WESTERN AUSTRALIAN
PLANNING COMMISSION

ASCOT WATERS

Public Environmental Review

LEPROVOST DAMES & MOORE

INVITATION

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

The Western Australian Planning Commission proposes to dredge two channels to connect an existing man-made waterbody to the Swan River. It is intended to integrate the waterbody with the Ascot Waters Residential Development that is currently being constructed. The subject site is adjacent to the Ascot foreshore within the City of Belmont, west of the Garrett Road Bridge and north of the Great Eastern Highway. In accordance with the *Environmental Protection Act* 1986, a Public Environmental Review (PER) has been prepared which describes this proposal and its likely effects on the environment. The PER is available for public review for eight weeks from 10 July 1995.

Comments from Government Agencies and the public will assist the EPA to prepare an assessment report in which it will make a recommendation 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 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 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 environmentally more acceptable.

When making comments on specific proposals in 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 the 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:

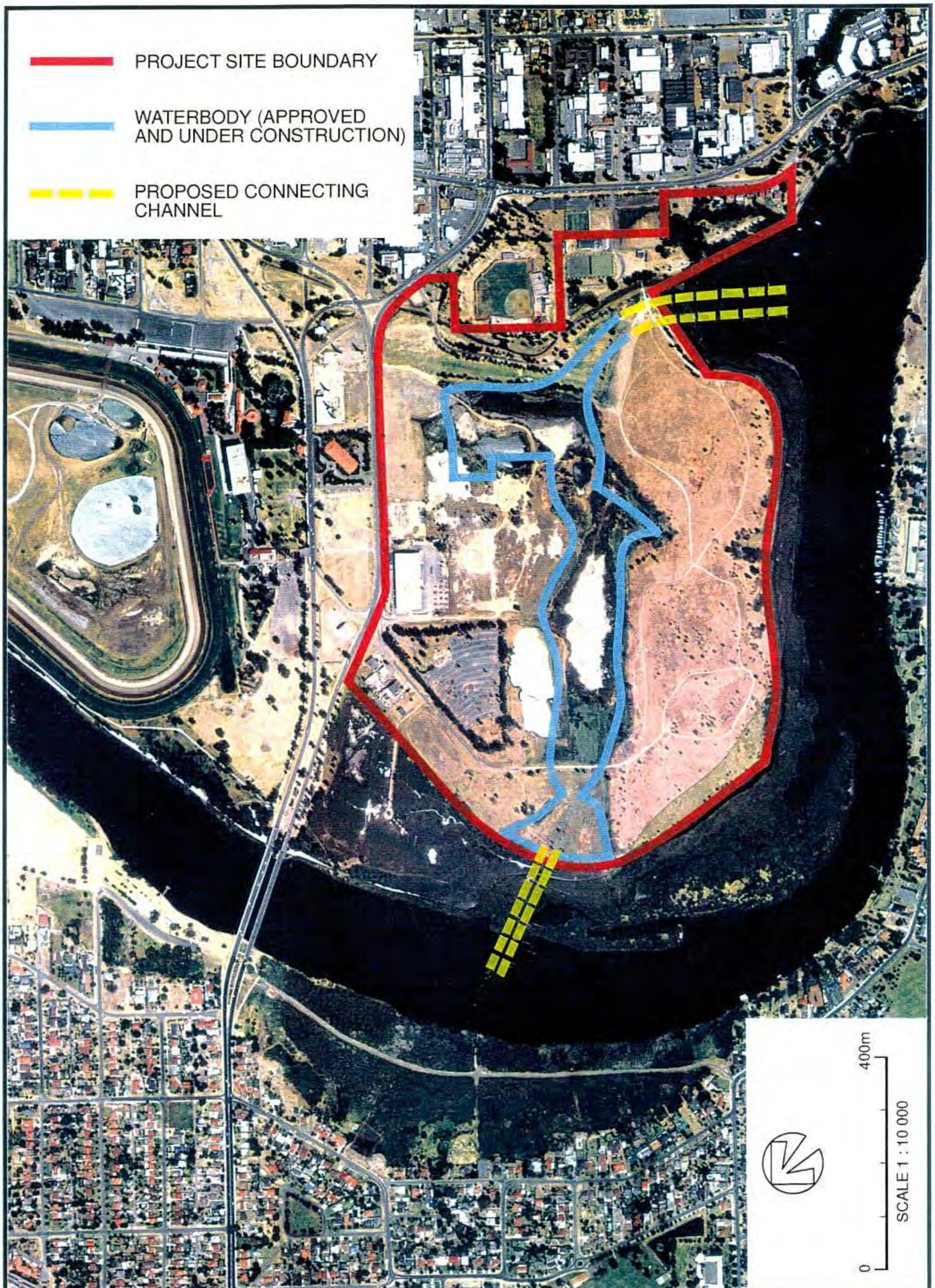
- your name;
- address;
- date; and
- whether you want your submission to be confidential.

The closing date for submissions is: 4 September 1995.

Submissions should be addressed to:

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

Attention: Gary Williams



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EXECUTIVE SUMMARY

THIS DOCUMENT

This document is a Public Environmental Review (PER) of a proposal to dredge two channels to connect an existing man-made lake to the Swan River on a site located at Ascot in the City of Belmont. One channel will be excavated through a disused tipsite, the other smaller channel through a System Six Area (M51). The purpose of this document is to seek environmental approval to dredge the two channels. The site is currently undergoing earthworks modification for an approved residential development known as Ascot Waters adjacent to the man-made lake.

THE PROPONENT

The Proponent for the Ascot Waters project is nominated as the Western Australian Planning Commission (WAPC). The WAPC, as lead Proponent, is supported by the City of Belmont. A Consortium is undertaking the development, and agreements exist whereby proponent responsibilities and undertakings under the *Environmental Protection Act* will be transferred to the Consortium as appropriate.

THE PROJECT SITE

The project location is known as Ascot. The major landform elements or features of the site were originally as follows:

- elevated developable land in the eastern and southern portions of the site in the vicinity of Resolution Drive, Harold Street, and Western Australian International Baseball Stadium;
- a disused tipsite adjacent to, and aligned parallel with, the eastern foreshore of the Swan River, opposite Maylands;
- a central low-lying floodplain running north to south between the developable land and the tipsite. The floodplain contains two large seasonal wetlands plus a clay pit;
- man-made clay pits adjacent to the floodplain;
- the Central Belmont Main Drain;
- a System Six Area (Part M51) fringing the Swan River and comprising saltmarshes and vegetated remnant sandbars; and
- the Swan River.

THE PROPOSAL

The proposal is to dredge two connecting channels through to the Swan River to connect with the internal waterbody. Specifically, this will involve:

- dredging of one 15 m wide by 1 m deep channel through the System Six Area and nearshore sandbars at the northern end of the wetland;

- the excavation of a 55 m wide channel to RL -2.5 m AHD through the southern end of the tipsite; plus

- the dredging of a 320 m long by 55 m wide navigation channel through river shallows to connect with the main deep channel of the river.

In addition, the downstream portion of the Belmont Drain will be remediated by constructing a series of three wet detention basins linked by pipe to a new discharge point located some 250 m downstream of the original outfall. It is also proposed to modify the mouth of the Abernethy Road Drain by constructing a wet detention basin on shore and undertaking localised foreshore and drainage improvement works.

The primary objective of this proposal is to rehabilitate the river floodplain and foreshore, and connect the internal waterbody to the Swan River in such a way as to:

- protect and enhance existing environmental values of the site;
- provide a net benefit to the Swan River environment; and
- provide a river foreshore as a regional recreation resource.

These actions will achieve a net benefit to the river by creating new river shallows and areas of fringing vegetation to replace similar areas which have historically been lost to development. It is also proposed to undertake works aimed at protection of the System Six conservation values, and provide for management of the System Six Area M51.

Increased recreational amenity of the area will be provided by a new destination for small powered craft in the southern part of the wetland, canoeing through the northern wetland and System Six channels, and a landscaped regional park with public walk trails and picnic areas on the tipsite.

ENVIRONMENTAL PROTECTION AUTHORITY PUBLIC ENVIRONMENTAL REVIEW (PER) GUIDELINES

The major concerns which have been expressed in association with this proposal and which the Proponent has been asked to address are:

- the effect of the source water quality from the Swan River and Central Belmont Main Drain on the development;

- protection of the Swan River environment from possible sources of contamination from within the site and from the effects of dredging;

- protection of System Six (M 51) values;

- protection of wetland values within the site; and

- future management responsibility for the environmental features of the development, i.e. the waterway, freshwater wetland, tipsite and System Six.

STRUCTURE OF THE DOCUMENT

This Public Environmental Review (PER) is slightly different to other environmental impact assessment reports in form and content. This is to make the document as relevant as possible to the Ascot Waters project, and to avoid inclusion of excessive information and material. The approach taken attempts to confine the document to discussing those topics of concern which have been raised by the Department of Environmental Protection and Swan River Trust (SRT) as requiring formal assessment.

Table 1 summarises the PER. Column 1 identifies the major environmental categories of physical, biological, social and pollution. Column 2 identifies the topics of concern associated with each category. Column 3 briefly describes the current status of each topic of concern. Column 4 outlines the development action proposed for each topic of concern (if appropriate) and Column 5 outlines the management action proposed to mitigate the development action. The last column outlines the outcome predicted by the Proponent as a result of both the development and management actions.

In summary, the desired outcome of this proposal is a net benefit to the Swan River environment and to the local community. To achieve this outcome, the project has been designed to be environmentally acceptable.

The remainder of this summary evaluates the costs and benefits of the proposal in terms of the river environment. The costs, or impacts, of the proposal are outlined first, and followed by description of the ameliorative actions proposed for their mitigation. The topics of concern are then addressed to show how the project proposes to resolve each topic and safeguard environmental values of the site. The perceived benefits of the proposal to the community are subsequently outlined. The summary concludes by identifying the range of management actions considered necessary to ensure the long term acceptability and viability of the proposal.

ENVIRONMENTAL IMPACTS

The existing Swan River environment will be subject to the following modifications (see Figure 18):

- the loss of some shallow subtidal flats and associated benthos in the vicinity of the proposed dredged downstream channel alignment, and the slight deepening (to -1m) of shallow sand bars within the alignment of the upstream dredged hydraulic link;

- the widening and slight deepening of an existing man-made channel through the narrowest part of the System Six Area and associated removal of sedge wetland;

- the extension of an existing man-made channel to form a protective moat (subject to landowner agreement) separating the development from the System Six Area and the associated removal of sedge wetland. This is proposed principally to protect System Six saltmarsh, and is not essential to the overall development;

- modification of the downstream portion of the Belmont Drain to include a series of three wet detention basins and extend the outfall some 250 m downstream;

- modification of the Abernethy Road Drain by constructing a wet detention basin onshore and removal of the intertidal outwash sediment fan at the mouth of the Drain by excavation to RL -0.5 m depth and removal of accumulated nearshore sand bars. These works are proposed by the City of Belmont for purposes of drainage and foreshore improvement; and

- a temporary and localised increase in water turbidity near the dredge and excavating equipment during the construction period.

PROPOSED MITIGATION

The above impacts will be thoroughly mitigated by:

- creation of a substantial area of new subtidal riverine habitat varying in depth between 0 and -2.5 m AHD within the existing waterbody (at least double the previous area);

- transplanting all sedge vegetation to be removed to the braided wetland and planting of substantial additional areas (at least double) of sedge vegetation throughout the upper reaches of the new waterway; and

- restriction of dredging to the most appropriate season (late autumn and winter) to minimise water quality effects.

RESOLUTION OF CONCERNS

It is submitted that all major topics of concern have been resolved by appropriate design solutions. Linking the internal waterbody to the river will not increase the risk of contamination of river waters as a result of groundwater seepage, efflux of tipsite leachate, or disposal of stormwater runoff. In addition, the new riverine waterbody will flush adequately and not become a source of additional nutrient enrichment and algal blooms.

Water quality within the new waterbody will be the same as that of the source waters in the adjacent river, and, as a result of both remediating and relocating the Belmont Drain outfall some 250 m downstream, will be suitable for the proposed beneficial use. In addition, the proposed remediation of both Belmont and Abernethy Road Drains will result in an improvement in water quality discharged to the river by both drains.

The conservation value of the System Six Area M51 has been recognised and its importance as a nutrient 'filter' for the river has been emphasised. Works proposed to control human access to the area include a boardwalk/nature trail, fencing to stop vehicle access off Resolution Drive, and a moat along the northern boundary of the development. These works are proposed both to protect the System Six Area from disturbance, and to ensure that the existing mosquito breeding problem in the saltmarsh is not exacerbated.

The works proposed to retain and enhance the waterfowl values of the predevelopment lakes include:

- retention and enhancement of one freshwater lake and the creation of additional freshwater wetlands within the stormwater management system;

- retention of existing sedge and samphire habitat and substantial revegetation of the eastern edge of the tipsite to provide both additional riverine habitat and a dense vegetative buffer; and

- creation of numerous island waterfowl refuges.

It is submitted that the new riverine waterway will when completed, provide substantially more useful feeding, breeding and roosting areas than originally existed, will maintain the drought refuge value of previous claypits, and will provide permanent rather than seasonal estuarine wetlands.

Furthermore, the substantial area of riverine habitat created within the new waterbody, including the braided wetlands, will provide additional nutrient stripping function for the Swan River. This, plus the creation of a substantial new area of shallow subtidal riverine habitat suitable for colonisation by fish and crustacea, means that the proposal will result in a substantial net benefit to the Swan River ecosystem.

MANAGEMENT REQUIREMENTS

The costs to the community arising from the project include:

- an additional improved area of riverine region open space to be maintained in perpetuity;

- an extension to the overall river waterways reserve to be managed in perpetuity; and

- navigable channels and hydraulic link to be maintained in perpetuity.

Management programmes have been designed to address potential environmental outcomes associated with:

- construction activity:
  - water turbidity;
  - soil stabilisation; and
  - public access and foreshore control;

- operational activity:
  - channel sedimentation, edge, foreshore and island soil stability;
  - vegetation planting;
  - marina and boating access;
  - vehicle access and parking;
  - water quality and circulation;
  - recolonisation of benthic habitat;
  - ongoing management of Open Space areas; and

- System Six Area (including access control, mosquito control).

It is considered that all environmental effects can be managed to avoid unacceptable outcomes.

The Proponent has accepted responsibility for a range of impacts associated with the project and is committed to implement the monitoring and management programmes as identified, to the satisfaction of the appropriate authorities.

BENEFITS TO THE COMMUNITY

The major benefits to accrue to the community as a result of this project will be:

- restored floodplain and floodplain function;
- increased regional recreational and leisure opportunities involving boating, canoeing and fishing;
- increased biological capacity/function of the river (additional estuarine habitat and nutrient stripping function);
- increased public access to the river foreshore;
- improved riverine landscape quality;
- improved opportunity for nature study and wildlife observation;
- provision for enhanced control of mosquito breeding; and
- increased land value and, as a result, economic return to the current landowners (the State and City of Belmont).

CONCLUSION

The Proponent gave considerable thought to the desirability of taking on what is in effect a major exercise in environmental design and engineering. A final decision to proceed with the challenge was made due to the conviction that the proposal offers tangible benefits to both the community and the river system as a whole. Significant formal and informal encouragement has been given to embark on the largest floodplain restoration project so far undertaken in the Swan River estuary.

TABLE 1

SUMMARY OF PROPONENT'S ADVICE TO ENVIRONMENTAL PROTECTION AUTHORITY

CATEGORY	TOPICS OF CONCERN	PRESENT STATUS	PROPOSED ACTION	PROPOSED MANAGEMENT	PREDICTED OUTCOME
Physical	Dredging/spoil disposal	Dredging previously widespread upriver	Two channels to connect internal wetland to river will be dredged in autumn/winter and spoil disposal to sealed settling pond Development site will be excavated in summer System Six and river channels dredged by small cutter suction dredge in autumn and winter	Channel bank stability to be monitored 'Return water' clarity to be monitored Potential leachate from tip to be monitored Management provision according to System Six Management Plan	No adverse effect No leachates from tip
	Hydrodynamics	Winter discharge - summer tidal	Channels and internal wetland designed to flush in 3 - 5 days (worst case)		No effect on river hydrodynamics, including drainage regime
	Sedimentation	Highly dynamic river system tending to shallow		Channel sedimentation to be monitored	Requirement for maintenance dredging is estimated at approx. every 10 years (worst case). (More frequent [1 in 5 years] additional maintenance dredging may be needed for the upstream channel.)
	Water turbidity	Very high in winter/low in summer	Spoil disposal to settling pond on tipsite Dredging to occur in autumn/winter	Settling pond water to be monitored for TSS and tip leachate for contaminants	No adverse effects on water turbidity
	Floodway	Requirements known and defined	Not impaired		Floodway capacity refined to WAWA satisfaction
Biological	Habitat loss	Widespread historical loss of riverine vegetation in upper estuary as result of filling	Creating estuarine fish nursery Braided riverine channels to be created in Kikuyu paddock between System Six and Stage 1 wetland	Monitor success of wetland revegetation and waterfowl use of wetlands General waterways management provisions to apply	Net increase in riverine habitat Colonisation by riverine flora and fauna Benthic ecology re-establishes
	Waterfowl values	Moderate	Freshwater wetland and fauna habitat value enhancement Wildlife conservation zone associated with riverine shallow with islands	General waterways management provisions to apply General waterways management provisions to apply	Improved wildlife management, and wildlife observation opportunities Maintain presence of waterfowl population and species diversity
	Fisheries	Moderate commercial/high recreation value	Creating estuarine fish nursery	Monitor success of benthos recolonisation	Increase in fish nursery habitat Improved recreational fishing opportunity
	Mosquitos	Recognised breeding area in System Six	Action dependent on outcome of Health Department study into physical control methods	Mosquitos to be monitored and management action implemented	Expected reduction in mosquito population
	Algal blooms/water quality	Transit occurrence during spring/early summer to late autumn		Freshwater wetland to be monitored and managed as appropriate Water quality of waterway to be monitored and general waterways management provisions to apply	Adequate flushing will prevent project being source of Swan River pollution Equal to existing shallow upper estuary water quality

TABLE 1

SUMMARY OF PROPONENT'S ADVICE TO ENVIRONMENTAL PROTECTION AUTHORITY

CATEGORY	TOPICS OF CONCERN	PRESENT STATUS	PROPOSED ACTION	PROPOSED MANAGEMENT	PREDICTED OUTCOME
Social	Aboriginal	No known archaeological sites	Undertaking given to consult with Aboriginal community	Involve Aboriginal community in System Six Monitoring for archaeological sites Consultation programme for potential projects	Increased opportunities for Aboriginal community
	System Six	High conservation value/no existing management	Moat proposed to be dredged along north side of System Six and other selected locations	System Six Management Plan to be prepared	Enhancement of System Six and wetland values
	Management (System Six and ROS) site	None, other than current mosquito control programme using chemical sprays	Boardwalk to be constructed in System Six	Removal of rubbish and exotic plants	Provision of waterway/wetland/tipsite management plan ROS management costs to increase overall (funding mechanism and management responsibility to be determined by Government)
	Landscape values	High in river environment, degraded on development site	Proposal is premised on need for restoration of river floodplain landscape values		Landscape values to be markedly increased
	Public access	Uncontrolled	To be controlled and guided through open space landscape plan		Increased managed public access to river foreshore
	Recreational boating	High on river, nil within development site	Power boating restricted to southern part of waterway and limited capacity marina Canoeing to be allowed elsewhere except in moat protecting saltmarsh	Provision of marina and waterway management	Provision of recreational facility (open space and marina) Recreational facilities for boaters
Pollution	Tipsite leachate	Minimal concern - previous studies indicate very low levels of leachate	Limited tipsite earthworks to RL 2.5 M to provide for floodway requirement Downstream channel edge and western section of braided channels edge to have clay-lined seal as required	Monitoring of leachates in waterbody during construction	No change in pre-existing situation expected
	Belmont Drain	Intermittent high bacteria/nutrient load	Matheson Drain to be piped and outfall extended 250 m downstream Wet detention basins on Belmont Drain, Matheson Drain (under negotiation) and Abernethy Drain BMP 'train' approach utilised in developed to settle and strip contaminants	WDB	Incremental improvement to water quality of discharge Contribution to ICMP Stimulus for further improvements in river water quality, management of Belmont Drain, and ICMP
	Stormwater runoff	Minimal at present, currently contained in wetlands	Comprehensive WSUD stormwater runoff treatment system proposed	Normal active/passive stormwater management to apply	Type example of WSUD applied to total urban precinct in sensitive area adjacent to river/wetland environment
	Contaminated site	Extremely low levels or organochlorines (well within specified health standards) in groundwater. No soil contamination	No action required	Continued monitoring during construction phase	Not applicable
	Noise and light (Parry Fields)	Intermittently high (event related)	Baseball stadium to be relocated by April 1996		Resolved

Terms used:

	BMP	=	Best Management Practice
	ICMP	=	Integrated Catchment Management
	ROS	=	Regional Open Space
	TSS	=	Total suspended solids
	WDB	=	Wet Detention Basin
	WSUD	=	Water Sensitive Urban Design

1 INTRODUCTION

1.1 THIS DOCUMENT

This document is a Public Environmental Review (PER) of a proposal to dredge two channels to connect an existing man-made lake to the Swan River on a site located at Ascot Fields in the City of Belmont. One channel will be excavated through a disused tipsite, the other through a System Six Area (M51). The purpose of this document is to seek environmental approval to dredge two channels to connect the lake to the Swan River. The site is currently undergoing earthworks modification for an approved residential development known as Ascot Waters adjacent to the man-made lake.

The Ascot Waters development already approved and under construction, to which this PER proposal relates, is a large-scale urban development project with a man-made lake setting.

1.2 THE PROPONENT

The Proponent for the Ascot Waters project is nominated as the Western Australian Planning Commission (WAPC). The WAPC, as lead Proponent, is supported by the City of Belmont. The project officer is Mr Bruce Cunningham of WAPC located at Albert Facey House, 469-489 Wellington Street, Perth, Western Australia 6000.

The development Consortium is a joint venture between Domain Project Development, Henry Walker Group and Estates Development Company.

1.3 THE PROJECT SITE

1.3.1 Site Location

The project location is known as the Ascot Fields (Figure 1). The overall development site of 97 ha is located in the City of Belmont, to the west of Resolution Drive and to the north of Great Eastern Highway (excluding the Parry Field baseball stadium). The site has frontage to the Swan River on the north and west side, and incorporates an extensive area of Swan River floodplain.

The principal focus of this PER, the connection of the internal waterbody to the Swan River, involves a portion of the overall site.

1.3.2 Major Site Elements

The major landform elements or features of the site were originally as follows (refer Figure 2 and Plate 1):

- elevated developable land in the eastern and southern portions of the site in the vicinity of Resolution Drive, Harold Street, and the Western Australian International Baseball Stadium;
- a disused tipsite adjacent to, and running parallel with, the Swan River, opposite Maylands;
- a central low-lying floodplain running north to south between the developable land and the tipsite. The floodplain contains two large seasonal wetlands plus a clay pit (lakes 2, 3 and 4 in Figure 2);
- man-made clay pits adjacent to the floodplain (lakes 1, 5 and 6 in Figure 2);
- Belmont Drain;
- a System Six Area comprising saltmarshes and vegetated remnant sandbars; and
- the Swan River.

1.4 BACKGROUND TO THE PROPOSAL

1.4.1 Government and Local Authority Initiative

For a considerable time the state government (Western Australian Planning Commission) and the City of Belmont have been interested in the redevelopment of the Ascot site. It has long been viewed as a large, strategically well positioned and under-utilised site in need of restoration and development, together with rehabilitation and creating facilities for community use. The current opportunity has come about largely due to the State Government and the City of Belmont being able to obtain funding from the Commonwealth Government through the Building Better Cities (BBC) Program.

1.4.2 Invitations to Submit Tenders

Expressions of interest were invited from commercial organisations interested in undertaking the development of the Ascot site in August 1994. A Project Implementation Brief (August 1994) was released jointly by the then State Planning Commission (now the WAPC) and the City of Belmont, which specified a number of considerations to be addressed. One of these included the development of an extended freshwater wetland system as previously proposed by Tingay and Associates (1993). Specifically the ecological value of wetland areas was to be enhanced by providing varied fauna and flora habitats and permanent water.

It is important to note that, subject to a number of conditions, the Environmental Protection Authority (EPA) had indicated that modification of the site to create a different wetland configuration would be environmentally acceptable and not require formal environmental impact assessment under Part IV of the Environmental Protection Act. This part of the development is referred to in the PER as Stage 1.

1.4.3 Successful Tender

Domain Project Development, The Henry Walker Group and Estates Development Company were selected as the successful tender on the basis that their proposal offered the most creative and environmentally integrated approach to restoring the site, enabling the site to be utilised in the most effective manner.

The development project proposed by the Consortium group involves bringing the Swan River into the site to enable small boat access to a commercial centre, rehabilitation of estuarine wetlands, enhanced mosquito control and management of the System Six Area, improved public access to the river foreshore and landscaping of the Belmont tipsite (refer Figure 3).

The tenderer recognised that the preferred development proposal would require formal environmental assessment because it involved both water-based recreational boating and dredging of access channels. To access Better Cities funding, however, earthworks needed to commence by June 1995. To enable this, a two stage earthworks programme was proposed whereby Stage 1 would conform to development guidelines established by the EPA for which an informal level of assessment had already been set.

A document providing a description of the earthworks programme proposed for Stage 1 (refer Figure 4) and the environmental management programme proposed to ensure minimal adverse effect on the river, the System Six conservation area, and the local community was submitted to the EPA in February 1995. Approval to undertake the Stage 1 earthworks was received in March 1995.

As a consequence the site is currently subject to comprehensive site modification to implement the Stage 1 earthworks concept. This concept includes the following aspects of the proposal:

- construction of an internal wetland varying in depth from 0 - 2.5 m depth. This has required filling of deep claypits to the desired level and excavating parts of existing shallow wetlands;
- construction of developable land on the eastern side of the site by the addition of fill;
- modification of the Belmont tipsite topography above RL 2.5 m to maintain WAWA floodway requirements and provide view corridors and clean fill material;
- preservation and enhancement of one freshwater lake (lake 1 in Figure 2). Enhancement involves filling to reduce depth, creation of island refuge and shallow banks for habitat rehabilitation;
- preservation of existing riverine wetland habitat adjacent to the eastern shore of the tipsite;
- creation of four vegetated island refuges within the internal waterbody to create a waterfowl conservation area; and

- topsoil modification on selected parts of the landfill site and the planting of trees adjacent to the riverine habitat to provide a buffer to waterfowl conservation areas and System Six M51.

The Stage 2 earthworks required for connecting the internal waterbody to the Swan River (the subject of this PER) will only be initiated if approval to proceed is obtained via the formal environmental assessment process.

1.5 THE PROPOSAL

The proposal is to dredge two connecting channels through to the Swan River to connect with the internal waterbody (refer Figure 5). Specifically, this will involve:

- dredging of one 15 m wide by 1 m deep channel through the System Six Area and nearshore sandbars at the northern end of the wetland;

- the excavation of a 55 m wide channel to RL -2.5 m AHD through the southern end of the tipsite; plus

- the dredging of a 320 m long by 55 m wide navigation channel through river shallows to connect with the main deep channel of the river.

In addition, the downstream portion of the Belmont Drain will be remediated by constructing a series of wet detention basins. The Matheson Drain will be linked by pipe. It is also proposed to remediate the mouth of the Abernethy Road Drain by constructing a wet detention basin on shore and undertaking localised foreshore and drainage improvement works.

The primary objective of this proposal is to rehabilitate the river floodplain and connect the internal waterbody to the Swan River in such a way as to:

- protect existing environmental values of the site;
- provide a net benefit to the Swan River environment and recreational opportunities; and
- provide a river foreshore as a regional recreation resource.

These actions will achieve a net benefit to the river by creating new river shallows and areas of fringing vegetation to replace similar areas which have historically been lost to development. It is also proposed to undertake works aimed at protection of the System Six conservation values, and provide for management of the System Six Area M51.

Increased recreational amenity of the area will be provided by a new destination for small powered craft in the southern part of the wetland, canoeing through the northern wetland and System Six M51 channels, and a landscaped regional park with walk trails and picnic areas on the tipsite.

From the outset the Proponent has maintained the following objectives for the proposal:

- the proposal must be environmentally sensitive, achieve a high level of environmental quality, and be visually integrated with the Swan River landscape;

- the landscape and environmental components of the development, together with the human activities that will be associated with them, must function correctly and without negative impacts on the adjacent river environment, nearby residents or occupiers of the development; and

- the overall design (urban, landscape and environmental) of the project must achieve as far as possible, a biologically healthy well functioning system in order to minimise the need for ongoing management.

The final development plan proposed for the new river suburb is shown in Figure 6.

1.6 COMMUNITY CONSULTATION

This project differs from many others in that its very inception has involved Commonwealth, State and the Local Government. The Proponent is indeed a key decision making authority.

Extensive consultation with all Decision Making Authorities (DMAs) involved with this project has taken place from the outset. This has included the Western Australian Planning Commission, the City of Belmont, the Department of Environmental Protection, the Waterways Commission/Swan River Trust, Department of Conservation and Land Management, the Water Authority of Western Australia and the Health Department of Western Australia. All concerns expressed and all advice given has been taken into account in the preparation of this PER.

Special interest groups, such as the Royal Australasian Ornithologists Union, local Aboriginal communities and the Western Australian Turf Club, have also been consulted.

1.7 ENVIRONMENTAL PROTECTION AUTHORITY PUBLIC ENVIRONMENTAL REVIEW (PER) GUIDELINES

The EPA has provided PER guidelines for the project. These are reproduced in Appendix A.

The major concerns which have been expressed in association with this proposal and which the Proponent has been asked to address are:

- the effect of the source water quality from the Swan River and Central Belmont Main Drain on the development;

- protection of the Swan River environment from possible sources of contamination from within the site and from the effects of dredging;

- protection of System Six (M51) values;

- protection of wetland values within the site; and

- future management responsibility for the environmental features of the development, i.e. the waterway, freshwater wetland, tipsite and System Six.

1.8 DESIGN STUDY TEAM

As a consequence of the design challenges associated with this site, an experienced team of individuals with expertise in the various aspects of the project have been assembled. The design study team comprises:

- LeProvost Dames & Moore - PER preparation and study coordination;
- M P Rogers and Associates Pty Ltd - design of waterway to ensure adequate flushing and water quality, and study of siltation and dredging aspects;
- Evangelisti & Associates - management of urban runoff and nutrient removal techniques
- CMPS & F Pty Ltd - earthworks, site contamination and groundwater characteristics
- Russell Taylor and William Burrell - development plan and urban design
- Jane Latchford, Murdoch University - System Six saltmarsh and mosquito management
- David Deeley, Murdoch University - Swan River hydrodynamics and water quality
- Prof. I Potter, Murdoch University - fish and macrobenthic fauna of the Swan River
- Mike Bamford, RAOU - waterfowl aspects
- Land Systems EBC - landscape aspects

1.9 STRUCTURE OF THE DOCUMENT

This Public Environmental Review (PER) is slightly different to other environmental impact assessment reports in form and content. This is to make the document as relevant as possible to the Ascot Waters project, and to avoid inclusion of excessive information and material. The approach taken attempts to:

- confine the document to discussing those topics of concerns which have been raised by the Department of Environmental Protection and SRT as requiring formal assessment under Part IV of the *Environmental Protection Act* (EP ACT, pt IV);

- explain the way in which the project has been designed to accommodate environmental needs (i.e. Project Design and Description); and

- provide detailed scientific discussion and explanation in supporting technical texts in the Appendices.

The structure of the report is as follows:

Section 1 - Introduction and Background
Section 2 - Description of Project Site (Physical, Biological and Social)
Section 3 - Project Design and Description
Section 4 - Environmental Management
Section 5 - Commitments and Undertakings
Section 6 - Conclusion
Section 7 - References

Supporting technical reports are appended as follows:

- Appendix A - Environmental Protection Authority: Redevelopment of Clay Pits for Waterways Development Affecting System Six Area M51, Public Environmental Review Guidelines

- Appendix B - M P Rogers & Associates: Ascot Waters Water Quality, Siltation and Dredging Study (Report R013 Rev. 1)

- Appendix C - D M Deeley, Marine and Freshwater Research Laboratory, Institute for Environmental Science, Murdoch University: Water Quality in the Upper Swan Estuary, Issues and opportunities

- Appendix D - J Latchford and R Segal, Marine and Freshwater Research Laboratory, Institute for Environmental Science, Murdoch University: Ascot Fields Saltmarsh Vegetation and Mosquito Survey (Report No. MAFRA 95/9)

- Appendix E - I C Potter, G A Hyndes and M E Platell, School Biological and Environmental Sciences, Murdoch University: The fish and macrobenthic faunas in the region of the proposed Ascot Fields development in the upper Swan Estuary

- Appendix F - M J & A R Bamford Consulting Ecologists: Conservation Value for Waterbirds: Ascot Waters (Report No. 2)

- Appendix G - CMPS & F Pty Limited - Environmental Division: Ascot Fields - Groundwater Analysis

2 DESCRIPTION OF PROJECT SITE

2.1 INTRODUCTION

This section provides a summary description of the salient environmental characteristics of the site. The description is divided into the following headings in accordance with Department of Environmental Protection (DEP) Guidelines:

- Physical
- Biological
- Social
- Pollution Sources

Coverage of each topic is kept as brief as possible. Those individuals and/or organisations wishing for more detailed information and discussion are referred to separate technical papers (Appendices A to G) provided by specialist sub-consultants.

Readers are reminded that this assessment is concerned with the formal environmental impact assessment of the waterway link of the internal water body to the Swan River and not the broader aspects of the development, hence does not include a comprehensive geographic description of site elements unrelated to the waterway link or creation of the internal waterbody. The site has been investigated and reported on extensively over many years, and a bibliography is included at the end of this document.

2.2 PHYSICAL ENVIRONMENT

2.2.1 Topography and Bathymetry

The physical landform elements of the site have been described previously in Section 1.3.2. The topography of the project site prior to the commencement of Stage 1 works and the bathymetry of the Swan River adjacent is shown in Figure 7.

The Ascot Waters site is located in the Swan River floodplain, with existing elevations over much of the eastern developable portion of the site at 2 m AHD. The area in the vicinity of Harold Street rises to 4 m AHD. The tip site located in the western portion of the site rises to 8 m AHD. Between these two parts of the site is a very low-lying (0.5 m AHD) 'floodway' area featuring both permanent and seasonal wetlands. The System Six riverine wetlands which fringe the river occur between 0 and 1 m AHD.

The bathymetry of the adjacent Swan River indicates that the Ascot Waters site is separated from the deep water channel by shallows on the south side of the river, part of which have built up to become the vegetated sandbars and saltmarsh of the System Six M51 area. Generally the deep water channel of the river is at approximately 2.5 to 3.5 m.

The landform of the Ascot Waters site is therefore an old floodplain landscape lying on the convex (inside) bend of the meandering upper estuary of the Swan River. This low lying landscape has been modified by the introduction of the tipsite rising to approximately 8 m, considerably higher in elevation than the 4 m of the highest ground in the eastern part of the site.

2.2.2 Geology and Geomorphology

The geology of the site is shown in Figures 8, 8a and 8b. In geological terms, the site is dominated by Guildford Formation which lies at between 3 and -8 m AHD, with much of the new internal waterbody aligned where the upper surface of the Guildford Formation is at 0 and -3 m AHD. The subcrop contours (approximations only) indicate that there is a dip or channel in the formation approximating to the location of the proposed waterbody, and a very deep channel (or valley) to -6 m AHD in the vicinity of the Belmont drain.

In the south-western part of the site, the Guildford Formation is overlain by Swan River Alluvium and in the north-eastern part of the site by inorganic fill and miscellaneous waste. In the case of the tipsite, the Guildford Formation is overlain by organic fill. The organic fill is 'separated' from the Guildford Formation by a thin (≈1 m) layer of sand fill. The Guildford Formation itself, although by no means uniform, is a sandy clay with 40 - 60% sand. This is a relatively impermeable substrate. The inorganic fill over portions of the site is unconsolidated and comprised primarily of building rubble and old tiles.

2.2.3 Hydrogeology

The groundwater contours, as indicated in Figure 9, indicate a general flow from east of the site towards the Swan River. The figure also indicates that the watertable level is very close to, or at, or above the original ground level for much of the floodplain portion of the site. Winter waterlogging is usual.

Salinity levels in the groundwater previously tested in most bores throughout the site (Tingay 1992) was relatively low. Only in a minority of bores was there a tendency for higher salinity levels at depth.

2.2.4 Wetland Hydrology

Prior to the commencement of Stage 1, there were six lakes on the site. Of these, only lake 1 (the most northerly - see Figure 2) now remains in its original form, and will be retained as a modified freshwater lake. The rest have been variously modified to accommodate the bulk earthworks for the approved elements of the Stage 1 development.

The current works are integrating lakes 2, 3, 4, and 5 to create a single fresh to brackish water lake system for the interim period, prior to approval to dredge the connecting channels to the Swan River. Lake 6 has been filled to provide developable land. The total area of the new waterbody created is significantly larger than the combined area of the former lakes.

The hydrology of the wetlands occupying the site prior to current construction activity varied according to their origin. The clay pits on the eastern side of the site were basically replenished by groundwater seepage. The seasonal wetlands in the floodplain were replenished by a combination of surface runoff, direct interception of rainfall, input of river water during flooding, and groundwater seepage. Water levels in these lakes were governed by a drain beneath the tip which links the floodplain to the Swan River.

The hydrology of the new internal waterbody is expected to be similar to that described above. Fresh groundwater inflow is expected in the vicinity of lake 5 while the drain beneath the tipsite is expected to enable Swan River water to also flow into the site. As before, this drain will govern water levels in the waterbody.

2.2.5 Swan River Hydrology

The hydrodynamics of the Swan River in the vicinity of the project site have been investigated and described by M.P. Rogers and Associates in Appendix B. Water quality aspects have been described by David Deeley in Appendix C. The salient physical features of the river hydrodynamics are summarised below.

- The Swan River estuary system comprises three main regions (lower, middle and upper region; Chalmer, 1976), and the section of riverline adjacent to Ascot Waters lies in the downstream section of the upper region. The upper estuary is defined as the reach of the river that is subject to tides and which extends from the Causeway to Middle Swan Bridge at Guildford. These waters have limited exchange with the ocean because the shallows of the Perth Water restrict tidal exchange.

- There are a number of forcing mechanisms which drive the motion of the water in the upper estuary. These are listed in the table below, along with their relative influence on the flushing of the proposed waterbody across the four seasons.

FLUSHING MECHANISM	RELATIVE EFFECT			
	WINTER	SPRING	SUMMER	AUTUMN
Stream Flow	Very high	High	Low to very low	Low
Astronomic Tides	Moderate	Moderate	Moderate	Moderate
Density Currents	~ Zero	~ Zero	Low	Low
Wind Shear	Very low	Low	Low	Very low

  Stream flow is the main flushing agent during winter and spring. During summer and autumn, tides become the dominant forcing mechanism.

- Comparison of tide gauge data for Barrack Street jetty and Guildford show a similar tidal range, implying that the Submergence Curve for the Barrack Street jetty (Figure 10) is applicable to Ascot Waters except during periods of high discharge. The average daily tidal range in the Ascot Waters area is 0.3 - 0.4 m. Mean water levels in the upper estuary are on average close to AHD, but tend to be about 0.1 m higher in winter and 0.1 m lower in summer. Peak levels typically occur during winter months as a consequence of rainfall.

- The upper estuary becomes almost completely fresh in mid-winter when river streamflow is at its peak. At this time river water tends to be dark brown in colour as a result of suspended sediment load, diatom growth and humic staining. With cessation of rainfall and runoff in spring, water salinities gradually increase as a result of penetration of marine waters upriver. The salinity increase occurs as a shallow wedge moving along the bottom of the river during spring and early summer. This leads to intense stratification of the vertical water column which causes deoxygenation of the deeper, more saline waters. Anoxia in these waters results in the release of nutrients from bottom sediments which in turn feed the growth of phytoplanktonic green and red algae. During spring and summer, water colour is markedly influenced by phytoplankton blooms and can be either bright green or rusty brown. The onset of winter runoff reduces salinities very quickly and begins the cycle anew.

The complex cycles of physical, chemical and biological activity in the Swan estuary at Ascot are summarised in Figure 11. This conceptual model of cyclical behaviour was derived from data from a single intensive investigation (Deeley & Hosja, 1995), and longer-term historical monitoring in the estuary.

2.2.5.1 Physical Water Quality

Salinities in the estuary from Rivervale to Maylands Pool averaged from 18 to 14 ppt, decreasing upstream, but ranged from 7 ppt in winter to above 25 ppt in late summer. Bottom water salinities reached a maximum of 28 ppt in autumn.

The repeating cycle of fresh to saline conditions is illustrated in Figure 11 using long-term (12 year) monitoring data from the Swan at Garratt Road bridge, and an understanding of cycles in the Peel-Harvey and other southwest estuaries (Hodgkin & Clark, 1988; Deeley & Hosja, 1995; James et al., 1995).

Salinity increases from a minimum over winter in a near linear fashion, governed by normal estuarine hydrological processes and tidal forcing. The salinity maxima in late autumn approaches marine salinities before it falls rapidly with the onset of fresh runoff from the catchment.

The cycles of these average conditions could be modified in the event of unseasonally wet summers which reduce summer salinities. Alternatively, exceptionally dry winters may be followed by higher than normal summer salinities in the upper estuary.

The occasional wet February is a feature of Perth's weather, and this is shown as the small ellipse below February on Figure 11a. Northern cyclonic activity is responsible for this occasional summer runoff which has been observed several times in recent years (Deeley & Hosja, 1995).

Dissolved oxygen averaged 70% saturation, but this masked the opposing effects of summer supersaturation from surface phytoplankton blooms and benthic anoxia shown in Figure 11. Dissolved oxygen in winter was relatively invariant at between 70% and 100%

saturation. Spring photosynthetic activity increases surface dissolved oxygen to supersaturated conditions above 130% saturation which remain high in surface waters for most of summer falling back to normal levels through autumn.

Dissolved oxygen levels in deeper bottom waters typically fall to below 50% saturation from spring through summer to late autumn. Minimum values of less than 15% saturation have become common in spring and late autumn (Deeley & Hosja, 1995).

2.2.5.2 Chemical Water Quality

Average inorganic nitrogen concentrations have been high, and ammonia-N levels have averaged more than 10 times draft national water quality guidelines (ANZECC, 1994). Nitrate N has been at acceptable levels and mean TN concentrations were equivalent to or in excess of the upper limit of draft national guidelines.

The seasonal picture on inorganic N in Figure 11 strongly reflects the effect of very high inputs from winter runoff. A large proportion of the ammonium-N load comes from the Avon catchment and is rural in origin (Donohue et al., 1994).

Filterable reactive P (FRP) Levels averaged around 30 µg/L which was well above draft national guidelines of <15 µg/L. Figure 11d shows a similar pattern of high levels of NH_4-N and FRP from winter runoff. Spring FRP levels are reduced, particularly when phytoplankton populations are increasing. Summer months sees higher FRP levels, probably reflecting nutrient release from anoxic sediments.

2.2.5.3 Biological Water Quality

Average chlorophyll-a levels have remained low at below 10 µg/L. Peak levels in excess of 30 µg/L have been observed in this location (Deeley & Hosja, 1995). The pattern of chlorophyll-a activity at Ascot is summarised in Figure 11e using a log scale.

Chlorophyll-a values were lowest in late winter and early spring and increased markedly to a summer maxima. Chlorophyll-a levels fall through autumn and increase markedly in early winter. Chlorophyll-a levels again fall through late winter.

Cell counts of phytoplankton averaged in excess of 5,000 cells/ml over the warmer months. Maximum cell counts in excess of 30,000 cells/ml have been common in the area. Phytoplankton species include dinoflagellates or 'Red Tides' in warmer months and diatoms in cooler months.

2.3 BIOLOGICAL ENVIRONMENT

This section describes the flora and fauna of the main elements of the project site which support vegetation and wildlife. They are:

- the Swan River;
- the System Six Area; and
- the degraded floodplain wetlands and claypits.

2.3.1 Swan River Fauna

The lower intertidal and subtidal zones of the river channel provide shallow and deep water habitats for 34 fish species and at least 47 species of benthic macroinvertebrates. The following account of these components of the riverine fauna has been summarised from a technical review by Potter, Hyndes and Platell of Murdoch University (Appendix D) and from information supplied by Mr J. Mountain (President, Swan River Freshwater Fishermen's Association) and Mr Gary Shugg (recreational fishery spokesperson).

Of the 34 fish species, two are introduced (mosquito fish and crucian carp) and eleven others are taken by recreational fishers. Most of the latter species, together with the Perth herring, were also targeted by a commercial fishery between the late 1940s and 1970s. Reductions in demand and prices during the 1980s accelerated the decline in the number of licensed commercial fishers, and the entire riverline upstream of the Causeway Bridge is now fully closed to commercial netting operations. Present commercial fishing activities in the river system are based on six active units. This effort is now focussed almost solely on blue manna crabs which are taken downstream of the Narrows and Canning Bridges in the middle region of the estuary.

The various fishes in the Ascot Waters project area can be grouped into one of five different life-style categories, with the majority (26 species) representing two of these divisions. Each category reflects a different pattern of use of the estuary system during the life cycle. One division contains 12 species which collectively are termed 'marine estuarine-opportunist' species. These include the sea mullet, yellow-eye mullet, mulloway and tailor (and also crustaceans such as the blue manna crab and western king prawn). These are all essentially marine species which breed at sea. However their juvenile stages subsequently enter estuaries, usually in large numbers. These species provide the main reason why estuaries are regarded as important 'fish nursery areas'.

The other major life style category in the project area contains 14 species which can complete their entire life cycle without having to leave the estuary. Termed 'estuarine species', these include the black bream, yellow-tail trumpeter and smaller taxa such as the hardyheads (Atherinidae) and gobies (Gobiidae).

The remaining eight species which occur in the project area comprise:

- one semi-anadromous species (the Perth herring, whose adults migrate up the river from the sea to spawn in the upper estuary and are typically very abundant in the project area);
- four freshwater species (including the introduced crucian carp and mosquito fish); and
- three 'marine stragglers'. These are errant species which occasionally move up the estuary (usually in relatively small numbers).

A five year research programme which examined the distribution of fish throughout the Swan estuary system found that the five most abundant species in the upper estuary region containing the Ascot Waters project area were Perth herring, sea mullet, anchovy, a hardyhead and a goby. These contributed over 92% of the total catch from this part of the system. All five species were most abundant during summer periods (when the upper region often provides lower salinity waters than other parts of the system).

In the shallower areas the most abundant fish was the Perth herring (contributing to over 75% of the total shallow water catch). This species also dominated the gill net catches in the deep water areas (87% of total catch), but only 9% of the catch taken by deep water trawling. The most predominant species taken by the latter method comprised gobbleguts (39% of the total catch), yellowfin trumpeter (35%), flathead (5%) and cobbler (5%). Western king prawns and school prawns also occur in moderate numbers, usually in summer and early autumn.

Black bream also occur in large numbers in the upper Swan estuary, but there are no accurate abundance estimates for this recreationally important species (its preferred habitat amongst tree roots and snags prevent abundance estimates by netting methods). However, the black bream population is known to be concentrated in the upper estuary of the estuary (including the project area), and is almost completely restricted to this region during the spawning season (from middle spring to early summer).

The various species of benthic macroinvertebrates in the project area are distributed according to depth and substrate type. Substrates in the shallow areas (<1m deep) are generally characterised by coarser sandy sediments whilst those in the deeper areas (>3m) typically consist of finer, softer and occasionally very muddy sediments. Ninety percent of the species occur in the shallow areas. By contrast, only five of the macro-invertebrate species taken from the deep water areas were not found in the shallows.

At shallow sites near the project area, the ten most predominant benthic species comprised three bivalve molluscs, four polychaete worms and three crustaceans, and these species represented 85% of the total mean density of the macrobenthic fauna (10,533 individuals per m^2). In the less productive deeper water areas, the mean density of macrobenthic animals near the project area is approximately one quarter of that in the shallow areas (i.e. 2,575 per m^2).

The three most abundant shallow water benthic species comprise the microbivalve mollusc *Arthritica semen* (28%), the estuarine mussel *Xenostrobus securis* (13%) and the amphipod crustacean *Paracorophium excavatum* (12%). A site at Maylands Pool, which is very close to the project site, supports particularly dense mats of estuarine mussels.

2.3.2 System Six M51

The System Six M51 area refers to remnant river saltmarshes and vegetated sandbanks immediately downstream of the Garrett Road Bridge, on both the north and south side of the river channel. System Six reserves were recommended to Government by the EPA in 1983 (Department of Conservation and Environment, 1983, Report 13). The recommendations were endorsed by Cabinet at that time, and the System Six recommendations have been a cornerstone of EPA's conservation protection policy ever since.

2.3.2.1 Vegetation

The vegetation of the System Six Area was mapped for this PER by Jane Latchford of Murdoch University. A detailed description is presented in Appendix E.

The saltmarsh that exists close to the development site is of particular importance, being an extensive remnant of a once much larger resource in the Swan River and one of the largest now remaining on the south side of the river. The saltmarsh supports a diversity of plant species, including *Sarcocornia quinqueflora*, *Suaeda australis*, *Halosarcia caldwellii*, *Halosarcia halocnemoides* and *Juncus krausii*.

The vegetated sandbank islands have a cover of *Casuarina* sp. with a fringing understorey of *Juncus* sp.

Vegetation mapping (Figure 12) undertaken in the preparation of this PER reveals that there are eight vegetation complexes in the overall System Six Area. These are as follows:

Class 1: *Casuarina* sp in the eastern corner of the System Six Area, adjacent to the development;

Class 2: *Halosarcia halocnemoides*, a common saltmarsh species found on higher ground;

Class 3: *Suaeda australis*, which exists where there is a fresh water influence;

Class 4: *Sarcocornia quinqueflora* and *H. halocnemoides*, which is an intermediate height to Classes 2 and 5;

Class 5: a low marsh consisting mainly of *S. quinqueflora*, *S. australis*, *Juncus* sp. This is termed a low marsh;

Class 6: composed of *Juncus* sp and *Casuarina* sp. with *Casuarina* often at the river edge of the marsh and usually at higher ground adjacent to the proposed development;

Class 7: composed of *Eucalyptus* sp and *Casuarina* sp on higher ground adjacent to the development; and

Class 8: a mixture of *S. quinqueflora*, *S. australis*, *Juncus* sp. and *Casuarina* sp. found on one of the islands.

The System Six Area is not entirely pristine, having been extensively modified in parts; for example, historical digging of a moat between the tipsite and the remnant saltmarsh and of drains and channels within the saltmarsh and fringing *Casuarina* stands, the existing radio transmitter mast together with an extensive below ground 'earthing grid' in the saltmarsh area on the south side, and the recent construction of a cycleway through the portion on the north side of the river. The vegetated sand banks do not have a pristine understorey and ground cover, there being extensive occurrence of introduced grasses, as well as substantial evidence of discarded rubbish as a result of human access. In addition the saltmarsh area is a major mosquito breeding area and subject to an ongoing mosquito control programme undertaken by the City of Belmont.

From a vegetation point of view a most significant part of the System Six riverine environment is the saltmarsh area. The Ascot Waters saltmarsh is in very good condition and consists of a wide variety of species and is good example of the marshes that were once prevalent along the river banks.

The System Six Area therefore is a river conservation area of considerable value and importance. It is one of relatively few remnant 'natural' fringing areas remaining in the upper estuary of the Swan River, and requires a high level of protection.

2.3.2.2 Fauna/waterbirds

A report produced by Tingay and Associates (1993) refers to a survey of the System Six saltmarsh over the period November 1992 to February 1993 that indicates that M51 was of little importance to waterbirds. However it was cautioned that conditions at the time could have yielded misleading results. During a site visit by consulting ecologists M J and A R Bamford in April 1995 (Appendix F), the area of islands and channels nearby contained 79 waterbirds of 10 different species. The overall conclusion is that M51 may be more important for waterbirds than is indicated by available data.

The value of the System Six Area to fauna other than waterbirds, is not known. As far as is known there have been no comprehensive fauna surveys to date. However, as saltmarsh areas are generally regarded as one of the most productive ecosystems in the world it can be assumed that there will be a diverse littoral fauna. Mosquitos are a natural part of the saltmarsh ecosystem. Adult and larval mosquitos are important components of the saltmarsh foodchain.

2.3.3 Wetlands

2.3.3.1 Remnant Vegetation

As pointed out in Section 2.2.4, the original lakes are now largely replaced by the recontoured earthworks to create one larger basin with only lake 1 and the western shores of lakes 2 and 3 being retained in their original form.

The original vegetation within the development site adjacent to the wetlands has been described by Tingay and Associates (1993) and was mostly covered with dense Kikuyu grass (refer Figure 13). Nearer the lake margins Kikuyu tended to give way to stands of sedge and Bulrushes (*Typha orientalis*). The original vegetation and wildlife characteristics of the wetlands is described here because one of the DEP concerns (Section 1.7) was that the original wetland values of the site be protected.

Vegetation within and around each lake varied. Lake 1 was mainly fringed with Kikuyu grass and some limited *Typha*, particularly in the northwest corner. Lake 2 had fringing samphire species (*Halosarcia indica* and *H. halocnemoides*) on the east and southern margins in water up to 20 cm deep. At the northern end and down the western edge *Juncus pallidus* formed a wide margin to the lake.

Much of the *Juncus* sp margin, and some of the fringing samphire has been retained as part of the earthworks for the new waterbody.

Lake 3 featured a stand of *Typha* along the northern lake edge. On slightly higher ground were several *Casuarina obesa* trees up to 10 m tall. Also nearby were a scattered stand of Flooded Gums (*Eucalyptus rudis*). The *Casuarina* and Flooded Gum have been retained by current earthworks.

The margins of Lake 4 mostly contained weed species with occasional *Casuarina obesa* and *Eucalyptus rudis* trees. In the northeast corner were *Typha*, Sedge and some *Halosarcia* species.

Lakes 5 and 6, both now entirely removed, featured virtually no native plants. Dense stands of Typha around Lake 6 provided some habitat value. Both lakes had thick growths of *Potamogeton pectinatus* in their shallow margins during spring and summer.

Apart from this vegetation the site had a scatter of native trees around the lakes, including Paperbarks (*Melaleuca rhaphiophylla*), *Acacia saligna*, and *Viminaria juncea*. There was also an abundance of Caster Oil plants (*Ricinus communis*), Bamboo (*Arundo donax*) and occasional Pine (*Pinus radiata*), Poplar (*Populus* sp) and Cape Lilac (*Melia zaedarach*) trees. These have all been removed.

2.3.3.2 Waterbirds and other Fauna

The value of the lakes to waterfowl and other fauna is not well documented. However, it was stated in correspondence from the DEP to the then State Planning Commission, 10 March 1994, that "the Claypits and surrounding upland are degraded and have limited value to wildlife". The correspondence continued, "... notwithstanding this, the claypits provide useful complementary wildlife habitat to the wetlands associated with the estuary ...".

Very little detailed information on waterbird usage of the site prior to current development is available (refer Appendix F). Irregular Royal Australasian Ornithological Union (RAOU) surveys over a number of years only recorded presence and absence of species over the entire area, including System Six. The only information which relates waterfowl usage to specific lakes is a brief study in summer 1992 by Tingay and Associates (1993) which provides the following information.

Lake 1 was recorded as having some value to water birds as a roosting site and a source of freshwater for birds which feed on the other nearby wetlands, especially lake 2. Previous studies (e.g. Tingay and Associates, 1993) suggest that bird species and numbers were linked to ecological changes in Lake 1. Availability of freshwater in summer when other shallow lakes become more saline was considered to be the principal value of lake 1.

The habitat value of lake 2 for nesting and feeding in late spring and early summer appeared to be the highest of all lakes in the Ascot Waters site. In one survey (November 1992; Tingay and Associates, 1993), nine species and a total of 99 birds were recorded as present. The number of birds was seen to decline thereafter as the lake dried up. The value to waterbirds was seen to be reflected in the abundant food sources.

Lake 4 was recorded as supporting a significant range of species and number of waterbirds (e.g. range of eight to 12 species, 1992 and 1993; Tingay and Associates, 1993). Its value to waterbirds appeared to be that it provided ecological requirements for a wide variety of species; it became shallow relatively later in the season compared to lake 2 and it provided a good range of both plant and animal foods.

While it was thought that lake 3 provided very little food owing to its depth, a combination of old poles emerging from the water and fringing bulrushes apparently provided roosting sites. This provided some value to waterbirds.

A similar pattern of bird presence was recorded for lake 6 also. The number of waterbirds present was found to increase in February as the shallower margins were exposed to provide mudflats attractive to wading species.

The value of the wetlands to mammals was apparently limited. Surveys conducted by Tingay and Associates in 1992 (Tingay and Associates, 1993) found no native mammals at all. Trapping techniques deliberately designed to attract the indigenous Water Rat (*Hydromys chrysogaster*), reported as present in the area, proved unsuccessful.

Two mammals were trapped these being the Black Rat (*Rattus rattus*) and the House Mouse (*Mus musculus*), both of which are typical species for modified sites, including severely disturbed and degraded sites. It was concluded that the site had no value for indigenous mammals and therefore that no special measures need to be taken to protect mammal habitats (Tingay and Associates, 1993).

In terms of frogs, only the Green and Golden Bell Frog (*Litoria moorei*) were trapped during survey (Tingay and Associates, 1993). Although it was concluded that the Moaning Frog (*Heleioporus eyrei*) and *Crinia georgiana* may also have been on the site, the frog fauna was limited in terms of both number of species and populations.

The only reptiles recorded on the site was the Long-necked Tortoise (*Chelodina oblonga*) and the Dugite (*Pseudonaja affinis*). The Long-necked Tortoise was previously recorded in lakes 1, 2 and 4, and very recently was found during earthwork activities on the western edge of lake 2 in large numbers (these were relocated to the Swan River). Long-necked Tortoises are capable of walking long distances between favourable habitats, and regular movement between the Swan River and internal wetlands would be expected.

2.3.4 Nuisance Organisms

Two nuisance organisms regularly occur within the immediate vicinity of the project site. These are mosquitos and algal blooms. Both are monitored and managed as appropriate by the relevant government agencies. Both are currently under investigation with the aim of developing a long-term management resolution. The purpose of describing them here is to acknowledge that these organisms exist in the area, and describe the processes which cause the nuisance as background to designing the proposed project to ensure that the nuisance is not exacerbated by the proposal. Relevant details on each nuisance organism are provided below.

2.3.4.1 Mosquitos

Mosquitos are both a nuisance insect and a disease vector. The saltmarsh areas of System Six adjacent to the Swan River are a recognised regional mosquito breeding ground. The most vigorous breeding ground for mosquitos is the area around the transmitting tower (Class 5 vegetation complex in Figure 12) and the track that runs due north of the tipsite. These sites are monitored weekly by Belmont City Council from August to April to assess mosquito population levels and need for population control via larvicide application.

The majority of the System Six saltmarsh will breed mosquitos throughout the year. A wider variety of mosquitos will breed during winter due to the decrease in salinity of the water. During the cooler months mosquitos do not transmit viruses and are just a nuisance.

During the warmer months from August to April, *Aedes camptorhynchus*, *Aedes vigilax* and some *Culex annulirostris* will breed in the saltmarsh. The warmer weather allows the mosquito larvae to develop to adults within five days, thus mosquito numbers tend to be higher during this period. Ross River and Barmah Forrest virus activity also increases with the warmer weather. The threat of contracting these diseases is therefore greatest in summer.

Both species are salt tolerant, and both lay eggs on damp exposed soil. The eggs hatch only when the soil is subsequently covered with water. The larvae undergo an aquatic phase of development which, under warm weather conditions, requires five days to produce a flying mosquito. Hence the worst breeding sites are areas in the salt marsh where pools of water can accumulate for at least five days in summer. Management of breeding can be achieved by either filling or draining ponds so that water does not accumulate over the five day breeding period, and ensuring that the proposal does not create breeding grounds.

The Mosquito Control Advisory Committee has recommended that no physical control methods be carried out until the imminent completion of a study for the Health Department of Western Australia on the effectiveness and environmental impacts of 'runnelling', a physical mosquito control method. If the outcome of the study proves to be positive, the area around the radio masts (the most intense mosquito breeding site) could have some form of physical control implemented. The details would depend on the location of the copper earthing mats. Such an approach would compliment the existing control programme undertaken by the City of Belmont of weekly monitoring and the use of liquid Vectobate and granular Abate during summer.

2.3.4.2 Algal Blooms

Algal blooms have become an increasing problem within the upper estuary in recent years, a symptom of the decline of physical, chemical and biological water quality of this part of the river system.

Part of the problem is that, on the one hand the river catchment has been extensively cleared and the estuary now receives far higher sediment and nutrient loads than previously under pre-settlement conditions. On the other hand, the river's capacity to cope with nutrients through natural biological and limnological processes has been radically reduced due to the extensive loss of fringing vegetation, saltmarshlands and natural floodplains.

There is therefore a considerable nutrient and contamination load within the river system which is artificially high and caused by society. In addition, the river has lost much of its 'natural' capacity to cope with 'natural' (pre-settlement) levels of nutrient due to extensive clearing and the loss of aquatic fringing vegetation. These riverine vegetation systems undertake a vital nutrient uptake, or 'stripping' function, and are therefore essential in maintaining water quality and a healthy productive river biology.

As indicated in Section 2.2.5, algal blooms are stimulated by the release of nutrients under anoxic conditions. This occurs normally in deep holes where the water body is intensely stratified. Oxygen depletion tends not to occur in shallow, well flushed and well mixed waters. Hence the waterway created by the proposal will need to be designed to flush well and minimise the potential for deoxygenation of bottom waters and maximise potential for nutrient stripping and reoxygenation of river waters.

With good flushing, the water within the Ascot Waters waterbody will at best be of the same quality as that of the Swan River. For most of the year (winter and spring) this is good, but in late spring and early summer (before the winter rains cease) especially, water quality can decline.

Phytoplankton species have included green chlorophytes and dinoflagellates or Red Tides in warmer months and diatoms in cooler months. The blooms of recent times in the vicinity of the Garrett Road bridge during summer have been of non-toxic species, and have been odourless and free of floating scum, and therefore have required little management other than to release media warnings to swimmers with sensitive skin. It is likely that the current minor nuisance blooms will continue to occur during spring and summer in the future.

The prognosis for the future water quality of the river is difficult to make. A very worst case scenario is that toxic blue-green algal blooms will develop as has occurred in the Canning, Kalgan, Blackwood and Serpentine Rivers. Should such blooms occur, they would prevent direct water contact recreation activities and consumption of fish. They will also cause odours and form an organic scum which may need to be removed by waterways managers as has happened at Mandurah.

However, as has happened in the Peel-Harvey, when a major problem develops, then the community finds the resources to solve it. State Government has recently established the Estuarine Research Foundation (W.A.) to fund research into the problem and many studies are currently ongoing. There is optimism that solutions exist and that their feasibility will have been tested within the next few years and a remedy undertaken within the next five to 10 years.

A realistic prognosis might therefore be that the red tides and green blooms will continue at the same levels.

2.4 SOCIAL ENVIRONMENT

2.4.1 Planning Context

In land use and planning terms the Ascot Waters proposed development is an appropriate use of the site. As stated previously the site is a former industrial precinct now vacant. Yet strategically it is a very well located site next to two regional roads providing access to Perth Airport, and the Perth City centre. Local and regional road access to the site is good.

To the south of the site are a mix of recreational, sports and commercial land uses. These include the Western Australian international baseball stadium, the Grove Farm Reserve and mixed commercial and office use on Great Eastern Highway.

The majority of the site is zoned Urban and a portion is reserved for Parks and Recreation purposes under the Metropolitan Region Scheme (MRS) (Figure 14). The site has also been the subject of an Improvement Plan (IP20) since 1984 under Section 37 of the Metropolitan Region Town Planning Scheme Act since 1984. This is a clear indication of the long term planning intent to bring about the comprehensive redevelopment of the Ascot Waters site. The City of Belmont has amended its Town Planning Scheme No. 11 to zone the land within the project area in accordance with the MRS.

2.4.2 Land Ownership

The total development site of approximately 97 ha comprised approximately 28 ha urban zoned land, 68.5 ha as Parks and Recreation reservation, and a remaining portion of approximately 0.7 ha. Ownership of the urban portion includes:

- Western Australian Planning Commission approximately 20 ha
- Council approximately 7.5 ha
- Private approximately 0.5 ha

The Parks and Recreation Reserve component of the site, which is the part of the site in which the new wetland, the freshwater lake, and the tipsite occur, currently remains in the same ownership:

- Western Australian Planning Commission approximately 56.4 ha;
- Council approximately 12 ha; and
- private approximately 0.1 ha.

2.4.3 History of the Site

The recent history of the development site includes the progressive cessation of virtually all previous activities and the closure of various facilities. A substantial part of the eastern half of the site was a former Bristile Ltd brick making factory. This included clay pit excavations (hence the origins of several of the lakes), stockpile areas and brick furnaces nearby. North of the Bristile Ltd operations was the former Belmont Drive-in Cinema which closed in the 1980s.

On the northern side of Harold Street and the nearby side of Resolution Drive there were a mix of commercial and residential premises. At the western end of Harold Street there is reputed to have once been a dairy, which would explain the existence of the Kikuyu paddock adjacent to the System Six Area.

The western portion of the Ascot Waters site was used as an urban organic and inorganic landfill site for 20 years from the 1960s until it closed in 1982. As a result of concern regarding tipsite leachate entering the river, a moat was excavated along the western and northern edge of the tip and the river alluvium was piled on the edge of the tip in an attempt to seal leachate within the tip. A number of man-made channels have also been excavated within the islands and saltmarsh of System Six.

The large radio mast presently occurring on the System Six saltmarsh was installed in the late 1950s or early 60s and includes a large radial copper earthing mat extending like the spokes of an umbrella beneath the samphire flat. This flat was extensively disturbed when the mats were installed and the samphires have since recolonised the site.

2.4.4 Current Uses of the Site

The current land uses are the Parry Field Baseball Stadium, the NTA and 6IX transmission towers, Whittakers and small light industrial workshops in Harold Street. However, the majority of the site is vacant and now subject to ongoing construction activities associated with the implementation of the Stage 1 Ascot Waters project.

Incidental use of the foreshore areas and the System Six Area by amateur fishermen, boat users, and other recreationists occurs from time to time, however such activity is confined to fairly limited accessible sites.

2.4.5 Guidelines for Future Use and Development

Guidelines for preferred development of the site were established by the Western Australian Planning Commission (former State Planning Commission) and the City of Belmont in the Project Implementation Brief of August 1994. The background to the tender process is provided in Section 1.4 of this PER.

In the Project Implementation Brief, upon which the successful tender was based, guidelines for the preferred form of development were provided. Firstly, the Brief identified the key features of the site as follows:

- the unique location of the site adjacent to the Swan River which can be beautified and made accessible for the enjoyment by the public;
- the opportunity for residential development which will offer Western Australians an exciting locality in which to live and create a desirable riverside suburb;

- the protection of important, natural environmental areas and the improvement of their environmental quality to encourage riverine flora and wildlife;

- the opportunity for commercial and mixed use developments which will provide an attractive gateway to the City of Belmont;

- the better use of existing infrastructure and facilities; and

- the stimulus of inner metropolitan area development.

The Brief specified a preferred form of development based on a concept development plan with the following features:

- protection of the System Six Area;

- beautifying the foreshore and making it accessible and a source of enjoyment to the public by protecting fringing vegetation, creating wildlife refuges and a beach and boardwalk;

- creating an attractive lake system from the existing clay pits and wetlands;

- the provision of housing;

- sensitively designed mixed use development which relates to the river and lake system and bringing vitality to the area; and

- the provision of a commercial/community focus which introduces an interesting and common architectural theme.

The Brief went on to state (page 15) that the preferred concept plan was "not fixed and development proposals which vary the plan are encouraged provided they are consistent with its objectives and with the development guidelines, and design principles, for the project."

A number of specific environmental guidelines were also provided in the Brief as follows:

- waterbird habitats should be maintained or expanded in the redevelopment of the wetlands at Ascot Waters;

- excavation and other modification of the wetlands for sand recovery or other purposes must be consistent with the ecological requirements of waterbirds (eg roosting, feeding, nesting, and freshwater sources);

- wetland features considered important include:

    - acceptable water quality,
    - variations in depth,
    - islands, exposed sandbars, and sheltered beaches,
    - fringing and island vegetation, and
    - protection from human intrusion;

- preparation and implementation of a management plan should be undertaken as part of the redevelopment;

- mosquito control programme in the System Six Area should be taken into account;

- modification of the Belmont Drain to help improve the environmental state of this watercourse would be encouraged;

- the shallow mudflats within the Belmont Inlet are an important habitat for birds and disturbance of them should be minimised;

- lake 1 is an important freshwater habitat and should be retained but could be modified;

- consideration of the landfill site should include differential settlement of the fill, and the potential for generation of landfill gases and leachate;

- account should be taken of any potential soil or water contamination from hazardous or intractable wastes on the site, both in the movement of earthfill on site and the management of groundwater and surface waters.

2.4.6 Conservation Values - System Six M51

The System Six Area M51 is statement of significant conservation value attached to the specified area (Figure 15). The System Six Report (Report 13, October 1983, Department of Conservation and Environment) identifies M51 as 'Swan River Saltmarshes, Belmont and Maylands'. Apart from a description of the site and its environmental features, the System Six Report identifies the environmental values of the site in the following way:

- the saltmarshes are most extensive on the southern side of the river;

- the saltmarshes, trees, and adjoining extensive wading areas make up one of the few undisturbed areas along the river which support a wide variety of waterbirds;

- the M51 area contributes to open space of regional significance extending along the Swan River because of its conservation and recreation values;

- important management considerations include:
    - encouraging growth and regeneration of local indigenous flora.
    - maintaining waterbird habitats, and
    - only allowing recreation activities which are compatible with the conservation of flora and fauna.

The recommendations for M51, contained in the System Six Report, are:

(i) that the general recommendations on planning and management of Regional Parks be applied to this area; and

(ii) that the former Metropolitan Region Planning Authority (now the WAPC), in consultation with the former Department of Conservation and the Environment (now the Department of Environmental Protection), prepare a management plan for the area.

No management plan has been prepared to date.

2.4.7 River Management Guidelines

The management of the river environment falls within the statutory responsibilities of several agencies. These include:

- the Waterways Commission (under the provisions of the Waterways Conservation Act 1976 Amended) whose duties are to:
    - preserve and enhance the environmental quality of the river environment,
    - control and prevent pollution of the river environment,
    - disseminate knowledge concerning the river system, and
    - consult with other organisations affected by the Commission's activities under the Act;
- The SRT has the areas of water and foreshore of the Swan River vested in its control, for the purposes of conserving and managing the waters and associated land, as defined in the Act.

2.4.8 Drainage Management Guidelines

2.4.8.1 Central Belmont Main Drain CBMD

The CBMD is operated by the Western Australian Water Authority (WAWA). Significant modification of its function or general design would require assessment by the DEP. Opportunity to modify this drain exists provided works comply with WAWA requirements and those of the City of Belmont.

2.4.8.2 Urban Runoff and General Surface Runoff

It is SRT Policy that stormwater from residential buildings, commercial buildings and adjacent carparks servicing such buildings constructed adjacent to the river, is to be disposed of on site unless special approval has been obtained.

In a large development such as Ascot Waters there is nevertheless an extensive spatial area of roads and public spaces generating significant volumes of surface runoff. The SRT and the EPA require that drainage be retained on site for three to four days. There should be no direct drainage into the Swan River.

There should be no direct stormwater runoff into the river or internal waterway, without appropriate treatment first.

2.4.8.3 Floodway

The representative predicted flood water levels for the Ascot Waters site are:

1 in 10 year flood	1.29 m
1 in 25 year flood	2.40 m
1 in 100 year flood	3.61 m

This means that development of the site must accommodate predicted flood levels in two ways:

- first, to ensure that the urban land use component is raised to a sufficient height to avoid future flood damage; and
- secondly, to maintain a low lying 'channel' through the site to accommodate the overall required 'floodway' capacity of the Swan River.

The design parameters for the floodway requirement are determined by the Flood Plain Management Section of the WAWA.

Floodway provisions are designated by the WAWA to be maintained as part of the river systems capacity to accommodate flood events up to a 1 in 100 year flood. The area required to be set aside as floodway is calculated by the WAWA and is illustrated in Figure 16. Within this floodway no development is permitted and development within the adjacent flood fringe areas will need to be above the 100 year flood levels in the floodway and the main river channel as predicted by the WAWA.

The floodway capacity is required to be maintained as any reduction in capacity would raise predicted flood levels upstream in the Swan River and would have the potential to flood and cause damage in areas currently considered to be safe from flooding.

2.4.9 Archaeological and Ethnographic Values

McDonald Hales and Associates was commissioned by the Consortium to undertake a study of Aboriginal heritage and interests in the Ascot area. The study involved an examination of archival material, previous reports and an ethnographic and archaeological field survey.

No archaeological or ethnographic sites were located by McDonald Hales and Associates, and previous surveys. The survey conducted for this report also failed to locate any sites, except for the Swan River, which has been listed as a site at the Heritage and Culture Division of the Aboriginal Affairs Department.

The archaeological survey did not locate any artefact scatters or isolated finds.

The consultants recommended that the development could proceed but that the Proponent should submit a Section 18(2) application under the Aboriginal Heritage Act 1972-80 to the Aboriginal Cultural Material Committee prior to commencement of construction.

They also recommended that the Proponent informs the Aboriginal people with an interest in the area about the extent of development near the Swan River. Both recommendations have been acted upon (refer Section 4).

2.4.10 Landscape and Other Values

Ascot Waters occupies a prominent site on the Swan River. Much of the site is hidden when viewed from the river (due to the tipsite) and the surrounding road system. It is however visually accessible from the residences occupying the northern side of the Swan River on Swan View Terrace and Stone Street, Maylands. However, the former visual qualities of the development site itself were low with much of the site in a degraded and unkempt condition. The previously existing wetlands represented the only items of landscape interest within the site. The majority of the site is now subject to bulk earthworks, hence the site can now be considered to be going through a dramatic stage of landscape and visual transformation.

2.5 POLLUTION SOURCES

2.5.1 Central Belmont Main Drain (CBMD)

The CBMD runs through the eastern and southern part of the development site from Resolution Drive to its outlet on the Swan River behind the present tennis club. The water quality of the Belmont Drain is known from repeated investigations to be particularly poor at certain times of year and for certain flow rate conditions (BSD, 1992).

Generally, the drain has been found to be fresh with a range during 1991-92 (BSD, 1993) of 368-600 mg/L TSS. Nutrient levels were found to be relatively high both for total phosphorus (1991-92 range from 0.97 to 2.5 mg/L). More importantly the bacterial counts in the drain in the form of faecal coliforms have at times been found to be extremely high due to runoff from Ascot Raceway, stable areas, sewered and unsewered residential land, as well as an industrial area. It has been found that the level of nutrients recorded in the Belmont drain are highest in summer both in absolute terms and relative to the inputs from the catchment.

2.5.2 The Tipsite

The tipsite occupies an extensive portion of the west side of the site adjacent to the Swan River. It generally comprises domestic waste materials on an initial sand base some 1 m thick (Figure 8). The surface capping layer comprises permeable building rubble, and hence the tipsite has not been 'capped' since it closed in the early 1980s. As a consequence, a high degree of leaching and biological breakdown of organic matter contained in the tip body would have occurred since the tipsite closed.

2.5.3 Development Site - Soil and Groundwater Contamination

The site was formerly an industrial area, and consequently concerns of potential contamination have been expressed. An audit of the Ascot Waters site in December 1993 revealed the presence of some organochlorines in thirteen out of twenty four groundwater samples. A further series of bore holes were drilled both on and off the Ascot Field site in February 1995 and groundwater was further tested (see Appendix G). This has revealed the presence of further minute quantities of organochlorines in some groundwater bores on the site and at several locations up to 1 km off the site. The results indicate that:

- no contamination was found in many bores. Where contamination occurred, the concentrations were extremely low (5 to 8 parts per trillion, or nanograms per litre);
- one sample of 15 nanograms was found in the old clay pits near lake 4, and a sample of 36 nanograms was found immediately adjacent to Resolution Drive;
- contamination is regional and the source is external to the Ascot Waters site; and
- there has been no soil contamination detected on the Ascot Waters site.

In summary, the status of the groundwater contamination detected is that it is less than the concentrations that are contained in the Belmont drain, and less than the concentrations found offsite up to 1 km away. To put the upper concentration of 8 nanograms per litre in perspective, it should be noted that this is significantly less than the current NHMRC-ARC (1987) guidelines for drinking water which have an upper limit of 1,000 nanograms per litre, and the draft 1994 NHMRC-ARMCANC guideline which has a level of 300 nanograms per litre. It has therefore been concluded that the known levels of contaminants poses no threat whatsoever to either the environment or future occupants of the site.

3 PROJECT DESIGN AND DESCRIPTION

3.1 INTRODUCTION AND EXPLANATION

This section of the PER differs from the usual approach of purely describing the proposed project in that it includes a discussion of the design background to each proposed action. This is because this project has been designed to be environmentally acceptable. Hence the environmental effects of the proposal are also discussed in this section of the report.

The topics of concern have been known to the Proponent and development Consortium from the outset of the project. The Consortium's approach was to establish a team of experts in various aspects of the project to produce designs which would meet the environmental objectives of the project by creating a net environmental benefit for both the Swan River and the local community. This part of the report therefore:

- identifies the particular topic of concern; and

- describes the way in which the project has been designed or managed to overcome that concern.

From this explanation it should be clear to readers which parts of the environment will be modified or altered (or not as the case may be), and the expected outcome in terms of environmental benefit or disbenefit.

As indicated in Section 1.5, the proposal is to connect the internal waterbody (constructed as part of Stage 1) to the Swan River by excavating both an upstream and a downstream channel connection (refer Figures 5 and 6). The major topics of concern (refer Section 1.7) associated with the proposal are:

- what effects will connecting the waterbody to the Swan River have on the ecosystem, and water quality in particular;
- potential effects of poor source water quality on the proposed waterway development;
- protection of System Six Area (M51) values;
- protection of wetland values;
- provision of and responsibilities for management of the waterway and public open space elements of the project.

The first four topics listed above are assessed in greater detail in this section. The last topic is detailed in Section 4.

3.2 PROTECTION OF THE SWAN RIVER ENVIRONMENT

3.2.1 Proposal

In order to achieve the environmental objectives of the Ascot Waters project with respect to the Swan River environment, it is proposed to:

- connect the internal waterbody to the Swan River by an upstream and a downstream channel;
- use the waters of the Swan River to flush the internal waterbody in order to maintain acceptable water quality of the Ascot Waters riverine wetland;
- through appropriate environmental design encourage ecological connectivity with the Swan River and achieve biological colonisation of the newly created riverine waters, to the benefit of the overall river system; and
- by virtue of the above allow limited navigable access to shallow draft boats to gain access to the 'limited area' marina within Ascot Waters, and enable canoeists access to the rest of the waterway and the channels through System Six.

The connection of the internal waterbody to the Swan River will involve the following activities (refer Figure 5):

- excavation and earthworks of the Kikuyu paddock to form a braided riverine sedge wetland with intervening channels of 0 - 1 m depth;
- excavation and earthworks of a 55 m wide channel entrance through the southern end of the tipsite but leaving a bund at the river shoreline to be breached by dredging;
- dredging of a 90 m long 15 m wide by 1 m deep channel through the narrowest and least vegetated portion of System Six to connect with the 1 m deep channel through the braided wetland;
- dredging of a 15 m wide by 1 m deep channel through shallows offshore from the System Six Area to provide hydraulic connection to deeper waters in the river;
- dredging of a 55 m wide by 2.5 m deep by 320 m long navigation channel through shallow mudflats to connect the southern entrance channel to deeper waters of the Swan River; and
- disposal of dredge spoil and dewatering liquids into a settling pond prior to return of clarified water to the river.

3.2.2 Concerns

The principal concerns raised by the proposal with respect to potential environmental impacts on the river are:

- loss of river habitat (fringing vegetation, shallows and benthic environment);
- impacts during dredging (sediment plumes); and
- creating an additional source of contaminants for the river to accommodate. Such contaminants might potentially originate from stormwater runoff, groundwater seepage, or seepage of leachate from the tipsite.

3.2.3 Design Response and Project Proposal

Protection of the Swan River environment from the effects of the development is discussed under the following headings:

- dredging and habitat removal,
- spoil disposal,
- tip leachate,
- stormwater runoff, and
- groundwater and other contamination.

Detail on the proposed dredging operation and spoil disposal methods are provided in Appendix B.

3.2.3.1 Dredging

The downstream channel at the southern end of the site will be approximately 320 m long, 55 m wide and 2.5 m deep at AHD. This cross section will allow for the desirable level of flushing and for safe navigation of commercial ferries and private boats that presently use the upper estuary of the Swan River (refer Appendix B). In total, about 22,000 m^3 of cohesive alluvial mud would be dredged to form the southern entrance channel.

The northern channel, cutting through the System Six Area, will be much smaller, and has been designed to be the smallest practical size that would enable adequate flushing of the waterways in the development (refer Section 3.3 and Appendix B). Through the System Six Area it would be 90 m long, 15 m wide and 1 m deep at AHD. Approximately 2,000 m^3 of mud would be dredged from the System Six Area. The 'outer' section of the northern connecting channel would be dredged through submerged banks to make a better hydraulic connection through to the deeper portion of the river. This would be about 125 m long, 15 m wide and 1 m deep. Approximately 6,000 m^3 of mud would be removed.

It is proposed that dredging will be undertaken in the autumn and winter months between April and early September. This coincides with periods of maximum turbidity and water flow as a consequence of winter rainfall conditions in the Swan and Avon river catchment. The freshwater regime of this time of year and the overall water quality conditions within the water column will combine to ensure there will be no discernible impact on water quality of the river at the time of dredging.

All riverine sedge vegetation occurring in the way of the dredge will be first removed and transplanted to the braided wetland. The area of riverine shallows removed by dredging the approach channels is small relative to the amount of similar shallows available in the upper estuary, and will be more than compensated for by the shallows to be created within the waterway and braided channels. Experience gained from inspection and survey of other man-made channels in this state (LeProvost Semeniuk & Chalmer, 1988) indicates that both the dredged channel and the new waterbodies will be rapidly colonised by benthic biota, fish and crustaceans.

3.2.3.2 Dredge Spoil Disposal

A small floating cutter-suction dredge would be used. This involves a process of cutting the muds and sucking them into a suction pipe with a slurry pump. The resultant slurry would be a mix of about 10-30% sediment and 70-90% water. In view of the measured settling velocity of the mud, it is proposed to transport the slurry by floating pipe to a specially designed settling pond. It is proposed that a bunded settling basin be located either on the southern portion of the tip site, or alternatively on the southern foreshore of the river. The settling pond would initially be sealed using clay from the marina and waterways, to prevent any seepage.

At any stage of the dredging work, the bunded area would be at least 70 metres long by 50 metres wide and 1 m deep in order to achieve a residence time of about 5 hours. This would cause most of the suspended sediment in the dredge slurry to settle out in the pond. The clarified return water would then be decanted back into the river. It is proposed to complete the dredging work during the autumn and winter months when the river waters are already quite turbid.

Dredging would take place during daylight hours only, which will allow additional overnight settling time.

Monitoring would be undertaken on a continuous basis to:

- establish the return water from the settling ponds is of sufficient clarity before being allowed to flow back into the Swan River; and
- ensure that minimal quantities of dredge water are percolating down through the tipsite or southern foreshore during the settling operation.

If required, the return water can be diverted direct to the main river channel, or to the internal waterbody within Ascot Waters, where further settling out of sediment can take place.

The dredge spoil residue remaining after settling and removal of the water fraction will be a clay-based material that can be readily used within the development, and on the surface of the tipsite in particular.

3.2.3.3 Tipsite Leachate

It is the intention of the project that the tipsite remain largely untouched and 'inert'. By this it is meant that only the upper surface layers of the tip are to be modified for landscaping purposes, largely to achieve a re-contouring of what is otherwise an artificial and unsightly visual feature of the site.

The surface of the tipsite has already been substantially re-contoured as part of Stage 1. This includes earthworks to 'cut back' the eastern edge of the tip to accommodate a realignment of the western edge of the WAWA floodway. Recontouring of the tip only involves material of the tip body down to RL 2.5 m. There is then intended to be landscape treatment of the tip and the tipsite edge, in order to present the re-contoured tipbody as a visually attractive setting to the rest of the development and as a community recreation asset.

The exception to the above is the excavation of the downstream connecting channel which requires cutting through the southern 'toe' of the original tipsite, at the furthest extent of original landfill. This potentially connects the tipbody directly with the river water.

Even though monitoring indicates no evidence of leachate remaining within the tip, it is proposed that a permanent impermeable barrier between the waters of the channel and the tipbody would be installed. Construction to achieve this is likely to include a clay lining, possibly in conjunction with stabilised wall structures.

These combined works have been incorporated to ensure that there is no additional leaching from the tipbody adjacent to the entrance channel and that in all other respects the tip will remain exactly as it was before the construction phase of the project. This includes:

- the regime of leaching from the tip due to rainfall or 'rainfall equivalent' to be unchanged; and
- tipbody to remain unmodified and undisturbed at RL 2.5 and below (below water level and at tipbody interface with groundwater), except as discussed in the case of the downstream channel.

3.2.3.4 Stormwater Runoff

Surface runoff originating within the development will be disposed of as sensitively as possible, maintaining as many environmental benefits as possible in relation to the overall site, and avoiding any adverse impacts. To achieve this the following considerations with respect to the management of surface runoff will be met in the development:

- direct run-off into the waterbody or System Six Area will be avoided; and
- water sensitive design Best Management Practices (BMPs) are to be applied wherever possible and appropriate;

The BMPs proposed for the Ascot Waters development are those which are used to control stormwater volume and peak discharge rates, as well as reducing the magnitude of pollutants in runoff through physical containment or flow restrictions designed to allow settling, filtration, percolation, chemical treatment or biological uptake and assimilation of nutrients.

The stormwater management system at Ascot Waters should be considered as a BMP treatment train in which individual BMPs are interlinked in series, with the more BMPs that are incorporated into the system, the better the overall performance of stormwater management systems. Furthermore by employing the treatment train philosophy, the system is not dependent solely on the performance of one BMP, which is collecting the runoff of the entire development that is placed immediately upstream of the outfall.

Consequently, the design of the stormwater management system has been an integral part of the development planning where BMPs have been integrated into the open space and landscape elements of the development.

The stormwater management system configuration as illustrated in Figure 17 would meet the requirements outlined above. The features of this configuration are that surface run-off from within the development would be directed as follows:

- runoff from zone A, which includes the commercial/marina area and extensive hard surface parking areas, will be directed into a series of gross pollutant traps and then into attractively landscaped 'nutrient stripping' wet detention basins prior to entering the Swan River;

- subject to the outcome of current negotiations with the landowner (the National Transmission Agency), runoff from zone B will be directed to a shallow, landscaped infiltration basin/swale along the northern edge of the development, to be installed between the rear property boundaries and the line of Casuarinas marking the edge of the System Six saltmarsh area. This infiltration basin/swale, to be constructed on the contour between 0.1 and 2.5 m RL, will hold water temporarily before it seeps away and enters the southern edge of the saltmarsh area. Freshwater seepage into the marshland edge is a natural occurrence, and is beneficial to various saltmarsh plant species, as well as to waterbirds and other fauna. The infiltration basin/swale will be appropriately landscaped and will accommodate a dual use path for public access around and through it. The basin will be designed for rapid infiltration of inflowing stormwater and to avoid holding standing water for any length of time through the inclusion of an underdrain for additional subsurface conveyance. This structure will act to remove all sediment and most of the contaminants contained in inflowing urban runoff;

- runoff from zone C will be directed down through the central open space corridor within the development, into the freshwater wetland. An overflow into the main waterbody will operate during extreme rainfall events. While the runoff water passes through the central open space it will be utilised as a landscape feature and in the process be naturally aerated and stripped of some sediment load. Entry of the water flow into the freshwater wetland will be through vegetated swales, micropools and biofilters to further remove solid particles. Containment in the wetland will allow further removal of suspended sediment/dissolved nutrients and aeration. Water flow out of the wetland into the main waterbody (only in extreme rainfall events) will then provide for progressive flushing of the small wetland and safe disposal and dilution of the original stormwater into the main waterbody and ultimately the Swan River.

The stormwater management system as outlined above effectively deals with both the major and minor storm events, namely:

- it provides a flow path for major events so that flooding of the property is prevented (see Figure 17A);

- it will limit the volume and peak flow rates of runoff to predevelopment conditions for minor storm events (see Figure 17B); and

- it will treat 90% of storm events per year via detention for a minimum of 72 hours or retention of the runoff via infiltration and/or re-use.

In combination, it is argued that these measures will provide an environmentally acceptable level of treatment of urban run-off from within the site and ensure that Ascot Waters does not contribute pollutants to the river.

3.2.3.5 Groundwater and Other Contamination

As outlined in Section 2.5.3, the Consortium has commissioned an extensive and independent audit for the Ascot Waters site (refer Appendix G). Whilst some groundwater contamination in the form of organochlorines has been found, it is from regional contamination sources and is in extremely low concentrations; so low in fact it easily meets recognised standards for drinking water purposes. No other significant contamination on the Ascot Waters site has been found. On the basis of the findings of the audit, it is concluded that the Ascot Waters development site poses no contamination risk to the Swan River.

3.3 INTERNAL WATERWAY WATER QUALITY - EFFECT OF SOURCE WATER

3.3.1 Proposal

The proposal is to create an additional area of upper estuary, riverine environment by connecting the enlarged and modified internal waterbody to the Swan River. To function satisfactorily the design of the waterbody must be such that it allows sufficient exchange and circulation of its waters with those of the larger river system.

3.3.2 Concerns

The broad concerns associated with the connection of the waterbody to the Swan River are as follows:

- that the waterbody will become a poorly flushed backwater and suffer severe water quality problems during spring, summer and autumn;
- that poor water quality within the development will contribute to poor water quality within the wider river system;
- contaminants discharging from the Belmont Drain will have an unacceptable impact on the water quality and hence proposed Beneficial Uses of the proposed waterway.

3.3.3 Design Parameters

Based on advice received from M.P. Rogers & Associates (Appendix B) and David Deeley (Appendix C), a number of design criteria were established to ensure that the new waterway would reflect source water quality and not contribute to poor water quality in the river. The main design criteria are as follows:

- the overall bottom bathymetry of the waterbody should be graded from 1.5 m depth upstream to 2.5 m depth downstream;
- there should be no deep holes to resist flushing and develop anaerobic conditions. (The above criteria have already been incorporated into the design of the waterbody currently being created in the Stage 1 earthworks programme);
- water turnover within five days under the worst case conditions (neap tides in spring) will ensure adequate flushing;
- connecting entrance channels should be of adequate dimensions for flushing water volumes;

Most of this section has been abstracted from Appendix B which contains a detailed assessment of this topic of concern.

3.3.4 Flushing and Water Exchange

The vigour of flushing is customarily expressed in terms of a residence time, which is the time required for the throughflow to fill the entire volume of the water body. In a well mixed system, this provides a good approximation to the average time the water remains inside the waterway. The Murray Lakes project near Mandurah has quite comparable source water and the beneficial uses are also similar to that at Ascot Waters. The flushing rate achieved at Murray Lakes is reportedly in the order of five days under worst case conditions (G. Robertson, pers. comm.), yet there appear to be few problems related to the flushing of these waterways. It is therefore proposed that a five day residence time is acceptable for Ascot Waters as a worst case scenario. This criterion will be used in the design of the waterways at Ascot Waters and this would provide a suitable factor of safety.

The region of the Swan River to which Ascot Waters is connected is subject to a variety of forcing mechanisms which drive the motion of the water. These same mechanisms will be responsible for the flushing of Ascot Waters, and are listed in the table below, along with their relative effect across the four seasons.

FLUSHING MECHANISM	RELATIVE EFFECT			
	WINTER	SPRING	SUMMER	AUTUMN
Stream Flow	Very High	High	Low-Very Low	Low
Astronomic Tides	Moderate	Moderate	Moderate	Moderate
Density Currents	~ Zero	~ Zero	Low	Low
Wind Shear	Very Low	Low	Low	Very Low

The important time of the year, in terms of the weakest flushing conditions, is when the streamflow is lowest. This generally occurs from late summer, through early autumn, and up to the point of the first significant rainfall. Within this time interval, the critical periods coincide with neap tides. Neap tides are characterised by relatively low amplitudes and occur regularly at approximately 14 day intervals with a duration in the order of two days. computer modelling suggests that, under these conditions, the residence time of the waterways would be approximately 55 hours (~2 - 3 days). The flushing is significantly improved under mean and spring tide conditions, with residence times in the order of 30 and 20 hours respectively.

During the environmental conditions expected to cause the weakest exchange of water between the Swan River and Ascot Waters, it is estimated that the waterways would have a residence time of just over two days. These conditions would occur regularly for durations of a few days approximately every two weeks throughout late summer and early autumn. At other times, the flushing of the waterways will be significantly stronger, with residence times in the order of one day or less.

It is important to note that this modelling accounts only for the effect of tidal forcing on the flushing of the waterway. Tides are persistent all year round, and so the exchange of water they generate should be viewed as a lower limit on the flushing that will actually occur. During winter and spring, the mean streamflow in the Swan increases to approximately 50 m^3/s, reducing the residence time of the proposed waterway to approximately seven hours. Even during the most critical periods - late summer during neap tides - the effects of density currents, which are strongest when streamflow is weakest, and wind shear will enhance the flushing generated by tidal forcing.

3.3.5 Water Quality Guidelines and Design Objectives

Guidelines pertaining to the water quality of fresh and marine water bodies in Western Australia have been published in draft form by the EPA (1993). In summary, with respect to artificial waterways, these require the following:

(i) the water quality must not significantly impact on the ecosystems of aquatic environments adjacent to, or in the near vicinity of, the artificial water body;

(ii) the water quality of the artificial waterway must be suitable for its proposed recreational uses.

Item (i) above has been addressed by ensuring that the waterway is well flushed and that input of nutrients and other pollutants through surface runoff and other mechanisms are minimised. Under this situation, the aquatic environment within the canals is expected to be very similar to that in the Swan River.

With respect to the recreational water quality requirements, item (ii), the draft EPA guidelines have been adopted as design criteria. Only secondary contact recreation is proposed for Ascot Waters, which includes both boating and fishing, but excludes activities involving frequent direct contact with the water, such as swimming. In view of the proximity of the CBMD, the discharge for which contains varying levels of faecal pollution, to the downstream entrance to the Ascot Waters waterbody, the two most important criteria in this context both relate to faecal bacteria. The first specifies a maximum concentration of faecal coliforms, and the second, a maximum concentration of enterococci (streptococci) bacteria, that the water may contain.

For the purpose of properly defining these design objectives, the downstream limit of the Ascot Waters waterways has been set at the intersection of the downstream entrance channel where it intersects with the original bank of the Swan River. Under this definition, as soon as any pollutant enters this entrance channel, it is deemed to have contaminated Ascot Waters.

3.3.6 Source Water

3.3.6.1 Central Belmont Main Drain (CBMD)

The outlet of the CBMD is presently located at the proposed southern entrance to Ascot Waters. As previously indicated, the catchment of the CBMD includes horse stables and wash down areas, and consequently the runoff collected by the drain through its Matheson Road tributary can carry extremely high concentrations of faecal coliforms and streptococci (both indicators of faecal pollution).

Analysis of a water quality study of the CBMD was performed in 1992 for the City of Belmont (BSD, 1992) shows that, for the sampling conducted between April and September 1992, the discharged wastewater regularly exceeded the EPA guidelines for secondary contact recreation, sometimes by an order of magnitude.

In view of this, it is considered inadvisable to discharge the low flow stormwater of the CBMD, and particularly the Matheson Road Drain, directly into the Ascot Waters waterways. Instead, the outlet should be located a sufficient distance downstream of the southern entrance so that, on flood tides, the concentration of faecal bacteria will dilute to levels which satisfy the EPA guidelines by the time the plume enters the waterway.

Further analysis of the 1992 study results reveals that the highest concentrations of faecal bacteria occurred in the discharge generated by moderate rainfall events, and that the wastewater would have to be diluted by at least 1 in 3 to satisfy the EPA guidelines. These events occurred during winter, when streamflow dominates tide-induced currents, and so there is little chance of the effluent propagating upstream.

For design purposes, the flow conditions associated with late summer and early autumn were adopted since at this time streamflow is lowest and tidal forcing strongest. Sporadic thunderstorms generating rainfall of similar intensity to that experienced during the moderate winter precipitation events observed in the 1992 study are often experienced during this period. It is reasonable to assume that the faecal bacteria concentrations of the CBMD/Matheson Road Drain wastewater generated from an autumn thunderstorm are similar to those associated with the discharge from a mild winter storm. Based on this premise, it is estimated that during neap tides (the worst case scenario) the wastewater would be diluted by a factor of three approximately 250 m from the outlet. During spring tide conditions, this distance would be reduced to approximately 65 m.

It is therefore proposed to pipe the Matheson Road Drain low flow to a point 250 m downstream of the southern entrance to the waterway. The section of CBMD downstream of Stoneham Street is to be converted from an open trapezoidal drain to a number of in-line wet detention basins each connected by sections of pipe drain. These wet detention basins will be heavily landscaped to function, as far as possible, as nutrient stripping basins and to be safe, attractive features in the landscape. It is envisaged that they will be permanent waterbodies, and provide additional useable habitat for waterbirds. The detention basins will act to reduce levels of nutrient, silt and faecal coliforms in discharge waters. The section downstream of the first detention basin will transport only minor storms with major storms being directed via an overflow weir in the wet detention basin to the 'off-line' basin associated with the stormwater system for Zone A of the Development. This will allow major flow events (with very low, diluted nutrient or contamination) to flush harmlessly into the Ascot Waters waterbody before entering the open river.

An outline description of the proposed remediation of the drain and the function of the wet detention basins is provided in Appendix H. Detailed design negotiations are currently underway with the WAWA. WAWA requirements for stormwater drainage, flow gauging and water quality monitoring will be incorporated into the final design.

In addition to the remediation works proposed for the CBMD, the development Consortium has agreed to undertake remediation of the mouth of the Abernethy Road Main Drain in conjunction with the City of Belmont. The City has requested the works for purposes of foreshore and drainage improvement. The proposal entails landscape improvements to the first 30 m of the current open drain. The final landscape details are yet to be determined, and would be subject to the approval of WAWA. It is proposed that the landscape treatment would include:

- creating a small, landscaped detention basin on the inland side of the cycle way/pedestrian bridge;
- removing the shallow delta of coarse sediment that has built up on the foreshore on either side of the outfall; and
- reinstating a 'natural' shoreline profile on either side of the drain outfall entrance.

Removal of sediment at the edge of the river would be undertaken principally by a shore-based excavator (long arm) with perhaps a minor amount of dredging of the outer edge of the delta.

At the time of this PER preparation, other parties are exploring the potential for additional treatment and nutrient stripping of the Matheson Road Drain and improvements to the Western Australian Turf Club stormwater and nutrient release arrangements. A successful outcome to these negotiations will further improve the current performance of the CBMD with correspondingly significant benefits for the Swan River environment.

3.3.6.2 Swan River

Ascot Waters is designed to be a relatively well flushed waterway, and consequently the source of essentially all of its water is the Swan River. Subsurface groundwater discharge will also contribute a small influx into the system, particularly during winter when precipitation is greatest. However, this is also the same time when the Swan River streamflow is strongest, flushing of the waterway is at a peak, and influxes of groundwater and surface runoff in the immediate vicinity of Ascot Waters are negligible in comparison to that provided by the Swan River.

With good flushing, the water within the waterway will at best be of the same quality as the Swan River. However, under certain conditions, Swan River waters in the vicinity of Ascot Waters have been of particularly poor quality in a number of respects. Significantly elevated concentrations of nitrates and phosphates in the water column has led to a series of algal blooms in the upper reaches of the Swan River. With algal blooms occurring in the source water, it is reasonable to expect similar phenomena to occur in Ascot Waters from time to time.

3.4 PROTECTION OF SYSTEM SIX VALUES

3.4.1 Concerns

As indicated previously (Section 2), the System Six Area is the largest remnant example of riverine flats remaining in the upper Swan estuary and, as such, has high conservation value. Given some of the water quality problems that have emerged in the river over recent years, there is now an even greater need to protect littoral vegetation fringing the river to provide areas for nutrient stripping and sediment deposition.

Most of the System Six Area is in reasonably good condition, particularly the saltmarsh and the reed beds. However, there are localised examples of degradation, primarily on the river banks and islands as a result of unrestricted vehicular and pedestrian access. Rubbish is pervasive in these areas. The areas which are generally in good condition are those to which ready access has been denied by virtue of historical construction of man-made channels and moats.

A major concern arising from the Ascot Waters development in general is the potential for increased public access into the System Six Area and the consequent disturbance it will cause with potential to exacerbate the mosquito breeding problems. Another concern is loss of riverine habitat as a result of disturbance or channel construction.

As a result of these concerns, the following general guidelines have been adopted as general design parameters for the System Six Area:

- retain the existing defined System Six Area free from any development or physical interference that does not constitute, or cannot be justified as, environmental restoration or river habitat re-creation;
- retain the existing defined System Six Area free from any activity that does not constitute an 'environmentally appreciative' human use (e.g. environmental interpretation, wildlife lookouts, nature trails or boardwalks, education, scientific research);
- where interference or habitat modification is suggested, to ensure that at least an equivalent area of habitat is replaced elsewhere within the development.

With these guidelines in mind the following sections focus on the specific changes proposed.

3.4.2 Connecting Channel

3.4.2.1 Proposal

To excavate an 'upstream' channel through the System Six Area for the purpose of connecting the internal waterbody to the Swan River.

3.4.2.2 Design Response

- A specialised, small floating cutter-suction dredge will be used to minimise disturbance to System Six, and excavated material in the form of slurry will be piped to a settling pond outside the System Six Area;
- the alignment of the channel has been selected to minimise the amount of vegetation loss and disturbance;
- the alignment of the upstream channel will follow that of an existing (man-made) channel which at points along its length is both narrower (approx. 4 m) and wider than the specified 15 m width of the proposed channel;
- this alignment will involve the removal of only some 900 m^2 of sedge (*Juncus* spp) and not samphire or *Casuarina* spp; and
- sedge vegetation from the alignment of the channel will be removed before dredging takes place and transplanted to the braided wetlands adjacent to System Six. Ample area is available within the development site adjacent to System Six for transplanting sedge habitat and ensuring no net loss of habitat;

3.4.3 Access Control

3.4.3.1 Proposal

It is proposed that improvements be put in place to better control all forms of access into the System Six Area. Specifically it is proposed to:

- establish a secure boundary configuration between the development and the samphire area in the vicinity of Harold Street at the northern edge of the development by extension of the existing man-made channel to create a moat. This is subject to agreement with landowners and determining the position of the earthing mat. In the event that a moat is found unacceptable a fence would be the only practical alternative; and

- to provide boardwalk access via a single pedestrian bridge to observation points on the larger vegetated island, for birdwatching and fishing access purposes.

3.4.3.2 Design Response

It is proposed that the protective moat (see Figure 5) would be:

- between 2.5 and 3 m in width and no deeper (approx 0.5 m) than the existing channel, upon which it would extend;
- aligned as close to the edge of the System Six Area as possible, and through sedge (*Juncus* sp) rather than samphire;
- excavated using the smallest appropriate machinery to avoid collateral damage to vegetation adjacent to the moat, and at a time most suitable for the machinery selected (e.g. winter for mini suction dredge, summer for mini excavator);
- excavated material to be disposed of outside the System Six Area (within the development);
- plant material (sedge or samphire) in the alignment of the proposed moat to be removed before excavation and transplanted to the braided wetland;
- incorporation of 'sill' at the entrance of the moat channel if necessary to modify the hydrological/drainage effects of the moat on the saltmarsh area; and
- access control bollards at the start of the saltmarsh moat if it is necessary to restrict canoe/small boat access.

The moat barrier is needed to control access of pedestrian and domestic pets (dogs and cats) into the System Six Area as well as provide an effective barrier against possible ground fires which could occur in the 'dry' landscaping proposed for the interface zone between the Open Space areas and the System Six reserve. The moat will also assist drainage of the site, remove some mosquito breeding areas, and increase fish access to parts of the saltmarsh, resulting in more efficient control of mosquito breeding locally.

The proposed alignment of the protective moat is indicated in Figure 5. It would commence as a 'branch' off the existing channel and is proposed to run along the edge of the existing fringing sedge and line of Sheoak and paperbark on the edge of the samphire area. It would run under the causeway (to the transmitter aerial) via a culvert, and then extend on through a firebreak adjacent to System Six to the easternmost corner of the development.

Wherever possible, the alignment of the moat will avoid well-vegetated System Six habitat. An alignment has been selected by Jane Latchford (pers. comm.) which minimises loss of wetland vegetation to some 200 - 250 m^2. The final alignment will be agreed with appropriate authorities prior to its installation.

The land on which the moat is to be located belongs to the National Transmission Agency and hence construction of the moat is subject to reaching agreement with the landowner.

It is to be noted that the eastern edge of the samphire area beside Resolution Drive is extremely degraded, and offers uncontrolled access to 4WD vehicles spilling off the main road to gain access to the river edge on the downstream side of the bridge. A vehicle barrier is required in this area to prevent such vehicle movement into the samphire area, and at the same time a formalised fishing spot, in conjunction with works to extend the dual use path, would control existing informal and uncontrolled activities at this location.

It is also suggested that there be an extension of the moat by widening an existing drain within the area of vegetated sandbars to afford more protection to the larger in-shore island. Site survey reveals that the smaller outer sandbar, which is separated by a deep 'man-made' channel is in considerably better condition than the former, which is noticeably affected by the spread of grasses and other weed species, and with noticeable quantities of rubbish. The latter indicates a high degree of uncontrolled pedestrian and vehicular access. In view of the high population of breeding ducks and other waterbirds observed on both vegetated sandbars, this would be highly beneficial in conservation/management terms.

Despite the preceding discussion which focuses on restricting access, it is reasonable for the community to expect some form of appropriate, legitimate access to the System Six Area, unless the site is decreed as a sanctuary and actively managed as such. It has not been indicated that this is, or will be, the case. Therefore to extend the opportunity for wildlife observation, educational study, as well as a more active management presence of the area, it is proposed that there be a suitably constructed boardwalk with controlled access (by virtue of appropriate design - e.g. appropriate positioning, side rails, interpretative signs, etc.) to observation points in the area of vegetated sandbars.

With respect to the controlled access and the proposed boardwalk, it is proposed that:

- a single entry/exit boardwalk be constructed across the existing moat to the north west of the tipsite; and

- the boardwalk be of suitable design and construction to:

  - be visually integrated into the environment,
  - be as maintenance free as possible,
  - encourage users to remain on the walkway/boardwalk, and
  - provide access to viewing points.

In conjunction with these proposals there will need to be some level of ongoing management of the System Six Area, especially rubbish removal, controlling pests, repair of structures (e.g. boardwalk, signs, etc.). It is proposed that an agreement will need to be reached between the City of Belmont and various government agencies for both siting of the structure and ongoing management of these items.

3.5 PROTECTION OF EXISTING WETLAND VALUES

3.5.1 Proposal

It is proposed that some of the existing values of the original lakes be protected and appropriately incorporated into the new proposed waterway. It is also proposed that a new riverine wetland system be established with wildlife habitat of greater value than previously existed.

3.5.2 Concern

The principal concern associated with the proposal is the loss of waterbird habitats.

3.5.3 Design Response

The earthworks to create the new wetland basin have been undertaken in such a way that riverine habitat qualities will be maximised. To accommodate the functional and ecological objectives the waterbody has been divided into two parts:

- the northern section, upstream of the causeway crossing which is to be the more natural wildlife habitat area; and
- the southern section, downstream of the causeway crossing which, while retaining a degree of naturalness along the western shoreline, has been designed to accommodate the marina and navigable boating area.

The conservation value of the project site to waterbirds has been evaluated by M J & A R Bamford Consulting Ecologists (refer Appendix F) as background to providing the development Consortium with design criteria for preserving existing wetland values.

It needs to be appreciated from the outset that waterfowl usage of the original wetlands on the site is not clearly known, and that the lakes were highly degraded and man-made. Data from Tingay and Associates (1993) and the RAOU indicate that the lakes were of importance for small numbers of a wide range of waterbird species. The lakes provided a variety of habitats as they varied seasonally and provided a range of salinities, depths and vegetation types. Low salinity levels in some of the lakes for at least part of the year was especially significant. The importance of M51 for waterbirds is unclear but may be greater than indicated by available data.

Based on the above information, the following criteria were identified as being of importance in ensuring that the conservation value for waterbirds of the site would be preserved or enhanced after development:

(i) maintain a freshwater lake with extensive shallows to provide the sorts of habitats presently provided by some of the claypits;

(ii) create wetland habitat rather than lawn areas around the edges of the lake and other waterways;

(iii) create islands and retain or introduce dead trees to act as perches for waterbirds;

(iv) maintain the existing mudflat off the mouth of the Belmont Drain; and

(v) ensure protection of M51.

The above criteria have been adopted by the Consortium.

In undertaking the bulk earthworks for Stage 1, areas of existing sedge have been retained around what will be the new wetland margins, and on newly created islands. This particularly applies to the previously existing sedge and samphire along the western edge of former lake 2. There will also be extensive recontouring of the former Kikuyu paddock between former lake 2 and the System Six Area to create an extensive additional area of open water, braided channels and islands featuring a range of environments (sedge, fringing paperbarks, differing depths, etc.).

In addition to the riverine wetland environment, the development will retain the original freshwater lake 1 in a modified and considerably improved form. This includes:

- infilling to reduce the overall depth, together with grading of the banks to create a more 'natural' edge bathymetry;
- establishing dense fringing vegetation of sedge and paperbarks; and
- retaining an island feature for waterbirds.

Figure 19 indicates the layout and landscaping features of the waterbody. In general terms the features include:

- a 'natural' shoreline shape, vegetated wherever possible with native fringing/littoral plant species (e.g. *Juncus*, samphire, *Melaleuca cuticularis*, etc.);
- a littoral zone along the western edge of the up-stream area which will experience intermittent exposure of the benthos creating a feeding ground for wading birds. All littoral zones will be gently graded to ensure proper drainage and minimise potential for mosquito breeding;
- the establishment of an ecotone of native plantings along the western shoreline to create habitat for waterbirds and other wildlife, and provide opportunity for roosting and nesting sites for waterbirds and habitat for long neck tortoises);
- the eastern slope of the tip adjacent to the western shoreline of the upper waterbody will be densely landscaped to provide a vegetative buffer to the waterfowl conservation area;
- four islands on which are retained previously existing stands of sedge and samphire. These islands will provide additional wildlife habitat sites, with the added advantage of providing some safety from domestic pets and general disturbance.

Beneath the water surface, the bathymetry is designed to provide a range of aquatic habitats. These will be complemented by existing fringing vegetation and the creation of specific habitat for particular fauna, including:

- selected areas of the wetland sediment covered with coarse gravel, shells or crushed limestone to encourage colonisation by filter feeding bivalves (e.g. mussels);
- installing underwater pipes to provide shelter for marine organisms and tortoises;
- laying down submerged 'snags' in specific areas to encourage the presence of black bream; and
- placing roosting perches for waterbirds.

The lack of adequate data on waterbird usage of Ascot Fields prior to development makes it difficult to reliably assess the effects of the proposed waterway on avifauna. However, the expanded area of riverine wetland habitat, the creation of many islands and a densely vegetated buffer along the western side of the upper waterbody, the varied depths and substrate types, the maintenance and enhancement of freshwater lake 1 and a number of wet detention basins as drought refuges, and construction of the moat in System Six will provide a substantial area of varied permanent wetland habitat suitable for maintenance of predevelopment waterfowl values. A summary of overall change in wetland habitat (i.e. lost, modified and created) is illustrated in Figure 18. Indicative landscape treatment and creation of habitat is indicated in Plates 2 to 6 following Figure 19.

3.6 SYNTHESIS OF EFFECTS

3.6.1 Introduction

The environmental acceptability of this proposal rests on whether or not the linking of the wetland created by the Stage 1 earthworks to the Swan River results in adverse impact to the river, or can be shown to be beneficial to the river environment. As indicated earlier, substantial effort has been expended by the development Consortium to resolve the topics of concern identified by the DEP and the SRT by appropriate design.

This section of the report attempts to objectively evaluate the costs and benefits of the proposal in terms of the river environment. The costs, or impacts, of the proposal are outlined first, and followed by description of the ameliorative actions proposed for their mitigation. The topics of concern are then addressed to show how the project proposes to resolve each topic and safeguard environmental values of the site. The perceived benefits of the proposal to the community are subsequently outlined. The section concludes by identifying the range of management actions considered necessary to ensure the long term acceptability and viability of the proposal.

3.6.2 Environmental Impacts

The existing Swan River environment will experience the following modifications:

- the loss of some 17,600 m^2 of shallow subtidal flats and associated benthos in the vicinity of the proposed dredged downstream channel alignment, and the slight deepening (to -1m) of shallow sand bars within the alignment of the upstream dredged hydraulic link;

- the widening and slight deepening of an existing man-made channel through the narrowest part of the System Six Area and associated removal of 900 m^2 of sedge wetland;

- the extension of an existing man-made channel to form a protective moat separating the development from the System Six Area and the associated removal of approximately 250 m^2 of sedge wetland. This is proposed principally to protect System Six M51 saltmarsh, and is not essential to the overall development;

- removal of the intertidal outwash sediment fan at the mouth of the Abernethy Road Drain by excavation to RL -0.5 m depth and removal of accumulated nearshore sand bars. These works are proposed by the City of Belmont for purposes of drainage and foreshore improvement; and

- a temporary and localised increase in water turbidity near the dredge and excavators during the construction period.

3.6.3 Proposed Mitigation

The above impacts will be thoroughly mitigated by:

- creation of a substantial area of new subtidal riverine habitat varying in depth between 0 and -2.5 m AHD (at least double that which previously existed);

- transplanting all sedge vegetation to be removed to the braided wetland and planting of substantial additional (at least double) areas of sedge vegetation throughout the upper reaches of the new waterway; and

- restriction of dredging to the most appropriate season (late autumn and winter).

3.6.4 Resolution of Concerns

It is submitted that all major topics of concern have been resolved by appropriate design solutions. Linking the internal waterbody to the river will not increase the risk of contamination of river waters as a result of groundwater seepage, efflux of tipsite leachate, or disposal of stormwater runoff. In addition, it should be clear that the new riverine waterbody will flush adequately and not become a source of additional nutrient enrichment and algal blooms.

Water quality within the new waterbody will be the same as that of the source waters in the adjacent river, and, as a result of both remediating and relocating the Belmont Drain outfall some 250 m downstream, will be suitable for the proposed beneficial use. In addition, the proposed remediation of both Belmont and Abernethy Road Drains will result in an improvement in water quality discharged to the river by both drains.

The conservation value of the System Six Area M51 has been recognised and its importance as a nutrient 'filter' for the river has been emphasised. Works proposed to control human access to the area are outlined in section 3.4 and include a boardwalk/nature trail, fencing to stop vehicle access off Resolution Drive, and a moat along the northern boundary of the development. These works are required both to protect the System Six Area from disturbance, and to ensure that the existing mosquito breeding problem in the saltmarsh is not exacerbated.

Section 3.5 outlines the works proposed to retain and enhance the waterfowl values of the predevelopment lakes. These include:

- retention and enhancement of the freshwater lake (lake 1; Figure 2) and the creation of additional freshwater wetlands within the stormwater management system;
- retention of existing sedge and samphire habitat along the western edge of lake 2 (Figure 2), and substantial revegetation of the eastern edge of the tipsite to provide both additional riverine habitat and a dense vegetative buffer; and
- creation of numerous island waterfowl refuges.

The lack of adequate data on waterfowl usage of the predevelopment wetlands and the riverine habitats of System Six makes reliable comparison of the pre- and post-development wetland values difficult. However, it is submitted that the new riverine waterway will when completed, provide substantially more useful feeding, breeding and roosting areas than originally existed, will maintain the drought refuge value of previous claypits, and will provide permanent rather than seasonal estuarine wetlands.

Furthermore, the substantial area of riverine habitat created within the new waterbody, including the braided wetlands in the old Kikuyu paddock, will provide additional nutrient stripping function for the Swan River. This, plus the creation of a substantial new area of shallow subtidal riverine habitat suitable for colonisation by fish and crustacea, means that the proposal will result in a substantial net benefit to the Swan River ecosystem.

3.6.5 Benefits to the Community

The major benefits to accrue to the community as a result of this project are:

- restored floodplain and floodplain function;
- increased biological capacity/function of the river (additional estuarine habitat and nutrient stripping function);
- increased public access to the river foreshore;
- increased regional recreational and leisure opportunities involving both boating, canoeing and fishing;
- improved riverine landscape quality;
- improved opportunity for nature study and wildlife observation; and

- increased land value and, as a result, economic return to the current landowners (the State and City of Belmont).

3.6.6 Management Requirements

The costs to the community arising from the project include:

- an additional improved area of riverine region open space to be maintained in perpetuity;
- an extension to the overall river waterways reserve to be managed in perpetuity; and
- navigable channels and hydraulic link to be maintained in perpetuity.

The following section of this report details the management undertakings by the Proponent for the project.

4 ENVIRONMENTAL MANAGEMENT

4.1 INTRODUCTION

The development proposal for Ascot Fields is designed so that the environmental components (e.g. the waterbody, drainage systems, landscaped areas and associated biological processes) operate efficiently and effectively with minimal adverse environmental effects. The modified and newly created riverine environments should function to the advantage of the overall river system.

While much of this advantage will be achieved 'passively' by virtue of good design to ensure the new waterway is biologically healthy, there still remains a need to set in place both temporary and ongoing management programmes. This part of the PER addresses the environmental management programme for the development.

4.2 HEADS OF AGREEMENT

The Consortium has entered into an agreement with the Western Australian Planning Commission and the City of Belmont which deals with a variety of matters including:

- waterway management,
- remediation,
- tipsite,
- Aboriginal interests.

The provisions of the agreement, and the commitments they embody, are summarised below under these headings.

The essential elements of the agreement (subject to the approval by the relevant authorities of the PER) require the following:

4.2.1 Waterways Management

(i) The land within the waterways including:

(a) passive recreational waterway (north-west of Causeway); and
(b) active recreational waterway (south-east of Causeway);

is to be vested in the Crown.

(ii) The Consortium is to provide a long term management and maintenance plan for the waterways, islands, ROS and POS, with special reference to treatment of the System Six Area.

(iii) The WAPC and the City of Belmont in conjunction with the Consortium will be responsible for negotiating with the appropriate authorities to establish which authority will be responsible for maintenance of the waterways.

(iv) The Consortium will be responsible for putting in place a management system for the Marina (being that part of the active recreational waterway shown on the attached plan), requiring no commitment of financial resources from the State and based on contributions from the land owners around the Marina.

The WAPC and the City of Belmont will support the Consortium's or land owners' application for Jetty and River Bed Leases and Licenses in respect of the Jetties and Moorings.

(v) The Consortium will be responsible for ensuring that the navigable waterway meets the specifications as established in this PER, and in respect to the water quality and depth including the issue of siltation and structural integrity of the edge treatments and will maintain the navigable channel to the Swan River for a period of five years from the date of practical completion to the satisfaction of the WAPC or until validation, whichever is the earlier.

Based on advice received from M P Rogers & Associates (Appendix B), who has modelled the effects of sedimentary accretion on the Swan River, there is expected, under normal conditions to be a buildup of sediment in the navigation channel for the Ascot Waters Project over a period of 20 - 25 years. This situation might require dredging. However, under various abnormal conditions of the river such as flood conditions, then dredging might be required more often (for example in the situation of a river flow exceeding the five year return period flood). These requirements will be determined by monitoring on an annual basis after winter for the next five years after completion of the channels.

4.2.2 Remediation

Under its agreement with the WAPC and the City of Belmont, the Consortium accepts responsibility for the testing, monitoring and necessary rehabilitation of any contaminated land within the Development Area, save and except the tipsite and the unrestricted fill site.

The Consortium has also agreed to a stringent monitored dewatering programme for the development, which necessitates that any water from the site must be below international, Australian and Western Australian guidelines for the control of nutrients, organochlorides and other potential contaminants.

4.2.3 Tipsite

As to disturbance of refuse on the tipsite:

(i) the Consortium is to obtain approval of the WAPC, the City of Belmont and to the extent necessary by the EPA and the SRT as to any excavation, re-contouring or disturbance whatsoever of the refuse in the tipsite.

In this regard the development plan and the detailed engineering solutions for the tipsite earthworks and abutting waterway excavations have been designed to minimise the impact on the tipsite, particularly below the 1:100 flood level, i.e. 2.5 m AHD.

That part of the waterway excavation to the Swan River which involves some excavation into the tip below the water level it is proposed to undertake precautionary measures (outlined in Section 5.2.3.3) to ensure that leachates do not escape from the tip.

4.2.4 Aboriginal Interests

The Consortium proposed in its tender and this has been consolidated into the agreement with the WAPC and the City of Belmont, that the Consortium will in conjunction with these authorities gain the relevant clearances under the State and Federal legislation dealing with Aboriginal interests in respect of the Ascot Waters project.

In addition it has been agreed that consultation should occur with the appropriate Aboriginal communities to discuss a range of issues including employment and training, a youth trust, and input into landscape design and species selection in particular for the waterway edge and tipsite rehabilitation.

To facilitate this programme of approval and consultations the consortium in conjunction with the WAPC and the Department of Aboriginal Affairs has taken appropriate steps which include:

(i) a formal application to the Aboriginal Cultural Material Committee (ACMC) for development of the Ascot Waters project submitted March 15, 1995;

(ii) this application prepared with the assistance of consultants McDonald, Hales & Associates and after consultation with Aboriginal groups was approved by the ACMC on March 28, 1995 with certain conditions namely:

(iii) the establishment of an ongoing communications and consultation programme with Aboriginal interests to investigate the potential for the project to create sustainable and meaningful benefits for Aboriginal people. It is the expectation of all contributors to this process that the procedures and management arrangements will be mutually beneficial, thereby establishing a model which might prove a successful basis for an improved and more certain relationship between Government, developers and Aboriginal groups;

(iv) an effective monitoring programme to ensure that archaeological interests are protected as defined under Section 16 of the Aboriginal Heritage Act 1972 -1980. This requires an independent assessment on a regular basis by a suitably qualified archaeologist during the earthworks period of the development programme.

4.3 MANAGEMENT

A management programme is proposed to mitigate potential environmental impacts of the proposed development, and to avoid those impacts occurring in the first place. The objectives of the management programme are:

- to minimise environmental impacts; and

- to adopt adaptive management practices which will maintain and enhance the recreation, aesthetic and general conservation values of the project area.

It is proposed that the overall management be comprised of a number of component parts, according to the aspect of the development involved.

4.3.1 Management of Construction Activity

Details of construction associated with the dredging of the channels, moats and the connections to the river are provided in Section 3. In summary, construction of these aspects of the project will involve:

- dredging of both connecting channels using a small floating dredge;
- piping dredged material to a bunded settling basin on the southern end of the tipsite or other appropriate location;
- allowing the sediment to settle out and the water fraction to return to the river or internal water body;
- extending the existing 3 to 4 m wide channels through the System Six Area to create protective moats around the northern edge of the development, and between the vegetated sandbar habitats;
- creating an area of islands and braided channels in the floodway immediately south of the System Six Area, at the upstream end of the new internal waterway; and
- replanting sedge removed from the System Six Area along the margins of the newly created braided channel system and islands within the development.

4.3.1.1 Construction Traffic and Noise

Dredge equipment will approach the site by the river, and would work from the river side through to the newly created internal water body. Construction will be confined to daylight hours if disturbance to local residents becomes an issue.

4.3.1.2 Water Turbidity

Dredging will take place during autumn and winter months when the level of suspended material in the river is high, hence turbidity caused by the suction dredge will not noticeably add to ambient levels. However, because the dredged material will have a high water fraction, use of a settling pond located on the tipsite or elsewhere will be necessary. Dredging will proceed at a rate commensurate with the capacity of the settling pond to ensure that sufficient sediment is removed from the dredged slurry.

4.3.1.3 Soil Stabilisation

Soil surfaces of all areas of open space and river/wetland foreshore subject to earthworks will be stabilised appropriately according to slope factor, topographic context and propensity to natural revegetation. Moats cut through the existing sedge/samphire saltmarsh areas have extremely stable sides and do not require further stabilisation. The majority of 'created' wetland foreshores have already been recontoured prior to being /re-vegetated, or have been aligned to retain existing fringing vegetation around the former wetlands. Stabilisation of the downstream connecting channel and within the marina area where the wash from boats will be experienced, will be stabilised by use of limestone and other constructed edge detailing.

Portions of the surface (top and sloping edges) of the tipsite have already been treated with topsoil containing an appropriate clay/silt fraction as a precursor to re-vegetation according to a 'forward planting landscape master plan'. The central tipsite surface area (to remain vacant) may receive a covering of the clay/silts taken from the settling pond following dredging works, as appropriate.

4.3.1.4 Public Access to Foreshore Areas and Dredge Channels

Public access to the areas of excavation, dredging and recontouring will be restricted until construction works and initial site restoration are completed. Thereafter, access will only be restricted where there are nominated wildlife habitats (samphire, reed beds, roosting areas, breeding/nesting sites, islands, etc.).

4.3.2 Post Excavation Management

4.3.2.1 Channel Edge, Foreshore and Island Soil Stability

The upstream connecting channel and constructed moat edges are not expected to require ongoing management to retain their shape and stability, however they will be monitored on a regular basis throughout the first year following effective completion as landscape detailing and maintenance is carried out.

The downstream connecting channel edges will be stabilised and 'strengthened' with appropriate constructed 'facing' (e.g. limestone 'brick brack', etc.) to absorb wash from boats, and to support a higher profile bank. The subsurface channel sides within the Swan River occur in silt/clay material which is understood to be sufficiently stable to retain the proposed dredged profile.

The 'soft' planted foreshore edges of the wetland and the islands will be stabilised by the existing vegetation which has been retained, or subsequent revegetation with native plant species.

4.3.2.2 Vegetation Planting

As earthworks are completed all re-contoured and previously vacant areas of open space will be replanted according to the Landscape Master Plan for the development. Areas needing rapid replanting (such as the tipsite recontouring) may be hydromulched and planted with appropriate species of seedlings, if necessary.

4.3.2.3 Marina and Boating Areas

The development provides for boating access to the downstream part of the internal water body once the connecting channels are opened up to the Swan River. The water area is designed to cater only for shallow draft boats (maximum draft of 1.5 metres) and will be confined to the downstream area by a causeway/bridge/line of bollards across the waterbody (Figure 19).

There will be no boat storage, slipways, dry standing boat yard, or boat servicing facilities. The marina is intended only as a 'boat accessible venue' limited to shallow draft boats. Rules for boating and navigation within the upper estuary will apply within the marina area.

It will be necessary to arrange for management of the commercial precinct of the development and the marina boating facilities. These arrangements are yet to be finalised.

Canoeing and small dinghy (not motorised) activity will be allowed in the remaining water areas, except where wildlife habitat is clearly identified and where structures are set in place to prevent access (e.g. 'in water' bollards).

4.3.2.4 Water Quality and Circulation

Water quality will be monitored at selected sites within both the waterway and the freshwater wetland following effective completion of the project, on a 3 monthly basis for the first two years after construction and opportunistically over the first five years after construction. The parameters to be monitored include:

- chlorophyll 'a' (integrated);
- suspended solids (midway between top and bottom of water);
- dissolved oxygen (surface and bottom of water);
- biochemical oxygen demand;
- inorganic nitrogen;
- inorganic phosphorus;
- salinity (through water column to check for stratification);
- faecal coliform counts;
- temperature; and
- light attenuation (by Secchi disk).

An intensive sampling period will be undertaken during the occurrence of an algal bloom in summer to confirm water quality characteristics in the waterway in comparison to those in the river, and confirm the time required for the waterway to return to normal conditions subsequent to the collapse of the bloom.

Appropriate action will be taken to mitigate unacceptable performance in any of the above parameters if conditions appear not to be temporary or self-correcting. In the case of the freshwater lake in particular, consideration would be given to:

- alum dosing;
- artificial aeration; and
- decreasing the depth.

Contingency plans will be developed to respond to water quality issues in conjunction with the authority/organisation appointed to be responsible for the management of the waterway.

4.3.2.5 Recolonisation of Benthic Habitat

It is the intention of the project to achieve recolonisation of benthic flora and fauna typical of a healthy upper estuary environment. Benthic surveys at selected sites will be conducted annually for the first five years following construction. If necessary, as a consequence of the findings of the surveys, attempts will be made to improve or increase the rate of colonisation by improving habitats and seeding with appropriate species.

4.3.2.6 Foreshore Protection

The foreshore areas around the internal riverine and freshwater wetland bodies will initially go through a period of adjustment in response to construction works and a new water quality/water level regime. As the new foreshore regime establishes it may be necessary from time to time to make adjustments to position of sedge and samphire. This will be undertaken as appropriate on the basis of monitoring the success of vegetation establishment along the wetland foreshores.

It is also important to maintain the foreshore and water edge zones free of incidental litter, 'unnatural' debris or the build up of excessive decaying organic matter (e.g. algal blooms). Regular removal of such materials will be undertaken as a part of the general landscape maintenance of the open space areas associated with the development.

4.3.2.7 Public Access

Access will be provided to pedestrians and cyclists along the length of the foreshore by means of a dual use pathway. The path will meander along the foreshore areas and around/across the landscaped tipsite. The pathway will be diverted away or screened from all sensitive wildlife habitat areas, and will generally be integrated into the landscape.

General access into the System Six Area will continue to be discouraged by the existing moat around the tipsite 'foreshore'. Limited and controlled access to the System Six Area will be provided by the construction of a carefully positioned boardwalk through the vegetated remnant sandbank islands to constructed lookouts. A single access point into the System Six Area will be provided to allow easy control.

4.4 LONG-TERM MANAGEMENT RESPONSIBILITY

The provisions of the Heads of Agreement (Section 4.2 and 4.2.1) require the Consortium to provide a long-term management and maintenance plan for the waterways, islands, ROS and POS, with special reference to treatment of the System Six Area. The Consortium is also responsible for setting in place a management system for the Marina, and providing for the maintenance of a navigable channel for a period of five years from the date of practical completion.

In view of the physical elements of the development requiring to be managed, and the most likely administrative arrangements to be negotiated and agreed to by government, it is proposed that the areas to be managed be classified as follows:

(i) Open Space and Parkland: this would include all publicly accessible open space land areas, including areas of dual use paths (paths, boardwalks, lookouts and pedestrian bridges), all 'active and passive' landscaped park areas (including the landscaped drainage swale), tipsite landscaping, river foreshore edges (to high water mark only), the 'off-line' detention basin, and the freshwater lake.

(ii) System Six: this is the System Six Area as defined, less the proposed connecting channels to Ascot Waters.

(iii) The Ascot Waters Internal Waterways: this includes the newly created internal waterway in its entirety (the waterbody itself, the connecting channels, the islands, and the marina).

The long-term maintenance and management plans for these areas are outlined in the following sections.

4.4.1 Open Space and Parkland Management Plan

4.4.1.1 Scope of Activities

The principal concerns of a management plan for the open space and parkland areas (excluding the civic open space/parks within the urban precincts of the Ascot Waters development) include:

- landscape maintenance (mowing/cutting of open turf/ground cover areas, pruning/lopping and removal of dead plant materials, planting and vegetation replacement, weed control, and occasional soil amendment and fertiliser application) including occasional pre-suppression works in dry-landscape areas to reduce fuel loads and minimise the risk of summer ground fires (e.g. on the tipsite);

- fixture maintenance (maintenance and repair of all fixtures including fixtures, dual use paths, seats, barbecues, signs, litter bins, lighting, pedestrian bridges/boardwalks, etc.) including sprinkler fixtures in the case of any irrigated turf/shrubbery areas; and

- rubbish removal (both the removal of incidental litter and the emptying of installed litter bins).

The Open Space and Parkland Management Plan will also be concerned with incidental control of public behaviour and public access. To a large degree public movement and access should be 'controlled' and guided as an outcome of design objectives incorporated into the landscaping. In other words easily accessible paths will lead away from sensitive and restricted sites, and guide users to carefully located observation points where 'visual access' rather than 'physical access' is provided. Management of public behaviour will therefore mainly be 'passively' rather than 'actively' controlled.

4.4.1.2 Administrative Responsibility and Funding

As part of the agreement between the Government and the Consortium, the WAPC and the City of Belmont, in conjunction with the Consortium, are responsible for negotiating with the appropriate authorities to establish which authority will be responsible for maintenance of the ROS and POS parkland areas. These negotiations are yet to be concluded.

4.4.2 System Six M51

4.4.2.1 Scope of Activities

The scope of management activities applicable to the System Six Area, in view of the Ascot Waters development, need not be extensive. In effect it is proposed that the System Six Area be cut off from ready access by users of the Ascot Waters open space foreshore areas by a moat and channels. In this situation there is no need for ongoing maintenance, as there would be no facilities or fixtures within the System Six Area.

It is notionally proposed that a pedestrian boardwalk be provided through to the largest of the vegetated sandbar 'islands' to two observation points, possibly with an 'interpretative' signboard. Approval for this would be required from the SRT. If it is accepted, then there would be a need for a low level of ongoing management and maintenance. This would include:

- maintenance of walking trail, boardwalk and bridge structure, signposts and railings;
- regular removal of litter, fallen timber, etc.; and
- possible control (restricted) access from time to time (according to need to protect nesting birds, avoid high fire risk season etc.).

Implementation of the above will be addressed as part of the management plan. It is argued that current/traditional access and use of the islands by boaters/fisherman should not be the responsibility of the Ascot Waters development.

Mosquito management activities currently undertaken by the City of Belmont would continue. However, the Consortium has agreed with the Proponent to commit additional funds to facilitate a physical mosquito control programme if and when such a programme is approved by the Health Department of Western Australia.

4.4.2.2 Administrative Responsibility and Funding

It is desirable that the System Six Area be transferred to the Crown and vested appropriately. The area has significant habitat and landscape value and should be a reserve for conservation of flora and fauna. It therefore follows that vesting should be in the appropriate government authority.

Funding requirements would be minimal/zero if access continues to be restricted and the area stays much as it is. If the board walk access is accepted a low level of maintenance funding would be required. On ground management (litter removal, etc.) needs would also be limited, and could easily be carried out as a minor extension of the management for the adjacent region open space area (river foreshore, tipsite,. etc.).

As part of the agreement between the Government and the Consortium, the WAPC and the City of Belmont, in conjunction with the Consortium, are responsible for negotiating with the appropriate authorities to establish which authority will be responsible for maintenance of the System Six Area. These negotiations are yet to be concluded.

4.4.3 The Ascot Waters Internal Waterways

4.4.3.1 Scope of Activities

The scope of activities include:

- litter and debris removal from the waterbody and the surrounding foreshore and littoral zones;
- removal of bulky submerged objects (sunken boats, extraneous materials or objects deposited or discarded into the waterbody);
- clean up of accidental spills (e.g. oil, etc.) into the waterbody;
- maintenance/revegetation of the landscape littoral zones;
- maintenance of adequate depth and bottom profiles to ensure continued flushing as well as navigable access to the marina area;
- maintenance of shoreline condition and stability, especially the engineered structures (e.g. retaining walls, rip rap, etc.);
- maintenance of all fixtures (e.g. navigation lights/markers, roosting perches, jetties); and
- control of boats, boat users, and use of moorings and jetties.

4.4.3.2 Administrative and Funding Requirements

As part of the agreement between the government and the Consortium, the WAPC and the City of Belmont in conjunction with the Consortium are responsible for negotiating with the appropriate authorities to establish which authority will be responsible for maintenance of the waterways. These negotiations are yet to be concluded.

4.4.4 Central Belmont Main Drain (CBMD)

The Consortium has agreed to undertake the works described for the CBMD and the Matheson Road Drain and to provide the net environmental gain to the Swan River by replacing the existing downstream section (Stoneham Street to the river outfall) of the Belmont Drain with the proposed solution.

The Consortium will undertake these works and, in conjunction with WAWA, monitor the quality of the water in the new retention drainage system for a period of 12 months. The existing WAWA monitoring system will be re-established by the Consortium to enable the ongoing monitoring by WAWA.

The responsibility for the control of the upstream drainage including Ascot Race Course and the private stable areas (upstream of Stoneham Street) and potential pollution of that system will not be that of the Consortium but of the relevant authority.

5 LIST OF COMMITMENTS

5.1 INTRODUCTION

This section of the report lists all the commitments made by the Proponent and described in this report and identifies the authorities to whose satisfaction those commitments must be carried out.

The Proponent will undertake to abide by all commitments made in this PER. Specifically this refers to undertaking all management programmes outlined in the preceding sections. These commitments will be incorporated into a final project between the Proponent and the State.

The following commitments are made by the Proponent for the satisfactory completion of this project.

5.2 COMMITMENTS

5.2.1 Construction of the Connecting Channel

(i) The Proponent/Consortium will use the most appropriate dredge available to minimise disturbance to the river environment.

(ii) Construction will be limited to daylight hours only (if residents objections are received).

(iii) All dredge material will be piped to a settling pond located within the development.

(iv) Return water from the settling pond will be monitored to ensure that most of the sediment has settled out before it is returned to the Swan River. All solid dredge spoil will be deposited outside the river environment, within the development.

5.2.2 Waterways

(i) The Proponent/Consortium undertakes to landscape the fringing zones of the freshwater lake and internal waterway (including the islands) in such a way that the habitat value to waterfowl and other fauna (fish, long necked tortoises, etc.) is maximised, to the satisfaction of the Waterways Commission and SRT. Plantings with native vegetation will be supplemented with seeding and hydromulching as required, to the satisfaction of the Waterways Commission and SRT.

(ii) The Proponent/Consortium undertakes to ensure that the navigable waterway meets the specifications and in respect to the water quality and depth as described in this PER, including the issue of siltation and structural integrity of the edge treatments and will maintain the navigable channel to the Swan River for a period of five years from the date of practical completion to the satisfaction of the Waterways Commission and SRT or until validation, whichever is the earlier.

(iii) The Proponent/Consortium will be responsible for putting in place a management system for the Marina requiring no commitment of financial resources from the State and the City of Belmont and based on contributions from the land owners around the Marina.

(iv) The Proponent/Consortium will be responsible for negotiating with the appropriate authorities to establish which authority will be responsible for the ongoing maintenance of the waterway.

5.2.3 Remediation

(i) The Proponent/Consortium will undertake the testing, monitoring and necessary rehabilitation of any contaminated land within the development, save and except the tipsite and the unrestricted fill site.

(ii) The Proponent/Consortium will monitor to the satisfaction of the Waterways Commission and SRT the newly connected internal waterbody at a selected period during the first year following practical completion to ensure that tipsite leachates are not unduly affecting/entering the waterbody.

5.2.4 Tipsite

(i) The tipsite is to be landscaped appropriately in order to improve its visual appearance, and to stabilise the surface and avoid winter erosion and summer dust problems.

5.2.5 Central Belmont Main Drain

(i) The Central Belmont Main Drain alignment and outlet will be modified in accordance with the proposed solutions in the PER by the Proponent/Consortium in order to accommodate the Ascot Waters development.

5.2.6 System Six

(i) If support and approval is given from the landowners and the EPA and SRT to construct a protective moat around the edge of the System Six Area, the Proponent/Consortium undertakes to design, locate and construct/excavate the moat with the advice of, and to the satisfaction of, the EPA, the SRT and the Health Department.

(ii) The Proponent/Consortium will give a commitment to carry out all undertakings contained in the PER, and with particular reference to Section 4.

6 SUMMARY CONCLUSION

6.1 BENEFITS

The Proponent's objectives are firstly, to undertake the extensive environmental restoration of a former floodplain landscape which had been badly degraded as a result of previous land use activities, and secondly, to create a high quality riverside urban precinct which will markedly increase the value of the developable portion of the site, and provide a greater economic return to the current land owners (the State Government and the City of Belmont), and the community at large.

The key action proposed to achieve the above, and the focus of this PER, is the connection of the large, internal wetland waterbody to the Swan River. This will convert the existing man-made waterbody from a fresh/brackish lake to a riverine system.

The benefits to flow from this include an extensive increase in the area of riverine environment habitat, (fringing, littoral and aquatic), with a commensurate increase in wildlife species and diversity in the Ascot/Maylands/Bayswater locality. This particularly includes fish nursery habitat and waterfowl refuges.

Other benefits include an extensive increase in river orientated recreation opportunity and improved, but controlled, access to a riverside precinct which was formerly restricted. The development will additionally transform a severely degraded floodplain landscape to one of high amenity which is well integrated with the adjacent river environment.

6.2 ENVIRONMENTAL EFFECTS

The principal environmental effect of this project is the cutting of a 15 m wide upstream channel through a narrow section of the System Six Area, following the alignment of an existing man made channel. A second downstream channel will be cut through shallows near the existing CBMD outlet.

All fringing sedge vegetation removed in this exercise will be transplanted in the new waterbody, hence no net loss of riverine vegetation will result; indeed, a significant net increase will occur.

There are then also the effects of marginally altering the hydrodynamic characteristics of the river channel to ensure the newly connected waterbody has appropriate water circulation and exchange. The Ascot Waters development should not add additional pollution to the Swan River, and the water quality is expected to be at least as good as the source waters of the Swan River.

A further outcome is that in accommodating the existing CBMD outlet, a new outlet position will result and some additional initiatives taken to seek a more permanent improvement in the quality of stormwater runoff entering the river system.

6.3 MANAGEMENT OF ENVIRONMENTAL CHANGE

Management programmes have been designed to address potential environmental outcomes associated with:

- management of construction activity:
    - water turbidity,
    - soil stabilisation,
    - public access and foreshore control;
- channel edge, foreshore and island soil stability;
- vegetation planting;
- marina and boating access;
- vehicle access and parking;
- water quality and circulation;
- recolonisation of benthic habitat;
- ongoing management of Open Space areas; and
- System Six Area (including access control, mosquito control).

It is considered that potentially adverse environmental effects can be managed to avoid unacceptable outcomes.

The Proponent has accepted responsibility for a range of impacts associated with the project (as outlined in sections 4 and 5) and is committed to implement the monitoring and management programmes as identified, to the satisfaction of the appropriate authorities.

6.4 CONCLUSION

The Proponent gave considerable thought to the desirability of taking on what is in effect a major exercise in environmental design and engineering. A final decision to proceed with the challenge was made due to the conviction that the proposal offers tangible benefits to both the community and the river system as a whole. Significant formal and informal encouragement has been given to embark on the largest floodplain restoration project so far undertaken in the Swan River estuary.

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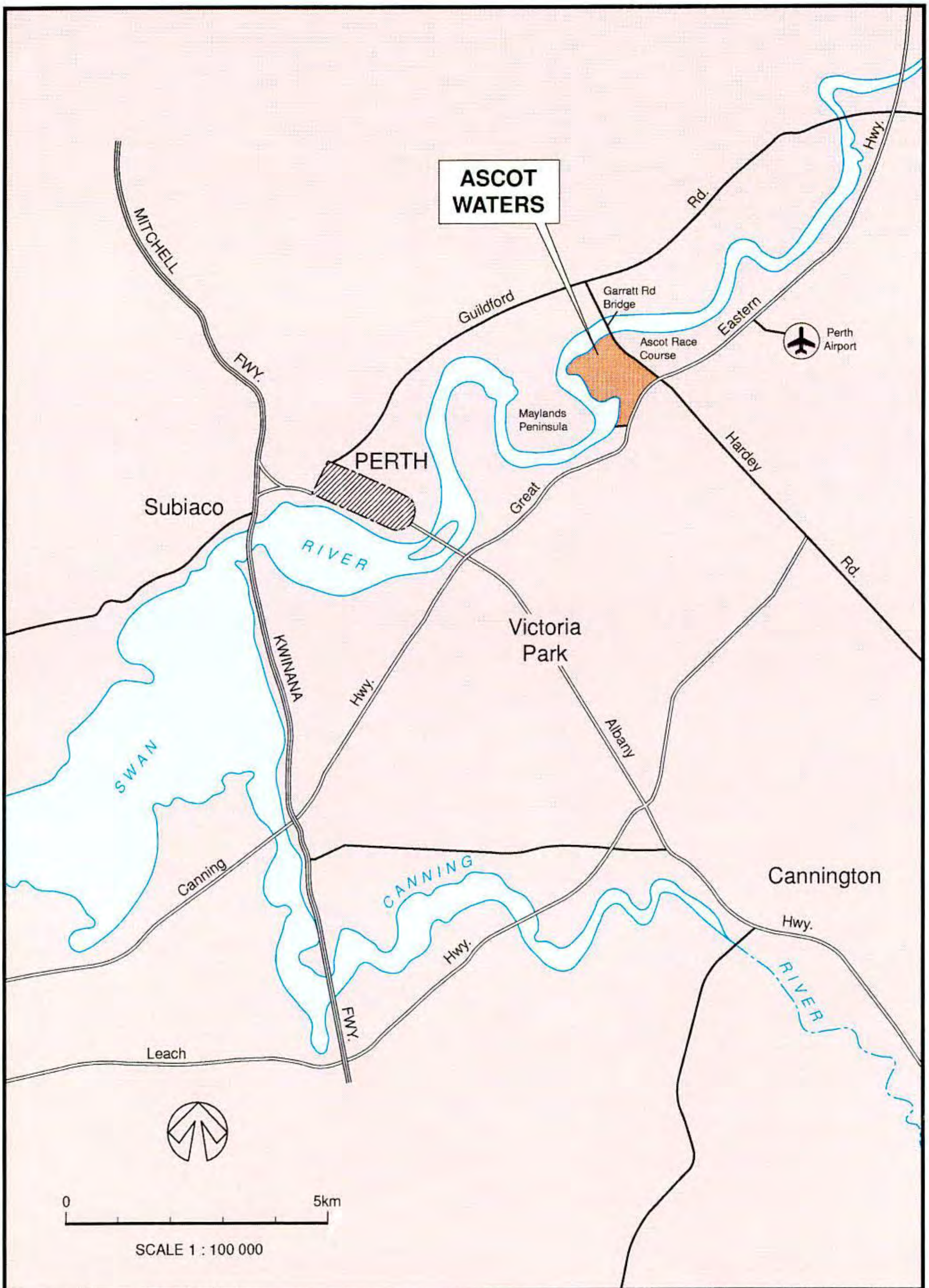
Figures



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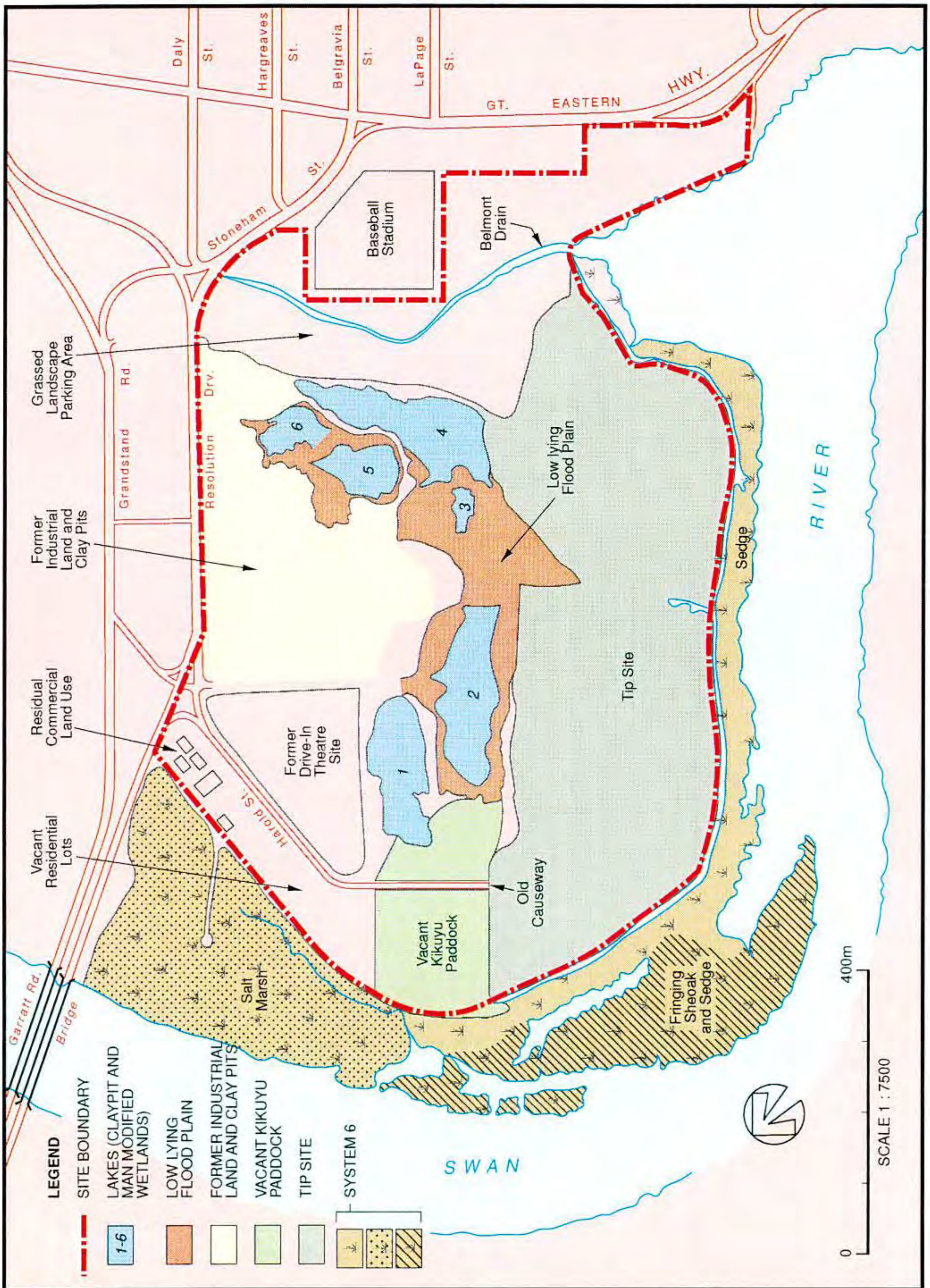
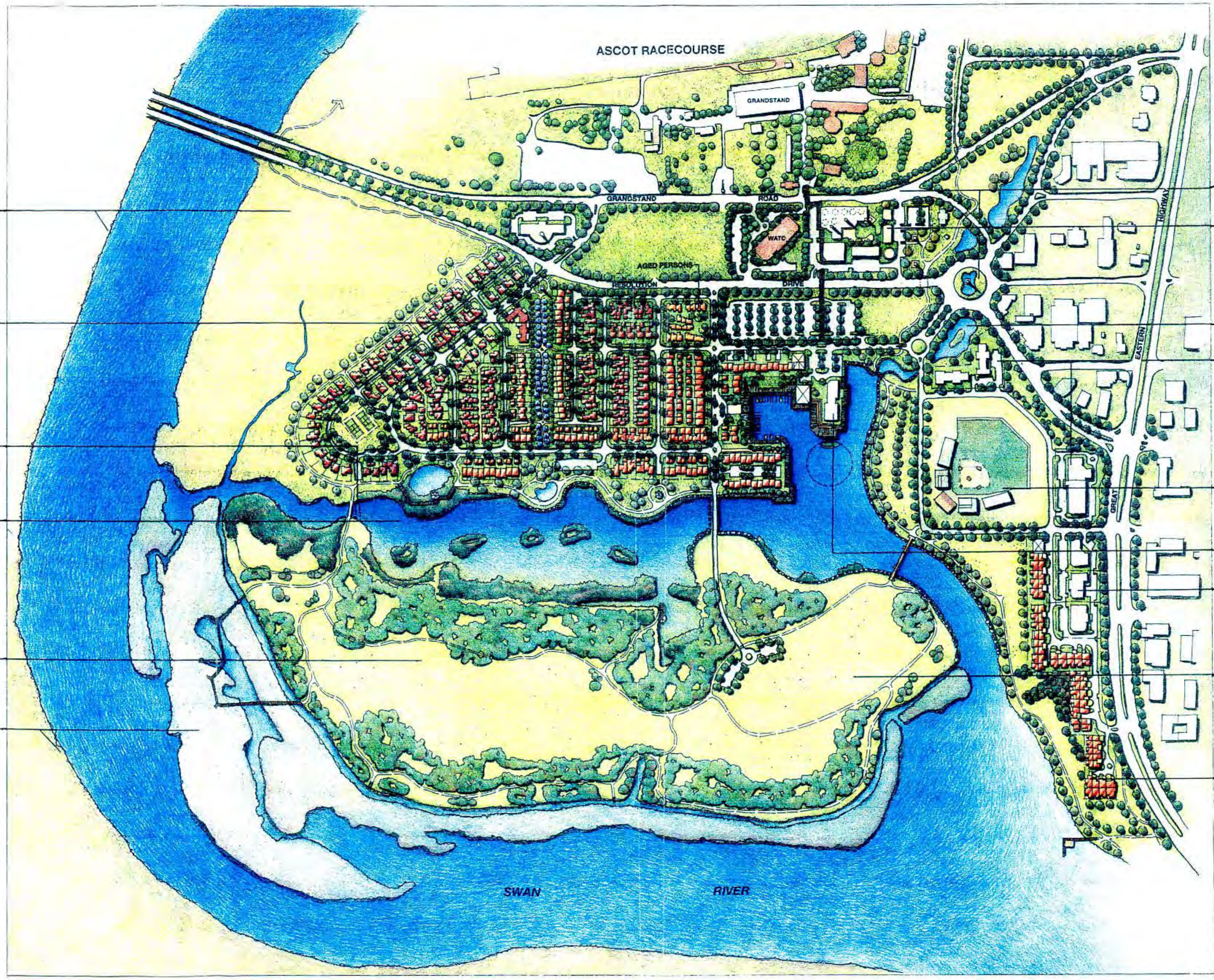
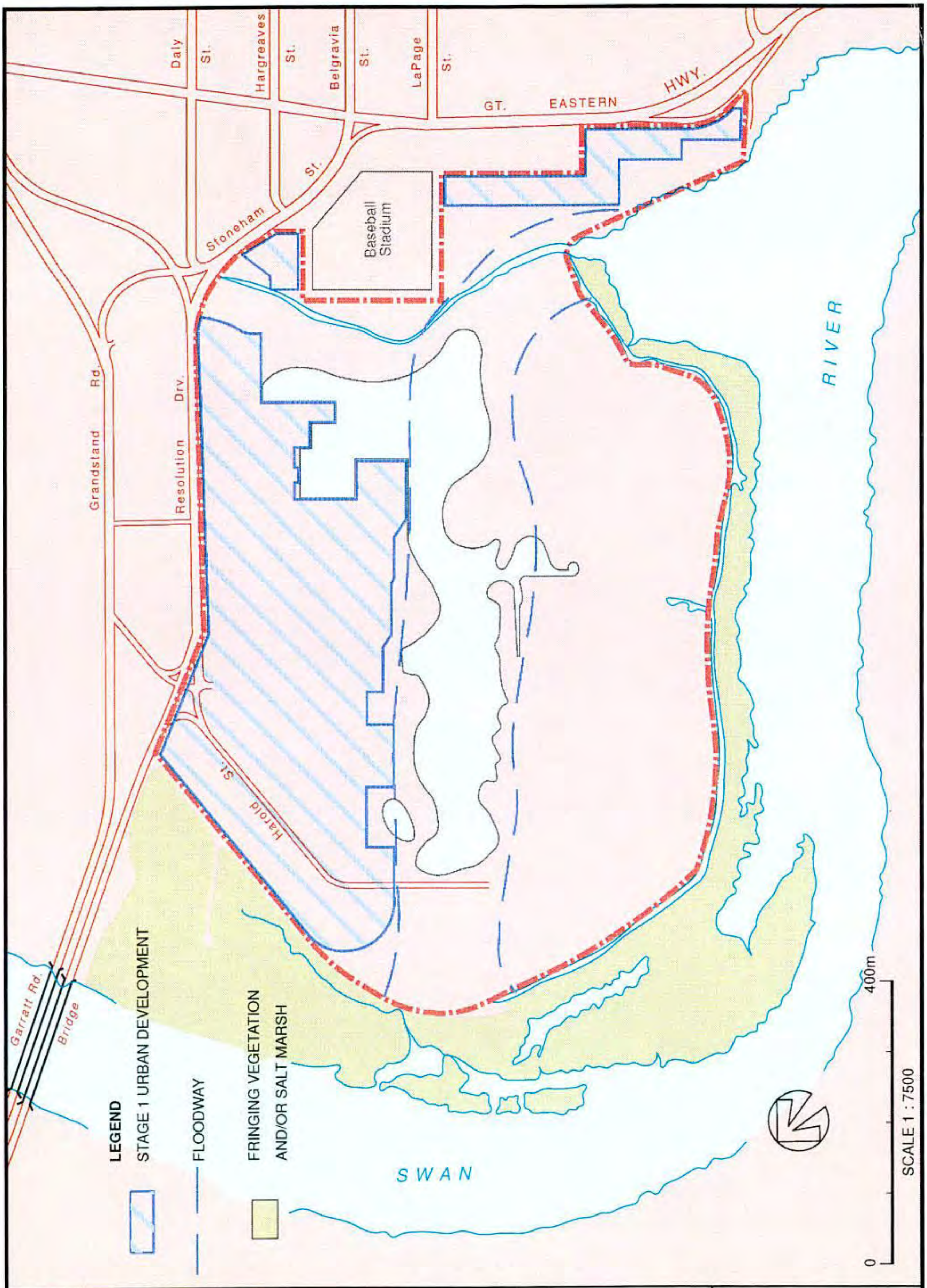
Chk'd. By	ILeP	3-7-95		**LEPROVOST DAMES & MOORE**
Rev. No.	2	6-7-95		



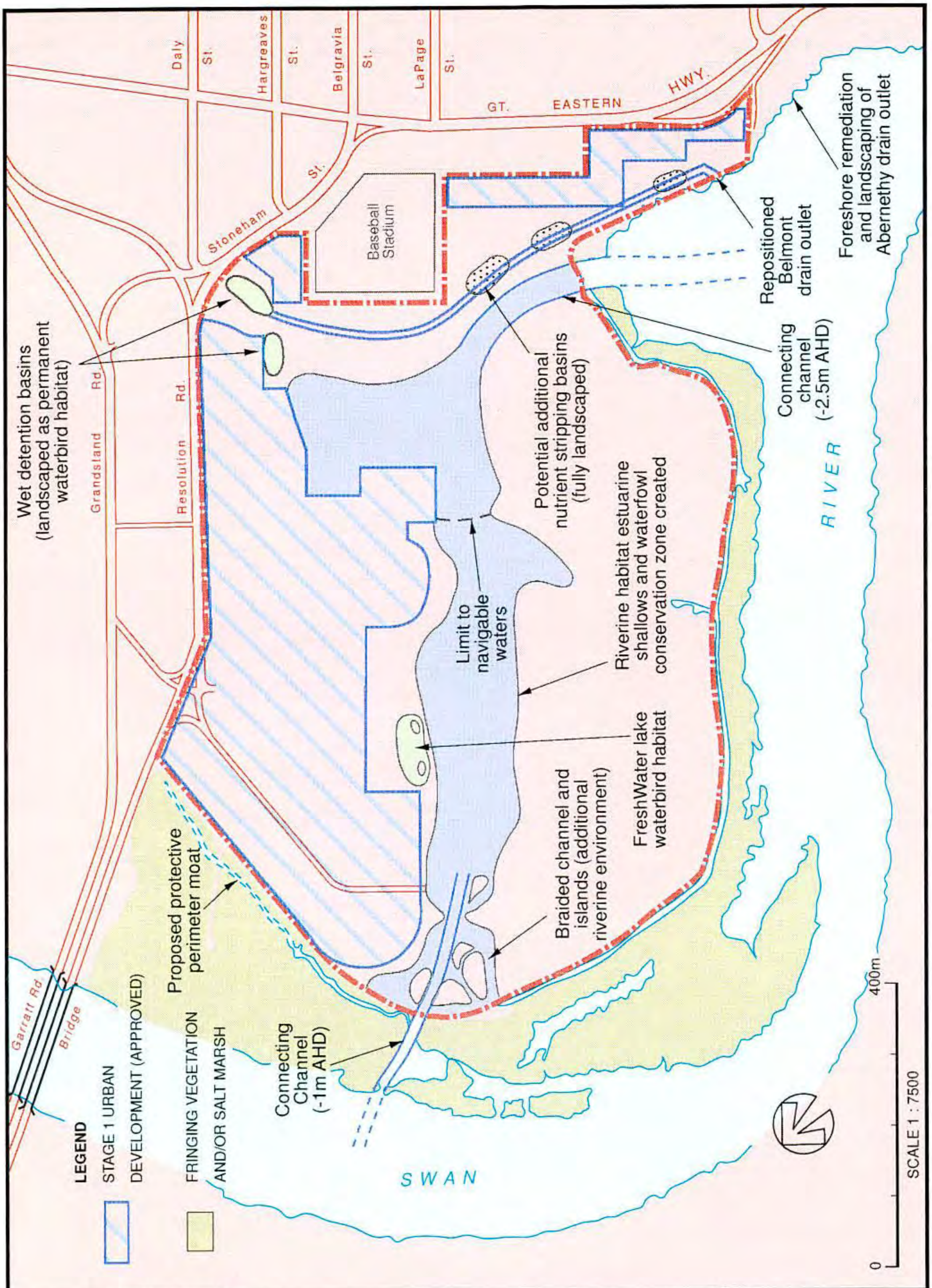
Job No.	29495-004-367		ASCOT WATERS	Figure No. 2
Prep. By	JS	21-6-95	**MAJOR LANDFORM ELEMENTS**	
Chk'd. By	ILeP	3-7-95		**LEPROVOST DAMES & MOORE**
Rev. No.	2	5-7-95		



Job No.	29495-004-367		ASCOT WATERS **DEVELOPMENT PLAN** SOURCE : Russell Taylor & William Burrell Town Planners	Figure No. 3
Prep. By	JS	21-6-95		
Chk'd. By	JS	5-7-95		**LEPROVOST DAMES & MOORE**
Rev. No.	2	5-7-95		



Job No.	29495-004-367		ASCOT WATERS **STAGE 1 EARTHWORKS PLAN** (PREVIOUSLY APPROVED)	Figure No. 4
Prep. By	JS	21-6-95		
Chk'd. By	ILeP	3-7-95		**LEPROVOST DAMES & MOORE**
Rev. No.	2	5-7-95		



Job No.	29495-004-367		ASCOT WATERS **CONNECTING CHANNELS - PER PROPOSAL**	Figure No. 5
Prep. By	JS	21-6-95		
Chk'd. By	ILeP	3-7-95		**LEPROVOST DAMES & MOORE**
Rev. No.	2	5-7-95		

1. STABLE EDGE TREATMENT USING COMBINATION OF HARD ENGINEERING AND SOFT VEGETATED DETAILING.

2. RECREATIONAL LANDING BEACH FOR SMALL BOATS AND PICNIC AREA.

3. PREDOMINATELY EDGE OF BEACH SAND AND SEDGE FRINGE, WITH PAPERBARK GROVES AND AS REQUIRED LOCALISED ENGINEERING STRUCTURES.

4. FRESHWATER LAKE WITH DENSE FRINGING SEDGE, AND PAPERBARKS, ISLAND HABITATS FOR WATER BIRDS.

5. (OLD KIKUYU PADDOCK) BRAIDED CHANNELS AND ISLAND FEATURES-KEY RIVERINE HABITAT RESTORATION AREA-MIXED INDIGENOUS PLANTS OF SEDGE, SAMPHIRE AND PAPERBARKS, WITH VARIABLE DEPTH RANGE.

6. FLUSHING CHANNEL WIDTH OF 15 METRES (MAX) DEPTH OF I METRE.

7. WILDLIFE REFUGE/HABITAT AREA FOR WATER BIRDS AND OTHER FAUNA. SAMPHIRE, SEDGE, CASUARINA AND PAPERBARK FRINGING VEGETATION FOR PRIVACY, SEPERATION OF DUAL USE PATH ON TIP.

8. CONTROL ACCESS TRAIL AND BROADWALK THROUGH TO LARGER VEGETATED ISLAND AND OBSERVATION DECK.

9. DRY LANDSCAPING OF RIVER FORESHORE/TIP EDGE WITH INDIGENOUS RIVERINE SPECIES.

10. EXISTING CHANNEL ACCESSIBLE AS CANOE TRAIL.

11. OPEN DRY LAND GRASSING WITH SELECTIVE INDIGENOUS TREES TO FORM OPEN PARK LAND/VISUAL SOFTENING.

12. PROPOSED BOUNDARY MOAT TO PROVIDE EFFECTIVE CONTROL OF ACCESS INTO SYSTEM 6 AREA (CANOE ACCESS MAY BE RESTRICTED) MAXIMUM WIDTH 3 METRES.

13. CONTROL BARRIER-RESTRICTED ACCESS TO TRANSMITTER MAST.

14. PROPOSED LANDSCAPED "INTERFACE" TO ACCOMMODATE DUAL USE PATH AND STORMWATER DISPOSAL SWALE STRUCTURE.

15. OPTIONAL PROPOSED EXTENSION TO MOAT BARRIER, OR PERIMETER FENCE.

16. ONLINE RETENTION BASIN FOR BELMONT DRAIN.

17. OFFLINE RETENTION BASIN FOR ZONE A DRAINAGE PRECINCT-ASCOT WATERS.

18. POSSIBLE ADDITIONAL RETENTION BASINS FOR BELMONT AND MATHIESON DRAINS.

19. BELMONT DRAIN LOW FLOW OUTFALL.

GENERAL

NOXIOUS WEEDS AND PEST PLANTS WILL BE CONTROLLED OVER THE WHOLE SITE

ASCOT WATERS
DOMAIN
HENRY WALKER GROUP
ESTATES DEVELOPMENT COMPANY

SOURCE:
1. RUSSELL TAYLOR & WILLIAM BURRELL
2. LE PROVOST DAMES & MOORE
3. OVERMAN ZUIDEVELD
4. CMPS&F
5. LANDSCAPE ARCHITECTURAL SERVICES
6. LAND SYSTEMS EBC (ADELAIDE)

0 — 500m

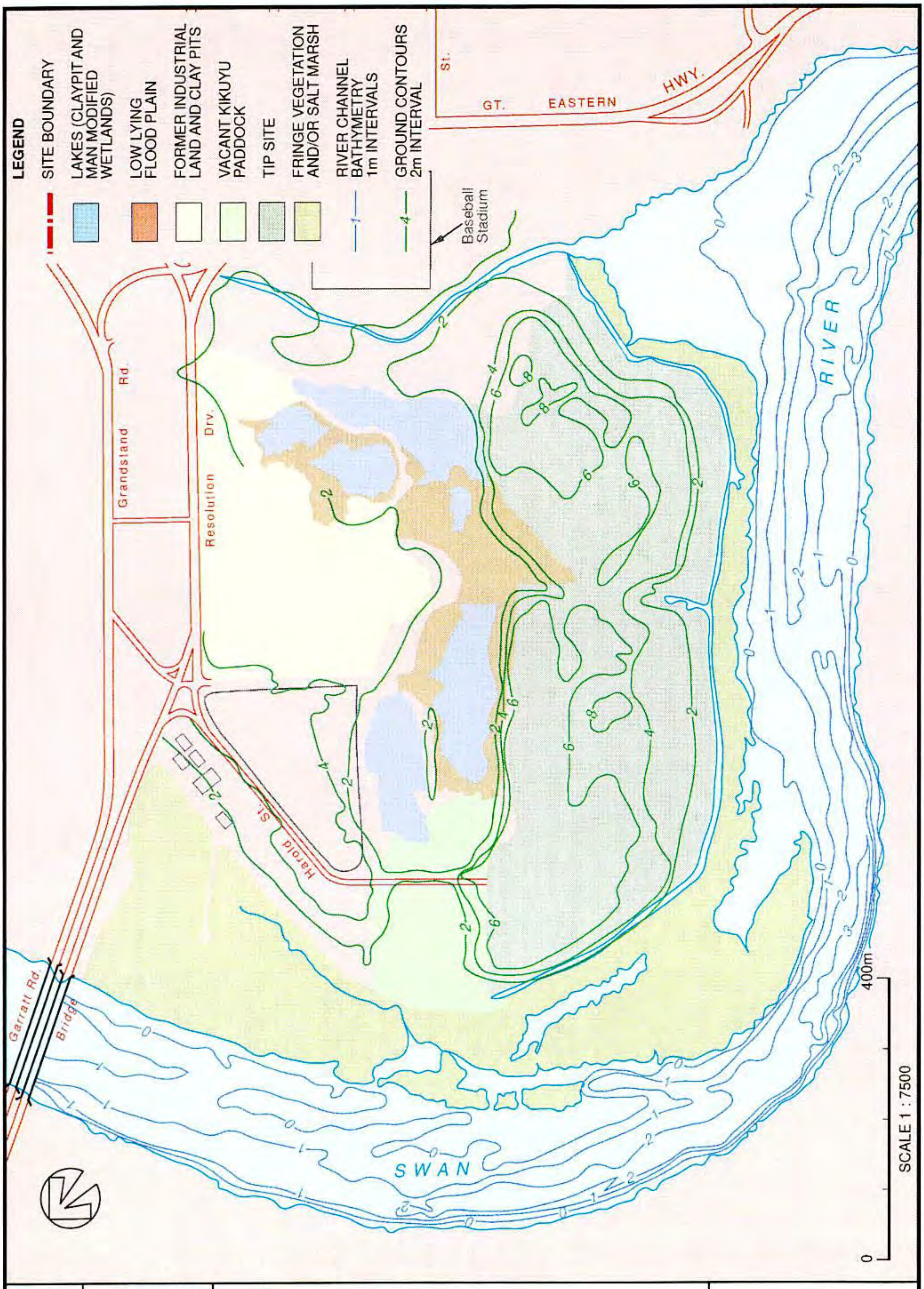
Job No.	29495-004-367	
Prep. By	JS	21-6-95
Chk'd. By	ILeP	3-7-95
Rev. No.	2	5-7-95

ASCOT WATERS

FINAL DEVELOPMENT PLAN

Figure No.
6

LEPROVOST DAMES & MOORE



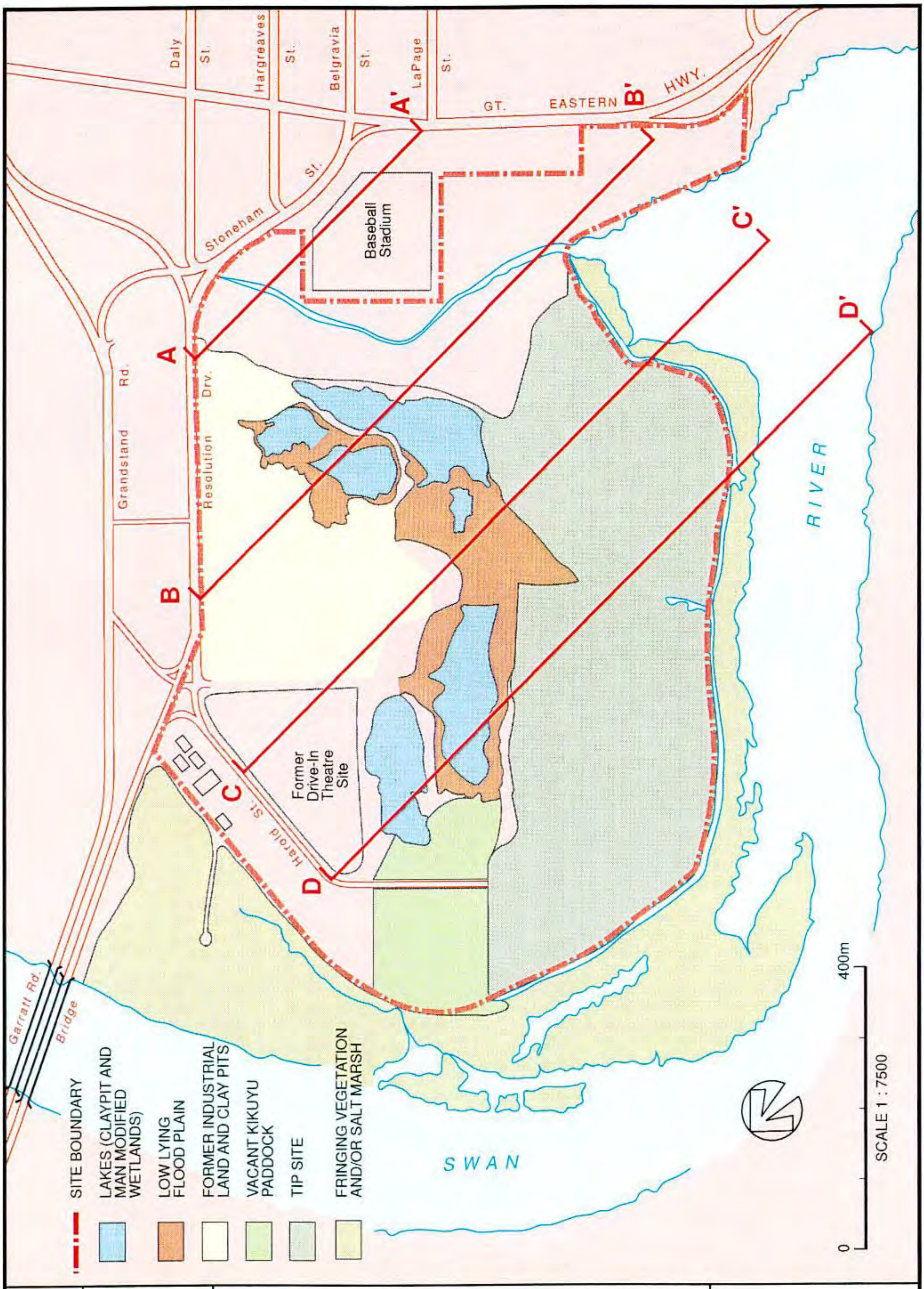
Job No.	29495-004-367	
Prep. By	JS	21-6-95
Chk'd. By	ILeP	3-7-95
Rev. No.	2	5-7-95

ASCOT WATERS

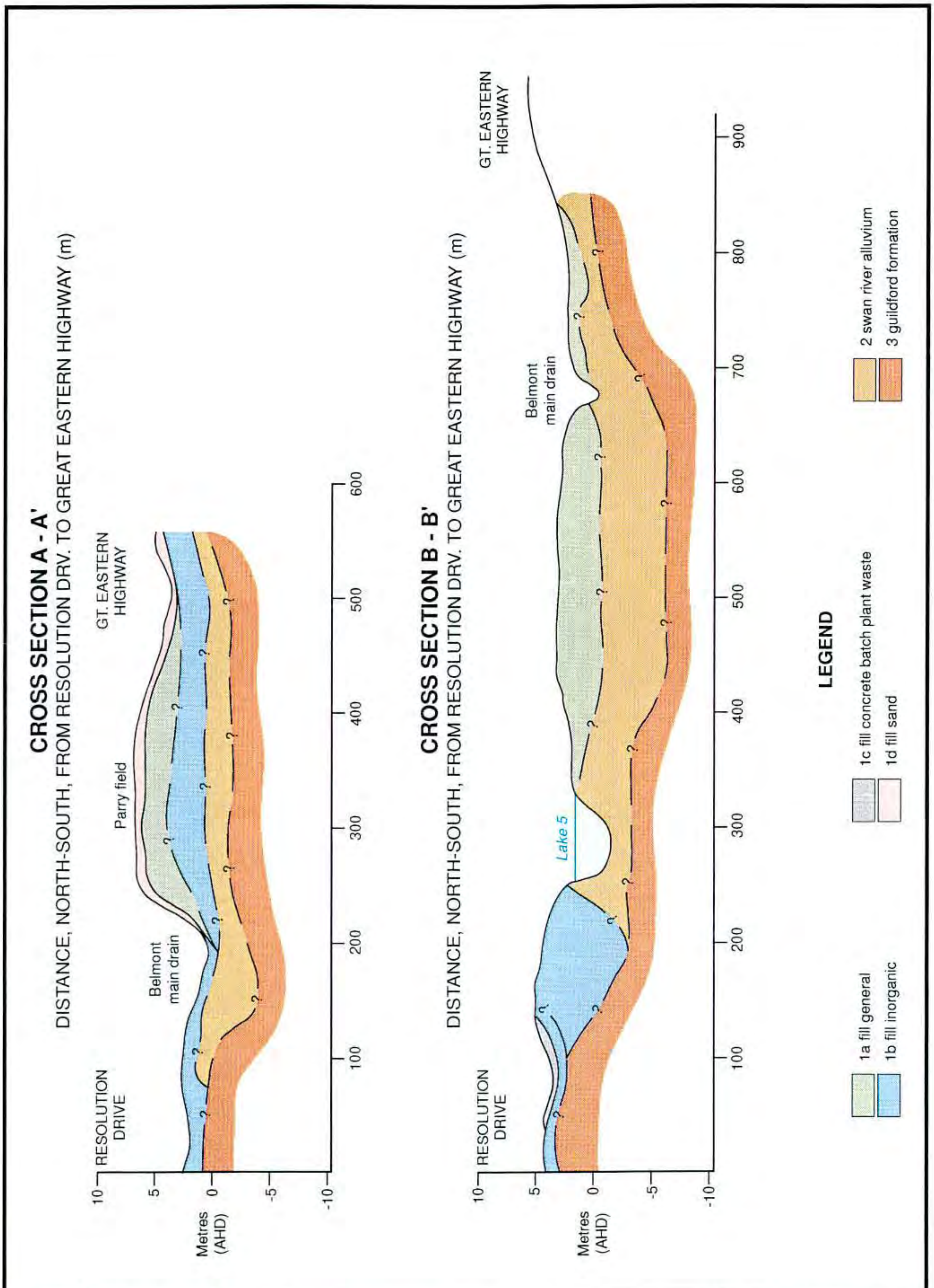
TOPOGRAPHY AND BATHYMETRY OF PROJECT SITE

Figure No. 7

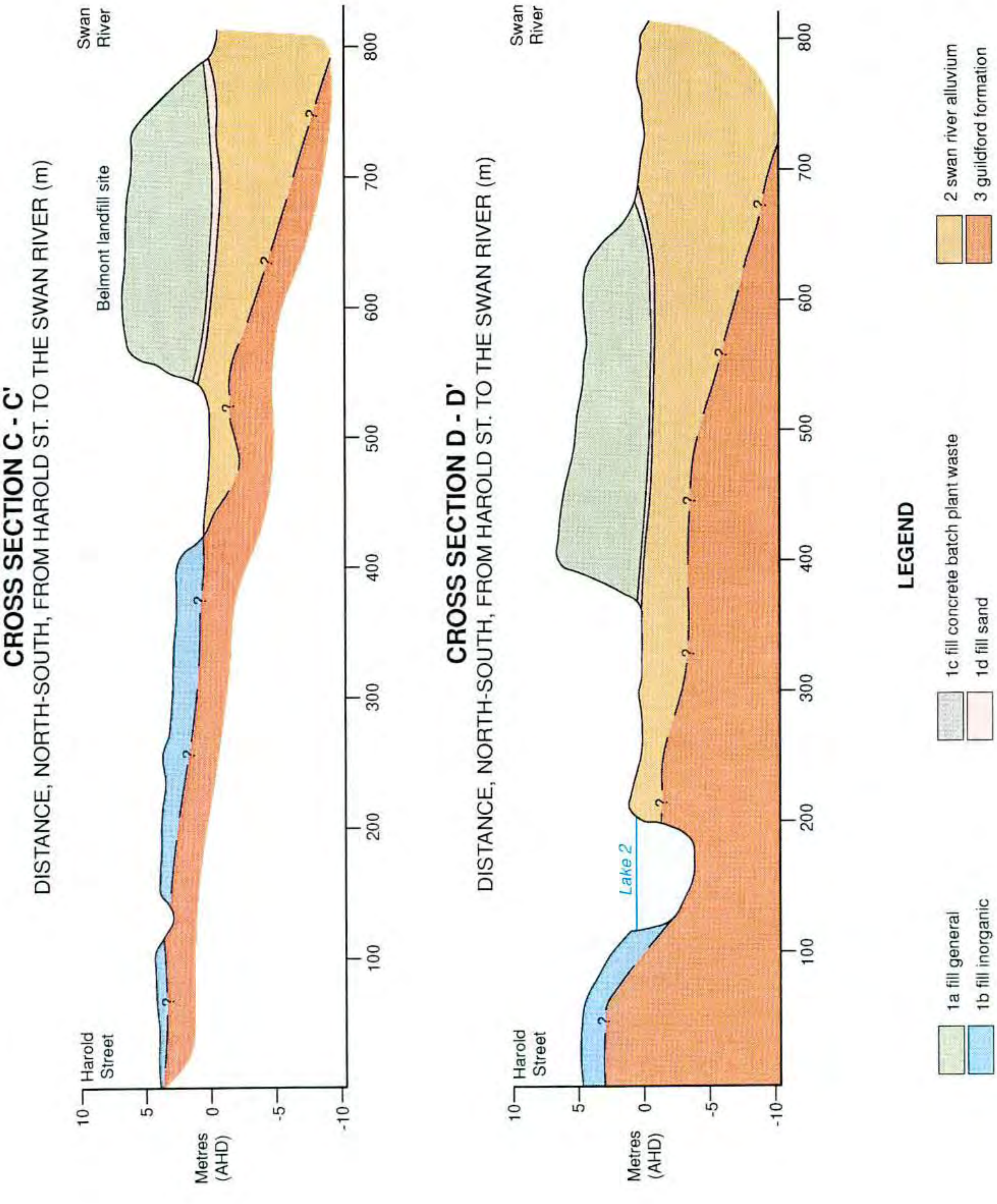
LEPROVOST DAMES & MOORE



Job No.	29495-004-367		ASCOT WATERS	Figure No. 8
Prep. By	JS	21-6-95	**GEOLOGY**	
Chk'd. By	ILeP	3-7-95		**LEPROVOST DAMES & MOORE**
Rev. No.	2	5-7-95	(SOURCE : Coffey Partners International Pty Ltd, 1995)	



Job No.	29495-004-367		ASCOT WATERS **GEOLOGICAL SITE CROSS SECTIONS A-A' & B-B'**	Figure No. 8a
Prep. By	JS	21-6-95		
Chk'd. By	ILeP	3-7-95		**LEPROVOST DAMES & MOORE**
Rev. No.	2	5-7-95		



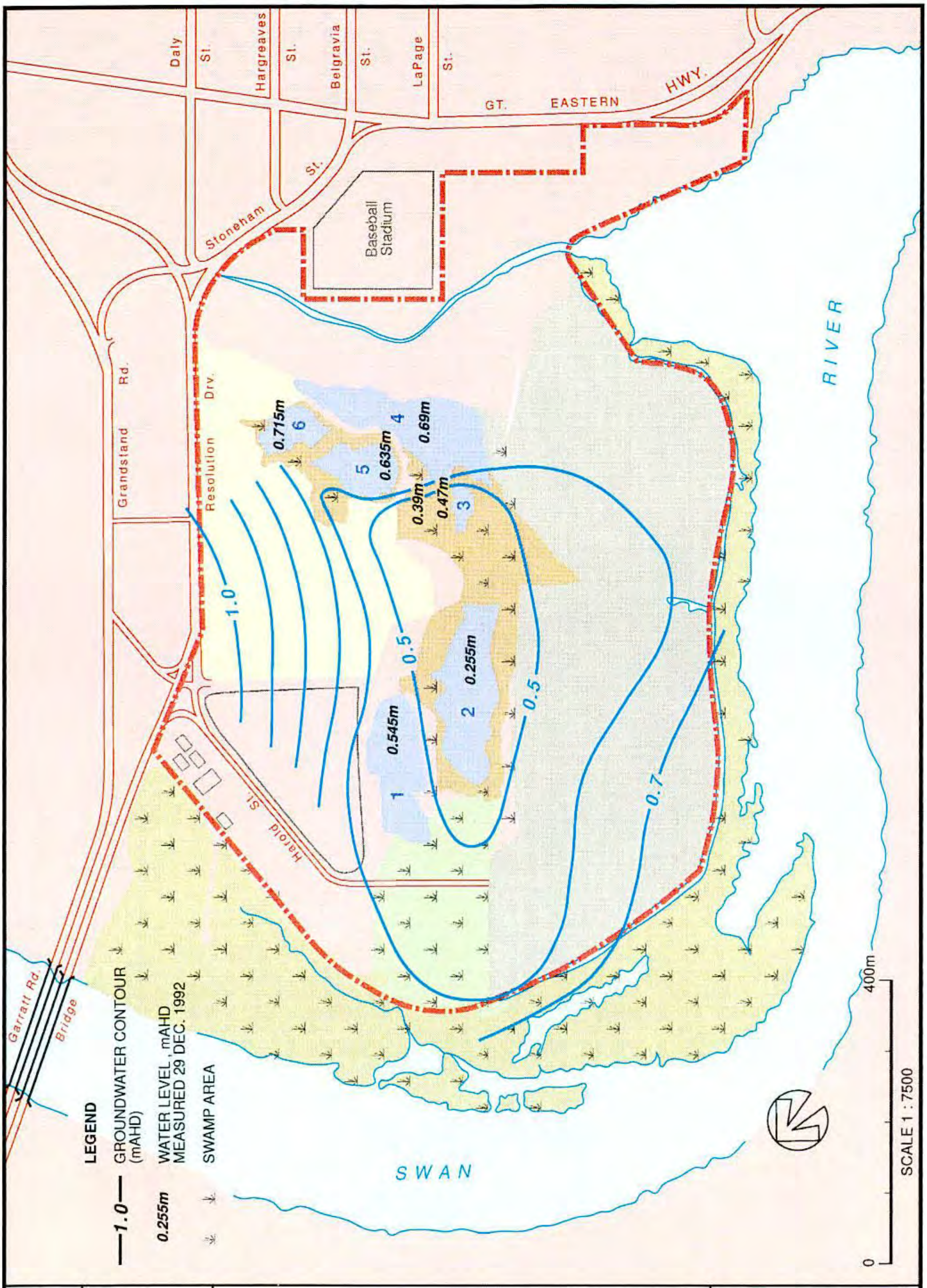
Job No.	29495-004-367	
Prep. By	JS	21-6-95
Chk'd. By	ILeP	3-7-95
Rev. No.	2	5-7-95

ASCOT WATERS

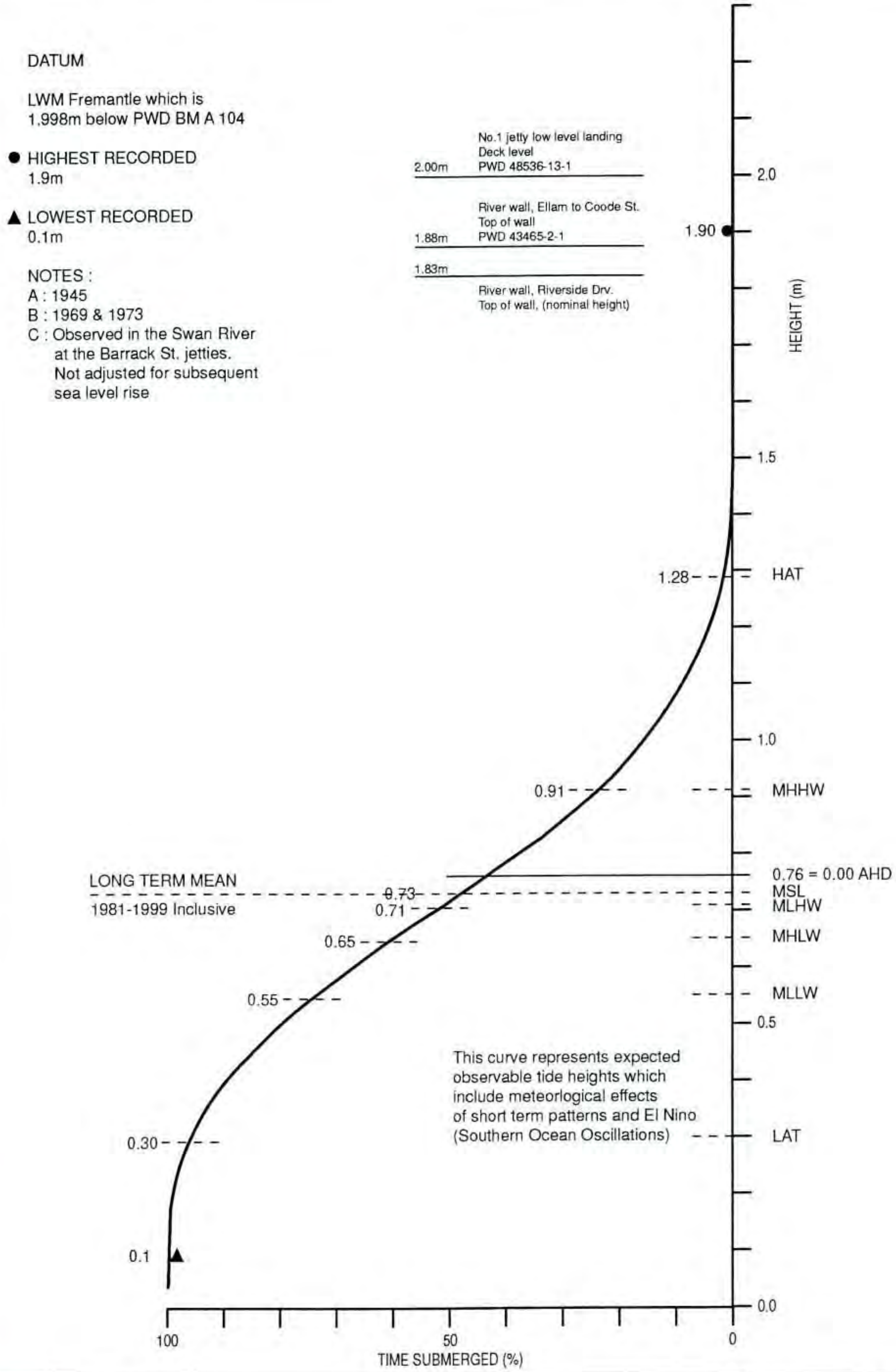
GEOLOGICAL SITE
CROSS SECTIONS C-C' & D-D'

Figure No.
8b

LEPROVOST
DAMES & MOORE



Job No.	29495-004-367		ASCOT WATERS **GROUNDWATER CONTOURS** (SOURCE : Tingay 1993)	Figure No. 9
Prep. By	JS	21-6-95		
Chk'd. By	JS	5-7-95		**LEPROVOST DAMES & MOORE**
Rev. No.	2	5-7-95		



Job No.	29495-004-367	
Prep. By	JS	21-6-95
Chk'd. By	ILeP	3-7-95
Rev. No.	2	5-7-95

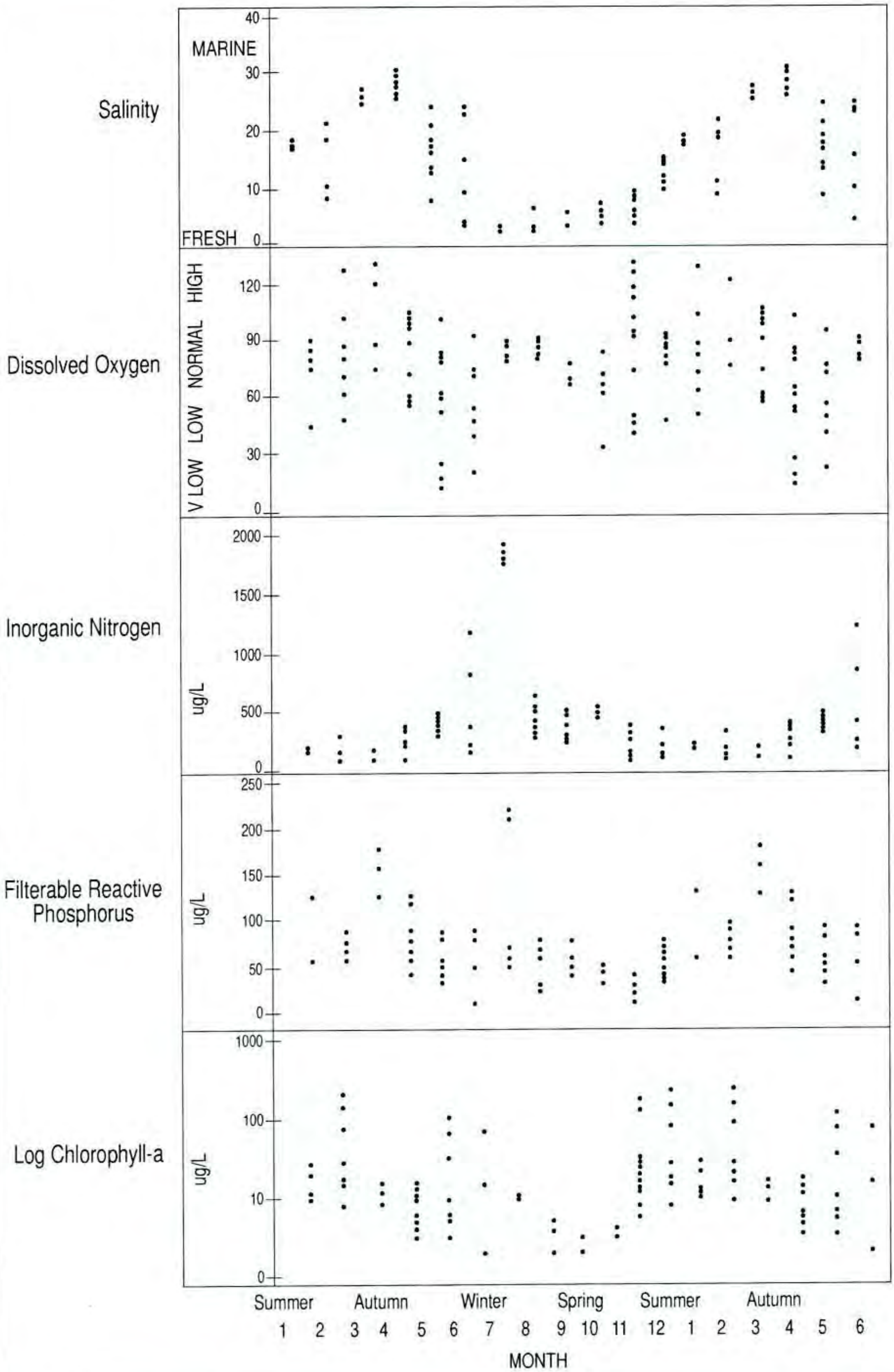
ASCOT WATERS

SUBMERGENCE CURVE FOR BARRACK STREET JETTY

SOURCE: MP Rogers and assoc - Appendix B

Figure No.
10

LEPROVOST DAMES & MOORE



Job No.	29495-004-367	
Prep. By	JS	21-6-95
Chk'd. By	ILeP	3-7-95
Rev. No.	2	5-7-95

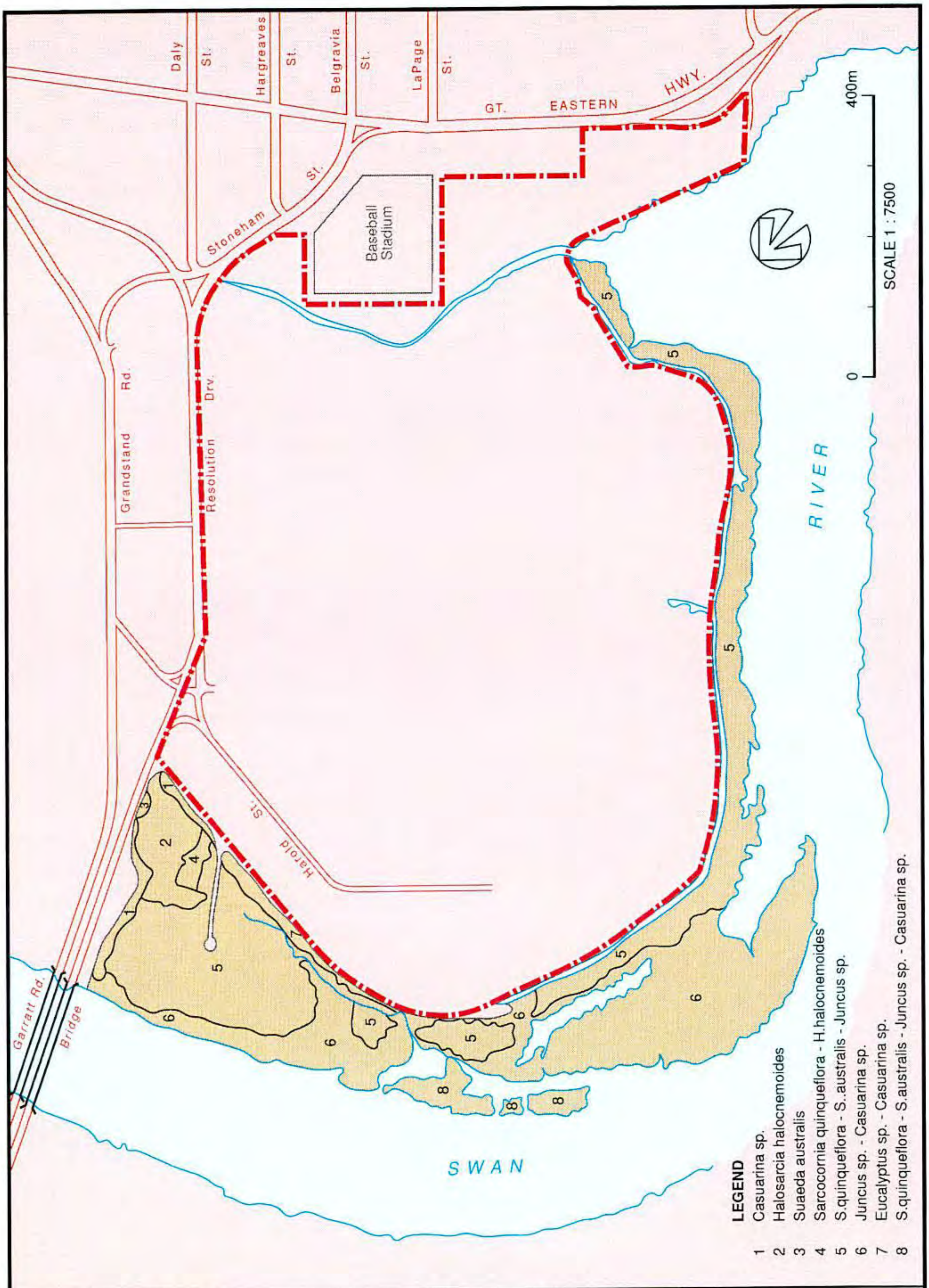
ASCOT WATERS

TYPICAL CYCLES IN THE SWAN ESTUARY AT ASCOT

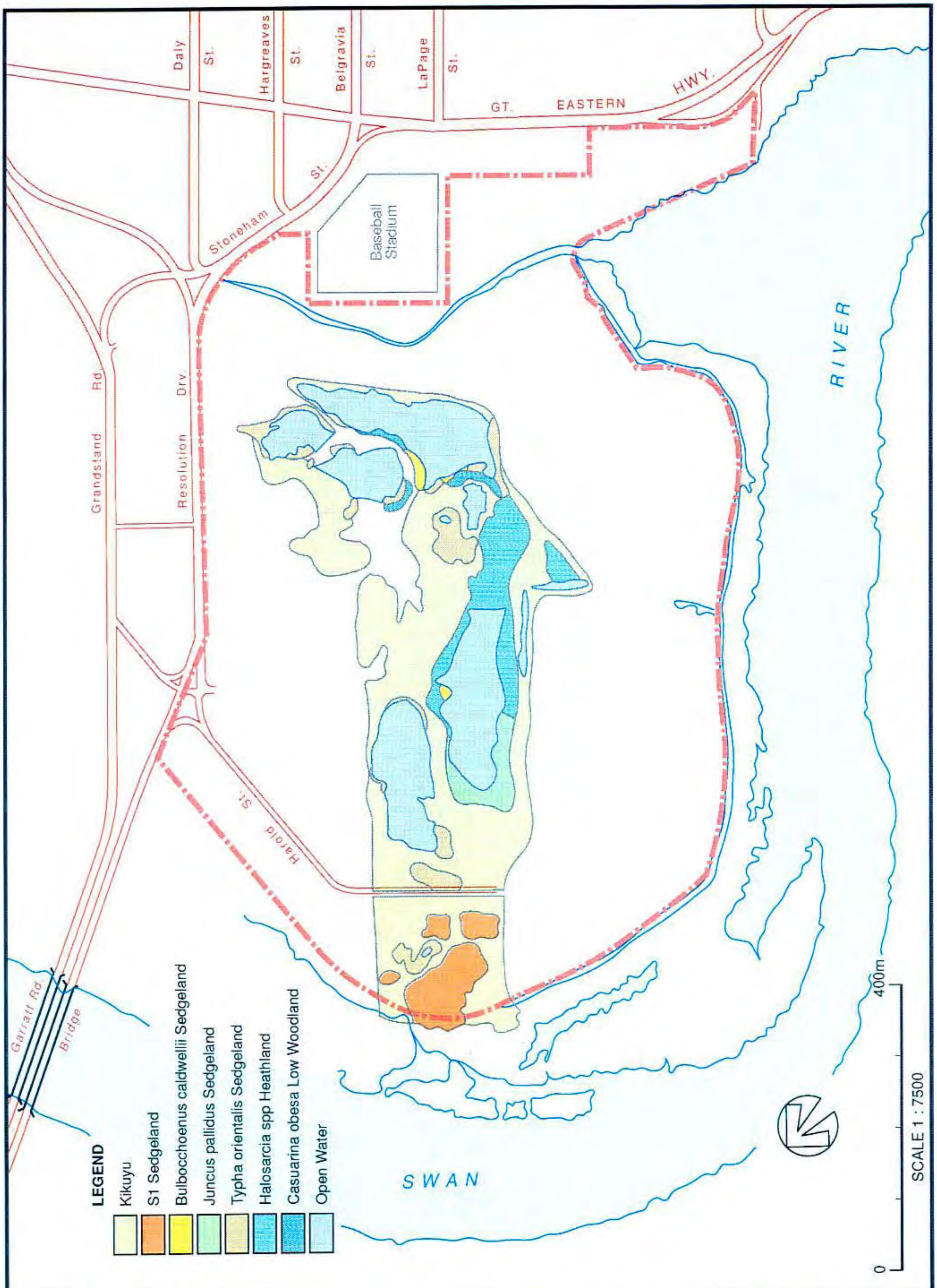
(Source: D. Deeley - Appendix C)

Figure No. 11

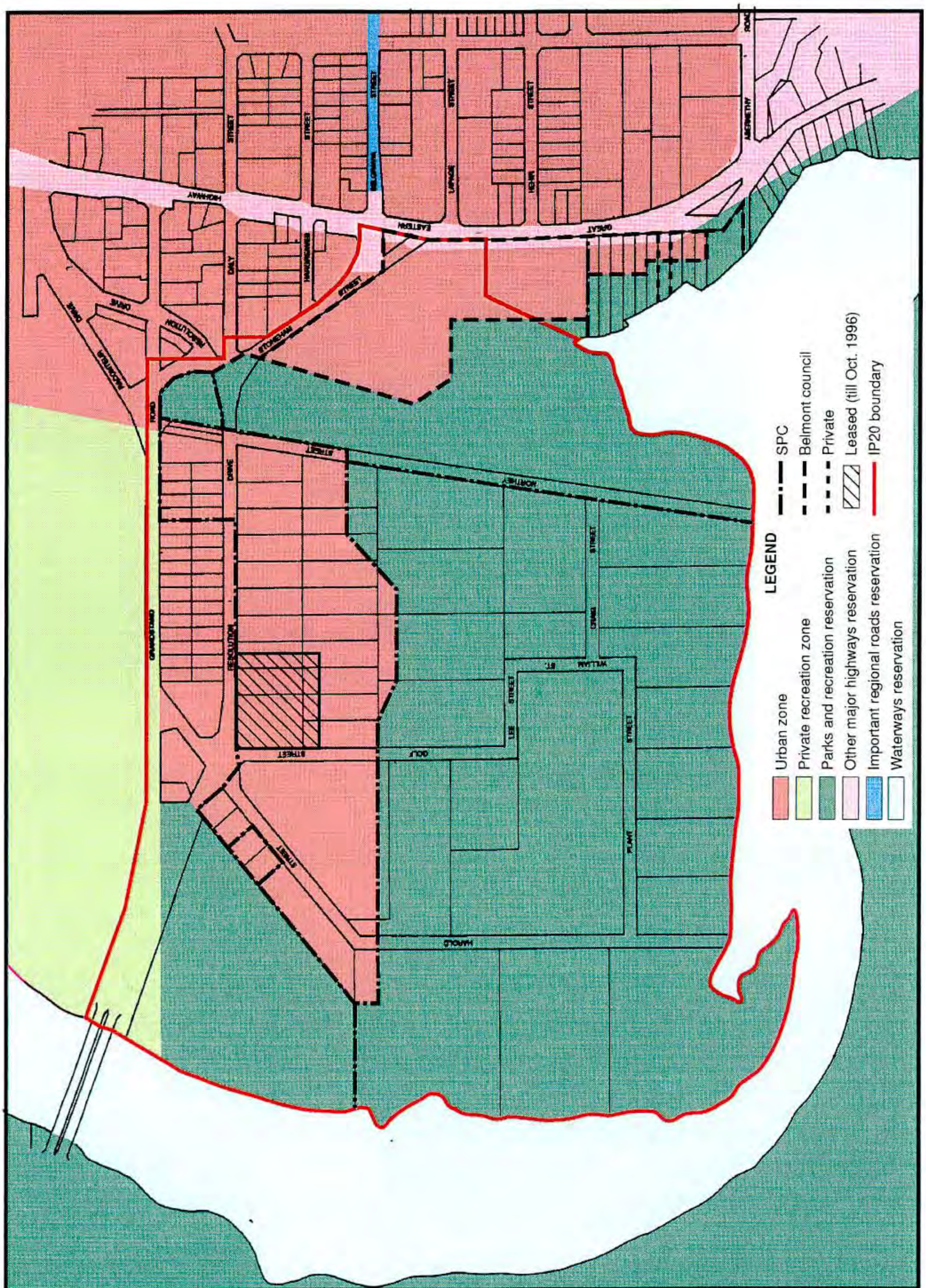
LEPROVOST DAMES & MOORE



Job No.	29495-004-367		ASCOT WATERS **VEGETATION DISTRIBUTION IN SYSTEM 6** (SOURCE : J.Latchford and R.Segal, 1995)	Figure No. 12
Prep. By	JS	21-6-95		
Chk'd. By	ILeP	3-7-95		**LEPROVOST DAMES & MOORE**
Rev. No.	2	5-7-95		



Job No.	29495-004-367		ASCOT WATERS	Figure No. 13
Prep. By	JS	21-6-95	**VEGETATION DISTRIBUTION AROUND LAKES IN FLOODPLAIN**	
Chk'd. By	ILeP	3-7-95		**LEPROVOST DAMES & MOORE**
Rev. No.	2	5-7-95	(SOURCE : Tingay and Associates, 1993)	



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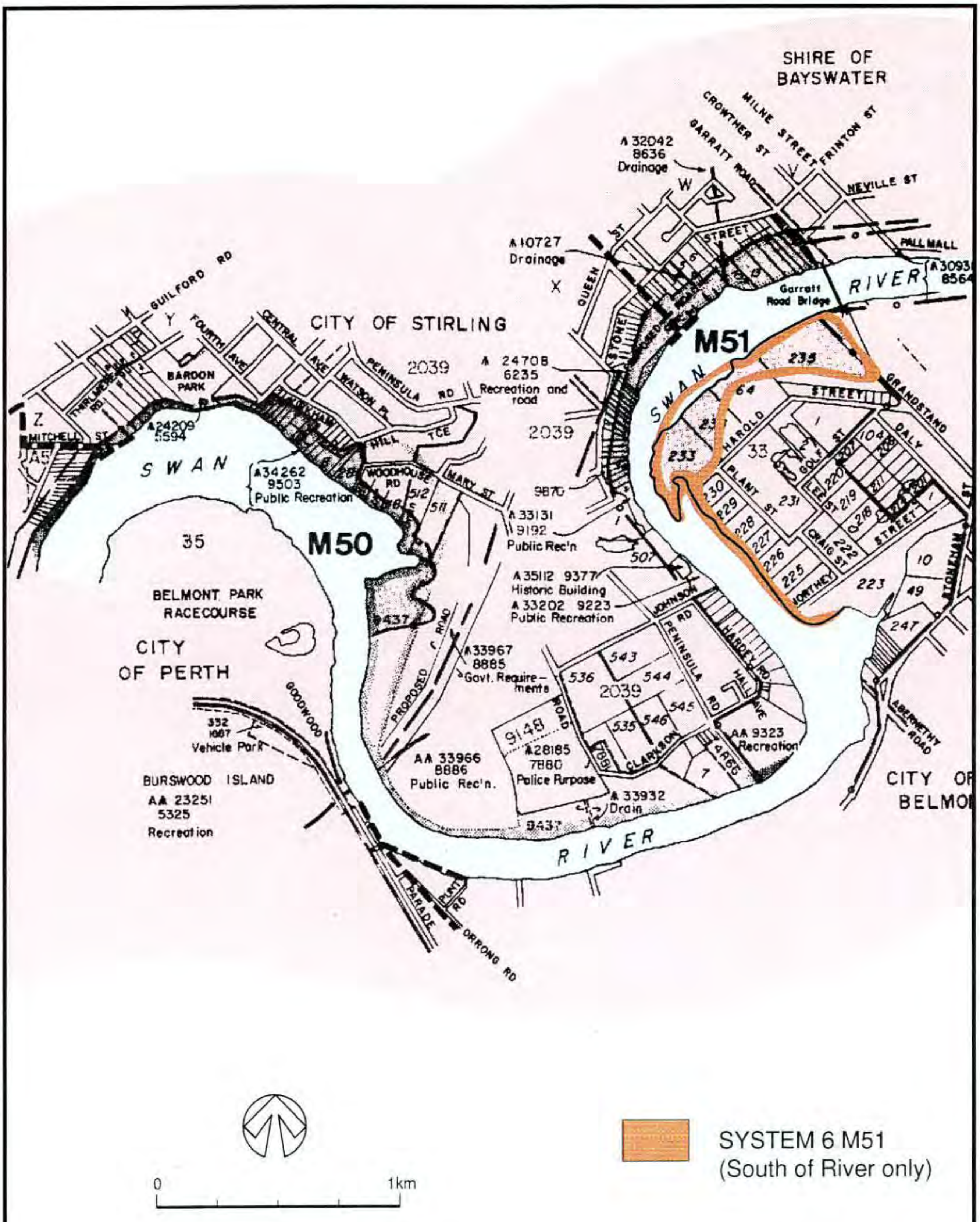
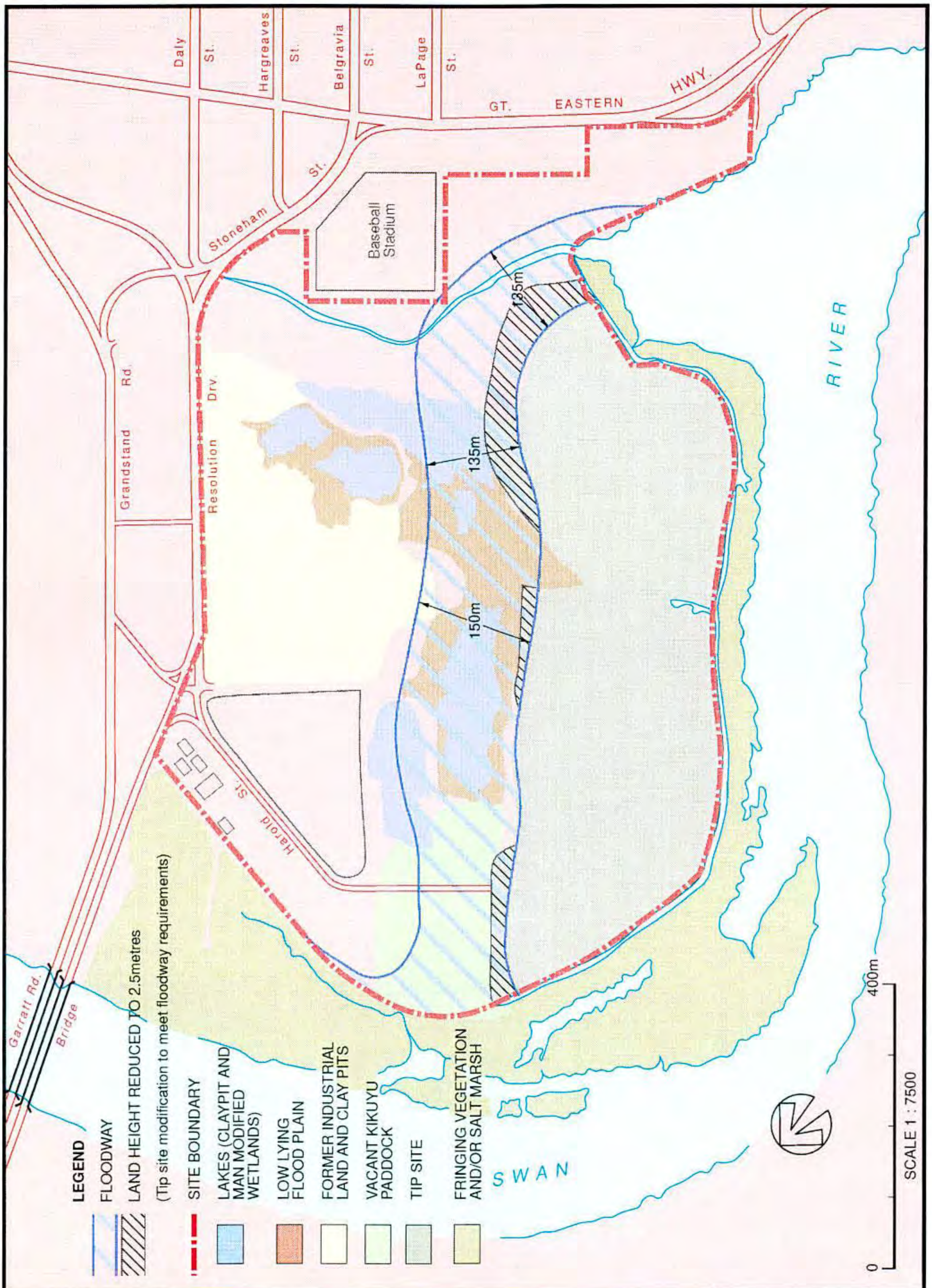
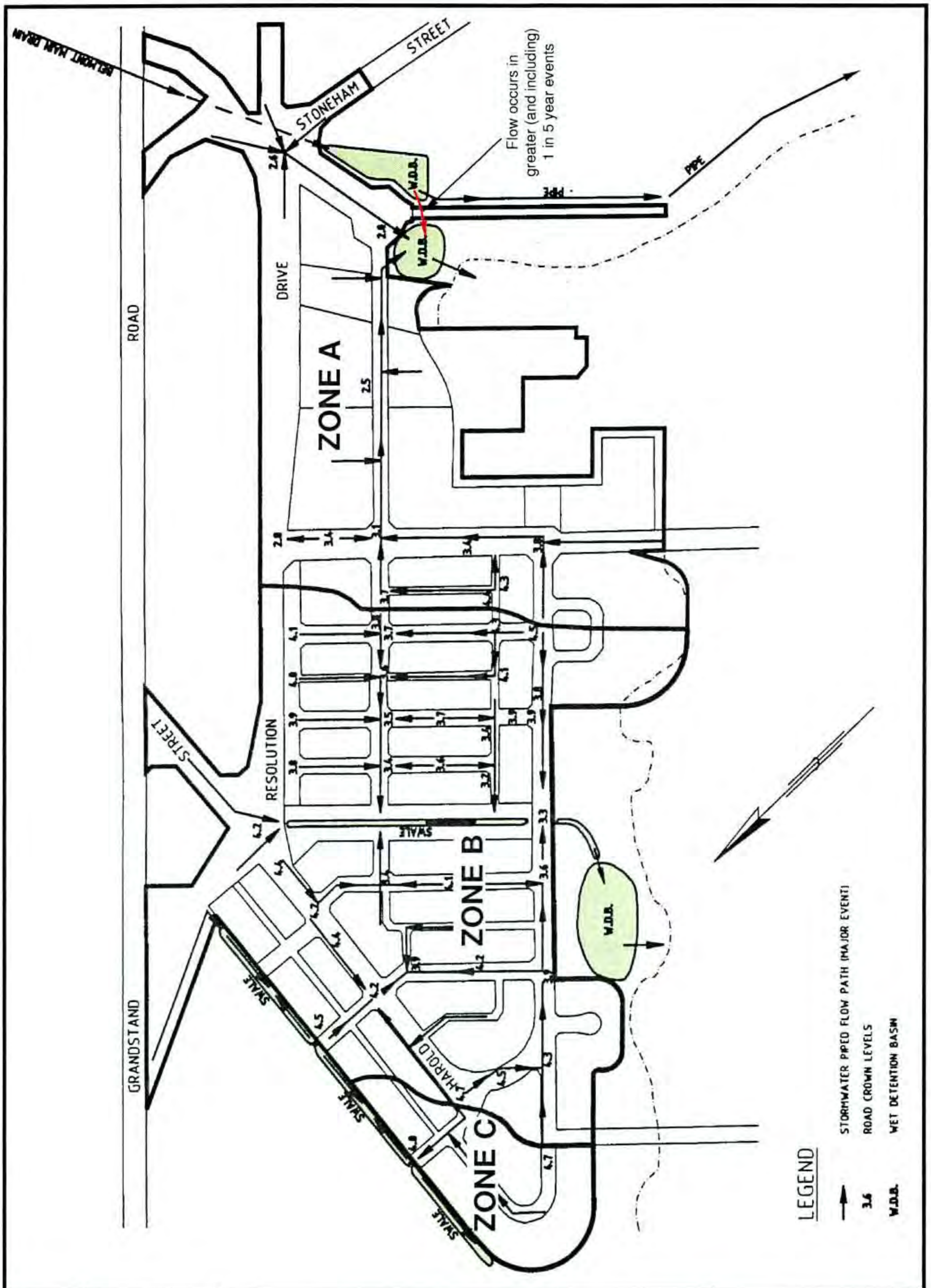
Prep. By	JS	21-6-95	**METROPOLITAN REGION**	14
Chk'd. By	ILeP	3-7-95	**SCHEME ZONING**	**LEPROVOST**
Rev. No.	2	5-7-95	(SOURCE : State Planning Commision)	**DAMES & MOORE**



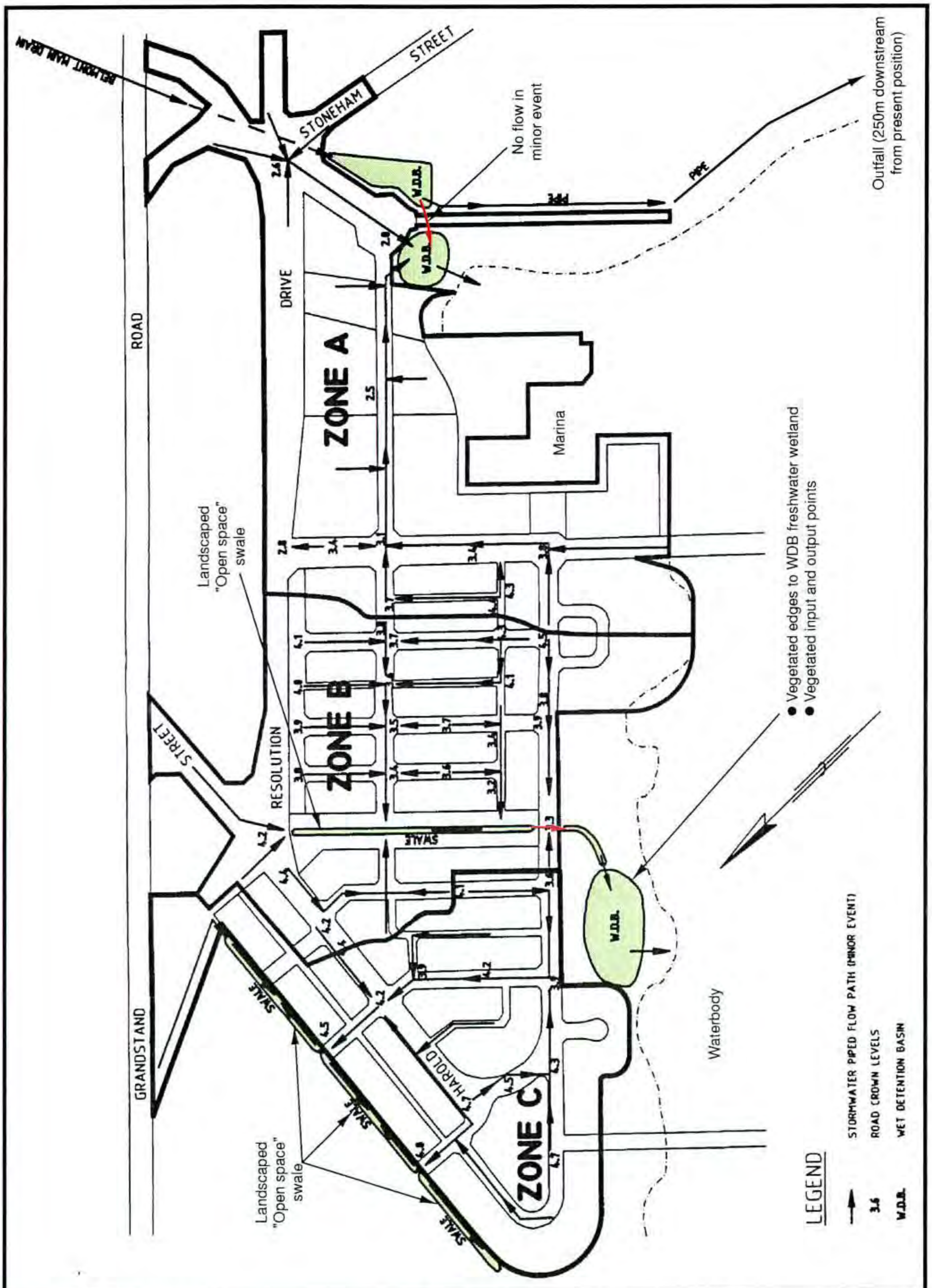
Job No.	29495-004-367		ASCOT WATERS	Figure No.
Prep. By	JS	21-6-95	**SYSTEM 6 M51 (CONSERVATION THROUGH RESERVES COMMITTEE)**	15
Chk'd. By	ILeP	3-7-95	(SOURCE : DCE, 1983)	**LEPROVOST DAMES & MOORE**
Rev. No.	2	5-7-95		



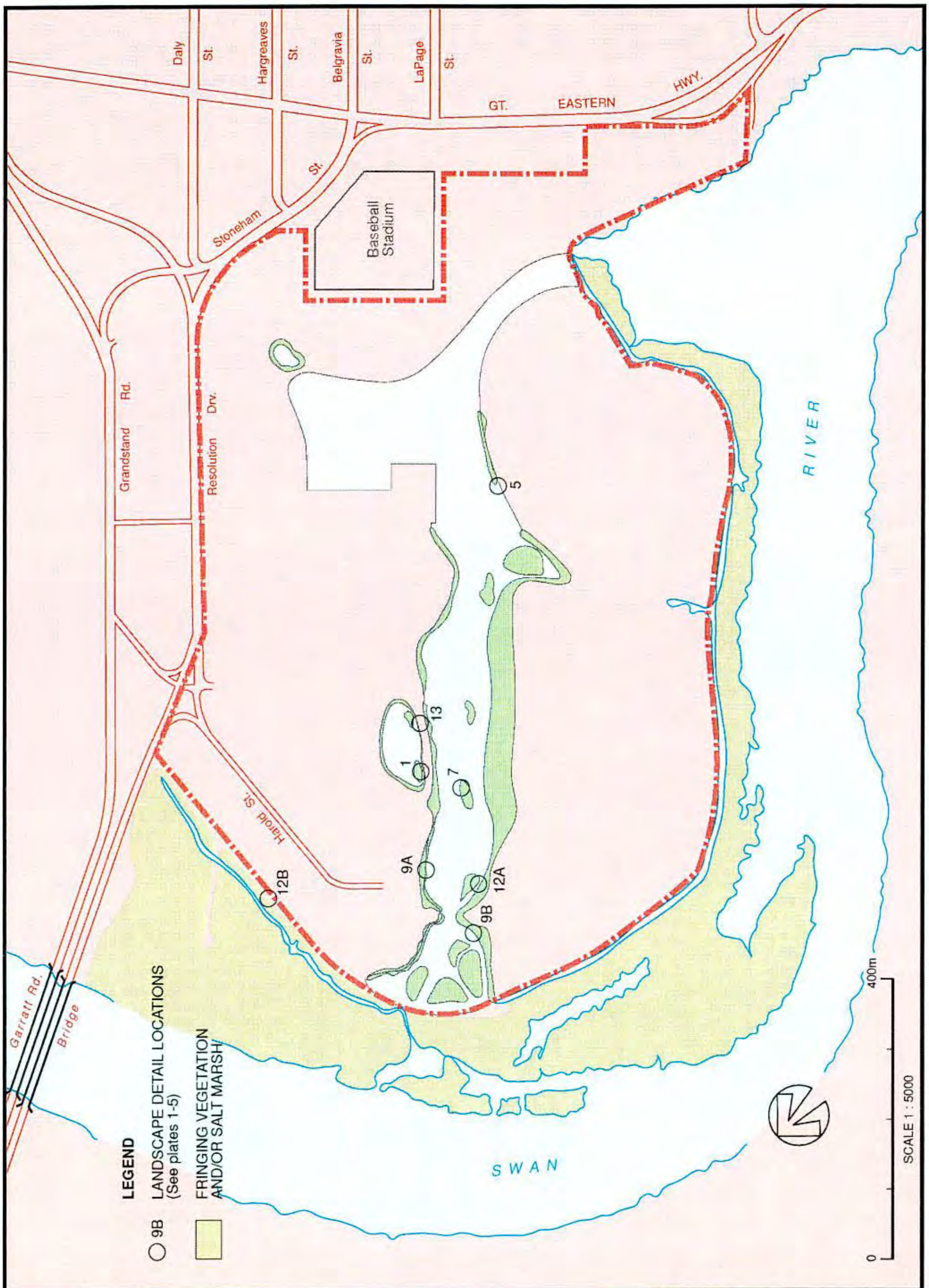
Job No.	29495-004-367		ASCOT WATERS	Figure No. 16
Prep. By	JS	21-6-95	**FLOODWAY REQUIREMENTS**	
Chk'd. By	ILeP	3-7-95		**LEPROVOST DAMES & MOORE**
Rev. No.	2	5-7-95	(Source: W.A.W.A. 1995)	



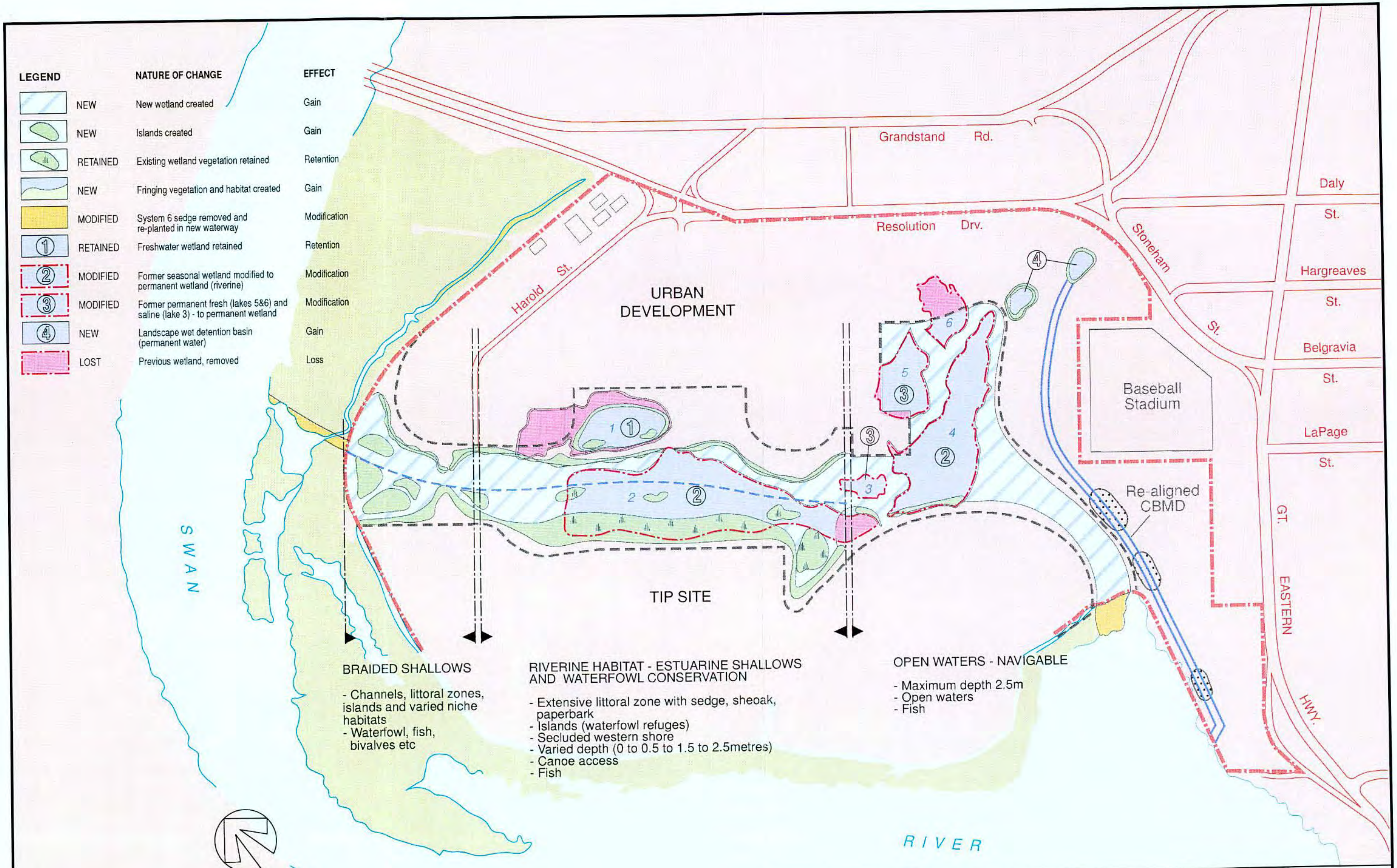
Job No.	29495-004-367		ASCOT WATERS **URBAN STORMWATER MANAGEMENT - MAJOR EVENT** (SOURCE : Evangelisti & Associates (Aust.) Pty Ltd, 1995)	Figure No. 17a
Prep. By	JS	21-6-95		
Chk'd. By	ILeP	3-7-95		**LEPROVOST DAMES & MOORE**
Rev. No.	2	5-7-95		



Job No.	29495-004-367		ASCOT WATERS	Figure No. 17b
Prep. By	JS	21-6-95	**URBAN STORMWATER MANAGEMENT - MINOR EVENT**	
Chk'd. By	ILeP	3-7-95		**LEPROVOST DAMES & MOORE**
Rev. No.	2	5-7-95	(SOURCE : Evangelisti & Associates (Aust.) Pty Ltd, 1995)	



Job No.	29495-004-367		ASCOT WATERS	Figure No. 19
Prep. By	JS	21-6-95	**KEY TO LANDSCAPE PERSPECTIVES - SEE PLATES 1-5**	
Chk'd. By	ILeP	3-7-95		**LEPROVOST DAMES & MOORE**
Rev. No.	2	5-7-95		



Job No.	29495-004-367		
Prep. By	JS	21-6-95	
Chk'd. By	ILeP	3-7-95	
Rev. No.	2	5-7-95	

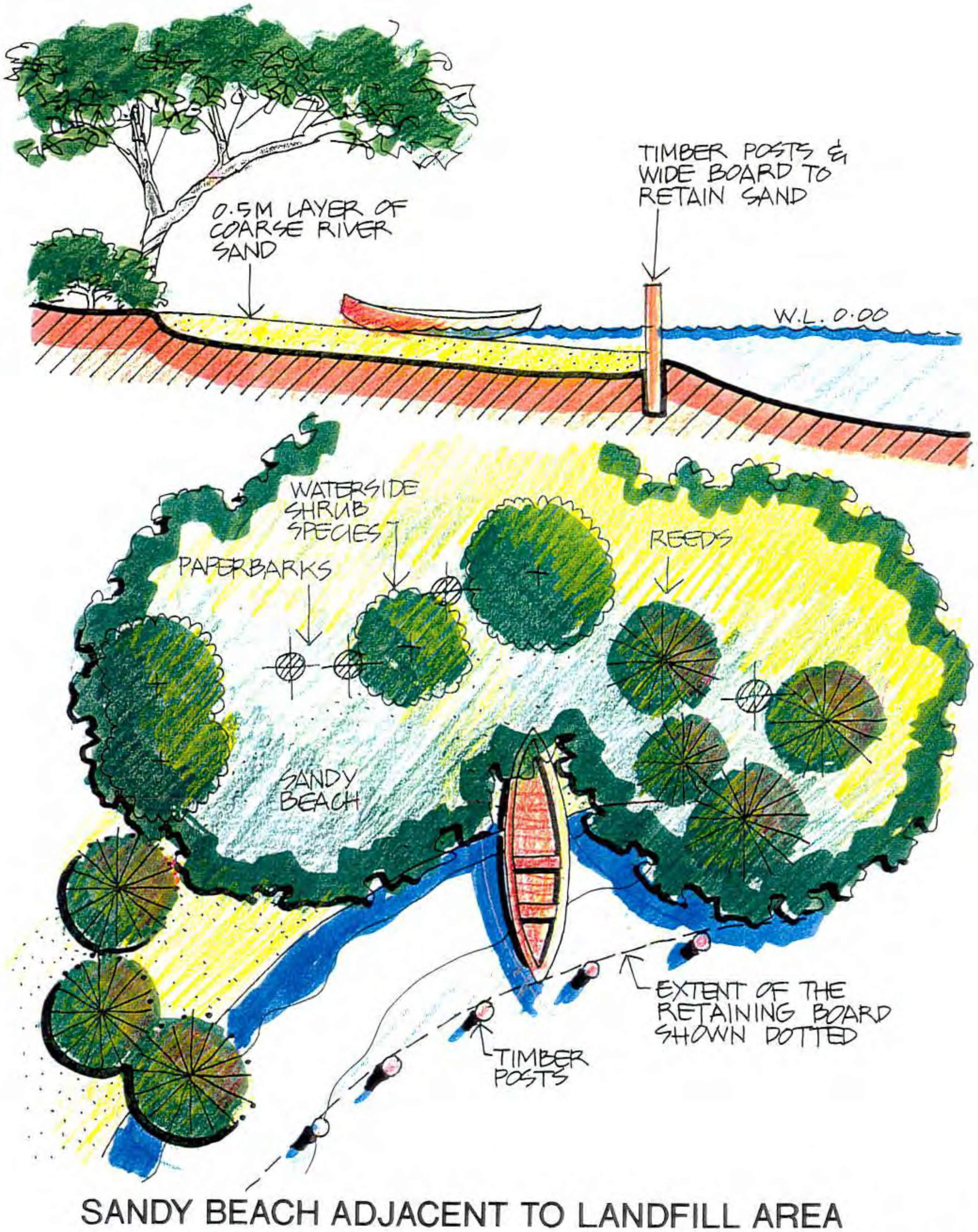
ASCOT WATERS

SUMMARY OF CHANGES IN WETLAND HABITAT

Figure No. 18

LEPROVOST DAMES & MOORE

Plates

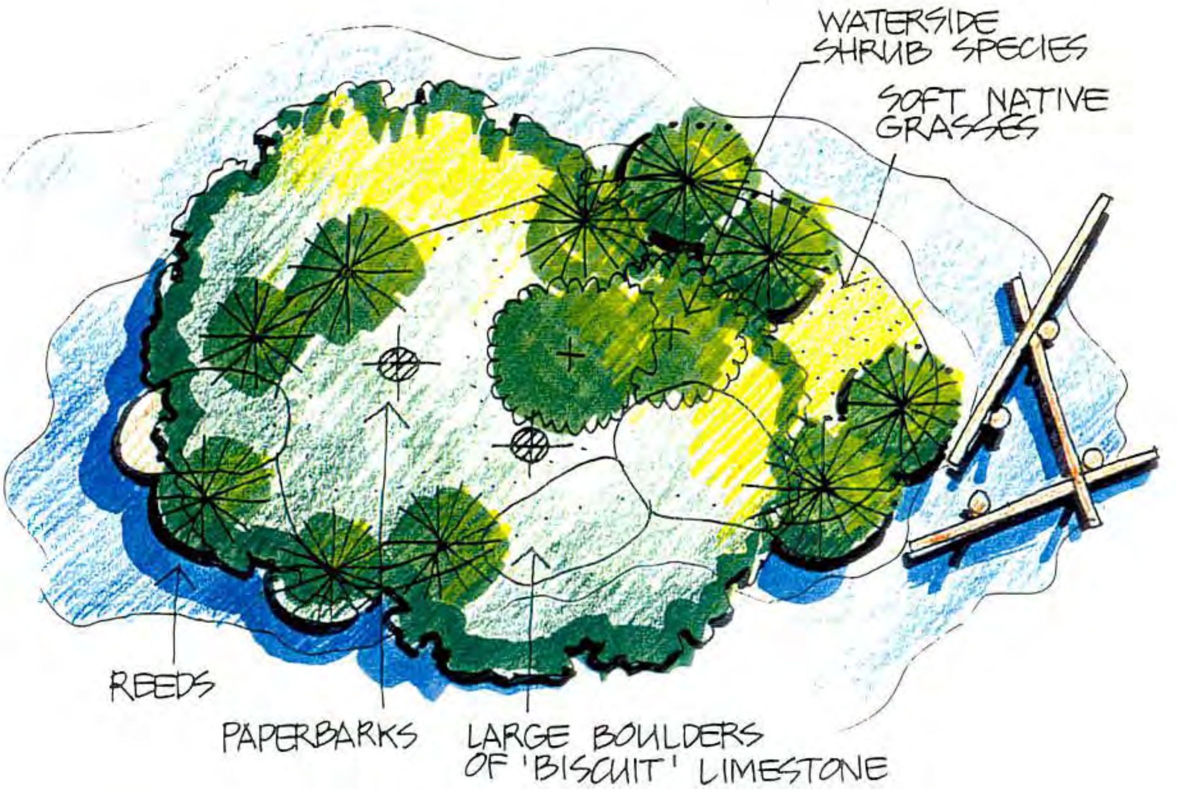


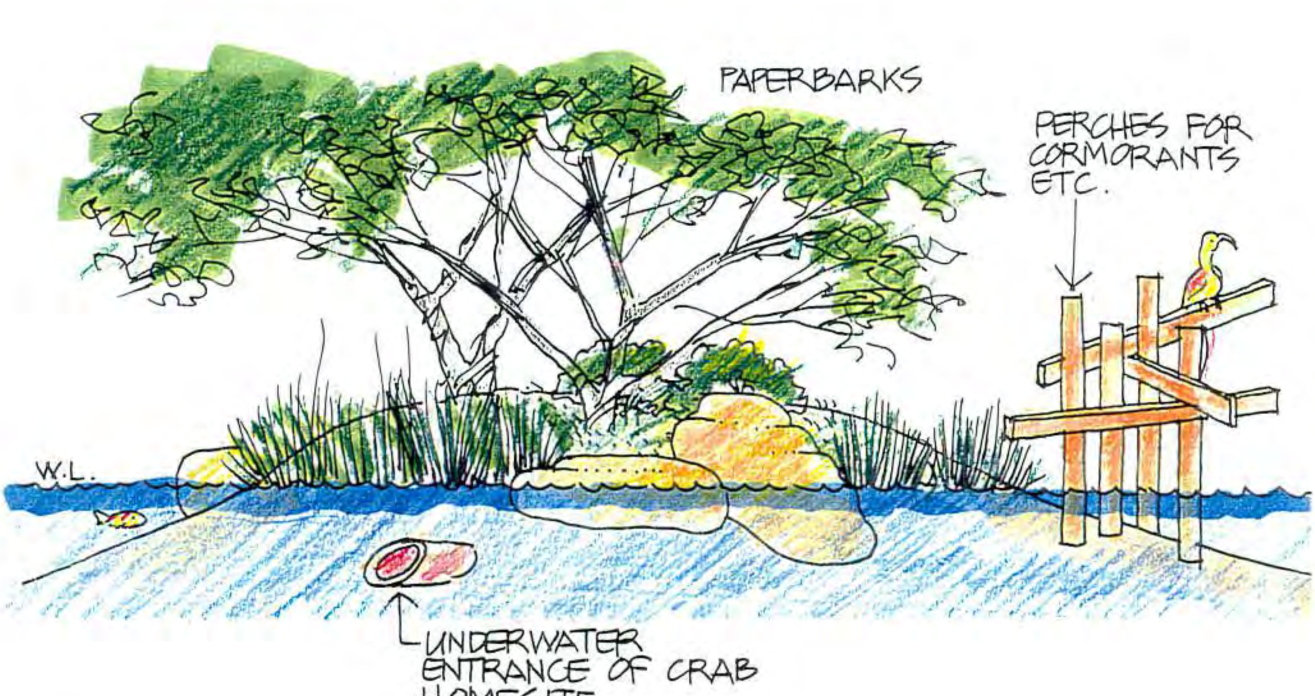
SANDY BEACH ADJACENT TO LANDFILL AREA

Location 5

ASCOT WATERS - LANDSCAPE DETAILS		5492
Land Systems EBC 70 Hindmarsh Square fax (08) 203 5200 ADELAIDE SA 5000 ph (08) 224 0355	Landscape Architectural Services 315 Rokeby Road fax (09) 388 1794 SUBIACO WA 6008 ph (09) 338 1793	JUNE 1995 5

Plate 1

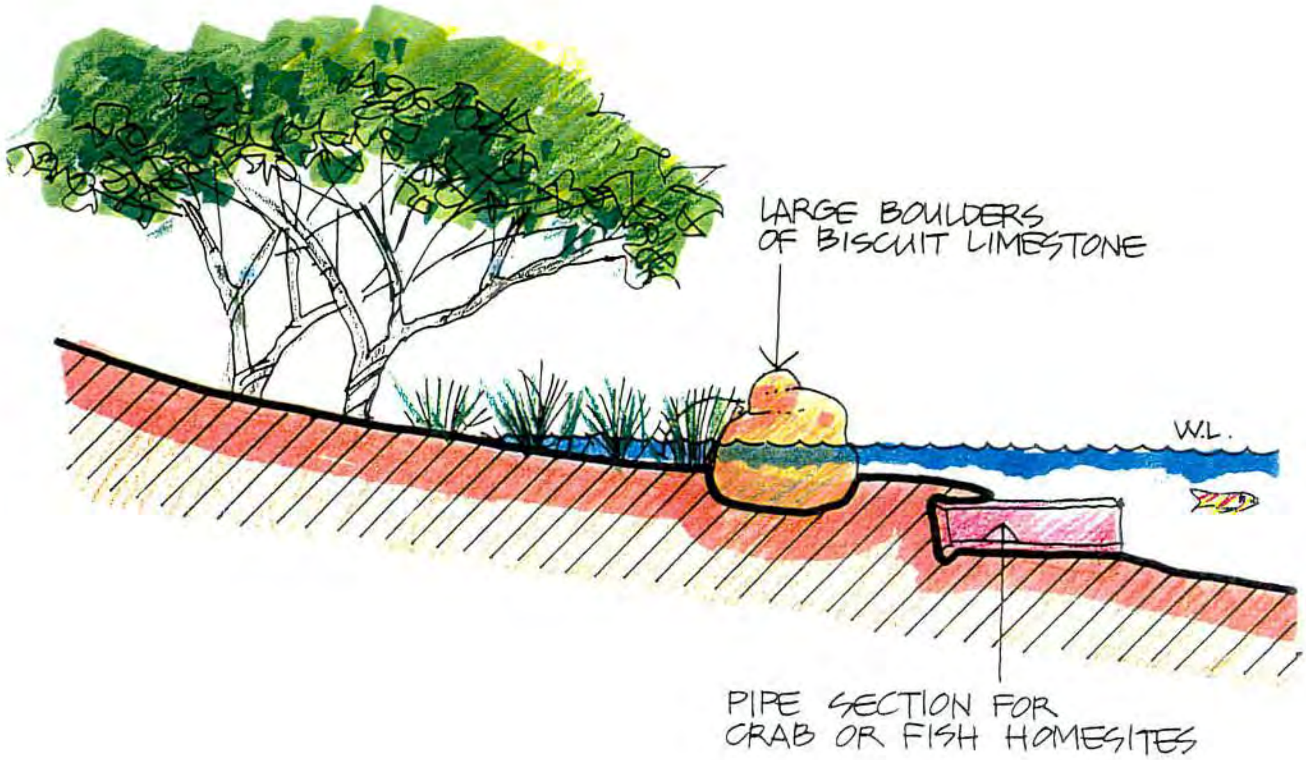




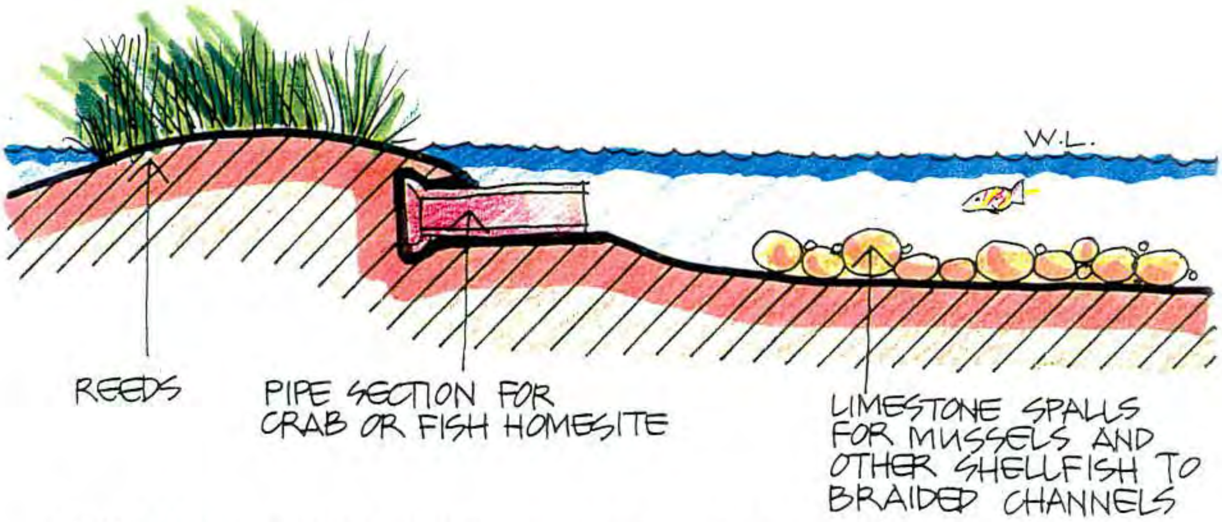
TYPICAL ISLAND TREATMENT

Location 7

ASCOT WATERS - LANDSCAPE DETAILS		5492
Land Systems EBC 70 Hindmarsh Square fax (08) 203 5200 ADELAIDE SA 5000 ph (08) 224 0355	Landscape Architectural Services 315 Rokeby Road fax (09) 388 1794 SUBIACO WA 6008 ph (09) 338 1793	JUNE 1995 7



Location 9A

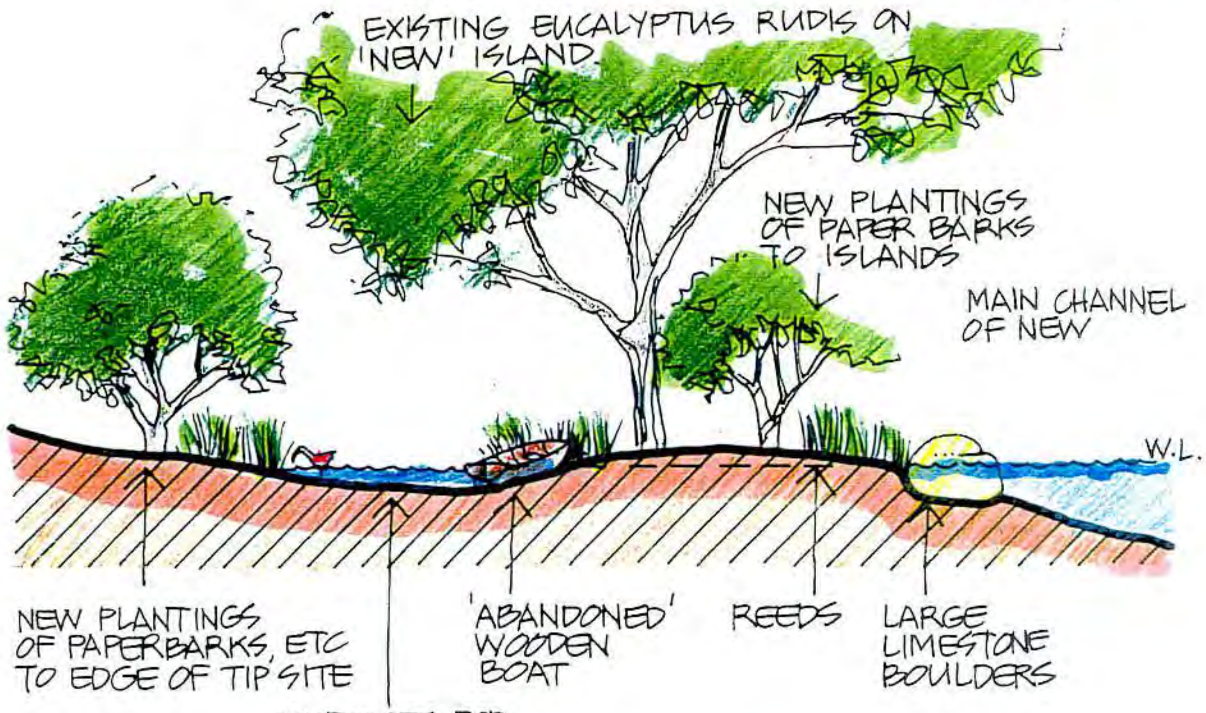


TYPICAL CHANNEL & EDGE TREATMENT

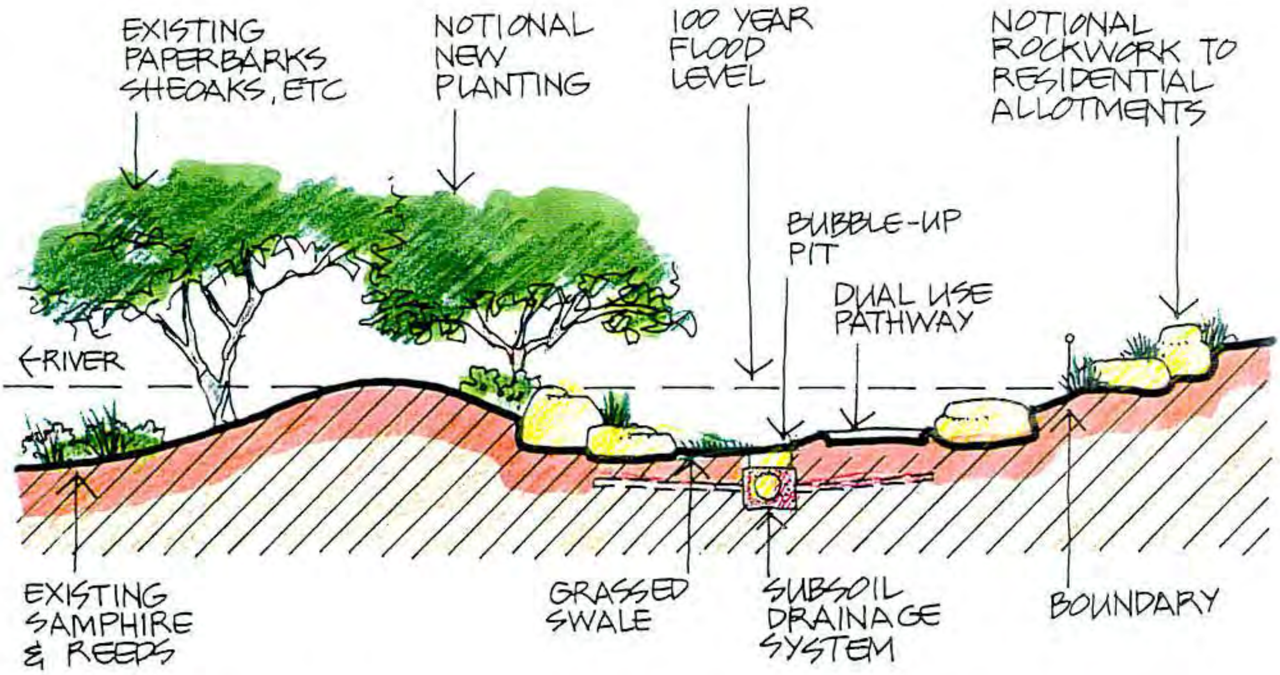
Location 9B

ASCOT WATERS - LANDSCAPE DETAILS		5492
Land Systems EBC 70 Hindmarsh Square fax (08) 203 5200 ADELAIDE SA 5000 ph (08) 224 0355	Landscape Architectural Services 315 Rokeby Road fax (09) 388 1794 SUBIACO WA 6008 ph (09) 338 1793	JUNE 1995 9

Location 12A



MUDFLATS & HABITAT AREA IN WATER COURSE

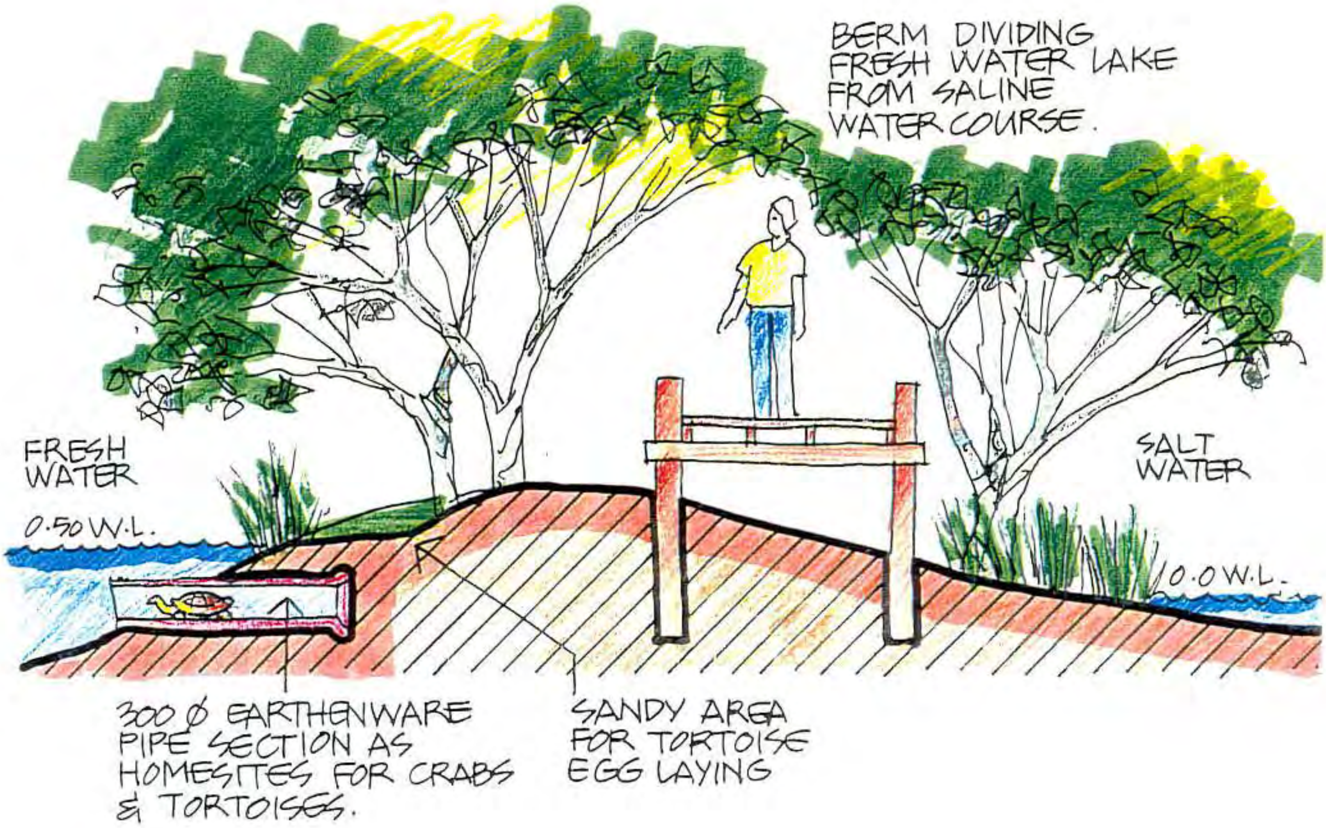


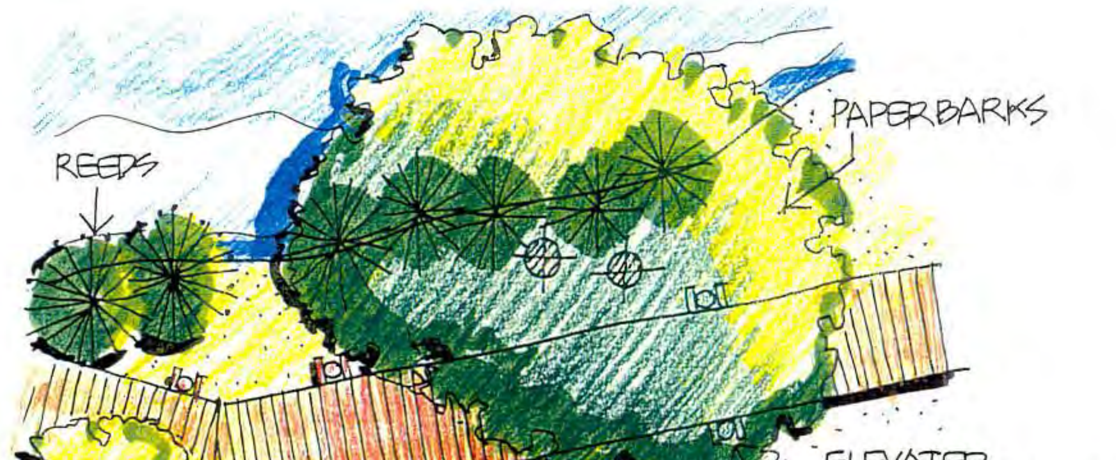
DRAINAGE SWALE IN FORESHORE PARK

Location 12B

ASCOT WATERS - LANDSCAPE DETAILS		5492
Land Systems EBC 70 Hindmarsh Square fax (08) 203 5200 ADELAIDE SA 5000 ph (08) 224 0355	Landscape Architectural Services 315 Rokeby Road fax (09) 388 1794 SUBIACO WA 6008 ph (09) 338 1793	JUNE 1995 12

Plate 4





BOARDWALK IN HABITAT AREA *Location 13*

ASCOT WATERS - LANDSCAPE DETAILS		5492
Land Systems EBC 70 Hindmarsh Square fax (08) 203 5200 ADELAIDE SA 5000 ph (08) 224 0355	Landscape Architectural Services 315 Rokeby Road fax (09) 388 1794 SUBIACO WA 6008 ph (09) 338 1793	JUNE 1995 13

Plate 5

Appendix A

Environmental Protection Authority

Redevelopment of Clay Pits for Waterways Development Affecting System Six Area M51

Public Environmental Review Guidelines

PROPOSED ASCOT FIELDS DEVELOPMENT

REDEVELOPMENT OF CLAY PITS FOR WATERWAYS DEVELOPMENT AFFECTING SYSTEM SIX AREA M51

PUBLIC ENVIRONMENTAL REVIEW GUIDELINES

Overview

In Western Australia all environmental reviews are about protecting the environment. The fundamental requirement is for the proponent to describe what they propose to do, to discuss the potential environmental impacts of the proposal, and then to describe how those environmental impacts are going to be managed so that the environment is protected.

If the proponent can demonstrate that the environment will be protected then the proposal will be found environmentally acceptable; if the proponent cannot show that the environment would be protected then the Environmental Protection Authority (EPA) would recommend against the proposal.

Throughout the process it is the aim of the EPA to advise and assist the proponent to improve or modify the proposal in such a way that the environment is protected. Nonetheless, the environmental review in Western Australia is proponent driven, and it is up to the proponent to identify the potential environmental impacts and design and implement proposals which protect the environment.

For this proposal, protecting the environment means that the natural and social values associated with the System Six area M51 and the Swan River are protected. Where they cannot be protected, proposals to mitigate the impacts are required.

Purpose of a Public Environmental Review

The primary function of a Public Environmental Review (PER) is to provide the basis for the EPA to provide advice to Government on protecting the environment. An additional function is to communicate clearly with the public so that EPA can obtain informed public comment. As such, environmental impact assessment is quite deliberately a public process. The PER should set out the series of decisions taken to develop this proposal at this place and time and why.

Objectives of the Review

The Public Environmental Review should have the following objectives:

- to place this project in the context of the regional environment and the regional planning framework;
- to explain the issues and decisions which led to the choice of this project at this place at this time;

- to set out the environmental impacts that the project may have; and
- for each impact, to describe any environmental management steps the proponent believes would avoid, mitigate or ameliorate that impact.

The PER should focus on the major topics/issues for the area and anticipate the questions that members of the public will raise. Data describing the environment should be directly related to the discussion of the potential impacts of the proposal. Both should then relate directly to the actions proposed to manage those impacts.

Key Topics/Issues

The critical issues for the proposal are protection of the System Six area and the impacts on the Swan River (dredging). The conservation values of the System Six area should be examined in detail. Any proposal to dredge the Swan River should be described in terms of relevant EPA and Swan River Trust policies.

The key topics/issues for this project should be clearly identified in the PER and the content of succeeding sections determined by their relevance to these topics/issues.

In this case the key topics/issues should include:

1. Biological & Physical Environment and Conservation

- impact on System Six area M51 on on-going management - regional significance for the flora, fauna and ecosystems;
- impact on the Swan River where dredging is to take place;
- management of waterways and water quality, including adequacy of circulation and flushing;
- feral fauna, weed, access and fire control; and
- landscape values.

2. Pollution, its Prevention and Management

- management of Belmont Drain and export of nutrients and other contaminants (NOTE: Water Authority approval required for any changes to drain);
- management of leachate from the old tip site;
- site contamination for both soil and groundwater - the discussion on groundwater contamination should consider contamination levels for both human use and ecosystem maintenance;
- beneficial uses in the waterways and appropriate water quality;

- stormwater management;
- impacts from Parry Fields - noise, light overspill and traffic management; and
- operational management issues:
    - dust and noise control,
    - overburden and topsoil management rehabilitation and final land use,
    - sources and transport of construction materials, and
    - contingency plans for accidents such as fuel spills, discharges and fires.

3. Social Aspects of Environment

- cultural impact on Aboriginal people with traditional affiliation to the land; and
- recreation management and the System Six area.

Any other key issues raised during the preparation of the report should also be discussed.

Public Participation and Consultation

A description should be provided of the public participation and consultation activities undertaken by the proponent in preparing the PER. It should describe the activities undertaken, the dates, the groups and individuals involved and the objectives of the activities. Cross reference should be made with the description of environmental management for the proposal which should clearly indicate how community concerns have been addressed. Where these concerns are dealt with via other departments or procedures, outside the EPA process, these can be noted and referenced here.

Detailed List of Environmental Commitments

The commitments being made by the proponent to protect the environment should be clearly defined and separately listed. Where an environmental problem has the potential to occur, there should be a commitment to rectify it. They should be numbered and take the form of:

a who will do the work;

b what the work is;

c when the work will be carried out; and

d to whose satisfaction the work will be carried out.

All actionable and auditable commitments made in the body of the document should be numbered and summarised in this list.

Appendix B

M P Rogers & Associates

Ascot Waters Water Quality, Siltation and Dredging Study

Domain, Henry Walker Group, and
Estate Development Company
June 1995

Ascot Waters Water Quality, Siltation and Dredging Study

Job 136
Report R013 Rev 1

Prepared by: Dan Smith Date: 27/6/95
Reviewed by: MP Rogers Date: 28/6/95
Approved by: MP Rogers Date: 28/6/95

M P ROGERS & ASSOCIATES PTY LTD
Consulting Engineers Specialising in Coastal, Ocean & Marine Projects
3/135 Main Street Osborne Park Western Australia 6017
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Table of Contents

1. Executive Summary

The water quality, dredging and siltation issues associated with the proposed Ascot Waters land and waterway development have been investigated.

With respect to the quality of the water within the Ascot Waters waterways, three key issues arise:

- the quality of the source water,
- the extent of the flushing of the waterway, and
- catchment management to minimise the influxes of nutrients and pollutants.

The water quality of Ascot Waters will, at best, be equal to that of its water source, the Swan River. This will only be achieved provided adequate flushing is maintained consistently throughout the year. Unfortunately, the quality of the Swan River water in the vicinity of Ascot Waters is occasionally poor, as evidenced by algal blooms, which indicate high nutrient levels, and the results of studies of the effluent from drains discharging into the river.

The main concern with regard to the quality of the source water is the fate of the effluent from the Central Belmont Main Drain (CBMD) which sometimes contains unacceptably high concentrations of faecal bacteria, and is presently discharged at the mouth of the proposed southern entrance channel to the waterway. To overcome this problem it is recommended that a low flow outlet for the CBMD be relocated at least 250 metres downstream of the mouth of the proposed entrance channel. This should ensure that under most flood tide conditions, faecal bacteria pollution in the effluent is diluted to an acceptable level for secondary contact by the time it enters the Ascot Waters waterway.

The design of the waterway has been tailored to ensure that adequate flushing is achieved all year round. At the same time, the environmental impact on the System 6 Area has been minimised by making the northern entrance as narrow as possible and aligning it along an existing channel. Approximately 900 m^2 of System 6 vegetation would be removed to create the northern entrance to Ascot Waters, and it is expected that this will be compensated for by the creation of a wetland area adjacent to the System 6 Area.

The environmental conditions expected to cause the weakest water exchange are neap tides during late summer / early autumn, prior to the first significant rains. Under these conditions, the Ascot Waters waterway is expected to have a residence time of about 2 to 3 days. Under more favourable conditions, this will be reduced to in the order of 1 day or less.

In addition to relocating the CBMD outlet and ensuring adequate water exchange between the waterway and the Swan River, all runoff and wastewater within the Ascot Waters catchment will be properly managed to minimise the influx of nutrients and other pollutants into the waterway. The development will be serviced by reticulated sewerage, there will be no septic tanks, and urban drainage will pass through oil and refuse traps, as well as settling / nutrient stripping ponds before being discharged into the waterway . Finally, the old landfill site will be partially capped with an impermeable clay layer.

With respect to the dredging and siltation issues associated with the Project, the bed of the Swan River in the vicinity of Ascot Waters is essentially cohesive mud containing small amounts of sand in some areas. It is estimated that over the last 25 years there has been accretion of about 0.5 metres in these areas, and hence it is expected that the waterways would require maintenance dredging every 20 to 25 years. More frequent maintenance may be required for the northern entrance channel as this cuts through a number of submarine mud banks which may be mobile during major flood events.

The construction of the two entrance channels to the waterway would require the dredging of approximately 30,000 m^3 of river sediments. It is anticipated that a cutter-suction dredge would be used to perform this work, in which case a settling pond with a residence time of approximately 5 hours would be required to treat the dredge slurry prior to the release of return water back into the Swan River. This return water is likely to have a concentration of suspended sediment of only 1% to 3%, however, to further minimise possible environmental impacts, it is recommended that the dredging be performed in autumn and winter when the river waters are naturally turbid.

2. Introduction

The Western Australian Ministry for Planning wishes to develop an area of land adjacent to the Swan River, to the south of Garratt Road Bridge and to the east of Great Eastern Highway. The Ministry for Planning has engaged a consortium comprising of Domain, Henry Walker Group, and Estate Development Company to manage this development.

The project, known as Ascot Waters, consists of the construction of an artificial waterway as well as residential and commercial subdivision

M P Rogers & Associates Pty Ltd was engaged by LeProvost Dames & Moore to provide advice concerning water quality, dredging, and siltation aspects of the Ascot Waters project. More specifically, the following issues were investigated:

- design criteria for waterway flushing,
- the flushing of the waterway throughout the year,
- the minimisation of nutrients and other pollutants entering the waterway from the Ascot Waters catchment,
- the effect of the discharge from the Central Belmont Main Drain on the water quality of the waterway,
- the sedimentation of the waterway, particularly its entrance channels, and
- the dredging requirements for the construction and maintenance of the waterway channels.

These studies involved a wide range of activities, including field investigations and hydrographic surveys; the set-up, calibration, and performance runs of a computer model; and the application of environmental fluid dynamics theory in concert with sound engineering judgement. This report outlines the methods adopted and the findings arrived at in this study.

3. Water Quality

3.1 Introduction

Water Quality is a term used to describe the chemical, physical, and microbiological characteristics of a water body. In general, the quality of a waterway depends on three external factors:

- the quality of the source water,
- exchange between the source water and the water, and
- nutrient and pollutant inputs to the water body.

In addition to these, physical, chemical, and biological processes occurring within the water body may either enhance or degrade the quality of its water. The extent to which such internal processes influence water quality depends on the interaction between the aquatic ecosystem and the aforementioned external factors. In general, these processes are only significant in water bodies characterised by long residence times, such as lakes and reservoirs. The waterway for Ascot Waters has been designed to be sufficiently well flushed so that its water quality is very similar to that of the source water, the Swan River. In view of this, the effect of the internal aquatic ecosystem on the water quality is expected to be small and, as a result, the present study has concentrated on assessing the three external influences on water quality.

3.2 Guidelines and Design Objectives

Guidelines pertaining to the water quality of fresh and marine water bodies in Western Australia have been published in draft form by Environmental Protection Authority (EPA, 1993). In summary, with respect to artificial waterways, these require the following:

1) The water quality must not significantly impact on the ecosystems of aquatic environments adjacent to, or in the near vicinity of, the artificial water body.

2) The water quality of the artificial waterway must be suitable for its proposed recreational uses.

Item (1) above has been addressed by ensuring that the waterway is well flushed and that inputs of nutrients and other pollutants through surface runoff and other mechanisms are minimised. The design criterion adopted with respect flushing was that the residence time of the waterway should not exceed 3 days under the worst foreseeable environmental conditions.

Under this situation, the water within the waterways of Ascot Waters is expected to be very similar to that in the Swan River, thus minimising environmental gradients between the two water bodies.

With respect to the recreational water quality requirements, item (2), the draft EPA guidelines have been adopted as design criteria. Only secondary contact recreation is proposed for Ascot Waters, which includes both boating and fishing, but excludes activities involving frequent direct contact with the water, such as swimming. Because the Central Belmont Main Drain (CBMD) enters the Swan River at the downstream end of the development, and this drain sometimes carries high levels of faecal pollution, the two most important criteria in this context both relate to faecal bacteria. Concentrations of up to 11,200 faecal coliforms per 100 mL, and 6,300 faecal streptococci per 100 mL, have been measured in the drainage water discharged from the CBMD outlet.

For secondary contact recreational use of a water body, the EPA guidelines stipulate that, for a minimum of five water samples taken at regular intervals not exceeding one month,

1) the median concentration of faecal coliforms should not exceed 1,000 organisms per 100 mL, with 80% of samples containing less than 4,000 organisms per 100 mL, and

2) the median concentration of enterococci (streptococci) bacteria should not exceed 230 organisms per 100 mL, with the maximum number in any one sample being 700 organisms per 100 mL.

For these guidelines to be properly utilised as design criteria, the geographic extent of the Ascot Waters waterways must be defined. The proposed artificial waterbody has two open boundaries - the northern and southern entrance channels - by which it is connected to the Swan River (see Figure 3.1). The upstream limit of the waterway corresponds to the northern boundary of the System 6 area, and thus includes the whole of the northern entrance channel. At the downstream end, the waterway boundary has been set at the intersection of the downstream entrance channel with the original bank of the Swan River. This includes all of the new waters created by the Ascot Waters development which may be used for recreational purposes. Under this definition, the waterway includes all of the southern entrance channel defined by land above mean sea level (MSL), but none of the submarine dredged channel to be dredged in the adjacent mud flats. As soon as any pollutant emanating from the CBMD enters this entrance channel, it is deemed to have contaminated Ascot Waters.

3.3 Waterway Layout

The layout of Ascot Waters is shown in Figure 3.1. The elevation of the bed of the waterways steadily decreases in the downstream direction to ensure that there are no deep areas in which denser water could become trapped and deteriorate in quality. From a hydraulic point of view, the critical section of the waterway that restricts flushing is the northern entrance channel that passes through the System 6 Area. To minimise the impact on the System 6 ecosystem, this should be as narrow as possible, however, the flow through Ascot Waters increases as the cross-section area of the channel becomes larger.

After investigating a number of different options, an alternative was identified for the northern entrance channel that would have minor environmental impact yet still maintain adequate flushing of the waterway. As illustrated in the cross-section shown in Figure 3.2, this consists of a single channel 15 metres wide with the bed at 1 metre below AHD passing through the System 6 Area. This would follow the present alignment of the existing channel in the area, with only 900 m^2 of System 6 vegetation being removed, and hence disruption to the System 6 Area would be minimised. Due to the presence of shallow mud banks in the vicinity of the mouth of the northern entrance, the channel would have to be extended to deeper waters of the Swan River by means of a submarine trench (see Figure 3.1). This would be overdredged to -1.5 metres AHD with the toe-lines splayed 20° out from perpendicular to the shore, and side slopes of 1 in 5. The overdredging and splayed toe-lines are recommended to minimise the impact of the possible increased siltation rates which may be associated with the migration of the mud banks during severe (> 1 in 5 year) floods.

Downstream of the System 6 Area, the waterway separates into a braided channel network. One arm of the braided channel would be maintained to at least the dimensions of the System 6 channel through to the footbridge, in order to ensure adequate flushing. Other sections could be shallower and more narrow, which would better suit a wetlands environment.

The upper basin extends from the footbridge downstream to the causeway, and has a bed graded from -1.5 metres to -2 metres AHD along the eastern half, while the western half is shallower at -0.5 metres AHD. The causeway is to be a minimum of 25 metres wide, and likely to be constructed of large culvert units. Downstream of this, the bed of the waterway steadily decreases to -2.5 metres AHD in the lower basin, to which the marina is adjacent. The southern entrance channel connects the lower basin to the deeper waters of the Swan River. Its minimum navigable width, namely that between the toes of the side slopes, is 35 metres, and it should be dredged to a depth of 2.5 metres at AHD. This would require the dredging of a submarine trench extending beyond the banks of the Swan River, through the mudflats, and out to a depth of 2.5 metres below AHD (see Figure 3.1). Figure 3.3 shows typical sections of this channel both inland and through the adjacent mudflats.

3.4 Source Water

3.4.1 General Description

Ascot Waters is designed to be a relatively well flushed waterway (refer to §3.5), and consequently the source of essentially all of its water is the Swan River. Of course, subsurface groundwater discharge and surface runoff will contribute a small influx into the system, which will be largest during winter when precipitation is greatest. However, this is also the time when the Swan River streamflow is strongest and the flushing of the waterways most vigourous. Therefore, even during this period, other influxes of water are negligible in comparison to that provided by the Swan River.

With good flushing, the water within Ascot Waters will at best be of the same quality as that of the Swan River. Unfortunately, in the past, under certain conditions, Swan River waters in the vicinity of Ascot Waters have been of particularly poor quality in a number of respects. It is well known that the continuous influx of nutrients into the Swan/Avon River system from agricultural areas of the catchment has resulted in significantly elevated concentrations of nitrates and phosphates in the water column. Recently this has led to a series of outbreaks of algal blooms in the upper reaches of the Swan River, with similar phenomenon also observed in the nearby Canning River. These are undesirable from both ecological and aesthetic perspectives, and indicate significant water quality problems. With algae occasionally blooming in the source water, it is reasonable to expect similar phenomenon to occur in Ascot Waters from time to time.

In addition to this, the outlet of the Central Belmont Main Drain (CBMD) is presently located at the proposed southern entrance to Ascot Waters. The catchment of the CBMD includes horse stables and wash down areas, and consequently the runoff collected by the drain at certain times carries extremely high concentrations for faecal coliforms and streptococci bacteria (both indicators of faecal pollution).

A water quality study of the CBMD was performed in 1992 for the City of Belmont (BSD Consultants, 1992). The data shows that, for the sampling conducted between April and September 1992, the drain water regularly exceeded the EPA guidelines for secondary contact recreation, sometimes by an order of magnitude.

In view of this, it is unacceptable to discharge the low flow (up to 1 in 1 year) stormwater of the CBMD directly into the Ascot Waters waterways. Instead, the outlet should be located a sufficient distance downstream so that, on flood tides, the concentration of faecal bacteria satisfy the EPA guidelines by the time the plume enters the Ascot Waters waterway.

3.4.2 Modelling of Central Belmont Main Drain Pollution

Analysis of the 1992 study results reveals that the highest concentrations of faecal bacteria occurred in the discharge generated by moderate rainfall events, and that the drain water would have to be diluted by at least 1 in 3 to satisfy the EPA guidelines. These events occur mainly during winter, when streamflow dominates tide induced currents, and so there is little chance of the effluent propagating upstream. The aim of the modelling was to determine the minimum distance downstream from the mouth of the southern entrance that the outlet of the CBMD should be located so that the EPA guidelines are satisfied for the water within Ascot Waters.

For design purposes, the flow conditions associated with late summer and early autumn were adopted since at this time streamflow is lowest and tidal forcing strongest. Sporadic thunderstorms generating rainfall of similar intensity to that experienced during the moderate winter precipitation events observed in the 1992 study are often experienced during this period. It is therefore reasonable to assume that the faecal bacteria concentrations of the CBMD drain water generated from an autumn thunderstorm are similar to those associated with the discharge from a mild winter storm.

The discharge of the drain water into the Swan River was modelled using turbulent diffusion and dispersion theory as applied to natural streams (Fischer et al, 1979, ch 5) to determine the dilution of the plume as it is advected upstream by the flooding tide. The behaviour of a buoyant effluent was analysed because the discharge from the CBMD was expected to be essentially "fresh" water (density ~ 1000 kg/m^3) while the riverine waters at this time of year are significantly more dense (~ 1025 kg/m^3). A consequence of adopting this approach is that vertical transport processes, apart from the initial vertical mixing that occurs at the discharge point, are considered to be negligible, and thus the modelled plume spreads out only in the horizontal plane. This provides a more conservative estimate of the effluent dilution than what would result from the modelling of a comparable neutrally buoyant plume (in which vertical mixing mechanisms are significant) however the latter approach would not be suitable for the design conditions adopted in this study.

The dilution of the buoyant drain water discharged from the CBMD is determined by the following:

- Initial vertical mixing,
- Horizontal turbulent diffusion, and
- Longitudinal (shear flow) dispersion.

Initial mixing down through the water column occurs at the discharge point due to the momentum possessed by the effluent as it exits the outlet pipe. This near field dilution establishes a surface layer with a relatively uniform vertical concentration profile, which is advected upstream by the flooding tide. Both the discharge rate (Q, m^3/s) and the thickness of the surface layer (h, m) determine this initial dilution. For the design event, namely a "typical" late summer thunderstorm, the discharge rate at the outlet is estimated to be 0.05 to 0.1 m^3/s (50 to 100 L/s). Furthermore, it was assumed, for flow of this order of magnitude, that the depth of nearfield mixing is directly proportional to the discharge rate, and be in the range of 0.5 to 1.0 metres.

Following the initial dilution at the point of discharge, the plume is carried upstream with the mean flow of the flood tide, and spreads out due to the random velocity fluctuations of the water associated with the river's turbulence. This whole process is known as "advected turbulent diffusion".

Further upstream the width of the plume will approach that of the river. When this occurs, the interaction of shear in the cross-stream velocity profile and turbulent diffusion produce a much more rapid dilution mechanism known as "shear flow dispersion", or simply "dispersion". In this study, the elapsed time required before dispersion effects become significant is in the order of weeks, which is far greater than the time scale of the tidal fluctuations that are of interest (~ 1 day). Dispersion effects are therefore negligible in this case and do not require modelling.

The problem to be analysed thus becomes that of the advected turbulent diffusion of the continuous side wall discharge of a buoyant effluent (see Figure 3.4). An analytical solution to this scenario has been developed by Fischer et al (1979):

$$c(x,y)=\frac{2Qc_0}{\bar{u}h\sqrt{4\pi K_h x/\bar{u}}}\exp\left(-\frac{y^2\bar{u}}{4K_h x}\right);\ x>0,\ y>0 \qquad \text{[eqn 1]}$$

where: $c(x,y)$ is the spatial distribution of the concentration of pollutant in the river, with x the distance from the outlet in the direction of the flow, and y the cross-stream location,

Q is the discharge rate of the effluent,

c_0 is the concentration of pollution in the effluent,

$\bar{u}$ is the mean river flow,

K_h is the horizontal eddy diffusion coefficient, and

h is the depth of the near field mixing.

In this analysis the primary interest concerns the dilution of the effluent pollution at some distance away from the outlet. As can be seen from either the above equation, or Figure 3.4, at any location "downflow" (which is actually upstream on a flooding tide) of the outlet, the pollution concentration is highest near the bank on which the outlet is located (peak concentration, c_{max}), and decreases across the river. The further "downflow" from the outlet, the lower the peak concentration but the wider the plume becomes.

For Ascot Waters, the peak concentration at the mouth of the waterway is of greatest concern as this represents the highest concentration of pollutant inside the waterway. More specifically, the dilution of the faecal bacteria pollution in the effluent should be at least 1 in 3 at this point. In other words:

$$\frac{c_{max}}{c_0}=\frac{2Q}{\bar{u}h\sqrt{4\pi K_h x/\bar{u}}}\leq\frac{1}{3} \qquad \text{[eqn 2]}$$

Given estimates of Q, h, K_h, and $\bar{u}$, the distance (x) that is required between the mouth of the waterway and the outlet of the CBMD, to achieve the nominated dilution of 1 in 3, can be estimated using this relationship.

3.4.3 Results of Modelling

Using the theory outlined in the previous section (§3.4.2) estimates of distances required for dilutions ranging from 1 in 2 to 1 in 5 were calculated for spring, mean, and neap tide conditions. The values of the parameters used for these three scenarios are given in the Table 3.1 below.

Table 3.1 Parameters for Diffusion Model

	Tide Scenario		
Parameter	**Spring**	**Mean**	**Neap**
Q (m^3/s)	0.1	0.1	0.1
$\bar{u}$ (m/s)	0.05	0.04	0.025
h (m)	1.0	1.0	1.0
K_h (m^2/s)	0.0090	0.0068	0.0045

At this stage, it is important to point out that, since it was assumed that the depth of the near field mixing was directly proportional to the discharge rate (ie. for $Q = 0.1$ m^3/s, $h = 1$ metre, and for $Q = 0.05$ m^3/s, $h = 0.5$ metres) and that from [eqn 2] the distance (x) is directly proportional to Q^2/h^2. Therefore, for a given dilution, the same distance will be calculated irrespective of the discharge rate from the outlet.

The results of these calculations are presented below in Table 3.2.

Table 3.2 Diffusion Model Results

Dilution (c_0/c_{max})	Distance, x (m) for each Scenario		
	Spring	Mean	Neap
2	28	49	113
3	64	111	255
4	113	197	453
5	177	308	707

In summary, it is estimated that during neap tides (the worst case scenario) the drain water would be diluted by a factor of three approximately 250 metres from the outlet, and by a factor of five roughly 700 metres from the outlet. During mean tides, these distances would be reduced to approximately 110 and 310 metres respectively, and even further during spring tide conditions, to 65 and 180 metres respectively. In the absence of any treatment to the water discharged by the CBMD, it is therefore recommended that the outlet should be relocated to a point at least 250 metres downstream of the southern entrance to the waterway.

It is important to note that any treatment of the CBMD drain water prior to its disposal into the Swan River which reduces its concentration of faecal bacteria may enable the drain outlet to be located closer to the waterway entrance. Treatment options such as detention ponds are being considered as part of the Ascot Waters project.

3.5 Flushing

3.5.1 General Description

In the previous section (§3.4) it was identified that the water quality inside the Ascot Waters development will, at best, be equal to that of the Swan River which feeds it, provided sufficient flushing is achieved. The vigour of flushing is customarily expressed in terms of a residence time, which is the time required for the throughflow to fill the entire volume of the water body. In a well mixed system, this provides a good approximation to the average time the water remains inside the waterway. For the purpose of the design of Ascot Waters, residence times in the order of a week or more were considered undesirable; in the order of 3 days was acceptable for "worst case scenarios", and 1-2 days, or less, ideal for the remainder of the time. These criteria should be put in perspective by comparison with those adopted for other developments. The Murray Lakes project near Mandurah has quite comparable source water and the beneficial uses are also similar to that at Ascot Waters. The flushing rate achieve at Murray Lakes is reportedly in the order of 5 days under the worst case conditions. Yet there appears to be little problems related to the flushing of these waterways. Consequently, the above more stringent criteria will be used in the design of the waterways at Ascot Waters and this would provide a suitable factor of safety to allow for possible inaccuracies in the flushing calculations.

The region of the Swan River to which Ascot Waters is connected is subject to a variety of forcing mechanisms which drive the motion of the water. These same mechanisms will be responsible for the flushing of Ascot Waters, and are listed below, along with an assessment of their relative effect across the four seasons.

Table 3.3 Relative Effect of Flushing Mechanism

Flushing Mechanism	Relative Effect			
	Winter	Spring	Summer	Autumn
Stream Flow	V.High	High	Low-V.Low	Low
Astronomic Tides	Moderate	Moderate	Moderate	Moderate
Density Currents	~ Zero	~ Zero	Low	Low
Wind Shear	V.Low	Low	Low	V.Low

The tidal regime of the Swan River in the vicinity of Ascot Waters is very similar to that measured at the Barrack Street Jetty. The amplitudes of the signals are within 1% (pers. comm. Don Wallace, Dept. of Transport, WA) and are approximately 85% of the ocean tide measured at Fremantle. The spring tide range at Barrack Street Jetty is in the order of 0.4 to 0.5 metres, while the neap tide range is only about 0.2 metres. The tidal submergence curve is shown in Figure 3.5

The worst time of the year, in terms of the weakest flushing conditions, is when the streamflow is lowest. This generally occurs from late summer, through early autumn, and up to the point of the first significant rainfall. Within this time interval the critical periods coincide with neap tides, which occur regularly at approximately 14 day intervals with a duration in the order of two days.

3.5.2 Modelling of the Flushing of the Waterways

The estimation of the residence time of the Ascot Waters required the set-up and calibration of a computer-based hydrodynamic model of Ascot Waters and the adjacent regions of the Swan River. The relevant output of the model is the instantaneous flow rates (Q) through both Ascot Waters and the section of the Swan River that runs parallel to it, from which the residence time (t_r) can be calculated as follows:

$$t_r = \frac{V}{Q} \qquad \text{[eqn 3]}$$

where: V is the total volume of the waterway.

In order to compute these flow characteristics, the model requires input of a geometric description of the waterway system of interest (Ascot Waters and the Swan River from Garratt Road Bridge to Clarkson Reserve, see Figure 3.1), the bed roughness, and the tidal signal at the downstream boundary.

To calibrate the model, the Ascot Waters waterways were excluded, and the results compared with field observations. The field data was collected between 07:00 and 17:00 on 5 May 1995, by means of a drogue tracking exercise conducted in the Swan River between Maylands Yacht Club and Garratt Road Bridge. The tide range on this day was 0.46 metres, which represents a "typical" spring tide range for the region. Low water occurred just before the previous midnight, and high water at just after 15:00. Since no significant rainfall had been received by the Swan River catchment in the months prior to this day, the tidal effects dominated the river hydrodynamics, with flooding flows persistent for the majority of the duration of the tracking exercise.

As it was known that water at different depths can possess different flow characteristics, particularly with respect to tidal estuaries, two different drogues were used:

- Subsurface Drogue - designed to follow the layer of water between 1.0 and 1.5 metres' depth (see Figure 3.6), and

- Surface Drogue - designed to follow the top 0.5 metres of water, similar to the subsurface drogue, but with no rope tether.

The tracks of these drogues are displayed in Figure 3.7 with spot times and average velocities given along the paths. Unfortunately, the wind was sufficiently strong (greater than 5 knots, typically ~10 knots) for most of the day to become the dominant forcing mechanism responsible for the motion of at least the upper 0.5 metre of the water column. As a result, the surface drogue was often blown ashore and became stranded, and consequently very few accurate tracks were obtained for this drogue. The performance of the subsurface drogue, however, was uninhibited, and its results are believed to be very reliable.

A comparison of the mean velocities computed from the track of the subsurface drogue with the computer model results showed the model to be performing very well. For example, between 0800 and 1200 the model predicted a flooding river flow of approximately 20 m^3/s and a mean velocity (averaged over the river cross-section) of 0.10 m/s in the vicinity of Bath Street Reserve. The observed velocity of the water between 1.0 and 1.5 metre's depth roughly along the midline of the channel was 0.109 m/s. It is to be expected that the velocity at this location will be slightly larger than that of the average for the cross-section since the influence of frictional effects associated with the river banks and bed are least in deep locations near the centreline (Massey, 1972, p 317)

With the model performing well under the present configuration of the river, the artificial waterways were added and flow regimes computed for a variety of tide conditions. During the worst case scenario, namely neap tides in late summer / early autumn, the model indicated that the residence time of the waterways would be approximately 55 hours (~2.3 days). Under the more favourable conditions of mean and spring tides, the flushing is significantly improved, with model estimates of residence times in the order of 30 and 20 hours respectively.

It is important to note that this modelling accounts only for the effect of tidal forcing on the flushing of the waterway. During periods of low river flow (summer and autumn), on a flooding tide, water moves up the Swan River. In the vicinity of southern entrance to Ascot Waters, some of the river water would enter the waterway through the mouth of the channel, while the remainder would continue to flow up the Swan River. The water flowing into Ascot Waters in this manner would exit the waterway system at the upstream end through the northern entrance channel. Conversely, on an ebbing tide, or during periods of moderate to high river flow (winter and spring), water flows in a downstream direction in the Swan River. Under these circumstances, some of the river water would enter the waterway system through the northern entrance channel and would exit at the south.

For both flooding and ebbing tides, the flow of water through the waterway would be essentially governed by the size and shape of the northern entrance channel. This would be the smallest constriction in the waterway system, and would essentially act like a tap - the wider and deeper the channel, the greater the flow of water through it. and the more vigourous the flushing of the waterway. In light of this, more vigourous flushing of the waterway can be achieved by simply dredging the northern entrance channel deeper and / or wider.

Tides are persistent all year round, and so the exchange of water they generate should be viewed as a lower limit on the flushing that will actually occur. During winter and spring the mean streamflow in the Swan increases to approximately 50 m^3/s, reducing the residence time of the proposed waterway to approximately 7 hours. Even during the most critical periods - late summer during neap tides - the effects of density currents, which are strongest when streamflow is weakest, and wind shear will enhance the flushing generated by tidal forcing.

3.6 Catchment Management

Ascot Waters has been designed specifically to ensure that good flushing of the waterways would be achieved all year round so that the quality of its water would be maintained close to that of its source water - namely that of the Swan River. In order to achieve this, the discharge of nutrients and other pollutants (eg. oils and grease from roads) into the waterway must be minimised. This is also important from a broader environmental objective, namely to minimise the impact of Ascot Waters on the local aquatic and terrestrial ecosystems associated with the Swan River.

The main mechanisms by which nutrients and other pollutants would enter the waterway are:

1) surface runoff, and

2) subsurface runoff / leachate.

Surface runoff from natural and revegetated areas is expected to have little, if any, adverse impact on the water quality of the water body. On the other hand, drainage collected from the developed urban areas may contain a variety of nutrients, oils and greases, particulate matter, and other pollutants in small, but possibly significant, concentrations. In order to minimise the influx of these substances into the waterways, and ultimately into the Swan River, all urban drainage discharged into Ascot Waters will pass through oil and refuse traps, and settling / nutrient stripping ponds. In addition to this, the entire development will be connected to the Water Authority of Western Australia's reticulated sewerage system, and therefore there will not be any septic tanks and no sewage would enter the waterway.

Due to the nature of the material buried at the old tip site, the surface runoff and leachate from this area of the catchment is of some concern. Presently the site is only covered with loose soil, yet limited studies do not indicate a significant efflux of leachate from the tip site. This may be due to the very low permeability of the clays and muds that dominate the soils in the area, or that tidal action has already leached out the majority of the pollutants. Despite this, it is proposed that a clay soil be placed over selected parts of the surface of the site, and the region be revegetated with species requiring minimal fertilising.

4. Sediments, Siltation and Dredging

4.1 Sediments

In 1965, the Public Works Department completed a major site investigation of the sediments in the Swan River near Maylands. The work was part of the investigations for the major dredging of the river that was completed in the late 1960's, and included a systematic probing to determine the nature of the substrate. The river bed in the vicinity of the Ascot Waters Project was included in these investigations. A profile taken at a cross-section near the mouth of the southern entrance channel of Ascot Waters (Figure 4.1, see also Figure 3.1) reveals the sediments in this area to be essentially muds and sands. For the Swan River in general, between Garratt Road Bridge and Clarkson Reserve, the probes extended to about 5 metres below AHD and indicated that the river bed was mainly mud with some sands.

As part of the current study, a number soil samples were taken from the surface of the river bed adjacent to the project site (see Figure 3.1 for sampling locations). All of these samples were basically cohesive muds, except the soil samples taken near the Garratt Road Bridge, which contained a minor amount of sand. Laboratory tests estimate the mean settling velocity of these sediments to be in the order of 0.5 mm/s. These tests showed that it takes about 5 hours for 95% of the sediment to fall through 1.9 metre of water in the settling tube. The remaining 5% of the sediment takes several days to settle out.

From these two investigations, it is believed that the sediments in the river bed near the project site are, for all practical purposes, basically cohesive muds which contain minor amounts of sand in some areas.

4.2 Siltation

Comparisons between profiles surveyed across the river in the late 1960's and early 1970's, and again in 1995, show a general accretion over almost all of the bed within this region (Figure 3.1 shows the location of transects). Comparisons of the 1970 and 1995 cross-stream river bed profiles taken near the northern and southern entrance channels are shown in Figures 4.2 and 4.3 respectively. The survey shows that the area has shoaled by about 0.5 metres over the 25 years, and this suggests an average siltation rate in the order of 2 cm per year. Ascot Waters, including its associated navigation channels, are therefore likely to require maintenance dredging approximately every 20 to 25 years. This is consistent with the fact that the Swan River in this area has not required any dredging over the last 25 years (pers. comm. Mr Trevor Leaver, Waterways Commission, 1995).

One area of uncertainty, with respect to siltation, concerns the movement of the banks in the vicinity of the proposed northern channel entrance to Ascot Waters (~500 metres downstream of the Garratt Road Bridge). Unfortunately, very little reliable data is available on the migration, or otherwise, of these banks and the sediment transport associated with this process. It is possible that the banks are gradually moving in a downstream direction, in which case the maintenance dredging requirements for the northern entrance channel may be more frequent. Experience elsewhere suggests that the banks are likely to be fairly stationary under the normal hydraulic regime, but may be moved during river flood events. In addition, the proposed cross section of the northern entrance channel includes a small allowance for future siltation. Consequently, any maintenance dredging is likely to be required only after major river flood events. Such maintenance dredging is expected only after river flows exceeding the 5 year return period event. Monitoring surveys should be used to confirm these siltation estimates.

4.3 Dredging

The proposed development includes two dredged channels to provide a connection to the river for flushing and navigation. The larger channel is to be at the southern end of the site, approximately 320 meters long, 55 metre wide and 2.5 metres deep at AHD (Figure 3.3). This cross section is adequate for safe navigation of the commercial ferries and private boats that presently used the upper reaches of the Swan River. In total about 22,000 m^3 of mud would be dredged to form the southern entrance channel.

The northern channel, which cuts through the System 6 Area, would be much smaller. In order to minimise the disruption to the System 6 environment, the proposed northern entrance channel has been limited to the smallest practical size that would enable adequate flushing of the waterways in the development. It would be about 90 metres long, 15 metres wide and a minimum of 1 metre deep at AHD through the System 6 Area (Figure 3.2). In addition, the channel would be located on the existing natural waterway in the area thereby minimising the area of vegetation that would be removed. In total about 2,000 m^3 of mud would be dredged from the System 6 Area. The northern entrance channel would also include dredging a channel through the submerged banks to make a better hydraulic connection through to the deeper portion of the river.

This connecting channel would be about 125 metres long, at least 15 metres wide and 1 metre deep at AHD. This portion of the northern channel would involve the dredging of about 6,000 m^3 of mud.

It is proposed to dredge all of the aforementioned channels using a small floating cutter-suction dredge. The pontoon of a suitable dredge would probably be in the order of 15 metres long and 5 metres wide with a draft of about 1 metre. The hydraulic system would probably have a discharge pipeline of about 200 to 300 mm in diameter. Given the likely size of the dredge pontoon, the proposed channel through the System 6 Area is the smallest that could be reasonably dredged.

In the dredging process, the muds would be cut by the cutter and sucked into the suction pipe by a slurry pump. The resultant slurry would be a mix of about 10% to 30% of sediment and 70% to 90% water. Special care would be needed in the disposal of the slurry mix. In view of the measured settling velocity of the mud, it is proposed to pump the dredged slurry into specially designed settling ponds (see Figure 4.4). At this stage it is proposed to build settling ponds on the top of the disused tip site. The envisaged construction sequence is to seal off parts of the tip surface using clay excavated from the marina and waterway areas, then build up a bund area with a special outlet to control the flow of return water. At any stage of the dredging work, the bund area would be at least 70 metres long by 50 metres wide and 1 metre deep in order to achieve a residence time of about 5 hours. This would cause about 95% of the suspended sediment in the dredge slurry to settle out in the pond. The return water would contain the remaining 5% of the sediment and would be carefully released back into the river. In view of the fact that the concentration of suspended solids in the dredge slurry is 10% to 30%, the suspended sediment concentration of the water discharged from the settling pond is likely to be in the range of 1% to 3%.

The dredging works would take about 2 to 3 months to complete. It is recommended to complete the dredging work during the autumn and winter months when the river waters are already quite turbid.

During the dredging operations, the suspended sediment content of the return water would be monitored to ensure that the settling ponds are removing at least 90% of the suspended sediment from the dredged slurry.

5. Conclusions

The water quality, dredging, and siltation aspects of the Ascot Waters Development have been investigated, with a number of conclusions being made.

First, the quality of the water within Ascot Waters will only ever be as good as that supplied to it by the Swan River. Some waters of the Swan in the vicinity of the Ascot Waters site presently experience occasional algae blooms. This suggests that, in some respects, a water quality problem already exists in the source water. In addition to this, the water currently discharged from the Central Belmont Main Drain (CBMD) at times significantly exceeds the EPA guidelines for secondary contact recreation with respect to faecal bacteria. The discharge point of this drain is presently located at the southern entrance of the proposed waterway and will have to be relocated. Since Ascot Waters is to be used for secondary contact recreation, the CBMD will not be directly discharged into the waterway. If the drainage water is to be discharged without any form of treatment, as is the present case, the low flow outlet will need to be located on the bank of the Swan River at least 250 metres downstream of the southern entrance to the waterways. The implementation of any treatment of the water prior to its disposal which reduces the concentration of faecal bacteria may enable the outlet to be located closer to the waterway entrance.

During the environmental conditions expected to cause the weakest exchange of water between the Swan River and Ascot Waters, it is estimated that the waterways would have a residence time of just over 2 days. These conditions would occur regularly for durations of a few days approximately every two weeks throughout later summer and early autumn. At other times, the flushing of the waterways will be significantly stronger, with residence times in the order of 1 day or less.

The influx of nutrients and other pollutants to Ascot Waters must be minimised in order maintain the desired water quality and not adversely impact on the ecology of the Swan River system. All urban drainage to be discharged into the waterway will pass through oil and refuse traps, as well as settling / nutrient stripping ponds. The development will be serviced with reticulated sewerage so there will not be any septic tanks or discharge of sewage into the waterway. In addition to this, the old tip site would be partially covered with clay soil and revegetated, which would improve the quality of the surface runoff.

The sediments near the project site are basically cohesive muds containing a minor amount of sand in some areas. The average sedimentation rate over the past 25 years is in the order of 2 cm per year, and hence it is envisaged that Ascot Waters will require maintenance dredging every 20 to 25 years. This may need to be more frequent for the northern entrance channel if major flood events cause significant movement of the nearby mud banks. Unfortunately, little is known about the behaviour of these features, however experience suggests that these are likely to be fairly immobile under the river's normal hydraulic conditions. Maintenance dredging is likely to be required only after significant river floods (>5 year return period).

In order to construct the northern and southern entrance channels, approximately 30,000 m^3 of river muds will have to be dredged. It is proposed to use a small floating dredge for this work. The pontoon of a suitable dredge would probably be in the order of 15 metres long by 5 metres wide, with a 200 to 300 mm delivery pipeline. This type of cutter-suction dredge would generate a slurry containing 10% to 30% sediment. Discharging this into settling ponds, with a residence time in the order of 5 hours, will enable the recovery of approximately 95% of the sediment. Under this scheme, the concentration of suspended sediment in the water finally discharged back into the Swan River will be in the range of 1% to 3%.

The dredging activities would take about 2 to 3 months to complete. In order to minimise the environmental impact of any silt plume that the dredging activities may generate, it is recommended that these dredging operations be conducted during autumn and winter when the river waters are naturally quite turbid.

8. References

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Figures

Figure 3.1 - Ascot Waters - General Layout

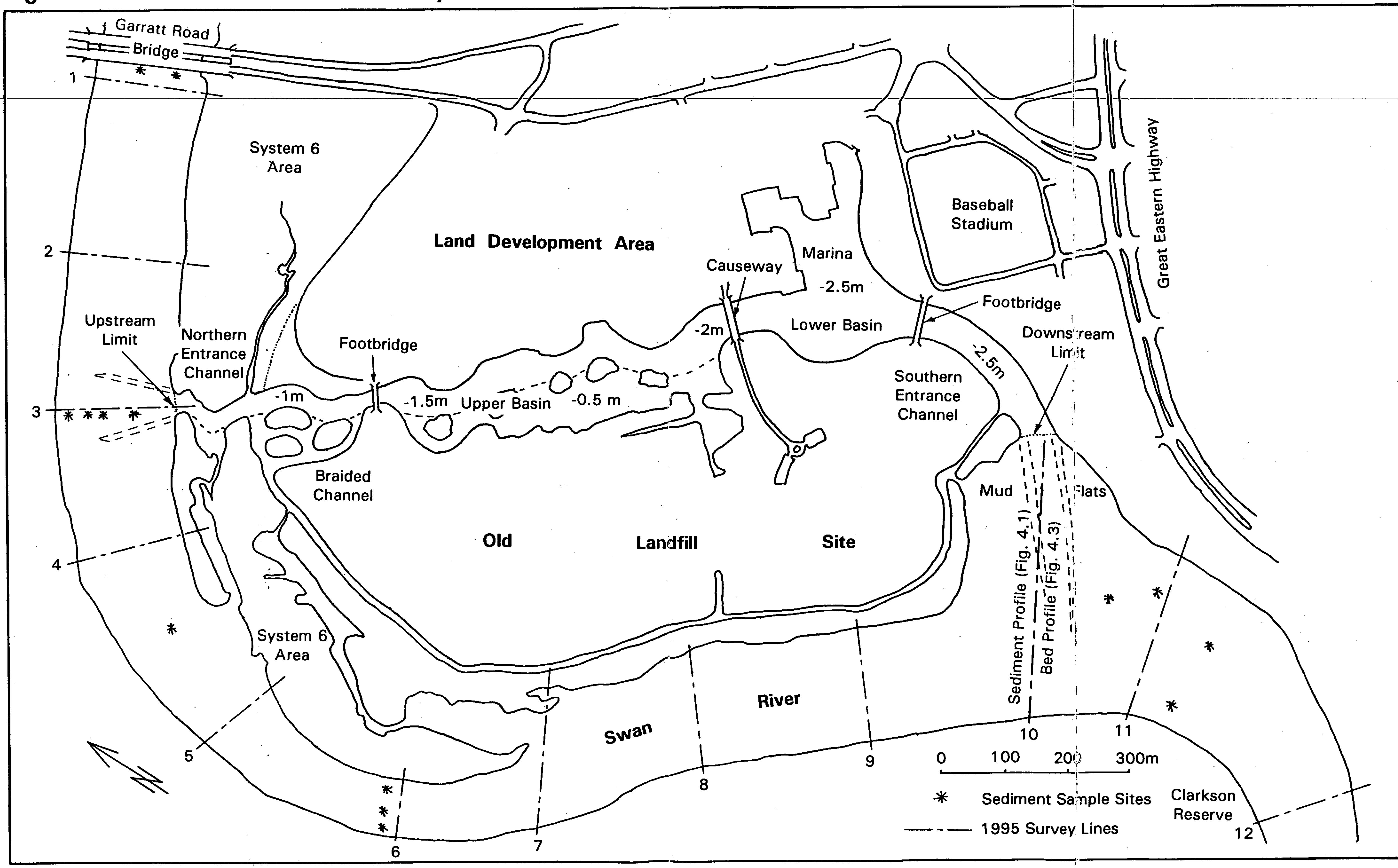


Figure 3.2 - Northern Entrance Channel Cross-Section

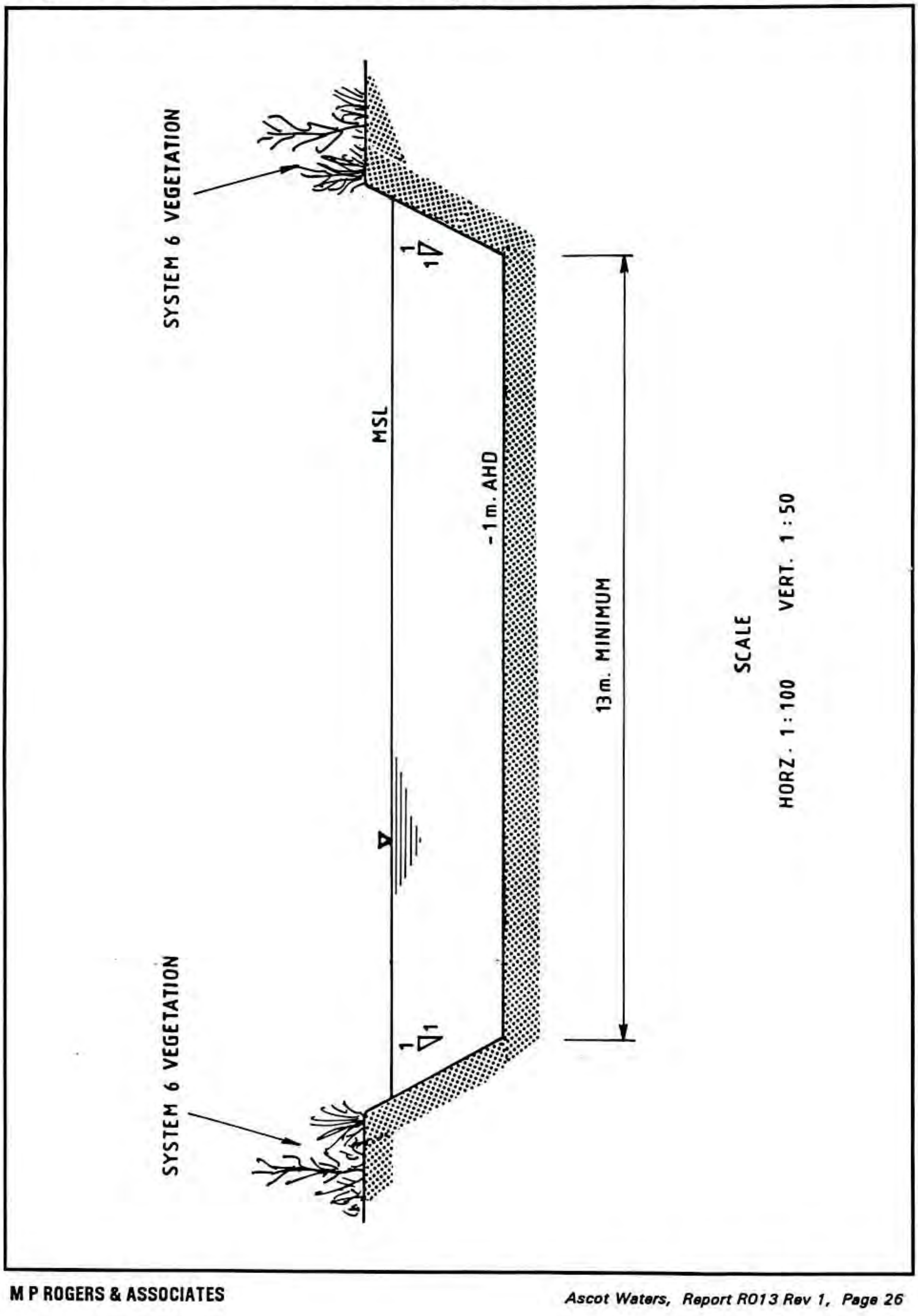


Figure 3.3 - Southern Entrance Channel Cross-Section

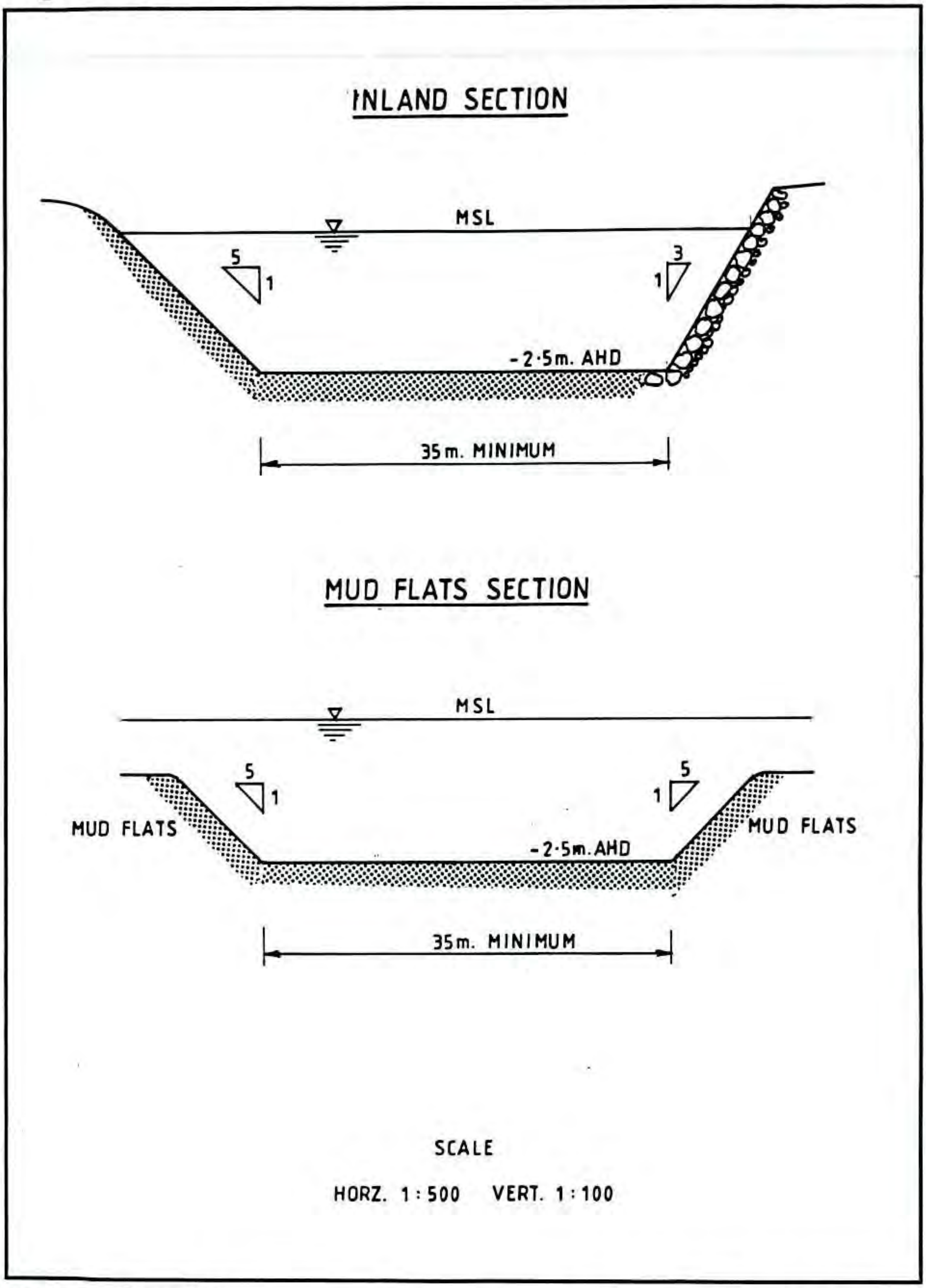


Figure 3.4 - Continuous Side-Wall Discharge

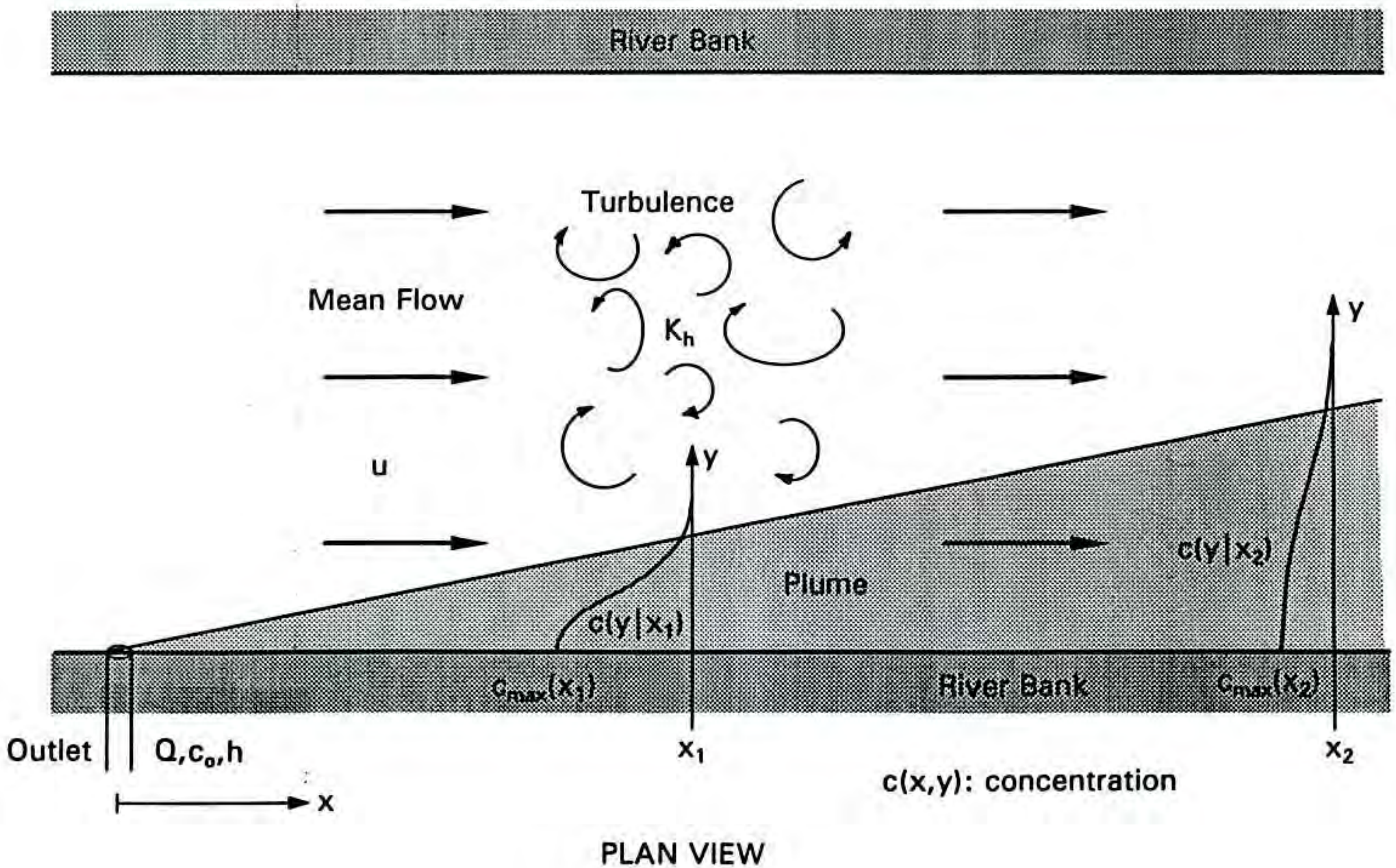


Figure 3.5 - Barrack Street Jetty
Tide Submergence Curve

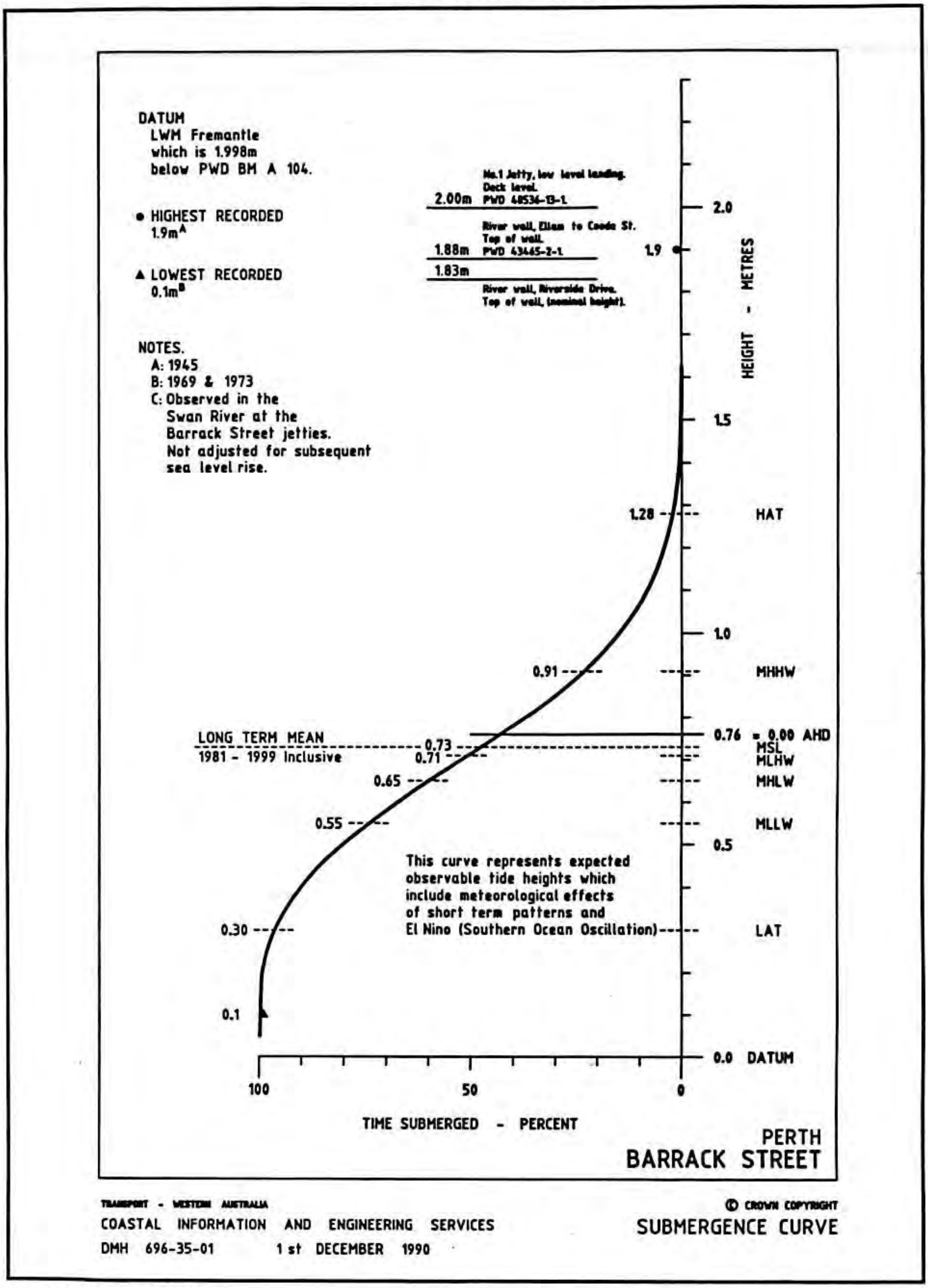


Figure 3.6 - Subsurface Drogue

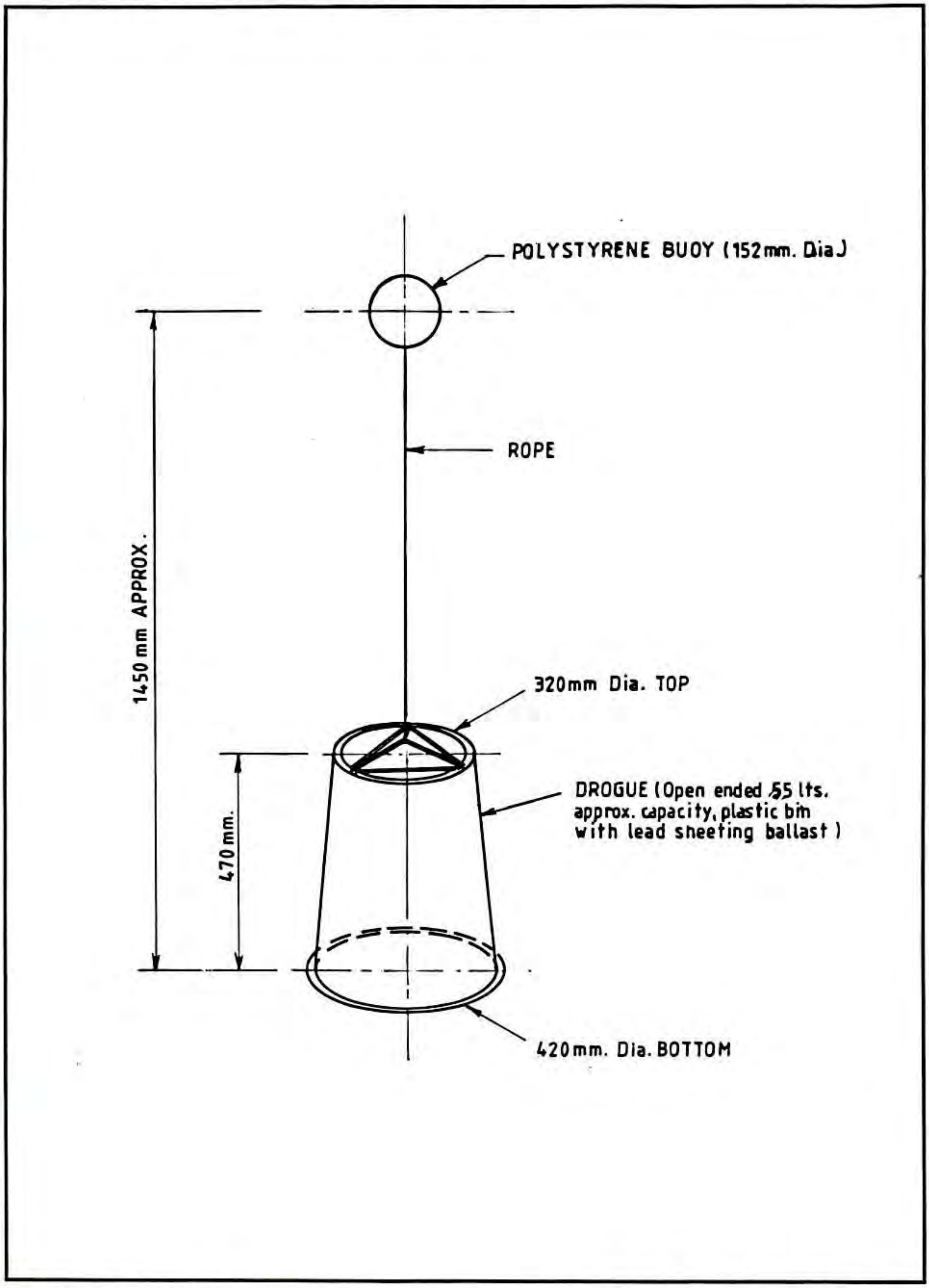


Figure 3.7 - Drogue Tracks

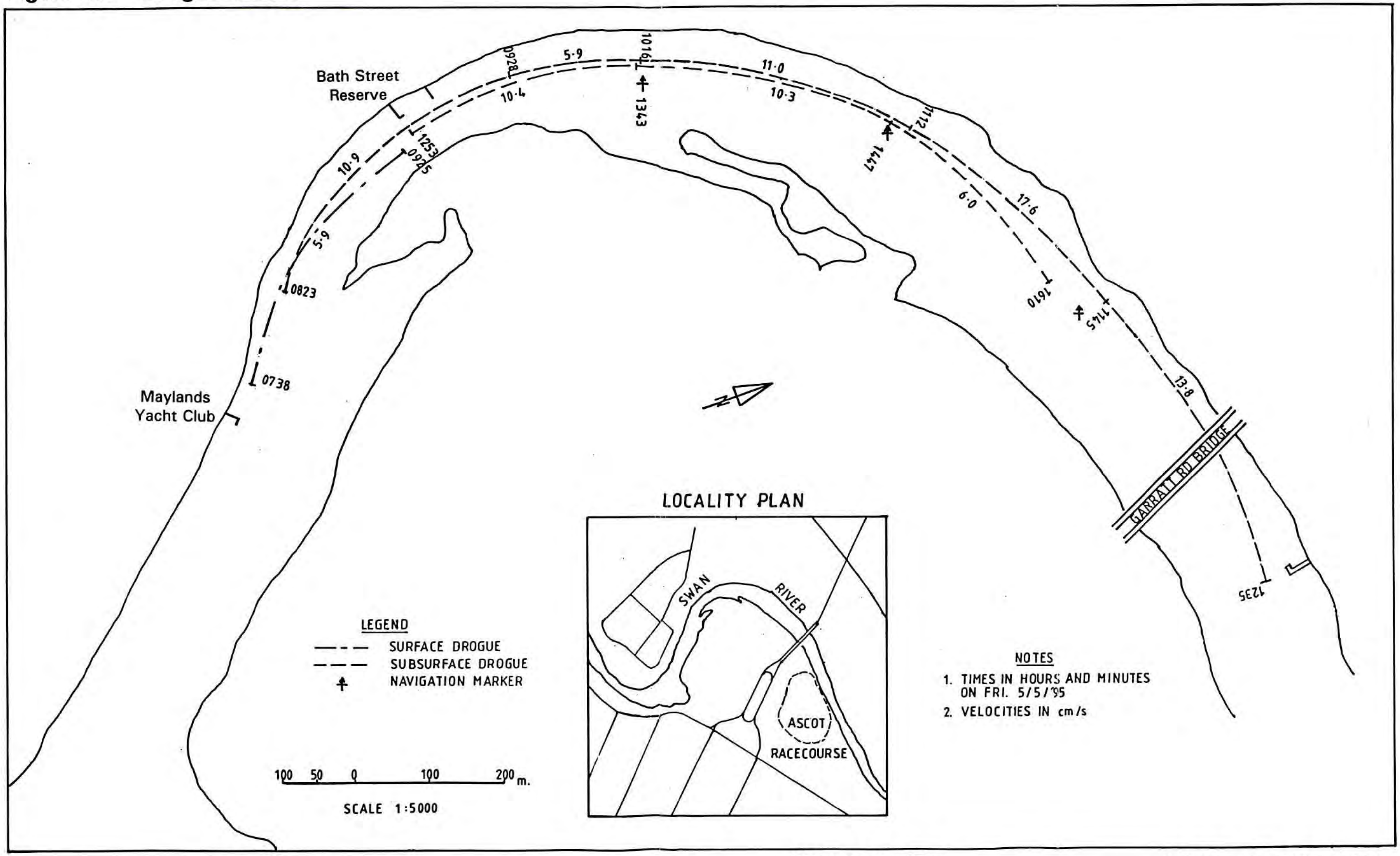


Figure 4.1 - Sediment Profile at Mouth of Southern Entrance Channel

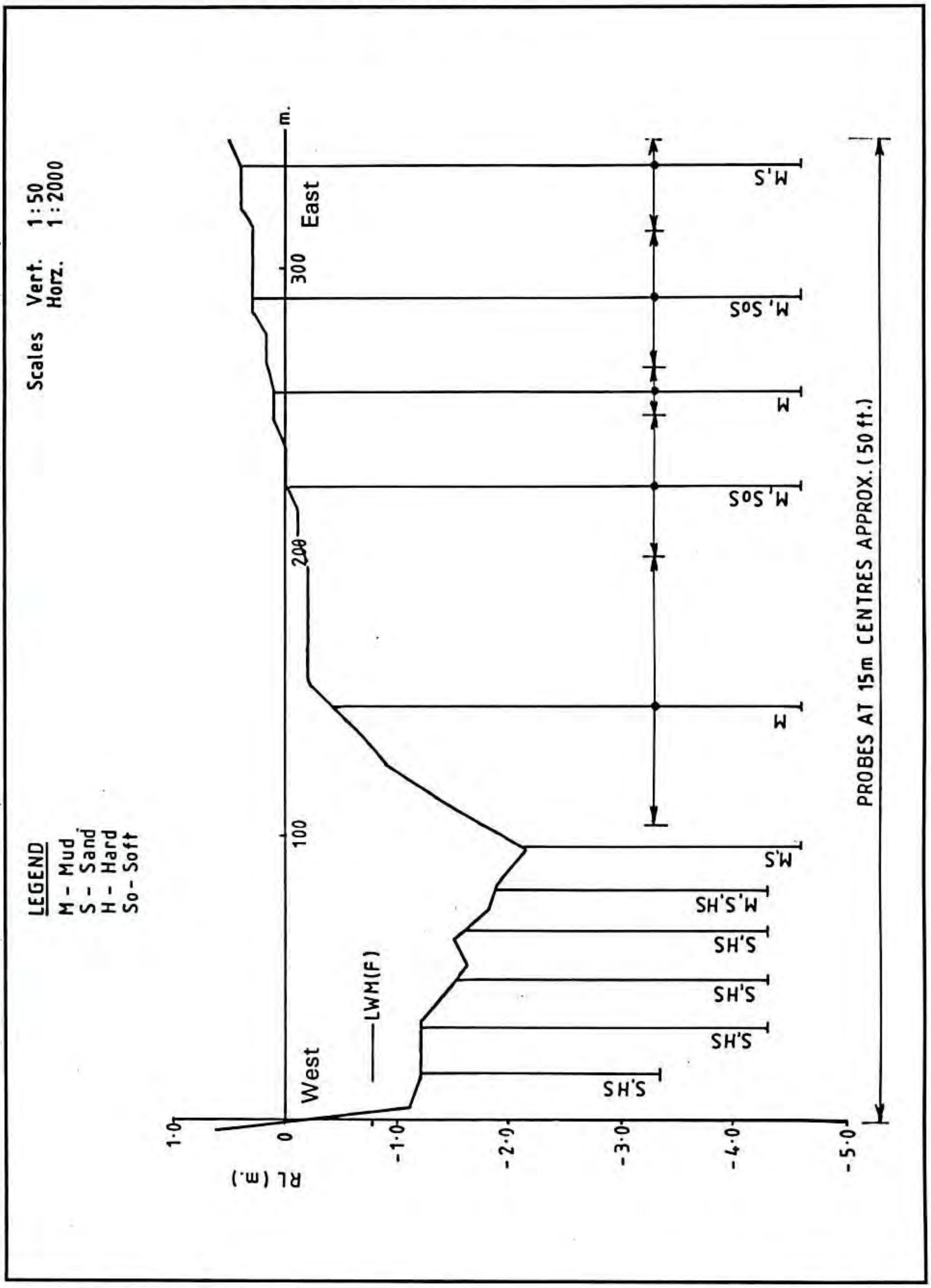
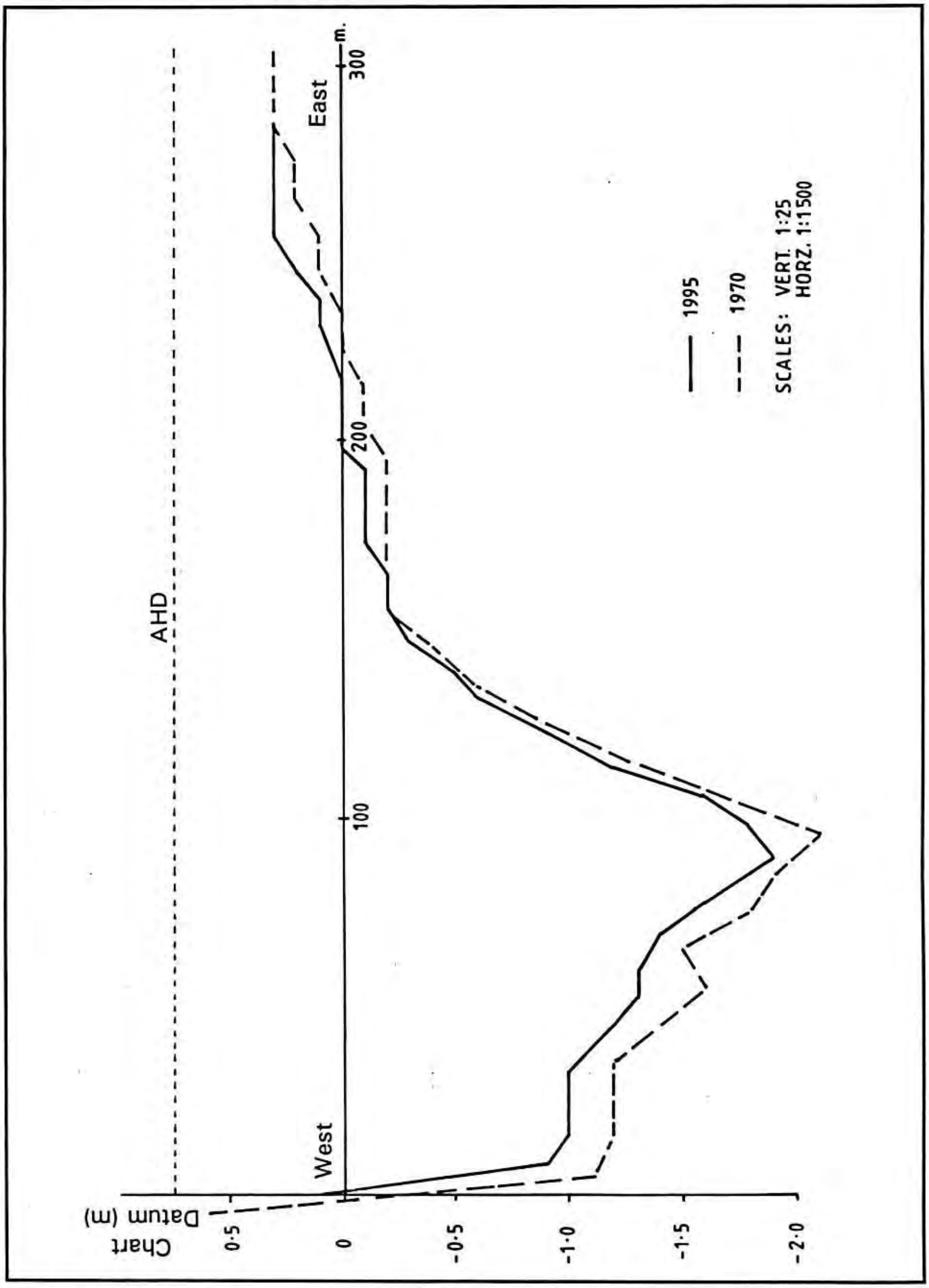


Figure 4.3 - River Bed Profile at Southern Entrance Channel



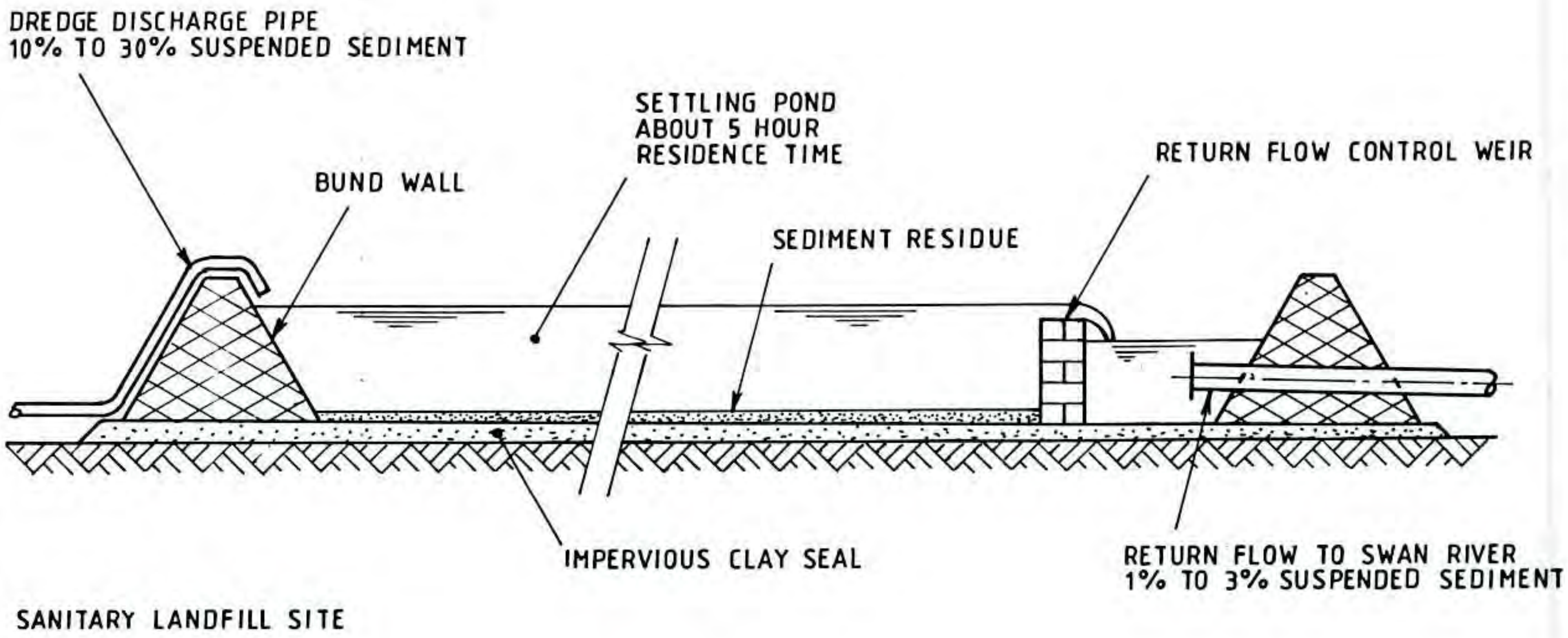


Figure 4.4 - Settling Pond for Dredge Slurry

Appendix C

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Water Quality in the Upper Swan Estuary, Issues and opportunities

ASCOT FIELDS

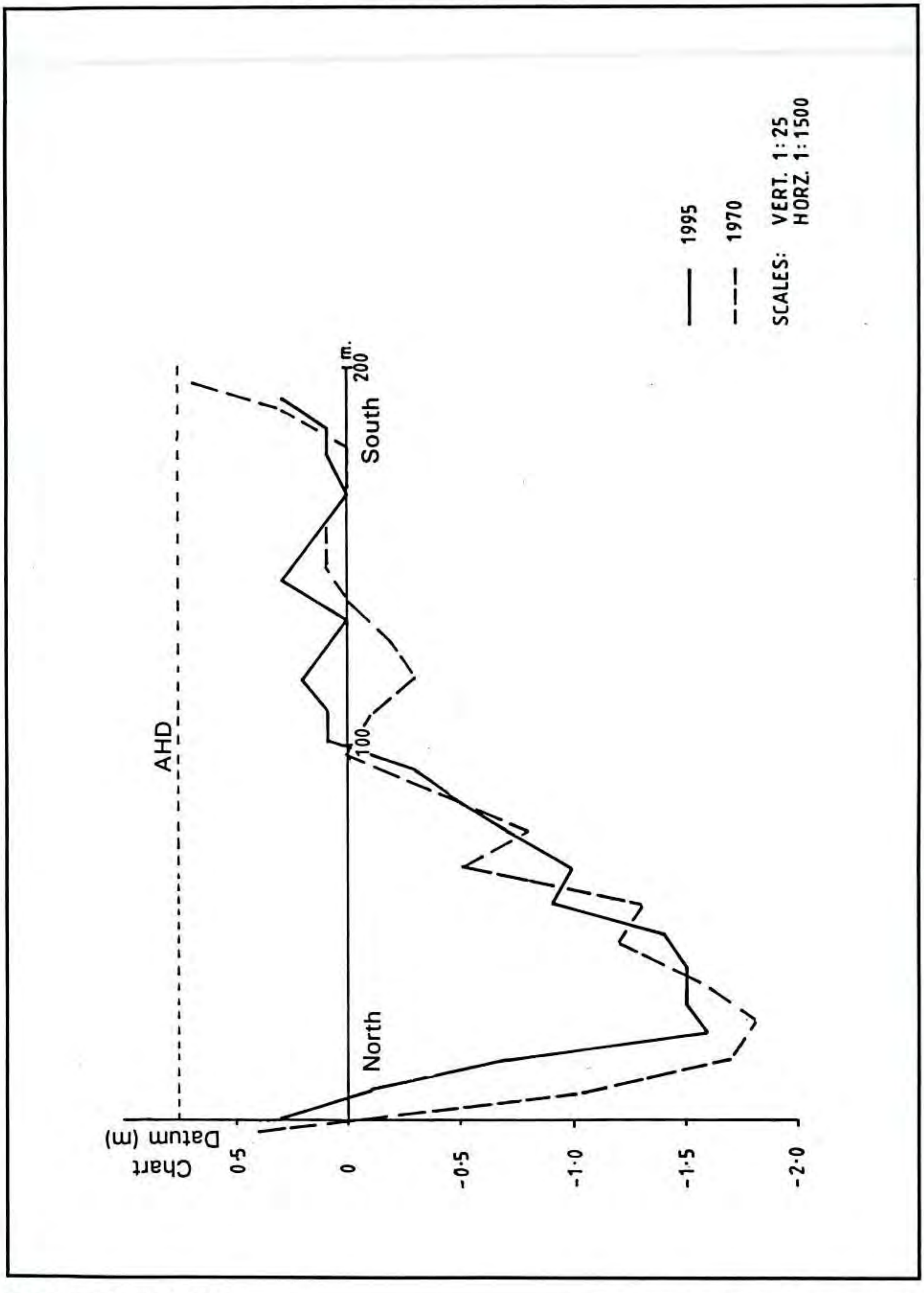
Water Quality in the Upper Swan Estuary
Issues and opportunities

Report to LeProvost, Dames and Moore
Perth, Western Australia

DM Deeley

Marine and Freshwater
Research Laboratory,
Environmental Science
Murdoch University
Murdoch, Western Australia 6150

Figure 4.2 - River Bed Profiles at Mouth of Northern Entrance Channel



SUMMARY

The waters of the Swan estuary upstream of the Causeway are poorly flushed and are exhibiting symptoms of nutrient and organic matter enrichment. Runoff polluted with sediment and nutrients from the 120,000 km^2 catchment has had a considerable impact on the upper estuary. In recent summers, this stretch of the river has experienced phytoplankton blooms and very low oxygen levels, particularly in deeper waters.

Phytoplankton blooms have been of minor consequence for direct contact recreation because of the absence of toxic species. Toxic blue-green blooms have occurred in the Canning River and the Peel-Harvey and Vasse-Wonnerup estuaries and similar phytoplankton species which preclude direct contact recreation are a strong possibility in the upper Swan. High levels of black ooze in sediments, salinity stratification, and very low benthic oxygen levels, and occasional fish deaths all serve to reduce public amenity of the river.

Despite occasional poor water quality, the upper Swan remains a productive aquatic environment highly prized by anglers and for other aquatic recreational pursuits. There are a number of significant conservation reserves along its length and public usage of this part of the river is high, particularly on weekends.

The WA Government has recently embarked on a major cleanup program for the Swan, and considerable resources have been provided for the Estuarine Research Foundation to investigate methods of controlling polluted runoff from rural, urban and industrial areas and to improve in-river water quality.

The nature of current problems in the upper Swan and the sheer scale of land management improvements required in the Swan/Avon catchment will probably not see rapid improvements in water quality.

At a local level, the Ascot Fields Estate has been designed to facilitate public usage of its aquatic environs. Water quality of the adjoining river is beyond the control of developers but careful waterway design will serve to limit periods of reduced water quality within the Estate and stimulate the establishment of stable benthic invertebrate communities and healthy fringing marshes. This will enhance the environmental values and public utility of the Estate's waterways and the river generally.

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1. DESCRIPTION OF THE EXISTING ENVIRONMENT

The upper Swan estuary can be defined as that reach of the river that is subject to tidal action, and which extends from the Causeway upstream to Middle Swan Bridge. This portion of the estuary currently consists of narrow meandering shallows through which a narrow navigation channel has been constructed.

Estuarine waters upstream of the Causeway have limited exchange with oceanic waters because of the shallow nature of the estuary and the physical distance to the ocean. The Mediterranean climate causes extreme seasonality in the pattern of rainfall and runoff to the river. Estuarine salinity varies from fresh to almost marine seasonally. Extensive clearing of the catchment for rural and urban development, and inappropriate disposal of domestic and industrial wastewater has seen large inputs of sediment and nutrients over past decades.

1.1 THE UPPER SWAN ESTUARY AND ITS CATCHMENT

The upper Swan catchment comprises the large (119,000 km^2) Avon River basin draining the lateritic uplands of the eastern scarp, and a smaller coastal plain catchment draining sandy coastal catchments. The metropolitan area of Perth also contributes significant runoff volumes and sediment and nutrient loads to the estuary (Donohue *et al* 1994).

Much of the Avon and coastal plain catchments have been cleared for agriculture with clearing percentages typically exceeding 85% (Govt WA 1993). Naturally infertile soils have required extensive use of artificial fertilizers for many decades. Soil erosion and loss from east of the scarp and from coastal plain areas moves fine nutrient-rich organic matter to waterways and ultimately to the Swan estuary. When fresh runoff containing suspended soil particles enters and mixes with salty estuarine waters, sediment particles settle at a much more rapid rate than in fresh water (Douglas 1995). This means that much of the suspended matter is accumulated in the estuary even though a significant portion may be passed out of the Swan during peak flood events.

1.1.1 The Catchment and Fringing Communities

Riparian vegetation serves to maintain the hydrological buffering of catchments and its removal increases water velocities and volumes. Increased runoff velocities and volumes following clearing and loss of riparian vegetation has seen a major increase in sediment and nutrient loads to waterways nationally.

1.1.1.1 Land use change and runoff quality

Average annual runoff is 607 million m^3 and more than 60% of this comes from the very large inland Avon catchment. The runoff percentage is low and runoff occurs mostly in winter (Deeley 1993, Donohue *et al* 1994).

The main sources of nutrients to the estuary have been identified as Ellenbrook, Southern River, the Avon River and Bayswater Main Drain, and these streams together contribute more than 75% of the 70 t TP load to the estuary. Annual Total N loads average 740 t (Donohue *et al* 1994).

1.1.1.2 Changes to fringing communities

There has been considerable removal of fringing marsh communities from the upper Swan estuary. Sanitary landfill was seen as an appropriate use for swamps and fringing marsh areas that adjoined the river (Singleton 1979, 1989). Fringing marsh communities play an important role in maintaining fundamental chemical and biological process in the estuarine ecosystem.

Fringing marsh areas trap silt and nutrients during floods and subsequently stimulate the decomposition of trapped organic matter. Fringing marshes therefore act as a sink for N and a trap for organic matter which consumes dissolved oxygen in the river during its decomposition.

Marsh communities are sinks for organic particulate matter, and coupled with denitrification and other biochemical processes form an important part of an ecosystems ability to self purify. The loss of fringing marshlands has probably contributed in an indirect way to the reduction in biological integrity of the estuarine sediments. The Swan currently has little ability to self purify and considerable external intervention is now necessary to restore this balance.

1.1.2 The Upper Estuary

The upper Swan estuary becomes almost completely fresh in mid-winter, when river flows are at their peak. Cessation of rainfall and runoff from the catchment in spring allows the gradual penetration of a saline wedge into the upper estuary. Narrow river reaches are sheltered from sea breezes and turbulent mixing of the water column is minimal, leading to stratified conditions which persist over the warmer months.

1.1.2.1 Physical water quality and dynamics

The river depth varies to a maximum of 5-7m in deeper pools but is mostly very shallow at less than 3 m. Average salinities from spring to autumn in the upper estuary range from 21 ppt at the Causeway to 10 ppt at Guildford (Table 1). The penetration of marine waters following winter increases salinity from an average of 8 ppt in Spring to 22 ppt in autumn (Table 2).

Average dissolved oxygen saturation decreased from 85% to 63% moving upstream (Table 1) and decreased from 92% in spring down to 60% in summer and autumn

(Table 2). Water temperatures ranged from 21 C° in spring with a summer peak of 26 C° and falling to 24 C° in winter.

1.1.2.2 Chemical water quality

Average nutrient concentrations are summarized in Tables 1 and 2, and indicate a moderate level of nutrient enrichment. Total N concentrations remained above 600 µg/L and TP concentrations remained above 45 µg/L. These concentrations are compared with draft ANZECC water quality guidelines summarised in Table 1.

1.1.2.3 Biological water quality

Mean chlorophyll-a values for the upper Swan estuary were moderate ranging from 6 to 19 µg/L (Table 1). Chlorophyll-a levels of 20 µg/L for an integrated sample have been classified in the eutrophic range (Vollenweider 1971). The nature of these average data masks any extreme values which may have implications for recreation. Considerably higher values of chlorophyll-a were found at particular locations on occasions and these episodic events are described in more detail Section 1.2.3.

1.2 THE PROJECT AREA

The estuary adjacent to the project area is typical of similar reaches found upstream of the Causeway. Depths range from 5m off the Sandringham Hotel reducing to <3 on the northern reach and again deepening to 5m off the Maylands Pool site. Sediments grade from coarse sands in littoral areas to silts in the sub-littoral fringe and to deep (up to 2 m thick) accumulations of 'organic ooze' in areas below 4 m depth. These deep ooze pockets are located in deeper water at the north east and southwest extent of the proposed project area.

The complex cycles of physical, chemical and biological activity in the Swan estuary at Ascot are summarised in Figure 1. This conceptual model of cyclical behaviour was derived from data from a single intensive investigation (Deeley & Hosja 1995), and longer term historical monitoring in the estuary.

1.2.1 Physical Water Quality

Salinities in the estuary from Rivervale to Maylands Pool averaged from 18 to 14 ppt, decreasing upstream, but ranged from 7 ppt in winter to above 25 ppt in late summer. Bottom water salinities reached a maximum of 28 ppt in autumn.

The repeating cycle of fresh to saline conditions is illustrated in Figure 1a using long term (12 year) monitoring data from the Swan at Garratt Road bridge, and an understanding of cycles in the Peel-Harvey and other southwest estuaries (James *et al* 1995, Deeley & Hosja 1995, Hodgkin & Clarke 1987).

Salinity increases from a minimum over winter in a near linear fashion, governed by normal estuarine hydrological processes and marine tidal forcing. The salinity maxima in late autumn approaches marine salinities before it falls rapidly with the onset of fresh runoff from the catchment.

Clearly, the cycles of these average conditions could be modified in the event of unseasonally wet summers which reduce summer salinities. Alternatively, exceptionally dry winters may be followed by higher than normal summer salinities in the upper estuary. In the Harvey estuary for example, autumn salinities exceeded 45 ppt following winters of reduced runoff which is well above marine salinities of 35 ppt. Hypersalinity of this level would be unlikely at Ascot however.

The occasional wet February is a feature of Perth's weather, and this is shown as the small ellipse below February. Northern cyclonic activity is responsible for this occasional summer runoff which has been observed several times in recent years (Deeley & Hosja 1995).

Dissolved oxygen averaged 70% saturation (Table 1), but this masked the opposing effects of summer supersaturation from surface phytoplankton blooms and benthic anoxia shown in Figure 1b. Dissolved oxygen in winter was relatively invariant at between 70% to 100% saturation. Spring photosynthetic activity increases surface dissolved oxygen to supersaturated conditions above 130% saturation which remain high in surface waters for most of summer falling back to normal levels through autumn.

Dissolved oxygen levels in deeper bottom waters typically fall to below 50% saturation from spring through summer to late autumn. Minimum values of less than 15% saturation have become common in spring and late autumn (Deeley & Hosja 1995).

1.2.2 Chemical Water Quality

Average inorganic nitrogen concentrations have been high (Table 1), and ammonia-N levels have averaged more than 10 times draft National water quality guidelines (ANZECC 1994). Nitrate N has been at acceptable levels and mean TN concentrations were equivalent to or in excess of the upper limit of draft National guidelines.

The seasonal picture on inorganic N in Figure 1 strongly reflects the effect of very high inputs from winter runoff. A large proportion of the ammonium-N load comes from the Avon catchment and is rural in origin (Donohue *et al* 1994).

Filterable reactive P levels averaged around 30 µg/L which was well above draft National guidelines of <15 µg/L. Figure 1d shows a similar pattern of high levels of NH_4-N and FRP from winter runoff. Spring FRP levels are reduced particularly when phytoplankton populations are increasing. Summer months sees higher FRP levels probably reflecting nutrient release from anoxic sediments.

1.2.3 Biological Water Quality

Average chlorophyll-a levels have remained low at below 10 µg/L (Table 1). Peak levels in excess of 30 µg/L have been observed in this location (Deeley & Hosja 1995). The pattern of chlorophyll-a activity at Ascot is summarized in Figure 1e using a log scale. This illustrative model was chosen because of higher order growth and decay for phytoplankton and so as to take better account of the skewed distribution with its occasional extreme chlorophyll-a values.

Chlorophyll-a values were lowest in late winter and early spring and increased markedly to a summer maxima. Chlorophyll-a levels fall through autumn and increase markedly in early winter. Chlorophyll-a levels again fall through late winter.

Cell counts of phytoplankton averaged in excess of 5,000 cells/ml over the warmer months (Table 1). Maximum cell counts in excess of 30,000 cells/ml have been common in the area. Phytoplankton species include dinoflagellates or 'Red Tides' in warmer months and diatoms in cooler months. The pattern of winter diatoms followed by blue-green or red tide organisms has been described for a number of southwest estuaries. (James *et al.* 1995, Hosja & Deeley 1994, John 1983).

2. PROGNOSIS

Preventing additional decline and ultimately improving the health of the upper Swan will require considerable expenditure of intellectual, human and financial resources. Reducing broadscale nutrient and sediment movement from very large catchments has proven difficult throughout the developed world.

Management measures which may serve to reduce runoff velocities, soil and nutrient loss from catchments include re-establishing riparian vegetation buffers, increasing the hydrological buffering of catchments through the establishment of off-line wetlands and detention structures which trap more polluted first flushes from urban areas, improved fertilizer use efficiency, improved erosion control and drainage management.

Because of the unique nature of the landform, soils, vegetation and climate in WA, management solutions need to be developed for the local situation. Management measures developed for eastern states and overseas situations may not apply to the Swan/Avon basin.

Possible in-estuarine management measures which may improve estuarine water quality include mud pumping, sediment chemical treatments, capping, bathymetric modifications, artificial mixing and strategic use of algicides. Engineering options such as these are very expensive to implement. There is often considerable logistical difficulty during the process of scale-up and field implementation of engineering solutions developed from computer simulations or laboratory based physical models.

Clearly, all of the above catchment and estuarine management measures require considerable human and financial resources and thorough impact assessment prior to implementation. Additionally, most in-estuarine solutions will only provide short term relief to current water quality problems and do little to manage the source of the sediment and nutrient problems.

Organic-rich sediment will continue to accumulate in deeper pools and cause problems even if removed or treated chemically. Permanent catchment-based solutions are required to address the problem in the longer term, unless there is to be a continuing cycle of mud pumping, artificial mixing, algicide application and so on.

Very lengthy (decade) time frames will be needed for permanent solutions to the current problems in the upper Swan estuary. Many of the management measures are yet to be developed, tested and implemented. Considerable human intervention to improve the Swan is essential.

Predicting such a future which is strongly influenced by political decisions of resource allocation, scientific uncertainty, complex bio-geochemical interactions and the normal human resistance to changes of behaviour is extremely difficult. An examination of both worst and best case management scenarios may provide insights to likely timescales involved and probable middle ground which may be taken. The following section discusses both worst and best case scenarios for the upper Swan estuary. It should be noted that the worst case scenario, although possible, is unlikely. The recent community and government resolve to improve the Swan (of which Ascot Waters may be viewed as an example) should mean the environmental quality of the Swan River will see an improvement in the coming decades rather than further decline.

2.1 THE UPPER SWAN ESTUARY AND ITS CATCHMENT

The population of Perth and its rural fringe continues to increase in an exponential manner. Clearing for agricultural, urban and industrial development continues within the catchment. The pressure of increased people and increased agricultural production will probably mask or eliminate hard fought runoff quality improvements in some areas.

2.1.1 The Catchment and Fringing Communities

The hydrological buffering of the catchment should be re-established. For rural areas, this will include broadscale erosion control, major plantings of fenced riparian vegetation, channel restoration measures (riffles and meanders) to dissipate the kinetic energy and erosivity of smaller streams (Newbury 1995). For urban areas, selective capture and treatment of first flush events with their proportionally high pollutant loads is possible through the use of best management practices.

These activities need to occur throughout the entire urban catchment not at the bottom end. Best management practices such as off-line or on-line detention, retention and infiltration basins need to be designed, sized and managed appropriately. Distributed best management practices have greater inbuilt redundancy and offer the best chance of water quality improvement.

2.1.1.1 Land use change and runoff quality

Current rural land and water management practices take little account of the downstream consequence of sediment and nutrient loss. Leaching of significant loads of soluble nutrients have been observed from sandy coastal plain catchments such as Ellen Brook and many of the Peel-Harvey coastal catchments (Deeley *et al.* 1993, 1995; Donohue *et al.* 1994).

Alternative management practices need to be developed and implemented to reduce current unacceptable loss of soluble nutrients from sandy coastal rural catchments (Kinhill 1988). The time frames required to achieve major reductions of soluble nutrients are likely to be several decades.

For rural catchments on heavier soils such as those east of the Darling scarp, agricultural development has seen an increase in runoff volumes and velocities which has resulted in large loads of sediment carrying bound nutrients to receiving waterways (Daniel *et al* 1994; Weaver *et al.* 1995). Managing sediment and nutrient loads from the Avon catchment will require broadscale improvements in erosion control. This means re-establishment of fenced riparian vegetation on all water courses, including smaller creeks and drains. Planting of perennial agricultural species along denuded smaller water courses will mean a maintenance or improvement in farm economic viability in the medium to longer term.

Reducing runoff velocities, volumes and quality through erosion control and riparian vegetation will take very lengthy time frames, in the order of decades. From overseas and local experience, it may take a decade to detect trends after management improvements for diffuse pollution have actually commenced (Deeley *et al.* 1995). A best case scenario following a massive riparian revegetation effort may see reductions in sediment loads within 5 to 10 years. In a worst case scenario where little progress is made, current unacceptable loads of nutrients and sediment may continue to increase for the next 50 years.

2.1.1.2 Changes to fringing communities

Increased areas of riparian and fringing marsh ecosystem will improve the environmental and public amenity of the Swan/Avon catchment. Time frames required to achieve mature restored ecosystems are from 5 to 20 years following planting. Apart from localized successes where resources can be concentrated, the restorative effort required for the catchment will require several decades.

2.1.2 The Upper Estuary

The current high nutrient loads to the upper Swan estuary from the rural catchments will probably continue to degrade the Swan for sometime yet. Without in-estuarine intervention, nuisance phytoplankton blooms and seasonal anoxia will continue

In a worst case scenario, direct contact recreation may occasionally be compromised along the estuarine reach because of episodes of phytoplankton blooms.

Major and rapid improvements to estuarine water quality can be achieved through engineering solutions including dredging, mud pumping, sediment treatment and through artificial mixing. In extreme cases chemical treatment of estuarine waters may be required to control toxic algal blooms.

2.1.2.1 Physical water quality

Without intervention, the annual cycle of stratified conditions, and anoxia will continue. The presence of natural deep pockets and uneven bathymetry caused by limestone mining will continue to trap anoxic waters. Despite regular high winds for Perth, wind mixing of the upper Swan will continue to be restricted because of the meandering nature of the upper estuary and short fetch lengths to prevailing wind directions.

It is therefore likely that seasonal salinity stratification in the upper Swan will continue, although external intervention such as artificial mixing could relieve the situation. Bathymetric modifications in the upper Swan which increase mixing and movement of dense saline waters in deep pockets may also prove advantageous. Clearly considerable hydrodynamic modelling and thorough environmental impact assessment would need to precede such broadscale changes to the upper estuary. It is likely that large expenditure will be required to provide any significant broadscale reductions in salinity stratification and anoxia in the upper Swan estuary.

In a best case scenario where the required funding is forthcoming, scientific investigations undertaken and environmental impact assessment completed, improvements in water quality may be observed within five years. Where the required level of funding for broadscale improvements is not available, water quality will continue to decline in the upper estuary. A probable scenario may see some localized testing of potential physical interventions for selected areas in the upper Swan over the next 5 to 10 years.

2.1.2.2 Chemical water quality

Without intervention, levels of nutrients in the estuary will remain high. The cycle of high estuarine nutrient concentrations accompanying runoff inputs and elevated summer FRP concentrations will probably continue. Much of what applies in Section 2.1.2.1 (physical water quality) applies for chemical water quality. The prognosis for high external nutrient loadings to the upper estuary from runoff have been described in Section 2.1.1.1.

Stratification and anoxia have led to high internal nutrient loadings to the upper Swan estuary through release from organic-rich sediments in deeper holes (Deeley & Hosja 1995). The two scenarios described for physical water quality above also apply for chemical water quality.

Waterways with high filterable reactive P (FRP), levels and brackish conditions like the upper Swan estuary are at risk from blooms of toxic blue-green algae. Toxic blue-greens including *Microcystis, Nodularia* and *Aphenozymenon* have recently occurred in Canning, Serpentine and Blackwood Rivers (Hosja & Deeley 1994).

The Swan River Trust together with the Health Department and Local Government Authorities currently provide surveillance and impact minimization strategies for algal bloom affected waterways.

2.1.2.3 Sediment quality

Sediments grade from coarse sands in littoral areas to silts in the sub-littoral fringe and to deep (up to 2 m thick) accumulations of organic ooze in areas below 4 m depth. These deep ooze pockets are located in deeper water at the north east and southwest extent of the proposed project area.

Without intervention, existing benthic ooze accumulations will persist and provide a considerable sink for dissolved oxygen and a source of available nutrients. The annual cycle of persistent summer hypoxia and anoxia may compromise the survival of benthic invertebrate communities.

Communities of invertebrates comprising of larger longer lived species may move toward those with greater populations of a smaller number of opportunistic species. These species tend to be small, short-lived and have high reproductive potential. Their opportunistic nature means they are able to rapidly re-colonize disturbed areas, which at one time may have experienced oxygen depletion or other adverse environmental conditions. Large and longer living mussels and worms are generally less able to cope with continuing stressful conditions in an estuary (Engle *et al* 1994).

2.1.2.4 Biological water quality

Recent red tides in the upper estuary have involved species of phytoplankton not normally known to be toxic (Deeley & Hosja 1995). The *Dinophyceae* and *Cyanophyceae* contain species which may occupy niches similar to those in the upper Swan and which have proven harmful to humans and other aquatic species elsewhere (Hosja & Deeley 1994). Harmful effects range from minor skin irritations to highly toxic waters which preclude direct contact recreation, consumption of seafood and use for stock watering.

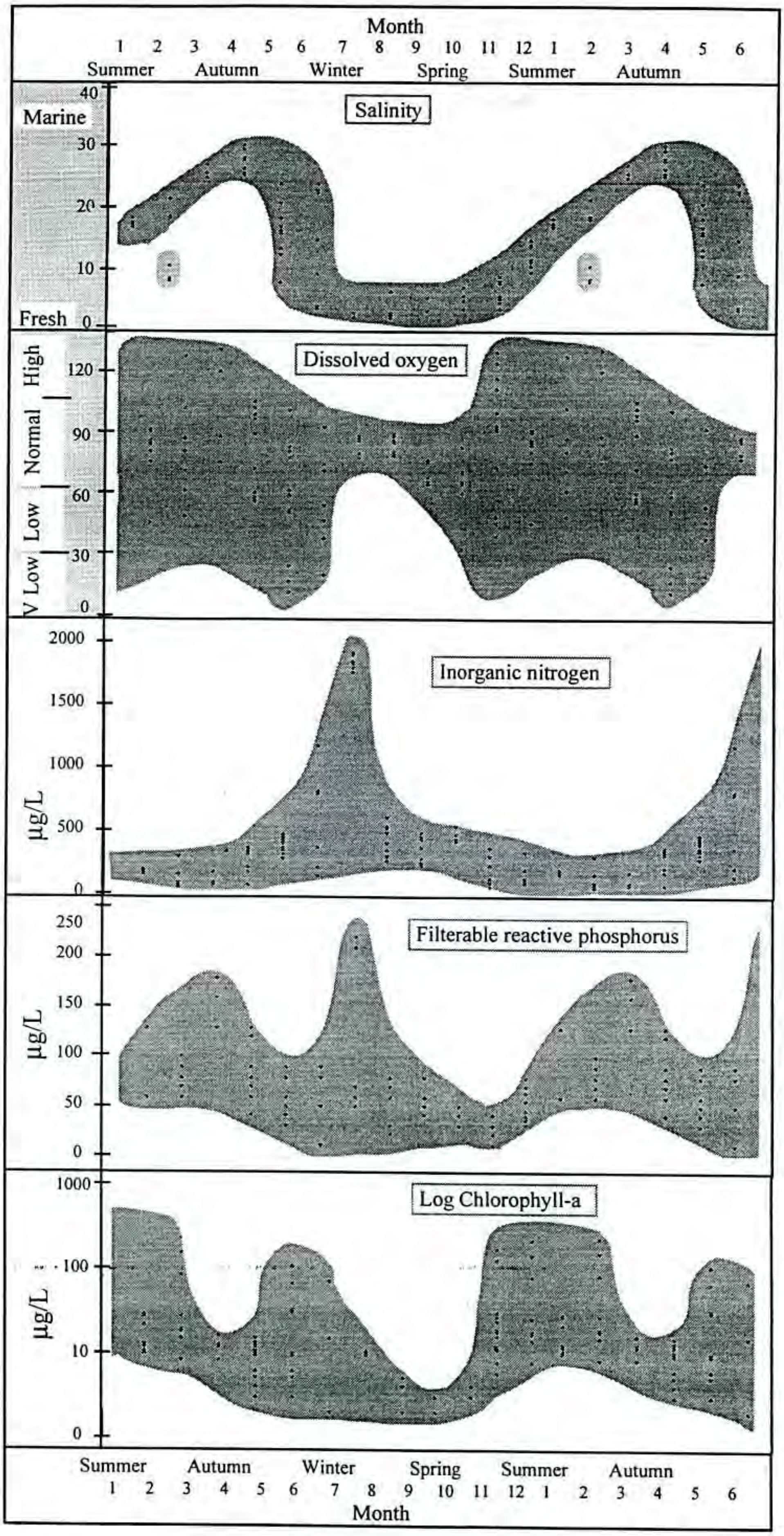

Figure 1 Seasonal cycles of key water quality variables in the upper reaches of the Swan. a) salinity, b) dissolved oxygen saturation, c) inorganic nitrogen, d) filterable reactive phosphorus, and e) log Chlorophyll-a.

Table 1 Average water quality for the Swan estuary upstream of the Causeway from Spring 1992 to Autumn 1993, by site.

	Site						National water
Variable	Causeway	Rivervale	Maylands	Ashfield	Bassendean	Guildford	quality guidelines
Salinity (ppt)	21	18	14	13	11	10	
Temperature (C°)	23	24	23	24	24	24	
% O2 Sat	85	69	70	68	69	63	
NH4-N (µg/L)	55	75	72	59	44	45	<5
NO3-N (µg/L)	38	34	49	34	30	26	10-100
TN (µg/L)	457	598	588	699	660	649	100-500
FRP (µg/L)	28	32	27	20	14	17	5-15
TP (µg/L)	48	69	51	67	59	45	5-50
Chlorophyll-a (µg/L)	6	10	9	18	19	13	<20
Total phytoplankton cells	2923	5696	5219	10469	11492	9745	

Table 2 Average water quality for the Swan estuary upstream of the Causeway from Spring 1992 to Autumn 1993, by season.

	Season		
Variable	1 Spring	2 Summer	3 Autumn
Salinity (ppt)	8	14	22
Temperature (C°)	21	26	24
% O2 Sat	92	60	60
NH4-N (µg/L)	57	62	53
NO3-N (µg/L)	40	33	30
TN (µg/L)	638	598	625
FRP (µg/L)	13	21	40
TP (µg/L)	33	63	77
Chlorophyll-a (µg/L)	12	12	14
Total phytoplankton cells	13465	5649	6179

(Tables 1& 2 copied from Hosja and Deeley 1994).

The loss of large and longer living bivalve molluscs and polychaete worms would have a serious impact on other aquatic animals in the food chain (Engle *et al* 1994). The invertebrate community is a major source of food to many prawn, crab, fish and waterbird species in the estuary.

2.2 THE PROJECT AREA

Without external intervention, current physical, chemical and biological cycles in the estuary adjacent to the Ascot Fields Estate (Figure 1), will probably remain unchanged for several decades.

Best case scenarios will see a maintenance of existing conditions or even a rapid reduction in salinity stratification and anoxia, following implementation of in-estuarine engineering solutions described earlier.

2.2.1 Physical Water Quality

Salinities will continue to vary from fresh, in winter to marine levels by autumn. Very low years of winter runoff may be followed by a summer with higher salinities. Dissolved oxygen will probably continue to remain low in deeper holes in the river bed adjacent to Ascot Fields unless engineering initiatives described in Section 2.1.2.1, are implemented.

Occasional kills of fish and other benthic organisms may accompany unseasonal summer runoff inputs such as occurred in 1992.

The collapse of a major phytoplankton bloom, high water temperatures and severe anoxia in the river may cause the release of ammonia and hydrogen sulphide from sediments. The presence of these compounds in sufficient concentrations can lead to unpleasant odours. Such a severe anoxic event may serve to reduce the public amenity of the area.

This worst case scenario is unlikely to be anything other than a localized or short term (hours - days) occurrence from between October to February. Residents of canal estates in the Peel-Harvey have complained of unpleasant odours accompanying periods of severe anoxia and major phytoplankton blooms.

2.2.2 Chemical Water Quality

As described in section 1.2.2, the annual passage in October and November of the leading edge of the saline wedge through this stretch of the river has been accompanied by anoxia and high concentrations of ammonium N (NH_4-N) and filterable reactive P (FRP) (Deeley & Hosja 1995).

Unless engineering initiatives described in Section 2.1.2.1, are implemented, waters adjacent to and feeding the Ascot Fields Estate will be continue to have seasonally high concentrations of NH_4-N and filterable reactive P FRP during this period. High concentrations of dissolved nutrients themselves in themselves are of no direct human consequence, but they stimulate phytoplankton blooms which may be potentially harmful (Hosja & Deeley 1994).

2.2.3 Biological Water Quality

Eutrophic conditions in the upper Swan estuary have stimulated recent blooms of diatoms and dinoflagellates. Unless engineering initiatives described in Section 2.1.2.1, are implemented, occasional blooms will probably continue to be observed in the Swan estuary adjacent to the Ascot Fields Estate, and within the waterways of the Estate. Engineering measures may reduce the occurrence of potentially harmful phytoplankton blooms

Phytoplankton blooms in the upper Swan estuary adjacent to the proposed Ascot Fields Estate have been of non-toxic species (Hosja & Deeley 1994, Deeley & Hosja 1995). A probable scenario for the waters of the Estate is occasional blooms of non-toxic chlorophytes, diatoms and dinoflagellates (red tides). Under this scenario, the intensity and frequency of blooms may remain the same, or even become slightly worse. This means that the upper reaches of the Swan estuary at times will continue at times to be turned bright green or rusty brown in colour through the presence of continuing phytoplankton blooms.

The probable scenario for the Estate's waters are occasional annual blooms of non-toxic phytoplankton from October to March.

3. MANAGEMENT OPTIONS

A detailed discussion of broadscale management options for the Swan estuary and its catchment is beyond the scope of this report. This report instead focuses on management options to enhance the environmental and public amenity of the estuary adjacent to and within the proposed development.

3.1 ENHANCING THE RIVERINE ENVIRONMENT

Environmental restoration through bathymetric modifications, mud pumping, sediment treatment with limestone and enhancement of fringing communities are all possible in the vicinity of the proposed development.

3.1.1 Dredging Issues

Removal of thick accumulations of organic-rich ooze from the deeper pool off the Sandringham Hotel and also from the Maylands Pool site would be desirable. As described earlier (Section 1.2.1-1.2.3), from October to December, these deeper pools are the sites of salinity stratification, severe oxygen depletion and blooms of red tide organisms. Removal of thick accumulations of organic material would may to reduce the consumption of dissolved oxygen during periods of salinity stratification accompanying with the passage of the saline wedge.

However, deepening of pools through mud pumping would serve to increase the possibility of stratification and nutrient release from future accumulations of ooze moving in from upstream. This means that hydrodynamic modelling studies to prove the feasibility of these measures would be needed. These investigations would need to be followed by appropriate environmental impact assessment.

A survey is needed of the extent and chemical composition of the organic-rich sediments that have accumulated in deeper holes of the river bed. Environmental regulators would require demonstrated improvements in estuarine health from such actions. Mud pumping in winter may serve to minimize negative impacts of mud pumping in the river. Activities which may cause an increase in the suspended sediment concentrations of the waters of the upper Swan estuary in the warmer months would come under more stringent environmental assessment.

Fine organic sediment added to the water column during summer dredging has the potential to consume oxygen and either bind or release ammonium N and FRP depending on the dissolved oxygen status of the water column.

The waters of the upper Swan have very low net dissolved oxygen status, suggesting that suspending sediments into the water column during dredging in periods with warmer water temperatures would probably cause an increase in anoxia and nutrient concentrations.
Clearly, this would be undesirable because of the adverse impacts on aquatic animals and the potential worsening of potentially harmful phytoplankton blooms.

3.1.2 Bathymetric Modifications

In situations where a saline wedge penetrates into a poorly mixed fresh estuary at the end of winter, deeper pools which trap stagnant waters are undesirable (Sections 1.2.1-1.2.3). A detailed survey of the bathymetry of the river adjacent to and immediately downstream of the proposed Ascot Fields Estate may reveal areas where bathymetric modifications can reduce the entrapment of heavier anoxic waters and enhance exchange with better mixed basins downstream.

Design channels of broad shallow margins along a narrow navigable channel will provide a surface area to volume ratio suitable for optimization of benthic aeration. Gentle slopes grading deeper to the main channel and downstream will enhance the movement and exchange of heavier saline waters.

3.1.3 Sediment Treatments

There are a number of possible sediment treatments to provide short and longer term solutions to anoxic sediments. Capping sediment oozes with crushed limestone and the application of powdered chalk ($CaCO_3$), has been used in Europe and elsewhere (Higgins *et al* 1976, Faugere 1986). The limestone provides a substrate where soluble P may be converted to less soluble forms such as dicalcium phosphate and apatite (Griffin & Jurinak 1973,1974, Freeman & Rowell 1981). Additions of limestone ($CaCO_3$) to organic sediments may enhance the decomposition of organic-matter stimulating the release of nutrients (Haynes 1982). Investigations are required to test the feasibility of additions of limestone or other sediment treatments.

Few technical details are available as to the suitability of local limestone or chalk supplies the required reactivity, particle size distribution, application rates and re-application strategies. Considerable research and extension has been undertaken by the WA Department of Agriculture on the role of agricultural lime and gypsum for reducing soil acidity and increasing dispersion of saline clays.

Expertise is available locally to provide theoretical estimates of desirable limestone application strategies for trailing on deep pools in the estuary.

Careful monitoring of such trials would provide much needed information on the practicality of this method of sediment treatment for cost effective broadscale restoration of degraded estuarine sediments. The longer term success of these forms of treatments will rely on a massive reduction of current erosion of fine silts from the rural and urban catchments.

3.1.4 Fringing Communities

As described in Section 1.1.1.1, shallow wetlands and fringing marshes are important sites for assisting in the maintenance of estuarine water quality. Settling and absorption of organic matter, re-oxygenation and nutrient removal are additional benefits to foreshore erosion control and habitat enhancement offered by healthy fringing marshes.

Gentle slopes across the littoral zone will stimulate establishment of stable marsh complexes and minimize the development of tidal pools which can become mosquito breeding sites. This means that shorelines not intended to have rock or concrete walling should have a gentle slope down to and slightly below low water mark so that fringing communities have the best chance of colonization (Newbury 1995).

3.2 THE PROJECT AREA

Water quality in the upper reaches of the Swan estuary adjacent to and feeding the proposed Ascot Fields Estate is relatively poor, particularly from October to February (Hosja & Deeley 1994, Deeley & Hosja 1995). The location of the waterways of the proposed development allows for design features which may minimize the impact of periods of poor water in the Estate's source waters, and reduce the impact of runoff on the local waterways.

3.2.1 Design Considerations

3.2.1.1 Hydrological buffering and runoff control

It has been found that the first flush of runoff contains a proportionally higher load of pollutants from urban runoff. Capture, detention and treatment of the initial runoff from summer and winter storms, while allowing direct discharge of the following cleaner runoff, will provide the best opportunity for runoff management for the Estate.

Water sensitive design principles will ensure a maximum hydrological buffering of the Ascot Fields catchment with optimum runoff management. Water sensitive urban stormwater management traps and treats the most polluted portion of runoff, allowing direct discharge of less polluted runoff.

Stormwater best management practices (BMPs), including off-line and on-line retention, detention and infiltration through swale drains, linear wetlands along drainage ways will provide the best measure of stormwater management. An appropriate BMP train for management of the Estate's stormwater drainage will see the maximum use of smaller treatment basins and other BMPs distributed throughout the Estate rather than concentrated at the bottom of sub-catchments where the chance of failure is greater.

3.2.1.2 Bathymetric gradients and water exchange

The southwest channel entering the development should be broad and grade gently downstream into the deeper water off the Sandringham Hotel. This will enhance the exchange of heavier saline waters with better mixed basins downstream, and preclude the entrapment of stagnant anoxic waters associated with the leading edge of the wedge.

The waters and channels to the northwest should have as large a surface area to volume ratio as possible. A desirable scenario would be a system of very shallow braided channels connected to a ring channel running northeast, with a single narrow and shallow opening to the main river in the northeast. This would minimize throughflow of sediment laden winter runoff, would enhance re-aeration of waters and sediments within the estate.

A system of shallow braided channels is consistent with the enhancement of valuable marshland ecosystems with associated fish and birdlife within the Estate and will stimulate recreational usage of the area through canoeing, fishing and bird watching.

3.2.1.3 Sediment and soil establishment

Little is known about what are the desirable physical and chemical properties of sediments and soils for re-created estuarine channels and marshlands in order to maintain viable fringing communities. Investigation of healthy estuarine channels and marshlands elsewhere in WA may identify the appropriate sediment characteristics required for rapid colonization of artificial marshlands and fringing channels.

Sediments in the vicinity of the proposed Ascot Fields Estate, where gentle slopes support healthy fringing communities, generally grade from coarser sands underlain by fine silts and clays in littoral areas to silts in the sub-littoral margin and channel. High carbonate content and low organic matter content would be desirable characteristics for soils used to recreate fringing communities.

Avoidance of a high percentage of very fine organic or clay particles in littoral and submerged sediments will enhance the diffusion of oxygen into sediments and will provide a greater physical volume of oxygenated sediment for invertebrate colonization.

3.2.1.4 Benthic communities

Invertebrate colonization of re-created sediments in the Estate is expected to occur relatively rapidly. If organic matter levels in the artificial sediments are too high, bloodworms and nematodes will form the dominant invertebrate populations. With coarser sediments and low levels of organic matter, more complex invertebrate communities may establish.

Recolonizing invertebtate communities may include gastropods, bivalve mussels and large polychaete worms which may eventually colonize, provided reproductively viable adults remain in the adjacent estuarine waters. Addition of fresh sediments containing reproductive adults from less eutrophic estuarine reaches may be required in order to enhance the colonization of invertebrate communities in fringing areas. From undocumented observations in similar estuarine reaches in other southwest estuaries, a small amount of coarse shell grit in the re-established sediment surface may greatly enhance the success of settlement of mollusc spat.

3.2.1.5 Fringing vegetation communities

Native fringing vegetation communities are able to readily colonize disturbed areas along rivers and estuaries provided, i) appropriate soil and sediment conditions are provided, ii) viable propagules or replanting stock is available, iii) there is proper protection from human or animal disturbance, iv) adequate nutrition in the establishment phase and, v) has follow-up weed management and replanting if required (Newbury 1995).

Soils for fringing marshes should be light and friable to enhance penetration of the roots of colonizing marshland plants. Compaction of superficial sediments during earthmoving and final contouring should be minimized. Mud pumped from the adjacent estuary may provide a suitable amendment for re-created marshland soils if applied at low to moderate rates and if thoroughly incorporated through carbonate-rich basement sands.

A heavy reliance on drought tolerant vegetation, minimization of water hungry palms shrubs and lawn areas will reduce future expenditure on irrigation and fertilization. The location of this development adjacent to a fragile and valuable waterway will mean that environmental regulators will require a minimum nutrient contribution to the Swan estuary in runoff from the Estate. Water and fertilizer minimization strategies will assist runoff quality control, and this principle should be encouraged throughout the public and residential areas of the Estate where possible.

If highly productive vegetation such as lawns are to be established, appropriate levels of phosphate retention can be ensured through amendment with oxide-rich loams. Water efficient irrigation design and scheduling and maximization of the use of micro irrigation systems will minimize irrigation requirements for the development.

3.2.2 Management Considerations

Clearly the quality of adjacent of Swan estuarine waters will control water quality within the area of the Ascot Fields Estate. Potential improvements over the ambient estuarine water quality are possible with careful design, construction and management of the created waterways of the Estate.

3.2.2.1 Estuarine health

The upper estuary and its fringe is still highly productive providing considerable recreational benefit to the community (Thurlow *et al* 1986). The productivity of the system will probably remain high although occasional potentially harmful phytoplankton blooms within the Estate's waters will reduce its amenity, particularly from October to February.

3.2.2.2 Sediment manipulations

Organic matter will accumulate in the Estate's sediments over time, unless major reductions occur in current inputs of silt in runoff from the broader catchment. Future requirements to treat or remove sediments from the Estate's waterways having accumulated unacceptable levels of organic matter are unlikely.

The bathymetry of the Estate's waterways should be smooth, shallow, and should grades gently downstream so that dense saline water can move freely in and out of the Estate under normal tidal action. Entrapment of dense saline water in pockets and pools within the Estate's waterways may cause problems described in Section 1.2.1, in the future if organic matter has accumulated in these areas.

After establishment of the artificial waterways movement of sediment and alterations to the fringing areas and channels may occur. Some re-contouring of basin morphology and navigation channels within the Estate may be required over time, but these are not expected to be major because of relatively low current speeds and restricted contact with the river upstream.

3.2.2.3 Artificial mixing

Appropriate design of the Estate's bathymetry should minimize the requirement for artificial mixing of the waterways. Low ambient dissolved oxygen levels in the waters of the adjacent Swan estuary will transfer to the Estate's waters. Maximizing surface area to volume ratios within the Estate through the use of shallow braided channels will provide a greater chance of re-oxygenation of waters within the Estate. These measures would need to minimize the disturbance of fine organic silts discussed in Section 3.1.1.

3.2.2.4 Phytoplankton bloom control

From current evidence, it is highly likely that phytoplankton blooms will occasionally occur in the Estate's waters, unless major reductions in catchment nutrient inputs and estuarine nutrient levels are achieved (Hosja & Deeley 1994, Deeley & Hosja 1995). In the event that unacceptable blooms occur requiring intervention, then experience elsewhere suggests a number of practical strategies. Local government agencies such as the City of Mandurah and the Shire of Murray have had to undertake scum management in some Peel-Harvey canal estates when buoyant blue-green algal scums have accumulated in downwind blind canals. Oil booms and sullage tankers have provided short term relief in these situations. Access to oil booms and skimming equipment may be required to manage algal scum in the future.

3.3 HUMAN HEALTH ISSUES

Potential human impacts arise from contact with potentially harmful phytoplankton blooms and from mosquitoes.

3.3.1 Potentially Harmful Phytoplankton

As discussed above, current non-toxic blooms of phytoplankton in the upper Swan estuary will probably continue for some years. They turn the water bright green or rusty brown from October to March each year. Health authorities currently recommend people with sensitive skins avoid direct contact when noticeable bloom conditions occur. It is possible that red tides or (less likely) even toxic blue-green blooms may occur in the Estate's waters. Appropriate surveillance and public warnings, as currently occurs in the Swan as well as other river systems, would avoid health impacts to river recreationists.

3.3.1.1 Surveillance and avoidance

State and local health authorities currently provide warnings as to when the public should avoid contact with toxic algae. Moves toward privatization of Government services may require future cost recovery of phytoplankton surveillance and public warnings and the Estate's management may need to meet the costs of ongoing phytoplankton surveillance.

4. GLOSSARY

anoxia - absence of dissolved oxygen

bathymetry - Shape of the lake bottom.

bathymetric modifications - reshaping of the river bottom with or without removal of additional material

benthic aeration - supplying air or oxygen to the bottom of the river

bio-geochemical interactions - processes where physical, chemical and biological process interact

biological treatment - microbial decomposition of organic matter

black ooze - slang term for organic-rich sediments. should not imply oozing movement

catchment - a discrete part of the landscape that collects drainag from rainfall

chlorophyll-a - a complex molecule to capture sunlight and convert it into a chemical form

conductivity - potential for movement of electrical current, influenced by dissolved salts

denitrification - microbial conversion of chemical forms of nitrogen to nitrogen gas

detention - basin to provide tempoary storage of runoff, peak flows in, lower flows out

eutrophic - highly nutrient enriched

external intervention - physical or chemical alteration to river such as dredging

hypersalinity - extreme in salinity, above marine salinities

hypoxia - very low levels of dissolved oxygen in water

hydrogen sulphide - rotton egg gas

hydrological buffering - tempoary storage capacity of catchment

infiltration - a basin which provides runoff the opportunity to soak into the soil

invertebrates - animals not having an internal skeleton, including worms, snails, crustaceans

leaching soils - soils that have a limited ability to retain nutrients such as phosphorus

littoral - part of landscape from high water to low water

mesotrophic - moderately nutrient enriched.

nutrient loadings - the flux or mass of nutrients entering a waterbody.

phytoplankton - microscopic plants, usually one or several cells

salinity stratification - conditions where dense salt water underlys lighter fresh water and mixing is absent

saline wedge - conditions where dense salt water moves upstream under lighter fresh water

sanitary landfill - quaint term given to rubbish tips in the past

skewed distribution - a group of data with many low values and a few very high values

suspended soil particles - fine or coarse mineral or organic soil carried in moving water

turbulent mixing - movement of water where turbulent currents cause mixing

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Appendix D

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Ascot Fields Saltmarsh Vegetation and Mosquito Survey

ASCOT FIELDS

SALTMARSH VEGETATION AND MOSQUITO SURVEY

Report to LeProvost, Dames and Moore
Perth, Western Australia

J. Latchford and R. Segal

Marine and Freshwater Research Laboratory

Institute for Environmental Science
(Report No. MAFRA 95/9)
Murdoch University
May 1995

Contents

1.0 INTRODUCTION

This report was commissioned by Le Provost Dames and Moore as part of a larger assessment for a residential development to be called Ascot Waters. Concern was raised by the Department of Environment over the potential impacts of the development on the adjacent System 6 saltmarsh and the problems of mosquito breeding in this area. A field survey was carried out to assess the mosquito breeding potential of the marsh and to map vegetation assemblages. This report discusses the functioning and importance of saltmarshes to the wider environment, the opinion of the authors on the health of this particular area, a review of saltmarsh mosquito problems in the southwest of Western Australia and the problems that are likely to be encountered in this area after development.

2.0 SALTMARSH ECOLOGY

2.1 Definition

Saltmarshes are among the most productive ecosystems in the world. They are distributed worldwide along coastlines in temperate climates. Different plant groups dominate different coastlines, but the ecological structure and function of any saltmarsh is similar around the world (Chapman, 1974; Montague & Wiegert, 1991; Adam, 1993; Mitsch & Gosselink, 1993). Saltmarshes in Western Australia are usually found in estuaries or on sheltered coastlines, and often adjacent to mangroves in the north west (Bridgewater *et al.*, 1981).

Saltmarshes are defined as areas of land, vegetated by herbs, grasses or low shrubs, bordering saline water bodies. They are subjected to periodic flooding as a result of fluctuations in the level of the saline adjacent water body. A saltmarsh can be regarded as a highly modified terrestrial ecosystem, as the organisms essential for the recognition of saltmarsh are vascular plants of terrestrial origin. However, as the marsh occupies area at the interface between land and sea, its environment has some features of both land and sea and its biota has both marine and terrestrial elements (Adam, 1993).

One of the dominant features influencing saltmarshes is the water level fluctuation, which is usually tidal in origin. Tides control soil salinity and the degree of waterlogging; they also carry sediment in and out of marshes. Saltmarshes are highly dynamic environments subject to erosion, accretion and progradation. Other environmental factors which characterise saltmarsh, such as nutrient availability, are responsible for some general features of the nature and distribution of the biota (Adam, 1993).

2.2 Physical Characteristics

Saltmarshes may occur as narrow fringes on steep shorelines, or on more shallow slopes as flat expanses several kilometres wide. They are found near river mouths, in bays, on protected coastal shores and around protected lagoons. Coastal saltmarshes are predominantly intertidal, that is, they are found in areas at least occasionally inundated by high tide, but not flooded during low tide. In the tropics of Australia saltmarshes are partially replaced by mangrove swamps, which function in a similar manner, any saltmarsh which are present adjacent to the mangrove community (Allen & Pye, 1992; Adam, 1993).

The sediments that build saltmarshes originate from upland runoff, marine reworking of coastal shelf sediments, and organic production within the marsh itself. The long-term stability of a saltmarsh is determined by the relative rates of two processes acting on the marsh: sediment increase, or accretion, which causes it to expand outward and grow upward in the intertidal zone; and by loss, or submergence, caused by rising sea level and marsh surface subsidence (Allen & Pye, 1992).

Although physical processes dominate sediment accretion, the effects of plants and animals can also be significant. Algae play an important role in the stabilisation of mudflats, which can then be colonised by flowering plants. These plants then slow water movement, allowing the sediment in the water to accrete in the marsh, where it can be trapped by algal, bacterial and diatom mats (Adam, 1993).

Saltmarshes act as a buffer to the intertidal zone. Erosion of the surface of the saltmarsh and its edges protects the shore behind it from erosion by high-energy estuary and ocean waves. Saltmarsh creeks also allow the dissipation of tidal energy, which would otherwise erode the mudflats and the shoreline behind them (Allen & Pye, 1992).

Tides influence a wide range of physical and chemical processes. These factors, in turn, influence the species that occur in the marsh and their growth. The lower and upper limits of the marsh are generally set by the tidal range. In fact, the marsh is often divided into two zones, the upper (or high) marsh and the lower (or intertidal) marsh. The upper marsh is flooded irregularly and has a minimum of ten days of continuous exposure to the air, whereas the lower marsh is flooded almost daily (Allen & Pye, 1992; Adam, 1993).

A notable feature of saltmarshes, especially low marsh, is the development of pans and tidal creeks. The term pan is used to describe periodic water-filled depressions on the marsh. They range in size from half a metre to several metres in width and often centimetres to a half a metre in depth. Because of their shallow depth and occasional submerged vegetation, pans are extensively used by migratory waterbirds searching for food. Tidal creeks, another feature of saltmarshes, serve as important conduits for material and energy transfer between the marsh and its adjacent body of water (Allen & Pye, 1992).

The development and zonation of vegetation in the saltmarsh are influenced by several chemical factors. Salinity of the overlying water and soil water is a dominant factor for the species present and their growth in the saltmarsh. This is affected by the frequency of tidal inundation; rainfall; soil texture; vegetation; depth of the water table; fresh water inflow; and occurrence of salt deposits. There can be fluctuations in water salinity and water level, and variations in dissolved oxygen and temperature (Montague & Wiegert, 1991; Adam, 1993).

As the elevation of a marsh surface increases, the number of flooding tides decreases. This results in an increase in salinity with an increase in elevation. Though the salinity of the interstitial soil water does not display a constant relationship with elevation. In the lower marsh, with frequent immersion during the year, soil salinity is relatively constant and rarely exceeds that of the flooding water. At higher elevations there is a stronger interaction between flooding and climate, leading to greater variability in soil salinity (Adams, 1993).

Soils of the saltmarsh are frequently waterlogged and anaerobic. After tidal immersion many areas of saltmarsh drain slowly, as a result of local topography and the low hydraulic conductivity of many saltmarsh soils (Adams, 1993).

2.3 Productivity

Woodwell *et al.* (1973) have suggested that although saltmarshes and estuaries make up only 0.35% of the world's surface area, they are estimated to produce some 2% of net world primary production.

Saltmarshes are often cited as exporting nutrients to the estuary, but this view has been challenged and refined in recent years. It is now believed that coastal marshes display a high degree of individuality. They are still able to fix carbon at very high rates, but the fate of this carbon is variable. Systems with large river flows are likely to transport large fractions of their net primary production during the spring runoff; those systems with broad tidal amplitude may export organic matter year round; or marshes experiencing rapid sea-level rise may accumulate plant matter in the sediments; and finally small, semi-enclosed marshes may use the energy of photosynthesis and recycle large portions of their fixed carbon. Thus, the high productivity is either exported as detritus, accumulated as peat, or released in respiration (Zedler, 1992).

In the Swan River system during winter and spring, there is the potential for organic matter and nutrients to be washed into the estuary from the samphire marsh. At other times, there may be an import of organic matter and nutrients from the estuarine waters. Saltmarshes are able to convert nutrients into forms that can be easily absorbed by estuarine plants and animals (Mitsch & Gosselink, 1993).

The availability of nutrients in the saltmarsh soil, particularly nitrogen and phosphorus, is important for the productivity of the saltmarsh ecosystem. Several studies have shown that saltmarsh vegetation can be nitrogen limited (Valiela *et al.*, 1978). Phosphorus, however, accumulates in high concentrations and apparently does not limit growth. Other nutrients which may influence the productivity of the saltmarsh are iron, manganese and sulphur (Mitsch & Gosselink, 1993).

2.4 Ecosystem Structure

The saltmarsh has many biological components. These include vegetation, animal and microbe communities in the marsh itself, and also plankton, invertebrates, and fish in the tidal creeks, pans, and estuaries (Montague & Wiegert, 1991; Mitsch & Gosselink, 1993).

The saltmarsh flora is composed of bacteria, fungi, algae, and flowering plants. In general the diversity of the flora increases with elevation above sea level, which results from differences in the soil, and competition with other plants (Adam, 1993).

Bacteria and fungi are important components of saltmarsh microflora. They are responsible for breaking down plant and animal matter and transforming it into valuable forms of nutrients. Fungi are also found in the soil and on the flowering plants in the higher marsh. Almost three-quarters of the detritus produced in the saltmarsh ecosystem is broken down by bacteria and fungi (Montague & Wiegert, 1991; Adam, 1993).

Algae are found attached to flowering plants, as free-living phytoplankton, and as macroalgae. The algae are important as food sources for aquatic and terrestrial animals. Algal mats, dominated by blue-green algae, diatoms and green algae are also present in the saltmarsh (Montague & Wiegert, 1991; Adam, 1993; Mitsch & Gosselink, 1993; Paling & McComb, 1994).

The flowering plants of the saltmarsh are composed of herbs, grasses, sedges, dwarf-shrubs and trees. They are dominated by halophytic flowering plants. The lower marsh is usually dominated by one species. With increasing elevation, species diversity tends to increase and distinct communities of flowering plants can be found (Chapman, 1974; Montague & Wigert, 1991; Adams, 1993).

Saltmarshes are harsh environments for animals because they have both terrestrial and aquatic characteristics. Salinity can be an added stress and variability of the environment through time is extreme. Very little is known about the saltmarsh fauna, especially that of Western Australia, however, the types of animals present can be described according to the habitat they occupy. The three habitats are the aerial habitat, which is the aboveground portions of the flowering plants; the benthic habitat, which is the marsh surface and lower portions of the plants; and the aquatic habitat, which consists of the marsh pans and creeks (Montague & Wiegert, 1991; Mitch & Gosselink, 1993).

The aerial habitat is dominated by insects, such as grasshoppers, plant hoppers, wasps and beetles, and spiders that live in and on plant leaves. The stems and leaves of saltmarsh plants are also visited by snails. This is the grazing portion of the saltmarsh food web. Large numbers of birds forage on the aerial invertebrate community, including egrets, little grassbirds, white-fronted chats, richard's pipits and Australian magpie-larks. The stems and leaves of saltmarsh plants are also used as nesting material for resident saltmarsh birds, such as the black-winged stilt which build their nests high enough to avoid all but the highest tides (Montague & Wiegert, 1991).

Less than 10% of the plant material of a saltmarsh is grazed by aerial animals. Most plant biomass dies and decays on the marsh surface, and its energy is processed by microbial fungi and bacteria. These organisms are then preyed upon by microscopic animals in the decaying vegetation on the surface layer of the marsh. Most of these benthic organisms are protozoa, nematodes, harpacticoid copepods, annelids, rotifers, and the larval stages of macro-invertebrates (Montague & Wiegert, 1991).

The benthic macrofauna forage on the sediment or filter floodwater. The common macro-invertebrates present in the sediment include polychaetes, gastropod molluscs and crustaceans which become food for a variety of predators, such as the blue manna crab and egret.

Aquatic animals in saltmarshes often overlap in distribution with those in the benthic habitat. Zooplankton in saltmarsh creeks and in the pans are similar in composition and abundance to those of nearby estuaries. These animals may include copepods, ostracods and chaetognaths. These animals are important food for small fish which shelter in the saltmarsh creeks and pans. The macroinvertebrates that inhabit the saltmarsh creeks and pans include fly and mosquito larvae. These larvae in turn are food for fish, wading birds, and ducks. Adult mosquitoes feed from the nectar of plants, and in doing so help to pollinate these plants.

Although the main fish habitat is the creek and associated marsh edge, fish and shellfish venture from tidal creeks into the marsh when it becomes flooded. When the water recedes, small fish may remain in pans in the marsh, where they are often eaten by wading birds or eventually die of exposure (Montague & Wiegert, 1991).

The wading birds often encountered on the saltmarshes in the Swan River include the great and little egret, the white-faced heron, the yellow-billed spoonbill, the common sandpiper, and the red-necked stint. Some of the waders are listed in the Japan-Australia Migratory Birds Agreement. These marshes also support a variety of waterfowl such as the Australian shelduck, pacific black duck, and musk duck (Halse *et al*, 1989; Chester & Klemm, 1990; Ninox, 1990).

Several species of reptile can be found in the Swan River saltmarshes, the most notorious being the common tiger snake which preys on frogs, fish, lizards, small mammals and birds. Introduced species, such as cats and foxes can also be found hunting birds of the marshes.

2.5 Ascot Fields Saltmarsh

The System 6 area adjacent to the Ascot Fields development is in very good condition and every attempt should be made to minimise disturbance (Appendix A). There are some small areas of weed infestations around the margins of the marsh and a small area of marsh has recently been burnt. The burnt area will regenerate with time, but weed control is advisable in this area and other infested parts of the marsh. Vehicle tracks are present in a few locations and this creates breeding areas for mosquitoes. These tracks need to be filled to even the ground out and further vehicle access should be prevented. The saltmarsh consists of a wide variety of species and is a good example of the marshes that were once commonly found along the Swan River shoreline. It is a refuge for birds and probably has a diverse aquatic flora and fauna.

A vegetation map was compiled and the vegetation was divided into eight complexes for ease of display. Class 1 was composed of *Casuarina* sp. and was found adjacent to the mainland, Class 2 consisted of *Halosarcia halocnemoides* which is a common saltmarsh species found on higher areas on the marsh. *Suaeda australis* (Class 3) is a species which exists where there is fresh water influence. Class 4 consists of *Sarcocornia quinqueflora* and *H. halocnemoides,* this is an area which is of intermediate height to Class 2 and Class 5. Class 5 (*S. quinqueflora, S. australis, Juncus* sp.) is termed the low marsh, a few minor species were also found in areas of lower salinity or soil structure. Class 6 was composed of *Juncus* sp. and *Casuarina* sp., with *Casuarina* often at the river edge of the marsh and usually related to areas of higher elevation. *Eucalyptus* sp. and *Casuarina* sp. (Class 7) existed on higher ground adjacent to the proposed development. Class 8, a mixture of *S. quinqueflora, S. australis, Juncus* sp. and *Casuarina* sp., was found on one of the islands.

The main saltmarsh species occurring in the System 6 area are described below:

Sarcocornia quinqueflora

A small green shrub, which turns from green to red during autumn. The decumbent stems and branches are succulent, and reach 50 cm in height (Pen, 1983 ; Marchant *et al.*, 1987). This complex was widely distributed in the saltmarsh.

Suaeda australis

This branching understorey shrub was found to grow up to 30 cm tall. It has slender fleshy leaves which are light green, turning red or purple in autumn. It was found with S. *quinqueflora* and in association with organic debris.

Bolboshoenus caldwellii

An ephemeral introduced species which bears long, grass-like leaves from rhizomes in the winter/spring period, when salinities are low; it senesces as salinities increase over summer and autumn. In this study, small stands were found growing closely interspersed with shoots of *S. quinqueflora* to form a closed sedgeland (Pen, 1983; Marchant *et al.*, 1987).

Halosarcia halocnemoides

The procumbent stems of this perennial species are hard and woody, but the branches contain fleshy segments and the branchlets are succulent, appearing articulate. They form an open heath in the high marsh which reaches high salinities during summer, with lower salinities, close to that of freshwater, during winter (Pen, 1983; Marchant *et al.*, 1987). *Halosarcia halocnemoides* is a small, bushy shrub growing 30 cm tall. It has reddish-green stem segments with many slender branchlets which soon lose their succulent tissue on maturity, and become woody (Pen, 1983; Marchant *et al.*, 1987). This species tended to occur in the drier, most saline regions of the saltmarsh.

Juncus kraussii

This tall rush has cylindrical, pointed stems that are solid with spongy pith. The loose, elongated, clusters were often found as dense bands of closed rushes, although it was also found more sparsely in localised spots on the *S. quinqueflora* complex. It grew up to 1.5 m high and occurred on the drier, elevated parts of the marsh or in brackish areas where the salinities were lower (Bridgewater *et al.*, 1981; Pen, 1983).

Atriplex species

These are decumbent herbs or shrubs with minute, bladder-shaped hairs which give the plants their characteristic grey colour (Morley & Toelken, 1987). *Atriplex hypoleuca* is a sprawling decumbent shrub which was found to grow up to 2 m in diameter (Marchant *et al.*, 1987). It was usually found associated with *J. kraussii* close to the water's edge. *Atriplex prostrata* is an introduced annual herb and was found to spread up to 60 cm long. The stems are slender and angular, with arrow shaped leaves (Marchant *et al.*, 1987; Morley & Toelkin, 1987). This was usually found on drier elevated banks.

Cotula coronopifolia

This small fleshy, annual daisy germinates and grows in winter and flowers in September (Stoner, 1976). The toothed leaves are found loosely sheathing the stem and the solitary flower heads are yellow (Marchant *et al.*, 1987). It was found in the higher damp areas of the marsh and, according to Bridgewater *et al.*, (1981) is influenced by fresh water.

3.0 MOSQUITO EVALUATION

3.1 Mosquito ecology

There are approximately three thousand species of mosquitoes worldwide, all of which belong to the Order Diptera, Family Culicidae. In the southwest of Western Australia, the most commonly encountered mosquito species belong to three genera: *Aedes*, *Anopheles* and *Culex*; another problem species encountered belongs to the genera *Coquillettidia*. Species belonging to the other genera are generally not significant as pests or vectors (Liehne, 1991; Clements, 1992; Russell, 1993).

The majority of mosquitoes have high fecundity, a short generation time, a high dispersal potential and are efficient colonisers. Populations experience large natural mortalities, but are extremely resilient and can quickly recover from such population reductions. Natural mortalities of immature mosquitoes can commonly be 95% or more, yet the numbers of emerging adults may still constitute a problem (Dale *et al.*, 1986).

Mosquitoes impact on humans as a result of the female mosquito's need to take sequential blood meals for the production of successive egg batches. This results in some mosquito species becoming either pests or vectors of disease. The potential of a species to be a pest depends upon the degree of contact between humans and the species in question. This contact is the product of a number of different biological traits: feeding preference; population size; dispersal characteristics; biting behaviour; seasonal prevalence; and reaction to bites by individuals (Liehne, 1991).

In the process of feeding, the female mosquito may pick up an infectious agent in an early blood meal and, after the elapse of any time needed for the development of the pathogen, pass it on in subsequent blood feeds. The vector capability of any species is the product of its innate capacity to support development of the pathogen, the selectivity of the pathogen with respect to vertebrate host range and the degree of contact between the vector and the respective susceptible host.

Vector/host contact is determined by those biological attributes previously mentioned for pest species (Liehne, 1991).

In the southwest of Western Australia the mosquitoes which breed predominantly in coastal wetlands are *Ae. camptorhynchus* and *Ae. vigilax*. Permanent fresh water wetlands support *An. annulipes, Cq. linealis,* and *Cx. annulirostris* and container breeding pest species include *Ae. notoscriptus, Cx. annulirostris, Cx. quinquefasciatus* (Liehne, 1991).

The two main pest species in the System 6 area are *Ae. camptorhynchus* and *Ae. vigilax*. Both species can be pests of major proportions within their distribution. *Aedes camptorhynchus* is present all year round while *Ae. vigilax.* is dominant in the summer months. They are considered to be vectors of Ross River virus and Barmah Forest virus. The viruses are an important cause of morbidity in human communities, affecting local industry and tourism (Ballard & Marshall, 1986; Russell, 1990; Vale *et al.*, 1992).

Ross River virus and Barmah Forest virus are alphaviruses causing a disease known as epidemic polyarthritis, the symptoms of which are fever, polyarthralgia (arthritic symptoms in several joints), rash and lethargy. The arthritic syndrome may persist for several months with Ross River virus, while Barmah Forrest virus produces less severe symptoms. Ross River virus is the most widespread and important of the Australian arboviruses. Epidemic polyarthritis is the only arboviral disease which is seen every year throughout Australia. Outbreaks can be quite large, depending on the climatic influences on vector populations. Although never fatal, the disease is extremely debilitating, resulting in significant economic impact through its effects on the efficiency of the work force (Liehne, 1991; Russell, 1993).

3.2 Ascot Fields Saltmarsh Breeding Potential

The majority of the System 6 saltmarsh will breed mosquitoes during the year. When very high tides, river overflow or high rainfall results in water lying on the marsh for five to ten days mosquitoes will breed. During winter a wider variety of mosquito species will breed in the marsh due to the decrease in salinity of the water. These mosquitoes are usually just a nuisance problem and do not transmit viruses during the cooler months.

During the warmer months, between August and April, the main mosquitoes which will breed in the saltmarsh are *Ae. camptorhynchus, Ae. vigilax.* and some *Culex annulirostris* in the freshwater ponds. The warmer weather allows the mosquito larvae to develop to adults within five days, thus mosquito numbers will be higher during this period. Ross River and Barmah Forrest virus activity also increases with the warmer weather. The combination of these two factors increases the risk of contraction of epidemic polyarthritis by residents. Ross River virus has also been isolated in areas where mammals such as horse and cows are kept. It is believed that these animals could be a good host for the virus. The close proximity of the race track may increase the chance of Ross River virus remaining active within the Belmont area.

The area surrounding the transmitting tower, classified as vegetation complex five, is a vigorous mosquito breeding area, as is the track that runs due north of the landfill site. The Belmont shire monitors these areas weekly between August and April, using liquid Vectobac and granular Abate to treat larval mosquitoes. The area was treated eight times over the last summer. This saltmarsh is recognised as being one of the most vigorous breeding areas on the Swan River.

The problem area was disturbed when the radio mast was constructed and has copper mats radiating out from the mast. The area around the tower was surveyed by the Belmont Shire with a view to make some physical alterations to reduce mosquito breeding. These alterations have not been implemented for two reasons, the first being the presence of the copper mats and the second the possible environmental implications.

A study has been funded by the Health Department of Western Australia to assess the effectiveness and environmental impacts of runnelling, a physical mosquito control method. This study has been conducted by the author and is due to be completed in July 1996. The Mosquito Control Advisory Committee has recommended that no physical control methods be carried out until the completion of this study. It is the opinion of the author that if the outcome of the study proves to be positive, the area around the radio masts could have some form of physical control implemented. The details of the modification would depend on the location of the copper mats.

It is important to note that even if physical controls were implemented, mosquito populations would only be reduced, not eliminated. Adult and larval mosquitoes are important components of the saltmarsh food chain and should not be eliminated. Adult mosquitoes will also fly across the Swan River from the saltmarsh on the shore opposite and downstream of the study area. It is important that the residents of the development are aware of the mosquito problem and know how to take protective measures against them.

4.0 CONCLUSIONS

The System 6 saltmarsh adjacent to the Ascot Fields development has a diversity of plants in a relatively undisturbed state. There is an interesting mixture of saline tolerant to freshwater plants. Healthy *Casuarina* trees are present which provide shelter and numerous small pans exist which add to the diversity and productivity of the marsh. These marshes act as nutrient and energy buffers to the shoreline, they provide refuges for wildlife and provide food for crustaceans and fish. Thus it is important that there is minimal disturbance of this area to ensure the health of the system and the Swan River.

A large mosquito problem exists in the saltmarshes, the worst area being that surrounding the radio mast. Some small physical modifications may be appropriate, but this will have to be assessed in more detail and a submission made to the Mosquito Control Advisory Committee. Physical modification of mosquito breeding areas would reduce numbers, but not eliminate them completely. Mosquitoes from surrounding saltmarshes can travel large distances and may add to the problem. Residents of the development should be made aware of the mosquito problem and be advised on how to protect themselves against infection.

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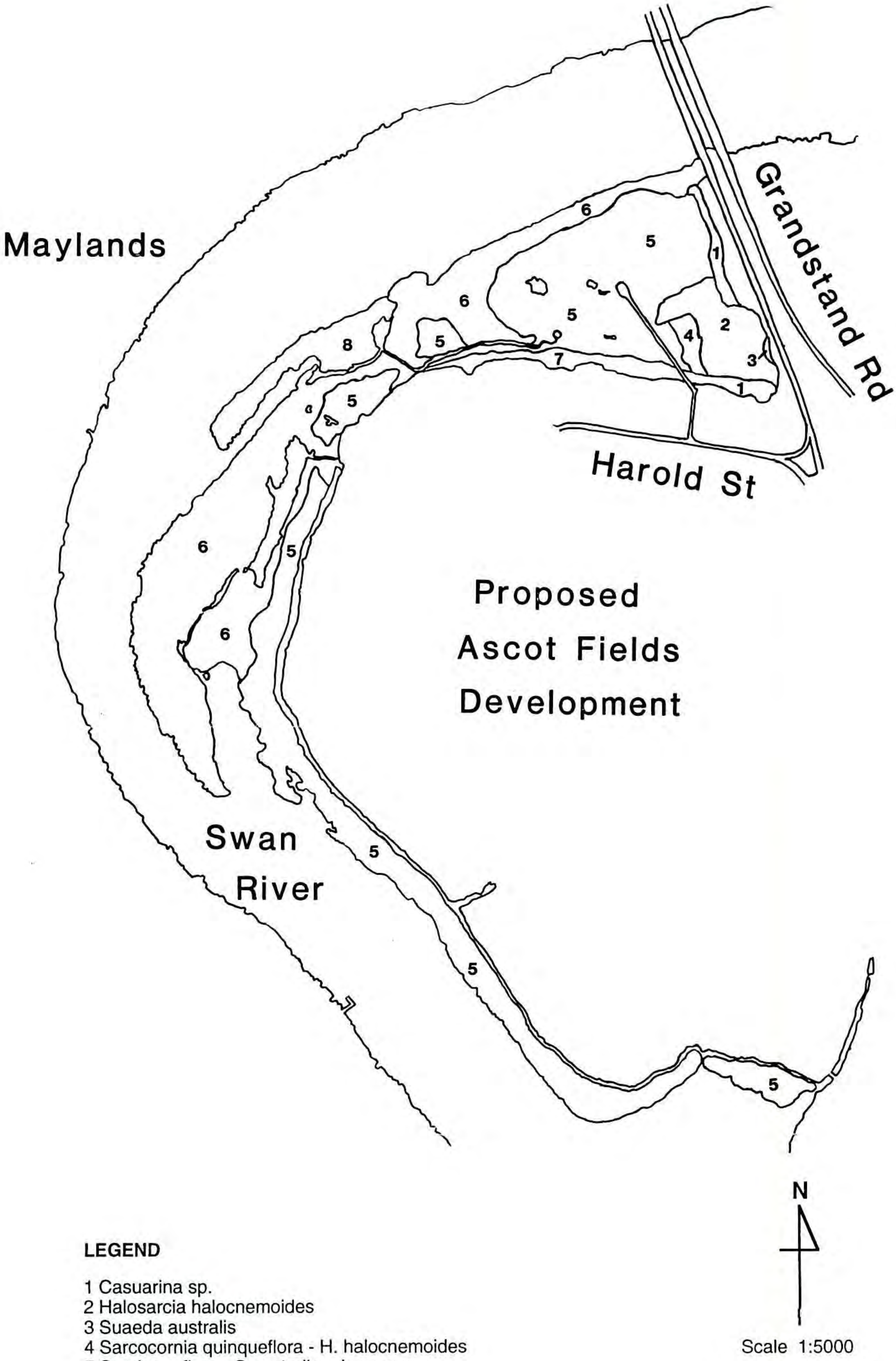
APPENDIX A

SYSTEM SIX VEGETATION MAP



LEGEND

1 Casuarina sp.
2 Halosarcia halocnemoides
3 Suaeda australis
4 Sarcocornia quinqueflora - H. halocnemoides
5 S.quinqueflora - S.australis - Juncus sp.
6 Juncus sp. - Casuarina sp.
7 Eucalyptus sp. - Casuarina sp.
8 S.quinqueflora - S.australis - Juncus sp. - Casuarina sp.

Appendix E

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The fish and macrobenthic faunas in the region of the proposed Ascot Fields development in the upper Swan Estuary

The fish and macrobenthic faunas in the region of the proposed Ascot Waters development in the upper Swan Estuary

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Report to: LeProvost, Dames and Moore

Introduction

Any assessment of the importance of an area in the Swan Estuary to the fish community of that system is dependent on an understanding of the characteristics of the different regions of this estuary and the way in which the major fish species utilise the estuary. Although the characteristics of the different regions of the Swan estuary will affect the distribution patterns of the macrobenthic species (Chalmer *et al.* 1976), these species, at least in their post-larval forms, are far less mobile than fish. Thus, they almost invariably complete their life cycle within the estuary and are often typically found mainly in one or two of the main regions of this system.

The Swan Estuary, which covers a surface area of approximately 53 km^2, comprises a 7.5 km long narrow entrance channel that opens into two large and wide basins, which in turn are fed by the tidal saline areas of the tributary rivers (Loneragan *et al.* 1989). Chalmer *et al.* (1976) have termed these three regions the lower, middle and upper estuary, respectively. The proposed area of development, which is the focus of this report, lies towards the downstream end of the upper estuarine component of the main axis of the Swan River.

Life cycle categories for fish

Detailed studies, carried out over the last 20 years, have provided extensive data on the life cycles of the main species of fish found in the estuaries of south-western Australia. There is also very comprehensive data on the way in which those species are distributed within the different regions of those estuaries, and in particular within the Swan Estuary (Loneragan *et al.* 1989; Loneragan and Potter 1990; Potter *et al.* 1990).

Many of the fish species that are found in the Swan Estuary are what are termed *marine stragglers* (Lenanton and Potter 1987). These species are typically found in marine environments, and typically only occur irregularly and in small numbers in the lower reaches of estuaries. In contrast, the *marine estuarine-opportunists* are marine species which enter estuaries in large numbers and usually in their juvenile stages. It is for this reason that estuaries have often been referred to as fish nursery areas. The estuarine environment is considered to be a particularly suitable environment for these juvenile fish because it is very productive and contains a lower number of large piscivorous predators than is found in the natal marine environment. Examples of fish species that fall into this category are the sea mullet (*Mugil cephalus*), yellow-eye mullet (*Aldrichetta forsteri*), mulloway (*Argyrosomus hololepidotus*) and tailor (*Pomatomus saltatrix*). It is also worth noting that, amongst the crustaceans, the blue manna crab (*Portunus pelagicus*) and the western king prawn (*Penaeus latisulcatus*) are also *marine estuarine-opportunist* species.

The estuaries of south-western Australia are unusual in that, in addition to the above *marine estuarine-opportunist* species, they also contain several species that complete their life cycles within these systems. Some of these species, which are termed *estuarine*, are also often relatively abundant in these estuaries. This life cycle category includes black bream (*Acanthopagrus butcheri*), yellow-tail trumpeter (*Amniataba caudavittatus*) and some small species constituting the families Atherinidae (hardyheads) and Gobiidae (gobies).

One species, the Perth herring (*Nematalosa vlaminghi*), can be regarded as *semi-anadromous*, i.e. it feeds predominantly at sea, but as maturity approaches it migrates through the estuaries to their upper reaches where spawning then takes place (Chubb and Potter 1984). Few freshwater species penetrate down into the estuary.

Fish fauna in the area of the proposed development

Seine netting of the shallows, in the region of the proposed development, at regular intervals over five years, yielded 34 species of teleost, representing 21 families (Table 1). Several of these species, and also the western school and king prawns are of either commercial and/or recreational value (Table 1). The Perth herring, which utilises the upper estuary as a spawning ground, was caught in particularly large numbers (Table 2). The appreciable catches of sea mullet also demonstrate that this species occurs in reasonable numbers in this region. The juveniles of this marine species are known to migrate upstream into the lower salinity waters of other estuarine systems (Thomson, 1957a). Although the catches of Perth herring and sea mullet together constituted approximately 80% of the total catch in the five year sampling period (Table 2), it should be recognised that the mesh in the bunt of this seine net (9.5 mm) would have allowed many very small fish to have escaped. Thus, the contribution to the total catch of between approximately 2 and 10% by the hardyhead *Leptatherina wallacei*, the anchovy *Engraulis australis* and the goby *Pseudogobius olorum* would have been an underestimate of their relative abundance in the environment.

The catches obtained with otter trawls and gill nets showed that the Perth herring is very abundant in deep as well as shallow waters (Table 2). Furthermore, otter trawl catches demonstrated that the yellow-tail trumpeter (*Amniataba caudavittatus*) and gobbleguts (*Apogon rueppellii*) were particularly abundant in deep waters. The commercially important cobbler (*Cnidoglanis macrocephalus*) and recreationally exploited flathead (*Platycephalus endrachtensis*) collectively constituted approximately 10% of the total numbers taken in the trawls in deep waters, while the sea mullet comprised nearly 3% of the catches obtained in gill nets in the same region (Table 2).

Although the black bream (*Acanthopagrus butcheri*) constituted less than 1% of the catch in the shallows, and only 2-3% in deep water (Table 2), these values are an underestimate. This conclusion is based on the fact that current work has shown that this species is very abundant in the upper estuary, but only in particular habitat types, such as those around tree roots and other snags which were not sampled in our previous study. There can now be little doubt that, within the Swan Estuary, the population of black bream is largely located in the upper estuary for much of the year. In this context, it is particularly relevant that spawning, which always occurs between the middle of spring and early summer, is almost entirely restricted to this region of the estuary.

The western school and western king prawns are found in moderate numbers in the downstream end of the upper estuary in summer and early autumn, i.e. in the region of the proposed development.

In terms of number of species, the fish fauna of the shallows of the upper estuary is dominated by *estuarine* species, i.e. 42.4% and *marine estuarine-opportunists* species, i.e. 33.3% (Table 3). However, in terms of number of individuals, the *semi-anadromous* category, represented solely by the Perth herring, constituted approximately three quarters of all fish caught in this region. The *estuarine* category contributed relatively more individuals than *marine estuarine-opportunists*, i.e. 18.5 vs 5.6% (Table 3).

The *marine estuarine-opportunist* and *estuarine* species contributed approximately 50 and 40%, respectively, to the catches taken by both trawl and gill nets in deep water (Table 3). However, in terms of numbers of individuals, the *semi-anadromous* category, again represented solely by the Perth herring, dominated the trawl net catches, i.e. it contributed 86.7%, whereas the *estuarine* category, represented mainly by the yellow-tail trumpeter and gobbleguts, dominated the gill net catches, i.e. they collectively contributed 83.0% (Table 3).

Macrobenthic invertebrate fauna

Macrobenthic invertebrate communities in the Swan Estuary have been less well studied than fish communities. However, data have recently been collected by Papas (1994) for the macrobenthos in the upper estuary, which extends earlier information recorded by Chalmer *et al.* (1976) and Wallace (1977). Each of the species of macrobenthic invertebrate is mainly present in either one or two regions of the estuary (Chalmer *et al.* 1976), e.g. the lower, middle or upper estuary, which results in distinct differences being found between the macrobenthic communities living in different regions. Within these regions, species are often distributed differently according to depth and substrate type. In the context of habitat types, it is relevant that shallow waters less than 1.0 m deep often have a coarser sand substrate and greater numbers of macrophytes than deeper waters (>3.0 m deep), which are characterised by softer and occasionally muddy substrates.

The macrobenthic invertebrate communities in the upper estuary contain 47 species, which mainly comprise species of bivalves (e.g. *Arthritica semen, Xenostrobus securis* and *Fluviolanatus subtorta*), polychaetes (e.g. sabellid sp, *Boccardiella limnicola, Ceratonereis aequisetis, Pseudopolydora* sp. and *Prionospio cirrifera*) and crustaceans (e.g. *Paracorophium excavatum* and *Melita matilda*) (Papas, 1994). Ninety percent of all macrobenthic species found in the upper estuary were recorded in the shallow waters of that region, while only five of the species that were collected in deeper waters were not found in shallow waters. Bivalve molluscs, such as the microbivalve *A. semen*, which lives within the sediments, and the estuarine mussel *X. securis*, which forms dense surface mats in the shallow waters, are mainly found in shallow areas (Table 4). Polychaetes, such as the deposit feeder *P. cirrifera* and the suspension feeder sabellid sp., contribute over 65% to the densities of all individuals in deeper waters. The amphipod crustaceans *P. excavatum* and *M. matilda* are more abundant in the shallow waters (Table 4).

The macrobenthic community of one site (Maylands Pool), which lies very close to the proposed area of development, was examined monthly by Papas (1994) as part of a study on the macrobenthos of the upper Swan Estuary. Of the four sites sampled in this study, Maylands Pool consistently yielded the greatest number of species and the highest density of individuals. The shallows of this site was described by Papas (1994) as having particularly dense mats of the estuarine mussel.

Diets of fish

There is a range of feeding strategies employed by fish living in the upper estuary, e.g. zooplanktivory, detritivory, generalised omnivory/carnivory and piscivory (see Thomson 1957b). The only primarily zooplanktivorous fish in the upper estuary is the Australian anchovy, which consumes small calanoid copepod crustaceans and feeds high in the water column. The small atherinid *L. wallacei* also consume copepods, but its diet is supplemented by bottom-dwelling nereid polychaetes.

All other fish are primarily benthic feeders and consume prey which tends to be more abundant in shallow than deeper waters. The Perth herring and sea mullet ingest predominantly organic detritus, diatoms and sediment. The diets of both the western school and western king prawn are also dominated by organic detritus. Other species, whose diet includes a large organic component, are the goby *P. olorum*, yellow-tail trumpeter and yellow-eye mullet. However, these species also consume a wider variety of benthic invertebrates, such as molluscs, polychaetes and amphipod crustaceans.

The diet of generalist predators, such as black bream and cobbler, ranges from mainly amphipods and nereid polychaetes in younger fish, to an almost exclusively molluscan diet in adult fish. It is worth noting that, in the upper estuary, the large molluscs consumed by these fish are mainly the estuarine mussel *X. securis*. The estuarine mussel is particularly susceptible to localised oxygen depletions following algal and dinoflagellate blooms in the upper Swan Estuary, these causing large mortalities in extreme cases.

The only species to prey largely upon teleosts and large decapods is the bar-tailed flathead. This ambush predator feeds upon species which are mainly found on the shallow banks of the upper estuary.

Conclusions

1. The proposed area of development is part of that region of the estuary which provides the main habitats for the commercially and recreationally important black bream, including those in which it spawns.

2. This area also acts as a crucial part of the route for the migration of the commercial fish species, the Perth herring, from the sea to its spawning areas in the region around Guildford.

3. The area is also utilised extensively by the commercial fish species, the sea mullet, and far less frequently by other commercial or recreational fish species, such as whitebait, cobbler, bar-tailed flathead and tailor.

4. The other fish species found in the proposed development area are mainly small species, such as hardyheads, gobies, the Australian anchovy and gobbleguts.

5. The macrobenthic invertebrates comprise 47 species of bivalves, polychaetes and crustaceans, with the majority of these species living in the shallow waters.

6. The macrobenthic invertebrate community in the shallows of the region of the proposed development is characterised by higher densities and species diversity than other areas of the upper estuary.

7. The diets of many of the fish species in the upper estuary consist mainly of organic detritus. Nereid polychaetes and amphipod crustaceans are of lesser importance. The adult black bream and cobbler consume mainly bivalves, in particular the estuarine mussel *Xenostrobus securis*. The estuarine mussel populations are at high densities near the region of proposed development, and are particularly sensitive to the effects of large algal and dinoflagellate blooms in the Swan Estuary.

Recommendations

The detailed quantitative data used to provide information on the fish fauna in the region of the proposed developments was mostly collected over a decade ago. It is thus recommended that sampling of the development area should be carried out immediately before the start of construction to verify that the composition of the fish and macrobenthic faunas have not changed markedly. Sampling of the area at two different times of the year, after construction has been completed for a year, would also be valuable to demonstrate that the changes have not had any detrimental effect on these faunas. It is also recommended that every attempt is made to provide a sufficiently heterogeneous river bottom, i.e. both soft and hard substrates, in the locality of the development. This will enable colonisation by benthic fauna with differing habitat requirements. On the basis of the proposals put forward in the PER, we are confident that the river fauna will colonise the new water body over an appropriate period of time.

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Table 1. Family, species and common names of fish and crustaceans found in the region of the proposed area of development in the upper Swan Estuary and whether they are fished commercially and/or recreationally.
N.B. * = commercial or recreational species in south-western Australia. ** = commercial or recreational species in the Swan Estuary.

Family Name	Species Name	Common Name	Commercial	Recreational
Fish				
Clupeidae	*Nematalosa vlaminghi*	Perth herring	**	
	Hyperlophus vittatus	Whitebait	*	
Engraulididae	*Engraulis australis*	Anchovy	*	
Galaxiidae	*Galaxias occidentalis*	Western minnow		
Plotosidae	*Cnidoglanis macrocephalus*	Cobbler	**	**
Atherinidae	*Atherinomorus ogilbyi*	Ogilby's hardyhead		
	Atherinosoma elongata	Elongate hardyhead		
	Craterocephalus mugiloides	Hardyhead		
	Leptatherina presbyteroides	Swan River hardyhead		
	Leptatherina wallacei	Wallace's hardyhead		
Hemiramphidae	*Hyporhampus regularis*	River garfish		**
Syngnathidae	*Urocampus carinirostris*	Pipefish		
Platycephalidae	*Platycephalus endrachtensis*	Bar-tailed flathead	**	**
Terapontidae	*Amniataba caudavittatus*	Yellow-tail trumpeter		
	Pelates sexlineatus	Six-lined trumpeter		
Kuhliidae	*Edelia vittata*	Western pygmy perch		
Apogonidae	*Apogon rueppellii*	Gobbleguts		
Sillaginidae	*Sillago burrus*	Trumpeter whiting		
Pomatomidae	*Pomatomus saltatrix*	Tailor	**	**
Carangidae	*Trachurus novaezelandiae*	Yellowtail	**	**
Sciaenidae	*Argyrosomus hololepidotus*	Mulloway	**	**
Gerreidae	*Gerres subfasciatus*	Roach		
Sparidae	*Acanthopagrus butcheri*	Black bream	**	**
	Rhabdosargus sarba	Tarwhine	**	**
Mugilidae	*Aldrichetta forsteri*	Yellow-eye mullet	**	**
	Mugil cephalus	Sea mullet	**	**
Gobiidae	*Afurcagobius suppositus*	Goby		
	Arenigobius bifrenatus	Bridled goby		
	Papillogobius punctatus	Goby		
	Pseudogobius olorum	Swan River goby		
Monacanthidae	*Meuschenia freycineti*	Six-spined leatherjacket	*	**
Tetradontidae	*Torquigener pleurogramma*	Banded toadfish		
Introduced Fish				
Poecilidae	*Gambusia affinis*	Mosquito fish		
Cyprinidae	*Carassius auratus*	Goldfish		
Crustaceans				
Penaeidae	*Penaeus latisulcatus*	Western king prawn		**
	Metapenaeus dalli	Western school prawn		**
Portunidae	*Portunus pelagicus*	Blue manna crab	**	**

Table 2. Percentage contributions to the total number of fish caught by seine netting in shallow waters and by trawl and gill netting in the deep waters in the upper Swan Estuary. Life cycle categories; A, semi-anadromous; E, estuarine; F, freshwater; O, marine estuarine-opportunist.

Species Name	Life cycle category	Shallow	Deep	
		Seine net %	Otter trawl %	Gill net %
Nematalosa vlaminghi	A	75.7	9.1	86.7
Leptatherina wallacei	E	10.0		
Mugil cephalus	O	4.2	<0.1	2.7
Engraulis australis	E	2.1	<0.1	1.1
Pseudogobius olorum	E	1.8	0.8	
Amniataba caudavittatus	E	1.4	35.0	4.6
Apogon rueppellii	E	1.2	39.4	
Acanthopagrus butcheri	E	0.7	2.9	2.1
Craterocephalus mugiloides	E	0.5		
Papillogobius punctatus	E	0.4		
Aldrichetta forsteri	O	0.4	<0.1	0.8
Pomatomus saltatrix	O	0.3		0.6
Atherinomorus ogilbyi	O	0.3		
Pelates sexlineatus	O	0.2	1.0	
Arenigobius bifrenatus	E	0.2	0.1	
Gambusia affinis	F	0.2		
Afurcagobius suppositus	E	0.2		
Hyperlophus vittatus	O	0.1	<0.1	
Gerres subfasciatus	O	0.1	0.4	
Platycephalus endrachtensis	E	<0.1	4.8	0.1
Cnidoglanis macrocephalus	O	<0.1	5.5	0.2
Torquigener pleurogramma	O	<0.1	0.1	
Leptatherina presbyteroides	O	<0.1	<0.1	
Trachurus novaezelandiae	S	<0.1	<0.1	
Atherinosoma elongata	E	<0.1		
Sillago burrus	O	<0.1		
Rhabdosargus sarba	S	<0.1		
Hyporhamphus regularis	E	<0.1		
Galaxias occidentalis	F	<0.1		
Meuschenia freycineti	S	<0.1		
Urocampus carinirostris	E	<0.1		
Carassius auratus	F	<0.1		
Edelia vittata	F	<0.1		
Argyrosomus hololepidotus	O		0.6	1.2
Total number of fish		238 171	1 129	1 197

Table 3. The percentage contributions of each life cycle category to the total number of species and total number of fish caught by seine netting in the shallow waters and by trawl and gill netting in the deep waters of the upper Swan Estuary.

Life cycle category	**Shallow**	**Deep**	
	Seine net %	Trawl net %	Gill net %
Species			
stragglers	9.1	0.0	0.0
opportunists	33.3	50.0	50.0
estuarine	42.4	40.0	43.8
anadromous	3.0	10.0	6.2
freshwater	12.1	0.0	0.0
Total number of species	33	10	16
Individuals			
stragglers	<0.1	0.1	0.0
opportunists	5.6	5.4	7.9
estuarine	18.5	7.8	83.0
anadromous	75.7	86.7	9.1
freshwater	0.2	0.0	0.0
Total number of fish	238 171	1 129	1 197

Table 4. Percentage contribution to the total density (numbers of individuals m^{-2}) of each of the ten most abundant macrobenthic species in the shallow (0.5 - 0.75 m) and deep (>3.0 m) waters of the upper Swan Estuary between September 1993 and February 1994. From Papas (1994).

Category	Species	Shallow %	Deep %
Bivalves	*Arthritica semen*	28.1	3.5
	Xenostrobus securis	13.0	
	Fluviolanatus subtorta	4.5	3.5
	Spisula trigonella		3.1
Polychaetes	sabellid sp.	9.9	20.0
	Boccardiella limnicola	4.1	2.2
	Ceratonereis aequisetis	3.5	0.5
	Pseudopolydora sp.	2.7	6.7
	Prionospio cirrifera		45.5
	Leitoscoloplos normalis		0.4
Crustaceans	*Paracorophium excavatum*	12.0	0.9
	Melita matilda	3.6	
	Munna brevicornis	3.5	
Mean density of all individuals (nos m^{-2})		10533	2575

Appendix F

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Conservation Value for Waterbirds: Ascot Waters

CONSERVATION VALUE FOR WATERBIRDS:

Ascot Waters
(Report No. 2)

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13/06/'95

BACKGROUND

Ascot Waters in the City of Belmont is a site of mostly vacant land adjacent to System Six Area M51 on the Swan River. In the past, the site has been used for the extraction of clay, leaving pits which fill with water and serve as wetlands, and for waste disposal. The waste disposal area is now a low hill immediately alongside the river shoreline. The site is generally degraded with little native vegetation except in M51, but it is known to be of some value for wildlife. In particular, waterbirds use both M51 and the flooded claypits. It has been regularly surveyed by the Royal Australasian Ornithologists Union (RAOU) which refers to it as Grove Farm, and has been studied by Tingay and Assoc. (1993), who refer to it as Ascot Fields.

Ascot Waters is proposed for redevelopment involving housing of moderate to high density and commercial development around a marina. The redevelopment will not directly affect M51 but will see the loss or alteration of the claypits. The Department of Environmental Protection advised that the redevelopment should be designed to minimize potential impacts on M51 through the use of Public Open Space as a buffer between residential areas and the foreshore reserve. The Department recognized that the claypits and uplands are degraded and of only moderate importance for waterbirds according the Storey *et al.* (1993), but did suggest that they "are worthy of conservation within Public Open Space".

We were initially asked to provide a review of existing information on the value of the site for waterbirds and to comment on the likely impact upon waterbirds of an early redevelopment plan. Subsequently, we were asked to comment on a modified version of the redevelopment plan.

Conservation Value of Ascot Waters for Waterbirds Prior to Redevelopment

The physical environment of Ascot Waters is described by Tingay and Assoc. (1993). There are two main features of importance for waterbirds:

i). a series of brackish to highly saline lakes, created by clay extraction (lakes 1, 5 and 6 being deep, fresh and permanent, lake 3 being deep, saline and permanent; and lakes 2 and 4 being shallow, brackish to saline and seasonal);

ii). river flats within System Six Area M51, consisting of mudflats, samphire low shrubland, sedgeland of *Juncus krausii*, Saltwater Sheoak *Casuarina obesa* woodland and river channels between vegetated islands.

The survey conducted by Tingay and Assoc. (1993) took place mainly over the period November 1992 to February 1993 and concentrated on the lakes. Samphire flats at the northern end of M51 were included in the survey but were dry during the survey period. The sedgelands, woodlands and river channels of M51 were outside the scope of the study. Mudflats at the mouth of the Central Belmont Main Drain were inundated throughout the survey period but were reported to support waterbirds when exposed by very low tides.

Thirty species of waterbirds were recorded on the lakes (Table 1). No waterbirds were recorded on the samphire flats of M51 or on the Belmont Drain mudflat. Numbers of species and individuals were highest in spring and early summer but declined in late summer as some of the lakes dried up. The highest single count was of 241 individuals of 19 species (10 December 1992). Lakes 2 and 4 were most important for waterbirds when they contained water and especially as water levels dropped, while lakes 1, 5 and 6 were important as sources of freshwater and as roosting sites for birds feeding on lakes 2 and 4. Lake 3 supported small numbers of only a few species of birds.

The report concluded that M51 was of little importance for waterbirds but cautioned that this result may have been aberrant because of the conditions experienced during the survey period. During preliminary visits by Tingay and Assoc. (1993), Great Egrets, Sacred Ibis and Yellow-billed Spoonbills were observed on the samphire flats of M51 near the radio tower. The lack of surveys in the complex of islands and channels on the western edge of M51 may be unfortunate, as during our site inspection of 13 April 1995, this complex contained 79 waterbirds of 10 species (see Table 1). According to the System Six Report on the area, however, waterbirds make little use of M51 but use habitats on the opposite bank.

The RAOU surveys covered the lakes and all parts of M51 but unfortunately did not record data separately for these areas and did not include counts for individual species. Records consisted only of surveys of presence/absence of species on regular visits over several years. The lakes were considered to be the most important area for waterbirds (T.Delaney, pers. comm.). The higher number of waterbird species recorded by the RAOU (46 species, see Table 1) than by Tingay and Assoc. (1993) reflects the number of surveys and the time over which surveys were carried out. The large number of species recorded breeding by the RAOU also reflects the intensity of surveys conducted.

The RAOU surveys included birds other than waterbirds (Table 2). Thirty-five such species have been recorded. Many of these species are typical for a site from which most natural, upland vegetation has been cleared and replaced with coarse grassland. A few species, however, such as the Inland Thornbill, Striated Pardalote, Rufous Whistler and Fan-tailed Cuckoo, are unusual for a disturbed site within the metropolitan area.

Of the waterbirds recorded at Ascot Waters, the Great Egret, Common Sandpiper, Red-necked Stint, Long-toed Stint, Curlew Sandpiper, *Gallinago* snipe and Caspian Tern are subject to conservation treaties between Japan and Australia and China and Australia. All these species were recorded in small numbers, however.

Data from Tingay and Assoc. (1993) and the RAOU indicate that the lakes are of importance for small numbers of a wide range of waterbird species. The lakes provide a variety of habitats as they vary seasonally and provide a range of salinities, depths and vegetation types. Low salinity levels in some of the lakes for at least part of the year may be especially significant. The importance of M51 for waterbirds is unclear but may be greater than indicated by available data. The mudflat at the mouth of the Belmont Drain is used by waterbirds only on very low tides.

Comments and Criteria for the Conservation of Waterbird Values; Development Plan October 1994

In April 1995, we examined an early development plan, dated October 1994. This plan includes one small freshwater lake (approximately lake 1) and a shallow, riverine channel or anabranch lined with native wetland vegetation. This anabranch enlarges and links lakes 2, 3 and 4 with the river. Lakes 4 and 5 form the embayment for a marina and lake 6 is filled in. The following criteria were identified as being of importance in ensuring that the conservation value for waterbirds of the site would be preserved or enhanced after development:

i). Maintain a freshwater lake with extensive shallows to provide the sorts of habitats presently provided by some of the claypits;

ii). Create wetland habitat rather than lawn areas around the edges of the lake and other waterways;

iii). Create islands and retain or introduce dead trees to act as perches for waterbirds;

iv). Maintain (and make more permanent?) the existing mudflat off the mouth of the Belmont Drain;

v). Ensure protection of M51.

The conversion of part of the lake system into an anabranch of the Swan River will have a profound effect on the salinity, seasonality and vegetation of this area. It could result in a reduction in environmental diversity which would reduce the number of species regularly using the site. Species most likely to be affected are those which favour freshwater, such as the Great Crested Grebe, Australasian Grebe, Eurasian Coot, Blue-billed Duck and Australasian Shoveler. Moreover, species which utilize riverine habitats may also be attracted to the site by the presence of freshwater. The retention of a larger freshwater lake than indicated on the October 1994 plan might therefore preserve the abundance and range of waterbird species on the site.

Habitats around the freshwater lake and the anabranch should be designed on natural wetland habitats of the area that support waterbirds. The freshwater lake should be shallow (the existing lake 1 is several metres deep whereas depths of less than half a metre over much of the area are more desirable). Fringing and emergent vegetation should include rushes and trees such as the Freshwater Paperbark *Melaleuca rhaphiophylla* and the Flooded Gum *Eucalyptus rudis*. The bulrush *Typha* spp. creates valuable habitat quickly although may need to be controlled as it can spread rapidly. It will probably colonize the lake naturally. Other species of rushes can be difficult to propagate but are now readily available from specialist nurseries. Lawn areas should be kept to a minimum although some lawn down to the water's edge is valuable for waterbirds such as Black Swans, Pacific Black Ducks and Australian Wood Ducks. An area of lawn to the water's edge also gives people limited access to the lake. It is desirable that people be able to get to the water to appreciate the environment, but it is good if this access is restricted.

Islands form a refuge for waterbirds where they are free from disturbance by people and dogs and they are inaccessible to feral predators like foxes and cats. Islands should therefore be a feature of the freshwater lake; they are indicated on the anabranch in the October 1994 plan.

Habitats along the anabranch should be an extension of the riverine habitats of M51; particularly sedgeland of *J.krausii* and woodland of Saltwater Sheoak. Trees such as the Flooded Gum and Freshwater Paperbark may grow on the edges of the anabranch where freshwater soaks occur, while the Saltwater Paperbark *Melaleuca cuticularis* should grow in more saline locations. At least some trees should be planted so that they eventually overhang the water, as ducks in particular like to roost on the water's edge underneath trees. The provision of perches (dead trees) might encourage use of the area by cormorants and herons. The anabranch should be shallow (depths of less than 0.2 m will attract herons, egrets, ibis, spoonbills and stilts) and the shoreline formed by fringing vegetation should be complex. The use of the anabranch by unpowered watercraft should be monitored to ensure that birds are not disturbed excessively.

The mudflat or sand-spit off the mouth of the Belmont Drain is reported to be used by waterbirds on the occasions when it is exposed. The entrance to the marina will have to be kept open to allow access for boats but the mudflat should be retained. It might even be valuable to enlarge it with dredge spoil so that it forms a more permanent sand-bar.

The development of the anabranch should have little impact upon M51 except where its western end links with the river. Disturbance at this point should be minimized. Sedges dug up to link the anabranch to the river could be translocated to other parts of the anabranch and could even be used to form islands. Trails and boardwalks within and adjacent to M51 need to be designed so that visitors experience something of the natural river shoreline without disturbing waterbirds. The October 1994 structure plan shows a boardwalk forming a loop around one end of a channel. It might be better to have a single crossing of the channel (the birds using the channel would be less exposed to people) with a loop across the island to the edge of the river. Widened sections of the boardwalk, with simple bench seats, can be used as observation and interpretation points. This has been done by the City of Melville with a boardwalk on Booragoon Swamp. Planting of shrubs and trees alongside walking trails that overlook the river would provide shelter for people and birds.

With the concentration of housing close to M51, consideration needs to be given to controlling access to the conservation area by people and pets. The main area of concern is the samphire flat around the radio tower. One option which would control the movement of people into M51, but would probably have little effect on pets, would be to construct a moat between the samphire and public open space on higher ground. This moat would also provide some waterbird habitat, although projected water levels and the potential of the moat as a mosquito breeding site would need to be investigated. The Dog Act makes it an offence to allow dogs to wander and potential residents should be reminded of this because of the juxtaposition of housing and M51. In the City of Armadale, regulations now apply which prohibit the keeping of cats on properties adjacent to conservation reserves. While this may be perceived as draconian, especially where housing for aged persons is being considered, residents should at least be encouraged to keep cats on their own properties.

Comments on the Modified Development Plan; May 1995, and an Assessment of the Impact of the Development upon Waterbird Usage of the Site

The modified Development Plan, dated May 1995, has adopted many of the design criteria suggested on the basis of our examination of the October 1994 Development Plan (see above). For example, lake 1 will be modified to form a large permanent freshwater lake with extensive shallows, island refuges and fringing vegetation around most of its shoreline. The emphasis of revegetation will be on the creation of natural habitats to encourage waterbirds. Water quality of this lake will be monitored. In addition, riverine habitats of the anabranch will be increased in area over that indicated in the October 1994 plan. The establishment of fringing vegetation in this area will follow guidelines as broadly outlined above. Perches for waterbirds such as cormorants and herons could consist of timber structures in place of or in addition to dead trees. The modified plan also includes a moat between Public Open Space and M51 to control access to the conservation area.

The lack of adequate data on waterbird usage of Ascot Waters before development makes it difficult to assess the likely impact of the development. Counts were made over only a few months by Tingay and Assoc. (1993), and the RAOU data contained only presence/absence informantion without reference to the different wetlands on the site.

The main sources of impact upon waterbirds will be the loss of some freshwater and brackish lakes, the creation of additional riverine habitat and the potential for increased disturbance in the System Six Area M51.

While the area of lakes will be reduced, the habitats of the lakes that existed prior to development were degraded and the large areas of deep water were of little value for waterbirds. The freshwater lake to be created from lake 1 will contain extensive shallows and enhanced habitats and will also be permanent. It should therefore be able to support a higher density of waterbirds than the lakes that existed previously. For this one lake to effectively replace the waterbird conservation value of lakes 1 to 6, it will need to support a maximum of over 200 waterbirds of approximately 20 species on at least some occasions. It will also need to be ecologically similar to the previous lakes.

Of the six lakes which occurred on the site, only three were fresh (all deep) and the remaining three varied from brackish to saline. Two of these brackish lakes,(lakes 2 and 4) were shallow, seasonal and supported a large proportion of the waterbirds recorded on the site. The abundance of waterbirds on lakes 2 and 4 may have been related to their shallowness rather than their salinity, however, as none of the species observed on them is known to be confined to brackish or saline wetlands. Therefore, the shallow, freshwater lake should be able to support the same waterbird species as the shallow, brackish lakes. There may be a need, however, to allow the water level in the freshwater lake to gradually fall over summer so that mudflats are progressively exposed to provide feeding habitat. This may be perceived as unattractive by nearby residents.

The creation of additional riverine habitat along the anabranch will be of benefit to waterbirds; the only questions relate to the importance of this sort of habitat for waterbirds and the extent to which birds that might have used the brackish lakes will use the anabranch. From our site inspection of 13 April 1995, it appeared that channels between sedge and sheoak vegetated islands are used by quite large numbers of waterbirds. The use of the anabranch by birds that previously used shallow, brackish lakes probably depends on the water depth in the anabranch. If depths of less than 0.2 m over a silt or mud bottom can be achieved, then the anabranch should support herons, egrets, ibis, spoonbills and stilts.

The enhancement of the mudflat in the mouth of the Belmont Drain may be of benefit to sandpipers and plovers which are currently poorly represented on the site. These waders have suffered severely from habitat loss on the Swan Estuary and most species are international migrants of special conservation significance.

Disturbance of waterbirds in M51 and elsewhere on the site can be expected to increase as a result of the introduction of housing in Ascot Waters. This disturbance needs to be managed and monitored. Planning can go a long way to managing the increased numbers of people in the area. Paths need to be located so that people are guided away from areas frequently used by birds. Waterbirds become habituated and will tolerate people on pathways but may be disturbed if people move off the pathway. Residents need to be informed of their responsibilities as pet owners. Design features such as islands give waterbirds somewhere to go where people can't disturb them. Ultimately, waterbirds need to be monitored at the site, by a group such as the RAOU, so that problems with disturbance can be identified and acted upon. Monitoring will also determine the difference in numbers and species richness of waterbirds before and after development.

TABLE 1. Waterbirds recorded at Ascot Fields. The data presented from Tingay and Assoc. (1993) are the maximum counts obtained for each species in the period November 1992 to February 1993. The data presented from Bamford are for Lake 1 (L1) and M51 from a single site visit on 13 April 1995. RAOU data (in parenthesis) give the number out of 10 visits made between January 1988 and December 1994 on which each species was recorded ('+' indicates a species present but not counted. 'b' indicates a species recorded breeding by the RAOU). RAOU data are from the RAOU's Database of W.A. Birds. Common names, scientific names and taxonomic order are taken from Blakers *et al.* (1984).

Species		Tingay	Bamford L1	Bamford M51	RAOU
Podicepididae (grebes)					
Great Crested Grebe	*Podiceps cristatus*	1	-	-	-
Hoary-headed Grebe	*Poliocephalus poliocephalus*	-	-	-	(1)
Australasian Grebe	*Tachybaptus novaehollandiae*	26	-	-	(8)b
Pelecanoididae (pelicans)					
Australian Pelican	*Pelecanus conspicillatus*	2	-	-	(7)
Anhingidae (darters)					
Darter	*Anhinga melanogaster*	3	-	2	(7)
Phalacrocoracidae (cormorants)					
Great Cormorant	*Phalacrocorax carbo*	-	-	-	(5)
Pied Cormorant	*Phalacrocorax varius*	-	-	-	(3)
Little Black Cormorant	*Phalacrocorax sulcirostris*	13	-	1	(6)
Little Pied Cormorant	*Phalacrocorax melanoleucos*	-	-	1	(6)
Ardeidae (herons and egrets)					
White-faced Heron	*Ardea novaehollandiae*	33	-	3	(8)
White-necked Heron	*Ardea pacifica*	-	-	-	(1)
Great Egret	*Egretta alba*	1	-	-	(8)
Little Egret	*Egretta garzetta*	-	-	-	(2)
Nankeen Night Heron	*Nycticorax caledonicus*	9	-	-	(4)

Table 1 (cont.)

Species		Tingay	Bamford L1	Bamford M51	RAOU
Plataleidae (ibis and spoonbills)					
Australian White Ibis	*Threskiornis molucca*	3	-	-	(6)
Yellow-billed Spoonbill	*Platalea flavipes*	8	-	-	(6)
Anatidae (ducks, geese and swans)					
Black Swan	*Cygnus atratus*	8	-	-	(8)b
Australian Shelduck	*Tadorna tadornoides*	9	-	-	(7)b
Pacific Black Duck	*Anas superciliosus*	56	-	50	(10)b
Grey Teal	*Anas gibberifrons*	68	-	2	(10)b
Australasian Shoveler	*Anas rhynchotis*	15	-	-	(4)
Pink-eared Duck	*Malacorhynchus membranaceus*	1	-	-	(3)
Hardhead	*Aythya australis*	24	-	-	(4)b
Musk Duck	*Biziura lobata*	1	-	-	-
Blue-billed Duck	*Oxyura australis*	2	-	-	(1)b
Pandionidae (osprey)					
Osprey	*Pandion haliaetus*	-	-	-	(2)
Accipitridae (hawks and eagles)					
Swamp Harrier	*Circus approximans*	-	-	-	(2)
Rallidae (crakes and rails)					
Baillon's Crake	*Porzana pusilla*	-	-	-	(1)
Spotless Crake	*Porzana tabuensis*	-	-	-	(2)
Buff-banded Rail	*Rallus philippensis*	+	-	-	(2)b
Dusky Moorhen	*Gallinula tenebrosa*	22	-	1	(6)b
Purple Swamphen	*Porphyrio porphyrio*	4	-	1	(7)b
Eurasian Coot	*Fulica atra*	42	6	-	(9)b
Charadriidae (lapwings and plovers)					
Red-kneed Dotterel	*Erythrogonys cinctus*	5	-	-	(3)b
Black-fronted Dotterel	*Charadrius melanops*	5	-	-	(5)b
Banded Lapwing	*Vanellus tricolor*	-	-	-	(1)
Recurvirostridae (stilts and avocets)					
Black-winged Stilt	*Himantopus himantopus*	31	-	-	(5)b

Table 1 (cont.)

Species		Tingay	Bamford L1	Bamford M51	RAOU
Scolopacidae (sandpipers)					
Common Sandpiper	*Tringa hypoleucos*	1	-	-	(3)
Red-necked Stint	*Calidris ruficollis*	-	-	-	(1)
Long-toed Stint	*Calidris subminuta*	-	-	-	(1)
Curlew Sandpiper	*Calidris ferruginea*	-	-	-	(1)
snipe	*Gallinago* sp.	-	-	-	(1)
Laridae (gulls and terns)					
Silver Gull	*Larus novaehollandiae*	+	-	15	(7)
Caspian Tern	*Sterna caspia*	-	-	-	(4)
Crested Tern	*Sterna bergii*	-	-	-	(3)
Sylviidae (old world warblers)					
Clamorous Reed-Warbler	*Acrocephalus stentoreus*	+	-	-	(5)
Little Grassbird	*Megalurus gramineus*	+	-	3	(4)

TABLE 2. Birds other than waterbirds recorded at Ascot Waters by the RAOU. Figures (in parenthesis) are the number out of 10 visits made between January 1988 and December 1994 on which each species was recorded. (I) indicates introduced species. 'b' indicates species recorded breeding.

Species		Number of records
Accipitridae (hawks and eagles)		
Black-shouldered Kite	*Elanus axillaris*	(8)b
Brown Goshawk	*Accipiter fasciatus*	(2)b
Little Eagle	*Hieraaetus morphnoides*	(2)
Falconidae (falcons)		
Australian Hobby	*Falco longipennis*	(3)
Nankeen Kestrel	*Falco cenchroides*	(8)
Columbidae (pigeons and doves)		
Feral Pigeon	*Columba livia* (I)	(4)
Spotted Turtle-Dove	*Streptopelia chinensis* (I)	(4)
Laughing Turtle-Dove	*Streptopelia senegalensis* (I)	(7)
Cacatuidae (cockatoos)		
Galah	*Cacatua roseicapilla*	(2)
Platycercidae (broad-tailed parrots)		
Port Lincoln Ringneck	*Barnardius zonarius*	(1)
Cuculidae (cuckoos)		
Pallid Cuckoo	*Cuculus pallidus*	(1)
Fan-tailed Cuckoo	*Cuculus pyrrhophanus*	(1)
Alcedinidae (kingfishers)		
Laughing Kookaburra	*Dacelo novaeguineae* (I)	(3)
Sacred Kingfisher	*Halcyon sancta*	(5)
Meropidae (bee-eaters)		
Rainbow Bee-eater	*Merops ornatus*	(4)
Hirundinidae (swallows)		
Welcome Swallow	*Hirundo neoxena*	(8)
Tree Martin	*Cecropis nigricans*	(9)
Motacillidae (pipits and true wagtails)		
Richard's Pipit	*Anthus novaeseelandiae*	(9)

Table 2 (cont.)

Species		Number of records
Campephagidae (cuckoo-shrikes)		
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	(8)
White-winged Triller	*Lalage sueurii*	(1)
Pachycephalidae (robins and whistlers)		
Rufous Whistler	*Pachycephala rufiventris*	(3)
Monarchidae (flycatchers and fantails)		
Grey Fantail	*Rhipidura fuliginosa*	(1)
Willie Wagtail	*Rhipidura leucophrys*	(9)
Sylviidae (old world warblers)		
Rufous Songlark	*Cinclorhamphus mathewsi*	(1)
Acanthizidae (thornbills and allies)		
Inland Thornbill	*Acanthiza apicalis*	(1)
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	(1)
Meliphagidae (honeyeaters)		
Red Wattlebird	*Anthochaera carunculata*	(5)
Singing Honeyeater	*Lichenostomus virescens*	(9)
Brown Honeyeater	*Lichmera indistincta*	(6)b
Dicaeidae (flower-peckers)		
Mistletoebird	*Dicaeum hirundinaceum*	(3)
Pardalotidae (pardalotes)		
Striated Pardalote	*Pardalotus striatus*	(4)
Zosteropidae (white-eyes)		
Silvereye	*Zosterops lateralis*	(5)
Grallinidae (magpie-larks)		
Magpie-lark	*Grallina cyanoleuca*	(5)
Cracticidae (butcherbirds)		
Australian Magpie	*Gymnorhina tibicen*	(5)
Corvidae (ravens and crows)		
Australian Raven	*Corvus coronoides*	(7)b

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Appendix G

CMPS & F Pty Limited - Environmental Division

Ascot Fields - Groundwater Analysis

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28 February 1995

Ms Fiona Roche
Estates Development Company
325 Churchill Avenue
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ASCOT FIELDS - GROUNDWATER ANALYSIS

Dear Ms Roche

Further to our meeting with Swan River Trust, EPA and others yesterday, the following is a brief report on analysis of groundwater at Ascot Fields.

We believe the matters dealt with reflect those raised at the meeting.

BACKGROUND

During an audit of the Ascot Fields site in December 1993, thirteen (13) out of twenty four (24) groundwater samples indicated the presence of dieldrin in small concentrations, ie in the order of 5 parts per trillion or 5 nanograms per litre.

Concern was expressed that a dieldrin leak may have occurred on the site which could cause difficulty during development.

A further series of bore holes were drilled, both onsite and offsite, during February 1995 and groundwater samples tested for dieldrin. The results confirmed the presence of dieldrin in groundwater beneath the site and in several locations up to 1 km off site, eg Centenary Lake. The offsite concentrations were higher than on the Ascot Fields site - indicating that the contamination is regional and the source is external to the Ascot Fields site.

Given the low concentrations of dieldrin in groundwater across the Ascot Fields site, there is negligible risk of levels in the Swan River exceeding the marine environment limit of 2 nanograms per litre - due to dilution by river flows and tidal movement. In any event, higher concentrations occur in the waters of the Belmont drain which discharges direct to the river.

During construction of the project, it will be necessary to de-water old clay pits on site. The discharge which will occur over a period of several weeks will have a dieldrin concentration of about 4 nanograms per litre. This discharge will be settled before pumping to the Swan River either direct or via the main drain.

River flows are expected to reduce the concentration to well below the limit of 2 nanograms/litre for the river environment. Obviously it will be necessary to monitor the quantity and quality of the discharge to ensure the expected results are in fact being obtained.

COMMENT ON WATER QUALITY

As stated above it is expected that river flows and tidal effects will reduce concentrations from groundwater and short term dewatering discharge to significantly less than the marine environment standard of 2 nanograms/litre.

With regard to the concentration of dieldrin in the groundwater, ie about 8 nanograms/litre, it should be noted that this is significantly less than the current NHMRC-ARC(1987) guidelines for drinking water - which has an upper limit of 1,000 nanograms/litre, and the draft 1994 NHMRC-ARMCANC guideline, which has a level of 300 nanograms/litre.

From the above, the dieldrin concentration poses no threat to future residents of Ascot Fields. Possible requirements to highlight the presence of dieldrin in such low concentrations would therefore appear pointless.

COMMENTS ON GROUNDWATER CONTAMINATION ISSUES

The following notes were prepared by our senior Hydrogeologist - Paul Bolger.

Groundwater investigations around the proposed Ascot Fields development has indicated that low level contamination with dieldrin are present in the groundwater. As a result of these findings investigations of the extent of the dieldrin have been undertaken to establish whether there is likely to be any impact of the dieldrin on the Swan River.

Extent of Investigations
The work completed has included the excavation and soil sampling of test pits to a depth of more than 2m and the installation of 22 groundwater monitoring bores. These bores were installed in two groups and supplement the six bores previously drilled on the site in the low lying areas around the lakes.

Groundwater Levels and Flow Directions
The groundwater level in the area varies from less than 1m in the low-lying areas to nearly 5m in the area south-east of Parry Field.

The groundwater flow appears to be largely controlled by the ground surface elevation. The general pattern of flow based on the groundwater elevation contours suggests that there is a groundwater divide along Resolution Drive with flow from this area to the low-lying areas including the Swan River and the lakes on the site. One bore to the south of Whittakers shows a high groundwater elevation which appears to be local feature.

Groundwater discharge occurs in the low-lying area of the site in the lake systems where there is extensive evaporation, demonstrated by the presence surface salt deposits. South of the site in the vicinity of Parry Field, the groundwater elevations suggest discharge to the Belmont Drain. Groundwater flows to the low-lying areas of the site from the groundwater divide are estimated to be in the order of 60 kL/day.

Groundwater Concentrations
The concentrations of dieldrin recorded in the groundwater range from below the detection limit of 1ng/L to a maximum of 36ng/L.

The highest concentrations are recorded in the area of the east of Resolution Drive where most of the bores have reported concentrations of over 20ng/L. These groundwater concentrations are significant in that the bores are located in the vicinity of the groundwater divide and are likely to represent background concentrations of dieldrin in the groundwater.

Dieldrin is recorded in a number of bores on the Ascot Fields site. In particular, there are three bores (AFH5, MB1 and MB2) in the former filled area of the site near Resolution Drive. All bores sited in the low-lying areas and the adjacent lakes report concentrations below 3ng/L. This suggests a marked reduction of the dieldrin in the groundwater in the vicinity of the discharge area. It is not clear how much the dieldrin has been concentrated by evaporation of the groundwater at the shallow water table. However a number of the bores indicate that there are high salinity groundwater present in the low lying bores.

There are no concentrations of dieldrin reported in the bores above the level of 2ng/L in the western or northern areas of the site near Lakes 1 & 2.

Impact f Dewatering
Dewatering of the lake areas during construction of the inlet/marina will require dewatering to -2.5m AHD.

A preliminary cross sectional groundwater model of the site suggests that by lowering the groundwater to -2.5m there is likely to be a four-fold increase in groundwater flow from the upgradient areas.

The groundwater in the northern area of the site has shown no migration of dieldrin towards the low-lying areas and suggests that there is no major pathway for dieldrin to migrate downgradient - despite the presence of a major sand body extending from near Whittakers towards the low-lying areas. It is therefore considered there is unlikely to be significant of further introduction of dieldrin to the low-lying areas in the northern and western areas of the site during the dewatering operations.

The main areas where contaminated groundwater is likely to be of concern during dewatering is the area to the south and south west of Whittakers where the highest concentrations of dieldrin have been detected. However it should be noted that the concentrations reduce from an average concentration of 8ng/L in the fill area to 3ng/L or less in the downgradient monitoring bores and the lakes.

The extent of the discharge of contaminated groundwater in this vicinity is across a front of approximately 300m, suggesting a current discharge of groundwater containing dieldrin of 30 kL/day. This water is at an average concentration of 2ng/L, with a loading of .06mg/day to the receiving environments.

Dewatering of the marina to a depth of -2.5m would increase the volume of groundwater discharging to the area by approximately four, and is likely to produce inflows from the landfill area. In addition there is likely to be a five fold increase in the upward flow of uncontaminated groundwater from lower levels of the aquifer. Assuming that in the worst case there is a concentration of 8ng/L dieldrin in the water flowing from the site to the discharge area this would suggest that in the order of 0.9 mg/day of dieldrin entering the groundwater at present. However even though there is likely to be an increase in the amount of groundwater migrating from the filled area, there is also likely to be a slight dilution of this flow by the upflow from the lower parts of the aquifer.

It is not possible at this stage to estimate accurately the amount of dilution from uncontaminated parts of the aquifer, however, it is likely to be up to approximately half of the water recovered during dewatering. This would suggested that the concentration of the water during dewatering may only be around 4ng/L.

APPENDICES

Appendix A provides details of the quality assurance procedures used in sampling groundwater.

Appendix B contains laboratory results and sampling location plan.

We trust the above information sums up our discussions with Swan River Trust and EPA.

Yours faithfully
CMPS&F PTY LIMITED

B M ROBBINS
Western Region Manager

LETTERS\FEBLETS.HEJ

APPENDIX A

APPENDIX A

SITE CONTAMINATION ASSESSMENT
QUALITY ASSURANCE PLAN - FEBRUARY 1995

1. INTRODUCTION

This Quality Assurance Plan documents procedures to be followed by employees of CMPS&F Environmental, their subconsultants/subcontractors when involved in field investigations designed to assess the nature and extent of ground contamination at potentially contaminated sites. This Quality Assurance Plan also applies when providing advice to assist clients in the remediation of contaminated sites.

The extent of field investigations will be as defined in the relevant proposal/cost estimate for ground contamination assessments.

All the work performed during this study will be performed under the direction of an experienced field engineer.

All personnel involved in the field investigations will conform with the requirements of a site specific health and safety plan (if one is required). Access to the investigation areas will be restricted to personnel directly involved in the investigation.

Underground site services will be located from the available plans, wherever possible, prior to commencement of the field work and relevant data will be assembled on a single plan for use by the field engineer.

All test pits, hand auger holes and bores will be located by reference to existing ground features, e.g. fences, buildings, etc. with distances being measured by graduated tapes, or pacing.

All depths measured in bores and hand auger holes will be referenced to Australian Height Datum (m AHD).

INSTALLATION OF GROUNDWATER MONITORING BORES

The drilling rig to be used will be in sound working order and free of oil leaks.

A cleaning pad will be established on the site where the drilling rig and other large equipment can be cleaned without risk of contamination to sampling locations. Power and water will need to be located nearby to enable use of a steam-clean unit. A suitable generator will be required where a power supply is not available.

On arrival at the site the drilling rig will be cleaned including all drilling equipment which will go into or be used near the borehole. The drilling rig and all drilling equipment will also be cleaned between boreholes.

Hollow auger equipment will be used to drill each borehole. No petroleum based lubricants are to be used on the drill string or any sampling equipment.

Logs of the soil encountered will be prepared on standard borehole log sheets. The soil will be logged using the Unified Method of Soil Classification and Notes and Abbreviations.

Monitoring bores are to be installed to enable subsequent groundwater monitoring and sampling.

Monitoring bores will consist of slotted PVC pipes. NO solvent cements are to be used for joining the PVC pipe.

Bores will be installed so that the slotted length posses the water table level by approximately 2m and is slotted to 1m above the water table.

The annulus around the bore shall be backfilled with clean sand to a level 0.3 to 0.5m above the slotting. A seal comprising 0.3 to 0.5m of bentonite pellets shall then be placed above the sand. The remainder of the hole shall be backfilled with sand to within about 0.5m of the surface. The top of the hole shall be cement grouted.

Where appropriate monitoring bores shall be covered with covers which are flushed with the ground surface.

3. SAMPLING AND CLEANING

All sampling equipment will be thoroughly cleaned before use and between samples. This includes the spatulas, trowels, scoops etc. any other equipment that is used. All cleaning will be performed on a clean surface, such as a plastic sheet. The cleaning procedure for all sampling equipment will involve:

- wash in tap water removing gross contamination
- wash in DECON solution (or similar phosphate-free laboratory detergent)
- rinse with distilled water

Field blanks will be prepared by running distilled water over the cleaned sampling tools and collecting the water in a clean jar, filling the jar to capacity.

The field engineer is to wear clean vinyl/rubber gloves when handling soil samples and cleaned equipment.

Each water sample is to be placed in a pre-washed or new amber glass bottle with a tight fitting screw top lid. The pre-washing will be performed in the laboratory using the procedure outlined above. Clean aluminium foil may be used to ensure an air tight seal.

Each sample jar is to be labelled with the following information:

- Sample identity
- Date of sampling
- Depth of sample

Chain-of-custody documentation is to be completed onsite. This will include the information listed above and if appropriate, the chemical analyses required for each sample. The field engineer is to sign the appropriate section of the chain-of-custody form before handing over the samples to the laboratory.

All samples are to be stored at approximately 4°C, or below, prior to analysis. This includes transportation and onsite storage.

Groundwater samples will be recovered using a once use disposable bailer. Prior to sampling the monitoring bore will be purged by bailing or otherwise pumping 3 bore volumes or until field parameters have stabilised. Groundwater samples will be transferred from the bailer to the clean sample containers using a bottom emptying device to minimise the loss of volatile species. Depth to groundwater will be determined after bore development but prior to purging and sampling, after allowing sufficient time for the groundwater levels to re-establish. The depth to groundwater will be measured using a clean water level indicator.

All samples are to be transported to the chemical laboratories by the field engineer, or a designated courier who must be documented in the chain-of-custody documentation.

APPENDIX B

ANALYTICAL REFERENCE LABORATORY (W.A.) PTY. LTD.

LABORATORY REPORT

REPORT NO: ARL/1387-93
DATE: 16 February 1995

CLIENT: CMPS & F Pty Ltd
PO Box 6311
EAST PERTH WA 6004

ATTENTION: Mr Nick Croston

SAMPLE DESCRIPTION: Ten samples of water for analysis of organochlorine pesticides.

PROJECT NAME: Ascot Fields

JOB NUMBER: WP 0489

DATE RECEIVED: 14 February 1995

RESULTS :

Lab No	Sample Marks		Dieldrin ug/l
1387	MB1	14.02.95	0.008
1388	MB2	14.02.95	0.015
1389	MB3	14.02.95	0.004
1390	MB4	14.02.95	0.001
1391	MB5	14.02.95	0.002
1392	MB6	14.02.95	0.036
1396	PWD11	14.02.95	0.001
1395	AFH5	14.02.95	0.008
1394	AFH4	14.02.95	0.001
1393	AFH1	14.02.95	0.003

No other common organochlorine pesticides were detected in the ten samples of water.

David Williams
Manager

CMPS & F PERTH

DATE	REC'D	DOC. No.	
17-2-95		8750	
DIST	ACTION	INITIAL	DATE
NJC	A		23-1-95

FILE No. WP0489 ENTERED

ANALYTICAL REFERENCE LABORATORY (W.A.) PTY. LTD.

LABORATORY REPORT

REPORT NO: ARL/1616
DATE: 24 February 1995

CLIENT: CMPS & F Pty Ltd
PO Box 6311
EAST PERTH WA 6004

ATTENTION: Mr Nick Croston

SAMPLE DESCRIPTION: Twenty five samples of water for analysis of organochlorine pesticides and polycyclic aromatic hydrocarbons.

PROJECT NAME: Ascot Fields

JOB NUMBER: WP 0489

DATE RECEIVED: 21 February 1995

RESULTS :

Organochlorine Pesticides :

Lab No	Sample Identification	Dieldrin	Heptachlor Epoxide
		ug/l	ug/l
1616	B1	0.029	0.006
1617	B2	0.022	<0.001
1602	B3	0.002	<0.001
1593	B4	0.002	<0.001
1592	B5	0.002	<0.001
1576	B6	0.002	<0.001
1577	B7	0.001	<0.001
1578	B8	0.003	<0.001
1579	B9	0.003	<0.001
1603	B10	0.010	<0.001
1605	B11	0.014	<0.001
1604	B12	0.004	<0.001
1618	B13	0.028	0.004
1606	B14	<0.001	<0.001
1619	B15	0.007	<0.001
1607	B16	0.007	<0.001

ANALYTICAL REFERENCE LABORATORY (W.A.) PTY. LTD.
A.C.N. 050 159 898
55 Wittenoom Street, East Perth, Western Australia 6004
Telephone: (09) 221 1415. Facsimile: (09) 325 2398
NATA Registration No. 2377

Organochlorine Pesticides Continued :

Lab No	Sample Identification	Dieldrin	Heptachlor Epoxide
		ug/l	ug/l
1584	Lake 1	<0.001	<0.001
1585	Lake 2	<0.001	<0.001
1586	Lake 3	0.003	<0.001
1587	Lake 4	<0.001	<0.001
1588	Centenary Park Lake	0.011	<0.001
1591	Grandstand Lake	<0.001	<0.001
1590	Finishing Post Lake	0.002	<0.001
1608	River	0.006	<0.001
1589	Main Drain	0.014	<0.001

No other common organochlorine pesticides were detected in the twenty five samples of water (ie less than 0.002 ug/l).

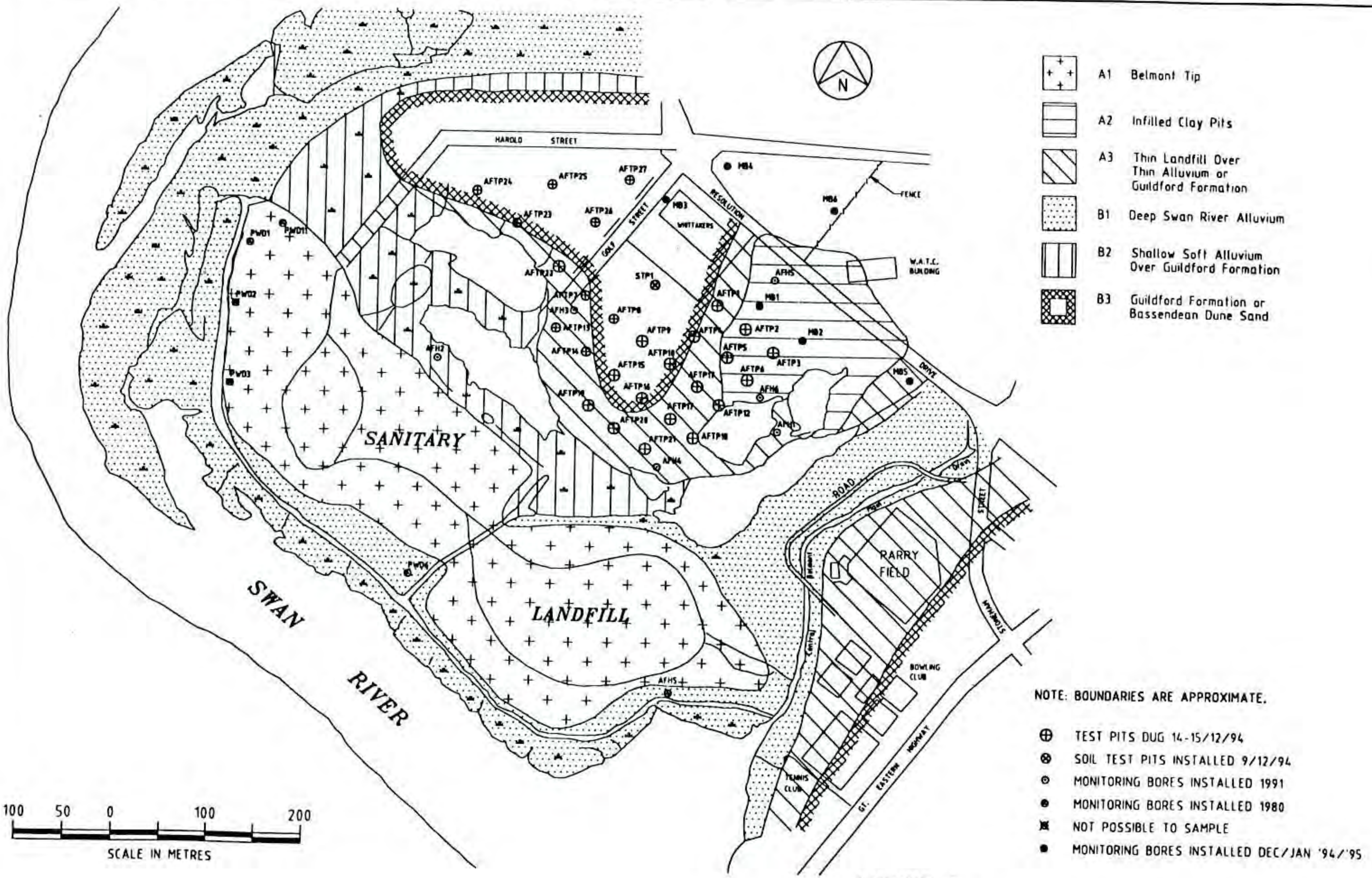

FIGURE 1

SITE LAYOUT AND SAMPLE LOCATIONS AT ASCOT FIELDS

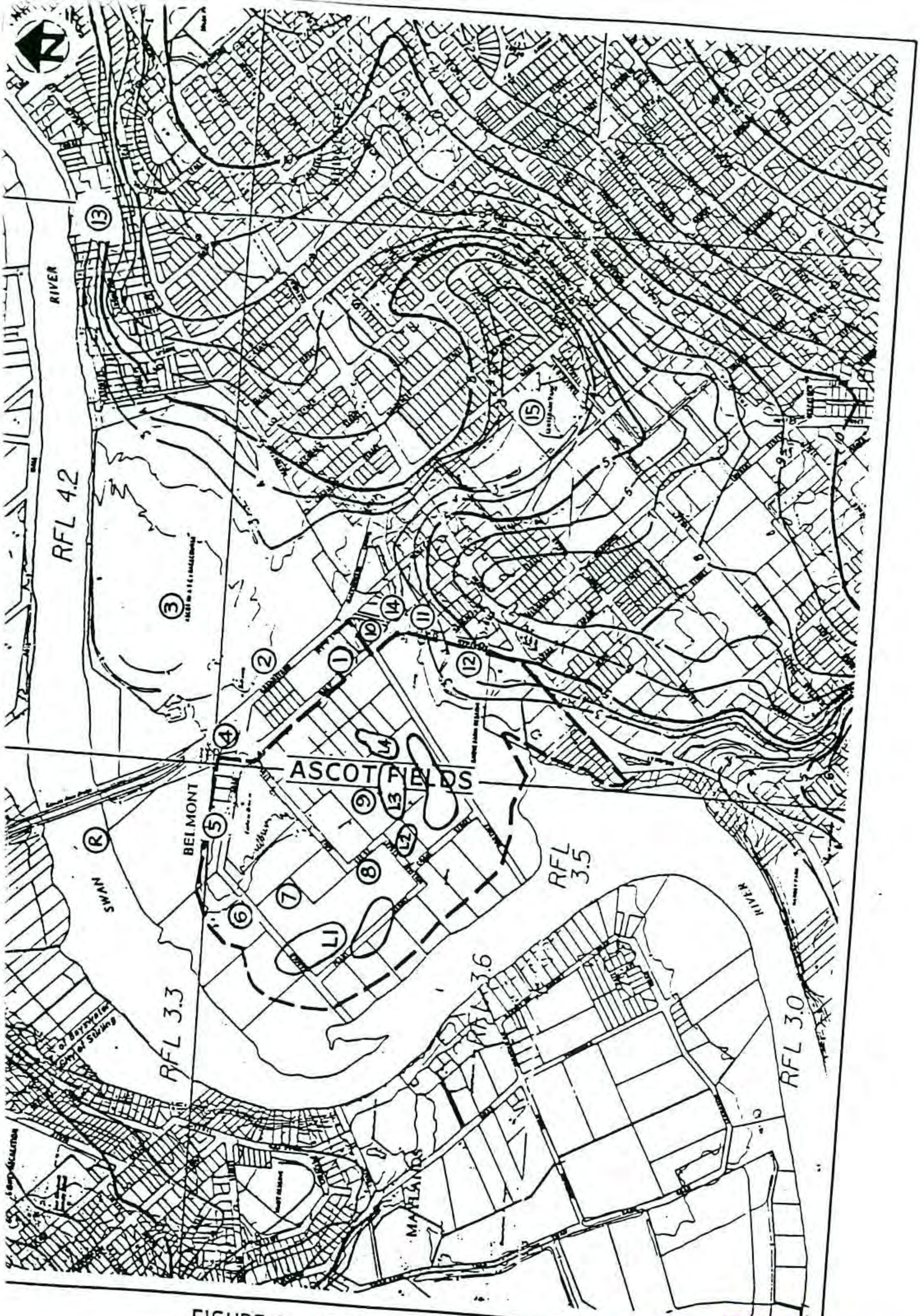

FIGURE 2 ASCOT FIELDS GROUNDWATER SAMPLE LOCATIONS 21-2-95