Monitoring and Evaluation Guide for the Peel-Yalgorup Ramsar Site

PEEL-HARVEY CATCHMENT COUNCIL (Inc.)

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GOVERNMENT OF WESTERN AUSTRALIA

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Introduction

The Peel-Yalgorup wetland system is designated as a wetland of international importance under the Ramsar Convention. Consistent with the obligations under this convention, an ecological character description (ECD) has recently been completed for the site (Hale and Butcher 2008) and a management plan has been developed (Peel-Harvey Catchment Council).

Central to the management plan will be a monitoring and evaluation program that will inform on management activities and assess the ecological character of the site against limits of acceptable change. As always, resources for the management and monitoring are finite and therefore it is essential that a carefully coordinated monitoring and evaluation guide be developed.

Monitoring, by definition is undertaken to inform management and consequently the design of a program is dependent on the management objectives. This monitoring and evaluation guide for the Peel-Yalgorup Ramsar site is based on the overall management aim of managing the site to maintain its ecological character and, more specifically, Objective 3 of the management plan:

> *Long term positive outcomes are achieved for the Peel-Yalgorup Ramsar System where the ecological character of the Peel-Yalgorup System, including services and values, is maintained or improved*

Therefore the objective of this project is to:

- Develop a monitoring and evaluation guide for the Peel-Yalgorup Ramsar site to:
    - Inform management of the site against Limits of Acceptable Changes (LAC) as detailed in the ECD;
    - Set baseline conditions, where there is currently information gaps, upon which Limits of Acceptable Change (LAC) can be based; and
    - Inform the refinement and review of LAC

Specifically, this project comprises of the following outputs (as summarised from the terms of reference):

- prioritised list of monitoring actions;
- scheduling of monitoring actions (timing and intervals for repeat measurements)
- responsible organisation/s for each action;
- estimated costs for each action;
- links to Limits of Acceptable Change;
- recommendations for data management; and
- recommendations for linkage with management decisions.

Context

Site

The Peel-Yalgorup Ramsar site comprises the Peel-Harvey Estuary, The Yalgorup Lakes and Lakes McLarty and Mealup in southwest Western Australia (Figure 1). In addition to the officially designated Ramsar site, this monitoring guide includes lakes Goegrup and Black, which are planned as extensions to the site in the near future (Hale and Butcher 2008). The site was first designated as a wetland of international importance in 1990 and currently meets six of the criteria for listing under the Ramsar Convention (Table 1).

Table 1: Criteria for identifying wetlands of international importance that are met by the Peel-Yalgorup Ramsar site (adapted from Hale and Butcher 2008).

Ramsar Criteria	Peel-Yalorup Justification
Criterion 1: A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.	The site includes the largest and most diverse estuarine complex in south-western Australia and also particularly good examples of coastal saline lakes and freshwater marshes.
Criterion 3: A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.	The site is one of only two locations in south-western Australia and one of very few in the world where living thrombolites occur in inland waters.
Criterion 4: A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.	The site supports and array of species and communities during critical life stages including: large numbers of migratory birds; breeding of waterbirds, fish, crabs and prawns; drought refuge for waterbirds, fish and invertebrates; and waterfowl such and Shelducks and Musk Ducks during moulting.
Criterion 5: A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds.	The site comprises the most important area for waterbirds in south-western Australia, supporting in excess of 20,000 waterbirds annually, with greater than 150,000 individuals recorded at one time (February 1977). Numbers exceeding 20,000 birds have been recorded in all comprehensive surveys conducted in the 1990s in the Peel-Harvey Estuary.
Criterion 6: A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird.	According to the 4th edition of Waterbird Population Estimates, the site regularly supports 1% of the population of: Red necked Avocet, Red necked Stint, Red-capped Plover, Hooded Plover, Black-winged Stilt, Banded Stilt, Curlew Sandpiper, Sharp-tailed Sandpiper, Fairy Tern, Musk Duck, Grey Teal, Australasian Shoveler, Australian Shelduck and, Eurasian Coot.
Criterion 8: A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.	The Peel-Yalgorup Ramsar Site is important as a nursery and/or breeding and/or feeding ground for at least 50 species of fish as well as the commercially significant Blue Swimmer Crab and Western King Prawn. In addition, the Peel - Harvey Estuary is a migratory route for the Pouched Lamprey (*Geotria australis*).

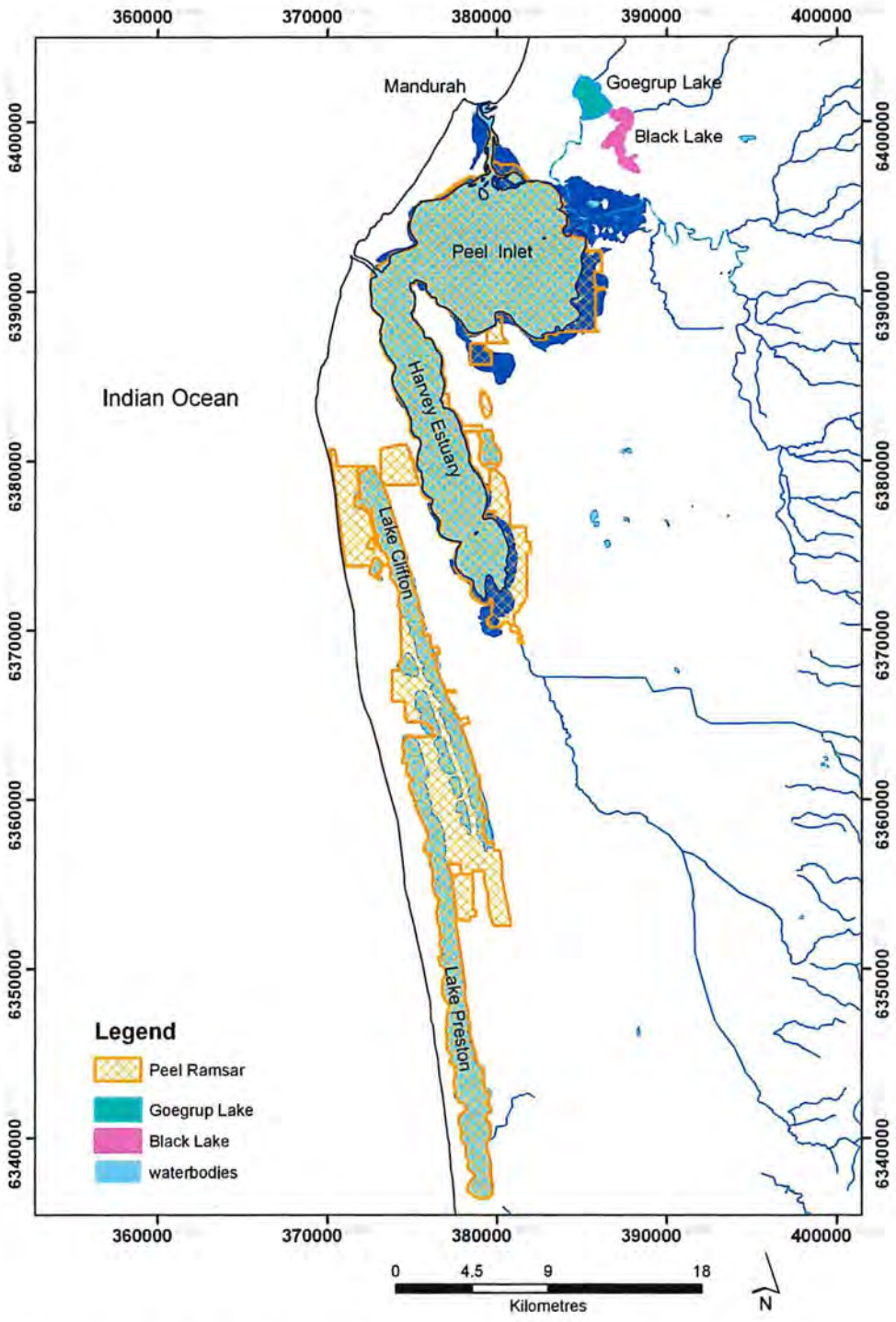

Figure 1: Area to which this monitoring and evaluation guide applies: the Peel-Yalgorup Ramsar site and lakes Goegrup and Black.

The act of designating a wetland as a Ramsar site carries with it certain obligations, including managing the site to retain its 'ecological character' and to have procedures in place to detect if any threatening processes are likely to, or have altered the 'ecological character'. Central to this is the development of an Ecological Character Description, which provides a detailed description of the site and sets Limits of Acceptable Change (LAC). LAC are defined as the

variation within specific ecosystem components and processes that are considered acceptable for maintaining the ecological character of the site (Phillips 2006). Simply stated they are "the lines in the sand" with respect to specific components and processes (e.g. water quality, waterbird communities) within which the system must be managed. Although monitoring is not a specific obligation under the Ramsar Convention, in order to ascertain if the ecological character of the site is being protected and the LAC met, a monitoring program is required.

Limits of Acceptable Change

This monitoring and evaluation guide builds on the approach and outputs of the Ecological Character Description (ECD) for the Peel-Yalgorup Ramsar site (Hale and Butcher 2008). This links monitoring programs with the LAC (both for assessing condition of the site against LAC and for informing the review and refinement of LAC). The primary aim of the LAC was to detect significant changes in ecological character in time to instigate a management response (i.e. before the change in ecological character is irrevocable). The ECD recognised that LAC could not be set nor monitored against for every component and process within the system. Rather, a strategic, three tiered hierarchical approach was adopted, which targeted the primary determinants of ecological character of the Peel-Yalgorup Ramsar site (Figure 2).

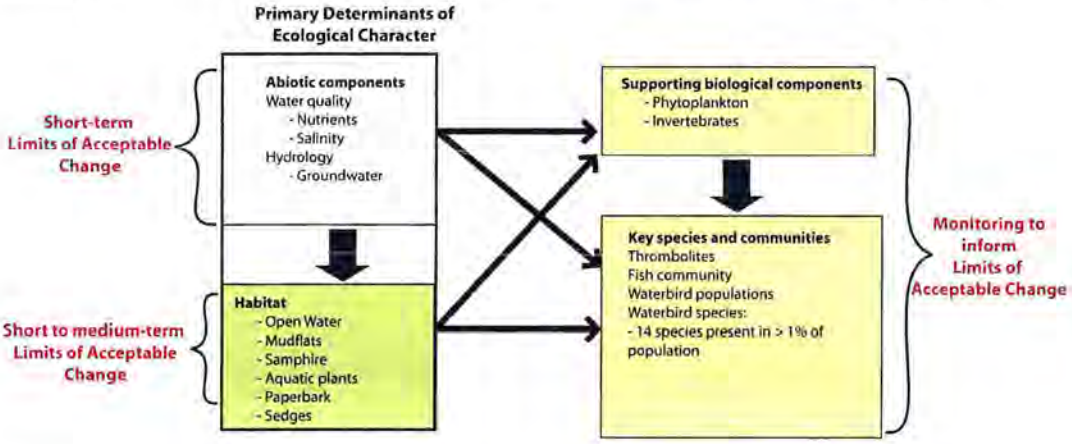

Figure 2: Hierarchical system for setting limits of acceptable change (Hale and Butcher 2008).

The three levels of LAC (and corresponding monitoring) are (adapted from Hale and Butcher 2008):

1. Key abiotic factors in the system (**Abiotic components**)– the easiest to monitor and detect change in the short term. LAC were set as "trigger" values based on a combination of natural variability (from historical data), nationally accepted standards (e.g. ANZECC water quality guidelines) and known tolerances for specific species. The ECD recommended that these be the most intensively monitored aspects of the system and include water quality and hydrological measures.
2. Primary response to the abiotic components and processes (**habitats and supporting biological components**)– primary production (phytoplankton) and key plant communities. LAC were set based on existing conditions (with respect to extent and community type) and habitat requirements of key faunal species and communities. It was suggested that monitoring of these components and processes aim to detect change over medium time scales.
3. Key Faunal components (**key species and communities**)– the most difficult to set LAC for and monitor against. The ECD suggested a strategic approach to monitoring of fauna in the Peel-Yalgorup Ramsar site, with the selection of a small number of programs targeted at the aspects of the system that are linked to the criteria for which the system was listed as a wetland of international importance.

Methods

Monitoring Program Design

The Ramsar Wise Use Handbook (11, 2007) provides a framework for designing and implementing a wetland monitoring program (Figure 3). Although this framework is not a prescriptive methodology, it provides guidance on what should be considered in program design. Elements of this framework have been adopted and adapted in the development of the monitoring and evaluation guide for the Peel-Yalgorup Ramsar site (Table 2).

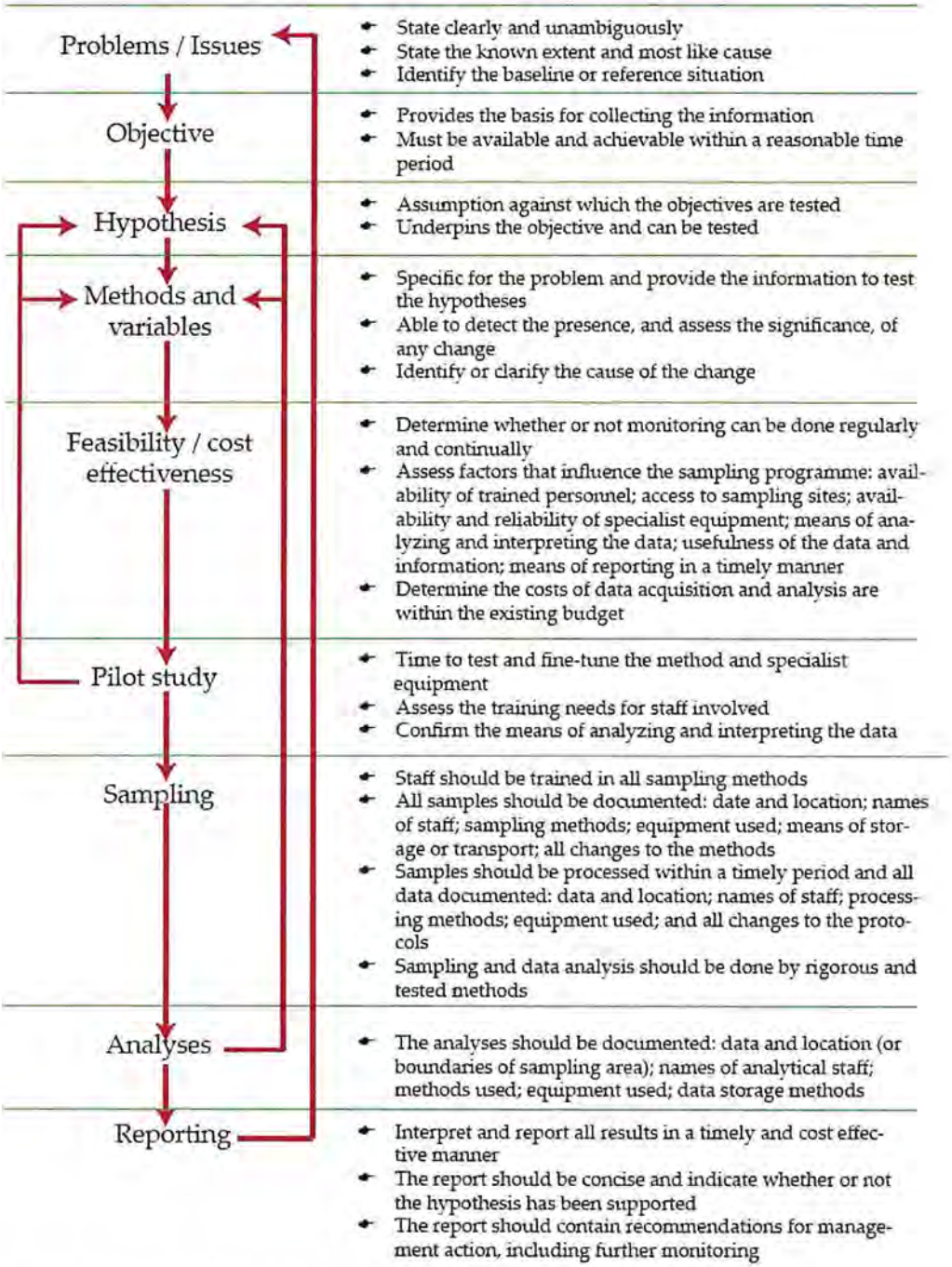

Figure 3: Framework for designing a wetland monitoring programme (Ramsar Wise Use Handbook 11, 2007).

This monitoring and evaluation guide has been developed with consideration of the monitoring recommendations contained within the ECD as well as current and historical monitoring programs. It should be noted, however, that although every effort has been made to consider existing programs, as with much natural resource monitoring in Australia, there is no integrated monitoring program for the Peel-Yalgorup site and many programs are run in isolation with little dissemination of findings. As such, it is likely that there are additional programs in existence that are not recognised in this monitoring and evaluation guide. However, the format of the monitoring guide provided here is such that additional existing programs should be able to be easily retrofitted. The monitoring guide design and links to the Ramsar framework are provided in Table 2.

Table 2: Elements of this monitoring and evaluation guide

Elements of the Monitoring Guide	Description / Considerations	Corresponding Ramsar Framework Element
Rationale	Describes the need for the monitoring program Links to relevant LAC	Problems / Issues
Objectives	The broad objectives of the monitoring program Specific, measureable and testable hypotheses where relevant	Objectives and Hypothesis
Current and Historical Programs	Any existing, relevant programs Provides information on potential responsibilities Informs monitoring design by ensuring that future data is collected in a manner to allow comparisons over time with existing and historical data	No direct link but incorporates some aspects of "Pilot Study"
Monitoring Method	Where possible based on standard, recognised and accepted methods Considers linkages to other programs at the regional, state and national levels Incorporates: Location and frequency of sampling Measurement parameters Method of collection and analysis Data analysis and interpretation Quality Control and Quality Assurance	Methods and variables, Sampling and Analysis
Reporting Information	How often data should be collated and reported Data storage Dissemination Links to management	Reporting
Links to other programs	Other monitoring programs within this monitoring and evaluation guide that are related and may warrant integrated analysis and reporting	
Responsibility	Agencies responsible for the implementation Data custodians	Reporting
Cost	Estimated costs (based on person days and approximations of laboratory costs)	Cost and feasibility
Priority	Priority for implementation (high, medium and low) based on the recommendations of the ECD	

Monitoring programs

This monitoring and evaluation guide is meant as a useable and practical document and as such has been limited to the monitoring recommendations within the ECD that were afforded a medium or high priority. A full and detailed methodology for the monitoring of components and processes that were considered of low priority was considered an inefficient use of available time and resources and these are not considered further. A summary of the programs contained in this monitoring and evaluation guide is contained in Table 3.

Table 3: Monitoring programs detailed within this monitoring and evaluation guide

Monitoring Program	Component / Process	Location	Priority (as cited in ECD)
Water Quality A: Peel-Harvey	Water Quality (nutrients, salinity, dissolved oxygen, pH, Chlorophyll a, turbidity)	Peel Inlet, Harvey Estuary, Goegrup Lake	High
Water Quality B: Yalgorup Lakes	Water Quality (nutrients, salinity, dissolved oxygen, pH, Chlorophyll a, turbidity)	Lakes Preston and Clifton	High
Water Quality C: Lakes McLarty and Mealup	Water Quality (nutrients, salinity, dissolved oxygen, pH, Chlorophyll a, turbidity)	Lakes Mealup and McLarty	High – Lake Mealup Low / Moderate Lake McLarty
Hydrology	Water regime (depth and extent of inundation, depth to groundwater)	Yalgorup Lakes, Lakes McLarty and Mealup	High
Phytoplankton	Identification and enumeration	Peel Inlet, Harvey Estuary, Goegrup Lake	Medium
Aquatic Plants	Composition and distribution of benthic plants	Peel Inlet, Harvey Estuary, Lake Preston	High – Peel-Harvey Medium – Lake Preston
Littoral Vegetation	Extent and condition of saltmarsh and paperbark communities	Peel Inlet, Harvey Estuary, Goegrup and Black Lakes, Lakes McLarty and Mealup	High
Fish	Composition and abundance	Peel-Harvey Estuary	Medium
Waterbirds A	Red-necked Stint counts	All wetlands in the Peel-Yalgorup System	High
Waterbirds B	Cormorant Breeding	Carrabungup Swamp	High
Waterbirds C	Hooded Plover breeding	Yalgorup Lakes	High
Waterbirds D	Collation and storage of existing and future data	All wetlands in the Peel-Yalgorup System	High

The majority of these monitoring programs represent simply more detailed guidance on recommended monitoring contained in the ECD document. However, the proposed program for waterbirds represents a strategic approach developed specifically for this monitoring and evaluation guide. Monitoring of waterbirds to produce statistically defensible results is inherently difficult. There is a large natural variability in waterbird numbers at any wetland at any given time, and they can move between wetlands, using a range of different areas to meet different needs (feeding, breeding and roosting). This coupled with the size of the Peel-Yalgorup Ramsar site means that it is unlikely that a sufficient program could be undertaken to monitor all waterbirds with the available resources. As such, a targeted, strategic approach is proposed that considers three aspects of waterbird usage of The Peel-Yalgorup system that are linked to the reasons for it being listed as a wetland of international importance. These are:

1. Monitoring of Red-necked Stint numbers – this is an easily identifiable bird and one for which the site regularly supports > 1 % of the flyway population. Annual, coordinated counts of this species will inform on changes in Red-necked Stint numbers and act as a surrogate for other wading species.

2. Monitoring of the Cormorant breeding colony at Carrabungup Swamp - this indicator informs about:

- a key ecosystem service of the Ramsar site (waterbird breeding within the boundaries),
- (indirectly) the condition of Melaleuca wetlands in the site, and
- (loosely) about availability of fish food resources in the estuary.

3. Monitoring of Hooded Plover at the Yalgorup Lakes – this indicator informs about a key ecosystem service of the Ramsar site (support to at least 1% of the size of a population) and addresses an 'iconic' species that should be reasonably straightforward to count comprehensively.

In addition, there is a large amount of data collected on waterbirds within the Peel-Yalgorup Ramsar site, by a number of government agencies, NGOs and community groups. The information collected represents a significant resource, but data is not stored or analysed in a systematic manner. A fourth program that coordinates the collation of this data is proposed.

Linking monitoring to management

By definition, monitoring programs are designed to inform management. In the case of Ramsar sites, monitoring programs are designed to inform management to maintain the ecological character of the site. As described above, the monitoring program for the Peel-Yalgorup Ramsar site has been designed to assess components and processes within the site against LAC.

LAC for the majority of components (particularly those that are abiotic or habitat based) have been designed for use as "trigger values". This means that exceedence does not necessarily indicate a change in ecological character, but rather the exceedence should trigger further investigative and possibly management actions. The proposed process for trigger value exceedence is provided in Figure 4 and described below.

The initial steps in the process are designed to ensure that the data indicating a potential exceedence of an LAC are accurate. Therefore, a verification of quality control and quality assurance data from both the laboratory and the field is required. If the results indicating an exceedence of the LAC are found to be inaccurate or not within acceptable quality standards, then monitoring should continue. However, if the results are a true reflection of the status of components and process within the Ramsar site, further action is required.

If LAC have been exceeded, it is important to next assess the ecological significance of this exceedence. This will involve expert opinion and analysis of the data and other supporting information to determine if the monitoring results indicate a risk or increased threat to the ecological character of the system. Typical analysis may include:

- The magnitude of the exceedence (e.g. if the LAC is a pH > 7 and a pH of 7.1 is recorded, this may not be considered a significant threat to the ecological of the system);
- The spatial or temporal extent of the exceedence (e.g. if the monitoring result limited to an isolated location and a single point in time this may not be considered a significant threat to the ecological character of the system).
- Potential contributing factors, or causes of the exceedence (i.e. supporting information should be analysed to determine potential causes for the monitoring results. This may include unusual weather patterns, extreme events, human activities. A decision will then need to be made as to whether this is likely to be a sustained and significant threat to ecological character or a one-off / rare event).

If expert opinion and analysis determines that the exceedence of LAC was not ecologically significant, this should trigger a review of the LAC to determine if they are appropriate. The LAC in many cases were developed based on limited knowledge. Therefore, as more information and data becomes available, they should be refined to better reflect the natural variability within the system.

Finally, if the exceedence of LAC is found to be ecologically significant, then management actions must be implemented to protect and maintain the ecological character of the system. Actions may range from increased frequency or extent of monitoring to increase understanding of the impact to the system, to on ground actions to address the threatening activities contributing to the impact to ecological character as per objective 3 of the management plan.

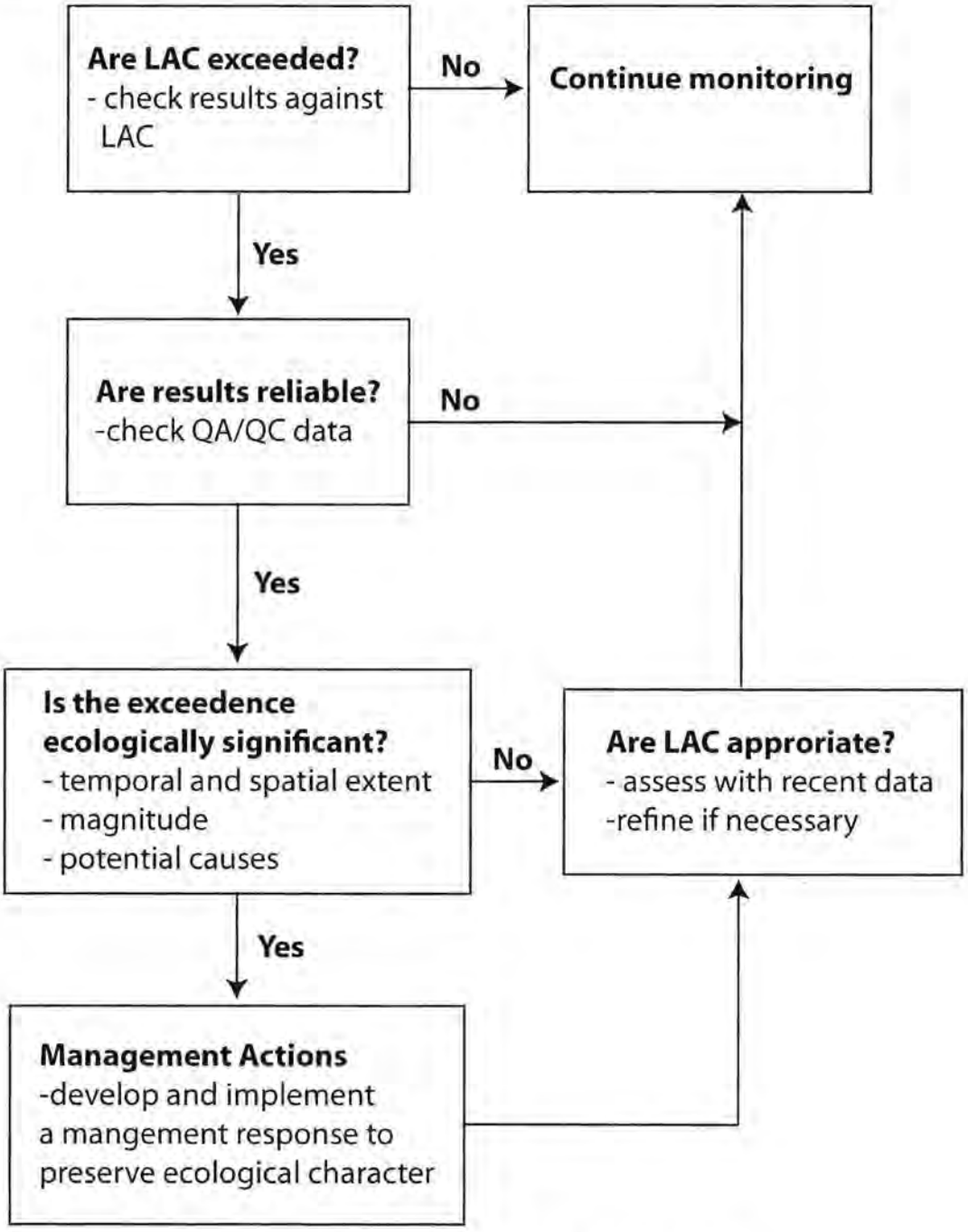

Figure 4: Process for assessing results of monitoring against LAC.

In order to implement the process described above and illustrated in Figure 4, it is recommended that a *Peel-Yalgorup Technical Advisory Panel* be established (note that this, together with the managerial arrangements for the Ramsar site are further described in the

management plan). This panel should comprise scientific experts with knowledge and experience in the Peel-Yalgorup Ramsar Site. At a minimum, the panel should include experts in the fields of: waterbird ecology, estuarine fish, saltmarsh and paperbark vegetation communities, seagrass and macro-algae, phytoplankton, thrombolites, water quality and hydrology. The panel should meet at least once a year to discuss the results of the previous years monitoring, determine if there have been changes to components and processes that represent a significant threat to the ecological character of the site and to recommend future monitoring and management actions.

Data storage and reporting

There have been a large number of disconnected monitoring and research programs conducted within the Peel-Yalgorup Ramsar site. However, with the exception of water quality, little of this data has been collated and stored in a manner that makes it accessible to the managers of the system. Therefore, as a part of the monitoring program for the Peel-Yalgorup Ramsar site, it is recommended that all information collected be stored in an accessible database. The Department of Environment and Conservation (DEC) has an existing Statewide Wetlands Database (WetlandBase), which is publicly available at www.calm.wa.gov.au. It is recommended that this Statewide database "Wetlandbase" be adopted as the repository for monitoring data.

The first priority should be to use this database to store information collected under the Peel-Yalgorup monitoring program. However, if additional historical, current and future monitoring conducted at the site could be included in the database, this would increase its value as a management tool.

The management body established for the on-going management of the Ramsar site should be responsible for coordination and ensuring that all data is forwarded to DEC in the appropriate format for storage in the Statewide database. In addition, the monitoring information collected should be reported to the Technical Advisory Panel, relevant stakeholders and the general community on an annual basis. More detail about the format of this reporting is provided under each of the monitoring programs as described below.

Review of Monitoring

Consistent with the principles of adaptive management adopted for the management of the Peel-Yalgorup Ramsar site, the monitoring programs should be reviewed and, if necessary refined based on results and outcomes from implementation. Minor reviews should be conducted annually by the Technical Advisory Group, with refinements or modifications to methods documented in the annual report. Every five years, however, a full and formal review of the program should be undertaken during which entire programs could be removed or added, depending on the outcomes of monitoring. The full review procedures are documented within the management plan and should be equally applied to the monitoring of the site.

Water Quality A: Peel-Harvey

Rationale

Nutrient concentrations and salinity were considered primary determinants of ecological character for the Peel-Yalgorup System. The Peel-Harvey Estuary has suffered the effects of cultural eutrophication for a number of decades and although the nutrient concentrations in the water column have reduced in the estuary since the opening of the Dawesville Channel, there has been no reduction in nutrient loads entering the system from the catchment.

Nutrient loads from agriculture as well as urban and peri urban development were identified as a key threat to the Peel-Yalgorup system and the Peel-Harvey Estuary in particular.

Relevant LAC Component	Baseline / Supporting Evidence	Limit of Acceptable Change
Nutrients	Total phosphorus limits have been set by the Water Quality Improvement Plan (EPA 2007)	< 30 µg/L (maximum)
	Dissolved inorganic nutrients, which are the form available for uptake. Current baseline suggests peaks in winter, but low concentrations during summer and autumn	PO_4, NH_4, NO_x - annual median concentrations < 10 µg/L
Dissolved oxygen	Limits have been set by the Water Quality Improvement Plan (EPA 2007)	70 – 80 % saturation
pH	Although marine systems have a large buffering capacity, disturbance of acid sulphate soils have the potential to lower pH values. Baseline conditions indicate pH typically 7.3 to 8.5	pH > 7 at all times
Salinity	Although the marine influence on the estuary cannot be managed, seasonal salinity fluctuations are important for biota.	Winter salinity in the centre of the Peel Inlet and Harvey Estuary < 30 ppt for a minimum of 3 months.
	Fish such as the long-headed river goby require salinities of < 30 ppt to trigger spawning.	Water in the Harvey River mouth over winter < 3 ppt
	Some waterbirds require fresh drinking water (< 3 ppt)	
Chlorophyll *a*	Phytoplankton biomass is typically low in the estuary although occasional blooms occur, but persist for only a matter of weeks	Chlorophyll a – annual median concentrations < 10 µg/L

Objectives / Hypothesis

The objective of the water quality program A: Peel-Harvey is:

- To monitor water quality within the Peel Harvey Estuary and Goegrup Lake on a minimum of 12 occasions per calendar year to measure against limits of acceptable change.

Specific hypotheses are:

- Total phosphorus concentrations will not exceed 30 µg/L at any site in the Peel Harvey Estuary during any monitoring event.
- Annual median concentrations of PO_4, NH_4, NO_x and chlorophyll *a* will be < 10 µg/L at all six water quality monitoring sites within the Peel-Harvey Estuary.
- Dissolved oxygen concentrations will not be less than 70 – 80% saturation at any site in the Peel Harvey Estuary during any monitoring event.

- pH will not be less than 7 at any site in the Peel Harvey Estuary during any monitoring event.
- Salinity at sites 2 and 58 in the Peel-Harvey Estuary will be < 30ppt for a minimum of three consecutive months between May and November.
- Salinity at site 31 in the Harvey Estuary will not exceed 3 ppt for a minimum of three consecutive months between May and November.
- There will be no significant difference ($p < 0.05$) in measured water quality variables (total phosphorus, orthophosphate, ammonium, nitrate-nitrite, salinity, pH and surface and bottom water dissolved oxygen) between current year monitored and historical (post Dawesville Channel) data.

Current and historical programs

Water quality in the Peel-Harvey Estuary has been monitored since August 1977 at three sites in the Peel Inlet and three in the Harvey Estuary (Kobryn et al. 2002). Frequency has varied between weekly and monthly, however current sampling occurs approximately 8 times per year. Parameters include: pH, dissolved oxygen, salinity, secchi depth, temperature, salinity, total nitrogen, total phosphorus, nitrate-nitrite, ammonium, phosphate, silicate and chlorophyll *a* from surface and bottom waters.

Currently water quality under the Water Quality Improvement Plan (WQIP) is also assessed at sites within the Serpentine, Murray and Harvey Rivers, which includes a site within in Lake Goegrup (DoW 2007).

Monitoring method

Given the extent of historical data sets for water quality in the Peel-Harvey Estuary there are benefits for detecting trends over time in aligning future monitoring with that collected historically. As such, the following program is based on historical monitoring described in Wilson et al. (1999) and that detailed in the WQIP.

Location

Three sites in the Peel Inlet and three sites in the Harvey Estuary (Figure 5). In addition the site in Lake Goegrup should also be maintained.

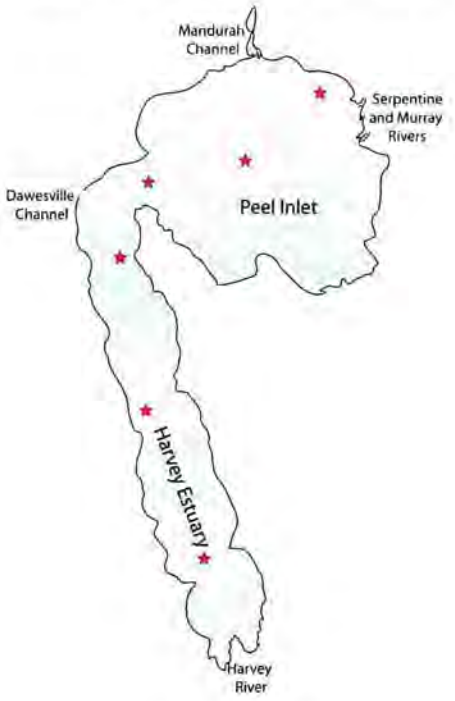

Figure 5: Water Quality monitoring sites for the Peel-Harvey Estuary (Wilson et al. 1999).

Frequency
Results of a power analysis (alpha = 0.05; beta = 0.8) on water quality data collected in 2006 (DoW 2007) indicated that between 9 and 12 samples were required to adequately test against LAC. Therefore a minimum of 12 samples is required per year, which should be collected monthly. However if nutrient concentrations begin to trend upwards, a more intensive sampling regime will be required.

Parameters and methods
Field collection

- Collection and analysis of water quality samples should be undertaken in accordance with relevant Australian Standards (Australian Guidelines for Water Quality Monitoring (AZECC 2000a); Reporting and the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 200b); and Standard Methods for the Examination of Water and Wastewater (APHA 1999)).
- *In-situ* profiles of pH, salinity and dissolved oxygen
- Samples collected for total nitrogen, total phosphorus, orthophosphate, nitrate-nitrite, ammonium and chlorophyll *a* from surface and bottom waters using a grab sampler (Niskin grab or similar). Dissolved nutrient samples filtered through a 0.45µm cellulose acetate membrane filter in the field. Samples stored on ice prior to transport to the laboratory.

Laboratory analysis

- Analysis of all samples should be undertaken by a NATA accredited laboratory according to accredited methods.

Data analysis and interpretation
Results collected for water quality parameters should be assessed against LAC annually.

Trend analysis using appropriate multi-variate statistical analysis to determine if results from current sampling year are significantly different to those collected in previous years. This can be simply achieved using tests of differences in means / medians using ANOVA or Kruskall-Wallace tests. However, in the future consideration could be given to developing and implementing control charting techniques (e.g. Exponentially Weighted Moving Averages – EWMA to detect changes in water quality over time; see Environmetrics 2007 for example).

Quality Assurance and Quality Control
Quality Assurance and Quality Control procedures contained in the Australian Guidelines for Water Quality Monitoring; Reporting and relevant NATA accreditation documents should be adhered to. This includes:

Field sampling

- Quality Assurance and Quality Control procedures contained in the Australian Guidelines for Water Quality Monitoring, including:
    - Duplicate samples (1 in 10 samples)
    - Field blanks (1 in 10 samples)
    - Calibration of field instruments (prior to each sampling event)

Laboratory
In accordance with NATA accreditation documents

- Calibration
- Standards
- Duplicates (copies provided with results)

Reporting information

Water quality data should be stored in the WIN Database (with appropriate links placed in Wetlandbase). A database for water quality in the Peel-Harvey Estuary exists for water quality monitoring conducted between 1977 and 2001. Priority should be given to updating this database with results collected since this time.

Exceedences of LAC should trigger the management process illustrated in Figure 4 above and relevant technical experts on the *Peel-Yalgorup Technical Advisory Panel* consulted where necessary.

An annual report describing the results of the monitoring program, against LAC and describing trends should be produced and made available to stakeholders and the wider community.

Links to other programs

The outputs of this program would also be of use in interpretation of following programs:

- Phytoplankton
- Benthic Plants

Roles and Responsibility

- Department of Water is currently responsible for undertaking the monitoring of water quality in the Peel-Harvey Estuary and the input of data into the WIN database.
- Department of Environment and Conservation is responsible for maintaining the Wetlandbase database.
- The body established to administer the management plan for the Peel-Yalgorup Ramsar site should be responsible for annual reporting and informing the Technical Advisory Panel

Estimated costs

Field collection:

- 1 person for 0.5 days calibration and field preparation (12 times per year)
- 2 persons for 1 day sampling (12 times per year)
- Vehicle and boat

Laboratory analysis

- Approximately $70 - $100 per suite of parameters = $15000 - $18000 per year

Interpretation and reporting:

- Approximately 10 person days per year

Priority

High

Water Quality B: Yalgorup Lakes

Rationale

Nutrient concentrations and salinity were considered primary determinants of ecological character for the Peel-Yalgorup System. The Yalgorup Lakes contain the thrombolites and there have been recent concerns over rising salinity and nutrient concentrations.

Relevant LAC Component	Baseline / Supporting Evidence	Limit of Acceptable Change
Nutrients	Dissolved inorganic nutrients are those that are available for plant uptake and therefore the most indicative of tropic status. Lane and Davies (1993) collected some information from Lake Clifton and this forms the baseline for this limit. It is likely that the limit will need to be refined as more data is collected.	PO_4, NH_4, NO_x - median concentrations < 10 µg/L
Salinity	Although many of the lakes are hypersaline, the thrombolite communities are reliant on freshwater.	Lake Clifton salinity < 35 ppt maximum and < 25 ppt during winter and spring
pH	Yalgorup Lakes are within a landscape considered at high risk from acid sulphate soils. Thrombolites rely on alkaline conditions for growth. Natural pH is between 7.2 and 8.5	pH > 7 at all times
Chlorophyll *a*	Data deficient	Baseline must be set before limits can be made.

Objectives / Hypothesis

The objectives of the water quality program B: Yalgorup Lakes are:

- To conduct a pilot study to determine variability in water quality (temporally and spatially) in Lakes Clifton and Preston to inform the design of on-going monitoring.
- To monitor water quality within Lakes Clifton and Preston on a minimum of 12 occasions per calendar year to measure against limits of acceptable change.
- To monitor groundwater quality prior to discharge into lakes to inform on potential sources of salts and nutrients.
- To monitor chlorophyll a concentrations to inform the development of quantitative LAC.

Specific hypotheses are:

- Annual median concentrations of PO_4, NH_4, and NO_x will be < 10 µg/L at all water quality monitoring sites within Lakes Preston and Clifton.
- Salinity in Lake Clifton will not exceed 35ppt on any monitoring occasion.
- Salinity in Lake Clifton will be < 25 ppt for a minimum of 5 consecutive months between May and December annually.
- pH will not be less than 7 at any site in Lakes Clifton and Preston during any monitoring event.
- Water quality within lakes Clifton and Preston is positively correlated with groundwater quality from inflowing aquifers.

Current and historical programs

Although there have been several research projects (e.g. Bourke and Knott 1989, Moore 1987, Shams, 1999) there has been no systematic monitoring of water quality at the Yalgorup Lakes. The Department of Water has a number of monitoring bores adjacent to the Yalgorup

Lakes and these have been monitored irregularly for parameters such as salinity, temperature and occasionally nutrients.

The Department of Environment and Conservation is planning to instigate monitoring at Lake Clifton under the Thrombolite Recovery Program. This will include the instalment of three loggers that will monitor surface water, groundwater and rainfall, levels and salinity on a continuous basis close to the Lake Clifton Boardwalk (Forbes and Vogwill 2008).

Monitoring method

With a lack of regular historical monitoring, there are no existing sites (with regular sampling extending for more than a year or so) to inform the monitoring program. As such a 12 month pilot study is proposed (and detailed below). The results of this pilot study can then be used to inform the on-going monitoring program with respect to site number and sampling frequency.

In recognition that there are limited funds and resources for monitoring in the Peel-Yalgorup Ramsar site, an alternative cheaper (but less scientifically defensible) method is also suggested. This uses the water quality monitoring sites of Moore (1987) in Lake Clifton and Preston as well as a small number of groundwater bores (from Shams 1999 and / or current DoW monitoring).

The two programs are provided under each section marked "Pilot" and "Alternative".

Location

Pilot:

Access to the lakes is likely to be problematic (especially given the annual changes in water level). As such, exact locations of sites will need to be determined following a site inspection. As a guide a minimum of five sites on a north south transect across each of lakes Preston and Clifton should be included in the pilot study. In addition, groundwater quality should be monitored at a minimum of six bores to the east of the lakes. These should be the same as those used in the Hydrology program and based on those samples by Shams (1999) and / or current DoW monitoring (Figure 6).

Alternative:

Sampling at two sites in each of Lake Clifton and Preston as described in Moore (1987) Figure 6. In addition, groundwater monitoring at a single bore location on the eastern shore of each lake (DoW Bore numbers 61319132 and 61319146).

Frequency

Pilot:

Fortnightly samples collected (this may decrease for the full program following the results of the pilot). Consideration should also be given to deploying continuous loggers for salinity within Lake Clifton for at least one year to determine variation and inform ongoing monitoring frequency.

Alternative:

Twelve samples annually collected monthly.

Parameters and methods

Field collection

- Collection and analysis of water quality samples should be undertaken in accordance with relevant Australian Standards (Australian Guidelines for Water Quality Monitoring (AZECC 2000a); Reporting and the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 200b); and Standard Methods for the Examination of Water and Wastewater (APHA 1999)).
- *In-situ* measurement of pH and salinity
- Samples collected for total nitrogen, total phosphorus, orthophosphate, nitrate-nitrite ammonium and chlorophyll *a* from mid water column using a grab sampler.

Dissolved nutrient samples filtered through a 0.45µm cellulose acetate membrane filter in the field. Samples stored on ice prior to transport to the laboratory.

Laboratory analysis

- Analysis of all samples should be undertaken by a NATA accredited laboratory according to accredited methods.

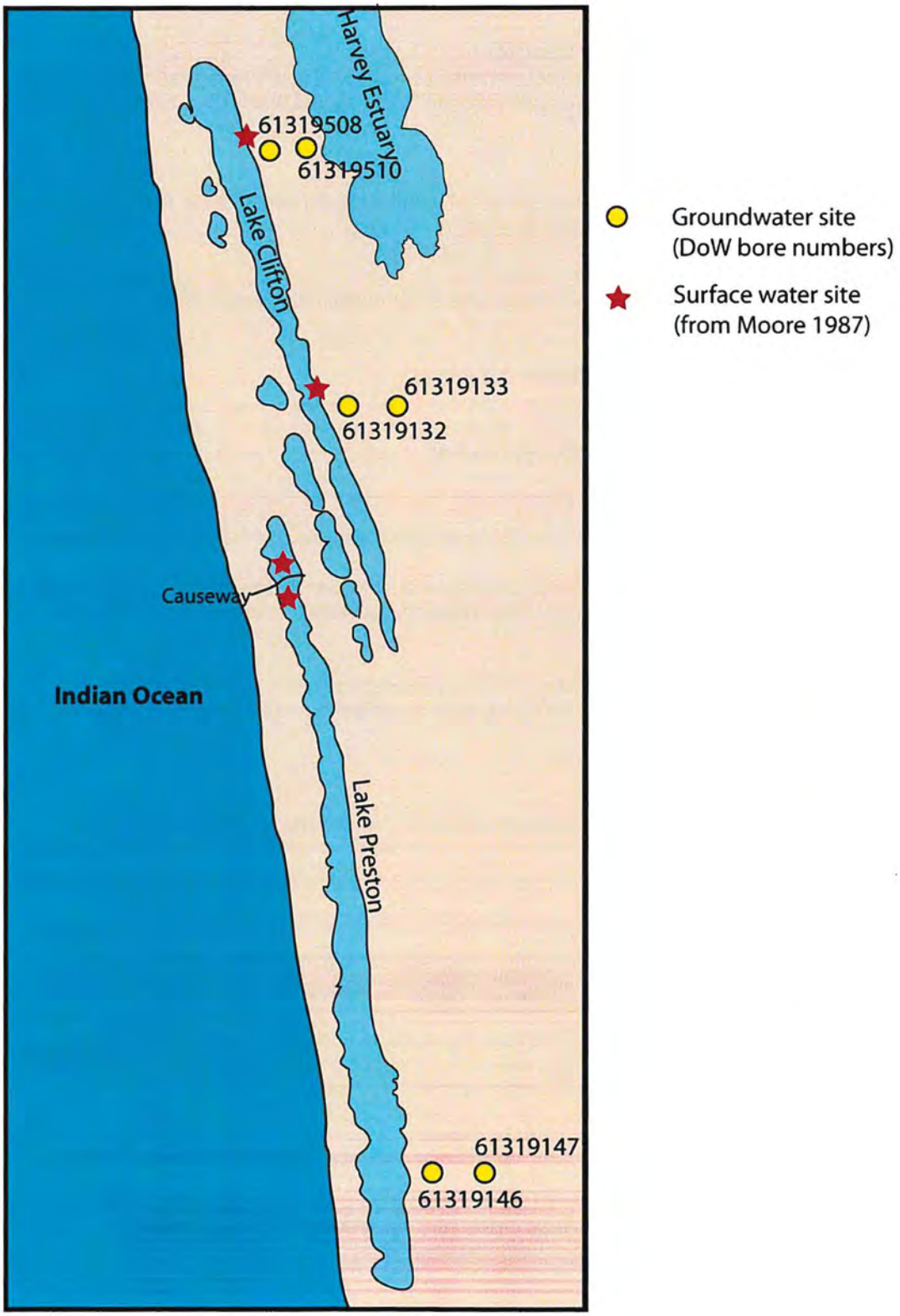

Figure 6: Water quality sampling sites at the Yalgorup Lakes.

Data analysis and interpretation
Results from the pilot study should be assessed through an appropriate statistical analysis (e.g. power analysis) to determine sampling frequency and site locations for on going monitoring. In addition, results collected for water quality parameters should be assessed against LAC for each site.

Quality Assurance and Quality Control
Quality Assurance and Quality Control procedures contained in the Australian Guidelines for Water Quality Monitoring; Reporting and relevant NATA accreditation documents should be adhered to. This includes:

Field sampling
- Quality Assurance and Quality Control procedures contained in the Australian Guidelines for Water Quality Monitoring, including:
    - Duplicate samples (1 in 10 samples)
    - Field blanks (1 in 10 samples)
    - Calibration of field instruments (prior to each sampling event)

Laboratory
In accordance with NATA accreditation documents
- Calibration
- Standards
- Duplicates (copies provided with results)

Reporting information

Water quality data should be stored in the DoW WIN database and the DEC Wetlandbase.

Exceedences of LAC should trigger the management process illustrated in Figure 4 above and relevant technical experts on the *Peel-Yalgorup Technical Advisory Panel* consulted where necessary.

An annual report describing the results of the monitoring program, against LAC and describing trends should be produced and made available to stakeholders and the wider community.

Links to other programs

The outputs of this program would also be of use in interpretation of following programs:
- Hydrology
- Phytoplankton

Roles and Responsibility

- Department of Water is currently responsible for maintaining the WIN database.
- Department of Environment and Conservation is responsible for maintaining the Wetlandbase database.
- The body established to administer the management plan for the Peel-Yalgorup Ramsar site should be responsible for coordination of monitoring as well as annual reporting and informing the Technical Advisory Panel.

Estimated costs

Pilot:
Field collection:
- 1 person for 0.5 days calibration and field preparation (26 times per year)
- 2 persons for 1 day sampling (26 times per year)
- Vehicle

Laboratory analysis

- Approximately $70 - $100 per suite of parameters = $29000 - $40000 per year

Interpretation and reporting:

- Approximately 10 person days

Alternative:
Field collection:

- 1 person for 0.5 days calibration and field preparation (12 times per year)
- 2 persons for 1 day sampling (12 times per year)
- Vehicle (?)

Laboratory analysis

- Approximately $70 - $100 per suite of parameters = $3500 - $4800 per year

Interpretation and reporting:

- Approximately 50 person days per annum

Priority

High

Water Quality C: Lakes Mealup and McLarty

Rationale

Nutrient concentrations and salinity were considered primary determinants of ecological character for the Peel-Yalgorup System. There are concerns over increasing salinity and nutrient concentrations at Lakes McLarty and Mealup and decreasing pH in Lake Mealup.

Relevant LAC Component	Baseline / Supporting Evidence	Limit of Acceptable Change
Nutrients	Dissolved inorganic nutrients are those that are available for plant uptake and therefore the most indicative of tropic status. However this is data deficient at Lakes McLarty and Mealup and likely to be highly seasonal as water levels fluctuate. As a consequence, trigger values for south-west Australian wetlands have been adopted (ANZECC 2000)	PO_4 < 30 µg/L NH_4, < 40 µg/L NO_x < 100 µg/L All to be applied only when water levels are > 500mm
Salinity	These represent the only freshwater systems within the Peel Yalgorup site. However, salinity will fluctuate as water levels rise and fall. Salinity should be based on the tolerances of the water dependant species and as such should be measured at times when these communities are inundated.	Salinity under rush and sedge communities < 1 ppt Salinity under paperbark communities < 0.5 ppt
pH	McLarty and Mealup are within a landscape considered at high risk from acid sulphate soils. Natural pH is between 7.2 and 8.5 for McLarty, but has declined to between 3.1 and 4 for Lake Mealup. As such a limit for Lake Mealup has not been set, but will need to be based on further investigative work.	pH > 7 at all times in Lake McLarty
Chlorophyll *a*	Data deficient	Baseline must be set before limits can be made.

Objectives / Hypothesis

The objective of the water quality program C: Lakes McLarty and Mealup is:

- To monitor water quality within Lakes MacLarty and Mealup to measure against limits of acceptable change.
- To monitor chlorophyll a concentrations at Lakes McLarty and Mealup to inform the development of quantitative LAC.

Specific hypotheses are:

- Concentrations of PO_4, will be < 30 µg/L within Lakes McLarty and Mealup whenever maximum water depth is > 500mm.
- Concentrations of NH_4 will be < 40 µg/L within Lakes McLarty and Mealup whenever maximum water depth is > 500mm.

- Concentrations of NO_x will be < 100 µg/L within Lakes McLarty and Mealup whenever maximum water depth is > 500mm.
- Salinity under sedge communities at Lakes McLarty and Mealup will not exceed 1ppt during any monitoring event.
- Salinity under paperbark communities at Lakes McLarty and Mealup will not exceed 0.5 ppt during any monitoring event.

Current and historical programs

There is little existing data on the water quality at Lake McLarty. However, there is community collected water quality monitoring undertaken at a central site in Lake Mealup (Lake Mealup Preservation society unpublished data).

Monitoring method

The variable lake levels at these seasonal wetlands have a significant impact on monitoring and interpreting results. Under natural cycles of wetting and drying concentration effects can result in high levels of nutrients and salt. This can be difficult to distinguish from human induced impacts resulting in increased salinity and eutrophication. As such, the LAC for these wetlands apply only to times when the wetland is inundated to a depth of > 500mm.

Location

As these waterbodies are relatively small, sampling in the past has been at a single central location (Lake Mealup). However, the variability in water quality across these wetlands is not know, and as such it is suggested that when water levels are sufficient to inundate emergent vegetation (rushes and sedges) and paperbark communities that additional sampling locations are included to measure water quality within these vegetation communities.

Therefore the following locations are suggested:

- Centre wetland (Lake McLarty and Mealup) – when water levels are > 500mm (maximum depth)
- Two sites within emergent reed communities in each wetland (when inundated > 200mm)
- Two sites within paperbark communities in each wetland (when inundated > 200mm)

Frequency

Sampling frequency is likely to be irregular due to the wetting and drying cycles of these wetlands and water quality samples should be taken opportunistically when vegetation communities are inundated. Centre wetland sites should be sampled a minimum of monthly whenever water levels are > 500mm.

Parameters and methods

Field collection

- Collection and analysis of water quality samples should be undertaken in accordance with relevant Australian Standards (Australian Guidelines for Water Quality Monitoring (AZECC 2000a); Reporting and the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 200b); and Standard Methods for the Examination of Water and Wastewater (APHA 1999)).
- *In-situ* profiles of pH and salinity
- Samples collected for total nitrogen, total phosphorus, orthophosphate, nitrate-nitrite, ammonium and chlorophyll *a* from mid water column using a grab sampler. Dissolved nutrient samples filtered through a 0.45µm cellulose acetate membrane filter in the field. Samples stored on ice prior to transport to the laboratory.

Laboratory analysis

- Analysis of all samples should be undertaken by a NATA accredited laboratory according to accredited methods.

Data analysis and interpretation

Results collected for water quality parameters should be assessed against LAC for each site.

Quality Assurance and Quality Control
Quality Assurance and Quality Control procedures contained in the Australian Guidelines for Water Quality Monitoring; Reporting and relevant NATA accreditation documents should be adhered to. This includes:

Field sampling

- Quality Assurance and Quality Control procedures contained in the Australian Guidelines for Water Quality Monitoring, including:
    - Duplicate samples (1 in 10 samples or a minimum of one per sampling event)
    - Field blanks (1 in 10 samples or a minimum of one per sampling event)
    - Calibration of field instruments (prior to each sampling event)

Laboratory
In accordance with NATA accreditation documents

- Calibration
- Standards
- Duplicates (copies provided with results)

Reporting information

Water quality data should be stored in Wetlandbase.

Exceedences of LAC should trigger the management process illustrated in Figure 4 above and relevant technical experts on the *Peel-Yalgorup Technical Advisory Panel* consulted where necessary.

An annual report describing the results of the monitoring program, against LAC and describing trends should be produced and made available to stakeholders and the wider community.

Links to other programs

The outputs of this program would also be of use in interpretation of following programs:

- Hydrology
- Phytoplankton

Roles and Responsibility

- Department of Environment and Conservation is responsible for maintaining the Wetlandbase database.
- The Lake Mealup Preservation Society currently undertakes water quality monitoring on a volunteer basis. This should be supported both in terms of advise and financially.
- The body established to administer the management plan for the Peel-Yalgorup Ramsar site should be responsible coordination of monitoring as well as for annual reporting and informing the Technical Advisory Panel

Estimated costs

Field collection:

- 1 person for 0.5 days calibration and field preparation (8 - 12 times per year)
- 2 persons for 1 day sampling (8 - 12 times per year)

Laboratory analysis

- Approximately $70 - $100 per suite of parameters = $2500 - $3000 per year

Interpretation and reporting:

- Approximately 5 person days per year

Priority

High – Lake Mealup, Moderate to Low – Lake McLarty

Hydrology

Rationale

Hydrology is considered one of the primary determinants of ecological character for the Peel-Yalgorup System, particularly for those systems that are groundwater dependant. There are concerns over increasing groundwater extraction and the potential effects of this on lake hydrology, salinity and nutrient concentrations. There was insufficient available information to determine limits of acceptable change for hydrology in the Yalgorup Lakes and Lakes McLarty and Mealup for the ECD.

Objectives / Hypothesis

The objective of the hydrology program is:

- To monitor groundwater and surface water levels (mAHD) within Lakes Clifton, Preston, MacLarty and Mealup to provide baseline information to set limits of acceptable change.

Current and historical programs

There have been isolated research investigations (e.g. Moore 1987, Shams 1999) that have monitored ground and or surface water for short periods (approximately 1 year). However, there has been no consistent monitoring of surface water in the Yalgorup Lakes and Lakes McLarty and Melaup. The Department of Water is responsible for the monitoring of a number of groundwater bores in eth vicinity f the Yalgorup Lakes and Lakes McLarty and Mealup. Some of these have data for depth to groundwater collected at various intervals (annually, quarterly and irregular intervals) over the period 1979 to current. In addition, there has been some water quality monitoring at these locations including salinity and nutrient concentrations, although frequency of sampling and the period of sampling is highly variable (data provided by DoW from the WIN database).

Monitoring method

In order to record surface water levels the most effective mechanism would be to put stage height gauges within each lake. In addition, depth to groundwater can be measured at existing bore locations that have been previously (or are currently) monitored by DoW. The most effective means would be to augment existing monitoring by ensuring regular sample collection at a small number of bores. This would require negotiation with DoW.

Location

Surface hydrology (as water depth) should be monitored at a single location within each of the following wetlands:

- Lake Clifton
- Lake Preston (possibly need two – one ether side of the causeway)
- Lake McLarty
- Lake Mealup

Ground water should be monitored at a number of bores throughput the flowpath of the groundwater sources of the nominated lakes. At Lake Clifton and Preston these should correspond with bores that are to be monitored for groundwater quality (see Water Quality B above and Figure 6). At Lakes McLarty and Mealup there are a number of existing bores, some of which are monitored for groundwater level by DoW (Figure 7) and these should be considered for inclusion in this program.

Figure 7: Map of existing bore locations adjacent to Lakes McLarty and Mealup (from DoW)

Frequency
Surface and groundwater levels should be recorded a minimum of 12 times per year, collected monthly.

Parameters and methods
Consistent with the National Indicators under the National Land and Water Resources Audit, the groundwater level should be measured in metres, read to the nearest centimetre (0.01m) and recorded in metres below (+ve) or above (-ve) a reference point. The level of accuracy required or allowable error in measuring the water level is plus or minus 5 cm (0.05m).

Surface hydrology should be read off installed water level gauges and recorded to the nearest 0.01m in metres AHD.

Data analysis and interpretation
Hydrographs should be developed for each of the monitoring locations and used to assess trends over time. Consideration should be given to climatic conditions (rainfall, evaporation, etc) in interpretation of trends observed. Consistent with the National Land and Water Resources Audit, Indicator program (http://www.nlwra.gov.au), interpretation for each hydrograph should include:

- identification of the baseline trend;
- comparisons with rainfall events and long term trends. and
- prediction of the trend shown in the hydrograph relative to the baseline under different climatic scenarios using simple models such as HAART (Hydrograph Analysis - Rainfall and Time Trend) or Flowtube.

Where possible, results should be assessed against any existing information and a baseline established to set quantitative limits of acceptable change for each of the lakes. Future monitoring can inform against this LAC.

Quality Assurance and Quality Control
Collection of hydrological information should comply with existing national and jurisdictional standards for collection of surface and groundwater hydrological information.

Reporting information

Data collected for trends analysis and development of LAC should be reported annually. Rainfall and climatic data should be used to determine expected surface and groundwater levels and these compared to those actually recorded during the year.

Data collected should be stored in Wetlandbase.

Links to other programs

The outputs of this program would also be of use in interpretation of following programs:

- Water Quality
- Phytoplankton

Roles and Responsibility

- Department of Water is currently responsible for undertaking the monitoring of groundwater and the input of data into the WIN database.
- Department of Environment and Conservation is responsible for maintaining the Wetlandbase database.
- The body established to administer the management plan for the Peel-Yalgorup Ramsar site should be responsible coordination of monitoring as well as for annual reporting and informing the Technical Advisory Panel

Estimated costs

It is anticipated that the field collection for the Hydrology Program could be undertaken in conjunction with the Water Quality Programs B and C. There would therefore be no additional field costs. However, there would be costs associated with establishing water level gauges at the lakes. Additional reporting and analysis costs in the order of 5 - 10 person days per year would be reasonable.

Priority

High

Phytoplankton

Rationale

Phytoplankton are primary producers and can respond rapidly to changes in water quality (nutrients, salinity, turbidity). Prior to the opening of the Dawesville Channel, high levels of nutrients resulted in regular phytoplankton blooms in the Peel-Harvey Estuary. In many cases these were of toxic taxa such as Nodularia. In addition the cyanobacteria Lyngbya has been recorded in bloom proportions in Goegrup Lake with concerns for ecosystem health.

The LAC for phytoplankton are centred on biomass (chlorophyll a) and these are addressed under water quality monitoring program A: Peel-Harvey Estuary.

Benthic Plants

Rationale

Seagrass and macroalgae form a significant ecological component of the Peel-Harvey Estuary. Prior to the opening of the Dawesville Channel, excess nutrient loads entering the system resulted in increased growth of macroalgae, particularly in the Peel Inlet. This resulted in both ecological and social impacts, with smothering of seagrass, decomposition of large amounts of macroalgae, noxious odours and deoxygenation of the water column. Since the opening of the Dawesville Channel, data is limited, but there are suggestions that seagrass beds are once more establishing. Seagrass beds provide habitat for fish and invertebrates and a food source for a number of fauna species including some waterbirds.

In addition, there have been reports for the Yalgorup Lakes that macroalgal growth within Lake Clifton may be causing a significant threat to the thrombolites.

There was insufficient available information to determine limits of acceptable change for macroalgae and seagrass in the Peel-Harvey Estuary or macroalge in Lake Clifton for the ECD.

Objectives / hypothesis

The objectives of the benthic plant monitoring program are:

- To determine the extent and community composition of macroalgae and seagrass in the Peel Harvey Estuary to inform development of LAC;
- To determine the extent of macroalgal cover of the thrombolites to determine LAC and the potential threat to thrombolites within the lake;
- To pilot test a method for ongoing monitoring.

Current and historical programs

Benthic plant biomass and extent was monitored in the Peel-Harvey Estuary from 1977 until 2001 (Wilson et al. 1999). Prior to the opening of the Dawesville Channel in 1994, monitoring was conducted seasonally (four times per year) after this time; sampling frequency was reduced to twice a year in spring and summer. Quantitative sampling was undertaken at 43 sites across the estuary, by divers, using 9 cm cores. Results were analysed a computer program (SYMAP) which determined density contours for different species (Wilson et al. 1999).

A recent research program conducted by Murdoch University has mapped the benthos of the Peel-Harvey Estuary using remote sensing techniques. However the results only indicate the extent of plant growth, bare sand and rocky substrate and do not provide information on community composition (F. Valesini, pers. comm.).

There has been no routine monitoring of macroalgae at Lake Clifton.

Monitoring method

There have been significant advances in benthic habitat mapping methods since the program was developed for the Peel-Harvey Estuary in 1977. However, many of the remote sensing methods are still in the development phase and may not be applicable in all situations (Holmes et al. 2006). It is therefore recommended that a pilot investigation be undertaken to determine the most appropriate method of benthic plant mapping and monitoring in the Peel-Yalgorup Ramsar Site.

A combination of remote sensing using Quickbird / IKONOS multispectral satellite imagery (1 - 4 m pixels) with ground truthing and field surveying has proven successful in mapping benthic habitat in other comparable locations in Australia (Phinn et al. 2006). It is recommended that the method described in Phinn et al. (2006) together with that for the field analysis in Rolfsema et al. (2006) be adapted and applied to the Peel-Yalgorup Ramsar Site.

Location
Sampling to be conducted in the Peel-Harvey Estuary and Lake Clifton in the Yalgorup Lakes. Satellite imagery will cover the entire extent of the waterbodies, however, a stratified random sampling design will be required for field validation and ground truthing (see Holmes et al. 2006 for guidance).

Frequency
Sampling to be conducted annually in spring or summer.

Parameters and methods
The recommended monitoring procedure, adapted from Phinn et al. (2006) is illustrated in Figure 8. Detailed methodology can be found in the source document and will need to be modified to suit the Peel-Yalgorup system. The process involves both the use of remote sensing imagery as well as field collected information to produce a map of the distribution, community composition and density (percentage cover) or benthic plants in the Peel-Harvey Estuary and Lake Clifton.

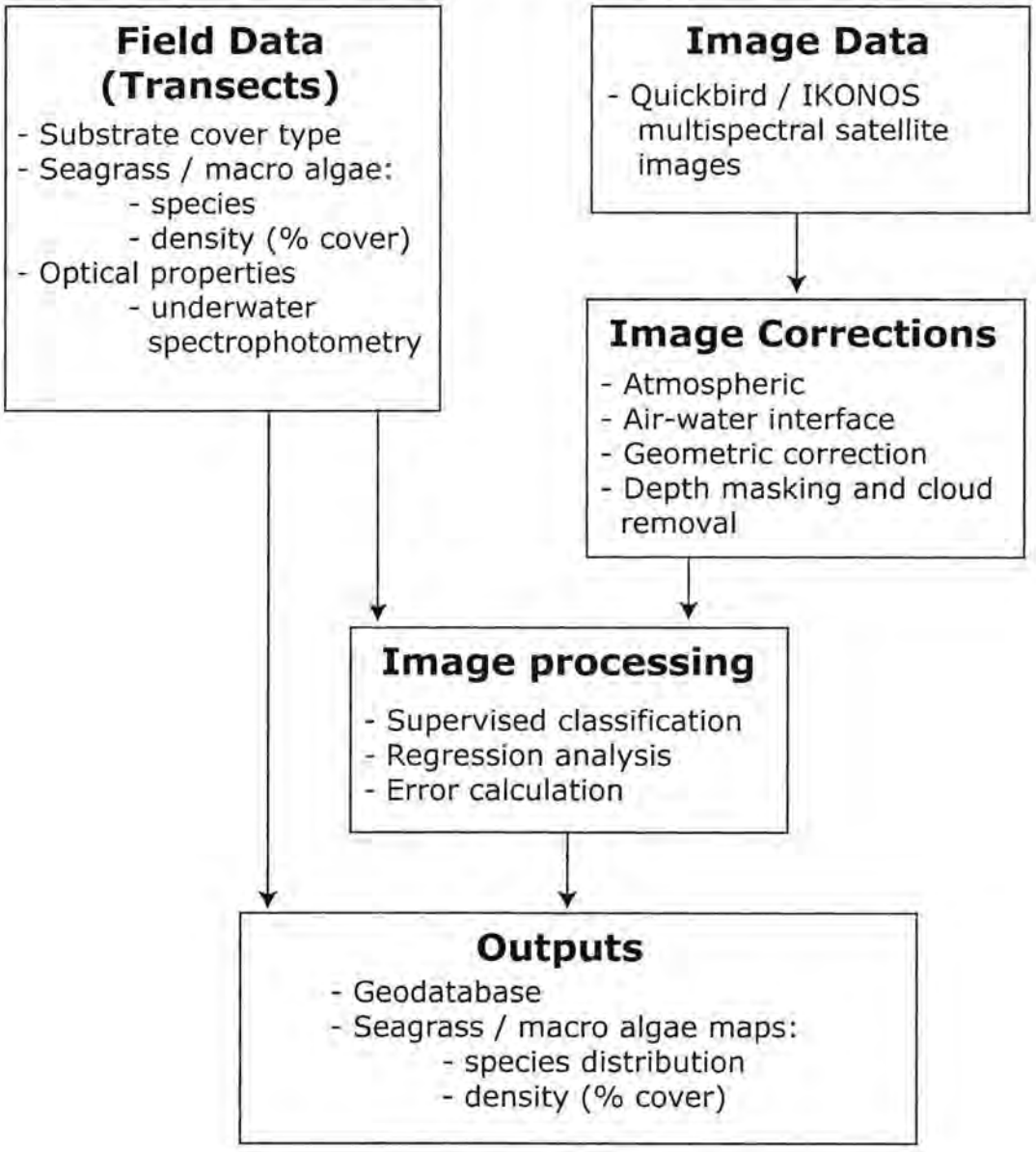

Figure 8: Proposed process for benthic plant monitoring (adapted from Phinn et al. 2006).

Data analysis and interpretation
Data collected is to be used to:

- Refine the method and develop a monitoring program that can be consistently implemented annually at the Peel-Yalgorup Ramsar Site; and
- Develop LAC for benthic plant community composition, and density.

It is likely that the development of LAC will require data from a number of years to adequately capture natural variation. As such, annual comparisons should be made to detect trends in benthic plant distribution, community composition and density. This will be particularly relevant for the macroalgal covering of the thrombolites at Lake Clifton. The *Peel-Yalgorup Technical Advisory Panel* should be responsible for identifying significant threats and / or impacts and recommending appropriate management actions.

Quality Assurance and Quality Control
Comparisons of field versus remote sensing data and error calculations can be used to determine the likely accuracy of mapping products. Any interpretation of the resulting maps and data should be undertaken with full consideration of these errors and level of uncertainty.

Reporting information

Mapping and geodata data should be stored in Wetlandbase.

Once LAC are developed, exceedences should trigger the management process illustrated in Figure 4 above and relevant technical experts on the *Peel-Yalgorup Technical Advisory Panel* consulted where necessary.

An annual report describing the results of the monitoring program, trends, LAC development and recommendations of the *Peel-Yalgorup Technical Advisory Panel* should be produced and made available to stakeholders and the wider community.

Links to Other Programs

The outputs of the water quality and hydrology programs could be useful in the interpretation of data collected under this benthic plants monitoring program.

Roles and Responsibility

- This will require engagement of a specialist group from a university or consulting firm and the body established for the administration of the management plan should be responsible for coordination and engagement of consultants.
- Department of Environment and Conservation has access to large spatial datasets and may be able to provide a role in the sourcing and supply of images. They are also responsible for maintaining Wetlandbase.
- The body established to administer the management plan for the Peel-Yalgorup Ramsar site should be responsible coordination of monitoring as well as for annual reporting and informing the Technical Advisory Panel.

Estimated Costs

The costs of this program are difficult to determine and will include a combination of the cost of image purchase, processing and field collection. Using the estimates contained in Holmes et al. (2006) it is likely that the imagery will cost between $10,000 - $20,000. Estimates for processing are difficult, and it is likely that the pilot study will be significantly more costly as methods are developed, than on-going monitoring. Minimum of 20 person days for image processing would be required. Field expenses are likely to be in the order of 10 – 20 person days plus boats, vehicles and equipment.

Priority
High

Littoral and Fringing Vegetation

Rationale

Littoral and fringing vegetation of the Peel-Yalgorup Ramsar site comprises of saltmarsh (samphire), paperbark and emergent reed communities. In addition to its intrinsic value it provides significant habitat for the fauna of the Ramsar site.

Relevant LAC

Location / Component	Baseline / Supporting Evidence	Limit of Acceptable Change
Peel-Yalgorup / Samphire and Paperbark	Current extent and health of samphire and paperbark communities unknown	Baseline must be set before limits can be made.
Lakes McLarty and Mealup / Littoral vegegation	Dominated by freshwater reeds, but encroachment of *Typha* sited as a problem at both wetlands. Sedges are an important habitat component for some waterbirds	*Typha* limited to < 20 % of the wetland area Freshwater sedges covering a minimum of 20% of the wetland area
Lakes McLarty and Mealup / Paperbark	Fringing freshwater paperbark community which is an important habitat for waterbirds No quantitative information	No decline in paperbark health No net loss of extent of paperbark community.
Lakes Goegrup and Black / Samphire	Approximately 83 hectares when mapped in 2006. However, there is no information on the natural variability in this community	Extent and distribution of samphire within patterns of natural variation.
Lakes Goegrup and Black / Paperbark	Fringing areas of both freshwater (47 ha) and saltwater paperbark (145 ha) communities. These perennial woody vegetation complexes would have low natural variability in extent	No change in the condition of paperbark communities. No loss of extent of paperbark communities.

Objectives / hypothesis

The objectives of the littoral and fringing vegetation monitoring program are:

- To determine the extent and composition of littoral vegetation and paperbark communities at Lakes McLarty and Mealup to set a baseline against which change can be assessed;
- To determine the extent and composition of samphire and paperbark communities fringing the Peel Harvey Estuary to set a baseline against which change can be assessed; and
- To monitor the extent and composition of samphire and paperbark communities at Lakes Goegrup and Black to assess against LAC.

Current and historical programs

There have been a number of previous programs that assessed extent and / or condition of littoral and fringing vegetation in the Peel-Yalgorup Ramsar site:

Glasson et al. (1995) – determined the extent of saltmarsh vegetation around the Peel-Harvey Estuary (including Goegrup and Black Lakes) from aerial photography. Comparisons were made from five points in time: 1957, 1965, 1977, 1986 and 1994.

Murray et al. (1995) – complimented the work of Glasson et al. (1995) by undertaking field investigations of community composition and biomass of saltmarsh vegetation at 10 locations. Transects were located around the Peel-Harvey Etuary and Lakes Goegrup and Black.

Monks and Gibson (2000) – assessed the composition and condition of saltmarsh and paperbark communities around the Peel-Harvey Estuary and Lake Mealup annually from 1994 to 1998.

Ecoscape and R & E O'Connor Pty Ltd. (2006) - Extent and composition of fringing vegetation (saltmarsh and paperbark) was mapped in 2006 as a part of the Goegrup and Black Lake Action Plan. This included aerial photograph interpretation and 37 on ground sites.

Monitoring method

The recommended procedure is to use remote sensing to map the extent of fringing vegetation communities in broad groups (saltmarsh, paperbark, emergent sedges and reeds) with ground truthing and assessment of community composition from field surveys at permanent transects.

Fringing and littoral vegetation communities often occur in narrow strips (< 50 m wide) around waterbodies. As such, accurate mapping by remote sensing requires imagery with a relatively high level of spatial resolution. Glasson et al. (1995) recommended the use of aerial photography, which has a pixel size of 0.05 – 1m (Holmes et al. 2006). However, Quickbird/ IKONOS satellite imagery may be sufficient and there could be advantages to using imagery sourced for the benthic plants to also map fringing vegetation.

Location

Mapping of fringing vegetation extent across the Peel-Harvey Estuary, Lakes McLarty and Mealup and Lakes Goegrup and Black.

Field surveys at the 10 permanent transects in the estuary and Lakes Goegrup and Black established by Glasson et al (1995) plus the Lake Mealup transects of Monks and Gibson (2000) and an additional pair of transects at Lake McLarty (Figure 9).

Frequency

Monks and Gibson (2000) reported the dynamic nature of saltmarsh vegetation in their four year study. However, their investigation was undertaken immediately following the opening of the Dawesville Channel, when tides and inundation of fringing vegetation underwent a dramatic change. Given the high variability in community composition and cover recorded in previous investigations the ideal frequency for mapping extent and assessing composition would be annually undertaken in spring. However the minimum frequency should be once every 3 – 5 years.

Parameters and methods

Extent of vegetation should be mapped from aerial photography (or high resolution satellite imagery) by supervised classification methods. Resulting maps and statistics should distinguish at a minimum the following broad groups:

- Saltmarsh
- Paperbark
- Freshwater reeds
- Bare ground
- Open water (Lakes McLarty and Mealup)

Field surveys should be undertaken at permanent transects extending from upland (terrestrial vegetation) to the water's edge (in the Peel-Harvey Estuary and Lakes Goegrup and Black) or the extent of vegetation (Lakes McLarty and Mealup). Following the method of Murray et al. (1995) transects should be stratified into zones of similar vegetation (Figure 10) in each zone percentage cover of each species should be recorded in 5 random quadrats (1m x 1m).

In addition, a minimum of 100 random points across the mapped area should be ground truthed to validate the remote sensing map.

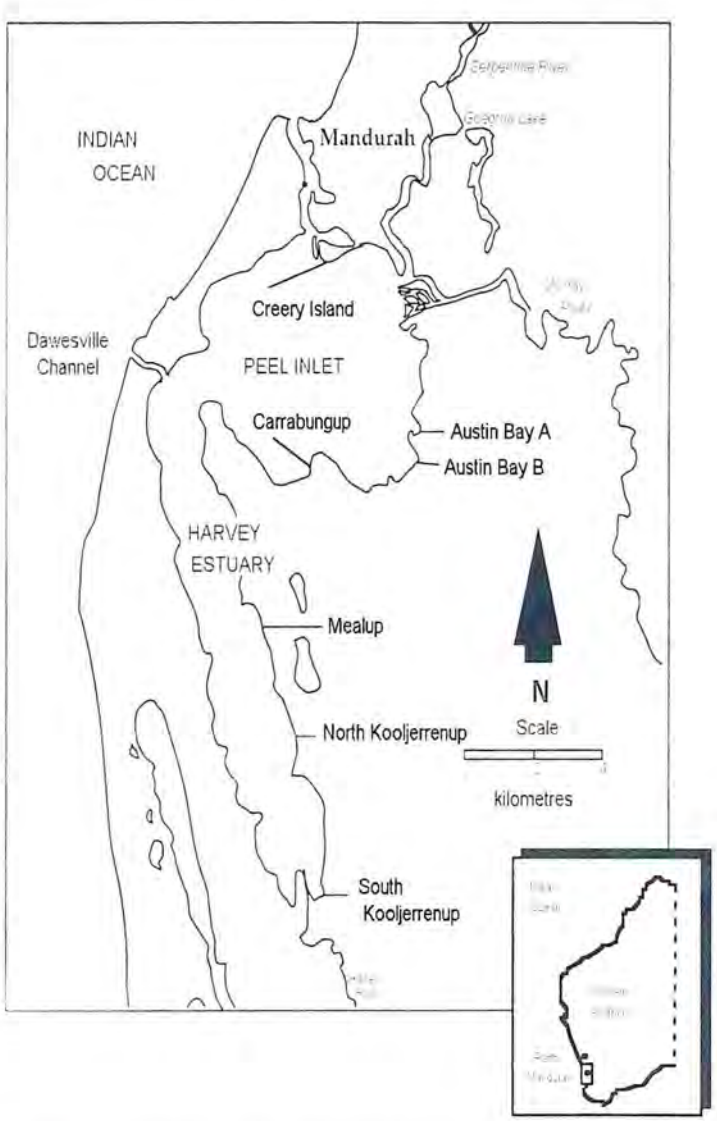

Figure 9: Location of vegetation transects (From Monk and Gibson 2000).

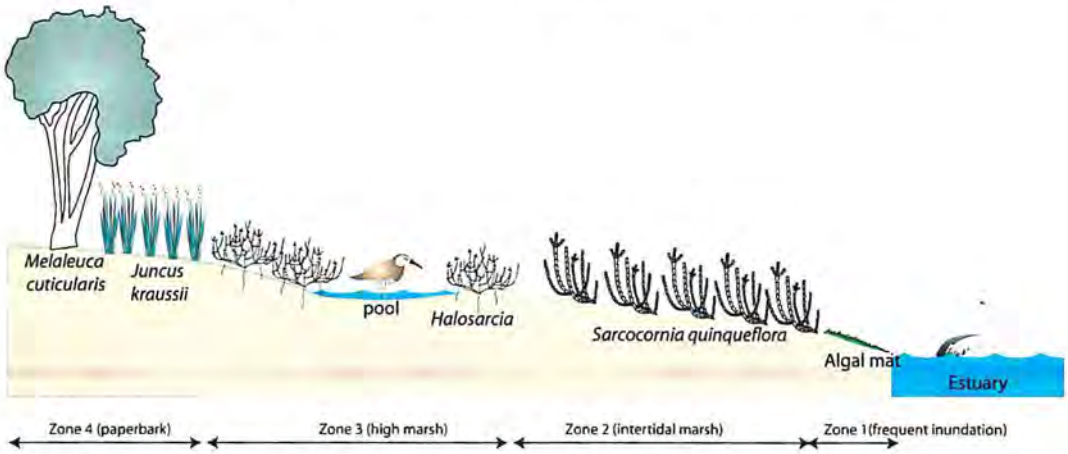

Figure 10: Fringing vegetation zones (adapted from Murray et al. 1995).

Data analysis and interpretation
Mapping of vegetation extent should be compared to the results of Glasson et al. (1995) and Ecoscape and R & E O'Connor Pty Ltd. (2006) in terms of change in cover since 1994 and 2006, respectively. The results from the Peel-Harvey Estuary and Lakes McLarty and Mealup should be used to inform quantitative limits of acceptable change.

The results of the field surveying and the remote sensing should be reported as average percentage cover of dominant species in each "zone" and the linear extent and position of each vegetation zone within a transect.

Quality Assurance and Quality Control
The field ground truthing data should be compared to the remote sensing map to determine the accuracy of the remote sensing techniques.

Field identifications of vegetation species should be checked for accuracy with the Western Australian Herbarium.

Reporting information

Mapping, geodata data and field data should be stored in the Wetlandbase.

Once LAC are developed, exceedences should trigger the management process illustrated in Figure 4 above and relevant technical experts on the *Peel-Yalgorup Technical Advisory Panel* consulted where necessary.

An annual report describing the results of the monitoring program, trends, LAC development and recommendations of the *Peel-Yalgorup Technical Advisory Panel* should be produced and made available to stakeholders and the wider community.

Links to Other Programs

The outputs of the water quality and hydrology programs may be of use in interpreting the results of the fringing and littoral vegetation monitoring program.

Roles and Responsibility

- This will require engagement of a specialist group from a university or consulting firm and the body established for the administration of the management plan should be responsible for coordination and engagement of consultants.
- Department of Environment and Conservation has access to large spatial datasets and may be able to provide a role in the sourcing and supply of images. They are also responsible for maintaining Wetlandbase.
- The body established to administer the management plan for the Peel-Yalgorup Ramsar site should be responsible coordination of monitoring as well as for annual reporting and informing the Technical Advisory Panel.

Estimated Costs

The costs of this program are difficult to determine and will include a combination of the cost of image purchase, processing and field collection. It is possible that imagery obtained fo rteh benthic plant monitoring could also be used for this program, representing a cost saving. In addition, aerial imagery is available on an annual basis for the entire study area. An inter-agency agreement with the Department of Lands may reduce costs.

Estimates for image processing, will be dependant on the skills of the operator and familiarity with identifying saltmarsh and wetland vegetation. Minimum of 1 0 - 15 person days for image processing would be required. Field expenses are likely to be in the order of 10 – 20 person days plus vehicles and equipment.

Priority

Peel-Harvey Estuary and Lakes McLarty and Mealup – High

Lakes Goegrup and Black - Medium

Fish

Rationale

The Peel-Harvey Estuary is an important commercial and recreational fishery. The system also provides important nursery habitat for some fish species and is a migratory route for the Pouched Lamprey. Fish are also an important food source for waterbirds. In addition, the system provides there is little recent information on the size and composition of the fish of the Estuary. As a consequence, there is no baseline information on which to base LAC.

Objectives / hypothesis

The objectives of the fish monitoring program are:

- To set a baseline in terms of fish community composition and populations to inform the development of LAC; and
- To monitor changes in fish community composition and population over time to inform the management of the site.

Current and historical programs

There have been a number of research programs focussed on specific fish / crustacean species or questions within the Peel Harvey Estuary (de Lestang et al. 2003a and 2003b; Lenanton and Potter 1987; Steckis et al. 1980; Young and Potter 2002, 2003a and 2003b). However, there has been little long-term monitoring.

Lonergan et al. (1986) monitored the fish fauna of the Peel-Harvey Estuary twice annually from 1979 to 1981. Fisheries WA (2006) annually monitors commercial catches, including those in the Peel-Harvey Estuary. They report in terms of catch per unit effort and total catch for a number of commercially important species. Murdoch University has a monitoring / research program that includes fish within the Peel-Harvey Estuary but results are yet to be published (F. Valesini pers. comm.).

Monitoring method

The most cost effective method of fish monitoring for the Peel-Harvey Estuary would be to collect data from the Fisheries WA program and use this to set LAC and inform management of the system. However, this does not include information on species that are not of commercial importance.

The alternative is to develop, fund and implement a dedicated fish monitoring program. Suggestions for such a program, based on the methodology of Lonergan et al. (1987) are provided below.

Location

Sampling at the eight locations of Lonergan et al. (1987) located within the Peel-Harvey Estuary and Lake Goegrup (Figure 11).

Frequency

Sampling frequency by Lonergan et al. (1987) was intense; every six weeks from August 1979 to September 1980, then bimonthly for the following year. However, this intensity of sampling is probably not warranted for routine monitoring and annual sampling in spring or summer should allow for meaningful characterisation of fish populations.

Parameters and methods

Following the methods of Lonergan et al. (1987) sampling should be undertaken using large beach seine nets at each of the eight sites. Total number (and optionally wet weight) of each species should be recorded.

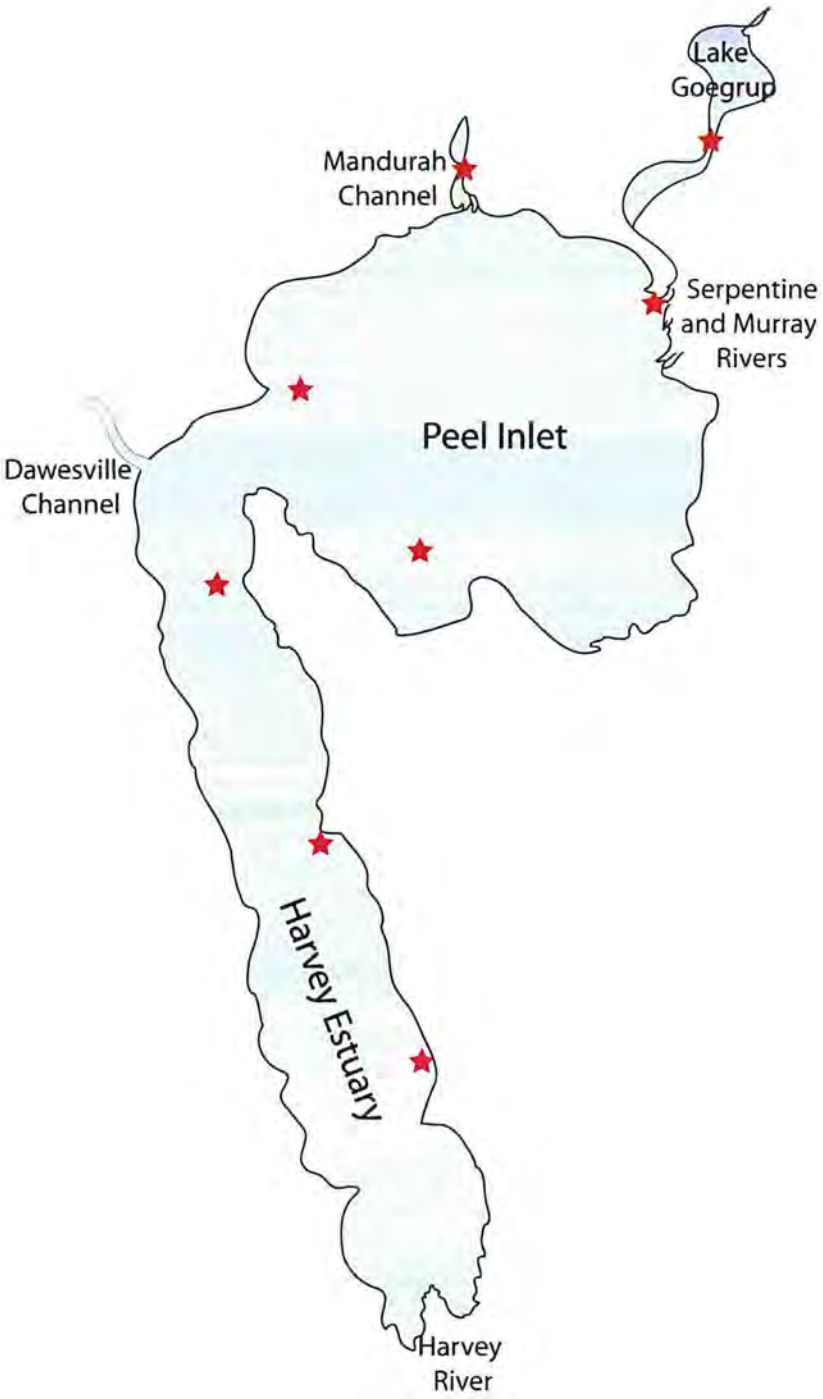

Figure 11: Fish sampling locations (from Lonergan et al. 1986).

Data analysis and interpretation

Data collected is to be used to:

- Set LAC in terms of fish community composition and density
- Assess against the LAC in subsequent monitoring events.

It is likely that the development of LAC will require data from a number of years to adequately capture natural variation. In the interim data collected should be statistically analysed to determine any changes in composition or density of fish species over time. In addition, data collected by Fisheries WA on commercially important species should be included in the analysis.

Reporting information

Density and species composition data should be stored in Wetlandbase.

Once LAC are developed, exceedences should trigger the management process illustrated in Figure 4 above and relevant technical experts on the *Peel-Yalgorup Technical Advisory Panel* consulted where necessary.

An annual report describing the results of the monitoring program (including that from Fisheries WA), trends, LAC development and recommendations of the *Peel-Yalgorup Technical Advisory Panel* should be produced and made available to stakeholders and the wider community.

Links to Other Programs

The outputs of the water quality and hydrology programs may be of use in interpreting the results of fish monitoring program.

Roles and Responsibility

- This will require engagement of a specialist group from a university or consulting firm and the body established for the administration of the management plan should be responsible for coordination and engagement of consultants.
- Department of Environment and Conservation are responsible for maintaining Wetlandbase.
- Fisheries WA are currently responsible for commercial fish monitoring and reporting.
- The body established to administer the management plan for the Peel-Yalgorup Ramsar site should be responsible coordination of monitoring as well as for annual reporting and informing the Technical Advisory Panel.

Estimated Costs

It is estimated that field sampling will take between 15 and 25 person days, plus vehicles and equipment. Data analysis, interpretation and report writing would be in the order of 10 – 15 person days for a basic summary report.

Priority

Medium

Waterbirds A: Red-necked Stints

Rationale

One of the reasons that the Peel-Yalgorup Ramsar site has been recognised as a Wetland of International Importance is that it regularly supports > 1 % of the flyway population (Ramsar Criterion 6) of each of 14 species of waterbirds (Hale and Butcher 2008). While it may not be feasible (with available resources) to monitor all of these species intensively, a strategic approach that focuses on two of these species, the Red-necked Stint (*Calidris ruficollis*) and the Sharp-tailed Sandpiper (*Calidris acuminata*) is recommended. These species has been selected because:

- data from previous surveys (since 1970s) indicate that the these species can be expected to be present within the Ramsar site each year, if suitable habitat is present
- they occur at multiple locations within the Ramsar site and so its presence is not dependent on a single area of habitat
- they are relatively abundant species, with numbers in the thousands at times and thereby contributing significantly to the site meeting Ramsar Criterion 5
- though presenting some challenges for inexperienced observers, an experienced observer can readily identify them in the field (ignoring several similar small-sized species that occur as vagrants or in very low numbers)
- being migratory shorebirds, they could be used as an indicator of the site's ongoing (substantial) support of migration by waterbirds (relates to Ramsar Criterion 4)
- the Red-necked Stint is by far the most abundant of the migratory shorebirds at the site and the Sharp-tailed Sandpiper provides different but complementary information

Two other waterbird species are also recommended for monitoring: see Waterbirds B and Waterbirds C below.

The relevant LAC is:

- Supports > 1 % of the population of the following waterbirds in 3 out of 5 years:
    - Red-necked Stint
    - Sharp-tailed Sandpiper

Objectives / hypothesis

The objective of the Waterbird A monitoring program is:

- To undertake counts of Red-necked Stint and Sharp-tailed Sandpiper annually at strategic locations across the Peel-Yalgorup Ramsar site to assess maintenance of ecological character.

The specific hypothesis of the Waterbird A program is:

- The Peel-Yalgorup Ramsar site will support > 1 % of the flyway population of Red-Necked Stints and Sharp-tailed Sandpipers at a minimum of 3 out of 5 years.

Current and historical programs

Lane and Pearson (2002) – Monitoring of waterbirds in the Peel-Harvey Estuary from 1975 – 1977. Counts undertaken every two months over four days involving aerial, boat-based and on-foot methods.

Lane et al. (2002a and 2002b) – Monitoring of waterbirds during October, December and February 1994 to 1999 over four days involving aerial, boat-based and on-foot methods.

Jaensch et al. (1988) – The Royal Australasian Ornithologists Union (RAOU) undertook waterbird counts at a number of wetlands including the nature reserves in eastern Peel Inlet, and Lakes McLarty and Mealup from 1981 to the late 1980s

Halse et al. (1990) – CALM undertook annual waterbird counts in wetlands in south-western Australia from 1986 to 1990. This included Lakes Preston, Clifton and McLarty as well as the Peel-Harvey Estuary.

Bamford and Bamford (2003) – Monthly surveys of waterbirds at the Creery Wetlands (Peel-Harvey Estuary) from 2000 to 2003.

Craig et al. (2001 and 2006) – Waterbird and shorebird surveys from Lake McLarty: 33 surveys between 1990 and 1995; regular (monthly and weekly during peak seasons) surveys between 1996 and 2001; irregular (27 total) surveys between 2001 and 2005.

Private individuals – Individuals such as D. Rule and B. Russell have collected a large amount of waterbird count data from the Peel-Yalgorup Ramsar site. The latter of these has assembled a database of counts from the Yalgorup Lakes from 1995 to 2007.

Monitoring method

Red-necked Stints and Sharp-tailed Sandpipers, as with other waterbirds in the Peel-Yalgorup Ramsar site, are highly mobile and the species be found at a number of locations within the site at any given time. Consequently, a coordinated monitoring program that involves annual counts simultaneously at these locations should provide a more comprehensive estimate of the total number of birds using the Ramsar site than fragmented counts that are undertaken at different locations at different times.

Location

Red-necked Stints have been previously recorded in significant numbers (at least 10% of their 1% threshold, ie. say > 300 birds) at: Lake Preston, Yalgorup Lake, Martins Tank and Lake Pollard (B. Russell unpublished data); Peel-Harvey Estuary (Jaensch et al. 1988; Bamford & Bamford 2003; Lane et al. 2002a and b; Lane and Pearson 2002); and Lake McLarty (Craig et al. 2001 and 2006). Therefore it is suggested that the monitoring program target and cover all of these areas. As some of these wetlands are very large (Peel-Harvey Estuary and Lake Preston), it is recommended that the system be divided into "zones". In the case of the Peel-Harvey Estuary, the zones described by Lane and Pearson (2002) would provide data that could be compared to that collected historically. Similarly the division of Lake Preston into the northern and middle sections previously monitored by Bill Russell would also provide new data comparable to existing count data.

Frequency

Red-necked Stints are international migrants that breed in Siberia. They are most likely to be in the Peel-Yalgorup Ramsar site between late August and early April. Therefore it is recommended that monitoring take place each year within this period. Annual population monitoring by the Australasian Wader Studies Group occurs in mid-summer, when southward migration has ceased, so this would be the primary count date (late January or early February).

Parameters and methods

Counts of Red-necked Stints should be undertaken simultaneously at each of the abovementioned locations/zones. Repetition of the survey on a second (consecutive) day would add robustness to the effort by enabling means and variance to be calculated.

Data analysis and interpretation

Counts each year can be compared with the most recent Waterbird Population Estimates (Wetland International) to ensure that the LAC is met for this species.

Quality Assurance and Quality Control
Application of the recommendations for observer training and monitoring protocols recommended in the Shorebirds 2020 program (Clemens et al. 2007).

Reporting information

Data collated should be stored in a dedicated Peel-Yalgorup Ramsar Site Waterbird Database (see Waterbird Program D). In addition, data should be forwarded to Birds Australia for inclusion in the Shorebirds 2020 program and Australian Bird Atlas as well as stored in Wetlandbase.

Exceedences of LAC should trigger the management process illustrated in Figure 4 above and relevant technical experts on the *Peel-Yalgorup Technical Advisory Panel* consulted where necessary.

An annual report describing the results of the monitoring program, against LAC and describing trends should be produced and made available to stakeholders and the wider community.

Links to Other Programs

Linking this program with the Birds Australia Shorebirds 2020 would have advantages.

Roles and Responsibility

- Currently waterbird monitoring is undertaken by a pool of volunteers coordinated at the State level by Birds WA and at the national level by Birds Australia. Consideration should be given to supporting volunteers in terms of coordination and financial remuneration for expenses incurred.
- Department of Environment and Conservation are responsible for maintaining Wetlandbase.
- The body established to administer the management plan for the Peel-Yalgorup Ramsar site should be responsible coordination of monitoring as well as for annual reporting and informing the Technical Advisory Panel.

Estimated Costs

The use of volunteers and linking with existing bird monitoring programs (e.g. Shorebirds 2020) would greatly reduce the cost of implementing this program. However, even with the majority of counters volunteering their services, a coordinator will need to be appointed (estimate 10 days annually). In addition, collation, analysis and reporting will require a dedicated person (estimated at 5 – 10 days per year).

Priority

High

Waterbirds B: Cormorants

Rationale

One of the reasons that the Peel-Yalgorup Ramsar site has been recognised as a wetland of international importance is that it supports plant/animal species at a critical stage in their lifecycles. This includes over 30 species of waterbirds during breeding (Hale and Butcher 2008). While it may not be feasible (with available resources) to monitor the breeding of all of these species intensively, a strategic approach is recommended that focuses on two species Little Black Cormorant (*Phalacrocorax sulcirostris*) and the Little Pied Cormorant (*P. melanoleucos*) which have significant breeding colonies at Carrabungup (sometimes referred to as Carraburmup) Nature Reserve adjacent to the Peel Inlet and within the Ramsar site. Colonial breeding species typically nest in relatively few locations and so their colonies are inherently vulnerable: loss of a major colony could have a huge impact on population size and viability. In the 1980s, over one thousand Little Black Cormorants and several hundred Little Pied Cormorants bred, possibly each year, at Carrabungup and these were among the largest known colonies of these species in south-western Australia (Jaensch et al. 1988; Wetlands International unpublished data). Given the high density of nesting and caution needed to avoid undue disturbance to nesting birds it is likely that these estimates were somewhat below the actual numbers of nests present at the time. The colonies are arguably the most significant aspect of waterbird breeding in the Ramsar site; breeding by Hooded Plover is also regionally important (see Waterbirds C).

Objectives / hypothesis

The objective of the Waterbirds B monitoring program is:

- To assess the breeding status of the Little Black Cormorant and Little Pied Cormorant at Carrabungup Reserve.
- To inform quantitative LAC for breeding for these waterbirds.

Current and historical programs

Jaensch et al. (1988) recorded > 1000 breeding pairs of Little Black Cormorants and > 300 pairs of breeding Little Pied Cormorants in the inundated paperbarks of Carrabungup Reserve in September and October (1981 – 1985). Movements of birds indicated that the adults fed in nearby parts of the estuary and/or freshwater wetlands. It is not known if the colonies have remained active subsequent to the 1980s: colonial nesting birds sometimes abandon colony sites for a year or so, during which time trees damaged by nesting may recover, returning to continue nesting in subsequent years. Colonies of cormorants in swamps at the eastern side of Peel Inlet had been known to government wildlife officers and/or ornithologists for some years.

Monitoring method

Confirmation of breeding simply requires an experienced ornithologist to visit the edge of the colony site on one to several occasions during the spring breeding months. (Sometimes cormorants, either these or other species, may nest in winter.) A common-sense systematic search of the colony site would enable all or most nests to be viewed, generally at distance, and contents and/or behaviour of adults documented. Number of active nests and stage of activity (building, sitting, feeding young, young recently out of nest) would be recorded for each species. This more complex monitoring of breeding colonies requires trained observers to avoid disturbance of nests; large nestlings are known to leap out of nests if approached too closely. To avoid disturbance and avoid confusion caused by presence of near-flying young (not readily distinguished from adults), the optimum time for surveys would be at the early stages of incubation rather than when young are present. However, due to non-synchronous breeding, nests with eggs may occur at the same time as some nests with young.

A map indicating approximate location of nesting birds in the reserve would be a useful item of additional information. Condition of nesting trees should be noted.

Location
Paperbark wooded swamp at Carrabungup Reserve.

Frequency
Annually in September and October

Parameters and methods
Visual counts of nests and breeding pairs by trained observers.

Data analysis and interpretation
Records of breeding (attempts and success) should be analysed to determine trends over time and inform refinement of LAC.

Quality Assurance and Quality Control
In order to avoid disturbance of nesting birds it is essential that only trained observers are used in this program.

Reporting information

Data collated should be stored in a dedicated Peel-Yalgorup Ramsar Site Waterbird Database (see Waterbird Program D). In addition, data should be forwarded to Birds Australia for inclusion in the Australian Bird Atlas as well as stored in Wetlandbase.

Exceedences of LAC should trigger the management process illustrated in Figure 4 above and relevant technical experts on the *Peel-Yalgorup Technical Advisory Panel* consulted where necessary.

An annual report describing the results of the monitoring program, against LAC and describing trends should be produced and made available to stakeholders and the wider community.

Links to Other Programs

There is no State or nation-wide program of monitoring breeding colonies of waterbirds but data should be copied to Wetlands International – Oceania, which has a database of systematic and anecdotal information on breeding colonies in Australia. These data are considered in providing advice to the compilers of updates to the global *Waterbird Population Estimates* initiative (Wetlands International 2006).

Roles and Responsibility

- Currently waterbird monitoring is undertaken by a pool of volunteers coordinated at the State level by Birds WA and at the national level by Birds Australia. This program, however, represents a new waterbird monitoring event and would require establishment and coordination. Consideration should be given to supporting volunteers in terms of coordination and financial remuneration for expenses incurred.
- Department of Environment and Conservation are responsible for maintaining Wetlandbase.
- The body established to administer the management plan for the Peel-Yalgorup Ramsar site should be responsible coordination of monitoring as well as for annual reporting and informing the Technical Advisory Panel.

Estimated Costs

The cots of implementing this program are likely to be moderate. Approximately 5 – 10 person days for the counts and an additional 5 days for data interpretation and analysis.

Priority

Medium to high

Waterbirds C: Hooded Plover

Rationale

Two of the criteria for wetlands of international importance met by the Peel-Yalgorup Ramsar Site are:

Criterion 4: A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions; and

Criterion 6: A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird.

As mentioned above it is not feasible to adequately monitor all of the waterbirds for which the site meets these criteria. Rather, a strategic approach is proposed in which intensive monitoring of selected species can act as indicators for the wider range of significant waterbird populations. The Yalgorup Lakes regularly support > 1% (60 birds) of the western population of the Hooded Plover (*Thinornis rubricollis*) and are a significant site bioregionally for breeding of these birds (Birds Australia 2006). Additional reasons for selecting the Hooded Plover for monitoring are:

- it occurs regularly at the site and similar, highly suitable lake habitat is scarce if not absent elsewhere on the Swan Coastal Plain (thus reducing the likelihood that the birds may temporarily be using other sites)
- the bird is easily identified, not readily confused with other species
- selection of this species ensures inclusion of a waterbird element that focuses solely on the Yalgorup Lakes (which provide different habitat to the other wetland components of the Ramsar site)

Relevant LAC are (Hale and Butcher 2008):

- Supports > 1 % of the population of the following birds 3 out of 5 years: Hooded Plover (60); and

- Successful breeding recorded for Hooded Plover in 3 out of 5 years.

Objectives / hypothesis

The objective of the Waterbird C monitoring program is:

- To undertake counts of Hooded Plover quarterly at Lakes Preston and Clifton to assess maintenance of ecological character.

The specific hypotheses of the Waterbird C program are:

- The Peel-Yalgorup Ramsar site will support > 60 Hooded Plovers in a minimum of 3 out of any 5 years.
- The Peel-Yalgorup Ramsar site will support successful breeding of Hooded Plovers in a minimum of 3 out of any 5 years.

Current and historical programs

Birds Australia (2006) has been involved in the monitoring of Hooded Plover at the Yalgorup Lakes from 1994 to current. This has included a banding program, regular summer surveys and breeding observations. Since 2000 the Mylaup Bird Observers Group has monitored Hooded Plover behaviour at a number of sites in the Yalgorup Lakes complex. Individual volunteers have been responsible for establishing and collecting information from a suite of sites.

Monitoring method

It is recommended that this monitoring program support the existing monitoring of Hooded Plovers at the Yalgorup Lakes and utilise the results to inform management of the site.

Location

The current program is undertaken at a number of sites locations, a review of these to determine if they represent adequate spatial coverage is recommended.

Frequency

Quarterly counts are recommended with observations of breeding behaviour concentrated on the breeding season (December – April).

Parameters and methods

Counts – Total counts of the area of likely occupancy should be attempted wherever possible.

Breeding behaviour – following the methods of the Victorian Hooded Plover Monitoring Program (Birds Australia). Pairs are monitored fortnightly to determine, nesting attempts, successful nesting, hatching and fledging (timing and successes). Monitoring protocols are established to minimise disturbance of nesting birds:

- Monitoring is undertaken by trained observers only;
- No observer within 5 m of a nest;
- No nest or pair observed for > 35 minutes;
- Observations in the cool of the morning or late afternoon (to avoid over heating of eggs); and
- Any behavioural signs of distress from birds (false brooding, distraction display) results in withdrawal of observers.

Data analysis and interpretation

Counts each year can be compared with the most recent Waterbird Population Estimates (Wetland International) to ensure that the LAC is met for this species.

Records of breeding (attempts and success) should be analysed to determine trends over time and inform refinement of LAC.

Quality Assurance and Quality Control

Application of the recommendations for observer training and monitoring protocols recommended in the Shorebirds 2020 program (Clemens et al. 2007).

Reporting information

Data collated should be stored in a dedicated Peel-Yalgorup Ramsar Site Waterbird Database (see Waterbird Program D). In addition, data should be forwarded to Birds Australia for inclusion in the Australian Bird Atlas as well as stored in Wetlandbase.

Exceedences of LAC should trigger the management process illustrated in Figure 4 above and relevant technical experts on the *Peel-Yalgorup Technical Advisory Panel* consulted where necessary.

An annual report describing the results of the monitoring program, against LAC and describing trends should be produced and made available to stakeholders and the wider community.

Links to Other Programs

Linking this program with the Birds Australia Shorebirds 2020 would have advantages.

Roles and Responsibility

- Currently waterbird monitoring is undertaken by a pool of volunteers coordinated at the State level by Birds WA and at the national level by Birds Australia. This program, however, represents a new waterbird monitoring event and would require

establishment and coordination. Consideration should be given to supporting volunteers in terms of coordination and financial remuneration for expenses incurred.

- Department of Environment and Conservation are responsible for maintaining Wetlandbase.
- The body established to administer the management plan for the Peel-Yalgorup Ramsar site should be responsible coordination of monitoring as well as for annual reporting and informing the Technical Advisory Panel.

Estimated Costs

The use of volunteers and linking with the existing Hooded Plover monitoring would greatly reduce the cost of implementing this program. However, even with the majority of observers volunteering their services, a coordinator will need to be appointed (estimate 5 - 10 days annually). In addition, collation, analysis and reporting will require a dedicated person (estimated at 5 – 10 days per year).

Priority

High

Waterbirds D: Coordination

Rationale

A large amount of information is currently being collected on waterbird numbers, breeding and other behaviours in the Peel-Yalgorup Ramsar site. However, little of this information is collated and used to inform management of the site. One of the most cost effective methods of monitoring waterbird populations within the Ramsar site would be to collate and analyse existing information and data currently collected under other programs or by local bird observers groups.

Objectives / hypothesis

The objectives of the Waterbirds program D are:

- To collate existing waterbird usage and monitoring data from the Peel-Yalgorup Ramsar site and store in a dedicated database (*Peel-Yalgorup Ramsar Waterbird Database)*;
- To coordinate the collection of future waterbird monitoring data for input to the database; and
- To analyse the waterbird data from the newly developed *Peel-Yalgorup Ramsar Waterbird Database* to detect trends, refine LAC and inform on-going management of the site.
- To oversee provision of new monitoring data to external users including Birds Australia and liaise on common tasks (such as reporting) to ensure effective use of resources

Current and historical programs

Lane and Pearson (2002) – Monitoring of waterbirds in the Peel-Harvey Estuary from 1975 – 1977. Counts undertaken every two months over four days involving plane, boat and foot methods.

Lane and Pearson (2002) – Monitoring of waterbirds in the Peel-Harvey Estuary from 1975 – 1977. Counts undertaken every two months over four days involving aerial, boat-based and on-foot methods.

Lane et al. (2002a and 2002b) – Monitoring of waterbirds during October, December and February 1994 to 1999 over four days involving aerial, boat-based and on-foot methods.

Jaensch et al. (1988) – The Royal Australasian Ornithologists Union (RAOU) undertook waterbird counts at a number of wetlands including the nature reserves in eastern Peel Inlet, and Lakes McLarty and Mealup from 1981 to the late 1980s

Halse et al. (1990) – CALM undertook annual waterbird counts in wetlands in south-western Australia from 1986 to 1990. This included Lakes Preston, Clifton and McLarty as well as the Peel-Harvey Estuary.

Bamford and Bamford (2003) – Monthly surveys of waterbirds at the Creery Wetlands (Peel-Harvey Estuary) from 2000 to 2003.

Craig et al. (2001 and 2006) – Waterbird and shorebird surveys from Lake McLarty: 33 surveys between 1990 and 1995; regular (monthly and weekly during peak seasons) surveys between 1996 and 2001; irregular (27 total) surveys between 2001 and 2005.

Private individuals – Individuals such as D. Rule and B. Russell have collected a large amount of waterbird count data from the Peel-Yalgorup Ramsar site. The latter of these has assembled a database of counts from the Yalgorup Lakes from 1995 to 2007.

Birds Australia (2006) – Hooded Plover monitoring program for the Yalgorup Lakes. This has included a banding program, regular summer surveys and breeding observations. Since

2000 the Mylaup Bird Observers Group has monitored Hooded Plover behaviour at 23 sites in the south western shore of Lake Preston.

Bamford and Wilcox (2003) – Monitoring of waterbirds (counts ad breeding) at Goegrup and Black Lakes form the mid 1980s until current by the Peel Preservation Group.

Consulting projects – A large number of private development proposals within the Peel-Yalgorup Ramsar site undertake waterbird monitoring to inform environmental impact assessments.

Method

Guidance for the development of a database and analysis of data should be taken from existing program such as the Australian Waders Studies Group (AWSG), Population Monitoring Program (Gosbell and Clemens 2006). The database developed by AWSG will contain relevant records for the Peel-Yalgorup Management Plan and may be able to be used as a starting point to building a dedicated database for the Ramsar site. In addition, existing compilations of waterbird data from the Peel-Yalgorup Ramsar Site are likely to have been collated for other programs (e.g. Shorebirds 2020, comparisons before and after the opening of the Dawesville Channel) and attempts should be made to minimise duplication of effort.

There are a number of bird observers groups that are currently involved in monitoring of birds within the Ramsar site. These include:

- Birds Australia WA
- Mandurah Birdwatchers Group
- Myalup Bird Observers Groups; and
- numerous unaligned individuals

While some records from these groups and individuals are forwarded to Birds Australia WA or Birds Australia for input into the Australian Bird Atlas, it is up to the individual to submit records and often common species or those that are regularly observed are not submitted (D. Rule, pers. comm.). In addition, the records submitted to the Australian Bird Atlas are not commonly extracted by government agencies to inform wetland management.

The following steps are recommended to address this situation and make the best use of existing information and programs:

- Appointment of a coordinator for waterbird data for the Peel-Yalgorup Ramsar site;
- Development of a suitable database;
- Negotiation with existing holders of data to allow for copies of records to be stored in the *Peel-Yalgorup Ramsar Waterbird Database* (this may involve establishment of formal data licensing agreements) as well as Wetlandbase;
- Input of existing and future data into the database; and
- Annual analysis of collected data to determine trends.

The types of analysis suitable for examination of waterbird data will depend on the records available. However, it is possible that this may involve analysis of monthly or annual maximum counts based on key individual species, bird guilds or all species. The analyses could characterise:

- Central tendency (mean, median);
- Variability (standard deviation, percentiles);
- Development of control charting techniques to determine deviation outside expected variability (see Emphron 2008).

Roles and Responsibility

- Currently waterbird monitoring is undertaken by a pool of volunteers coordinated at the State level by Birds WA and at the national level by Birds Australia. This program, however, represents a new waterbird monitoring event and would require

establishment and coordination. Consideration should be given to supporting volunteers in terms of coordination and financial remuneration for expenses incurred.

- Department of Environment and Conservation are responsible for maintaining Wetlandbase.
- The body established to administer the management plan for the Peel-Yalgorup Ramsar site should be responsible coordination of monitoring and facilitation of communication between the different groups involved.

Estimated Costs

Appointment of a coordinator – estimated at 2 days per week during establishment of database and then this could be reduced to 5 – 10 days per year;
Development of the database may require expert services
Statistical advice should be sought for appropriate data analysis.

Priority

High

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