HOMESWEST

PUBLIC ENVIRONMENTAL REVIEW

PROPOSED URBAN DEVELOPMENT
AMARILLO FARM
KARNUP

PART I

(MAIN DOCUMENT)

PUBLIC ENVIRONMENTAL REVIEW

JUNE, 1996

PROPOSED URBAN DEVELOPMENT OF AMARILLO FARM, KARNUP

INVITATION

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

The Public Environmental Review (PER) proposes the development of an urban residential project at Amarillo Farm, Karnup. In accordance with the Environmental Protection Act, a (PER) has been prepared which describes this proposal and its likely effects on the environment. The PER is available for a public review period of 8 weeks from 22 July, 1996 closing on 16 September, 1996.

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

Why write a submission?

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

All submissions received by the EPA will be acknowledged. Submissions will be treated as public document unless specifically marked confidential, and may be quoted in full or in part of 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 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,
- data; and
- whether you want your submission to be confidential.

The closing date for submissions is: **16 September, 1996**

Submissions should be addressed to:

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

Attention: Mr Ron Van Delft

EXECUTIVE SUMMARY

Homeswest proposes the residential development of Amarillo Farm which is located at Karnup between Rockingham and Mandurah, six kilometres inland from the coast. Homeswest purchased the site for its urban development potential and, in view of its size (3980 hectares), it represents a strategic source of future residential land in the South-West Corridor.

The site either straddles or abuts the Serpentine River, although most of the landholding (about 3,000 hectares) lies on the eastern side of the river. The 1-in-100 year floodway encompasses 735 hectares of the site. Most of the site has been cleared for pastoral purposes, with the notable exception of fringing vegetation along the Serpentine River. The eastern area of the property is characterised by a shallow groundwater table and is predominantly flat, Bassendean sand landform, except in some areas where low sandy rises occur. It is considered to have very limited ecological value primarily as a result of disturbance from previous land uses.

Evaluation of the change in land use from fertilised pasture to urban residential indicates several potential environmental benefits of the development proposal. These include removal of stock, improved drainage management, reduced nutrient export (especially losses of phosphorus), revegetation initiatives, creation of wetlands and allocation of land along the Serpentine River for conservation/recreation purposes.

Consideration of the potential environmental effects associated with this development proposal has identified the following principal issues:

- conservation along the Serpentine River - protection of remnant ecological values, recreation resources and floodway;
- drainage and water quality - protection of the Serpentine River pools and Peel-Harvey Estuarine System from excessive nutrient loadings, particularly phosphorus;
- groundwater management - protection of environmental requirements (eg wetlands) and future resource utilisation potential (eg abstraction for potable supply);
- compatibility of adjacent land uses - potential effects of odour and noise emissions from Wandalup Farms piggery and Murrayfield Airpark.

It is recognised that some aspects of management of the above issues require additional investigation and technical detail and these matters will be addressed in the proposed Environmental Management Programme (EMP).

A summary of the environmental issues, proposed management and predicted outcomes in respect of the urban development project is provided at Table 1 which follows. One of the key components of the proposal is the recognition that drainage management will require allocation of sufficient land to allow implementation of appropriate techniques, particularly in relation to control of phosphorus export in drainage to the river. In response to this requirement, the strategic Structure Plan (refer to Figure 8) provisionally allocates approximately 800 hectares for POS/drainage function, which represents about 25% of the development area.

A summary of the proponent's commitments to meet the nominated environmental protection objectives is provided at the end of Part I of the PER.

This PER seeks endorsement of the environmental objectives and the management framework outlined to meet those objectives.

TABLE 1

SUMMARY OF THE ISSUES AND MANAGEMENT OF THE AMARILLO FARM URBAN DEVELOPMENT PROJECT

Category/Topic	Aspects of Concern	Present Status of Environment	Proposed Action	Proposed Management	Predicted Outcome
BIOPHYSICAL ENVIRONMENT Protection of regionally and locally significant vegetation and flora.	Loss or degradation of remnant vegetation communities and flora species. Protection of conservation values along the Serpentine River.	The 3980ha site has been cleared and developed as a pastoral property. The site straddles the Serpentine River and most remnant vegetation is confined to the river margins; some of which is degraded. Only small pockets of remnant vegetation, in variable condition, occur in other areas of the property.	Earthworks, including placement of fill in residential areas, will necessarily result in removal of isolated remnants of vegetation and flora where it exists. Most vegetation removal will be confined to areas that have been parkland cleared i.e. removal of scattered trees only.	• The areas of remnant native vegetation with regional conservation significance, which occur along the Serpentine River, will be protected and incorporated into the proposed Regional Park. • The river pools and principal remnant vegetation encompass 550ha and the proponent has nominated a Regional Park boundary which encompasses 730ha (i.e. a buffer of 180ha which is predominantly pasture). • Pockets of remnant vegetation elsewhere on the site, which are locally significant (mostly for their landscape values), will be included in Public Open Space. • Most of the site's remnant vegetation with residual conservation and landscape values will be retained and protected during the development process. • Extensive replanting and revegetation of Public Open Space and proposed drainage corridors will enhance the existing remnant ecological values.	No adverse impacts anticipated, due to retention of most remnant vegetation. Any loss of existing remnants will be substantially compensated for by replacement, rehabilitation and enhancement during landscaping of the site.
Fauna habitat.	Impacts on rare, restricted and endangered fauna. Habitat reduction.	No specific fauna surveys conducted for this project. Existing Royal Australasian Ornithologists Union counts indicate high seasonal waterbird usage of Serpentine River.	Urban development will mostly only result in removal of small amounts of degraded natural habitat. Some pasture areas which become 'winter-wet' are utilized by waterbirds as opportunistic feeding areas and these areas will be lost.	• Potential fauna impacts will be managed by protection of habitat. • The most significant fauna habitat occurs along the Serpentine River and will be protected (as above). • Proposed bridge crossings will be managed to ensure continuation of fauna corridors along the river. • Proposed drainage corridors and constructed wetlands will provide additional fauna habitat within the development area.	A net gain in fauna habitat is predicted for the site.
Wetlands.	Direct disturbance to wetlands, particularly EPP Wetlands, and potential adverse indirect effects due to hydrological changes (water quantity and quality).	Four EPP Wetlands occur on site (two are pools on the Serpentine River) and there are some on adjoining land to the south, north and east. Most of the site on the eastern side of the Serpentine River may be classified as 'degraded palusplain' (seasonally waterlogged flats, cleared for pasture).	Only degraded palusplain and degraded damplands will be directly affected by the development.	• All of the on-site EPP Wetlands will be incorporated within the proposed Regional Park. • Within the proposed development areas, all damplands and portions of palusplain with residual natural values will be incorporated within POS and/or the drainage corridors. • Adverse hydrological effects to off-site wetlands will be prevented by control of water table fluctuations within the drainage system. • The proponent will continue to liaise with the Water Corporation to ensure that appropriate action is taken to prevent sedimentation within Amarillo Pool, an EPP Wetland, due to Dirk Brook drain.	Protection of EPP Wetlands will be enhanced by inclusion within the proposed Regional Park. No adverse effects on other important wetlands are anticipated.

Category/Topic	Aspects of Concern	Present Status of Environment	Proposed Action	Proposed Management	Predicted Outcome
BIOPHYSICAL ENVIRONMENT (cont'd)					
Protection of groundater resources.	Effects on water quantity due to alteration of existing water table levels, in important regional aquifers (Superficial and Leederville)	Water table levels in the Superficial Aquifer reflect both natural and artificial influences, however the degree of alteration due to the combined effects at Amarillo is uncertain. For example, current water table levels could be lower than normal (due to rainfall trends), or higher (due to replacement of native vegetation with pasture) or lower (due to the agricultural drains).	A drainage system is proposed to prevent groundwater rise due to urbanisation. On-site groundwater will be used extensively for irrigation of private gardens and Public Open Space.	• The drainage system will be designed such that the invert level of drains will be set at the average annual maximum groundwater level (AAMGL). • This will ensure that the water table will not be lowered by the drainage system. • In addition, potential adverse effects of water table rise due to urbanisation will be avoided.	It is anticipated that urbanisation at the site can be managed to avoid adverse water table effects, in the context of the range of influences on the water table due to historical climate trends and land uses at the site.
Protection of the flow regimes in regional drainage systems.	Floodplain/floodway management along the Serpentine River to prevent upstream flooding. Protection of Dirk Brook drain flowpath through the site.	The 1-in-100 year floodway for the Serpentine River was originally estimated to encompass 920ha of the site. All of the low-lying land to the east of the Serpentine River is artificially drained to the river via a multitude of shallow agricultural drains (average depth approx 0.5m)	Two bridges are proposed across the Serpentine River to provide access to the main development area on the eastern side and a number of crossings will be constructed over the Dirk Brook drain for the internal road network. Some encroachment within the 1-in-100 year floodplain is also proposed.	• The Proponent has previously negotiated with the (then) Water Authority to determine and agree a revised 1-in-100 year floodplain for the Serpentine River. • A revised floodplain, encompassing approximately 735ha, has been set by the Water Authority which incorporates the effects of two bridges and some filling of land within the original floodplain. • The Proponent is prepared to liaise with the Water Corporation and/or Water and Rivers Commission to determine the potential for, and mechanisms of, incorporation and amelioration of Dirk Brook drain within the development.	Floodplain protection is incorporated within the current Structure Plan for Amarillo. No adverse effects due to flooding as a result of the development are anticipated.

Category/Topic	Aspects of Concern	Present Status of Environment	Proposed Action	Proposed Management	Predicted Outcome
POLLUTION PREVENTION					
Existing soil/groundwater "store" of phosphorus.	Potential for the urban drainage system to intersect shallow groundwater and therefore mobilise phosphorus to the Serpentine River.	Land on the eastern side of the Serpentine River, comprising approximately 3000ha, has been used extensively for pasture and consequently has been subject to historical application rates of phosphorus in fertilizer. Approximately 70% of this area may experience winter water table levels at or near the ground surface. Regional groundwater flow is westerly and discharges to the Serpentine River.	The existing agricultural drainage system will be replaced by an urban drainage system. Urbanisation of the site will result in an increase in the peak rate of drainage discharge and an increase in the proportion of rainfall which becomes groundwater recharge.	• As an interim management and land use measure, the proponent has planted 1000ha of trees which will substantially reduce the mobility of phosphorus in groundwater. The trees will also take up a proportion of the existing phosphorus store. • Fill will be applied to residential areas to provide the necessary clearance above the water table for houses. • Sub-soil drains will be installed to prevent groundwater rise as a result of enhanced recharge. The invert level of the drains will be set at the AAMGL as previously defined. • In some sectors of the development, amended soil will be added to the soil profile around the sub-soil drains to provide a fail safe mechanism of phosphorus removal. This mechanism will essentially involve placing the sub-soil drains in a 'blanket' of amended soil, similar to a filter, such that all the water entering the drains must first pass through the amended soil filter which will have strong phosphorus adsorbing properties. • Dewatering of groundwater during the construction phase will be disposed back on the property in the areas of plantation trees. This will avoid transport of phosphorus in dewatered groundwater to the Serpentine River.	Minimal mobilisation and transport of phosphorus from the existing groundwater store is expected due to the management techniques proposed.
Nutrient export, particularly phosphorus, to the Serpentine River and subsequently to the Peel-Harvey Estuary.	Drainage from the coastal plain catchment of the Peel-Harvey estuary is responsible for the majority of nutrient inputs to the system. Substantial reductions in nutrient export are required by the State government's Catchment Management Strategy.	Nutrients from applied fertilizer are presently exported from the site to the Serpentine River via direct processes (as surface runoff when groundwater reaches the surface in low lying areas) and by indirect processes (via shallow groundwater discharge to drains).	As with the existing agricultural drainage system, there will be potential for the export of nutrients, including phosphorus, to the Peel-Harvey Estuary in the proposed urban drainage system. This may be sourced from phosphorus applied in residential areas and also the existing groundwater store of phosphorus.	• POS, including areas of plantation trees retained within the drainage corridors, will be irrigated with water from retention basins to recycle stormwater. • As a fail safe mechanism for phosphorus removal, chemical treatment (using alum or ferric chloride or similar) will be implemented within the drainage system and particularly within the final constructed wetlands prior to discharge to the Serpentine River. Chemical dosing will be conducted to ensure that the export of phosphorus meets the catchment targets. • Trials will be conducted of constructed wetlands to determine their optimum performance for phosphorus removal.	A substantial reduction in phosphorus export to the Serpentine River is anticipated as a result of the proposed change in land use. At least a 60% reduction is anticipated. Phosphorus levels in export water to the Serpentine River will meet the catchment targets, due to implementation of fail safe management techniques.

Category/Topic	Aspects of Concern	Present Status of Environment	Proposed Action	Proposed Management	Predicted Outcome
POLLUTION PREVENTION (cont'd)					
General water quality aspects of stormwater runoff.	A range of potential contaminants may be present in stormwater runoff in urban areas. Given the high groundwater levels over much of the property, most stormwater will need to be discharged to the Serpentine River as the prospects for on-site infiltration are low.	An extensive agricultural drainage system has been constructed on the property. At present this drainage system carries contaminants to the Serpentine River generated from the pastoral use of the property, including losses of nutrients from applied fertilizer, organic or bacterial contamination from stock, and sediment transport due to disturbance of drains by stock access.	Urban stormwater will be directed to the proposed drainage system and hence eventually to the Serpentine River.	• Water sensitive design will be implemented at Amarillo, to meet the following objectives: - To minimise changes to water balance; - To enhance water quality of the future drainage watercourses; - To encourage water conservation; - To maintain and enhance water related environmental, recreational and cultural values. • A 'treatment train' approach will be adopted to achieve nutrient and contaminant control. • Other than the sub-soil drainage system, piped drainage systems will be avoided in favour of retention basins and artificial open channels within the defined drainage corridors. • Landscaping of the drainage corridors and artificial channels will be implemented for water quality management purposes and for aesthetic purposes. • Constructed wetlands and biofilters will be incorporated in the drainage corridors to assist in the removal of contaminants from stormwater. Designs for these facilities will be presented in the EMP and will be trialed in the initial phase of development. • Sufficient buffer areas around the constructed wetlands and the biofilters will be provided in the first phase of development to cater for contingency that these facilities may need to be enlarged once their performance is monitored and reviewed.	Information gathered from the first phase of development will provide extremely valuable information on the design specifications, construction, maintenance and performance of constructed wetland filters under Western Australian conditions. Significant improvements in water quality in comparison to that currently discharged from similar sites in Perth (e.g. parts of Bayswater, Bassendean, Riverton, Shelley, Rossmoyne, Thornlie) is anticipated.
Protection of groundwater quality.	There is a proposal to establish a public water supply area to the east of the development site. Some concern exists regarding the potential for the development to compromise the quality of this groundwater resource.	The groundwater resource area is not in pristine condition as most of the land has been cleared for agricultural purposes. Presumably groundwater treatment will be required. Groundwater flows away from the resource area into the Amarillo site, so the risk of direct contamination is minimal.	Residential development near the eastern boundary of Amarillo may occur within the capture zones of future bores, if these capture zones extend 'downgradient' into the development area.	• Liaison will continue with the Water and Rivers Commission in respect of land use management requirements in the potential capture zones of future borefields.	No significant deterioration of water quality potential is anticipated in the groundwater resource area.

Category/Topic	Aspects of Concern	Present Status of Environment	Proposed Action	Proposed Management	Predicted Outcome
SOCIAL SURROUNDINGS Odour emissions from the Wandalup Piggery.	Potential incompatibility with residential development in respect of odour emission.	The Wandalup Piggery property abuts the southern boundary of Amarillo Farm. The nearest odour source is approximately 1km south of the southern boundary. The pig sheds are located approximately 1.2km south of the southern boundary.	The initial phase of the residential subdivision is proposed for the northern half of Amarillo, which is more than 5km from the odour sources. Rezoning is sought for the entire site.	• A buffer zone will be applied to separate residential development from potential odour nuisance. • Initial size of the buffer zone to be agreed during the rezoning process. • There is an option to investigate a more rigorous buffer zone via the process of dynamic olfactometry and dispersion modelling. • The long timeframe for full development of Amarillo suggests that other options will also emerge, including relocation of the piggery.	No unacceptable impacts on future residents is envisaged due to application of appropriate buffer zones whilst there remains a source of odour emission.
Potential noise emissions from Wandalup Piggery and circuit training at the Murrayfield Aerodrome.	Potential noise disturbance to future residents as a result of aircraft fly-over during circuit training, or from the Wandalup Piggery during feeding times, particularly at night.	The current landing ground is parallel to Lakes Road more than 3km south of the southern boundary. Expansion of the facilities to an Airpark, including a new runway, was recently subject to formal environmental assessment. ANEF contours and diagrams of proposed training circuits for the Airpark were presented in the proponents CER. The northern training circuit for the Airpark involves a segment which is just coincident with the southern boundary of Amarillo.	No specific action is considered necessary for the planning of Amarillo with respect to Murrayfield. The same applied to the noise issue at the piggery (until the odour buffer is revised).	• No specific management response is required at this stage. • It is expected that the Airpark will be developed in compliance with the proposals put forward during the formal assessment process. • Should investigations proceed in respect of defining a smaller odour buffer for the piggery, noise measurements will also be conducted to ensure this factor is taken into account.	No unacceptable impacts are anticipated.
Effects of construction activities and tree harvesting on neighbours.	The potential effects of dust emissions during construction and also disturbance during transport of fill to the property need to be taken into account.	With the exception of the piggery and aerodrome, most of the adjoining land on the eastern side of the Serpentine River has a low population density as the land use is predominantly rural-agricultural. There are Special Rural developments on the western side of the property, in the northwest sector and the southwest sector. These will be mostly separated from the proposed urban development by the Regional Park.	The initial phase of development is not proposed in close proximity to any of the site's boundaries, and therefore no special precautions are considered necessary. No fill will be transported to the site during the initial phase of development, as it will be self-contained.	• Subdivision will be staged over many years, possibly a 30 year timeframe. • Management of construction activities will therefore be to a standard which protects the residents in the initial subdivision from any adverse nuisance effects. • Industry standards will be followed internal to the site which will also protect off-site residents from nuisance effects, given the lower density of residential use on adjoining land.	No significant off-site impacts expected from construction activities.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

TABLES

FIGURES

Rear of Report

PART II : Conceptual Nutrient Management Strategy

Other Documentation (available on request)

- Bowman Bishaw Gorham (1992) - Provisional Regional Park Boundary for Urban Structure Plan - Amarillo Farm
- Trudgen, M.E. (1993) - Vegetation and Flora Conservation Values at Homeswest's Amarillo Property
- McDonald Hales & Associates (1993) - Report of an Aboriginal Heritage Survey for Amarillo Structure Plan

1.0 INTRODUCTION

1.1 Proponent, Development Proposal and Key Environmental Benefit

Homeswest is the proponent for the proposed residential development of Amarillo Farm, a large landholding which straddles and/or abuts the Serpentine River at Karnup, approximately mid-way between Rockingham and Mandurah and about six kilometres inland from the coast. The location of Amarillo relative to Rockingham and Mandurah is shown on Figure 1.

The Amarillo Farm property was acquired by Homeswest during 1992 as an urban development prospect for the medium-to-long term. Market activity since that time has seen increasing pressure being placed upon land supply and the need for further sources if the Government's objectives for residential land at reasonable prices are to be achieved. As a result, an important short term objective is to have the land clearly identified as a future urban area within the South-West Corridor.

The majority of the site, particularly the deep grey sands which characterise land on the eastern side of the Serpentine River, has previously been cleared and utilised for pastoral purposes. On a regional basis, the combination of pastoral use on this soil type is recognised as a major contributor of phosphorus discharges in drainage to the Peel-Harvey Estuarine System (Kinhill Engineers Pty Ltd, 1988). **The proposed change in land use to urban residential, in combination with a range of management practices, is predicted to result in a substantial reduction in the quantities of phosphorus leaving the site and affecting the Estuarine System.** This desirable environmental outcome is demonstrated elsewhere in this document.

1.2 The Statutory Environmental Approvals Process

The *Environmental Protection Act, 1986* (as amended) requires that any development which has the potential to affect the environment must be assessed by the Environmental Protection Authority (EPA). One of four levels of assessment may be assigned to a proposal by the EPA. These are:

- Informal Review with Public Advice

- Consultative Environmental Review (CER)
- Public Environmental Review (PER)
- Environmental Review and Management Program (ERMP)

The EPA may also recommend to the Minister that a Public Enquiry should be held.

This proposal has been assigned a Public Environmental Review. There are two key issues which have contributed to this level of assessment, namely conservation along the Serpentine River and drainage and nutrient management. Amarillo is unusual in that it embraces a nine kilometre section of the Serpentine River, which is part of System Six Recommendation M108 and much of the site experiences groundwater at or near the surface during the latter months of winter which gives rise to high potential for nutrient export to the Peel-Harvey Estuary.

The PER is made available for public review and comment for a period of eight weeks during which submissions may be made regarding the proposal. At the conclusion of the public comment period the EPA will consider the proposal together with any public submissions. Submissions will be treated as public documents unless specifically marked confidential. Homeswest will be asked to comment on any issues which are raised by the public, by way of a summary of issues prepared by the Department of Environmental Protection (DEP) on behalf of the EPA. Where appropriate, the proponent may amend the proposal and/or change the management commitments in response to comments raised during the review period.

When its assessment is completed, the EPA will prepare a report (Bulletin) which will summarise the issues and advise firstly, whether the project is environmentally acceptable and secondly, recommend appropriate conditions. Once published by the Minister for the Environment, anyone can appeal against the recommendations of an EPA assessment report within a two week period of its release.

The project can not proceed without the approval of the Minister for the Environment, who may also advise under what conditions approval is granted. Only the proponent can appeal against Ministerial conditions which, when set, are legally binding for the life of the project.

1.3 Timing and Schedules

(i) Environmental Assessment Process: This PER was released on 22 July, 1996 and will be available for public comment for an eight week period, closing 16 September, 1996. Details on how to make a submission are included at the front of this document. The draft timeline for the balance of the assessment process indicates that, subject to environmental acceptability, Ministerial conditions could be set for the project in about December, 1996.

(ii) Planning Process: There is no over-riding reason why the environmental and planning approval processes can not proceed in tandem during the next several months, with the proviso that no "decision-making authority", including Local Government and the Western Australian Planning Commission, can make a decision which allows implementation of the project until the Minister for the Environment has granted approval.

(iii) Development Timetable: Homeswest has recently reviewed the potential timing of development and believes that Stage One of the Amarillo project could feasibly be implemented in the shorter term, that is, in a three year timeframe. However, it is important to realise that the site is unusually large for a 'single' urban project (approximately 3980 hectares) and will be a staged development over a period of three or more decades.

1.4 Purpose and Structure of the Public Environmental Review (PER)

This PER has been structured in accordance with the general provisions of the *Environmental Impact Assessment Administrative Procedures 1993* and EPA Guidelines for the project (Section 11.0).

This document has the purpose of describing the development proposal, including an outline of Homeswest's proposed environmental design and management strategies which are intended to mitigate any potential adverse environmental impacts. The PER also describes the existing environmental characteristics of the site and surrounding area relevant to assessment, and any anticipated residual environmental impacts. The environmental commitments proposed by the proponent are listed in Table 5 (Section 8.0). Part II of the document provides an overview of water sensitive design and its implementation at Amarillo, and addresses nutrient management in further detail.

Two supporting documents, which are the basis for some of the summarised information in the PER are available upon request either individually or in total, and are identified as follows:

A. Bowman Bishaw Gorham (1992) - Provisional Regional Park Boundary for Urban Structure Plan - Amarillo Farm **(40 pages)**

B. Trudgen, M.E. (1993) - Vegetation and Flora Conservation Values at Homeswest's Amarillo Property **(16 pages)**

Document A was widely distributed in November, 1992 to fourteen agencies and organisations for information and comment. Three written responses were received and to date, no resolution of the Regional Park boundary has been achieved.

1.5 Public Consultation

Preliminary planning and a range of technical investigations have been conducted over the last four years. During that time, consultations have been held with numerous organisations pertaining to one or more aspects associated with the Amarillo proposal. These consultations have involved formal and informal meetings, presentations, telephone communications and exchange of documentation. Organisations consulted in the locality include the following:

- Shire of Murray;
- City of Rockingham;
- Peel Inlet Management Authority;
- South-West Corridor Community Consultative Committee;
- City of Mandurah;
- Community Catchment Centre, Pinjarra;
- Peel Region Planning Advisory Committee;
- Local informal lobby group re freeway extension;
- Peel Development Commission.

2.0 BACKGROUND AND RATIONALE FOR THE PROPOSAL

2.1 Background

Since purchase of the property in early 1992, Homeswest has pursued two avenues of activity in regard to current and future changes to the 'pre-purchase' land use, which was predominantly pastoral:

- establishment of approximately 1000 hectares of plantation forest for eventual harvesting for woodchips, although a primary purpose has been to achieve benefits in respect of phosphorus and groundwater management (a proportion may be retained to form the basis of revegetation initiatives to assist drainage and nutrient management and landscape enhancement in the long-term);
- conduct of hydrological investigations and modelling of stormwater and groundwater dynamics (water quality and quantity) in order to prepare a Nutrient Management Strategy for the proposed urban development.

At the same time as the necessary background technical investigations were being conducted, fundamental structure planning elements were initiated through periodic liaison with the (then) Department of Planning and Urban Development (now Ministry for Planning) and relevant local authorities. Numerous but irregular meetings have also been held with those regulatory agencies responsible for review of technical issues, notably the (then) Water Authority and the Department of Environmental Protection (DEP).

Representatives of planning authorities have previously indicated that they are essentially awaiting confirmation that urban development is feasible at Amarillo in respect of the shallow water table and drainage constraints, prior to initiating more detailed planning and rezoning processes. This sentiment is expressed in the Peel Regional Strategy (September 1994), in which Amarillo is identified with the following task outstanding; "Establish suitability of the site for urban purposes" (p35). Resolution of the technical issues at Amarillo, particularly with regard to drainage and nutrient management, will assist land use planning considerations within the imminent Peel Region Structure Plan.

The elements listed below comprise the principal 'approval process milestones' for the short-term planning of urbanisation at Amarillo.

(i) Confirmation of Environmental Acceptability - Assessment of this Public Environmental Review documentation which evaluates the relevant environmental issues and proposes a management framework for more detailed technical work via an Environmental Management Programme.

(ii) Rezoning and Implementation of AMARILLO SPECIAL DEVELOPMENT ZONE - Amarillo straddles the Metropolitan Region Scheme boundary and is located within both the City of Rockingham and the Shire of Murray, consequently a 'special development zone' is considered to be a practical means of simplifying achievement of a strategic zoning for the site.

From the technical perspective, successful urbanisation at Amarillo will be dependent on satisfactory resolution of the drainage issue. Considerable progress has been made with the technical investigations and Homeswest is confident that the water issues can be overcome to the satisfaction of the review agencies. **The project is expected to result in net environmental benefits (refer Section 2.5).**

2.2 Existing Policies, Guidelines and Strategies

The main regulatory "instruments" which apply to, or have an influence on, the proposal to develop Amarillo for urban purposes are listed below.

- Policy No. DC 6.3 Planning Considerations in the Metropolitan Region for Sources of Public Water Supply and Sensitive Water Resource Areas (as per Water Authority advice).
- Conservation Reserves for Western Australia - The Darling System, System 6 ("Red Book"), 1983.
- The Environmental Conditions for the Peel Inlet-Harvey Estuary Management Strategy - Stage 2 (January 1989 and October 1991).
- Statement of Planning Policy No. 2 The Peel-Harvey Coastal Plain Catchment (February 1992).
- Peel Inlet Management Programme (1992) Waterways Commission Report No 27.

- Environmental Protection (Peel Inlet-Harvey Estuary) Policy 1992 (December).
- Environmental Protection (Swan Coastal Plain Lakes) Policy 1992 (December).
- Peel Regional Park, Proposals for Establishment, Administration and Use (1993).
- Planning & Management Guidelines for Water Sensitive Urban (Residential) Design (June 1994), Consultants Report prepared for DPUD, WAWA & EPA.
- Peel Regional Strategy (September, 1994).

The Amarillo urbanisation proposal acknowledges the requirements and advice contained within these documents and endeavours to conform to the intent and objectives expressed therein.

2.3 Rationale for the Proposal

Homeswest is the State's Public Housing Authority and is active in the development and sale of residential land in order to adequately resource its programs in the public housing arena. The Amarillo site was purchased because of its potential for urban development.

In view of the size of the Amarillo property (approximately 3980 hectares) and its single ownership, planning has focused on the land's strategic importance as a major source of future urban land in the Rockingham to Mandurah region. The site represents a substantial landholding for residential development and, in comparison to many of the fragmented land parcels in the South-West Corridor, offers strategic opportunities to assist in fulfilling the demand for urban land in the region on a relatively large scale and over an extended time period.

2.4 Interim Land Uses

Homeswest has continued to operate parts of the property for pastoral purposes consistent with the land use practice of the previous owner. The property had been in receivership for about three years and its state was such that considerable investment and effort was

required to repair fences, bridges and roads, erect new fences and control weeds and other undesirable regrowth.

In addition, Homeswest has developed parts of the site for forestry purposes as a major interim land use initiative. Approximately 1000 hectares of land on the eastern side of the Serpentine River has been planted with perennial trees; predominantly 'Tasmanian blue-gums' (*Eucalyptus globulus*) with a 5-10% mix of other native species. Figure 2 shows the areas where plantation trees have been established. The majority of the initial plantings will eventually be harvested and sold for woodchips. This land use was recommended in the Peel-Harvey Catchment Management ERMP as a means of reducing phosphorus loadings to the estuary from existing agricultural practices.

Whilst the trees will provide an income when eventually harvested, they are also providing important benefits in the context of staged, concurrent urban development in respect of the water balance and phosphorus dynamics at the site. In addition, useful information will be derived from the plantations regarding the extent of water table control that is achievable via revegetation. Many of the existing trees may be retained for future landscape benefit and to assist with drainage management, supplemented by additional landscape plantings.

2.5 Environmental Benefits of the Project

It is considered that the change in land use proposed for the Amarillo site, in combination with appropriate environmental management initiatives as described in subsequent sections, will result in environmental benefits at the local and regional levels. These benefits include:

- cessation of pastoral use over approximately 3000 hectares of the so-called 'highly leaching deep-grey Bassendean sands', in which regular fertiliser applications result in substantial direct and indirect losses of nutrients (particularly phosphorus) to drainage and hence to the Peel-Harvey Estuary;

- removal of domesticated stock from the property which has three significant benefits, arising from the following:

  - animal excreta is a major source of nutrient and bacterial contamination to the site's drains and the Serpentine River, via direct addition from grazing animals or wash-off and sub-surface percolation from adjoining land, and

- stock access to remnant vegetation, particularly understorey components along the Serpentine River's fringes, results in further degradation of these valuable areas, and

- soil disturbance adjacent to the river and drains during grazing activity which results in erosion and subsequent sedimentation of the river;

- allocation of substantial tracts of land along the Serpentine River to form part of a Regional Park and therefore exclude this area from development in order to protect the high conservation and recreation values of the remnant riverine ecosystem;

- replacement of annual pastures in specific areas by revegetation with perennial trees (in the interim, 1000 hectares and finally, up to 300 hectares of drainage/landscape plantings) to assist water balance control and hence reduce nutrient transport and losses from the site;

- construction of artificial wetlands which, amongst other things, will provide the following important functions:

  - detention of drainage water generated within the development which will assist in the removal of pollutants from this water via physical and biological processes, prior to its discharge to the Serpentine River, and

  - enhancement of habitat values for transient fauna, including creation of open water areas for waterfowl during the summer months;

- implementation of trials of state-of-the-art phosphorus management techniques in the early phase of development, which will have regional application to other potential urban development areas within the Peel-Harvey catchment that have drainage and nutrient constraints;

- initiation of action to reduce the extremely high sediment loads (sand transport) within the Dirk Brook Drain, which is part of the Water Corporation's regional drainage system and currently crosses the northern sector of Homeswest's site, discharging to Amarillo pool on the Serpentine River and causing severe sedimentation problems.

All development has an impact and, even though the abovementioned benefits are significant and substantial, the proposed land use of urban development will still affect the environment. It is the role of this document and the assessment, management and audit processes, to demonstrate and ensure that firstly, the identifiable impacts are within acceptable limits and secondly, the risk to the environment is sufficiently low to be confident that unforeseen, adverse problems will not arise.

3.0 DESCRIPTION OF RECEIVING ENVIRONMENT AND IDENTIFICATION OF ENVIRONMENTAL ISSUES

As suggested within the EPA's guidelines for the PER (Section 11.0), only those aspects of the receiving environment relevant to assessment of the potential impacts of the proposal are described herein. Key environmental issues which arise in respect of particular elements of the environment are also identified where relevant.

3.1 Regional Context

As with most other areas of the coastal plain south of Perth, the Amarillo property has been extensively cleared for agricultural purposes (notably pasture) and a network of shallow drains has been installed to drain excess water from the site. The discharge of this water is not the primary issue, rather it is the phosphorus content of the water that is the main concern. An overview of broader environmental aspects related to phosphorus and drainage is provided below for perspective.

3.1.1 Peel-Harvey Estuarine System

All drainage from Amarillo Farm enters the Serpentine River, which eventually discharges to the Peel Inlet via Goegrup Lakes (refer Figure 1).

The Peel-Harvey Estuarine System is suffering from severe eutrophication (nutrient enrichment) and the consequent excessive algal growth greatly reduces its recreational, environmental and socio-economic values. The cause of the eutrophication is the inflow of nutrients (mainly phosphorus and nitrogen) from the coastal plain catchment and a primary source of the nutrients is agricultural runoff from the sandy soils within the catchment, which have been extensively cleared and drained.

A comprehensive strategy to reduce the causes and alleviate the symptoms of eutrophication has been implemented by the State Government. The two principal elements of this strategy are catchment management, to reduce nutrient inflows, and construction of the Dawesville Channel, to improve the flushing of the estuary to the ocean. The former has been in operation for several years whilst the latter was only constructed recently and opened to the ocean in the summer of 1995.

The proposed development of Amarillo therefore needs to be assessed in the context of the regional nutrient management objectives for land uses on the coastal plain catchment. The catchment management strategy imposes constraints on existing and proposed developments with the overall objective of reducing the flow of nutrients into the estuary to about half the levels experienced prior to the management strategy being formalised (ie, prior to about 1988).

3.1.2 Rainfall Trends and Drainage

Rainfall has an important influence on many aspects of the environment and is a particularly important parameter when evaluating the flow of nutrients from the coastal plain catchment to the Peel-Harvey Estuary. Factors such as rainfall intensity, duration and frequency can be highly variable, both within seasons and between seasons, and will influence the total drainage from the catchment (where drainage is defined as stormwater runoff and groundwater discharge to drains). In simplistic terms, rainfall, drainage and phosphorus transport are strongly linked; whereby higher rainfall will lead to an increase in drainage and hence phosphorus export to the estuary.

The effect of longer term trends in rainfall on drainage is also a relevant factor. For example, in a year of average annual rainfall, the volume of drainage from a particular area of the catchment would be, in part, dependent upon the amount of rainfall in previous years. This phenomenon mainly relates to the depth of the water table below ground surface; a very shallow water table, which may occur after a number of 'above average' rainfall years, would tend to yield more of the groundwater component of drainage than a deeper water table. If an average rainfall year was preceded by a number of 'drier than average' years, then drainage from the area would be expected to be less than the situation if the same year was preceded by a number of 'wetter than average' years.

Based on long-term rainfall records for Perth, the coastal plain catchment of the Peel-Harvey Estuary which includes Amarillo, is in an extended period of below average rainfall (refer to Figure 3). A return to an extended period of average rainfall years, or above average years, would necessarily mean higher seasonal water tables and more drainage.

3.1.3 Catchment Clearing and Drainage

Clearing of native vegetation over vast areas of the coastal plain catchment, and replacement with annual pastures, has altered the regional water balance significantly, resulting in higher-than-natural groundwater levels and larger drainage requirements. For example, data described in the Peel-Harvey ERMP (Kinhill Engineers Pty Ltd, 1988) indicates that annual drainage volume from uncleared land is 100,000m^3/km^2, and that this figure can almost double when the land is cleared.

This effect is simply because perennial vegetation has a greater evapotranspiration than annual pastures, viz:

- tree and shrub canopies intercept and directly evaporate a greater proportion of rainfall than pasture;

- permanent deep-rooted vegetation can more efficiently transpire soil moisture (and groundwater), and for longer periods of the year, than shallow-rooted pasture which dies off over summer.

Additional data from research on the Gnangara Mound, quoted in the Peel-Harvey ERMP (op. cit.), indicates that the approximate levels of evapotranspiration of native woodland and non-irrigated agriculture (eg annual pastures) are equivalent to 80% of rainfall and 65% of rainfall, respectively.

It is these differences in hydrological effects which result in higher groundwater levels when land is cleared and planted with pasture, in comparison to the original native vegetation. This has necessitated a greater drainage density (defined as the total length of drains per unit area) in agricultural areas than would otherwise have been the case.

At Amarillo, it is not possible to define the amount of water table rise that has occurred due to clearing because no data is available for the period prior to agricultural development. It is also not possible to define whether or not the existing network of agricultural drains has fully counteracted the induced water table rise. However, there is indirect evidence that the current seasonal water table fluctuations may still occur at levels higher than the natural (ie, pre-clearing) situation. This indirect evidence arises from the distribution of *Juncus kraussii* regrowth, which is a dampland sedge that would grow extensively over the

Amarillo site if it was left uncontrolled. Management of the site for pasture production requires routine removal of *Juncus* regrowth and colonisation.

When the site was left idle for a period prior to Homeswest's purchase, extensive areas of *Juncus* had developed. However, in the opinion of an experienced botanist (Trudgen, 1993), the wide distribution of *Juncus* is more likely an artefact of higher water tables (creating conditions more favourable to the plant) rather than a true indication of the original extent of the species prior to clearing.

3.2 Physical Environment

The most pertinent aspects of the physical environment are the groundwater regime, drainage patterns and quality, the size of the floodway associated with the Serpentine River and the landform/soils. These aspects are discussed below.

3.2.1 Groundwater Regime

The characteristics of the shallow groundwater regime (superficial aquifer) which are important for this development proposal may be summarised as follows:

- a large proportion of the eastern side of the property may experience maximum winter water table levels at or near the ground surface and estimates based on the preliminary mapping at Figure 4 indicate that about 745 hectares (26%) of the potentially developable land in this area has reasonable groundwater clearance;
- the superficial aquifer is deep (generally in excess of 50 metres) but some intermittent and localised perching of groundwater may occur due to the presence of shallow iron-organic hardpan (coffee rock) which can be highly variable in depth, thickness and hardness over short distances;
- regional groundwater flow is westerly to west-north-westerly and discharges to the Serpentine River;
- the total phosphorus (TP) content of the groundwater is high with bore samples averaging 1.00 mg-TP/L in early summer (November 1992) and 0.74 mg-TP/L in late summer (April 1993), although these concentrations are within the range

reported in other studies on similar soil types and with similar land use in the Peel-Harvey catchment (e.g. Height *et al* , 1988 and Silberstein and Bennett, 1990).

On the eastern side of the river the superficial aquifer overlies older sediments known as the Leederville Formation, which is an important regional groundwater resource. The Leederville Formation consists of interbedded sands, siltstones and shales.

- Issues

  The issues associated with superficial groundwater resources at Amarillo in respect of proposed residential development are the potential for contamination of groundwater and the potential for water quantity changes. The latter issue relates to the need to control the water table to prevent flooding of houses and is considered to be the principal issue requiring evaluation.

  Water quality issues are also important but in this respect the potential effects on groundwater quality at Amarillo are no different to elsewhere on the Swan Coastal Plain where urbanisation has occurred over shallow groundwater resources.

  Hydrological evidence from the regional monitor bore network indicates that there is potential for upward leakage from the underlying Leederville Formation aquifer into the superficial aquifer near to the Serpentine River. Therefore, lowering of the water table within the superficial aquifer (by drainage, abstraction via bores, plantation forestry and/or other means) would tend to increase the rate of upward leakage, if leakage is occurring.

3.2.2 Drainage

The eastern side of Amarillo has been classified as palusplain (seasonally waterlogged) on regional wetland mapping conducted by the (then) Water Authority. The waterlogging occurs due to rainfall causing the water table to rise near to the ground surface during the winter months. Runoff occurs due to the 'saturation-excess' mechanism and it has been estimated that between 25% and 40% of annual rainfall becomes runoff on the areas of palusplain which are predominantly pasture (Peck and Davies, 1993).

Stormwater runoff is collected in the numerous shallow agricultural drains which have been constructed to alleviate waterlogging and flooding and is discharged to the Serpentine River. Most of the surface drainage originates on the property or is carried as throughflow via a major regional drain (Dirk Brook Drain), which crosses the site from east to west in the northern sector.

Preliminary investigations by Peck and Davies (1993) showed phosphorus concentrations of between 0.064 and 3.7 mg-TP/L in surface drains (a total of 92 samples were collected), with an average from all samples of 0.94 mg-TP/L. This is relatively high and is probably attributable to the application of agricultural fertilisers over a number of years. It is also believed from anecdotal evidence that there have been 'contributions' in the past from land utilised for a piggery located immediately south of the site. The drain samples would be recording phosphorus in both stormwater runoff and groundwater inflow.

- Issues

  Consideration of the likely water quality of drainage from the development proposal to the Serpentine River is a fundamental environmental concern, particularly in regard to the phosphorus content of this drainage water. The change in land use from pasture to urban needs to be consistent with the Statement of Planning Policy (SPP No. 2), which aims to prevent land uses that are likely to result in excessive nutrient export into the drainage system.

  Another issue is that shallow groundwater contains elevated levels of phosphorus from historical fertiliser practices and therefore changes to groundwater drainage from the site will likely change the rate of phosphorus discharge, albeit temporarily until a new equilibrium is reached. This needs to be assessed from the perspective of the degree of improvement which will ultimately be attained.

3.2.3 Landform and Soils

The landform and soils of the two primary areas with development potential are described as follows:

West of the river in the central-west sector there is a moderately large area of Spearwood Dune System which is flat-to-gently undulating sandplain varying in height from about 3.0

metres AHD near the river to about 10 metres AHD at the boundary of the property. In parts this land most likely overlies alluvial formations at variable depth.

East of the river the terrain is predominantly Bassendean Dune System with some Pinjarra Plain Clays in the north-eastern sector adjacent to the river. For the most part the Bassendean Dune sandplain has very low relief with only occasional low sandy rises. The plain rises away from the river at an average gradient of about 1-in-350 metres (between the 5.0m and 12.5m AHD contours, refer to Figure 4). In the central-eastern and south-eastern sectors the terrain rises relatively sharply from about the 12.5 metre AHD contour and becomes more undulating. Some of the dunes in this area rise to 20 metres AHD or more. The highest dune occurs at the central-eastern boundary and rises to 27 metres AHD.

- Issues

  The eastern sands are highly leached and have the very low phosphorus adsorption capability which is typical of the 'deep grey sands' of the Bassendean Dune System. The current pastoral use on this landform and soil type is recognised, on the basis of broader catchment studies, as responsible for high phosphorus discharges in drainage and comparatively, the change in land use to urban has high potential to result in an improvement to the existing situation.

3.2.4 Serpentine River Floodway

Estimates of the 1-in-100 year floodway and flood fringe for the Serpentine River were obtained from the Floodplain Management Section of the (then) Water Authority. The Amarillo property includes an 8.7 kilometres segment of the river and the 100 year floodway, in its unmodified state, encompasses approximately 920 hectares of Homeswest's land (refer to Figure 9).

- Issues

  The issues associated with the floodway are essentially threefold:

  - protection of the proposed development from the effects of floodwaters;

- protection of the flow path of floodwaters during the development process to ensure that there are no deleterious flood effects caused upstream of the site;
- ensuring that any encroachment within the floodway, which may be deemed acceptable on hydrological grounds, is ecologically acceptable.

3.3 Biological Environment

The only areas of remnant native vegetation and habitat which are considered to have regional conservation significance are located along the fringes of the Serpentine River and the riverine system itself. These areas will be incorporated into the proposed Regional Park for which a provisional boundary has been determined encompassing approximately 730 hectares. A report describing the ecological values along the river was prepared in 1992, which also presents the rationale for the proposed Regional Park boundary (Bowman Bishaw Gorham, 1992).

There are limited ecological remnants elsewhere on the property and the following description of the biological environment focuses on vegetation and wetlands only.

3.3.1 Remnant Vegetation

The majority of the Amarillo site has been either cleared for pasture, disturbed by the trampling and grazing of livestock or planted with 'bluegums', therefore little of the original vegetation remains intact.

Nevertheless, there are pockets of remnant vegetation distributed on the site which are worthy of protection; if not for their ecological values then certainly for their landscape values and potential for enhancement of local open space in an urban context. These areas have been identified and mapped for protection during the development of Amarillo. They are included in the proposed Local Open Space allocations (refer to Figure 8) but are generally too small to be clearly mapped at the scale of the PER diagrams.

A recent Waterways Commission study of the fringing vegetation of the Serpentine River in the Shire of Serpentine-Jarrahdale and City of Rockingham concluded that the *Juncus kraussii* community on the Amarillo property is of "regional significance in terms of the

extent of the sedgeland. The conservation value of this area is extremely high" (Siemon *et al* ., 1993) The areas of *Juncus* sedgeland identified in this study extend outside of the proposed Regional Park and therefore would be subject to development. As a consequence, an assessment of the conservation significance of the sedgeland has been conducted independently of the above report to ensure that proper consideration is given to this matter (refer to Section 5.5.1 and Trudgen, 1993).

- Issues

  The extensive clearing of the Swan Coastal Plain for agriculture, particularly south of Perth, requires that the presence of remnant vegetation is carefully examined and evaluated in respect of its potential conservation significance.

3.3.2 Wetlands (EPP Lakes and other wetlands)

EPP Lakes: There are four wetlands on the site which are protected in accordance with the Swan Coastal Plain Lakes Environmental Protection Policy (1992). All are located in the north-west of the property, as shown on Figure 5; two are pools on the Serpentine River while two are groundwater-fed wetlands to the west of the river. It is recognised that no action can be taken that results in "...filling, mining, excavation, pollution or changes in drainage capable of reducing or destroying the values..." of any EPP wetland without the approval of the Minister for the Environment, and that there is an implicit preference for protection rather than to allow any disturbance.

There are several EPP wetlands located on adjacent land, including to the north (on the western side of the Serpentine River) and others to the east and south (Figure 5).

Other Wetlands: The Water and River Commission's Wetland Mapping System recognises five types of wetland at Amarillo, namely sumpland, dampland, river channel, floodplain and palusplain (Figure 6). Nearly the entire portion of the site on the eastern side of the Serpentine River is mapped as palusplain, apart from the low dunes and sandy rises and some areas of dampland/sumpland. EPA Bulletin 686 and the preliminary management categories assigned by the Water and Rivers Commission's wetland work have been used to assist environmental planning decisions for the site.

- Issues

  Direct disturbance of wetlands is not an issue in this instance because the wetlands of value are located outside of the proposed development area. However, potential changes to groundwater hydrology, notably water table levels, as a result of urban development and the drainage system at Amarillo, need to be considered for the off-site wetlands in particular.

3.4 Social Environment

The elements of the social environment which have been considered are listed below and briefly described subsequently.

1. Land uses of adjoining areas in respect of the compatibility of urban development, ie, the potential constraints which are imposed by particular land uses in the surrounding area, on the Amarillo site.

2. Potential Aboriginal and European heritage values of the Amarillo site.

3.4.1 Adjacent Land Uses

The adjacent land uses are listed below and shown on Figure 7.

- Special Rural developments, including a dog kennel estate.
- State forest (pine plantation) and explosives storage area.
- Broad-acre rural; predominantly pastoral, some horticultural, some eucalypt plantation and a winery.
- A light aircraft landing strip.
- Wandalup Farm piggery.
- Murrayfield aerodrome.
- Freeway reserve.
- Natural bushland (Paganoni Reserve).

The principal socio-environmental issue associated with the relatively close proximity of the piggery is nuisance from odour emissions. In addition, potential noise nuisance may also need to be considered. Amarillo has three potential sources of noise disturbance to the south, namely the dog kennel Special Rural estate, Wandalup Farms piggery and

Murrayfield Airpark, and one potential source to the north-east, namely the small aircraft landing strip.

3.4.2 Ethnographic and Archaeological Heritage

An Aboriginal heritage assessment was conducted by McDonald Hales and Associates during 1993 and the results are summarised below.

3.4.2.1 Archaeology

The archaeological survey did not locate any new archaeological material within the Amarillo development area. An attempt was made to locate a previously recorded artefact scatter (S02445) but this proved to be unsuccessful. It has probably been disturbed by the farming and forestry activities which have occurred over most of the site.

Permission will be sought from the Department of Aboriginal Sites to allow urban development in the area where the site was previously recorded.

3.4.2.2 Ethnography

The Serpentine River is recognised as an ethnographic site with mythological and historical economic significance to the Aboriginal people. No new ethnographic sites were identified at Amarillo by the informants consulted during the survey.

It has been recommended that a 30 metre buffer is maintained on either side of the river during the development process. This will be readily accommodated within the proposed Regional Park.

3.4.3 European Heritage

European heritage values arise mainly in respect of the natural heritage values along the Serpentine River. The social values of importance which may be attributed to this area are 'landscape' and 'recreation'. There has been little systematic study of these social resources, which is perhaps exacerbated by the degree of subjectivity involved, however some comments are provided below.

3.4.3.1 Landscape

The combination of water, meandering channels and diversity of vegetation form and structure provides a visually attractive landscape along the Serpentine River. Views to the west are also interesting because of the elevated terrain associated with the Spearwood Dune System, which provides a backdrop for the river.

There is no doubt that the loss of vegetation due to disturbance has caused a degree of visual alienation in foreshore areas, but this could be readily enhanced by controlling access and conducting appropriate rehabilitation.

Overall, the landscape appeal of the river must be rated as highly significant, especially in the context of the flat, featureless sandplain to the east.

3.4.3.2 Recreation Opportunities

Given that the majority of the river at Amarillo is privately owned and surrounding population densities are low, recreational use has been slight to date. There is anecdotal evidence of illicit duck-shooting in the last several years.

However, there are a range of passive and active recreation activities which could be conducted at Amarillo as the population in the locality increases. These range from canoeing, cycling on foreshore paths, waterbird observation and picnicking in a bush setting, to nodal development of active recreation areas fringing the floodplain.

It is noted that the Peel Inlet Management Programme includes the following recommendation for the Goegrup Lake area and adjacent lake systems extending up to Amarillo:

> "A.168 *Investigate the recreational potential of the waterways above Barragup Bridge* (PIMA)." (Waterways Commission, 1992).

There is some concern with the potential for increased boating pressure, especially in areas of important wetland habitats, and it is implicit to the above recommendation that recreation activities will need to be controlled and directed to environmentally benign pursuits.

4.0 DESCRIPTION OF PROJECT AND PROPOSED ENVIRONMENTAL MANAGEMENT

This project is 'drainage-driven' from two main perspectives; firstly there is a requirement to protect the Serpentine River from excessive nutrient (phosphorus) loadings and secondly, there is a requirement to protect future landholders from the effects of waterlogging and possible flooding due to a high winter water table. Resolution of the drainage issue has largely influenced the broad layout of the development to date.

Prior to detailed planning of the project it has been necessary to develop a framework of environmental management (for drainage and other issues) to ensure that there will be no adverse environmental and socio-environmental effects. Overall, the suite of environmental issues which have been addressed may be summarised as follows:

1. Conservation along the Serpentine River.
2. Drainage management and nutrient export to the Peel-Harvey Estuary.
3. Compatibility with (existing) adjacent land uses.
4. Other minor issues (eg. remnant vegetation, wetlands, construction impacts).

An outline of Homeswest's proposals for the management of these issues is provided in this section. A brief overview of the project components is provided first. **(Note that detailed management proposals will be prepared and submitted for approval via an Environmental Management Programme, subsequent to assessment of this PER).**

4.1 Project Components

4.1.1 Draft Structure Plan

At the present time, planning of the layout for urban development of Amarillo Farm has not proceeded beyond preparation of a draft Structure Plan which broadly identifies land use components such as the major arterial road network, a district centre, industrial area, residential cells including schools and other uses, a boundary for the proposed Regional Park and an allocation of land for water management in the form of lakes and drainage corridors. The draft Structure Plan is shown at Figure 8. Note that two bridge crossings are required across the Serpentine River and the potential effect on the floodway has been given special consideration, as outlined in Section 4.2.2 below.

It is anticipated that the project may yield in the order of approximately 1,500 to 2,000 hectares of residential land, which could be expected to accommodate a population in the order of 55,000 to 75,000.

The arterial road network shows potential connections to the south and north of Amarillo but this should be recognised as being flexible as there are no definite plans for urban development in these directions. The size of Amarillo allows the project to be successful as a 'stand alone' development.

4.1.2 Service Infrastructure

Notwithstanding the arterial roads shown on the Structure Plan, the provision of other services such as water supply and sewerage has yet to be determined in detail. Despite the relative isolation of the site, connection of water supply, sewerage, electricity, gas and telecommunications is economically feasible given that the costs will be amortised over a landholding of this scale, and that temporary infrastructure could be provided in some instances.

In the medium-to-long term, the provision of these services is likely to be simplified because of the continual expansion of urban development within the South-West Corridor, including the near coastal areas west of Amarillo. In the short-to-medium term, extension of these facilities to Amarillo may, in some instances, be in advance of the anticipated 'development front' and would therefore require special consideration by the appropriate authorities. For example, preliminary advice from the Water Corporation in respect of water supply and sewerage is as follows:

- Water

  Servicing of the Amarillo site requires the construction of water reservoirs at Karnup and Paganoni Roads. The construction of the two reservoirs will provide a gravity supply to the majority of Amarillo. Land lying between 20 and 27m AHD may be served by a small booster system or elevated tanks.

- Sewerage

  The Amarillo site falls outside of the Water Corporation's current sewerage strategic planning area.

Discussions with the Water Corporation indicate that a temporary sewerage pump station could serve approximately 2,800 lots in the short to medium term via approximately 9 kilometres of pressure main discharging into existing infrastructure at Peelhurst.

Ultimately, Amarillo would discharge into the proposed new Rockingham Sewerage Treatment Plant.

4.1.3 Quantity and Source of Fill

The first stages of development would be self-sufficient in terms of fill requirements, ie none would need to be imported to the site. Fill will be obtained on site during subdivisional development, particularly from drainage features such as the water pollution control ponds and the drainage swales where they pass through elevated terrain. There is also a large deposit of sandy sediments at the mouth of the Dirk Brook Drain. It is estimated that approximately 1.7Mm^3 of fill can be obtained from these sources.

The balance of fill requirements, estimated to be approximately 5.5Mm^3, will need to be imported to the site. There are a number of sand quarries currently being mined in the region, including the Baldivis Cemetry site in Baldivis Road and a site on the southern side of Paganoni Reserve. Additional potential sources of fill will be considered, if necessary, during the more detailed drainage management planning prior to the first subdivision.

4.1.4 Dirk Brook Drain

There is potential to incorporate the Dirk Brook Drain into the development concept and at the same time modify the configuration of the drain to improve its aesthetics and function. This has been recognised during preliminary discussions with the Water Corporation, although at present no firm proposals have been considered.

Whilst the current Structure Plan shows Dirk Brook Drain unaltered, there will be ample opportunity to incorporate the drain as a feature within the development during subsequent detailed design phases. The issue of responsibility for water quality will need to be resolved with the appropriate Regulatory Authorities.

4.2 Management of Conservation/Recreation Values Along the Serpentine River

The area of the Serpentine River encompassed by the Amarillo property is part of System 6 Recommendation M108 (Goegrup Lakes). It is currently in private ownership. The area is recognised as valuable for both conservation and recreation by the EPA and other authorities and has been recommended as an area suitable for establishment of a Regional Park. Therefore the primary management response at this stage of project planning is to define the boundary for that portion of M108 within Amarillo to ensure protection of the conservation and recreation values. Floodway protection and bridge crossings are also issues which have been examined.

4.2.1 Boundary Determination for Proposed Regional Park (M108)

The proposed development at Amarillo is not impinging upon (ie, reducing) an existing System 6 area, because the area has never been precisely defined. Homeswest is seeking to define, essentially for the first time in the draft Structure Plan, an appropriate boundary for the 'System 6 values' which are recognised along the Serpentine River so that the area can be adequately protected and managed as the development proposal proceeds.

A discussion paper has previously been submitted to EPA, PIMA, Ministry for Planning and other authorities which nominates a boundary for consideration:

> Bowman Bishaw Gorham (November 1992), Provisional Regional Park Boundary for Urban Structure Plan, Discussion Paper, Prepared for Homeswest.

The boundary was determined on the basis of the following criteria:

- Include river wetlands and associated remnant vegetation;
- Include all EPP wetlands identified within the floodplain;
- Provide a buffer zone to the fringing vegetation and which enables revegetation;
- Provide a buffer zone to allow for recreational use;
- Rationalise the proposed boundary for management purposes;
- Link the boundary to adjacent conservation areas;
- Include some areas which are higher than the floodplain for fauna retreat;

- Ensure that the floodway is sufficiently protected;
- Integrate the proposed freeway with the regional park;
- Recognise the potential for alternate land uses in parts of the floodplain.

The current draft Structure Plan prepared by Homeswest reflects the boundary nominated in the above report and encompasses an area of approximately 730 hectares. The process of boundary determination is summarised on Figure 9.

The general consensus of current policies and recommendations is that the M108 area should form part of a Regional Park. Most of M108 is located within the boundary of the proposed Peel Regional Park, for which implementation plans are relatively well advanced. However the portion of M108 within the Metropolitan Region Scheme (ie, the northern two-thirds of Amarillo) is not included in this planning initiative.

Homeswest's development proposal offers the benefit that it will facilitate regional park planning for the entire M108 area during the rezoning process for Amarillo. It would seem logical to extend the proposed Peel Regional Park further north, from the boundary of the Metropolitan Region Scheme.

To ensure co-ordination of planning and management of the Peel Regional Park, a joint management agreement between PIMA, CALM and local authorities has been recommended (DPUD, 1993). This joint approach also seems logical for the balance of M108 within Amarillo, although PIMA's area of management responsibility would also need to be extended.

4.2.2 Protection of 100 Year Floodway

Protection of the floodway is clearly defined by the Water and Rivers Commission's Floodplain Management Strategy, in which no development is permitted within the central floodway and there are specific restrictions and requirements which apply to residential development proposals within the flood fringe.

As mentioned in Section 3.2.4, the existing 1-in-100 year floodway is estimated to be 920 hectares, which is a much greater area than the area allocated for the provisional Regional Park (730 hectares). Given that the land required to protect all of the conservation values along the river, including buffer zones and public land for recreational activity, is substantially less than the 920 hectare floodway, there is opportunity to encroach into the

floodway by the addition of fill. Therefore, consultations were held with the (then) Water Authority in order to rationalise the floodway requirements with the objective of reducing the area of land "sterilised" for urban purposes by the floodway.

A revised floodway was agreed which allows for two bridge crossings and requires low-lying land in the flood fringe to be filled prior to possible residential development. The area which could be filled is also dependent on the ultimate location of the Regional Park boundary, however overall there is at least 100 hectares of 'reclaimable' land between the flood fringe and either the Regional Park boundary or the revised floodway. The revised floodway encompasses 735 hectares of Homeswest's land (Figure 9). If a third bridge is required the Water and Rivers Commission has indicated that the original floodway may apply and no encroachment would be allowed.

4.2.3 Serpentine River Bridge Crossings

Site selection and bridge design are the two primary elements to which management attention can be applied in order to minimise potential adverse effects of the bridge crossings.

Whilst the preliminary locations of the crossings have been determined from initial planning and transport studies (refer to Structure Plan, Figure 8), there is still sufficient flexibility in the selection of final crossover points and alignments to allow environmental factors to be properly addressed. In addition, the 'footprint' of each bridge can be altered through design to cater for hydrological requirements in respect to flood mitigation. Potential foreshore impacts will also be addressed through good design.

Detailed environmental planning and management will be implemented, and approvals sought, prior to bridge construction to minimise adverse effects on foreshore vegetation and the river channel. As mentioned in Section 4.2.2, the effect of the bridge crossings on flood levels has already been taken into account by the (then) Water Authority in calculating the revised floodway for Amarillo. These aspects will be addressed in further detail in the Environmental Management Programme.

4.3 Nutrient, Drainage and Groundwater Management

4.3.1 General

The approach to management and resolution of the nutrient and drainage issue at Amarillo is based upon two fundamental premises, listed below.

1. The change in land use from fertilised pasture to urban residential represents an immediate improvement to the nutrient export potential of the site because of the change in state in respect of the pathways for phosphorus transport (overland vs sub-surface) and the different phosphorus cycling mechanisms which will apply (fertilised gardens with at least 1.2 metres of clearance above the water table vs fertilised and grazed paddocks with, in some instances, no clearance above the winter water table).

2. The principal constraining factor in respect of drainage discharge to the Serpentine River is the phosphorus content of the water, not the volume of water *per se*.

A Conceptual Nutrient Management Strategy has been prepared (refer to Part II of this document) based on the principles of Water Sensitive Design. This document was prepared in close consultation with the relevant agencies, following review of an earlier draft which was distributed in January, 1995. In broad terms the principal management approaches which will be applied at Amarillo are as follows:

- minimisation of the quantity of drainage which is required to be exported, by the use of fill as opposed to deep sub-soil drains, extensive landscaping with perennial trees and shrubs, and the widespread use of on-site groundwater for irrigation of gardens and POS;

- removal of phosphorus from drainage prior to discharge to the river by the application of 'best management practices', including extensive detention and treatment in constructed biological wetlands and, as a contingency, the application of fail safe techniques such as chemical treatment.

Critical elements of the management strategy are outlined in the sections which follow, however the reader is referred to the nutrient management strategy document (Part II) for background detail.

4.3.2 Management Criteria for Phosphorus Export to Serpentine River

The Peel-Harvey Environmental Protection Policy (1992) establishes the broad environmental quality objectives for protection of the Peel-Harvey Estuary. The environmental quality objective relevant to the Amarillo area is as follows:

- "(a) the median load (mass) of total phosphorus flowing into the Estuary from the Serpentine River being less than 21 tonnes;"

The validity of the objectives in the EPP has recently been questioned because the original phosphorus and flow data upon which the objectives were based (and the methodology used to collect the data) has not been made available to the Water and Rivers Commission; the authority responsible for auditing the success of the catchment management strategy (EPA Bulletin 749, 1994). However, the above objective for the Serpentine River equates to an export rate of approximately 0.27 kg total phosphorus per hectare per year (kg-TP/ha/a) from the coastal plain portion of the Serpentine River catchment. The objective for the whole coastal plain catchment of the Peel-Harvey Estuary is 75 tonnes, which equates to a target load of 0.375 kg-TP/ha/a. (The rationale in the EPP for this variation in targets, dependent on a river versus 'whole-of-catchment' approach, is not clear).

Whilst it is acknowledged that the target load (0.27 kg-TP/ha/a) may be seen as a useful yardstick for assessing the performance of proposals such as Amarillo, **post-development**, there are difficulties in applying it as a criterion by which to assess a proposal prior to its implementation. This is partly because of the uncertainty in accurately predicting the likely phosphorus export rate for a development proposal. Consequently, there has been less emphasis on this approach in the EPA's assessment process in recent years. There are other complicating factors, such as load sharing and the non-linear relationship between catchment size and phosphorus export rate, which have also been raised recently. Interpretation of the EPP in respect to these issues has not been resolved despite its application to the catchment since December 1992.

For the proposed urbanisation of Amarillo, a combination of both general and specific criteria have been proposed by the Proponent to assist in the future evaluation of, and contingency planning for, the drainage management strategy. These objectives and criteria are listed below.

- The long-term phosphorus discharges to the Peel-Harvey Estuary should not adversely affect the trophic status of the estuary and therefore cause a burden to future generations.

- Conservative predictions regarding the performance of the drainage management strategy should demonstrate an 'environmental gain' in respect of phosphorus discharges to the Serpentine River as a result of the change in land use (ie, estimates of phosphorus loadings to the river should show a clear reduction based on available data for sandy catchments).

- The long-term equilibrium phosphorus export for the urban land use should achieve at least a 50% reduction in comparison to the previous pastoral land use (ie, prior to 1988).

- The phosphorus export rate should not exceed the "overall catchment target" of 0.375 kg-TP/ha/a (but recognise that it may take some time, say 5-8 years, for an equilibrium situation to be achieved which can be effectively audited unless fail safe treatment mechanisms are introduced).

- Aim to achieve to the greatest practicable extent a phosphorus export rate lower than the Serpentine River catchment target of 0.27 kg-TP/ha/a in four years out of five, with a desirable objective in the vicinity of 0.19 kg-TP/ha/a, which is one-half of the overall catchment target (but recognise that it may take some time, say 5-8 years, for an equilibrium situation to be achieved which can be effectively audited unless fail safe treatment mechanisms are introduced).

- Aim to achieve to the greatest practicable extent a 'flow-weighted mean' phosphorus concentration in the final discharge to the Serpentine River, from the artificial drainage system, in the range 0.05 to 0.1 mg/L (total phosphorus) in the long-term.

The time-lag of 5 to 8 years mentioned above is somewhat arbitrary but is believed to be a realistic period for equilibrium to occur following the change in land use and as specific Best Management Practices, such as the constructed wetlands, mature to optimum efficiency. Other factors relevant to the achievement of phosphorus export criteria are the existing soil/groundwater store of phosphorus, input to the site of phosphorus via groundwater flow from the east and the current proposals for fail safe phosphorus removal techniques.

The above criteria were proposed by the Proponent in 1995 in initial drafts of the PER. In March 1996 different criteria were proposed in preliminary advice by the Water and Rivers Commission and these have been debated in recent months. The current position of the Water and Rivers Commission is outlined below.

The Water and Rivers Commission recommends that a Best Management Practice (BMP) approach is adopted at Amarillo to reduce phosphorus export levels as far as is practicable and economic. This is similar to the approach adopted by the Proponent in setting a desirable objective for phosphorus export at about one-half of the overall catchment target.

The Water and Rivers Commission also proposes a performance standard by which the BMPs implemented at Amarillo can be assessed. These performance standards are expressed as follows:

- a total mass of phosphorus entering the Serpentine River being less than 0.225 kg-TP/ha/a;

- a flow weighted annual average total phosphorus concentration in discharge waters of less than 0.075mg/L.

The recommended criterion for mass load of phosphorus represents 83% of the Serpentine River's catchment target of 0.27 kg-TP/ha/a specified in the EPP. Exceedence of this level would act as a trigger for implementation of the Proponent's contingency plan, which would involve additional control measures to reduce phosphorus export.

The Proponent is prepared to adopt the Water and Rivers Commission recommendation. The full text of the Water and Rivers Commission recommendation is included in Section 12.

4.3.3 Water Quality Management - Phosphorus Removal

The BMP approach based on the principles of water sensitive design is the key to phosphorus management in drainage waters at Amarillo. The conceptual approach to water sensitive design at Amarillo is outlined in Part II of the PER. Specific details of individual BMPs will be developed and presented in the proposed Environmental Management Programme. A list of BMPs has also been recommended by the Water and Rivers Commission in their advice of 12th June 1996 (refer Section 12). All of these BMPs are included in the Proponent's management strategy.

The Proponent believes that rigorous implementation of water sensitive design through appropriate BMPs will achieve the water quality target for phosphorus export to the Serpentine River. It is significant to note that the Water and Rivers Commission also supports this view (refer to Section 12). Properly designed and constructed BMPs must have a substantial water quality benefit in comparison to drainage waters from unmanaged urban development.

Technical debate which preceded the public release of this PER has primarily revolved around two items of concern:

- scepticism regarding the likely performance of constructed wetlands for phosphorus removal, particularly in sandy soil catchments;

- the issue of potential mobilisation of the existing soil/groundwater store of phosphorus which may contribute high phosphorus levels to drainage waters in comparison to stormwater runoff from roads and other shedding surfaces.

As a result of the above concerns, the Proponent has been directed to formulate additional phosphorus control measures which could be readily implemented as a contingency measure should the BMP approach not achieve the phosphorus target in drainage to the Serpentine River. The issue of uncertainty in respect to constructed wetland performance and the contingency measures for phosphorus management are discussed in the sections which follow, and subsequently Section 5.2.

4.3.3.1 Constructed Wetlands

Constructed wetlands will form an important component of the BMP treatment train phosphorus management system at Amarillo.

Interest in constructed wetlands for water pollution control has increased significantly during the past decade or so. Whilst the performance of constructed wetlands for phosphorus removal is highly variable for the diverse range of case studies reported in the literature, properly designed and constructed wetland systems can now successfully meet performance objectives for phosphorus removal. For example, Bavor (1996) states that "Constructed wetlands technology is now entering a phase in its development where it can provide reliable water and wastewater treatment in a wide range of circumstances". Bavor reports removal efficiencies of 60 - 90% for phosphorus where the initial phosphorus

concentration is 1mg/L or lower, with output phosphorus levels down to 0.06mg/L and lower. (Professor John Bavor is Director of the Water Research Laboratory at the University of Western Sydney, Hawkesbury).

Concerns were raised during 1995 by DEP/EPA that constructed wetlands, or nutrient stripping ponds as they are sometimes called, have not yet been proven in Western Australia. There is very limited verification data on the performance of local constructed wetlands upon which authorities can make their assessment. Furthermore, monitoring data from the Bartram Road buffer lakes, which treat stormwater runoff from urban development at South Jandakot, show that this wetland system is not yet achieving its design objective of a 30% reduction in phosphorus from throughflow drainage waters. A review of the performance of the Bartram Road wetland and two other wetlands treating urban runoff is provided by Braid (1995).

The review by Braid (op. cit.) concludes that constructed wetlands can effectively remove pollutants from urban stormwater. However the design process is critical to formulation of a successful wetland project. The three Perth wetlands examined in the review are not meeting their phosphorus removal objectives mainly because they do not meet appropriate design criteria. This gives the Proponent confidence that if the proper design process is followed then an effective wetland will be produced.

A key disadvantage of constructed wetlands is that they require an extensive land area to be effective. The aspect of land allocation for drainage management is the most common factor which is compromised and generally results in performance objectives not being met (Braid, op. cit.).

This will not be the case at Amarillo. The Proponent has allocated approximately 25% of the development area for drainage management purposes. Within this land use allocation, more than 300 hectares is allocated for constructed wetlands and other water detention facilities. Based upon a design average residence time of water in the wetlands of 21 days, and consideration of the likely phosphorus loading rates to the wetlands, the area of wetlands required to serve the 3,000 hectares of land on the eastern side of the Serpentine River is estimated to be between 100 and 150 hectares. Therefore, the land allocation in the Structure Plan for Amarillo is more than adequate to cater for the contingency that larger wetlands would be required.

A conservative performance objective of a 30% reduction in the phosphorus content of drainage throughflow will be assumed for the proposed Amarillo wetlands. This is well within the capability of well designed and properly constructed wetlands reported in the literature.

4.3.3.2 Soil Amendment around Sub-soil Drains

Development at Amarillo will require the application of fill to proposed allotments and installation of sub-soil drains to control water table rise. This aspect of groundwater control is discussed further in section 4.3.4. During installation of sub-soil drains the opportunity arises to amend the soil profile to enhance its phosphorus removal characteristics. The existing Bassendean sands have a very low ability to retain phosphorus.

Soil amendment around the sub-soil drains is proposed as a contingency management measure to address the issue of the high existing levels of soluble phosphorus in the groundwater at the site. The proposed method is to simply form a filter around the sub-soil drain such that any groundwater entering the drain must first flow through this filter and phosphorus adsorption would occur during this process.

Whilst it is a contingency management technique, trials would definitely be conducted during the initial phase of development on the eastern side of the Serpentine River. The primary focus of this technique is on the existing groundwater store of phosphorus. Therefore it is not envisaged that the amended soil filter would be considered for replacement once its phosphorus adsorption ability was exhausted. It is proposed as a one-off treatment technique with a lifetime of 10 - 20 years.

The soil amendment material would be bauxite residue (red mud and red sand), which is a bi-product of the alumina industry. The advantage of using this material is that it has been demonstrated through detailed research and also practical applications to have the ability to significantly reduce phosphorus losses to the environment by soil adsorption mechanisms. This is proven technology and is therefore considered appropriate by the Proponent as a contingency management measure or fail-safe phosphorus removal technique.

4.3.3.3 Chemical Treatment

Chemical treatment of stormwater has previously been suggested by the Water and Rivers Commission for consideration as a fail-safe phosphorus removal technique. A range of chemicals are known to have good phosphorus removal abilities, such as aluminium salts (eg alum or aluminium sulphate), iron salts (eg ferrous chloride, ferric sulphate) and also calcium salts such as calcium hydroxide.

The process of chemical treatment is relatively straightforward and could comprise the following method:

- injection of the selected chemical at the appropriate dose rate into a stormwater drain where turbulent flow will ensure that mixing occurs;
- the chemical/water mix would be directed to a large shallow detention basin where the precipitation reactions would be allowed to occur;
- these detention basins would be designed such that they were above the summer groundwater level and would enable eventual sludge removal when the capacity of the basin became reduced;
- if necessary and dependent on the rate of sludge production, a dual detention basin system could be provided to ensure that there was always a reaction basin available.

Whilst chemical treatment of stormwater is not known to be practised in Australia, this method of phosphorus reduction is used for wastewater (sewage) treatment and benefits include:

- a high level of predictable phosphorus removal;
- relatively low capital cost;
- treatment facilities easily installed and operated (*pers. comm.* J. Dymke; Manager Water Quality and Supply Branch, ACTEW Corporation).

For stormwater management, a chemical treatment system may derive a cost/benefit advantage over constructed wetlands and other forms of retention/detention basins, in that the land area required for chemical treatment is significantly less.

4.3.4 Water Resource Management - Superficial Groundwater

Urbanisation is likely to increase groundwater recharge and consequently there will be a need to prevent water table rise through the use of sub-soil drainage. Therefore, there is a potential need to export more water from the site than is currently the case, although a range of techniques will be employed to minimise increases in off-site discharges. A primary focus of groundwater resource management is on the water quantity issue, notably the degree to which the existing water table can be controlled or altered without causing adverse effects, either on-site or off-site. The manner in which the water table is controlled is thus an important management consideration.

Lowering of the existing water table by the use of sub-soil or open drains is not favoured by the Water and Rivers Commission because, amongst other things, it means there is likely to be a requirement to discharge excessive volumes of groundwater from the site. Whilst the volume of water is not necessarily of concern, the potential mobilisation of nutrients and consequent water quality management problem is considered to be the main issue.

The Water and Rivers Commission's preferred position in respect of drainage design in shallow water table areas is that the sub-soil drainage systems must be no lower than the average annual maximum groundwater level (AAMGL), in order to minimise mobilisation of nutrients. This has been accepted by Homeswest as the initial basis of groundwater management for the urban drainage system, although the following factors indicate that some flexibility should be maintained in the management approach:

- determination of the AAMGL is difficult due to the lack of long-term records of groundwater fluctuations;

- rainfall for the past two decades is much lower relative to that experienced for the previous part of this century, which would suggest that the average maximum groundwater levels experienced recently are lower than the long-term AAMGL (refer to Section 3.1.2);

- regional-scale clearing of native vegetation during the last 30 to 40 years is likely to have caused significant groundwater rise, which would suggest that the average maximum groundwater levels experienced recently are higher than the long-term AAMGL (refer to Section 3.1.3);

- the groundwater component of drainage from the site is not a critical issue, provided the phosphorus content of this water does not prevent achievement of the overall export criteria for phosphorus, as proposed in Section 4.3.2.

Notwithstanding the above, the Water and Rivers Commission does support lowering of the water table by using urban forestry (perennial trees) as "groundwater pumps", in comparison to conventional drainage methods. In addition, maximising the on-site utilisation of groundwater for irrigation of domestic gardens and public parks is also encouraged as an effective means of water table control.

Both of these techniques will be employed at Amarillo.

4.3.5 Water Resource Management - Leederville Formation

The issue of potential upward leakage of deep groundwater from the underlying Leederville Formation aquifer, into the superficial aquifer, was raised in Section 3.2.1. The need for active management is considered to be low as there is no known unrestricted flow path between the two aquifers and hence the probability of leakage from the Leederville Formation to the superficial is low. Obviously a substantial increase in the rate of upward leakage would be considered undesirable from a water conservation perspective, but this will be readily managed by minimising the drawdown of the superficial aquifer.

4.3.6 Surface Drainage (Flow Criteria)

Flow criteria have been applied in preliminary design considerations for the drainage strategy. The principal criterion is that the peak design discharge from the urbanised area should be no greater than the flow rates under the former agricultural land use. This will be a relatively easy criterion to meet because of the need for large detention basins to assist in nutrient removal, which will exceed the size required for flow reduction purposes. As mentioned previously, the key environmental objective of drainage management is to minimise the phosphorus discharges to the Serpentine River. Criteria for phosphorus management are presented in Section 4.3.2.

4.4 Management of Land Use Compatibility

The key issues are potential odour and noise emissions from neighbouring land uses.

4.4.1 Odour Emissions from Wandalup Piggery

The primary management method to prevent nuisance effects from noxious odour emissions in future residential areas is to apply a suitable buffer zone around the piggery. A buffer zone has not yet been established around Wandalup as there is an absence of technical data upon which a reliable buffer zone could be derived. The EPA's recommended separation distance between major piggeries and residential areas is based on buffer zones applied in Victoria, and this may prove to be an excessive separation distance for Western Australian conditions depending on specific site circumstances. Land uses other than residential may be suitable within the buffer zone.

Detailed site investigations would be required to define a specific buffer zone around the Wandalup piggery for adjacent residential use. This may involve a complex process of atmospheric dispersion modelling based on the results of "dynamic olfactometry", for which there is little experience in Western Australia. Homeswest has been reluctant to pursue this management approach to date, essentially for four reasons:

- the timing of initial development and the rate at which subsequent stages would progress suggests that there is more than sufficient time for alternative solutions to emerge without the need for precise definition of a buffer zone in the short term;
- a simpler means of buffer zone determination may be derived locally on the basis of practical experience with other odour sources;
- land uses other than residential, but within an urban zoning framework, could be acceptable within the buffer zone;
- the timeframe for full development of the Amarillo site is substantial, and other management techniques and options will likely arise for consideration in that time, including relocation of the piggery.

Other management options would involve focussing attention on the piggery in order to reduce the buffer zone requirements within the Amarillo property. For example, the

upgrading of waste handling and treatment techniques may have potential to reduce odour emissions and therefore significantly reduce buffer zone requirements. In the longer term, relocation of the piggery may emerge as the most practical and economic solution.

4.4.2 Potential Noise Disturbance

Management options for residential developments which encroach within the noise 'influence' of an existing land use include application of the buffer zone concept, provision of noise shielding devices, alteration to the method of operation of the noise emitting land use to reduce noise intensity and, relocation of the noise emitting land use. The need for noise management will be kept under review during subsequent detailed planning phases for the Amarillo development.

4.5 Management of Miscellaneous (Relatively Minor) Issues

4.5.1 Remnant Vegetation

The management approach to the remnant vegetation issue at Amarillo has three main components:

- assessment of vegetation condition and degree of fragmentation in order to determine the site's residual conservation values;
- incorporation of all of the high value fringing vegetation along the Serpentine River into the proposed Regional Park and therefore protecting it for conservation and recreational purposes;
- incorporation of most pockets of remnant vegetation throughout the site within the linked POS network, and assurance that these areas will not be used for artificial wetlands, new growth tree plantations and active POS.

As a result, all of the remnant vegetation with residual conservation and landscape values will be retained during the development process.

4.5.2 Wetlands (EPP Lakes and other wetlands)

EPP Lakes: The EPP wetlands on-site have been assigned various management categories in the Water and Rivers Commission's wetland mapping system, including resource enhancement, multiple use and conservation. The conservation category applies to the river pools, whilst the two sumplands have been given the categories which denote a lower conservation priority. All but one of the EPP wetlands are included in the proposed Regional Park which is the primary management response to the recognised values. The fourth wetland, a sumpland, is partly within the site and partly within the freeway reserve for the future extension of the Kwinana Freeway.

The off-site EPP wetlands will not be directly impacted by the development, therefore selection of an appropriate management response is dependent on the degree of water table change which may be induced by the drainage strategy. However, given that the drainage strategy will be based upon management of groundwater levels at the average annual maximum (AAMGL), adverse water level changes in off-site EPP wetlands are not anticipated.

Other Wetlands: The approach adopted for Amarillo is that any wetland (sumpland or dampland) with residual natural attributes, despite being significantly degraded, has value in a development context even if only to form the basis for future landscape enhancement. Therefore the management response is to retain these areas in a linked POS system so that decisions on how they are best incorporated or utilised can be made during subsequent detailed planning phases. The draft Structure Plan has 'captured' all recognisable damplands and portions of palusplain with residual natural values within the POS/drainage network.

4.5.3 Management of Trees (Landscape Value and Groundwater Pumps)

Trees are seen as an important component of drainage management for Amarillo and, given their additional aesthetic appeal and landscape value, are considered essential elements despite any perceived management disadvantages. The alternative to trees as a partial means of drainage management is an additional reliance on the treatment of drainage prior to discharge from the site. In the long term, constructed wetlands may be sufficient for effective drainage treatment, but this is unable to be determined until extensive trials

have been conducted. The drainage strategy will not be reliant upon one main management tool, in accordance with the philosophy expressed in the "treatment train" approach of water sensitive design. Contingency management measures are also proposed to support elements of uncertainty in the performance of water sensitive design.

Should there occur a catastrophic tree death over large areas of the site, the resultant rapid change in water balance, including potential water table rise, would be easily managed by the installed sub-soil drain system. Therefore management to ensure a guaranteed minimum tree cover is only a desirable objective, not an essential one.

Expertise for management of trees, including landscape and fire aspects, is readily available in Western Australia so the issue of tree revegetation and sustainability is not of great concern. In addition, direct experience will be gained from the existing tree plantations which have been established on Amarillo. Management responsibility of the revegetated POS/drainage network would likely be via a consultative committee comprising representatives with appropriate expertise, which is ultimately co-ordinated by the relevant local authority.

4.5.4 Management of Potential Impacts of the Construction Phase

Construction will entail extensive site works to establish the principal drainage corridors and wetlands (on a staged basis) and roads and services. The use of heavy machinery and disturbance to soils means that the potential for noise and dust emissions will require careful management to minimise the impact on the surrounding community. The relatively low density of development in the vicinity is a mitigating factor in this regard, but will not reduce the need to implement management practices in line with regulatory guidelines and current community standards.

- Noise and Dust Control

As per standard practice, the operation of heavy equipment will be restricted to daylight hours (Monday to Saturday). All vehicles will be fitted with noise suppression devices and comply with standard vehicle emission and noise regulations.

Dust levels will be managed in accordance with the EPA's "Guidelines for Assessment and Control of Dust and Windborne Material for Land Development Sites". These guidelines provide procedures by which to prevent and/or suppress excessive dust

volumes leaving the site during and after the construction of the works. The guidelines are currently under review and the revised guidelines will be applied as appropriate.

An important mitigating factor in the early stages of development is the size of the site; this means that the initial phases of development on the eastern side of the Serpentine River will have a substantial 'internal' buffer of vacant land between the core construction activity and the nearest neighbours.

- Fuel Management

A centralised refuelling area will be established during the construction phase. Protection of the groundwater resource from accidental fuel spills will be achieved by sealing the area under the fuel storage vessel with a continuous, double-thickness polythene sheet covered with soil of sufficient volume to contain any spill which may occur during refuelling.

- Public Safety

Access to the development site during the construction phase will be restricted to authorised personnel only and appropriate warning signs will be placed in prominent locations.

4.6 Timing and Staging

4.6.1 Commencement of Development

It is anticipated that the development would commence sometime in the next 3 to 5 years, depending upon market requirements.

4.6.2 Staging

The location of the first phase of development will be determined by a number of factors, including provision of trunk mains for water and sewerage, drainage management requirements, interim odour buffer zones, the status of tree plantations for harvest and market considerations for subdivided land.

It is currently proposed that the first phase of development would occur on the western side of the river, on land which does not have the same groundwater constraints which occur on the eastern side.

The initial phase of development on the eastern side of the Serpentine River (which would occur some time later) is likely to be located in areas A and B shown on the Structure Plan at Figure 8. Most land in these areas is outside of the maximum potential buffer zone for the piggery and not affected by tree plantations. This development area will potentially yield about 3,000 lots, sufficient for (say) 5 - 8 years of the project.

5.0 ASSESSMENT OF ENVIRONMENTAL EFFECTS

This section evaluates the environmental effects of the project on the basis of the management proposed in Section 4.0. There are both benefits and disbenefits of the project which are considered below to enable assessment of the overall environmental acceptability of the change in land use. The disbenefits or environmental impacts are the predicted residual effects after application of the management strategies and techniques described previously.

5.1 Effects on Conservation Values Along the Serpentine River

5.1.1 Proposed Regional Park (Part System 6 Area M108)

The proposed development would have a beneficial effect on the fringing vegetation of the river in that stock would be permanently removed from the foreshore where virtually unlimited grazing has previously occurred. Whilst Homeswest has generally improved the fencing along the foreshore, some restricted grazing is still allowed in order to reduce the fuel load and hence the summer fire hazard.

As the Amarillo site becomes fully urbanised, potential indirect impacts on the System 6 area include an increase in recreational activities as the population expands and additional pest introductions (domestic animals and weeds). The advantage which Amarillo offers in comparison to established urban areas abutting river and estuarine systems, is that it is a 'greenfields' development and appropriate management measures can be introduced from the outset. For example, fencing or other means of access restrictions can be introduced early in the development process. Nodes of recreational activity can be established and sanctuary zones identified in order to protect areas of highest conservation value. Homeswest will facilitate implementation of these techniques early in the development phase in consultation with the relevant managing authority.

5.1.2 100 Year Floodway

The 100 year floodway is very broad in most sectors of the Serpentine River floodplain within the Amarillo property. However the edges of the floodway do not define a strong ecological boundary in this area and, in any event, much of the vegetation and natural

habitat within the floodway has been cleared for pasture. This was an important factor in support of Homeswest's request to the (then) Water Authority to revise the extent of the floodway so that additional areas could be considered for development.

The modified floodway (refer to Figure 9) is smaller than the original floodway, but this reduction has not exposed areas of significant ecological value which would require assessment prior to development. This is because all of the significant conservation values which are recognisable within the floodway and peripheral areas are included within Homeswest's nominated Regional Park boundary (refer to Section 4.2.1).

The net result is that the boundary between 'developable' and 'non-developable' areas adjacent to the river is sometimes determined on hydrological grounds (ie, to ensure protection of the 100 year floodway) and sometimes on ecological grounds (ie, protection of conservation values).

Another factor which requires consideration is the effect of drainage discharges from Amarillo on the flow in the Serpentine River. Data generated during technical work on earlier development and drainage options allows assessment of this issue, as outlined below.

- The flow rates of drainage discharges from the site will decrease following residential development due to the large compensation facilities which will be provided in the drainage scheme. Comparative review of estimated peak flows for 100 year ARI storm events reveals substantial decreases in flow rates, for example, from a maximum of about $57m^3/s$ (pre-development) to a maximum of about $14m^3/s$ (post-development).

- Groundwater modelling and calculation of discharge volumes for two of the initial options under consideration suggest that only a small change in drainage volume will occur following development, and most likely a decrease in groundwater drainage to the river. For example, the pre-development drainage discharge is estimated to be 8.24Mm3/a, whilst the post-development options modelled are estimated to result in a 4% increase in discharge volume ($8.27Mm^3/a$ for a deep drainage option) or a 6% decrease in discharge volume ($7.74Mm^3/a$ for a shallow drainage option). Even less groundwater drainage would be expected for the AAMGL option, which is now the requirement (refer to Section 5.3.1).

The abovementioned data indicates that there will be no significant change to the flow regime of the Serpentine River as a result of the Amarillo development proposal.

5.1.3 Serpentine River Bridge Crossings

The two crossings are located at the northern and central sectors of the site (refer to Structure Plan, Figure 8). Preliminary appraisal of these broad locations suggests that environmentally acceptable crossings can be selected. The reasons for this conclusion include:

- at both locations the river is restricted to a well-defined channel during normal summer and winter flow, therefore the expansive and ecologically productive pools have been avoided;
- in the northern sector the main channel of the river is actually a constructed "drain", which is a result of historical river training works, and the original foreshore and fringing vegetation has previously been cleared;
- the immediate river environs, including the majority of the floodway, have been grazed continuously for many years in both sectors and, due to the replacement of dryland vegetation with pasture there is no significant ecological linkage between the fringing, upland vegetation and river environment;
- there are sections of the central sector where the riverine vegetation is also relatively depauperate and therefore, as with the northern sector, a minimum impact crossing should be readily selected.

5.2 Effects of the Nutrient Management Strategy

This section reviews the anticipated performance of the nutrient management strategy, with a focus on the proposed constructed wetlands and the contingency phosphorus management measures. Potential environmental impacts of these elements are also addressed.

In order to evaluate the performance of the phosphorus management techniques which are proposed, particularly with respect to the phosphorus criteria for export to the Serpentine River, it is necessary to predict the likely phosphorus export rate which would occur prior

to application of any of the management techniques. Given the nature of the current database on phosphorus discharges from urban areas in Perth, there is an element of uncertainty in predicting phosphorus export from urban development proposals and the approach adopted is to estimate a broad range of export rates within which the development is most likely to fall.

Using this approach, estimates of phosphorus export from the site are presented in the Conceptual Nutrient Management Strategy (Part II) and the basis for these estimates is also presented. Without the benefit of treatment in any of the proposed BMPs, the range of export rates is estimated to be 0.28 to 1.0 kg-TP/ha/a. These are conservative estimates and they have been deliberately targeted on the high side of the likely export rates.

Data collected by the (then) Water Authority during 1990/91 at a number of urban sites in sandy catchments in Perth has been summarised by the Water and Rivers Commission in Section 12. The database has allowed derivation of estimates of phosphorus export rates and these fall in the range 0.095 to 0.538 kg-TP/ha/a. Note that this range of estimates is much lower than the estimates derived by the Proponent.

Consideration of the export rates derived in the Part II document and also those presented by the Water and Rivers Commission leads to the following salient points:

- It is possible that the export rate of phosphorus from a mature urban development at Amarillo, without modern BMP treatment techniques, will fall under the Serpentine River EPP limit of 0.27 kg-TP/ha/a.

- Implementation of a wide range of BMPs will be a prerequisite to development at Amarillo, therefore suggesting that the ultimate phosphorus export rate will be substantially below the EPP limit as recommended and supported by the Water and Rivers Commission.

- If the ultimate phosphorus export rate is at the high end of the range of estimates presented (ie approximately 1.0 kg-TP/ha/a) then at least a 73% reduction in phosphorus export from the site would be required in order for the development to meet the EPP target.

Further to the above estimates, monitoring data for major drains which discharge into the Swan-Canning Estuary strongly suggest that export rates of phosphorus from the predominantly sandy catchments are generally less than 0.60 kg-TP/ha/a. Summary data

from these catchments were published in EPA Bulletin 754 in September 1994. The significance of these data is that they indicate that the upper levels of the range of phosphorus export presented in the Part II document are highly unlikely to be experienced. This leads to the conclusion that, at most, management techniques will need to be introduced at Amarillo to achieve a 50% reduction in the phosphorus export rate in order to meet the catchment target. It seems likely that less than a 50% reduction will be required, which tends to alleviate concern regarding the uncertainty in the performance of the management techniques.

The calculations in the nutrient strategy document (Part II) ignore the present phosphorus content of the shallow groundwater and are based on figures derived from drainage studies in urban areas elsewhere ie, the figures assume long-term equilibrium conditions for a 'mature' or fully developed site. One of the potential interim impacts of the development proposal is that there may be an acceleration of phosphorus discharge from the existing soil/groundwater store because parts of the urban drainage system will be more efficient than the existing agricultural drains. This would only be a relatively short term effect but it is difficult to quantify.

There are four factors which should be considered when assessing this issue:

- fail safe phosphorus removal techniques are proposed as a contingency to control phosphorus export, including chemical treatment and soil amendment around sub-soil drains;

- the AAMGL requirement for the drainage system will restrict groundwater drainage and constructed wetlands will be used to maximise the retention of water from the 'more efficient' urban drainage system, which in combination will minimise the rapid transport of soil store phosphorus from the site and allow for treatment;

- the 1000 hectare tree plantation will substantially reduce the movement of phosphorus in shallow groundwater, which will counteract the potential increases in phosphorus transport in the early stages of urban development; and

- the long-term improvement to the phosphorus export regime which is expected at the site when an equilibrium situation is achieved.

If the short term and/or long term phosphorus export rate is at the higher end of the range presented herein, then clearly fail safe phosphorus management techniques will need to be implemented. These management techniques are described in Section 4.3.3 and are evaluated further below. A brief assessment of the BMP approach is also provided.

5.2.1 Best Management Practices

(i) Performance Evaluation

The suite of BMPs proposed for the Amarillo development are considered likely to achieve phosphorus levels which meet the EPP phosphorus export target. These BMPs include measures to reduce the quantity of drainage which is required to be discharged to the Serpentine River, extensive revegetation and riparian planting (fringing drains and watercourses) which will prevent erosion and assimilate phosphorus, and the constructed wetlands as previously mentioned. It is not possible to accurately predict the level of phosphorus reduction which will be achieved by individual BMP techniques. However, it is believed that at least a 50% reduction in phosphorus export is readily achievable by the combination of these methods.

The constructed wetlands on their own may achieve the requisite level of phosphorus reduction. Stringent adherence to the necessary design criteria will be followed by the Proponent. These criteria include the following:

- A residence time of inflowing water within the wetland in the range of 15 to 25 days to maximise the prospects for dissolved phosphorus removal.
- Adequate recognition of groundwater input to the wetland to ensure that sufficient treatment volume above groundwater level is provided for incoming stormwater.
- Surface area of wetland to be equivalent to 2 to 5% of the catchment area.
- A length to width (aspect) ratio within the wetland as a minimum of 2:1 and optimum aspect ratio of between 3 and 4.
- The desirable peak flow velocity through the system should not exceed 0.45m/s.
- The desirable cross-section should be a flat base with gentle banks. Other aspects of flow optimisation include avoidance of stagnant zones within the wetlands and

also avoidance of channelisation which would cause short-circuiting of water through the system therefore reducing treatment time.

- The treatment storage volume, or spare capacity within the wetland, should be sufficient to accommodate 90% of the annual peak drainage input.

- The estimated phosphorus mass loading to the system should not exceed $5g/m^2/a$.

- The desirable maximum water loading to the wetland should be in the vicinity of 190 $m^3/ha/day$.

The above design criteria have emerged from the literature describing successful constructed wetland systems. Important design information could also be gained from study of natural wetlands which act as a sink for phosphorus. For example, research has shown that The Spectacles wetland removes about 60 - 75% of nitrogen and phosphorus from throughflow drainage water in the Peel Main Drain (Murdoch University, 1995). This case study wetland is situated in a similar geomorphic setting to Amarillo.

(ii) Environmental Effects

It is acknowledged that there is very little local experience in the use of constructed wetlands for phosphorus removal and that most case studies are from overseas, although there is some experience accumulating in the eastern states. However, the overseas case studies demonstrate that considerable water quality improvement can be obtained through the use of artificial wetlands as water pollution control ponds. Importantly, they are used extensively in urban situations for stormwater treatment and are often incorporated as aesthetic features in public open space. There seem to be very few reports of unmanageable nuisance effects as a result of water quality problems within these wetlands.

The preliminary design approach at Amarillo is to allow a buffer of open space around each wetland comprising a minimum width of 50 metres to allow for vegetation screens to be planted in the event that a midge or mosquito nuisance develops and to enhance the nutrient removal capability of the wetlands.

Diversity is the key factor in a wetland system which will act to minimise the expression of biological productivity in a nuisance fashion, which may otherwise lead to midge problems. Therefore the most strategic management response is good hydrological design

to promote mixing throughout the wetland and a good biological design which incorporates as many features of a natural system as possible (fringing vegetation, extensive shallows with aquatic macrophytes, deep pools, introduction of aquatic fauna etc).

If the constructed wetlands form a relatively complete ecosystem this will also encourage the establishment of mosquito predators, such as fish and dragonflies. Control of mosquitoes and midges can also be carried out by chemical means, but this has a number of drawbacks and would only be considered as a management option of last resort.

5.2.2 Soil Amendment Around Sub-soil Drains

(i) Performance Evaluation

The use of red mud or bauxite residue as a soil amendment material is well documented locally. An example of performance capability is available from long term trials of the Ecomax effluent disposal system, which essentially uses amended soil as a filter medium for sewage treatment. Performance data are provided in Table 2 (courtesy of Ecomax Waste Management Systems Pty Ltd).

As shown in the table, the Ecomax system can achieve phosphorus concentrations in the range 0.01 - 0.05 mg/L. This is well below the criterion recommended by the Water and Rivers Commission which is 0.075 mg/L. Furthermore a phosphorus removal capability to 0.05 mg/L would yield an export rate in groundwater drainage from the proposed Amarillo development in the vicinity of 0.15 kg-TP/ha/a, which is below all of the proposed phosphorus criteria.

The fine particle size of bauxite residue will decrease the permeability of the sandy soils as the percentage of bauxite residue to sand increases. This would need to be carefully controlled to ensure the sub-soil drains function correctly in controlling excessive groundwater rise. This is not anticipated to be an issue because the amount of bauxite residue required to be blended in the soil profile is only small in order to achieve the benefits required. For example, only a 5 to 10% blend of bauxite residue in sand is considered necessary and the resultant amended soil mixture will have a soil permeability in the range 5 - 10 m/day. It is noted that the Ecomax system utilises a red mud/sandy soil blend containing approximately 15 to 20% red mud and the resultant permeability of the mixture is generally about 5 m/day.

Table 2

Perth Long Term Data
Typical Effluent Quality from Ecomax Septic System (mg/L)

Parameter	Final Concentration	Removal Efficiency
Total persulphate phosphorus	0.01 - 0.05mg/L	>99.6%
Total persulphate nitrogen	2.0 - 10.0mg/L	>80%
Ammonia nitrogen	<5mg/L	>90%
BOD	<10mg/L	>90%
pH	7.5 - 8.5	
Faecal coliforms	0 - 500/100ml	>99.95%
Suspended solids	<10mg/L	>90%

(Source: Ecomax Waste Management Systems Pty Ltd)

(ii) Environmental Effects

The potential environmental effects of soil amendment arise from the physical and chemical characteristics of bauxite residue, notably its alkalinity (high pH), its salt content and also the presence of trace elements and heavy metals. The potential effects of water quality changes as a result of bauxite residue usage needs to be considered in respect to the downstream receiving environment.

The effect of the alkalinity of bauxite residue on the pH of drainage waters can be reduced by adding gypsum to the amended soil. The need for gypsum addition would be determined during the initial trial period.

It is not considered that any increases in total soluble salts from the bauxite residue are likely to be of concern given the dilution factors which will occur subsequently through the drainage system. Note that the bauxite residue amendment technique will only affect groundwater quality which is collected within the sub-soil drainage system. This water will undergo substantial dilution through the wetlands and also via the addition of significant stormwater runoff which would also be directed through the sub-soil system. In any event the salts which leach from bauxite residue are common in aquatic systems.

In respect to trace elements and heavy metals, most elements are tightly bound and are unlikely to be released except under extremely acidic circumstances. However it is acknowledged that there may be an initial release of small amounts of some elements following initial placement of the amended soil material.

The above issues have previously been assessed by the Environmental Protection Authority during consideration of the broad scale use of bauxite residue as a soil amendment for existing agricultural and horticultural properties throughout the Peel-Harvey catchment (Bulletin 714, November 1993). The proposal involved the application of bauxite residue to grazing land at rates in the order of 10 to 20 tonnes/hectare with reapplication considered to be necessary after about five years. The proposal was considered environmentally acceptable by the EPA subject to an ongoing research and monitoring program to clarify some of the abovementioned concerns.

At the application rates envisaged for the sub-soil technique proposed at Amarillo the quantity of bauxite residue utilised is expected to be in the range 20 to 30 tonnes/hectare.

However reapplication will not occur. Furthermore there will not be an extensive or broad scale application of amended material in any one year. Should this contingency measure be implemented it would only be placed around the sub-soil drains during the subdivision process and therefore the rate of application would correspond to the rate of subdivision development. This may only be in the vicinity of 30 to 50 hectares/annum.

5.2.3 Chemical Treatment

(i) Performance Evaluation

Chemical treatment of stormwater is not commonly practised although the ability to precipitate phosphorus from wastewater using a variety of chemicals is well established. No published information has been identified describing chemical treatment of stormwater as a case study in Australia (Duncan, 1995; Scott, 1996). Chemical treatment of urban stormwater has been implemented overseas and published experience at Florida in the United States is available.

In Florida, specialised dosing equipment is utilised to inject a phosphorus scavenging chemical into the stormwater system prior to its discharge into nearby lakes. Some results from this experience are reproduced in Table 3. This is an example from a lake restoration project in Tallahassee, Florida and confirms the high performance capability of chemical treatment. The total phosphorus concentration in the lake water was reduced to less than 0.03 mg/L (Harper and Herr, 1992).

A phosphorus removal capability to approximately 0.03 mg/L would yield an export rate in stormwater drainage from the proposed Amarillo development in the vicinity of 0.09 kg-TP/ha/a, which is below all of the proposed phosphorus criteria.

The stormwater treatment at Florida was conducted using alum. Alum is the chemical most often used because the precipitated phosphorus complexes are apparently more stable in the deep water lakes which are typical of the northern hemisphere. In deep water lakes there is concern with phosphorus release during the development of anoxic conditions (Cooke *et. al.*, 1986).

Other chemicals are available, for example ferrous chloride which is commonly used for phosphorus removal in sewerage effluent, notably in the Eastern States. Perhaps the best example of the performance capability of ferrous chloride is available from the experience

Table 3

Comparison of Water Quality Characteristics of Lake Ella Before and After Initiation of Alum Stormwater Treatment

Parameter	Units	Mean Chemical Characteristics Prior to Alum Treatment (1974-1985)	Mean Chemical Characteristics With Alum Treatment (1/88-5/90)	Percent Change (%)
pH	s.u.	7.41	6.43	-13
Dissolved O_2	mg/L	3.5	7.4	+111
Turbidity	Ntu	22	2.5	-89
Total N	mg/L	1.88	0.417	-78
Ortho-P	mg/L	0.023	0.002	-91
Total P	mg/L	0.232	0.026	-89
Chlorophyll-a	mg/m^3	180	5.1	-97
BOD	mg/L	41	3.0	-93
Secchi Disk Depth (Transparency)	m	<0.5	>2.2	+340
Diss. Aluminum	µg/L	-	44	-
Total Aluminum	µg/L	-	193	-

(Source: Harper and Herr, 1992)

at the Lower Molonglo treatment plant in Canberra. This treatment plant is the largest inland wastewater treatment facility in Australia and treats approximately 100ML/day and removes phosphorus using a combination of lime and ferrous chloride dosing. The effluent output from the Lower Molonglo treatment plant has total phosphorus concentrations which average approximately 0.08 mg/L (Schmidt, 1995). The effluent consistently achieves soluble orthophosphate concentrations of less than 0.05 mg/L (FERRAQ, 1996).

The Lower Molonglo experience in Canberra demonstrates that large volumes of water can be effectively treated for phosphorus. The main limitation in removal of total phosphorus concentrations is the residual suspended solids concentration from the initial sewerage effluent. However the reduction of soluble phosphorus exceeds the requirements to meet the proposed phosphorus criteria for Amarillo. It is this latter component of phosphorus which may be difficult to consistently remove to low levels in the constructed wetlands and therefore chemical treatment is a technically viable contingency measure.

(ii) Environmental Effects

Concern has been expressed at the residual levels of aluminium evident from the Florida experience (Table 3) and the possible toxic effects in aquatic ecosystems. The ANZECC guidelines for water quality to protect aquatic ecosystems states that the total aluminium concentration in fresh waters should not exceed 5µg/L if the pH is 6.5 or less, and should not exceed 100µg/L if the pH is greater than 6.5 (ANZECC, 1992). As shown on Table 3 the residual aluminium in Florida would exceed the ANZECC guideline for Australian fresh waters.

It is for this reason that other chemicals such as ferrous chloride or calcium hydroxide would most likely be used at Amarillo should chemical treatment be required as a contingency measure. There is less concern over the use of iron salts in this situation given that the ANZECC water quality guideline for iron in aquatic ecosystems is much higher at 1,000 µg/L.

There is a local case study involving alum dosing to a natural wetland, which was conducted as a trial to control phosphorus levels and consequently reduce algal bloom and midge nuisance effects. Alum was applied to Jackadder Lake over a two day period in 1988 and chemical and biological monitoring was conducted over a seven month period.

The conclusion of this study was that the "treatment of Jackadder Lake with alum appears to have enhanced water quality with no detrimental effects on the biota" (Lund & Chester, 1991). Residual aluminium levels in the water were not reported.

5.3 Effects of the Drainage Strategy on Groundwater

5.3.1 Effects of Changes to the Superficial Groundwater Regime

From the environmental perspective, the degree of shallow groundwater protection that is necessary is related to the presence of remnant vegetation and wetlands which may be reliant on a specific water table regime. The two main factors which are relevant to assessment of this issue are as follows:

- there will be minimal adverse change to the water table because the drainage system is required to operate such that the average annual maximum groundwater level (AAMGL) is maintained following development;
- the ecological condition and conservation value of the remnant vegetation and wetlands on the Amarillo site does not preclude a change in water table, particularly because the potential loss of some or all of these elements would be more than compensated by the proposed landscaping and wetland creation.

As discussed further in Sections 5.5.1 and 5.5.2 below, none of the remnant vegetation and damplands on the eastern side of the Serpentine River are considered to have regional conservation significance. In addition, they have survived relatively large water balance and hence, groundwater level, changes in the past as a result of clearing in the region and development of agricultural drainage. Therefore it has been concluded that some water table alteration would be acceptable.

The issue of conservation of water resources for future potable supply also requires assessment. In this context, it is not necessary to protect the on-site groundwater because once the site is developed for urban purposes it would have limited value as a potential future potable supply. Furthermore, it is not necessary to consider protection of 'down-gradient' resource areas for drinking water supplies because the shallow groundwater discharges to the Serpentine River. However, land adjoining the eastern boundary of Amarillo is proposed as a future groundwater abstraction area by the Water Corporation (Figure 5).

The proposed urbanisation of Amarillo would not affect the water quality of the groundwater resource to the east, because the direction of flow is from east to west.

The degree to which water quantity is affected would be dependent on the amount of water table change (lowering) within Amarillo and the extent to which this affects the water table position to the east of the site. As mentioned above, the requirement is that the proposed drainage system maintains the average annual maximum groundwater level (AAMGL). However, the long-term AAMGL may be slightly lower than current water table maxima, because of the water table rise which would have occurred following clearing of the regional native vegetation.

At present it is not possible to quantify the degree of water table change to the east of Amarillo, as the AAMGL is still under investigation. However, it will only be a minor change, if any. Consequently, it is doubtful that there would be a major impact on the total amount of water available from the proposed borefield.

Groundwater abstraction by the Water Corporation may be limited more by environmental factors within the proposed borefield, as opposed to the potential effects of the Amarillo development. For example, there are more substantive tracts of remnant vegetation on private land immediately to the east of Amarillo which may be considered to be locally significant in the context of the paucity of native vegetation on a regional scale. Phreatophytic (groundwater dependent) components of these remnants may experience reduced water availability if there is water table drawdown due to the Water Corporation's proposed borefield and/or the development on Amarillo. However, the groundwater and stratigraphic investigations conducted on the Amarillo property indicate that the presence of 'coffee rock' layers in the sub-surface would act to mitigate the effects of a lower water table within the main or regional superficial aquifer. This is because the coffee rock provides a localised perching mechanism for recharge water which would tend to reduce the impact of any regional drawdown effects. Also, it is noted that the vegetation is not protected from clearing and is subject to a variety of on-going disturbances such as weed invasion and stock access.

5.3.2 Potential for Upward Leakage from the Leederville Formation

The primary evidence of upward leakage potential derives from the differential hydrological heads recorded in regional monitor bores located near the western boundary of Amarillo Farm. However, these bores and other deep bores drilled for the Amarillo investigations, indicate that leakage is likely to be strongly attenuated, if not prevented, by

confining layers which separate the aquifers. For example, an artesian monitor bore on the western boundary of the site encountered glauconitic sandstone at 64 metres below ground level (mbgl), clay at 78 and 87 mbgl, and shale at 185 mbgl. Two of the three deep bores drilled on the eastern side of the Serpentine River on behalf of Homeswest also encountered confining layers (a third bore did not encounter a confining layer to a depth of 75 mbgl, which was the limit of rods available to the driller at the time). The other two bores recorded a dense black clay layer at 14-16 mbgl and dense grey to black clay layer at 54-57 mbgl, respectively.

Notwithstanding the above, the zone of potential upward leakage only encompasses approximately 25-30% of the proposed Amarillo development area on the eastern side of the Serpentine River (Figure 11). Evaluation of relative water level gradients in the Leederville Formation and the superficial aquifer indicates that the difference in water levels decreases to the east and eventually there is no potential for upward leakage (refer to Figure 10). Calculations by A.J. Peck and Associates (Groundwater Hydrologists) reveal that the potential for leakage is zero at approximately the 6 metre (AHD) water table contour. Potential leakage would be downwards to the east of this line and therefore there is a potential upward leakage from the underlying Leederville aquifer only over a relatively narrow strip of the Amarillo property proposed for development (refer to Figure 11).

5.4 Assessment of Adjacent Land Use Compatibility

5.4.1 Odour Emissions from Wandalup Piggery

As described in Section 4.4.1, interim management of the odour issue involves allocation of a buffer zone to separate the initial residential areas from the piggery and hence, minimise odour nuisance.

Preliminary assessment of wind data indicates that the risk of odour nuisance is not substantial. Wind data were obtained from the Bureau of Meteorology for Mandurah, the closest long-term monitoring station, for the period 1965 to 1985. Annual wind rose plots were produced for 9am and 3pm, as shown on Figure 12.

Odour dispersion patterns are affected by the direction and strength of the prevailing winds, and the stability of the atmosphere (ie, the degree of vertical, turbulent mixing of air between ground-level and say, 1000 metres).

The risks of odour problems occurring within the Amarillo property are greatest as follows:

- during periods of southerly winds, which occur for about 11% of the year in the mornings and for about 16% of the year in the afternoons (Figure 12);
- during periods of very light winds from the southern quadrant in combination with stable atmospheric conditions, however it is not possible, from wind roses alone, to determine the frequency of occurrence of these conditions (mostly late-autumn, winter and early-spring).

Homeswest will establish an interim odour buffer in consultation with the EPA and planning authorities. Figure 7 shows the relationship between the Wandalup piggery and the Amarillo site.

5.4.2 Potential for Noise Disturbance

At present none of the potential noise generating activities in the vicinity of the site represent a constraint to the proposed residential development of Amarillo. Some brief comments are provided below in support of this preliminary conclusion.

- The dog kennel Special Rural estate is not a substantial noise source and is too remote to be of concern (the northern boundary of the estate is located approximately 1800 metres from the southern boundary of Amarillo).
- The Murrayfield Airpark was the subject of two Consultative Environmental Reviews (CER's) prepared in 1993. The Airpark was approved on the basis of the second CER. Figure 13, reproduced from this CER, shows the northern training circuit for the Airpark as being just coincident with the southern boundary of Amarillo. Figure 14 shows that the 25 ANEF contour for the ultimate capacity of the Airpark falls well outside the southern boundary of Amarillo. The 25 ANEF contour is regarded by aviation authorities as being the upper limit for residential development.
- There is conflicting anecdotal evidence regarding noise from the Wandalup piggery (the principal source of noise is the pigs during feeding), but some advice suggests that noise may be audible at night under certain circumstances for some

distance from the sheds. No noise monitoring has been conducted to assess the extent of potential nuisance. The sheds housing the pigs are located approximately 1,500 metres south of Amarillo's southern boundary and, given that a buffer zone will be required for odours (Section 4.4.1 above), there will be ample separation between the noise source and future residences. Piggery noise may only be an issue of concern if the buffer zone is substantially reduced, and would require further investigation at the time.

- The small aircraft landing strip to the north-east of the site (1,500m from the NE corner) is used by a private club only and does not support large numbers of aircraft. Some aircraft have previously conducted low manouvres over Amarillo resulting in disturbance to stock. However, approaches to the club via the Civil Aviation Authority have excluded this activity and similar control would be implemented for the proposed residential development.

5.5 Assessment of Other (Minor) Issues

5.5.1 Remnant Vegetation

The draft Structure Plan protects most pockets of remnant vegetation within the proposed POS network. This is because they are perceived to be locally significant, at least from a landscape perspective, although some disturbance would be acceptable given that they do not have regionally significant conservation value. Consequently, it is not critical that these remnants are sustained, particularly in view of the substantial revegetation which is proposed during development of the site. Any loss of the existing remnants will be substantially compensated for by replacement, rehabilitation and enhancement throughout the site.

The above assessment that there are no regionally significant conservation values outside of the proposed Regional Park is at odds with the Waterways Commission report (Siemon *et al*, 1993). This report states that there is a *Juncus kraussii* community of high conservation value which is apparently extensive and clearly implies that it continues outside of the proposed Regional Park. The report's findings are disputed on two grounds. Firstly, at the time of the study the sedgeland was not extensive as it was characterised by a relatively fragmented distribution with variable density (it is even more reduced now because the site is again being actively managed as a pastoral property, since lying idle for the period 1989-1991). Secondly, much of the sedgeland is not original

vegetation and would have developed as a result of a combination of the water table rising (creating more areas with sufficient water availability for the species) and the fact that it is not palatable to stock. Therefore the "extensive" attribute of the sedgeland is an artefact of agricultural practice and consequently has no significance for the conservation of native vegetation (Trudgen, 1993).

5.5.2 Wetlands (EPP Lakes and other wetlands)

EPP Lakes: None of the on-site EPP lakes will be directly affected by the development proposal as they will be retained within the proposed Regional Park. They will not be indirectly affected by potential water table alteration on the eastern side of the river, because of the hydrological boundary represented by the river. In addition, there will be no direct discharge of drainage to any of the wetlands. One of the EPP wetlands, "Lake Amarillo", is actually a pool on the Serpentine River and will thus receive some drainage from residential areas. A biological wetland filter will be constructed to treat drainage prior to entering this wetland. Furthermore, Lake Amarillo is currently subject to severe sedimentation problems due to inflow from the Dirk Brook Drain and Homeswest is actively liaising with the Water Corporation (who have responsibility for the Dirk Brook Drain) to ensure that the appropriate steps are implemented to rectify the problem as soon as possible.

In the long term, some of the off-site EPP wetlands may be affected by water level changes due to the combined effects of the urbanisation proposal and the proposed Water Corporation borefield. Careful management will be required to ensure that adverse changes do not occur. There are two principal mitigating factors in respect of the potential impacts of regional water table drawdown:

- it is most likely that the regional water table has risen in the past due to extensive clearing and the consequent changes to the water balance following the conversion of native vegetation to pasture, therefore any drawdown may simply reverse this trend;

- the apparent local perching of groundwater above coffee rock would also act to dampen the effects of any regional water table decline.

Detailed assessment is not warranted at this stage because the combined effects of the Amarillo development and the proposed borefield are indeterminate. Also, the location

and current condition of the EPP wetlands require verification as the regional wetland mapping conducted for the EPP has on occasion been misleading.

Other Wetlands: The majority of the Amarillo site is mapped as palusplain ie, seasonally waterlogged flats. The ecological impact of development on these areas will be negligible as they are a completely altered ecosystem due to clearing for pasture. Remnant areas which have not been cleared will be retained and enhanced in the development of the multiple use drainage network.

5.5.3 Trees (Landscaping and Groundwater Pumps)

Every tree planted on Amarillo Farm will have a beneficial effect on the environment, from the perspectives of water balance, phosphorus dynamics, landscape and resource enhancement.

On the issue of persistence, it is erroneous to assume that all the trees would be the same age or a species monoculture, with consequent greater risk of a calamitous event destroying large areas of the POS/drainage network. Amarillo would be developed over at least a 30-40 year lifespan which would mean that the trees would be in a variety of age classes. In addition, a mix of species would be planted in the longer-term, in comparison to the present emphasis on mostly Tasmanian Bluegums for the interim period, when yield for woodchips is a primary consideration.

5.5.4 Construction Phase Effects

The construction phase for the Amarillo project will proceed in stages over many years, as mentioned previously. No adverse effects are anticipated during construction periods, as the appropriate management techniques which have been formulated elsewhere in the land development industry will be applied as a matter of routine (for example, refer to Section 4.5.4).

The need to dewater groundwater during certain construction works is also recognised as an issue in respect to disposal of the groundwater. This groundwater may have elevated levels of phosphorus and therefore will be retained on-site via infiltration in nearby areas (during periods of low water table) or irrigated to areas of tree plantations.

6.0 MANAGEMENT RESPONSIBILITIES AND PROPOSED ENVIRONMENTAL MANAGEMENT PROGRAMME

The proposed environmental management of each key issue is summarised in Section 4.0 and an evaluation of the residual environmental impacts is conducted in Section 5.0. It is clear from these sections that improved environmental performance of the proposed urban development will necessitate an on-going commitment to management, which is consistent with modern environmental practice.

The critical elements of on-going management are discussed below.

6.1 Management Responsibilities

The main areas where management responsibilities need to be identified at this stage of development planning are as follows:

1. Regional Open Space, and

2. Drainage System.

These are discussed separately below.

6.1.1 Management Responsibility for the Proposed Regional Open Space

Homeswest is not responsible for management of the Regional Open Space (ROS). Allocation of land for, and establishment of, the ROS is a requirement of the State Government in accordance with the System 6 Report and the South-West Corridor Structure Plan. Management is therefore a Government responsibility.

The expertise for management of the nominated ROS lies with a number of Government agencies. A joint approach is recommended, with one agency adopting a lead role to co-ordinate the various inputs required. As mentioned in Section 4.2.1, the appropriate lead agency is likely to be the Peel Inlet Management Authority (PIMA).

In its management plan for the Peel Inlet and associated waterways, PIMA has prepared specific management recommendations for the Goegrup Lakes area, which includes Yalbanberup Pool and parts of the Serpentine River to the north (up to the MRS boundary which therefore encompasses the southern one-third of the Amarillo section of the river). The recommendations in PIMA's management plan include a number of items related to management responsibilities, notably:

- *"Investigate the conservation value of Goegrup Lake and the adjacent lake systems. Consider vesting environmentally valuable areas in NPNCA in the context of the proposed Peel-Harvey Regional Park."*

- *"Acquire appropriate foreshore reserves as a condition of any rezoning or subdivision."*

- *"Ensure the appropriate vesting and management of foreshore reserves."*

- *"Implement the General Recommendation 23 relating to the Waterways Protection Precinct"*. An indication of the Waterways Protection Precinct is shown in PIMA's management programme, which also lists a range of measures which PIMA will implement in order to protect the waterways and fringing areas in the precinct.

PIMA is proposing to extend its administrative boundary further along the Serpentine River, ie, upstream of the MRS boundary. Once this is achieved, the above initiatives would encompass the entire river section within the Amarillo property.

6.1.2 Management Responsibility for the Proposed Drainage System

Initially the proponent accepts management responsibility for the drainage system, however ultimately the on-going management will be the responsibility of State Government and/or Local Government agencies.

It is proposed that a Technical Review Committee (TRC) be established prior to the initial stage of development to facilitate all aspects of drainage management. This is consistent with recent practice for other urban developments where drainage has been a major issue, for example at South Jandakot and the Ellenbrook development.

The two most important functions of the Technical Review Committee will be firstly, to determine the transitional arrangements for handover of management responsibility from the proponent to the final "manager" and secondly, to provide the relevant expertise for review and auditing of the drainage scheme. Therefore, in the instance where components of the drainage scheme are ultimately managed by the relevant Local Authority (City of Rockingham or Shire of Murray), and these authorities initially do not have the necessary expertise, then the TRC would be able to provide this expertise.

The composition of the Technical Review Committee is expected to be senior technical personnel from agencies such as the Water Corporation, the Water and Rivers Commission, the Department of Environmental Protection, the Peel Inlet Management Authority and Local Government. Both Engineering and Environmental representatives would most likely be required, including the proponent's technical representatives.

There is an emerging regulatory perspective that stormwater management needs to be treated like a business with identifiable customers. The eventual management body may adopt this approach and indeed, the new Water Corporation may be the most appropriate lead organisation in this regard. The Proponent has approached the Water Corporation seeking its interest in becoming involved in drainage treatment for nutrient removal at Amarillo. The Water Corporation has responded positively in this regard (refer copy of correspondence in Section 12).

The complete organisational structure and functions of the Technical Review Committee will be determined during the detailed design stage, prior to subdivision. This will be contained within a detailed Environmental Management Programme that will be prepared and agreed prior to subdivision approval.

6.2 Environmental Management Programme

The Environmental Management Programme will provide the additional technical information which is now being requested for this project, particularly in regard to fail safe phosphorus removal techniques. The scope, content and period of regulatory scrutiny of the Environmental Management Programme will be agreed with key Decision-Making Authorities. Some important aspects of the Environmental Management Programme include design and management planning, monitoring, reporting and contingency planning, which are briefly discussed below.

6.2.1 Design and Management Planning

The Environmental Management Programme will provide all of the detailed design and management planning to allow implementation of the project. All of the environmental objectives for the project will be included in the EMP along with a description of the management techniques which are intended to meet those objectives.A preliminary outline of proposed management is included elsewhere in this document (Section 4.0 and Summary Table 1) and these elements will be expanded in the EMP.

Specific design and management requirements to be addressed in the EMP include, but are not necessarily limited to, the following elements:

- Definition of the AAMGL, in consultation with the Water and Rivers Commission;

- Selection of a range of Best Management Practices (BMPs) for consideration as per the requirements of water sensitive design. This will involve a range of non-structural and structural BMPs. Non-structural BMPs include public education and community involvement programmes for example, to encourage minimal fertiliser usage and to maximise tree planting within subdivisions. Structural BMPs include local disposal by infiltration in filled areas, minimising directly-connected impervious areas, grass swales and buffer strips, extended detention basins and constructed wetlands including fail safe phosphorus removal techniques as a backup.

- Particular attention will be devoted to the relatively new (for Perth) stormwater quality management practices. These include:

  - design criteria for constructed wetlands as nutrient stripping ponds;
  - design and management requirements for chemical dosing including fate of nutrients;
  - design and implementation techniques for the proposed sub-soil drain filters (red mud amended soils).

- Strategic trials will be outlined to test different management techniques for drainage, nutrient and groundwater control within sub-precincts of the development on the eastern side of the Serpentine River, to be completed during the first three to five years. The objective will be to assess the various techniques

and further refine the drainage strategy for subsequent stages of development, on the basis of monitoring of the performance of the sub-precinct trials, with emphasis on achieving minimal phosphorus export.

- A staging plan will be prepared, with particular emphasis on the staged implementation of drainage management works. A flexible approach will be required given that future stages may be dependent on the results of the trials outlined above, therefore the EMP would be revised after (say) five years, in consultation with the proposed Technical Review Committee.

- A management plan will be prepared for construction activities including transport and distribution of fill and the fate of groundwater dewatering.

- The results of consultation with the Regional Park Manager (or interim nominee) will be outlined, notably the management measures to be implemented by the Proponent to facilitate protection of the conservation values of the riverine system during the early stages of development, whilst optimising the recreational benefits of the river for the future landowners at Amarillo.

- Environmental assessment and management of the proposed bridge crossings across the Serpentine River.

- A staging plan of investigations and consultations with respect to resolution of the Wandalup piggery odour buffer, which has been informally advised as 5km. The EMP will outline for agreement the scope and nature of investigations which would be required to rigorously define an appropriate buffer.

- Land use management requirements in the potential capture zones of future groundwater abstraction bores will be presented, following consultation with the Water and Rivers Commission.

6.2.2 Monitoring and Reporting

A monitoring programme will be designed to allow quantitative assessment of the environmental performance of the Amarillo urban development. Monitoring will mostly be associated with aspects of the drainage strategy, involving water quality and quantity parameters in respect of surface water discharges from the development and the effects on

the shallow groundwater regime. A reporting and review process (audit programme) will also be established to enable review of the monitoring data on a regular basis and this will be linked with the staging of development so that modifications can be made (if required) to elements of the drainage strategy during subsequent stages.

Again, the monitoring and reporting process will be similar to the programmes established for the South Jandakot and Ellenbrook developments. Initially, at least a ten year programme for Amarillo is envisaged because of the following factors:

- there will be variability in seasonal factors between years, such as rainfall and groundwater levels, which may affect the performance of the drainage system and therefore these differences will need to be taken into account;

- functional components of the drainage system, such as the artificial wetlands (water pollution control ponds) are expected to take time to reach maturity in respect of biological production and hence their maximum performance level may not be reached for a number of years;

- the staged development of the project, and the fact that techniques new to urban drainage management in Western Australia are proposed, means that a reliable indication of the equilibrium position with respect to phosphorus discharges from the urban development in its own right, may not become apparent for a number of years.

The Proponent will be responsible for design of the monitoring programme, in consultation with regulatory authorities as represented on the Technical Review Committee. The Proponent will initiate the programme, including the collection of appropriate baseline data, and conduct post-development monitoring for a period yet to be specified and agreed.

The adequacy of the monitoring programme and management of the resultant data will also be kept under review to ensure that it is responsive to the needs of the audit process and the on-going detailed design of subsequent stages of the development.

In summary, the objectives of the monitoring and reporting programme may be stated as follows:

- to allow an assessment of the overall drainage strategy against specific performance criteria (as outlined in Section 4.3.2 for phosphorus export) to determine the need for modification of 'macro' elements of the strategy, such as the best planning practices of water sensitive design;

- to evaluate the effectiveness of individual elements of the drainage works, such as chemical treatment and the water pollution control ponds, in reducing the pollutant loads in stormwater and subsoil drainage, so that modifications can be made and/or additional treatment techniques introduced within the ponds or elsewhere in the drainage system;

- to identify any adverse impacts off-site, for example due to changes in groundwater levels (which may potentially affect vegetation and wetlands) or due to discharge of drainage waters (which may potentially cause erosion, sediment deposition, flooding and water quality changes);

- to provide baseline and on-going data for the review of operating criteria for the drainage system in order to determine the need for modification of future design criteria.

6.2.3 Contingency Planning

A contingency plan will be prepared to guide the future development of the site in respect of potential modifications which may be required to project elements. The need for implementation of any contingent items will be ascertained from the monitoring programme, ie, by assessment of monitoring results and comparison with management criteria (performance objectives).

A comprehensive contingency plan will be prepared during the detailed design stage of the initial development. However, at the present stage of technical design and project planning, some consideration has been given to the potential problems which may arise (ie, non-performance of elements of the strategy) and to the potential solutions which could be implemented.

The potential problems and optional solutions for the water quality aspects of the Amarillo project are summarised in Table 4. This may be regarded as a preliminary contingency plan for the project, in which the main focus is on the drainage strategy.

Table 4 : Outline of Contingency Plan for Water Quality (Phosphorus)

(i)	Element	Drainage to Serpentine River.
(ii)	Problem	Phosphorus export exceeds criteria (load and/or concentration).
(iii)	General Solutions	Hierarchical Approach: Firstly, introduce additional techniques to reduce phosphorus content of water, and/or secondly, reduce volume of water discharged to river.

Contingency Options - As per list below

- Increase size of detention basins or add more basins (only effective for particulate phosphorus of "settleable" size).
- Introduce more vegetated drainage swales in local drainage system.
- Increase size of artificial wetlands or add more wetlands (for potential biological removal of phosphorus).
- Provide a greater proportion of wetland area with shallow macrophyte zones.
- Allocate more land to dedicated tree plantations.
- Achieve more groundwater utilisation on-site, for example, more use on private gardens, irrigation of trees to maximise evapotranspiration etc.
- Create larger wetlands to maximise evaporative losses.
- Use more fill on allotments to further reduce groundwater drainage requirements.
- Consider separation of groundwater and stormwater drainage in some areas, with direct discharge of stormwater if quality is satisfactory. (This will enable more storage of sub-soil drainage on-site).
- Introduce red mud soil amendment to achieve phosphorus removal from groundwater drainage, for example:
  - in active POS (ovals) ie, when not in use, divert groundwater drainage from higher in the catchment to an oval which has been soil-amended and designed as an "infiltration basin" (by using sub-soil drains beneath the oval).
- Introduce chemical treatment of stormwater, as described elsewhere in this document.
- Design for larger lot sizes with restrictive covenants to ensure establishment of a specific minimum tree density to be achieved within (say) three years of house construction.
- Education of landholders/builders to achieve zero surface discharge from allotments (ie total infiltration) and minimal fertiliser usage.
- Pump a proportion of drainage to infiltration basins to the west of the property, in the Spearwood dune system (ie, use as recharge for Stakehill Groundwater Mound).

7.0 CONCLUSIONS

1. The proposed environmental management of the change in land use from pastoral to urban residential at Amarillo is predicted to have a nett beneficial effect on the receiving environments (on-site and off-site). Evaluation of the potential impacts on the environment confirms that Amarillo Farm could be developed for urban purposes in an environmentally acceptable fashion. This evaluation is based on conservative assumptions regarding the performance of the management techniques proposed. The principal benefits which would emerge are summarised in the list below, in regard to the previous and current impacts of pastoral use, which are identified in bold type.

- **Peel-Harvey Eutrophication:** A substantial reduction in the export of phosphorus to the Serpentine River and hence the Peel-Harvey Estuary will occur in the longer term in comparison to the previous losses from pastoral activity; estimated to be in the vicinity of a 60% reduction.

- **Riverine Vegetation Loss:** The loss of remnant fringing vegetation along the Serpentine River which has occurred due to clearing for pasture and indiscriminate stock access will cease and approximately 730 hectares of land, including all of the important river pools and associated wetlands, will be allocated to form part of a Regional Park.

- **Erosion and Siltation:** Erosion of soil disturbed by livestock will cease with the change in land use and in addition, the revegetation of drainage lines and construction of large detention basins during the urbanisation process will prevent the transport of sediment along drainage lines to the river (with the exception of Dirk Brook Drain, which is the Water Corporation's responsibility).

- **Landscape Degradation:** Substantial landscape enhancement will occur at the site which is currently a flat, almost featureless, pastured plain. Improvements will include revegetation with perennial trees, retention of all pockets of remnant vegetation deemed to have residual natural and landscape values, and the construction of artificial wetlands.

2. Consideration of the environmental issues associated with urbanisation of the Amarillo site, and the residual environmental impacts which would potentially occur after application of the proposed management initiatives, indicates that none of the identified issues are an absolute impediment to implementation of the development proposal. The principal issues which require further consultation and government approval are essentially twofold, as listed below.

- **Average Annual Maximum Groundwater Level:** The maximum design depth of the open drains and sub-soil drains, which relates to the issue of water table drawdown below the AAMGL and potential for mobilisation of the existing soil/groundwater phosphorus, needs to be established prior to further detailed drainage management planning.

- **Odour Buffer:** The size of the odour buffer zone around the Wandalup Farm piggery needs to be established prior to residential development in the south-eastern sector of the site. Alternatively, a decision is required on whether or not the piggery will eventually be relocated within the timescale of the project (which is more than 25 years), prior to initiation of the complex studies which would be required to accurately define the buffer zone.

3. Detailed management plans need to be prepared for specific issues, supported by additional investigations in some instances to assist design and/or establish an appropriate monitoring regime. However, sufficient information is available from the work that has been conducted so far to confirm the technical feasibility and environmental acceptability of the project. The primary detailed tasks which require attention prior to implementation of the project are listed below.

- **Refinement of Strategy:** Detailed design of the major components of the drainage strategy needs to be conducted prior to the first stage of subdivision. For example, the main drainage corridors and the water pollution control ponds require detailed planning and design to confirm the initial design specifications (volumes and retention times etc), including incorporation of fail safe phosphorus removal techniques.

- **Management Responsibilities:** The ultimate manager(s) of the drainage system should be resolved prior to subdivision so that the transitional period can be defined, ie, the handover arrangements between the proponent and the final

manager. Also, the manager of the Regional Park is not yet resolved but this is clearly a State Government responsibility and is independent of the Amarillo project as the same applies to other Regional Parks elsewhere.

- **Monitoring and Contingency:** Monitoring and contingency plans need to be prepared as outlined in Section 6.2 above. The size of the site and the fact that the development will be staged over many years, means that there is considerable flexibility in terms of modifications (if necessary) to the drainage management strategy in subsequent stages of development, as indicated in the contingency plan outline (Table 4).

4. The assessment conducted herein, in combination with the technical information in the supporting appendices, is sufficient for the project to proceed through the planning process to enable the site to be rezoned to Urban. The additional detailed management and design items will be completed and submitted for approval prior to subdivision, in the Environmental Management Programme.

8.0 PROPONENT'S COMMITMENTS

The Proponent is committed to resolving all of the issues associated with the urbanisation of Amarillo Farm in an environmentally acceptable fashion. This is implicit to the land allocated for drainage functions in the draft Structure Plan for the project (Figure 8), the conceptual nutrient strategy (Part II) and the proposed environmental criteria, management and contingency planning discussed in previous sections of this document. A summary of the principal commitments which are implicit to the Proponent's environmental management strategy is provided in Table 5 which follows.

TABLE 5

SUMMARY OF PROPONENT'S COMMITMENTS

Issue	Objective	Commitment	Timing (Phase)	To Whose Satisfaction	Performance Indicator (if any exist)
A: Management Framework Environmental Management Programme (EMP)	To develop and implement an Environmental Management Programme as the basis for 'best industry practice' environmental management of the project's construction and operation phases.	***Commitment 1*** Prior to subdivision, the Proponent will prepare and implement an Environmental Management Programme, including monitoring and audit programmes, for both the construction and operational phases of the proposed residential development as outlined in Section 6.2 of the PER. Furthermore, the Proponent will ensure that all contractors involved in the project will comply with the environmental management strategies and procedures described in the EMP.	(i) <u>Relative to Planning Process</u> • Develop EMP during re-zoning process and submit prior to subdivision approval. (ii) <u>Relative to Development Process</u> • Develop EMP in the pre-construction (i.e. design) phase. • Implement EMP during the construction phase	Develop in consultation with the Water and Rivers Commission (WRC), DEP and other relevant State and Local Government agencies to meet the requirements of the EPA.	Scope, content and period of regulatory scrutiny of EMP to be agreed with key Decision Making Authorities (DMA's). Preliminary outline of EMP provided in Section 6.2.
B: Biophysical Impacts Protection of regionally significant vegetation, flora and fauna habitat (Serpentine River).	To define a boundary for the proposed Serpentine Regional Park within Amarillo which reflects the intent and objectives of the System Six Recommendation for the area and includes an adequate buffer zone between development and areas of high conservation value.	***Commitment 2*** The Proponent will facilitate implementation of the proposed Serpentine Regional Park during Amarillo's planning and development process. When the boundary has been agreed and surveyed, the proponent will manage its activities outside of the boundary to ensure that these activities do not degrade the conservation values inside the boundary. Environmental assessment and management of the bridge crossings will be included within the EMP.	Different boundaries have been nominated in various studies over recent years and these need to be reconciled when the land is re-zoned.	EPA, Ministry for Planning (MFP), CALM, WRC, PIMA.	Over time, regeneration of native vegetation to occur within Regional Park. Floodplain protected and no upstream flooding as a result of the development.
Protection of remnant vegetation (locally significant) and wetlands, including EPP wetlands.	To minimise disturbance to good condition remnant vegetation and wetlands (on-site) and ensure that vegetation and wetlands (off-site) are protected from adverse hydrological effects.	***Commitment 3*** The Proponent will incorporate the principal good condition vegetation and on-site wetlands into Public Open Space (POS, including the proposed multi-purpose drainage corridors) to ensure their protection. Changes to the water table which may cause adverse hydrological effects to vegetation and wetlands, both on-site and off-site, will be prevented (refer Commitment 4).	Construction and Operation Phases	EPA, WRC	Maintenance of vegetation and wetland condition at nominated locations on-site (inference is that protection of on-site elements, for example from adverse water table changes, will also protect off-site elements).

Issue	Objective	Commitment	Timing (Phase)	To Whose Satisfaction	Performance Indicator (if any exist)
B: Biophysical Impacts (Cont'd) Protection of groundwater resources	To minimise changes to the superficial water table, as a result of the proposed drainage system, which would jeopardise regional groundwater resources, notably the proposed Serpentine public water supply area and groundwater source protection area.	***Commitment 4*** The Proponent undertakes to install a drainage system which maintains the 'average annual maximum groundwater level' (AAMGL) in accordance with Water and Rivers Commission advice, until such time that confirmation (satisfactory to EPA) is available that phosphorus export can be controlled irrespective of the depth of the drainage system, and that minor lowering of the water table does not cause an unacceptable water resource impact, on-site or elsewhere. Furthermore, the Proponent undertakes to manage the drainage system passing through the Leederville aquifer discharge area (i.e. close to the Serpentine River) such that piezometric levels in the Leederville aquifer are not adversely affected.	AAMGL to be defined and agreed prior to subdivision, along with the width of the Leederville aquifer discharge zone. Changes to AAMGL drainage condition can only be considered after achievement of phosphorus export target is demonstrated by monitoring of the initial phase of development.	EPA, WRC	Seasonal peak water table levels at site boundaries to be maintained within the range as specified by the AAMGL. Maintenance of groundwater trends in existing Leederville aquifer monitor bores.
Protection of the flow regimes in regional drainage systems	To avoid obstructions to flow within the Serpentine River and the Dirk Brook main drain, as a result of development, in the floodplain and/or excessive drainage discharges, which may cause flooding upstream of the Amarillo site.	***Commitment 5*** The Proponent will design and construct a drainage system such that the peak rate of discharge following development is no greater than the peak rate of discharge when the site was operated as a pastoral property. The Proponent will also ensure that the drainage system includes appropriate erosion control and traps for sediment such that sediment transport and siltation does not occur in the regional drainage systems.	Designed in the pre-construction phase. Developed and monitored during the construction and operations phases.	Water Corporation, WRC, PIMA, and Local Authorities.	To the extent that flood history is adequately documented, the development should not exacerbate flood problems in low lying areas along the Serpentine River.
Protection of water balance	To minimise the use of imported scheme water on lawns, gardens and POS, by encouraging the use of on-site groundwater for irrigation. This has the additional objective of reducing groundwater drainage requirements, as a result of the enhanced recharge and groundwater rise following urbanisation.	***Commitment 6*** The Proponent will develop and implement strategies and incentives to encourage future landowners and land managers to use groundwater in preference to scheme water for irrigation.	On-going during operations phase	WRC and relevant Local Authorities.	Success of strategies to be measured by proportion of landowners with access to a groundwater bore.

Issue	Objective	Commitment	Timing (Phase)	To Whose Satisfaction	Performance Indicator (if any exist)
C: Pollution Issues Existing soil/groundwater "store" of phosphorus.	To avoid the mobilisation of phosphorus in shallow groundwater, which has accumulated as a result of historical fertiliser practises, within the drainage system proposed for the development.	***Commitment 7*** The Proponent undertakes to install a drainage system such that the invert level of the drains is no deeper than the AAMGL (refer Commitment 4). Fill will be used to achieve adequate separation between house foundations and the AAMGL. A contingency plan for phosphorus control will also be prepared, incorporating fail safe phosphorus removal techniques.	Drainage design to be agreed in the pre-construction phase.	EPA, WRC.	Compliance with the AAMGL as the depth criteria for drains.
Nutrient export, particularly phosphorus, to the Serpentine River and subsequently to the Peel-Harvey Estuary.	To meet the catchment target for phosphorus export to the Peel-Harvey Estuary via the Serpentine River.	***Commitment 8*** The Proponent will develop and implement Best Management Practices consistent with water sensitive design in order to minimise the export of nutrient and other contaminants off-site, with particular attention to meeting the catchment target for phosphorus (expressed as loads and/or concentrations). Furthermore, in the event that monitoring of phosphorus export in the first phase of development indicates that the management strategies are not working, then subsequent phases of development will be deferred until such time that it can be demonstrated through monitoring that the phosphorus target will be met.	Initial phase of development, until such time that the ultimate management authority assumes responsibility.	EPA, WRC, PIMA, Local Authorities, Water Corporation.	Phosphorus content of drainage waters to meet catchment specifications on an annual basis, in four years out of five.
Protection of groundwater quality.	To ensure that the potential for groundwater abstraction for potable water supply from the proposed Public Water Supply Area on the eastern side of Amarillo is not affected by the development.	***Commitment 9*** The Proponent will continue its liaison with the Water and Rivers Commission to identify potential land use management requirements near the eastern boundary of Amarillo to ensure adverse impacts on groundwater quality do not occur in the potential capture zones of future borefields.	Prior to final subdivision approval.	WRC, EPA.	To be agreed with Water and Rivers Commission and EPA.

Issue	Objective	Commitment	Timing (Phase)	To Whose Satisfaction	Performance Indicator (if any exist)
D: Social Surroundings Odour emissions from the Wandalup Piggery.	To minimise land use conflicts and avoid potential nuisance odour effects on future residents	***Commitment 10*** Whilst the structure plan nominates residential development at the southern boundary of Amarillo in close proximity to Wandalup Piggery, the Proponent will implement appropriate buffer zone requirements until the odour issue is resolved. Once the site has been rezoned, the Proponent will consult with the owners of the piggery and relevant authorities to resolve long term options.	On-going.	Interim buffer zones to be applied to the satisfaction of EPA and Ministry for Planning.	No odour nuisance i.e. no regular complaints.
Potential noise emissions from Wandalup Piggery and circuit training at the Murrayfield Aerodrome.	To ensure minimal noise impact as a result of adjoining land uses.	***Commitment 11*** The Proponent will ensure that future residential areas will not be exposed to noise from Wandalup Piggery or Murrayfield Aerodrome in excess of the requirements of the *Noise Abatement (Neighbourhood Annoyance) Regulations 1979.*	Prior to subdivision approval.	EPA, Ministry for Planning and Local Authorities.	*Noise Abatement (Neighbourhood Annoyance) Regulations 1979* and Murrayfield CER (ANEF contours, etc.).
Effects of construction activities and tree harvesting on neighbours.	To minimise dust generation as a result of construction phase activities and tree harvesting.	***Commitment 12*** The Proponent will implement appropriate dust mitigation measures, particularly during the transport and distribution of fill, to control any adverse dust generation. The Proponent will manage tree harvesting programs to avoid potential adverse effects on future landholders.	Construction and operations phases.	EPA, Local Authorities.	Compliance with industry standards, EPA Dust Management Guidelines and no complaints of nuisance.
Location of the WANG natural gas pipeline.	To ensure that future residential areas are not located within an unacceptable risk envelope relative to the gas pipeline.	***Commitment 13*** The Proponent will consult with appropriate authorities to determine the levels of risk associated with the gas pipeline and plan adjoining land uses in accordance with that risk.	Prior to subdivision	EPA, Ministry for Planning, Department of Minerals and Energy (DME).	DME guidelines.

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10.0 ABBREVIATIONS

AAMGL	Average annual maximum groundwater level
AHD	Australian Height Datum
ANEF	Australian Noise Exposure Forecast
CALM	Department of Conservation and Land Management
CER	Consultative Environmental Review
DEP	Department of Environmental Protection
DPUD	Department of Planning and Urban Development
EPA	Environmental Protection Authority
EPP	Environmental Protection Policy
ERMP	Environmental Review and Management Program
mbgl	metres below ground level
Mm^3/a	million cubic metres per annum
m^3/s	cubic metres per second
MRS	Metropolitan Region Scheme
NPNCA	National Parks and Nature Conservation Authority
PER	Public Environmental Review
PIMA	Peel Inlet Management Authority
POS	public open space
TP	Total Phosphorus
TRC	Technical Review Committee
ROS	regional open space
WRC	Water and Rivers Commission

11.0 EPA Guidelines for the PER

RESIDENTIAL DEVELOPMENT AND DRAINAGE, AMARILLO FARM, KARNUP (940)

PUBLIC ENVIRONMENTAL REVIEW GUIDELINES

1. Introduction

1.1. About Environmental Reviews

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 avoided, ameliorated or managed so that the environment is protected to an acceptable level.

These Guidelines have been prepared to assist the proponent in identifying issues that should be addressed within the Environmental Review. They are not intended to be exhaustive and the proponent may consider that other issues should also be included in the document.

Throughout the process it is the aim of the Department of Environmental Protection (DEP) 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.

1.2. Functions of a PER document

The primary functions of a Public Environmental Review (PER) document include;

- providing a basis for the Environmental Protection Authority (EPA) to provide advice to Government on protecting the environment;
- communicating clearly with the public so that EPA can obtain informed public comment;
- describing the proposal adequately, so that the Minister for the Environment can consider a well-defined project. If approved by the Minister for the Environment, the PER forms the legal basis of that approval of the proposal; and
- providing the basis of the proponent's environmental management programme, which shows that the environmental issues resulting from the proposal can be acceptably managed.

The language used in the body of the PER should be kept simple and concise, considering the audience includes non-technical people, and extensive, technical detail should be referenced or appended to the PER.

The DEP recommends that the basis of an environmental management and an audit programme be developed within the PER.

The Public Environmental Review document should:

- identify this project in the context of the local and regional environment;
- set out the environmental impacts that the project may have; and
- for each key issue, describe any environmental management steps the proponent believes would avoid, mitigate or ameliorate environmental impacts relevant to that issue.

The Public Environmental Review should focus on the key issues for the area and anticipate the questions that members of the public or planning agencies such as the State Planning Commission and the Shires of Rockingham and Mandurah 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. Assessments of the significance of an impact should be soundly based and referenced rather than unsubstantiated opinions, and the assessment should lead to a discussion of the management of the issue.

1.3. Format of the PER document

It should be noted that the guidelines are not intended to convey the EPA's wishes with respect to the format of the document. Excepting a requirement for an overview summary, a summary of the commitments and some information on how to make a submission at the front of the document, the format is a matter for the proponent. The overview summary should include a brief summary of:

- salient features of the proposal;
- reasons for the proposal;
- investigations undertaken and proposed;
- alternatives considered;
- description of receiving environment;
- analysis of potential impacts and their significance;
- environmental monitoring, management, safeguards and commitments as to proposed mitigation of any significant environmental impacts; and
- conclusions.

The overview summary should not exceed two pages and may be utilised in the EPA report and recommendations.

It is not intended that the document be unduly lengthy. Rather, all relevant material should be succinctly presented in order that the key environmental issues may be assessed.

Information used to reach conclusions should be properly referenced, including personal communications.

A copy of these guidelines should appear as an appendix in the PER.

2 Key issues

The proponents referral documentation summarised the issues and provided a brief overview of the likely significance of each issue.

Key issues associated with this proposal include:

- conservation along the Serpentine River (including the floodway);
- drainage management and nutrient export to the Peel-Harvey Estuary;
- impact on groundwater quality;
- compatibility of adjacent land-uses; and
- other issues.

These guidelines are not exhaustive. Further key issues may be raised during the preparation of the PER, and on-going consultation with the Department of Environmental Protection and relevant agencies is recommended.

2.1 Conservation along the Serpentine River

The System 6 Report recommendation M 108 identified the Serpentine River as having high conservation and recreation values, and recommended that a section of the river become and be managed as Regional Park. Since then the Environmental Protection (Swan Coastal Plain Lakes) Policy 1992 has gazetted lakes along the river for protection, the proponent initiated a study to determine regional park boundaries, and in 1993 the Department of Planning and Urban Development released for public comment *Peel Regional Park; Proposals for establishment administration and use.*

If there are other studies than those noted above which assess the conservation values of the Serpentine River in this area, they should be summarised in the PER.

The PER should identify the open space boundaries which ensure the protection of conservation values. Other factors which could be taken into consideration in determining the open space boundaries include;

- planning issues such as the provision of adequate recreational areas to ensure that conservation areas are protected; and
- flood management issues.

Responsibility for on-going management of open space areas or private areas which are not to be developed should be identified.

2.2 Drainage management and nutrient export to the Peel-Harvey Estuary

Drainage from the site reaches the Peel-Harvey Estuary which is already nutrient enriched. The State Government has taken a number of initiatives during the last decade to reduce and minimise nutrient export from the Swan Coastal Plain Catchment, including gazettal of the Environmental Protection (Peel Inlet-Harvey Estuary) Policy 1992, and the Statement of Planning Policy No 2.

The PER should;

- include a preferred structure plan and land management options, with a discussion of how different planning and land management options would affect nutrient export, groundwater levels and volumes of water drained to the Serpentine River;
- describe the drainage plans in the context of the structure plan and detail;
    - strategies to minimise nutrient export off-site. Particular attention should be directed to phosphorus and to design features which ensure the strategies themselves do not have unacceptable impacts on residents (e.g. midge or odour from artificial wetlands);
    - on-going management requirements and responsibilities for the operation of the drainage plan. Particular attention should be directed to the management of artificial wetlands and tree plantations (if plantations are proposed to be used to lower the groundwater table);
    - changes (if any) to groundwater levels and the likely off-site impacts of those changes. If changes are likely, impacts on nearby wetlands, remnant vegetation and the proposed Public Water Supply Area to the east should be described;
    - significance of changes to the flows in the Serpentine river from drainage waters. This issues should be considered in the context of cumulative impacts from up-river flows and measures taken to ensure peak flows in the river are not altered;
    - a management plan (which responds to a monitoring programmes) which sets criteria proposed to protect the Peel-Harvey Estuary and ensures that those criteria are not exceeded;

- proposals for the integration of Dirk Brook Main Drain into the development; and
- potential impacts of drainage plan on the Leederville aquifer.

Reference should be made to implementation of water sensitive urban design measures as outlined in *Planning & management guidelines for water sensitive urban (residential) design* as published by the (then) State Planning Commission in June 1994.

You should be aware that the drainage plan must also be considered by;

- the Commissioner for Soil Conservation. The drainage plan would be considered in the context of the vision for the catchment;
- the Water Authority of Western Australia; and
- the Peel Inlet Management Authority.

2.3 Impact on groundwater quality

The boundaries of the proposed Public Water Supply Area have not yet been determined. The Public Environmental Review should demonstrate liaison has taken place with the Water Authority of Western Australia regarding the likely boundaries and potential for impacts on groundwater quality where the proposed Public Water Supply Area overlaps or is near to the Amarillo development.

2.4 Compatibility of adjacent land-uses

The need for separation between various land-uses to reduce or eliminate land-use conflicts should be considered in the context of the structure plan and long-term development of the site.

Nearby land-uses which should be discussed include the Wandalup Piggery and Murrayfield Airpark.

2.5 Other issues

Other issues which should be discussed include;

- quantity and source of fill;
- construction impacts (e.g. traffic impacts associated with filling operations & dust management until housing is established);
- measures to be taken to comply with strategies developed and recommended by the Water Authority for developments in the Serpentine River Floodplain;
- sewage effluent disposal;
- existing vegetation and protection of remnant vegetation on the subject land;
- potential impacts on other nearby natural assets (e.g. beaches, National Parks).

A range of planning issues may also need to be considered (e.g. see Shire of Murray Minutes of Planning, Health Building and Environment Committee 14/11/94) in any structure plan prepared for the area.

3. Public 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 or individuals involved and the objectives of the activities. Cross reference should be made with the description of environmental management of the issues which should clearly indicate how community concerns have been addressed. Those concerns which are dealt with outside the environmental impact assessment process can be noted and referenced.

4. Environmental management commitments

The method of implementation of the proposal and all commitments made by the proponent in the PER would become legally enforceable under the environmental conditions of the Minister for the Environment's approval. Where an environmental problem has the potential to occur, there should be a commitment to rectify it. Specific commitments to protect the environment, typically related to the key issues, should be separately listed, 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;

(d) **TO WHOSE REQUIREMENTS** the work will be carried out (ie which agencies).

All actionable and auditable commitments made in the body of the document should be numbered and summarised in this list. The commitments should be identified as pre, during or post construction and the proposed method of verification should be stated.

The commitments should show that the proponent is committed to actionable and auditable management of the environmental issues.

12.0 CORRESPONDENCE FROM WATER AND RIVERS COMMISSION AND THE WATER CORPORATION

Water and Rivers Commission
Recommended Amarillo phosphorus Strategy

Objective

The Water and Rivers Commission recommends that the management of surplus water at the Amarillo subdivision should include best management practices to ensure that phosphorus and water discharges from the site are minimised. Setting a phosphorus export target as the primary objective may tell against minimising phosphorus export and is not recommended. However a standard is required as a performance guarantee and as a trigger to invoke additional control measures to limit phosphorus export.

Best Management Practice

The minimum components of a BMP system are listed below. The BMP system must be designed for approval during the EMP phase.

Best practice is to include;

- detailed studies and modelling of the water and phosphorus balances on the site to optimise design of the management systems.
- riparian vegetation along the drains to trap sediment, prevent erosion and assimilate phosphorus and other deleterious substances
- wetlands to strip nutrients and trap sediments
- a drainage system designed to minimise lowering of groundwater levels by keeping drains above the AAMGL.
- extensive tree plantings in POS and reserves to maximise evaporation and transpiration.
- local use of groundwater to reduce the water table levels and minimise drain flows, preferably including a public irrigation water supply based on local wells.
- sewers to collect all wastewater
- extensive riparian vegetation protection along the Serpentine River.
- "continuous" measurement of phosphorus and water flow in drain outlets from the developed urban areas until there is confidence in the performance of the drainage system.
- conduct trials of alternative treatments to demonstrate that the phosphorus criteria are met and to refine the practice to reduce phosphorus levels further, as far as is practical and economic.

Performance Standard

The BMP approach must be backed by performance standards to protect the Serpentine River and ensure that the practices are properly designed and operated. If the BMP system fails to achieve a flow weighted annual average total phosphorus concentration of discharging waters less than 0.075 mg/L or a total mass of phosphorus entering the Serpentine River less than 0.225 kgP/ha/a additional measures must be employed to reduce the phosphorus levels below those levels.

The Commission believes that phosphorus levels well below these levels will be achieved with the BMP approach.

Appendix 1 - Background to acceptable phosphorus export criteria

General Drain Water Quality

Generalised phosphorus criteria for drains (OCM publication "Catching the Slug" June 1992) includes the following.

phosphorus (mg/L)	Class
less than 0.05	pristine
0.05 to 0.15	Low
0.15 to 0.25	Moderate
0.25 to 0.40	High

The recommendation puts the site within the Low class.

Peel Harvey EPP Phosphorus Criteria

The EPP allowable average phosphorus yield from the Serpentine River Catchment is 0.27 kg/ha/a. At an expected drainage water yield of 3,000 kL/a this represents 0.09 mg/L, if the drainage water is the only export source of phosphorus.

The recommendation allows a phosphorus load of 83% of the EPP areal average load.

Other urban drains

Comprehensive phosphorus monitoring of urban sandy Western Australian drains is not available.

Occasional monitoring of drainage water quality in seven urban sandy sites in Perth undertaken by the Water Authority during 1990/91 gave phosphorus concentrations of 0.014 to 1.72 mg/L for 175 samples with a mean of 0.193 mg/L. This has allowed phosphorus yields in the range 0.095 to 0.538 kg/ha/a to be estimated for the seven sites, 5 of which fell under the Peel Harvey EPP limit of 0.27 kg per ha limit. The monitoring was limited in duration and frequency and can not be reliably extended to the Amarillo site which will have different mixes of residential, commercial and POS areas and different drainage characteristics. The most similar siteto Amarilo and the one with the lowest phosphorus discharge, South Lakes, had a phosphorus concentration of 0.02 to 0.40 mg/L with an average of 0.094 mg/L.

EPA Guidelines for phosphorus in aquatic Ecosystems

EPA guidelines indicate that phosphorus criteria should be determined on a site specific basis. However a phosphorus concentration of 0.1 mg/L is cited as an upper limit, above which deleterious impacts may occur.

Appendix 2 - Urban Drainage Phosphorus sampling (WAWA, 1990/91)

Total phosphorus mg/l	Season	Place	No Samples
0.444	Autumn	Balcatta	10
0.050	Spring	Balcatta	8
0.102	Winter	Balcatta	7
0.377	Autumn	Bayswater II	8
0.080	Spring	Bayswater II	9
0.048	Winter	Bayswater II	8
0.233	Autumn	Bayswater I	10
0.040	Spring	Bayswater I	6
0.130	Winter	Bayswater I	7
0.730	Autumn	Beatrice Ave	6
0.219	Spring	Beatrice Ave	10
0.374	Winter	Beatrice Ave	12
0.322	Autumn	Myaree	10
0.111	Spring	Myaree	11
0.107	Winter	Myaree	9
0.156	Autumn	South Lake	13
0.041	Spring	South Lake	10
0.056	Winter	South Lake	7
0.181	Autumn	Woodlands	5
0.058	Spring	Woodlands	6
0.035	Winter	Woodlands	3

WATER CORPORATION

629 Newcastle Street
Leederville 6007
Western Australia

PO Box 100
Leederville WA 6902

Tel (09) 420 2420
Fax (09) 420 3200

Mr W P Griffiths
Stanthony Consultants Pty Ltd
25 Cousins Street
KARRINYUP
WA 6018

Dear Mr Griffiths

"AMARILLO" - INVOLVEMENT OF THE WATER CORPORATION IN SERVICING ANALYSIS AND OPERATIONS

I refer to your letter of February 15 1996 regarding the above-mentioned matter.

I am pleased to confirm that the Water Corporation is interested in becoming involved with Homeswest in developing a package that may lead to the Corporation's involvement in the planning for and provision of water services, sewerage services and drainage treatment or nutrient removal services for the Amarillo development.

I am confident that we have the expertise, experience and resources necessary to provide these services on a competitive basis and look forward to negotiations commencing in the near future.

If you have any queries regarding the above, our contact for this project is Garry Meinck, General Manager of Planning & Development Division, telephone 420 2660. Mr Bob Becu has been appointed our Project Manager for this project and is contactable on 420 3614.

Yours sincerely

J. I. Gill
MANAGING DIRECTOR

FIGURES

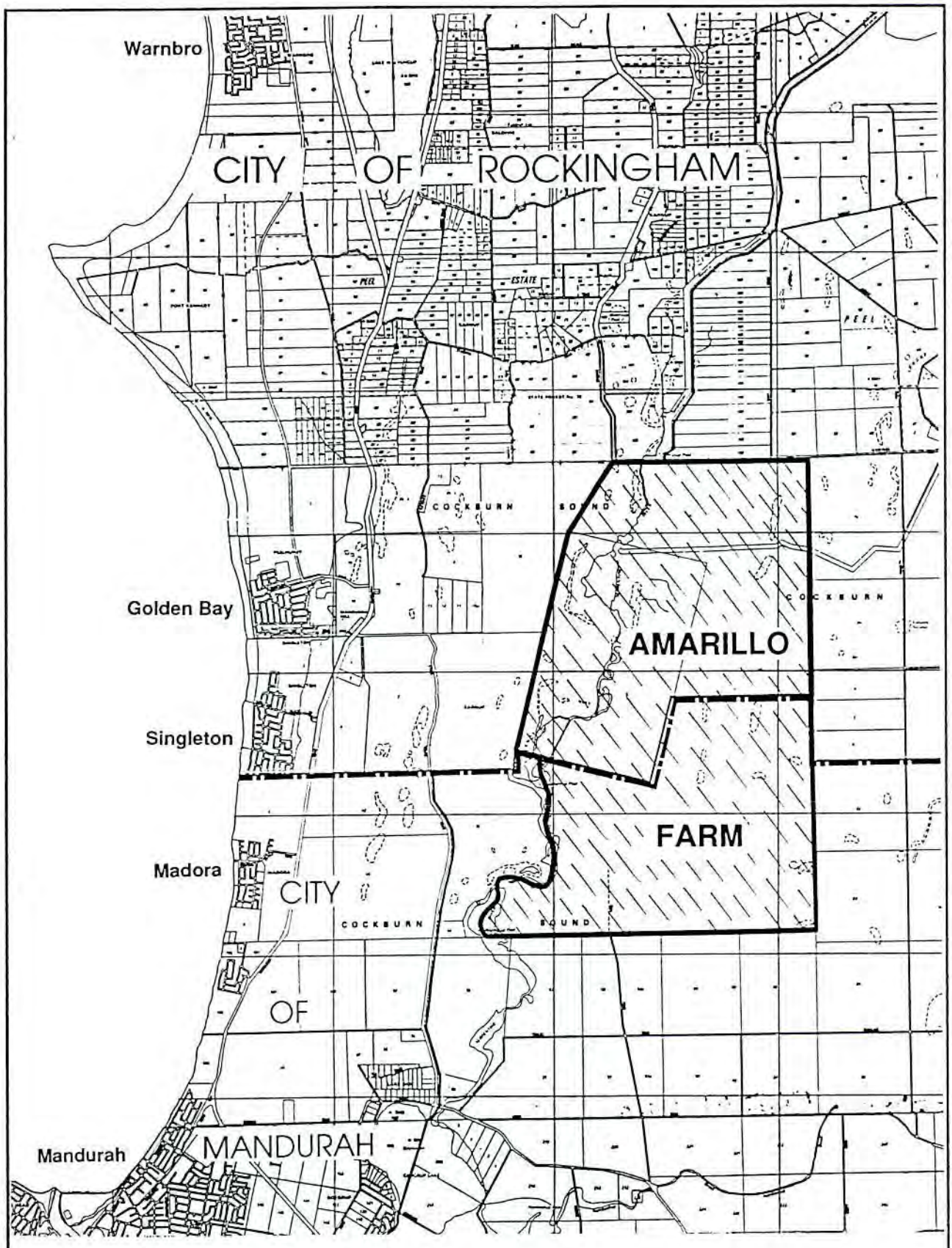


Figure 1

LOCATION

BOWMAN BISHAW GORHAM

ENVIRONMENTAL MANAGEMENT CONSULTANTS

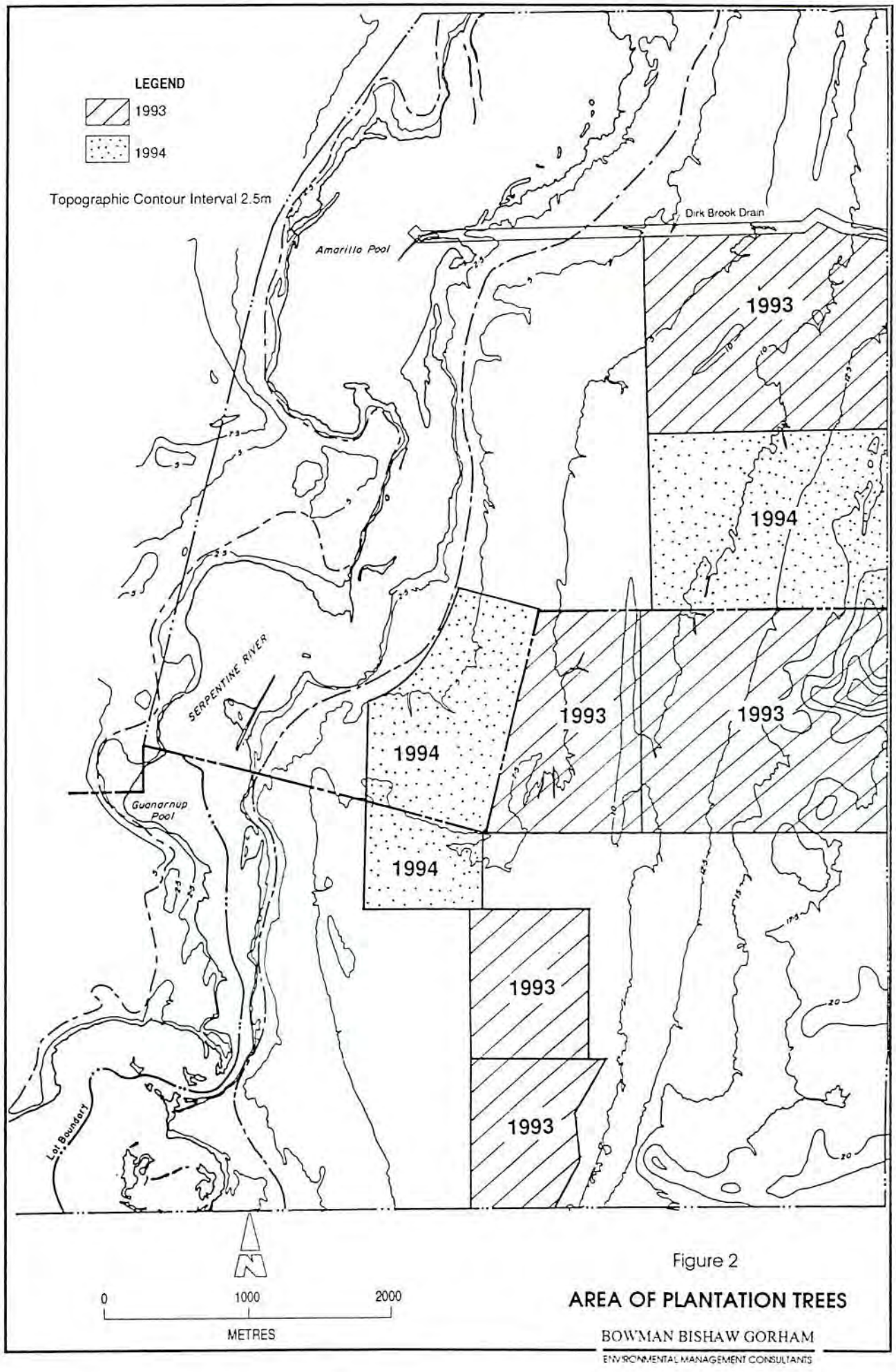


Figure 2

AREA OF PLANTATION TREES

BOWMAN BISHAW GORHAM

ENVIRONMENTAL MANAGEMENT CONSULTANTS

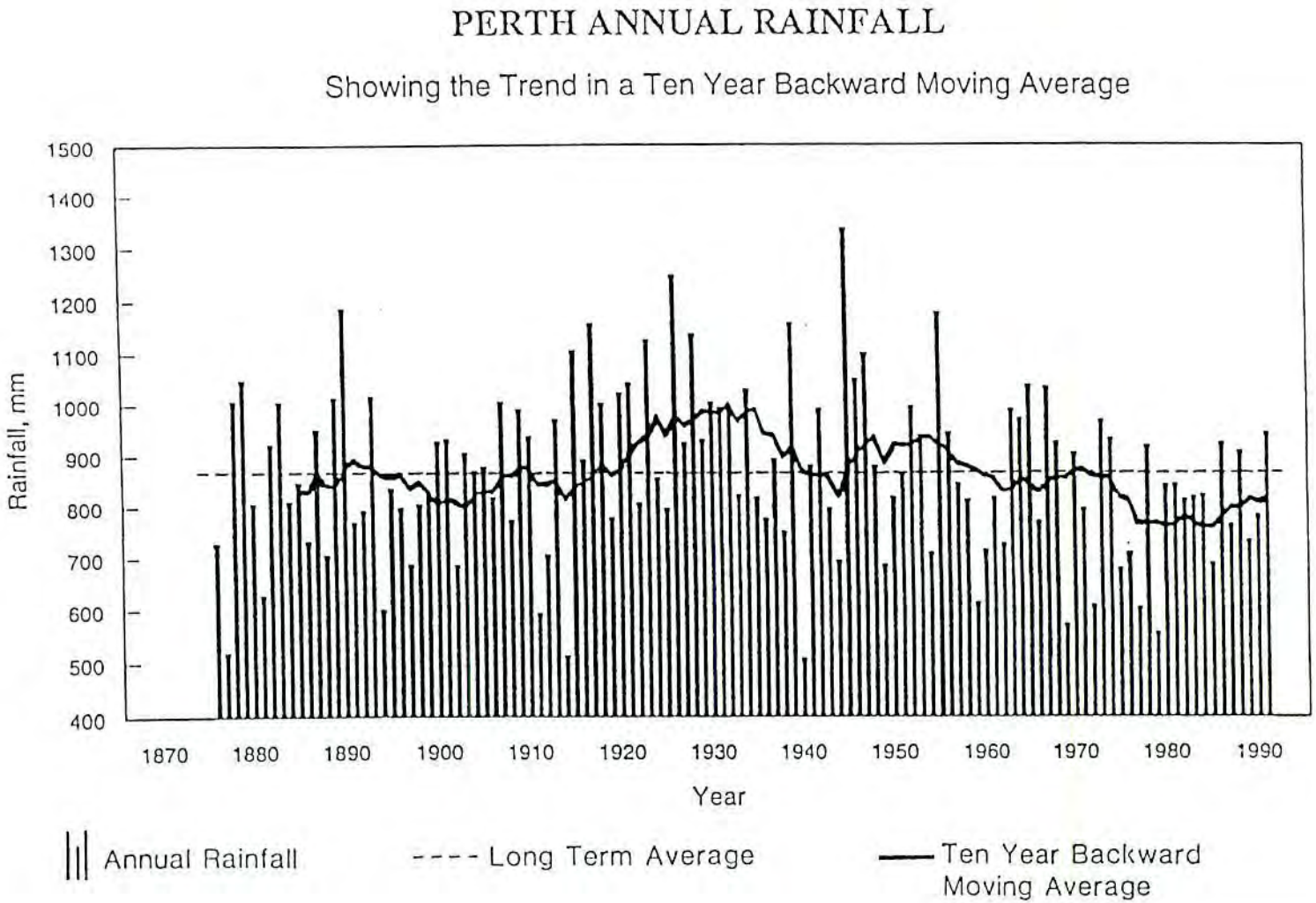


Figure 3

RAINFALL TREND

BOWMAN BISHAW GORHAM

ENVIRONMENTAL MANAGEMENT CONSULTANTS

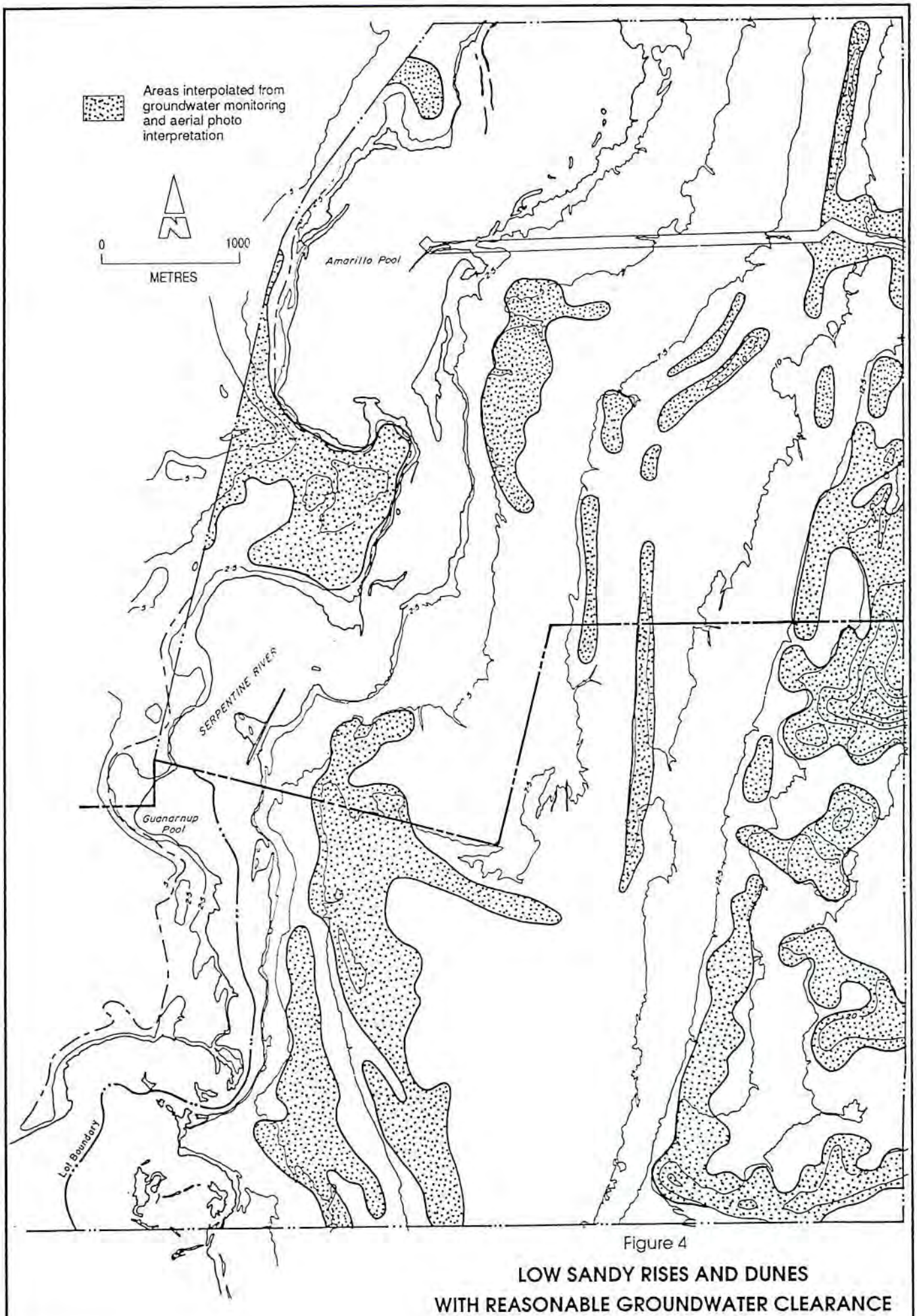


Figure 4

LOW SANDY RISES AND DUNES WITH REASONABLE GROUNDWATER CLEARANCE

BOWMAN BISHAW GORHAM

ENVIRONMENTAL MANAGEMENT CONSULTANTS

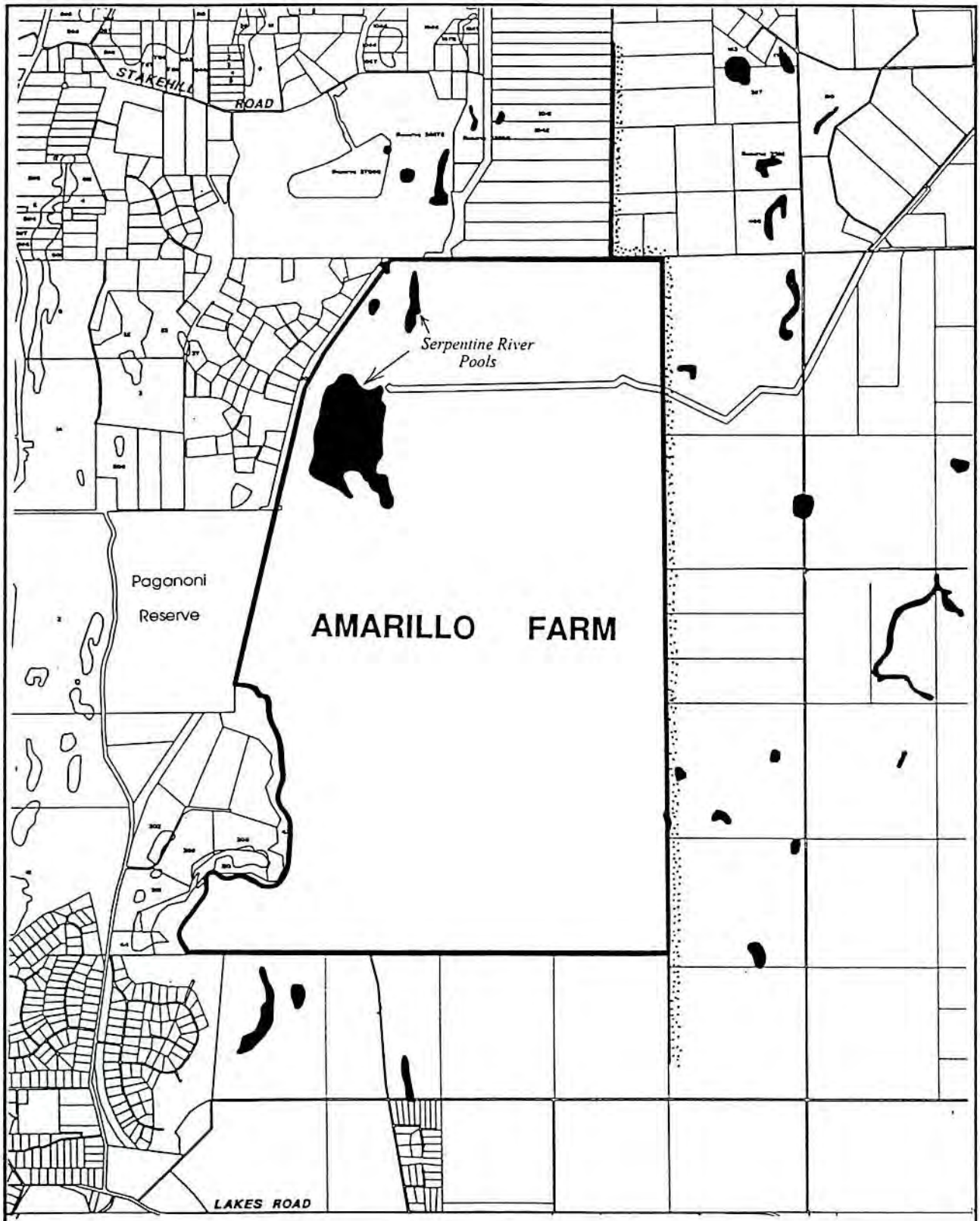


Figure 5

EPP LAKES

BOWMAN BISHAW GORHAM

ENVIRONMENTAL MANAGEMENT CONSULTANTS

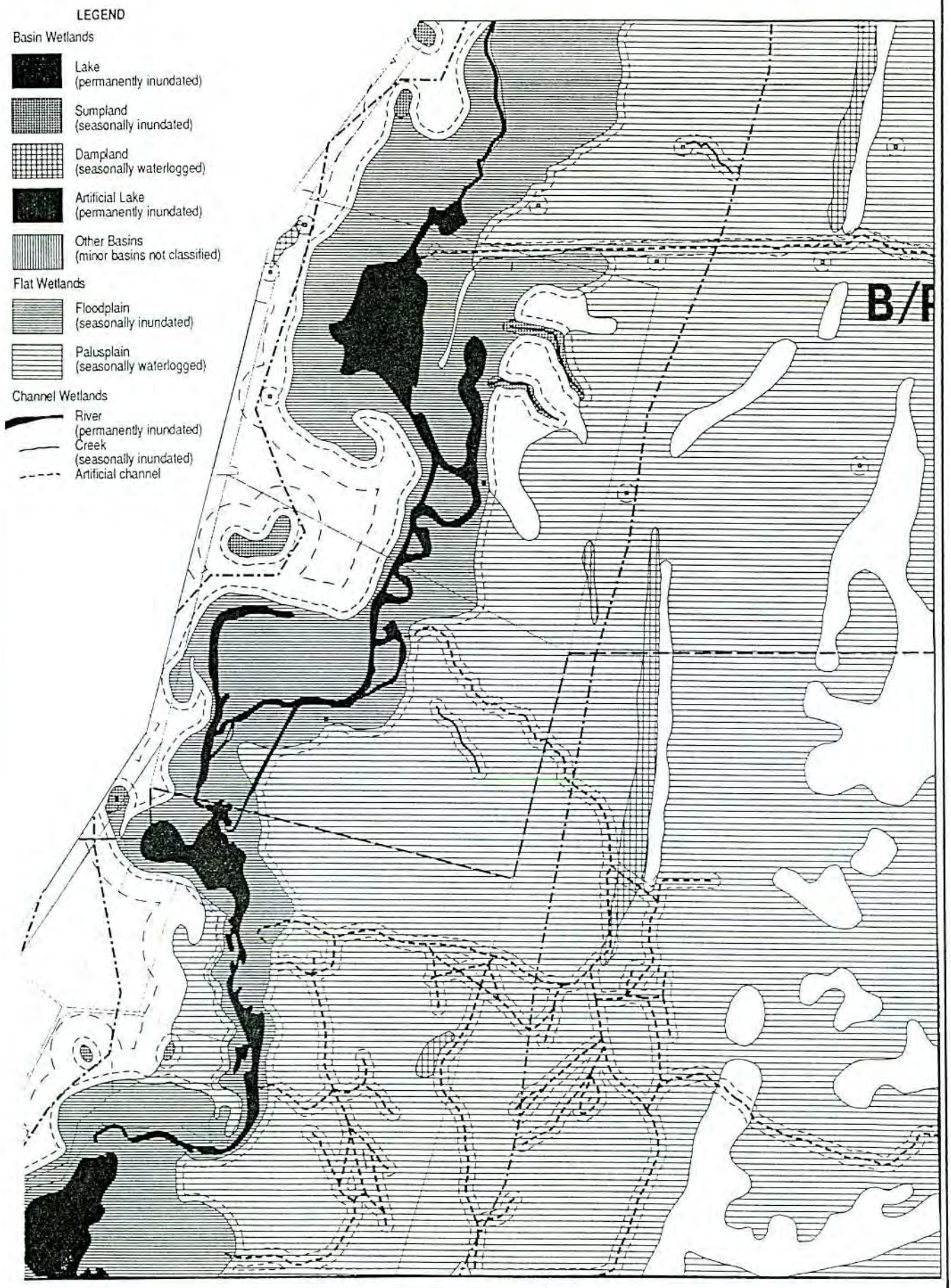


Figure 6

WETLAND MAPPING

BOWMAN BISHAW GORHAM

ENVIRONMENTAL MANAGEMENT CONSULTANTS

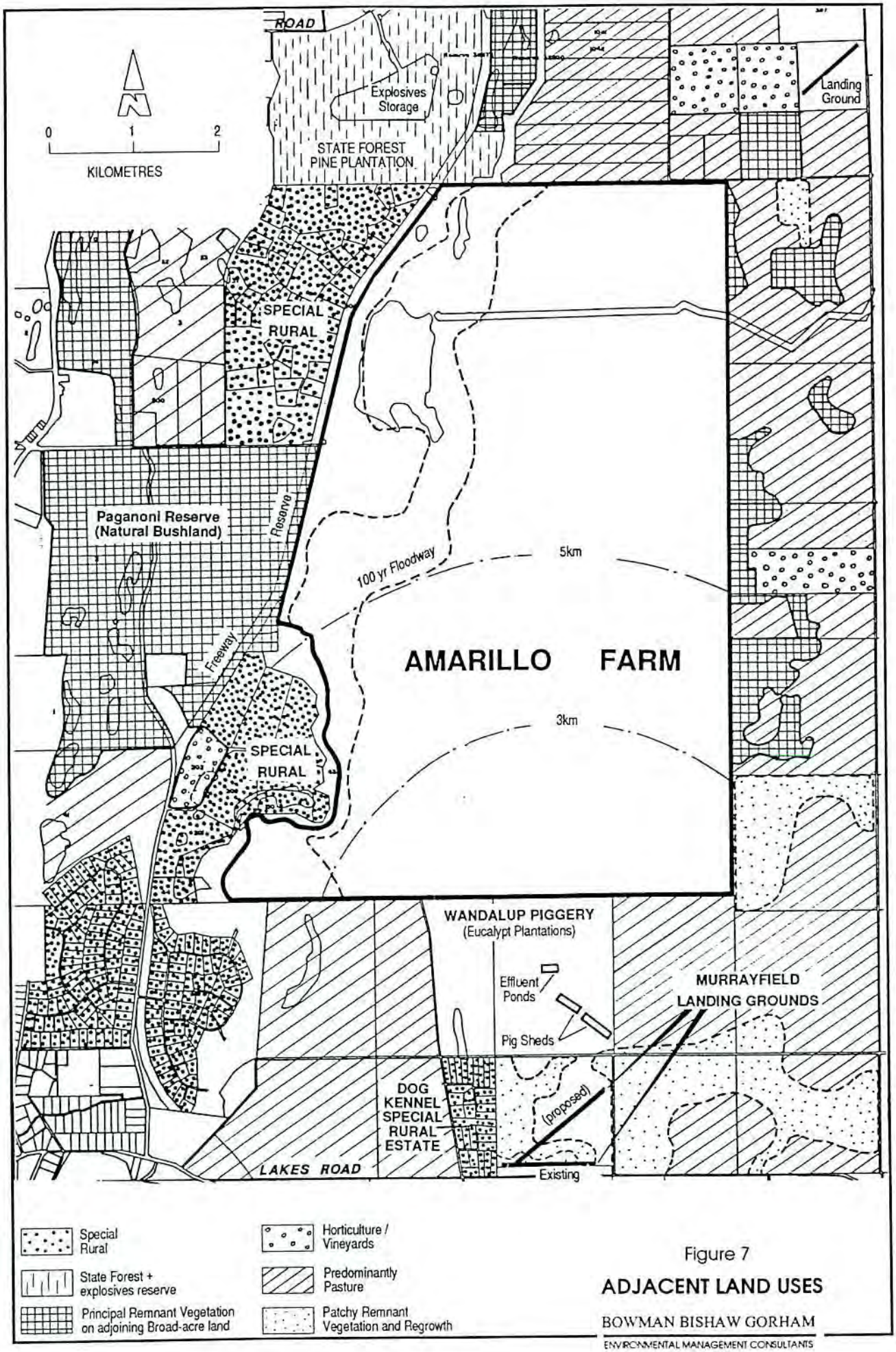


Figure 7

ADJACENT LAND USES

BOWMAN BISHAW GORHAM

ENVIRONMENTAL MANAGEMENT CONSULTANTS

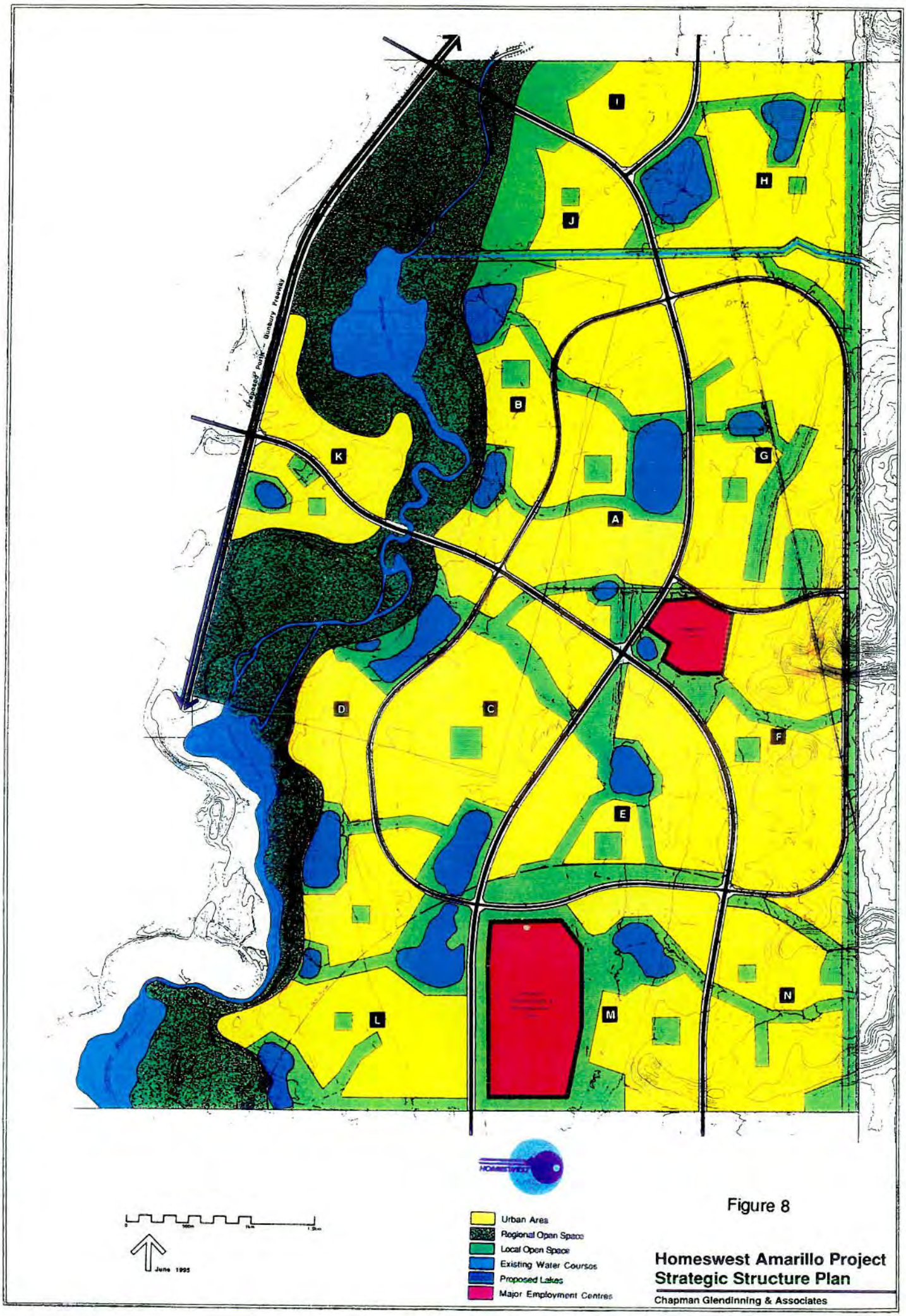


Figure 8

Homeswest Amarillo Project
Strategic Structure Plan

Chapman Glendinning & Associates

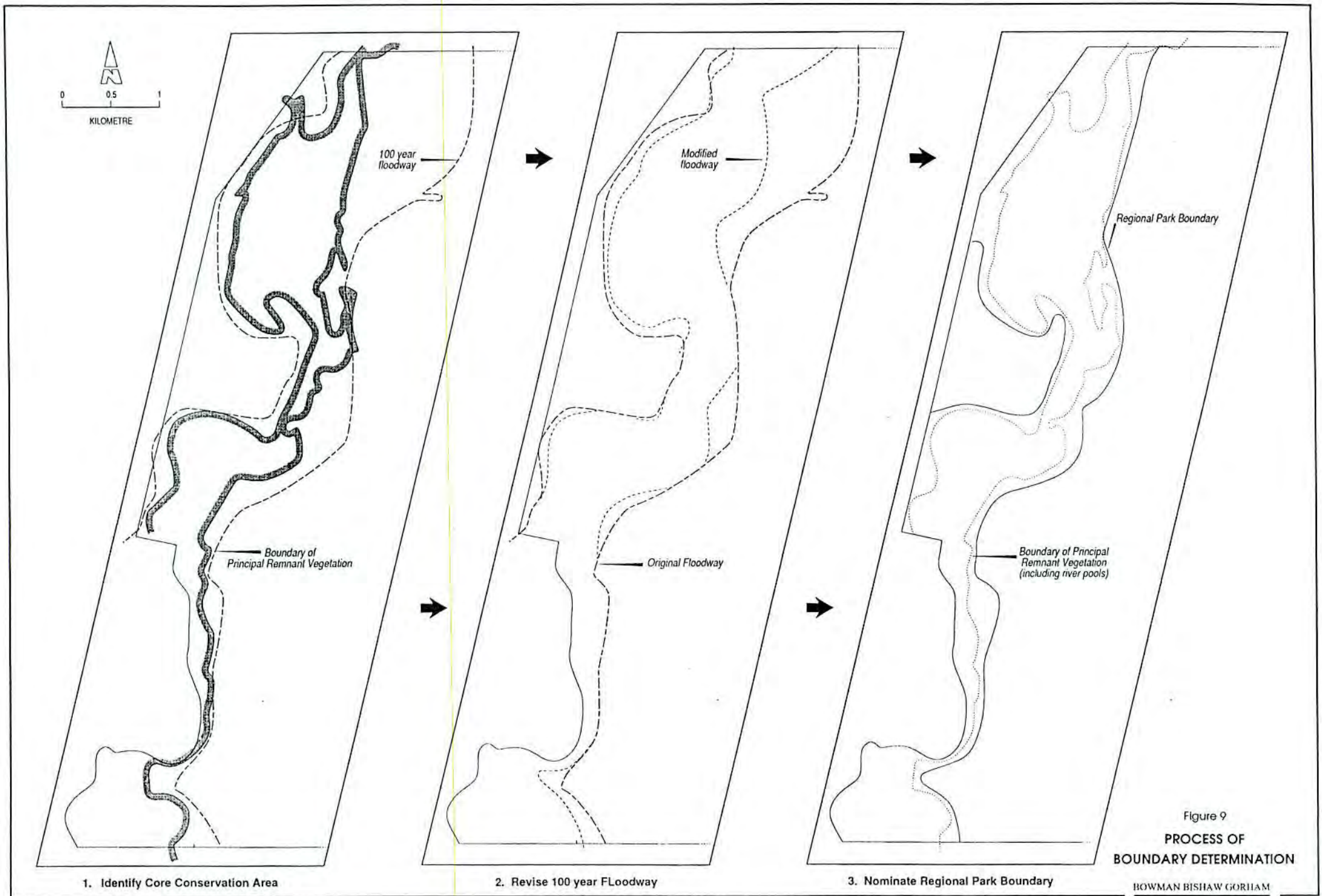


Figure 9

PROCESS OF BOUNDARY DETERMINATION

BOWMAN BISHAW GORHAM

ENVIRONMENTAL MANAGEMENT CONSULTANTS

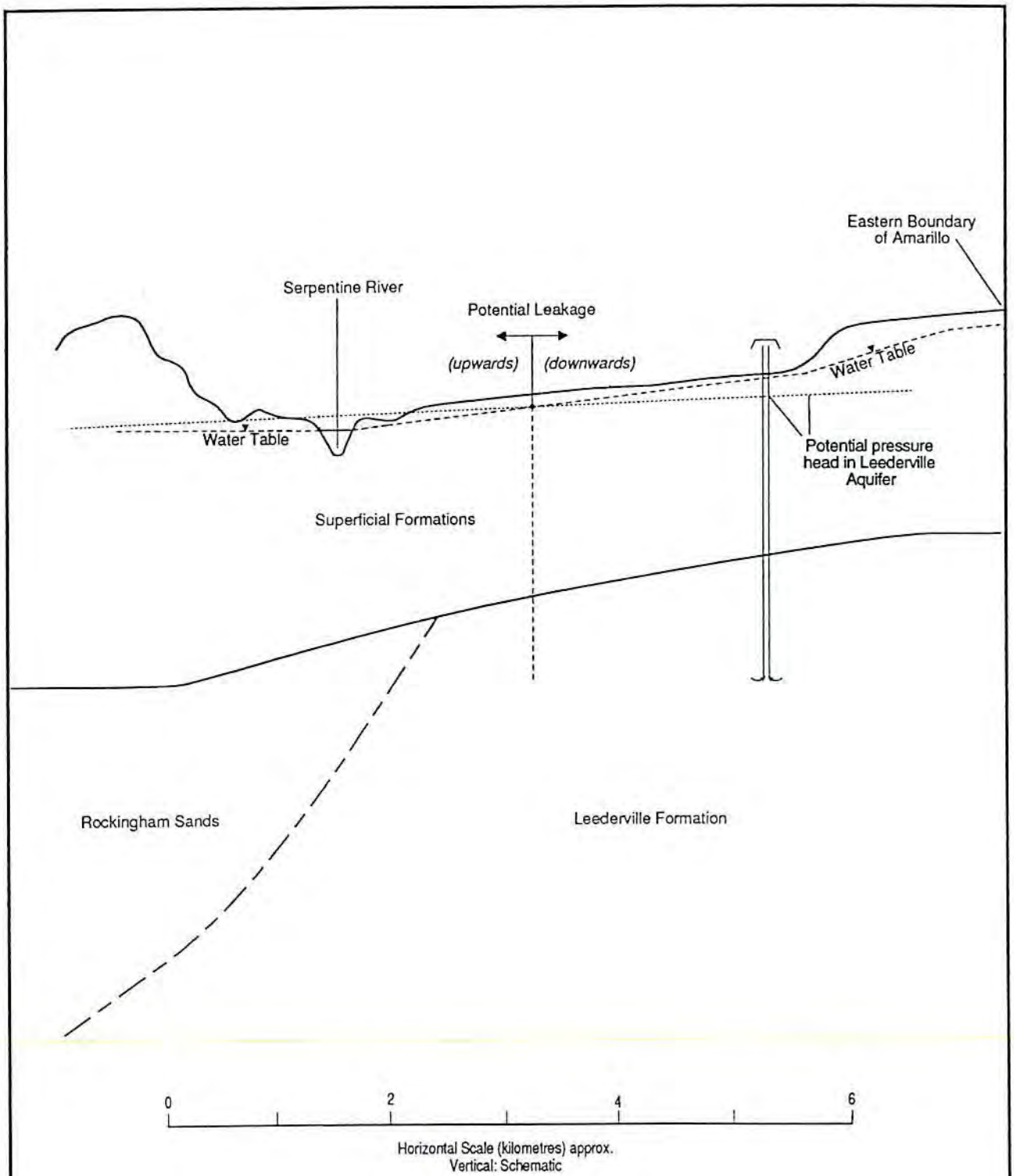


Figure 10

DIFFERENTIAL GROUNDWATER LEVELS: LEEDERVILLE vs SUPERFICIAL FORMATIONS

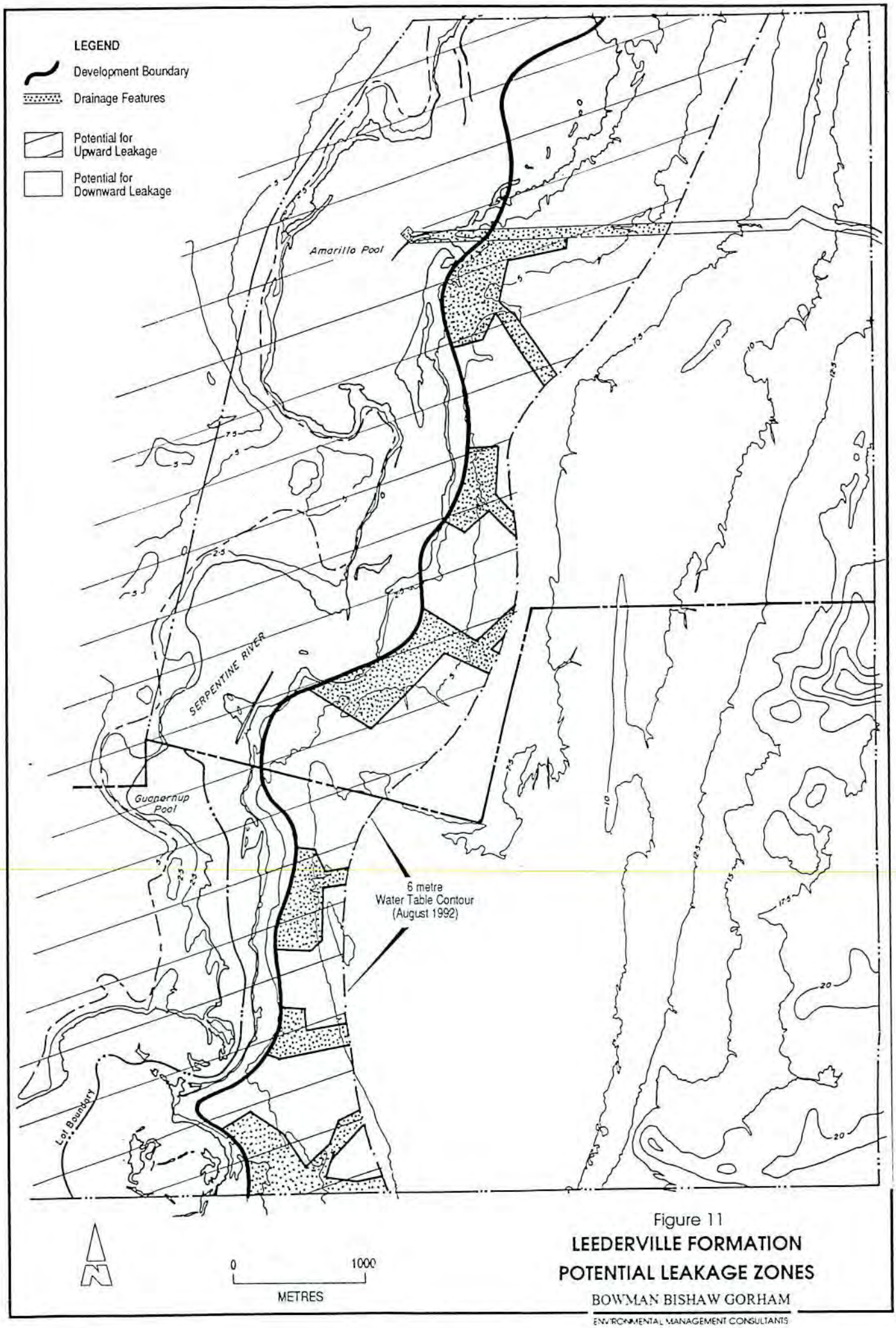


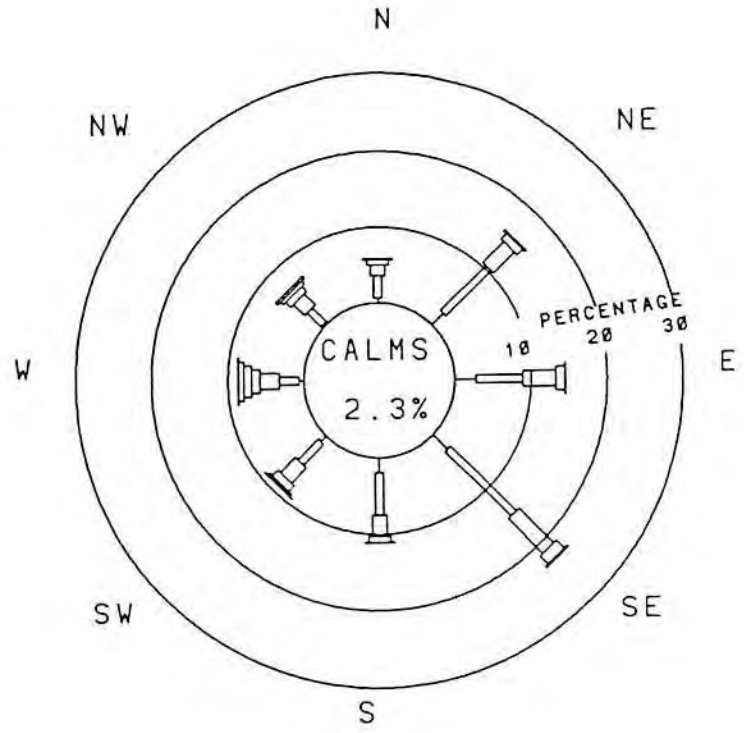
Figure 11

LEEDERVILLE FORMATION

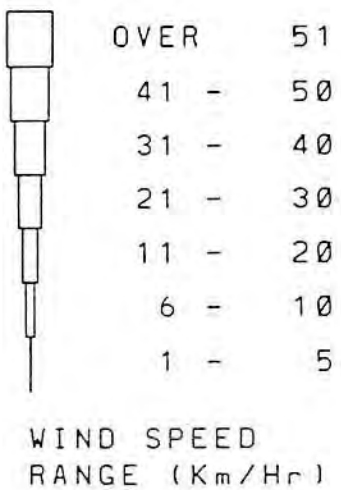
POTENTIAL LEAKAGE ZONES

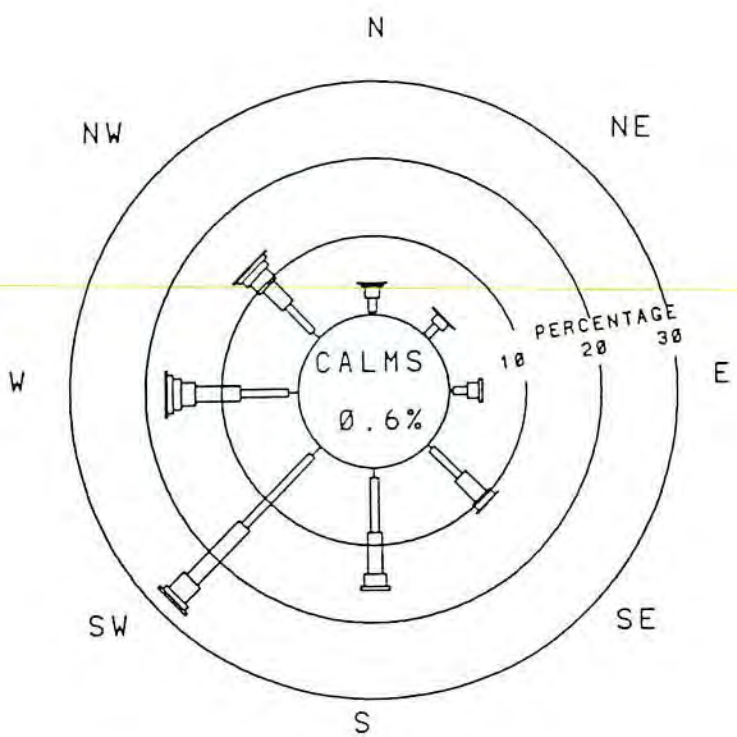
BOWMAN BISHAW GORHAM

ENVIRONMENTAL MANAGEMENT CONSULTANTS



MORNING WINDS (0900 HOURS)





AFTERNOON WINDS (1500 HOURS)

Figure 12

ANNUAL WIND ROSES FOR MANDURAH

BOWMAN BISHAW GORHAM
ENVIRONMENTAL MANAGEMENT CONSULTANTS

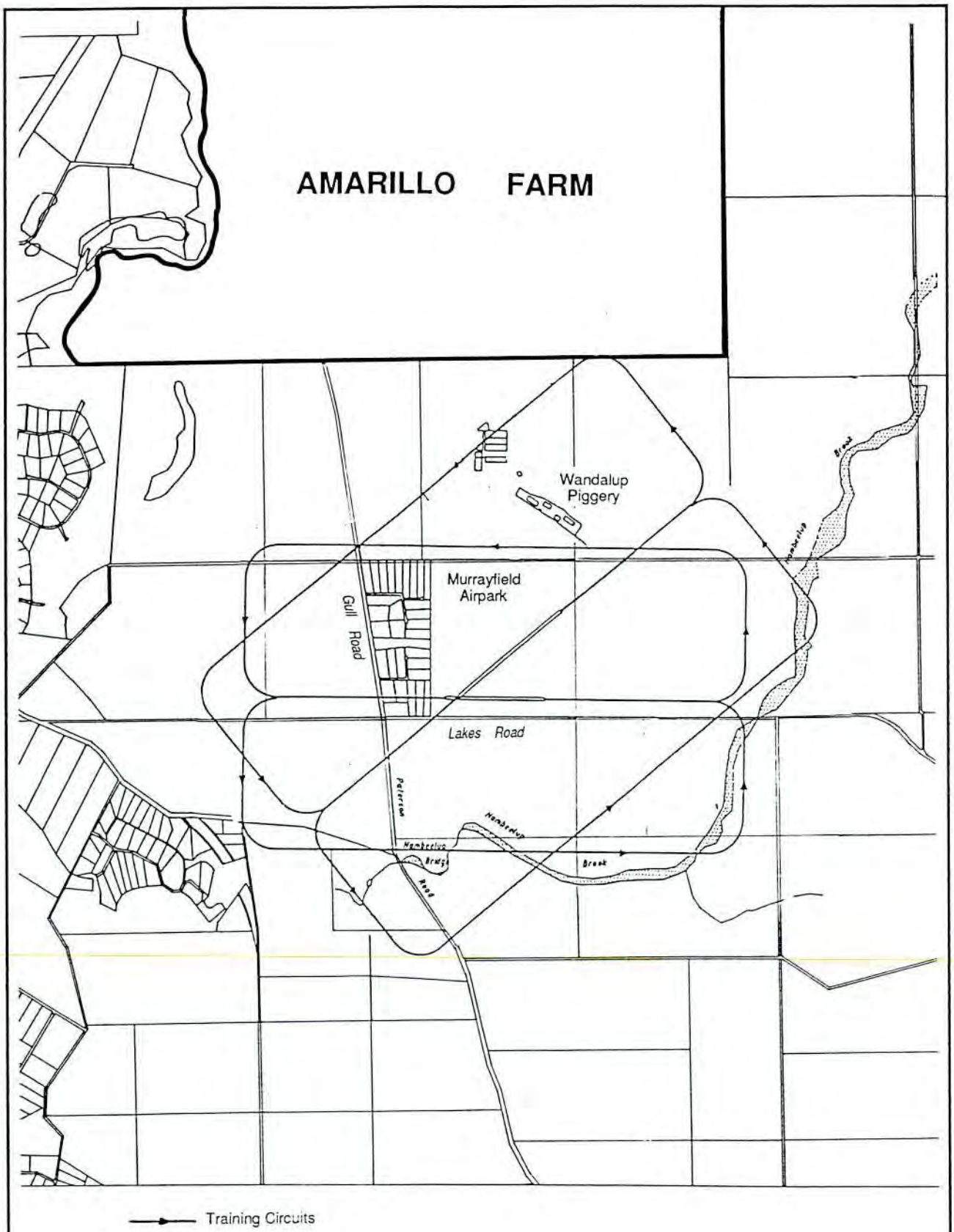


Figure 13

MURRAYFIELD TRAINING CIRCUITS

BOWMAN BISHAW GORHAM

ENVIRONMENTAL MANAGEMENT CONSULTANTS

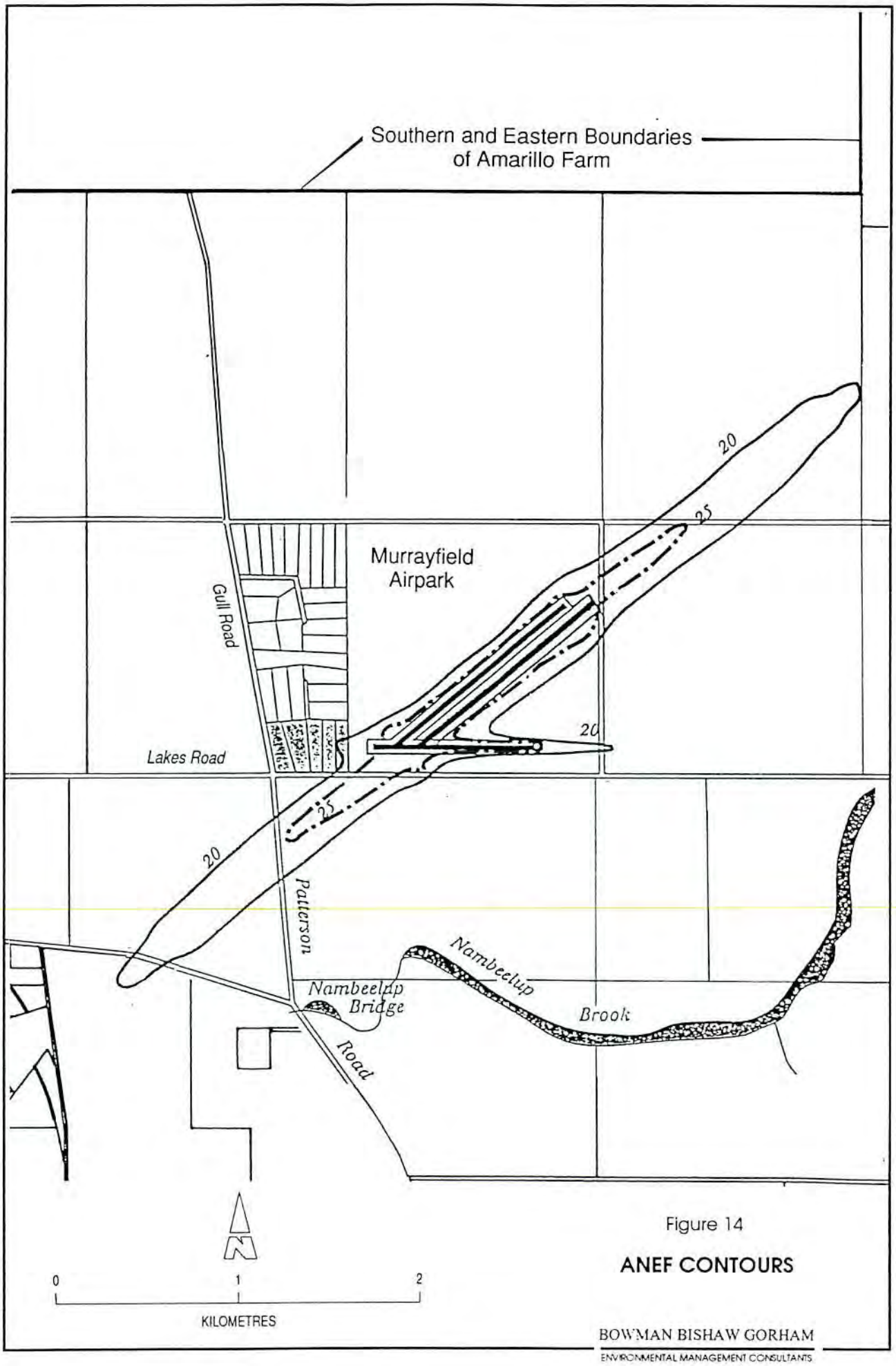


Figure 14

ANEF CONTOURS

BOWMAN BISHAW GORHAM

ENVIRONMENTAL MANAGEMENT CONSULTANTS

PART II

HOMESWEST
Proposed Urbanisation of Amarillo Farm

CONCEPTUAL NUTRIENT MANAGEMENT STRATEGY

January, 1995

(Revised May, 1995)

(Revised April, 1996)

Prepared by:
Bowman Bishaw Gorham
(with advice from Evangelisti & Associates)

Report No: MI4184

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

TABLES

FIGURES

1.0 INTRODUCTION

1.1 Development Proposal

The Amarillo Farm property was acquired by Homeswest during 1992 as a landholding for urban development in the longer term. In view of the size of the property (approximately 3980 hectares) and its single ownership, planning has focused on the land's strategic importance as a major source of future urban land in the Rockingham to Mandurah region.

Homeswest has recently adopted a more pragmatic approach to the timing of development and believes that Amarillo could feasibly be developed in the shorter term, that is, in a five year timeframe. The most important short term objective is therefore to have the land clearly identified as a future urban area within the planning process.

1.2 Background

A consultant team was appointed to work on the Amarillo project some four years ago with an emphasis on resolution of the environmental and engineering aspects, and in particular the drainage issue. At the same time as the necessary background technical investigations were being conducted, fundamental structure planning elements were initiated through periodic liaison with the (then) Department of Planning and Urban Development (now Ministry of Planning) and relevant local authorities. Numerous but irregular meetings have also been held with those regulatory agencies responsible for review of technical issues, notably the Water and Rivers Commission (WRC) and the Department of Environmental Protection (DEP).

From the technical perspective, successful urbanisation at Amarillo will be dependent on satisfactory resolution of the drainage issue. It has been recognised at outset that the project would be 'drainage driven' and it is fair to say that there has been a degree of scepticism in the minds of some observers that the drainage issues could be resolved. Considerable progress has been made with the technical investigations and the Amarillo team is confident that the water issues can be overcome in an environmentally acceptable manner and to the satisfaction of the review agencies.

1.3 Structure and Content of Report

Subsequent sections of this report are listed below to provide an overview of the format.

Section 2.0 provides a description of some relevant site characteristics, outlines the approach adopted in applying water sensitive design principles to Amarillo and presents a drainage strategy for consideration.

Section 3.0 describes the approach to nutrient management in groundwater and stormwater drainage and assesses the performance of the nutrient management strategy.

Appendix A briefly reviews the regulatory framework (policies, environmental conditions and guidelines) for the Peel-Harvey catchment in general and for constrained sites such as at Amarillo in particular, and provides responses to the issues relevant to urban development.

2.0 WATER SENSITIVE DESIGN AT AMARILLO

Implementation of water sensitive design (WSD) at Amarillo is based on an extensive site evaluation and hydrological modelling (quantity and quality). The site characteristics important to WSD are presented below, followed by discussion of the water resource management objectives for Amarillo and then the drainage management strategy is summarised in terms of the best planning and management approaches.

The primary focus of the technical discussion in this document relates to land on the eastern side of the Serpentine River only, because of the shallow groundwater constraints in this area. The relatively small parcel of land on the western side of the river does not have the same magnitude of drainage constraint and therefore, is easier to develop.

2.1 Site Characteristics

A summary of the relevant site characteristics is provided below. A more detailed evaluation of specific environmental aspects may be found in the main document (Part I) and other background information may be found in earlier technical reports which have been widely distributed, listed as follows:

- Discussion Paper, 'Provisional Regional Park Boundary for Urban Structure Plan' (Bowman Bishaw Gorham, November 1992);

- Amarillo Farm Final Hydrology Report (A J Peck & Assoc. and J Davies & Assoc., October 1993).

2.1.1 Remnant Vegetation

The majority of the Amarillo site has been either cleared for pasture, disturbed by the trampling and grazing of livestock or planted with 'bluegums', therefore little of the original vegetation remains intact. As a result, the only areas of remnant native vegetation which could be considered to have regional conservation significance are located along the fringes of the Serpentine River. These areas will be incorporated into the proposed

Regional Park for which a provisional boundary has been determined encompassing approximately 730 hectares.

Nevertheless, there are pockets of remnant vegetation distributed elsewhere on the site which are worthy of protection; if not for their ecological values then certainly for their landscape values and potential for enhancement of local open space in an urban context. These areas have been identified and mapped for inclusion in the structure planning process for Amarillo.

2.1.2 Serpentine River Floodway

Estimates of the 1-in-100 year floodway and flood fringe for the Serpentine River were obtained from the Floodplain Management Section of the (then) Water Authority. The Amarillo property includes an 8.7 kilometres segment of the river and the initial 100 year floodway encompassed approximately 920 hectares of Homeswest's land. This was a much greater area than the area allocated for the provisional Regional Park (approximately 730 hectares) and effectively "sterilised" land for consideration for urban purposes. Negotiations were held to rationalise the floodway requirements, in light of the future need to 'bridge' the river twice for access and recognising the opportunity to encroach into the floodway by the addition of fill (given the economics of the change in land use from pastoral to urban).

A revised floodway was agreed with the (then) Water Authority which allows for two bridge crossings and requires low-lying land to be filled prior to possible residential development. The area to be filled is also dependent on the location of the Regional Park boundary and overall there is at least 100 hectares of 'reclaimable' land between the flood fringe and either the Regional Park boundary or the agreed floodway. The modified floodway encompasses 735 hectares of Homeswest's land. If a third bridge is required the original floodway may apply and no encroachment would be allowed.

2.1.3 Landform and Soils

Only the potential 'developable' land is discussed below.

West of the river in the central-west sector there is a moderately large area of Spearwood Dune System which is flat-to-gently undulating sandplain varying in height from about 3.0 metres AHD near the river to about 10 metres AHD at the boundary of the property. In the

north-western corner there is a small parcel of land which is also above the 100 year floodway and has development potential. This land comprises Bassendean sands and most likely overlies alluvial formations at variable depth.

East of the river the terrain is predominantly Bassendean Dune System with some Pinjarra Plain Clays in the north-eastern sector adjacent to the river. For the most part the Bassendean Dune sandplain has very low relief with only occasional low sandy rises. The plain rises away from the river at an average gradient of about 1-in-350 metres (between the 5.0m and 12.5m AHD contours). In the central-eastern and south-eastern sectors the terrain rises relatively sharply from about the 12.5 metre AHD contour and becomes more undulating. Some of the dunes in this area rise to 20 metres AHD or more. The highest dune occurs at the central-eastern boundary and rises to 27 metres AHD.

The eastern sands are highly leached and have the very low phosphorus adsorption capability which is typical of the 'deep grey sands' of the Bassendean Dune System.

2.1.4 Groundwater Regime

The characteristics which are important for this development proposal may be summarised as follows:

- most of the eastern side of the property presently experiences maximum winter water table levels at or near the ground surface, and preliminary technical work indicates that only about 745 hectares of the potentially developable land in this area has reasonable groundwater clearance;
- the superficial aquifer is deep (generally in excess of 50 metres) but some intermittent and localised perching of groundwater may occur due to the presence of shallow iron-organic hardpan (coffee rock) which can be highly variable in depth, thickness and hardness over short distances but is generally deeper and softer than indicated on the Department of Agriculture's land resource mapping;
- regional groundwater flow is westerly to west-north-westerly and discharges to the Serpentine River;

- the phosphorus content of the groundwater is high with bore samples averaging 1.00 mg-TP/L in early summer (November) and 0.74 mg-TP/L in late summer (April); although these concentrations are recognised as high, they are within the range reported in other studies on similar soil types and with similar land use in the Peel-Harvey catchment (e.g. Height et al, 1988 and Silberstein and Bennett, 1990).

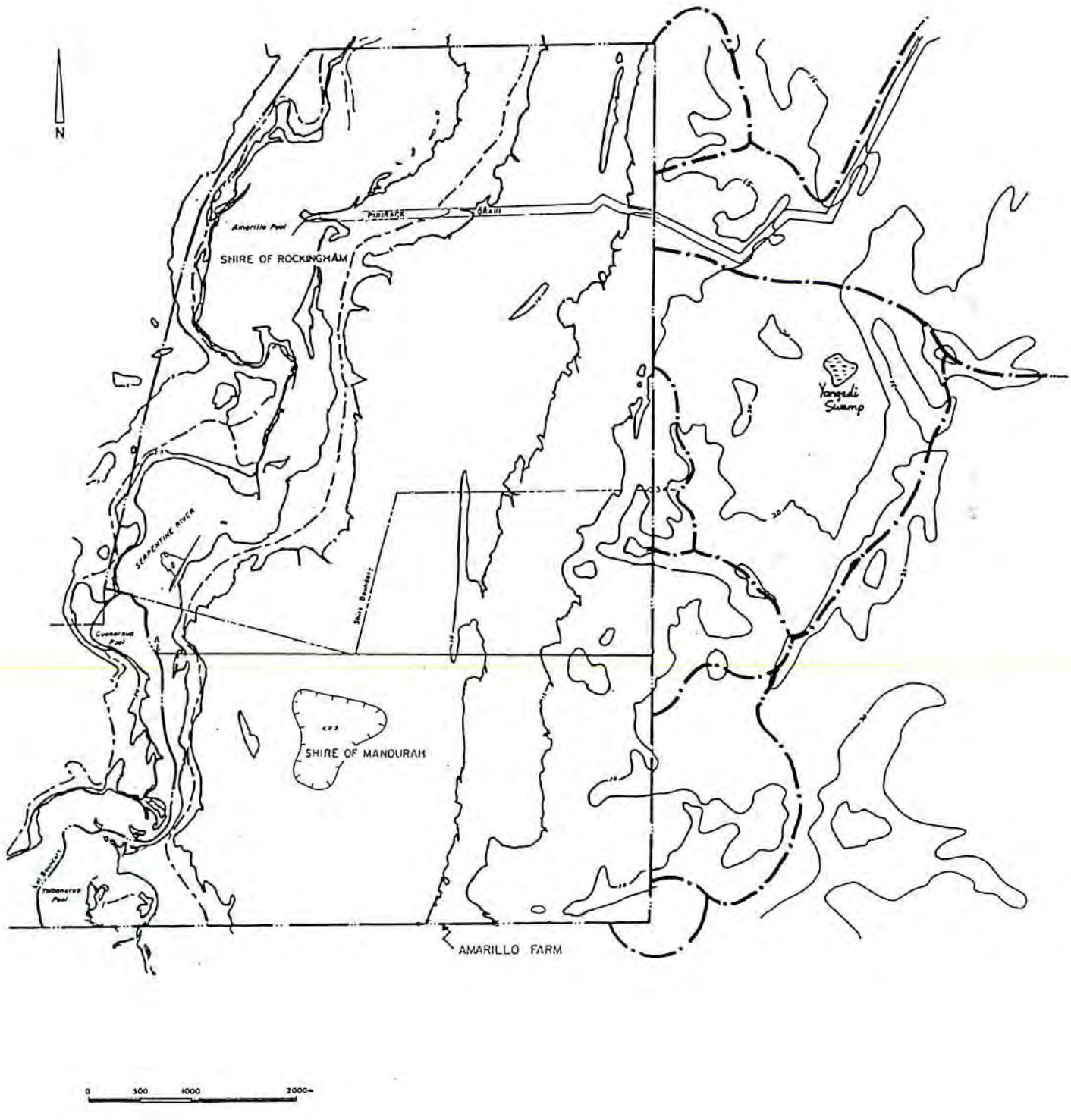
2.1.5 Surface Drainage

The eastern side of Amarillo has been classified as palusplain (seasonally waterlogged) on regional wetland mapping published by the Water and Rivers Commission. The waterlogging occurs due to rainfall causing the water table to rise to near the ground surface during the winter months. Runoff occurs due to the 'saturation-excess' mechanism and it has been estimated that between 25% and 40% of annual rainfall becomes runoff when the land use is predominantly pastoral (Peck and Davies, 1993).

Surface drainage is collected in the numerous shallow agricultural drains which have been constructed to alleviate waterlogging and flooding and is discharged to the Serpentine River. Most of the surface drainage originates on the property although some external inputs have recently been diverted at the southern end of the property. There are boundary drains which follow both the northern and southern fencelines for most of their length and which are located on Homeswest's land. A major regional drain (Dirk Brook Drain) crosses the site from east to west in the northern sector. The drainage catchment boundaries in the locality which affect Amarillo are shown on Figure 1, with the exception of part of the Dirk Brook drain catchment, which extends to the Darling Scarp and is therefore too vast to show at the scale of Figure 1.

Preliminary investigations by Peck and Davies (1993) showed phosphorus concentrations of between 0.064 and 3.7 mg-TP/L in surface drains, with an average from all samples of 0.94 mg-TP/L. This is relatively high and is probably attributable to the application of agricultural fertilisers over a number of years and it is also believed from anecdotal evidence that there have been 'contributions' in the past from land utilised for a piggery located immediately south of the site.

FIGURE 1
EXTERNAL CATCHMENT BOUNDARIES



2.2 Water Resource Management Objectives and Criteria

The water sensitive design guidelines state that in order to fully achieve WSD, a development project should implement a stormwater management system which ensures that the peak discharge rate, volume and pollution load of stormwater leaving the site after development is no greater than pre-development. This is particularly important at Amarillo given the status of the receiving water body; the Peel-Harvey Estuary.

Furthermore, there are broader water resource management objectives which need to be applied during consideration of WSD aspects, which can be grouped under four categories; water balance, water quality, water conservation (supply) and water-related environmental and cultural uses. The priority objectives for implementation of WSD at Amarillo are discussed below for these four categories.

2.2.1 Water Balance

Development of Amarillo for residential purposes will alter the water balance of the site and one of the most useful indicators of water balance change, for discussion purposes, is the position of the water table. The objectives of water balance management at Amarillo may be stated as:

- ensure that there are no adverse changes to the water table in terms of its assigned beneficial uses (this may be compared to the Water Authority's policy for groundwater abstraction of **environmentally sustainable draw** which requires that abstraction does not alter the water table to the extent that damage occurs to coastal plain vegetation or wetlands);

- ensure that any changes to streamflow in the Serpentine River do not cause flood damage and erosion impacts.

Water table controls are required at Amarillo in all those areas where the winter water table (maximum) is closer than 1.2 metres to ground surface. This represents approximately 80% of the available 'developable' land on the eastern side of the Serpentine River.

2.2.2 Water Quality

The most important aspect of water quality at Amarillo is the nutrient content of drainage as previously discussed, particularly the phosphorus content and the issue of mobilisation of the existing soil and groundwater store of phosphorus. Other aspects are also important, however, and the broad objectives for Amarillo may be stated as:

- minimise the generation of pollutants within the development via community education;
- minimise pollutant inputs to local groundwaters and discharges off-site in surface waters;
- prevent adverse sedimentation of downstream watercourses;
- protect and, where possible, enhance existing fringing vegetation along drains and watercourses for water quality purposes and revegetate artificial wetlands;
- demonstrate an 'environmental gain' in respect of phosphorus discharges to the Serpentine River as a result of the change in land use (i.e. phosphorus loadings to the river should be reduced and the long-term phosphorus discharges should not be a burden to future generations).

In regard to the latter objective, it is important to recognise that significant phosphorus discharges occurred from the previous extensive pastoral use of the property and the option of continued pastoral use is probably the least desirable environmentally.

2.2.3 Water Conservation (Supply)

The potential for increased discharge of water and nutrient to the Serpentine River is one of the primary constraints to development of Amarillo and one of the obvious means of minimising any increases is to promote the use of on-site water within the development. The objectives for water consumption at Amarillo may be stated as:

- encourage revegetation with deep-rooted perennial trees in an urban context to the greatest practicable extent;

- promote on-site utilisation of groundwater and stormwater for irrigation purposes for both private and public land (maximise the use of private bores);
- retain drainage on-site in ponds and lakes to the extent practicable in order to maximise evaporative losses;
- minimise the import and use of scheme water, especially 'ex-house' use.

Clearing of the site for pasture and construction of an extensive network of agricultural drains has already caused an increase in drainage to the river. The acceptability of further increases in drainage is largely dependent on the phosphorus content of that water.

2.2.4 Water-related Environmental and Cultural Uses

Another facet of water resource management at Amarillo involves a consideration of the beneficial uses of, primarily, groundwater resources. These beneficial uses can be for environmental and human purposes. The objectives for the protection of water resource beneficial uses at Amarillo may be stated as:

- maintain water-related environmental values both on-site and off-site, particularly for wetlands and vegetation which may be sensitive to changes in groundwater level and nutrient enrichment;
- maintain water-related recreational/cultural values, both on-site and off-site including downstream watercourses;
- minimise changes to water balance in terms of diminishment of water resources to the detriment of existing and potential public water supplies.

The clearing of the site for pasture and extensive livestock grazing has substantially reduced the environmental values at the site, particularly on the eastern side of the Serpentine River. Therefore, the beneficial uses of the site's water resources are mainly off-site environmental (wetlands and Goegrup Lakes/Peel-Harvey Estuary) and potential human uses, including irrigation of public and private land on-site.

2.3 Elements of the Strategy

Formulation of the nutrient, drainage and groundwater management strategy commenced with a groundwater model which was based on an initial strategic structure plan prepared by Chapman Glendinning and Associates in October, 1993. This structure plan was used as a guide only to 'set-up' the model, and had the nominal land use distribution summarised in Table 2.1. Substantial changes were subsequently made to the initial structure plan to incorporate drainage management initiatives.

A range of alternative approaches were examined during the iterative modelling process which was adopted to derive the drainage strategy. For each approach a selection of techniques was applied from a 'tool-box' of available strategy elements. These include the following:

- fill
- constructed wetlands
- open drains and sub-soil drains
- revegetation with perennial trees
- on-site bores for public/domestic irrigation
- multi-purpose POS/drainage function areas equipped with WSD techniques
- fail safe phosphorus removal techniques as back-up.

The application of these elements to the Amarillo site, and the degree to which the water resource management objectives would be met, is outlined below. Further supporting detail in relation to groundwater, stormwater and nutrient modelling will be provided in the Environmental Management Programme.

2.3.1 Overview of Drainage Strategy

The key element of the drainage strategy which has emerged during consultations with the WRC is the degree of water table drawdown proposed by drainage (ie the depth of the open drains and sub-soil drains).

The WRC's position is that the invert of the drains should be no deeper than the "average annual maximum groundwater level" (AAMGL). This is to ensure, amongst other things, that there is minimal mobilisation of phosphorus from the existing soil and groundwater store of phosphorus at the site.

Table 2.1

Land Use Distribution within Initial Structure Plan (October, 1993)

Land Use	Area (ha)
Residential Precincts (2915ha):	
- Nett residential area	2072
- District centres	60
- Major neighbourhood centres	32
- Intermediate neighbourhood centres	30
- Minor neighbourhood centres	40
- High schools	80
- Primary schools	128
- Drainage lakes	36
- 15% POS	437
Non-Residential (1090ha):	
- Regional Open Space	750
- Regional Centre	45
- Mixed Business & Service Trades	30
- University/TAFE	75
- Arterial Roads (est 20km x 60m)	120
- SECWA Easement & alienated land (est 8.5km x 80m)	70
TOTAL	**4005**

Notes:

- The areas in the table are approximate only and are shown for indicative purposes and subsequent comparisons (for example, the total area of the site is about 3980ha, not 4005ha).
- The initial structure plan included a POS allocation of 15%, which was largely arbitrary at the time it was selected but recognised the need to allocate additional land for water management.

Unfortunately, it is not possible to precisely define the AAMGL across the Amarillo site because there is insufficient long-term data describing seasonal groundwater fluctuations. Additional confounding issues arise at this site in respect of determination of the AAMGL, notably:

- this region of the Swan Coastal Plain is currently experiencing a long period (circa 20 years) of below average rainfall which may be resulting in lower groundwater levels than would be experienced during a wetter period;
- since about the 1940's and 1950's there has been extensive clearing of perennial native vegetation in the region and replacement with annual pastures, and the resultant water balance changes would have induced significant rises in the water table;
- the only long-term monitor bore at the site (WRC bore T590) does not pre-date either of the above periods and in addition, the hydrograph exhibits a relatively recent change in water levels (a sharp decline) which cannot be explained.

Given the above lack of reliable data, it may be necessary to base the drainage strategy upon a less definitive interpretation of the AAMGL and to focus more on management of phosphorus in drainage. A reasonable compromise in respect of defining the maximum depth of the urban drainage system could be considered to be the depth of the existing shallow agricultural drains. These are, on average, no more than 0.5 metres below surface. The AAMGL will be determined to the satisfaction of the Water and Rivers Commission.

A brief mention should be made of the 'do nothing' option, which would involve a continuation of pastoral use with consequent high discharges of phosphorus in drainage to the Serpentine River. Homeswest is only interested in this option as an interim phase before residential development and hence it is no longer considered as a viable long-term alternative. However, where relevant this land use option is discussed in subsequent sections for comparative purposes.

2.3.2 'Best Planning Practices' Approach

At the strategic level, derivation of the drainage strategy has been conducted in accordance with the Best Planning Practices (BPP's) of WSD to ensure that the major structural elements are properly allocated to maximise achievement of the water resource

management objectives. Application of strategic BPP's at Amarillo has been conducted by an iterative process in the following logical sequence:

(i) Identification of remnant vegetation (refer Section 2.1.1), natural drainage lines and wetlands/damplands for inclusion in the proposed public open space network. Pockets of remnant vegetation, although degraded, are deemed to have landscape value and can be readily enhanced during the detailed design and development of the site. Degraded damplands will most likely be utilised for drainage retention facilities.

(ii) Identification of land for an integrated stormwater, groundwater drainage and public open space system, including allocations for storage/detention facilities, peak flow drainage paths and discharge points via constructed wetland systems. At the present level of planning, the POS/drains network comprise 100 metre wide 'swales', although ultimately these areas will vary in width to accommodate other elements and to enhance aesthetics, suitability for passive/active recreation and to create a more 'natural watercourse feel'. This approach automatically leads to a multi-function POS network which is relatively evenly distributed across the site because it is responsive to drainage requirements.

(iii) Identification of other areas of 'non-developable' land in order to define residential development precincts. This aspect mainly arises from the presumed need to maximise the consumption of water on-site using trees, although trees also have a very important complementary function of landscape enhancement. This reduces the quantity of drainage which is discharged to the Serpentine River and therefore the phosphorus loading.

An evaluation of the drainage strategy is conducted in Table 2.2 to highlight the provisional land areas allocated to specific BPP elements and to evaluate the potential for achievement of the water resource management criteria and objectives.

2.3.3 'Best Management Practices' Approach

The application of Best Management Practices (BMP's) to Amarillo was considered in terms of the broad management categories or "treatment trees" defined in the WSD guidelines document. The structural or regional-scale results of this approach are

Table 2.2

Nominal Land Use Distribution arising from the Drainage Strategy and Summary of Potential to Meet Water Resource Management Objectives

(i) Land Use Distribution	Structure Plan (June 1995)	
	Area (ha)	(%)
• Drainage Lakes and Nutrient Stripping Ponds	338	(11.1)
• Primary POS/Drainage Swales and Tree Plantings	313	(10.2)
• Remnant Vegetation/Landscape Protection	165	(5.4)
• Active POS	47	(1.5)
• Non-Residential (Schools, Centres, Industrial, SECWA easement)	386	(12.6)
• Residential	1809	(59.2)
(ii) Water Resource Management Objectives	**Appraisal**	
• Water Balance	- Objectives can be met. - Maintain average annual maximum water table position. - Modelling indicates a likely reduction in groundwater drainage to river. - Recognise that clearing for pasture has increased water table position. - Recognise that dry period has decreased water table position.	
• Water Quality	- Objectives can be met. - Existing soil/groundwater store of P will continue to drain to river via sub-surface flow. - Groundwater discharge to drains will be treated by WSD techniques. - Long term improvement to phosphorus export.	
• Water Conservation (Supply)	- Objectives can be met. - Revegetation of primary POS areas plus additional landscape enhancement with perennial trees. - Scheme water minimised by provision of on-site irrigation water.	
• Water-related Environmental and Cultural Values	- Objectives can be met. - Maximises use of on-site irrigation resource (shallow groundwater). - Average minimum water table position may rise (including off-site).	

described below. (A range of smaller-scale BMP's will be introduced during the detailed planning and design stage, consistent with the "treatment train" approach recommended by WSD).

(i) *Measures to promote infiltration and detention:* There is limited scope for infiltration of stormwater runoff over most of the site because of the high water table. Areas where infiltration could form a primary management practice are essentially confined to the higher ground on the western side of the Serpentine River and on some of the higher dunes on the eastern side of the property. Small infiltration retention basins would be located in these areas to capture local runoff.

Elsewhere on the site, infiltration could also be achieved early in winter before the water table rises significantly from its summer minimum. Techniques to capture and infiltrate some of the 'first flush' of runoff could be introduced in shallow water table areas by taking advantage of seasonal water table position and incorporating multi-purpose elements in the POS/drainage network. For example, ovals could be used as infiltration areas (perhaps with some treatment capability via initial amendment of the oval's soil profile during establishment) until the water table rises to the extent that the saturation-runoff mechanism applies. This technique is mentioned as an example of detailed WSD which could be designed into the project during subsequent phases. Active management may be required in some instances.

Substantial revegetation, especially within the POS/drainage network, is proposed as one of the major BMP's for reducing runoff and groundwater drainage export from the site, as previously described.

In addition, detention basins will be used as a means of runoff control by delaying discharge at strategic locations, as described elsewhere in this report.

(ii) *Measures to control scour, erosion and sedimentation:* At the strategic planning level, the BMP's to prevent scouring, erosion and sedimentation are essentially fourfold:

- preservation of riparian vegetation along the Serpentine River and existing drainage lines which cross the property;

- revegetation of existing drainage lines, where retained in the final design, and provision of new vegetated swales for drainage (i.e. "streamlining" as defined by the Community Catchment Centre in Pinjarra);

- allocation of sufficient land within drainage swales to introduce appropriate BMP's at the detailed design stage (the 100 metre wide swales are the key element here as they provide the opportunity to implement drop structures, stilling basins and other energy dissipators on an 'as required' basis);

- provision of wet detention basins with storage capacity for runoff to slow the rate of discharge.

The existing sedimentation problem in Amarillo Pool on the Serpentine River, due to the Water Corporation's Dirk Brook drain, is a valuable case study of inadequate drainage design and management on this landform and soil type. Whilst a primary factor in this sediment transport is disturbance to the banks of the drain due to livestock access, the slope and straight configuration of the drain also contributes to its inherent instability. Livestock disturbance of the proposed drainage system at Amarillo will not be an issue when it is developed for residential purposes, however special attention will be devoted to management of erosion risk during construction activity.

There is a clear lesson from the Dirk Brook drain to adopt a design philosophy of dispersal of drainage through a meandering system rather than a concentration of drainage through a straight system. Again it is the 100 metre wide POS/drainage swales which provide the basis for implementation of this design philosophy, but it will also incorporate roads, parking lots and ovals as diversion paths for peak flows to disperse and dissipate energy for erosion control.

(iii) *Measures to control stormwater runoff pollution:* The principal means of achieving stormwater runoff and groundwater drainage pollution control at the strategic level will be by revegetation including provision of vegetated drainage swales, infiltration through soil amended facilities where possible, sedimentation in wet detention basins and biologically-enhanced treatment in constructed wetlands. The focus of design input to the Structure Plan has been to estimate drainage volumes via modelling, to enable provisional sizing of the basins and wetlands and therefore allocate land for these facilities. Particular consideration

will be given to the optimum means of staging these facilities during implementation of the initial phase of development and the addition of fail safe phosphorus removal techniques.

The assumed performance of the detention basins and in particular the constructed wetlands (water pollution control ponds) was a key issue during consultations with key agencies in 1995. Concern regarding the performance of the wetlands has lead to the need to consider other control methods for phosphorus, such as chemical treatment. However it is relevant to note that constructed wetlands as drainage management techniques are consistent with the Statement of Planning Policy for the Peel-Harvey Coastal Plain Catchment (refer Appendix A), promoted as a BMP in the WSD guidelines and recognised internationally as a 'best practicable technology' for urban stormwater pollution control.

(iv) *Measures to minimise pollution from sewage and encourage wastewater recycling:* As it is intended that residential development at Amarillo would be provided with a reticulated sewerage system that is connected to the Water Corporation's future regional network (i.e. sewage would be exported off-site), there has been no consideration of BMP's under this category. Furthermore, wastewater recycling and re-use on the Amarillo property is not an option that could be seriously contemplated because this would only serve to exacerbate the existing excess water problems.

(v) *Measures to promote water conservation:* The appropriate response to the water conservation ethic at Amarillo is to minimise the use of imported scheme water to the greatest practicable extent. This will have regional benefit in terms of minimising demand on the Water Corporation's domestic water supply obligations. The benefit for the Amarillo site derives from replacement of scheme water, where possible, with on-site groundwater for all 'ex-house' uses. Comprehensive use of private bores for garden irrigation will be encouraged to enhance the degree of water table decline during the drier months of the year and therefore enable a higher proportion of stormwater runoff to be infiltrated on-site, especially during the initial 'first-flush' of the wet period which is so important in the context of pollution control. This would help to minimise the export of urban drainage to the Serpentine River during this period which is of obvious environmental merit.

There is an implicit requirement to maximise the proportion of allotments which have access to a groundwater bore for garden irrigation. This is because the recharge rate applied in the groundwater model is low relative to that which would be expected for average residential development, where there is more imported scheme water used on gardens and private bore usage only occurs on about 25-30% of allotments.

3.0 NUTRIENT MANAGEMENT

This section addresses the water quality issues associated with management of stormwater and groundwater and primarily discusses phosphorus, as it is considered the 'indicator parameter' by which environmental acceptability may be assessed in the Peel-Harvey catchment, although other pollutants are important.

Prior to examining the likely post-development phosphorus regime, the phosphorus export from the existing pastoral land use is discussed for comparative purposes, and the benefits of trees are briefly reviewed.

3.1 Pre-development Phosphorus Regime

3.1.1 Fertiliser Application History

Accurate records of fertiliser application rates are not available, especially for the period prior to Homeswest's purchase of the land. The areas developed for pasture would previously have been fertilised with Superphosphate at the traditional rate of "one bag to the acre", which is equivalent to 18 kilograms of phosphorus per hectare. This would have been on an 'as-required' basis; annually in some areas of the site and perhaps each two or three years in other areas. On average, the annual Superphosphate application would most likely have been in the range 0.5 - 0.75 "bags/acre/year", i.e. 9 - 14 kilograms of phosphorus per hectare. For the approximate 3000 hectares of agricultural land on the eastern side of the Serpentine River, this equates to an annual phosphorus loading to the site of between 27 to 42 tonnes.

No fertiliser was applied during the three year period 1989 - 1991, when the property was in receivership prior to purchase by Homeswest.

Since that time, the areas of pasture have been fertilised annually with Coastal Superphosphate at the rate of 0.5 "bags to the acre". In addition, the tree plantations have been given specific fertiliser treatments during establishment, namely with Agras #1 for the initial planting and a subsequent application of DAP.

3.1.2 Mechanisms of Phosphorus Export

The current mechanisms of phosphorus losses to the Serpentine River are relevant to note for the purposes of considering the potential benefits of the proposed change in land use in subsequent sections. Research data summarised in the Peel-Harvey ERMP indicates that, for the deep grey sand areas typical of the Amarillo site, about 60% of the phosphorus is transported to drains via sub-surface flow (shallow groundwater), while about 40% is transported as overland flow when the water table rises to the surface during winter (i.e. surface runoff generated by the 'saturation-excess' mechanism).

The overland flow mechanism is very important because it can result in the direct loss of soluble and particlate phosphorus from fertiliser in the year of application, which is essentially an instantaneous loss of phosphorus. The sub-surface mechanism is slower but over time results in relatively high and almost continuous export of phosphorus to drainage from the accumulated soil/groundwater store.

3.1.3 Estimates of Phosphorus Discharge to Serpentine River

A detailed investigation of phosphorus dynamics has not been conducted at Amarillo so the annual export to the Serpentine River in drainage and sub-surface flow can only be estimated for the existing agricultural and tree plantation uses. Some data was collected during the 1992/93 hydrological study (refer Sections 2.1.4 and 2.1.5), however an extensive investigation was not considered warranted at the time. This is because a change in land use from pastoral to pastoral/plantation forestry was in progress and in any event, the phosphorus export for the proposed urban land use would also need to be estimated and it is considered that estimates can be made for the pre-development situation with a similar degree of confidence. The absence of detailed information is not a constraint to evaluation of the relative merits and effects of the proposed land use change because suitable data is available from other sources to enable a valid assessment to be made (A detailed nutrient study would be costly, complex and time-consuming, and would largely be of academic interest).

Research data from the "Peel-Harvey Catchment Demonstration Farm Hydrological Study Under National Afforestation Program Project 15" (Silberstein and Bennett, 1990) can be extrapolated to the Amarillo site in order to provide indicative estimates of phosphorus discharges to the Serpentine River. This study was a paired catchment study of a site (Caratti's farm) south of Harvey Estuary, which has similar coarse sandy soils to the

Bassendean sands at Amarillo and is essentially representative of the topography, drainage and land use on large parts of Amarillo. A summary of the rainfall, runoff and phosphorus data from the research report is provided in Table 3.1; this is compiled from a comprehensive monitoring programme in which continuous flow data was recorded and daily water samples analyzed for phosphorus content.

Table 3.1: Summary Data on Rainfall, Drain Flow and Phosphorus Loads From the Paired Catchment Study at Caratti's Farm (Silberstein and Bennett, 1990).

Catchments	East	West
Period: 6 June to 31 December 1989		
Rainfall (mm)	600	575
Drain Flow ($x10^3$ m^3)	75.6	63.6
P Load (kg)	31.4	37.5
*FWMP (mg/L)	0.42	0.59
Runoff (mm)	264	237
Runoff/Rainfall	0.44	0.41
Period: 1 January to 25 September 1990		
Rainfall (mm)	781	752
Drain Flow ($x10^3$ m^3)	46.2	31.0
P Load (kg)	34.7	22.4
*FWMP (mg/L)	0.75	0.72
Runoff (mm)	172	115
Runoff/Rainfall	0.22	0.15

* FWMP = Flow Weighted Mean Phosphorus.

Estimates of phosphorus export from Amarillo under pastoral land use may be derived by applying the range of 'flow weighted mean' phosphorus concentrations from Caratti's farm to some earlier modelled drainage volumes calculated for Amarillo. It is considered sufficient for this stage of broad comparative review to derive estimates on an annual basis only, to avoid the complexities of short-term fluctuations in flow rates and phosphorus loadings which would only serve to confuse the principal issues being addressed herein.

The calculated groundwater discharge to drains 'before development' is 8.24 Mm^3/a (Peck, 1993) and, by applying the appropriate range of phosphorus concentrations (0.42-0.75 mg/L as per Table 3.1), this leads to a groundwater drainage phosphorus discharge in the range 3460 kg-TP/a (minimum) to 6180 kg-TP/a (maximum).

The groundwater discharge to drains was calculated from the groundwater model for 18 sub-catchment areas comprising a total of 2747 hectares on the eastern side of the Serpentine River. The equivalent range of export rates for this area is therefore estimated to be 1.3-2.2kg/ha/a. This is considerably in excess of the Peel-Harvey catchment target of 0.37kg-TP/ha/a.

3.2 Effect of Tree Plantations

3.2.1 Benefits of Interim Plantation Forestry

The 1000 hectares of *E. globulus* plantation which have been established at Amarillo will have a number of benefits, including water table control, drainage reduction to the Serpentine River and nutrient uptake from the existing soil/groundwater store. Other benefits, such as future income from harvesting, landscape enhancement and erosion control, are also important but not relevant to this discussion.

The water table benefits of converting cleared and pastured land to plantation forestry are well-documented elsewhere and, in summary, principally involve a shift in the water balance as a consequence of the higher interception and evapotranspiration losses from trees. Recharge rates (as a proportion of annual rainfall) are estimated to reduce from about 40% for annual pasture to about 4% for plantation trees.

The water quality benefits in terms of phosphorus reduction are less well-defined but still important. Two mechanisms operate to reduce phosphorus discharge from the site:

- a reduction in drainage due to greater evapotranspiration;
- uptake of phosphorus as plant biomass (discussed below).

Cromer and Williams (1982) studied biomass and nutrient accumulation in an *E. globulus* plantation in Victoria and, for unfertilised trees planted at a density of about 2000 stems per hectare, they measured the phosphorus accumulation in biomass to be 4.9 kg/ha for

9.5 year old trees. The soils at the test site in Victoria have a high capacity to adsorb phosphorus and may have limited the uptake of phosphorus, given that fertilised trees showed almost 3 times the uptake (albeit with a low percentage recovery of added phosphorus).

For Amarillo, the plantings are at a density of about 1000 stems per hectare which would yield a phosphorus accumulation of 2.5 kg/ha, but the soils have a low capacity to adsorb phosphorus and phosphorus uptake may not be limited. Therefore, it would appear reasonable to assume an uptake rate of at least 3.0 kg/ha of phosphorus, which would equate to a removal rate in harvested biomass of 3 tonnes from the 1000 hectares of trees, for a crop rotation of (say) 10 years. In Section 3.1.3 the annual export of phosphorus in drainage is estimated to be in the range of 3-6 tonnes for the whole site. Given this annual export, a once-in-10-year removal of 3 tonnes via tree biomass is equivalent to, at best, 10% of the phosphorus budget for the period.

3.2.2 Benefits of Revegetation During Urbanisation

In terms of phosphorus reduction, the benefits of revegetation and landscaping for the urban development of Amarillo will largely derive from water balance benefits rather than direct uptake in biomass. This is because the percentage removal of phosphorus for perennial trees is relatively small as estimated above and, furthermore, the trees planted within urban cells will not be regularly harvested, if at all.

The primary benefit of landscape enhancement with perennial trees will arise from the increase in evapotranspiration and direct rainfall interception, with consequent reduced drainage compared to both existing land use and traditional residential subdivision. The increased evapotranspiration is estimated to represent approximately 320 mm/a of rainfall equivalent, in comparison to annual pasture, which is a substantial alteration to the water balance given that in the 'before urban' situation, an average of 34% of rainfall or 300 mm/ha/a is estimated to be lost as groundwater discharge to drains. The areas of trees will therefore result in localised lowering of the water table until a new equilibrium position is attained and the reduction in drainage from these areas will proportionately reduce phosphorus export.

Further water balance benefit could be derived by irrigating selected areas of trees with on-site groundwater during the summer months. For example, it is commonly held that trees (*E. globulus*) with access to a plentiful water supply, such as shallow groundwater as at

Amarillo, can transpire at close to pan evaporation rates (AJ Peck & Associates, 1993). Irrigation during the summer months to supplement in-situ water can increase evapotranspiration even further, with the possibility that it may even exceed the pan evaporation rate. This is supported by recent measurements of water use by trees at Wandalup piggery. This work supersedes earlier local estimates by Marshall and Chester (1991) in the Wellard area, who estimated that *E. globulus* growing under irrigation with piggery effluent used only 0.6 pan evaporation.

3.3 Post-development Phosphorus Regime

3.3.1 Estimates of Phosphorus Content of Urban Drainage

Quantification of the phosphorus content of urban drainage from sandy soil catchments is most difficult because of the number of variables involved and the intensity of sampling effort required to gain statistical reliability and to derive relationships for different component land uses within an urban situation. Nevertheless, in order to place the proposed change in land use at Amarillo in an appropriate perspective, some broad estimates of likely phosphorus loads after development are considered beneficial.

Data published by the Swan River Trust (1993) provide average water and nutrient loads from sub-catchments of the Swan River with highly variable land uses, soil conditions and drainage characteristics. The sub-catchments which most closely approximate soil and drainage conditions at Amarillo are believed to be Bayswater Main Drain, South Belmont MD, Mill Street MD and Bannister Creek. The phosphorus load from each of these sub-catchments has been measured as 1.88, 0.57, 1.0 and 0.43 kg-TP/ha/a, respectively. Unfortunately these data can not be directly related to Amarillo for predictive purposes because the sub-catchments encompass land uses which are not proposed at Amarillo, such as unsewered residential (estimated to comprise 15-45% of specific catchments) and unsewered light industrial. Overall, the Swan River Trust data is insufficient to determine a relationship between sewered residential land use and phosphorus load.

The value of the above data is that it is indicative of a 'worst case' scenario relative to the proposed development of Amarillo, because of the unsewered areas and poor historical drainage management practises in these sub-catchments. Development of Amarillo for primarily residential purposes, provision of a reticulated sewerage system and implementation of water sensitive design principles should markedly improve the

phosphorus loads in comparison to these older developed areas in the Swan River catchment. Note also that only one of the abovementioned urban sub-catchments (Bayswater MD) has a phosphorus export rate on a per hectare basis which is within the range estimated for Amarillo under pastoral use (refer Section 3.1.3). This indicates that even unmanaged urban development would be an improvement on the existing situation at Amarillo in the long term, although clearly the objective of nutrient management is to achieve marked improvement in comparison to the historical urban developments adjoining the Swan River.

In recent years, studies by various researchers including Tan, 1991, Bayley *et al*, (1989) and the Swan River Trust (pers. comm.) have endeavoured to measure and estimate phosphorus loadings from specific land uses and soil types, with an emphasis on primarily residential areas. No conclusive results have emerged from these studies which could be used for predictive purposes without some uncertainty, because of the variability in the data and other factors, although useful data has been obtained. For example, monitoring of drainage from four residential areas in the Bayswater catchment over a two year period yielded flow weighted mean phosphorus concentrations in the range 0.03 - 0.1 mg-TP/L. These are much lower than the concentrations recorded at the main drain outlet, indicating that the residential areas within the main drain's catchment are contributing significantly less phosphorus than the average rate for the catchment, which is very high at 1.88 kg/ha/a. Clearly there must be some point sources of phosphorus or diffuse sources other than residential which are contributing these excessive levels.

Based on very limited data from a residential subdivision at South Lakes, H. Tan (pers. comm.) has suggested that it would be appropriate to use 0.3 mg-TP/L as a concentration in order to predict the future phosphorus content of urban drainage at Amarillo, which will have a large component of groundwater discharge via sub-soil drains and the open drain system. However, the more recent surveys by the Swan River Trust suggest that lower mean phosphorus concentrations could also be applicable, especially for sewered residential development.

For the purposes of estimation and comparative evaluation in this document, a range of phosphorus concentrations will be applied consistent with the recent studies mentioned above. Therefore, the phosphorus content of "raw" urban drainage at Amarillo is estimated to be in the range 0.1 - 0.35 mg/L prior to treatment in any of the water pollution control facilities, which are discussed in the section below.

3.3.2 Strategic Design Criteria for Phosphorus Removal

At the conceptual management planning level, the strategic design criteria to minimise the export of phosphorus to the Serpentine River have been summarised in Sections 2.3.2 and 2.3.3 in terms of the water sensitive design approaches for the site. The overall emphasis is on retention of drainage near to source to enable treatment and to provide environmental/aesthetic benefits prior to discharge, rather than direct conveyance off-site.

Given the high volumes of drainage leaving the site now and the anticipated volumes requiring management following development, specific allowances need to be made at the early structure planning stage for water pollution control ponds and artificial wetlands. The design approach for these facilities is based upon the recommendations of Evangelisti & Associates and is summarised below (constructed wetland will still form an important component of drainage management at Amarillo, even though fail safe phosphorus removal techniques are initially required in order to meet the catchment target).

(i) Stormwater Treatment

The generally accepted criterion for stormwater (ie, surface runoff) treatment is to retain the water in a detention/sedimentation pond for a period of 3-4 days prior to discharge off-site. The basis of this criterion is that most of the phosphorus is in particulate form and a relatively small proportion, other than during the first Autumn rains, is in 'dissolved' form, i.e., filterable reactive phosphorus. Provision of ponds to achieve sedimentation of particulate phosphorus is a primary requirement of conceptual drainage management.

The Precipitation-Interevent-Frequency (PIF) methodology has been applied in order to derive preliminary sizes for the treatment ponds for stormwater runoff. Using the PIF table for the Perth Metropolitan Area, a design rainfall can be chosen by selecting a percentage of the total storm events which are required to be treated for a minimum of 72 hours, i.e., the 'inter-event frequency'. The PIF table is derived from an analysis of 37 years of rainfall records to define all storms that were separated by a minimum of 72 hours from the next storm.

Given the sensitivity of the Amarillo area to phosphorus export, a target treatment of 95% of storms was selected, which leads to a design rainfall of approximately 80 mm. This design rainfall is applied in the following equation:

$$V = C \cdot R \cdot A$$

where V is the treatment volume (m^3), C is the runoff coefficient, R is the design rainfall (m) and A is the catchment area (m^2). For each nominated catchment, a composite value of C is derived from the individual C values for each land use in accordance with the following:

POS/Trees	-	C = 0.1
Residential	-	C = 0.3
Local/District Centres	-	C = 0.6
Schools	-	C = 0.5.

From the above equation, the area of pond may by determined by assuming an average depth, which in this instance, is taken to be about 1.5 metres. This area is in addition to the area of pond required for groundwater treatment, as determined below.

(ii) Groundwater Treatment

Phosphorus in shallow groundwater is assumed to be primarily in the dissolved form as filterable reactive phosphorus, and is likely to be phosphorus enriched relative to stormwater because of the low Phosphorus Retention Index of the soils. As a consequence, the primary treatment process in the ponds will need to be biological rather than via sedimentation of particulate matter. Therefore the main ponds for groundwater treatment will need to be designed as artificial wetlands and most likely incorporate some form of biomass production/harvesting to remove phosphorus in the biological form.

A plug flow model based on artificial wetlands for wastewater treatment has been employed to size the ponds. The detention time is the critical parameter as there is a direct correlation between this parameter and phosphorus removal. Detention time needs to be high for three principal reasons; firstly because the phosphorus removal mechanism will be primarily biological, secondly because the target removal rate should be a minimum of 50% or preferably greater and thirdly, because there will be seepage of groundwater through the sides of the ponds so the plug flow assumption should be modified accordingly.

To determine pond volumes the following equation is applied:

$$V_{lake} = Q \cdot D$$

where V is the volume (m^3), Q is the rate of groundwater discharge into the pond for the

peak month (kL/d) and D is the detention time (days). Peak groundwater discharges were calculated by A.J. Peck & Associates during earlier groundwater modelling exercises.

An average detention time of 28 days is considered desirable to maximise the phosphorus removal efficiency and, in the situations where short-circuiting occurs due to direct seepage via the sides of the ponds, the detention time is modified by a factor of 1.5 - 2.0 times. The size of the multiplier is dependent on such factors as the morphology of the pond (as it affects the ratio of seepage vs inflow) and the extent to which inflowing drainage has been treated in an 'upstream' pond. It also makes an allowance for stormwater input to the same pond and consequent impact on the plug flow assumption. The optimum detention time could be determined on a trial basis by building ponds of various sizes to service small sub-catchments during the initial stages of development.

(iii) Total Pond Areas and Volumes

As with the stormwater pond determination, the area of each pond for groundwater treatment is determined from the calculated peak drainage volume in the wettest month and by assuming an average depth of about 1.5 metres. The total area of ponds for stormwater/groundwater treatment has been provisionally calculated to be in the order of 135 hectares, to be refined as more detailed analyses and design are conducted. A total area of 338 hectares has been allocated in the Structure Plan for drainage basins and nutrient stripping ponds (refer Table 2.2) so there is sufficient contingency area available should it be required.

3.3.3 Estimates of Phosphorus Discharge to Serpentine River

Broad estimates of the potential phosphorus discharges to the Serpentine River can be derived from the data mentioned above. Only groundwater discharges will be considered for the present purposes because it is the major component of phosphorus export and enables easy comparison to the 'before development' scenario discussed in Section 3.1.3. In addition, only a long term perspective will be adopted (i.e., assuming full development and steady state in respect of the soil/groundwater store of phosphorus) in order to avoid complexity.

The calculated groundwater discharge to drains for a Deep Drainage Option is 8.27 Mm^3/a and, by applying the nominated range of phosphorus concentrations (0.1-0.35 mg/L as per Section 3.3.1) and assuming a 50% phosphorus removal performance in the treatment ponds, this leads to a groundwater drainage phosphorus discharge in the range 414 kg-TP/a (minimum) to 1447 kg-TP/a (maximum). The equivalent range of export rates for the 2747 hectares of land area considered in the model is 0.15-0.53 kg/ha/a.

Similarly, for a Shallow Drainage Option, which yielded a groundwater discharge of 7.74 Mm^3/a in the model, the groundwater drainage phosphorus discharge would be in the range 387 kg-TP/a (minimum) to 1354 kg-TP/a (maximum). The equivalent range of export rates for the 2747 hectares of land area considered in the model is 0.14-0.50 kg/ha/a.

These preliminary results are considered to be indicative of worst case scenarios, because the modelled drainage options are now redundant in view of the requirement to minimise groundwater drainage by maintaining drain inverts at the AAMGL. The AAMGL option should yield less groundwater discharge in comparison to the above scenarios.

3.4 Potential Benefits of the Development Proposal

3.4.1 Changes to Phosphorus Transport Mechanism

Drainage management techniques applied at Amarillo will prevent the water table rising to the ground surface during the main winter recharge period. This 'change of state' will negate one of the principal mechanisms for phosphorus export from the site, which is surface runoff generated by the "saturation excess mechanism". The particular effect of negating this mechanism is to preclude the direct loss of soluble phosphorus from fertiliser applied to future allotments and active POS areas, which can be compared to the existing pasture situation of 40% of phosphorus lost in the year of application as overland transport. Obviously this will be a significant improvement to the current phosphorus transport mechanisms.

3.4.2 Comparative Phosphorus Export

The discharge of phosphorus in groundwater drainage is predicted to decrease as a result of the urban development proposal. Whilst preliminary groundwater modelling indicates little change in the quantity of groundwater drainage from the 'before development' situation to the post-development situation, the quality of this water is expected to improve with respect to phosphorus content as summarised in Table 3.2. These estimates should be taken as indicative only particularly for the urban land use because they are considered to represent 'worst-case' approximations.

It is significant to note that even without an assumed 50% reduction of phosphorus (this is an arbitrary reduction, for the purposes of this exercise, which would be achieved via Best Management Practices), the post-development export rates would still be less than the before development pastoral situation. Therefore it is believed that some latitude could be allowed in the estimates which have been conducted and there would still be confidence that the phosphorus regime will be improved. Furthermore, these estimates do not take into account the anticipated benefit of the plantation forestry in removing phosphorus upon harvesting which, albeit small (as indicated in Section 3.2.1) is still an improvement over the pastoral land use.

Table 3.2: Comparative Phosphorus Export to Serpentine River

Scenario	Estimated Phosphorus Export (Range)	
	kg per annum	kg per hectare
Pre-development (pasture)	3460 - 6180	1.3 - 2.2
Post-development (without treatment)	774 - 2708	0.28 - 1.0
Post-development (assumed 50% reduction)	387- 1354	0.14 - 0.50

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APPENDIX A:

Regulatory Framework

APPENDIX A REGULATORY FRAMEWORK

The main regulatory "instruments" which apply to the proposal to develop Amarillo for urban purposes are listed below and briefly discussed in the sections which follow.

- Policy No. DC 6.3 Planning Considerations in the Metropolitan Region for Sources of Public Water Supply and Sensitive Water Resource Areas (as per Water Authority advice).
- The Environmental Conditions for the Peel Inlet-Harvey Estuary Management Strategy - Stage 2 (January 1989 and October 1991).
- Statement of Planning Policy No. 2 The Peel-Harvey Coastal Plain Catchment (February 1992).
- Environmental Protection (Peel Inlet-Harvey Estuary) Policy 1992 (December).
- Planning & Management Guidelines for Water Sensitive Urban (Residential) Design (June 1994), Consultants Report prepared for DPUD, WAWA & EPA.

A.1 Policy No. DC 6.3

This policy was adopted due to the need to protect and conserve water resources for public and private water supplies and for support of the natural environment, notably wetlands, and foreshadowed the water sensitive design guidelines. The policy applies to proposed Public Water Supply Areas and Underground Water Pollution Control Areas and it is noted that land immediately to the east of Amarillo is earmarked as a potential future groundwater abstraction area. The (then) Water Authority has indicated informally that Policy DC 6.3 should be applied to the Amarillo development proposal.

In its assessment of proposals for the zoning of land, the policy requires the State Planning Commission (SPC) to take into account the effects the development will have on:

- the quality and quantity of groundwater;
- any permanent or seasonal wetland or sensitive environmental area;
- any natural watercourse or drain;

and may require a Water Resource Management Plan to be prepared for the area.

Amarillo - Implications and Response

The broad structure plan and drainage strategy derived for Amarillo is cognisant of the need to ensure that:

- there is minimal risk of unacceptable pollution to surface water or groundwater;
- there is no modification to the water balance which is detrimental to any environmental features;
- water resources are not diminished to the detriment of proposed public water supplies.

There is believed to be no over-riding constraint to some lowering of the water table at Amarillo, provided the degree of water table drawdown can be managed to ensure that there are no adverse effects.

A.2 Peel Inlet-Harvey Estuary Environmental Conditions

The Environmental Conditions relevant to Amarillo are those which embrace catchment management and have the objective of reducing the input of phosphorus into the estuary. These conditions are binding on the Ministers for Transport, Agriculture and Waterways. They are currently under review and a public discussion paper was released by the EPA in July 1994 (Bulletin 749).

The conditions which apply to urban developments such as the Amarillo proposal are paraphrased and discussed below.

- *Decisions on development which may release phosphorus or nitrogen to the coastal plain catchment and the estuary should be conservative until the new assimilative capacity of the Peel-Harvey Estuary System is determined.*

Whilst each development is meant to be 'conservative' in its impact on nutrient loads, the interpretation of this condition is necessarily subjective and therefore needs to be judged on the best available information. The term 'assimilative capacity' is no longer favoured in the context of phosphorus inputs to the Peel-Harvey Estuary and "target loads" is now the preferred term. However, there is debate as to the validity and relevance of the two phosphorus targets (i.e. the catchment target of 85 tonnes of annual phosphorus input in a 60 percentile year and the estuary target of an average phosphorus concentration not

exceeding 0.2 milligrams per litre in a 90 percentile year). It is generally acknowledged that there is considerable difficulty in the application of these targets to the land development process.

- *There shall be a moratorium on clearing and drainage in the coastal plain catchment until the Minister for Environment is satisfied that these activities would be environmentally acceptable.*

During the assessment of new development proposals, specific drainage controls have been applied through the formal EPA process and/or through application of the Statement of Planning Policy (SPP). For urban or special rural developments, clearing and drainage has sometimes been allowed where the proponent could demonstrate that nutrient loads would not be increased by the development proposal. For rural residential development the interpretation has generally been more specific, in that a proposal which involved some clearing and drainage would be allowed to proceed provided the change in land use was managed to achieve a reduction in phosphorus export of about 50%. The recent review of the environmental conditions (Part 2 of Bulletin 749) recommends that this condition could be cleared.

- *Proposals which may release nitrogen or phosphorus to the environment shall not be referred to the EPA provided that they are consistent with the Statement of Planning Policy.*

This condition was included in October 1991 and most subdivision for assessments are now conducted under the above arrangement, whereby the Ministry for Planning assesses nutrient management of the proposals. The rationale for this change was that the SPP adequately addressed the key environmental issues.

Amarillo - Implications and Responses

Given that the Environmental Conditions have not been consistently applied and that they are currently under review, it is clear that the SPP is now the key regulatory instrument under which the Amarillo proposal must conform to gain planning endorsement. However, application of the SPP requires that the catchment management objectives implicit to the above environmental conditions are adequately interpreted. Whilst the interpretation of phosphorus targets to individual development proposals is not clear, it is noted that catchment management since 1990 has been responsible for reducing the

quantity of phosphorus entering the estuary by over 35 tonnes (refer Part 2, Bulletin 749). This would appear to demonstrate that the current control measures are working and that development decisions in recent years have been sufficiently 'conservative'.

It is also noted that, given the difficulty in applying phosphorus targets, the EPA endorses the use of 'best management practices' as part of catchment management. The Amarillo proposal will implement best management practices for drainage management.

A.3 Statement of Planning Policy No. 2 - The Peel-Harvey Coastal Plain Catchment

The objectives of the SPP are aimed at ensuring changes to land use are controlled so as to 'avoid and minimise' environmental damage to the Peel-Harvey Estuary and particularly to prevent land uses likely to result in excessive nutrient export into the drainage system. A number of the policy provisions relate to urban development proposals, either generally or specifically, and include the following 'requirements':

- connect to an adequate sewerage service;
- take account of land capability/suitability criteria;
- retain and rehabilitate existing remnant vegetation and attempt to establish 50% of the land area to deep-rooted perennial plants, preferably local indigenous species but including high water-using and suitable exotic species;
- replanting is particularly to be encouraged along watercourses and drains and around wetlands;
- provide for a drainage system which maximises the 'consumption and retention' of drainage on site, including incorporation of biological wetland filters;
- recognise that conservation reserves are not appropriate as wetland filters;
- nutrient management plans should be prepared for open space recreation areas which identify appropriate irrigation and fertiliser regimes and vegetation patterns, and provide for nutrient retentive soil amendment in areas where soil phosphorus retention is low.

Amarillo - Implications and Responses

The development strategy for Amarillo recognises the above requirements and the main emphasis of structure planning for the site to date has been to make sufficient allowance, or provide for sufficient contingency, in terms of the potential land allocation needs to

meet the objectives for drainage and nutrient management. In addition, the following points are made in respect of application of the above policy provisions at Amarillo:

- The land capability/suitability criteria are derived from land resource assessments conducted by the Department of Agriculture, however these assessments have not included urbanisation as one of the potential land uses under consideration in deriving their capability ratings. Furthermore, the capability ratings are always based on existing site conditions and conventional development practices, whereas development at Amarillo will involve a change of state at the site in terms of control of the water table and will be employing some non-conventional techniques. Therefore the existing land capability/suitability assessments are not relevant to Amarillo.

- The preferred target of 50% of the catchment converted to deep-rooted perennial plants was based on earlier enthusiasm and impetus for large-scale conversion of the sandy soils from agriculture to forestry. This possibility is no longer being actively considered by the Department of Agriculture or CALM. However it is recognised that revegetation is still an important component of catchment management and this is a major initiative associated with the Amarillo project, including the interim land use of plantation forestry as described previously.

- Whilst the drainage strategy aims to "maximise the consumption and retention of drainage on site", drainage to the Serpentine River will most likely increase once Amarillo is developed, given the enhanced recharge which accompanies urbanisation and the existing high water table at the site. Additional drainage to the river is not necessarily an issue of concern from the perspective of water quantity, however the likely phosphorus content of this water needs careful consideration and management attention. This also needs to be balanced with the existing high levels of phosphorus-enriched drainage in the site's agricultural drains which is being discharged directly to the river. When Amarillo is urbanised there will be no discharge of drainage off site unless it has been treated through a constructed biological wetland filter. The fate of dewatering discharges during the construction phase will also need careful attention.

- A Nutrient Management Plan has not been prepared for the open space recreation areas yet because it is important to receive endorsement for the overall approach

to development and the drainage strategy before conducting this level of detailed work. Detailed nutrient management will be conducted during the more detailed planning phases.

A.4 Environmental Protection (Peel Inlet-Harvey Estuary) Policy 1992

The Peel-Harvey EPP sets the broad environmental quality objectives for protection of the Peel-Harvey Estuary. These objectives are to be 'achieved and maintained' principally through implementation of the Statement of Planning Policy (which was gazetted when the EPP was still in draft form). The EPP's quality objectives are quite specific and can be translated into target loads. These target loads have not been carried into the SPP, but the SPP contains specific management measures designed to meet the objectives of the EPP.

Amarillo - Implications and Responses

The environmental quality objective relevant to the Amarillo area is as follows:

- "(a) the median load (mass) of total phosphorus flowing into the Estuary from the Serpentine River being less than 21 tonnes;"

The validity of the objectives or targets in the EPP has recently been questioned because the original data set upon which the objectives are based (and the methodology used to collect the data) has not been made available to the Waterways Commission, which is responsible for auditing the success of the catchment management strategy. However, the above objective for the Serpentine River equates to an export rate of approximately 0.27 kg phosphorus per hectare per year (kg-P/ha/yr) for the catchment.

Whilst it is acknowledged that the target load of 0.27 kg-P/ha/yr may be seen as a useful yardstick for assessing developments such as Amarillo, there are difficulties in applying it as a criterion and there has been less emphasis on this absolute figure in the EPA's assessment process in recent years. Notwithstanding the above, it is noted that the licence criterion for the Wandalup Piggery located on the southern boundary of Amarillo stipulates a significantly more lenient target load of 1.0 kg-P/ha/yr.

A.5 Water Sensitive Urban (Residential) Design Guidelines

The fundamental aim of water sensitive design is to ensure that urban development occurs in a manner which minimises adverse effects on water resources by integration of the following management objectives:

- to manage water balance;
- to maintain and, where possible, enhance water quality;
- to encourage water conservation;
- to maintain water-related environmental, cultural and recreational values.

Water sensitive design applies at the 'macro' and 'micro' levels of the urban development process, from strategic structure planning to subdivision design and even as far as to the individual level (house and garden design and landholder responsibilities).

In simple terms, the application of water sensitive design to the issue of urban drainage, which is the main issue at Amarillo, requires that stormwater is 'captured' and 'treated' as close as possible to the source. This means that drainage is either stored in numerous surface impoundments located throughout the development area and designed to achieve some degree of water treatment prior to discharge off-site, or, where possible, infiltrated and evaporated on-site via detention/infiltration basins. The emphasis is also on a "treatment train" approach rather than collection of drainage and passing through a single treatment facility at the point of discharge. This is in stark contrast to the traditional 'collect, convey and discharge' approach which focussed on safe disposal off-site without any consideration of water quality issues.

The water sensitive approach has many other facets which are too diverse to discuss here (refer to the Guidelines Discussion Paper).

Amarillo - Implications and Responses

The implications of water sensitive design for the Amarillo urban proposal and the interpretation of water sensitive design principles to the drainage strategy are discussed in Section 2.0 of the Part II document.