

Evaluation of Saline Discharge to Taarblin Lake within the Context of Toolibin Lake Recovery Plan

GROUNDWATER PUMPING AND DRAINAGE PROPOSALS

**Submission to the Commissioner of Soil and Land
Conservation and the Department of Environmental
Protection, Western Australia.**

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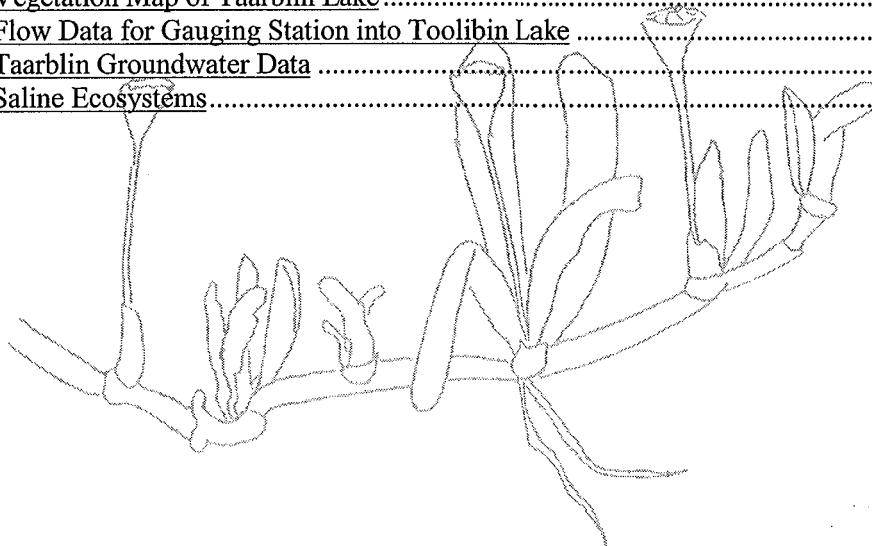


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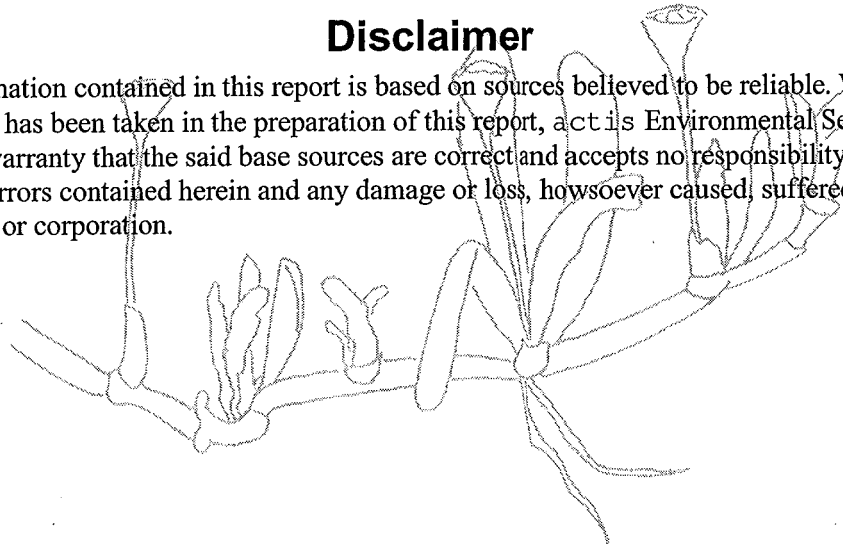
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1 Executive Summary

Wheatbelt wetlands have either become salinised or are seriously under threat from secondary salinisation. Toolibin and Taarblin Lakes are two nearby wetlands of significance in the Narrogin District of the Department of Conservation and Land Management (CALM). The biological condition of Taarblin declined in the 1950s due to increasingly saline inflows and rising saline groundwater. Today most of the wooded vegetation on the floor of the lake has died, with the only remaining vegetation on the raised banks within the lake and shores. While the condition of Toolibin Lake began to decline in the 1970s, the lake still contains living vegetation (including trees) over significant parts of the lake floor, and the water quality is much better than that of Taarblin. Toolibin Lake is listed under the Ramsar Convention as a Wetland of International Importance given that it represents the last, significant wetland of its type in the south-west.

CALM are working to recover Toolibin Lake by a series of long-term management strategies – such as revegetation in the catchment - and emergency measures to protect the lake while longer-term measures take effect. One important emergency measure is to stop groundwater from rising under the floor of the lake and lower it to the point where it no longer threatens the lake's ecological communities. An initial bore field, approved by the Commissioner for Soil and Land Conservation and Department of Environmental Protection (DEP), is currently pumping small volumes of groundwater and diverting the more saline creek flushes to Taarblin Lake. Details of the wide range of activities currently being undertaken to recover the lake can be found in the recovery plan (Toolibin Lake Recovery Team and Toolibin Lake Technical Advisory Group, 1994).

The ground water pumping up to date has focused on protecting about 20% of the lake floor and ameliorating salinity rise on nearby farmland. There is now clear evidence around some pumps that the pumping program has been successful. More recent hydrological studies have identified pumping sites that would allow a greater volume of groundwater to be removed. Modeling predicts that these new pumps, located in a palaeochannel, will increase the level of lake floor protection to over 80% and a corresponding increase in the protection of nearby farmland. Three of the eight pumps are on private land adjoining Toolibin Lake.

The existing approval to discharge groundwater to Taarblin Lake will be exceeded if all of the planned pumps are commissioned and pumped at their full capacity. Concurrently with the work at Toolibin, on the initiative of CALM, a draft methodology for evaluating impacts of saline discharges has been developed by Coleman and Meney (2000). This methodology was applied to the whole saline discharge to Taarblin Lake, as opposed to only the additional discharge amount.

It was determined, using the draft methodology, that the saline groundwater discharge from Toolibin Lake to Taarblin Lake would significantly increase the salinity and salt load within Taarblin Lake. A more detailed technical evaluation determined that the salinity and salt load would be concentrated in the lower area judged to be an existing bare playa in the south of Taarblin Lake. An area of less than 50 ha will be significantly affected, with a much greater area affected to a lesser extent. Hydroperiod will not be affected.

The area most likely to be affected does not have any significant plant species, and the species are represented elsewhere in the locality. While Taarblin is an important regional wetland, it is judged that the effect of the discharge will be minimal, at least in the short term. By protecting Toolibin Lake the plant and animal communities will be preserved to recolonise Taarblin Lake if needed at a later date.

Alternative strategies for removing the need to discharge are being investigated and implemented, such as:

- ? commercial harvesting of salts,
- ? surface water control,
- ? lake outlet control,
- ? lake and reserve revegetation,
- ? catchment revegetation, and
- ? agronomic manipulation.

All of the above remediation strategies have been implemented to varying degrees with over one million dollars been spent so far. If no action is taken to protect Toolibin Lake, the Lake will continue to increase in salinity, with the result that salt will move through the intermediate wetlands to Taarblin Lake in due course. The pumping is seen as only one part of a comprehensive approach to the management of salinity in the Toolibin Lake Catchment. It is thought that if these actions were not undertaken then, not only would Toolibin Lake become more saline, but parts of the surrounding farmland and reserves would also be affected by rising groundwater and salt scalds.

Taarblin Lake will be monitored for changes to its vegetation and water quality.

It is recommended that the discharge of saline groundwater at a rate of 12,000 tonnes of salt and 350,000 KL per year from Toolibin Lake to Taarblin Lake be permitted under the proviso of regular monitoring, and the continued investigation and implementation of alternative strategies.

2 Introduction

2.1 Background

Wetlands in the agricultural region of Western Australia are under increasing threat from rising groundwater. The rising groundwater is a result of changed land use since European settlement of the region allowing greater runoff and reduced evapo-transpiration. The higher groundwater results in evaporative wicking through the soils in areas where the groundwater is close to the surface, causing a crust of salt on the surface. This salt is mobilised rapidly to downstream wetlands. Wetlands are typically areas that intercept groundwater for some time during the year, and are a result of the delicate equilibrium between surface runoff, evaporation, groundwater discharge and groundwater recharge.

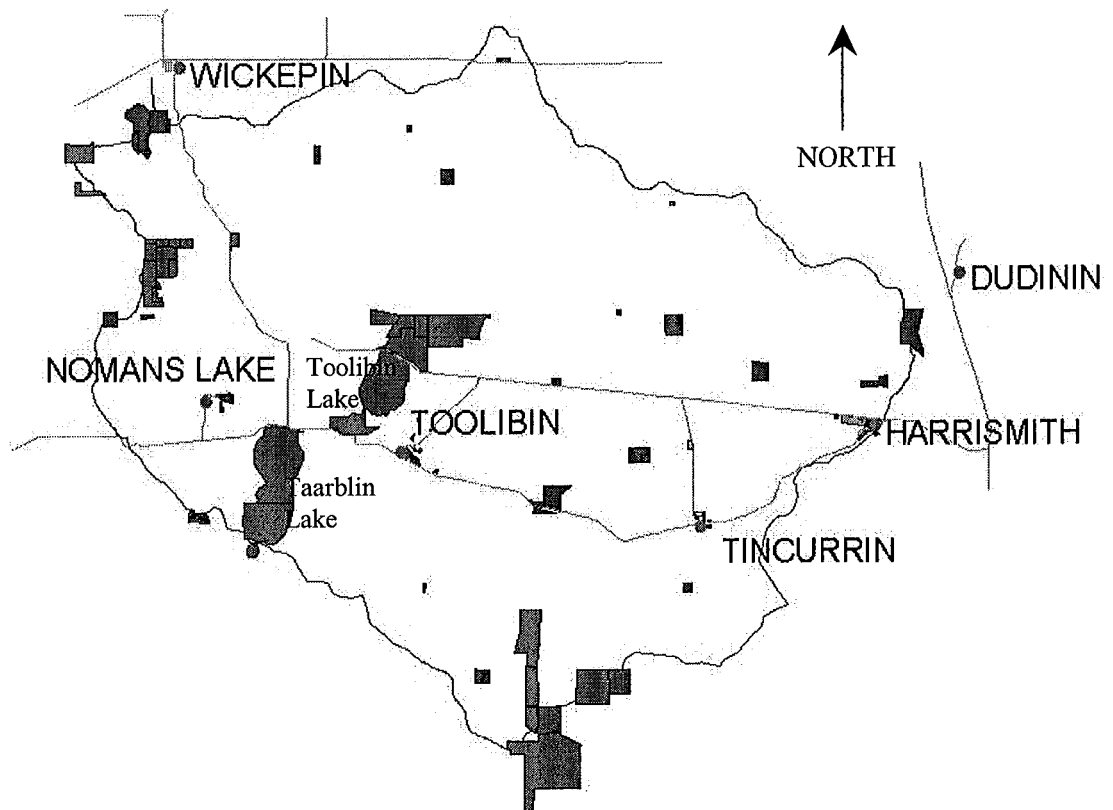
A higher groundwater level means that a wetland is flooded for longer (hydroperiod), and the net evaporation is much greater, resulting in an elevated salinity. This is in addition to the increased salt load brought to the wetlands from salt mobilisation in the catchment. Most wetlands have been seriously changed to a stage that their hydrology and ecology no longer reflect that of pre-European settlement. As a result, most lakes showing signs of secondary salinisation support a cosmopolitan species suite of plants and animals with low species diversity.

Toolibin Lake is a significant lake in the wheatbelt because it still supports a brackish-freshwater ecosystem. It is listed under the Ramsar Convention as a Wetland of International Importance, and the signatories (including Australia) have undertaken to maintain and protect these important wetlands. The vegetation in Toolibin Lake is showing increasing signs of groundwater saturation stress and in the period 1994-97 a number of emergency actions were implemented. These included a groundwater pumping system that removes groundwater from beneath part of the lakebed and an inlet/outlet control that diverts saline water around the Lake into Taarblin Lake (see Figure 1) lower in the catchment.

These actions are not long-term solutions by themselves and are the short-term processes in a more comprehensive catchment recovery plan (Toolibin Lake Recovery Plan (Toolibin Lake Recovery Team and Toolibin Lake Technical Advisory Group, 1994), see also Section 2.2).

Taarblin Lake is a significant wetland in its own right. It is a nature reserve (purpose of Conservation of Flora and Fauna Reserve No. 9550). It has been and will continue to be impacted by the changing water regime in the catchment. In addition to the changing water regime in the catchment, it has recently been the recipient of saline discharge water from Toolibin Lake and the initial first flush of saline water diverted from Toolibin Lake to Taarblin Lake.

Figure 1 Locality of Toolibin and Taarblin Lakes



At present there is a proposal to increase the groundwater pumping from Toolibin Lake in order to protect this important wetland over and above the amount specified in the application by the Department of Conservation and Land Management (CALM), October 1994. It is proposed that this brine be pumped into Taarblin Lake until alternative management strategies such as commercial extraction of salt or catchment management reduce the need for pumping to a natural lake. This is expected to take decades unless commercial harvesting of salt is used as a mechanism for removing excess salts from the catchment ecosystem.

2.2 Concurrent Catchment Management Strategies

The report titled *The Status and Future of Lake Toolibin as a Wildlife Reserve* prepared by the Northern Arthur River Wetlands Committee (1987) listed a number of key strategies for the recovery of Toolibin Lake. The key strategies are as follows:

- ? Revegetation of the Western Buffer Zone
- ? Groundwater Control
- ? Maintain Health of Lake Toolibin Reserve Vegetation
- ? Diversion of Saline Flow from Interceptor Banks (see Figure 2)
- ? Catchment Regeneration to Reduce Inflow Salinity
- ? Monitoring
- ? Further Investigation of Groundwater Pumping
- ? Strategic Lake Emptying

These strategies were further formalized in a Recovery Plan in September 1994 (Toolibin Lake Recovery Team and Toolibin Lake Technical Advisory Group 1994).

The key activities by CALM to protect Toolibin Lake undertaken in the period between February 1997 and June 2000 are outlined in Table 1. The monies outlaid for these activities during this period have also been included. It is considered that the Department of Conservation and Land Management task list is broadly on schedule with the original recovery plan.

Table 1 Recovery of Toolibin Lake related work activities Feb'97 to June'00

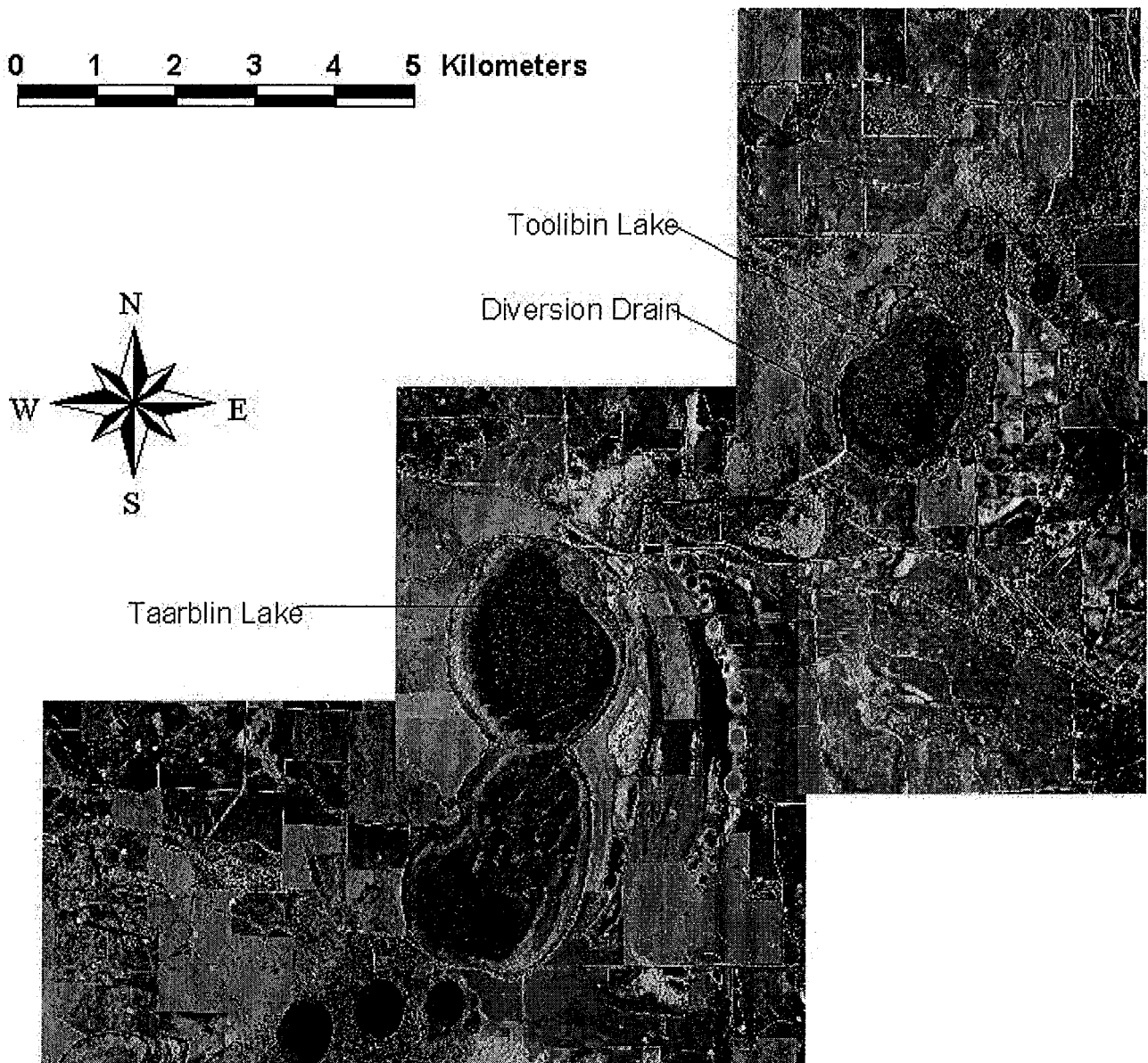
Task	Cost (\$)
Expanded Conservation Estate	95,310
Biological Surveys	89,484
Buffers, corridors planting	89,867
Rehab. of degraded Crown land	70,031
Planning and Construction of Engineering Works on Crown land	851,084
Planning and Construction of Engineering Works on Private land	68,386
Catchment monitoring and research	157,744
Management and communication	29,190
Total	1,451,096

Pumping is seen as one of many strategies to reduce the salinisation of the wetlands and possibly is only a short-term strategy if the alternatives are successful. Groundwater pumping is seen as an expedient response to an issue that threatens to seriously degrade a world class heritage lake.

2.3 Brief

This report examines the existing discharge plus the proposal to increase the pumping of groundwater from beneath Toolibin Lake into Taarblin Lake and the resulting impact.

Figure 2 Aerial of Taarblin Lake



3 Wetland Values at Risk From Proposed Actions

Both Toolibin and Taarblin Lakes are in the headwaters of the Arthur River. The Arthur River feeds into the Blackwood River, which discharges into the sea at Augusta (Commander 1989). The Blackwood system is a large and significant water catchment in the south west of Western Australia.

3.1 Values of the Blackwood System

The Blackwood is a major river system that, while degraded by increasing water salinities and other factors, retains many important conservation, recreation, aesthetic and other values. As will be detailed below, it is not anticipated that the pumping will affect wetlands beyond Taarblin Lake significantly, therefore the values of the Blackwood are not discussed further in this document.

3.2 Value of Taarblin Lake

Given its proposed status as the storage point for drainage and groundwater, Taarblin Lake is considered to be the feature most at risk from the proposals. The Lake lies within a nature reserve for which the Conservation Commission holds the management order.

Taarblin Lake was a seasonal freshwater lake until the 1950s, although Ray Aitken stated that it was brackish in the 1930s (information from an oral history project conducted by Angela Sanders in 1991, transcripts held by the Battye Library, see also Sanders 1991). It has been salinised by rising groundwater and increasingly saline surface inflows. Most melaleuca and casuarina vegetation on the floor of the Lake has died. More frequent and prolonged flooding of the Lake may have also affected the vegetation. The Lake rarely fills, and the last time that it filled and overflowed was in the winter of 1983. Thus salt accumulated in Taarblin is only discharged downstream in conjunction with very high flows. For this reason it is considered unlikely that changes to Taarblin's hydrology will have any impact on the down stream Blackwood River.

Samphire grows across much of the Lake floor. Fringing the Lake are swamp sheoak (*Casuarina obesa*) and occasional paperbarks (*Melaleuca* spp). The vegetation condition within the wetland is given in Sections 7.3 and 10.2.

As a consequence of salinisation, the major value of the Lake is now as a feeding and loafing area for waterbirds. Thirty species of waterbirds have been recorded as using the Lake. While a number of waterbirds used the Lake for breeding in 1983, a winter of above average rainfall, this is unusual. Toolibin, Walbyring (a small reserve between Toolibin and Taarblin) and other better-vegetated lakes are much more important for breeding than Taarblin Lake.

Apart from biological values, it was also suggested during the 1992 workshop on Toolibin (see Appendix A in CALM (1994)) that Taarblin, as an area of groundwater discharge, may contribute to the protection of Toolibin Lake. If Taarblin were to fill more frequently, it is possible that this may lead to greater groundwater pressures on Toolibin. Geophysical surveys have subsequently shown that large dyke suites south of Toolibin probably prevent significant groundwater flow towards Taarblin (CALM 1994).

A small area at the south end of Taarblin has been used for recreational boating activities. In recent years there has been insufficient water in the Lake for recreation. If the Lake becomes saturated with salt, then it will be less pleasant for recreation. For example, while Dumbleyung Lake is currently used for recreation, many people complain that it is too saline and causes an unpleasant crusting on the skin.

In summary, while badly degraded by salinity from both groundwater and surface in-flows, Taarblin's nature conservation values are such that it would not normally be considered for disposal of saline groundwater unless this was essential to protect more important nature conservation values at risk. Finally, it should be noted that, if Taarblin is ever to be rehabilitated, it is essential that Toolibin Lake remain as a freshwater wetland.

3.3 Value of Toolibin Lake

Toolibin Lake is listed under the Ramsar Convention as a Wetland of International Importance. Signatories to the Convention have agreed to designate suitable wetlands within their territories for inclusion in a List of Wetlands of International Importance. They have also agreed to ensure the conservation of these wetlands and their flora and fauna, and the wise use of wetlands generally. Toolibin Lake has also been nominated for listing on the Register of the National Estate. The Lake's conservation values are severely threatened by increasing salinity, both from surface inflows and rising groundwater. The values of Toolibin Lake are described in the Toolibin Lake Recovery Plan (Toolibin Lake Recovery Team and Toolibin Lake Technical Advisory Group, 1994).

The very high nature conservation values of Toolibin Lake are well recognised nationally, and listing under the Ramsar Convention provides an International profile for the Lake. Given this unique status amongst wetlands of the agricultural area, major actions are considered essential to protect its values.

3.4 Project Proposal

The Toolibin Lake Recovery team and Technical Advisory Group have determined that groundwater pumping from the Toolibin Lake basin is fundamental for the protection and recovery of Toolibin Lake. The initial proposals stem from the work of the Northern Arthur River Wetlands Committee (1987). A multi-stage approach to the groundwater pumping has been undertaken to allow for changes in technology and effort needed, as new information on the surface and groundwater hydrology is gathered from existing pumping.

Three stages have been implemented;

- ? pumping from eight air pumps,
- ? pumping from a single air pump,
- ? and pumping from a single pump on the eastern side of Toolibin Lake.

All three stages have been implemented under the original licence to discharge from Toolibin Lake. The pumping volumes and the salt load they have added to Taarblin Lake are shown in Table 2. In addition, a further two pumps on the eastern side of Toolibin Lake are planned. The capacities of these pumps are also shown in Table 2.

The objective of the project is to pump sufficient groundwater from beneath the Lake floor to maintain saline groundwater levels at least 1.5 metres (and preferably 3 metres) below the Lake bed in spring. This distance should be sufficient to prevent salinisation of the root zone of vegetation growing in the Lake floor, either directly, or through capillary action. The proposed borefield will also prevent water within the Lake from becoming salinised by groundwater.

Table 2 Potential Annual Volume and Salt¹ load pumped from Toolibin Lake to Taarblin Lake

Sequence of Pump Installation	Date of initial pumping	Number of Pumps	Salinity g/L	Volume Pump L/day	Volume per Stage L/day	Incremental Volume L/day	Incremental Volume M3/day	Salt Load per Pump tonnes/year	Salt Load per Stage tonnes/year	Incremental Salt Load tonnes/year	Incremental Salinity g/L
Eight air pumps	1-Mar-1997	8	42.9	26,247	209,976	209,976	210	411	3,288	3,288	43
One air pump	1-Mar-2000	1	41.5	24,672	24,672	234,648	235	374	374	3,662	43
Eastern Side	1-Mar-2001	1	36.7	223,333	223,333	457,981	458	2,990	2,990	6,652	40
Eastern Side	Proposed	2	36.7	223,333	446,667	904,648	905	2,990	5,981	12,633	38
Total		12			904,648				12,633		

¹ Salt load refers to total salts in solution not just halite (NaCl).

4 Method of Evaluating Impacts

The method used to evaluate the impact of groundwater pumping on Taarblin Lake is documented in Coleman and Meney (2000).

The method requires the proponent to identify the principal wetlands to be affected by the discharge and limits the evaluation to those wetlands. This is an important step as any discharge will have an effect on wetlands beyond the immediate discharge wetland but the impact will be temporally distant and difficult to distinguish amongst natural and other fluctuations.

The methodology identifies several receiving wetland parameters by which the impacts of the proposed discharge should be evaluated. These include:

- ? Vegetation condition
- ? Flood risk
- ? Hydroperiod
- ? Salt concentration
- ? Salt load
- ? Ionic concentration
- ? Nutrient concentration

Once the wetlands that will be affected are identified and the above parameters measured, it is necessary to place the proposed additional discharge (in this case from pumping) within the context of the natural discharge of the total catchment to the receiving wetland(s). This has been quantified by assuming that if all of the proposed discharges in a catchment total to less than ten percent variation from the natural discharge level for each parameter, then the change is too small to be considered environmentally significant. If a number of proposals each contributed a ten percent increase to the natural environment in salt or water, then the catchment would be overwhelmed. It is therefore necessary to proportion each proposed, individual discharge to the potential discharge from the catchment. It was therefore determined that the maximum variation from the background level by an individual discharge for each parameter would be the proponent's proportion of the catchment under their influence multiplied by ten percent of a parameter. Control is normally interpreted to be ownership of land within the catchment.

Example

If the natural level of salt were 30 g/L, ten percent would be 3 g/L. If the proponent owned all of the land in the catchment then the total discharge may vary from the background level by 3 g/L. If is normally the case, the proponent owns part of the catchment, say 5%, then the discharge may only change in comparison with the background levels by 0.15 g/L (30 times 0.1 times 0.05).

If the proposed discharge falls above this threshold for any parameter, then a more detailed study is required to determine whether the discharge should proceed. There are often good reasons why this first rapid assessment method can be discounted as being too conservative.

The method specifies that if the proponent can identify the wetland and the parameters, and the discharge falls within the proponent's allowable proportion of the natural variation; then a simple self-evaluation is all that is required. If the proponent cannot identify the wetland, or individual factors fall above the specified thresholds, then a more detailed technical analysis is required.

5 Defining the System

5.1 Pumping Statistics

The current proposal does not incorporate an engineered drainage system as is normally the case in rural works. Rather, it incorporates a set of bores that discharge into pipe work that transports the saline water directly to Taarblin Lake. However, this is effectively the same as evaluating endpoint discharge from a main drain into a receiving wetland.

It is expected that the discharge will have the following characteristics when fully developed.

Table 3 Pumping Characteristics after complete installation²

Total Volume	Average Salinity	Total Salt Load
KL per day	g/L	Tonnes per year
905	38.3	12,663

Step 1: Discharge System Checklist

A. Drainage Area

- i. Name of the surface hydrological subcatchment
Toolibin Lake
- ii. Area of the surface subcatchment to be drained (ha)
1200 ha area of reserves including Toolibin Lake area of 300 ha
- iii. Using a soil map or on-site test data, list the main soil types (eg. clay, sand, loam) and area of each soil type in the proposed drainage area:
Not applicable
- iv. Project maps attached?
Yes

B. Drainage Design

Not applicable as the project involves pumping groundwater from the site to the final wetland

² The pumps installed last have a lower salinity than the initial pumps.

5.2 Receiving Wetland System

There is no intermediate receiving wetland in the system. The discharge is pumped directly to the final receiving wetland, Taarblin Lake.

The turnover (T-factor) is defined as how often the final receiving basin overflows the holding capacity. This is an important factor, as a wetland with a high turnover may not become a basin that evaporates and thus concentrates solutes. It has been determined that Taarblin Lake rarely overflows and it has been estimated that it may overflow once every thirty years. Because the period between overflow events is more than 2 years, the turnover factor defaults to 30, and Taarblin Lake is confirmed as being the final receiving wetland as defined by the draft.

Step 2: Receiving Wetlands Checklist

A. Receiving Wetland System:

- i. Name of the final receiving wetland catchment Taarblin Lake
- ii. Total area of the final receiving wetland catchment (ha) 78,800 ha
- iii. Approximate number of receiving wetland types between point of discharge and final receiving wetland: (0-5, 5-10 or >10).

Channels: 0 Flats: 0 Basins: 0

B. Final receiving wetland:

- i. Name: Taarblin Lake
- ii. Wetland Type: Basin
- iii. Area (ha): 916 ha (Reserve 1013.5 ha)
- iv. T-factor (years) 30+

5.3 Conservation Risk Assessment

Step 3: Conservation Risk Assessment

A. Receiving Wetland System:

- i. Does the final receiving wetland have a conservation listing?

Yes/No **Yes**

If yes, describe **Conservation Flora and Fauna #9550**

5.4 Project Details

Step 4: Project Details

A. PROJECT TITLE & GOALS

- i. Title **Water and Salinity Management of Toolibin Lake**
- ii. Briefly outline what you intend to do and what you expect to gain from your drainage project.
Recover Toolibin Lake from existing salt and groundwater stresses by pumping groundwater to Taarblin Lake downstream of Toolibin Lake

D. INFORMING OF STAKEHOLDERS

- iii. Have relevant stakeholders been informed of the project? **Yes**

C. MONITORING PLAN

- iv. Monitoring plan attached? **Yes Taarblin Lake will be monitored under existing saline wetland program.**

5.5 *Determining the Type of Evaluation*

Three evaluation approaches are considered appropriate for assessing the impact of saline drainage (after Coleman and Meney 2000):

1. SELF-ASSESSMENT
2. TECHNICAL ASSESSMENT
3. FORMAL ASSESSMENT

Selection of the most appropriate method is determined by the:

- ? Conservation status of the receiving wetland
- ? Outcome of self-assessment approach
- ? Choice

Due to the conservation status of the final receiving wetland, Taarblin Lake, it is more appropriate for a technical assessment to be made of the potential impact of groundwater discharge on the receiving wetland. However the self-assessment was completed in addition to the technical assessment in order to highlight the important aspects of the discharge to a natural wetland and to evaluate the process.

A self-assessment has been completed in Section 6 and a technical assessment in Section 7.

6 Self Evaluation

6.1 Key Data

The following data was calculated using the spreadsheet provided by Coleman and Meney (2000) and follows the same format.

The data was provided by CALM Narragin and where possible collaborated with written records. The area of Taarblin Lake was taken from Halse, Pearson et al. (1993) as 916 ha. Other records give the Lake as having an area of 985 ha. The total area of the Taarblin Nature Reserve (Reserve No. 9550) is gazetted as 1013 ha in area.

The 'T Factor' is the number of years on average between flood events of sufficient volume for the Lake to overflow. The 'T Factor' is only used to determine whether the final wetland is being discussed. In this case the 'T Factor' indicates for the purpose of this evaluation that Taarblin is the final receiving wetland as defined by Coleman and Meney (2000).

The 'P Factor' is the proportion of the catchment area that is under the control of the proponent, in this case the Crown. The 'P Factor' is the ratio of 4,515 of Reserves and unallocated land to 78,800 hectares of Taarblin catchment.

The median effective evaporation is the median Class 'A' daily pan evaporation by a lake factor (normally 0.7) and a salinity factor (between 1.0 and 0.8, reducing for salinity).

Key Data

1. T-factor (years) 30
2. P-factor 0.057
3. Drain discharge over 6 months (Q_d), m³ Not Applicable
4. Peak flow in primary receiving channel (m³) Not Applicable
5. Ellipsoid wetland area (ha) 916 ha
6. Wetland depth (m) 2 m
7. Ellipsoid wetland volume (m³) 12,000,000
8. Median effective evaporation (mm/day) 2.16 mm/day

6.2 Vegetation Condition

When keying out the Vegetation Condition component of the assessment, it was noticed that the choices were for vegetation fringing the wetland, not necessarily within the wetland. At Taarblin Lake, the fringing vegetation appeared to be in good condition, the dead trees were on the floor of the lake itself. An estimate of percentage of dead trees on the lake bed is >90% dead. There is a small band of living trees in the southern section of the lake that are growing on a series of lunettes. Dead trees appeared to have been dead for many years as all of the small twigs and branches had gone, leaving only the major branches and trunk. There did not appear to be recent deaths. Eucalyptus trees, which were further up in the height profile above the lake than the casuarina trees, were large and healthy specimens. A number of large Eucalyptus trees on the eastern side of the lake had fallen in past storms (blocking the track) – some time ago judging by their condition.

Samphires on the lake floor were generally in good health considering the current dry period. The samphires on the lowest vegetated portion of the lake floor were small and very dry but still alive, however, others higher up in the height profile (the majority of the samphire population) were proportionally larger and not so dry.

The samphire species at Taarblin Lake suggest that there are extended periods of flooding of the lake but the water is not particularly saline for the majority of

B. RECEIVING WETLAND	
1. Is there remnant vegetation present fringing the wetland	YES/NO
Approximate % cover living	90
2. Identify habitat types:	
(a) Large trees present?	YES/NO
<i>Eucalyptus</i> , <i>Casuarina</i> , <i>Melaleuca</i>	% living
b) Understorey present?	YES/NO
Shrubs	% living
Rushes/sedges	% living
Samphires/saltmarsh	% living
	90

that time. There are 5 species of samphire at Taarblin Lake, with possibly another two subspecies. The species at Taarblin Lake are the same as those found at Toolibin Lake, with the exception of the previously undescribed *Halosarcia pergranulata* subspecies. This subspecies was found at a clay pan/samphire flat near Toolibin Lake, not on the lake proper.

6.3 Water – Fate and Flood Risk

QUESTION

Will water from pumping increase the maximum wetted area of the receiving wetland by less than 10%? Compare with a year of median rainfall.

Evaluation

☐ Yes

Go to HYDROPERIOD

☒ No

Discharge high risk, undertake technical assessment or consider alternatives.

RATIONALE

Water depth and surface area

The depth of water in a drain or wetland is a factor affecting the rate of any seepage to or from any underlying aquifer. Moreover, the depth of water controls the wetted area of the wetland bed. This usually has a major effect on the rate of leakage from the wetland by seepage through its bed.

Minimising the change of water depth will ensure that there is minimal change to the rate of seepage of water through the bed of a wetland to the groundwater.

There will be a large change in the surface area for only small changes in the water level in the great majority of streams and wetlands in rural areas of WA. Therefore, it is considered that control of water surface area will provide control of both area and water depth.

CALCULATION

Table 4 Calculations for Flood Risk

Final Wetland	
Is the additional flood risk due to the water load from drainage insignificant?	No
Maximum volume for Final Wetland (cubic metres)	12,252,240
Drain Flow for six months (cubic metres)	162,837
Percentage Change	1.3%
Proponent's proportion of total catchment	5.7%
Proponent's proportion of total discharge change	23.2%

The flood risk to the final wetland was determined as having increased by 1.3% by the discharge of groundwater from Toolibin to Taarblin Lake. It was calculated that the maximum volume of Taarblin Lake was approximately 12 million cubic metres and that the pumped volume over the six wet months³ was about one hundred and sixty thousand cubic metres (see Table 4).

It was estimated that the area under Crown control in the catchment was 5.7% of the total catchment. This means that if every controller of land in the catchment were to discharge at an equal rate then 23% of the Lake's volume would be taken up by discharges. By itself, the proposed discharge does not represent a significant increase in flood risk, but in context of potentially the entire catchment using groundwater discharge as a mechanism to reduce rising groundwater, there would be a significant flood risk.

For the reason above it was determined that the discharge should evaluate the flood risk in more detail in a technical review.

³ The original draft guidelines used six months and, although the pumping will continue over twelve months, it was decided that the flood risk is only during the six months of low evaporation and higher rainfall.

6.4 Water - Hydroperiod

QUESTION

Is the pumped discharge (during the month of lowest evaporation) less than 45 times the median effective daily evaporation from the wetland (x P-factor)?

EVALUATION (please tick correct box)

☒

Yes

Go to SALT

☐

No

Discharge high risk, undertake technical assessment or consider alternatives

RATIONALE

The period that the level of water in a wetland exceeds a specified level affects wetland vegetation, dependent fauna etc, and is referred to as the hydroperiod. The hydroperiod for any specified water level can be derived from the hydrograph of water level in the wetland.

Most wetlands in the wheatbelt have evaporation potential in excess of the water available from evaporation (while the wetland is at its lowest) and groundwater discharge will contribute little to the water level while the effective evaporation is high. The danger period for detrimental increases in hydroperiod is during the 6 months of the year with the lowest effective evaporation.

Changes in the biomass and species composition of submerged aquatic plants are strongly modified by the hydroperiod. Biomass declines significantly with longer flooding duration. This also reduces the amount of food resources to waterbirds, most of which prefer comparatively shallow water for feeding. For instance most wading birds feed in areas less than ten centimetres in depth.

Modified flow regimes that prolong periods of wetland flooding may significantly alter invertebrate diversity and abundance, favouring only resilient taxa. The duration of high water levels is considered a more significant factor than seasonality in determining microfaunal communities.

Some aquatic and fringing plant species need a dry wetland floor to germinate and establish.

It is assumed that 45 days of increased saturation / flooding at any point within the wetland profile will have a detrimental effect on the ecosystem at that point. This has been observed for selected rush & sedge species (Meney personal observation, C. Semeniuk, unpublished).

CALCULATION

The self-evaluation method determined that changes in hydroperiod would not increase the likelihood of plant deaths significantly in Taarblin Lake. It was estimated that the increase in hydroperiod would be less than one and a half days per year for the individual discharge and about 24 days per year if all land owners in the catchment discharged to Taarblin Lake. This calculation was based on the median net evaporation at Narrogin and the volume of ground water to be discharged to Taarblin Lake.

Table 5 Calculations for Hydroperiod Changes to the Final Wetland

<i>Will the drainage discharge over a month be less than 45 days of moderate (median) evaporation?</i>		Yes
Median Effective Evaporation (mm/day)	2.156mm per day	
Area of final receiving wetland	9,160,000metres squared	
One month of discharge	27,139cubic metres	
Proponent's proportion of catchment above final wetland	6%	
Volume evaporated in one day of median evaporation	19,749cubic metres	
Days to evaporate one months drainage	1.4days	
Proponent's proportion of increased hydroperiod	24.0days	

6.5 Salt – Concentration

QUESTION

Will there be less than 10 percent change in TDS concentration of the receiving wetland after pumped water has been added?



<i>EVALUATION (please tick correct box)</i>	
<input type="checkbox"/> Yes	Go to SALT LOAD
<input checked="" type="checkbox"/> No	Discharge high risk, undertake technical assessment or consider alternatives

RATIONALE

The concentration of salt in a stream or drain will generally increase in the direction of flow, due to evaporation. It will reach a very high level in a wetland, where the entire flow is lost by evaporation alone. Peak salinity will be lower in wetlands where water is lost by a combination of evaporation and seepage into the bed of the wetland, or overflow.

A maximum salinity criterion may be almost impossible to meet. As stream salinity will be lower during the higher flows that spread over a larger area of land, it is argued that the criterion should be a flow-related concentration.

An immediate indication of the salinity range characterising a receiving wetland can be gauged from a biological assessment of the wetland. The following table gives indicative species for each salinity category. As a guide, a receiving wetland in the meiomesosaline or hyposaline range will probably be unsuitable as drainage discharge wetlands. (see Table 15, Appendix Saline Ecosystems)

CALCULATION

Table 6 Calculation of Salt Concentration

Will the net change in Total Dissolved Salts be insignificant?	No
Average annual stream flow into wetland	4,523,754 cubic metres
Estimated salt runoff from catchment	25,559,583 kilograms
Estimated salt runoff from drained scalds (do nothing option)	3,000,000 kilograms
Estimated average salt concentration from runoff	5.65 g/L
Estimate average salt concentration with drain water (six months)	6.14 g/L
Percentage increase in salinity after drain water added	9%
Proponent's proportion of catchment above final wetland	6%
Percentage proportion of increased salinity	153%

The self-evaluation found that there would be a significant change to salt concentration in Taarblin Lake with the proposed discharge. The formula used in the calculation gave a salt movement from the catchment of approximately 25,000 tonnes of salt (see Table 6). The calculation uses only six months flow from the discharge because the original formula was designed for drains that do not flow during summer months. Although technically the groundwater discharge from Toolibin will continue through out summer, there is an argument that most of the brine discharged during the summer months will recharge to the groundwater, and therefore the formula has not been modified.

In any case, the discharge will significantly increase the salinity of the wetland, even allowing for only six months flow and an estimated 3,000 tonnes of salt from salt scalds if the discharge does not take place. This compares to approximately 6,200 tonnes from the discharge (see Table 7)

It has been estimated that if the discharge was the only discharge then the salinity of Taarblin Lake will increase by 9% but an increase based on the proportion of the catchment controlled by the Crown could be as high as 153%.

6.6 Salt - Load

QUESTION

Will there be less than 10 percent change in SALT Load in the wetland after drain water has been added?

Evaluation	
<input type="checkbox"/> Yes	Go to IONIC COMPOSITION
<input checked="" type="checkbox"/> No	Discharge high risk, undertake technical assessment or consider alternatives

RATIONALE

Basins and temporary storage wetlands will accumulate salts over time. It is important that the TDS load (that is, amount) does not increase to a level that is detrimental to the receiving wetlands.

The only types of wetland that would not be affected in the long term by increased loading of salt are those that are already hypersaline for the greater part of a year or those that 'turnover' (discharge their own volume) more frequently than every two years.

The self-assessment spread sheet has calculated that the salt load will be increased by more than ten percent in Taarblin Lake.

CALCULATION

Table 7 Calculation of Estimated Salt Load increase in Taarblin Lake

Will the net change in Salt Load be insignificant?	No
Estimated salt runoff from catchment	25,559,583 kilograms
Estimated salt load from drains for six months	6,236,643 kilograms
Estimated salt runoff from drained scalds (do nothing option)	3,000,000 kilograms
Percentage increase in salt load	13%
Proponent's proportion of catchment above final wetland	6%
Proponent's proportion of increased salt load	221%

The formula used by the self-assessment determined that the increased salt load due to the discharge into Taarblin Lake would be a significant increase. 25,000 tonnes are estimated to run into Taarblin from runoff each year. This is added to by approximately 3,000 tonnes of salt from salt scalds in the do nothing scenario. The salt load from the discharge is approximately 6,200 tonnes per annum and this will contribute a 13% increase in the salt load, which adjusted for the proportion of the catchment controlled by the Crown, would mean a potential increase of 220% in salt load if all land owners discharged at the same rate.

6.7 Ionic Composition and Nutrients

QUESTIONS

1. Is the pH of the pumped groundwater less than 2 units different from the receiving wetland?

Evaluation	
<input checked="" type="checkbox"/> Yes	Go to ION RATIO
<input type="checkbox"/> No	Discharge high risk, undertake technical assessment or consider alternatives

The pH is a measure of the acidity of the water. A low pH will increase the release of phosphates from the sediment affecting the number and type of algae species. A low pH will also dissolve limestone and increase the bicarbonate concentration. A high pH will precipitate out limestone causing scale and in general reduce the nutrient concentration in the water. Both a high and low pH will have implications for animal and plant life.

Whereas pH is a measure of the hydrogen ion or acidity, the other dissolved chemicals or ions are just as important. The concentration of dissolved chemicals such as calcium will affect the precipitation of gypsum and limestone and is implicated in the fixing of nutrients. Most plants and animals also use it. The ratio of potassium to sodium plays an important role in the osmotic regulation of both plants and animals. Sulphate is an important chemical used by hypersaline bacteria that are part of the biological cycle.

Ionic composition changes with changing total ion concentration, and it is therefore necessary to compare brines from different sources with a standard such as evaporated seawater. The selection criteria should consider whether the drainage water would significantly change this balance.

2. Is the ratio of ions in the pumped groundwater within 20% of the receiving water?

Evaluation	
<input checked="" type="checkbox"/> Yes	Go to NUTRIENTS
<input type="checkbox"/> No	Discharge high risk, undertake technical assessment or consider alternatives

Increases in the concentration of nitrogen and phosphorus in soil, soil water and ground water is known to be a significant contributor to the decline of riparian vegetation and spread of weeds in agricultural regions of Australia and overseas.

Altered nutrient regimes significantly affect invertebrate, phytoplankton and macrophyte diversity and abundance.

Excessive nutrients in waterways can lead to algal blooms that are toxic to livestock and native flora. Metal and organic pollutants (i.e. pesticides, herbicide, other agri-chemicals) from human activities can have a detrimental effect on the flora and fauna of a natural wetland.

- Compare the nitrogen & phosphorus of the wetland and the nitrogen & phosphorus of the drain. Will the drain increase the Total Nitrogen and/or Total Phosphorus concentration in the receiving wetland by less than 10%?

Evaluation	
<input type="checkbox"/> Yes	EVALUATION COMPLETE
<input checked="" type="checkbox"/> N/A	EVALUATION COMPLETE
<input type="checkbox"/> No	Discharge high risk, undertake technical assessment or consider alternatives

Increased nutrient loading will increase the depth of organic sediments and anaerobic recycling of nutrients will become a more prominent feature of the wetland. Significant changes to biology may result.

CALCULATION

The pH, ionic composition and nutrient levels were similar for the pumped groundwater and the water in the receiving wetland.

6.8 Summary of Self Evaluation

The discharge from the Toolibin Lake bore field goes directly to Taarblin Lake via an enclosed pipeline. The primary receiving wetland and the final receiving wetland, as per the terminology by Coleman and Meney (2000) amount to the same thing in this study. The primary receiving wetland for this reason has been omitted. Taarblin Lake is a medium size lake of 916 hectares. It rarely overflows but when it does the water from the lake flows to a succession of smaller lakes, the Arthur River and finally the Blackwood River on its way to the sea. It has been estimated that the overflow occurs once every thirty years. Taarblin Lake is set aside for the purpose of *Conservation of Flora and Fauna* (Reserve No. 9550).

The discharge flow will be approximately at a rate of 10.5 L/sec with a salinity of 38.3 g/L. As a result the discharge will contribute 6,200 tonnes of salt over six months or 12,400 tonnes per annum. It is interesting to note that the self-evaluation sheet does not calculate the discharge over an entire year as it assumes that the discharge is from a drain and will not discharge for the entire year. This was not modified because it was reasoned that most brine in the summer would evaporate and rapidly recharge into the groundwater.

The vegetation condition of Taarblin Lake is patchy. The fringing vegetation is in good health with stands of *Casuarina obesa* and some *E. longicornis*. The lake bed was different, with most trees having died a number of years ago. These trees were probably *Casuarina obesa*. The understorey was composed of a number of Chenopod (samphire) species. The chenopod population was stressed from the summer but otherwise formed a viable community. The species composition was similar to that found on Toolibin Lake.

Of the criteria specified by the evaluation method, it was determined that the discharge would not increase the hydroperiod at Taarblin Lake. Nutrients were not considered an issue due to the discharge being from the common groundwater of both lakes, and there being no addition of nutrients from run off into the discharge. The pH of the discharge water approximates that of the receiving water. The ionic composition actually returned a significant difference but on examination of the comparison, it was found that only one element, magnesium, was slightly over the level needed to trigger the significance test.

Changes to the salt load and salt concentration in the receiving lake were considered a concern as they exceed the limits set down by the evaluation method. The quantity of brine proposed to be pumped into Taarblin may also increase the flooding if all landowners in the catchment decided to discharge at the same rate. As a result the following technical review of the discharge focuses on the flood potential, increased salt load and concentration in Taarblin Lake.

7 Technical Assessment

The technical assessment includes a preliminary mass balance of Taarblin Lake in order to identify the major water and salt fluxes within the environment. This information was used to model the hydrology of Taarblin Lake under two scenarios, with and without the current and proposed discharge. The model was used to generate a comparison of changes to salt load and concentration, and hydroperiod over time. A more detailed analysis of Taarblin's vegetation is included in section 7.3.

7.1 Mass Balance

The best data available for the stream flow into Taarblin Lake is the Northern Arthur River gauging station 609-010 as it flows into Toolibin Lake⁴. This gauge actually records the flow into Toolibin Lake. The Toolibin catchment is sufficiently like Taarblin's catchment to serve as an estimation of its characteristics.

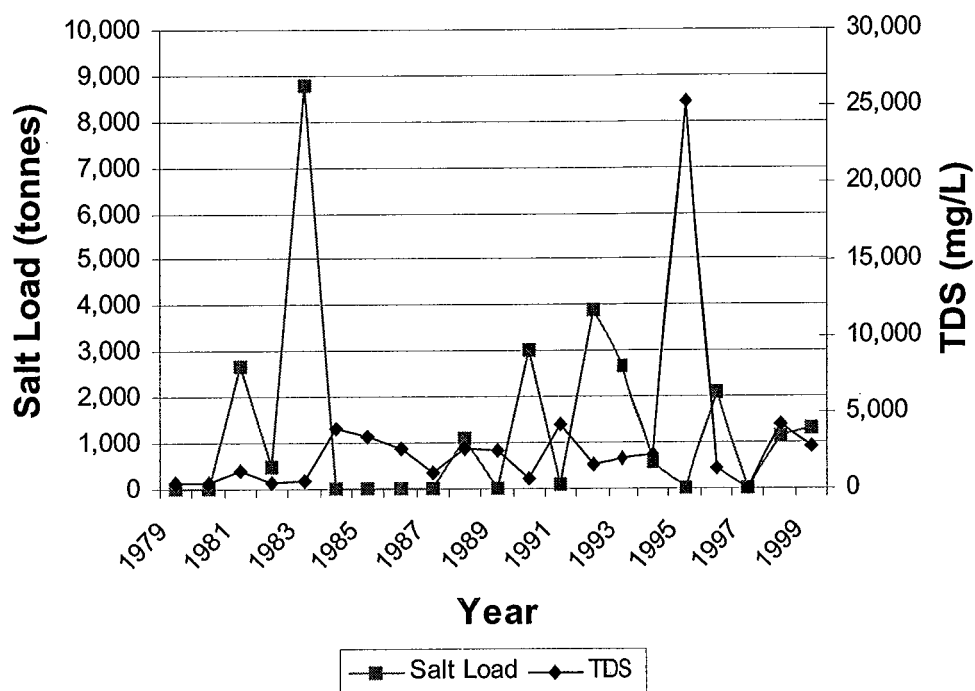
Table 8 Measured Parameters at Gauge Station 609-010

Year	Flow Salt Load		TDS	Rainfall	
	ML/annum	(t/annum)		TotAnn mm	MaxMth mm
1979	0.01	0.01	385	238.18	40.00
1980	0.14	0.05	352	393.19	79.40
1981	2,164.04	2,642.53	1,221	350.93	72.59
1982	1,340.24	485.01	362	401.56	117.49
1983	15,708.01	8,775.47	559	485.89	156.49
1984	0.15	0.60	3,934	355.80	71.69
1985	0.10	0.33	3,402	273.43	73.86
1986	0.02	0.05	2,684	305.07	90.06
1987	0.00	0.00	1,000	294.65	69.37
1988	422.75	1,103.30	2,610	353.80	63.62
1989	0.65	1.62	2,485	296.86	68.54
1990	4,338.58	3,021.57	696	450.20	114.60
1991	19.97	82.84	4,148	356.11	77.46
1992	2,526.15	3,905.85	1,546	397.58	88.55
1993	1,309.15	2,646.02	2,021	418.40	70.40
1994	258.18	568.28	2,201	248.87	63.93
1995	0.09	2.30	25,231	321.10	68.68
1996	1,633.62	2,076.38	1,271	363.33	104.80
1997	1.03	0.01	5	373.94	76.50
1998	268.42	1,120.25	4,173	389.50	73.38
1999	463.04	1,298.74	2,805	374.20	63.70
Sum	30,454	27,731	-	-	-
Average	1,450	1,321	911	-	-

⁴ Feature Type Stream gauging AWRC Name LAKE TOOLIBIN INFLOW
Northing 6359098 Easting 557420

The average salinity of the water at Station 609-010 is 911 mg/L or 0.9 g/L. It is probable that the salinity of the water discharging into Taarblin Lake is slightly higher than that into Toolibin Lake as it is from a drier region, but the difference is expected to be small. The Toolibin catchment is common to over 60% of the Taarblin catchment, however Toolibin rarely overflows into Taarblin Lake. The salinity did vary according to stream flow (Figure 3). It should be noted that the salt load does not follow the TDS of the inflow.

Figure 3 Recorded Salt Load and Concentration of stream flow into Toolibin Lake



The ratio of the Taarblin Lake catchment to Toolibin Lake's catchment is approximately 1.6 (see Table 9). The flow into Taarblin Lake is probably best characterized by the stream flow into Toolibin but of a magnitude 1.6 times larger.

Table 9 Catchment of respective Lakes⁵

48920 ha	Toolibin Lake
78800 ha	Taarblin Lake
1.61	ratio

Samples of Taarblin Lake's playa were analysed for salt. The results showed that the average salt load in the top two centimetres was 1.05 kg/M² or 10.5 tonnes per hectare. This suggests that the total salt load on the surface of Taarblin Lake is approximately 10,000 tonnes.

The soil was dry to 0.5 metres when holes were dug and there were no tell tale salt scalds. There are a number of smaller lakes to the east, which have a very high salinity and substantial

⁵ The areas were derived from the "State Cadastral Data Base (SCDB) 1999" (CALM, pers. comm.).

salt crust. Interestingly these small lakes are in evaporative sequence, increasing in salinity towards the south west. However the relevance of these lakes to Taarblin is not known.

It is estimated that the holding capacity of Taarblin Lake is in excess of 12,000 ML. Only once in the time between 1979 and June 2000 has the calculated flow into Taarblin Lake over the winter months exceeded this value. In the winter of 1983, the estimated runoff into Taarblin Lake was calculated as being 25,000 ML over the four months of winter rainfall. Taarblin Lake was observed overflowing during this period (K. Wallace pers. comm.). From the rainfall and salinity readings it is estimated that 14,000 tonnes of salt flowed into Taarblin Lake. Obviously some flowed out of Taarblin Lake during this period. The flow and salt load into Taarblin Lake were estimated from the flow into Toolibin Lake, and are given in Table 10.

Table 10 Calculated Water and Salt flow into Taarblin Lake⁶

	Flow	Salt Load
Year	ML/annum	Tones/annum
1979	0	0
1980	0	0
1981	3,486	4,257
1982	2,159	781
1983	25,302	14,135
1984	0	1
1985	0	1
1986	0	0
1987	0	0
1988	681	1,777
1989	1	3
1990	6,989	4,867
1991	32	133
1992	4,069	6,292
1993	2,109	4,262
1994	416	915
1995	0	4
1996	2,631	3,345
1997	2	0
1998	432	1,804
1999	746	2,092
Average	2,336	2,127

Hingston and Gailitis (1976) determined that the salt load from rainfall in Narrogin was approximately 30.9 kg/ha/year. This would put the salt load from rain in the Taarblin catchment at 2,300 tonnes per year. This is remarkably similar to the recorded average salt load from Table 10.

⁶ Calculated by multiplying measuring station 609-010 records by a relative catchment ratio of 1.6. It is expected that the salt load from the rest of the Taarblin Catchment is higher than the salt load into Toolibin, however the difference is not expected to be significant considering that the Toolibin catchment is over 60% of the Taarblin catchment.

The above figures plus some provided for Toolibin Lake (Dogramaci pers. com.) were used to construct a tentative mass balance of Taarblin Lake and its catchment. The results of these calculations are given in Table 11. The assumptions are important and should be considered in context with the results. The mass balance indicates that the salt load from the discharge is significant compared to the annual input into the Lake but insignificant compared to the total static load. The water volume of discharge is small compared to the input and static load.

Table 11 Tentative Mass Balance of Taarblin Lake⁷

	Volume (m3)	Salt (tonne)
Input per annum		
Rain direct	3,938,800	28
Rain runoff	2,500,000	2,435
Palaeo system	15,000	570
Aeolian	0	0
Total	6,453,800	3,033
Static		
Lake layers		
Lake sediments	5,496,000	208,848
River sediments	105,340,000	4,002,920
Fractured Basement	0	0
Surface	0	9,160
Total	110,836,000	4,220,928
Output per annum		
Palaeo	15,000	570
Aeolian Discharge	0	0
Evaporation	4,523,208	0
Total	4,538,208	570
Discharge	330,325	12,700

It should be noted that the previous EIA used the data for the entire North Arthur River Catchment east of the Albany Highway during a very high rainfall period (1983). The

⁷

- ? Interchange between Taarblin and other lake is restricted to groundwater flows in the river sediments.
- ? Aeolian salt transfer does not exceed the boundaries of the catchment.
- ? Evaporation transfers water only.
- ? Salt only enters the catchment through rainfall and groundwater flows in the river sediments.
- ? Salt does not come from the decomposition of rock.
- ? The sediments beneath Taarblin Lake are homogenous within each of the three types.
- ? The salinity of the groundwater is homogenous.
- ? That there is no groundwater movement other than that through the Palaeo channel or river sediments out of the Lake's catchment.
- ? The evaporation factor used to calculate the net evaporation over Taarblin Lake was estimated as 0.3 of Class 'A' pan evaporation.

Committee (1987) report used data from the North Arthur River and Northwest Creek running into Toolibin Lake for the period of 1981 to 1983. Both of these reports reported a much higher salt load for Toolibin Lake at approximately 4,000 tonnes per annum. This would make the salt load into Taarblin Lake approximately 6,500 tonnes per annum. It is believed that the long term data used in this report will better reflect the average salt load into the lakes but it should be noted that short-term peaks would occur.

7.2 Water and Salt Model for Taarblin Lake

A mathematical model was used to generate the hydrological characteristics of Taarblin Lake. This model used local evaporation and rainfall data, and calculated runoff to estimate changes over time. The average rainfall for the area was estimated by averaging the Bureau of Meteorology (BOM) data for Lake Grace and Narrogin. It was determined that the rainfall from Narrogin alone was much higher than what falls at Taarblin Lake. The average of Narrogin and Lake Grace records is almost identical to the unofficial records at Wickenpin. This long-term average data was only used for the period from July 2000 into the future. All other rainfall data was collected on a monthly basis from the Toolibin Catchment (Wickenpin) (see Table 10). The evaporation data was that from the Narrogin BOM site. Gross evaporation data is not recorded at all BOM sites and was not available for Lake Grace. Evaporation does not vary as much as rainfall and it can be assumed that the Narrogin averages reasonably represent the evaporation at Taarblin Lake. A constant groundwater recharge of 1mm per day was used in the model. This figure is in all likelihood an overestimation for winter months and an underestimation for the drier months. The modeled evaporation of the lake's water varied with the estimated salinity and depth of water/brine in the basin.

Monthly information used to compile Table 10 was used for the period from 1980 to late 1999, regional rainfall for the period from 1999 to early 2001, and average rainfall thereafter was used to calculate the runoff as per Adrian Peck (personal communication, unpublished 2001). The salinity of the runoff was estimated at 1 g/L.

This model has been used by actis Environmental Services in other discharge scenarios and has been found to reproduce reliable estimates of area affected by the discharge, volume of water, salt load and to a more limited extent salt concentration in the discharge basin. Two scenarios were run together, one with additional bore discharge and the other without any discharge.

The results of the modeling are illustrated in Figure 4 to Figure 7.

7.2.1 Flooding and Hydroperiod

The effects of the proposed and existing discharge are illustrated in Figure 4 and Figure 5. As for the self-evaluation there is no significant increase in hydroperiod as demonstrated by height of water in the basin and volume of water.

As modeled, there is a minor increase in the basin volume for the proposed increase in pumping. According to the model, Taarblin Lake would not have overflowed during this period, although for a few years it would have had a covered basin approaching 1,000 ha.

The difference between modeled discharge and non discharge scenario lake volumes is only noticable during the winter months after the new pumps are installed. The increased lake volume with discharge is likely to be higher than modeled due to reduced groundwater recharge but not significantly.

It is not expected that the existing pump regime will significantly increase the chance of Taarblin flooding into the upper Blackwood River. The salt will undoubtedly recharge into the ground and the water will principally evaporate.

Figure 4 Modelled Water Height and Area Flooded in Taarblin Lake

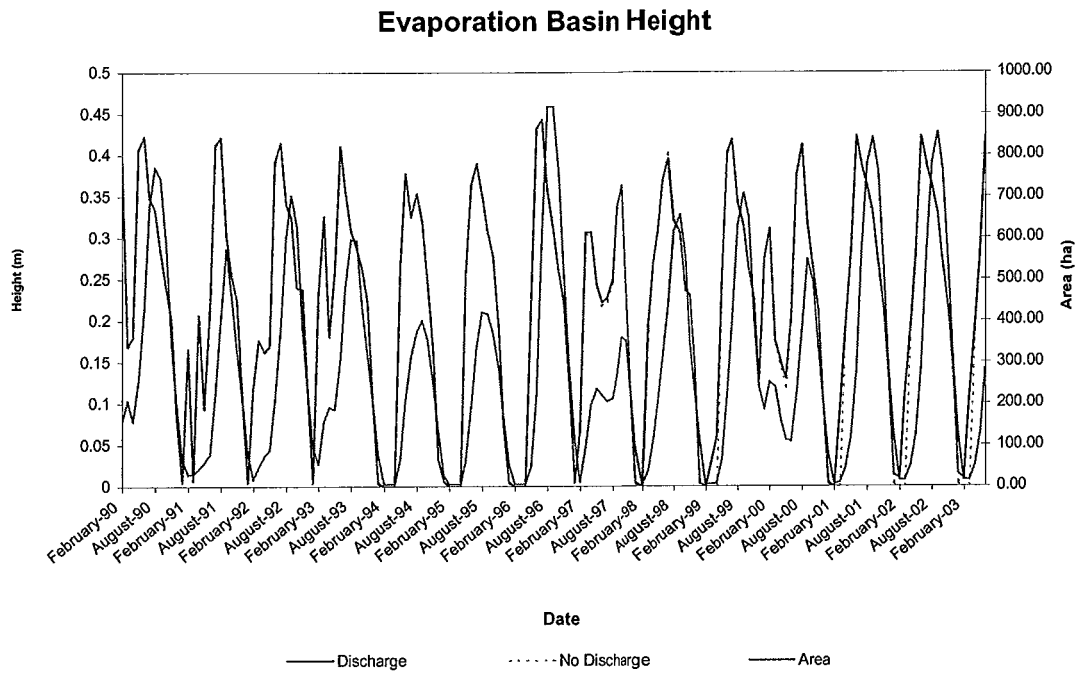
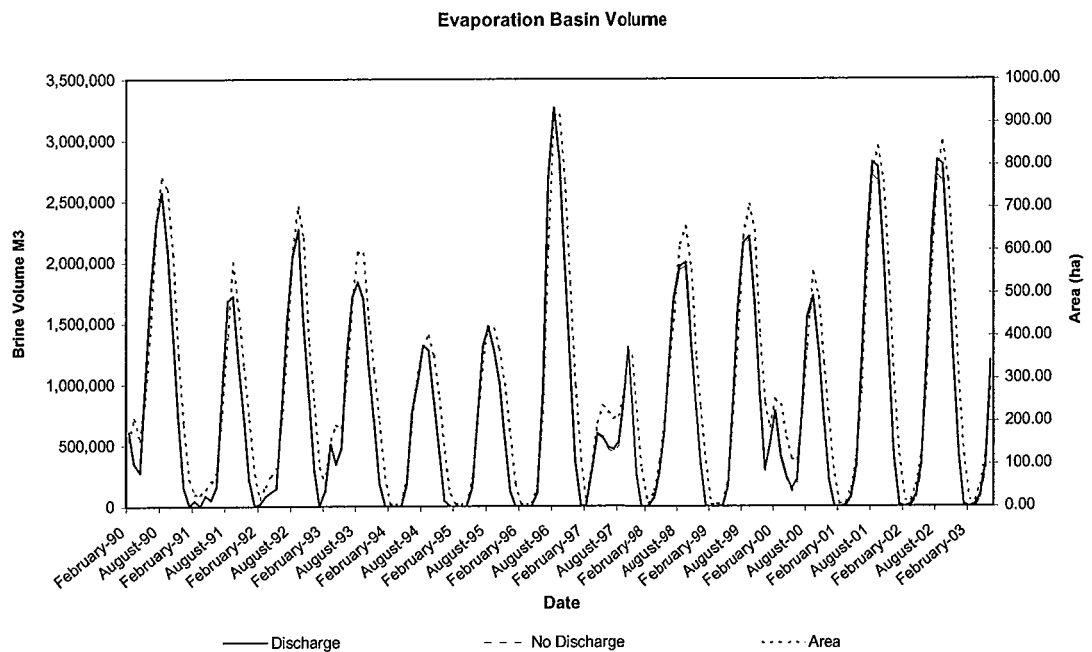


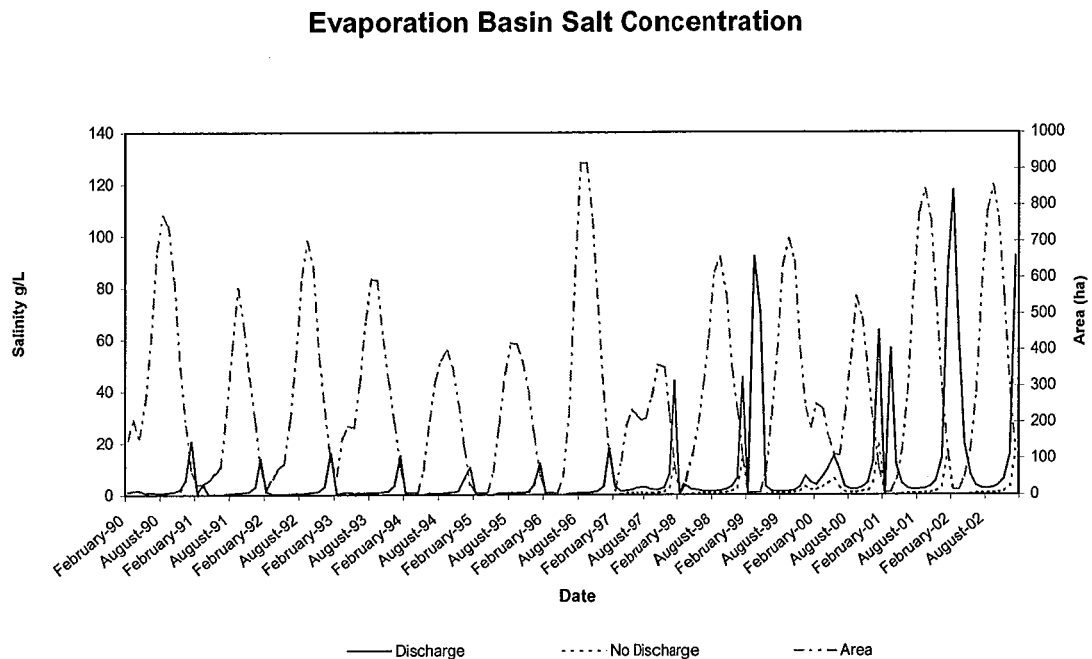
Figure 5 Modelled Volume of Water and Area Flooded in Taarblin Lake



7.2.2 Salt Concentration

The self-evaluation found that the salt concentration from the proposed discharge exceeded the guidelines. The model does suggest that the salinity will increase significantly for some periods but closer examination shows that the salinity increase falls as the basin dries after flooding. All the significant increases in salinity are when the area flooded is less than 50 ha or confined within the bare playa to the south of the Lake. The salinity will reach saturation for a small period of time as the last pond dries. On this basis it is unlikely to be a major concern but needs to be monitored. The salinity as predicted by the model is of the same magnitude as that reported in internal CALM wetland records, however it is difficult to make a detailed comparison due to the sparseness of the data.

Figure 6 Modelled Salt Concentration and Area Flooded in Taarblin Lake



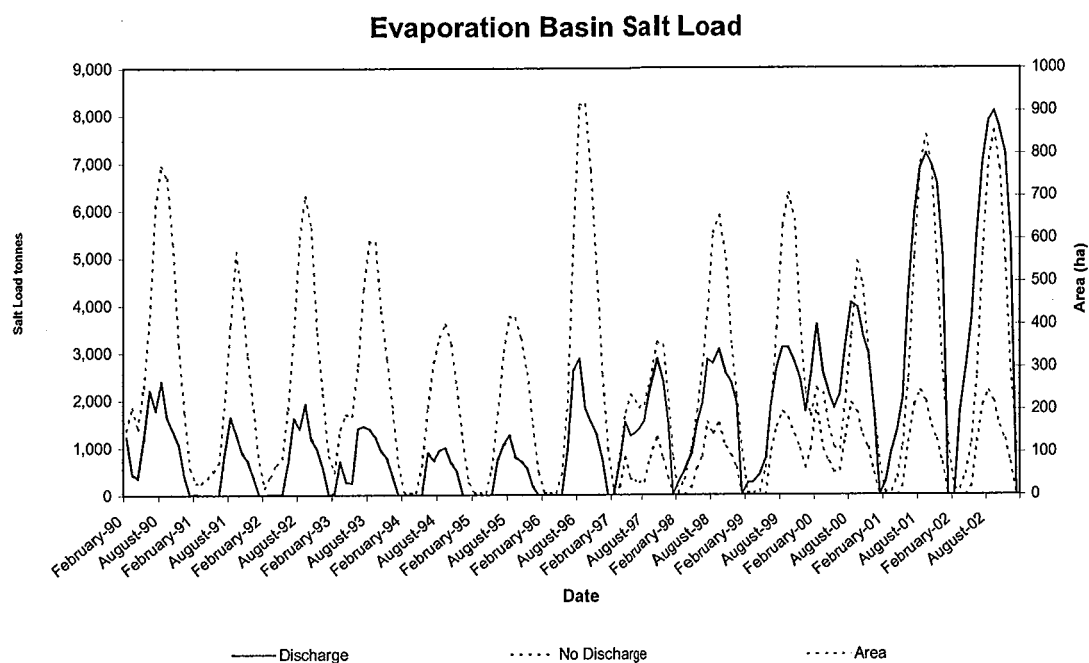
7.2.3 Salt Load

As for the salt concentration, the salt load was found to exceed the guidelines as specified in the self-evaluation. The modeled results (Figure 7) show that the discharge will contribute a significant amount of the total salt load coming into the wetland. The peak salt load was modeled as being 8,000 tonnes into the future. A characteristic of the salt load over time is that the salt load builds up while the natural flooding is occurring. When the Lake is dry the salt is recharged into the sediment albeit at the relatively low rates of 1mm per day. This illustrates that there is a seasonal aspect of the salt loading in the wetland. The salt load peaks at 6,000 tonnes more than the natural load, with the new pumps installed.

An additional aspect of the salt load is that only the incoming salt load is modeled. From the mass balance, it has been estimated that there is a static salt load in Taarblin Lake of about 10,000 tonnes. Other sources of salt could be groundwater discharge plus the runoff from the catchment. In equilibrium state the outgoing salt load would be equal to the incoming, with groundwater movements being the principal method of salt loss from the system. A marginal decrease in salt load from the Toolibin catchment groundwater could be expected, as this is the discharge water, but realistically this could not be expected to be much.

The model suggests that there will a small area of salt crust of about 40 ha during the summer months at equilibrium. Currently there is no salt crust.

Figure 7 Modelled Salt Load and Area Flooded in Taarblin Lake⁸



⁸ Only the surface water's contribution to salt load has been modeled. The total load is estimated to be at least 10,000 in Feb 01.

7.3 Flora and Fauna

Taarblin Lake was inspected on the 19/2/2001

At the time of the site visit, the fringing vegetation at Taarblin Lake appeared to be in good condition, the evident dead trees were on the floor of the lake itself. An estimate of percentage of dead trees on the lake bed would be about 90% dead. These trees appeared to have been dead for many years, as all of the small twigs and branches had gone, leaving only the major branches and trunk. There did not appear to be recent deaths. Eucalyptus trees (*Eucalyptus longicornis*), which were further up in the height profile above the lake than the casuarina trees, were large and healthy specimens. A number of large eucalyptus trees on the eastern side of the lake had fallen in past storms (blocking the track) – some time ago judging by their condition.

Samphires on the lake floor were generally in good health considering the current dry period. The samphires on the lowest vegetated portion of the lake floor were small and very dry but still alive, however others higher up in the height profile (the majority of the samphire population) were proportionally large and not so dry.

The samphire species at Taarblin Lake suggest that there are extended periods of flooding of the lake but the water is not particularly saline for the majority of that time. There are 5 species of samphire at Taarblin Lake, with possibly another two subspecies. The species at Taarblin Lake are the same as the ones found at Toolibin Lake, with the exception of the suspected previously undescribed *Halosarcia pergranulata* subspecies. This subspecies was found at a clay pan/samphire flat near Toolibin Lake, not on the lake proper.

Many shot gun cartridges were evident over the lake bed – probably in excess of 100 were counted during the site visit over a relatively small area. Samples were collected from eight sites over Tarblin's surface. These sites are described below. The location of each site is shown in Figure 8.

Site 1 This site was at the lower part of the samphire-covered pan, adjacent to the large bare pan visible on the aerial photograph. There were many large dead trees, which appeared to have been dead for some years – all twigs and small branches had gone, leaving only major branches. The samphires in this area were very dry, as was the surface of the lake – hard, dry and dusty. There was no sign of a salt crust. The samphire species indicated that the lake becomes wet for extended periods but is not particularly saline – less than seawater at its most saline. One species, *Halosarcia lepidosperma* was not found at this site but found at all the others. This is probably because this site is at the lowest vegetated point in the lake and stays flooded for too long to support this species.

Species at this site were:

Halosarcia indica bidens (small var)

H. pergranulata

Sarcocornia blackiana

S. quinqueflora

Site 2 This site was between the lowest vegetated point of the lake and the higher ground at Site 3 – slightly higher than Site 1. The vegetation was slightly taller and not so dry. As at Site 1 there were many large long-dead trees, which were on top of slightly elevated ground or

mounds. The samphires on these 'mounds' were taller than the ones on the floor and the species *Halosarcia lepidosperma* was evident.

Species at this site were:

Halosarcia lepidosperma

H. pergranulata

Sarcocornia quinqueflora

Site 3 This site was on higher ground – a curving lip then back to a slightly lower portion but still higher than Site 2. The higher 'lip' featured live trees – *Casuarina obesa*, but the trees on the lower portion were dead. Samphires at this site were considerably bigger than those on the lower ground and not so dry.

Species at this site were:

Casuarina obesa

Halosarcia indica bidens

H. lepidosperma

H. pergranulata

Sarcocornia quinqueflora

Site 4 This site was on the track out of the southern end of the lake. The trees, *Casuarina obesa* were healthy with *Halosarcia lepidosperma* growing beneath them. *Sarcocornia quinqueflora* was not present here - it was too high above the lake floor.

Species at this site were:

Casuarina obesa

Halosarcia lepidosperma

Site 5 This site was approximately half way along the eastern side of the lake. The trees and shrubs at this site were healthy and tall. The trees were *Casuarina obesa* close to the lake and large trees – *Eucalyptus longicornis* were on higher ground. The samphires were about 50cm tall and healthy at this site. The two *Sarcocornia* sps were not present here – they grow in areas of prolonged inundation.

Species at this site were:

Casuarina obesa

Eucalyptus longicornis

Halosarcia indica bidens (tall var)

H. indica bidens (small var)

H. lepidosperma

H. pergranulata

Site 6 This site was the Toolibin Lake diversion channel. The soil was very dry, as were the samphires. Two species were identified in the channel.

Species at this site were:

Halosarcia lepidosperma

H. pergranulata

Site 7 This site was at the northern end of Taarblin Lake. The lake bed was very dry. There were many long-dead trees on the lake bed, but the trees on the edge of the lake were alive (*Casuarina obesa*).

Species at this site were:

Casuarina obesa

Disphyma crassifolium

Halosarcia lepidosperma

H. pergranulata

Site 8 This site was at the northern end of Taarblin Lake, near Site 7. The lake bed was very dry. There was evidence of an algal mat on the floor and caught in some of the samphires. This site stays inundated for longer than Site 7 judging by the presence of both *Sarcocornia blackiana* and *Sarcocornia quinqueflora*.

Species at this site were:

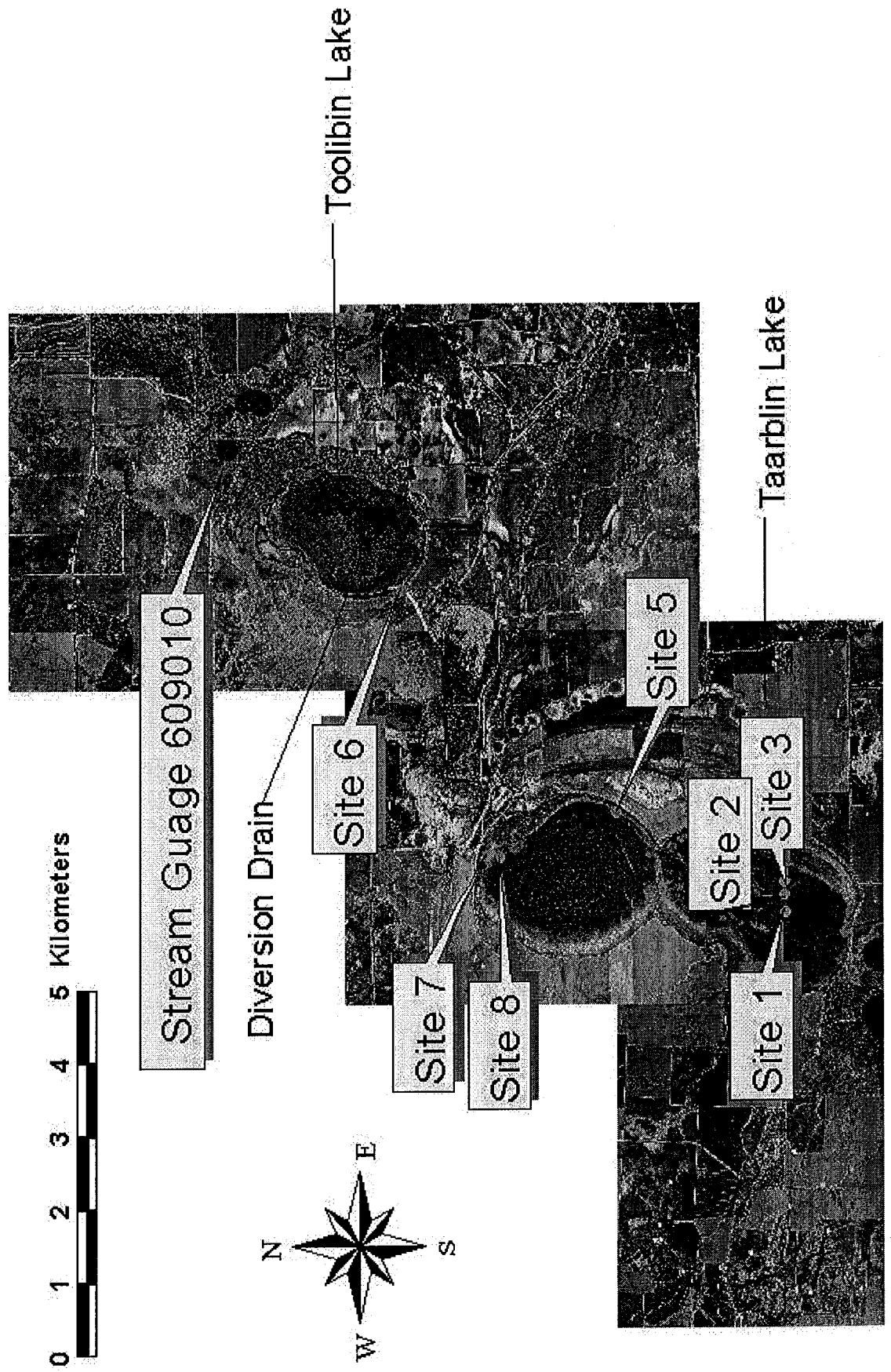
Halosarcia lepidosperma

H. pergranulata

Sarcocornia blackiana

S. quinqueflora

Figure 8 Locations of Vegetation Sampling Sites



7.4 Summary of Technical Assessment

Taarblin Lake is filled by runoff with a significant salinity. The salinity varies from almost zero to 25g/L depending on the velocity of the runoff and the history of rainfall events. An average of 0.9g/L was calculated. This figure was used in the subsequent calculations of salt load and concentration. On an average year the salt load from runoff was estimated to be about 3,000 tonnes. This can be compared with proposed 12,500 tonnes per annum discharge from Toolibin Lake.

The salt load in the top 2 centimeters of Taarblin Lake's playa was measured by sampling and dissolving the upper layer. From these samples the total salt load on the surface of the Lake was estimated to be 10,000 tonnes.

As modeled, Taarblin Lake will not have a significant increase in hydroperiod with the proposed discharge. A rough calculation supports the model. The total annual flow from the groundwater pumping will only increase the height of Taarblin by 3.6cm. This is equivalent of 4 days summer evaporation or roughly 10 days of average evaporation (Table 12).

Table 12 Increase in Water Height

Daily Pumped Volume (m ³)	Annual Volume (m ³)	Rise (cm)
905	330,325	3.6

There will be a significant increase in the salinity and salt load. These increases are likely to be within the bare playa at the southern end of Taarblin Lake. It is not expected that the salinity of the Lake will be significantly increased at a time of bird breeding for most years. Some salt crusting can be expected over this southern playa for most years. The large annual variations in runoff do not allow the prediction to be specific.

It is not expected that there will be a significant increase in salt transferred to the upper reaches of the Blackwood River.

At Taarblin Lake the fringing vegetation appeared to be in good condition, the dead trees were on the floor of the lake itself. An estimate of percentage of dead trees on the lakebed would be about 90% dead. These dead trees appeared to have been dead for many years, as all of the small twigs and branches had gone, leaving only the major branches and trunk. There did not appear to be recent deaths.

The samphire species at Taarblin Lake suggest that there are extended periods of flooding of the lake but the water is not particularly saline for the majority of that time. Samphires on the lake floor were generally in good health. There are 5 species of samphire at Taarblin Lake, with possibly another two subspecies.

8 Summary and Recommendations

The pumping of groundwater from Toolibin Lake to Taarblin Lake is part of an extensive strategy to protect Toolibin Lake and surrounding farmland from rising groundwater levels and secondary salinisation. It is believed that groundwater pumping from beneath Toolibin Lake and surrounding farmland is needed to protect large tracts of vegetation within Toolibin Lake and adjacent farmland. The groundwater pumping is one part of a broader catchment management plan, which includes revegetation, farmland and surface water runoff management. It is also believed that Taarblin Lake has been largely amended by the rising groundwater and increasing secondary salinisation common throughout the wheat belt. As the salinity increases within Toolibin Lake, the salt load into Taarblin will also increase with or without active groundwater discharge to Taarblin Lake. This current submission is based on the current approved discharge plus the proposed increase in discharge amounts. The evaluation has not been made of the incremental impact due to the additional pumping but rather the total discharge.

Both the technical and self-evaluation process identified salt load and salt concentration as the principal concern with the discharge to Taarblin Lake from Toolibin Lake. They also identified Taarblin Lake as a wetland of some value, although severely stressed and not as 'natural' as Toolibin Lake.

Hydroperiod is not likely to be changed by the limited discharge proposed, especially in the light of increasing groundwater levels. The vegetation in Taarblin Lake is approximately the same as in Toolibin Lake with the same species represented. All plants found in and around Taarblin Lake are found elsewhere and do not have a priority listing.

The technical evaluation further identified that the area within Taarblin Lake that will be affected by the discharge to a significant degree is less than 50 ha. Onsite inspections indicated that the southern playa is most likely the lowest area and the site of salt accumulation. The discharge will affect the fringing vegetation (comprising four samphire species) around the current bare playa (the existing bare pan is approximately 28ha). The plants are already in a precarious position, although recent recruitment has occurred along the edge of the playa. It is expected that these plants will be killed by the discharge but the species composition is well represented elsewhere in Taarblin Lake and in Toolibin Lake. With a change in salinity from the extra saline water from Toolibin Lake, the samphire species dominance around the area that contains water for the longest period of time will probably alter, with the more salt tolerant species becoming more dominant.

The discharge will not have any long term or major effects on the plant species composition within Taarblin Lake. The modelled elevated salinity is predicted to occur when the brine has condensed to a small area and as such is not expected to alter species composition but may change the species dominance.

The groundwater levels within Taarblin are monitored and a summary is given in section 10.4. The groundwater levels do not show an increase that can be obviously attributed to the existing discharge to Taarblin Lake. The data was not used in this report because it would be more suitable to compare the values as part of a regional groundwater study. It is unlikely that the data would show a marked increase due to the small amount of discharge that has been pumped to Taarblin lake up to this time.

Given that the groundwater pumping has been shown to have some beneficial effect on the ecology of Toolibin Lake, the relatively small impact on Taarblin Lake, which is already seriously amended, seems justified. It is recommended that the discharge be allowed.

It is recommended that the following parameters be monitored as part of the ongoing management of the discharge into Taarblin Lake:

- ? Salinity of Taarblin versus lake depth.
- ? Salinity of groundwater versus groundwater depth.
- ? Total salt load in Taarblin Lake
- ? Permanent vegetation monitoring transects.

It is also recommended that the concurrent management strategies to reduce the movement of salt in the catchment to the valley lakes are maintained at their current high priority and be reviewed. It is expected that the Toolibin Lake Recovery Team and Toolibin Lake Technical Advisory Group would provide the review.

9 References

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10 Appendix

10.1 Reserves in Region

Table 13 List of Nature Reserves for the purposes of conservation of flora and fauna vested in the National Parks and Nature Conservation Authority⁹

Name	Reserve Number	Legal area (Ha)	Class
Birdwhistle Nature Reserve	19120	396.07	A
Brooks Nature Reserve	4723	22.03	A
Dingerlin Nature Reserve	15266	62.63	A
Dongolocking Nature Reserve	19082	719.95	A
Dongolocking Nature Reserve	19083	198.00	A
Dongolocking Nature Reserve	19096	338.97	A
Dulbining Nature Reserve	9617	245.04	A
Dulbining Nature Reserve	27286	343.32	A
Ibis Lake Nature Reserve	9629	26.92	A
Mallee Plain Nature Reserve	19084	316.00	A
Taarblin Lake Nature Reserve	9550	1013.49	A
Toolibin Nature Reserve	24556	496.76	A
Walbyring Nature Reserve	14398	144.14	A
Yarling Nature Reserve	19118	102.76	A
	15787	2.25	C
	15788	2.02	C
	19119	40.31	A

⁹ State Cadastral Database (SCDB) 1999 and gazetted area

10.2 Vegetation Map of Taarblin Lake

Lake Taarblin

Nature Reserve :	Taarblin Lake NR	Reserve Number :	20962
Vesting :	NPNCA	Purpose :	Cons. Flora and Fauna
Lake Area :	916.0 ha	Vegetation Area :	766.0 ha
Open Water :	150.0 ha (16.38%)		
Lake Permanence :	Seasonal	Lake Salinity :	Brackish
Coordinates :	32.59 S, 117.33 E		

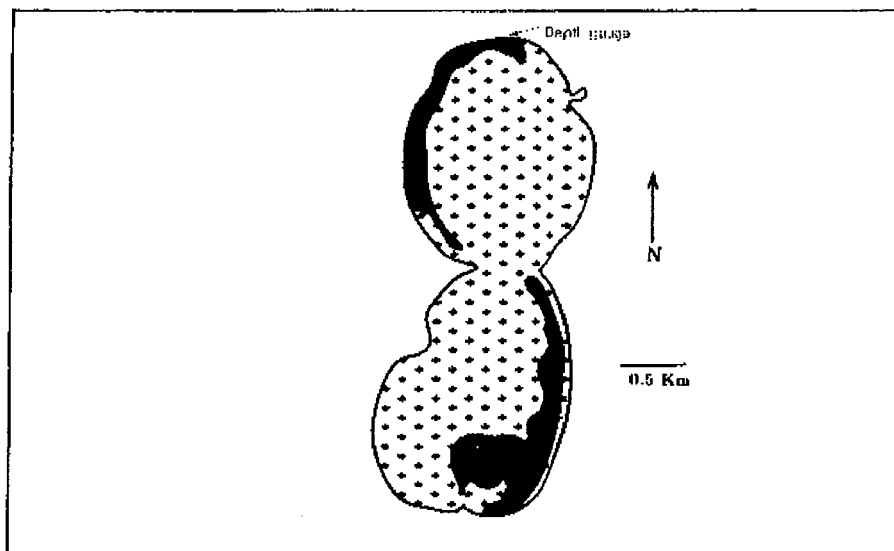
Vegetation Structure :

	Height (m)	% Area	% Cover
herbs	0.10	80	10
samphires	0.30	20	60
dead trees	5.00	85	50

A large brackish-to-saline lake with extensive areas of long-dead *Casuarina obesa* trees below the water mark. There are live *C. obesa* trees in some raised sections of the lake bed. *Halosarcia pergranulata* and *Wilsonia rotundifolia* grow under the dead trees. Above the water mark live *C. obesa* trees occur, with *Disphyma crassifolium* growing on the ground near the edge of the inundated area.

Plant species list (zones indicated by a single numeral)

- 3 *Disphyma crassifolium*
- 3 *Halosarcia pergranulata*
- 3 *Wilsonia rotundifolia*
- 4 *Casuarina obesa*



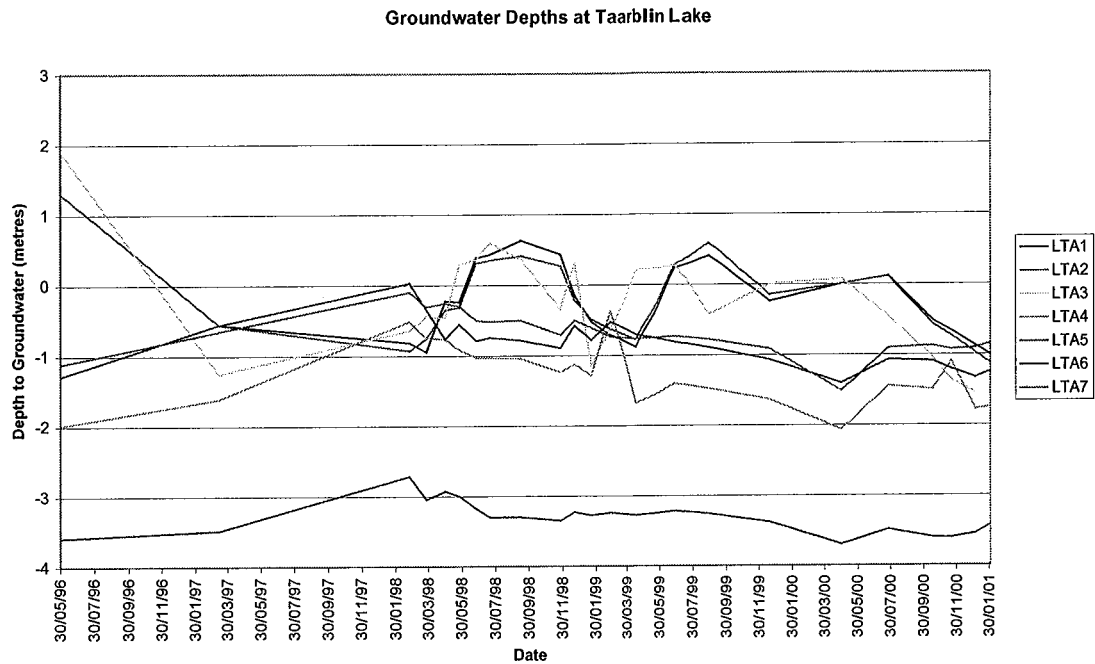
10.3 Flow Data for Gauging Station into Toolibin Lake

Table 14 Salt and Runoff Statistics for Toolibin Lake

	Flow	Salt Load	TDS
Year	ML/mth	(t)	mg/L
1979	0.01	0.01	385
1980	0.14	0.05	352
1981	2,164.04	2,642.53	1,221
1982	1,340.24	485.01	362
1983	15,708.01	8,775.47	559
1984	0.15	0.60	3,934
1985	0.10	0.33	3,402
1986	0.02	0.05	2,684
1987	0.00	0.00	1,000
1988	422.75	1,103.30	2,610
1989	0.65	1.62	2,485
1990	4,338.58	3,021.57	696
1991	19.97	82.84	4,148
1992	2,526.15	3,905.85	1,546
1993	1,309.15	2,646.02	2,021
1994	258.18	568.28	2,201
1995	0.09	2.30	25,231
1996	1,633.62	2,076.38	1,271
1997	1.03	0.01	5
1998	268.42	1,120.25	4,173
1999	463.04	1,298.74	2,805
Sum	30,454	27,731	911
Average	1,450	1,321	911

10.4 Taarblin Groundwater Data

Figure 9 Groundwater Depths beneath Taarblin Lake¹⁰



¹⁰ Groundwater bores 1,2 and 3 are on the bed of Taarblin Lake. All others are on adjacent private property.

10.5 Saline Ecosystems

Table 15 Ecology of Changing Salinity for non tidal saline wetlands¹¹

Terms	Meiomesosaline	Hyposaline	Mesosaline	Polysaline	Hypersaline
Salinity Range ppm	1,000 – 3,000	3,000 – 20,000	20,000 – 50,000	50,000 – 100,000	> 100,000
Diversity	High	High	Moderate	Reduced	Low
Vertebrates	Frogs numerous, numerous fish species (eg. minnows, <i>Galaxiella</i> spp, western pygmy perch, <i>Edelia vittata</i>)	Frogs uncommon	Estuarine fish species (black bream, <i>Acanthopagrus butcherii</i>), numerous bird species (eg. black ducks)	One or two fish species present of <i>Chrinodon</i> and <i>Atherinosoma</i> genera. <i>Galaxias maculatus</i> Waders very common (eg. stilts, avocets)	Waders very common
Invertebrates	Numerous crustaceae (eg. cladocerans, isopods, amphipods, shrimps yabbies, (Cherax spp)), damselfly, dragonflies	Few crustaceae, Shield shrimp (<i>Triops</i> spp) dominate <i>Daphnia carinata</i> <i>Alona</i> sp.	Rotifera (<i>Brachionus</i> , <i>Hexarthra</i>) Anostraca (<i>Paratemia</i>) <i>Daphniopsis pusilla</i> <i>Daphniopsis australis</i> <i>Gladioferens spinosus</i> <i>Mytilocypris splendida</i>	<i>Artemia/Paratemia</i> start. Some species of <i>Diptera</i> , isopod crustacean (<i>Haloniscus searlei</i> , <i>Austrochiltonia subtenuis</i>) at lower range. Species of gastropod <i>Coxiella</i> at lower range	<i>Artemia</i> common, Trichoptera (<i>Symphytoneuria wheeleri</i>)
Macrophytes	Nardoo (<i>Marsilea</i> spp) Duckweed (<i>Lemna</i> spp.), Water fern (<i>Azolla</i> spp.), Pondweed (<i>Potamogeton</i> spp), Water Ribbons (<i>Triglochin</i> spp) Sedges & rushes (<i>Baumea</i> spp., <i>Gahnia trifida</i> , <i>Juncus</i> spp, <i>Typha domingensis</i>)	Nardoo (<i>Marsilea</i> spp), Water Ribbons (<i>Triglochin</i> spp), Pondweed (<i>Potamogeton</i> spp), <i>Ruppia</i> spp Sedges & rushes (<i>Baumea</i> spp., <i>Gahnia trifida</i> , <i>Juncus</i> spp, <i>Typha domingensis</i>)	Estuarine species, <i>Ruppia</i> spp.	Rare clumps of <i>Ruppia</i> , <i>Lepilaena</i> species	Upper range of <i>Ruppia</i> , <i>Lepilaena</i> ¹² (rarely seen)
		Mainly green algae, <i>Ulva</i> , <i>Chaetomorpha</i> . Estuarine species, green algae diatoms, dinoflagellates	Filamentous green algae in small numbers. Diatoms and dinoflagellates dominate biota		<i>Dunaliella salina</i> , <i>Carteria</i> sp

¹¹ Originally reported in (Coleman and Meney (2000))