



Natural Area  
CONSULTING MANAGEMENT SERVICES

## **Blackwood Basin Group**

# **Schwenkes Dam Wetland Management Plan**

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### Document Control

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## Executive Summary

Schwenkes Dam, currently a steep-sided water body resulting from previous mining activities, is being rehabilitated to create wetland habitat designed to attract and establish populations of water birds including three priority bitterns; the endangered (EN) Australasian Bittern (*Botaurus poiciloptilus*), priority listed Black Bittern (*Ixobrychus flavicollis australis*) (P3) and Little Bittern (*Ixobrychus minutus*) (P4).

This management plan aims to promote the sites recovery from mining activities and establish a healthy and resilient wetland supporting a range of native biota. To achieve this, the following objectives have been identified:

1. Establish breeding and feeding habitat suitable to support Department of Parks and Wildlife priority species Australasian Bittern (*Botaurus poiciloptilus*), Black Bittern (*Ixobrychus flavicollis australis*) and Australian Little Bittern (*Ixobrychus minutus*).
2. Increase populations of water-dependent birds from a range of functional groups and observe an increase in breeding events.
3. Increase vegetation diversity and cover, and improve vegetation condition within the wetland complex (including submerged, emergent and ephemeral vegetation).

Specific targets associated with the above objectives include:

- Littoral zone vegetation community in Little Schwenkes Dam covering a greater area (target of four to seven hectares).
- Littoral zone vegetation species diversity increased.
- Recruitment of littoral zone vegetation species (via germination or vegetation expansion) following drawdown events.
- No net loss of littoral zone sedge or rush species as a result of proposed earthworks.
- Record an increase in diversity (>10) and abundance of water bird species during surveys across a range of functional groups and abundances using a range of habitats.
- Record evidence of water bird species breeding.
- Establish submerged and emergent zone aquatic vegetation species.
- Support the recruitment of submerged vegetation by implementing a drawdown phase.
- Reduce percentage cover of invasive plant species and prevent new invasive species from becoming established.

To achieve the objectives for Schwenkes Dam, active management of the wetlands hydrology and a range of other associated actions are proposed for the period 2014-2019 including acid sulphate assessment, determining the soil and subsoil properties and determining the aquatic macro-invertebrate community. The wetland should be adaptively managed and a range of triggers have been identified which should initiate a review of the current or planned management.

Earthworks design is discussed in Section 8.2. The aim of the earthworks is to increase the area of the wetland by lowering the surrounding terrestrial landscape through shallow excavations. As the wetland overflows when the dam reaches 244.9 m above sea level, the area excavated needs to be below this level. This will allow for an increased area of inundation. To promote the successful establishment of wetland vegetation, vegetative zones need to be established at specific water depths.

Monitoring of Schwenkes Dam and how it responds to change is essential to adaptive management. Ongoing monitoring assesses if the management objectives are being achieved and enables the refinement of management actions. It is essential to establish permanent monitoring sites and describe its physical characteristics in detail. It is recommended that the following parameters form an ongoing monitoring program:

- surface water quality
- groundwater levels
- vegetation condition
- diversity and abundance of frog populations
- diversity and abundance of fish populations
- diversity and abundance of water bird populations
- diversity and abundance of macro-invertebrate populations.

Management actions associated with the Northern ponds area of the Talison complex has been excluded from discussion due to the lack of information available at the time of preparing this management plan. Information on physical and ecological parameters and site-specific characteristics should be collected prior to the development of an in-depth management plan. It is expected that the desired outcomes of the project will be achieved through the earthworks and rehabilitation of Schwenkes Dam alone.

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## 1.0 Introduction

Schwenkes Dam, is located at the Talison Lithium Operations at Greenbushes, approximately 250 km south of Perth and 90 km south-east of Bunbury, in Western Australia. Tin mining operations commenced in 1888. The development of the lithium ore body began in 1983 and since that time has been expanded several times. Talison Lithium manages rehabilitation programs for Greenbushes historical and inactive mining sites with the assistance of local regulators.

Schwenkes Dam, currently a steep-sided water body resulting from previous mining activities, can be rehabilitated to create wetland habitat designed to attract and establish populations of water birds including three priority bitterns; the endangered (EN) Australasian Bittern (*Botaurus poiciloptilus*), priority listed Black Bittern (*Ixobrychus flavicollis australis*) (P3) and Little Bittern (*Ixobrychus minutus*) (P4).

A range of issues threaten Schwenkes Dam including the impact of vegetation clearing from past mining activities, introduced flora and fauna, dieback and the lack of seasonal variation in wetland water levels.

This management plan aims to promote the sites recovery from mining activities and establish a healthy and resilient wetland supporting a range of native biota. To achieve this, the following objectives have been identified:

1. Establish breeding and feeding habitat suitable to support Department of Parks and Wildlife (DPaW) priority species Australasian Bittern (*Botaurus poiciloptilus*), Black Bittern (*Ixobrychus flavicollis australis*) and Australian Little Bittern (*Ixobrychus minutus*).
2. Increase populations of water-dependent birds from a range of functional groups and observe an increase in breeding events.
3. Increase vegetation diversity and cover, and improve vegetation condition within the wetland complex (including submerged, emergent and ephemeral vegetation).

Earthworks, revegetation and specific actions targeting the control of introduced flora and fauna will be undertaken to achieve these objectives. Ongoing monitoring will inform the management of the wetland and enable progress against the plan's objectives to be evaluated.

## **2.0 Wetland description**

The following section provides information on the location, physical characteristics and hydrology of Schwenkes Dam.

### **2.1 Location**

Talison Lithium Operations is located in Greenbushes, approximately 250 km south of Perth and 90 km south-east of Bunbury in Western Australia. The mineral tenements cover approximately 10,000 ha and includes the historic Greenbushes tin, tantalum and current lithium mining areas. Tin, tantalum and lithium mining has resulted in a series of water bodies varying in both surface area and depth.

Talison Lithium manages rehabilitation programs for Greenbushes historical and inactive mining sites with the assistance of local regulators. Approximately 650 ha of rehabilitated mine workings are currently being managed with the intention of returning these areas to be managed by The Western Australian Government as State Forest. Rehabilitation areas are monitored annually by assessing flora abundance and diversity.

The Greenbushes area has a temperate climate with distinct summer and winter seasons. The mean minimum temperatures range from 4°C to 12°C, with mean maximum temperatures between 16°C and 30°C. There is a distinct rainfall pattern with most of the rain occurring between May and October. The area averages 970 mm per annum (range of 610 mm to 1,680 mm) with an evaporation rate of approximately 1,190 mm per annum (Behre Dolbear Australia, 2011).

Schwenkes Dam is a historical, steep-sided water body resulting from past mining activity. Vegetation adjacent to the dam has been partially or fully cleared for mining operations.

### **2.2 Physical Characteristics**

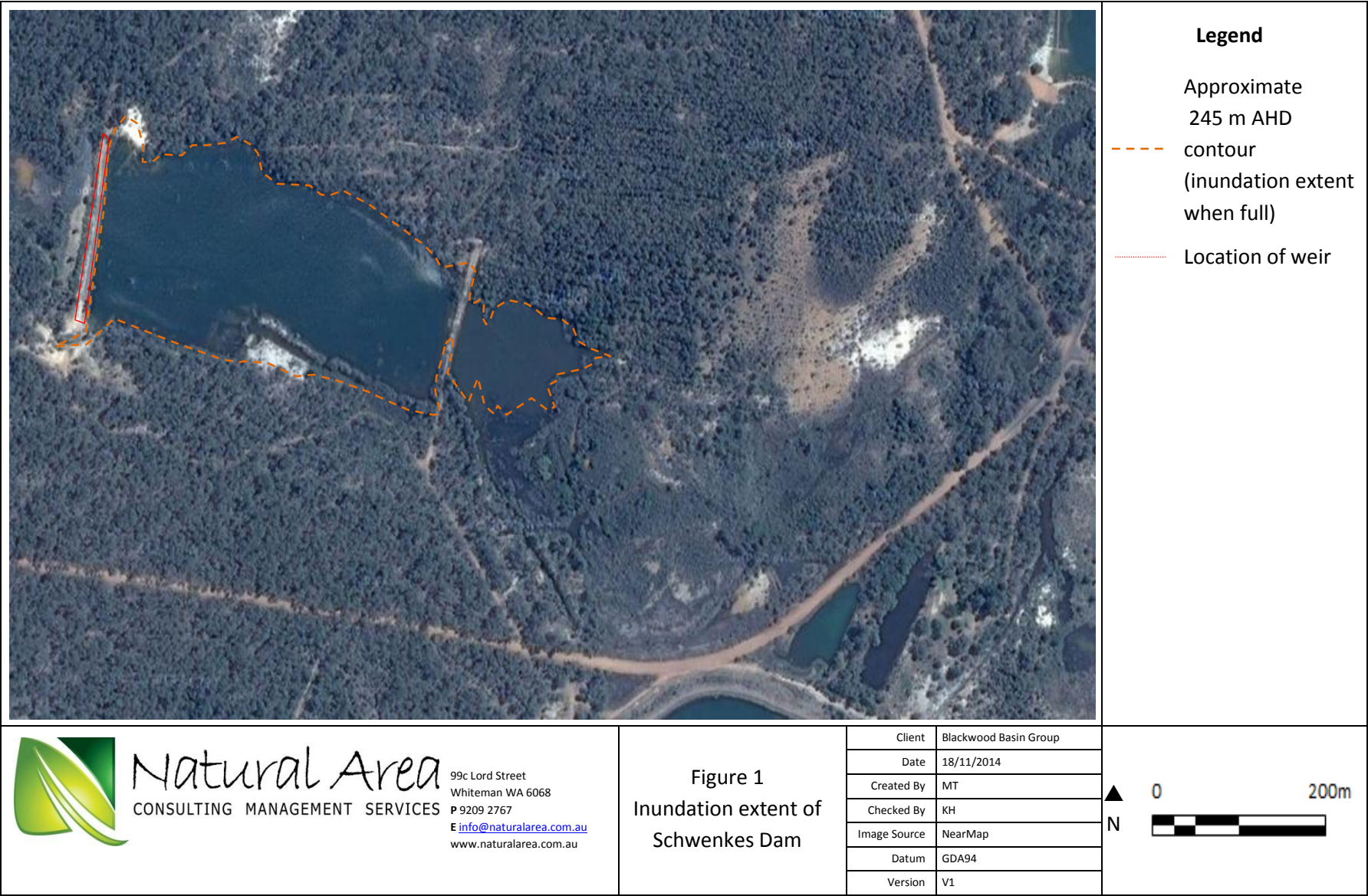
The Greenbushes mine site is situated approximately 300 m above mean sea level within the Darling Plateau in the Blackwood Valley Catchment. Surface soil types surrounding Schwenkes Dam consist predominantly of gravelly sands, sandy clays and clay (Wildy, 2014). Excavation, dredging and mining activities have altered the physical characteristics of Schwenkes Dam and surrounding areas.

### **2.3 Wetland Hydrology**

Water for mineral processing is sourced from rainfall and stored in several process dams, with the majority of water used being recovered and recycled through the water circuit. Surface water quality and depth is measured and reported on a monthly basis.

Schwenkes Dam is a permanent water body and its hydrology is determined by rainfall. Schwenkes Dam is approximately five metres deep, with a maximum open water area of approximately seven ha. Water currently flows from Little Schwenkes to Schwenkes Dam and during times of high water levels, the two basins are connected. Water is retained in Schwenkes Dam by the presence of a weir at the western end (Figure 1). The dam has an overflow point at the western end, which overflows at 245 m above sea level. There are currently no structures within the complex that allow for the implementation of a hydrological regime or a managed wetting and drying cycle.





**Figure 1:** Inundation extent of Schwenkes Dam.

## 3.0 Wetland Values

### 3.1 Environmental Values

Schwenkes Dam is located in the Blackwood Valley catchment and supports a range of wetland and terrestrial flora and fauna. A NatureMap report obtained in October 2014 suggested that a total of 44 fauna species and 60 flora species could be present within a 3 km radius of Schwenkes Dam. Species of conservation significance are outlined in Tables 1 and 2.

**Table 1:** Flora species of conservation significance that could be found at Schwenkes Dam (information from NatureMap, full report included in Appendix 1).

Scientific Name	Common Name	Conservation status/significance	Recorded at Schwenkes Dam
<i>Grevillea ripicola</i>	Collie Grevillea	WC Act: Priority 4	
<i>Melaleuca viminalis</i>		WC Act: Priority 2	

**Table 2:** Fauna species of conservation significance that could be found at Schwenkes Dam (information from NatureMap, full report included in Appendix 1).

Scientific name	Common name	Conservation status/significance	Recorded at Schwenkes Dam
<b>Birds</b>			
<i>Apus pacificus</i>	Fork-tailed Swift	EPBC Act: Migratory WC Act: Schedule 3	
<i>Ardea alba</i>	Great Egret	EPBC Act: Migratory WC Act: Schedule 3	
<i>Burhinus grallarius</i>	Bush Stone-Curlew	DPaW: Priority 4	
<i>Calyptorhynchus banksii</i> subsp. <i>naso</i>	Forest Red-tailed Black-cockatoo	EPBC Act: Vulnerable	Biologic 2011
<i>Calyptorhynchus baudinii</i>	Baudin's Cockatoo	EPBC Act: Vulnerable IUCN: Endangered	Biologic 2011
<i>Calyptorhynchus latirostris</i>	Carnaby's Cockatoo	EPBC Act: Endangered IUCN: Endangered	Biologic 2011
<i>Falco peregrinus</i>	Peregrine Falcon	WC Act: Schedule 4	
<i>Merops ornatus</i>	Rainbow Bee-eater	EPBC Act: Migratory	Biologic 2011
<i>Ninox connivens connivens</i>	Barking Owl	DPaW: Priority 2	
<i>Tyto novaehollandiae</i> subsp. <i>novaehollandiae</i>	Masked Owl	DPaW: Priority 3	

Scientific name	Common name	Conservation status/significance	Recorded at Schwenkes Dam
<b>Mammals</b>			
<i>Dasyurus geoffroii</i>	Western Quoll	EPBC Act: Vulnerable IUCN: Near threatened WC Act: Schedule 1	
<i>Falsistrellus mackenziei</i>	Western False Pipistrelle	DPaW: Priority 4	
<i>Hydromys chrysogaster</i>	Water Rat	DPaW: Priority 4	
<i>Isodon obesulus fusciventer</i>	Southern Brown Bandicoot	DPaW: Priority 5	
<i>Macropus irma</i>	Western Brush Wallaby	DPaW: Priority 4	
<i>Phascogale calura</i>	Red-tailed Phascogale	EPBC Act: Endangered IUCN: Vulnerable WC Act: Schedule 1	
<i>Phascogale tapoatafa</i> subsp. <i>tapoatafa</i>	Southern Brush-tailed Phascogale	ICUN: Near threatened	Biologic 2011
<i>Setonix brachyurus</i>	Quokka	EPBC Act: Vulnerable IUCN: Vulnerable WC Act: Schedule 1	
<b>Reptiles</b>			
<i>Ctenotus delli</i>	Dell's Skink	DPaW: Priority 4	
<i>Morelia spilota imbricata</i>	Carpet Python	DPaW: Priority 4	

### 3.2 Aboriginal Cultural Values

Prior to European settlement, the area was inhabited by Aboriginal tribes of the *Nyungar* groups. Specific tribes *Kaneang* and *Pibelmen* occupied portions of the land within the Shire of Bridgetown-Greenbushes. No Aboriginal sites of significance have been found within the vicinity of Schwenkes Dam (Aboriginal Heritage Inquiry System, 2014).

### 3.3 Social Values

Schwenkes Dam is located close to the township of Greenbushes and is managed by Talison Lithium Operations. Access into the dam is restricted and a key is required to open gates. There are a number of walking trails around Greenbushes, including part of the Bibbulmun Track. Close to the Dam is Greenbushes Pool, a large water body and recreational area. Locals and visitors frequent the pool and the area includes picnic facilities and a playground. There is potential for Schwenkes Dam to be made into a wildlife educational area through the construction of boardwalks and informative signage. However, this will not be discussed as part of this wetland management plan.

## 4.0 Issues and Threats

A range of issues affect the environmental values of Schwenkes Dam. These are discussed in the following section.

### 4.1 Introduced Species

#### 4.1.1 Flora

Invasive weeds displace native species and are a serious threat to the natural environment. Weed invasion can change the natural diversity of ecological communities. A number of weeds have been found in the area surrounding Schwenkes Dam including but not limited to *Watsonia* sp., *Asparagus asparagoides* (Bridal Creeper), *Leptospermum laevigatum* (Victorian Tea Tree), *Gomphocarpus fruticosus* (Cottonbush), *Zantedeschia aethiopica* (Arum Lily), *Cortaderia selloana* (Pampas Grass) and *Echium plantagineum* (Patterson's Curse).

Weed control will be conducted in accordance with relevant permits using up to date information found on FloraBase and will be assessed annually as part of the ongoing vegetation monitoring.

#### 4.1.2 Fauna

Feral foxes, cats and pigs have been observed within the Schwenkes Dam complex (Animal Pest Management Services, 2014).

Fox predation is a major threat to the survival of many species of native fauna. Small ground-dwelling mammals and ground-nesting birds are at greatest risk of predation (Department of Sustainability, Environment, Water, Populations and Communities, 2011a). Feral cats are a major cause of decline for many land-based native species. Predation by feral cats is listed as a key threatening process under the *Environmental Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act, 1999). Feral cats can also carry infectious diseases that can be transmitted to native animals (Department of Sustainability, Environment, Water, Populations and Communities, 2011b). Feral pigs can destroy native vegetation through trampling or feeding activities. Feral pigs have a varied diet which can include bird chicks, reptiles, frogs, invertebrates, fruit, seeds, tubers, bulbs and plant foliage. They can cause a range of habitat changes including the destruction of plants, reduced regeneration, altered soil structure, reduced water quality and availability and can increase the invasion of weeds. They can also spread dieback, the root-rot fungus *Phytophthora cinnamomi* (Department of Sustainability, Environment, Water, Populations and Communities, 2011c).

Fauna control has been undertaken using 1080 baiting and cage traps (Animal Pest Management Services, 2014). This will be assessed annually as part of the ongoing monitoring program.

### 4.2 Dieback

The fungus caused by *Phytophthora cinnamomi* is listed as a key threatening process under the *EPBC Act 1999* (Cwlth). *P. Cinnamomi* is a fungus that grows through the root system of a plant, preventing the plant from absorbing water and nutrients. Once the fungus has spread to the root system of a plant, it releases

asexual spores into the soil, which can be spread through drainage water. Many native plants are susceptible to the fungus including eucalypts, grevilleas, banksias, heath vegetation, rushes and hibbertias.

A survey is currently planned for 2015 to determine what, if any, measures need to be taken at Schwenkes Dam to control the spread of the fungus.

### **4.3 Seasonal Variation**

A lack of seasonal variation in water levels and steep sides of the dam has resulted in a restriction in the distribution and diversity of littoral zone vegetation and habitat. This also reduces the abundance and diversity of fauna found at the site.

### **4.4 Vegetation Clearing**

Vegetation clearing affects native fauna through loss of habitat, with the area usually remaining fragmented or modified. Cleared areas are subject to new disturbance regimes, invasive species, disease and changes in physical effects (wind, temperature, rain). Mining operations have the potential to spread weeds, disturb and destroy habitat and pollute surface water and groundwater sources.

Wherever possible, these issues and threats are addressed in the objectives, proposed wetland management, adaptive management and monitoring sections of this management plan.



## 5.0 Management History

Tin, tantalum and lithium mining has created a series of water bodies of varying sizes and depths. Most of the vegetation surrounding the water bodies has previously been cleared for mining purposes. However, several are fringed with native sedges and rushes that have established naturally.

Schwenkes Dam has already undergone a series of management actions to increase the ecological value to fauna and flora. Actions by the Blackwood Basin Group have included infilling edges along the dam to create shallow shelves suitable for emergent plants (Figure 2). Approximately 14,000 seedlings and 800 mature endemic rushes and sedges (predominantly *Baumea articulata* and *Juncus pallidus*) have been planted into the created zones.



**Figure 2:** Example of a shallow-water shelf created as part of previous earthworks and revegetation undertaken at Schwenkes Dam.

## 6.0 Summary of Monitoring Data

A number of ecological parameters have been monitored at Schwenkes Dam, with data collected on the following physical and ecological parameters:

- surface water quality (salinity, pH, TDS)
- groundwater (elevation and salinity)
- vegetation type and condition
- fish populations
- frog populations
- bird populations
- aquatic macro-invertebrate populations.

In all instances, the latest data have been incorporated into this management plan. Gaps exist in available data and hence there are limitations to interpreting the results. A summary of the available data is presented in the following sections.

### 6.1 Physical Parameters

#### 6.1.1 Surface Water Quality

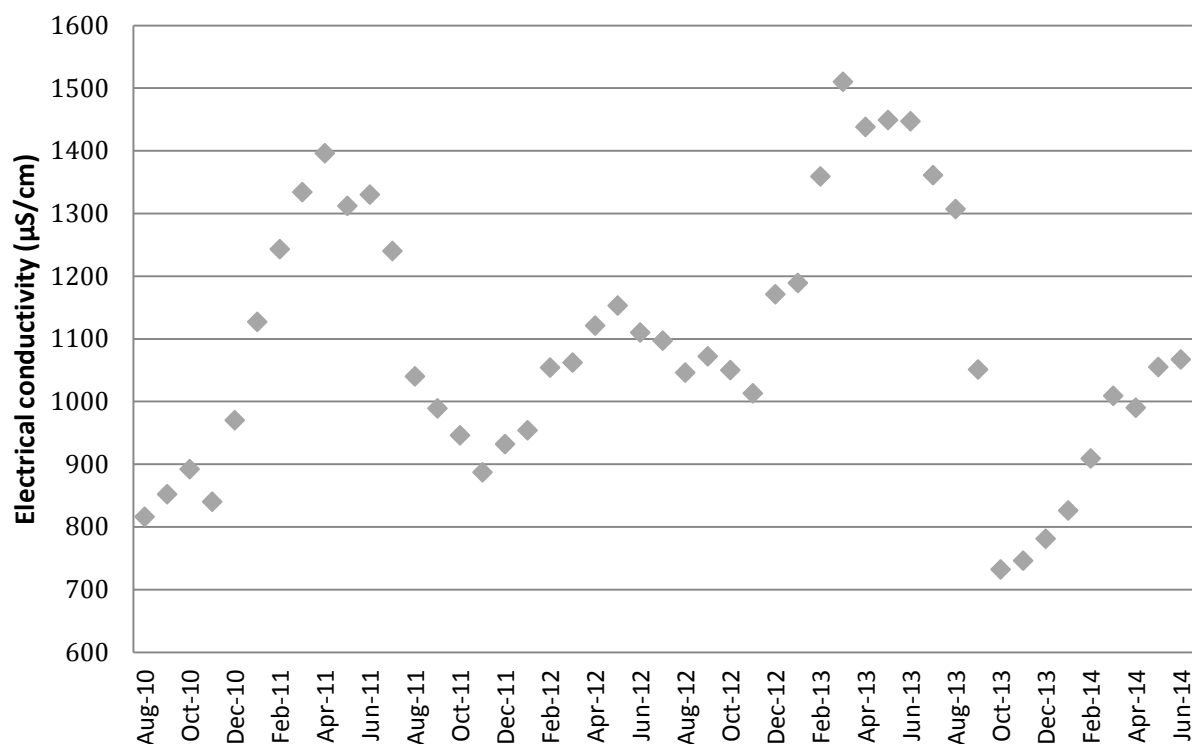
Surface water quality (salinity, turbidity, dissolved oxygen, pH, total dissolved solids, nutrients and cations) is a critical factor in determining wetland aquatic biota communities and is vital in wetland management.

Physical and chemical variations can change over short timeframes (e.g. diurnally) and longer timeframes (e.g. seasonally). Water quality is determined by various factors including flow to groundwater, the surface topography, geology of the wetland bed and banks and the management of the wetland (Tiner, 1999; Mitsch & Gosselink, 2007; Haslam, 2003). As such, water quality parameters are unique for each wetland and can vary considerably over time.

Surface water quality at Schwenkes Dam has been monitored monthly by Talison with data available from August 2010. Samples have been taken from four sites around the dam, the locations of which are shown in Appendix 2.

Surface water salinity is measured as electrical conductivity (EC) ( $\mu\text{S}/\text{cm}$ ). Surface water EC usually reflects the hydrological phases occurring within a wetland, such as wetting and drying. Lower surface water EC levels are likely as a result of freshening flows with salts diluted and/or flushed from the wetland (Tucker 2002). Higher surface water EC readings are likely due to evapoconcentration of salt within the water column as the wetland is undergoing a drying phase (Cramer & Hobbs, 2002; Baldwin et al., 2005). Surface water EC data is presented in Figure 3.

EC within Schwenkes Dam shows a seasonal trend, with the highest values recorded in summer and the lowest at the end of winter. The lowest EC recorded was 732  $\mu\text{S}/\text{cm}$  in October 2013 and the highest was 1,510  $\mu\text{S}/\text{cm}$  in March 2013. The average EC is 1,091  $\mu\text{S}/\text{cm}$ . ANZECC guidelines for south-western Australian wetlands indicate that salinity values between 300-1,500  $\mu\text{S}/\text{cm}$  are within the normal range, with higher values (up to 3,000  $\mu\text{S}/\text{cm}$ ) measured in summer due to evaporative water loss.

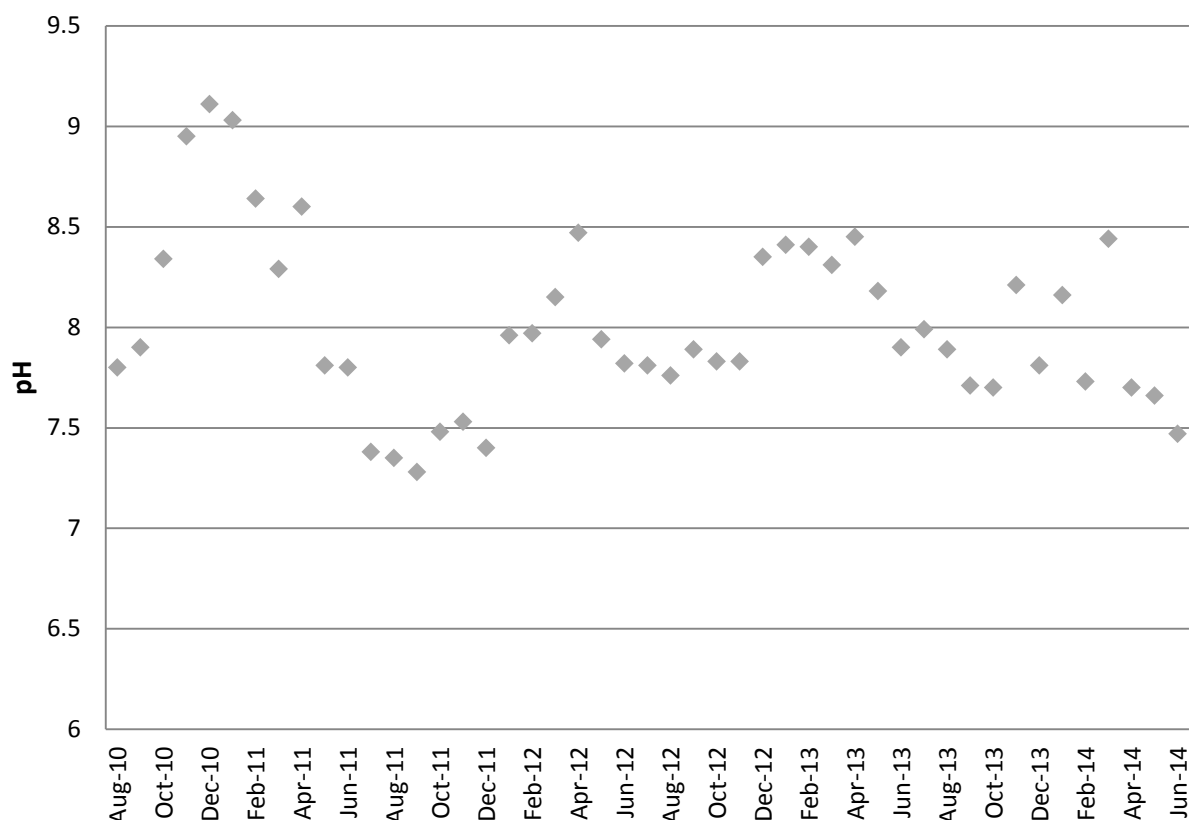


**Figure 3:** Surface water electrical conductivity (µS/cm), Schwenkes Dam August 2010 - June 2014.  
(Note: EC can be converted from µS/cm to parts per million (ppm) or mg/L by multiplying by 0.64).

Surface water pH is a measure of the acidity or alkalinity of the water. Typically, pH falls between 7 – 8.5 (ANZECC, 2000), and any levels outside of this range may indicate unusual processes occurring within the wetland (Baldwin *et al.*, 2005). Higher surface water pH may occur as a result of abundant aquatic macrophytes which remove carbon dioxide from the water column through photosynthesis. This results in elevated pH levels being observed, particularly in summer when photosynthesis rates are high (Cronk & Fennessy, 2001). Additionally, surface water pH may be increased through some bacterial processes, such as denitrification or accelerated algal growth (Baldwin *et al.*, 2005). Lower surface water pH may be caused by high organic loads, bacteria processes (such as nitrification) or oxidation of sulfidic sediments (Baldwin *et al.*, 2005).

Surface water pH within Schwenkes Dam followed seasonal trends, with the highest pH of 9.11 recorded in December 2011 and the lowest of 7.31 recorded in September 2011. Levels have remained below 8.5 since May 2011 (Figure 4).





**Figure 4:** Surface water pH, Schwenkes Dam August 2010 – June 2014.

### 6.1.2 Groundwater

Groundwater variation is a key monitoring component as it affects the way a wetland is managed, particularly hydrologically. Groundwater information can be used to determine the effects of groundwater levels on the salinity of the wetland, with potential impacts including saline seeps or the evaporative concentrations of salts. The below-ground level and salinity of groundwater is determined by several factors including the regional hydrology and wetland geomorphology, particularly the local geology such as the physical and chemical properties of soils and subsoils of the wetland banks, groundwater flow geometry and extraction.

Groundwater levels are measured by recording the depth of water within a piezometer. If the top of the piezometer is measured to a standard height, (i.e. Australian Height Datum, AHD) the water levels in the bores can be calculated and compared to each other. Groundwater gradients may be determined by comparing groundwater levels of two or more bores in a transect. Lateral movement of groundwater is towards the lowest groundwater depth (Figure 5).

There are currently no groundwater bores established at Schwenkes Dam.

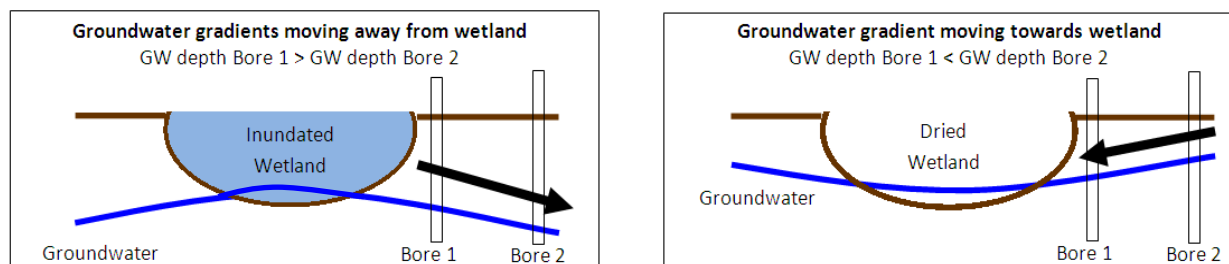


Figure 5: Conceptual diagram of groundwater gradients.

## 6.2 Ecological Parameters

The ecological parameters monitored at Schwenkes Dam are vegetation, fish, frogs, birds and macro-invertebrates.

### 6.2.1 Vegetation

The existing vegetation types within and adjacent to Schwenkes Dam have been described and mapped (Wildy, 2014). An on-ground survey recorded the following details for each group of vegetation:

- topography, slope and surface soil type
- leaf litter cover, occurrence and type of exposed rock
- average height of dominant taxa in each strata
- canopy cover of dominant taxa within each strata
- vegetation condition
- presence of Threatened or Priority flora or other significant flora
- list of all identifiable flora observed.

Nine discrete vegetation types were identified, mapped (Appendix 3) and defined as:

- Disturbed Marri-Jarrah Woodland
- Intact Marri-Jarrah Woodland
- Fringing Vegetation
- Scattered Passive Vegetation
- Jarrah with Bull Banksia
- Paperbarks over Dense Shrubs
- Upland Rehabilitation
- Sedgelands
- Blackbutt Woodland.

The vegetation surrounding the dam is primarily natural regrowth and post-mining revegetation. Dominant shrub species include *Taxandria*, *Astartea* and *Hakea prostrata*. There is a small area of intact *Eucalyptus marginata* over *Banksia grandis*, having some resemblance to historical floristic composition and structure (Wildy, 2014).

### 6.2.2 Fish

Murdoch's University Freshwater Fish Unit undertook fish surveys in 2014. Three fish species were recorded in Schwenkes dam including two native and one non-native species. The native species were Western Minnow (*Galaxias occidentalis*) and Western Pygmy Perch (*Edelia vittata*) and the non-native was

Mosquitofish (*Gambusia holbrooki*). Although recorded in the swimming pool upstream of Schwenkes Dam, there has been no record of Redfin Perch (*Perca fluviatilis*), a voracious predator, in the dam itself. Ongoing monitoring should be undertaken to make sure that Redfin Perch does not access Schwenkes Dam.

### 6.2.3 Frogs

Biologic undertook fauna monitoring surveys at Schwenkes Dam and surrounding areas in October 2011. Each species of frog has a unique call (only males will call) which can be identified from other species. Five species were recorded during the survey:

- Quacking Frog (*Crinia georgiana*)
- Clicking Froglet (*Crinia glauerti*)
- Western Banjo Frog (*Limnodynastes dorsalis*)
- Slender Tree Frog (*Litoria adelaidensis*)
- Motorbike Frog (*Litoria moorei*).

Individuals of the Western Banjo Frog and Quacking Frog were visually identified during the nocturnal surveys.

### 6.2.4 Birds

Water bird surveys have been undertaken by members of the Blackwood Basin Group at Schwenkes Dam in order to determine changes in species composition, richness and abundance in response to changes in wetland conditions. Wetland surface water levels influence what types of birds can utilise the wetland, while surface water quality influences food resources available to birds, therefore also determining the community composition. Variations of water levels within a wetland increases the diversity of habitats for foraging and breeding which are essential for water-bird communities (Kingsford *et al.*, 2004).

Water bird monitoring has occurred on four occasions at three sites in Schwenkes Dam. A total of 10 water bird species (Table 3) has been recorded from a range of functional groups including piscivores (such as Cormorants, Darters and Grebes), deep water foragers (Musk Duck and Eurasian Coot), dabbling ducks (Pacific Black Duck) and small waders (Black Fronted Dotterel).

**Table 3:** Bird Survey results at Schwenkes Dam 2013-2014

Scientific name	Common name	October 2013	December 2013	February 2014	May 2014
<i>Anas superciliosa</i>	Pacific Black Duck	X			
<i>Anhinga novaehollandiae</i>	Australasian Darter				X
<i>Biziura lobata</i>	Musk Duck	X	X		X
<i>Egretta novaehollandiae</i>	White-faced Heron	X		X	X
<i>Charadrius melanops</i>	Black-fronted Dotterel			X	
<i>Fulica atra</i>	Eurasian Coot	X			

Scientific name	Common name	October 2013	December 2013	February 2014	May 2014
<i>Phalacrocorax melanoleucos</i>	Little Pied Cormorant	X	X	X	X
<i>Phalacrocorax carbo</i>	Great Cormorant		X		
<i>Poliiocephalus poliocephalus</i>	Hoary-headed Grebe				X
<i>Tachybaptus novaehollandiae</i>	Australasian Grebe			X	X

### 6.2.5 Aquatic Macro-invertebrates

Aquatic macro-invertebrates form an important part of the food chain for fish, frogs and birds. They are also useful indicators of wetland health with some species sensitive to pollutants or changes in water quality. It is important to monitor changes in species composition and abundance to gain an indication of the effects of point and non-point pollution, changes in physical condition of a wetland and overall water quality.

Currently, aquatic macro-invertebrate sampling and analysis at Schwenkes Dam is inconsistent, with sampling techniques and timing varying between sites. Sampling techniques that are comparable between surveys need to be implemented to monitor species diversity and abundance over time. Sampling techniques and monitoring designs are discussed in Section 9.0.

## 7.0 Wetland Management Objectives

The management objectives for Schwenkes Dam have been developed based on a review of:

- monitoring data from the site
- topographical, climate and geological data for the site
- information that has become available since the development of the project.

The objectives for Schwenkes Dam, which aim to support the site's recovery from the effects of recent mining activities, and create a healthy and resilient wetland supporting a range of native biota are:

1. Establish breeding and feeding habitat suitable to support Department of Parks and Wildlife (DPaW) priority species Australasian Bittern (*Botaurus poiciloptilus*), Black Bittern (*Ixobrychus flavicollis australis*) and Australian Little Bittern (*Ixobrychus minutus*).
2. Increase populations of water-dependent birds from a range of functional groups and observe an increase in breeding events.
3. Increase vegetation diversity and cover, and improve vegetation condition within the wetland complex (including submerged, emergent and ephemeral vegetation).

### 7.1 Primary Objective: Establish breeding and foraging habitat suitable to support DPaW listed Australasian Bittern, Black Bittern and Little Bittern

#### 7.1.1 Rationale

The population range of the three listed or protected Bitterns in Western Australia has reduced due to changes in wetland habitat particularly vegetation clearing and land use. Bitterns are able to move between wetlands as site and habitat suitability changes. However, they have comparatively specialised habitat requirements.

The Australasian Bittern is found in shallow freshwater or brackish wetlands which contain large stands of rushes or sedges. Pairs occupy territories containing a mixture of tall and short sedges for breeding, though will feed in more open swamp vegetation (Marchant and Higgins, 1990). They forage predominantly at night on a range of fauna including birds, mammals, fish, frogs and macro-invertebrates. Breeding season is from September to December and nests are well constructed in reed beds.

The Black Bittern inhabits dense vegetation growing at the margins of permanent wetlands. They predominantly feed on fish and amphibians, foraging in both day and night. Black Bitterns roost and nest in trees over water.

Australian Little Bitterns are found in freshwater wetlands with dense emergent vegetation and inundated shrub thickets. They are solitary and secretive, feeding predominantly at dusk or night.

In wetlands used by Bitterns, littoral zone vegetation grows around the margins in the area that is periodically both exposed and inundated by water level fluctuations. The width of this band reflects the water level variability and wetland topography. Due to relatively static water levels in Schwenkes Dam, this zone is limited in size. The various emergent species within this zone grow on different sections of the elevation gradient depending on their inundation depth and duration requirements and tolerances.

Littoral zone vegetation forms important habitat for a wide range of wetland biota and performs a number of other important functions within wetlands such as improving water quality, reducing erosion, aiding oxygen transport to sediments and influencing wetland temperature and light penetration.

Restoring and expanding littoral zone vegetation diversity and encouraging this community to expand further up and down the elevation gradient will create increased Bittern habitat extent and hence is a key objective for the management of the site over the next five years.

### **7.1.2 Targets**

The specific targets associated with meeting this objective are:

- Littoral zone vegetation community in Little Schwenkes Dam covering a greater area (target of four to seven ha).
- Littoral zone vegetation species diversity increased.
- Recruitment of littoral zone vegetation species (via germination or vegetation expansion) following draw down events.
- No net loss of littoral zone sedge or rush species as a result of proposed earthworks.

### **7.1.3 Management Actions**

The recommended management actions associated with this objective are:

- Design earthworks for Little Schwenkes Dam to restore and expand littoral zone rush and sedge vegetation community.
- Create (or facilitate) fluctuating water levels to encourage the establishment and maintenance of a range of littoral zone vegetation species.
- Reduce percentage cover of invasive plant species and prevent new invasive species from becoming established, particularly during the earthworks stages.
- Ensure that dry phases do not exceed the maximum inter-flood dry period tolerated by the target vegetation species in the littoral zone.

### **7.1.4 Monitoring**

The recommended monitoring requirements associated with this objective are:

- Quantitative vegetation monitoring across the littoral zone.
- Vegetation transects across the littoral zone.
- Photo point monitoring which record the areal extent of vegetation.
- Recording level of vegetation recruitment during drawdown events.

These monitoring events are discussed further in Section 9.0.

## **7.2 Secondary Objective 1: Increase populations of water-dependent birds from a range of functional groups and observe an increase in breeding events**

### **7.2.1 Rationale**

Schwenkes Dam can support a large number of water-dependent bird species from a range of functional groups, including species of conservation significance. As a high-order consumer, water birds are important indicators of habitat condition and food resource availability (Tucker 2002). It is anticipated that through the

establishment of a range of wetland habitats (such as, but not limited to, deep and shallow water habitats and wet mud), a range of water-dependent bird species across functional groups will be supported.

### **7.2.2 Targets**

The specific targets associated with this objective are:

- Record an increase in diversity (>10) and abundance of water bird species during surveys across a range of functional groups and abundances utilising a range of habitats.
- Record evidence of species breeding.

### **7.2.3 Management Actions**

The management actions recommended to the achieve of this objective are:

- Implement an operational regime that supports water level fluctuations to assist in the establishment of foraging and breeding habitats by increasing and maintaining emergent macrophytes, mudflats and fringing vegetation.
- Investigate the feasibility of making further improvements to habitat to increase water bird abundance and breeding activity (e.g. the addition of roosting logs).

### **7.2.4 Monitoring**

The monitoring associated with this objective to inform management and measure success is:

- Bird surveys undertaken in at least spring and autumn of each year.
- Increase the frequency of surveys during refill and drawdown phases in order to detect cryptic species such as crakes and rails.

## **7.3 Secondary Objective 2: Increase the diversity and cover, and improve the condition of vegetation within the wetland complex (including submerged, emergent and flood dependent vegetation)**

### **7.3.1 Rationale**

Submerged vegetation provides habitat for frogs, fish, crustaceans and macro-invertebrates (Tucker 2002), important food sources for water birds particularly the Australasian Bittern. Long-lived flood-dependent vegetation such as *Melaleuca raphiophylla*, also provide important habitat and ecological functions. Managing the site for an improvement in habitat is likely to benefit a wide range of fauna, improving the ecological value of the site. It is anticipated that the introduction of a variable hydrological regime will result in submerged and emergent vegetation extending further up and down the elevation gradient.

### **7.3.2 Targets**

The specific targets associated with meeting this objective are:

- Establish submerged and emergent zone aquatic vegetation species.
- Support the recruitment of submerged vegetation by implementing a drawdown phase.
- Reduce percentage cover of invasive plant species and prevent new invasive species from becoming established, particularly during the earthworks stages.

### **7.3.3 Management Actions**

The management actions recommended to achieve this objective are:

- Implement a hydrological regime that provides increased seasonal variations in water levels (to allow wetting and drying of the root zone vegetation) through earthworks or the release of water from the downstream weir.
- Plant a diverse variety of wetland plant species across the range of elevations and water levels.
- Undertake weed control activities.

#### **7.3.4 Monitoring**

The monitoring associated with this objective to inform management and measure success is:

- Photo point monitoring.
- Quantitative vegetation monitoring across a range of elevations.
- Recording of recruitment events following flood, drawdown and refill.
- Frog and macro-invertebrate monitoring to ensure diversity and abundance is increasing to provide a food source for Bitterns and other fauna.



## 8.0 Proposed Wetland Management

To achieve the objectives for the rehabilitation of Schwenkes Dam, active management of the wetland's hydrology and a range of other associated actions are proposed for the period 2015-2020. These are discussed below. The wetland should be adaptively managed and a range of triggers have been identified to initiate a review of the current or planned management.

### 8.1 Hydrology

The hydrological management of Schwenkes Dam will be achieved through earthworks predominantly in Little Schwenkes Dam and it will require adaptive management. The operational regime (defined in Table 5 below) aims to manage (and maintain) wetland area expansion and revegetation by extending the current wetland boundaries through shallow excavations. The operational regime has an initial 5-year cycle, from January 2015 until December 2019 at which point (if not earlier) it should be reviewed and updated.

The operational regime should be considered a guide to the hydrological management of the site and should therefore be modified, as appropriate, if monitoring results provide and support sufficient evidence to initiate a change in management strategies. Changes may occur as a result of the findings from monitoring, which will be undertaken for the duration of the management period, as a result of natural process such as high or low rainfall years or as directed by relevant authorities.

As hydrological management of Schwenkes Dam is currently limited, if the management objectives are not met by natural inundation, the retention of floodwaters within the wetland to increase flood duration should be considered. This could be achieved by installing a flow control structure at the interface between Schwenkes and Little Schwenkes Dam and closing the structure when water levels start to recede. Although this will provide valuable benefits for the upper littoral and riparian zone, the closing of the structure can have negative impacts by impeding passage to fish or restricting flows downstream. Therefore, this management decision should only be considered if the duration of natural inundation is shorter than desired and the littoral zone has not received suitable inundation to achieve objectives.

### 8.2 Earthworks

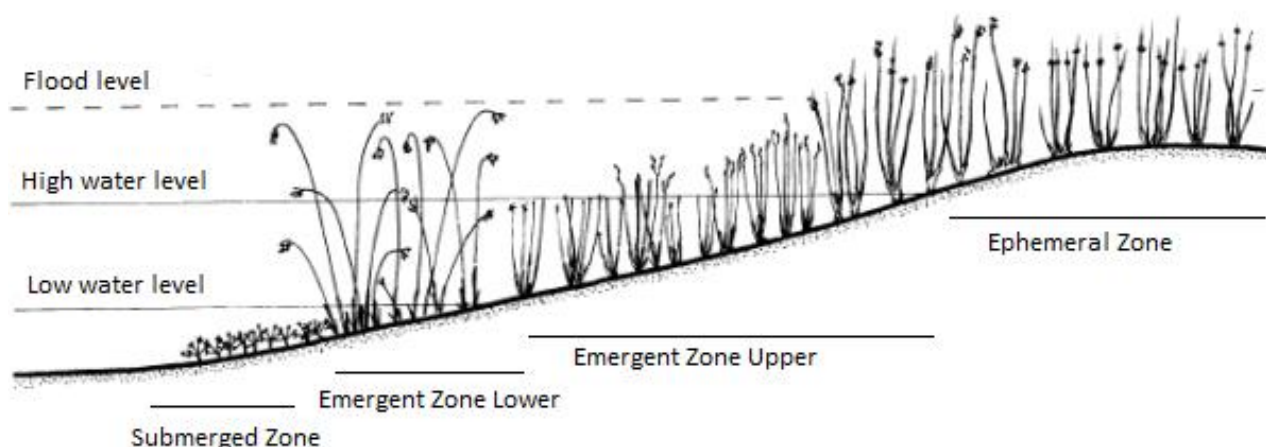
In order to achieve the management objectives and proposed hydrological regime for Schwenkes Dam, it is necessary to implement earthwork strategies. A number of actions are recommended to be completed prior to the implementation of the earthworks program including:

- acid sulphate soil assessment
- measuring depth to groundwater
- soil and subsoil testing
- determine macro-invertebrate community.

Understanding groundwater processes will ensure that potential saline regional groundwater will not pose a threat to the wetland. Groundwater bores should be established to study groundwater movement and quality. To ensure the dam's water holding capacity is maintained, soil and subsoil layers needs to be identified prior to excavations. This will ensure that earthworks do not occur in unsuitable soil types (e.g. in porous materials which may act as conduits to drain water away from the dam).

Earthworks are scheduled to coincide with periods of low water levels and completed in the most efficient way possible so as not to cause damage to fauna within the dam. If water levels are not suitable at the proposed excavation time, water release through the weir at the western end of Schwenkes Dam should be considered. Machinery should be operated out of the waterway on dry and stable areas within the works site where practical. An Environmental Management Plan that addresses the possibility of hydraulic oil leaks and fuel spills should be implemented prior to any earthworks.

The aim of the earthworks is to increase the area of the wetland by lowering the surrounding landscape through shallow excavations. As the wetland overflows at 244.9 m above sea level, the area excavated needs to be below this level allowing for an increased area of inundation. To promote the successful establishment of wetland vegetation, vegetative zones need to be established at specific water depths. There are clear distinctions between vegetative zones within a wetland and they include; submergent zone, emergent zone (upper and lower) and ephemeral zone (Figure 6). Planting shelves can be constructed in the dam to provide areas suitable for emergent macrophytes and should have an average water depth of 0.1 - 0.8 m. Vegetation zones at Schwenkes Dam, as defined by the earthworks are outlined in Figure 6. The species suitable are discussed further in Section 8.2.1.



**Figure 6:** Wetland vegetation zones (adapted from Water and Rivers Commission, 2000).

Ephemeral zones have greater species diversity than permanently inundated zones and provides important foraging habitat for water birds. The ephemeral zone should be 0.2 - 0.8 m deep at maximum water level (244.9m above sea level). This will result in the inundation of the ephemeral zone throughout winter and into late spring, with a drying phase from late spring to early autumn.

It is important that the earthworks implementation be completed over two years, to allow for adaptive management of the works. Stage One will be completed in the first year of earthworks and will provide a greater understanding of the inundation extent and management objectives that can be achieved. If Stage One is successful, Stage Two can be implemented in the following year. If Stage One is not successful, the operational plan will need to be reviewed and updated to reflect changes in management. Figure 7 shows the proposed earthworks.

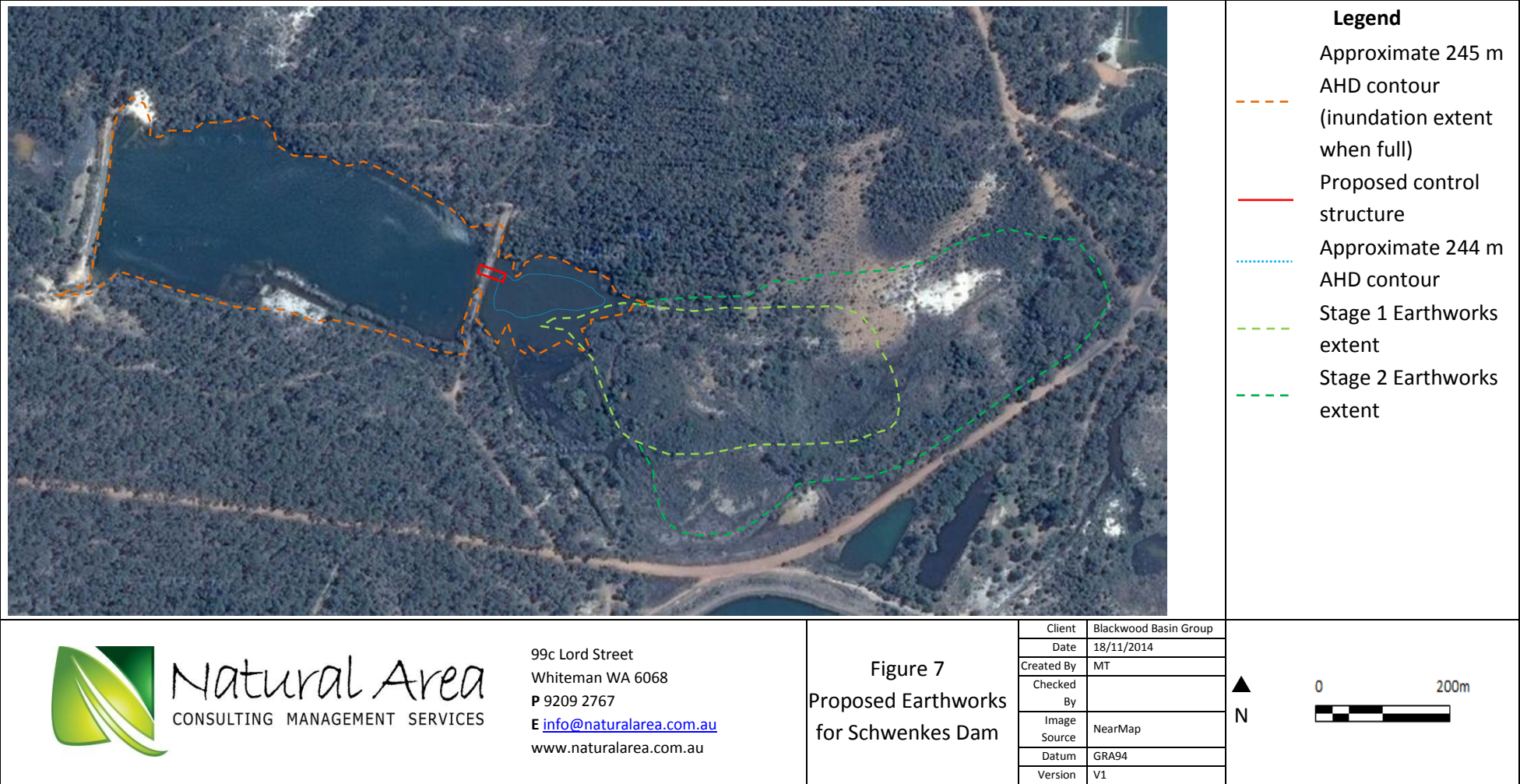


Figure 7: Proposed earthworks for Schwenkes Dam

## 8.3 Associated Management

In addition to the hydrological management of Schwenkes Dam, a number of associated management actions are recommended. These are outlined and discussed below.

### 8.2.1 Revegetation

The vegetation species selected to plant in the excavated area of Schwenkes Dam are based on preferred habitat for Bittern foraging and nesting (Marchant and Higgins, 1990). Rushes and sedges have specific hydrological requirements and are not adapted to stable water levels.

An understanding of the hydrology of the site is important to ensure survivorship of the revegetation. Water levels should be recorded after earthworks to define the wetland zones. To avoid a monoculture developing and to encourage a diversity of fauna, a variety of plant species have been considered (Table 4).

A concept diagram, showing Schwenkes Dam after the proposed earthworks summarises the overall planting zones (Figure 8). Revegetation should be undertaken when water levels are low (late summer, early autumn), as plants require depths of less than 0.2 m for their establishment. Seedlings can tolerate some water logging but excessive water can drown seedlings. It is anticipated that planting will occur in February to April. During the establishment phase, plant growth should be monitored regularly to allow for a rapid response to any problems. Ongoing weed control is necessary to stop the infiltration of invasive plants into the revegetation area.

Planting densities should be between three and five plants per square metre during the initial planting phase. Infill plantings will be calculated to achieve the target of 80% survival rate of seedlings after three years. Performance criteria associated with the revegetation of Schwenkes Dam include:

- 80% survival rate of seedlings after three years.
- Natural establishment of native seedlings within three years.
- No decline in the condition of vegetation in the area.

**Table 4:** Plant species for Schwenkes Dam revegetation

Zone	Species	Water depth	Notes
Submerged			Through the introduction of a wet/dry water regime, submerged vegetation will naturally expand
Emergent upper	<i>Baumea arthropphylla</i>	Damp to 1 m	
	<i>Baumea articulata</i>	Damp to 1 m	
	<i>Baumea juncea</i>	Ephemeral to 30 cm	
	<i>Baumea preissii</i>	Damp to 30 cm	
	<i>Eleocharis acuta</i>	Damp to 30 cm	Low salinity tolerance

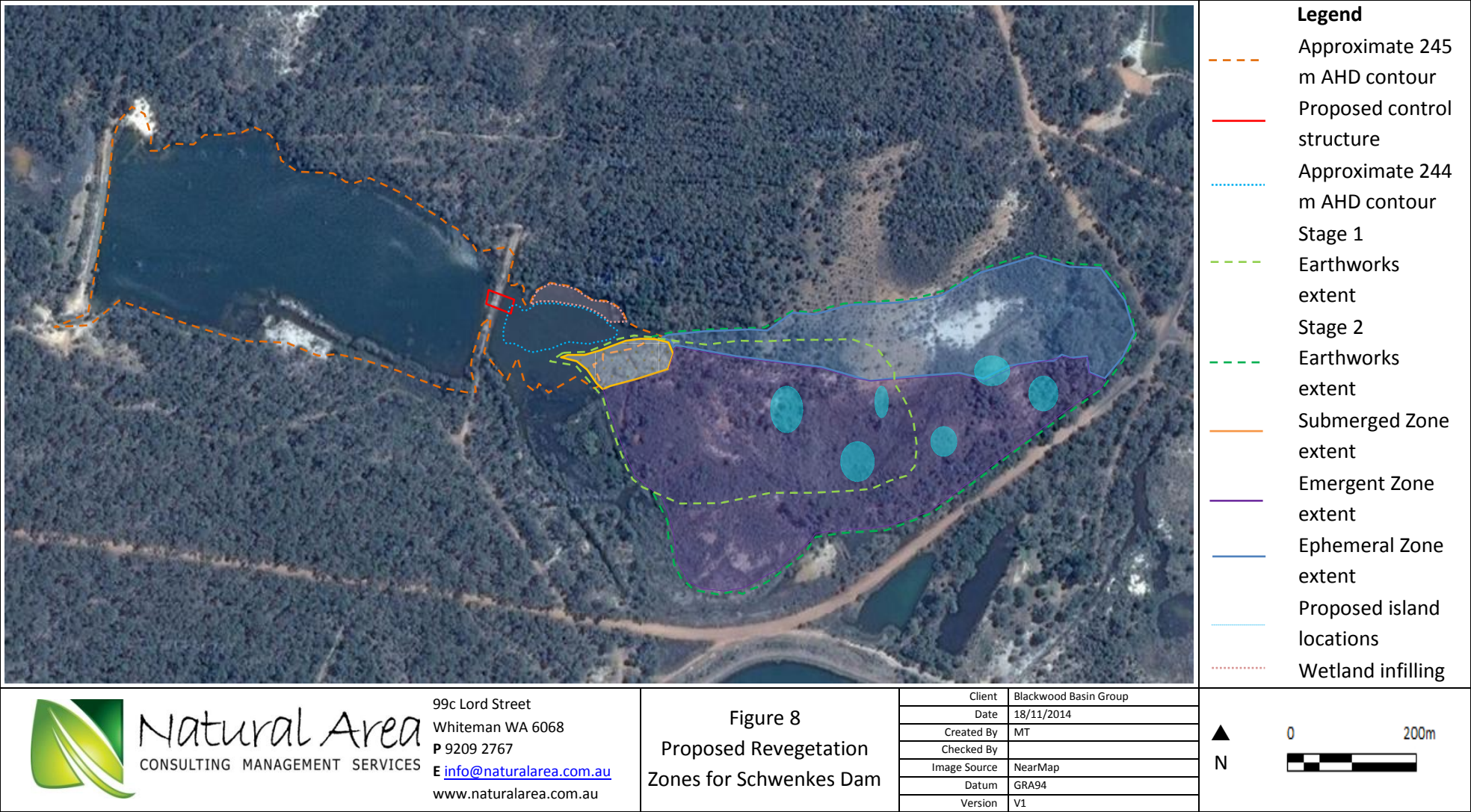
Zone	Species	Water depth	Notes
Emergent lower	<i>Schoenoplectus validus</i>	Emergent upper to 1 m	Tolerates brackish water and drying for up to 217 days in two years but more abundant in permanent water
	<i>Schoenoplectus pungens</i>	40 cm	
	<i>Eleocharis sphacelatus</i>	Damp to 1 m	
Ephemeral	<i>Juncus kraussii</i>	Damp	
	<i>Juncus pallidus</i>	Damp	
	<i>Juncus pauciflorus</i>	Damp	
	<i>Juncus subsecundus</i>	Damp	
	<i>Carex appressa</i>	Damp to 10 cm	
	<i>Carex fascicularis</i>	Damp to 20 cm	
	<i>Bolboschoenus caldwellii</i>	Damp to 20 cm	Found in sites infrequently flooded; survival depends on amount of emergent tissue
	<i>Lepidosperma effusum</i>	Damp	
	<i>Gahnia decomposita</i>	Damp	
	<i>Gahnia trifida</i>	Damp	
	<i>Bolboschoenus caldwellii</i>	Damp	Prefers permanently saturated or water-covered mud
	<i>Eucalyptus rudis</i>	Edges	
	<i>Melaleuca raphiophylla</i>	Edges	
	<i>Melaleuca preissiana</i>	Edges	

### 8.2.2 Other

The proposed management actions are defined in Table 5. Other actions required at Schwenkes Dam include:

- surveying the existing wetland area to locate *Melaleuca sp.* to retain and keep as islands
- installation of groundwater bores (pre-earthworks), if deemed as required by the Blackwood Basin Group
- establishing additional photo points
- establishing vegetation quadrats and transects
- weed control pre- and post-earthworks
- test for acid sulphate potential.





**Table 5:** Proposed management actions for Schwenkes Dam 2015 - 2019

Year	Timing and duration	Associated management actions	Description and expected responses
1 (January 2015 - November 2015)	January - February	Ensure pre-management data is collected	Install and monitor groundwater bores (if deemed necessary by the Blackwood Basin Group), survey the wetland bed for its soil/subsoil properties, test for acid sulphate potential in area to be cleared, establish additional photo points, conduct a baseline aquatic macro-invertebrate survey. Determine if water needs to be released from weir in order to reach optimum depth for earthworks. Should be around the 244 m above sea level inundation extent.
	February	Earthworks Stage 1	To occur when wetland water level is low. This will also encourage the expansion of submerged and emergent vegetation along the wetland bed and create new and higher quality habitat for macro-invertebrates and frogs.  Monitor groundwater levels throughout this process.
	February - April	Revegetation	Revegetate in zones as defined by anticipated hydrology post-earthworks.
	May - October	Monitoring	Monitor water level depth, inundation extent, groundwater levels and surface water quality as a result of earthworks. Take note of rainfall data (is it an above, below or average year for the area?). Did the water level reach overflow of 245 and inundate the main area of Schwenkes Dam?  Set up transects and quadrats for on-going vegetation monitoring.
	July – November	Ongoing management	Weed control as necessary.
	October -November	Monitoring	Monitor rate of water level decline (how long is the area inundated for, rate of water decline, depth?). How has this differed from previous years?  Continue to monitor groundwater bores.

Year	Timing and duration	Associated management actions	Description and expected responses
2 (December 2015 - November 2016)	December - February	Drawdown	Drawdown (via evaporation) should encourage the colonisation of littoral zone vegetation species across the vegetation gradients as soil moisture is retained for sufficient time to allow seedling establishment. As well, summer is the ideal germination season for most species. Water levels at this time of year should expose the lower (deeper, less frequently exposed) littoral zone. May need to assist drawdown through water release from weir. Monitor drawdown and apply management actions as deemed necessary.
	February	Earthworks Stage 2	Adaptive management, will only be needed if objectives are not met with initial earthworks. The ephemeral zone can be extended beyond initially proposed boundaries described in the earthworks plan. If deemed feasible, earthworks should occur when water level is at its lowest. Consider earthworks actions and planning.
	February - April	Revegetation	Complete revegetation of earthworks Stage 1 and start revegetation of earthworks Stage 2.
	May - October	Refill phase	Wetland should inundate the upper littoral zone and support the germination and establishment of submerged aquatic vegetation. The inundation should support the range of biota that rely on spring flooding such as fish, frogs and birds.  Consider retaining additional water (via flow control structure) to prolong duration of high water levels if the natural peak is likely to be too low or too short.



Year	Timing and duration	Associated management actions	Description and expected responses
3 (December 2016 - November 2017)	October - November	Drawdown phase	<p>Wetland should naturally drawdown to support the establishment of littoral zone vegetation by exposing the wetland bed.</p> <p>Adaptive management may be needed if the drawdown phase does not reach expected levels.</p> <p>Weed control as deemed necessary.</p>
	December - May	Monitoring	<p>Monitor drawdown phase (water levels, groundwater and surface water).</p> <p>Consider installing bird resting logs as defined by species using the area.</p>
	May - November	Monitoring during refill and drawdown phases	<p>Wetland should naturally drawdown to support the establishment of littoral zone vegetation by exposing the wetland bed.</p> <p>The wetland should refill to the upper littoral zone.</p> <p>Adaptive management may be needed if the drawdown or refill phases do not reach expected levels.</p>
	July – September	On-going management	Weed control as necessary.
4 (December 2017 - November 2018)	December - November	Monitoring	<p>Weed control and feral animal control as water-dependent bird abundance and diversity increase in the dam.</p> <p>Have the management actions been successful in meeting objectives? Is the revegetation successful and being maintained in the area?</p>

Year	Timing and duration	Associated management actions	Description and expected responses
5 (December 2018 - December 2019)	December - December	Drawdown and refill phases	<p>Wetland should naturally drawdown to support the establishment of littoral zone vegetation by exposing the wetland bed.</p> <p>The wetland should refill to the upper littoral zone.</p> <p>Adaptive management may be needed if the drawdown or refill phases do not reach expected levels.</p> <p>Have the management actions been successful in meeting objectives?</p>

## 8.4 Adaptive Management Triggers

Wetlands are highly complex, dynamic and variable ecosystems that are influenced by a wide range of internal and external biotic and abiotic factors. Although the best available information has been used to develop this plan, management of the wetland into the future needs to be adaptive – altering where required based on changing environmental conditions and the onground information provided by monitoring. Where possible, this process should be maximised by incorporating trials and experimentation into the management of the wetland (active adaptive management).

A range of events and monitoring results have been identified which should trigger a review of the Schwenkes Dam's management (Table 6). Wherever possible these triggers have been set at a 'pre-impact' level of change. This maximises the likelihood that a management response can be considered, and if necessary applied, prior to negative impacts being experienced. The triggers are therefore not intended to represent thresholds beyond which ecosystem decline occurs, but rather to alert wetland managers of potential trends in this direction. The triggers identified for Schwenkes Dam are:

- Widespread germination of Typha across the wetland bed.
- Threat of saline groundwater intrusion.
- Short duration of winter flooding predicted.
- Inadequate water depths achieved during winter flooding.
- Decline in surface water quality.
- Widespread germination of emergent plants, blocking channel connecting Schwenkes and Little Schwenkes Dam.
- Loss of aquatic vegetation in the wetland body or deterioration in condition of riparian edge vegetation.
- Lack of adequate seasonal drops in wetland level.
- Lowered pH due to exposure of acid sulphate soils should they exist on site.
- Lower than expected survival rate of seedlings or natural regeneration is not occurring.

**Table 6:** Triggers to review the management of Schwenkes Dam

Trigger	Potential response(s)
Widespread germination of Typha across the wetland bed	<ul style="list-style-type: none"> <li>Consider physical removal of seedlings prior to refill.</li> </ul>
Threat of saline groundwater intrusion	<ul style="list-style-type: none"> <li>Thorough groundwater survey and monitoring log prior to any earthworks being completed.</li> <li>Assess likely impacts and consider need to alter planned management (including assessment of impacts of changing management on other objectives).</li> </ul>
Short duration of winter flooding	<ul style="list-style-type: none"> <li>Consider closing flow control structure (if implemented) at water level peak to hold in water and prolong inundation duration, particularly if flood of short duration was experienced in previous year.</li> </ul>
Inadequate water depths achieved during winter flooding	<ul style="list-style-type: none"> <li>Consider closing flow control structure (if implemented) at flood peak and pumping water into the dam to raise water level, particularly if flood of suitable height has not been experienced in previous year.</li> </ul>
Decline in surface water quality	<ul style="list-style-type: none"> <li>Determine possible causes of surface water quality decline.</li> <li>Consider whether a change in proposed management will result in negative impacts on other objectives.</li> </ul>
Widespread germination of emergent plants, blocking connection between Schwenkes and Little Schwenkes Dam	<ul style="list-style-type: none"> <li>Assess likely impacts and consider the need to alter management (including assessment on impacts of changing management on other objectives).</li> <li>Consider other methods of controlling vegetation growth (e.g. slashing/spraying) to overcome the need to alter the planned management.</li> </ul>
Lack of adequate seasonal drop in wetland level	<ul style="list-style-type: none"> <li>Monitor any decline in littoral zone vegetation, particularly species that are flooded for longer than their tolerance limits.</li> <li>Assess likelihood that decline in littoral zone vegetation condition is resulting from lack of water level drawdown.</li> <li>Consider releasing water from Schwenkes Dam weir.</li> </ul>
Lowered pH due to the presence of acid sulphate soils	<ul style="list-style-type: none"> <li>Pre-test for acid sulphate potential.</li> <li>Consider whether a change in proposed management will result in negative impacts on other objectives.</li> </ul>
Less survival rate of seedlings than expected (80%) or natural regeneration is not occurring.	<ul style="list-style-type: none"> <li>Organise infill planting of species from the list provided.</li> <li>Research alternate strategies to rehabilitate these areas (i.e. planting seedlings, direct seeding, transplanting wetland plants from other wetlands around Greenbushes).</li> </ul>

## 9.0 Monitoring

On-going monitoring is essential for assessing the success or otherwise of the Wetland Management Plan's objectives and for allowing adaptive management to occur. Table 7 below outlines the monitoring schedule required for Schwenkes Dam. The table identifies monitoring techniques, timing, the purpose of the monitoring and its priority level.

### 9.1 Monitoring Methodology

Monitoring of Schwenkes Dam and how it responds to change is essential to facilitate adaptive management. Ongoing monitoring assesses if the management objectives are being achieved and enables the refinement of management actions. It is essential to establish permanent monitoring sites and describe their biological and physical characteristics in detail. This section suggests possible monitoring techniques that are based on standard monitoring procedures.

#### 9.1.1 Surface water

A depth gauge should be positioned at a permanently inundated point in the wetland and surveyed to Australian Height Datum. This will allow for the monitoring of seasonal changes in water depth. In-situ monitoring of water quality should be carried out at least quarterly and include:

- pH
- dissolved oxygen
- electrical conductivity
- temperature
- turbidity
- external environmental conditions (such as time, temperature, recent rainfall).

This data is then compared with ANZECC guidelines and trigger values (ANZECC 2000).

#### 9.1.2 Groundwater

Groundwater bores should be established at a minimum of six locations and monitored for water depth and electrical conductivity. Water within the piezometer should be bailed to remove at least three times the volume of water within the bore casing to ensure a representative sample is used. Once the groundwater has seeped back into the bore, water level can be measured and the bailer can be used to collect a sample to obtain electrical conductivity analysis. This should be done at least quarterly and carried out in conjunction with surface water monitoring.

#### 9.1.3 Vegetation

To measure the rehabilitation success, transects and quadrats should be established and monitored each spring or more frequently if possible. Transects should be 30 m long and marked with galvanised star pickets. Each transect will have 1 m x 1 m quadrats spaced four metres apart to give a total of six quadrats per transect. The minimum data collection requirement for each vegetation transect should be:

- location coordinates
- hydrological information (i.e. water levels)
- vegetation structure and percentage cover

- vegetation condition
- species presence
- count of planted seedlings and naturally regenerated seedlings.

Photographs should be taken at every quadrat along the transect to show the nature and condition of the vegetation present.

Vegetation condition and reproductive success should be measured to assess the success of the management objectives. This can be done through the establishment of monitoring quadrats in the area. Three to ten 5 m x 5 m permanent quadrats should be assessed for species diversity and abundance, indicators of stress, reproductive success and presence of weeds.

#### **9.1.4 Fish**

Fish monitoring should take place at least once per year, preferably in spring (and again in autumn if possible). Fish community data can determine if recruitment has occurred or if population changes have occurred as a result of management actions. To allow data comparisons, surveys should be repeated using the same methodology and time frame as previously used.

#### **9.1.5 Frogs**

Frog diversity can be determined by identifying their calls. Surveys should be conducted throughout spring and early summer during the evening. At minimum of three permanent monitoring sites should be established at least 150 m apart. Calls can be recorded for approximately 10 minutes at each site. Frog abundances can be categorised into the following:

1. Zero = no frogs heard
2. One = one frog heard
3. Few = 2 - 9 frogs heard
4. Many = 10 - 50 frogs heard
5. Lots = Greater than 50 frogs heard

Weather conditions (particularly rainfall) and habitat observations should be recorded. Spotlight surveys can be combined with the call survey monitoring events.

#### **9.1.6 Birds**

On-ground bird surveys should be conducted in spring and summer during the early morning and early evening. Survey sites should be selected based on vantage points around the wetland and should encompass the greatest area covering a range of vegetation. The area should be visually searched using binoculars, with all bird individuals counted and identified.

Bittern surveys should be conducted using methods outlined by Pickering (2013) and should combine audio and visual surveys. Audio surveys should be conducted at post-dusk and pre-dawn with visual surveys during the day. Bitterns are cryptic birds with males calling during the breeding season. Audio surveys are an efficient survey method in determining the presence of Bitterns. However, absence is not certain if no bittern is heard calling. At least three sites should be chosen for audio surveys, with surveys lasting for approximately 30 minutes on at least six occasions between September and December. Visual surveys for

feeding and nesting areas should be carried out between September and December across the entire site, with care to minimise nest disturbance.

#### **9.1.7 Aquatic Macro-invertebrates**

At least three samples should be collected from Schwenkes Dam using a sweep net with a 250 µm mesh. Sweeps should be 10 m long and encompass a range of habitats. The use of a sub-sampling box will help the sorting process. If there are any large pieces of debris present, rinse them carefully into the net and discard them. Pour the water from the bucket into the box sub-sampler. Agitate the sub-sampler to distribute the sample evenly across the cells. Randomly select a cell and remove macro-invertebrates from a sorting tray using a pipette or tweezers. Care should be taken to look for inconspicuous taxa and avoiding bias towards larger taxa. The number of animals can be counted using a handheld counter, with a minimum subsample of 200 individuals collected to adequately represent family richness and species diversity. Macro-invertebrates can then be sorted and identified to at least family level using a microscope and taxonomic key. Surveys can be done at the same time and at the same sites as the surface water quality monitoring since water quality data can affect species richness.

**Table 7:** Timeline of monitoring activities

	Monitoring Activity	Technique	Timing												Purpose of monitoring	Priority
			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC		
VEGETATION	Species composition, cover/abundance, life stage.	Quantitative vegetation monitoring										✓			<ul style="list-style-type: none"> <li>Primary Objective and Secondary Objectives 1 and 2.</li> <li>Data for adaptive mgt / triggers.</li> <li>General background monitoring.</li> </ul>	HIGH
	Visual change over time.	Photo points (including estimate of new sites in littoral zone)	✓			✓			✓			✓			<ul style="list-style-type: none"> <li>Primary Objective and Secondary Objectives 1 and 2</li> <li>Data for adaptive mgt / triggers.</li> <li>Support / inform management log.</li> </ul>	HIGH
FAUNA	Birds	Fixed area search									✓	✓	✓	✓	<ul style="list-style-type: none"> <li>Primary Objective and Secondary Objective 1.</li> </ul>	HIGH
	Frogs	Recording frog calls									✓		✓		<ul style="list-style-type: none"> <li>Data for adaptive mgt.</li> <li>General background monitoring.</li> </ul>	HIGH
	Fish	Fyke nets and box traps										✓			<ul style="list-style-type: none"> <li>Data for adaptive mgt / triggers.</li> <li>General background monitoring.</li> </ul>	MED
	Macro-invertebrates	10m sweeps	✓			✓			✓			✓			<ul style="list-style-type: none"> <li>Data for adaptive management.</li> <li>General background monitoring.</li> </ul>	HIGH
GROUND-WATER	Groundwater elevation / gradients	Depth to water table in piezometers	✓			✓			✓			✓			<ul style="list-style-type: none"> <li>Data for adaptive mgt / triggers.</li> </ul>	MED
	Groundwater salinity	Salinity of water in piezometers	✓			✓			✓			✓			<ul style="list-style-type: none"> <li>Data for adaptive mgt / triggers.</li> </ul>	MED
SURFACE WATER	Water quality	EC, pH, NTU, DO, °C	✓			✓			✓			✓			<ul style="list-style-type: none"> <li>Data for adaptive mgt / triggers.</li> <li>Assist interpretation of other monitoring data.</li> </ul>	HIGH
	Water level	Gauge boards	✓			✓			✓			✓			<ul style="list-style-type: none"> <li>Data for adaptive mgt / triggers.</li> <li>Support / inform management log.</li> </ul>	HIGH
GENERAL	All parameters	Incidental observations – record / map data not captured via formal monitoring.	On-going / opportunistic												<ul style="list-style-type: none"> <li>Potentially all objectives.</li> <li>Ensure data capture / use is not limited to formal monitoring program.</li> </ul>	MED

## **10.0 Management Arrangements**

The Blackwood Basin Group currently manages Schwenkes Dam. Hydrological management actions will be guided by the recommendations in this management plan but may be altered based on adaptive management and the triggers discussed above.



## 11.0 References

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## Appendix 1: NatureMap Report



# NatureMap Species Report

Created By Guest user on 10/11/2014

Current Names Only	Yes
Core Datasets Only	Yes
Method	'By Circle'
Centre	116°02' 26" E, 33°51' 11" S
Buffer	3km
Group By	Species Group

Species Group	Species	Records
Amphibian	3	16
Bird	32	51
Dicotyledon	37	47
Fish	1	1
Gymnosperm	3	8
Invertebrate	1	1
Lichen	4	4
Mammal	5	9
Monocotyledon	20	24
Reptile	2	2
Water Mould	1	4
<b>TOTAL</b>	<b>109</b>	<b>167</b>

Name ID	Species Name	Naturalised	Conservation Code	Endemic To Query Area
<b>Amphibian</b>				
1.	25398 <i>Crinia georgiana</i> (Quacking Frog)			
2.	25399 <i>Crinia glauerti</i> (Clicking Frog)			
3.	25398 <i>Litoria moorei</i> (Motorbike Frog)			
<b>Bird</b>				
4.	24260 <i>Acanthiza apicalis</i> (Broad-tailed Thornbill, Inland Thornbill)			
5.	24261 <i>Acanthiza chrysanthea</i> (Yellow-rumped Thornbill)			
6.	24262 <i>Acanthiza lineata</i> (Western Thornbill)			
7.	24316 <i>Anas superciliosa</i> (Pacific Black Duck)			
8.	24561 <i>Anthochaera carunculata</i> (Red Wattlebird)			
9.	42307 <i>Cacomantis pallidus</i> (Pallid Cuckoo)			
10.	25717 <i>Calyptrorhynchus banksii</i> (Red-tailed Black-Cockatoo)			
11.	24731 <i>Calyptrorhynchus banksii</i> subsp. <i>naso</i> (Forest Red-tailed Black-Cockatoo)		T	
12.	24734 <i>Calyptrorhynchus latirostris</i> (Carnaby's Cockatoo (short-billed black-cockatoo), Carnaby's Cockatoo)		T	
13.	24432 <i>Chrysococcyx lucidus</i> subsp. <i>plagusus</i> (Shining Bronze Cuckoo)			
14.	25592 <i>Corvus coronoides</i> (Australian Raven)			
15.	25595 <i>Cracticus tibicen</i> (Australian Magpie)			
16.	30901 <i>Dacelo novaeguineae</i> (Laughing Kookaburra)	Y		
17.	25607 <i>Dicaeum hirundinaceum</i> (Mistletoebird)			
18.	24470 <i>Dromolus novaehollandiae</i> (Emu)			
19.	24652 <i>Eopsaltria georgiana</i> (White-breasted Robin)			
20.	25530 <i>Gerygone fusca</i> (Western Gerygone)			
21.	24295 <i>Haliastur sphenurus</i> (Whistling Kite)			
22.	24491 <i>Hirundo neoxena</i> (Welcome Swallow)			
23.	25661 <i>Lichmera indistincta</i> (Brown Honeyeater)			
24.	25664 <i>Malurus splendens</i> (Splendid Fairy-wren)			
25.	25682 <i>Paralotus striatus</i> (Striated Pardalote)			
26.	24409 <i>Phaps chalcoptera</i> (Common Bronzewing)			
27.	24596 <i>Phylidonyrs novaehollandiae</i> (New Holland Honeyeater)			
28.	25720 <i>Platycercus icterotis</i> (Western Rosea)			
29.	24679 <i>Pseudophryne olivacea</i> subsp. <i>brachypterus</i> (Tawny Frogmouth)			
30.	25534 <i>Sericornis frontalis</i> (White-browed Scrubwren)			
31.	24844 <i>Threskiornis molucca</i> (Australian White Ibis)			
32.	25549 <i>Todiramphus sanctus</i> (Sacred Kingfisher)			
33.	25764 <i>Tyto novaehollandiae</i> (Masked Owl)			
34.	24855 <i>Tyto novaehollandiae</i> subsp. <i>novaehollandiae</i> (Masked Owl (southern subspecies))		P3	
35.	25765 <i>Zosterops lateralis</i> (Grey-breasted White-eye, Silvereye)			

NatureMap is a collaborative project of the Department of Environment and Conservation, Western Australia, and the Western Australian Museum.



## Appendix 2: Water sampling locations





### Appendix 3: Vegetation types (Wildy, 2014)

