Monitoring Design and Data Analysis Toolibin Lake and Catchment

Part 2: Monitoring Design

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1.0 INTRODUCTION

1.1 Background

Toolibin Lake lies approximately 200 km south-east of Perth. Along with Lake Taarblin, Lake Walbyring, Lake Dulbining and several smaller lakes, Toolibin Lake comprises a chain of lakes at the headwaters of the Northern Arthur River. It is the only major lake in the chain that has not become saline and is the only inland lake that has retained an extensive area of *Casuarina/Melaleuca* association on the lake floor. The lake is seriously threatened by salinisation and monitoring of the lake since 1978 indicates that the lake and its environs have deteriorated.

The nature reserves including and adjoining Toolibin Lake are managed by the Department of Conservation and Land Management (CALM) on behalf of the National Parks and Nature Conservation Authority (NPNCA). The lake itself is an important waterbird breeding habitat and is listed as a "Wetland of International Importance" under the Ramsar Convention.

In November 1992 consultants prepared a draft Recovery Plan for Toolibin Lake and surrounding nature reserves for CALM. The draft was subsequently expanded, part of which was the inclusion of a Recovery Team and Technical Advisory Group (Bowman *et al.*, 1994). The Plan was endorsed by the NPNCA and officially launched in 1994, and is being implemented under the guidance of CALM's Director of Nature Conservation.

In accordance with the Recovery Plan, significant catchment surface water management works, inflow diversion channels and groundwater abstraction bores have been constructed and more works are planned. The approach has been to utilise engineering solutions as short- to medium term remediation, in an attempt to prevent further deterioration in the condition of the wetland until catchment management actions, such as revegetation, start to take effect. However, it is now time to develop a comprehensive monitoring program consistent with the objectives of the Recovery Plan. In order to assess the condition of Toolibin Lake and the success of the recovery program, CALM has commissioned a review of past monitoring of the wetland and catchment (Part 1 of this report) and the design of a monitoring program (Part 2) that complement the Recovery Plan.

A description of the lake, associated wetlands and nature reserves are presented in detail in Part 1 of this report and are not repeated. Part 2 presents a detailed monitoring program designed to detect changes (improvement/deterioration) in the condition of the lake and its catchment, and which may be used to assess the success of the Recovery Plan. An outline of the Recovery Plan and its criteria are presented in Part 1.

2.0 PROJECT AIMS

2.1 OBJECTIVES

The objectives of the study as set out by CALM are:

Part 1: Analyse and Report the Results of Past Monitoring Works on Toolibin Lake and its Catchment

i) Collect, collate and document all available data pertaining to the monitoring of Toolibin Lake and catchment including its current condition.

ii) Where practicable, digitise into a computer database all numeric data collected except for vegetation condition (the Mattiske reports) and groundwater monitoring data.

iii) Analyse all information on the condition of the lake and write a detailed report describing changes in the condition and processes of the lake since monitoring began. This report must contain a bibliography of all published and unpublished reports used.

Part 2: Design and Document in Detail a Monitoring Program for Toolibin Lake and its Catchment

i) Discuss with each member of the Toolibin Technical Advisory Group (TAG) their monitoring outline, and undertake any consequent research or data gathering that may be necessary to write up detailed and accurate documentation of each monitoring element and sub-element (see Table 2.2.1). Note that each TAG member will prepare a brief outline of monitoring requirements for monitoring elements.

ii) Write a detailed account of how monitoring should be undertaken. This report will include objectives of monitoring, recovery criteria, and detailed descriptions of each monitoring element and how it should be monitored. The report will include for each element:

- Parameters to be monitored and a numeric description of their acceptable limits for Toolibin and how they are calculated.
- Criteria for deciding when parameters have reached levels that are, for example, unacceptably bad, degrading, improving, require management intervention, etc.
- Information on equipment standards, measurement problems or tolerances.
- Estimates of annual monitoring costs.
- References where relevant.

2.2 Grouping of Monitoring Elements into Generic Categories.

Many of the monitoring elements identified in the Contract, as listed in Table 2.2.1 are repeated within different catchment/geomorphic components. The following review of past and present monitoring is structured into generic element types, e.g. lake hydrology, birds, vegetation, invertebrates, groundwater etc. Information for different sites is included within each review of generic elements. This reorganisation of the monitoring elements assists in the interpretation of past monitoring and comparison between sites, and avoids repetition in the development of monitoring protocols. Table 2.2.2 summarises the generic monitoring elements and what they include.

Table 2.2.1 Proposed Monitoring Elements - Toolibin Lake and Catchment

SITE TYPE	ELEMENT	SUB-ELEMENT
Lakes (Toolibin, Walbyring, Dulbining)	birds	frequency season
	amphibians	
	invertebrates	
	phytoplankton	
	vegetation	Mattiske's work, new sites
Dunes/flats vegetation	mammals, retiles, amphibians	inventory/monitoring surveys
	vegetation	Mattiske's work regeneration experiments
Water	Toolibin West Drain	salinity volume flow rate nutrients pH
	inflows to Toolibin Lake at Wickepin Rd.	salinity volume flow rate
	inflows to lake at separator	volume flow rate
	flows down separator channel (including north-west creek)	salinity volume flow rate nutrients
	piezometers in floor of lake, water table	height pressure salinity
	piezometers around lake, in reserves	height pressure salinity
	piezometers in catchment	height pressure salinity
	groundwater pumping model	is pumping working? trees starved of water?
	pumped groundwater	salinity volume flow rate
	body of lake	depth nutrients
Toolibin Catchment	extent of salinity	NLP and CSIRO modelling projects
	farm productivity	economic changes in farm practice
	cultural change	attitudes values practice
	earthworks and drainage	
	woody vegetation	remnants revegetation
	piezometers	height pressure salinity
Toolibin Alley Farming Trial	pasture production	
	woody production	
	water table	
Taarblin	vegetation	
	birds	
	invertebrates	
	piezometers	floor of lake, outlet of pump, impact of pumping
	water quality	salinity, depth

Table 2.2.2 Summary of the sites and topics included in each of the generic monitoring elements

Generic Element	Sites and Topics Included
Lake Hydrology	Toolibin, Walbyring, Dulbining, Taarblin surface inflows to lake (Wickepin Rd, separator, NW creek), lake water, groundwater beneath lake (piezometers in lake floor and around lake), groundwater pumping (model, pumped groundwater).
Catchment Hydrology: Groundwater	Toolibin catchment, lake chain piezometers in catchment
Catchment Hydrology: Drainage	Toolibin catchment, lake chain Toolibin West drain, earthworks and drainage, surface water control
Lake Vegetation	Toolibin, Walbyring, Dulbining, Taarblin lake floor and fringing tree species
Terrestrial Vegetation	Toolibin reserves (dunes/flats), remnant vegetation in catchment all native terrestrial plant communities
Phytoplankton and Aquatic Plants	Toolibin, Walbyring, Dulbining, Taarblin phytoplankton, submerged and floating aquatic plants
Waterbirds	Toolibin, Walbyring, Dulbining, Taarblin all water bird species
Amphibians	Toolibin, Walbyring, Dulbining, Taarblin
Fish	Toolibin, Walbyring, Dulbining, Taarblin
Aquatic Invertebrates	Toolibin, Walbyring, Dulbining, Taarblin, farm dams aquatic invertebrates only
Mammals	Nature Reserves in the Toolibin System
Reptiles	Nature Reserves in the Toolibin System
Terrestrial Birds	Nature Reserves in the Toolibin System
Terrestrial Invertebrates	Nature Reserves in the Toolibin System
Agricultural Practices	Toolibin catchment extent of salinity, farm productivity, cultural change, alley farming, revegetation.

3.0 DESIGN SPECIFICATIONS FOR MONITORING ELEMENTS

3.1 Lake Hydrology

3.1.1 Water and Salt Inputs, In-Lake Levels, Volumes and Salt Storage

3.1.1.1 Aims

- Commitment to maintaining up-to-date and accurate records. Changes to the structure of the government agency (Water Authority to Water and Rivers Commission) responsible for the maintenance of hydrographic monitoring stations at Toolibin Lake and the databasing of information, may adversely impact on the provision of these services. There needs to be a commitment to maintaining a high quality of monitoring and data analysis, especially when considering the Commissions new role in wetland management in this State.
- In-lake salinities and outflow volumes and salinities need to be monitored. As recommended by Greenbase Consulting in 1991, the authors strongly recommend that in-lake salinity is monitored continuously at the float well station in Toolibin Lake. In order to determine accurate water and salt balances for the lake, outflow volumes and salinity also need to be monitored continuously. Monitoring of these parameters are of key importance to the conservation of the Lake ecosystem and measurement of recovery success. CALM's annual monitoring of in-lake salinities, depth, pH and nutrients should continue and will complement monitoring of these parameters at the float well by the WRC.

- Continued monitoring at the current stations at Toolibin Lake.
- Nutrient monitoring be continued and expanded. Nutrient monitoring within the lake should be continued but conducted more frequently and at regular intervals. The number of sampling stations within the body of the lake as well as the type of nutrient analysed for, can be reduced.
- An assessment of salt storage in the lake be conducted. The importance of lake sediments in storage of salts during water recession and dry periods, and the release of salts upon re-wetting, has not been quantified. Knowledge of this process will assist the calculation of a more complete lake system salt storage. A salt budget for the lake can be calculated once in-lake and outflow water quality is monitored regularly. Addition information on salt storage can be gained from EM38 transects on the lake floor and pumpage monitoring (quality over time)
- Monitoring of lake levels and salinities at lakes other than Toolibin should continue.

3.1.1.2 Methodology

Specifications of current and proposed monitoring stations and activities are listed below. The authors propose that all monitoring activities at current sites continue unless otherwise stated. Suggested improvements to existing structures/procedures are also stated.

Existing monitoring sites:

Lake Inflow Water Quantity

Number:	609010.A
Purpose:	Water level (stage)
Facilities:	Two floatwells (upstream and downstream of control) equipped with Unidata water level transducers and Unidata loggers and telephone telemetry. Road culvert pipes act as the controlling feature.
Visit schedule:	Routine six weekly visits by Water & Rivers Commission, Bunbury.
Data availability:	Stage height data has been recorded almost continuously since August 1978.
Data quality:	The derived data for flow has a high likelihood of acceptable accuracy at high flows. Low and medium flow accuracy are lower quality due to inadequacy of the control structure and tailwater in the channel.
Suggested improvements:	The road culverts should be replaced with box culverts set at a level to minimise low flow tailwater. The addition of a "V" weir is required to improve sensitivity at low flows.

Lake Inflow Water Quality

Number: 609010.C & E

Purpose: Water quality (conductivity)

Facilities: Unidata conductivity transducer linked to station continuous logger and remote telephone telemetry.

Visit schedule: Routine six weekly visits plus polling as required by Water & Rivers Commission, Bunbury.

Data availability: Conductivity data has been recorded almost continuously since August 1978. Up to 40% of this data is poor or unavailable.

Data quality: Problems were encountered over the greater part of the recorded period with accuracy of the recorded values. These problems were analysed and corrected during 1992 and records are now considered to be within the required bounds of accuracy.

Suggested improvements: Repositioning of the conductivity transducer in 1992 appears to allow accurate recording of representative inflow water quality. It is recommended that check calibrations are made periodically and future operators are made aware of the reasons for positioning the transducer in its current location ie it should not be relocated without justification. (Ref - History file notes W. Fowlie, K. Baldock and outcomes of conductivity data audit 1994/95)

Lake Inflow Water Temperature

Number: 609010.T.

Purpose: Water temperature.

Facilities: Unidata water temperature transducer linked to station continuous logger and remote telephone telemetry.

Visit schedule: Routine six weekly visits plus polling as required. by Water & Rivers Commission, Bunbury.

Data availability: Temperature data has been recorded almost continuously since April 1989. Up to 20% of this data is poor or unavailable.

Data quality: Good quality is assumed.

Suggested improvements: It is recommended that check calibrations are made regularly.

Lake Inflow Rainfall (Pluviometer)

Number:	510353
Purpose:	Rainfall measurement.
Facilities:	Unidata tipping bucket transducer and Unidata logger with Water Corporation standard calibration facilities.
Visit schedule:	Routine six weekly visits by Water & Rivers Commission, Bunbury.
Data availability:	Rainfall data has been recorded almost continuously since December 1977. Approx 8 months of data was not recorded in 1985-86 and 1 month in 1988.
Data quality:	Very good.
Suggested improvements:	This station should be operated and maintained at its current status.

NB. A second rainfall and evaporation station (510253 Stanley Park) operates in the catchment. Management was ceded to the Bureau of Meteorology in 1987.

Lake Water Level

Number:	609009.A.
Purpose:	Water level.
Facilities:	Floatwell equipped with Unidata water level transducer and Unidata logger.
Visit schedule:	Routine six weekly visits by Water & Rivers Commission, Bunbury.
Data availability:	Water level data has been recorded almost continuously since December 1977. Only 2.5% of this data is poor or unavailable.
Data quality:	Very good.
Suggested improvements:	This station should be maintained at least at its current status. It is recommended that a precision water conductivity transducer and water temperature transducer also be installed to provide continuous and ongoing record of water quality indication.

Water Quality Sample Sites

Number:	609010	Toolibin Lake Inflow
	609009	Lake Level
	609013	Toolibin Lake Booloo
	60901024	Toolibin Lake North End
	6091025	Toolibin Lake South East Lagoon
	6091026	Toolibin Lake Outflow
	6091027	Toolibin Lake West Lagoon
	6091028	Toolibin Lake At North West Creek

Purpose: Water quality - Comprehensive, nutrient and chlorophyll a.

Facilities: Marked sites only.

Visit schedule: Quarterly collections by CALM, except for inflow site which is flow dependent and collected by Water & Rivers Commission, Bunbury.

Data availability: Surface water sampling has been conducted in an *ad hoc* manner since 1977. Sample results for the various parameter analysis values are stored on the State Water Resources Information System (SWRIS).

Data quality: Quality before introduction of a detailed sampling procedure in 1993 is unknown. Assuming compliance with the procedure it is expected that data since 1994 is of acceptable quality. No assessment of laboratory practices and procedures was undertaken.

Suggested improvements: It is recommended that:

- written procedures for water sample collection (Appendix 1) as stipulated by the Water Authority in 1995, be strictly adhered to and periodically reviewed;
- either a qualified water chemist or a fully trained field assistant with appropriate support be employed to collect samples using the above quality assured procedures;
- water analysis requirements should be reviewed and clearly defined. Preliminary recommendations are to restrict analysis to TP, FRP, TN, $N0_2$+$N0_3$, chlorophyll-a, Conductivity, Temperature and pH unless significant change occurs;
- a NATA accredited laboratory be used to analyse samples;

- sampling locations be reduced to a maximum of 5 including the inflow and outflow of the lake;

Proposed Monitoring Stations

One new monitoring site is suggested for collecting flow related data. This is the outflow of Toolibin Lake and is considered a high priority (see section 3.3.2 for proposed new monitoring station at the separator). It will provide data to calculate retention loads of salt and nutrients, and the water source apportionment between inflow, ground and rain water.

The specifications of the new monitoring station should be equivalent to the existing Northern Arthur River gauging station (609010). Monitoring procedures and site visit frequency should also match current arrangements.

3.1.1.3 Criteria

Recovery criteria relevant to water and salt inputs, in-lake levels, volumes and salt storage that are stated in the Toolibin Lake Recovery Plan are as follows:

- The maximum salinity of the lake water when the lake is full should be 1,000 mg/L Total Dissolved Salts (TDS)
- The maximum salinity of inflow to the lake measured at the Water Corporation gauging station 609010 on the Northern Arthur River should be 1000 mg/L TDS during the winter months.
- The lake bed dries periodically by evaporation, on average once every three years.
- The levels of nutrients within Toolibin Lake should not cause excessive growths of algae or other aquatic plants, or cause deleterious reductions in dissolved oxygen concentrations in the water. Total phosphorus levels in the water not to exceed 100 µg/L unless long-term monitoring indicates that this criterion may be modified.

In addition to those criteria above:

- Salt-storage in the lake ecosystem should not exceed 4000 tonnes TSS (salt load within the lake reflects the salinity and volume of water entering the lake, the salinity and volume of water within the lake and the frequency of outflow).

3.1.1.4 Personnel

Currently, trained hydrographic staff from the Water and Rivers Commission are responsible for the maintenance of the monitoring stations and downloading and databasing of data. CALM staff are responsible for quarterly collection of water samples for quality analysis from sites within the lake. It is recommended that this arrangement is maintained for existing and proposed monitoring sites. It is essential also that CALM monitors any episodic inflow events that may not be sufficiently recorded by WRC monitoring stations. Confirmation of the WRC's commitment to continued monitoring and databasing of hydrographic data should be confirmed by the Recovery Team as this represents an integral and expensive investment towards the lake's recovery.

If water sampling by CALM staff is to continue, and if monitoring/ maintenance of hydrographic stations is to be taken over by CALM staff, it is important to ensure the staff are properly trained in the appropriate sampling techniques. It is preferred that properly trained hydrographers continue to be responsible for the maintenance of hydrographic monitoring stations.

A central database of hydrographic information should continue to be maintained by the WRC. A commitment from the WRC should be sought to continue assessment and maintenance data quality.

3.1.1.5 Cost

This section provides an estimate of future capital cost for construction of new flow monitoring stations and alterations to existing sites, and anticipated operating costs.

New Gauging Stations

Costs for establishing each site would be similar, depending on final locations, but savings may be gained by combining investigation, design and site works.

Table 3.1.1. Establishment costs for new gauging stations.

Component	Details	Cost ($)
Investigation and design:	(Hydrographer & engineer)	5000-00
Hardware components:	(Floatwells, shelter, formwork, transport)	4000-00
Electronic instruments:	(Water level, logger, conductivity, temperature)	3000-00
Installation:	(Backhoe, concrete, labour and supervision)	9000-00
Commissioning	(Hydrographer, assistant, history file and report)	5000-00
	Total =	26000-00

Table 3.1.2. Annual operating costs for flow gauging stations.

Component	Details	Cost ($)
Site visits:	(Hydrographer & assistant by 8 visits)	8000-00
Flow gauging	(Hydrographer & assistant by 2 visits)	2000-00
Data processing	(Hydrographic technician, validation and editing)	300-00
Data management	(Hydrographic technician, reporting)	1700-00
	Total =	12000-00
	Total station costs for the first year =	38000-00

Existing Gauging Station and Pluviometer

Table 3.1.3. Estimated upgrade costs for low flow control.

Component	Details	Cost ($)
Investigation and design:	(Hydrographer & engineer)	5000-00
Hardware components:	(Culverts, formwork, transport)	13000-00
Installation:	(Excavator, road works, concrete, labour and supervision)	12000-00
	Total =	30000-00

Note: These costs may vary and be dependent on the availability of local Shire labour and goodwill.

Table 3.1.4. Annual operating costs for gauging stations and pluviometer.

Component	Details	Cost ($)
Site visits:	(Hydrographer & assistant by 8 visits)	8000-00
Flow gauging	(Hydrographer & assistant by 2 visits)	2000-00
Data processing	(Hydrographic technician, validation and editing)	500-00
Data management	(Hydrographic technician, reporting)	2000-00
	Total =	12500-00

Existing Lake Level Station

Table 3.1.5. Estimated upgrade costs for continuous conductivity measurement.

Component	Details	Cost ($)
Investigation and design:	(Hydrographer)	600-00
Hardware components:	(Unidata Toroidal Cell Conductivity Instrument)	2900-00
Installation:	(Hydrographic technician)	1500-00
	Total =	5000-00

Table 3.1.6. Annual operating costs for continuous conductivity measurement.

Component	Details	Cost ($)
Site visits:	(Hydrographer & assistant by 8 visits)	4000-00
Data processing	(Hydrographic technician, validation and editing)	200-00
Data management	(Hydrographic technician, reporting)	1300-00
	Total =	5500-00

Combining the visits for each site will result in significant savings. One experienced hydrographic team can complete three routine station visits in one day. The complexity of the inflow station with pluviometer and conductivity meter will stretch time resources, as will travel to and from the site. In summer months less time at site is required. In winter however, overnight accommodation may be required. A fourth station would guarantee a second day in the field.

Lake Water Monitoring

Table 3.1.7. Annual operating costs for in-lake water monitoring
It is estimated that actual costs for sample collection and analysis should be as follows:

Component	Details	Cost ($)
Site visits:	(Water chemist & assistant by 4 visits)	5200-00
Analysis	(Laboratory and sample bottles: 5 sites TP, FRP, TN, NO_2+NO_3, Cond, Temp, pH)	2200-00
Reporting	(Water chemist)	1500-00
Data management	(Hydrographic technician)	500-00
	Total =	9400-00

Table 3.1.8. Costs for additional *ad hoc* sampling.

Component	Details	Cost ($)
Collection	Water Chemist and travel @ $1000-00 per day	5000-00
Analysis	Allow 5 visits and up to 10 samples per visit @ $120-00 per sample including bottles, etc.	6000-00
	Total =	11000-00
	Annual report: Water Chemist and clerical staff =	5000-00

3.2 Catchment Hydrology: Groundwater

3.2.1 Lake System and Catchment

3.2.2.1 Aims

- Monitor piezometers to determine the impact of groundwater pumping. A selection of the shallow bores on the bed of the lake should continue to be monitored regularly to determine the affect of groundwater abstraction.
- Standardise monitoring. Given the diversity of monitoring bores in the reserves and the catchment, it is important that every effort is made to standardise the frequency of monitoring and the collation of data. Ideally bores should be monitored monthly or at least on a seasonal basis, including at least two measurements in late summer (March-May) and two in mid-winter (July-September).
- Maintain a central groundwater database. The diversity of monitoring bores in the catchment, and the likelihood of more bores being established, requires efficient databasing. A single groundwater database should be maintained that is easily accessed by CALM and AgWA staff on a day to day basis. The newly developed AGBORES database should be used and will fulfil these goals. Updates from this database can then be exported to the WRC for inclusion in the state databases. All bores within the catchment should have a minimum data set of information that includes location (easting/northing), depth, static water level and salinity. A list of abandoned bore holes should also be collated.

- Investigate the impact groundwater abstraction may have on lake bed trees. It is unclear whether the trees on the lake bed have any 'dependency' on shallow sedimentary aquifers during dry periods and how these aquifers will be affected by the groundwater pumping.
- Continue to monitor the bore network. The groundwater monitoring network within the catchment should continue to be monitored by AgWA/WRC. Additional bores should be established at higher elevations in the landscape, especially along the eastern and western catchment divides and upper slope areas to the north. All monitoring data should be entered into the AGBORES database on a monthly basis.
- Modelling of the lake system groundwater using monitoring bore and abstraction bore data after the first year of pumping system operation. A groundwater modelling consultant should be employed to conduct a short study into the effectiveness of the groundwater pumping system. The consultant should be able to indicate the likelihood of success by modelling the pumping at various rates and taking account of regional inflows and local interactions between bores and geologic structures (see George and Bennett, 1995 for specific recommendations).
- A feasibility study of salt harvesting and aquaculture be conducted to determine the viable alternative uses of saline groundwater discharged from Toolibin Lake. It may be appropriate to install a salt management system (evaporation basins) within the floor of Lake Taarblin, or elsewhere, to prevent uncontrolled loss of salts to downstream catchments and manage it so that salt is harvested or only released ahead of large floods (George and Bennett, 1995).
- An airborne magnetics survey, which was useful in defining the location of major faults and dykes at Toolibin Lake, may be appropriate within Lake Taarblin and its surrounds to help determine the location of the evaporation ponds.

3.2.2.2 Methodology

Groundwater monitoring is currently being conducted by AgWA, the Toolibin Catchment Group, (LCD farmers) and CALM. Multi-port, pump and monitoring bores installed in the floor of the lake by the Geological Survey of WA, and currently the responsibility of the WRC are not being monitored.

The existing monitoring can be broken into 4 categories under the general headings of (1) Toolibin catchment and (2) Toolibin lake,

1. Catchment: (a) AgWA research bores, (b) Toolibin farmers bores, and (c) CALM Toolibin Alley project bores, and:

2. Lake: (d) CALM monitoring bores. Includes old WRC (ex GSWA 1986-1990) monitoring and pump bores and new pump and observation bores drilled with AgWA (1995). An additional (March 1996) 13 monitoring bores installed by contractors at Taarblin and in Toolibin Lake (East) have been included (data held by Tim Bowra, CALM Narrogin).

Table 3.2.1: Agencies currently responsible for different categories of groundwater monitoring within the catchment and at Toolibin Lake.

Category	Managers	Database	Number of Bores
a	AgWA	AgWA	34 at 19 sites
b	Toolibin Catchment Group	AgWA, LTCG	50 at 50 sites
c	CALM Alleys	CALM	114 at 2 farms (Whites, Davenports)
d	CALM (WRC Lake)	CALM (WRC)	69 at 56 sites
Total			**267 monitoring bores**

The majority of the bores occur near to, or on Toolibin Lake. Other bores have also been drilled throughout the catchment and some occur on and around Taarblin Lake. Ongoing monitoring of the piezometers at the lake and within the catchment will require a coordinated approach. Currently a number of agencies and groups are involved in the monitoring of bores. It is recommended that all groundwater monitoring be coordinated collaboratively by CALM and AgWA. A central database of groundwater information should be managed and held by CALM. The AGBORES database (AgWA) should be developed as the means of collating and storing the hydrographic (groundwater) data. Copies of data in digital form should be forwarded to CALM each quarter in the form of EXCEL (Microsoft) spreadsheets. Data will be sent to the WRC for inclusion in the States database programs (HYDSYS or AQWABASE).

It is proposed that the groundwater database be structured into two parts for operational reasons : i) The Catchment (category a and b, Table 3.2.1), and ii) The Lake and Trials (category c and d, Table 3.2.1).
CALM should have a stand-alone AGBORES database system that is used to collate all Lake and revegetation trial groundwater records and receive quarterly updates of catchment groundwater records from AgWA. CALM therefore, remains the sole agency responsible for maintaining a complete and up to date groundwater data set for the lake and the catchment, however, the work of data collection and entering is shared between agencies. Joint data can be sent to the WRC for inclusion in the State database.

The monitoring methods should be standardised for all piezometers. Ideally, bores should be monitored on a monthly basis. If this is not possible the bores should be monitored seasonally, including at least two measurements in late summer (March-May) and two in mid-winter (July-September). Monitoring the peaks and troughs will pick up the summer minimum and winter maximums. This frequency of observation, which is generally used to determine longer term trends (eg rates of watertable rise), should also be adequate to assess the biological consequences of water management systems implemented at Toolibin. In areas where or at times when the impacts on the biota are of key concern, monitoring frequency should be increased.

It is essential that the available data for all the bores which exist in the catchment are all entered onto the new AGBORES database. Existing records on BORES and Excel can be copied over to the new system (AGBORES) when finished. However, many of the bores on the database have almost no site data available. It is essential that all of the bores have a minimum data set which includes location details (easting and northing, eg GPS located), total depth of bores, static water level and salinity. Many of the older bores may be damaged or have been lost as a result of earthworks on the lake floor. A list of 'abandoned' holes (either lost and/or unserviceable) should be collated.

It is recommended that a local person be directed (Agency) or contracted (locally) to (i) review the available site data and (ii) visit all of the bore sites in the catchment to obtain a GPS location (use or hire an accurate GPS or base station), baseline bore details and a groundwater sample. A compressor and bailer should be used to 'flush' out the bores prior to sampling. Additional data relating to ownership (farmers name, location number etc), bore construction (casing type, screen location and other statistics) and site details (elevation, landform, date of clearing etc) should be collected or collated onto the database if they are known or can be assessed.

The bores at Toolibin Lake should all be surveyed to a Australian standard height benchmark (m AHD) and the data used to interpret the extent and impact of pumping. Many of the bores have already been located and surveyed into the grid, however no 'tying together' of the surveys has occurred (pers. comm. Richard George, AgWA). Without surveying it will be difficult to determine the effect of the management system installed. The alternative is to assess the year to year trend in the bores and rely on surface and biological changes. It is recommended that a surveyor be contracted to assess the available site data and undertake to re-survey or collate the existing data as required. This task could be undertaken by graduate University students in surveying or similar courses to reduce costs.

Priority actions and the time (days) which these may require are outlined (Table 3.2.1). The monitoring outline is already in place, although it may be an overestimate in some cases. Each of the Agencies should determine their commitment and assess resources.

Table 3.2.1 Groundwater monitoring priority actions and time required in days (source: Richard George, AgWA)

Action	**(a) Research bores**	**(b) Farmers bores**	**(c) Alley bores**	**(d) Lake bores**
Responsible Group	AgWA	Farmers, AgWA	CALM	CALM
Monitoring	seasonal	seasonal	seasonal	monthly
time	*10*	*na*	*15*	*30*
Collect Minimum Site Details	AgWA	AgWA	CALM	CALM
time	*5*	*10*	*5*	*10*
Database (held and managed by)	AgWA	AgWA	CALM	CALM
time	*5*	*5*	*5*	*10*
Surveying	not essential	not essential	not essential	CALM
time	*nil*	*nil*	*nil*	*5*
Totals	**20**	**15**	**20**	**55**

Ongoing monitoring of vegetation transects on the lake bed and relating results to changes in groundwater levels beneath the lake will enable consideration of possible drawdown effects on the lake bed trees. The suggested post-graduate student project on wetland tree rhizosphere salt and water balance (Section 3.4), will also address this concern.

3.2.2.3 Criteria

- The minimum depth to the water table beneath Toolibin Lake and Toolibin Flats in spring, when the lake is dry, should be 1.5m.

The above minimum water table depth, stated in the Toolibin Recovery Plan, is the minimum depth required to eliminate/reduce capillary rise of saline groundwater. At present the depth to water table is 0m in the SW of the lake and 1.5-2.0m in the NE. Ideally, the water table should be at least 3m from the surface of the lake bed.

3.2.2.4 Personnel

Ongoing monitoring of the piezometers at the lake and within the catchment will require a coordinated approach. Currently a number of agencies and groups are involved in the monitoring of bores. It is recommended that all groundwater monitoring be coordinated collaboratively by CALM and AgWA.

3.2.2.5 Cost

Costs associated with the coordination of the groundwater monitoring bore network, data collection, maintenance of existing bores, establishment of supplementary bores, and collation of data into the AGBORES database, cannot be determined until the scope of this portion of the Toolibin monitoring programme is agreed upon by the different state agencies involved. The suggestions stated above under methodology, and the priority issues and time required table supplied by Richard George, give an indication of the type of expenditure required.

3.3 Catchment Hydrology: Drainage

3.3.1 West Toolibin Flats

3.3.1.1 Aims

It is recommended that an existing surface water monitoring program currently implemented and funded by AgWA is continued until the effectiveness of the drainage modifications in the West Toolibin Flats becomes evident. The program should collect flow and water quality data from the two main drains prior to their entering Dulbining Nature Reserve, to assess changes in salinity, discharge/volume and nutrient status. In addition, sediment deposition in the drains must be monitored on an ongoing and longterm basis so that any blockages that may reduce the effectiveness of the drains are quickly identified and cleared.

As discussed in Part 1 of this report, the CALM drain into Dulbining Nature Reserve collects drainage water additional to that entering from the eastern drain. Therefore, monitoring data from the eastern drain does not adequately reflect water quality entering the reserve from this area. It is recommended that water quality of discharge in the CALM drain downstream of Browns Road crossing is monitored.

3.3.1.2 Methodology

As described above, the two main drains on West Toolibin Flats that have been modified are currently monitored by AgWA. The program is designed to collect flow and water quality data from the drains prior to flows entering Dulbining Nature Reserve. Data collected as part of this program may be classified under rainfall, discharge and water quality.

Rainfall data are collected at three locations in the catchment; Martins, Tilbrooks and Napowie stations using tipping bucket rain gauges. This information is used to characterise the hydrology of the West Toolibin catchment and will help to discriminate drainage effects on the western side of the catchment from those originating on eastern catchment areas.

Discharge is monitored at two sites, situated in the western drain south of Brown's Road and in the eastern drain north of Brown's Road. Depth and velocity are recorded with an acoustic Doppler meter mounted on the channel bed (because of the low gradients it is not possible to construct a gauging station with a weir, therefore, all flow monitoring data are derived using channel characteristics). Currently, there is only one instrument which is alternated between sites, and it is presently located on the western drain (June 1996). Due to the experimental nature of this instrument, the quality of the data is not consistent and further development of this technique is required. Additional measurements of depth at each site are recorded using two capacitance probes and data loggers, and maximum depth is recorded by depth indicators (perspex tubes containing talcum powder). These gauges assist in calibrating the capacitance probes. Velocities are recorded by propeller meter readings at different depths during flow events and these data will assist in converting recorded depths to flow rates (m^3 sec^{-1}; cumecs). Flow velocities will be calibrated using the propeller velocity meter. These sites are in addition to data collected by the Water Corporation at the gauging station on the Wickepin-Harrismith Road (609010).

Water quality is assessed from samples collected in rising stage sampling bottles. These bottles are arranged in a vertical profile to allow water sampling at different depths. This allows measurement of the concentration of different parameters as a function of depth. These data then may be used to determine flow-weighted concentrations and then 'loads' of each parameter. Salinities are recorded as electrical conductivities (mS/m) at each site. Nutrient levels are recorded on the same occasions as salinities and include total nitrogen (mg L^{-1}) and total phosphorous (mg L^{-1}). The final parameter recorded is total suspended sediment concentration, expressed in mg L^{-1}. Generally, the drains are not expected to carry high sediment loads because of the low gradients and low rainfall.

3.3.1.3 Criteria

Development of criteria on which to assess the effectiveness of the Western and Eastern Drains is restricted both by the absence of baseline data and the likelihood of the drains reflecting broadscale changes in the catchment in addition to localised changes due to the drains themselves.

The general aim of the drainage scheme is to increase drainage and so reduce waterlogging and in turn increase vegetation growth and therefore water and nutrient conversions. It is hoped that this will reduce flushing of salt and nutrients from the catchment. Therefore, any criteria must be based on general reductions in these parameters. Because of the absence of baseline data, there are no values on which to assess change. Therefore, it is recommended that a baseline is established using the first three to four years data on salinities, discharge and nutrient levels in the drains, and extent of waterlogging in surrounding land. Values must be converted to 'loads' of each parameter discharged via the drains to allow for annual differences in discharge (*viz.* rainfall). In addition, criteria must allow for annual changes in rainfall patterns, particularly where the extent of waterlogging is being considered. Finally, in developing criteria, it must be realised that salinity/nutrient levels in the drains may increase in the short-term, due to continued deterioration in the catchment as a result of past and present catchment landuse, and the effectiveness of the drains may not become evident until the mid- to long term.

In the short-term, to assess the effectiveness of the drains, it is critical that the drains remain functional, therefore, monitoring must ensure that:

- Discharge via the Western and Eastern Drains is not impeded by sedimentation or other obstructions.

Other specific criteria may be developed following the collection of representative data.

3.3.1.4 Equipment

As the monitoring program is currently in place, all equipment are either in location, or available through AgWA. Equipment include:

Tipping bucket rainfall gauges (x3)
Acoustic Doppler meter (x 1)
Capacitance probes to record depth (x2)
Data loggers for recording depth (x4, two at each site, one as back-up)
Maximum depth indicators (perspex tubes containing talcum powder) (x2)
Rising stage bottle arrays (x2)
Hand-held propeller velocity meter (x1)
Portable conductivity meter (x1)

3.3.1.5 Personnel

Currently, all monitoring is conducted by staff from AgWA, with water samples either analyses by the AgWA using benchtop/field meters (conductivities) or are sent to the Chemistry Centre (WA) for determination of water quality parameters (Total N & P and turbidity).

3.3.1.6 Cost

Table 3.3.1. Costs for equipment specific to monitoring the effectiveness of drainage modifications in the West Toolibin Flats

Item		Cost ($)
Equipment Costs		
Running costs for laptop computer for downloading data loggers		300-00
Maintenance of data loggers and sensors		400-00
Replacement batteries for equipment		100-00
Site housekeeping		200-00
Bottles for collecting water samples		100-00
Licences for computer software (HYDSYS & others)		800-00
	Total =	1900-00

Table 3.3.2. Annual costs for monitoring the effectiveness of the drainage modifications in the West Toolibin Flats

Component		Cost ($)
Field		
One technical officer for 2 days x 9 visits @ $300-00 day^{-1}		5400-00
Mileage & travel allowances		1980-00
Office - data processing		
One technical officer x 15 days @ $300-00 day^{-1}		4500-00
Laboratory - analysis of water samples		
Total nitrogen, 20 samples @ $20-00 sample^{-1}		400-00
Total phosphorus, 20 samples @ $20-00 sample^{-1}		400-00
Conductivity, 40 samples @ $5-00 sample^{-1}		200-00
Turbidity, 40 samples @ $12-00 sample^{-1}		480-00
	Total =	13360-00

3.3.2 Toolibin Lake Separator Channel

3.3.2.1 Aims

The effectiveness of the system for separating flows was assessed in winter 1996. The system was shown to be very effective at diverting low volume, highly saline waters past Toolibin Lake when the separator was open, and sending higher volume, low salinity water into the lake when closed.

As part of ongoing management of lake inflows using this system, the salinity and volume of inflows to the lake and down the diversion channel must be monitored. The Water Corporation gauging station (609010) is located ~ 1 km upstream from the separator, and this provides data on the volume and quality of water reaching the separator. But additional data are required to determine the volume and salinity of water passing either down the diversion channel or into Toolibin Lake.

Given the diffuse nature of the inflow to the lake, it is recommended that an additional monitoring site is established to record discharge and salinity on the better defined diversion channel, immediately downstream of the separator (i.e. within 1 - 200 m). These data, combined with data from the Water Corporation gauging station (609 010), will provide the required information.

In addition, when the Northern Arthur River is flowing, salinity and discharge must be continually monitored, even after the initial low volume, high salinity 'first flush' event has passed. This is to identify any additional pulses of salt from the catchment, particularly later in the spring as discharge falls. Management of the separator may be required in response to these events. Following cessation of flow in spring, the separator must be opened and left open until diversion of fresh water flows into the lake is required. This is to avoid unexpected events, such as summer storms or cyclonic rains, inadvertently flushing salt into the lake; it is likely that the separator will be opened in late spring as discharge declines and salinities start to rise.

Following the initial successful operation of the separator in winter 1996, some minor repairs/alterations are required to the separator boards to ensure they act as an adequate barrier to both high and low flows. In the long term it may be beneficial to automate the operation of the separator, however this may be prohibitively expensive and is not required in the short term.

The existing decision support system for operating the separator needs to be improved. When flowing, salinity and discharge data need to be provided to the CALM district office on a daily basis to allow an immediate response to any changes. In addition, additional work is required to better correlate relationships between discharge and salinity to determine if the current criteria for opening and closing the separator is adequate.

3.3.2.2 Methodology

Monitoring should be implemented using the same methodology, and to collect data compatible to that collected by the WRC at the gauging station on the Northern Arthur River (609 010) . Monitoring should be conducted at a suitable location on the diversion channel, immediately downstream of the separator (i.e. within 1 - 200 m). Because of the low gradients and low flows it is likely that all monitoring will be conducted either from a level concrete pad/sill to be set into the bed of the diversion channel, or at a location where channel characteristics may be used to determine discharge.

Flow periodicity in relation to rainfall will be assessed using the same rainfall data as currently collected by the WRC. Parameters to be measured should include salinity, recorded as electrical conductivities (mS/m), and discharge (cumecs).The measurement of conductivities at different discharges will allow the determination of the 'salt load' to the lake.

The effectiveness of the separator and diversion channel should be assessed visually, with appropriate remediation work implemented in the case of failure. Possible scenarios are that either low flow, high salinity water passes into Toolibin Lake, when it should flow down the diversion channel, or high flow, low salinity water passes through gaps in the separator boards, even when closed, and continues down the diversion channel and does not enter Toolibin Lake.

3.3.2.3 Criteria

- The maximum salinity of inflow to the lake, measured at the Water Corporation gauging station (609 010) on the Northern Arthur River, should be 1000 mg/L TDS during the winter months when the lake is filling.
- The minimum salinity of water flowing down the diversion channel, bypassing Toolibin Lake, as measured at the proposed gauging station on the diversion channel, should be 1000 mg/L TDS during the winter months when the lake is filling.
- The maximum salinity of water flowing into Toolibin Lake, at the separator on the diversion channel, as determined from the proposed gauging station on the diversion channel, should be 1000 mg/L TDS during the winter months when the lake is filling.
- Low flow, high salinity water (> 1000 mg/L TDS) passes down the diversion channel.
- Higher flow, low salinity water (< 1000 mg/L TDS) is diverted by the separator into Toolibin Lake.

3.3.2.4 Equipment

Equipment required to establish and conduct monitoring of discharge and salinity at an additional gauging station on the separator channel are as detailed in section 3.1.1.2. and are not repeated.

3.3.2.5 Personnel

Personnel arrangements for operating the new gauging station on the separator channel are as detailed in section 3.1.1.4. and are not repeated.

3.3.2.6 Cost

Costs for establishing a new site are as detailed in section 3.1.1.5 but are repeated here for convenience. As previously stated, savings may be gained by combining investigation, design and site works for all new gauging stations proposed for the system.

Table 3.3.3. Establishment costs for a new gauging station on the diversion channel.

Component	Details	Cost ($)
Investigation and design:	(Hydrographer & engineer)	5000-00
Hardware components:	(Floatwells, shelter, formwork, transport)	4000-00
Electronic instruments:	(Water level, logger, conductivity)	3000-00
Installation:	(Backhoe, concrete, labour and supervision)	9000-00
Commissioning	(Hydrographer, assistant, history file and report)	5000-00
	Total =	26000-00

Table 3.3.4. Annual operating costs for a new gauging station on the diversion channel.

Component	Details	Cost ($)
Site visits:	(Hydrographer & assistant by 8 visits)	8000-00
Flow gauging	(Hydrographer & assistant by 2 visits)	2000-00
Data processing	(Hydrographic technician, validation and editing)	300-00
Data management	(Hydrographic technician, reporting)	1700-00
	Total =	12000-00
	Total station costs for the first year =	38000-00

3.3.3 Surface Water Control in Other Parts of the Catchment

In Part 1 of this report it was recommended that no drainage work be undertaken in the East Toolibin Flats area until the effectiveness of drainage remediation work in the West Toolibin Flats is determined. Therefore, there are no surface water controls in other parts of the catchment that require monitoring.

3.4 Lake Vegetation

3.4.1 Monitoring Plots

3.4.1.1 Aims

- All Mattiske vegetation monitoring plots on Toolibin Lake continue to be monitored. These plots represent an invaluable asset to the understanding of the long-term changes in the vegetation floristics and structure that have taken place, and the development of recovery success criteria. The last monitoring took place in 1992 and resampling is overdue.
- Additional plots be established to cover the southeast portion of the lake bed. The south east portion of the lake bed in under-represented in the Mattiske monitoring programme.
- Reassessment of the Froend study transects be conducted. This information would be a valuable supplement to the Mattiske plot data.
- Monitoring the survival and growth of seedlings on the lake bed. Although monitoring has identified that seedling recruitment of *Casuarina obesa* has occurred, there has been little attempt to closely monitor the seedlings progress and identify the causes of mortality. Exclosures should be erected to ascertain the impact of grazing and seedling progress monitored annually. Attention should also be focussed on other species such as *Melaleuca strobophylla*.
- Determine the population age structure of lake bed species and assess their requirements for successful recruitment. The Recovery Team may have unrealistic expectations for the rate at which the lake bed vegetation may recover. Natural recruitment may take many years. An understanding of the age structure of the populations of lake bed tree species may prove to be valuable in identifying appropriate recovery success criteria for tree recruitment and maintenance of wetland tree populations. Successful recruitment of tree species may be an infrequent event that is dependant on a range of conditions that occur

simultaneously or in series. Knowledge of the age structure of the lake bed trees will reveal the length of time between successful recruitment events and how it may vary.

- Determine the relationship between seasonal soil water and salinity fluctuations and the rooting patterns and water requirements of the lake bed trees. There are many assumptions as to the actual processes that are causing tree stress and mortality. Little is known about the soil water and salt dynamics within the rhizosphere of the trees, or the impact of abstracting water from beneath the lake bed.
- Map the distribution of stressed/dead trees and relate to soil conditions. There is no accurate map of current distribution of stressed/dead trees and saline soils on the lake bed. This will be valuable for assessment of recovery success.

3.4.2.2 Methodology

It is important to maintain the continuity of monitoring standards and, therefore, it is suggested that experienced qualified botanists continue to monitor the existing Mattiske transects/plots. Frequency of monitoring should remain at no more than every 2 years, longer intervals will not provide sufficient information to monitor vegetation response to surface flow and groundwater pumping management, particularly at the early stages of implementing the Recovery Plan. Resampling of the Mattiske transects is overdue. It is vital that monitoring of one of the most important indicators of success of the recovery plan is not compromised.

Parameters of the vegetation to be monitored should be the same as outlined in section 3.4.1.1 of Part 1. Additional transects may be required to cover lake bed vegetation in the southern and southeast portions of the lake. The appropriate number and location of transects should be determined by consultant botanists. The methodology of establishing the additional transects should be the same as used for the Mattiske transects. Specimens of all plant species collected during establishment and monitoring of the plots should be pressed, dried and identified at the State Herbarium of WA. All plots to be 20x20m and established by compass and tape. Trees within each plot located by tape to the corners of the plot and mapped for future reference. Species, height, diameter at breast height and condition (subjective scale: healthy, slightly stressed, stressed or sick, very stressed or sick, recent death and dead) recorded for every tree. Where present, selected data on the understorey such as species, density and percentage foliage cover, should be collected.

The presence of tree seedlings should be recorded by subdividing the relevant plots into subplots and total numbers and heights noted. Seedling recruitment events outside established monitoring plots should also be monitored by establishing exclosure plots . The size and number of exclosure plots will be determined by the distribution and significance of seedling recruitment. The largest recommend plot size is 10x10m, however plots of this size may not be possible in areas of dense vegetation and/or woody debris. Fencing material should be sufficient to exclude rabbits and kangaroos to allow assessment of the grazing impacts on seedling establishment. Adjacent unfenced control plots that contain seedlings should also be established. It is suggested that the monitoring plots be assessed every 2 months during the first year and every 6 months during years 2 and 3, or more frequently if practical. After the third year plots may be assessed annually or when permanent vegetation transects are monitored. Recruitment of all native tree species on the lake bed should be assessed. This includes *Melaleuca strobophylla, Eucalyptus rudis* and *Casuarina obesa.*

Reassessment of the Froend transects (total of 4 established in 1983) should also be conducted by an experienced botanist. Individual trees were tagged, and diameter at breast height, tree height and vigour determined. The transects have already been reassessed in 1988 (see Part 1, section 3.4.1.3) and showed varying degrees of decline. A further assessment should follow the methods outlined in Part 1, section 3.4.1.3.

Determining the age structure of the lake bed tree populations should be the focus of a once-off short-term study. It is suggested that a tertiary student project commence to focus on this issue and address the implications of the findings to the Recovery Plan. Such a student project will be economic.

Seasonal salt and water fluctuations within the rhizosphere of the lake bed trees is another area of focus that can be addressed by a tertiary student project. It is not clear what seasonal/long-term fluctuations in salt accumulation and surface/ground water level are tolerable by the tree species, and there is a unique opportunity to quantity the changes in the soil and groundwater characteristics relevant to the plants in response to saltwater abstraction and surface flow diversion. The nature of the study requires a focussed, longer-term approach and therefore requires a post-graduate student project. This would be the most cost-effective approach.

Mapping of lake bed salinity and tree vigour would require aerial photography/remote sensing assessment (colour, infra-red, airborne video) and groundtruthing (observation, EM38 measurement). If this assessment was to form part of the monitoring programme, assessment should be repeated every 3 years.

3.4.3.3 Criteria

Recovery criteria relevant to lake vegetation that are stated in the Toolibin Lake Recovery Plan are as follows:

- No further deterioration is observed in the health of the vegetation of the lake or the reserves.
- Successful tree and shrub regeneration in the lake and reserves is established in all vegetation associations.

Although these criteria cover the most important objectives of the Recovery Plan, more specific objectives that relate to those above may be useful in the implementation of a monitoring program.

- A nett increase in the observed vigour of *Casuarina obesa, Melaleuca strobophylla* and *Eucalyptus rudis* (where present) populations on the lake bed.
- Maintenance of area of vegetation as waterbird habitat, including maintenance of species and structural diversity as considered important for waterbird habitat.
- Maintenance or provision of conditions conducive to tree seedling establishment on the lake bed.

- Successful natural recruitment of *Casuarina obesa* and *Melaleuca* seedlings on the lake bed. "Successful" recruitment can be quantified as occurring in two stages a) survival beyond 5 years since establishment, and b) recruits reaching reproductive maturity.

3.4.4.4 Personnel

A range of personnel will be involved in different aspects of in-lake vegetation monitoring. For continuity, it is recommended that monitoring of vegetation transects established by Libby Mattiske is continued by the same consultant. Suitably supervised students may undertake the majority of other projects, with specific expertise sourced for mapping projects etc.

3.4.5.5 Cost

Table 3.4.1. Costs for monitoring condition of in-lake vegetation.

Component	Cost ($)
Continued monitoring of established vegetation transects:	
Consultant botanist @ $500 per day, 14 days including report writing	7000-00
Establish additional vegetation transects on lake bed:	
Consultant botanist @ $500 per day, estimate 2 additional transects in southern portion of lake, 5 days including report writing	2500-00
Additional routine monitoring associated with new transects:	
Consultant botanist @ $500 per day, estimate 2 new transects, 2 days including report writing	2500-00
Reassessment of Froend Transects:	
Consultant botanist @ $500 per day, 5 days including report writing	2500-00
Seedling establishment plots, establishment and monitoring:	
Consultant botanist @ $500 per day, estimate 6 seedling plots, identify distribution and design of plots, initial assessment, 7 days including report writing	3500-00
Material and labour for fencing of seedling plots:	
Labour @ $200 per day, 2 persons, 3 days	1200-00
Materials, star pickets, fencing wire, wire mesh. Estimated at $10 per 10 m, 40m per plot x 6 plots.	240-00
Continued monitoring of seedling plots:	
Consultant botanist @ $500 per day, 6 seedling plots.:	
1st year, every 2 months, 1 day each assessment, including report writing	3000-00
2nd and 3rd year, 2 visits each year, including report writing	2000-00
Additional costs for including seedling plots in permanent transect assessment routine:	
One additional day @ $500 per day.	500-00
Tertiary student project on age structure of lake bed tree populations:	
Travel and laboratory costs	5000-00

Table 3.4.1 (cont.)

Post-graduate student project on seasonal salt and water fluctuations in rhizosphere of lake bed trees:	
Stipend of $15,000 per year for 3 years	45000-00
Maintenance and travel expenses, $5000 pa (NB: Stipend not required if student receives scholarship)	15,000-00
Additional Monitoring/R&D Projects to be costed:	
Mapping of lake bed salinity and tree vigour:	
Commissioned aerial photography, airborne video	
Groundtruthing	
EM 38 measurements	

3.5 Terrestrial Vegetation

3.5.1 Monitoring Plots

3.5.1.1 Aims

- Continue the monitoring of the Mattiske terrestrial vegetation plots. These plots represent an invaluable asset to the understanding of the long-term changes in the vegetation floristics and structure that have taken place, and the development of recovery success criteria. The last monitoring took place in 1992 and resampling is overdue.
- Establish additional plots in the *Banksia prionotes* woodland communities to the east of Toolibin Lake. This community type is under-represented in the Mattiske monitoring plots but represents a significant proportion of the Toolibin Lake Nature Reserve. As a terrestrial plant community, the *Banksia prionotes* woodland is a unique component of the reserve and, therefore, the impact of the management program should be monitored.
- Determine the strategies required to actively manage the recruitment within plant communities of the reserves. The *Banksia* and Salmon Gum Woodlands of the reserves in particular, require investigations into the recruitment biology of dominant species and the impact a burning regime would have on the population dynamics.
- Control of herbivore numbers. Rabbits should be controlled and the impact of high grazing pressure by kangaroos resolved. Exclosures should be erected to ascertain the impact of grazing and seedling progress monitored annually

3.5.2.2 Methodology

Monitoring of the Mattiske vegetation plots that cover terrestrial vegetation, should continue. It is important to maintain the continuity of monitoring standards and therefore it is suggested that experienced qualified botanists continue to monitor the existing Mattiske transects/plots.

Frequency of monitoring should remain at no more than every 2 years, longer intervals will not provide sufficient information. Resampling of these terrestrial vegetation transects is overdue. It should be a matter of urgency to conduct a reassessment of all Mattiske transects.

Parameters of the vegetation to be monitored should be the same as outlined in sections 3.4.1.1 and 3.5.1.1 of Part 1. Additional transects may be required to assess *Banksia prionotes* woodland in the eastern portion of the Toolibin Reserve. The appropriate number and location of transects should be determined by consultant botanists. The methodology of establishing the additional transects should be the same as used for the Mattiske transects. Specimens of all plant species collected during establishment and monitoring of the plots should be pressed, dried and identified at the State Herbarium of WA. All plots to be 20x20m and established by compass and tape. Trees within each plot located by tape to the corners of the plot and mapped for future reference. Species, height, diameter at breast height and condition (subjective scale: healthy, slightly stressed, stressed or sick, very stressed or sick, recent death and dead) recorded for every tree. Assessment of the understorey species should include species, density and percentage foliage cover.

The presence of seedlings of *Banksia* (and other species) should be recorded by subdividing the relevant plots into subplots and total numbers and heights noted. Significant seedling recruitment events outside established monitoring plots should also be monitored by establishing exclosure plots . The size and number of exclosure plots will be determined by the distribution and significance of seedling recruitment. The largest recommended plot size is 10x10m, however, plots of this size may not be possible is areas of dense vegetation and/or woody debris. Fencing material should be sufficient to exclude rabbits and kangaroos to allow assessment of the grazing impacts on seedling establishment. Adjacent unfenced control plots that contain seedlings should also be established. It is suggested that the monitoring plots be assessed every 2 months during the first year and every 6 months during years 2 and 3, or more frequently if practical. After the third year plots may be assessed annually or when permanent vegetation transects are monitored. As a minimum requirement, recruitment of all overstorey species in the *Banksia* woodland should be assessed.

Seedling recruitment is also suggested as an issue for the Salmon Gum woodland to the northeast of Toolibin Lake (section 3.5.1.1, Part 1). It is suggested that seedling recruitment trials be conducted within this plant community in exclosures similar to those proposed for other areas. Exclosures should be erected around natural recruitment events or seeded artificially. Depth to groundwater, time since fire, soil salinity and structure, should be determined for each trial to ascertain the impact of factors other than grazing. CALM staff may be able to establish and conduct these trials, otherwise it is suggested that this form part of a tertiary student project.

Little is known about the effectiveness of a management burning regime on *Banksia* and Salmon Gum seedling recruitment. It is recommended that a thorough investigation of other factors that may influence seedling recruitment be conducted. Parameters such as groundwater depth and quality, soil structure, interspecific interactions, and grazing could be investigated along with trial burning. Given the recruitment status of the *Banksia* and Salmon Gum woodlands, it is not recommended that management burns be conducted before further investigations are conducted. Again, the most cost effective way to implement these investigations is to fund a tertiary student project(s).

The impact of grazing on seedling recruitment should be addresses with a rabbit culling program, and if required, kangaroos as well.

3.5.3.3 Criteria

Recovery criteria relevant to terrestrial (reserve) vegetation that are stated in the Toolibin Lake Recovery Plan are as follows:

- No further deterioration is observed in the health of the vegetation of the lake or the reserves.
- Successful tree and shrub regeneration in the lake and reserves is established in all vegetation associations.

Although these criteria cover the most important objectives of the Recovery Plan, more specific objectives that relate to those above may be useful in the implementation of a monitoring program.

- A nett increase in the observed vigour of terrestrial plant communities within the reserves associated with Toolibin Lake.
- Maintenance of species and structural diversity within terrestrial plant communities within the reserves associated with Toolibin Lake.
- Maintenance or provision of conditions conducive to overstorey species seedling establishment within the reserves associated with Toolibin Lake.
- Successful natural recruitment of *Banksia prionotes* and *Eucalyptus salmonophloia* seedlings within the reserves associated with Toolibin Lake. "Successful" recruitment can be quantified as occurring in two stages a) survival beyond 5 years since establishment, and b) recruits reaching reproductive maturity.

3.5.4.4 Personnel

Because of the diversity of projects recommended it is difficult to make specific recommendations on personnel to be involved. Ideally, CALM staff should establish and conduct as many trials as possible to reduce costs, and, otherwise it is suggested that tertiary students, with appropriate supervision, are involved where possible.

3.5.5.5 Cost

Table 3.5.1. Costs for monitoring change in condition of terrestrial vegetation

Component	Cost ($)
Continued monitoring of established vegetation transects:	
Consultant botanist @ $500 per day, 7 days including report writing in addition to time spent on wetland vegetation	3500-00
Establish additional vegetation transects on in *Banksia* woodland:	
Consultant botanist @ $500 per day, estimate 2 additional transects on eastern portion of Toolibin Reserve, 5 days including report writing	2500-00
Additional routine monitoring associated with new transects:	
Consultant botanist @ $500 per day, estimate 2 new transects, 2 days including report writing	2500-00
Seedling establishment plots, establishment and monitoring:	
Consultant botanist @ $500 per day, estimate 6 seedling plots with *Banksia* and Salmon Gum woodlands, identify distribution and design of plots, initial assessment, 7 days including report writing	3500-00
Material and labour for fencing of seedling plots:	
Labour @ $200 per day, 2 persons, 3 days	1200-00
Materials, star pickets, fencing wire, wire mesh. Estimated at $10 per 10 m, 40m per plot x 6 plots.	240-00
Continued monitoring of seedling plots:	
Consultant botanist @ $500 per day, 6 seedling plots:	
1st year, every 2 months, 1 day each assessment, including report writing	3000-00
2nd and 3rd year, 2 visits each year, including report writing	2000-00
Additional costs for including seedling plots in permanent transect assessment routine. One additional day @ $500 per day.	500-00
Tertiary student project on seedling recruitment requirements in *Banksia* woodland:	
Travel and laboratory costs	5000-00

3.6 Phytoplankton and Aquatic Plants

3.6.1 Aims

- Conduct a baseline survey of aquatic plants (submerged, floating) and phytoplankton/periphyton at Toolibin Lake. Apart from information included in Brock & Lane (1983) there are no data on the aquatic submerged, floating and benthic plants species at Toolibin Lake. An inaugural survey for such plants should be conducted. Limited information on the epiphyton at Toolibin Lake does exist (pers. comm. Jacob John, Curtin University) but was not made available to the authors of this report.

3.6.2 Methodology

Sampling during spring/early summer in years when the lake holds water, should involve traversing the lake at several points (wading or canoe). Periods of shallow lake levels (<0.5m) are the optimal times for sampling of benthic and submerged flora. Specimens of all species found should be collected, pressed and/or preserved in 5% formalin, and identified with herbarium specimens (if available). Semi-quantitative descriptions of relative importance/distribution of species found should be recorded. It is important to have this work performed by a qualified botanist/field ecologist to ensure a thorough survey and correct species identification. Other wetlands adjacent to and included in the Toolibin Reserves should also be surveyed to determine changes in species composition due to secondary salinity, and the presence of freshwater refugia and sources of propagules.

Depending on the outcome of an aquatic plant survey, the importance of this flora to waterbirds and other fauna should be assessed. Existing information on the diet of waterbird species as well as the ecology of aquatic plant species, should be reviewed.

3.6.3 Criteria

Recovery criteria relevant to aquatic vegetation that are stated in the Toolibin Lake Recovery Plan are as follows:

- No further deterioration is observed in the health of the vegetation of the lake or the reserves.
- Successful tree and shrub regeneration in the lake and reserves is established in all vegetation associations.

Although these criteria cover the most important objectives of the Recovery Plan, a more specific objective that relates to those above may be useful in the implementation of a monitoring program.

- Maintenance of aquatic plant species diversity within Toolibin Lake.

3.6.4 Personnel

Once funding is approved, appropriately experienced personnel should be sought from Tertiary Institutions and/or Government Agencies. Because of the diversity in the aquatic flora, and the specificity of the expertise required (i.e. benthic and planktonic algae/diatoms versus submerged/emergent macrophytes), it is likely that the work would be undertaken by several specialists.

3.6.5 Cost

Table 3.6.1. Costs for initial survey of aquatic plants of Toolibin Lake.

Component	Cost ($)
Inaugural survey for aquatic plant species in Toolibin Lake and adjacent wetlands:	
Consultant botanist @ $500 per day, 7 days including report writing.	3500-00

3.7 Waterbirds:

3.7.1 Aims

There is an immediate and urgent need to recommence regular monitoring of waterbird usage of Toolibin Lake, with a standardised survey method, at specific times during the year (assuming water is present) to record absolute counts of all waterbirds and their breeding activity. These data must be associated with information on water levels, salinity and vegetation condition. Methods to reduce and standardise the existing database to comparable single surveys at the same time (month) as future surveys should be investigated so that valid assessment of temporal changes in waterbird usage from baseline conditions (pre-1980) may be conducted.

It is also recommended that Lake Walbyring be surveyed at the same time as Toolibin Lake, using the same methodology. Although smaller and less diverse in terms of habitat availability than Toolibin, and therefore, unlikely to ever hold as rich or abundant waterbird fauna, Lake Walbyring will provide a useful comparison for minimal extra cost. Given the already degraded nature of Lake Taarblin, there is no perceived benefit to monitoring waterbird usage of this wetland. It is envisaged that pumping of saline groundwater to Lake Taarblin will have a negligible impact on waterbird usage of the wetland. The presence of evaporation ponds or additional standing water may even attract additional birds, particularly waders, when the lake would otherwise have been dry. Similarly, it is recommended that Dulbining lakes should not be monitored given their small size, degraded nature and the fact that they are upstream of the influence of any current mitigation works (i.e. groundwater pumping and surface water diversions).

The aims of the surveys of Toolibin Lake and Lake Walbyring will be to quantitatively document waterbird usage of the wetland (e.g. numbers and breeding activity by each species) using a standardised, repeatable methodology that will provide comparable data which may be used to assess temporal changes in waterbird usage.

3.7.2 Methodology

Because Toolibin Lake varies in size depending on the extent of inundation, and the dense cover of vegetation makes observations difficult, waterbird counts must be conducted by wading and by canoe (a canoe is easier to manoeuvre amongst the trees than a punt), and the survey must cover the whole wetland. The observer(s) will determine the total number of each species of waterbird present on the whole wetland on each occasion. Counts also should include waterbirds present on wetland-dependent vegetation in the riparian zone. In addition to counts of waterbirds, the observers must actively search for and record evidence of nesting/breeding activity. Observers should look for nests in hollows, forks of trees, floating on the water (i.e. on grass/reed/tree debris), in sedges/grass on land and on bare ground along the shore and on islands/gilgai mounds. Breeding activity should be recorded as number of nests with eggs and number of broods for each species. All waterbirds should be identified to species, and if this is not possible, recorded as the next taxonomic level to which identification was confirmed (i.e. unidentified duck, grebe, wader, cormorant).

Depth must be recorded at the time each survey is conducted. Historically, for waterbird surveys, depth has been recorded from the CALM depth gauge which is located towards the eastern shore of Toolibin Lake, but calibrated to the deepest point in the wetland. For continuity, depth readings at the time of each survey should continue. However, depth readings could be calibrated against the central float well maintained by the Water Corporation, as this gauge provides an automated continuous record for the wetland, and these data used for depth records. Salinity measurements similarly could be taken from the float well. The continuous measurement of this parameter was previously recommended in Section 3.1.

Waterbird surveys should be conducted four times per year, provided water depth at the gauge is > 0.6 m. This depth, although arbitrary, will restrict surveying to periods when sufficient water is present so that birds have not started to leave the lake because it is drying. Surveys should occur in August, October, December and March of any 12 month period. Monitoring in August and October should detect most breeding activity. The greatest number of species lay in October, whilst most species of duck, which tend to nest earlier, will be nesting in August. Monitoring in December will detect any late breeding and will provide data on numbers of waterbirds congregating on the lake post-breeding; Toolibin Lake is probably a reasonably important site for moulting and other post-breeding activities. Surveys in March will provide additional data on species of bird utilising the lake over the 12 month period.

The most important wetland to be surveyed is Toolibin Lake, as it is the Wetland of International Importance. However, Lake Walbyring also should be surveyed at the same time at Toolibin Lake to provide comparative data. Depth and salinity data should be recorded for Lake Walbyring, as recommended in Section 3.1.

It is not seen as necessary to survey waterbird usage on the Dulbining lakes, as these wetlands are smaller than Toolibin and never likely to hold comparable waterbird communities (either visitations or breeding). They are already salt affected and are upstream of the major mitigation projects (i.e. groundwater pumping and diversion of low volume high salinity flows) and therefore, unlikely to show any recovery in the short term.

Similarly, Lake Taarblin should not be surveyed. It is outside the zone of influence of any remediation works for Toolibin Lake, although it will receive high salinity water diverted from Toolibin Lake (both pumped groundwater and diverted low volume, high salinity water). Currently, the ultimate fate of groundwater pumped from Toolibin Lake is not clear (e.g. directly into Lake Taarblin or into evaporation ponds adjacent to, but outside the wetland). If pumped into Lake Taarblin it is likely that salinities in Lake Taarblin will increase, but it is unlikely that waterbird usage of the wetland will be further impacted as the lake is already severely degraded. In addition, the lake covers a much greater area than Toolibin Lake, requiring a far greater effort (expense) to survey for little return in information. If a waterbird survey of the wetland was required it would either take two people at least 2 days by boat and foot, or else a combination of aerial survey by fixed-wing aircraft for total numbers of each species and ground survey by boat/foot to determine breeding activity. In either instance, the survey would be expensive. Depth and salinity data should be recorded for Lake Taarblin, as recommended in Section 3.1, to assess the effects of pumping on wetland water quality.

3.7.3 Criteria

The same criteria as identified in the recovery plan should be the aim of current and future management:

- The numbers and species of waterbird visitation (41 species) and breeding success (24 species) that occurs in Toolibin Lake is maintained or improved.

Analysis of all data gathered since the 1960s at Toolibin Lake (Part 1) identified a greater number of waterbirds have used the lake than set in the above criteria; 49 species, with breeding activity recorded for 25 species. Number of species visiting the lake were higher due to sightings of Darter, Australasian Bittern, Banded Lapwing, Common Sandpiper, Glossy Ibis, Red-necked Stint, Red-necked Avocet and Wood Sandpiper. Breeding records were higher due to the presence of Purple Swamphen. The majority of additional records came from observations by Ray Garstone (Goodsell *et al.*, 1978). Some of these taxa are rare and unlikely to be seen regularly at the wetland (i.e. Wood Sandpiper), whilst others no longer visit the site because of habitat alteration (i.e. Black Bittern and Purple Swamphen). These taxa would be included in the 'improvement' part of the criteria, with the original 41 taxa visiting and 24 species breeding being included in the 'maintained' criteria. Before these additional taxa could be expected to return, there would need to be a significant change in the vegetation characteristics of the site.

Toolibin Lake does not have a history of supporting very high numbers of waterbirds and an improvement in water quality is unlikely to increase the total number of birds. Therefore, at this stage, waterbird criteria should be restricted to species composition and breeding. However, abundance data must be recorded for future comparisons.

It is not likely that the above criteria will be met in every year. Very often waterbird usage of a wetland is relatively good in the first year following a period in which the lake has been dry for 12 months or longer (pers. comm. S.A. Halse, CALM). However, this may not always be the case, and usage of the lake may be influenced by conditions extraneous to the system (i.e. particularly wet or dry conditions in some other biogeographical region affecting waterbird distributions). Therefore, the criteria should be applied over a two or three year period in which the lake holds water.

3.7.4 Equipment

Personnel adequately qualified and experienced to be conducting the type of survey required in Toolibin Lake and Lake Walbyring should already possess the necessary equipment. This would include good quality binoculars (i.e. 10 x 40 or 10 x 50 magnification), a telescope, waders and canoe with paddle. Therefore, there should be no additional cost component for equipment.

3.7.5 Personnel

There are a variety of personnel who would be adequately qualified to undertake this work (i.e. CALM staff, various private consultants and volunteers from the RAOU). However, it is recommended that surveys are conducted by staff from CALM. A major consideration in this monitoring program is to introduce continuity and maintain consistency in methodology over time (see Part 1). This is best achieved by selecting appropriately experienced and permanently employed personnel. It must be remembered that the waterbird fauna of the wetland is the major criteria for which the site was nominated as a Wetland of International Importance. Therefore, any studies on the waterbird fauna must be of the highest quality.

3.7.6 Cost

There are no specific costs associated with equipment, as all equipment should be available for use. Other costs involve salary and expenses. Toolibin Lake and Lake Walbyring should both be surveyed on the same day, with half an additional day in the office to collate, enter and check the data following each fieldtrip. Since the work involves boating, for safety reasons, two personnel (one research scientist and one technical officer) are required for each survey.

Table 3.7.1. Annual costs for waterbird surveys of Toolibin Lake and Lake Walbyring

Component	Cost ($)
Field	
Research scientist for 1 day x 4 surveys per year @ $400-00 day^{-1}	1600-00
Technical officer for 1 day x 4 surveys per year @ $200-00 day^{-1}	800-00
Travel: Perth - Toolibin Lake via Narrogin return = 500 km x 4 surveys = 2000 km @ 45^{c} per km (CALM rate)	900-00
Office	
Technical officer for $^{1}/_{2}$ day for data collation x 4 surveys @ $200-00 day^{-1}	400-00
Total =	3700-00

NB. There is no field allowance required for day trips.

Regular re-analysis of the data will be required to assess the status of waterbird usage of Toolibin Lake in relation to recovery criteria. Initially, this should be repeated once in every three years, unless the lake has not held water during that time. If the lake has been dry for three years, then the re-analysis should be undertaken within three years following which the lake refilled and additional waterbird data were gathered. Subsequent analyses then should be repeated every three years from this time. It is estimated that one week would be sufficient to prepare an adequate, but not extensive report, that documents number of species and breeding activity and relates changes to baseline data (Part 1) and data presented in Halse (1987) and Halse *et al.* (1993). This analysis will be greatly assisted by updating spreadsheets of waterbird counts of the wetlands prepared as part of this report.

Table 3.7.2. Costs for re-analysis of waterbird data for Toolibin Lake following additional surveys

Component	Cost ($)
Consultant for 5 days once every three years @ $400-00 per day	2500-00

3.8 Amphibians:

3.8.1 Aims

Part 1 of this report identified frogs as being the only major component of the Amphibia likely to be present on the reserve. In addition, it was recognised that changes in water quality, particularly changes in salinity have the potential to affect populations of wetland-dependent species of frog. Given the current paucity of information on the frog fauna of the reserve, the initial aim of any work on the amphibian fauna of Toolibin Nature Reserve should be to determine extant species of frog. This should best be achieved by conducting a comprehensive survey of the reserve. Once the composition of the frog fauna is established, particularly with respect to published information on the fauna expected from this area pre-European settlement and pre-clearing for agriculture (see Section 3.8; Part 1), a routine monitoring program may be developed. This would be in association with recommended pitfall trapping programs for mammals and reptiles. A survey and subsequent monitoring program of Lake Walbyring Nature Reserve also should be conducted as this wetland, historically is fresher than Toolibin Lake and may still hold components already absent from Toolibin Lake Nature Reserve.

3.8.2 Methodology

A number of survey methods have been identified, a combination of which should be adopted for the initial comprehensive survey and then, based upon their success, standardised for any subsequent monitoring program.

Tadpoles.

Tadpoles are best surveyed either by dip-netting or by the use of tadpole traps (Richter 1995). Opportunistic dip-netting in waterbodies should be conducted as part of pit-fall trapping for mammals/reptiles (see below). Tadpole traps consist of an inverted 1 L softdrink container with the neck cut off and inverted into the bottle. The bottle is then attached to a pole and half submerged in the water so that the funnel is submerged, but there is a pocket of air retained within the bottle. Tadpoles enter the bottle via the inverted funnel and are caught inside the bottle. A series of these traps may be trialed in various waterbodies. They may be set over night and checked the next day and may stay in place for the duration of each trapping survey (five days/four nights). Specimens may be identified by mouth-parts using Main (1965) or sent to specialist taxonomists at the WA Museum.

Adults.

All species of adult frog likely to be encountered in the Wheatbelt Region are readily identified by call (Roberts 1995). Calls can be either monitored by visiting the site on nights during and after rain and checking calls against Roberts (1995) or recorded on tape for later checks. An automated recording system is being developed in the USA (Frogwatch, 1996) (NB an alternative and less expensive system has been constructed in Australia (D. Roberts, UWA, pers. comm.)). The system consists of a timer which automatically activates a tape recorder to log animal vocalisations. The system has been used with great success to record species thought to have been absent from areas and of a species from a site at which it was thought to have become extinct. The system is self-contained, portable and weather resistant. This would obviate the need for prolonged site visits during rainy and/or breeding periods.

Spotlight transects.

Many frog species produce good eye shine, particularly the larger species. *Litoria, Heleioporus, Limnodynastes* and *Neobatrachus* might all be detected this way. As part of spotlighting for mammals, any species of frog should be recorded. Survey transects should cover both ground level and elevated perches in reed beds, bushes and trees in or around the lake margin as well as areas away from the lake.

Pit traps.

Most frog species are easily caught in pit traps. There are a large number of trap designs and trap plus fence arrays that might be used. However, **it is essential that trapping includes nights with rain or nights following days with rain**. This tends to conflict with the best times for mammal/reptile trapping! Capture rates on dry nights may be around zero even at sites with dense frog populations. Several of the frog species likely to occur can be found long distances from water (up to 2.5 km, Bamford, 1992). Pit trap arrays should be both close to the waters edge (5 - 10 m upslope) and set out in habitats away from water - not necessarily wet in any way. For aquatic breeders that move away from water, drift fences plus pits that can intercept frogs entering or leaving breeding sites might be most effective. Pit trapping for frogs should be conducted as part of surveys for mammals and reptiles.

Taxonomy and identification.

Tyler *et al.* (1994) provide a good guide to identifying frogs, and Roberts (1995) supplies call details. *Litoria moorei* and *L. cyclorhynchus* hybridise where their ranges meet (Cale 1991), which may occur at Toolibin. The survey personnel should be aware that Tyler *et al.* (1994) use the name *Ranidella* for some species referred to as *Crinia*, however, Heyer *et al.* (1982) synonymised *Crinia* and *Ranidella*.

It is again stressed that it is **vitally important** that any fieldwork is conducted at the appropriate time of year (see Part 1, Section 3.8) and under the appropriate weather conditions. Generally, during or immediately after rain is the best time to sample. Surveying during/after a prolonged wet period may not be as productive as after a rainy period which follows three or four days of drier weather. Recommended survey times for each species are summarised in Part 1, Table 3.8.1, and these times must be considered when designing a survey in association with pit trapping for mammals and reptiles. It is likely that optimum times for pit-trapping for frogs may be sub-optimal for mammals and reptiles (i.e. cooler, wet winter days/nights). However, some frogs will be taken during optimal times for mammals/reptiles (warm, dry spring days/nights). Therefore, it is recommended that an additional 'winter' survey is conducted specifically for frogs in addition to late spring and summer trappings for mammals and reptiles (see below). For pitfall trapping for frogs, mammals and reptiles, there will be an initial set-up cost, to establish the permanent pitfall grids. Subsequently, the same grids will be re-used each year. Details of the grid design, number and location of grids, survey techniques, equipment costs and personnel costs are summarised under the section on mammals. Equipment and costs specific to frog surveys are reported in this section.

In summary, the proposed approach will utilise a variety of methods to survey adult and tadpole stages in Toolibin Lake and Lake Walbyring Nature Reserves:

- Late spring and mid-summer pitfall, Elliott and cage trapping events for mammals and reptiles, which will record frogs in pitfalls. Each pitfall survey will consist of four nights and five days of trapping, with traps being checked early each morning.
- Winter survey specifically for frogs, timed to follow a period of significant rains (Elliott & cage traps, which are part of the reptile/mammal trapping program, do not need to be set for the early spring frog survey).
- One night time spotlighting survey per pitfall trapping event (preferably on a wet night, in suitable habitat for a duration of 1 hr).
- One daytime sweep-netting for tadpoles in standing water (within the Lake and marginal, flooded areas) per pitfall trapping event (1 hr of searching).
- Use of tadpole traps set in areas of standing water for the duration of each pitfall trapping event (to be checked each morning).
- A frog-logger to be placed at a different location on the reserve each night of the pitfall trapping event to record frog calls. The device would be set to record for a specific length of time at different periods throughout the night.

The total number of each life stage of each species of frog will be recorded for each survey period from each grid/area. Species identified from vocalisations, but without actual specimens will be recorded separately.

Following completion of the initial intensive survey, and based upon the results, a monitoring program will be established subsequently. It is likely that a frequency of once every three to five years will be sufficient, using the most productive methods described above (i.e. methods that record the most specimens, the most species and the most 'infrequently occurring' species).

3.8.3 Criteria

As there are no comprehensive data on the frog fauna of Toolibin Lake Nature Reserve it is not possible to set specific criteria. However, based on the outcome of a comprehensive survey, criteria should be:

- The number of species of frog present on the Nature Reserve is maintained or increased.
- The number of species successfully breeding on the Nature Reserve is maintained or improved.

Following successful remediation to prevent rising salinity in Toolibin Lake, and assuming that surveys reveal that some species of frog that would be expected from this area are not present, consideration should be given to reintroducing these species of frog to the reserve. In the face of continuing land degradation in the Wheatbelt, Toolibin Lake Nature Reserve may present an invaluable refuge for species of frog once common across the region.

3.8.4 Equipment

The majority of equipment relates to setting-up permanent pitfall grids and purchasing Elliott traps for mammal/reptile surveys and is listed under the section on mammals. Equipment specific to surveying frog populations includes:

- Pond Net (1 -to- 2 mm mesh aperture) for sweep-netting tadpoles,
- Portable automated recording system (Frog-logger) for recording frog vocalisations, and,
- Incidentals, such as batteries for the frog-logger and torches, adhesive, stakes and softdrink bottles for making tadpole traps.

3.8.5 Personnel

Personnel requirements associated with the additional winter survey specifically for frogs are listed here. Personnel requirements for spring and summer surveys of mammals and reptiles, which will include records of frog sightings are listed under the section on mammals.

As for waterbird surveys, it is recommended that all work is conducted by CALM, preferably by District staff located at Narrogin. This will introduce continuity and consistency and will reduce costs, since each pitfall trapping event takes five days, attracting accommodation expenses if external people are involved. It is expected that two staff will complete the early spring survey for frogs (volunteers will be sought to assist with the late spring and mid-summer surveys of mammals and reptiles; see below), including checking pitfall traps, spotlighting and sampling tadpoles. Field work will be completed by late morning each day, leaving time in the afternoons to identify specimens and collate data. An additional contingency is required to pay for expertise to identify/confirm frog specimens and calls recorded by the frog-logger.

3.8.6 Cost

Table 3.8.1. Costs for equipment specific to conducting surveys of frogs in Toolibin Lake Nature Reserve

Item	Cost ($)
Portable automated system for recording frog vocalisations (Frog-logger)	600-00[a]
Pond Net (1-2 mm mesh aperture) for sweep-netting tadpoles	100-00
Incidentals (batteries for frog-logger & torches, adhesive, stakes etc for tadpole traps, specimen jars, and preservative)	100-00
Total =	800-00

[a] This is unit cost from USA. A cheaper version has been constructed within Australia

Table 3.8.2. Costs for an additional winter survey of frogs in Toolibin Lake Nature Reserve

Component	Cost ($)
Field	
Two technical officers for 5 days @ \$200-00 day^{-1}	2000-00
Travel: Narrogin -Toolibin Lake return = 100 km x 7 trips = 700 km @ 45^{c} per km	315-00
Consultant	
Taxonomic specialist to confirm/identify specimens & frog calls: 1 day @ \$400-00 day^{-1}	400-00
Total =	2715-00

NB. There is no field allowance required for day trips.

3.9 Fish:

Part 1 of this report established that there were few records of fish from Toolibin Lake, with the majority of the records being of introduced species (Carp & Redfin Perch), although two species of native fish, Swan River Goby (*Pseudogobius olorum*) and Western Hardyhead (*Atherinosoma wallacei*) were taken from the inflow in winter 1994. The general absence of fish in the wetland is because the lake is seasonal and must be reinvaded/restocked each time it refills and reinvasions will depend either upon a refuge population in the near vicinity, or else established flows along the Arthur River for sufficient time to allow invasions from the lower river system (as probably occurred in winter 1994). Also, given the depauperate nature of the fish fauna of the south west of Western Australia and that few of these species would likely be encountered this far inland, in such a seasonal system, it was determined that a monitoring program of the fish fauna of Toolibin Lake should not be implemented. Opportunistic records of fish sighted whilst undertaking other sampling programs (i.e. invertebrates, frogs and waterbirds) should be maintained.

3.10 Aquatic Invertebrates:

3.10.1 Aims

As recommended in Part 1, a standardised and routine monitoring program should be developed to assess changes in relative abundance and community composition of aquatic invertebrates in Toolibin Lake and Lake Walbyring. Aquatic invertebrates form an important component of the diet of many species of juvenile and adult waterbirds, and any dramatic changes in this food source must be detected (i.e. disappearance of possible key groups, such as the midge *Chironomus tepperi*). The monitoring program also will aim to detect changes in community composition either towards a more freshwater adapted fauna or towards that characteristic of more saline conditions. Monitoring data must be supplemented by data on water quality (i.e. depth, salinity and nutrient loads). This information will be collected as part of other recommended monitoring programs (see Section 3.1).

A monitoring program for Taarblin Lake was not recommended. This lake receives saline groundwater pumped from beneath Toolibin Lake and 'first flush' low volume, high salinity water diverted around Toolibin Lake. However, maximum salinities experienced in Taarblin are already elevated well above the upper tolerances of any fresh/brackish adapted species of aquatic invertebrates and those taxa currently utilising the wetland are salt tolerant and unlikely to be affected by the pumping. These taxa will be common in other saline wetlands in the Wheatbelt. Opportunistic invasions by fresh/brackish taxa will occur in Taarblin when the system first fills and is fresh, prior to the dehydrated salt load coming into solution, and these taxa may be opportunistically utilised by waterbirds at that time. Their presence does not indicate any improvement in water quality in the wetland.

Similarly, there is no perceived value in monitoring aquatic invertebrate communities in the Dulbining lakes. These lakes are small, seasonal, salt affected and are upstream of the effects of short-term remediation action affecting Toolibin Lake, and, therefore, unlikely to show any improvement in water quality.

The time taken for re-invasion of Toolibin Lake and Lake Walbyring by fresh/brackish water adapted taxa is dependent to a certain extent on the presence of refuge populations in the near vicinity. It was recommended that a one-off survey of farm dams in the area be conducted to establish the extent of possible refuge populations of these types of taxa. Dams to be selected should be fresh in spring and no more than brackish in late summer and contain some aquatic and riparian vegetation. Doupé & Horwitz (Edith Cowan University, pers. comm.) have compiled a list of suitable dams within a 5 km radius of Toolibin Lake and it is intended that such a survey will be undertaken as an honours degree project from Edith Cowan University (P. Horwitz, pers. comm.). Funding to support this project (travel and chemical analyses) will be required.

3.10.2 Methodology

All surveys of Toolibin Lake, Lake Walbyring and selected farm dams will target the aquatic macroinvertebrate fauna and also the Ostracoda, a component of the microinvertebrate fauna. The macroinvertebrate fauna are relatively large, easy to sample, fast to process and easy to identify, compared to the microinvertebrate fauna which require specialist taxonomic expertise. Targeting the macroinvertebrate fauna will minimise costs and maximise information return. To sample this component, a standard FBA-type pond net with mesh aperture of 250 µm must be used. In addition to the macroinvertebrates, the Ostracoda, a component of the microcrustacea, should be sampled. This group includes taxa with a range of salt-tolerances, providing a useful monitoring tool. They also often form the majority of standing stock biomass in wetlands. However, because of their small size, a smaller mesh size is required for sampling. Therefore, an additional sample, using a 110 µm mesh net will be taken at each site to characterise the ostracod fauna. The whole of the 250µm mesh sample will be sorted and identified, whilst only the Ostracoda from the 110µm mesh sample will be picked and identified.

In Toolibin Lake and Lake Walbyring, three separate sampling transects will be established in each wetland to encompass within-wetland variability in physico-chemical conditions. For example, in Toolibin Lake, separate transects will run from the east, south and west shorelines towards the centre of the lake. Each transect maybe upto 200 m long, but over this distance, a standard 50m sweep will be conducted of all dominant microhabitats using both net sizes, with the intention of maximising the number of taxa recorded. Because of the flat bathometry of the lake, a 200 m transect is required to provide a range of different microhabitats.

Samples should be preserved in 70% alcohol and returned to the laboratory for processing. Ostracoda do not preserve well in formalin for subsequent identifications. Therefore, if formalin is used in the field, samples must be washed and transferred to 70% alcohol within a few days of returning to the laboratory. In the laboratory, samples must be processed to record the relative abundance of each species of macroinvertebrate. Where specimens cannot be identified to species level, specimens will be assigned voucher numbers.

Sampling should be repeated in October and March of each annual cycle, with sampling restricted to periods when water depth is > 0.6m (as per waterbirds; see Section 3.7.2). This will maximise the number of taxa recorded and will maximise extremes in fauna type (*viz.* fresh versus more saline conditions). Sampling then should be repeated once every three years, or if the lake is dry for a period of three years, it should be sampled on the next occasion that it holds water and then every three years.

Basic water quality parameters must be recorded at the time of sampling, or be available from additional monitoring programs (see Section 3.1). Parameters should include; water depth, salinity, pH, temperature, dissolved oxygen, Total Nitrogen and Total Phosphorus.

As an honours project, a total of approximately 15 farm dams in the vicinity of Toolibin Lake should be selected for intensive surveys. The dams should be fresh to brackish at the end of summer and preferably contain emergent and submergent vegetation to provide habitat heterogeneity . In each dam, all definable microhabitats should be sampled for macroinvertebrates and Ostracoda using the 250µm and 110µm mesh nets to provide two separate composite samples per site. The objective will be to maximise the number of taxa recorded. Sampling should be repeated in September, December and March in one annual cycle. This will characterise the fauna, their salt tolerances and the range of salinities experienced in the dams over the annual cycle.

In association with each sample, three replicate measurements of water quality parameters must be taken on each occasion to characterise each dam. Parameters to be measured must include; salinity, pH, temperature (vertical gradient to assess stratification), dissolved oxygen (vertical gradient to assess stratification), turbidity (NTU), secchi disk transparency, nitrate/nitrite, ammonium, orthophosphate, total-N and total-P. Costing for this survey also must include a component for a specialist taxonomist to confirm identifications.

Any tadpoles collected as part of invertebrate samples, either in Toolibin Lake, Lake Walbyring, or in the farm dams should be preserved, labelled and forwarded to CALM Narrogin District staff (or other relevant personnel) who are conducting the survey of frogs of Toolibin Nature Reserve.

3.10.3 Criteria

The general criterion specified by Bowman *et al.* (1994) should apply to monitoring of Toolibin Lake:

- The lake supports sufficient species richness and numbers of invertebrates to assure waterbird food resources.

In addition, a criterion relating macroinvertebrate community structure to salinity tolerances of the taxa should apply:

- The invertebrate fauna must be dominated by fresh/brackish water adapted taxa during the waterbird breeding seasons, when the lake is relatively full (i.e. > 0.6 m depth)

Given the current state of knowledge of the invertebrate fauna of Toolibin Lake, it is not possible to set more specific criteria in advance. Data from Doupé & Horwitz (1995) should provide some guidance, as well as unpublished data of Bachhuber & Halse (CALM). Literature cited in Part 1, Section 3.10 may be used to determine the significance of changes in the fauna with respect to salinity tolerances of the taxa.

3.10.4 Equipment

Personnel experienced in conducting the above sampling will already posses the necessary and appropriate sampling and laboratory equipment. This includes standard FBA-style pond nets with 250μm and 110 μm aperture mesh (replacement nets will be required). Plastic bags or appropriate containers for storing samples, preservatives, labels and vials are all standard consumables. There are a range of different makes and models of portable field meters for measuring pH, temperature, salinity (conductivity) and dissolved oxygen, most of which are adequate. However, it is **imperative** that the meters are correctly calibrated using the appropriate standards prior to commencing sampling at each wetland. Collection of water samples for nutrient analysis must use appropriately-sized clean containers. The actual number and size of containers (*viz.* water samples) and how the samples are treated (i.e. pre-filtered through a 0.45μm filter, frozen after collection, kept in the dark etc) will depend on the requirements of the laboratory conducting the analyses. Sample processing in the laboratory will require trays, sieves, microscope (binocular dissecting 'scope), forceps, vials and labels. Apart from expendables, the selected personnel should already posses all capital equipment. A reasonably comprehensive analysis of water chemistry is proposed for the farm dam survey. This is to differentiate between effects of salinity versus nutrient enrichment. All chemical analyses will be conducted in-house by Edith Cowan University at the cost of $8-00 per chemical per sample.

3.10.5 Personnel

The three main tertiary education institutes (Edith Cowan, Murdoch and The University of Western Australia) and CALM all have research staff well qualified and experienced in conducting the above sampling to the required standard. There are also several private consultants operating in Perth with the required expertise. CALM have the relevant taxonomic expertise to identify Ostracoda. Each sampling trip to Toolibin Lake and Lake Walbyring should be completed in one day, requiring two persons. The survey of farm dams should take approximately three days for each sampling trip (5 sites per day). Salary component is not required as this will be a student project.

In the laboratory, each replicate sample (three samples from Toolibin Lake and Lake Walbyring) will take 1 to $1^1/_2$ days to process fully (sort, identify and enumerate), with an additional day to collate and enter all data onto a spreadsheet. For costing, the best approach is to adopt a cost per sample estimate of approximately \$350-00. Additional funding may be required if the macroinvertebrate and ostracod samples are processed and identified independently. A salary component is not required for the survey of farm dams (one sample from each of 15 farm dams) as this is a student project. However, some funding will be required for specialist taxonomists to confirm identifications of voucher specimens collected from farm dams.

3.10.6 Cost

Table 3.10.1. Costs for equipment required to conduct annual (x 2 sampling trips) surveys of macroinvertebrates in Toolibin Lake and Lake Walbyring

Item	Cost ($)
Replacement nets (250 µm and 110µm mesh aperture) for FBA sweep-nets	200-00
Incidentals (batteries for meters, calibration standards, preservatives, bags, vials, labels)	300-00
Total =	500-00

Table 3.10.2. Costs for personnel to conduct annual (x 2 sampling trips) surveys of macroinvertebrates in Toolibin Lake and Lake Walbyring

Component	Cost ($)
Field	
Two technical officers for 1 day x 2 trips @ \$200-00 day^{-1}	800-00
Travel: Perth -Toolibin Lake via Narrogin return = 500 km x 2 trips = 1000 km @ 45^c per km	450-00
Laboratory	
Process, identify and enumerate 6 samples x 2 sampling trips @ \$350-00 per sample	4200-00
Total =	5450-00

NB. There is no field allowance required for day trips.

Table 3.10.3. Costs for equipment required to conduct one-off (x 3 sampling trips) survey of macroinvertebrates in farm dams in the vicinity of Toolibin Lake

Item	Cost ($)
Chemical analysis of water samples: 5 chemicals x 3 replicate samples x 15 dams x 3 sampling trips @ \$8-00 per analysis	5400-00
Replacement nets (250 µm and 110µm mesh aperture) for FBA sweep-nets	200-00
Incidentals (batteries for meters, calibration standards, preservatives, bags, vials, labels)	300-00
Total =	5900-00

Table 3.10.4. Costs for personnel to conduct one-off (x 3 sampling trips) survey of macroinvertebrates in farm dams in the vicinity of Toolibin Lake

Component	Cost ($)
Field	
Field allowance for one student for 3 days x 3 field trips @ $20-00 day^{-1}	180-00
Travel: Perth -Toolibin Lake via Narrogin return + additional mileage on-site = 800 km x 3 trips = 2400 km @ 35^{c} per km (Edith Cowan University vehicle)	840-00
Laboratory	
Specialist consultant(s) to confirm/identify voucher specimens	1000-00
Total =	5450-00

Additional funding will be required to contract reanalysis of existing and additional data and to prepare a review of the current status of the aquatic macroinvertebrate fauna of the wetlands. This analysis will be greatly assisted by updating spreadsheets of macroinvertebrate surveys of the wetlands prepared as part of this report.

Table 3.10.5 Costs for re-analysis of macroinvertebrate data for Toolibin Lake following additional surveys

Component	Cost ($)
Consultant for 5 days once every three years @ $400-00 per day	2500-00

3.11 Mammals:

3.11.1 Aims

In Part 1 it was recommended that a comprehensive survey of Toolibin Lake Nature Reserve be conducted on a seasonal basis to determine the current mammalian fauna. Such a survey will indicate any gross changes (additions/losses) in the mammalian fauna over the last two decades (*cf.* Goodsell, *et al.* 1978).

Once the current, extant fauna has been determined, a routine monitoring program should be implemented to assess future changes in the fauna. This will provide a measure of the health of the terrestrial vegetation and will supplement specific monitoring of the vegetation of the reserves (Section 3.5). Because animal numbers vary greatly both spatially and temporally, and trapping methods are relatively inefficient, a truly quantitative program with replicated sampling to determine population sizes of each component is not justifiable. A standard catch per unit effort approach will provide temporally comparable data on the numbers of each species retained in standardised grids.

Trapping should target mammalian fauna in all major vegetation associations in the reserve; in particular the *Eucalyptus rudis* and York gum woodlands on the dunes and areas to the north-east of Toolibin Lake, the *Banksia* woodland on deep sandy soils, and Salmon gum areas on the flats to the north of Toolibin Lake Nature Reserve.

Equivalent dominant vegetation associations in Walbyring Nature Reserve, if available, should be trapped for comparison.

The potential to involve local interest groups in the surveying, such as the WA Naturalist Club, Central-South Naturalist Club, Scrivener Soak Catchment Group and West Toolibin Catchment Group should be investigated. Volunteers could valuably assist with establishing pitfall trap grids, checking traps and performing active searches for small mammals, scats and any other evidence of activity (i.e. feeding platforms of water rats).

The trap design and monitoring approach also will record reptiles and amphibians (frogs). Therefore, costs for equipment and personnel for surveying mammals includes the collection of reptile and amphibian data and are not reported specifically in each respective section (Sections 3.8 & 3.12).

3.11.2 Methodology

Large and small mammals would best be surveyed using a combination of pitfall traps, Elliott traps, cage traps, spotlighting at night and active searching during the day. It is recommended that the standard CALM trapping design is adopted for this survey. This consists of a 5 x 5 grid of 25 pitfall traps, with 20 metres between traps, and flyscreen drift fences on each trap. Pitfall traps should consist of 20 L plastic buckets with sealable lids (so that they may be sealed and left *in situ* between surveys). Drift fences should consist of ~7 m sections of fibreglass or aluminium flyscreen cut into 30cm deep strips and positioned across the pitfall traps, with the bottom edge slightly buried. Grids located close to the wetland should have drift fences orientated parallel to the shoreline.

An Elliott trap should be associated with each pitfall trap, located within 1-2 metres of each trap and set with 'universal' bait (i.e. rolled oats, peanut paste & raisins). Trapping period on each grid should be complemented with a standardised effort of spotlighting at night and active searching during the day (i.e. turning logs, lifting bark etc) for additional taxa. Because of the nature of Toolibin Lake Nature Reserve, spotlighting will best be done whilst driving a circuit of the perimeter of the reserve. Additional time (max. 1 hr) should be spent spotlighting on foot in the vicinity of the pitfall grids. Active searches during the day (max 1 hr) for small vertebrates involves turning over logs, looking under bark and raking leaf litter. This is a fairly destructive method, and as such should be used only for the initial survey, and not for any subsequent routine monitoring program. Spotlighting and active searching should be conducted once in every five day pitfall survey.

In addition, cage traps should be set to target larger mammals (i.e. possums, woylies, water rats, cats, foxes etc). It is recommended that, initially, 30 cage traps are set every 100 m along a driven route and in areas close to the water. This will identify additional mammals utilising the area. If the cages are productive, then they may be associated with each grid in any subsequent monitoring program. The ideal design is one cage on each corner of the grid, with one located in the centre (5 cages per grid x 6 grids = 30 cages).

Number of each species of mammal retained by each individual trap must be recorded, with taxa observed during spotlighting and active searches and in the cages recorded separately. This will provide data on the number of individuals of each species in each area/vegetation complex, and the number of species present on the reserve. Standard measurements should be taken of all individuals caught (i.e. weight, head length, snout length, total body length, leg/tibia length, sex (where possible), breeding condition (where possible), and comments as to condition). Comparisons will be made between total numbers of each species caught in each grid over the duration of each trapping survey, and between grids in comparable vegetation complexes in Toolibin Lake and Lake Walbyring Nature Reserves.

For the initial survey, pitfall trapping will be conducted over five days and four nights, with all traps checked early each morning, and trapping will be repeated in late spring and mid-summer. Depending upon the results, duration of trapping subsequently may be reduced to four days and three nights.

Experience shows that two experienced personnel can efficiently operate six trap grids (Dave Mitchell, CALM, pers. comm.). Therefore, a total of six grids should be established in the reserves. Four grids in Toolibin Lake Nature Reserve, and two in Lake Walbyring Nature Reserve. Each grid in each reserve should be in a different vegetation complex. Pitfall trapping also will target frogs (see Section 3.8), therefore, some consideration needs to be given in the design to the location of grids, targeting the immediate riparian zone so that fauna moving into and away from the wetland are sampled. Suggested locations are; two grids in the fringing vegetation of the lake, comprising the *E. rudis* and York gum woodlands on the dunes and areas to the north-east, salmon gum woodland to the north of the reserve (consideration should be given to establishing this grid in Dulbining Nature Reserve if suitable salmon gum habitat is not present in Toolibin Lake Nature Reserve), and finally, the *Banksia* woodland on sandy soil. Two grids should be established on comparable vegetation complexes in Lake Walbyring Nature Reserve.

Establishment of the grids will take approximately two person days per grid to dig pitfalls and set drift fences. Use of volunteers will greatly assist with this task.

Once a monitoring program is established, it would not need to be repeated every year, since changes in the vegetation of the reserve are expected to be gradual. A frequency of one in three or five years would be adequate. Between monitoring periods, the pitfall traps either may be sealed, using the lids, or else filled with sand and then emptied when again required.

3.11.3 Criteria

Until more detailed information are available as to the composition of the fauna, it is not possible to set specific criteria. General interim criteria should be:

- Number of species of native mammals present on the reserve is maintained or increased.

If the survey detects locally rare/endangered taxa, such as the water rat, consideration should be given to establishing a baiting/eradication program for feral animals (i.e. foxes and cats). Similarly, any feral animals caught in traps should be euthanased.

3.11.4 Equipment

The majority of equipment that is required is to establish and maintain the grids. Some of this equipment will be readily available in the District Office at Narrogin (i.e. cage traps), although some new traps may need to be purchased. Other items, such as the buckets and drift fences will be permanently located in the field and therefore, new items must be purchased for this project. Equipment required for six grids of 25 pitfall traps will include:

- two shovels for digging pits and small sledge hammer for setting drift fences
- 150 x 20 L buckets with lids for pitfall traps
- aluminium flyscreen, stakes, wire and markers for drift fences and pitfall traps
- 150 Elliott traps
- approximately 30 cage traps
- spotlights and torches
- Measuring and holding materials (scales, callipers, cotton bags etc)

3.11.5 Personnel

It is recommended that all work is conducted by CALM, preferably by District staff located at Narrogin. This approach will introduce continuity and consistency and will reduce costs, since each pitfall trapping event takes five days, attracting accommodation expenses if external people are involved. It is expected that two staff will complete each survey and a maximum of two volunteers should be sourced to assist with the work (i.e. digging and setting-up the pitfall trap grids, checking pitfall traps, spotlighting and active searching). Field work will be completed by late morning each day, leaving time in the afternoons to identify specimens and collate data.

3.11.6 Cost

Table 3.11.1. Costs for equipment required to conduct annual (x 2) surveys of mammals in Toolibin Lake and Lake Walbyring Nature Reserves

Item	Cost ($)
150 x Rheem 20 L Mk 8 Natural buckets without handles, with lids, UV stabilised @ $1200-00 for a pallet of 192 buckets	940-00
150 x 7 m lengths of aluminium flyscreen of 25cm depth	600-00
Incidentals & expendables (i.e. stakes, wire, markers, universal bait)	100-00
Total =	1640-00

NB. Elliott and cage traps, shovels, measuring and handling equipment will be readily available from the District Office, assuming this work is conducted by CALM. However, costings are provided below if additional/new traps are required:
150 Elliott traps @ $450-00 per box of 25 = $2700-00
20 cage traps @ $45-00 each = $900-00

Table 3.11.2. Costs for personnel to conduct annual (x 2) surveys of mammals in Toolibin Lake and Lake Walbyring Nature Reserves

Component	Cost ($)
Field - set-up	
Two technical officers for 1 day to establish each pitfall grid x 6 grids @ $200-00 day^{-1}	2400-00
Travel: Narrogin -Toolibin Lake return + additional travel = 120 km x 6 trips = 720 km @ 45^{c} per km	325-00
Field - surveys	
Two technical officers x 5 days per survey x 2 surveys per year @ $200-00 day^{-1}	4000-00
Travel: Narrogin -Toolibin Lake return + additional travel = 120 km x 6 trips x 2 surveys = 1440 km @ 45^{c} per km	650-00
Laboratory	
Technical officer for 1 day per survey to collate, enter and check data @ $200-00 day^{-1}	400-00
Total =	7450-00

NB. There is no field allowance required for day trips.

3.12 Reptiles:

3.12.1 Aims

As for the mammalian fauna, it is recommended that the current community composition of reptiles on Toolibin Lake Nature Reserve be established through a comprehensive survey of the reserve. This will indicate any gross changes that have occurred over the past two decades (*cf.* Goodsell *et al.* 1978), and will provide a reference point on which to judge effects of future changes in vegetation condition. Data on the reptilian fauna will be gathered as part of the surveys of the mammal fauna, using the same trapping equipment and personnel.

As for the mammalian survey, it is valid to target reptilian fauna in all major vegetation associations in the reserve; in particular the *Eucalyptus rudis* and York gum woodlands on the dunes and areas to the north-east of Toolibin Lake, the *Banksia* woodland on deep sandy soils, and Salmon gum areas on the flats to the north of Toolibin Lake Nature Reserve. Equivalent dominant vegetation associations in Walbyring Nature Reserve should be trapped for comparison.

3.12.2 Methodology

The reptilian fauna will be surveyed using the same methodology as applied to the mammalian fauna; a combination of pitfall traps, Elliott traps, cage traps, spotlighting at night and active searching during the day. The grid design and application of techniques are described in detail in Section 3.11.2, and are not repeated here.

Number of each species of reptile retained by each individual trap must be recorded, with taxa observed during spotlighting and active searches and in the cages recorded separately. This will provide data on the number of individuals of each species in each area/vegetation complex, and the number of species present on the reserve. Standard measurements should be taken of all individuals caught (i.e. weight, head length, snout length, total body length, leg/tibia length, sex (where possible), breeding condition (where possible), and comments as to condition). Comparisons will be made between total numbers of each species caught in each grid over the duration of each trapping survey, and between grids in comparable vegetation complexes in Toolibin Lake and Lake Walbyring Nature Reserves.

For the initial survey, pitfall trapping will be conducted over five days and four nights, with all traps checked early each morning, and trapping will be repeated in late spring and mid-summer. Depending upon the results, duration of trapping subsequently may be reduced to four days and three nights.

As for the mammalian fauna, once a monitoring program is established, it would not need to be repeated every year, since changes in the vegetation of the reserve are expected to be gradual. A frequency of one in three or five years would be adequate. Between monitoring periods, the pitfall traps either may be sealed, using the lids, or else filled with sand and then emptied when again required.

3.12.3 Criteria

Until more detailed information are available as to the composition of the fauna, it is not possible to set specific criteria. General interim criteria should be:

- Number of species of reptile present on the reserve is maintained or increased.

3.12.4 Equipment

Equipment required to conduct this survey is described in Section 3.11.4, and is not repeated here.

3.12.5 Personnel

Personnel required to conduct this survey are listed in Section 3.11.5, and are not repeated here.

3.12.6 Cost

Costs to conduct this survey are detailed in Section 3.11.6, and include survey costs for mammals, reptiles and frogs.

3.13 Terrestrial Birds:

3.13.1 Aims

As for surveys of mammals and reptiles, the presence of certain species of terrestrial birds will be indicative of the general overall health of the vegetation of the reserve. It would be valuable to conduct a one-off comprehensive survey of the terrestrial bird fauna of the reserve, to better determine the resident fauna in Toolibin Lake Nature

Reserve. This will indicate any gross changes (additions/losses) in the bird fauna over the last two decades (*cf* Goodsell *et al.* 1978).

Once the current, extant fauna has been determined, a routine monitoring program may be implemented to document changes in the bird fauna that may reflect changes in the health of the terrestrial vegetation. However, this is not seen as a high priority.

3.13.2 Methodology

Any survey of the reserve must use a standardised quantitative approach, in which numbers of each species and breeding activity are recorded. Surveying would best be associated with the trapping program for mammals and reptiles. Observations should be restricted to the same vegetation type as sampled by each pitfall trap grid, with each survey restricted to a standard time of 1 hr in the vicinity of each grid. Numbers of all species of terrestrial bird observed within the vegetation type should be recorded, as well as breeding activity (i.e. old nest, nest under construction, occupied nest, brood). Any species flying overhead should be recorded in such a way as to be differentiated from species utilising the bush, and species seen in a bordering vegetation complex should not be recorded. Surveys must be standardised to the same time of day (i.e. early morning or late afternoon) and seasonality must be incorporated in any program (i.e. early summer and early winter). This approach is based upon survey techniques used by CALM (P. Fuller, CALM, Science & Information Division, pers. com.).

As with the pit fall trapping, the potential to involve local interest groups in the surveying, such as the RAOU, WA Naturalist Club, Central-South Naturalist Club, Scrivener Soak Catchment Group and West Toolibin Catchment Group should be investigated.

Similarly, monitoring would not need to be repeated every year, since changes in the vegetation of the reserve are expected to be gradual. A frequency of one in three or five years would be adequate.

3.13.3 Criteria

Until more detailed information are available as to the composition of the terrestrial bird fauna, it is not possible to set specific criteria. General interim criteria should be:

- Number of species of non-wetland dependent species of bird present on the reserve is maintained or increased.
- Number of species of non-wetland dependent species of bird breeding on the reserve is maintained or increased.

3.13.4 Equipment

Personnel adequately qualified and experienced to be conducting the type of survey required in Toolibin Lake Nature Reserve and Lake Walbyring Nature Reserve should already possess the necessary equipment. This would include good quality binoculars (i.e. 10 x 40 or 10 x 50 magnification) and a telescope. Therefore, there should be no additional cost component for equipment.

3.13.5 Personnel

There are a variety of personnel who would be adequately experienced to undertake this work (i.e. CALM staff, various private consultants and volunteers from various groups (e.g. RAOU, WA Naturalist Club, Central-South Naturalist Club, Scrivener Soak Catchment Group and West Toolibin Catchment Group)). If volunteers are used, initial training may be required to ensure consistency in standard application of the methodology over time. Optimum use of resources would be achieved by conducting the bird surveys at the same time as the pitfall trapping surveys.

3.13.6 Cost

There are no equipment costs associated with this component. Similarly, there will be no personnel or travel costs if the surveys are conducted at the same time as the pitfall trapping surveys. If the terrestrial bird surveys are conducted by a volunteer, independently of the pitfall trapping, there will be no salary component, but there will be a minor travel component. Greatest costs will be incurred if the terrestrial bird surveys are conducted by salaried staff/consultant, independently of the pitfall tapping surveys. It is anticipated that to standardise surveys to the same time of day (i.e. early morning), with 1 hr spent surveying in the vicinity of each grid, two grids could be surveyed each morning, requiring three visits to the reserves for each survey.

Table 3.13.1. Costs for personnel to conduct annual (x 2) surveys of terrestrial birds in Toolibin Lake and Lake Walbyring Nature Reserves

Component	Cost ($)
Field - surveys	
One technical officer x 3 halfdays per survey x 2 surveys per year @ $200-00 day $^{-1}$	600-00
Travel: Narrogin -Toolibin Lake return + additional travel = 120 km x 3 trips x 2 surveys = 720 km @ 45^{c} per km	325-00
Total =	925-00

NB. There is no field allowance required for day trips.

3.14 Terrestrial invertebrates:

In Part 1 of this report it was determined that a monitoring program of terrestrial invertebrates on Toolibin Lake Nature Reserve should not be implemented. This was in light of the cost of implementing a program that would produce reliable quantitative data, and the value of such data when obtained.

3.15 Agricultural Practices

3.15.1 Aims

- A strategic revegetation plan for the catchment should be developed which clearly identifies the objectives, stakeholders and the processes to be implemented.

- Develop a catchment management plan that incorporates revegetation and altered agricultural practices/land use. The plan should incorporate a review of biophysical and socio-economic characteristics of the catchment and collate this information in a GIS. The objectives of the plan should be sustainable land use and protection of Toolibin Lake conservation values.
- Conduct surveys of cultural change within the catchment. Aspects to cover include understanding of catchment hydrology, knowledge of biodiversity/sustainable agriculture relationship, knowledge of role of woody vegetation in catchment recovery. Attitudes towards maintaining remnants of native vegetation and revegetation projects also should be evaluated.
- Catchment parameters to do with revegetation and 'health' should be monitored. Extent of salinity, area of revegetation, health of remnant vegetation, degree of implementation of high water use cropping and extent of waterlogging are some parameters that could be monitored as part of a catchment management programme.
- Measurement of the economic health of the catchment should be monitored to determine farm productivity response to remedial activities. Aspects of farm productivity such as livestock, pasture and crop indicators should be monitored.
- Monitoring of the Toolibin Alley Farming Trial should continue.

3.15.2 Methodology

It should be noted that any catchment monitoring programme for the Toolibin catchment, as identified in the Toolibin Lake Recovery Plan, should maintain the recovery of Toolibin Lake as its focus. Therefore the elements that are monitored should reflect the key biophysical and socio-economic parameters that are critical to successful (and long-term) recovery of the lake. Emphasis should be placed upon the following parameters:

- Surface water runoff quantity and quality (conductivity and nutrients)
- Groundwater levels and quality (salinity)
- Silvicultural parameters and water use of revegetation programmes
- Extent of secondary salinity, waterlogging and ponding, rate of increase, key areas impacted, sites of potential impact.
- Condition of remnant vegetation, natural regeneration, proportion and cover of exotic species.
- Cultural parameters relevant to the implementation of catchment rehabilitation measures, acceptance of revegetation, drainage works, economic impacts of rehabilitation.

It is important that the above parameters be considered both in terms of short-term implementation and long-term integration into the catchment management plan.

Surface water monitoring methods should follow those outlined for catchment surface water monitoring in section 3.3.1.2. The scale of the sampling cannot be finalised until a catchment management/revegetation plan is completed and priorities set. Groundwater monitoring is to continue and be expanded as identified in section 3.2 and as required by a future revegetation strategic plan.

Silvicultural monitoring should be conducted as specified by the Toolibin Alley Farming Trial report (Arborescence Consultancy, 1996) but will be determined by the objectives of future trials. Plantings as part of a revegetation plan rather than trials will require less intensive monitoring if revegetation is on a large scale. The focus should then be on survival and simple growth parameters. Groundwater monitoring, to determine the effect of revegetation, should be reviewed in light of the revegetation plan to determine whether the current bore network can adequately represent changes in groundwater levels due to plantings.

The area of salinisation, waterlogging and ponding in the catchment should be accurately determined to identify key areas of impact and rate of increase. Aerial photography and satellite imagery (Thematic Mapper), combined with airborne electromagnetic surveys should be used to determine the above, as well as identify strategic areas for revegetation. It is important that periodic assessment (at least every 4 years) using the above techniques be conducted if change in condition is to be determined.

The remnant vegetation in the catchment, other than the Toolibin reserves which are dealt with in detail in other sections, should be assessed for condition and monitored for indicators of recovery or decline. The maintenance of remnant vegetation and its integration with revegetation plans should be a key consideration in the catchment management plan. Important indicators of decline/recovery are:

- presence and proportion (species and cover) of exotic species in understorey.
- successful recruitment (seedlings or asexual reproduction (clonal)) of native understorey and overstorey species. Mass seedling emergence of perennial species that fails after 1st or 2nd summer is not considered successful (ie. reach reproductive maturity).
- change in the native species richness and diversity.
- change in soil physical and chemical properties. Water repellency, compaction, nutrient status, litter cover/surface soil organic matter, salinity.
- change in disturbance/stress regime. Grazing/trampling by stock, fire frequency/intensity, depth to groundwater, flooding.

Measurement of remnant vegetation change over time should follow the methods outlined for Toolibin Lake and reserves. However, a preliminary assessment of all remnant vegetation in the catchment should determine the required techniques that are more specific to the vegetation.

Monitoring of the socio-economic impact/processes involved in catchment rehabilitation, should be considered for the Toolibin Lake catchment. There is currently no information on the likely degree of acceptance within the local community for the cultural change associated with alternative land management practices. Such information would be useful in identifying the real potential for broad scale or strategic reforestation within the catchment, and what this would imply to the socio-economic structure of the community. A review of the above for the Toolibin catchment would be integral to a partnership approach to rehabilitation, one that recognises that state agencies, local government, catchment groups and individuals all have a role. The review, like the revegetation plan, should be an integral component of the catchment management plan. The use of planning models, such as LUPIS and AEAM, should be considered as a means of documenting community values.

The above monitoring parameters should be components of an integrated catchment management plan that identifies the management objectives and forms a consistent reference for all rehabilitation and management activities within the catchment. Associated with the plan should be a central database, preferably a GIS, that holds data on the biophysical characteristics of the agricultural landscape and identifies land use, distribution of crop/pasture categories, landform, surface and groundwater hydrology, extent of salinisation, distribution and values of remnant vegetation, extent of reforestation and other remedial measures. A GIS will allow an overview of the catchment features and modelling of different catchment rehabilitation scenarios and will provide a focus for the catchment rehabilitation component of the recovery plan.

AgWA has prepared farm plans for all properties in the catchment and the planning process is being further developed to ensure plans are integrated on a subcatchment basis.

3.15.3 Criteria

There are no management criteria stated in the Toolibin Lake Recovery Plan specifically for the rehabilitation of the Toolibin catchment. One physical criterion is specific to the quality of runoff from the catchment entering Toolibin Lake:

- The maximum salinity of inflow to the lake measured at the Water Authority gauging station 609 010 on the Northern Arthur River should be 1000 mg/l TDS during the winter months when the lake is filling.

Given the broad spectrum of possible catchment parameters to monitor, only a subset of key criteria, critical to the recovery of Toolibin Lake, are listed below:

- Surface water runoff quantity and quality (conductivity and nutrients). Covered in section 3.3 of this volume. Surface flow monitoring of experimental revegetation sites is a lower priority and is not dealt with here.
- Groundwater levels and quality (salinity). Covered in section 3.2.
- Silvicultural parameters and water use of revegetation programmes. Criteria will depend on the recommendations of a strategic revegetation plan which has not been developed to-date.
- Extent of secondary salinity, rate of increase. There is insufficient information available to develop realistic/achievable criteria for this parameter. (No further increase in the area of land affected by salinisation?)
- Condition of remnant vegetation. There should be no further decline in remnant vegetation condition within the Toolibin catchment.

As part of the recovery actions in the Toolibin Lake Recovery Plan, land management planning, revegetation of recharge and discharge areas, salinity surveys and soil structure improvement have either commenced or are planned.

3.15.5 Personnel

Due to the non-specific nature of the catchment monitoring parameters, that have not already been covered in sections 3.2, 3.3 and 3.5, it is not possible to identify the required personnel and equipment.

The key stakeholders in catchment monitoring are:

- CALM. Development of catchment management plans, farm forestry initiatives and trials, remnant vegetation condition.
- AgWA. Development of farm and catchment plans, revegetation plans, soil condition and alternative crop/pasture trials, groundwater bore network, salinity surveys.
- Toolibin Lake Catchment Committee. Catchment plans, farm forestry, alternative crop/soil condition trials.
- Landholders. Farm plans, catchment plans, farm forestry, alternative crop/soil condition trials.

3.15.5 Cost

Other than costs given in sections 3.2, 3.3 and 3.5 for associated monitoring activities in the catchment, it is not possible to determine monitoring costs until more specific details on catchment rehabilitation/monitoring activities are available.

4.0 PRIORITIES FOR MONITORING

Priorities for implementation of each component of the monitoring program, separated into levels of urgency are presented below (Table 4.1). Within each category, monitoring components have been ranked according to their envisaged importance and information return.

5.0 DATABASES AND DATA STORAGE

Following the collection of any additional monitoring data, the data must be entered onto an appropriate database/spreadsheet and checked for errors before entry is finalised. The database should include all other data on that topic to facilitate rapid retrieval and reanalysis of data relevant to a topic (i.e. all data on waterbird usage should be standardised to the same database). This will allow rapid reporting of the results of monitoring to management. The database must be regularly backed-up, with safe storage of the back-up in an alternative location to the original. It is recommended that the database is housed at the Wheatbelt Regional Headquarters of CALM, along with a complete reference collection of all reports/papers etc pertaining to the wetland. For some components of the monitoring program the data will be collected and entered onto corporate databases belonging to other organisations (i.e. AgWA, Water Corporation or Water & Rivers Commission). A system should be established whereby these data are regularly appended (i.e. quarterly or annually) to the established database for the wetland.

Table 4.1. Priorities and rankings for implementation of monitoring components for Toolibin Lake and nature reserve.

Priority	Component	Ranking
Existing programs to be continued	Inflow volumes and salinity	1
	Lake level	1
	Pluviometer	1
	West Toolibin Flats Drainage	1
	Existing Mattiske lake and terrestrial vegetation transects	1
	Toolibin Alley Farming Trials	2
For immediate implementation	Waterbirds	1
	Aquatic Invertebrates	1
	Toolibin Lake Separator Channel	1
	In-lake salinity and overflow volume and salinity	1
	Additional Lake and Terrestrial Vegetation Plots	1
	Development and implementation of catchment management plan	1
	Development and implementation of strategic revegetation plan	1
	Monitoring catchment revegetation	2
	Aquatic macrophyte survey	2
	Amphibians	2
Desirable, but not critical	Mammals	1
	Reptiles	1
	Seedling Recruitment Investigations in Lake and Terrestrial Vegetation	1
	Reassessment of Froend Vegetation Transects	1
	Rhizosphere Research	2
	Survey of cultural change in the catchment	2
	Terrestrial Birds	3
Not necessary	Fish	1
	Terrestrial Invertebrates	1
	East Toolibin Flats Drainage	1

As part of this report, Excel spreadsheets have been prepared for all monitoring data collected and analysed to date. The names and content of these spreadsheets are summarised in Part 1 of this report. The routine updating of these spreadsheets is seen as the most economical way of maintaining a central database for the site. This will also facilitate the rapid re-analysis of the data and preparation of an update of the current status of individual components of the system. Provided the appropriate security is available, it would be beneficial to develop access to these data via the world wide web system.

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8.0 APPENDIX

8.1 Appendix 1

PROCEDURE FOR COLLECTION,
PRESERVATION AND TRANSPORT OF WATER SAMPLES
FROM TOOLIBIN LAKE
(As proposed by the Water Authority of WA, 1995)

1. Sampling Sites

There are seven sites from which water samples are to be taken. Five sites are known as Surface Sampling Sites (Q), two as Stream Inflow Sites and one as a Lake Level Site.

2. Sampling Frequency

All sites are to be sampled quarterly (every three months). Two of the sample dates should coincide with the extremes of water quality in the Lake.

3. Water Quality Components

The water samples are to be analysed for uncompensated conductivity, *insitu* temperature, nutrient components and Chlorophyll *a*.

4. PROCEDURES FOR SAMPLING

4.1 General Rules of Sampling

a) Always take extreme care to avoid contamination:

- Remove caps from sample bottles ONLY at the time of sampling.
- NEVER put sample bottle caps on the ground.
- DO NOT touch the inside of the bottles or caps with the hand or sampling equipment.

b) DO NOT RINSE sample bottles unless otherwise specified.

c) Bottles should be capped IMMEDIATELY on collection of sample

d) Write labels on bottles BEFORE taking samples. This avoids possible mix ups, and also avoids the difficulty of trying to write on wet bottles.

* NOTE: **The sampling program and procedures for ground water is different to that of surface water**

4.2 Sample Collection

Each site is to be sampled and water stored in requested LDPE (Low density polyethylene) bottles.

A sample pack of 500 ml (conductivity), 1000 ml and 125 ml (nutrients) and 500 ml black plastic is required for each site. ie 4 bottles per sample pack

4.2.1 On-site Measurements

4.2. 1.1 Temperature

Temperature must always be measured in the field. Use either an alcohol-in-glass thermometer with a range of 0-50'C, or a suitable calibrated electronic thermometer.

4.2.1.2 Unfiltered Samples

Samples for 1000ml poly, 500ml poly and 500 ml black plastic bottles (with Iml Magnesium Carbonate) are filled to within 5 mm of the top, except for the 500 ml poly.

4.2.1.3 Filtered Samples

Samples for the 125ml poly bottle have to be filtered.

Collect samples at each site and:

a) with clean dry hands unscrew the filter holder and fit a gasket and a new 0.45 um membrane filter. Take care not to damage either the gasket or the filter when screwing the filter holder back together.

b) Pour the sample from the sampling vessel into a clean, rinsed beaker and withdraw 50 ml of sample from the beaker with a syringe and rinse.

c) Withdraw another 50 ml of sample, fit the filter holder to the syringe and slowly expel through the filter into the bottle (discarding the first 5 - 10 ml).

d) Remove the filter holder and repeat step c) until bottle contains approximately 100 ml.

Any samples proving difficult to filter, a note on the bottle and paper work is required. ie vacuum filtering or centrifuge of sample is required.

4.3 Sample Labelling, Field Observation Forms and Dispatch

a) Clearly label each bottle with the sample ID. This bottle number must be cross referenced on the paper work with site number provided.

b) On the field observation forms sample number, station number, time, day, date, stn key and temperature must be completed. FORMS WRS69/7120, @S73/7123. The proformas are attached.

c) All 5 bottles in the pack for each site can have the same bottle number indicating the one site.

d) Samples and paperwork shall be sent as soon as possible after collection (preferably the same day) to:

SWB
WATER AUTHORITY
JOHN TONKIN WATER CENTRE
629 NEWCASTLE STREET
LEEDERVILLE 6007

ALL SAMPLES MUST BE STORED AT 1-4^{0}C DURING TRANSPORT

4.4 Sampling Equipment

IIN No	Name	Description
18551	Syringe, water sampling	Plastic, 50 ml, graduated x 2.5 ml
18552	Filter body, fluid	Swinnex, SX0002500, 2 piece screwed assembly
18553	Filtering disc	Cellulose acetate, 25 mm dia, 0.45 microns, to suit Swinnex filter body, Sartorius II 106025 - N, pack 100
18554	Gasket	Filter holder, SX0002501, to suit Swinnex body, pack of 5