PRDW
Consulting Port and Coastal Engineers

GRANGER BAY PHASE 0

Functional Requirements

Detail Design

GB00-PRD-XX-XX-RP-MA-0001

12 November 2024

V&A WATERFRONT
Cape Town, South Africa

prdw.com

Consulting Port and Coastal Engineers

GRANGER BAY PHASE 0

Functional Requirements

Detail Design

GB00-PRD-XX-XX-RP-MA-0001

12 November 2024

REVISION	DATE	EXECUTED	CHECK	APPROVED	CLIENT	DESCRIPTION / COMMENTS
0	07-10-2024	MM/DWC	SAH	AHH		Client Review
1	12-11-2024	MM/DWC	SAH	AHH		Client Review

(A) Interdisciplinary coordination (B) For approval (C,D,E...) Modifications (0) Approved (1,2,3...) Scope modification (N) Void

V&A WATERFRONT
Cape Town, South Africa

PRDW
Consulting Port and Coastal Engineers

CONTENT

TABLES

FIGURES

V&A WATERFRONT

GRANGER BAY PHASE 0

Functional Requirements

Detail Design

1. INTRODUCTION

This document defines the functional requirements for the marine infrastructure for the marine works for the Granger Bay Phase 0 Development to be built by the V&A Waterfront. The general layout of the Phase 0 Development is illustrated schematically in Figure 1-1.

The layout was developed by Heatherwick Studios to address a number of experiences that do not form part of typical marina developments, it is therefore not referred to as a marina. Specifically, the breakwaters are short and allow more wave energy to penetrate in the embayment. Crest levels are also as low as +5 m MSL, allowing significant overtopping in places.

Key elements of the marine infrastructure forming part of the Phase 0 development include:

- Breakwaters and Revetments: Provides protection from wave action and coastal erosion.
- Capping: Provides vehicular and pedestrian access to the breakwaters and revetments.
- Walkways and Stairs: Facilitates pedestrian movement throughout the development.
- Tidal Pools and beaches: Provides area for seasonal (summer) recreational swimming and beach going.
- Seawater Replenishment System: Provides a supply of raw seawater to the tidal pools.
- Quay with a vertical wall and steps with provision for temporary walk-on moorings: To provide a space for public events and facilitate the mooring and boarding of vessels.
- Slipway and permanent walk-on mooring: To support the launching and retrieval of recreational boats.
- Stormwater outfalls: Provide culverts through the revetment for all stormwater outfalls pipes.

The following sections detail the specific functional requirements for each component of the marina.

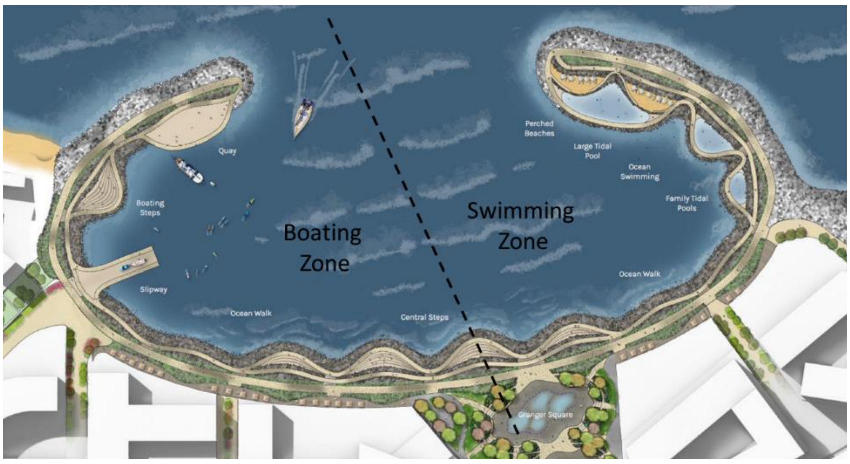

Figure 1-1: Conceptual layout of Granger Bay [1].

2. GENERAL CONSIDERATIONS

2.1 Design life and risk

The design life is typically defined by the owner with the assistance of the designer. A number of guidelines are available: see AS 4997:2005, BS EN 1990:2002, and Simm and Masters (2003), suggesting the following design life periods for different types and purposes of facilities:

- Temporary works 10 years or less
- Small craft facilities 25 years
- Normal commercial structures 50 years
- Special structures 100 years

The design life of marine structures forming part of Phase 0 is selected as **50 years**.

In order to define the return period for design, the acceptable probability of exceedance of extreme storm events needs to be selected. Recommended allowable probabilities, for coastal and marine structures to experience the design event during their design lives, are provided in AS 4997:2005 and shown in Table 2-1 below:

Table 2-1: Probability of exceedance of the design event for marine structures (adapted from Table 5.4 and 6.1, AS 4997:2005).

Lifetime (years)	Low degree of hazard to life or property	Normal structures	High risk to life and property	Structure Type
5 or less	0.23	0.10	0.05	temporary works
25	0.40	0.12	0.05	small craft facilities
50	0.22	0.10	0.05	normal maritime structures
100	0.18	0.10	0.05	special structures/ residential developments

The return period (T_r) may be defined as the relationship between design life (L) and probability of exceedance (P). The return period or estimated time interval between two successive events of similar magnitude can be calculated using Eq. (2-1):

$$T_r = \frac{1}{1-\left(1-\frac{P}{100}\right)^{1/L}} \qquad (2\text{-}1)$$

Where:

T_r	=	return period or average recurrence interval (years) of the design event
L	=	design life (years)
P	=	probability of exceedance of the design event

Phase 0 is considered a normal structure and therefore a probability of exceedance of the design event of **10 percent** is considered appropriate. The corresponding return period for a **50-year lifetime** can be calculated as **475 years**.

The lee armour for the development may be exposed to overtopping waves from the period of completion of Phase 0 and construction of reclamation. This period is expected to be approximately **1.2 years** and a probability of exceedance of the design event of **23 percent** is considered appropriate for this part of Phase 0, which gives a return period of **5 years**. The basis for calculation of return periods is provided in the following paragraph.

The walk on floating jetty is considered as a fair-weather facility with a proposed design life of **25 years** and a low degree of hazard to life or property, thus a probability of exceedance of **40 percent** is proposed which results in a design condition of **50 years**.

2.2 Materials

2.2.1 Concrete

The project will make use of two types of concrete:

- Plain (unreinforced) concrete.
- Reinforced concrete.

In general, plain concrete will be used wherever possible. Reinforced concrete will be used for concrete elements that are subjected to high bending and tensile loads.

Concrete elements will be designed to be durable over the design working life of the development. Typically, this will require resistance to the following deterioration mechanisms:

- Early age thermal cracking of massive elements due to the development of excessive heat of hydration and restraint.
- Long-term thermal and shrinkage cracking due to fluctuations in ambient temperature and ongoing shrinkage of the concrete elements.
- Stress induced flexural cracking
- Abrasion due to wave action and foot traffic.
- Alkali aggregate reaction and sulphate attack

In addition to these, the marine nature of the project creates a high risk of chloride-induced reinforcement corrosion. To mitigate this risk the reinforced concrete elements will require:

- High performance concrete mixes.
- Adequate concrete cover.

The use of inert or protected reinforcement, such as basalt fibre reinforced polymer (BFRP) reinforcement or galvanised steel, will also be considered wherever possible.

Due to the large volumes of concrete required the associated costs will have a large contribution to the overall development costs. Consideration will be given to the following measures to mitigate the cost impact:

- Minimisation of concrete volumes.
- Minimisation of cement-binder content.
- Use of cheaper aggregates wherever possible, without reducing the quality and durability.

To try and limit the impact the use of concrete on the environment consideration will be given to more sustainable ways of using concrete, such as:

- Using locally available aggregates, cement, and cement extenders wherever possible.
- Using low embodied carbon cement extenders, such as fly ash and calcined clay (metakaolin), wherever possible.
- Using recycled aggregates, wherever possible.
- Introducing specialised admixtures and element shapes to encourage growth of marine life and the formation of biodiverse marine habitats, wherever possible.

Consideration will also be given to constructability taking the following into consideration:

- Simplification of elements shapes wherever possible, to allow for simpler formwork.
- Consideration of the effect of tidal and wave action on the construction process.

2.2.2 Quarried Rock

All quarried rock will comply with PRDW's generic rock specification (PRDW, 2019) which is based on the Rock Manual (CIRIA; CUR; CETMEF, 2007).

2.3 Architectural Finishes

An exposed aggregate finish, like what is presently visible in the V&A Waterfront, has been requested by Heatherwick Studios. Refer to Figure 2-2 for an example of the V&A Waterfront surface finish.

The final finish to be applied will be dependent on the following:

- Confirmation of aggregates available locally (City of Cape Town Metropolitan area) and regionally (outside City of Cape Town Metropolitan area)
- A review of the available aggregates, including:
  - Aggregate size range
  - Aggregate colour range (see Figure 2-1)
  - Cost range for various aggregates and mix designs

- A review of potential options for creating the exposed aggregate finish (see Figure 2-2), such as:
  - Application of surface retarder
  - Sand blasting
  - Screed

Grey (standard) Brown Grey (standard) & White

Figure 2-1: Different aggregate colour samples

Figure 2-2: Example of exposed aggregate finish at the V&A Waterfront.

3. BREAKWATERS AND REVETMENTS

3.1 Functional requirements

The rubble mound structures are broken down into five different areas, as shown in Figure 3-1. The eastern and western breakwaters protrude into the sea, providing protection for the areas within the bay. The three revetments are armoured slopes that will back onto the land once the reclamation is complete. Typically, harbours would be designed based on a set of functional requirements such as the protection required for vessels, allowable overtopping and prevention of damage to infrastructure and equipment. Seeing as the intention of Granger Bay is not to provide safe mooring for vessels but more of a tourist attraction, this design followed a different process, with the geometry being designed by Heatherwick Studios architects. PRDW were involved in previous project stages and engaged with Heatherwick Studios and the project team to provide engineering advice on the proposed designs. In this phase PRDW will undertake the detailed design of the rubble mound structures that make up the bay, whilst maintaining the layout provided by Heatherwick. This will include undertaking both numerical and physical model studies of the selected layout to verify the stability of the rubble mound structures.

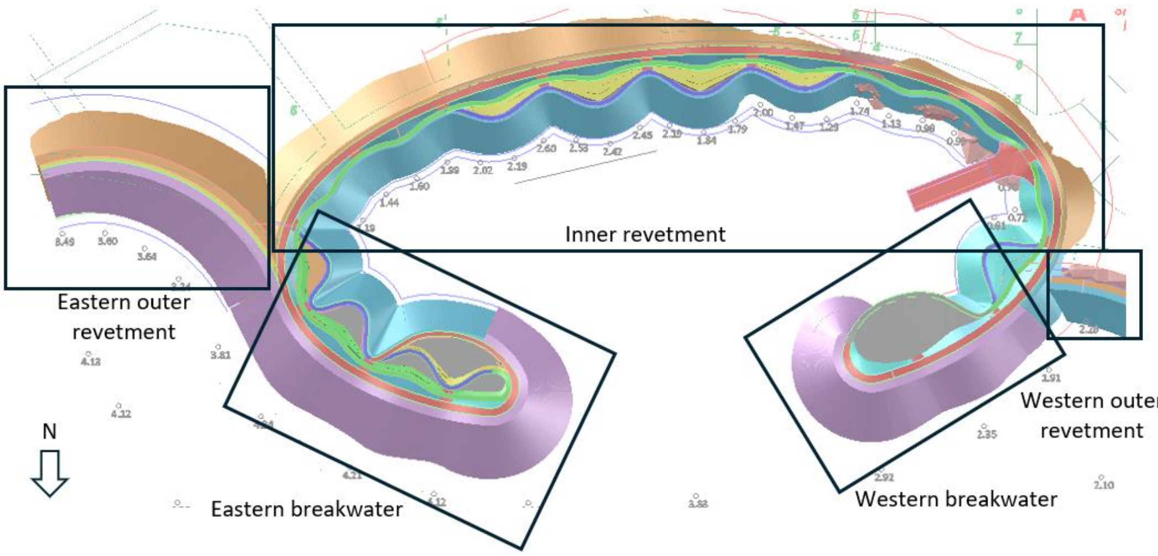

Figure 3-1: Five areas that comprise the rubble mound structures.

The existing layout does not allow typical maintenance access onto the breakwaters. The Core-loc layers on the two breakwaters will therefore be designed for zero maintenance. It should be noted that armour stability shows variability in results due to the random nature of interlocking between units. Even if model results indicate zero damage there may be the potential of extraction of a few units over the lifetime of the structure. The project should acknowledge that in the unlikely loss of units, replacement will be more expensive due to the restricted access imposed by the 3.5 m wide main pathway.

3.2 Operational requirements

Small vehicle access to the eastern breakwater head must be allowed for so that the beach sand may be removed during winter, when it will likely experience large overtopping and the sand would likely be washed away.

As detailed in Section 9 a total of 5 manholes (3 at GB1, one each at GB2 and GB3) must be included on the rubble mound structures to facilitate maintenance access to the storm water outlets. Alternative access via culvert openings will be investigated.

During construction of the bay, access from the Oceana Power Boat Club (OPBC) slipway into the ocean must be always maintained. The existing slipway may only be blocked once the new slipway has been completed and is operational.

4. CAPPING, WALKWAYS AND STAIRS

4.1 Functional requirements

The layout and geometry of the capping, walkways and stairs will be in accordance with the final architectural layout illustrated in Figure 4-1, providing a plan view with the different elements identified.

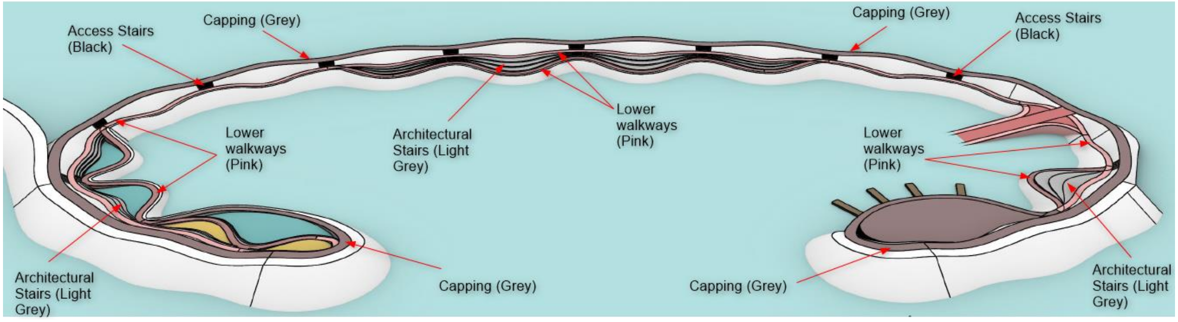

Figure 4-1: Plan View of capping, walkways and stairs identifications.

Plain mass concrete with an architectural finish will be used for the bulk of the concrete work. A cross fall will be provided to allow water to runoff and prevent water ponding on the trafficked surfaces. The longitudinal slope or gradient will be as defined by the architectural layout. Expansion and construction joints, spaced at roughly 3 to 5m, will be provided and will be visible on the surface. Provision will also be made for service conduits in the capping. Standard details for draw pits, manholes and service boxes will be provided and positioned based on information provided by others.

The stairs are categorized into:

- Access stairs - stairs used by the public to access various parts or features of the development
- Architectural stairs or steps – stairs providing an architectural function (e.g. seating) or feature (e.g. aesthetic)

All stairs will be according to Heatherwick Studio's details. Where any stair width reduces to zero, a practical construction detail will be proposed for approval.

The stability of the capping, walkways and stairs will be determined in the 2D physical model. A minimum cross-sectional area required will be determined in the physical model.

The 3.5 m wide capping will be designed to accommodate a vehicle load up to a 10-tonne truck. All other stairs and walkways will allow for pedestrian access and gatherings. It should be noted that the 3.5 m wide capping will require very careful driving and that there is no point for the truck to turn around, so any distance travelled forwards on the breakwaters will require an equal distance reversing. Any truck movement will have to be extremely slow and will require guidance by pedestrians to avoid any wheel accidentally coming off the cap. While the cap will be designed for a 10 t truck load, it will be advisable to use smaller vehicles for access and maintenance activities whenever possible.

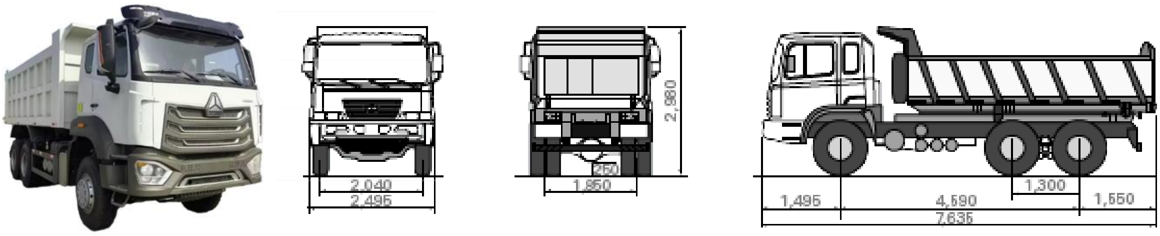

Figure 4-2: Example of a 10-tonne dump truck.

4.2 Operational requirements

Operational requirements associated with the capping, walkways and stairs are limited to general ongoing inspections and maintenance. Typically, this would entail activities such as:

- Removal of sand build-up
- Removal of algae on the lower walkways
- Repairing damaged concrete

5. TIDAL POOLS AND BEACHES

5.1 Functional requirements

The tidal pools are identified in Figure 5-1, along with their associated design water levels. The design water levels, depths and slopes are tabulated in Table 5-1.

Table 5-1: Design parameters

Tidal Pool	Design Water Levels (m MSL)	Approximate Design Water Depths (m)	Design Slopes (x:y)
Kid's Pool	+1.7m	0.48 m to 0.6 m	1:60
Family Pool	+1.4m	1.0 m to 1.2 m	1:60
Swimming Pool	+1.1m	1.1 m to 1.5 m	1:60/1:12

All structures and equipment will be designed/specified for maximum durability in the marine environment with minimum requirements for major in-service maintenance during the specified design life. The serviceability requirements that would apply to concrete structures, steel structures, piping, fittings, lifting equipment, mechanical, electrical and control equipment will be taken into consideration.

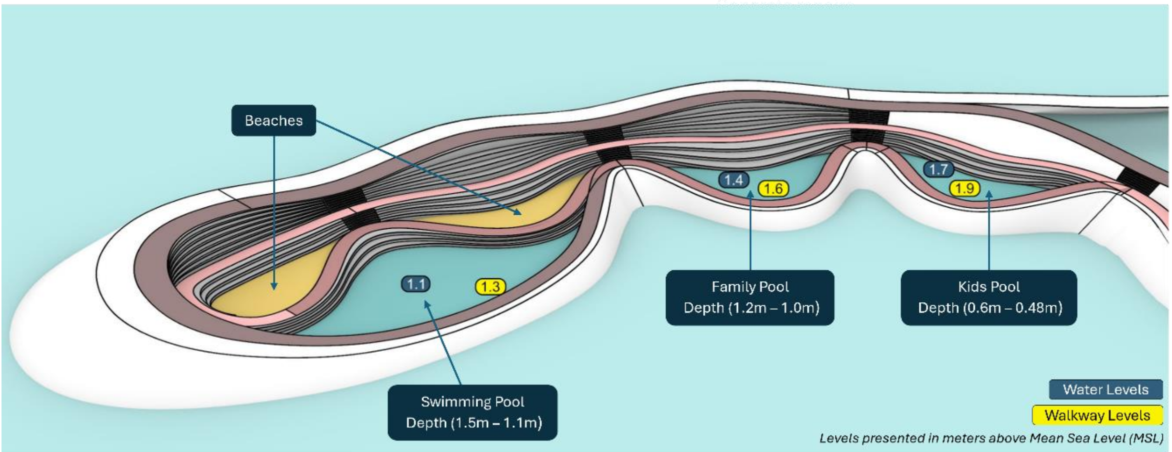

Figure 5-1: Tidal pool water levels (Heatherwick Studio, 2024).

Plain, unreinforced concrete units will be used to construct the pool slab, retaining walls, and staircase units. The pools will be as watertight as possible to ensure that water retention is maximized, maintaining adequate water levels and optimal swimming conditions.

A smooth concrete finish screed with a minimum thickness of 100 mm will be used to create the slopes for the tidal pool floors.

A minimum sand layer thickness of 300 mm is required for the beach areas. It is recommended that the beach sand be removed and securely stored prior to the winter storm season, and then replenished before the summer season begins. During the winter months, when the sand is stored, there is an option to expose artwork or surface finishes (to be confirmed by the Client).

5.2 Operational requirements

V&A Waterfront's operational requirements associated with the tidal pools and beaches are limited to general ongoing monitoring, inspections, maintenance and cleaning. Typically, this would entail activities such as:

- Inspection and maintenance of the water replenishment system components within the tidal pools
- Inspection and maintenance of tidal pool structures, particularly post storms
- Ongoing cleaning to remove debris and waste material that has accumulated in the tidal pools and on the beaches
- Regular monitoring of water quality to ensure safe swimming conditions (e.g., checking pH levels, salinity, and microbial content).
- Ongoing monitoring and management of marine growth within the tidal pools
- Ongoing monitoring and management of beach sand.

6. SEAWATER REPLENISHMENT SYSTEM

6.1 Functional requirements

The seawater replenishment system will be designed to replace the total volume of water in all three pools within a maximum duration of three days, assuming that there is no assistance from tidal flushing. Seawater will be abstracted from within the core rock of the reclamation area. The proposed abstraction location is indicated below in Figure 6-1.

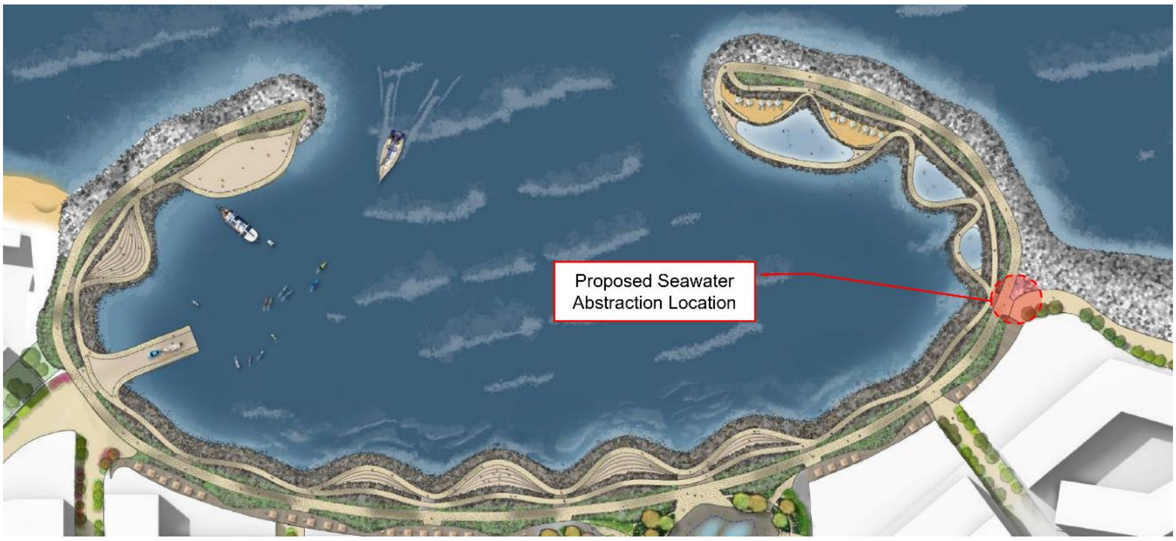

Figure 6-1: Proposed seawater abstraction location.

A schematic of the proposed seawater replenishment system is presented in

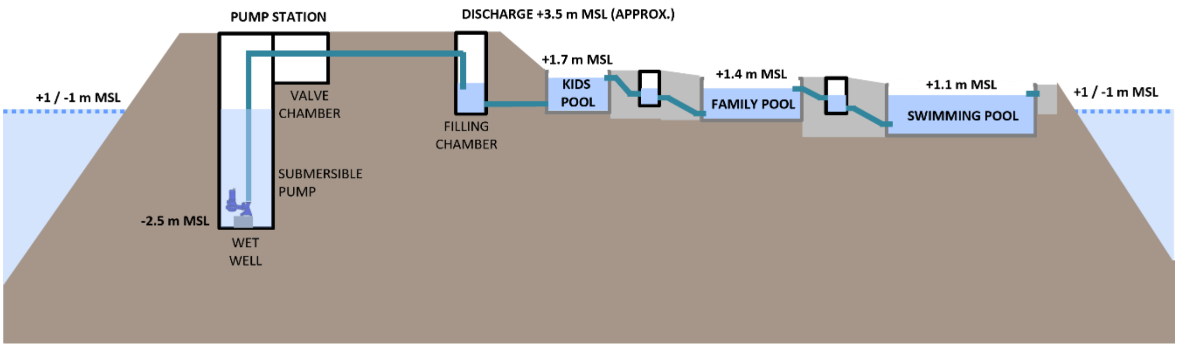

Figure 6-2.

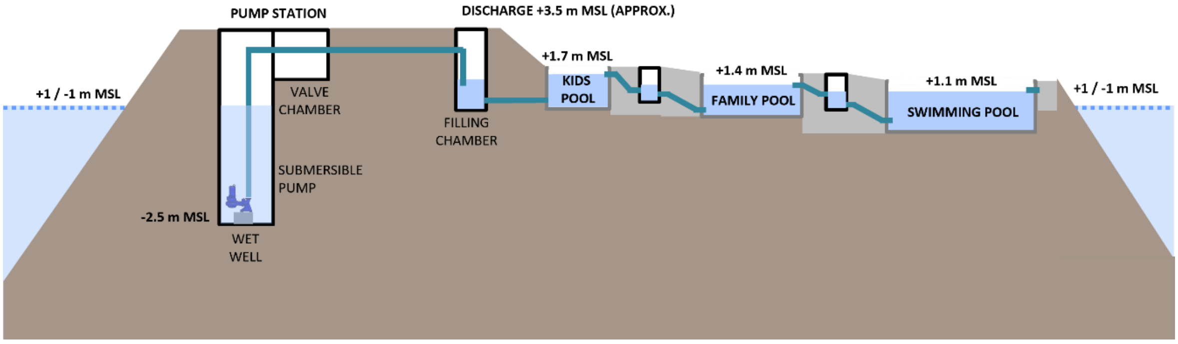

Figure 6-2: Typical seawater replenishment system.

The pump station will house two submersible seawater replenishment pumps (one duty pump and one standby pump) in a wet well and associated valves and pipework in an adjacent valve chamber.

Spatial requirements for the seawater pump station facility will consider access requirements for personnel to perform inspections and maintenance.

The depth of the pump station will be determined by considering the minimum design seawater level in the pump station wet well and the minimum required water depth for continuous pump operation.

Considering the significance of the Granger Bay project, the pump station facility must, as far as practically possible, be hidden from sight and therefore be located below ground level. The electrical motor control centre (MCC) for the seawater pumps will be housed either in a weatherproof kiosk adjacent to the pump station or in a suitable above-ground, air-conditioned building in close proximity to the pump station.

Vehicular access to the pump station is necessary for maintenance activities to be performed.

The electrical supply to the seawater pump station MCC will be designed and supplied by others.

6.2 Operational requirements

Operational requirements associated with seawater replenishment system typically include the following:

- Regular inspection and maintenance of the water replenishment system
- Ongoing monitoring and management of marine growth to ensure the effectiveness of the system
- One duty pump and one standby pump will be provided to allow one pump to be taken out of service for maintenance while continuing operation of the replenishment system using the second pump. The replenishment system will be designed for continuous operation.
- The tidal pools will always be operated simultaneously. During maintenance of one or more pools, all three pools will be out of service and no seawater will be supplied to the pools (i.e. the replenishment system will be switched off).
- Seawater will be pumped from the pump station to a filling chamber. From this chamber, the tidal pools will be filled through interconnected pipes and chambers.
- The specified seawater levels in the pools will be achieved as part of the configuration of the system. The locations and configurations of the infrastructure associated to the seawater replenishment system will be determined as part of the study.
- A drain valve will be provided for each of the pools. This drain valve will remain closed during normal operation and will only be opened to drain the pool for maintenance and cleaning purposes.

7. QUAY WITH PERMANENT STEPS AND TEMPORARY JETTY

7.1 Functional requirements

The purpose of the quay is to provide a space that brings the community closer to the sea, offering a versatile recreational area that can accommodate a wide range of activities, such as food markets, theatrical performances, and concerts.

Vehicular access onto the quay is not provided and therefore there is no need to make provision for vehicular loads.

The design vessel for the quay wall area is determined by the available minimum water depth of -4 m msl. The maximum vessel dimensions are presented in table 7-1 below:

Table 7-1: Design Vessel Characteristics

Vessel Type	Length (m)	Beam (Width) (m)	Draft (m)		Weight (t)
			Average	95 Percentile	
Power Boats	20	<6.5	2.0	2.4	25
Sail Boats	15	< 6.0	2.0	2.4	25

The quay wall berthing facilities are intended for fair weather operations only. The berths will not be used when wave conditions exceed an H_{mo} of 0.5 m. Allowance shall be made for a minimum under keel clearance of 0.5 m at Mean Low Water Spring tide (MLWS, -0.35 m MSL). At Lowest Astronomical Tide (LAT, -0.77 m MSL) the allowance for wave condition is reduced to 0.33 m.

Access to the vessels shall be via concrete stairways with staging platforms to accommodate different tidal water levels.

The quay wall will allow for the installation of temporary walk-on moorings for events during summer and autumn seasons.

7.2 Operational requirements

Operational requirements associated with quay and temporary walk on moorings typically include the following:

- Inspection and maintenance of the various structures, particularly post storms
- Floating walking moorings will only be installed for events during the summer and autumn seasons

- The use of berths limited to wave conditions less than 0.5 m or as determined safe by the harbour master.

8. SLIPWAY AND WALK ON MOORING

8.1 Functional requirements

The intention is to replace the existing slipway at the Oceana Power Boat Club (OPBC), taking current standards and OPBC's functional requirements into consideration, with a new slipway. The location of the new slipway is shown in Figure 8-1.

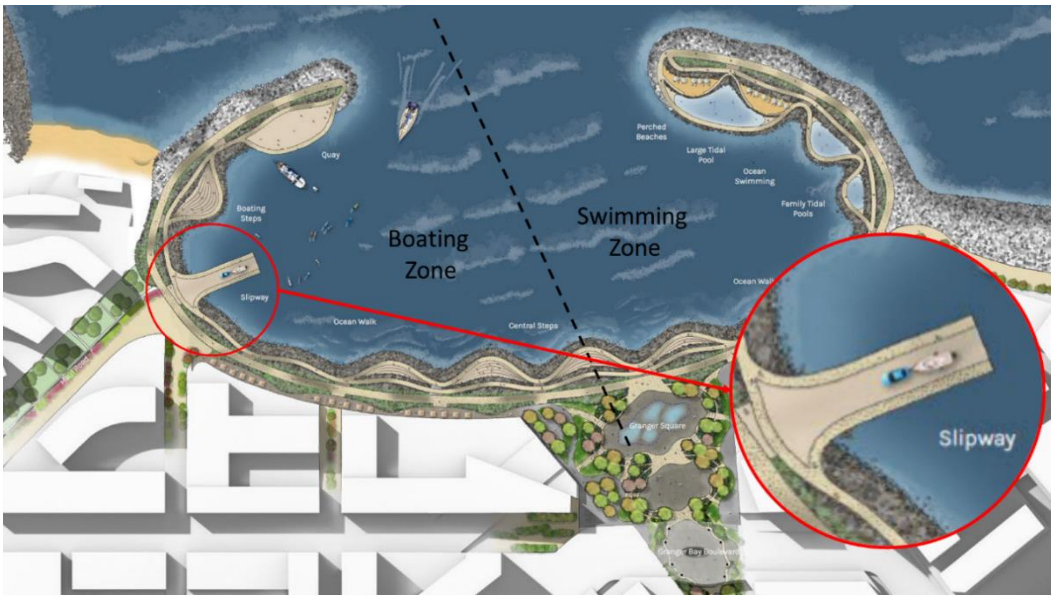

Figure 8-1: Image showing the location of the slipway (Heatherwick Studio, 2024).

The slipway will need to accommodate the following users:

- Recreational and commercial fishing boats
- Recreational activities, such as:
  - Jet skiing
  - Surf skiing
  - Kayaking

Figure 8-2: Typical slipway users.

The geometry of the slipway will be governed by the requirements of the recreational and commercial fishing boats. Table 8-1 provides the design vessel characteristics for the largest boat to be considered.

The maximum draft will be based on the 95-percentile value, which is 1.1 m. The required minimum water depth at the seaward end of the slipway will include a safety margin or under keel clearance of 0.5 m, and a wave action allowance of 0.37 m, equating to a required seabed level of -2.5 m MSL at the toe of the ramp. This will enable the design vessel to use the slipway at the Mean Low Water Spring tide (MLWS), -0.53 m MSL. For Lowest Astronomical Tide (LAT), -0.77 m MSL, the allowance for wave action reduces to 0.13 m for the seabed level of -2.5 m MSL.

Table 8-1: Design Vessel Characteristics (Standards Australia Committee, CE-030, Marine Structures, 2020, pp. 18-19).

Vessel Type	Length (m)	Beam (Width) (m)	Draft (m)		Weight (kg)
			Average	95 Percentile	
Power Boats	10	3.9	0.9	1.1	Up to 2 500

The slipway will have a width of 10 meters, providing two traffic lanes for users, and a slope of 1:8. The surface of the slipway will have a rough texture to enhance grip and prevent slipping. A kerb will be provided down each side of the slipway, as well as at the seaward end, to prevent users from driving off the slipway into deeper water.

A walk-on jetty will be provided adjacent to the slipway to allow users to temporarily moor up against while launching or retrieving their boat. The jetty will be accessed from land via a gangway designed to accommodate tidal variation and wave action.

For reference the existing Marina Basin slipway is shown in Figure 8-3.

Figure 8-3: Existing V&A Marina Basin slipway.

8.2 Operational requirements

Operational requirements associated with quay and jetty typically include the following:

- Inspection and maintenance of the various structures, particularly post storms
- Ongoing monitoring and management of marine growth to ensure good traction on slipway

9. STORMWATER OUTFALLS AND SERVICES

9.1 Stormwater outfalls

Three stormwater outfalls will be included in the construction of the rubble mound structures, as shown in Figure 9-1 from the ARUP Stage 2 infrastructure report (ARUP, 2023). For the western breakwater outfall (GB1), three manholes are included on ARUP's layout, and will be included in the breakwater design. One manhole must be included for GB2, and another for GB3. If possible, ARUP will be requested to move GB1 to the same location as GB2 and GB3, in which case GB1 will also only require a single manhole. The following pipeline diameters apply to the outfalls:

- GB1: 750 mm diameter
- GB2: 1500 mm diameter
- GB1: 1200 mm diameter

Three culverts will be constructed of sufficient size for the pipelines to be installed as part of the next development phase. During the time after completion of Phase 0 and before reclamation, GB2 will be discharging into the water behind the development. This water will flow out to sea through the core and armour layers of Phase 0. The body of water behind Phase 0 is likely to be polluted by plastic and other debris that would likely require cleaning to avoid unsightly floating pollution.

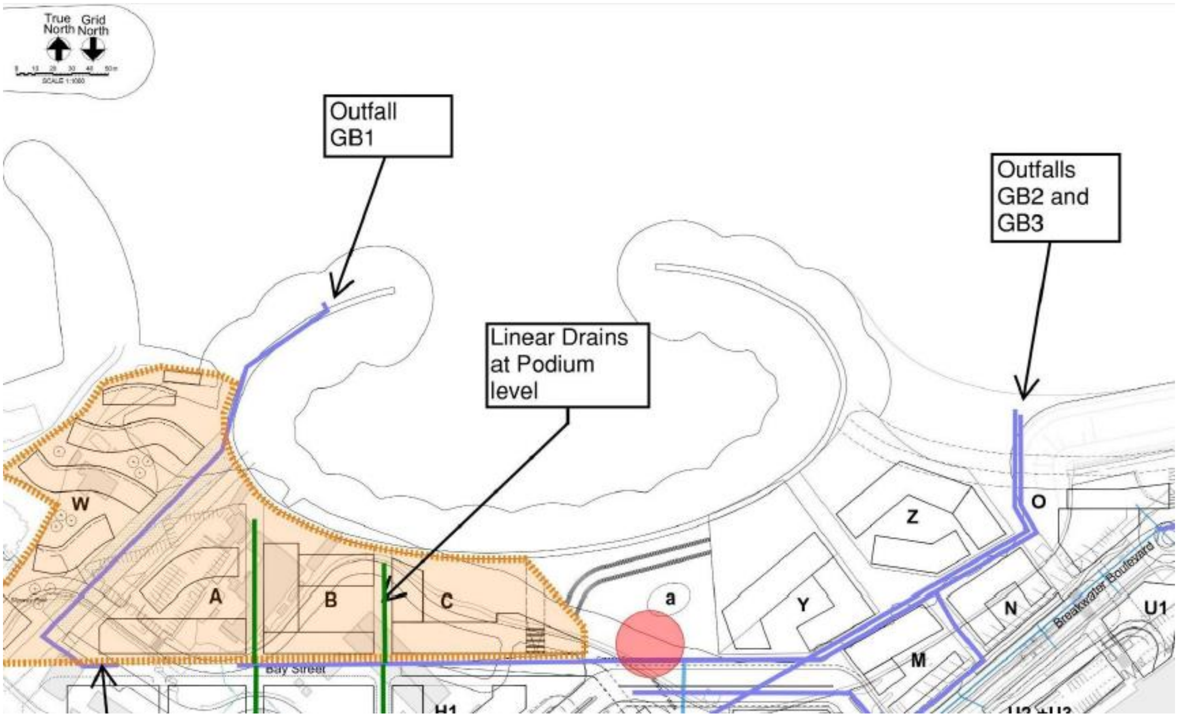

Figure 9-1: Location of three stormwater outfalls that will pass through rubble mound structures.

9.2 Services

Provision will be made for the services conduits at the top of the capping walkways. Standard details for draw pits, manholes and service boxes will be provided with the required spacing thereof to be determined by others.

The following services are required according to the Granger Bay Masterplan document (ARUP, 2023):

- Potable water (see Figure 9-2) – Required size to be provided by others. Maximum of 160mm diameter pipe is currently assumed based on size of the pipe network it will tie into (see Figure 9-3).
- Non-potable water requirement is still to be confirmed, see Figure 9-4 for proposed layout.
- Electrical sleeves for lighting – 2 no. 45 diameter sleeves (see Figure 9-5).
- ELV V&A Fibre + CCTV – 2 no. 110mm diameter sleeves (see Figure 9-6).

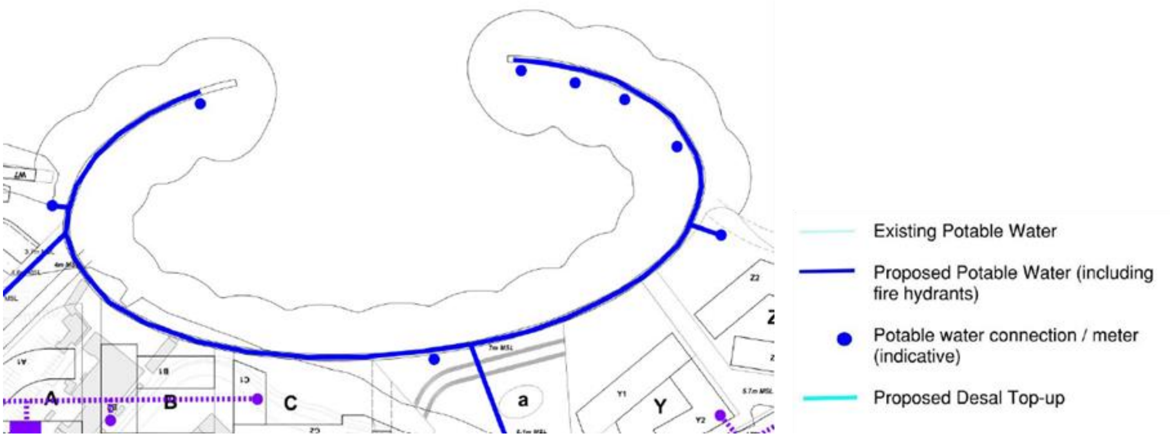

Figure 9-2: Proposed potable water layout (ARUP, 2023, p. 104).

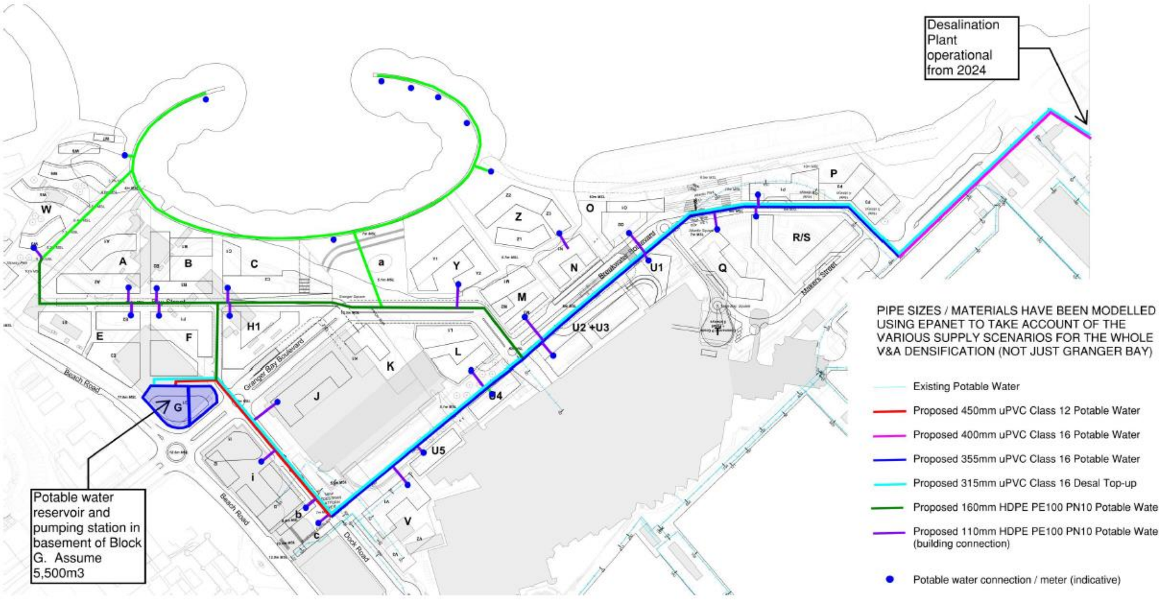

Figure 9-3: Proposed potable water pipe sizes (ARUP, 2023, p. 144).

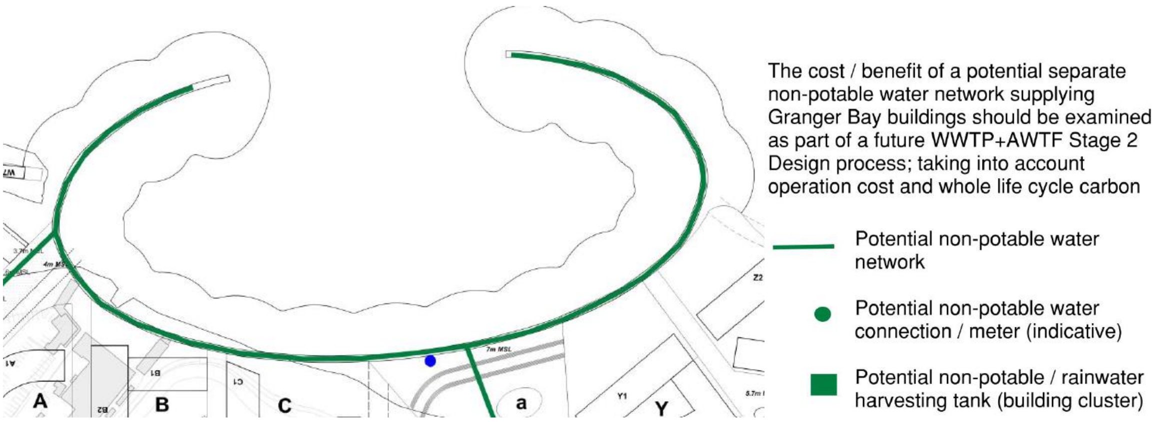

Figure 9-4: Proposed non-potable water layout (ARUP, 2023, p. 46).

Figure 9-5: Proposed lighting layout (ARUP, 2023, p. 64).

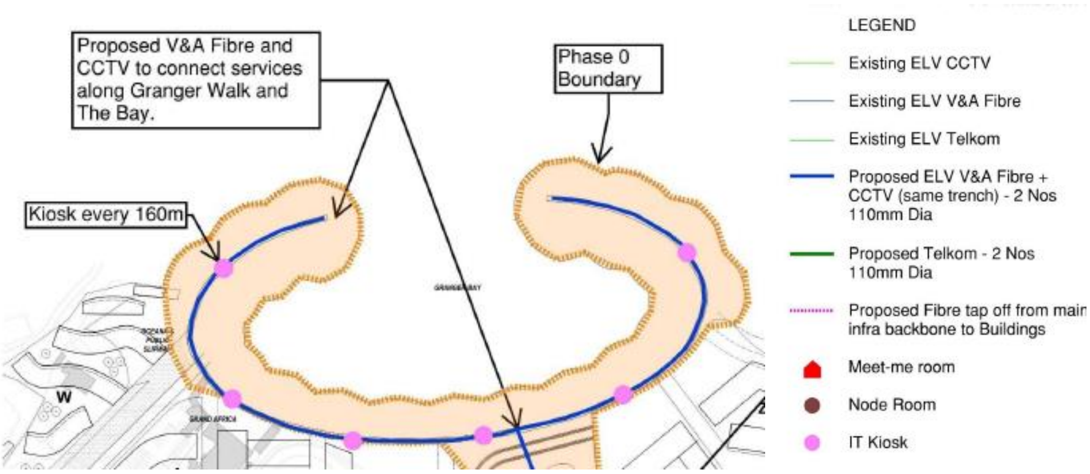

Figure 9-6: Proposed Fibre and CCTV services (ARUP, 2023, p. 80).

10. REFERENCES

ARUP. (2023). *Granger Bay Masterplan: Infrastructure Stage 2 Report.* Cape Town: ARUP.

CIRIA; CUR; CETMEF. (2007). *The Rock Manual. The use of rock in hydraulic engineering (2nd edition).* London: C683, CIRIA, London.

Department of Transport (Maritime Division), Abu Dhabi. (2013). Design Code for Maritime Infrastructure. Abu Dhabi, United Arab Emirates (UAE).

Heatherwick Studio. (2024, June 19). Granger Bay Presentation: Pre-stage 3: Marine Modelling (Progress Meeting 2). London, England.

PIANC WG N°149 /part IV. (2017). *Guidelines for marina design.*

PRDW. (2019). *Generic Specifications. Rock for Rubble Mound Structures.* Cape Town: PRDW.

Standards Australia Committee, CE-030, Marine Structures. (2020, March 6). AS 3962:2020 Marina Design. Sydney, Australia.

TNPA. (2015). *Port Engineering Handbook.* Johannesburg.

Consulting Port and Coastal Engineers

For contact or more information, find us at

prdw.com