UPDATED MARINE IMPACT ASSESSMENT FOR THE PROPOSED MARINE PIPELINE SERVITUDE AT THE COEGA SPECIAL ECONOMIC ZONE, PORT OF NGQURA, SOUTH AFRICA

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EXECUTIVE SUMMARY

The Coega Development Corporation (CDC) has proposed the construction of an integrated common user marine pipeline servitude project within the Coega Special Economic Zone (SEZ), at the Port of Ngqura within Algoa Bay. This project is designed to allow current and future investors to establish infrastructure for the abstraction of seawater and the discharge of effluent as required by industrial or factory processes.

This report serves as the updated Marine Impact Assessment for the proposed development to assess the impacts of the construction and operation of the servitudes and the intake and discharge infrastructure along the shore and in the marine environment adjacent to the Coega SEZ. Specifically, this report updates the existing impact assessment (Laird *et al*. 2016) with the revised effluent dispersion modelling results produced by PRDW (2020) to assess the impacts of the proposed discharge on sensitive environments, marine users and aquaculture water quality requirements.

Affected environment

The proposed marine pipeline servitude project will be constructed in Algoa Bay. Algoa Bay falls within the warm temperate Agulhas ecoregion, one of four inshore ecoregions spanning the coast of South Africa.

Temperature and current dynamics are complex and vary over small spatial scales within the bay due to periodic upwelling that may occur near the rocky headlands during easterly winds, which causes sharp drops in temperature. Wave climate in Algoa Bay is predominantly from the south west with swells of less than 2 m most common and occurring approximately 80% of the time. Generally, winter water temperatures in Algoa Bay range from 14-22°C and the water column is generally homogenous. In summer, temperatures can reach 27°C, with a strong thermocline often evident in water deeper than 15 m.

Due to the localised upwelling, high concentrations of nitrate (>10 µmol/ℓ) have been reported in offshore waters (outer shelf and shelf edge), and off Cape Padrone and Cape Recife. However, within the bay itself, nitrate concentrations are much lower (around 1 µmol/l or less). Turbidity levels (i.e. measure of the suspended solids in the water column) in surface waters during both summer and winter were mostly low (<10 NTU), which is indicative of clear water, with elevated levels towards the bottom where values exceeded 10 NTU. Concentrations of most trace metals in Port waters were low or below detection limits aside from mercury, zinc, arsenic, and copper (the latter exceeded guideline levels). Hydrocarbon concentrations were very low both inside and outside the Port.

Algoa Bay is known to support a high biodiversity of marine life, particularly reef-associated invertebrates and fish, as well as several breeding colonies of endangered or vulnerable seabirds and a suite of cetaceans. For these reasons, 1200 km^2 of Algoa Bay has been protected within the Addo Elephant National Park Marine Protected Area (MPA) as of 2019. This MPA extends the protection of the land based Addo Elephant National Park to include marine species such as the great white shark and several whale species that frequent the Algoa Bay coastline (Bryde's, Minke, Humpback and Southern Right whales). In addition, the MPA protects the breeding and important feeding grounds of two endangered bird species, namely African penguin and Cape gannet, which breed on the St Croix and Bird Islands located within the MPA.

In this report, existing recreational and commercial users of marine waters in Algoa Bay are described, as well as the degree of spatial overlap of the two. Recreational non-motorized water sports such as swimming, surfing, kayaking, and kite surfing take place far to the south-west of the proposed servitude project; while the shallow reef in Algoa Bay provides sites for recreational SCUBA diving, three of which are located in close proximity to the Coega SEZ. Key commercial fisheries within the bay include the commercial line fishery, the small pelagic purse seine fishery, the squid fishery and the shark longline fishery. The proposed marine pipeline servitude project area offshore of the Port of Ngqura overlaps with a squid fishing ground which accounts for nearly 1% of average annual fishing effort, and approximately 12% of the Eastern Cape annual average for the small pelagics fishery. The Coega SEZ also lies in close proximity to the Algoa 7 precinct, an area within the Algoa Bay Aquaculture Development Zone (ADZ) set aside for finfish farming (Environmental Authorization for the ADZ currently in the appeals phase). An application for environmental authorisation for the development of a land-based ADZ in the Coega Industrial Development Zone was granted in 2018.

Effluent modelling

The revised dispersion modelling assessment (PRDW 2020) considered water quality and volume requirements for abstraction of seawater as well as effluent characteristics and volumes from four broad industrial types that may be established in the Coega SEZ – i.e. aquaculture, desalination, industrial wastewater, including the planned Coega Waste Water Treatment Works (WWTW), and thermal cooling (e.g. the planned gas to power plants). As such, six effluent discharge pipeline options were modelled (detailed in Table 1 below). Two scenarios were modelled, based on differing effluent source mixes (Table 1).

Table 1. Effluent streams and scenarios modelled by PRDW (2020).

<table>
<tr><th rowspan="2">Effluent stream</th><th rowspan="2">Effluent type and discharge</th><th colspan="2">Scenario modelled</th></tr>
<tr><th>1</th><th>2</th></tr>
<tr><td>1</td><td>Land based abalone aquaculture effluent, discharged into the surf zone</td><td>X</td><td>X</td></tr>
<tr><td>2</td><td>Wastewater 1: effluent discharged into the Coega River which in turn discharges into the Port of Ngqura</td><td>X</td><td>X</td></tr>
<tr><td>3</td><td>Wastewater 2: effluent discharged offshore via a submarine pipeline (-20 m CD, 3000 m offshore)</td><td>X</td><td>X</td></tr>
<tr><td>4</td><td>Finfish effluent from land-based aquaculture discharged offshore via a submarine pipeline (-16 m CD, 1500 m offshore)</td><td>X</td><td rowspan="2">X</td></tr>
<tr><td>5</td><td>Desalination brine from a 60 MLD Reverse Osmosis desalination plant discharged offshore via a submarine pipeline (-13.5 m CD, 1000 m offshore)</td><td>X</td></tr>
<tr><td>6</td><td>Cooling water from the two Liquefied Natural Gas (LNG) power plants discharged offshore via a subterranean tunnel (-11 m CD, 650 m offshore). Combined with heating water from LGN vaporiser (effluent stream 7). Three separate cooling water options:
1. CW1: Once through cooling (Zone 10S) plus wet mechanical cooling (Zone 10N).
2. CW2: Once through cooling (Zone 10S) plus air cooling (Zone 10N).</td><td>CW2+HW1</td><td>CW3+HW2</td></tr>
</table>

Effluent stream	Effluent type and discharge	Scenario modelled	
		1	2
	3. CW3: Wet mechanical cooling (Zone 10S) plus wet mechanical cooling (Zone 10N).		
7	**Heating water** from LNG vaporiser discharged offshore via a subterranean tunnel (-11 m CD, 650 m offshore). Combined with cooling water from LGN power plants (effluent stream 6). Two separate cooling water options: 1. HW1: The vaporisers use the warm cooling water from the power plant (only possible for once through cooling). 2. HW2: The vaporisers use sea water from an intake in the Port of Ngqura	CW2+HW1	CW3+HW2

PRDW (2020) and Lwandle (2020) have recommended a 300 m mixing zone for all outfalls. Under ordinary conditions however, a 300 m mixing zone for the proposed Wastewater 1 discharge into the Port of Ngqura via the Coega River would be considered unacceptable. The Assessment Framework for Effluent Discharged from Land Based Sources requires that such a discharge into an estuary meet water quality guidelines at pipe end. However, the Coega Estuary has been assessed by the National Biodiversity Assessment (2018 and 2011) as being been irreversibly modified, with an almost complete loss of natural habitat and biota, and that the basic ecosystem functions and processes of the system have been destroyed. As such, a 300 m mixing zone is considered acceptable in this case, on condition that Wastewater 1 effluent does not contain excessively high levels of trace metals (ostensibly from industrial effluent) as per PRDW (2020).

Impact assessment

A total of seventeen potential marine environmental impacts were assessed for this report, ranging from habitat loss to operational effects (see Table 5.20) (impacts that have been assessed in other marine specialist studies undertaken for the particular industries within the Coega SEZ, such as the bio-active compound and disease risks associated with aquaculture, are not reassessed here). The impacts of the proposed development of fisheries in Algoa Bay were assessed separately. Scenario 1 and Scenario 2 were assessed together for construction impacts, with all impacts assessed as either 'low' or 'very low' after mitigation. Scenario 1 and Scenario 2 were assessed separately for operational impacts. There were nine identified operational impacts (including the impacts on fisheries), of which three were assessed as being of 'high' significance. However, all operational impacts were assessed as 'low', 'very low' or 'insignificant' after mitigation. All impacts on fisheries are considered 'low' or 'very low' with mitigation. Impacts are summarised in Table 2 below.

Table 2. Summary of identified and assessed impacts before and after mitigation.

Phase	Impact identified	Without mitigation		With mitigation
		Scenario 1	Scenario 2	
Construction	Impact 1: Loss of sandy beach, intertidal and subtidal habitat and biota.	MEDIUM		LOW
Construction	Impact 2: Ecological effects due to the disturbance of pelagic open water habitats	LOW		VERY LOW
Constr uction	Impact 3: Barotrauma of marine fauna as a result of blasting.	MEDIUM		VERY LOW

Phase	Impact identified	Without mitigation		With mitigation
		Scenario 1	Scenario 2	
	Impact 4: Noise disturbance to marine fauna.	MEDIUM		VERY LOW
	Impact 5: Reduced water quality from blasting, drilling and dredging.	LOW		VERY LOW
	Impact 6: Pollution generated during construction.	LOW		VERY LOW
	Impact 7: The effect of the spillage of hazardous substances on marine biota.	LOW		VERY LOW
Operation	Impact 8: Disturbance and/or mortality of marine life due to the intake of seawater.	LOW		VERY LOW
	Impact 9: Elevated temperature.	LOW	VERY LOW	VERY LOW
	Impact 10: Changes in salinity.	VERY LOW		INSIGNIFICANT
	Impact 11: Elevated nutrients from aquaculture effluent and wastewater effluent.	HIGH		LOW
	Impact 12: Increased suspended solid concentrations.	MEDIUM		LOW
	Impact 13: Increased trace metal and inorganic constituent concentrations	HIGH		LOW
	Impact 14: Reduced dissolved oxygen concentrations.	MEDIUM		VERY LOW
	Impact 15: Sediment scouring and shifts in sediment movement patterns.	LOW		LOW
	Impact 16: Pathogens present in effluent.	HIGH		LOW

		SP	LF	SQ	S	SP	LF	SQ	S
	Impact 17: Impacts on fisheries *	L	H	L	VL	VL	L	VL	VL

Cumulative impacts	HIGH	LOW

* SP = Small pelagics, LF = Linefish, SQ = Squid jig, S = Shark longline

Cumulative marine environmental impacts emanating from the proposed project are primarily related to the overlap in use with various other water users in the vicinity of the proposed marine pipeline servitude project. As sea-based finfish farms tend to be significant sources of nitrogenous waste (i.e. nutrients), there is particular concern about the cumulative impacts of increased nutrient concentrations arising from both the sea based finfish aquaculture in the Algoa 7 finfish ADZ, and the nutrients discharges by the wastewater and finfish pipelines of the Coega SEZ. However, dispersion modelling by PRDW (2020) shows that required dilutions of nitrogenous waste (TKN + NH_4) from Wastewater 1 achieve dilutions of ~1 870 at Algoa 7 (required dilution to meet WQG is 120), and that the finfish + brine effluent combination under Scenario 2 archives dilutions of ~580 at Algoa 7 (required dilution to meet WQG is 39.1). As such, it is considered unlikely that there will be significant interaction between these nutrient sources, especially if the recommended scenario is implemented (PRDW 2020), and end of pipeline requirements are met.

However, there is a low level of confidence in the assessment of cumulative impacts of the simultaneous operation of multiple discharge pipelines. While the effluents are relatively different to each other (i.e. dense brine vs buoyant finfish aquaculture effluent), there are potential interactions between effluent constituents that can only be identified by a far field dispersion model. In order to improve the confidence in the assessment of cumulative impacts (currently low/ not possible), this simultaneous discharge scenario should be modelled.

Given that there is limited difference in the assessment of ecological impacts between Scenario 1 and Scenario 2, this report recommends that Scenario 1 be followed with the recommended adjustments as stipulated by PRDW (2020). These adjustments to Scenario 1 include:

1. Wastewater 1: limit the maximum allowable effluent concentrations (end of pipe) for *E.coli*, TKN + NH_4 and TSS (see Table 3) (wastewater must be treated on land to meet appropriate standards prior to discharge).
2. Wastewater 2: limit the maximum allowable effluent concentrations (end of pipe) for heavy metals and COD (see Table 3) (wastewater must be treated on land to meet appropriate standards prior to discharge).
3. Although both Cooling Water + Heating Water mix options meet the guidelines, the Scenario 2 option of Cooling Water 3 + Heating Water 2 is preferred over the Scenario 1 option of Cooling Water 2 + Heating Water 1.

It is critical that end of pipe limits stipulated by the dispersion modelling report be adhered to so as to safeguard the marine environment of Algoa Bay and mitigate impacts on other water users. Based on the impacts assessed in this report, it is recommended that the proposed development proceed with the implementation of strict environmentally responsible practices as outlined in the mitigation measures below. However, it is critical that the cumulative impacts of the proposed discharges be assessed with a higher level of confidence though modelling, and this report be updated with the results thereof.

Recommended mitigation

Essential and best practise mitigation measures recommended to reduce the severity of the impacts during the **construction**/decommissioning phase as outlined above are as follows:

- Rehabilitate the disturbed area immediately following construction by removing all artificial structures or beach modifications created during construction from above and within the intertidal zone. No accumulation of excavated beach sediments should be left above the high-water mark, and any substantial sediment accumulations below the high-water mark should be levelled.
- Undertake baseline and comparative monitoring of biota in the construction footprint. Monitoring should focus on physical habitat variables (sediment particle size composition and organic content) and biota (e.g. benthic infaunal soft sediment communities). The latter have been shown to provide a good indication of habitat recovery following physical disturbance. Surveys should be done once prior to construction and again approximately 12 months after construction is complete.
- The spatial extent and duration of construction must be limited as far as possible (construction of the different infrastructure should be undertaken sequentially to minimise disturbance on pelagic habitat).
- Mitigation for blasting and construction noise includes the following:
    - A visual survey of the area (both the immediate vicinity of the construction footprint

and within a 1000 m radius) should be conducted by trained marine mammal observers (MMO's) 30 minutes before the blasting is to commence. Permission to blast must be delayed until all marine mammals are outside the 1 km radius form the blast site. Similarly, all blasting should be halted once marine mammals are seen entering the 1 km radius. Blasting should not commence when environmental conditions, such as darkness, mist, rain, fog or high sea states greater than Beaufort 4 prohibit adequate monitoring of the 1 km safety zone.

  - No blasting may take place during the annual sardine run (May-June) and should only be undertaken during daylight hours.
  - No blasting should be undertaken in the early mornings (6h00-10h00) or late afternoons (15h00-19h00) due to coastal dolphin activity in inshore waters. Ideally, blasting should only be undertaken between 12h00 and 14h00.
  - A soft-start (i.e. gradual ramping up of piling/ drilling power) period of at least 20 minutes is recommended. If an animal enters the safety zone during soft-start, the power should not be increased until the animal exits and remains outside of the zone for 20 minutes.
- Vehicles must be checked for hydrocarbon leaks daily.
- Protocols for dealing with accidental spills must be in place.
- All fuel and oil is to be stored with adequate spill protection, and no leaking vehicles are permitted on site.
- Emergency equipment to isolate spills must be accessible.
- Suitable containers for the disposal of all waste, including recycling, must be provided.
- All hazardous substances must be accompanied by a permit, a hazard report sheet, and a first aid treatment protocol and may only be handled by suitably trained operators.
- Intentional disposal of any substance into the environment is strictly prohibited, while accidental spillage must be prevented, contained and reported immediately.
- A rigorous environmental management and control plan (including procedures for remediation) must be implemented.
- A monitoring programme should be implemented to monitor water quality in the vicinity of the construction site. Six monitoring stations, three on either side of the pipeline at 10, 15 m and 18 m depth, respectively, should be identified for this purpose. Measurements should be collected daily for 20-30 days prior to the commencement of dredging operations (to develop an appropriate baseline) and should continue as long as dredging continues. The median TSS concentration in monitoring data should not exceed the threshold limit which is set as the greater of the 80th percentile of the baseline monitoring data, or ten percent (10%) greater than the natural background turbidity. If the TSS approaches the threshold limit set above at any of the surveillance monitoring stations, mitigation measures are to be put in place to prevent any further increase in suspended solid concentration (e.g. reduce rate of construction activities). If median turbidity levels (calculated from measured values in any one and a half hour period) exceed the threshold, construction activities are to be suspended until measured levels drop below the threshold.

Essential mitigation measures recommended to reduce the severity of the impacts during the **operational** phase as outlined above are as follows:

- Intake velocities should be kept below 0.15 m/s to ensure that fish and other mobile organisms can escape the intake current through the use of footer valves. This velocity is according to USA Environmental Protection Agency (EPA) and is regarded as industry best practice. A footer valve is a flared (or expanded) section of pipe that is fitted on the end of the intake that will allow ensure intake velocity does not exceed a specified threshold at the entrance to the intake structure. Note that velocity decreases as cross-sectional area increases and the size of the intake valve required will depend on the amount by which velocity needs to be reduced (if the velocity must be reduced by 50%, then cross sectional area must double).

- Intake structures should ensure the horizontal intake of water and be positioned away from sensitive environments or areas with high species diversity or abundance, like rocky reefs, and should not draw in water from the upper meter of the water column.
- The preferred Scenario recommended by PRDW (2020) must be implemented with the recommended adjustments.
- A water quality monitoring programme must be implemented to validate the predictions of the hydrodynamic modelling study and monitor constituents of the effluent to ensure compliance with water quality guidelines. Should monitoring reveal non-compliance adaptive management must be implemented to improve effluent quality and compliance with WQGs. These measures must include options to reduce or stop discharges until improvements are implemented.
- Should the proposed Wet Mechanical Cooling water intake jetty be constructed **outside** of the Port, a sediment transport study must be undertaken to assess the impacts of on sediment transport patterns in the area. This modelling study must be undertaken prior to construction outside of the Port, and this impact must be reassessed based on the results of this modelling study.
- Sodium metabisulfite is an oxygen scavenger chemical that is typically used to neutralise the oxidising potential of the residual chlorine from the biocide dosing of the abstracted seawater before being processed through the RO plant so as to avoid damage to the RO membranes. Chlorine is used to dose the abstraction line to restrict marine growth. If the dosing of sodium metabisulphate is well-managed, the levels of sodium metabisulphate in the effluent should be low enough to avoid an "oxygen sag" in the marine environment receiving the effluent. Environmental best-practise is to ensure aeration of the effluent prior to discharge.
- Ensure end of pipe limits for discharges not included in the model (i.e. biocides) do not exceed water quality guideline limits (i.e. 0.2 mg/l pipe end for chlorine).
- End of pipe concentrations recommended by PRDW (2020) be adhered to and are specified in Table 3 below. Wastewater must be treated on land to meet appropriate standards prior to discharge. These end of pipe concentrations should be reflected in any awarded Coastal Waters Discharge Permit.

Table 3. Required end of pipe concentrations for containments of concern within various effluents, as stipulated by PRDW (2020).

Effluent stream	Constituent	Unit	Maximum end of pipe concentration
Wastewater 1	Salinity	PSU	17
	TKN + NH4	mg/l	5

Effluent stream	Constituent	Unit	Maximum end of pipe concentration
Wastewater 1 (cont.)	TSS		50
	E. coli	Cfu/100ml	4500
Wastewater 2	Sulphide	mg/l	0.21
	Hg		0.062
	Co		0.21
	Cu		1.04
	Cd		0.83
Brine + Finfish	Ammonia, nitrates, nitrites	mg/l	13.37

Monitoring

On receipt of Coastal Waters Discharge Permits (CWDPs), the end of pipe concentrations for each outfall as published in the permit conditions must be met to ensure compliance at the edge of the Recommended Mixing Zone (RMZ). Compliance monitoring of the effluent before discharge should be performed to minimise environmental impacts. If discharged effluent exceeds the end of pipe values at any time, the operation will be in violation of the CWDP and the cause of poor effluent quality must be identified, reported and rectified immediately.

A monitoring program at the edge of each RMZ should be implemented prior to construction to better determine ambient water quality and to ensure that required Water Quality Guidelines (WQGs) are being met at the edge of the RMZ. This can be achieved by mooring a data logging instrument capable of measuring conductivity (i.e. salinity), temperature and depth (CTD) 1 m above the ocean bottom for a period of one month pre- and one year after operations commences. Monitoring should also be undertaken to assess dissolved oxygen levels, microbiological indicators (*Enterococci* sp. and/or *E. coli*), turbidity, ammonia, nitrate and pH. Monitoring for salinity and temperature should take place continuously (via the moored instrument), while the other environmental water quality parameters should be assessed quarterly (i.e. four times per year).

It is also recommended that benthic macrofaunal samples be collected and analysed both pre- and post-discharge. Benthic macrofauna biological indicators, such as species abundance, biomass, and diversity, provide a direct measure of the state of the ecosystem in space and time and tend to be directly affected by pollution/disturbance. It is recommended that a minimum of six sites be monitored in the vicinity of each outfall with three samples collected per site. Two control sites should be included to assess potential impacts relative to broader changes within Algoa Bay. These samples must be accompanied by an assessment of sediment granulometry and organic content to permit correct interpretation of the macrofauna results, because sediment particle size, Total Organic Carbon (TOC) and Total Organic Nitrogen (TON) within the sediment influence macrofaunal community structure in marine systems. These factors must therefore be controlled to correctly interpret changes in community structure, should such changes be detected. These benthic samples should be collected and assessed annually. Sediments from control and impacts sites must also be analysed for trace metal content in order to detect potential enrichment due to effluent discharges.

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GLOSSARY

Amphipod/a	Crustaceans with no carapace and a laterally compressed body.
Anaerobic	Relating to or requiring an absence of free oxygen.
Anthropogenic	Environmental pollution originating from human activity
Aquaculture Development Zone	A selection of designated precincts that provide opportunities for existing aquaculture operations to expand and new ones to be established.
Ascidian	Primitive chordates resembling sac-like marine filter feeders, also known as sea squirts.
Avifauna	The birdlife of a particular region or habitat.
Balanoid zone	The middle portion of shoreline zone on a rocky shore. The upper balanoid (barnacle) zone is dominated by barnacles, winkles, limpets and a few seaweeds able to survive the semi-dry conditions that prevail in this zone. The lower balanoid (barnacle) zone on the west coast supports thick beds of fleshy seaweed. On the east coast the upper balanoid is inhabited by slippery, green zoanthids and brightly coloured sponges, brown mussels and coralline seaweeds.
Baseline	Information gathered at the beginning of a study which describes the environment prior to development of a project and against which predicted changes (impacts) are measured.
Benthic	Pertaining to the environment inhabited by organisms living on or in the ocean bottom
Biodiversity	The variety of plant and animal life in a particular habitat.
Biological monitoring survey	A scientific study of organisms to assess the condition of an ecological resource, involving the collection and analysis of animal and/or plant samples which serve as indicators to the health/recovery of an affected system.
Biomass	The mass of living biological organisms in a given area or ecosystem.
Bioregion	A region defined by characteristics of the natural environment rather than by man-made divisions.
Biota	Living organisms within a habitat or region
Chart datum	Chart Datum is level on the shore corresponding with the Lowest Astronomical Tide (LAT) as from 1 January 2003.
Cochlear zone	A portion of the shoreline occurs between the infratidal and the lower Balanoid zones). One the south coast, this zone supports dense bands of pear limpets at the low-tide mark. The cochlear/argenville zone is a feature of the west coast. The zone takes its name from the tall, Argenville's limpet, which occurs in a band, together with large numbers of pear limpets. Black mussels are also found in this zone.
Construction phase	The stage of project development comprising site preparation as well as all construction activities associated with the development.
Copepod	A group of small crustaceans found in the sea and nearly every freshwater habitat. Some species are planktonic (drifting in the water column), while some are benthic (living on the ocean floor).
Crinoid	Feather stars belong to the phylum Echinodermata. As juveniles, they are attached to the sea bottom by a stalk with root-like branches. In the adult stage, they break away from the stalk and move about freely.
Crustacea/n	Generally differ from other arthropods in having two pairs of appendages (antennules and antennae) in front of the mouth and paired appendages near the mouth that function as jaws.
Cumulative impacts	Direct and indirect impacts that act together with current or future potential

	impacts of other activities or proposed activities in the area/region that affect the same resources and/or receptors.
Desulfovibria	Sulphate-reducing bacteria
Diatom	A major group of algae that makes up the most common type of phytoplankton. Most are unicellular but they can group together to form colonies.
Dinoflagellate	A large and diverse group of unicellular protists, most of which are marine, and that can either be free-living in the plankton, or benthic.
Dissipative beach	Waves break further offshore and lose energy (dissipate) across the wide surf zone. At a dissipative beach high waves and a wide surf zone restrict most bathers to the inner swash zone.
Echinoderm/ata	Marine invertebrates with fivefold radial symmetry, a calcareous skeleton and tube feet (e.g. starfishes, sea urchins, sea cucumbers)
Endemicity /endemism	A species unique to a defined geographic location. Organisms that are indigenous to an area are not endemic if they are found elsewhere.
Environment	The external circumstances, conditions and objects that affect the existence of an individual, organism or group. These circumstances include biophysical, social, economic, historical and cultural aspects.
Environmental Authorisation	Permission granted by the competent authority for the applicant to undertake listed activities in terms of the NEMA EIA Regulations, 2014.
Environmental Impact Assessment	A process of evaluating the environmental and socio-economic consequences of a proposed course of action or project.
Far field	The region of the receiving water where buoyant spreading motions and passive diffusion control the trajectory and dilution of the effluent discharge plume.
Faunal community	A naturally occurring group of native animals that interact in a unique habitat.
Gastropod/a	Molluscs (e.g. snails and slugs)
Harmful algal blooms	These blooms occur when colonies of algae (simple plants that live in the sea and freshwater) grow out of control and produce toxic or harmful effects on people, fish, shellfish, marine mammals and birds. The human illnesses caused by these blooms, though rare, can be debilitating or even fatal.
High shore	The section of the intertidal zone reaching from the extreme high water spring tide to the mean high water neap tide.
Impact	A change to the existing environment, either adverse or beneficial, that is directly or indirectly due to the development of the project and its associated activities.
Infauna	The assemblage of organisms inhabiting the seafloor.
Infratidal zone	The lowest region on the shore and the richest in plant and animal life especially red bait (sea squirts), anemones, sea urchins and starfish. Colourful, branched seaweeds are found on the east coast, while large kelps flourish on the west coast
Intermediate beaches	A type of beach that has characteristics of both dissipative and reflective beaches.
Intertidal zone	The section of the marine environment that lies exposed at low tide and submerged at high tide.
Invasive species	Alien species capable of spreading beyond the initial introduction area and have the potential to cause significant harm to the environment, economy or society.
Invertebrate	An animal without a backbone (e.g. a starfish, crab, or worm)
Littorina zone	The upper most portion of shoreline zone on a rocky shore. The highest and most barren zone on the shore. Small, air-breathing littorinid snails, one species on the west and south coasts and three species on the east coast, inhabit it. Purple laver (Porphyra capensis), a hardy sea plant able to withstand severe desiccation, also

	occurs in this zone.
Longshore current/drift	The movement of material along a coast by waves that approach at an angle to the shore but recede directly away from it.
Low shore	The section of the intertidal zone reaching from the mean low water neap tide to the extreme low water spring tide.
Macrofauna	Animals larger than 0.5 mm.
Macroscopic	Visible to the naked eye.
Marine Protected Area	An area of sea and coastline that is dedicated to the protection of biodiversity and natural and cultural resources and is managed in a structured and legal manner. Different levels of MPAs exist, ranging from complete no-take zones (where nothing may be disturbed, caught or removed) to partial-take MPAs which have a suite of regulations that determine what activities may take place in which zone.
Meiofauna (meiobenthos)	Small benthic invertebrates that are larger than microfauna but smaller than macrofauna.
Microscopic	So small as to be visible only with a microscope.
Mitigation measures	Design or management measures that are intended to minimise or enhance an impact, depending on the desired effect. These measures are ideally incorporated into a design at an early stage.
Mixing zone	An administrative construct which defines a limited area or volume of the receiving water where the initial dilution of a discharge is allowed to occur, until the water quality standards are met. In practice, it may occur within the near field or farfield of a hydrodynamic mixing process and therefore depends on source, ambient, and regulatory constraints.
Mollusc/a	Invertebrate with a soft unsegmented body and often a shell, secreted by the mantle.
Near field	The region of a receiving water where the initial jet characteristic of momentum flux, buoyancy flux and outfall geometry influence the jet trajectory and mixing of an effluent discharge.
Nearshore	Zone extending seawards of Chart Datum to a point where the seabed is less than 10 m depth at Chart Datum, or the distance offshore from Chart Datum is less than 500 m, whichever is greater.
No-take zone	A type of MPA where no fishing is allowed
Offshore	The area seaward of the nearshore environment boundary.
Operational phase	The stage of the works following the Construction Phase, during which the development will function or be used as anticipated in the Environmental Authorisation.
Pelagic	Within the water column.
Phytoplankton	Ocean dwelling microalgae that contain chlorophyll and require sunlight in order to live and grow.
Polychaete	Segmented worms with many bristles (i.e. bristle worms).
PSU	Ocean salinity is generally defined as the salt concentration in sea water. It is measured in unit of PSU (Practical Salinity Unit), which is a unit based on the properties of sea water conductivity. It is equivalent to per thousand or (o/00) or to g/kg.
Recommended Mixing Zone (RMZ)	An administrative construct which defines a limited area or volume of the receiving water where the initial dilution of a discharge is allowed to occur, until the water quality standards are met. In practice, it may occur within the near field or far field of a hydrodynamic mixing process and therefore depends on source, ambient, and regulatory constraints. The following recommendations

	have been tabled for South Africa (Anchor Environmental Consultants 2015): 300 m in an offshore environment, 100 m in a nearshore open coast environment, 30 m in sheltered coastal environments and special management areas, 0 m for outfalls in established or proposed MPAs, the surf zone and estuaries
Reflective beaches	A type of beach characterised by low wave energy, coarse grains (>500 µm sand) and narrow and steep intertidal beach faces. The relative absence of a surf zone causes the waves to break directly on the shore causing a high turnover of sand. The result is depauperate faunal communities.
Scoping	A procedure to consult with stakeholders to determine issues and concerns and for determining the extent of and approach to an EIA and EMP (one of the phases in an EIA and EMP). This process results in the development of a scope of work for the EIA, EMP and specialist studies.
Semi-diurnal tides	When there are two high tides and two low tides within a day that are about the same height,
Specialist study	A study into a particular aspect of the environment, undertaken by an expert in that discipline.
Species	A category of biological classification ranking immediately below the genus, grouping related organisms. A species is identified by a two part name; the name of the genus followed by a Latin or Latinised un-capitalised noun.
Species richness	The number of different species represented in an ecological community. It is simply a count of species and does not take into account the abundance of species.
Subtidal	The marine habitat that lies below the level of mean low water for spring tides.
Subtidal zone	See “Infratidal zone”.
Surf zone	Zone extending seawards of the high water mark to a point where the largest waves begin to break, off any section of coast defined as “sandy coast” or “mixed coast” on the National Coastline Layer, available from the South African National Biodiversity Institute’s BGIS website (http://bgis.sanbi.org).
Surficial sediments	Calculated conservatively as the upper 20 cm of sediment for the purposes of offshore disposal.
Total Kjeldahl nitrogen	The sum of organically bound nutrients.
Total nitrogen	The sum of inorganic and organic nutrients.
Total Suspended Solids	A measure of the mass per unit volume of TSS in the water column.
Trophodynamics	The dynamics of nutrition and metabolism.
Turbidity	A measure of light conditions in the water column.
Vertebrate	An animal of a large group distinguished by the possession of a backbone or spinal column, including mammals, birds, reptiles, amphibians, and fishes.
Wind forcing	The movement of surface waters and the resulting transfer of energy to deeper waters by the predominant wind (i.e. a strong easterly wind will result in an eastward flowing surface current).

LIST OF ABBREVIATIONS

ABYC	Algoa Bay Yacht Club
ADCP	Acoustic Doppler Current Profiler
ADDs	Acoustic Deterrent Devices
ADZ	Aquaculture Development Zone
Anchor	Anchor Environnemental Consultants (Pty) Ltd
BA	Basic Assessment
BMSL	Below Mean Sea Level
CD	Chart Datum
CDC	Coega Development Corporation
CSIR	Council for Scientific and Industrial Research
CTD	Conductivity, temperature, depth
CWDP	Coastal Water Discharge Permit
DEA&DP	Department of Environmental Affairs and Development Planning
DEA: O&C	Department of Environmental Affairs: Oceans and Coasts
DEAT	Department of Environmental Affairs and Tourism
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
EA	Environmental Authorisation
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
FSRU	Floating Storage & Regasification Unit
GA	General Authorisation
GAENP MPA	Greater Addo Elephant National Park Marine Protected Area
GDA	General Discharge Authorisation
HABs	Harmful algal blooms
HDPE	High Density Poly Ethylene
ICMA	Integrated Coastal Management Act (No. 24 of 2008)
IEM	Integrated Environmental Management
IUCN	International Union for Conservation of Nature
LNG	Liquefied Natural Gas
MMO's	Marine Mammal Observers
MPA	Marine Protected Area
MSL	Mean Sea Level
NBA	National Biodiversity Assessment
NEMA	National Environmental Management Act (No. 107 of 1998, as amended)
NWA	National Water Act (No. 36 of 1998)
PSU	Practical Salinity Unit
RMZ	Recommended Mixing Zone
RWQ	Receiving Water Quality
SANParks	South African National Parks
SEZ	Special Economic Zone

TKN	Total Kjeldahl nitrogen
TOC	Total Organic Carbon
TON	Total Organic Nitrogen
TSS	Total Suspended Solids
WEROP	Wave Energy Reverse Osmosis Pump
WQBEL	Water Quality Based Effluent Limits
WQG	Water Quality Guidelines
WUA	Water Use Authorisation
WWTW	Waste Water Treatment Works

DECLARATION OF INDEPENDENCE

Anchor Research & Monitoring (Pty) Ltd is an independent consultant and has no business, financial, personal or other interest in the activity, application or appeal in respect of which the company was appointed other than fair remuneration for work performed in connection with the activity, application or appeal. No circumstances arose during the course of the project that compromised the objectivity of the specialists that performed the work.

BACKGROUND AND QUALIFICATIONS OF SPECIALIST CONSULTANTS

The study was undertaken by Dr Barry Clark, Dr Kenneth Hutchings, Amy Wright and Dr Jessica Dawson.

Dr Barry Clark has twenty-eight years' experience in marine biological research and consulting on coastal zone and marine issues. He has worked as a scientific researcher, lecturer and consultant and has experience in tropical, subtropical and temperate ecosystems. He is one of the founding partners at Anchor Environmental Consultants and a Research Associate at the University of Cape Town. As a consultant has been concerned primarily with conservation planning, monitoring and assessment of human impacts on estuarine, rocky shore, sandy beach, mangrove, and coral reef ecosystems as well as coastal and littoral zone processes, aquaculture and fisheries. Dr Clark is the author of 27 scientific publications in class A scientific journals as well as numerous scientific reports and popular articles in the free press. Geographically, his main area of expertise is southern Africa (South Africa, Lesotho, Namibia, Mozambique, Tanzania, Seychelles, Mauritius and Angola), but he also has working experience from elsewhere in Africa (Republic of Congo, Sierra Leone, Liberia, Cote d'Ivoire, Ghana, Nigeria), the Middle East (UAE) and Europe (Azerbaijan).

Dr Hutchings has more than 20 years of research and consulting experience in the fields of fisheries management, mariculture, estuarine research and management, marine and estuarine spatial planning, marine impact assessment, research and conservation strategy development, fishery socio-economic surveys and analyses, biological sampling and life-history analyses of fish (age and growth, reproduction, mortality, migration, diet, ecology), taxonomic methodology, population genetics, fisheries modelling, marine ecotoxicity trials, trace metal pollution and physico-chemical, ecological and biodiversity surveys of marine, estuarine and freshwater habitats. Dr Hutchings is experienced in developing estuarine and coastal management plans and in conducting public participation processes. Dr Hutchings is a research associate of the University of Cape Town's Marine Research Institute. He has excellent verbal and writing communication skills, is competent with most software packages used in scientific research and consulting projects. He has published 19 scientific papers and compiled more than 50 consulting reports. Dr Hutchings is comfortable working as part of a team in both a leadership and mentoring position or as a team member. Dr Hutchings has participated in international collaborative studies in Angola, Tanzania, Namibia, Sierra Leone, Republic of Congo, Somaliland and Mauritius. He has practical experience in several fishing sectors and has good understanding of most commercial fishing methods (line, spear, pole, gill net, trammel, net, beach seine net, trap, longline, trawl and purse-seine). He has personally collected scientific data for the demersal trawl and longline hake fisheries, designed, implemented and managed fishery observer training programmes for line, longline, lobster trap and demersal trawl fisheries. He has project managed and completed two, three-year contract research projects for the South African Department of Environmental Affairs and Tourism (Marine and Coastal Management) and numerous consulting projects for state and private sector clients.

Amy Wright has an MSc degree in Biological Sciences and BSc. (Hons) degrees in Marine Biology and Applied Biology from the University of Cape Town. Amy specialises in two- and three-dimensional hydrodynamic modelling of marine, estuarine and freshwater systems to inform impact assessments, water regulatory guideline compliance and monitoring programs design. She is proficient in both hydrodynamic, water quality and particle tracking applications across a range of numerical model systems, with experience in Delft3D modelling suite (FLOW, SWAN, WAQ, PART), CorMIX, Deltares MAMPEC and Ancylus MOM, with training in Delft3D FM (FLOW, WAQ). She has dispersion modelling experience spanning a range of projects including fish farm effluent, brine, heating water discharge, heavy metals and antifoulants. Her work has included biophysical and socio-economic assessment of human impacts on temperate and tropical coastal regions of South Africa, Namibia, Mozambique, Mauritius, Kenya and Tanzania. Her work intersects with environmental law and permitting requirements, along with environmental monitoring program design and implementation. She also has a background in taxonomy (BSc Hons., UCT), and deep-water crustacean ecology (MSc, UCT). Amy is involved in staff training, data management and analysis, and has worked as an invertebrate taxonomist for the De Beers Marine Namibia and the NAMDEB Diamond Corporation Environmental Monitoring Programmes. She is the author of scientific publications in Class A scientific journals as well as numerous popular articles in the free press, including as a children's author.

Dr Jessica Dawson has a background in marine biology, estuarine community ecology and food webs, benthic invertebrate biology and taxonomy. She earned her PhD in Zoology (specifically estuarine ecology) from the University of Cape Town. Jessica has worked on the taxonomic descriptions of new species (BSc Hon. UCT), the effects of grazers on community structure of soft-sediment estuarine and rocky shore communities (BSc Hon. and MSc., UCT) and the indirect effects of the presence of large herbivore species on benthic estuarine communities and food web structure during a drought (PhD). Through her ecological training and work conducted for Anchor Environmental Consultants, she has gained experience to consult on a variety of research projects including estuarine and marine baseline assessments and monitoring programs, estuarine valuation, specialist impact assessments, basic assessment reports and the development of an Estuarine Management Plan, as well as being a marine and estuarine taxonomic specialist on benthic invertebrates of Southern Africa. Jessica has co-authored six peer-reviewed articles in well recognised scientific journals as well as a review for the Quarterly Review of Biology.

1 INTRODUCTION

1.1 Background

The Coega Special Economic Zone (SEZ) at the Port of Ngqura is situated 10 km north-east of the city of Port Elizabeth in Algoa Bay and adjacent to the western border of Addo Marine Protected Area (MPA) (Figure 1-1). Activities within Algoa Bay include commercial and recreational fishing, motorised and non-motorised water sports, SCUBA diving, and beach utilisation. Sensitive environments comprise offshore islands and reefs, estuaries, and nearshore environments.

Figure 1-1. Algoa Bay: placed discussed in the text, rivers of importance and the Addo Marine Protected Area (MPA) (DEA 2020). The Port of Ngqura is situated within the Coega Special Economic Zone (SEZ) and is located adjacent to the western border of the Addo MPA (Google Earth 2020).

The Coega Development Corporation (CDC) proposed the construction of an integrated common user marine pipeline servitude project within the Coega SEZ to enable numerous investors to make use of seawater for factory and industrial processes. Discharge of cooling water, seawater for mariculture activities, and desalination wastewater needs to be facilitated, while treated wastewater and other types of effluent are likely to be discharged in the future. An Environmental Impact Assessment (EIA) for the Marine Pipeline Servitude project commenced in 2010 and the scoping phase was completed and approved by the Department of Environmental Affairs (DEA) in March 2012. Given the proposed discharge of land-derived effluent into the marine environment, a Coastal Waters Discharge Permit (CWDP) is also required, and as such an application has been made to the Department of Environmental Affairs: Oceans & Coast (DEA:O&C).

This report serves as the updated Marine Impact Assessment for the proposed development to assess the impacts of the construction and operation of the servitudes and the intake and discharge infrastructure along the shore and in the marine environment adjacent to the Coega SEZ. Specifically, this report updates the existing impact assessment (Laird *et al*. 2016) with revised effluent dispersion modelling results produced by PRDW (2020) to assess the impacts of the proposed discharge on sensitive environments, marine users and aquaculture water quality requirements.

The revised dispersion modelling assessment (PRDW 2020) considered water quality and volume requirements for abstraction of seawater as well as effluent characteristics and volumes from four broad industrial types that may be established in the Coega SEZ – i.e. aquaculture, desalination, industrial wastewater (including the planned Coega Waste Water Treatment Works (WWTW)), and thermal cooling (e.g. the planned gas to power plants). This dispersion modelling report is to be read in conjunction with Lwandle (2020), which provided an environmental context, specified receiving water quality guidelines, defined mixing zone dimensions, and conducted evaluations on toxicity effects based on the PRDW (2020) predicted effluent dispersion.

1.2 Description of the proposed development

The rationale for developing an integrated seawater intake and effluent discharge marine servitudes is to have common user servitudes in which a number of possible industries can establish infrastructure required to abstract seawater and discharge effluent into the marine environment. This Section will provide a high-level description of the technical options that are most likely to be included in the proposed seawater intake and effluent discharge marine servitudes from the Coega SEZ. It should be noted here however that there has been no final decision made with respect to the appropriate seawater intake and effluent discharge technology, nor are there any detailed designs. The technical options are conceptual at this stage in the respective industry development processes. One or more of these technical options may be constructed within the proposed marine seawater intake and effluent discharge servitudes.

1.2.1 Intake infrastructure

The need for the marine seawater abstraction servitudes is driven by the water requirements for the following proposed Coega SEZ industries include:

- Cooling water for two 1000 MW Liquefied Natural Gas (LNG) power stations, for which an EIA is currently in progress. WSP (2020) specified the **construction of an intake basin** comprising concrete intake channels located inside the Port of Ngqura. The intake channels would consist of four concrete channels (25 x 3.5 x 3 m) and sump areas (4 x 3.5 x 3 m).
- Marine intake for Wet Mechanical Cooling system which will involve the construction of a 50 m **jetty** to accommodate a 710 mm diameter High Density Polyethylene (HDPE) pipeline extending to a depth of about 6 m below mean sea level (MSL). The jetty will be fitted with two vertical pumps located on the shoreline above the highwater mark (1 active and 1 on standby).
- Land based abalone and finfish aquaculture (42370 t/year), for which Environmental Authorization (EA) was received on the 7th of February 2018, and the development of a

desalination plant with a maximum capacity of 60 Ml/day (EA received as part of the authorisation for the aquaculture development zone on the 7th of February 2018). **Seawater abstraction pipelines** for these types of development are typically buried in trenches in the high impact beach and surf zone and anchored to the sea floor beyond the high active surf zone. Excavation or dredging of sand may also be required at the intake position, as well as scour protection to ensure that the structure is stable on the seabed. A **sump and pumping station should be located above the spring high water mark** and expected tidal surge heights on the shoreline. The depth of the sump needs to be well below the spring low water mark and the depth and breadth of the sump will be dictated by the water volume requirements. Seawater that flows by gravity into the beach sump would then be pumped out using submersible or land-based pumps into a holding tank or directly to operating sites. **Beach well** abstraction points may be used for applications requiring relatively smaller volumes (< $1m^3/s$) of high-quality seawater, such as a recirculating system for land-based finfish aquaculture. Wave Energy Reverse Osmosis Pump (WEROP) technology may be installed to use wave energy for the abstraction of water and low levels of electricity production and will be utilised for the pumping of smaller volumes of water for example either into a sump or directly to the user.

1.2.2 Outfall infrastructure

The need for the marine effluent discharge servitudes is mostly driven by a corresponding need of the respective Coega SEZ industries to return abstracted seawater back into the offshore marine environment. Details are alternatively are outlined in the Environmental Scoping Report (see CES 2021). Maximum (worse case) effluent discharge requirements are shown in Table 1.1.

Table 1.1. Maximum (worse-case) effluent discharge requirements for the proposed Coega SEZ servitude project.

Purpose	Effluent type
Cooling water: once through cooling	Seawater at 28°C and 35 ppt
Cooling water: wet mechanical cooling (seawater)	Seawater at 23°C and 53 ppt
LNG Gas hub	TBC
Aquaculture flow through system for abalone	Seawater
Aquaculture recirculation system for finfish	Seawater
Desalination brine	Brine at 60 ppt
Wastewater	Domestic and industrial waste.

WSP (2020) recommends the following technologies may be implemented to discharge the various effluent streams from the various proposed land-based uses into the sea:

- **Tunnel discharge** for power stations and LNG hub. A 3 m outer diameter tunnel will be required; length from the upper beach to offshore would be about 600 m. Beyond this, seabed mounted pipelines may be used for the diffuser section. The tunnel would consist of a concrete conduit (concrete pipe section installed by means of jacking and a tunnel boring machine from land). The tunnel boring and pipe jacking is large scale operation. Pipe jacking would be installed from the land side to the -11 m relief well (offshore retrieval pit) to extract the drilling equipment. It is likely that a marine jack-up barge may be required for this purpose.

- A **pipeline structure** for the discharge of seawater from the wet mechanical power station option. The outfall structure for the wet mechanical cooling system would be about 600 m diameter HDPE pipeline for each plant. The pipeline would lay on the seabed and weighed down by concrete collars. The pipeline outfall would cross the surf zone and discharge at a distance of about 650 m offshore at a depth of about -11 m below MSL.
- Seawater from the abalone farms will be discharged directly to the shoreline marine environment via a **beach discharge pipeline** into the surf zone.
- Finfish effluent from various users will be treated on site by each investor before being discharged via a **pipeline** to the marine environment. The pipeline would be similar to the seawater abstraction pipeline described above and discharge at a distance of about 1 500 m offshore at a depth of about -16 m below MSL.
- Brine from the desalination plant will be discharged directly to the marine environment via a **pipeline.** The pipeline would be similar to the seawater abstraction pipeline described above and discharge at a distance of about 1 000 m offshore at a depth of about -14 m below MSL.
- Wastewater from the Coega wastewater treatment plant would be discharged directly to the marine environment via a **pipeline** The pipeline would be similar to the seawater abstraction pipeline described above and discharge at a distance of about 3 000 m offshore at a depth of about -20 m below MSL.

2 OVERVIEW OF THE RECEIVING ENVIRONMENT

2.1 Physical oceanography

The physical oceanography of an area, particularly water temperature, nutrient levels, oxygen levels, and wave exposure, are the principal driving forces that shape marine communities. The oceanography and marine ecology of the Algoa Bay system is well understood, and this desktop study is based on published and grey literature from 1972-2016 (a full description of the receiving environment is available in Laird *et al.* 2016). The Algoa Bay region has been the focus of many studies in the past and the available knowledge and understanding of the system is extensive. Therefore, this assessment is assumed to have no limitations.

2.1.1 Currents

The Coega SEZ is situated within Algoa Bay on the south coast of South Africa. The waters off the south coast are warm temperate in nature, with average sea surface temperatures of 17-22°C (Figure 2-1) (Goschen & Schumann 1988, Schumann *et al.* 2005). The south-flowing Agulhas Current is the dominant oceanic-scale feature and typically flows along the coast at an average of approximately 1 m.s^{-1} (Grundlingh & Lutjeharms 1979, Ross 1988). Several hundred kilometres to the north east of Port Elizabeth, near East London, the current begins to move away from the shore as the continental shelf begins to widen (Dingle *et al.* 1987). This generally results in the inshore waters being cooler by a few degrees compared with the Agulhas Current water further offshore (Goschen & Schumann 1988).

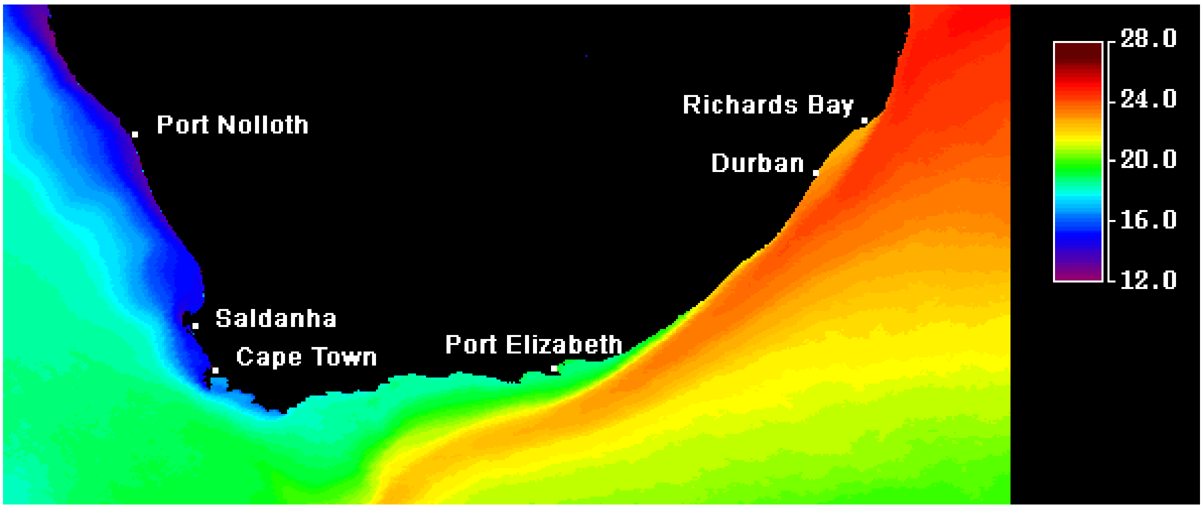

Figure 2-1. A map of South Africa showing average sea surface temperatures (°C). The warm water Agulhas Current can be seen moving in a south westerly direction along the coast (AquaMODIS 4km-resolution, nine-year time composite image) (Laird &Clark 2016).

Within Algoa Bay itself, the Agulhas Current plays an intermittent role in determining the current and temperature structure, while prevailing winds are important on the wider shelf areas as one moves inshore (Goschen & Schumann 2011). Current speeds of less than 10 cm.s^{-1} have been measured most frequently within the bay, although currents exceeding 20 cm.s^{-1} are not uncommon (Roberts 1990, Goschen & Schumann 2011, Goschen *et al.* 2012). Currents in Algoa Bay are known to be highly variable in both direction and magnitude and show considerable variation depending on the area in which they are measured (see Harris 1978, Goschen & Schumann 1988, Roberts 1990, Schumann *et al.* 2005).

2.1.2 Waves and tides

Wave climate in Algoa Bay is predominantly from the south west with swells of less than 2 m most common and occurring approximately 80% of the time (MacLachlan 1983). In addition, a small percentage of waves in excess of 3 m emanate from the south west and are generated by storms in the vast reaches of the Southern Ocean. Most of Algoa Bay is protected from these swells by the rocky headland at Cape Recife, although some degree of refraction does occur (Goschen & Schumann 2011). Maximum wave heights of 6 m have been recorded along the surf zone of Algoa Bay by MacLachlan (1983), possibly from easterly swell. In summer, the Council for Scientific and Industrial Research (CSIR) buoy-data have recorded wave heights of between 0.5-5.0 m with 87% of waves between 1-3 m, while wave heights between 1.0-6.5 m were recorded in winter (CSIR 1987).

The South African coastline, including Algoa Bay, experiences semi-diurnal tides, with each successive high (and low) tide separated by 12 hours. Each high tide occurs approximately 25 minutes later every day, which is due to the 28-day rotational cycle of the moon around the earth. Spring tides occur once a fortnight during full and new moons. Tidal activity greatly influences the biological cycles (feeding, breeding and movement) of intertidal marine organisms, and influences the times that people visit the coastline to partake in various activities (e.g. relax, bathe and harvest marine resources).

2.1.3 Water quality

Generally, winter water temperatures in Algoa Bay range from 14-22°C, and up to 27°C in summer (Beckley 1983, 1988, Schumann *et al.* 2005). A strong thermocline is often evident in water deeper than 15 m, whereas in winter, conditions are generally homogenous (Schumann *et al.* 2005). There is, however, variability in the water temperature data in this region due to the offshore movement of the Agulhas current in the vicinity of East London. This offshore movement creates shear edge features such as eddies, which circulate warm water inshore near Port Elizabeth periodically (Stone 1988, Laird *et al.* 2016). Upwelling events are a further source of temperature variability characteristic of the Eastern Cape coast, with upwelled water moving into Algoa Bay causing sharp changes in temperature by approximately 8°C within a 24-hour period (Figure 2-2) (Beckley 1983, Schumann 1999, Schumann *et al.* 1988, Churchill 1995, Goschen & Schumann 1995).

This phenomenon is caused by wind driven currents particularly during easterly winds (Churchill 1995). Upwelling cells are prominent adjacent to many of the rocky headlands, as off Cape Recife (south west of Coega) and Cape Padrone (north east of Coega) and may move into Algoa Bay (see Figure 1-1) (Goschen *et al.* 2012). Cold upwelled water originating from Cape Recife during relatively short-lived easterly winds, particularly during summer, moves into the bay when the wind swings to a westerly shortly after upwelling has occurred (Schumann *et al.* 1982, Goschen & Schumann 1995). When upwelling occurs off Cape Padrone, cool water moves into Algoa Bay causing rapid temperature decreases (Goschen *et al.* 2012). The easterly wind along this stretch of coast has an offshore component, which combined with Ekman transport and the steep and prominent bathymetry, readily draws cold bottom water to the surface within the inertial period of 21 hours (Roberts 2005).

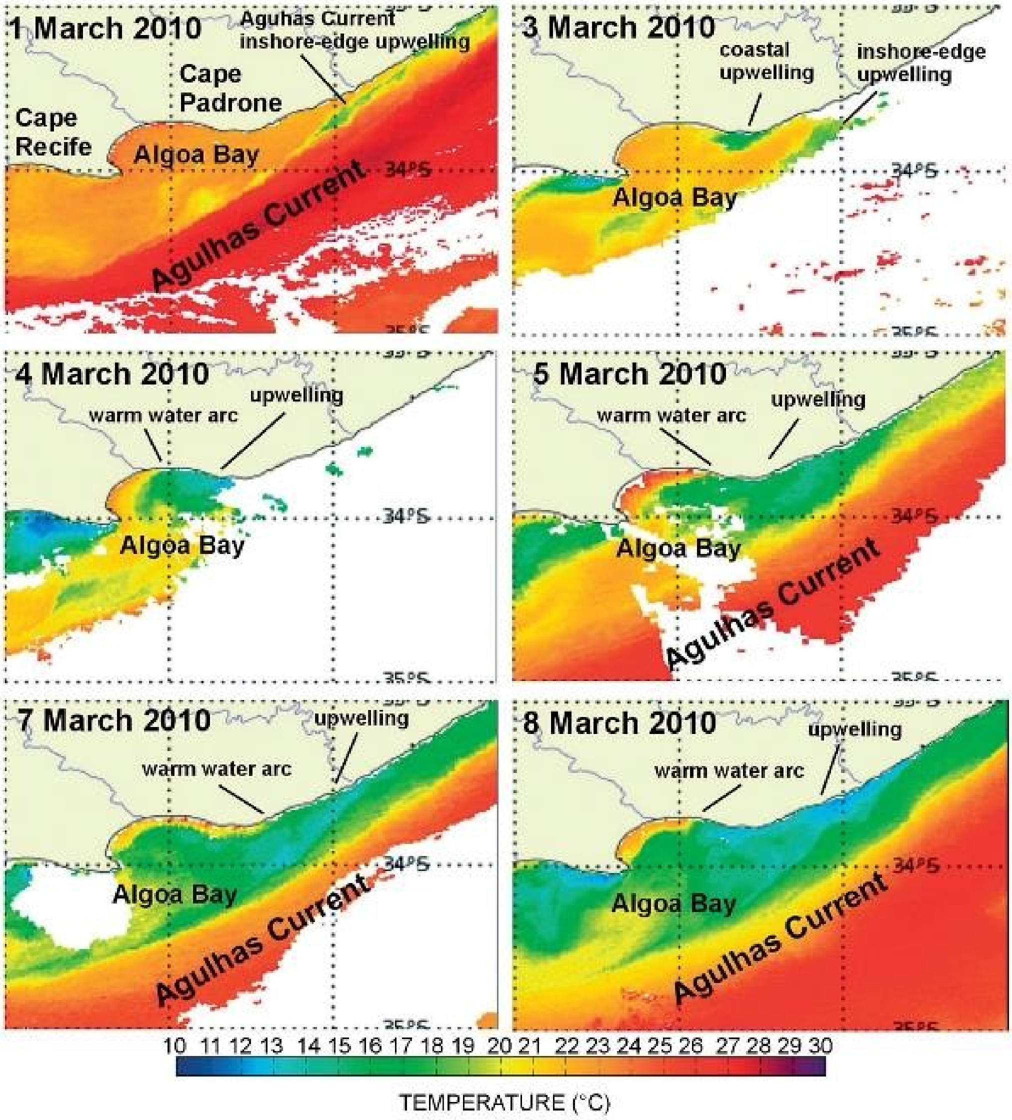

Figure 2-2. Satellite imagery of sea surface temperature between 1 and 8 March 2010 showing an upwelling event. Cool water first emerges at Cape Padrone and expands into Algoa Bay (Laird *et al.* 2016).

Within Algoa Bay, salinity remains relatively constant at 35.2 ‰ (Schumann et al. 1988); however, salinity values as low as 34.7 ‰ have been recorded close to the mouth of the Swartkops River and at the New Brighton Pier outfall (Laird *et al*. 2016). Importantly, this layer remains in the top 5 m of water and does not penetrate deeper (Schumann et al. 2005). Low salinity levels were measured in the upper two meters of water at sites in the vicinity of the Coega River, but below this depth salinity levels were indicative of normal sea water (CSIR 2012). Dissolved oxygen within the Port has been classified as “good” (6-8 mg/l, ≥100% saturation) in the upper 4 m of water but values were considerably lower towards the bottom of the water column (generally <5 mg/l, ≤60% saturation). In winter, the water column was well mixed and little difference was evident between dissolved oxygen concentrations at both the surface and at the bottom (CSIR 2012). There is little variation in pH with depth. Typical values range between 7 and 9 and were slightly higher in winter, and pH values measured directly opposite the Coega River mouth were slightly lower than at other stations (CSIR 2012).

High concentrations of nitrate (>10 µmol/ℓ) have been reported in offshore waters (outer shelf and shelf edge), and off Cape Padrone and Cape Recife, but much lower concentrations (around 1 µmol/l or less) in the Bay itself (Goschen & Schumann 1988). The CSIR (2012) found that concentrations of all nutrients (dissolved inorganic nitrogen, ammonia, nitrate, nitrite, orthophosphate, and silica) in surface waters in the Port were low, although concentrations within the Port were typically higher than at the entrance channel. Turbidity levels (i.e. measure of the suspended solids in the water column) in surface waters during both summer and winter were mostly low (<10 NTU), which is indicative of clear water (Laird *et al.* 2016). Turbidity readings from the bottom water in winter were similar to those at the surface, but the same was not true in summer. Elevated turbidity was detected towards the bottom where values exceeded 10 NTU (Laird *et al*. 2016). Elevated levels outside of the Port are presumably caused by wave action, while high values within the Port are likely a result of propeller wash. Concentrations of most trace metals in Port waters were low or below detection limits aside from mercury, zinc, arsenic, and copper (CSIR 2012, Laird *et al*. 2016). Arsenic and mercury were elevated at stations inside and outside the Port, while levels of copper and zinc were elevated at stations in the Port. Copper was the only trace metal that slightly exceeded guideline levels, while hydrocarbon concentrations were very low both inside and outside the Port (CSIR 2012, Laird *et al*. 2016).

2.1.4 Offshore pelagic region and islands

Within Algoa Bay, two groups of islands support large colonies of birds as well as the eastern most distribution of breeding Cape fur seals (Figure 2-3). One island group comprises the large St Croix Island with the smaller outcrops of Jahleel and Brenton Rocks. St Croix Island lies 4 km from the coast and is situated between the Coega and Sundays river mouths. The second island group consists of Bird, Seal and Stag Islands and lies near Cape Padrone, 7 km from the coastal Woody Cape Nature Reserve (Figure 2-3).

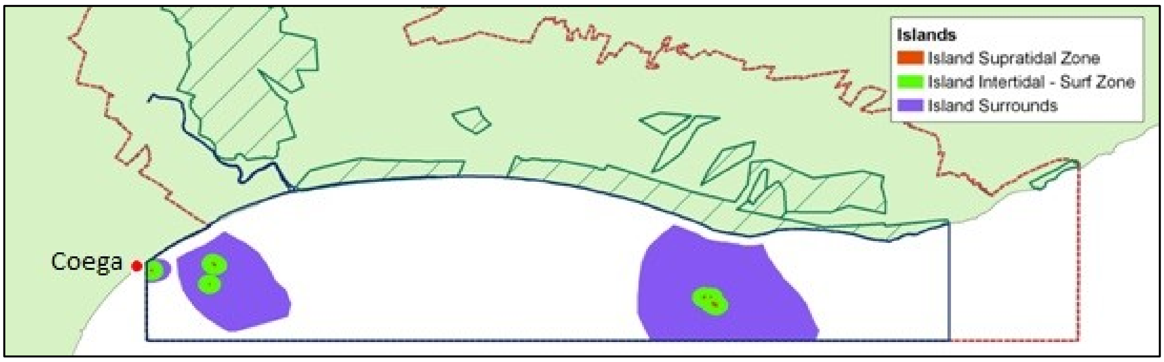

Figure 2-3. Demarcated island habitats in the Addo MPA. The area to the left of the dotted red line is included in the sanctuary zone of the Addo MPA. Red dots indicate the positions of the Port of Ngqura. (Source: A. Oostehuizen, SANParks, from Laird *et al.* 2016).

2.2 Marine ecology

2.2.1 Regional biogeography

Algoa Bay falls within the warm temperate Agulhas ecoregion, one of four inshore ecoregions spanning the coast of South Africa (Emanuel *et al.* 1992, Bustamante & Branch 1996, Turpie *et al.* 2000, Branch *et al.* 2017). This ecoregion extends from the Mbashe River in the Eastern Cape west to Cape Point. It is an important area of mixing where warm Agulhas Current water mixes with cool Benguela Current water. The shelf margin also extends considerably further offshore relative to the east and west of this bioregion (Emery *et al.* 1975). At a finer scale, the area encompassing Algoa Bay is considered the Agulhas Inner Shelf Ecozone (Sink *et al.* 2012) (Figure 2-4). These characteristics of the coast play an important role in providing habitat for many organisms and contribute to the maintenance of important fisheries (Wallace *et al.* 1984). The wide oceanic shelf provides an array of habitats and the temperature mixing also plays a large role in accounting for high levels of biodiversity and endemicity, including the highest number of endemic fish species along the South African coast (Turpie *et al.* 2000, Sink *et al.* 2012).

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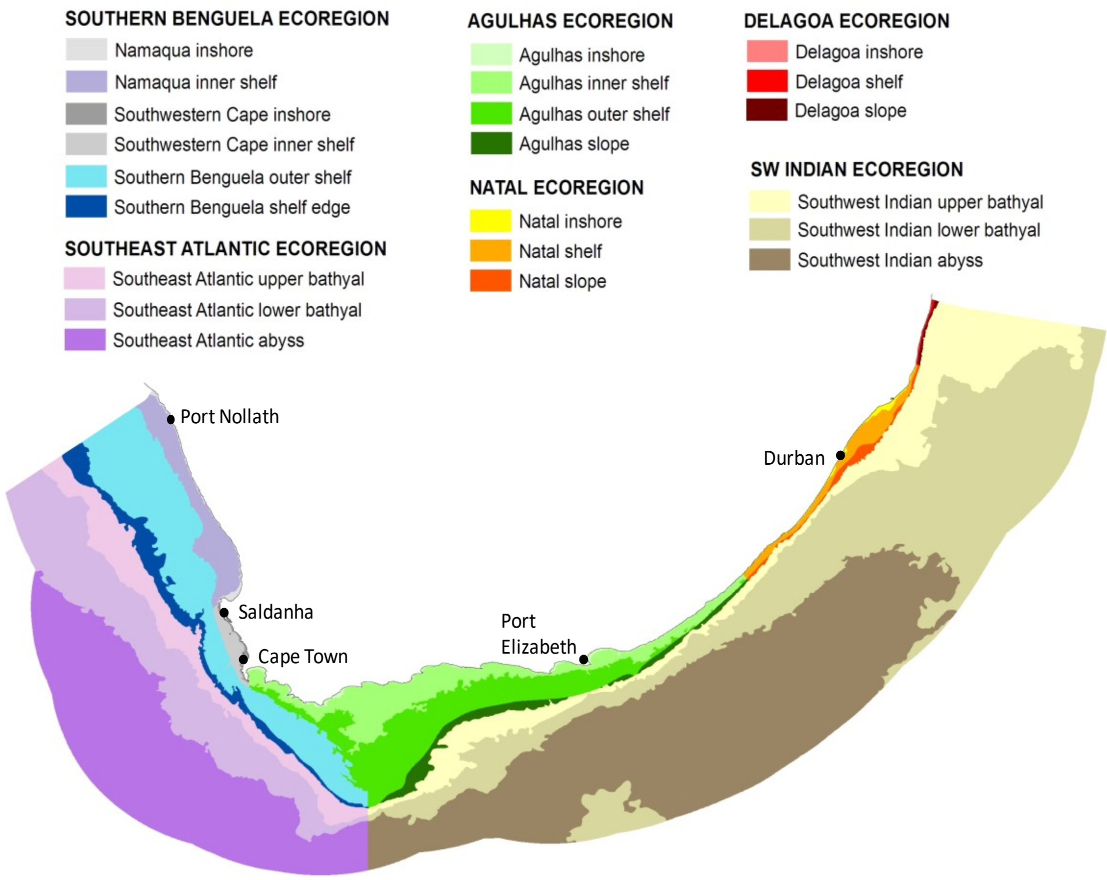

Figure 2-4. Inshore and offshore bioregions in South Africa as defined by Sink *et al.* (2012).

2.2.2 Rocky intertidal shores

Zonation patterns of marine organisms on rocky shores result from the variation in environmental variables across the shore (e.g. the amount of time each zone is exposed to the air), which in turn influences the organisms which inhabit each section of the shore (Branch & Branch 1981, Beckley 1988a). Species that are more tolerant to desiccation (drying out) are found near the high-water mark, while those that cannot withstand long periods of water recession are found near the low-water mark. Five distinct zones are typically found on rocky shores of South Africa's coast, most of which are present on the south coast (Figure 2-5). These zones from the high-water mark downwards are named the Infratidal zone, the Cochlear zone, the Lower Balanoid zone, the Upper Balanoid zone and the Littorina zone.

Figure 2-5. A section of rocky shore adjacent to the Port of Ngqura (Laird *et al.* 2016).

On intertidal reefs, red algae dominate and brown algae are an important component of intertidal community composition (Seagrief 1988, Lubke & Seagrief 1998). Grazers and filter feeders are the most prolific fauna. In the Littorina zone, species of the periwinkle are abundant (Wooldridge & Coetzee 1998). The Balanoid zone is typically dominated by barnacles, topshells (snails), beds of mussels as well as limpets. Predatory whelks, echinoderms (starfish, urchins and sea cucumbers) and various sea anemones are also common, especially in rock pools. Lower down the shore, the Cochlear zone is characterised by a dominance of the limpet *Patella cochlear*, however this zone may be absent on very sheltered shores (Beckley 1988a). Below the Cochlear zone, and the beginning of the subtidal zone, the red bait ascidian *Pyura stoloinfera* is usually dominant (Beckley 1988a).

Fish that are found in rock pools in the intertidal zone include clinids (klipvis), gobies and juvenile sparids (e.g. blacktail, fransmadam and mullet), which all utilize the intertidal rock pools and prey on invertebrates and algae found on the rocky shore (Laird *et al.* 2016). Some species of bird also utilise intertidal rocky shores as important foraging areas in the region; in particular, the near threatened Cape cormorant and black oystercatcher, the pied kingfisher, the kelp and grey-headed gulls, as well as swift and common terns.

2.2.3 Sandy shores and surf zones

Intertidal sandy beaches are very dynamic environments, and the faunal community composition is largely dependent on the interaction of wave energy, beach slope and sand particle size (beach morphodynamics). There are three general morphodynamic beach types: dissipative, reflective and intermediate beaches (McLachlan *et al.* 1993). Dissipative beaches are wide and flat with fine sands and high wave energy. Waves start to break far from the shore in a series of spilling breakers that 'dissipate' their energy across a broad surf zone. This generates slow swashes with long periods, resulting in less turbulent conditions on the gently sloping beach face. These beaches usually harbour the richest intertidal faunal communities. Reflective beaches have low wave energy, are coarse grained (>500 µm sand) and have narrow and steep intertidal beach faces. The relative absence of a surf zone causes the waves to break directly on the shore causing a high turnover of sand. The result is depauperate faunal communities. Intermediate beach conditions exist between these extremes and have a very variable species composition (McLachlan *et al.* 1993, Jaramillo *et al.* 1995, Soares 2003). This variability is mainly attributable to the amount and quality of food available. The Algoa Bay beaches close to Coega are generally considered to be this intermediate type (Figure 2-6).

Figure 2-6. The sandy beach and surf zone adjacent to the Port of Ngqura.

Relatively few species occur on sandy beaches due to their unstable and harsh nature, but those that do occur are hardy, and well adapted to life in these environments (Branch & Branch 1981). Animals living here are, however, offered some degree of protection by burrowing into the layers of sand to escape desiccation, overheating and strong waves (Branch & Branch 1981).

Sandy beach organisms feed largely on seaweeds deposited sporadically on the beach and organic rich froth, or spume, which provides a more consistent source of nutrients (Branch & Branch 1981). Five groups of organisms are typically found on sandy beaches: aquatic scavengers, aquatic particle feeders, air breathing scavengers, meiofauna (smaller than 1 mm in size), and higher predators, such as birds (Branch & Branch 1981). Aquatic scavengers feed on dead or dying animals that wash up on the beach thus their activity is largely regulated by the tides. This group includes plough snails *Bullia* sp., which are deposited close to debris and decaying matter by incoming waves. As the tide recedes, they follow the tide down the shore to avoid being eaten by terrestrial predators (Beckley 1988a, Wooldridge & Coetzee 1998). Other important aquatic scavengers in the region include crabs and burrowing polychaete worms (Beckley 1988a, Wooldridge & Coetzee 1998).

The dominant aquatic filter feeders on south coast beaches are sand mussels that remain buried on the low and mid-shore and feed on small organic particles, which they suck in through siphons that protrude above the sand (Beckley 1988a). Small crustaceans, such as surf mysid shrimps are abundant on sandy beaches in the area (Beckely 1988, Wooldridge and Coetzee 1998). These animals burrow in the sand during the day and emerge into the water column at night. They are an important component in the diet of many surf zone fish (Branch *et al.* 2017).

Meiofauna (organisms < 1mm in size) are by far the most abundant of the animals found on sandy beaches, as their small size enables them to live between sand grains. The two most common groups are nematode worms and copepods (Wooldridge & Coetzee 1998). Air breathing scavengers (some species of amphipods and isopods) live high on the shore and feed on washed up seaweed, as well as dead and decaying animal matter. These species emerge from the sand during low tide, when there is less risk of being washed away, and are almost strictly nocturnal to avoid desiccation and predation. They are important for the breakdown of seaweed and are a major food source for shore birds and fish that feed on sandy beaches.

Surf-zone diatoms are recognised by dense brown coloured patches of foam along some exposed sandy coastlines (Talbot *et al.* 1990). These organisms migrate vertically, rising up to the water surface during the day and sinking towards the ocean floor at night. During calm conditions, these diatoms move shoreward, but when the sea is rough they remain in the surf-zone. Surf-zone diatoms are primary producers which provide food for many species including bivalves, mysids, mullet and prawns. A common species in the areas is *Anaulus australis*, which is abundant in the Sundays River surf-zone, some 17 km north-east of the Port of Ngqura (see Figure 1-1).

Harmful algal blooms (HABs) are considered rare in Algoa Bay, given that upwelling events in the area are generally relatively weak and short lived. However, a large and persistent harmful algal bloom of *Lingulodinium polyedrum* did form within Algoa Bay in December 2013 and March 2014, and spread along the east coast as far as Wilderness (Bornman 2014). The species involved was the dinoflagellate, *Lingulodinium polyedrum*, which produces yessotoxins that have been proven to be toxic to mice and may accumulate in bivalves, although human toxicity is not known (Bornman 2014). This species irritates the gills of fish, interfering with respiration and caused fish kills in several places within Algoa Bay (Bornman 2014). Vertebrate predators that feed on sandy beach organisms include birds such as kelp gulls *Larus dominicanus* and grey-headed gulls *Chroicocephalus cirrocephalus*, white fronted plovers Charadrius marginatus, swift, common and the near-threatened Caspian tern (*Sterna bergii*, *S. hirundo* and *Hydroprogne caspia* rspectively) and sanderlings *Calidris alba* (Craig 1998). Fish such as galjoen *Dichistius capensis* and white steenbras *Lithognathus lithognathus* swim over submerged beaches at high tide to feed (Branch & Branch 1981), and elf (shad) *Pomatomus saltatrix*, leervis (garrick) *Lichia amia*, sand shark and white seacatfish *Galeichthys feliceps* are some of the also characteristic species that favour the sandy surf zones.

2.2.4 Estuaries

Estuaries are extremely productive ecosystems due to the combination of high nutrient river water with a shallow, sheltered habitat (Robins *et al.* 2006). They are valued for their importance as nursery grounds 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 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 (Laird *et al*. 2016).

Three rivers drain via estuaries into Algoa Bay. These are the Swartkops, Coega (Ngqura) and Sundays Rivers (see Figure 1-1). The Swartkops and Sundays estuaries are both considered to be important systems and have 'critically endangered' threat status (van Niekerk & Turpie 2011). Many species of fish rely heavily on the Swartkops and Sundays estuaries as nursery grounds (Marais & Baird 1980, Marais 1981, Beckley 1984). Of particular importance are the populations of overexploited, dusky kob and spotted grunter that frequent these estuaries and the broader Algoa Bay region (Marais 1981, Marais & Baird 1980, Smale & Buxton 1998, Griffiths 1996). The Coega Estuary, on the other hand, is listed as critically modified i.e. it has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions and processes have been destroyed and the changes are irreversible in both the 2011 and 2018 National Biodiversity Assessments (van Niekerk & Turpie 2011, Van Niekerk *et al*. 2019).

2.2.5 Subtidal habitats

Relative to sandy habitats, reefs are scarce in Algoa Bay. On shallow subtidal reefs (<10 m), algae, grazers and filter feeders are the most prolific fauna. Red foliose algae is dominant and diverse, while the redbait ascidian is also abundant (Beckley 1988a). Cape rock oyster *Striostrea margaritacea* are prevalent, particularly in areas prone to periodic sanding. Abalone (perlemoen) are an important commercial fishing species that occur on shallow, subtidal, algae dominated reefs. This species is no longer collected recreationally as a result of the decline in population numbers largely due to illegal poaching. A large predatory whelk known as the pink lady (due to the snail's bright pink foot) is also frequently encountered, particularly on deeper reefs.

Deeper reefs (>10 m) are characterised by exceptionally high levels of diversity and are dominated by many species of filter feeders, particularly colonial ascidians, sponges, sea fans, soft corals, hydroids and bryozoans (Wooldridge & Coetzee 1998) (Figure 2-7). Sponges and ascidians (sea squirts) are especially diverse on subtidal reefs in the region and are particularly poorly studied. Sea fans and purple soft coral are both common in the area, as are bryozoans and feather stars, which become more abundant with depth due to their fragile structures. Characteristic fishes on these deeper reefs include panga *Pterogymnus laniarius*, piggy grunter *Pomadasys olivaceus*, santer, fransmadam *Boopsoidea inornata*, carpenter *Argyrozona argyrozona*, roman *Chrysoblephus laticeps*, dageraad *Chrysoblephus cristiceps,* yellowbelly rockcod *Epinephelus marginatus*, steentjie *Spondyliosoma emarginatum* and white musselcracker *Sparodon durbanensis* (Smale & Buxton 1998, Chalmers 2012).

Figure 2-7. Typical subtidal reef found in the Algoa Bay area of the Agulhas Bioregion.

2.2.6 Birds

The islands of Algoa Bay are home to many endangered, vulnerable and near-threatened birds including breeding colonies of African penguin *Spheniscus demersus*, Cape gannet *Morus capensis*, African black oystercatchers *Haematopus moquini*, Roseate terns *Sterna dougallii*, the endangered Cape Cormorant *Phalacrocorax capensis*, as well as Damara terns *Sternula balaenarum* and Antarctic terns *Sterna vittata*, which visit in winter (see Laird *et al.* 2016).

The African penguin colony at St Croix Island is the largest in the world (Pichegru *et al.* 2010). In 2010, the African Penguin was up-listed to 'Endangered', under the International Union for Conservation of Nature's (IUCN) red data list due to recent data revealing rapid population declines (Laird *et al.* 2016). In South Africa, the penguins breed mainly on offshore islands in the Western and Eastern Cape with strong downward trends detected at all major colonies (Whittington *et al.* 2005).

Penguins feed largely on pelagic fish species, such as pelagic sardines (*Sardinops sagax*) and anchovies (*Engraulis encrasicolus*), which are found in Algoa Bay, and the survival and breeding success of the birds is closely tied to the availability of these fish within 20-30 km of their breeding sites (Crawford *et al.* 1999, Pichegru *et al.* 2009). The mobility of their small pelagic fish prey means that the foraging ground of penguins in Algoa Bay is variable and governed by the movements of these fish (Figure 2-8) (Pichegru *et al.* 2010).

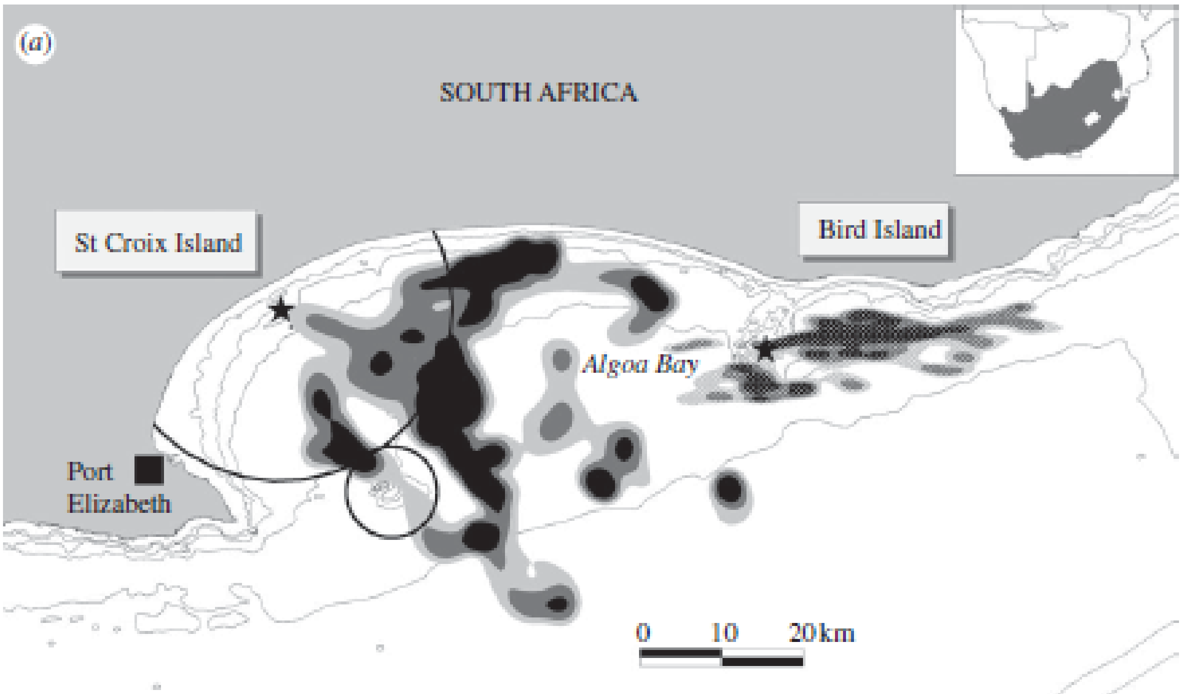

Figure 2-8. Foraging areas (density of feeding dives) of African penguins breeding on St Croix Island and Bird Island (stars). Foraging range (feeding dives): black, 50%; dark grey, 50-75%; and light grey, 75-90% (Pichegru *et al.* 2010).

2.2.7 Cetaceans

Six species of cetaceans are regularly seen in Algoa Bay; including southern right whales *Eubalaena australis*, humpback whales *Megaptera novaeangliae*, Bryde's whales *Balaenoptera brydei*, Indian Ocean bottlenose dolphins *Tursiops aduncus*, Indo-Pacific humpback dolphins *Sousa chinensis*, and longbeaked common dolphins *Delphinus capensis* (Saayman *et al.* 1972, Karczmarski *et al.* 2000, Reisinger & Karczmarski 2009, Melly 2011). Algoa Bay serves as a breeding and nursery area for southern right whales, and as a potentially important nursery area and migration route for humpback whales (Laird & lark 2016). A key habitat area for southern right whales, humpback dolphins and bottlenose dolphins was identified between the Port of Port Elizabeth and Cape Recife. A long coastal strip just east of the Sundays River mouth to Woody Cape was identified as key habitat for southern right whales, humpback whales, and bottlenose dolphins. The near-shore distribution of humpback dolphins makes them susceptible to small-scale multi-species and artisanal fisheries as well as recreational fishermen, spearfishers and shark control programs. Due to declining population trends worldwide, this species is listed as a 'Near Threatened' by the IUCN in the Red List of Threatened species (Jefferson & Smith 2016).

2.2.8 Seals and sharks

Black Rocks, an island complex 1.6 km due west of Bird Island, is the most easterly Cape fur seal breeding colony in southern Africa, with a population of approximately 2 000 seals (Kirkman *et al.* 2007). The Cape fur seal *Arctocephalus pusillus pusillus* is the only pinniped (aquatic, fin-footed mammal) indigenous to southern Africa and is the primary prey species of the great white shark *Carcharodon carcharias* (Kirkman *et al.* 2007). As a result, the inshore waters surrounding the islands of Algoa Bay are frequented by great white sharks during the winter when white sharks hunt juvenile seals (Dicken& Booth 2013). A tourism industry has developed around the presence of these sharks whereby boats visit the islands to view the animals in their natural environment.

The ragged-tooth shark (*Carcharias taurus*) is a wide-ranging coastal species found primarily in warm-temperate and tropical waters. In South Africa, the shark is most commonly found at depths between 10 and 40 m close to inshore reefs and islands from Cape Town to KwaZulu-Natal (Dicken 2006, Dicken *et al.* 2008). Mating occurs off the coast of Natal after which near-term pregnant females move towards the cooler waters of the Eastern Cape, where they give birth around September (Dicken 2006). Algoa Bay provides shelter for juveniles of the species in the form of nursery areas.

2.2.9 Alien and invasive species

After habitat destruction, non-indigenous species are considered the greatest cause for loss of biological diversity globally (Vitousek *et al.* 1997). For this reason, Ports, marinas and important conservation hotspots in the vicinity of these areas should be surveyed for introduced species regularly. During a 2012 port survey, 18% of the 83 invertebrate species surveyed were confirmed alien introductions, including the barnacle *Balanus glandula*, the isopod *Dynamene bidentata* and the ascidian *Styela plicata* (Laird *et al*. 2013).

2.3 Human uses and influences

Marine user groups can be broadly defined as recreational or commercial. Recreational marine activities that are most likely to be affected by the proposed development include recreational boat (skiboat) fishing, recreational scuba diving and yacht sailing. Other recreational marine activities such as open water swimming, surfing, surf skiing, kayaking, as well as wind and kite surfing that may be affected are also considered.

Several commercial marine activities take place within the broader Algoa Bay region; these include shipping, marine ecotourism, and a range of commercial fisheries. Mining and gas exploration may also take place within Algoa Bay in the future.

2.3.1 Recreational users

Marine user groups can be broadly defined as recreational or commercial. Recreational marine activities that may be affected by the construction of the proposed marine pipeline servitudes at the Port of Ngqura include shore-based fishing, recreational scuba diving, beach utilisation, motorised water sports and non-motorised water sports.

Motorised water sports include jet skiing, water skiing and tubing; while non-motorised recreational marine activities include sunbathing, open water swimming, surfing, stand up paddle boarding, sailing, kayaking, and kite surfing. These activities provide social recreational value to users, while at the same time generating income for the metropole through organised sporting events, gear rental, retail and restaurants. Recreational swimming beaches within close proximity to the Port of Ngqura include

Joorst Park (1 km), St George's Strand (2.5 km), Wells Estate (4 km), Bluewater Bay (7 km) and New Brighton (12 km) all situated to the south of the harbour.

Should water quality in Algoa Bay be compromised, it may directly affect this source of income. Although effluent from the proposed marine pipeline servitudes at the Port of Ngqura may be unlikely to affect non-motorized recreational marine users as these activities mostly take place within 1 km of the coast towards the south-west corner of Algoa Bay.

Algoa Bay Yacht Club (ABYC) was established approximately 54 years ago. The club includes a large clubhouse and marina with over 130 yachts moored within the Port of Port Elizabeth. ABYC has been host to many national and international sailing events including the Algoa Bay Week. The area between Cape Recife and the Sundays River mouth is utilised by yachtsmen as depicted by the red polygon in Figure 2-9.

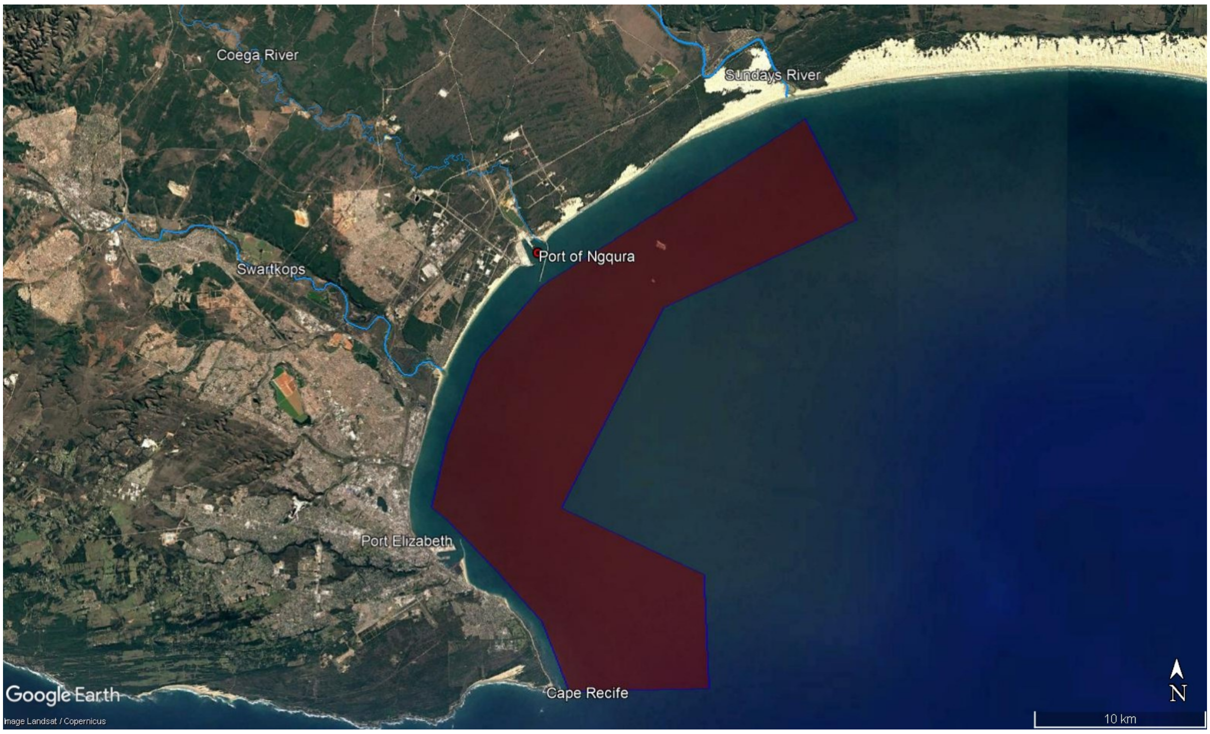

Figure 2-9. Yacht sailing area within Algoa Bay (Source: Arthur Rump, ABYC; adapted from Laird *et al.* 2016).

Recreational scuba diving is a popular activity within Algoa Bay and there are at least 18a sites (mostly reefs) that are popular recreational SCUBA diving spots (Figure 2-10). Only three of the sites (Parish, Brenton and Evan's Reef) are within a 12 km radius of the Port of Ngqura and it is unlikely that deterioration of visibility, increase of algal growth or siltation of reefs will occur.

Figure 2-10. Popular recreational SCUBA dive sites within Algoa Bay relative to the Port of Ngqura. (Dive site positions provided by Prodive Port Elizabeth, from Laird *et al*. 2016).

A recreational ski boat fishing club, (Port Elizabeth Deep Sea Angling Club) operates out of Port Elizabeth Harbour and is the main launch site for recreational fishing vessels. The Swartkops and Sundays estuaries are also used by a few recreational fishing vessels to access the sea, but these are not legally registered launch sites (Hutchings *et al.* 2013). Popular fishing spots close to the Port of Ngqura are situated at Joorst Park and south of New Brighton (Figure 2-11). Recreational boat fishing takes place throughout Algoa Bay and Chalmers (2012) estimated annual recreational ski boat fishing effort in Algoa Bay to equal 2 118 boat days. Effort calculated to 61 074 angler hours of recreational line fishing per annum with an estimated retained catch of ~21 000 fish of 26 different species (Chalmers 2012). In terms of catch composition, geelbek, santer and silver kob dominate the catches in the western sector of Algoa Bay (Chalmers 2012). Recreational ski boat fishing effort to the south-west of the Port of Ngqura is considered 'low', while effort to the north-east was found to be higher (Figure 2-11, Chalmers 2012). The increase to the north-east is likely due to shallow reef surrounding the offshore islands in this area.

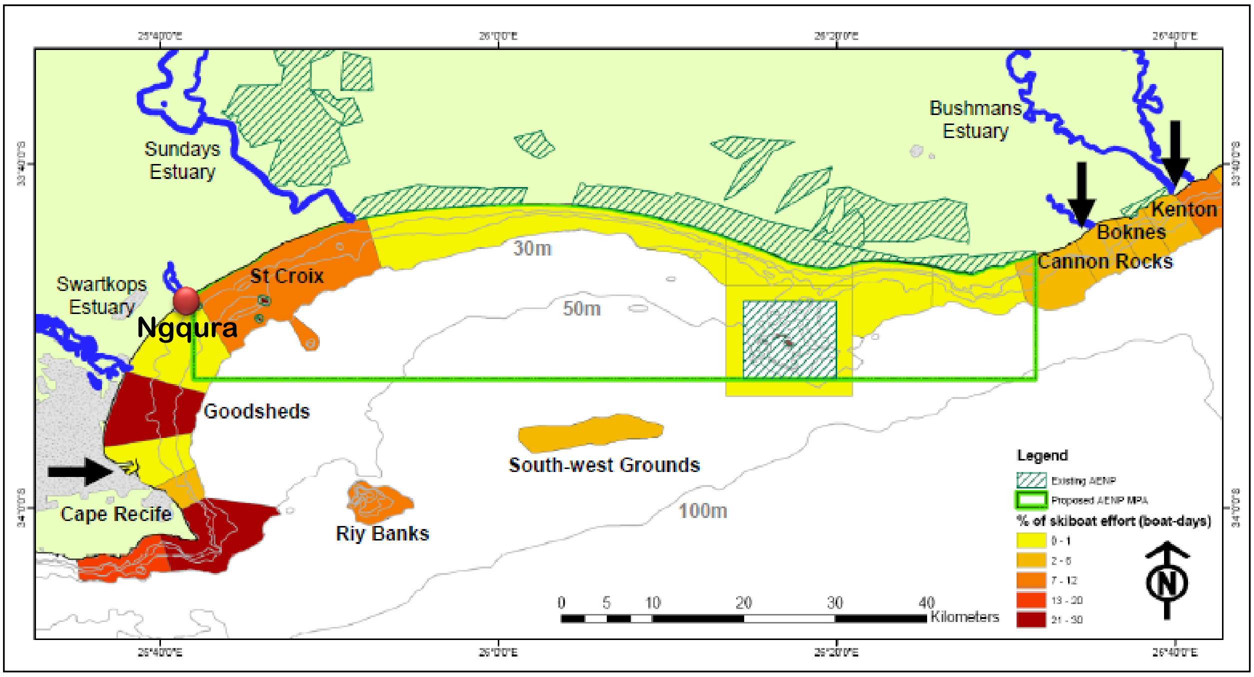

Figure 2-11. Estimated distribution of recreational boat line fishing effort throughout Algoa Bay (Source: Chalmers 2012) (from Laird *et al.* 2016).

2.3.2 Commercial users

A number of commercial marine activities take place within the broader Algoa Bay region including commercial shipping, mining (oil and gas), marine ecotourism (whale and shark watching), and a range of commercial fisheries. Spatially referenced catch and effort data for commercial fisheries that operate in the Algoa Bay area were obtained from the Department of Agriculture, Forestry and Fisheries (DAFF) and mapped using GIS by Hutchings *et al.* (2013).

Four commercial fisheries operate within Algoa Bay and may potentially be affected by the proposed project. These are the small pelagic, traditional linefish, squid longline and shark longline fisheries. A description of each of these fisheries was sourced from Turpie *et al.* (2012) and the area of operation relative to the proposed marine pipeline servitudes is provided below.

2.3.3 Wild caught fisheries

2.3.3.1 Small pelagics

The small pelagic fishery in South Africa originated in St Helena Bay on the west coast, originally targeting sardine or pilchard *Sardinops sagax* and horse mackerel *Trachurus trachurus capensis* (Sauer *et al.* 2003). These resources declined after 1962 due to overfishing, and mesh sizes were reduced to target the smaller anchovy *Engraulis encrasicolus*, which became dominant in catches for two decades. Sardines have subsequently recovered to a large extent. The fishery also exploits the red-eye round herring *Etrumeus whiteheadi* and the chub mackerel *Scomber japonicas*, which is a valuable by-catch species. The fishery is managed through quota allocations in the form of Total Allowable Catches (TACs) for adult sardine, anchovy and sardine by-catch. Pilchard is the only targeted species in Algoa Bay, with some incidental by-catch of horse mackerel and chub mackerel, as well as maasbanker *Trachurus trachurus*.

The spatial distribution in effort and catch in the small pelagics fishery is shown in Figure 2-12. Average effort and catch maps are slightly misleading, as there is considerable inter-annual variability in the spatial location of fishing effort. Since fish are highly mobile, fishing grounds may change quite radically from year to year. In terms of average annual effort and catch, the Port of Ngqura lies within reporting grid blocks that account for a very small proportion of the national catch and effort (1-5 hauls per year), but approximately 12 % of the Eastern Cape annual average.

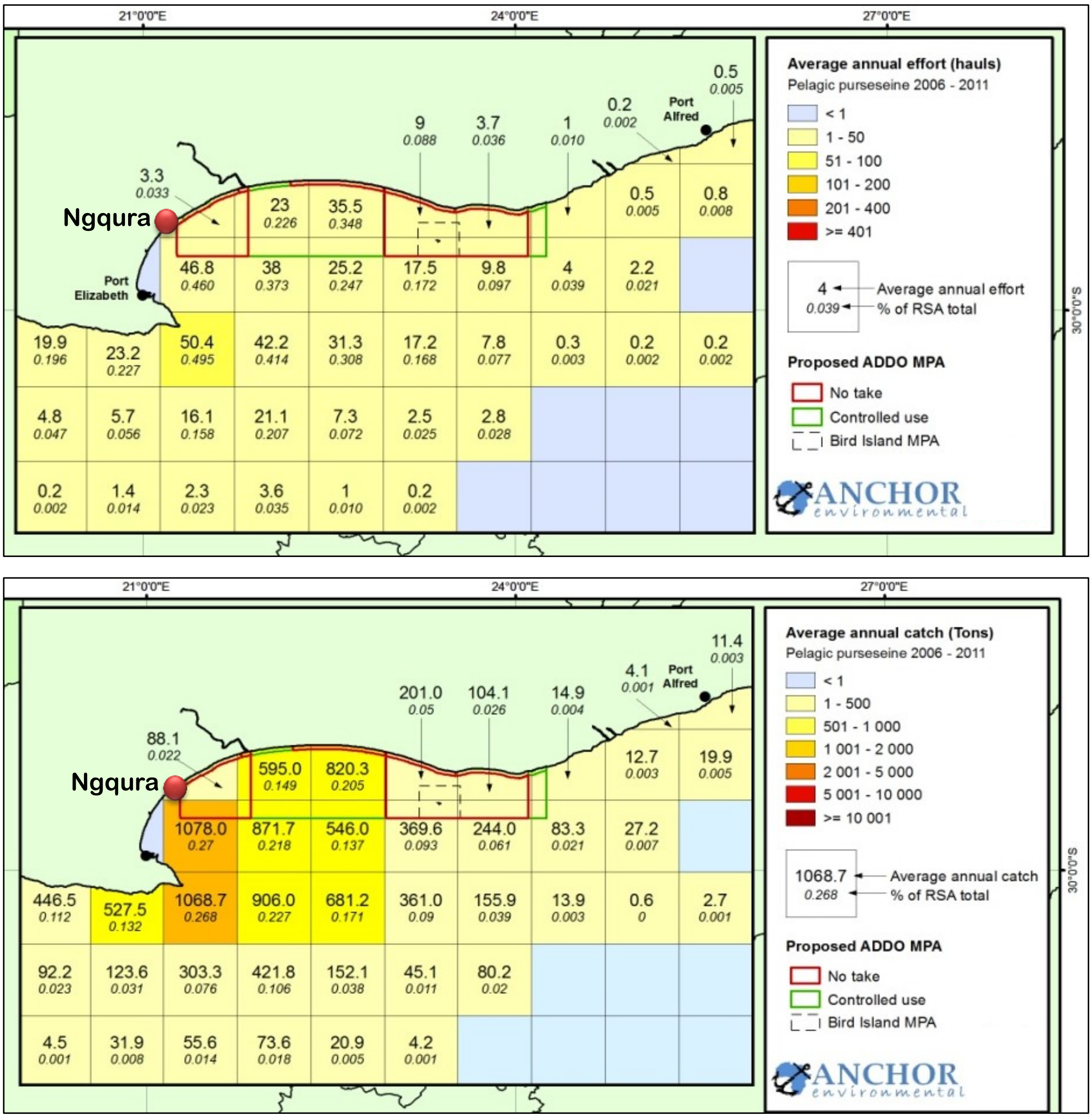

Figure 2-12. Average annual effort (top) and catch (bottom) in the small pelagic sector in relation to the Port of Ngqura in Algoa Bay from 2006 to 2009 (Data source: DAFF; from Laird *et al*. 2016).

The small pelagics purse-seine fishery nationally involves 95 rights holders and 101 vessels. While the fishery is still concentrated on the west coast, it has spread to the south coast, centred around Mossel

Bay and Port Elizabeth. About 4-5 boats are based in Port Elizabeth and 1-2 in Port St Francis, but the Mossel Bay boats occasionally move eastwards to fish in the Algoa Bay area. Thus, there can be up to 10 boats operating in Algoa Bay at one time. Likewise, the Port Elizabeth based boats occasionally fish further west. In those situations, fish might be offloaded at the nearest port and trucked back to the processing plants.

In Algoa Bay, boats typically depart in the early evening to search for fish and catch as late as possible to minimise the time they are stored in the hold. In a westerly wind, fishing tends to be in the east. Westerly winds exceeding 15 knots, and strong south easterly winds curtail fishing activity entirely, since the rolling action of the ship affects fish quality. Fishing takes place all year as far as possible, but activity is influenced by market demand.

2.3.3.2 Squid jig fishery

Squid *Loligo vulgaris reynaudii* was historically targeted by a demersal trawl fishery and landed as by-catch in the South African inshore trawl fishery. A dedicated jig fishery for squid was initiated in 1984 and the landed catch is now worth more than R180 million per year (DEAT: MCM 2005a). The jig fishery was established in the area between Plettenberg Bay and Port Elizabeth, although it now ranges further east as far as the Wild Coast. Typical squid boats are deck boats of about 20 m in length and are equipped with blast freezers and powerful lights for night fishing (Sauer *et al.* 2003). The fishery operates in depths of 20-120 m, but boats fish mostly in the shallower waters where adult squid are targeted in spawning aggregations.

The squid jig fishery usually produces in the order of 7 000 tons per annum but catches of up to 12 000 tons have been recorded. Squid by-catch in the demersal trawl fishery fluctuates between 200 and 600 tons annually. Squid only live for two years and there is substantial inter-annual variability in stock abundance that is linked to a variety of influencing factors. Although there is a high level of uncertainty regarding the status of the squid stock, the commercial squid fishery seems to be sustainable at current effort levels. The fishery is currently regulated by means of Total Applied Effort (TAE), which limits the number of vessels and crew. Fishing decisions are subject to the MPAs at Sardinia, Bird Island and Tsitsikamma, closed seasons, and range is restricted by the South African Maritime Safety Authority (SAMSA) regulations to 40 NM or 200 NM limit.

The fishery currently comprises 109 rights holders, 123 vessels and 2 233 crew. Since 1988, the fishery has been closed once a year for four weeks in an attempt to counter the effects of "creeping effort" associated with increases in vessel efficiency and catch technology. The closed season corresponds with the peak spawning season for this species, and generally occurs around the month of November (Glazer & Butterworth 2006). There are some 123 vessels in the fishery, of which about 80 discharge in Port Elizabeth and the balance in Port St Francis. About half of the boats are independent operators but all supply exporters, which comprise about eight big, cold storage/exporters and some smaller ones. Of the larger companies, five are in Port Elizabeth and three are in St Francis. All of squid caught in the jig fishery is exported, while squid caught as trawl by-catch is sold locally. The squid fishery provides employment for approximately 3 500 people, including land-based personnel (Roel & Butterworth 2000). Larger boats (>12m) are able to range as far as squid are distributed. Smaller vessels based in Port Elizabeth (about 15% of the fleet) can range from the Gamtoos River to Bird Island. In strong easterly winds the boats typically fish in the Tsitsikamma area but can fish anywhere in a westerly wind provided the swell is not too big (<4m). All boats must shelter when winds are >25 knots. In winter, fishing is mostly on sea anchor in deep areas (100-200m), whereas in summer fishing is mainly on nests in 20-60m depth.

The distribution of effort and catch for the squid jig fishery in the Algoa Bay area for the period 2006-2011 is shown in Figure 2-13. The area offshore of the Port of Ngqura overlaps with a squid fishing ground which accounts for nearly 1% of average annual fishing effort.

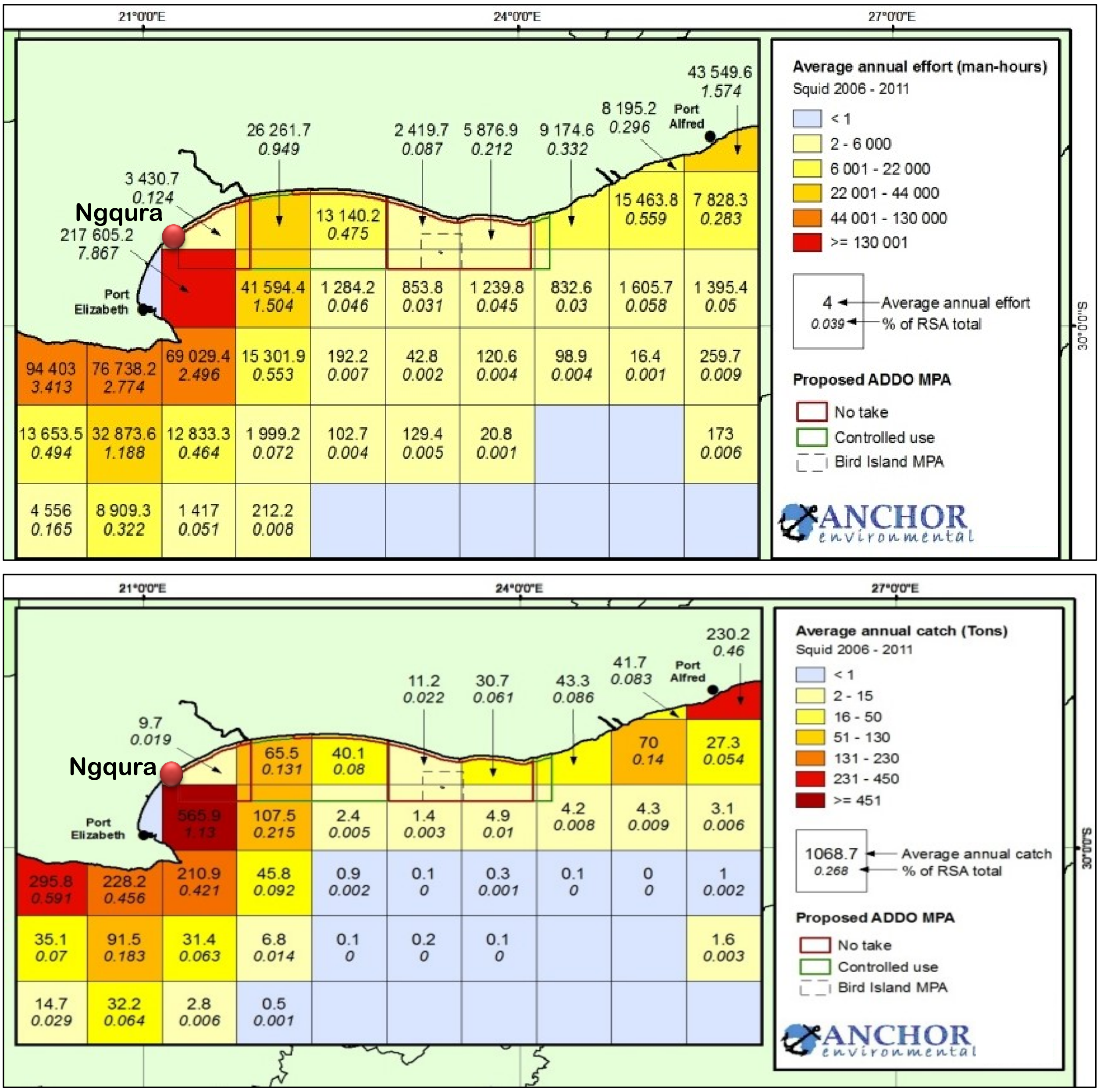

Figure 2-13. **Reported annual average catch and effort by the squid jig fishery in relation to the Port of Ngqura in Algoa Bay from 2006 to 2011 (Data source: DAFF; from Laird *et al*. 2016).**

2.3.3.3 Traditional linefishery

The South African commercial line fishery is a boat-based fishery that dates back to the 1500's (Thompson 1913). By the end of the 1990s there were approximately 3 000 fishing boats ranging from 3 m dinghies to 15 m deck boats carrying a total of around 3000 crew (Griffiths 2000, Mann 2000). This fishery lands about 250 different species annually, although only about 20 of these are commercially important (Lamberth & Joubert 1999). Lines are set with no more than 10 baited hooks and boats operate inshore.

A management framework that included a comprehensive suite of regulations was introduced in 1985, including revised minimum size limits equal to sizes at maturity, daily bag limits, closed seasons, commercial fishing bans for certain species, and the capping of the commercial effort. The Minister of Environmental affairs and Tourism declared an environmental emergency in the traditional line fishery in December 2000 and restricted the number of vessels and fishers in the commercial fishery, as well as bag and size limits for commercial and recreational line fishers. The commercial line fishery was split into three regional management zones, restricting the movement of vessels from one region to the next (MCM 2006).

Until 2003, the commercial fleet was large and consisted of approximately 3 000 vessels nationally, many of them part-time participants who had other sources of income. During this time the mobility of the fleet was not restricted. After 2003, the number of licensed vessels in the commercial fleet was reduced by a tenth; however, effective effort has not diminished to the same degree due largely to an improvement in boats. During the last rights allocation, a total of 455 long-term traditional line fish rights were issued nationally, of which 62 licences were for the area from Cape Infanta to Port St Johns. Of these, about 25 vessels operate in the Algoa Bay area with an average of eight crew. The total crew working in Algoa Bay amounts to approximately 200 people, each of whom support about five people (DEAT: MCM 2005b).

Within the Algoa Bay area, line fishers target mainly reef fish such as carpenter *Argyrozona argyrozona*, red roman *Chrysoblephus laticeps*, santer *Cheimerius nufar*, and red stumpnose *Chrysoblephus gibbiceps*, which are consistent but not always the most abundant. Geelbek *Atractoscion aequidens*, yellowtail *Seriola lalandi* and kob *Argyrosomus inodorus* are targeted when available. Geelbek, santer, and silver kob dominate the catches in the western sector of the Bay (Chalmers 2012).

Fishers are constrained in terms of what species they can target, as well as by bag and size limits but effort is primarily limited by weather and sea conditions as ski boats go out only when the wind is less than 15 knots. Fishing takes place throughout the year but there is some seasonality in catches. Ski boats typically fish for about 12 hours at a time and overnight trips are becoming more common as fish abundance declines. Boats are limited to 40 NM offshore and are constrained by MPAs (Bird Island MPA in Algoa Bay and Tstikamma west of Port St Francis).

Total catch in the traditional line fishery within the Algoa Bay region averaged just over 500 tons per year from 2006 to 2010. The catch was dominated by three species: geelbek *A. aequidens*, carpenter *A. argyrozona* and kob *A. inodorus*, with geelbek making up 45% of catches and more than half of the total landed value. The current landed value of the average annual catch is in the order of R12 million.

The overall effort of the traditional line fishery is limited mainly to the Sundays River and Rij banks, as well as around the point to the west of Cape Recife, whereas effort by the Port Alfred-based boats ranges westwards to Bird Island, where fishing is to the north and south of the Bird Island MPA (Figure 2-14). Only a small proportion of the average annual reported catch and effort for the Algoa Bay area is off the Port of Ngqura.

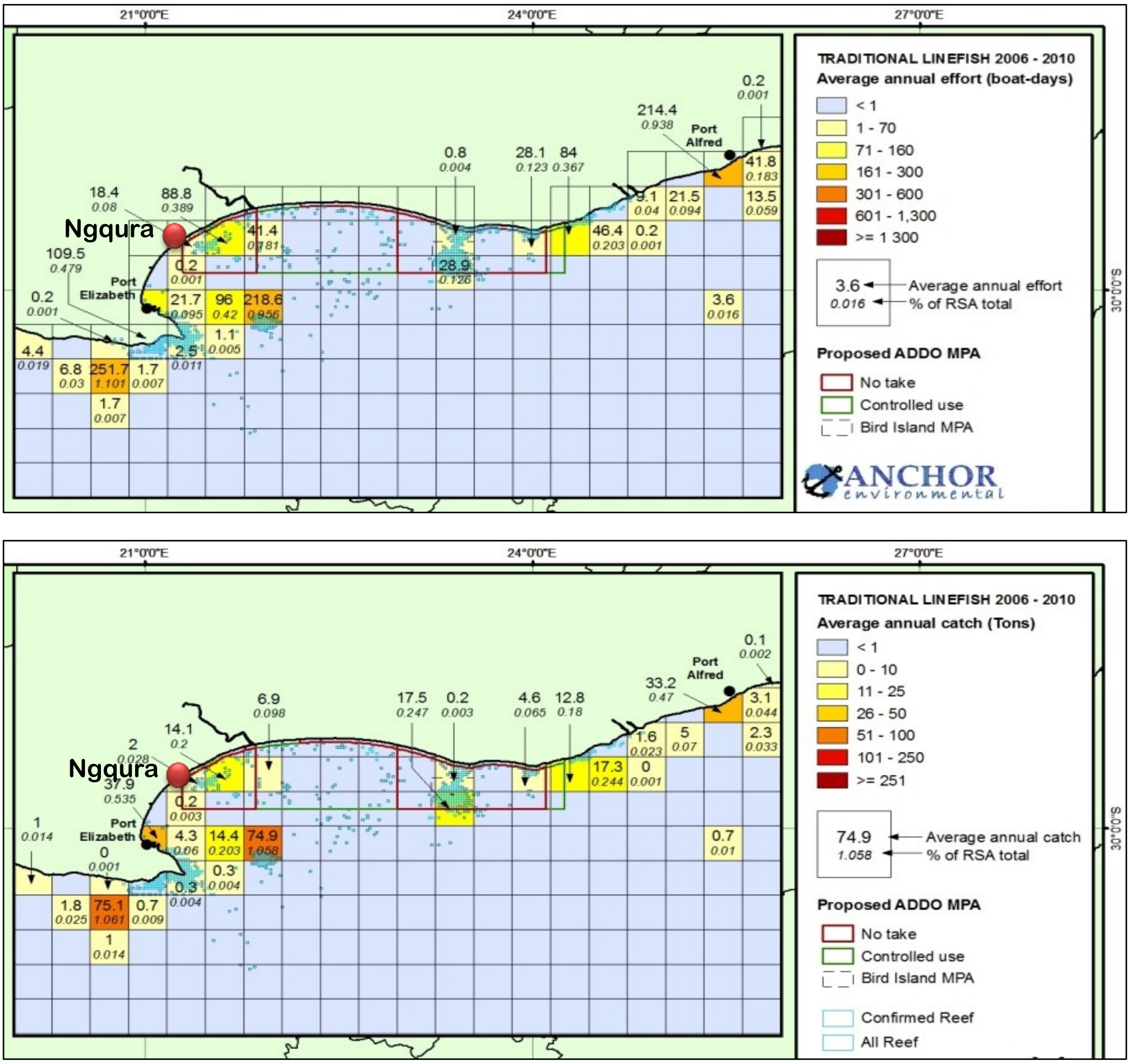

Figure 2-14. Average annual linefish effort (top) and catch (bottom) from 2006 to 2010 in relation to the Port of Ngqura in Algoa Bay (from Laird *et al*. 2016).

2.3.3.4 Shark longline

Demersal sharks in South Africa are either targeted directly or caught as by-catch, with the bulk of the catches being taken by the traditional linefishery, the inshore trawl fisheries, and the demersal shark longline fishery (Da Silva and Bürgener 2007). Longline permits for the directed catching of sharks were first issued in 1991, although catches of pelagic sharks are now included within the pelagic tuna and swordfish sector. In Algoa Bay, the fishery targets smooth hound *Mustelus mustelus*, soupfin *Galeorhinus galeus*, smooth hammerhead *Sphyrna zygaena*, bronze whaler *Carcharhinus brachyurus*, blacktip *Carcharhinus limbatus*, dusky *C. obscures* and cow sharks *Notorynchus cepedianus*.

The footprint of the proposed marine pipeline servitude overlaps with the shark longline fishery off the Port of Ngqura (Figure 2-15). This area appears particularly important to this fishery, with numerous sets and some 5% of the annual average catch made within this reporting block.

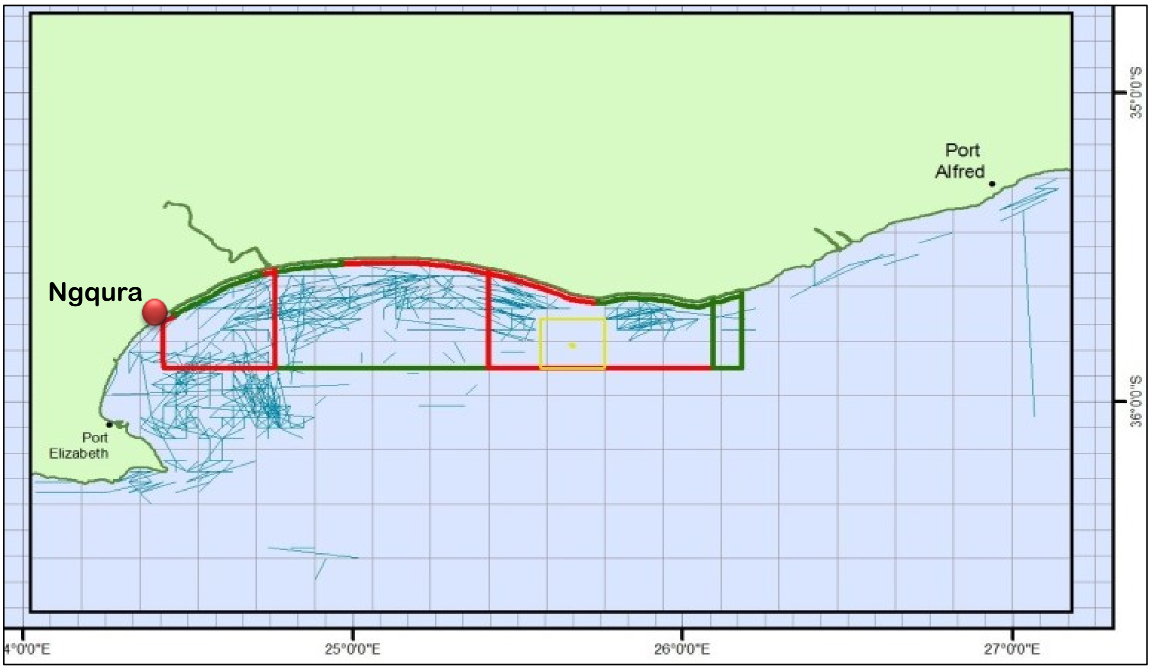

Figure 2-15. Reported shark long line sets made by the PE based shark longline operator from 2006 to 2012 (Data source: DAFF from Laird *et al*. 2016).

Currently, demersal shark longlining is restricted to coastal waters up to 100 m depth and are permitted to fish up to East London. Vessels may use longlines with up to 3 000 hooks and all landings are independently monitored (DAFF 2013). There are a total of six rights holders in the demersal shark longline fishery, one of which operates in the Algoa Bay area with a single vessel. This vessel fishes year-round. Fishing is possible in winds of up to 25 knots and wind direction influences the choice of fishing grounds. Prevailing winds force fishing to the west during winter, and to the east (Sundays to Port Alfred) during summer. About three trips are undertaken per month, and vessels stay out for up to nine days. Fishing is usually close to shore.

2.3.4 Aquaculture

The Department of Environment, Forestry and Fisheries (DEFF), as the lead agent for aquaculture management and development in South Africa, is in the process of establishing a sea-based Aquaculture Development Zone (ADZ) in Algoa Bay. A Sea-based ADZ typically consists of a selection of designated precincts that provide opportunities for existing aquaculture operations to expand and new ones to be established. It is anticipated that an ADZ will create incentives for industry growth, provide marine aquaculture services and enhance consumer confidence. In addition, an ADZ can provide economic benefits to the local community through job creation and regional economic diversification. DEFF intends for the ADZ to accommodate finfish as well as bivalve culture (oysters/mussels) within a combination of precincts namely, Algoa 1, Algoa 6 and Algoa 7 precincts (Figure 2-16).

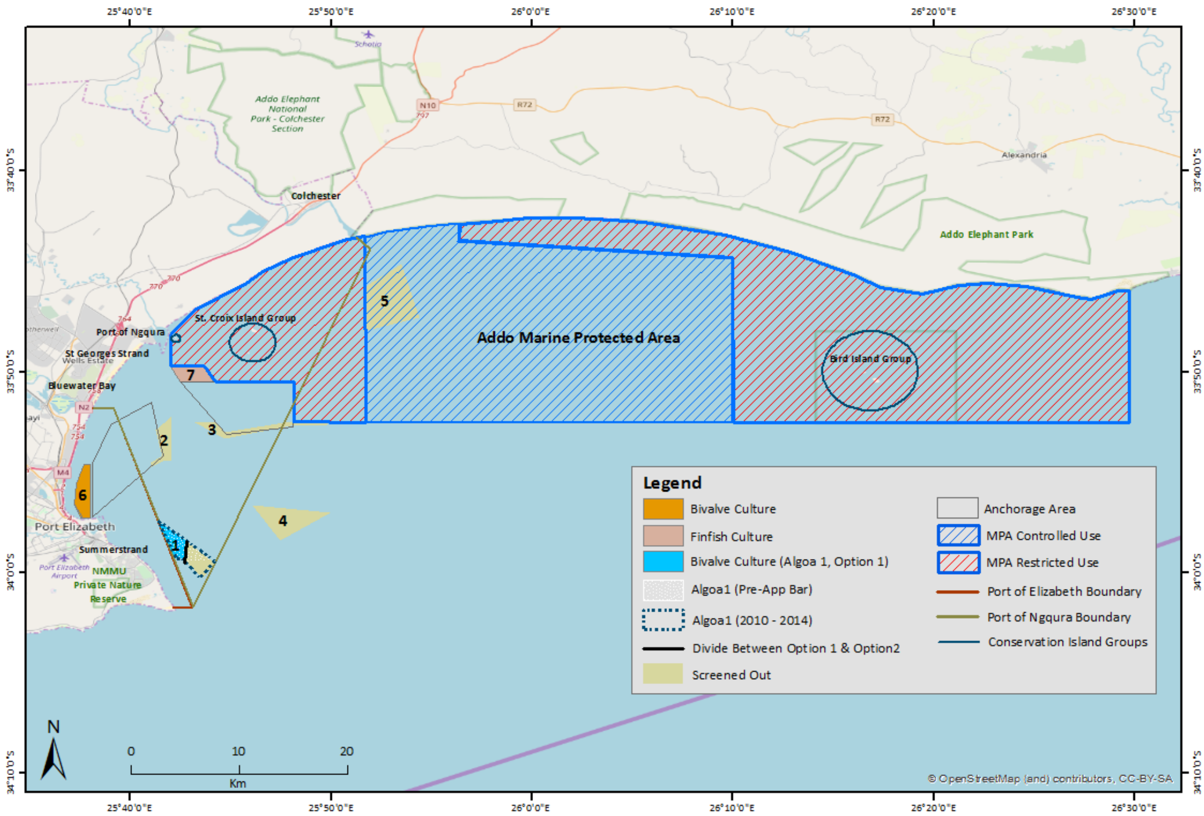

Figure 2-16. Precincts considered during the 2010-2014 and current application for environmental authorisation for a sea-based Aquaculture Development Zone in Algoa Bay, Eastern Cape. Precincts 2, 3, 4 and 5 were found to be unfeasible and were screened out. The southern portion of Algoa 1 (Option 2) has been screened out to reduce impacts on the chokka squid fishing industry. Precincts 1 Option 1, 6 and 7 constitute feasible sites and have been considered during the present Basic Assessment process (Massie *et al.* 2019).

A number of mariculture activities have occurred in Algoa Bay and at the Port Elizabeth harbour, these included both finfish and bivalve aquaculture. However, there is presently only one sea-based aquaculture company in operation in the Bay. Zwembesi Farms (Pty) Ltd (Knysna Oyster Company) has been operating in Algoa Bay since 1998 and is one of the oldest and largest oyster producers in South Africa, currently producing 100 tons annually on 13 ha (pers. comm. Simon Burton – Knysna Oyster Company 2019). The farm falls within the southern portion of the proposed ADZ Algoa 6 (PE Harbour) site. Zwembesi currently leases 6% of the Algoa 6 precinct (i.e. 27.7 ha) and intends to produce 140 t in 2019 on 15 ha. Zwembesi is expected to produce over 200 t per year on 27.5 ha. No other sea-based aquaculture activities currently occur in Algoa Bay.

If the Environmental Authorization for the ADZ is granted (currently in the appeals phase) finfish farming will be undertaken in the Algoa 7 precinct which located to the southeast of the Port of Ngqura at the border of the Addo MPA (Figure 2-16). Finfish are animals with a skull and in most cases a backbone, that have gills throughout their life and whose limbs, if any, are in the shape of fins. The development of modern sea cage finfish farming which began in the 1970s, occurred largely due to the growth of the salmon farming industry in countries with glaciated coastlines (e.g. Scotland, Norway, British Columbia, Chile) (Hutchings *et al*. 2013a,b). The number of finfish species used in marine cage culture internationally has since grown dramatically and now includes salmon, tuna, flatfish, kingfish, bream, Sciaenids (e.g. sea bass) and a host of other species grown in a variety of cage culture systems (Staniford 2002). Although some sea cage farming operations rely on wild caught stock e.g. southern and northern bluefin tuna farms (located largely in Australia and the Mediterranean, respectively), most farms use finfish fingerlings that are obtained from land based hatcheries, where brood stock, egg and larvae husbandry can be carried out under controlled conditions. Fingerlings are stocked into sea cages at species- and environmentally specific optimal sizes and densities, are fed, usually with commercially available protein and lipid rich dry food, treated for diseases and parasites, graded, and harvested at a size that results in the maximum economic return.

The Department of Science and Technology - in partnership with Irvin & Johnson Ltd - conducted a 2-year pilot project to ascertain the commercial, technical and environmental viability of sea-based cages for breeding three indigenous and overfished South African line-fish species, namely dusky kob (*Argyrosomus japonicus*), silver kob (*Argyrosomus inodorus*) and yellowtail (Seriola lalandi). Fish that reached 1 kg were sold through an uptake agreement with I&J. Four HDPE cages were deployed 1 km offshore near the Port Elizabeth harbour, which is relatively sheltered from the wind. In December 2007, 40 000 dusky kob fingerlings with an average mass of 8 g were added to one of the cages. The successful introduction of kob was followed in January 2008 by the introduction of 18 000 yellowtail fingerlings (average weight of 5 g) in the second sea cage. Both cages were equipped with locally produced predator nets together with an inside net; all nets are weighted to maintain the cage structure of the nets in the water. Fish sampling after the third production month indicated an average weight of 74.73 g for kob and 17.57 g for yellowtail, compared to the respective target weight of 53.32 g and 15 g respectively (Department of Science and Technology 2011a). The insight gained from this pilot project is hoped to assist with the development of a commercially viable model that would benefit the public and offer some BEE opportunities.

NMU undertook independent environmental monitoring and reported regularly to the then DAFF. No significant impact was detected. No whale or dolphin entanglements were observed, only one seal incident, two ragged tooth sharks breached the netting and were removed without harm, and one tern breached the bird netting. The only incident of disease involved dusky kob, which were treated with hydrogen peroxide. At the conclusion of the pilot project in July 2010, the cages and mooring system were removed. The second phase for yellowtail was not realised due to the lack of fingerling availability and the project was closed in 2013 (pers. comm. G le Roux, Stellenbosch University 2018).

An application for environmental authorisation for the development of a land-based aquaculture development zone (ADZ) in the Coega Industrial Development Zone was granted in 2018 (Figure 2-17). While no detailed or specific project descriptions are available (dependent on the requirements of future aquaculture investors) the EIA application considered a variety of species groups including marine fish (such as Dusky kob *Argyrosomus japonicus*, Yellowtail *Seriola lalandi* Natal stumpnose *Rhabdosargus sarba*, White stumpnose *Rhabdosargus globiceps*, Spotted grunter *Pomadasys commersonnii*), marine invertebrates (including east and west coast rock lobster, abalone *Haliotis midae*, sea urchin *Tripneustes gratilla*, and scallops *Pectin sulcicostatus*) as well as a variet of freshwater species (Nile tilapia *Oreochromis niloticus*, Mozambique tilapia *Oreochromis mossambicus*, Sharptooth catfish *Clarias gariepinus*, rainbow trout *Oncorhynchus mykiss*) (Aquatic Ecosystem Services 2017a).

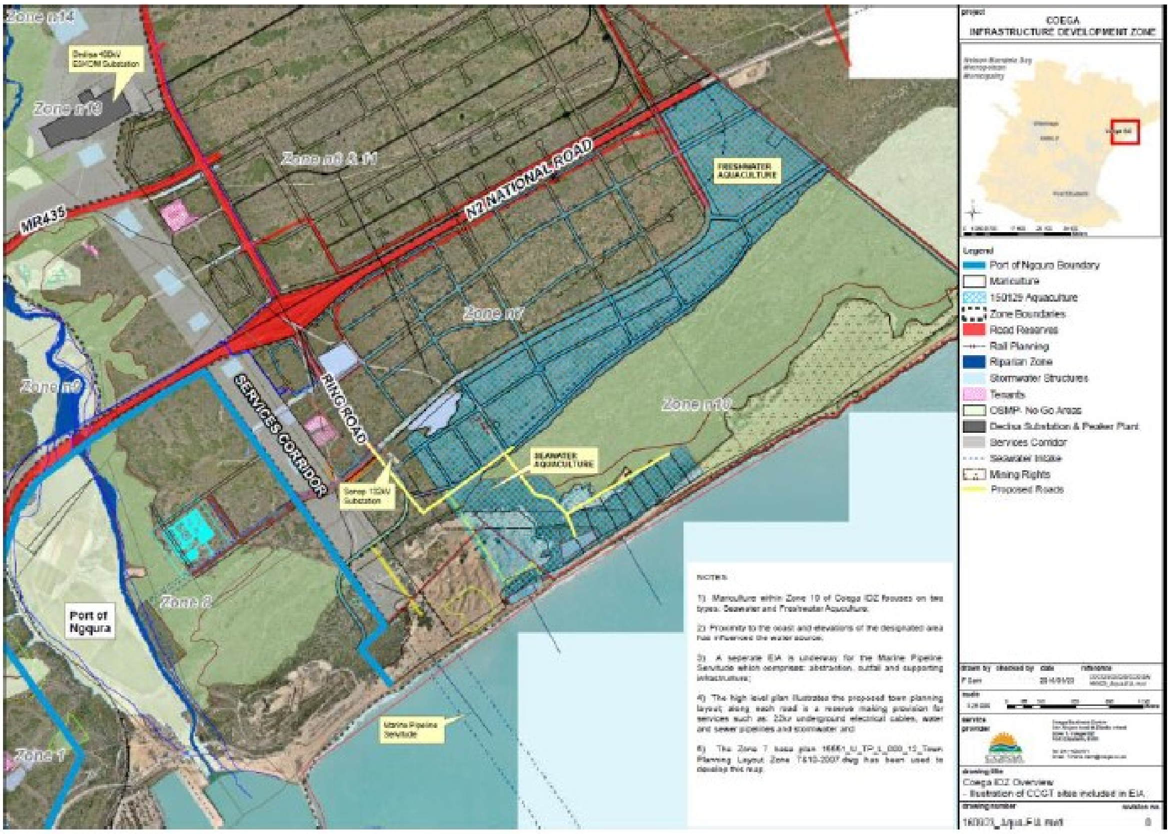

Figure 2-17. Conceptual layout of aquaculture facilities in Zone 10 of the land based ADZ (Aquatic Ecosystem Services 2017a).

2.4 Significance and sensitivity of the system

Due to the high diversity of habitats, marine organisms and seabirds in Algoa Bay (several of which are of conservation concern), significant biodiversity importance is attributed to many areas in the Bay (Figure 2-19) (Chalmers 2012).

In May 2019, the government formally gazetted the addition of 20 new or expanded Marine Protected Areas (MPA), increasing the total protected area of South Africa's Exclusive Economic Zone (EEZ) to 5% (Government Gazette 42478, Notice No. 757). This area provides some protection to 87% of the different marine ecosystem types found in South African waters, thereby ensuring that the MPA network is representative of the country's important diversity (SANBI 2019). Included in this was the addition of the Addo Elephant National Park Marine Protected Area. An MPA is an area of ocean and/or coastline specifically protected for the benefit of people and the environment.

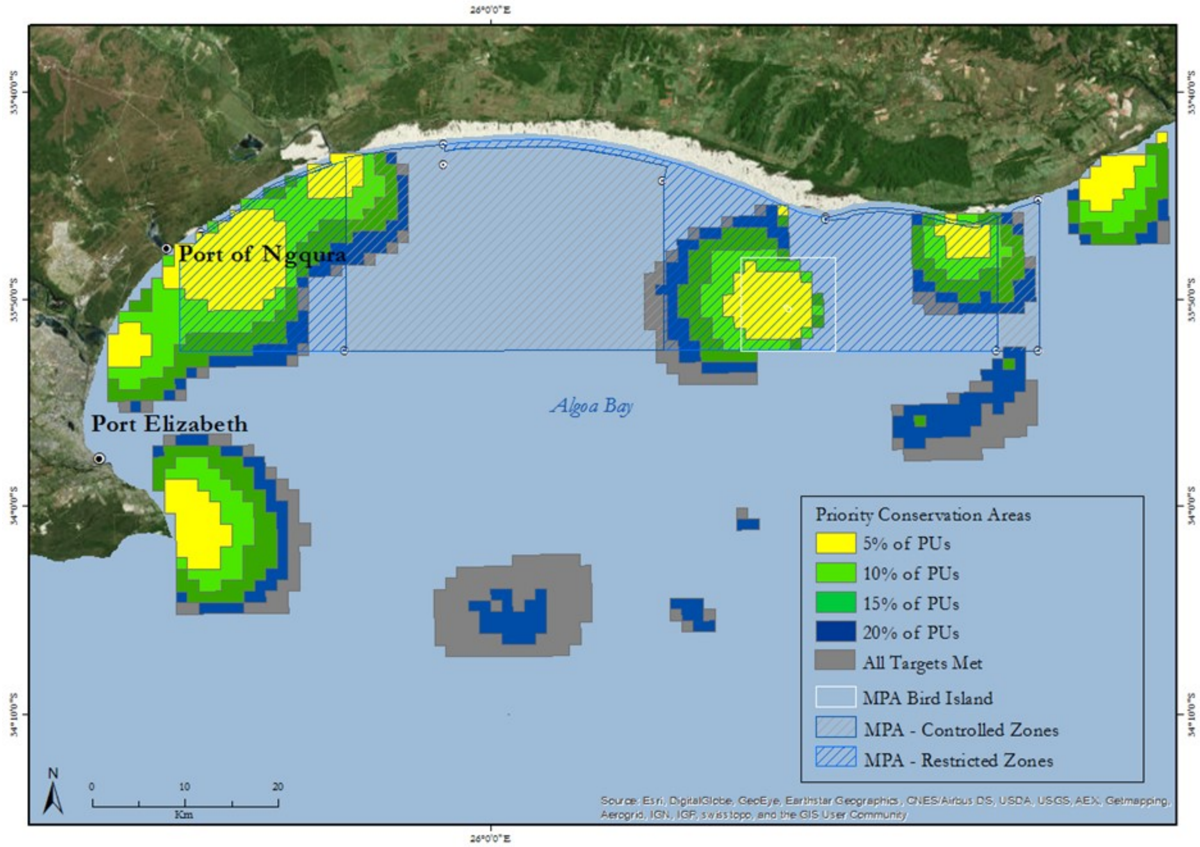

Figure 2-18. Priority conservation areas within Algoa Bay (data source: Chalmers 2012). The Port of Ngqura is situated within the Coega Industrial Development Zone (SEZ) and is located adjacent to the western border of the recently drafted Addo MPA. (Laird *et al*. 2016).

The original Bird Island MPA declared in Government Gazette 26432, Notice No. 696 of 4 June 2004 was expanded and the new MPA proclaimed as the Addo Elephant National Park MPA which covers an area for 1200 km^2 (Figure 2-19).

The MPA extends the land based Addo Elephant National Park protection to include further large marine species such as the great white shark and several whale species that frequent the Algoa Bay coastline (including Bryde's, Minke, Humpback and Southern Right whales). In addition, the MPA protects the breeding and important feeding grounds two endangered bird species, the African penguins and Cape gannets which breed on the St Croix and Bird Islands located within the MPA.

The Addo Elephant MPA regulations (Government Gazette No. 42479, 23 May 2019) states:

10. Dumping at sea and discharge into Marine Protected Area

(2) Any existing discharge of effluent…which commences after the date of commencement of these regulations, as contemplated in section 69 of the Integrated Coastal Management Act, is hereby authorised to continue and commence, within the Marine Protected Area, provided such discharge is authorised in terms of section 69 of the Integrated Coastal Management Act.

And thereby makes provision for the proposed marine pipeline servitude project to discharge within the MPA.

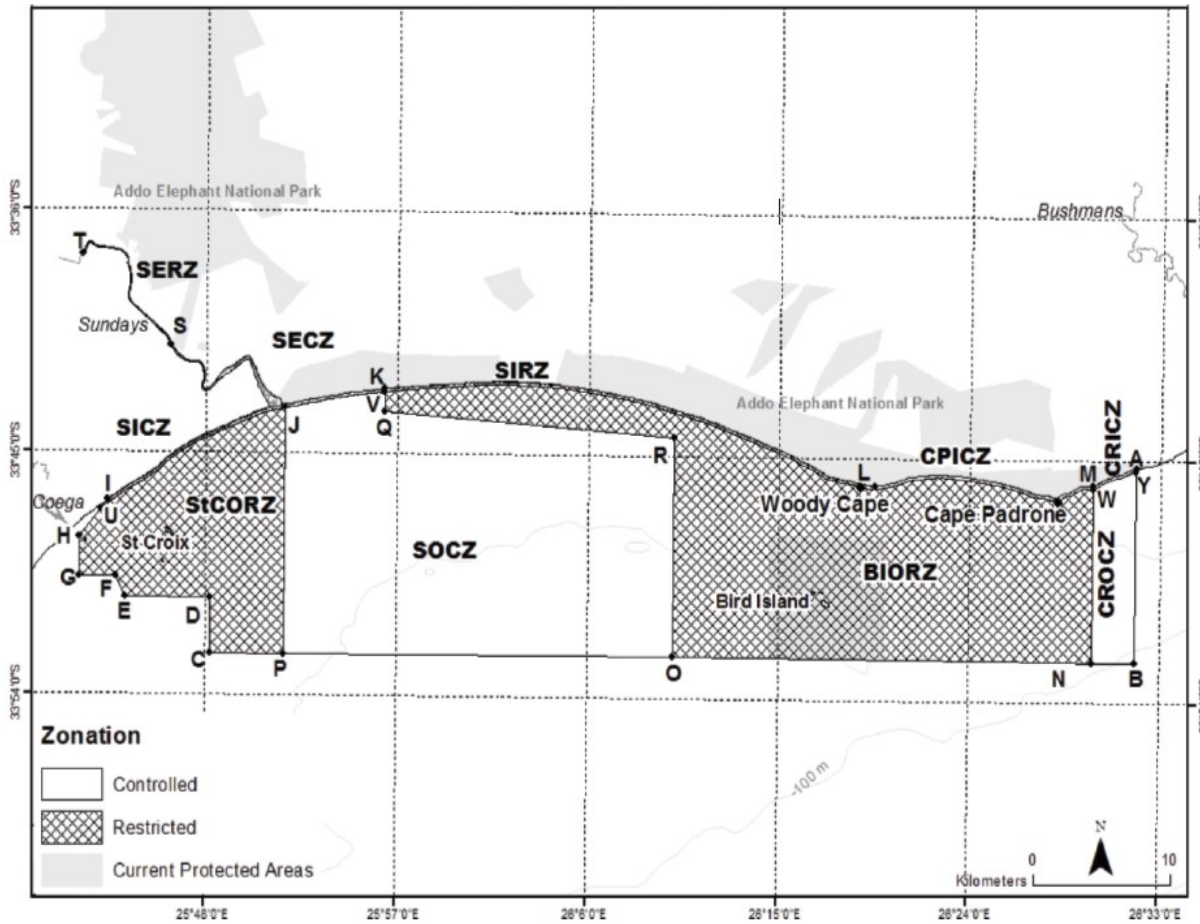

Figure 2-19. **Map showing the boundaries of the Addo Elephant Marine Protected Area as Gazetted in May 2019. (Government Gazette 42478, Notice No. 757 of 23 May 2019).**

3 LEGISLATIVE CONTEXT FOR POLLUTION CONTROL IN SOUTH AFRICA

Contemporary coastal water management strategies around the world focus on maintaining or achieving receiving water quality such that the water body remains or becomes fit for all designated uses. Designated uses of the marine environment include aquaculture, recreational use, industrial use, as well as the protection of biodiversity and ecosystem functioning. This goal-oriented management approach arose from the recognition that enforcing end of pipe effluent limits in the absence of an established context, i.e. not recognising the assimilative capacity and requirements of receiving environments, would reach a point where water bodies would only be marginally fit for their recognised uses. This management approach is referred to as the Receiving Water Quality (RWQ) framework (Anchor 2015a) which most countries have adopted. Many have developed water quality guidelines for a variety of uses, which include target values for a range of contaminants that must be met in the receiving environment. Furthermore, in most countries Water Quality Guidelines (WQGs) are legislated standards and are legal requirements to be met by every user/outfall. Although the importance of managing water quality through the RWQ framework is undisputed, the degree to which this is implemented differs widely between countries.

3.1 General discharge authorisation

In terms of the National Water Act (Act No 36 of 1998), discharging of waste or water containing waste into a “water resource through a sea outfall or other conduit” is listed as a water use for which a licence is required, unless such use was authorised through a General Discharge Authorisation (GDA) indicated by a notice published in the Government Gazette. The Revised General Authorisation of 2013 (No. 36820 of 2013) exempts users from having to apply for water use licences for the discharge of water containing waste into a water resource provided that the discharge was within certain specified limits and conditions (DWA 2013).

With the promulgation of the National Environmental Management: Integrated Coastal Management Act (No. 24 of 2008) (ICMA) (as amended), responsibility for regulating land-derived effluent discharges into coastal waters was transferred to the Department of Environmental Affairs (DEA). In terms of Section 69 of ICMA, no person is permitted to discharge effluent originating from a source on land into coastal waters except in terms of a GDA or a Coastal Waters Discharge Permit (CWDP). Exemptions were issued to proponents who, at the time of promulgation, were discharging effluent into coastal waters in terms of permits issued under the NWA provided that the effluent was treated to meet the General and Special Standards (Government Gazette No. 20526, 8 October 1999), and that they applied for a CWDP within three years of promulgation of the ICMA. New operators wishing to discharge effluent to coastal waters are required to apply for a CWDP before commencing and are also required to comply with the applicable WQGs. Applications for CWDP are expected to include data on contaminant levels in the effluent to be discharged, as well as results of dilution and dispersion model studies. These models are required to simulate the worst-case scenario and indicate maximum expected levels for the same contaminants at the edge of the Recommended Mixing Zone (RMZ). These levels are expected to comply with published guideline levels as defined by other existing, or potential, beneficial uses of the receiving environment.

The DEA is currently in the process of developing a permitting system for such effluent discharges and for this purpose, the Assessment Framework for the Management of Effluent from Land Based Sources Discharged to the Marine Environment was recently developed (Anchor 2015b). This framework recognises that discharges differ in effluent characteristics (volume and quality) and discharge locality (i.e. biophysical conditions, use of the receiving environment), which ultimately determines the risk a particular discharge poses to the receiving environment. It was recommended that the potential scope of a GDA, the level of assessment during the application process for a CWDP, as well as licensing conditions should be based entirely on the environmental risk posed by a particular effluent. Accordingly, the guidelines provide a framework within which an effluent can be characterised (effluent components and properties) and potential impacts be assessed within the context of the receiving environment (i.e. sensitive versus robust receiving environments).

3.2 Water quality guidelines

There are a wide variety of legal instruments that are utilised by countries to maintain and/or achieve WQGs in the receiving environment. These include setting appropriate contaminant limits, the banning or restricting of certain types of discharges in specified areas, prohibiting or restricting discharge of certain substances, as well as providing financial incentives to reduce pollution at the source alongside the implementation of cleaner treatment technology. The only effective method, however, that ensures compliance of an effluent with water quality guidelines/standards is to determine site-specific effluent limits that are calculated based on the WQGs (or standards) of a given water body, the effluent volume and concentration, as well as the site-specific assimilative capacity of the receiving environment. This method is also identified as the water quality-based effluent limits (WQBEL) approach (Anchor 2015a) and recognises that effluent (and its associated contaminants) is rapidly diluted by the receiving waters as it enters the environment. In order to take advantage of this beneficial effect, allowance is generally made for a RMZ which extends a short distance from the outfall point (or pipe end) and is an area in which contaminant levels are allowed to exceed the established WQGs (or standards) for the receiving environment. The magnitude of the RMZ should, in theory, vary in accordance with the sensitivity and significance of the receiving environment and the location of the outfall point in the environment, but in practice is usually set at a distance of around 100 m from the pipe end for marine systems. The WQBEL approach differs from the Uniform Effluent Standard (UES) approach in which fixed maximum concentrations or loads are applicable for contaminants in wastewater discharges for all users or outfalls, irrespective of where they are located (Anchor 2015a).

South Africa has adopted the RWQ framework for the management of water quality in both inland (freshwater) and marine water bodies and uses both the WQBEL and the UES approaches to implement the framework. Receiving water quality guidelines have thus been published for the full range of beneficial uses for inland water (human consumption, aquaculture, irrigation, recreational use, industrial use, and protection of biodiversity and ecosystem functioning) and also for the marine environment (aquaculture, recreational use, industrial use, and protection of biodiversity and ecosystem functioning) (see Table 3.1).

Table 3.1. Water quality guidelines for physio-chemical properties of seawater as contained in the 2018 South African Water Quality Guidelines for Coastal Marine Waters: Volume 1: Natural Environment and Mariculture Use (DEA 2018). The 1995 guidelines are also given.

Parameter	WQGs (DAWF 1995)		WQGs (DEA 2018)	
Temperature	The maximum acceptable variation in ambient temperature is + or - 1°C.		20th and 80th percentiles of the seasonal and/or event-driven distributions for the receiving system.	
Salinity	The target range for the South African coastal zone is 33-36 ppt.		20th and 80th percentiles of the seasonal and/or event-driven distributions for the receiving system.	
Suspended solids	The concentration of suspended solids should not be increased by more than 10% of the ambient concentration.		Guideline values should not exceed the 80th percentile of the seasonal and/or event-driven distributions for the receiving system. Additionally, the natural euphotic depth (Z_n) should not be permitted to change by more than 10%.	
pH	The target range for the South African coastal zone is 7.3-8.2		20th and 80th percentiles of the seasonal and/or event-driven distributions for the receiving system. pH changes of more than 0.5 pH units from the seasonal maximum or minimum defined by the reference systems should be fully investigated.	
Colour/Turbidity/Clarity	Turbidity and colour acting singly or in combination should not reduce the depth of the euphotic zone by more than 10 % of background levels measured at a comparable control site. The colour (substances in solution) of water should not exceed background levels by more than 35 Hazen units.		Guideline values should not exceed the 80th percentile of the seasonal and/or event-driven distributions for the receiving system. Additionally, the natural euphotic depth (Z_n) should not be permitted to change by more than 10%.	
Dissolved oxygen	For the south and east coasts, the dissolved oxygen should not fall below 5 mg/L (99 % of the time) and below 6 mg/L (95 % of the time).		Guideline values should not be allowed to drop below the 20th percentile of the seasonal and/or event-driven distributions for the receiving system.	
Dissolved nutrients (mg/l): Phosphates (PO_4-P), Nitrogen (NO_2^-, NO_3 and NH_3)	Should not cause excessive algal growth and the loads should not exceed the levels which are introduced by natural processes such as upwelling.		The guideline value should be determined as the 80th percentile of the receiving system distribution.	
Total Ammonia as a toxicant (NH_3-N + NH_4-N) (ug/l)	600		The guideline value should be determined as the 80th percentile of the receiving system distribution.	
Toxic inorganics (ug/l)	As total recoverable *x* (ug/l) (Chronic):		As total recoverable *x* (ug/l) (Chronic):	
	Arsenic (AS)	12	Arsenic (As)	8
	Cadmium (Cd)	4	Cadmium (Cd)	0.12
	Chromium (Cr)	8	Chromium (Cr)	2
	Copper (Cu)	5	Copper (Cu)	3
	Lead (Pb)	12	Lead (Pb)	2
	Mercury (Hg)	0.3	Mercury (Hg)	0.016
	Nickle (Ni)	25	Nickle (Ni)	5
	Zinc (Zn)	25	Zinc (Zn)	20

4 DISPERSION MODELLING RESULTS

The far field hydrodynamic dispersion and behaviour of the effluent discharged from the Coega SEZ was assessed using the three-dimensional MIKE 3 Flow Flexible Mesh Model by PRDW (2020). Near field plume behaviour and diffuser assessment was undertaken by coupling a near-field jet model to the hydrodynamic model (PRDW 2020). Nearshore wave transformation was simulated with the MIKE 21 Spectral Waves (SW) Flexible Mesh model.

Model set-up and calibration are detailed in PRDW (2020). A range of environmental conditions were assessed, with the model run over a period of well-mixed winter conditions (June), and stratified summer conditions (December). The model performance is adequate, although the model is slightly conservative in the reproduction of dominant current directions and reproduces measured temperature time series (including the well-mixed winter conditions and summer upwelling) (PRDW 2020). This model assessed the dilutions of key water quality parameters (such as temperature, salinity, suspended solids and a conservative tracer) in relation to legislated water quality guidelines at a stipulated mixing zone (see Section 3). Six effluent profiles were modelled under two Scenarios (see Table 4.1, and Figure 4-1). Here, a "scenario" refers to a specific intake and outfall location for each of the six effluent types discussed above, chosen to align with relevant infrastructure within the SEZ. Each effluent was modelled for independently for each Scenario.

Effluent constituent characterisation as well as required dilutions and diffuser geometry are detailed in PRDW (2020). It is noted that power plant and desalination co-discharges (such as biocides, like chlorine) were not explicitly modelled, and PRDW (2020) specifies that designers of these plants must ensure that end of pipe water quality guideline limits are met (i.e. 0.2 mg/l pipe end for chlorine).

Table 4.1. Effluent profiles and scenarios modelled by PRDW (2020)

<table>
<tr><th rowspan="2">Effluent stream</th><th rowspan="2">Effluent type and discharge</th><th colspan="2">Scenario modelled</th></tr>
<tr><th>1</th><th>2</th></tr>
<tr><td>1</td><td>Land based abalone aquaculture effluent, discharged into the surf zone</td><td>X</td><td>X</td></tr>
<tr><td>2</td><td>Wastewater 1: domestic and industrial waste effluent discharged into the Coega River which in turn discharges into the Port of Ngqura</td><td>X</td><td>X</td></tr>
<tr><td>3</td><td>Wastewater 2: domestic and industrial effluent discharged offshore via a submarine pipeline (-20 m CD, 3000 m offshore)</td><td>X</td><td>X</td></tr>
<tr><td>4</td><td>Finfish effluent from land-based aquaculture discharged offshore via a submarine pipeline (-16 m CD, 1500 m offshore)</td><td>X</td><td rowspan="2">X</td></tr>
<tr><td>5</td><td>Desalination brine from a 60 MLD Reverse Osmosis desalination plant discharged offshore via a submarine pipeline (-13.5 m CD, 1000 m offshore)</td><td>X</td></tr>
<tr><td>6</td><td>Cooling water from the two Liquefied Natural Gas (LNG) power plants discharged offshore via a subterranean tunnel (-11 m CD, 650 m offshore). Combined with heating water from LGN vaporiser (effluent stream 7). Three separate cooling water options:
4. CW1: Once through cooling (Zone 10S) plus wet mechanical cooling (Zone 10N).
5. CW2: Once through cooling (Zone 10S) plus air cooling (Zone 10N).
6. CW3: Wet mechanical cooling (Zone 10S) plus wet mechanical cooling (Zone 10N).</td><td>CW2+HW1</td><td>CW3+HW2</td></tr>
</table>

Effluent stream	Effluent type and discharge	Scenario modelled	
		1	2
7	**Heating water** from LNG vaporiser discharged offshore via a subterranean tunnel (-11 m CD, 650 m offshore). Combined with cooling water from LGN power plants (effluent stream 6). Two separate cooling water options: 3. HW1: The vaporisers use the warm cooling water from the power plant (only possible for once through cooling). 4. HW2: The vaporisers use sea water from an intake in the Port of Ngqura	CW2+HW1	CW3+HW2

PRDW (2020) and Lwandle (2020) have recommended a 300 m mixing zone for all outfalls. Under ordinary conditions however, a 300 m mixing zone for the proposed Wastewater 1 discharge into the Port of Ngqura via the Coega River would be considered unacceptable. The Assessment Framework for Effluent Discharged from Land Based Sources requires that such a discharge into an estuary meet water quality guidelines at pipe end. However, the Coega Estuary has been assessed by the National Biodiversity Assessment (2018 and 2011) as being irreversibly modified, with an almost complete loss of natural habitat and biota, and that the basic ecosystem functions and processes of the system have been destroyed. As such, a 300 m mixing zone is considered acceptable in this case, on condition that Wastewater 1 effluent does not contain excessively high levels of trace metals (ostensibly from industrial effluent) as per PRDW (2020).

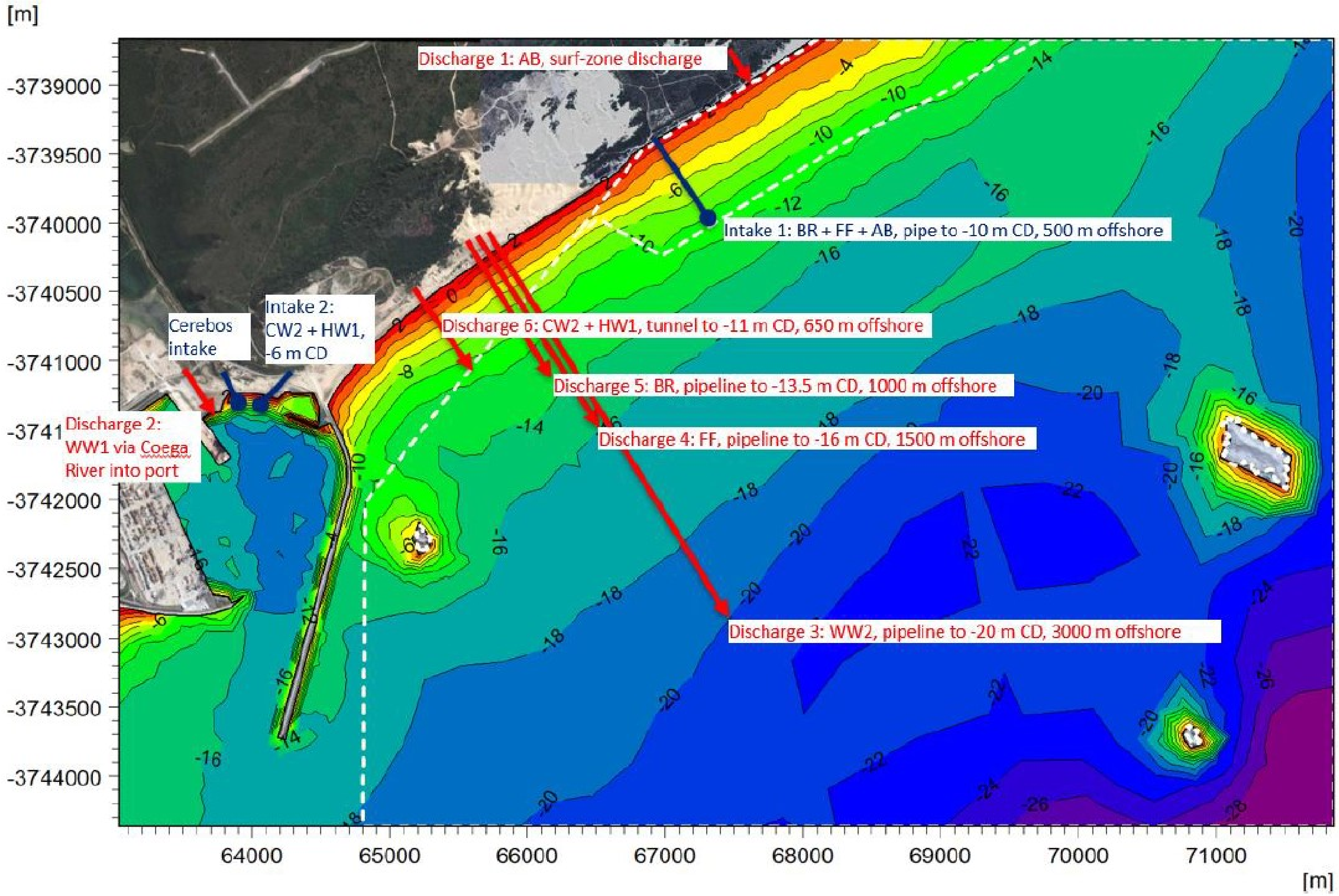

Figure 4-1. Scenario 1 (top) and Scenario 2 (bottom) outfall and intake configurations modelled by PRDW (2020).

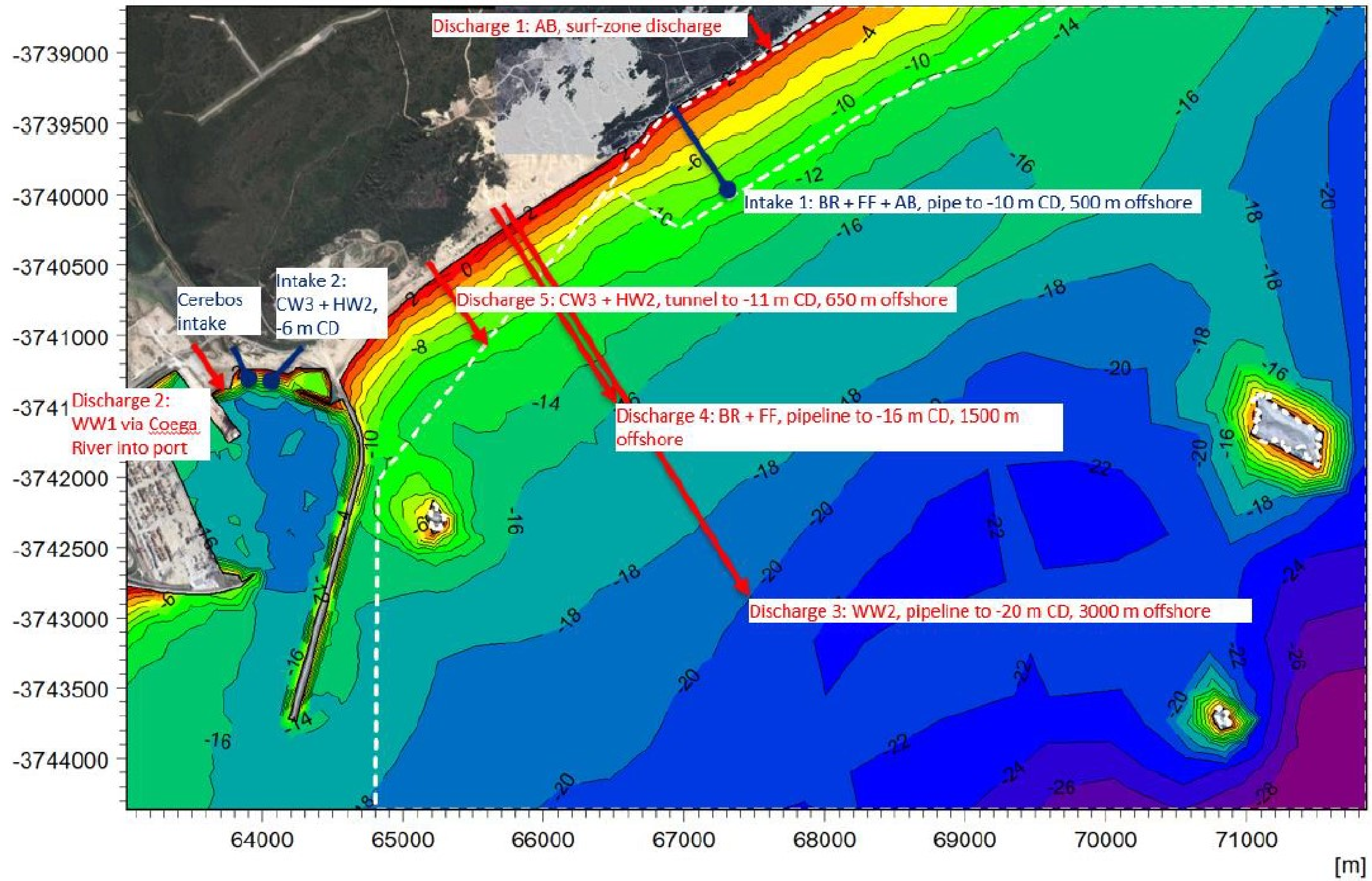

Figure 4-1. (Cont.) Scenario 1 (top) and Scenario 2 (bottom) outfall and intake configurations modelled by PRDW (2020).

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These far field modelling results indicate that:

- Required dilutions of all parameters measured for the **land-based abalone aquaculture** met the required dilutions at the 100 m and 300 m RMZ under both Scenario 1 and Scenario 2, despite the surf zone discharge causing the effluent to become trapped in the nearshore environment (Figure 4-2).

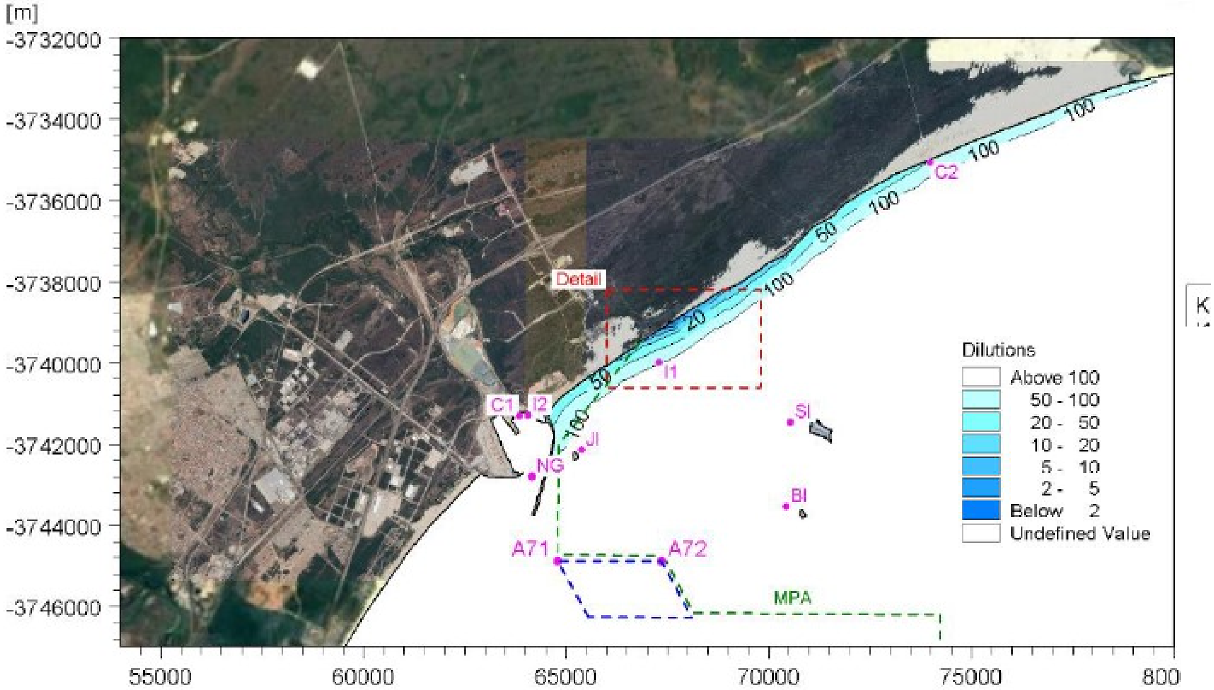

Figure 4-2. Land based abalone effluent discharge: Contours of 5th percentile dilutions at worst depth in water column (surface). Required dilution for TSS = 1 (the green line shows the Addo MPA and the blue line shows the Algoa 7 mariculture area. SI = St Croix Island, BI = Brenton Island, and JI = Jaheel Island) (PRDW 2020).

- Required dilutions were not achieved at the 300 m RMZ under Scenario 1 or Scenario 2 for any of the constituents of **Wastewater 1** that were modelled (*E. coli,* TKN + NH_4, total suspended solids, salinity) (Figure 4-3). This is because, "the river discharge into the port results in low dilutions due to the stagnant currents in the port and the plume buoyancy which inhibits vertical mixing" (PRDW 2020). End of pipe effluent quality must be improved, given that a diffuser is not feasible at the proposed site (see Table 4.2 for required end of pipe values).

- Required dilutions were not achieved at the 300 m RMZ under Scenario 1 or Scenario 2 for any of the trace metals modelled for **Wastewater 2**, including Hg, Co, Cu, Cd as well as sulphides and Chemical Oxygen Demand (COD) (Figure 4-4). In contrast, *E. coli,* TKN + NH_4, total suspended solids and salinity dilutions all met required targets at the 100 m and 300 m RMZ for WW2 discharge for both Scenarios (Figure 4-4). While dilution is improved due to the diffuser placement at 20 m depth, end of pipe effluent quality must be still improved, (see Table 4.2 for required end of pipe values).

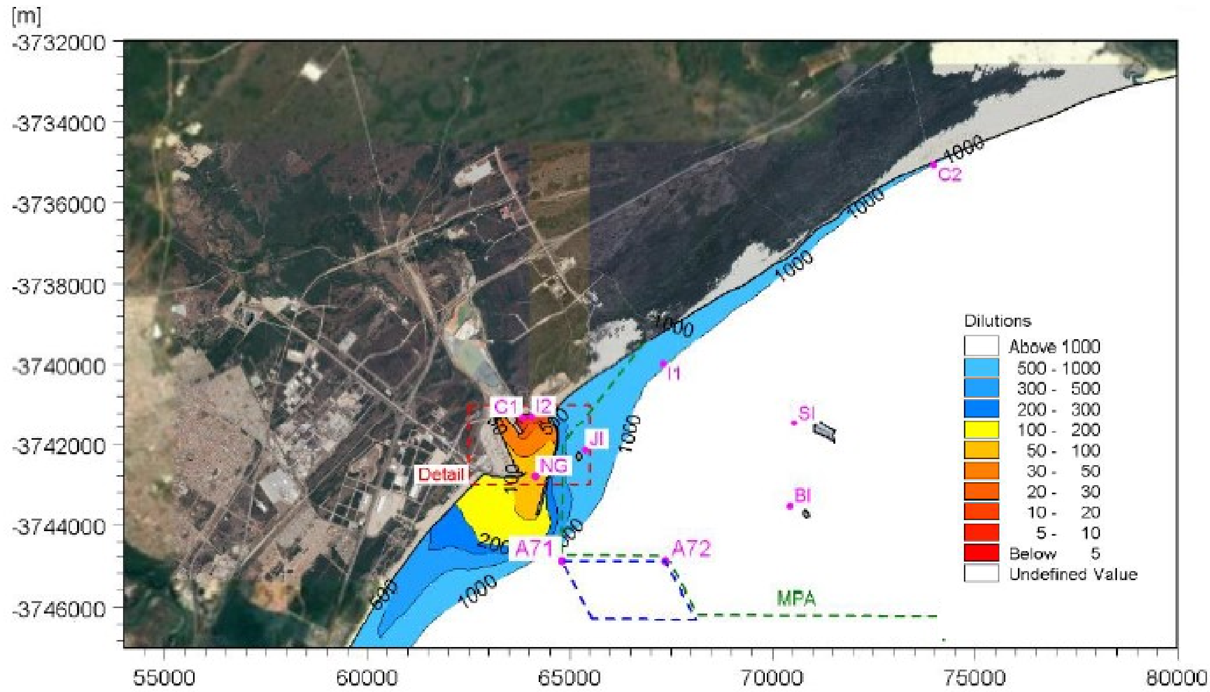

Figure 4-3. Wastewater 1 effluent discharge: Contours of 5th percentile dilutions at worst depth in water column (surface). Required dilution for TSS = 120; required dilution for salinity = 17.5 (PRDW 2020).

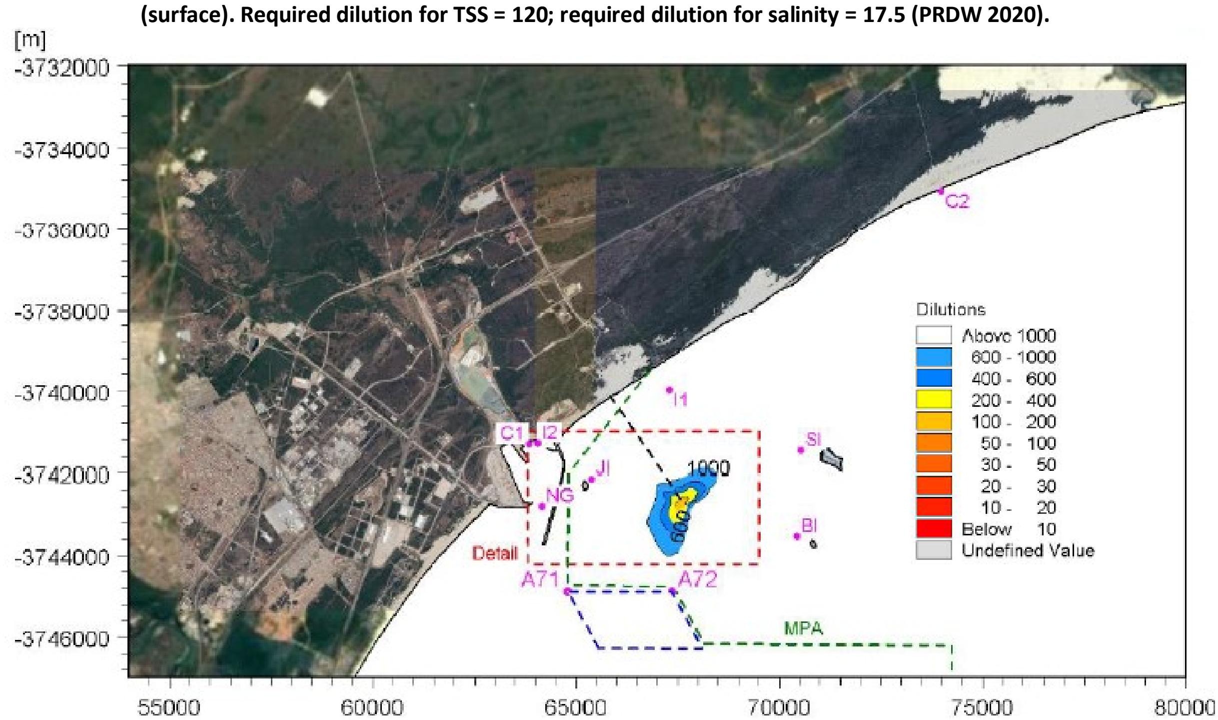

Figure 4-4. Wastewater 2 effluent discharge: Contours of 5th percentile dilutions at worst depth in water column (surface). Required dilution for TSS = 200; required dilution for Hg = 16667 (PRDW 2020).

- Required dilutions were met for **land-based finish aquaculture** effluent at the 300 m RMZ under Scenario 1 (Figure 4-5). Adequate dilution was achieved through the diffuser and the 20 m water depth. The required dilutions were not met for ammonia, nitrates and nitrites at the 100 m RMZ. Under Scenario 2 (finfish effluent and brine effluent combined), the diffuser and high jet velocities result in moderate dilutions of the dense mixed effluent, but the required dilutions were not met for ammonia, nitrates and nitrites at the 300 m RMZ (Figure 4-5). PRDW (2020) state that "the achieved dilutions are worse in the near-field for the combined effluent (Scenario 2) compared to the separate effluents (Scenario 1)". PRDW (2020) therefore recommended that the brine and finfish effluent are discharged separately (under Scenario 1), where the required dilutions for all constituents are met.

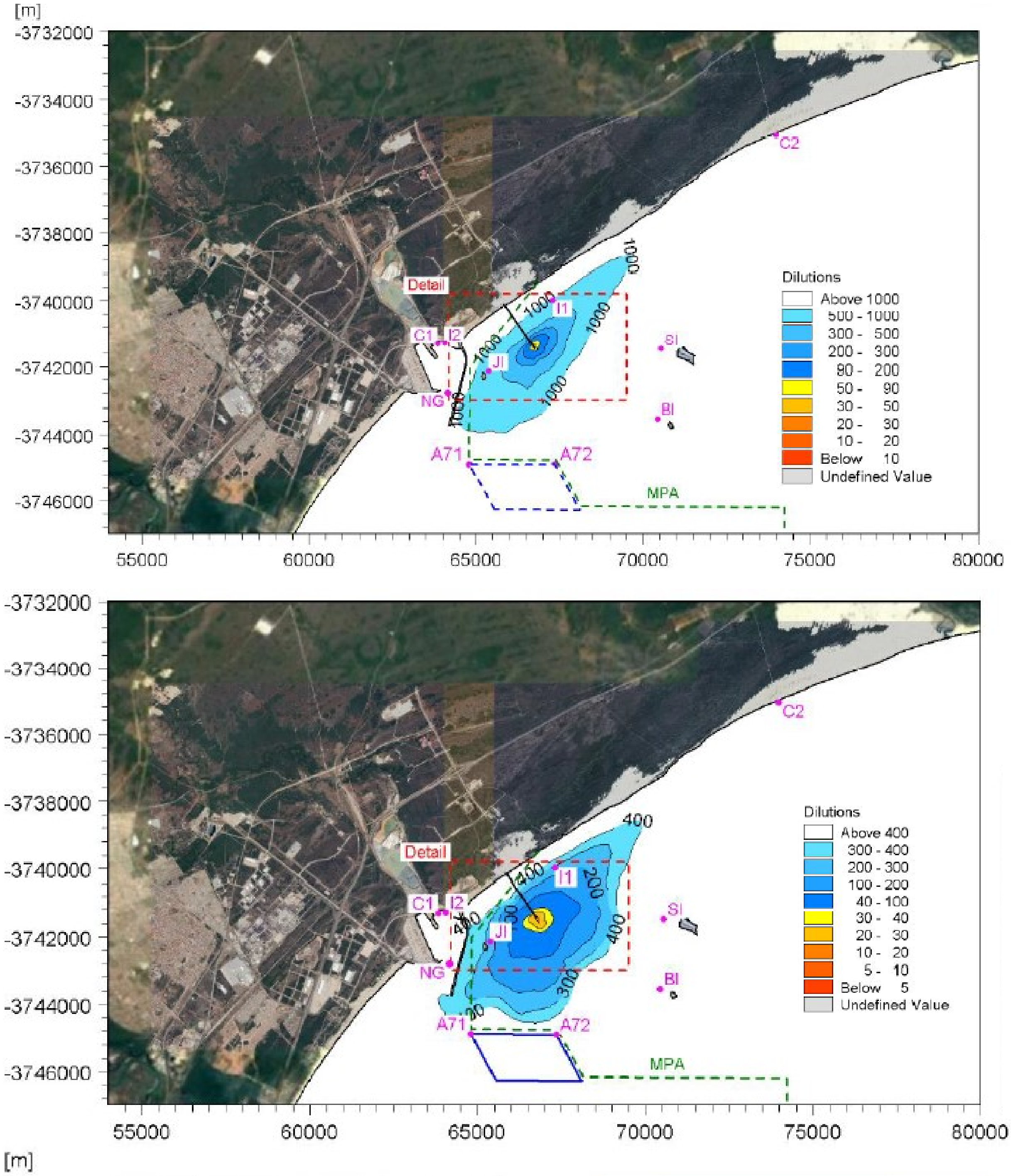

Figure 4-5. **(Top) Land-based finfish aquaculture effluent discharge Scenario 1 and (bottom) Scenario 2: Contours of 5th percentile dilutions at worst depth in water column (surface). Required dilution for Ammonia, Nitrates, Nitrates under Scenario 1 = 90. Required dilution for Ammonia, Nitrates, Nitrates under Scenario 2 = 39.1 (PRDW 2020).**

- Required dilutions were met for the **brine effluent** at the 100 m and 300 m RMZ under Scenario 1 (Figure 4-6), as a result of the mixing facilitated by the diffuser and high jet velocities (PRDW 2020).

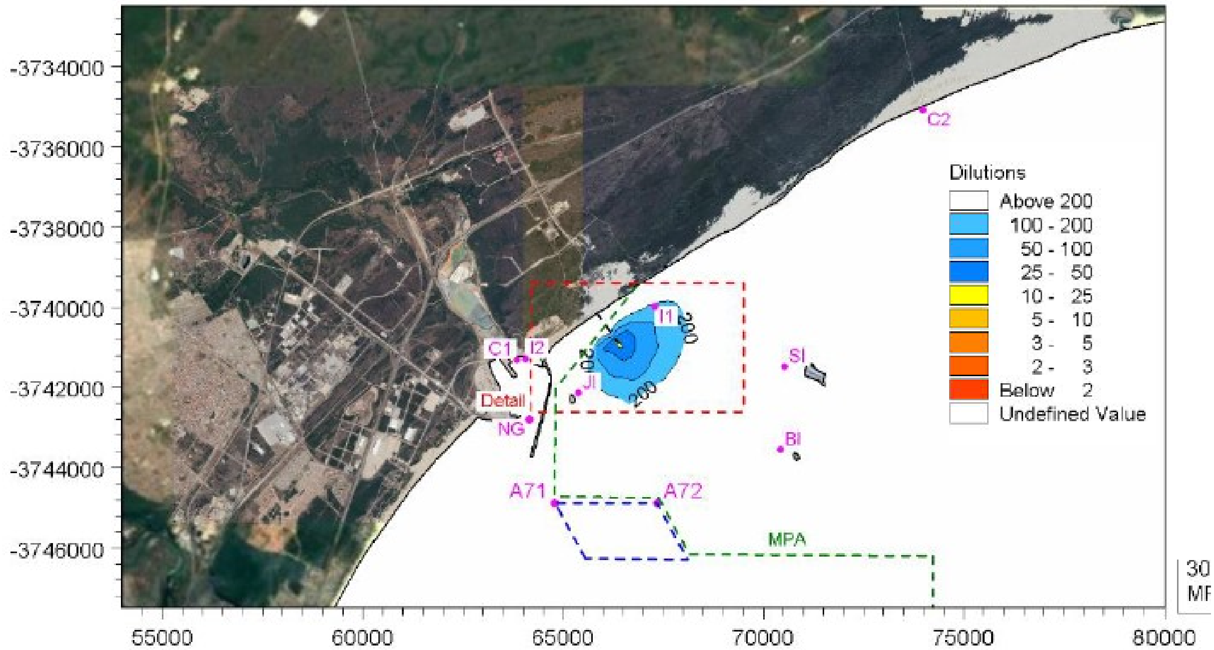

Figure 4-6. Brine effluent discharge Scenario 1: Contours of 5th percentile dilutions at worst depth in water column (surface). Required dilution for salinity = 25 (PRDW 2020).

- Required dilutions for the Scenario 1 mix of **Cooling Water 2 and Heating Water 1** were met at the 300 m RMZ (Figure 4-7), with the diffuser at 10 m water depth resulting in moderate dilutions. PRDW (2020) noted that blending the heating and cooling water reduces the difference in temperature, and thus the required dilutions.
- Required dilutions for the Scenario 2 mix of **Cooling Water 3 and Heating Water 2** were met at the 300 m RMZ, with an improvement in dilutions achieved over the Scenario 1 mix of Cooling Water 2 = Heating Water 1. PRDW (2020) does note that, should Cooling Water 1 be selected instead of Cooling Water 2 there will be minimal change in the results, i.e. Cooling Water 2 + Heating Water 1 can be changed to Cooling Water 1 + Heating Water 1.

PRDW (2020) therefore **recommends Scenario 1**, with the following adjustments (see Figure 4-9):

1. Wastewater 1: limit the maximum allowable effluent concentrations (end of pipe) for *E.coli*, TKN + NH_4 and TSS (Table 4.2).
2. Wastewater 2: limit the maximum allowable effluent concentrations (end of pipe) for heavy metals and COD (Table 4.2).
3. Although both Cooling Water + Heating Water mix options meet the guidelines, the Scenario 2 option of Cooling Water 3 + Heating Water 2 is preferred over the Scenario 1 option of Cooling Water 2 + Heating Water 1.

Lwandle (2020) notes that both Scenario 1 and Scenario 2 generally meet the DWAF (1995) receiving environment WQGs at realistic RMZ for all discharges except for the Wastewater 1 and Wastewater 2 discharges. Under these discharge scenarios, TSS, nitrogen, trace metals, salinity and COD "are predicted to be concentrated in the nearfield of the Wastewater 1 discharge but extend into the far-field for Wastewater 2 (especially in the case of Hg)" (Lwandle 2020).

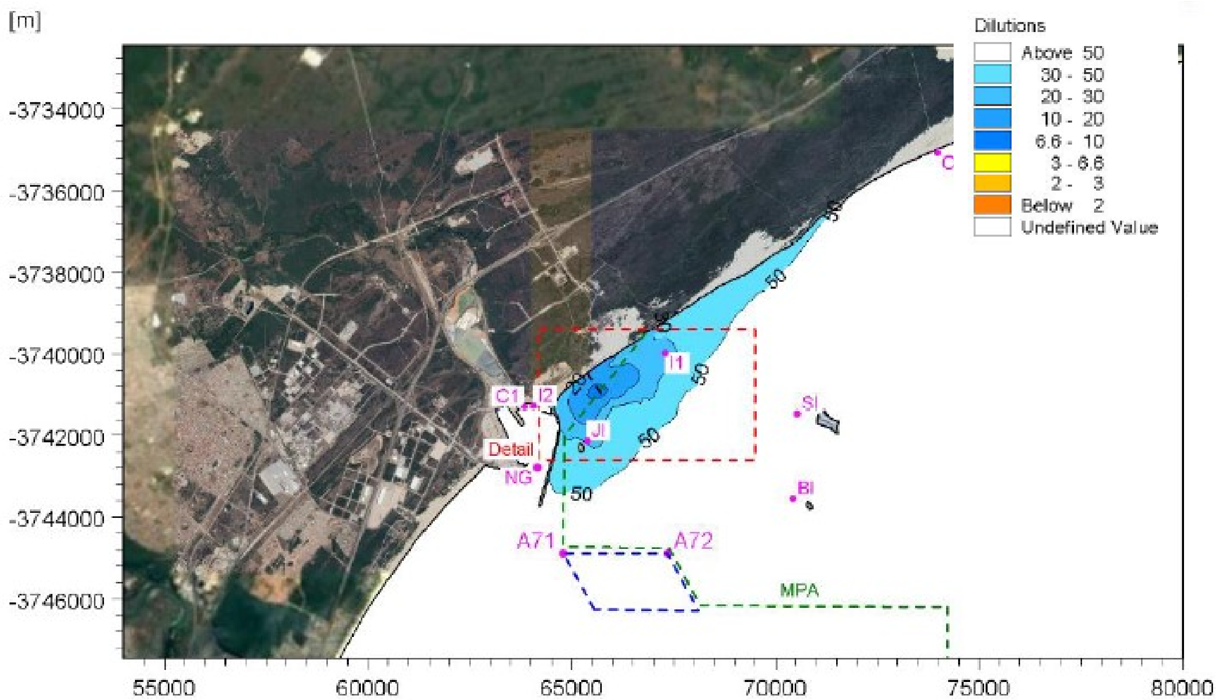

Figure 4-7. **Cooling Water 2 + Heated Water 1 effluent discharge Scenario 1: Contours of 5th percentile dilutions at worst depth in water column (surface). Required dilution for temperature =**

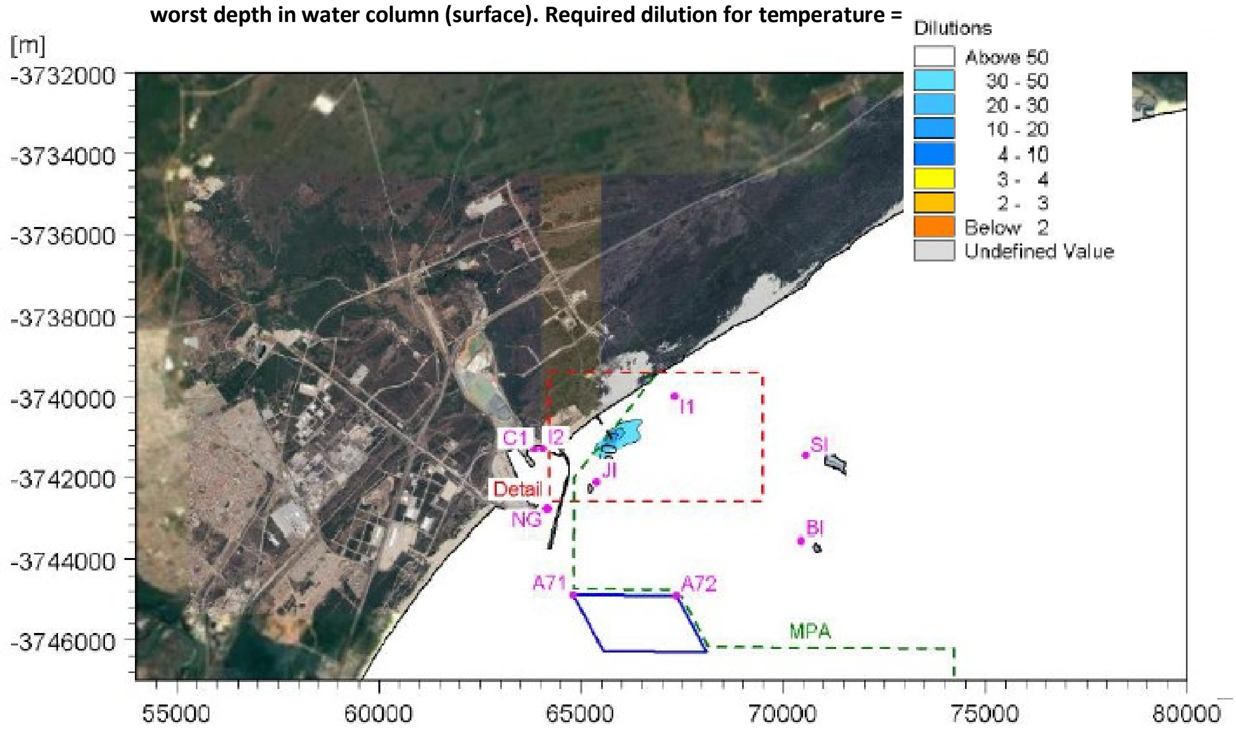

Figure 4-8. **Cooling Water 3 + Heated Water 2 effluent discharge Scenario 2: Contours of 5th percentile dilutions at worst depth in water column (surface). Required dilution for temperature = 4; Required dilution for salinity = 2.1 (PRDW 2020).**

Of particular concern was the exceedingly high trace metal concentrations present in the wastewater 2 effluent: Lwandle (2020) recommends reduction in end of pipe levels of these metals to prevent the exceedance of acute (lethal effect) toxicity thresholds (see Table 4.2). Within the dedicated mixing zone, these levels are too high to be permitted. Beyond the 300 m RMZ, Lwandle (2020) notes "low-risk levels primarily to planktonic organisms", due to "short duration of exposure" before the plumes are dispersed in the far field.

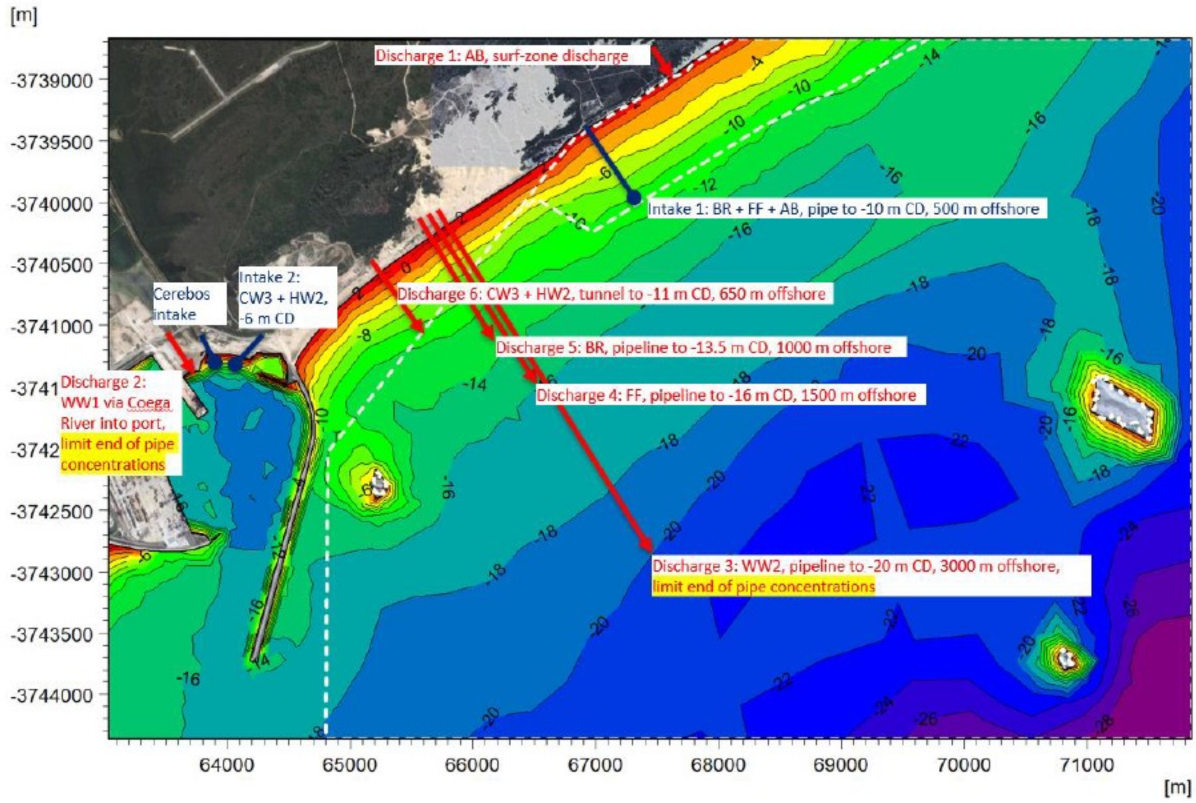

Figure 4-9. **The recommended discharge Scenario for the proposed Coega Development Corporation (CDC) integrated common user marine pipeline servitudes (PRDW 2020).**

Table 4.2. **Required end of pipe concentrations for containments of concern within various effluents, as stipulated by PRDW (2020).**

Effluent stream	Constituent	Unit	Maximum end of pipe concentration
Wastewater 1	Salinity	PSU	17
	TKN + NH4	mg/l	5
	TSS		55
	E. coli	Cfu/100ml	4500
Wastewater 2	Sulphides	mg/l	0.21
	Hg		0.062
	Co		0.21
	Cu		1.04
	Cd		0.83
Brine + Finfish	Ammonia, nitrates, nitrites	mg/l	13.37

5 IMPACT ASSESSMENT

In the marine environment a disturbance can be relatively short-lived (e.g. accidental spill which is diluted in the water column below threshold limits within hours) but the effect of such a disturbance may have a much longer lifetime (e.g. attachment of pollutants to sediment which may be disturbed frequently). The assessment and rating procedure described in Appendix 1 addresses the effects and consequences (i.e. the impact) on the environment rather than the cause or initial disturbance alone. To reduce negative impacts, precautions referred to as ‘mitigation measures’ are set, and attainable mitigation actions are recommended. In this report, the ‘construction footprint’ is defined as the total area of new infrastructure as determined by design engineers.

Both ‘worst case’ impacts and cumulative impacts are assessed in this report. Negative impacts associated with the construction and operation of the proposed marine servitude project at the Port of Ngqura fall into two main categories:

- Construction impacts, including loss of habitat, disturbance to and/or mortality of marine life due to construction activities associated with installation of the discharge pipelines and/or canal.
- Operational impacts, including disturbance to and/or mortality of marine life due to the intake of seawater and discharge of effluent into the marine environment.

Each of these impacts 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 biota. Both Scenario 1 and Scenario 2 (as defined in Section 4) will be assessed here. Results of each assessment are presented in Table 5.1 to Table 5.17 and are summarised in Table 5.20.

5.1 Construction phase impacts

Construction of the various intake and outfall pipelines will involve heavy vehicle traffic on the beach and the utilisation of machinery for laying the infrastructure over the intertidal and subtidal sandy and rocky substrate. Underwater construction, dredging and blasting may also be required. Five potential impacts associated with pipeline, tunnel and intake basin construction were identified and addressed below. These include the loss of biota and habitat, barotrauma, noise and disturbance of biota, reduced water quality and litter and pollution.

5.1.1 Loss of sandy beach, intertidal and subtidal habitat and biota

Intake and outfall infrastructure will be constructed intertidally and subtidally, mostly on sandy beach habitat, over an ~4 km stretch of coastline. This infrastructure will extend a cumulative ±6500 m into the ocean. Intake and outfall seawater pipelines are likely to be buried in trenches in the beach and surf zone and anchored to the sea floor beyond the high active surf zone (see Section 1.2). This will require excavation or dredging activities. The proposed Wet Mechanical Cooling water intake jetty will also disturb/remove sandy beach, intertidal and subtidal habitat within the Port (see Section 1.2). Beach well abstraction points may also be used. The outfall structure for the wet mechanical cooling system would be about 600 m diameter HDPE pipeline for each plant. The pipeline would lay on the seabed and weighed down by concrete collars. In addition, pipeline construction will involve some traffic on the beach by heavy vehicles and machinery, as well as vessels sailing within the surf zone and offshore to transport sections of pipe.

The construction of these pipelines and tunnels will result in disturbance of the sandy and rocky intertidal and subtidal surfaces, and associated macrofauna and flora will experience displacement and mortality. Sessile biota along the infrastructure length will become smothered and mobile fauna will be disturbed. Therefore, it is expected that a significant, short-term decrease in macrofaunal abundance and biomass will occur as a result of the proposed construction operations. Subtidally, it is likely that the pipe will be laid on the sediment surface and will become gradually buried by shifting sand. Any birds feeding and/or roosting in the area will also be disturbed and displaced for the duration of construction activities. In the case of an embedded pipeline, a channel would be blasted into the rocky shore from above the spring high water mark to below the spring low water mark. This will result in the direct mortality of intertidal biota but will also create new artificial hard substrate habitat in the intertidal zone. Soft sediment beach habitat will also be lost to the use of beach wells, and the construction of concrete intake channels inside the Port of Ngqura.

Should pipelines be laid over subtidal reefs, direct mortality of reef associated species will occur in the short term, but the hard substrate created will be similar to the reef habitat lost, and is likely to be recolonized. Species of particular concern that are associated with subtidal reef habitats include abalone (overexploitation has resulted in abalone becoming rare around the South African coastline). However, pipeline construction over such a small section of reef is unlikely to displace a high enough number of individuals to affect the population. Subtidal reef has been identified as a biodiversity hotspot and is a priority for conservation (Chalmers 2012, Laird *et al.* 2016). Commercial and recreational fishers depend on these reefs which support a number of important fish species. However, as the construction footprint of the proposed development is adjacent to the Addo MPA, the impact of habitat loss will be completely offset by the benefits of the area protected. In the case of an aboveground pipeline, it is expected that the structure will be recolonized by benthic biota over time and will constitute artificial habitat similar to the reef habitat lost.

The construction of an intake basin comprising concrete intake channels inside the Port of Ngqura constitutes a substantial, permanent disturbance to subtidal and intertidal habitat, resulting in severe disturbance of the sandy and rocky intertidal and subtidal surfaces and associated macrofauna and flora will probably experience high levels of mortality.

Construction activities will likely involve some traffic on the beach (heavy vehicles and machinery), which is likely to cause disturbance to and loss of sandy habitat within the construction footprint (and will likely cause mortality of resident infauna), especially if excavation is required. Impacts on vegetation and fauna present are expected to be limited to the areas within the actual development footprint (i.e. in the paths of any roads, parking areas, paths, tanks, etc.). As this impact will be limited to the duration of construction and maintenance activities, it is considered a ‘short-term’ impact. Sandy beaches are highly dynamic environments, and the animals that inhabit them are adapted to such (Section 2.2.3). Recovery of sandy beach assemblages will occur primarily through immigration from adjacent areas. Any birds feeding and/or roosting in the area will be disturbed and displaced for the duration of construction activities but are expected to return on completion of construction activities.

The significance of the loss of sandy beach, intertidal and subtidal habitat and biota in the development footprint is rated in Table 5.1. The duration of the impact depends on whether or not organisms will be able to re-inhabit the disturbed area. Organisms are expected to re-colonise areas both above and below the pipelines, reducing the rating to short-term, and organisms are expected to re-colonise some of the areas affected and new habitat will be created (specifically hard substrate).

The disturbance of sandy beach biota on the upper shore is not of great concern as the majority of these organisms are able to move away from the source of disturbance. Intertidal and subtidal species are adapted to highly dynamic environments (see Section 2.2.3). While intertidal sand habitat is not uncommon in this area and temporary disturbance within the relatively small construction footprint compared to the availability of this habitat within Algoa Bay, the permanent loss of habitat through the construction of concrete intake channels inside the Port of Ngqura does also need to be considered. In addition, as the subtidal reef around all offshore outfall pipelines are within an area of conservation priority (Chalmers 2012, Laird *et al.* 2016), best practice mitigation measures are recommended (Table 5.1).

Given that loss of habitat and mortality of fauna will be directly proportional to the length of the pipeline, Scenario 2 could be conserved lower impact that Scenario 1 (Scenario 2 has fewer pipelines, and a footprint 1000 m smaller). However, the Scenario 1 pipeline that is absent from Scenario 2 runs directly parallel to other, longer pipelines, this difference is considered insignificant in terms of habitat loss when compared to the habitat lost due to the construction of concrete intake channels inside the Port of Ngqura.

Table 5.1. **<u>Impact 1</u>: Loss of sandy beach, intertidal and subtidal habitat and biota.**

<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>Long term
3</td><td>Medium
6</td><td>Definite</td><td>MEDIUM</td><td>-ve</td><td>High</td></tr>
<tr><td colspan="9"><u>Best practice mitigation measures:</u>
• Minimise vehicle and pedestrian traffic in the coastal zone.
• Minimise the surface area impacted by bolting the pipeline directly to the rocky substratum.
• Minimise the use of blasting.
<u>Essential mitigation measures:</u>
• Rehabilitate the disturbed area immediately following construction by removing all artificial structures or beach modifications created during construction from above and within the intertidal zone. No accumulation of excavated beach sediments should be left above the high-water mark, and any substantial sediment accumulations below the high water mark should be levelled.
• Undertake baseline and comparative monitoring of biota in the construction footprint. Monitoring should focus on physical habitat variables (sediment particle size composition and organic content) and biota (e.g. benthic infaunal soft sediment communities). The latter have been shown to provide a good indication of habitat recovery following physical disturbance. Surveys should be done once prior to construction and again approximately 12 months after construction is complete.</td></tr>
<tr><td>With mitigation</td><td>Local
1</td><td>Low
1</td><td>Long term
3</td><td>Low
5</td><td>Definite</td><td>LOW</td><td>-ve</td><td>Medium</td></tr>
</table>

5.1.2 Disturbance of pelagic open water habitat

Construction of the proposed infrastructure will result in the temporary disturbance of deep pelagic habitat within the construction footprint and surrounds. However, mobile fish and elasmobranchs (sharks, rays and skates) that utilise the habitat will be able to move to adjacent areas. Seabirds of the islands within the Bay are of particular concern — a large scale disturbance of pelagic habitat may have significant consequences given high site fidelity to the islands.

It should be noted however that the area is already disturbed by constant vessel movement and that the impact will be limited to the duration of the construction, and that the pelagic habitat affected will be relatively small in comparison to adjacent areas of similar habitat in Algoa Bay. As such, this impact is considered to be of 'low' significance (Table 5.2). Mitigation that can be implemented is to limit the duration and spatial extent of construction as far as possible (i.e. construction should be undertaken sequentially to minimise the area of disturbance at any given time).

Table 5.2. <u>Impact 2</u>: Ecological effects due to the disturbance of pelagic open water habitats.

	Extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Without mitigation	Local 1	Medium 2	Short-term 1	Low 4	Definite	**LOW**	-ve	High
<u>Mitigation measures:</u> • The spatial extent and duration of construction must be limited as far as possible (construction of the different infrastructure should be undertaken sequentially to minimise disturbance on pelagic habitat).								
With mitigation	Local 1	Low 1	Short-term 1	Very Low 3	Definite	**VERY LOW**	-ve	High

5.1.3 Barotrauma impacts on marine fauna as a result of blasting

The energy of detonating an explosive is released as physical, thermal and gaseous products. The thermal and detonation impacts associated with an explosion are important to consider near the blast (3 to 10 m), while the impacts of shockwaves, noise and gaseous chemical products are likely to be experienced at greater distances from the blast. Explosive charges in, adjacent to, or beneath a water column produce pressure waves or shockwaves that pass into the water medium. Shockwaves produced by an explosive detonation are "converted suddenly into potential energy of compression and kinetic energy of outward motion in the water medium" (Kramer *et al.* 1968). Shockwaves have harmful and often fatal impacts on organisms with gas cavities, for example swim bladders in fish and sinus cavities and lungs in birds and mammals.

Results of several experiments have shown that underwater blasts cause lung haemorrhages, gastrointestinal lesions and ruptured eardrums in mammals; pulmonary haemorrhages, coronary air embolisms and ruptured air sacs, eardrums, livers and kidneys in birds (Yelverton *et al.* 1973); and ruptures of air bladders, organs and intestines as well as broken ribs in fish (Aplin 1947, Yelverton *et al.* 1975, Wright 1982). Marine invertebrates do not possess gas filled cavities; therefore, the direct impacts of shockwaves produced by blasting are predicted to be negligible. The impacts of underwater blasting on marine fauna are related to the size of the explosion, the type of explosive used and the water depth.

Fauna likely to be at risk from blasting activities at the proposed site include coastal fish species, marine birds, sharks and mammals. The marine habitats in the vicinity of the site are not unique to the site, are relatively well represented along adjacent sections of coast and are protected within nearby MPAs (Sardinia Bay MPA and the Bird Island MPA which is to be expanded into the Addo MPA in 2017). Fish kills that may result from blasting are unlikely to result in an irreplaceable loss of biodiversity or resources, as recruitment from adjacent areas should be sufficient to compensate for any mortalities. A potential problem may arise where several blasts are triggered throughout the day as predators (birds, fish and mammals) are likely to be attracted to the area to feed on fish killed by the initial blast. This should be mitigated by limiting blasting activities to one detonation per day (see details in Table 5.3 below).

Table 5.3. **Impact 3: Barotrauma of marine fauna as a result of blasting.**

	Extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Without mitigation	Regional 2	High 3	Short term 1	Medium 6	Definite	**MEDIUM**	-ve	High
Essential mitigation measures: • A visual survey of the area (both the immediate vicinity of the construction footprint and within a 1000 m radius) should be conducted by trained marine mammal observers (MMO's) 30 minutes before the blasting is to commence. Permission to blast must be delayed until all marine mammals are outside the 1 km radius form the blast site. Similarly, all blasting should be halted once marine mammals are seen entering the 1 km radius. Blasting should not commence when environmental conditions, such as darkness, mist, rain, fog or high sea states greater than Beaufort 4 prohibit adequate monitoring of the 1 km safety zone. • No blasting may take place during the annual sardine run (May-June) and should only be undertaken during daylight hours. • No blasting should be undertaken in the early mornings (6h00-10h00) or late afternoons (15h00-19h00) due to coastal dolphin activity in inshore waters. Ideally, blasting should only be undertaken between 12h00 and 14h00. • Blasting should be restricted to where alternative construction technologies are found to be unfeasible. Alternatives to the use of explosives could be the use of cutting techniques, such as wire, abrasive-, mechanical-, and torch cutting, which produce sound levels that are 80 dB less than the sound levels produced by normal blasting (TSB 2000, Spence *et al.* 2007, Transnet 2014).								
With mitigation	Regional 2	High 3	Short term 1	Medium 6	Possible	**LOW**	-ve	High

5.1.4 Noise disturbance to marine fauna

Noise will be generated during construction by drilling and blasting activities. Cetaceans have highly developed acoustic sensory systems that enable them to communicate, navigate, forage and avoid predators in the marine environment where hearing is a much more important sense than vision. Increased noise levels may mask acoustic signals or reduce the range at which mammals can detect the signals. This may impact their ability to maintain biological functions such as feeding, mating and protecting and raising young. Marine mammals are likely to avoid the construction area and may potentially change behaviour or become stressed due to noise produced by blasting and drilling. There are high densities of southern right whales supported in Algoa Bay over the winter and spring period. Migrating humpback whales travel through the area with bi-annual peaks in abundance during May-June and November-December and the inshore area along the western shore of Algoa Bay is an important habitat for endangered Indo-Pacific humpback dolphins. Due to the well documented sensitivity of cetaceans to noise disturbance (particularly explosions), the intensity of impacts due to increased noise in the construction area during this period are potentially considerable and mitigation measures must be taken.

Indeed, the potential impacts of anthropogenic noise on marine mammals in Algoa Bay during planned construction at the Port of Ngqura, such as blasting, piling, drilling, dredging, revetment work, relocation of the Cerebos Ltd Seawater Intake pipeline and increased shipping, were assessed in a Noise Effects on Marine Mammals report for the EIA undertaken for the *Provision of Marine Infrastructure, including a General Cargo Berth and Liquid Bulk Terminals at the Port of Ngqura* (2014). The report assessed that the planned development activities were expected to have a high or medium impact, but that there is a paucity of data for hearing ranges of local species as well as expected noise outputs from the planned construction (Transnet 2014). Strict mitigation measures are therefore deemed necessary for this development, and that intensive monitoring is to be carried out where mitigation is not possible (Transnet 2014). This mitigation outlined in Transnet (2014) is applicable to this proposed development, and has been indicated in Table 5.4 below. Primary mitigation includes that blasting be limited as far as possible between June and December as whales are likely to be in the vicinity. No blasting may take place during the annual sardine run (May), and that blasting should only occur once per day during daylight hours, ideally between 12h00 and 14h00. If possible, construction activities should be liomited early mornings (6h00-10h00) or late afternoons (15h00-19h00) due to coastal dolphin activity in inshore waters. Trained marine mammal observers (MMO's) need to be onsite to assess marine mammal presence within the immediate vicinity of the construction footprint and within a 1000 m radius) 30 minutes before the commencement of blasting. Permission to blast must be delayed until all marine mammals are outside the 1 km radius form the blast site. Similarly, all blasting should be halted once marine mammals are seen entering the 1 km radius. Blasting should not commence when environmental conditions, such as darkness, mist, rain, fog or high sea states greater than Beaufort 4 prohibit adequate monitoring of the 1 km safety zone (Transnet 2014). In terms of construction activities, a soft-start (i.e. gradual ramping up of piling/ drilling power) period of at least 20 minutes is recommended. If an animal enters the safety zone during soft-start, the power should not be increased until the animal exits and remains outside of the zone for 20 minutes (Transnet 2014).

Table 5.4. **<u>Impact 4</u>: Noise disturbance to marine fauna.**

	Extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Without mitigation	Regional 2	High 3	Short term 1	Medium 6	Probable	**MEDIUM**	-ve	High

<u>Essential mitigation measures:</u>

- A visual survey of the area (both the immediate vicinity of the construction footprint and within a 1000 m radius) should be conducted by trained marine mammal observers (MMO's) 30 minutes before the blasting is to commence. Permission to blast must be delayed until all marine mammals are outside the 1 km radius form the blast site. Similarly, all blasting should be halted once marine mammals are seen entering the 1 km radius. Blasting should not commence when environmental conditions, such as darkness, mist, rain, fog or high sea states greater than Beaufort 4 prohibit adequate monitoring of the 1 km safety zone.
- No blasting may take place during the annual sardine run (May-June) and should only be undertaken during daylight

hours.

- No blasting should be undertaken in the early mornings (6h00-10h00) or late afternoons (15h00-19h00) due to coastal dolphin activity in inshore waters. Ideally, blasting should only be undertaken between 12h00 and 14h00.
- Blasting should be restricted to where alternative construction technologies are found to be unfeasible. Alternatives to the use of explosives could be the use of cutting techniques, such as wire, abrasive-, mechanical-, and torch cutting, which produce sound levels that are 80 dB less than the sound levels produced by normal blasting (TSB 2000, Spence *et al.* 2007, Transnet 2014).A soft-start (i.e. gradual ramping up of piling/ drilling power) period of at least 20 minutes is recommended. If an animal enters the safety zone during soft-start, the power should not be increased until the animal exits and remains outside of the zone for 20 minutes (Transnet 2014).
- Acoustic deterrent devices (ADDs) may be utilised if the effectiveness of candidate devices on the key marine mammal species can be demonstrated prior to the start of construction (Transnet 2014).
- The charge weights required for the blasting should be carefully evaluated, and shape charges and shock wave focusing charges could be employed to reduce the charge weight by 90%. It is recommended that a number of small test blasts be conducted by the blasting contractor to measure the sound outputs at set distances from the source, both inside and outside the breakwater. This will allow adjustment of the charge weight and associated reduction in noise output as well as establish the impact that the breakwaters (both eastern and western) have on the propagation of underwater sound. Extensive monitoring should be done in this respect, both pre-and during construction (Transnet 2014).
- Sound containment measures should be implemented during blasting as they pose the best mitigation measure, since they aim to partially enclose the produced sound within a certain area around the blast site. Potential mitigation measures could include the use of blasting mats (Spence *et al*. 2007) or bubble curtains, which is the main mitigation technique employed in the USA and Europe, or other technical measures for sound absorption. The reduction in sound should be such that it does not exceed 160 dB MSP (as per Southall *et al*. 2007, Transnet 2014).
- Drilling, piling and dredging activities are to be carried out the lowest possible power levels known to contribute to ocean noise pollution (ACCOBAMS 2010, JNCC 2010, EPBCA 2012). Power limits can be restricted by shutting down the power of operational systems prior as well as after usage to avoid leaving them idling (EPBCA 2012).
- Platforms should use thrusters, fibre glass insulation, or damping techniques, such as the use of damping tiles, around machinery to reduce vibration noise. Ramming and drilling piles and machinery should be enclosed with acoustically-insulating material, such as fibreglass, mineral wool, and plastic; in addition, modified drilling caps could be used.

With mitigation	Regional 2	High 3	Short term 1	Medium 6	Possible	**LOW**	-ve	High

5.1.5 Reduced water quality

Construction activities activities such as drilling and blasting are likely to generate sediment plumes that will increase the turbidity of the water and settle on the surrounding seafloor. Increased erosion and sedimentation may occur during the construction phase when heavy duty vehicles will be moving sediment. Loose sediment may be washed down with rainfall, leading to increased turbidity and sedimentation. Dredging activities will cause the resuspension of sediment into the water column, causing increases in turbidity. Sessile organisms, particularly those that filter-feed are most likely to be impacted as material suspended by dredging and other construction activities is likely to be largely inorganic resulting in feeding difficulties. They generally ingest high levels of inorganic material filtered from the water, resulting in lower growth rates, starvation and, in the worst cases, mortality. For autotrophic organisms such as microphytobenthos and phytoplankton, suspended material blocks light, the higher the suspended solids the more light is attenuated. This is likely to cause a temporary decrease in the productivity of autotrophic microphytobenthos and phytoplankton. However, given that the area surrounding the construction site is exposed, it is anticipated that sand particles suspended by construction will be readily dispersed by wave action.

In addition, sand movement in the nearshore marine environment occurs naturally both in the coastal zone and intertidally. Consequently, nearshore biota is resilient to sand movement and additional sediment input to the marine environment during construction is unlikely to be detrimental.

Dredging activities may also result in the suspension of sediment associated pollutants such as trace metals. As pollutants are strongly associated with the cohesive fraction of sediment, pollutant deposition is most likely to occur where effluent plumes come into close contact with a muddy benthic environment. A geological survey of the area northeast of the Port of Ngqura showed that approximately 65% of the seafloor area consists of rocks with unconsolidated sediment cover of less than 0.5 m (CSIR 2010a) (Figure 5-1).

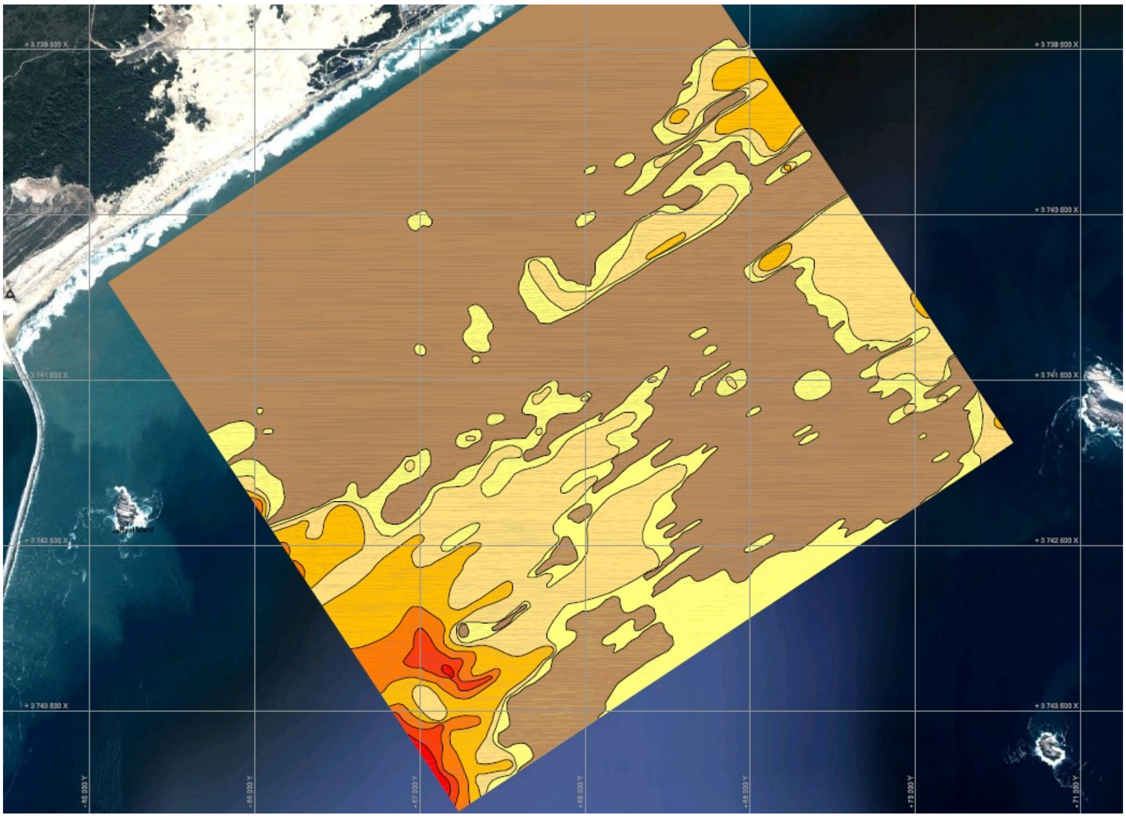

Figure 5-1. Sediment thickness in the area north-east of the Port of Ngqura. Areas that are predominantly rocky are indicated in brown (CSIR 2010b).

Superficial sediments within the Port of Ngqura were found to be very muddy, indicating that the Port is a depositional area for fine sediments (CSIR 2010b). It can be inferred that the Port area is thus more susceptible to the absorption of contaminants than the area north-east of the eastern breakwater. To limit the possibility of pollutant deposition, effluent outfalls have been positioned far enough away from the Port entrance to prevent entrainment within the Port.

Mitigation for dredging and blasting activities includes the setup of water quality monitoring stations in the vicinity of the construction (~300 m from the site). The median TSS concentration (as calculated from baseline monitoring data) should not exceed the threshold limit which is set as the greater of the 80th percentile of the baseline monitoring data, or ten percent (10%) greater than the natural background turbidity. Consequently, this impact is rated as very low with the implementation of these best practice mitigation measures (Table 5.5).

Table 5.5. Impact 5: Reduced water quality from blasting, drilling and dredging.

	Extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Without mitigation	Regional 2	High 3	Short term 1	Medium 6	Possible	**LOW**	-ve	High
Best practice mitigation measures: • A monitoring programme should be implemented to monitor water quality in the vicinity of the construction site. Six monitoring stations, three on either side of the pipeline at 10, 15 m and 18 m depth, respectively, should be identified for this purpose. Measurements should be collected daily for 20-30 days prior to the commencement of dredging operations (to develop an appropriate baseline) and should continue as long as dredging continues. The median TSS concentration in monitoring data should not exceed the threshold limit which is set as the greater of the 80th percentile of the baseline monitoring data, or ten percent (10%) greater than the natural background turbidity. If the TSS approaches the threshold limit set above at any of the surveillance monitoring stations, mitigation measures are to be put in place to prevent any further increase in suspended solid concentration (e.g. reduce rate of construction activities). If median turbidity levels (calculated from measured values in any one and a half hour period) exceed the threshold, construction activities are to be suspended until measured levels drop below the threshold.								
With mitigation	Local 1	Medium 2	Short term 1	Very Low 4	Probable	**VERY LOW**	-ve	High

5.1.6 Pollution generated during construction

The problem of litter entering the marine environment has escalated dramatically in recent decades, with an ever-increasing proportion of litter consisting of non-biodegradable plastic materials. South Africa has laws against littering, both on land and in the coastal zone, but unfortunately these laws are seldom rigorously enforced. Objects which are particularly detrimental to aquatic fauna include plastic bags and bottles, pieces of rope and small plastic particles. Large numbers of aquatic organisms are killed or injured daily by becoming entangled in debris or as a result of the ingestion of small plastic particles (Gregory 2009, Wright *et al.* 2013). If allowed to enter the ocean, solid waste may be transported by currents for long distances out to sea and around the coast. Thus, unlike fuel or sewage contamination, the extent of the damage caused by solid waste is potentially large. The impact of floating or submerged solid materials on aquatic life (especially birds and fish) can be lethal and can affect rare and endangered species. Suitable management mechanisms as outlined in Table 5.6 must be in implemented.

Table 5.6. Impact 6: Pollution generated during construction.

	Extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Without mitigation	Regional 2	Low 1	Medium term 2	Low 5	Probable	**LOW**	-ve	High

Essential mitigation measures: • Check vehicles for hydrocarbon leaks daily. • Protocols for dealing with accidental spills must be in place. • Emergency equipment to isolate spills must be accessible. • Provide suitable containers for the disposal of all waste, including recycling. **Best practice mitigation measures:** • Inform all staff about sensitive marine species and suitable disposal of construction waste.								
With mitigation	Regional 2	Low 1	Medium term 2	Low 5	Possible	**VERY LOW**	-ve	High

5.1.7 Hazardous substance spills

The risk of spillage of a variety of hazardous substances may occur during the use of heavy machinery, construction vehicles and construction vessels. For example, spillage may occur as a result of fuel leaks, refuelling, or collision. Hydrocarbons are toxic to aquatic organisms and precautions must be taken to prevent them from contaminating the environment. This impact can be mitigated successfully if authorities implement a rigorous environmental management and control plan to limit ecological risks from accidents. All fuel and oil must be stored with adequate spill protection and no leaking vehicles should be permitted on site. Intentional disposal of any substance into the aquatic environment is strictly prohibited, while accidental spillage must be prevented, contained and reported immediately. After mitigation, the impact of accidental spillage is considered to be 'very low' (Table 5.7).

Table 5.7. **Impact 7: The effect of the spillage of hazardous substances on marine biota.**

	Extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Without mitigation	Local 1	High 3	Medium term 2	Medium 6	Possible	**LOW**	-ve	Medium
Essential mitigation measures: • Intentional disposal of any substance into the environment is strictly prohibited, while accidental spillage must be prevented, contained and reported immediately. • Implementation of a rigorous environmental management and control plan (including procedures for remediation). • All fuel and oil is to be stored with adequate spill protection. • No leaking vehicles are permitted on site. • All hazardous substances must be accompanied by a permit, a hazard report sheet, and a first aid treatment protocol and may only be handled by suitably trained operators.								
With mitigation	Local 1	Medium 2	Medium term 2	Low 5	Improbable	**VERY LOW**	-ve	Medium

5.2 Operational phase impacts

The primary operational phase impact is that of effluent discharge and seawater intake. Physico-chemical attributes of the effluent can impact negatively on the marine ecology and on marine users depending on the effluent concentrations and dilution rates achieved in the receiving environment. Assessment of these impacts will be assessed based on the dispersion modelling results discussed in Section 4. Give that Scenario 1 and Scenario 2 (as defined in Section 4) are fundamentally different in terms of effluent composition and dilution, these Scenarios will be assessed separately.

5.2.1 Impacts of seawater abstraction on marine biota

The impacts of seawater abstraction on marine life can include entrainment and impingement. Entrainment occurs when organisms pass through intake structures and into the processing equipment (Pankratz 2004). Organisms small enough to pass through most intake screens include holoplanktonic organisms (permanent members of the plankton, such as copepods, diatoms and bacteria) and meroplanktonic organisms (temporary members of the plankton, such as juvenile shrimps and the planktonic eggs and larvae of invertebrates and fish). Impingement occurs when larger marine organisms are trapped against intake screens by the velocity of the water flow. These organisms may suffer mortality due to starvation, suffocation or exhaustion. While some studies estimated a 100% mortality rate of entrained organisms in power plant cooling systems (California Coastal Commission 2004), a study by Bamber & Seaby (2004) demonstrated mortalities ranging from 10 to 20%. Although some hardy species may survive impingement, the 24 h survival rate of less robust species is probably less than 15% (Pankratz 2004).

The significance of these impacts is related to the location of an intake. Intake structures should be positioned away from sensitive environments or areas with high species diversity or abundance, like rocky reefs, and should not draw in water from the upper meter of the water column, as planktonic organisms tend to concentrate in this zone. The intake should also avoid the bottom meter of the water column to minimise potential intake of disturbed sediment.

While the significance of both impingement and entrainment is related to the location of an intake, impingement is primarily a function of intake velocity, and entrainment depends largely on the overall volume of water drawn into plant. Impingement and entrainment can be mitigated through optimal designs to open water intakes. The horizontal extraction of water should aid in reducing fish entrainment as fish have been shown to avoid rapid changes in horizontal flow (Pankratz 2004).

The number of mobile organisms becoming entrained in the intake structure and the ability of larger organisms to escape impingement is dependent on the intake velocity. There is a broadly accepted rule that water extraction velocities should not exceed 0.15 m/s to minimize debris and marine life impingement (Fedorenko 1991). However, this mitigation measure is only effective for mobile organisms which can swim away and not planktonic organisms, which have little or no mobility and drift passively with currents, or organisms that are incapable of sustained mobility against water flow. Intake velocities can be reduced to the requisite 0.15 m/s through the use of footer values — these increase the area of intake, resulting in a decrease in intake velocity to safe levels.

The use of beach wells for intake of sea water is anticipated to have impacts of 'very low' significance on the marine environment (Table 5.8). Entrainment and associated mortality of marine organisms by the intake pumps is not expected as the subsurface seawater is naturally filtered by the beach sand before entering the intake wells.

The significance of the disturbance and/or mortality of marine life due to the intake of seawater through abstraction pipelines is assessed in Table 5.8. The impacts are expected to last for the duration that the plant is on operation (i.e. in the summer months) for the lifetime of the plant. Predicted impacts are rated as 'low' significance before mitigation and 'very low' following mitigation (Table 5.8).

Table 5.8. Impact 8: Disturbance and/or mortality of marine life due to the intake of seawater via pipeline.

	Extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Beach wells Without mitigation	Low 1	Low 1	Long term 3	Low 5	Possible	**VERY LOW**	-ve	Medium
Intake pipeline Without mitigation	Low 1	Low 1	Long term 3	Low 5	Definite	**LOW**	-ve	Medium
Essential mitigation measures: • Intake velocities should be kept below 0.15 m/s to ensure that fish and other mobile organisms can escape the intake current. Intake velocities can be reduced to the requisite 0.15 m/s through the use of footer values. • Intake structures should be positioned away from sensitive environments or areas with high species diversity or abundance, like rocky reefs, and should not draw in water from the upper meter of the water column. • Intake structures should ensure the horizontal intake of water.								
With mitigation	Low 1	Low 1	Long term 3	Low 5	Possible	**VERY LOW**	-ve	Medium

5.2.2 Impacts of elevated temperature

Changes in water temperature can have a substantial impact on marine species and ecosystems, with the effects either influencing the physiology of the biota (e.g. growth and metabolism, reproduction timing and success, mobility and migration patterns and production); and/or influencing ecosystem functioning (e.g. through altered oxygen solubility). This includes impacts on plankton and the pelagic food web. South African WQGs recommend that the maximum acceptable variation in ambient temperature should not exceed 1°C at the edge of the RMZ. This is a conservative value considering the negligible effects of thermal plumes on benthic assemblages reported for a change in temperature of 5°C or less (van Ballegooyen *et al.* 2007).

Far field modelling results indicate that effluent temperature under both Scenario 1 and 2 achieve the required dilutions at the edge of the stipulated RMZ (Section 4). However, PRDW (2020) recommends Scenario 2 because there is better performance in terms of temperature dilutions, and a larger "margin of safety" (4 dilutions required vs 25 dilutions achieved) which allows the option of reducing number of ports and/or the port exit velocities. As such, Scenario 1 is rated as 'low', and

Scenario 2 rated as having 'very low' impact (Table 5.10). Mitigation measures are the implementation of the preferred Scenario recommended by PRDW (2020) (see Section 4).

Table 5.9. Impact 9: Elevated temperature.

	Extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Scenario 1: Without mitigation	Low 1	Low 1	Long term 3	Low 5	Probable	**LOW**	-ve	High
Scenario 2: Without mitigation	Low 1	Low 1	Long term 3	Low 5	Possible	**VERY LOW**	-ve	High
Essential mitigation measures: • Implement the preferred Scenario recommended by PRDW (2020), see Section 4. • A water quality monitoring programme must be implemented to validate the predictions of the hydrodynamic modelling study and monitor constituents of the effluent. Adaptive management, informed by monitoring results must be implemented to ensure compliance with water quality guidelines.								
With mitigation	Local 1	Low 1	Medium term 2	Very Low 4	Possible	**VERY LOW**	-ve	High

5.2.3 Impacts of changes in salinity

All marine organisms have a range of tolerance to salinity, which is related to their ability to regulate the osmotic balance of their individual cells and organs to maintain positive turgor pressure. Aquatic organisms are commonly classified in relation to their range of tolerance as stenohaline (able to adapt to only a narrow range of salinities) or euryhaline (able to adapt to a wide salinity range), with most organisms falling into the first category. The South African WQG (DWAF 1995) set an upper target value for salinity of 36 PSU. At levels exceeding 40 PSU, significant negative effects are expected, including possible disruptions to the recruitment of molluscan bivalves (e.g. mussels, oysters and clams), crustaceans, and possibly fish (Clarke 1992).

Far field modelling results indicate that elevated effluent salinity (i.e. brine from the desalination plant) under both Scenario 1 and 2 achieves the required dilutions at the edge of the stipulated RMZ (Section 4). However, release of a considerable amount of freshwater into the marine environment from the wastewater outfalls may lower the salinity in the receiving environment and could negatively impact the fauna and flora in the immediate vicinity of the impact site. Indeed, model results indicate that Wastewater 1 salinity does not meet the required dilutions (under Scenario 1 or 2). However, the impact of both Scenario 1 and 2 salinity fluctuations is rated "very low" prior to mitigation due to the low intensity rating (Table 5.10).

Mitigation measures include implementing the recommended Scenario presented by PRDW (2020), which requires the Wastewater 1 outfall to reach a maximum end of pipe effluent salinity of 17 PSU.

Table 5.10. Impact 10: Changes in salinity.

	Extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Scenario 1: Without mitigation	Local 1	Low 1	Medium term 2	Very Low 4	Probable	**VERY LOW**	-ve	High
Scenario 2: Without mitigation	Local 1	Low 1	Medium term 2	Very Low 4	Probable	**VERY LOW**	-ve	High
Essential mitigation measures: • Implement the preferred Scenario recommended by PRDW (2020), see Section 4. • Wastewater 1 outfall effluent must have an end of pipe effluent salinity of 17 PSU. • A water quality monitoring programme must be implemented to validate the predictions of the hydrodynamic modelling study and monitor constituents of the effluent. Adaptive management, informed by monitoring results must be implemented to ensure compliance with water quality guidelines.								
With mitigation	Local 1	Low 1	Medium term 2	Very Low 4	Possible	**INSIGNIFICANT**	-ve	High

5.2.4 Impacts of elevated nutrients

Increased nutrient levels in receiving waters can encourage plant growth, which may lead to algal blooms and local eutrophication. Prolific seaweed growth on intertidal rocky shores and foul-smelling subtidal sediments are often indications of enrichment. There are three forms of nitrogen that are commonly measured in water bodies: ammonia, nitrates and nitrites. Total Kjeldahl nitrogen (TKN) is the sum of organically bound nutrients, while total nitrogen is the sum of inorganic and organic nutrients. Organic nutrients include nitrogen, ammonia (NH^3) and ammonium (NH_{4+}), while inorganic nutrients include nitrates (NO_3) and nitrite (NO_2). Organic nutrients need to be broken down into inorganic nutrients before being absorbed by organisms; therefore, inorganic nutrients can be described as being readily available sources of energy.

Nitrogen is an essential nutrient for plants and animals; however, an excess amount of nitrogen may lead to low levels of dissolved oxygen in the water (anoxia) and may negatively affecting organisms within the marine environment. For example, a surplus of ammonia and organic nitrogen in a body of water can result in eutrophication and lead to prolific algal growth. Sources of nitrogen include WWTW, runoff from fertilized lawns and croplands, failing septic tank systems, and input from processing factories, aquaculture facilities and industrial discharges. Thus, ammonia and the associated ions are required parameters for regulatory reporting at many treatment plants to assist in the monitoring of operations and effluent quality. Ammonia is highly toxic to most organisms and even low levels can cause toxicity issues for animals. Increased concentrations of nitrate (>30 mg/L) can have serious impacts on aquatic organisms as it inhibits growth of some organisms and promotes that in others, and can cause a number of stresses on aquatic life. Increased phosphates can also lead to enrichment and potentially eutrophication, which will result in significant changes to species composition and species diversity in the affected area. Increased levels of nitrates and phosphate can result in an increased abundance of certain algal species and may facilitate the generation of harmful algal blooms.

Under natural conditions, high concentrations of nitrate (>10 µmol/l) are present in offshore waters (outer shelf and shelf edge), and off Cape Padrone and Cape Recife, but much lower concentrations (around 1 µmol/l or less) occur within Algoa Bay itself.

Modelling indicates that nutrient concentrations (specifically, TKN and NH_4) within the Wastewater 1 effluent stream do not achieve the required dilutions at the 300 m RMZ under Scenario 1 or Scenario 2 (see Section 4). PRDW (2020) recommends that the end of pipe effluent quality must be improved, given that a diffuser is not feasible at the proposed site. The maximum permitted end of pipe concentrations of TKN and NH_4 for this effluent under Scenario 1 are defined by PRDW (2020) as 5 mg/l. With Wastewater 2, however, the longer pipe length and deeper discharge allows the required TKN and NH_4 dilutions to be met under both Scenario 1 and 2 (PRDW 2020, Section 4).

Other nutrients modelled are ammonia, nitrates and nitrates, from the finfish discharge (Scenario 1), and the combined brine and finish discharge (Scenario 2). Required dilutions were met for land-based finish aquaculture effluent at the 300 m RMZ under Scenario 1 due to the use of a diffuser and adequate depth of discharge. In contrast however, the Scenario 2 combined finfish and brine effluent does not meet the required dilutions for ammonia, nitrates and nitrates (Section 4). PRDW (2020) therefore recommends that the brine and finfish effluent are discharged separately (under Scenario 1), where the required dilutions for all constituents are met.

As such, both Scenario 1 and Scenario 2 are rated as having ‘high’ impacts without mitigation (Table 5.11). Mitigation measures include implementing the recommended Scenario presented by PRDW (2020), which requires the Wastewater 1 outfall to limit the maximum allowable effluent concentrations (end of pipe) for TKN + NH_4 to below 5 mg/l (**wastewater must be treated on land to meet appropriate standards prior to discharge**). Additionally, the recommended Scenario specifies that the brine and fin fish effluents are discharge separately; otherwise, the ammonia, nitrate and nitrate end of pipe concentrations must be reduced to below 13.37 mg/l (PRDW 2020).

The implementation of this mitigation will reduce the impact to ‘low’ significance (Table 5.11).

Table 5.11. Impact 11: Elevated nutrients from aquaculture effluent and wastewater effluent.

	Extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Scenario 1: Without mitigation	Local 1	High 3	Long term 3	High 7	Probable	**HIGH**	-ve	High
Scenario 2: Without mitigation	Local 1	High 3	Long term 3	High 7	Probable	**HIGH**	-ve	High

Essential mitigation measures:

- Implement the preferred Scenario recommended by PRDW (2020), see Section 4.
- Wastewater 1 outfall to limit the maximum allowable effluent concentrations (end of pipe) for TKN + NH_4 to below 5

mg/l (wastewater must be treated on land to meet appropriate standards prior to discharge). • The brine and fin fish effluents are to be discharge separately; otherwise, the ammonia, nitrate and nitrate end of pipe concentrations must be reduced to below 13.37 mg/l. • A water quality monitoring programme must be implemented to validate the predictions of the hydrodynamic modelling study and monitor constituents of the effluent. Adaptive management, informed by monitoring results must be implemented to ensure compliance with water quality guidelines.								
With mitigation	Local 1	Low 1	Long term 3	Low 5	Probable	**LOW**	-ve	High

5.2.5 Impacts of elevated suspended solids

High levels of suspended solids have been known to cause growth deficiencies in marine organisms and in some cases lead to mortalities should smothering of benthic habitats occur. High TSS levels also increase turbidity and decrease light penetration which impacts on primary productivity, respiration and feeding in many marine species (such as plankton and small pelagic fish species). Elevated turbidity also impacts negatively on squid fishing catch rates and the popularity of reefs for SCUBA diving. It should be noted that while coastal water TSS concentrations in the vicinity of Algoa Bay rivers increases naturally during flood events, in general, the water within Algoa Bay has low levels of suspended solids (i.e. turbidity) at the surface, increasing slightly towards the seafloor (see Section 2.1.3).

Dispersion modelling results show that required dilutions for the end of pipe TSS concentrations in the Wastewater 1 effluent were not achieved at the 300 m RMZ under Scenario 1 or Scenario 2 (see Section 4). PRDW (2020) states that end of pipe effluent quality must be improved, given that a diffuser is not feasible at the proposed site. As such, the end of pipe TSS value for the Wastewater 1 effluent must not exceed 55 mg/l (PRDW 2020). Required dilutions for TSS are however achieved for Wastewater 2 effluent under Scenario 1 and 2, the finish discharge under Scenario 1, and the combined brine and finish effluent under Scenario 2 (Section 4).

As such, both Scenario 1 and 2 are rated as being of ‘medium’ significance (Table 5.12). Mitigation measures include implementing the recommended Scenario presented by PRDW (2020), which requires the Wastewater 1 outfall to limit the maximum allowable effluent concentrations (end of pipe) for TSS to below 50 mg/l (wastewater must be treated on land to meet appropriate standards prior to discharge).

This mitigation reduced the impact to one of ‘low’ significance (Table 5.12).

Table 5.12. Impact 12: Increased suspended solid concentrations.

	Extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Scenario 1: Without mitigation	Local 1	Medium 2	Long term 3	Medium 6	Probable	**MEDIUM**	-ve	High
Scenario	Local	Medium	Long term	Medium	Probable	**MEDIUM**	-ve	High

2: Without mitigation	1	2	3	6				
Essential mitigation measures: • Implement the preferred Scenario recommended by PRDW (2020), see Section 4. • Wastewater 1 outfall to limit the maximum allowable effluent concentrations (end of pipe) for TSS to below 50 mg/l (wastewater must be treated on land to meet appropriate standards prior to discharge). • A water quality monitoring programme must be implemented to validate the predictions of the hydrodynamic modelling study and monitor constituents of the effluent. Adaptive management, informed by monitoring results must be implemented to ensure compliance with water quality guidelines.								
With mitigation	Local 1	Medium 2	Long-term 3	Medium 6	Possible	**LOW**	-ve	High

5.2.6 Impacts of elevated trace metal and inorganic compound concentrations

Trace or heavy metals occur naturally in the marine environment, and some are important in fulfilling key physiological roles. Unlike most organic substances, metals are neither created nor destroyed by biological or chemical processes. Rather, they are transformed from one chemical form to another. Many abiotic and biotic processes can modify the availability of metals, even rendering them unavailable for uptake. This means that the toxic fraction may be a very small part of the total metal present. Bioavailability may be affected by a range of physio-chemical parameters such as the pH, hardness of water and the Dissolved Organic Carbon (DOC). Trace metals are normally found in low concentrations in the environment and include elements such as mercury, cadmium, arsenic, lead, chromium, zinc and copper. These metals occur naturally in the earth's crust and are released through chemical weathering processes at very slow rates. Mining and the use of these metals as catalysts in industrial processes, however, can result in discharges of trace metals at levels that are far greater than those associated with the 'normal' chemical weathering processes.

While some trace metals are known to provide important micronutrients for living organisms (e.g. iron, zinc, manganese, copper, cobalt, molybdenum and nickel), others (e.g. lead, silver and mercury) are biological inhibitors which are not known to assist with any metabolic functions (Sunda 1989, Roesijadi & Robinson 1994). At elevated levels, however, all trace metals and even important micronutrients, can become toxic (Sunda 1989). Trace metals exist in a variety of chemical species in seawater, which strongly influences if, how, and at what quantities they are taken up by marine organisms (Sunda 1989). Furthermore, the effect of trace metals at the biomolecular level varies at the species level. For example, trace metals variably influence growth and productivity of phytoplankton and as a result, bioavailable trace metal composition and concentration can determine community composition (Sunda 1989).

Disturbance to the environment by either anthropogenic or natural factors can lead to an increase in metal concentrations above established safety thresholds, which can result in negative impacts on marine organisms, especially filter feeders such as mussels that tend to accumulate metals in their flesh (Andersen *et al.* 1996, Pérez-López *et al.* 2003, Rainbow 1997). High concentrations of metals can render these species unsuitable for human consumption which has resulted in the implementation of measures to reduce trace metal input into the environment (Fowler 1983). Elevated trace metal concentrations in the marine environment as a result of anthropogenic activity have been shown to decrease aquatic diversity (Andersen *et al.* 1996).

Dispersion model results (Section 4) indicate unacceptably high levels of Hg, Co, Cu and Cd entering the marine environment through in the Wastewater 1 effluent under both Scenario 1 and Scenario 2. Lwandle (2020) recommends reduction in end of pipe levels of these metals to prevent the exceedance of acute (lethal effect) toxicity thresholds because, within the dedicated mixing zone, these levels are too high to be permitted. The total permitted end of pipe trace metal concentrations are specified in Table 5.13

Table 5.13. PRDW (2020) specified end of pipe limits for trace metals in Wastewater 1 effluent.

Metal	Unit	Maximum permitted end of pipe concentration
Mercury (Hg)	mg/l	0.062
Cobalt (Co)	mg/l	0.21
Copper (Cu)	mg/l	1.04
Cadmium (Cd)	mg/l	0.83

While not a metal, sulphide end of pipe concentrations were also flagged by PRDW (2020) as being too high to achieve the required dilutions at the edge of the RMZ. Hydrogen sulphide (H_2S) is a poisonous gas which readily dissolves in water. Solubility decreases with increasing temperature and salinity (Douabul & Riley 1979). No heterotrophic life can exist in water containing hydrogen sulphide, and affected areas are transformed into oceanic 'deserts' (Grasshoff *et al.* 1976). Sulphide is harmful to aquatic organism health but is not considered toxic to human health. Although H_2S is usually not directly introduced to the marine environment through anthropogenic sources, habitats with high oxygen demand can favour conditions for the formation of this gas (US EPA 1986). Hydrogen sulphide behaves as a weak acid, is very volatile and reacts rapidly with oxygen (Riley & Skirrow 1975). It is produced in anaerobic environments by the activities of sulphate-reducing bacteria (desulfovibria) which derive energy from a process of anaerobic respiration. In many environments, it reacts with iron to form insoluble iron sulphide, an abundant constituent of anaerobic organic rich sediments. Much of the sulphide that is not immobilised is oxidised by bacteria as soon as it reaches the aerobic level of the water profile to form sulphate (SO_4^{2-}) (Hutzinger 1980). Typical water quality problems that may be associated with acute exposure to hydrogen sulphide include failure of fish eggs to hatch, reduced fish egg deposition, mortalities of biota and growth deficiencies (US EPA 1986).

Hydrogen sulphide is a frequent component of anoxic waters, attaining concentrations as high as 70 mg/L under extreme conditions (Hutzinger 1980). The recommended guideline for sulphide (as hydrogen sulphide) in the marine environment is 2 µg/L (Massie *et al.* 2017). To meet this required target, PRDW (2020) specifies a maximum pipe end concentration of 0.21 mg/l for sulphides within Wastewater 1 effluent.

All considered, the impacts of discharge under Scenario 1 and Scenario 2 before mitigation is rated 'high' (Table 5.14). Mitigation measures include implementing the recommended Scenario presented by PRDW (2020), which requires the Wastewater 1 outfall to limit the maximum allowable effluent concentrations (end of pipe) for metals as per Table 5.13, and sulphides to below 0.21 mg/l. This mitigation reduced the impact to one of 'low' significance (Table 5.12).

Table 5.14. **Impact 13: Increased trace metal and inorganic constituent concentrations.**

	Extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Scenario 1: Without mitigation	Local 1	High 3	Long term 3	High 7	Probable	**HIGH**	-ve	High
Scenario 2: Without mitigation	Local 1	High 3	Long term 3	High 7	Probable	**HIGH**	-ve	High
Essential mitigation measures: • Implement the preferred Scenario recommended by PRDW (2020), see Section 4. • Wastewater 1 outfall to limit the maximum allowable effluent concentrations (end of pipe) for sulphide to below 0.21 mg/l; for Hg to below 0.062 mg/l, Co t below 0.21 mg/l; Cu to below 1.04 mg/l, and Cd to below 0.83 mg/l. • A water quality monitoring programme must be implemented to validate the predictions of the hydrodynamic modelling study and monitor constituents of the effluent. Adaptive management, informed by monitoring results must be implemented to ensure compliance with water quality guidelines.								
With mitigation	Local 1	Medium 2	Long term 3	Medium 6	Possible	**LOW**	-ve	High

5.2.7 Impacts of reduced dissolved oxygen

Sufficient dissolved oxygen (DO) in sea water is essential for the survival of the majority of marine organisms. Excessive discharge of organic effluent via municipal sewage, factory waste, and/or stormwater drains often results in low oxygen concentrations in nearshore waters. Following the depletion of oxygen in a water body, anaerobic bacteria that survive without oxygen continue the decay process. Microbial breakdown of excessive organic matter further depletes oxygen levels and anaerobic digestion by hydrogen sulphide producing bacteria can cause "black tides" when large plankton blooms sink and decompose. Occasionally this results in mass mortality of numerous marine species. DO levels were not modelled in this study as waves, wind and storm events all affect DO levels in the marine environment. In addition, no clear guidelines exist for DO offshore, although levels below 3 mg/L are not suitable for most species of fish, including those species targeted in Algoa Bay (Section 2.3.3).

DO levels along the coastline within the study area are expected to be high as a result of high wave action. However, because oxygen is a gas, its solubility in seawater is dependent on salinity and temperature. Increases in these parameters (specifically as a result of cooling water or brine discharge) may result in a decline of dissolved oxygen levels. For example, saturation levels of dissolved oxygen in seawater decrease with rising salinity from 5.84 ml/l- at 15 ˚C and 35 PSU, to 4.90 ml/l at 63 PSU (DWAF 1995). In addition, oxygen depletion in brine effluent might also occur through the addition of sodium metabisulfite, an oxygen scavenger, should it be used as a neutralizing agent for chlorine to protect the RO membranes (Lattemann & Höpner 2003). Sodium metabisulfite is an oxygen scavenger chemical that is typically used to neutralise the oxidising potential of the residual chlorine from the biocide dosing of the abstracted seawater before being processed through the RO plant so as to avoid damage to the RO membranes. Chlorine is used to dose the abstraction line to restrict marine growth. If the dosing of sodium metabisulphate is well-managed, the levels of sodium metabisulphate in the effluent should be low enough to avoid an "oxygen sag" in the marine environment receiving the effluent. Environmental best-practise is to ensure aeration of the effluent prior to discharge.

The South African Water Quality Guidelines for Coastal Marine Waters (DWAF 1995) state that for the west coast, dissolved oxygen should not fall below 10% of the established natural variation at the edge of the RMZ. Whilst not directly modelled, PRDW (2020) did assess Chemical Oxygen Demand (COD) in the brine outfall under Scenario 1, and in the brine and finish combined effluent under Scenario 2. In both scenarios, COD levels met the required dilutions at the RMZ. However, required COD dilutions were not met for Wastewater 1 under either Scenario, and the impact is therefore assessed as of 'medium' impact (Table 5.14). Mitigation, such as the implementation of the preferred Scenario outlined by PRDW (2020), the treatment of wastewater on land to meet appropriate standards prior to discharge, and the limiting of pipe end COD effluent concentrations to below 3110 mg/l reduces the impact to 'very low' (Table 5.14).

Table 5.15. **<u>Impact 14</u>: Reduced dissolved oxygen concentrations.**

	Extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Scenario 1: Without mitigation	Local 1	Medium 2	Long term 3	Medium 6	Probable	**MEDIUM**	-ve	High
Scenario 2: Without mitigation	Local 1	Medium 2	Long term 3	Medium 6	Probable	**MEDIUM**	-ve	High
<u>Essential mitigation measures:</u> • Implement the preferred Scenario recommended by PRDW (2020), see Section 4. • Wastewater 1 outfall to limit the maximum allowable effluent concentrations (end of pipe) for COD to below 3110 mg/l (wastewater must be treated on land to meet appropriate standards prior to discharge).. • Sodium metabisulfite is an oxygen scavenger chemical that is typically used to neutralise the oxidising potential of the residual chlorine from the biocide dosing of the abstracted seawater before being processed through the RO plant so as to avoid damage to the RO membranes. Chlorine is used to dose the abstraction line to restrict marine growth. If the dosing of sodium metabisulphate is well-managed, the levels of sodium metabisulphate in the effluent should be low enough to avoid an "oxygen sag" in the marine environment receiving the effluent. Environmental best-practise is to ensure aeration of the effluent prior to discharge. • A water quality monitoring programme must be implemented to validate the predictions of the hydrodynamic modelling study and monitor constituents of the effluent. Adaptive management, informed by monitoring results must be implemented to ensure compliance with water quality guidelines.								
With mitigation	Local 1	Low 1	Long term 3	Low 5	Improbable	**VERY LOW**	-ve	High

5.2.8 Impacts on sediments

Scouring of sediment around the discharge outlet can become a serious design issue for poorly designed pipe ends discharging into shallow receiving water bodies (Carter & van Ballegooyen 1998). Outfall design as recommended by PRDW (2020) generally is selected to maximise dilution potential while simultaneously minimising erosion of the sandy seabed. A further operational impact will be the potential shift in sediment movement and transport due to the installation of the four pipelines >500 m under Scenario 1, and the three >500 m pipelines under Scenario 2. However, it is likely that these pipelines will eventually be buried by sediment, resulting in minimal long-term impacts to sediment movement. However, the proposed Wet Mechanical Cooling water intake jetty will likely consist of numerous concrete caissons anchored to the seafloor. These caissons will redirect and reconfigure longshore sediment transport.

This impact is expected to be of 'low' significance (However, should the proposed Wet Mechanical Cooling water intake jetty be constructed **outside** of the Port, a sediment transport study must be undertaken to assess the impacts of on sediment transport patterns in the area. This modelling study must be undertaken prior to construction outside of the Port, and this impact must be reassessed based on the results of this modelling study.

Table 5.16). However, should the proposed Wet Mechanical Cooling water intake jetty be constructed **outside** of the Port, a sediment transport study must be undertaken to assess the impacts of on sediment transport patterns in the area. This modelling study must be undertaken prior to construction outside of the Port, and this impact must be reassessed based on the results of this modelling study.

Table 5.16. Impact 15: Sediment scouring and shifts in sediment movement patterns.

	Extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Scenario 1: Without mitigation	Local 1	Low 1	Long term 3	Low 5	Probable	**LOW**	-ve	Low
Scenario 2: Without mitigation	Local 1	Low 1	Long term 3	Low 5	Probable	**LOW**	-ve	Low
Essential mitigation measures: • Sould the proposed Wet Mechanical Cooling water intake jetty be constructed outside of the Port, a sediment transport study must be undertaken to assess the impacts of on sediment transport patterns in the area. This modelling study must be undertaken prior to construction outside of the Port, and this impact must be reassessed based on the results of this modelling study.								
With mitigation	Local 1	Low 1	Long term 3	Low 5	Probable	**LOW**	-ve	**Low**

5.2.9 Impacts of elevated pathogen levels

Faecal pollution contained in, for example, untreated sewage or stormwater runoff, may introduce disease-causing micro-organisms into coastal waters. These pathogenic micro-organisms constitute a threat to water users and consumers of seafood. Due to the extensive use of Algoa Bay by non-consumptive (swimmers, surfers, divers, ABYC etc.) and consumptive (fishers) coastal water users, it is critical that contamination of near shore water is prevented. Additionally, the Blue Flag status of the beaches may be threatened if contamination occurs. *Bacterial* indicators such as *Escherichia coli* are used to detect the presence of faecal pollution. Recreational users of the Bay that are in contact with the water over the outfalls (such as divers, or the ABYC members) may be at risk should effluent contain high levels of these pathogens.

Modelling indicates that pathogens (specifically, *E. coli*) within the Wastewater 1 effluent stream do not achieve the required dilutions at the 300 m RMZ under Scenario 1 or Scenario 2 (see Section 4). As such, PRDW (2020) recommends that the end of pipe effluent quality must be improved, given that a diffuser is not feasible at the proposed site. The maximum permitted end of pipe concentrations of *E. coli* for this effluent under Scenario 1 are defined by PRDW (2020) as 4500 cfu/100ml. With Wastewater 2, the longer pipe length and deeper discharge allows the required *E. coli* dilutions to be met under both Scenario 1 and 2 (PRDW 2020, Section 4). As such, both Scenario 1 and Scenario 2 are rated as having 'high' impact without mitigation (Table 5.17).

Mitigation measures include implementing the recommended Scenario presented by PRDW (2020), which requires the Wastewater 1 outfall to limit the maximum allowable effluent concentrations (end of pipe) for *E. coli* to below 4500 cfu/100ml (wastewater must be treated on land to meet appropriate standards prior to discharge). The implementation of this mitigation will reduce the impact to 'low' significance (Table 5.17).

Table 5.17. <u>Impact 16</u>: Pathogens present in effluent.

	Extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Scenario 1: Without mitigation	Local 1	High 3	Long term 3	High 7	Probable	**HIGH**	-ve	High
Scenario 2: Without mitigation	Local 1	High 3	Long term 3	High 7	Probable	**HIGH**	-ve	High
Essential mitigation measures: • Implement the preferred Scenario recommended by PRDW (2020), see Section 4. • Wastewater 1 outfall to limit the maximum allowable effluent concentrations (end of pipe) for E. coli to below 4500 cfu/100 ml (wastewater must be treated on land to meet appropriate standards prior to discharge). • A water quality monitoring programme must be implemented to validate the predictions of the hydrodynamic modelling study and monitor constituents of the effluent. Adaptive management, informed by monitoring results must be implemented to ensure compliance with water quality guidelines.								
With mitigation	Local 1	Low 1	Long-term 3	Low 5	Probable	**LOW**	-ve	High

5.2.10 Impacts on fisheries

Small pelagic species are known to be sensitive to temperature, with the upper limit of 20°C for sardine and 21°C for anchovy (Van der Lingen *et al*. 2001). These are highly mobile, migratory populations, that move in and out of the Bay as conditions allow (see Section 2.1.3). Given that far field modelling results indicate that effluent temperature under both Scenario 1 and 2 achieve the required dilutions at the edge of the stipulated RMZ (Section 4) and given that summer water temperatures in Algoa Bay can reach 27°C, the impact of the proposed development on small pelagic fisheries is considered to be 'low' (Table 5.18). Mitigation is the same as that outlined in Table 5.9.

Linefish species actively avoid low oxygen waters and should persistent low oxygen conditions develop around the proposed outfalls, these species are likely to move elsewhere. However, the area of the modelled plume for the outfalls that may result in low oxygen conditions has little overlap with areas where linefish are targeted (see Section 2.3.3.3, Figure 2-14). For example, the primary line fishery effort is concentrated to the southwest near Cape Recife, some 25 km from the proposed development. As such, and given that the areas affected represents a relatively small portion of the total area where linefish are targeted in Algoa Bay, the impact of the development operations on the fishery is expected to be of low significance.

However, of significant concern is the potential for heavy metal accumulation in linefish species, given that dispersion model results (Section 4) indicate unacceptably high levels of Hg, Co, Cu and Cd entering the marine environment through in the Wastewater 1 effluent under both Scenario 1 and Scenario 2. Bioaccumulation of toxic metals in fish causes serious threats to the human when they are consumed (Rajeshkumar & Li 2018, see Section 5.2.6). The significance of this impact is rated 'high' without mitigation (Table 5.18). Mitigation measures are those that ensure compliance with WQG in the receiving environment, as outlined in Table 5.13.

Squid are particularly sensitive to high turbidity levels and water temperature (Sauer 1994). As such, elevated turbidity and suspended solids in the receiving environment as a result of the outfall operation may impact this fishery (see Section 5.2.5). Mitigation measures are the same as those outlined in Table 5.12. While Figure 2-13 shows high catches of squid near the proposed development, these catches tend to be concentrated below 20 m depth, and therefore do not overlap significantly with the proposed infrastructure (i.e. the deepest proposed outfall is some 20 m below MSL, Figure 4-1). As such, the significance of this impact is assessed as 'low' (Table 5.18).

The shark longline fishery in Algoa Bay do not deploy significant numbers of shark long line sets in the area of the proposed development, and therefore, the significance of this impact is assessed as 'very low' given the lack of overlap in spatial use, the relatively small area of impact within the Bay and the availability of other, preferred grounds for this fishery in Algoa Bay (Table 5.18).

After mitigation, no impact is assessed as being above 'low' significance (Table 5.18).

Table 5.18. Impact 17: Impacts on fisheries.

	Extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Small pelagics Without mitigation	Low 1	Low 1	Long term 3	Low 5	Probable	**LOW**	-ve	High
Line fish Without mitigation	Local 1	High 3	Long term 3	High 7	Probable	**HIGH**	-ve	High
Squid Without mitigation	Low 1	Low 1	Long term 3	Low 5	Probable	**LOW**	-ve	High
Sharks Without mitigation	Low 1	Low 1	Long term 3	Low 5	Possible	**VERY LOW**	-ve	High
• See Table 5.9. • See Table 5.13. • See Table 5.12.								
Small pelagics With mitigation	Low 1	Low 1	Long term 3	Low 5	Possible	**VERY LOW**	-ve	High
Line fish With mitigation	Local 1	Medium 2	Long term 3	Medium 6	Possible	**LOW**	-ve	High
Squid With mitigation	Low 1	Low 1	Long term 3	Low 5	Probable	**VERY LOW**	-ve	High
Sharks With mitigation	Low 1	Low 1	Long term 3	Low 5	Possible	**VERY LOW**	-ve	High

5.2.11 Impacts of introduction of alien and invasive species

The introduction of alien species into new environments through aquaculture operations is well established and well-studied. Although land-based aquaculture is more secure than cage aquaculture, it is still possible for species to be introduced by farmed organisms escaping into the adjacent marine environment. The impacts due to introduction of alien and invasive species has however already been assessed in the Marine Ecological Specialist and Biosecurity and Biodiversity Risk Assessment Specialist reports for the Coega ADZ (Aquatic Ecosystem Services 2017a, b) and is as such not repeated here.

5.2.12 Impact of increased bio-active compounds use and disease transmission

Increase risk of disease transmission to surrounding environment as a result of aquaculture activities has been identified as a biosecurity risk and addressed through the implementation of management systems designed to protect the environment against potentially harmful organisms and biological materials (Aquatic Ecosystem Services 2017b). Bio-active compounds are compounds defined as having an effect upon a living organism, tissue, or cell. Biologically active antibiotic, enzymes, and vitamins, chemotherapeutants (for disease treatment), disinfectants and hormones are all bioactive substances (Aquatic Ecosystem Services 2017b).

The impacts of enhanced disease risk and use of bio-active compounds have however already been assessed in the Biosecurity and Biodiversity Risk Assessment Specialist reports for the Coega ADZ (Aquatic Ecosystem Services 2017b) and is as such not repeated here.

5.3 Decommissioning Phase

No decommissioning procedures or restoration plans have been compiled at this stage, although impacts are expected to be similar (if not less) to those assessed during the construction phase. The potential impacts during the de-commissioning phase are expected to be minimal in comparison to those occurring during the operational phase, and no key issues related to the marine environment have been identified at this stage. The same mitigation procedures as those explained in the construction phase should be adhered to in the decommissioning phase in order to mitigate for any of the impacts listed above.

5.4 Cumulative impacts

Anthropogenic activities can result in numerous and complex effects on the natural environment. While many of these are direct and immediate, the environmental effects of individual activities or projects can interact with each other in time and space to cause incremental or aggregate effects. Impacts from unrelated activities may accumulate or interact to cause additional effects that may not be apparent when assessing the activities individually. Cumulative effects are defined as the total impact that a series of developments, either present, past or future, will have on the environment within a specific region over a particular period of time (DEAT IEM Guideline 7, Cumulative effects assessment 2004).

Cumulative marine environmental impacts emanating from the proposed project are primarily related to the overlap in use with various other water users in the vicinity of the proposed servitudes (i.e. the Algoa 7 finfish development area, the Addo MPA, areas of importance to various fisheries).

As sea based finfish farms tend to be significant sources of nitrogenous waste (i.e. nutrients), there is particular concern about the cumulative impacts of increased nutrient concentrations arising from both the sea based finfish aquaculture in Algoa 7 (see Section 2.3.4), and the nutrients discharges by the wastewater and finfish pipelines (assessed in Section 5.2.4). However, dispersion modelling by PRDW (2020) shows that required dilutions of TKN + NH_4 from Wastewater 1 achieve dilutions of ~1 870 at Algoa 7 (required dilution to meet WQG is 120), and that the finfish + brine effluent combination under Scenario 2 archives dilutions of ~580 at Algoa 7 (required dilution to meet WQG is 39.1). Plume dimensions are shown in Figure 4-3 and Figure 4-5. As such, it is considered unlikely that there will be significant interaction between these nutrient sources, especially if the recommended scenario is implemented (PRDW 2020), and end of pipeline requirements are met (see mitigation measures in Table 5.11).

There is some level of uncertainty, however, about the cumulative impact of the simultaneous operation of multiple discharge pipelines. While the effluents are relatively different to each other (i.e. dense brine vs buoyant finfish aquaculture effluent), there are potential interactions between effluent constituents that can only be identified by a far field dispersion model. These interactions could possibly exacerbate the impacts discussed above and render the mitigation measures ineffective. As such, these cumulative impacts are rated 'high' (Table 5.19). This simultaneous discharge scenario should therefore be modelled, and the results used to assess the impacts thereof with higher degree of certainty, as well as provide maximum effluent pipe end constituent limits to safeguard the Algoa Bay marine environment and protect water users.

Table 5.19. **Cumulative impacts.**

	Extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Scenario 1: Without mitigation	Local 1	High 3	Long term 3	High 7	Probable	**HIGH**	-ve	Low
Scenario 2: Without mitigation	Local 1	High 3	Long term 3	High 7	Probable	**HIGH**	-ve	Low
Essential mitigation measures: • Undertake far field dispersion modelling to assess the interactions of effluent plumes under the simultaneous operation of multiple effluent outfalls. Use these dispersion modelling results to recommend maximum effluent pipe end constituent limits. • Implement these maximum recommended effluent pipe end constituent limits. • A water quality monitoring programme must be implemented to validate the predictions of the hydrodynamic modelling study and monitor constituents of the effluent to ensure compliance with water quality guidelines.								
With mitigation	Local 1	Low 1	Long-term 3	Low 5	Probable	**LOW**	-ve	Low

5.5 Summary of potential impacts

The impacts that may be experienced during construction and operation before and after mitigation are summarised in Table 5.20. A total of seventeen impacts were identified and, after mitigation, none of the identified impacts were assessed as being above 'low' significance.

Impacts that have been assessed in other marine specialist studies undertaken for the particular industries within the Coega SEZ (such as the bio-active compound and disease risks associated with aquaculture) are not reassessed here.

Table 5.20. Summary of potential impacts as a result of construction and operation of Coega SEZ servitudes.

	Impact identified	Consequence	Probability	Significance	Status	Confidence
Construction	Impact 1: Loss of sandy beach, intertidal and subtidal habitat and biota.					
	Scenario 1 and 2	Medium	Definite	**MEDIUM**	-'ve	Hight
	With mitigation	Low	Definite	**LOW**	-'ve	Medium
	Impact 2: Ecological effects due to the disturbance of pelagic open water habitats					
	Scenario 1 and 2	Very Low	Definite	**LOW**	-ve	High
	With mitigation	Very Low	Possible	**VERY LOW**	-ve	High
	Impact 3: Barotrauma of marine fauna as a result of blasting.					
	Scenario 1 and 2	Medium	Probable	**MEDIUM**	-'ve	Hight
	With mitigation	Very Low	Probable	**VERY LOW**	-ve	Medium
	Impact 4: Noise disturbance to marine fauna.					
	Scenario 1 and 2	Medium	Probable	**MEDIUM**	-'ve	Hight
	With mitigation	Very Low	Probable	**VERY LOW**	-ve	Medium
	Impact 5: Reduced water quality from blasting, drilling and dredging.					
	Scenario 1 and 2	Medium	Possible	**LOW**	-'ve	Hight
	With mitigation	Very Low	Probable	**VERY LOW**	-ve	High
	Impact 6: Pollution generated during construction.					
	Scenario 1 and 2	Low	Probable	**LOW**	-'ve	Hight
	With mitigation	Low	Possible	**VERY LOW**	-'ve	Hight
	Impact 7: The effect of the spillage of hazardous substances on marine biota.					
	Scenario 1 and 2	Medium	Possible	**LOW**	-'ve	Medium
	With mitigation	Low	Improbable	**VERY LOW**	-ve	Medium
Operation	Impact 8: Disturbance and/or mortality of marine life due to the intake of seawater.					
	Beach wells	Low	Possible	**VERY LOW**	-'ve	Medium
	Intake pipeline	Low	Definite	**LOW**	-'ve	Medium
	With mitigation	Low	Possible	**VERY LOW**	-'ve	Medium
	Impact 9: Elevated temperature.					
	Scenario 1	Low	Probable	**LOW**	-ve	High
	Scenario 2	Low	Possible	**VERY LOW**	-ve	High
	With mitigation	Very Low	Possible	**VERY LOW**	-ve	High

	Impact identified	Consequence	Probability	Significance	Status	Confidence
Operation (cont.)	Impact 10: Changes in salinity.					
	Scenario 1	Very Low	Probable	**VERY LOW**	-ve	High
	Scenario 2	Very Low	Probable	**VERY LOW**	-ve	High
	With mitigation	Very Low	Possible	**INSIGNIFICANT**	-ve	High
	Impact 11: Elevated nutrients from aquaculture effluent and wastewater effluent.					
	Scenario 1	High	Probable	**HIGH**	-ve	High
	Scenario 2	High	Probable	**HIGH**	-ve	High
	With mitigation	Low	Possible	**LOW**	-ve	High
	Impact 12: Increased suspended solid concentrations.					
	Scenario 1	Medium	Probable	**MEDIUM**	-ve	High
	Scenario 2	Medium	Probable	**MEDIUM**	-ve	High
	With mitigation	Medium	Possible	**LOW**	-ve	High
	Impact 13: Increased trace metal and inorganic constituent concentrations.					
	Scenario 1	High	Probable	**HIGH**	-ve	High
	Scenario 2	High	Probable	**HIGH**	-ve	High
	With mitigation	Medium	Possible	**LOW**	-ve	High
	Impact 14: Reduced dissolved oxygen concentrations.					
	Scenario 1	Low	Improbable	**MEDIUM**	-ve	High
	Scenario 2	Low	Improbable	**MEDIUM**	-ve	High
	With mitigation	Low	Improbable	**VERY LOW**	-ve	High
	Impact 15: Sediment scouring and shifts in sediment movement patterns.					
	Scenario 1	Low	Probable	**LOW**	-ve	Low
	Scenario 2	Low	Probable	**LOW**	-ve	Low
	With mitigation	Low	Probable	**LOW**	-ve	Low
	Impact 16: Pathogens present in effluent.					
		High	Probable	**HIGH**	-ve	High
	Scenario 2	High	Probable	**HIGH**	-ve	High
	With mitigation	Low	Probable	**LOW**	-ve	High
	Impact 17: Impacts on fisheries.					
	Small pelagics	Low	Probable	**LOW**	-ve	High

	Impact identified	Consequence	Probability	Significance	Status	Confidence
Operation (cont.)	With mitigation	Low	Possible	**VERY LOW**	-ve	High
	Line fish	High	Probable	**HIGH**	-ve	High
	With mitigation	Low	Probable	**LOW**	-ve	High
	Squid	Low	Probable	**LOW**	-ve	High
	With mitigation	Low	Possible	**VERY LOW**	-ve	High
	Sharks	Low	Possible	**VERY LOW**	-ve	High
	With mitigation	Low	Possible	**VERY LOW**	-ve	High

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Impact assessment

A total of seventeen potential marine environmental impacts were assessed for this report, ranging from habitat loss to operational effects (see Table 5.20) (impacts that have been assessed in other marine specialist studies undertaken for the particular industries within the Coega SEZ, such as the bio-active compound and disease risks associated with aquaculture, are not reassessed here). The impacts of the proposed development on fisheries in Algoa Bay were assessed separately. Scenario 1 and Scenario 2 were assessed together for construction impact, with three impacts rated as 'medium' before mitigation (reduced to 'low' or 'very low' after mitigation), and four impacts were rated as 'low' (reduced to 'very low' after mitigation) (Table 5.20).

Scenario 1 and Scenario 2 were assessed separately under operational impacts. Under Scenario 1, one impact was rated 'very low' and one was reduced to 'insignificant' rating after mitigation (Table 5.20). Three impacts were rated 'low' under Scenario 1 (reduced to 'very low', or remaining of 'low' significance after mitigation), while two impacts were rated medium (reduced to 'low' and 'very low' after mitigation), and three impacts were rated as of 'high' significance (Table 5.20). These 'high' significance impacts were however reduced to 'low' after the implementation of mitigation measures.

There were two impacts rated 'very low' under Scenario 2 and two as 'low' (reduced to 'low', 'very low' or 'insignificant' after mitigation). Two impacts were assessed to be of 'medium' significance, and three were rated as 'high'. Again, mitigation reduced these 'medium' and 'high' impacts to either 'very low' or 'low' after mitigation (Table 5.20). All impacts on fisheries are considered 'low' or 'very low' with mitigation (Table 5.20).

Cumulative marine environmental impacts emanating from the proposed project are primarily related to the overlap in use with various other water users in the vicinity of the proposed servitudes. As sea-based finfish farms tend to be significant sources of nitrogenous waste (i.e. nutrients), there is particular concern about the cumulative impacts of increased nutrient concentrations arising from both the sea based finfish aquaculture in Algoa 7, and the nutrients discharges by the wastewater and finfish pipelines. However, dispersion modelling by PRDW (2020) shows that required dilutions of TKN + NH_4 from Wastewater 1 achieve dilutions of ~1870 at Algoa 7 (required dilution to meet WQG is 120), and that the finfish + brine effluent combination under Scenario 2 archives dilutions of ~580 at Algoa 7 (required dilution to meet WQG is 39.1). As such, it is considered unlikely that there will be significant interaction between these nutrient sources, especially if the recommended scenario is implemented (PRDW 2020), and end of pipeline requirements are met. However, there is some level of uncertainty (i.e. low confidence) in the assessment of the cumulative impact of the simultaneous operation of multiple discharge pipelines. While the effluents are relatively different to each other (i.e. dense brine vs buoyant finfish aquaculture effluent), there are potential interactions between effluent constituents that can only be identified by a far field dispersion model. This simultaneous discharge scenario should therefore be modelled, and the results used to assess the impacts thereof with high degree of certainty.

It is critical that end of pipe limits stipulated by the dispersion modelling report be adhered to so as to safeguard the marine environment of Algoa Bay and mitigate impacts on other water users. Based on the impacts assessed in this report, it is recommended that the proposed development proceed with the implementation of strict environmentally responsible practices as outlined in the mitigation measures below. This assessment is based on the results presented by PRDW (2020), under a 300 m RMZ for all outfalls. This is considered acceptable, given the status of the receiving environment (and in particular, that of the Coega estuary). However, **this assessment is only valid on condition that Wastewater 1 effluent does not contain excessively high levels of trace metals (ostensibly from industrial effluent) as per PRDW (2020).**

6.2 Recommended mitigation

Essential and best practise mitigation measures recommended to reduce the severity of the impacts during the **construction**/decommissioning **phase** as outlined above are as follows:

- Rehabilitate the disturbed area immediately following construction by removing all artificial structures or beach modifications created during construction from above and within the intertidal zone. No accumulation of excavated beach sediments should be left above the high-water mark, and any substantial sediment accumulations below the high-water mark should be levelled.
- The spatial extent and duration of construction must be limited as far as possible (construction of the different infrastructure should be undertaken sequentially to minimise disturbance on pelagic habitat).
- Undertake baseline and comparative monitoring of biota in the construction footprint. Monitoring should focus on physical habitat variables (sediment particle size composition and organic content) and biota (e.g. benthic infaunal soft sediment communities). The latter have been shown to provide a good indication of habitat recovery following physical disturbance. Surveys should be done once prior to construction and again approximately 12 months after construction is complete.
- Mitigation for blasting and construction noise includes the following:
    - A visual survey of the area (both the immediate vicinity of the construction footprint and within a 1000 m radius) should be conducted by trained marine mammal observers (MMO's) 30 minutes before the blasting is to commence. Permission to blast must be delayed until all marine mammals are outside the 1 km radius form the blast site. Similarly, all blasting should be halted once marine mammals are seen entering the 1 km radius. Blasting should not commence when environmental conditions, such as darkness, mist, rain, fog or high sea states greater than Beaufort 4 prohibit adequate monitoring of the 1 km safety zone.
    - No blasting may take place during the annual sardine run (May-June) and should only be undertaken during daylight hours.
    - No blasting should be undertaken in the early mornings (6h00-10h00) or late afternoons (15h00-19h00) due to coastal dolphin activity in inshore waters. Ideally, blasting should only be undertaken between 12h00 and 14h00.
    - A soft-start (i.e. gradual ramping up of piling/ drilling power) period of at least 20 minutes is recommended. If an animal enters the safety zone during soft-start, the power should not be increased until the animal exits and remains outside of the zone for 20 minutes.
- Check vehicles for hydrocarbon leaks daily.

- Protocols for dealing with accidental spills must be in place.
- Emergency equipment to isolate spills must be accessible.
- Provide suitable containers for the disposal of all waste, including recycling.
- All hazardous substances must be accompanied by a permit, a hazard report sheet, and a first aid treatment protocol and may only be handled by suitably trained operators.
- Intentional disposal of any substance into the environment is strictly prohibited, while accidental spillage must be prevented, contained and reported immediately.
- Implementation of a rigorous environmental management and control plan (including procedures for remediation).
- All fuel and oil is to be stored with adequate spill protection.
- No leaking vehicles are permitted on site.
- A monitoring programme should be implemented to monitor water quality in the vicinity of the construction site. Six monitoring stations, three on either side of the pipeline at 10, 15 m and 18 m depth, respectively, should be identified for this purpose. Measurements should be collected daily for 20-30 days prior to the commencement of dredging operations (to develop an appropriate baseline) and should continue as long as dredging continues. The median TSS concentration in monitoring data should not exceed the threshold limit which is set as the greater of the 80th percentile of the baseline monitoring data, or ten percent (10%) greater than the natural background turbidity. If the TSS approaches the threshold limit set above at any of the surveillance monitoring stations, mitigation measures are to be put in place to prevent any further increase in suspended solid concentration (e.g. reduce rate of construction activities). If median turbidity levels (calculated from measured values in any one and a half hour period) exceed the threshold, construction activities are to be suspended until measured levels drop below the threshold.

Essential mitigation measures recommended to reduce the severity of the impacts during the **operational** phase as outlined above are as follows:

- Intake velocities should be kept below 0.15 m/s to ensure that fish and other mobile organisms can escape the intake current. Intake velocities can be reduced to the requisite 0.15 m/s through the use of footer valves. A footer valve is a flared (or expanded) section of pipe that is fitted on the end of the intake that will allow ensure intake velocity does not exceed a specified threshold at the entrance to the intake structure. Note that velocity decreases as cross-sectional area increases and the size of the intake valve required will depend on the amount by which velocity needs to be reduced (if the velocity must be reduced by 50%, then cross sectional area must double).
- Intake structures should ensure the horizontal intake of water and be positioned away from sensitive environments or areas with high species diversity or abundance, like rocky reefs, and should not draw in water from the upper meter of the water column.
- The preferred Scenario recommended by PRDW (2020) must be implemented with the recommended adjustments.
- A water quality monitoring programme must be implemented to validate the predictions of the hydrodynamic modelling study and monitor constituents of the effluent to ensure compliance with water quality guidelines. Should monitoring reveal non-compliance adaptive management must be implemented to improve effluent quality and compliance with WQGs. These measures must include options to reduce or stop discharges until

improvements are implemented.

- Should the the proposed Wet Mechanical Cooling water intake jetty be constructed **outside** of the Port, a sediment transport study must be undertaken to assess the impacts of on sediment transport patterns in the area. This modelling study must be undertaken prior to construction outside of the Port, and this impact must be reassessed based on the results of this modelling study.
- Sodium metabisulfite is an oxygen scavenger chemical that is typically used to neutralise the oxidising potential of the residual chlorine from the biocide dosing of the abstracted seawater before being processed through the RO plant so as to avoid damage to the RO membranes. Chlorine is used to dose the abstraction line to restrict marine growth. If the dosing of sodium metabisulphate is well-managed, the levels of sodium metabisulphate in the effluent should be low enough to avoid an "oxygen sag" in the marine environment receiving the effluent. Environmental best-practise is to ensure aeration of the effluent prior to discharge.
- Ensure end of pipe limits for discharges not included in the model (i.e. biocides) do not exceed water quality guideline limits (i.e. 0.2 mg/l pipe end for chlorine).
- End of pipe concentrations recommended by PRDW (2020) be adhered to and are specified in Table 6.1 below. Wastewater must be treated on land to meet appropriate standards prior to discharge. These end of pipe concentrations should be reflected in any awarded Coastal Waters Discharge Permit.

Table 6.1 Required end of pipe concentrations for containments of concern within various effluents, as stipulated by PRDW (2020).

Effluent stream	Constituent	Unit	Maximum end of pipe concentration
Wastewater 1	Salinity	PSU	17
	TKN + NH4	mg/l	5
	TSS		50
	E. coli	Cfu/100ml	4500
Wastewater 2	Sulphide	mg/l	0.21
	Hg		0.062
	Co		0.21
	Cu		1.04
	Cd		0.83
Brine + Finfish	Ammonia, nitrates, nitrites	mg/l	13.37

6.3 Monitoring

On receipt of Coastal Waters Discharge Permits (CWDPs), the end of pipe concentrations for each outfall as published in the permit conditions must be met to ensure compliance at the edge of the Recommended Mixing Zone (RMZ). Compliance monitoring of the effluent before discharge should be performed to minimise environmental impacts. If discharged effluent exceeds the end of pipe values at any time, the operation will be in violation of the CWDP and the cause of poor effluent quality must be identified, reported and rectified immediately.

A monitoring program at the edge of each RMZ should be implemented prior to construction to better determine ambient water quality and to ensure that required Water Quality Guidelines (WQGs) are being met at the edge of the RMZ. This can be achieved by mooring a data logging instrument capable of measuring conductivity (i.e. salinity), temperature and depth (CTD) 1 m above the ocean bottom for a period of one month pre- and one year after operations commences. Monitoring should also be undertaken to assess dissolved oxygen levels, microbiological indicators (*Enterococci* sp. and/or *E. coli*)turbidity, ammonia, nitrate and pH. Monitoring for salinity and temperature should take place continuously (via the moored instrument), while the other environmental water quality parameters should be assessed quarterly (i.e. four times per year).

It is also recommended that benthic macrofaunal samples be collected and analysed both pre- and post-discharge. Benthic macrofauna biological indicators, such as species abundance, biomass, and diversity, provide a direct measure of the state of the ecosystem in space and time and tend to be directly affected by pollution/disturbance. It is recommended that a minimum of six sites be monitored in the vicinity of each outfall with three samples collected per site. Two control sites should be included to assess potential impacts relative to broader changes within Algoa Bay. These samples must be accompanied by an assessment of sediment granulometry and organic content to permit correct interpretation of the macrofauna results, because sediment particle size, Total Organic Carbon (TOC) and Total Organic Nitrogen (TON) within the sediment influence macrofaunal community structure in marine systems. These factors must therefore be controlled for to correctly interpret changes in community structure, should such changes be detected. These benthic samples should be collected and assessed annually. Sediments from control and impacts sites must also be analysed for trace metal content in order to detect potential enrichment due to effluent discharges.

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8 APPENDIX 1

Impact Assessment Methodology

The significance of all potential impacts that would result from the proposed project is determined in order to assist decision-makers. 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 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:

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).

Impacts are also considered in terms of their status (positive or negative impact) and the confidence in the ascribed impact significance rating. The prescribed system for considering impacts status and confidence (in assessment) is laid out in the table below. 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.

Confidence rating	
Status of impact	+ ve (beneficial) or – ve (cost)
Confidence of assessment	Low, Medium or High

Example 5:

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

The significance rating of impacts is considered by decision-makers, as shown below. Note, this method does not apply to minor impacts which can be logically grouped into a single assessment.

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

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:

1. Essential: must be implemented and are non-negotiable; and

2. Best Practice: 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:

	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
<u>Impact 1</u>: XXXX	Medium	Improbable	LOW	–ve	High
With Mitigation	Low	Improbable	VERY LOW		High
<u>Impact 2:</u> 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.

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