



YENYENING LAKES MANAGEMENT STRATEGY 2002 - 2012



**Water and Rivers
Commission**

**Department of Conservation and
Land Management**

YENYENING LAKES MANAGEMENT STRATEGY 2002 - 2012

Prepared for
Water and Rivers Commission and
Department of Conservation & Land Management
in consultation with the Yenyening Lakes
Management Committee

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Foreword

The Yenyening Lakes are an important part of the Wheatbelt environment from an environmental, economic and social viewpoint. At landscape scale, the lakes are located at the junction of the inland zone of ancient drainage and the zone of rejuvenated drainage, at the point where the sluggish saline valleys meet the channelised east branch of the Avon River. Thus all of the drainage from the Lockhart and Yilgarn catchments flows through the lakes.

Environmentally, the lakes have significant biodiversity resources and also provide important habitat for water birds. Economically, regulation of the flows past the Qualandary crossing provides a means of managing flood risk further down in the Avon and Swan Rivers. At the same time, careful water flow management is important to prevent excessive salinisation of farmland adjacent to the lakes. Socially, the lakes are an important asset for water sports and other recreation in an area that is generally devoid of large surface water bodies. Local communities place a high level of value on these recreational opportunities.

In recognition of the importance of the Yenyening Lakes, a Management Strategy was developed in 1996 to be implemented by a Management Committee. Progress has been sound and the Management Committee have discharged their responsibilities well. However, given the considerable developments in biophysical research since that time, and institutional changes at government level, it is appropriate that performance against the strategy's objectives is reviewed and a new 10-year strategy developed to take advantage of recent findings and events.

This project reviews the previous strategy and management arrangements, factors in available new information, and presents a new 10-year strategy with supporting biophysical information and management commitments.

The process undertaken in the development of this plan has ensured that the competing and sometimes conflicting uses or management issues have been systematically evaluated using available information and the advice of people with relevant experience. The plan is compatible with the local management guidelines of the Department of Conservation and Land Management and the broader waterway management policies of the Water and Rivers Commission.

The Yenyening Lakes Management Strategy 2002-2012 has been prepared by URS Australia under direction from the Water and Rivers Commission, Department of Conservation and Land Management in consultation with Yenyening Lakes Management Group. It is intended for use by those with an active interest in the management of the Lakes, including the Yenyening Lakes Management Group. The Strategy is also expected to be of interest and useful to adjacent landholders, The Shires of Beverley, Quairading and Brookton, members of the scientific community and the public of Western Australia.

The Strategy has been reviewed and approved by Department of Conservation and Land Management and Water & Rivers Commission, endorsed by Avon Waterways Committee, recognised by the Shires of Beverley, Quairading and Brookton and accepted by the Yenyening Lakes Management Committee.

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1. Introduction

This Report presents a Strategy for the management of the **Yenyening Lakes and surrounds** for the period from 2002 to 2012. In this document, this new strategy is referred to as the ‘10 year Strategy’. The purpose of the Strategy is the management of the Yenyening lakes and associated lands between Qualandary Crossing and the Corrigin-Quairading Road – described in this strategy as the ‘**Yenyening Lakes Management Area (YLMA)**’.

The strategy has also considered the role and structure of the **Yenyening Lakes Group and its Management Committee** hereafter also termed ‘the Group’ and the ‘Management Committee (YLMC)’ in addressing the objectives and actions listed in the 10 year Strategy.

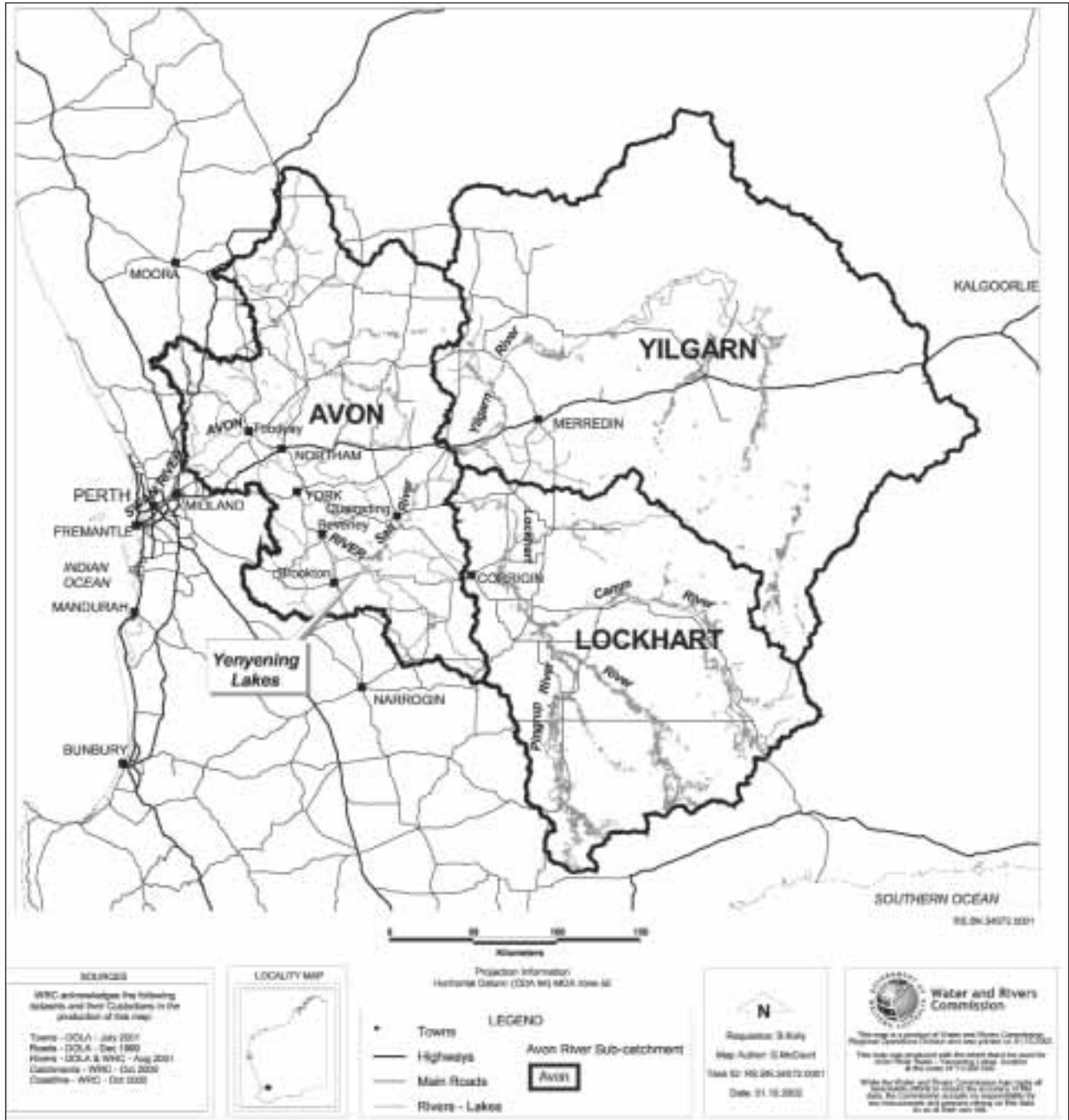
1.1 The Yenyening Lakes

The Yenyening Lakes are a very significant feature in the context of wheatbelt hydrology. At landscape scale, the lakes are located at the junction of the inland zone of ancient drainage and the zone of rejuvenated drainage, at the point where the sluggish saline valleys meet the channelised Avon River. Thus all of the drainage from the Lockhart and Yilgarn catchments flows through the lakes and into the Avon River.

The Yilgarn and Lockhart catchments above the Yenyening Lakes cover about 91,000 square kilometres of mainly cleared agricultural land. These two drainage systems merge at the Caroline Gap south of Tammin, to form a broad drainage floor called the ‘Salt River’.

1.1.1 The physical environment

The Salt River drainage floor crosses the Quairading – Corrigin Road about 6-km south east of Quairading. This southwest trending section of the Salt River is broad and flat, up to 3 km wide, with small and ill-defined salt lakes comprising about 40 per cent of the valley floor. A paleo-channel lies beneath this drainage floor. The most prominent lake is Lake Yenyening, which is 6 kilometres due south of Quairading. About 17 kilometres down from the road crossing, the Kunjin Brook enters from the south. Paleo-channel sediments underlie the Brook. Below the Kunjin Brook junction, near Morrell Pool, the drainage floor widens to 5 kilometres, in an area known as ‘the channels’. A further 5 kilometres downstream is the first of the large defined lakes. From this point, to the Qualandary Crossing (approximately 9 kilometres), the major lakes are found, separated by sandy rises, saline drainage floors and diffuse drainage lines. On the southern side of the line of lakes are some short, generally steep drainage lines that enter the lake system. On the northern side of the lake system is the Morbinning Gully system that rises about 25 kilometres away, to the north west of Dangin. This extensive drainage system terminates in a deltaic formation of alluvial plains and diffuse drainage lines that carry surface water into the lake system. The lakes and channels are the terminus for all of the local drainage systems from adjacent farmland.



Map 1: Location of Yenyening Lakes

Immediately below Qualandary Crossing this broad ill-defined and low slope drainage system to the east enters the Avon River, which is narrow, defined, and generally fast flowing. As indicated in the previous section, this is a major junction point for wheatbelt drainage.

Based on the above analysis, it is possible to sub-divide the Yenyening Lakes system and surrounds into the following four functional sub-systems.

- Salt River drainage floor. Consists of the drainage floor, and associated saline plains, minor sandy ridges, drainage lines and small ill-defined lakes down-stream from the Corrigin-Quairading road. This sub-system is subject to frequent inundation, and has shallow freely available groundwater, overlying deeper paleo-channel aquifers. The saline plains support a saltbush, samphire and bluebush shrubland that is grazed intermittently, with a ti-tree shrubland on areas with slightly more relief. This land is nearly all privately held.
- Lakes and channels. Consists of the large well-defined lakes, sandy banks, channels and drainage lines that occur up stream from the Qualandary Crossing. The bare lake beds are separated by well-vegetated sandy banks and rises supporting mallee and ti-tree shrublands, with occasional stands of York gum. Much of this land is held in two nature reserves – Reserve 31837 and Reserve 28088, which are vested with the Conservation Commission of Western Australia.
- Adjacent alluvial plains. The adjacent alluvial plains are found on farming land located north and south of the main drainage system. Most areas are located across the broad and almost flat valley floors located at the downstream ends of drainage lines such as the Morbinning Gully and the Kunjin Brook. These gently sloping plains carry surface run-off from higher slopes into the lakes and Salt River. This water also recharges local groundwater supplies. As a consequence, water tables on low-lying land are generally shallow. Nearly all of this land is privately held and is farmed.
- Uplands. Uplands are associated either with the extensive sand dunes and sand plains to the south of the major drainage zone, or are adjacent to outcropping granites and lateritic remnants (such as County Peak). Nearly all of this land is privately held and farmed.

1.1.2 The Yenyening Lakes management area as a drainage system

The average annual rainfall is about 350 mm, decreasing eastward, and the average annual evaporation is about 2100 mm, increasing to the northeast.

For low flow situations, runoff from a relatively small part of the Salt River catchment drains southwest into these lakes. The significant tributaries from the north (Morbinning Gully) and east past Lake Mears (Kunjin Brook, aka Stock Pool Creek) contribute significant flow. In periods of moderate to high flow, runoff from an area of 91 000 km² flows through the lakes into the Avon River near Qualandary Crossing (Harris, 1996). The drainage gradient from the Quairading–Corrigin Road (just under 220 m AHD) in a direct line to the outlet (209.06 m AHD) some 33 km away is less than 3 in 10,000. This is sufficient to keep water moving at walking speed, with no erosion risk. As the area is undulating with low relief, the catchment area and path of surface runoff may change both during and between high flow events – for example near Morrell Pool. However, confinement of water and increasing water speed can result in erosion as seen in one bypass drain.

In periods of low flow, but with high flow in the Avon River, water has historically backed up into the lakes. Qualandary Crossing was put in place in the early 1900s and gradually increased in height that has limited backflow from the river. The Crossing was also used to retain some water and to preserve the quality of downstream pools in the Avon River for stock use.

The current structure was completed in 1998. The gates are opened to allow flow into the Avon River during moderate flow. The top of the Crossing is 211.36 m AHD and a channel has been excavated on the upstream side of the gates to 209.36 m AHD. The base of the gates is at 209.06 m AHD. Lane (1994) gives the history of Crossing heights.

1.2 The need for a strategy

The Yenyening Lakes are an important part of the wheatbelt environment from an environmental, economic and social viewpoint.

- At landscape scale, the lakes are located at the junction of the inland zone of ancient drainage and the zone of rejuvenated drainage, at the point where the sluggish saline valleys meet the channelised Avon

River. Thus all of the drainage from the Lockhart and Yilgarn catchments flows through the lakes.

- Environmentally, the lakes have locally significant biodiversity resources and also provide important habitat for water birds.
- Economically, regulation of the flows past the Qualandary Crossing provides a means of managing flood risk further down in the Avon and Swan Rivers. At the same time, careful water flow management is important to prevent salty water flooding onto farmland adjacent to the lakes and the river. Further, the lakes and channels form an important drainage line for water discharge from neighbouring farmland.
- Socially, the lakes are an important asset for water sports and other recreation in an area that is generally devoid of large surface water bodies. Local communities place a high level of value on these recreational opportunities.

In recognition of the importance of the Yenyening Lakes, a Management Strategy was developed in 1996 to be implemented by a Management Committee. Progress has been sound and the Management Committee have discharged their responsibilities well. However, given the considerable developments in biophysical research since that time, and institutional changes at government level, it is appropriate that a new 10-year strategy developed to take advantage of recent findings and events.

1.3 Defining the geographic limits for the 10 year strategy

The 1996 Strategy focused on the land within the 220m AHD contour line, as shown in Map 2. However, many of the strategy's actions considered land use and management outside this area. This decision was driven by concerns that off-site water management affected the status of groundwater beneath the land within the 220 m contour line.

Recent research has shown that while surface water management away from the lakes, channels and Salt River will impact on surface flows, groundwater behaviour is very locally driven – with the implication being that action to manage groundwater needs to be taken on-site. Thus, this 10 year Strategy retains its commitment to management of the lakes and channels, Salt River and immediate surrounds.

The definition of the Yenyening Lakes Management Area is changed slightly to:

the lakes and channels and Salt River system between Qualandary Crossing and the Corrigin-Quairading Road and the adjacent landholdings that intersect or adjoin the 220 m contour line. This area will define the extent of the Strategy's coverage.

Land within this area is held by a number of private landholders and the Conservation Commission who hold two nature reserves - Reserve 31837 and Reserve 28088, which are managed by the Department of Conservation and Land Management on the Commission's behalf.

The stakeholders who form the Yenyening Lakes Group are listed in **Appendix A**.

1.4 Objectives for the 10 year strategy

The following four over-arching objectives for the lake system and surrounds contain very similar words to those used in the objectives adopted for the 1996 strategy. The minor changes reflect the aspirations of those people who attended the strategic planning workshops in April 2002.

1.4.1 Surface water management

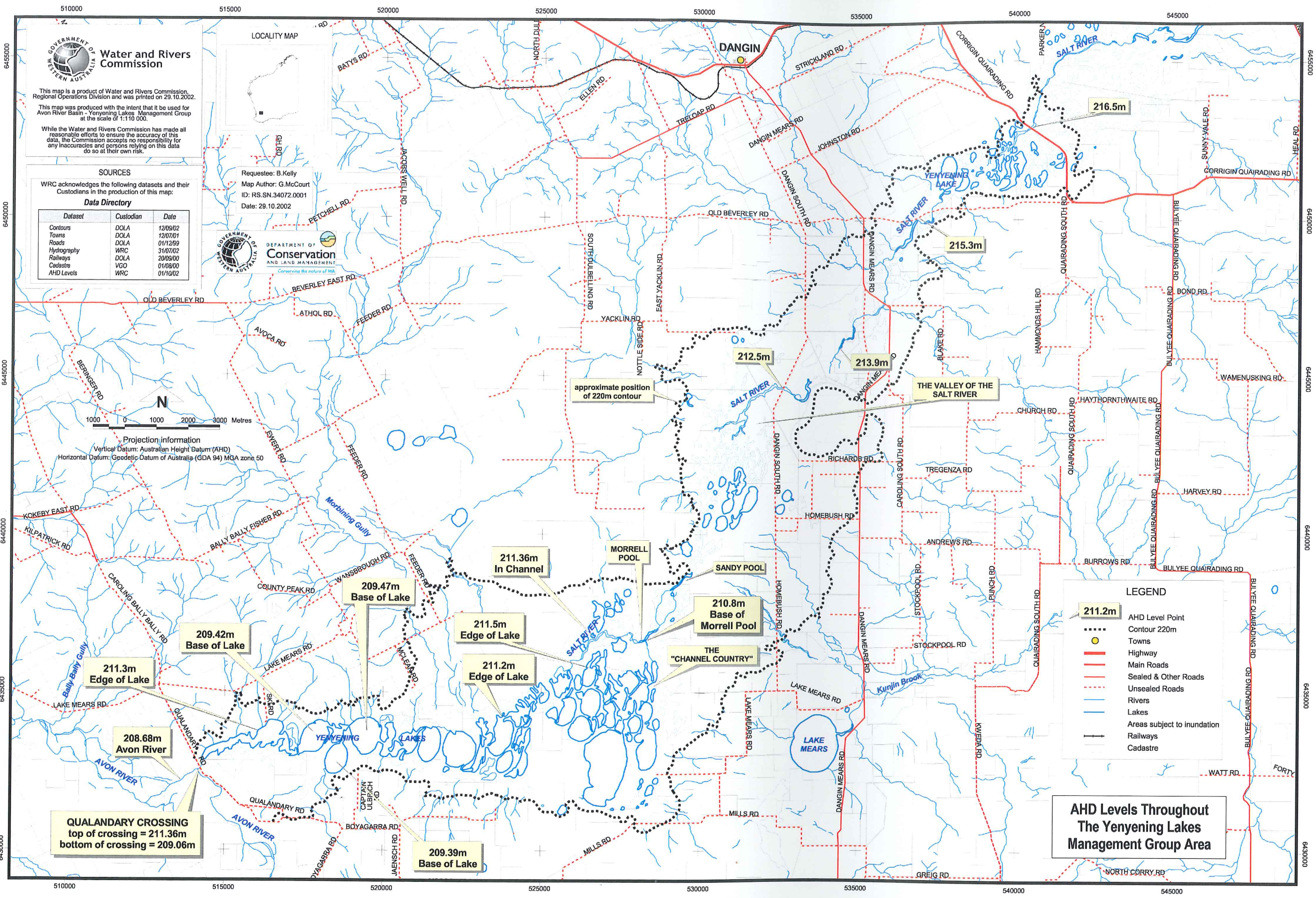
To manage Qualandary Crossing so as to maintain adequate water levels in the lakes for recreation and wildlife, while minimising back up of waters onto agricultural land; also to minimise the flow of silt and salt into the lakes and the Avon River and to ensure that the management of lakes helps prevent downstream flooding by regulating water flows through the system.

1.4.2 Groundwater management

To implement practices that limit groundwater rise in the lake system and surrounds and which also reduces groundwater impacts on the environmental and agricultural values of the area being managed.

1.4.3 Nature conservation

To maintain and where possible improve existing nature conservation values by ensuring viable populations of indigenous flora and fauna in and around the lakes.



Water and Rivers Commission

This map is a product of Water and Rivers Commission, Regional Operations Division and was printed on 29.10.2002.

This map was produced with the intent that it be used for Avon River Basin - Yenying Lakes Management Group at the scale of 1:110 000.

While the Water and Rivers Commission has made all reasonable efforts to ensure the accuracy of this data, the Commission accepts no responsibility for any inaccuracies and persons relying on this data do so at their own risk.

SOURCES

WRC acknowledges the following datasets and their Custodians in the production of this map:

Data Directory

Dataset	Custodian	Date
Contours	DOLA	12/08/02
Towns	DOLA	12/07/01
Roads	DOLA	01/12/99
Hydrography	WRC	31/07/02
Railways	DOLA	20/09/00
Cadastre	VGD	01/08/00
AHD Levels	WRC	01/10/02

Requestee: B.Kelly
 Map Author: G.McCourt
 ID: RS.SN.34072.0001
 Date: 29.10.2002



LEGEND

- AHD Level Point
- Contour 220m
- Towns
- Highway
- Main Roads
- Sealed & Other Roads
- Unsealed Roads
- Rivers
- Lakes
- Areas subject to inundation
- Railways
- Cadastre

AHD Levels Throughout The Yenying Lakes Management Group Area

Map 2: AHD Levels throughout the Yenying Lakes Management Group Area.

1.4.4 Recreation and tourism

To provide for recreational activities by managing the lake waters for approved water-based recreation, and providing appropriate facilities for visitors; to attract tourists, facilitate their enjoyment of the lakes and educate them about the area and its management; and to protect and restore the beauty of the lakes, including the bushland and adjoining land.

1.4.5 Management arrangements

To establish management structures and processes that involve all key stakeholders in the management of the Yenyening Lakes Management Area, by encouraging collective action, quality communication between all parties, and incorporation of new information into management actions as it becomes available.

1.5 The Yenyening Lakes management committee

The Yenyening Lakes Management Committee has had responsibility for facilitating the implementation of the 1996 Strategy. They will continue to facilitate management actions relating to the Yenyening Lakes Management Area on behalf of the Yenyening Lakes Group according to the objectives and actions presented

in this Strategy document. Recommended actions are given in Section 3.5.

1.5.1 Partners in implementation

The Yenyening Lakes Management Committee will work with the accountable parties in implementing actions. Authority for these lie with the relevant private and public landholders and managers. The role of the Committee is to facilitate action and provide a forum for discussion and dealing with issues.

1.6 About this document

Section 1 introduces the purpose of the Strategy, its geographical extent and major objectives.

Section 2 describes how the Strategy was developed and who was involved.

Section 3 presents the Objectives, with associated actions and responsibilities.

Section 4 discusses the process for implementation by the Yenyening Lakes Management Committee.

The **Appendices** contain lists of people involved in the five planning workshops, specific workshop reports, technical information and the revised Constitution for the Yenyening Lakes Group.

2. Developing a strategy

2.1 Reviewing the 1996 strategy

Three tasks were completed in reviewing the 1996 Strategy.

- Documentary material was reviewed for the key events in strategy implementation and in the management of the Yenyening Lakes Management Area. The period covered was 1996 to the present.
- The objectives and actions of the 1996 Strategy were reviewed by the Yenyening Lakes Management Committee at a meeting held in Beverley on March 6, 2002. The approach taken was to ask members of the Management Committee to comment on each of the actions contained in the 1996 Strategy in respect of the achievements and any other points of note.
- Some of the key stakeholders were interviewed about their perceptions on the effectiveness of the 1996 strategy and its implementation.

The completed brief review was provided to the Water and Rivers Commission and Department of Conservation and Land Management and the Yenyening Lakes Management Committee as a separate stand-alone Report.

2.2 Hydrology investigations

2.2.1 Surface water hydrology

The surface hydrology of the Lakes has been well quantified in a number of studies in the past. Quite a bit of work has been done on salt dynamics within the Lake, including mixing and flushing of salt during floods. The Water and Rivers Commission and other groups monitor water and salt levels in and around the Lakes. There is also considerable collective memory of the behaviour and characteristics of the Lakes amongst the Lake's users and Management Committee.

Broadly, the lakes have three main catchments:

- **Yilgarn River system** - catchment area of 55,680 km², about 61 per cent of the total catchment area for the Yenyening Lakes, but generating less runoff than the Lockhart catchment.
- **Lockhart River** - catchment area of 32,150 km², about 35 per cent of the total catchment area, and a

significant source of water for Yenyening Lakes in wet years.

- **Local flows** – catchment area 3,700 km², about 4 per cent of the total catchment area. Important source of runoff in years when the Yilgarn and Lockhart don't flow.

The Yenyening Lakes have a capacity of about 10 million cubic metres at the overflow depth of 211.36 m AHD. This point is defined as the lowest point on the bitumen roadway that goes across the Qualandary Crossing. At that depth the surface area of the lake becomes 9.7 km². During the period of study (1973-2000) there was overflow from the Yenyening Lakes in most of the years. During that period there was an average annual inflow of 39.5 million cubic metres. About 92 per cent and 8 per cent of the total input was lost by the over flow and evaporation process respectively and loss through seepage to the deep aquifer systems was negligible. The median salinity of the lake was in the order of 60,000 mg/L TDS. Annual average salt input was 381 thousand tonnes. Most of the stored salt (99%) was lost due to overflow and net leakage through the lake bed was negligible.

In developing the new strategy, the surface water behaviour of the Yenyening Lakes Management Area was investigated using bathymetric survey and simulation modeling to address four issues:

- the source and movement of water in the lake system under different environmental conditions;
- the source and movement of salt in the lake system under different environmental conditions;
- the impact of gate management and water release on the Yenyening Lakes Management Area upstream from the Qualandary Crossing, and
- the impact of gate management and water release on the Avon River system down-stream from the Qualandary Crossing.

The available surface water information and modelling data were presented to the Surface Water Workshop in Beverley (see 2.3.1 and **Appendix C**). This included work undertaken by hydrologists in the Water and Rivers

Commission and URS Australia. Recent information derived from a bathymetry survey undertaken in April 2002 that was commissioned by the Department of Conservation and Land Management has also been referred to where relevant.



Surface Water overflow, Qualandary Crossing February 1990. (Photo courtesy Ingrid Bell)



Surface Water Management Gates at Qualandary. (Photo courtesy Stephanie Cobb)

2.2.2 Groundwater hydrology

The general situation in respect of wheatbelt groundwater hydrology is well understood. Prior to clearing for agriculture, the hydrological system across the wide valleys in the zone of ancient drainage is considered to have been in balance, with water tables maintained at constant depths with the native vegetation able to use all of the rainfall infiltrating the soil profiles. There is likely to have been much less run-off due to

rainfall interception by the vegetation coverage. However, the landscape has always been naturally salinising with a long-term accumulation of rain-borne-salt in soil profiles and the deeper regolith.

The hydrological situation has been altered dramatically through clearing, with annual crops and pastures unable to use all the water entering the soil profile, leading to continual recharge of groundwater stores, with a rise in groundwater levels, mobilisation of the stored salt, and increased movement of saline water into streamlines and the surface.

No new investigations were done for this study, and the analysis of groundwater behaviour relied on work done in recent years by the Water and Rivers Commission and CSIRO, plus the observations and investigations of local people. DEWCP has maps of the *Land Monitor* data for the region including Quairading and Corrigin districts. A substantial area with depth to groundwater 0.5 to 1 m adjoins the main drainage line and is fringed by a lesser area with depth to groundwater 1 to 1.5 m.

Local groundwater pumping on one farm adjacent to the upper lake system has operated for 12 months (July 2001 to July 2002), with the landholder observing reduced waterlogging within a 500m radius of the bores.

The available groundwater information was presented to the Groundwater Workshop in Quairading (see Section 2.3.2 and **Appendix D**).



Groundwater Relief pumping, Dangin. (Photo courtesy Shane Boladeras)

2.3 Issue workshops

Four 'Issue Workshops' were held in the area in early April 2002. These were advertised through the local media and organisations with a focus on land and water management, and were open to all those interested in the Yenyening Lakes Management Area. The attendance lists are shown in **Appendix B**.

2.3.1 Surface hydrology workshop

This workshop was held at Beverley and Qualandary Crossing, 2 April 2002, and was attended by 18 people. The Workshop Report is presented in **Appendix C**.

Key discussion points

- **Objectives for management.** The objectives for surface water management in respect of up-stream, downstream and within the lake system itself and the needs of the Avon River downstream from Qualandary were considered.
- **Yenyening Lake system behaviour** in dry years, moderate years and flood years. Water and Rivers Commission staff and the Consultant Team presented findings from the modelling of surface water flows from the Yilgarn, Lockhart and local Yenyening Catchment and the impact of gate management on water flows and levels. The need for more 'real-time' flow data in the Avon River to assist in gate management was discussed.
- **Impact of gate management.** The heights above sea level within the Yenyening lakes system were questioned, the impact of the gate on flooding of adjacent farming land was queried and the need to shift water from adjacent farmland into the lake system proposed. Serious concern was expressed about the impact of stored surface water on local groundwater levels.
- **Changes to drainage management up-stream.** The possibility that the system may end up having to handle more water and salt as a result of major drainage schemes being planned above the Corrigin-Quairading Road was raised.
- **The possibility of salt accumulation in the YLMA over time.** Although there is no evidence from past work that salt is accumulating in lake floors over the long-term or as a result of gate management, the issue

remains contentious in scientific and community circles.

2.3.2 Groundwater hydrology workshop

Held at Quairading and Greg Richard's farm, 9 April, attended by 32 people. The Workshop Report is presented in **Appendix D**.

Key discussion points

- **Objectives for groundwater management.** Relative merits of tools for lowering groundwater and / or preventing groundwater rise – trees and storm water drainage preventing recharge, deep drains and relief pumping of groundwater. Assessing financial returns for investments in groundwater management.
- **The role of the lake and channels as a drainage system.** Flood risk as a result of higher ground water levels in the wheatbelt. Impacts of increased drainage activity on the Yenyening Lake system, disposal of surplus water from neighbouring farmland into the lake system.
- **The role for regional / arterial drainage in the area.** Land Monitor predictions for salinity increases in the region. Managing for upstream and downstream impacts

2.3.3 Nature conservation workshop

Held at Morbinning Hall and Bill and Richard Walker's farm, 3 April, attended by 24 people. The Workshop Report is presented in **Appendix E**.

Key discussion points

- **Objectives for nature conservation management.** The contribution that the Yenyening environment can make to the overall objective for the wheatbelt 'to protect and if possible restore WA's natural diversity' – vision and goals. Within reserve versus outside reserve conservation management.
- **The environmental values of the lake system.** For example 41 species of water birds, 46 species of land birds, terrestrial fauna not well recorded, numerous sandy banks which still are relatively unaffected by salinity. Environmental values in the limited amount of remnant bush away from the lake system. Current trends in wildlife in the reserve – some observed improvement, some observed decline.

- **Managing threats to conservation values in the lake system.** Deciding what can be achieved? Kangaroo management. Rabbit management. Weed management. The role and management of fire in the lake system. The role for 'strategic revegetation'. Impact of skiing on water bird habitat.

2.3.4 Recreation and tourism workshop

Held at Ian Hall's farm and the Yenyening Ski Lakes, 10 April, attended by 16 people. The Workshop Report is presented in **Appendix F**.

Key discussion points

- **The importance of the lakes for recreation.** Significant history of inland boating on the lake systems – back to the 1960s, visits from Perth clubs, 30 boats on Lake Mears one Boxing Day, really good until 1969. Ski Lake provides excellent competition skiing conditions. Other water sports are important – canoeing, surfcat sailing. A separate but related strategy for Lake Mears is seeking to improve its function for water sports.
- **Legal issues for water sports.** Legal limits on water depths for skiing – 1.5 m (but can ski to 0.7 m). Access through farmland to lakes is an issue - Trevor McLean for access to Ski Lake, Wally Mills for access on the south side of the lake. Discussion of previous attempts to have the lake gazetted for skiing in the 1960s? – paper-work lost by Department of Transport? The history of gazettal needs to be documented by the Beverley Ski Club.
- **Current actions.** The Department of Conservation and Land Management has contracted the Department of Land Administration to undertake bathymetry mapping of Ski, Ossigs and Racecourse Lakes.

- **Future actions.** Concern about the Department of Conservation and Land Management's legal exposure – wants to see the situation formalised as a matter of urgency. Opportunities for engineering intervention to improve skiing – e.g. excavation of the lake. Department of Conservation and Land Management is happy to evaluate any proposal on its merits. Tourist value of the lake – some people from outside the district are attracted to the lake by signage and come to it expecting to see permanent water. Problem in maintaining facilities at Ski Lake.

2.4 Strategic planning workshop

Summaries of conclusions and recommended actions from each workshop were collated for review by all stakeholders at a strategic planning workshop held in Beverley on April 24, 2002. The objectives contained within the 1996 Strategy were adopted for the 10-year Strategy with little modification. Those present also worked through the aggregated recommended actions, and accepted, rejected or modified them in finalising a series of actions that are shown in Section 3 of this document.

2.5 Review of the constitution

The existing Constitution for the Yenyening Lakes Group was reviewed and modifications proposed. The revised Constitution is shown in **Appendix G**. The main substance of the changes is a clearer definition of membership of the Yenyening Lakes Group and a separation between the Group in its entirety and the definition of a Management Committee empowered to implement the Strategy on the Group's behalf.

3. Objectives and actions

In this section, the five objectives are presented, with conclusions about management issues and needs, and a series of actions to progress towards the objectives. Each action is presented with some context, issues to be addressed and current activities. Also shown is a table documenting key criteria for action. These criteria are explained below.

- **Lead organisation(s) and their role.** A lead organisation(s) is defined for each action. The nominated organisation(s) has the responsibility of ensuring the action occurs through a mixture of leading, facilitating, auditing and service delivery.
- **Key Partners and their roles.** The key partners are those organisations and groups that have an important stake in the outcome resulting from implementation of the action, and/or those that have a key role to play in service delivery. In most cases, the key partners will be involved in service delivery, either through collaborative projects or in stand-alone activities.
- **Target.** Targets have been suggested for each action. In all situations, the target may need refining during the process of implementation planning.
- **Indicator of success.** As with the target, the indicator of success provides a measure that will enable the YLMC to track performance in the action.
- **Priority.** Each action was evaluated against all others for its relative importance and urgency.
- **Resourcing the action.** Some of the actions are already fully resourced, some will require additional resourcing to achieve the targets, and others are new.

3.1 Surface water management

3.1.1 Objective

To manage Qualandary Crossing so as to maintain adequate water levels in the lakes, while minimising back up of waters onto agricultural land; also to minimise the flow of silt and salt into the lakes and the Avon River and to ensure that the lakes continue to retain their natural function of floodwater detention.

3.1.2 Surface water management - issues

Management of surface water in the Yenyening Lakes Management Area needs to consider the requirements of the environment and landholders above and below the Qualandary Crossing. Above the crossing, the most important stakeholders are the landowners adjacent to the lakes and channels, which include farmers and the Department of Conservation and Land Management. A wider community is also interested in water management through this drainage system. Below the crossing, water release into the Avon needs to be managed to prevent damage to the aquatic riparian vegetation. The health of the Avon River system as it is affected by gate management addresses both private and public needs, with greater emphasis on the latter.

To assist in understanding surface water behaviour under different management regimes, a review of existing information was followed by modelling of surface water scenarios – shown in **Appendix C**.

Current gate management arrangements for the Qualandary Crossing were established in the 1996 strategy and state:

- ‘that the water level be maintained at 211.01 m above sea level’ (note – recent surveying has confirmed the level of the lowest point of the roadway as 211.36 m AHD);
- gates opened each year there is sufficient streamflow, to allow discharge of water from the lakes into a flowing Avon River;
- ensuring that water levels do not exceed 35 cm below the top of the Crossing (211.01 m AHD);
- before gates are opened Avon River Management Authority (ARMA) and the Department of Conservation and Land Management are to be consulted, with water release not permitted into a dry Avon River channel;
- gates shut at end of winter so as to maintain the level (211.01 m AHD), which is 35 cm below the roadway level, and
- opening and closing of gates authorised by the YLMC.

- If any doubt surrounds the opening and closing of the gates, final authority rests with ARMA who will consult with the District Manager (Narrogin), Department of Conservation and Land Management. This will only occur in exceptional circumstances. For example, a situation may arise where the gates are required to be opened quickly to allow flood waters (mainly fresh) from unexpected localised summer thunderstorms to pass through into the river.

The current management arrangements for the Qualandary Gate Crossing remain a source of considerable contention, with some of the key stakeholders concerned that they are causing localised flooding and groundwater rise. This is disputed by others in the stakeholder group, and there was no scientific evidence provided during the strategic planning process to suggest that the management regime is causing environmental harm (see **Appendix C**). Concerns remain about the influence of stored surface water on groundwater levels in and on low-lying farmland adjacent to the lakes – but groundwater data are generally inadequate to confirm or deny these concerns. Similarly, stored water may be affecting remnant vegetation condition, but again there is no hard evidence. Steps to address these uncertainties are proved below.

Surveyed levels from the recently completed Lakes Survey show that when the water is held 'at rest' 35 cm below the roadway at the Qualandary Crossing (211.01 m AHD), the water level will be influenced to a distance of approximately 15 kilometres above the Crossing, or at about the point where the system develops into the series of channels.

This is in the vicinity of Morrell Pool. (Map 2). The survey data also show the quite complex micro-relief in the drainage floors in the area upstream from the defined lakes, which suggests an opportunity for some further modification of flowlines to improve localised surface drainage regimes.

In flood events, the presence of the gate and raised crossing at Qualandary will have no influence on water levels in drainage systems above the Crossing. There is no hard evidence of long-term salt accumulation in the lake system under the current management arrangement, although the issue may not have been investigated beyond reasonable doubt. Further research may be needed.

Modeling of lake management scenarios shows that if the gate is kept always open, the median salinity of the lake will increase compared to the present. However, if the gate is always closed, the median water level in the lake will be approximately 0.7 m higher and the median salinity will be about 7,000 mg/L TDS lower than the present value (for additional information see **Appendix C**). This surface water modelling work suggests that the current management arrangement is a reasonable compromise between the needs of the lakes, and the needs of the Avon River. It will result in some salt accumulation in low flow years above that occurring with no gate, but the large flow years will even the situation out by removing stored salt.

The management regime also needs to accommodate surface and sub-surface water removal from farmland adjacent to the lakes.

The amount of water and salt entering the lakes and heights of flood peaks could increase in the future as a result of increasing salinisation and/or implementation by private or public interests of large scale arterial drainage schemes in the upstream catchments. This situation needs to be tracked.



Sign at Qualandary Crossing. (Photo courtesy Bernard Kelly)

3.1.3 Managing surface water - actions

3.1.3.1 Monitoring surface water management outside the Yenyening Lakes Management Area

The Yenyening Lakes Management Area is already carrying more flow than they would have done in pre-clearing times. As described in **Appendix C**, some of

this emanates from local sources, whereas following large rainfall events, the system carries regional flow, which dominates the system.

There is a feeling that plans for major arterial and sub-regional drainage systems in the Yilgarn and Lockhart catchments, will if implemented, ‘overload’ the Yenyening Lakes Management Area downstream from the Corrigin-Quairading Road. If this situation arises, additional engineering action will be required to ensure that the extra water can be safely carried through the Yenyening lake system. An alternative view is that even if there is greatly increased drainage activity in the Yilgarn and Lockhart systems, it is unlikely that water

flows through the system will increase greatly and the lake systems should be able to handle it.

While this issue is not of immediate importance, the Management Committee needs to maintain a ‘watching brief’ on drainage developments above the Corrigin-Quairading Road that may lead to more salt and water entering the system, and working with partners, develop and extend a set of principles for water management as it affects the Yenyening system. Analysis of the long-term trends in recordings at gauging stations along the Yilgarn and Lockhart drainage systems will be an important source of information.

Item	Response
Lead Organisation	Yenyening Lakes Management Committee
Role	Maintain contact with key partners and contribute to any regional drainage planning
Key Partners	Water and Rivers Commission, Avon Waterways Committee, Avon Catchment Council, Department of Conservation & Land Management, upstream catchment managers
Target	Issues raised by Yenyening Lakes Management Committee addressed by key partners Contribution to regional drainage planning
Indicator of success	Drainage planning considers needs of Yenyening Lakes Management Area
Priority	High
Resources	No additional resources required

3.1.3.2 *Improve qualandary crossing gate management arrangements*

The existing Qualandary Crossing gate management rules as stated in Section 3.1.2 can stand, as they represent a reasonable compromise between the needs of the Yenyening Lakes Management Area for nature conservation and recreation, and the needs of the Avon River for riparian health. However, to address the concerns raised and discussed in previous sections, six suggested actions are:

- undertake further modelling of scenarios to improve understanding of surface water behaviour as it is affected by gate management and other influences;
- develop a protocol that involves all stakeholders, to improve the timing of gate opening and closing by

linking it with telemetered (reported hourly) flow data from gauging stations in the Avon River above and below Qualandary and at Kwolyn;

- because of the uncertainty about the influence of stored water in the lakes on groundwater levels, review and improve the groundwater monitoring network adjacent to the lakes;
- investigate means for monitoring long-term salt trends in the lake system (e.g. salt depths after the system dries out), and
- use the recent survey data (commissioned by the Department of Conservation and Land Management) to improve understanding of water depths in and near the main lakes and channels, and in the channel downstream into the Avon River.

Item	Response
Lead Organisation	Yenyening Lakes Management Committee
Role	Manage Qualandary gate according to stated rules. Initiate further actions to research impact of management on the lake and surrounds environment.
Key Partners	Water and Rivers Commission, Department of Conservation & Land Management
Target	Improved timing mechanisms for Qualandary gate management Monitoring technologies in place
Indicator of success	Impact of gate management determined beyond doubt
Priority	High
Resources	Additional resources required for additional telemetered gauging, modelling and groundwater trend measurement

3.1.3.3 Improving drainage within the Lakes and channels and salt river

The YLMC has already supported small-scale works that have encouraged surface flows through the Salt River and Lakes and Channels zones. The recent survey data show there is potential for further small-scale engineering intervention that will improve the rate of flow through the system, provided that erosion can be

avoided. In particular, engineering intervention to improve water flow across the Old Beverley Road, and from there, upstream to the Quairading-Corrigin Road is a priority. Management of flows from Lake Mears Kunjin Brook is also important. It will be very important for the YLMC to lead in carefully evaluating any amendments to surface water management through the system, and in assisting proponents (local landholders, shires) in seeking funding for the works.

Item	Response
Lead Organisation	Yenyening Lakes Management Committee
Role	Facilitate and coordinate removal of existing minor barriers to effective water flow within the Salt River and Yenyening Lakes Management Area
Key Partners	Commissioner for Soil and Land Conservation, Water and Rivers Commission, Department of Conservation and Land Management, Shires of Quairading and Beverley
Target	Removal of remaining localised high spots and the Old Beverley Road barrier
Indicator of success	Improved water flows through the system; reduced localised inundation along the length of the system
Priority	High
Resources	Additional resources required

3.1.3.4 Disposal of surplus water from adjacent farmland into the salt river and lakes and channels

The adjacent alluvial plains are affected by locally driven groundwater rise and surface run-on from higher slopes. *Land Monitor* predictions suggest that a considerable percentage of these areas may be affected by shallow watertables over the next 50 years. Farmers with this land type are looking for opportunities to reduce water accumulation through the use of perennial vegetation, and to remove both surface and groundwater, with engineering works. In the case of the latter, the Salt River and lakes and channels provide an obvious point of disposal for neighbouring landholders who wish to remove storm water from farming land via surface drainage, or groundwater via deep drainage or pumping. In most situations the storm water will be fresh. However, groundwater quality will vary greatly according to site, from brackish to very saline. Disposal of very saline water into the lakes and surrounds is not recommended.

Modelling and expert opinion suggests that the system in total can handle more run-off and mildly saline

discharge from neighbouring farmland without environmental harm. The amount of water and salt involved will be miniscule compared to inflows from above the Yenyening Lakes Management Area. On this basis, the YLMC will provide 'in principle' support for the discharge of surface, sub-surface and ground water into the Salt River and Lakes and Channels. These works may be put in place as experiments, or as commercially focused projects. The YLMC will help identify suitable research projects into water management on adjacent farmland and will assist in seeking funding to support such projects. The National Action Plan for Salinity and Water Quality is a potential source of funding.

However, the YLMC recognises that each individual proposal, whether of an experimental or commercial nature, will need to satisfy the requirements specified in relevant legislation and regulation. The Commissioner for Soil and Land Conservation, and the Water and Rivers Commission and Conservation and Land Management will assess any proposal for water disposal in the lakes on its merits with assistance from the YLMC.

Item	Response
Lead Organisation	Water and Rivers Commission
Role	Provision of advice to neighbouring landholders, followed by assessment of localised drainage and groundwater removal schemes
Key Partners	Yenyening Lakes Management Committee, Department of Conservation & Land Management, Conservation Commission of WA, Commissioner for Soil and Land Conservation.
Target	Drainage and groundwater systems installed meet formal requirements
Indicator of success	Satisfaction with water management options amongst all stakeholders Zero added environmental harm to the Yenyening Lakes Management Area
Priority	High
Resources	Adequate

3.2 Groundwater management

3.2.1 Objective

To implement practices that limit groundwater rise in the lake system and surrounds and which also reduce groundwater impacts on the environmental and agricultural values of the area being managed.

3.2.2 Groundwater management – issues

Since clearing commenced the water table has risen and the discharge of saline groundwater to the surface drainage has increased. Groundwater is within 2 metres of the surface, expressing itself on or near the surface and discharging, around the lakes. The lake system throughout its length (Qualandary Crossing to Quairading-Corrigin Road) is fully saturated, and there is likely to be very little recharge of groundwater from surface or sub-surface water flowing across the system. Evaporation either concentrates the salts in groundwater near the surface or accumulates salts at the soil surface causing salt scalds.

The area affected by groundwater rise and secondary salinity will increase adjacent to the lakes – but this is a local effect and is not influenced by the lakes. Further, the Yenyening Lakes Management Area as defined in Section 1.1 and the tributaries (Morbinning Gully and Kunjin Brook) can be considered as groundwater systems in isolation – management of the lakes will not affect groundwater rise along these systems and vice versa.

This has implications for management of the Yenyening Lakes Management Area and at individual farm scale. Recent research and investigation has suggested that groundwater rise in these situations needs to be managed locally. Thus lowering groundwater levels in the Lakes and Channels will not improve the situation on the adjacent alluvial plains – localised action on the adjacent farmland itself is required. Significant intervention is

required to lower groundwater levels in all except very localised situations. Further, low rates of lateral flow of groundwater will generally limit the area affected by any intervention (e.g. pumping) with current experience suggesting that the area with lowered groundwater is around 500 metres from the point where water is being removed.

In summary, the main groundwater and salinity issues for the land adjacent to the lakes are caused locally – and surface and groundwater management in these areas needs to be the focus of management by landholders and Management Committee (see Action 3.1.3.4). The Committee needs also to be involved in the management of the outflow from the Kunjin Brook and Morbinning Gully systems.

3.2.3 Groundwater management - actions

3.2.3.1 *Improve groundwater monitoring adjacent to the lakes and channels and salt river*

Land Monitor predictions suggest that a significant area of land adjacent to the lakes and channels and Salt River will be affected by shallow groundwater levels at some time over the next 50 years. While this is not caused by the water flows or inundation in the main drainage system, the trends require monitoring. The current groundwater monitoring system in the study area is inadequate, with insufficient piezometers placed in inappropriate locations and without full bore logs or regular water level records.

The need for additional groundwater monitoring adjacent to the area influenced by gate management at Qualandary Crossing is discussed in Action 3.1.3.2. This work needs to be extended to installation of groundwater monitoring in all areas predicted to be at risk of shallow groundwater levels. Trend information will be required as a precursor to deciding on action to lower water levels or prevent further rise.

Item	Response
Lead Organisation	Yenyening Lakes Management Committee
Role	Coordinate installation of groundwater monitoring system in all areas at risk of shallow groundwater levels.
Key Partners	Water and Rivers Commission, Avon Catchment Council, Avon Waterways Committee.
Target	Groundwater monitoring system in place and properly resourced by 2004.
Indicator of success	Trend information available to guide action by Yenyening Lakes Management Committee and individual landholders
Priority	High
Resources	Additional funds will be required

3.2.3.2 Opportunities for localised dewatering within the lakes

The lakes and channels and Salt River are effectively saturated. Water in many places is less than one metre below the surface. This is putting nature conservation values at risk. Locating production bores into the paleo-channel sands, 50 m below confining clays, will have little effect on the water balance at the surface. Similarly, deep linear drainage (2 m) is likely to lower water tables within only a few metres of the excavation, because of the low rate of lateral movement of water through the soil profile.

However, it may be feasible to dewater localised parts of the lake (e.g. radius of 300 to 500 m) for specific purposes – such as protecting important local and

regionally significant parts of the natural environment. The cost of this type of intervention will be high and would need careful assessment for the overall cost-benefit. However, plans are in place for further dewatering systems on adjacent farmland. The YLMC can investigate situations where localised groundwater removal within the lakes and channels may benefit the natural environment. This should wait until the botanical survey is completed and any locations of high environmental value that are at risk from shallow groundwater are identified.

Undertaking this work will also yield valuable information on options for dewatering that can be applied to adjacent farming land.

Item	Response
Lead Organisation	Yenyening Lakes Management Committee
Role	Investigate opportunities where localised groundwater removal will benefit the natural environment.
Key Partners	Water and Rivers Commission, Department of Conservation & Land Management, Avon Catchment Council
Target	Selection of suitable options for groundwater removal
Indicator of success	Benefits for nature conservation values Information gained benefits landholders seeking engineering options for groundwater management
Priority	High, if nature conservation values justify the action
Resources	Substantial resources will be required

3.2.3.3 Consider options for economic use of water in the system.

Saline groundwater is now being considered as a resource capable of providing economic benefits. Examples include use in aquaculture, the potential for

minerals harvesting and as a feedstock for desalination to replace expensive imported potable water.

Although the prospects are uncertain at this stage, the YLMC should encourage investment of risk capital into researching economic uses of saline water.

Item	Response
Lead Organisation	Yenyening Lakes Management Committee
Role	Encourage investment by key partners in research work that looks for alternative uses for saline water
Key Partners	Water and Rivers Commission, Department of Agriculture
Target	Key partners investing in appropriate research
Indicator of success	Availability of economic use for saline water
Priority	Moderate
Resources	Adequate

3.3 Nature conservation

To maintain nature conservation values by ensuring viable populations of indigenous flora and fauna in and around the lakes.

3.3.1 Nature conservation - issues

The workshop decided to revise the goal for nature conservation as... ‘to protect and *where possible restore* the natural diversity of the Yenyening Lakes System’. The strategy’s objective for nature conservation presented in Section 1.4.3 reflects this goal.

Advice from the Department of Conservation and Land Management suggested that this will not be easily done – maintaining what is there now will be a significant achievement. Expert advice is that any impacts on locally significant biodiversity would have occurred long ago. Salinity and excess water has degraded the vegetation in the lakes and channels and the Salt River.

The existing extent of inundation and shallow groundwater across the lakes and drainage floors cannot be reversed across the whole area, although as presented in Action 3.2.3.2, there is scope for localised dewatering of parts of the lakes and channels that warrant protection.

In response to these pressures, the natural diversity appears to be ‘migrating’ up slope away from the rising

saline water levels. This suggests two ‘mega-alternatives’ – either (i) lower the water table in specific areas to protect immediate surrounding habitat from the impact of saline water or (ii) help the diversity (plants and animals) re-establish on higher land. In the case of (i) through strategic de-watering - it is possible to lower water levels by pumping and drainage in very localised situations in the lake to protect special sites if these can be identified. In the case of (ii), providing wider fenced corridors adjacent to the lakes and channels and the Salt River can facilitate the ‘migration’.

In the face of these threats and difficult choices, there is a need to identify with more certainty the environmental values within the strategy boundary and re-set achievable targets. These need to consider objectives for remnant vegetation throughout the Yenyening Lakes Management Area. Given the scarcity of habitat in the area, all remaining remnants are valuable. The *Living Landscapes* approach used in the Morbinning Catchment may have application in planning nature conservation actions in the Yenyening Lakes area.

The nine generic threats used by the Department of Conservation and Land Management in planning conservation management were used as a basis for developing actions for the strategy. These are presented in **Appendix E**.

3.3.2 Nature conservation - actions

3.3.2.1 Complete biological survey of the lakes and channels and revise nature conservation objectives

The YLMC has commissioned a botanical survey to be completed by the Wildflower Society. This information will provide fundamental information about the nature and condition of the flora and fauna in about half the

Yenyening Lakes Management Area (Stage I). The Department of Conservation and Land Management is commencing faunal studies in the area. These data will be used to revise current nature conservation objectives and targets, and to define the baseline condition of the flora and fauna in the survey area. Monitoring techniques will be put in place to track future trends, and to detect the result of management actions.

Item	Response
Lead Organisation	Yenyening Lakes Management Committee
Role	Supervise successful completion of a full biological survey, and use the information in planning further actions
Key Partners	Department of Conservation & Land Management, Wildflower Society of WA
Target	Current botanical survey completed and published by 2003
Indicator of success	Findings used in revising nature conservation objectives and in planning actions
Priority	High
Resources	Adequate for Stage I, additional resources needed for completion of whole area

3.3.2.2 Increase habitat for endemic (native) flora and fauna

Exclusion of stock from natural habitat in the lakes and channels is essential to achieve nature conservation objectives in these areas. Most of the boundary between farming land and the Lakes and Channels zone is fenced to exclude domestic stock grazing the native vegetation. There is evidence of recruitment of native vegetation on sandy rises through the lakes and channels. Completion of all boundary fencing around the areas of natural vegetation is a critical need. Encouragement of wider fenced margins to the drainage zones will allow the native vegetation to establish adequate corridors, particularly for that vegetation that is 'migrating' upslope away from the influence of salt and water

logging. This may require funds to support land 'buy-back' schemes. Within the Salt River and Lakes and Channels themselves, it will be feasible to undertake localised dewatering using pumping or drainage if particular species are encountered that urgently need protection. This option is considered more fully in Section 3.2.3.2.

Outside the main drainage system, remnant vegetation is very scarce. Protection of this remaining habitat is critical. All stakeholders will be encouraged to fence remaining remnants. Where revegetation is occurring, landholders will be encouraged to plan their works to enhance vegetation that is already there, and coordinate activities with neighbours to get the maximum nature conservation value for the dollars invested.

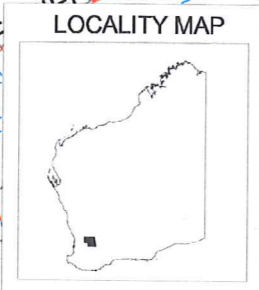


Water and Rivers Commission

This map is a product of Water and Rivers Commission, Regional Operations Division and was printed on 29.10.2002.

This map was produced with the intent that it be used for Avon River Basin - Yenyening Lakes Management Group at the scale of 1:75 000.

While the Water and Rivers Commission has made all reasonable efforts to ensure the accuracy of this data, the Commission accepts no responsibility for any inaccuracies and persons relying on this data do so at their own risk.



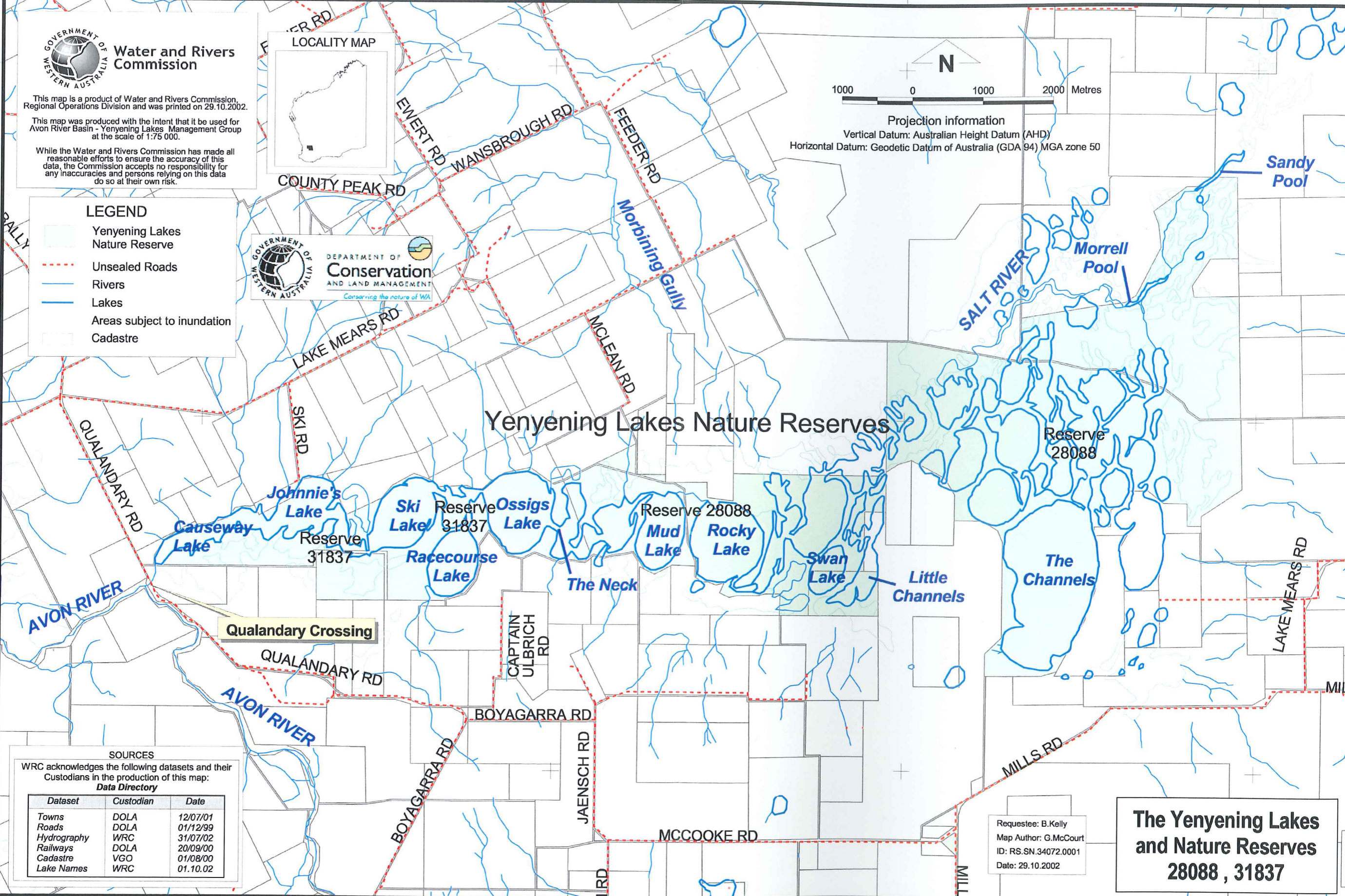
Projection information
 Vertical Datum: Australian Height Datum (AHD)
 Horizontal Datum: Geodetic Datum of Australia (GDA 94) MGA zone 50

LEGEND

- Yenyening Lakes Nature Reserve
- Unsealed Roads
- Rivers
- Lakes
- Areas subject to inundation
- Cadastre



Yenyening Lakes Nature Reserves



Qualandary Crossing

SOURCES

WRC acknowledges the following datasets and their Custodians in the production of this map:
Data Directory

Dataset	Custodian	Date
Towns	DOLA	12/07/01
Roads	DOLA	01/12/99
Hydrography	WRC	31/07/02
Railways	DOLA	20/09/00
Cadastre	VGO	01/08/00
Lake Names	WRC	01.10.02

Requestee: B.Kelly
 Map Author: G.McCourt
 ID: RS.SN.34072.0001
 Date: 29.10.2002

The Yenyening Lakes and Nature Reserves 28088, 31837

Map 3: The Yenyening Lakes and Nature reserves 28088, 31837.

Item	Response
Lead Organisation	Yenyening Lakes Management Committee
Role	Encourage fencing of remnant vegetation and additional strategic establishment of native vegetation Seek additional funding for these purposes
Key Partners	Avon Catchment Council, Water and Rivers Commission, Department of Conservation & Land Management
Target	All remnants within Yenyening Lakes Management Area fenced. Additional areas planted to endemics adjacent to lakes and channels and Salt River
Indicator of success	Increased habitat area in the Yenyening Lakes Management Area
Priority	High
Resources	Seek additional resources through NHT II / Gordon Reid Foundation/NAP

3.3.2.3 Manage local rabbit grazing pressure

Rabbit grazing of native vegetation, particularly recruits, imposes a continual pressure on nature conservation values. Rabbit baiting needs to be done on a coordinated basis, involving all landholders at least twice during the

summer months. Ready access to 1080 poison is required if the level of control is to be adequate. Further assistance will be sought from the Departments of Agriculture and Conservation and Land Management; and the Shires of Beverley, Brookton and Quairading.

Item	Response
Lead Organisation	Yenyening Lakes Management Committee
Role	Coordinate, facilitate and encourage greater rabbit control
Key Partners	Department of Agriculture, private landholders, Shires of Beverley, Brookton and Quairading, Department of Conservation & Land Management
Target	Increased investment in rabbit control by landholders Department of Conservation & Land Management to maintain current level of control
Indicator of success	Increased recruitment noted in susceptible species
Priority	High
Resources	Additional resources to be sought.

3.3.2.4 Improve weed management

There is little knowledge on the degree of environmental weed infestation of the native vegetation in the Lakes and Channels, or the Salt River. The flora and fauna survey currently being done by the Wildflower Society of WA will improve the knowledge base. However, that

work should be extended with a weed survey following the principles of the Western Australian Herbarium's Weed Information Network Project (WIN) to determine what species are present, and where they are located. This information can then be used to guide management.

Item	Response
Lead Organisation	Yenyening Lakes Management Committee
Role	Initiate a weed survey as a follow-up activity to the flora survey
Key Partners	Department of Conservation & Land Management, Avon Catchment Council
Target	Weed survey completed by 2005
Indicator of success	Information from weed survey used in implementing weed management strategies/actions
Priority	Low
Resources	Resources would need to be sought from external funders

3.3.2.5 Manage the local kangaroo population

The kangaroo population in the area imposes excessive grazing pressure on native vegetation and causes economic damage to crops and pastures. The kangaroo grazing pressure needs to be reduced to encourage

regeneration of native species. *Ad hoc* approaches to control – such as occasional un-coordinated culling - is having little effect on the population. Coordinated control is required that is consistent with regulations and codes of practice for kangaroo control.

Item	Response
Lead Organisation	Yenyening Lakes Management Committee
Role	Encourage and facilitate responsible control of kangaroo grazing pressure.
Key Partners	Department of Conservation & Land Management
Target	Control efforts are coordinated between landholders and the regulating body
Indicator of success	Increased recruitment of native species is evident in areas grazed by kangaroos
Priority	High
Resources	Adequate

3.3.2.6 Develop an appropriate fire strategy

There is only a low risk of uncontrolled fires starting in the vegetated areas in the Yenyening Lakes Management Area. However, controlled fire management can be used to encourage native species regeneration in the vegetated

parts of the system. A fire management strategy is required that will enhance the value of fire in encouraging regeneration. This strategy also needs to be able to monitor post-fire to gauge effect on vegetation.

Item	Response
Lead Organisation	Yenyening Lakes Management Committee/ Department of Conservation and Land Management
Role	Encourage key partners to work together in establishing a fire management strategy for the Yenyening Lakes Management Area and Salt River areas
Key Partners	Fire and Emergency Services Authority, Department of Conservation & Land Management, Shires of Beverley, Brookton, and Quairading
Target	Fire management strategy in place by 2004
Indicator of success	Fire used successfully to encourage regeneration; reduced wildfires
Priority	Moderate
Resources	Additional resources

3.3.2.7 Encourage economic benefits of nature conservation

YLMC should seek and investigate any available opportunities to 'sell' the commercial benefits of investment in nature conservation or perennial vegetation on private land. The Management

Committee will encourage opportunities for market-based options for revegetation, fencing of remnants – e.g. brush timber cultivation, pines (for water management), and commercial wild flower farming.

Item	Response
Lead Organisation	Yenyening Lakes Management Committee
Role	Maintain watching brief on commercial opportunities with nature conservation benefits; and encourage investment in the area. Participate in the promotion of the use of woody perennial vegetation programs on farms.
Key Partners	Department of Conservation & Land Management, Department of Agriculture, Wheatbelt Development Commission
Target	Five beneficial land uses in the area by 2006
Indicator of success	Commercial investment by landholders in land uses that have nature conservation benefits
Priority	Moderate
Resources	Additional resources required

3.4 Recreation and tourism

To provide for recreational activities by managing the lake waters for approved water-based recreation, and providing appropriate facilities for visitors. To attract tourists, facilitate their enjoyment of the lakes and educate them about the area and its management; and to protect and restore the beauty of the lakes, the bushland and adjoining land.

3.4.1 Recreation and tourism - issues

Skiing is an opportunity sport with considerable local and Perth interest in the right conditions. Other water sports (canoeing and surfcat sailing) can be encouraged. To support continued access to these opportunities, the legal arrangements permitting skiing and other water sports must be completed as a matter of urgency for the sake of users, the Beverley Ski Club and the Department of Conservation and Land Management.

The Navigable Waters Act controls water skiing and other inland water use. There is a need to ensure that legal liability covers boat travel from the gate to Ossigs Lake, and that Ossigs, Racecourse and Ski Lakes are covered. The bathymetry survey completed by the Department of Conservation and Land Management covers these three lakes, the area down to the Qualandary Crossing and below the crossing into the Avon River. This information will be used to support the application for gazettal. Only after gazettal is it worth considering investment in any engineering modifications to the lakes, or improvements to the facilities and the promotion for tourism. However, some consideration of viable engineering options for site improvement could assist the gazettal process. These two exercises of

gazettal and considering engineering options could proceed together.

There is also a need to formalise access arrangements through adjacent farming properties to the ski lakes. Current arrangements do not provide legal protection for the private landholders over whose land visitors to the lakes traverse.

3.4.2 Recreation and tourism - actions

3.4.2.1 Negotiate legal arrangements for water sports

Securing gazettal of the waterways from the Qualandary Crossing to Ossigs Lake, including Ossigs, Racecourse and Ski Lakes is an urgent requirement to meet the needs of the land manager (Department of Conservation and Land Management) and the Beverley Ski Club. The bathymetry data from this survey will be used to progress the gazettal process. This data show that when the Qualandary Crossing gate is closed at the accepted level of 211.01 m AHD (35 cm below the roadway), there will be a maximum of 1.59 m of water in Ski Lake, 1.62 m of water in Racecourse Lake and 1.54 m of water in Ossigs Lake. These depths are just sufficient to permit legal water sports for a period at the end of winter, and provide the justification for gazettal for these purposes.

Access arrangements through portions of Avon Location Nos 2622, 4436 and 10569 to the Ski Lake needs to be discussed with the Shire of Beverley – to determine the most sensible approach for all parties. Similar actions may be required on the south side of the lakes in conjunction with the Shire of Brookton. All parties need to maintain a watching brief on the issue of riparian rights as it may affect the use of landholdings adjacent to the lakes and waterways.

Item	Response
Lead Organisation	Beverley Ski Club / Yenyening Lakes Management Committee.
Role	Progress gazettal of the three lakes and connecting channels. Formalise arrangements for access to the lakes
Key Partners	Department of Conservation & Land Management, Shires of Beverley and Brookton, Department for Planning & Infrastructure.
Target	Gazettal completed in 2004, access formalised.
Indicator of success	Official recognition of long-term water sports use of the lakes
Priority	Very high
Resources	Adequate – assistance can be sought from other parties

3.4.2.2 Ensure legal coverage for water-based activities

It makes sense for Brookton-based lake users (Brookton Ski Club) to join with the members of the Beverley Ski Club to ensure adequate legal coverage for water-based activities. This needs to be progressed by the committees / spokespersons of each group.



Ski boat moored at Ski Lake, February 2000. (Photo courtesy Ingrid Bell)

Item	Response
Lead Organisation	Beverley Ski Club / Brookton Ski Club
Role	Amalgamation of all members into one club – Beverley Ski Club, and secure legal protection
Key Partners	YLMC, Department of Conservation & Land Management, Shires of Beverley and Brookton, Department for Planning & Infrastructure.
Target	Amalgamation completed by 2003
Indicator of success	All water users with adequate legal protection
Priority	Very high
Resources	Adequate

3.4.2.3 Determine feasibility of upgrading facilities

After legal arrangements have been finalised, the Beverley Ski Club, in cooperation with the Department of Conservation and Land Management and the YLMC will be able to consider investment in any viable engineering options at the lakes, and the development of improved recreational facilities. As the land manager, the Department will need to be fully involved in assessing the opportunities, and where land on nature reserves is involved, the approval of the landholder (Conservation Commission of WA) will be required before work can proceed. Any proposition for deepening the lakes, or impounding additional water will

be assessed on its merits by these organisations. As discussed in Section 3.1.3.1, planning for any lake development needs to recognise the possibility that more water may be managed through the system in the future.

Other actions that can be taken include clarifying the signage that attracts people to the lakes, improving the fixed facilities, and development of interpretative opportunities. Any development work on land managed by the Department of Conservation and Land Management will require approval from the Conservation Commission of WA, based on departmental standards.

Item	Response
Lead Organisation	Beverley Ski Club
Role	Initiate investigation of engineering options for improving the water bodies; seeking funds for improving fixed facilities
Key Partners	Yenyening Lakes Management Committee, funding bodies (e.g. Gordon Reid Foundation/Lotteries Commission), Shires of Beverley and Brookton, Department of Conservation and Land Management, Conservation Commission of WA
Target	Feasibility of engineering options adequately evaluated, facilities in good condition and secured
Indicator of success	Facilities appropriate for needs that conform to Department of Conservation and Land Management standards
Priority	Only after gazettal completed
Resources	Substantial resources would be required

3.5 Management arrangements

3.5.1 Objective

To establish management structures and processes that involve all key stakeholders in the management of the Yenyening Lakes Management Area, by encouraging collective action, quality communication between all parties, and incorporation of new information into management actions as it becomes available.

3.5.2 Management arrangements – the issues

The Yenyening Lakes Management Committee is an effective facilitating body for the stakeholders defined in this strategy as the Yenyening Lakes Management Group, with a sound understanding of the issues being managed. The controversies and conflicts associated with lake management, particularly focused on the Qualandary Crossing and the gate use, have lessened with the passage of time. However, many stakeholders in the Group are still concerned about various aspects of the management objectives and methods being used. It is important that the management arrangements for the 10-year strategy ensure that:

- the responsibilities of the YLMC and the stakeholders in the Group are clearly defined;
- all Group members within the area being managed are involved in management processes and fully aware of the actions being taken;

- that management plans and actions of neighbouring catchment groups are compatible with the Yenyening Lakes Management Strategy and the needs of the Yenyening Lakes Management Area;
- the YLMC is able to measure progress and report on its activities and their impacts, and
- management proceeds with the best information available.

The first point is addressed in the suggested revised constitution shown in **Appendix G**. The last point is addressed elsewhere in Section 3. The remaining three requirements are covered by the following four actions.

3.5.3 Management arrangements - actions

3.5.3.1 Increasing landholder participation

This strategy defines the key landholder stakeholders as being all those with property intersecting with or adjoining the 220 m contour line around the Yenyening Lakes and channels. The private landholders are shown in **Appendix A**. Some of these landholders have had limited involvement in management activities through the 1996 Strategy, and there have been competing demands and opinions about management actions. It is important that the 10-Year Strategy makes special effort to ensure maximum involvement and participation of *all* affected landholders in the management of the Yenyening Lakes Management Area.

Item	Response
Lead Organisation	Yenyening Lakes Management Committee
Role	Foster involvement in management affairs by all landholders along the length of the Yenyening Lakes Management Area
Key Partners	Water and Rivers Commission, Shire of Beverley, Shire of Brookton, Shire of Quairading, Department of Conservation & Land Management.
Target	All landholders become involved in at least one Yenyening Lakes Management Committee activity / event per annum
Indicator of success	Support for the management actions being taken by the Yenyening Lakes Management Committee.
Priority	High
Resources	Adequate

3.5.3.2 Improving communication between stakeholders

Past communication between key stakeholders has been inadequate, leading to mis-understandings about the purpose of the strategy and the actions taken. In particular, better contact is needed between ‘upstream’

and ‘downstream’ landholders. The workshops held as part of strategic review and planning helped build better contacts. Further effort is required, through use of Shire newsletters, articles in mass media, site inspections and an inclusive AGM.

Item	Response
Lead Organisation	Yenyening Lakes Management Committee.
Role	Develop simple communication tools for regular contact with stakeholders
Key Partners	Water and Rivers Commission, Shire of Beverley, Shire of Brookton, Shire of Quairading, Department of Conservation & Land Management, Avon Catchment Council
Target	Quarterly and annual information updates for all stakeholders
Indicator of success	Full understanding of the management objectives and actions being undertaken by the Yenyening Lakes Management Committee.
Priority	High
Resources	Adequate – assistance can be provided by shires

3.5.3.3 *Encouraging partnerships with neighbouring catchments*

As discussed elsewhere, the condition of the Yenyening Lakes Management Area will in part be influenced by management actions taken outside the boundary of the study area – particularly those actions that relate to regional drainage. The YLMC needs to track developments outside its boundaries. It needs to develop partnerships with landholders in neighbouring catchment systems which discharge water into the Yenyening Lakes – principally Morbinning Gully and

Kunjin Brook (including Lake Mears). Beyond this, it needs its issues and requirements to be represented strongly on the Avon Waterways Committee and the Avon Catchment Council – particularly in respect of regional drainage principles and guidelines. This will be particularly important in coming months as planning proceeds for an Avon Regional Strategy that addresses requirements under the National Action Plan for Salinity and Water Quality.

Item	Response
Lead Organisation	Yenyening Lakes Management Committee.
Role	Development of partnerships with other catchment management groups; promotion of principles that respect management needs of the Yenyening system
Key Partners	Morbinning Catchment Group, Lake Mears Group, Lower Lockhart Catchment Group, Cooling Catchment Group, Wamenesking Catchment Group, Avon Catchment Council, Avon Waterways Committee
Target	Contribution to regional drainage planning
Indicator of success	Good relationships with neighbouring groups Regional drainage principles address needs of the Yenyening Lakes Management Area
Priority	High
Resources	Adequate

3.5.3.4 *Improving the information available to guide management*

A number of the actions proposed are not supported with complete information about the nature of the resources being managed. The YLMC needs to be able to measure the impact of actions taken and use this information in guiding further management of the system.

Outcomes, targets and indicators are shown throughout the Strategy. These will provide the basis for an overall approach to evaluating progress with the 10 year Strategy throughout its life. It is suggested that an external mid-term evaluation be done after four years of operation.

Item	Response
Lead Organisation	Yenyening Lakes Management Committee.
Role	Development of performance indicators to monitor the impact of actions taken by the YLMC
Key Partners	Water and Rivers Commission, Department of Conservation & Land Management
Target	Monitoring systems in place to track indicators
Indicator of success	Yenyening Lakes Management Committee able to report annually to stakeholders and funders about progress towards objectives
Priority	Moderate
Resources	Some additional resources may be required – key partners will be able to assist.

4. Implementing the strategy

The Yenyening Lakes Management Committee will implement, or coordinate, support and encourage the actions presented in this strategy, on behalf of the Yenyening Lakes Group.

4.1 The Yenyening Lakes group

The Yenyening Lakes Group consists of all persons including private and public organisations that hold and/or manage land that is within or intersects the 220 m AHD contour line on either side of the Yenyening Lakes Management Area between the Qualandary Crossing and the Corrigin-Quairading Road. This includes private landholders, and the Department of Conservation and Land Management, the Shires of Beverley, Brookton and Quairading.

The Group also includes the Water and Rivers Commission the Beverley Ski Club and the Brookton Ski Club.

Group membership is shown in **Appendix A**.

4.2 The Yenyening Lakes management committee

The Yenyening Lakes Management Committee will implement, or coordinate, support and encourage the

actions presented in this strategy. It is a community-chaired and led Management Committee. Management Committee membership includes representatives of the area's landholders, local government and State government agencies.

This Management Committee will establish management arrangements such as Memoranda of Understanding for the implementation of actions where other organisations have statutory or other designated responsibilities. These are:

- Water and Rivers Commission;
- Department of Conservation and Land Management;
- Shires of Beverley, Brookton and Quairading;
- Avon Catchment Council
- Avon Waterways Committee.

The Management Committee will continue to represent and coordinate the views of its members; work towards implementation of the actions; further refine the targets, indicators and priorities; and improve avenues of cooperation with State and local Government agencies.

Yenyening Lakes management strategy 2002 - 2012

Appendices

Appendix A: Yenyening Lakes group members

Landholders adjacent to the Yenyening Lakes

George Nelson

Wally Mills*

Ian Hall*

Don Handscombe*

David Bell

Ron McLean*

Trevor McLean*

Neville McLean* (a)

Gary Haythornthwaite

Lindsay Johnston

Brian Johnston

Brett Johnston Paul O'Hare

Lance Clemens*

Bill and Richard Walker

Alan Gelmi

Tom* and Greg Richards

Mark Haythornthwaite

Ted and John Haythornthwaite

Bob Hall

Rohan Johnston

Geoff Stone

Rod Simpson

* also members of the Yenyening Lakes Management
Committee

(a)representing Shire of Beverley

Management committee members who are not adjacent the lakes

Barry Coote (representing Shire of Brookton)

Darryl Richards (representing Shire of Quairading)

Tim Kilpatrick (representing Beverley Ski Club)

Greg Durell (representing Department of Conservation
and Land Management)

Bern Kelly (representing Water and Rivers Commission)

Appendix B: Workshop attendees

Surface water hydrology workshop – Beverley, 2 April 2002

Tom Richards, Don Handscombe, Laurie Adamson, Brian Whittington, Greg Durell, Mohammed Bari, Kate Robinson, Don Woodcock, Don Burnside, Robin Connolly, Shane Boladeras, Peter Muirden, Martin Revell, Bern Kelly, Bill Walker, Lex Stone, Alan Gelmi, Neville McLean, Harvey Morrell, Ron McLean, Trevor McLean

Groundwater hydrology workshop – Quairading, 9 April, 2002

Scott Morrell, Brendan McLean, Wayde McLean, Chris Broun, Greg Richards, Rohan Johnston, Lindsay Johnston, Bern Kelly, Ron McLean, Robin Connolly, Trevor McLean, Margaret Carmody, Michael Carmody, Darryl Richards, Bill Walker, Lex Stone, Campbell Schilling, Brett Johnston, Martin Revell, Robin Smith, John Ruprecht, Don Handscombe, Jack Wilson, Laurie Adamson, Rob Wilson, Laurie Carmody, Stuart Tohl, George Smith, Shane Boladeras, Shawan Dogramaci, Greg Durell, Don Burnside, Don Woodcock, John Dunne, Andrew Cooper, Graham Sudholz

Nature conservation workshop – Morbinning Hall, 3 April, 2002

Greg Durell, Mike Lyons, Ron McLean, Laurie Adamson, Ken Atkins, Tom Richards, Julia Murphy, Shane Boladeras, Don Burnside, Trevor McLean,

F. Aynsley, R. Petchell, Harvey Morrell, Kate Robinson, Brendan McLean, Amanda McLean, Avril Baxter, Bill Walker, Alan Gelmi, Richard Walker, Don Woodcock, Bern Kelly, Bob Hall, Deane Aynsley, Brett Johnson

Recreation and tourism workshop – Ian Hall's farm, 10 April 2002

Chris Sudholz, Laurie Adamson, Ross Mills, Don Burnside, Wally Mills, Ron McLean, Neil Jefferson, Scott McLean, Tim Kilpatrick, Ian Hill, Ken Wallace, Bern Kelly, Trevor McLean, B. Murray, Shane Boladeras, Bill Walker, Don Woodcock, Graham Sudholz, Ben Sudholz.

Strategic planning workshop

Wally Mills, Ian Hall, Don Handscombe, David Bell, Ron McLean, Trevor McLean, Bob Hall, Bill Walker, Greg Richards, Mark Haythornthwaite, Tim Kilpatrick, Greg Durell, Bern Kelly, Don Burnside, Shane Boladeras.

Apologies: Tom Richards, Richard Walker, Barry Coote, Darryl Richards, Neville McLean, Alan Gelmi, Ted and John Haythornthwaite

Appendix C: Report – Surface water hydrology workshop

Review of the surface water characteristics of the Yenyening Lakes

Robin Connolly, Principal Hydrologist, URS Australia Ltd

1. Previous studies

The surface water hydrology of the Lakes has been well quantified in a number of studies in the past. Quite a bit of work has been done on salt dynamics within the Lake, including mixing and flushing of salt during floods. The Water and Rivers Commission and other groups monitor water and salt levels in and around the Lakes.

There is also considerable collective memory of the behaviour and characteristics of the Lakes amongst the Lakes users and Management Committee.

2. Surface water catchments

Broadly, the lakes have three main catchments:

- **Yilgarn River system** - catchment area of 55,680 km², about 61% of the total catchment area for the Yenyening Lakes, but generates less runoff than the Lockhart catchment.
- **Lockhart River** - catchment area of 32,150 km², about 35% of the total catchment area, and is a significant source of water for Yenyening Lakes in wet years.
- **Local flows** – catchment area 3,700 km², about 4% of the total catchment area. Important source of runoff in years when the Yilgarn and Lockhart don't flow.

Inflows to the lakes in most years come from the local catchment, although the total volumes and salt tonnages are low. Only in wet years does significant runoff from the Yilgarn and Lockhart river systems flow into Yenyening Lakes. However, over the long-term almost all of the salt and water entering the system comes from these major inflows from outside the system.

3. Surface water salinity

Surface water salinity levels are highly variable. Observed concentration of runoff water from the Yilgarn and Lockhart River catchments varies from about 1,000

mg/L to > 300,000 mg/L. Salt levels vary with time during runoff events and with flood magnitude. Typically, inflow salinity levels are high during periods of low flow – either before or after flood events, and salinity levels are low during flood events. Salt accumulates in seeps and scalds in drainage lines and low-lying areas throughout the catchment. During runoff events, this salt on the surface and in pools throughout the catchment is flushed, leading to high initial salt levels. After this, salinity levels decline. During the peak of floods, water is typically close to fresh.

4. The gates at Qualandary Crossing

The causeway and gates at Qualandary Crossing have an important effect on the salt and water balance of the Lakes. The road and gates system has been changed many times, but general observations over many years are that the various causeway/gate systems have allowed:

- improved management of the timing of release of salt and water from the Lakes into the Avon River; and
- maintenance of higher water levels in the Lakes.

Improved management of timing of releases is important to minimise the impact of salt flushing on the Avon. The current management system of the gates is designed to release salty water from the Lakes only when there is sufficient flow in the Avon to dilute the released water. Strategic management of the gate also allows flushing of salt during most years and possibly a reduction in salt levels during the low flow years.

During large flood events when water flows over the causeway, the gates have effectively no impact on flows. During these large flow events most residual salt in the Lakes is flushed out into the Avon. As a result, salt will not accumulate over the longer term in the lakes, regardless of the operation of the gate.

Higher water levels in the lakes are important for recreation and as a water source for wildlife, particularly water birds. Closing the gates during the latter stages of a flood maintains the water at a higher level for longer than would occur if there were no causeway or gates.

The effect of the gates on water levels only extends up to the top of the Yenyening lake system itself, about 5 km upstream from Swan lake. This may cause some flooding around the margins of the main lakes, but will not impact on flow water levels upstream toward Quairading, nor on groundwater levels or surface salinisation away from the edges of the Lakes.

The gates do increase the short-term salinity in the lakes. Water that is retained when the gates are closed evaporates and this salt concentrates, forming white salt beds when the Lakes dry. Over the long-term, though, it appears from previous research that this salt is flushed out, either through strategic opening of the gates during low flow events, or during larger flood events regardless of the gate setting. This issue would benefit from further investigation.

5. Lake water balance

The main paths of water and salt into and out of the Lakes are:

Inflows:

- Runoff from the upstream catchments. This pathway brings the vast majority of salt and water to the Lakes.
- Rainfall in. This water is 'fresh', but a small component of the water flows in.
- Seepage in. This is considered to be a very small contributor of water or salt. More water is thought to move out of the lakes as seepage than in.

Outflows

- Runoff out. The timing and amount of outflow is influenced by gate management in drier years, and by inflow runoff volumes during floods. Most salt that moves out of the lakes does so via this pathway, particularly in larger floods.
- Evaporation out. Evaporation causes the Lakes to dry during periods when runoff or rainfall inflows are low and is the cause of increasing salinity concentrations in the Lakes.

- Seepage out. This is considered to be a fairly small.

The general conclusion from previous studies and general observations of the behaviour of the Lakes is that:

- There is no hard evidence that salt in the lakes is accumulating. Salt is flushed out in large flood events, regardless of the influence of the gates or causeway;
- neither the gates nor causeway have any impact on flow dynamics in very large floods; but
- the gates have a large impact on smaller events, particularly on the timing of release of saline water and the salinity levels and water depths in the lake.

Preliminary water balance modelling by Mohammed Bari, WRC, has shown that:

- the major salt input is from surface water flows in;
- the major water source is from surface water flows in;
- the gates and their current management hold more water and salt in the Lakes for longer than if the gate/causeway was not there, but greatly improves the timeliness of release of salty water;
- if the gate was left open at all times, water levels would not be as high as with the current management for as long and there would frequently be a steady release of a small volume of highly saline water;
- if the gate was always closed, water levels would be higher than with current management and salinity levels would be lower. Salinity levels would still increase, though, as the water evaporated and the higher water levels would impact more on land around the Lake.

The salt and water balance modelling of the Yenyening Lakes system and its catchment

PROGRESS REPORT JUNE 2002

M A BARI

1. Introduction

The salt lakes are the natural features of the landscape in the southern part of Western Australia. Other lakes have formed due to clearing of native forest for agricultural development. One of the frequently discussed management options to improve salt affected and water logged land is to improve ground and surface water drainage in the catchment. Lake systems are a natural receiving point for drainage water. Changes to water quality and quantity may have a detrimental or beneficial impact on the hydrological, ecological or social values of these receiving bodies.

The Yenyening Lakes System is a series of interconnected lakes located within the central-western wheat belt, approximately 30 km north-east of Brockton and 39 km south-east of Beverly (Figure 1). The lakes have been known since the earliest days of exploration. Clearing of the surrounding areas of the Lakes began in the 1890s. The lakes and the adjoining lands bring a wide range of benefits to people, including: (i) habitat for native flora and fauna, (ii) recreation, (iii) agricultural production, and (iv) tourism. The lakes system is the natural disposal point for discharge from the catchment.

Over the years a number of concerns about the Lakes have developed among the community. The main concerns are: (i) the salinity of the lakes has increased, (ii) there has been more water in the lakes, and (iii) the surrounding bush land has degraded. The community is divided about management of Qualandary Crossing, a man-made structure built at the outlet for damming up waters in the Lakes. The conflict about the Crossing led

to a decision in 1995 to form the Yenyening Lakes Management Group (YLMG), representing all interested parties and responsible for the development and implementation of the management strategy for the Lakes and the surrounding areas. The Yenyening Lakes Management Group (1996) developed the management strategy for the Lakes System.

The objective of this study is to gain basic understanding of the salt and water balance of the Yenyening Lakes. A simple spread-sheet type model will be applied to the lake to evaluate different operational strategies for the culvert at the Qualandary Crossing. A catchment hydrology model will also be applied to create a long-term inflow series to the Lake. Findings of the report will be used to develop five-year management strategy for the Yenyening Lakes System.F

2. Description of the study area

The study area is located in the Avon River Basin of Western Australia (Figure 1). The Yenyening Lakes System has a catchment area of 91,500 km², covering most of the Avon River basin. It is located just downstream of the discharge point of the Yilgarn and Lockhart sub-catchments. Over the last 200 years nearly all of the catchment area has been cleared for agricultural development. The Yenyening Lakes System is also known as "The Beverley Lakes" and consists of a number of small interconnecting lakes. The Yenyening Lakes System lies at the foot of the Salt River and frequently overflows downstream, to the Avon River. The Lakes System is highly saline. A short description of the Avon River Basin is provided by Harris (1996).



Figure 1 Location of the Yenyening Lakes System and its catchment.

2.1 Lake description

The main inflow to the Yenyening Lakes System is from the Lockhart and Yilgarn Rivers entering through the broad and flat Salt River channel at the north-east side of the Lake. Overflow occurs to the west into the Avon River system at Qualandary Crossing. Qualandary Crossing is a man-made structure located on a road reserve under the management of the Shire of Beverley. The crossing comprises a raised roadway which forms a weir, damming up the water in the lake and occasionally preventing flow from the Avon River back into the Lakes. A gated culvert has been installed through which lake water can flow under the road and then into the Avon River. A short history of the gated culvert is given by Lane (1994).

There are three forms of land ownership in the Yenyening Lakes area: crown reserves, privately owned farm land, and reserves vested in Shires.

The lake side bushland is extremely degraded. Many areas which were formerly eucalypt woodlands are now dead. In some areas regeneration of paperbarks is seen, but in general occurrence of young plants are rare. Within the Lakes System there are numerous sandy banks which are still above the water level and relatively unaffected by salinity. These sandy banks carry a range of plant species such as sandalwood (*Santalum spicatum*), banksia (*Banksia menziesii*), blackbutt (*Eucalyptus patens*), yenyening mallee (*Eucalyptus vegrandis*) and salt river gum (*E. sargentii*).

Older local residents recall the Yenyening Lakes System teeming with bird life and the fringing green woodlands supporting abundant native animals and mammals.

2.2 Significance

The Yenyening Lakes System is a significant area for water bird habitat and breeding. Forty one different species of water bird have been recorded using the Lake. An additional 46 species of land birds have been recorded in the lake side bushland. There are extensive populations of grey kangaroos and reports of snakes and lizards are common in the area.

The Yenyening Lakes System offers a wide range of benefits and pleasure to people from surrounding farms and country towns. It is used for recreation, including pleasure boating, water skiing, picnicking and duck shooting.

3. Lake modelling

The Yenyening Lakes System is conceptualized as a simple bucket, with salt and water always well-mixed. That means when the lake overflows, the outflow salinity is identical to the lake salinity. About 96% of the catchment area of the Yenyening Lakes System is gauged and streamflow and some salinity sample data are available from mid-1976 onward.

3.1 Description of the Lakes model

The Lake Model is a simple spread-sheet type volumetric salt and water balance model (Bari and Peck, 2002). The time step is monthly, however it can be run on a daily or yearly basis. The volume of water in the lakes at a given time is always known. From the lake water volume, the water level and surface area is calculated from a look-up table of depth-surface area-volume relationship. A simple representation of the Lake Model is shown in Figure 2. Gains and losses of water from the lake are:

- (i) stream inflow,
- (ii) rainfall on the lake surface,
- (iii) evaporation from the lake surface,
- (iv) streamflow from the lake, and
- (v) seepage to and/or from the lake bottom.

The salt balance component is very similar to the water balance component of the model. However, it has an additional component of salt exchange (deposition/dilution) on the soil surface during the contraction/expansion of the lake water surface (Figure 2). When the lakes contract, the model leaves some salt

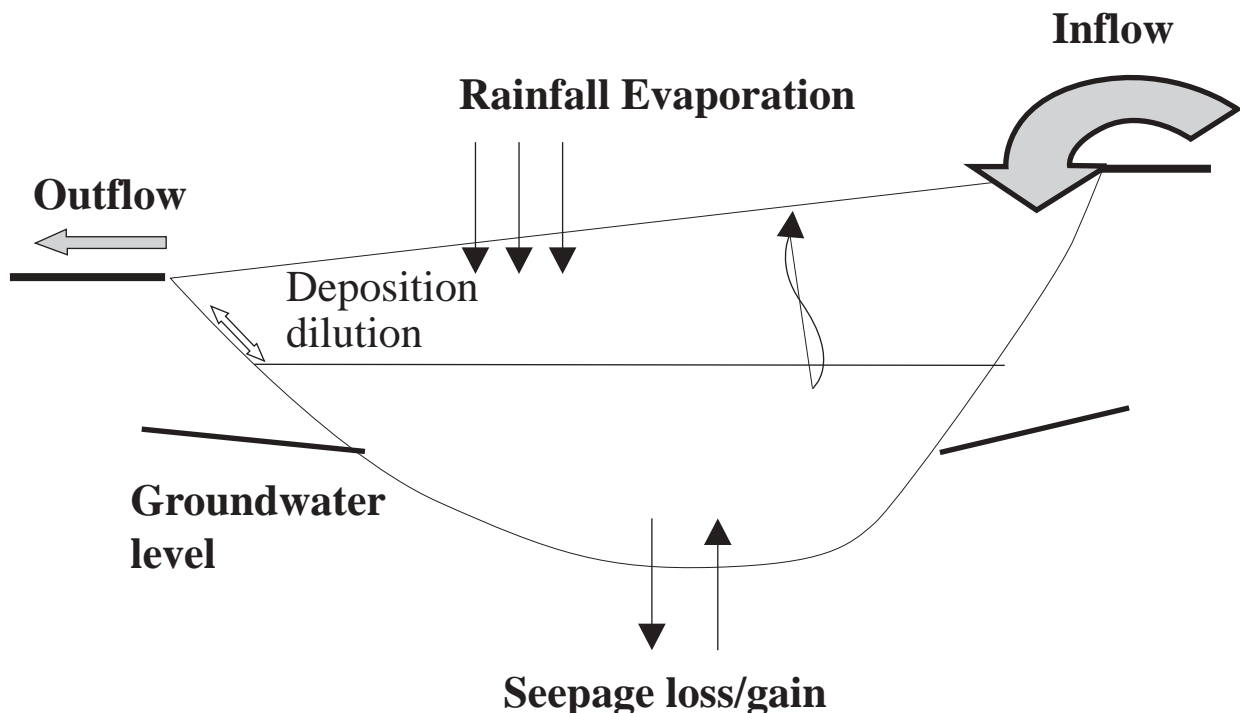


Figure 2 Conceptual representation of the lakes model

on the dry lake beds and dissolves again when it expands (given as parameter).

3.2 Data sources

Surveyed lake depth-volume-surface area information for the Yenyening Lakes System is not available. However, an approximate lake depth-volume-surface area relationship was developed from contour maps. It shows that the Lake Yenyening has a capacity of 10.8 million cubic metres at the overflow level of 211.45 m AHD. At that depth the surface area of the lake reaches 9.7 km².

The characteristics of the outflow channel, the bed slope, roughness, depth-width are required in the model. The cross-section of the culvert at the Qualandary Crossing was changed few times over the study period (1973-2000). Best-estimated data available for the cross-section has been incorporated into the model.

The daily rainfall on the surface of the Yenyening Lakes System is calculated from adjacent pluviometers. A long-term daily series of 1909 to 2000 has already been created. The salt fall is estimated at 7.2 mg/L Total Dissolved Solids (Hingston and Gailitis, 1976). Annual pan evaporation was estimated from Luke et al. (1988) and converted to daily using a harmonic function.

The lake water level data for the Yenyening Lakes System was provided by Dr. Jim Lane, CALM. Monitoring started in 1978. However, from 1986 onward, only two records per year – September and November, are available. Water level records show that the Yenyening Lake system overflows down stream through the culvert almost every year. Salinity data for the Lakes are available for the same period. It ranges from 10,000 mg/L to in excess of 350,000 mg/L TDS.

No information is available on lake-bed conductance and the lake bed aquifer properties.

4. Catchment modelling

The Yenyening Lakes system has a catchment area of 91,500 km² (Figure 1). The catchment was divided into 3 sub-catchments. Yilgarn and Lockhart River gauging stations cover an area of 55,680 and 32,150 km² respectively, while upstream of the Yenyening Lakes System 3,700 km² are un-gauged (Figure 1). A simple, lumped salt and water balance model was applied to each of the sub-catchments to create a long-term daily series.

4.1 Description of the catchment model

The salt and water balance model (LUCICAT – Land Use Change Incorporated CATCHment model) was developed following a ‘downward approach’ and successfully applied to the Collie River catchment (Bari et al., 2002). In the model, the catchment is represented by the ‘open book’ approach (Figure 2) and catchment average soil depth and porosity was introduced. It consists of three main components: (i) two-layer unsaturated soil module (upper and lower zone unsaturated store), (ii) saturated sub-surface groundwater module, and (iii) a transient stream zone module. The upper zone unsaturated store is represented by a VIC-type model (Zhao and Liu, 1995; Wood, et al., 1992), a simple probability distribution function of the soil moisture capacity. The transient stream zone store represents the groundwater induced ‘saturated areas’, along the stream line. The model was also successfully applied to Lake Toolibin and upper Blackwood catchments and a long-term series (1909-2000) has been created (Bari and Peck, 2002).

At present, the model does not have any overland flow or channel routing scheme.

4.2 Data sources

Most of the south-eastern part of the Salt River catchment was cleared for agriculture. In the north-eastern part, significant native woodlands exists. Salt storage data for the unsaturated profile is not available. It was estimated from the records of other catchments.

Daily rainfall at the centroid of each of the sub-catchments was estimated from 12 pluviometers within and around the Salt River catchment. Daily pan evaporation data was developed using a harmonic function and the annual record published by Luke et al (1988). A long term series of both rainfall and pan evaporation was created for the period of 1909 to 2000.

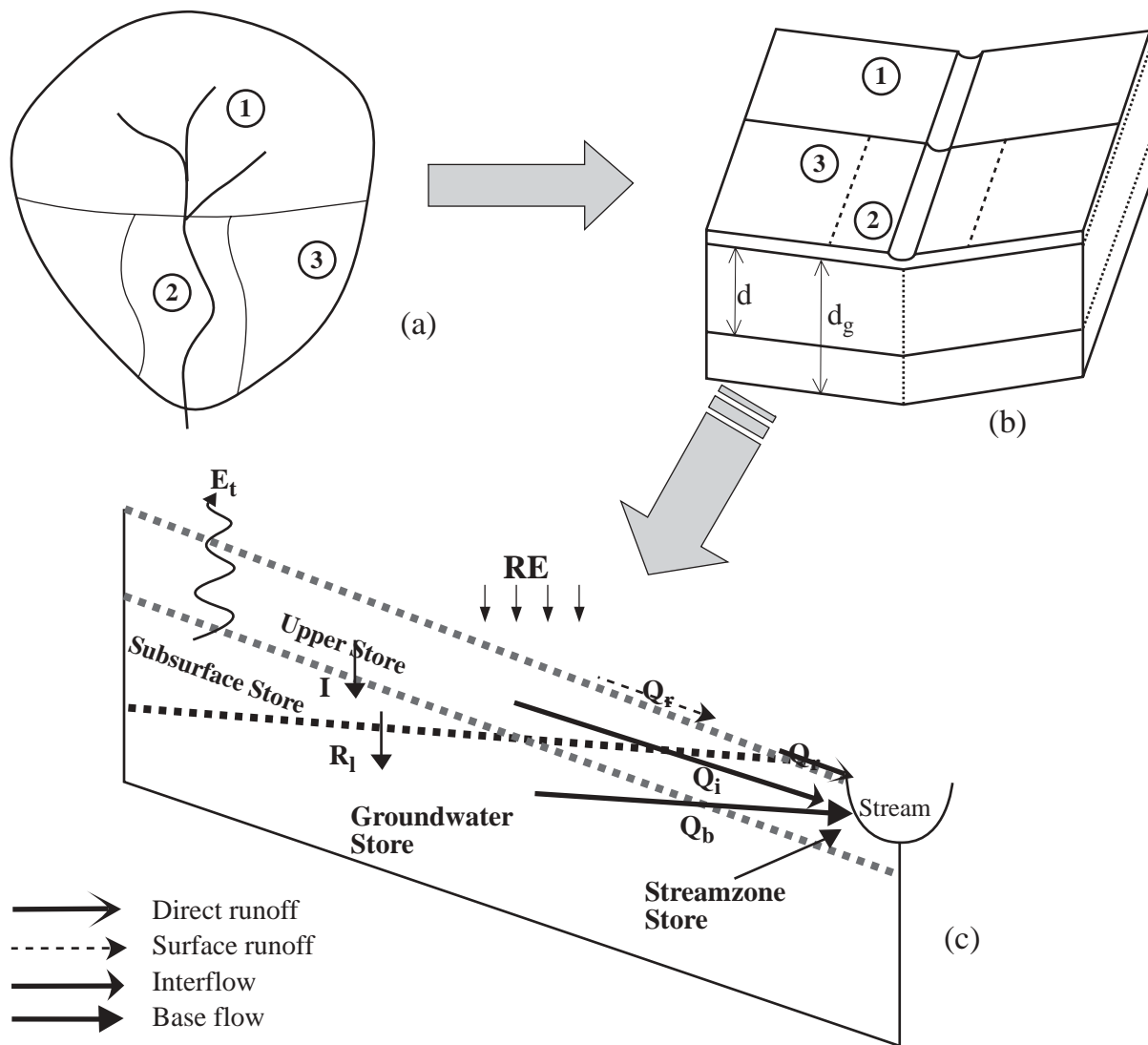


Figure 3 Conceptual structure of LUCICAT model: (a) hypothetical catchment, (b) open book representation, (c) model stores

Streamflow and salinity data are recorded at two major gauging stations: (i) Yilgarn River at Gairdner's Crossing and (ii) Lockhart River at Kwolyn Hill. Flow records are available mid-1970s onwards. These two gauging stations cover 96% of the catchment area of the Yenyening Lakes System. Some salinity samples were collected from the Lockhart River gauging station until 1997 when a continuous conductivity recorder was installed. Salinity samples, a few per year, are being collected from the Yilgarn River gauging station.

5. Initial results and discussion

5.1 Catchment model

The catchment model was calibrated using the available streamflow data from both the gauging stations. The observed and predicted annual streamflow record at the Avon River south-west Lakes shown in Figure 4. It is clear that a reasonable match between the observed and predicted streamflow was achieved, given that the Salt River catchment was divided into only three sub-catchments. The catchment model has a tendency to over-predict the annual streamflow, particularly during the 1990s (Figure 4). However, the annual salinity concentrations were reasonably well-matched (Figure 5).

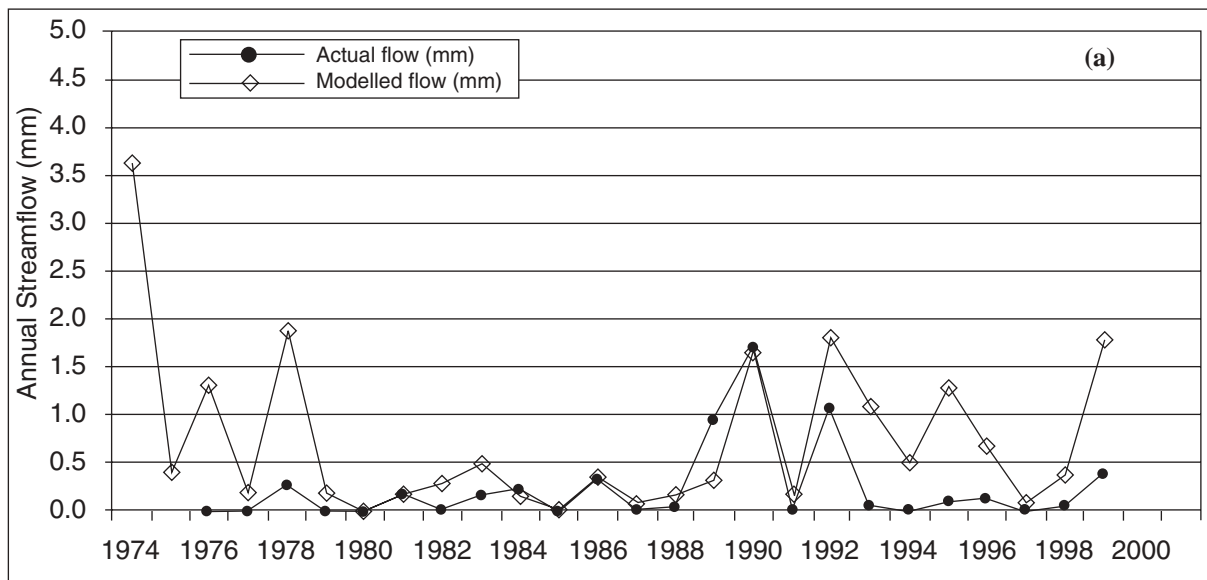


Figure 4 Observed and predicted annual streamflow at Lockhart River at Kwolyn Hill gauging station

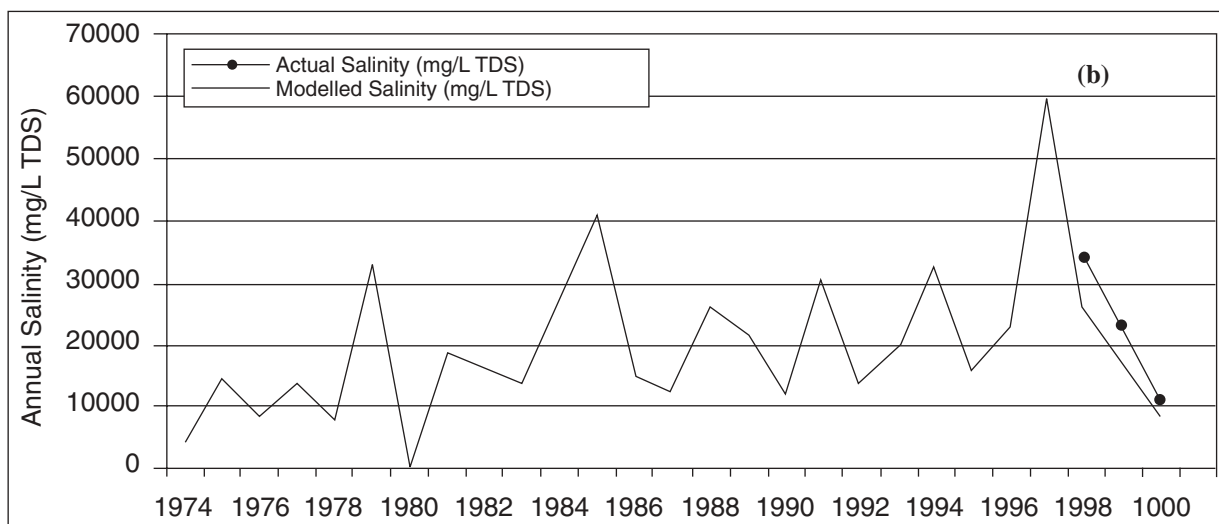


Figure 5 Observed and predicted annual stream salinity at Lockhart River at Kwolyn Hill gauging station

5.2 Lake model

The Lake Model was set up for the Yenyening Lakes System using all the available data. Streamflow and salt load output from the catchment model was sequentially added to the Lakes model set up for Yenyening Lakes.

Initially the model parameters were identical to the application of the model to Lake Toolibin (Bari and Peck, 2002) and Dumbleyung Lake (Bari, 2002). The observed streamflow data was used to calibrated the Lake Model. However, the calibration process proved to be very difficult, particularly for the salinity component, due to the short period of continuous, reliable salinity data.

The inflow and salt load, predicted by the catchment model was used to calibrate the Lake Model, starting from January 1973. At the beginning of the simulation it was assumed that the volume and the quantity of dissolved salts in the Lake were 1 m³ and 10 kg respectively. Outflow channel characteristics (width, slope, roughness etc.) and culvert cross-section were incorporated into the model based on site visit and available information. A pan factor of 0.7 and lake-bed conductance of 0.0003 per day was found to be reasonable to get stability.

Figure 6 shows the observed and predicted water level in the Yenyening Lakes. The water level, predicted by the lake model, is reasonably well matched during the period 1977-2000. That means the inflow series predicted by the catchment model (Figure 4), is considered to reasonably represent the Yenyening catchment.

During the period of study (1973-2000) there was out flow from the Yenyening Lakes in most of the years (Figure 6). During that period there was average annual inflow of 39.5 million cubic metres and average annual rainfall on the water surface of the lake was 1.8 million cubic metres. About 8% and 92% of the total input was lost by the evaporation process and over flow respectively (Figure 7). The loss of water as seepage through the base of the lake to the deep aquifer systems was negligible (Figure 7).

The predicted salinity concentration of the lakes generally followed the observed records (Figure 8). However during the high-flow year of 1982, the model significantly over-predicted the salinity of the lakes. The median salinity of the lakes was in the order of 60,000 mg/L TDS. The predicted salinity of the lake was fixed to a maximum of 450,000 mg/L TDS. There was a periodic loss of salt through the base of the Lakes as seepage and at times there was some gain (Figure 9). However, in terms of over all salt balance, the salt loss through the base was negligible (Figure 10). Average annual input to Yenyening Lakes, including the rainfall salt was 381,000 tonnes during the study period (1973-2000). Most of the input salt (99%) was lost due to overflow (Figure 10). It appears that the salt storage in the lake slightly increased in 1990s compared to 1970s (Figure 11).

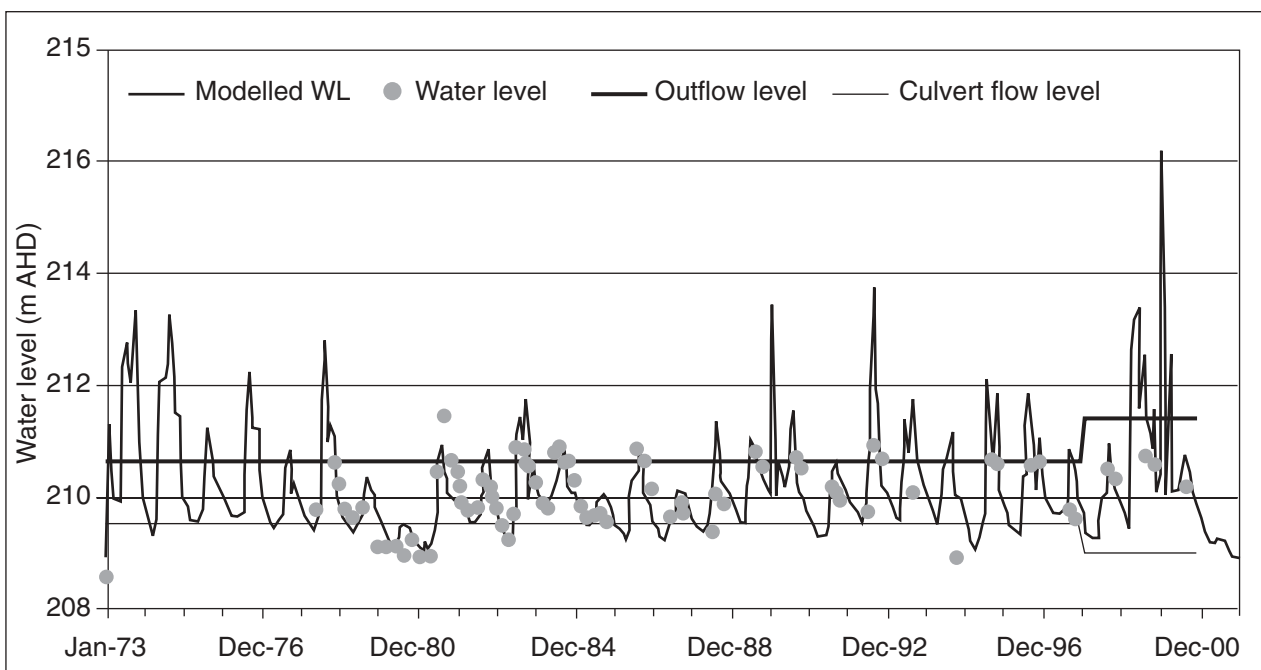


Figure 6 Observed and predicted water level of the Yenyening Lakes System

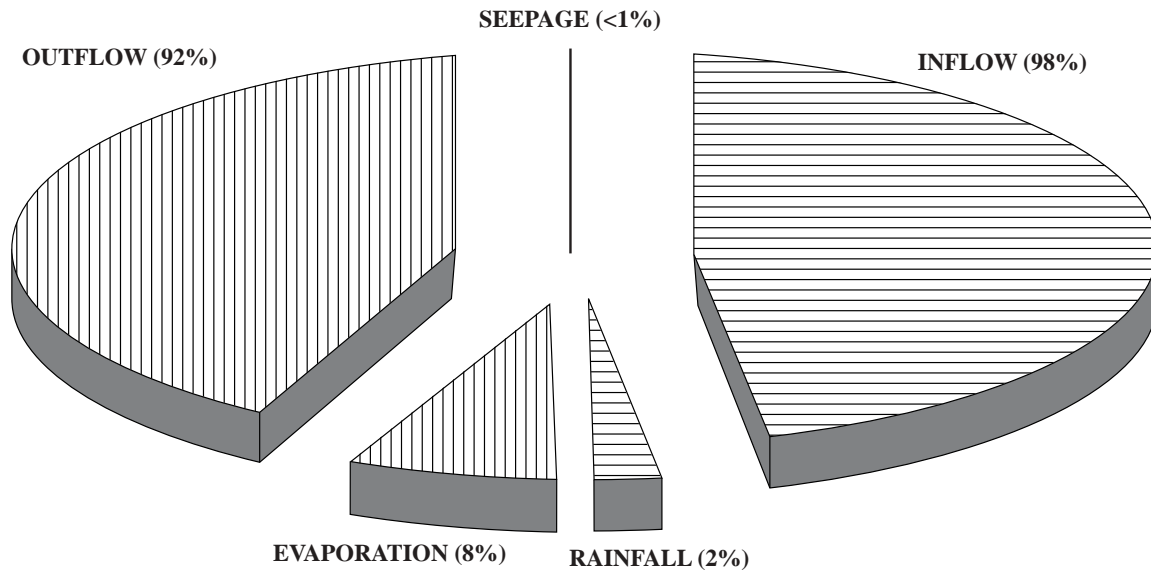


Figure 7 Water balance components of the Yenyening Lakes System

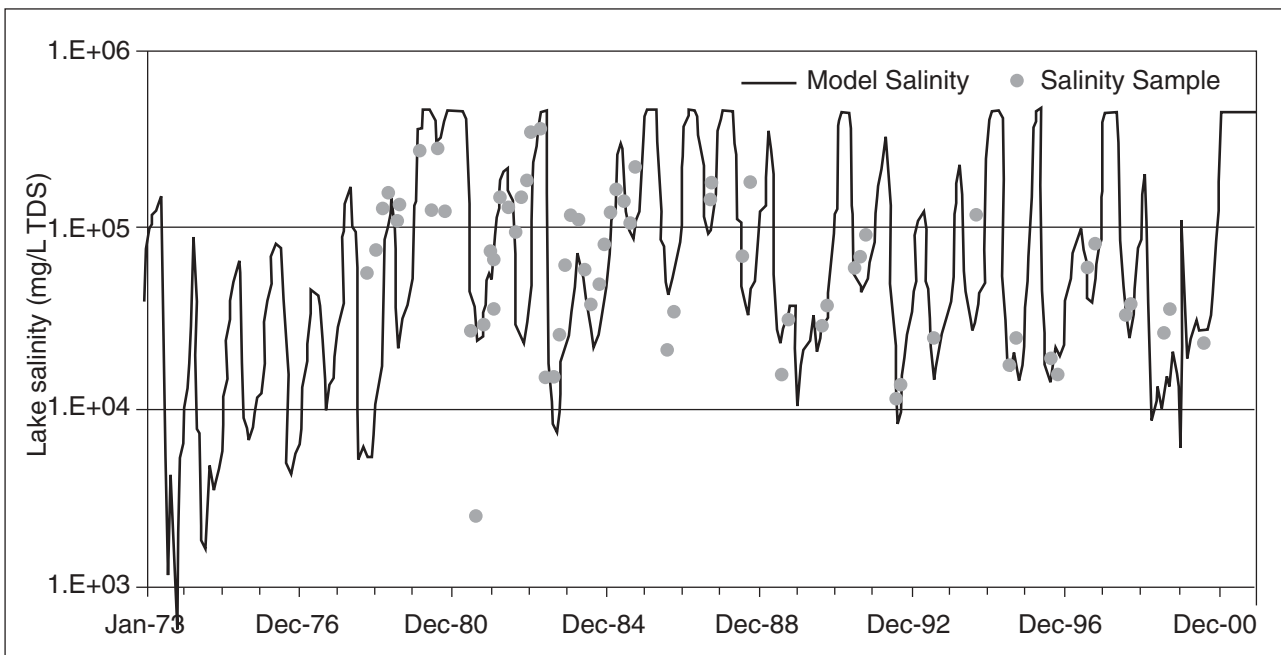


Figure 8 Observed and predicted salinity of Yenyening Lakes System

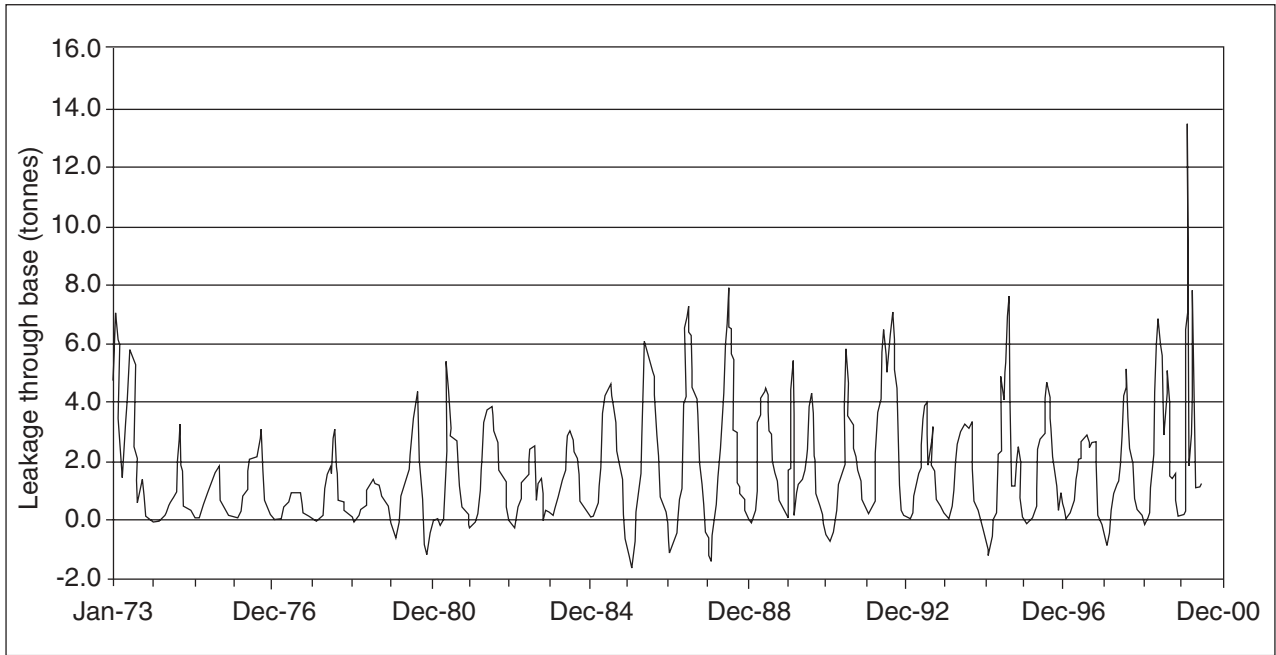


Figure 9 Leakage of salt through the base of Yenyening Lakes System

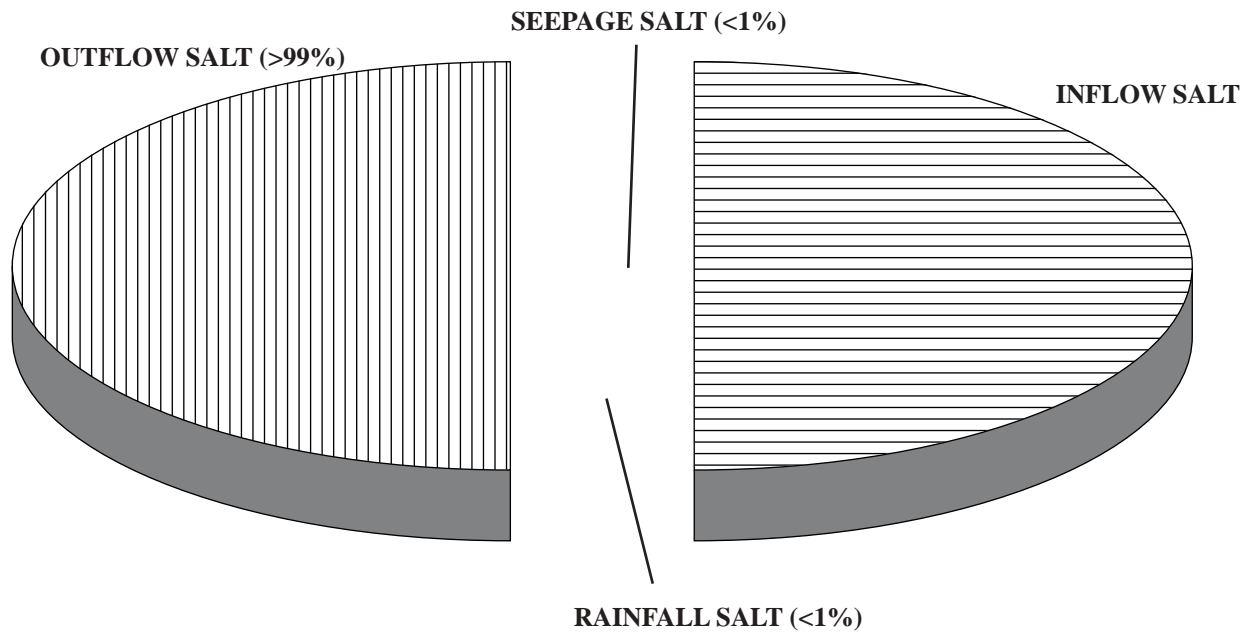


Figure 10 Salt balance components of the Yenyening Lakes System

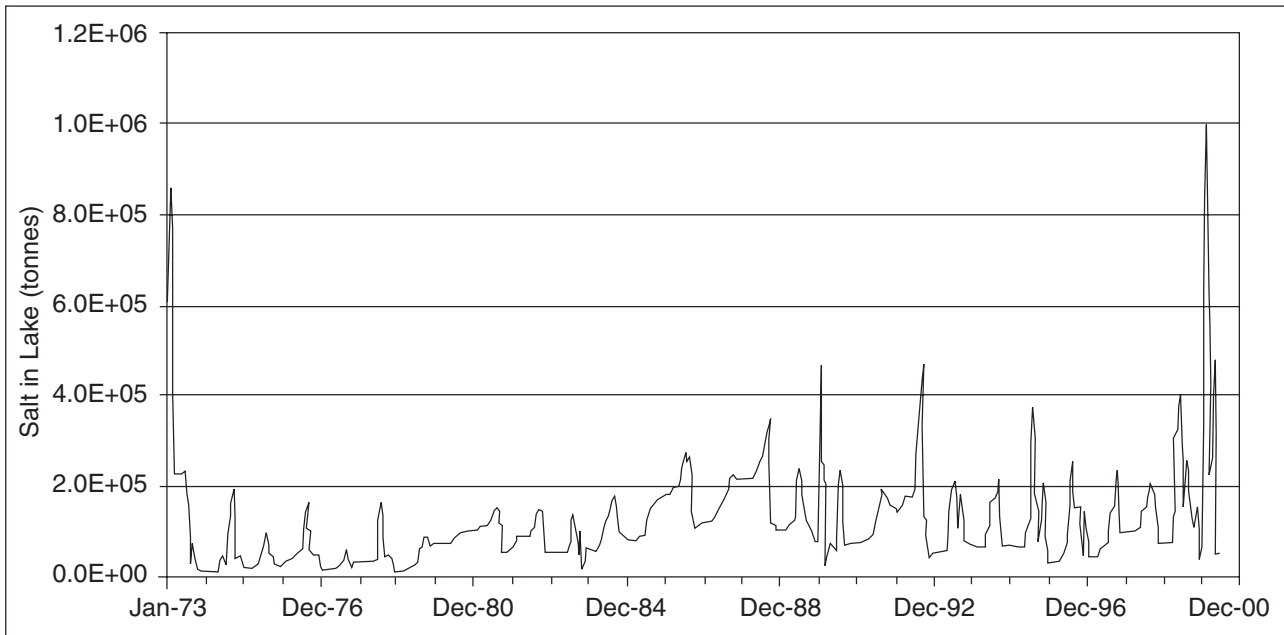


Figure 11 Simulated salt storage in the Yenyening Lakes System

6. Scenario predictions

As a reasonable calibration of both the lakes and catchment models has been achieved, two simple management scenarios for the Yenyening Lakes System outflow culvert were incorporated into the models. Modelling results for the period of 1973-2000 were used for comparison. The Base Run is defined as the operation of the gate the way it is at present. Two management scenarios are:

(1) Gate always open: If the gate of the culvert is always open instead of operating as it is now (Base run), the median water level in the Lakes will be slightly lower (Figure 12). However, the median salinity of the Lakes will increase compared to the base run (Figure 13) and the median salt storage in the Lakes will be lower than the present (Figure 14).

(2) Gate always closed: If the gate of the culvert remains always closed the median water level in the Lakes will be 0.7 m higher (Figure 12) than the base run. The median salinity of the Lakes will be about 7,000 mg/L TDS lower (Figure 13) than the base run. The lake salinity will remain lower than the base run for about 70% of the time. The salt storage in the lakes will be greater than the present value for about 90% of the time (Figure 14).

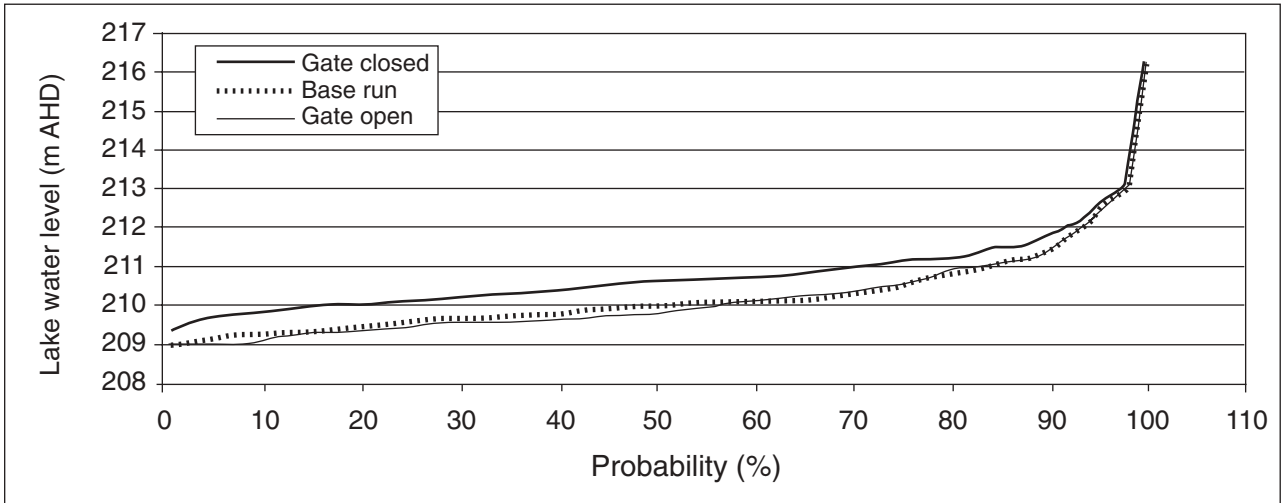


Figure 12 Lake water level volume under different management scenarios.

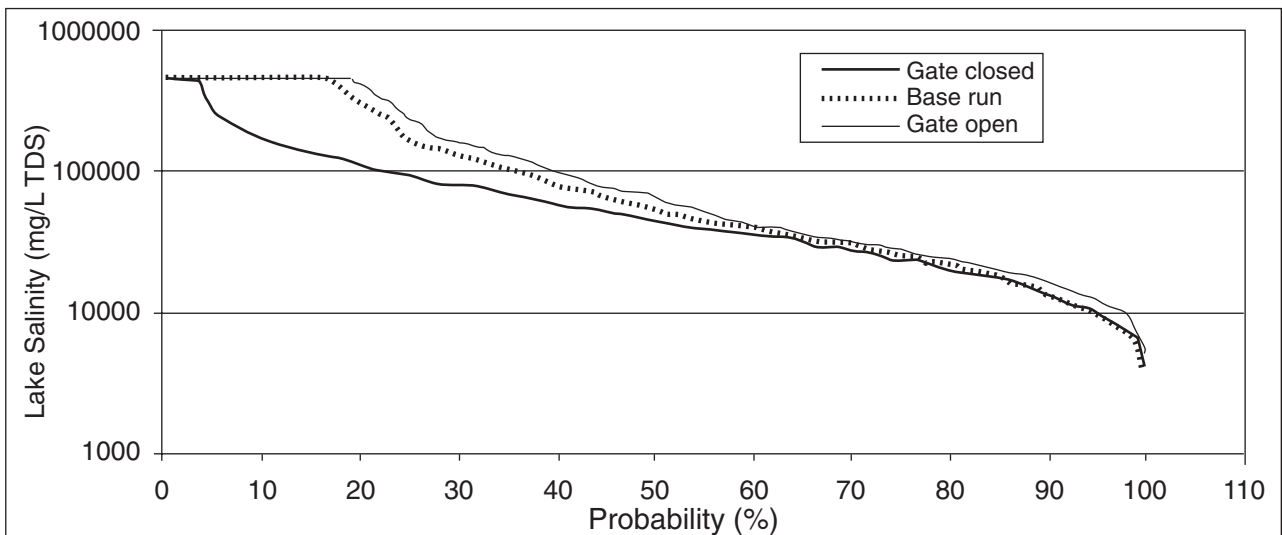


Figure 13 Lake salinity under different management scenarios.

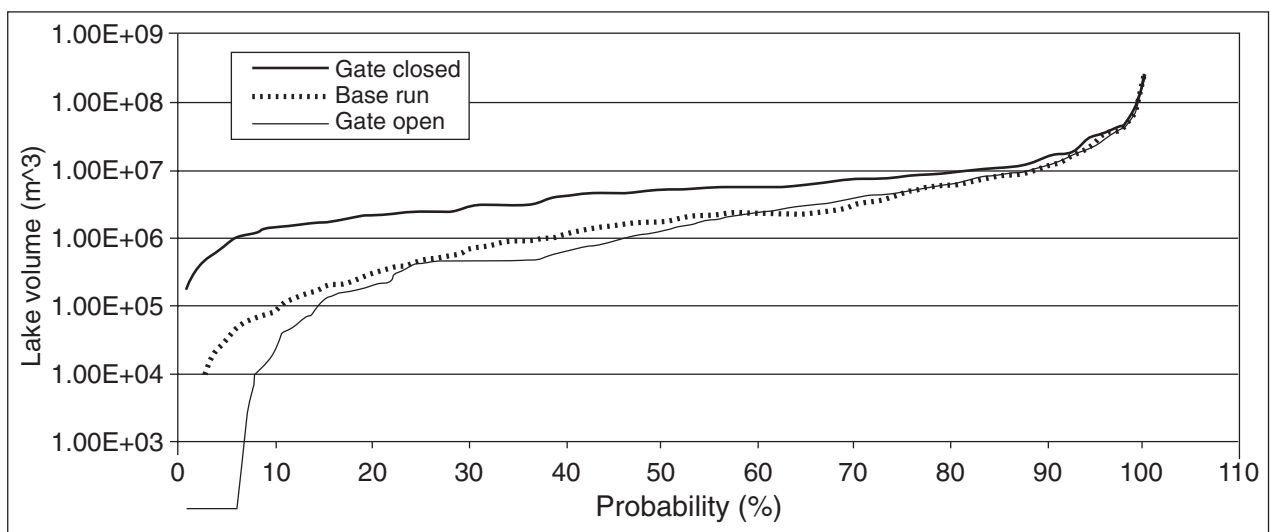


Figure 14 Storage volume under different management scenarios.

7. Concluding remarks

A daily rainfall and pan evaporation series for the period of 1909-2000 has been developed. The relationships between the lake surface area-depth-volume for the Yenyening Lakes System were developed based on contour and other available data. Lake salinity and depth data are available for the period of 1978-2000. However, there is no data available describing the lake-bed conductance and outflow channel characteristic. Streamflow and salinity data are monitored at two major gauging stations: (i) Yilgarn River north-and (ii) Lockhart River. These two gauging stations cover 96% of the catchment area of Lake Yenyening. Streamflow and salinity data are available mid-1970s onwards.

A simple spread-sheet type salt and water balance model for the Yenyening Lakes System has been completed and a reasonable calibration achieved.

The Yenyening Lakes System has a capacity of 10.8 million cubic metres at the overflow depth of 211.45 m AHD. At that depth the surface area of the lake reaches 9.7 km². During the period of study (1973-2000) there was out flow from the Yenyening Lakes System in most of the years. During that period there was an average annual inflow of 39.5 million cubic metres. About 92% and 8% of the total input was lost by the out flow and evaporation process respectively and loss through seepage to the deep aquifer systems was negligible. The median salinity of the lake was in the order of 60,000 mg/L TDS. Annual average salt input was 381,000 tonnes. Most of the stored salt (99%) was lost due to out flow and net leakage through the lake-bed was negligible.

The Salt River catchment was divided into 3 sub-catchments and a simple bucket-type model (LUCICAT) was applied. A reasonable calibration against the observed data has been achieved. Inflow and salt load series, predicted by the catchment model for the period of 1973-2000, was added to the lake model set up for the Yenyening Lakes System.

Two lake management scenarios were predicted by the model. If the gate is kept always open, the median salinity of the lake will increase compared to the present. However, if the gate is always closed, the median water level in the lake will be approximately 0.7 m higher and the median salinity will be about 7000 mg/L TDS lower than the present value.

8. Future modelling

The catchment model needs further calibration. The Salt River could be divided into 100-200 sub-catchments to achieve better calibration. The salt and water balance of different lakes will be incorporated into the catchment model. Once satisfactory calibration has been achieved, the model could be run for predicting catchment management scenarios. Some of the management scenarios may include (i) do nothing different, (ii) use of engineering options to increase discharge, and (iii) high water use agronomic solutions to reduce recharge.

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Appendix D: Report – Groundwater hydrology workshop

Overview of the salt river between Quairading and Qualandary

Robin Smith, Department of Environment, Water and Catchment Protection.

Location and description

The area draining to the Salt River between its outlet at Qualandary Crossing (just upstream of the confluence of the Salt and Avon Rivers) and the Quairading–Corrigin Road extends about 70 km east-to-west and 55 km north-to-south mainly on the southeast side of the Salt River (Fig. 1). The area is shown on 1:100 000 scale topographic sheets of Cunderdin (2334), Corrigin (2433) and Brookton (2333) and has good road access. Localities within the catchment are Jacobs Well, Dulbelling and Dangin (near the Quairading–York Road in the northwest), and Lomos, Jubuk and Kunjin in the southeast (near the Brookton–Corrigin Road). Both Corrigin and Quairading are outside the catchment boundary although Quairading is within the management boundary shown northeast of the Quairading–Corrigin Road. On the catchment boundary the elevation rises to be over 300 m AHD at many points with the maximum of just over 410 m AHD at Wogerlin Hill, 18 km north of Corrigin. The average annual rainfall is about 350 mm, decreasing eastward and the average annual evaporation is about 2100 mm, increasing to the northeast (Fig 2.).

This southwest trending section of the Salt River is broad and flat, up to 3 km wide, with salt lakes comprising about 40 per cent of the valley floor. The Salt River runs through Yenyening Lake, 10 km south of Quairading (Caccetta et al., 1999), and then the 30 km chain of lakes known as the Yenyening or Beverley Lakes to the Qualandary Crossing, about 30 km southeast of Beverley. For low flow situations, runoff from a relatively small part of the Salt River catchment drains southwest into these lakes. Significant tributaries join from the north (Morbinning Gully) and east past Lake Mears (Kunjin Brook, aka Stock Pool Creek). Inflow from the east tributary occurs once it fills and backs up from Lake Mears. However in periods of moderate to high flow, runoff from an area of 91 000 km² flows through the lakes into the Avon River near

Qualandary Crossing (Harris, 1996). The drainage gradient from the Quairading–Corrigin Road (just under 220 m AHD) in a direct line to the outlet (209.06 m AHD) some 33 km away is 3 in 10⁴. As the area is undulating with low relief, the catchment area and path of surface runoff may change both during and between high flow events.

In periods of low flow, but with high flow in the Avon River, water has historically backed up into the lakes. Qualandary Crossing was put in place in the early 1900s and gradually increased in height to limit backflow. The Crossing was also used to retain some water and to preserve the quality of downstream pools in the Avon River for stock use. The gates are opened to allow flow into the Avon River during moderate flow. The top of the Crossing is 211.36 m AHD and a channel has been excavated on the upstream side of the gates to 209.06 m AHD. Lane (1994) gives the history of Crossing heights.

Previous investigation

The geology has been mapped on the Kellerberrin (SH50-15) and Corrigin (SI50-3) 1:250 000 sheets by Chin (1986a, b). The basement comprises medium to coarse adamellite and other granitoid rock, gneiss, rare dolerite and quartz dykes and is 30 % exposed on the slopes and higher ground together with 30 % colluvium. Sand plain and laterite also occur high in the landscape (Fig. 3). The valleys contain alluvium and Cainozoic sediments (Qs, Qa, Qd, Cza).

The Salt River follows an ancient drainage channel that is now infilled with sediments (Salama, 1997). The exact route of the palaeochannel is not known but it may pass south of Qualandary Crossing, as this is reputedly built on a dolerite bar. Adamson (2000, pers. comm.) has it passing under the northern end of the Crossing. Drilling by Salama et al. (1989) revealed about 73 m of Tertiary sediments 10 km south of Quairading. Below about 163 m AHD they comprise 20 m of sand aquifer on bedrock. Water levels in all these bores were within 3 m of the surface and rose at up to 0.4 m/a in the first year after completion, confirming that groundwater is moving into the palaeochannel aquifer from the weathered bedrock (the saprolite aquifer in Fig. 4).

Earlier drilling also indicated shallow depths to bedrock and small saline groundwater supplies were common (WIN database, Water and Rivers Commission).

The WRC has plots of the Land Monitor data including Quairading and Corrigin. A substantial area with depth to groundwater 0.5 to 1 m adjoins the main drainage line and is fringed by a lesser area with depth to groundwater 1 to 1.5 m. The plots indicate that the area of salinised land was significant in 1989, had increased by 1998 and will increase significantly (Land Monitor, 2000). They reveal a largely cleared agricultural landscape with few significant blocks of remnant vegetation (Fig. 5). These remnants are near Lomos, Jubuk and Kunjin in the southeast, near Quairading and also on the rocky catchment divide near and north of Wogerlin Hill.

The report by the Yenyening Lakes Management Group (1996) gives the background to the area. In wet years the lakes are over 2 m deep and 1700 ha in area. The report summarises the concerns about the Yenyening Lakes system. The main concerns about the Crossing are whether it is the principal cause of inundation of farmland up to 30 km upstream, and leads to high salinity in the lakes. The waterlogged area around the lakes may in fact be greater during the brief periods when the river flows over Qualandary Crossing than it would in the absence of the Crossing (Smith, 2000c), but would not persist after the flooding passes.

Salt movement

The lowlying areas in this relatively small local subcatchment of the Salt River accumulate salt near the surface through groundwater discharge and evaporation (Smith, 2000b & c). Since clearing commenced the water table has risen and the discharge of saline groundwater to the surface drainage has increased (Fig. 4). Groundwater is within 2 m of the surface, and therefore discharging by evaporation around the lakes. Evaporation from the shallow water table concentrates the salts in groundwater near the surface and accumulates them in the soil (Fig 2.)

Gradients for surface runoff along the Salt River are low, less than 3×10^{-4} . The substantially flat broad valley bottom of the sub-catchment has poor drainage, resulting in a significant part of the Salt River sub-catchment being prone to flooding. Water retained in lakes becomes more saline through evaporation.

Road barriers, including Qualandary Crossing, retain surface water on flat low-lying areas in the Yenyening Lakes. These areas are usually saline and waterlogged so the intermittent retention of surface water does not reverse the sluggish movement of groundwater and drive groundwater or salt up onto the adjoining slopes (Figures 4 & 5).

Significant floods periodically flush the salt into the Avon River (at intervals of decades). Although this cycle has only been observed over the 100 years since the introduction of agriculture, salt has been accumulating locally and discharging during large flood events for thousands of years.

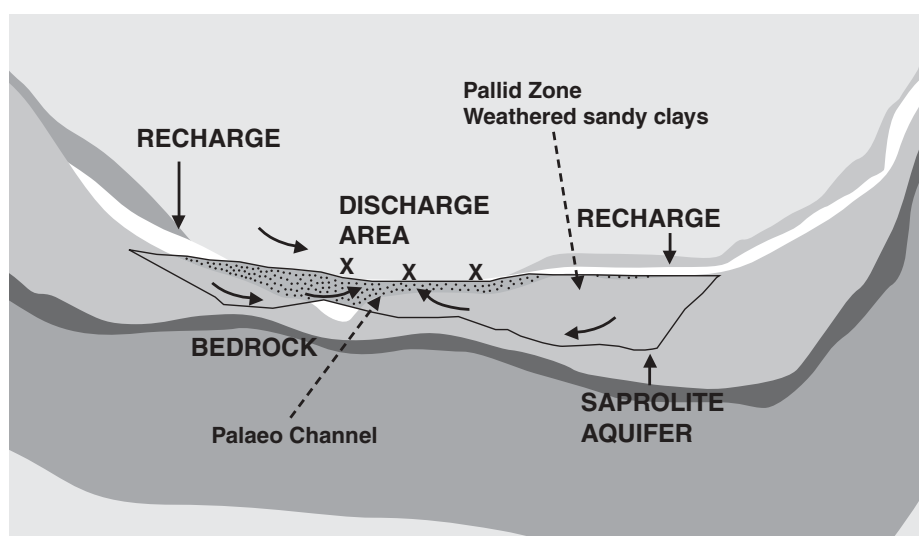


Figure 4: Section of groundwater occurrence and flow into the Salt River

Next things

Water and salt balance modelling by the Water and Rivers Commission (Bari, 2002, pers. comm.) will be used in determining scenarios where opening or closing the gate at Qualandary would affect these balances or the upstream or downstream water quality. Lane (1994) indicates that such retention could be useful in managing the egress of salt into downstream pools, as was the practise until the adjoining reaches of the Avon River becoming saline in recent decades. The quality of the retained water varies with the level of flooding but is generally less than that in constructed drains on adjoining properties (Lane, 1994).

Clearly the Qualandary Crossing gate opening is significant only in low flow, especially prior to or following a big flow event. Removal of the barrier will allow the earlier formation of salt pans in summer, but this is not expected to lower the water table over a significant area due to groundwater inflow. Attempting to further lower the water level or to drain groundwater such as with the existing 2 m deep excavated channel upstream from the outlet is likely to influence groundwater levels only within tens of metres (eg 80 m) laterally (Dogramaci, 2000, pers. comm.). There is likely to be only a small increase in groundwater discharge from the catchment by removal of part of the dolerite barrier (Smith, 2000a). Using production bores in the palaeochannel sands, 50 m below confining clays, is also predicted to have little effect on the water balance.

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<http://www.landmonitor.wa.gov.au/index.html>

Workshop summary

Key discussion points

- Flood risk as a result of higher ground water levels in the wheatbelt
- Relative merits of tools for lowering groundwater and/ or preventing groundwater rise – trees and storm water drainage preventing recharge, deep drains and pumping removing groundwater
- Impacts of increased drainage activity on Yenyening Lake system
- Disposal of surplus water from neighbouring farmland into the lake system
- The role for regional / arterial drainage in the area
- Managing for upstream and downstream impacts
- Assessing financial returns for investments in groundwater management
- Land Monitor predictions for salinity increases in the region
- Defining the objectives for groundwater management

Conclusions

- The area affected by salinity will increase adjacent to the system – but this is a local effect not influenced by the lakes.
- Significant intervention is required to lower groundwater levels in all except localised situations – eg \$150,000 pa at Lake Toolibin.
- Low rates of lateral flow of groundwater limit the area affected by any intervention (eg pumping).
- Main groundwater and salinity issues for the land adjacent to the lakes is caused locally – needs to be focus of management by landholders and Management Committee.
- Very little recharge of groundwater beneath the lake as it is already fully saturated.
- Need to define objectives in groundwater management – protect farmland? Protect conservation?
- Need for improved groundwater monitoring.

Suggestions for progressing regional drainage plan

People at the meeting interested in regional/ arterial drainage developed the following requirements to be addressed in the context of the Avon Regional Drainage Plan

- Build political will for action
- Sort out the funding arrangements
- Establish a 'Drainage Board'
- Recognise recreation/ conservation benefits.
- Focus efforts where analysis shows high financial returns.
- Ensure a balance between getting action on the ground and getting it in the right place.

Suggested items for the Strategy

The Yenyening stakeholders at the meeting developed six actions to be considered in the strategy.

In the event that even if there is greatly increased drainage activity in the Yilgarn and Lockhart systems, it is unlikely that water flows through the system will increase greatly and the systems should be able to handle it – but see the suggestions in the surface water workshop










The Yenyening Lakes and tributaries (Morbinning Gully and Kunjin Brook) can be considered as groundwater systems in isolation – reducing secondary salinisation requires action on the local site.

The lake system throughout its length (Qualandary Crossing to Quairading-Corrigin Road) is fully saturated, and there is likely to be very little recharge from surface water flowing across the system

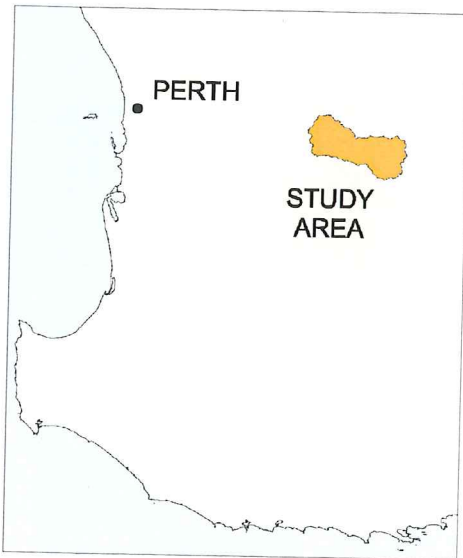
The lakes system can handle more local runoff and 'fresh-ish' discharge from neighbouring farmland without too many problems.

There is the opportunity for some more 'water training' through the lake system.

Legend

-  Town, Railway Siding
-  Major Road, Highway
-  Railway
-  River
-  Topographic Contour (10 m)
-  Local Government Boundary
-  Valley floor Salt River, Intermittent Lake
-  Lake
-  Study Area

Location Map



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Figure 1: Salt River Catchment between Qualandary Crossing and Quairading

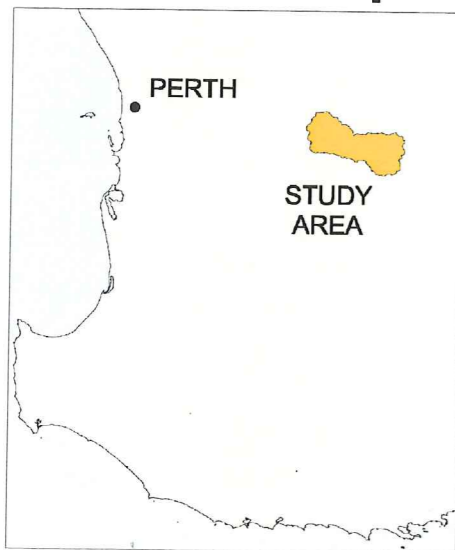
Legend

- ◻ Town, Railway Siding
- Major Road, Highway
- Rainfall (mm/a)
- Evapotranspiration (mm/a)
- Bore (WIN)
- ◻ Study Area

Groundwater Salinity (mg/L)

- ◻ 7000-14000
- ◻ 14000-35000
- ◻ >35000

Location Map



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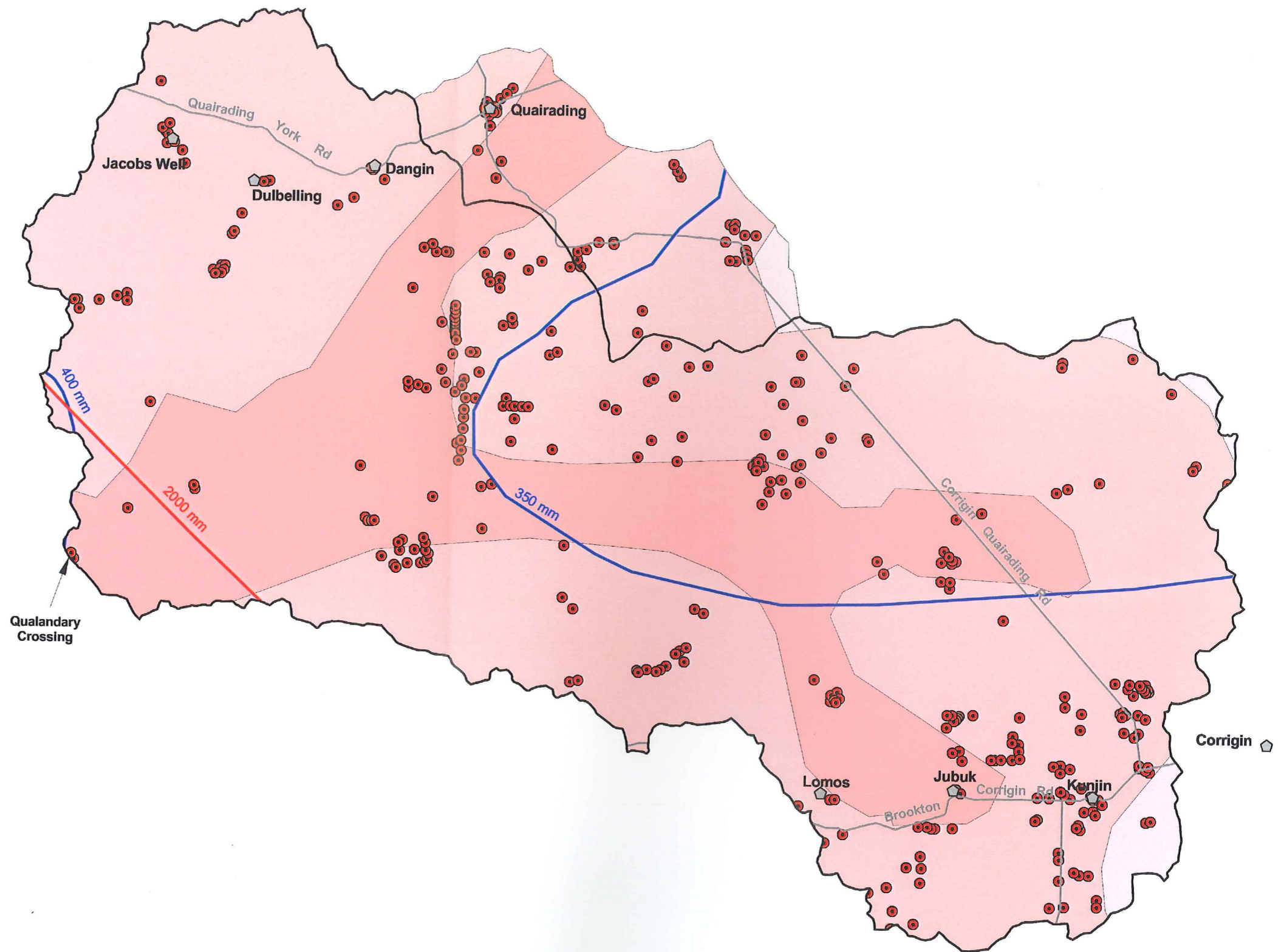


Figure 2: Rainfall, evaporation and groundwater salinity

Legend

- ◻ Town, Railway Siding
- Major Road, Highway
- ◻ Study Area

Geology

- Qa - Alluvium
- Ql - Lacustrine deposits
- Qc - Colluvium
- Qd - Eolian and alluvial deposits

- Cza - Alluvium
- Czs - Sandplain
- Czl - Laterite

- Agv
 - Agl
 - Agp
 - Agn
 - Age
- Granite

- Ans
 - Anp
 - Anh
 - Anu
 - Ang
 - Anb
 - Ana
 - Am
- Gneiss

- Al - Muscovite-quartz

- Ahf
 - Ahi
- Mafic Rocks

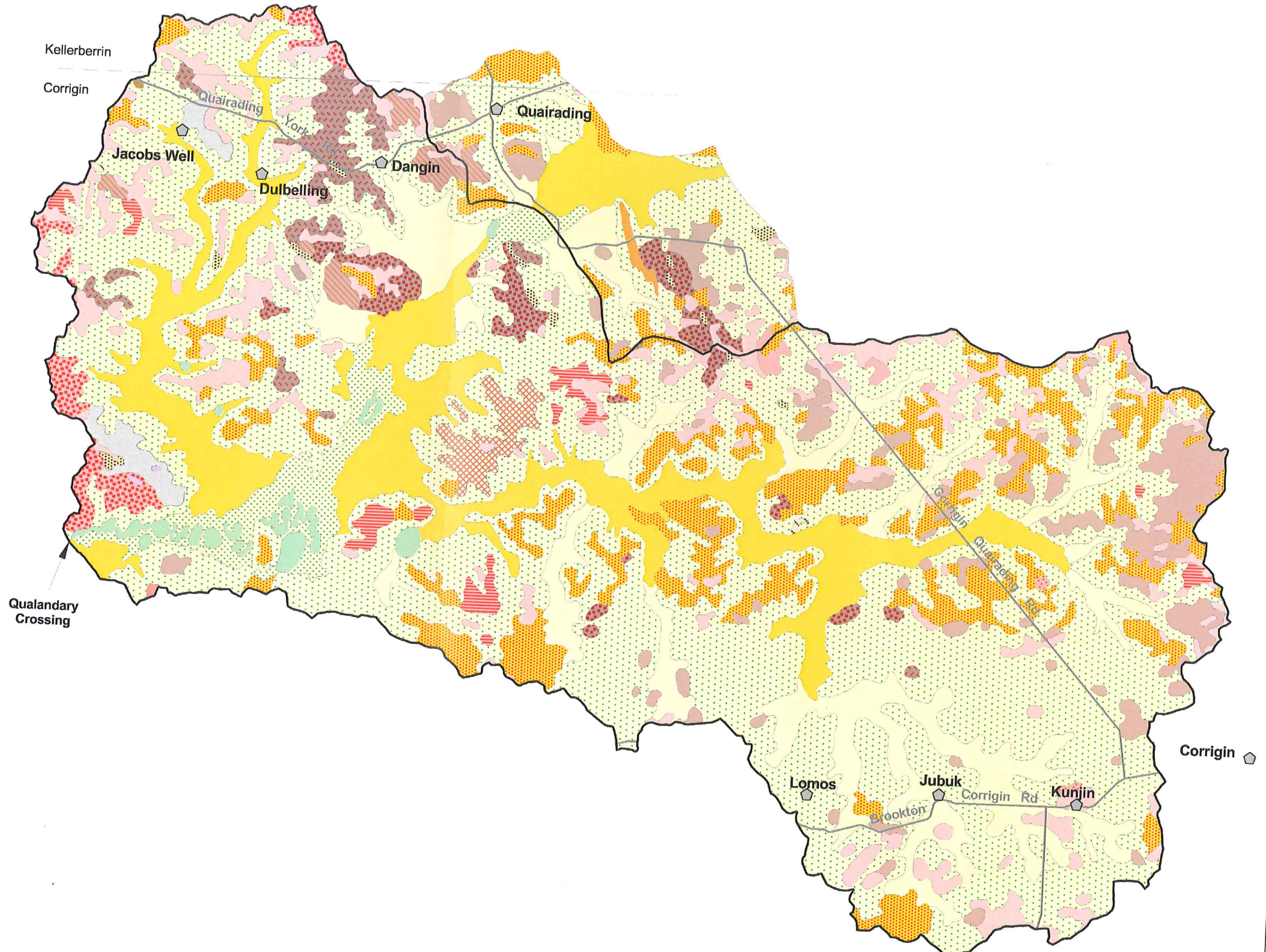


Figure 3: Geology

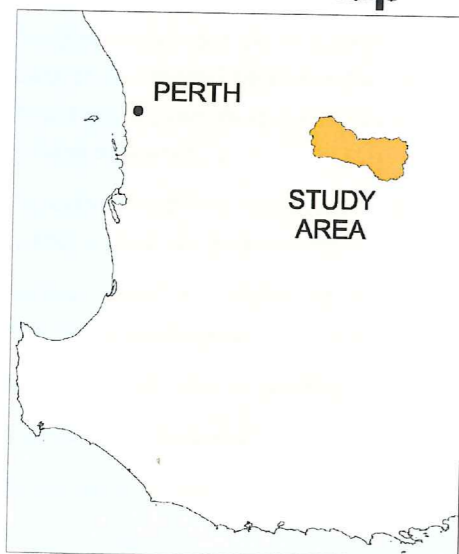
Legend

- Town, Railway Siding
- Major Road, Highways
- Railway
- Local Government Boundary
- Study Area

Land Monitor Salinity Mapping

- Areas at risk of becoming saline
- Recent Saline Areas (1995-1998)
- Older Saline Areas (1989-1995)
- Year 2000 Bush mask
- Landsat TM Band 5 background
- Water

Location Map



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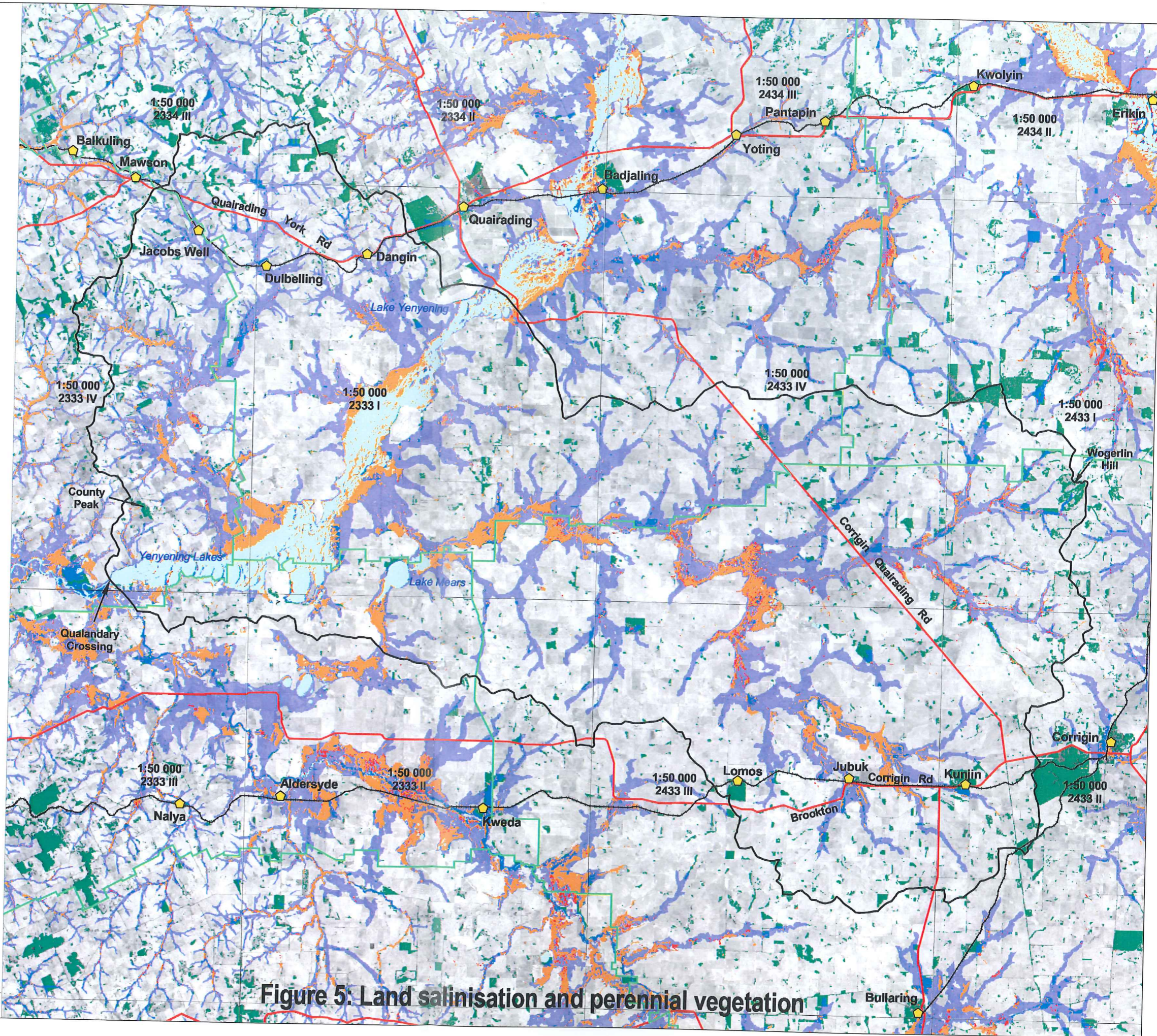


Figure 5: Land salinisation and perennial vegetation

Appendix E: Report – Nature conservation workshop

It is feasible to dewater localised parts of the lake (eg radius of 300 m) for some purposes – such as nature conservation.

Workshop summary

Key discussion points

- The environmental values of the lake system – for example 41 species of water birds, 46 species of land birds, terrestrial fauna not well recorded, numerous sandy banks which still are relatively unaffected by salinity.
- Environmental values in the limited amount of remnant bush away from the lake system.
- Within reserve versus outside reserve conservation management.
- The contribution that the Yenyening environment can make to the overall objective for the wheatbelt ‘to protect and if possible restore WA’s natural diversity’ – vision and goals.
- Managing threats to conservation values in the lake system – what can be achieved?
- Current trends in wildlife in the reserve – some observed improvement, some observed decline.
- Recognition of value of fencing.
- Kangaroo management.
- Rabbit management.
- Weed management.
- The role and management of fire in the lake system.
- The role for ‘strategic revegetation’.
- Impact of skiing on water bird habitat.

Conclusions

- Revised goal is to protect and *where possible restore* the natural diversity of the Yenyening Lakes System.
- Advice from the Department of Conservation and Land Management suggested that this will not be easily done – maintaining what is there now will be a

significant achievement.

- Need to identify with more certainty the environmental values within the strategy boundary and re-set goals.
- The natural diversity appears to be ‘migrating’ up slope away from the rising saline water levels. This suggests two ‘mega-alternatives’ – either lower the water table or help the diversity (plants and animals) re-establish on higher land.
- Defining objectives for revegetation adjacent to lakes and elsewhere in the area
- There is a scarcity of habitat in the strategy area which makes all remnants valuable.

Managing the threats - suggested items for the Strategy

The nine generic threats used by the Department of Conservation and Land Management in planning conservation management were used as a basis for developing actions for the strategy.

Altered biogeochemical processes

- Impact of broad zone of existing zone of inundation / shallow groundwater levels cannot be reversed to any great degree. Any impacts would have occurred long ago.
- Salinity and excess water have degraded vegetation – causing vegetation to ‘migrate’ up slope. Suggest this be facilitated by wider fenced corridors adjacent the lake zone.
- Strategic de-watering - possible to lower local water table by pumping and drainage in very localised situations in the lake to protect special sites if these can be identified.

Impacts of introduced plants and animals

- Continue with rabbit baiting – improve access to 1080 poison.
- Fence all remnants in the strategy area, they are all important.

- Undertaking a weed survey to determine what is there and where.

Impacts of problem native species

- Reduce kangaroo grazing pressure to encourage regeneration.
- Encourage coordinated control on neighbouring farmland.

Impacts of disease

- Not likely to be a problem in the Yenyening system, but maintain a watching brief.

Detrimental regimes of physical disturbance

- Develop an appropriate fire strategy that will enhance value of fire in encouraging regeneration and which will minimise damage from uncontrolled fires.
- Monitor post-fire to gauge effect on vegetation.

Impacts of pollution

- Likely to be some nutrient pollution – relatively minor, but should be discouraged.

Impacts of competing land uses

- Skiing activity unlikely to affecting waterbirds unless breeding – low risk.
- Widen fenced corridor on fringing land near lakes, buy-back schemes?

An unsympathetic culture

- Sell the commercial benefits – encourage opportunities for market-based options for revegetation, fencing of remnants – eg. brush timber cultivation, pines, commercial wild- flower farming.

Insufficient biological resources to maintain viable populations

- Possible role for strategic local de-watering to protect special sites/species etc
- Develop guiding statements about revegetation
- Encourage increase in habitat area with strategic revegetation

Over-arching recommendations

- Improve base data on inventory and condition.
- Establish capability to monitor trends.
- Improve strategic directions – recognise the tradeoffs between options.
- Set targets and monitor outcomes.
- Improve coordination between landholders.
- Coordinated control of introduced species and reduce kangaroo grazing pressure.
- Targeting of revegetation to enhance what is there already.

Appendix F: Report – recreation and tourism workshop

Workshop summary

Key discussion points

- Significant history of inland boating on the lake systems – back to the 1960s, visits from Perth clubs, 30 boats on Lake Mears one Boxing Day, really good until 1969.
- Ski Lake provides excellent competition skiing conditions.
- Legal limits on water depths for skiing – 1.5 m (but can ski to 0.7 m).
- The Department of Conservation and Land Management is very concerned about Department's legal exposure – wants to see the situation formalised as a matter of urgency.
- Some query about previous attempts to have the lake gazetted for skiing in the 1960s? – paper work lost by the then Department of Transport?
- Other water sports are important – canoeing, surfcat sailing.
- Area is covered by Bathymetric survey by the Department of Conservation and Land Management.
- Opportunities for engineering intervention to improve skiing – e.g. excavation of the lake. The Department of Conservation and Land Management is happy to evaluate any proposal on its merits.
- Tourist value of the lake – people come to it expecting to see permanent water.
- Problem in maintaining facilities at Ski Lake.
- Access through farmland to lakes is an issue - Trevor McLean for access to Ski Lake by Ski Road on the north, Wally Mills for access on the South side of the lake.

Conclusions

- Skiing is an opportunity sport with considerable local and Perth interest in the right conditions.
- Other water sports (canoeing and surfcat sailing) can be encouraged.
- The legal arrangements permitting skiing and other water sports must be done as a matter of urgency for

the sake of users, the Beverley Ski Club and the Department of Conservation and Land Management.

- Navigable Waters Act controls water skiing and other inland water use.
- Need to ensure that legal liability covers boat travel from the gate to Ossigs Lake, and that Ossigs, Racecourse and Ski Lakes are covered.
- Bathymetry to cover the three lakes and the area down to the Qualandary Crossing and below in to the Avon River Channel.
- Formalise access arrangements to ski lake.
- Only after gazettal is it worth thinking about engineering modifications to the lakes.

Suggested items for the strategy

- Contact Hedley Giles / Kath Jas for the old Minute Book of the Beverley Ski Club – may have reference to gazettal of the lakes by Marine and Harbours Department for skiing in the 1960s.
- Use bathymetry data from the Department of Conservation and Land Management survey to progress the gazettal process.
- Discuss access arrangements through Avon Location Nos 2622, 4436 & 10569 to the ski lake with the Shire of Beverley – determine the most sensible approach for all parties.
- When gazettal is in place, seek funds to upgrade facilities work with Shire and Beverley Tourist Association.
- Brookton-based lake users (Racecourse Lake) to join with Beverley Ski Club to ensure adequate legal coverage for water-based activities.
- After legal arrangements have been finalised consider options for engineering at the lake – involve the Department of Conservation and Land Management fully.
- Clarify the signage that attracts people to the lakes.
- Recognise the possibility that more water may be managed in the future.
- Maintain a watching brief on the issue of riparian rights. Saltland/saltwater 'ownership' may become an issue.

Appendix G: Constitution

Yenyening Lakes management group

1. NAME

The name of the Association/Club is Yenyening Lakes Management Group (Inc.) hereinafter referred to as the "Group".

2. OBJECTS

The object of the Group is to develop and implement a comprehensive management strategy for the Yenyening Lakes Management Area as defined in the strategy, that achieves the following four objectives.

- 2.1 *Surface water management.* To manage Qualandary Crossing so as to maintain adequate water levels in the lakes, while minimising back up of waters onto agricultural land; also to minimise the flow of silt and salt into the lakes and the Avon River and to ensure that the lakes continue to retain their natural function of floodwater detention.
- 2.2 *Groundwater management.* To implement practices that limit groundwater rise in the lake system and surrounds and which also reduces groundwater impacts on the environmental and agricultural values of the area being managed.
- 2.3 *Nature conservation.* To maintain nature conservation values by ensuring viable populations of indigenous flora and fauna in and around the lakes.
- 2.4 *Recreation and tourism.* To provide for recreational activities by managing the lake waters for approved water-based recreation, and providing appropriate facilities for visitors; to attract tourists, facilitate their enjoyment of the lakes and educate them about the area and its management; and to protect and restore the beauty of the lakes, the bushland and adjoining land.
- 2.5 *Management arrangements.* To establish management structures and processes that involve all key stakeholders in the management of the Yenyening Lakes Management Area, by encouraging collective action, quality communication between all parties, and incorporation of new information into management actions as it becomes available.

3. POWERS OF THE GROUP: (as conferred by Section 13 of the ACT).

- 3.1 To acquire, hold, deal with, and dispose of any real or personal property;
- 3.2 To open and operate bank accounts;
- 3.3 To invest its money –
 - (i) in any security in which trust moneys maybe invested; or
 - (ii) in any other manner authorised by the rules of the Group;
- 3.4 To give such security for the discharge of liabilities incurred by the Group as the Group thinks fit;
- 3.5 To appoint agents to transact any business of the Group on its behalf; and
- 3.6 To enter into any other contract the Group considers necessary or desirable.

4. MEMBERSHIP

- 4.1 Membership of the Group will include:
 - (i) All persons and private and public organisations who hold or manage land that is within or intersects or adjoins the 220 m AHD contour line on either side of the Yenyening Lakes Management Area between the Qualandary Crossing and the Corrigin-Quairading Road.
 - (ia) Where the land is owned by a private company, one (1) representative of that company is eligible for membership of the Group.
 - (ii) A representative of the Water and Rivers Commission or its new identity.
 - (iii) A representative of the Department of Conservation and Land Management.
 - (iv) A representative of the Shire Councils of Brookton, Beverley and Quairading.
 - (v) The Beverley Ski Club, Brookton Ski Club.

4.2 Each person and organisation defined as a member under 4.1 (i), (ii), (iii) and (iv) shall be;

4.2.1 bound by the Constitution and Operating Rules of the Group except where these conflict with the statutory responsibilities of organisations included as per 4.1 (i), (ii), (iii) and (iv), in which case the statutory responsibilities will have precedence.

4.2.2 entitled to all advantages and privileges of membership.

4.3 Membership Categories:

4.3.1 ORDINARY MEMBER

Any person who is defined as per point 4.1 (i) and (ia) above.

4.3.2 CORPORATE MEMBER

Organisations defined as per points 4.1 (ii), (iii) (iv) and (v).

4.4 An up to date register of the members of the Group will be kept by the secretary.

4.5 A member may at any reasonable time inspect the records and documents of the Association.

5. TERMINATION OF MEMBERSHIP

5.1 Any person's membership may be terminated by the following events;

5.1.1 Sale of landholdings that entitle membership

5.1.2 False or inaccurate statements made in the member's application for membership of the Association, breach of any rule, regulation or By-law of the Association or committal of any act detrimental to the Association that is not covered by 4.2.1.

5.2 The Group shall have the power to suspend or expel any member of the Association for any of the events in Item 5.1 above. The process for expulsion will be as follows –

(i) a motion for expulsion of a member must be moved and seconded by members and circulated amongst all members at least three weeks prior to an AGM;

(ii) the motion must be formally moved at the AGM by the mover in person, and seconded by the seconder in person;

(iii) After debate, the motion will be put by the Chairman of the Management Committee.

(iv) Expulsion requires a three quarters majority of the total membership in favour.

5.3 Any member who is expelled, suspended or has their membership terminated shall have the right to appeal against their suspension or expulsion by presenting their case to a General meeting called for such purpose, and the decision of the General Meeting shall be final.

6. MANAGEMENT COMMITTEE

6.1 Management of the Group shall be vested in the Yenyening Lakes Management Committee hereinafter referred to as the "Management Committee" which will consist of;

6.1.1 Between five and nine private landholder Group members.

6.1.2 One representative nominated by the Shire of Brookton.

6.1.3 One representative nominated by the Shire of Beverley.

6.1.4 One representative nominated by the Shire of Quairading.

6.1.5 One representative nominated by the Beverley and Brookton Ski Club (combined).

6.1.6 One representative nominated by the Water and Rivers Commission.

6.1.7 One representative nominated by the Department of Conservation and Land Management.

6.2 There is no limit to the length of time that a person may serve on the Management Committee.

6.3 A quorum of the Management Committee shall be half plus one.

6.4 If the Chairman is unable to attend, then a Chairman nominated by the meeting shall chair the meeting.

6.5 Group members who are not Management Committee members have the right to attend ordinary Management Committee meetings, without voting rights, and with speaking rights as determined by the Management Committee.

7. POWERS OF THE MANAGEMENT COMMITTEE

7.1 The Management Committee shall carry out the day to day running of the Group and shall have the power to establish and publicise Operating Rules for how the Management Committee and Group conducts its business, including but not confined to the following rules:

7.1.1 Call for and approve nominations for Management Committee membership from the categories in 6.1.2, 6.1.3, 6.1.4., 6.1.5, 6.1.6 and 6.1.7;

7.1.2 Design and manage the process for selection of private landholder Group members to the Management Committee as described in 6.1.1. The process will be as follows.

- (i) those private landholder Group members wishing to nominate for the Management Committee will need to present their nomination in writing to the Secretary, supported by two other members.
- (ii) compliant nominations will be circulated to all members with the Notice of AGM.
- (iii) At the AGM, if there are less than the maximum number of nominees, all will be appointed to the Management Committee for a period of two years.
- (iv) In the event that more than the maximum number of compliant nominations are received, a Returning Officer selected from the categories in 6.1.2, 6.1.3, 6.1.4., 6.1.5, 6.1.6 and 6.1.7 will manage a secret ballot to ensure nine appointees to the Management Committee for a period of two years.
- (v) The process will be managed over time so that approximately half of the Management Committee will retire at the AGM, with all those retiring eligible for re-nomination.

7.1.3 elect office-bearers – Chairman, Secretary, Treasurer.

7.1.4 conduct at least three ordinary meetings of the Management Committee each year, between AGMs

7.1.5 administer the finances, appoint bankers, and direct the opening of banking accounts for specific purposes and to transfer funds from one account to another, and to close any such account;

7.1.6 fix the manner in which such banking accounts shall be operated upon, providing all payments are passed by the Management Committee;

7.1.7 adjudicate on all matters brought before it which in any way affect the Association;

7.1.8 cause minutes to be made of all proceedings at meetings of the Management Committee and General Meetings of members;

7.1.9 make, amend and rescind rulings and Operating Rules;

7.1.10 have the power to form and appoint any sub committee/s as required for specific purposes;

7.1.11 may at their discretion employ a person or persons to carry out certain duties required by the Association at salaries or remuneration for such period of time, as may be deemed necessary;

7.1.12 appoint an officer/s or agent of the Management Committee to have custody of the Association's records, documents and securities.

8. AUDITOR

8.1 At a General Meeting the Group shall elect or appoint an Auditor or Auditors

8.2 The Auditor/s shall examine and audit all the books and accounts of the Association annually, and have the power to call for all books, paper, accounts, receipts etc. of the Association and report thereon to the Annual General Meeting.

9. GENERAL MEETINGS

9.1 Annual General Meeting

- 9.1.1 The Annual General Meeting of the Group must be held within four months of the end of the Group's financial year.
- 9.1.2 The Secretary shall give at least fourteen (14) days notice of the date of the Annual General Meeting to members.
- 9.1.3 All Group members may attend the Annual General Meeting with full voting and speaking rights;
- 9.1.4 Members of the general public may attend the AGM, but they will not have voting rights, nor will they be able to speak to motions put to the AGM. They will be able to question the Management Committee's Executive during General Business.
- 9.1.5 The quorum at the Annual General Meeting, shall be minimum 6 members. If at the end of 30 minutes after the time appointed in the notice for the opening of the Meeting there be no quorum the meeting shall stand and adjourn for one week. If such meeting there is no quorum those members present shall be competent to discharge the business of the meeting.
- 9.1.6 The agenda for an Annual General Meeting shall be:
- Opening of Meeting
 - Apologies
 - Confirmation of Minutes of previous Annual General Meeting
 - Presentation of Annual Report by the Management Committee Chairman
 - Adoption of Annual Report
 - Presentation of Treasurer's statement
 - Appointment or election of new members to the Committee
 - Election of New Executive for the Management Committee and appointment of Auditor for the Group
 - Vote of Thanks to outgoing Executive
 - Notice/s of Motion
 - Urgent general business
 - Closure

9.2 General Meetings

- 9.2.1 General meetings may be called by the Management Committee or at the request of the Chairman and Secretary or written request of all members of the Association present at the previous meeting.
- 9.2.2 The Chairman or Secretary shall give at least seven (7) days notice, in writing, of the date of the General Meeting to the members. Notice of General Meetings shall set out clearly the business for which the meeting has been called. No other business shall be dealt with at the General Meeting.
- 9.2.3 The quorum at the General Meeting shall be a minimum of 11 members.

10. VOTING

- 10.1 Voting powers at the Annual General Meeting, General Meetings and Management Committee Meetings:
- 10.1.1 The Chairman shall be entitled to one (1) deliberative vote.
- 10.1.2 At AGMs and General Meetings, each individual Group member present shall have one (1) vote.
- 10.1.3 At Committee meetings, Management Committee members present shall have one (1) vote.
- 10.2 Unless otherwise specified, all decisions will be made on the basis of simple majorities, with the Chairman exercising the casting vote if necessary
- 10.3 Decisions that relate to changes to the Constitution, or to expulsion of a Group Member, will require a three quarters majority as described in 5.2 and 13.4.

11. FINANCE

- 11.1 All funds of the Group shall be deposited into the Group's accounts at such bank or recognised financial institution as the Management Committee may determine.
- 11.2 All accounts due by the Group shall be paid by cheque after having been passed for payment at the Management Committee Meeting.

- 11.3 The Secretary shall not spend more than a set amount of Petty Cash (decided by the Management Committee) without the consent of the Management Committee and shall keep a record of such expenditure in a Petty Cash Book.
- 11.4 A statement showing the financial position of the Group shall be tabled at each Management Committee Meeting by the Treasurer.
- 11.5 A statement of Income and Expenditure, Assets and Liabilities shall be submitted to the Annual General Meeting. The auditor's report shall be attached to such financial report.
- 11.6 The financial year of the Group shall commence on 1 July of each year and conclude on 30 June of the next year. The accounts, books and all financial records of the Group shall be audited each year.
- 11.7 The signatories to the Group's account/s will be the Treasurer, the Chairman and Secretary. Two signatures will be required for approved payment.
- 11.8 All property and income of the Group will apply solely to the promotion of the objects of the Group and no part of that property or income shall be paid or otherwise distributed, directly, or indirectly, to members, except in good faith in the promotion of these objects.

12. COMMON SEAL

(A rubber stamp on which is engraved the Group's name).

The common seal of the Group shall be kept in the care of the Secretary of the Management Committee. The seal shall not be used or affixed to any deed or other document except pursuant to a resolution of the Management Committee and in the presence of at least the Chairman and two members of the Management Committee, both of whom shall subscribe their names as witness.

13. ALTERATIONS TO THE CONSTITUTION AND OPERATING RULES:

- 13.1 No alteration, repeal or addition shall be made to the Constitution except at the Annual General Meeting, or General Meeting called for that purpose and notice of all motions to

alter, repeal or add to the Constitution shall be given to all Committee members fourteen (14) days prior to the Annual General Meeting, or seven (7) days prior to a General Meeting called for such purpose.

- 13.2 The Secretary shall forward such notices of motion to each Management Committee member at least fourteen (14) days prior to the Annual General Meeting or seven (7) days prior to a General Meeting.
- 13.3 Alteration to the Operating Rules can only be made at Management Committee Meetings provided notice of the proposed alteration/s has been duly notified to Management Committee Members.
- 13.4 Such motions or any part thereof shall be of no effect unless passed by a seventy five percent (75%) majority (Special Resolution) of those present and entitled to vote at the Annual General Meeting, General Meeting or Management Committee Meeting, as the case may be:
- 13.5 Within one month of the passing of a Special Resolution, the Secretary shall notify the Ministry of Fair Trading of the amendment.

14. DISSOLUTION

If, on the winding up of the Group, any property of the Group remains after satisfaction of the debts and liabilities of the Group and the costs, charges and expenses of that winding up, that property shall be distributed;

- (a) to another incorporated association having objects similar to those of the Group; or
- (b) for charitable or benevolent purposes, which incorporated association or purposes, as the case requires, shall be determined by resolution of the members, or
- (c) returned to the funding source with explanation of the reasons of why the funds were not spent.

15. ADMINISTRATIVE ROLE:

The Management Committee may engage a non-voting secretary to assist with the administration requirements on terms decided by the Management Committee.

Appendix H: Bathymetric survey results



Line Legend

- Minor Contour (0.25m)
- Major Contour (1.0m)
- Base of Bank
- Top of Bank
- Cadastral Boundary

Notes:

- The topographic detail and features shown on this plan are modelled from data acquired by use of differential Real Time kinematic GPS between the 8th and 12th April 2002. The expected accuracy is within +/- 0.05m for both horizontal and vertical.
- The coordinate system is MGA zone 50 and vertical datum is AHD. The origin for the survey (base station) is SSM COR90 (518592.588 E, 6433931.444 N RL 212.873). The Geoid Field File was derived from the AusGeoid08 undulation model. The undulation model was attached to the coordinate system to yield real time orthometric heights.
- The contour interval is 0.25m with major contours being at 1.0m.
- The cadastral information shown on this plan was supplied by DOLA in digital format. No alterations have been made.

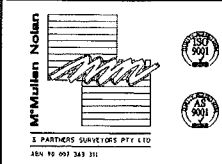
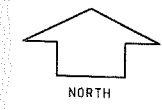
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A	INITIAL ISSUE	EJS	11/25/02	

YENYENING LAKE SYSTEM
LAKE BED SURVEY
WESTERN LAKE

50 0 200
SCALE 1:2500
ALL DISTANCES ARE IN METRES

All areas and dimensions are subject to survey and Titles Office registration
FILES
CCADS - 93102A
Drawing - DWG-01

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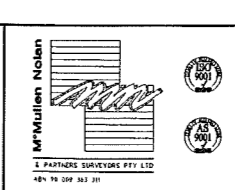
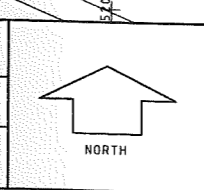
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Surveyed	April 2002
FB No.	FB 1646
Drawing	93102-01
Revision	A



Revision	Description	Drawn	Date	Checked
A	INITIAL ISSUE	EJS	11/25/02	[Signature]

YENYENING LAKE SYSTEM
 LAKE BED SURVEY
 EASTERN LAKE

50 0 200
 SCALE 1:2500
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Surveyor	DJ
Surveyed	April 2002
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Revision	A

- Line Legend**
- Minor Contour (0.25m)
 - Major Contour (1.0m)
 - - - - - Base of Bank
 - - - - - Top of Bank
 - Cadastral Boundary

- Notes:**
- The topographic detail and features shown on this plan are modelled from data acquired by use of differential Real Time Kinematic GPS between the 8th and 12th April 2002. The expected accuracy is within +/- 0.05m for both horizontal and vertical.
 - The coordinate system is MGA zone 50 and vertical datum is AMD. The origin for the survey (base station) is SSM COR99 (518592.588 E, 6433931.440 N & RL 212.873). The Geoid field file was derived from the AusGeoid98 undulation model. The undulation model was attached to the coordinate system to yield real time orthometric heights.
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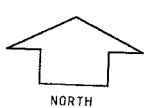
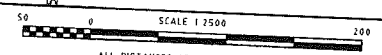
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- Base of Bank
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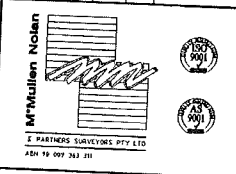
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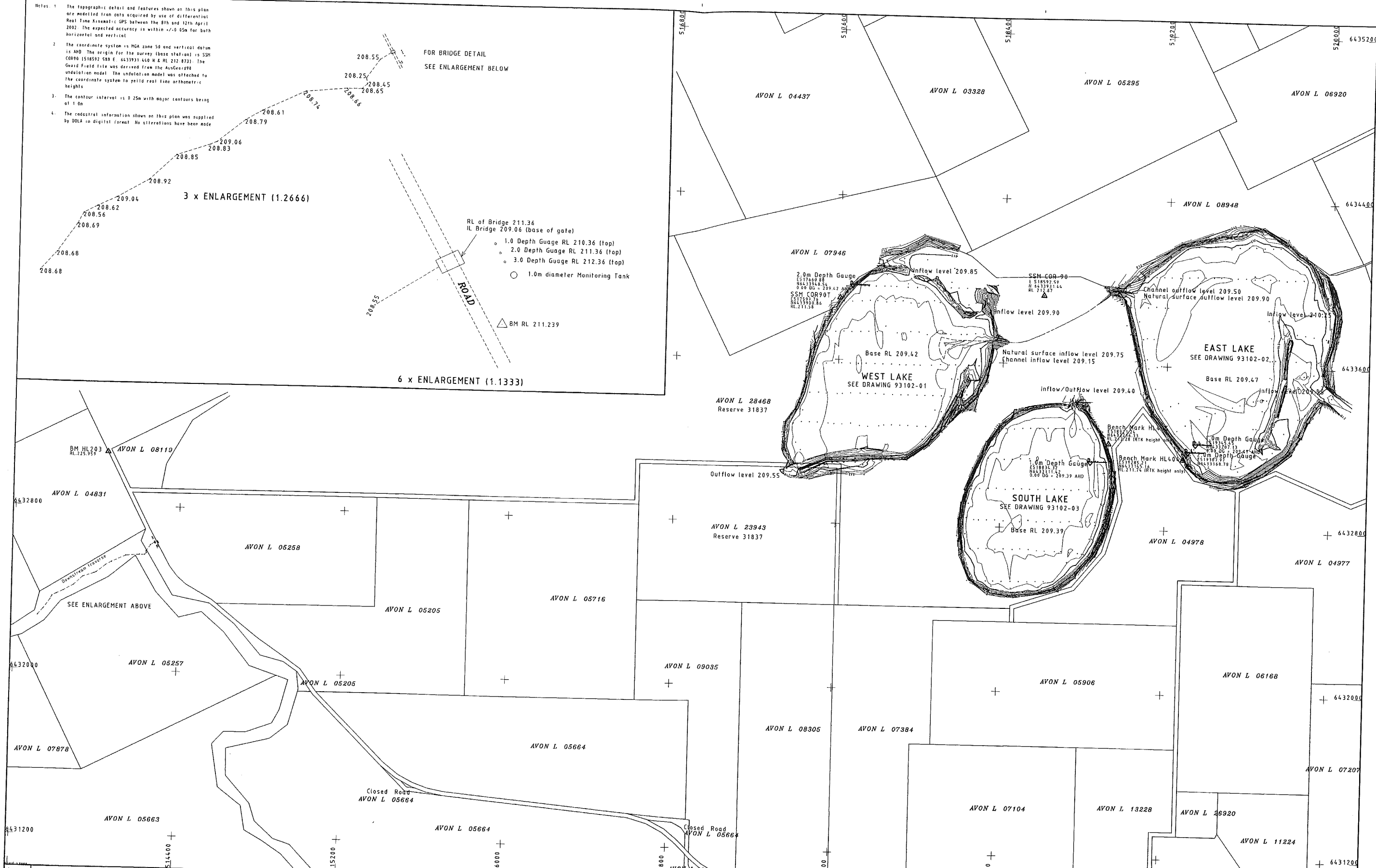
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Surveyor	DJ
Surveyed	April 2002
FB No.	FB 1646
Drawing	93102-03
Revision	A

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3. The contour interval is 0.25m with major contours being at 1.0m.

4. The cadastral information shown on this plan was supplied by ODLA in digital format. No alterations have been made.



3 x ENLARGEMENT (1:2666)

6 x ENLARGEMENT (1:1333)

FOR BRIDGE DETAIL
SEE ENLARGEMENT BELOW

- RL of Bridge 211.36
- IL Bridge 209.06 (base of gate)
- 1.0m Depth Gauge RL 210.36 (top)
- 2.0m Depth Gauge RL 211.36 (top)
- 3.0m Depth Gauge RL 212.36 (top)
- 1.0m diameter Monitoring Tank
- △ BM RL 211.239

YENYENING LAKE SYSTEM
LAKE BED SURVEYS
INDEX SHEET AND ROAD CROSSING DETAIL

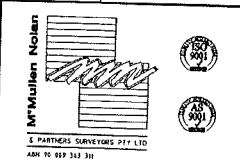
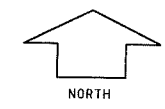
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160 0 640 SCALE 1:8000

ALL DISTANCES ARE IN METRES

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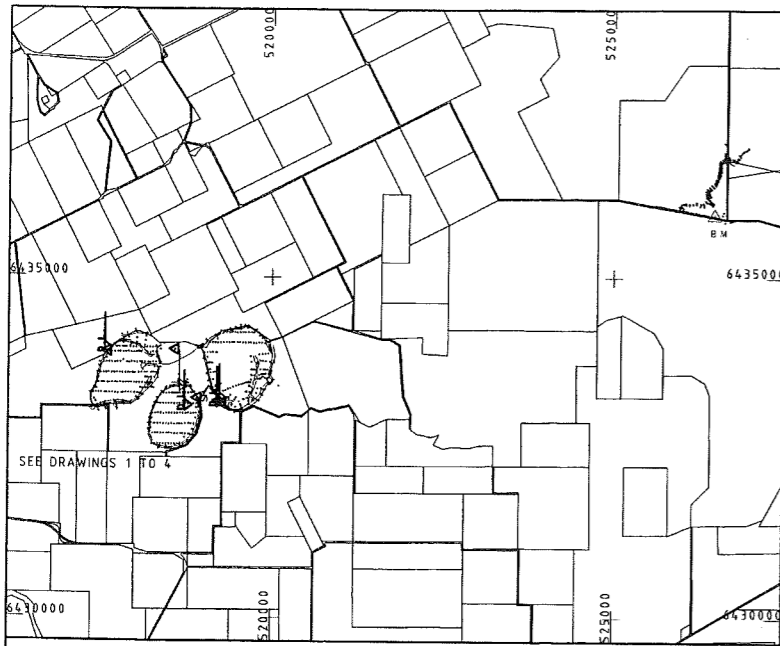
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Drawing - DWG-94



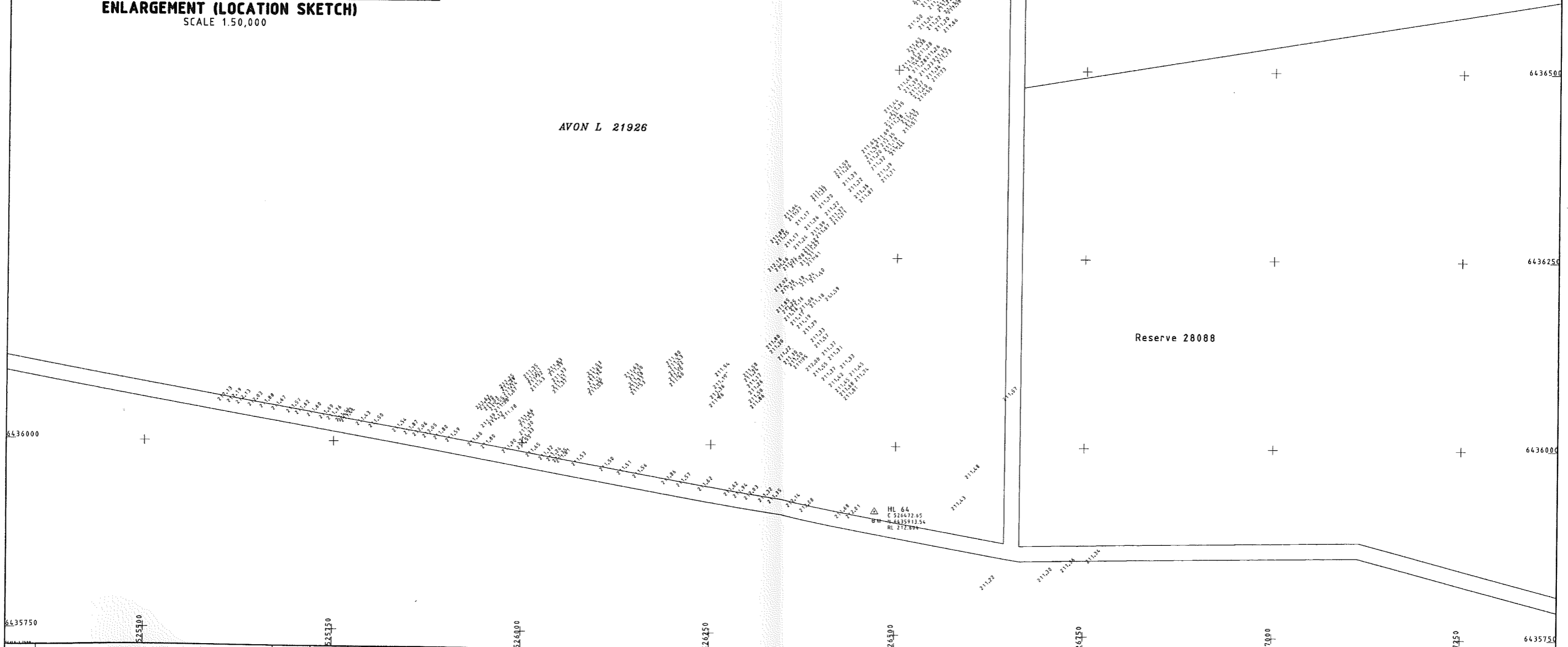
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Drawing	93102-04
Revision	A

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ENLARGEMENT (LOCATION SKETCH)
SCALE 1:50,000



Revision	Description	Drawn	Date	Checked
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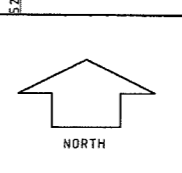
YEYENING LAKE SYSTEM
UPSTREAM LOCATION OF
DOWNSTREAM BRIDGE HEIGHT (212.36)

50 0 200
SCALE 1:2500
ALL DISTANCES ARE IN METRES

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FILES
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Drawing - DWG-05

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