Rezoning from Rural to Special Rural of Part Lot 7, Old Coast Road and Dunkeld Drive, Herron, Amendment 213 to City of Mandurah, Town Planning Scheme No 1A — within the catchment of Lake Clifton

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Advice of the Environmental Protection Authority under Section 16 (j) of the Environmental Protection Act

Environmental Protection Authority
Perth, Western Australia
Bulletin 822
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THE PURPOSE OF THIS REPORT

This report contains the Environmental Protection Authority's advice on the environmental factors of the proposed Amendment to the City of Mandurah's Town Planning Scheme. It has been issued under the provisions of Section 16 (j) of the Environmental Protection Act.

APPEALS

There are no appeal rights associated with this report.

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This report provides the Environmental Protection Authority's advice on the environmental acceptability of the Rezoning from Rural to Special Rural of Part Lot 7, Old Coast Road and Dunkeld Drive, Herron; Amendment 213 to City of Mandurah, Town Planning Scheme No 1A.

The land which is the subject of the proposed rezoning is within the Lake Clifton catchment. Accompanying the rezoning document is a draft subdivision plan which proposes subdivision the land into five (5) lots of approximately 2 ha each.

The rezoning is located within the Lake Clifton catchment area. Lake Clifton is one of the most significant wetlands in Western Australia due to its international importance as a waterbird habitat and because it contains the largest known example of living microbialites[1] in a lake environment in the southern hemisphere. Lake Clifton is recommended for protection in the EPA's System Six report of 1983 and is protected by the Environmental Protection (Swan Coastal Plain Lakes) Policy 1992.

The EPA is developing a set of environmental criteria to limit the environmental effects of changes to land use on private land within Lake Clifton's catchment in order to conserve the microbialites and the environmental processes which enable the microbialites to continue to exist. A draft of these criteria was published for public review (EPA, Bulletin 788, November 1995).

The draft criteria were not used as the policy basis for the assessment of this rezoning, rather, the criteria provided the broad framework for the EPA to assess the environmental acceptability of this rezoning. This rezoning was assessed on its merits by the EPA using available information and pre-existing policy. The EPA concluded that for this rezoning the key environmental issues requiring detailed consideration were as follows:

Biophysical impacts

- Maintenance of water balance;

Pollution management

- Management of nutrients.

The public review component of the assessment was the eight week review period of the draft environmental criteria for Lake Clifton (EPA, Bulletin 788, 1995). Some of the issues identified in Bulletin 788 directly pertain to this rezoning, thus some submissions received for EPA Bulletin 788 also apply to this rezoning. The EPA, during its assessment has received the advice of government agencies, and has taken into account additional information supplied by other government agencies and the public.

Conclusion

With respect to the key environmental issues and environmental objectives, the EPA has concluded that the rezoning can meet the EPA's objectives subject to the implementation of the EPA's recommendations in this assessment report.

[1] The microbialite structures in Lake Clifton are thrombolites (having a "clotted" internal structure), but have traditionally been called stromatolites. To avoid confusion this Bulletin will use the generic term microbialites.

Recom-mendation Number	Summary of Environmental Protection Authority recommendations
1	The proposal can be managed to meet the Environmental Protection Authority's objectives, subject to the successful implementation of the EPA's recommendations.
2	Annual groundwater abstraction for the subdivided land should be constrained to the EPA approved relationship between lot size (ha) and annual abstraction allowance (kL per year) as described by the hydrological model provided in Appendix 2, or any prospective changes to that model. For example, applying this relationship to an average lot size of 2 ha the current hydrological model shows that no water may be abstracted, and should this be the case, alternative water supplies should be considered or the lot size increased. The relevant government agency(s) should ensure that appropriate mechanisms are in place.
3	High water-using activities and high fertiliser using activities (eg. horticulture) should not be permitted on these lots and the relevant government agency(s) should ensure that appropriate mechanisms are in place.
4	Relevant government agencies should continue studies on the hydrology of Lake Clifton and the outcome of that work and any on-going monitoring should be used to further refine the hydrological model used in this assessment (Appendix 2). It may be necessary to change the amount of groundwater made available for human use in the catchment as a result of further work. A whole-of-catchment approach should be adopted to ensure the quality and quantity of fresh groundwater entering Lake Clifton will maintain the growth and function of the microbialites.
5	Alternative waste-water disposal systems with nutrient removing capabilities should be used. The number of any stock allowed per lot should be restricted consistent with stocking rates as advised by Agriculture Western Australia. Restrictions on high fertiliser using ancillary land uses which are standard for rural-residential developments should apply. The relevant government agency(s) should ensure that appropriate mechanisms are in place.

1. Introduction and background

1.1 The purpose of this report

This report provides the Environmental Protection Authority's advice on the environmental acceptability of the Rezoning from Rural to Special Rural of Part Lot 7, Old Coast Road and Dunkeld Drive, Herron; Amendment 213 to City of Mandurah, Town Planning Scheme No 1A - within the catchment of Lake Clifton, Western Australia.

1.2 Background

1.2.1 Importance of Lake Clifton

Lake Clifton is located about 100 kilometres (km) south of Perth and 25 km south of Mandurah on the western edge of the Swan Coastal Plain between the Peel-Harvey Estuary and the coast (Figure 1). The lake proper and much of the catchment to the west, north and south are within the Yalgorup National Park. However, for most of the eastern catchment only a narrow foreshore reserve is within the park, with the remainder of the land privately owned.

1.2.2 History of environmental criteria for Lake Clifton

Between 1991 and 1993 the EPA assessed a number of proposals, mostly for horticultural purposes, in the Lake Clifton catchment because of concerns about their potential impacts on the lake and the microbialites. In December 1993 the EPA endorsed a set of principles which would form the basis of a draft Strategy to address the environmental issues associated with new rural-residential, horticulture and tourist developments in the catchment. These were approved in early 1996.

The purpose of the Strategy was to develop a set of environmental criteria which would form the basis of planning controls. The controls are necessary to manage the environmental effects of changes to land use on private land within Lake Clifton's catchment, in order to conserve the microbialites and the environmental processes which enable the microbialites to continue to exist.

The fresh groundwater that flows into the lake, while not directly important to microbialite growth, has two important indirect effects:

- it regulates lake salinity; and
- it provides carbonate and bicarbonate ions necessary for continued microbialite growth.

This aquifer is contained within the Spearwood landform which is typically sand over limestone. The limestone is high in calcium carbonate providing a rich supply of the carbonate and bicarbonate ions.

Whilst nutrients are essential for microbialite growth, excessive levels of nutrients will encourage the growth of other algal species. Algal blooms will reduce the amount of light reaching the microbialites, inhibiting or stopping growth.

Direct disturbance of the microbialites can inhibit growth through trampling of the microbialites, loss of fringing vegetation, erosion through trampling and increased water turbidity. Thus the most important environmental aspects are groundwater hydrology, water quality and direct disturbance.

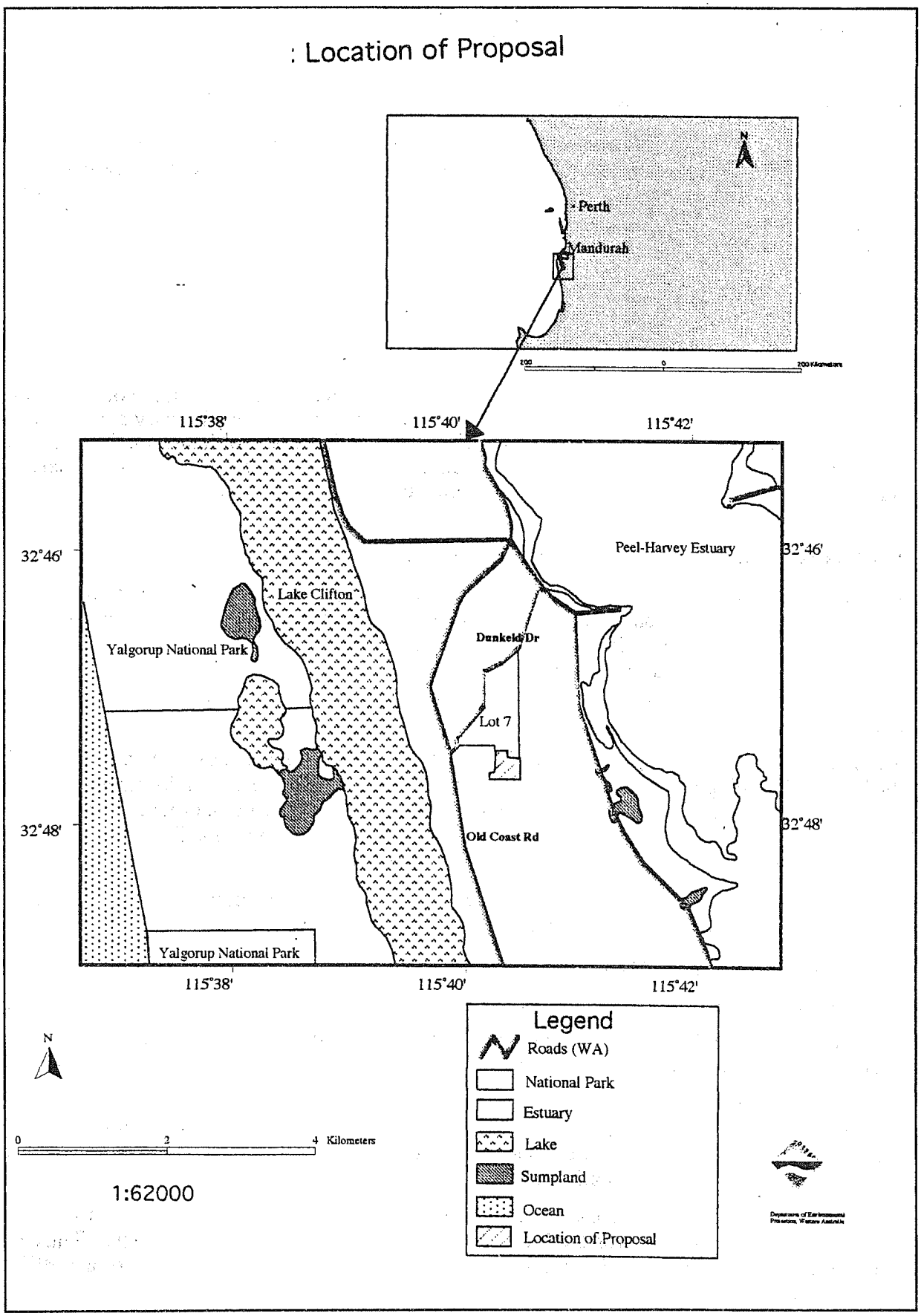

Figure 1. Lake Clifton

Considerable consultation occurred in the development of the Strategy. The first draft of the Strategy was sent to key officers within the Department of Environmental Protection for comment in February 1994 and a revised draft was sent to key Government agencies for comment in April 1994 - (the then) Department of Planning and Urban Development, Water Authority of Western Australia, Western Australian Department of Agriculture, Department of Conservation and Land Management, CSIRO, City of Mandurah and Shire of Waroona.

A public meeting was organised by land owners, mostly from the Shire of Waroona, to discuss the draft Strategy in July 1994 and this meeting was attended by a representative of the Department of Environmental Protection.

In September 1994 the EPA endorsed modifications to the December 1993 version of the Strategy, including a requirement that houses are setback 300 m from the lake, and minimum lot size for rural-residential developments of 10 ha adjacent to the lake and 5 ha elsewhere. The key elements of the draft Strategy were released in September 1994 as a discussion paper for comment and copies were sent to all key government agencies, community groups and most land owners.

The Environmental Assessments Committee of the EPA received an update of the Strategy in November 1994. Officers of key government agencies and representatives of land owners addressed the committee. The EPA expressed concerns over the land use control approach adopted in the draft Strategy and requested that officers of the Department of Environmental Protection liaise with officers of (the then named) Department of Planning and Urban Development to resolve issues, most notably, minimum lot size and setbacks from the lake. No changes to the draft Strategy were endorsed.

Another draft of the Strategy was circulated to key agencies in February 1995 with important modifications: minimum lot size to be 5 ha, with lots adjacent to the lake to have a wide frontage to the lake; setbacks at least 100 m from Lake with at least 20 m from fringing wetland vegetation.

During discussions of the draft Strategy, officers of the Ministry for Planning raised concerns that the Strategy was too prescriptive and that the specification of land use controls was the domain of the planning agencies. It was agreed that the emphasis of the Strategy should become one of setting environmental criteria which would form the basis of appropriate land use controls to be set through the planning process. This approach is seen as giving planners greater flexibility in dealing with developments in the catchment whilst ensuring the environment would be protected. With this in mind, the Strategy was renamed to become the draft criteria, ie. "Criteria of environmental acceptability for land use proposals within the catchment of Lake Clifton" (EPA, Bulletin 788, 1995).

In June 1995 the EPA agreed to assess all the proposed rural-residential developments (rezonings and subdivisions) in the Lake Clifton catchment at the same time and to use the eight week public review period of the draft criteria for the five formal assessments.

The draft criteria were released in November 1995 following consultation with the Western Australian Planning Commission and the Ministry for Planning. The draft criteria were not used as the policy basis for the assessment of the five proposals (including this one). Instead, the best available scientific data were used, including some of the data used in Bulletin 788. Only existing EPA policy positions were applied.

The development of the draft criteria complements two other studies currently being undertaken: the Yalgorup Lakes study by the Water Authority of Western Australia (now the Water and Rivers Commission); and the Coastal and Lakelands Planning Strategy being carried out by the Ministry for Planning for the Western Australian Planning Commission.

1.2.3 Referral of proposal

In April 1995 the City of Mandurah sent to the EPA for comment an application to rezone from Rural to Special Rural Part Lot 7, Old Coast Road and Dunkeld Drive, Herron, which was Amendment 213 to the City of Mandurah's Town Planning Scheme No 1A (Figure 2).

Many of the issues identified during the development of the environmental criteria for Lake Clifton (EPA, Bulletin 788) directly pertain to this rezoning, thus some of the submissions

received for EPA Bulletin 788 also apply to this rezoning. During the environmental assessment of this rezoning the EPA utilised information supplied by other government agencies, the public and the applicant.

1.3 Structure of this report

This document has been divided into six sections.

Section 1 describes the historical background to the rezoning and its assessment and explains the structure of this report. Section 2 briefly describes the rezoning. Section 3 explains the method of assessment and provides an analysis of public submissions with the ultimate aim of identifying the key environmental issues to be evaluated in section 4.

Section 4 sets out the evaluation of the key environmental issues associated with the rezoning. In each sub-section, the objectives of the assessment and the policy and technical framework relating to that issue are defined. The likely effect of the rezoning and the advice to the EPA from submissions are discussed. The adequacy of the original application to rezone is considered in achieving an acceptable outcome. The EPA's analysis and recommendations with respect to the identified issues are contained in this section. Where inadequacies are identified, recommendations are made to achieve the environmental assessment objective.

Section 5 summarises the conclusions and EPA advice. References cited in this report are provided in section 6.

2. Summary description of proposal

The proposed rezoning lies in the north-western portion of the Lake Clifton catchment. Accompanying the rezoning documents is a draft subdivision plan which would subdivide Lot 7 into five (5) lots ranging in size from 2 ha up to 2.5 ha (Figure 2).

Lot 7 is on Spearwood soils and is mostly cleared parkland with stands of tuart, jarrah, marri and banksia.

The proposed rezoning would not involve the provision of reticulated sewerage or scheme water. Human effluent would be disposed of on-site, although the type of system to be used is not specified. Water for human use would be from groundwater bores which may be supplemented by rainwater tanks.

3. Identification of environmental issues

3.1 Method of assessment

The purpose of environmental impact assessment, including assessments carried out under Section 16 of the Environmental Protection Act, is to determine whether a proposal, or in this case a rezoning, is environmentally acceptable.

The environmental acceptability of this rezoning was assessed by the Environmental Protection Authority using the draft environmental criteria for Lake Clifton as the broad framework. However, this rezoning was assessed on its merits using available information separate from the EPA's consideration relating to the finalisation of the criteria. Only existing EPA policy positions were applied in this assessment.

In this case the EPA decided to assess the rezoning at the same time as it finalised the draft criteria (EPA, Bulletin 788, 1995) The draft criteria had been released for public comment, and this was used to seek submissions on the management of proposed developments, including this rezoning, within the catchment of Lake Clifton.

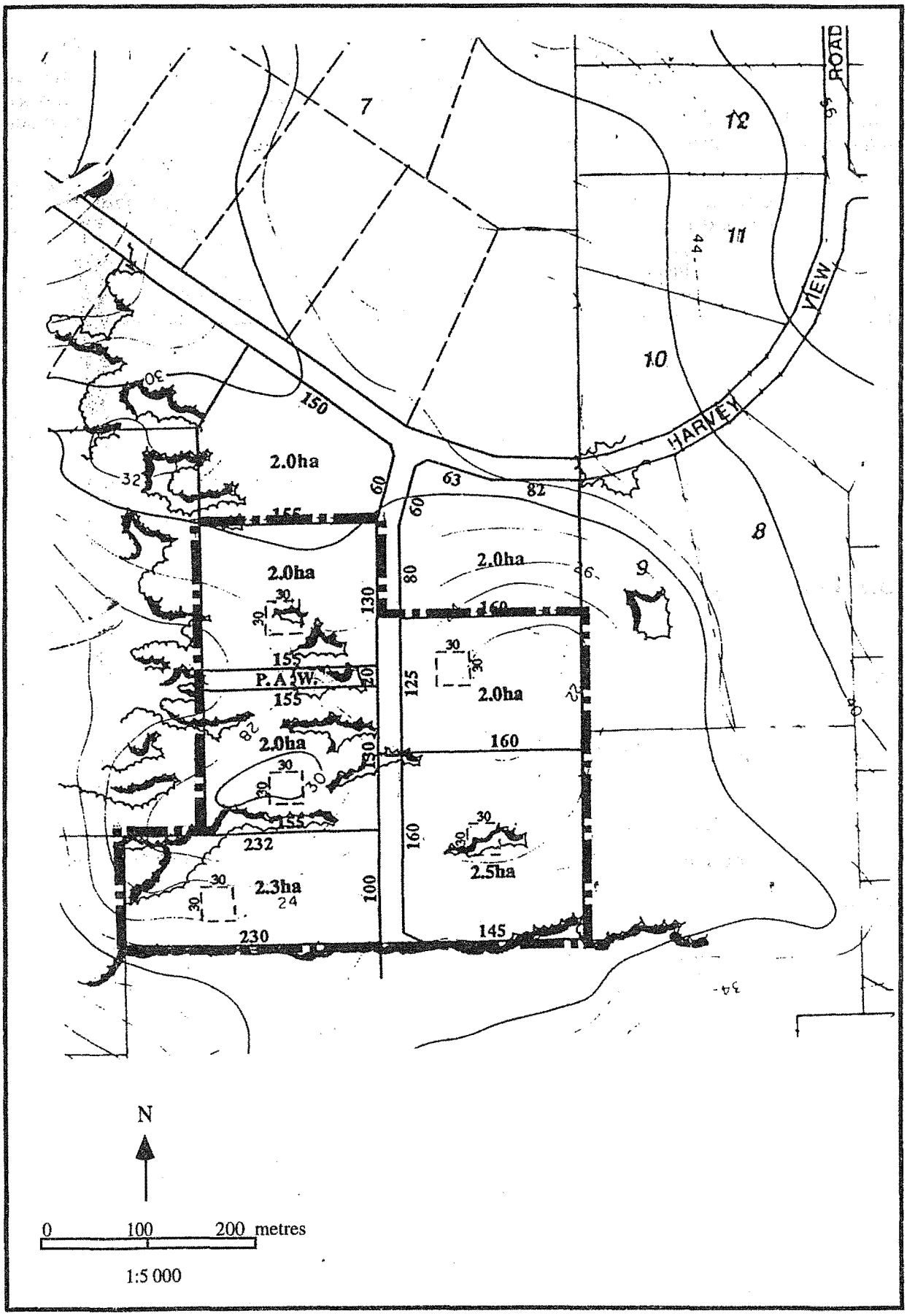

Figure 2. Proposed subdivision plan for Part Lot 7 Old Coast Road and Dunkeld Drive, Herron

The submissions received were summarised and this process can add environmental topics which need to be considered in terms of the acceptability of potential environmental impact.

By this stage in the assessment, 8 topics had been identified, of varying environmental significance. The EPA considered all the topics and identified those issues that required further evaluation by the EPA. Other topics were considered not environmentally significant or did not require further evaluation by the EPA.

For each environmental issue, the environmental impacts of the rezoning, and the original application to rezone, were evaluated in the context of the EPA's assessment objective and relevant policy and technical information. If the original application to rezone meets the assessment objectives, there is no need for the EPA to give specific advice on that issue. Where the rezoning could have unacceptable environmental impacts through the down-stream subdivision and development, the EPA can provide advice against the rezoning proceeding or provide advice to ensure the environmental acceptability of the application to rezone.

Limitation

This evaluation has been undertaken using information currently available. The information has been provided by the proponent through the initial referral document, by officers of the Department of Environmental Protection utilising their own expertise and reference material, by utilising expertise and information from other State government agencies, information provided by members of the public, and by contributions from EPA members.

The EPA recognises that further studies and research may affect the conclusions.

3.2 Public and agency submissions

Comments were sought on the draft environmental criteria for Lake Clifton (EPA, Bulletin 788, 1995) from the public, interest groups and local and State government agencies. During the public review twenty-one (21) submissions were received, being:

- 12 from members of the public;
- 4 from Government agencies;
- 3 from Local Government; and
- 2 from community groups.

The principal topics of concern raised in the submissions and relevant to this proposal were:

<u>Biophysical Impacts</u>

- Water balance;

<u>Pollution Management</u>

- Nutrients;
- Conventional septic tanks;

<u>Other</u>

- Compensation;
- Monitoring land use controls;
- Agriculture vs Rural-residential development;
- Rural-residential development; and
- Retrospectivity of criteria.

As part of the assessment of this rezoning, the EPA has only considered those topics raised in the submissions received which related to Rural-residential developments.

3.3 Review of topics

3.3.1 Identification of topics

The eight topics raised in the public submissions were the same as those identified during the environmental impact assessment process including those topics identified at the commencement of this assessment, subsequent consultations and the submissions described above which related to this rezoning.

These topics are analysed below to identify issues requiring more detailed EPA evaluation. The other topics are considered to be appropriately managed through existing planning controls or compliance with Department of Environmental Protection regulations and guidelines (see Table 1) and do not require further evaluation by the EPA.

3.3.2 Identification of environmental issues

Biophysical impacts

Water balance

The proposal is for Lot 7 to be re-zoned from Rural to Special Rural under the City of Mandurah's Town Planning Scheme. Accompanying the rezoning documents was a draft subdivision plan which would subdivide Lot 7 into five (5) lots ranging in size from 2 ha up to 2.5 ha. Bores will be provided on each lot for human use. Changes to the water table and the flow of fresh groundwater could inhibit microbialite growth.

The potential impacts on the water table due to abstraction of groundwater need further evaluation by the EPA, which is contained in section 4.1.

Pollution Management

Nutrients

Following the development of this lot for rural-residential purposes, there is the potential for export of nutrients to Lake Clifton from waste-water disposal systems, limited horticultural uses and keeping of livestock. Excessive levels of nutrients can encourage the growth of other algal species that would limit light penetration thus inhibiting microbialite growth.

In Lake Clifton phosphorus is the limiting nutrient rather than nitrogen, therefore the possibility of phosphorus input to the lake requires further evaluation by the EPA, which is discussed in section 4.2.

Conventional septic tanks

A public submission suggested that conventional septic tanks should not be permitted, however this matter is dealt with by the preceding topic.

Further evaluation by EPA is not required.

Other

Compensation

A submission raised the topic that restrictions on land use de-value the land and that compensation measures should be sought.

This is a planning issue and can be adequately handled through the planning process. Further evaluation by the EPA is not required.

Monitoring land use controls

A submission raised the topic that effectiveness of land use controls should be checked regularly.

The outcome of the planning process is legally enforceable land use controls through the Town Planning Scheme or subdivision conditions. Further evaluation of this topic by the EPA is not required.

Agriculture vs Rural-residential development

One submission suggested that horticulture has a greater potential to export nutrients to the lake than does rural-residential development, as controls can be better implemented through planning controls. Conversely, another submission suggests that rural land uses have existed next to the lake and been in harmony with it for many years, and Rural-residential land uses are the problem.

The environmental impact assessment process does not allow the EPA to recommend one land use as being preferable to another. Rather, the EPA sets objectives and criteria for the land use being proposed. Further evaluation by the EPA is not required.

Rural-residential development

A submission raised the topic that it would be preferable if no more rural-residential development be allowed in the catchment and where it does occur on the east, it should create a vegetated buffer.

The purpose of developing criteria of environmental acceptability for land use proposals within the catchment of Lake Clifton was to provide a basis for determining what land uses might be allowed in the catchment. Further evaluation by the EPA of this topic is not appropriate in relation to this proposal.

Retrospectivity of criteria

A submission raised the topic that proposals and rezoning already in the planning system should not be subject to criteria, including proposals currently subject to Consultative Environmental Reviews and rezonings subject to Section 16 advice.

This rezoning is being assessed on its merits using existing technical data and policy. The criteria are being used as a framework only. Further discussion by the EPA regarding retrospectivity of the criteria is not required and is dealt with in the EPA Bulletin containing the final criteria (to be released later this year).

3.3.3 Summary

Table 1 summarises the process used by the EPA to evaluate the topics raised during the environmental impact assessment process. The table identifies the topics, the relevant proposal characteristics, and comments received from specialist government agencies and the public. If a topic is considered environmentally significant it becomes an issue and is further evaluated by the EPA (as summarised in Table 2). Section 4 of the report provides the detail of this evaluation.

4. Evaluation of key environmental issues

4.1 Maintenance of water balance

4.1.1 Objective

The Environmental Protection Authority's objective is to ensure that on an annual basis the quantity of fresh groundwater entering Lake Clifton following development is as close as possible to that entering the lake before development.

4.1.2 Policy information

The precedent of past assessments in the catchment provides a policy framework for consideration of this issue. The Environmental Protection Authority provided advice on the Mt John Wood proposal and subsequent amendment at the level of Informal Review with Public

TOPICS	PROPOSAL CHARACTERISTICS	GOVERNMENT AGENCY'S COMMENTS	PUBLIC COMMENTS	IDENTIFICATION OF ISSUES
Biophysical				
Water balance	Subdivision of Part Lot 7 as proposed in the rezoning would results in five (5) lots of approx 2 ha each. Bores for human use allowed under the current TPS provisions. A water consumption allowed up to 1500 kL per lot per year. *Trend described in Bulletin 788 indicates the smaller the lot size, the greater the change in water balance following development. EPA concluded that for a standard subdivision design using 1 500 kL per lot per year, changes to water balance became unacceptable below 5 ha.*	Given the data supplied in the draft criteria (Bulletin 788) minimum lot size should be set at 5 ha with no variation unless scientifically justified. (City of Mandurah) Support 5 ha minimum lot size with controls to prevent further subdivision. (Water and Rivers Commission) 5 ha lot size supported but this size is too large to be looked after properly (research in USA supports this view). Have "notional" lot size of 5 ha with living lot size of 2 ha eg. giving up foreshore land to CALM. 2 ha lots are generally not subdivided whereas larger lots often are (Yalgorup Lakes NLP advisory group). Avoid using lot size as this is a planning matter. Use "living unit" per hectare as this is what causes the impact. Planners can use criteria to design subdivisions accordingly. (Yalgorup Lakes NLP advisory group)	Setting of minimum lot size is the province of the planning agencies and not the EPA. No variation to less than 5 ha as it is difficult to justify "innovative" design. Any research on this matter should be carried out outside Lake Clifton catchment. Water abstraction should be monitored to ensure no excess usage.	Impact on the water table due to extraction of groundwater requires EPA evaluation.
Pollution				
Nutrients	Vegetable gardens will be allowed.	Risk of nitrogen leaching into lake should be considered. (Waters and Rivers Commission)		Phosphorus is the limiting nutrient, thus phosphorus export to the lake requires EPA evaluation.
	General horticulture may be allowed.		Intensive horticulture should not be permitted.	
	Stocking rates - Stock will be discouraged. Dry sheep equivalent of 5 per ha. *Bulletin 788 recommended stocking rates for dry pasture with no importation of feed.*	Difficult to monitor, especially no importation of feed. Using area of cleared land to set stocking rates encourages clearing of land. (Shire of Waroona)	No stock should be allowed for uncleared lots. This would decrease the nutrient export and allow for smaller rural-residential lots. Stocking rates recommended are unreasonable.	

Table 1: Identification of issues requiring Environmental Protection Authority evaluation.

TOPICS	PROPOSAL CHARACTERISTICS	GOVERNMENT AGENCY'S COMMENTS	PUBLIC COMMENTS	IDENTIFICATION OF ISSUES
Conventional septic tanks	Existing provisions of the TPS for Special Rural developments would allow for conventional septic tanks to be used.		Conventional septic tanks should not be permitted.	Rezoning would allow for the use conventional septic tanks. Further evaluation by EPA required. covered under the "Nutrients" topic
Other				
Compensation		Restrictions on land use de-value land and compensation measures sought (Yalgorup Lakes NLP advisory group).		This is a planning issue and can be adequately handled through the planning process. Further evaluation by the EPA is not required.
Monitoring land use controls			Effectiveness of land use controls should be checked regularly.	The outcome of the planning process is legally enforceable land use controls through the Town Planning Scheme or through subdivision conditions. Further evaluation of this topic by the EPA is not required.
Agriculture vs rural residential development			Horticulture has a greater potential to export nutrients to lake than does rural-residential development as controls can be better implemented through planning controls. Rural land uses have existed next to the lake and been in harmony with it for many years. Rural-residential land uses are the problem.	This assessment process does not allow the EPA to recommend one land over another. Rather, the EPA sets objectives and criteria for the land use being proposed. Further evaluation by the EPA is not required.
Rural residential development		Prefer no more in catchment but where it occurs on the east should create vegetated buffer. No rural residential to west of lake (CALM).		Environmental criteria have been developed to determine what land uses might be allowed in the catchment. Further evaluation by the EPA is not required.
Retrospectivity of criteria			Proposal and rezonings already in the planning system should not be subject to criteria.	This proposal is being assessed on its merits using existing technical data and policy. The criteria are being used as a framework only. Further evaluation by the EPA is not required.

Advice (Appendix 1). The EPA advised that a subdivision to create 25 ten ha lots would be acceptable provided that water allocation was either 650 kL per lot per year unmetered, or 1000 kL per lot per year metered.

4.1.3 Technical information

The microbialites of Lake Clifton are structures which have similar chemical composition to limestone. The algae that build them have critical growth requirements which are:- a constant source of carbonate and bicarbonate ions; minimal levels of nutrients; and light. The freshwater that flows into the lake is not directly important to microbialite growth as most of the fresh water in Lake Clifton comes from direct rainfall, however it is indirectly important because it regulates salinity and provides carbonate and bicarbonate ions necessary for continued microbialite growth.

Rural-residential developments can lead to a significant change to the existing water balance caused by:

- clearing of deep-rooted native vegetation (less evapotranspiration);
- revegetation where lots are already cleared of native vegetation;
- greater runoff of stormwater from hard surfaces (roads and buildings) and subsequent greater recharge to groundwater; and
- water abstraction for human purposes.

Changes to water balance in Lake Clifton which would lead to either an increased or decreased net rate of recharge to the aquifer could affect microbialite growth.

The Water Authority of Western Australia (now Water and Rivers Commission) has developed a policy for allocating water in the catchment of Lake Clifton. The catchment is comprised of three subcatchments and this proposal falls within the Lake Clifton subarea. The Water Authority has determined the water balances for each subcatchment and have allocated 2 000 kL per ha per year of groundwater for human purposes on a sustainable yield basis for the Lake Clifton subarea.

The Department of Environmental Protection produced a technical report showing how change in lot size may affect the overall water balance for a standard subdivision design, due to the combined effects of clearing, revegetation and groundwater abstraction (this report was included as Appendix 3 of Bulletin 788, 1995). A trend was observed which indicated that as lot size decreased, there was a greater change in water balance following development (Figure 3). The EPA concluded that for a standard subdivision design using 1500 kL per lot per year of groundwater for human purposes, changes to water balance became unacceptable below 5 ha (EPA, Bulletin 788, 1995). However, the EPA went on to say that lot sizes below 5 ha may be possible, where the variables which cause water balance changes are set at what would be expected for 5 ha lots.

Continuing from this work, Appendix 2 of this report further explores the relationship between water balance and subdivision design. The study used the 5 ha/1500 kL per lot per year standard and examined how lot size would vary when water abstraction also varied, other variables kept constant. It would be expected that as groundwater abstraction is reduced below 1500 kL, a lot size of less than 5 ha would produce the same change in water balance as the 5 ha/1500 kL standard, all other variables being kept constant (Figure 4).

4.1.4 Comments from key government agencies and public submissions

The comments from the submissions pertained to minimum lot size, however as explained above there is a relationship between lot size and the amount of water available for human use.

Two submissions suggested that the setting of minimum lot size was the domain of the Ministry for Planning.

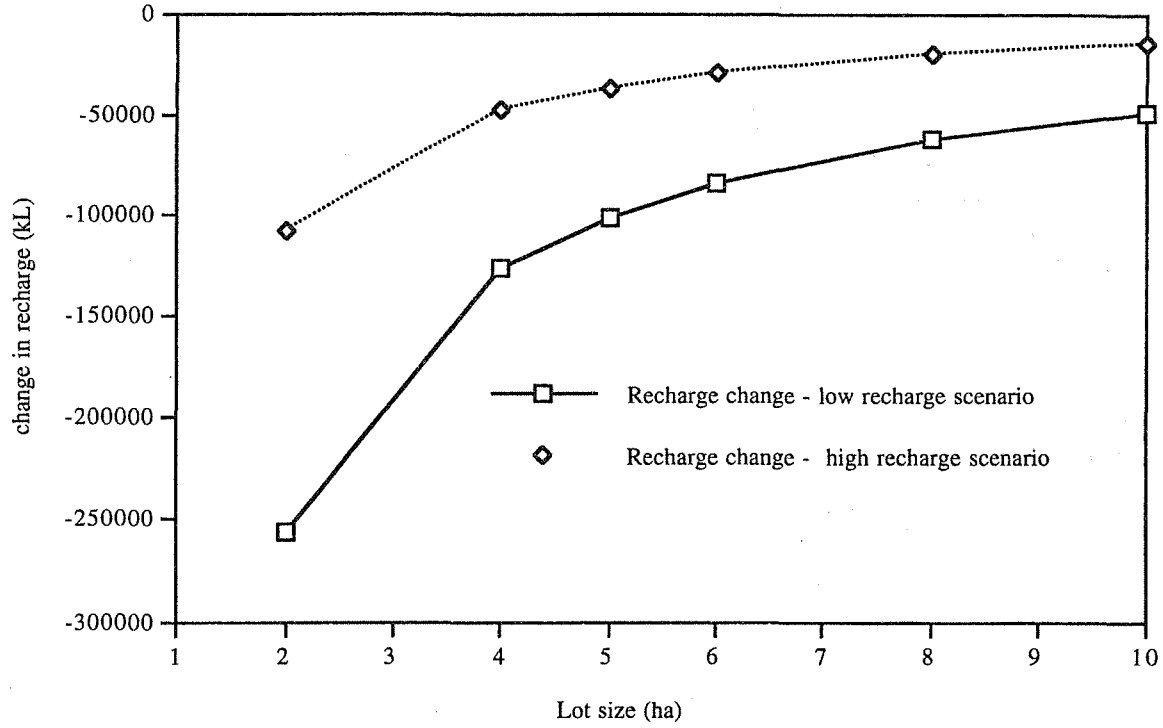

Figure 3. Change in groundwater recharge as a function of lot size following subdivision for land cleared of native vegetation prior to development

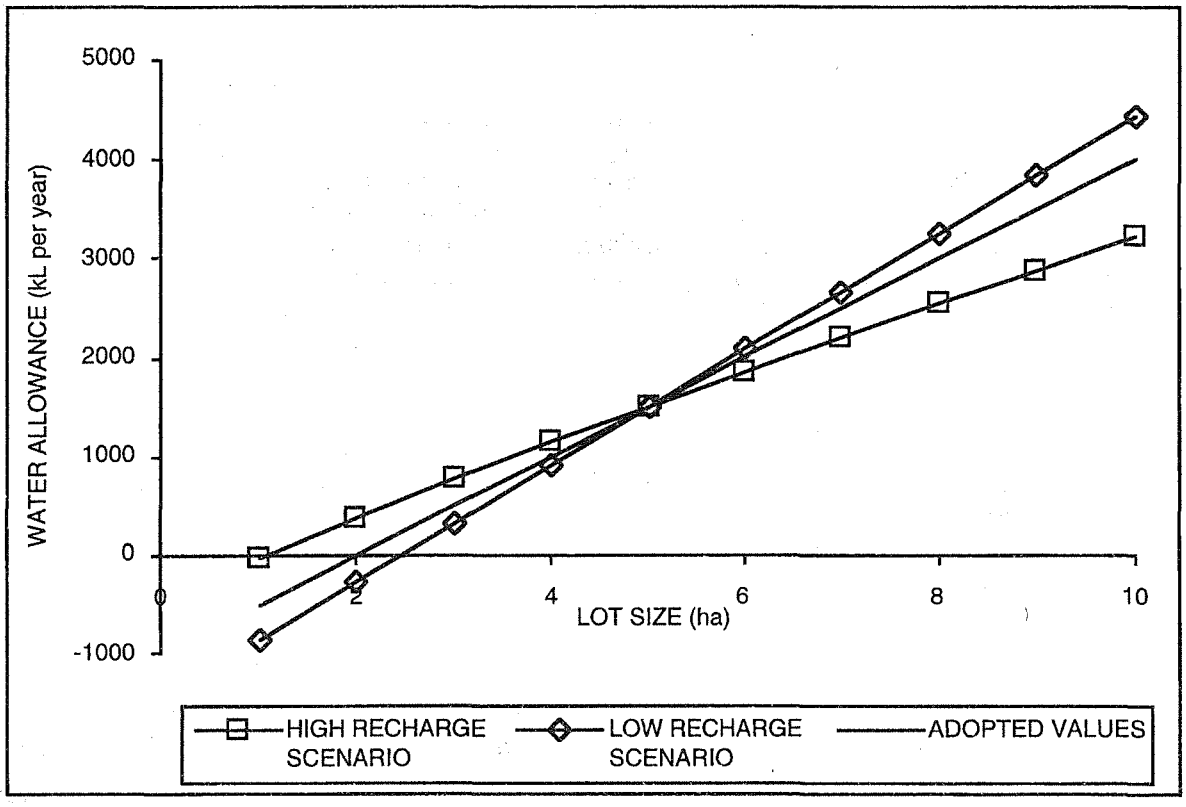

Figure 4: Water usage versus lot size based on 5 ha/1500 kL per lot per year (see Appendix 2).

Three submissions supported a 5 ha minimum lot size. The first, from the City of Mandurah, stated that there should be no variation to this size unless it was scientifically justified. One from a conservation group suggested that experimentation with smaller lots should be conducted outside the Lake Clifton catchment. The third, from the Water and Rivers Commission supported the 5 ha minimum lot size and suggested there should also be controls in place to prevent further subdivision.

The Yalgorup Lakes National Landcare Project advisory group also supported the 5 ha minimum lot size, but suggested there should be some scope for variation through innovative lot design.

One conservation group was concerned that water abstraction should be monitored to ensure no excess usage.

4.1.5 Management proposed in the original application to rezone

The original application to rezone envisaged a water consumption to be set at 1500 kL per lot per year as allowed for by the Water and Rivers Commission policy.

4.1.6 Environmental Protection Authority Evaluation

An annual groundwater abstraction rate of 1500 kL per lot per year was proposed with the original application to rezone. Following advice from the Department of Environmental Protection on water balance change following development (refer Appendix 2), the comments contained in public submissions and the environmental criteria developed in Bulletin 788, the EPA concludes that annual groundwater abstraction for this rezoning should be constrained to the EPA approved relationship between lot size (ha) and annual abstraction allowance (kL per year) as described by the hydrological model provided in Appendix 2, or any prospective changes to that model. For example, applying this relationship to an average lot size of 2 ha the current hydrological model shows that no water may be abstracted, and should this be the case, alternative water supplies should be considered or the lot size increased. The relevant government agency(s) should ensure that appropriate mechanisms are in place prior to finalisation of the subdivision. **(Recommendation 2)**

High water using activities and high fertiliser using activities (eg. horticulture) are not permitted on these lots and the relevant government agency(s) should ensure that appropriate mechanisms are in place prior to finalisation of the rezoning. **(Recommendation 3)**

Relevant government agencies should continue studies on the hydrology of Lake Clifton and the outcome of that work and any on-going monitoring should be used to further refine the hydrological model used in this assessment (Appendix 2). It may be necessary to change the amount of groundwater made available for human use in the catchment as a result of further work. A whole of catchment approach should be adopted to ensure the quality and quantity of fresh groundwater entering Lake Clifton will maintain the growth and function of the microbialites. **(Recommendation 4)**

Pollution management

4.2 Management of nutrients

4.2.1 Objective

The EPA's objective is to ensure that phosphorus export to Lake Clifton from land uses in the catchment is reduced as far as practicable.

4.2.2 Policy information

The precedent of past assessments in the Lake Clifton catchment provides a policy framework for consideration of this issue. The EPA provided advice on the Mt John Wood proposal and

subsequent amendment at the level of Informal Review with Public Advice (Appendix 1). The EPA advised that a subdivision to create 25 ten ha lots would be acceptable provided that domestic waste treatment be through systems approved by the Health Department with an acceptable phosphorus retention capacity and that appropriate controls be applied to the number of stock.

4.2.3 Technical information

As discussed in sections 4.1.3 and 4.2.3, the microbialites of Lake Clifton have critical growth requirements which include adequate light and minimal levels of nutrients. Whilst nutrients are essential for microbialite growth, excessive levels of nutrients will encourage the growth of other algal species. Algal blooms will reduce the amount of light reaching the microbialites, inhibiting or stopping growth. In Lake Clifton phosphorus is the limiting nutrient rather than nitrogen.

The major sources of nutrients from rural-residential developments are from domestic effluent disposal, domestic gardens and stock.

Septic tanks produce around 3.5 kg of phosphorus per year (human effluent and phosphorus detergents), and 18 kg of nitrogen per year (Gerritse et al, 1992). Work carried out by the Water Authority in Kwinana and Canning Vale where secondary treated effluent was allowed to recharge the superficial aquifer via treatment ponds built directly on different soil types, showed that Spearwood soils were very poor at removing nutrients from the effluent as it leached through to the water table, and that most of the nutrients reached the water table (Ho et al, 1992).

Nutrients from stock (horses and sheep) should not pose a risk to the lake provided that the feed is produced on the lot and no supplementary feeding of stock is carried out. If stocking rates are determined in this manner, it is expected that the nutrient balance on the lots (excluding human sources) will be maintained with no export of nutrients.

The EPA concluded in Bulletin 788 that future rural-residential developments should be required to install "alternative effluent systems" which use amended soil with high nutrient retaining capacities to treat human effluent. It was also concluded that domestic gardens are not considered to be a major concern provided that adequate land use controls are applied through the planning process to exclude commercial horticultural activities. The EPA also concluded that stock should only be allowed to control fire risk from uncontrolled growth of grasses, and at stocking rates for dry pasture, with no importation of feed to be allowed.

4.2.4 Comments from key government agencies and public submissions

The Water and Rivers Commission suggested that the risk of nitrogen leaching into lake should also be considered.

A conservation group suggested that intensive horticulture should not be permitted.

The Shire of Waroona suggested that stocking rates and the requirement for no importation of feed are difficult to monitor and that using the area of cleared land to set stocking rates encourages clearing of land.

Other submissions suggested that no stock should be allowed for uncleared lots as this would decrease the nutrient export and allow for smaller rural-residential lots, and that the stocking rates recommended are unreasonable.

4.2.5 Management proposed in the original application to rezone

The original proposal was for the normal provisions of the Town Planning Scheme to apply in this case including the provision of conventional septic tanks and controls on stock numbers and intensive land uses.

4.2.6 Environmental Protection Authority Evaluation

In Lake Clifton phosphorus is the limiting nutrient rather than nitrogen, therefore it is phosphorus levels that must be restricted.

Following advice from the Department of Environmental Protection and Agriculture Western Australia, the comments contained in public submissions and the environmental criteria developed in Bulletin 788, the EPA concludes that alternative waste-water disposal systems with nutrient-removing capabilities should be used. The number of any stock allowed per lot should be restricted consistent with stocking rates as advised by Agriculture Western Australia. All usual restrictions on high fertiliser-using ancillary land uses should apply. **(Recommendation 5)**

5. Conclusions & recommendations

5.1 Overall conclusion

The Environmental Protection Authority draws the general conclusion that the application to rezone Lot 7 from Rural to Special Rural can be managed to meet the EPA's objectives, subject to the EPA recommendations. A summary of the EPA's views are set out in Table 2 and the specific conclusions of the evaluation are detailed in section 4 of this report.

5.2 Specific recommendations

Noting the conclusion reached, the Environmental Protection Authority submits the following recommendations.

Recommendation 1

The EPA has concluded that the rezoning can be managed to meet the EPA's objectives, subject to the successful implementation of the EPA's advice.

Recommendation 2

The EPA recommends that annual groundwater abstraction for this rezoning once subdivided should be constrained to the EPA approved relationship between lot size (ha) and annual abstraction allowance (kL per year) as described by the hydrological model provided in Appendix 2, or any prospective changes to that model. For example, applying this relationship to an average lot size of 2 ha the current hydrological model shows that no water may be abstracted, and should this be the case, alternative water supplies should be considered or the lot size increased. The relevant government agency(s), including the City of Mandurah, Water and Rivers Commission and the WAPC, should ensure that appropriate mechanisms are in place.

Recommendation 3

The EPA recommends that high water-using activities and high fertiliser-using activities (eg. horticulture) should not be permitted on these lots and the relevant government agency(s), including the City of Mandurah and the WAPC, should ensure that appropriate mechanisms are in place.

Recommendation 4

The EPA recommends that the relevant government agencies, in particular the Water and Rivers Commission, should continue studies on the hydrology of Lake Clifton and the outcome of that work and any on-going monitoring should be used to further refine the hydrological model used in this assessment (Appendix 2). It may be necessary to change the amount of groundwater made available for human use in the catchment as a result of further work. A whole-of-catchment approach should be adopted to ensure the quality and quantity of fresh groundwater entering Lake Clifton will maintain the growth and function of the microbialites.

ISSUES	ENVIRONMENTAL OBJECTIVE	EVALUATION FRAMEWORK	MANAGEMENT PROPOSED BY PROPONENT	EPA RECOMMENDATION
Biophysical				
Water balance	On an annual basis the quantity of fresh groundwater entering Lake Clifton following development is as close as possible to that entering the lake before development.	DEP study shows relationship between water balance and lot design (Appendix 3); most lots already parkland cleared and some re-vegetation likely; little opportunity for extra recharge.	Groundwater abstraction up to 1500 kL per lot per year.	Annual groundwater abstraction for this proposal should be constrained to the Environmental Protection Authority approved relationship between lot size (ha) and annual abstraction allowance (kL per year) as described by the hydrological model provided in Appendix 2, or any prospective changes to that model. For example, applying this relationship to an average lot size of 2 ha the current hydrological model shows that no water may be abstracted, and should this be the case, alternative water supplies should be considered or the lot size increased. The relevant government agency(s), including the City of Mandurah, Water and Rivers Commission and the WAPC, should ensure that appropriate mechanisms are in place (EPA recommendation 2). High water-using activities and high fertiliser-using activities (eg. horticulture) are not permitted on these lots and the relevant government agency(s), including the City of Mandurah and the WAPC, should ensure that appropriate mechanisms are in place (EPA recommendation 3) Government should continue studies on the hydrology of Lake Clifton and the outcome of that work and any on-going monitoring should be used to further refine the hydrological model used in this assessment (Appendix 2). It may be necessary to change the amount of groundwater made available for human use in the catchment as a result of further work. A whole-of-catchment approach should be adopted to ensure the quality and quantity of fresh groundwater entering Lake Clifton will maintain the growth and function of the microbialites (EPA recommendation 4).
Pollution				
Nutrients	Phosphorus export to the lake from land uses in the catchment should be minimal.	Septic tanks, stock and ancillary land uses are sources of phosphorus.	Conventional septic systems allowed. Controls on intensive land uses and stock numbers.	Alternative waste-water disposal systems with nutrient removing capabilities should be used. The number of any stock allowed per lot should be restricted consistent with stocking rates as advised by Agriculture Western Australia. All usual restrictions on high fertiliser using ancillary land uses should apply. The relevant government agency(s), including the City of Mandurah, Health Department and the WAPC, should ensure that appropriate mechanisms are in place (EPA recommendation 5).

Recommendation 5

The EPA recommends that alternative waste-water disposal systems with nutrient-removing capabilities should be used. The number of any stock allowed per lot should be restricted consistent with stocking rates as advised by Agriculture Western Australia. All usual restrictions on high fertiliser-using ancillary land uses should apply. The relevant government agency(s), including the City of Mandurah, Health Department and the WAPC, should ensure that appropriate mechanisms are in place.

6. References

Department of Planning and Urban Development (1992) Statement of Planning Policy No 2 - The Peel-Harvey Coastal Plain Catchment.

EPA (1992) *Environmental Protection (Peel Inlet-Harvey Estuary) Policy 1992.*

EPA (1995) Criteria of environmental acceptability for land use proposals within the catchment of Lake Clifton: Report and recommendations of the Environmental Protection Authority. Bulletin 788. Environmental Protection Authority, Perth, Western Australia.

Davies, P. M., and Lane, J. A. K. (1995) Guidelines for designs of effective buffers for wetlands on the Swan Coastal Plain. Report to Australian Nature Conservation Agency, Canberra.

Gerritse, R. G., Adeney, J. A. & Bates, L. E. (1992) Nutrient Inputs from Various Land Uses on the Darling Plateau in Western Australia: Results of a survey. Report No 92/3, April 1992, CSIRO, Perth, Western Australia.

Ho, Goen E., Gibbs, Robyn A., Mathew, Kuruvilla and Parker, William F. (1992) Groundwater Recharge of Sewage Effluent through Amended Sand. Water Research, 36(3) pp. 285-293.

Appendix 1

Informal Review with Public Advice for Mt John Wood

Chief Executive
Department of Planning and Urban Development
469-489 Wellington Street
PERTH WA 6000

85803
Your ref: TP 91.132
Our ref: Mr Garry Middle
Enquiries: tm 52128 & 52703

ATTENTION: BRETT FLUGGE

PROPOSED DEVELOPMENT - PT MURRAY 721 & 1390 MT JOHN ROAD

I write in response to the above proposed development and offer the following advice and comments.

1. General comments
As the subject land is within the Peel-Harvey Catchment, the Scheme Amendment that accompanies this development must be consistent with the Statement of Planning Policy for that region. A further constraint on development is that this land abuts the internationally significant wetland Lake Clifton, and Yalgorup National Park. Consequently, additional controls need to be applied, and the proposed Scheme Amendment goes a long way to addressing the environmental issues associated with these constraints.

In general, the provision of the Amendment are acceptable to the Authority. There are, however, a few issues that require additional comment.

2. Land use controls
The Authority's position has been that it does not normally support rural subdivisions, but that if they are to proceed in the Peel-Harvey catchment the minimum lot size should be 20 hectares with land uses restricted to broadacre dryland grazing. The land-use management controls proposed for this land are acceptable provided they can be successfully implemented in the long term.

3. The proposed Rural Subdivision - Scheme amendment provisions
i) On-site effluent systems (2b)
Sub-section (iii) should be re-worded to allow only alternative systems approved by the Health Department with an acceptable phosphorus retention capacity to be used on the lots.

ii) Stormwater drainage
There is no need for the Environmental Protection Authority to be involved in this issue, but adequate controls should be in place to ensure the nutrient stripping aspects are implemented.

Environmental
Protection Authority

1 Mount Street Perth
Western Australia 6000
Telephone (09) 222 7000

Lake Clifton is a sink for groundwater and has a complex hydrology involving freshwater inflow from direct precipitation and groundwater, and water loss through evaporation. The thin wedge of fresh groundwater that flows into the lake is important for the survival of the microbialites as it regulates lake salinity. The groundwater also provides carbonate and bicarbonate ions (from the limestone) necessary for continued stromatolite growth.

Development in the area needs to ensure:

- water balance to the lake is maintained;
- water quality of the lake is protected; and
- impacts on the fringing vegetation are minimised.

In support of the case for bores, the proponent made the point that the key issue in managing the water and protecting the stromatolites was maintaining the water balance. That is, the aim should be not to change (either increase of decrease) the amount to freshwater entering the lake. Subsequent advice suggests that a reduction in fresh water entering the lake would certainly be a problem, but it is not so clear whether an increased in the freshwater flow would be a problem as well.

The proponent argued that the land to be developed is mostly covered with native vegetation, and that clearing the land to provide service roads, fire breaks and building envelopes would result in a net increase in the fresh water recharging the aquifer through decreased evapo-transpiration rates. This would result in an increase in fresh water flowing into the lake. It is argued, therefore, that by allowing residents to have bores some, if not all, of this extra recharge will be removed restoring the water balance close to predevelopment levels.

Increasing the size of the building envelopes will also lead to further clearing and further recharge.

The proponent has provided some figures on expected increased water recharge and expected water useage following development . Whilst there are some obvious uncertainties with some of the assumptions used in the calculations of total recharge and extraction, it is highly likely that there will be a net recharge of freshwater. These figures have been checked by officers of the Authority and the Water Authority.

In the absence of evidence to the contrary, it would seem difficult to opposed the use of bores provided that extraction rates are conservative. This can be ensured by including a provision in the Town Planning Scheme that water useage be set at 1 000 kilolitres per lot per year, meters on the bores are installed, and controls on land uses which prohibit high water using activities are implemented. The Scheme already has the provisions to prohibit intensive land uses. The proponent has indicated that meters will be provided at his expense.

Increased size of building envelopes

The Authority is less supportive of this proposal. The apparent reason for the request is to allow residents to locate stables well away from houses. Increasing the size of the building envelopes to 1 ha could signal to future residents that more intensive, high water and fertliser using activities are acceptable. These activities would be undesirable on these lots. A compromise solution would be to permit two building envelope areas where requested. The combined building envelopes for house and stables should be a maximum total size of 5 000 square metres.

Fencing requirements

The Authority has no comments to offer on the changes to fencing requirements.

AN ENVIRONMENT WORTH PROTECTION

Chief Executive Officer
City of Mandurah
PO Box 210
MANDURAH WA 6210

Your ref: 18/16/203
Our ref: TP 91.132: 70652
Enquiries: Garry Middle
222 7103

ATTENTION: Colin Summerville

CITY OF MANDURAH TOWN PLANNING SCHEME NO 1, AMENDMENT NO 203 - AREA 7, LAKES CLIFTON

I write regarding the above proposed development referred to the Authority on 1 November 1993 where level of assessment was set at Informal with Public Advice. The following advice and comment is offered.

History of the proposal

This original proposal, referred to the Authority in November 1991, had level of assessment set at Informal with Public Advice. This level was set because the proposed management measures adequately addressed the key environmental issues, and could be be enforced through the City of Mandurah's Town Planning Scheme.

As you are aware, the proponent has requested three changes to the original provisions, which are the subject of Amendment 203 to the City of Mandurah's Town Planning Scheme. The Amendment was referred to the Authority, and level of assessment set at Informal with Public Advice. This level of assessment was set based on:

- information provided by the proponent and other interested parties;
- a judgement based on this information that the changes, with minor modifications, would be environmentally acceptable; and
- the willingness of Council officers to accept the Authority's advice.

Provision of bore water

Lake Clifton is internationally important as a waterbird habitat and because it contains the largest know example of living microbialites in a lake environment in the southern hemisphere (400 ha in a 8km long reef). It is one of only two lakes in the world where these stromatolite-like structures occur in hyposaline water, and has been listed under the Ramsar Convention as having international importance. Lake Clifton, its fringing vegetation and the catchment to the west are contained within Yalgorup National Park, which is an area subject to System 6 recommendations. It is also a wetland protected by the Environmental Protection (Swan Coastal Plain Lakes) Policy 1992.

iii) Landuses other than Residential (2d)
The primary purpose of these proposed lots should be residential. Additional uses should not be permitted.

iv) Stocking rates (2e)
The building envelope will be at most 4000 square metres, and the allowance of two horse equivalent of stock seems excessive. One horse equivalent would be preferable.

4. Special Rural lots

These lots should be developed in a manner consistent with the Peel-Harvey Statement of Planning Policy.

5. Public consultation

One of the issues raised as part of an appeal on level of assessment on this project was that, given the importance of Lake Clifton, the public should be given the opportunity to have an input into the development. The Minister for the Environment dismissed this part of the appeal on the grounds that a limited public consultation would be carried out as part of the Authority's deliberation regarding this proposal. That limited public consultation has now been completed. However, should your Department decided that this proposal should be the subject of a re-zoning, then further public comment can be sought, thus minimising public concern regarding the perceived lack of public consultation.

Subject to the above advice and comments, the above proposed development would be environmentally acceptable.

Yours sincerely

R A D Sippe
DIRECTOR
EVALUATION DIVISION

11 February 1992

cc: BSD Consultants Pty Ltd, Peel Preservation Group (inc), City of Mandurah, Conservation Council, Waterbird Protection Group

Bouvard DPUD advice 110292 GMI

Strategy for the management of developments within the Lake Clifton catchment
The Authority is concerned about managing developments within the catchment of Lake Clifton, as the catchment is coming under increasing pressure for development, and there are clear signs that the water quality in the lake is deteriorating. The Environmental Protection Authority is currently drafting a strategy for the catchment which will address the management issues, and Council will be fully consulted prior to its finalisation. It would be desirable that the key elements of the strategy are included in Town Planning Scheme No 2 and the Rural Strategy.

Subject to the above advice and comments, the proposed changes to the development would be environmentally acceptable. Should you require further information regarding these matters please contact Garry Middle on (09) 222 7103.

Yours sincerely

R A D Sippe
DIRECTOR
EVALUATION DIVISION

30 November 1993

CC: Department of Planning and Urban Development
Water Authority of Western Australia;
Ms Linda Moore
Conservation Council
Peel Preservation Society
Shire of Waroona
Community Catchment Centre
Department of Conservation and Land Management

Am 203 Clifton advice 301193 GMi

Appendix 2

Water use and lot size for a standard special rural subdivision

Department of Environmental Protection

1. Introduction

The Environmental Protection Authority recently released a Bulletin entitled "Criteria of environmental acceptability for land use proposals within the catchment of Lake Clifton" (EPA, 1995). Special Rural developments were identified as being a land use within the catchment which required special management to avoid unacceptable impacts on the lake. One of the main issues of concern was maintenance at pre-development levels of the groundwater flows into the lake (ie. water balance) following development.

Maintenance of groundwater flows into the lake is seen as critical for the survival of the microbialites. Microbialites are limestone structures built by algae to provide themselves with a safe habitat. In order that these structures can continue to grow a constant supply of carbonate and bicarbonate ions is required. This is provided from the in-flowing groundwater.

Much of the soil within the catchment is underlain with limestone at or near the surface. Rain falling within the catchment infiltrates through the sand and the limestone dissolving some of the limestone on the way to the aquifer. This carbonate and bicarbonate-rich, mostly fresh, groundwater then makes its way to the lake.

It is crucial, therefore, that this supply of groundwater is maintained. Recent evidence from a study co-ordinated by the Water and Rivers Commission indicates that the freshwater aquifer containing the carbonate and bicarbonate-rich water is very thin, as little as four meters thick in some places. Human abstraction poses the greatest threat to the continued movement of this groundwater.

Appendix 3 of the EPA Lake Clifton bulletin showed the relationship between lot size and changes to water balance following the development of a parcel of land for special rural purposes. As land is developed, recharge to the aquifer can increase through run-off from additional hard surfaces (roads tracks and buildings) and through the clearing of native vegetation to provide for the houses, building envelopes and roads. This is balanced through the abstraction of groundwater for human purposes and, for land already cleared of native vegetation, re-vegetation as owners seek to improve the amenity of their properties.

A mathematical model was set up to show what happens to the water balance following development, and the Appendix concluded that, based on a typical subdivision design, the change in water balance became unacceptable below 5 ha.

These calculations showed that the amount of groundwater abstracted for human purposes was one of the main contributors to the change in water balance. As a follow-up to this work in the EPA's Lake Clifton Bulletin, it was decided to explore the relationship between lot size and the amount of water used for human purposes further. The work used the 5 ha/1500 kL change in water balance as the environmentally acceptable standard. It would be expected that as groundwater abstraction is reduced below 1500 kL, a lot size of less than 5 ha would produce the same change in water balance as the 5 ha/1500 kL standard, all other variables being kept constant.

The calculations in this Appendix show that relationship. The results shown here are only for land cleared or parkland cleared prior to development as these are the results relevant to the proposal assessed in this bulletin.

2. The relationship between lot size and groundwater abstraction for a typical special rural subdivision - for land cleared of native vegetation prior to development

2.1 Introduction

The base formula used here is derived from Appendix 3 of the EPA original Lake Clifton Bulletin (EPA, 1995). The symbols used in the equation represent the following:

R = recharge (litres per year);

r_n = recharge rate of variable n (for example, for native vegetation areas and hard surfaces);

ΔR = change in recharge (litres per year);

ET = evapotranspiration rate (litres per year);

W = groundwater abstraction (litres per year);

A = area of land to be subdivided (hectares);

a = area of each lot (hectares);

$\sqrt{a}$ = length of one side of the lot assuming lot is square (metres);

2.2 The derivation of the equation showing the relationship

Using the equation from Appendix 3 of the EPA Lake Clifton Bulletin (EPA, 1995):

ΔR = [R(p) - ET(rehab) - W + R(pvte)] x A/a

= [(500 + 3.5 $\sqrt{a}$) % diff recharge/100 x 0.900

- (4000 x % diff recharge/100) x .900 - 1500 + (1500 x recharge pvte/100)] x A/a

Now, let W = water used for human uses

and r_n = the respective recharge variables

= [(500 + 3.5 $\sqrt{a}$) r_1 /100 x 0.900 - (4000 x r_2 /100) x .900 - W + (W x r_3 /100)] x A/a

or, taking the total area out of the equation

$\Delta R/A$ = [(500 + 3.5 $\sqrt{a}$) r_1 /100 x 0.900 - (4000 x r_2 /100) x .900 - W + (W x r_3 /100)] x 1/a

Solving for a lot size of 5 ha and groundwater abstraction of 1500 kL per lot per year, for both high and low recharge scenarios

$\Delta R/A$ = -403 - low recharge scenario

$\Delta R/A$ = -143 - high recharge scenario

It is now possible to set up a relationship between W (groundwater abstraction) and a (lot size) using the figure of $\Delta R/A$ for lot size of 5 ha and groundwater abstraction of 1500 kL per lot per year as a standard.

(a) low recharge scenario

$\Delta R/A$ = [(500 + 3.5 $\sqrt{a}$) r_1 /100 x 0.900 - (4000 x r_2 /100) x .900 - W + (W x r_3 /100)] x 1/a

-403 = (500 + 3.5 $\sqrt{a}$) r_1 /100 x 0.900 - (4000 x r_2 /100) x .900 - W + (W x r_3 /100)] x 1/a

Solving for W

-403 x a = (500 + 3.5 $\sqrt{a}$) r_1 /100 x 0.900 - (4000 x r_2 /100) x .900 - W + (W x r_3 /100)

-403 x a - (500 + 3.5 $\sqrt{a}$) r_1 /100 x 0.900 + (4000 x r_2 /100) x .900 = - W + (W x r_3 /100)

or

-403 x a - (500 + 3.5 $\sqrt{a}$) r_1 /100 x 0.900 + (4000 x r_2 /100) x .900 = - W (1 - 1 x r_3 /100)

or

W = [403 x a + (500 + 3.5 $\sqrt{a}$) r_1 /100 x 0.900 - (4000 x r_2 /100) x .900]/(1 - 1 x r_3 /100)

simplifying

W = [403 x a + 4.5r_1 + 0.0315 $\sqrt{a}$ x r_1 - 36 x r_2]/(1 - 1 x r_3 /100)

(b) high recharge scenario

The equivalent equation is:

W = [142 x a + 4.5r_1 + 0.0315 $\sqrt{a}$ x r_1 - 36 x r_2]/(1 - 1 x r_3 /100)

2.3 Results

Table 1 and Figure 1 present, for a range of lot sizes, the results of calculations of groundwater abstractions which are equivalent to an abstraction of 1500 kL per year on a 5 ha lot using high and low recharge scenarios. A set of values lying between those extremes has been adopted for the purposes of assessing this proposal.

Table 1: The relationship between lot size and groundwater abstraction based on the 5 ha/1500 kL standard

LOT SIZE (ha)	WATER USE (kL per year)		
	HIGH RECHARGE SCENARIO	LOW RECHARGE SCENARIO	ADOPTED VALUES
1	-30	-858	-500
2	386	-264	0
3	771	326	500
4	1141	914	1000
5	1500	1500	1500
6	1852	2085	2000
7	2199	2670	2500
8	2542	3253	3000
9	2881	3837	3500
10	3217	4420	4000

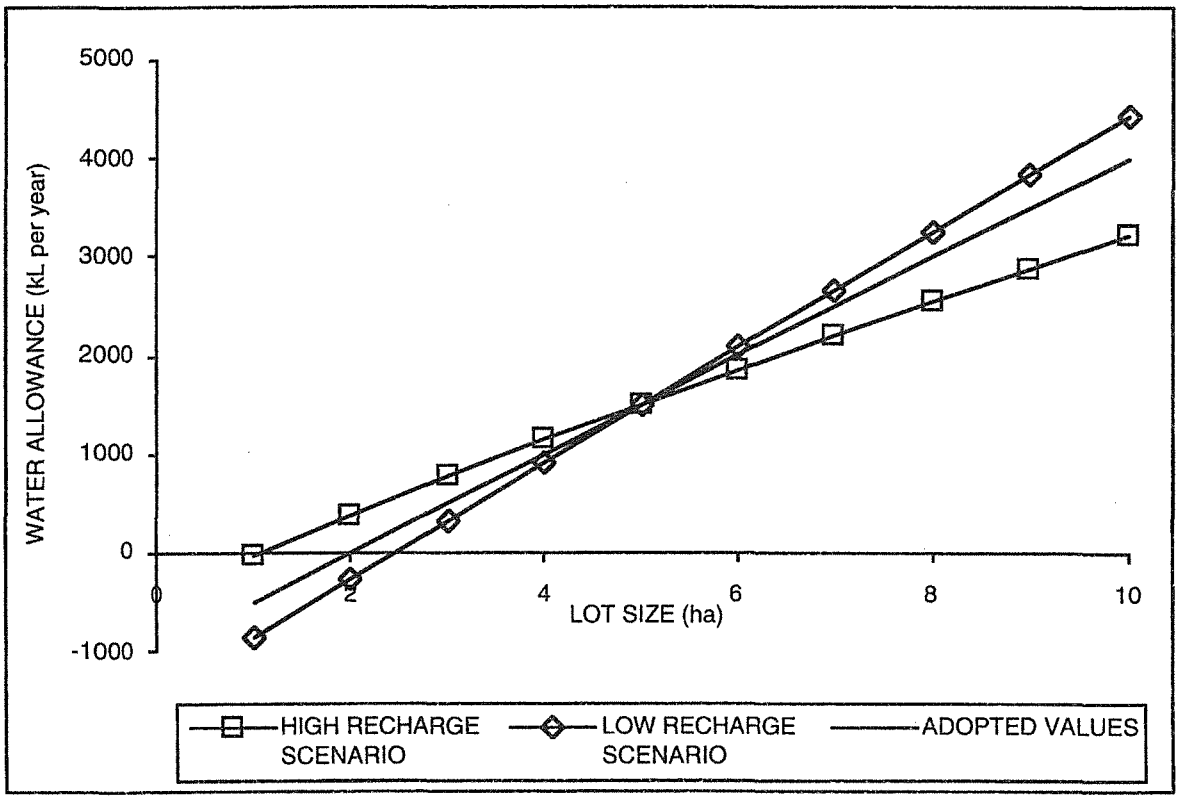

Figure 1: Water usage versus lot size based on the 5 ha/1500 kL per lot per year standard.

2.4 Conclusion

The data indicate that groundwater abstraction and lot size should conform to the relationship:

$$W = (A - 2) \times 500$$

where W is the water abstraction allowance in kL per year
and A is the lot size in ha.

From this it follows that no groundwater abstraction should be allowed where the lot size is less than 2 ha and at an average lot size of 4 ha, abstraction of groundwater should not exceed 1000 kL per lot per year.