Bunbury: Proposed ocean outlet for treated wastewater

Public Environmental Review Document

WATER CORPORATION

BUNBURY

PROPOSED OCEAN OUTLET FOR TREATED WASTEWATER

PUBLIC ENVIRONMENTAL REVIEW DOCUMENT

Prepared for:

WATER CORPORATION OF WESTERN AUSTRALIA

Prepared by:

D.A. LORD & ASSOCIATES PTY LTD

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ENVIRONMENTAL PROTECTION AUTHORITY
INVITATION TO MAKE A SUBMISSION

The Environmental Protection Authority (EPA) invites people to make a submission on this proposal.

The Water Corporation of Western Australia (Water Corporation) proposes to dispose of treated wastewater from the Bunbury Wastewater Treatment Plant (WWTP) to the ocean a distance of 1.7 km offshore from the coast adjacent to the WWTP. In accordance with the Environmental Protection Act, a Public Environmental Review (PER) document has been prepared which describes the proposal and its likely effects on the environment. The PER is available for a public review period of 8 weeks from **16 October 2000** closing on **11 December 2000**.

Comments from government agencies and from the public will help the EPA to prepare an assessment report in which it will make recommendations to Government.

Why write a submission?

A submission is a way to provide information, express your opinion and put forward your suggested course of action - including any alternative approach. It is useful if you indicate any suggestions you have to improve the proposal.

All submissions received by the EPA will be acknowledged. Submissions will be treated as public documents unless provided and received in confidence subject to the requirements of the Freedom of Information Act, and may be quoted in full or in part in the EPA's report.

Why not join a group?

If you prefer not to write your own comments, it may be worthwhile joining with a group interested in making a submission on similar issues. Joint submissions may help to reduce the workload for an individual or group, as well as increase the pool of ideas and information. If you form a small group (up to 10 people) please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

Developing a submission

You may agree or disagree with, or comment on, the general issues discussed in the PER or the specific proposals. It helps if you give reasons for your conclusions, supported by relevant data. You may make an important contribution by suggesting ways to make the proposal more environmentally acceptable.

When making comments on specific elements of the PER:

- Clearly state your point of view;
- Indicate the source of your information or argument if this is applicable; and
- Suggest recommendations, safeguards or alternatives.

Points to keep in mind

By keeping the following points in mind, you will make it easier for your submission to be analysed:

- Attempt to list points so that issues raised are clear;
- A summary of your submission is helpful;
- Refer each point to the appropriate section, chapter or recommendation in the PER;
- If you discuss different sections of the PER, keep them distinct and separate, so there is no confusion as to which section you are considering;
- Attach any factual information you may wish to provide and give details of the source; and
- Make sure any supporting information is accurate.

Remember to include:

- Your name;
- Address;
- Date; and
- Whether you want your submission to be confidential.

The closing date for submissions is: **11 December 2000**.

Submissions should be addressed to:

The Environmental Protection Authority
Westralia Square
141 St. George's Terrace
PERTH WA 6000

Attention: Ann Barter

PUBLIC ENVIRONMENTAL REVIEW PREPARATION

This PER has been prepared by the following organisations.

Project Directors

- *Water Corporation*: Project Management Branch.

Project Managers

- *GHD Pty Ltd.*

PER Production and Technical Managers

- *D.A. Lord & Associates Pty Ltd.*

Technical Consultants (in alphabetical order)

- *Alex Wyllie & Associates Pty Ltd*: Aerial image production for benthic habitat mapping;
- *Botany Department, University of Western Australia*: Benthic habitat mapping;
- *Centre for Water Research, University of Western Australia*: Phytoplankton ecology and productivity study;
- *Consulting Environmental Engineers (Victoria)*: Conceptual design advice;
- *D.A. Lord & Associates Pty Ltd*: Coastal processes study and water quality reporting;
- *GHD Pty Ltd*: GIS services; coastal processes study; and, graphic design;
- *Halpern Glick Maunsell*: Numerical modelling study;
- *Marine and Freshwater Laboratory, Murdoch University*: Collection and analysis of samples for water and sediment quality studies;
- *Sinclair Knight Merz*: Sediment quality survey and periphyton growth surveys;
- *Water Corporation*: Engineering; bacteriological water quality data collection; public consultation; and, graphic design; and
- *WNI Science and Engineering*: Wave climate studies, current data collection, wind data collection and assistance on numerical modelling.

Copies of the technical reports produced in preparation of this PER are available from the Water Corporation on request. The reports can either be viewed at the Water Corporation or copies can be mailed out for the price of copying and postage.

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OVERVIEW

Bunbury is the administrative centre of Western Australia's South West region, the State's fastest growing region outside the Perth metropolitan area.

The Water Corporation of Western Australia (Water Corporation) treats all the wastewater from the sewered properties within Bunbury City wastewater catchment at the Bunbury wastewater treatment plant (WWTP). The plant has limited capacity to dispose of treated wastewater. This capacity will soon be exceeded due to the strong growth of the region and to additional sewerage connections under the Bunbury Infill Sewerage Program.

Since 1994, the Water Corporation has commissioned a number of studies and has consulted widely with the local community to develop a long-term strategy for wastewater disposal which fulfils community expectations and environmental requirements. This process found that the preferred option is wastewater reuse. Unfortunately, insufficient suitable land for woodlots and the lack of agricultural activities means year round irrigation is not viable. The Water Corporation proposed a strategy to use a combination of reuse and disposal to the ocean, where the amount reused would be maximised at every viable opportunity.

Since announcing the strategy, the Water Corporation commissioned a suite of scientific studies to establish the likely impacts of ocean disposal and the best location for an ocean outlet. These studies were used in preparing this Public Environmental Review (PER) document which details the proposal and its impacts. The purpose of the document is to allow the public to make comment on the proposal and to obtain approval from the Environmental Protection Authority (EPA).

BUNBURY WWTP

The Bunbury WWTP is located approximately 7 km south of Bunbury and is situated on the coast behind the foredunes, approximately 300 m east of the beach.

On average, the WWTP treats 6,600,000 L (6.6 ML) of wastewater a day from the 6,000 domestic and commercial sources. After treatment, the wastewater typically has the following characteristics:

Treated wastewater characteristics

PARAMETER	MEAN CONCENTRATION OR VALUE
Total Nitrogen (TN)	15 mg/L
Total Phosphorus (TP)	10 mg/L
Faecal coliform bacteria counts	100,000 cfu/100 mL
Suspended solids (SS)	30 mg/L
Biological oxygen demand (BOD_5)	20 mg/L

The plant also produces 350 tonnes of biosolids each year, which are trucked offsite and used by agricultural and horticultural enterprises as soil conditioner.

BUNBURY WWTP: FUTURE LOADING

It has been forecast that average flows to the Bunbury WWTP will increase to 16 ML/d by the year 2040. This increase is due to the continued development and population growth in the catchment and the implementation of the Bunbury Infill Sewerage Program.

CURRENT DISPOSAL PRACTICE

Following treatment, the wastewater is discharged to seven permeable lagoons on the WWTP site. The treated wastewater filters down through the sand into the groundwater and then joins the groundwater flowing to the ocean at shoreline. The infiltration through the sand acts to reduce coliform bacterial concentrations. Recent measurements show faecal coliform levels along the shore in this area of the order of 10–20 cfu/100 mL. These levels are well within the National guidelines for primary contact recreation. The nitrogen and phosphorus (nutrient) levels in the treated wastewater are higher than those found in the natural environment and the current disposal practice has resulted in elevated nutrient levels in the nearshore adjacent to the WWTP.

Studies modelling groundwater flows at the WWTP have shown that an increase in discharge above the current average of 6.6 ML/d has the potential to cause elevation of local groundwater levels to the extent that ponding may occur on the beach. It has been concluded that the lagoons are operating at, or near to, capacity and the ability of the plant to deal with any further increase in flows is constrained by the current disposal practice. The existing capacity constraints have not caused any significant environmental impacts.

PUBLIC CONSULTATION AND THE DEVELOPMENT OF THE BUNBURY DISPOSAL STRATEGY

The planning and development of Bunbury's sewerage system has involved close consultation with local government, key stakeholders and the community since the original Bunbury WWTP was constructed in 1963.

In 1992, the Water Corporation initiated the Wastewater 2040 study which involved extensive consultation with the communities from Australind, Eaton and Bunbury to determine the regional strategy for wastewater treatment and disposal.

The community expressed a preference for land disposal methods and the re-use of treated wastewater. In 1995, *Wastewater 2040: Strategy for the South West Region* was comprehensively reported to the community through local government, participating groups, individuals and the media.

In 1996, the Water Corporation initiated a major investigation of land disposal and reuse options for the Greater Bunbury area.

It was found that there were limited land disposal opportunities at Bunbury for the following reasons:

- Lack of land areas of sufficient size for woodlots;
- Lack of land in areas suitable for year-round reticulation as much of the surrounding land cannot accommodate reticulation due to high water tables and high winter rainfall;
- Lack of demand for agricultural irrigation outside summer months; and
- The sensitivity of many possible sites with respect to run-off of treated wastewater containing nutrients.

After further public consultation, a revised strategy was announced:

- Eaton and Australind – full land disposal and reuse, with treated wastewater pumped to Binningup to irrigate a blue gum plantation; and

- Bunbury – Summer irrigation of Hay Park using up to 3 ML/d with discharge of the balance of the flow to the ocean through an ocean outlet, with the overall aim of actively pursuing further options for reuse at Bunbury, including the supply of treated wastewater to industry if viable.

The Water Corporation has continued to engage the Bunbury community in the wastewater disposal strategy, by:

- Publicising the ocean outlet proposal in the local media;
- Conducting a random telephone survey of 300 Bunbury residents;
- Publishing advertisements in the local papers outlining the need for the strategy;
- Briefing 11 community groups on ocean disposal and re-use;
- Forming a local Community Reference Group (CRG) to advise the Water Corporation on appropriate community communication;
- Briefing key government stakeholders;
- Communicating with key target audiences through corporate sponsorship agreements;
- Providing a Keynote Address and a major display featuring the strategy at Bunbury's *World Environment Day 2000 Celebrations*;
- Delivering two brochures to 13,500 Bunbury households and businesses, in November 1999 and June 2000 respectively, informing residents of the ocean disposal proposal; and
- Producing the PER document which details the environmental impacts of the proposal and provides opportunity for additional public submissions.

PROPOSED OCEAN OUTLET

It is proposed to dispose of treated wastewater via an ocean outlet that will enter the sea adjacent to the existing Bunbury WWTP approximately 7 km south of Bunbury with the key characteristics as summarised below.

Key project characteristics

ELEMENT	DESCRIPTION
Tertiary treatment lagoons	Two lined lagoons designed to achieve bacterial levels in wastewater of <10,000 cfu/100 mL. These lagoons will be constructed in existing Lagoons 1 and 2.
Connecting pipeline	Wastewater from the lagoons will enter a 900 mm diameter pipeline which leads to the outlet pipeline. This pipeline will pass through the dunes between the lagoons and the dune blowout area.
Outlet pipeline	Pipeline dimensions: 610 mm outside diameter and 530 mm inside diameter. Buried under the beach and surfzone and then sitting on the seabed leading to the diffuser of 120 m length that starts 1.6 km offshore.
Outlet diffuser	Pipe section resting on seabed, 120 m long containing 30 ports. End of diffuser is 1.7 km offshore from mean high water.

Description of the project

1. WWTP Lagoons 1 and 2 will be drained, scraped and lined such that they become impervious. Secondary treated wastewater from the plant will be discharged to the lined lagoons to allow further polishing and reduction in bacterial levels.
2. A weir manhole will be constructed adjacent to Lagoon 1 to allow tertiary treated wastewater to flow by gravity from the two lagoons to the ocean outlet pipeline through a 900 mm outside diameter (OD) pipe.
3. An ocean outlet will be constructed, consisting of a 610 mm OD pipeline, heading offshore from the HWM at a bearing of 290° from the dune blowout north of the

WWTP. This will lead to a diffuser section 120 m long fitted with 30 ports which will have an 80 mm inside diameter. The diffuser will be located in approximately 11 m of water and end 1.7 km offshore.

4. The pipeline will be constructed through the blow-out foredune area and buried to a depth of at least 2 m across the beach and surf breaker zone.
5. Beyond the surf breaker zone, the pipeline will be laid on top of the seabed within ±20 m of the proposed alignment inshore and within ±50 m at the offshore end.

Aspects relating to management of the Bunbury WWTP

1. All flows from the WWTP not subject to reuse will be discharged to the ocean outlet within the foreseeable future, subject to the limitations listed below.
2. Annual average flows discharged via the ocean outlet will be limited to 16 ML/d with a peak flow forecast of 24 ML/d for the peak winter day.
3. Annual average TN discharged to the ocean will be limited to 60 tpa (approximately 160 kg/d average).
4. Bacterial levels in the treated wastewater will be reduced such that primary contact bathing criteria are met within 100 m of the diffuser.
5. The WWTP currently utilises two secondary treatment processes, a trickling filter plant and a more recently constructed intermittently decanted extended aeration (IDEA) plant. To ensure that the proposed annual TN load is not exceeded, the trickling filter plant capacity will be limited to 3.0 ML/d (80% of design capacity) and if required, the existing IDEA plant can be readily upgraded to increase its capacity from 5.4 ML/d to at least 6.2 ML/d while maintaining design performance levels.
6. In the event of a WWTP process breakdown or power failure, partially treated wastewater will continue to be directed to the lagoons and then to the outlet. In the event of a significant deterioration of treated wastewater quality over an extended timeframe (>24 hours), the existing effluent pumping station can be used to pump from Lagoon 1 and 2 to some of the remaining lagoons. This will allow cessation of discharge to the ocean outlet for approximately 48 hours. These contingency measures will be detailed in the Environmental Management Plan (EMP) to be developed for the project.

Aspects not part of this proposal

1. The Water Corporation will maximise wastewater reuse where practicable and environmentally acceptable.
2. The Water Corporation is currently developing a proposal to implement a direct wastewater reuse scheme based on providing irrigation to Hay Park.
3. It is planned to replace the trickling filter plant with a second module of the IDEA plant before average inflows exceed present licence capacity of 9.2 ML/d, the timing will depend on growth rates in the region.

TIMING

The anticipated schedule of events for the project is shown below.

Project timetable

EVENT	TIMING
PER document released for public comment	October 2000
Approval by Minister for the Environment	March/April 2001
Commence construction	June 2001
Commission ocean outlet	June 2002

The implementation of treated wastewater reuse to water Hay Park is scheduled to occur in the summer of 2001/02, however, this is dependent on obtaining EPA approval and the approval of the City of Bunbury and the Health Department.

EXISTING ENVIRONMENT

Before committing to construction of the outlet, the Water Corporation commissioned an integrated suite of scientific studies designed to establish the nature of the existing marine environment and determine the likely impacts of the ocean outlet. The key findings of the studies were:

- The seafloor in the region has a gentle slope offshore with occasional bands of limestone reef running parallel to the shore. A depth of 10 m generally occurs about 1.4 km offshore;
- The currents within 2 km of the WWTP are dominated by the wind, with some influence from larger scale dynamics (e.g. Leeuwin Current and Capes Current);
- The consistent wind and wave climate means the water is generally well mixed from top to bottom;
- The seafloor habitat contains an extensive mixture of algae-covered reef, seagrass on sand, and large bare sand patches, which were concentrated to the north-west of the WWTP;
- Summer and spring nitrogen and phosphorus concentrations in the water offshore of the WWTP were similar to or lower than those observed in Perth's coastal waters;
- Nutrient concentrations in the region peaked in winter and were lowest in summer, in a manner similar to that seen in Perth's coastal waters;
- The seafloor at Bunbury appears to be more productive than the seafloor at Perth, resulting in higher winter nutrient peaks and lower summer troughs;
- The water at the shoreline near the Bunbury WWTP had higher nutrient concentrations than Perth's shoreline waters — probably due to elevated nutrient concentrations in the groundwater resulting from discharge of treated wastewater to the lagoons and possibly also agricultural activity inland;
- Nitrogen is the nutrient limiting biomass growth in the marine ecosystem in summer, as has been found for Perth's coastal waters;
- A seasonal cycle in phytoplankton biomass was found, with a spring bloom in September/October. There appeared to be a direct link between the winter dissolved nitrogen peak and the spring peak in biomass;
- Higher phytoplankton and nutrient levels were found in water near the seafloor compared with water near the surface. This suggests a nutrient source at the seafloor, thought to be nutrient recycling from the seafloor ecosystem;
- The marine ecosystem was shown to be healthy, productive and diverse; and
- The metal and pesticide levels observed in the sediments and in the tissues of deployed mussels indicate that the sediments and waters in the vicinity of the proposed ocean outlet are clean.

ENVIRONMENTAL IMPACTS AND THEIR MANAGEMENT

Primary environmental issues

The primary environmental issues associated with the proposal are:

- The potential for nutrient enrichment of coastal waters;

- The potential for increased bacterial concentrations in coastal waters;
- The potential impact on the marine environment through installation of the undersea pipeline;
- The potential for contamination of sediments by heavy metals and organic chemicals;
- The disturbance and rehabilitation of coastal dunes;
- The potential effect on Tuarts of return of local groundwater to the levels seen prior to operation of lagoon disposal system; and
- The potential restriction of recreational activities in the vicinity of the discharge point.

Primary environmental impacts

The primary conclusions reached in undertaking the environmental impact assessment can be summarised as follows:

Groundwater
Groundwater quality in the vicinity of the WWTP should improve when the practice of disposal to the lagoons stops.

Coastal Processes
Once constructed, the pipeline will not have any visual, environmental or physical impact on the beach. The dune blowout area will be revegetated and stabilised. The return to natural groundwater levels in the vicinity will reduce the risk of erosion of the upper beach during winter storms.

Terrestrial Flora and Fauna
The project will not have a significant impact on terrestrial flora and fauna. Additional natural habitat will be created following rehabilitation of the foredune and dune blowout area.

The proposal to stop using the lagoons for wastewater disposal will result in local groundwater levels dropping to natural levels. As large trees in the vicinity may have adapted to the higher water levels, the Water Corporation will determine an acceptable rate for water level reduction to minimise any stress on nearby trees.

Recreation
The sand dune blowout is used by off-road vehicles, this is exacerbating the erosion problem. The blowout area will be revegetated and access to off-road vehicles will be restricted.

The area offshore contains known recreational crayfishing locations. The project will not impact on these locations and 1.7 km of pipeline and diffuser, which will be mostly above the seabed, will provide additional habitat.

Near the shoreline the pipeline will be buried 2–3 m below the beach and surf zone and will not be visible from the beach.

Water Quality
After release near the seabed, the plume will follow the ambient currents which generally run parallel to the coast. The operation of the outlet will not have an impact on the water quality at the beach and recreational bathing criteria will be met within 100 m of the diffuser.

The very small amount of suspended material in the treated wastewater will consist of very fine particles which have not settled out in the three phases of treatment at the WWTP. By the time the plume rises to the surface, concentrations of suspended material will be similar to those found naturally in the ocean.

The annual load of dissolved inorganic nitrogen (DIN: the biologically available form of nitrogen) to the ocean from the Bunbury outlet will be less than one tenth the load of DIN any one of the Perth Metropolitan outlets and approximately one third of the load of DIN from the Leschenault Inlet.

Under summer conditions, upon discharge, wastewater will typically remain within 500 m of the diffuser for four hours and be diluted by a factor of up to 1:1000 in this time. The rapid dilution and advection of the plume means that a measurable increase in productivity in the water column (and associated potential for algal blooms) is unlikely. The nutrient concentrations along the shoreline in front of the WWTP should improve when the lagoons are decommissioned

The project will not have any impact on the wider marine environment (i.e. Geographe Bay).

Environmental Values and Objectives
In accordance with the scheme developed in the EPA working document, 'Perth's Coastal Waters: Environmental Values and Objectives', environmental quality objectives (EQOs) have been designated for the region impacted by the diffuser.

Although primary contact criteria will generally be met in the surface waters above the diffuser, the Water Corporation will designate the area within 100 m of the diffuser as unsuitable for swimming. As this area is not used for swimming and is not a local recreational dive site, the impact on recreational amenity will be negligible.

The diffuser is not located in an area used for recreational or commercial shellfish harvesting nor would harvesting occur in the surface waters affected by the plume. However, as a precaution the Water Corporation will designate the area within 500 m of the diffuser as unsuitable for harvesting of shellfish. This will have negligible impact on social amenity.

Although the proposal is considered unlikely to result in measurable change in productivity in the water column or on the seafloor adjacent to the diffuser, the surface water within 500 m of the diffuser over which nutrient concentrations in the plume are diluted to background levels will be designated as E3 (moderate level of ecosystem protection) as opposed to E2 (high level of ecosystem protection) which applies to the rest of the waters.

Marine Flora and Fauna
Approximately 0.1 hectare of existing marine habitat will be lost through construction of the pipe (the pipeline 'footprint'). However, the pipeline will provide a new habitat and experience with Perth's outlets has shown that the pipelines are rapidly colonised by flora and fauna generally associated with reefs, including crayfish.

The primary construction impact will occur if blasting is required to remove small sections of limestone reef. An advance warning blast will be used to scare off marine mammals and fish, however, there is likely to be adverse affects on marine fauna remaining within 20 m of the blast. Blasting will be undertaken only if mechanical excavation of reef is not viable.

The wastewater plume will not affect the ecological function, diversity or distribution of benthic flora or seagrasses or the marine fauna of the region.

KEY COMMITMENTS

The Water Corporation has made a number of commitments in this document which will become legally binding if and when the project is approved. Key commitments are:

- The Water Corporation will continue to investigate options for viable wastewater reuse at Bunbury;
- The Water Corporation will manage the WWTP to ensure maximum nitrogen load to marine environment is 60 tpa;
- The Water Corporation will prepare EMPs for the construction and operation phases of the project which will include monitoring, assessment and reporting of any impact;
- The Water Corporation will rehabilitate the beach, dune blowout and foredune after construction; and
- The Water Corporation will control groundwater levels to reduce stress on nearby trees.

ENVIRONMENTAL MANAGEMENT

The Water Corporation has already undertaken extensive environmental monitoring in the region. As part of their commitment to prepare an EMP for the development, they will design and implement an environmental monitoring and reporting program which meets the requirements of the Department of Environmental Protection (DEP). This program will include regular water and sediment quality monitoring as well as programs to ensure the health of the flora and fauna are not affected. If it is found that the operation of the outlet is causing an adverse impact on the ecosystem the Water Corporation will implement an appropriate scheme to prevent further impact in consultation with the DEP.

The table below summarises the environmental impacts and their management relative to the guidelines developed for the proposal by the EPA.

EPA FACTOR	EPA OBJECTIVE	EXISTING ENVIRONMENT	POTENTIAL IMPACT	ENVIRONMENTAL MANAGEMENT	PREDICTED OUTCOME
Recreation	Not to compromise recreational uses of the area, as developed by planning agencies. Protect the recreational value of the area consistent with EQOs 2, 3, 4, 5: Fishing and Aquaculture and Recreation and Aesthetics as defined in the Perth Coastal Waters - Environmental Values and Objectives (EPA, 2000).	The dune blowout area is currently used for recreation by four wheel drive enthusiasts and trail bike riders. The beach is traversed by four wheel drive enthusiasts moving between Bunbury and Dalyellup several kilometres south. The beach adjacent to the WWTP is occasionally used for swimming and recreational activities. The beach is not a surfing beach. The reefs offshore are targeted for fish and crayfish by recreational fishers.	Access to the dune blowout area for recreational vehicle use will be restricted. The operation of the outlet will result in an area within 500 m of the diffuser which will may not meet national criteria for shellfish harvesting. The operation of the outlet will generally result in primary contact criteria being met in surface waters above the diffuser. However, Water Corporation suggest that an area within 100 m of the diffuser is unsuitable for primary contact recreation.	The beach and dune system will be fully rehabilitated after construction in accordance with the construction of a EMP. The area is not used for shellfish harvesting, however, the Water Corporation will advertise the location of the affected zone in the local press. The location of the outlet will be marked in future editions of local navigation charts. The operations EMP will include a program of bacteriological monitoring around the diffuser designed to confirm the extent of the plume. The Water Corporation will operate the Bunbury WWTP plant such that designated Environmental Quality Objectives are met.	After construction the rehabilitated dune blowout area will not be used for recreational vehicle use. The beach will look the same as it did before the outlet was installed. The nearshore water quality will be improved by ceasing the practise of wastewater disposal to the rear of the foredunes. The designation of zones 1.7 km offshore where swimming, diving or harvesting of shellfish is unsuitable will not have a significant impact on the recreational amenity of the region as the proposed restriction affects a very small part of the area used by the public.
Public safety during construction	Maintain public safety during construction.	Combination of Water Corporation owned land (dune blowout), crown land (beach) and offshore waters.	Access to the dune blowout area for recreational vehicle use will be restricted during construction. Temporary restrictions will be placed on access to a small section of beach during construction.	The management of construction activities will be detailed in the Construction EMP submitted to the DEP for approval. Public access to the construction site will be prohibited for the duration of construction and rehabilitation. Marine equipment associated with the laying of the pipeline will be in full compliance with Department of Transport regulations.	Minor inconvenience for members of the public wishing to traverse the beach during the pulling of the pipeline out to sea over a period of several weeks.

EPA FACTOR	EPA OBJECTIVE	EXISTING ENVIRONMENT	POTENTIAL IMPACT	ENVIRONMENTAL MANAGEMENT	PREDICTED OUTCOME
Amenity	Ensure that the amenity of the area adjacent to the project should not be unduly affected by the proposal. Protect the aesthetical value of the area consistent with EQO 5: Perth Coastal Waters - Environmental Values and Objectives (EPA, 2000).	Coastal dune system bordering developing residential areas.	The project will not have any impact on the odour associated with the WWTP. The project will not affect the visual aesthetics of the area after commissioning is complete. The rehabilitation of the dune blowout area will improve visual amenity.	No management required for odour or visual amenity.	Visual amenity improved through rehabilitation of dune blowout. No impact on odour.
Road transport	Ensure that noise levels meet acceptable standards and that an adequate level of service, safety and public amenity is maintained. Ensure that the noise levels generated by the project meet acceptable standards. Ensure that noise and vibration levels meet statutory requirements and acceptable standards.	WWTP is accessed via sub-arterial road and unsealed track.	No significant impact on the local community arising from transport during construction. The construction and operation of the project will not result in noise levels above those currently experienced in adjacent residential areas.	The management of construction activities will be detailed in the Construction EMP submitted to the DEP for approval.	No significant impact.
Marine Flora (general)	Maintain the ecological function, abundance, species diversity and geographic distribution of marine flora locally and regionally.	Waters offshore support a diverse assemblage of algae and seagrass species on the seabed. The coverage is extensive and far ranging. The water column supports a population of phytoplankton, dominated by diatom species, considered typical of healthy marine waters.	The construction of the outlet will result in direct loss of approximately 0.1 ha of marine habitat. Operation of the outlet may result in slightly elevated productivity in the water column within 500 m of the diffuser under calm conditions.	Construction EMP submitted to the DEP for approval prior to construction. Management of construction activities will include implementing procedures to minimise disturbance of marine habitat. The quality of the water surrounding the diffuser will be monitored as will potential for epiphyte growth. The program for these activities will be detailed in the Operations EMP submitted to the DEP for approval prior to commissioning.	No significant loss of marine flora through construction activities. The pipeline will be colonised by species associated with reefs. Nutrient levels sufficient to stimulate epiphyte growth may occur in surface waters, but not near the seabed. Elevated phytoplankton growth is unlikely to be detectable under most conditions. No loss of benthic flora due to shading effects (by epiphytes and/or phytoplankton) is expected.

EPA FACTOR	EPA OBJECTIVE	EXISTING ENVIRONMENT	POTENTIAL IMPACT	ENVIRONMENTAL MANAGEMENT	PREDICTED OUTCOME
Marine Flora: Declared Rare and Priority Flora (specific)	Protect Declared Rare and Priority Flora, consistent with the provisions of the Wildlife Conservation Act 1950.	Intensive mapping of the area has been undertaken. No declared rare or priority marine flora are listed for the area.	There are no declared rare species.	No management required.	No impact.
Marine Flora: Seagrass and its habitat (specific)	Maintain the ecological function, abundance, species diversity and geographic distribution of seagrasses locally and regionally. Encourage the development and implementation of practical technical solutions for the rehabilitation of the environment. Refer to EPA Guidance Notes 22 and 29.	Waters offshore support significant quantities of seagrasses which are generally found on sandy substrate. There are seagrasses in the vicinity of the outlet, however, the outlet has been located to minimise disturbance to seagrass.	The construction of the outlet will result in direct loss of approximately 0.1 ha of marine habitat, which will include some seagrass. Operation of the outlet may result in slightly elevated productivity in the water column within 500 m of the diffuser under calm conditions.	Construction EMP submitted to the DEP for approval prior to construction. Management of construction activities will include implementing procedures to minimise disturbance of marine habitat. The quality of the water surrounding the diffuser will be monitored as will potential for epiphyte growth. The program for these activities will be detailed in the Operations EMP submitted to the DEP for approval prior to commissioning.	The construction of the pipeline will result in minor (<<0.1 ha) loss of seagrass. No impact on seagrasses. Nitrogen concentrations at levels sufficient to stimulate algal and epiphyte growth are not expected near the seabed.
Marine Flora: Algae and its habitat (specific)	Minimise interference with the process of nutrient and carbon cycling from algae. Maintain the ecological function, abundance, species diversity, productivity and geographic distribution of algae.	Waters offshore support an extensive and diverse assemblage of algae, this is generally found on limestone reef substrate.	The construction of the outlet will result in direct loss of approximately 0.1 ha of marine habitat which will include some algae. Operation of the outlet will result in slightly elevated productivity in the water column within 500 m of the diffuser under calm conditions.	Initially, no management required as monitoring of epiphyte growth and water quality adjacent to the diffuser will provide an indication as to whether changes in the benthic macroalgae community may occur. If monitoring suggests impacts are greater than expected, macroalgal monitoring may be undertaken following consultation with the DEP.	Experience with Perth's ocean outlets suggests that the operation of the outlet will not result in any impacts on macroalgae and that the outlet will be largely colonised by algae species. No impact on existing flora. Nitrogen concentrations at levels sufficient to stimulate macroalgal growth are not expected near the seabed (monitoring of Perth outlets has confirmed this).

EPA FACTOR	EPA OBJECTIVE	EXISTING ENVIRONMENT	POTENTIAL IMPACT	ENVIRONMENTAL MANAGEMENT	PREDICTED OUTCOME
Marine Fauna (general)	Maintain the abundance, species diversity and geographic distribution of marine fauna.	The region contains a diverse community of marine fauna. The ocean conditions and the habitat type in the vicinity of the outlet are common throughout the region.	In the event that localised blasting of sections of limestone reef is required, there will be loss on fauna within approximately 20 m of each blast. The operational phase of the project is unlikely to have any impact on marine fauna in the area.	Blasting is not the preferred construction technique and the contractor will be discouraged from using blasting, which will be used only as a last resort. If blasting is necessary, an underwater blasting procedure will be developed to the requirements of DEP and CALM such that any impacts on marine fauna are minimised. Blasting activities would be monitored by CALM. The Water Corporation will monitor the sediments in the region for toxicants. The Water Corporation will monitor the treated wastewater for toxicants. The operations of the WWTP will be conducted such that designated EQOs are met at the diffuser. The water and sediment monitoring program will be detailed in the Operations EMP.	No loss of benthic fauna due to competition with macroalgae or other flora is expected. If blasting is required there will be adverse impacts on marine fauna within approximately 20 m of each blast. No contamination of local biota. No impact on commercial fish stocks.

EPA FACTOR	EPA OBJECTIVE	EXISTING ENVIRONMENT	POTENTIAL IMPACT	ENVIRONMENTAL MANAGEMENT	PREDICTED OUTCOME
Marine Fauna Specifically Protected (Threatened Fauna) (specific)	Protect Specially Protected (Threatened) Fauna, consistent with the provisions of the Wildlife Conservation Act 1950. Maintain or improve the ecology consistent with EQO 1: Maintenance of Ecosystem Integrity (level 2-high protection) defined in the Southern Metropolitan Coastal Waters Study (SMCWS, 1996) and Perth Coastal Waters - Environmental Values and Objectives (EPA, 2000).	The waters host a number of protected marine species, including bottlenose dolphins and humpback whales.	The operation of the outlet will not have any impact on protected marine fauna in the area. In the event that blasting is required strict procedures will be followed to ensure that no protected species are harmed.	Blasting is not the preferred construction technique and the contractor will be discouraged from using blasting, which will be used only as a last resort. If blasting is necessary, an underwater blasting procedure will be developed to the requirements of DEP and CALM such that any impacts on marine fauna are minimised. Blasting activities would be monitored by CALM. The Water Corporation will monitor the sediments in the region for toxicants. The Water Corporation will monitor the treated wastewater for toxicants. The operations of the WWTP will be conducted such that designated EQOs are met at the diffuser. The water and sediment monitoring program will be detailed in the Operations EMP.	No impact on marine mammals (protected marine fauna).

EPA FACTOR	EPA OBJECTIVE	EXISTING ENVIRONMENT	POTENTIAL IMPACT	ENVIRONMENTAL MANAGEMENT	PREDICTED OUTCOME
Marine Flora and Fauna: Benthic community (specific)	Maintain the biodiversity of the seafloor within the relevant geographical area and to ensure that impacts upon locally significant marine flora and fauna communities are avoided.	Waters offshore support a diverse assemblage of algae and seagrass species. The coverage is extensive and far ranging.	In the event that blasting is necessary, there may be adverse impacts on attached benthic fauna within approximately 20 m of each blast. The operation of the outlet will not have an impact on the diversity of the marine flora and fauna in the area.	Blasting is not the preferred construction technique and the contractor will be discouraged from using blasting, which will be used only as a last resort. If blasting is necessary, an underwater blasting procedure will be developed to the requirements of DEP and CALM such that any impacts on marine fauna are minimised. The Water Corporation will monitor the sediments in the region for toxicants. The Water Corporation will monitor the treated wastewater for toxicants. The operations of the WWTP will be conducted such that designated EQOs are met at the diffuser. The water and sediment monitoring program will be detailed in the Operations EMP. The Water Corporation will monitor the phytoplankton community in the vicinity of the diffuser for changes in species assemblage arising from increased nutrient loads.	If blasting is used, benthic flora and fauna will recover rapidly after the localised blasting and there will be no long-term impact. Nutrient levels sufficient to stimulate algal growth are not expected near the seabed. No change of benthic fauna or epifauna diversity is expected.

EPA FACTOR	EPA OBJECTIVE	EXISTING ENVIRONMENT	POTENTIAL IMPACT	ENVIRONMENTAL MANAGEMENT	PREDICTED OUTCOME
Marine water and sediment quality	Maintain or improve the quality of marine water consistent with the draft Western Australia Guidelines for Fresh and Marine Waters (EPA, 1993). Maintain or improve marine water and sediment quality consistent with EQO 1 and Environmental Quality Criteria (EQCs) defined in the SMCWS (1996) and Perth Coastal Waters - Environmental Values and Objectives (EPA, 2000).	The water quality of the region is typical for south-west Western Australian waters, characterised by low nutrients and with anthropogenic impacts generally confined to localised areas affected by flows of drains, creeks and rivers containing elevated nutrients due to agricultural practises.	There is no dredging associated with this project. An excavator or similar machine will be used in burying the outlet across the surfzone. The impacts on water clarity will be highly localised and short-term. The project will not have an impact on nutrient concentrations at distances greater than 500 m from the diffuser and there will be no effect on the wider marine area (Geographe Bay). Operation of the outlet will result in slightly elevated productivity in the water column within 500 m of the diffuser under calm conditions. The operation of the outlet will result in an area within 500 m of the diffuser which will may not meet National criteria for shellfish harvesting. The operation of the outlet will generally result in primary contact criteria being met at the water surface above the diffuser. However, Water Corporation suggest that an area within 100 m of the diffuser is unsuitable for direct contact recreation. The wastewater will be tertiary treated wastewater. Following initial dilution, the turbidity will be similar to naturally occurring turbidity in seawater.	Turbidity generated by construction activities will be managed in accordance with the Construction EMP prepared for approval prior to construction. The Water Corporation will monitor the sediments in the region for toxicants. The Water Corporation will monitor the treated wastewater for toxicants. The Water Corporation will monitor the phytoplankton community in the vicinity of the diffuser for changes in species assemblage arising from increased nutrient loads. The area is not used for shellfish harvesting, however, the Water Corporation will advertise the location of the affected zone in the local press. The location of the outlet will be marked in future editions of local navigation charts. The Operations EMP will include a program of bacteriological monitoring around the diffuser designed to confirm the extent of the plume. The operations of the WWTP will be conducted such that designated EQOs are met at the diffuser.	The construction of the outlet will not have a significant impact on water quality. Because of the rapid dilution and advection of treated wastewater plume, elevated nutrient concentrations will generally not be high enough for long enough to cause increased productivity near the diffuser. Under prolonged calm conditions there may be a measurable increase in productivity near the diffuser. It is predicted that there will be no adverse impacts on the local marine ecology. The water quality of the nearshore waters adjacent to the WWTP should improve through the cessation of the practise of disposing wastewater to the lagoons behind the foredunes. The designation of zones 1.7 km offshore where swimming, diving or harvesting of shellfish is unsuitable will not have a significant impact on the recreational amenity of the region as the proposed restriction affects a small area seldom used by the public. The outlet will not have an adverse impact on sediment quality.

EPA FACTOR	EPA OBJECTIVE	EXISTING ENVIRONMENT	POTENTIAL IMPACT	ENVIRONMENTAL MANAGEMENT	PREDICTED OUTCOME
Management of treated wastewater	Ensure that the management of treated wastewater during construction and operation is environmentally acceptable.	The Bunbury WWTP current treats approximately 6.6 ML/d of wastewater from the Bunbury area and it is forecast that this will increase to 16 ML/d by 2040. Existing disposal is to infiltration ponds surrounding the WWTP. This system is close to its maximum capacity.	The primary potential impacts of the proposal are: • Elevated nutrient levels 1.7 km offshore; • Increased bacterial levels 1.7 km offshore; and • Loss of habitat due to installation of the outlet.	The decision to construct an ocean outlet has arisen through a lengthy and detailed investigation of options based on a hierarchical approach which had reuse as the preferred option. The most manageable and environmentally responsible solution is to treat the wastewater to a tertiary level and dispose of it to the ocean. The impacts of the project will be managed through the implementation of Construction and Operations EMPs prepared to the approval of the DEP.	An environmentally, socially and economically sustainable solution for disposal of Bunbury's wastewater, which has the capacity to cater for Bunbury's growth to 2040.

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1. INTRODUCTION

1.1 PURPOSE OF THIS DOCUMENT

This document presents the proposal by the Water Corporation of Western Australia (Water Corporation) to dispose of tertiary treated wastewater (refer to glossary) generated by the Bunbury wastewater treatment plant (WWTP) to sea using an ocean outlet discharging a distance of 1.7 km offshore from the high water mark (HWM) at a bearing of 290° from the dune blowout immediately north of the WWTP. This proposal is part the Water Corporation's wider strategy for the disposal of treated wastewater in the Bunbury region which has been developed in consultation with the local community.

Figure 1.1 shows the location of the Bunbury WWTP relative to the region and Western Australia.

It is intended that the information provided in this document will allow the Environmental Protection Authority (EPA) to assess the project under the *Environmental Protection Act 1986.*

1.2 PROPONENT

The Water Corporation is the proponent for this project. The Water Corporation is responsible for the collection, treatment and disposal of wastewater from the Bunbury region. The level of treatment and method of disposal is determined by public health, environmental and economic criteria (economic – as the community must be able to afford the system provided).

Extensive information on the various activities of the Water Corporation and this document can be viewed by visiting their website at www.watercorporation.com.au.

1.3 TIMING

The Water Corporation is confident of meeting the timetable in Table 1.1 for the project.

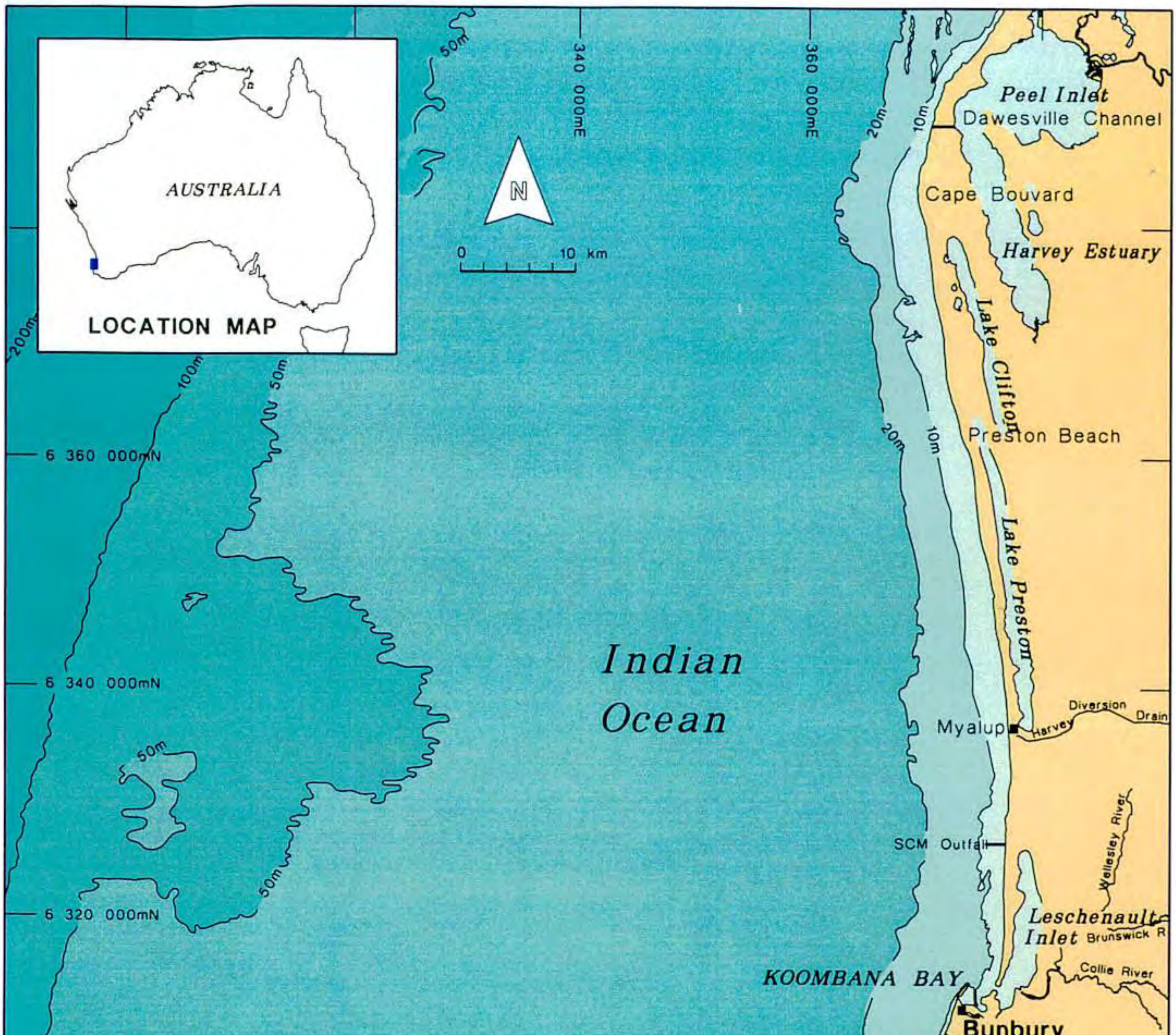
Table 1.1 Project timetable

EVENT	TIMING
PER document released for public comment	October 2000
Approval by Minister for the Environment	March/April 2001
Commence construction	June 2001
Commission ocean outlet	June 2002

The implementation of treated wastewater reuse for Hay Park does not form part of this proposal, this project is currently scheduled to be implemented in summer 2001/02 depending on the necessary approvals being obtained.

1.4 CONSULTATION

The Water Corporation has briefed both the EPA and Department of Environmental Protection (DEP) regarding this proposal and the broader strategy for wastewater disposal and has initiated and undertaken extensive public consultation. This document provides the opportunity for additional public input on the ocean outlet proposal. Section 8 presents a summary of the consultation process undertaken to date.



WATER CORPORATION
BUNBURY WASTEWATER
TREATMENT PLANT OCEAN OUTLET

BUNBURY WASTEWATER TREATMENT PLANT
LOCATION MAP

FIGURE 1.1

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1.5 WATER CORPORATION ENVIRONMENTAL POLICY

The Water Corporation has made a public commitment to implement the following policy across all its activities, including treated wastewater disposal.

"The Water Corporation is committed to efficient and effective water, sewerage and drainage services. We will meet all legislative, regulatory and other requirements relevant to the water industry, and minimise adverse impacts on the environment.

An environmental management system, consistent with international standards, will provide the framework for proactively managing and continuously improving environmental performance outcomes.

We will work towards:

1. *Ensuring environmental considerations are integrated into all asset planning, design, construction, operational and decommissioning processes through:*
    - *Assessing current and planned operations and projects for environmental impact and, where appropriate, developing environmental objectives, targets and improvement plans;*
    - *Developing and implementing procedures to avoid or manage incidents which may have an adverse environmental impact; and*
    - *Incorporating environmental requirements into tender and contract documents.*

2. *Developing our environmental expertise, both as a foundation for excellence in our environmental performance and as a source of advantage for our customers and our business.*

3. *Developing environmental awareness, responsibility and skills in our employees, contractors and suppliers, through targeted education and training programs.*

4. *Informing, consulting and cooperating with external stakeholders and the community.*

5. *Monitoring, measuring and reporting our environmental performance to employees, stakeholders and the community.*

6. *Developing and implementing, where practicable, resource efficiency, waste reduction and recycling programs throughout the Corporation.*

7. *Promoting the efficient and environmentally sound use of water by our customers.*

8. *Promoting, contributing to and undertaking research and development targeted at improved environmental and commercial outcomes, including cost-effective reuse of stormwater, effluent and biosolids."*

1.6 ENVIRONMENTAL APPROVAL PROCESS

Section 1.6 is based on information provided to the public by the EPA.

1.6.1 Overview

The environmental impact assessment (EIA) process is aimed at protecting the environment by ensuring development is environmentally sound and sustainable. Proponents are required to inform the EPA and the community what the development is, what the expected environmental impacts are, and how they plan to manage the project so the environment will be protected. They also are required to commit to the environmentally responsible implementation of their proposals.

EIA provides a way in which independent environmental advice can be given to the Government so it can properly decide the balance on the basis of a range of advice covering political, environmental, economic, social and cultural issues. EIA is aimed at resolving questions of 'how to' manage projects so the environment is protected rather than to say 'yes' or 'no' to development.

The EPA provides independent advice to the Government and the community on ways to ensure environmentally acceptable development. The Government decides whether it accepts that advice.

1.6.2 Aims of the process

Environmental protection in Western Australia is based on a value that captures the hopes and aspirations of most people.
It is:

"The world should be a good place in which to live, and to make a living, for all of us, and for our children and theirs."

EIA, therefore, is designed to ensure that the environment is looked after when new development proceeds. The process runs in parallel with project development so that designers and planners can incorporate environmental protection and developers can commit themselves to continuing, responsible environmental management.

The process also is designed to:

- Ensure that Governments get timely and sound environmental advice before they make decisions;
- Encourage and provide opportunities for public involvement in the environmental aspects of proposals before decisions are made;
- Ensure that proponents take primary responsibility for protecting the environment affected by their proposals;
- Encourage environmentally sound proposals which minimise adverse environmental impacts and maximise environmental benefits;
- Provide for continuing environmental management; and
- Promote environmental awareness and education.

1.6.3 The process

The EPA in Western Australia is a five member independent advisory board that recommends to the Government whether projects are environmentally acceptable. It does not decide whether projects should proceed. That task is properly left with the Government.

The first formal step of environmental assessment is the referral of a proposal to the EPA for a determination as to the level of assessment required. The proposal document includes a brief description of the project, the likely environmental impact and how that impact will be managed.

If the EPA decides that a formal assessment is necessary, the level of assessment may be set as:

- Environmental Protection Statement (EPS);
- Public Environmental Review (PER);
- Environmental Review and Management Program (ERMP); or
- Proposal is Unlikely to be Environmentally Acceptable (PUEA).

All formal assessments are reviewed and evaluated by the EPA who advise the Government on environmental acceptability. The Government then decides whether to approve.

This proposal was referred to the EPA in November 1999 and in this case, the level of assessment was advertised in the *West Australian* on 27 November 1999 as PER with an eight week public review period. There were no appeals from the public on this level of assessment.

1.6.4 Public Environmental Review

PER is used for proposals with either major public interest or potential for significant environmental impact. In these cases, the EPA issues a detailed, project-specific list of guidelines which should be examined by the proponent in its PER. The guidelines provided for the Bunbury Ocean Outlet proposal are attached as Appendix 1.

The PER process is designed to ensure that people are told about proposed developments, have a say, and are heard before decisions are made. People having an interest in, or living near, a proposed development often have important local knowledge which can contribute to better environmental management.

The EPA will provide a summary of issues raised during the public review of the PER documents. All submissions received by the EPA will be treated as publicly available unless specifically marked confidential. Proponents then must provide a written response to the issues, including commitments to their management where appropriate. The issues and the proponent's response to them are published by the EPA in its report and recommendations to the Minister for the Environment.

1.6.5 Environmental Protection Authority recommendations

In its assessment of a proposal, the EPA will consider issues raised by the public, specialist advice from Government agencies, the proponent's response to those issues, the EPA's own research and, in some cases, research provided by other expert agencies. The consolidation of advice and resolution of issues requiring further investigation is generally coordinated by the DEP prior to the EPA preparing the assessment bulletin. The time for the EPA to issue their assessment bulletin varies depending on the complexity of issues and the level of assessment. At the end of an assessment, the EPA reports and makes recommendations, which include suggested environmental conditions, to the Minister for the Environment. This advice indicates whether the EPA considers the proposal to be environmentally acceptable and, if so, whether environmental conditions should be imposed. The Minister makes the final decision on whether a proposal may proceed.

2. PROJECT BACKGROUND

2.1 OVERVIEW

2.1.1 A growing regional city

Bunbury is the administrative centre of the South West region, the State's fastest growing region outside of the Perth metropolitan area, with an estimated population just exceeding 119,000.

The region's population is expected to grow to 132,000 by 2006 and 142,200 by 2011. Population distribution favours the western coastal strip with the biggest increases in recent decades being around Bunbury, Capel, Busselton and Margaret River. More than 50,000 of the region's population is concentrated in the Greater Bunbury area, encompassing the city itself and the dormitory centres of Australind, Eaton and Gelorup in the adjacent shires of Harvey, Dardanup and Capel.

The Bunbury WWTP treats all the wastewater from the Bunbury city wastewater catchment consisting of some 6,000 homes and businesses. It is located approximately 7 km south of Bunbury and is situated on the coast behind the foredunes, approximately 300 m east of the beach (Figure 2.1).

2.1.2 What is wastewater?

Wastewater is the spent or used water from a community, it is also known as sewage, the term 'treated wastewater' is applied to the wastewater which has been treated to the degree where it is suitable for release back to the environment. In Bunbury, 6,600,000 L (6.6 ML) of wastewater a day comes from 6,000 domestic and commercial sources with the average person producing close to 200 L of wastewater every day.

2.1.3 Role of wastewater treatment

Urban society obtains water through harvesting from the natural environment. The primary role of wastewater treatment is to allow the return of this 'used' water back to the natural environment in a sustainable manner in terms of public health and the environment.

Wastewater is approximately 99.97% water by mass, the remainder consists of organic or inorganic material dissolved or suspended in the water column (solids). Wastewater treatment is a series of processes which remove pollutant materials from the wastewater, such as solids, oil and greases, detergents, nutrients, heavy metals and bacteria. These processes are carried out at WWTPs.

Wastewater treatment consists of a series of unit processes which are traditionally referred to as primary, secondary and tertiary processes.

Primary treatment consists of physical processes: screens to remove large floating objects; grit tanks to remove sand, grit and seeds; and sedimentation tanks to remove most of the remaining settleable solids. Only a small reduction in biological oxygen demand is generally achieved.

WATER CORPORATION BUNBURY WASTEWATER TREATMENT PLANT OCEAN OUTLET	BUNBURY WWTP LOCATION RELATIVE TO BUNBURY
	FIGURE 2.1

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Secondary treatment consists of biological processes to oxidise carbonaceous matter using micro-organisms in an aerobic (oxygen rich) environment. There are many technical variations of this process such as ponds, trickling filters and activated sludge processes. The process significantly reduces the levels of biological oxygen demand and harmful bacteria in the treated wastewater. Secondary treatment can reduce the levels of nutrients (nitrogen and phosphorus).

Tertiary treatment processes are generally applied to achieve specific outcomes where higher quality effluent is required for either environmental reasons (further reduction of nutrient or turbidity levels) or social reasons (further reduction of bacterial levels). Examples of tertiary treatment include: additional physical processes such as sand filtration and micro or nano-filtration; chemical processes including coagulation/precipitation and chlorination; and, biological processes such as polishing ponds.

The end products of the treatment process are wastewater and biosolids. Biosolids are extracted from the system and converted to soil conditioner by commercial operations for sale and reuse (approximately 350 tonnes of Bunbury's biosolids are used by agricultural and horticultural industries each year). Biosolids are also used directly in agriculture and forestry as a soil amendment and fertiliser.

The earlier days of wastewater treatment focussed on reducing suspended solids and biological oxygen demand. This utilised physical processes such as primary sedimentation to remove settleable solids, followed by biological processes such as earlier versions of the 'activated sludge' process.

Within the last 20 years the emphasis in wastewater treatment has moved to nutrient reduction. The development of controlled and effective nutrient removal mechanisms through the 'activated sludge' process has been one of the most significant advances in modern wastewater treatment.

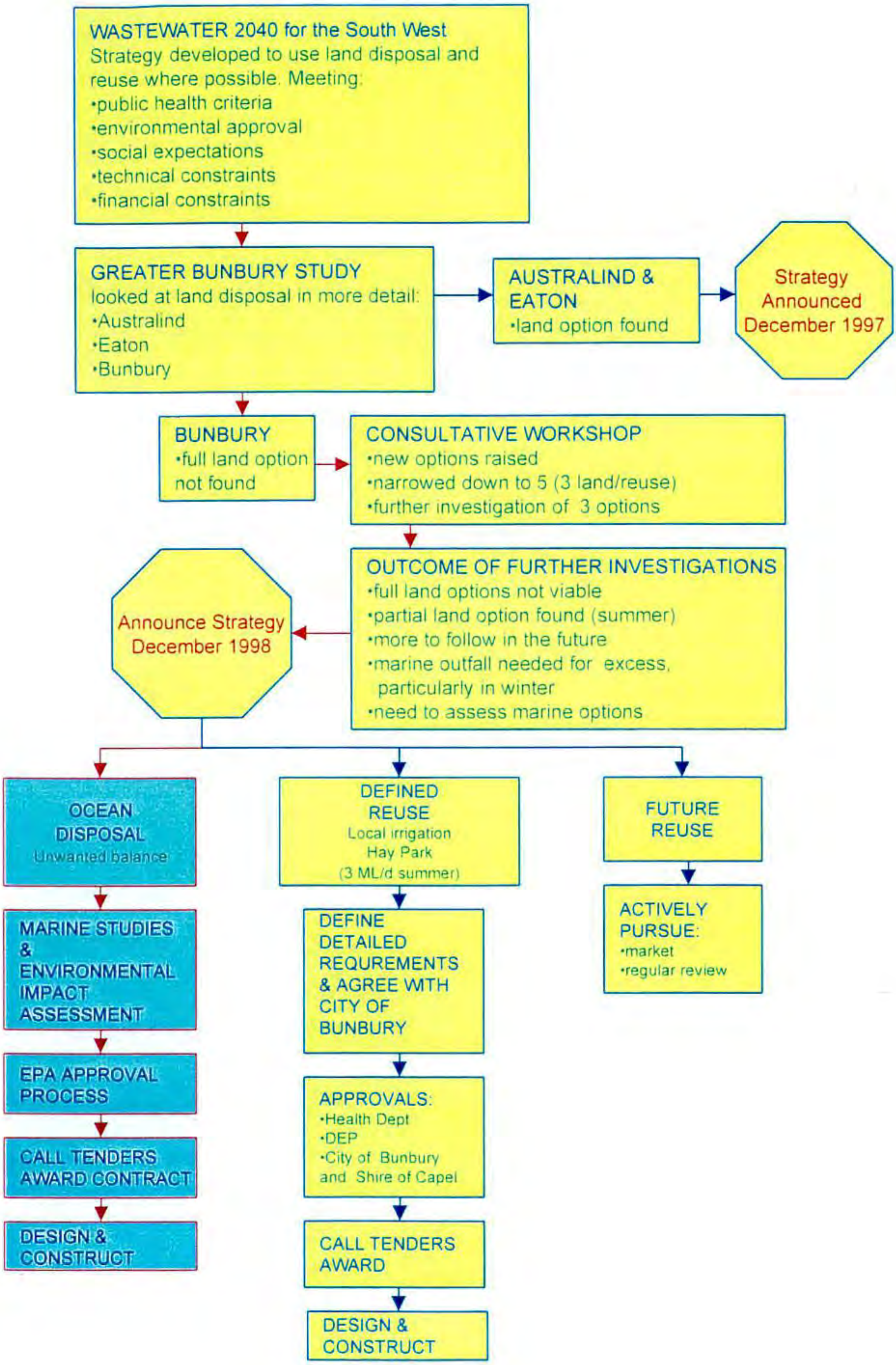
The Water Corporation has embarked on a program of installing advanced secondary treatment (nutrient removal) plants at the larger regional centres in the south-west, including Bunbury.

2.2 REGIONAL WASTEWATER STRATEGY

2.2.1 Background

In 1986, the Water Corporation adopted a strategy for the Greater Bunbury area to consolidate treatment at the Bunbury WWTP (previously known as the Bunbury No. 2 WWTP), with treated wastewater being disposed to the ocean and both the Eaton and Australind WWTPs to be diverted to Bunbury WWTP in the long-term.

The 1995 'Wastewater 2040' report gave a commitment to pursue land disposal and/or reuse where feasible, a long-term strategy widely supported by the community (Water Authority of Western Australia, 1994 and 1995). This was a major change in direction, requiring a complete reversal of the previous strategy for some WWTPs, such as Australind. The present strategy for Bunbury is traced back to this point in Figure 2.2.



WATER CORPORATION BUNBURY WASTE WATER TREATMENT PLANT OCEAN OUTLET	DEVELOPMENT OF BUNBURY WASTEWATER DISPOSAL STRATEGY FIGURE 2.2

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2.2.2 *Alternatives considered*

Following on from the broad directions set by 'Wastewater 2040', a more detailed study of land disposal of treated wastewater in the Greater Bunbury area was undertaken. This study initially identified 12 sites for further investigation and subsequently undertook a detailed field investigation of three of the 12 sites. The detailed investigation showed that land disposal opportunities may be limited for Bunbury for the following reasons:

- Lack of suitable land areas of sufficient size for woodlots;
- Lack of land in areas suitable for year-round reticulation as much of the surrounding land cannot accommodate reticulation due to high water tables and high winter rainfall;
- No demand for agricultural irrigation outside summer months; and
- The sensitivity of many possible sites with respect to run-off of treated wastewater containing nutrients.

As a result of the studies into options for treated wastewater disposal in the region:

- The Water Corporation announced a new long-term strategy based on land disposal/reuse for Eaton and Australind, a key component of this strategy was to pump treated wastewater to a site near Binningup to irrigate a bluegum plantation; and
- It was concluded that a full land disposal/reuse option was not currently viable for Bunbury.

A consultative workshop to resolve the options for treated wastewater disposal/reuse for Bunbury was held in May 1998. Further investigations arising from the workshop did not result in a feasible land disposal/reuse option being found for all of the flow. A brief summary of these options further investigated is presented in Table 2.1. The major shortfall of most of the options identified is the lack of demand during winter when wastewater flows are at their peak. However, it is envisaged that some of these options will form a part of the strategy to maximise reuse in the longer term.

Table 2.1 Summary of investigated alternatives to ocean disposal

Woodlots near Binningup   The Greater Bunbury Study identified a suitable (400 ha) site near Binningup that would be sufficient to cater for growth for Australind and Eaton to the year 2040. It is possible to also pump treated wastewater from Bunbury to this site, but the area would only provide capacity to the year 2015 (600–800 ha would be needed in 2040). While additional areas would need to be identified to cater for long-term growth, this area does have more potential with extensive horticultural industries to the north and south and the Kemerton Industrial Park nearby. Such a scheme would involve pumping over 35 km from Bunbury to the Binningup area. The pipeline would skirt the Bunbury, Eaton and Australind urban areas. This option was not further assessed because of its high cost to local ratepayers.
Deep well injection   Deep well injection is commonly used for treated wastewater disposal in North America and is also used to prevent salt water intrusion into aquifers. Additionally, water injected during periods of low demand can be recovered during periods of high demand (through the same bore). Fundamentally, the injection water needs to be of a quality similar to the receiving aquifer. Nearly all carbon, nutrients, and bacteria need to be removed prior to injection to prevent blockage of the bores. In California, the trend is to treat secondary effluent prior to injection by passing it through a microfiltration plant, then through a reverse osmosis plant. This option was not further assessed due to high costs.

Supply to irrigation areas This option involved pumping treated wastewater some 23 km east to storage at the head of the South Supply Channel near Burekup. Treated wastewater would be 'shandied' with irrigation water and flood irrigated over pasture during the irrigation season. Residual water would be discharged to the tail drainage system. This option was discounted because of public health and environmental concerns.
Supply to industry in Capel This option involved pumping treated wastewater some 20 km to Capel for use as processing water by industry. This option was discounted because it is not currently viable.

2.2.3 Current wastewater disposal strategy

Subsequently, in December 1998, the Water Corporation announced that it would pursue the following long-term strategy for Bunbury:

- Summer irrigation of Hay Park using up to 3 ML/d;
- Actively pursue further reuse, including the supply of treated wastewater to industry if viable; and
- Discharge the balance of the flow to the ocean through an ocean outlet.

The above process has also been summarised in Figure 2.2.

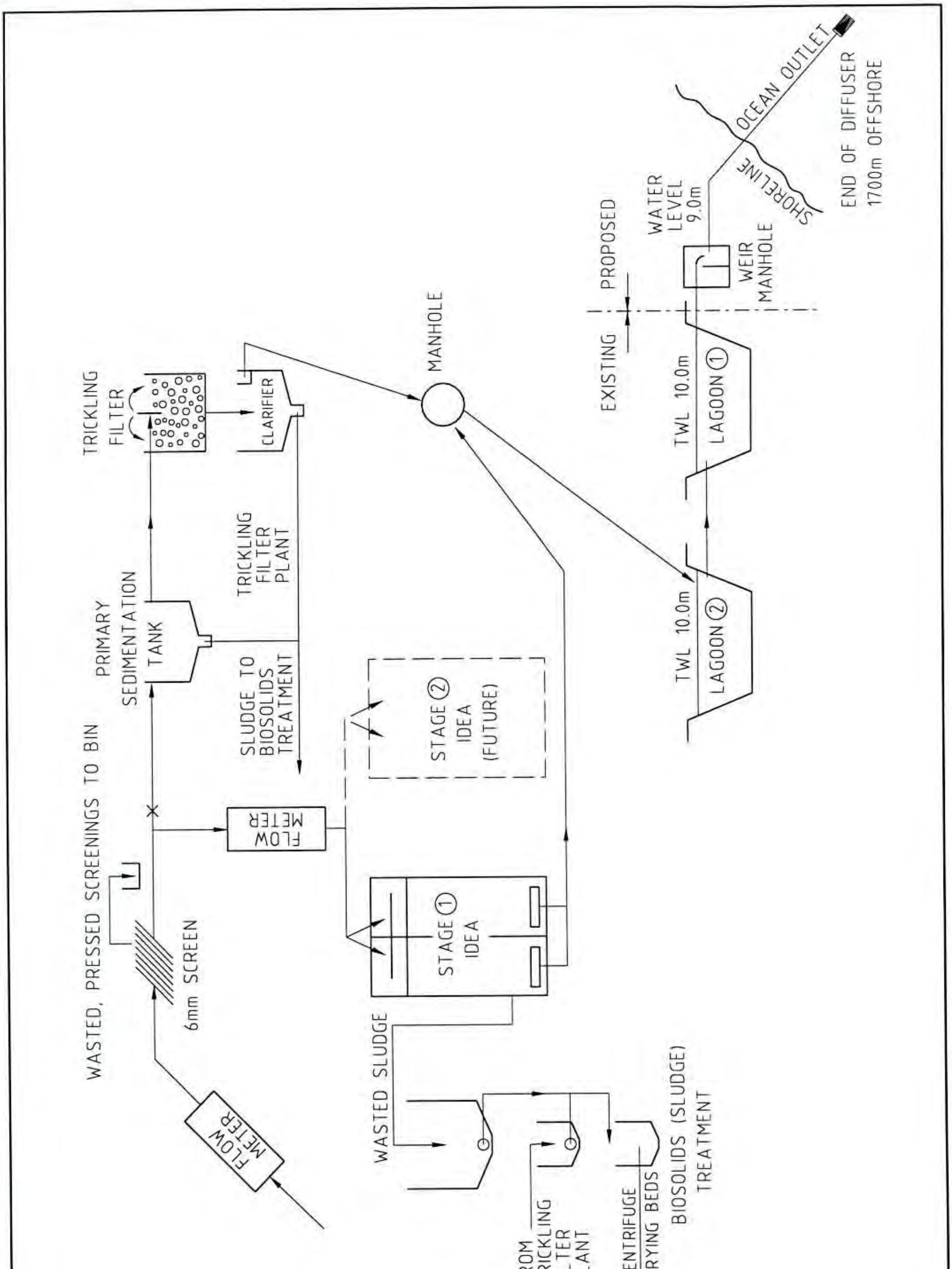
2.3 BUNBURY WASTEWATER TREATMENT PLANT

2.3.1 Existing facilities

The Bunbury WWTP was first commissioned in 1979. It used trickling filter technology to produce secondary treated wastewater which was then infiltrated into lagoons surrounding the plant. The trickling filter system was upgraded to increase capacity in 1987. The plant was further upgraded in 1995 with the commissioning of the IDEA plant, an advanced version of the 'activated sludge' process, capable of reducing nitrogen concentrations by more than 80%. Up until 1995, the plant was known as the Bunbury No. 2 WWTP as there was a smaller WWTP (Bunbury No. 1 WWTP) to the north which discharged into the ocean west of the Bunbury Marina. The No. 1 WWTP was decommissioned in 1995 and all flows were diverted to the Bunbury WWTP.

At present the trickling filter treatment system can treat up to 3.8 ML/d, producing treated wastewater of quality 35 mg/L total nitrogen (TN), 10 mg/L total phosphorus (TP) while the IDEA plant can treat up to 5.4 ML/d producing a treated wastewater quality of 10 mg/L TN, 10 mg/L TP. The combined treatment processes at the WWTP have the capacity to treat inflows of up to 9.2 ML/d based on annual average daily flows. Additional treatment capacity will be added prior to flows reaching these levels.

Figure 2.3 depicts, in a schematic manner, the treatment processes that wastewater entering the Bunbury WWTP undergoes prior to discharge. This figure also includes the connection to the proposed ocean outlet.



WATER CORPORATION BUNBURY WASTEWATER TREATMENT PLANT OCEAN OUTLET	**WASTEWATER TREATMENT PROCESSES AT BUNBURY WWTP**
	FIGURE 2.3

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Currently, the average daily flow to the Bunbury WWTP is approximately 6.6 ML/d. This wastewater arrives at the WWTP with a distinctive daily and weekly cycle which reflects the water use habits of the local community. During the working week, there are two peaks; the first of 130 L/s arriving at 9:00 am and the second of 110 L/s arriving at 8:00 pm, between these peaks flows fall as low as 30 L/s overnight and to 70 L/s at 3:00 pm. On Saturdays the morning peak is delayed by one hour and the evening peak occurs at 7:00 pm. On Sundays, the morning peak is delayed by two hours and occurs at 10:00 am while the evening peak occurs at 8:00 pm.

After treatment by a combination of the two processes, the wastewater on average, contains approximately 15 mg/L TN, 10 mg/l TP, 20 mg/L five day biological oxygen demand (BOD_5), 30 mg/L suspended solids and faecal coliform levels of approximately 100,000 cfu/100 mL. The final level of treatment is considered to be 'tertiary' as the IDEA plant produces 'advanced secondary' treated wastewater while the trickling filter plant produces 'secondary' treated wastewater, after retention in the lagoons the wastewater meets the criteria used to define 'tertiary' treated wastewater (refer Glossary).

The plant produces 350 tpa of biosolids, which are trucked offsite and used by agricultural and horticultural enterprises as soil conditioner.

The bulk of the Water Corporation's effluent testing effort at Bunbury has been focussed on nutrient and bacterial parameters, this is because there is no known hazardous industrial discharge to the facility. Although the Water Corporation has undertaken initial testing of the treated wastewater for contaminants (e.g. pesticides, hydrocarbons and heavy metals) and early testing suggest that levels will be low or below detection, there has been insufficient testing to derive average contaminant levels for the treated wastewater. The Water Corporation recognises that this is a shortcoming in the present assessment and have recently implemented a weekly testing program. The results of the testing program will be presented to the DEP as part of the proponent's response to submissions so that the DEP have all the information required to make their recommendations to the EPA.

In the absence of data from Bunbury, it is useful to consider the characteristics of treated wastewater from the Beenyup, Subiaco and Woodman Point WWTPs in Perth. The treated wastewater from the Bunbury WWTP should contain similar or lower concentrations of contaminants as the treated wastewater from Perth's outlets. Unlike Perth's WWTPs, the Bunbury plant does not treat wastewater from heavy industrial sources, the majority of the wastewater is from residential and commercial premises and any discharges to sewer from light industry are licenced under the Bunbury Industrial Waste Policy.

In a 1998 survey (Kinhill, 1998; refer Table 2.2), the concentration of chromium and nickel in the wastewater discharged from the three ocean outlets were below the guidelines for the protection of marine ecosystems (ANZECC, 1992). The concentrations of copper and zinc in the wastewater discharged from the three ocean outlets were above the guidelines for the protection of marine ecosystems. The detection limits for four metals (cadmium, lead, mercury and silver) were above the water quality guidelines for the protection of aquatic ecosystems. It was considered that the design of the diffusers would ensure sufficient dilution of the elevated metals so that water quality guidelines would be easily met beyond the immediate region of the diffuser. The concentration of pesticides in the wastewater from the three ocean outlets were all below the detection limits, and for all pesticides except DDT and Heptachlor, the detection limits were below the proposed guidelines for protection of aquatic ecosystems.

Table 2.2 Analysis of wastewater samples: Beenyup, Subiaco and Woodman Point WWTPs (Kinhill, 1998)

CONTAM-INANT*	DETEC-TION LIMIT[1]	BEENYUP		SUBIACO		WOODMAN POINT		GUIDE-LINES[2]
		S1	S2	S1	S2	S1	S2	
Metals								
Cadmium	5	<5	<5	<5	<5	<5	<5	2
Chromium	10	<10	<10	<10	<10	<10	<10	50
Copper	10	55	40	30	40	75	70	5
Lead	20	<20	<20	<20	<20	<20	<20	5
Mercury	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.1
Nickel	10	<10	<10	<10	<10	<10	<10	15
Silver	5	<5	<5	<5	<5	<5	<5	0.45
Zinc	10	80	50	70	65	70	35	20
Pesticides								
Aldrin	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
Chlordane	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004
DDT	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0005
Dieldrin	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
Heptachlor	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003
Lindane	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003
Organohalogens								
AOX	2	170	195	310	340	160	240	-
EOX	1	3.1	3.6	7.6	2.8	25	62	-

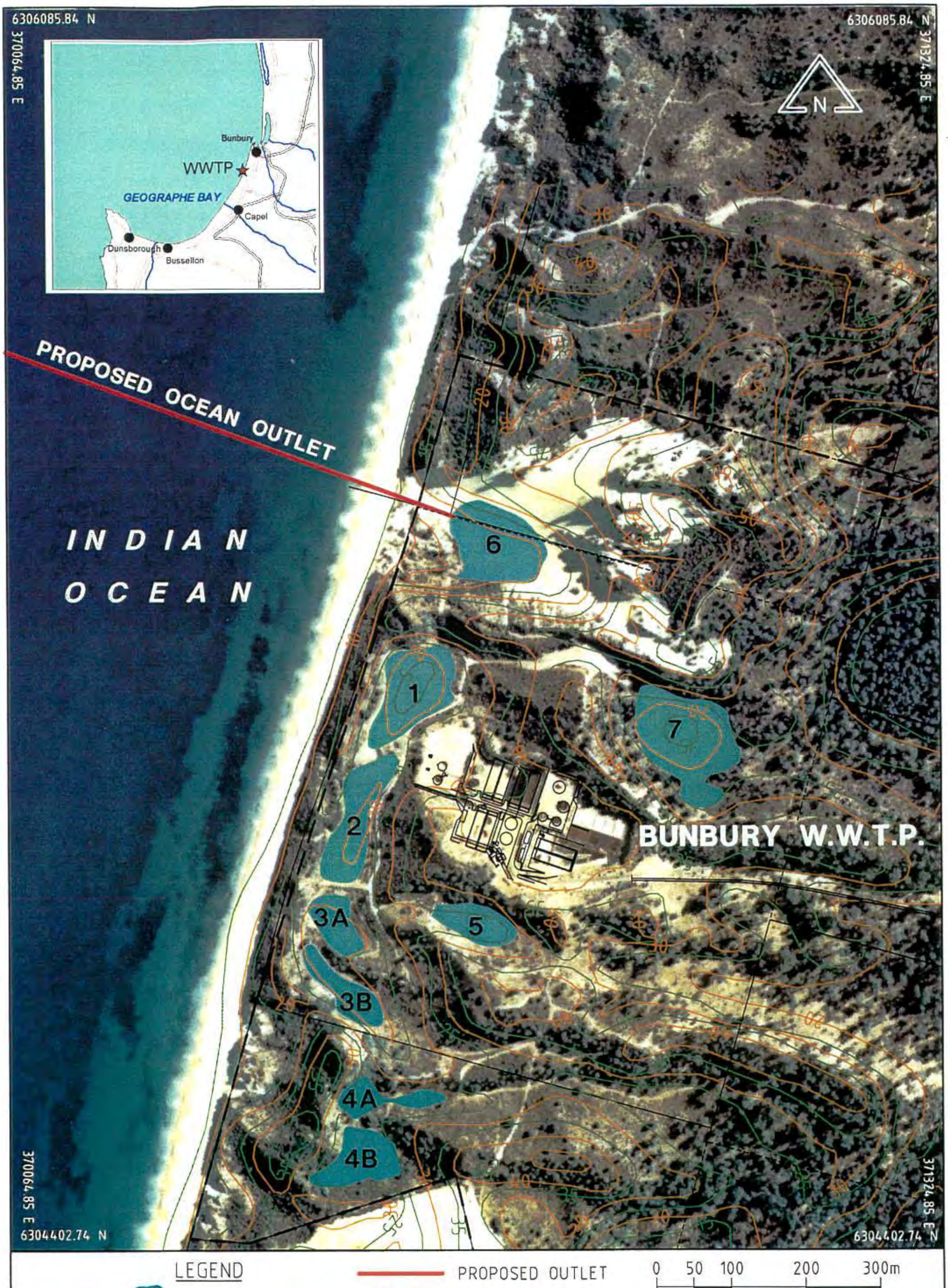
** All measurements in $\mu g\ L^{-1}$; nd: not detected.*
1 Detection limits refer to current survey only.
2 ANZECC (1992); EPA (1993); DEP (1996): The guidelines are for protection of marine ecosystems, they are not wastewater guidelines; -: No criteria.
S Sample.

2.3.2 Lagoons

Following treatment, the wastewater is discharged to seven lagoons constructed in the coastal dunes (Figure 2.4). The wastewater discharged to the lagoons undergoes continuous infiltration into the dune system to reduce coliform bacterial concentrations. The level of treatment is effectively tertiary due to the additional clarification and reduction of bacterial levels obtained in the lagoons and then the filtration through the sand (measurements of bacterial die-off rates in the lagoons show at least 100-fold reduction after two days). The wastewater then joins the groundwater flow and flows to the ocean at shoreline. Measurements (D.A. Lord & Associates Pty Ltd (DAL), 1999a, 1999b, and 2000a) show faecal coliform levels along the shore in this area of the order of 10–20 cfu/100 mL. These levels are well within guidelines for primary contact recreation.

The rate of infiltration (and hence treated wastewater discharge rate) depends on the permeability of the lagoons and the head difference between the surface of the lagoons and the sea level.

Recent modelling (Rockwater, 1997) indicates that increases in discharges above the average of 6.6 ML/d currently being discharged to the lagoons may cause surface ponding in winter and spring on the beach in front of the WWTP. It is concluded that the lagoons are operating at, or near to, capacity. Therefore, any future increase in flow to the plant is currently constrained by the method of wastewater disposal. The existing capacity constraints have not caused any significant environmental impacts.



WATER CORPORATION
BUNBURY WASTEWATER
TREATMENT PLANT OCEAN OUTLET

BUNBURY WWTP AND LAGOONS

FIGURE 2.4

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2.3.3 Department of Environmental Protection Licence

The Bunbury WWTP currently operates under a licence granted by the DEP (Number 5972/3) which is reviewed annually. The Water Corporation is required to provide detailed annual reports to DEP assessing performance against the licence conditions.

2.3.4 Future requirements

It has been forecast that flows to the Bunbury WWTP will increase to an anticipated 16 ML/d by the year 2040. This increase is due to the implementation of the Bunbury Infill Sewerage Program and the continued development and population growth in the catchment. The Water Corporation currently plan to meet increased demand by commissioning a second IDEA plant (capacity 5.4 ML/d) and decommissioning the Trickling Filter plant when the existing treatment capacity is reached. The result will be an increase in treatment capacity to 10.8 ML/d and a further improvement in overall treated wastewater quality. Further modules of the IDEA process will be added as required.

2.3.5 What happens in the event of process failure?

Due to longer hydraulic and solids retention times, the IDEA process is more robust than conventional activated sludge during process failure. All key equipment is configured in duty/standby arrangements. Extended (>3 hours) interruption of the power supply to the site is a rare event (typically no more than one occurrence every two years).

During extended power failure all wastewater delivered to the site still gravitates to the IDEA and trickling filter plants for treatment. The trickling filter plant is essentially a gravity system, except for sidestream recycles. The mainstream treatment process does not require power, however, without site power, solids will continue to accumulate in the clarifiers, and eventually treated wastewater quality will deteriorate with solids carryover from the peripheral weirs. Noticeable deterioration would not occur for at least 12 hours. Treated wastewater quality from the IDEA plant would not noticeably deteriorate for at least 6 hours following power failure. The 'activated sludge' biomass has an average residence time of about 20 days. While nitrogen removal will start to deteriorate within two hours, basic secondary treatment will continue for at least six hours.

The robustness of the treatment processes is backed up by the lagoon system. All treated wastewater flows by gravity to the lagoon system. These lagoons, because of their large surface area, also serve as a very conservative backup clarifier.

In summary, effective secondary treatment will continue at the site for about 24 hours following an extended power failure. At worst, a high level of primary treatment can always be provided.

3. PROPOSAL FOR BUNBURY OCEAN OUTLET

3.1 SCOPE OF THE PROPOSAL

This proposal is specifically for the construction and operation of the ocean outlet component of the wastewater disposal strategy. Other components of the disposal/reuse strategy (plant upgrade and summer irrigation) are not part of this proposal, and will be referred as separate projects to the EPA.

The location of the outlet is shown in Figure 3.1. What this proposal includes and doesn't include are detailed below.

3.1.1 Physical aspects of the project

1. WWTP Lagoons 1 and 2 (Figure 2.4) will be drained, scraped and lined such that they become impervious. Secondary treated wastewater from the plant will be discharged to the lined lagoons to allow further polishing and reduction in bacterial levels.
2. Lagoons 1 and 2 have volumes of 16 ML and 14 ML respectively and will have retention times of approximately 24 hours. Recent measurements of bacterial die-off rates in the lagoons have shown that within two days at there is at least a 100 fold decrease in bacterial concentrations. This means that an assumption of 10,000 cfu/mL in the treated wastewater at the diffuser is conservative.
3. A weir manhole will be constructed adjacent to Lagoon 1 to allow tertiary treated wastewater to flow by gravity from the system of 'polishing' lagoons to the ocean outlet pipeline through a 900 mm outside diameter (OD) pipe.
4. An ocean outlet will be constructed, consisting of a 610 mm OD pipeline heading offshore from the HWM at a bearing of 290° from the dune blowout north of the WWTP. This will lead to a diffuser section 120 m long fitted with 30 ports which will have an 80 mm inside diameter. The diffuser will be located in approximately 11 m of water and end 1.7 km offshore.
5. The pipeline will be constructed through the blow-out foredune area and buried to a depth of at least 2 m across the beach and surf breaker zone.

3.1.2 Aspects relating to management of the Bunbury Wastewater Treatment Plant

1. All flows from the WWTP not subject to reuse will be discharged to the ocean outlet subject to the limitations listed below.
2. Annual average flows discharged via the ocean outlet will be limited to 16 ML/d with a peak flow forecast of 24 ML/d for the peak winter day.
3. Annual average TN discharged to the ocean will be limited to 60 tpa (approximately 160 kg/d average).
4. Bacterial levels in the treated wastewater will be reduced such that primary contact bathing criteria are met within 100 m of the diffuser.
5. The WWTP currently utilises two secondary treatment processes, a trickling filter plant and an IDEA plant. To ensure that the proposed annual TN load is not exceeded, the trickling filter plant capacity will be limited to 3.0 ML/d (80% of design capacity) and if required, the existing IDEA plant can be readily upgraded to increase its capacity from 5.4 ML/d to at least 6.2 ML/d while maintaining design performance levels.

WATER CORPORATION BUNBURY WASTEWATER TREATMENT PLANT OCEAN OUTLET	LOCATION OF PROPOSED BUNBURY WWTP OCEAN OUTLET
	FIGURE 3.1

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6. In the event of a process breakdown or power failure at the WWTP, partially treated wastewater will continue to be directed to the lagoons and then to the outlet. In the event of a significant deterioration of treated wastewater quality over an extended timeframe (>24 hours), the existing effluent pumping station can be used to pump from Lagoon 1 and 2 to some of the remaining lagoons. This will allow cessation of discharge to the ocean outlet for approximately 48 hours. These contingency measures will be detailed in the Operations EMP to be developed for the project.

3.1.3 Aspects not assessed in this proposal

1. The Water Corporation will maximise wastewater reuse where practicable and environmentally acceptable.
2. The Water Corporation is currently developing a proposal to implement a direct wastewater reuse scheme based on providing irrigation to Hay Park.
3. It is planned to replace the trickling filter plant with a second module of the IDEA plant before average inflows exceed present licence capacity of 9.2 ML/d, the timing will depend on growth rates in the region.

3.2 OUTLET LOCATION

The selection of the ultimate location of the outfall depended on the assessment of factors in hierarchical fashion. In order of importance (and decreasing physical scale), the factors were:

- Proximity to degraded dune blowout area north of the WWTP;
- Diffuser to be located at minimum water depth of 10 m to achieve a necessary level of initial dilution (refer glossary of terms);
- Requirement for diffuser to be well beyond the surf zone and in an area of predominantly longshore (parallel to the coast) currents;
- Suitable bathymetry to place pipe and diffuser; and
- Location of benthic habitat least likely to be impacted by any local increase in nitrogen concentrations.

The baseline environmental and engineering studies commissioned by the Water Corporation and described in Section 6.7 enabled an informed decision on the pipeline location to be made.

The start point for the pipeline was logically at the dune blow out area as this is a degraded region in need of rehabilitation and is also adjacent to the WWTP. The point for the diffuser location was selected primarily on the basis of an extensive marine habitat survey as the bathymetry was fairly uniform and unlikely to pose significant engineering problems.

3.3 DETAILED DESIGN

The concept design for the diffuser is shown in Figure 3.2. The proposed pipeline diameter and diffuser configuration has been developed on the basis of the projected flows to 2040 and the environmental requirements have governed the alignment and distance of the diffuser offshore. Further detailed design work will be carried out prior to construction, however, this is unlikely to vary the proposal substantially from that presented here. The design work will involve developing the scheme for discharging treated wastewater from the plant to lined holding ponds in a way that reduces peaks and troughs in the flow and reduces average faecal coliform levels to below 10,000 cfu/100 mL.

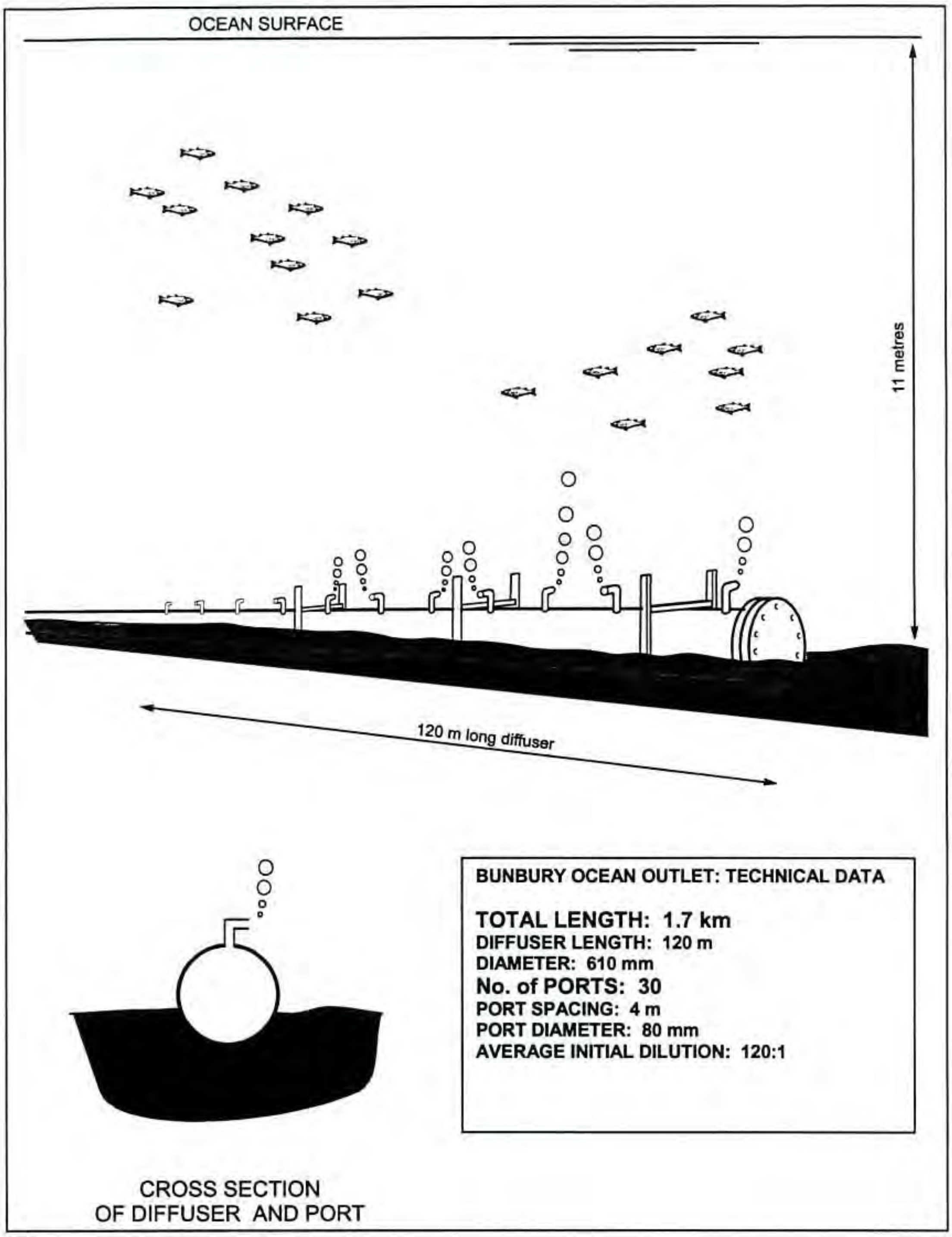


Figure 3.2 Bunbury WWTP: conceptual diffuser design

3.4 CONSTRUCTION METHODS

The construction method will largely be selected by the contractor and hence the details of the construction procedures will not be finalised until after the award of the construction tender. However, the following possible procedure is outlined to provide an indication of a realistic construction program.

3.4.1 *Pipeline fabrication*

The pipeline is likely to be fabricated in Perth and transported to the site in 12 m lengths on semi-trailers. There is likely to be approximately 25 truck deliveries at a rate of two trucks per day.

The individual pipes will be joined into eight or nine pipe strings each about 220 m long, in a temporary construction site prepared in the dune blowout area to the north of the Bunbury WWTP. This site is owned by the Water Corporation. A temporary railway line about 240 m long will be constructed to enable the pipe strings to be prepared. Completed pipe strings will be stored on sleepers beside the railway line.

3.4.2 *Seabed preparation*

A wire cable will be installed across the seafloor to mark the line of the proposed pipeline. The pipe can accommodate small variations in the seafloor but it may be necessary to remove any pinnacles and to prepare a flat trench through reef ridges. The Water Corporation will stipulate that its preferred construction methods will be for any removal of reef or rock to be done mechanically. However, given the nature of some of the material offshore, blasting of small parts of limestone reef may be necessary, the potential impacts of any blasting are discussed in Section 7.15.

3.4.3 *Beach crossing*

The pipeline will be buried below the sand level on the beach and to the 5 m depth contour to ensure that the pipe is not visible. A temporary construction groyne will be built across the beach offshore to the 3 m depth contour. A trench will be constructed beside the groyne offshore to the 5 m depth contour using excavators.

3.4.4 *Towing operation*

When the pipeline, seabed profile and beach crossing work have been completed, the pipe will be towed offshore using a tug or winch on a barge. The pipe strings would be joined progressively during towing operation to produce the full 1.7 km long pipeline. Towing would take about two days.

3.4.5 *Secure pipeline*

After the pipeline has been towed into the correct position, it will be filled with water and the sand across the beach crossing will be reinstated. The thirty diffuser ports and the zinc anodes (to prevent corrosion) would be fitted.

3.4.6 *Connecting pipeline*

A 900 mm pipeline would be constructed from the outlet of two polishing lagoons to the beginning of the outfall pipeline. It is most likely that part of this pipeline will be installed by jacking to avoid deep excavation through a sand dune.

3.4.7 *Polishing lagoons*

Lagoons number 1 and 2 will be drained, scraped and lined with HDPE liner or clay to ensure they are impermeable.

3.4.8 *Ancillary site works*

During the construction period, an access road, sheds, amenities, car park and other normal construction facilities would be provided.

3.4.9 Removal and reinstatement

The temporary groyne, the railway and all other temporary construction facilities would be removed. The beach would be reinstated to natural conditions. A small dune would be created across the back of the beach and planted with native dune species. The dune blowout area would be reshaped and prepared to maximise survival of replanted native dune vegetation. The access track will be closed and rehabilitated with native vegetation. On completion of rehabilitation, there will be no visual evidence of the pipeline or the construction area.

4. OCEAN OUTLETS IN WESTERN AUSTRALIA

Ocean outlets have long been used as a means of disposing of treated wastewater in a manner which maximises dilution and are the most common method, worldwide, for disposal of treated wastewater from cities. There have been varying degrees of success with outlets. Some outlets have resulted in significant social, health and/or environmental impacts arising through poor siting, poor design and/or insufficient treatment prior to discharge. However, the majority of outlets are well designed and operate in a manner which results in minimal environmental and social impact: the Water Corporation's outlets in the Perth metropolitan waters are a good example.

Ocean outlets work on the principle of utilising the buoyancy of the wastewater discharge in seawater to maximise dilution of the discharge, the salt and sunlight to act as an effective mechanism for rapid reduction of bacterial levels, the large pool of dissolved oxygen to enhance breakdown of organic material and waves and currents provide energy to mix and disperse the plume. Treated wastewater enters the sea from a diffuser located on the sea floor, buoyancy causes it to rise through the water column and it is rapidly diluted as it entrains surrounding seawater, and spreads out on the surface of the sea (Figure 4.1). The wastewater plume then moves with the surrounding seawater, under the influence of the prevailing currents, which are generated mainly by wind.

The diffuser is fitted to the end of outlet pipe, it is essentially a pipe which is closed at one end and fitted with ports along its length designed to maximise the dilution of the treated wastewater while preventing seawater from entering. The design has to take in to account the daily variations in wastewater flows and the forecast long-term increase in wastewater discharge.

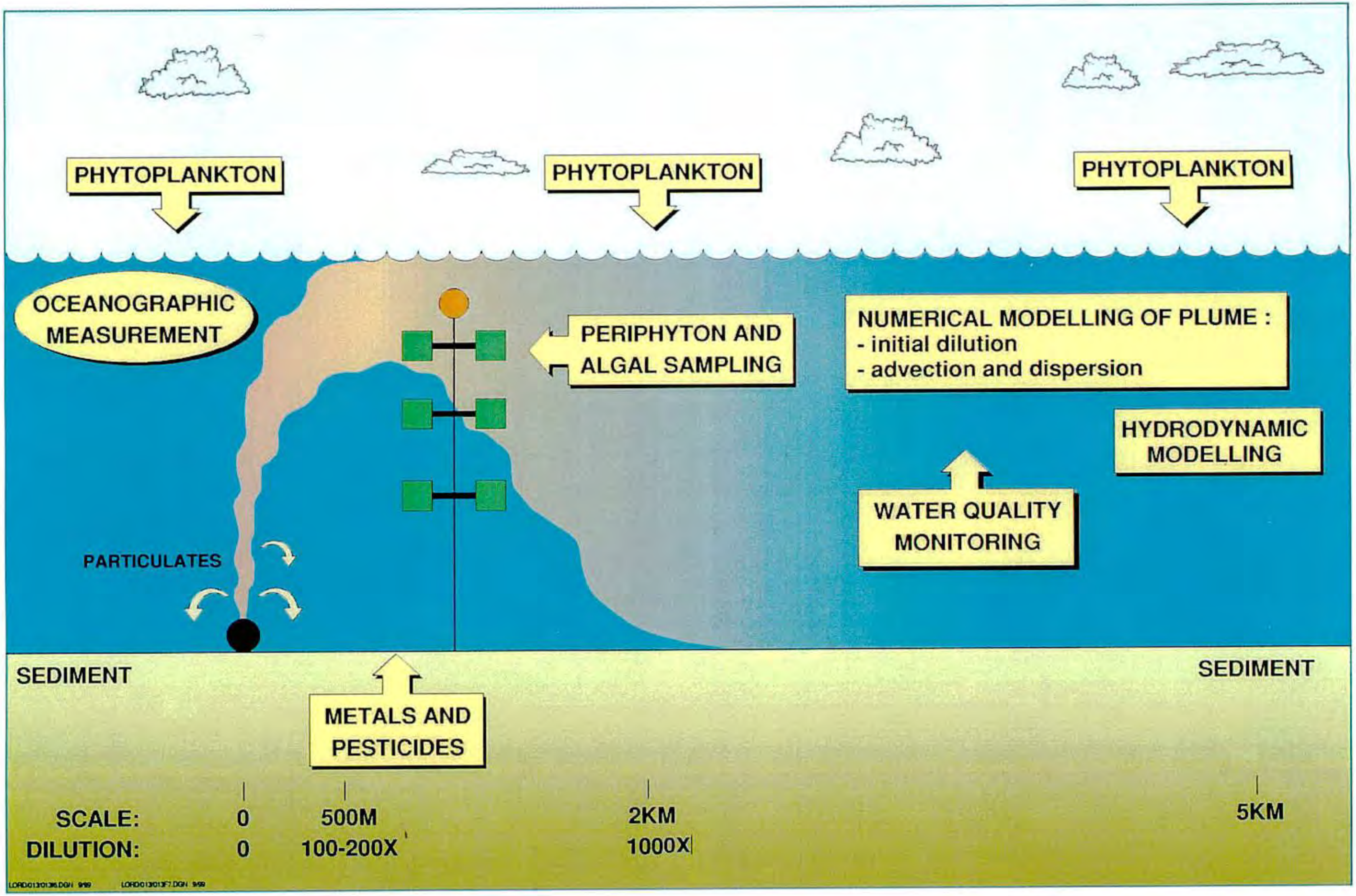
4.1 PERTH'S OCEAN OUTFALLS

It is useful to review the characteristics of Perth's ocean outlets as the behaviour of the Bunbury outlet will mirror these, albeit on a smaller scale.

The Water Corporation undertakes wastewater treatment for the Perth metropolitan area at three major treatment works located at Beenyup, Subiaco and Woodman Point, and 98% of Perth's treated wastewater is discharged to sea via marine outlets at Ocean Reef, Swanbourne and the Sepia Depression, respectively. Examples of diffusers operating in Perth's coastal waters are shown in Plate 4.1 and Plate 4.2.

Monitoring of the effects of these discharges has been routinely undertaken since the construction of the outlets. The intensity of monitoring increased with the implementation of the Perth Coastal Waters Study (PCWS) from 1992–1994 (Lord and Hillman, 1995); this was followed by implementation of the Perth Long-Term Ocean Outlet Monitoring (PLOOM) Program (1996–2000) (DAL, 1999c).

The PLOOM Program was developed based on an understanding of the processes occurring during the discharge of the treated wastewater and a knowledge of the likely effects of the wastewater on the environment. The major findings of the monitoring program are reported annually (DAL, 1999c).



WATER CORPORATION
BUNBURY WASTE WATER
TREATMENT PLANT OCEAN OUTLET

SCHEMATIC OF PLUME BEHAVIOUR
AND IMPACT STUDY AREA

FIGURE 4.1

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Plate 4.1 Example of diffuser in Perth coastal waters

Plate 4.2 Marine growth on diffuser operating in Perth coastal waters

The rise of buoyant effluent from a diffuser to the sea surface results in rapid dilution of the wastewater plume and is termed the 'initial dilution'. The average of the measured initial dilutions observed at the surface above each of Perth's ocean outlets since 1995 are shown in Table 4.1.

Table 4.1 Average minimum initial dilution above Perth's ocean outlets

OCEAN OUTLET	DEPTH (m)	AVERAGE DAILY FLOW (ML/day)	TN PRIOR TO DILUTION (mg/L)	AVERAGE MIN. INITIAL DILUTION	TN AFTER DILUTION (mg/L)
Ocean Reef	10	80	27	1:153	0.18
Swanbourne	11	54	24	1:273	0.09
Sepia Depression	20	103	46	1:380	0.12

Source: DAL, 1999c.

Perth's wastewater plumes were shown to be narrow and buoyant and moving in the direction of the prevailing currents. The observed plumes at each of the three ocean outlets were typically directed northward from the diffuser and were aligned parallel to the shore. At Ocean Reef the surface plume extended between 0.5–2.5 km from the outlet; at Swanbourne the plume extended between 1–2 km from the outlet; and at Sepia Depression the plume extended from the outlet over a range between 2–5 km.

The long-term mean concentration of chlorophyll a at the Sepia Depression and Ocean Reef outlets suggests that nutrient discharges may be having a slight effect on phytoplankton biomass to the north of the outlet. It appears that any environmental impacts are limited to summer when background chlorophyll a levels are approximately 0.2 g L^{-1}. During summer, the median chlorophyll a concentrations at stations to the north of the Sepia Depression outlet were 0.4 g L^{-1} which may be due to nutrients discharged from the outlet. However, it should be noted that these concentrations are considerably below the proposed PCWS 'healthy' summer criteria of 0.6 g L^{-1}.

The phytoplankton species assemblage at Ocean Reef and Sepia Depression were dominated throughout the year by diatoms which is generally a sign of a healthy marine ecosystem. Although annual blooms of blue green algae (Cyanophyta) have been commonly observed during autumn in the coastal waters off Perth, only a few occasions of significant blue green algae (*Trichodesmium*) concentrations were observed during the 1999/2000 monitoring and these were mostly in autumn.

The PLOOM Program has reinforced the fact that Perth's coastal waters are an ecosystem where biomass is limited by the availability of nitrogen. The seasonal variation in inorganic nutrient concentrations and phytoplankton biomass indicate that nitrogen limitation is most pronounced during the summer months, with other factors such as mixing, light availability and low temperatures, probably limiting growth in winter.

Surveys of metals and pesticides have confirmed that there was no detectable contamination of sediment or biota by the three ocean outlets (Sinclair Knight Merz (SKM), 1999).

4.2 THE MARINE ENVIRONMENT: CONTAMINANTS OF CONCERN

The materials of principal concern in the wastewater disposed to Perth's coastal waters are: contaminants (heavy metals and pesticides usually attached to particulate material); nutrients; and bacteria.

As far as impacts on the marine environment go, the primary contaminant of concern is nitrogen as a number of studies have shown growth to be significantly limited by nitrogen in Perth's coastal waters (Lord and Hillman, 1995; DEP, 1996; DAL, 1998). Work undertaken as part of this PER study has also shown that growth in the waters offshore of Bunbury is nitrogen limited (Waite and Alexander, 2000).

In order to better understand the marine environment at Bunbury and the way in which offshore disposal of treated wastewater would impact on this environment, a suite of detailed studies were implemented as part of the process of preparing this PER.

Figure 4.1 provides a schematic representation of a buoyant treated wastewater plume and the studies undertaken to determine the impacts of the plume on the marine environment. The critical nutrient pathway within the system shown can be summarised as follows (Lord et al., 1994):

- Dissolved nutrients are discharged in treated wastewater from the outlet;
- Initial dilution of the rising plume occurs with concentrations of nutrients at the surface approximately 100 times less than the concentration in the treated wastewater;
- Wind mixes the surface plume over the depth of the water column within a horizontal length scale of 500–2,000 m;
- Horizontal advection disperses the water masses progressively over the ocean; and
- Mixing coupled with biological activity, reduces dissolved nutrient levels to background concentrations in the water column within a distance of 500–2,000 m of the outlet.

The disposal of treated wastewater results in a zone of continuously raised dissolved nutrient levels which potentially enhances primary production (biological growth) in the immediate vicinity of the outlet. Outside of this zone, nutrients from the outlet can only contribute to enhanced production by recycling, that is, by prior incorporation into primary production within the zone of elevated water column nutrient levels, followed by transport of living or dead material out of the zone, and then remineralisation of this material either in the water column or through the sediments. However, it should be said that in marine areas that are well flushed such as the coast of Bunbury, the opportunity for nutrient build up resulting from the operation of the outlet is largely eliminated (DAL, 1999a, 1999b).

The representation of these nutrient cycling processes requires understanding of two physical features, namely, small scale features associated with the horizontal and vertical mixing of the plume and larger scale features greater than 500 m associated with the advection of the plume. These features are characterised in the numerical modelling study described in Section 7.8.

4.3 NITROGEN LOADS

4.3.1 Geographe Bay

In 1995, the Water Authority of Western Australia (now the Water Corporation) commissioned a study of Geographe Bay which included estimating the sources and quantities of nutrients and contaminants to the Bay (DAL, 1995). The estimated summer and winter nutrient loads are summarised in Table 4.2, the table does not include sediment nutrient loads.

Table 4.2 Nutrient loads to Geographe Bay 1993–94

SOURCE	SEASON	TN TONNES	TP TONNES	% OF TOTAL TN	% OF TOTAL TP
Wastewater					
Bunbury WWTP #1 & #2	winter	27.71	8.18	2.25	5.80
	summer	23.98	7.08	15.18	27.85
Unsewered Bunbury area	winter	14.23	4.27	1.15	3.03
	summer	14.34	4.30	9.08	16.92
Unsewered Busselton area	winter	10.35	3.10	0.84	2.20
	summer	11.58	3.47	7.33	13.65
Total wastewater	**winter**	**52.29**	**15.55**	**4.25**	**11.03**
	summer	**49.90**	**14.85**	**31.60**	**58.46**
Groundwater	**winter**	**47.53**	**2.41**	**3.87**	**1.71**
	summer	**34.21**	**2.06**	**21.66**	**8.10**
Rivers and drains				**% OF TOTAL RIVERS**	
Harvey Diversion Drain	winter	83.43	11.54	7.38	9.38
	summer	6.74	0.63	9.13	7.41
Leschenault Inlet	winter	580.8	52.45	51.40	42.64
	summer	33.17	3.39	44.93	39.88
Capel River	winter	186.55	22.67	16.51	18.43
	summer	6.13	0.82	8.31	9.65
Vasse/Wonnerup Lagoons	winter	185.40	24.60	16.41	20.00
	summer	18.60	2.50	25.20	29.41
Vasse Diversion Drain	winter	15.37	1.54	1.36	1.25
	summer	1.35	0.14	1.83	1.65
Carbanup and Buayanup catchment	winter	78.30	10.20	6.93	8.29
	summer	7.83	1.02	10.61	12.00
				% OF TOTAL	
Total rivers	**winter**	**1129.85**	**123.00**	**91.88**	**87.26**
	summer	**73.82**	**8.50**	**46.74**	**33.44**
TOTAL	**winter**	**1229.67**	**140.96**	**100.00**	**100.00**
	summer	**157.93**	**25.42**	**100.00**	**100.00**

Source: DAL, 1995.

Total annual nutrient discharges into Geographe Bay for 1992/93 were estimated to be 1,388 tonnes of nitrogen and 166 tonnes of phosphorus. These totals could be divided into a winter discharge of 1,230 tonnes of nitrogen and 141 tonnes of phosphorus, and a summer discharge of 158 and 25 tonnes of nitrogen and phosphorus respectively. In decreasing order of magnitude, these loads were derived from: surface flows from rivers and drains; groundwater efflux; and, discharges from coastal WWTPs and unsewered urban areas adjacent to the coast. The total nitrogen from rivers and drains comprises of approximately 2/3 organic nitrogen and 1/3 dissolved inorganic nitrogen, the dissolved forms are immediately available for biological uptake. The total nitrogen introduced by treated wastewater disposal comprises primary of dissolved inorganic nitrogen.

The principal surface flows into Geographe Bay are: the Harvey Diversion Drain discharging at Myalup; the catchment of the Leschenault Inlet discharging through

The Cut at Bunbury; the Capel River; the catchment of the Vasse/Wonnerup Lagoons; the Vasse Diversion Drain; and the catchments to the West of Busselton, notably the Carbarup and Buayanup catchments. Flows from rivers and drains during winter accounted for 1,230 tonnes of nitrogen and 123 tonnes of phosphorus, whereas during summer the total nutrient discharges from surface waters were 123 tonnes and 8.5 tonnes of nitrogen and phosphorus respectively. Surface discharges accounted for 92% of all nitrogen and 87% of all phosphorus discharges during winter and 47% of all nitrogen and 33% of all phosphorus discharges during summer. The Leschenault Inlet delivered the greatest nutrient load; during winter it contributed 51% of all nitrogen and 43% of all phosphorus carried by surface waters into Geographe Bay; during summer these proportions reduced to 45% and 40% respectively.

In 1992/93, the two Bunbury WWTPs discharged a total of approximately 52 tonnes of nitrogen and 16 tonnes of phosphorus to sea per annum. During winter this discharge was insignificant compared to the nutrient loads derived from rivers and drains, but provided 15% of the total nitrogen and 28% of the total phosphorus load during summer. When dissolved forms are considered, the WWTP probably contributes about 1/3 of the total dissolved nitrogen load to the region. Other (much smaller) WWTPs in the region (e.g. Dunsborough and Busselton) discharge to the land a significant distance from the shore and their contribution to nutrient discharges to the ocean is minor.

4.3.2 Bunbury Wastewater Treatment Plant

Presently the WWTP discharges nutrients to the ocean via the discharge to the lagoons which flow in turn into the groundwater which discharges to the nearshore zone. The commissioning of the outlet will effectively move this nearshore loading offshore. As part of this proposal, the Water Corporation are committing to keep the nitrogen load to the ocean at less than 60 tpa. The current plan is to upgrade the treatment process to reduce the concentration of TN in the treated wastewater when the present treatment capacity of the WWTP is reached. The reuse of treated wastewater over summer will result in further reductions in the nitrogen load to the ocean.

The forecast flows and nitrogen loads for the Bunbury WWTP are shown in Figure 4.2 and Table 4.3. These figures are based on the Water Corporation's commitment to maintain a ceiling on nitrogen load to the ocean of 60 tpa. The date of the upgrade and the nature of the upgrade undertaken may change depending on growth in the region and changes in technology. However, the assumed upgrade date of 2005 is based on a realistic forecast of flows and loads for planning purposes.

Figure 4.2 presents the TN loads to the environment for two possible options. Option One is for all wastewater to be discharged to the ocean following commissioning of the outlet. Option Two assumes that wastewater reuse of 3 ML/d can occur directly from the plant.

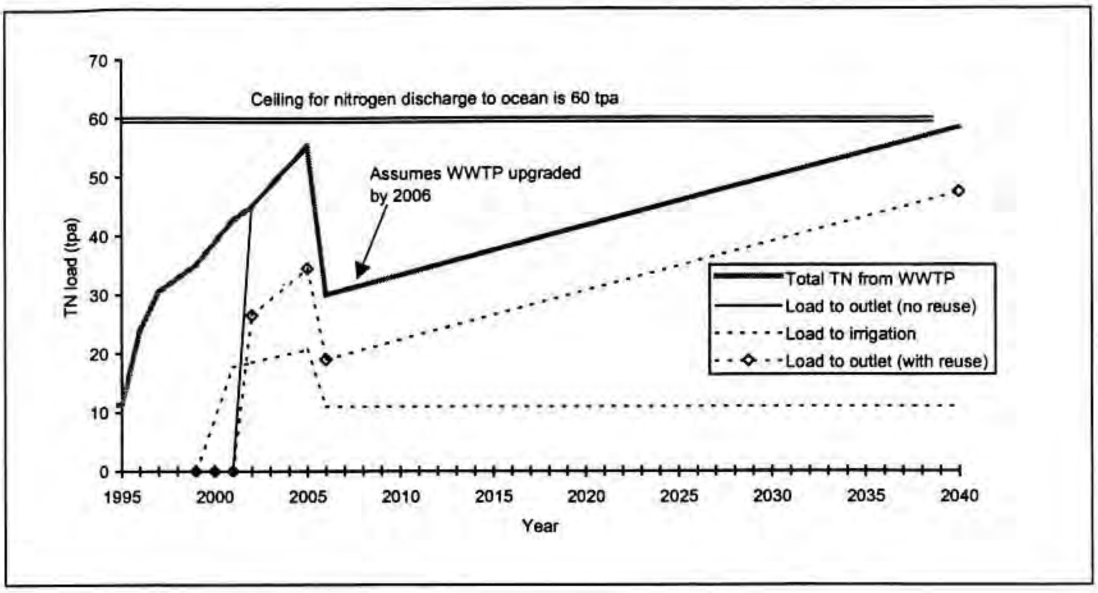

Figure 4.2 Bunbury WWTP: possible nitrogen loads to ocean with and without reuse

Table 4.3 Possible annual average daily flows and nitrogen loads from Bunbury WWTP

YEAR	FLOWS AND TN CONCENTRATIONS		SCENARIO 1 NO DISCHARGE TO LAGOONS NO REUSE POST OUTLET		SCENARIO 2 NO DISCHARGE TO LAGOONS DIRECT REUSE		
	Total flow AADF see #1, #2 ML/d	Mean [TN] mg/L	Load to nearshore via lagoons tpa	Load to outlet see #3 tpa	Load to nearshore via lagoons tpa	Load to irrigation see#4 tpa	Load to outlet tpa
1999 (no reuse)	6.6	14.5	35.0	0.0	35.0	0.0	0.0
2001 (earliest reuse)	7.2	16.2	42.6	0.0	24.8	17.8	0.0
2002 (post outlet)	7.3	16.9	0.0	45.0	0.0	18.5	26.5
2005 (pre WWTP upgrade)	8.0	18.9	0.0	55.2	0.0	20.7	34.5
2006 (post WWTP upgrade)	8.2	10.0	0.0	30.0	0.0	11.0	19.0
2040	16	10.0	0.0	58.4	0.0	11.0	47.4

Notes:
#1. Present capacity of IDEA plant is 5.4 ML/d (AADF basis).
#2. Present capacity of TF plant is 3.8 ML/d, but will be capped at 3.0 ML/d.
#3. Commitment not to exceed TN 60 tpa.
#4. Flow to irrigation is 3 ML/d.

4.4 NITROGEN LOADS RELATIVE TO THOSE FROM OTHER SOURCES

It is informative to compare the projected TN loads of the Bunbury outlet with present TN loads from the Perth outlets and the Leschenault Inlet. Figure 4.3 shows that the proposed maximum load to the ocean from the Bunbury outlet will be less than one tenth the load from any one of the Perth Metropolitan outlets and approximately one tenth of the current load from the Leschenault Inlet (the dissolved inorganic nitrogen load is of the order of ⅓ of that from the Leschenault Inlet). The Swanbourne and Ocean Reef outlets provide the best comparison with Bunbury as they are at a similar depth to the proposed Bunbury outlet and the mixing regimes are expected to be similar.

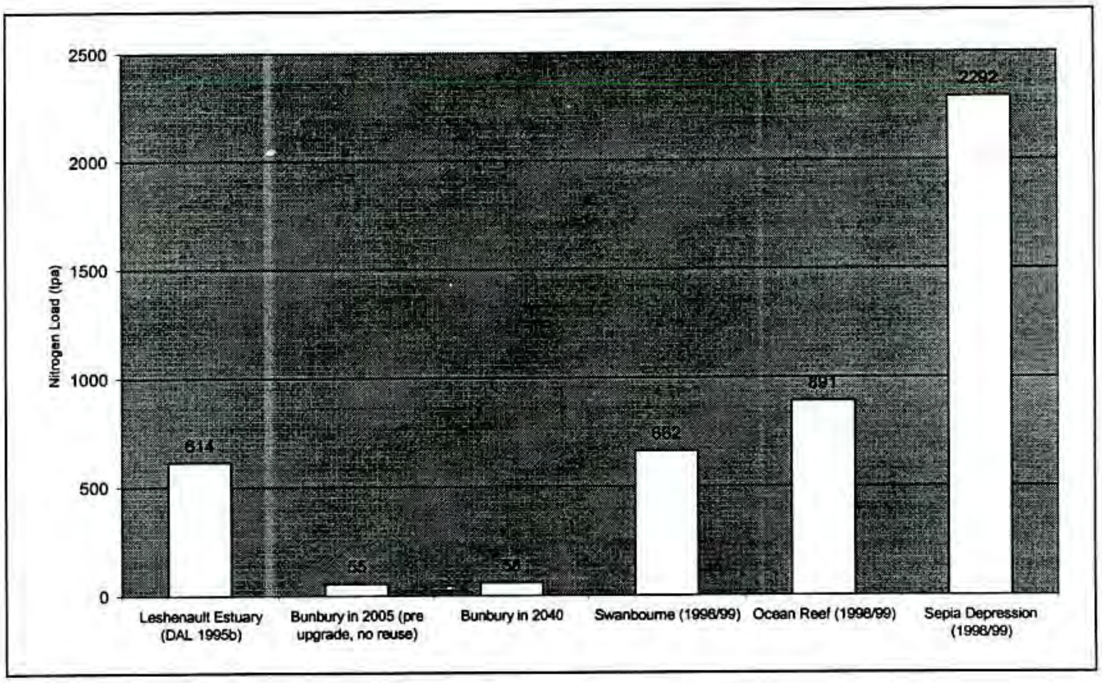

Figure 4.3 Comparison of average annual TN loads to local marine waters

5. EXISTING ENVIRONMENT: TERRESTRIAL

5.1 CLIMATE

Bunbury experiences a climate characterised by hot dry summers and cold wet winters. The monthly mean maximum temperatures range from 27.8°C in February to 16.8°C in July and monthly mean minimum temperatures range from 15.1°C in February to 8.4°C in August. The annual average rainfall at Bunbury is 871 mm with the majority falling between May and September. The monthly rainfall averages range from 11.1 mm in January to 182.9 mm in June. It is interesting to note that the annual rainfall in the SW land division has shown a statistically significant declining trend over the past 100 years, with average annual rainfalls now approximately 185 mm less (Nicholls et al., 2000).

The synoptic wind climate of Bunbury is largely controlled by the annual variation in the location of the mid-latitude anticyclonic belt. During winter this belt is located at a latitude of approximately 30°S and brings cool moist westerlies to the central regions of the state. During summer, the belt moves to a latitude of approximately 40°S and brings easterlies and fine warm weather. Low pressure systems occasionally interrupt the sequence of anticyclonic cells and cause period north-westerly gales, particularly during winter and early spring. Tropical cyclones may occasionally occur to the north during late summer and early autumn and bring strong winds and heavy rains. Extended periods of calm conditions may occur during mid to late spring and early autumn.

The influence of local-scale effects are also significant, in particular the diurnal sea breeze cycle which occurs during summer. During summer and autumn there is generally a pattern where the morning winds are south easterly between 6 and 20 km/h and in the afternoon there is a south westerly seabreeze between 6 to 20 km/h. Winter winds are more variable with occasional calms and strong storm winds. The dominant wind direction in winter is westerly, although northerly winds frequently occur.

5.2 GEOLOGIC SETTING

Inland south-western Australia is largely composed of Pre-Cambrian igneous, metamorphic and sedimentary rocks (Geological Survey of Western Australia, 1990). Along the west coast, between Geraldton and Cape Naturaliste, the Pre-Cambrian rocks are fringed by a broad coastal plain of younger Phanerozoic sedimentary rocks, mainly sandstone and limestone which extend offshore to form a wide (approximately 50 km) continental shelf. The Phanerozoic sediments of the Perth Basin provide a basement to the Quaternary coastal deposits on the west coast. These Quaternary deposits include lithified Pleistocene marine and aeolianitic calcarenites and unconsolidated Holocene calcareous sands (Woods et al., 1985). In the vicinity of Bunbury, the calcarenite outcrops at the shore as a limestone pavement and offshore a low-relief reef and pavement.

The present form of the Bunbury coast is largely the product of sediment deposition and relocation in Pleistocene basins during, and following, the Holocene marine transgression. Evidence of the sea level history of south-western Australia suggests the following sequence of events:

- At approximately 10,000 years before present (BP) sea-level was still 27 m below present levels;
- Sea-level reached a position of 20 m below present levels by about 8,000 BP;
- At approximately 6,400 BP the sea-level was slightly elevated above the present level (mid-Holocene sea-level high-stand);
- From 6,400 BP to 1,500 BP there has been a decline of sea-level to the present level; and
- Since 1,500 BP the sea-level has remained at the present level.

The rise in sea-levels during the early Holocene resulted in the delivery of a large supply of sand to the coast. In the vicinity of the Bunbury WWTP this sand has resulted in the development of large parabolic dune sequences (termed the Quindalup Dunes). In the vicinity of the Bunbury WWTP these parabolic dunes extend up to 1 km inland from the base of the berm. The crest of these dunes typically have a height from 20 to 30 m with several peaks rising to 40 to 50 m. The interdunal depressions typically have an elevation of 10 m. The majority of the parabolic dunes are vegetated and stable. However, a large unvegetated and active parabolic dune blow-out is located towards the northern boundary of the Bunbury WWTP and extends approximately 450 m east from the beach. Wastewater disposal lagoon #6 is located in this blow-out depression (Figure 2.4 and Plate 5.1).

Plate 5.1 Dune blowout adjacent to WWTP (May 1999)

The beach in the vicinity of the Bunbury WWTP is composed medium to coarse grained carbonate sand. The beach is linear and aligned in a north to north-easterly to south south-westerly direction. Beach cusps with a spacing of approximately 30–40 m and an amplitude of 10–15 m are typically observed along this beach (Plate 5.2).

Plate 5.2 Beach in front of WWTP (May 1999)

Offshore of the Bunbury WWTP the seabed consists of a sand veneer over rock outcrops and reef. The rock and reef first outcrops approximately 150 m from the shoreline (Cambridge and Kendrick, 2000). The offshore seabed slope is relatively gentle (the seabed slope between the 10 and 15 m isobath is approximately 1:500) whereas the inshore slope is moderate (the seabed slope between the 5 and 10 m isobath is approximately 1:150 and between the 0 and 5 m isobath is 1:100). Figure 5.1 shows an idealised cross-section through the WWTP site.

5.3 GROUNDWATER

The surficial groundwater flows towards the coast and discharges from the Safety Bay Sand aquifer at the intertidal zone. Effects of human activities on the coastal strip are most likely to be seen in this surficial groundwater, for example septic tanks and fertiliser application in residential areas and market gardening areas may raise nutrient levels (Johannes and Hearn, 1995). Groundwater deeper within the Tamala Limestone aquifer may also discharge offshore via permeable sections of the seafloor, usually limestone reef, this submarine groundwater discharge is common along the coast of Western Australia and can also contain high nitrogen concentrations (Johannes, 1980).

In the vicinity of the Bunbury WWTP, both surficial and submarine groundwater discharge occurs. Plumes of submarine groundwater have been observed offshore on calm days, while fresh surficial groundwater may be found by digging into the beach above the high tide mark. Figure 5.1 shows an idealised cross-section through the WWTP site.

WATER CORPORATION
BUNBURY WASTEWATER
TREATMENT PLANT OCEAN OUTLET

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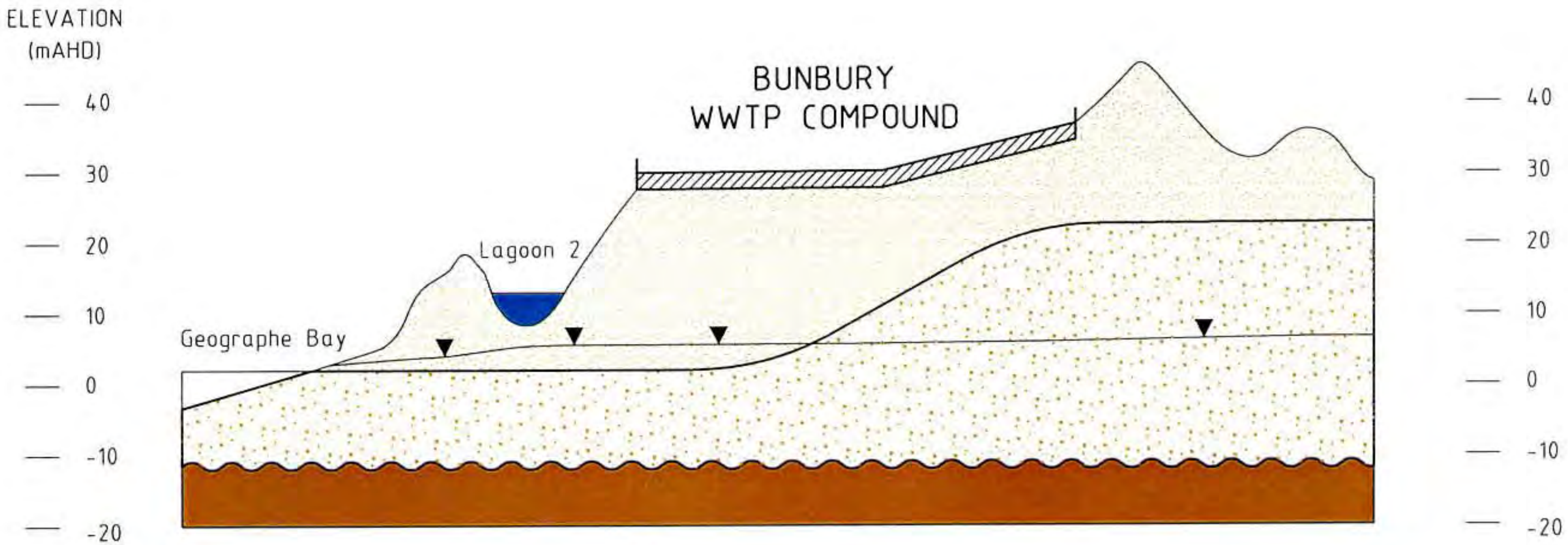
IDEALISED CROSS SECTION
THROUGH WWTP AREA

FIGURE 5.1



SAFETY BAY SAND (CALCAREOUS SAND)

TAMALA LIMESTONE (LIMESTONE, SAND)

YARRAGADEE FORMATION (SANDSTONE, MINOR SHALE)

GROUNDWATER LEVEL

100 50 0 100 200m

HORIZONTAL SCALE 1:5000
5 x VERTICAL SCALE EXAGGERATION

(SOURCE: ROCKWATER, 1997)

5.3.1 *Groundwater levels*

Groundwater monitoring of the bores shown in Figure 5.2 (Rockwater, 1997) suggests that the practise of discharging treated wastewater to the lagoons (Figure 2.4) at the rear of the foredunes has elevated the groundwater table in the immediate vicinity of the WWTP. Monitoring has shown a steady rise in water table levels, with water levels under the WWTP rising by 0.6 m since February 1996 (Rockwater, 1997). The rise has been steady with no seasonal variation.

The elevated groundwater levels appear to have resulted in ponding of groundwater on the beach during winter and spring under adverse conditions which potentially increases the mobility of the beach. Sustained elevated groundwater levels may also have repercussions for the health of stands of Tuarts in the north-west part of the site (refer Section 5.4 and Ecologia, 1997).

The Water Corporation is aware of the potential impact on the Tuarts and has been monitoring the health of these trees, to date there is no sign of detrimental impact of operations on the health of the trees. Recent vegetation monitoring (Ecoscape, 1999) was inconclusive as to the effect of groundwater level changes on the health of the Tuarts in the WWTP premises (refer also to Section 5.4).

5.3.2 *Groundwater quality*

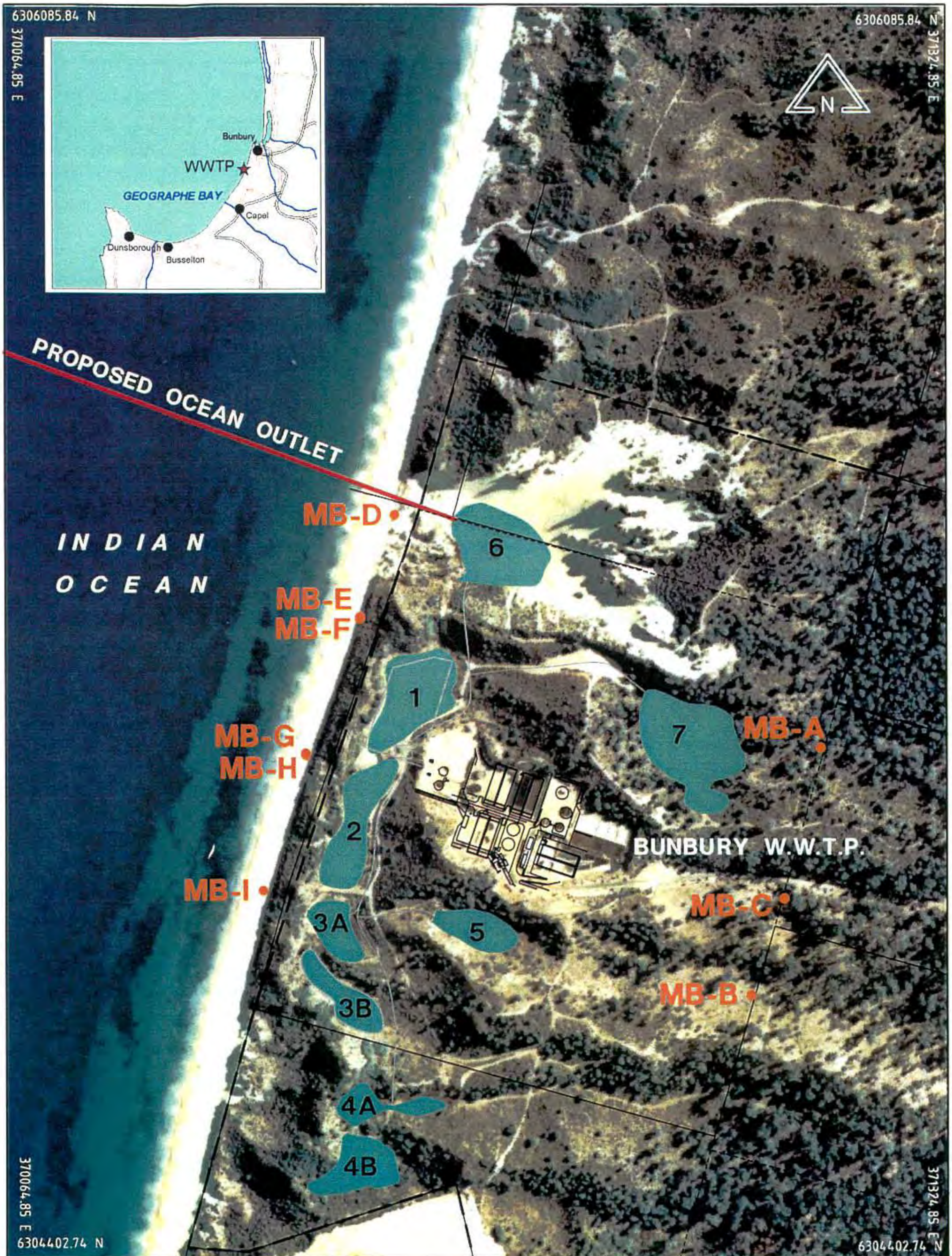
Monitoring of the groundwater below the WWTP lagoons by the Water Corporation at the bore locations in Figure 5.2 shows that concentrations of nitrate + nitrite and ammonia are elevated above those found nearby. The median concentrations of relevant bore survey data from 15 surveys (February 1996 to January 1999) are shown in Table 5.1 below.

Table 5.1 Groundwater quality in the vicinity of Bunbury WWTP

BORE	A	B	C	D	E	F	G	H	I
Total Nitrogen (mg/l)	1.3	2.1	2.0	1.9	6.3	17.0	9.1	23.0	8.9
Nitrate + Nitrite (mg/l)	0.9	1.1	1.6	0.8	0.0	0.2	0.2	0.1	0.1
Ammonia (mg/l)	<0.05	<0.05	<0.05	0.8	4.1	14.0	9.1	21.5	8.8
Total Phosphorus (mg/l)	0.2	0.3	0.3	0.1	1.0	7.9	5.7	0.6	4.7
Faecal Streptococci (cfu/100 mL)	<10	<10	<10	<10	<10	<10	<10	<10	<10

The nitrogen and phosphorus levels in the vicinity of the lagoons are approximately an order of magnitude greater than the levels away from the lagoons while the low faecal streptococci levels suggest that the combination of secondary treatment followed by filtration through the sand below the lagoons acts in a very efficient manner for removal of bacteria. The proximity of the lagoons to the ocean means that these nutrient concentrations are reflected in elevated nearshore ocean concentrations (Claudius and Nener, 1995).

The influence of the increased nutrient concentrations in groundwater may also have an effect on the vegetation in the region and the monitoring undertaken by Ecoscape (1999) makes a note of this. The monitoring for effects of altered groundwater quality on the vegetation will form part on the ongoing terrestrial management plan developed by the Water Corporation in 1997 and which will be reviewed as part of the preparation of the Construction EMP for this proposal.



LEGEND

Datum: AHD
Grid: AMG84

1 WWTP LAGOONS

PROPOSED OUTLET

MB-I • MONITORING BORE

0 50 100 200 300m
SCALE 1:7000

WATER CORPORATION
BUNBURY WASTEWATER
TREATMENT PLANT OCEAN OUTLET

LOCATION OF
GROUNDWATER MONITORING BORES

FIGURE 5.2

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5.4 VEGETATION AND FLORA

The terrestrial environment in the vicinity of the WWTP grounds has been subject to assessment as part of a broader regional survey by Tingay & Associates (1991) and a site specific survey by E.M. Mattiske & Associates (1992). On the basis of this information, an EMP was prepared for the plant by Ecologia consultants (1997). The first vegetation monitoring report was produced in 1999 by Ecoscape consultants (1999).

The WWTP is situated in the Quindalup Dune system and the local geology is characterised by a layer of Safety Bay Sand overlaying Tamala Limestone formation. The Safety Bay Sand is generally unconsolidated and readily eroded by wind and waves when vegetation is removed, an example of this is seen in the blowout to the north of the WWTP (Figure 2.4 and Figure 5.3).

The WWTP site bushland occurs in the Swan Coastal Plain sub-region of the Drummond sub-district within the South-West Botanical Province (Beard, 1981). The WWTP site bushland lies in the Quindalup vegetation system which is formed from both fixed and mobile north-trending sand dunes adjacent to the coast and extending from Hill River to Cape Leeuwin (Beard, 1979a, 1979b, 1981).

The high alkalinity and lack of soil profile of the Quindalup sands described by Havel (1968) supports specialised and fragile plant communities. The mobility of the dunes predisposes Quindalup vegetation associations to a high level of disturbance (Havel, 1968).

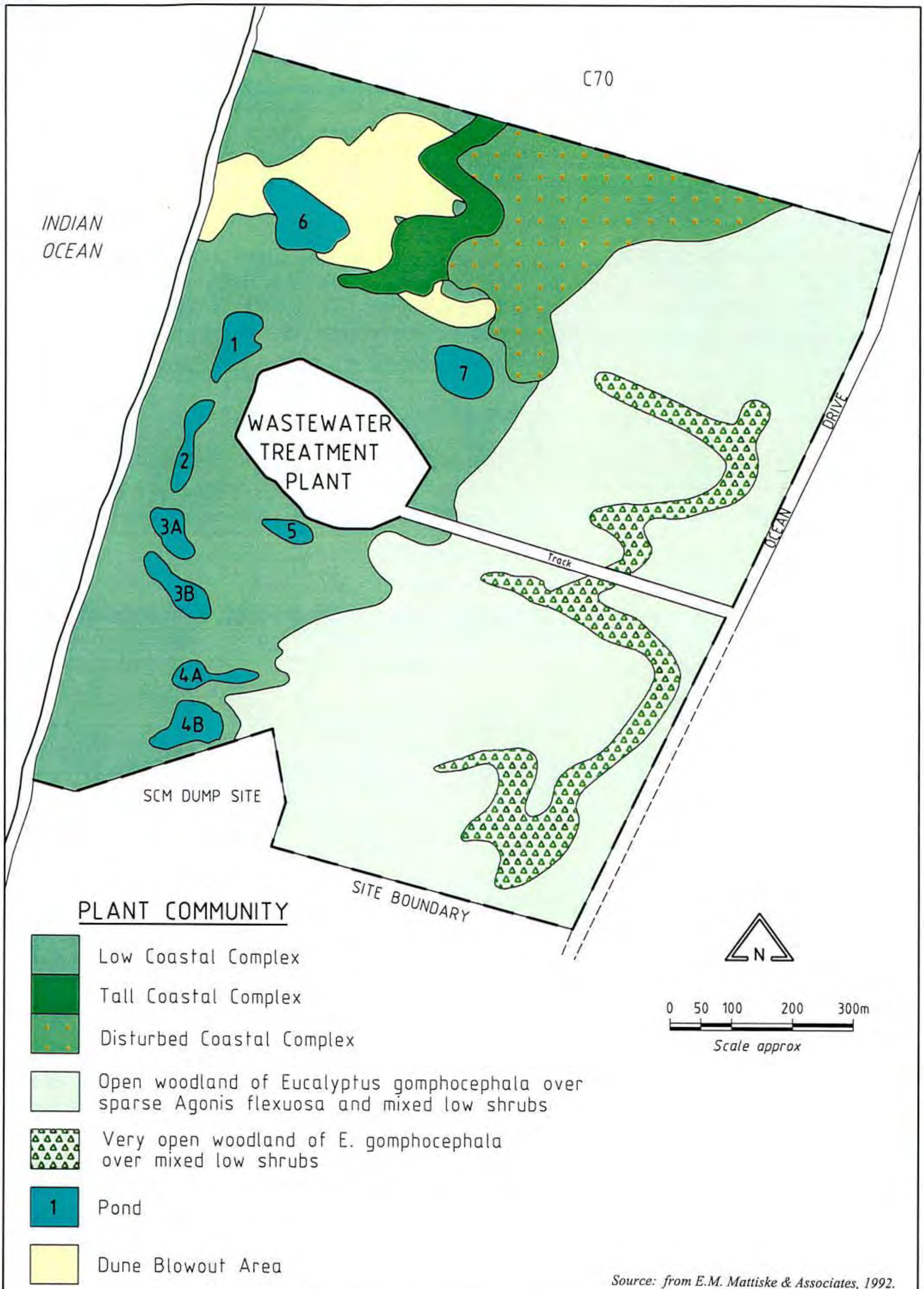
5.4.1 Vegetation types

Vegetation mapping of this area has been undertaken by E.M. Mattiske & Associates for a previous study by the (then) Water Authority of Western Australia, and has been undertaken at a more regional scale by Tingay & Associates in the Usher-Stratham Environmental Study for the (then) Department of Planning and Urban Development (Tingay & Associates, 1991). Part of the vegetation was also mapped by Hart, Simpson and Associates in 1994 as part of the EIA of proposed development in the Maidens (EPA, 1995). The vegetation mapping exercises used different methodologies, the vegetation map prepared by E.M. Mattiske & Associates (1992) is reproduced as Figure 5.3.

All vegetation maps identify the same dominant species, E.M. Mattiske & Associates identified the following vegetation associations as occurring within the WWTP site.

Low coastal complex

This vegetation association occurs in a narrow band in the northern section of the project area (Figure 5.3). It consists of closed, low heterogeneous heath dominated by *Acacia cochlearis, Rhagodia baccata, Hemiandra pungens, Hibbertia cuneiformis, Acanthocarpus preissii, Conostylis aculeata, *Trachyandra divaricata* and *Lepidosperma gladiatum.*



Source: from E.M. Mattiske & Associates, 1992.

WATER CORPORATION
BUNBURY WASTEWATER
TREATMENT PLANT OCEAN OUTLET

BUNBURY WWTP AREA
VEGETATION ASSOCIATIONS

FIGURE 5.3

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Tall coastal complex

This association occurs on the foredunes surrounding the nine infiltration ponds. It consists of closed, tall heterogeneous heath dominated by *Agonis flexuosa, Diplolaena microcephala, Hibbertia cuneiformis, Alyxia buxifolia,* and *Acacia cochlearis* over low heterogeneous heath dominated by *Acanthocarpus preissii, Lepidosperma angustatum, Leucopogon australis* and *Scaevola crassifolia.*

Disturbed coastal complex

Found in an area in the northern part of the project area, this association consists of open, low heterogeneous heath dominated by *Rhagodia baccata, Hemiandra pungens, Acanthocarpus preissii, Conostylis aculeata, *Trachyandra divaricata* and *Lepidosperma angustatum.*

Open woodland of* Eucalyptus gomphocephala *(Tuart) over sparse* Agonis flexuosa *and mixed low shrubs

This vegetation association occupies the majority of the eastern part of the project area. It consists of occasional *Eucalyptus gomphocephala* over sparse *Agonis flexuosa* over closed low heterogeneous heath dominated by *Acacia cochlearis, Jacksonia furcellata, Acanthocarpus preissii, Stipa tenuiglumis, Schoenus grandiflorus, Gompholobium capitatum* and *Olearia axillaris.*

Very open woodland of* Eucalyptus gomphocephala *(Tuart) over mixed low shrubs

This vegetation association occupies a narrow area within eastern half of the WWTP site. It consists of very occasional *Eucalyptus gomphocephala* over closed low heterogeneous heath dominated by *Lepidosperma gladiatum, *Trachyandra divaricata, Stipa ?puberula, *Bromus diaandrus* and **Ammophilia arenana.*

5.4.2 Declared rare and priority flora

Declared Rare Flora and Priority flora are classified by the Department of Conservation and Land Management (CALM), with Declared Rare Flora having statutory protection under the *Wildlife Conservation Act* 1950. CALM maintains a list of Declared Rare and Priority flora which is updated periodically.

Based on flora species identified by E.M. Mattiske & Associates (1992), and the current listing of Declared Rare and Priority flora prepared by Atkins (1996), no Declared Rare Flora or Priority flora are located within the project area.

5.4.3 Weeds

Introduced species are present mainly along the borders of tracks and in or near areas already utilised for waste treatment or recreation (E.M. Mattiske & Associates, 1992).

The 27 weed species recorded in the study area are generally common disturbance and naturalised species of grasses and perennial and annual herbs.

There are no declared noxious species although several are acknowledged environmental weeds. Environmental weeds are those plants which devalue or degrade an area of bushland by displacing native species.

The Agriculture Protection Board is able to declare introduced species as current or potential pests. Plants are declared under the *Agriculture and Related Resources Protection Act* 1976 and classifications are combined with management prescriptions. None of the weed species present at the WWTP site are currently gazetted as Declared Plants by the Agriculture Protection Board.

5.4.4 Conservation significance

The Usher-Stratham Environmental study notes that 'a case could be made for the protection of all the natural vegetation on the Quindalup Dunes in the Usher-Stratham areas' but then acknowledges that it is necessary to determine which areas should be protected and which are suitable for development. The study then notes that the vegetation to the north and around the WWTP is in relatively good condition and is important because it is continuous with high quality Tuart forest to the east, representing an opportunity for conservation of all the major vegetation associations of the area across the east-west continuum (Tingay & Associates, 1991).

The study by Hart Simpson and Associates (EPA, 1995) identified that the conservation significance of the Tuart woodlands is high.

The vegetation, habitats and communities represented by the Tuart Woodlands and forests in the WWTP area are given a high conservation value because of their good condition and because of the general scarcity of this unit in good condition, particularly in conservation reserves. *Tuart itself is widespread and is well represented in Reserves: Tuart-dominated vegetation in good condition is not.* Tuart woodlands in reserves elsewhere tend to have significantly degraded understoreys (Tingay & Associates, 1991).

Generally, the vegetation in the project area has considerable significance as a sand trapping and stabilisation agent, and therefore requires protection, preservation and management in order to prevent large scale erosion of the beach and dune environment.

Gibson et al. (1994) analysed the reservation and conservation status of communities occurring in the Swan Coastal Plain of Western Australia. They developed the following 'Reservation Status' categories for the communities:

- *Well Reserved:* represented in two widely separated National Parks and/or Nature Reserves;
- *Poorly Reserved:* occurring in only one National Park and/or Nature Reserve (endangered in the event of a catastrophe); and
- *Unreserved,* not known from any National Park or Nature Reserve.

Seven 'Conservation Status' categories were also developed by Gibson et al. (1994) (see Table 1) in order to assign each of the identified community types a conservation ranking.

Community Type 25 identified by Gibson et al. (1994), 'Southern *Eucalyptus gomphocephala - Agonis flexuosa* woodlands', may correlate with the open woodland and *Eucalyptus gomphocephala/Agonis flexuosa* Forest associations identified on the eastern side of the Bunbury WWTP site. Gibson et al. (1994) assigned this community type a Reservation Status of 'Poorly Reserved' and a Conservation Status of 'Susceptible'. Susceptible meaning, 'a community of concern because there is evidence that it can be modified or destroyed by human activities, or would be vulnerable to new threatening processes'.

5.4.5 *Tuart trees and environmental perturbations*

The Tuart/Peppermint vegetation associations within the study area are considered to be of high conservation significance. Ecoscape (1999) found that the most significant impact influencing the site is currently fire. Fire events have occurred at different times and at different places at the WWTP site, these have had a direct impact on the vegetation assemblage and also provide pathways for the establishment of weed species following the fire.

Ecoscape (1999) concluded that it is unlikely that any significant impact has occurred to date as a result of changes in groundwater levels, however, they propose the following issues be considered in future vegetation monitoring:

- If groundwater levels rise, plant community composition may change resulting in species which are more tolerant of moist conditions;
- If groundwater levels fall, plant community composition may change resulting in species which are more tolerant of drier conditions;
- Tuart trees grow in a wide range of niches, from low in the landscape to higher areas and are therefore likely to tolerate variations in groundwater level. However, the threshold of this variation is unknown;
- An increase in weed species at the WWTP site does not mean a change to underlying conditions and could just be due to these species out competing native species; and
- Other factors such as fire, access and increases in urban development need to be considered as having and impact on the vegetation.

The Operations and Construction EMPs will incorporate the findings of previous terrestrial vegetation survey work.

5.5 FAUNA

5.5.1 *Potential species*

Information about potential vertebrate fauna which could occur or which have been observed in the region is provided both in the Usher-Stratham Environmental Study (Tingay & Associates, 1991*)*, for birds and mammals. Appendix 2 also includes a list of reptile and amphibian species expected within the project area and the type of habitat in which they are likely to occur.

The tables listed in Appendix 2 indicate some 40 bird and 10 native mammal species that may occur in the study area, based on observations and desk top review of previous studies. Up to nine frog species and 42 reptile species are likely to occur in the area.

Eight of the mammal species listed are likely to occur at the site. Population densities of native mammal species in the south-west, excluding macropods, generally appear to be low (How et al., *1987).* In keeping with the known low densities of south-west populations it would be expected that only a few scattered signs of species such as the Echidna *Tachyglossus aculeatus* and Southern Brown Bandicoot *Isoodon* *obesulus* would be noted. Conversely the Western Grey Kangaroo *Macropus fulginosus* would be expected to be more common.

Eight species of introduced mammal, including cats *Felis catus* and rabbits *Oryctolagus cuniculus,* are expected to be present in the project area.

Twenty seven species of birds were identified in a survey of the coastal dunes at Minninup, including the Southern Emu-wren *Stipiturs malachurus* (Tingay & Associates, 1991).

Nine species of frogs may occur in the WWTP site bushland. Some of these species, such as the Glauert's froglet *Crinia glauerti,* require a permanent water source and this species may be satisfied with the year round water source provided by the human made infiltration ponds. Other species such as the Red-thighed froglet *Crinia georgiana* require only ephemeral water bodies. Two of the expected species, the Moaning Frog, *Heleioporus eyrei* and the Turtle Frog, *Myobatrachus gouldii,* are often found some distance from wetlands so are more likely to occur on the site. The Turtle frog *Myobatrachus gouldii* is common beneath logs in dense scrub on sand hills, habitat not dissimilar to that common to the study area.

Up to 42 species of reptiles are expected to occur in the WWTP site bushland (Appendix 2). This prediction can be validated by referring to previous studies conducted in the region and also by knowing the preferred habitat of the species listed. The majority (42%) of the species expected would be lizards belonging to family Scincidae, front fanged snakes (Elapids) would be the next richest, closely followed by the Geckos and Pygopods. The Carpet Python *Morelia spilota is* the only species of python expected in the area. Only two species from the families Typhlopidae and Varanidae (Blind snakes and Varanids, respectively) are thought to occur.

Several reptile species are either in the southern or northern limits of their range in the Bunbury region. Four species with Eyrean affinities, *Ctenotis fallens Hemiergus quadrodrilineatum, Lerista elegans* and *Simoselaps bertholdi,* are at their southern limit. The Australian wide species, *Lialis burtonis* also reaches its southern limits here.

5.5.2 Rare and specially protected fauna

Several species listed in the 1996 CALM Rare and Endangered Fauna Schedule have the potential to occur in the project area. These are described below.

Western Ringtail Possum Pseudocheirus occidentalis

The abundance of the Western Ringtail Possum has apparently been affected by land clearing and predation by foxes and cats. The species in the south-west is largely confined to Tuart / Peppermint forests. It was once considered abundant in the south-west (How et al., 1987) but viable populations are now only recorded near the towns of Busselton, Quindalup, Dunsborough and Albany (How et al., 1987), in several forest locations (Christensen et al., 1985*)* and Two People's Bay Reserve. Quindalup and Bunbury support similar vegetation associations as the project area, and it is possible that the species may be present.

Additionally, the following two species gazetted as Schedule 4 as 'specially protected fauna' may also occur in the project area:

Carpet Python Morelia spilota imbricata

The Carpet Python occurs over a wide area in the south-west, north to Geraldton and east to Kalgoorlie, Norseman and Cape Le Grand. It occupies most habitats in its range, sheltering in hollow logs, trunks, rock crevices and caves. While potentially occurring in the project area, the probability is low.

***Peregrine Falcon* Falco peregrinus**

The Peregrine Falcon is a sedentary species that inhabits inland treelined watercourses, woodland, pasture, swamps and Eucalypt forest near the coast. It is quite possible that it could be found in the project area.

5.6 ABORIGINAL HERITAGE AND NATIVE TITLE

5.6.1 Native title

Enquiries with the National Native Title Tribunal have shown that the Bunbury WWTP and land required to construct the ocean outfall are located within one registered Native Title Claim, being claim WC98/59 – Gnaarla Karla Booja claim. This large claim extends from the northern point of Garden Island, along the western shore of Garden Island south along the coast at the low water mark to a point due west of Capel. From here the claim boundary runs easterly in an arc to Kojonup, including the townships of Balingup and Boyup Brook. From Kojonup it runs in a north-easterly line up to and including Wagin and then to Corrigin and then continuing in a westerly direction to Armadale and back to Garden Island.

Since passing the registration test in 1998 under the *Native Title Act (C'wlth) 1993*, the claim was set aside by Justice Carr in 1999 and application for re-registration has been made. The status of claim remains uncertain and native title has been extinguished over most of the property in question as it is freehold, held by Water Corporation.

5.6.2 Aboriginal heritage

The local Aboriginal population will be consulted prior to commencement of construction with regard to the significance of the site and appropriate action taken as required following the consultation.

Aboriginal burial sites are commonly found in Holocene coastal dunes along the Western Australian coast. Although the dune blowout area affected by the proposal has been substantially modified due to unauthorised recreational vehicle use and the effects of natural erosion, the excavation of the beach and dune blowout area will be excavated in accordance with a plan prepared as part of the Construction EMP. This plan will be a strategy for response to ensure that the work is undertaken in accordance the *Aboriginal Heritage Act, 1972*.

5.7 RECREATIONAL USES

The following recreational uses have been observed for the area of the proposal:

- The dune blowout area is presently used by unauthorised trail bike riders (a practise not condoned by the Water Corporation or the local authority);
- The beach fronting the WWTP is traversed by 4-wheel-drive vehicles on the way to fishing and other recreational spots to the south;

- The 'Maidens' to the north is a valuable System 6 reserve and used for walking and bird watching;
- Beach directly in front of the WWTP is generally not used for swimming or beach based recreation as it is very similar in character to large areas of more accessible beaches in the region; and
- The area offshore of the WWTP contains several known recreational crayfishing and fishing locations.

6. EXISTING ENVIRONMENT: COASTAL AND MARINE

As a part of the PER preparation process, the Water Corporation undertook an extensive marine survey of the region to better understand existing environment. The study was designed around the concept illustrated by Figure 4.1 with measurement and sampling sites as shown in Figure 6.1.

6.1 COASTAL ENVIRONMENT

The project is located in the north-eastern corner of Geographe Bay, a shallow, north-facing, bay in the south-west of Western Australia, located approximately 200 km south of Perth (Figure 1.1). Geographe Bay is considered to extend from Cape Naturaliste in the west, to Bunbury in the north-east and has always enjoyed clear, clean, waters which has resulted in considerable use of the beaches and the sea for both recreational and commercial purposes.

The Bunbury WWTP is located within the dunes at the northern end of Geographe Bay. The sea floor is well covered with vegetation with algae dominant on the limestone reef and platform and seagrasses dominant in sandy areas. A series of relatively large stable parabolic dunes are located in the vicinity of the Bunbury WWTP with typical crest elevations of 20 to 30 m. A large unvegetated and active parabolic dune (blow-out) is located at the northern boundary of the WWTP and extends approximately 450 m east from the beach. The coastline in the area is relatively exposed to the west and north-west. Cape Naturaliste provides some degree of shelter to the south south-west. Offshore of the Bunbury WWTP the seabed consists of a sand veneer over limestone which outcrops as pavement and reef.

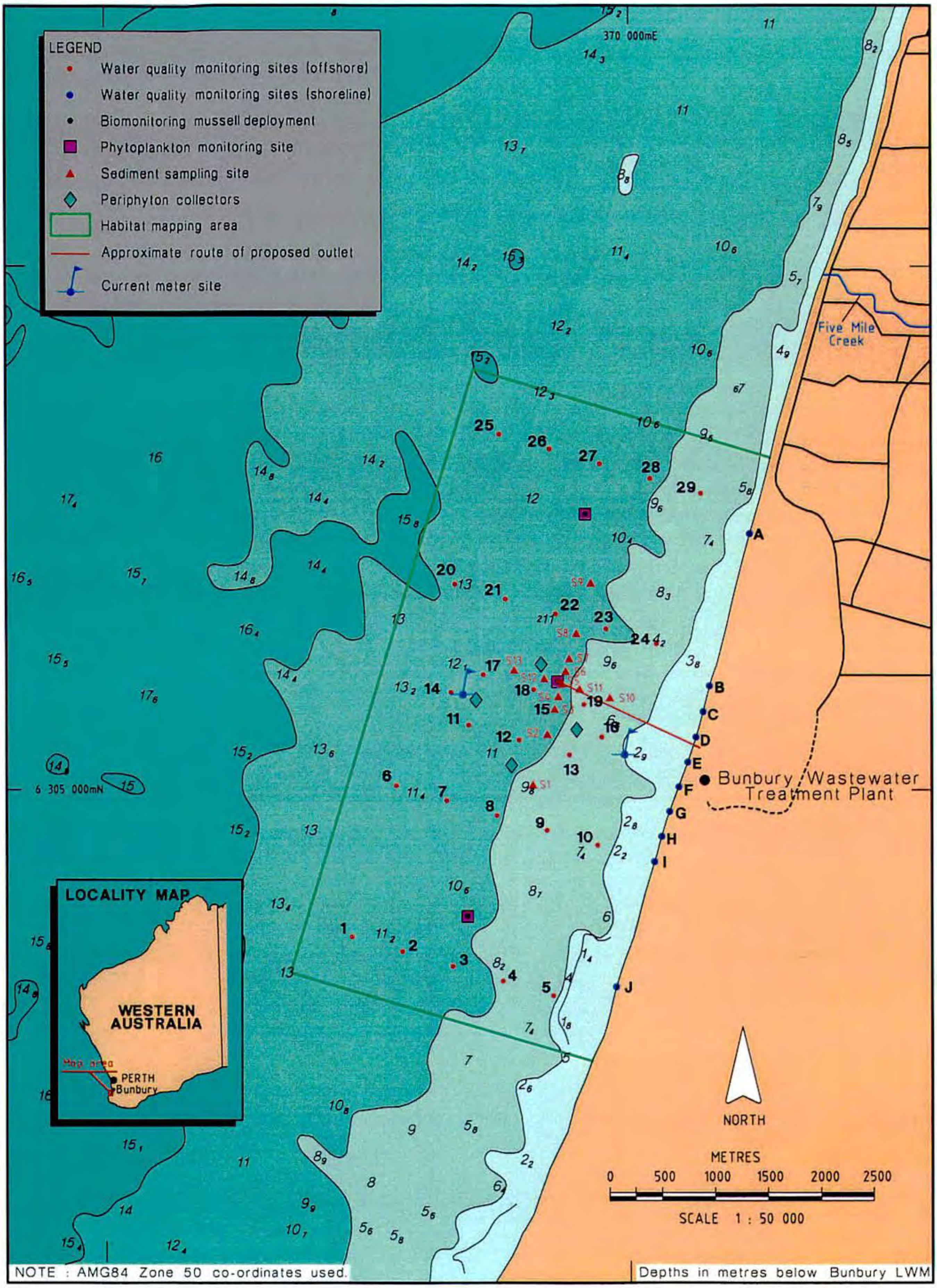
Recent sediment probing and drilling along the shoreline and the base of the foredunes did not encounter any limestone. The subsurface sediments were observed to be relatively consistent and generally comprised loose to medium dense sands which were overlying a veneer of loose to very loose sand (with some silt) which in turn were overlying medium to very dense sands (with some weakly cemented bands) to depths of approximately 10 m.

An analysis of aerial photography suggests that the shoreline in the vicinity of the Bunbury WWTP is relatively stable and is not undergoing net erosion or accretion. Analysis of the longshore sediment transport suggests that this shoreline experiences a net northward sediment transport of 30,000 m^3 to 60,000 m^3 per year.

6.1.1 Bathymetry

The Water Corporation commissioned a detailed hydrographic survey, side-scan sonar survey and seismic survey of the region to provide the best quality information for the project engineering.

The seabed in Geographe Bay has a relatively simple bathymetry with gentle offshore gradients. Offshore from the Bunbury WWTP, the seabed slopes evenly between 1:30 and 1:35 from the shore to a depth of 7 m (a distance of approximately 250 m offshore), the seafloor slope then reduced to 1:350 to 1:400 for the region further offshore, with a depth of 13 m generally occurring about 2.5 km offshore. The approximate depth and associated distance offshore of the WWTP is summarised in Table 6.1.



WATER CORPORATION
BUNBURY WASTEWATER
TREATMENT PLANT OCEAN OUTLET

LOCATIONS OF MARINE STUDY SAMPLING SITES

FIGURE 6.1

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Table 6.1 Distance offshore and corresponding depth adjacent to Bunbury WWTP

DISTANCE OFFSHORE (M)	DEPTH (M)
30	1
60	2
90	3
120	4
150	5
200	6
250	7
620	8
990	9
1360	10
1730	11
2100	12
2470	13

The sea-bed consists of a mixture of sand and reef pavement, with the difference in depth between pavement and surrounding sand generally less than 1.5 m.

6.2 TIDES

Bunbury experiences a mixed predominantly diurnal micro tide with a Lowest Astronomical Tide (LAT) to Highest Astronomical Tide (HAT) range of 1.3 m (Table 6.2).

Table 6.2 Tidal planes observed at Bunbury

TIDAL PLANE	ELEVATION RELATIVE TO CHART DATUM (m)
Highest Astronomical Tide (HAT)	+1.2
Mean Higher High Water (MHHW)	+0.8
Mean Lower High Water (MLHW)	+0.5
Mean Sea Level (MSL)	+0.6
Mean Higher Low Water (MHLW)	+0.6
Mean Lower Low Water (MLLW)	+0.3
Lowest Astronomical Tide (LAT)	–0.1

Source: Australian National Tide Tables (1999).

Storm surge levels at Bunbury are reported to generally be in the range of 0.4 m to 1.05 m between 1930 and 1980 (Steedman, 1981). In 1978 Cyclone Alby caused an extreme water level of 2.48 m above Chart Datum (Department of Marine and Harbours, 1992).

6.3 WIND

The wind is the dominant force generating currents in the region and, therefore, a good understanding of the wind climate is required before the fate of a treated wastewater plume can be established.

WNI Science & Engineering (WNI) were commissioned to conduct a study of the local oceanography (WNI, 2000a, 2000b). The objective of this work was to gain an understanding of the physical factors affecting circulation in the receiving waters and use this understanding to support the development of a hydrodynamic model to predict the behaviour of the plume from the outfall. This work included installation of a weather station on top of the dunes adjacent to the WWTP for the year April 1999–July 2000 and analysis of the data collected and historic data.

6.3.1 *Overview of the wind climate at Bunbury*

Winds at Bunbury are determined largely by the locations of the sub-tropical high pressure ridge and the migratory low pressure systems (extra-tropical cyclones) which exist on the poleward side of the ridge. The wind field has the following generally seasonal characteristics.

Summer (December to March)

From December to March, the subtropical ridge is usually located to the south of Australia. A predominantly easterly airflow is therefore directed over the area. However, meso-scale breezes and the Western Australian heat trough, modify this airflow considerably.

Sea and land breezes are generated near coastal locations owing to the different thermal properties of land and water. At Bunbury such an influence is likely to be experienced frequently. Sea breezes of the lower west coast of Australia tend to be between south and west. They often begin mid-morning and last until mid-evening. The land breeze effect causes a reversal at night in which the winds blow offshore reinforcing the basically easterly flow.

During the summer months, a heat trough—an elongated zone of relatively low pressure—often forms near the west coast and has a major effect on the weather of the region. The trough may be variously located along the coast, inland or offshore. On the eastern side of the developing trough, winds gradually become more northerly while on its western side the winds become more southerly, that is, the perturbation in the easterly flow is increased. Usually at some time in this development, synoptic scale features cause the trough system to move eastward, causing a change from the hot, dry, northerly airstream to a cooler, moist, southerly airstream. The usual lifetime of such cycles is 3 to 7 days with a frequency of about 5 per month during summer.

As a result of these influences, winds in the Bunbury area at nights and in the mornings are generally from between east and south at speeds of 2–7 ms^{-1}. In the afternoons and evenings winds are generally south-westerly at speed of up to 15 ms^{-1}.

Winter (June to September)

Extra-tropical cyclones occur on average about once every three to five days and pass from west to east just south of the Australian continent. They are some 500 to 1000 km in diameter. As the low pressure system and its associated cold front (relatively sharp boundary between warm northerly air and cooler southerly air) move eastward the winds at Bunbury change from north-westerly through to south-westerly to southerly. Mean north-westerly and westerly wind speeds in such systems are frequently of order 12 ms^{-1} but on occasions, perhaps once per winter month, they may reach up to 25 ms^{-1}. Winds from the south-west and south generally reach 10–15 ms^{-1} and rarely, perhaps once per season, reach 20 ms^{-1}. Winds exceed gale force for less than 5 per cent of the time. Between such extra-tropical cyclone events, winds are generally less than 8 ms^{-1} and for some 40 percent of the total time are less than 5 ms^{-1}.

Dissipating tropical cyclones

Occasionally in the late summer (March/April) decaying tropical cyclones may travel southward along the west coast. As they move southward they weaken and change their characteristics. In the southern Indian Ocean they are almost always influenced by a nearby southern depression and cold frontal system. However winds associated with these systems can be of intensity similar to those of winter extra tropical cyclones.

Transitional periods

The other periods—April/May and October/November—are transition periods between the summer and winter patterns when conditions are generally calmer and may reflect characteristics of both patterns.

6.3.2 1999–2000 wind data

Wind measurements were obtained from the weather station installed at the Bunbury WWTP from April 1999 to July 2000. The results are summarised in Figure 6.2 and Figure 6.3.

In April 1999, a high pressure system was located in the Bight directing an easterly airflow over the State. Consequently, east and south-east were the most common wind directions, as well as the direction for the maximum wind speeds. In May 1999, once again, the most frequent winds came from the E; however, the strongest winds came from the south-west, west and north-west. This marked the onset of winter, as the subtropical high pressure ridge started to migrate towards the equator and extra-tropical cyclones track further north.

In June 1999, the most frequent wind direction was north-east although there was also a significant contribution from the west and north. July, August, September and October were characterised by strong winds from the western quadrants, associated with the passage of winter extra-tropical cyclones. November 1999 to March 2000 see a transition to more frequent easterly winds.

Sea breezes commenced in October 1999 and went through to April 2000. These events were interspersed with heat troughs forming down the West Coast, it was observed that there was less seabreeze activity than may usually be expected over the summer months.

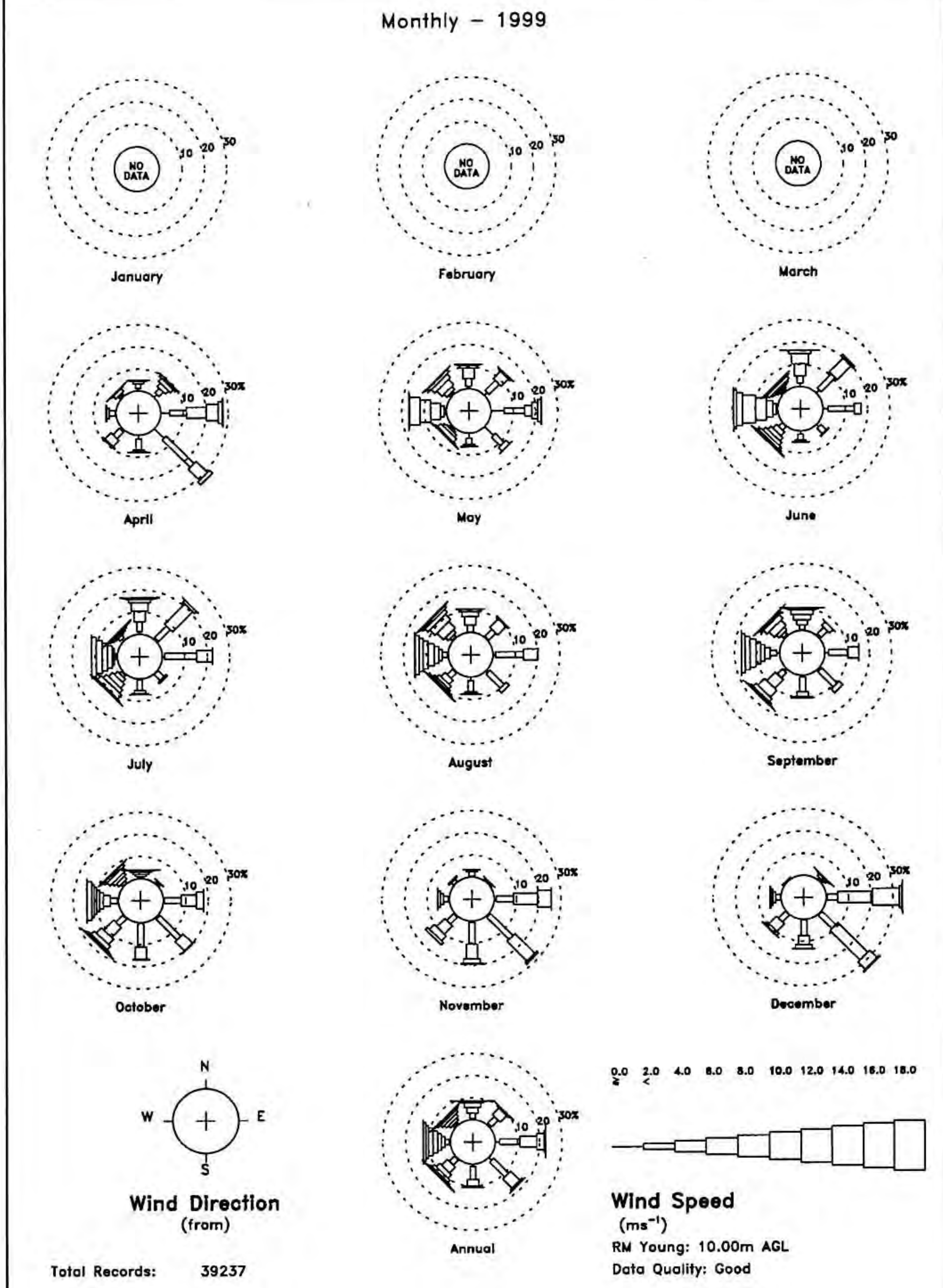
May and the first half of June 2000 was characterised by calm easterly conditions then the winter pattern of strong west and north-west winds emerged for mid-June and July 2000.

6.3.3 Representativeness of the 1999/2000 summer winds

The summer winds were of particular importance for the following reasons:

- This is when most recreational activity is likely to occur;
- Higher water temperatures result in maximum growth of phytoplankton;
- South-west seabreeze may tend to blow the plume toward the beach; and
- Calm conditions at the end of summer will result in lowest initial dilutions.

The hydrodynamic modelling exercise (described in Section 7.0) was undertaken using the 1999/2000 wind records. The measured 1999/2000 summer winds were compared with the historical wind records presented by Fahrner and Pattiaratchi (1994) to assess how representative the 1999/2000 summer season was for the region as this has a bearing on the interpretation of the numerical modelling results, which generated results using wind data collected over 1999/2000.



WATER CORPORATION
BUNBURY WASTE WATER
TREATMENT PLANT OCEAN OUTLET

BUNBURY WWTP
MONTHLY WIND ROSES FOR 1999

FIGURE 6.2

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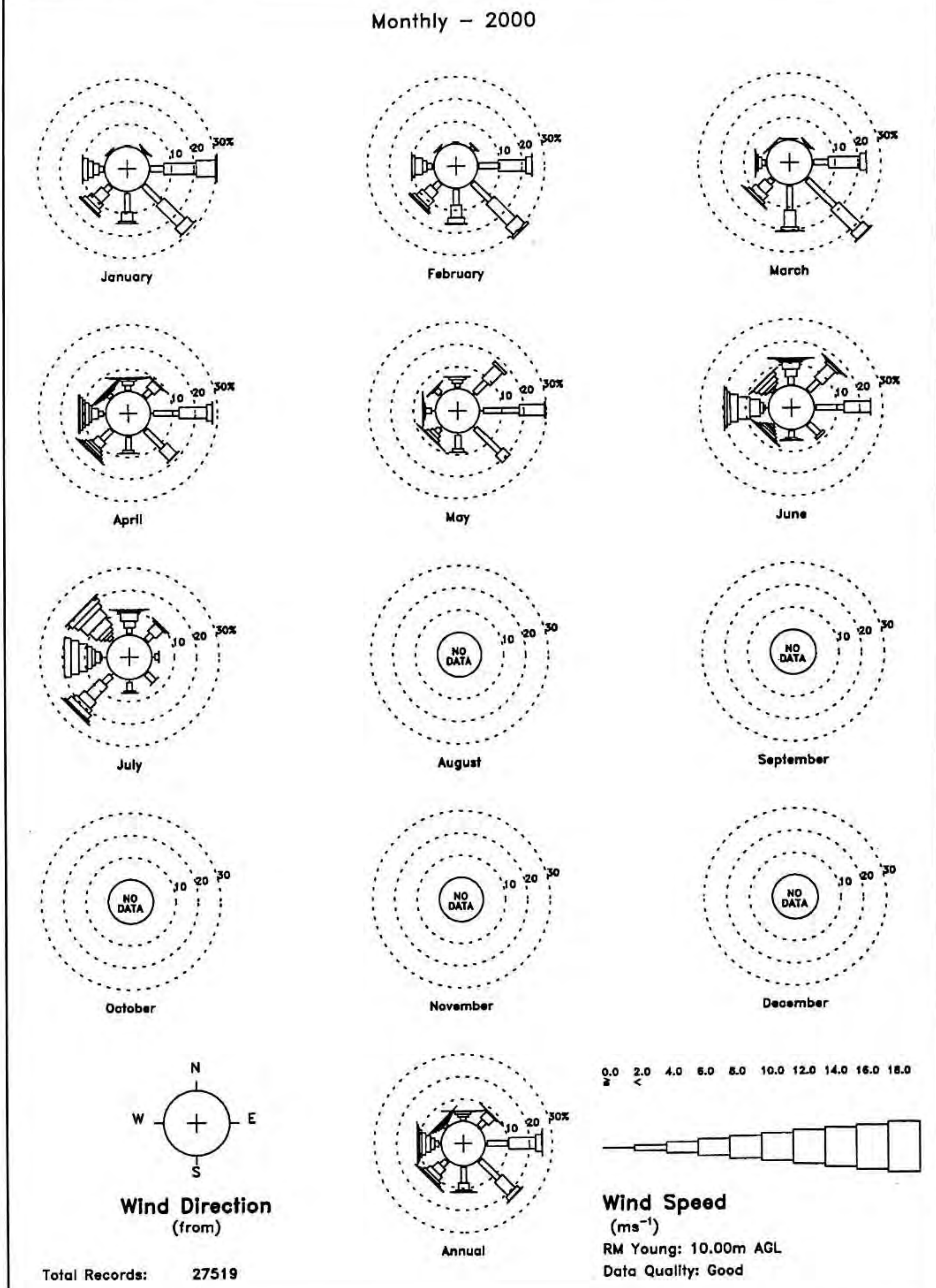

WATER CORPORATION BUNBURY WASTE WATER TREATMENT PLANT OCEAN OUTLET	BUNBURY WWTP MONTHLY WIND ROSES FOR 2000
	FIGURE 6.3

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Figure 6.4 and Figure 6.5 show comparisons between the two data sets for the months of December to February between 09:00–10:00 hrs and 15:00–16:00 hrs, respectively. The % occurrence of wind in the afternoon, by direction octant, in the 1999/2000 data was compared with the 6 year data set. It was found that, for the 1999/2000 summer the occurrence of wind from the W and SW was about 12% less than the 6 year record and from the E and SE was about 22% greater than the 6 year record. This implies that the conditions observed over the summer 1999/2000 were calmer than 'usual' as the seabreeze is a greater source of energy to the coastal zone than the offshore, easterly wind.

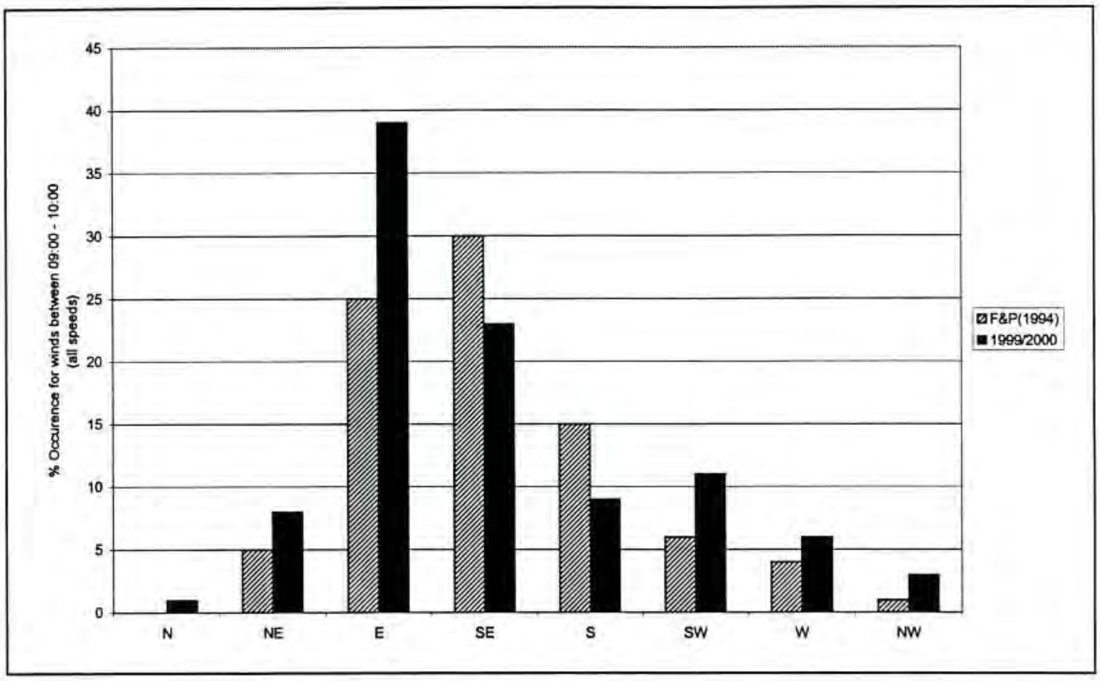


Figure 6.4 Bunbury WWTP: comparison between 6 year wind data set and summer 1999/2000 winds—morning

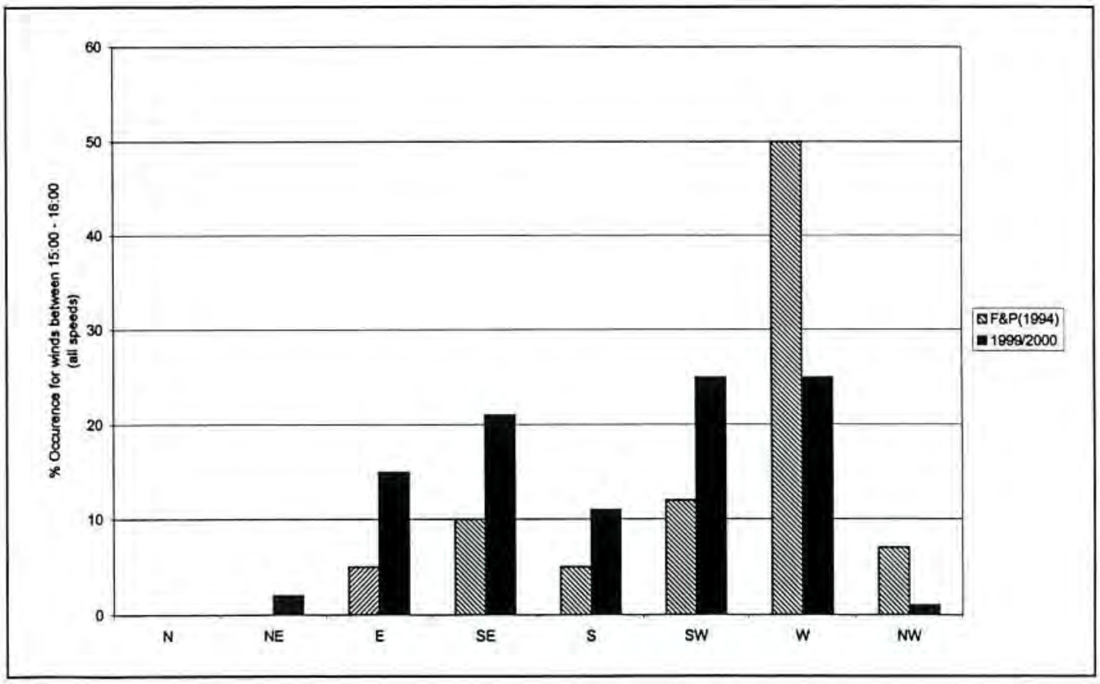


Figure 6.5 Bunbury WWTP: comparison between 6 year wind data set and summer 1999/2000 winds—afternoon

This implication for the modelling is that the results will be slightly conservative as stronger winds result in greater mixing of the plume and more rapid dispersion via stronger currents.

6.4 CURRENTS

The circulation in the region is the result of a combination of forces including: wind stress, sea level fluctuations (tides, seiches, continental shelf waves and meteorological affects), short period sea and swell waves, density gradients and larger scale oceanic circulation features (mainly the Leeuwin Current).

For this PER, an oceanographic study by WNI Science and Engineering was commissioned (WNI, 2000b). This included the measurement of currents at two stations offshore from the Bunbury WWTP (refer Figure 6.1), opportunistic conductivity-temperature-depth (CTD) profiles during field visits and an assessment of the regional and local scale factors responsible for water movement at the outlet site.

6.4.1 Oceanic currents

The Geographe Bay region is influenced by the flows of two ocean currents: the Leeuwin Current and the Capes Current.

The Leeuwin Current exerts a persistent influence on the circulation in the winter months mainly in the form of a residual drift towards the south. The core of the Leeuwin Current is located over or just seaward of the shelf break, generally defined as the 200 m isobath, all year round (Church et al., 1989, Smith et al., 1991, Cresswell and Peterson, 1993 and Gersbach et al., 1999). The landward boundary of the Leeuwin Current varies seasonally, closer to the shore during the autumn and winter months and retreating offshore to approximately the 50 m isobath during the spring and summer months.

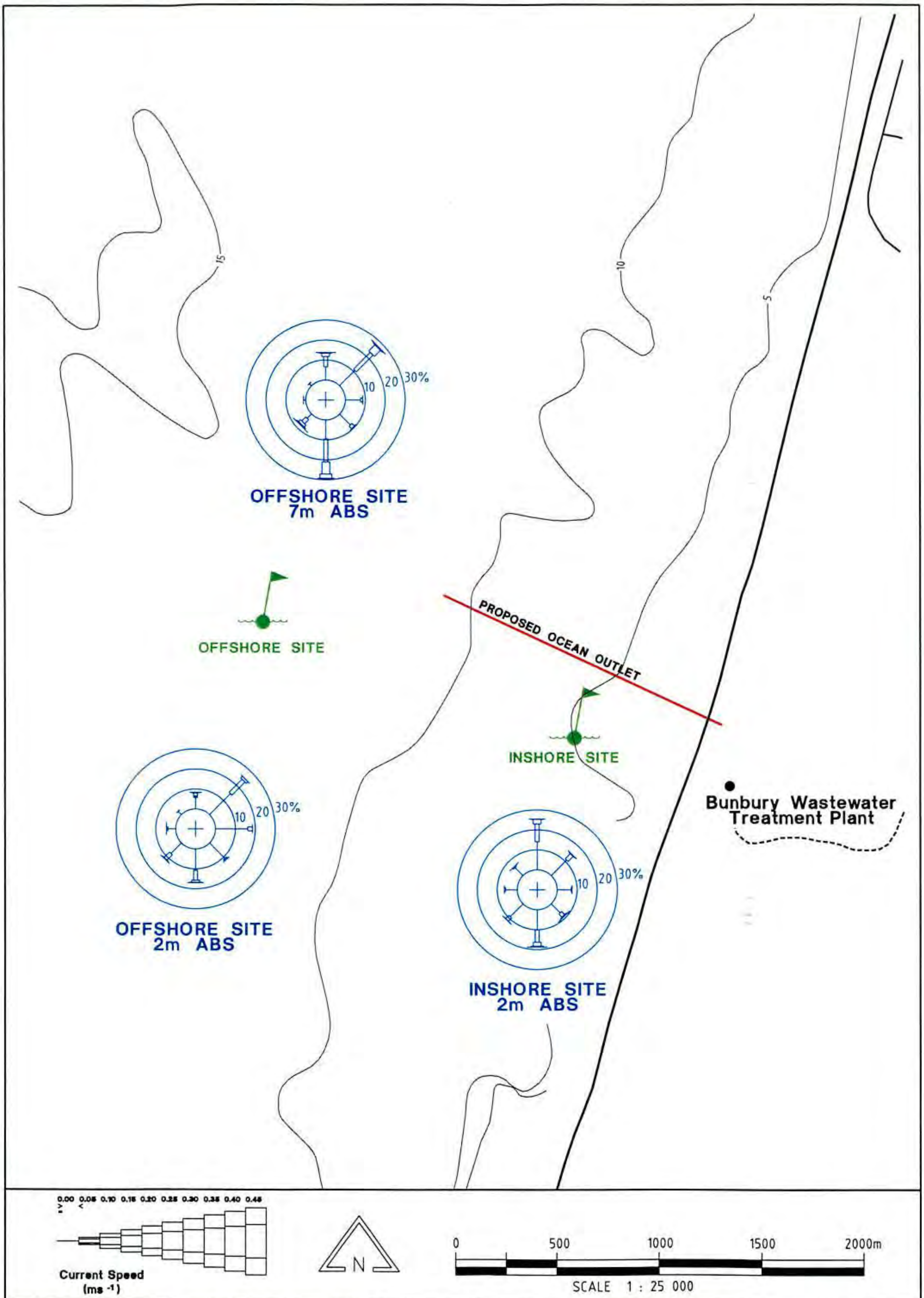
The Capes Current has been identified from satellite imagery and other data sources as a cool, seasonal inner shelf current which flows northwards opposite to the direction of the Leeuwin Current in the summer months when the seasonal southerly wind is at its maximum strength (Pearce and Pattiaratchi, 1999). The unique feature of the Capes Current is that it has been shown that the source water of the cool Capes Current is augmented or fully supplied by upwelling between Capes Leeuwin and Naturaliste (Gersbach et al., 1999).

The contribution of the ocean currents to the water motion will be variable and it is likely to be less than 0.05 ms^{-1}.

6.4.2 Measured currents

Current meters were deployed at the locations shown in Figure 6.1 between March 5 and July 30, 1999 and between January 13 and March 5, 2000. One meter was installed at the inshore location 2.0 m above the seabed (ASB) in 6 m deep water, two meters were installed in 12 m deep water at the offshore location, one 2.0 m ASB, the other 7.5 m ASB. This configuration was chosen to allow data representative of seasonal horizontal and vertical characteristics of the regional current field to be obtained.

The results of the two deployments are summarised in Figure 6.6, a more detailed analysis is presented by WNI (WNI, 2000b).



WATER CORPORATION
BUNBURY WASTEWATER
TREATMENT PLANT OCEAN OUTLET

MEASURED CURRENTS
(5.3.99 - 30.6.99 AND 13.1.00 - 5.3.00)

FIGURE 6.6

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Currents measured in the waters offshore from Bunbury were generally weak and variable with speeds predominantly less than 0.1 ms^{-1}. The maximum current speed measured was 0.3 ms^{-1} during a storm event in June, 1999. The currents at the offshore site increased with distance from the seabed. The directions were predominantly parallel to the shore (longshore), constrained by the coastline and bathymetry. The residual drift was to the north in the summer and to the south in the winter.

The currents at the offshore site are likely to be most similar to the currents at the diffuser site given the close proximity and similarity in water depths.

Of relevance to the efficient mixing of the wastewater plume is the persistence of calm conditions. According to Fahrner and Pattiaratchi (1994), wind speeds are likely to be too low to affect circulation patterns for about 5–10% of the time and the persistence of calm conditions is generally less than 12 hours.

Tidal forcing is small and its contribution to water movement is estimated to be of the order 0.01 ms^{-1}. The propagation of continental shelf waves are less regular but could contribute currents of up to 0.2 ms^{-1}. Seiches and storm surges may contribute slightly higher currents than tides but the magnitude will still be small (although the wind stress associated with the storm surge will generate large currents).

Sea and swell waves will generate drift in the surface waters in the direction the swell is running. This will only be significant for larger, short period and therefore locally generated waves.

The study clearly showed that the dominant force driving local currents is wind stress and, as such, accurate wind data is the most important requirement for generating an accurate hydrodynamic model.

6.5 VERTICAL STRUCTURE

The vertical structure of the water column has an important bearing on the potential behaviour of a wastewater plume. If the water column is stratified (characterised distinct horizontal layers of differing salinity or temperature, with denser water at the bottom) then the plume may not mix so efficiently as if the water column was uniform.

To measure the degree of vertical stratification, conductivity and temperature profiles were recorded (conductivity-temperature-depth: CTD) during field visits. These allowed the vertical density structure of the water column to be observed, if groundwater or some other flow (i.e. from local creeks or the Leschenault Inlet) was important in the region, then the effect of this inflow would appear in the vertical structure of the water column.

It was found that differences in vertical structure were not substantial enough to warrant the inclusion of regional density effects in the hydrodynamic model (WNI, 2000b). The waters of the area proposed for the outlet are regularly mixed from the top to the bottom by wind stirring, wind speeds of >5 ms^{-1} for several hours are generally sufficient.

6.6 WAVE CLIMATE

Both wind waves (waves being generated by the prevailing winds) and swell waves (waves that are distant from their place of generation) are experienced at the shoreline in Bunbury. A detailed review of wave measurements obtained in the vicinity of Bunbury and a description of the Bunbury wave climate is presented by WNI Science and Engineering (WNI, 2000a).

The predominant swells affecting the Bunbury region are generated by low-pressure systems in the southern Indian Ocean. These swells typically arrive from the south-west and, at the site of the Bunbury WWTP, these waves are refracted and partly attenuated around Cape Naturaliste. North-westerly and westerly swells are also generated by cold fronts in the Indian Ocean and these swells often combine with wind waves to produce relatively high energy storm waves. Wave conditions were observed in 12.5 m of water offshore of Bunbury between April 1997 and May 1999 and the mean significant wave height (refer to glossary) ranged from 0.5 m during January to April to 1.1 m in August, with an annual mean of 0.8 m. The mean spectral wave period ranged from 3.6 s in January to 6.4 s in July.

An analysis of the extreme wave conditions associated with extra-tropical storms and cyclone events for Bunbury was conducted by WNI Science and Engineering (WNI, 2000a). This analysis indicated extreme significant wave heights (in 10 m of water) of 3.9 m to 4.9 m for extra-tropical and cyclone storms, respectively. In late-summer, the wind field associated with a dissipating tropical cyclones may generate high-energy north to north-westerly sea waves which may propagate directly to the shoreline adjacent to the Bunbury WWTP.

6.7 BENTHIC HABITAT

As part of the preparation of this PER, the Water Corporation commissioned the Department of Botany, University of Western Australia and Alex Wyllie & Associates Pty Ltd to undertake a detailed marine habitat mapping exercise for the region (Cambridge and Kendrick, 2000).

The key tasks undertaken for the habitat mapping were:

- Acquisition of high quality aerial photography of region offshore which maximised penetration through the water column;
- Rectification, geo-referencing and mosaicing of aerial photography;
- Bare sand and vegetated areas delimited manually on 1:25,000 aerial mosaic using variations in phototonal density;
- Broad scale ground truthing undertaken using a series of manta video tows across the photographed region;
- Spot dives to confirm habitat type and species concentrated in the finely grided 1 km^2 area in the most likely region for the pipeline diffuser;
- Species assemblage and cover assessed non-destructively by photographing $1m^2$ quadrats (6 replicates) from one seagrass and sand habitat near the end of the pipeline, collections were made of the seagrasses from a 0.25 m^2 quadrat in each of the photoquadrats;
- Finer scale habitat mapping, covering an area of 1 km x 1 km at the most likely region for locating the pipeline diffuser;
- Selection of most suitable location on basis of habitat; and

- Revisit region selected for additional ground truthing and mapping over an area 200 m x 500 m.

6.7.1 *Mapping process*

High quality aerial photography of the region was obtained for the study. This was rectified, geo-referenced and mosaiced to ensure complete spatial accuracy and maximum definition of subsea features. On the basis of the aerial mapping, an extensive program of ground truthing (inspection of the seafloor by marine botanist divers) was devised. This resulted in more than 1000 referenced points where the habitat was known and some 19 km of video transect footage.

6.7.2 *Benthic habitat types*

From the mapping, Cambridge and Kendrick (2000) developed the following descriptions species/habitat associations.

Bare sand areas

These formed patches varying in size from a few metres to more than 150 m in width. At depths shallower than 13 m, they had prominent north-south trending ripples some 30-40 cm in height and 1 m apart, indicating considerable sand mobility. Sand patches in deeper water (15 m) were not rippled. Many of the sand patches had long lines of drifting algae and seagrass leaves, which formed slowly rolling wrack lines in the hollows between ripple crests (Plate 6.1).

Plate 6.1 Seagrass wrack on sand habitat near proposed diffuser location

Reef pavement and high relief reef

Reef habitats ranged from limestone pavement partially covered by sand, ridges and gullies with a relief of as much as 2 m, to isolated rock pinnacles and undercut limestone outcrops, 1-2 m high (Plate 6.2). Reef pavement emerging though a thin covering of sand, carried attached suspension-feeding animals (sponges and ascidians), and plants such as the brown alga, *Scaberia agardhii* growing amongst sparse seagrass. The seagrasses *Amphibolis antarctica* and *A. griffithii* also formed dense stands in some areas on sand-covered reef pavement (Plate 6.3), as well as growing directly on flat surfaces of higher rocky outcrops (Plate 6.4). High relief reef surfaces carried a diverse covering of algal turf and foliose brown and red algae, particularly *Sargassum*, *Dictymenia sonderii* and *Callophycus dorsiferus* (Plate 6.2). Similar complex assemblages have been recorded from south of Mandurah (Montgomery, 1995) and Walker et al. (1994). The seagrasses *Amphibolis antarctica* and *A. griffithii* were observed growing directly on flat surfaces of some areas of high relief reef (Plate 6.4). Kelp (*Ecklonia radiata*) was rare. *Thalassodendron pachyrhizum*, a seagrass which only occurs on rock, was observed once in the video. Because of its rarity, it was not recorded as a separate category.

Plate 6.2 High relief reef with white encrusting sponge algae, surrounded by* Posidonia angustifolia *on coarse sand

Seagrasses

The ribbon weed, *Posidonia angustifolia*, was the most widespread seagrass and occurred only on sand (Plate 6.3). *Amphibolis antarctica* and *A. griffithii* formed dense stands in some areas on sand-covered reef. *Halophila ovalis* is a small species which grows hidden under the leaf canopy of larger seagrasses or at the edge of patches. Although it is a common species, it was not recorded as a separate category because of its temporary occurrence and small size, which made it difficult to record consistently from video footage.

Plate 6.3 **Posidonia angustifolia** ***on sand over reef and*** **Amphibolis antarctica** ***and algae on reef, sand in background***

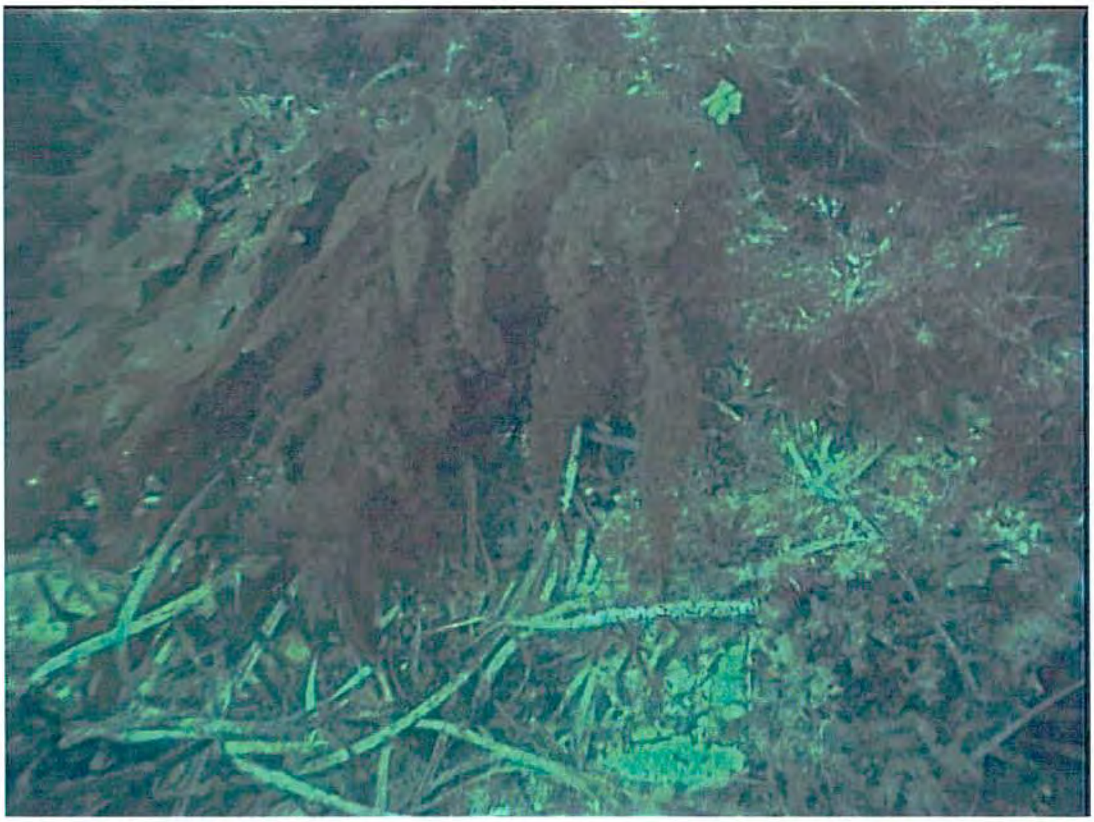


Plate 6.4 Brown algae on reef pavement with seagrass on sand pockets

Results from the side-scan sonar indicate that some of the sand areas cover the basement Pleistocene rock to a depth of several metres. The deeper sands are vegetated by seagrass or remain unvegetated. On shallower sands, *Posidonia* meadows graded into algae-covered rock pavement. The presence of sand waves up to 1 m high indicated considerable movement of sand within the seagrass areas. On the leeward side of the sand waves (facing east), steep cutaways were observed, which have been formed by the erosion of sand and fibre under the living seagrass. These erosion features are typical of seagrass meadows growing on sand in areas exposed to wave action, both in Western Australia and other parts of the world.

6.7.3 Biota associated with benthic habitats

The mosaic of seagrass and small rocky outcrops provides an array of habitats for marine invertebrates through the provision of attachment sites and sheltered holes. Seagrasses with their associated algal and faunal epiphytes are very distinctive along southern Western Australia and contain a high abundance and production of small invertebrates (Edgar, 1990a; Brearley and Wells, 1998). Fauna associated with seagrasses are important in the diet of fishes and large invertebrates such as the Western rock lobster, *Panulirus cygnus* (Edgar 1990b). The small rocky outcrops scattered among the seagrass patches were often occupied by *P. cygnus* they are typically found in this type of habitat (Jernakoff et al., 1987). The rocky outcrops were also covered with large ascidians such as *Herdmonia momus*, encrusting and large upright sponges some of these 50 cm tall (Plate 6.5), as well as temperate corals such as *Turbinaria* and *Coscinarea*. The sponges and ascidians are filter feeders and characteristically flourish where there are strong water movements.

*Plate 6.5 Sponge on rock between seagrass (***Amphibolis***)*

6.7.4 Summary of mapping results

The seabed in the survey area consisted of algae-covered reef, seagrass on sand and small sand patches forming mosaics at scales often less than 10s of metres, interspersed by large bare sand patches and detritus (floating seagrass and algal wrack).

Reef pavement occurred through out the study area but more frequently in the northern sector of the survey area where seagrass meadow was less frequent. The high diversity of habitat encourages rich communities of submarine plants and animals in the reef and sand mosaic.

There was a north-east to south-west trending pattern in the presence of high relief reef with ridges spaced approximately 500 m apart, following ancient coastlines.

The initial survey showed that bare sand areas were concentrated in the NW sector of the survey area. A subsequent, more detailed survey of an area 200 m x 500 m found that sand was most common in the north-western third of the survey zone but some patches of seagrass and reef pavement were also present (Figure 6.7). Seagrass and reef pavement were the dominant habitat type in the eastern half of the survey zone, with only small (1–10 m) sand patches. There were no declared rare or priority marine flora in the survey region.

Quantitative sampling was carried out for seagrass and reef pavement within the diffuser zone and several observations are pertinent to the proposal. Firstly, seagrasses consisting mostly of a species of ribbon weed, *Posidonia angustifolia*, are very dynamic in terms of forming meadows on sand patches and sand waves. Many seedlings, about 3 months old, were observed growing from seeds released in the previous December. Some seedlings can be expected to survive the winter storms and eventually grow into patches, which expand laterally to form a continuous meadow. In other areas, sections of seagrass meadow were being eroded by wave action to form cutaways. Secondly, there was a particularly rich variety of large sponges (15-50 cm wide), which were present on reef and partially buried reef pavement, often growing amongst algae and seagrass. Counts of large sponges made from video tows of the survey area suggested that there is approximately 10–20 sponges per 500 m of transect. Sponges provide habitats for a range of invertebrates, including the much prized cowrie shell, *Cypraea (Zoila) friendii*. Sponges also filter seawater and use particulate matter suspended in the water column as food. During the sampling in March 2000, large quantities of organic particulate matter were observed in the water (described as 'marine snow', possibly benthic diatoms or bacterial strings). The nature of this suspended matter has not been investigated in detail in this area but may be significant in the ecology and nutrient cycling.

6.7.5 Selection of most suitable diffuser site

Figure 6.7 shows the results of the benthic habitat survey relative to the proposed pipeline and diffuser location. The location for the diffuser was chosen on the basis of maximising the amount of sand and reef habitat and minimising the seagrass habitat in the vicinity of the diffuser. The rationale being that seagrass habitat was the more fragile and environmentally significant habitat, followed by reef habitat and then sand habitat.

This resulted in the location chosen for the end of the diffuser being a distance of 1.7 km offshore from the high water mark heading offshore from the dune blowout at a bearing of 290°. The ultimate location of the end of the diffuser will be within ±50 m of this point as there will need to be tolerance allowed for laying the pipe to avoid reef. Additionally, the mobile nature of the sand and seagrass may mean that at the time of construction the diffuser may be moved slightly to maximise the amount of sand under the diffuser.

• REEF
• SAND
• SEAGRASS

0 100 200 400 600m
SCALE 1:15000

WATER CORPORATION
BUNBURY WASTEWATER TREATMENT PLANT OCEAN OUTLET

MARINE BENTHIC HABITAT AND PROPOSED OUTLET LOCATION

FIGURE 6.7

N:\611\43440700\Jobrequest\1.8.2000\07VF14.DGN

6.8 WATER QUALITY

6.8.1 Regional influences

Geographe Bay, which forms the coast off Bunbury, is somewhat more sheltered than the coast to the north. The bay is relatively shallow and the sea-floor dominated by a biologically diverse habitat consisting of seagrass, reef and sand communities (Cambridge and Kendrick, 2000). The Leeuwin Current and the Capes Current both influence Geographe Bay through intrusions of eddies from these currents (WNI, 2000b; Pearce and Pattiaratchi, 1999) (refer Section 6.4).

The Leeuwin and Capes Currents may also make a contribution to the nutrient status of the outfall site. The Capes and Leeuwin Currents contain relatively low concentrations of nitrate (<5.6 µg/L) and phosphate (<9.0 µg/L) between Capes Naturaliste and Leeuwin (Gersbach et al., 1999), which is consistent with observations at Perth by Pearce et al. (1992). The Capes Current has relatively but not substantially higher concentrations of phosphate and nitrate than the Leeuwin Current. The range of the nutrient concentrations are shown in Table 6.3. The reason for the relatively small difference in concentrations of phosphate and nitrate between the Leeuwin Current and Capes Current in the upper 50 metres of the water column is due to the Leeuwin Current preventing nutrient rich waters from upwelling from the outer, deep shelf region. The Leeuwin Current therefore restricts upwelling associated with the Capes Current to the nutrient poor waters over the outer shelf region.

Table 6.3 Nutrient concentration range of the Leeuwin and Capes Currents of the south-west coast of Western Australia

NUTRIENT	LEEUWIN CURRENT	CAPES CURRENT
Nitrate	2.8–5.6 µg. N/L	3.5-5.6 µg.N/L
Phosphate	3.1–7.8 µg. P/L	4.7–7.8 µg.P/L

Source: Gersbach et al., 1999.

6.8.2 Measurement of water quality at Bunbury

As part of the PER preparation process a dedicated, ongoing water quality monitoring program was implemented (DAL, 1999a, 1999b, 2000a). Water quality in the waters offshore of the Bunbury WWTP was measured on three occasions: early autumn (9 March 1999); mid-spring (5 October 1999) and mid- summer (9 February 2000). In addition, the University of Western Australia (UWA) measured water quality parameters at three sites as part of the phytoplankton and productivity study (Waite and Alexander, 2000).

The locations of the water quality sampling sites and the phytoplankton sampling sites are shown in (Figure 6.1). The figure shows the original 29 water quality sampling sites, following the first survey an additional 5 sites were sampled midway between sites 5, 10, 16, 24 and 29 and the shoreline. These sites were introduced to better pick up any gradient in water quality between the shoreline and the ocean (DAL, 2000a).

For the dedicated water quality surveys, at each ocean site, samples were obtained from the 'surface' (1 m depth) and 'depth' (approximately 2 m from the bottom). Shoreline samples were obtained at the 14 sites along the coast on either side of the proposed outlet location. Salinity and temperature profiles were measured at Sites 3, 8, 20, 24 and 27.

At each site, samples were obtained from the surface and bottom waters and analysed for: total phosphorus (TP); total Kjeldahl nitrogen (TKN); filterable reactive phosphorus (FRP); ammonium; nitrate + nitrite; chlorophyll; thermo-tolerant coliform; and, faecal streptococci.

The phytoplankton study undertook monthly sample collection near the proposed outlet during summer (November-April) and every six weeks during winter (May-October): Among other activities this study measured depth integrated or near surface water column nutrients (TN, NO_3, NH_4, FRP, TP) and chlorophyll a at three stations.

The three stations were selected to be in about the same depth of water, all a similar distance (~1500 m) from shore. 'Station 0' was at the site of the proposed outfall, 'Station N' was 2 km north of 'Station 0' and 'Station S' was 2 km south (refer Figure 6.1).

Because the dedicated water quality survey analysed a larger number of samples and the analyses were performed by a NATA registered laboratory (Marine and Freshwater Science Laboratory, Murdoch University), these are the results presented in Table 6.4. MAFRL have undertaken most of the nutrient analysis for Perth's coastal water studies for many years and as such there is considerable confidence in the results from MAFRL. The water quality results from the phytoplankton study allowed an assessment of the seasonality in nutrient levels to be made.

6.8.3 *Water quality offshore*

In the March 1999 and February 2000 surveys, waters one to two kilometres offshore showed typical conditions for late-summer in northern Geographe Bay (DAL, 1995), with low nutrient concentrations and low chlorophyll a concentrations throughout the water column (refer Table 6.4). The offshore concentrations of total phosphorus, free reactive phosphorus, ammonium and nitrate + nitrite were relatively low and generally just above the laboratory detection limits. However, in winter concentrations of total phosphorus, free reactive phosphorus, ammonium and nitrate + nitrite near the bottom were considerably elevated above the concentrations found in surface samples (refer Table 6.4). Also of note was that the nutrient and chlorophyll concentrations were generally higher with depth at all sites. This probably reflects the fact that the seabed of the area sampled was covered with a productive habitat of algae covered reef and seagrass which would have been recycling large quantities of nutrients via the surrounding waters. Submarine groundwater discharge was discounted as a direct cause, because although it occurs in the region, it tends to be patchy in nature and also the fresher nature of groundwater discharge means that effect of the discharge should also be seen at the surface.

The concentration of thermo-tolerant coliform for all offshore samples was below the detection limit of 2 cfu/100 mL and the faecal streptococci concentrations of all but two samples were also below the detection limit of 2 cfu/100 mL.

6.8.4 *Shoreline water quality*

The most significant feature demonstrated by all the surveys were the elevated levels of all nutrients and chlorophyll a along the shore (refer Table 6.4). This effect was not observed further than 500 m offshore and the elevated levels were attributed to nutrient contained in the groundwater entering the nearshore area.

Table 6.4 Summary of water quality offshore of Bunbury WWTP: March 1999 to February 2000

PARAMETER	SAMPLE LOCATION	9/03/99			5/10/99			11/02/00		
		NUMBER OF SAMPLES	MEDIAN VALUE	RANGE	NUMBER OF SAMPLES	MEDIAN VALUE	RANGE	NUMBER OF SAMPLES	MEDIAN VALUE	RANGE
Total Phosphorus (mg/m^3)	Surface	29	18.0	15.0 – 27.5	34	27.9	25.3 – 32.5	34	27.5	26.1 – 30.2
	Depth	29	19.0	15.0 – 43.0	34	29.8	26.1 – 67.9	34	27.4	26.3 – 30.5
	Shoreline	10	271.2	116.5 – 582.0	14	88.4	30.6 – 138.7	14	56.6	23.6 – 101.0
Free Reactive Phosphorus (mg/m^3)	Surface	29	2.6	2.1 – 4.1	34	4.6	3.6 – 6.9	34	3.3	2.6 – 8.3
	Depth	29	2.6	2.0 – 3.2	34	5.9	4.1 – 7.3	34	3.0	2.0 – 4.0
	Shoreline	10	6.7	5.6 – 62.5	14	7.1	5.1 – 30.1	14	7.7	6.6 – 24.0
Total Nitrogen (mg/m^3)	Surface	29	114.0	73.0 – 167.2	34	127.7	100.8 – 265.7	34	126.8	112.5 – 181.9
	Depth	29	123.0	65.0 – 300.0	34	133.5	113.0 – 350.2	34	127.0	107.0 – 178.9
	Shoreline	10	509.2	332.7 – 786.9	14	280.2	141.3 – 468.4	14	386.6	170.1 – 722.0
Total Kjeldahl Nitrogen (mg/m^3)	Surface	29	110.0	72.0 – 164.0	34	124.6	91.4 – 258.7	34	122.7	105.7 – 180.4
	Depth	29	122.0	64.0 – 299.0	34	125.2	101.2 – 342.6	34	125.4	105.5 – 177.4
	Shoreline	10	490.5	326.0 – 764.0	14	251.6	138.2 – 441.8	14	350.0	135.9 – 708.9
Ammonium (mg/m^3)	Surface	29	1.5	3.1 – 9.5	34	4.0	2.5 – 23.8	34	1.5	1.7 – 10.0
	Depth	29	4.2	3.2 – 11.5	34	15.7	2.9 – 20.3	34	1.5	2.1 – 5.5
	Shoreline	10	10.2	4.4 – 100.2	14	20.6	3.2 – 43.0	14	26.9	6.4 – 57.7
Nitrate + Nitrite (mg/m^3)	Surface Samples	29	1.0	3.0 – 5.0	34	3.3	1.9 – 12.0	34	2.4	1.8 – 4.2
	Depth Samples	29	1.0	3.2 – 5.0	34	9.6	2.2 – 15.2	34	2.3	1.8 – 3.2
	Shoreline	10	19.0	6.7 – 26.9	14	13.5	3.1 – 43.6	14	10.3	3.1 – 43.6
Chl. a (mg/m^3)	Surface	29	0.36	0.3 – 1.8	34	0.78	0.4 – 6.2	34	0.24	0.2 – 0.4
	Depth	29	0.42	0.3 – 0.7	34	1.56	0.5 – 8.7	34	0.24	0.2 – 0.3
	Shoreline	10	0.86	0.7 – 1.0	14	2.33	0.2 – 4.7	14	1.05	0.3 – 3.1
Thermo-tolerant coliforms cfu/100 mL	Surface	28	cc	<2	33	<2	<2	34	<2	<2
	Depth	28	cc	<2	28	<2	<2	34	<2	<2
	Shoreline	10	1.0	<2 – 12.0	14	cc	<2 – 44	14	cc	<2 – 1200
Faecal streptococci cfu/100 mL	Surface	28	cc	<2	33	<2	<2	34	<2	<2
	Depth	28	cc	<2	28	<2	<2	34	<2	<2 – 4
	Shoreline	10	2.0	<2 - 18	14	cc	<2 -4	14	cc	<2 - 5000

Note: cc = cannot calculate.

The shoreline samples immediately adjacent to the existing WWTP generally showed higher levels of ammonia, free reactive phosphorus, chlorophyll a and thermo-tolerant coliforms than other sites and it was concluded that the leachate from the WWTP lagoons was the cause of these elevated concentrations in the nearshore. However, there was also evidence that other sources of nutrients occasionally affected the nearshore region with elevated nutrients and chlorophyll observed up to 5 km away from the WWTP coast (DAL, 1999a; DAL, 1999b; DAL, 2000a).

The concentrations of bacteria at the shoreline samples were low with maximum thermo-tolerant coliform and faecal streptococci concentrations of 44 and 18 cfu/100 mL, respectively. In February 2000, very high levels were recorded at a site 2.25 km south of the WWTP this was attributed to localised contamination (DAL, 2000a).

6.8.5 Bunbury waters compared with Perth's coastal waters

The observations from the three Bunbury water quality surveys were compared with observations of 'background' water quality obtained during the summer 2000 water quality surveys of the three metropolitan ocean outlets (Ocean Reef, Swanbourne and Sepia Depression) (Table 6.5). The Perth coastal 'background' levels offshore were taken to be the lowest 10^{th} %ile of observations which had the effect of excluding all possible plume effects, the background values for shoreline monitoring were set to equal the median value. The ranges quoted for Perth's coastal waters include measurements made in waters influenced by wastewater disposal.

It can be seen by comparing Table 6.4 and Table 6.5 that for the summer of 1999/2000 the nutrient concentrations offshore at Bunbury were generally similar to or lower than the background levels observed in Perth's coastal waters. However, Waite and Alexander found that the annual average nutrient levels at Bunbury for 1999/2000 were slightly higher than those for Perth's offshore waters. This may be because the seafloor at Bunbury appears to be more productive than the seafloor at Perth and winter peaks may be higher and summer troughs may be lower. This interesting issue will require further investigation before firm conclusions can be drawn.

Waite and Alexander found that nitrate concentrations in the region peaked in winter, in a manner similar to that seen in Perth's coastal waters (Lord and Hillman, 1995), but with a slightly higher peak concentration. Ammonium levels at Bunbury peaked in July 1999 and like ammonium levels in Perth's waters, had a strong winter peak and concentrations were lowest in summer.

The shoreline samples obtained during the Bunbury water quality surveys were generally elevated above the shoreline concentrations observed during the summer 2000 metropolitan water quality surveys. This was particularly the case during the 9 March 2000 Bunbury survey for the following analytes: total phosphorus, total nitrogen and total Kjeldahl nitrogen which were up to two times higher than shoreline observations obtained during the summer Perth surveys.

Table 6.5 Summary of water quality data collected over summer 2000: Perth coastal waters

PARAMETER	SAMPLE LOCATION	OCEAN REEF 25/01/00			SWANBOURNE 11/01/00			SEPIA DEPRESSION 08/02/00		
		NUMBER OF SAMPLES	'BACK-GROUND' VALUE	RANGE	NUMBER OF SAMPLES	'BACK-GROUND' VALUE	RANGE	NUMBER OF SAMPLES	'BACK-GROUND' VALUE	RANGE
Total Phosphorus (mg/m^3)	Surface	51	31.1	30-48.7	30	29.6	28.5-44.3	29	27.8	26.5-64.9
	Depth	51	35.4	29.1-47.8	30	32.3	26.8-38.8	29	31.0	24.6-51.7
	Shoreline	9	49.7	40.9-66.8	9	39.6	36.5-54.3	9	40.1	32.8-62
Free Reactive Phosphorus (mg/m^3)	Surface	51	6.1	5-23	30	3.7	3.5-16.7	29	4.7	4.3-33.4
	Depth	51	7.2	5.1-22.9	30	3.9	3.3-10	29	6.8	4.8-27.9
	Shoreline	9	11.4	9.7-15.6	9	9.4	6.8-12.2	9	6.3	5.4-13.2
Total Nitrogen (mg/m^3)	Surface	51	145.0	118.6-243.3	30	127.9	122.5-244.2	29	140.0	124-348.8
	Depth	51	177.4	116.8-238.5	30	119.7	131.6-228.5	29	173.0	109.5-305.9
	Shoreline	9	320.0	230.7-463.7	9	192.7	176-238.4	9	304.4	185.5-684
Total Kjeldahl Nitrogen (mg/m^3)	Surface	51	135.0	108.9-232.6	30	125.4	120-242	29	135.2	118.4-343.8
	Depth	51	149.7	108-230.9	30	117.3	129.4-226.3	29	168.3	105.2-302.4
	Shoreline	9	274.0	227.1-386.7	9	181.9	169.3-230.9	9	296.5	180.9-669.8
Ammonium (mg/m^3)	Surface	51	3.0	1.5-19	30	3.0	1.5-9.8	29	2.3	1.5-173.3
	Depth	51	1.5	1.5-13.8	30	1.5	1.5-8	29	13.5	1.5-146.2
	Shoreline	9	6.6	3.6-13.9	9	3.2	2.7-18.8	9	13.0	4.2-35.5
Nitrate + Nitrite (mg/m^3)	Surface	51	2.7	2-49.7	30	2.2	1.7-38.7	29	3.1	2.9-18.2
	Depth	51	4.3	2.3-47.6	30	2.3	2-27.3	29	3.5	2-17.3
	Shoreline	9	22.6	2.6-92.9	9	7.9	3.8-12.9	9	7.9	2.1-38
Chl. a (mg/m^3)	Surface	51	0.17	0.12-0.58	30	0.30	0.27-0.52	29	0.26	0.08-1.67
	Depth	51	0.22	0.1-0.46	30	0.32	0.27-0.65	29	0.46	0.08-1.29
	Shoreline	9	0.32	0.2-0.7	9	0.57	0.52-0.63	9	0.75	0.4-1.19
Thermo-tolerant coliforms cfu/100 mL	Surface	51	1.0	1-70	30	1.0	1-240	29	1.0	1-1100
	Depth	51	1.0	1-160	30	1.0	1-320	29	1.0	1-1100
	Shoreline	9	1.0	1-10	9	8.0	1-18	9	1.0	1-16
Faecal streptococci cfu/100 mL	Surface	51	1.0	1-30	30	1.0	1-20	29	1.0	1-640
	Depth	51	1.0	1-5	30	1.0	1-14	29	1.0	1-860
	Shoreline	9	1.0	1-4	9	4.0	2-14	9	1.0	1-18

6.9 PHYTOPLANKTON AND PRODUCTIVITY

The primary impact of discharging treated wastewater will be on the nutrient status of the receiving waters, which in turn will have the greatest potential impact on local phytoplankton ecology. Water Corporation commissioned the Centre for Water Research, University of Western Australia to conduct a phytoplankton monitoring study (Waite and Alexander, 2000). The study investigated the nutrient concentrations, phytoplankton biomass, phytoplankton species and primary production (growth) rates in the water column on a regular basis at three sites near the proposed location of the ocean outlet.

6.9.1 Key tasks

The phytoplankton study undertook the following tasks on the basis of a field program which required monthly sample collection at three locations near the proposed outlet during summer (November-April) and every six weeks during winter (May-October):

- Measured vertical profiles of temperature, salinity and light (*in situ*);
- Measured integrated or near surface water column nutrients (TN, NO_3, NH_4, FRP, TP), chlorophyll a, and phaeopigments;
- Prepared maps of phytoplankton spatial distribution as measured by *in vivo* fluorescence;
- Analysed samples for phytoplankton species composition;
- Determined phytoplankton growth rates (primary productivity), including the relationship between photosynthesis and irradiance in Bunbury's coastal waters; and
- Compared information gathered on phytoplankton species composition and seasonal changes in biomass with that obtained from previous studies to the north of Bunbury.

The results of the water quality related aspects of this study have largely been discussed in Section 6.8.

6.9.2 Limiting nutrient

The results of the water quality surveys showing the depletion of dissolved nitrate and ammonium in summer after a winter peak while free reactive phosphorus remains available, strongly suggests that nitrogen is the nutrient limiting phytoplankton production in summer. This has previously been shown to be the case for Perth's coastal waters (Lord and Hillman, 1995; DEP, 1996).

6.9.3 Phytoplankton biomass

A clear seasonal cycle in chlorophyll concentration (a measure of phytoplankton biomass) was found, with an increase in biomass with a spring bloom in September and October (Figure 6.8). This was a higher biomass peak than occurred simultaneously during the spring bloom at Ocean Reef. It was found that the increase in chlorophyll matched the decrease in seasonal nitrate concentrations. This coupling between nitrogen availability and phytoplankton growth in the spring suggests a direct link between the higher winter dissolved nitrate peak and higher peak chlorophyll biomass in the subsequent bloom.

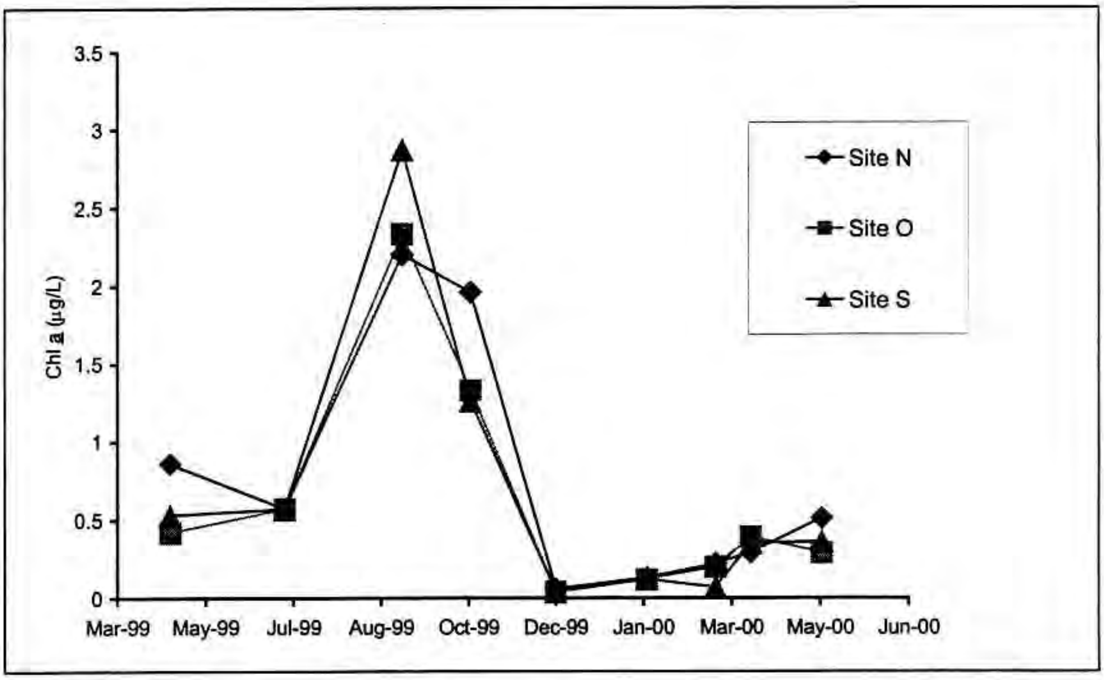


Figure 6.8 Seasonal variation in depth-averaged chlorophyll a concentrations

The survey consistently found higher chlorophyll concentrations deeper in the water column and higher concentrations of nutrients in deep waters in comparison with surface waters. This was also found in the water quality monitoring survey (DAL, 2000a) and reflected in the higher periphyton monitoring (SKM, 2000a). The implication is that this deeper chlorophyll peak is driven by a bottom nutrient source, possibly due to large scale nutrient recycling from within the rich benthic habitat observed by Cambridge and Kendrick (2000).

6.9.4 Phytoplankton species

The ecosystem off Bunbury was shown to support a healthy, productive and highly diverse phytoplankton community dominated by diatom species (diatom species generally dominate in healthy Western Australian waters). Over 120 species of phytoplankton were identified over the nine months of the study. Diatoms dominated the cell numbers, reaching over 90% of biomass, primarily composed of *Chaetoceros, Licomphora*, and *Nitzschia* species. The spring bloom was dominated by the small diatom species *Chaetoceros* sp., *Asterionelopsis glacialis*, and *Skeletonema costatum*, as well as a significant component of cryptophyte flagellates.

Several species of phytoplankton present in the samples should be noted for ecological and environmental interest. As in most of Western Australia's marine waters, potentially harmful dinoflagellate species are naturally present at trace levels including *Dinophysis* sp., and *Gyrodinium* sp. in addition to potentially harmful diatoms including *Pseudonitzschia delicatissima* which can produce domoic acid, and large spiny *Chaetoceros* species whose spines in large numbers can cause the clogging of fish gills. However, none of the potentially harmful diatom or dinoflagellate species were present in concentrations high enough to be any cause for concern.

Of the non-harmful species, Prymnesiophytes (*Phaeocystis*) are present in significant numbers and formed a large fraction of the biomass, including a strong contribution to the September 1999 spring bloom. The blue-green algae *Oscillatoria* (*Trichodesmium*) and *Richelia intracellularis* are found through Western Australian water. They are of interest since they are well adapted to low nitrogen concentrations by the capacity to fix nitrogen directly from the atmosphere and as such are immune to the general nitrogen limitation in the coastal waters off Western Australia. *Oscillatoria* is known to form massive blooms offshore covering thousands of square kilometres and is often seen in local waters over summer. Their ability to fix nitrogen directly from the atmosphere means that the biomass associated with blooms of these species is limited by factors other than the availability of nitrogen in the water column. The presence of these species in particular indicate the long-term and large-scale prevalence of N-limitation in Western Australian coastal waters. Monitoring of Perth's ocean outlets has not demonstrated any increase in the magnitude or frequency of *Oscillatoria* in the vicinity of blooms, it has been concluded that at present there is insufficient knowledge of the ecology of the species to determine the primary factor limiting its growth (Thompson and Waite, 2000).

6.9.5 Primary productivity

Phytoplankton growth rate was up to 2.5 times higher at Bunbury than at Ocean Reef stations, with peaks to 25 mg $C/m^3/hr$. Photoinhibition was strong only occasionally (July and December) indicating light super-saturation and bleaching at ambient light levels at that time.

The maximum photosynthetic rate varied strongly with season, showing a maximum in early spring (September) and mid-summer (December), and a minimum in April. The spring productivity peak coincided with the spring bloom, and indicates the increased productivity at this time of year by diatoms and cryptophytes, which leads to biomass accumulation at that time.

In addition, there is a strong December peak when productivity is high, however, low water column nutrient concentrations keep biomass low. It is possible that following the collapse of the spring bloom the nutrients previously contained in the phytoplankton may have been taken up by the benthic flora and the bacterial 'marine snow' observed by Cambridge and Kendrick (2000).

6.9.6 Bioassays

Bioassays were undertaken to establish the extent to which the availability of primary nutrients (N or P) limit the growth of phytoplankton in the waters at Bunbury. The results confirmed that nitrogen is the nutrient limiting biomass growth in the ecosystem off Bunbury, with phosphorus being about 1/3 as limiting as nitrogen.

6.10 PERIPHYTON GROWTH

Periphyton is defined as: *The mucous-like layer of microalgae, macroalgae, algal propagules, bacteria, microfauna and particulate matter commonly found coating seagrass leaves, sessile organisms, moorings and other marine surfaces.*

The measurement of periphyton growth provides a temporally integrated measure of the productivity of the marine ecosystem. Periphyton collection was undertaken at fixed distances around the proposed ocean outlet site (Figure 6.1) to provide baseline data for subsequent monitoring (SKM, 2000a).

Periphyton collectors consisted of rigid PVC plastic plates (150 mm by 150 mm) that were lightly abraded with sandpaper to facilitate colonisation by periphyton. The collectors were deployed at two depths (2 m and 8 m below the mean sea level) to simulate the natural habitats present in the area: coastal marine platform (2 m depth) and low relief reef and pavement (8 m depth). Six collectors were suspended at each depth at each site during each collection exercise.

The following schedule of work was undertaken:

- Deployment of replicate (6) periphyton collectors for exactly 30 days at two depths of water at each of four sites surrounding the proposed diffuser location;
- Collection of periphyton during autumn 1999, spring 1999 and summer 1999/2000;
- Measurement of organic and carbonate contents on three replicates at each depth at each location;
- Measurement of chlorophyll a, b and c on three replicates at each depth at each location; and
- Establishment of periphyton collection at two control sites to the south of the proposed ocean outlet during spring and summer sampling.

The organic content and carbonate content of the periphyton were quantified for three replicates at each site and depth by ashing in a kiln. The remaining replicates were used for the determination of periphyton chlorophyll a, b and c contents.

6.10.1 Summary of results

The findings obtained from the periphyton growth survey around the proposed Bunbury WWTP ocean outlet location can be summarised as follows (SKM, 2000a):

- The organic content of the periphyton found to grow on collectors in the vicinity of the proposed ocean outlet varied seasonally and with depth and was similar to that recorded at the control sites 2.5 km to the south;
- The organic content of the periphyton appeared greatest with depth during spring and summer indicating a possible nutrient source from the seabed;
- The carbonate content of the periphyton found to grow on collectors in the vicinity of the proposed ocean outlet varied seasonally and with depth and was similar to that recorded at the control sites 2.5 km to the south;
- The carbonate content of the periphyton was found to be in the range given by National Parks and Nature Conservation Authority as typical for healthy marine ecosystems;
- Periphyton chlorophyll b levels and the a/b ratio are generally low or below detection limits indicating that the periphyton assemblage has a low proportion of green algae;
- Periphyton chlorophyll c levels and the a/c ratio are comparable to average values found in the literature and are indicative of an assemblage dominated by diatoms and/or brown algae; and
- The low levels of periphyton growth are indicative of a low nutrient environment that could potentially be impacted by nutrient enrichment.

A comparison was undertaken of the organic content of periphyton collected at Bunbury with that observed at control sites for the Beenyup ocean outlet and sites to the north at Burns Beach and Ocean Reef. It was found that the organic content of periphyton observed during autumn, spring and summer in the vicinity of the proposed Bunbury WWTP ocean outlet was significantly lower that that observed at Beenyup, Burns Beach and Ocean Reef.

6.11 SEDIMENT QUALITY AND MUSSEL MONITORING

Surveys to establish levels of existing metal and pesticide contamination were undertaken at the 13 locations shown in Figure 6.1 (SKM, 2000b). Sediment samples and tissue samples from mussels deployed at fixed distances from the proposed ocean outlet site were analysed for metals and pesticides to allow the existing environmental conditions to be established and provide baseline data for subsequent monitoring.

Heavy metals (As, Ag, Cd, Cu, Cr, Hg, Ni, Pb, Zn), organochlorine pesticides, extractable organohalogens (EOX), loss on ignition (LOI), calcium carbonate and particle size distribution were measured in the sediments.

Mussels were deployed near the surface and near the sea bed at three locations (proposed ocean outlet location; 500 m north and 500 m south) for a 6 week period and subsequently analysed for heavy metals (As, Ag, Cd, Cu, Cr, Hg, Ni, Pb, Zn), organochlorine pesticides and EOX contamination.

Mussels are excellent indicators of contaminants in the environment because they filter large quantities of water to feed and levels of contaminants in the flesh depend on the prevailing ambient concentrations, without regulation. However, mussels do regulate copper and zinc to some degree; therefore, they will always have elevated levels of these metals. What is important is the contrast in results from the areas being surveyed for contamination with results from control regions establishing background/pristine levels.

Mussels of uniform size (60–70 mm long) were obtained from cultured stocks in Cockburn Sound, Western Australia. The mussels were transported directly to each of the monitoring sites where they were deployed.

At each of the three locations (Figure 6.1), two cages containing 50 mussels each were suspended at each depth (1 m above the sea floor and another 2 m from the surface). The mussels deployed were monitored every three weeks and cleaned when necessary to prevent the accumulation of algal growth which could smother and kill the mussels. The mussels were deployed for exactly six weeks at the three locations after which they were retrieved, placed into plastic bags on ice, and returned to the laboratory for analysis.

6.11.1 Summary of results

The findings obtained from the survey of metals and pesticides around the proposed Bunbury WWTP ocean outlet can be summarised as follows:

- The physical properties measured indicate that spatially the sediments in the vicinity of the proposed outlet are variable and indicative of the variability in habitat. Seagrasses, such as those at the 500 m north site, trap finer particles and would contribute to higher organic and calcium carbonate contents;
- Pesticides were below laboratory detection levels in all sediment and mussel tissue samples at all sites;
- Metals were below draft ANZECC (2000) guidelines in all sediment and mussel tissue samples with the exception of arsenic at the site 1,000 m north of the proposed outlet which exceeded the draft ANZECC (2000) ERL screening level. There was no apparent reason for the elevated arsenic concentration and

the measured level was not considered to be any cause for concern, future sediment monitoring should establish whether the result was anomalous;

- The metal and pesticide levels observed in the sediments and in the tissues of deployed mussels indicate that the sediments and waters in the vicinity of the proposed ocean outlet are clean on a regional and national scale; and
- The sediments are clean.

6.12 REVIEW OF MARINE FAUNA

There have been two studies of the Koombana Bay region and waters offshore containing extensive surveys of the local marine fauna (Walker, 1979; LeProvost, Semenuik & Chalmer, 1983). These provide a good indication of the species of fish, crustacea, other benthic invertebrate fauna and marine mammals likely to be found in the vicinity of the outlet. The species list from LeProvost, Semenuik & Chalmer, (1983) is replicated in Appendix 3. It was found that the areas containing the greatest diversity and most important breeding locations were the estuarine waters of the Leschenault Inlet and the Collie River.

The waters of Koombana Bay and Geographe Bay support a large variety of fish, including commercially targeted species such as: whitebait, salmon, herring, scaly mackrel, pilchards and shark. The fish offshore largely consist of pelagic, migratory fish or reef fish.

Bottlenose dolphins are common in the region, remaining in Koombana Bay and surrounds all year round and humpback whales (*Megaptera novaeangliae*) migrate south along the coast towards Antarctica in spring. The whales and dolphins form the basis for a valuable and growing local tourism industry. Australian sealions are also occasionally seen in the region.

The region is also home to large numbers of crustacea, including: Blue swimmer crab (*Portunus pelagicus*), rock lobster (*Panulirus cygnus* and *Jasus novaehollandia*); xanthidae; sponge crabs and snapping shrimp. With the Blue swimmer crab and lobster having commercial significance.

LeProvost, Semenuik & Chalmer (1983) found 17 species of gastropod molluscs, 16 species of bivalve molluscs, three species of amphineuran molluscs, five species of sea urchins, 16 species of brittle stars, 17 species of seastars, two species of feather stars, one specie of lamp shell and six species of corals in the northern part of Geographe Bay. They found no patterns on the distribution of these fauna relative to distance from shore or water depth. The rich diversity of the fauna reflects the mixture of limestone reef and sand habitats, however, the species recorded were common to the south-west coast of Australia.

7. ASSESSMENT OF ENVIRONMENTAL IMPACTS

The EPA have developed a set of guidelines for this proposal which outline the principal environmental issues which need to be addressed (refer Appendix 1). This section of the PER describes how the project will impact on the environment and how these impacts will be managed.

The Water Corporation conducted a detailed study of the region over the past year, and believe the key issues are as follows:

- Potential for nutrient enrichment of oligotrophic coastal waters;
- Potential for bacterial contamination of marine waters;
- Disruption/modification of benthic habitat by the undersea pipeline;
- Potential for contamination of sediments by heavy metals and organics;
- Disturbance and rehabilitation of coastal dune;
- Effect on Tuarts of return of local groundwater to the levels seen prior to operation of lagoon disposal system; and
- Potential for restriction of recreational activities in the vicinity of the discharge point.

7.1 GROUNDWATER

The project will have a beneficial impact on groundwater quality in that the current practise of disposal of the treated wastewater by infiltration to the series of seven lagoons will be stopped. This will result in improved groundwater quality and a return to natural groundwater levels (refer to Section 5.3).

7.2 COASTAL PROCESSES

Beach profile modelling was undertaken to assist in estimating the required burial depth of the ocean outlet at the shoreline (DAL, 2000b). The beach response to a number of simulated storm events was modelled. The modelling indicated that the greatest vertical change (0.3 to 0.5 m) would occur across the berm from the toe of the dune to 30 m seaward.

The beach modelling study found that the pipeline should be buried at least 2 m below the beach surface as it crosses the beach, and that an allowance should be made for the shoreline to retreat up to 15 m. The study also recommended that the beach crossing be located adjacent to the active dune blow-out as this will ensure the project does not disturb any intact dunes and associated vegetation.

To install the pipeline across the beach and the surf zone a trench approximately 50 m wide, extending from the base of the foredune to the start of the surf zone, will be excavated to water level to allow cranes and excavators access to a trench (2–4 m wide) for the pipeline excavated to approximately 2 m below water level. Following burial of the pipeline, the beach will be returned to its natural state and there will be no indication that the beach has been disturbed. A Construction EMP which includes the management and rehabilitation of the impacts of the beach crossing and onshore construction activities will be prepared in consultation with the DEP prior to commencement of construction.

The project will have a net environmental benefit for local coastal processes in that the pipeline will not have any impact on the coastline (visual, environmental or physical) and the Water Corporation will implement a program of rehabilitation of the presently degraded foredune using native vegetation such that the area will eventually become more stable and similar in appearance to the adjacent dunes. Additionally the return of groundwater levels to natural levels will reduce the risk of severe erosion of the upper beach and foredunes during winter storms.

7.3 TERRESTRIAL VEGETATION

The construction and operation of the ocean outfall will not result in any direct negative impact on terrestrial vegetation. The construction activities will be confined to the sand bowl in the dune blow out and the outlet pipeline will be built through the existing degraded foredune (Figure 2.4). A pipeline is required to connect the lagoon weir manhole to the start of the ocean outlet. To maintain gravity flow, this pipeline will be laid at some 15 metres below the low point in the dune saddle separating Lagoon 1 from the launch site (see Figure 2.4). To avoid major disruption to the dune system, this section of pipeline will be tunnelled. There will be some disruption at either end of the tunnel operation. Following construction, the degraded foredunes and dune blowout area will be stabilised and rehabilitated.

The Water Corporation has in place an EMP for the existing WWTP (Ecologia, 1997) and have been undertaking vegetation monitoring since completion of this report (Ecoscape, 1999). This plan will form the basis for the Construction EMP for the proposal which will include plans for the protection of the existing vegetation and the rehabilitation of the dune blow out area.

The proposal to stop using the lagoons for wastewater disposal will result in local groundwater levels dropping at most 1.5 m to natural the levels. The root systems of the Tuart trees on the site may have adjusted to make use of the current elevated levels during summer and a sudden return to previous levels may stress the trees.

The Water Corporation will address this issue in the Construction EMP as appropriate. The plan will determine an acceptable rate for water level reduction which will minimise stress on the trees. This may involve lowering water levels over winter when the trees are less likely to be stressed or over several seasons to allow the trees to adapt or a combination of these approaches. In addition the plan will detail a program for ongoing monitoring of the health of the trees and groundwater levels during and following implementation of the proposal.

7.4 TERRESTRIAL FAUNA

The project will not result in any impacts on terrestrial fauna, and additional natural habitat will be created following rehabilitation of the dune blowout area.

7.5 RECREATION: COASTAL AREAS

The sand dune blow out is currently used for recreation by four-wheel drive enthusiasts and trail bike riders, which will be exacerbating the erosion problem. The project will result in the sand dune blow out area becoming off limits for recreational vehicle use during construction as it is likely that the area will largely be taken up by the contractor and then following construction the blow out area will be fenced off and public access restricted while the blow out is rehabilitated and stabilised. Access by trail bikes and four wheel drives to the dune blow out area is not currently condoned by the Water Corporation or Bunbury City Council. This prohibition may need to be more rigidly enforced.

The burial of the pipeline across the beach will result in restriction of public access to a section of the beach approximately 150 m wide from the dunes to the surf zone during the construction work. The section of beach which will be closed is part of the extensive sandy beach which extends south of Bunbury to Dunsborough and is not a popular recreational part of the beach due to the difficulty of access. As such, the temporary closure of this small section of beach will not result in appreciable loss of recreational amenity. The beach is used by four wheel drives to access areas further south, this will not be possible during construction. Alternative vehicle access to the beach is available a few kilometres south at Dalyellup.

The area offshore contains some known recreational crayfishing locations. The project will not impact on the viability of these locations. Experience with the pipelines leading to the diffusers in Perth's coastal waters is that the pipeline becomes habitat for a significant number of fish and crayfish and as such the recreational crayfishing in the area is likely to be enhanced.

7.6 ROAD TRANSPORT

The construction period will result in the arrival of trucks bringing in construction sheds, medium size earthmoving equipment and other general construction related items. There will also be approximately 25 truckloads of pipe delivered to the site and possibly a similar number of trucks bring rock armour (depending on final construction method). In additional there will be small vehicle movement s associated with the small workforce, there may be of the order of 10–20 small vehicles associated with the project. The truck movements will take place during normal working hours and may be spread over several weeks. The small number of movements will not cause any significant inconvenience to local residents and construction personnel will endeavour to minimise traffic through the local community. Road transport issues will be covered in the Construction EMP which will form part of the construction contract.

The operation of the outlet will not result in any change to local transport patterns.

7.7 WATER QUALITY

7.7.1 Environmental quality objectives and environmental quality criteria

The EPA's guidelines for this project refer the proponent to the Environmental Quality Criteria (EQC) and Environmental Quality Objectives (EQO) defined in the DEP's Southern Metropolitan Coastal Waters Study (SMCWS; DEP, 1996) and the EPA document, Perth Coastal Waters – Environmental Values and Objectives (EPA, 2000).

It is important to understand that the EQCs defined in the SMCWS document are draft and a process is currently underway to finalise criteria for Perth's coastal waters. Furthermore, both documents were produced specifically for Perth's coastal waters. The water quality monitoring program undertaken for this project has shown that the waters near the Bunbury WWTP may more productive than those near Perth.

The draft revised ANZECC water and sediment quality criteria (ANZECC, 2000) adopt the approach that quality criteria developed elsewhere should be applied if there is insufficient information to develop site specific criteria. The Water Corporation has taken the approach of consulting the DEP, EPA and ANZECC documents for guidance on the overall strategy for water quality management and will draw on the extensive existing data and future data collected in the region of the WWTP to develop appropriate site specific criteria in consultation with the DEP.

It should be noted that the term 'guideline' used in the ANZECC documentation is largely synonymous with the term 'criteria' used by the DEP and EPA.

7.7.2 Environmental quality objectives

EQOs represent the goals of an EMP and relate to both ecological (i.e. maintenance of biodiversity and ecosystem integrity) and social values (i.e. maintenance of community uses and aspirations) of natural systems. Ecological EQOs are fundamental management goals whereas social EQOs are, by definition, negotiable and generally derived from a balance between existing and future uses after due consideration of economic, social or political factors.

The EQOs proposed (EPA, 2000) comprise one ecological EQO (EQO 1) and five social EQOs (EQOs 2–6), and are as follows:

- EQO 1. Maintenance of ecosystem integrity. Ecosystem integrity, considered in terms of structure (e.g. the biodiversity, biomass and abundance of biota) and function (e.g. food chains and nutrient cycles), will be maintained throughout Perth's coastal waters. The level of protection of ecosystem integrity shall be high (E2) throughout Perth's coastal waters, except in areas designated E3 (moderate protection) and E4 (low protection);
- EQO 2. Maintenance of aquatic life for human consumption. Seafood will be safe for human consumption when collected or grown in all of Perth's coastal waters except areas designated S2;
- EQO 3. Maintenance of primary contact recreation values. Primary contact recreation (e.g. swimming) is safe in all of Perth coastal waters except areas designated S3;
- EQO 4. Maintenance of primary contact recreation values. Secondary contact recreation (e.g. boating) is safe in all of Perth coastal waters except areas designated S4;
- EQO 5. Maintenance of aesthetic values. The aesthetic values of Perth's coastal waters will be protected except in those areas designated S5; and
- EQO 6. Maintenance of industrial water supply values. Perth's coastal waters will be of suitable quality for industrial water supply purposes except in areas designated S6.

EQC are the benchmarks used to make a decision or judgement concerning the ability of the environment of a given quality to maintain a designated EQO. The criteria for the ecological EQO (EQO 1) and some cultural EQOs (e.g. EQO 2) are determined on the basis of technical information.

Environmental quality management areas will be defined according to which EQC are applied to meet the management goals set by agreed EQOs for that area. The boundaries around areas will be defined in accordance with what changes are seen to be acceptable. This involves two major steps: i) defining what constitutes *change*; and ii) determining limits for *acceptability*.

For the five social EQOs (EQOs 2–6), the EQOs are either protected or they are not (e.g. for EQO 3 it is either safe to swim, or it is not). For EQO 1 various levels of protection have been defined to allow for the impacts of various levels of human use, as follows:

- Level 1 (E1). Total protection. No detectable changes from natural variation. (such areas are likely to be small and rare in Western Australia, and in fact anywhere in the world, because humans have some impact on most coastal waters);
- Level 2 (E2). High protection. Some small changes from natural variation allowable (representing the large majority of Perth's coastal waters);
- Level 3 (E3). Moderate protection. Moderate changes from natural variation allowable (areas of environmental quality intermediate between E2 and E4); and
- Level 4 (E4). Low protection. Large changes from natural variation allowable (areas such as harbours, wastewater discharge areas and boat marinas).

7.7.3 Water quality criteria

ANZECC (2000) state: "*A water quality guideline is a numerical concentration limit or narrative statement recommended to support and maintain a designated water use. These water quality guidelines include guidelines for chemical and physical parameters in water and sediment, as well as biological indicators. They form the basis for determining water quality objectives that protect and support the designated environmental values of our water resources, and against which performance can be measured. The guidelines have been derived on the basis of providing some confidence that there will be no significant impact on the environmental values if they are achieved. Exceedence of the guidelines indicates that there is potential for an impact to occur, but does not provide certainty that an impact will occur.*"

In areas, such as the waters off Bunbury, where protection of aquatic ecosystems is a designated environmental value, ANZECC considers that direct assessment of the biological community is considered the best measure of whether ecosystem integrity is being maintained or threatened. For this reason, the Water Corporation has initiated an extensive biological monitoring program to allow for the development of site specific criteria and the assessment of the level of impact on the ecosystem.

In the revised ANZECC approach, the old single number guidelines (ANZECC, 1992) are regarded as *guideline trigger levels* (criteria) that can be modified into regional, local or site specific criteria by taking into account factors such as ecosystem/environmental variability and exposure. Trigger levels are concentrations that if exceeded would indicate a *potential* environmental problem, and so 'trigger' further investigation and subsequent refinement of the criteria according to local conditions.

The DEP is currently in the process of preparing specific EQC for Western Australian waters (EPA, 2000), this is a process which allows consultation with the public and the wider community will be given the opportunity to be consulted.

Bacteriological criteria

Table 7.1 outlines the bacteriological criteria which will apply for the proposal. As revised criteria have not been issued, the ANZECC (1992) criteria are used.

Table 7.1 ANZECC (1992) criteria for microbiological water quality

	MICROBIOLOGICAL CHARACTERISTICS
1	*Harvesting of shellfish for human consumption* The median faecal coliform bacterial concentration should not exceed 14 cfu/100 mL, with no more than 10% of the samples exceeding 43 cfu/100 mL
2	*Primary contact* The median bacterial content in samples of fresh or marine waters taken over the bathing season should not exceed: • 150 faecal coliform organisms/100 mL (minimum of five samples taken at regular intervals not exceeding one month, with four out of five samples containing less than 600 organisms/100 mL). • 35 enterococci organisms/100 mL (maximum number in any one sample: 60–100 organisms/100 mL). Pathogenic free-living protozoans should be absent from bodies of fresh water. (It is not necessary to analyse water for these pathogens unless the temperature is greater than 24°C.)
3	*Secondary contact* The median bacterial content in fresh and marine waters should not exceed: • 1,000 faecal coliform organisms/100 mL (minimum of five samples taken at regular intervals not exceeding one month, with four out of five samples containing less than 4,000 organisms/100 mL). • 230 enterococci organisms/100 mL (maximum number in any one sample 450–700 organisms/100 mL).

Note 1. MPN = most probable number of organisms = cfu = colony forming units.
2. Numerically, enterococci = faecal streptococci.

The criteria for shellfish harvesting have been interpreted broadly by the DEP (EPA, 2000) as being protective for **all** seafood for human consumption, i.e. if Guideline 1 is exceeded in Western Australia then any shellfish, pelagic fish or motile species caught in the region where the exceedence occurred is considered by the DEP as potentially unsafe to eat. This was not the original purpose of the stated guideline value which was specifically derived to be protective of water quality standards for the commercial harvesting of shellfish (Department of Health and Human Services, USA, 1995). This issue is currently under further investigation by the Water Corporation and the criteria to be applied will be finalised in consultation with DEP prior to construction.

Guideline 2 regarding primary contact recreation is relevant to this proposal as although primary contact criteria will be met above the plume the primary contact criteria will not be met in the water column immediately above the plume, ie, it should be safe to swim above the plume but not to dive above the plume.

ANZECC ecological guidelines for south-west Australia

Table 7.2 outlines draft ecological trigger values proposed for southern Western Australia in the revised ANZECC (2000) guidelines. The ANZECC approach is that where regional guideline trigger values have been developed, those values should be used in preference to the default values provided below. To illustrate this point the proposed draft values have been compared with corresponding medians and ranges of values measured in the region over the past year. The values analysed for Table 7.2 did not include any measurements taken in the surfzone which was obviously impacted by nutrient rich groundwater flows (refer Table 6.4). It can be seen that 'background' (refer Glossary) levels in Bunbury's coastal waters are already higher than the trigger levels in the case of the mean chlorophyll a, total phosphorus and ammonium and that other draft trigger values are close to background.

Table 7.2 Default trigger values for south-west Australia

	Chl *a* ($\mu g L^{-1}$)	TP (μg P L^{-1})	FRP (μg P L^{-1})	TN (μg N L^{-1})	NO_x (μg N L^{-1})	NH_4^+ (μg N L^{-1})	DO (% satn) Lower limit	DO (% satn) Upper limit	pH Lower limit	pH Upper limit
Draft guideline trigger levels										
Marine inshore	0.7	20	5	230	5	5	<90	na	8.0	8.4
Offshore	0.3	20	5	230	5	5	<90	na	8.2	8.2
Measured at Bunbury (194 samples, 3 surveys)										
Median background	0.4	27.2	3.3	126.9	2.7	4.7				
Mean background	0.8	26.2	3.8	135.4	4.7	8.2				
Maximum background	8.7	67.9	8.3	350.2	15.2	23.8				
Minimum background	0.2	15.0	2.0	65.0	1.8	1.7				

na = not applicable.
Data derived from Trigger Values supplied by DEP Western Australia.

The proposed draft trigger values for inshore waters are defined as applying to coastal lagoons (excluding estuaries) and embayments and waters less than 20 meters depth, however, it is specifically recommended that for Albany and Geographe Bay, it may be more appropriate to use offshore values for inshore waters. It is therefore apparent that the first task in preparing the Operations EMP for management of impacts on the marine environment will be to derive site specific trigger levels and provide revised information to the DEP to allow more representative ranges of trigger values to be set for the region.

7.7.4 *Issue of concern*

A feature of Western Australia's coastal waters, including those off Bunbury, is that they contain relatively low levels of nitrogen compared to other marine systems around the world. Thus, the growth of algae in local coastal waters is generally strongly limited by nitrogen supply, particularly in summer. For this reason, management concerns about nutrient inputs to local coastal waters are focussed on nitrogen.

When nitrogen is discharged to nitrogen-poor waters it is rapidly assimilated to form new plant tissue, effectively indistinguishable from the natural pool of nitrogen that is in constant flux between water, sediments, biota and atmosphere. Even when large loads of nitrogen are discharged they rarely reach concentrations that cause concentration-related toxic effects. The 'effect' is manifested through the increased biomass of planktonic, epiphytic and benthic algae, which if severe enough in temperate marine ecosystems, can lead to a decline in benthic plant communities through light starvation induced by shading and smothering (DEP, 1996). If this 'effect' is not severe, the end result is slightly increased primary productivity with no impacts on the health of the ecosystem. In some situations, increased nitrogen availability may provide a competitive advantage to phytoplankton species that previously unable to dominate the assemblage. However, monitoring of phytoplankton species at Perth's ocean outlets suggests that this is unlikely (DAL, 1999c).

7.7.5 *Management strategy*

The strategy in general terms is as follows:

- Identify the *environmental values* that are to be protected in the waters offshore of the WWTP and the spatial designation of the environmental values (i.e. decide what values will apply where);
- Identify *management goals* and then select the relevant *water quality guidelines* for measuring performance. Based on these guidelines, set *water quality objectives* that must be met to maintain the environmental values;
- Develop statistical performance criteria to evaluate the results of the monitoring programs (e.g. statistical decision criteria for determining whether the water quality objectives have been exceeded or not);
- Develop tactical monitoring programs focusing on the water quality objectives; and
- Initiate appropriate management responses to attain (or maintain if already achieved) the water quality objectives.

A concentration-based approach to nutrient management is inappropriate for this project as it will not provide sufficient information to establish whether environmental values will be protected. An alternative is to adopt the concept that a natural system has the capacity to receive some level of anthropogenic nutrient input without unacceptable changes occurring (ANZECC, 2000). This ecosystem-based approach is recognised as central to the principle of ecological sustainability.

In the current situation, the ecosystem approach is based on establishing linkages between total nutrient loadings to the waters offshore of Bunbury and establishing the response of the most sensitive/important component of the ecosystem. When there is some quantitative understanding of the responses, and the desired management outcomes defined, ecologically-based maximum nutrient loadings consistent with maintaining the desired environmental quality can be set.

Given the difficulty in predicting ecological response to nutrient loading, it is essential that the water quality and the attainment of management goals is regularly assessed through monitoring to determine whether impacts are acceptable. As such, the Water Corporation has already commenced a monitoring program for the life of the project, this program will form the basis of the Operations EMP to developed in consultation with the DEP and other relevant stakeholders.

7.7.6 *The mixing zone*

Action will be required to maintain the desired values for Bunbury's coastal waters and achieve the agreed management goals, and hence protect the identified values. However, even as in this proposal, when stringent discharge limits are set and best practise wastewater treatment undertaken, wastewater will generally be of poorer quality than the receiving water. It is therefore accepted practice to apply the concept of the *mixing zone*, an explicitly defined area around a wastewater discharge where certain environmental values are not protected (ANZECC, 2000).

As a mixing zone is to be applied, the discharge will be managed to ensure that the agreed designated environmental values and uses of the broader ecosystem are not compromised, are effectively contained within the mixing zone and that the size of the zone is insignificantly small relative to the ecosystem to be protected.

The size of the mixing zone has been determined through the numerical modelling study described below.

7.8 NUMERICAL MODELLING STUDY

The potential scale of impact of the treated wastewater plume has been assessed through a detailed hydrodynamic modelling study which predicted the movement of the plume and the dilution of nutrients and bacteria following release to the marine environment.

The Water Corporation commissioned Halpern Glick Maunsell (HGM) to undertake the numerical modelling study to predict the fate of the buoyant wastewater plume from a multi-port diffuser on the seabed (HGM, 2000).

The behaviour of the plume can be categorised by two physical scales: the near-field mixing region and the far-field mixing region (refer Figure 4.1). Within the near-field region, the mixing process is dominated by the combination of jet momentum and buoyancy of the plume. Once at the surface, the fate of the plume is determined by the dynamics (currents and wind mixing) of the receiving water as it transports the plume away from the source.

HGM chose to apply the Environmental Fluid Dynamics Code (EFDC) model to this study. The EFDC model is a three-dimensional hydrodynamic model which solves the equations of motion for surface elevation, tidal and wind induced current, as well as the transport of pollutants including discharges from point sources. The model is endorsed by the United States EPA and has been tested and applied in Australia (HGM 1998; HGM 1999) and in the United States (e.g. Hamrick 1991; Hamrick 1992a; Hamrick 1992b; Hamrick 1993; Hamrick 1994a; Hamrick 1995a; Hamrick 1996; Hamrick et al., 1995; Hamrick and Mills 1999; Moustafa and Hamrick, 1994; Shen et al., 1998; and, Sucsy et al., 1998).

The hydrodynamic model was specifically used to:

- Quantify the zone of influence of the proposed discharge at maximum mean flows (year 2040) under a variety of seasonal conditions;
- Quantify the near and far field dilution characteristics of the plume for typical diurnal flows in 2040 (mean 16 ML/d, peak 24 ML/d); and
- Assess the influence of outfall distance offshore with respect to likely impacts on nearshore water quality.

The modelling exercise was specifically undertaken using maximum flow conditions for all scenarios making the results characteristic of worst case episodes. By using typical diurnal flows from the year 2040, the maximum physical extent of the plume is modelled. The assumed nitrogen concentration in the year 2040 for the model runs was 10 mg/L (rather than the current 15 mg/L) as this is the concentration which matches the Water Corporation's primary commitment to cap nitrogen loads to the ocean below 60 tpa. The bacterial concentrations in 2040 were assumed to be the same as at the commencement of ocean discharge (10,000 cfu/100 mL), meaning the results give the maximum likely extent of bacterial contamination.

7.8.1 *Near field representation*

The EFDC model incorporates an internal near-field model for the numerical modelling of a multi-port diffuser. The near-field model is used for the computation of sub-gridscale mixing (less than 100 m x 100 m) and dilution resulting from submerged buoyant outfalls.

The near field model provides analysis capabilities similar to the widely used CORMIX model (Jirka and Akar, 1991; Jirka and Doneker, 1991) while offering two distinct advantages:

- A more realistic representation of ambient currents in the analysis; and
- Multiple discharges and multiple near field analysis times may be specified to account for varying ambient current and stratification conditions.

To assess the ability of the near-field model to represent the diffuser, a checking exercise was undertaken comparing the EFDC model against the widely used and accepted US EPA near-field dilution models, CORMIX and PLUMES.

The results of the near-field model comparison clearly demonstrated that the EFDC model was able to reproduce the results of both the CORMIX and PLUMES models (HGM, 2000).

7.8.2 *Initial dilution*

The calculated average initial dilutions for the maximum peak daily flow in 2040 under typical summer, winter and still water conditions are shown in Table 7.3. It would only be under the worst case conditions (dead calm) at peak 2040 flows that average initial dilutions will drop below 1:100. The dilution will be greater at lower flows.

Table 7.3 Peak flow initial dilutions

MAXIMUM PEAK FLOW	STILL WATER	SUMMER	WINTER
24.0 ML/d	90:1	120:1	150:1

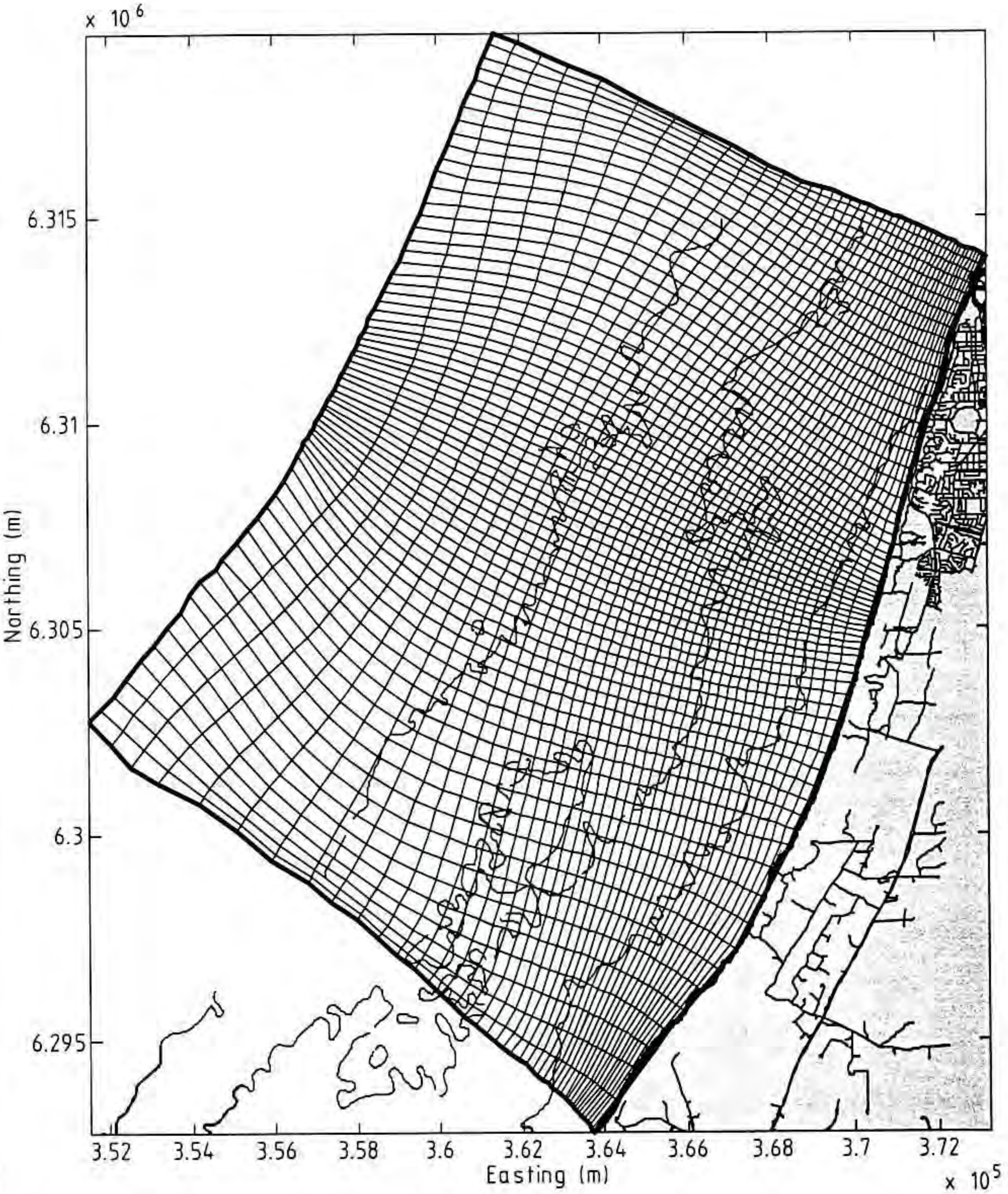
7.8.3 *Model domain and grid*

The model domain extends approximately 25 km in the north/south direction, and approximately 20 km in the offshore direction to the 25 m depth contour (Figure 7.1).

The domain allows a cross-shore component to the modelled currents as well as providing adequate fetch resolution to fully develop the cross-shore momentum. In the long-shore direction, the grid boundaries are distant from the region of interest so that model boundary effects do not affect the results from adjacent to the WWTP.

A curvilinear coordinate system was used for the horizontal model grid to maximise computational efficiency (Figure 7.1). The curvilinear representation allows for fine resolution near the outlet and coarser resolution further offshore and to the north and south. The grid resolution near the outlet is approximately 100 m x 100 m and it increases to approximately 1,000 m x 1,000 m offshore.

Within the vertical, the model accounted for four layers: with the bottom layer being 40% of the depth at any location, the next layer being 30% of depth, the next 20% of depth and the surface layer being 10% of model depth. For a diffuser located in 12 m of water, the modelled surface layer was 1.2 m thick.



(SOURCE: HALPERN GLICK MAUNSELL, 2000)

WATER CORPORATION
BUNBURY WASTEWATER
TREATMENT PLANT OCEAN OUTLET

HYDRODYNAMIC MODEL DOMAIN AND GRID

FIGURE 7.1

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This model resolution produces a relatively more detailed modelling near the surface which is desirable as the flows from the outfall are buoyant and depending on conditions, the plume will rises and mix outward in the top 1–3 m of the water column.

7.8.4 *Model scenarios*

The assessment of the regional oceanography (WNI, 2000b) concluded that, locally, the currents were dominated by local wind forcing and that the water was generally unstratified. As such, baroclinic effects (flows due to density differences between different parts of the water body) and tidal conditions were not modelled as part of the process.

The plume was modelled for periods of seabreeze activity, calm spring conditions and winter storms. The following data and selected sequences were used for the modelling:

- Primary wind data set—these data were obtained from direct measurement at the WWTP over the period of one year and were used for all model validation and subsequent predictive runs;
- Model calibration data—the current meter data collected from 5 March to 30 July, 1999 (containing autumn calms and winter storms) and from 13 January to 5 March, 2000 (containing summer seabreeze events);
- Summer period—the period 4 January to 24 January, 2000 was chosen as it contained periodic sea breeze events;
- Winter—the behaviour of the plume during a winter storm and intervening calms was modelled over the period 1 July to 18 July, 1999; and
- Calm spring—the worst case dilutions will occur during calm conditions, the outlet was modelled over the period 10 October to 30 October, 1999.

In addition two simulations were undertaken with the beginning of a 120 m long diffuser located 1500 m and 1870 m offshore to determine the influence of distance offshore on nearshore water quality, i.e. to assess the likelihood of the plume reaching the beach.

7.8.5 *Representation of thermo-tolerant coliforms*

In addition to dilution through mixing and dispersion, the concentration of coliforms is also influenced by breakdown due to temperature, dissolved oxygen and sunlight. For this reason the model for coliforms includes an exponential decay rate related to the likely temperature range, oxygen status of the water and available sunlight. The rate of decay is governed by selection of a coefficient known as the T_{90} value which is the time the bacteria takes to die off to 90% of its original concentration. For this study the T_{90} value was selected as 4.5 hours during daylight and 50 hours at night.

7.8.6 *Model validation*

Confidence in the numerical model results was generated through a process of model validation against the two sets of current data measured specifically for the purpose, as detailed in Section 6.4. The wind data recorded at the WWTP (corrected to 10m height) corresponding to the time of the current meter deployments was used to force the circulation within the model. The model output for the positions of the current meters was then compared directly against the observed current data.

Winter

Figure 7.2 and Figure 7.3 show the modelled and the observed data at both measurement sites and also the observed wind field for the duration May-June 1999. The model recreated the general circulation in the vicinity of the outlet, with model variation in modelled against observed tends to become more significant with wind speeds less than 5 m/s. In general the model gave a good representation of the wind driven current speed and direction at both inshore and offshore sites.

Figure 7.2 and Figure 7.3 also highlight some features which are unable to be included in the model. In particular, the current meter data suggest there is a cross-shore periodic variation which may be due to seiching across the continental shelf (WNI, 2000b).

Summer

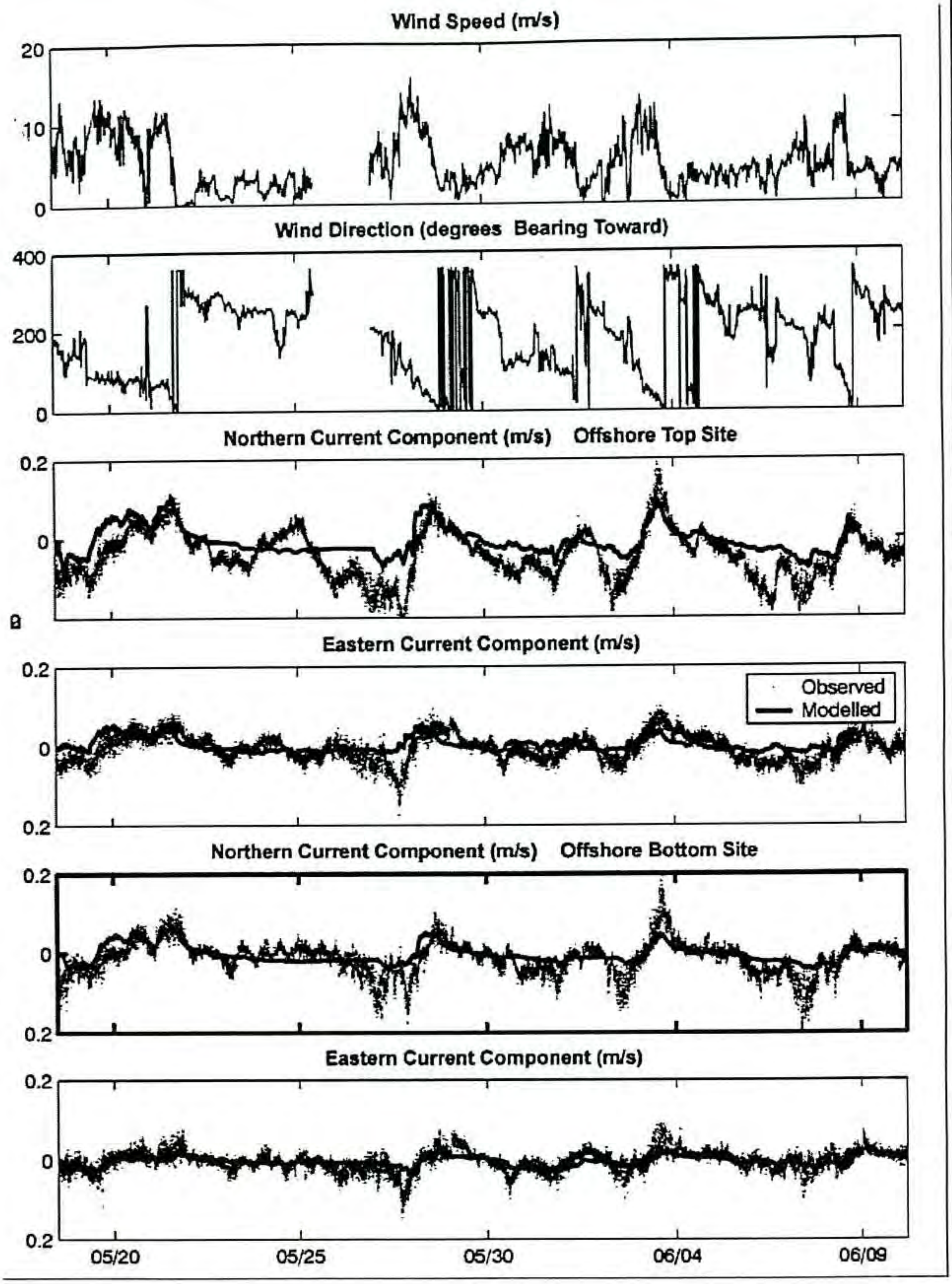
The model was also validated against current data collected from 13 January to 5 March 2000. This deployment recorded currents influenced by diurnal easterly and seabreeze patterns, the difference between the summer pattern and the longer period winter pattern can be seen by comparing Figure 7.2 and Figure 7.4. The results of the validation against this data set are shown in Figure 7.4 and Figure 7.5. The model reproduced the diurnal pattern well at the surface and tended to underestimate the currents near the seabed. This means the actual dilution of the plume in summer will generally be greater than that estimated by the model i.e. the model is conservative.

7.8.7 *Methods of analysis*

The results have been presented as a statistical representation of the plume dilution for the duration of each model simulation with flows in the year 2040. The contours indicate the boundary of a region for which the dilution is below a specified value, e.g. the 50% exceedence contour for a dilution of 1:1000 indicates the region within which the dilution is less than 1:1000 for 50% of the time. This approach was used to estimate the extent of influence of the plume on bacterial and nutrient levels.

For nutrients, the extent of median dilutions of 1:100 and 1:1000 was modelled. For treated wastewater containing 10 mg/L dissolved inorganic nitrogen (concentration required in 2040 for Water Corporation to meet 60 tpa maximum TN loading), these contours correspond to concentrations of 100 μg/L and 10 μg/L respectively where a concentration of 10 μg/L is approximate to background levels in the region (Table 6.4).

The model output chosen for the concentrations of thermo-tolerant coliforms was based on the 1992 ANZECC guidelines (Table 7.1). The 50% exceedence contours for thermo-tolerant faecal coliforms were output for values of 14 cfu/100 mL (median criteria for shellfish harvesting) and for 150 cfu/100 mL (median criteria for primary contact recreation; i.e. swimming, surfing, diving etc) following a discharge with concentration of 10,000 cfu/100 mL. These concentrations are approximately equivalent to respective initial dilutions of 1:714 and 1:67 (without bacterial die off).



WATER CORPORATION **BUNBURY WASTE WATER** **TREATMENT PLANT OCEAN OUTLET**	**MODELLED vs MEASURED CURRENTS** **MAY-JUNE 1999 - OFFSHORE**
	FIGURE 7.2

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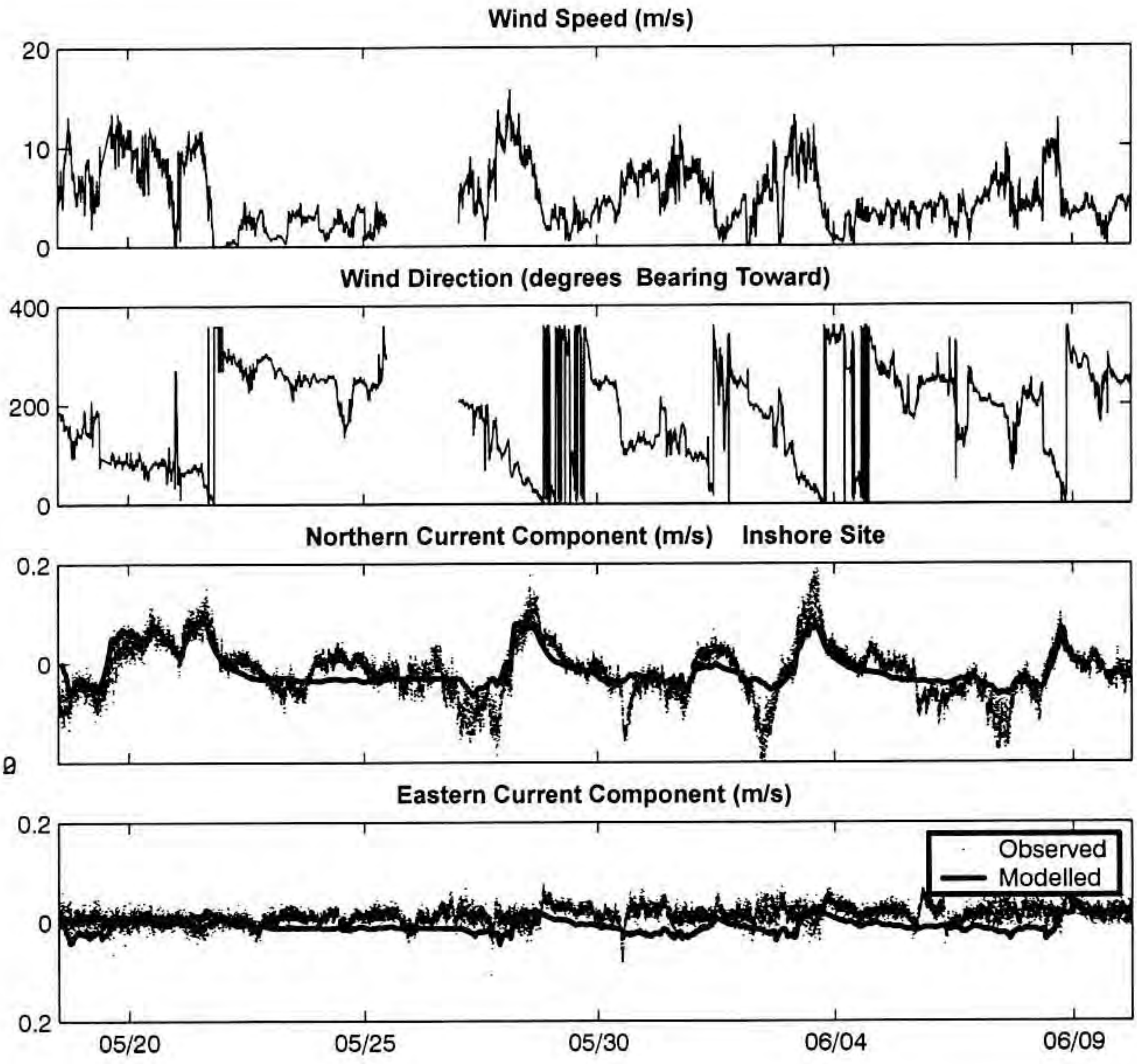

WATER CORPORATION
BUNBURY WASTE WATER
TREATMENT PLANT OCEAN OUTLET

MODELLED vs MEASURED CURRENTS
MAY-JUNE 1999 - INSHORE SITES

FIGURE 7.3

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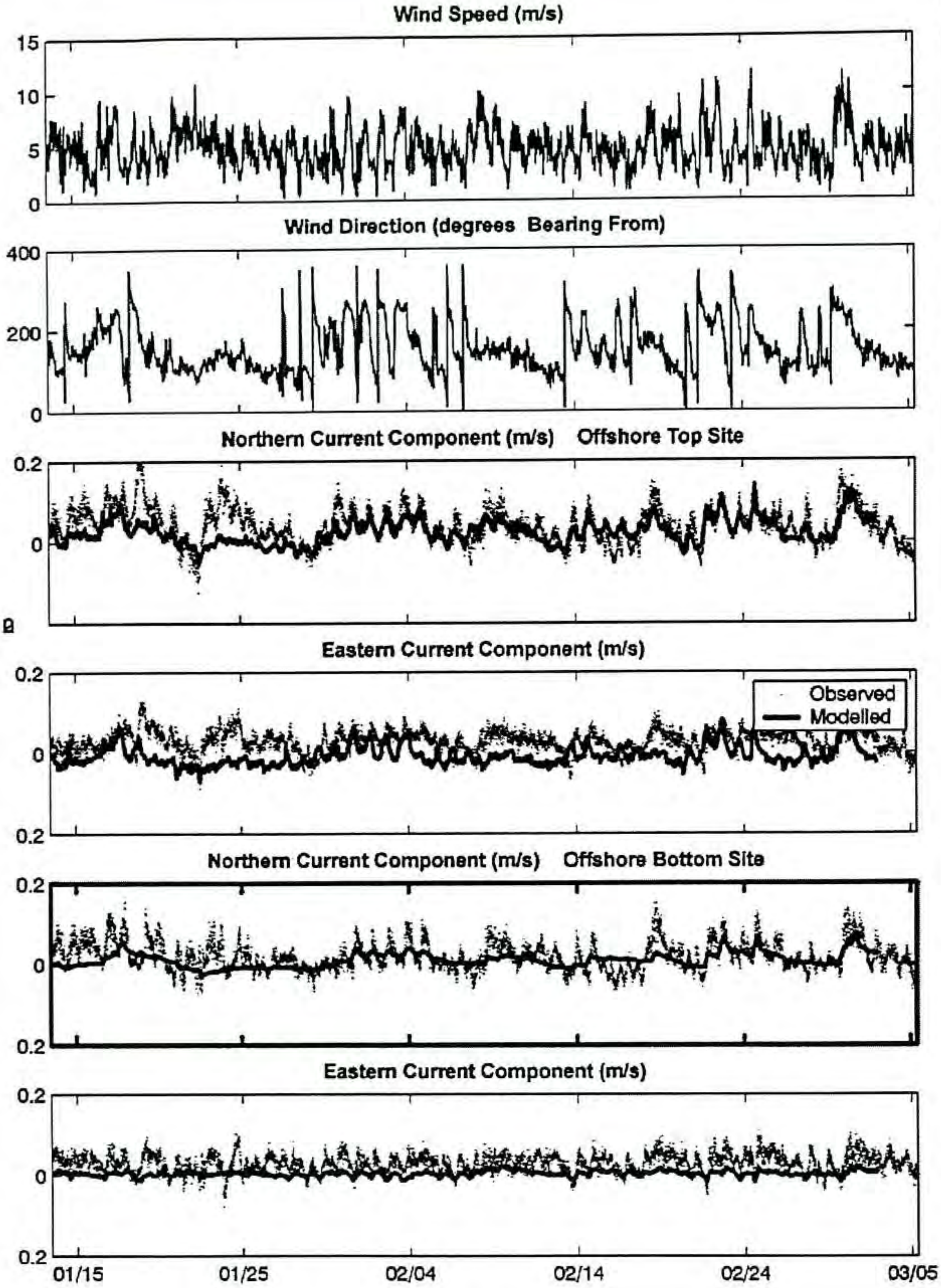
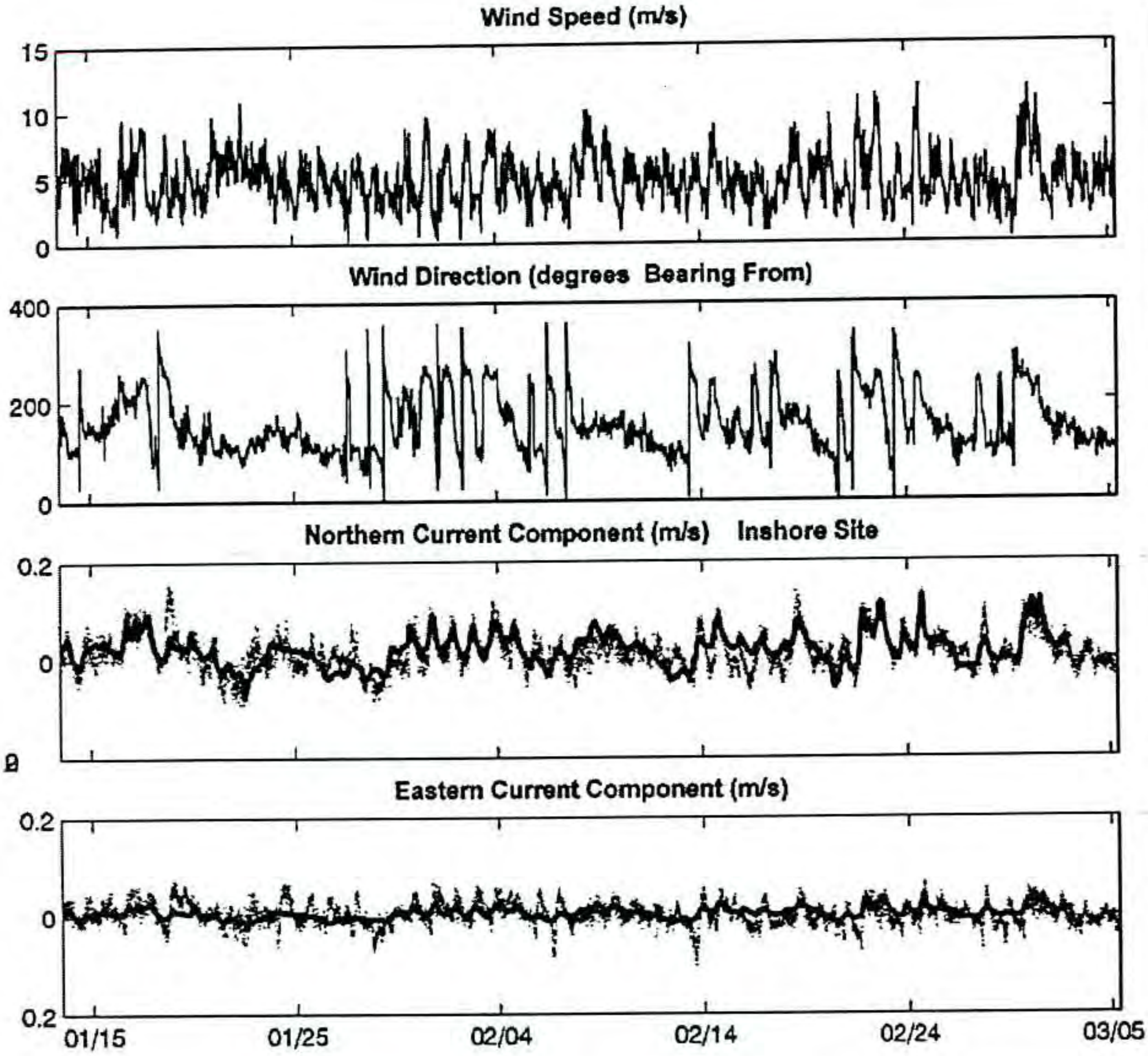


WATER CORPORATION BUNBURY WASTE WATER TREATMENT PLANT OCEAN OUTLET	MODELLED vs MEASURED CURRENTS JANUARY-MARCH 2000 - OFFSHORE SITES
	FIGURE 7.4

N:\611\43440700\Jobrequest\LL2000\07V19.DGN



WATER CORPORATION
BUNBURY WASTE WATER
TREATMENT PLANT OCEAN OUTLET

MODELLED vs MEASURED CURRENTS
JANUARY-MARCH 2000 - INSHORE SITES

FIGURE 7.5

N:\611\4344070\Jobrequest\LB2000\07V20.DGN

In addition to the percentage exceedence contours, a residence time (or 'flushing') analysis was undertaken for summer conditions. The flushing of a 500 m x 500 m region around the diffuser was computed as follows:

- The model was initialised with a large number of particles in a 500 m x 500 m region surrounding the diffuser;
- After the model was started a particle tracking routine tracked the movement of each particle;
- The region was considered flushed when the number of particles remaining within the region had reduced to 37% (1/e) of the original number;
- Once the region was flushed and the time required for this to happen recorded (also known as the e-folding value), the model reset the particles to their original position in the 500 m x 500 m region and repeated the process for the next string of wind data; and
- The result was a series of flushing times for the region for the period of the model run and an average flushing time was calculated from this series.

7.8.8 Outlet 1,500 m offshore vs. 1,870 m offshore

Two model simulations for 2040 flows were undertaken to determine the relative difference in impacts between locating the outlet 1,500 m offshore at a depth of 10.5 m and 1,870 m offshore at a depth of 11.5 m and whether the Water Corporation could consider moving the outlet diffuser closer to shore.

The primary issue was whether a diffuser a distance of 1,500 m offshore would impact on the recreational water quality of the beach. For this reason the transport of thermo-tolerant coliforms was simulated and the simulation forced by wind data containing a period of onshore flow (summer seabreeze).

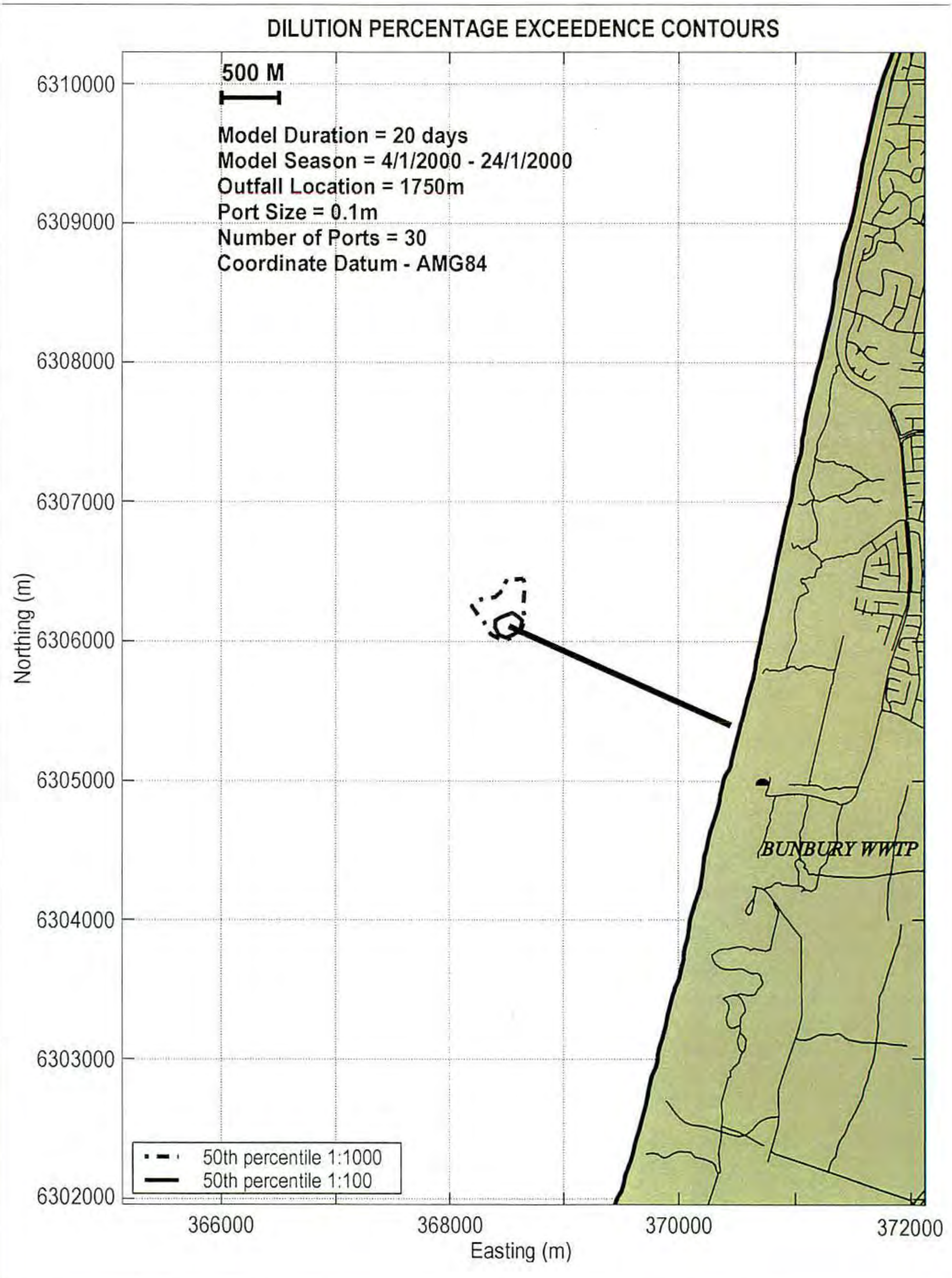
The model results showed that the operation of the outlet would have no impact on the water quality at the beach even if it was located a distance of 1,500 m offshore (HGM, 2000). However, it was subsequently decided to locate the diffuser approximately 1.7 km offshore as the benthic habitat type was considered more suitable for a diffuser at this location.

7.8.9 Summer condition

This model simulation extended over the period 4/1/2000 to 24/1/2000 and the results are shown in Figure 7.6 in terms of percentage exceedence of dilution contours for the total period for 2040 flows. This model period was selected as it contained a variety of wind conditions including periods of calm wind conditions and also seabreeze events typical of summer wind conditions.

The results indicate that for 50% of the time in 2040, nutrient levels will return to background levels within 500 m of the outlet and nutrient levels will be approximately 10-fold higher than background within 70–100 m of the outlet.

The bacterial modelling found that in 2040 the 150 cfu/100 mL criteria would generally not be exceeded at the surface and that the shellfish harvesting criteria is met within 500 m of the outlet.



WATER CORPORATION BUNBURY WASTE WATER TREATMENT PLANT OCEAN OUTLET	BUNBURY WWTP SIMULATED SUMMER CONDITION
	FIGURE 7.6

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The average flushing time for a 500 m x 500 m zone over the duration of the model simulation was found to be 4 hours. This is equivalent to saying that, on average, in summer conditions water emanating from the diffuser will generally remain within 500 m of the diffuser for four hours and be diluted by a factor of up to 1:1000 in this time.

These results are indicative of maximum flows results and would represent a very conservative estimate of impacts with present flows.

7.8.10 Winter condition

This model simulation extended over the period 1/7/1999 to 18/7/1999 and the results are shown in Figure 7.7. This model period included a couple of winter storm events and also intermediate periods of low winds between storms.

The bacterial modelling found that in 2040, the 150 cfu/100 mL criteria would generally not be exceeded at the surface and that the shellfish harvesting criteria would generally be met within 300 m of the outlet.

As a result of the increased wind energy for mixing the extent of the plume is decreased. The results shown in Figure 7.7 indicate that the extent of the 1:1000 dilution contour in 2040 is approximately 300 m from the outfall i.e. nutrient levels to background within this distance.

7.8.11 Spring condition

The spring model simulation extended over the period 10/10/1999 to 30/10/1999 and is a 'worst case' scenario as it contains relatively long calm periods. The results are shown in Figure 7.8. For the year 2040, the 1:1000 dilution contour extends approximately 500 m from the outfall and the 1:100 dilution contour extends approximately 100 m.

The bacterial modelling found that in 2040, the 150 cfu/100 mL criteria would occasionally be exceeded immediately above the diffuser and that the shellfish harvesting criteria is met within 500 m of the outlet.

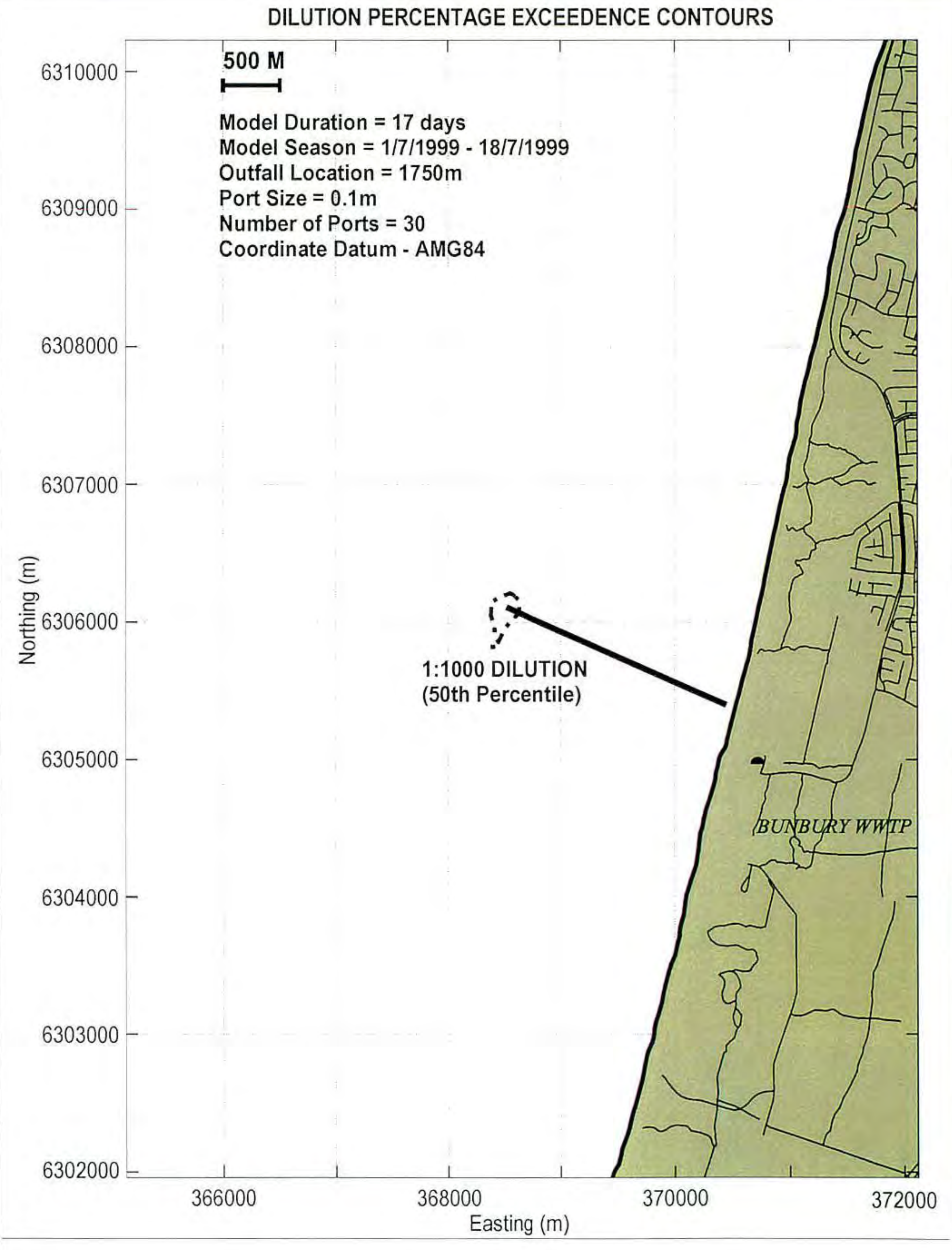
7.9 IMPACTS ON SOCIAL ENVIRONMENTAL VALUES

7.9.1 Beneficial impacts

By removing the process of infiltration to the lagoon system, the project will result in improved water quality along the shoreline in front of the WWTP. This is a significant improvement as, of all the regions affected by the operations of the WWTP, the beach and shoreline waters are the most likely to be used by the public.

7.9.2 Adverse impacts

The model results suggest there will be occasions where primary contact criteria (EQO 3) are not met above the plume. Therefore, to reduce any risk to public health, the Water Corporation intends that the area within 100 m of the diffuser is designated as unsuitable for swimming (Figure 7.9). As this area is not used for swimming and is not a local recreational dive site, the impact on social amenity is not significant.



WATER CORPORATION BUNBURY WASTE WATER TREATMENT PLANT OCEAN OUTLET	BUNBURY WWTP SIMULATED WINTER CONDITION
	FIGURE 7.7

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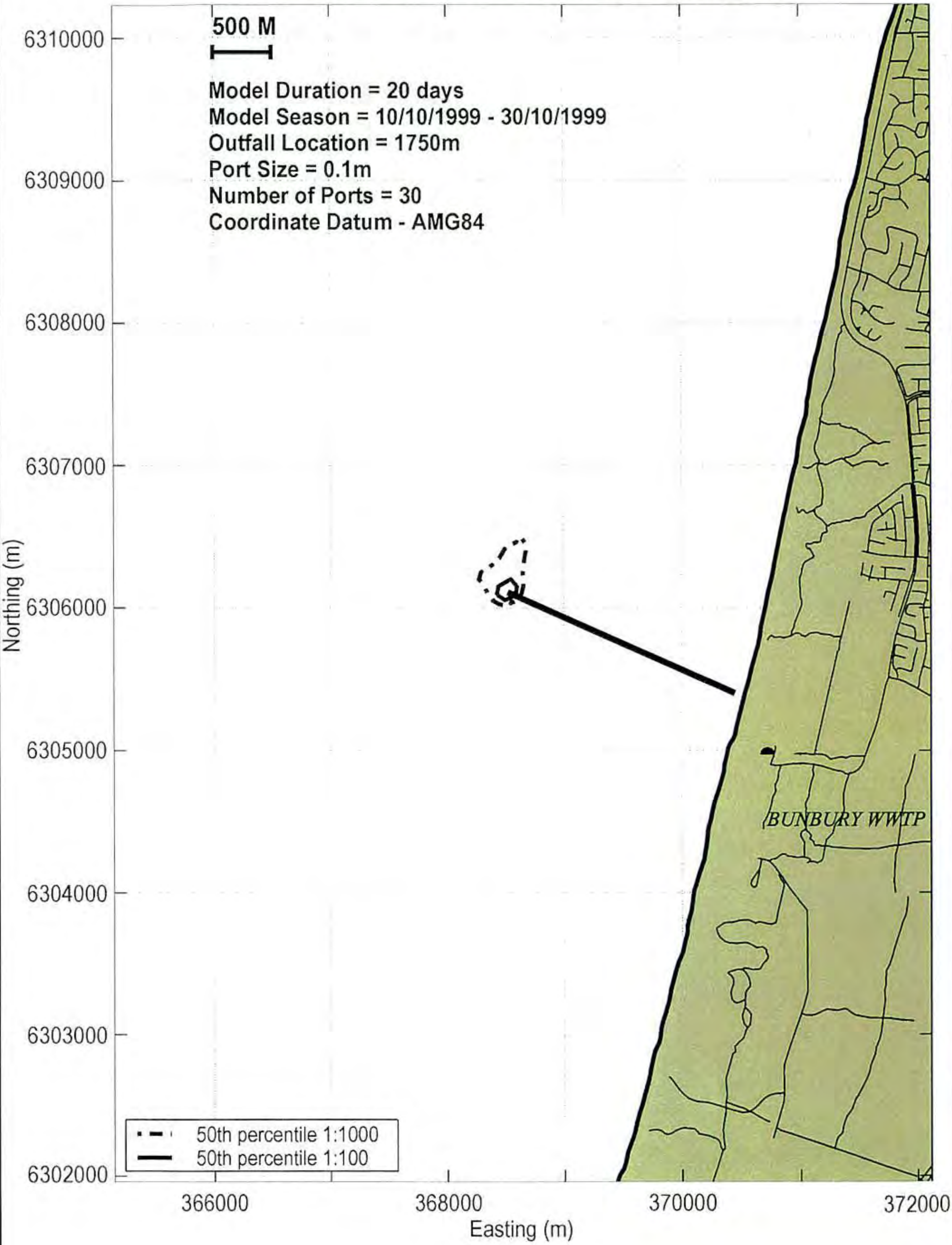
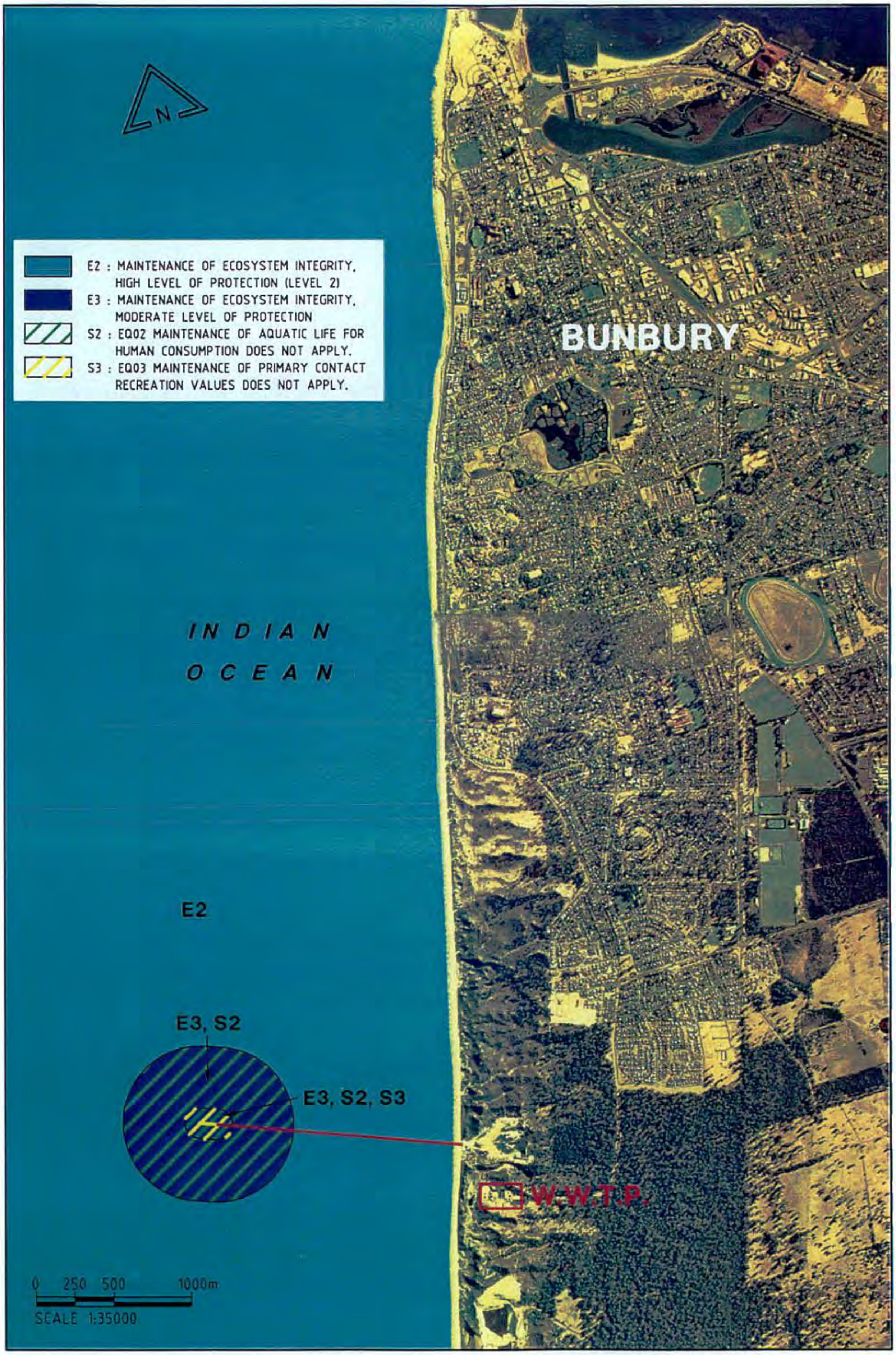
DILUTION PERCENTAGE EXCEEDENCE CONTOURS



WATER CORPORATION BUNBURY WASTE WATER TREATMENT PLANT OCEAN OUTLET	**BUNBURY WWTP SIMULATED SPRING CONDITION**
	FIGURE 7.8

N:\611\43440700\JOBREQUEST\1.8.2000\07V23.DGN



WATER CORPORATION
BUNBURY WASTEWATER
TREATMENT PLANT OCEAN OUTLET

PROPOSED ENVIRONMENTAL QUALITY OBJECTIVES FOR BUNBURY WWTP OCEAN OUTLET (EPA, 2000)

FIGURE 7.9

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A previous survey of the spatial extent of bacterial contamination from an ocean outlet (Sepia Depression outlet, Perth) confirm the model results in that dilution and die-off means that bacterial levels at the beach will not be affected by the operation of the outlet under any wind conditions (SKM, 1999).

The area where the diffuser will be located is not used for recreational or commercial shellfish harvesting. However, to reduce any risk to public health, the Water Corporation intends that an area containing all points within 500 m of any point of the diffuser is designated as not suitable for harvesting of shellfish (Figure 7.9). This will not have a significant impact on social amenity.

7.10 WATER CLARITY AND AESTHETIC VALUES

The turbidity of the treated waste water will be approximately 15 NTU prior to discharge. Turbidity is a measure of the clarity or 'cloudiness' of water, the higher the turbidity (measured in nephelometric turbidity units, NTU) the cloudier the water. To provide context: the turbidity scale ranges from 0 to 1000 NTU; Perth's tap water is 0.3–4 NTU the turbidity of clear seawater in calm condition is of the order 1–5 NTU and fresh river water can range in turbidity from approximately 10 NTU to several hundred NTU during floods. After initial dilution, the plume of treated wastewater will have a turbidity in the range of that measured in clear seawater (1–2 NTU). Therefore, the discharge of treated wastewater will not have any detrimental effect on benthic habitat through reducing available light.

Prior to initial dilution, the treated wastewater will be a relatively clear liquid. The plume may occasionally be visible at the surface during calm conditions and this visibility will primarily result from the difference in refractive index between the plume and the receiving water body rather than differences in colour or clarity.

7.11 SUSPENDED MATERIAL

There will not be any 'large' solids emerging from the outlet. Any suspended solids will consist of fine particulates which have not settled out in the three phases of treatment at the plant. Prior to release the wastewater will contain a maximum suspended solids concentration of 20 mg/L (20 parts per million). There will not be any accumulation of 'sludge' or fines near the outlet as following initial dilution concentrations will reduce to approximately 0.2 mg/L which will then be subsequently dispersed by ambient currents over scales of kilometres and 10s of kilometres.

7.12 BIOLOGICAL OXYGEN DEMAND

The treated wastewater will have a net biological oxygen demand (BOD) on release to the ocean of less than 20 mg/L. Surveys of the marine environment have shown that it is well oxygenated and well mixed. The rapidity of mixing and considerable amount of oxygen available in the system mean there will not be any local depletion of oxygen due to the operation of the outlet. BOD loadings tend to be of most concern in poorly mixed systems or smaller water bodies, where the BOD can cause significant impacts.

7.13 NUTRIENTS AND PHYTOPLANKTON

This proposal will alter the location to which nutrients are discharged from the WWTP to the ocean. It will decrease the load to the shoreline region caused by operation of the WWTP to zero and the load 1.7 km offshore will increase by a corresponding amount.

The implementation of this proposal will result in some beneficial environmental outcomes in terms of nutrient loading, namely:

- A reduction in total nutrient load to the nearshore zone;
- Discharge of nutrients at depth offshore will result in significant and predictable dilution;
- A reduction in the regional scale nutrient discharge to groundwater will occur as septic tanks are replaced as part of Water Corporation's 'Infill Sewerage Program'; and
- The nature of offshore impacts are well understood and can be measured and managed.

The issues concerning ecosystem function result from the consistent increase in nutrient concentrations around the discharge and the possibility for long-term nutrient build up in the sediments adjacent to the diffuser.

In Section 4.4, the projected total nitrogen loads from the Bunbury outlet were compared with the present total nitrogen loads from the Perth outlets. It was shown that the annual dissolved inorganic nitrogen load to the ocean from the Bunbury outlet will be less than one tenth the load from any one of the Perth Metropolitan outlets and approximately one third of the current load from the Leschenault Inlet. At present nutrient loads to the region are dominated by high loads in runoff, which in turn is partly due to the use of fertilisers in agriculture. Over time it is hoped that a more efficient use of fertilisers will reduce land based loads to the region and over similar timeframes, improvements in affordable and efficient wastewater nutrient removal methodologies will also occur and these may be implemented at Bunbury. The continued implementation of the infill sewage program effectively reduces nitrogen loads to the ocean as nitrogen is not appreciably reduced by septic systems (concentrations are typically 50–60 mg/L compared to 10–15 mg/L from the WWTP), the nitrogen enters the surficial groundwater as dissolved inorganic nitrogen and eventually discharges to the shoreline or waterways leading to the coast.

The nutrient load from the outlet will not act 'cumulatively' with loads from other sources as nutrient concentrations will have been reduced to background levels before the plume from the outfall interacts with other nutrient rich plumes from the land (e.g. Five Mile Creek and Leschenault Inlet).

The hydrodynamic model results suggest there will be increased dissolved inorganic nitrogen concentrations within approximately 500 m of the diffuser, and a parcel of water containing elevated nitrogen concentration is generally diluted such that nitrogen levels are at background within about four hours under summer conditions. Under calm conditions, this elevation in nutrient concentrations may result in slightly increased chlorophyll levels in the water near the diffuser. Under more typical (windier) conditions, the nutrient concentrations will be rapidly reduced to near background levels and increase chlorophyll concentrations are unlikely. Chlorophyll levels may occasionally increase above the diffuser with the export of algae which may have formed in the polishing lagoons. Algae exported from the polishing lagoons will generally be freshwater species and will not survive in the marine environment. The discharge will not result in a change in phytoplankton species composition. The project will not have any significant impacts on the wider marine environment (i.e. Geographe Bay).

Using the concepts proposed in the EPA (2000) document on EQOs, it is suggested that the region over which nitrogen concentrations generally decrease to background levels is designated as EQO 1–3. This translates as providing a moderate level of protection for the marine environment rather than the high level of protection implied by EQO1–E2 which could be applied to the majority of Western Australia's waters. The numerical modelling results suggest this region should contain the area within 500 m of the diffuser (Figure 7.9).

7.14 SEAGRASS/BENTHIC HABITAT

Benthic habitat surveys undertaken for this proposal (Cambridge and Kendrick, 2000) and for another potential project north of the Leschenault Inlet (International Risk Consultants, 1999) showed that at the broad scale, benthic habitat from at least 10 km south to 15 km north of Bunbury and 3 km offshore is very similar, being a diverse assemblage of mixed seagrass, reef and sand assemblages. The diffuser and pipeline will be located in habitat which is typical of the larger area and no declared rare or priority marine flora were recorded in the survey region.

The pipe and diffuser will be located in the same habitat with a deliberate attempt to select a location for the diffuser which contains less seagrass habitat and more sand and reef habitat than elsewhere in the vicinity. The underlying seabed along the alignment of the Bunbury outfall comprises sand to a distance of 250 m from shore and then a relatively flat limestone sheet with a thin veneer of sand in places over the remaining 1450 m. Making up part of the limestone sheet are four small limestone reefs which run parallel to the coastline and protrude up to 1 m above the level of the surrounding seabed. Between the reefs, the limestone sheet has numerous small pits and pinnacles with a scale of 0.3 m above and below the general seabed.

It is planned to install the pipeline along the seabed over the limestone sheet to avoid the adverse impacts which would be caused by excavating a trench along the whole length. However a trench will be need to be excavated in raised sections of sand and reef. The area of habitat impacted directly by the pipe will be approximately 0.1 ha, (the pipeline 'footprint' is assumed to be 0.7 m wide for the most part and 0.9 m wide for trenched sections). The pipeline will provide a new habitat and experience with Perth's outlets has shown that the pipe is rapidly colonised by flora and fauna generally associated with reefs, including crayfish.

Limestone excavated in creating any trench through raised reef ridges offshore will be placed beside the trenched area and will rapidly be recolonised as new reef substrate.

The potential for any impact on benthic habitat, including seagrasses, due to decreased light penetration from turbidity caused by construction is low. Firstly, the sediment is predominantly sand sized and settles quickly and any turbidity plumes will not last more than a few hours and, secondly, the construction will not create a continuous plume of suspended sediment (as occurs with dredging). Additionally, the habitat in the region is naturally adapted to turbidity generated from swell and storm events as well as river discharges and these natural events will generate turbidity over much larger temporal and spatial scales than could be generated by this proposal. The pulling out and installation of the pipeline will take approximately two weeks. The habitat impacted will recover rapidly and the Construction EMP will include procedures designed to minimise the impact of construction activities on benthic habitat.

The discharge of treated wastewater to the ocean will not have significant impact on the ecological function, diversity or distribution of benthic flora or seagrasses. The buoyancy of the plume carries the initially high nutrient concentration to the surface and adjacent benthic flora will not 'see' the nutrients discharged from the outlet. By the time the discharged wastewater has been mixed through the water column, the associated nutrient concentrations near the seabed will be at background levels. The plume will not have a significant impact on the light reaching the benthic habitat adjacent to the diffuser and, as light is not limiting growth in this region at this depth, there will not be any light related impacts on surrounding benthic habitat.

The Water Corporation will prepare and implement an ongoing marine water and sediment quality monitoring program which will be detailed in the Operations EMP. In the event that adverse effects due to the operation of the diffuser are observed, a contingency plan will be implemented, this will most likely involve altering operations at the WWTP and increasing the monitoring effort. The contingency plan will form part of the Operations EMP.

7.15 MARINE FAUNA

7.15.1 Construction impacts

The pipeline can accommodate small variations in the seafloor but it may be necessary to remove any pinnacles and to prepare a flat trench through reef ridges. The construction methods have not been finalised and there may be the need for blasting of small sections of limestone reef. However, the preferred construction method will be for limestone to be dug or ripped without blasting and this will be specified in the construction tender documents.

If blasting is required, the following procedures will be in place at minimum:

- Detonation time delays will be used to minimise the water shock wave and ground vibration effects;
- Blasting will not occur in spring when migrating humpbacks and calves are likely to be in the region;
- Prior to blasting, visual checks will be made for marine mammals, blasting will not be undertaken if marine mammals are observed in the vicinity;
- A small surface test charge will be fired in advance of the main blast as a warning to marine mammals and fish;
- The blasting sequence and the detonation of charges at the base of drilled holes will limit the external effect of each blast; and
- The blast will be designed to ensure that the peak particle velocity is within 50 mm/s at the shore and at a distance of 500 m from the blasting area.

In the event of blasting, there will be a loss of small numbers of territorial fish and sessile organisms within approximately 20 m of each blast. This will not affect the diversity of the environment and new populations will rapidly re-establish following completion of construction.

Any blasting will only be used in reef sections where limestone cannot be ripped or dug. Blasting will be carried out in accordance with an underwater blasting plan which will be included in the Construction EMP in the event that blasting is absolutely necessary. The plan will be submitted to the DEP and CALM for approval prior to construction.

Other construction techniques will cause temporary increases in turbidity and loss of some habitat along the pipeline route. There will not be any long-term impacts on marine fauna.

7.15.2 Operations impacts

As the operation of project is unlikely to result any long-term impacts on the marine flora and phytoplankton of the region there is less likely to be any change in marine flora diversity which could impact on local fauna (protected or otherwise). Likewise, there will not be a change in the underwater light climate of a magnitude which could result in a long-term shift in ecosystem diversity, as such there will be no impacts on marine fauna due to changed light climate.

The WWTP will be operated in a manner such that the draft ANZECC (2000) guideline concentrations for toxicants in marine waters are met in the surface waters above the diffuser. The low levels of any toxicants in the treated wastewater suggest there is unlikely to be any accumulation of toxicants in marine fauna due to the operation of the outlet.

Monitoring of Perth's outfalls also suggests that operation of the outlet is unlikely to result in any increased concentrations of toxicants in the adjacent sediments, surrounding waters or biota (Kinhill, 1998; SKM, 1999). If sediments were to be contaminated with toxicants, there could be an effect on benthic marine fauna and fauna further up the food chain feeding on these organisms. As stated above, the quality of wastewater discharged will be monitored and there is unlikely to be any material of significant toxicity discharged. However, a program of sediment monitoring will be also be implemented to ensure that if levels of contaminants are found to be increasing in adjacent sediments WWTP operations can be reviewed before contamination reaches levels likely to cause adverse effects. Baseline sediment monitoring has already been undertaken and the future program will be detailed in the Operations EMP for approval by the DEP. Monitoring of sediments and water will provide a better indication of any possible contamination effects than direct monitoring of fauna.

The operation of the outlet will not have any impact on commercial fish stocks in the area, however, mooring of large vessels and trawling activities near the pipeline will not be permitted. The location of the pipeline will be marked on subsequent versions of navigation charts.

8. PUBLIC CONSULTATION

The proposal has been developed in conjunction with an extensive consultation process for the future of wastewater treatment and disposal in Bunbury. The various stages of the consultation process are summarised below.

8.1 WASTEWATER 2040

The planning and development of Bunbury's sewerage system has involved close consultation with local government, key stakeholders and the general community since the first Bunbury WWTP was constructed in 1963.

In 1992 Water Corporation initiated Wastewater 2040 and involved communities from Australind, Eaton and Bunbury in a series of seminars and workshops to help determine the future planning of wastewater treatment and disposal. Although these communities had separate wastewater schemes it was recognised that a 'Greater Bunbury' community existed and that wastewater schemes may not remain confined to local government boundaries.

Wastewater 2040 encouraged the community to identify future directions and strategies and this was expressed as a preference for land disposal methods and the re-use of treated wastewater. In 1995 *Wastewater 2040: Strategy for the South West Region* was comprehensively reported to the community through local government, participating groups and individuals and the media.

8.2 THE GREATER BUNBURY STUDY

In 1996, following the direction set by Wastewater 2040, the Water Corporation initiated the *Greater Bunbury Study*, a major examination of land disposal options for the Greater Bunbury area. In 1998, after extensive investigation and field testing, the report recommended that land disposal solutions on the coastal plain hinterland around Bunbury were limited due to the generally high water table, high winter rainfall, and sensitivity of many possible sites with respect to run-off of treated wastewater containing nutrients. One option, a treefarm immediately east of Binningup, was found to be environmentally sustainable. This site was not capable of accepting treated wastewater from Greater Bunbury for the long-term; however, if treated wastewater from the Bunbury WWTP was directed elsewhere, it could provide a long-term sustainable disposal solution for the rapidly growing communities of Australind and Eaton.

8.3 BUNBURY CONSULTATIVE WORKSHOP

The Water Corporation publicised the study findings, informed local government authorities and convened a one-day public workshop in Bunbury on Saturday 23 May 1998 to discuss examine and discuss future strategies. The workshop was attended by over 40 representatives of state and local government agencies, community groups and interested individuals and identified the top three options for Bunbury as:

- Ocean disposal;
- Re-use on public parks and gardens with the balance to the ocean; and
- Irrigation of the Binningup treefarm.

The workshop also suggested investigation of industrial re-use and agricultural irrigation re-use.

All options were investigated (refer Section 2.2) and, following consultation with key stakeholders, the option of 're-use on public parks and gardens with the balance to the ocean' was recommended by the Water Corporation.

8.4 ANNOUNCEMENT

On 4 December 1998 this option was presented to the City of Bunbury in a public presentation. It was also presented to the Shires of Harvey and Dardanup in early 1999. Local media coverage of the strategy was widespread.

8.5 COMMUNITY CONSULTATION

To ensure the Bunbury community fully understood the ocean disposal and re-use strategy the Water Corporation:

1. Regularly publicised the ocean outlet proposal in the local media.
2. Sampled the understanding and attitudes of 300 Bunbury residents to ocean disposal and re-use through a random telephone survey conducted by an independent market research company in April 1998.
3. Published 8 full page advertisements in the Bunbury Mail and the South Western Times to highlight key concepts of the disposal strategy in February and March 1999.
4. Responded to requests for briefings on ocean disposal and re-use from 11 community groups in 1999 and 2000.
5. Formed a six member Community Reference Group (later expanded to seven with representation from SW Environment Centre) to advise the Water Corporation on an appropriate community communications plan. The CRG met for the first time on Thursday 11 November 1999 and has met on a 4–6 weekly basis since.
6. Convened a three hour Stakeholder briefing on Thursday 11 November 1999 to detail the ocean outlet proposal.
7. Communicated with key target audiences through new and existing corporate sponsorship agreements.
8. Provided a Keynote Address and major display featuring ocean disposal at *World Environment Day 2000 Celebrations* at Edith Cowan University (Bunbury Campus) on Sunday 4 June 2000.
9. Delivered two brochures to 13,500 Bunbury households and businesses, in November 1999 and June 2000 respectively, informing residents of the ocean disposal proposal.

The Water Corporation has publicly released information on the ocean disposal project as project planning advanced through media statements and media advertising.

8.6 FUTURE CONSULTATION

During the statutory PER community consultation period the Water Corporation will:

1. Maintain a display at local shopping centres for at least two weeks.

2. Convene an Open Day at the City of Bunbury Surf Life Saving Club.
3. Advertise the proposal in local newspapers.

Provide contact opportunities for the public to access information on the project via mail, telephone, facsimile, Internet and e-mail.

9. COMMITMENTS AND MANAGEMENT OF IMPACTS

Throughout this PER document the Water Corporation has made commitments to implement or undertake various activities to ensure that any environmental impacts associated with the project are manageable. Table 9.1 summarises the commitments and their objectives relative to the guidelines for the project issued by the EPA.

9.1 OUTLINE OF ENVIRONMENTAL MANAGEMENT PLANS

One of the core commitments is for Water Corporation to prepare a Construction EMP and an Operations EMP which will provide the template for the management of all aspects of the project. The Construction EMP has to be approved by the DEP prior to construction and the Operations EMP has to be approved prior to commissioning of the outlet. The actions incorporated in the plans become binding on the Water Corporation under the Ministerial conditions of approval. The EMPs will address the following key factors:

Construction EMP: which will address issues specific to the construction and commissioning of the outlet and will include:

- Plans for beach and dune rehabilitation;
- Plans to minimise impacts of pipe construction on marine habitat;
- Plans for designated contractors areas and hours of operation; and
- Plans for safe operation of marine equipment.

Operations EMP: which will address issues associated with the ongoing management of the WWTP, including:

- Groundwater levels and impacts on surrounding vegetation;
- Monitoring of Tuarts for signs of stress induced by changing water levels;
- General management framework for vegetation on entire WWTP site;
- Establishment of local ecological water quality criteria from the available data according to methods set out in the ANZECC guidelines;
- Design water and sediment monitoring programs to measure performance against the agreed ecological criteria;
- Design procedures to be followed in the event that criteria are not met; and
- Design bacterial monitoring program to ensure that the extent of influence of the plume on public health criteria is well understood and that the outlet is operating within agreed parameters.

To support the project management of the environmental studies for the proposal, the Water Corporation has created a GIS database. The considerable quantity of data and associated interpretation generated in preparing this PER have already been stored in this database. This database will then form an invaluable tool for ongoing management and reporting.

Table 9.1 Summary of proponent commitments

	TOPIC	ACTION	OBJECTIVE/S	TIMING	ADVICE
1	Wastewater management	Continue to investigate options for viable wastewater reuse at Bunbury. (The Water Corporation recognise this commitment cannot be audited by DEP).	Although not a direct part of this proposal, the Water Corporation has made a clear commitment to the community of Bunbury to maximise viable reuse of wastewater in the Bunbury region and minimise disposal of treated wastewater to the ocean.	Ongoing.	
2	Construction Environmental Management Program (EMP)	Prepare EMP for construction phase of the project which includes management plans for: • Dune rehabilitation and revegetation; • Beach rehabilitation; • Marine construction; • Underwater blasting (if required); • Protection of terrestrial vegetation; • Public safety; and • Transport.	Prepare and implement an effective Construction EMP to provide a framework for environmental management of the construction phase of the project, such that: • DEP can audit commitments to environmental management made as outlined below; • Detailed management plans for each commitment can be reviewed and approved by DEP prior to implementation; • Any adverse impacts can be revealed in a timely manner; and • Provide contingency plans to deal with any adverse impacts.	Prior to construction.	DEP, CALM, City of Bunbury and Shire of Capel (Local Authorities)
2.1	Construction EMP: Dune management plan	Prepare dune management plan which addresses: • Minimisation of construction impacts on dune erosion; and • Stabilisation and revegetation of the foredune area and areas impacted by construction.	Maintain or improve the integrity, function and environmental values of the dune system. Ensure the amenity of the area adjacent to the project should not be unduly affected by the proposal.	Prior to construction.	DEP and Local Authorities
2.2	Construction EMP: Dune management plan	Implement dune management plan.	Maintain or improve the integrity, function and environmental values of the dune system.	Complete within 12 months of completion of construction.	DEP and Local Authorities
2.3	Construction EMP: Beach rehabilitation plan	Prepare a beach rehabilitation plan which addresses the rehabilitation of the beach after construction.	The integrity, function and environmental values of the foreshore area will be restored.	Prior to construction.	DEP and Local Authorities
2.4	Construction EMP: Beach rehabilitation plan	Implement beach rehabilitation plan.	The integrity, function and environmental values of the foreshore area will be restored.	Within 1 month of completion of construction.	DEP and Local Authorities
2.5	Construction EMP: Terrestrial flora management plan (including Declared Rare and Priority Flora)	Prepare terrestrial flora management plan which addresses the issues: • That changes in local groundwater levels do not result in the loss of nearby Tuarts and other significant flora; and • That construction results in minimal and reversible impact on dune vegetation.	Protect Declared Rare and Priority Flora, consistent with the provisions of the *Wildlife Conservation Act 1950*. Protect threatened ecological communities and critical habitats.	Prior to construction.	DEP and CALM

	TOPIC	ACTION	OBJECTIVE/S	TIMING	ADVICE
2.6	Construction EMP: Terrestrial flora management plan (including Declared Rare and Priority Flora)	Implement terrestrial flora management plan.	Protect Declared Rare and Priority Flora, consistent with the provisions of the *Wildlife Conservation Act 1950*. Protect threatened ecological communities and critical habitats.	Complete within 12 months of completion of construction.	DEP and CALM
2.7	Construction EMP: Marine construction management plan	Prepare a management plan which outlines procedures to minimise impacts of marine construction on: • Marine flora and fauna; and • Marine water quality.	Maintain the biodiversity of the seafloor within the relevant geographical area and to ensure that impacts upon locally significant marine flora and fauna communities are avoided.	Prior to construction.	DEP and CALM
2.8	Construction EMP: Marine construction management plan	Implement marine construction management plan.	Maintain the biodiversity of the seafloor within the relevant geographical area and to ensure that impacts upon locally significant marine flora and fauna communities are avoided.	Complete at end of construction.	DEP and CALM
2.9	Construction EMP: Underwater blasting management plan (if required)	Make it clear to prospective contractors that underwater blasting is not a preferred construction technique. If blasting must be used, prepare a management plan with the aim of minimising the effect of underwater blasting on marine fauna and eliminating possible effects on protected marine fauna. The plan will specifically address issues associated with the protection of marine mammals.	Protect Specially Protected (Threatened) Fauna, consistent with the provisions of the Wildlife Conservation Act 1950. Maintain the biodiversity of the seafloor within the relevant geographical area and to ensure that impacts upon locally significant marine flora and fauna communities are avoided.	Prior to construction.	DEP and CALM
2.10	Construction EMP: Underwater blasting management plan (if required)	Implement underwater blasting management plan (if required).	Protect Specially Protected (Threatened) Fauna, consistent with the provisions of the Wildlife Conservation Act 1950. Maintain the biodiversity of the seafloor within the relevant geographical area and to ensure that impacts upon locally significant marine flora and fauna communities are avoided.	Complete at end of construction.	DEP and CALM
2.11	Construction EMP: Public safety plan	Prepare public safety plan which addresses the issues of: • Restriction of public access to the construction site; • Marine equipment complies with Department of Transport regulations; and • Public notification of any restrictions.	Maintain public safety during construction.	Prior to construction.	DEP and Local Authorities
2.12	Construction EMP: Public safety plan	Implement public safety plan.	Maintain public safety during construction.	Complete at end of construction.	DEP and Local Authorities

	TOPIC	ACTION	OBJECTIVE/S	TIMING	ADVICE
2.13	Construction EMP: Road transport plan	Prepare plan to minimise impacts of transport activities on local residents.	Ensure that noise levels meet acceptable standards and that an adequate level of service, safety and public amenity is maintained. Ensure that the noise levels generated by the project meet acceptable standards. Ensure that noise and vibration levels meet statutory requirements and acceptable standards.	Prior to construction.	DEP and Local Authorities
2.14	Construction EMP: Road transport plan	Implement road transport plan.	Ensure that noise levels meet acceptable standards and that an adequate level of service, safety and public amenity is maintained. Ensure that the noise levels generated by the project meet acceptable standards. Ensure that noise and vibration levels meet statutory requirements and acceptable standards.	Complete at end of construction.	DEP and Local Authorities
3	Operations EMP	Prepare EMP for the operations phase of the project which includes plans for: • Sediment monitoring; • Water quality monitoring; • Protection of recreational amenity; and • Wastewater management.	Prepare and implement an effective Operations EMP to provide a framework for environmental management of the operations phase of the project, such that: • DEP can audit commitments to environmental management made as outlined below; • Detailed management plans for each commitment can be reviewed and approved by DEP prior to implementation; • Any adverse impacts can be revealed in a timely manner; and • Provide contingency plans to deal with any adverse impacts.	Prior to commissioning.	DEP, CALM and Local Authorities

	TOPIC	ACTION	OBJECTIVE/S	TIMING	ADVICE
3.1	Operations EMP: Marine sediment and water quality management plan	Prepare a marine sediment and water quality management plan which addresses the following issues: • Derive site specific trigger levels for waters in the vicinity of the outlet (ANZECC, 2000); • Design monitoring programs for the sediments in the vicinity of the outlet; • Design of water quality monitoring programs which have the ability to measure long-term changes in water quality, including changes in productivity; • Contingency planning to improve water quality if monitoring shows that agreed criteria are not met; • Reporting procedures to DEP; and • Monitoring of contaminant levels in treated wastewater at Bunbury WWTP.	Maintain the biodiversity of the seafloor within the relevant geographical area and to ensure that impacts upon locally significant marine flora and fauna communities are avoided. Maintain or improve the quality of marine water consistent with the draft Western Australia Guidelines for Fresh and Marine Waters (EPA, 1993). Maintain or improve marine water and sediment quality consistent with agreed EQOs and EQC.	Provision of initial wastewater contaminant survey data to DEP in the Water Corporation's response to public submissions on this PER. All other aspects of the plan prior to commissioning of the outlet.	DEP and CALM
3.2	Operations EMP: Marine sediment and water quality management plan	Implement marine sediment and water quality management plan for five years after completion of construction, after which time it will be reviewed in consultation with DEP.	Maintain the biodiversity of the seafloor within the relevant geographical area and to ensure that impacts upon locally significant marine flora and fauna communities are avoided. Maintain or improve the quality of marine water consistent with the draft Western Australia Guidelines for Fresh and Marine Waters (EPA, 1993). Maintain or improve marine water and sediment quality consistent with agreed EQOs and EQC.	For five years after completion of construction, after which time the program will be reviewed.	DEP and CALM
3.3	Operations EMP: Recreational water quality management plan	Prepare a recreational water quality management plan which addresses the following issues: • Design a bacterial monitoring program which will establish whether primary contact criteria are met within 100 m of the diffuser and whether shellfish harvesting criteria within 500 m of the diffuser; and • Contingency planning to improve water quality if monitoring shows that agreed criteria are not met.	Not to compromise recreational uses of the area. Protect the recreational values of the area consistent with agreed EQOs and EQC.	Prior to commissioning of the outlet.	DEP, Health Department and Local Authorities
3.4	Operations EMP: Recreational water quality management plan	Implement recreational water quality management plan for five years after completion of construction, after which time it will be reviewed in consultation with DEP.	Not to compromise recreational uses of the area. Protect the recreational value of the area consistent with agreed EQOs and EQC.	For five years after completion of construction, after which time the program will be reviewed.	DEP, Health Department and Local Authorities
3.5	Recreation (land based)	Maintain legitimate recreational uses of the beach and dune areas (no plan required).	Not to compromise recreational uses of the area.	Following commissioning of the outlet.	Relevant Local Authorities

	TOPIC	ACTION	OBJECTIVE/S	TIMING	ADVICE
3.6	Operations EMP: Wastewater treatment management plan	Prepare a management plan for the WWTP which addresses the following environmental issues: • Operate WWTP such that national guidelines for toxicant concentrations in marine waters are met; • Operate WWTP such that agreed EQOs and EQC are met; • Discontinue the current practice of discharging treated wastewater to unlined lagoons, except where flows are required to reduce stress on nearby trees; and • Ensure maximum annual average nitrogen load to the ocean from the outlet is less than 60 tpa.	Reduce nitrogen loads to nearshore and reduce potential for erosion of beach during storm events. Ensure that the management of wastewater effluent during construction and operation is environmentally acceptable.	Prior to commissioning of the outlet.	DEP
3.7	Operations EMP: Wastewater treatment management plan	Implement wastewater treatment management plan for five years after completion of construction, after which time it will be reviewed in consultation with DEP.	Reduce nitrogen loads to nearshore and reduce potential for erosion of beach during storm events. Ensure that the management of wastewater effluent during construction and operation is environmentally acceptable.	For five years after completion of construction, after which time the program will be reviewed.	DEP

10. GLOSSARY OF TERMS AND ABBREVIATIONS

10.1 GLOSSARY

Advanced secondary treatment	Secondary treatment incorporating additional treatment steps to enhance the biological removal of nitrogen.
Algae	Non-flowering aquatic plants. The larger plants of this group that occur in marine environments, are called seaweed and the microscopic plants that float in the water are called phytoplankton.
Anaerobic	Without oxygen.
Aquatic	Growing or living in or near water.
Aquifer	A layer of rock or soil capable of holding or transmitting water.
Assemblage	Recognisable grouping or collection of individuals or organisms.
Background level	The level of an environmental pollutant or indicator that would exist if the source under observation was absent.
Bathymetry	Measurement of the changing ocean depth to determine the sea floor topography.
Benthic	That related to the seabed.
Biodiversity	The variety of all life forms: the different plants, animals and micro-organisms, the genes they contain and the ecosystems they form.
Biota	Defined as all the plants, animals and micro-organisms of a region.
Biological oxygen demand (BOD)	Measures of oxygen depletion in water due to bacteria decay of organic pollutants. BOD_5 is the biological oxygen demand measured after 5 days of incubation.
Biomass	The living weight of a plant or animal population, usually expressed on a unit area basis.
Chlorophyll a	A molecule that is able to capture sunlight and convert it into a form that can be used for photosynthesis. Chlorophyll a is the primary photosynthetic pigment in photosynthetic organisms and the concentration of this molecule in water is commonly used as a measure of phytoplankton biomass.
Chlorophyll b	A pigment primarily found in green algae, acts to absorb additional light for transfer to chlorophyll a for primary photo-chemistry.
Chlorophyll c	An accessory light gathering pigment found in algae species
Colonisation	Movement of an organism into an area in which it was not previously present.
Compliance	The degree to which stated project goals or requirements are attained.
Contaminant	Any physical, chemical or biological substance or property which is introduced into the environment.
Diffuser	A mechanism that enhances the natural spread of a liquid stream into the receiving environment.
Diffusion	The transfer of substances along a gradient from regions of high concentrations to regions of lower concentrations.
Diurnal	Daily.
Ecological function	Combined characteristics and processes occurring within an area.
Ecology	Studies of the relations of animals and plants, particularly of animal and plant communities, to their surroundings.
Ecosystem	A community of organisms, interacting with each other plus the environment in which they live and with which they also interact.
Ecosystem integrity	The ability to support and maintain a balanced, integrative, adaptive community of organisms having a species composition, diversity and functional organisation comparable to that of natural habitat of the region.
Effluent	Discharged treated wastewater.
Enterococci	See faecal coliform/faecal streptococci.
Environmental quality criteria	The scientific benchmarks upon which a decision may be made concerning the ability of an environment to maintain certain designated environmental quality objectives.
Environmental quality objectives	The long-term goals in relation to the maintenance of the environmental (ecological and cultural) values of natural systems.
Environmental values	The ways society uses or values an area.
Epiphyte	Plant that grows attached to the outside of another plant.
Eutrophic	Nutrient enriched (usually associated with deterioration of natural water bodies where nutrient enrichment occurs through man's activities).
Eutrophication	An increase in the rate of supply of organic matter to an ecosystem caused by unnaturally high loads of nutrients to that system.

Faecal bacteria	Includes bacteria like coliforms and streptococci that inhabit the large intestine of humans and other warm blooded animals.
Faecal coliform/faecal streptococci	Bacteria which inhabit the large intestine of humans and other warm blooded mammals. Their presence in the environment is used to provide an indication for the presence of faecal contamination and, therefore, the presence of faecal pathogens.
Faecal pathogens	Pathogenic (disease causing) organisms present in faecal matter, e.g. Salmonella, Shigella, or Vibrio spp. Due to the complexity of testing, the presence of these organisms is only tested for in special surveys.
Farfield	An area around the nearfield area where further dilution of the wastewater becomes dominated by ocean currents.
Fauna	Animals.
Filterable reactive phosphorus	Dissolved phosphorus (ortho-phosphate PO_4^{3-}), directly available for biological uptake.
Flora	Plants.
Habitat	The place or environment occupied by individuals of a particular species, population or community; has physical, chemical and biological attributes conducive to the maintenance and propagation of those biota.
Heavy metals	Such as zinc, copper, chromium which accumulate in sediments and tissues of biota, and may be passed-up in the food chain. Heavy metals can be toxic at high levels.
Hydrodynamic	The movement or mixing of water as a result of applied forces, such as wind stress at the water surface.
Infauna	Animals that live within the sediments of the sea floor.
Influent	In-flowing wastewater prior to treatment.
Initial dilution	The dilution of a rising plume caused by the mixing with the receiving water as it rises to the surface. The initial dilution is the dilution measured where the plume first reaches the surface of the receiving water.
Invertebrate	Collective term for all animals which do not have a backbone or spinal column.
Light attenuation	Light reduction which occurs with increasing depth of water, attenuation increases as light penetration decreases.
Macroalgae	Large algae; seaweed.
Median	A statistical measure equivalent to the middle measurement in an ordered set of data (there are as many observations larger than the median as there are smaller).
Neap tides	Sets of moderate tides, which recur every two weeks and alternate with spring tides.
Nearfield	The area in the immediate vicinity of the outlet diffuser where effluent is rapidly diluted due to entrainment of seawater in the diffuser jets and mixing caused as the buoyant plume rises to the surface.
Nitrogen loading	The quantity in tonnes per annum of nitrogen released into the marine environment.
Nutrients	Elements or compounds essential for organic growth and development such as nitrogen and phosphorus.
Nutrient load	The quantity in tonnes per annum of nutrients released into the marine environment.
Order of magnitude	Approximately 10 fold difference, e.g. 50 m is an order of magnitude longer than 3 m.
Percentile	A measure that divides a group of ordered data into hundredths by quantities.
Periphyton	Mucous-like layer of microalgae, algal propagules, bacteria, microfauna and particulate matter commonly found coating seagrass leaves and hard surfaces.
Phytoplankton	Microscopic algae that float in the water column.
Primary contact	Water used for primary contact activities, such as swimming, bathing and other direct water-contact sports, should be sufficiently free from faecal contamination, pathogenic organisms and other hazards to protect the health and safety of the user (ANZECC, 1992).
Primary treatment	Settling of wastewater to partially remove solids and associated contaminants.
Secondary contact	Water used for secondary contact activities, such as boating and fishing, is required to meet the guidelines suggested by ANZECC (1992).
Secondary treatment	Aeration of wastewater to produce a relatively clear effluent and also substantially reduces loads of faecal bacteria and heavy metals. Generally removes 85% of BOD and suspended solids, often by biological treatment processes.
Sewage	Domestic wastewater.

Sewerage system	The infrastructure used to transport sewage or wastewater.
Significant wave height	The average height of the highest 1/3 of the waves.
Species composition	Number and abundance of different types of species in a habitat.
Species richness	Number of different types of species in a habitat.
Spring tides	Extremely high and low tides which alternate with neap tides and recur every two weeks.
Stratification	Layering (vertical or horizontal) in a water property such as salinity or temperature.
Surficial	Found on the surface or making up the surface.
Suspended solids	Any solid substance present in water in an undissolved state.
Terrestrial	Of the land.
Tertiary Treatment	Wastewater treatment which includes treatment processes beyond secondary or biological processes which improve wastewater quality beyond secondary treatment. Tertiary treatment processes include detention in lagoons, conventional filtration via sand, dual media or membrane filters which may include coagulant dosing and land based or wetland processes.
Thermo-tolerant coliforms	Heat tolerant bacteria (see faecal bacteria).
Topography	Detailed description of a land or sea surface represented for example on a map.
Total Kjeldahl Nitrogen	Fraction of nitrogen which consists of the N in the organic material (i.e. in proteins and acids) plus the nitrogen in the water column as ammonia (NH_3/NH_4).
Total Nitrogen	The sum of all concentrations of nitrogen in water column regardless of form.
Trophic	Energy level in a food chain.
Turbidity	Measure of the clarity of a water body, the unit of measurement is NTU (see below).
Wastewater	Domestic, industrial and municipal effluent.
Zone of influence	An area around the Sepia Depression ocean outlet where a bacteriological influence from the discharge can be measured.

10.2 ABBREVIATIONS

AADF	Annual average daily flow
ANZECC	Australian and New Zealand Environment and Conservation Council
BOD	Biological oxygen demand
cfu	Colony forming units
DEP	Department of Environmental Protection
EFDC	Environmental fluid dynamics code
EPA	Environmental Protection Authority
EPP	Environmental Protection Policy
EQO	Environmental quality objective
EQC	Environmental quality criteria
FRP	Filterable reactive phosphorus
IDEA	Intermittently Decanted Extended Aeration
NH & MRC	National Health and Medical Research Council
NH_4	Ammonium nitrogen
$NO_{3,2}$	Nitrate + nitrite-nitrogen
NTU	Nephelometric Turbidity Units
pH	Measure of acidity
PCWS	Perth Coastal Waters Study
PLOOM	Perth Long-term Ocean Outlet Monitoring
SMCWS	Southern Metropolitan Coastal Waters Study
SS	Suspended solids
TF	Trickling Filter
TKN	Total Kjeldahl nitrogen
TN	Total nitrogen
TP	Total phosphorus
TSS	Total suspended solids
WWTP	Wastewater treatment plant

10.3 WEIGHTS AND MEASURES

%	percent
°C	degree Celsius
cm	centimetre
cm/s	centimetres per second
cfu/100 mL	colony forming units per 100 millilitres
ha	hectare
kg	kilogram
kg/M^3	kilogram per cubic metre
km	kilometre
km/d	kilometres per day
kL	kilolitres
L/s	litre per second
m	metre
mm	millimetre
µm	micrometres
m/s	metres per second
m^2	square metre
m^3	cubic metre
mgm^{-3}	milligram per cubic metre
m^3/s	cubic metres per second
mg/L	milligram per litre
mL	millilitres
ML	million litres
ML/d	million litres per day
t	tonne
tpa	tonne per annum
µg/g	microgram per gram
µg/L	microgram per litre

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APPENDIX 1
EPA GUIDELINES

Environmental Protection Authority
Guidelines

WASTEWATER TREATMENT PLANT - OCEAN OUTLET, BUNBURY

(Assessment Number 1302)

Part A	Specific Guidelines for the preparation of the Public Environmental Review
Part B	Generic Guidelines for the preparation of an environmental review document

Attachment 1	Example of the invitation to make a submission
Attachment 2	Advertising the environmental review
Attachment 3	Map showing proposed ocean outfall pipeline

These guidelines are provided for the preparation of the proponent's environmental review document. The specific environmental factors to be addressed are identified in Part A. The generic guidelines for the format of an environmental review document are provided in Part B.

The environmental review document <u>must</u> address all elements of Part 'A' and Part 'B' of these guidelines prior to approval being given to commence the public review.

Part A: Specific Guidelines for the preparation of the Public Environmental Review

1. The proposal

The Water Corporation Western Australia (Water Corporation) (the proponent) intends to dispose of secondary treated municipal wastewater to sea using an ocean outlet and diffuser which is to be located approximately 1.5 to 2.0 km offshore, in about 11m of water. The proposed pipeline and diffuser is indicated on the attached plan (Attachment 3).

The project will involve the installation of approximately 600 mm diameter pipeline which runs from the wastewater treatment plant to a dune blowout immediately to the north, and then west to a distance between 1.5 and 2.0 km offshore. The pipeline will be buried through the foredune and littoral (nearshore) zone. The proposal is to limit flows discharged to the ocean outlet to 5,840 ML/annum (16ML/day average), but up to 24 ML/day during the peak winter day. The proposal aims to limit the total nitrogen loads to the ocean (nearshore and offshore) to 60 tonnes/annum (approximately 160kg/day average).

The proposal area includes areas impacted from the treatment plant to the offshore pipeline, dune, foreshore and nearshore bed areas, seabed along pipeline route and areas of seabed, marine waters and shore impacted by wastewater discharge.

2. Environmental factors relevant to this proposal

At this preliminary stage, the Environmental Protection Authority (EPA) believes the relevant environmental factors, objectives and work required is as detailed in the table below:

CONTENT		SCOPE OF WORK	
Factor	**Site specific factor**	**EPA objective**	**Work required for the environmental review**
COASTAL SYSTEM			
BIOPHYSICAL			
Coastal	Dune	Maintain or improve the integrity, function and environmental values of the dune system.	Assess potential impacts (direct and indirect) on morphology, fauna or flora as a result of alteration to dune structure during construction and operation of pipeline. Detail proposed measures to manage, mitigate and remediate impacts. Detail contingency plan for the rehabilitation and long-term management of the dune.
	Foreshore (beach)	Maintain the stability of beaches. Maintain the integrity, function and environmental values of the foreshore area.	Assess the impact of alteration to foreshore contours during and post-construction of the pipeline. Detail proposed measures to manage and/or mitigate impacts.
	Nearshore bed	Ensure that development does not have a significant impact on existing coastal systems including sediment and nearshore bed	Detail proposed measures to manage and/or mitigate impact during and post-construction of pipeline on existing coastal systems including sediment and nearshore bed.

CONTENT		SCOPE OF WORK	
Factor	**Site specific factor**	**EPA objective**	**Work required for the environmental review**
Terrestrial Flora	Vegetation	Protect threatened ecological communities and critical habitats.	Map and describe the native vegetation areas and assess representation in a local and regional context.
Terrestrial Flora	Declared Rare and Priority Flora (terrestrial)	Protect Declared Rare and Priority Flora, consistent with the provisions of the *Wildlife Conservation Act 1950.*	Map and describe areas of conservational value in terms of declared rare and priority flora likely to be impacted during and post-construction of pipeline. Assess potential impacts (direct and indirect) on declared species during and post-construction of pipeline. Assess the long-term proposal in its local context and against the present condition and distribution of the declared rare and priority flora in the region. Detail proposed measures to manage and/or mitigate impacts.
SOCIAL SURROUNDINGS			
	Recreation	Not to compromise recreational uses of the area, as developed by planning agencies. Protect the recreational value of the area consistent with Environmental Quality Objectives (EQO 2,3,4,5): Fishing and Aquaculture and Recreation and Aesthetics as defined in the Perth Coastal Waters - Environmental Values and Objectives (EPA, 2000)	Assess potential impact of construction and operation of pipeline on recreational uses of the area.
	Public safety during construction	Maintain public safety during construction.	Assess potential impact of construction of pipeline on public health and safety.
	Amenity	Ensure that the amenity of the area adjacent to the project should not be unduly affected by the proposal. Protect the aesthetical value of the area consistent with Environmental Quality Objectives (EQO 5): Perth Coastal Waters - Environmental Values and Objectives (EPA, 2000	Assess the potential impact of construction and operation of pipeline on amenity including effects on amenity due to odour.

CONTENT		SCOPE OF WORK	
Factor	**Site specific factor**	**EPA objective**	**Work required for the environmental review**
	Road transport	Ensure that noise levels meet acceptable standards and that an adequate level of service, safety and public amenity is maintained. Ensure that the noise levels generated by the project meet acceptable standards. Ensure that noise and vibration levels meet statutory requirements and acceptable standards.	Assess the potential impacts (direct and indirect) of noise and vibration generated from road transport during construction of pipework. Detail proposed measures to manage and/or mitigate impacts of noise on public amenity.
MARINE SYSTEM			
BIOPHYSICAL			
Marine Flora	Flora (general)	Maintain the ecological function, abundance, species diversity and geographic distribution of marine flora locally and regionally.	Identify flora abundance, species diversity and geographic distribution of marine flora. Outline of sampling methods, results of analysis and methodology for determining marine flora Assess potential impacts of pipeline construction and of wastewater discharge on marine flora.
Marine Flora	Declared Rare and Priority Flora (specific)	Protect Declared Rare and Priority Flora, consistent with the provisions of the *Wildlife Conservation Act 1950.*	Map and describe areas of conservational value in terms of declared rare and priority flora. Assess potential impacts (direct and indirect) on declared species as a result of the proposal. Assess the long-term proposal in its local context and against the present condition and distribution of the declared rare and priority flora in the region. Detail proposed measures to manage and/or mitigate impacts.
Marine Flora	Seagrass and its habitat (specific)	Maintain the ecological function, abundance, species diversity and geographic distribution of seagrasses locally and regionally Encourage the development and implementation of practical technical solutions for the rehabilitation of the environment. (Refer to EPA Guidance Notes 22 and 29)	Outline of sampling methods, results of analysis and methodology for determining marine seagrass. Map and describe seagrass areas near proposed pipeline and diffuser and in any areas of potential impact from wastewater discharge. Assess potential impacts (direct and indirect) on seagrass as a result of the proposal. Assess the long-term impacts of the proposal in its local context and against the present condition and distribution of the seagrasses in the region.

CONTENT		SCOPE OF WORK	
Factor	**Site specific factor**	**EPA objective**	**Work required for the environmental review**
			Assess the value of seagrass as a functional biological component of the ecosystem. Assess the significance of seagrass distribution likely to be impacted by the proposed outfall pipe. Detail proposed measures to monitor, manage and mitigate potential impacts.
Marine Flora	Algae and its habitat (specific)	Minimise interference with the process of nutrient and carbon cycling from algae. Maintain the ecological function, abundance, species diversity, productivity and geographic distribution of algae.	Outline sampling methods, results of analysis and methodology for determining marine algae. Assess potential impacts (direct and indirect) on algae as a result of the proposal. Assess the long-term proposal in its local context and against the present condition and distribution of the algae in the region. Assess the value of algae as a functional biological component of the ecosystem. Assess the significance of algae distribution likely to be impacted by the proposed outfall pipe and its operations. Propose measures to manage and/or mitigate impacts.
Marine Fauna	Fauna (general)	Maintain the abundance, species diversity and geographic distribution of marine fauna.	Undertake baseline studies to identify existing fauna in the project area. Assess potential impacts (direct and indirect) on marine fauna as a result of the project, including any impacts on commercial or recreational fishing. Detail proposed measures to manage and/or mitigate impacts.
Marine Fauna	Specifically Protected (Threatened) Fauna) (specific)	Protect Specially Protected (Threatened) Fauna, consistent with the provisions of the Wildlife Conservation Act 1950. Maintain or improve the ecology consistent with Environmental Quality Objectives (EQO 1): Maintenance of Ecosystem Integrity (level 2-high protection) defined in the Southern Metropolitan Coastal Waters Study (1996) and Perth Coastal Waters - Environmental Values and Objectives (EPA, 2000	Carry out baseline studies to identify existing fauna in the project area. Assess potential impacts (direct and indirect) on specifically protected fauna as a result of the project. Detail proposed measures to manage and/or mitigate impacts.

CONTENT		SCOPE OF WORK	
Factor	**Site specific factor**	**EPA objective**	**Work required for the environmental review**
Marine Flora and Fauna	Benthic community (specific)	Maintain the biodiversity of the seafloor within the relevant geographical area and to ensure that impacts upon locally significant marine flora and fauna communities are avoided.	Assess potential impacts of pipeline construction and of wastewater discharge on benthic communities.
POLLUTION MANAGEMENT			
Marine water and sediment quality		Maintain or improve the quality of marine water consistent with the draft WA Guidelines for Fresh and Marine Waters (EPA, 1993); Maintain or improve marine water and sediment quality consistent with Environmental Quality Objectives (EQO 1) and Environmental Quality Criteria (EQC's) defined in the Southern Metropolitan Coastal Waters Study (1996) and Perth Coastal Waters - Environmental Values and Objectives (EPA, 2000).	Assess the potential impact of dredging and other headworks on: • marine water quality including turbidity; • ecological processes within the construction area. Describe proposed modelling of plume and determine wastewater plume dispersion rates. Determine via modelling the zones of influence of the wastewater effluent about the outfall on a seasonal basis, including worst case conditions (considering summer irrigation option). Determine whether wastewater discharge will have any effect upon the wider marine area (Geographe Bay). Detail plume contaminants and show extent of plume for each contaminant, including turbidity. Detail proposed measures to manage and/or mitigate impacts on marine water and sediment quality during construction and operation of pipeline. Outline proposed monitoring program, including action levels. Outline contingency plans in event of monitoring showing potential problems and in the event of process breakdowns. Estimate the geographical extent of the Bunbury wastewaster catchment that discharges to the outfall zone of influence. Estimate the nutrient load discharged to the outfall zone of influence from other point and diffuse sources based on available information. Consider how the total nutrient load to this area will change to 2040.
Management of wastewater effluent	Wastewater effluent	Ensure that the management of wastewater effluent during construction and operation is environmentally acceptable.	Detail the management of wastewater effluent during construction and operation of pipeline, including monitoring and disposal. Estimate the annual effluent volumes and nutrients loads produced by the plant.

CONTENT		SCOPE OF WORK	
Factor	**Site specific factor**	**EPA objective**	**Work required for the environmental review**
			Describe the wastewater disposal program by taking into account summer irrigation and outfall disposal. Consider the hierarchy approach to wastewater management and options such as recycling, direct reuse for summer irrigation and aquifer recharge and explain why ocean outfall is preferred option.
SOCIAL SURROUNDINGS			
	Recreation	Not to compromise recreational uses of the area, as developed by planning agencies. Protect the recreational value of the area consistent with Environmental Quality Objectives (EQO 2,3,4,5): Fishing and Aquaculture and Recreation and Aesthetics as defined in the Perth Coastal Waters - Environmental Values and Objectives (EPA, 2000)	Assess potential impact of construction and operation of pipeline on recreational uses of the area. Carry out health risk assessment in relation to the outfall and identify any areas not suitable for recreation.
	Public safety during construction	Maintain public safety during construction.	Assess potential impact of construction and operation of pipeline on public health and safety.

Note: Impacts from all contaminants found in the wastewater (eg. nutrients, thermotolerant coliforms, heavy metals, pesticides and hydrocarbons) should be considered and addressed where the impact is found to be significant.

These factors should be addressed within the environmental review document for the public to consider and make comment to the EPA. The EPA expects to address these factors in its report to the Minister for the Environment.

The EPA expects the proponent to take due care in ensuring any other relevant environmental factors which may be of interest to the public are addressed.

3. Availability of the environmental review

3.1 Copies for distribution free of charge

Supplied to DEP:

- Library/Information Centre 9
- EPA members 6
- Officers of the DEP (Perth) 6

Distributed by the proponent to:

Government departments
- Department of Conservation and Land Management 2
- Department of Transport 1
- Fisheries Western Australia 1
- Health Department of Western Australia 1
- Department of Environmental Protection 3

Local government authorities
- Town of Bunbury 2
- Shire of Capel 2

Libraries
- J S Battye Library 3
- The Environment Centre 2
- Town of Bunbury 2
- Shire of Capel 2

Other
- Conservation Council of WA 1
- Environment Australia 1
- Coastal Water Alliance 1
- Recfishwest 1
- Marine and Coastal Community Network 1
- South West Environment Centre 1

3.2 Available for public viewing

- J S Battye Library;
- Shire of Capel Library
- Town of Bunbury Library;
- Department of Environmental Protection Library;

Part B: Generic Guidelines for the preparation of an environmental review document

1. Overview

All environmental reviews have the objective of protecting the environment. Environmental impact assessment is deliberately a public process in order to obtain broad ranging advice. The review requires the proponent to describe:

- the proposal (include discussion on the geographical extent of the Bunbury wastewater catchment, nutrient sources within this catchment and the extent by which the total nutrient load from this catchment is likely to change to the year 2040);
- receiving environment;
- potential impacts of the proposal on factors of the environment; and
- proposed management strategies to ensure those environmental factors are appropriately protected.

Throughout the assessment process it is the objective of the Environmental Protection Authority (EPA) to help the proponent to improve the proposal so the environment is protected. The DEP administers the environmental impact assessment process on behalf of the EPA.

The primary purpose of the environmental review is to provide information on the proposal within the local and regional framework to the EPA, with the aim of emphasising how the proposal may impact the relevant environmental factors and how those impacts may be mitigated and managed.

The language used in the body of the environmental review should be kept simple and concise, considering the audience includes non-technical people, and any extensive, technical detail should either be referenced or appended to the environmental review. The environmental review document will form the legal basis of the Minister for the Environment's approval of the proposal and therefore should include a description of all the main and ancillary components of the proposal, including options where relevant.

Information used to reach conclusions should be properly referenced, including personal communications. Such information should not be misleading or presented in a way that could be construed to mislead readers. Assessments of the significance of an impact should be soundly based rather than unsubstantiated opinion, and each assessment should lead to a discussion of the management of the environmental factor.

2. Objectives of the environmental review

The objectives of the environmental review are to:

- place this proposal in the context of the local and regional environment;
- adequately describe all components of the proposal, so that the Minister for the Environment can consider approval of a well-defined project;
- provide the basis of the proponent's environmental management program, which shows that the environmental impacts resulting from the proposal, including cumulative impact, can be acceptably managed; and
- communicate clearly with the public (including government agencies), so that the EPA can obtain informed public comment to assist in providing advice to government.

3. Environmental management

The EPA expects the proponent to have in place an environmental management system appropriate to the scale and impacts of the proposal including provisions for performance review and a commitment to continuous improvement. The system may be integrated with quality and health and safety systems and should include the following elements:

- environmental policy and commitment;
- planning of environmental requirements;
- implementation and operation of environmental requirements;
- measurement and evaluation of environmental performance;
- review and improvement of environmental outcomes.

A description of the proposed environmental management system should be included in the environmental review documentation. If appropriate, the documentation can be incorporated into a formal environmental management system (such as AS/NZS ISO 14001). Public accountability should be incorporated into the approach on environmental management.

The environmental management program (EMP) is the key document of an environmental management system that should be adequately defined in an environmental review document. The EMP should provide plans to manage the relevant environmental factors, define the performance objectives, describe the resources to be used, outline the operational procedures and outline the monitoring and reporting procedures which would demonstrate the achievement of the objectives.

4. Format of the environmental review document

The environmental review should be provided to the DEP officer for comment. At this stage the document should have all figures produced in the final format and colours.

Following approval to release the review for public comment, the final document should also be provided to the DEP in an electronic format.

The proponent is requested to supply the project officer with an electronic copy of the environmental review document for use on Macintosh, Microsoft Word Version 6, and any scanned figures. Where possible, figures should be reproducible in a black and white format.

5. Contents of the environmental review document

The contents of the environmental review should include an executive summary, introduction and at least the following:

5.1 The proposal

A comprehensive description of the proposal including its location (address and certificate of title details where relevant) is required.

Justification and alternatives

- justification and objectives for the proposed development;
- the legal framework, including existing zoning and environmental approvals, and decision making authorities and involved agencies; and
- consideration of alternative options.

Key characteristics

The Minister's statement will bind the proponent to implementing the proposal in accordance with any technical specifications and key characteristics[1] in the environmental review document. It is important therefore, that the level of technical detail in the environmental review, while sufficient for environmental assessment, does not bind the proponent in areas where the project is likely to change in ways that have no environmental significance.

Include a description of the components of the proposal, including the nature and extent of works proposed. This information must be summarised in the form of a table as follows:

Table 1: Key characteristics (example only)

Element	Description
Life of project (mine production)	< 5yrs (continual operation)
Size of ore body	682 000 tonnes (upper limit)
Area of disturbance (including access)	100 hectares
List of major components • pit • waste dump • infrastructure (water supply, roads, etc)	refer plans, specifications, charts section immediately below for details of map requirements
Ore mining rate • maximum	 • 200 000 tonnes per year
Solid waste materials • maximum	 • 800,000 tonnes per year
Water supply • source • maximum hourly requirement • maximum annual requirement	 • XYZ borefield, ABC aquifer • 180 cubic metres • 1 000 000 cubic metres
Fuel storage capacity and quantity used	litres; litres per year
Heavy mineral concentrate transport • truck movements (maximum)	 • 75 return truck loads per week

Plans, Specifications, Charts

Adequately dimensioned plans showing clearly the location and elements of the proposal which are significant from the point of view of environmental protection, should be included. The location and dimensions (for progressive stages of development, if relevant) of plant, amenities buildings, accessways, stockpile areas, dredge areas, waste product disposal and treatment areas, all dams and water storage areas, mining areas, storage areas including fuel storage, landscaped areas etc.

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[1] Changes to the key characteristics of the proposal following final approval, would require assessment of the change and can be treated as non-substantial and approved by the Minister, if the environmental impacts are not significant. If the change is significant, it would require assessment under section 38 or section 46. Changes to other aspects of the proposal are generally inconsequential and can be implemented without further assessment. It is prudent to consult with the Department of Environmental Protection about changes to the proposal.

Only those elements of plans, specifications and charts that are significant from the point of view of environmental protection are of relevance here.

Figures that should always be included are:

- a map showing the proposal in the local context - an overlay of the proposal on a base map of the main environmental constraints;
- a map showing the proposal in the regional context; and, if appropriate,
- a process chart / mass balance diagram showing inputs, outputs and waste streams.

The plan/s should include contours, a north arrow, a scale bar, a legend, grid co-ordinates, the source of the data, and a title. If the data is overlaid on an aerial photo then the date of the aerial photo should be shown.

Other logistics

- timing and staging of project; and
- ownership and liability for waste during transport, disposal operations and long-term disposal (where appropriate to the proposal).

5.2 Environmental factors

The environmental review should focus on the relevant environmental factors for the proposal, and these should be agreed in consultation with the EPA and DEP and relevant public and government agencies. Preliminary environmental factors identified for the proposal are shown in Part A of these guidelines.

Further environmental factors may be identified during the preparation of the environmental review, therefore on-going consultation with the EPA, DEP and other relevant agencies is recommended. The DEP can advise the proponent on the recommended EPA objective for any new environmental factors raised. Minor matters which can be readily managed as part of normal operations for the existing operations or similar projects may be briefly described.

Items that should be discussed under each environmental factor are:

- a clear definition of the area of assessment for this factor;
- the EPA objective for this factor;
- a description of what is being affected - why this factor is relevant to the proposal;
- a description of how this factor is being affected by the proposal - the predicted extent of impact;
- a description of where this factor fits into the broader environmental / ecological context (only if relevant - this may not be applicable to all factors);
- a straightforward description or explanation of any relevant standards / regulations / policy;
- environmental evaluation - does the proposal meet the EPA's objective as defined above;
- if not, environmental management proposed to ensure the EPA's objective is met;
- predicted outcome.

The proponent should provide a summary table of the above information for all environmental factors, under the three categories of biophysical, pollution management and social surroundings:

Table 2: Environmental factors and management (example only)

Environ-mental Factor	EPA Objective	Existing environment	Potential impact	Environ-mental management	Predicted outcome
BIOPHYSICAL					
vegetation community types 3b and 20b	Maintain the abundance, species diversity, geographic distribution and productivity of vegetation community types 3b and 20b	Reserve 34587 contains 45 ha of community type 20b and 34 ha of community type 3b	Proposal avoids all areas of community types 20b and 3b	Surrounding area will be fully rehabilitated following construction	Community types 20b and 3b will remain untouched Area surrounding will be revegetated with seed stock of 20b and 3b community types
POLLUTION MANAGEMENT					
Dust	Ensure that the dust levels generated by the proposal do not adversely impact upon welfare and amenity or cause health problems by meeting statutory requirements and acceptable standards	Light industrial area - three other dust producing industries in close vicinity Nearest residential area is 800 metres	Proposal may generate dust on two days of each working week.	Dust Control Plan will be implemented	Dust can be managed to meet EPA's objective
SOCIAL SURROUNDINGS					
Visual amenity	Visual amenity of the area adjacent to the project should not be unduly affected by the proposal	Area already built-up	This proposal will contribute negligibly to the overall visual amenity of the area	Main building will be in 'forest colours' and screening trees will be planted on road	Proposal will blend well with existing visual amenity and the EPA's objective can be met

5.3 Environmental management commitments

Environmental management commitments

The final stage of the Environmental Impact Assessment (EIA) process is reached when the Minister for the Environment issues the Ministerial statement for the project, which is a set of legally enforceable conditions and procedures for the implementation of the project. One of the standard procedures is a requirement for the proponent to implement the commitments which have been made (by the proponent) during the EIA process. It is accepted practice for a consolidated list of the proponent's commitments to be attached to the Minister's statement.

Commitment formatting

1. Commitment components

Commitments which address key environmental factors will be audited by the DEP, together with the environmental conditions. Unless the commitments are framed in a standard format, it may become difficult in practice to implement or audit them. By applying the principles of quality management, a standard format for the commitments has been arrived at. The format ensures that a chain of responsibility is established to facilitate compliance and that redundant, overlapping or non-enforceable commitments are avoided.

The required standard format for all commitments comprises a number of components as follows:

The proponent **(who)** will undertake an action **(what, how, where)** to meet an environmental objective **(why)** to a time frame **(when)**, and on advice of somebody **(to whom**, eg. third party, government agencies such as Department of Conservation and Land Management, Department of Minerals and Energy, Water and Rivers Commission, Shire Council). With regard to 'whom' this need only be included if the expertise of a third party is relevant to implementing the commitment.

It is important for the consolidated list of commitments to be numbered correctly for easy reference in the implementation and auditing stages of the project. These should therefore be sequentially numbered 1, 2, 3, ... without use of subgroups such as 1.1, 1.2 or 2(i) or 2(a), 2(b).

2. Paragraph format

In applying the standard components (who, what, why, how, where, when, to whom) an example of a commitment in paragraph form is as follows:

The proponent will prepare and implement a Dust Control Program which will minimise dust generation on-site and prevent dust emission from construction of the foreshore extension in order to protect the amenity of nearby land users. The Program will be prepared during the design (project planning) phase and will meet EPA dust control criteria (EPA, 1996), on advice of the Shire of Widgiemooltha. The approved Program will be implemented during the construction phase.

However in writing the commitment in paragraph form, a confusing or clumsy sentence structure can result that may be difficult to interpret for future auditing purposes. Also it is difficult to verify that all components have been incorporated into every commitment. A paragraph format is therefore not the preferred format.

3. Tabular format

Due to the limitations of the paragraph format, it is preferable to format a commitment in tabular form. It is recommended that the table column headings be ordered as: 'commitment number', 'topic', 'action', 'objective', 'timing' and 'advice'. However table headings can be re-ordered if necessary.

The example in paragraph form on page 1 can therefore be written in tabular form as per examples 1 and 2 below. Note that the tabular format makes it easier to ensure that no component of the commitment is left out and that each action is recognised as a separate commitment. This format also permits the inclusion of additional clauses or more precise wording of clauses which can be difficult in a sentence structure. It is acceptable for table columns to be re-ordered if necessary. Finally, the tabular format provides an immediate audit framework for use by the proponent and the DEP, enabling efficient administration of environmental approvals.

Examples 1 & 2.

The proponent' is committed to the following:

No.	Topic	Action (What/How/Where)	Objective/s (Why)	Timing (When)	Advice (To whom)
1.	Dust management	Prepare a Dust Control Program for the foreshore construction site which addresses: 1) abc 2) xyz	• Minimise dust during the construction phase • Maintain the amenity of nearby land users • To meet EPA dust control criteria	Pre- construction	Shire
2.	Dust management	Implement the approved Dust Control Program	Achieve the objectives of Commitment 1	Construction	-

Example 3.

No.	Topic	Action	Objective/s	Timing	Advice
3.	Fauna protection	Undertake a trapping program for capturing and relocating the Southern Brown Bandicoots	Minimise impact on Southern Brown Bandicoots	Pre- construction (prior to commencement of ground disturbance)	CALM

Example 4.

No.	Topic	Action	Objective/s	Timing	Advice
4.	Vege-tation	Revegetate disturbed areas with vegetation types indigenous to the area	• To minimise impact on local flora • To achieve the completion criteria stated in CER (Section 5.1.1)	Post-construction (progressively during operations)	Kings Park Board

Example 5.

No	Topic	Objective	Action	Timing	Advice
5.	Groundwater	Minimise impact on groundwater levels, surface water levels and surrounding vegetation	Groundwater drawdown shall not exceed 0.5 m at any boundary of the mine site	Operation	Water and Rivers Commission

Example 6.

No.	Topic	Action	Objective	Timing	Advice
6.	Clean-up	Post-clean up activities will only proceed after demonstrating to (and gaining approval from) the DEP that the site clean-up criteria identified in the 1993 CER have been met	To achieve the soil quality objectives in the Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites, Jan 1992	Post-clean up (On completion of cleanup and prior to commencement of post-cleanup activities)	--

5.4 Public consultation

A description should be provided of the public participation and consultation activities undertaken by the proponent in preparing the environmental review. It should describe the activities undertaken, the dates, the groups/individuals involved and the objectives of the activities. Cross reference should be made with the description of environmental management of the factors which should clearly indicate how community concerns have been addressed. Those concerns which are dealt with outside the EPA process can be noted and referenced.

5.5 Other information

Additional detail and description of the proposal, if provided, should go in a separate section.

Attachment 1

The first page of the proponent's environmental review document must be the following invitation to make a submission, with the parts in square brackets amended to apply to each specific proposal. Its purpose is to explain what submissions are used for and to detail why and how to make a submission.

Invitation to make a submission

The Environmental Protection Authority (EPA) invites people to make a submission on this proposal.

[the proponent] proposes [the rezoning of land and the development of a Marina Complex in the City of Bunbury]. In accordance with the Environmental Protection Act, a [PER] has been prepared which describes this proposal and its likely effects on the environment. The [PER] is available for a public review period of [8] weeks from [**date**] closing on [**date**].

Comments from government agencies and from the public will help the EPA to prepare an assessment report in which it will make recommendations to government.

Why write a submission?

A submission is a way to provide information, express your opinion and put forward your suggested course of action - including any alternative approach. It is useful if you indicate any suggestions you have to improve the proposal.

All submissions received by the EPA will be acknowledged. Submissions will be treated as public documents unless provided and received in confidence subject to the requirements of the Freedom of Information Act, and may be quoted in full or in part in the EPA's report.

Why not join a group?

If you prefer not to write your own comments, it may be worthwhile joining with a group interested in making a submission on similar issues. Joint submissions may help to reduce the workload for an individual or group, as well as increase the pool of ideas and information. If you form a small group (up to 10 people) please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

Developing a submission

You may agree or disagree with, or comment on, the general issues discussed in the [PER] or the specific proposals. It helps if you give reasons for your conclusions, supported by relevant data. You may make an important contribution by suggesting ways to make the proposal more environmentally acceptable.

When making comments on specific elements of the [PER]:

- clearly state your point of view;
- indicate the source of your information or argument if this is applicable;
- suggest recommendations, safeguards or alternatives.

Points to keep in mind

By keeping the following points in mind, you will make it easier for your submission to be analysed:

- attempt to list points so that issues raised are clear. A summary of your submission is helpful;
- refer each point to the appropriate section, chapter or recommendation in the [PER];
- if you discuss different sections of the [PER], keep them distinct and separate, so there is no confusion as to which section you are considering;
- attach any factual information you may wish to provide and give details of the source. Make sure your information is accurate.

Remember to include:

- your name;
- address;
- date; and
- whether you want your submission to be confidential.

The closing date for submissions is: [**date**]

Submissions should be addressed to:

The Environmental Protection Authority
Westralia Square
141 St George's Terrace
PERTH WA 6000

Attention: [**Project Officer name**]

Attachment 2

Advertising the environmental review

The proponent is responsible for advertising the release and arranging the availability of the environmental review document in accordance with the following guidelines:

Format and content

The format and content of the advertisement should be approved by the DEP before appearing in the media. For joint State-Commonwealth assessments, the Commonwealth also has to approve the advertisement. The advertisement should be consistent with the attached example.

Note that the DEP officer's name should appear in the advertisement.

Size

The size of the advertisement should be two newspaper columns (about 10 cm) wide by about 14 cm long. Dimensions less than these would be difficult to read.

Location

The approved advertisement should, for CER's, appear in the news section of the main local newspaper and, for PER's and ERMP's, appear in the news section of the main daily paper's ("The West Australian") Saturday edition, and in the news section of the main local paper at the commencement of the public review period and again two weeks prior to the closure of the public review period.

Timing

Within the guidelines already given, it is the proponent's prerogative to set the time of release, although the DEP should be informed. The advertisement should not go out before the report is actually available, or the review period may need to be extended.

Example of the newspaper advertisement

Proponent Name

Consultative/Public/ Environmental Review/and Management Program

TITLE OF PROPOSAL

(Public Review Period: **[date]** to **[date]**)

Proponent is planning to brief description of proposal.

A Consultative Environmental Review (CER)/Public Environmental Review (PER)/Environmental Review and Management Program (ERMP) has been prepared by the company to examine the environmental effects associated with the proposed development, in accordance with Western Australian Government procedures. The CER/PER/ERMP describes the proposal, examines the likely environmental effects and the proposed environmental management procedures.

Proponent has prepared a project summary which is available free of charge from the company's office address.

Copies of the CER/PER/ERMP may be purchased for $5/$10 from:

Company Name
Street
Suburb/Town WA Postcode
Telephone: (08) 9xxx xxxx

Copies of the complete CER/PER/ERMP will be available for examination at:

- Department of Environmental Protection
  Library Information Centre
  8th Floor, Westralia Square
  141 St Georges Terrace
  PERTH WA 6000
- Department of Environmental Protection
  Regional Office - if appropriate
- Relevant local libraries

Submissions on this proposal are invited by [**closing date**]. Please address your submission to:

Chairman
Environmental Protection Authority
8th Floor, Westralia Square
141 St Georges Terrace
PERTH WA 6000
Attention: [**Project Officer name**]

If you have any questions on how to make a submission, please ring the project officer, [**Project Officer name**], on (08) 9222 7xxx.

APPENDIX 2
BUNBURY WWTP REGION
LIST OF POTENTIAL TERRESTRIAL FAUNA

REPTILE SPECIES WHICH ARE EXPECTED TO OCCUR IN THE BUSSELTON - CAVES ROAD PROJECT AREA.

Fauna Habitats:		W	MD	H	DSF
MYOBATRACHIDAE					
Crinia georgiana	Quacking Frog	+			
Crinia glauerti	Glauert's Froglet	+			
Crinia insignifera	Squelching Froglet	+			
Heleioporus eyrei	Moaning Frog	+		+	
Heleioporus psammophilus	Sand Frog	+		+	
Limnodynastes dorsalis	Banjo Frog	+			
Myobatrachus gouldii	Turtle Frog	+			
HYLIDAE					
Litoria adelaidensis	Slender Tree Frog	+			
Litoria moorei	Bell Frog	+			
GEKKONIDAE					
Christinus marmoratus	Marbled Gecko			+	+
Diplodactylus polyophthalmus				+	+
Diplodactylus spinigerus	Wester Spiny-tailed Gecko			+	+
Gehyr variegata	Tree Dtella				+

Fauna Habitats:		W	MD	H	DSF	
PYGOPIDIDAE						
Aprasia repens	Fry's worm lizard			+	+	
Delma fraseri					+	
Lialis burtonis	Burton's Snake Lizard		+	+	+	
Pygopus lepidopodus	Common Scaly-foot		+	+	+	
AGAMIDAE						
Pogona minima	Western Bearded Dragon				+	+
VARANIDAE						
Varanus gouldii	Gould's Monitor		+	+	+	+
Varanus rosenbergi	Rosenberg's Monitor	+	+	+	+	
SCINCIDAE						
Cryptoblepharus plagiocephalus	Fence Skink			+	+	
Ctenotus fallens			+	+		
Ctenotus gemmula				+	+	
Ctenotus impar					+	+
Ctenotus labillardieri					+	
Cyclodomorphus branchialus				+	+	
Egernia napoleonis				+	+	
Egernia pulchra				+	+	+
Glaphyromorphus gracilipes				+	+	
Hemiergis peronii				+	+	
Hemiergis quadrilineatum				+		
Lerista distinguenda				+	+	

Fauna Habitats:		W	MD	H	DSF
Lerista elegans				+	+
Lerista lineopunctulata				+	
Menetia greyii	Grey's Skink			+	+
Morethia lineoocellata				+	+
Morethia obscura				+	+
Pseudemoia trilineata		+			
Trachydosaurus rugosus	Shingle-back	+	+	+	+
TYPHLOPIDAE					
Rhamphotyphlops australis					+
Rhamphotyphlops pinguis					+
BOIDAE					
Morelia spilota	Carpet Python				+
ELAPIDAE					
Echiopsis curta	Bardick				+
Notechis ater	Tiger Snake	+	+	+	+
Pseudonaja affinis	Dugite			+	+
Rhinoplocephalus bicolor	Square-nosed Snake			+	
Simoselaps bertholdi	Jan's Banded Snake		+	+	+
Simoselaps bimaculatus	Black-naped Snake			+	
Simoselaps semifasculatus	Half-girdled Snake		+	+	
Suta gouldii	Black-headed Snake			+	+
Suta nigriceps	Black-backed Snake		+		

TABLE 2

BIRDS OF THE TUART FOREST & COASTAL DUNES

Bird Species	Vegetation Type TP	OTP	CD
Whistling Kite	X	X	X
Wedge-tailed Eagle			
Little Eagle		X	X
Australian Hobby			X
Brown Falcon			X
Common Bronzewing	X	X	X
White-tailed Black Cockatoo	X	X	
Purple-crowned Lorikeet	X	X	
Red-capped Parrot	X	X	X
Western Rosella	X	X	X
Port Lincoln Ringneck	X	X	X
Elegant Parrot	X		X
Pallid Cuckoo			
Fan-tailed Cuckoo	X	X	
Shinning Bronze Cuckoo	X	X	
Laughing Kookaburra	X	X	
Sacred Kingfisher			
Rainbow Bee-eater	X	X	
Welcome Swallow			X
Tree Martin		X	X
Richard's Pipit			X
Black-faced Cuckoo-shrike	X	X	X
Scarlet Robin	X	X	
Golden Whistler	X	X	
Rufous Whistler	X	X	
Grey Fantail	X	X	X
Willy Wagtail			X
Splendid Fairy-wren	X	X	X
Southern Emu-wren			X
White-browed Scrubwren			X
Weebill	X	X	X
Western Gerygone	X	X	X
Inland Thornbill	X	X	X
Yellow-rumped Thornbill	X	X	
Varied Sitella	X	X	
Red Wattlebird	X	X	X
Singing Honeyeater			X
White-naped Honeyeater			

TABLE 2

(Continued)

Bird Species	Vegetation Type TP	OTP	CD
Brown Honeyeater	X	X	X
New Holland Honeyeater			X
Western Spinebill			X
Spotted Pardalote	X	X	
Striated Pardalote	X	X	
Silvereye	X	X	X
Black-faced Wood Swallow	X		
Grey Butcherbird	X	X	
Australian Magpie	X	X	
Australian Raven	X	X	
TOTAL NUMBER OF SPECIES	32	32	27

KEY:

TP = Tuart/Peppermint Forest
OTP = Open Peppermint Forest
CD = Coastal Dunes

Compiled from McNee (1987)

TABLE 4

POTENTIAL MAMMALS OF THE USHER-STRATHAM AREA

Southern Brown Bandicoot	Probable near wetlands
Western Ringtail Possum	Tuart/Peppermint Forest
Brush-tailed Possum	Forest
Quokka	Possible near Muddy Lake
Black-gloved Wallaby	Forest
Western Grey Kangaroo	Forest and pasture
Lesser Long-eared Bat	All habitats
Gould's Wattled Bat	All habitats
King River Eptesicus	Forest
Bush Rat	Coastal Dunes

APPENDIX 3
BUNBURY WWTP REGION
LIST OF POTENTIAL MARINE FAUNA

Appendix 3 Bunbury WWTP region—List of potential marine fauna

FAMILY	SCIENTIFIC NAME	COMMON NAME
HETERODONTIDAE	*Heterodontus portusjacksoni*	Port Jackson Shark
ORECTOLOBIDAE	*Sutorectus tentaculatus*	Cobbler Carpet Shark
TRIAKIDAE	*Furgaleus ventralis*	Whiskery Shark
	Mustelus antarcticus	Gummy Shark
CARCHARHINIDAE	*Carcharhinus obscurus*	Dusky Shark
SPHYNIDAE	*Sphyrna lewini*	Hammerhead Shark
RHINOBATIDAE	*Aptychotremata vincentiana*	Southern Shovelnose Ray
	Trygonorhina fasciata	Southern Fiddler
DASYATIDAE	*Dasyatis thetides*	Black Stingray
MYLIOBATIDAE	*Myliobatis australis*	Eagle Ray
PLOTOSIDAE	*Cnidoglanis macrocephalus*	Cobbler
MORIDAE	*Lotella fuliginosa*	Beardie
PATAECIDAE	*Aetapcus maculatus*	Warty Prow Fish
PLESIOPIDAE	*Paraplesiops meleagris*	Blue Devil
TERAPONIDAE	*Pelates sexlineatus*	Striped Trumpeter
APOGONIDAE	*Apogon ruppellii*	Gobbleguts
SILLAGINIDAE	*Sillago bassensis*	Silver Whiting
CARANGIDAE	*Caranx georgianus*	Skipjack Trevally
	Seriola hippos	Samson Fish
GERRIDAE	*Gerres subfasciatus*	Silver Belly
	Parequula melbournensis	Silver Belly
PEMPHERIDAE	*Pempheris klunzingeri*	Rough Bullseye
	Pempheris multiradiata	Common Bullseye
SCORPIDIDAE	*Scorpis aequipinnis*	Sea Sweep
	Scorpis georgianus	Banded Sweep
	Vinculum sexfasciatum	Moonliqhter
CHAETQDONTIDAE	*Chelmonops truncatus*	Truncate Coralfish
POMACENTRIDAE	*Parma victoriae*	
CHIRONEMIDAE	*Threpterius maculosus*	Silver Spot
CHEILODACTYLIDAE	*Dactylophora nigricans*	Dusky Morwong
	Nemadactylus valenciennesi	Blue Morwong
SPHYRAENIDAE	*Sphyraena obtusata*	Striped Sea Pike
LABRIDAE	*Austrolabrus maculatus*	Black-spotted Wrasse
	Bodianus frenchii	Fox Fish
	Ophthalmolepis lineolatus	Maori Wrasse
	Pseudolabrus parilus	Brown-spotted Wrasse
ODACIDAE	*Olisthops cyanomelas*	Herring Cale
MONACANTHIDAE	*Meuschinia freycineti*	Six-spined Leatherjacket
	Penicipelta vittiger	Toothbrush Leatherjacket
	Scobinichthys granulatus	Rough Leatherjacket
OSTRACIONTIDAE	*Aracana aurita*	Shaw's Cowfish