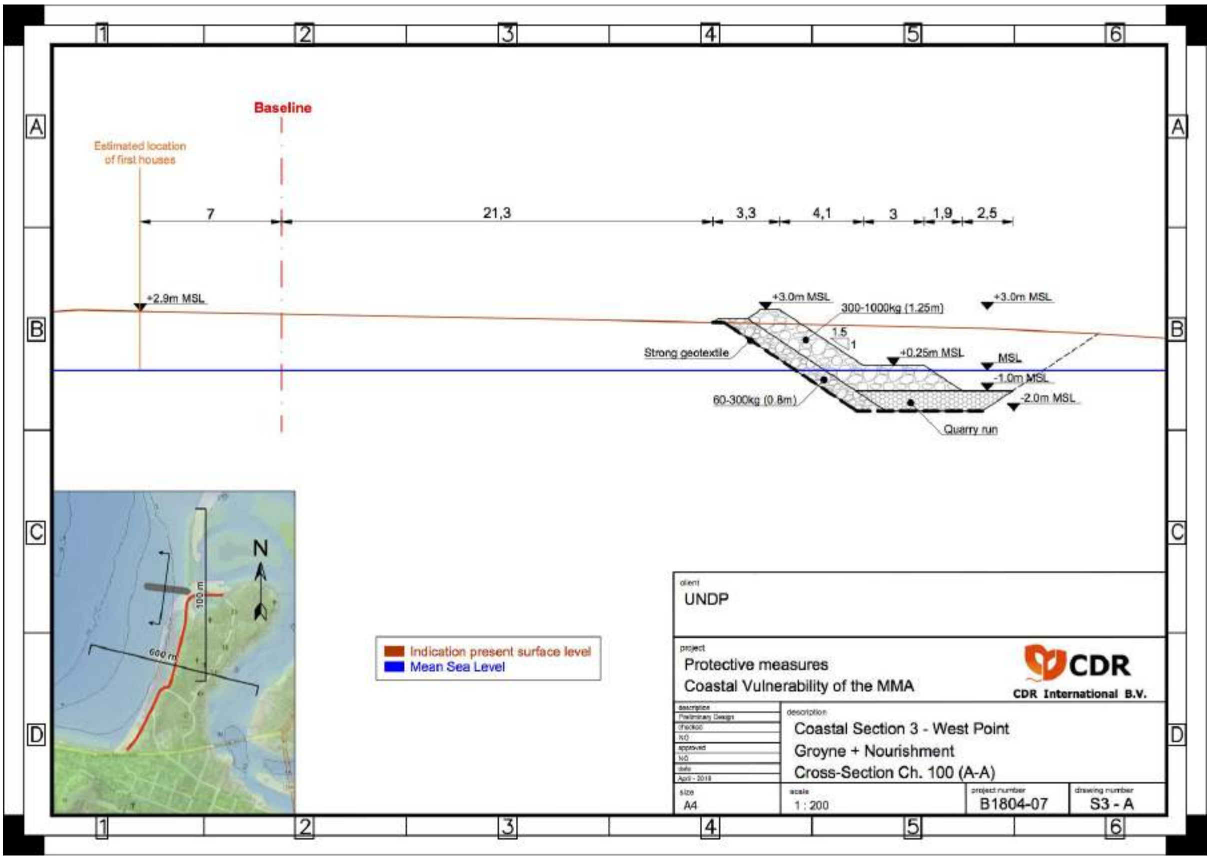
Baseline
Estimated location of first houses
7
2,5
18,8
3,3
4,1
3
1,9
2,5
+2.9m MSL
6
+3.0m MSL
300-1000kg (1.25m)
+3.0m MSL
Strong geotextile
+0.25m MSL
MSL
-1.0m MSL
-2.0m MSL
60-300kg (0.8m)
Quarry run
N
160 m
450 m
900 m
1100 m
Indication present surface level
Mean Sea Level
client
UNDP
project
Protective measures
Coastal Vulnerability of the MMA
CDR
CDR International B.V.
description
Coastal Section 3 - West Point
Revetment
Cross-Section Ch. 100
size
A4
scale
1 : 200
project number
B1804-07
drawing number
S3 - 1


Baseline
Estimated location of first houses
7,4
6,6
6,7
13
6,9
+3.8m MSL
+4.3m MSL
Armour 2-5t (2.0m)
Filter layer 60-300kg (0.8m)
+4.3m MSL
+2.65m MSL
6
Hd: +1.27m MSL
MSL
Quarry run
-2.2m MSL
Strong Geotextile
-5.0m MSL
N
160 m
450 m
900 m
1100 m
Indication present surface level
Mean Sea Level
client
UNDP
project
Protective measures
Coastal Vulnerability of the MMA
CDR
CDR International B.V.
description
Coastal Section 3 - West Point
Revetment
Cross-Section Ch. 450
size
A4
scale
1 : 200
project number
B1804-07
drawing number
S3 - 2

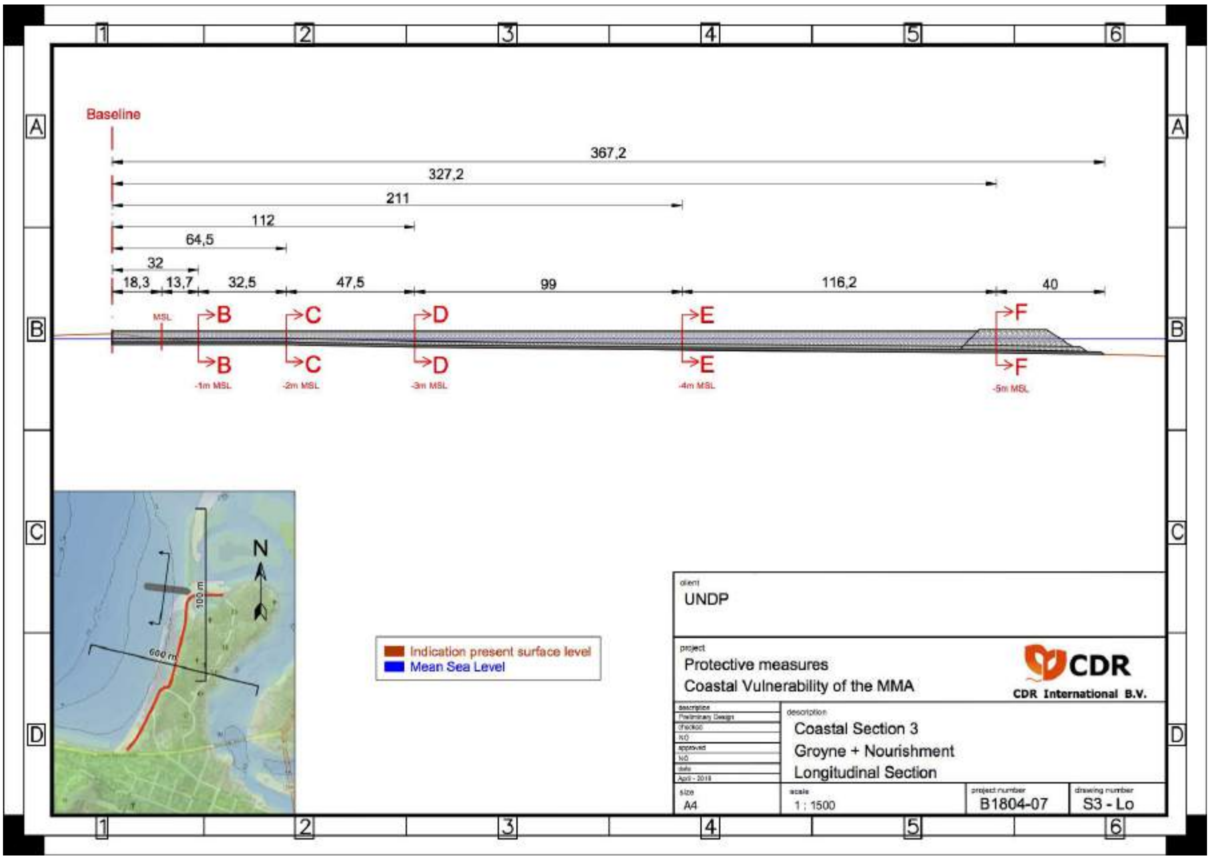

Baseline
Estimated location of first houses
4,2
11,9
6,4
13
6,9
+3.8m MSL
+4.3m MSL
Armour 2-5t (2.0m)
Filter layer 60-300kg (0.8m)
+4.3m MSL
+2.15m MSL
6
Hd: +1.27m MSL
MSL
Quarry run
-2.2m MSL
Strong Geotextile
-5.0m MSL
N
160 m
450 m
900 m
1100 m
Indication present surface level
Mean Sea Level
client
UNDP
project
Protective measures
Coastal Vulnerability of the MMA
CDR
CDR International B.V.
description
Coastal Section 3 - West Point
Revetment
Cross-Section Ch. 900
size
A4
scale
1 : 200
project number
B1804-07
drawing number
S3 - 3


Baseline
Estimated location of first houses
10,8
2,8
11,8
55,9
6
5
+3.8m MSL
+3.0m MSL
Nourished landing site for fishermen
10
1
Hd: +1.27m MSL
MSL
Quarry run
N
100 m
450 m
900 m
1100 m
Indication present surface level
Mean Sea Level
client
UNDP
project
Protective measures
Coastal Vulnerability of the MMA
CDR
CDR International B.V.
description
Coastal Section 3 - West Point
Revetment
Cross-Section Ch. 1100
size
A4
scale
1 : 300
project number
B1804-07
drawing number
S3 - 4

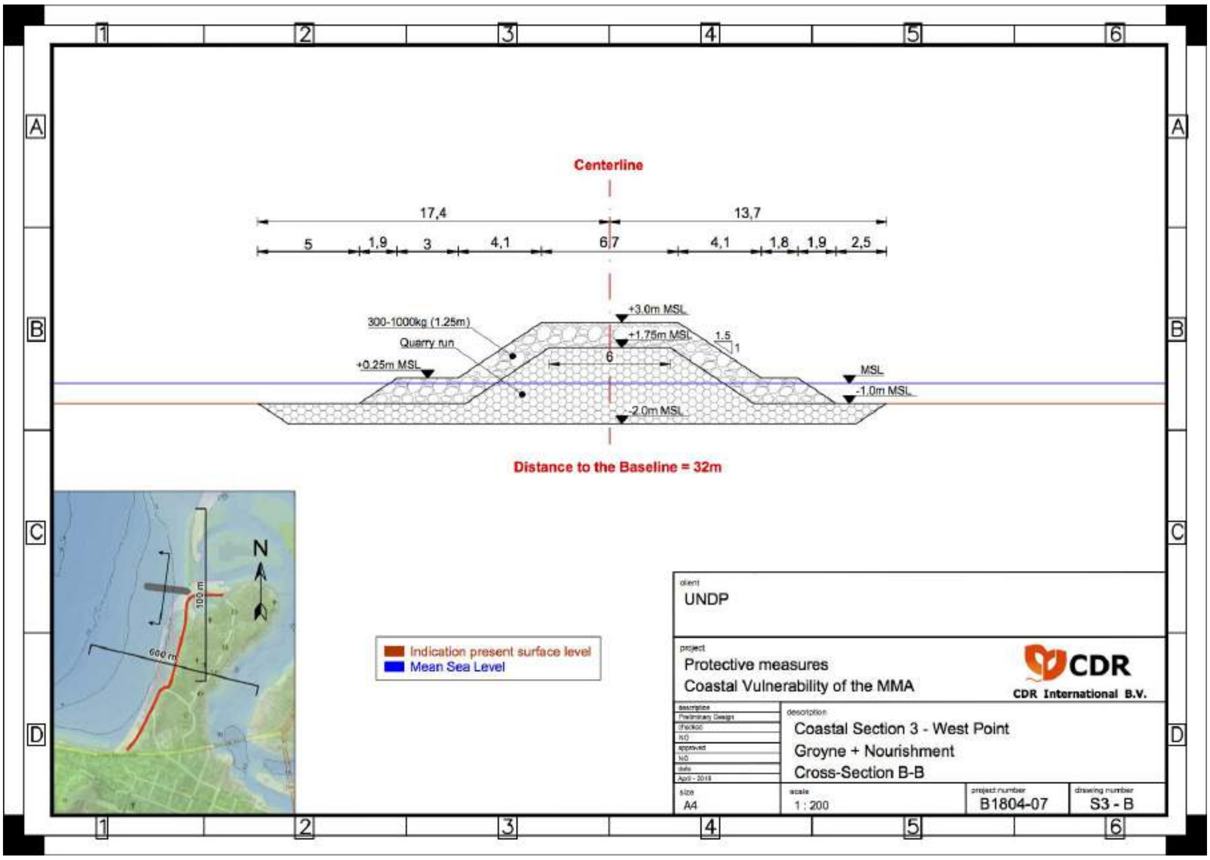

Baseline
Estimated location of first houses
35
6,3
2,8
6,6
6,4
13
6,9
3
9,8
5,7
9
3
3
5
6
+3.8m MSL
+4.3m MSL
Armour 2-5t (2.0m)
2
1
Hd: +1.27m MSL
MSL
Quarry run
-2.2m MSL
Filter layer 60-300kg (0.8m)
-5.0m MSL
Strong Geotextile
0.3-1t (1.25m)
1.5
1
+4.3m MSL
+2.3m MSL
6
Armour 2-5t (2.0m)
2
1
-0.2m MSL
-2.2m MSL
Quarry run
±40m long
Indication present surface level
Mean Sea Level
client
UNDP
project
Protective measures
Coastal Vulnerability of the MMA
CDR
CDR International B.V.
description
Coastal Section 3 - West Point
Revetment - Detail Landing site
Cross-Section Ch. 700
size
A4
scale
1 : 400
project number
B1804-07
drawing number
S3 - 5

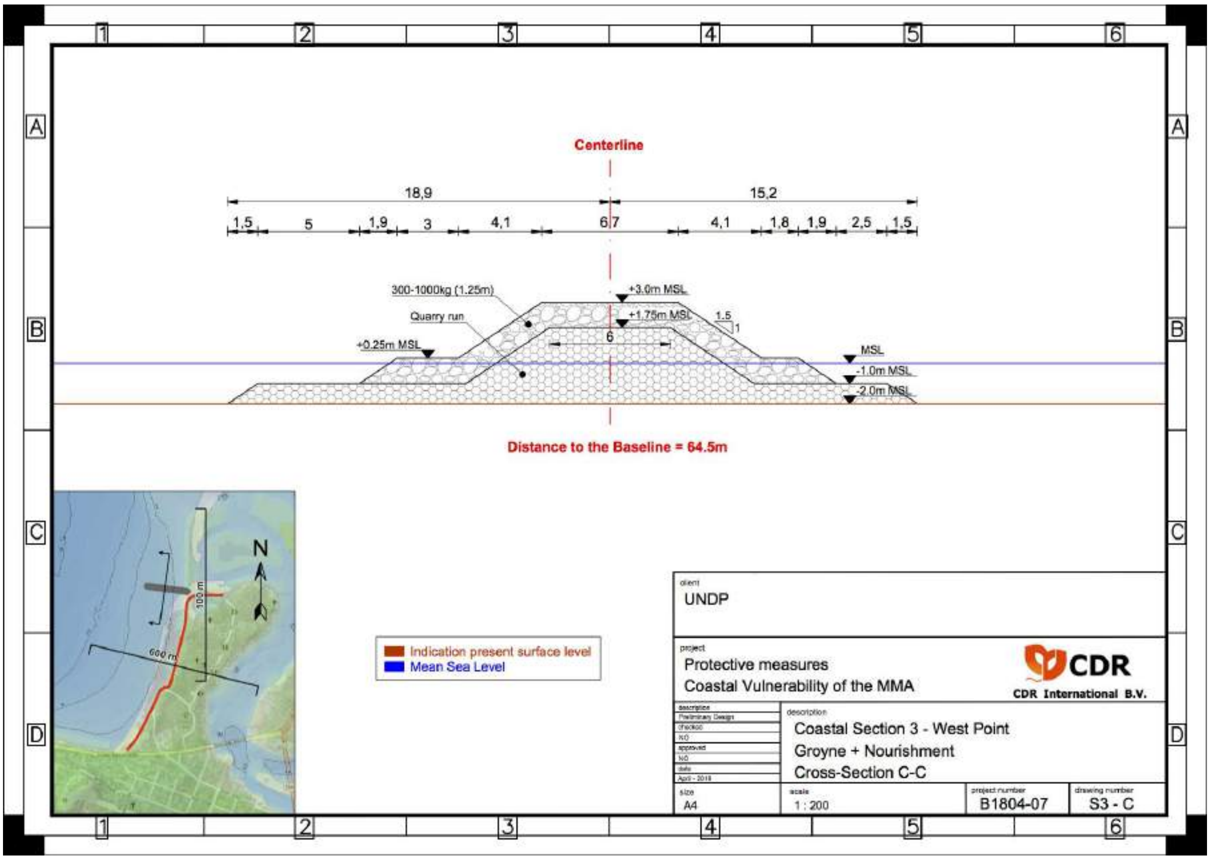


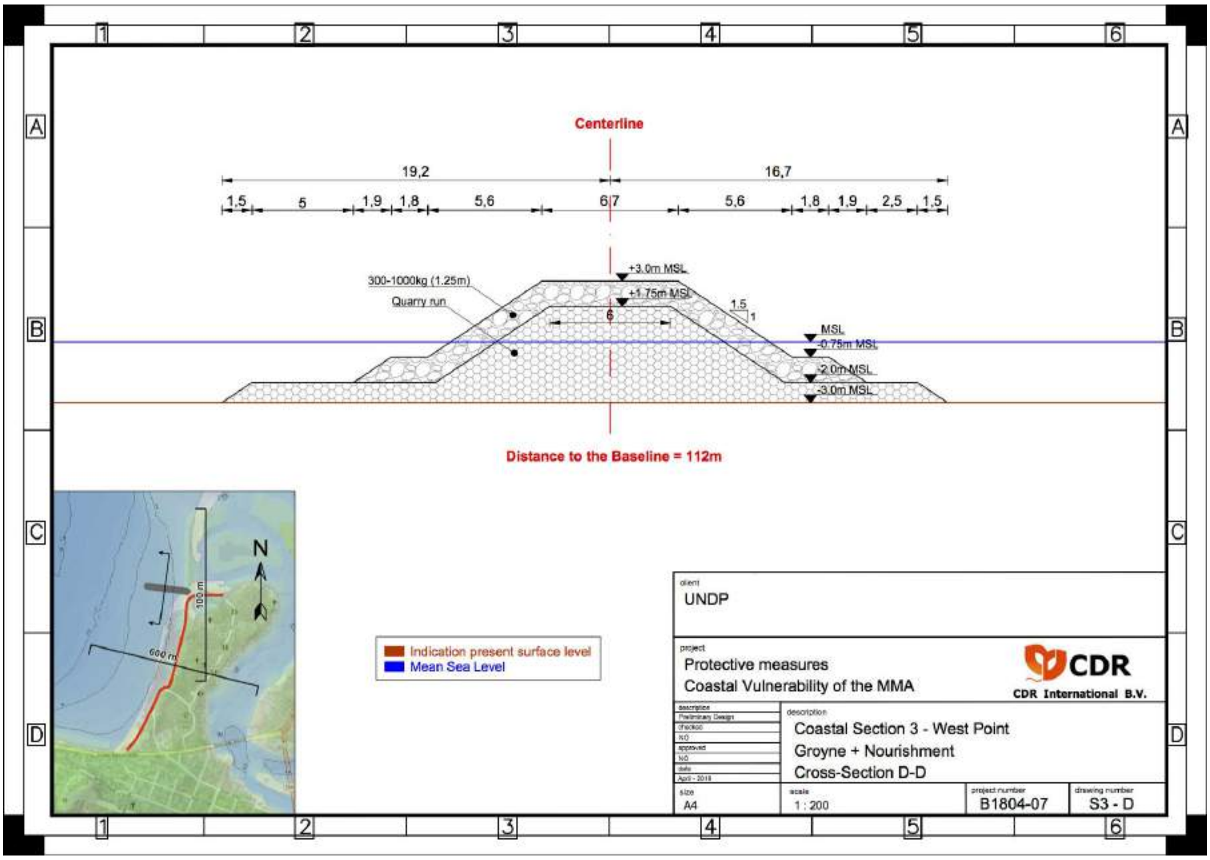
Baseline
Estimated location of first houses
7
21,3
3,3
4,1
3
1,9
2,5
+2.9m MSL
+3.0m MSL
300-1000kg (1.25m)
+3.0m MSL
1.5
1
Strong geotextile
+0.25m MSL
MSL
-1.0m MSL
-2.0m MSL
60-300kg (0.8m)
Quarry run
N
100 m
600 m
Indication present surface level
Mean Sea Level
client
UNDP
project
Protective measures
Coastal Vulnerability of the MMA
CDR
CDR International B.V.
description
Coastal Section 3 - West Point
Groyne + Nourishment
Cross-Section Ch. 100 (A-A)
size
A4
scale
1 : 200
project number
B1804-07
drawing number
S3 - A



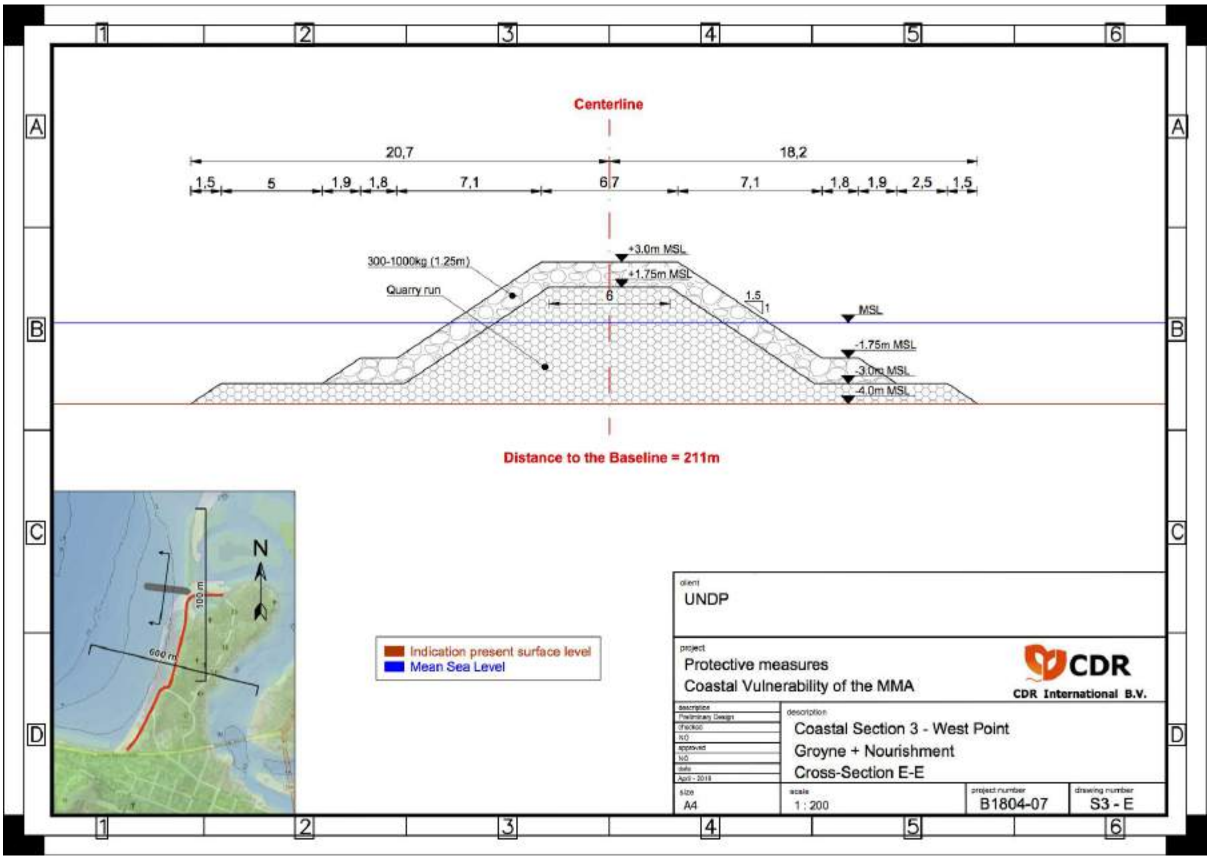
Baseline
367,2
327,2
211
112
64,5
32
18,3
13,7
32,5
47,5
99
116,2
40
MSL
B
C
D
E
F
-1m MSL
-2m MSL
-3m MSL
-4m MSL
-5m MSL
N
100 m
600 m
Indication present surface level
Mean Sea Level
client
UNDP
project
Protective measures
Coastal Vulnerability of the MMA
CDR
CDR International B.V.
description
Coastal Section 3
Groyne + Nourishment
Longitudinal Section
size
A4
scale
1 : 1500
project number
B1804-07
drawing number
S3 - Lo


Centerline
17,4
13,7
5
1,9
3
4,1
6,7
4,1
1,8
1,9
2,5
300-1000kg (1.25m)
Quarry run
+0.25m MSL
+3.0m MSL
+1.75m MSL
1.5
1
6
MSL
-1.0m MSL
-2.0m MSL
Distance to the Baseline = 32m
N
100 m
600 m
Indication present surface level
Mean Sea Level
client
UNDP
project
Protective measures
Coastal Vulnerability of the MMA
CDR
CDR International B.V.
description
Coastal Section 3 - West Point
Groyne + Nourishment
Cross-Section B-B
size
A4
scale
1 : 200
project number
B1804-07
drawing number
S3 - B

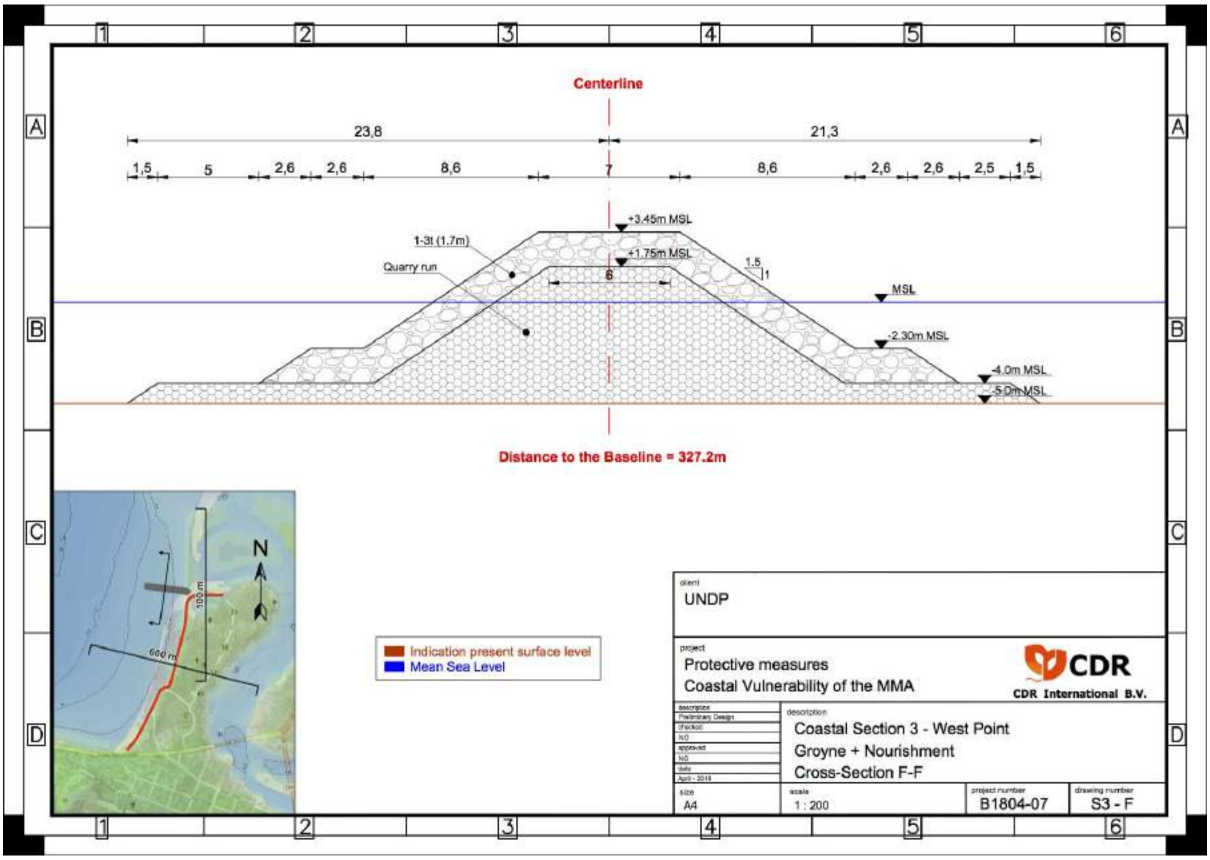

Centerline
18,9
15,2
1,5
5
1,9
3
4,1
6,7
4,1
1,8
1,9
2,5
1,5
300-1000kg (1.25m)
Quarry run
+0.25m MSL
+3.0m MSL
+1.75m MSL
1.5
1
6
MSL
-1.0m MSL
-2.0m MSL
Distance to the Baseline = 64.5m
N
100 m
600 m
Indication present surface level
Mean Sea Level
client
UNDP
project
Protective measures
Coastal Vulnerability of the MMA
CDR
CDR International B.V.
description
Coastal Section 3 - West Point
Groyne + Nourishment
Cross-Section C-C
size
A4
scale
1 : 200
project number
B1804-07
drawing number
S3 - C

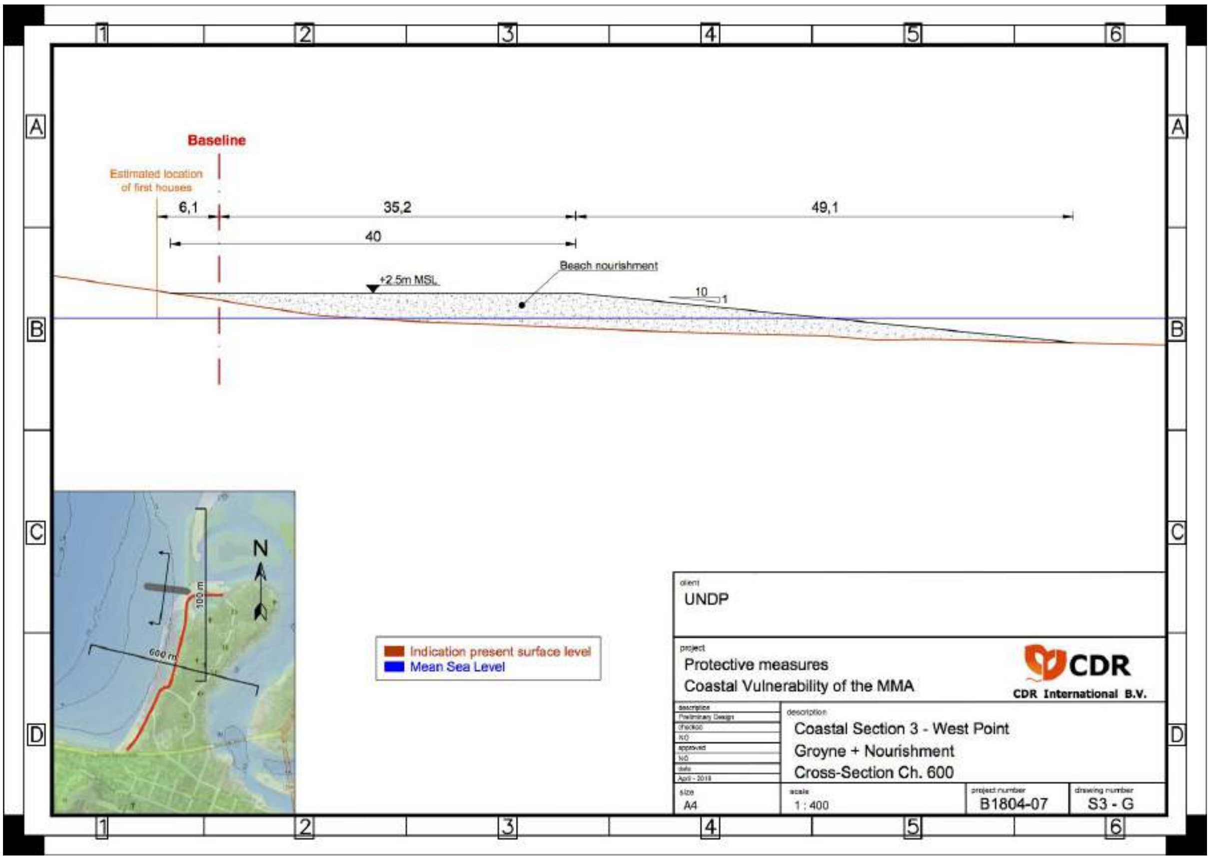


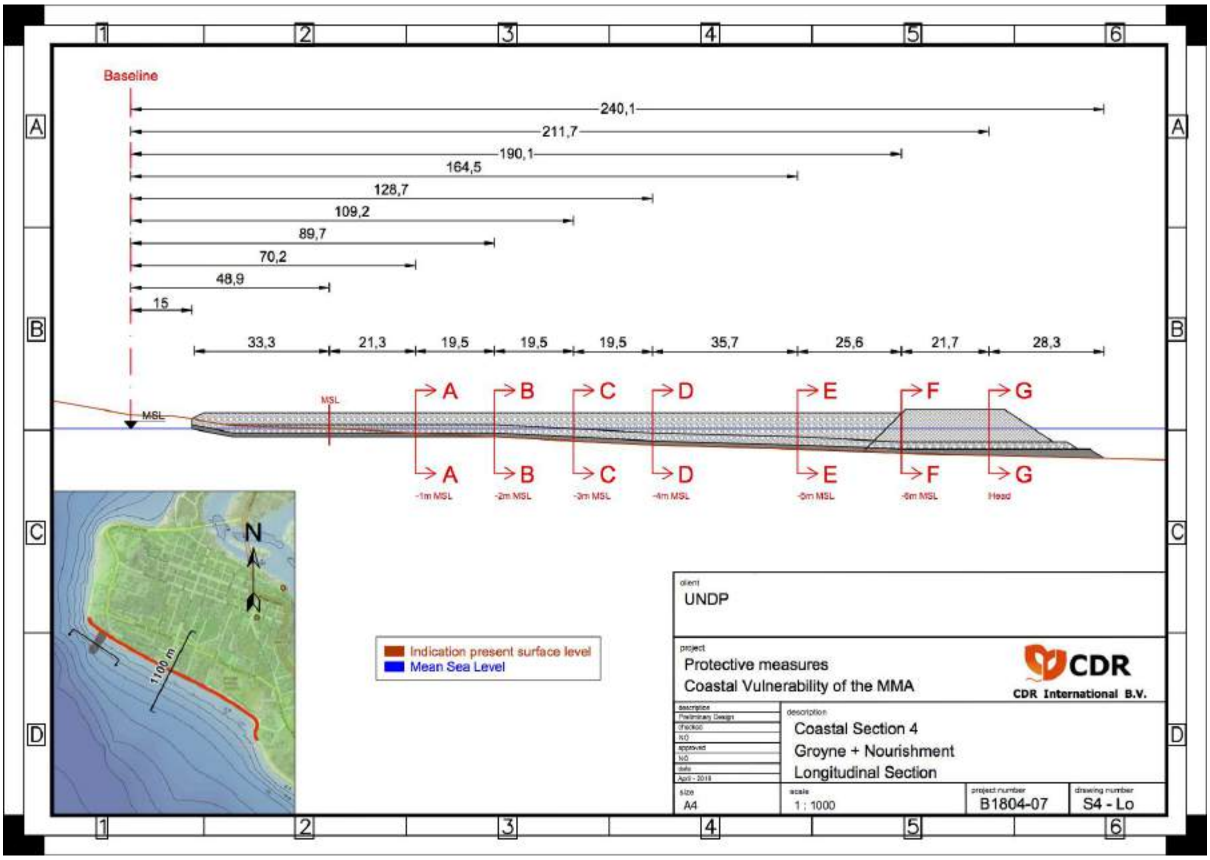
Centerline
19,2
16,7
1,5
5
1,9
1,8
5,6
6
7
5,6
1,8
1,9
2,5
1,5
+3.0m MSL
300-1000kg (1.25m)
+1.75m MSL
Quarry run
1,5
1
6
MSL
-0.75m MSL
-2.0m MSL
-3.0m MSL
Distance to the Baseline = 112m
N
100 m
600 m
Indication present surface level
Mean Sea Level
client
UNDP
project
Protective measures
Coastal Vulnerability of the MMA
CDR
CDR International B.V.
description
Coastal Section 3 - West Point
Groyne + Nourishment
Cross-Section D-D
size
A4
scale
1 : 200
project number
B1804-07
drawing number
S3 - D

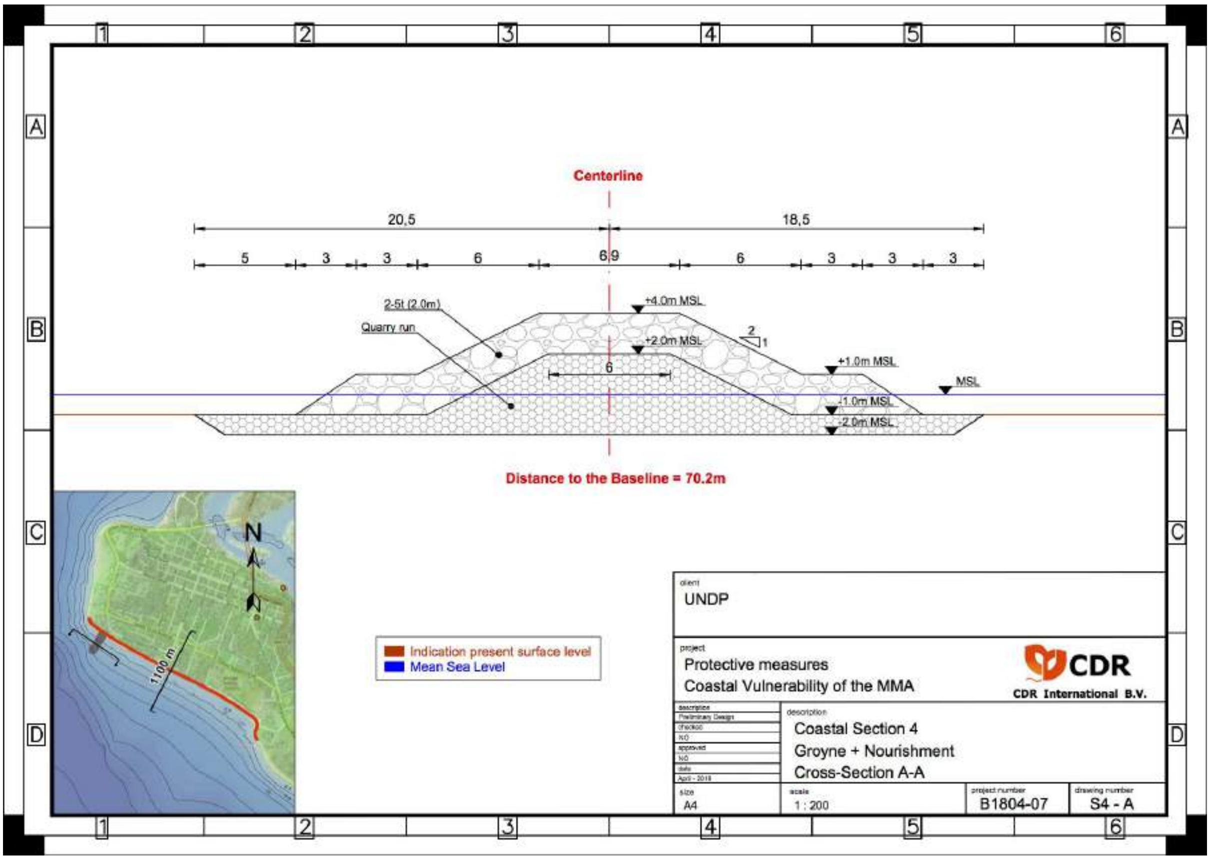


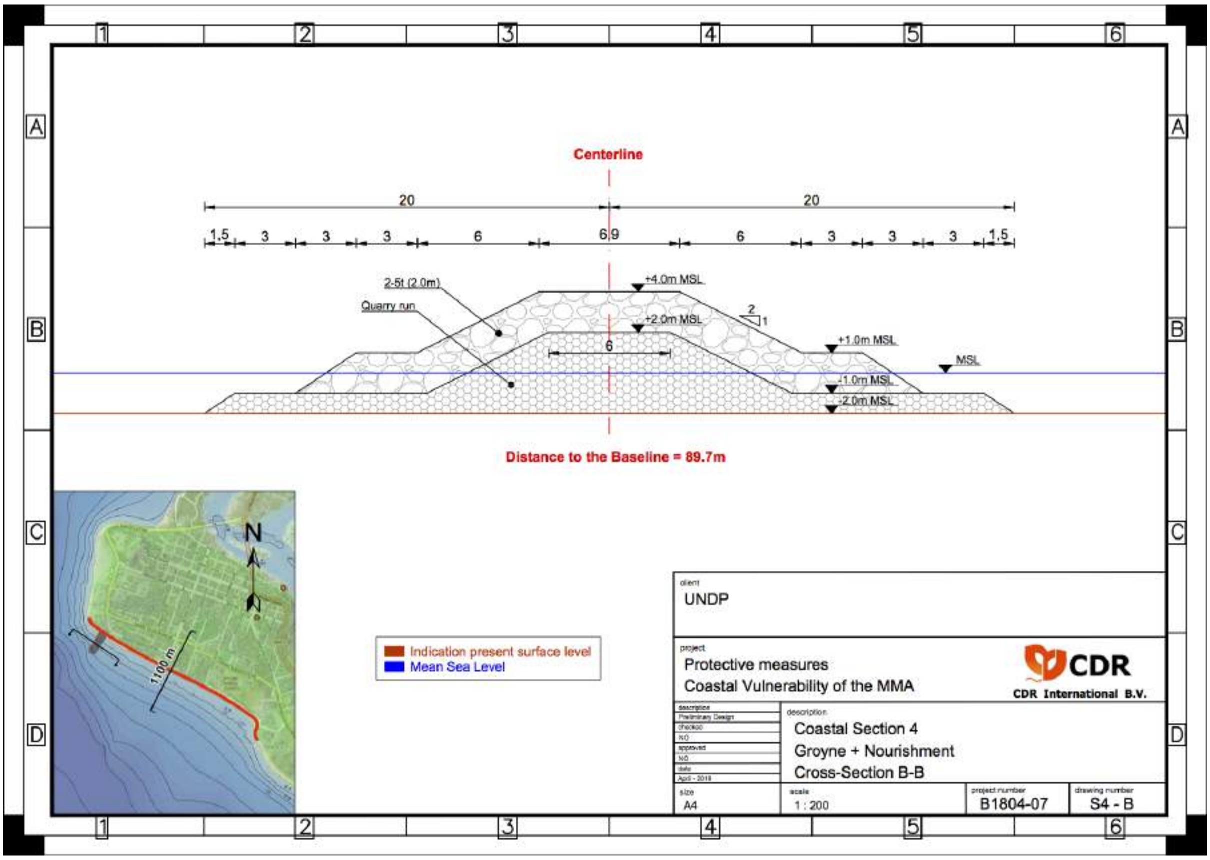
Centerline
20,7
18,2
1,5
5
1,9
1,8
7,1
6
7
7,1
1,8
1,9
2,5
1,5
+3.0m MSL
300-1000kg (1.25m)
+1.75m MSL
Quarry run
1,5
1
6
MSL
-1.75m MSL
-3.0m MSL
-4.0m MSL
Distance to the Baseline = 211m
N
100 m
600 m
Indication present surface level
Mean Sea Level
client
UNDP
project
Protective measures
Coastal Vulnerability of the MMA
CDR
CDR International B.V.
description
Coastal Section 3 - West Point
Groyne + Nourishment
Cross-Section E-E
size
A4
scale
1 : 200
project number
B1804-07
drawing number
S3 - E


Centerline
23,8
21,3
1,5
5
2,6
2,6
8,6
7
8,6
2,6
2,6
2,5
1,5
+3.45m MSL
1-3t (1.7m)
+1.75m MSL
Quarry run
6
1.5
1
MSL
-2.30m MSL
-4.0m MSL
-5.0m MSL
Distance to the Baseline = 327.2m
100 m
600 m
N
Indication present surface level
Mean Sea Level
client
UNDP
project
Protective measures
Coastal Vulnerability of the MMA
CDR
CDR International B.V.
description
Coastal Section 3 - West Point
Groyne + Nourishment
Cross-Section F-F
size
A4
scale
1 : 200
project number
B1804-07
drawing number
S3 - F

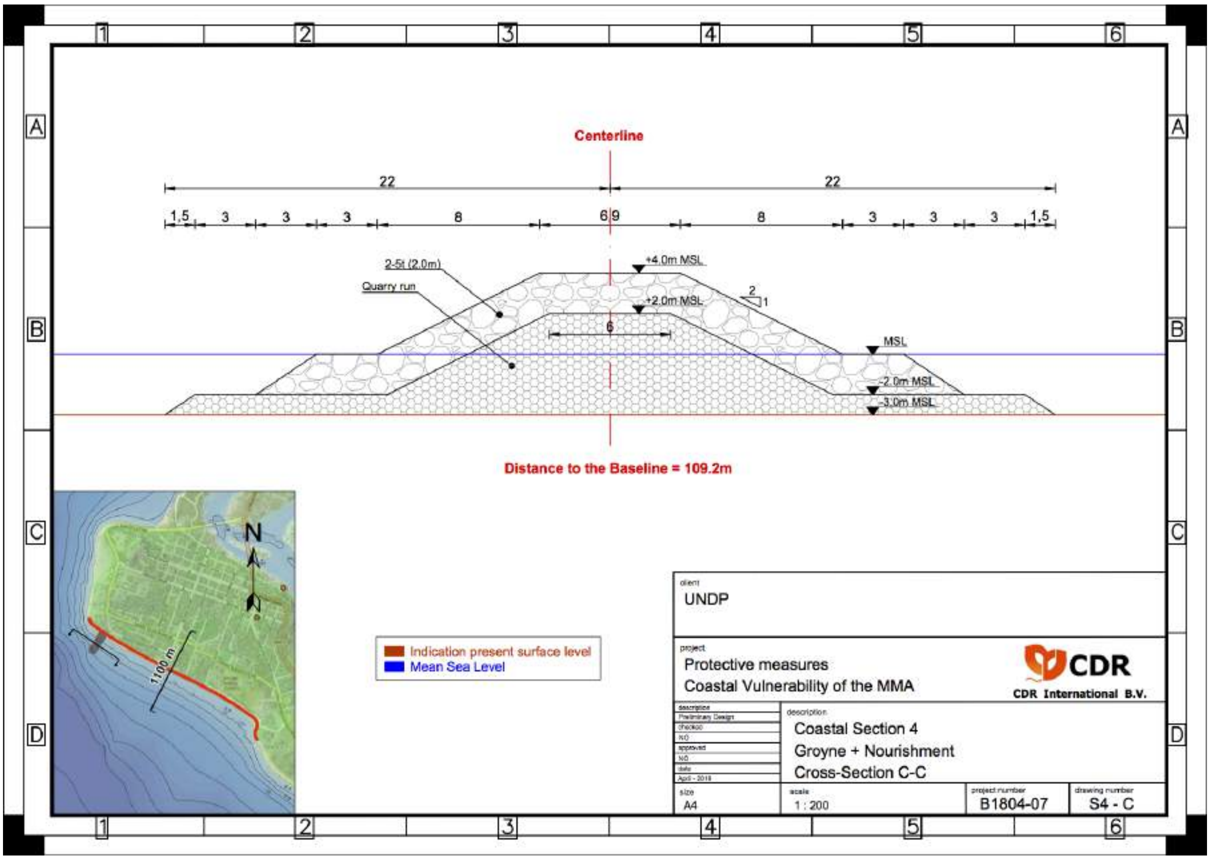

Baseline
Estimated location
of first houses
6,1
35,2
49,1
40
+2.5m MSL
Beach nourishment
10
1
100 m
600 m
N
Indication present surface level
Mean Sea Level
client
UNDP
project
Protective measures
Coastal Vulnerability of the MMA
CDR
CDR International B.V.
description
Coastal Section 3 - West Point
Groyne + Nourishment
Cross-Section Ch. 600
size
A4
scale
1 : 400
project number
B1804-07
drawing number
S3 - G


Baseline
240,1
211,7
190,1
164,5
128,7
109,2
89,7
70,2
48,9
15
33,3
21,3
19,5
19,5
19,5
35,7
25,6
21,7
28,3
MSL
A B C D E F G
-1m MSL
-2m MSL
-3m MSL
-4m MSL
-5m MSL
-6m MSL
Head
N
1100 m
Indication present surface level
Mean Sea Level
client
UNDP
project
Protective measures
Coastal Vulnerability of the MMA
CDR
CDR International B.V.
description
Coastal Section 4
Groyne + Nourishment
Longitudinal Section
size
A4
scale
1 : 1000
project number
B1804-07
drawing number
S4 - Lo

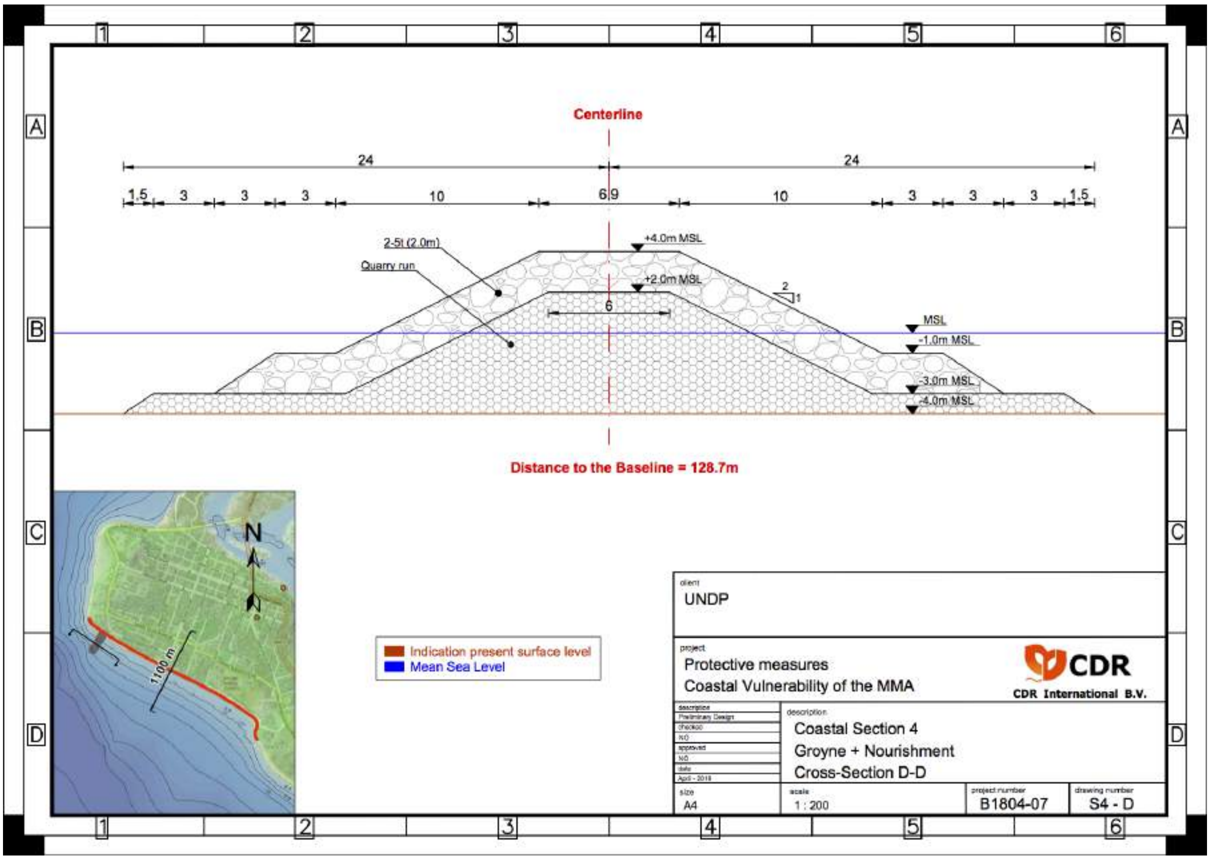

Centerline
20,5
18,5
5
3
3
6
6,9
6
3
3
3
2-5t (2.0m)
Quarry run
+4.0m MSL
+2.0m MSL
+1.0m MSL
MSL
-1.0m MSL
-2.0m MSL
2
1
6
Distance to the Baseline = 70.2m
N
1100 m
Indication present surface level
Mean Sea Level
client
UNDP
project
Protective measures
Coastal Vulnerability of the MMA
CDR
CDR International B.V.
description
Coastal Section 4
Groyne + Nourishment
Cross-Section A-A
size
A4
scale
1 : 200
project number
B1804-07
drawing number
S4 - A

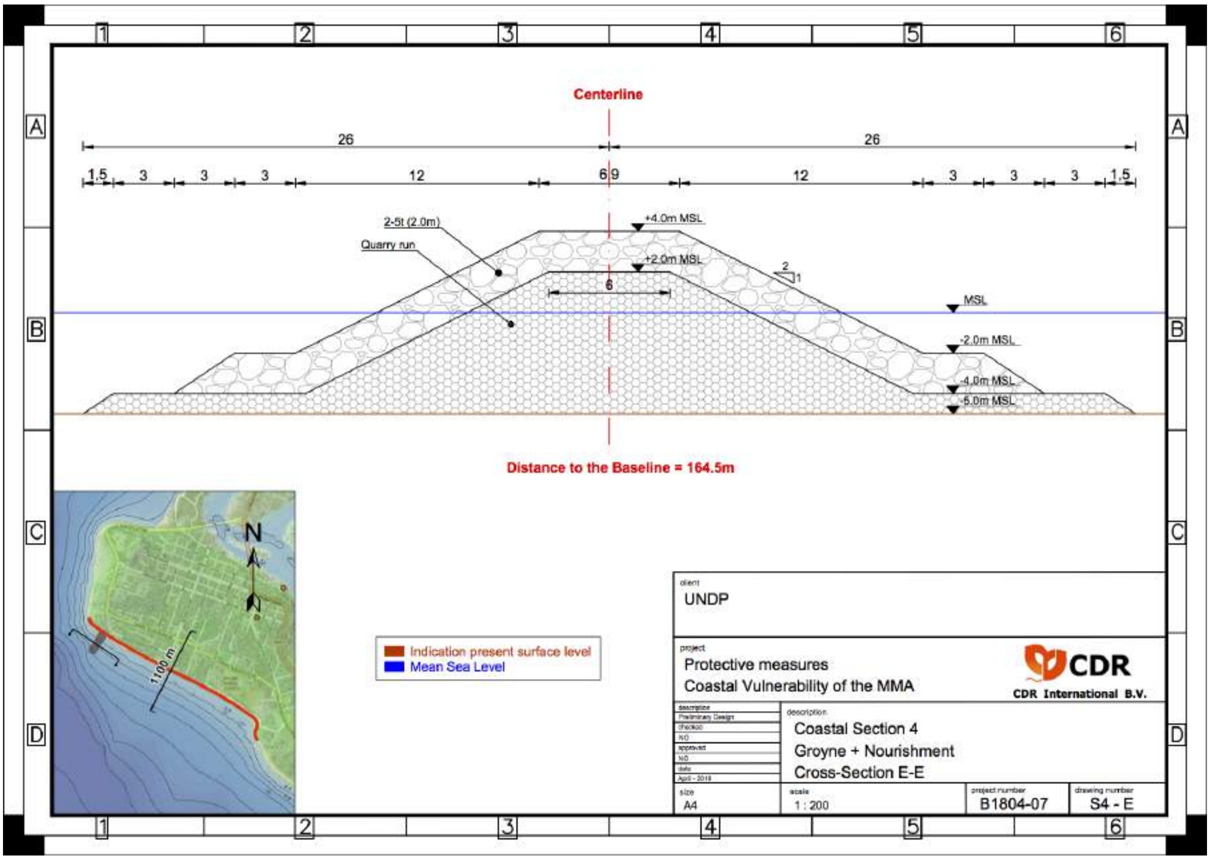


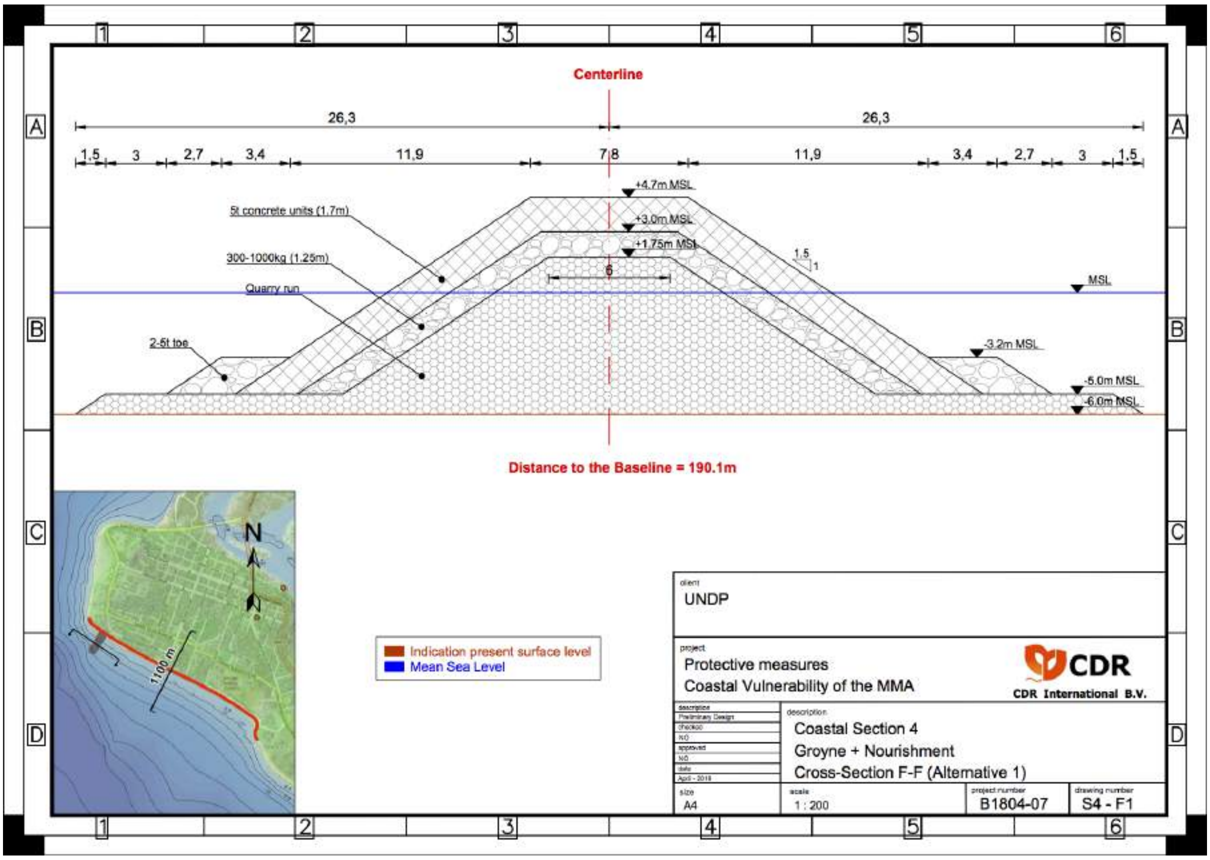
Centerline
20
20
2-5t (2.0m)
Quarry run
+4.0m MSL
+2.0m MSL
+1.0m MSL
MSL
-1.0m MSL
-2.0m MSL
Distance to the Baseline = 89.7m
1100 m
Indication present surface level
Mean Sea Level
client
UNDP
project
Protective measures
Coastal Vulnerability of the MMA
CDR
CDR International B.V.
description
Coastal Section 4
Groyne + Nourishment
Cross-Section B-B
size
A4
scale
1 : 200
project number
B1804-07
drawing number
S4 - B

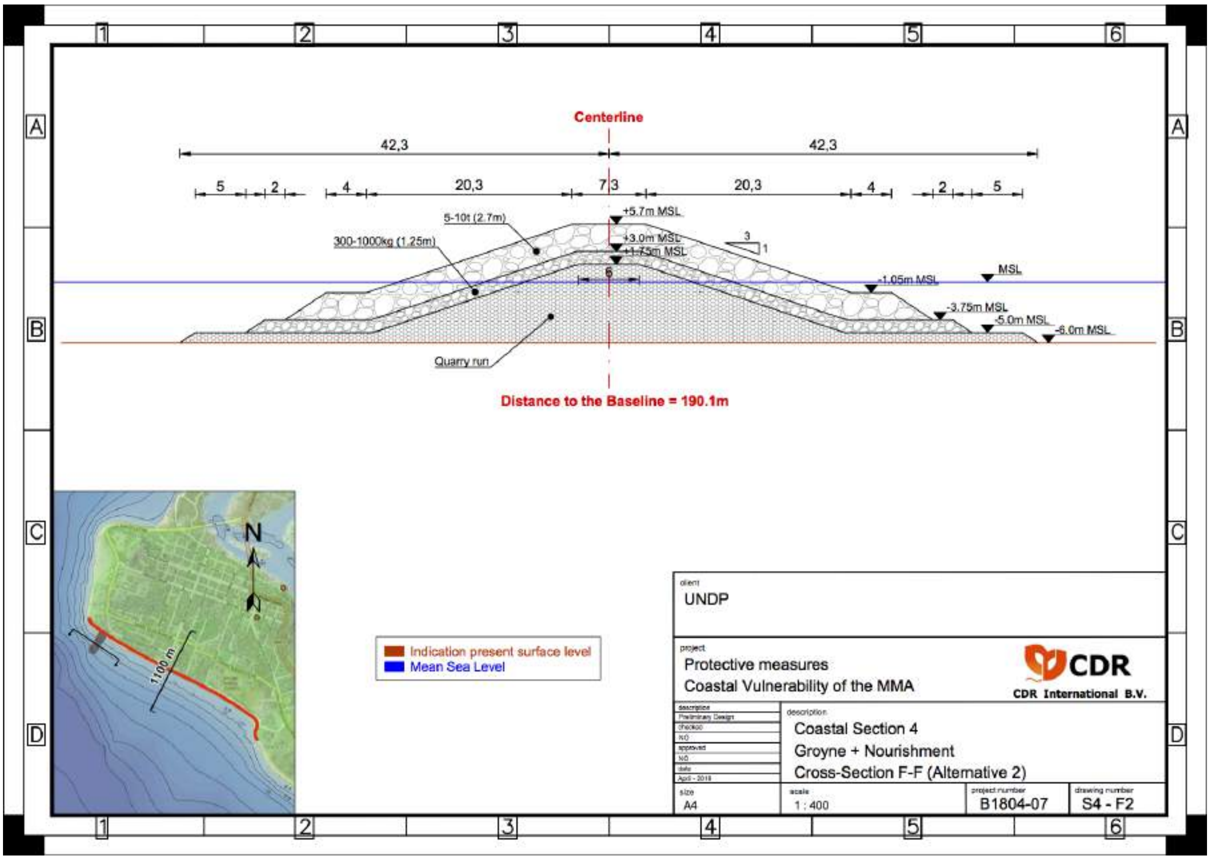


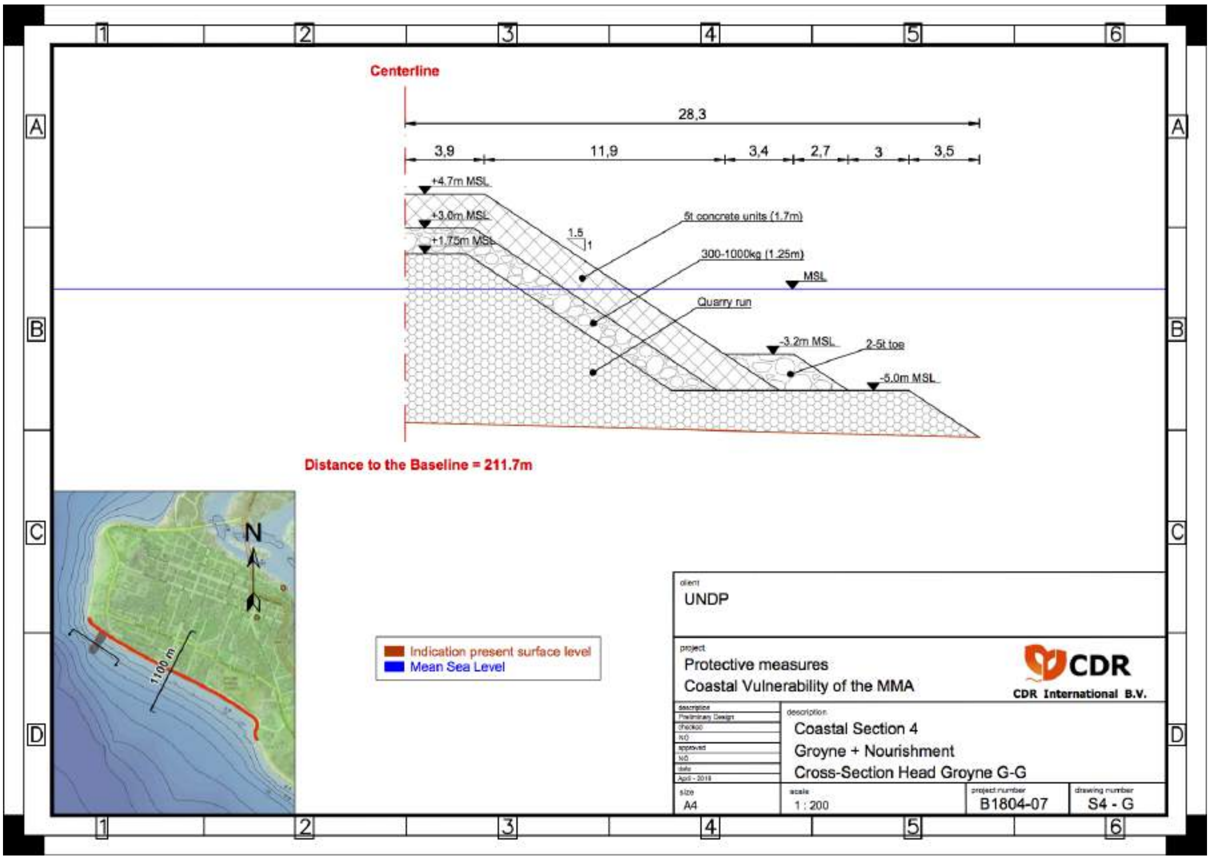
Centerline
22
22
2-5t (2.0m)
Quarry run
+4.0m MSL
+2.0m MSL
MSL
-2.0m MSL
-3.0m MSL
Distance to the Baseline = 109.2m
1100 m
Indication present surface level
Mean Sea Level
client
UNDP
project
Protective measures
Coastal Vulnerability of the MMA
CDR
CDR International B.V.
description
Coastal Section 4
Groyne + Nourishment
Cross-Section C-C
size
A4
scale
1 : 200
project number
B1804-07
drawing number
S4 - C


Centerline
24
24
1.5
3
3
3
10
6
9
10
3
3
3
1.5
2-5t (2.0m)
Quarry run
+4.0m MSL
+2.0m MSL
6
MSL
-1.0m MSL
-3.0m MSL
-4.0m MSL
Distance to the Baseline = 128.7m
Indication present surface level
Mean Sea Level
1100 m
N
client
UNDP
project
Protective measures
Coastal Vulnerability of the MMA
CDR
CDR International B.V.
description
Coastal Section 4
Groyne + Nourishment
Cross-Section D-D
size
A4
scale
1 : 200
project number
B1804-07
drawing number
S4 - D

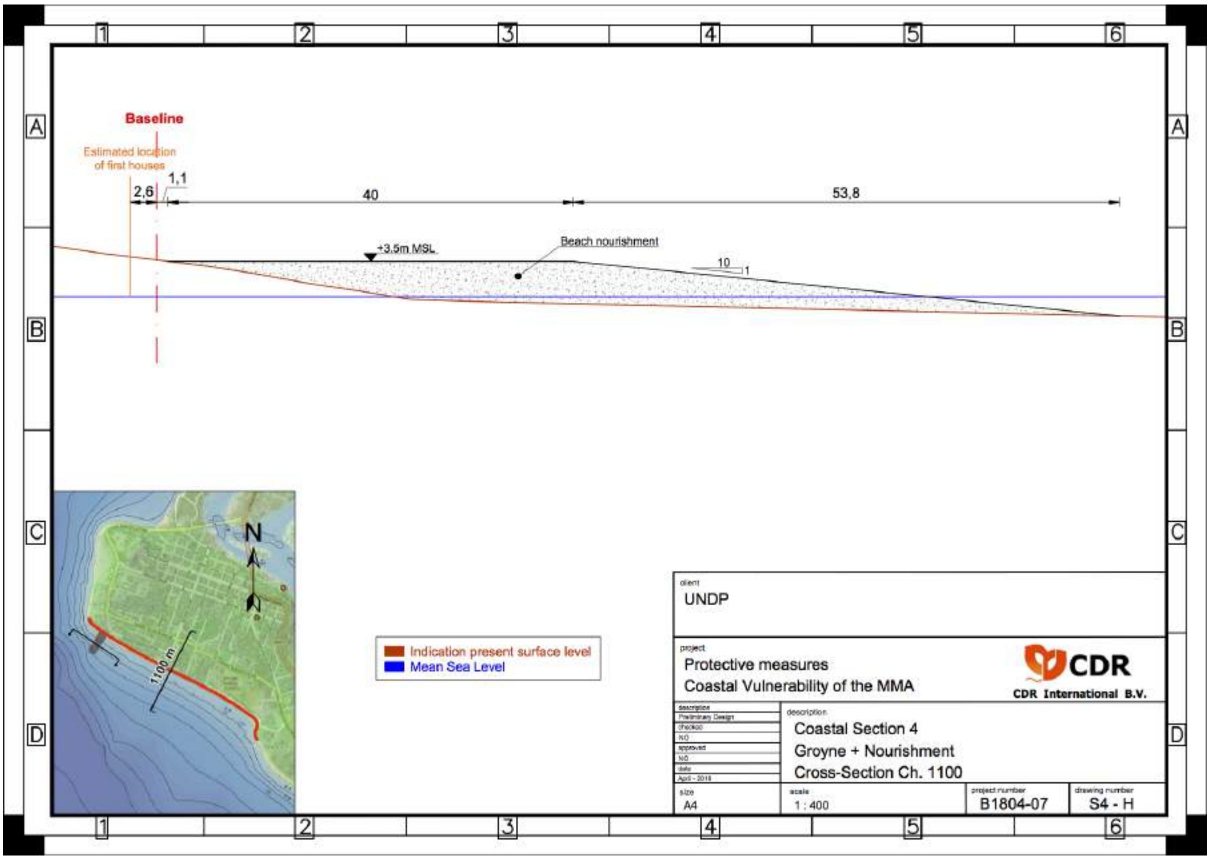

Centerline
26
26
1.5
3
3
3
12
6
9
12
3
3
3
1.5
2-5t (2.0m)
Quarry run
+4.0m MSL
+2.0m MSL
6
MSL
-2.0m MSL
-4.0m MSL
-5.0m MSL
Distance to the Baseline = 164.5m
Indication present surface level
Mean Sea Level
1100 m
N
client
UNDP
project
Protective measures
Coastal Vulnerability of the MMA
CDR
CDR International B.V.
description
Coastal Section 4
Groyne + Nourishment
Cross-Section E-E
size
A4
scale
1 : 200
project number
B1804-07
drawing number
S4 - E


Centerline
26,3
26,3
1,5 3 2,7 3,4 11,9 7,8 11,9 3,4 2,7 3 1,5
+4.7m MSL
+3.0m MSL
+1.75m MSL
5t concrete units (1.7m)
300-1000kg (1.25m)
Quarry run
2-6t toe
1,5
1
MSL
-3.2m MSL
-5.0m MSL
-6.0m MSL
Distance to the Baseline = 190.1m
1100 m
Indication present surface level
Mean Sea Level
client
UNDP
project
Protective measures
Coastal Vulnerability of the MMA
CDR
CDR International B.V.
description
Preliminary Design
Coastal Section 4
Groyne + Nourishment
Cross-Section F-F (Alternative 1)
size
A4
scale
1 : 200
project number
B1804-07
drawing number
S4 - F1


Centerline
42,3
42,3
5 2 4 20,3 7,3 20,3 4 2 5
5-10t (2.7m)
300-1000kg (1.25m)
+5.7m MSL
+3.0m MSL
+1.75m MSL
3
1
MSL
-1.05m MSL
-3.75m MSL
-5.0m MSL
-6.0m MSL
Quarry run
Distance to the Baseline = 190.1m
1100 m
Indication present surface level
Mean Sea Level
client
UNDP
project
Protective measures
Coastal Vulnerability of the MMA
CDR
CDR International B.V.
description
Preliminary Design
Coastal Section 4
Groyne + Nourishment
Cross-Section F-F (Alternative 2)
size
A4
scale
1 : 400
project number
B1804-07
drawing number
S4 - F2



Centerline
28,3
3,9
11,9
3,4
2,7
3
3,5
+4.7m MSL
+3.0m MSL
+1.75m MSL
1.5
1
5t concrete units (1.7m)
300-1000kg (1.25m)
MSL
Quarry run
-3.2m MSL
2-5t toe
-5.0m MSL
Distance to the Baseline = 211.7m
1100 m
Indication present surface level
Mean Sea Level
client
UNDP
project
Protective measures
Coastal Vulnerability of the MMA
CDR
CDR International B.V.
description
Coastal Section 4
Groyne + Nourishment
Cross-Section Head Groyne G-G
size
A4
scale
1 : 200
project number
B1804-07
drawing number
S4 - G



Baseline
Estimated location of first houses
2,6
1,1
40
53,8
+3.5m MSL
Beach nourishment
10
1
1100 m
Indication present surface level
Mean Sea Level
client
UNDP
project
Protective measures
Coastal Vulnerability of the MMA
CDR
CDR International B.V.
description
Coastal Section 4
Groyne + Nourishment
Cross-Section Ch. 1100
size
A4
scale
1 : 400
project number
B1804-07
drawing number
S4 - H

F. BOQ

BOQ New Kru Town

General						Item:	Quarry run						Item:	Underlayer 60-300 kg					
Location	Chainage	Length	Item	Drawing #	Comments	Qty/m	Qty_Quarry run	Unit	Unit rate - Low	Unit rate - high	Cost_Quarry run low	Cost_Quarry run high	Qty/m	Qty_Underlayer 60-300 kg	Unit	Unit rate - Low	Unit rate - high	Cost_Underlayer 60-300 kg low	Cost_Underlayer 60-300kg high
	0	50	Revetment light	S2 - 1		12.56	628	m3	$ 95.00	$ 133.00	$ 59,660.00	$ 83,524.00	6.6	330	m3	$ 114.00	$ 152.00	$ 37,620.00	$ 50,160.00
	50	50	Revetment light	S2 - 1		12.56	628	m3	$ 95.00	$ 133.00	$ 59,660.00	$ 83,524.00	6.6	330	m3	$ 114.00	$ 152.00	$ 37,620.00	$ 50,160.00
	100	50	Revetment light	S2 - 1		12.56	628	m3	$ 95.00	$ 133.00	$ 59,660.00	$ 83,524.00	6.6	330	m3	$ 114.00	$ 152.00	$ 37,620.00	$ 50,160.00
	150	50	Revetment light	S2 - 1		12.56	628	m3	$ 95.00	$ 133.00	$ 59,660.00	$ 83,524.00	6.6	330	m3	$ 114.00	$ 152.00	$ 37,620.00	$ 50,160.00
	200	50	Revetment light	S2 - 1		12.56	628	m3	$ 95.00	$ 133.00	$ 59,660.00	$ 83,524.00	6.6	330	m3	$ 114.00	$ 152.00	$ 37,620.00	$ 50,160.00
	250	50	Revetment light	S2 - 1		12.56	628	m3	$ 95.00	$ 133.00	$ 59,660.00	$ 83,524.00	6.6	330	m3	$ 114.00	$ 152.00	$ 37,620.00	$ 50,160.00
	300	50	Revetment light	S2 - 1		12.56	628	m3	$ 95.00	$ 133.00	$ 59,660.00	$ 83,524.00	6.6	330	m3	$ 114.00	$ 152.00	$ 37,620.00	$ 50,160.00
	350	50	Revetment light	S2 - 1		12.56	628	m3	$ 95.00	$ 133.00	$ 59,660.00	$ 83,524.00	6.6	330	m3	$ 114.00	$ 152.00	$ 37,620.00	$ 50,160.00
	400	50	Revetment light	S2 - 1		12.56	628	m3	$ 95.00	$ 133.00	$ 59,660.00	$ 83,524.00	6.6	330	m3	$ 114.00	$ 152.00	$ 37,620.00	$ 50,160.00
	450	50	Revetment light	S2 - 1		12.56	628	m3	$ 95.00	$ 133.00	$ 59,660.00	$ 83,524.00	6.6	330	m3	$ 114.00	$ 152.00	$ 37,620.00	$ 50,160.00
	500	50	Revetment light	S2 - 1		12.56	628	m3	$ 95.00	$ 133.00	$ 59,660.00	$ 83,524.00	6.6	330	m3	$ 114.00	$ 152.00	$ 37,620.00	$ 50,160.00
	550	50	Revetment light	S2 - 1		12.56	628	m3	$ 95.00	$ 133.00	$ 59,660.00	$ 83,524.00	6.6	330	m3	$ 114.00	$ 152.00	$ 37,620.00	$ 50,160.00
	600	50	Revetment light	S2 - 1		12.56	628	m3	$ 95.00	$ 133.00	$ 59,660.00	$ 83,524.00	6.6	330	m3	$ 114.00	$ 152.00	$ 37,620.00	$ 50,160.00
	650	50	Revtment NKT	S2 - 2		47.8	2,390	m3	$ 95.00	$ 133.00	$ 227,050.00	$ 317,870.00	22.2	1,110	m3	$ 114.00	$ 152.00	$ 126,540.00	$ 168,720.00
	700	50	Revtment NKT	S2 - 2		47.8	2,390	m3	$ 95.00	$ 133.00	$ 227,050.00	$ 317,870.00	22.2	1,110	m3	$ 114.00	$ 152.00	$ 126,540.00	$ 168,720.00
	750	50	Revtment NKT	S2 - 2		47.8	2,390	m3	$ 95.00	$ 133.00	$ 227,050.00	$ 317,870.00	22.2	1,110	m3	$ 114.00	$ 152.00	$ 126,540.00	$ 168,720.00
	800	50	Revtment NKT	S2 - 2		47.8	2,390	m3	$ 95.00	$ 133.00	$ 227,050.00	$ 317,870.00	22.2	1,110	m3	$ 114.00	$ 152.00	$ 126,540.00	$ 168,720.00
	850	50	Revtment NKT	S2 - 2		47.8	2,390	m3	$ 95.00	$ 133.00	$ 227,050.00	$ 317,870.00	22.2	1,110	m3	$ 114.00	$ 152.00	$ 126,540.00	$ 168,720.00
	900	50	Revtment NKT	S2 - 3		7.4	370	m3	$ 95.00	$ 133.00	$ 35,150.00	$ 49,210.00	17.8	890	m3	$ 114.00	$ 152.00	$ 101,460.00	$ 135,280.00
	950	50	Revtment NKT	S2 - 3		7.4	370	m3	$ 95.00	$ 133.00	$ 35,150.00	$ 49,210.00	17.8	890	m3	$ 114.00	$ 152.00	$ 101,460.00	$ 135,280.00
	1000	50	Revtment NKT	S2 - 3		7.4	370	m3	$ 95.00	$ 133.00	$ 35,150.00	$ 49,210.00	17.8	890	m3	$ 114.00	$ 152.00	$ 101,460.00	$ 135,280.00
	1050	50	Revtment NKT	S2 - 3		7.4	370	m3	$ 95.00	$ 133.00	$ 35,150.00	$ 49,210.00	17.8	890	m3	$ 114.00	$ 152.00	$ 101,460.00	$ 135,280.00
	1100	50	Revtment NKT	S2 - 3		7.4	370	m3	$ 95.00	$ 133.00	$ 35,150.00	$ 49,210.00	17.8	890	m3	$ 114.00	$ 152.00	$ 101,460.00	$ 135,280.00
	1150	50	Revtment NKT	S2 - 3		7.4	370	m3	$ 95.00	$ 133.00	$ 35,150.00	$ 49,210.00	17.8	890	m3	$ 114.00	$ 152.00	$ 101,460.00	$ 135,280.00
	1200	40	Revtment NKT	S2 - 3		7.4	296	m3	$ 95.00	$ 133.00	$ 28,120.00	$ 39,368.00	17.8	712	m3	$ 114.00	$ 152.00	$ 81,168.00	$ 108,224.00
	1240	50	Landing site NKT	S2 - 6	Revet + Groyne	113.6	5,680	m3	$ 95.00	$ 133.00	$ 539,600.00	$ 755,440.00	17.8	890	m3	$ 114.00	$ 152.00	$ 101,460.00	$ 135,280.00
	1290	30	Landing site NKT	-	Groyne + Beach	106.8	3,204	m3	$ 95.00	$ 133.00	$ 304,380.00	$ 426,132.00		-	m3	$ 114.00	$ 152.00	$ -	$ -
	1320	30	Landing site NKT	S2 - 3		7.4	222	m3	$ 95.00	$ 133.00	$ 21,090.00	$ 29,526.00	17.8	534	m3	$ 114.00	$ 152.00	$ 60,876.00	$ 81,168.00
	1350	50	Revtment NKT	S2 - 3		7.4	370	m3	$ 95.00	$ 133.00	$ 35,150.00	$ 49,210.00	17.8	890	m3	$ 114.00	$ 152.00	$ 101,460.00	$ 135,280.00
	1400	50	Revtment NKT	S2 - 4			-	m3	$ 95.00	$ 133.00	$ -	$ -	19.4	970	m3	$ 114.00	$ 152.00	$ 110,580.00	$ 147,440.00
	1450	50	Revtment NKT	S2 - 4			-	m3	$ 95.00	$ 133.00	$ -	$ -	19.4	970	m3	$ 114.00	$ 152.00	$ 110,580.00	$ 147,440.00
	1500	50	Revtment NKT	S2 - 4			-	m3	$ 95.00	$ 133.00	$ -	$ -	19.4	970	m3	$ 114.00	$ 152.00	$ 110,580.00	$ 147,440.00
	1550	50	Revtment NKT	S2 - 4			-	m3	$ 95.00	$ 133.00	$ -	$ -	19.4	970	m3	$ 114.00	$ 152.00	$ 110,580.00	$ 147,440.00
	1600	50	Revtment NKT	S2 - 4			-	m3	$ 95.00	$ 133.00	$ -	$ -	19.4	970	m3	$ 114.00	$ 152.00	$ 110,580.00	$ 147,440.00
	1650	50	Revtment NKT	S2 - 4			-	m3	$ 95.00	$ 133.00	$ -	$ -	19.4	970	m3	$ 114.00	$ 152.00	$ 110,580.00	$ 147,440.00
	1700	50	Revtment NKT	S2 - 4			-	m3	$ 95.00	$ 133.00	$ -	$ -	19.4	970	m3	$ 114.00	$ 152.00	$ 110,580.00	$ 147,440.00
	1750	50	Revtment NKT	S2 - 2		47.8	2,390	m3	$ 95.00	$ 133.00	$ 227,050.00	$ 317,870.00	22.2	1,110	m3	$ 114.00	$ 152.00	$ 126,540.00	$ 168,720.00
	1800	50	Revtment NKT	S2 - 2		47.8	2,390	m3	$ 95.00	$ 133.00	$ 227,050.00	$ 317,870.00	22.2	1,110	m3	$ 114.00	$ 152.00	$ 126,540.00	$ 168,720.00
	1850	70	Revtment NKT	S2 - 2		47.8	3,346	m3	$ 95.00	$ 133.00	$ 317,870.00	$ 445,018.00	22.2	1,554	m3	$ 114.00	$ 152.00	$ 177,156.00	$ 236,208.00
	1920	30	Landing site NKT	S2 - 5		31.5	945	m3	$ 95.00	$ 133.00	$ 89,775.00	$ 125,685.00	0	-	m3	$ 114.00	$ 152.00	$ -	$ -
	1950	50	Landing site NKT	S2 - 5		31.5	1,575	m3	$ 95.00	$ 133.00	$ 149,625.00	$ 209,475.00	0	-	m3	$ 114.00	$ 152.00	$ -	$ -
	2000	70	Landing site NKT	S2 - 5		31.5	2,205	m3	$ 95.00	$ 133.00	$ 209,475.00	$ 293,265.00	0	-	m3	$ 114.00	$ 152.00	$ -	$ -
	2070	30			Outside project area		-	m3	$ 95.00	$ 133.00	$ -	$ -	0	-	m3	$ 114.00	$ 152.00	$ -	$ -
	2100	50		-	Outside project area		-	m3	$ 95.00	$ 133.00	$ -	$ -	0	-	m3	$ 114.00	$ 152.00	$ -	$ -
	2150	50		-	Outside project area		-	m3	$ 95.00	$ 133.00	$ -	$ -	0	-	m3	$ 114.00	$ 152.00	$ -	$ -
	2200	50		-	Outside project area		-	m3	$ 95.00	$ 133.00	$ -	$ -	0	-	m3	$ 114.00	$ 152.00	$ -	$ -
	2250						-												
TOTALS							44,857				$ 4,270,915.00	$ 5,978,281.00		28,770				$ 3,279,780.00	$ 4,373,040.00

Page 1 of 6

BOQ New Kru Town

General						Item:	Geotextile						Item:	Armour 300-1000kg					
Location	Chainage	Length	Item	Drawing #	Comments	Qty/m	Qty_Geotextile	Unit	Unit rate - Low	Unit rate - high	Cost_Geotextile low	Cost_Geotextile high	Qty/m	Qty_Armour 300-1000kg	Unit	Unit rate - Low	Unit rate - high	Cost_Armour 300-1000kg low	Cost_Armour 300-1000kg high
	0	50	Revetment light	S2 - 1		23	1,150	m2	$ 10.00	$ 15.00	$ 11,500.00	$ 17,250.00	12.5	625	m3	$ 108.00	$ 144.00	$ 67,500.00	$ 90,000.00
	50	50	Revetment light	S2 - 1		23	1,150	m2	$ 10.00	$ 15.00	$ 11,500.00	$ 17,250.00	12.5	625	m3	$ 108.00	$ 144.00	$ 67,500.00	$ 90,000.00
	100	50	Revetment light	S2 - 1		23	1,150	m2	$ 10.00	$ 15.00	$ 11,500.00	$ 17,250.00	12.5	625	m3	$ 108.00	$ 144.00	$ 67,500.00	$ 90,000.00
	150	50	Revetment light	S2 - 1		23	1,150	m2	$ 10.00	$ 15.00	$ 11,500.00	$ 17,250.00	12.5	625	m3	$ 108.00	$ 144.00	$ 67,500.00	$ 90,000.00
	200	50	Revetment light	S2 - 1		23	1,150	m2	$ 10.00	$ 15.00	$ 11,500.00	$ 17,250.00	12.5	625	m3	$ 108.00	$ 144.00	$ 67,500.00	$ 90,000.00
	250	50	Revetment light	S2 - 1		23	1,150	m2	$ 10.00	$ 15.00	$ 11,500.00	$ 17,250.00	12.5	625	m3	$ 108.00	$ 144.00	$ 67,500.00	$ 90,000.00
	300	50	Revetment light	S2 - 1		23	1,150	m2	$ 10.00	$ 15.00	$ 11,500.00	$ 17,250.00	12.5	625	m3	$ 108.00	$ 144.00	$ 67,500.00	$ 90,000.00
	350	50	Revetment light	S2 - 1		23	1,150	m2	$ 10.00	$ 15.00	$ 11,500.00	$ 17,250.00	12.5	625	m3	$ 108.00	$ 144.00	$ 67,500.00	$ 90,000.00
	400	50	Revetment light	S2 - 1		23	1,150	m2	$ 10.00	$ 15.00	$ 11,500.00	$ 17,250.00	12.5	625	m3	$ 108.00	$ 144.00	$ 67,500.00	$ 90,000.00
	450	50	Revetment light	S2 - 1		23	1,150	m2	$ 10.00	$ 15.00	$ 11,500.00	$ 17,250.00	12.5	625	m3	$ 108.00	$ 144.00	$ 67,500.00	$ 90,000.00
	500	50	Revetment light	S2 - 1		23	1,150	m2	$ 10.00	$ 15.00	$ 11,500.00	$ 17,250.00	12.5	625	m3	$ 108.00	$ 144.00	$ 67,500.00	$ 90,000.00
	550	50	Revetment light	S2 - 1		23	1,150	m2	$ 10.00	$ 15.00	$ 11,500.00	$ 17,250.00	12.5	625	m3	$ 108.00	$ 144.00	$ 67,500.00	$ 90,000.00
	600	50	Revetment light	S2 - 1		23	1,150	m2	$ 10.00	$ 15.00	$ 11,500.00	$ 17,250.00	12.5	625	m3	$ 108.00	$ 144.00	$ 67,500.00	$ 90,000.00
	650	50	Revtment NKT	S2 - 2		39.5	1,975	m2	$ 10.00	$ 15.00	$ 19,750.00	$ 29,625.00		-	m3	$ 108.00	$ 144.00	$ -	$ -
	700	50	Revtment NKT	S2 - 2		39.5	1,975	m2	$ 10.00	$ 15.00	$ 19,750.00	$ 29,625.00		-	m3	$ 108.00	$ 144.00	$ -	$ -
	750	50	Revtment NKT	S2 - 2		39.5	1,975	m2	$ 10.00	$ 15.00	$ 19,750.00	$ 29,625.00		-	m3	$ 108.00	$ 144.00	$ -	$ -
	800	50	Revtment NKT	S2 - 2		39.5	1,975	m2	$ 10.00	$ 15.00	$ 19,750.00	$ 29,625.00		-	m3	$ 108.00	$ 144.00	$ -	$ -
	850	50	Revtment NKT	S2 - 2		39.5	1,975	m2	$ 10.00	$ 15.00	$ 19,750.00	$ 29,625.00		-	m3	$ 108.00	$ 144.00	$ -	$ -
	900	50	Revtment NKT	S2 - 3		21.5	1,075	m2	$ 10.00	$ 15.00	$ 10,750.00	$ 16,125.00		-	m3	$ 108.00	$ 144.00	$ -	$ -
	950	50	Revtment NKT	S2 - 3		21.5	1,075	m2	$ 10.00	$ 15.00	$ 10,750.00	$ 16,125.00		-	m3	$ 108.00	$ 144.00	$ -	$ -
	1000	50	Revtment NKT	S2 - 3		21.5	1,075	m2	$ 10.00	$ 15.00	$ 10,750.00	$ 16,125.00		-	m3	$ 108.00	$ 144.00	$ -	$ -
	1050	50	Revtment NKT	S2 - 3		21.5	1,075	m2	$ 10.00	$ 15.00	$ 10,750.00	$ 16,125.00		-	m3	$ 108.00	$ 144.00	$ -	$ -
	1100	50	Revtment NKT	S2 - 3		21.5	1,075	m2	$ 10.00	$ 15.00	$ 10,750.00	$ 16,125.00		-	m3	$ 108.00	$ 144.00	$ -	$ -
	1150	50	Revtment NKT	S2 - 3		21.5	1,075	m2	$ 10.00	$ 15.00	$ 10,750.00	$ 16,125.00		-	m3	$ 108.00	$ 144.00	$ -	$ -
	1200	40	Revtment NKT	S2 - 3		21.5	860	m2	$ 10.00	$ 15.00	$ 8,600.00	$ 12,900.00		-	m3	$ 108.00	$ 144.00	$ -	$ -
	1240	50	Landing site NKT	S2 - 6	Revet + Groyne	21.5	1,075	m2	$ 10.00	$ 15.00	$ 10,750.00	$ 16,125.00	10.8	540	m3	$ 108.00	$ 144.00	$ 58,320.00	$ 77,760.00
	1290	30	Landing site NKT	-	Groyne + Beach		-	m2	$ 10.00	$ 15.00	$ -	$ -	10.8	324	m3	$ 108.00	$ 144.00	$ 34,992.00	$ 46,656.00
	1320	30	Landing site NKT	S2 - 3		21.5	645	m2	$ 10.00	$ 15.00	$ 6,450.00	$ 9,675.00		-	m3	$ 108.00	$ 144.00	$ -	$ -
	1350	50	Revtment NKT	S2 - 3		21.5	1,075	m2	$ 10.00	$ 15.00	$ 10,750.00	$ 16,125.00		-	m3	$ 108.00	$ 144.00	$ -	$ -
	1400	50	Revtment NKT	S2 - 4		23.5	1,175	m2	$ 10.00	$ 15.00	$ 11,750.00	$ 17,625.00		-	m3	$ 108.00	$ 144.00	$ -	$ -
	1450	50	Revtment NKT	S2 - 4		23.5	1,175	m2	$ 10.00	$ 15.00	$ 11,750.00	$ 17,625.00		-	m3	$ 108.00	$ 144.00	$ -	$ -
	1500	50	Revtment NKT	S2 - 4		23.5	1,175	m2	$ 10.00	$ 15.00	$ 11,750.00	$ 17,625.00		-	m3	$ 108.00	$ 144.00	$ -	$ -
	1550	50	Revtment NKT	S2 - 4		23.5	1,175	m2	$ 10.00	$ 15.00	$ 11,750.00	$ 17,625.00		-	m3	$ 108.00	$ 144.00	$ -	$ -
	1600	50	Revtment NKT	S2 - 4		23.5	1,175	m2	$ 10.00	$ 15.00	$ 11,750.00	$ 17,625.00		-	m3	$ 108.00	$ 144.00	$ -	$ -
	1650	50	Revtment NKT	S2 - 4		23.5	1,175	m2	$ 10.00	$ 15.00	$ 11,750.00	$ 17,625.00		-	m3	$ 108.00	$ 144.00	$ -	$ -
	1700	50	Revtment NKT	S2 - 4		23.5	1,175	m2	$ 10.00	$ 15.00	$ 11,750.00	$ 17,625.00		-	m3	$ 108.00	$ 144.00	$ -	$ -
	1750	50	Revtment NKT	S2 - 2		39.5	1,975	m2	$ 10.00	$ 15.00	$ 19,750.00	$ 29,625.00		-	m3	$ 108.00	$ 144.00	$ -	$ -
	1800	50	Revtment NKT	S2 - 2		39.5	1,975	m2	$ 10.00	$ 15.00	$ 19,750.00	$ 29,625.00		-	m3	$ 108.00	$ 144.00	$ -	$ -
	1850	70	Revtment NKT	S2 - 2		39.5	2,765	m2	$ 10.00	$ 15.00	$ 27,650.00	$ 41,475.00		-	m3	$ 108.00	$ 144.00	$ -	$ -
	1920	30	Landing site NKT	S2 - 5		17	510	m2	$ 10.00	$ 15.00	$ 5,100.00	$ 7,650.00		-	m3	$ 108.00	$ 144.00	$ -	$ -
	1950	50	Landing site NKT	S2 - 5		17	850	m2	$ 10.00	$ 15.00	$ 8,500.00	$ 12,750.00		-	m3	$ 108.00	$ 144.00	$ -	$ -
	2000	70	Landing site NKT	S2 - 5		17	1,190	m2	$ 10.00	$ 15.00	$ 11,900.00	$ 17,850.00		-	m3	$ 108.00	$ 144.00	$ -	$ -
	2070	30			Outside project area		-	m2	$ 10.00	$ 15.00	$ -	$ -		-	m3	$ 108.00	$ 144.00	$ -	$ -
	2100	50		-	Outside project area	0	-	m2	$ 10.00	$ 15.00	$ -	$ -		-	m3	$ 108.00	$ 144.00	$ -	$ -
	2150	50		-	Outside project area	0	-	m2	$ 10.00	$ 15.00	$ -	$ -		-	m3	$ 108.00	$ 144.00	$ -	$ -
	2200	50		-	Outside project area	0	-	m2	$ 10.00	$ 15.00	$ -	$ -		-	m3	$ 108.00	$ 144.00	$ -	$ -
	2250													-					
TOTALS							52,420				$ 524,200.00	$ 786,300.00		8,989				$ 970,812.00	$ 1,294,416.00

Page 2 of 6

BOQ New Kru Town

General						Item:	Excavation						Item:	Backfill					
Location	Chainage	Length	Item	Drawing #	Comments	Qty/m	Qty_Excavation	Unit	Unit rate - low	Unit rate - high	Cost_Excavation low	Cost_Excavation high	Qty/m	Qty_Backfill	Unit	Unit rate - low	Unit rate - high	Cost_Backfill low	Cost_Backfill high
	0	50	Revetment light	S2 - 1		40	2,000	m3	$ 8.00	$ 12.00	$ 16,000.00	$ 24,000.00	19.3	965	m3	$ 4.00	$ 6.00	$ 3,860.00	$ 5,790.00
	50	50	Revetment light	S2 - 1		40	2,000	m3	$ 8.00	$ 12.00	$ 16,000.00	$ 24,000.00	19.3	965	m3	$ 4.00	$ 6.00	$ 3,860.00	$ 5,790.00
	100	50	Revetment light	S2 - 1		40	2,000	m3	$ 8.00	$ 12.00	$ 16,000.00	$ 24,000.00	19.3	965	m3	$ 4.00	$ 6.00	$ 3,860.00	$ 5,790.00
	150	50	Revetment light	S2 - 1		40	2,000	m3	$ 8.00	$ 12.00	$ 16,000.00	$ 24,000.00	19.3	965	m3	$ 4.00	$ 6.00	$ 3,860.00	$ 5,790.00
	200	50	Revetment light	S2 - 1		40	2,000	m3	$ 8.00	$ 12.00	$ 16,000.00	$ 24,000.00	19.3	965	m3	$ 4.00	$ 6.00	$ 3,860.00	$ 5,790.00
	250	50	Revetment light	S2 - 1		40	2,000	m3	$ 8.00	$ 12.00	$ 16,000.00	$ 24,000.00	19.3	965	m3	$ 4.00	$ 6.00	$ 3,860.00	$ 5,790.00
	300	50	Revetment light	S2 - 1		40	2,000	m3	$ 8.00	$ 12.00	$ 16,000.00	$ 24,000.00	19.3	965	m3	$ 4.00	$ 6.00	$ 3,860.00	$ 5,790.00
	350	50	Revetment light	S2 - 1		40	2,000	m3	$ 8.00	$ 12.00	$ 16,000.00	$ 24,000.00	19.3	965	m3	$ 4.00	$ 6.00	$ 3,860.00	$ 5,790.00
	400	50	Revetment light	S2 - 1		40	2,000	m3	$ 8.00	$ 12.00	$ 16,000.00	$ 24,000.00	19.3	965	m3	$ 4.00	$ 6.00	$ 3,860.00	$ 5,790.00
	450	50	Revetment light	S2 - 1		40	2,000	m3	$ 8.00	$ 12.00	$ 16,000.00	$ 24,000.00	19.3	965	m3	$ 4.00	$ 6.00	$ 3,860.00	$ 5,790.00
	500	50	Revetment light	S2 - 1		40	2,000	m3	$ 8.00	$ 12.00	$ 16,000.00	$ 24,000.00	19.3	965	m3	$ 4.00	$ 6.00	$ 3,860.00	$ 5,790.00
	550	50	Revetment light	S2 - 1		40	2,000	m3	$ 8.00	$ 12.00	$ 16,000.00	$ 24,000.00	19.3	965	m3	$ 4.00	$ 6.00	$ 3,860.00	$ 5,790.00
	600	50	Revetment light	S2 - 1		40	2,000	m3	$ 8.00	$ 12.00	$ 16,000.00	$ 24,000.00	19.3	965	m3	$ 4.00	$ 6.00	$ 3,860.00	$ 5,790.00
	650	50	Revtment NKT	S2 - 2		57	2,850	m3	$ 8.00	$ 12.00	$ 22,800.00	$ 34,200.00	7.6	380	m3	$ 4.00	$ 6.00	$ 1,520.00	$ 2,280.00
	700	50	Revtment NKT	S2 - 2		57	2,850	m3	$ 8.00	$ 12.00	$ 22,800.00	$ 34,200.00	7.6	380	m3	$ 4.00	$ 6.00	$ 1,520.00	$ 2,280.00
	750	50	Revtment NKT	S2 - 2		57	2,850	m3	$ 8.00	$ 12.00	$ 22,800.00	$ 34,200.00	7.6	380	m3	$ 4.00	$ 6.00	$ 1,520.00	$ 2,280.00
	800	50	Revtment NKT	S2 - 2		57	2,850	m3	$ 8.00	$ 12.00	$ 22,800.00	$ 34,200.00	7.6	380	m3	$ 4.00	$ 6.00	$ 1,520.00	$ 2,280.00
	850	50	Revtment NKT	S2 - 2		57	2,850	m3	$ 8.00	$ 12.00	$ 22,800.00	$ 34,200.00	7.6	380	m3	$ 4.00	$ 6.00	$ 1,520.00	$ 2,280.00
	900	50	Revtment NKT	S2 - 3		72.4	3,620	m3	$ 8.00	$ 12.00	$ 28,960.00	$ 43,440.00	0	-	m3	$ 4.00	$ 6.00	$ -	$ -
	950	50	Revtment NKT	S2 - 3		72.4	3,620	m3	$ 8.00	$ 12.00	$ 28,960.00	$ 43,440.00	0	-	m3	$ 4.00	$ 6.00	$ -	$ -
	1000	50	Revtment NKT	S2 - 3		72.4	3,620	m3	$ 8.00	$ 12.00	$ 28,960.00	$ 43,440.00	0	-	m3	$ 4.00	$ 6.00	$ -	$ -
	1050	50	Revtment NKT	S2 - 3		72.4	3,620	m3	$ 8.00	$ 12.00	$ 28,960.00	$ 43,440.00	0	-	m3	$ 4.00	$ 6.00	$ -	$ -
	1100	50	Revtment NKT	S2 - 3		72.4	3,620	m3	$ 8.00	$ 12.00	$ 28,960.00	$ 43,440.00	0	-	m3	$ 4.00	$ 6.00	$ -	$ -
	1150	50	Revtment NKT	S2 - 3		72.4	3,620	m3	$ 8.00	$ 12.00	$ 28,960.00	$ 43,440.00	0	-	m3	$ 4.00	$ 6.00	$ -	$ -
	1200	40	Revtment NKT	S2 - 3		72.4	2,896	m3	$ 8.00	$ 12.00	$ 23,168.00	$ 34,752.00	0	-	m3	$ 4.00	$ 6.00	$ -	$ -
	1240	50	Landing site NKT	S2 - 6	Revet + Groyne	188.6	9,430	m3	$ 8.00	$ 12.00	$ 75,440.00	$ 113,160.00	0	-	m3	$ 4.00	$ 6.00	$ -	$ -
	1290	30	Landing site NKT	-	Groyne + Beach	75.4	2,262	m3	$ 8.00	$ 12.00	$ 18,096.00	$ 27,144.00	0	-	m3	$ 4.00	$ 6.00	$ -	$ -
	1320	30	Landing site NKT	S2 - 3		72.4	2,172	m3	$ 8.00	$ 12.00	$ 17,376.00	$ 26,064.00	0	-	m3	$ 4.00	$ 6.00	$ -	$ -
	1350	50	Revtment NKT	S2 - 3		72.4	3,620	m3	$ 8.00	$ 12.00	$ 28,960.00	$ 43,440.00	0	-	m3	$ 4.00	$ 6.00	$ -	$ -
	1400	50	Revtment NKT	S2 - 4		65	3,250	m3	$ 8.00	$ 12.00	$ 26,000.00	$ 39,000.00	0	-	m3	$ 4.00	$ 6.00	$ -	$ -
	1450	50	Revtment NKT	S2 - 4		65	3,250	m3	$ 8.00	$ 12.00	$ 26,000.00	$ 39,000.00	0	-	m3	$ 4.00	$ 6.00	$ -	$ -
	1500	50	Revtment NKT	S2 - 4		65	3,250	m3	$ 8.00	$ 12.00	$ 26,000.00	$ 39,000.00	0	-	m3	$ 4.00	$ 6.00	$ -	$ -
	1550	50	Revtment NKT	S2 - 4		65	3,250	m3	$ 8.00	$ 12.00	$ 26,000.00	$ 39,000.00	0	-	m3	$ 4.00	$ 6.00	$ -	$ -
	1600	50	Revtment NKT	S2 - 4		65	3,250	m3	$ 8.00	$ 12.00	$ 26,000.00	$ 39,000.00	0	-	m3	$ 4.00	$ 6.00	$ -	$ -
	1650	50	Revtment NKT	S2 - 4		65	3,250	m3	$ 8.00	$ 12.00	$ 26,000.00	$ 39,000.00	0	-	m3	$ 4.00	$ 6.00	$ -	$ -
	1700	50	Revtment NKT	S2 - 4		65	3,250	m3	$ 8.00	$ 12.00	$ 26,000.00	$ 39,000.00	0	-	m3	$ 4.00	$ 6.00	$ -	$ -
	1750	50	Revtment NKT	S2 - 2		57	2,850	m3	$ 8.00	$ 12.00	$ 22,800.00	$ 34,200.00	7.6	380	m3	$ 4.00	$ 6.00	$ 1,520.00	$ 2,280.00
	1800	50	Revtment NKT	S2 - 2		57	2,850	m3	$ 8.00	$ 12.00	$ 22,800.00	$ 34,200.00	7.6	380	m3	$ 4.00	$ 6.00	$ 1,520.00	$ 2,280.00
	1850	70	Revtment NKT	S2 - 2		57	3,990	m3	$ 8.00	$ 12.00	$ 31,920.00	$ 47,880.00	7.6	532	m3	$ 4.00	$ 6.00	$ 2,128.00	$ 3,192.00
	1920	30	Landing site NKT	S2 - 5		0	-	m3	$ 8.00	$ 12.00	$ -	$ -	0	-	m3	$ 4.00	$ 6.00	$ -	$ -
	1950	50	Landing site NKT	S2 - 5		0	-	m3	$ 8.00	$ 12.00	$ -	$ -	0	-	m3	$ 4.00	$ 6.00	$ -	$ -
	2000	70	Landing site NKT	S2 - 5		0	-	m3	$ 8.00	$ 12.00	$ -	$ -	0	-	m3	$ 4.00	$ 6.00	$ -	$ -
	2070	30			Outside project area	0	-	m3	$ 8.00	$ 12.00	$ -	$ -	0	-	m3	$ 4.00	$ 6.00	$ -	$ -
	2100	50		-	Outside project area	0	-	m3	$ 8.00	$ 12.00	$ -	$ -	0	-	m3	$ 4.00	$ 6.00	$ -	$ -
	2150	50		-	Outside project area	0	-	m3	$ 8.00	$ 12.00	$ -	$ -	0	-	m3	$ 4.00	$ 6.00	$ -	$ -
	2200	50		-	Outside project area	0	-	m3	$ 8.00	$ 12.00	$ -	$ -	0	-	m3	$ 4.00	$ 6.00	$ -	$ -
	2250																		
TOTALS							114,790				$ 918,320.00	$ 1,377,480.00		15,737				$ 62,948.00	$ 94,422.00

Page 3 of 6

BOQ New Kru Town

General						Item:	Armour 2-5 t						Item:	Promenade pavement					
Location	Chainage	Length	Item	Drawing #	Comments	Qty/m	Qty_Armour 2-5 t	Unit	Unit rate - Low	Unit rate - high	Cost_Armour 2-5 t low	Cost_Armour 2-5 t high	Qty/m	Qty_Promenade pavement	Unit	Unit rate - Low	Unit rate - high	Cost_Promenade pavement low	Cost_Promenade pavement high
	0	50	Revetment light	S2 - 1			-	m3	$ 108.00	$ 144.00	$ -	$ -	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	50	50	Revetment light	S2 - 1			-	m3	$ 108.00	$ 144.00	$ -	$ -	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	100	50	Revetment light	S2 - 1			-	m3	$ 108.00	$ 144.00	$ -	$ -	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	150	50	Revetment light	S2 - 1			-	m3	$ 108.00	$ 144.00	$ -	$ -	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	200	50	Revetment light	S2 - 1			-	m3	$ 108.00	$ 144.00	$ -	$ -	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	250	50	Revetment light	S2 - 1			-	m3	$ 108.00	$ 144.00	$ -	$ -	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	300	50	Revetment light	S2 - 1			-	m3	$ 108.00	$ 144.00	$ -	$ -	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	350	50	Revetment light	S2 - 1			-	m3	$ 108.00	$ 144.00	$ -	$ -	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	400	50	Revetment light	S2 - 1			-	m3	$ 108.00	$ 144.00	$ -	$ -	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	450	50	Revetment light	S2 - 1			-	m3	$ 108.00	$ 144.00	$ -	$ -	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	500	50	Revetment light	S2 - 1			-	m3	$ 108.00	$ 144.00	$ -	$ -	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	550	50	Revetment light	S2 - 1			-	m3	$ 108.00	$ 144.00	$ -	$ -	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	600	50	Revetment light	S2 - 1			-	m3	$ 108.00	$ 144.00	$ -	$ -	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	650	50	Revtment NKT	S2 - 2		43.4	2,170	m3	$ 108.00	$ 144.00	$ 234,360.00	$ 312,480.00	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	700	50	Revtment NKT	S2 - 2		43.4	2,170	m3	$ 108.00	$ 144.00	$ 234,360.00	$ 312,480.00	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	750	50	Revtment NKT	S2 - 2		43.4	2,170	m3	$ 108.00	$ 144.00	$ 234,360.00	$ 312,480.00	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	800	50	Revtment NKT	S2 - 2		43.4	2,170	m3	$ 108.00	$ 144.00	$ 234,360.00	$ 312,480.00	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	850	50	Revtment NKT	S2 - 2		43.4	2,170	m3	$ 108.00	$ 144.00	$ 234,360.00	$ 312,480.00	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	900	50	Revtment NKT	S2 - 3		44.4	2,220	m3	$ 108.00	$ 144.00	$ 239,760.00	$ 319,680.00	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	950	50	Revtment NKT	S2 - 3		44.4	2,220	m3	$ 108.00	$ 144.00	$ 239,760.00	$ 319,680.00	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	1000	50	Revtment NKT	S2 - 3		44.4	2,220	m3	$ 108.00	$ 144.00	$ 239,760.00	$ 319,680.00	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	1050	50	Revtment NKT	S2 - 3		44.4	2,220	m3	$ 108.00	$ 144.00	$ 239,760.00	$ 319,680.00	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	1100	50	Revtment NKT	S2 - 3		44.4	2,220	m3	$ 108.00	$ 144.00	$ 239,760.00	$ 319,680.00	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	1150	50	Revtment NKT	S2 - 3		44.4	2,220	m3	$ 108.00	$ 144.00	$ 239,760.00	$ 319,680.00	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	1200	40	Revtment NKT	S2 - 3		44.4	1,776	m3	$ 108.00	$ 144.00	$ 191,808.00	$ 255,744.00	6	240	m2	$ 30.00	$ 50.00	$ 7,200.00	$ 12,000.00
	1240	50	Landing site NKT	S2 - 6	Revet + Groyne	89.4	4,470	m3	$ 108.00	$ 144.00	$ 482,760.00	$ 643,680.00	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	1290	30	Landing site NKT	-	Groyne + Beach	45.0	1,350	m3	$ 108.00	$ 144.00	$ 145,800.00	$ 194,400.00	6	180	m2	$ 30.00	$ 50.00	$ 5,400.00	$ 9,000.00
	1320	30	Landing site NKT	S2 - 3		44.4	1,332	m3	$ 108.00	$ 144.00	$ 143,856.00	$ 191,808.00	6	180	m2	$ 30.00	$ 50.00	$ 5,400.00	$ 9,000.00
	1350	50	Revtment NKT	S2 - 3		44.4	2,220	m3	$ 108.00	$ 144.00	$ 239,760.00	$ 319,680.00	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	1400	50	Revtment NKT	S2 - 4		43.3	2,165	m3	$ 108.00	$ 144.00	$ 233,820.00	$ 311,760.00	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	1450	50	Revtment NKT	S2 - 4		43.3	2,165	m3	$ 108.00	$ 144.00	$ 233,820.00	$ 311,760.00	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	1500	50	Revtment NKT	S2 - 4		43.3	2,165	m3	$ 108.00	$ 144.00	$ 233,820.00	$ 311,760.00	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	1550	50	Revtment NKT	S2 - 4		43.3	2,165	m3	$ 108.00	$ 144.00	$ 233,820.00	$ 311,760.00	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	1600	50	Revtment NKT	S2 - 4		43.3	2,165	m3	$ 108.00	$ 144.00	$ 233,820.00	$ 311,760.00	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	1650	50	Revtment NKT	S2 - 4		43.3	2,165	m3	$ 108.00	$ 144.00	$ 233,820.00	$ 311,760.00	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	1700	50	Revtment NKT	S2 - 4		43.3	2,165	m3	$ 108.00	$ 144.00	$ 233,820.00	$ 311,760.00	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	1750	50	Revtment NKT	S2 - 2		43.4	2,170	m3	$ 108.00	$ 144.00	$ 234,360.00	$ 312,480.00	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	1800	50	Revtment NKT	S2 - 2		43.4	2,170	m3	$ 108.00	$ 144.00	$ 234,360.00	$ 312,480.00	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	1850	70	Revtment NKT	S2 - 2		43.4	3,038	m3	$ 108.00	$ 144.00	$ 328,104.00	$ 437,472.00	6	420	m2	$ 30.00	$ 50.00	$ 12,600.00	$ 21,000.00
	1920	30	Landing site NKT	S2 - 5		0	-	m3	$ 108.00	$ 144.00	$ -	$ -	6	180	m2	$ 30.00	$ 50.00	$ 5,400.00	$ 9,000.00
	1950	50	Landing site NKT	S2 - 5		0	-	m3	$ 108.00	$ 144.00	$ -	$ -	6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	2000	70	Landing site NKT	S2 - 5		0	-	m3	$ 108.00	$ 144.00	$ -	$ -	6	420	m2	$ 30.00	$ 50.00	$ 12,600.00	$ 21,000.00
	2070	30			Outside project area	0	-	m3	$ 108.00	$ 144.00	$ -	$ -	0	-	m2	$ 30.00	$ 50.00	$ -	$ -
	2100	50		-	Outside project area	0	-	m3	$ 108.00	$ 144.00	$ -	$ -	0	-	m2	$ 30.00	$ 50.00	$ -	$ -
	2150	50		-	Outside project area	0	-	m3	$ 108.00	$ 144.00	$ -	$ -	0	-	m2	$ 30.00	$ 50.00	$ -	$ -
	2200	50		-	Outside project area	0	-	m3	$ 108.00	$ 144.00	$ -	$ -	0	-	m2	$ 30.00	$ 50.00	$ -	$ -
	2250																		
TOTALS							57,851				$ 6,247,908.00	$ 8,330,544.00		12,420				$ 372,600.00	$ 621,000.00

Page 4 of 6

BOQ New Kru Town

General						Item:	Landscaping						Item:	Drainage (onesided)					
Location	Chainage	Length	Item	Drawing #	Comments	Qty/m	Qty_Landscaping	Unit	Unit rate - Low	Unit rate - high	Cost_Landscaping low	Cost_Landscaping high	Qty/m	Qty_Drainage (onesided)	Unit	Unit rate - Low	Unit rate - high	Cost_Drainage (onesided) low	Cost_Drainage (onesided) high
	0	50	Revetment light	S2 - 1		0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	50	50	Revetment light	S2 - 1		0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	100	50	Revetment light	S2 - 1		0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	150	50	Revetment light	S2 - 1		0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	200	50	Revetment light	S2 - 1		0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	250	50	Revetment light	S2 - 1		0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	300	50	Revetment light	S2 - 1		0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	350	50	Revetment light	S2 - 1		0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	400	50	Revetment light	S2 - 1		0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	450	50	Revetment light	S2 - 1		0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	500	50	Revetment light	S2 - 1		0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	550	50	Revetment light	S2 - 1		0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	600	50	Revetment light	S2 - 1		0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	650	50	Revtment NKT	S2 - 2		0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	700	50	Revtment NKT	S2 - 2		0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	750	50	Revtment NKT	S2 - 2		0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	800	50	Revtment NKT	S2 - 2		0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	850	50	Revtment NKT	S2 - 2		0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	900	50	Revtment NKT	S2 - 3		0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	950	50	Revtment NKT	S2 - 3		0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	1000	50	Revtment NKT	S2 - 3		0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	1050	50	Revtment NKT	S2 - 3		0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	1100	50	Revtment NKT	S2 - 3		0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	1150	50	Revtment NKT	S2 - 3		0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	1200	40	Revtment NKT	S2 - 3		0.04	2	trees	$ 400.00	$ 600.00	$ 640.00	$ 960.00	1	40	m	$ 80.00	$ 100.00	$ 3,200.00	$ 4,000.00
	1240	50	Landing site NKT	S2 - 6	Revet + Groyne	0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	1290	30	Landing site NKT	-	Groyne + Beach	0.04	1	trees	$ 400.00	$ 600.00	$ 480.00	$ 720.00	1	30	m	$ 80.00	$ 100.00	$ 2,400.00	$ 3,000.00
	1320	30	Landing site NKT	S2 - 3		0.04	1	trees	$ 400.00	$ 600.00	$ 480.00	$ 720.00	1	30	m	$ 80.00	$ 100.00	$ 2,400.00	$ 3,000.00
	1350	50	Revtment NKT	S2 - 3		0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	1400	50	Revtment NKT	S2 - 4		0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	1450	50	Revtment NKT	S2 - 4		0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	1500	50	Revtment NKT	S2 - 4		0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	1550	50	Revtment NKT	S2 - 4		0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	1600	50	Revtment NKT	S2 - 4		0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	1650	50	Revtment NKT	S2 - 4		0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	1700	50	Revtment NKT	S2 - 4		0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	1750	50	Revtment NKT	S2 - 2		0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	1800	50	Revtment NKT	S2 - 2		0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	1850	70	Revtment NKT	S2 - 2		0.04	3	trees	$ 400.00	$ 600.00	$ 1,120.00	$ 1,680.00	1	70	m	$ 80.00	$ 100.00	$ 5,600.00	$ 7,000.00
	1920	30	Landing site NKT	S2 - 5		0.04	1	trees	$ 400.00	$ 600.00	$ 480.00	$ 720.00	1	30	m	$ 80.00	$ 100.00	$ 2,400.00	$ 3,000.00
	1950	50	Landing site NKT	S2 - 5		0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00	1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	2000	70	Landing site NKT	S2 - 5		0.04	3	trees	$ 400.00	$ 600.00	$ 1,120.00	$ 1,680.00	1	70	m	$ 80.00	$ 100.00	$ 5,600.00	$ 7,000.00
	2070	30			Outside project area	0	-	trees	$ 400.00	$ 600.00	$ -	$ -	0	-	m	$ 80.00	$ 100.00	$ -	$ -
	2100	50		-	Outside project area	0	-	trees	$ 400.00	$ 600.00	$ -	$ -	0	-	m	$ 80.00	$ 100.00	$ -	$ -
	2150	50		-	Outside project area	0	-	trees	$ 400.00	$ 600.00	$ -	$ -	0	-	m	$ 80.00	$ 100.00	$ -	$ -
	2200	50		-	Outside project area	0	-	trees	$ 400.00	$ 600.00	$ -	$ -	0	-	m	$ 80.00	$ 100.00	$ -	$ -
	2250																		
TOTALS							83				$ 33,120.00	$ 49,680.00		2,070				$ 165,600.00	$ 207,000.00

BOQ New Kru Town

General						Item:	Sand (nourished)					
Location	Chainage	Length	Item	Drawing #	Comments	Qty/m	Qty_Sand (nourished)	Unit	Unit rate - Low	Unit rate - high	Cost_Sand (nourished) low	Cost_Sand (nourished) high
	0	50	Revetment light	S2 - 1			-	m3	$ 4.00	$ 8.00	$ -	$ -
	50	50	Revetment light	S2 - 1			-	m3	$ 4.00	$ 8.00	$ -	$ -
	100	50	Revetment light	S2 - 1			-	m3	$ 4.00	$ 8.00	$ -	$ -
	150	50	Revetment light	S2 - 1			-	m3	$ 4.00	$ 8.00	$ -	$ -
	200	50	Revetment light	S2 - 1			-	m3	$ 4.00	$ 8.00	$ -	$ -
	250	50	Revetment light	S2 - 1			-	m3	$ 4.00	$ 8.00	$ -	$ -
	300	50	Revetment light	S2 - 1			-	m3	$ 4.00	$ 8.00	$ -	$ -
	350	50	Revetment light	S2 - 1			-	m3	$ 4.00	$ 8.00	$ -	$ -
	400	50	Revetment light	S2 - 1			-	m3	$ 4.00	$ 8.00	$ -	$ -
	450	50	Revetment light	S2 - 1			-	m3	$ 4.00	$ 8.00	$ -	$ -
	500	50	Revetment light	S2 - 1			-	m3	$ 4.00	$ 8.00	$ -	$ -
	550	50	Revetment light	S2 - 1			-	m3	$ 4.00	$ 8.00	$ -	$ -
	600	50	Revetment light	S2 - 1			-	m3	$ 4.00	$ 8.00	$ -	$ -
	650	50	Revtment NKT	S2 - 2			-	m3	$ 4.00	$ 8.00	$ -	$ -
	700	50	Revtment NKT	S2 - 2			-	m3	$ 4.00	$ 8.00	$ -	$ -
	750	50	Revtment NKT	S2 - 2			-	m3	$ 4.00	$ 8.00	$ -	$ -
	800	50	Revtment NKT	S2 - 2			-	m3	$ 4.00	$ 8.00	$ -	$ -
	850	50	Revtment NKT	S2 - 2			-	m3	$ 4.00	$ 8.00	$ -	$ -
	900	50	Revtment NKT	S2 - 3			-	m3	$ 4.00	$ 8.00	$ -	$ -
	950	50	Revtment NKT	S2 - 3			-	m3	$ 4.00	$ 8.00	$ -	$ -
	1000	50	Revtment NKT	S2 - 3			-	m3	$ 4.00	$ 8.00	$ -	$ -
	1050	50	Revtment NKT	S2 - 3			-	m3	$ 4.00	$ 8.00	$ -	$ -
	1100	50	Revtment NKT	S2 - 3			-	m3	$ 4.00	$ 8.00	$ -	$ -
	1150	50	Revtment NKT	S2 - 3			-	m3	$ 4.00	$ 8.00	$ -	$ -
	1200	40	Revtment NKT	S2 - 3			-	m3	$ 4.00	$ 8.00	$ -	$ -
	1240	50	Landing site NKT	S2 - 6	Revet + Groyne		-	m3	$ 4.00	$ 8.00	$ -	$ -
	1290	30	Landing site NKT	-	Groyne + Beach	80	2,400	m3	$ 4.00	$ 8.00	$ 9,600.00	$ 19,200.00
	1320	30	Landing site NKT	S2 - 3			-	m3	$ 4.00	$ 8.00	$ -	$ -
	1350	50	Revtment NKT	S2 - 3			-	m3	$ 4.00	$ 8.00	$ -	$ -
	1400	50	Revtment NKT	S2 - 4			-	m3	$ 4.00	$ 8.00	$ -	$ -
	1450	50	Revtment NKT	S2 - 4			-	m3	$ 4.00	$ 8.00	$ -	$ -
	1500	50	Revtment NKT	S2 - 4			-	m3	$ 4.00	$ 8.00	$ -	$ -
	1550	50	Revtment NKT	S2 - 4			-	m3	$ 4.00	$ 8.00	$ -	$ -
	1600	50	Revtment NKT	S2 - 4			-	m3	$ 4.00	$ 8.00	$ -	$ -
	1650	50	Revtment NKT	S2 - 4			-	m3	$ 4.00	$ 8.00	$ -	$ -
	1700	50	Revtment NKT	S2 - 4			-	m3	$ 4.00	$ 8.00	$ -	$ -
	1750	50	Revtment NKT	S2 - 2			-	m3	$ 4.00	$ 8.00	$ -	$ -
	1800	50	Revtment NKT	S2 - 2			-	m3	$ 4.00	$ 8.00	$ -	$ -
	1850	70	Revtment NKT	S2 - 2			-	m3	$ 4.00	$ 8.00	$ -	$ -
	1920	30	Landing site NKT	S2 - 5		136	4,080	m3	$ 4.00	$ 8.00	$ 16,320.00	$ 32,640.00
	1950	50	Landing site NKT	S2 - 5		136	6,800	m3	$ 4.00	$ 8.00	$ 27,200.00	$ 54,400.00
	2000	70	Landing site NKT	S2 - 5		136	9,520	m3	$ 4.00	$ 8.00	$ 38,080.00	$ 76,160.00
	2070	30			Outside project area		-	m3	$ 4.00	$ 8.00	$ -	$ -
	2100	50		-	Outside project area		-	m3	$ 4.00	$ 8.00	$ -	$ -
	2150	50		-	Outside project area		-	m3	$ 4.00	$ 8.00	$ -	$ -
	2200	50		-	Outside project area		-	m3	$ 4.00	$ 8.00	$ -	$ -
	2250											
TOTALS							22,800				$ 91,200.00	$ 182,400.00

BOQ Westpoint - Alternative A (Revetment)

General						Item:	Quarry run						Item:	Underlayer 60-300 kg					
Location	Chainage	Length	Item	Drawing #	Comments	Qty/m	Qty_Quarry run	Unit	Unit rate - Low	Unit rate - high	Cost_Quarry run low	Cost_Quarry run high	Qty/m	Qty_Underlayer 60-300 kg	Unit	Unit rate - Low	Unit rate - high	Cost_Underlayer 60-300 kg low	Cost_Underlayer 60-300 kg high
	0	50	Revetment light	S3 - 1		6.3	315	m3	$ 95.00	$ 133.00	$ 29,925.00	$ 41,895.00	6.6	330	m3	$ 114.00	$ 152.00	$ 37,620.00	$ 50,160.00
	50	50	Revetment light	S3 - 1		6.3	315	m3	$ 95.00	$ 133.00	$ 29,925.00	$ 41,895.00	6.6	330	m3	$ 114.00	$ 152.00	$ 37,620.00	$ 50,160.00
	100	50	Revetment light	S3 - 1		6.3	315	m3	$ 95.00	$ 133.00	$ 29,925.00	$ 41,895.00	6.6	330	m3	$ 114.00	$ 152.00	$ 37,620.00	$ 50,160.00
	150	50	Revetment light	S3 - 1		6.3	315	m3	$ 95.00	$ 133.00	$ 29,925.00	$ 41,895.00	6.6	330	m3	$ 114.00	$ 152.00	$ 37,620.00	$ 50,160.00
	200	50	Revetment	S3 - 2		38.6	1,930	m3	$ 95.00	$ 133.00	$ 183,350.00	$ 256,690.00	22.2	1,110	m3	$ 114.00	$ 152.00	$ 126,540.00	$ 168,720.00
	250	50	Revetment	S3 - 2		38.6	1,930	m3	$ 95.00	$ 133.00	$ 183,350.00	$ 256,690.00	22.2	1,110	m3	$ 114.00	$ 152.00	$ 126,540.00	$ 168,720.00
	300	50	Revetment	S3 - 2		38.6	1,930	m3	$ 95.00	$ 133.00	$ 183,350.00	$ 256,690.00	22.2	1,110	m3	$ 114.00	$ 152.00	$ 126,540.00	$ 168,720.00
	350	50	Revetment	S3 - 2		38.6	1,930	m3	$ 95.00	$ 133.00	$ 183,350.00	$ 256,690.00	22.2	1,110	m3	$ 114.00	$ 152.00	$ 126,540.00	$ 168,720.00
	400	50	Revetment	S3 - 2		38.6	1,930	m3	$ 95.00	$ 133.00	$ 183,350.00	$ 256,690.00	22.2	1,110	m3	$ 114.00	$ 152.00	$ 126,540.00	$ 168,720.00
	450	50	Revetment	S3 - 2		38.6	1,930	m3	$ 95.00	$ 133.00	$ 183,350.00	$ 256,690.00	22.2	1,110	m3	$ 114.00	$ 152.00	$ 126,540.00	$ 168,720.00
	500	50	Revetment	S3 - 2		38.6	1,930	m3	$ 95.00	$ 133.00	$ 183,350.00	$ 256,690.00	22.2	1,110	m3	$ 114.00	$ 152.00	$ 126,540.00	$ 168,720.00
	550	50	Revetment	S3 - 2		38.6	1,930	m3	$ 95.00	$ 133.00	$ 183,350.00	$ 256,690.00	22.2	1,110	m3	$ 114.00	$ 152.00	$ 126,540.00	$ 168,720.00
	600	50	Revetment	S3 - 2		38.6	1,930	m3	$ 95.00	$ 133.00	$ 183,350.00	$ 256,690.00	22.2	1,110	m3	$ 114.00	$ 152.00	$ 126,540.00	$ 168,720.00
	650	40	Revetment	S3 - 2		38.6	1,544	m3	$ 95.00	$ 133.00	$ 146,680.00	$ 205,352.00	22.2	888	m3	$ 114.00	$ 152.00	$ 101,232.00	$ 134,976.00
	690	30	Landing site WP	S3 - 5	Revet + Groyne	138.4	4,152	m3	$ 95.00	$ 133.00	$ 394,440.00	$ 552,216.00	22.2	666	m3	$ 114.00	$ 152.00	$ 75,924.00	$ 101,232.00
	720	10	Landing site WP	-	Groyne + Beach	99.0	990	m3	$ 95.00	$ 133.00	$ 94,050.00	$ 131,670.00		-	m3	$ 114.00	$ 152.00	$ -	$ -
	730	20	Revetment	S3 - 2		38.6	772	m3	$ 95.00	$ 133.00	$ 73,340.00	$ 102,676.00	22.2	444	m3	$ 114.00	$ 152.00	$ 50,616.00	$ 67,488.00
	750	50	Revetment	S3 - 3		42.1	2,105	m3	$ 95.00	$ 133.00	$ 199,975.00	$ 279,965.00	22.1	1,105	m3	$ 114.00	$ 152.00	$ 125,970.00	$ 167,960.00
	800	50	Revetment	S3 - 3		42.1	2,105	m3	$ 95.00	$ 133.00	$ 199,975.00	$ 279,965.00	22.1	1,105	m3	$ 114.00	$ 152.00	$ 125,970.00	$ 167,960.00
	850	50	Revetment	S3 - 3		42.1	2,105	m3	$ 95.00	$ 133.00	$ 199,975.00	$ 279,965.00	22.1	1,105	m3	$ 114.00	$ 152.00	$ 125,970.00	$ 167,960.00
	900	50	Revetment	S3 - 3		42.1	2,105	m3	$ 95.00	$ 133.00	$ 199,975.00	$ 279,965.00	22.1	1,105	m3	$ 114.00	$ 152.00	$ 125,970.00	$ 167,960.00
	950	50	Revetment	S3 - 3		42.1	2,105	m3	$ 95.00	$ 133.00	$ 199,975.00	$ 279,965.00	22.1	1,105	m3	$ 114.00	$ 152.00	$ 125,970.00	$ 167,960.00
	1000	50	Revetment	S3 - 3		42.1	2,105	m3	$ 95.00	$ 133.00	$ 199,975.00	$ 279,965.00	22.1	1,105	m3	$ 114.00	$ 152.00	$ 125,970.00	$ 167,960.00
	1050	50	Landing site WP	S3 - 4		32.7	1,635	m3	$ 95.00	$ 133.00	$ 155,325.00	$ 217,455.00		-	m3	$ 114.00	$ 152.00	$ -	$ -
	1100	50	Landing site WP	S3 - 4		32.7	1,635	m3	$ 95.00	$ 133.00	$ 155,325.00	$ 217,455.00		-	m3	$ 114.00	$ 152.00	$ -	$ -
	1150	30	Landing site WP	S3 - 4		32.7	981	m3	$ 95.00	$ 133.00	$ 93,195.00	$ 130,473.00		-	m3	$ 114.00	$ 152.00	$ -	$ -
	1180																		
	TOTALS						42,969				$ 4,082,055.00	$ 5,714,877.00		19,938				$ 2,272,932.00	$ 3,030,576.00

Page 1 of 6

BOQ Westpoint - Alternative A (Revetment)

General						Item:	Armour 300-1000kg						Item:	Geotextile					
Location	Chainage	Length	Item	Drawing #	Comments	Qty/m	Qty_Armour 300-1000kg	Unit	Unit rate - Low	Unit rate - high	Cost_Armour 300-1000kg low	Cost_Armour 300-1000kg high	Qty/m	Qty_Geotextile	Unit	Unit rate - Low	Unit rate - high	Cost_Geotextile low	Cost_Geotextile high
	0	50	Revetment light	S3 - 1		12.5	625	m3	$ 108.00	$ 144.00	$ 67,500.00	$ 90,000.00	15	750	m2	$ 10.00	$ 15.00	$ 7,500.00	$ 11,250.00
	50	50	Revetment light	S3 - 1		12.5	625	m3	$ 108.00	$ 144.00	$ 67,500.00	$ 90,000.00	15	750	m2	$ 10.00	$ 15.00	$ 7,500.00	$ 11,250.00
	100	50	Revetment light	S3 - 1		12.5	625	m3	$ 108.00	$ 144.00	$ 67,500.00	$ 90,000.00	15	750	m2	$ 10.00	$ 15.00	$ 7,500.00	$ 11,250.00
	150	50	Revetment light	S3 - 1		12.5	625	m3	$ 108.00	$ 144.00	$ 67,500.00	$ 90,000.00	15	750	m2	$ 10.00	$ 15.00	$ 7,500.00	$ 11,250.00
	200	50	Revetment	S3 - 2			-	m3	$ 108.00	$ 144.00	$ -	$ -	38	1,900	m2	$ 10.00	$ 15.00	$ 19,000.00	$ 28,500.00
	250	50	Revetment	S3 - 2			-	m3	$ 108.00	$ 144.00	$ -	$ -	38	1,900	m2	$ 10.00	$ 15.00	$ 19,000.00	$ 28,500.00
	300	50	Revetment	S3 - 2			-	m3	$ 108.00	$ 144.00	$ -	$ -	38	1,900	m2	$ 10.00	$ 15.00	$ 19,000.00	$ 28,500.00
	350	50	Revetment	S3 - 2			-	m3	$ 108.00	$ 144.00	$ -	$ -	38	1,900	m2	$ 10.00	$ 15.00	$ 19,000.00	$ 28,500.00
	400	50	Revetment	S3 - 2			-	m3	$ 108.00	$ 144.00	$ -	$ -	38	1,900	m2	$ 10.00	$ 15.00	$ 19,000.00	$ 28,500.00
	450	50	Revetment	S3 - 2			-	m3	$ 108.00	$ 144.00	$ -	$ -	38	1,900	m2	$ 10.00	$ 15.00	$ 19,000.00	$ 28,500.00
	500	50	Revetment	S3 - 2			-	m3	$ 108.00	$ 144.00	$ -	$ -	38	1,900	m2	$ 10.00	$ 15.00	$ 19,000.00	$ 28,500.00
	550	50	Revetment	S3 - 2			-	m3	$ 108.00	$ 144.00	$ -	$ -	38	1,900	m2	$ 10.00	$ 15.00	$ 19,000.00	$ 28,500.00
	600	50	Revetment	S3 - 2			-	m3	$ 108.00	$ 144.00	$ -	$ -	38	1,900	m2	$ 10.00	$ 15.00	$ 19,000.00	$ 28,500.00
	650	40	Revetment	S3 - 2			-	m3	$ 108.00	$ 144.00	$ -	$ -	38	1,520	m2	$ 10.00	$ 15.00	$ 15,200.00	$ 22,800.00
	690	30	Landing site WP	S3 - 5	Revet + Groyne	10.2	306	m3	$ 108.00	$ 144.00	$ 33,048.00	$ 44,064.00	38	1,140	m2	$ 10.00	$ 15.00	$ 11,400.00	$ 17,100.00
	720	10	Landing site WP	-	Groyne + Beach	10.2	102	m3	$ 108.00	$ 144.00	$ 11,016.00	$ 14,688.00		-	m2	$ 10.00	$ 15.00	$ -	$ -
	730	20	Revetment	S3 - 2			-	m3	$ 108.00	$ 144.00	$ -	$ -	38	760	m2	$ 10.00	$ 15.00	$ 7,600.00	$ 11,400.00
	750	50	Revetment	S3 - 3			-	m3	$ 108.00	$ 144.00	$ -	$ -	38.5	1,925	m2	$ 10.00	$ 15.00	$ 19,250.00	$ 28,875.00
	800	50	Revetment	S3 - 3			-	m3	$ 108.00	$ 144.00	$ -	$ -	38.5	1,925	m2	$ 10.00	$ 15.00	$ 19,250.00	$ 28,875.00
	850	50	Revetment	S3 - 3			-	m3	$ 108.00	$ 144.00	$ -	$ -	38.5	1,925	m2	$ 10.00	$ 15.00	$ 19,250.00	$ 28,875.00
	900	50	Revetment	S3 - 3			-	m3	$ 108.00	$ 144.00	$ -	$ -	38.5	1,925	m2	$ 10.00	$ 15.00	$ 19,250.00	$ 28,875.00
	950	50	Revetment	S3 - 3			-	m3	$ 108.00	$ 144.00	$ -	$ -	38.5	1,925	m2	$ 10.00	$ 15.00	$ 19,250.00	$ 28,875.00
	1000	50	Revetment	S3 - 3			-	m3	$ 108.00	$ 144.00	$ -	$ -	38.5	1,925	m2	$ 10.00	$ 15.00	$ 19,250.00	$ 28,875.00
	1050	50	Landing site WP	S3 - 4			-	m3	$ 108.00	$ 144.00	$ -	$ -	18	900	m2	$ 10.00	$ 15.00	$ 9,000.00	$ 13,500.00
	1100	50	Landing site WP	S3 - 4			-	m3	$ 108.00	$ 144.00	$ -	$ -	18	900	m2	$ 10.00	$ 15.00	$ 9,000.00	$ 13,500.00
	1150	30	Landing site WP	S3 - 4			-	m3	$ 108.00	$ 144.00	$ -	$ -	18	540	m2	$ 10.00	$ 15.00	$ 5,400.00	$ 8,100.00
	1180																		
	TOTALS						2,908				$ 314,064.00	$ 418,752.00		37,410				$ 374,100.00	$ 561,150.00

Page 2 of 6

BOQ Westpoint - Alternative A (Revetment)

General						Item:	Sand (nourished)						Item:	Excavation					
Location	Chainage	Length	Item	Drawing #	Comments	Qty/m	Qty_Sand (nourished)	Unit	Unit rate - Low	Unit rate - high	Cost_Sand (nourished) low	Cost_Sand (nourished) high	Qty/m	Qty_Excavation	Unit	Unit rate - Low	Unit rate - high	Cost_Excavation low	Cost_Excavation high
	0	50	Revetment light	S3 - 1			-	m3	$ 4.00	$ 8.00	$ -	$ -	51.5	2,575	m3	$ 8.00	$ 12.00	$ 20,600.00	$ 30,900.00
	50	50	Revetment light	S3 - 1			-	m3	$ 4.00	$ 8.00	$ -	$ -	51.5	2,575	m3	$ 8.00	$ 12.00	$ 20,600.00	$ 30,900.00
	100	50	Revetment light	S3 - 1			-	m3	$ 4.00	$ 8.00	$ -	$ -	51.5	2,575	m3	$ 8.00	$ 12.00	$ 20,600.00	$ 30,900.00
	150	50	Revetment light	S3 - 1			-	m3	$ 4.00	$ 8.00	$ -	$ -	51.5	2,575	m3	$ 8.00	$ 12.00	$ 20,600.00	$ 30,900.00
	200	50	Revetment	S3 - 2			-	m3	$ 4.00	$ 8.00	$ -	$ -	46.5	2,325	m3	$ 8.00	$ 12.00	$ 18,600.00	$ 27,900.00
	250	50	Revetment	S3 - 2			-	m3	$ 4.00	$ 8.00	$ -	$ -	46.5	2,325	m3	$ 8.00	$ 12.00	$ 18,600.00	$ 27,900.00
	300	50	Revetment	S3 - 2			-	m3	$ 4.00	$ 8.00	$ -	$ -	46.5	2,325	m3	$ 8.00	$ 12.00	$ 18,600.00	$ 27,900.00
	350	50	Revetment	S3 - 2			-	m3	$ 4.00	$ 8.00	$ -	$ -	46.5	2,325	m3	$ 8.00	$ 12.00	$ 18,600.00	$ 27,900.00
	400	50	Revetment	S3 - 2			-	m3	$ 4.00	$ 8.00	$ -	$ -	46.5	2,325	m3	$ 8.00	$ 12.00	$ 18,600.00	$ 27,900.00
	450	50	Revetment	S3 - 2			-	m3	$ 4.00	$ 8.00	$ -	$ -	46.5	2,325	m3	$ 8.00	$ 12.00	$ 18,600.00	$ 27,900.00
	500	50	Revetment	S3 - 2			-	m3	$ 4.00	$ 8.00	$ -	$ -	46.5	2,325	m3	$ 8.00	$ 12.00	$ 18,600.00	$ 27,900.00
	550	50	Revetment	S3 - 2			-	m3	$ 4.00	$ 8.00	$ -	$ -	46.5	2,325	m3	$ 8.00	$ 12.00	$ 18,600.00	$ 27,900.00
	600	50	Revetment	S3 - 2			-	m3	$ 4.00	$ 8.00	$ -	$ -	46.5	2,325	m3	$ 8.00	$ 12.00	$ 18,600.00	$ 27,900.00
	650	40	Revetment	S3 - 2			-	m3	$ 4.00	$ 8.00	$ -	$ -	46.5	1,860	m3	$ 8.00	$ 12.00	$ 14,880.00	$ 22,320.00
	690	30	Landing site WP	S3 - 5	Revet + Groyne		-	m3	$ 4.00	$ 8.00	$ -	$ -	121.8	3,654	m3	$ 8.00	$ 12.00	$ 29,232.00	$ 43,848.00
	720	10	Landing site WP	-	Groyne + Beach	70	700	m3	$ 4.00	$ 8.00	$ 2,800.00	$ 5,600.00	41.5	415	m3	$ 8.00	$ 12.00	$ 3,320.00	$ 4,980.00
	730	20	Revetment	S3 - 2			-	m3	$ 4.00	$ 8.00	$ -	$ -	46.5	930	m3	$ 8.00	$ 12.00	$ 7,440.00	$ 11,160.00
	750	50	Revetment	S3 - 3			-	m3	$ 4.00	$ 8.00	$ -	$ -	41	2,050	m3	$ 8.00	$ 12.00	$ 16,400.00	$ 24,600.00
	800	50	Revetment	S3 - 3			-	m3	$ 4.00	$ 8.00	$ -	$ -	41	2,050	m3	$ 8.00	$ 12.00	$ 16,400.00	$ 24,600.00
	850	50	Revetment	S3 - 3			-	m3	$ 4.00	$ 8.00	$ -	$ -	41	2,050	m3	$ 8.00	$ 12.00	$ 16,400.00	$ 24,600.00
	900	50	Revetment	S3 - 3			-	m3	$ 4.00	$ 8.00	$ -	$ -	41	2,050	m3	$ 8.00	$ 12.00	$ 16,400.00	$ 24,600.00
	950	50	Revetment	S3 - 3			-	m3	$ 4.00	$ 8.00	$ -	$ -	41	2,050	m3	$ 8.00	$ 12.00	$ 16,400.00	$ 24,600.00
	1000	50	Revetment	S3 - 3			-	m3	$ 4.00	$ 8.00	$ -	$ -	41	2,050	m3	$ 8.00	$ 12.00	$ 16,400.00	$ 24,600.00
	1050	50	Landing site WP	S3 - 4		88.5	4,425	m3	$ 4.00	$ 8.00	$ 17,700.00	$ 35,400.00		-	m3	$ 8.00	$ 12.00	$ -	$ -
	1100	50	Landing site WP	S3 - 4		88.5	4,425	m3	$ 4.00	$ 8.00	$ 17,700.00	$ 35,400.00		-	m3	$ 8.00	$ 12.00	$ -	$ -
	1150	30	Landing site WP	S3 - 4		88.5	2,655	m3	$ 4.00	$ 8.00	$ 10,620.00	$ 21,240.00		-	m3	$ 8.00	$ 12.00	$ -	$ -
	1180																		
TOTALS							12,205				$ 48,820.00	$ 97,640.00		50,384				$ 403,072.00	$ 604,608.00

Page 3 of 6

BOQ Westpoint - Alternative A (Revetment)

General						Item:	Backfill						Item:	Armour 2-5 t					
Location	Chainage	Length	Item	Drawing #	Comments	Qty/m	Qty_Backfill	Unit	Unit rate - Low	Unit rate - high	Cost_Backfill low	Cost_Backfill high	Qty/m	Qty_Armour 2-5 t	Unit	Unit rate - Low	Unit rate - high	Cost_Armour 2-5 t low	Cost_Armour 2-5 t high
	0	50	Revetment light	S3 - 1		27.5	1,375	m3	$ 4.00	$ 6.00	$ 5,500.00	$ 8,250.00		-	m3	$ 108.00	$ 144.00	$ -	$ -
	50	50	Revetment light	S3 - 1		27.5	1,375	m3	$ 4.00	$ 6.00	$ 5,500.00	$ 8,250.00		-	m3	$ 108.00	$ 144.00	$ -	$ -
	100	50	Revetment light	S3 - 1		27.5	1,375	m3	$ 4.00	$ 6.00	$ 5,500.00	$ 8,250.00		-	m3	$ 108.00	$ 144.00	$ -	$ -
	150	50	Revetment light	S3 - 1		27.5	1,375	m3	$ 4.00	$ 6.00	$ 5,500.00	$ 8,250.00		-	m3	$ 108.00	$ 144.00	$ -	$ -
	200	50	Revetment	S3 - 2			-	m3	$ 4.00	$ 6.00	$ -	$ -	42.0	2,100	m3	$ 108.00	$ 144.00	$ 226,800.00	$ 302,400.00
	250	50	Revetment	S3 - 2			-	m3	$ 4.00	$ 6.00	$ -	$ -	42.0	2,100	m3	$ 108.00	$ 144.00	$ 226,800.00	$ 302,400.00
	300	50	Revetment	S3 - 2			-	m3	$ 4.00	$ 6.00	$ -	$ -	42.0	2,100	m3	$ 108.00	$ 144.00	$ 226,800.00	$ 302,400.00
	350	50	Revetment	S3 - 2			-	m3	$ 4.00	$ 6.00	$ -	$ -	42.0	2,100	m3	$ 108.00	$ 144.00	$ 226,800.00	$ 302,400.00
	400	50	Revetment	S3 - 2			-	m3	$ 4.00	$ 6.00	$ -	$ -	42.0	2,100	m3	$ 108.00	$ 144.00	$ 226,800.00	$ 302,400.00
	450	50	Revetment	S3 - 2			-	m3	$ 4.00	$ 6.00	$ -	$ -	42.0	2,100	m3	$ 108.00	$ 144.00	$ 226,800.00	$ 302,400.00
	500	50	Revetment	S3 - 2			-	m3	$ 4.00	$ 6.00	$ -	$ -	42.0	2,100	m3	$ 108.00	$ 144.00	$ 226,800.00	$ 302,400.00
	550	50	Revetment	S3 - 2			-	m3	$ 4.00	$ 6.00	$ -	$ -	42.0	2,100	m3	$ 108.00	$ 144.00	$ 226,800.00	$ 302,400.00
	600	50	Revetment	S3 - 2			-	m3	$ 4.00	$ 6.00	$ -	$ -	42.0	2,100	m3	$ 108.00	$ 144.00	$ 226,800.00	$ 302,400.00
	650	40	Revetment	S3 - 2			-	m3	$ 4.00	$ 6.00	$ -	$ -	42.0	1,680	m3	$ 108.00	$ 144.00	$ 181,440.00	$ 241,920.00
	690	30	Landing site WP	S3 - 5	Revet + Groyne		-	m3	$ 4.00	$ 6.00	$ -	$ -	85.6	2,568	m3	$ 108.00	$ 144.00	$ 277,344.00	$ 369,792.00
	720	10	Landing site WP	-	Groyne + Beach		-	m3	$ 4.00	$ 6.00	$ -	$ -	43.6	436	m3	$ 108.00	$ 144.00	$ 47,088.00	$ 62,784.00
	730	20	Revetment	S3 - 2			-	m3	$ 4.00	$ 6.00	$ -	$ -	42.0	840	m3	$ 108.00	$ 144.00	$ 90,720.00	$ 120,960.00
	750	50	Revetment	S3 - 3			-	m3	$ 4.00	$ 6.00	$ -	$ -	42.0	2,100	m3	$ 108.00	$ 144.00	$ 226,800.00	$ 302,400.00
	800	50	Revetment	S3 - 3			-	m3	$ 4.00	$ 6.00	$ -	$ -	42.0	2,100	m3	$ 108.00	$ 144.00	$ 226,800.00	$ 302,400.00
	850	50	Revetment	S3 - 3			-	m3	$ 4.00	$ 6.00	$ -	$ -	42.0	2,100	m3	$ 108.00	$ 144.00	$ 226,800.00	$ 302,400.00
	900	50	Revetment	S3 - 3			-	m3	$ 4.00	$ 6.00	$ -	$ -	42.0	2,100	m3	$ 108.00	$ 144.00	$ 226,800.00	$ 302,400.00
	950	50	Revetment	S3 - 3			-	m3	$ 4.00	$ 6.00	$ -	$ -	42.0	2,100	m3	$ 108.00	$ 144.00	$ 226,800.00	$ 302,400.00
	1000	50	Revetment	S3 - 3			-	m3	$ 4.00	$ 6.00	$ -	$ -	42.0	2,100	m3	$ 108.00	$ 144.00	$ 226,800.00	$ 302,400.00
	1050	50	Landing site WP	S3 - 4			-	m3	$ 4.00	$ 6.00	$ -	$ -		-	m3	$ 108.00	$ 144.00	$ -	$ -
	1100	50	Landing site WP	S3 - 4			-	m3	$ 4.00	$ 6.00	$ -	$ -		-	m3	$ 108.00	$ 144.00	$ -	$ -
	1150	30	Landing site WP	S3 - 4			-	m3	$ 4.00	$ 6.00	$ -	$ -		-	m3	$ 108.00	$ 144.00	$ -	$ -
	1180																		
TOTALS							5,500				$ 22,000.00	$ 33,000.00		37,024				$ 3,998,592.00	$ 5,331,456.00

Page 4 of 6

BOQ Westpoint - Alternative A (Revetment)

General						Item:	Promenade pavement					
Location	Chainage	Length	Item	Drawing #	Comments	Qty/m	Qty_Promenade pavement	Unit	Unit rate - Low	Unit rate - high	Cost_Promenade pavement low	Cost_Promenade pavement high
	0	50	Revetment light	S3 - 1		6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	50	50	Revetment light	S3 - 1		6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	100	50	Revetment light	S3 - 1		6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	150	50	Revetment light	S3 - 1		6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	200	50	Revetment	S3 - 2		6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	250	50	Revetment	S3 - 2		6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	300	50	Revetment	S3 - 2		6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	350	50	Revetment	S3 - 2		6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	400	50	Revetment	S3 - 2		6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	450	50	Revetment	S3 - 2		6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	500	50	Revetment	S3 - 2		6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	550	50	Revetment	S3 - 2		6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	600	50	Revetment	S3 - 2		6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	650	40	Revetment	S3 - 2		6	240	m2	$ 30.00	$ 50.00	$ 7,200.00	$ 12,000.00
	690	30	Landing site WP	S3 - 5	Revet + Groyne	6	180	m2	$ 30.00	$ 50.00	$ 5,400.00	$ 9,000.00
	720	10	Landing site WP	-	Groyne + Beach	6	60	m2	$ 30.00	$ 50.00	$ 1,800.00	$ 3,000.00
	730	20	Revetment	S3 - 2		6	120	m2	$ 30.00	$ 50.00	$ 3,600.00	$ 6,000.00
	750	50	Revetment	S3 - 3		6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	800	50	Revetment	S3 - 3		6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	850	50	Revetment	S3 - 3		6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	900	50	Revetment	S3 - 3		6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	950	50	Revetment	S3 - 3		6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	1000	50	Revetment	S3 - 3		6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	1050	50	Landing site WP	S3 - 4		6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	1100	50	Landing site WP	S3 - 4		6	300	m2	$ 30.00	$ 50.00	$ 9,000.00	$ 15,000.00
	1150	30	Landing site WP	S3 - 4		6	180	m2	$ 30.00	$ 50.00	$ 5,400.00	$ 9,000.00
	1180											
TOTALS						144	7,080				$ 212,400.00	$ 354,000.00

Chainage	Item:	Landscaping					
	Qty/m	Qty_Landscaping	Unit	Unit rate - low	Unit rate - high	Cost_Landscaping low	Cost_Landscaping high
0	0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00
50	0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00
100	0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00
150	0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00
200	0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00
250	0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00
300	0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00
350	0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00
400	0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00
450	0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00
500	0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00
550	0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00
600	0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00
650	0.04	2	trees	$ 400.00	$ 600.00	$ 640.00	$ 960.00
690	0.04	1	trees	$ 400.00	$ 600.00	$ 480.00	$ 720.00
720	0.04	0	trees	$ 400.00	$ 600.00	$ 160.00	$ 240.00
730	0.04	1	trees	$ 400.00	$ 600.00	$ 320.00	$ 480.00
750	0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00
800	0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00
850	0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00
900	0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00
950	0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00
1000	0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00
1050	0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00
1100	0.04	2	trees	$ 400.00	$ 600.00	$ 800.00	$ 1,200.00
1150	0.04	1	trees	$ 400.00	$ 600.00	$ 480.00	$ 720.00
1180							
TOTALS		47				$ 18,880.00	$ 28,320.00

BOQ Westpoint - Alternative A (Revetment)

General						Item:	Drainage (onesided)					
Location	Chainage	Length	Item	Drawing #	Comments	Qty/m	Qty_Drainage (onesided)	Unit	Unit rate - Low	Unit rate - high	Cost_Drainage (onesided) low	Cost_Drainage (onesided) high
	0	50	Revetment light	S3 - 1		1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	50	50	Revetment light	S3 - 1		1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	100	50	Revetment light	S3 - 1		1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	150	50	Revetment light	S3 - 1		1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	200	50	Revetment	S3 - 2		1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	250	50	Revetment	S3 - 2		1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	300	50	Revetment	S3 - 2		1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	350	50	Revetment	S3 - 2		1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	400	50	Revetment	S3 - 2		1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	450	50	Revetment	S3 - 2		1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	500	50	Revetment	S3 - 2		1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	550	50	Revetment	S3 - 2		1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	600	50	Revetment	S3 - 2		1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	650	40	Revetment	S3 - 2		1	40	m	$ 80.00	$ 100.00	$ 3,200.00	$ 4,000.00
	690	30	Landing site WP	S3 - 5	Revet + Groyne	1	30	m	$ 80.00	$ 100.00	$ 2,400.00	$ 3,000.00
	720	10	Landing site WP	-	Groyne + Beach	1	10	m	$ 80.00	$ 100.00	$ 800.00	$ 1,000.00
	730	20	Revetment	S3 - 2		1	20	m	$ 80.00	$ 100.00	$ 1,600.00	$ 2,000.00
	750	50	Revetment	S3 - 3		1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	800	50	Revetment	S3 - 3		1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	850	50	Revetment	S3 - 3		1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	900	50	Revetment	S3 - 3		1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	950	50	Revetment	S3 - 3		1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	1000	50	Revetment	S3 - 3		1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	1050	50	Landing site WP	S3 - 4		1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	1100	50	Landing site WP	S3 - 4		1	50	m	$ 80.00	$ 100.00	$ 4,000.00	$ 5,000.00
	1150	30	Landing site WP	S3 - 4		1	30	m	$ 80.00	$ 100.00	$ 2,400.00	$ 3,000.00
	1180											
TOTALS							1,180				$ 94,400.00	$ 118,000.00

BOQ Westpoint - Alternative B (Beach Replenishment + Groyne)

General						Item:	Quarry run						Item:	Underlayer 60-300 kg					
Location	Chainage	Length	Item	Drawing #	Comments	Qty/m	Qty_Quarry run	Unit	Unit rate - Low	Unit rate - high	Cost_Quarry run low	Cost_Quarry run high	Qty/m	Qty_Underlayer 60-300 kg	Unit	Unit rate - Low	Unit rate - high	Cost_Underlayer 60-300 kg low	Cost_Underlayer 60-300 kg high
	0	50	Groyne revet	S3 - A		6.3	315	m3	$ 95.00	$ 133.00	$ 29,925.00	$ 41,895.00	6.6	330	m3	$ 114.00	$ 152.00	$ 37,620.00	$ 50,160.00
	50	50	Groyne revet	S3 - A		6.3	315	m3	$ 95.00	$ 133.00	$ 29,925.00	$ 41,895.00	6.6	330	m3	$ 114.00	$ 152.00	$ 37,620.00	$ 50,160.00
	100	50	Groyne revet	S3 - A		6.3	315	m3	$ 95.00	$ 133.00	$ 29,925.00	$ 41,895.00	6.6	330	m3	$ 114.00	$ 152.00	$ 37,620.00	$ 50,160.00
	150	50	Groyne revet	S3 - A		6.3	315	m3	$ 95.00	$ 133.00	$ 29,925.00	$ 41,895.00	6.6	330	m3	$ 114.00	$ 152.00	$ 37,620.00	$ 50,160.00
	200	50	**GROYNE (see separate BOQ)**		See separate sheet		-	m3	$ 95.00	$ 133.00	$ -	$ -		-	m3	$ 114.00	$ 152.00	$ -	$ -
	250	50	Beach	S3 - G			-	m3	$ 95.00	$ 133.00	$ -	$ -		-	m3	$ 114.00	$ 152.00	$ -	$ -
	300	50	Beach	S3 - G			-	m3	$ 95.00	$ 133.00	$ -	$ -		-	m3	$ 114.00	$ 152.00	$ -	$ -
	350	50	Beach	S3 - G			-	m3	$ 95.00	$ 133.00	$ -	$ -		-	m3	$ 114.00	$ 152.00	$ -	$ -
	400	50	Beach	S3 - G			-	m3	$ 95.00	$ 133.00	$ -	$ -		-	m3	$ 114.00	$ 152.00	$ -	$ -
	450	50	Beach	S3 - G			-	m3	$ 95.00	$ 133.00	$ -	$ -		-	m3	$ 114.00	$ 152.00	$ -	$ -
	500	50	Beach	S3 - G			-	m3	$ 95.00	$ 133.00	$ -	$ -		-	m3	$ 114.00	$ 152.00	$ -	$ -
	550	50	Beach	S3 - G			-	m3	$ 95.00	$ 133.00	$ -	$ -		-	m3	$ 114.00	$ 152.00	$ -	$ -
	600	50	Beach	S3 - G			-	m3	$ 95.00	$ 133.00	$ -	$ -		-	m3	$ 114.00	$ 152.00	$ -	$ -
	650	50	Beach	S3 - G			-	m3	$ 95.00	$ 133.00	$ -	$ -		-	m3	$ 114.00	$ 152.00	$ -	$ -
	700	50	Beach	S3 - G			-	m3	$ 95.00	$ 133.00	$ -	$ -		-	m3	$ 114.00	$ 152.00	$ -	$ -
	750	50	Beach	S3 - G			-	m3	$ 95.00	$ 133.00	$ -	$ -		-	m3	$ 114.00	$ 152.00	$ -	$ -
	800	50	Beach	S3 - G			-	m3	$ 95.00	$ 133.00	$ -	$ -		-	m3	$ 114.00	$ 152.00	$ -	$ -
	850	50	Beach	S3 - G			-	m3	$ 95.00	$ 133.00	$ -	$ -		-	m3	$ 114.00	$ 152.00	$ -	$ -
	900	50	Beach	S3 - G			-	m3	$ 95.00	$ 133.00	$ -	$ -		-	m3	$ 114.00	$ 152.00	$ -	$ -
	950	50	Beach	S3 - G			-	m3	$ 95.00	$ 133.00	$ -	$ -		-	m3	$ 114.00	$ 152.00	$ -	$ -
	1000	50	Beach	S3 - G			-	m3	$ 95.00	$ 133.00	$ -	$ -		-	m3	$ 114.00	$ 152.00	$ -	$ -
	1050	50	Beach	S3 - G			-	m3	$ 95.00	$ 133.00	$ -	$ -		-	m3	$ 114.00	$ 152.00	$ -	$ -
	1100	80	Beach	S3 - G			-	m3	$ 95.00	$ 133.00	$ -	$ -		-	m3	$ 114.00	$ 152.00	$ -	$ -
	1180																		
	TOTALS						1,260				$ 119,700.00	$ 167,580.00		1,320				$ 150,480.00	$ 200,640.00

BOQ Westpoint - Alternative B (Beach Replenishment + Groyn

General						Item:	Armour 300-1000kg						Item:	Geotextile					
Location	Chainage	Length	Item	Drawing #	Comments	Qty/m	Qty_Armour 300-1000kg	Unit	Unit rate - Low	Unit rate - high	Cost_Armour 300-1000kg low	Cost_Armour 300-1000kg high	Qty/m	Qty_Geotextile	Unit	Unit rate - Low	Unit rate - high	Cost_Geotextile low	Cost_Geotextile high
	0	50	Groyne revet	S3 - A		12.5	625	m3	$ 108.00	$ 144.00	$ 67,500.00	$ 90,000.00	15	750	m2	$ 10.00	$ 15.00	$ 7,500.00	$ 11,250.00
	50	50	Groyne revet	S3 - A		12.5	625	m3	$ 108.00	$ 144.00	$ 67,500.00	$ 90,000.00	15	750	m2	$ 10.00	$ 15.00	$ 7,500.00	$ 11,250.00
	100	50	Groyne revet	S3 - A		12.5	625	m3	$ 108.00	$ 144.00	$ 67,500.00	$ 90,000.00	15	750	m2	$ 10.00	$ 15.00	$ 7,500.00	$ 11,250.00
	150	50	Groyne revet	S3 - A		12.5	625	m3	$ 108.00	$ 144.00	$ 67,500.00	$ 90,000.00	15	750	m2	$ 10.00	$ 15.00	$ 7,500.00	$ 11,250.00
	200	50	**GROYNE (see separate BOQ)**		See separate sheet		-	m3	$ 108.00	$ 144.00	$ -	$ -		-	m2	$ 10.00	$ 15.00	$ -	$ -
	250	50	Beach	S3 - G			-	m3	$ 108.00	$ 144.00	$ -	$ -		-	m2	$ 10.00	$ 15.00	$ -	$ -
	300	50	Beach	S3 - G			-	m3	$ 108.00	$ 144.00	$ -	$ -		-	m2	$ 10.00	$ 15.00	$ -	$ -
	350	50	Beach	S3 - G			-	m3	$ 108.00	$ 144.00	$ -	$ -		-	m2	$ 10.00	$ 15.00	$ -	$ -
	400	50	Beach	S3 - G			-	m3	$ 108.00	$ 144.00	$ -	$ -		-	m2	$ 10.00	$ 15.00	$ -	$ -
	450	50	Beach	S3 - G			-	m3	$ 108.00	$ 144.00	$ -	$ -		-	m2	$ 10.00	$ 15.00	$ -	$ -
	500	50	Beach	S3 - G			-	m3	$ 108.00	$ 144.00	$ -	$ -		-	m2	$ 10.00	$ 15.00	$ -	$ -
	550	50	Beach	S3 - G			-	m3	$ 108.00	$ 144.00	$ -	$ -		-	m2	$ 10.00	$ 15.00	$ -	$ -
	600	50	Beach	S3 - G			-	m3	$ 108.00	$ 144.00	$ -	$ -		-	m2	$ 10.00	$ 15.00	$ -	$ -
	650	50	Beach	S3 - G			-	m3	$ 108.00	$ 144.00	$ -	$ -		-	m2	$ 10.00	$ 15.00	$ -	$ -
	700	50	Beach	S3 - G			-	m3	$ 108.00	$ 144.00	$ -	$ -		-	m2	$ 10.00	$ 15.00	$ -	$ -
	750	50	Beach	S3 - G			-	m3	$ 108.00	$ 144.00	$ -	$ -		-	m2	$ 10.00	$ 15.00	$ -	$ -
	800	50	Beach	S3 - G			-	m3	$ 108.00	$ 144.00	$ -	$ -		-	m2	$ 10.00	$ 15.00	$ -	$ -
	850	50	Beach	S3 - G			-	m3	$ 108.00	$ 144.00	$ -	$ -		-	m2	$ 10.00	$ 15.00	$ -	$ -
	900	50	Beach	S3 - G			-	m3	$ 108.00	$ 144.00	$ -	$ -		-	m2	$ 10.00	$ 15.00	$ -	$ -
	950	50	Beach	S3 - G			-	m3	$ 108.00	$ 144.00	$ -	$ -		-	m2	$ 10.00	$ 15.00	$ -	$ -
	1000	50	Beach	S3 - G			-	m3	$ 108.00	$ 144.00	$ -	$ -		-	m2	$ 10.00	$ 15.00	$ -	$ -
	1050	50	Beach	S3 - G			-	m3	$ 108.00	$ 144.00	$ -	$ -		-	m2	$ 10.00	$ 15.00	$ -	$ -
	1100	80	Beach	S3 - G			-	m3	$ 108.00	$ 144.00	$ -	$ -		-	m2	$ 10.00	$ 15.00	$ -	$ -
	1180																		
	TOTALS						2,500				$ 270,000.00	$ 360,000.00		3,000				$ 30,000.00	$ 45,000.00

BOQ Westpoint - Alternative B (Beach Replenishment + Groyne

General						Item:	Sand (nourished)						Item:	Excavation					
Location	Chainage	Length	Item	Drawing #	Comments	Qty/m	Qty_Sand (nourished)	Unit	Unit rate - Low	Unit rate - high	Cost_Sand (nourished) low	Cost_Sand (nourished) high	Qty/m	Qty_Excavation	Unit	Unit rate - Low	Unit rate - high	Cost_Excavation low	Cost_Excavation high
	0	50	Groyne revet	S3 - A			-	m3	$ 4.00	$ 8.00	$ -	$ -	51.5	2,575	m3	$ 8.00	$ 12.00	$ 20,600.00	$ 30,900.00
	50	50	Groyne revet	S3 - A			-	m3	$ 4.00	$ 8.00	$ -	$ -	51.5	2,575	m3	$ 8.00	$ 12.00	$ 20,600.00	$ 30,900.00
	100	50	Groyne revet	S3 - A			-	m3	$ 4.00	$ 8.00	$ -	$ -	51.5	2,575	m3	$ 8.00	$ 12.00	$ 20,600.00	$ 30,900.00
	150	50	Groyne revet	S3 - A			-	m3	$ 4.00	$ 8.00	$ -	$ -	51.5	2,575	m3	$ 8.00	$ 12.00	$ 20,600.00	$ 30,900.00
	200	50	**GROYNE (see separate BOQ)**		See separate sheet	500	25,000	m3	$ 4.00	$ 8.00	$ 100,000.00	$ 200,000.00		-	m3	$ 8.00	$ 12.00	$ -	$ -
	250	50	Beach	S3 - G		500	25,000	m3	$ 4.00	$ 8.00	$ 100,000.00	$ 200,000.00		-	m3	$ 8.00	$ 12.00	$ -	$ -
	300	50	Beach	S3 - G		500	25,000	m3	$ 4.00	$ 8.00	$ 100,000.00	$ 200,000.00		-	m3	$ 8.00	$ 12.00	$ -	$ -
	350	50	Beach	S3 - G		500	25,000	m3	$ 4.00	$ 8.00	$ 100,000.00	$ 200,000.00		-	m3	$ 8.00	$ 12.00	$ -	$ -
	400	50	Beach	S3 - G		500	25,000	m3	$ 4.00	$ 8.00	$ 100,000.00	$ 200,000.00		-	m3	$ 8.00	$ 12.00	$ -	$ -
	450	50	Beach	S3 - G		500	25,000	m3	$ 4.00	$ 8.00	$ 100,000.00	$ 200,000.00		-	m3	$ 8.00	$ 12.00	$ -	$ -
	500	50	Beach	S3 - G		500	25,000	m3	$ 4.00	$ 8.00	$ 100,000.00	$ 200,000.00		-	m3	$ 8.00	$ 12.00	$ -	$ -
	550	50	Beach	S3 - G		500	25,000	m3	$ 4.00	$ 8.00	$ 100,000.00	$ 200,000.00		-	m3	$ 8.00	$ 12.00	$ -	$ -
	600	50	Beach	S3 - G		500	25,000	m3	$ 4.00	$ 8.00	$ 100,000.00	$ 200,000.00		-	m3	$ 8.00	$ 12.00	$ -	$ -
	650	50	Beach	S3 - G		500	25,000	m3	$ 4.00	$ 8.00	$ 100,000.00	$ 200,000.00		-	m3	$ 8.00	$ 12.00	$ -	$ -
	700	50	Beach	S3 - G		500	25,000	m3	$ 4.00	$ 8.00	$ 100,000.00	$ 200,000.00		-	m3	$ 8.00	$ 12.00	$ -	$ -
	750	50	Beach	S3 - G		500	25,000	m3	$ 4.00	$ 8.00	$ 100,000.00	$ 200,000.00		-	m3	$ 8.00	$ 12.00	$ -	$ -
	800	50	Beach	S3 - G		500	25,000	m3	$ 4.00	$ 8.00	$ 100,000.00	$ 200,000.00		-	m3	$ 8.00	$ 12.00	$ -	$ -
	850	50	Beach	S3 - G		500	25,000	m3	$ 4.00	$ 8.00	$ 100,000.00	$ 200,000.00		-	m3	$ 8.00	$ 12.00	$ -	$ -
	900	50	Beach	S3 - G		500	25,000	m3	$ 4.00	$ 8.00	$ 100,000.00	$ 200,000.00		-	m3	$ 8.00	$ 12.00	$ -	$ -
	950	50	Beach	S3 - G		500	25,000	m3	$ 4.00	$ 8.00	$ 100,000.00	$ 200,000.00		-	m3	$ 8.00	$ 12.00	$ -	$ -
	1000	50	Beach	S3 - G		500	25,000	m3	$ 4.00	$ 8.00	$ 100,000.00	$ 200,000.00		-	m3	$ 8.00	$ 12.00	$ -	$ -
	1050	50	Beach	S3 - G		500	25,000	m3	$ 4.00	$ 8.00	$ 100,000.00	$ 200,000.00		-	m3	$ 8.00	$ 12.00	$ -	$ -
	1100	80	Beach	S3 - G		500	40,000	m3	$ 4.00	$ 8.00	$ 160,000.00	$ 320,000.00		-	m3	$ 8.00	$ 12.00	$ -	$ -
	1180																		
	TOTALS						490,000				$ 1,960,000.00	$ 3,920,000.00		10,300				$ 82,400.00	$ 123,600.00

BOQ Westpoint - Alternative B (Beach Replenishment + Groyne

General						Item:	Backfill					
Location	Chainage	Length	Item	Drawing #	Comments	Qty/m	Qty_Backfill	Unit	Unit rate - Low	Unit rate - high	Cost_Backfill low	Cost_Backfill high
	0	50	Groyne revet	S3 - A		27.5	1,375	m3	$ 4.00	$ 6.00	$ 5,500.00	$ 8,250.00
	50	50	Groyne revet	S3 - A		27.5	1,375	m3	$ 4.00	$ 6.00	$ 5,500.00	$ 8,250.00
	100	50	Groyne revet	S3 - A		27.5	1,375	m3	$ 4.00	$ 6.00	$ 5,500.00	$ 8,250.00
	150	50	Groyne revet	S3 - A		27.5	1,375	m3	$ 4.00	$ 6.00	$ 5,500.00	$ 8,250.00
	200	50	**GROYNE (see separate BOQ)**		See separate sheet		-	m3	$ 4.00	$ 6.00	$ -	$ -
	250	50	Beach	S3 - G			-	m3	$ 4.00	$ 6.00	$ -	$ -
	300	50	Beach	S3 - G			-	m3	$ 4.00	$ 6.00	$ -	$ -
	350	50	Beach	S3 - G			-	m3	$ 4.00	$ 6.00	$ -	$ -
	400	50	Beach	S3 - G			-	m3	$ 4.00	$ 6.00	$ -	$ -
	450	50	Beach	S3 - G			-	m3	$ 4.00	$ 6.00	$ -	$ -
	500	50	Beach	S3 - G			-	m3	$ 4.00	$ 6.00	$ -	$ -
	550	50	Beach	S3 - G			-	m3	$ 4.00	$ 6.00	$ -	$ -
	600	50	Beach	S3 - G			-	m3	$ 4.00	$ 6.00	$ -	$ -
	650	50	Beach	S3 - G			-	m3	$ 4.00	$ 6.00	$ -	$ -
	700	50	Beach	S3 - G			-	m3	$ 4.00	$ 6.00	$ -	$ -
	750	50	Beach	S3 - G			-	m3	$ 4.00	$ 6.00	$ -	$ -
	800	50	Beach	S3 - G			-	m3	$ 4.00	$ 6.00	$ -	$ -
	850	50	Beach	S3 - G			-	m3	$ 4.00	$ 6.00	$ -	$ -
	900	50	Beach	S3 - G			-	m3	$ 4.00	$ 6.00	$ -	$ -
	950	50	Beach	S3 - G			-	m3	$ 4.00	$ 6.00	$ -	$ -
	1000	50	Beach	S3 - G			-	m3	$ 4.00	$ 6.00	$ -	$ -
	1050	50	Beach	S3 - G			-	m3	$ 4.00	$ 6.00	$ -	$ -
	1100	80	Beach	S3 - G			-	m3	$ 4.00	$ 6.00	$ -	$ -
	1180											
	TOTALS						5,500				$ 22,000.00	$ 33,000.00

BOQ Groyne - Westpoint

General						Item:	Quarry run						Item:	Armour 1-3 t					
Location	Chainage	Length	Item	Drawing #	Comments	Qty/m	Qty_Quarry run	Unit	Unit rate - Low	Unit rate - high	Cost_Quarry run low	Cost_Quarry run high	Qty/m	Qty_Armour 1-3 t	Unit	Unit rate - Low	Unit rate - high	Cost_Armour 1-3 t low	Cost_Armour 1-3 t high
	-17.43	17.43	Head	53 - F		127.5	2,222	m3	$ 95.00	$ 133.00	$ 211,120.88	$ 295,569.23	60.4	1,053	m3	$ 108.00	$ 144.00	$ 113,699.38	$ 151,599.17
	0	25	Head trunk	53 - F		127.5	3,188	m3	$ 95.00	$ 133.00	$ 302,812.50	$ 423,937.50	60.4	1,510	m3	$ 108.00	$ 144.00	$ 163,080.00	$ 217,440.00
	25	53.2	Trunk -5	-		124.3	6,613	m3	$ 95.00	$ 133.00	$ 628,212.20	$ 879,497.08		-	m3	$ 108.00	$ 144.00	$ -	$ -
	78.2	102.7	Trunk -4	53 - E		99.6	10,229	m3	$ 95.00	$ 133.00	$ 971,747.40	$ 1,360,446.36		-	m3	$ 108.00	$ 144.00	$ -	$ -
	180.9	73.3	Trunk -3	53 - D		77.8	5,703	m3	$ 95.00	$ 133.00	$ 541,760.80	$ 758,464.62		-	m3	$ 108.00	$ 144.00	$ -	$ -
	254.2	40	Trunk -2	53 - C		60.3	2,412	m3	$ 95.00	$ 133.00	$ 229,140.00	$ 320,796.00		-	m3	$ 108.00	$ 144.00	$ -	$ -
	294.2	23.1	Trunk -1	53 - B		57.3	1,324	m3	$ 95.00	$ 133.00	$ 125,744.85	$ 176,042.79		-	m3	$ 108.00	$ 144.00	$ -	$ -
	317.3	25.1	Trunk 0	53 - B		57.3	1,440	m3	$ 95.00	$ 133.00	$ 136,831.85	$ 191,284.59		-	m3	$ 108.00	$ 144.00	$ -	$ -
	342.4						-	m3	$ 95.00		$ -			-	m3	$ 108.00		$ -	
	TOTALS						33,128				$ 3,147,369.98	$ 4,406,037.97		2,563				$ 276,779.38	$ 369,039.17

Page 1 of 2

BOQ Groyne - Westpoint

General						Item:	Armour 300-1000kg						Item:	Excavation					
Location	Chainage	Length	Item	Drawing #	Comments	Qty/m	Armour 300-100	Unit	Unit rate - Low	Unit rate - high	Cost_Armour 300-1000kg low	Cost_Armour 300-1000kg high	Qty/m	Qty_Excavation	Unit	Unit rate - Low	Unit rate - high	Cost_Excavation low	Cost_Excavation high
	-17.43	17.43	Head	53 - F			-	m3	$ 108.00	$ 144.00	$ -	$ -		-	m3	$ 8.00	$ 12.00	$ -	$ -
	0	25	Head trunk	53 - F			-	m3	$ 108.00	$ 144.00	$ -	$ -		-	m3	$ 8.00	$ 12.00	$ -	$ -
	25	53.2	Trunk -5	-		41.2	2,192	m3	$ 108.00	$ 144.00	$ 236,718.72	$ 315,624.96		-	m3	$ 8.00	$ 12.00	$ -	$ -
	78.2	102.7	Trunk -4	53 - E		36.7	3,769	m3	$ 108.00	$ 144.00	$ 407,061.72	$ 542,748.96		-	m3	$ 8.00	$ 12.00	$ -	$ -
	180.9	73.3	Trunk -3	53 - D		32.2	2,360	m3	$ 108.00	$ 144.00	$ 254,908.08	$ 339,877.44		-	m3	$ 8.00	$ 12.00	$ -	$ -
	254.2	40	Trunk -2	53 - C		29.2	1,168	m3	$ 108.00	$ 144.00	$ 126,144.00	$ 168,192.00		-	m3	$ 8.00	$ 12.00	$ -	$ -
	294.2	23.1	Trunk -1	53 - B		29.2	675	m3	$ 108.00	$ 144.00	$ 72,848.16	$ 97,130.88	29.6	684	m3	$ 8.00	$ 12.00	$ 5,470.08	$ 8,205.12
	317.3	25.1	Trunk 0	53 - B		29.2	733	m3	$ 108.00	$ 144.00	$ 79,155.96	$ 105,540.48	62.1	1,559	m3	$ 8.00	$ 12.00	$ 12,469.68	$ 18,704.52
	342.4						-	m3	$ 108.00		$ -			-	m3	$ 8.00		$ -	
	TOTALS						10,897				$ 1,176,836.64	$ 1,569,114.72		2,242				$ 17,939.76	$ 26,909.64

Page 2 of 2

BOQ American Embassy

General						Item:	Sand (nourished)					
Location	Chainage	Length	Item	Drawing #	Comments	Qty/m	y_Sand (nourishe	Unit	Unit rate - Low	Unit rate - high	Cost_Sand (nourished) low	Cost_Sand (nourished) high
	0	50					-	m3	$ 4.00	$ 8.00	$ -	$ -
	50	50					-	m3	$ 4.00	$ 8.00	$ -	$ -
	100	50					-	m3	$ 4.00	$ 8.00	$ -	$ -
	150	50					-	m3	$ 4.00	$ 8.00	$ -	$ -
	200	50					-	m3	$ 4.00	$ 8.00	$ -	$ -
	250	50	GROYNE separate BOQ		sepeate sheet	320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	300	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	350	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	400	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	450	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	500	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	550	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	600	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	650	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	700	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	750	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	800	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	850	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	900	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	950	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	1000	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	1050	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	1100	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	1150	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	1200	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	1250	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	1300	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	1350	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	1400	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	1450	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	1500	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	1550	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	1600	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	1650	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	1700	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	1750	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	1800	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	1850	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	1900	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	1950	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	2000	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	2050	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	2100	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	2150	50	Beach			320	16,000	m3	$ 4.00	$ 8.00	$ 64,000.00	$ 128,000.00
	2200	50							$ 4.00	$ 8.00	$ -	$ -
	2250	50							$ 4.00	$ 8.00	$ -	$ -
	2300	50							$ 4.00	$ 8.00	$ -	$ -
	2350	50							$ 4.00	$ 8.00	$ -	$ -
	2400											
	TOTALS						*624,000*				*$ 2,496,000.00*	*$ 4,992,000.00*

Page 1 of 1

BOQ Groyne - American Embassy - Concrete Head altnerative

General						Item:	Quarry run						Item:	Armour 300-1000kg					
Location	Chainage	Length	Item	Drawing #	Comments	Qty/m	Qty_Quarry run	Unit	Unit rate - Low	Unit rate - high	Cost_Quarry run low	Cost_Quarry run high	Qty/m	r_Armour 300-100C	Unit	Unit rate - Low	Unit rate - high	Cost_Armour 300-1000kg low	Cost_Armour 300-1000kg high
	-19.81	19.81	Head	S4 - F1		160	3,170	m3	$ 95.00	$ 133.00	$ 301,112.00	$ 421,556.80	41.2	816	m3	$ 108.00	$ 144.00	$ 88,146.58	$ 117,528.77
	0	25	Head trunk	S4 - F1		160	4,000	m3	$ 95.00	$ 133.00	$ 380,000.00	$ 532,000.00	41.2	1,030	m3	$ 108.00	$ 144.00	$ 111,240.00	$ 148,320.00
	25	11.15	Trunk -6	-		194.5	2,169	m3	$ 95.00	$ 133.00	$ 206,024.13	$ 288,433.78		-	m3	$ 108.00	$ 144.00	$ -	$ -
	36.15	29	Trunk -5	S4 - E		158.5	4,597	m3	$ 95.00	$ 133.00	$ 436,667.50	$ 611,334.50		-	m3	$ 108.00	$ 144.00	$ -	$ -
	65.15	27.6	Trunk -4	S4 - D		126.5	3,491	m3	$ 95.00	$ 133.00	$ 331,683.00	$ 464,356.20		-	m3	$ 108.00	$ 144.00	$ -	$ -
	92.75	19.5	Trunk -3	S4 - C		98.5	1,921	m3	$ 95.00	$ 133.00	$ 182,471.25	$ 255,459.75		-	m3	$ 108.00	$ 144.00	$ -	$ -
	112.25	19.5	Trunk -2	S4 - B		74.5	1,453	m3	$ 95.00	$ 133.00	$ 138,011.25	$ 193,215.75		-	m3	$ 108.00	$ 144.00	$ -	$ -
	131.75	20.4	Trunk -1	S4 - A		73.5	1,499	m3	$ 95.00	$ 133.00	$ 142,443.00	$ 199,420.20		-	m3	$ 108.00	$ 144.00	$ -	$ -
	152.15	44.55	Trunk 0	S4 - A		73.5	3,274	m3	$ 95.00	$ 133.00	$ 311,070.38	$ 435,498.53		-	m3	$ 108.00	$ 144.00	$ -	$ -
	196.7													-	m3				
	TOTALS						*25,574*				*$ 2,429,482.50*	*$ 3,401,275.50*		*1,846*				*$ 199,386.58*	*$ 265,848.77*

Page 1 of 1

BOQ Groyne - American Embassy - Concrete Head al

General						Item:	St units						Item:	Armour 2-5 t					
Location	Chainage	Length	Item	Drawing #	Comments	Qty/m	Qty_St units	Unit	Unit rate - Low	Unit rate - high	Cost_St units low	Cost_St units high	Qty/m	Qty_Armour 2-5 t	Unit	Unit rate - Low	Unit rate - high	Cost_Armour 2-5 t low	Cost_Armour 2-5 t high
	-19.81	19.81	Head	S4 - F1			245	units	$ 1,200.00	$ 1,600.00	$ 294,000.00	$ 392,000.00	12.5	248	m3	$ 108.00	$ 144.00	$ 26,743.50	$ 35,658.00
	0	25	Head trunk	S4 - F1			212	units	$ 1,200.00	$ 1,600.00	$ 254,400.00	$ 339,200.00	12.5	313	m3	$ 108.00	$ 144.00	$ 33,750.00	$ 45,000.00
	25	11.15	Trunk -6	-			-	units	$ 1,200.00	$ 1,600.00	$ -	$ -	94.5	1,054	m3	$ 108.00	$ 144.00	$ 113,796.90	$ 151,729.20
	36.15	29	Trunk -5	S4 - E			-	units	$ 1,200.00	$ 1,600.00	$ -	$ -	85.6	2,482	m3	$ 108.00	$ 144.00	$ 268,099.20	$ 357,465.60
	65.15	27.6	Trunk -4	S4 - D			-	units	$ 1,200.00	$ 1,600.00	$ -	$ -	76.6	2,114	m3	$ 108.00	$ 144.00	$ 228,329.28	$ 304,439.04
	92.75	19.5	Trunk -3	S4 - C			-	units	$ 1,200.00	$ 1,600.00	$ -	$ -	67.7	1,320	m3	$ 108.00	$ 144.00	$ 142,576.20	$ 190,101.60
	112.25	19.5	Trunk -2	S4 - B			-	units	$ 1,200.00	$ 1,600.00	$ -	$ -	58.7	1,145	m3	$ 108.00	$ 144.00	$ 123,622.20	$ 164,829.60
	131.75	20.4	Trunk -1	S4 - A			-	units	$ 1,200.00	$ 1,600.00	$ -	$ -	58.8	1,200	m3	$ 108.00	$ 144.00	$ 129,548.16	$ 172,730.88
	152.15	44.55	Trunk 0	S4 - A			-	units	$ 1,200.00	$ 1,600.00	$ -	$ -	58.8	2,620	m3	$ 108.00	$ 144.00	$ 282,910.32	$ 377,213.76
	196.7						-	units						-	m3				
	TOTALS						457				$ 548,400.00	$ 731,200.00		12,494				$ 1,349,375.76	$ 1,799,167.68

BOQ Groyne - American Embassy - Concrete Head al

General						Item:	Excavation					
Location	Chainage	Length	Item	Drawing #	Comments	Qty/m	Qty_Excavation	Unit	Unit rate - Low	Unit rate - high	Cost_Excavation low	Cost_Excavation high
	-19.81	19.81	Head	S4 - F1			-	m3	$ 8.00	$ 12.00	$ -	$ -
	0	25	Head trunk	S4 - F1			-	m3	$ 8.00	$ 12.00	$ -	$ -
	25	11.15	Trunk -6	-			-	m3	$ 8.00	$ 12.00	$ -	$ -
	36.15	29	Trunk -5	S4 - E			-	m3	$ 8.00	$ 12.00	$ -	$ -
	65.15	27.6	Trunk -4	S4 - D			-	m3	$ 8.00	$ 12.00	$ -	$ -
	92.75	19.5	Trunk -3	S4 - C			-	m3	$ 8.00	$ 12.00	$ -	$ -
	112.25	19.5	Trunk -2	S4 - B			-	m3	$ 8.00	$ 12.00	$ -	$ -
	131.75	20.4	Trunk -1	S4 - A		37.5	765	m3	$ 8.00	$ 12.00	$ 6,120.00	$ 9,180.00
	152.15	44.55	Trunk 0	S4 - A		78.0	3,475	m3	$ 8.00	$ 12.00	$ 27,799.20	$ 41,698.80
	196.7						-	m3				
	TOTALS						4,240				$ 33,919.20	$ 50,878.80

BOQ Groyne - American Embassy - Rock head alternative

General						Item:	Quarry run					
Location	Chainage	Length	Item	Drawing #	Comments	Qty/m	Qty_Quarry run	Unit	Unit rate - Low	Unit rate - high	Cost_Quarry run low	Cost_Quarry run high
	-19.81	19.81	Head	S4 - F2		200.2	5,157	m3	$ 95.00	$ 133.00	$ 489,871.50	$ 685,820.22
	0	25	Head trunk	S4 - F2		260.2	6,508	m3	$ 95.00	$ 133.00	$ 618,212.50	$ 865,497.50
	25	11.15	Trunk -6	–		194.5	2,169	m3	$ 95.00	$ 133.00	$ 206,024.13	$ 288,433.78
	36.15	29	Trunk -5	S4 - E		158.5	4,597	m3	$ 95.00	$ 133.00	$ 436,667.50	$ 611,334.50
	65.15	27.6	Trunk -4	S4 - D		126.5	3,491	m3	$ 95.00	$ 133.00	$ 331,683.00	$ 464,356.20
	92.75	19.5	Trunk -3	S4 - C		98.5	1,921	m3	$ 95.00	$ 133.00	$ 182,471.25	$ 255,459.75
	112.25	19.5	Trunk -2	S4 - B		74.5	1,453	m3	$ 95.00	$ 133.00	$ 138,011.25	$ 193,215.75
	131.75	20.4	Trunk -1	S4 - A		73.5	1,499	m3	$ 95.00	$ 133.00	$ 142,443.00	$ 199,420.20
	152.15	44.55	Trunk 0	S4 - A		73.5	3,274	m3	$ 95.00	$ 133.00	$ 311,070.38	$ 435,498.53
	196.7											
	TOTALS						30,068				$ 2,836,454.59	$ 3,995,036.42

Item	Item:	Armour 300-1000kg					
Item	Qty/m	_Armour 300-1000	Unit	Unit rate - Low	Unit rate - high	Cost_Armour 300-1000kg low	Cost_Armour 300-1000kg high
Head	90.0	1,783	m3	$ 108.00	$ 144.00	$ 192,553.20	$ 256,737.60
Head trunk	90.0	2,250	m3	$ 108.00	$ 144.00	$ 243,000.00	$ 324,000.00
Trunk -6		-	m3	$ 108.00	$ 144.00	$ -	$ -
Trunk -5		-	m3	$ 108.00	$ 144.00	$ -	$ -
Trunk -4		-	m3	$ 108.00	$ 144.00	$ -	$ -
Trunk -3		-	m3	$ 108.00	$ 144.00	$ -	$ -
Trunk -2		-	m3	$ 108.00	$ 144.00	$ -	$ -
Trunk -1		-	m3	$ 108.00	$ 144.00	$ -	$ -
Trunk 0		-	m3	$ 108.00	$ 144.00	$ -	$ -
		-	m3				
TOTALS		4,033				$ 435,553.20	$ 580,737.60

BOQ Groyne - American Embassy - Rock head altern

General						Item:	Armour 1-3 t					
Location	Chainage	Length	Item	Drawing #	Comments	Qty/m	Qty_Armour 1-3 t	Unit	Unit rate - Low	Unit rate - high	Cost_Armour 1-3 t low	Cost_Armour 1-3 t high
	-19.81	19.81	Head	S4 - F2			-	m3	$ 108.00	$ 144.00	$ -	$ -
	0	25	Head trunk	S4 - F2			-	m3	$ 108.00	$ 144.00	$ -	$ -
	25	11.15	Trunk -6	–			-	m3	$ 108.00	$ 144.00	$ -	$ -
	36.15	29	Trunk -5	S4 - E			-	m3	$ 108.00	$ 144.00	$ -	$ -
	65.15	27.6	Trunk -4	S4 - D			-	m3	$ 108.00	$ 144.00	$ -	$ -
	92.75	19.5	Trunk -3	S4 - C			-	m3	$ 108.00	$ 144.00	$ -	$ -
	112.25	19.5	Trunk -2	S4 - B			-	m3	$ 108.00	$ 144.00	$ -	$ -
	131.75	20.4	Trunk -1	S4 - A			-	m3	$ 108.00	$ 144.00	$ -	$ -
	152.15	44.55	Trunk 0	S4 - A			-	m3	$ 108.00	$ 144.00	$ -	$ -
	196.7						-	m3				
	TOTALS					0	-				$ -	$ -

Item	Item:	Armour 5-10 t					
Item	Qty/m	Qty_Armour 5-10	Unit	Unit rate - Low	Unit rate - high	Cost_Armour 5-10 t low	Cost_Armour 5-10 t high
Head	167.5	3,318	m3	$ 108.00	$ 144.00	$ 358,362.90	$ 477,817.20
Head trunk	167.5	4,188	m3	$ 108.00	$ 144.00	$ 452,250.00	$ 603,000.00
Trunk -6		-	m3	$ 108.00	$ 144.00	$ -	$ -
Trunk -5		-	m3	$ 108.00	$ 144.00	$ -	$ -
Trunk -4		-	m3	$ 108.00	$ 144.00	$ -	$ -
Trunk -3		-	m3	$ 108.00	$ 144.00	$ -	$ -
Trunk -2		-	m3	$ 108.00	$ 144.00	$ -	$ -
Trunk -1		-	m3	$ 108.00	$ 144.00	$ -	$ -
Trunk 0		-	m3	$ 108.00	$ 144.00	$ -	$ -
		-	m3				
TOTALS	335	7,506				$ 810,612.90	$ 1,080,817.20

BOQ Groyne - American Embassy - Rock head altern

General						Item:	Armour 2-5 t						Item:	Excavation					
Location	Chainage	Length	Item	Drawing #	Comments	Qty/m	Qty_Armour 2-5 t	Unit	Unit rate - Low	Unit rate - high	Cost_Armour 2-5 t low	Cost_Armour 2-5 t high	Qty/m	Qty_Excavation	Unit	Unit rate - Low	Unit rate - high	Cost_Excavation low	Cost_Excavation high
	-19.81	19.81	Head	S4 - F2			-	m3	$ 108.00	$ 144.00	$ -	$ -		-	m3	$ 8.00	$ 12.00	$ -	$ -
	0	25	Head trunk	S4 - F2			-	m3	$ 108.00	$ 144.00	$ -	$ -		-	m3	$ 8.00	$ 12.00	$ -	$ -
	25	11.15	Trunk -6	-		94.5	1,054	m3	$ 108.00	$ 144.00	$ 113,796.90	$ 151,729.20		-	m3	$ 8.00	$ 12.00	$ -	$ -
	36.15	29	Trunk -5	S4 - E		85.6	2,482	m3	$ 108.00	$ 144.00	$ 268,099.20	$ 357,465.60		-	m3	$ 8.00	$ 12.00	$ -	$ -
	65.15	27.6	Trunk -4	S4 - D		76.6	2,114	m3	$ 108.00	$ 144.00	$ 228,329.28	$ 304,439.04		-	m3	$ 8.00	$ 12.00	$ -	$ -
	92.75	19.5	Trunk -3	S4 - C		67.7	1,320	m3	$ 108.00	$ 144.00	$ 142,576.20	$ 190,101.60		-	m3	$ 8.00	$ 12.00	$ -	$ -
	112.25	19.5	Trunk -2	S4 - B		58.7	1,145	m3	$ 108.00	$ 144.00	$ 123,622.20	$ 164,829.60		-	m3	$ 8.00	$ 12.00	$ -	$ -
	131.75	20.4	Trunk -1	S4 - A		58.8	1,200	m3	$ 108.00	$ 144.00	$ 129,548.16	$ 172,730.88	37.5	765	m3	$ 8.00	$ 12.00	$ 6,120.00	$ 9,180.00
	152.15	44.55	Trunk 0	S4 - A		58.8	2,620	m3	$ 108.00	$ 144.00	$ 282,910.32	$ 377,213.76	78.0	3,475	m3	$ 8.00	$ 12.00	$ 27,799.20	$ 41,698.80
	196.7						-	m3						-	m3				
	TOTALS						11,934				$ 1,288,882.26	$ 1,718,509.68		4,240				$ 33,919.20	$ 50,878.80

New Kru Town - Quantities (m3 or m2)

Row Labels	Sum of Qty_Quarry run	Sum of Qty_Underlayer 60-300 kg	Sum of Qty_Geotextile	Sum of Qty_Armour 300-1000kg	Sum of Qty_Excavation	Sum of Qty_Backfill	Sum of Qty_Armour 2-5 t	Sum of Qty_Promenade pavement	Sum of Qty_Landscaping	Sum of Qty_Drainage (seeded)	Sum of Qty_Sand (nourished)
Revetment light	8,164	4,298	14,050	6,121	25,808	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Revetment NKT	23,963	21,056	33,300	-	74,826	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Landing site NKT	13,831	1,424	4,270	884	13,864	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Grand Total	[illegible]	26,778	51,620	[illegible]	114,798	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Row Labels	Sum of Cost_Quarry run low	Sum of Cost_Underlayer 60-300 kg low	Sum of Cost_Geotextile low	Sum of Cost_Armour 300-1000kg low	Sum of Cost_Excavation low	Sum of Cost_Backfill low	Sum of Cost_Armour 2-5 t low	Sum of Cost_Promenade pavement low	Sum of Cost_Landscaping low	Sum of Cost_Drainage (seeded) low	Sum of Cost_Sand (nourished) low	SUM
Revetment light	$ 775,580.00	$ 489,000.00	$ 140,190.00	$ 877,500.00	$ 206,000.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Revetment NKT	[illegible]	[illegible]	[illegible]	$ -	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Landing site NKT	[illegible]	$ 161,336.00	$ 42,700.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Grand Total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Row Labels	Sum of Cost_Quarry run high	Sum of Cost_Underlayer 60-300 kg High	Sum of Cost_Geotextile High	Sum of Cost_Armour 300-1000kg high	Sum of Cost_Excavation high	Sum of Cost_Backfill high	Sum of Cost_Armour 2-5 t High	Sum of Cost_Promenade pavement high	Sum of Cost_Landscaping high	Sum of Cost_Drainage (seeded) high	Sum of Cost_Sand (nourished) high	SUM
Revetment light	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Revetment NKT	[illegible]	[illegible]	[illegible]	$ -	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Landing site NKT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Grand Total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Westpoint Revetment Option - Quantities (m3 or m2)

Row Labels	Sum of Qty_Quarry run	Sum of Qty_Underlayer 60-300kg	Sum of Qty_Armour 300-1000kg	Sum of Qty_Geotextile	Sum of Qty_Excavation	Sum of Qty_Backfill	Sum of Qty_Armour 2-5 t	Sum of Qty_Promenade pavement	Sum of Qty_Landscaping	Sum of Qty_Drainage (seeded)	Sum of Qty_Sand (nourished)
Revetment light	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Revetment	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Landing site WP	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Grand Total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

Separate BOQ - GROYNE WESTPOINT		Quantities (m3 or m2)		
Row Labels	Sum of Qty_Quarry run	Sum of Qty_Armour 1-3 t	Sum of Qty_Armour 300-1000kg	Sum of Qty_Excavation
Head	3,222	1,853	-	-
Head trunk	3,188	1,538	-	-
Trunk 0	1,438	-	735	1,559
Trunk -1	1,324	-	676	484
Trunk -2	2,413	-	1,159	-
Trunk -3	5,701	-	2,360	-
Trunk -4	10,229	-	3,769	-
Trunk -5	6,612	-	2,100	-
Grand Total	[illegible]	3,391	10,807	2,143

Row Labels	Sum of Cost_Quarry run low	Sum of Cost_Armour 1-3 t low	Sum of Cost_Armour 300-1000kg low	Sum of Cost_Excavation low	SUM
Head	$ 211,120.00	$ 113,600.20	$ -	$ -	$ 324,800.21
Head trunk	$ 301,852.50	$ 163,080.00	$ -	$ -	$ 465,892.50
Trunk 0	$ 136,631.85	$ -	$ 75,153.30	$ 12,485.68	$ 224,250.85
Trunk -1	$ 125,788.85	$ -	$ 72,448.16	$ 5,670.08	$ 204,061.09
Trunk -2	$ 229,140.00	$ -	$ 125,144.05	$ -	$ 354,284.05
Trunk -3	$ 541,760.30	$ -	$ 264,908.08	$ -	$ 806,668.38
Trunk -4	$ 971,747.40	$ -	$ 407,061.32	$ -	$ 1,378,808.72
Trunk -5	$ 628,252.20	$ -	$ 235,718.72	$ -	$ 864,000.92
Grand Total	$ 3,147,308.96	$ 276,276.18	$ 1,180,[illegible]	$ 17,[illegible]	$ 4,618,735.14

Row Labels	Sum of Cost_Quarry run high	Sum of Cost_Armour 1-3 t high	Sum of Cost_Armour 300-1000kg high	Sum of Cost_Excavation high	SUM
Head	$ 291,580.23	$ 151,800.17	$ -	$ -	$ 447,380.39
Head trunk	$ 423,937.50	$ 217,440.00	$ -	$ -	$ 641,377.50
Trunk 0	$ 191,284.09	$ -	$ 105,140.48	$ 18,704.52	$ 315,129.09
Trunk -1	$ 176,042.78	$ -	$ 97,150.88	$ 8,505.12	$ 281,678.78
Trunk -2	$ 320,796.00	$ -	$ 168,137.00	$ -	$ 488,933.00
Trunk -3	$ 758,464.41	$ -	$ 339,877.44	$ -	$ 1,098,341.86
Trunk -4	$ 1,360,446.36	$ -	$ 542,748.50	$ -	$ 1,903,195.33
Trunk -5	$ 879,497.08	$ -	$ 331,624.06	$ -	$ 1,211,121.44
Grand Total	$ 4,406,037.97	$ 369,098.17	$ 1,585,114.30	$ 26,969.64	$ 6,371,[illegible]

American Embassy - Quantities Concrete units (m3 or m2)

Row Labels	Sum of Qty_Sand (nourished)
GROYNE see sheet	16000
Beach	608000
Grand Total	624000

American Embassy - Costs low estimate

Row Labels	Sum of Cost_Sand (nourished) low
GROYNE see sheet	$ 64,000.00
Beach	$ 2,432,000.00
Grand Total	$ 2,496,000.00

American Embassy - Costs high estimate

Row Labels	Sum of Cost_Sand (nourished) high
GROYNE see sheet	$ 128,000.00
Beach	$ 4,864,000.00
Grand Total	$ 4,992,000.00

Page 2 of 4

Separate BOQ - GROYNE CONCRETE UNITS AMERICAN EMBASSY				Quantities (m3 or m2 or units)		
Row Labels	Sum of Qty_Quarry run	Sum of Qty_Armour 300-1000kg	Sum of Qty_Armour 1-3 t	Sum of Qty_XI units	Sum of Qty_Armour 2-5 t	Sum of Qty_Excavation
Head	3,176	836	-	241	248	-
Head trunk	4,000	1,038	-	212	313	-
Trunk 0	3,274	-	-	-	2,626	3,473
Trunk -1	1,498	-	-	-	1,208	763
Trunk -2	1,453	-	-	-	1,345	-
Trunk -3	1,821	-	-	-	1,226	-
Trunk -4	4,691	-	-	-	2,114	-
Trunk -5	4,537	-	-	-	2,482	-
Trunk -6	2,148	-	-	-	1,094	-
Grand Total	25,374	1,846	-	457	12,494	4,236

Row Labels	Sum of Cost_Quarry run low	Sum of Cost_Armour 300-1000kg low	Sum of Cost_Armour 1-3 t low	Sum of Cost_XI units low	Sum of Cost_Armour 2-5 t low	Sum of Cost_Excavation low	SUM
Head	$ 331,112.00	$ 88,346.56	$ -	$ 194,000.00	$ 26,343.50	$ -	$ 733,097.08
Head trunk	$ 380,000.00	$ 111,240.00	$ -	$ 234,400.00	$ 33,750.00	$ -	$ 775,390.00
Trunk 0	$ 311,030.38	$ -	$ -	$ -	$ 282,810.11	$ 27,289.39	$ 621,779.90
Trunk -1	$ 142,445.00	$ -	$ -	$ -	$ 129,546.16	$ 6,120.00	$ 278,111.16
Trunk -2	$ 138,031.26	$ -	$ -	$ -	$ 121,623.30	$ -	$ 261,655.06
Trunk -3	$ 183,471.35	$ -	$ -	$ -	$ 161,576.30	$ -	$ 345,047.65
Trunk -4	$ 331,680.00	$ -	$ -	$ -	$ 228,320.28	$ -	$ 560,011.28
Trunk -5	$ 436,882.50	$ -	$ -	$ -	$ 268,099.20	$ -	$ 705,766.70
Trunk -6	$ 206,024.13	$ -	$ -	$ -	$ 113,796.90	$ -	$ 319,821.03
Grand Total	$ 2,470,683.50	$ 199,586.56	$ -	$ 448,000.00	$ 1,369,[illegible]	$ 33,[illegible]	$ 4,[illegible]

Row Labels	Sum of Cost_Quarry run high	Sum of Cost_Armour 300-1000kg high	Sum of Cost_Armour 1-3 t high	Sum of Cost_XI units high	Sum of Cost_Armour 2-5 t high	Sum of Cost_Excavation high	SUM
Head	$ 421,550.80	$ 117,520.77	$ -	$ 392,000.00	$ 35,020.00	$ -	$ 966,791.57
Head trunk	$ 551,000.00	$ 148,520.00	$ -	$ 339,200.00	$ 45,000.00	$ -	$ 1,090,920.00
Trunk 0	$ 435,406.53	$ -	$ -	$ -	$ 377,253.76	$ 41,650.80	$ 854,411.09
Trunk -1	$ 199,420.30	$ -	$ -	$ -	$ 171,790.88	$ 9,180.00	$ 381,391.08
Trunk -2	$ 193,205.70	$ -	$ -	$ -	$ 164,829.60	$ -	$ 358,035.30
Trunk -3	$ 255,450.75	$ -	$ -	$ -	$ 190,321.60	$ -	$ 445,741.26
Trunk -4	$ 464,295.30	$ -	$ -	$ -	$ 304,435.64	$ -	$ 768,795.24
Trunk -5	$ 611,224.50	$ -	$ -	$ -	$ 357,465.60	$ -	$ 968,690.10
Trunk -6	$ 288,430.78	$ -	$ -	$ -	$ 151,729.30	$ -	$ 440,152.58
Grand Total	$ 3,401,275.50	$ 265,040.77	$ -	$ 731,200.00	$ 1,795,[illegible]	$ 50,870.00	$ 6,245,375.75

American Embassy - Stone Head - Quantities (m3 or m2)

Row Labels	Sum of Qty_Sand (nourished)
GROYNE see sheet	16000
Beach	608000
Grand Total	624000

American Embassy - Costs low estimate

Row Labels	Sum of Cost_Sand (nourished) low
GROYNE see sheet	$ 64,000.00
Beach	$ 2,432,000.00
Grand Total	$ 2,496,000.00

American Embassy - Costs high estimate

Row Labels	Sum of Cost_Sand (nourished) high
GROYNE see sheet	$ 128,000.00
Beach	$ 4,864,000.00
Grand Total	$ 4,992,000.00

Page 3 of 4

Separate BOQ - [illegible] STONE ROAD - AMERICAN EMBASSY				Quantities (m3 or m2 or units)	
Row Labels	Sum of Qty_Quarry run	Sum of Qty_Armour 300-1000kg	Sum of Qty_Armour 2-5 t	Sum of Qty_Armour 5-10	Sum of Qty_Excavation
Head	3,157	1,780	-	3,118	-
Head trunk	6,908	2,250	-	4,188	-
Trunk 0	3,274	-	2,020	-	3,475
Trunk -1	1,498	-	1,200	-	765
Trunk -2	1,453	-	1,145	-	-
Trunk -3	1,821	-	1,220	-	-
Trunk -4	4,691	-	2,110	-	-
Trunk -5	4,537	-	2,482	-	-
Trunk -6	2,149	-	1,066	-	-
Grand Total	**30,838**	**4,031**	**11,998**	**7,306**	**4,240**

Row Labels	Sum of Cost_Quarry run low	Sum of Cost_Armour 300-1000kg low	Sum of Cost_Armour 2-5 t low	Sum of Cost_Armour 5-10	Sum of Cost_Excavation low	SUM
Head	$ 489,871.59	$ 191,555.33	$ -	$ 558,962.98	$ -	$ 1,040,787.89
Head trunk	$ 618,212.10	$ 245,000.00	$ -	$ 652,250.00	$ -	$ 1,515,462.10
Trunk 0	$ 311,020.38	$ -	$ 282,910.32	$ -	$ 27,799.20	$ 621,729.90
Trunk -1	$ 141,445.00	$ -	$ 129,346.35	$ -	$ 6,320.00	$ 276,111.15
Trunk -2	$ 108,151.26	$ -	$ 123,421.20	$ -	$ -	$ 261,822.85
Trunk -3	$ 181,471.25	$ -	$ 143,576.20	$ -	$ -	$ 325,047.45
Trunk -4	$ 331,680.00	$ -	$ 226,129.28	$ -	$ -	$ 560,022.28
Trunk -5	$ 416,867.50	$ -	$ 288,089.20	$ -	$ -	$ 705,786.70
Trunk -6	$ 196,024.15	$ -	$ 115,796.50	$ -	$ -	$ 319,821.00
Grand Total	**$ 2,814,058.98**	**$ 435,555.33**	**$ 1,308,303.26**	**$ 859,652.98**	**$ 33,839.20**	**$ 6,021,022.14**

Row Labels	Sum of Cost_Quarry run high	Sum of Cost_Armour 300-1000kg high	Sum of Cost_Armour 2-5 t high	Sum of Cost_Armour 5-10	Sum of Cost_Excavation high	SUM
Head	$ 685,820.33	$ 254,707.60	$ -	$ 477,827.10	$ -	$ 1,420,275.03
Head trunk	$ 885,497.50	$ 504,000.00	$ -	$ 609,000.00	$ -	$ 1,792,497.50
Trunk 0	$ 435,408.53	$ -	$ 377,313.76	$ -	$ 41,638.80	$ 854,411.09
Trunk -1	$ 199,420.30	$ -	$ 172,730.88	$ -	$ 9,180.00	$ 381,331.08
Trunk -2	$ 193,203.75	$ -	$ 164,829.60	$ -	$ -	$ 358,045.35
Trunk -3	$ 255,450.75	$ -	$ 190,191.60	$ -	$ -	$ 445,641.35
Trunk -4	$ 464,356.30	$ -	$ 304,439.04	$ -	$ -	$ 768,795.34
Trunk -5	$ 611,224.50	$ -	$ 387,765.60	$ -	$ -	$ 998,990.10
Trunk -6	$ 188,433.78	$ -	$ 151,729.20	$ -	$ -	$ 340,162.98
Grand Total	**$ 3,999,036.42**	**$ 380,707.60**	**$ 1,750,509.68**	**$ 1,088,827.10**	**$ 50,878.80**	**$ 7,423,879.79**

Page 4 of 4