ESTUARINE ECOLOGY IMPACT ASSESSMENT REPORT FOR THE CONSTRUCTION OF A FLOATING DRY DOCK AT THE DORMAC REPAIR QUAY, BAYHEAD DOCK IN THE PORT OF DURBAN

Report prepared for:

WSP

by

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Executive Summary

This report provides an assessment of the potential ecological impacts of a proposal by Dormac to install a floating dry dock to the west of their existing ship repair facility in the Port of Durban, South Africa. The proposed quay wall will measure approximately 160 m in length, while the floating dry dock moored alongside the quay will measure 173 m in length and 42 m in breadth. The construction will require removal of approximately 2 298 m^2 of existing embankment, dredging of approximately 4 369 m^2 of existing water space to the depth of 14 m, and the removal and disposal of approximately 140 000 m^3 of dredge spoil. Two construction options exist, namely the Sheet Pile Method and a Braced Diaphragm Wall. Each of the two options affects a similar amount of subtidal habitat and the impacts of each option on the estuarine environment were concluded to be of similar significance.

Over 563 marine species have been recorded within the Port of Durban. The port is widely recognised as being an extremely important nursery area for juvenile fishes, many of which are critically dependent on estuaries. Intertidal and shallow subtidal sand flats are particularly important in this respect and also support large populations of Callianasid prawns and other invertebrates, which in turn support large numbers of waders and other water birds. Deeper subtidal areas are dominated by many different species of polychaete worm and diverse fish communities.

The area potentially affected by this project is located in the western section of the Harbour, and is restricted to open water habitats and subtidal soft sediments at Bayhead and surrounds. The subtidal habitat in this area comprises mostly dredged channels, ranging in depth from 0 to 16 m. Sediments comprise 30 to 70% mud and have been shown, in past studies reviewed, to include moderately high levels of trace metals. Fauna in these sediments are mostly depauperate.

Analytical testing of sediment samples collected from the dredge area as part of this study indicated that levels of trace metals were not as high as previous studies had indicated (in fact below Action Levels for most elements) but that biological (toxicity) testing of the sediment was nonetheless warranted. Biological (toxicity) tests were performed using the urchin fertilisation test. Dredge sediment was agitated in seawater, allowed to settle and the supernatant extracted for testing purposes. Rates of fertilisation were examined in serial dilutions of the supernatant to assess the level of dilution required to reduce toxicity to an acceptable level. High levels of inhibition were evident in the undiluted supernatant (64.8% in 100% contaminated water vs. 3.2% for normal seawater), but were not significantly different to that observed in the control samples at anything more than 50% dilution. These results suggested that while unconfined open-water disposal of the dredge spoil is acceptable in terms of South African law, taking precautions during dredging would be advisable to protect sensitive fauna and flora in the Port of Durban.

An assessment of the expected impacts of the proposed project include the destruction and disturbance of pelagic and subtidal soft bottom habitat and associated invertebrate communities during the construction phase. These impacts are mostly localised and hence of low significance. However, due to the toxicity of the sediment to marine life, the significance of the impacts must be further reduced through adherence to a suite of essential mitigation measures that include the use of a suction dredge as well as adherence to strict operating rules during dredging. The latter have been designed to minimise levels of suspended sediments and toxic elements bound to these sediments.

In the event that one or more of the essential mitigation measures cannot be met, 'Silt Curtains' must be placed around the dredge area to prevent large amounts of sediment from moving beyond the development footprint. The lower end of the 'skirt' must rest upon the seafloor, and the top of the 'skirt' must float on the water surface. To ensure that appropriate levels of dilution are achieved in the dredge material prior to disposal, it is recommended that the dredge area be divided into blocks, each of which must be dredged to the full dredging depth required. This will ensure that the deeper, less toxic sediments are mixed with the more toxic surficial sediment layer to reduce effects of toxins on the benthic community both at the dredge site and at the disposal site.

Ecological effects of increased ship movement during the operational phase were assessed to be of very low significance and no mitigation is required. Ecological effects of hull scraping and grit blasting were assessed to be of high significance, thus a number of mitigation measures are proposed in this report. Most importantly, no paint or anti-fouling chips removed from the hull of a vessel in the dry dock facility may be deposited or washed into the Port. In addition, paint overspray should be kept to an absolute minimum, ballast sediments are to be placed into temporary waste disposal facilities and serviced by a registered waste contractor and no ballast water or hull fouling organisms are to be discharged into the water at Bayhead. If these mitigation measures are followed, the significance of the identified impacts will be reduced to a medium level.

Taking into account that the affected area is relatively small, that existing structures are artificial and that the area is regarded as being highly disturbed due to various activities associated with ship repair, it is recommended that permission for the proposed construction is granted on the condition that all the essential mitigation measures are implemented. Importantly, monitoring of turbidity levels during dredging is vital to ensure that threshold limits are not exceeded.

Table of Contents

1 Introduction

Dormac, a marine engineering company with existing ship repair premises at Bayhead Dock in the Port of Durban, has proposed the installation of a floating dry dock to the west of their ship repair facility (Figure 1 & Figure 2). The purpose of the project is to improve facilities at Dormac and to supplement services to the international maritime industry. The proposed alterations aim to improve the attractiveness of Dormac to vessels entering the Port for repair work and to increase the capacity for ship repair from eight to approximately 42 vessels per year.

Figure 1. Arial view of the Port of Durban showing the Dormac premises which are indicated by a yellow marker (Google Earth 2014).

WSP Environment and Energy (WSP) was appointed by Dormac to conduct a Basic Assessment (BA), and subsequently appointed Anchor Environmental Consultants (AEC) to conduct a specialist study on the potential impacts of the floating dry dock on the estuarine ecology of the Bayhead area. Dormac received official approval from TNPA (the landowner) for the lease of land and water areas to accommodate the proposed project on 13 September 2013.

Figure 2. Red shading indicates the approximate position of the development site – the proposed floating dry dock and adjacent quay (Google Earth 2014).

2 Terms of reference

It was agreed that the Marine Ecology Impact Assessment Report shall include:

i) a summary description of project components and activities to be implemented in the construction and operation phases as well as proposed alternatives;
ii) a description of the affected marine environment and associated faunal and floral communities with respect to their sensitivity and significance;
iii) analysis of sediment samples derived from the dredge area for trace metal content and biological (toxicity) testing of the same samples using the sea urchin fertilisation test;
iv) an assessment of the impacts associated with the construction phase including dredging, excavation and the construction of the quay wall based on available data;
v) an assessment of the impacts on the water quality (potential for contamination and bioaccumulation) and marine invertebrates during the operation of the facility with attention to the pumping of water in and out of the buoyancy chambers;
vi) an impact assessment of two methods for the construction of a quay wall (braced diaphragm wall and sheet piling);
vii) recommendations for suitable mitigation measures as required;
viii) monitoring recommendations;
ix) submission of the draft report and subsequent revision thereof; and
x) a meeting to respond to stakeholder comments.

3 Construction methods

Dormac are proposing to modify the existing quay in its shipyard located within the designated Ship Repair Area in the Port of Durban to allow for a floating dry dock to be moored alongside the upgraded quay. The expansion (construction) phase is expected to last approximately two years, and is proposed to entail the following:

- construction of a new quay wall approximately 160 m long;
- removal of a portion of an existing embankment (approximately 2 298 m^2);
- dredging approximately 4 369 m^2 of existing water space to the depth of 14 m;
- removal and disposal of approximately 140 000 m^3 of material (infill and dredged); and
- construction of a composite floating dry dock, to be moored alongside the quay (length 173 m, breadth 42 m).

A floating dry dock is an anchored platform with floodable buoyancy chambers and a "U"-shaped cross-section (Figure 3). It is used for dry docking ships during repair and routine maintenance. When valves are opened, the chambers fill with water, causing the dry dock to float lower in the water. The deck becomes submerged, allowing a ship to be positioned over the bilge and keel blocks located on the deck of the dry dock. The walls of the structure are used to give the dry dock stability while the deck is below the surface of the water. When the water is pumped out of the buoyancy chambers, the dry dock rises and the ship is lifted out of the water, allowing work to proceed on the ship's hull.

The proposed floating dry dock at Dormac is a composite dock. Steel reinforced concrete will be used to build the pontoon while the side walls will be constructed from marine grade steel. The pontoon deck of the dock will be 156 m long with a total area of floating dry dock totalling 6 552 m^2.

Figure 3. Vessels moored in a floating dry dock awaiting repairs (image courtesy of Nestoil).

Two methods of construction have been proposed for the quay, namely, the sheet pile option and the braced diaphragm wall.

3.1 Sheet pile method

The sheet pile method requires dredging of the area to the specified depth, after which two tubular steel piles are buried in the sediment using a vibratory hammer. These allow the floating dry dock to be raised and submerged in place.

A sheet wall is a thin, flexible retaining wall that resists loads by bending. The sheets will be lifted up individually and attached to each other by means of a crane. A scaffold platform will be constructed to provide support for the assembled sheets until they are driven into the sediment. Sand and stones will be placed on either side of sheet pile wall for support (Figure 4). Spoil disposal is proposed to take place at an approved TNPA offshore disposal site (see WSP 2013).

A composite wall will be constructed on land adjacent to the existing west wall of slipway one, 17 m east of the existing bank. The depth of the wall is not expected to exceed 24 m. This will be sufficient to support the hard stand area, the 250 mm reinforced concrete surface bed, and the equipment that will be used to secure and operate the floating dock.

Following construction of the composite wall, the existing topsoil west of the wall will be removed and stockpiled in the slipway for future use in the Port. Long-reach excavators will be used for the bulk excavations. The first 2 m of excavations will take place from land, after which a jack-up barge will be utilized. Once excavations are complete, the existing sheet piles will be removed.

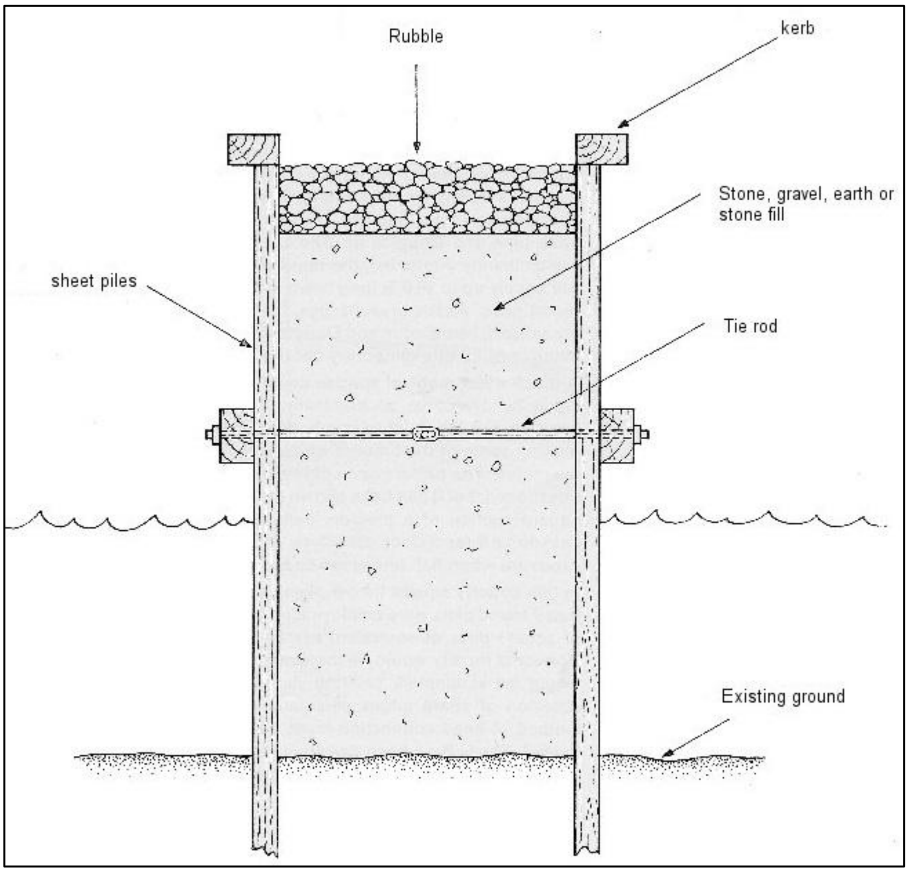

Figure 4. A sheet piling technique (illustration courtesy of www.trada.co.uk).

3.2 Braced diaphragm wall

A diaphragm wall is a reinforced concrete wall that is secured at ground level using slurry techniques. Diaphragm walls are widely used in submerged areas with unstable soil profiles where continuous support and watertight conditions are required to prevent erosion. This is often chosen as the preferred construction method due to the flexibility of plan layout, the speed at which construction takes place and the lack of vibration and loud noises.

Preceding construction of the diaphragm wall, a pair of guide walls is built using concrete (Figure 5). They mark the area to be dredged and function as a working platform during construction. The inside support wall is demolished following construction of the diaphragm wall. The main wall consists of a number of interlocking panels, which are joined by means of stop-ends. These are placed in the wet concrete to mould the end of the panel and are removed before the concrete sets rock hard. For anchored walls, steel is attached to the reinforcing cage to allow anchors to be installed. Sediment is excavated by means of a grab, which is suspended from a crane. Bentonite slurry is used to top up the trench during the excavation, and a pump located in the trench transports the slurry back to storage tanks during concreting.

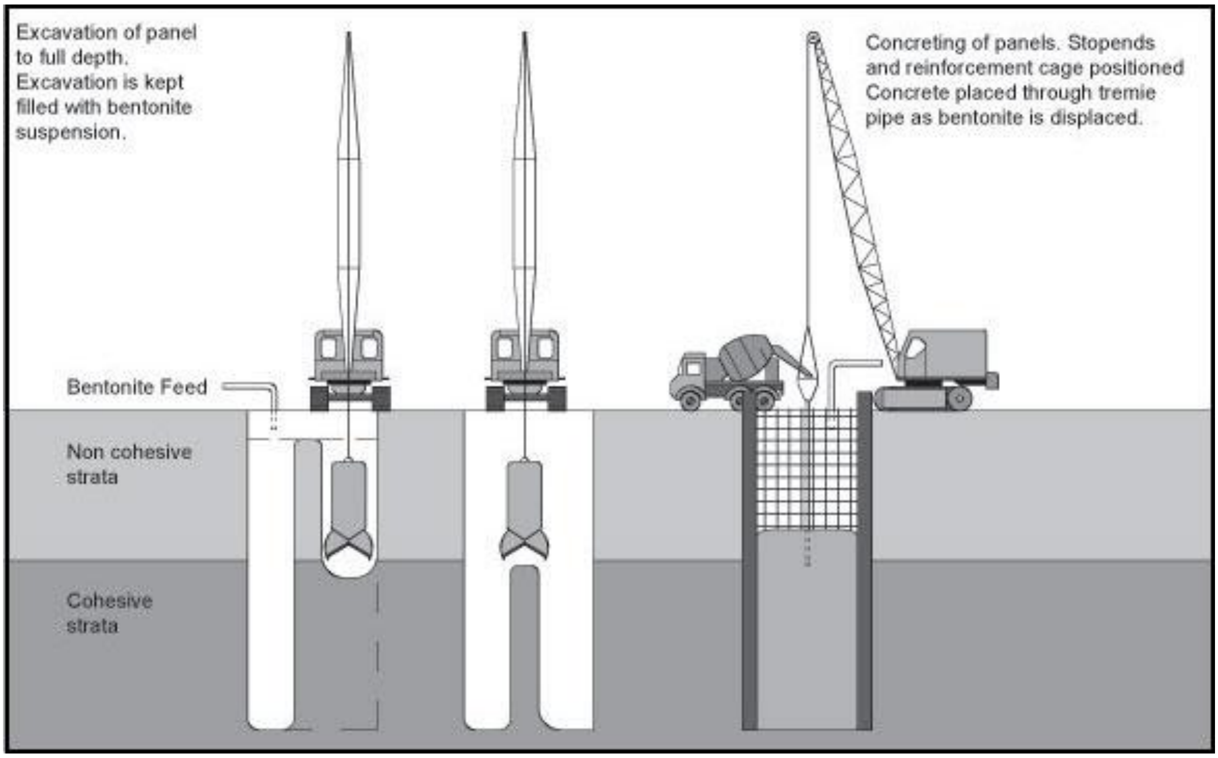

Figure 5. The methods used in constructing a diaphragm wall (source: Balfour Beatty Ground Engineering).

4 Operational phase

The proposed floating dry dock will be pump controlled involving two ballast tanks each with two pumps, although adjustments in depth of the platform will be obtainable with only one pump if necessary.

Maintenance and repair operations currently taking place at the existing repair quay include:

- blasting and repainting of ships (e.g. hull, freeboard, superstructure, interior tanks and work areas);
- major rebuilding and installation of machinery (e.g. diesel engines, turbines, generators, pump stations);
- system overhauls, maintenance, and installation (e.g. piping system flushing, testing and installation);
- system replacement and installation (e.g. navigational systems, communication systems, piping systems);
- propeller and rudder repairs, modification and alignment;
- creation of new machinery spaces through cut outs of the existing steel structure; and
- the addition of new structures (e.g. walls, stiffeners, webbing).

The above activities will continue to take place at the existing repair quay, while the following activities will take place at the proposed floating dry dock (activities associated with proposed project seeking authorisation):

- pressure washing and abrasive blasting;
- painting and coating (including anti-fouling paint);
- engine maintenance and repair; and
- electric and gas welding.

Other activities such as machining, metal working, solvent cleaning and degreasing will continue to take place within existing workshop located within the shipyard.

4.1 Surface preparation

In order to repaint the hull of a vessel, marine growth must be removed along with the existing paint and anti-fouling coatings. The most common method of surface preparation used in shipyards is abrasive blasting. This method will be employed at the proposed floating dry dock and will be undertaken within open air blast booths using mineral slag as grit material. Hand tool preparation will also be employed for small jobs in hard to reach areas and where grit blasting would be too difficult to contain. In these circumstances grinders, wire brushes, sanders, chipping hammers and needle guns will be used.

4.2 Painting and coating

Anti-fouling paint is a specialized coating applied to the hull of a vessel to slow the growth of organisms, which affect a vessel's performance and durability. Hull coatings may have other functions, such as acting as a barrier against corrosion on metal hulls. Dormac will use airless spray guns for spray painting this coating onto the hull. This technique is favoured over conventional spray systems for 3 reasons:

- reduced overspray and rebound;
- high application rates and transfer efficiency; and
- application of high-build coatings, thus fewer coats are required.

Mixing and application of paint will take place on the floating dry dock. Dormac does not supply anti-fouling paint for vessels as these are specific to the preferences of each vessel owner.

5 Description of the affected environment

5.1 The ecological importance of estuaries

Estuaries are extremely productive ecosystems due to the combination of high nutrient river water with a shallow, sheltered habitat (Robins *et al*. 2006). Estuaries are also valued for their importance as nurseries for juvenile marine fish and invertebrates, which recruit to these protected and nutrient rich areas during their developmental stages (Beck *et al*. 2001). Despite their massive importance, estuaries are impacted by poor catchment management upstream including erosion, pollution and water abstraction. This, along with the development of harbours, has resulted in the majority of these estuarine ecosystems becoming severely degraded, leading to concern about the biota within the systems. It is important to conserve and manage the remaining mangroves, mudflats and sandbanks of Durban Harbour in order to retain the valuable ecological functions that they offer to the system.

5.2 Habitat types within the Durban Harbour

A number of studies have been completed in recent years focusing on the estuarine biota of the Port of Durban (see for example Allan *et al*. 1999, Pillay 2002, Blackler *et al.* 2004, Forbes & Demetriades 2006, Angel and Clark 2008, Newman *et al*. 2008, Weerts 2010, MER/ERM 2012). These data were used to assess the significance of potential impacts that the proposed development may have on the biota of the Port of Durban.

Habitats available to estuarine flora and fauna include intertidal areas, benthic substratum and the overlying water column that are each utilised by a range of organisms, the most important of which include microalgae, phytoplankton, invertebrates, zooplankton, fish and birds. As few macroalgae and no mangroves occur in the affected area, these organisms are not considered in detail in this report.

The intertidal areas at Bayhead, adjacent to the mangroves, have a sand fraction of 50 to 70% and mud is quite prevalent (Wright 1996). Only a small proportion of shallow and moderately shallow subtidal areas of Durban Bay remain, as most of it has been dredged to 12.8 m below sea-level (Weerts 2010). The majority of these deep subtidal areas of the harbour consist of varying proportions of sand and mud; however, mud content is generally higher, ranging from 10 to 90% (Wright 1996). Mud content is highest towards the head of the Bay and lowest near the Harbour mouth (Figure 6).

Durban Harbour is considered to be highly transformed, with most of the natural habitat destroyed as a result of dredging operations during the construction of the Harbour (Allan *et al*. 1999). It is estimated that only 14% of the original tidal flats remain (Allan *et al*. 1999). The mangrove swamp area has also been severely reduced. Durban Harbour had an extensive mangrove forest of approximately 200 ha in extent but 78% of this was physically removed in 1979 when construction of the Harbour began (Ward and Steinke 1982). These habitats have been replaced with open water areas and concrete berths to allow for the safe passage and mooring of large vessels. The substratum lying beneath the open waters, which was artificalliy created by dredging, is the dominant habitat covering an area of 714.6 ha (McInnes *et al*. 2005).

Recent physico-chemical data were collected for the Port of Durban by Newman *et al*. (2008). Bottom salinity levels of the Harbour waters were found to be homogenous at 35 ppt, despite the input of freshwater at Bayhead. Bottom water temperatures show little spatial variation and typically range from 19 to 22°C seasonally. Bottom dissolved oxygen levels are low (approximately 6 $mg.L^{-1}$, 70-80% saturation) for most of the central area of the harbour. Measurements are lower near Bayhead (around 5$mg.L^{-1}$, 50-60% saturation) but are still within the tolerance range for most aquatic species (i.e. ≥5 mg/L^{-1}, USEPA 2003).

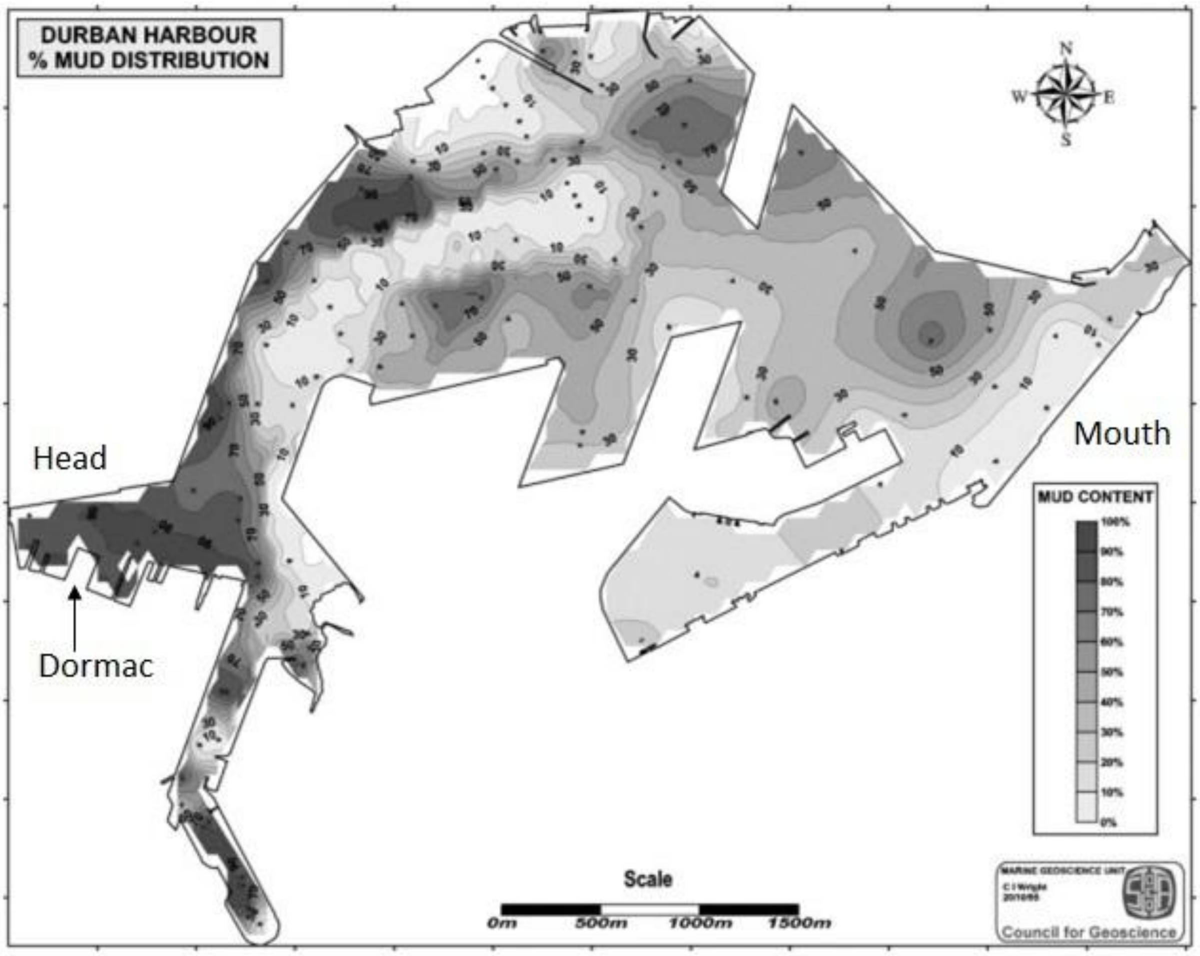

Figure 6. Proportion of mud in sediments of Durban Harbour (adapted from Wright 1996).

5.2.1 Centre Bank

Centre Bank is a large intertidal and subtidal sand flat approximately 2 km north-east of Dormac (Figure 7). It has an intertidal area of approximately 83 hectares and a steep subtidal section that forms the slopes of the sand flat, which falls away quickly to the Port operational depth of 12.8 m (Weerts 2010). The intertidal area comprises material with a median grain size of approximately 0.25 mm (Newman *et al*. 2008). The majority (≈90%) of this material consists of fine to medium sands, with only 3% comprising mud (Figure 6 &Figure 11). Sorting coefficients average 0.4 and range from 0.21 to 0.65 depending on the area of the bank (Newman *et al*. 2008). Total organic content is relatively low compared to other sand banks in the Harbour and ranges from 0 to 0.5% (Newman *et al*. 2008). Salinity levels correspond with that of seawater (35 ppt) and turbidity levels are very low, generally between 2 and 5 NTU (Newman *et al*. 2008). Dissolved oxygen levels are close to saturation at 5-6 $mg.l^{-1}$.

Figure 7. Location of Centre Bank and Little Lagoon in relation to Dormac and the impact area. The impact area includes all water west of the red line (Google Earth 2014).

The intertidal sand flats that make up Centre Bank have been identified as extremely important to the ecological functioning of the Port of Durban (Newman *et al*. 2008, Weerts 2010). This area is important from a conservation perspective (Allan *et al*. 2005), and has accordingly been zoned for conservation by the Bay of Natal Estuary Management Plan (MER/ERM 2012). Furthermore, Durban Bay has been included in a subset of estuaries identified in the estuary component of the South African National Biodiversity Assessment as requiring partial protection in order to provide for the conservation of estuarine biodiversity in South Africa (Van Niekerk and Turpie 2012). Large populations of sand prawns, densities possibly matching those of the Kosi estuarine system, are found on these banks (Weerts 2010). In addition, the sand banks represent very important habitat for juvenile fishes (Day and Morgan 1956, Cyrus and Forbes 1996, Forbes *et al*. 1996).

McInnes *et al.* (2005) stated that based on a four-year study of the avifauna of the Port of Durban, "potentially half of the waterbird population of Durban Harbour could be negatively impacted as a result of any modification of this area." This is because the intertidal sand banks play a critical role in providing food in the form of invertebrates to many of the bird species in the Bay. Furthermore, there is a high abundance of juvenile fishes within the Bay, a large proportion of which feed specifically on intertidal invertebrates (Cyrus and Forbes 1996; Forbes *et al.* 1996). If the invertebrate prey decline due to the reduction of intertidal habitat, this will almost certainly result in a decrease in the abundance of juvenile fish, which will have a negative effect on piscivorous birds (Hockey and Turpie 1999). Many species of birds, particularly Palaearctic waders, are dependent on Centre Bank for food and are protected by the Bonn Convention on the Conservation of Migratory Species of which South Africa is a signatory member (Bonn 2013).

Centre Bank is one of the least polluted areas in the Port and presents the most favourable conditions for growth of benthic microalgae or diatoms (MER/ERM 2012). Sediment-core samples have shown that this site hosts a greater diversity of species compared to the other banks in the Port, probably because of the more favourable water quality (MER/ERM 2012). The abundance of diatoms supports a suite of microorganisms that in turn, support many species of macrofauna and juveniles fishes (MER/ERM 2012). As previously mentioned, shallow areas such as sand banks are known to be extremely important nursery areas for juvenile fishes (Blaber 1974, Cyrus and Forbes 1996, Weerts and Cyrus 2002). The most diverse group of macrofauna at Centre Bank appear to be the Polychaetes, followed by Malacostracans. The sand bank supports high densities of sand prawn *Callichirus kraussi,* higher than most of the other sand banks in the Port (Newman *et al*. 2008). These crustaceans play a crucial role as bioturbators by increasing the sediment-water interface, thereby facilitating particle exchange between the sediment and water column. They are also a very important food source for fishes. The most abundant fish species in the waters surrounding Centre Bank are *Ambassis gymnocephalus*, *A. natalensis, Diplodus capensis*, *Sillago sihama* and *Liza* dumerili (Angel and Clark 2008, Newman *et al.* 2008). Other species recorded on Centre Bank include *Amblyrhynchotes honckenii, Crenidens crenidens, Favonigobius reichei, Gerres longirostris, G. filamentosus, G. methueni, Platycephalus indicus, Pomadasys commersonnii, Sphyraena barracuda, Liza richardsonii, Valamugil buchanani, Lactoria cornuta* and an undescribed species of the genus *Torquigener.* None of these species are threatened.

5.2.2 Little Lagoon habitat and biodiversity

Little Lagoon is located on the southern end of the Centre Bank sand flat, approximately 1 km from Dormac (Figure 7). It comprises predominantly intertidal habitat, but incorporates an important shallow subtidal area of 19 200 m^2 that reaches depths of 1.6 m during spring low tide. The sediment and water quality data presented below have been extracted from Forbes and Demetriades (2003). The deeper areas of Little Lagoon comprise relatively fine sediments with median particle sizes of 0.1 mm (very fine grained sand according to the Wentworth Scale), while shallower areas that are more exposed to wave action have slightly coarser median grain sizes of 0.2 - 0.3 mm (medium grained sand). The sediments in this area have relatively high proportions of organic matter ranging from 2.0

to 6.9% organic content, with an overall mean of 3.4%. These values are significantly higher than those calculated for the intertidal areas of Centre Bank. Water temperatures are generally typical of shallow parts of subtropical estuaries and ranged between 18 and 29°C depending on the season. Salinity levels generally corresponded to that of sea water (35 ppt), although during high periods of rainfall, values as low as 21 ppt are recorded. Levels of suspended sediment in this area are generally low with average values of 28 and 14 Nephelometric Turbidity Units (NTU) for summer and winter months respectively. However, values as high as 100 NTU have been recorded for short periods during windy and turbulent conditions. Dissolved oxygen levels are high in this area (6.9 – 7.7 $mg.l^{-1}$).

Phytoplankton densities are considered to be low as chlorophyll-*a* values of only 0.06 – 1.3 $\mu g.L^{-1}$ were recorded by Forbes and Demetriades (2003) over the course of a two year period. Zooplankton present in Little Lagoon are numerically dominated by Copepods, especially *Parvocalanus crassirostris*. Other important components of the zooplankton are larvae of Caridean crustaceans.

In terms of benthic macrofauna, intertidal areas are dominated by the sand prawn *Callichirus kraussi* and the soldier crab *Dotilla fenestrate*. Shallow subtidal areas are generally more diverse and a total of 37 taxa were found in these parts by Forbes and Demetriades (2003). This community is dominated by polychaete worms (especially *Prionospio sexoculata*), followed by isopods (particularly *Leptanthura laevigata*), Cumaceans and the Molluscs *Nassarius kraussianus, Dosinia hepatica* and *Eumercia paupercula* (Table 1). Densities of organisms lie between 500 and 2 000 animals/m^2, although densities of greater than 10 000 animals/m^2 have been recorded at some areas during certain times of the year (Forbes and Demetriades 2003).

At least 36 species of fishes occur in Little Lagoon, the most abundant species (>80%) being *Ambassis dussumieri* (Forbes and Demetriades 2003). Other notable species that occur at considerably lower numbers (<5%), were *Thryssa vitrirostris*, *Gerres filamentosus*, *G. longirostris, Leiognathus equulus, Liza dumerili* and *Sillago sihama.* The majority of these species are estuary-dependent, which is not surprising as it is well recognised that Little Lagoon provides extremely valuable nursery habitat for many juvenile fishes (Cyrus and Forbes 1996, Forbes and Demetriades 2003).

6 Overview of marine biodiversity in the Port of Durban

Historical records show that the Port of Durban supported a high diversity of flora and fauna with a mixture of both tropical and subtropical species. Day and Morgan (1956) were the first to conduct a comprehensive inventory of the fauna present. They recorded a total of 563 species from various habitats within the Port area. Forty years later a similar survey was conducted by Hay *et al*. (1995). The latter study did not consider fauna closely associated with the mangroves but the change in the numbers of species present is nonetheless profound. The study by Hay *et al*. (1995) highlighted both the importance of the Bay as a nursery area, and the disappearance of juvenile Penaeid prawns due to reduced habitat. Figure 8 compares the number of invertebrate species collected from different taxonomic groups between the two surveys.

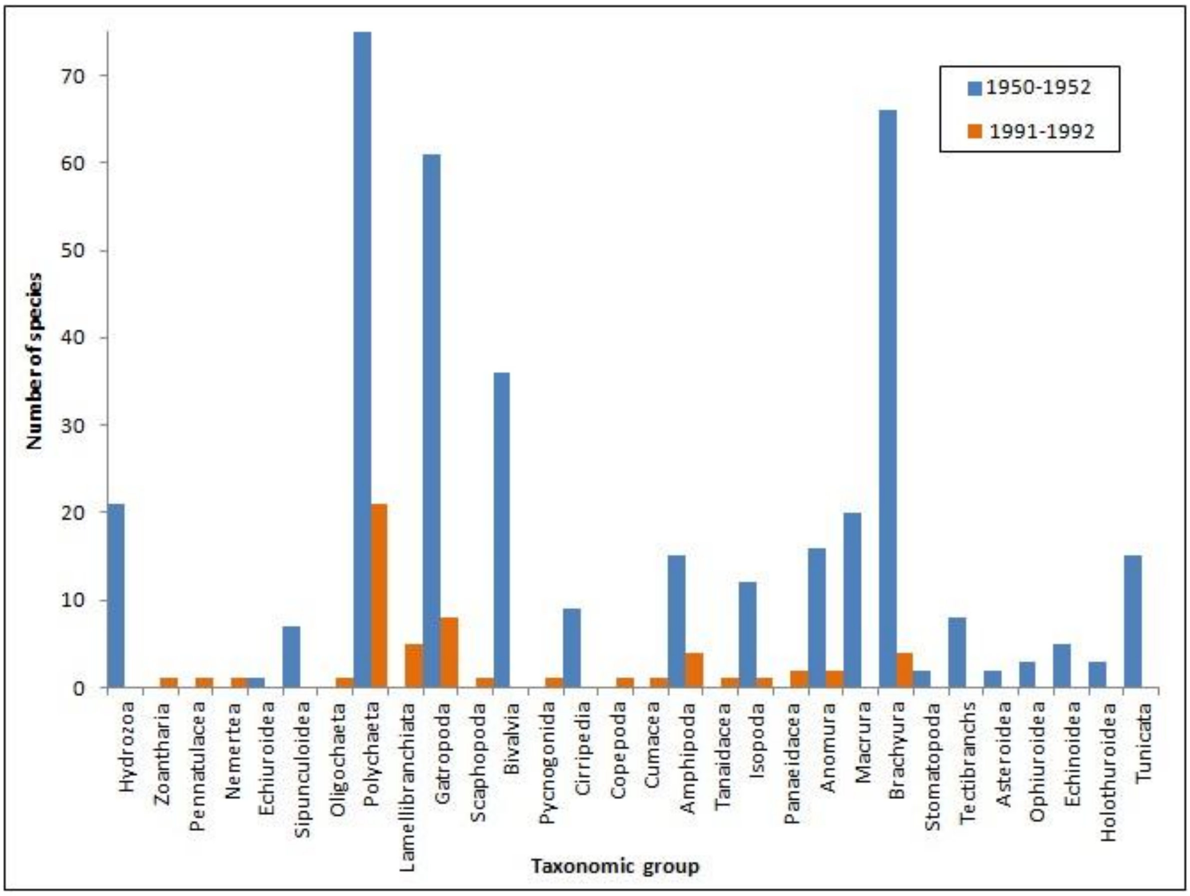

Figure 8. Total number of species, from 20 taxonomic groups, found within Durban Harbour. Species collected from 1950 to 1952 (Day and Morgan 1956) are depicted in blue, while those collected from 1991 to 1992 are depicted in orange (Hay *et al.* 1995).

Concern has been growing regarding the poor biological status and loss of estuarine habitat in the KwaZulu-Natal region brought on by sedimentation and increasing frequency of estuary mouth closure. Despite the decline in biodiversity within the Port of Durban over the decades, the development of harbours at Richards Bay and Durban have in some way mitigated the complete disappearance of this habitat type by providing permanently open estuary mouth states. As a result, these ports now support the largest areas of sheltered intertidal habitat in the province (Cyrus and Forbes 1996).

6.1 Macrofaunal community composition within the Port of Durban

A number of recent surveys have been conducted in the soft-sediment habitats of the Port of Durban (Pillay 2002, Angel and Clark 2008, Newman *et al.* 2008 and Weerts 2010). Site specific data used in this report has been extracted from Angel and Clark (2008) and Pillay (2002) with the relevant sites depicted in Figure 9.

Collection methods included quadrat scrapes from hard surfaces (piers and pilings), sediment core grab samples from soft sediments, crab traps, gill nets, seine nets and phytoplankton tows. Information of species recorded in the different habitats is summarised in Table 1.

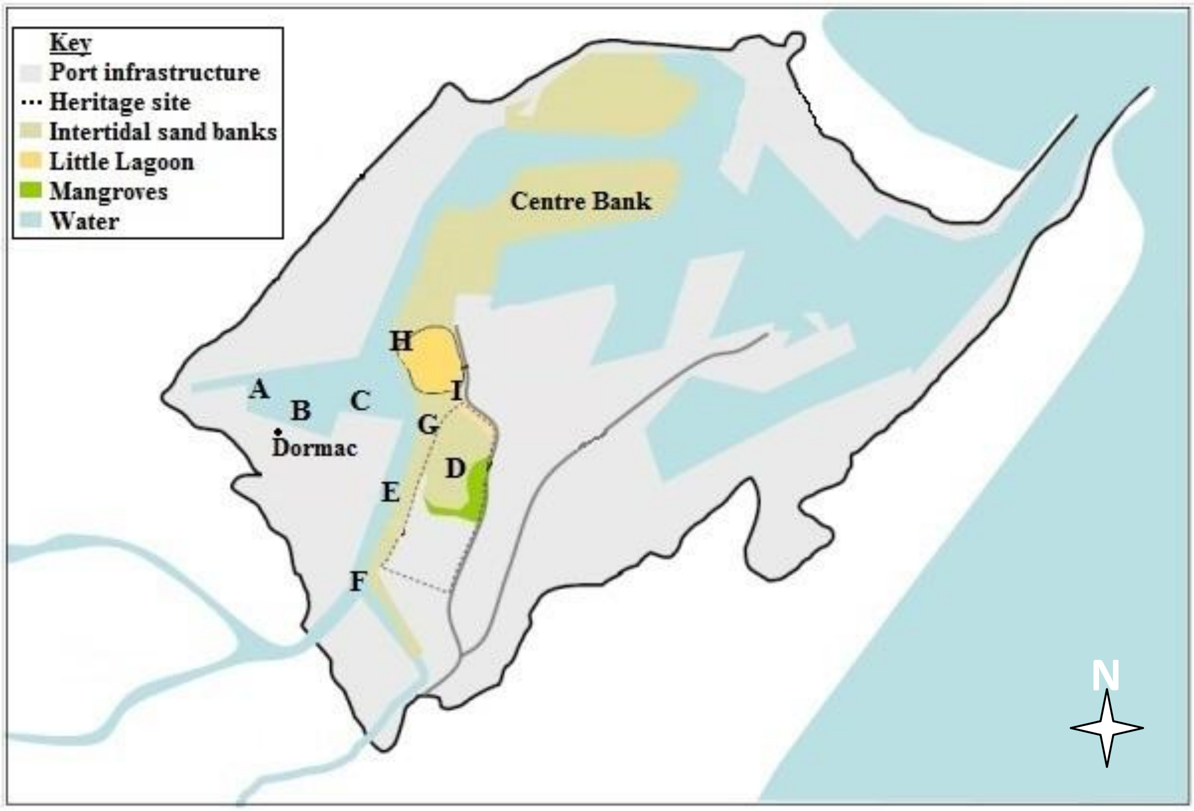

Figure 9. Map showing sites that have been sampled in Bayhead and Little Lagoon. Site specific data used in this report were extracted from Angel and Clark (2008) and Pillay (2002).

Recent surveys show that a total of approximately 85 invertebrate species have been recorded in the soft-sediment habitats of the Port of Durban (Pillay 2002, Angel and Clark 2008, Newman *et al.* 2008 and Weerts 2010). Overall, diversity was highest among the Polychaetes with 27 taxa recorded, followed by the Malacostraca with 18 taxa. Other important classes well represented in the fauna included the Gastropods and Bivalves.

In recent times, relatively more sampling has been conducted in sand-flat habitats than in the deeper subtidal areas of the Durban Bay, partly because the ecological role that the sand banks play has been recognised as being disproportionately important. The benthic fauna in the deeply dredged channels is reportedly depauperate, consisting of a few species of coelenterates, amphipods, isopods, polychaetes, annelids and crabs (Hay 1995). Results show very low abundance (<50 individuals.m^{-2}) and low levels of diversity (<6 taxa.m^{-2}) of invertebrates in these areas (Angel and Clark, unpublished data). This is likely due to the periodic dredging operations required to maintain the operating depth of the Port, disturbance caused by ship propellers and the anoxic conditions that are characteristic of much of the deeper sediments in the Harbour (Newman *et al*. 2008).

Highest diversity and biomass of invertebrates is undoubtedly attained at the remaining intertidal and shallow subtidal sand-flat habitats that have not been dredged and are comparatively well oxygenated. These areas are not within the direct impact zone for this project as they are situated 1 km north-east of Bayhead. Newman *et al.* (2008) recorded an average of 11 taxa per square meter of sandbank, while Pillay (2002) recorded a total of 38 taxa at Little Lagoon alone. Highest diversities appear to be found at Little Lagoon, which is a shallow subtidal flat opposite Bayhead. Densities of organisms at Little Lagoon are high, with an average density of 2 888 individuals.m^{-2} recorded by Newman *et al.* (2008), while Pillay (2002) recorded 3 226 individuals of *Halmyrapseudes cooperi* per square metre and 578 individuals.m^{-2} of *Prionospio sexoculata*. Average densities were also high for the intertidal flats, with Centre Bank reportedly supporting an average density of 902 individuals.m^{-2} (Newman *et al*. 2008). Intertidal sand flats are also well recognised for the abundance of Callianassid prawns (*Callichirus kraussi*) that occur in these areas (Newman 2008, Weerts 2010). Macrofauna residing in these sand flats support important assemblages of fishes and birds (Allan *et al*. 1999, McInnes *et al*. 2005, Newman *et al.* 2008).

Table 1. Invertebrate taxa recorded from Bayhead (Angel and Clark 2008) and Little Lagoon (Pillay 2002) in the Port of Durban. Crosses (X) indicate the presence of a species at a particular site. See Figure 9 for site locations.

				Method	**Quadrat scrape**		**Sediment core**			***Grab**		**Crab trap**	**Gill net**		**Seine net**		**Phyto - plankton**
Phylum	**Class**	**Order**	**Family**	**Site**	**A**	**C**	**C**	**D**	**I**	**G**	**H**	**D**	**A**	**D**	**C**	**E**	**C**
Annelida	Polychaeta	Eunicida	Dorvilleidae	*Papilliodorvillea gardineri*	X	X											
Annelida	Polychaeta	Eunicida	Eunicidae	*Marphysa depressa*					X								
Annelida	Polychaeta	Eunicida	Eunicidae	*Marphysa purcellana*		X											
Annelida	Polychaeta	Eunicida	Lumbrineridae	*Lumbrineris cavifrons*		X											
Annelida	Polychaeta	Phyllodocida	Glyceridae	*Glycera alba*					X					X			
Annelida	Polychaeta	Phyllodocida	Glyceridae	*Glycera natalensis*							X						
Annelida	Polychaeta	Phyllodocida	Glyceridae	*Glycera tridactyla*						X							
Annelida	Polychaeta	Phyllodocida	Nereididae	*Dendronereis arborifera*					X	X	X						
Annelida	Polychaeta	Phyllodocida	Nereididae	*Leonnates decipiens*		X											
Annelida	Polychaeta	Phyllodocida	Nereididae	*Simplisetia erythraeensis*					X								
Annelida	Polychaeta	Phyllodocida	Phyllodocidae	*Nereiphylla castanea*				X	X								
Annelida	Polychaeta	Phyllodocida	Polynoidae	*Harmothoe dictyophora*	X	X											
Annelida	Polychaeta	Phyllodocida	Polynoidae	*Harmothoe goreensis*	X	X											
Annelida	Polychaeta	Phyllodocida	Polynoidae	*Lepidonotus tenuisetosus*		X											
Annelida	Polychaeta	Phyllodocida	Syllidae	*Syllis gracilis*		X											
Annelida	Polychaeta	Sabellida	Sabellidae	*Desdemona ornata*					X	X							
Annelida	Polychaeta	Sabellida	Sabellidae	*Hypsicomus phaeotaenia*	X												
Annelida	Polychaeta	Sabellida	Sabellidae	*Megalomma spp.*					X								
Annelida	Polychaeta	Sabellida	Sabellidae	*Pseudopotamilla reniformis*	X												
Annelida	Polychaeta	Sabellida	Sabellidae	*Sabellastarte sanctijosephi*		X											
Annelida	Polychaeta	Sabellida	Serpulidae	*Ficopomatus enigmaticus*	X												
Annelida	Polychaeta	Sabellida	Serpulidae	*Hydroides diramphus*	X												
Annelida	Polychaeta	Sabellida	Serpulidae	*Serpula vermicularis*		X											
Annelida	Polychaeta	Sabellida	Serpulidae	*Spirobranchus spp.*	X												

				Method	Quadrat scrape		Sediment core			*Grab		Crab trap	Gill net		Seine net		Phyto - plankton
Phylum	**Class**	**Order**	**Family**	**Site**	**A**	**C**	**C**	**D**	**I**	**G**	**H**	**D**	**A**	**D**	**C**	**E**	**C**
Annelida	Polychaeta	Sabellida	Serpulidae	*Spirobranchus tetraceros*	X	X											
Annelida	Polychaeta	Scolecida	Capitellidae	*Capitella capitata*						X							
Annelida	Polychaeta	Scolecida	Capitellidae	*Notomastus latericeus*				X	X	X							
Annelida	Polychaeta	Scolecida	Cossuridae	*Cossura coasta*					X	X							
Annelida	Polychaeta	Scolecida	Maldanidae	Unidentified					X								
Annelida	Polychaeta	Scolecida	Orbiniidae	*Scoloplos johnstonei*					X								
Annelida	Polychaeta	Spionida	Poecilochaetidae	*Poecilochaetus serpens*						X							
Annelida	Polychaeta	Spionida	Spionidae	*Polydora ciliata*		X											
Annelida	Polychaeta	Spionida	Spionidae	*Polydora spp.*	X	X			X	X	X						
Annelida	Polychaeta	Spionida	Spionidae	*Prionospio cirrifera*							X						
Annelida	Polychaeta	Spionida	Spionidae	*Prionospio sexoculata*					X	X	X						
Annelida	Polychaeta	Spionida	Spionidae	*Scolelepis squamata*					X								
Annelida	Polychaeta	Terebellida	Cirratulidae	*Cirriformia punctata*		X			X								
Annelida	Polychaeta	Terebellida	Cirratulidae	*Dodecaceria spp.*	X	X											
Annelida	Polychaeta	Terebellida	Cirratulidae	*Monticellina*							X						
Annelida	Polychaeta	Terebellida	Terebellidae	*Eupolymnia nebulosa*	X	X											
Annelida	Polychaeta	Terebellida	Terebellidae	*Streblosoma hesslei*		X											
Annelida	Polychaeta	Terebellida	Trichobranchidae	*Trichobranchus glacialis*		X											
Arthropoda	Malacostraca	Amphipoda	Aoridae	*Grandidierella*					X								
Arthropoda	Malacostraca	Amphipoda	Corophiidae	*Americorophium triaeonyx*					X								
Arthropoda	Malacostraca	Amphipoda	Lysianassidae	*Lysianassa ceratina*		X											
Arthropoda	Malacostraca	Amphipoda	Melitidae	*Melita zeylanica*					X								
Arthropoda	Malacostraca	Cumacea	Unidentified	Unidentified					X								
Arthropoda	Malacostraca	Decapoda	Alpheidae	*Alpheus bisincisus*	X												
Arthropoda	Malacostraca	Decapoda	Alpheidae	*Betaeus jucundus*					X								
Arthropoda	Malacostraca	Decapoda	Alpheidae	*Synalpheus tumidomanus*		X											

				Method	Quadrat scrape		Sediment core			*Grab		Crab trap	Gill net		Seine net		Phyto - plankton
Phylum	**Class**	**Order**	**Family**	**Site**	**A**	**C**	**C**	**D**	**I**	**G**	**H**	**D**	**A**	**D**	**C**	**E**	**C**
Arthropoda	Malacostraca	Decapoda	Callianassidae	*Callichirus kraussi*					X	X	X			X			
Arthropoda	Malacostraca	Decapoda	Camptandriidae	*Paratylodiplax*					X								
Arthropoda	Malacostraca	Decapoda	Caridea	Unidentified	X	X											
Arthropoda	Malacostraca	Decapoda	Hexapodidae	*Spiroplax spiralis*					X		X						
Arthropoda	Malacostraca	Decapoda	Hymenosomatida	*Hymenosoma orbiculare*					X								
Arthropoda	Malacostraca	Decapoda	Ocypodidae	*Dotilla fenestrata*											X		
Arthropoda	Malacostraca	Decapoda	Ocypodidae	*Ocypode ceratophthalmus*									X				
Arthropoda	Malacostraca	Decapoda	Penaeidae	*Fenneropenaeus indicus*									X				
Arthropoda	Malacostraca	Decapoda	Penaeidae	*Marsupenaeus japonicus*												X	
Arthropoda	Malacostraca	Decapoda	Portunidae	*Portunus pelagicus*										X			
Arthropoda	Malacostraca	Decapoda	Portunidae	*Thalamita admete*	X												
Arthropoda	Malacostraca	Decapoda	Upogebiidae	*Upogebia africana*					X								
Arthropoda	Malacostraca	Isopoda	Anthuridae	*Cyathura estuaria*					X								
Arthropoda	Malacostraca	Isopoda	Cirolanidae	*Cirolana luciae*	X				X								
Arthropoda	Malacostraca	Isopoda	Leptanthuridae	*Leptanthura laevigata*					X								
Arthropoda	Malacostraca	Isopoda	Ligiidae	*Ligia exotica*	X												
Arthropoda	Malacostraca	Isopoda	Sphaeromatidae	*Sphaeroma walkeri*		X											
Arthropoda	Malacostraca	Tanaidacea	Parapseuddidae	*Halmyrapseudes digitalis*					X								
Arthropoda	Maxillopoda	Sessilia	Balanidae	*Amphibalanus amphitrite*	X	X											
Bacillariophyt	Coscinodiscophycea	Thalassiosirales	Skeletonemaceae	*Skeletonema costatum*													X
Mollusca	Bivalvia	Euheterodonta	Solenidae	*Solen cylindraceus*					X								
Mollusca	Bivalvia	Mytiloida	Mytilidae	*Arcuatula capensis*		X											
Mollusca	Bivalvia	Mytiloida	Mytilidae	*Brachidontes virgiliae*					X								
Mollusca	Bivalvia	Ostreoida	Ostreidae	*Striostrea margaritacea*	X	X											
Mollusca	Bivalvia	Veneroida	Cardiidae	*Fulvia laevigata*					X								
Mollusca	Bivalvia	Veneroida	Tellinidae	*Tellina prismatica*					X								

				Method	Quadrat scrape		Sediment core			*Grab		Crab trap	Gill net		Seine net		Phyto - plankton
Phylum	**Class**	**Order**	**Family**	**Site**	**A**	**C**	**C**	**D**	**I**	**G**	**H**	**D**	**A**	**D**	**C**	**E**	**C**
Mollusca	Bivalvia	Veneroida	Veneridae	*Dosinia hepatica*					X	X	X						
Mollusca	Bivalvia	Veneroida	Veneridae	*Eumarcia paupercula*					X	X	X						
Mollusca	Gastropoda	Cephalaspidea	Cylichnidae	*Acteocina fusiformis*					X								
Mollusca	Gastropoda	Neogastropoda	Muricidae	*Ergalatax heptagonalis*		X											
Mollusca	Gastropoda	Neogastropoda	Nassariidae	*Nassarius kraussianus*					X				X	X			
Mollusca	Gastropoda	Neotaenioglossa	Littorinidae	*Littoraria scabra*		X											
Mollusca	Gastropoda	Neotaenioglossa	Naticidae	*Polinices tumidus*										X			
Mollusca	Gastropoda	Neotaenioglossa	Potamididae	*Terebralia palustris*									X				
Mollusca	Gastropoda	Veneroida	Solenidae	*Solen cylindraceus*										X			

6.2 Fish fauna in the Port of Durban

The fish fauna in the Port of Durban was considered to be very diverse in the 1950s when a total of 186 species were recorded by Day and Morgan (1956). The most-common fish species recorded during this time were *Terapon jarbua*, *Mugil cephalus*, *Lisa dumerili*, *Ambassis gymnocephalus* and *Leiognathus equulus*. Many of these species are recognised as being dependent on estuaries, and the Bay was found to be a valuable nursery ground for these fishes. The two most recent surveys conducted by Angel and Clark (2008) and Newman *et al*. (2008) recorded many fewer species, at 29 and 34 species respectively. Despite this, they still confirmed the findings of previous studies, in that the majority of fishes in the Bay were estuary dependent (Day and Morgan 1956, Cyrus and Forbes 1996, Forbes *et al.* 1996). Similar methods were used between surveys, although the effort, timing and specific sample localities differed somewhat.

Detailed information on catches is available from a survey undertaken by Angel and Clark (2008) in which a total of 696 fishes were collected in 19 gill and seine net samples. The most prolific species in terms of abundance were the Ambassids (29.9%), mainly because of a high catch of bald glassies (*Ambassis gymnocephalus*), Leiognathids (10.5%) comprising the common ponyfish (*Leiognathus equulus*), and five species of Mugilids (8.2%) consisting mainly of groovy mullet (*Liza dumerili*). These three families contributed nearly half the fish sampled (48%). Table 2 shows that the majority of species caught were similar to those recorded by Hay *et al*. (1995), Day and Morgan (1956) and Whitfield (1998). Most of the species are either listed as 'Least Concern' on the IUCN Red List (2013) or have not been assessed at all, with the exception of the tropical sand gobi *Favonigobius reichei*, which is listed as 'Low Risk/Near Threatened'. The data for this species is outdated and needs to be revised.

Table 2. **Species of fish recorded by Angel and Clark (2008), Hay *et al.* (1995), Day and Morgan (1956) and Whitfield (1998) are indicated by crosses (X). Species that are near-threatened are marked with an asterisk (*). The Estuarine Dependence Category (EDC) is also listed where available.**

Order	Family	Species	Common name	EDC	Angel & Clark (2008)	Hay *et al.* (1995)	Day & Morgan (1956)	Whitfield (1998)
Beloniformes	Belonidae	*Strongylura leiura*	Banded needlefish	III				X
Beloniformes	Belonidae	*Tylosurus crocodilus*	Hound needlefish		X	X	X	
Clupeiformes	Clupeidae	*Hilsa kelee*	Kelee shad	IIc				X
Clupeiformes	Engraulidae	*Thryssa vitrirostris*	Orangemouth anchovy	IIa				X
Elopiformes	Elopidae	*Elops machnata*	Tenpounder		X	X	X	
Gonorhynchiformes	Chanidae	*Chanos chanos*	Milkfish		X		X	
Mugiliformes	Mugilidae	*Liza alata*	Diamond mullet					X
Mugiliformes	Mugilidae	*Liza dumerili*	Groovy mullet	IIb	X	X	X	X
Mugiliformes	Mugilidae	*Liza macrolepis*	Large-scaled mullet	IIa	X	X	X	X
Mugiliformes	Mugilidae	*Liza richardsonii*	Southern mullet		X		X	
Mugiliformes	Mugilidae	*Mugil cephalus*	Striped mullet					X
Mugiliformes	Mugilidae	*Myxus capensis*	Freshwater mullet	IIa				X
Mugiliformes	Mugilidae	*Valamugil buchanani*	Bluetail mullet	IIa	X	X	X	X
Mugiliformes	Mugilidae	*Valamugil cunnesius*	Longarm mullet	IIa				X
Mugiliformes	Mugilidae	*Valamugil robustus*	Robust mullet		X		X	
Perciformes	Ambassidae	*Ambassis dussumieri*	Barehead glassy	Ib				X
Perciformes	Ambassidae	*Ambassis gymnocephalus*	Bald glassy		X	X	X	
Perciformes	Ambassidae	*Ambassis natalensis*	Slender glassy	Ib	X	X	X	X
Perciformes	Carangidae	*Caranx sexfasciatus*	Bigeye trevally	IIb	X		X	X
Perciformes	Carangidae	*Lichia amia*	Garrick	IIa				X
Perciformes	Carangidae	*Scomberoides lysan*	Doublespotted queenfish		X		X	
Perciformes	Carangidae	*Scomberoides tol*	Needlescaled queenfish	III				X
Perciformes	Echeneidae	*Phtheirichthys lineatus*	Slender suckerfish		X			

Order	Family	Species	Common name	EDC	Angel & Clark (2008)	Hay *et al.* (1995)	Day & Morgan (1956)	Whitfield (1998)
Perciformes	Gerreidae	*Gerres filamentosus*	Threadfin pursemouth	IIb	X	X	X	X
Perciformes	Gerreidae	*Gerres longirostris*	Smallscale pursemouth	IIb	X	X	X	X
Perciformes	Gerreidae	*Gerres methueni*	Striped silver pursemouth	IIb				X
Perciformes	Haemulidae	*Pomadasys commersonnii*	Spotted grunter	IIa	X	X	X	X
Perciformes	Haemulidae	*Pomadasys maculatus*	Saddle grunter		X			
Perciformes	Haemulidae	*Pomadasys olivaceus*	Olive grunter					X
Perciformes	Leiognathidae	*Leiognathus equulus*	Common ponyfish	IIc	X	X	X	X
Perciformes	Lutjanidae	*Lutjanus russellii*	Russell's snapper	IIc?				X
Perciformes	Lutjanidae	*Lactoria cornuta*	Longhorn cowfish	III				X
Perciformes	Sillaginidae	*Sillago sihama*	Silver sillago	IIc	X	X	X	X
Perciformes	Sparidae	*Crenidens crenidens*	Karenteen	III	X		X	X
Perciformes	Sparidae	*Diplodus capensis*	White seabream		X		X	
Perciformes	Sparidae	*Rhabdosargus holubi*	Cape stumpnose	IIa				X
Perciformes	Sparidae	*Rhabdosargus sarba*	Yellowfin seabream	IIa	X	X	X	X
Perciformes	Sphyraenidae	*Sphyraena jello*	Pickhandle barracuda	IIc?				X
Perciformes	Sphyraenidae	*Sphyraena putnamae*	Sawtooth barracuda		X		X	
Perciformes	Gerreidae	*Gerres methueni*	Evenfin pursemouth		X	X		
Perciformes	Gobiidae	***Favonigobius reichei*	Tropical sand goby		X			
Perciformes	Gobiidae	*Glossogobius callidus*	River goby					X
Perciformes	Gobiidae	*Glossogobius giuris*	Tank goby	Ib				X
Perciformes	Gobiidae	*Oxyurichtyhs ophthalmonema*	Eyebrow goby					X
Pleuronectiformes	Paralichthyidae	*Pseudorhombus arsius*	Largetooth flounder	III	X	X	X	X
Scorpaeniformes	Platycephalidae	*Platycephalus indicus*	Indian flathead	IIc	X	X	X	X
Tetraodontiformes	Ostraciidae	*Lactoria cornuta*	Longhorn cowfish		X	X	X	
Tetraodontiformes	Tetraodontidae	*Amblyrhynchotes honckenii*	Evileye blaasop	III				X
Tetraodontiformes	Tetraodontidae	*Torquigener balteus*	Slender blaasop		X			

A study conducted by Newman *et al.* (2008) was published a few months after Angel and Clark (2008). This study focused on the fish communities of the shallow sand flats along the western margin of the Bay only (i.e. opposite to the Dormac site), but results were similar to those of the previous study. Three species of Ambassidae made up most of the community (83%), followed by Mugilidae with six species (7%) and three species of Gerreidae (5%). These three families comprised 95% of the fishes.

Species not necessarily recorded by these two studies, but which have been recorded from sandy beach habitats immediately to the north and south of Durban Harbour and are thus likely to inhabit areas affected by the proposed development, are included in Table 3.

Table 3. Soft bottom demersal fish species recorded in beach seine net catches off Durban Bay [adapted from Beckley and Fennessey (1996)].

Class	Order	Family	Species	Common name
Actinopterygii	Perciformes	Sciaenidae	*Argyrosomus japonicus*	Dusky kob
Actinopterygii	Perciformes	Sciaenidae	*Argyrosomus thorpei*	Squaretail kob
Actinopterygii	Scorpaeniformes	Platycephalidae	*Cociella sp.*	Spotfin flathead
Actinopterygii	Pleuronectiformes	Cynoglossidae	*Cynoglossus lida*	Roughscale tongue sole
Actinopterygii	Perciformes	Sciaenidae	*Johnius dussumieri*	Mini-kob
Actinopterygii	Perciformes	Sparidae	*Lithognathus mormyrus*	Sand steenbras
Actinopterygii	Perciformes	Sciaenidae	*Otolithes ruber*	Snapper kob
Actinopterygii	Pleuronectiformes	Pleuronectidae	*Paralichthodes algoensis*	Measels flounder
Actinopterygii	Pleuronectiformes	Cynoglossidae	*Paraplagusia bilineata*	Fringelip tonguefish
Actinopterygii	Perciformes	Mullidae	*Parupeneus macronemus*	Band-dot goatfish
Actinopterygii	Perciformes	Mullidae	*Parupeneus rubescens*	Blacksaddle goat fish
Actinopterygii	Siluriformes	Plotosidae	*Plotosus lineatus*	Striped eel catfish
Actinopterygii	Perciformes	Haemulidae	*Pomadasys kaakan*	Javelin grunter
Actinopterygii	Perciformes	Haemulidae	*Pomadasys olivaceus*	Olive grunter
Actinopterygii	Pleuronectiformes	Paralichthyidae	*Pseudorhombus elevatus*	Ringed flounder
Actinopterygii	Aulopiformes	Synodontidae	*Saurida undosquamis*	Largescale lizzardfish
Actinopterygii	Perciformes	Sciaenidae	*Umbrina ronchus*	Slender bardman
Elasmobranchii	Rajiformes	Myliobatidae	*Aetobatus narinari*	Spotted eagleray
Elasmobranchii	Rajiformes	Dasyatidae	*Dasyatis chrysonota*	Blue stingray
Elasmobranchii	Rajiformes	Dasyatidae	*Neotrygon kuhlii*	Blue spotted sting ray
Elasmobranchii	Rajiformes	Gymnuridae	*Gymnura natalensis*	Butterfly ray
Elasmobranchii	Rajiformes	Dasyatidae	*Himantura gerrardi*	Sharpnose stingray
Elasmobranchii	Rajiformes	Rhinobatidae	*Rhinobatos annulatus*	Lesser guitarfish
Elasmobranchii	Rajiformes	Rhinobatidae	*Rhinobatos leucospilus*	Greyspot guitarfish
Elasmobranchii	Rajiformes	Rhinobatidae	*Rhyncobatus djiddensis*	Giant guitarfish
Elasmobranchii	Torpediniformes	Torpedinidae	*Torpedo sinuspersici*	Marbled electric ray

7 Areas within the Port of Durban that will potentially be affected by dredging, excavation, and other construction related activities at Dormac

7.1 Likely extent of the dredge plume

No dispersion modelling has been conducted to assess the spatial extent of the turbidity plume from the dredging operation to be conducted as part of this study, but a recent modelling study undertaken for the dredging operations at Berth 205 immediately west of Centre Bank (ZAA 2012) provides a good indication of the extent of such a plume. These models were conservatively based on suspended sediment resulting from the use of a cutter suction dredge and will be higher if a grab dredge is used. Sediment dispersion is mostly driven by tidal action and is projected to peak during spring tidal periods. It can be seen from this study that the turbidity plume can extend as far as 2.5 km from the actual dredge site (Figure 10B). However, suspended sediment levels at this point are at extremely low levels (<4.0 $mg.L^{-1}$) and probably would not significantly affect the organisms at such a distance.

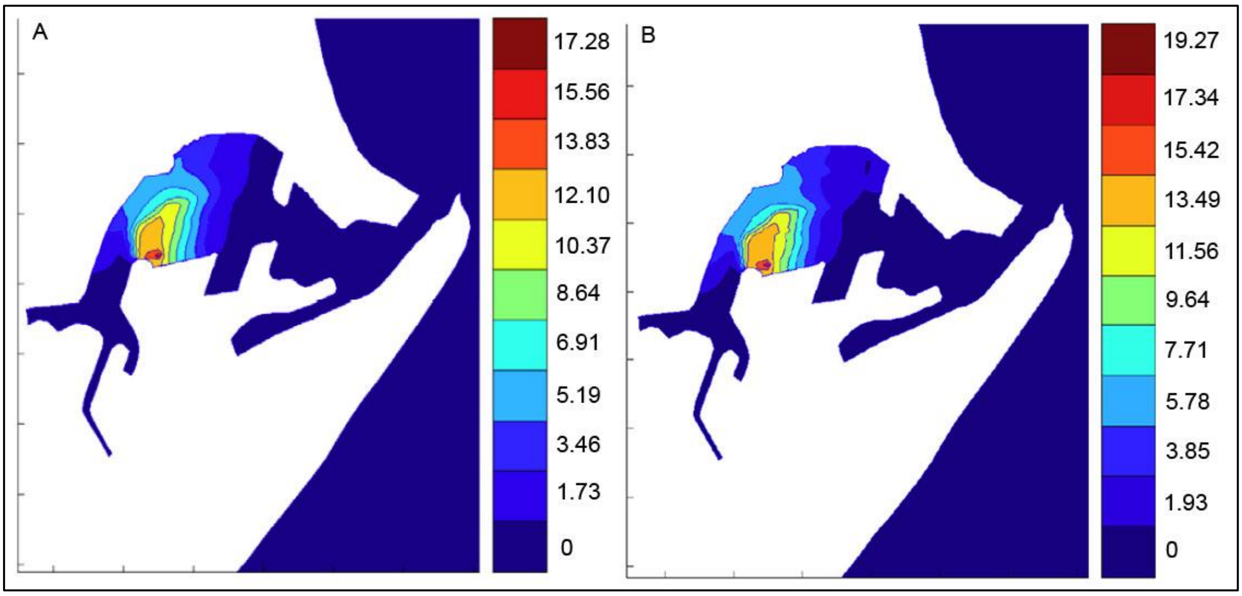

Figure 10. Model simulation data showing the dispersion of sediment during dredging operations at Berth 205 (Source: ZAA 2012). These data show sediment concentrations ($mg.L^{-1}$) in A) surface and B) bottom layers under worst case scenario conditions (spring tides combined with strong south-westerly winds).

Marine invertebrates are considered to be amongst the most sensitive organisms to elevated suspended sediment levels given that they are mostly sedentary and are unable to move away from the source of impact. Steffani *et al.* (2003) provided guidelines for concentrations of suspended solids in relation to the risk it poses to benthic marine invertebrates, as follows:

- Low risk: < 20 $mg.L^{-1}$
- Medium risk: 20-80 $mg.L^{-1}$
- High risk, requiring mitigation: > 80 $mg.L^{-1}$

Risk levels according to the South African Marine Water Quality Guidelines (DWAF 1995) are similar in as much as they recommend that suspended sediment concentrations should be less than 20 mg.L^{-1} for a low risk scenario with respect to the feeding of oysters. They also report that sand prawns prefer suspended sediment levels in the range of 2 to 14 mg.L^{-1}. Thus, the concentration of suspended sediment should not exceed 20 mg.L^{-1} during dredging.

Based on the above sediment dispersion models, the radius of the concentration fronts of suspended sediment from the source of dredging are likely to be:

- 2.5 km at a concentration between 1.9 and 3.7 mg.L^{-1}
- 2 km at a concentration between 3.8 and 5.6 mg.L^{-1}
- 1.5 km at a concentration between 5.7 and 7.6 mg.L^{-1}
- 1 km at a concentration between 7.7 and 9.5 mg.L^{-1}
- 950 m at a concentration between 9.6 and 11.4 mg.L^{-1}
- 850 m at a concentration between 11.5 and 13.3 mg.L^{-1}
- 650 m at a concentration between 13.4 and 15.3 mg.L^{-1}
- 100 m at a concentration between 15.4 and 17.3 mg.L^{-1}

If a cutter suction dredge is used, concentrations of suspended sediment are not expected to rise above 19.27 mg.L^{-1} (Figure 10B), which falls within the low risk category. The distance from the dredge site (Dormac quay) to the entrance of the Bayhead area is approximately 500 m (Figure 7), which suggests that turbidity plumes generated at the Dormac site are unlikely to have a significant impact outside of the Bayhead dock area if this dredge method is used. Sensitive habitats such as the Central Sandbanks, Little Lagoon and the Bayhead Mangroves are all comfortably outside of the potential impact zone. Only the fauna within the deeper dredged channels in the Bayhead area could potentially to be impacted during the construction or operational phases of the project. These are described in some detail in the next section.

7.2 Bayhead dredge channel

Most of the shipping channels in the Port of Durban have been dredged to a depth of approximately 12.8 m. For the purposes of this report, characteristics of only the dredge channels in the area proposed for dredging will be described. Data for this section have been extracted from Newman *et al*. (2008). According to this study, most of the area to be dredged for this project comprise muddy sediment, which is distributed into the silt canal by the Umbilo River, while sand typically dominates the areas adjacent to the eastern side of Bayhead (Figure 11A). Poorly sorted sediment was prevalent in the ship repair area and adjacent to the quays (Figure 11B), most likely due to the influences of propeller wash. Total organic content of these sediments was strongly positively correlated with the proportion of mud and inversely correlated to the sand grain size (Figure 11C). Salinity levels at depth approximated those of seawater (35 ppt), while surface waters had lower salinities due to river and storm water inflow. Bottom turbidity levels were generally between 2 and 6 NTU, but increased to 12 NTU during periods of vessel activity (Newman *et al*. 2008). This is due to the disturbance of fine mud below the propeller of the vessel in motion. Average dissolved oxygen levels were extremely low (2.5 $mg.l^{-1}$), most likely due to decomposition of organic matter brought into the system by rivers and storm water outfalls (Newman *et al.* 2008).

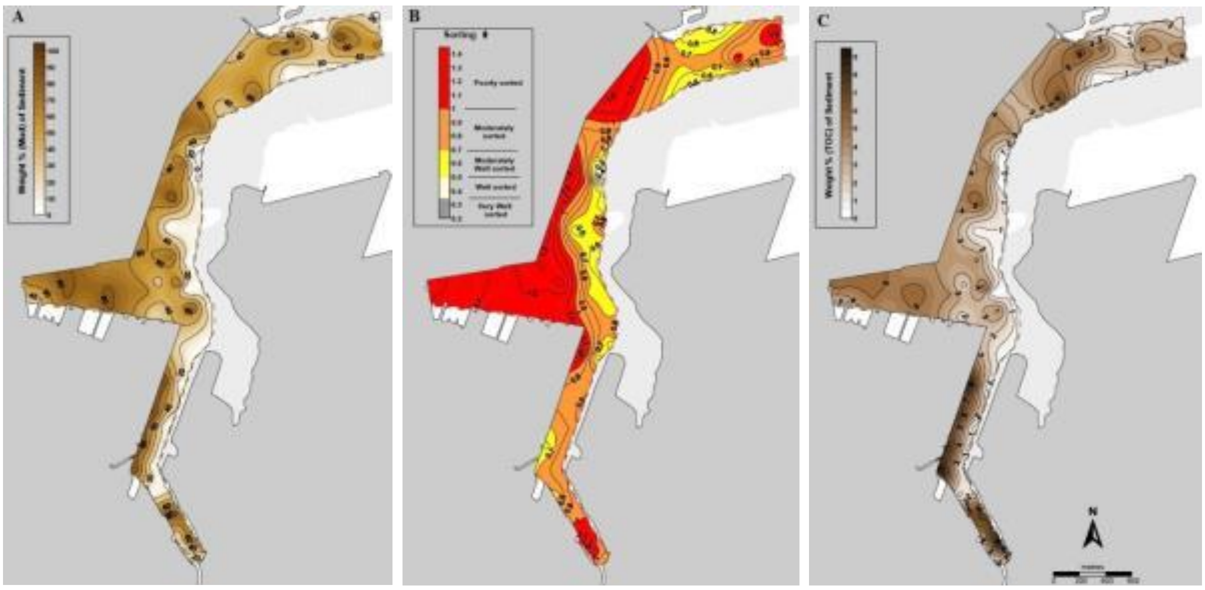

Figure 11. Interpolated spatial distribution of A) mud, B) the sorting coefficient and C) Total Organic Content (TOC) of sediment in Durban Bay (adapted from Newman *et al*. (2008) courtesy of CSIR and EMS). On panel A and C, pale colouration indicates a low percentage contribution, while dark colours depict high percentage contributions. On panel B, grey depicts very well sorted, pale yellow well sorted, yellow moderately well sorted, orange moderately sorted and red poorly sorted sediment. Stippled areas are intertidal sandbanks, while areas shaded in white are subtidal estuarine environments.

Benthic primary productivity is likely to be relatively low when compared to that of Centre Bank. This result is most likely due to increased turbidity and consequent the attenuation of light by the overlying water column due to vessel activity. As a consequence, benthic diatom biomass was found to be low. The most abundant macrofauna in the dredge channels were Polychaetes, especially *Notomastus latericeus,* followed by Gastropods particularly the tick shells *Nassarius kraussianus* (Table 1). A number of species of Decapod were also present including *Callichirus kraussi* and *Spiroplax spiralis* (Angel and Clark 2008).

According to Angel and Clark (2008), the ichthyofaunal community in the dredge channels comprised various species of Mugilids (Mullets), especially *Valamugil buchanani*, *Liza macrolepis* and *L. richardsonii*. Other common species included pursemouths (*Gerres methueni* and *G. longirostris*), spotted grunter (*Pomadasys commersonnii*), and Karenteen (*Crenidens crenidens*). Species that were most prevalent in the upper reaches of the water column included the Carangids such as the queenfish *Scomberoides lysan* (Table 4). None of these species are protected or threatened.

Table 4. Fish species recorded by Angel and Clark (2008) from each of the five sample locations distributed in Bayhead and Little Lagoon in Durban Harbour.

				Method	Gill		Seine netting			
Class	**Order**	**Family**	**Species**	**Site**	**A**	**D**	**C**	**D**	**E**	**F**
Osteichthye	Perciforme	Ambassidae	*Ambassis*	Bald glassy				X	X	
Osteichthye	Perciforme	Ambassidae	*Ambassis natalensis*	Slender glassy				X		
Osteichthye	Perciforme	Bothidae	*Pseudorhombus arsius*	Largetooth flounder			X			
Osteichthye	Perciforme	Carangidae	*Scomberoides lysan*	Double spotted	X					
Osteichthye	Perciforme	Gerreidae	*Gerres longirostris*	Smallscale pursemouth				X		X
Osteichthye	Perciforme	Gerreidae	*Gerres filamentosus*	Threadfin pursemouth					X	
Osteichthye	Perciforme	Gerreidae	*Gerres methueni*	Evenfin pursemouth		X				
Osteichthye	Perciforme	Haemulidae	*Pomadasys*	Spotted grunter			X			
Osteichthye	Perciforme	Leiognathida	*Leiognathus equulus*	Slimy	X		X	X	X	
Osteichthye	Perciforme	Mugilidae	*Liza dumerili*	Groovy mullet			X			X
Osteichthye	Perciforme	Mugilidae	*Liza macrolepis*	Large scale mullet	X					
Osteichthye	Perciforme	Mugilidae	*Liza richardsonii*	Southern mullet		X			X	
Osteichthye	Perciforme	Mugilidae	*Valamugil buchanani*	Bluetail mullet		X	X			
Osteichthye	Perciforme	Mugilidae	*Valamugil robustus*	Robust mullet	X					
Osteichthye	Perciforme	Sillaginidae	*Sillago sihama*	Silver silago			X			X
Osteichthye	Perciforme	Sparidae	*Crenidens crenidens*	Karanteen	X		X		X	

This area is the only area within the Port of Durban that has been included in the risk assessment presented in Section 11 as impacts are not expected to extend beyond this area for reasons described above.

8 Toxicity of sediments in the proposed excavation and dredge area

8.1 Background

South Africa is a signatory to the London Convention on the Prevention of Marine Pollution by Dumping of Waste and Other Matter (1972) (the London Convention) and to the 1996 Protocol to the London Convention (the London Protocol). The London Convention and London Protocol regulate the deliberate disposal of waste materials in the marine environment. In South Africa, the National Environmental Management: Integrated Coastal Management Act 2008 (Act 24 of 2008) (ICMA) gives effect to the provisions of the London Convention and London Protocol. There are seven categories of waste and other material that are regulated under ICMA; dredged material being derived mostly from Ports, forms by far the most common type.

Oceans and Coasts, a branch of the Department of Environmental Affairs (DEA), is mandated with the responsibility of regulating the disposal of waste material in the marine environment in South Africa and uses a National Action list based on a corresponding list in the London Convention and London Protocol to make decisions as to whether sediment identified for dredging is of a suitable quality for unconfined open water disposal (Table 5).

Table 5. National Action List for trace metals used to make decisions on the suitability of dredged material for unconfined, open water disposal in South African coastal waters measured in micrograms per gram (µg/g). Source: DEA (Undated)

Metal	Action level	Prohibition level
ANNEX I SUBSTANCES		
Cadmium	1.5-10.0	>10.0
Mercury	0.5-5.0	>5.0
A combined level of cadmium and mercury	1.0-5.0	>5.0
ANNEX II SUBSTANCES		
Arsenic	30-150	>150 (1000)
Chromium	50-500	>500
Copper	50-500	>500 (1000)
Lead	100-500	>500 (500)
Nickel	50-500	>500
Zinc	150-750	>750 (1000)
or combined level of these substances	50-500	>500 (1000)

- Explanatory notes on application:

1. Once the level of contamination in the sediment has been determined through checmical analsyis, these are compared with the Action levels contained in the above List (presented as $\mu g.g^{-1}$ dry weight sediment).
2. A decision on whether or not to require biological testing, or to prohibit disposal of the sediment at sea , is determined as follows:
   i. If none of the metals measured exceed the Action Levels, then no biological testing is required, and the material can be dumped.
   ii. If the combined Action Levels for Annex 1 metals (Cd and Hg) are exceeded, or the combined level of Cd and Hg is >5 $\mu g.g^{-1}$, then biological testing is required.
   iii. If the Action Level for either of the Annex I metals, and two or more of the Annex II metals are exceeded, then biological testing is required.

iv. If the Action Levels of three or more Annex II metals are exceeded, and the total of Annex II metals is >500 µg.g-1, then biological testing is required.
v. If the combined level of Annex II metals is >1 000 µg.g-1, then biological testing is required.
vi. If any of the Prohibition Levels for the Annex I metals is exceeded, or if the Prohibition Level of two or more of the Annex II metals is exceeded, dumping will not be allowed.

8.2 Desktop study of existing contamination data

Limited data is available from historic studies on sediments in the areas targeted for dredging and excavation in this study. Available evidence suggests that the surficial sediments in the dredge and excavation areas may be contaminated with trace metals. This evidence is derived from a suite of sediment samples collected from four boreholes drilled in the proposed excavation area by WSP in 2013 (Table 6, WSP 2013) as well as a suite of samples collected from the immediate vicinity of the dredge site (Figure 14, CSIR 2011). In the case of the samples collected from the Dormac excavation areas, Chromium and Copper were seen to be in excess of Action Levels at several sites (BH1, BH2 and BH3, and BH4, respectively) and Zinc in excess of Prohibition Levels at one site (BH4). When averaged across all depth zones though, trace metal levels were within guideline limits. Note that it is likely that sediment from all depth horizons will be mixed together during the excavation process before sediment is dumped thus limiting risk from this source.

Table 6. Trace metals in sediment samples collected at various depths from four sites within the Dormac excavation area. Bold text indicates values in excess of the Action Levels and underlined text indicates values exceeding Prohibition Levels (Source: WSP 2013).

Site	Depth	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc
BH1	1	<6.00	<0.2	**53.8**	<14.00	12.80	<0.14	5.92	<19
	2	6.22	<0.02	10.9	3.02	3.05	<0.14	2.72	6.81
	4	3.65	<0.02	30.5	3.32	5.47	<0.14	4.69	7.35
	6.8	2.70	<0.02	11.8	5.32	4.81	<0.14	2.41	4.99
BH2		6.14	0.0731	8.9	3.48	3.48	<0.14	2.74	8.27
	2.5	3.54	<0.02	15.8	3.14	5.60	<0.14	2.82	9.47
	5	1.68	<0.02	13.1	3.40	4.88	<0.14	4.85	5.37
	10	1.93	<0.02	**94.9**	20.60	15.10	<0.14	10.5	25.3
BH3	1	5.81	<0.02	11.3	3.23	3.39	<0.14	2.86	7.9
	6.5	4.47	<0.02	29.7	6.81	6.02	<0.14	5.62	10.5
	10.2	6.87	<0.02	**133.0**	22.00	17.20	<0.14	12.00	27.7
BH4	0.5	6.10	<0.02	49.5	**167.00**	1240	<0.14	25.30	**<u>615</u>**
	1	3.44	<0.02	49.2	15.30	11.00	<0.14	8.03	19.2
	4	5.19	<0.02	19.4	4.31	4.03	<0.14	4.22	11.6
	4.8	5.24	<0.02	15.2	23.50	7.49	<0.14	3.38	26
	7	3.92	<0.02	31.2	3.54	9.40	<0.14	4.48	5.56

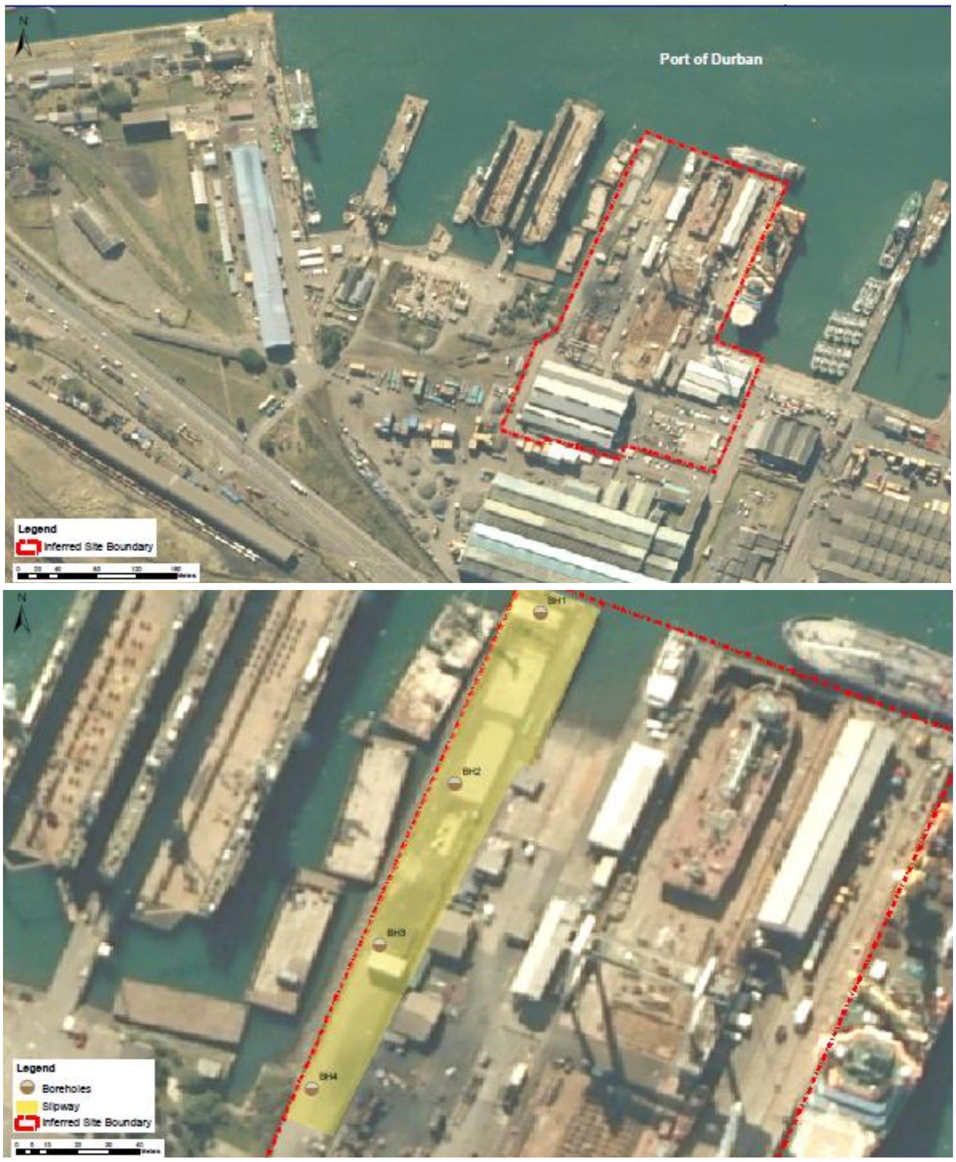

Figure 12. Locations of boreholes in the Dormac excavation area from which sediment samples were derived as part of the EIA (Source: WSP 2013).

In 2011, the CSIR examined trace metal levels in sediments from 38 sites distributed around the Port of Durban to determine the sediment quality in the Port (CSIR 2011). Sites sampled are depicted in Figure 13.

Figure 13. Sites tested for trace metals during a recent assessment of sediment quality in Durban Bay (Source: CSIR 2011).

For the purposes of this study, the CSIR sites were grouped into four areas: Bayhead, Little Lagoon, Centre Bank and Harbour mouth. Cadmium and mercury levels were low for all areas, while copper levels were above the action level for all sites barring the Harbour mouth (Figure 14). Lead, zinc and chromium levels were low for at all sites with the exception of Bayhead. In this area, the latter trace metals were found to be above the action level but below the prohibition level.

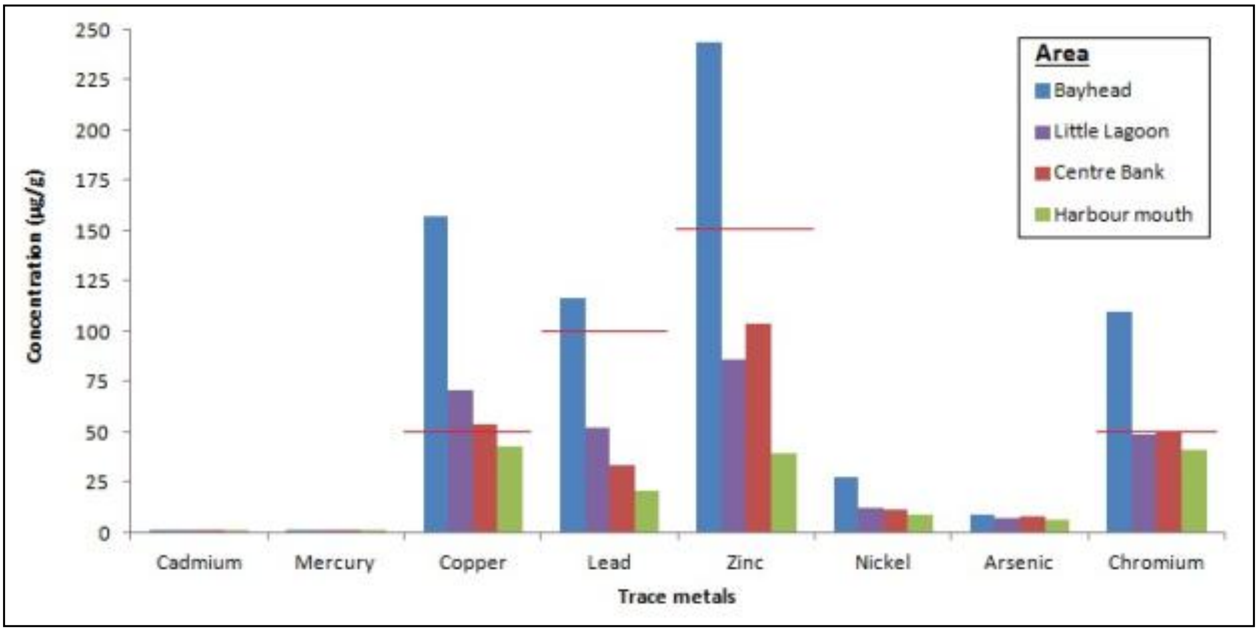

Figure 14. Trace metal results from a recent assessment of sediment quality in Durban bay (CSIR 2011) which motivated for the testing of sediments adjacent to the Dormac quay. Red lines indicate Action Levels.

Results from both studies (CSIR 2011 and WSP 2012) indicated that further assessment of the sediments in the dredge area in particular was warranted. Thus, for this study, an additional five sediment samples were collected.

8.3 Dredge sediment collection methods

Five sediment samples were collected from the top 5 cm of sandy substratum (surficial sediment layer) within the proposed footprint of the dredge area at Bayhead Dock in the Port of Durban (Figure 15) for the purpose of conducting biological (toxicity) tests as required in terms of the legislation. Exact localities are listed in Table 7. The surface of the benthic sediment was scooped directly into clean, uncontaminated plastic tubes and sealed at depth by SCUBA divers. On arrival at the surface, they were packed into insulated boxes with ice and kept below 6°C during transport to the AEC laboratory in Cape Town.

Table 7. GPS Coordinates and degree of transhipment influence at the site of water sample collections.

Sample	GPS coordinates	
	Latitude	Longitude
1	29° 53' 15.43"S	030° 59' 53.10"E
2	29° 53' 14.43"S	030° 59' 53.62"E
3	29° 53' 13.46"S	030° 59' 54.07"E
4	29° 53' 12.36"S	030° 59' 54.56"E
5	29° 53' 11.23"S	030° 59' 55.08"E

Figure 15. Location of the five sediment sample sites within the Bayhead Dock parallel to the Dormac quay (Google Earth 2013).

In the laboratory, each sediment sample was split into three separate containers and sent to Scientific Services and CSIR for the following analyses:

- Trace metals
- Total organic carbon (TOC)
- Sediment particle size
- Polycyclic aromatic hydrocarbons (PAH)
- Total petroleum hydrocarbons (TPH)

8.4 Results for dredge sediment

Results of these analyses confirmed findings from the previous studies. Copper concentrations were above the Action Level for four of the five sites, while the average concentration for all five sites was well above the Action Level (Table 8). Apart from copper, two other metals were above the Action Level, namely cadmium at Site 4 (2.0 µg/g) and chromium at Site 1 (64.8 µg/g). Averages for the area adjacent to the Dormac quay were acceptable (Table 8). Levels of mercury at Site 4 (0.482) were extremely close to the Action Level of 0.5 µg/g.

Table 8. Trace metals found at five sites sampled at the proposed construction site in the Bayhead Dock. Cadmium (Cd), copper (Cu), lead (Pb), zinc (Zn), nickel (Ni), arsenic (As) and chromium (Cr) are measured in micrograms per gram (µg/g). Values that are higher than the action levels are underlined and highlighted in bold.

Sample	Pb	Cd	Cu	Pb	Zn	Ni	As	Cr
1	0.127	1.2	**161.6**	30.3	133.0	9.1	2.2	**64.8**
2	0.185	1.2	**157.7**	38.3	127.8	9.0	3.4	49.8
3	0.72	0.7	**66.6**	44.9	53.0	5.5	2.5	23.7
4	0.482	**2.0**	**103.7**	40.9	91.3	7.9	5.3	48.1
5	0.26	0.6	38.9	10.8	37.2	6.4	2.2	20.7
Average	0.178	1.1	**105.7**	33.0	88.5	7.6	3.1	41.4

Analysis of sediment particle for these samples revealed that fine to medium grained sands predominate adjacent to the Dormac quay (Table 9). These sediments were found to be moderately to poorly sorted. These data are in contrast to Wright (1996) and Newman *et al*. (2008) who reported predominantly fine muds from the Bayhead Dock (Figure 6 & Figure 11A).

Table 9. Sediment particle size results for the proposed construction site at Dormac.

	Site 1	Site 2	Site 3	Site 4	Site 5
Mean particle size (µm)	334.0	317.8	356.1	625.1	414.7
Mean	Fine sand	Fine sand	Medium sand	Medium sand	Medium sand
Sorting*	Poorly sorted	Moderately sorted	Moderately sorted	Poorly sorted	Moderately sorted
Skewness**	Symmetrical	Symmetrical	Symmetrical	Coarse Skewed	Symmetrical

*Sorting: Inclusive graphic standard deviation values <0.5 = well sorted or >1 = poorly sorted.
**Skewness: Inclusive graphic skewness values <-0.1 ϕ = coarse skewed or >0.1 ϕ = fine skewed.

Concentrations of Polycyclic Aromatic Hydrocarbons (PAH) and Total Petroleum Hydrocarbons (TPH) in these samples were measurable in the CSIR laboratory. Values below 100 µg/kg are not detectable by Scientific Services laboratory equipment, thus Acenaphthylene, Acenaphthene, Fluorene, 2-Methylnaphthalene, Indeno(1,2,3-c,d)pyrene, Dibenz(a-h)anthracene and Benzo(g,h,i)perylene were not included in this report. While these elements are not included in the National Action List for South Africa, they are included in the National Action list for a number of other countries (see DEA 2012 and Table 10).

Values exceeding screening level 2 indicate chemicals that are of greater environmental concern than those exceeding screening level 1. Exceeding an upper screening level increases the degree of scrutiny that should be undertaken before a decision is made, but the regulatory authority must also consider many other factors, including the total number of screening factors analysed, the toxicological importance of each screened contaminant, the volume of waste or other matter to be disposed, and other project specific items (DEA 2013).

Table 10. Annex I and II substances not included in the South African National Action List. Units measured in micrograms per gram (µg/g)

Range(ppm)	Action level	Prohibition level
ANNEX I SUBSTANCES		
Organohalogens	0.05-0.1	>0.1
Oils	1000-1500	>1500
Persistent plastics	4% by volume	
Radioactive materials	To be determined by the IAEA	
ANNEX II SUBSTANCES		
Cyanides	0.1	(1000)
Fluorides		(1000)
Organosilicon compounds		(1000)
Pesticides		(500)

Table 11. The United States Army Corps of Engineers (USACE 2006) sediment quality guidelines for Polycyclic Aromatic Hydrocarbons (PAH) outlined in micrograms per kilogram of organic carbon (µg/kg-OC) are regulated by Screening Level 1 and 2. The National Oceanic and Atmospheric Administration (NOAA) guidelines for Total Petroleum Hydrocarbons (TPH) measured in milligrams per kilogram of organic carbon are regulated by the Effects Range Low (ERL) and the Effects Range Median (ERM).

Chemical	Screening Level 1	Screening Level 2
Polycyclic Aromatic Hydrocarbons (µg/kg-OC)		
Naphthalene	99	170
Phenanthrene	100	480
Anthracene	220	1 200
Fluoranthene	160	1 200
Pyrene	1 000	1 400
Benz(a)anthracene	110	270
Chrysene	110	460
Benzofluoranthenes(b+k)	230	450
Benzo(a)pyrene	99	210
TPH (mg/kg-OC)	4 (ERL)	44.7 (ERM)

Table 12. Polycyclic Aromatic Hydrocarbons (PAH) and Total Petroleum Hydrocarbons (TPH) measured in µg/kg from five sites adjacent to the proposed construction area. Values that are higher than the screening levels are underlined and highlighted in bold.

Chemical	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
PAH (µg.kg-1)					
Naphthalene	<100	<100	<100	<100	<100
Phenanthrene	**150**	**100**	<100	<100	<100
Anthracene	<100	<100	<100	<100	<100
Fluoranthene	**310**	**230**	110	<100	<100
Pyrene	270	200	<100	<100	<100
Benz(a)anthracene	**140**	**120**	<100	<100	<100
Chrysene	**160**	**130**	<100	<100	<100
Benzofluoranthenes(b+k)	<100	<100	<100	<100	<100
Benzo(a)pyrene	**160**	**120**	<100	<100	<100
TPH	**480**	**460**	**180**	**240**	**280**

Results of the laboratory analyses (Table 12) showed that phenanthrene, fluoranthene, benz(a)anthracene, chrysene and benzo(a)pyrene exceeded screening level 1. TPH exceeded the NOAA Effects Range Low (ERL) level and the Effects Range Median (ERM) level for all sites.

Levels of organic material in the five samples from the dredge area are presented in Table 13. The percentage Total Organic Carbon (TOC) was highest at site two (5.26%), lowest at site five (1.81%) and averaged 2.93% between the five sites. TOC values vary widely in the natural environment and a value of between 1 and 6% is typical for Durban Harbour. No standards or guidelines exist for TOC. It is a measure of organic content, thus extremely high levels (e.g. 50%) may indicate an anoxic environment.

Table 13. The percentage of Total Organic Carbon (TOC) at each of the five sample sites adjacent to the Dormac quay.

Site	% TOC
1	2.02
2	3.50
3	2.05
4	5.26
5	1.81
Average	2.93

Based on the results of the chemical testing of the sediment samples from the dredge area it was clear that biological (toxicity) testing of the dredge spoil was required before it can be dumped at sea using normal protocols (i.e. unconfined, open water disposal). The purpose of such biological (toxicity) testing is to establish whether the metals in question (and any other toxic substances that may be present in the dredge spoil) are "bioavailable" or not. "Bioavailability" refers to the phenomenon that many potentially toxic elements are only toxic to living organism in specific chemical forms and can easily be rendered non-toxic if they are contained within the sediment matrix or are permanently bound to other substances.

The principal means used for assessing sediment toxicity in South Africa is known as the sea urchin fertilization test (DEA Undated), which entails comparing fertilization rates or sea urchin embryos in the presence of elutriate derived from the potentially contaminated sediment to those achieved in normal seawater. Provided it can be shown that the toxicity of the dredge sediments is low in spite of elevated levels of key trace metals (which would indicate that the trace metals in question are not bioavailable and hence do not pose a risk to the environment), then the dredge spoil can be disposed of in the conventional way (i.e. unconfined, openwater disposal). The alternatives are likely to be more costly, as the sediments in question would have to be disposed of at a landfill site or blended with uncontaminated sediment prior to disposal at sea.

The methods used for the conduction of these tests and results from the tests are presented in Section 9 below.

9 Marine fertilisation test using the sea urchin, *Parechinus angulosus*

9.1 Background

A chronic bioassay toxicity test was undertaken using the echinoderm species*, Parechinus angulosus,* using internationally accepted methods (Standard Methods 2005) to determine whether dredged sediment from the proposed floating dry dock site is suitable for disposal offshore and whether trace metal levels will be within safe limits during dredging operations.

9.2 Methods

9.2.1 Preparation of sample water

250 ml of sediment from each sample and 1000 ml of seawater was placed into sterile plastic containers into which compressed air was bubbled for 30 minutes. As the disturbance of sediment is known to release a proportion of the attached toxins, this method mimicked the disturbance that would be caused by dredging. After agitation, the supernatant was extracted from each bucket and allowed to settle for one hour to allow for the removal of the majority of the fine mud particles. Again the supernatant was extracted and this liquid was used for the experiment. In order to determine at what dilution toxins became acceptable, the contaminated water was diluted with uncontaminated seawater to 50, 25, 12.5 and 6.25%.

9.2.2 Test organisms

Sea urchins of the species *Parechinus angulosus* were collected at Kommetjie, Cape Town, South Africa (34°08'42.99''S, 18°19'05.26'' E). The organisms were collected one week prior to testing, allowing them time to acclimatise to tank conditions before commencement of the experiment. This was necessary to prevent any non-induced spawning events that may occur as a result of the change in environment.

Figure 16. A) *Parechinus angulosus* collected from Kommetjie B) were spawned and gametes were collected in order to perform toxicity tests.

9.2.3 Gamete Preparation

The sea urchin fertilisation tests were performed at the AEC laboratory, Tokai, Cape Town. Sea urchins were induced to spawn by injecting 2 x 0.5 ml 1.0 M potassium chloride (KCl) solution into the coelomic cavity. A hypodermic syringe with a 30 gauge insulin needle was used to pierce the peristaltic membrane surrounding the mouth, taking care to avoid the mouth and digestive system (Standard Methods 2005). Each urchin was gently shaken for a few seconds to mix the KCl solution inside the cavity. On production of gametes, the urchins were sexed. Gametes were collected from at least four females and four males to increase sample quality.

Female urchins were identified by the production of round orange eggs, while males were identified by the production of cloudy, white sperm. Following injection, females were inverted (oral side up) and placed on top of glass conical flasks filled to the brim with 20^{o}C seawater (Figure 16B). Mature eggs were then free to fall from the test to the bottom of the conical flask. On completion of spawning, mature eggs of the four urchins were mixed into one flask.

After injection of male urchins, individuals were placed in dry petri dishes. The sperm was collected in a pipette with an enlarged tip and placed in a 10 ml glass tube. Care was taken to keep sperm away from water to prevent premature activation. A subsample was diluted in seawater and motility was assessed as a measure of quality. The sperm was stored in the refrigerator at 4°C.

Figure 17. FlowCAM® manufactured by Fluid Imaging Inc., ME, USA.

Sperm and egg quality and density were determined using a FlowCAM® (flow cytometer and microscope) manufactured by Fluid Imaging Inc., ME, USA (Figure 18). The analysis was conducted in auto-image mode with a 10x objective lens and 100 micron flowcell for sperm and 300 micron flowcell for eggs.

9.2.4 Test Procedure

9.8 ml of seawater was added to each of two replicate 16 ml glass test tubes. Sample water was equilibrated to ± 20°C before test initiation. Within 30 minutes of collection, 0.2 ml sperm (final dilution 1.7 x 10^8 sperm/ml) was added to each test tube with an addition interval of approximately five seconds. The test tubes were incubated for 20 minutes at ± 20°C, after which 2 ml of egg suspension (final dilution 7 120 eggs/ml) was added to each test tube. The test tubes were incubated for a further 40 minutes before 0.05 ml of 5% formalin was added to prevent further fertilisation, thus terminating the test (Standard Methods 2005).

Eggs were inspected on the FlowCAM® for evidence of fertilisation, which is indicated by the presence of a clear fertilisation membrane surrounding the egg (Figure 18). Samples were analysed within a 24 hour period, as extended formalin preservation is known to damage the fertilisation membrane. After discarding all unfocused and partial images, a total of 100 eggs per replicate were selected from the images obtained by the FlowCAM®. The number of fertilised versus unfertilised eggs was then recorded and fertilization rates were calculated.

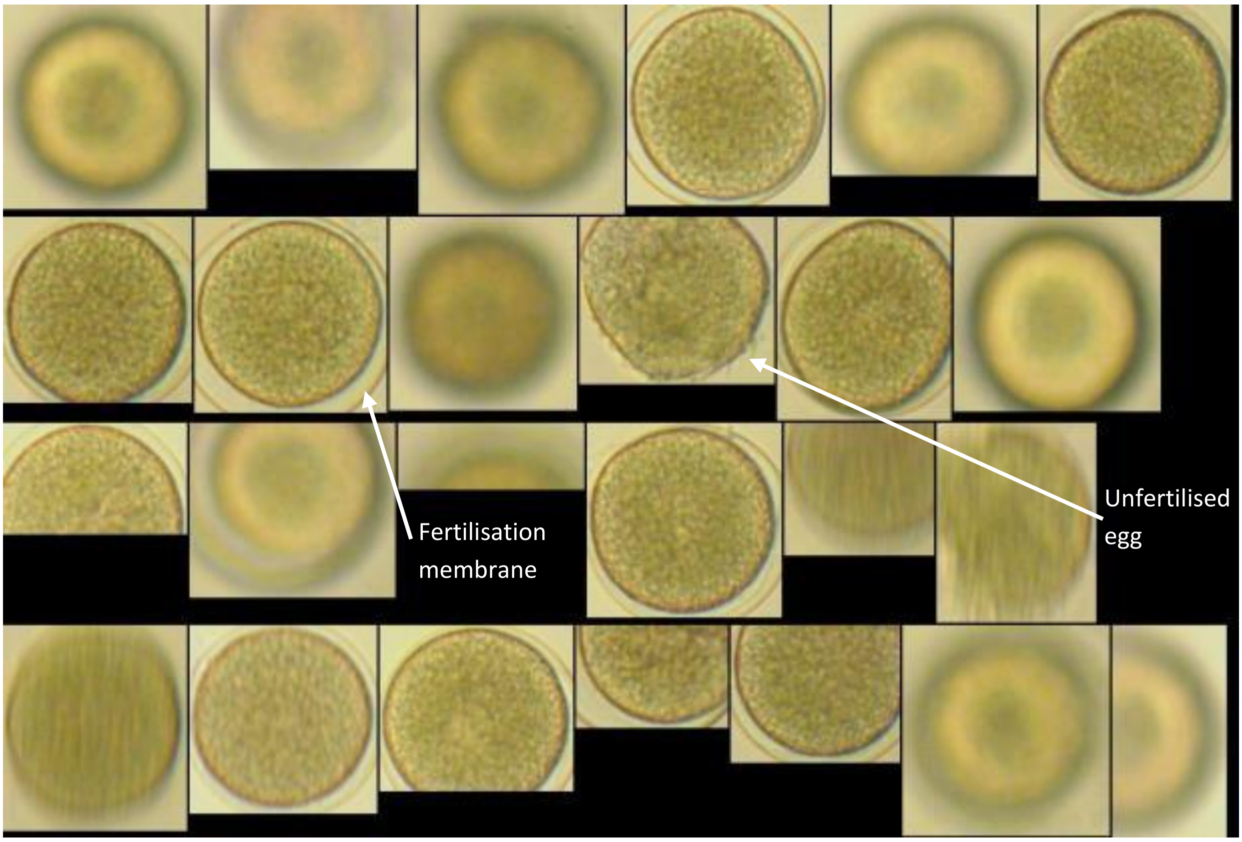

Figure 18. An example of images captured on the FlowCAM® showing fertilised and unfertilised eggs. Fertilised eggs are surrounded by a clear fertilisation membrane which envelops the gamete. Unfocused images were excluded from the count.

9.2.5 Statistical analysis

In order to assess the statistical significance of the changes in sea urchin fertilisation percentage among dilutions of the water samples, Dunnett's multiple comparison procedure for proportions (alpha = 0.05) was performed in Statistica version 11 (2013) following arcsine transformation of the data.

The toxicity of the water samples was described using three statistics, which were calculated from the dose response data from the dilution series. The EC_{50} (median effective concentration) was calculated. This statistic represents the concentration of sample calculated to produce a 50% reduction in fertilisation (Bay *et al*. 2003) and was calculated using probit analysis in Excel (2007).

9.3 Results

The average percentage of sea urchin fertilisation was greatest for uncontaminated seawater (96.8 ±1.3), which was used as the control (Table 14). The average percentage of sea urchin fertilisation was lowest for undiluted contaminated water (35.2 ±3.8).

Table 14. Average percentage fertilisation of urchin eggs and the Coefficient of Variation (CV). Standard errors are displayed in parentheses. Percentage inhibition is defined as the percentage decrease of urchin egg fertilisation based on the control.

Percentage contamination	Ave. percentage fertilisation (±) Standard error	Coefficient of variation (CV)	% inhibition
100% (No dilution)	35.2 ±3.8	0.15	64
50%	50.5 ±5.7	0.16	48
25%	66.4 ±10.2	0.28	31
12.5%	74.0 ±1.2	0.02	24
6.25%	81.1 ±3.7	0.06	16
0% (Control)	96.8 ±1.3	0.02	-

The results from Dunnet's multiple comparison procedure are shown in Table 15. There was a significant difference between the control and both the percentage fertilisation that took place in 100% contaminated seawater ($q'=2.15$, $p<0.05$) and in 50% contaminated seawater ($q'=1.70$, $p<0.05$). No significant differences were found between the control and seawater samples diluted by greater than 50%.

Table 15. Results of Dunnett's multiple comparison procedure for proportions (n=14). P<0.05 rejects the null hypothesis and indicates a significant difference between the control and test.

Percentage contamination	q'	q'p Crit.(0.05)	P-value
100%	2.15	1.64	P<0.05
50%	1.70	1.64	P<0.05
25%	1.25	1.64	P>0.05
12.50%	1.01	1.64	P>0.05
6.25%	1.46	1.64	P>0.05

The average percentage failure of sea urchin egg fertilisation increased as the percentage concentration of contaminated seawater increased (Figure 19). The half maximal Effective Concentration (EC_{50}) was calculated to be 49%.

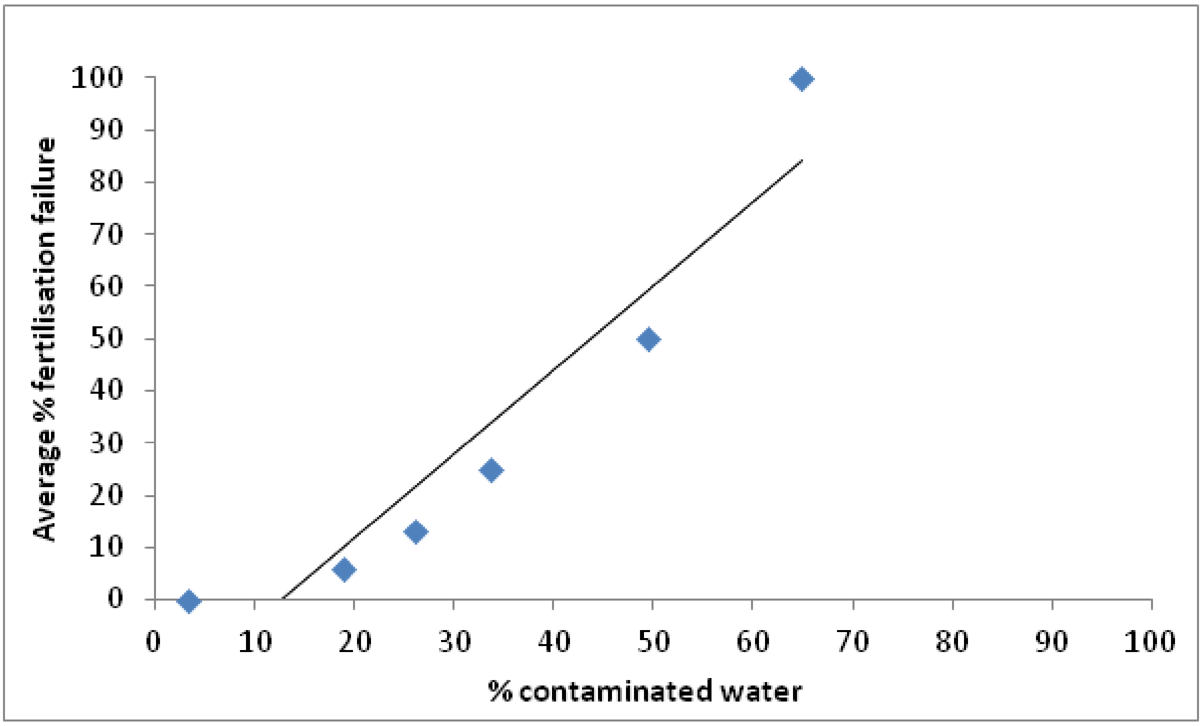

Figure 19. Relationship between average sea urchin toxicity and the concentration of contaminated water (%).

9.4 Conclusion

Contaminants, such as metals and organic toxic pollutants, are predominantly associated with fine sediment particles (mud or cohesive sediments). This is due to the fact that fine grained particles have a relatively larger surface area for the adsorption and binding of pollutants. Higher proportions of mud, relative to sand or gravel, can thus lead to high organic loading and trace metal contamination. Disturbance to the sediment (e.g. dredging) can lead to re-suspension of the mud component from underlying sediments, along with the associated organic pollutants and metals. Sediment particles adjacent to the Dormac quay consisted of fine to medium grained sand. Sand is more coarse than mud, thus organic loading and trace metal contamination is likely to be slightly less than previously expected.

A recent study showed that copper, lead, zinc and chromium concentrations were above the recommended action levels for these trace metals (CSIR 2011). These results indicated that a trace metal analysis was needed adjacent to the Dormac quay to determine whether the sediment in the dredge area contained potentially toxic contaminants. Results of this analysis indicated that copper was the only metal that exceeded the action level. Copper is an important constituent of antifouling coatings applied to the hulls of vessels to limit fouling. Any repair to a vessel hull is likely to release copper into the water and ultimately the sediment. Thus, ship repair facilities are the most likely contributor to this contamination (CSIR 2011). In addition to high levels of copper, phenanthrene, fluoranthene, benz(a)anthracene, chrysene and benzo(a)pyrene concentrations exceeded screening level 1 and TPH exceeded the NOAA Effects Range Low (ERL) level and the Effects Range Median (ERM) level for all sites.

Based on trace metal data in the literature (CSIR 2011) and hydrocarbon data obtained from the existing Dormac dock, toxicity testing was required to determine the effect of increased concentrations of dissolved trace metals on marine life due to dredging. The experiments were performed by calculating the percentage fertilisation of sea urchin eggs. Results indicated that the average percentage failure of sea urchin egg fertilisation increased as the percentage concentration of contaminated seawater increased. The half maximal Effective Concentration (EC_{50}) was calculated to be 49%, meaning that half of the sea urchin eggs remained unfertilised at 49% dilution of contaminated seawater.

10 Potential impacts associated with construction and operation of the proposed Dormac floating dry dock on the biodiversity of Durban Harbour

The construction of the floating dry dock may result in a range of negative impacts on the environment within the Bayhead area, all of which are described below.

Forbes *et al*. (1996) have shown that species abundance is two to seven times greater in undredged habitats than in shipping channels, which are periodically dredged and disturbed. Potential impacts that may arise from dredging and construction include:

- loss and disturbance of subtidal habitat and associated benthic microalgae, macrofauna and ichthyofaunal communities ;
- loss and disturbance of water column habitat and associated phytoplankton, zooplankton and ichthyofaunal communities;
- suspension of fine sediment and increased turbidity at and adjacent to the dredge sites impacting on primary production, and filter-feeding organisms on the substrate and in the water column in and adjacent to the dredge area;
- sediment deposition around the dredging site (largely fine sediment rejected from screening and from hopper overfill);
- re-suspension of potentially toxic trace metals and hydrocarbons in dredge sediments from the harbour and their effects on macrofauna and fish communities in the vicinity of the dredge footprint.

In assessing potential impacts on the macrofauna of subtidal areas in the vicinity of dredging operations, consideration is given to the fact that these areas are already highly disturbed by previous dredging operations and propeller wash, and sediments are near anoxic. Each of the impacts mentioned above is likely to affect the associated biota in different ways and at varying intensities depending on the nature of the affected habitat and the sensitivity of the associated biota.

11 Impact assessment

Each envisaged impact resulting during the construction (Table 16 to Table 24) and operation (Table 25 & Table 26) phases of the floating dry dock was assessed separately, results of which are presented in the tables below and are summarised in **Error! Reference source not found.**. A detailed description of how impacts are assessed is given in Appendix 1.

Impacts during construction are likely to result in disturbances to subtidal organisms in the near vicinity of the construction site. A brief summary of the construction methods was provided in Section 3 of this report. The two construction methods (Sheet pile vs. Braced diaphragm walls) are likely to be very similar in terms of their impact on the estuarine environment. A slight advantage of the braced diaphragm wall is the lack of vibration and loud noises during construction. Some level of noise disturbance can be expected during the construction phase; however, the species inhabiting the Bayhead area of the Port of Durban are not likely to be impacted by this as they have a high tolerance for noise due to frequent shipping traffic. Although bentonite slurry is used during the construction of braced diaphragm walls, this type of slurry is non-toxic, non-corrosive and non-flammable. It is also inert, preventing contamination of and the development of bacteria within the slurry.

11.1 Construction impacts

11.1.1 Loss of deep subtidal and open water habitats

The impact of construction on the subtidal habitat within the footprint of the quay is negative (Table 16), as construction will result in a permanent loss of habitat to soft sediment organisms. However, it will create new habitat in the form of hard substrata, which is likely to be colonised by different assemblages of marine invertebrates and fishes. No mitigation measures are required as the estuarine environment that will be removed will be relatively small, it is already artificial and it is an area that is regarded as being highly disturbed due to various activities associated with ship repair.

Table 16. Impact 1: Ecological effects due to the permanent loss of deep subtidal and open water habitats.

	Extent	*Intensity*	*Duration*	*Consequence*	*Probability*	*Significance*	*Status*	*Confidence*
Without mitigation	**Local 1**	**Low 1**	**Long-term 3**	**Low 5**	**Definite**	**Low**	**-ve**	**High**
Essential mitigation measures: None required								
With mitigation	**Not applicable**							

11.1.2 Loss soft sediment habitat

The habitat within the development footprint will be permanently lost; however, benthic infauna in the area around the proposed construction is expected to recover relatively quickly. As long as dredging equipment is kept within the developmental footprint and the sediment outside this area is not disturbed, the significance of this impact is expected to be low (Table 17).

Table 17. Impact 2: Ecological effects due to the temporary loss of soft sediment habitat at the Dormac quay and associated infauna in the dredging footprint.

	Extent	*Intensity*	*Duration*	*Consequence*	*Probability*	*Significance*	*Status*	*Confidence*
Without mitigation	**Local 1**	**Medium 2**	**Long-term 3**	**Medium 6**	**Definite**	**Medium**	**-ve**	**High**
<u>Essential mitigation measures:</u> i) Keep disturbance to a minimum by confining dredging equipment to the developmental footprint.								
With mitigation	**Local 1**	**Low 1**	**Long-term 3**	**Low 5**	**Definite**	**Low**	**-ve**	**Medium**

11.1.3 Toxicity to benthic organisms at Bayhead

CSIR (2011) and a number of other studies have indicated that trace metals in the surficial sediments in the dredge area exceed action levels included in the DEA sediment quality guidelines (DEA 2012). Levels of trace metal in sediments in the dredge area were therefore assessed in detail and biological (toxicity) studies were undertaken to determine the bioavailability of trace metals in these sediments.

The levels of contaminants in the sediments in the dredge area were found to be below guideline levels for all trace metals with the exception of copper, while TPH levels were found to be high. Toxicity tests showed that significant concentrations of toxic chemicals are likely to be released into the water column during dredging. This indicates that toxins are bioavailable and able to negatively affect marine life. It is therefore essential that a suction dredge is used; however, if this is not possible, a silt curtain must be installed around the burrow pit.

Although only one trace metal exceeded guideline (action) levels, the results of the toxicity tests indicate the presence of highly toxic substances. According to the South African National Action List, the sediment is considered safe for dredging and disposal at sea, although necessary precautions must be taken. This assessment puts the risk of toxicity resulting from the suspension of heavy metals, hydrocarbons and organics associated with the suspended dredge material at a low level (Table 18) based on the South African guidelines; although when taking into account the toxicity of the sediment to marine life and the importance of the local invertebrate fauna (i.e. prawns) to the estuarine ecosystem, additional precautions must be taken during dredging (such as the use of a suction dredge) in order to reduce the significance of impacts to an acceptable level.

Table 18. Impact 3: Ecological effects on benthic organisms in the Bayhead area due to the release of contaminants in the sediment during dredging.

<table>
<tr><th></th><th>Extent</th><th>Intensity</th><th>Duration</th><th>Consequence</th><th>Probability</th><th>Significance</th><th>Status</th><th>Confidence</th></tr>
<tr><td>Without mitigation</td><td>Local
1</td><td>Medium
2</td><td>Medium-term 2</td><td>Low
5</td><td>Probable</td><td>Low</td><td>-ve</td><td>High</td></tr>
<tr><td colspan="9">
<u>Essential mitigation measures:</u>
i) Continuous monitoring of turbidity levels must be undertaken during the dredge operations. Data from the turbidity monitoring instruments must be available in real time to the person coordinating dredging activities. Dredging operations must be halted immediately if turbidity levels exceed a threshold level of 20 $mg.L^{-1}$ at the entrance to the Bayhead area, and should not recommence until values have dropped below this level.
ii) The dredge hopper must be choked with a fully automated overflow system. A computerized process controller must ensure dynamic adjustment of the valve in the overflow funnel, which chokes the flow in such a way that a constant fluid level in the hopper is maintained. This prevents overflow of the hopper, decreasing the likelihood of fine silts escaping back into the dredge area and resulting in a significant decrease in turbidity.
iii) The time period over which the dredging operation is to take place must be minimised, to avoid the daily re-suspension of sediments. Dredging should not take place during spring tides and strong south-westerly winds.
iv) A suction dredge must be used to minimise suspended sediment. A grab dredge must not be used.

<u>Recommended mitigation measures:</u>
v) ‘Silt Curtains’ may be placed at the burrow pit to prevent fine sediments from dispersing. The lower end of the ‘skirt’ must be allowed to rest upon the seafloor, and the top of the ‘skirt’ must be above the water surface. This mitigation measure must be implemented if one or more of the essential mitigation measures are not followed.
</td></tr>
<tr><td>With mitigation</td><td>Local
1</td><td>Low
1</td><td>Medium-term 2</td><td>Very low
4</td><td>Improbable</td><td>Insignificant</td><td>-ve</td><td>High</td></tr>
</table>

11.1.4 Toxicity to benthic organisms at offshore disposal site

Surficial sediments, calculated conservatively as the upper 20 cm of sediment for the purposes of offshore disposal, include high levels of copper and are clearly toxic to marine organisms as demonstrated by high levels of inhibition of sea urchin fertilisation with undiluted elutriate (64%) relative to uncontaminated control water (Table 14). However, much reduced levels of inhibition were recorded for serial dilutions of the effluent, which suggests that this is an effective way of mitigating impacts from this source. To ensure that appropriate levels of dilution are achieved in the dredge material prior to disposal, it is recommended that the dredge area be divided into blocks, each of which must be dredged to the full dredging depth required. This will ensure that the deeper, less toxic sediments are mixed with the more toxic surficial sediment layer, decreasing the significance of the impact from low to very low (Table 19). Provided such an approach is adopted, we can expect to achieve an average dilution level of at least 7% in the dredge spoil, which corresponds with the lowest dilution level used in the toxicity testing study, where a fertilisation rate of 81.1% was observed.

Table 19. Impact 4: Ecological effects on benthic organisms at the offshore dredge disposal site due to the release of contaminants in the sediment.

	Extent	*Intensity*	*Duration*	*Consequence*	*Probability*	*Significance*	*Status*	*Confidence*
Without mitigation	**Local 1**	**Medium 2**	**Medium-term 2**	**Low 5**	**Probable**	**Low**	**-ve**	**Medium**
Recommended mitigation measures: i) The dredge area should be divided up into blocks. Each block should be dredged to the full dredging depth required in order to ensure maximum dilution of toxic surficial sediments with deeper, less toxic sediments.								
With mitigation	**Local 1**	**Low 1**	**Medium-term 2**	**Very low 4**	**Probable**	**Very low**	**-ve**	**Medium**

11.1.5 Release of excess nutrients

Due to the dynamic nature of microalgal blooms within the Port of Durban and the constant supply of nutrients from rivers and storm water drains in the Bayhead area, the effect of the release of excess nutrients from disturbed sediments is considered to be insignificant (Table 20).

Table 20. Impact 5: Ecological effects due to the release of nutrients stimulating microalgae to bloom.

	Extent	*Intensity*	*Duration*	*Consequence*	*Probability*	*Significance*	*Status*	*Confidence*
Without mitigation	**Local 1**	**Medium 2**	**Short-term 1**	**Very low 4**	**Improbable**	**Insignificant**	**-ve**	**Medium**
Essential mitigation measures: None required								
With mitigation	**Not applicable**							

11.1.6 Reduction of dissolved oxygen concentrations

Dissolved oxygen in the Bayhead area was found to be extremely low, most likely due to decomposition of organic matter brought into the system by rivers and storm water outfalls (Newman *et al.* 2008). Thus, reduction in dissolved oxygen concentration due to dredging of potentially anoxic sediments is not likely to have a significant negative effect on the estuarine biota (Table 21).

Table 21. Impact 6: Ecological effects due to the reduction in dissolved oxygen concentrations.

	Extent	*Intensity*	*Duration*	*Consequence*	*Probability*	*Significance*	*Status*	*Confidence*
Without mitigation	**Local 1**	**Low 1**	**Short-term 1**	**Very low 3**	**Improbable**	**Insignificant**	**-ve**	**High**
Essential mitigation measures: None required								
With mitigation	**Not applicable**							

11.1.7 Smothering of marine organisms

The impacts of dredging activities largely relate to the physical removal of substratum and the associated fauna residing on or in the benthos. The impact of resultant deposition of material rejected by screening and the consequences of overfill of the hopper must also be taken into account (Newell *et al*. 1998). In general, macrofaunal communities residing in the fine sediments of estuaries, such as those in the deeper subtidal areas of the Durban Harbour, are low in diversity and comprise species well adapted to rapid recolonisation on substratum that is frequently disturbed (Newell *et al*. 1998). Rates of recovery reportedly are in the range of 6-8 months for estuaries with fine muds, such as the subtidal areas in much of the Port of Durban, where disturbance is frequent and precludes the establishment of relatively long lived organisms (Newell *et al*. 1998).

Sessile organisms, particularly those that filter-feed, are most likely to be impacted by suspended sediments as material is expected to be largely inorganic, resulting in feeding difficulties. For autotrophic organisms, such as microphytobenthos and phytoplankton, suspended material blocks out light - the denser the suspended solids the more light is attenuated. Turbidity plumes are most widespread during conditions of spring tides and south-westerly winds (ZAA 2012).

Benthic invertebrates, particularly those that filter-feed, are susceptible to the effects of turbidity as many lack the mobility inherent to fishes. They generally ingest high levels of inorganic material filtered from the water, resulting in lower growth rates, starvation and in the worst cases mortality.

Turbidity plumes are expected to extend up to 2.5 km away from the proposed construction site, although at suspended sediment concentrations that fall within the low risk category. Biotic communities within 500 m of the proposed dredge site are generally depauperate (see Section 7.1 and 7.2, respectively, for further discussion on this matter), thus impacts from this source are likely to be of low significance, especially if appropriate mitigation measures are applied. It is a requirement, nonetheless, that turbidity levels are monitored at the entrance to the Bayhead area whilst dredging is ongoing. Turbidity levels should not be permitted to exceed 20 $mg.L^{-1}$ at any time at this point and dredging operations should be halted if this does happen.

Table 22. Impact 7: Ecological effects caused by smothering of subtidal bottom-dwelling organisms, benthic microalgae, and filter feeding organisms in the Bayhead area due to increased turbidity and the settlement of suspended sediment during construction.

	Extent	*Intensity*	*Duration*	*Consequence*	*Probability*	*Significance*	*Status*	*Confidence*
Without mitigation	**Local 1**	**High 3**	**Short-term 1**	**Low 5**	**Definite**	**Low**	**-ve**	**Medium**

Essential mitigation measures:

i) Continuous monitoring of turbidity levels must be undertaken during the dredge operations. Data from the turbidity monitoring instruments must be available in real time to the person coordinating dredging activities. Dredging operations must be halted immediately if turbidity levels exceed a threshold level of 20 $mg.L^{-1}$ at the entrance to the Bayhead area, and should not recommence until values have dropped below this level.

ii) The dredge hopper must be choked with a fully automated overflow system. A computerized process controller must ensure dynamic adjustment of the valve in the overflow funnel, which chokes the flow in such a way that a constant fluid level in the hopper is maintained. This prevents overflow of the hopper, decreasing the likelihood of fine silts escaping back into the dredge area and resulting in a significant decrease in turbidity.

iii) The time period over which the dredging operation is to take place must be minimised, to avoid the daily re-suspension of sediments. Dredging should not take place during spring tides and strong south-westerly winds.

iv) A suction dredge must be used to minimise suspended sediment. A grab dredge must not be used.

Recommended mitigation measures:

v) 'Silt Curtains' may be placed at the burrow pit to prevent fine sediments from dispersing. The lower end of the 'skirt' must be allowed to rest upon the seafloor, and the top of the 'skirt' must be above the water surface. This mitigation measure must be implemented if one or more of the essential mitigation measures are not followed.

	Extent	*Intensity*	*Duration*	*Consequence*	*Probability*	*Significance*	*Status*	*Confidence*
With mitigation	**Local 1**	**Low 1**	**Short-term 1**	**Very low 3**	**Possible**	**Insignificant**	**-ve**	**Medium**

11.1.8 Turbidity on pelagic organisms

Some fishes may be affected by dredging, particularly those that are bottom dwelling such as gobies and sole, as they are sucked up by the dredger and are often killed in the process. Other larger species may simply be disturbed temporarily.

Both turbidity and the concentration of potentially toxic trace metals increase with dredging. Most estuarine-associated fishes in KwaZulu-Natal are well adapted to high levels of turbidity (Blaber 1981). Few estuaries fall into the clear water categories measuring < 10 NTU (Cyrus 1988), with most being either semi-turbid (10-50 NTU) or turbid (> 50 NTU). While Durban Harbour is relatively low in turbidity (≈ 10-15 NTU), values of at least 25 NTU near the bottom are not uncommon (Newman *et al*. 2008).

Piscivorous fishes in estuaries often rely on visual detection methods for capturing their prey, and increasing turbidity levels can impair prey capture. However, piscivorous species are generally of marine origin and can exit the estuary if turbidity levels become too high or too widespread. Many fishes in the Durban Bay estuary are semi-turbid water species (Cyrus 1988) and are likely to be unperturbed by increased levels of turbidity. Those that may be negatively affected, such as pursemouths, can move to more favourable areas of the harbour as the plume is likely to be localised. Due to the localised effect of the turbidity plume if a suction dredge is used or if 'silt curtains' are put in place, the impact on primary production and the disturbance of pelagic organisms that are able to move away from areas experiencing unfavourable conditions, is considered to be insignificant (Table 23).

Table 23. Impact 8: Ecological effects of increased suspended solid concentrations and turbidity on pelagic fauna and flora.

<table>
<tr><th></th><th>Extent</th><th>Intensity</th><th>Duration</th><th>Consequence</th><th>Probability</th><th>Significance</th><th>Status</th><th>Confidence</th></tr>
<tr><td>Without mitigation</td><td>Local 1</td><td>Medium 2</td><td>Short-term 1</td><td>Very low 4</td><td>Probable</td><td>Very low</td><td>-ve</td><td>Medium</td></tr>
<tr><td colspan="9">
<u>Essential mitigation measures:</u>
i) Continuous monitoring of turbidity levels must be undertaken during the dredge operations. Data from the turbidity monitoring instruments must be available in real time to the person coordinating dredging activities. Dredging operations must be halted immediately if turbidity levels exceed a threshold level of 20 $mg.L^{-1}$ at the entrance to the Bayhead area, and should not recommence until values have dropped below this level.
ii) The dredge hopper must be choked with a fully automated overflow system. A computerized process controller must ensure dynamic adjustment of the valve in the overflow funnel, which chokes the flow in such a way that a constant fluid level in the hopper is maintained. This prevents overflow of the hopper, decreasing the likelihood of fine silts escaping back into the dredge area and resulting in a significant decrease in turbidity.
iii) The time period over which the dredging operation is to take place must be minimised, to avoid the daily re-suspension of sediments. Dredging should not take place during spring tides and strong south-westerly winds.
iv) A suction dredge must be used to minimise suspended sediment. A grab dredge must not be used.

<u>Recommended mitigation measures:</u>
v) 'Silt Curtains' may be placed at the burrow pit to prevent fine sediments from dispersing. The lower end of the 'skirt' must be allowed to rest upon the seafloor, and the top of the 'skirt' must be above the water surface. This mitigation measure must be implemented if one or more of the essential mitigation measures are not followed.
</td></tr>
<tr><td>With mitigation</td><td>Local 1</td><td>Low 1</td><td>Short-term 1</td><td>Very low 3</td><td>Improbable</td><td>Insignificant</td><td>-ve</td><td>Medium</td></tr>
</table>

11.1.9 Use of bentonite slurry (Diaphragm wall)

If the braced diaphragm wall method is chosen, bentonite slurry will be pumped into the trench to prevent collapse. Bentonite slurry is a type of montmorillonite clay consisting of aluminium, magnesium, silicate and hydroxide mixed with water, and is used to counteract the hydraulic pressure from the surrounding soil (Górriz 2012). This method requires the stabilising wall to be assembled in a slurry filled trench into which concrete is poured. As the liquid concrete is heavier than the bentonite slurry, the slurry is displaced and removed from the trench for reuse. This type of slurry is non-toxic, non-corrosive and non-flammable. It is also inert, preventing contamination of and the development of bacteria within the slurry. Due to the non-toxic and inert nature of this substance, the risk of the slurry entering the water column and becoming toxic to the biota is insignificant. However, if this substance is allowed to settle on the benthos, smothering of local benthic organisms may occur. Thus, the mitigation measures presented in Table 24 must be followed to prevent smothering.

Table 24. Impact 9: Ecological effects of the use of bentonite slurry during construction.

	Extent	*Intensity*	*Duration*	*Consequence*	*Probability*	*Significance*	*Status*	*Confidence*
Without mitigation	**Local 1**	**Medium 2**	**Short-term 1**	**Very low 4**	**Probable**	**Very low**	**-ve**	**Medium**
Essential mitigation measures: i) Bentonite slurry is to be removed from the trench using a pump and reused if possible. ii) No bentonite slurry is to spill into the Port of Durban.								
With mitigation	**Local 1**	**Low 1**	**Short-term 1**	**Very low 3**	**Improbable**	**Insignificant**	**-ve**	**Medium**

11.2 Operational impacts

11.2.1 Increased vessel movement

Increased ship movement will result in increased turbidity as the fine, muddy sediments characteristic of the Bayhead area are disturbed. The levels of contaminants in the sediments in the dredge area were found to be below guideline levels for all trace metals with the exception of copper, although TPH levels were found to be high. It should be noted that toxicity testing was designed specifically to mimic dredging and not propeller disturbance. As the disturbance caused by ship propellers is much less than that caused by dredging, the results of toxicity experiments are not applicable for this impact. Considering the disturbed nature of Bayhead and the fact that only one trace metal exceeded guideline Action Levels, the significance of this impact is expected to be very low and no mitigation is required (Table 25).

Table 25. Impact 10: Ecological effects of increased ship movement in the Bayhead area.

	Extent	*Intensity*	*Duration*	*Consequence*	*Probability*	*Significance*	*Status*	*Confidence*
Without mitigation	**Local 1**	**Low 1**	**Medium-term 2**	**Very low 4**	**Definite**	**Very low**	**-ve**	**High**
Essential mitigation measures: None required								
With mitigation	**Not applicable**							

11.2.2 Paint and anti-fouling chips as a cause for contamination

The following activities will take place at the proposed floating dry dock:

- pressure washing and abrasive blasting;
- painting and coating (including anti-fouling paint);
- engine maintenance and repair; and
- electric and gas welding.

It is noted that grit blasting and painting already occurs at the existing slipway and the impact of these activities will increase when the dry dock is fully functional. Although the floating dry dock wing walls will serve as a shrouding system to prevent overflow of blast containment into the water and to help contain any paint overspray, it is important that no paint chips or other materials are deposited or washed into the Port. Anti-fouling paint is known to contain copper, which is toxic to marine life. Excessive accumulation of this metal in the sediment will have a negative effect on the biodiversity and abundance of sandy macrofauna, particularly the mud prawn *Callichirus kraussi*. As this type of contamination will be continuous and concentrated in a small area, the significance of the impact of paint and anti-fouling paint chips entering the water is assessed as high before mitigation and medium following mitigation (Table 26).

Table 26. Impact 11: Ecological effects of paint and anti-fouling chips entering the water at Dormac during hull cleaning and painting.

<table>
<tr><th></th><th>Extent</th><th>Intensity</th><th>Duration</th><th>Consequence</th><th>Probability</th><th>Significance</th><th>Status</th><th>Confidence</th></tr>
<tr><td>Without mitigation</td><td>Local
1</td><td>High
3</td><td>Long-term
3</td><td>High
7</td><td>Probable</td><td>High</td><td>-ve</td><td>High</td></tr>
<tr><td colspan="9"><u>Essential mitigation measures:</u>
i) Ensure that paint and anti-fouling chips are not washed into the Port by closing all drainage holes in the dry dock deck and plugging all exits from the deck.
ii) Place all waste from hull cleaning, scraping and grit blasting into allocated temporary waste disposal containers supplied by a certified waste collector.
iii) This material must all be collected and disposed of at a registered landfill site.
iv) Paint overspray should be kept to an absolute minimum.</td></tr>
<tr><td>Without mitigation</td><td>Local
1</td><td>High
3</td><td>Long-term
3</td><td>High
7</td><td>Possible</td><td>Medium</td><td>-ve</td><td>High</td></tr>
</table>

11.2.3 Hull fouling organisms and ballast disposal

Alien invasive species reproduce rapidly and have little competition from native species, thus they have the potential to inhabit large areas that would otherwise be available to native species. As alien species pose a huge risk to native marine species, especially in port environments where vessels arrive from all over the world, it is extremely important to ensure that no hull fouling organisms enter the water at Dormac.

Ballast tanks will be cleaned and repaired onsite. All sediments will be placed into temporary waste disposal facilities provided by a certified waste collector. The site will not provide ballast water reception facilities for vessels requiring repair and no ballast water is to be discharged into the water at Bayhead. The significance of alien species introduction is high and can be reduced to medium if efforts are taken to prevent foreign organisms from entering the water (Table 27).

Table 27. Impact 12: Ecological effects of hull fouling organisms and ballast sediment entering the water at Dormac during hull and ballast tank cleaning.

<table>
<tr><th></th><th>Extent</th><th>Intensity</th><th>Duration</th><th>Consequence</th><th>Probability</th><th>Significance</th><th>Status</th><th>Confidence</th></tr>
<tr><td>Without mitigation</td><td>Local
1</td><td>High
3</td><td>Long-term 3</td><td>High
7</td><td>Probable</td><td>High</td><td>-ve</td><td>High</td></tr>
<tr><td colspan="9"><u>Essential mitigation measures:</u>
i) Ensure that hull fouling organismsand ballast sediment is not washed into the water at Dormac. This material must all be collected and disposed of at a registered landfill site.
ii) Place all ballast sediment and other material into temporary waste disposal facilities supplied by a certified waste collector.
iii) No ballast water shall be discharged into the Bayhead area.</td></tr>
<tr><td>Without mitigation</td><td>Local
1</td><td>High
3</td><td>Long-term 3</td><td>High
7</td><td>Possible</td><td>Medium</td><td>-ve</td><td>High</td></tr>
</table>

11.2.4 Raising and lowering of floating dry dock

The operation of the floating dry dock requires lifting and lowering of the deck to allow vessels to dock and cast off from the platform. This operation is not anticipated to affect marine life in the Bayhead area, thus no mitigation measures are required for this operation (Table 28).

Table 28. Impact 13: Ecological effects of raising and lowering of the floating dry dock platform.

	Extent	*Intensity*	*Duration*	*Consequence*	*Probability*	*Significance*	*Status*	*Confidence*
Without mitigation	**Local 1**	**Low 1**	**Short-term 1**	**Very low 3**	**Improbable**	**Insignificant**	**-ve**	**High**
<u>Essential mitigation measures:</u> None required								
With mitigation	**Not applicable**							

Table 29. Summary of potential impacts as a result of the proposed floating dry dock development.

Source	Impact identified	Consequence	Probability	Significance	Status	Confidence
Construction	**Impact 1**: Loss of deep subtidal habitat	Low	Definite	**Low**	-ve	High
	With Mitigation	None required				
	Impact 2: Loss of soft sediment habitat	Medium	Definite	**Medium**	-ve	High
	With Mitigation	Low	Definite	**Low**	-ve	Medium
	Impact 3: Toxicity to benthic organisms at Bayhead	Low	Probable	**Low**	-ve	High
	With Mitigation	Very low	Improbable	**Insignificant**	-ve	Low
	Impact 4: Toxicity to benthic organisms at offshore disposal site	Low	Probable	**Low**	-ve	Medium
	With Mitigation	Very low	Probable	**Very low**	-ve	Medium
	Impact 5: Release of excess nutrients	Very low	Improbable	**Insignificant**	-ve	Medium
	With Mitigation	None required				
	Impact 6: Reduction of dissolved oxygen concentrations	Very low	Improbable	**Insignificant**	-ve	High
	With Mitigation	None required				

Source	Impact identified	Consequence	Probability	Significance	Status	Confidence
Construction	**Impact 7**: Smothering of marine organisms	Low	Definite	**Low**	-ve	Medium
Construction	With Mitigation	Very low	Possible	**Insignificant**	-ve	Medium
Construction	**Impact 8**: Turbidity on pelagic organisms	Very low	Probable	**Very low**	-ve	Medium
Construction	With Mitigation	Very low	Improbable	**Insignificant**	-ve	Medium
Construction	**Impact 9**: Use of bentonite slurry (Diaphragm)	Very low	Probable	**Very low**	-ve	Medium
Construction	With Mitigation	Very low	Improbable	**Insignificant**	-ve	Medium
Operation	**Impact 10**: Increased vessel movement	Very low	Definite	**Very low**	-ve	High
Operation	With Mitigation	None required				
Operation	**Impact 11**: Paint and anti-fouling chips	High	Probable	**High**	-ve	High
Operation	With Mitigation	High	Possible	**Medium**	-ve	High
Operation	**Impact 12**: Hull fouling organisms and ballast	High	Probable	**High**	-ve	High
Operation	With Mitigation	High	Possible	**Medium**	-ve	High
Operation	**Impact 13**: Raising and lowering of dry dock	Very low	Improbable	**Insignificant**	-ve	High
Operation	With Mitigation	None required				

12 Mitigation and recommendations

Impacts are summarised in

Table 29. All essential mitigation measures outlined in Section 11 above are considered to be necessary to retain the integrity and functionality of the Durban Harbour estuary during construction and operation of the proposed project. These mitigation measures include the following:

12.1 Construction, management and mitigation measures

12.1.1 Essential mitigation measures

1. Continuous monitoring of turbidity levels must be undertaken during the dredge operations and data from such monitoring work must be available in real time to the person coordinating dredging activities. Dredging operations should be halted immediately if turbidity levels exceed a threshold level of 20 $mg.L^{-1}$ at the entrance of the Bayhead area, and should not recommence until values have declined below this level.
2. Turbidity must be minimised by choking the dredge hopper overflow with a fully automated system. In this scenario, a computerized process controller ensures dynamic adjustment of the valve in the overflow funnel, which chokes the flow in such a way that a constant fluid level in the hopper is maintained and no air is taken down with the suspension leaving the hopper.
3. The time period over which the dredging operation is to take place must be kept as short as possible, to avoid the daily re-suspension of sediments. Dredging should not take place during spring tides and strong south-westerly winds owing to the risk of the turbidity plumes being advected out of the Bayhead Dock area into the main port channel.
4. A suction dredge must be used to minimise suspended sediment. A grab dredge must not be used.
5. Keep disturbance to a minimum by confining dredging equipment to the developmental footprint.

12.1.2 Recommended mitigation measures

In the event that one or more of the above mentioned essential mitigation measures cannot be met, both of the following mitigation measures must be implemented:

1. ‘Silt Curtains’ are to be placed around the dredge area to prevent large amounts of sediment from moving beyond the development footprint. The lower end of the ‘skirt’ must rest upon the seafloor, and the top of the ‘skirt’ must float on the water surface.
2. The dredge area should be divided up into blocks. Each block should be dredged to the full dredging depth required in order to ensure maximum dilution of toxic surficial sediments with deeper, less toxic sediments.

Silt curtains (also known as turbidity curtains, silt barriers, or turbidity barriers) are floating barriers designed specifically to contain and control the dispersion of silt in a water body (Figure 20). These barriers are often implemented in areas experiencing marine construction, pile driving, or dredging activities and they work to keep the site in compliance for the duration of the project.

Turbidity curtains are available in three standard types for different water conditions:

- Type 1 – calm water (lakes and harbours)
- Type 2 – fast water (rivers and streams)
- Type 3 – rough water (tidal areas)

Figure 20. A silt curtain in use during construction (Source: www.landmsupplyco.com).

A type 1 silt curtain would be recommended for this project, as this section of the harbour is relatively calm. The skirt can be made out of either a permeable geotextile filter, or an impermeable material. The curtain typically consists of a top floatation device (boom) attached to a skirt that touches the sea floor, preventing sediment from escaping underneath the skirt. The device can be held in place with a bottom ballast chain made of galvanised steel, and curtains are usually connected to each other by means of shackles and reinforced eyelets (Figure 21).

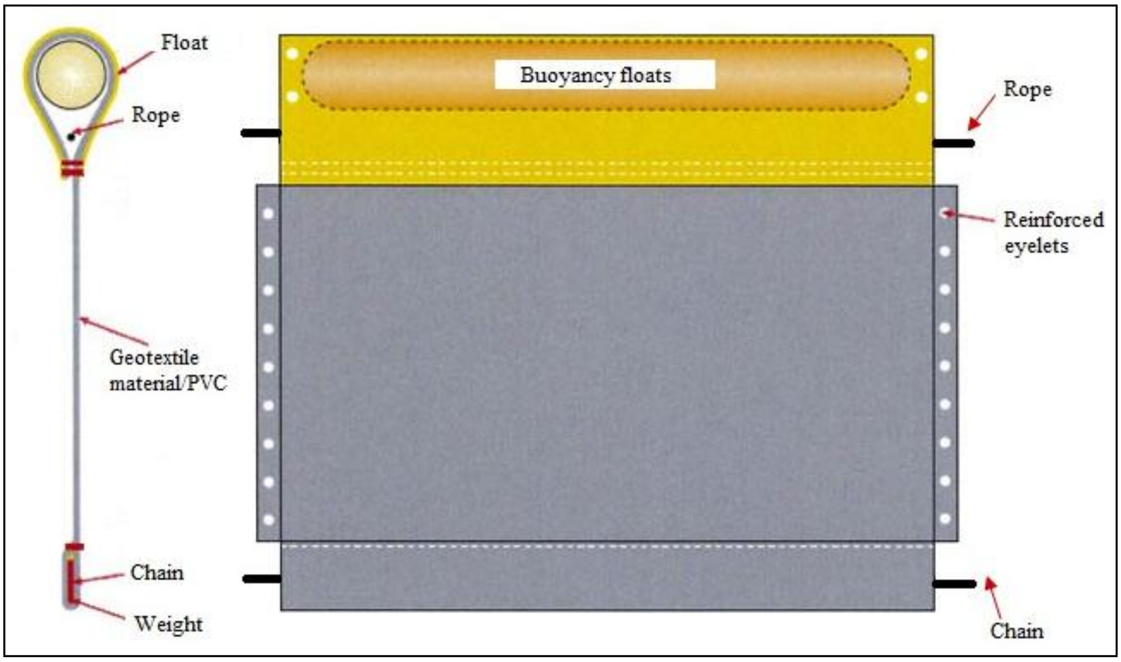

Figure 21. A diagram showing a sheet of silt curtain on the right and a longitudinal section of a silt curtain on the left (Source: modified from www.aquasol.net.au).

12.2 Operational management and mitigation measures

1. Bentonite slurry is to be removed from the trench using a pump and reused if possible. No bentonite slurry is to spill into the Durban Harbour.
2. Ensure that anti-fouling paint and hull fouling organisms are not washed into the Port.
3. Place all sediment from ballast tanks into allocated bins supplied by a certified waste collector.
4. Suitable waste temporary storage facilities are to be available for all types of waste generated.
5. No ballast water shall be discharged in the Bayhead area.

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Appendix 1: Impact Rating Methodology

The significance of all potential impacts that would result from the proposed project is determined in order to assist decision-makers. The significance rating of impacts is considered by decision-makers, as shown below.

- **INSIGNIFICANT**: the potential impact is negligible and **will not** have an influence on the decision regarding the proposed activity.
- **VERY LOW**: the potential impact is very small and **should not** have any meaningful influence on the decision regarding the proposed activity.
- **LOW**: the potential impact **may not** have any meaningful influence on the decision regarding the proposed activity.
- **MEDIUM**: the potential impact **should** influence the decision regarding the proposed activity.
- **HIGH**: the potential impact **will** affect a decision regarding the proposed activity.
- **VERY HIGH**: The proposed activity should only be approved under special circumstances.

The **significance** of an impact is defined as a combination of the **consequence** of the impact occurring and the **probability** that the impact will occur. The significance of each identified impact[1] was thus rated according to the methodology set out below:

Step 1 – Determine the **consequence** rating for the impact by determining the score for each of the three criteria (A-C) listed below and then **adding** them. The rationale for assigning a specific rating, and comments on the degree to which the impact may cause irreplaceable loss of resources and be irreversible, must be included in the narrative accompanying the impact rating:

Rating	Definition of Rating	Score
A. ***Extent*** *– the area over which the impact will be experienced*		
Local	Confined to project or study area or part thereof (e.g. limits of the concession area)	1
Regional	The region (e.g. the whole of Namaqualand coast)	2
(Inter) national	Significantly beyond Saldanha Bay and adjacent land areas	3
B. ***Intensity*** *– the magnitude of the impact in relation to the sensitivity of the receiving environment, taking into account the degree to which the impact may cause irreplaceable loss of resources*		
Low	Site-specific and wider natural and/or social functions and processes are negligibly altered	1
Medium	Site-specific and wider natural and/or social functions and processes continue albeit in a modified way	2
High	Site-specific and wider natural and/or social functions or processes are severely altered	3
C. ***Duration*** *– the time frame for which the impact will be experienced and its reversibility*		
Short-term	Up to 2 years	1
Medium-term	2 to 15 years	2
Long-term	More than 15 years (state whether impact is irreversible)	3

The combined score of these three criteria corresponds to a **Consequence Rating**, as follows:

Combined Score **(A+B+C)**	3 – 4	5	6	7	8 – 9
Consequence Rating	Very low	Low	Medium	High	Very high

Example 1:

[1] This does not apply to minor impacts which can be logically grouped into a single assessment.

Extent	*Intensity*	*Duration*	*Consequence*
Regional **2**	Medium **2**	Long-term **3**	**High** **7**

Step 2 – Assess the **probability** of the impact occurring according to the following definitions:

***Probability**– the likelihood of the impact occurring*	
Improbable	< 40% chance of occurring
Possible	40% - 70% chance of occurring
Probable	> 70% - 90% chance of occurring
Definite	> 90% chance of occurring

Example 2:

Extent	*Intensity*	*Duration*	*Consequence*	*Probability*
Regional **2**	Medium **2**	Long-term **3**	**High** **7**	Probable

Step 3 – Determine the overall **significance** of the impact as a combination of the **consequence** and **probability** ratings, as set out below:

		Probability			
		Improbable	Possible	Probable	Definite
Consequence	Very Low	**INSIGNIFICANT**	**INSIGNIFICANT**	**VERY LOW**	**VERY LOW**
	Low	**VERY LOW**	**VERY LOW**	**LOW**	**LOW**
	Medium	**LOW**	**LOW**	**MEDIUM**	**MEDIUM**
	High	**MEDIUM**	**MEDIUM**	**HIGH**	**HIGH**
	Very High	**HIGH**	**HIGH**	**VERY HIGH**	**VERY HIGH**

Example 3:

Extent	*Intensity*	*Duration*	*Consequence*	*Probability*	*Significance*
Regional **2**	Medium **2**	Long-term **3**	**High** **7**	Probable	**HIGH**

Step 4 – Note the **status** of the impact (i.e. will the effect of the impact be negative or positive?)

Example 4:

Extent	*Intensity*	*Duration*	*Consequence*	*Probability*	*Significance*	*Status*
Regional **2**	Medium **2**	Long-term **3**	**High** **7**	Probable	**HIGH**	**– ve**

Step 5 – State the level of **confidence** in the assessment of the impact (high, medium or low).

Depending on the data available, a higher level of confidence may be attached to the assessment of some impacts than others. For example, if the assessment is based on extrapolated data, this may reduce the confidence level to low, noting that further ground truthing is required to improve this.

Example 5:

Extent	*Intensity*	*Duration*	*Consequence*	*Probability*	*Significance*	*Status*	*Confidence*
Regional	Medium	Long-term	**High**				

2	**2**	**3**	**7**	Probable	**HIGH**	**– ve**	High

Step 6 – Identify and describe practical **mitigation** and **optimisation** measures that can be implemented effectively to reduce or enhance the significance of the impact. Mitigation and optimisation measures must be described as either:

- **Essential**: must be implemented and are non-negotiable; and
- **Optional**: must be shown to have been considered and sound reasons provided by the proponent if not implemented.

Essential mitigation and optimisation measures must be inserted into the completed impact assessment table. The impact should be re-assessed with mitigation, by following Steps 1-5 again to demonstrate how the extent, intensity, duration and/or probability change after implementation of the proposed mitigation measures.

Example 6: A completed impact assessment table

	Extent	***Intensity***	***Duration***	***Consequence***	***Probability***	***Significance***	***Status***	***Confidence***
Without mitigation	Regional **2**	Medium **2**	Long-term **3**	**High 7**	Probable	**HIGH**	**– ve**	High
Essential mitigation measures: • xxxxx • xxxxx								
With mitigation	Local 1	Low 1	Long-term 3	**Low 5**	Improbable	**VERY LOW**	**– ve**	High

Step 7 – Prepare a summary table of all impact significance ratings as follows:

Impact	***Consequence***	***Probability***	**Significance**	***Status***	***Confidence***
Impact 1: XXXX	Medium	Improbable	**LOW**	–ve	High
With Mitigation	Low	Improbable	**VERY LOW**		High
Impact 2: XXXX	Very Low	Definite	**VERY LOW**	–ve	Medium
With Mitigation:	*Not applicable*				

Indicate whether the proposed development alternatives are environmentally suitable or unsuitable in terms of the respective impacts assessed by the relevant specialist and the environmentally preferred alternative.

Appendix 2

A number of issues were raised by Interested and Affected Parties during the stakeholder consultation process. Those that are relevant to this specialist study are listed in Table 30 below.

Table 30. Issues relevant to this specialist study that were raised during the stakeholder consultation process.

COMMENT/QUERY/ISSUE	RESPONSE	STAKEHOLDER
Will there be encroachment into the surface water area?	The proposed floating dry dock is a semi-permanent feature that will encroach into the Port and will have some impact on water movement patterns and fauna in the immediate area.	Coastwatch
What are the proposed methods of avoiding sediment plume migration during embankment removal and dredging? Further degradation of the Harbour water quality is a concern during the construction phase.	The most commonly employed approach for minimizing turbidity plumes during dredging is to (a) avoid dredging during spring tides and (b) to use silt curtains to prevent dispersal of turbidity plumes.	Coastwatch
The disposal of spoil must be detailed to include disposal site, method of disposal and the amount of time spoil shall remain on site. The waste streams during construction and operation are to be identified as are management options of such streams. Waste management during both normal and abnormal conditions is to be considered.	The disposal of spoil is dealt with in the 'Assessment for offshore disposal of excavated materials' compiled by WSP. Waste management is dealt with in the 'Best available technique for pollution prevention and waste minimization' document compiled by WSP.	Coastwatch
A situation Assessment of the Durban Bay for the Estuarine Management Plan (EstMP) has been undertaken. A number of issues have been raised in the assessment, especially regarding management and improving function of the estuarine bay and the EAP must ensure that these issues are also addressed during this process.	Compulsory mitigation and recommendations have been included in this report.	Environmental Planning and Climate Protection Department
There is a need to address the generation and storage of waste as a fair amount of hazardous waste would be produced during the operation phase.	The disposal of spoil is dealt with in the 'Assessment for offshore disposal of excavated materials' compiled by WSP. Waste management is dealt with in the 'Best available technique for pollution prevention and waste minimization' document compiled by WSP.	Durban Solid Waste
A full geotechnical investigation will have to be undertaken to assess founding conditions for the new wall as the harbour sediments will not support such a structure without deep founding.	This has not been included in the report as it should be dealt with in a separate specialist engineers report.	Geotechnical Engineering Branch
A full geotechnical investigation will have to be undertaken to assess the nature of the sediments (sand or clay) being evacuated from the existing embankment or dredged	This has not been included in the report as it should be dealt with in a separate specialist geologist report. The disposal of spoil is dealt with in the 'Assessment	Geotechnical Engineering Branch

COMMENT/QUERY/ISSUE	RESPONSE	STAKEHOLDER
out of the water. Levels of possible contamination must be addressed in the report as this will affect how this material is disposed of (or reused as backfill behind the wall). It will also reveal the likelihood of mobile contaminants and/or copious quantities of suspended silt and clay to be released into the local harbour environment during dredging.	for offshore disposal of excavated materials' compiled by WSP.	