Halpern
Glick
Maunsell

Department of Commerce and Trade

Breakwater Extension: Northern Harbour Precinct, Jervoise Bay

Consultative Environmental Review

October 1996

Invitation

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

In accordance with the Environmental Protection Act (1986), a Consultative Environmental Review (CER) has been prepared which describes the proposal and its likely effects on the environment. The CER is available for a public review period of 2 weeks from Monday 14 October 1996 and closing on Monday 28 October 1996.

Comments from the public and government agencies will assist the EPA to prepare an assessment report in which it will make recommendations to the 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 specifically marked confidential, and may be quoted in full or in part in each report.

Why Not Join a Group?

If you prefer not to write your own comments, it may be worthwhile joining with a group or other groups 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 CER 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 environmentally more acceptable.

When making comments on specific proposals in the CER:

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

Remember to include:

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

The closing date for submission is Monday 28 October 1996.

Submissions should be addressed to:

The Chairman
Environmental Protection Authority
9th Floor, Westralia Square
141 St George's Terrace
PERTH WA 6000

Attention: Mr Kim Martin

Consultative Environmental Review Breakwater Extension: Northern Harbour Precinct, Jervoise Bay

Contents

Appendices

Figures

Tables

1.0 Executive Summary

As a result of the growth and international success of marine related industries within the Northern Harbour Precinct at the Jervoise Bay/Henderson Estate, it is an urgent requirement that infrastructure be upgraded to maintain the competitiveness of these industries and promote their expansion. The Western Australian Government has recognised these needs and is committed to fostering the shipbuilding activity and its growth in a planned and efficient manner.

The Precinct currently supports a range of shipbuilding industries (predominantly the construction of aluminium vessels). An infrastructure planning study of the Jervoise Bay/Henderson Estate (Halpern Glick Maunsell, 1994) identified the need for extension of the existing breakwaters in the Northern Harbour Precinct to provide greater wave protection for the industries located on the foreshore, facilitate their expansion and to provide for the introduction of similar industries along the northern foreshore. The extension will be of limestone rubble mound construction as previously used to construct the existing breakwaters.

The preferred layout of the breakwater extension has been developed on the basis of engineering, environmental and operational constraints. The preferred layout offers the greatest wave protection, the safest navigability for both industrial and recreational craft and operational flexibility.

The potential environmental and social impacts of the development are:

- seagrass loss. The breakwater will be built over an area which has a seagrass covering of 0 - 5%. The breakwater will result in a minor and unavoidable loss of seagrass consisting of patchy *Posidonia australis* with individuals of *Posidonia sinuosa, Halophila ovalis* and *Heterozostera tasmanica* also recorded. The area is considered to be of negligible conservation significance;

- water circulation. The breakwater is calculated to increase the retention time of water within the harbour from 2.4 days, computed for the existing configuration, to 3 to 5 days when the extension is completed;

- water quality. The increase in retention time is not expected to have a significant effect on the water quality within the harbour. Existing data suggest that the water quality within the harbour is dominated by the quality of the water in Cockburn Sound. Modelling demonstrates that this is unlikely to change with construction of the extension. The primary source of nutrients to the harbour, other than Cockburn Sound, is via local groundwater inflows and sediment release. The breakwater and associated construction activity will not result in additional nutrient loads to the harbour;

- breakwater construction. A localised and temporary plume will result during construction and this is not expected to have a significant impact on local marine flora. Trucking operations associated with construction will be performed in a manner acceptable to the City of Cockburn;

- coastal stability. The extension of the breakwater will assist in stabilising the foreshore within the Northern Harbour Precinct and will not have a significant impact on coastal processes along the adjacent coastline;

- public access. Public access for recreational fishing from the Harbour Precinct will be maintained; and

- maritime archaeological sites. No maritime archaeological sites will be impacted by the breakwater construction.

It is believed that the potential impacts are manageable and will not have a significant impact on the ecology of Cockburn Sound. A programme of water quality monitoring is proposed, with the results to be reported to the relevant regulatory authorities for review. The key factors originating from the proposal are summarised in Table 1.1.

Table 1.1
Summary of Key Factors

Factor	EPA's Objective	Proposal Characteristics	Impact	Comment on Impact	Proposed Management of Environmental Factor and Proponent Commitment
Biophysical issues					
Locally significant marine fauna and habitat	To ensure that, where possible, impacts upon locally significant marine fauna and habitat are avoided.	Involves placement of limestone core and armour material on the seabed.	Coverage of 2.8 ha of seabed. Alteration of local wave heights.	Coverage is unavoidable and will have no impact on significant fauna. Alteration of local wave climate will have no significant impact on habitat.	No commitment required
Marine habitat including seagrass	To ensure the ecological function of Cockburn Sound is maintained.	Involves placement of limestone core and armour material on the seabed.	Coverage of 2.8 ha of seabed with 0 - 5% seagrass cover.	Coverage is unavoidable and will have no impact on important seagrass habitats.	Unlikely to require ongoing management. No commitment required
Coastal stability/ sediment dynamics	To ensure that the proposed development does not have a significant impact on existing coastal processes.	Alters local wave dynamics and wave energy within the harbour.	Will reduce sediment movements within the harbour. Will not have a significant impact on local coastal processes.	Will benefit coastal stability within the harbour and will not alter regional sediment transport patterns.	Unlikely to require ongoing management. No commitment required
Pollution issues					
Water quality	To meet requirements of the EPA's Environmental Water Quality Objectives.	The extension will alter the flushing characteristics of the harbour.	There will be an increase in the residence time of water within the harbour of 0.5 to 2.5 days.	Water quality within the harbour will continue to be dominated by the water quality in Cockburn Sound.	Monitoring of chlorophyll *a*, light attenuation and nutrients within the harbour and reporting of results to the DEP. Key assessment factor to be managed under Part IV of the Environmental Protection Act, 1986. Commitment 4.

Turbidity	To meet EPA water quality criteria.	Involves placement of limestone rubble.	Increase in turbidity adjacent to the breakwater	This will be minor, intermittent and temporary.	Not required.
Noise and Vibration	To protect the amenity of nearby residents from noise and vibration impacts resulting from activities associated with the proposal by ensuring that noise and vibration levels meet statutory requirements and acceptable standards.	Construction activities may generate noise and vibration.	Minor and temporary.	Management required.	Managed under Part V of the Environmental Protection Act, 1986, and in accordance with the existing and proposed Noise Regulations. Commitment 2.
Dust	To protect the surrounding land uses such that dust emissions will not adversely impact upon their welfare and amenity or cause health problems.	Potential for dust generation during construction.	Minor and temporary.	Management required.	Managed under Part V of the Environmental Protection Act, 1986, and in accordance with Draft EPA Dust Control Guidelines. Commitment 1.
Social issues					
Heritage (indigenous and non indigenous cultures)	To comply with statutory requirements in relation to cultural or historic significance.	Construction will result in loss of seabed.	Minor and localised.	No heritage sites will be impacted.	Managed under the Heritage Council of WA listing. No commitment required.
Traffic	To ensure that the increase in traffic activities resulting from the construction and operation of the proposal does not adversely impact on the safety and amenity of local residents.	Trucking and construction activity is likely to occur over a 40 week period. Increase in community use once completed.	Increased numbers of trucks and community use on gazetted roads.	Trucking will occur during daylight hours.	Any noise, vibration or dust to be managed under Part V of the Environmental Protection Act, 1986. Traffic impacts from construction work to be managed through hours of operation complying with the requirements of the Local Authority and development and implementation of a management plan by the proponent. Commitment 3.

2.0 Introduction

2.1 Background

Jervoise Bay is located approximately 10 km south of Fremantle at the northern end of Cockburn Sound, immediately south of Woodman Point. The region which is covered by this Consultative Environmental Review (CER) is the Northern Harbour Precinct (Figure 2.1) which lies in the north-east corner of Jervoise Bay to the east of the Medina Channel.

Over the last 10 years marine related industries based in the Northern Harbour Precinct have developed into international standard, cost competitive industries serving both domestic and international markets. Growth in the scale and variety of these activities has arisen from growing markets in shipbuilding, ship repair and maintenance. The activities have developed new vessel technologies, new materials and more sophisticated control technologies. These industries successfully compete on international markets as a result of improved industrial relations and the concerted effort by all sectors to incorporate quality based systems.

The first section of the Jervoise Bay Northern Harbour breakwater was constructed in 1984/85. This was then extended to its present length in 1986. The southern spur protecting the AMS shiplifter was completed in 1990. All of these phases of breakwater construction proceeded on the basis of informal assessment by the Environmental Protection Authority (EPA). Recent planning and development studies of the Jervoise Bay/Henderson Estate (Halpern Glick Maunsell, 1994) recommended extension to the existing breakwaters to provide full wave protection for the operations within the Northern Harbour Precinct. This CER details the location and layout of the proposed breakwater extension.

2.2 The Proponent

The proponent for this development is the WA Department of Commerce and Trade. All correspondence pertaining to the CER should be addressed to:

Halpern Glick Maunsell Pty Ltd
PO Box 524
West Perth WA 6872

2.3 Timing

The proponent wishes to commence construction of the breakwater extension immediately. It is estimated that the project will take 40 weeks to completion from commencement of construction.

2.4 Relevant Legislation and the Approvals Process

The proposal to construct the Northern Harbour Breakwater extension is subject to the requirements of the *Environmental Protection* Act 1986, and will require formal environmental assessment and approval by the West Australian Government in accordance with Part IV of that Act (Environmental Impact Assessment).

This document has been prepared in accordance with the guidelines issued by the EPA (Appendix A). It is being released for public review for a period of 2 weeks. During this period government agencies, private organisations and the public are invited to make submissions to the EPA regarding the proposal. The EPA will evaluate the CER, the submissions received and the proponent's response to those submissions, and make recommendations to the Minister for the Environment on the acceptability of the proposal and the conditions that should apply if the development is to proceed. The public may appeal the EPA Report and Recommendations to the Minister. Only after the Minister has set Environmental Conditions may other authorities issue approval allowing the development to proceed.

2.5 Community Consultation

The following organisations have been consulted during preparation of the CER:

- Department of Environmental Protection;
- City of Cockburn;
- Water Corporation;
- Fremantle Port Authority;
- Department of Transport;
- Conservation Council of WA;
- Representatives of the Cockburn Sound Conservation Committee;
- Coastal Waters Alliance;
- Coastal Community Network;
- Cockburn Power Boat Association; and
- Representatives of the shipbuilders operating within the Northern Harbour Precinct.

The CER has addressed the key issues raised by these organisations in respect of potential environmental and operational impacts.

2.6 Structure of the CER

The purpose of the CER is to describe the proposed development, identify the key environmental issues, assess the potential for impacts and detail strategies for the management of such impacts.

Section 3.0 of the CER presents the justification for the proposed breakwater extension, the alternatives considered and the proposal's relationship to other developments in the area. Section 4.0 details the potential environmental impacts and their management. Section 5.0 details the potential socio-economic impacts and their management. Section 6.0 describes the proposed environmental monitoring and management programmes and includes a list of the proponent's commitments to minimise the potential for impact arising from the development.

3.0 The Proposal

3.1 Justification

The Northern Harbour Precinct at Jervoise Bay presently supports a range of shipbuilding related industries with the construction of large aluminium vessels being the predominant industry. It is widely acknowledged that the aluminium shipbuilding industry in WA is a world leader. As a result, many of the ships built are destined for international clients. The industry has enjoyed strong growth over the past decade and is expected to continue to expand.

The proposed breakwater extension will play a vital role in the ability of the industry to safely meet delivery schedules for projects which are already large and complicated (contracts involving large high speed ferry construction are of the order of $50 million each).

Without the breakwater extension, vessels are at risk due to exposure to the west-northwest ocean swells. In 1995, the storms were so severe that the precinct foreshore was eroded and incomplete vessels had to be moved at short notice to HMAS Stirling. Storms in 1996 have been more sustained causing disruptions to delivery schedules.

At the urgent request of the Western Australian Shipbuilders Association, the WA State Cabinet has approved the bringing forward of funds to this financial year (1996/97) for the construction of the breakwater extension before the onset of winter 1997.

Without the extension it is possible that industry in Jervoise Bay will become less competitive with emerging suppliers in other regions due to problems foreseen with delivery, reliability and safety. Contracts to build larger vessels will be endangered due to the increased risks associated with swell penetration during the longer sea trial times.

All industries in the precinct will benefit from increased operability of berthing facilities as a result of the breakwater extension. Vessel launch, retrieval and maintenance availability will be improved, costs will decrease and worker safety enhanced. Expansion of the shipbuilding industry into the northern section of the harbour will also become viable.

The breakwater will also provide greater protection for leisure boat launching at the Woodman Point launching ramp.

3.2 Alternatives Considered

The Northern Harbour Precinct is currently bounded by two breakwaters, one extending from west of the Cockburn Power Boat Association's launching ramp facility on Woodman Point and the other protecting the southern section of the Precinct (Figure 3.1).

Two options for the breakwater extension were considered:

(a) the preferred breakwater extension (Figure 3.2). This is an extension to the existing breakwater protecting the Cockburn Power Boat Association's launching ramp facility; and

(b) an alternative breakwater extension extending from the existing southern breakwater (Figure 3.3).

This CER demonstrates that there is little difference in the potential environmental impact of either option. The preferred option has been selected on the basis of providing greatest wave protection, safest navigability and operational flexibility.

The layout of the preferred breakwater extension shown in Figure 3.2 provides greatest protection from the westerly sea and swell conditions that are the main cause of operational problems within the Northern Harbour Precinct. Whilst the entrance is open to south to south-westerly seas, these are short period wave conditions which will dissipate rapidly within the protected harbour and will not result in excessive moored vessel motions. In any case, the preferred layout will reduce sea wave penetration into the Northern Harbour compared to the current breakwater arrangement.

The preferred layout also has navigational advantages over the alternate north facing entrance as shown in Figure 3.3. Vessels exiting the preferred layout will generally head into the prevailing south-west wind and seas whereas vessels exiting the alternate north facing entrance would often be beam-on to the prevailing seas. The preferred layout also provides a safer, more direct entry/exit for all vessels reducing the potential for conflict between industrial and recreational craft.

The effective entrance channel width of 125 m at mean sea level is significantly greater than the mean sea level widths at Rous Head Harbour (70 m), Hillarys Boat Harbour (85 m), Fremantle Fishing Boat Harbour (90 m), Challenger Harbour (60 m), Geraldton Harbour (60 m) and Yanchep Marina (50 m). This is considered adequate for the safe navigation of large vessels and for the accommodation of both industrial and recreational boat traffic utilising the harbour. A designated small boat lane is not considered necessary given the relatively infrequent movement of large vessels although a maximum boat speed of 8 knots is recommended within the harbour entrance.

3.3 The Proposal in Relation to Other Developments in Jervoise Bay/Henderson Estate

Industries currently operating within the Northern Harbour Precinct are focused on shipbuilding, with a particular emphasis on aluminium vessel construction. Extension of the Northern Harbour breakwater as proposed in this CER will facilitate expansion of this existing industry. Development of a Southern Harbour Precinct has also been proposed (Halpern Glick Maunsell, 1994) to attract and foster different marine related industries, both in type and scale of operations to those operating within the Northern Harbour. Planning of the Southern Harbour Precinct is still at a conceptual stage with market needs yet to be confirmed. Extension of the Northern Harbour breakwater is not linked to the planning of the Southern Harbour Precinct and it is therefore appropriate to separately address the breakwater extension proposed in this CER.

3.4 Summary of Scope of Works

The works described in this CER comprise construction of a 700 m long rubble-mound limestone breakwater. A navigation aid will be installed at the seaward end of the breakwater extension. The armour will be sourced from local quarries as was done for previous breakwaters constructed in Cockburn Sound. Construction access will be via existing roads. These roads will be appropriately maintained and signposted during construction. No dredging will be required.

4.0 Potential Environmental Impacts and Their Management

4.1 Introduction

Figure 4.1 presents an aerial photograph of the precinct with an overlay showing the location of the proposed breakwater extension. It is evident that all works will be completed offshore with no direct impacts on the terrestrial environment. This section addresses the potential environmental impacts of the breakwater extension on the marine environment and the likely significance of such impact. These include the effects on the benthic flora and fauna, coastal stability and sediment dynamics, hydrodynamic exchange between the harbour and the ocean, water quality within the harbour and the potential effects of increased boat building activity in terms of toxicants released to the harbour precinct. Where appropriate, monitoring and management strategies have been developed as each issue is addressed.

4.2 Benthic Communities

Seagrass communities are considered to be one of the most important components of the temperate coastal ecosystems of Western Australia. Their ecological significance lies in that they are often the dominant primary producers of these regions, they provide habitat, food and nursery areas for marine animals, and they stabilise sediments and therefore reduce the turbidity of coastal waters.

The marginal sills of Cockburn Sound were once covered with extensive seagrass meadows, but since the mid 1950s the seagrass beds have largely disappeared along the eastern margin of the Sound. Catastrophic loss of seagrass meadows during the 1960s and 1970s has been attributed to extensive algal blooms resulting from nutrient-rich industrial wastes discharged into Cockburn Sound (Cambridge and McComb, 1984).

The most recent mapping of seagrasses within Jervoise Bay was completed in 1991 (Le Provost Environmental Consultants, 1991). Mapping, based primarily on aerial photographs from 1954 to 1978 but without verification by underwater inspection, showed that there were no seagrass meadows within the bay.

Halpern Glick Maunsell undertook an underwater survey within the Northern Harbour Precinct on 14 May 1996 in order to confirm the existence and extent of remaining seagrass communities in the vicinity of the proposed breakwater construction. The results of this survey are summarised below, together with an assessment of other benthic communities.

4.2.1 Seagrass Communities

Methodology

The methodology for the seagrass survey consisted of an initial review of aerial photographs of the area taken over the last four decades followed by underwater inspection by divers. The aerial photography yielded little information on the potential distribution of seagrass within the project area as none of the photographs had sufficient penetration for any patterns of distribution to be discerned.

A series of 50 m transects were then plotted at 200 m intervals along the length of the two breakwater options under consideration (see Figures 3.2, 3.3 and 4.2). The survey strategy consisted of documenting transects A1, A3, A5, B1 and B4, and then refining the resultant mapping by surveying the remaining transects as warranted by the initial observations.

The field survey was carried out over the defined transects using a Global Positioning System (GPS) unit and taking bearings on existing landmarks to locate the beginnings of transects. Two divers swam each transect, one recording information on the benthic community present while the other maintained the correct bearing by means of an underwater compass.

Communities Present

Turbidity in the waters of the project area was very high at the time of the survey. Conditions were calm and relatively still, yet the sediment load was still high compared to similar embayments along the coast. This possibly accounts for the poor penetration of the historical aerial photography.

No seagrass meadows were observed on any of the transects surveyed. The occurrence of seagrass was restricted to scattered individual plants at very low percentage cover (0-5%) and there were extensive stretches of sediment bare of any seagrass. One transect (B2) recorded no seagrass at all. There was no evidence of viable rhizome material in sediment investigated, indicating that the seagrass community has been at its current sparse density for a significant period of time.

Four species of seagrass were recorded from within the study area. The most common was *Posidonia australis* but the occurrence of even this species was restricted to a scatter of occasional, individual plants. *Posidonia sinuosa* was recorded as isolated single plants from three of the transects and single occurrences of *Halophila ovalis* and *Heterozostera tasmanica* were recorded. In all cases the seagrasses present were in poor condition, carrying a moderate to high load of epiphytic growth which, in combination with the high sediment load in the water, accounted for their level of debilitation.

4.2.2. Benthic Invertebrate Communities

The invertebrate communities consisted almost entirely of scattered sessile invertebrates including Poriferans (sponges), Cnidarians (Hydroids), Anthozoans (Anemones)), and occasional colonial Ascidians (Sea Squirts). Species diversity within each of these groups appeared to be very low, with the same species being repeatedly recorded along survey transects. It is likely that only a small subset of the locally occurring species in each group can persist in the turbid conditions present in the project area.

There was little evidence of the occurrence of any larger Malacostracan invertebrates such as Prawns and Crabs in the study area and it is unlikely that the area has any significant habitat function for such larger species. The lack of seagrass meadows in the area also means that it does not act as an important nursery habitat resource for juveniles of these species.

4.2.3 Conservation Significance of Marine Communities

On the basis of the field survey results, and in comparison to other documented seagrass communities in adjacent areas of Cockburn Sound, the study area has low conservation value for seagrass. There are several examples in Perth's coastal waters where extensive meadows of seagrass are present at far greater density than the scattered individuals present in the study area (see Table 4.1).

Table 4.1
Comparison of seagrass recorded from the project area with that recorded from other areas in Perth's coastal waters

Study Area	Meadow Area (ha)	No. of species	Source
Jervoise Bay	0	4	This study
Success Bank	1,520	8	LeProvost, 1991
Rottnest Island	630	9	Lukatelich, et al, 1987
Parmelia Bank	940	9	Hillman, 1986

The observations from the project area confirm the results of other seagrass mapping exercises in Cockburn Sound, which show no significant seagrass in the Jervoise Bay northern harbour area (Hillman, 1986; Lukatelich et al., 1987; Paling, pers. comm., 1996).

In addition to being low in density, the seagrass community recorded in the study area is low in species diversity in comparison to other areas (see Table 4.1). High sediment load and high epiphyte load on the plants has resulted in remaining seagrass being in poor condition and degraded in nature. Transects recorded from healthy seagrass meadows typically record dominant species and a variety of co-dominant and understorey species in dense growth from within the same transect. In the study area, there was no such structural species diversity and two of the four species were recorded as individual occurrences only.

The breakwater extension will cover a linear strip of seabed some 700 m in length and 40 m in width. The direct environmental impact on benthic marine communities is not considered to be significant. There will be a short term indirect impact of a minor turbidity plume during construction, however, previous construction monitoring has shown that these turbidity plumes are highly localised and temporary with no long term impact on either local or regional benthic communities.

4.3 Physical Processes

4.3.1 Harbour Flushing

Flushing of the Northern Harbour in both its existing form and the proposed configuration has been calculated using the techniques described in Lewis and Imberger (1988), where flushing is defined as the time for complete harbour water volume replacement based on mean flows. Because both the proposed and alternative configuration of the breakwater extension have very similar enclosed areas and volumes, the flushing times will be similar for both extension options.

The principal mechanisms contributing to harbour flushing are;

- astronomical tides;
- barometric tides;
- wind mixing (based on annual mean wind speed); and
- gravitational flows (computed from estimates of annual average groundwater influx).

The flushing time due solely to astronomical tides for the proposed harbour extension is computed to be 20.6 days based on a tidal range of 0.4 m and a mean harbour depth of 7.35 m. This compares with a time of 21.3 days for the existing harbour based on a mean depth of 7.61 m (which is slightly deeper than the proposed new embayment) and the same tidal range. The flushing time due solely to barometric tides for the proposed extension and the existing harbour is approximately 100 days. This is based on an annual average barometric tidal return period of 5 days with a range of 0.2 m.

The flushing time due solely to shear dispersion caused by winds acting over the harbour water surface is similar for the existing and proposed harbour configurations as the typical internal horizontal dimension (measured to the harbour entrance) is approximately 500 m for both configurations. This mechanism gives a flushing time of 5.7 days.

The overall harbour flushing time due to the combined action of astronomical and barometric tides and wind shear is computed to be less than 5 days for both the existing and proposed harbour configurations. Previous studies of harbours along the Perth coastline have shown that this flushing is significantly enhanced by gravitational flows. Computations of the flushing time based on the work of Lewis and Imberger (1988) and Schwartz (1988) give a flushing time of less than 3 days for both the existing and the proposed harbour when gravitational effects are included. This is based on groundwater inflow of 2.5 m^3/m of impounded shoreline/day and an average sea temperature of 20 °C. This value is similar to results given in other studies in the region (eg. Lewis and Imberger (1988); Schwartz (1988)). Groundwater flows are not expected to vary significantly between seasons in the Woodman Point region (Appleyard 1994) and as a consequence gravitational flushing will be a dominant mechanism in exchanges between the harbour and the sound throughout the year.

Previously, Halpern Glick (1985) calculated a flushing time for the existing harbour of 2.4 days based on a two-dimensional depth averaged circulation model. Whilst the method of determination was different, the result of the above assessment suggests that the flushing time of the proposed harbour will not be significantly different to the flushing time of the existing layout. Thus, an appropriate time scale for flushing of the proposed configuration is within the range of 3 - 5 days.

4.3.2 Coastal Sediment Transport

Discussions with industry users operating within the Northern Harbour Precinct indicate that there is seasonal movement of sediment from north to south within the Northern Harbour. This is consistent with the refraction/diffraction of wave energy in the lee of the existing main breakwater such that the incident wave energy on the foreshore decreases from north to south. Extension of the existing breakwater will significantly reduce the wave energy incident on the foreshore within the harbour with a consequent stabilisation of longshore sediment migration within the harbour.

Extension of the existing breakwater will have minimal impact on sedimentation processes external to the harbour. There is presently a minor accumulation of sand to the west of the Cockburn Power Boat Association's breakwater on Woodman Point as a result of easterly transport along Woodman Point under westerly and south-westerly sea and swell conditions. Extension of this breakwater will allow increased sediment accumulation in this pocket and prevent sediment accretion in the Northern Harbour. This will not result in any significant environmental impact.

The breakwater extension will not have any impact on coastal processes on, or adjacent to, Woodman Point, as the incident nearshore wave climate on the Point will be unchanged as a result of the breakwater extension. There will be some increase in reflected wave energy immediately west of the new breakwater. However, the water in the these areas is approximately 10m deep and consequently there will be minimal impact on the seabed and associated habitats.

4.4 Water Quality

The Environmental Protection Agency believes that the most relevant environmental factor to be addressed is that of water quality within the harbour (Appendix A). To satisfy the EPA guidelines, this section of the report addresses the impact on water quality within the harbour, as a result of enclosing the harbour, in relation to:

- nutrient status and clarity (sections 4.4.1 and 4.4.2);
- impact of contaminated groundwater flow into the harbour (section 4.4.2); and
- potential impact of the Water Corporation emergency discharge outfall (section 4.4.3).

The water quality in the Harbour will potentially be affected by the increased hydraulic residence times, the inflow of nutrient enriched groundwater and increased boat building activity. The effects of increased residence times and groundwater inflows have been assessed using a well-mixed, annual-average, first-order total nitrogen (TN) concentration model coupled with a review of water quality data collected to date. Total nitrogen budget modelling provides meaningful information about an aquatic ecosystem if the major sources and sinks of nitrogen can be quantified (Wetzel, 1983).

Water quality modelling of the harbour firstly involved collation and review of relevant water quality data. As there is a full set of TN loading data and measurements of TN concentrations available for Cockburn Sound in 1990, the Sound was modelled for 1990 using the well-mixed equilibrium model as a means of checking the validity of this approach. The model was then applied to the Jervoise Bay Northern Harbour for both existing and proposed configurations to illustrate the potential effects on water quality if the northern breakwater extension is built.

4.4.1 Review of Relevant Water Quality Data

In order to model water quality in Cockburn Sound and the Jervoise Bay Northern Harbour, values of TN concentrations and annual loads of TN from sediments and point sources were sought from previous studies.

Chlorophyll *a* concentration (chl *a*), dissolved inorganic nitrogen (DIN) and vertical light attenuation (K_d) data were also obtained where possible to illustrate changes in essential water quality parameters over the past decade. Although DIN concentration is the primary indication of biologically available nitrogen, the complexity of modelling nutrient dynamics precluded any modelling of this constituent.

Where possible these values were obtained for the waters adjacent to Cockburn Sound, within Cockburn Sound and within the Jervoise Bay Northern Harbour.

- **Perth Coastal Waters Study**

The Perth Coastal Waters Study (PCWS) Summary Report (Lord and Hillman, 1995) provides background values of water quality parameters for comparison with Cockburn Sound and the Jervoise Bay Northern Harbour. Table 4.2 provides a summary of the relevant parameter values described in that study.

Table 4.2
Surface water quality parameters - median values, with tenth and ninetieth percentile values in brackets (from Table 5.1 Lord and Hillman, 1995)

	Southern Waters - offshore, depth > 25 m		**Southern Waters - nearshore, depth < 25 m**	
Parameter	**Winter**	**Summer**	**Winter**	**Summer**
DIN (μg/L)	N/A	5.1 (3.3,12.3)	N/A	4.2 (2.4,16.8)
TKN (μg/L)	214 (137,307)	112 (87,154)	224 (140,295)	136 (78,181)
TN (μg/L)	217 (139,309)	115 (92,155)	227 (140,298)	138 (84,185)
Chl *a* (μg/L)	0.18 (0.15,0.3)	0.2 (0.12,0.34)	0.44 (0.28,0.86)	0.2 (0.14,0.33)

For comparison with Cockburn Sound the means of the offshore summer and winter median values have been used, ie, the annual average background oceanic TN concentration value is calculated to be 166.0 μg/L with a range of 92 - 309 μg/L. This value is used as the ocean TN concentration in exchanges between the ocean and Cockburn Sound.

The PCWS found that sediments within Cockburn Sound and Warnbro Sound had significantly higher nutrient concentrations and nutrient release rates than sediments from other Perth coastal waters. For example, the total Kjeldhal nitrogen (TKN) concentration in Cockburn Sound sediments was 4.8 to 52 times the TKN concentrations found in other Perth coastal sediments. The implication is that the loadings to Cockburn Sound over the past 3 decades have resulted in substantial accumulation of nitrogen in the sediments of the Sound.

- **Water Quality Studies in Cockburn Sound**

The nutrient loading in Cockburn Sound is derived from the following primary sources (in decreasing order of total TN contribution to the Sound):

- exchange with Perth coastal waters;
- sediment release;
- groundwater flows; and
- industrial outfalls.

The importance of the water quality of nearshore waters on the water quality within Cockburn Sound should not be underestimated. The results of the PCWS suggest that the Sound is flushed with nearshore waters containing nutrients at higher levels than background open-ocean concentrations. If DIN is considered, rather than TN, the findings of the PCWS suggest that the input of DIN from the ocean to the Sound will be less than DIN inputs from the other primary sources.

Table 4.3 gives average values of water quality parameters (where available) measured throughout Cockburn Sound. Where two values are present in brackets after the mean value, a range is implied, where a single value is present a standard error is implied.

Table 4.3
Water quality parameters for Cockburn Sound

Source	Year of Data	DIN (μg/L)	TN (μg/L)	K_d (m^{-1})	chl *a* (μg/L)
EPA (1991)	1977/78	23 (16-38)	184 (172-208)	0.15 (0.14-0.16)	4.3 (3.2-5.2)
EPA (1991)	1982/83	21(13-39)	366 (279-492)	0.08 (0.06-0.13)	0.71 (0.2-1.2)
EPA (1991)	1984/85	17 (10-39)	496 (445-536)	0.1 (0.09-0.13)	1.1 (0.4-1.9)
EPA (1991)	1986/87	19 (12-44)	310 (238-367)	0.1 (0.08-0.12)	0.93 (0.3-0.7)
EPA (1991)	1989/90 (summer)	17 (10)	252 (35)	0.12 (0.02)	1.8 (0.7)
Bastyan & Paling (1992)	1990/91 (summer)	N/A	N/A	0.13 (0.02)	1.65 (0.1)
	1992 (summer)	N/A	N/A	0.14 (0.02)	2.55 (0.5)
Buckee et al. (1994)	1993 (winter)	N/A	273 (66-351)	N/A	1.2 (0.9-3.5)
	1993 (summer)	2.9 (2.6-8.0)	119 (97-138)	N/A	0.9 (0.8-1.15)
Bastyan et al. (1994)	1993 (summer)	9.15 (6.35)	N/A	0.12 (0.02)	1.8 (0.55)
S. Helleron, Curtin Uni. pers. comm. (1996)	1995/96	N/A	N/A	N/A	2.5 (0.14-17.0)

Based on studies of sediment cores taken throughout the Sound, Bastyan and Paling (1995) estimated the annual loading of TN to Cockburn Sound from the sediments to be between 398 and 1552 tonnes per annum (tpa). The sediment release rates were highest in the south of Cockburn Sound and in Mangles Bay.

Based on a borefield monitoring program, Appleyard (1994) estimated the TN loading into Cockburn Sound due to groundwater flows to be 330 (± 100) tpa and 2 (±1) tpa of phosphorus. Figures 4.3.1 and 4.3.2 (from Appleyard 1994) show the respective nitrogen fluxes from the Tamala Limestone and the Safety Bay Sand aquifers. Much of this loading has been associated with local industrial and market gardening activity near James Point and Woodman Point. These groundwater nutrient loadings are expected to drop with improved work practices.

Martinick et al. (1993) calculated the total loading of TN into Cockburn Sound due to industry via direct input in 1990 to be 540 tpa. Based on recent monitoring results from CSBP and projections of loadings given by Martinick et al (1993) it is estimated that this loading will have fallen to approximately 185 tpa for 1995. These sources are concentrated near James Point as shown in Figure 4.3.3. The Woodman Point Wastewater Treatment Plant outfall is no longer in use.

There is a general east-west trend in chlorophyll *a* concentrations, whereby concentrations increase close to the shore of Cockburn Sound and there is also a north-south trend whereby concentrations increase towards Mangles Bay in the south of the Sound (Figure 4.3.4). These trends have persisted and are still present in recent (1995/6) monitoring studies (S. Helleron, pers. comm.). This distribution of concentrations may be due to a combination of the effects of water depth, the concentration of point sources to the south of the Sound, nutrient enriched groundwater release close to the eastern margin of the sound and higher nutrient levels within the groundwater towards the south of the Sound.

- **Jervoise Bay Northern Harbour Precinct**

Martinick et al (1993) found that there was no significant point source of pollutants inside the Northern Harbour Precinct, with the exception of the Woodman Point emergency outfall. The potential impact of this outfall on water quality within the Northern Harbour is discussed in Section 4.4.3.

Water quality parameters have been sampled intermittently over an 11 year period at a location near the head of the Jervoise Bay Harbour Southern Breakwater and these values have been taken to be indicative of the water quality within the harbour. Values relevant to this study are shown in Table 4.4. The data mirrors the trends found in Cockburn Sound, whereby nutrient loadings decreased from the mid 1980s but chlorophyll *a* concentrations do not reflect the decreased nitrogen loading. Figures 4.3.5 (a-d) plot the mean values given in Tables 4.2, 4.3 and 4.4 and suggest that water quality near the harbour mouth is closely related to the basin average water quality within Cockburn Sound.

Table 4.4
Water quality parameters for Jervoise Bay

Source	Year of Data	DIN (μg/L)	TN (μg/L)	K_d (m^{-1})	chl *a* (μg/L)
EPA (1991)	1982/83	27 (32)	424 (173)	0.08 (0.02)	1.1 (0.9)
EPA (1991)	1984/85	12 (6)	536 (139)	0.13 (0.04)	1.6 (0.8)
EPA (1991)	1986/87	18 (13)	302 (149)	0.11 (0.01)	1.4 (0.6)
EPA (1991)	1989/90	15 (11)	262 (77)	0.13 (0.04)	2.2 (1.1)
Bastyan et al. (1994)	1993 (summer)	16.9 (16.2)	N/A	0.14 (0.02)	2.8 (1.55)
S. Helleron, Curtin Uni. pers. comm. (1996)	1995/96	N/A	N/A	N/A	2.3

Appleyard (1994) has recently identified that regional groundwater influx to Cockburn Sound and Jervoise Bay is likely to be a significant diffuse source of pollutants to these water bodies. Calculations based on Appleyard (1994) and the length of impounded coastline in the Jervoise Bay Northern Harbour Precinct suggest that the annual TN load due to groundwater entering the harbour precinct is in the range of 20.7 to 38.9 tpa. Based on Martinick et al. (1993) the loading of TN due to groundwater entering the harbour is calculated to be 34.6 tpa.

This loading is understood to flow predominantly from the Tamala limestone aquifer which discharges some distance offshore, possibly near the 10 m depth contour. As such it is difficult to ascertain what percentage of this discharge will flow into the harbour precinct. For the purposes of this study it has been conservatively assumed that all groundwater flow along the impounded coast flows into the harbour.

If it is assumed that the sediment nutrient release rate is the same in the Northern Harbour as in the entire Sound, then based on Bastyan and Paling (1995) the loading due to sediment release within the harbour will be in the range 3.1 to 11.9 tpa.

Nutrient loads to the harbour enclosure would appear to be dominated by groundwater loadings and release from sediments. Runoff and the occasional flushing of the Woodman Point Wastewater Treatment Plant (WPWWTP) emergency outfall with groundwater (see Section 4.4.3) are the only other possible sources of nutrients.

Nitrogen levels in the groundwater strongly reflect impact of land use, both local and regional. Levels are presently considered to be elevated at Woodman Point due to market gardening activity, industrial activity and possible leaching from the WPWWTP. These loadings are likely to decrease markedly over the next five years as market gardening activities in the region are reduced due to rezoning, industrial pollutants reduced due to more stringent disposal requirements and leaching from the WPWWTP is reduced as the plant is upgraded.

4.4.2 Potential Impact on Water Quality

- **Water Quality Modelling**

The model takes into account the effects of dilution due to flushing and first-order decay losses to sediments, with constituent concentrations modelled as uniform within the system and concentrations computed at equilibrium conditions.
This type of model provides useful information on the governing mechanisms and the results are applicable in an annual averaged sense. Detailed two- or three-dimensional process based hydrodynamic water quality modelling is not considered necessary given the scale of the Northern Harbour relative to Cockburn Sound and, furthermore, significant parameter values such as groundwater and sediment nutrient loadings are available only as annual mean approximations.

- **Cockburn Sound**

The rate of flushing of Cockburn Sound waters with regional coastal waters has been estimated in a number of studies. In a review by D'Adamo (1992) the fastest exchange was estimated to be 10 days, while the slowest was estimated to be 60 days. On average, volume replacement of waters within the Sound was estimated to take approximately 35 days. Hearn (1991) describes results of a hydrodynamic model of the Sound which computed a minimum flushing time of 16 days and a maximum flushing time of 72 days, being generally consistent with the review by D'Adamo (1992).

TN in Cockburn Sound was modelled for 1990, when the best estimates of loadings were available (within ranges) and there were measurements of the concentrations of TN in the Sound to check the model results and assumptions.

By using the median groundwater and sediment loadings of TN of 330 tpa and 975 tpa respectively, the measured industry loading for 1990 of 540 tpa, a mean offshore TN concentration of 166 μg/L and a flushing time of 35 days, the computed equilibrium TN concentration for Cockburn Sound is 257 μg/L. This compares well with the measured value of 252 μg/L, however, given the wide range of the input parameters the modelled result realistically returns a range of values between 218 and 296 μg/L as shown in Table 4.5. This range is further increased if background ocean values are varied.

Table 4.5
Water Quality Modelling for Cockburn Sound - verification against ranges of 1990 parameters for TN equilibrium concentrations

Residence Time (Days)	Ground water Loading (tpa)	Sediment Loading (tpa)	Nearshore Ocean Background (μg/L)	Industry Loading (tpa (1990))	Equilibrium Concentration (μg/L)
35	230	398	166	540	218
35	330	398	166	540	224
35	430	398	166	540	229
35	230	975	166	540	251
35	330	975	166	540	257
35	430	975	166	540	263
35	230	1,552	166	540	285
35	330	1,552	166	540	290
35	430	1,552	166	540	296

The model results suggest that for an annually averaged flushing time of 35 days the sediment release of TN will have the greatest bearing on TN concentration in the Sound. If industry inputs of TN are reduced to the estimated loading of 185 tpa for 1995 and all other variables are unchanged, the background TN concentration in the Sound becomes 236 µg/L. This is not a significant change, reflecting the dominant influence of the background ocean TN concentration and the sediment loads. The effects of ocean concentrations could be expected to be dramatically reduced if DIN concentrations were to be modelled, however the present paucity of data precludes this.

- **Jervoise Bay Northern Harbour**

The effectiveness of the simple equilibrium model in modelling annual mean TN concentrations for Cockburn Sound allows it to be applied to the Jervoise Bay Harbour Precinct with reasonable confidence, in that results will reflect the effect of altered harbour flushing times on annual mean harbour concentrations.

Using mean annual loadings associated with groundwater and sediment release of 30 tpa and 7.48 tpa respectively combined with a flushing time of 3 days and a background concentration of 252 µg/L in Cockburn Sound (ie 1990 values), the equilibrium concentration in the harbour is 302 µg/L. The prime factor influencing this is the background concentration in the Sound, the secondary factor is the loading due to groundwater flows. Table 4.6 shows the range of equilibrium concentrations based on the expected range of parameter values, these values are all based on 1990 data. The table also shows the equilibrium concentrations to be expected with the existing harbour configuration which have been based on a flushing time of 2.4 days. The worst case scenario, consisting of a flushing time of 5 days combined with a groundwater loading of 50 tpa and a sediment loading of 11.9 tpa, results in an equilibrium TN concentration of 393 μg/L for the proposed harbour compared with an equilibrium concentration of 320 μg/L for the existing harbour under the same loading conditions.
The modelling process highlighted the following points concerning Jervoise Bay Northern Harbour Water Quality:

- the dominant factor is the water quality in Cockburn Sound. Improvements in water quality in the Sound will be reflected in similar magnitude improvements in the Harbour

- the groundwater nutrient loading has the greatest local impact on Harbour water quality. Improvements in local groundwater quality should be reflected in improvements in Harbour water quality.

Table 4.6
Jervoise Bay Northern Harbour TN equilibrium concentrations

Harbour Residence Time (Days)	Groundwater Loading to Harbour (tpa)	Sediment Loading to Harbour (tpa)	Cockburn Sound Background (μg/L)	Proposed Extension Equilibrium Conc. (μg/L)	Existing Harbour Equilibrium Conc. based on a residence time of 2.4 days (μg/L)
3	20	3.07	252	282	276
3	30	3.07	252	296	287
3	40	3.07	252	310	299
3	50	3.07	252	324	310
5	20	3.07	252	302	276
5	30	3.07	252	325	287
5	40	3.07	252	349	299
5	50	3.07	252	372	310
3	20	7.48	252	288	281
3	30	7.48	252	302	292
3	40	7.48	252	317	304
3	50	7.48	252	331	315
5	20	7.48	252	312	281
5	30	7.48	252	335	292
5	40	7.48	252	359	304
5	50	7.48	252	382	315
3	20	11.9	252	294	286
3	30	11.9	252	309	297
3	40	11.9	252	323	309
3	50	11.9	252	337	320
5	20	11.9	252	322	286
5	30	11.9	252	346	297
5	40	11.9	252	369	309
5	50	11.9	252	393	320

4.4.3 Woodman Point Emergency Sewage Outfall

The Woodman Point Wastewater Treatment Plant (WPWWTP) discharged primary treated effluent to Cockburn Sound from an outfall on Woodman Point until 1984 (Figure 4.3.3), after which wastewater was redirected to the Cape Peron outfall. However, between 1984 and 1991 the outfall was used as an emergency discharge outfall and 33 emergency discharges were made in this period (Martinick et al. 1993).

The Water Corporation constructed a new emergency sewage outfall from the Woodman Point Wastewater Treatment Plant into the Northern Harbour Precinct entering at the southern boundary of Lot 64 (see Figure 3.1). The outfall, which was commissioned in 1991, consists of a 1.2 m diameter concrete pipe projecting 170 m into the harbour exiting at a depth of 6 m below AHD. Discussions with the Woodman Point Treatment Plant Supervisor and the Water Corporation Engineer in charge of the facility detailed the operational background of the Jervoise Bay outfall as follows:

- The outfall exists as an emergency outfall. It is envisaged that the outfall will only be required in the event of a power failure at the plant combined with the plant experiencing flows greater than the existing bypass capacity of ~2000 L/s.

- Since the new emergency outfall was commissioned there has only been one overflow. This was on 20 October 1995, when 1140 m^3 of effluent containing 57 kg of TN and 12.5 kg of TP was released.
- Any discharge from the Woodman Point Wastewater Treatment Plant into the Northern Harbour is done so under DEP Licence conditions and as such must be immediately reported to the Department of Environmental Protection by the Water Corporation.
- The likelyhood of use increases as the plant approaches full treatment capacity.

If there is a culmination of events resulting in outfall discharge, then there will be a period when water quality in the harbour will be degraded. This will occur regardless of whether the harbour is in its present configuration or if the breakwater extension is in place. The impact of such an event will depend on the amount of discharge, the pretreatment of the discharge, the effectiveness of any cleanup procedures following a discharge and the mixing conditions at the time of the discharge. The frequency of occurrence of such discharge is considered to be very low with a consequently small potential public health risk. Whilst the potential exists for cleanup and recovery of such spillages, the natural mixing and flushing processes within the harbour are expected to be reasonably efficient in reducing contaminant concentrations within the harbour.

4.4.4 Toxins

Monitoring studies have shown widespread contamination of Cockburn Sound by organotin (TBT) compounds, as shown in Figure 4.4.1. Legislation was introduced in 1991 by the EPA prohibiting the use of TBT antifouling paints on vessels less than 25 m in length. In spite of this, TBT concentrations in sediments increased from 35 μg/L in 1991 to 130 μg/L in 1994 (DEP, 1995). Contamination in mussels has been noted both within the existing Northern Harbour Precinct and external to the harbour (LeProvost, Dames and Moore, 1995) with concentrations of TBT ranging from 338-407 μg/kg.

Slow leaching rate TBT antifouling paints may still be used on international vessels longer than 25 m although this is not recommended under international guidelines. Most vessels constructed or maintained in the Northern Harbour are aluminium and use non-TBT antifouling paints.

The DEP is presently drafting regulations regarding the licensing and registration of organisations involved in the building and maintenance of boats. The following is an extract from the draft legislation outlining the operations which will soon be subject to Works Approval and Licencing or Registration requirements.

"*Environmental Protection Amendment Regulations (No. 3) 1996. Draft 26/8/96*

42) Boat building and maintenance: premises on which

(a) vessels are commercially built or maintained; and
(b) organotin compounds are used or removed from vessels."

This legislation is expected to help reduce the contamination of harbour waters with TBT. However, the effect of boat building and maintenance operations on the harbour water quality remains an issue, as in all harbours. Construction of the proposed breakwater extension should not result in any increase of TBT levels in the Northern Harbour, however, monitoring of heavy metals and TBT should continue as a matter of course.

5.0 Potential Socio-economic Impacts and Their Management

5.1 European Heritage

McCarthy (1983) listed seven shipwreck sites of archeological significance within the Northern Harbour Precinct (see Figure 5.1). None of the wrecks are situated on the alignment of the proposed breakwater extension. Consequently, there will be no impact upon any maritime archaeological sites. Negotiations have commenced with the Western Australian Maritime Museum with respect to other proposed maritime developments within the Jervoise Bay/Henderson Estate which may impact on some of these sites or access to them.

5.2 Aboriginal Heritage

Perth's nearshore waters, including Cockburn Sound, are regarded by some Aboriginal people as a mythological site. This is yet to be formally recognised.

5.3 Construction Issues

- **Trucking**

Trucking of materials during the construction of the breakwater will occur on gazetted roads and take place with full consultation with the City of Cockburn. Trucking will be restricted to daylight hours between 7 am and 6 pm.

- **Noise, Dust and Vibration**

Because of the location of the construction site, dust, noise and vibration levels are expected to be of minimal concern to residents. Management of the construction works will include ensuring the noise and dust levels are acceptable to local residents.

5.4 Community Access and Public Usage

Following completion of the breakwater public access to the breakwater will be permitted for recreational fishing.

6.0 Management Recommendations and Commitments

The Northern Harbour Precinct lies within waters controlled by the Fremantle Port Authority (FPA) but with operational responsibility delegated to the WA Department of Transport (DOT). The DOT is therefore responsible for enforcement of maritime regulations within the harbour. The DOT maintains an Oil Spill Contingency Plan covering its operations throughout the state. In the event of a major spill within the Northern Harbour, however, the FPA would be requested to respond under the National Plan arrangement between Federal, State and Territory Governments. The FPA maintains a stockpile of response equipment in Fremantle.

The present DOT position on management of the Northern Harbour Precinct is for management responsibility to be delegated to the Harbour Master as designated under the Shipping and Pilotage Act. The Harbour Master would most likely be a representative of the users of the harbour, appointed by the Minister for Transport. The Harbour Master would carry out his tasks in accordance with guidelines set by the Department of Transport.

Presently there is no requirement or provision for stockpiling of basic equipment for control of small waste spillages. With further growth and development of this facility, together with activities associated with the AMS shiplifter, an integrated management plan may be warranted. This planning, however, is outside the scope of this CER and must be promoted at an intra-Governmental level.

In relation to the Northern Harbour Precinct, the proponent makes the following commitments:

1. Dust generated during construction will be managed under Part V of the Environmental Protection Act, 1986, to the satisfaction of the DEP to ensure that public amenity is not impacted.

2. Noise will be managed under Part V of the Environmental Protection Act, 1986 to the satisfaction of the DEP during site works to ensure that public amenity is not impacted.

3. Any noise, vibration or dust as a result of traffic impacts during construction will be managed under Part V of the Environmental Protection Act, 1986. Traffic impacts from construction work will be managed through hours of operation complying with the requirements of the Local Authority and development and implementation of a management plan by the proponent.

4. Water quality within the Precinct will be managed under Part IV of the Environmental Protection Act 1986. Monitoring will occur initially on a quarterly basis for nutrients, chlorophyll *a* and light attenuation to allow any changes in water quality as a result of construction of the Precinct to be quantified. An annual summary report will be provided to the DEP.

7.0 References

Appleyard, S. J. (1994).
The Discharge of Nitrogen and Phosphorus from Groundwater into Cockburn Sound, Perth Metropolitan Region. Western Australian Geological Survey Report 1994/39.

Australian and New Zealand Environment and Conservation Council (1992).
Australian Water Quality Guidelines for Fresh and Marine Waters.

Bastyan, G. and Paling, E.I. (1992).
Chlorophyll Concentrations and Nutrient Loading into Cockburn Sound. Results of Measurements in 1991 and 1992. Environmental Science Report No. 92/3 Murdoch University.

Bastyan, G., Paling, E.I. and Wilson, C. (1994).
Cockburn Sound Water Quality Studies; Nutrient release from the sediments and water quality. Environmental Science Report No. 94/2 Murdoch University.

Bastyan, G. and Paling, E.I. (1995).
Experimental Studies on Coastal Sediment Nutrient Release and Content (Report to CSBP). Institute for Environmental Science MAFRA 95/5 Murdoch University.

Buckee, J., Rosich, R.S. and Van Senden, D.C. (1992).
Perth Coastal Waters Study; Water Quality Data. Water Authority of Western Australia.

Burt, J.S. and Ebell, G.F. (1995).
Organic Pollutants in Mussels and Sediments of the Coastal Waters off Perth, Western Australia in Marine Pollution Bulletin Vol. 30 No. 11, 723-732.

Cambridge, M.L. (1975).
Seagrasses of South-western Australia with Particular Reference to Cockburn Sound, a Polluted Marine Embayment. *Aqu. Bot.* 1:149-161

Cambridge, M.L. and McComb, A.J. (1984).
The Loss of Seagrasses in Cockburn Sound, Western Australia. 1. The Time Course and Magnitude of Seagrass Decline in Relation to Industrial Development. Aquatic Botany 20:229-243.

D'Adamo N. (1992).
Hydrodynamics and Recommendations for Further Studies in Cockburn Sound and Adjacent Waters. EPA Technical Series 41.

Department of Conservation and Environment (DCE) (1979).
Cockburn Sound Study: Technical Report on Nutrient Enrichment and Phytoplankton. Report No. 3

Department of Environmental Protection (DEP) (1995)
Annual Report.

Environmental Protection Authority (EPA) (1990).
The Environmental Impact of Organotin Antifouling Paints in Western Australia. EPA Bulletin No. 447.

Environmental Protection Authority (EPA) (1991).
Water Quality in Cockburn Sound. Results of the 1989/90 Summer Monitoring Programme. Technical Series No. 47.

Environmental Protection Authority (EPA) (1993).
Southern Metropolitan Coastal Waters Study (1991 - 1994) Progress Report, August 1993. EPA Technical Series 53.

Halpern Glick (1985).
Industrial Land Development Authority - Jervoise Bay Breakwater Environmental Report.

Halpern Glick Maunsell (1994).
Jervoise Bay/Henderson Marine Industry Estate Planning Study. Draft submitted to the Department of Commerce and Trade.

Hearn C. J. (1991).
A Review of Past Studies of the Hydrodynamics of Cockburn Sound and Surrounding Waters with an Appraisal of Physical Processes and Recommendations for Future Data Collection and Modelling. Australian Defence Force Academy ACT. Report to the EPA 75 pp.

Hillman, K.. (1986).
Nutrient Load Reduction, Water Quality and Seagrass Dieback in Cockburn Sound 1984-1985. Technical Series No. 5, Department of Conservation and Environment, Perth.

Hillman, K., Lord, D. A., McComb, A. J. and Laver, P. (1995).
Perth Coastal Waters Study - Environmental Values. Water Authority of Western Australia.

LeProvost, Dames and Moore (1995).
Shiplift Breakwater, Jervoise Bay. Marine Monitoring Programme, 1994, Survey Report.

LeProvost Environmental Consultants (1991).
Seagrass Density on Success Bank: Preliminary Ground Truthing and Evaluation of Sampling Methods. Cockburn Cement Ltd.

Lewis D.P. and Imberger J. (1988).
An Assessment of Harbour Exchange for the Fremantle Inner Harbour Deepening Project. University of Western Australia, Centre for Water Research Report WP-88-040.

Lord, D.A. and Hillman, K. (1995).
Perth Coastal Waters Study - Summary Report. Water Authority of Western Australia.

Lukatelich, R.J., Bastyan, G. Walker, D.I. and McComb A.J. (1987).
Effect of Boat Moorings on Seagrass Beds in the Perth Metropolitan Region. Technical Series No. 21, Environmental Protection Authority, Perth.

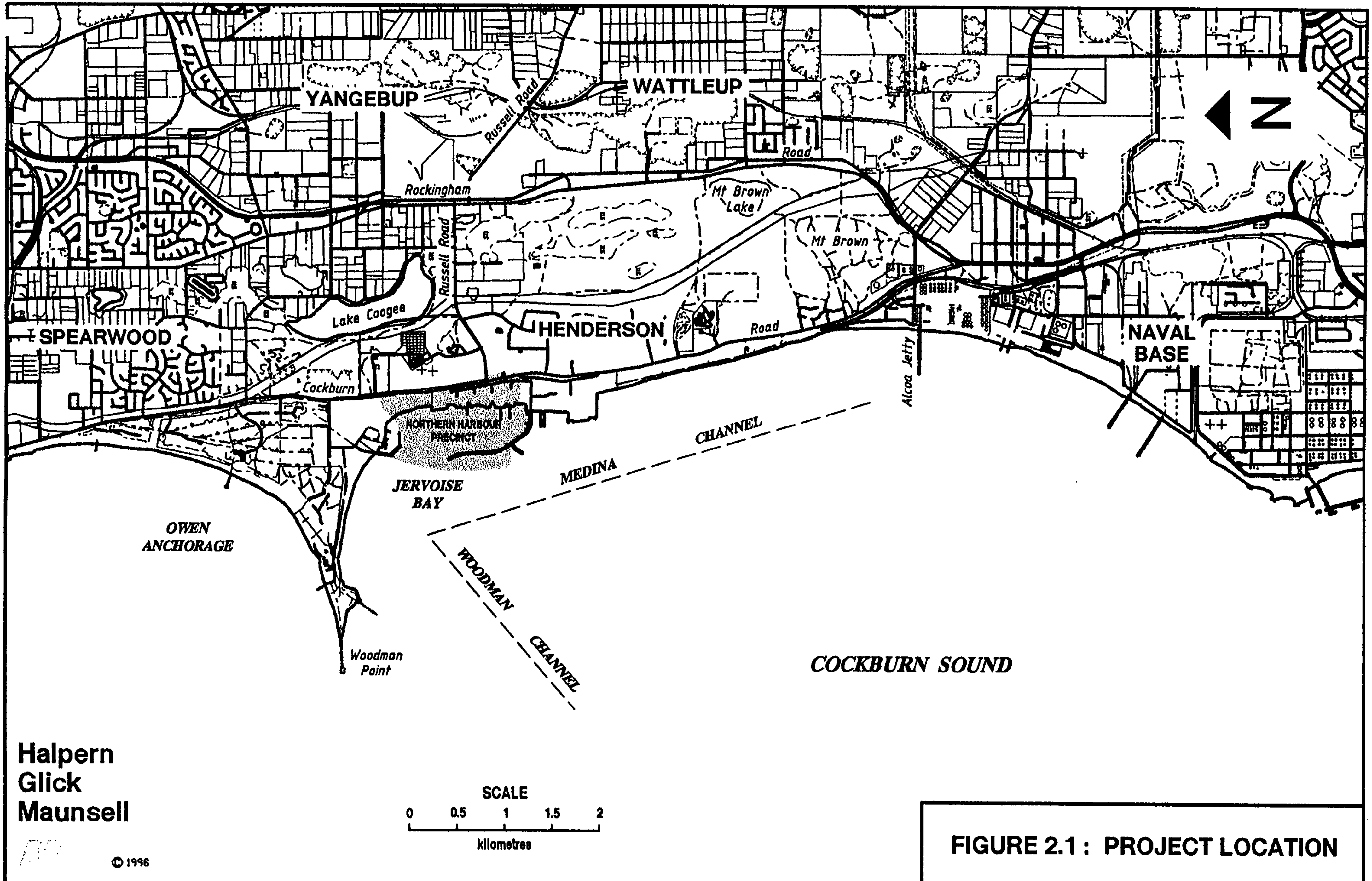
McCarthy M. (1983).
Shipwrecks in Jervoise Bay. Rec. West. Aust. Mus. 10:335-372.

Martinick, W.G. and Mackie Martin and Associates (1993).
Contaminant Inputs Inventory of the Southern Metropolitan Coastal Waters of Perth. Report to the Environmental Protection Authority, Western Australia.

Schwartz R.A. (1988).
The Flushing Behaviour of a Coastal Marina. 21st Intl. Conf. Coastal Eng. (Spain).

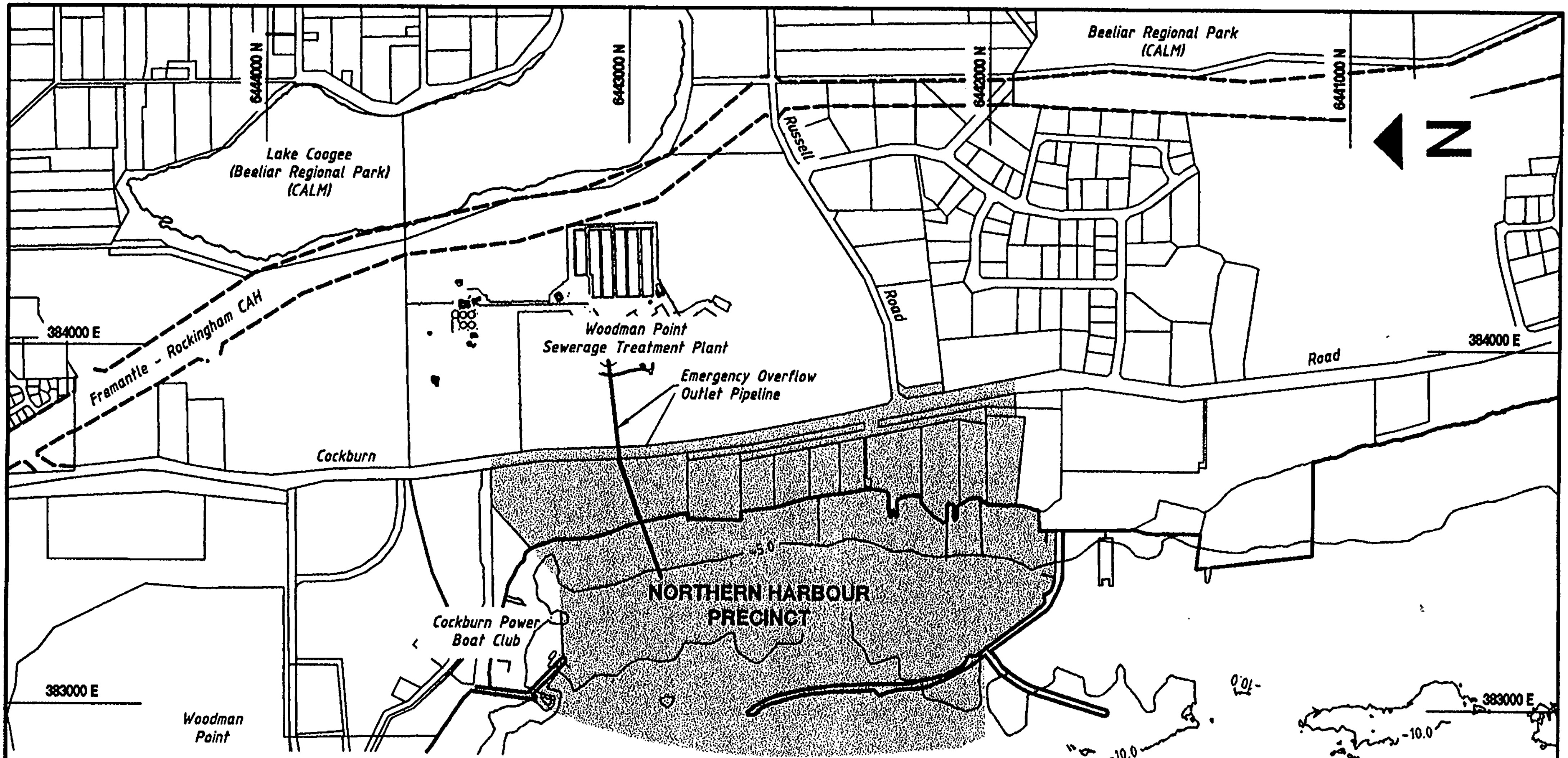
Wetzel R.G. (1983).
Limnology. 2nd edition Saunders College USA.

Figures



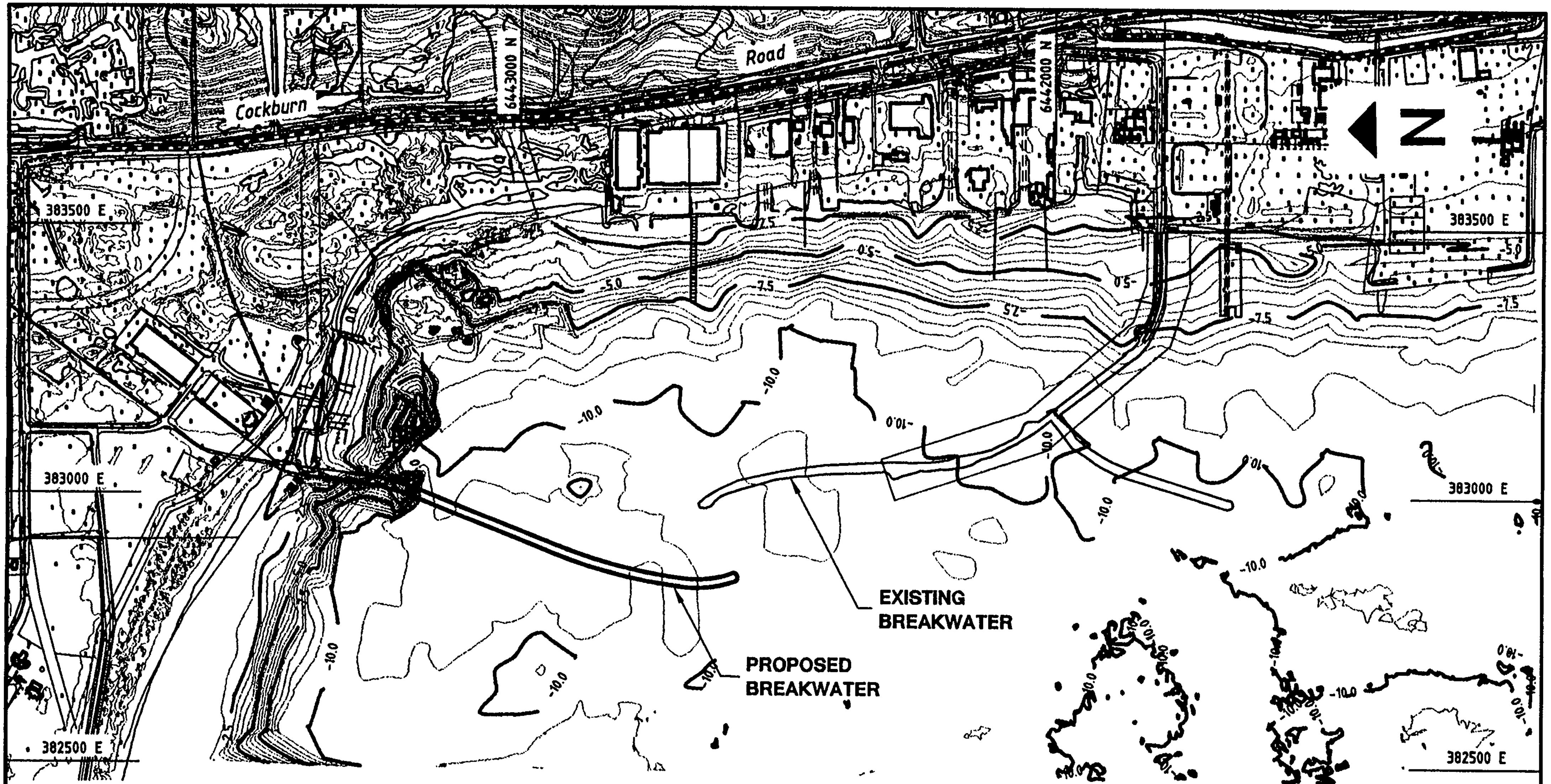
Halpern
Glick
Maunsell

FIGURE 2.1 : PROJECT LOCATION



Halpern
Glick
Maunsell

FIGURE 3.1 : NORTHERN HARBOUR PRECINCT SHOWING EXISTING BREAKWATERS

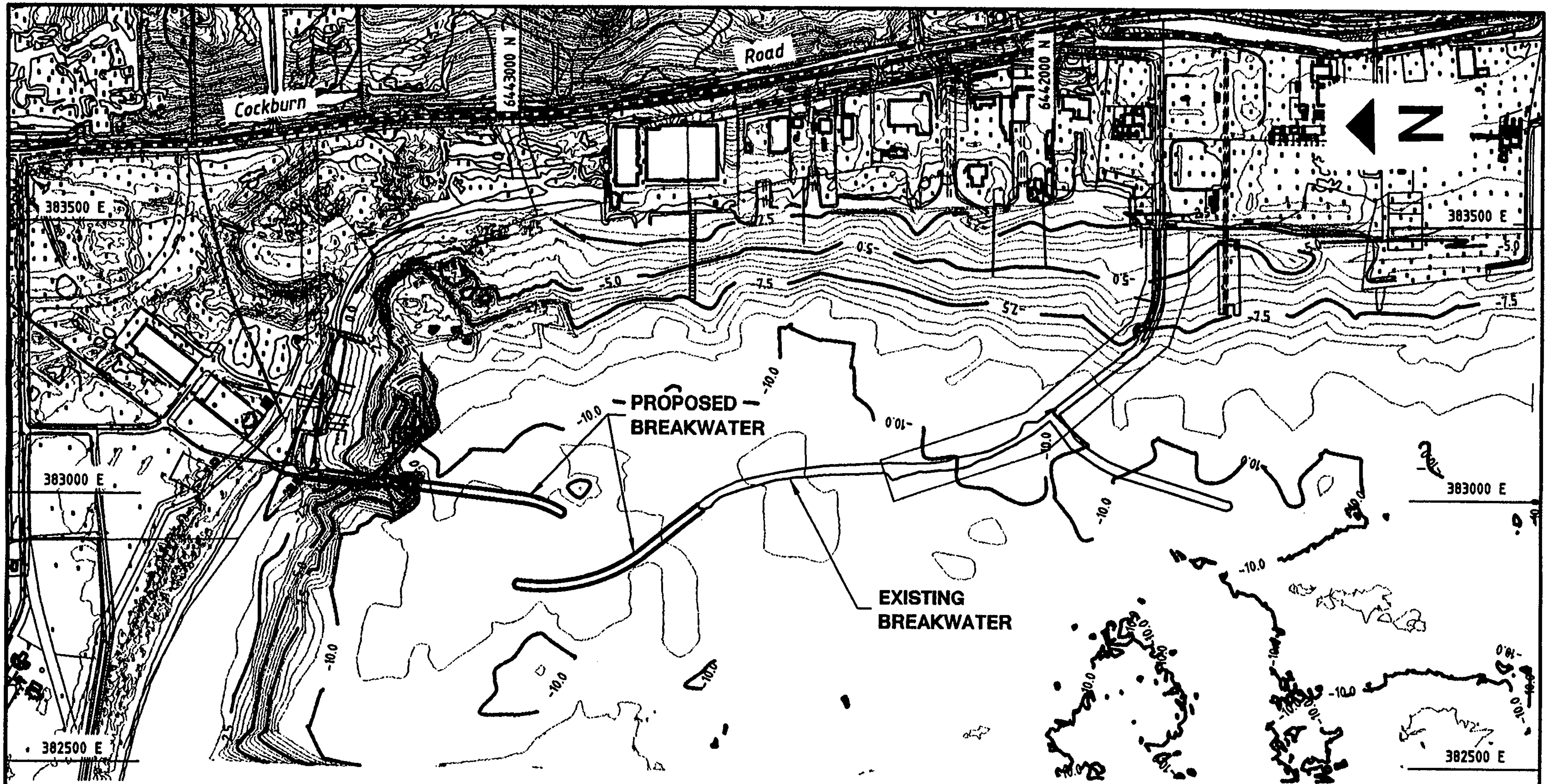


Halpern
Glick
Maunsell

SCALE
0 100 200 300 400
metres

FIGURE 3.2 : PROPOSED BREAKWATER EXTENSION

L:\T4076A\FIGURE32.DGN



Halpern
Glick
Maunsell

© 1996

SCALE
0 100 200 300 400
metres

FIGURE 3.3 : ALTERNATIVE BREAKWATER EXTENSIONS

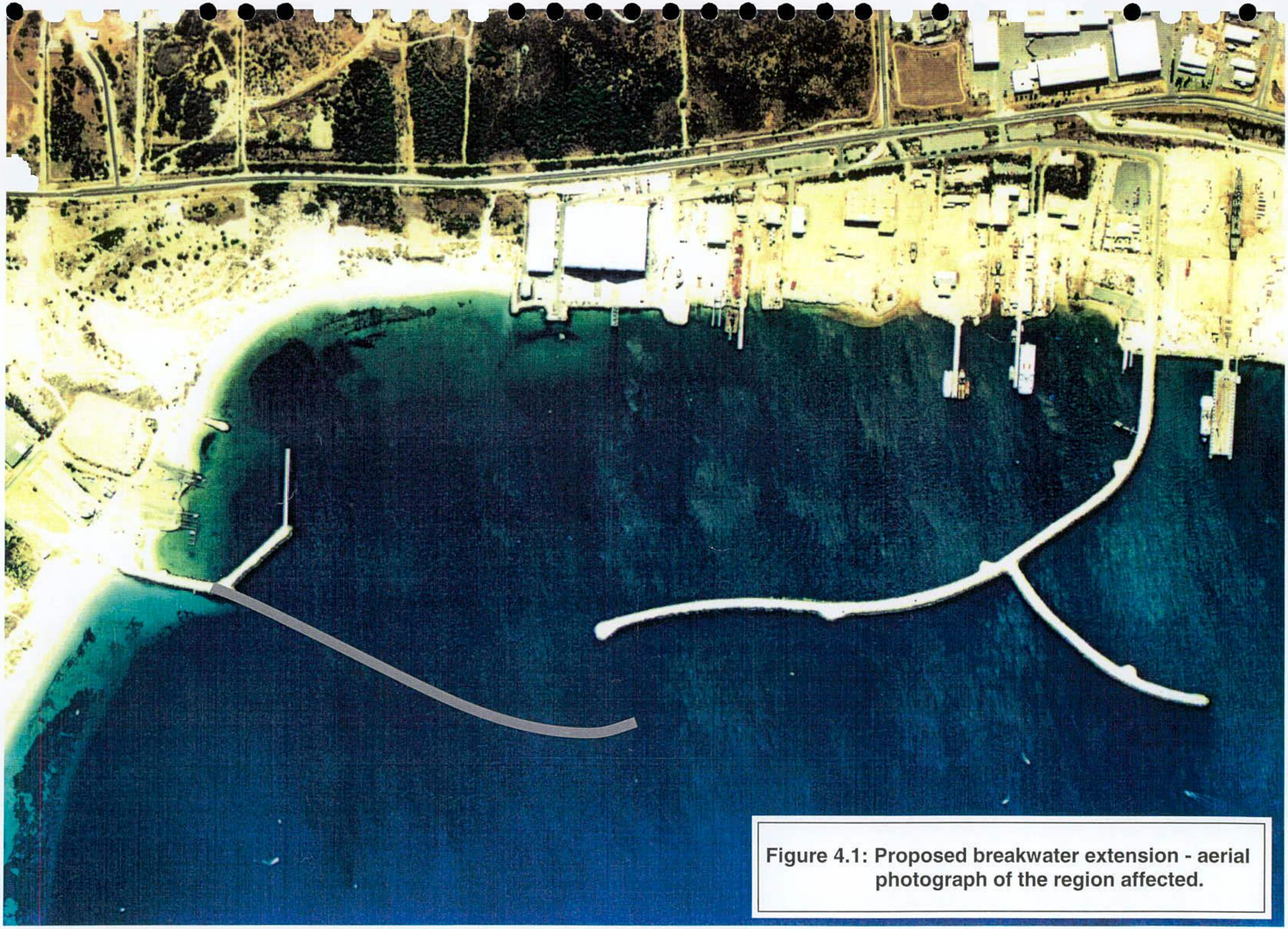
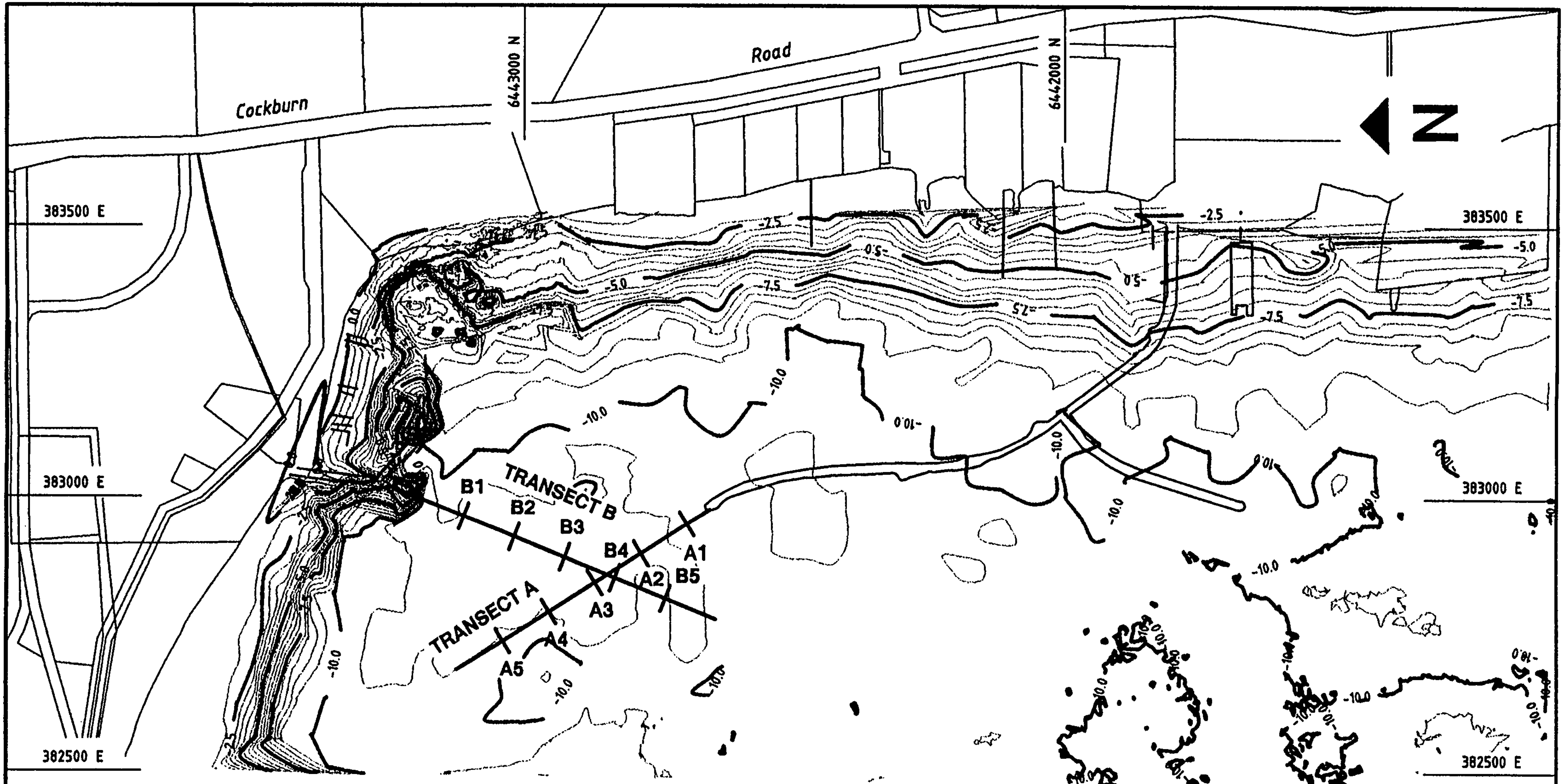


Figure 4.1: Proposed breakwater extension - aerial photograph of the region affected.



Halpern
Glick
Maunsell

SCALE
0 100 200 300 400
metres

FIGURE 4.2 : SEAGRASS SURVEY TRANSECTS

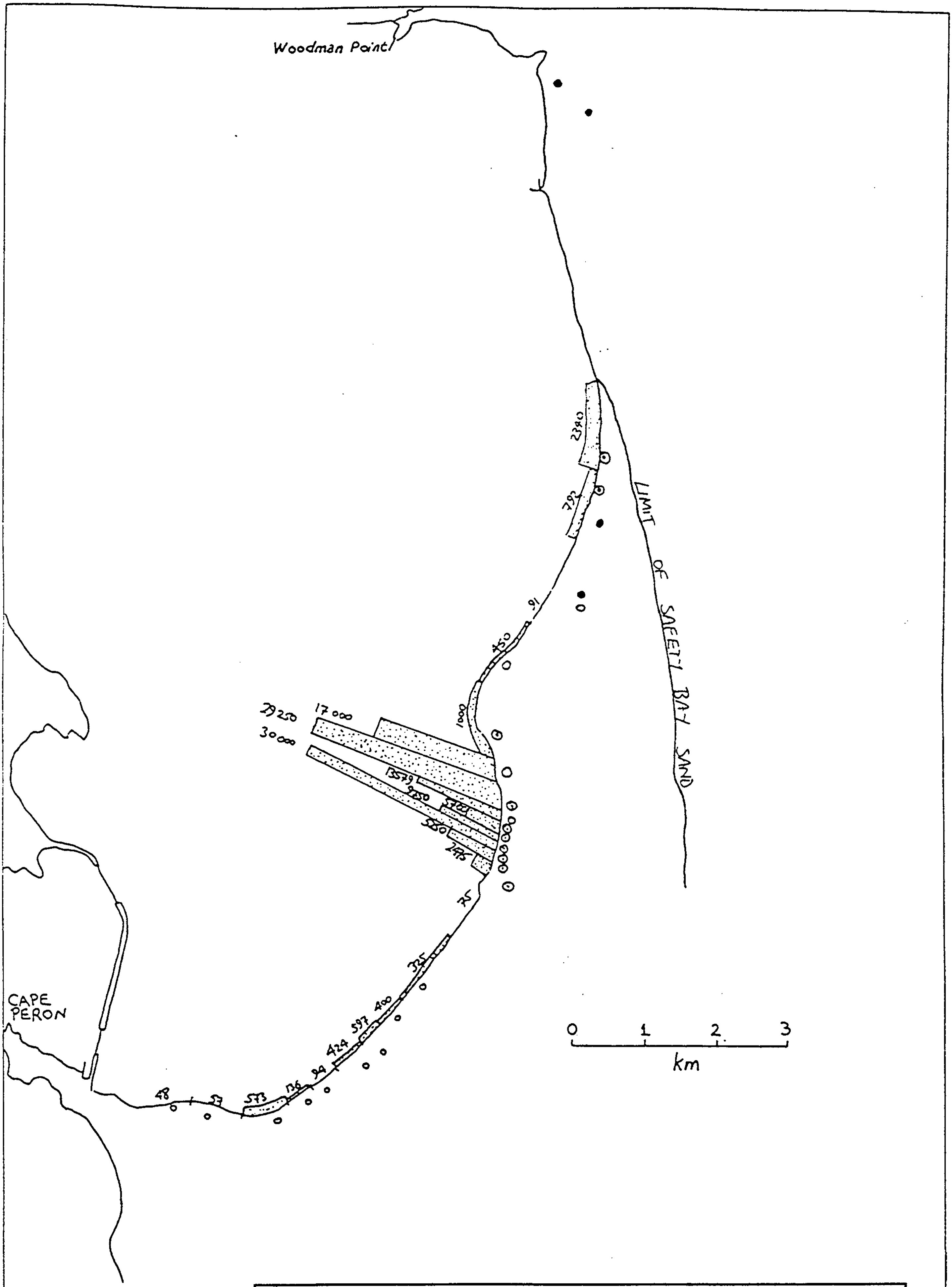


Figure 4.3.1: Nitrogen flux (kg/year/km) from Safety Bay Sand
(from Appleyard 1994)

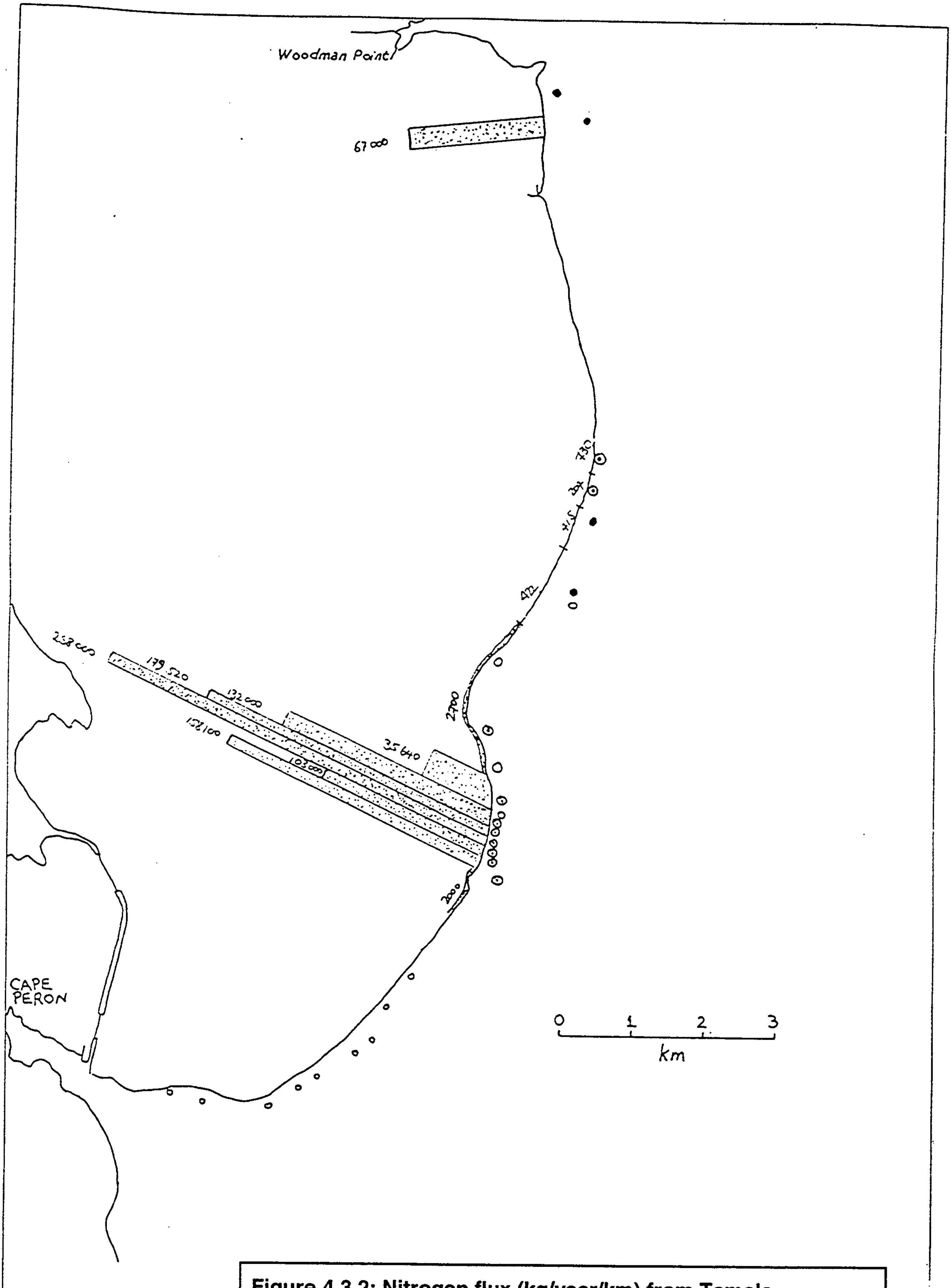


Figure 4.3.2: Nitrogen flux (kg/year/km) from Tamala Limestone (from Appleyard 1994)

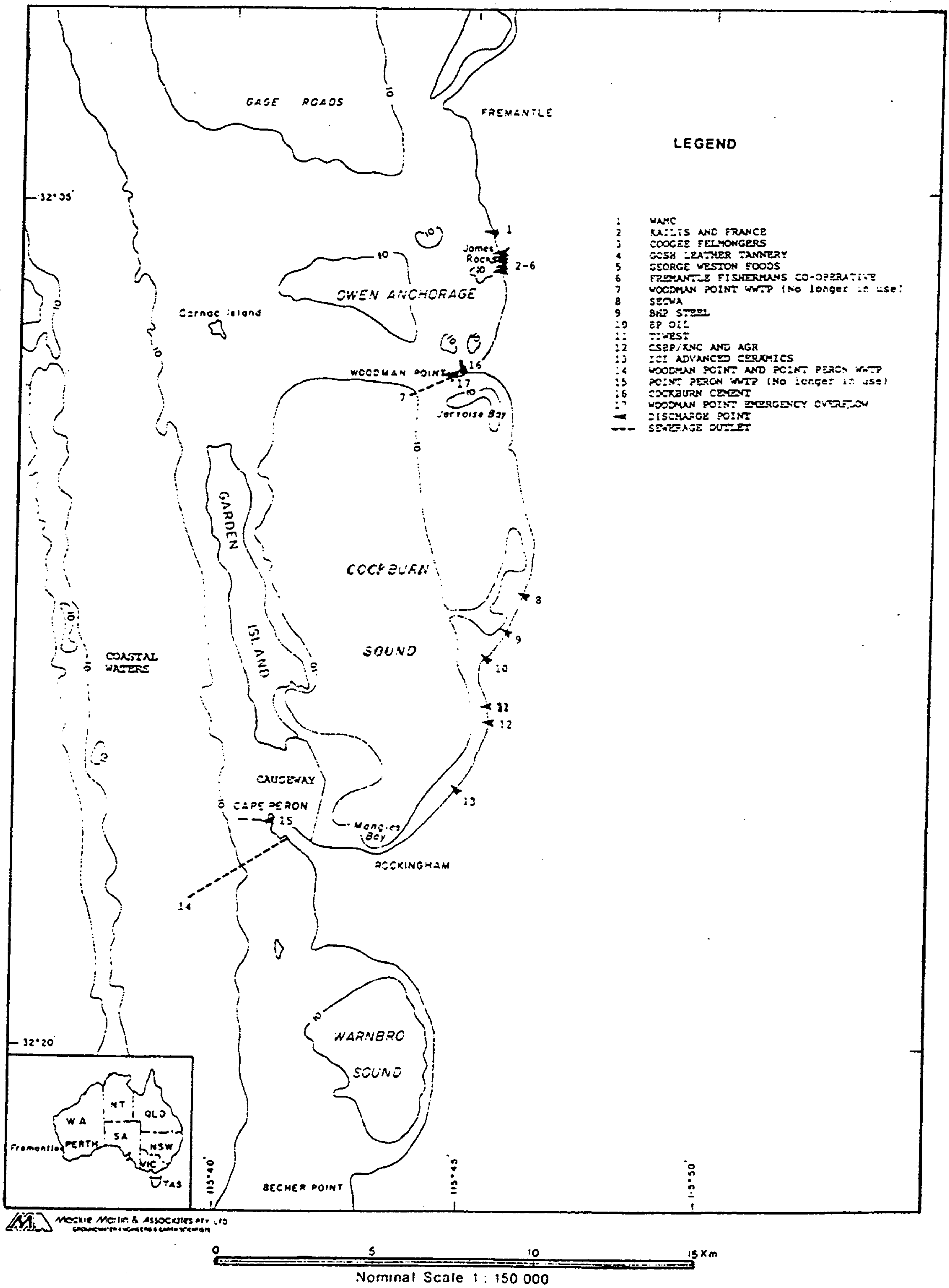


Figure 4.3.3: Locations of point source discharges to Cockburn Sound, 1990 (from Martinick et al. 1993)

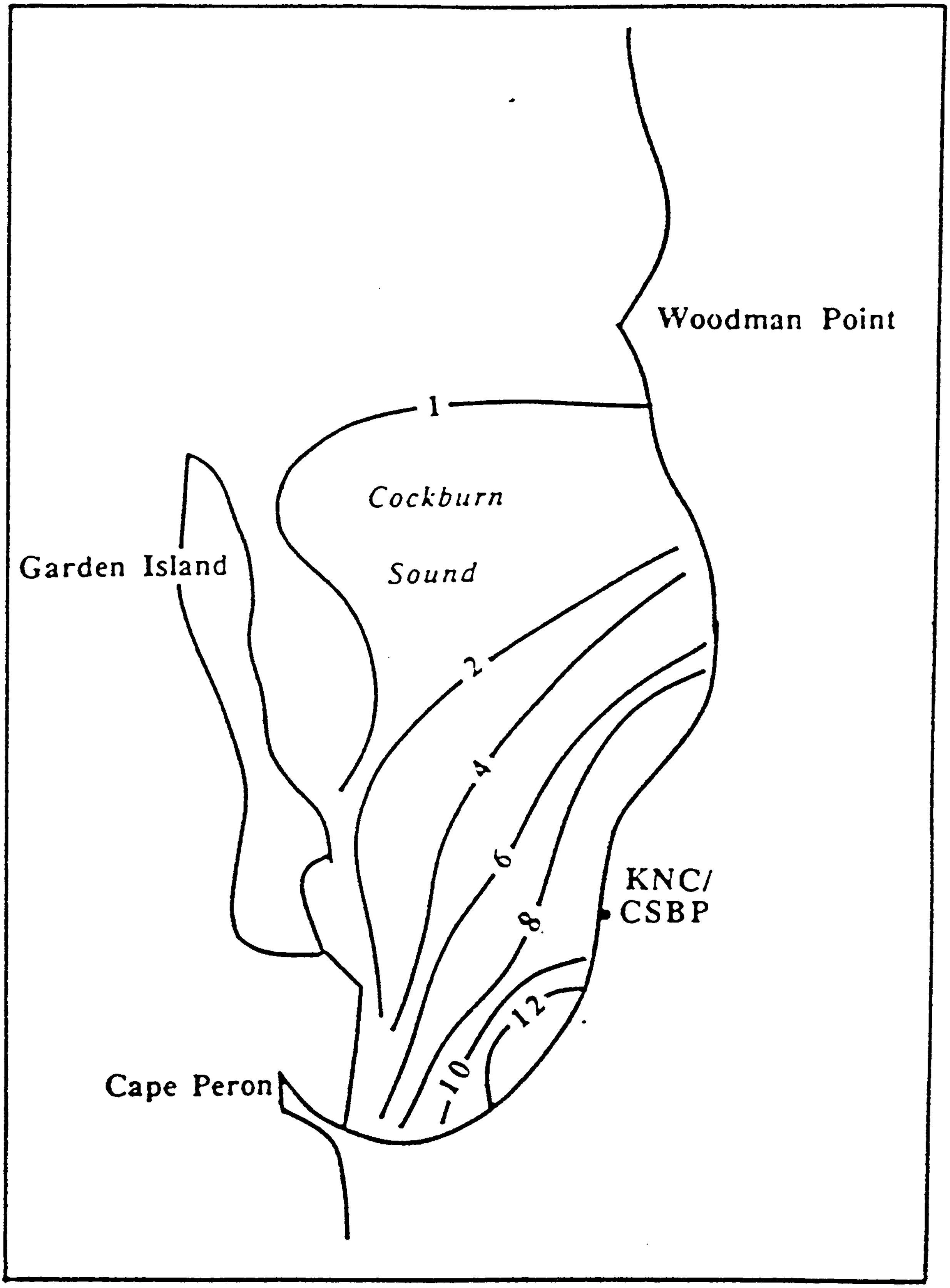


Figure 4.3.4:Chlorophyll *a* concentrations (μg/L) in Cockburn Sound on May 16, 1990 (from EPA 1991)

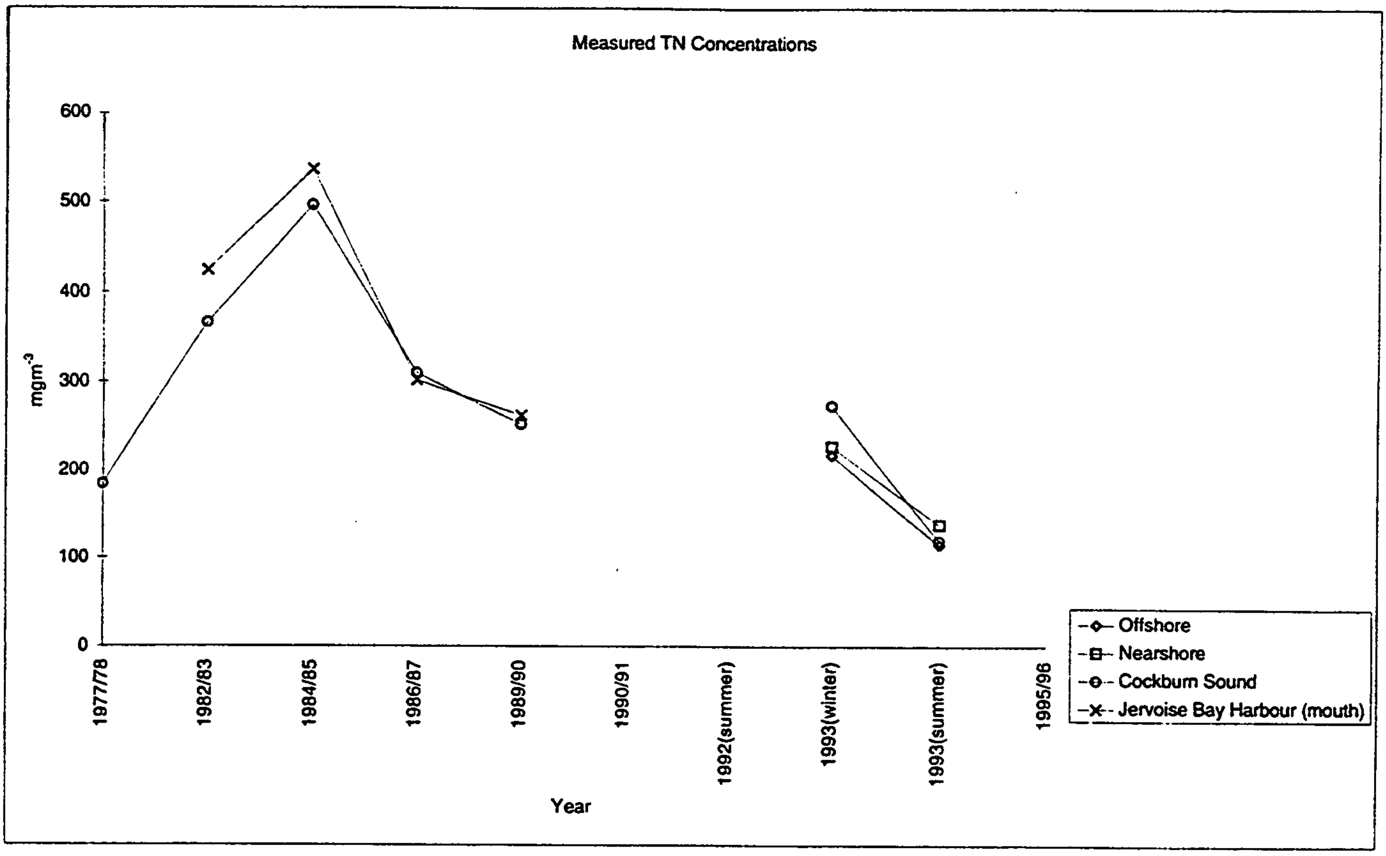


Figure 4.3.5 (a): Measured total nitrogen (TN) concentrations in Cockburn Sound and nearby waters.

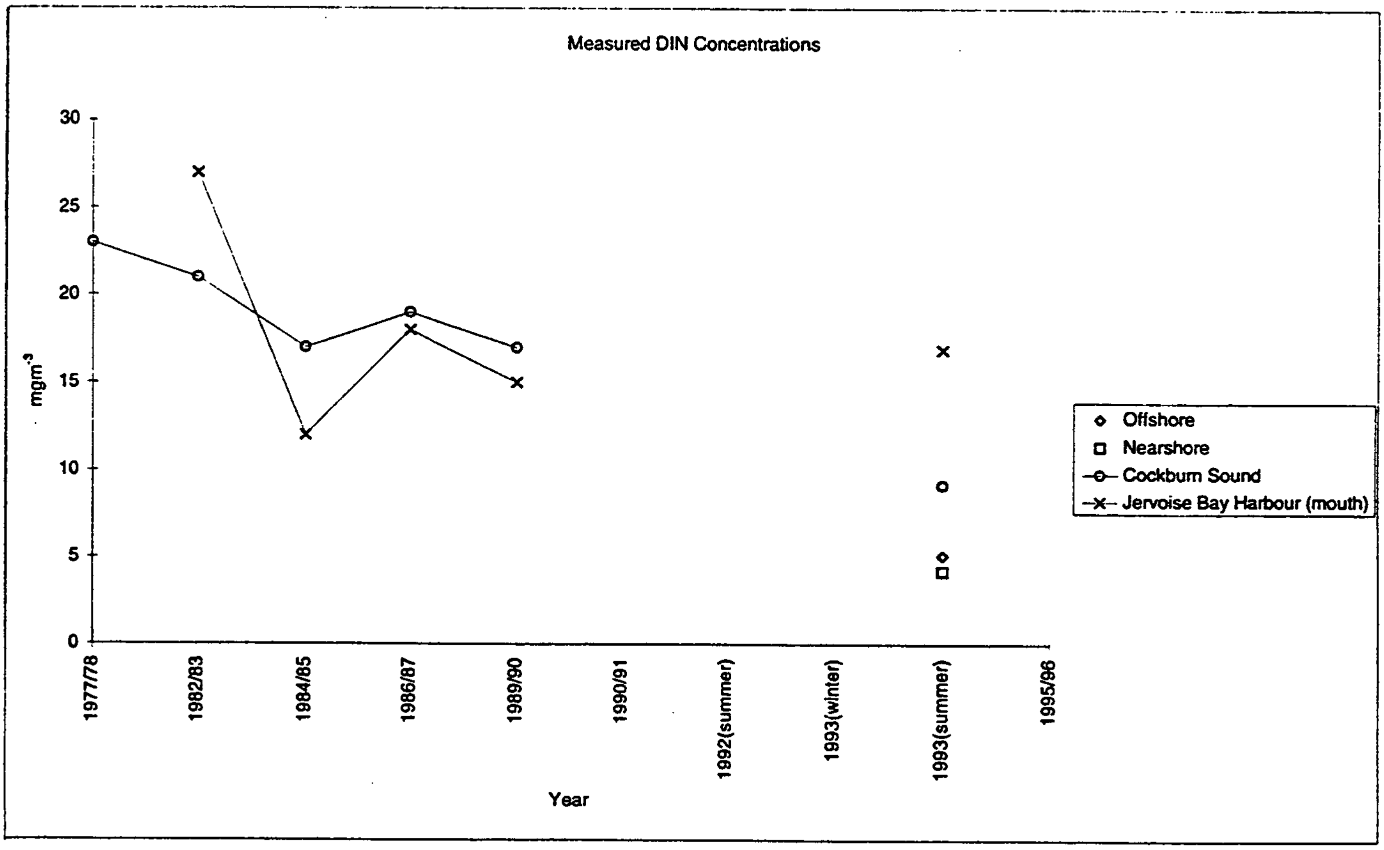


Figure 4.3.5 (b): Measured dissolved inorganic nitrogen (DIN) concentrations in Cockburn Sound and nearby waters.

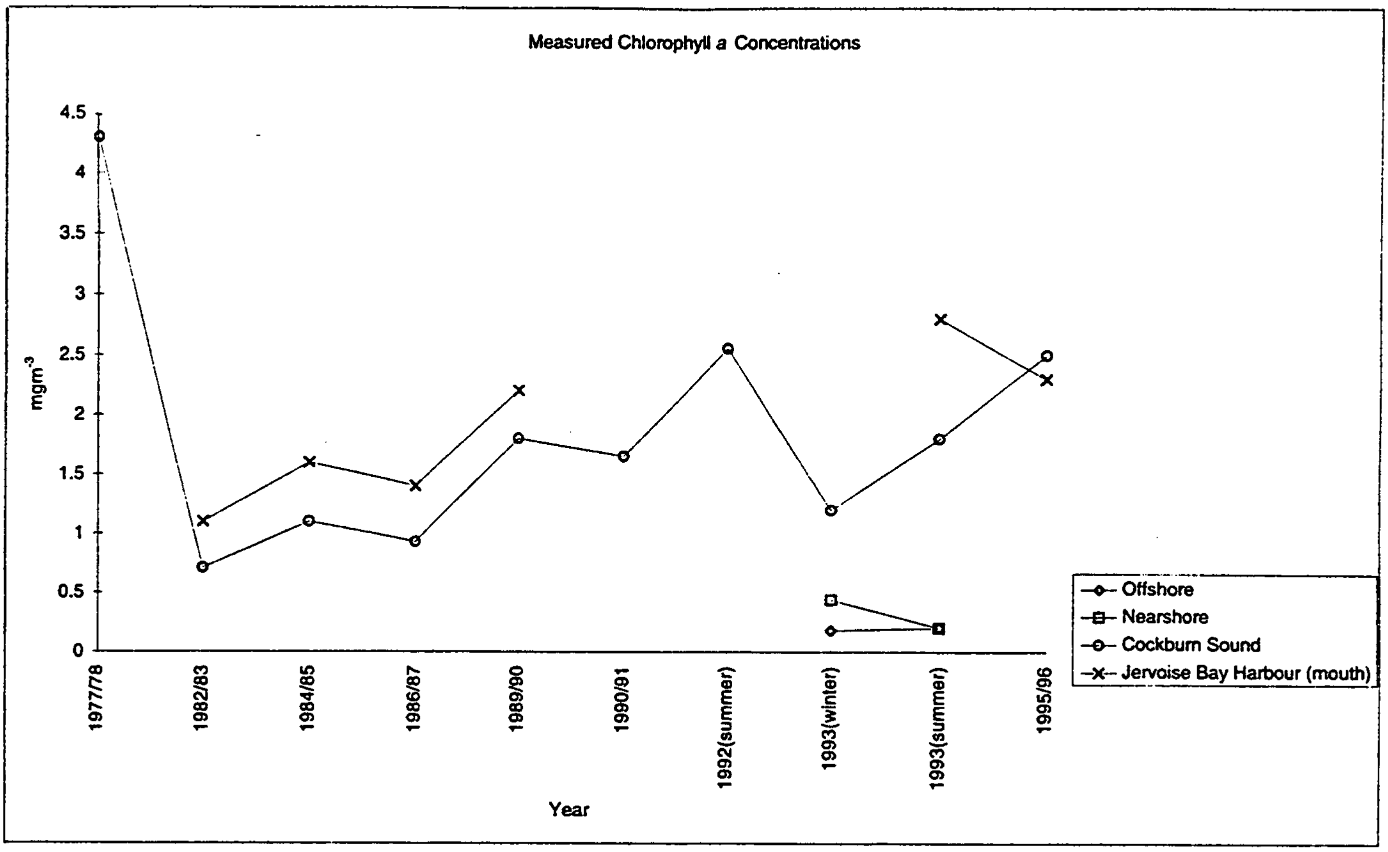


Figure 4.3.5 (c): Measured chlorophyll *a* concentrations in Cockburn Sound and nearby waters.

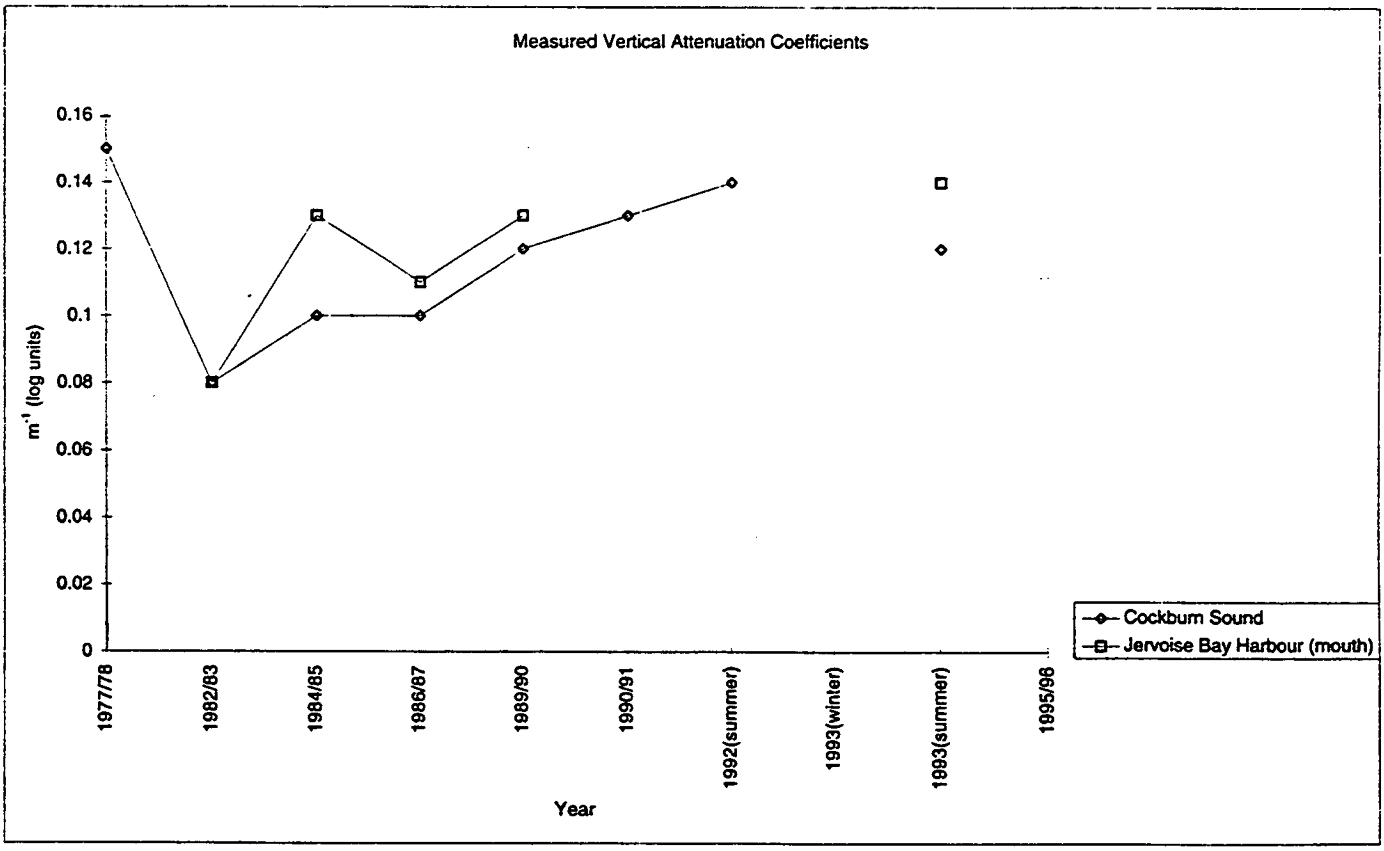


Figure 4.3.5 (d): Measured vertical light attenuation coefficients in Cockburn Sound and nearby waters.

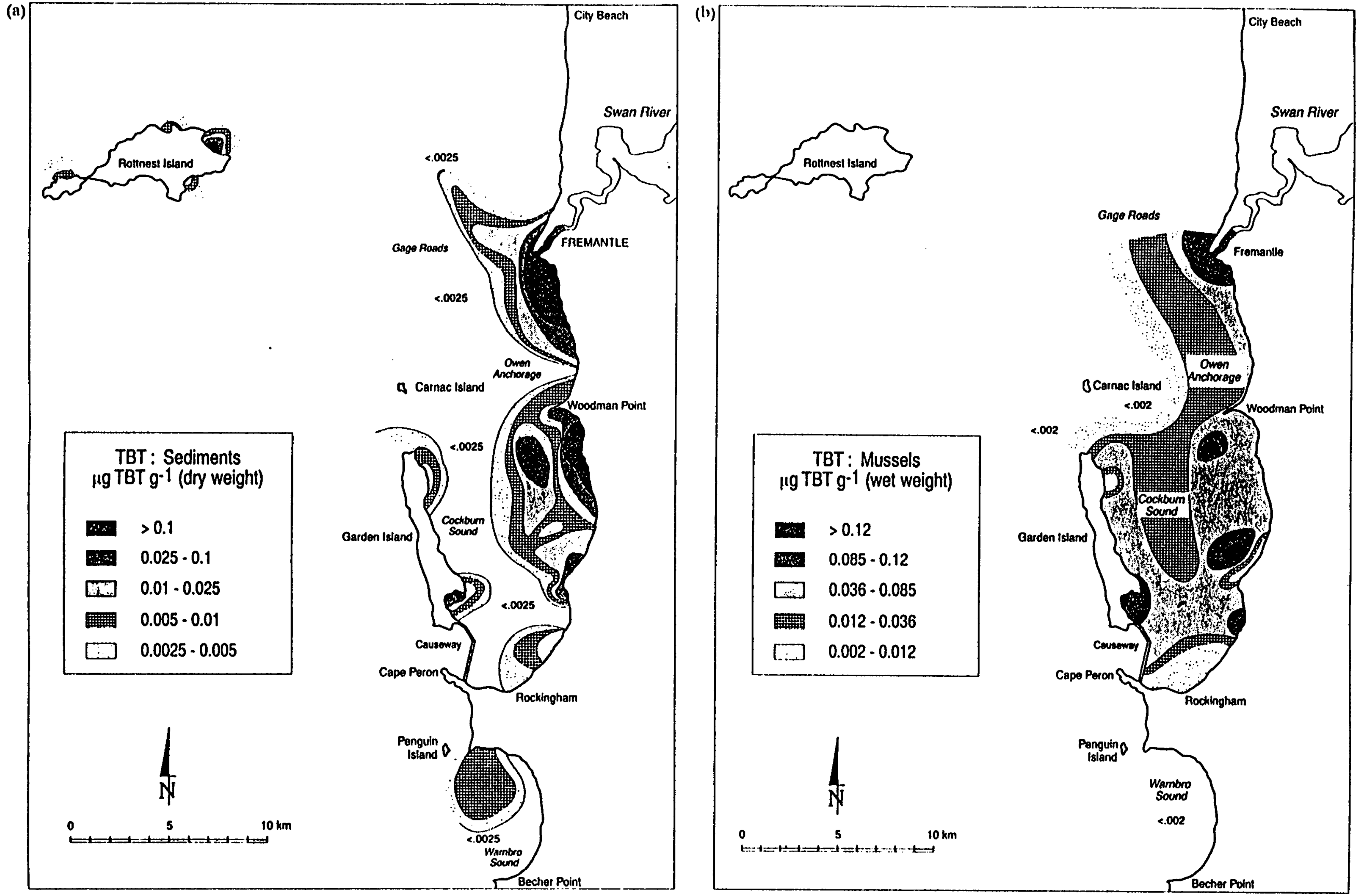
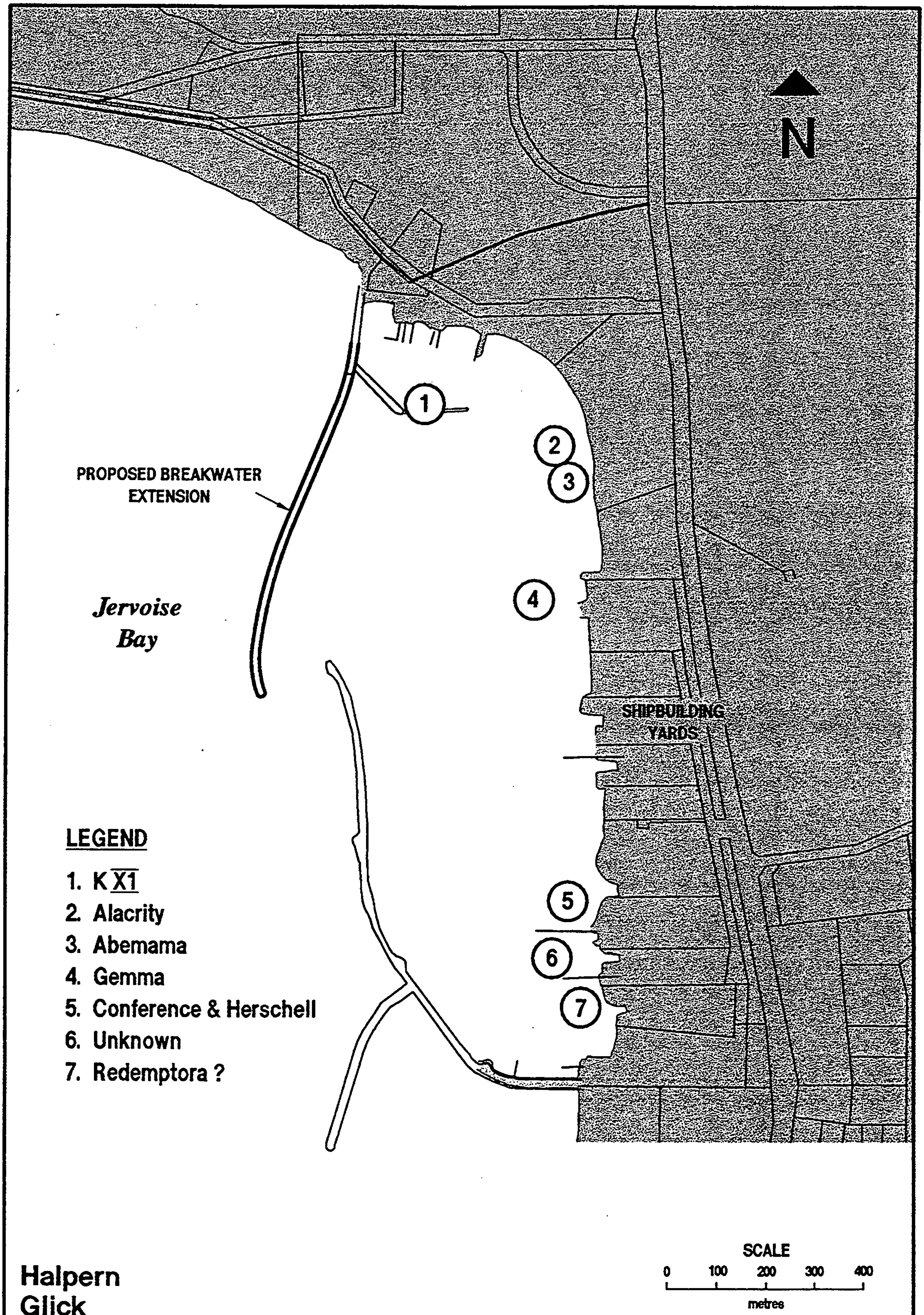


Figure 4.4.1: Distribution of Tributyltin in sediments (a) and mussels (b) throughout Perth's southern coastal waters (from Burt and Ebell 1995)



Halpern
Glick
Maunsell

FIGURE 5.1 : KNOWN WRECK SITES

Appendix A

Guidelines

JERVOISE BAY BREAKWATER EXTENSION

CONSULTATIVE ENVIRONMENTAL REVIEW GUIDELINES

Introduction

The Department of Commerce and Trade intend to extend the existing breakwaters within the Northern Harbour Precinct , Jervoise Bay (as indicated on attached map).

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, receiving environment, potential environmental impacts and the management of the issues arising from the environmental impacts, so that the environment is protected to an acceptable level.

Throughout the assessment process it is the objective of the Department of Environmental Protection (DEP) to assist the proponent to improve the proposal such that the environment is protected in the best manner possible. The Department will co-ordinate relevant government agencies and the public in providing advice about environmental matters during the assessment of the CER for this proposal.

Environmental Management

The proponent should approach environmental management in terms of best practise. Best practice environmental management includes:

- development of an environmental policy;
- agreed environmental objectives;
- management of environmental objectives;
- involve the public as appropriate;
- audit performance against agreed indicators;
- regular reporting to the DEP (or nominated agencies);
- commitment to a quality assured management system and continuous improvement;
- periodic (for example 5 yearly) review in conjunction with the DEP or nominated agencies.

Contents of the CER

The contents reflect the purpose of the CER, which is:

- to communicate clearly with the public (including government agencies), so that the Environmental Protection Authority (EPA) can obtain informed public comment to assist in providing advice to the two governments;
- to describe the proposal adequately, so that the Minister for the Environment can consider approval of a well-defined project; and
- to provide the basis of the proponent's environmental management programme, which shows that the environmental issues resulting from the proposal can be acceptably managed.

The language used in the body of the CER 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 CER. It should be noted that the CER will form the legal basis of the Minister for the Environment's approval of the proposal. Hence the CER should include a description of all the main and ancillary components of the proposal, including options where relevant.

The contents of the CER should include:

Overview

- introduction of the proposal, including a brief history of the project and location, and possible future stages. A clear overlay of a suitably scaled aerial photograph, which clearly indicates the nature and extent of works proposed. A regional map should be included which identifies the proposal within a social and regional setting.

Justification

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

The proposal

- description of the components of the proposal, including details of the ultimate scale, and proposed stages. This information could be presented in the form of a table which describes the key characteristics of the proposal; and
- timing and staging of project.

Existing environment

- description of the receiving environment which may be impacted;
- nearshore water quality within Jervoise Bay/ Cockburn Sound;
- marine flora and fauna which may be affected by the proposed construction of the breakwater; and
- existing public and private recreational use of the area (including fishing, swimming, boat launching, sight seeing).

Environmental factors

The environmental factors can be determined from a consideration, called scoping, of the potential impacts from the various components of the proposal on a receiving environment, including people. The CER should focus on the relevant environmental factors for the proposal, and it is recommended that these be agreed in consultation with the DEP and relevant public and government agencies. A description of the project component and the receiving environment should be directly included with, or referenced to, the discussion of the issue. The technical basis for measuring the impact and any specifications or standards for assessing and managing the issue should be provided.

The EPA considers that the proponent should provide a table which describes the following:

(a) the present state of the environment;
(b) potential impacts of the proposal on the environment;
(c) nominate environmental management objectives(s) for those aspects which require management;
(d) environmental management response to manage impacts to meet the above objective(s); and
(e) envisaged state of the environment.

The environmental factors from which the recommended environmental factors are derived (and their corresponding objectives) at this stage should be set out below under the following categories :

• biophysical;
• pollution; and
• social surroundings.

The factors identified and the EPA's management objective for these factors have been identified in the table below.

Environmental Factor	Environmental Objective	Proposed Management of Environmental Factor
Biophysical		
Marine habitat, including seagrass	To ensure the ecological function of Cockburn Sound is maintained.	No seagrass present in area affected by proposal.
Coastal stability/ sediment dynamics	To ensure that the proposed development does not have a significant impact on existing coastal processes.	Unlikely to require ongoing management.
Pollution		
Water quality	To meet requirements of the EPA's Environmental Water Quality Objectives.	Key assessment factor to be managed under Part IV of the Environmental Protection Act [1986].
Noise and vibration	To protect the amenity of nearby residents from noise and vibration impacts resulting from activities associated with the proposal by ensuring that noise and vibration levels meet statutory requirements and acceptable standards.	Managed under Part V of the Environmental Protection Act [1986] and in accordance with the existing and proposed Noise Regulations.
Dust	To protect the surrounding land uses such that dust emissions will not adversely impact upon their welfare and amenity or cause health problems.	Managed under Part V of the Environmental Protection Act [1986] and in accordance with the Draft EPA Dust Control Guidelines.
Social surroundings		
Heritage (Indigenous and non-indigenous cultures)	To comply with statutory requirements in relation to cultural or historic significance.	Managed under the Heritage Council of WA listing.
Traffic	To ensure that the increase in traffic activities resulting from the construction and operation of the proposal does not adversely impact on the public safety and amenity of local residents.	Any noise, vibration or dust to be managed under Part V of the Environmental Protection Act [1986]. Traffic impacts from construction work to be managed through hours of operation complying with the requirements of the Local Authority and development and implementation of a management plan by the proponent.

Further key issues may be raised during the preparation of the CER, and on-going consultation with the DEP and relevant agencies is recommended. Minor issues which can be readily managed as part of normal operations for similar projects may be briefly described. Information used to reach conclusions should be properly referenced, including personal communications. Assessments of the significance of an impact should be soundly based rather than unsubstantiated opinions, and the assessment should lead to a discussion of the management of the issue.

Relevant Environmental Factors and Management

At this stage, the EPA believes the relevant environmental factor is water quality. This factor should be addressed within the CER for the public to consider and make comment to the EPA, and will be addressed by the EPA in it's report to the Minister for the Environment.

Impacts :

- impact on water quality within the harbour, as a result of enclosing the harbour, specifically in relation to :
  - nutrient status and clarity;
  - potential impact of emergency Water Corporation sewage outfall; and
  - impact of contaminated groundwater flow into harbour.

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.

Management :

- discussion of the relevant environmental factors as related to relevant policies, objectives and/or standards which may apply;
- discussion of the management of the relevant environmental factors, including commitments to appropriate action; and
- a summary of the environmental management programme, including the key commitments, monitoring work and the auditing of the programme.

Public consultation

A description should be provided of the public participation and consultation activities undertaken by the proponent in preparing the CER. 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 issues 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.

Environmental management commitments

The method of implementation of the proposal and all commitments made by the proponent become legally enforceable under the conditions of environmental approval issued by the Minister for the Environment in the statement. Proponents are encouraged to consolidate the important commitments in the public review document, and these are attached to the Minister's statement.

Commitments which address relevant environmental factors will be audited by the DEP, along with the environmental conditions. The commitments should have the form of:

• the proponent (who) will prepare a plan or take action (what) to meet an environmental objective (why) by doing something (how/where), to a timeframe (when), and to whose requirements or advice, if not the DEP, the action/plan will be prepared. These commitments may be addressed in tabular form.

Other commitments, which address less contentious issues (and may be contained either within the public review document or in the summary of commitments), show that the proponent is dedicated to good environmental management of the project. The DEP expects that the proponent will audit these commitments by internal processes (under an Environmental Management System). Though not subject to routine audit by the DEP, it may periodically request that compliance with these commitments be demonstrated, so as to verify satisfactory environmental performance in the proponent's implementation of the proposal.

All commitments should define the objective and action in sufficient detail so that the achievement of compliance can be measured. The DEP acknowledges that, with the implementation of best practice and continuous improvement, the procedures to implement the commitment may need to be changed; these changes can be made in updates to the environmental management programme, whilst ensuring the objective is still achieved.