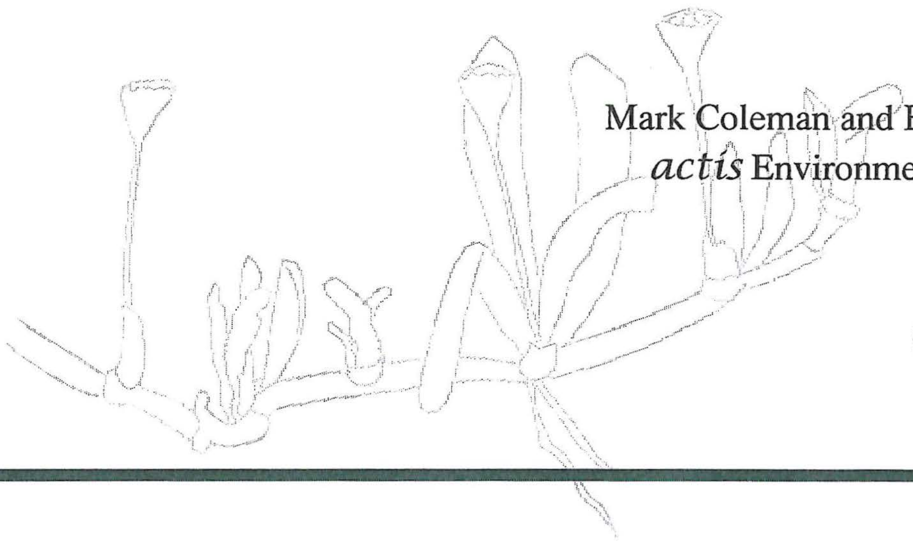
Lake Mears Discharge Evaluation

Report Prepared For:

Department of Conservation and Land Management

Narrogin



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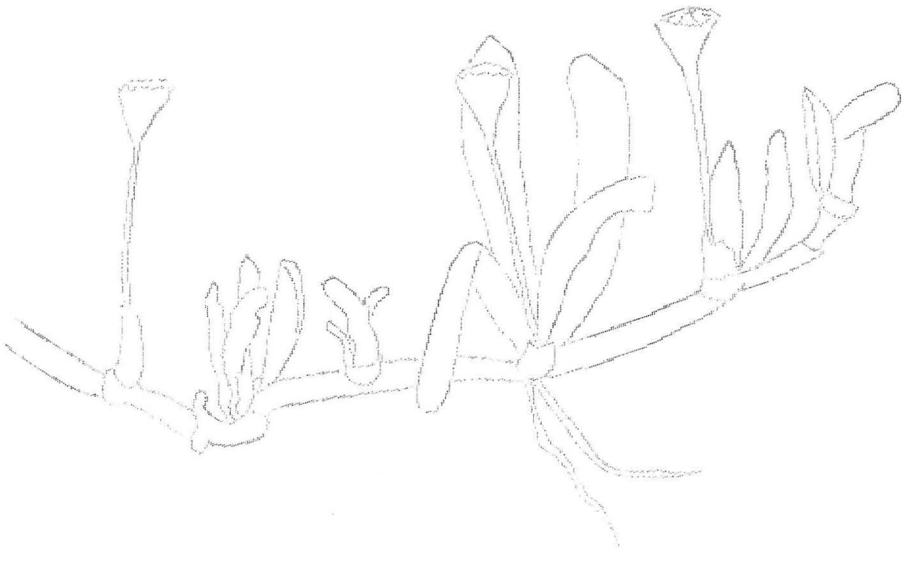

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1 Executive Summary

Lake Mears is situated in the Shire of Brookton, approximately 180 kms east of Perth, within the Avon River Catchment. The lake forms part of Lake Mears Nature Reserve (Number 12398). The reserve is Class A with a Management Order in favour of the Conservation Commission. It is managed for the Conservation of Flora and Fauna. Lake Mears is adjacent to the Yenyening Lakes system on the southern side. It is in the Avon Wheatbelt 1 (Ancient Drainage) IBRA region.

Lake Mears is 'peripheral' to the main flow down Kunjin Brook. That is the flow from Kunjin Brook reaches a fork or break point where the flow historically has been split between bypassing Lake Mears and filling Lake Mears. It has been estimated that this flow is in the region of 20% of the total flow entering Lake Mears but this would be very dependant on flow regime. Changes in the catchment such as clearing and increased sedimentation mean that the current situation does not reflect what would have been the situation prior to clearing. In addition, the control of water into and out of the Lake has been mechanically manipulated for a variety of reasons in the last 70-80 years. The ground and surface water flows have also changed over the last century with land management changes such as cultivation, clearing, road construction and dams. As a result the water quality and conservation of the Lake Mears environs has deteriorated with water logging and saline scalds becoming common.

A proposal has been put forward by the community to further change the hydrology of the landscape in order to recover some of the conservation and recreation values lost over an extended period (the loss accelerating over the last few decades).

The main features in the study area are shown in Figure 1. These are the upstream Kunjin Brook forming a split at the constructed gate with one flow going to Lake Mears and the second towards Yenyening Lakes System. This upper flow further divides to become what has been called Kunjin Brook South and Kunjin Brook North.

The community proposal has been reviewed by URS (2002) and that report has provided two options other than the do-nothing option. These can be simply described as the flushing and drain scenarios. This report does not seek to replicate the detailed discussion in URS (2002) but provides an indication of infrastructure paths in Figure 2. In brief, both proposals require the discharge of saline water from Lake Mears over time to the Yenyening Lakes System and the discharge and its potential impact on the downstream environment is the subject of the current report.

This report has followed a process outlined by (but modified from) that described by Coleman and Meney (2000). These parameters were evaluated for changes to Lake Mears, Kunjin Brook and Yenyening Lakes System and summarised in Table 2. All the changes are relative to the 'current' situation and not to the 'do nothing' scenario. The 'do nothing' requires determination of what changes are likely in the catchment and this is always debatable. It can be expected that salinity and salt load in the runoff will increase in the short to medium term. The volume of water and therefore the hydroperiod in the wetlands will also increase over the same period.

Table 1 Summary of Criteria Outcomes

Criteria	Lake Mears		Kunjin Brook		Yenyening Lake System	
	Flush	Drain	Flush	Drain	Flush	Drain
Salinity	Reduced	Reduced	Significant 'average' increase but within range	Significant 'average' increase but within range	Not significant	Not significant
Salt load	Reduced	Reduced	High initial discharge[1]	High initial discharge[3]	Not significant	Not significant
Hydroperiod	More frequent low events	More frequent low events	Not significant	Not significant	Not significant	Not significant
Ionic differences	No change	No change	Not significant	Not significant	Not significant	Not significant
pH	No change	Potential acid soils	Not significant	Potential acid soils	Unlikely to be significant	Unlikely to be significant
Nutrient concentration	Reduced	Reduced	High initial discharge	High initial discharge	Minor impact depending on flood scenario	Minor impact depending on flood scenario
Biomass	No change	No change	No change	No change	No change	No change
Encrustation	No change	No change	No change	No change	No change	No change
Conservation	Improved	Improved	Initial impact but no change in long term	Initial impact but no change in long term	Minor impact but no change in long term	Minor impact but no change in long term

1.1 Impact on Kunjin Brook and implied Agricultural Impact

In essence this report has concluded that the salinity in Kunjin Brook *below* Lake Mears will on average be higher but well within the current range of salinities found in the Brook. This is primarily a function of the initial higher salt load moving from Lake Mears to Yenyening Lakes System. The timing of this movement is entirely dependant on flooding regimes. It is noted that it is likely that 'natural' movements of large salt loads happens on a regular but infrequent basis. These salt loadings are going to become more common in the short to medium time frame unless the management of the upper catchment changes.

The other item of concern is the high nutrient concentration in Lake Mears compared to that in the Brook. This was a single spot value and should be substantiated with more samples over time. The issue is that it would seem that the nutrients have accumulated in Lake Mears from elevated levels in runoff, increased groundwater interaction and perhaps fauna. Potentially the high nutrient concentration may have more effect on nature conservation than the salt, as most natural environments in south-western Australia are adapted to low nutrient and variable salt concentrations. It is unlikely that the higher nutrient concentration will have an effect on the agricultural values of down stream Kunjin Brook.

The reason for the elevated nutrients needs to be determined before the nutrients can be discounted entirely. Amelioration may be needed in the future.

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[1] The salt load discharge for the initial receiving wetland was not evaluated in the Coleman and Meney (2000) criteria for provided reasons. It has been included as a comment here because of the concern for agricultural land downstream.

The agricultural impact has not been highlighted in this report due the more sensitive nature of the natural systems. However, the final route for the water coming out of Lake Mears needs to be evaluated on several issues. Namely the presence and absence of sands and clay soils and revegetation of the Kunjin Brook with plant species conducive to nutrient removal, water uptake and salinity tolerance. Local 'pre clearing' species will not be appropriate in most areas due to changed conditions. Planting with species having agricultural synergies (eg fodder) should be considered. Some areas with more natural values may be replanted with endemic species.

1.2 Impact on Nature Conservation Values of Lake Mears and Yenyening Lakes System

Other than the direct excavation impact which must be addressed at the time of detailed planning, the net conservation effect of both proposals to Lake Mears will be positive. There will be an overall reduction of salinity, salt load and hydroperiod. All three changes will move the balance more towards the historical natural balance. The question of large events being less frequent (that is large freshwater events) may be an issue depending on the management plan (control of gates) but it is assumed that large freshwater events will be retained.

It is expected that the issues that need to be addressed at the time of scoping and implementing any engineering activities, are potential

- acid soil excavation with the drain option, and
- rare plants and communities within the clearance (footprint) areas.

The impacts of the proposals on the Yenyening Lakes System are all negative and there is no perceived benefit to this system by the changes to Lake Mears. It is the view of this report that the changes are within the natural variation, and that the changes will be minor, especially given the long-term changes to the catchment. However in the case of the nutrient loading some consideration should be given to ameliorating the cause at the source (potentially agricultural runoff) or intercepting the nutrients before they reach the Yenyening Lakes System.

During the field trip it was evident that the areas where Kunjin Creek North and South discharge into the Yenyening Lakes System were both affected by secondary salinisation. Melaleuca shrub lands were deteriorating or dead and the samphires commonly found on recently salt/water logged land were dominant. No Declared Rare Flora or Priority species were seen at any site visited. There is the potential for *Sarcocornia globosa* (Priority3) to occur within the Yenyening Lakes system but it was not seen during this visit – a site visit in spring would pick this species up if it was present.

It is thought that the flushing or drainage discharge from Lake Mears would have little effect on these areas. Further to the west however, there are still areas of conservation value. Given that all discharge parameters except nutrients are within the natural variations of the System it is unlikely that the discharge from Lake Mears alone will have a long-term effect on the nature conservation of Yenyening Lakes. It is not known what the effect of short-term elevated nutrient levels will be on nature conservation – much will depend on the amount of rainfall accompanying the Lake Mears discharge and the subsequent flushing of the whole Yenyening Lakes System.

1.3 Last Word

It is noted that proposed projects do not attempt to address the underlying cause of the problem at Lake Mears. That being poor upper catchment management for water balance, salt or nutrients. The proposal does seem helpful for the health of the Lake Mears environment but displaces the existing impact to further downstream. Nutrients in particular are an issue to the Swan Estuary and salt load and salinity are problems to down stream communities on the Swan/Avon River. Remedial upstream and downstream works that may be already proposed should be referred to in the current proposal. Potential increased impacts to the Yenyening Lakes System may be reduced by land care changes to the route taken from Lake Mears to Yenyening Lakes System.

2 Introduction

Lake Mears is situated in the Shire of Brookton, approximately 180 kms east of Perth, within the Avon River Catchment. The lake forms part of Lake Mears Nature Reserve (Number 12398). The reserve is Class A with a Management Order in favour of the Conservation Commission. It is managed for the Conservation of Flora and Fauna. Lake Mears is adjacent to the Yenyening Lake system on the southern side. It is in the Avon sub catchment of the Avon catchment.

Lake Mears is not listed as a Wetland of National Importance (A Directory of Important Wetlands in Australia, 3rd Edition[2]), but is valued locally for its conservation and recreational attributes.

The Department of Conservation and Land Management (CALM) is working with the Lake Mears Catchment Group to determine ways to prevent the further decline in the water quality of the lake. In 2002, URS Pty Ltd was commissioned by CALM to undertake a feasibility of engineering solutions to improve the water quality of the Lake. The study identified two engineering possibilities. These were a drain option and a flushing option. In addition to this investigation URS completed modelling of surface flows and salt loads and investigated some of the environmental constraints for each option. They also considered longer-term catchment impacts affecting the lake.

The community takes an active interest in Lake Mears and generally wishes to see the lake managed to:

- maintain an adequate water level in the lake that is low in salinity when full, whilst ensuring that the lake continues to retain its natural function especially during flooding events;
- provide favourable conditions for approved water-based recreation activities and restore the beauty of the lake's native vegetation and adjoining bush land;
- maintain viable populations of indigenous flora and fauna in and around the lakes; control feral and pest species (notably rabbits, cats and foxes); minimize the infestations of weeds in bush land around the lakes; and rehabilitate degraded bush land around the lakes;
- provide a wetland habitat suitable for waterfowl; and
- use the lake for recreational purposes.

This study is to provide information on the longer term management of the Reserve within the context of the broader catchment.

[2] http://www.deh.gov.au/water/wetlands/database/directory/index.html

The main features in the study area are shown in Figure 1. These are the upstream Kunjin Brook forming a split at the constructed gate with one flow going to Lake Mears and the second towards Yenyening Lakes System. This upper flow further divides to become what has been called Kunjin Brook South and Kunjin Brook North.

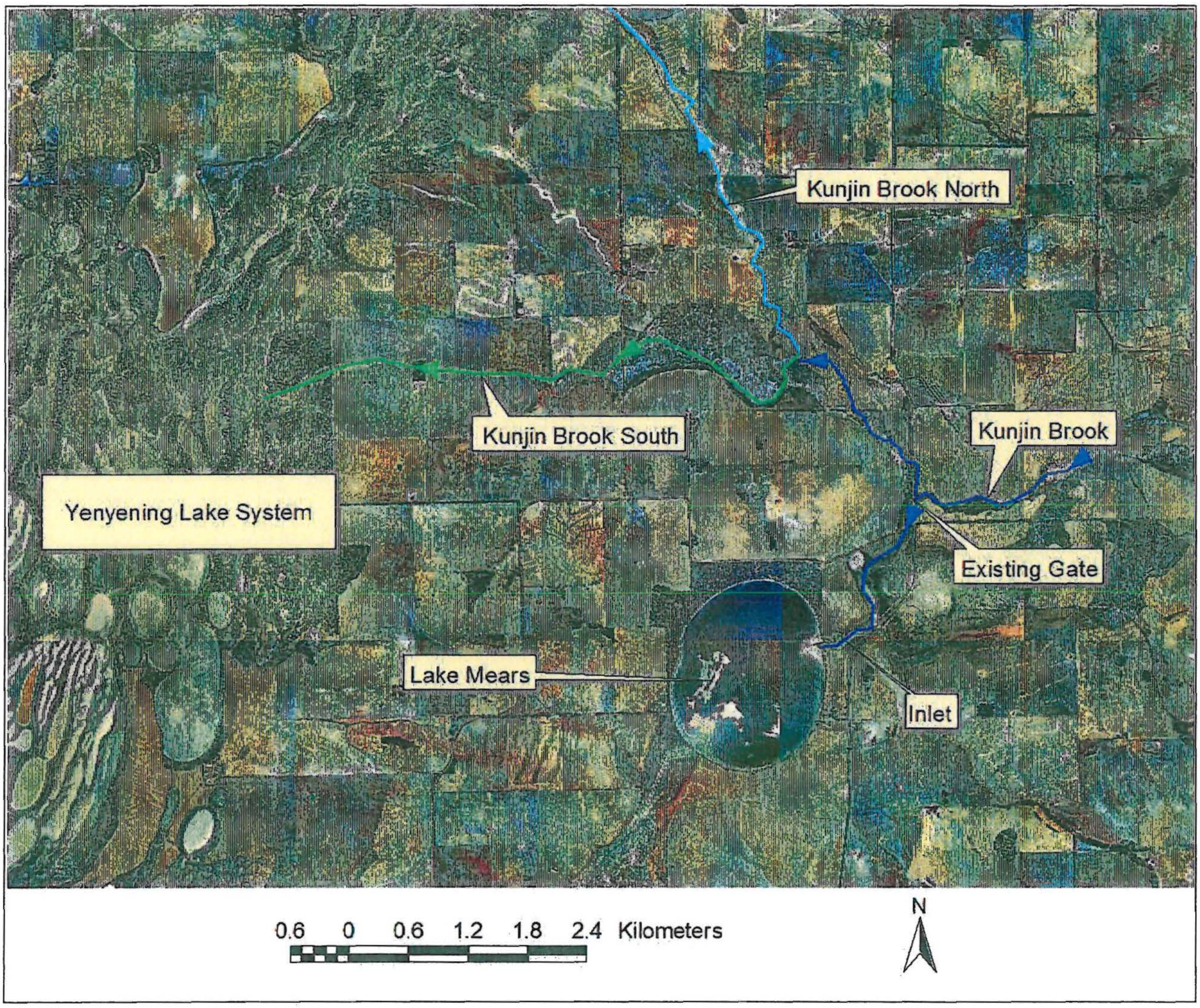

Figure 1 Main features of study

The community proposals have been reviewed by URS (2002) and that report has provided two options other than the do-nothing option. These can be simply described as the flushing and drain scenarios. This report does not seek to replicate the detailed discussion in URS (2002) but provides an indication of infrastructure paths in Figure 2. In brief, both proposals require the discharge of saline water from Lake Mears over time to the Yenyening Lakes System and the discharge and its potential impact on the downstream environment is the subject of the current report.

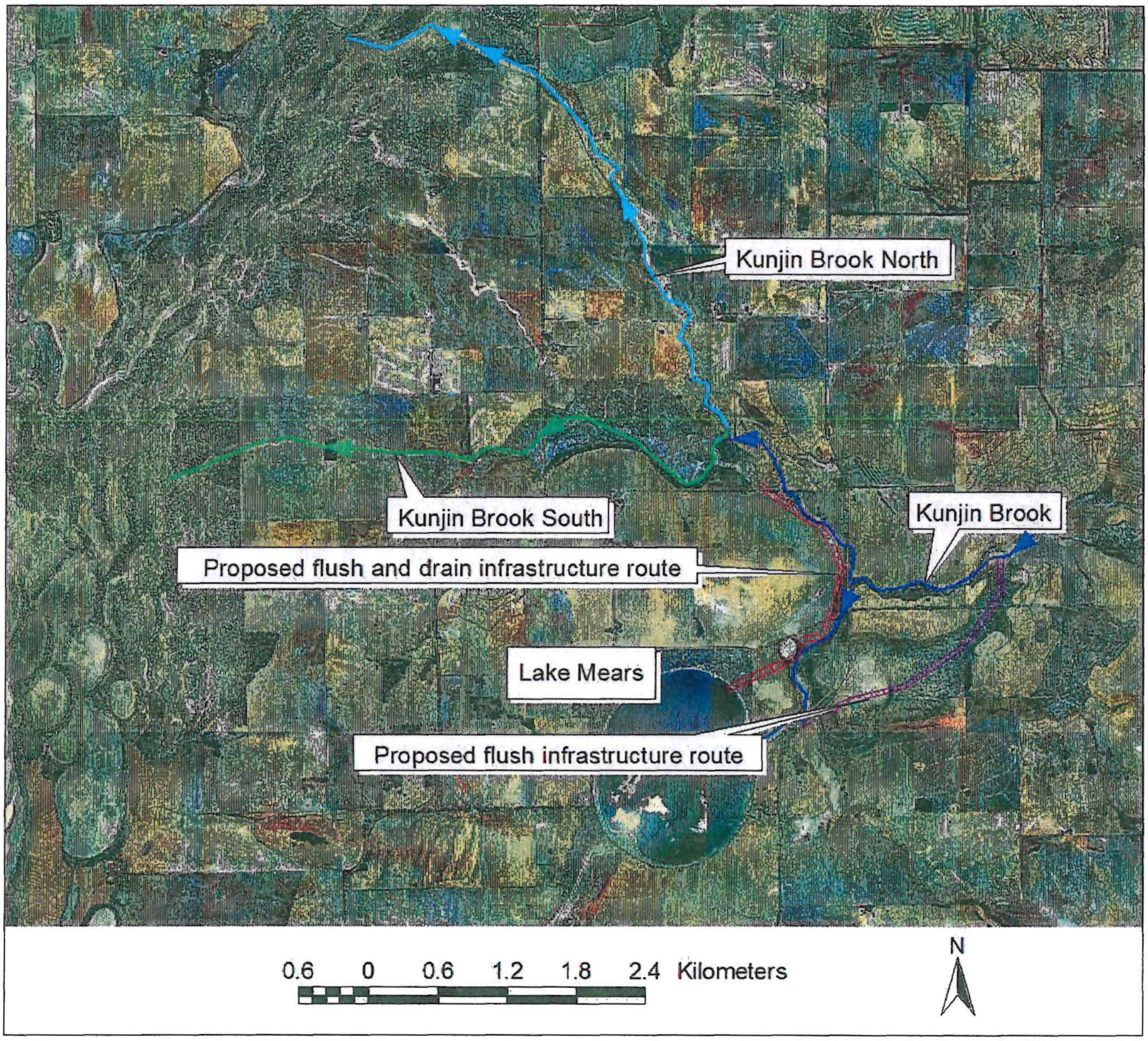

Figure 2 Proposed infrastructure routes

3 Objective and Scope

The objectives of this project are to assess the direct (to Lake Mears Nature Reserve) and indirect (downstream from Lake Mears via Kunjin Brook to the Yenyening Lakes system) environmental and agricultural impacts of three engineering options:

- the "drain" option;
- the "flushing" option;
- a combination of both options (drain first then construct flushing system); and
- the status quo.

The scope is:

1. Assess the environmental impact on nature conservation and other values (agricultural and hydrological) of the drain or flushing option, status quo, or a combination of both described in the report " Feasibility of Engineering works to improve Water Quality in Lake Mears" (URS 2002). The assessment of hydrological impacts on receiving environments followed the methodology described in the report "Impacts of Rural Drainage on Nature Conservation Values" (Coleman and Meney, 2000) with documented modifications.

2. Assess the net impact on nature conservation values to Lake Mears Nature Reserve and Yenyening Lakes Nature Reserve. The study considers the direct short and long-term impacts, both negative and positive, to the reserve, as well as, the indirect impacts from draining Lake Mears and the indirect impacts to the receiving environment at Yenyening.

4 Discussion of Options with Particular Reference to URS (2002)

The URS (2002) report for the Department of Conservation and Land Management titled 'Feasibility of Engineering Works to Improve Water Quality in Lake Mears' is an important document in the planning of the maintenance and disposal of water into and out of Lake Mears. For this reason it was reviewed and summarised within the context of the current project and the experience of the Authors.

The principal stream into (and, as is typical of wheat belt lakes – out of) Lake Mears is named Kunjin Brook. Prior to the construction and excavation of the Brook in *cira* 1965and in times of stream flow (during winter and potentially in high rainfall events in summer), the Brook flowed into Lake Mears and in addition to local flows and seepage, created a lake with a depth of up to 2.4 metres. At this height the flow reverses to a 'divide point at the installed gate (see Figure 1) and flows down an alternative branch(s) to the Yenyening Lakes region. This alternative branch receives water from the upper catchment even when Lake Mears is not full. URS(2002) estimate that about a quarter of the flow down Kunjin Brook enters Lake Mears and contributes to 75% of the total water in the Lake with direct rainfall and local runoff making up the remainder in the Lake.

It is known that the local community constructed an adjustable height weir in 1931 that allowed more water to be directed into Lake Mears by reducing the bypass flow and to trap more water than was historically possible in the Lake. The apparent objective was to increase the period of time that the Lake would be useful for recreational sport. With the construction of the new gates in 1965 and earth works it is believed by URS (2002) that the Brook water would not enter the Lake unless the gates are shut. It appears that normal operation of the gates in their present form is to be open until substantial low salinity flows occur whereupon the flow is redirected into Lake Mears. This practice has only been used in the last decade or so. Prior to this time the gates were routinely left shut diverting all flows to Lake Mears.

The character of the catchment has also changed during this period. Land management during this period has resulted in the reduction of net transpiration (removal of trees), increased catchment surface flows and velocity (roads, trees again, soil compaction) and increased deep soil recharge. As a result the trend has been for increased stream flows and velocity at least for local precipitation, rising water tables and interception with the surface, and mobilisation of salt on the surface. Some land management practices have attempted to reverse this process such as interception drains but generally they have not reversed the trend, especially as other drains have been constructed to increase the removal of water and salt off land.

URS (2002) stated that the salinisation in the Lake is extensive and worsening, and that rising water tables and secondary salinisation in the catchment will result in bigger floods, increased salt loads and likely increased salt concentration in smaller runoffs.

URS (2002) reviewed the options for reducing salinity in the Lake and opted for two options. These are[3] :

- Drain option – retain existing gates to operate as per the past, and construct a drain from Lake Mears to Kunjin Brook downstream of current gates. The drain would be controlled with another set of gates. Various capital works will be needed.
- Flushing option – all water from the Kunjin Brook enters the Lake and exits from a natural low point and drained to downstream Kunjin Brook. The Lake instead of becoming an appendix to the main flow becomes a basin within the main flow of the Brook.

[3] Refer to URS (2002) for more detailed description.

According to URS (2002) both options will reduce the salinity of Lake Mears but that the flushing option is more robust an engineering project. The interpretations of the modelled scenarios by this report's authors, given URS (2002) statements, are; the drain will reduce the salt load in the Lake but not significantly change the water load into the lake (it may be reduced), and the flushing option will increase the water load and reduce the salt load. Both will depend on the operation of the gates and the management of the infrastructure. URS (2002) requested flow characteristics which suggest that the modelling is subject to assumed flow patterns and therefore there is an inherent risk in the modelled outcomes being incorrect.

There are several questions as to the accuracy of the modelling. These comments are made in the light of highlighting the vulnerability of relying on modelled outcomes and the need to assess the risk involved in any decision process.

It is notable with the URS model that the evaporation is significantly overestimated because the lake factor used is too large (more like 0.7-0.8 rather than 0.9) and there is no mention of reflective potential of salt crust and small water depths reducing the modelled evaporation. If the bathymetry was not modelled and changing areas incorporated into the model this would also significantly over-estimate the evaporation due to low fill events.

The salt load in 2002 according to the URS (2002) report was 140,000 tonnes. The recorded figures in the same report (Figure 3-1) show that it has varied around 40,000 but perhaps up to 100,000 tonnes in the period up to 1999 when allowing for an inaccurate estimate of volume. There are two readings post the 1999 flood that show that the salt load may have been 141kt. These estimations are based on salinity-volume recording but do not allow for the Lake's bathymetry. The mass of salt at the time of *actis* Environmental Services visit in 2005 was not investigated but experience and one spot measurement of salinity would place the salt load in the lake as significantly below 40,000 tonnes and more likely as low as 15,000 tonnes. The current report has come to the conclusion that the 141,000 tonnes is an inaccurate or exceptional estimate (perhaps generated by anecdotal evidence), and that the actual salt load varies between 15 and 40 kt depending on recent flood events. There can be no doubt that the salt load and therefore the average salinity has increased over the period and the trend will be for the amount to increase- it is only the magnitude in question.

The URS (2002) modelled detailed data for the expected outcomes for each engineering option in terms of salinity, volume and salt load. This data must be accepted within the model assumptions as it seems a comprehensive attempt to predict the changes to the water and salt cycles within Lake Mears. This data is referred to in subsequent text and analysis (section 5).

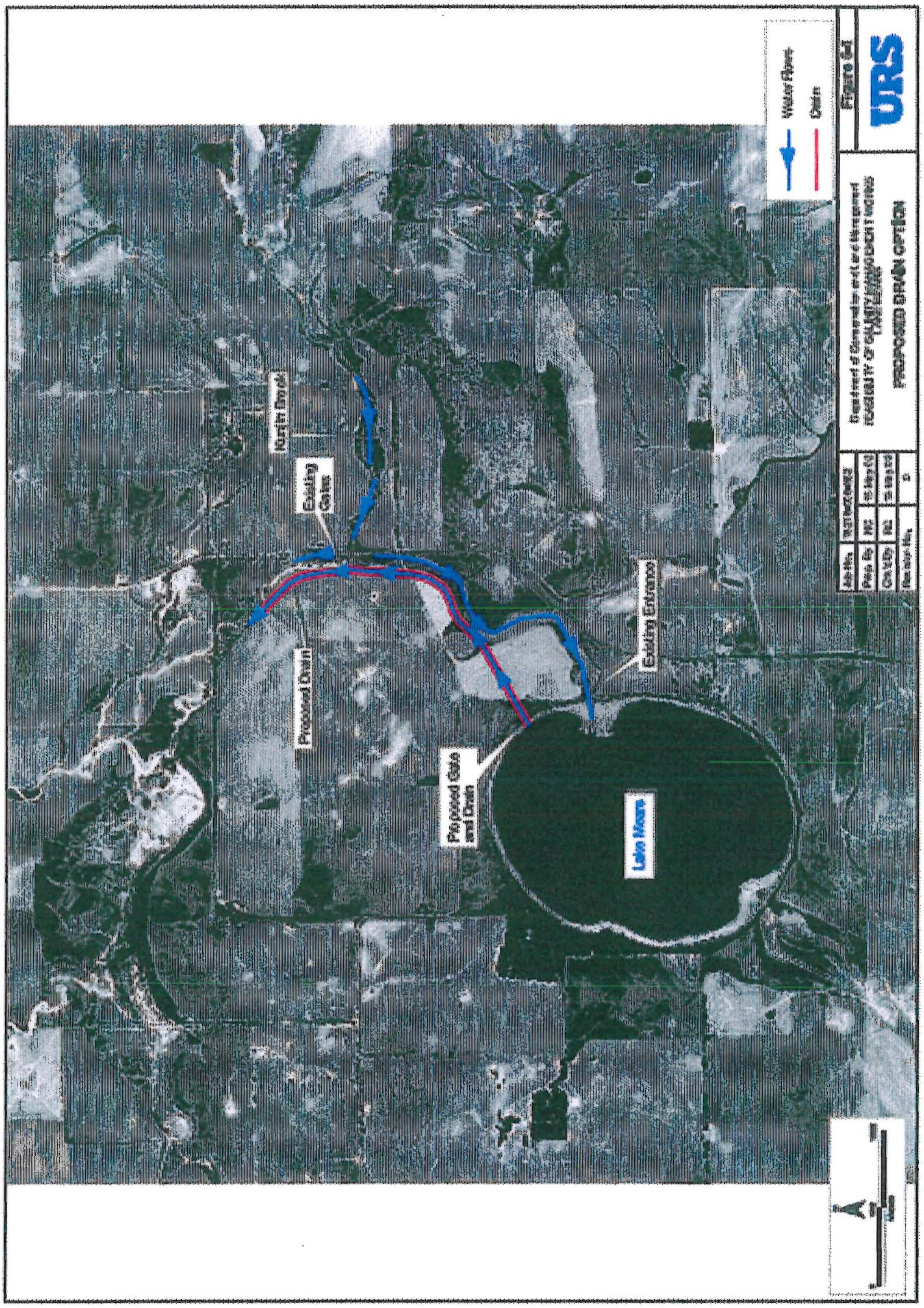

Figure 3 Drain Option (URS 2002)

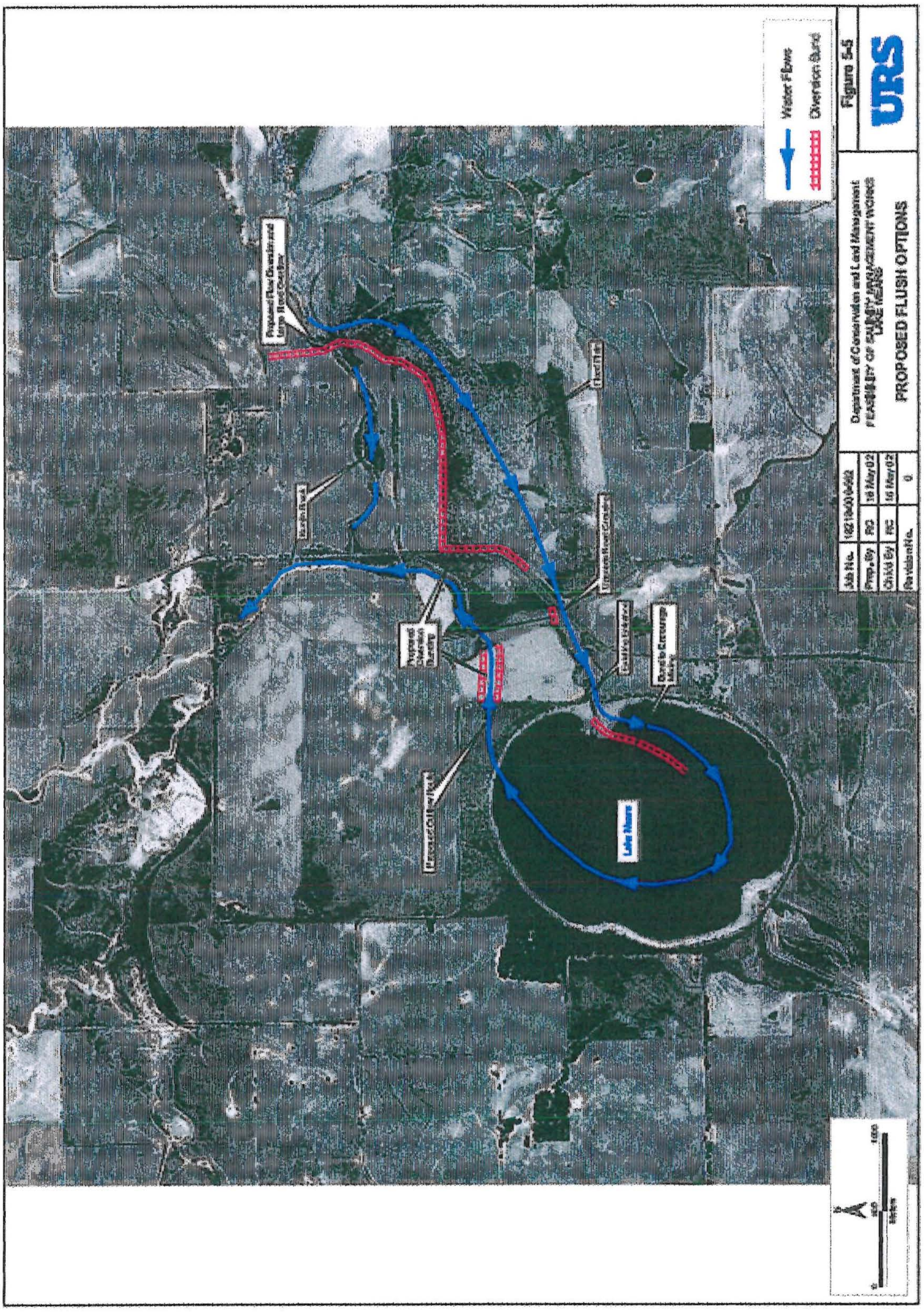

Figure 4 Flush Option (URS 2002)

5 Coleman and Meney Evaluation Criteria

Coleman and Meney (2000) considered the following key processes as critical to the maintenance of wetland biological communities:

- Wetlands operate within, and depend on, their natural fluctuating salinity range. That is, much biota requires the lower end of the salinity range to germinate and breed. A change in the distribution of high and low salinity levels is likely to be reflected in a shift in species composition. Therefore, both the upper critical thresholds and the lower critical thresholds need to be understood on a temporal basis.
- Wetlands operate within, and depend on, their natural fluctuating hydroperiod range.
- The natural diversity values of secondary saline wetlands are likely to vary from wetland to wetland, depending on other variables such as hydroperiod change, surrounding habitat and original salinity status. In many cases, the loss of fauna will reflect degradation of vegetation assemblages, both within and surrounding the wetland.

The key physical parameters in the processes, characteristics and/or functions of a natural wetland are:

Water
Salt
Ionic Composition
Nutrients

These parameters manifest in wetlands as:

- Salinity
- Salt load
- Hydroperiod
- Ionic differences
- pH
- Nutrient concentration
- Biomass
- Encrustation by precipitates that are not highly soluble or redissolved in the wet part of the hydroperiod

Some of the key parameters mentioned by Coleman and Meney (2000) can be modelled to give an indication of potential changes to the ecosystem. The ones that can be modelled are salinity, salt load and hydroperiod. The parameters that cannot be modelled are nutrient concentration, ionic differences, pH and biomass. These can only be determined by measuring the background levels and comparing them with that being proposed in the discharge.

Concurrent with the study of the key parameters, outstanding conservation issues need to be evaluated, such as rare species and communities that may be found in the region. If these may be influenced then further work is needed to demonstrate the level of impact on those important values. The proposed study only identifies if there are key conservation issues.

The receiving wetlands for the proposed engineering works are the Yenyening Lakes System and associated water courses. It is these wetlands that the criteria should evaluate as it is assumed that the changes to Lake Mears will be beneficial. However it is proposed to apply the evaluation criteria to the Lake under the two scenarios compared to the do nothing option for completeness. The Coleman and Meney (2000) criteria was designed for artificial drains and therefore the *proforma* method provided does not apply but the logic and factors do apply and only require modification in regards to the evaluation of the criteria. Lake Mears is being considered because of the significant changes to its hydrological function.

The definitions of the receiving wetlands as presented in Coleman and Meney (2000) are:

The **primary receiving wetland** is defined as:

The first wetland at the end of the drainage network. In some cases there will be multiple discharge points to this wetland.

The **final receiving wetland** is defined as:

The first basin or flat downstream of the discharge point which discharges less frequently than every two years.

By these definitions Kunjin Brook would be the primary receiving wetland and the Indian Ocean the final receiving wetland. The Yenyening Lakes System discharges every year and has a input of nearly 400 kt of salt per year for a residual of approximately 200kt (various sections WRC 2002). The Yenyening Lakes System is therefore not the final receiving wetland but is important enough to be considered as well as the Kunjin Brook. The ocean does not need to be evaluated as a final receiving wetland according to the Coleman and Meney (2000) criteria.

Lake Mears could be considered as the 'drainage system' but since it is a natural system with some conservation values it is also being considered a final receiving wetland as a measure of changes to its conservation value.

The following uses the criteria to evaluate the changes to the wetlands and unless stated it can be assumed that the data quoted is from the URS (2002) report.

5.1 Lake Mears

5.1.1 Salinity

Both the flushing and drain option will reduce the salinity of the Lake to having a cumulative probability of having a salinity less than 10,000 mg/L or brackish for about 50% of the flooding time. This is not as low as expected for the pre-clearing period (cira 500 mg/L and less than brackish for most if not all of the flooding cycle) but is significantly better than the less than 5% probability of being brackish or less for the do nothing option. See Figure 5 for details. Lake Mears had a TDS of 300 g/L at the time of visit in April 2005 although the inlet channel had a much lower TDS at 34 g/L.

Without intervention the salinity will be higher for more prolonged wetting events. The salinity will occasionally be reduced during discharge events.

5.1.2 Salt load

The salt load was modelled by the URS report in their Figure 5-2. Although the current salt load is contentious, given that the volume and salinity are expected to fall under the two proposed engineering projects it is expected that the salt load will also fall. This is considered beneficial for the ecology of Lake Mears. The URS (2002) report gave the salt load in Lake Mears at that time as being 141,000 tonnes of salt. At the time of the visit by the authors the salt load in Lake Mears was estimated as being closer to 18,000 tonnes of salt. This was based on the TDS at 300 g/L and less than 50% coverage at an average depth of 5 cm. The difference in estimated salt load can not be attributed to anything in particular but it could be that a rain event had flushed the system between 2002 and 2005. This has implications for management as the Lake then does not accumulate salt continuously but flushes during episodic events, albeit to a higher salt load than was probably there before clearing of the catchment.

Without intervention the salt load will continue to increase with occasional expulsion of high salt loads during flooding events. This pulse of salt may be of no consequence during a major flood but also can have serious repercussions during minor or local flood events to the downstream environment.

5.1.3 Hydroperiod

The URS (2002) report predicted that in both the drain and flushing scenario the probability of more water being in the Lake for small flow events is higher but the probability of water for the high flow events is lower. That is the Lake will be flooded for less time than it is currently. Like most wetlands in the wheatbelt, Lake Mears is suffering from increased water logging and salinity so it is probable (without much more detailed surveys) that the reduced hydroperiod will be beneficial for the ecology. It is thought that the social amenity of the Lake will be reduced by having a reduced water flooding.

5.1.4 Ionic differences, pH, Nutrient concentration, Biomass and Precipitates

Water quality, such as ionic differences, are not expected to change as the same water would be flowing into the Lake as for the do nothing scenario. Lake Mears' water did have a TP and TN concentration that was significantly higher than the surrounding water bodies (see Table 3). These high values are of concern as it probably reflects local land use more than broader catchment changes.

5.1.5 Conservation

The vegetation around Lake Mears is a Class 'A' reserve and therefore any disturbance to the vegetation will require a check of the disturbance pathway for priority species and ecosystems. It is not a priority wetland although it has value as a recreational and conservation wetland for the region.

The vegetation at Lake Mears itself has degraded from the natural state with extensive plant deaths and species displacement near the Lake. However, the remaining vegetation was in reasonable health and there is the potential for the Lake to rehabilitate, given a water/salt regime similar to that which occurred historically.

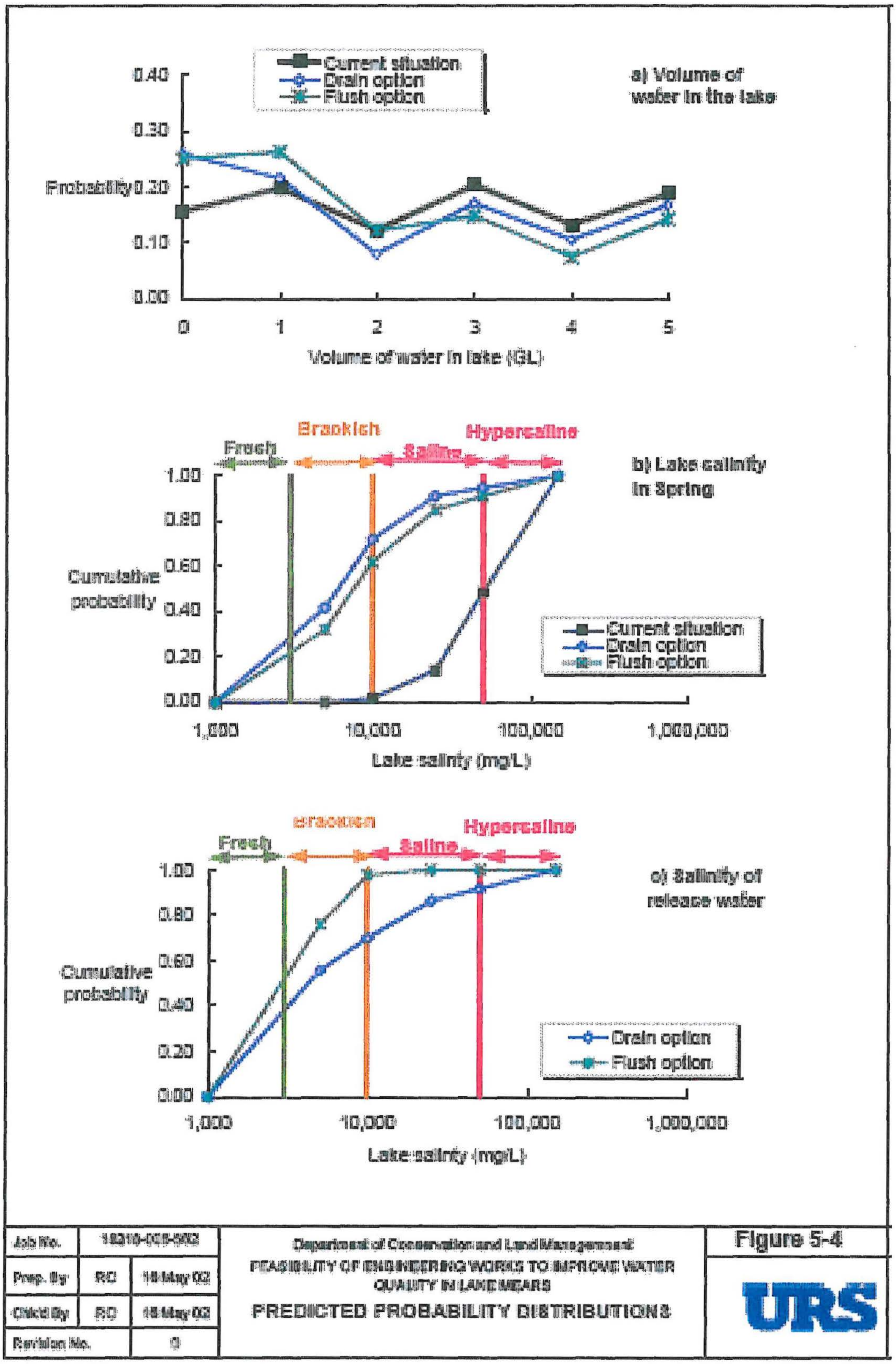

Figure 5 Lake Mears modelled water quality (URS 2002)

5.2 *Yenyening Lakes System and water ways*

The discharge from Lake Mears runs into the Kunjin Brook and from there to the Yenyening Lakes system. There are two alternative routes to the Yenyening Lakes. It is unknown whether the two drainage channels have any other name other than Kunjin Brook.

5.3 *Kunjin Brook (primary receiving wetland)*

5.3.1 Salinity

The predicted annual stream flow from Kunjin Brook to Lake Mears (URS 2002) was 2 GL with a salt load of 3,419 t giving an average TDS of 1.7g/L. (The total annual stream flow for Kunjin Brook as predicted by URS (2002, page 5-4) was for 9 GL at a salt load of 102,731,880 t giving an average TDS of 11,000 g/L which is obviously incorrect, so has not been used.) Furthermore, Table 4-7 in the URS (2002) report provides alternative figures for the salinity of Lake Mears catchment of which Kunjin Brook is the major component with an annual salt concentration of between 40 and 1.4 g/L depending on the flood event.

The Coleman and Meney (2000) criteria provides for a 10% variation from normal before the discharge is considered significant.

5.3.1.1 Flushing Option

For the flushing option the URS (2002) report in Tables 5-6 and 5-7 gave a release volume from Lake Mears of 2.6 GL and salt load of 8,074 t on an annual basis. This converts to a salt concentration of 3.1 g/L. In a comparative time frame and assumption basis, the Kunjin Brook has a TDS of 1.68 g/L.

As a result the salinity increase due to the discharge was in the region of 100% but the salinity of the discharge was within the 'normal' range expected for Kunjin Brook.

5.3.1.2 Drain Option

For the drain option the (URS 2002)report in Tables 5-2 and 5-3 gave a release volume from Lake Mears of 0.5 GL and salt load of 4,846 t on an annual basis. This converts to a salt concentration of 9.6 g/L. In a comparative time frame and assumption basis, the Kunjin Brook has a TDS of 1.64 g/L.

As a result the salinity increase due to the discharge was in the region of 600% but again the salinity of the discharge was within the 'normal' range expected for Kunjin Brook.

5.3.2 Hydroperiod

It is predicted by URS (2002) that in a 'normal' year the flow from Kunjin Brook to Lake Mears is about 2 GL and that none of it is returned to Kunjin Brook. The flow is of the order of 22% of the total flow.

5.3.2.1 Flushing Option

In this option more water is diverted from Kunjin Brook but also water is returned. The net change in flow from Kunjin Brook to Lake Mears over what is being considered as normal is an outflow of

0.3 GL per annum. This equates to an outflow change of 3% and below what would be considered significant to the hydroperiod of Kunjin Brook.

5.3.2.2 Drain Option

In this option more water is diverted from Kunjin Brook but also water is returned. The net change in flow from Kunjin Brook to Lake Mears over what is being considered as normal is an outflow of 0.2 GL per annum. This equates to an outflow change of 2% and below what would be considered significant to the hydroperiod of Kunjin Brook.

5.3.3 Ionic differences, pH, Nutrient concentration, Biomass and Precipitates

There are no perceived issues with the water quality other than the salt concentration, as the objective is to recycle water from Kunjin Brook though Lake Mears and back to Kunjin Brook. The only caution is that the drain water may be more acidic and nutrient-rich. This should be a temporary issue until the anaerobic layers in the Lake become oxidised. The initial flush from Lake Mears will be higher in nutrients (and salt) than the receiving waters. To a limited degree this will always be true as birds use the Lake as a roosting site, contributing to the nutrient load. This phenomenon has been reported for enclosed wetlands elsewhere.

5.3.4 Conservation

Kunjin Brook runs through agricultural land for the main part so has already been modified from its original form. It also has been excavated and re-formed into a drain and has had gates placed to direct water flows. Most of Kunjin Brook is sparsely vegetated however in places samphires feature. At the site in Kunjin Brook that was visited were mostly samphire species commonly seen in areas that have secondary salinisation – *Halosarcia pergranulata, Halosarcia lepidosperma, Sarcocornia blackiana,* also *Frankenia* sp and domestic grasses. It is thought that any flora and fauna now living in Kunjin Brook should not be affected in the long term by either the flushing or draining of Lake Mears. In the short term extra nutrients and/or salt may have a temporary effect on some flora or fauna living in the creek but this is unlikely to be permanent.

5.4 Yenyening Lakes System (secondary receiving wetland)

5.4.1 Salinity

It has already been determined that salinity of the discharge water will be higher than the water currently emptying from the Kunjin Brook into the Yenyening Lakes system (1.5-2 g/L). The salinity from the flushing option will be approximately 3g/L on average whereas the drain option water will be approximately 9.5g/L on average.

It was reported in (WRC 2002) page 36 that the salinity varied from 1 to 300 g/L TDS and that the modelling (on page 45-46) showed that the TDS varied between 10 and 300 g/L in more recent times with a median of 60 g/L. The input salinity was calculated, from the data provided, to be in the region of 10 g/L on average. Based on this information the conclusion can be reached that the discharge from Lake Mears in both options will not be at all different from the salinity of the Yenyening Lakes in their current form. The species in the Lakes would not be adversely affected by salinity.

5.4.2 Salt load

Technically the salt load does not need to be considered according to the (Coleman and Meney 2000) evaluation method as the Yenyening Lakes 'turnover' more often than once every two years. This is an important parameter as although the salinity may be similar in the discharge water to the receiving water the accumulation of salt in the receiving wetland can be significant. The salt load is not considered for the primary receiving wetland as it is considered that the salt will flow though the system and not accumulate.

5.4.2.1 Flushing Option

URS (2002) stated that the annual salt load from Lake Mears in the flushing scenario will be 8000 tonnes per year. WRC (2002) found that the average annual salt load into the Yenyening Lake system for the period from 1973 to 2000 was 381,000 tonnes per annum. This would make the increase in salt load into the Yenyening Lakes in the order of 2% per annum. This is not considered to be significant given the turnover period of less than a year on average.

5.4.2.2 Drain Option

URS (2002) stated that the annual salt load from Lake Mears in the drain scenario will be 5,000 tonnes per year. This would make the increase in salt load into the Yenyening Lakes in the order of 1% per annum, worked out on the same basis as for the flushing option. This is not considered to be a significant load into the Yenyening Lakes given the turnover period of less than a year on average.

5.4.3 Hydroperiod

The water flow into and out of the Yenyening Lakes is more than four times the flow down the Kunjin Brook. Since the change in flow and therefore hydroperiod was not considered significant for the Kunjin Brook it is similarly of less impact on the Yenyening Lake system.

5.4.4 Ionic differences

The major ions were compared in Lake Mears and Qualandary Crossing. The ratio of major ions was referenced to standard seawater to counter the varying ratios due to salinity differences. Unless this is done the ion differences reflect changes in salinity and not different source water. The ratio of sodium and chloride is the same for Lake Mears and Qualandary Crossing with lower sodium to chloride ratio than standard seawater. The calcium to sulphate ratio was not only much higher than standard seawater for both locations but the calcium to sulphate ratio was higher in Lake Mears than Qualandary Crossing. This is due to the elevated calcium concentration in the water. The sulphate ion is still the dominant ion in the solubility product and will still dominate the final water. Again it was considered that the water has a similar ionic composition.

5.4.5 pH

All of the water had near neutral pH. The drain option will need to be monitored for acidity contributed by the disturbance of organically rich soils from Lake Mears.

5.4.6 Nutrient concentration

The nutrient concentration in the Lake Mears water was a factor of four higher than all other samples including Qualandary Crossing (see Table 3). The nutrients would be discharged to the streams and finally pass through to the Yenyening Lakes and the Swan River. It is expected that the nutrients would be higher for the draining scenario than the flushing scenario, but initially would be substantial for both scenarios.

5.4.7 Biomass

No biomass is expected to be discharged from Lake Mears other than plankton. This has been discussed in the nutrient loading. The nutrient concentration of the discharge on an ongoing basis will be similar to what is already in the system assuming that the nutrient concentration follows the salinity as modelled.

5.4.8 Precipitates

The salinity of the discharge on an ongoing basis as modelled will be similar to what is already in the system.

5.4.9 Conservation

During the field trip it was evident that the areas where Kunjin Creek North and South discharge into the Yenyening Lakes System were both affected by secondary salinisation. Melaleuca shrub lands were deteriorating or dead and the samphires commonly found on recently salinised land were dominant. It is thought that the flushing or drainage discharge from Lake Mears would have little effect on these areas. Further to the west however, there are still areas of conservation value. Given that all discharge parameters except nutrients are within the natural variations of the System it is unlikely that the discharge from Lake Mears alone will have a long-term effect on the nature conservation of Yenyening Lakes. It is not known what the effect of short-term elevated nutrient levels will be on nature conservation – much will depend on the amount of rainfall accompanying the Lake Mears discharge and the subsequent flushing of the whole Yenyening Lakes System.

Possible effects of the extra nutrient load could be accelerated growth of *Ruppia* sp or algae, which could be beneficial to water birds.

6 Summary

This report has followed a process outlined by (but modified from) that described by Coleman and Meney (2000). The philosophy of the criteria in Coleman and Meney (2000) is to identify the more important functions of wetlands and describe the impact of changes on those functions. A tolerance of ten percent was allowed in the Coleman and Meney (2000) because it was believed that this variation was well within the natural variation of ecosystems and measurement.

These parameters were evaluated for changes to Lake Mears, Kunjin Brook and Yenyening Lakes System and summarised in Table 2. All the changes are relative to the 'current' situation and not to the 'do nothing' scenario. The 'do nothing' requires determination of what changes are likely in the catchment and this is always debatable. It can be expected that salinity and salt load in the runoff will increase in the short to medium term. The volume of water and therefore the hydroperiod in the wetlands will also increase over the same period.

The report relies heavily on the models proposed in URS (2002) and whereas that report appears competent, models are inherently flawed approximations of reality. There were issues with some conclusions reached in the URS (2002) report, notably the estimations of salt load.

Table 2 Summary of Criteria Outcomes

	Lake Mears		Kunjin Brook		Yenyening Lake System	
Criteria	Flush	Drain	Flush	Drain	Flush	Drain
Salinity	Reduced	Reduced	Significant 'average' increase but within range	Significant 'average' increase but within range	Not significant	Not significant
Salt load	Reduced	Reduced	High initial discharge[4]	High initial discharge[3]	Not significant	Not significant
Hydroperiod	More frequent low events	More frequent low events	Not significant	Not significant	Not significant	Not significant
Ionic differences	No change	No change	Not significant	Not significant	Not significant	Not significant
pH	No change	Potential acid soils	Not significant	Potential acid soils	Unlikely to be significant	Unlikely to be significant
Nutrient concentration	Reduced	Reduced	High initial discharge	High initial discharge	Minor impact depending on flood scenario	Minor impact depending on flood scenario
Biomass	No change	No change	No change	No change	No change	No change
Encrustation	No change	No change	No change	No change	No change	No change
Conservation	Improved	Improved	Initial impact but no change in long term	Initial impact but no change in long term	Minor impact but no change in long term	Minor impact but no change in long term

[4] The salt load discharge for the initial receiving wetland was not evaluated in the Coleman and Meney (2000) criteria for provided reasons. It has been included as a comment here because of the concern for agricultural land downstream.

6.1 Impact on Kunjin Brook and implied Agricultural Impact

There will be no impact of the current proposal on the *upstream* Kunjin Brook, with the exception of increased flow from the diversion gate region to Lake Mears, and so has not been included in the discussion.

In essence this report has concluded that the salinity in Kunjin Brook *below* Lake Mears will on average be higher but well within the current range of salinities found in the Brook. This is primarily a function of the initial higher salt load moving from Lake Mears to Yenyening Lakes System. The timing of this movement is entirely dependant on flooding regimes. It is noted that it is likely that 'natural' movements of large salt loads happens on a regular but infrequent basis. These salt loadings are going to become more common in the short to medium time frame unless the management of the upper catchment changes.

The other item of concern is the high spot nutrient concentration in Lake Mears compared to that in the Brook. This was a single spot value and should be substantiated with more samples over time. The issue is that it would seem that the nutrients have accumulated in Lake Mears from elevated levels in runoff, increased groundwater interaction and perhaps fauna. Potentially the high nutrient concentration may have more effect on nature conservation than the salt, as most natural environments in south-western Australia are adapted to low nutrient and variable salt concentrations. It is unlikely that the higher nutrient concentration will have an effect on the agricultural values of down stream Kunjin Brook.

It is unlikely that the higher nutrient concentration will have any long-term effect on the flora or fauna of down-stream Kunjin Brook. There may be short-term effects while the accumulated nutrients in Lake Mears mobilise and flush or drain from the Lake. The reason for the elevated nutrients needs to be determined before the nutrients can be discounted. Amelioration may be needed in the future.

Changes in hydroperiod will be negative due to less evaporation occurring in Lake Mears but within the context of the existing stressed and changing environment it is unlikely to be detectable.

The agricultural impact has not been highlighted in this report due the more sensitive nature of the natural systems. The final route for the water coming out of Lake Mears needs to be evaluated on several issues. Namely the presence and absence of sands and clay soils, revegetation of the Kunjin Brook with plant species conducive to nutrient removal, water uptake and be saline tolerant. Local 'pre clearing' species will not be appropriate in most areas due to changed conditions. Planting with species having agricultural synergies (eg fodder) should be considered. Some areas with more natural values may be replanted with endemic species.

6.2 Impact on Nature Conservation Values of Lake Mears and Yenyening Lakes System

Other than the direct excavation impact which must be addressed at the time of detailed planning, the net conservation effect of both proposals to Lake Mears will be positive. There will be an overall reduction of salinity, salt load and hydroperiod. All three changes will be move the balance more towards the historical natural balance. The question of large events being less frequent (that is large freshwater events) may be an issue depending on the management plan (control of gates) but it is assumed that large freshwater events will be retained.

It is expected that the issues that need to be addressed at the time of scoping and implementing any engineering activities are potential

- acid soil excavation with the drain option, and
- rare plants and communities within the clearance (footprint) areas.

The impacts of the proposals on the Yenyening Lakes System are all negative and there is no perceived benefit to this system by the changes to Lake Mears. It is the view of this report that the changes are within the natural variation, and that the changes will be minor, especially given the long-term changes to the catchment. However in the case of the nutrient loading some consideration should be given to ameliorating the cause at the source (potentially agricultural runoff) or intercepting the nutrients before they reach the Yenyening Lakes System.

During the field trip it was evident that the areas where Kunjin Creek North and South discharge into the Yenyening Lakes System were both affected by secondary salinisation. Melaleuca shrub lands were deteriorating or dead and the samphires commonly found on recently salinised land were dominant. No Declared Rare Flora or Priority species were seen at any site visited. There is the potential for *Sarcocornia globosa* (Priority 3) to occur within the Yenyening Lakes system but it was not seen during this visit – a site visit in spring would pick this species up if it was present.

It is thought that the flushing or drainage discharge from Lake Mears would have little effect on these areas. Further to the west however, there are still areas of conservation value. Given that all discharge parameters except nutrients are within the natural variations of the System it is unlikely that the discharge from Lake Mears alone will have a long-term effect on the nature conservation of Yenyening Lakes. It is not known what the effect of short-term elevated nutrient levels will be on nature conservation – much will depend on the amount of rainfall accompanying the Lake Mears discharge and the subsequent flushing of the whole Yenyening Lakes System.

Possible effects of the extra nutrient load could be accelerated growth of *Ruppia* sp or algae, which could be beneficial to water birds.

7 Appendix

7.1 Waypoint Descriptions

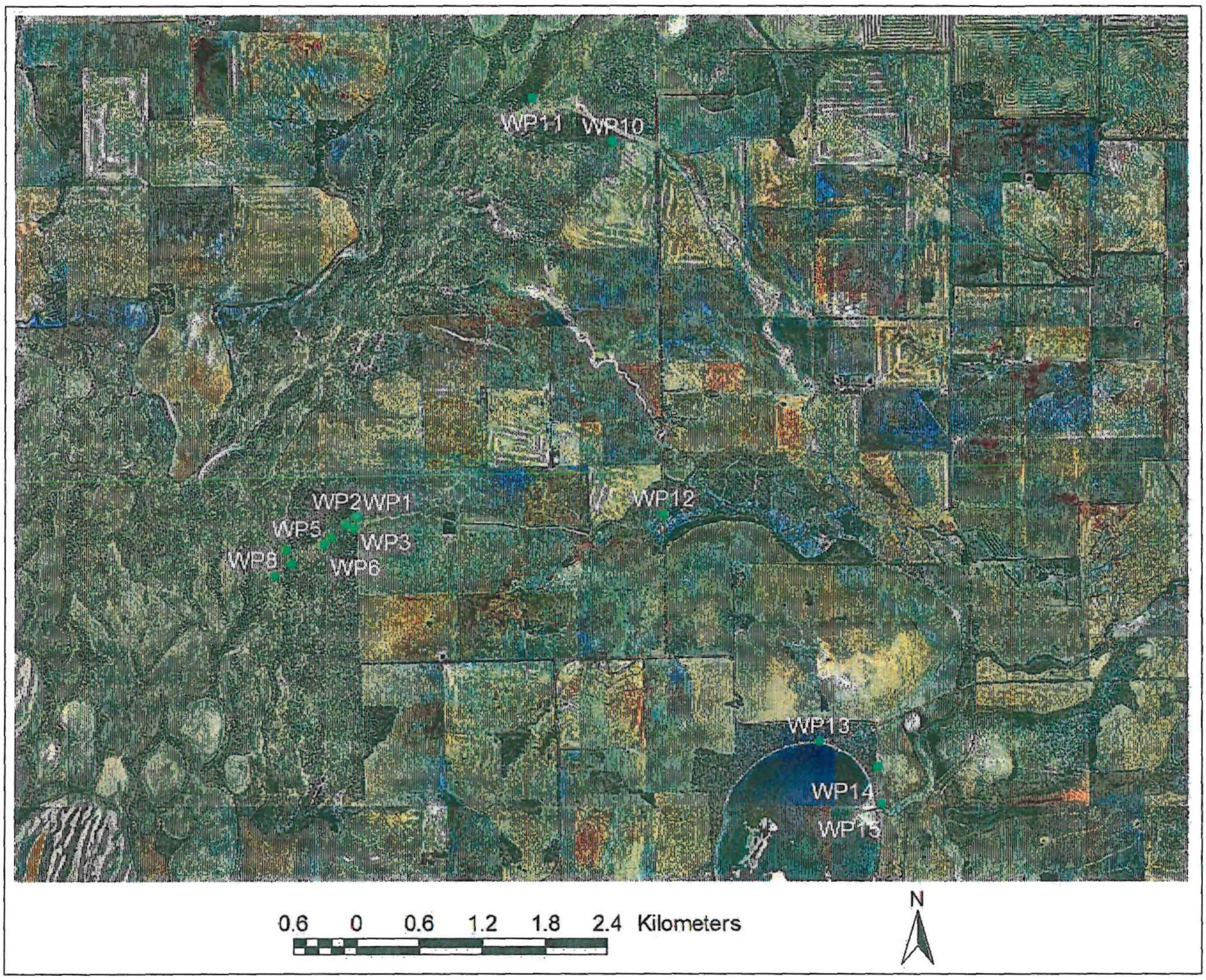

Figure 6 Way Points at Lake Mears and potential discharge points into Yenyening Lakes System

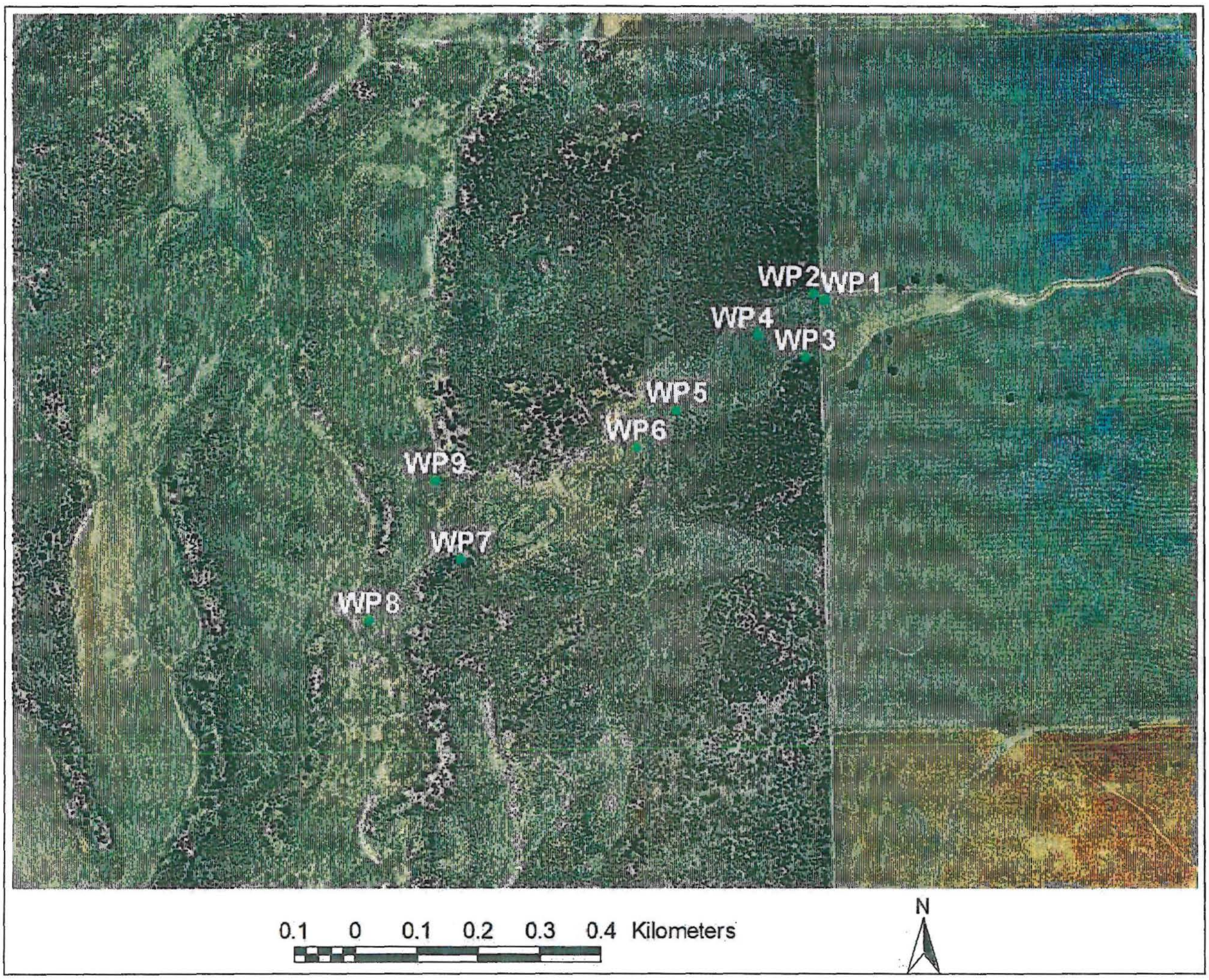

Figure 7 Waypoints at the southern Lake Mears draining/flushing potential discharge site into Yenyening Lakes System

Sixteen sites were visited on the 13th April 2005 – the first eleven were near two potential discharge sites (Kunjin Creek North and South) within the Yenyening Lakes system, four were at Lake Mears and one was at Qualandary Crossing.

A water sample was taken from Qualandary Crossing to compare with the water coming from Lake Mears, as Qualandary Crossing is considered to be the receiving wetland for the purposes of this report. The water course becomes the Avon River down stream of the Qualandary Crossing weir.

WP1

The first waypoint is at the edge of the CALM Yenyening Lakes Reserve, approximately where one of the proposed Lake Mears discharge drains would enter the Reserve. The adjoining farming property has a minor drainage ditch discharging into the lowest part of the samphire flat. The vegetation is a 200m swathe of samphires bordered by *Melaleuca* sp, mainly *lateriflora* shrubs up to 2m in height. While the site has obviously always been low-lying it is unlikely that there were samphire plants here pre-clearing as the species are few and are those commonly seen in secondary salinisation.

Figure 8 WP1 edge of CALM Yenyening Lakes Reserve

WP2

This site is in the samphire flat seen in Figure 8. The samphire species seen were *Halosarcia lepidosperma* (in the slightly higher profiles) and *Halosarcia pergranulata* (in the lower-lying areas). These are species commonly seen in secondary salinisation. Also present in the higher profiles were domestic grasses, the succulent *Disphyma* sp, *Maireana* sp and *Rhagodia* sp. About 50% of the (mainly) *Melaleuca lateriflora* at the edge of the samphire flat were dead. No juvenile shrubs were seen. There were some long-dead shrubs on the floor of the samphire flat – these had fallen and were rotting away.

WP4

This site is in a lower portion of the samphire flat – reflected by the change in samphire species to mostly *Halosarcia pergranulata* and *Sarcocornia blackiana*. At the edge of the samphire flat were some *Senecio* sp juveniles (daisies) and the Melaleuca species had changed to include some *M. uncinata*.

WP5

This site is at the edge of the samphire flat, on slightly higher ground. The *Melaleuca uncinata* shrubs were taller – up to 3m, about 50% of which were dead. The understorey contained *Halosarcia lepidosperma*, *Rhagodia drummondii* and some *Lyceum australe.* On adjacent lower ground were *Halosarcia lepidosperma*, *Disphyma* sp, *Rhagodia drummondii* and some *Senecio* sp seedlings.

WP6

WP6 was a low point containing water and surrounded by long-dead trees (only main trunk remaining). Samphires were *Halosarcia pergranulata* and *Halosarcia lepidosperma.*

Figure 9 WP6 CALM Yenyening Lakes Reserve

WP7

This was slightly higher ground – *Melaleuca uncinata* to 3m high over an understorey of *Halosarcia indica* subsp *bidens*, *Halosarcia lepidosperma, Rhagodia drummondii, Lyceum australe* and rush (probably *Hopkinsia* sp).

WP8

Further along a natural low-lying channel, this site had long-dead trees, *Halosarcia pergranulata*, *Halosarcia lepidosperma, Halosarcia leptoclada* subsp *inclusa* and *Halosarcia halocnemoides* subsp *catenulata* - the latter indicated that the site was damper and more saline than the previous sites. This part of the CALM Yenyening Lakes Reserve featured braided channels and many bare or sparsely vegetated low-lying areas. Many of the fringing trees in the distance were dead or had died.

Figure 10 WP8 CALM Reserve

WP10

This site was to the north-east of Sites 1 to 8 and has been considered as a potential discharge point for Lake Mears overflow water. It is part of the Yenyening Lakes system but is not a CALM Reserve – it is 'upstream' of the CALM Yenyening Lakes Reserve. There is a substantial drain with raised sides carrying water from the adjoining farming property (much of it overflow water from Lake Mears) that had been a natural drainage line and which was enhanced. This drain carries water to lower parts of the adjacent samphire flat and then into the Yenyening Lakes system. The plants at this site were those typical of secondary salinisation – *Halosarcia halocnemoides* subsp *catenulata, Halosarcia lepidosperma*, *Halosarcia pergranulata* and *Sarcocornia blackiana.* The majority of the plants seen in the photo were *Halosarcia pergranulata* and domestic grasses – the other species appeared as the profile became lower. In the distance, on the other side of the samphire flat could be seen *Melaleuca* sp, some of which were alive, many of them dead.

Figure 11 WP10 Area 2

WP11

This site is the high ground seen in the distance in Figure 11. The Melaleuca species were *M. lateriflora, M. uncinata* and *M. viminaea* over an understorey of *Halosarcia lepidosperma, Exocarpus aphyllus, Lyceum australe* and *Rhagodia drummondii.* The following four photographs were taken between WP1 and WP10. They show samphire flat typical of secondary salinisation and the bunded drain from the adjoining property.

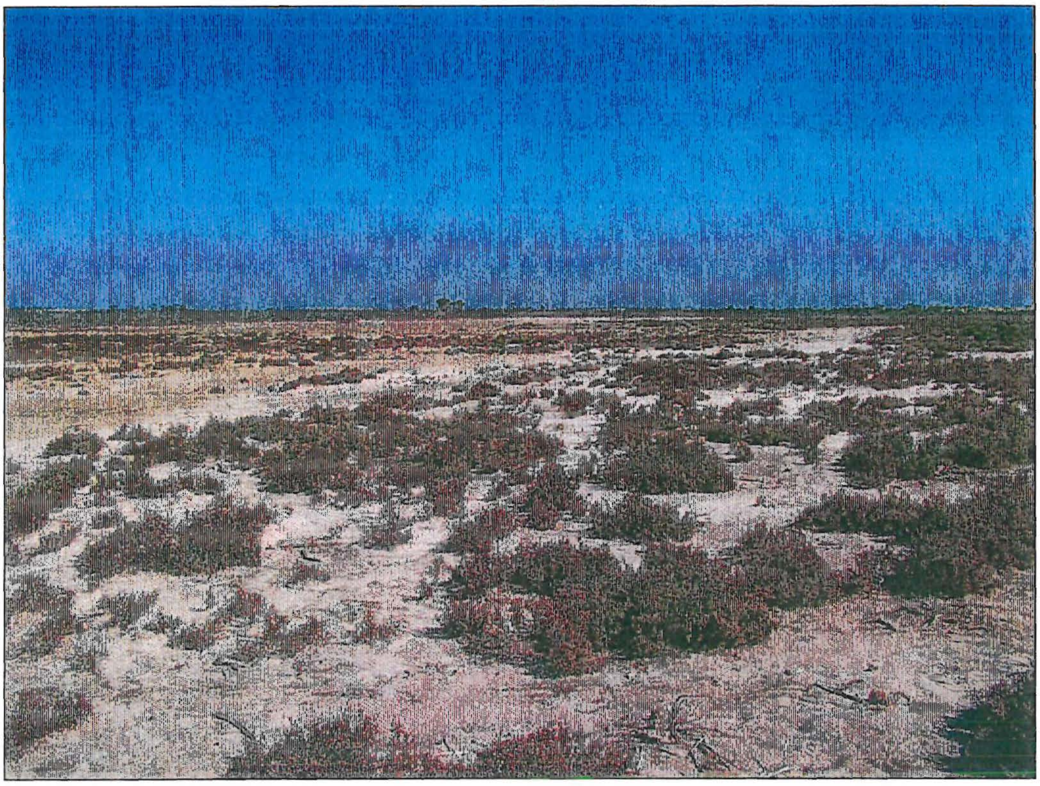

Figure 12 WP11 Area 2

Figure 13 WP11 Area 2B

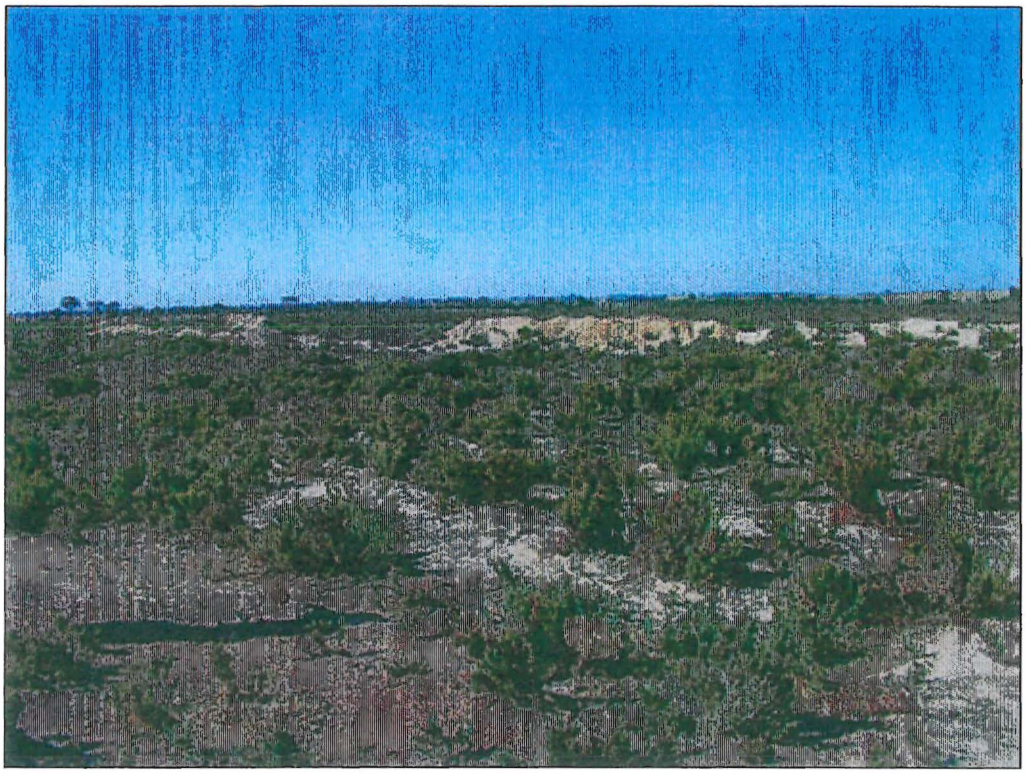

Figure 14 WP11 Area 2C

Figure 15 WP11 Area 2D

WP12

WP12 is in Kunjin Brook. Most of Kunjin Brook is sparsely vegetated however in places samphires feature. At this site were mostly samphire species commonly seen in areas that have secondary salinisation – *Halosarcia pergranulata, Halosarcia lepidosperma, Sarcocornia blackiana,* also *Frankenia* sp and domestic grasses.

WP13

This site is at Lake Mears, a small almost circular lake which pre-clearing was fresh to slightly brackish. Historically it was a seasonally important feeding and maybe breeding site for several bird species. In recent years these birds have been seen less and less frequently. The fringing trees are mostly in reasonable health though all those on the lake bed, some at the high water mark and a few above the high water mark have died - there was no evidence of juveniles recolonising the playa.

The playa itself was bare with some evidence of past *Ruppia* sp growth, washed up around the edge also some small pink gastropods in a 'tide mark'. There were also some samphire juveniles growing at the edge of the playa. On the lake 'beach' were growing *Halosarcia pergranulata* (two subspecies), Pig Face, and *Frankenia pauciflora*. Taller trees and shrubs included *Eucalyptus loxophloeba, Eucalyptus wandoo,* and *Casuarina obesa* – most were healthy, a small number had died.

Further away from the lake and at a higher elevation was sand heath vegetation, including Woody Pears and *Hakea* sp.

Figure 16 WP13 Lake Mears near boat ramp

WP14
This is the site of the proposed exit point from Lake Mears. The higher vegetation was *Eucalyptus loxophloeba*, *Casuarina obesa* and *Acacia* sp. In this zone and at the highest point of the lake 'beach' were juvenile *Casuarina obesa*. There were some large old Paperbarks (*Melaleuca preissiana*) in the zone between the samphires and the terrestrial vegetation, on the lake 'beach'. Three of these were alive and reasonably healthy; however there were also several dead individuals. The samphire zone featured *Halosarcia pergranulata* (two different subspecies) in the lower profile and *Halosarcia lepidosperma* slightly higher up. There were also Pig Face and some domestic grasses. The vegetation at Lake Mears itself has degraded but the remaining vegetation was in reasonable health and there is the potential for the Lake to rehabilitate, given a water/salt regime similar to that which occurred historically.

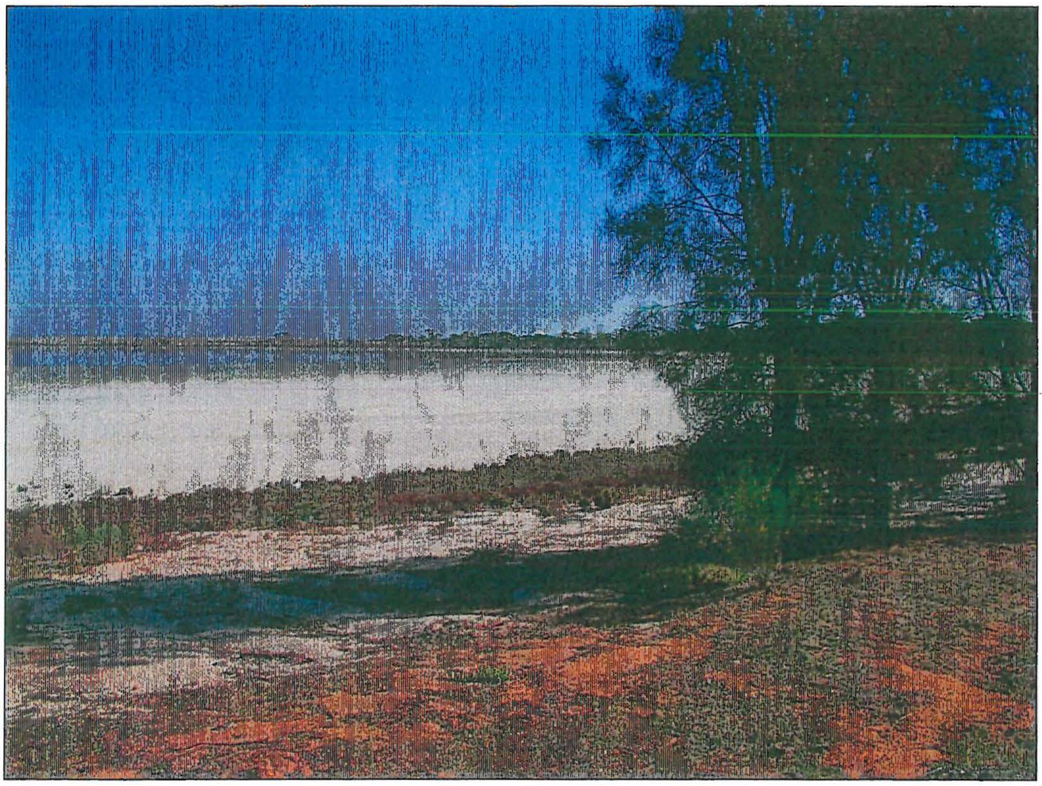

Figure 17 WP14 Proposed exit point from Lake Mears

WP15

This site is the natural entry and exit point for Lake Mears, which has been enlarged over the years. The vegetation species here were *Halosarcia pergranulata*, *Frankenia pauciflora* and 'Semaphore' sedges. There was also a 'tidemark' of small pink snails – these were also seen in places around Lake Mears proper.

Figure 18 WP15 Current entry into and exit out of Lake Mears

WP16

Qualandary crossing is at the Western end of the Yenyening Lakes System and has a weir controlling water height. For the purposes of this report this site is the receiving wetland for Lake Mears' water. A water sample was taken here. The water channel from here on becomes the Avon River.

7.2 Vegetation Species

Casuarina obesa
Disphyma sp
Eucalyptus loxophloeba
Exocarpus aphyllus
Frankenia sp
Halosarcia doleiformis
Halosarcia halocnemoides subsp *catenulata*
Halosarcia lepidosperma
Halosarcia leptoclada subsp *inclusa*
Halosarica pergranulata
Halosarcia indica subsp *bidens*
Lyceum australe
Maireana sp
Melaleuca lateriflora
Melaleuca preissiana
Melaleuca uncinata
Melaleuca viminaea
Rhagodia drummondii
Sarcocornia blackiana
Senecio sp

8 Chemical data

Table 3 Nutrient data

	TDS	TP	TN
	ppm	ug.P/L	ug.N/L
Reporting Limit	<10	<5	<50
WP4 Kunjin South- Yenyening	1,100	94	2,000
WP11 Kunjin North - Yenyening	20,100	560	4,700
WP13 Lake Mears	306,000	1,100	18,000
WP15 Inlet Lake Mears	34,000	240	4,100
WP16 Qualandary Crossing	45,600	260	3,900

9 References

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