13. Marine Environment

This chapter provides a summary of the existing marine environmental conditions at the location and surrounds of the intake and outlet structures for the proposed Desalination Plant, the potential impacts to water quality, marine ecology, fisheries and species or communities of conservation significance within this marine environment. The environmental monitoring program which is currently being carried out to establish baseline conditions, confirm modelling results and verify the extent of predicted impacts to the marine environment, is outlined..

*Further information on marine ecology and water quality can be found in the Water Quality and Marine Ecology Impact Assessment, and the monitoring program attached in **Appendix 13**.*

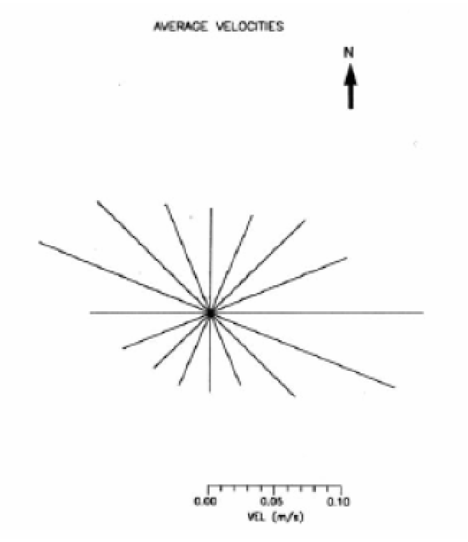
13.1 Existing Environment

13.1.1 Oceanography

Current and Wave Climate

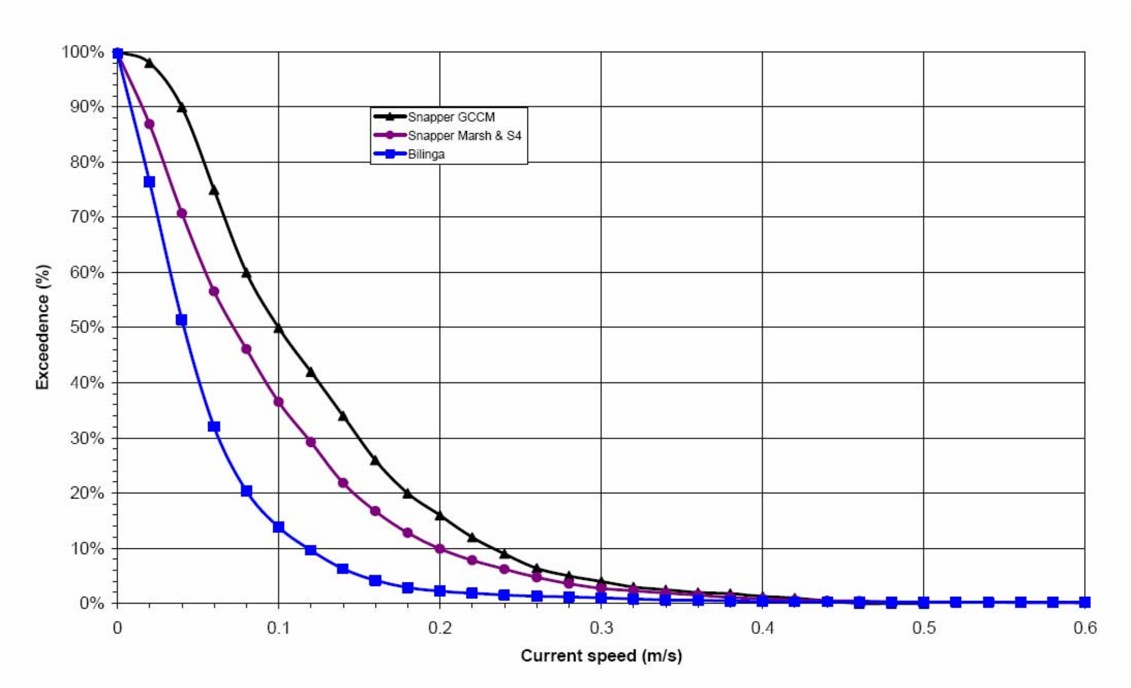
Large-scale circulation in the area is driven by the East Australian Current (EAC). In offshore waters of depths greater than about 30 m the EAC flows to the southeast along the coast at speeds of up to 2 knots, but in the shallower Gold Coast Embayment the EAC's influence is to set up eddy-like circulation cells that result in a predominantly north-westerly flow (Tomlinson *et al*., 2005). Localised, shallow-water circulation in the Embayment, however, is dominated by coastal processes, namely coastal trapped waves and to a lesser extent breaking internal waves. These processes modify the larger-scale residual northward flow so that the currents periodically reverse and flow to the southeast on time scales of days to weeks (Tomlinson *et al*., 2005, Tomlinson & Hughes, 2006 (**Appendix 13**)). Tidal currents at the intake/outlet site are negligible.

The resultant current flows are predominantly in a NW-SE direction parallel to shore (**Figure 13-1 Directional Current Speeds at Snapper Rocks**). Current speeds are typically low. Tomlinson & Cox (1993; reported in Tomlinson & Hughes, 2005) reported that current speeds exceeded 0.2 m/s less than 20% of the time in 3-1/2 years' of current measurements (Oct 1988 – Feb 1992) at Snapper Rocks, about 5 km SE of the intake and outlet sites. Current data provided for Snapper Rocks (various periods between 1988 and 1995) and Bilinga (May 1991 – Aug 1995) indicate lower current speeds at Bilinga, immediately adjacent to the intake/outlet site, than at Snapper Rocks. The available data (**Figure 13-2 Current Speed Exceedance Curves based on Data Collected at Snapper Rocks**) indicate, that current speeds at the intake/outfall site will be less than 0.2 m/s at least 90% of the time.



Source: Tomlinson and Cox, 1993, after Tomlinson et al., 2005.

- **Figure 13-1 Directional Current Speeds at Snapper Rocks**



Source: Tomlinson & Cox, 1993 (Snapper GCCM), data for Snapper Rocks provided by QLD EPA (Snapper March & S4), and data for Bilinga provided by QLD EPA.

- **Figure 13-2 Current Speed Exceedance Curves based on Data Collected at Snapper Rocks**

Significant wave heights in the Gold Coast region are generally in the 0.7 – 4 m range (Tomlinson *et al*., 2005) but are occasionally larger due to swell generated by distant storms. Cyclones sometimes generate larger waves with significant wave heights up to 12 m, with maximum recorded wave height of 14 m. The Gold Coast is affected by cyclones about 1.5 times per year as a long-term average, but cyclone frequency has been less than this over the past 3 decades (Tomlinson *et al*., 2005.)

Waves generate orbital movement of water under the wave down to a depth of about half the wavelength, with the velocity of orbital motion decreasing with depth. In water deeper than half the wavelength these orbital "currents" are essentially circular, but in shallower depth the orbital water motion is constrained into back-and-forth surge. This surge drives the formation of storm bars up to 4 m in height. Variation in wave energy generates cross-shore sand (i.e. the movement of sand on and off shore), with the bars moving onshore in calm periods and offshore when waves are high. This on- and-offshore movement of sand bars extends out about 700 m offshore (Tomlinson *et al*., 2005) and does not affect the proposed intake/outlet location.

Theoretical calculations, the presence of sand ripples at the depths of the proposed intake/outlet, and diver observations of suspended near-bottom sediment confirm that wave influence is not expected (Natural Solutions, 2006a; Tomlinson & Hughes, 2006).

The impingement of waves and surf at an angle to the coastline generates longshore currents, also known as littoral drift, which transport sediment along the coast. Since the predominant wave direction on the Eastern Seaboard of Australia is from the SE, the resultant littoral drift flows to the northwest. On the Gold Coast most of the littoral transport occurs in depths shallower 7m (i.e. less than about 300m from shore) and 90% in depths less than 15 m (<900 m of shore); littoral drift at the depths of the proposed intake/outlet is negligible (GHD, 2005; Tomlinson et al., 2005).

Sedimentary Environment

The proposed intake/outlet site area has a uniform seafloor of fine to medium grained quarts sand, with 61-87% of the sediment in the 0.15 – 1.18 mm grain size fraction (**Appendix 13**); Tomlinson et. al., 2005). Other components include shell and small amounts (< 3%) of silt and clay (Natural Solutions, 2006a; Tomlinson &Hughes, 2006). The bottom is essentially homogenous over distances of several kilometres from the proposed intake/outlet site. The nearest rocky reefs are Kirra Reef, some 3 km to the southeast, Palm Beach Reef, 4 km northwest, and 18 fathom reef, lying at a depth of 33 m offshore (Natural Solutions, 2006a). In recent years Kirra Reef has been covered by an accumulation of sand from the activities of dredging and the Tweed River bypass processes.

Sand dredging for beach replenishment has occurred in several areas near the proposed intake/outlet site and there are several approved dredging areas in the immediate vicinity (Tomlinson & Hughes, 2006). Only small quantities of sand have been dredged from the approved area overlaying the site as it contains pockets of shell that are unsuitable for beach replenishment (R. Tomlinson, pers. comm.)

Dredged slots in the seabed may be noticeable on bathymetry, although Tomlinson & Hughes (2006) report that in 2004 there were no visible signs of dredging trenches made during the North Kirra groyne project in the mid-1980s.

Natural Solutions (2006a) collected 5 grab samples of sediments from the intake/outlet area, which were analysed for:

- Total metals
- Total petroleum hydrocarbons
- Total PCBs
- Organic pesticides and residues
- Polycyclic aromatic hydrocarbons (PAHs)
- Total organic carbon (TOC)

The results are shown in **Table 13-1**. All metals except silver were below screening levels specified in the National Ocean Disposal Guidelines for Dredged Material (NODGM). Silver is marginally above screening level but well below the maximum level permitted for ocean disposal.

Petroleum hydrocarbons, PCBs, and pesticides were all below detection limits (for some pesticides measurement uncertainty results in 95% upper confidence limits above NODGM screening levels). Individual PAHs were also below detection limits (again with 95% UCLs sometimes above screening). Low molecular weight PAHs, high molecular weight PAHs, and total PAHs were detectable but below screening levels.

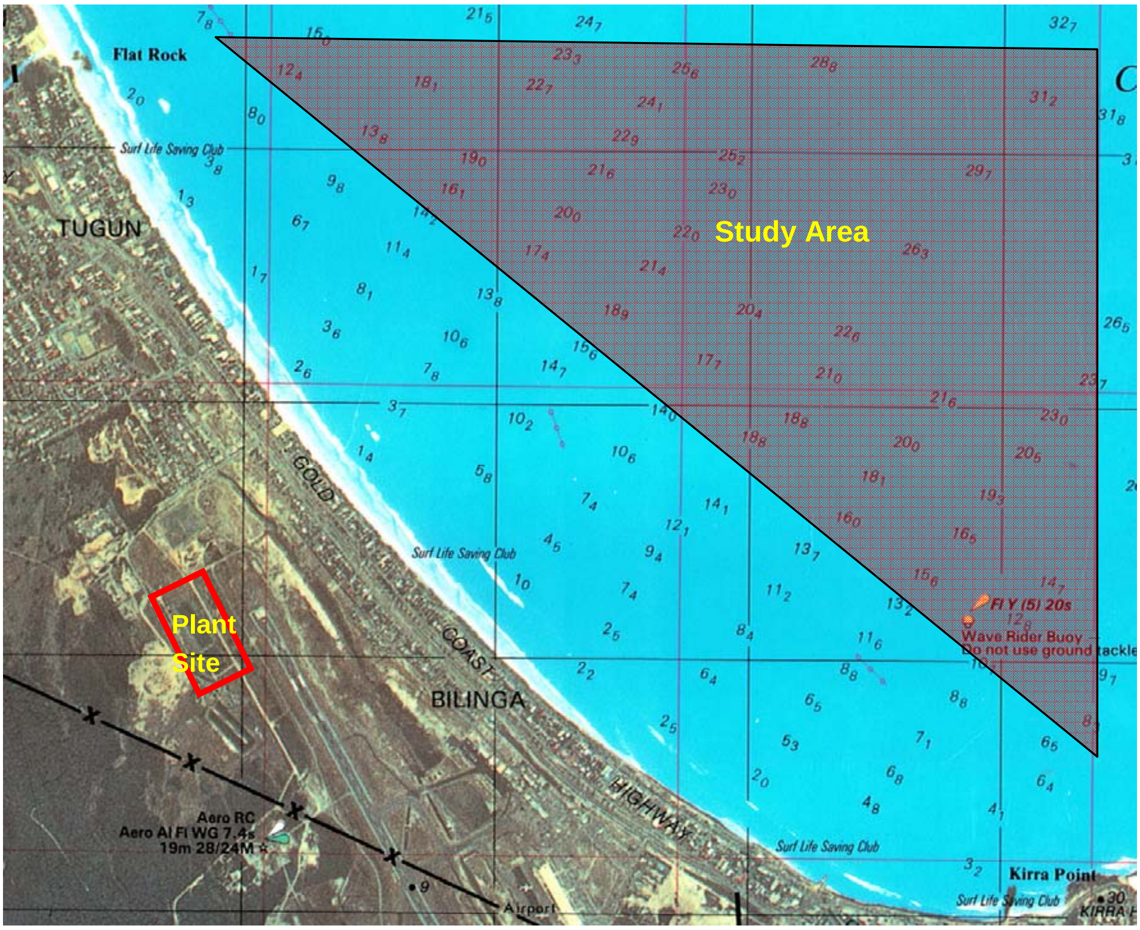
The organic carbon content of the sediments is low, with measured TOC levels of 0.06 – 0.11%.

- ## Table 13-1 Site Survey 1 Sediment Contaminant Concentrations Compared Against Sediment Quality Guidelines (NODGDM 2002=ANZECC/ARMCANZ 2000)

Analytical Parameter		Units	PQL	Sea dumping							95%UCL	Sea Dumping		
				Screening	Maximum	D1	D2	D3	D4	D5		Below Screening	Greater than Screening	Greater than Maximum
Metals and Metalloids														
	Aluminium	mg/kg	10			2110	1350	1260	1180	1250	1767			
	Antimony	mg/kg	0.1	2	25	<0.1	<0.1	<0.1	<0.1	<0.1	0.05	5	0	0
	Arsenic	mg/kg	0.5	20	70	6.2	5	5.6	4.1	4.2	5.8	5	0	0
	Cadmium	mg/kg	0.1	1.5	10	<0.1	<0.1	<0.1	<0.1	<0.1	0.05	5	0	0
	Chromium	mg/kg	0.5	80	370	0.7	<0.1	<0.1	<0.1	<0.1	0.4	5	0	0
	Copper	mg/kg	0.5	65	270	<0.1	<0.1	<0.1	<0.1	<0.1	0.05	5	0	0
	Iron	mg/kg	10			2820	1640	1700	1080	1140	2288			
	Lead	mg/kg	1	50	220	0.5	<0.1	<0.1	<0.1	<0.1	0.3	5	0	0
	Manganese	mg/kg	1			13.8	8.1	6.8	5.1	5.6	11.0			
	Mercury	mg/kg	0.01	0.15	1	<0.1	<0.1	<0.1	<0.1	<0.1	0.05	5	0	0
	Nickel	mg/kg	0.5	21	52	0.5	<0.1	<0.1	<0.1	<0.1	0.3	5	0	0
	Selenium	mg/kg				<1	<1	<1	<1	<1	0.5			
	Silver	mg/kg	0.1	1	3.7	**1.8**	**1.5**	**1.6**	**1.5**	**1.6**	**1.7**	0	5	0
	Vanadium	mg/kg	1.1			5	3	3	2	2	4.1			
	Zinc	mg/kg	0.5	200	410	<0.1	<0.1	<0.1	<0.1	<0.1	0.05	5	0	0
Total Petroleum Hydrocarbons														
	C6-C9	mg/kg	10-50			<2	<2	<2	<2	<2	<2			
	C10-C14	mg/kg	10-50			<50	<50	<50	<50	<50	<50			
	C15-C28	mg/kg	10-50			<100	<100	<100	<100	<100	<100			
	C29-C36	mg/kg	10-50			<100	<100	<100	<100	<100	<100			
Polychlorinated biphenyls														
	Total PCBs	µg/kg	5	23		<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5	0	0
Pesticides														
	pp'-DDD	µg/kg	5	2	20	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	5	0	0
	pp'-DDE	µg/kg	5	2.2	27	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	5	0	0
	pp'-DDT	µg/kg	5	1.6	46	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	5	0	0
	Total DDT+DDD+DDE	µg/kg				<0.50	<0.50	<0.50	<0.50	<0.50	<0.50			
	Dieldrin	µg/kg	5	0.02	8	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	5	0	0
	alpha-Chlordane	µg/kg	5	0.5	6	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	5	0	0
	gamma-Chlordane	µg/kg	5	0.5	6	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	5	0	0
	Lindane	µg/kg	5	0.32	1	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	5	0	0
	Endrin	µg/kg	5	0.02	8	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	5	0	0
	alpha-BHC	µg/kg	5			<0.50	<0.50	<0.50	<0.50	<0.50	<0.50			
	beta-BHC	µg/kg	5			<0.50	<0.50	<0.50	<0.50	<0.50	<0.50			
	delta-BHC	µg/kg	5			<0.50	<0.50	<0.50	<0.50	<0.50	<0.50			
	Aldrin	µg/kg	5			<0.50	<0.50	<0.50	<0.50	<0.50	<0.50			
	alpha-Endosulfan	µg/kg	5			<0.50	<0.50	<0.50	<0.50	<0.50	<0.50			
	beta-Endosulfan	µg/kg	5			<0.50	<0.50	<0.50	<0.50	<0.50	<0.50			
	Endosulfan sulphate	µg/kg	5			<0.50	<0.50	<0.50	<0.50	<0.50	<0.50			
	Endrin Ketone	µg/kg	5			<0.50	<0.50	<0.50	<0.50	<0.50	<0.50			
	Heptachlor	µg/kg	5			<0.50	<0.50	<0.50	<0.50	<0.50	<0.50			
	Heptachlor epoxide	µg/kg	5			<0.50	<0.50	<0.50	<0.50	<0.50	<0.50			
	Methoxychlor	µg/kg	5			<0.50	<0.50	<0.50	<0.50	<0.50	<0.50			
Polycyclic Aromatic Hydrocarbons														
	Acenaphthene	µg/kg	10	16	500	<10	<10	<10	<10	<10	<10	5	0	0
	Acenaphthylene	µg/kg	10	44	640	<10	<10	<10	<10	<10	<10	5	0	0
	Anthracene	µg/kg	10	85	110	<10	<10	<10	<10	<10	<10	5	0	0
	Fluorene	µg/kg	10	19	540	<10	<10	<10	<10	<10	<10	5	0	0
	Naphthalene	µg/kg	10	160	2100	<10	<10	<10	<10	<10	<10	5	0	0
	Phenanthrene	µg/kg	10	240	1500	<10	<10	<10	<10	<10	<10	5	0	0
	Low Molecular Weight PAH's	µg/kg	10	552	3160	NA	NA	NA	NA	NA	NA	5	0	0
	Benzo[a]anthracene	µg/kg	10	261	1600	<10	<10	<10	<10	<10	<10	5	0	0
	Benzo[a]pyrene	µg/kg	10	430	1600	<10	<10	<10	<10	<10	<10	5	0	0
	Benzo[b]fluoranthene	µg/kg	10			<10	<10	<10	<10	<10	<10			
	Benzo[k]fluoranthene	µg/kg	10			<10	<10	<10	<10	<10	<10			
	Benzo[ghi]perylene	µg/kg	10			<10	<10	<10	<10	<10	<10			
	Dibenzo[ah]anthracene	µg/kg	10	63	260	<10	<10	<10	<10	<10	<10	5	0	0
	Chrysene	µg/kg	10	384	2800	<10	<10	<10	<10	<10	<10	5	0	0
	Fluoranthene	µg/kg	10	600	5100	<10	<10	<10	<10	<10	<10	5	0	0
	Indeno[123-cd]pyrene	µg/kg				<10	<10	<10	<10	<10	<10			
	2-methylnaphthalene	µg/kg	10	70	670	<10	<10	<10	<10	<10	<10	5	0	0
	Pyrene	µg/kg	10	665	2600	<10	<10	<10	<10	<10	<10	5	0	0
	High Molecular Weight PAH's	µg/kg		1700	9600	NA	NA	NA	NA	NA	NA	5	0	0
	Total PAH	µg/kg		4000	45000	NA	NA	NA	NA	NA	NA	5	0	0
TOC		%	0.005			0.11	0.06	0.07	0.06	0.06				

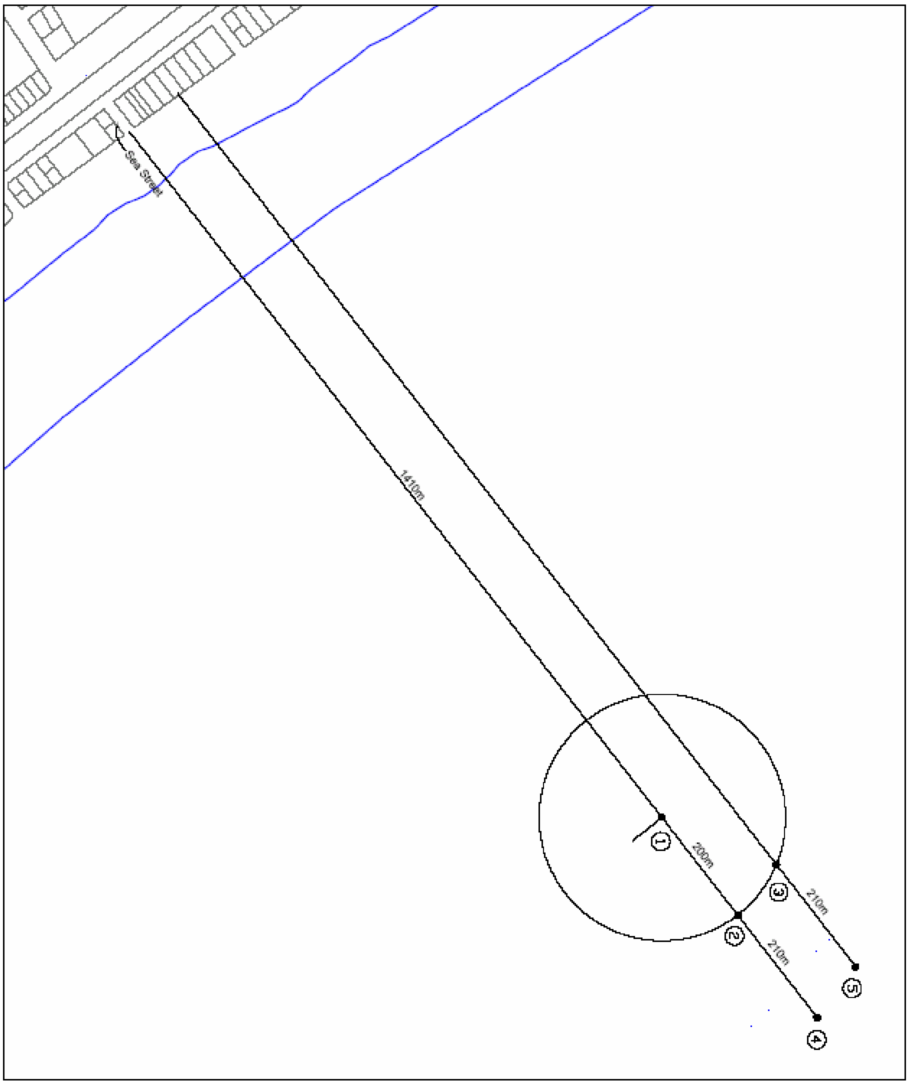
13.2 Study Area

For the purposes of the Marine Ecology and Water Quality Impact Assessment, the study area is defined as extending from Currumbin Creek in the north, to Point Kirra in the south, west to the water interface with the beaches of Tugun and Bilinga, and east to approximately the 33 m depth profile where rocky reef is known to occur (18 Fathom Reef). This area is broadly represented in **Figure 13-3 Marine Environment Study Area**.



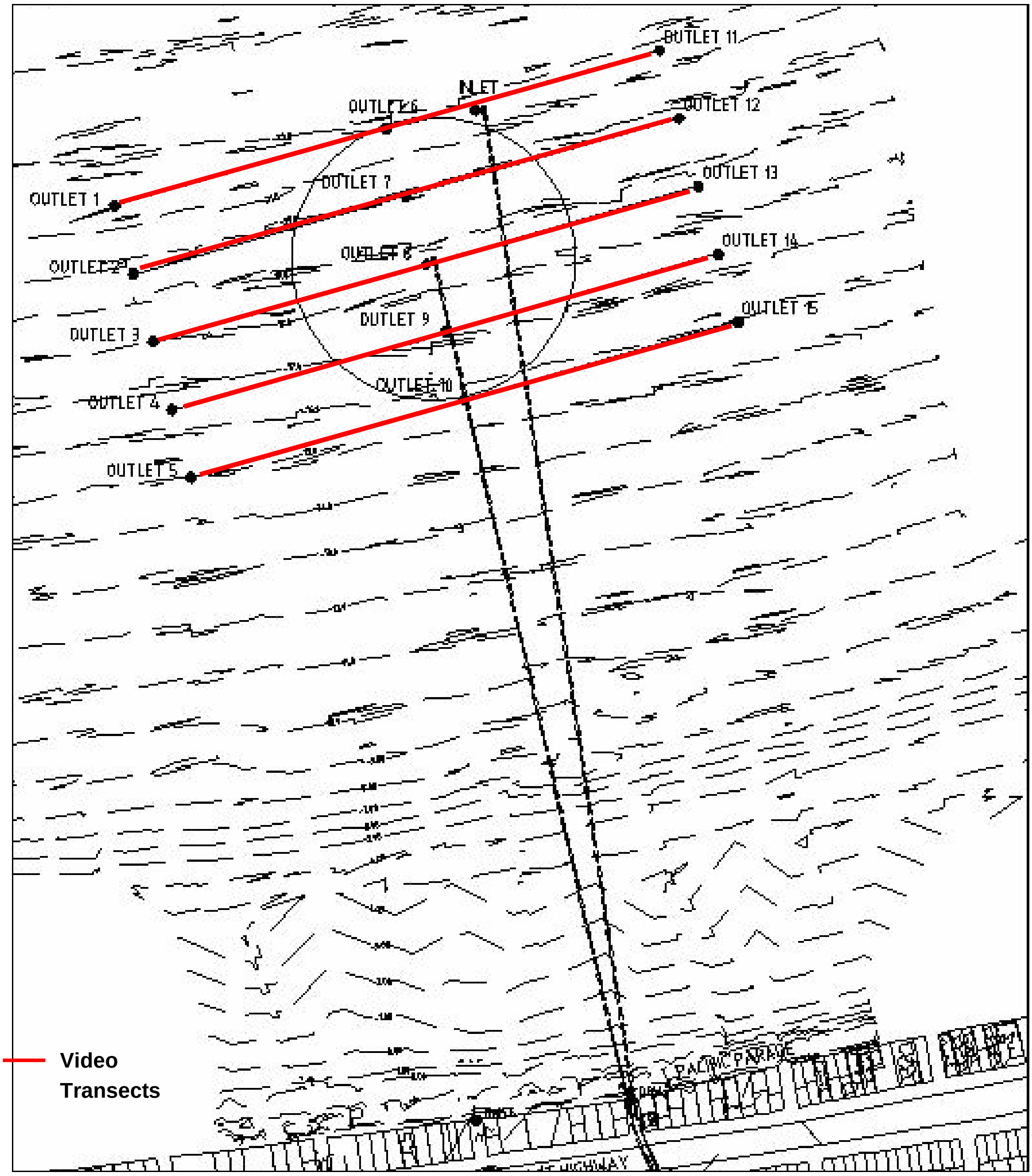
■ **Figure 13-3 Marine Environment Study Area**

Two field surveys were conducted to gather site specific information regarding sediment quality, benthic infauna (living in the top 10 cm of the sea bed) and benthic epifauna communities (living at the seabed surface). The first field survey was conducted in February 2006 in relation to the initial 55 ML/day project design, which incorporated one intake riser and four possible outlet riser locations. **Figure 13-4 Location of February 2006 Marine Survey and Study Sites** identifies the five study sites that were assessed, which correspond to these potential riser sites.



■ **Figure 13-4 Location of February 2006 Marine Survey and Study Sites**

The second site survey was undertaken in June 2006 to more broadly survey the marine environment due to the increase in plant size and brine discharge and the change in location of the single outlet point. Six study sites were assessed, which corresponded to the intake and outlet riser points, and four sites arranged around the outlet at 200 m and 400 m (**Figure 13-5 Location of June 2006 Marine Survey and Study Sites**). These sites are arranged within a 400 m wide x 800 m long survey grid, over which video transects were recorded.



■ **Figure 13-5 Location of June 2006 Marine Survey and Study Sites**

13.3 Potential Impacts – Water Quality

Potential impacts to water quality and marine ecology from the discharge of brine relate primarily to:

- Increase in salinity;
- Decrease in dissolved oxygen; and
- Increase in heavy metals.

These potential impacts are most pertinent to the benthic habitat as at certain concentrations, these could result in:

- Toxicity to benthic fauna from salinity;
- Suffocation of in-fauna, due to a decrease in dissolved oxygen;
- Changes to fauna abundance, diversity and community composition where tolerant species dominate sensitive species;
- Release of sediment-bound metals to the water column; and
- Release of nutrients to the water column, which could stimulate plant growth.

13.3.1 Salinity

The brine discharge is calculated to have a maximum salinity of 67 PSU (=ppt = g/L), resulting from a 1.8-1.9 times concentration of seawater during the reverse osmosis process. This is the expected concentration under the typical operating scenario of 100% duty plus treated backwash water, which is anticipated to be the level of operation more than 90% of the time.

An iterative process of outlet diffuser design and modelling has resulted in the preferred design being an eight-port outlet diffuser manifold of 185 metres in length (**Section 3.6**). Near-field modelling demonstrates a sustainable, high level of dilution of 71 times under typical operating condition of 100% plant duty plus backwash water, with virtually no cross plume interaction (refer **Table 13-2**). Under worst-case scenario of 33% duty plus make-up water (to maintain volume for water for diffuser efficiency) or 66% duty, a 40 times dilution would be effected at the boundary of the mixing zone (refer **Table 13-2**).

The position of the mixing zone would be dynamic around the diffuser depending on the strength and direction of current movements, therefore the mixing zone may not remain centred on the diffuser manifold at all times. The calculations do not account for current and therefore any current/wave/tidal activity that is present at the site, will increase the noted dilution factors.

- **Table 13-2 Brine Discharge Dilution and Salinity within Near-field**

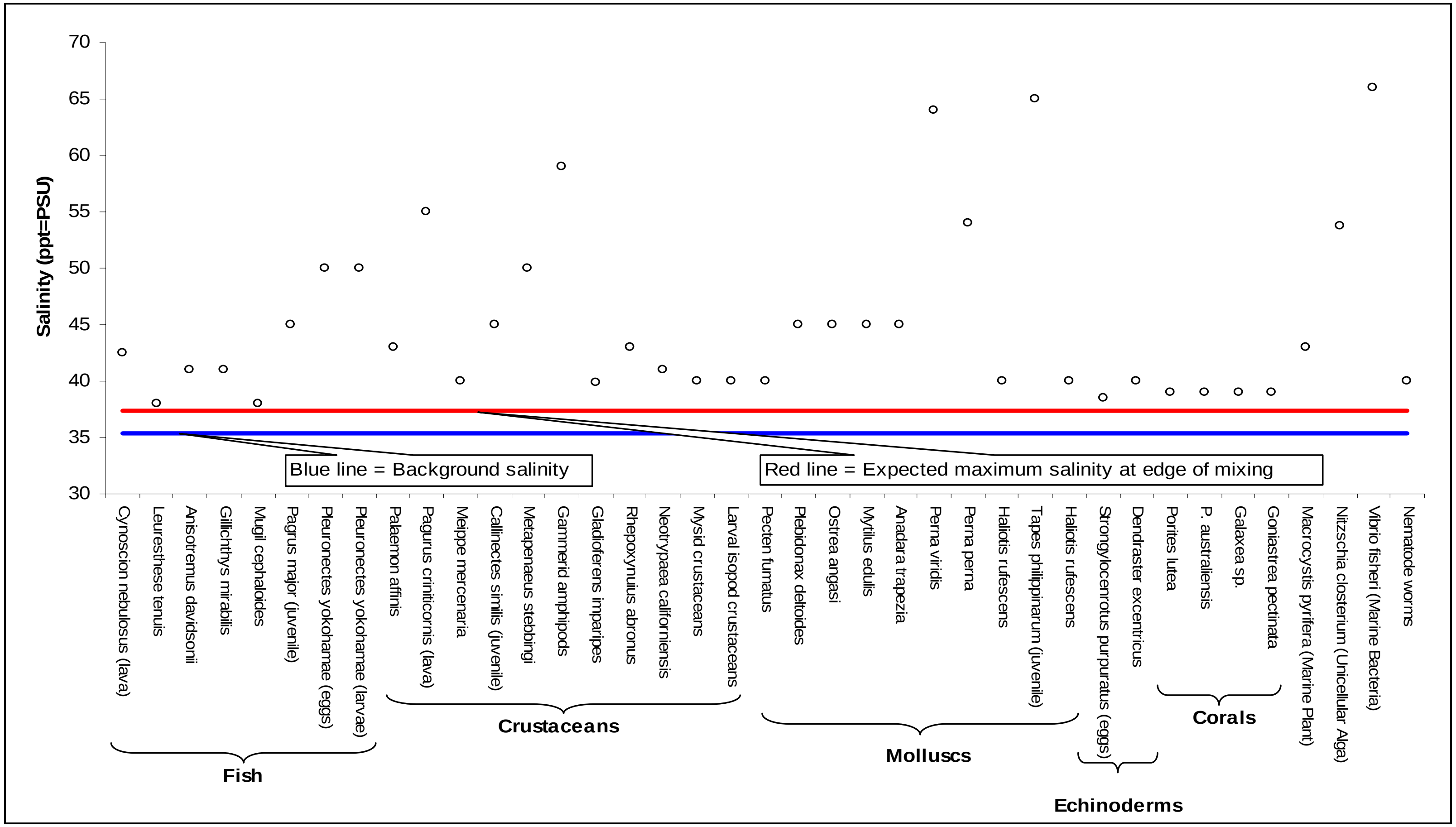
Duty	Minimum Dilution Factor	Salinity Level (PSU=PPT=G/L)
Brine 33% duty + makeup water	40	36.01
Brine 66% duty	40	36.26
Brine 100% duty	63	35.99
Brine 100% duty + backwash water	71	35.94

Source: GCDA 15 September 2006.

Modelling of diffuser plumes indicates that individual plumes will result in a maximum impact circle diameter of 43 m and a dilution plume impact point at 16 m from the diffusers. Based on this, the predicted near-field mixing zone is expected to be about 120 m wide and 225 m long, centred on the outlet manifold (**Figure 3-12**). Allowing for error in the model calculations, it is expected that salinity at the sediment surface at the boundary of the mixing zone will not exceed 2 ppt above background (i.e. 37.5 ppt compared with background salinity of 35.5 ppt) under any operational scenario.

Review of literature demonstrates that most aquatic organisms can readily tolerate salinities above 40 ppt (refer **Figure 13-6 Salinity Tolerances / Sensitivities for a Range of Marine Organisms**). However, the most sensitive fauna were noted to tolerate only about 38 ppt before physical impacts began to occur (e.g. fish pro-larvae [Californian grunion] and sea urchin egg development). Consequently, it is expected that no benthic fauna beyond the 225 m x 120 m mixing zone will be impacted by salinity increases, which are expected to remain less than 37.5 ppt (**Figure 3-14 Mixing Zone**).

It is similarly expected that impacts on benthic marine organisms will not occur within the mixing zone. This is because there is a minimum of 25 fold dilution predicted to occur at the dilution impact point within the mixing zone under any proposed operating scenario. This minimum dilution is calculated to result in a salinity of 36.23 ppt, which is still below the conservatively adopted 38 ppt sensitivity level. A dilution factor of less than 10 would be required to result in salinity levels above 38 ppt. This low level of dilution will not result under any proposed operating scenario for the Desalination Plant.



▪ Figure 13-6 Salinity Tolerances / Sensitivities for a Range of Marine Organisms

13.3.2 Dissolved Oxygen

Dissolved oxygen is critical to sediment biogeochemical processes and the respiratory processes of aquatic fauna.

Different benthic in-fauna have different tolerances to low dissolved oxygen levels. Should low dissolved oxygen levels occur, the following impacts could result:

- Reduced diversity of taxa present due to the dominance of low dissolved oxygen tolerant and / or hypersaline tolerant organisms; and
- Modification of benthic community structure.

Oxygen becomes less soluble in seawater with increased temperature and salinity. It is estimated that the brine discharge will be approximately 1-2°C above background level when it enters the tunnel and be less than this when it enters the sea at the outlet. It will also have a maximum salinity of 67 ppt. It is calculated that this could result in a lowering of DO in the brine discharge by 1.5-2.0 mg/L, depending on the background level.

In addition to this, dissolved oxygen concentrations in the brine will occasionally be further reduced through the use of chemicals (sodium bisulphite, SBS) to neutralise cleaning chemicals and chlorine dosing. It is expected that SBS dosing would reduce dissolved oxygen levels by another 0.5 mg/L during the estimated 1.5 hours cleaning each day. It is possible then that in the worst-case times, the gross dissolved oxygen decrease due to the effects of temperature, salinity, and chemical neutralisation, could be about 2-2.5 mg/L

Alliance process engineers estimate that under these worst-case conditions (i.e. during summer when temperatures are highest at about 28°C and dissolved oxygen levels in ambient waters are lowest at about 6.5 mg/L), oxygen levels in the brine discharge at the discharge point will most likely be 4.4 mg/L.

A theoretical worst case of 3.4 mg/L was also developed based on an ambient dissolved oxygen level of 5.9 mg/L, which was derived from a table of dissolved oxygen values for different salinities and temperatures and applying a 95% saturation.

Dilution based calculations for these worst-case scenarios have been undertaken by the Alliance. (14 September 2006, for process engineers worst-case) and Natural Solutions (for theoretical worst case), the results of which are summarised in **Table 13-3**. These calculations demonstrate the large influence of dilution from the diffusers, with resulting concentrations being less than 0.1 mg/L below ambient water dissolved oxygen levels. Sensitivity testing of the model using anoxic (0 mg/L DO) discharges, resulted in mixing zone boundary concentrations of only 0.2 mg/L below ambient.

Review of literature indicates that an indicative for the lower dissolved oxygen limit for having no respiratory effects on marine fauna is 2 mg/L, while the level causing oxygen stress is 1 mg/L Diaz & Rosenberg (1995).

Without any dilution of the discharge by the receiving waters, the dissolved oxygen concentration of the discharge compares favourably with the dissolved oxygen levels presented by Diaz & Rosenberg (1995). The effect of dilution on the discharges ensures that dissolved oxygen levels remain close to ambient and well above levels that could cause oxygen stress to marine fauna.

- **Table 13-3 Summary of Dissolved Oxygen Concentrations at Mixing Zone Boundary for Different Operating and Worst-case Scenarios**

Scenario	Brine concentration (mg/l)	Ambient concentration (mg/l)	Dilution factor	Resultant concentration of DO (mg/l)
Alliance process engineers expected worst case discharge of 4.4 mg/L into ambient DO concentration of 6.5 mg/L				
33% duty with make-up water/ 66% duty	4.4	6.5	40	6.45
100% duty plus backwash water (typical operating scenario)	4.4	6.5	71	6.47
Theoretical worst case discharge of 3.4 mg/L into ambient DO concentration of 5.90 mg/L (95% saturation of 6.22 mg/L at 30°C and 35 ppt)				
33% duty with make-up water/ 66% duty	3.4	5.90	40	5.84
100% duty plus backwash water (typical operating scenario)	3.4	5.90	71	5.87
Sensitivity testing release of anoxic discharge (0 mg/L) into ambient DO concentration of 5.90 mg/L (95% saturation of 6.22 mg/L at 30°C and 35 ppt)				
33% duty with make-up water/ 66% duty	0	5.90	40	5.76
100% duty plus backwash water (typical operating scenario)	0	5.90	71	5.82

These calculations indicate the Dissolved Oxygen levels are unlikely to fall to levels which will cause any stress on any marine organisms.

While the receiving marine environment is expected to remain well-oxygenated, a number of assumptions have been made in the modelling and it is prudent to verify that dissolved oxygen levels to not become depleted, so monitoring of dissolved oxygen levels will be undertaken.

13.3.3 Antiscalant

There are two different antiscalants that the Alliance may use in the desalination process:

- PermaTreat PC-1020T; and
- Hypersperse MDC220.

The antiscalant PermaTreat PC-1020T, which is not classified as hazardous by the National Occupational Health and Safety Commission (NOHSC), is broadly characterised in the Material Safety Data Sheet (**Appendix 13**) as having "low potential for environmental hazard", however no toxicity studies have been conducted on this product to support this statement.

Hypersperse MDC220 is a blend of caustic and phosphoric acids. Toxicity information provided on the Material Safety Data Sheet for Hypersperse MDC220 (**Appendix 13**) indicates that the antiscalant has no acute effect on fish (as represented by Fathead Minnow) at concentrations of 5,000 mg/L following exposure for 96 hours. Similarly no effect was found on the invertebrate crustacean Daphnia following exposure at 1,540 mg/L for a duration of 48 hours

The expected maximum antiscalant concentration (Hypersperse) in the brine stream is 4.7 mg/L. Therefore, in the immediate near-field mixing zone, 4.7 mg/L would not be exceeded and antiscalant concentrations would rapidly reduce via efflux dilution. When the expected minimum 40-fold dilution in the near-field is applied to this initial 4.7 mg/L it would be expected that the benthic organisms in the lower water column would be exposed to less than 0.2 mg/L (i.e. at the edge of the mixing zone). Based on the above toxicology data it is predicted with a high degree of confidence that projected antiscalant concentrations at and around the Desalination Plant outlet will be well below concentrations that elicit any biological effects.

13.3.4 Metals

The reverse osmosis process results in the concentration of ions, which in most other plants around the world, are retained in the brine concentrate and returned to the marine environment. These ions include metals that occur naturally in seawater and are not toxic to fauna at background levels or below levels of environmental concern. Further, residual iron from the addition of ferric sulphate as a coagulant in the pre-filtration process may occur in the brine discharge, contributing less than 70 kg/day to the marine environment as Fe(OH)3.

A large proportion of metals taken into the Gold Coast Desalination Plant in seawater will be retained in sludges for land-based disposal and hence not be returned to the marine environment. This is a significant improvement in plant operational design compared with other plants around the world.

The small amounts of residual metals that may remain in the brine discharge are likely to become adsorbed to any fine particulate matter in the brine stream or in the receiving sea water and settle to the seabed. Theoretically, these could function independently or synergistically to cause changes to benthic communities, particularly if DO levels become anoxic and metals are released from the sediments. However, the release of metals in bioavailable forms is not expected to occur as dissolved oxygen modelling under worst-case scenario indicates that levels will be much higher than those required to release metals (i.e. anoxic conditions, <0.1 mg/L).

Therefore, no impact to the marine environment is expected from metals in the brine discharge given that a large proportion of metals will be retained in sludges for land-based disposal (and hence not be returned to the marine environment) and anoxic conditions are not expected because DO will not reduce to the extent necessary for this to occur. Consequently, monitoring for metals impacts is not proposed.

13.3.5 Nutrients

The desalination plant will add approximately 7 kg per day of nitrogen to the receiving marine environment. This additional nitrogen will be sourced from polymer dosing and is expected to be largely in inorganic nitrogen form. Results of calculations of inorganic nitrogen concentrations at the boundary of the 120 m x 225 m mixing zone demonstrate the high efficiency of the diffusers (refer **Table 13-4**), with concentrations being less than 7 % above background, even without further mixing beyond the mixing zone. Based on this, the addition of 7 kg per day of nitrogen from the desalination plant, will not be a significant source of nitrogen in the marine environment and no direct or indirect impact is expected to water quality.

- **Table 13-4 Calculated Inorganic Nitrogen Concentrations at the Edge of the Mixing Zone Resulting from Additional Nitrogen Loads**

Scenario	Brine concentration (g/L)	Median ambient concentration (g/L)	Dilution factor	Resultant Concentration (g/L)
33% duty with make-up water/ 66% duty	51	14	40	14.9
100% duty plus backwash water (typical operating scenario)	51	14	71	14.5

Note: Brine concentration = Ambient concentration of 14 μg/L + additional concentration of 37 μg/L.

Phosphorus and nitrogen can also be released from sediments under low dissolved oxygen conditions, although the mechanisms for release are different. As discussed in **Section 13.3.2**, modelling of dissolved oxygen levels indicates that anoxic or low dissolved oxygen conditions are not expected to occur within the brine discharge or in the marine environment following discharge. Dissolved oxygen levels at the edge of the mixing zone are expected to remain above 5 mg/L, therefore impacts relating to nutrients release are not expected to occur. Consequently, impacts arising from nutrient release from sediments are not expected to occur.

13.4 Potential Impacts - Fish, Fish Habitat Areas and Fisheries

13.4.1 Construction

No Fish Habitat Areas (FHAs) are present in marine area in the vicinity of the proposed intake or outlet risers, or within the project area generally. The nearest Fish Habitat Area to the proposed site is located within Currumbin Creek, about 5 km north of the intake/outlet sites. The construction of the inlet and outlet structures will have only very localised physical impacts (limited to tens of metres) and will not extend to the FHA.

Construction of the intake and outlet riser structures will result in only very localised disturbance of sediments when the seabed is penetrated by the drilling equipment and during installation of the diffusers. This would result in localised mortality of benthic infauna (primarily sessile fauna such as molluscs, crustaceans and worms) directly disturbed by the drilling activity. The area of potential drilling impact for the intake and outlet diffuser risers is estimated to be no more than about 10m x 10m at both the intake and outlet riser sites. Further minor sediment disturbance may occur when the outlet manifold pipe is positioned on the seabed. Impacts from these low levels of disturbance will be negligible and there is relatively low environmental value attached to this sand substrate.

Construction of the intake and outlet structures may create noise that could result in skittish fish species temporarily avoiding the area until construction is completed. As with all seabed protrusions, the development of the intake and outlet riser structures is likely to increase the presence of some fish species. Based on commercial fishing catches (refer **Appendix 13**), the project area does not currently represent a highly valuable fishing ground to the fishing industry, so impacts to fisheries are expected to be relatively minor.

13.4.2 Operation

The intake of seawater and discharge of brine concentrate is unlikely to have any significant impact on fish or fisheries and will not impact on declared Fish Habitat Areas (FHAs).

Fish Attraction to Intake and Outlet Risers

It is possible that fish may be attracted to the intake and outlet risers protruding above the substrate because they will be a point of difference to the area that is characterised by bare sandy habitat with no significant features. The slight increase in salinity and jetting water will probably act as a distractor to the fish. Monitoring to provide base line data and an ongoing program to determine whether there are changes in the regime, will be implemented.

Fish Entrainment in Intakes

As discussed in **Section 3.6**, the intake has been designed to minimise the potential for marine life entrainment and impingement at the intake screens by sizing to achieve low approach water velocities at around 0.05m/s, generally less than ambient sea currents in the area. The proposed design is based on an intake head that combines maximum intake water efficiency with reduced potential for marine life entrainment and impingement.

The Alliance will monitor the entrainment rates of marine organisms as part of its Operational Environmental Management Plan. Flexibility has been designed into the intake structure and if ever entrainment rates become an issue a review of the intake performance and design will be undertaken.

Barrier to Fish Movement

The discharge of brine would not represent a barrier to fish movement. Modelling of the brine plume demonstrates that the dense saline waters would initially jet up toward the water surface and then sink under gravity to the seabed. The conservative projected extent of the mixing zone for the brine discharge is 120 m x 225 m at the seabed surface and the lateral extent of the mixing zone in the upper portion of the water column would be significantly narrower than this. Consequently, the brine discharge occupies only a small proportion of the water column, particularly in the upper layers, so the possible extent of barrier to fish movement is minimal.

Marine Mammals

Marine mammals (whales, dolphins or Dugong) are unlikely to be impacted by the construction of the intake or outlet risers or the release of brine discharge. These fauna are large and very mobile and can actively avoid areas of disturbance. The area does not represent significant habitat or feeding grounds to these species.

As discussed in **Section 1.2.6**, the DEH determined that the project was not a 'controlled action', provided that the action was undertaken in accordance with the specified manner. The Department of the Environment and Heritage did specify, however, that precautionary measures should be undertaken during construction of the intake and outlet pipes to minimise potential impacts on Humpback whales should construction coincide with the migration period (May-October) for this species. It is only during the driving of the outer caison, that any sonic impact might potentially occur to marine mammals and this will be limited to a short period – less than a week of activity at each of the intake and outlet riser sites.

Barrier to Benthic Fauna Distribution

A concern was that the brine plume may represent a barrier to benthic fauna and dispersal of juvenile fauna, particularly along a perceived depth-related dispersal corridor around 20 m depth.

The presence of brine within the expected mixing zone is unlikely to present any barrier to benthic fauna distribution. Benthic organisms, along with many fauna in the ocean, commonly reproduce and distribute spatially using pelagic life-stages, since currents can carry gametes and larvae significantly further than individual motility across the seabed. Further, as discussed in **Section 13.3.1**, a relatively small mixing zone of about 120 m x 225 m is predicted, largely due to the efficient dilution design of the outlet manifold. This mixing zone represents a small spatial area, even at the local scale, and so it is not expected to present a barrier to movement.

13.5 Mitigation and Management

The following provides a brief overview of the management measures to be implemented in order to minimise any potential impacts on the marine environment. Environmental Management Plans have been prepared for the construction and operational phase of the project and are attached in **Appendix A CEMP**.

Construction

Construction activities in the marine environment are expected to take approximately seven months, with construction timing of May – December to take advantage of seasonally calm weather and reduce construction safety risk from significant weather events.

Potential impacts to water quality and marine ecology during the construction phase of the Gold Coast Desalination project are not predicted to be significant due o the following:

- construction impacts will be limited in extent and associated only with the drilling and installation of the risers into the underground tunnels. There is not likely to be any impact from spillage of excavated waste because of the way of containment of this material in a barge and remote disposal of the material;
- the seabed in the construction area is open sandy substrate, lacking significant environmental habitat value; and
- the environmental precautionary measures that are attributed to the Riser Construction (as outlined in the Construction EMP).

Operation

Historically, the commissioning phase of desalination plants has had the potential to impact on the environment, particularly through the discharge of wastewaters containing fines from pre-filter media (commonly anthracite).

The Alliance proposes to process the commissioning wastewater from the pre-treatment filters at the Plant in order to capture solids, so that they are not discharged to the ocean with the return brine flow. The captured solids will then be disposed of at an appropriate landfill, or another approved method. This process will carry through to post-commissioning operation of the plant where wastewater from the pre-treatment filters and lime sludge will continue to be processed on-site to capture solids and dispose of these to an appropriate off-site repository.

Potential impacts on water quality and marine ecology relating to the operation of the desalination plant relate primarily to the release of brine discharge that is about 1.9 times the concentration of seawater (for salts and trace elements) and has slightly decreased oxygen levels. Impacts from antiscalants are not expected. The impact on the receiving water from brine discharge is likely to be relatively minor, primarily due to the 40 - 71 times dilution that would occur through the mixing effects of the outlet diffusers.

Key considerations for benthic communities relate to the establishment of stratification above the substrate due to salinity differences between the brine plume and overlying water. While this scenario is not predicted, this could lead to oxygen depletion, organism intolerance to increased salinity concentrations, release of metals and nutrients and changes to benthic community structure. Therefore the Alliance is committed to implementing a regular monitoring program to maintain records on any changes to the marine environment – both water quality and ecological biodata. The proposed program has already been implemented with the first collection run occurring in October 2006. This will continue throughout the construction and Operational life of the project at regular intervals. The program is detailed in **Appendix 13 Marine Monitoring Program.**