Australasian Bittern in Southwest Australia

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Contents

Appendices

A. Target Wetlands
B. Annual Bittern Survey Summaries
C. Bittern Survey Summary 2007 to 2012
D. Australasian Bittern Confirmation Criteria
E. Available chemical analysis of wetlands and data sources
F. BirdLife Western Australian Wetland Chemistry data
G. Wetlands with records above the ANZECC guidelines
H. Graphs of Wetland Chemistry Components
I. Fine Scale Habitat Form
J. Broad scale Habitat Data
K. Flora found at wetlands with Australasian Bittern Present
L. Australian Little Bittern records from this study
M. Education and Awareness
N. Draft threats to Australasian Bittern in Western Australia

Executive Summary

BirdLife Western Australia (formerly Birds Australia) commenced surveys of Australasian Bittern (*Botaurus poiciloptilus*) on the Swan Coastal Plain in 2007. In 2008 the organisation partnered with the Department of Environment and Conservation (DEC) to conduct surveys throughout the known range of the species in Western Australia.

In July 2010 Lotterywest funded BirdLife WA to continue the initially unfunded project to the end of December 2012. This report outlines the findings of the Lotterywest funded project and the years prior to funding.

The aims of the project were to:

- Determine the current range, population and wetlands inhabited by Australasian Bittern.
- Document wetland characteristics to determine specific habitat requirements including drought refuges.
- Document threatening processes.
- Increase awareness of the species and the importance of wetland conservation.
- Make recommendations for conservation of Australasian Bittern and the wetlands that support populations of the species.

The study consisted of 513 surveys at 105 wetlands and resulted in 132 records of Australasian Bittern and 88 records of Australian Little Bittern. Australasian Bittern was recorded at 29 wetlands throughout the southwest, however, it is likely that they occur at other wetlands particularly during the non-breeding season. Australian Little Bittern was recorded at 37 wetlands.

The current range of the Australasian Bittern in southwest Australia is from Perth in the northwest to Condingup in the southeast. Australasian Bittern was distributed patchily through in coastal, near coastal and southwest forest wetlands during the breeding season. The only Australasian Bittern recorded out of this range during this study was at Katanning during the non-breeding season.

The population of Australasian Bittern in Western Australia estimated from the data collected during this study was 38 to 154 (Pickering 2010). The estimate process was also used to estimate the population present in WA during the 1980s and this indicated the species had declined by 24 to 51% since the 1980s. The species is thought to be still in decline in Western Australia.

A total of 95 wetlands were sampled for chemistry data in spring 2010, spring 2011 or spring 2012, or data were gathered from other sources from various time periods. These data indicated that pH and conductivity (salinity) levels influenced the presence or absence of Australasian Bittern during the breeding season, however, other chemical analyses performed did not seem to influence bittern presence.

Broad scale wetland habitat data were documented at 162 wetlands in southwest Australia. Vegetation mapping was conducted by a botanist at four important wetlands in the deep southwest and southeast.

Awareness raising, education and community engagement has been a key part of the work undertaken. Over 130 people were involved in surveys. While many of the survey teams were from Perth, other observers came from Bunbury, Busselton, Bridgetown, Kojonup, Katanning, Manjimup, Denmark, Albany, Esperance and Condingup. One of the aims was to educate and use local people to undertake surveys. The project contributed to awareness raising in a number of ways, including the publication of articles, presentations at conferences and other events, and the design and publication of information brochures.

Threats to the species were assessed and ranked by the technical advisory committee as part of the planning for the draft Interim Recovery Plan. Major threats to the species were identified as:

- Climate change
- Acid sulphate soils and acid flush following rewetting
- Tree farms changing to livestock (increasing sedimentation)
- Predation by introduced animals - fox, cat, rat, pig
- Decreasing water levels due to draw down by current plantations
- Decreasing water levels due to decreased rainfall
- Inappropriate fire regimes - drying climate & hydrology; infrequent burning; too frequent burning
- Predation by native animals - Swamp Harrier, native rats, snakes

The Australasian Bittern project has delivered a number of key outcomes. It has greatly increased knowledge about the range and abundance of this threatened and still declining species in Western Australia, and has added significantly to knowledge about habitat preferences of the species. An important outcome has been the development of a technical advisory group for the species and the development of a draft Interim Recovery Plan for the species in Western Australia. The project has also played a critically important role in collating existing and new knowledge, and actively bringing together key stakeholders.

It is recommended that the project continue with continued data gathering, awareness raising, education, research and on ground conservation in order to improve the status of the Australasian Bittern.

Figure 1- Australasian Bittern descending into *Baumea articulata* stand at Lake Pleasant View November 2011. Photographer: Robyn Pickering

Acknowledgements

The Australasian Bittern project would have not been possible without the concerted efforts of a technical advisory committee and a dedicated team of volunteers.

The project technical advisory committee was comprised of John Blyth (BirdLife Australia), Allan Burbidge (DEC), Alan Clarke (DEC), Sarah Comer (DEC), Cheryl Gole (BirdLife Australia), Roger Hearn (DEC), Jim Lane (DEC), Robyn Pickering (BirdLife Australia), Andrew Story (Wetland Management and Research and the University of WA), Peter Taylor (BirdLife Australia), Ian Wheeler (DEC) and Kim Williams (DEC). Other people who provided input at technical advisory committee meetings included Steve Butler (DEC), Christine Fleay (DEC), Patrick Gillespie (DEC), John Graff (BirdLife Australia), Janine Liddelow (DEC), and John Pridham (DEC).

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Our volunteers spent many hours standing in wetlands from sunset onwards or before sunrise listening for calling Australasian Bitterns or walking through wetlands in rubber boots or waders trying to find Australasian Bitterns or their nests. They were an extremely hard working group. Thank you all for amazing efforts:

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Introduction

The Australasian Bittern

The Australasian Bittern (*Botaurus poiciloptilus*) is an endangered waterbird found primarily in Australia and New Zealand. While it is a reasonably large bird, it is cryptic and more often heard than seen.

In Australia the species' range includes the southwest Australia and southern Queensland to Tasmania and the southeast of South Australia. In Australia numbers of the Australasian Bittern have declined dramatically over the last 40 years (Peter 2009).

Birdlife International estimates the global population of the Australasian Bittern to be approximately 1000 to 2499 mature birds with a decreasing trend (BirdLife International 2011). In New Zealand the last estimate was 580 to 725 birds in 1985 (Marchant and Higgins 1990) and it is estimated that no more than 50 resides in New Caledonia (Bird Life International 2011).

The Australasian Bittern is listed as a threatened species in Western Australia, Victoria, New South Wales and South Australia. The Western Australian and New South Wales governments up-listed the species from Vulnerable to Endangered in 2010. The species was listed under the EPBC Act as Endangered in March 2011.

It is the only *Botaurus* species that is listed by IUCN as endangered. Table 1 provides an overview of the four species of *Botaurus* bitterns.

Table 1 - Overview of *Botaurus* bitterns (BirdLife International 2011 a, b, c and d)

Species	**Australasian Bittern**	**Great Bittern**	**American Bittern**	**Pinnated Bittern**
Location	Australia, New Zealand and New Caledonia	Europe,	North America and Central America	South America and Central America
Population	1,000-2,499	110,000-340,000	3,000,000	50,000-499,999
Distribution Size	323,000 km^2	18,100,000 km^2	8,781,000 km^2	2,180,000 km^2
Population Trend	Decreasing and above 30% criteria	Decreasing but below 30% criteria	Decreasing but below 30% criteria	Unknown
IUCN Category	Endangered	Least concern	Least concern	Least concern

In Western Australia the Australasian Bittern is confined to the southwest in four main areas: the Swan Coastal Plain, Manjimup wetlands, south coast from Augusta to Bremer Bay and the south coast from Esperance to Cape Arid (Figure 2). It is found in wetlands with large stands of sedges and/or rushes, particularly *Baumea articulata* and *Typha species*. The species' numbers are in decline with a 24% to 51% decline estimated since the 1980s (Pickering 2010).

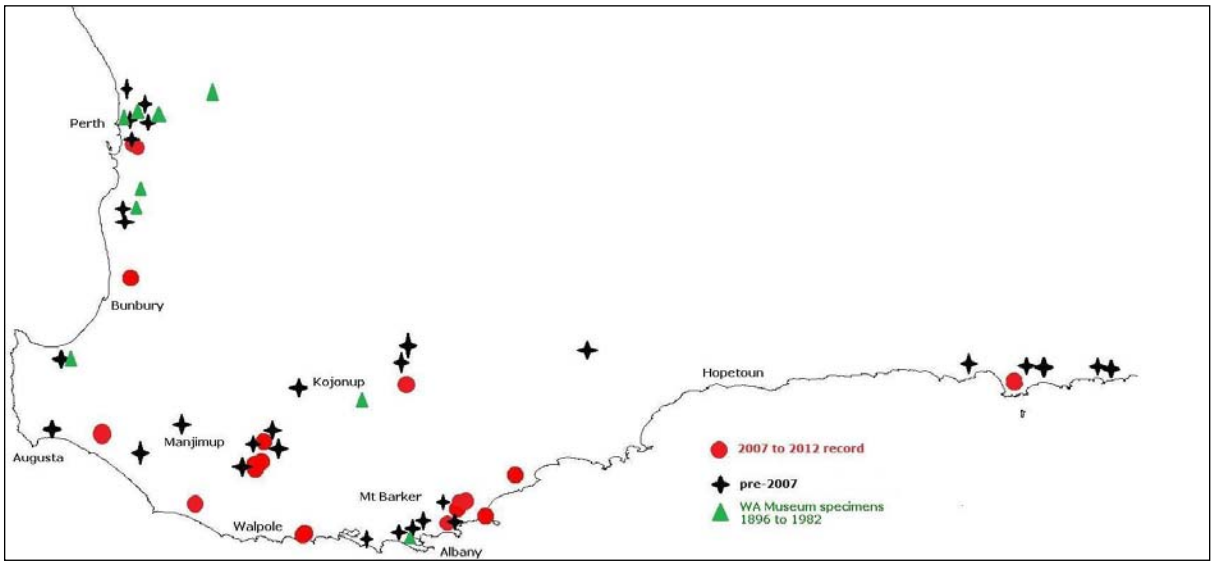


Figure 2 Records of the Australasian Bittern in southwest Australia

The project

In 2007 BirdLife Australia, then Birds Australia, commenced surveys for Australasian Bittern as part of the Important Bird Areas (IBA) project. These surveys were conducted at three Swan Coastal Plain wetlands: Jandabup Lake, Thomson's Lake and Benger Swamp.

In 2008 BirdLife partnered with the Department of Environment and Conservation (DEC) and the joint project was expanded to all areas of the known range. This was an important step in ensuring that the project could cover the entire Western Australian range, include DEC's local knowledge, provide access to wetlands in the conservation estate and provide resources for surveys and research.

In 2008 the BirdLife Australia commenced a national project to survey Australasian Bittern and Australian Little Bittern. This also increased resources for the Western Australian project as a national bittern database was established and information sharing improved project efficiencies.

In June 2010 Lotterywest provided a $136, 159 Grant to BirdLife WA to fast track aspects of the project so that it could develop from a survey/information gathering project into a conservation project.

The aims of the project were to:

- Determine the current range, population size and wetlands inhabited by Australasian Bittern.
- Document wetland characteristics to determine the specific habitat requirements including drought refuges.
- Document threatening processes.
- Increase awareness of the species and the importance of wetland conservation.
- Make recommendations for conservation of the Australasian Bittern and the wetlands that support populations of the species.

During the project several areas of work were completed to meet the aims of the project. These included:

- Conducting evening listening, daytime flushing and nest searching surveys to identify wetlands where Australasian Bittern are present and where conditions appear suitable for breeding.

- Reviewing wetlands where the Australasian Bittern has previously been found to determine changes to wetland chemistry, water levels, habitat and population.
- Documenting wetland habitats requirements by taking aerial oblique photographs to assist in the assessment of vegetation. Documenting available habitat using aerial photographs across the range of the species and conducting vegetation mapping at several wetlands important to the species.
- Documenting wetland chemistry at a large number of wetlands within the species' range.
- Producing pamphlets on the species and its management.
- Engaging local communities to participate in surveys.
- Audio recording Australasian Bittern calls to determine whether individual birds could be identified on the basis of their calls. This will aid in population monitoring and determine some biological information such as wetland fidelity
- Audio recording frog calls during listening surveys to aid in scoring wetland health and availability of food resources.

Climate within the range of the Australasian Bittern

Although southwest Australia has a Mediterranean climate, it is quite variable within the range of the Australasian Bittern. Variations in rainfall and evaporation in particular are important elements in determining the amount of water entering wetlands each year, wetland permanence, time of year that wetland water levels peak etc. Some other important aspects include catchment size, whether wetlands are perched or not, and types of water flows into wetlands (groundwater, drains, creeks etc).

Data from Bureau of Meteorology weather stations were used to provide local climate information and observation data. Choosing weather stations to assess climatic characteristics was a compromise between distance from important wetlands, difference in climate in the region, weather station data quality and the length of time a weather station had been in operation.

Figure 3 provides an overview of the annual rainfall near wetlands of interest to this study. It shows there is a large difference in total annual rainfall at these sites from 583mm at Bokerup (closest weather station to the Muir-Unicup wetlands) to 1316mm at Walpole (sited between Maringup Lake and the Owingup Swamp/Boat Harbour system).

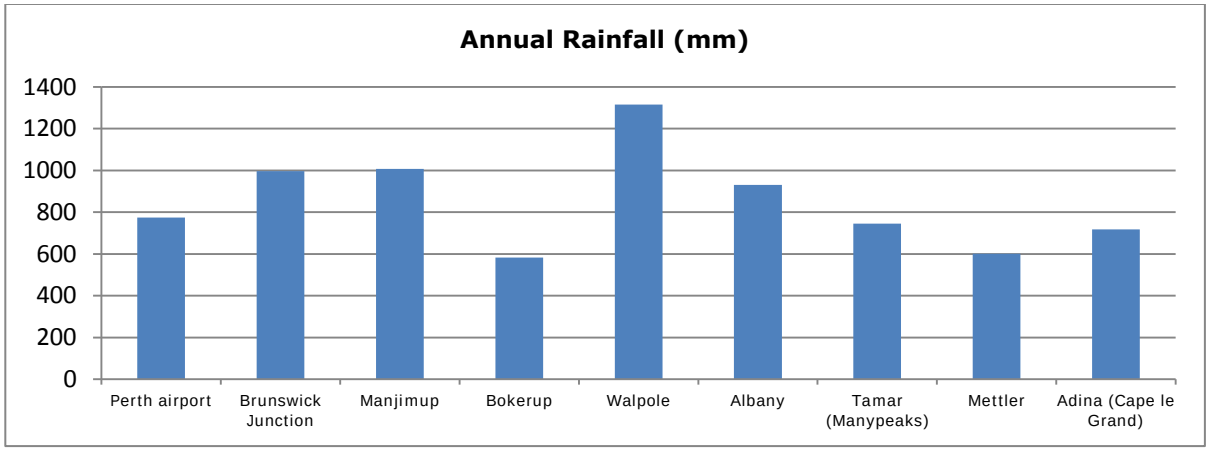


Figure 3 - Annual Average Rainfall at key locations within the range (data sourced from the Bureau of Meteorology website). Note average period is from weather station establishment to present. Weather station establishment ranges from 1877 for Albany to 1969 for Adina.

There is a large variation in rainfall within a short distance in the Manjimup region with the Manjimup annual rainfall of 908mm (1980 to present) being nearly double that of Bokerup at 566mm (1980 to present). These sites are only 68km apart.

The seasonal pattern of rainfall within the area is also quite variable with rainfall in Mettler being relatively consistent throughout the year while rainfall in the upper Swan Coastal Plain largely occurs in the winter months. Figure 4 shows the variation in rainfall at sites within the range of the Australasian Bittern.

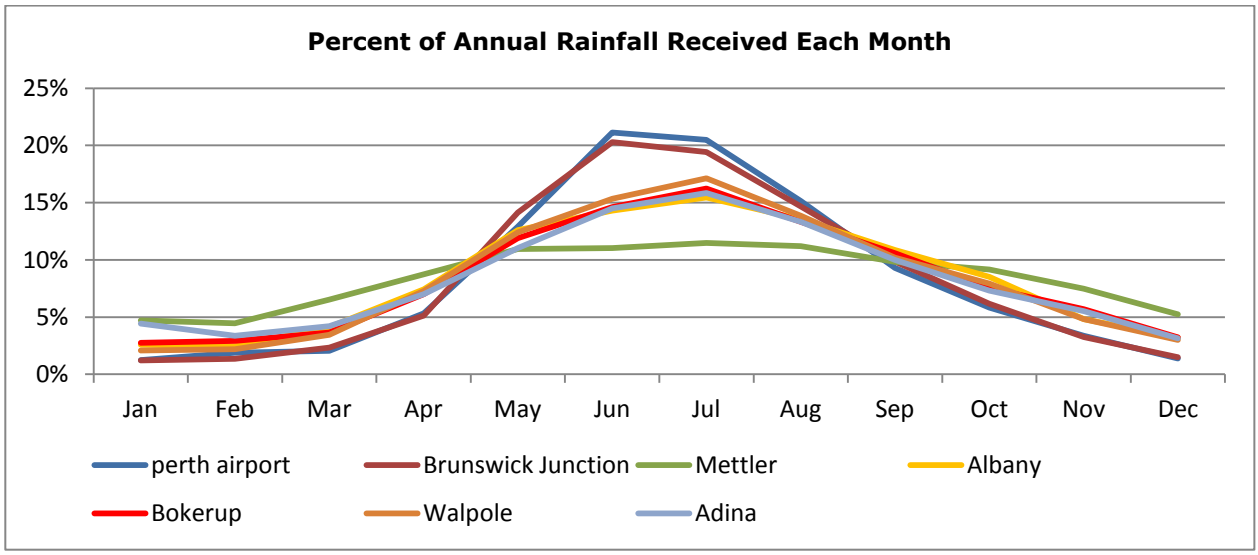


Figure 4 - Monthly rainfall as a percentage of annual rainfall (Data sourced from the Bureau of Meteorology website). Note average period is from weather station establishment to present. Weather station establishment ranges from 1877 for Albany to 1969 for Adina.

During the study period (July 2007 to December 2012) rainfall was generally below average. Figure 5 shows the annual rainfall for each area over the period 2005/6 to 2011/12. While surveys started in 2007/8, the rainfall in the years prior to this is important as recent rainfall will affect wetland/groundwater levels prior at the start of the period and so impact the wetland water level during the study period.

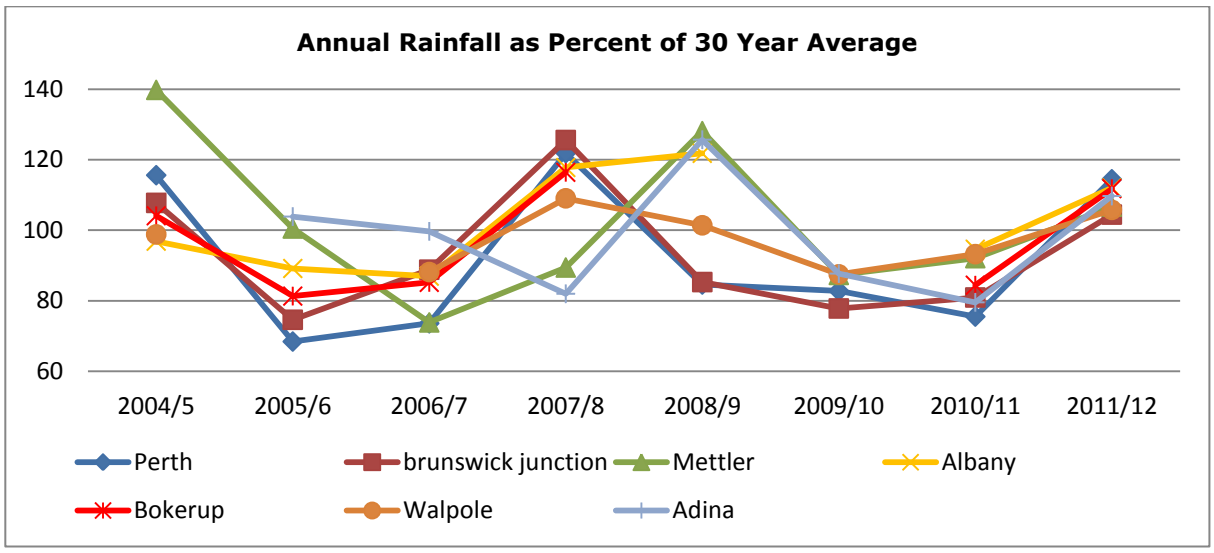


Figure 5 Annual Rainfall as a percentage of the 30 year annual average for each region in the bitterns range (Data sourced from the Bureau of Meteorology website).

Figure 6 – Survey times in late spring targeted the peak water levels in wetlands and often made access difficult. This flooded track in the crown land north of Cape Le Grand National Park is probably only traversable in summer so team members walked into wetlands. Photographer: Robyn Pickering

Australasian Bittern records review

A review of Australasian Bittern records was conducted at the start of the project so that a target group of wetlands for surveys could be established. Literature, the BirdLife Western Australia database, the BirdLife Australia Atlas, the Department of Environment and Conservation database, data sheets from the 1981 to 1985 south Western Australia waterbirds study, and the Western Australia Museum records were all reviewed to find records of Australasian Bittern. A variety of people knowledgeable about wetlands in southwest Australia were also asked if they could suggest wetlands that might have suitable habitat.

Once a target list of wetlands (Appendix A) was established these were visited to assess the current conditions and to determine whether habitat suitable for Australasian or Australian Little Bittern existed. As the project progressed further records were found in the literature and aerial photography of other wetlands was examined. During this review records of Australian Little Bittern were also noted. This provided a starting point for surveys and other work.

Australian Little Bittern

The Australasian Bittern project provided an ideal opportunity to also survey for Australian Little Bittern which is a poorly recorded species, has similar habitat preferences to Australasian Bittern and has an unclear status in Western Australia. Most records of Australian Little Bittern from this study were recorded opportunistically while conducting Australasian Bittern surveys, however, a small number of surveys on the Swan Coastal Plain were conducted by volunteers specifically for Australian Little Bittern.

Surveys for Australasian Bittern

During this study Australasian Bittern surveys were generally conducted using two methods:

- Listening surveys, primarily conducted post-dusk and pre-dawn, and
- Bittern and nest searching surveys during the day.

However, a large number of records was also obtained opportunistically particularly in the Manjimup region where DEC was conducting weekly wetland sampling and monthly waterbird counts. Many of the records of Australasian Bittern prior to this study were opportunistic, however, some were a result of listening surveys or flushing and nest searching surveys.

In this study, 513 surveys were conducted at 105 wetlands. Many wetlands were only surveyed once while others were surveyed every spring or more often.

Appendix B provides a summary of each year's surveys and Appendix C summarises records for each wetland and survey effort throughout the study. All Australasian Bittern records were assessed for degree of confidence, utilising a confirmation criteria (see Appendix D) drafted by Cheryl Gole and Allan Burbidge and finalised with input from other members of the technical advisory group in June 2009.

Of the 513 surveys 278 (54%) were evening listening surveys, and 212 (41%) were daytime bittern and nest searching surveys. Table 2 outlines the distribution of surveys and survey types in each region. Opportunistic records have not been included in this survey effort table.

Table 2: Number of surveys from July 2007 to June 2012 conducted by BirdLife WA and DEC

Region	**Wetlands surveyed**	**Evening Listening surveys**	**Daytime surveys**	**Dawn surveys**	**Total surveys**
Swan Coastal Plain	28	106	100	7	213
Manjimup	22	50	17	3	70
Western South Coast	27	94	69	13	176
Eastern South Coast	28	28	26	0	54
Total	105	278	212	23	513

Figure 7 is a histogram of the duration of each survey conducted between July 2007 and June 2012. Figure 8 shows the proportion of surveys for various survey periods for evening listening surveys and daytime surveys. This shows that evening listening surveys were usually less than 60 minutes in duration (55% of surveys) with most surveys between 20 minutes and 40 minutes long (30% of surveys). Daytime surveys were generally more than 60minutes in duration (84% of surveys) with most surveys more than 2 hours long (39% of surveys).

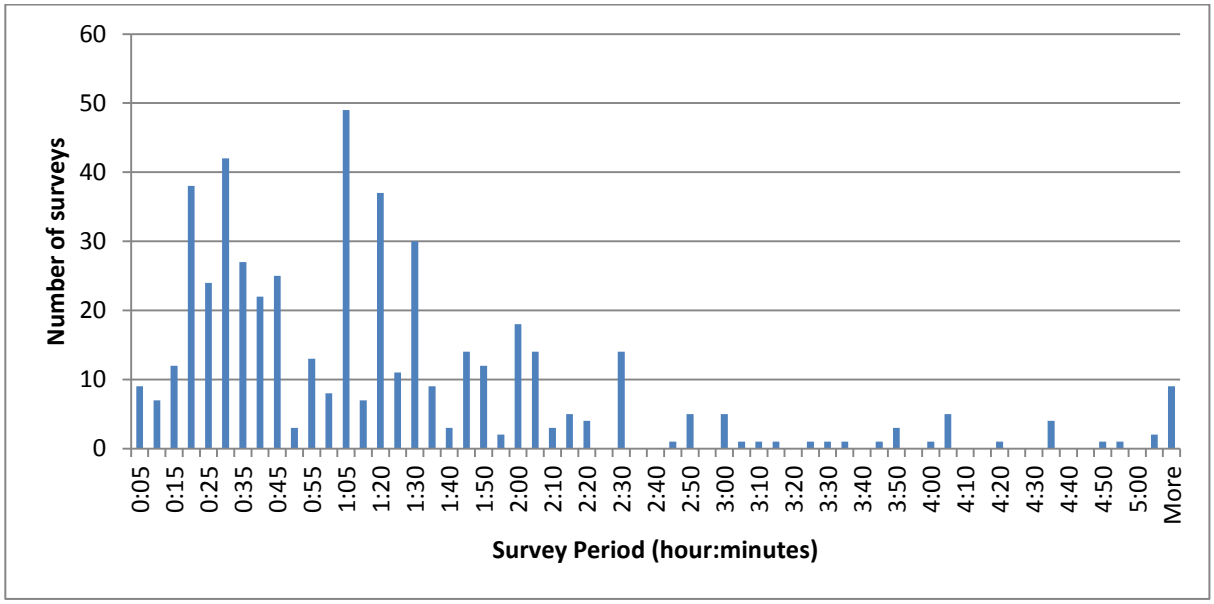


Figure 7 : Histogram of survey duration for all surveys from July 2007 to June 2012 (5 minute intervals)

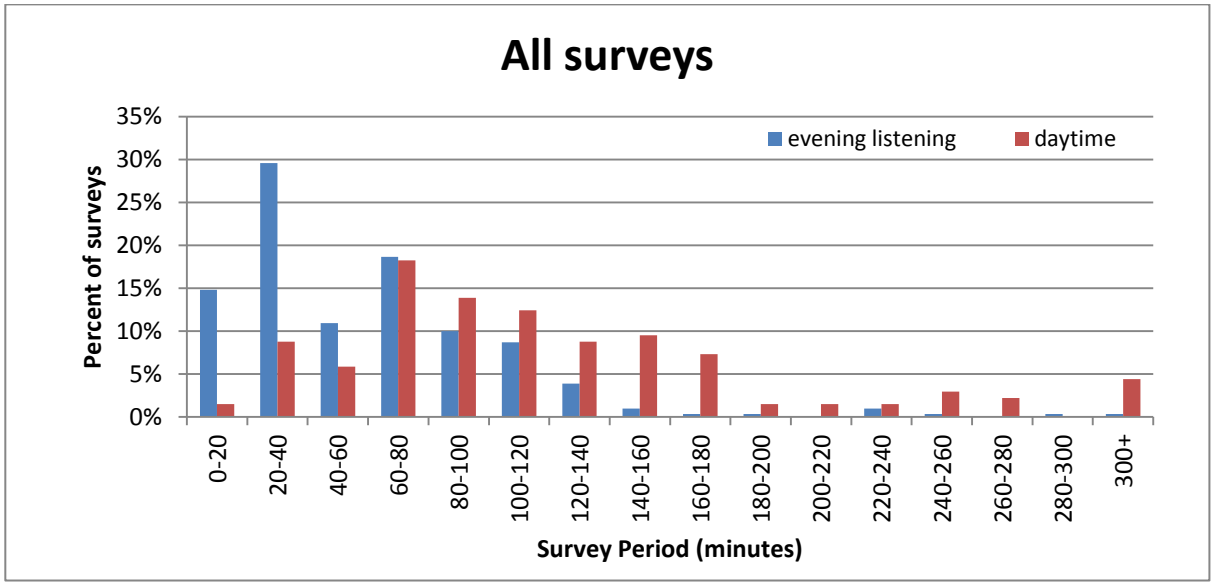


Figure 8 - Survey duration for each daytime and evening listening survey for July 2007 to June 2012 (20 minute intervals) expressed as a percent of surveys

Daytime surveys take longer as it takes much more time to search through the wetland than listening for calls in the evening.

Listening surveys

Australasian Bittern are cryptic birds so it is difficult to observe them for much of the year. Bittern are more readily heard than seen. It is thought that only the male calls with a series of booms during the breeding season (Marchant and Higgins 1990). In this study it is assumed that only the male calls and this seems to be supported with some records where one bittern was heard calling but on approaching the area two birds were flushed (R. Hearn pers. comm.). Listening for calling Australasian Bittern is an

efficient survey method to determine bittern presence and possible breeding. However, it's important to note that bittern absence is not assured if no bittern is heard calling.

Listening surveys for bitterns have been used in many parts of the world to determine presence, population size (Puglisi et al 1995, Poulin and Lefebvre 2003a, Pierce 2004, Wotton et al 2007, Wotton et al 2008) and individual survival (McGregor and Byle 1992, Gilbert 2002).

Pierce (2004) provided guidelines for surveying Australasian Bittern in the Whangamarino Wetlands in New Zealand. These guidelines were developed to determine total numbers of Australasian Bittern calling within the 7,100 hectare wetland system thought to support the highest number of Australasian Bittern in NZ (Pierce 2004). The guidelines suggested that five paired listening stations should survey for 1.5 hours on four calm nights at around sunset (e.g. 1701 to 1831 for 1 October – sunset at 1815hrs) in September and October. Pierce (2004) identified sunset surveys as more effective than surveys in the dark as after dark "the call rate from individual birds increased dramatically, with calls resonating around the wetland, sometimes making it impossible to pinpoint the precise direction of calling birds".

This is not the situation in Western Australian wetlands where usually only one or two Australasian Bittern call in any wetland and since 1980 the highest number of birds heard calling was five to six. For this reason the Western Australian listening surveys are targeted for the post-sunset period when it appears that Australasian Bittern call more frequently.

Poulin and Lefebvre (2003a) provided guidelines for surveying Great Bittern (Botaurus stellaris); these guidelines were based on their research in the Camargue in southern France. The guidelines for surveys provided a 95% detection of calling male bittern for population estimates at high bittern density and low bittern density sites. The recommended survey protocols from these guidelines were to survey high density sites for two ten minute periods at dawn and for low density sites for four fifteen minute dusk surveys or two forty minute dusk surveys should be undertaken during the peak booming period (April to May in the northern hemisphere).

Poulin and Lefebvre (2003a) recommended that for small reedbeds of less than 10 hectares a single fixed listening post should be established. For larger reedbeds, fixed locations every 400m or 400m transects were recommended.

The survey duration and exact timing in relation to sunset or sunrise in this study has varied. The main reason for this variation is survey opportunity. Surveys were conducted over a large area from Esperance in the southeast to Augusta in the southwest, and north of Perth. The project required surveys to be conducted in a two to three month peak calling period by a relatively small number of volunteers largely based in Perth. This meant that often a wetland could only be surveyed once for a very short period. Many of the surveys were conducted within a weekend with several wetlands surveyed each night. This meant that each group of volunteers would survey one site at early twilight before moving to a second or third site during that evening. Figure 10 shows survey duration for evening listening surveys conducted between July 2007 and June 2012.

Figure 9: Listening survey team walking to an unnamed wetland in Cape Le Grand National Park at sunset. Photographer: Robyn Pickering

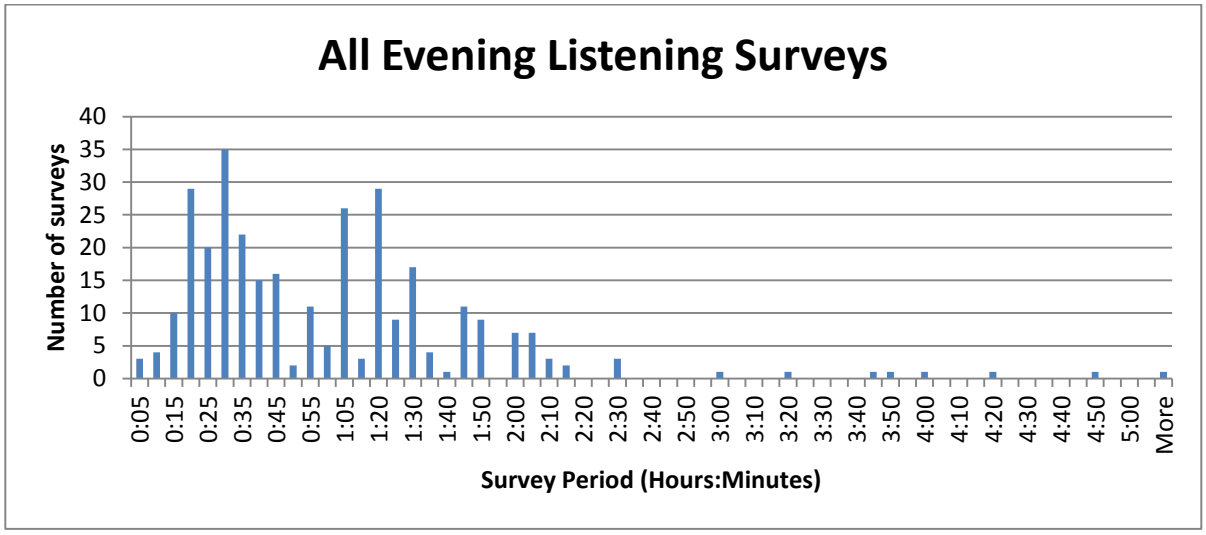


Figure 10 - Duration of evening listening surveys in this study between July 2007 and June 2012

Australasian Bittern calls are reported as being repeated every 2-10mins (average 5 min) (Marchant and Higgins 1990). During this study call frequency varied significantly and was highly dependent on time of day (see below). However, within the peak calling period after dusk large variations were also observed and this may be related to time or year, weather conditions, presence of other bitterns etc. At unnamed wetland "Big Boom Swamp" in October 2011 individuals called at different rates with one bittern calling every few minutes while others only called once during the two hour survey period. Surveys at other locations where only a single bittern was heard also shows a similar variation in calling frequency. Listening survey duration needs to take into account the variations within bittern calling behavior.

Generally, evening listening surveys ranged from 5 minutes to 1hour in duration (55%), however, some evening listening surveys on the Swan Coastal Plain and South Coast were conducted for periods of more than one hour. In June 2011 the project technical group decided to set a standard survey time of 30 minutes for evening listening surveys, however for practical or research reasons shorter or longer surveys were still conducted.

Time of day for listening surveys

Australasian Bittern calling frequency varies with the time of day. This is a common feature of *Botaurus* bitterns and other bittern species. Marchant and Higgins (1990) note that Australasian Bitterns call mainly at dawn and dusk. Poulin and Lefebvre (2003a) found that Great Bittern booming peaked at 0-30 minutes after sunset and 30 to 60 minutes prior to sunrise.

Figure 11 depicts data for Australasian Bittern calling frequencies relative to sunset from July 2007 until June 2012 in southwest Australia. This study found the peak calling of Australasian Bittern was from 15 to 75 minutes after sunset. Very few pre dawn surveys were conducted, however the data collected to date indicate the peak pre-dawn calling period stops at approximately 30 minutes before sunrise. More data are needed to determine if this is a regular occurrence.

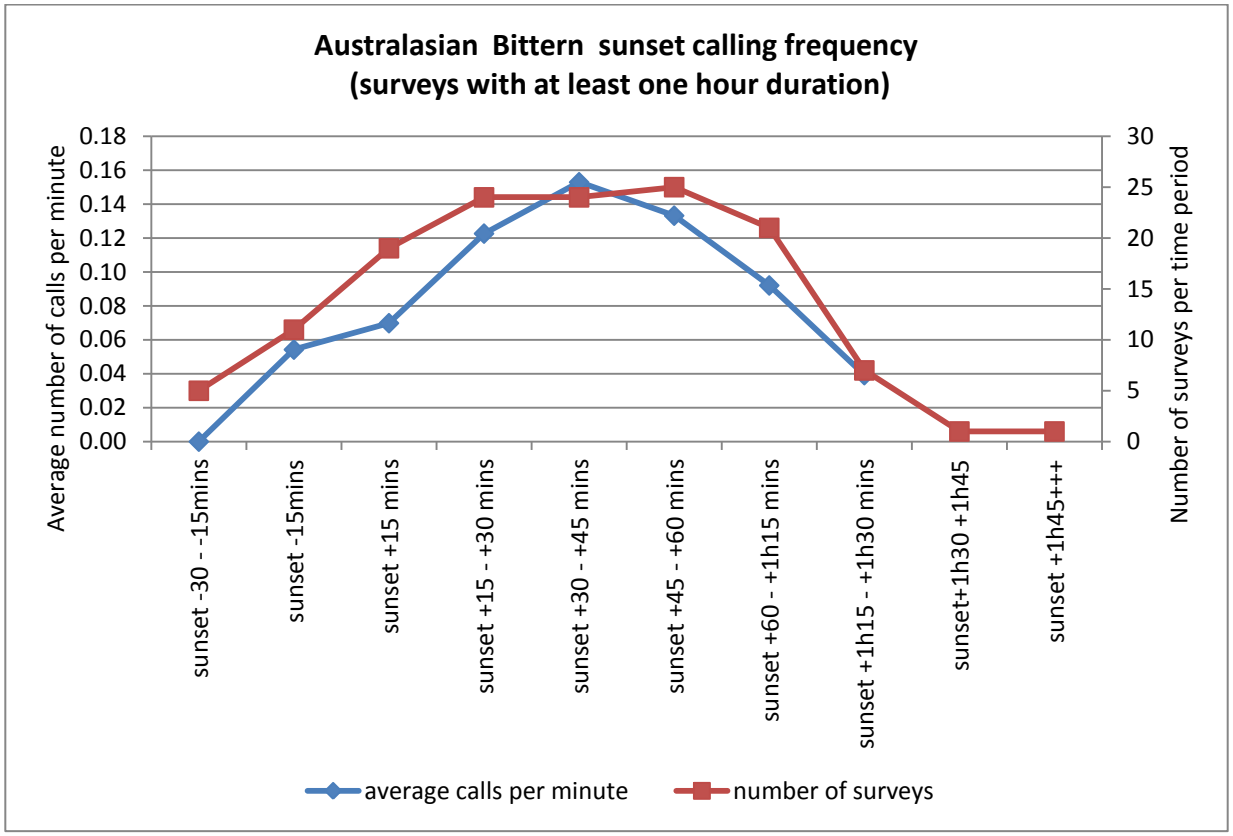


Figure 11: Australasian Bittern calling frequency relative to sunset from survey data collected between July 2007 and June 2012 with more than one hour survey duration and with all call time data recorded.

Time of year for listening surveys

A review of 181 records of Australasian Bittern in Western Australia prior to this study provided an understanding of the peak calling period in Western Australia. Most records noted whether the bittern was heard or seen or both, however 55 records did not provide information on the type of record (heard, seen or both). Figure 13 shows a summary of this records review with each record tabulated into the month of the record and whether the Australasian Bittern was seen or heard. This shows that the peak calling period is from September to December. Marchant and Higgins (1990) have also noted that the calling period is spring and summer.

Figure 12: Listening survey team at Kulunilup Swamp with audio recorder.

Photographer: Robyn Pickering

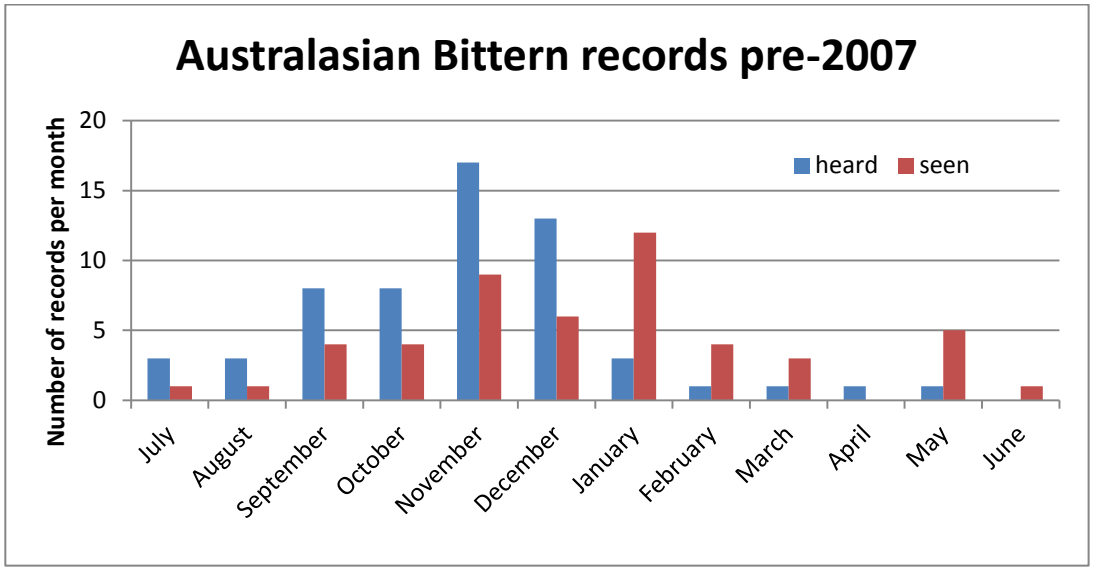


Figure 13 Monthly records of Australasian Bittern prior to this study indicating peak calling period

Figure 13 indicates that the best months to conduct listening surveys in Western Australia are from September to December. For this study listening surveys have largely been limited to this period, however, in some remote wetlands where daytime flushing surveys have been conducted a listening survey has also been conducted at a time outside this peak calling period.

Figure 14 shows monthly Australasian Bittern records, both historical and from this project. For this analysis only one positive heard or seen result per month per wetland was used in the analysis. It is likely that the data from this study may skew the results as surveys were targeted to the peak calling period, particularly October and November.

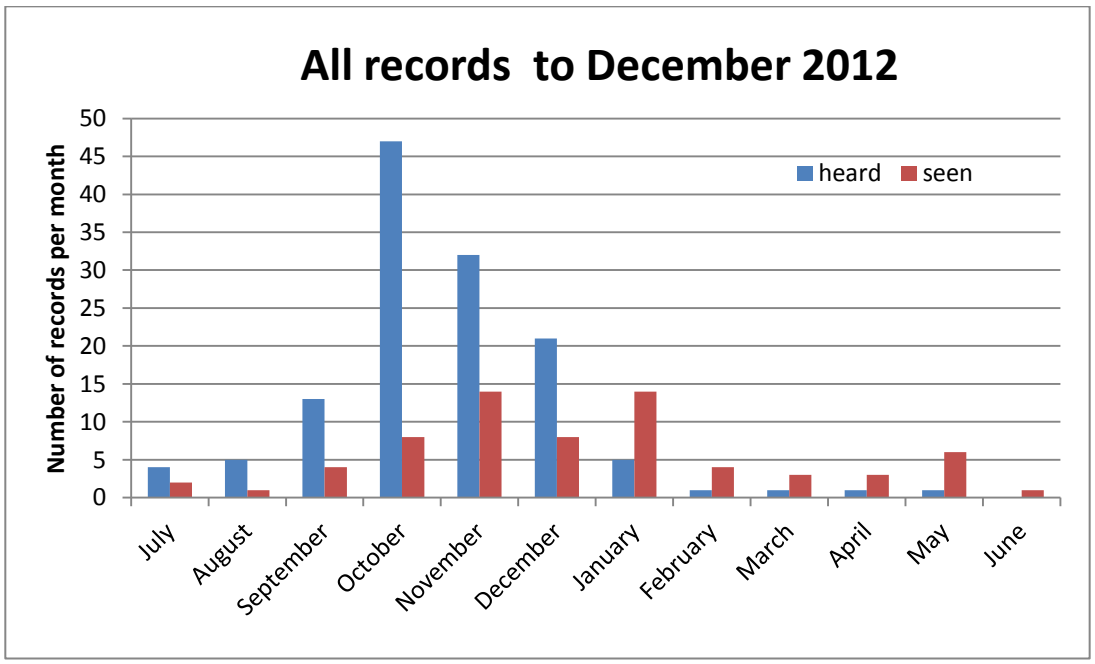


Figure 14 - Monthly records of Australasian Bittern in Western Australia from historical records and this study

Teal (1989) found the Australasian Bittern at Whangamarino Wetlands in New Zealand to call from as early as June and as late as February but that more calls were heard in the late spring and early summer months. Teal (1989) also cites Moon (1967) as reporting most Australasian Bittern calling from September to January.

Similarly, in France the Great Bittern calls most frequently in April and May (Poulin and Lefebvre 2003) which is equivalent to October and November in the southern hemisphere. White et al (2006) reported that in the United Kingdom Great Bittern commenced calling as early as January (equivalent of July in southern hemisphere) and as late as June (equivalent of December in southern hemisphere) with most bittern commencing calls in March (equivalent of September).

The exact triggers for the commencement of calling are not well understood but White (2006) suggests that it may be influenced by water depths and food availability (citing Gilbert et al in press), local population trends (citing Fontanelli et al 1995, Puglisi et al 2003), female fertility (citing Polak 2006) and weather.

It has been argued that in Western Australia water levels may have been the biggest factor in the onset of calling as it appeared to coincide with the time that wetland water levels peaked or began to recede. Halse and Jaensch (1989) found that for waterbirds in southwest Australia rainfall is the most important factor for timing of the breeding season and photoperiod affected only a small number of species. The Halse and Jaensch study also noted that "a hierarchy of factors may often be involved, of which rainfall is usually most important in south-western Australia waterbirds".

Wetland water depth peaks shortly after the rainfall peak in southwest Australia. Halse and Jaensch (1989) plotted rainfall and water depth for wetlands in various parts of southwest Australia and found rainfall peaked between May and August while water depth peaked between July and December. Data collected by the Department of Environment and Conservation at Manjimup show that Australasian Bittern start calling when wetland depth peaks or shortly after the peak in wetland depth (R. Hearn pers. comm.).

Trials of call broadcast in listening surveys

During this study Australasian Bittern calls were sometimes broadcast in an attempt to get bitterns present to call. The procedure adopted in 2010 for broadcasts were that 10 minutes of listening would occur before any broadcast and broadcast would occur only if not bitterns were calling. After broadcasting a call the survey team listened for another 10 minutes prior to playing another call, again only if no bitterns called. Only two calls were played during a survey so that broadcasting was not overused and of detriment to the natural calling behaviour of the bitterns.

It is difficult to accurately assess the success of this trial due to limited numbers of positive records and limited attempts to broadcast calls. However, it seems that in wetlands with few bittern call broadcast was not effective. Where more than one male bittern was regularly present the broadcasts sometimes appeared to be answered by apparently territorial male bitterns. Hence it appeared that in most situationscall broadcast would be ineffective.

Other notes from listening surveys

Australasian Bittern calls can be heard up to 800 to 1000m away (Marchant and Higgins 1990). During this study Australasian Bittern were often heard at shorter distances than this but at times they were also heard further away. Weather conditions appear to have a great influence on the distance sound from calls travel. In quite windy conditions it is more difficult to conduct listening surveys as there is more background noise and the calls and other noises become distorted and difficult to determine if the sounds are from Australasian Bittern, cattle, Purple Swamphen (*Porphyrio porphyrio)* or other sounds.

In several surveys calls were estimated to have come from over one kilometre away. The longest distance over which calls were heard was 1.8 kilometers at Pfieffer Lake, Manypeaks in October 2010. This location of the call was confirmed at 3 separate sites. However, in other instances bitterns called quietly or conditions resulted in calls being heard at much smaller distances (i.e. less than 500m).

Bittern/nest searching surveys

This second survey method is less efficient but provides more information on Australasian Bittern habitat preferences and biology. Unfortunately, this type of survey is very time consuming and physically demanding, as wading in water for hours while traversing sedges is taxing.

These surveys were conducted to target potential feeding areas and/or nest sites. In most cases surveys were conducted by one to six people across sweeps of large parts of wetlands. When near tall vegetation such as *Baumea articulata*, *Typha orientalis* or *Gahnia sp.* these vegetation types were usually searched for nest structures. However, during the period where it was thought that bittern may be incubating eggs or young present on the nest, the nesting habitat was avoided if possible to minimize disturbance. Any feeding platforms in short or tall sedge were examined for recent use, feathers, scats, gilgae carapaces or other indicators of bittern presence or use.

Figure 15 –Rob Schmidt nest searching at Cheynes Beach Road Swamp. Photographer: Robyn Pickering

Opportunistic data

Many records of Australasian Bittern were made when no bittern survey was being conducted. The largest number of opportunistic records was provided by the DEC Warren Region staff conducting weekly monitoring of water levels and chemistry within wetlands in the Muir-Unicup system. Other DEC and BirdLife wetland chemistry monitoring also resulted in opportunistic records.

Most of these opportunistic records were calling rather than sight records, with most of these calls being shortened or "warm-up" calls.

Audio auto loggers

In spring 2012 DEC successfully trailed the use of audio auto recording units (ARUs) at Cheynes Beach Swamp and Lake Pleasant View (Sarah Comer pers. comm.). The purchase of more ARUs is likely to enable more wetlands to be surveyed with fewer people and is recommended.

Wetland Chemistry

A total of 95 wetlands were sampled in spring 2010, spring 2011 or spring 2012, or data were gathered from other sources from various time periods. Wetlands sampled were those which:

- had recent records of Australasian Bittern,
- had historical records of Australasian Bittern,
- or were near these wetlands.

Some wetlands were sampled for just pH and electrical conductivity (salinity indicator). Others were also sampled for total nitrogen and total phosphorous analysis. A smaller group of wetlands were also sampled for analysis of aluminium, arsenic, cadmium, calcium, chloride, chromium, copper, hardness, iron, magnesium, manganese, nickel, sulphate, and zinc. Those with more types of analyses conducted were those more important to bittern or neighbouring wetlands with altered chemistry. A review of this data indicated that the chemical components which appeared to have the most influence on bittern presence were pH and salinity.

Some wetlands with Australasian Bittern records were not sampled for a variety of reasons. These included:

- Crackers Swamp: record could not be confirmed and it appears habitat is not suitable (J.Lane pers. comm.)
- Star Swamp and Pagononi Swamp: records seem likely to have been erroneous when current habitat is considered.
- Bayswater Bird Sanctuary, Scott Basin (Blackwood River) and Vasse-Wonnerup Estuary: these wetlands appear to have only been used by non-breeding Australasian Bittern.
- Neeranup Lagoon and Anstey Swamp: had very low water level during survey period and it is likely these wetlands are only used by bitterns in times of higher than average rainfall.
- Pfieffer Lake, Katanning WAMMCO Dam, Ten Mile Swamp (Manypeaks), and two wetlands east of Cape Le Grand Road are on private property and access was not possible.
- Ewarts Lake, Pipidinny Swamp, Police Pools Reserve, Toolibin Lake and Yackamia Swamp no longer provide suitable habitat.

Aim

Determine the chemistry of wetlands where Australasian Bittern are present to help define habitat characteristics of wetlands frequented by Australasian Bittern.

Method

Surface samples were taken from each wetland and usually from two well separated locations within the wetland. Where previous sampling has occurred we endeavoured to sample from the same location. However, time constraints, access difficulties and lack of information about the exact sampling location sometimes resulted in sampling from new locations.

Samples were taken using new sample bottles provided by the WA ChemCentre. As an added precaution the bottles were rinsed at the sampling location with wetland water. Sample bottles required for nutrient analysis were three quarters filled and frozen. Sample bottles for metal analysis and general chemistry (hardness, calcium, sulphate etc) were filled to the brim and chilled.

Field analysis by BirdLife WA included pH, conductivity and temperature using a TPS WP-81 meter.

For some wetlands DEC Senior Technical Officer Alan Clarke kindly took samples and conducted analyses or provided the samples to BirdLife for analysis. Field analyses were conducted as in Lane et al 2010 and sampling and sample storage as noted above.

Data were obtained from other sources for several wetlands to reduce costs. Sources included nutrient data from DEC (Lane et al 2010, Gillespie 2011 and Wetland Research Management 2005), the Department of Water database, and the Lake Mealup Preservation Society.

Results

Wetlands sampling data, analyses and data sources are shown in Appendix E. The chemical analysis results conducted by BirdLife WA are shown in Appendix F along with ANZECC guidelines for freshwater wetlands.

Graphs showing the results by area and in ascending order are shown in Appendix H. These graphs use a colour coding system to show whether the wetland surveys have confirmed Australasian Bittern present or not. This appendix also provides some commentary on Australian and New Zealand Conservation Council (ANZECC) guidelines and general factors influencing the results.

The data were compared against relevant ANZECC guidelines and Appendix G outlines those wetlands where ANZECC guidelines were not met.

pH

The range of pH values recorded was 3.5 (Lake Mealup) to 9.5 (Red Lake). ANZECC guidelines for wetlands in southwest Australia is pH 7.0 to 8.5, however, only 15 wetlands had at least one sample which met this criteria. All wetlands where bitterns regularly occur had pH ranging from 5.4 to 8.6 and wetlands where bitterns occur sporadically had pH ranging from 6.2 to 9.4. It appears that for bitterns pH out of ANZECC setandards is acceptable as long as the pH is not below 5.5. This means that bitterns are found in wetlands where the pH is neutral to circumnuetral. Circumneutral wetlands have a pH ranging from 5.5 to 7.4.

Wetlands with pH below 5.5 were those that had undergone acidification due to wetland drying or rewetting after wetland drying exposing or mixing sulphides. It seems that when this occurs, food resources plummet due to acid toxicity and this is the likely reason that Australasian Bittern do not occur in wetlands with such acid conditions. Alkaline conditions usually indicate high salinity levels and this appears to be unfavourable to bittern.

Conductivity/salinity

The range of electrical conductivity recorded was 0.12 mS/cm (Cheynes Beach Road Swamp) to 21.8 mS/cm (Heath's Swamp). ANZECC guidelines for salinity (as conductivity) in southwest Australian wetlands are 0.3 to 1.5 mS/cm.

DEC uses the following classifications for salinity: Very fresh (<1000 mg/L), fresh (1000-3000 mg/L), brackish (3000-10000 mg/L), Saline (10000-50000 mg/L) and hypersaline (>50000 mg/L) (Lane et al 2004). These categories are expressed as salinity units rather than conductivity measurements. While conductivity provides an easy method of estimating salinity, precise conversion to salinity is difficult as it is dependent on the types and quantities of various salts present in the water. However, these approximate to the following conductivities: Very fresh (<1.6 mS/cm), fresh (1.6−4.6 mS/cm), brackish (4.6-14 mS/cm) and saline (>14 mS/cm). These categories were used in this study as they appear to be the most relevant to wetlands in Western Australia. No wetlands in this study were hypersaline so this category is not used.

Only four wetlands (Lake Bryde, Heath's Swamp, unnamed wetland on Pindicup Road and Lake Bannitup) was found to be saline. Lake Bryde, Lake Bannitup and unnamed wetland on Pindicup Road are not wetlands where Australasian Bittern would be expected to be present due to the limited vegetative present. Heath's Swamp in comparison had good vegetation present but very low water levels. Heath's Swamp is within a tree plantation with only a firebreak between the swamp edge and plantation edge on all sides.

Eleven wetlands were found to have at least one sample location classed as brackish.

The data showed that more wetlands with bitterns present were very fresh than any other category. However some fresh and brackish wetlands had bitterns present. No saline wetlands surveyed had bittern present but these also had no or limited vegetation present.

Nitrogen and phosphorous

Nitrogen levels varied within regions as it relates largely to neighbouring land uses and incoming streams and drains. Nearly all wetlands had nitrogen concentrations above ANZECC guidelines of 0.5 mg/L. The data inicate that bittern presence does not seem to be affected by nitrogen concentrations.

Phosphorous was highly variable from wetland to wetland and levels are related to neighbouring land uses and the phosphorous levels of incoming drains and streams. The highest phosphorous level recorded was at Lake Sadie (1.4 mg/L) which is well abobe ANZECC guidelines (0.05 mg/L). Several wetlands where bittern are present regularly or sporadicallly also were above the ANZECC guideline, however, most were near to or within the guidelines. Several wetlands were below detection limits for phosphorous.

The data suggests that nitrogen and phospohorous levels above ANZECC standards may not deter Australasian Bitterns, however, there may be a limiting value higher than those experienced during this study.

Metals

A number of wetlands were analysed for metals and other chemical componants associated with acid sulphate wetlands. The wetlands selected were those with known acid sulphate problems, wetlands neighbouring those with acid sulphate problems, or wetlands significant for bittern.

Metals analysed were aluminium, arsenic, cadmium, chromium, copper, iron, magnesium, manganese, nickel, and zinc. Hardness, calcium, chloride and sulphate were also analysed from the same wetlands.

The ANZECC guideline for aluminium concentration to ensure the protection of 95% of species is 0.055 mg/L. Twenty wetlands had aluminium concentrations above this guideline: Lake Mealup (4.5 and 0.42), Mariginiup Lake (2.5 and 1.0), Corymup Lake (1.2), Owingup Swamp (0.91), Cheyne Beach Road Swamp (one of two samples at 0.43), Poorginup Swamp (0.34 and 0.23), Gingilup Swamp (0.3 and 0.2), Jandabup Lake (0.26, 0.11 and 0.085), Moates Lagoon (0.25 and 0.11), Tarnup Lake (one of two samples 0.25), unnamed wetland "South of Adams" (0.24), Cobertup Swamp North (0.23), Noobijup Lake (one of two samples at 0.21), Black Cat Lagoon (0.18 and 0.17), James Swamp (one of two samples at 0.16), Yarnup Swamp (0.16 and 0.14), Benger Swamp (one of two samples at 0.12), Mettler Lake (0.12 and 0.085), South Sister Swamp (0.094 and 0.066), unnamed wetland "Big Boom Swamp" (one of two samples at 0.092), Boat Harbour East (0.09), and Geordinup Swamp West (one of two samples 0.064). These wetlands with aluminium concentrations above the guidelines occur in all four regions of the Australasian Bitterns range.

More wetlands exceeded the guideline than had aluminium levels below the guideline. However, the four wetlands with an aluminium concentration of greater than 1.0 mg/L had strong acid sulphate problems

and no bitterns were recorded. Wetlands with less than 1 mg/L of aluminimium usually had acceptable pH levels and many of these had bittern present.

Arsenic concentration increases with increasing pH and all wetlands sampled were below the guidelines.

Cadmium concentration in the samples was usually below the detection limit, which ranged from 0.0001 to 0.0005 mg/L. The 95% protection guideline is 0.0002 mg/L which was often below the detection limit. Only one sample from Lake Pleasant View (0.0001) had a detectable amount of cadmium. It is difficult to make any comment regarding cadmium as detection limits smothered nearly all the data.

Chromium concentrations are difficult to compare against the ANZECC guidelines as chromium speciation is required (i.e. chromium III or chromium VI). The ANZECC guideline for chromium VI is 0.001 mg/L which was also the detection limit of the analyses. ANZECC does not have a guideline for chromium III as there are insufficient toxicity data available. The samples were analysed for total chromium and 12 wetlands exceeded the guideline for chromium IV but it is unknown what ratio of the chromium present would have been the chromium VI species. Most wetlands with chromium above or at the guideline had Australasian Bittern sporadically or regularly present, so it would seem that the levels of chromium detected were of no consequence.

Using the ANZECC hardness modified guideline algorithm, copper concentrations at Lake Pleasant View, Cobertup East, unnamed wetland "South of Adams" and Benger Swamp were above the guideline. All of these but Cobertup East have Australasian Bittern regularly present so it does not seem to be important.

There is no ANZECC guideline for iron concentration in wetlands. Iron increased with increasing acidity and the highest concentration detected was 4.9 mg/L at Lake Mealup which had a corresponding pH of 3.5 (acid).

There is no ANZECC guideline for magnesium concentration (like calcium) in wetlands. Magnesium increases with increasing conductivity. The highest concentration detected was 390 mg/L at Byenup Lagoon which is a wetland which regularly hosts Australasian Bittern.

Only one wetland reached the ANZECC 95% protection guideline of 1.9 mg/L of manganese and this was Corymup Lake, an acidified wetland. All other wetlands were well below the guideline.

The nickel concentration using the ANZECC hardness modified guideline algorithm was never exceeded during this study. The highest nickel concentration was at Corymup Lake (0.022 mg/L).

Several wetlands had zinc concentrations at or above the ANZECC hardness modified guideline algorithm. These were Cheynes Beach Swamp, unnamed wetland "South of Adams", Poorginup Swamp, Jandabup Swamp, Tarnup Lake, Benger Swamp, Mariginiup Lake, unnamed wetland "Big Boom Swamp", Lake Pleasant View, Gingilup Swamp, and James Swamp. Many of these wetlands have Australasian Bittern regularly or sporadically present so it does not appear to be an important factor at the levels recorded.

Calcium increases at higher and lower pH but is fairly insoluble in neutral pH wetlands. It also increases with increased electrical conductivity. Corymup Lake which had a high conductivity and low pH had the highest calcium concentration (321 mg/L).

Chloride has no ANZECC guideline, however, is a large component of salinity concentration. Chlorine strongly correlates to electrical conductivity. The highest chloride levels recorded were at Noobijup Lake (4700 mg/L) and Byenup Lagoon (4530 mg/L).

Sulphate has no ANZECC guideline and is dependent on wetland pH. Like calcium, the sulphate concentration increases with lower and higher pH but is relatively insoluble at neutral pH. Corymup Lake

had the highest sulphate concentration at 1890 mg/L which was a reflection of the acidity at this wetland (pH 4.0).

Hardness increases with increasing conductivity and there is no ANZECC guideline, however, it is used to calculate the hardness modified guidelines of many metals which are more toxic in wetlands with lower hardness (e.g. nickel).

Summary

The data indicate that, while many of the wetlands at which Australasian Bittern occur are above one or more ANZECC guidelines, the main indicators of bittern presence are pH and conductivity (salinity). Both of these are easily analysed using relatively inexpensive field equipment.

All wetlands where bitterns regularly occur had pH ranging from 5.4 to 8.6 and wetlands where bitterns sporadically occur had pH ranging from 6.2 to 9.4. The data showed that more wetlands with bitterns present were very fresh than any other salinity category. However some fresh and brackish wetlands had bitterns present. No saline wetlands surveyed had bittern present but only one had suitable habitat but was almost dry. With the exception of Byenyup Lagoon (7.8 and 13.3 mS/cm), bittern were present in wetlands with a conductivity of less than 8 mS/cm.

Figure 16 - Sample bottles showing a wide range of colour. Colour was not measured in this project. Photographer: Robyn Pickering

Wetland Habitat Review

Australasian Bittern are usually found within sedge or rush vegetated freshwater wetlands (Marchant and Higgins 1990). However, they can be found in estuarine locations (Marchant and Higgins 1990), herbfields adjoining wetlands (Teal 1989) and wetland uplands (O'Donnell 2011, Menkhorst 2012, and Menkhorst and Silcocks 2004). In southeast Australia Australasian Bittern are found in rice fields (Andrew Silcocks pers. comm.) and the grassy edges of channels (Menkhorst).

In New Zealand Whiteside (1989) found that Australasian Bittern at Whangamarino wetlands in New Zealand preferred inundated water purslane (*Ludwigia sp.)* and willow weed (*Polygonum sp*.) vegetation for feeding. A review of Australasian Bittern nesting data in New Zealand (24 nests) by O'Donnell (2011) showed that the species nested in *Typha orientalis* (7 nests), *Scirpus* reedbeds (3 nests), mixed vegetation (3 nests), *Salix sp*. (2 nest), *Carex secta* sedgeland (2 nests), *Baumea* reedbeds (2 nests), *Juncus* rushland (1 nest), *Leptocarpus similis* (1 nest), *Cortaderia sp*. (1 nest), grasses under bracken (*Pteridium esculentum*) (1 nest) and peat bog (1 nest).

Great Bittern have similar habitat requirements to Australasian Bittern. They mostly use wetlands with common reed (*Phragmites australis)*, reedmace (*Typha* spp.), bulrush (*Schoenoplectus lacustris),* saw-sedge (*Cladium spp.)* or sedge (*Carex* spp.) but also utilise other similarly vegetated wetlands (White et al 2006).

American Bittern have quite different habitat preferences to Great Bitterns as they nest both in wetlands and in uplands of idle grassland and shrubs (Dechant et al 2002). While they use many habitats that Great Bittern use such as tall, dense emergent vegetation in shallow or deep water and vegetation in wet fields, they also use native or tame vegetation in uplands adjacent to wetlands (Dechant 2002 citing Bent 1963, Stewart 1975, Duebbert and Lokemoen 1977, Hanowski and Niemi 1986, 1988, Faanes and Lingle 1995, Kent and Dinsmore 1996).

A single record of an Australasian Bittern nesting under bracken 800m from the nearest water (O'Donnell 2011) shows that the species use upland vegetation, however, all other available literature suggests that use of uplands is rare or uncommon. Several photographs in the BirdLife Australia photographic library show Australasian Bittern feeding in modified upland vegetation, such as grasses and herbs. This information suggests that Australasian Bittern may utilise upland vegetation at times but it is difficult to determine the regularity of this use. This project has focused on bittern use of wetlands, however, in future it may be useful to conduct daytime surveys in upland areas or make concerted notes of opportunistic data from upland areas.

Broad scale habitat documentation

In 2011, vegetation data and other data from Halse et al 1993 was entered into a spreadsheet and a multivariate analysis performed to see if any statistically significant grouping of "bittern wetlands" would result. This analysis was undertaken by Allan Burbidge (DEC) and showed that the wetlands known to have bitterns present in the 1980s and 1990s were in two main groups. Most wetlands with Australasian Bittern present were grouped together in wetlands with extensive areas of sedge with fresh water.

This analysis provided an indication that collating some broad scale data on a large number of wetlands in which Australasian Bittern were present or absent would be worthwhile. A multivariate analysis on these wetlands could be performed and from this it should be possible to provide broad scale indicators of possible bittern presence in wetlands.

A consultant was engaged to document the habitat availability of 99 wetlands in the Muir-Unicup region and along the south coast between Albany and Cape Arid. Other wetland habitat data was collated by the author. Habitat estimates, bittern survey data and chemistry data provide the data for future multivariate or other statistical analysis.

The wetlands selected for habitat estimates were those where Australasian Bittern are or were present, some nearby wetlands and wetlands where aerial photography suggests habitat is available. Aerial photographs from Landgate, maps supplied by DEC and GIS software allowed an estimate of lake areas, open water areas, areas of sedge and areas of shrubs within the wetland.

The wetland habitat estimation of 162 wetlands provides a very good starting point for estimating the total habitat available to Australasian Bittern in Western Australia. Some areas not included in the estimates were estuarine habitat and the complex wetlands systems such as that west of Broke Inlet. But overall the vast majority of suitable wetlands and some wetlands which neighbour those were included in this work.

Some of the data collated for each wetland are shown in Appendix J. Of these 162 wetlands 17 regularly host bittern, nine support bittern sporadically, 39 have been surveyed and do not appear to host bittern and it is unknown whether bittern are present in the other 96 wetlands. Table 3 provides an overview of these data and supports the theory that Australasian Bittern are present in vegetated wetlands. On average, wetlands with bittern present were larger and had higher areas of sedges and shrubs and a lower area of open water. The area of sedge present was the most significant factor differentiating wetlands with bittern present or absent.

The minimum area of sedges in a wetland with bittern present was 3 hectares at Black Cat Lagoon while the average area of sedge in wetlands with bittern regularly present was 152 hectares.

Table 3: Broad scale habitat data overview

Wetland category (number of wetlands in dataset)		Lake area (ha)	Vegetation area (ha)	Open water (ha)	Sedge area (ha)	Shrub area (ha)
All wetlands (162)	- Average	124	54	70	38	9
	- Max	4600	933	4500	509	305
	- Min	1	0	0	0	0
Wetlands with bittern regularly present (17)	- Average	278	215	52	152	19
	- Max	1247	933	225	509	158
	- Min	12	3	0	3	0
Wetlands with bittern apparently absent (39)	- Average	198	34	167	21	16
	- Max	4600	305	4500	100	305
	- Min	3	0	0	0	0

The collated data show that these 162 wetlands provide 6254 hectares of sedge habitat. It is worth noting however, that some of the habitat used in this calculation is in wetlands which are acidified and have limited food available for foraging. Other wetlands have very small areas of sedge. When this is totaled over many wetlands it suggests large areas of habitat but the small size in some wetlands means it is not likely to be used by Australasian Bittern. Similarly Lake Muir, the largest wetland (4600 hectares), has a vegetation cover of less than one percent and the width of sedge beds is very small, however, in total there is approximately 100 hectares of sedge. Bittern are not known to be present at Lake Muir.

Broad scale multivariate and other statistical analysis

Further statistical analysis of this data is recommended so that indicators of possible bittern presence in wetlands can be determined and documented. Several members of the technical advisory group and long term volunteers have a good understanding of habitat requirements and can identify good habitat or inadequate habitat, however, documentation of these factors will provide this information to other conservationists.

The flora of Australasian Bittern wetlands

Wetland floras found in wetlands where Australasian Bittern are or were present were reviewed using relevant literature or derived from field work. During the study a consultant botanist was engaged to conduct vegetation mapping of four wetlands significant for bittern (Sandiford 2012a and Sandiford 2012b). These were: Kulunilup Nature Reserve (Kulunilup Lake and Kulunilup Swamps), Lake Pleasant View, Cheynes Beach Road Swamp and unnamed wetland "Big Boom Swamp". This work was done to provide some detail on fine scale bittern habitat preferences, however, it also provides information on vegetation species present in a variety of good quality bittern wetlands.

Most wetlands where Australasian Bittern call and are thought to be breeding support the sedges *Baumea articulata*, *Gahnia sp* or *Typha orientalis*. It appears that these taller sedges are the dominant plants used by bittern for nesting sites. However, the wetlands usually have small to large areas vegetated by other sedges, grasses or herbs which provide good foraging areas. In particular *Baumea arthrophylla* and similar low to medium density sedgelands provides good foraging for Australasian Bittern. In some wetlands inundated *Melalueca laterita* mixed with low density *Baumea sp*. is used regularly for bittern foraging. Appendix K provides a list of plant species found in wetlands where Australasian Bittern are present.

Habitat documentation

A sub-group of the technical advisory group identified a need to record the habitat characteristics of any feeding platform, nest or bittern feeding site (where a bittern was flushed or seen). This would identify fine scale habitat preferences of Australasian Bittern. Expert opinion and a literature review provided information that allowed for the development of a fine scale habitat data form; the form was finalised and adopted by the group in June 2011. This fine scale habitat form appears in Appendix I.

Figure 17 - *Baumea articulata* habitat where Australasian Bittern flushed at unnamed wetland "South of Adams" Cape Le Grand Road UCL October 2011. Photographer: Robyn Pickering

Vegetation mapping at four wetlands by the consultant botanist provided data from entire wetlands which could be compared against the fine scale data collected at bittern foraging, nesting and feeding platform sites. The collection of fine scale habitat data from these wetlands will continue to be collected in the coming years. At present there are insufficient data to adequately describe fine scale habitat preferences of Australasian Bittern. This is a knowledge gap which needs to be filled.

Aerial oblique photographs were taken at many wetlands important to Australasian Bittern. The DEC have been taking aerial oblique photographs at wetlands over several years and BirdLife Australia had consultants take many aerial oblique photographs not in the DEC program. These photographs aid documentation of wetland habitat, provide information for best conducting future surveys and where access is best available through dense vegetation.

Figure 18 - Aerial oblique photograph of western part of Gingilup Swamps taken by Airpix for BirdLife Australia.

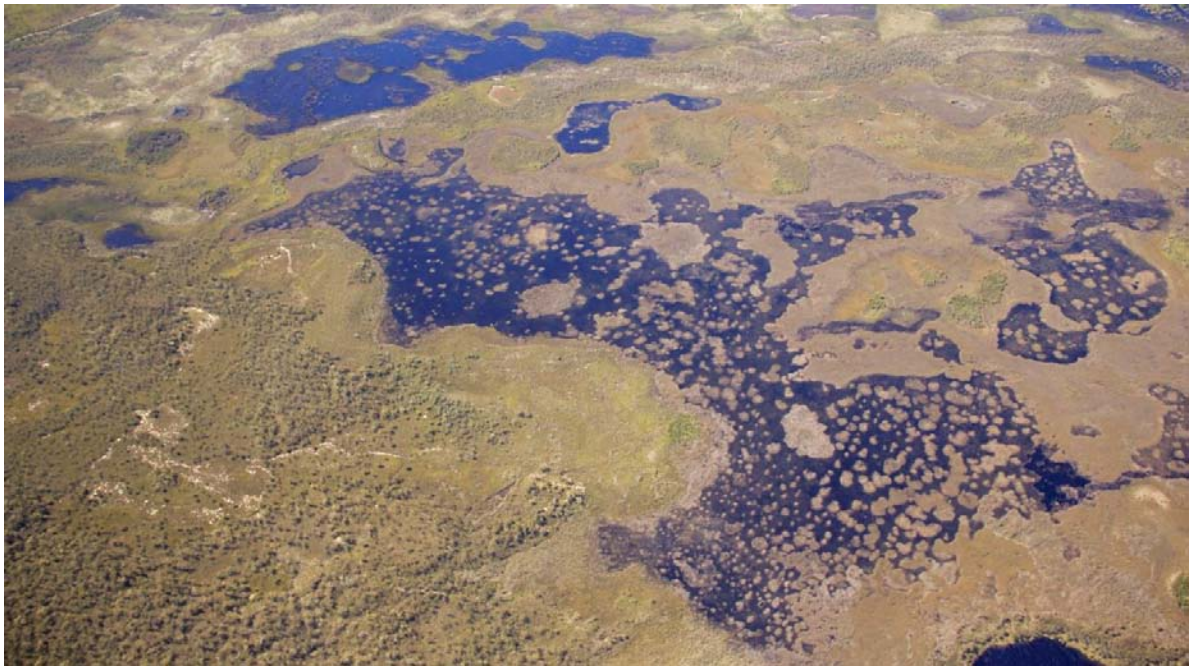


Figure 19 - Gingilup Swamps aerial oblique detail. Photographer: Airpix for BirdLife Australia.

Nesting habitat

Marchant and Higgins (1990) note that Australasian Bittern nests mainly occur in *Phragmites*, *Typha* and rushes such as (*Baumea* and *Juncus*) in swamps, usually 30cm above water and constructed as a flat saucer of cut off pieces of rush or reed. O'Donnell (2011) reported the vegetation habitat of 24 Australasian Bittern nests in New Zealand. Three nests were in dry locations in wetlands while the remainders were in vegetation over water. Plant species containing nests included *Baumea* (rush), *Typha* (bulrush), *Juncus* (rush), *Carex* (sedge)*, Leptocarpus* (rush), *Scirpus* (rush)*, Cortaderia* (grass e.g. pampas grass), and *Salix* (willow). Peat bog and mixed vegetation types were also present. One nest was 800 meters from water under bracken and made from grasses.

The American Bittern (*Botaurus lentiginosus*) nests both in wetlands and upland areas (Dechant 2002) and it has been suggested that nest sites for this species are largely based on nearness to foraging areas rather than specific nest habitat (Wiggins 2006).

The Great Bittern (*Botaurus stellaris*) appears to be more specific in its nesting requirements with the literature showing nests to be restricted to being within wetlands, however, as per O'Donnell the site may be in a dry or inundated location (Demongin et al 2007). Polak (2007) note nests in *Phragmites, Typha, Carex* and *Scirpus* at water depths of 10 and 97 cm. Poulin et al 2005 note that in the Camargue marshes salt presence reduces reed density and bittern have adapted by nesting on the ground. Demongin et al 2007 found nests in wetland vegetation, usually *Phragmites australis*, at water depths of 0cm to 80cm.

Few nests have been found during this WA study with most nests found on surveys led by DEC officer Alan Clarke. Nests found to date fit the general descriptions given by O'Donnell (2011) and Marchant and Higgins (1990) and have been found within wetlands in *Baumea articulata* and *Gahnia* rushes (Clarke and Wheeler, 2010). Further data need to be collected over coming years.

Foraging habitat

Some authors suggest most feeding occurs at night, dusk or dawn, with some records of daytime feeding Marchant and Higgins (1990). However, in New Zealand, Whiteside (1989) found Australasian Bittern feeding occurs throughout the day during autumn while winter feeding was mainly in the middle part of the day with a midday peak, with little evidence of night time feeding. Whiteside observed Australasian Bitterns from a hide in the Whangamarimo wetlands in New Zealand for 90 hours between April to August 1986. Individual birds fed for 7 to 60 minutes at a time with an average of 30 minutes. Whiteside (1989) found bitterns walked between 10 to 500 meters during a feeding session and all fed at the edges of ponds and waterways.

Menkhorst (2012) observed Australasian Bittern feeding during the day along vegetated banks of channels and within channels in southeast Australia for a total of 9.5 hours between May and August 2010. The vegetated banks used by the bittern for foraging was largely vegetation of less than 40cm in height and included grasses, sedges and herbaceous plants with some clumps of *Phragmites australis* or shallow water in the channel (Menkhorst 2012).

During this study Australasian Bittern were most frequently found feeding during the day, however, our daytime survey technique is most likely to find foraging bitterns. On one occasion a bittern flew up from a foraging site during a dusk survey at Kulunilup Swamp and many of the listening surveys indicated that bitterns were calling from foraging sites during dusk and dawn. On occasions it was noted that the calling bitterns moved around the wetland while calling suggesting foraging, however, most bitterns appeared to remain reasonably stationary during the listening survey period.

Figure 20a and b – Team member David Secomb at Lake Pleasant View Australasian Bittern foraging site November 2011. Note shallow water with low density *Baumea arthrophylla* and some *Baumea articulata.* Photographer: Robyn Pickering

Australasian Bittern have been recorded in the literature as foraging in still shallow water to 0.3m deep or from a platform or mat of vegetation over deep water Marchant and Higgins (1990). Most records from this study have been of bitterns foraging in shallow water in low to medium density rushes.

Feeding platforms

Feeding platforms are also used by Australasian Bittern. The most well documented use is for adult bitterns feeding young who had left the nest but were still dependant on the adult. Teal (1989) reported that several feeding platforms were used by young and that these were not far from the nest. During this study feeding platforms have also been found near to nests (Alan Clarke pers. comm.).

Habitat data are being collected for feeding platforms, nests and foraging sites, however, there is insufficient data available to draw any firm conclusions. Further fine scale habitat data will be collected over coming years.

Food Resources

Australasian Bittern have a varied diet which includes small to medium sized fauna. Prey items include insects, mammals, reptiles, amphibians, birds, crustaceans, and fish (Whiteside 1989, Marchant and Higgins 1990, Menkhorst 2012, Menkhorst and Silcocks 2004, Serventy And Whittell 1948). Cleland et al (1918) also noted that leaves and fruits were eaten.

White et al (2006) concluded that prey availability appeared to be the most important factor in successful breeding of Great Bittern as long as other basic requirements were available. Therefore it is likely that good prey availability is important for successful breeding of Australasian Bittern.

Very little work has been conducted during this study of prey availability, however, audio recordings of frogs and anecdotal records from observers provide some information on prey availability. Further data collection may provide evidence that bittern presence or density is dependent on prey availability. If this were to occur then this information could be used to improve the conservation status of the species.

White et al (2006) reported that micro-habitat enhancements have been carried out in some European wetlands to increase prey availability for bittern. These have included creating open water areas, increasing reed/water interfaces, altering the profile of ditch edges, and increasing water connectivity. Gurney (2007) reported the release of fish into a wetland in the United Kingdom specifically to improve conditions for Great Bittern (Botaurus stellaris) provided some success with a pair nesting in the wetland soon after the fish introduction. It is possible that some of these actions could be taken to improve breeding success in some Western Australian wetlands. However, first it is necessary to determine if prey availability is restricting breeding success in southwest Australia.

Figure 21 - Australasian Bittern feeding in vegetation surrounding a wetland in Victoria. Photographer: Peter O'Connell

Audio Recordings of Australasian Bittern Calls

It is thought bitterns call to advertise their presence to mates and to defend territory (Marchant and Higgins 1990, Cramp and Simmons 1977, Puglisi et al 1997). Great Bittern (Botaurus stellaris) produce calls that are very similar to Australasian Bittern calls. Variation in the calls of Great Bittern has been documented noting differences in the calls of individual bittern (Gilbert et al 1994, Gilbert et al 2002 and Puglisi and Adamo 2004).

While audio recordings of Australasian Bittern were taken by several volunteers, the calls are being documented and analysed by honors' student John Graff. With such a small population of bittern in Western Australia it may be possible from this work to track individual bittern from year to year and determine biological information such as wetland fidelity, seasonal movements and regularity of potential breeding periods.

Teal (1989) noted with Australasian Bittern calling in the Whangamarino Wetlands of New Zealand that each bittern had a "different pitch, pace and loudness, which allowed individuals to be distinguished". This is easier to discern where more than one bittern is calling within a wetland as the calls from bittern calling from different directions can be compared.

Typically Australasian Bittern calls are up to four gasps, followed by "woomph", then gasp then "woom" more resonant and longer than first boom, usually repeated 2-3 times (Marchant and Higgins 1990). This was usually the case in this study. Sometimes very short calls were heard which consisted of one "oom". These were thought to be warning or "warm-up" calls.

Teal (1989) found Australasian Bittern to call with usually 3-4 booms but up to 7 booms were heard from an individual during a study in the Whangamarino Wetlands in New Zealand. Teal (1989) observed that the booms were preceded with 2-3 short coughs or grunts. These coughs or grunts are described as pumps (Gilbert et al 1994) or gasps (Marchant and Higgins 1990).

Figure 22 shows a recording of an Australasian Bittern calling at Byenup Lagoon with five gasps preceding the first of three "ooms". In comparison Figure 23 shows a recorded call from unnamed wetland "Big Boom Swamp" which has two gasps preceding five "ooms". Noticeable in these recordings is two different "oom" structures or sounds. In reviewing recorded calls it appears that ooms fit within one of these two types of audio structures.

It is recommended that once the audio recordings have been analysed and documented by the honours' student this information be utilized for bittern conservation.

In New Zealand calls are being recorded at Whangamarino Wetlands by Masters student Emma Williams at Massey University in conjunction with Colin O'Donnell of the Department of Conservation (Emma Williams pers. comm.) It may be possible that these calls and any documentation of these calls maybe compared with those collected and documented in Western Australia to determine if there are differences in the calls of the populations in New Zealand and southwest Australia.

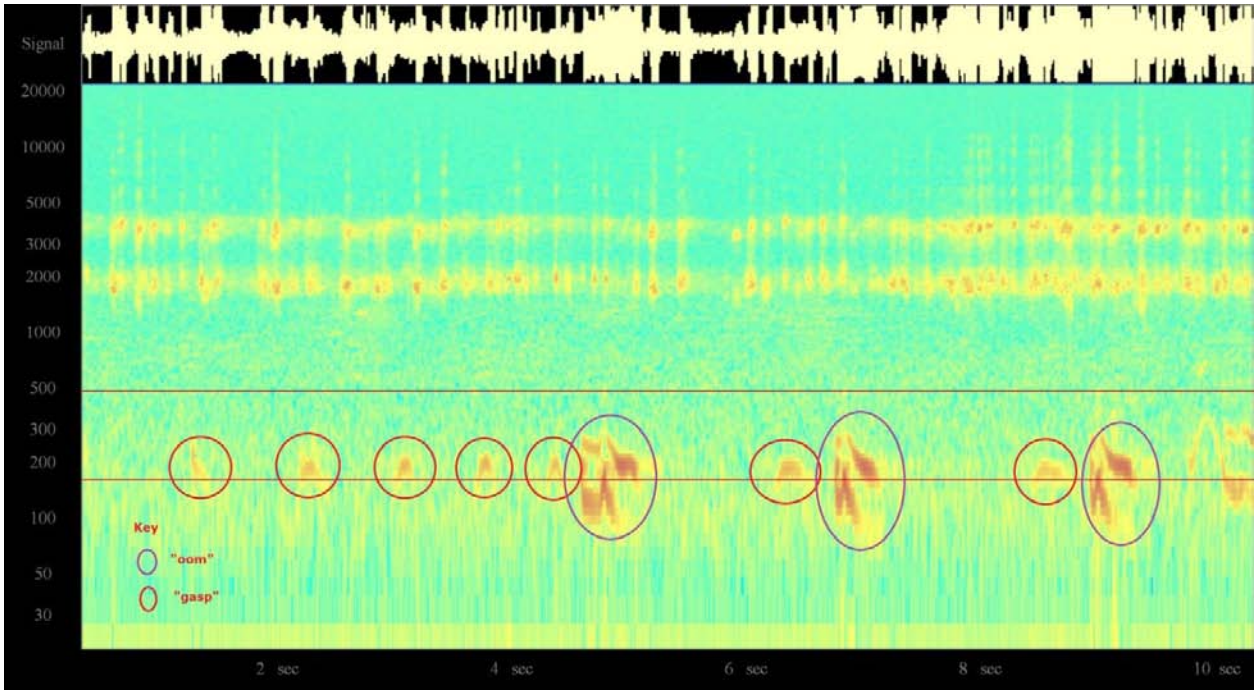


Figure 22 - Sonagram of an Australasian Bittern calling at Byenup Lagoon in November 2009 recorded by Robyn Pickering. Note the complex structure of the ooms.

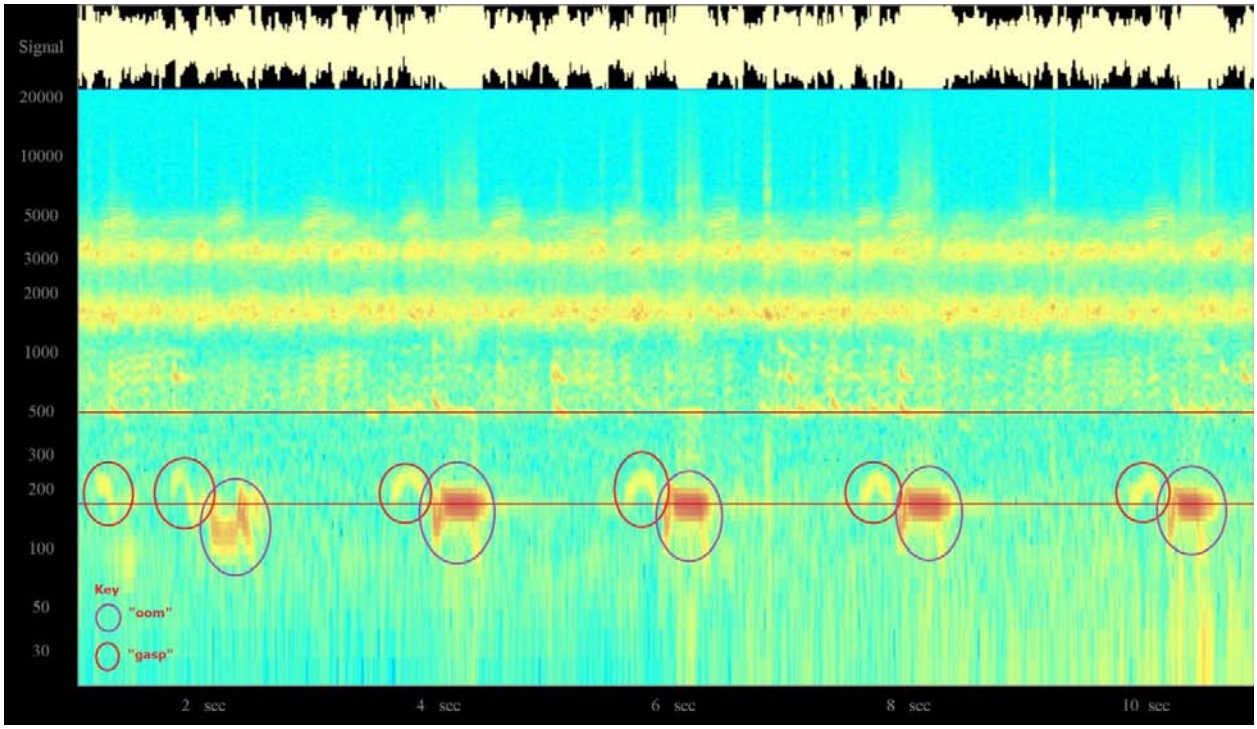


Figure 23 - Sonagram of an Australasian Bittern calling at unnamed wetland "Big Boom Swamp" in October 2011 recorded by Robyn Pickering. Note the simple structure of the ooms.

Australian Little Bittern

The Australasian Bittern project provided an ideal opportunity to also survey for Australian Little Bittern which is a poorly recorded species, has similar habitat preferences to Australasian Bittern and has an unclear status in Western Australia. Most records of Australian Little Bittern from this study were recorded opportunistically while conducting Australasian Bittern surveys, however, a small number of surveys on the Swan Coastal Plain were conducted by volunteers specifically for Australian Little Bittern.

A literature and data review found that, prior to this study, Australian Little Bittern had been recorded at 37 wetlands in the southwestern Australia. Australian Little Bittern was found in 36 wetlands during the project, compared to 14 during the 1981-1985 waterbirds study (Jaensch et al 1988). The increased number of records is likely to be related to the dusk survey methodology which is likely to provide a better record rate than daytime waterbird surveys.

In 2009 the Little Bittern Blitz was established to try to increase records of Australian little Bittern. It was recognised during the Australasian Bittern project that calls of Australian Little Bittern were often heard at only comparatively short distances and records indicated a latter time of year peak calling period than for Australasian Bittern. So the Little Bittern Blitz was setup with a different survey technique and was conducted mainly in November and early December.

The Little Bittern Blitz survey methodology was as below:

- Survey at least 30 minutes at a wetland between 6.30pm and 7.30pm (this is 30 minutes before and after sunset in early November).
- Start at some Bullrushes or other tall rushes (1.8m high or higher is good). This stand of rushes or reeds should be in water at least 30cm deep - i.e. not dry). Listen at this site for 7 to 10 minutes and then walk to another stand of rushes at least 70m away. Listen again for 7-10 minutes before walking to the next likely spot. Little Bittern calls do not carry vary far, anywhere from 30m to 100m so it is important to move along to survey a bigger area.
- If audio broadcast equipment is available and you have not heard an Australian Little Bittern calling, play a single call at conversational sound level after 7 minutes of listening. Then listen for 2-3 minutes prior to moving to your next site.

Appendix L provides records of Australian Little Bittern recorded in this study.

Figure 24 - Australian Little Bittern, Kununurra, Western Australia. Photographer: Robin Ashford

Education and Awareness

One of the aims of the project was to raise awareness about the species and its status within Western Australia, and to educate people with an interest in wetlands, birds or bitterns in particular. The project also aimed to recruit observers, and train them in bittern survey techniques.

During the project these aims were achieved as follows (Appendix M):

1. Calls for survey volunteers were made through BirdLife Australia's quarterly *Western Australian Bird Notes*, and through the organisation's regular *Western Australia e-news*. People registering an interest in the project were sent an identification kit and recordings of Australasian Bittern calls. In the very early part of the project a small CD of calls from bittern and other "oomers" was sent to volunteers. In the field volunteers were organised into small groups with a mix of more experienced and less experienced members within a group. This was a highly successful education process as the project started in 2007 with a very limited number of people who could confidently identify Australasian Bittern aurally or visually but this number increased dramatically by the end of the 2011/2012 survey season. The campouts in Manjimup and Albany were particularly useful as there were more bittern to hear or see and campout participants spent two to three days together learning survey techniques, gaining experience in the field and talking together.

2. BirdLife Australia established a bittern web page on the organisation's website and included information on the status of the species, identification kits and survey techniques. Volunteers and the BirdLife WA membership were directed to this webpage through regular emails and publications. The national bittern website can be found at http://www.birdlife.org.au/projects/bittern-project. While the WA page is found at http://www.birdlife.org.au/projects/bittern-project/AB-in-WA.

3. Summaries of the project were published in Western Australian Bird Notes to update the BirdLife WA membership about the project and its progress. These updates included an annual summary in June of each year and other updates as particularly important information came to light.

4. The project established an email group which was primarily used to provide updates and requests for volunteers for upcoming surveys. These emails also provided an opportunity to provide educational material.

5. A 45 minute presentation was given at the BirdLife WA monthly meeting on 25 May 2009 at the Ecology Centre in Floreat (title page is shown in Appendix M). Approximately 50 attendees were provided with an overview of the species including: a comparison with the other *Botaurus* bitterns, status, declines across Australia, distribution in Western Australia, identification confusions, wetland changes, survey techniques, and survey results.

6. A one hour presentation was given at the Western Australian Wetland Management Conference on 2 February 2011 at the Cockburn Wetlands Centre (title page is shown in Appendix M). This enabled the project to raise awareness to a wider conservation audience and was the first time the project had been presented to a group wider than the BirdLife Australia membership. This provided attendees with in introduction to the Australasian Bittern, identification tips, status, population estimates, declines in population, threats, distribution in Western Australia, the project aims, survey techniques, and project achievements.

7. A ten minute presentation was provided to the Birds Australia AGM at the University of Western Australia in May 2011(title page is shown in Appendix M). This presentation allowed dissemination of information to a wider audience and included many people from other states. The presentation fitted within the conference theme of Important Bird Areas and the session

theme of community action. It provided attendees with information on the distribution in Western Australia, declines in the population in Western Australia, the designation of Important Bird Areas for Australasian Bittern in Western Australia and the other Australian states, project aims, project achievements, community involvement and conservation measures.

8. Four A2 posters were prepared for the Birds Australia AGM at the University of Western Australia in May 2011 (Appendix M). These were then used by the BirdLife WA Community and Education Committee for displays at Festivals, schools, libraries etc. They were also sent to the DEC Regional Offices for use within the range of the species.

9. Two articles were published in *Western Wildlife* magazine to promote the project and to raise awareness of the species (the cover page for one of these articles in Appendix M). *Western Wildlife* is a DEC publication primarily for Land for Wildlife property holders.

10. An article on Australasian Bittern was published in *Wingspan* in Spring 2011 to raise awareness about the species and the national project to the entire Birds Australia membership. The cover page appears in Appendix M.

11. Two tri-fold, full colour brochures were produced for the general public, with distribution from the BirdLife WA office, regional offices of DEC and at various events (Appendix M). The first was a general pamphlet raising awareness about the species. The second pamphlet focused on wetland management for Australasian Bittern on private property.

12. A poster was presented at the Western Australian wetlands Conservation Conference on 1 February 2013.

13. Several articles on the project were published. These included:

- "Swan Coastal Plain Australasian Bittern Surveys, 2007-2008" *WA Bird Notes*, No 126 June 2008, p1-4;
- "Summary of Australasian Bittern Surveys 2008/9" WA Bird Notes, No 131 September 2009, p8.
- "Summary of the Australasian Bittern and Australian Little Bittern Surveys 2009/10", WA Bird Notes, No. 134, June 2010, p13-14.
- "The Australasian Bittern Project" *Western Wildlife*, Oct 2011;
- "Bitterns in the west" *The Bittern Chronicle*, Sept 2011, p7;
- "The Australasian Bittern Project in Western Australia" *Wingspan* p26 Spring 2011;
- "Summary of the Australasian Bittern and Australian Little Bittern Surveys 20010/11" *WA Bird Notes*, Vol 138 June 2011, p15-17;
- "Australasian Bittern booming near Cape Le Grand" *WA Bird Notes* Vol 140 December 2011, p12-13.
- "Things that go 'boom!' in the night – the Australasian Bittern" was published in December 2011 in Western Wildlife, Vol 16 (1) Jan 2012, p1,4 & 5;
- "The Australasian Bittern Project 2011/12" *WA Bird Notes*, No. 142 June 2012, p 16-17;
- "The Australasian Bittern and its water requirements" *Wetlands Australia: National Wetland Update,* February 2013.

Discussion and Conclusions

Range of the Australasian Bittern in Western Australia

The range of the Australasian Bittern has changed over the past century, largely as a result of changes to wetland chemistry and vegetation as a result of large scale vegetation clearance or changes in surrounding land usage. The decline of wetlands with habitat supportive of Australasian Bittern has been documented in the literature. Some examples are Lake Towerrinning (Cale et al 2004) and Lake Toolibin (Froend and Storey 1996).

Figure 25 - Australasian Bittern were once recorded at Lake Gundaring (east of Wagin) but this wetland has undergone secondary salinisation and no longer has habitat for the species. Photograph: Robyn Pickering

Figure 26 is a map of records of Australasian Bittern in southwest Australia and provides a good indication of the range of the species in this region. The key shows 3 types of data:

- Current project records from (month) 2007 to December 2012 records. This includes data from both BirdLife Australia and DEC surveys.
- Records prior to 2007 from literature and BirdLife and DEC databases with most records from the waterbirds studies between 1981 and 1991. Only sites not included in the 2007-2012 data are noted on the map.
- Museum specimen records. There are 15 specimens from southwest Australia; four of these are undated. The dated records are from 1896 (specimen from Perth) to 1982 (Kojonup).

Given the high number of surveys since 2007 this map provides an indication of:

- Locations where habitat has deteriorated or been destroyed. This is particularly so for wetlands on the Swan Coastal Plain and Muir-Unicup system.

- Some sites are known non-breeding season sites, with very low numbers of records, which were not surveyed in the non-breeding season during this study. These include Hardy Inlet and Vasse-Wonnerup Estuary.
- Some sites could not be surveyed in this study due to access difficulties or time constraints.

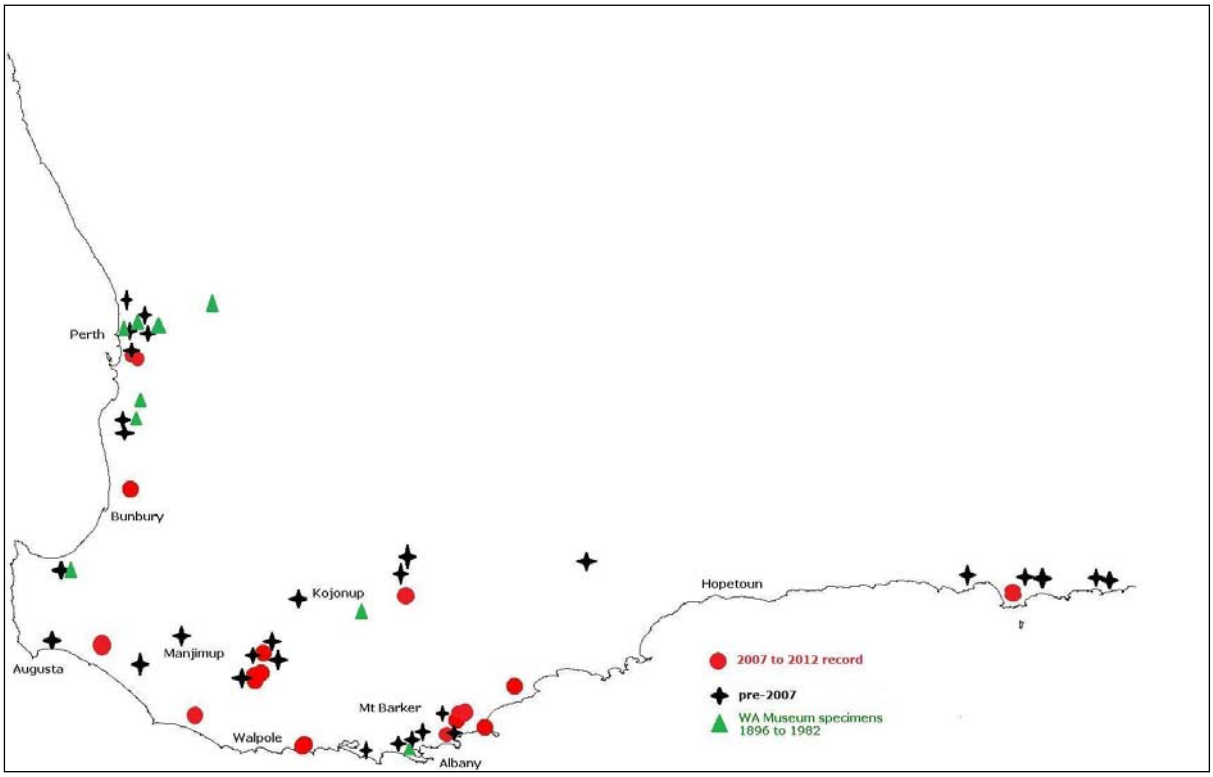


Figure 26 - Australasian Bittern records past and present in southwest Australia

It appears that the number of wetlands used by Australasian Bittern has declined in the northern Swan Coastal Plain, the eastern South Coast and the interior. However, wetlands in all parts of the range have been affected by habitat change, resulting in bitterns no longer or rarely using them.

Densities of Australasian Bittern in Western Australia

Differences in water level, time of year, habitat and local conditions will have a large affect on the density of Australasian Bittern at any given wetland.

Australasian Bittern are mostly seen singly but are also seen in pairs or groups of up to 12 (Marchant and Higgins 1990). Surveys from this project have supported this with the largest group found was eight to nine birds in one small area of Lake Pleasant View in April 2012. This record corresponded with the wetland dry period after a drought year. The lack of water in other wetlands would have contributed to the increased density at this wetland at that time. It is not known if the increased number of bittern at Lake Pleasant View in autumn is a result of local bitterns moving to this wetland to make use of particularly good conditions or whether some bitterns migrate from the northern parts of the range to the south during the post-breeding, dry period. There was a record one year earlier, in March 2011, where seven to eight Australasian Bittern were also recorded at Lake Pleasant View (A. Clarke pers. comm.) indicating this may be an annual event.

There are only nine other records of five or more bitterns in a wetland in the database and these are:

- eight at Benger Swamp in November 1983
- seven at Benger Swamp in October 1983
- six to eight at Lake Pleasant View in October 1992
- five males heard calling at Benger Swamp October 1982
- five at Kulunilup Swamp December 1983
- five at Owingup Swamp January 1992
- five at Lake Pleasant View December 1981
- five at Lake Pleasant View November 1986
- five to six heard calling at unnamed wetland "Big Boom Swamp" in October 2012.

Figure 27 shows the frequency distribution for the numbers of Australasian Bittern recorded at all southwest Australian wetlands in the database. Data range from 1976 to the July 2012 and depict the data from this study as separate to those prior to 2007. It includes both bittern seen and heard. This shows that 67.6 percent of the 272 records were of single bittern, 22.1 percent of records were of pairs, 8.8 percent of records were of three to five bittern and 1.5 percent of records were of six to eight bittern.

Figure 27 show that this study has fewer records of multiple bitterns in wetlands than the older data. Certainly some wetlands, such as Benger Swamp, seem to have fewer Australasian Bittern present than in the past.

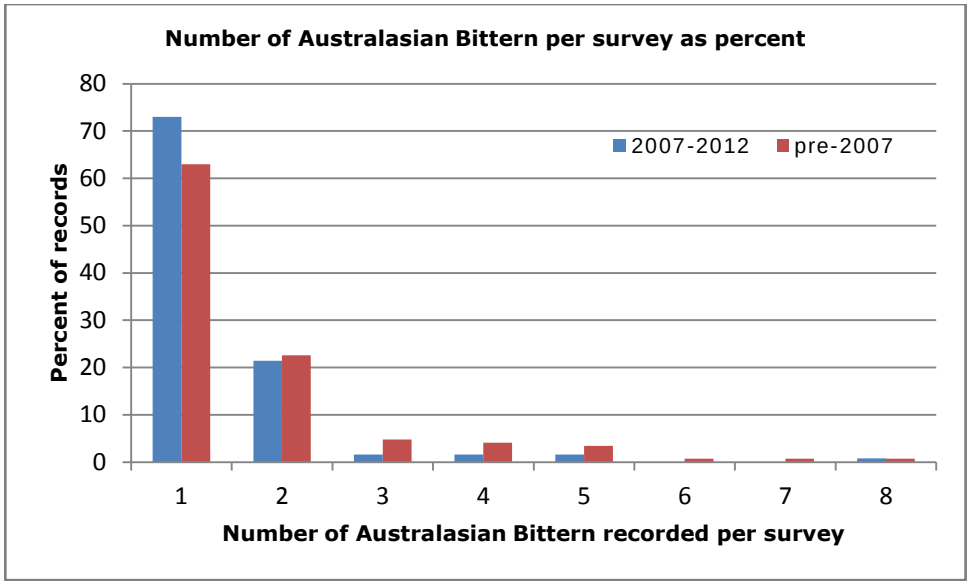


Figure 27 - Frequency distribution of the number of Australasian Bittern recorded in a wetland during a survey (Data period: 1976-June 2012).

Records of only calling bitterns in are shown in Figure 28. During this study the highest number of calling bittern in one wetland was five. By far the largest proportion of surveys had one or two bitterns calling (92.6%) and of those 69.3 percent of records were single calling bittern.

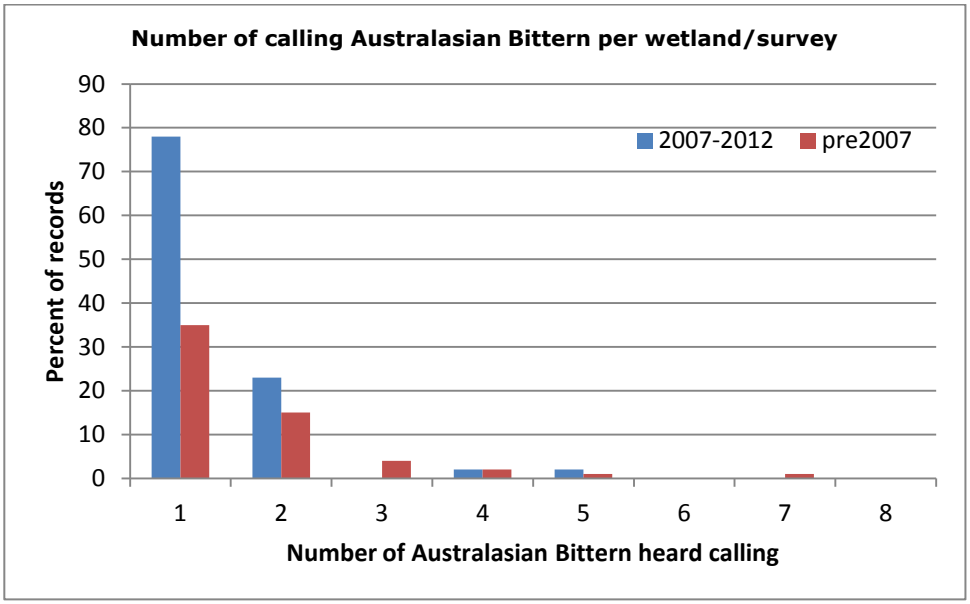


Figure 28 - Frequency distribution of the number of calling Australasian Bittern within a wetland (Data period: 1976 to June 2012).

Whiteside (1989) found Australasian Bittern at Whangamarino Wetlands to be between two per hectare to 30 per hectare. Whiteside cited Ogle and Cheyne (1981) as reporting an average density of one Australasian Bittern per 49 hectare in New Zealand and a maximum of one per 8.3 hectares.

In this study, lake areas and sedge and shrub areas were estimated using aerial photography. The number of calling Australasian Bittern was then used to calculate densities for the breeding season. Figure 29 shows the densities of calling Australasian Bittern for each wetland this was calculated for in Western Australia. The density ranged from one calling Australasian Bittern per 7 hectares of lake area at Pfieffer Lake to one per 323 hectares at Owingup Swamp with a mean of one per 105 hectares.

When related to sedge areas the range was one calling Australasian Bittern per 3 hectares at Black Cat Lagoon to one per 170 hectares at Tordit-Gurrup Lagoon with a mean of one per 63 hectares of sedge.

For some wetlands the area of tall sedge was able to be measured. The area of tall sedge per Australasian Bittern calling ranged from 3 at Black Cat Lagoon to 159 hectares at Benger Swamp and a mean of one Australasian Bittern per 28 hectares of tall sedge. The two *Typha* dominated wetlands, Benger Swamp and Forrestdale Lake had the lowest density of bitterns calling per area of tall sedge with one bittern calling per 159 and 46 hectares, respectively. Wetlands where the tall sedge *Baumea articulata* dominated had a higher density of bitterns calling, ranging from one bittern per 3 hectares at Black Cat Lagoon to one bittern per 27 hectares of tall sedge at Cobertup NW. While this indicates bittern may be in higher densities in *Baumea* wetlands, the small dataset where area of tall sedge per bittern calling has been calculated makes it difficult to draw strong conclusions.

Poulin et al 2005 found that Great Bittern density varied from fewer than 0.01 to 0.095 bitterns per hectare which is equivalent to 1 calling bittern per 10 hectares to less than one per 100 hectares. This is similar to that found in this study and the work conducted in New Zealand by Ogle and Cheyne (1981).

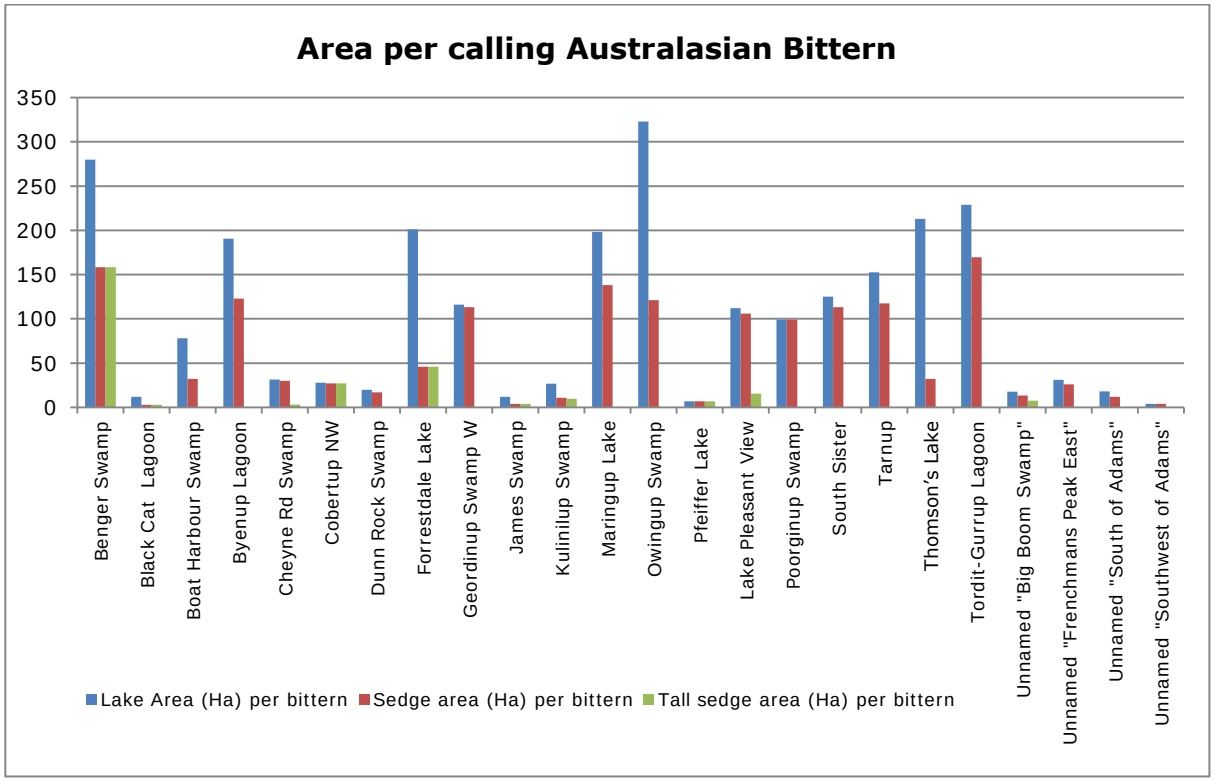


Figure 29 Density of Australasian Bittern in some Western Australian wetlands

Population Estimate for Australasian Bittern in Western Australia

In 2010 Birds Australia estimated the Australian population to be between 274 to 796 mature birds. This estimate was compiled on a region by region basis using 'accumulated local knowledge' (Silcocks 2010). The estimate on a state by state basis is shown in Table 4. The Western Australian data was compiled by the author.

Table 4: Minimum and maximum population estimates of Australasian Bittern occuring in each state. The numbers relate to mature individuals.

	Minimum	**Maximum**
Queensland	3	16
New South Wales (including ACT)	82	162
Victoria	86	248
Tasmania	12	100
South Australia	26	116
Western Australia	38	154
Northern Territory	0	0
Total	247	796

Wetlands utilised by Australasian Bittern – Past and Present

While the type of wetland inhabited by Australasian Bittern is unlikely to have changed over the last century, the individual wetlands used have. This is a result of changes to habitat in each wetland.

Some wetlands with historical records of Australasian Bittern which appear to no longer support the species are:

- Anstey Swamp and Bakers Junction Reserve – the only record found was during the very wet years of the early 1990s. It is likely that in years of above average rainfall this wetland may be used by bittern again.
- Bokerup Nature Reserve – a single record from December 1984 of a bittern calling. The two wetlands in this reserve have undergone major habitat changes which are likely are result of surrounding landuse changes (R. Hearn pers. comm.). These were once fully vegetated with sedges but are now largely open water and unsuitable for Australasian Bittern.
- Chorkerup – An approximately 100 acre wetland in this area had at least 3 pairs of Australasian Bittern breeding in the late 1940s in *Baumea* rush but the wetland was drained and planted with vegetables (T. Bush pers. comm.). There are still wetlands in the Chorkerup area that may be suitable for fencing and revegetating for bitterns.
- Cobertup East Swamp – there have been no records since 2005 and this change has coincided with acidification of the wetland.
- Ewarts (Mortup) Lake – a single record of a calling bittern in November 1988 but this wetland has been historically under surveyed and it is possible bittern regularly used this wetland in the past. This wetland is now very dry and is showing signs of terrestrialisation.
- Lake Eyrie (Narricup) – Australasian Bittern bred at Lake Eyrie in 1961 when it was a deep lake with good stands of *Baumea* and *Typha* but after a succession of dry years cattle incursions destroyed the habitat (T. Bush pers. comm.). This lake maybe a good candidate for fencing and revegetation.
- Lake Gundarring – This was mentioned in Storr 1991, however, the date of the record is unknown. This wetland is saline with little habitat. It is likely there has been deterioration of habitat due to secondary salinity or that the record was of a non-breeding passage vagrant.
- Kogolup Lake – single record of a bittern calling in December 1988, however, there is anecdotal evidence by local landholders that Australasian Bitterns were regularly heard calling in years prior to this (Jeff Spencer pers. comm.). Habitat is still suitable for Australasian Bittern but it is likely that this was used as an additional feeding area for bittern using Thomson's Lake, a larger neighbouring wetland. If Kogolup Lake bitterns were previously dependent on Thompson's Lake, then declining water levels at Thomson's Lake is a possible reason for there being no recent records.
- Lake McLarty – a single bittern heard calling in November 1983. Since then this once fully vegetated wetland has become almost completely open. Recently some natural revegetation has occurred and it is possible that habitat for Australasian Bittern will return as hydrology and wetland chemistry are good. It is unknown why vegetation was lost.
- Lake Mealup – a single record of a bittern seen in February 1984. Since then the wetland has undergone major changes in hydrology and acidified. However, in 2012 a gate and drain was installed to direct water from an agricultural drain to the wetland rather than the estuary. It is possible that this change will result in the wetland providing good habitat for the species in the future. Lake Mealup held water for all of summer 2012/13 and is now near neutral.
- Neeranup Lagoon – two records December 1984 and November 1986. This wetland has been dry in recent years but it is possible it will again support Australasian Bittern when water levels are higher.
- Pipidinny Road Swamp – this swamp no longer provides habitat, probably because of lower water levels due to groundwater abstraction.
- Police Pools Katanning – one record June 1987. Current habitat is unlikely to support Australasian Bittern (David Secomb pers. comm.). It is likely there has been deterioration of habitat due to secondary salinity or that the record was of a non-breeding passage vagrant.
- Lake Powell (Grasmere Lake) – at least 12 separate records between 1982 and 2004 for bitterns both seen and heard. This wetland has agricultural drains entering and exiting it and the hydrology is not controlled. Large areas of *Typha* and small areas of *Baumea* exist and would provide habitat for Australasian Bittern, however, no recent records from surveys in this study suggests it is less favoured by the species. The reasons are unknown. This wetland is a good candidate for improvements to increase available habitat for Australasian Bittern.
- Toolibin Lake – records from the 1970's prior to secondary salinisation of the wetland. Current water level and habitat are unlikely to support bitterns.

- Yackamia Swamp – drainage has changed in this area and it no longer supports Australasian Bittern (Tony Bush pers. comm.).
- Yarnup Lagoon – there were six records between April 1983 to December 1984 of 1 to 2 bittern. Since then salinity levels have increased from very fresh to brackish (Lane et al 2009) and there have been significant changes to vegetation structure, in particular reduction of the area of *Baumea articulata* (Clarke et al 2011 and Gibson et al 2004).

Some wetlands with historical records were not surveyed as they were thought to be wetlands used by non-breeding birds. Other wetlands were surveyed but, on reflection, has probably only held non-breeding birds. Some of the wetlands which fall into these categories are below:

- Lake Angove – single records of Australasian Bittern were in January 1984 and November 1983. Both these records were of bittern seen rather than heard. It is possible that Angove Lake is not preferred for breeding. Recent surveys at Lake Angove have been listening surveys which target breeding bittern. It is likely Lake Angove is used by non-breeding birds and especially during the autumn months when inland and non-coastal wetlands are dryer.
- Bayswater Bird Sanctuary- a record in March 1987 and a probable record in January 1999. This site is likely to be a non-breeding site which may be still used in the non-breeding season.
- Lake Gardner – a single bittern seen in February 1983 and a second record from August 2001. Both of these records are suggestive that this wetland is used by bitterns during the non-breeding season and this wetland provides very little habitat. It is possible that a fire in early 2000s also caused deterioration of habitat.
- Hardy Inlet (Scott basin) – two records in March 1975 and March 1974 from a study where monthly waterbird records were taken (Lane 1976). Based on the timing of records and habitat this site is likely to be used by bittern during the non-breeding season.
- Heath's Swamp – one record of a bittern seen in January 1985. This wetland was visited in October 2012 and was very dry and sedges had been burnt several months earlier. Regenerating sedges looked like they would provide good breeding and foraging habitat once regenerated from the fire and with wetter conditions.
- Jandabup Lake – two records of bittern seen in July 1982 and December 1983. This wetland was well surveyed during the 1980's and so does not appear to have been a breeding location as no Australasian Bittern were heard calling. Several searches have been done at this large wetland during the current project but were never complete. This wetland acidified in the early 2000s. It is possible that non-breeding Australasian Bittern still use this wetland and possibly neighboring Lake Mariginiup.
- Lechenault inlet – Tony Bush flushed an Australasian Bittern out of tall sedges here in the early 1960s (T. Bush pers. comm.).
- Moates Lake –records in March 1984 and April 2001. It is likely Moates Lake is used by non-breeding birds and especially during the autumn months when inland and non-coastal wetlands are dryer. It is possible that a fire in the early 2000s has caused deterioration of habitat.
- Lake Muir – three records in December 1991, July 1995 and November 2005. This wetland is brackish to saline with only minimal fringing vegetation. It probably rarely supports bittern as they move from site to site.
- Lake Sadie – one sight record in August 1984 and a possible sight record from 2009. This wetland appears to be used by non-breeding birds as listening surveys recorded no bittern.
- Lake Seppings – only has two confirmed records both of bitterns seen in January 1984 and January 1985. The summer sight records and the lack of calling birds during spring listening surveys suggest this wetland is used in the non-breeding season.
- Shark Lake – one sight record from January 1983. This wetland has very little habitat and so is likely to rarely support non-breeding bittern.
- Star Swamp – one record from 1988. As habitat is unsuitable, the record is a likely misidentification.
- Unicup Lake – one record February 2001 is likely to be a non-breeding bird moving from site to site.
- Vasse-Wonnerup Estuary – two records from 1986 and summer 1988. Both were sight records of foraging bittern. This estuary may still support bittern in the non-breeding season.
- White Lake – an anecdotal note that bittern were once present in this wetland (Jaensch et al 1988). The wetland now has a very low water level and many of the *Baumea* sedges are brown or browning off. If water levels increase it may support bittern again.

Threats

There are many threats to Australasian Bittern and it is likely that a combination of all these threats is contributing to the continued decline of the species. Figure 30 provides an outline of current threats to Australasian Bittern. These threats and any others identified by the Technical Advisory Group were assessed and ranked as part of the process of establishing an Interim Recovery Plan for the species in Western Australia. This full listing of threats and ranking is in Appendix N.

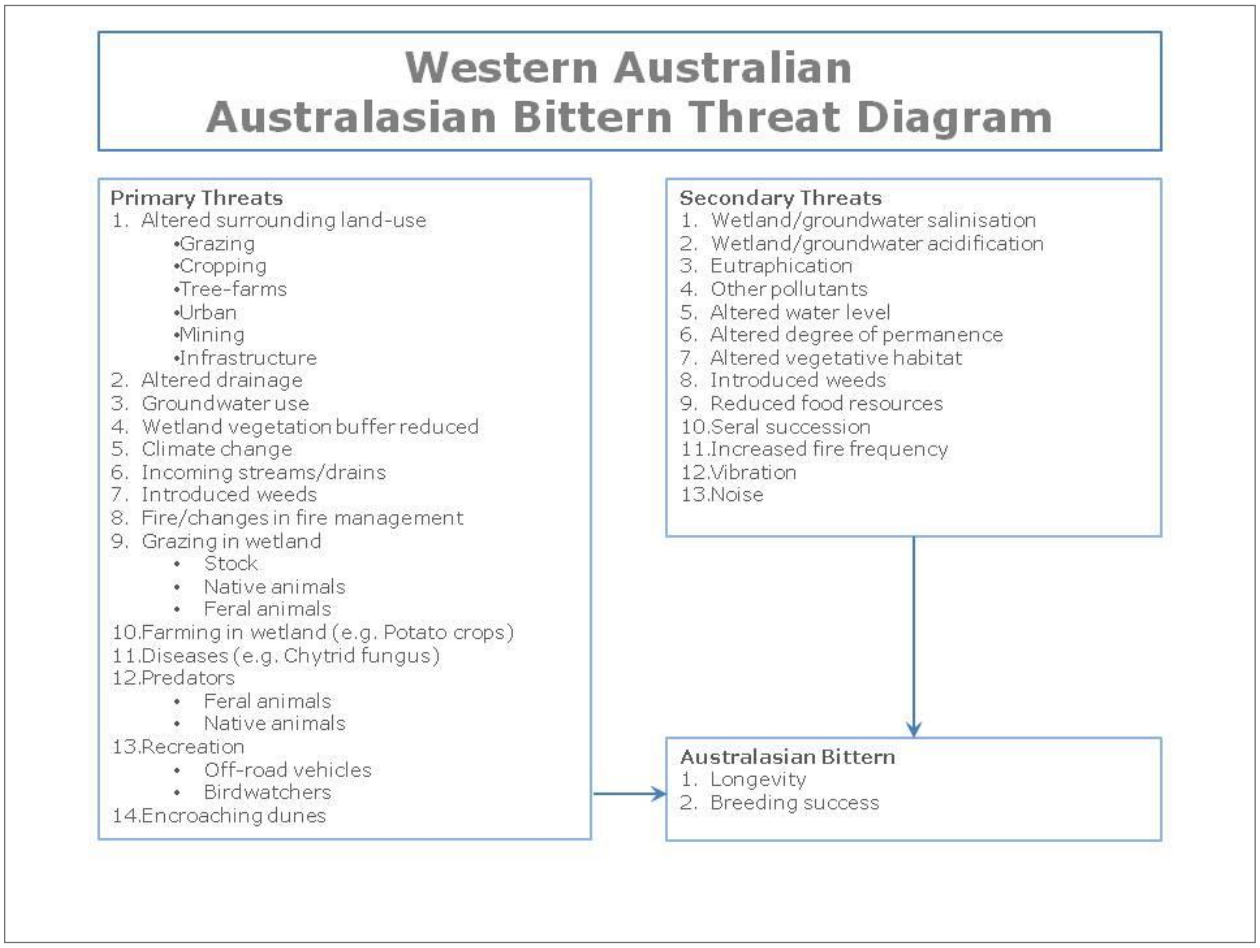


Figure 30 - Threats to Australasian Bittern in Western Australia

Major threats to the species were identified as:

- Climate change
- Acid sulphate soils and acid flush following rewetting
- Tree farms changing to livestock (increasing sedimentation)
- Predation by introduced animals - fox, cat, rat, pig
- Decreasing water levels due to draw down by current plantations
- Decreasing water levels due to decreased rainfall
- Inappropriate fire regimes - drying climate & hydrology; infrequent burning; too frequent burning
- Predation by native animals - Swamp Harrier, native rats, snakes

Australian Little Bittern

The Australasian Bittern project provided an ideal opportunity to also survey for Australian Little Bittern. A records review found Australian Little Bittern at 37 wetlands in southwest Australia prior to this study. Australian Little Bittern was found in 36 wetlands during the project, compared to the 14 wetlands where Australian Little Bittern was recorded in during the 1981-1985 waterbirds study (Jaensch et al 1988). However, the increased recording of this species is likely to be related to the survey methodology of dusk surveys which is likely to provide a better record rate than daytime waterbird surveys.

Conservation Measures for bittern in Other Countries

In Australia and Western Australia little has been done to actively conserve and manage habitat for Australasian Bittern. It is likely that conservation efforts in Australia will increase now that the species is listed as endangered at a national level. In Western Australia an interim recovery plan is being developed for the species and this will provide a focus for bittern conservation in this state. It is likely that a national recovery plan will be developed in the near future as the species is included on the Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) recovery plans in preparation list.

In Western Australia conservation actions to date have not occurred in a systematic fashion but have been implemented at a local level. For example:

- Many of the DEC regions conduct introduced animal control in and around some wetlands where Australasian Bittern are present, although this is largely not done to actively manage for the species.
- At Benger Swamp *Typha* is ploughed each summer in sections of the swamp to aid Australasian Bittern feeding, however, this is not being done in other *Typha* wetlands.

In the absence of a management plan or recovery plan, these actions are ad hoc and highly localized, rather than strategic in approach. A more strategic approach is likely to occur once the recovery planning process is further developed.

The literature indicates that there has been a more concerted effort in conserving Great Bittern in parts of Europe and the United Kingdom than for other *Botaurus* bitterns and locations. Actions have included (White et al 2006):

- A much higher level of research to understand the requirements of Great Bittern
- Good communication and information sharing between researchers and conservation organisations to improve conservation knowledge and efforts
- On ground works including: water level control, reedbed management and restoration, reedbed cutting and burning (conservation and commercial), reedbed lowering, creation of new reedbeds, grazing management, commercial fishpond management, floodplain restoration, management and supplementation of food resources,
- Awareness raising and education

The Australasian Bittern would benefit from many of these actions if they were to occur in Australia.

Recommendations

While this study has been the most important to date for Australasian Bittern in Western Australia there is still much to learn about Australasian Bittern and much that can be done to manage their habitat in order to improve their conservation status.

At a strategic level, it is recommended that:

- Work continues on drafting an interim recovery plan for the Australasian Bittern in Western Australia. This will be the most effective way to ensure a holistic and systematic approach to bittern conservation occurs in the absence of a national recovery plan for the species.

- Development of a national recovery plan be hastened and this should be advocated by BirdLife Australia, and state conservation agencies.

In the absence of recovery plans it is recommended that conservation measures address the key areas of data gathering, education and awareness, research and on ground conservation actions. The results of this study suggest the following recommendations for each of these areas are:

Data gathering

- Wetlands not yet sampled for wetland chemistry should be checked for pH and conductivity (salinity) as these appear to be the most important chemistry characters that determine bittern presence. Wetlands which have not been sampled to date are those with access difficulties due to remoteness or difficult access terrain, that have been dry during the project period, or are located on private property. Some of these wetlands include: Pfieffer Lake (Manypeaks), Ten Mile Lake (Manypeaks), North Sister (Manypeaks), Boat Harbour north and east wetlands (Quarram), wetlands north of Dunn Rock (Condingup), wetland 5km west of Cape Le Grand Road on the north boundary of the crown land (Condingup), Woodup Swamp (Merrivale), Blue Lagoon Suite (Bremer Bay), Neeranup (Muir-Unicup), Cobertup south (Muir-Unicup) and some wetlands north of Byenup Lagoon (Muir-Unicup).

- Wetlands not yet surveyed for Australasian Bittern but have been identified by aerial photography as containing suitable habitat should be surveyed. These are mostly wetlands which with access difficulties due to remoteness or difficult access terrain or are located on private property. Some of these include: Boat Harbour north and east wetlands (Quarram), wetlands north of Dunn Rock (Condingup), wetland 5km west of Cape Le Grand Road on the north boundary of the crown land (Condingup), Woodup Swamp (Merrivale), Blue Lagoon Suite (Bremer Bay), Lake Quitjup and Pingerup Road Swamp (D'Entrecasteaux National Park), Waychinnicup wetlands suite and wetlands north of Byenup Lagoon (Nerbichup).

- Complete the broad scale habitat review and conduct the multivariate analysis on the broad scale data from across the south west range. Use this data to estimate better the habitat available to the species in Western Australia.

- Continue collecting fine scale habitat data at bittern foraging sites, nests and feeding platforms so that fine scale characteristics can be more thoroughly documented.

- This study has concentrated on wetlands which appear to be used by breeding bitterns. That is, the surveys have mainly aimed to find males calling in the breeding season and to characterize these wetlands. It would be useful to know more about the wetlands bittern inhabit during the non-breeding period. It is clear from records collected during the non-breeding period that bitterns utilise more habitat-diverse wetlands during this period and many wetlands used in this period are coastal wetlands as many other wetlands are dry in late summer to early winter. It is

possible that at least some of these wetlands are also critical to the long-term survival of the species.

- Several wetlands that are important to Australasian Bittern have had water level data loggers and rainfall gauges installed and maintained by DEC. These include: Gingilup Swamp, Maringup Lake, Lake Pleasant View, Cheynes Beach Road Swamp, unnamed wetland "Big Boom Swamp", and Mettler Lake. These data loggers and rainfall gauges provide important information about wetland hydrology. This is necessary as many wetlands important to Australasian Bittern have little hydrological data available. It is recommended that DEC install and maintain these loggers at a number of additional wetlands known to be significant for Australasian Bittern such as Benger Swamp, Kulunilup Swamp, South Sister and Boat Harbour Swamp.

- The audio auto recording unit (ARU) trial by DEC at Cheynes Beach Swamp and Lake Pleasant View was a success. It is recommended that further auto recorders be purchased and used in wetlands. By rotating a number of loggers into a number of different wetlands or regions it would be possible to monitor bittern presence with a smaller number of volunteers. This may enable a larger number of wetlands to be surveyed within a season.

- Conduct a trial of ARU calling records and water level data at wetlands where the water level data loggers are present to assess whether pre-dawn calling of Australasian Bittern is more reliable monitoring time than post dusk surveys. Anecdotal information and data from Europe suggests pre-dawn calling is slightly more reliable than post dusk calling.

- Collate ARU and water level data logger data to confirm more adequately that Australasian Bittern calling commences at or just after the peak wetland water level is reached.

- Monitoring of bittern presence in the future is recommended to assess whether the population is still declining, stablised or increasing. During the study the numbers of volunteers in the project declined with time suggesting volunteers were less interested or tired of the project. As such it would be better that surveys are conducted less regularly – perhaps every 2 to 5 years.

- Annual rainfall had a large impact on bittern calling behaviour within wetlands. The study period included several very dry years and during these years many wetlands which regularly supported calling bitterns did not have bitterns calling in them. It is likely that water levels were unsuitable for breeding. Hence, it would be best to conduct surveys in normal or near normal rainfall years.

Education and awareness

- BirdLife Australia and other organisations promote awareness of the Australasian Bittern, its status and the importance of protecting vegetated freshwater wetlands. This promotion should be given to landholders, conservation groups and the general public.

- BirdLife Australia and other organisations promote wetlands as important to ecological functions and interesting places to visit and enjoy. Wetlands need to be more loved by conservation groups and general public in order to increase awareness of their importance and increase pressure for their protection and restoration.

Research

- Statistical analysis of the broadscale and chemistry data is recommended so that indicators of possible bittern presence in wetlands can be documented. Several members of the technical advisory group and long term volunteers have a good understanding of habitat requirements and can identify good habitat or inadequate habitat. Documentation of these requirements will

provide this information to other conservationists or DEC employees so that increased protection of wetlands with good habitat occurs.

- Prey availability in bittern wetlands and methods for improving prey availability in order to improve breeding success should be researched. White et al (2006) concluded that food availability was the most important factor in Great Bittern breeding success. Little has been done in Western Australia to estimate prey availability in bittern wetlands or how to increase prey availability in order to increase breeding success.

- The affect of tree farming on a variety of wetlands that support bittern should be researched. Most wetlands that support bitterns either have native vegetation, grazing or tree farming on the surrounding land. While the effect of clearing for grazing is reasonably well understood the affect of tree farming is less well known, particularly at different stages of the growing/harvesting cycle and in combination with the different geologies found throughout the range of the Australasian Bittern.

- Quantification of the effect of introduced predators on Australasian Bittern should be researched. The Red Fox Threat Abatement Plan includes Australasian Bittern as a species likely to be threatened by the Red Fox (*Vulpes vulpes*) (Department of the Environment, Water, Heritage and the Arts 2008), but conservation efforts would be assisted by quantification of this threat.

- Conduct research on bittern biology such as breeding requirements, breeding success, food requirements, seasonal movement, wetland fidelity etc.

On ground conservation

- The most important recommendation is to protect vegetated freshwater wetlands from changes in hydrology, chemistry and habitat. Some important wetlands such as Lake Pleasant View have part of the wetland on adjacent farms and this could easily be fenced from stock so that successive dry years combined with stock intrusion does not destroy habitat.

- Many vegetated wetlands have been affected by drainage and hydrological changes in surrounding catchments which may have affected the use of these wetlands by Australasian Bittern. Under a drying climate it would be wise to invest in directing agricultural drains that have acceptable chemistries towards wetlands which currently have a dry hydrology as a result of climate change. Two examples of this are Lake Mealup which has just had a project completed which allows agricultural drainage to flow into the wetland and Benger Swamp which would benefit from such action and already has a drain structure in place within the wetland. Other seasonal wetlands in the Grasmere to Youngs Siding area may also benefit from redirection of drainage.

- This report recommends that BirdLife Australia and DEC aid landholders who wish to protect and restore vegetated freshwater wetlands. An example is the restoration of seasonally flooded paddocks on private land to shallow, vegetated, freshwater wetlands by fencing and revegetating. Landholders should be assisted to provide additional habitat for foraging, especially where land is near existing bittern wetlands. It would seem prudent to focus this work on south coastal wetlands where the majority of the Australasian Bittern population resides.

- Fire management should be aimed to protecting the Australasian Bittern and its wetland habitat. During this study several wetlands have be burnt by wildfires or prescribed burning. In most cases this has been to the detriment of Australasian Bittern and the habitat it uses.

- Increase the coverage of fox control to provide protection over a larger number of wetlands where Australasian Bittern are present. Wetlands where bitterns call during the breeding season should be prioritized as eggs, chicks and juveniles would be particularly vulnerable to predators.

Other

- DEC has commenced the process of vesting some crown land wetlands north of Cape Le Grand National Park in the conservation estate. This suite of wetlands appears to be the most important to Australasian Bittern in Western Australia. BirdLife Australia fully supports the continuation of this process.

- The suite of wetlands in crown land north of Cape Le Grand National Park should be listed as an Important Bird Area by BirdLife International.

References

Bent, A.C. (1963). Life histories of North American marsh birds. Dover publications, Inc., New York.

BirdLife International (2011a). Species factsheet: *Botaurus poiciloptilus*. At http://www.birdlife.org, accessed on 20/01/2011.

BirdLife International (2011b). Species factsheet: *Botaurus stellaris*. At http://www.birdlife.org, accessed on 20/01/2011.

BirdLife International (2011c). Species factsheet: *Botaurus lentiginosus*. At http://www.birdlife.org, accessed on 20/01/2011.

BirdLife International (2011d). Species factsheet: *Botaurus pinnatus*. At http://www.birdlife.org, accessed on 20/01/2011.

Cale, D.J., Halse, S.A. and Walker, C.D. (2004). Wetland monitoring in the Wheatbelt of south-west Western Australia: site descriptions, waterbird, aquatic invertebrate, and groundwater data. Conservation Science Western Australia 5 (1) :20 − 135 (2004).

Christidis, L. and Boles, W. (2008). Systematics and Taxomony of Australian Birds. CSIRO Publishing, Australia.

Clarke, A., Lane, J. and Jaensch, R. (2011). Surveys of waterbirds in selected wetlands of south-western Australia in spring-summer 2009-10. Department of Environment and Conservation unpublished report.

Clarke, Alan and Wheeler, Ian (2009). Australasian and Little Bittern Survey at Byenup Lagoon and Kulunilup Nature Reserve, December 2009. Department of Environment and Conservation unpublished report.

Cramp, S. & Simmons, K.E.L. (1977). The Birds of the Western Palearctic,Vol.1.—Oxford University Press, Oxford.

Dechant, J.M., Sondreal, M.L., Johnson, D.H., Igl, L.D., Goldade, C.M., Zimmerman, A.L., and Euliss, B.R. (2002). Effects of management practices on grassland birds: American Bittern. Northern Prairie Wildlife Research Centre, Jamestown, ND.

Department of Environment and Conservation (2010). Rockingham Lakes Regional Park Proposed Final Management Plan.

Department of the Environment, Water, Heritage and the Arts (DEWHA) (2008). *Threat abatement plan for predation by the European red fox,* DEWHA, Canberra.

Demongin, L., Dmitrenok, M., and Bretagnolle, V. (2007). Determining Great Bittern *Botaurus stellaris* egg laying date from egg and chick biometrics. Bird Study 54:54-60.

Deubbert, H.F. and Lokemoen, J.T. (1977). Upland nesting of American Bittern, Marsh Hawks, and Short-eared Owls. *Prairie Naturalist* 9:33-40.

Faanes, C.A. and Lingle, G.R. (1995). Breeding birds of the Platte River Valley of Nebraska. Jamestown, ND: Northern Prairie Wildlife Research Center home page. http://www.npwrc.usgs.govindex.htm (Version 02SEP99).

Froend, R.H. and Storey, A.W. (1996). Monitoring Design and Data Analysis Toolibin Lake and Catchment Part 1: Review and Analysis of Monitoring Data. Report prepared by Froend Bowen &

Associates and Wetland Research & Management for the Department of Conservation and Land Management.

Gibson, N., Keighery, G.J., and Lane, J.A.K. (2004). Five years of monitoring of the Muir-Unicup wetland system, south-western Australia. J. Royal Society of Western Australia 74: 123-128

Gilbert. G., McGregor, P. and Tyler, G. (1994). Vocal individuality as a census tool: practical considerations illustrated by a study of two rare species. *J. Field Ornithology* 65: 335-348.

Gilbert, G., Tyler, G.A. and Smith, K.W. (2002). Local annual survival of booming male Great Bittern Botaurus stellaris in Britain, in the period 1990 − 1999. *Ibis* 144:51-61.

Gillespie, P. (2011). Protection of the Owingup Wetland System. WA Department of Environment and Conservation, Walpole. 89 pp. Unpublished report.

Gurney, M. (2007). Introduction of rudd *Scardinius erythropthalmus* as food for bitterns *Botaurus stellaris* at Titchwell Marsh RSPB reserve, Norfolk, England. Conservation Evidence 4:4-5.

Halse, S.A., Pearson, G.A., and Patrick, S. (1993). Vegetation of depth-gauged wetlands in nature reserves of south-west Western Australia. Department of Conservation and Land Management Technical Report No. 30.

Hanowski,J.M. and Niemi, G.J. (1986). Habitat characteristics for bird species of special concern. Unpublished report to Minnesota Department of Natural Resources, St Paul, Minnesota.

Hanowski,J.M. and Niemi, G.J. (1988). An approach for quantifying habitat characteristics for rare wetland birds. Pages 51-56 in Ecosystem management: rare and endangered species and significant habitats. Proceedings of the 15th Annual Natural Areas Conference.

Jaensch, RP and Vervest, RM 1988 "Waterbirds in the Eastern Muir Wetlands 1986-87" RAOU Report No.47.

Jaensch, R.P., Vervest, R.M., and Hewish, M.J. (1988). "Waterbirds in Nature Reserves of South-Western Australia 1981-1985: Reserve Accounts" RAOU report No. 30.

Jaensch, R.P. (1992). Waterbirds in the Wetlands on the South Coast of Western Australia, Summer 1991-2. Department of Conservation and Land Management, Woodvale, WA.

Kent, T.H. and Dinsmore, J.J. (1996). Birds of Iowa. Published by the authors, Iowa City and Ames, Iowa.

Lane, J.A.K. (1976). Birdlife of the Blackwood River Estuary. Technical Report 7 to the Estuarine and Marine Advisory Committee of the Environmental Protection Authority.

Lane, J.A.K., Pearson, G.B, Clarke, A.G., Winchcombe, Y.C., and Munro, D.R. (dec) (2004). Depths and Salinities of Wetlands in South-western Australia: 1977 − 2000. Department of Conservation and Land Management.

Lane, J.A.K., Clarke, A.G. and Winchcombe, Y.C. (2010). *South West Wetlands Monitoring Program Report 1977-2009*. WA Department of Environment and Conservation, Busselton. 153 pp.

Marchant, S., and Higgins, P. J. (Eds) (1990). 'Handbook of Australian, New Zealand and Antarctic Birds. Vol. 1B. Pelicans to Ducks.' Oxford University Press: Melbourne.

McGregor, P.K. & Byle, P. (1992). Individually distinctive bittern booms: potential as a census tool. Bioacoustics 4(2): 93-109

Menkhorst, P. (2012). The food and foraging rate of an Australasian Bittern. Australian Field Ornithology: 29, pp133-142.

Menkhorst, P. and Silcocks, A. (2004). Observations of Australasian Bitterns eating small mammals. Australian Field Ornithology: 21, pp37-39.

Moon, G.J.H (1967). Refocus on New Zealand Birds. A.H and A.W. Reed, Wellington, 143 pp.

O'Donnell, C. (2011). Breeding of the Australasian Bittern (Botaurus poiciloptilus) in New Zealand. Emu, 2011, 111, pp197-201.

Ogle, C. C., and Cheyne, J. (1981). The wildlife and wildlife values of the Whangamarino wetlands. Fauna Survey Unit Report No. 28, NZ Wildlife Service, Department of Internal Affairs, Wellington.

Peter, J. (2009). Australasian Bittern: On the way out? The Bittern Chronicle 1, 1.

Pickering, R. (2010). Summary of the Australasian Bittern and Australian Little Bittern surveys 2009/10. Western Australian Bird Notes 134, 13-14.

Pierce, R.J. (2004). A revised methodology for monitoring wetland birds in the Whangamarino Wetland Complex. Wildland Consultants Contract Report 874 for the Department of Conservation, Hamilton, New Zealand.

Polak, M. 2007. Nest-site selection and nest predation in the Great Bittern *Botaurus stellaris* population in eastern Poland.Ardea 95(1): 31–38.

Poulin, B. And Lefebvre, G. (2003a). Optimal sampling of booming Bitterns Botaurus stellaris. Ornis Fennica 80:11-20.

Poulin, Brigitte; Lefebvre, Gaetan; and Mathevet, Raphael (2005). Habitat selection by booming bittern Botaurus stellaris in French Mediterranean reed-beds. Oryx 39 (3) pp265-274.

Puglisi, L. Fontanelli, Perfetti, A. and Taverni, M. (1995). The population of Bittern *Botaurus stellaris* in the Diaccia Botrona marsh, Central Italy: four years of census (1991 – 94). *Avocetta* 19, 182-188.

Puglisi, L., Cima, O., and Baldacinni, E. (1997). A study of the seasonal booming activity of the Bittern *Botaurus stellaris*; what is the biological significance of the booms? Ibis 139, 638-645.

Puglisi, L. and Adamo, C. (2004). Discrimination of individual voices in male great bitterns (*Botaurus stellaris*) in Italy. *The Auk* 121 (2), 541-547.

Sandiford, Libby (2012a). Vegetation of three swamps in south western Western Australia in Cheynes Rd, Lake Pleasant View and Kulunilup Nature Reserves: Habitat for the endangered Australasian Bittern. Unpublished report to BirdLife Western Australia.

Sandiford, Libby (2012b). Vegetation of "Big Boom Swamp" Esperance, Western Australia: Habitat for the endangered Australasian Bittern. Unpublished report to BirdLife Western Australia.

Serventy, D.L. and Whittell, H.M. (1948). Birds of Western Australia. Patersons Press Ltd. Perth, WA.

Silcocks, A. (2010). Australasian Bittern: national population estimate for spring-summer 2009-10. *The Bittern Chronicle* 2, 2.

Stewart, R.E. (1975). Breeding birds of North Dakota. Tri-College Centre for Environmental Studies, Fargo, North Dakota.

Storey, AW, Vervest, RM, Pearson, GB, and Halse, SA. (1993).Wetlands of the Swan Coastal Plains Volume 7 Waterbird Usage of Wetlands of the Swan Coastal Plain. Water Authority of Western Australia and Environmental Protection Authority, Perth.

Storr, G.M. (1991). Birds of the South-West Division of Western Australia. Perth, Western Australian Museum.

Van Delft, R. (1987). Birding Sites around Perth. Second (Revised) Edition. Perth: Birds Australia.

Watkins, Doug (1986). Benger Swamp Nature Reserve draft management plan. Department of Conservation and Land Management, Management Plan No.7, 1986

Wetland Research Management (2005). Re-assessment of the nature conservation values of the Byenup-Muir peat swamp system. Wetland Research Management, Glen Forrest. 111p. Unpublished draft report.

White, G., Purps, J. & Alsbury S. (2006) The bittern in Europe: a guide to species and habitat management. The RSPB, Sandy.

Whiteside, Andrew J. (1989). The behaviour of bitterns and their use of habitat. *Notornis* 36: 89-95 (1989).

Wiggins, David A. (2006) American Bittern (Botaurus lentiginosus) A Technical Conservation Assessment. Prepared for the USDA Forest Service, Rocky Mountain Region, Species Conservation Project.

Wotton, S., Lodge, C., Fairhurst, D., Slaymaker, M., Kellett, K., Gregory, R., and Brown, A. (2007). Bittern *Botaurus stellaris* monitoring in the UK: Summary of the 2007 season. Natural England and RSPB report.

Wotton, S., Lodge, C., Lewis, B., Schmitt, S., Kellett, K., Gregory, R., and Brown, A. (2008). Bittern *Botaurus stellaris* monitoring in the UK: Summary of the 2008 season. RSPB and Natural England report.

Appendix A Target Wetlands

Wetland	Latitude	Longitude	Last record prior to this study	Reference	Listings
Angove Lake	-34.9418	118.1654	29/1/84	Jaensch et al 1988	ND, IBA
Anstey Swamp	-32.4142	115.7791		DEC 2010	
Ascot waters	-31.9439	115.9161			ND
Bakers Junction Reserve			21/1/93	WA Bird Notes	
Bayswater Bird Sanctuary			7/3/87	WA Bird Notes	
Benger Swamp	-33.1724	115.8342	17/11/92	WA Bird Notes	ND, IBA
Black Cat Lagoon	-34.9656	118.0838			
Blue Lagoon	-34.4482	119.2183			
Boat Harbour Swamp	-35.0155	117.0896	31/7/88	WA Bird Notes	ND, IBA
Bokarup Swamp	-34.3347	116.8319	4/12/84	Jaensch et al 1988	ND, IBA
Lake Bryde NR			1/10/97	DEC database	
Byenup Lagoon	-34.49	116.73	3/11/91	WA Bird Notes	ND, IBA
Canning River Regional Park					ND
Cape Arid Swamps			11/8/84	WA Bird Notes	
Cheynes Beach Swamp	-34.8102	118.2954	13/5/82	Jaensch et al 1988	
Cobertup Swamp NR	-34.455	116.8361	4/11/2005	WA Bird Notes	ND, IBA
Condingup area			Sep84	WA Bird Notes	
Lake Corymup	-34.762	118.133			
Corymup Rd East Swamp	-34.763	118.184			
Crackers Swamp	-30.9096	115.5885	1981-92*	Jaensch 1992	
Esperance (55km east of)			1/6/84	WA Bird Notes	
Ewarts Lake (Mortup Lake)	-33.8398	122.8271	24/11/88	WABN, Jaensch 1992	
Lake Gardner	-34.9617	118.1575	1/8/01	BA Atlas	ND, IBA
Geordinup Swamp	-34.49	116.77	13/11/05	WABN	
Gingalup Swamps	-34.3463	115.477			ND
Graham's Pool			9/3/91	WA Bird Notes	
Lake Gundaring	-33.2989	117.4919		Storr 1991	
Hardy Inlet	-34.2868	115.1832	March 1975	Lane 1976	
Heath's Swamp	-33.7849	122.4233	18/1/85	Jaensch et al 1988	
Herdsman Lake	-31.9281	115.8056	winter, summer and spring	Van Delft 1987	ND

Wetland	Latitude	Longitude	Last record prior to this study	Reference	Listings
Lake Jandabup	-31.7406	115.8403	7/12/83	Jaensch et al 1988	
Lake Jasper	-34.4219	115.6911	2/11/99	BA atlas	ND
Joondalup Lake	-31.7585	115.7927			ND
Kogolup Lake	-32.1357	115.8314	1/12/88	WA Bird Notes	
Kulunilup Swamp NR	-34.3411	116.7856	1/11/2005	DEC database	ND, IBA
Maringup Lake	-34.833	116.200			ND
Lake McLarty	-32.7057	115.7146	17/11/83	Jaensch et al 1988	Ramsar, ND, IBA
Merivale (Charleys) Swamp	-33.8287	122.2274	2/11/86	Jaensch et al 1988	
Lake Mealup	-32.6773	115.7110	18/2/84	Jaensch et al 1988	Ramsar, ND
Mettler Lake	-34.5845	118.5942	13/3/02	BA Atlas	
Moates Lake	-34.967	118.1239	11/4/01	BA Atlas	ND, IBA
Mortijinup Swamps	-33.8074	121.6519			ND
Lake Muir	-34.49	116.67	1/11/2005	DEC database	Ramsar, ND, IBA
Neeranup Lagoon	-34.50	116.75	28/11/86	Jaensch and Vervest 1988	ND
North Le Grand Swamp			1981-92*	Jaensch 1992	
Owingup Swamp	-34.9985	117.0715	9/1/92	Jaensch 1992	ND, IBA
Oyster Harbour Marsh	-34.991	117.940			ND
Paganoni Swamp	-32.446	115.7837		DEC 2010	
Perup MPA (Boyup Brook)			9/11/91	BAWA database	
Pipidinny Swamp			8/2/86	WA Bird Notes No.42	
Pfieffer Road No.1 Swamp	-34.736	118.210			
Pfieffer Road tree farm wetland	-34.804	118.208			
Lake Pleasant View	-34.8294	118.1761	1/3/2000	DEC database	ND, IBA
Police Pools Reserve (Katanning)			1/6/87	BAWA database	
Poorginup Swamp	-34.54	116.74			ND, IBA
Lake Powell (Grasmere Lake)	-35.0197	117.7486	13/1/04	BA Atlas	
Lake Sadie	-35.0391	117.4749	28/8/84	Jaensch et al 1988	
Lake Seppings	-35.0129	117.9139	15/1/85	Jaensch et al 1988	

Wetland	Latitude	Longitude	Last record prior to this study	Reference	Listings
Shark Lake	-33.47	121.52	13/1/83	Jaensch et al 1988	
Star Swamp			23/2/88	WA Bird Notes	
South Sister Swamp	-34.7948	118.1580	20/11/83	Jaensch et al 1988	ND
Tarnup Lake	-34.7880	118.2029	25/5/82	Jaensch et al 1988	ND
Ten Mile Swamp (Manypeaks)	-34.7911	118.1229	25/11/88	WA Bird Notes	
Thomson's Lake	-32.15	115.8281	Jan 1991	Storey et al 1993	Ramsar, ND
Toolibin Lake	-32.9201	117.6061	Late 1970s	Froend and Storey 1996	ND
Tordit-Garrup Lagoon	-34.52	116.72	3/11/91	WA Bird Notes	ND, IBA
Unicup Lake	-34.3417	116.7208	18/2/01	BA Atlas	Ramsar, ND, IBA
Vasse-Wonnerup Estuary	-33.6418	115.4004	Oct88-Jan89	WA Bird Notes	Ramsar, ND, IBA
Unnamed "Waychinicup wetlands" Hassel Beach Rd	-34.8345	118.3798			
White Lake (Albany)	-34.7663	118.1613	Pre-1981	Jaensch et al 1988	
Wilgarup Swamp	-34.1407	116.1628	18/12/87	WA Bird Notes	
Swamp near Woodup Swamp	-33.8657 (Woodup Swamp)	122.1407 (Woodup Swamp)	30/9/89	WA Bird Notes	
Yackamia Swamp			1981-92	Jaensch 1992	
Yarnup Lagoon	-34.3457	116.7319	28/12/84	Jaensch et al 1988	ND

Note: Ramsar = Ramsar Internationally important wetland, ND = National Directory of Important Wetlands I Australia (DSewPAC), IBA = Important Bird Area (BirdLife International)

Note the records of specimens in the WA Museum provided some information on historical presence of Australasian Bittern, however, largely these were from wetlands which no longer existed, where habitat has since been destroyed or reflected a greater abundance of bitterns using smaller wetlands as well as larger wetlands. Records are from Albany, Caversham, Dandalup, Herdsman Lake, Kimberley, Kojonup, Mt Lawley, Muchea, Perth (2 specimens) , Pinjarra, South Belmont (2 specimens), Swanbourne, West Leederville and Wonnerup.

Due to these specimens largely reflecting another time period this was not used to target wetlands for surveys in this project.

Appendix B Annual Bittern Survey Summaries

Results of the 2007/8 Bittern Survey in Western Australia.

Wetland	Surveys Conducted	Bittern Records
Benger Swamp	2 day surveys and 2 twilight surveys	No confirmed records
Herdsman Lake	1 day survey and 1 twilight survey	No confirmed records 1 possible record
Jandabup Lake	1 day survey and 4 twilight surveys	No confirmed records
Kogolup Lake	6 day surveys and 1 twilight survey	No confirmed records
Thomson's Lake	16 day surveys, 2 dawn surveys and 6 twilight surveys	No confirmed records 3 possible records
Cobertup Swamp	1 twilight survey	1 x AB and 1 x ALB P. Taylor 18/10/07

Note: All records are confirmed unless otherwise stated. AB=Australasian Bittern and ALB= Australian Little Bittern

Results of the 2008/9 Australasian Bittern Survey in Western Australia.

	Wetland	Surveys Conducted	Bittern Records
	Marginiup Lake	1 day survey	No bitterns
	Jandabup Lake	2 day surveys	No bitterns
	Joondalup Lake	1 day survey	No bitterns
1 prob AB, 1xALB	Herdsman Lake	3 day survey and 4 twilight survey	1 prob AB heard 12/10/08 (Collins et al), 1 poss AB heard 11Oct08 (David Secomb et al), 1 x ALB heard 7/10/08 (Collins & Abbotts)
	Kogolup Lake	5 day surveys and 1 twilight survey	No bitterns
1 prob AB	Thomson's Lake	13 day surveys and 3 twilight surveys	1 prob. AB 12/10/08 (R&D Ashford), 1 poss. AB 22Oct08 (D&J Crossley et al)
	Mealup Lake	Reviewed habitat	No bitterns
	Nine Mile Lake	1 day survey	1xALB heard Clarke & Jaensch 25/11/08
2xAB	Benger Swamp	6 twilight surveys (DEC) RP attended 1 in Nov	1xAB Sep08, 2xAB Nov08 (Nicole Lincoln et al)
2-3xAB, 1 xALB	Kulunilup Swamp,	1 twilight, 1 day survey & weekly opportunistic surveys	1xAB seen Taylor et al 18/10/08, 1xAB seen Hearn 18/12/08, 1xAB heard Wheeler et al 17/10/08, 1xAB heard 23/10/08 Hearn, 2xAB Hearn 27/11/08, 1xAB 18/12/08, 1x AB heard Hearn 30/12/08, 1xALB heard (Dec08)D.Secomb
1xALB	Cobertup Swamp,	2 twilight surveys & weekly opportunistic surveys	1xALB heard (Hearn, Wheeler, Taylor et al and David Secomb)22/10/08,
1 AB	Geordinup Swamp,	1 twilight surveys & weekly opportunistic surveys	1x AB Taylor et al 17/10/08,
3xAB	Tordit-Gurrup	1 twilight survey & weekly opportunistic surveys	3xAB heard Wheeler et al 18/10/08, 1xAB heard Wheeler 30/10/08, 1 AB heard 10/12/08 I.Wheeler
1xAB	Poorginup	1 twilight survey & weekly opportunistic surveys	1xAB heard Hearn 26/9/08, 1xAB heard Taylor et al 18/10/08, 1xAB heard R.Hearn et al 23/10/08, 1xAB heard Wheeler et al 10/11/08
4xAB	Byenup Lagoon	1 twilight survey & weekly opportunistic surveys	1xAB Byenup Lagoon 23/10/08 Wheeler & Hearn, 4xAB at Byenup Mar 09 (2 seen each end) Clarke and Wheeler
	Yarnup Swamp	3 twilight & 2 days surveys & weekly opportunistic surveys	No Bitterns
	Muir-Unicup wetlands:, Lake Unicup, Tone River, Little Unicup, Noobijup Lake, Neeranup, East Tolkerup, Moorinup, Pinticup, Bokarup, Nix's corner,	1 twilight/darkness at each site + weekly opportunistic surveys at Noobijup Lake only	No bitterns
	Owingup Swamp	1x daytime survey	No bitterns
3xAB + 3xALB	Boat Harbour swamp	2 twilight and 1 day surveys	1xAB 2/12/08 Clarke & Jaensch, 3xAB (1 heard 2 seen)+3xALB heard Clarke & Graff 9/1/09
	Lake Saide	1 day and 1 twilight survey	No bitterns
	Lake Powell	1 day and 1 twilight survey	No bitterns
	Lake Seppings	Several day surveys	No bitterns

	Bakers Junction Reserve	Reviewed habitat	No Bitterns
2-3xAB, 2xALB	Lake Pleasant View	3 day and 1 twilight survey	2-3xAB (2 heard, 1 seen) and 2xALB seen near nest Clarke et al 10/1/09
	Tarnup Lake	Reviewed habitat	No bitterns
	South Sister Swamp	1 day survey	No bitterns
1xAB + 1ALB	Mettler Lake	1 day and 1 twilight survey	1xAB seen Clarke&Jaensch 28/11/08, 1xALB heard 11/1/2009 (Clarke & Graff
1xALB	Shark Lake	1 twilight survey	1xALB heard & seen Clarke & Jaensch 30/11/08

Note: All records are confirmed unless otherwise stated. AB=Australasian Bittern and ALB= Australian Little Bittern

Results of the 2009/10 Australasian Bittern Survey in Western Australia.

	Wetland	Surveys Conducted	Bittern Records
	Marginiup Lake		
1xALB	Jandabup Lake	4 twilight survey	No confirmed AB records. 1 x ALB heard 12/11/09 (J.Purvis), 1 x ALB heard 24/11/09 (S.Ford)
	Joondalup Lake	4 twilight surveys	No confirmed records
1xALB	Goolellal Lake	2 twilight surveys	1xALB heard 11/09 (M.Lauva et al)
	Carine Swamp	1 twilight survey	No confirmed records
	Lake Gwelup	1 twilight survey	No confirmed records
1xALB	Herdsman Lake	4 twilight surveys and 2 morning survey	No confirmed AB records. 1xALB heard 8/11/09 (J.Litherland), 1 ALB seen 13/12/09 (H.Clarke)
	Baigup Wetland	2 twilight survey	No confirmed records
	Ascot waters	1 twilight survey	No confirmed records
	Bayswater Bird Sanctuary	1 twilight survey	No confirmed records
	Forrestdale Lake	1 twilight survey	No confirmed records
1xALB	James Swamp	1 twilight survey	1xALB heard (D.James)
1xALB	Kogolup Lake	1 day survey and 3 twilight survey	No confirmed records of AB. 1x ALB heard 11/10/09 (R.Pickering et al)
2xALB, 1 prob AB	Thomson's Lake	4 twilight surveys	No confirmed records 1 probable AB 11Oct09 (RP et al). 2 ALB heard 15/11/09 (R.Ashford et al)
	Mealup Lake	No surveys	
2xAB, 2xALB	Benger Swamp	3 late afternoon surveys, 2 morning surveys and 1 twilight survey BAWA	2x AB confirmed calling 8/11/09, 1xAB heard on 15/11/09, 27/11/09, and 6/12/09 (R.Pickering et al). 2xALB heard 8/11/09 (M.Lauva et al) 1 ALB heard 6/12/09 (J.Graff et al)
	Byrd Swamp	2 twilight surveys	Nil
	Wellard NR	2 twilight surveys	Nil
	Richardson Rd	1 twilight survey	Nil
	Vasse-Wonnerup	2 twilight surveys	Nil
2xAB, 6-12xALB	Kulunilup Swamp	1 twilight survey, 3+morning surveys many day surveys	1x AB Sep09, 3/11/09 x2AB heard R.Hearn, 7/11/09x1AB D. Secomb, 27/11/09 2Abheard + 1seen P. Taylor et al, Dec09 2Abnests found Wheeler & Clarke. 7/11/09 3ALB heard D. Secomb, 27-28/11/09 6-12ALB heard/seen+nests found (Wheeler et al), AB nest (A. Clarke)
	Bokarup Swamp	1 twilight survey	No confirmed records
1xALB	Yarnup Swamp,	1 twilight survey	1xALB (Wheeler&Clarke)
	Cobertup Swamp,	1 twilight survey	No confirmed records
1 AB	Poorginup	1 twilight survey	1AB 3/11/09 R,Hearn
2xALB, 1poss AB	Geordinup Swamp, ,	1 twilight survey	28/11/09x1possibleAB + 2xALB heard P. Taylor et al, 1ALB heard 14/12/09 R. Hearn
	Neeranup	1 twilight survey	No confirmed records
2xAB, 1xALB nest	Byenup Lagoon	1 twilight survey	1xAB 14/10/09, 28/11/09 x2AB

	Wetland	Surveys Conducted	Bittern Records
			heard I. Wheeler, Rpickering et al, Dec 09 x1 nest +1 fledgling +1 adult A. Clarke & I. Wheeler ALB nest found Dec09
1 ALB	Lake NW of Byenup Lagoon	1 day survey	1 ALB 14/12/09 Wheeler & Clarke
1xAB	Tordit-Gurrup,	1 twilight survey	1xAB Oct09, 1 AB 10/12/09 I. Wheeler
1xALB	Pardelup Swamp	1 twilight survey	1xALB Feb2010 (J. Liddelow)
1xAB, 1xALB nest	Owingup Swamp	2 day surveys	1xAB Dec09 (A. Clarke), 1 ALB nest Nov09 (A. Clarke)
1xAB	Boat Harbour swamp	1 day surveys	1xAB Feb10 (A. Clarke)
	Lake Saide	1 day and 1 twilight survey	No confirmed records
	Lake Powell	1 day and 1 twilight survey	No confirmed records
	Lake Seppings	1 early morning survey, 2 twilight surveys	No confirmed records 1x possible AL 2/10/09 (A&F Bondin)
1xAB	Black Cat Lagoon	1 twilight & 1 day survey	1 confirmed AB 2/10/09 (S. Comer et al)
1 poss AB	Moates Lake	1 twilight & 1 day survey	1 possible AB 2/10/09 (S. Comer et al)
	Gardner Lake	1 twilight survey	No confirmed records
2xAB, 1xALB	Lake Pleasant View	2 day and 2 twilight surveys	1xprobable AB 3/10/09 (R. Pickering et al), 2xAB flushed Dec09 (A. Clarke), 1ALB Dec09 (A. Clarke)
1poss AB	North Sister Swamp	1 twilight survey	No confirmed records 1 possible AB (J.Graff et al)
	White Lake Manypeaks	1 twilight survey	No confirmed records
2xAB+nest	Cheyne Beach Rd Swamp	1 twilight & 1 day survey	1 confirmed AB 3/10/09 (S. Comer et al), 2xAB + nest with down Dec2009 (A. Clarke)
1xAB	Mettler Lake	2 day surveys	1 AB (S. Comer)
1xALB	Quaelup Lake Kojonup	1 morning survey	1 ALB (W. Zadow)

Note: All records are confirmed unless otherwise stated. AB=Australasian Bittern and ALB= Australian Little Bittern

Results of the 2010/11 Australasian Bittern Survey in Western Australia.

Summary	Wetland	Surveys Conducted	Bittern Records
	Marginiup Lake	Nil	
0	Jandabup Lake	1 twilight survey (20/11/10)	No confirmed records water level too low
3ALB	Joondalup Lake	7 twilight surveys (31/10/10, 9/11/10, 14/11/10, 15/11/10, 16/11/10, 18/11/10, 21/11/10)	1 ALB heard 9/11/10 D&C Reidy, 3ALB heard 15/11/10 C. Reidy et al, 2 ALB heard 18/11/10 W. Merritt, 1 ALB heard 21/11/10 D&C Reidy
0	Herdsman Lake	4 twilight surveys (13/9/10, 17/10/10, 31/10/10& 14/11/10)	No confirmed records
2ALB	Lake Monger	4 twilight & 1 dawn surveys	1 ALB heard 7/11/10 R. Schmidt, 1 ALB seen& heard 8/11/10 J&M Graff, 2 ALB heard 9/11/10 S. Abbotts
2-3ALB	Kogolup Lake & Swamp	6 day surveys (21/10/10, 29/10/10, 25/11/10, 26/11/10, 29/11/10, & 9/1/11) 3 twilight surveys 1(6/10/10, 17/10/10, 30/10/10 & 24/11/10) and 2 dawn surveys (5/12/10 & 2/1/11)	1 ALB heard 16/10/10 T&M Cawley, 1 ALB heard 17/10/10 D Crosbie et al, 1 ALB seen 29/10/10 T&M Cawley, 2 ALB heard 30/10/10 R&M Pickering ,& 1 ALB heard R&M Pickering 24/11/10,
0	Thomson's Lake	6 day (11/8/10, 1/9/10, 16/10/10, 1/11/10, 24/11/10 & 28/11/10) and 1 twilight (17/10/10) surveys	No confirmed records water level too low
0	Pagononi Swamp	1 day survey (18/8/10)	No confirmed records
	Mealup Lake	Nil	
0	Benger Swamp	2 day surveys (15/8/10& 6/9/10) too dry	No confirmed records
1ALB	Kulunilup Swamp	weekly day surveys (10-30mins), monthly day surveys (1-3hrs) and 1 dawn survey (27/11/10)	1ALB NW wetland heard 27/11/10 D. Secomb
0	Bokarup Swamp	weekly day surveys (10-30mins), monthly day surveys (1-3hrs)	No confirmed records
2ALB nests	Yarnup Swamp,	weekly day surveys (10-30mins), monthly day surveys (1-3hrs)	2 ALB nests with egg shells I. Wheeler & A Clarke 26/11/10
0	Noobijup NR	weekly day surveys (10-30mins), monthly day surveys (1-3hrs)	No confirmed records
0	Cobertup Swamp,	weekly day surveys (10-30mins), monthly day surveys (1-3hrs)	No confirmed records
0	Poorginup	weekly day surveys (10-30mins), monthly day surveys (1-3hrs)	No confirmed records
1poss AB, 1ALB	Geordinup Swamp,	2 day surveys (13/10/10, 14/10/10) and weekly day surveys (10-30mins), monthly day surveys (1-3hrs)	1 ALB 13/10/10 M. Blythman, 1 ALB 14/10/10 R.Hearn and I. Wheeler, 1 probable AB Nov 2010 R.Hearn
0	Byenup Lagoon	weekly day surveys (10-30mins), monthly day surveys (1-3hrs)	No confirmed records
0	Tordit-Gurrup,	weekly day surveys (10-30mins), monthly day surveys (1-3hrs)	No confirmed records
	Pardelup Swamp		
1 AB & 1 ALB nest	Gingilup Swamps	2 day surveys (10-11/3/11 & April 2011)	1 AB seen 11/3/11 & 1ALB nest seen A. Clarke & A Webb
2-3 AB	Maringup Lake	1 day (24/11/10) & 1 twilight survey (23/11/10)	2-3 AB 24/11/10 A. Clarke & J. Graff
1 AB	Owingup Swamp	4 twilight (Oct 2010, Dec 2010 x3) and 2 day (Oct 2010, 20 May 2011) surveys	1 AB seen Oct 2010 A Clarke, 1 AB seen 20 May 2011 P. Gillespie
1 AB	Boat Harbour swamp	3 day (Oct 2010, 20 April, 10 May) and 2 twilight surveys (Oct 2010& 10/12/10)	1 AB heard Oct 2010 J. Liddelow & 1 AB heard Oct 2010 A. Clarke et al. 1 AB seen 20 April and 10 May P. Gillespie
0	Lake Saide	1hr at site during mid-morning but not searching	No confirmed records
0	Lake Powell	1 dawn survey (24/10/10)	No confirmed records

Summary	Wetland	Surveys Conducted	Bittern Records
1ALB	Lake Seppings	1 dawn survey (23/10/10), 1 day survey 14/1/11	1 ALB seen 14/1/11 T. Bush
1 AB	Black Cat Lagoon	1 twilight survey (22/10/10)	1 AB heard S. Comer et al 22/10/10
0	Moates Lake	1 twilight survey (22/10/10)	No confirmed records
0	Gardner Lake	1 twilight survey (22/10/10)	No confirmed records
2AB ad +1 juv +1 nest 1 ALB 7-8AB March	Lake Pleasant View	3 twilight surveys (20/10/10, 23/10/10, & 11/12/10), and 4 day surveys (aug2010, 23/10/10, 12/1/11 & 28/3/11)	1 AB flushed A. Clarke Aug2010, 1 AB heard 20/10/10 A. Clarke, 1 old AB nest 23/10/10 R.Pickering, 2 AB heard D. Secomb et al 23/10/10, 1ad & 2 juv AB seen, 1 ALB seen & 1 AB nest A. Carke et al 12/1/11, 7-8 AB seen 28/3/11 A. Clarke et al
0	Angove Lake	1 twilight (22/10/10) and 1 day survey (23/10/10)	No confirmed records
0	Corymup Lake	1 twilight survey (23/10/10)	No confirmed records
1 AB & 1 ALB	South Sister Swamp	1 twilight (23/10/10) and 1 day survey (22/10/10)	1 AB and 1 ALB recorded 23/10/10 R.Pickering et al.
0-2 AB & 1-2 ALB	Tarnup Lake	2 twilight surveys (23/10/10 & 27/10/10)	1-2 ALB heard & 1 AB heard 23/10/10 J&T Bush, 1-2 AB heard 27/10/10 J&T Bush
0-2 AB & 1 ALB	Pfieffer Lake	1 twilight survey (23/10/10)	1 ALB & 2 AB heard R.Pickering et al 23/10/10
0	White Lake Manypeaks	1 day survey – dry (23/10/10)	No confirmed records
2-3ad AB+1dead juv+1nest	Cheyne Beach Rd Swamp	6 day surveys (Aug 2010, 23/10/10, 27/11/10, 11/1/11 & 13/1/11, 28/3/11), 7 twilight (21/10/10, 22/10/10, 23/10/10, 26/11/10, 11/12/10, 23/12/10, & 29/10/10) and 2 dawn surveys (23/10/10 & 24/10/10)	1 AB flushed A. Clarke Aug2010, 1 AB heard 21/10/10 A. Clarke, 1 AB heard 22-24/10/10 J Graff et al & D Secomb, 2 AB heard, 1 AB heard A. Clarke, 11/12/10 M. Newman & S. Burns, 1 AB heard 23/12/10 R.Pickering, 2-3 AB seen, 1 dead juvenile & 1 AB nest 11/1/11 A. Clarke et al.
1 prob AB	Unnamed wetland "Waychinnicup 1"	1 evening survey (23/10/10) & 1 day survey (28/3/11)	1 probable AB heard M. Morcombe et al.
0	Unnamed wetland "Waychinnicup 2"	1 day survey 11/1/11	No confirmed records
1ALB nest with eggs	Mettler Lake	1 day survey (Nov 2010) & 2 twilight survey (early Oct2010x2 – A&M Nield)	1 ALB nest with eggs Nov2010 A. Clarke
4AB & 1 ALB	Unnamed wetland "Big Boom Swamp"	2 evening & 1 day surveys	4 AB heard & 1 ALB heard 26/10/10 S. Comer etal, 1 AB heard 2?/10/10 A. Clarke et al
0	Cape Le Grand Swamp	1 evening survey (Oct 2010) & 1 day survey (Oct 2010)	No bitterns recorded
0	Unnamed wetlands "Mt Hawes Wetlands"	1 evening survey (Oct 2010)	No bitterns recorded
0	Ewarts Swamp	1 day survey (Oct 2010)	Swamp dry with Melaleucas growing up – showing signs of terrestialisation. Baumea stressed
1ALB	Wetlands east of Frenchmans Peak	1 day survey (Oct 2010)	1 ALB heard & 1 ALB seen Oct 2010 S. Comer et al
1AB	WAMMCO dams Katanning	1 day survey 26/2/11	1 AB seen flying up out of dams and then returned 23/2/11 D. Secomb. None seen on 26/2/11 when surveyed dams.

Note: All records are confirmed unless otherwise stated. AB=Australasian Bittern and ALB= Australian Little Bittern

Survey Summary of the 2011/12 Australasian Bittern Survey in Western Australia.

Summary	Wetland	Surveys Conducted	Bittern Records
	Jandabup Lake	2 day surveys (26/8/11 & 9/11/11)	
1ALB	Joondalup Lake	4 twilight survey (?/10/11, 23/11/11, 2?/11/11, 7/3/12)	1ALB heard Wayne Merritt ?/10/11. 1 ALB seen/photo Steven Spragg 7/3/12.
	Lake Gwelup	1 twilight survey 19/11/11	No Bitterns
3 ALB	Herdsman Lake	5 twilight surveys 4/10/11, 23/11/11, 8/12/11, 4/1/12 & 13/1/12	1ALB heard Rutherford 24/9/11, 1ALB heard (Graff & Seddon) 4/10/11, 1ALB heard Mark Carter 8/12/11, 3 ALB seen 4/1/12 (Phil Snow), 2 ALB heard 13/1/12 (Snow & Merritt)
	Lake Monger	1 twilight survey 15/11/11 & 1 dawn survey 11/11/11	No bitterns
	Ascot waters	1 day survey 3/6/11	No Bitterns
	Lake Claremont	1 twilight survey 2/12/11	No Bitterns
	Bibra Lake north end	1 twilight survey	No Bitterns
1 ALB	Kogolup Lake & Swamp	1 pre-dawn survey (11/12/11) & 3 day surveys (19/8/11, 23/6/11, 7/12/11)	1 ALB heard Graff et al 11/12/11
1AB	Thomson's Lake	5 day survey (1/9/11, 22/9/11, 16/11/11, 29/11/11, 9/12/11), 3 evening survey (5/10/11, 11/10/11, 19/10/11)	1 x AB heard 5/10/11 (Collins, White & Smith)
1 AB	Forrestdale Lake	3 twilight surveys (19/10/11, 17/10/11, 25/11/11) and 1 day survey (31/10/11)	1AB heard 17/10/11 (Collins and Graff), 1AB heard Graff et al 19/10/11, 1AB heard 25/10/11 (Graff and Waugh)
1AB (same bird as at Forrestdale)	James Swamp	Opportunistic records	1AB heard 9/10/11 (D.James), 1AB heard 11/10/11 (B. Fremlin). Note from Pam ?James? that Bittern calling at James Swamp for about a week up to 11/10/11.
1AB (same bird as at Forrestdale)	Tonkin Hwy	1 opportunistic record	1AB flying over from Forrestdale lake area to Tonkin Hwy Forrest rd east area. M. Newman 22/11/11
	Mealup Lake	1 day survey (20/9/11)	No Bitterns
1-2 AB 1ALB	Benger Swamp	4 day surveys (4/7/11, 10/8/11, 14/9/11, 1/11/11 & 12/12/11) & 3 twilight survey (22/9, 24/9 &26/11/11)	1-2AB R.Pickering& S. Abbott 14/9/11, 1-2 AB K. Williams et al, 1ALB + 2 AB heard Pickering et al 24/9/11
3-5 ALB	Wilgarrup Swamp	10 surveys (mid Oct-mid Dec)	Little Bittern calling in 3 locations Marco Groot
2-3 AB,3 ALB	Kulunilup Swamp	4 day survey (2hrs- 17/9/11), 5 twilight surveys (27/10, 28/10, 29/10, 17/11 & 18/11/11) and 1 dawn surveys (18/11/11) + Every week 30 min day survey while water monitoring	1AB heard R. Hearn 24/8/11, 1AB Wheeler 21/9/11, 1AB heard Wheeler & Hearn 28/9/11, 2AB heard R. Hearn 20/10/11, 1AB + 2ALB Zadow 27/10/11, 1 AB & 1-2 ALB (Hearn et al) 28/10/11, 2-3 AB + 1ALB (Wheeler et al) 29/10/11, 1 AB heard I. Wheeler 1/11/11, 1AB heard I. Wheeler 8/11/11, 1AB heard 12/11/11 Spencer & Spencer, 1-2AB heard + 3+ALB heard Graff (17&18/11/11), 1 AB heard R. Hearn 23/11/11,1 AB heard I. Wheeler 1/12/11, 1 ALB heard I. Wheeler 14/12/11.
3-5 ALB	Kulunilup small SE *Baumea* swamp	2 day surveys	1ALB flushed (22/2/12) E. Sandiford. 3-5 ALB seen R. Pickering et al (10/3/12).
	Bokarup Swamp	DEC sampling round	No Bitterns
	Yarnup Swamp,	1 twilight survey (28/10/11)	No bitterns
	Noobijup NR	1 twilight survey (18/11/11)	No bitterns
	Cobertup Swamp,	2 twilight surveys (28/10/11&18/11/11)	No bitterns
	Poorginup	1 twilight survey (29/10/11)	

Summary	Wetland	Surveys Conducted	Bittern Records
1xAB, 1x ALB	Geordinup Swamp,	2 twilight surveys (28/10/11 & 29/10/11)	1ALB heard R.Hearn 11/10/11, 1 AB Hearn et al 28/10/11
	Byenup Lagoon	1 twilight survey (28/10/11)	No bitterns
1-2 AB	Tordit-Gurrup,	1 twilight survey (28/10/11) +weekly 30min water sampling	?1AB Wheeler & Hearn 21/9/11(south end), 1 AB N end I. Wheeler 4/10/11, 1 AB heard N end R.Hearn 11/10/11
1-2 AB	Gingilup Swamps	2 twilight surveys (1/11/11 & 2/11/11)	1-2 AB Clarke et al
2AB +3ALB	Maringup Lake	1 twilight survey & 1 day survey	2AB & 3ALB heard Clarke & Wheeler 23-24/11/11
	Owingup Swamp	2 listening surveys	Recorder kept in field for 2 months
	Boat Harbour swamp	2 listening surveys	
	Lake Powell	1 twilight survey Oct 2011	No bitterns
1 prob AB	Black Cat Lagoon	1 twilight survey (4/11/11)	1 probable AB call found on recording
	Moates Lake	1 twilight survey (4/11/11)	No bitterns
2 AB (8-9AB April 2012)	Lake Pleasant View	3 day survey (5/11/11, 21/4/12 & 22/4/12), 5 twilight surveys (9/10/11, 4& 5/11/11, 15&16/12/11) & 3 dawn survey (5/11/11, 6/11/11& 16/12/11) 1 opportunistic (17/4/12)	1 AB heard D. Secomb (5/11/11), 2 AB seen (Pickering et al 5/11/11), 1-2 AB heard Graff& Collins 15-16/12/11, 4 AB seen A. Clarke (17/4/12), 8-9 AB seen R. Pickering et al (22/4/12)
	Angove Lake	1 twilight survey (4/11/11)	No bitterns
	Corymup Lake	Too dry, acidified & saline	
1 poss AB	South Sister (North Sister Swamp West)	1 twilight survey (5/11/11)	1 poss AB heard J. Spencer 5/11/11
1-2 AB	Tarnup Lake (North Sister Swamp East)	2 twilight survey (5/11/11, 16/12/11)	1-2 AB heard Bush & Abbotts (5/11/11)
1x AB 3xALB	Pfieffer Lake	3 twilight surveys (7/10/11, 9/10/11, 5/11/11) and 1 dawn surveys (16/12/11)	AB x 1 heard Graff and Collins 9/10/11, ALBx3 heard (Graff & Collins 16/12/11)
1xAB	Cheyne Beach Rd Swamp	2 dawn survey (10/8 & 6/11/11), 2 day survey (15/10/11 & 21/4/12), 6 twilight surveys (7/10, 9/10, 5/11, 10/12/11, 15/12/11 & 16/12/11)	1AB heard D. Secomb 10/8/11, 1AB heard Graff & Collins (7/10/11&9/10/11), 1AB heard Graff et al 5/11/11, 1AB heard 6/11/11, 1AB heard Newman & Burns 10/12/11, 1AB heard 15&16/12/11 (Graff & Collins), 1AB seen Abbotts et al (21/4/12)
	Elders Stoney Treefarm wetland	1 twilight survey (5/11/11)	No bitterns
	Elders Treefarm wetland 2	1 twilight survey (5/11/11)	No bitterns
	Unnamed wetland "Waychinnicup south"	1 day survey	No bitterns
	Mettler Lake	1 day survey 15/10/11 + ?Nields	No bitterns
1 pos AB	Gardner River	Opportunistic record	1 possible AB seen 6pm 6/2/12 (G Johnson)
?5-6+ AB 2 ALB	Unnamed wetland "Big Boom Swamp"	3 twilight surveys (9/10,11, 12/10/11, 16/1/12) & 2 day surveys (16/1/12, 29/5/12)	4-5 AB Comer et al 9/10/11, 5+ AB Comer et al 12/10/11, 1 AB flushed 29/5/12 EM Sandiford.
	Unnamed wetland "Adam's swamp"	1 twilight (10/10/11) & 1 day survey (10/10/11)	No bitterns
2-3 AB	Unnamed wetland "SW of Adams Le Grand UCL"	1 twilight survey (10/10/11) & 1 partial day survey (10/10/11)	2-3 AB Comer & Pickering 10/10/11
1 AB +3 SW of here – probably big boom swamp	Unnamed wetland "S of Adams Le Grand UCL"	3 day surveys (11/10/11, 14/10/11 & 16/1/12) and 1 twilight survey (14/10/11)	1 AB flushed Comer et al 11/10/11, 1 AB heard (RP et al) 14/10/11 11.40am, 1 AB heard (RP & ML) 14/10/11, +3AB heard distant in SW of swamp Pickering & Lauva 14/10/11
1 AB heard + 2 seen	Unnamed wetland "UCL swamp crossing	2 day survey (11/10/11 & 16/1/12) & 2 twilight surveys	1AB seen flying towards Big Boom swamp M. Lauva 11/10/11, 1AB seen flying C Ross

Summary	Wetland	Surveys Conducted	Bittern Records
	road"	(10/10/11 & 14/10/11)	14/10/11, 1AB heard (RP&ML) 14/10/11
2 AB	Private property opposite unnamed wetland "UCL swamp crossing road" (Lockes property?)	3 twilight surveys from road (10/10/11, 13/10/11, 14/10/11)	2 AB 12/10/11 (RP)
Poss 1 AB	Chalmer's Swamp	1 twilight surveys (14/10/11)	Seen in low light conditions (RP & SC) 13/10/11
	Wetlands N& NW of Frenchman's Peak	1 day survey 17/1/12	No bitterns and habitat not good.
Poss 1 x AB 1xALB	3 Wetlands E of Frenchman's Peak	2 twilight surveys (11/10/11 & 10/11/11)	1 possible AB heard R.Pickering (11/10/11), 1 ALB heard S. Comer 11/10/11 – separate wetlands
	Unnamed wetland "Cape Le Grand ticket office wetland"	1 twilight survey 14/10/11	No bitterns
	Unnamed wetland on "Lucky Bay road "	1 twilight survey (12/10/11)	No Bitterns

Total = 26-30 ALB & 26-37 AB. Note still working on cape Le Grand UCL data
Note: All records are confirmed unless otherwise stated. AB=Australasian Bittern and ALB= Australian Little Bittern

Results of the 2012/13 Australasian Bittern Survey in Western Australia.

Summary	Wetland	Surveys Conducted	Bittern Records
1ALB	Joondalup Lake	3 twilight surveys (6/11/12, 11/11/12, 12/11/12)	1 ALB heard D&C Reidy 11/11/12, 1ALB heard 15/11/10 D&C Reidy 12/11/12
1 possible AB	Herdsman Lake	2 twilight surveys (21/10/12, 27/10/12)	1 possible AB Mark Carter 21/10/12
0	Kogolup Lake & Swamp	2 day surveys (21/7/12 & 6/11/12)	No confirmed records
0	Thomson's Lake	5 day surveys(10/8/12, 7/9/12, 24/9/12, 26/10/12, 27/11/12)	No confirmed records water level too low
1 AB	Benger Swamp	2 day surveys (8/8/12 & 11/9/12) very dry	1 AB heard R.Pickering 11/9/12
0	Wellard Wetlands	1 morning survey 10/11/12	No confirmed records
0	Moorinup	1 day survey 16/11/12	No confirmed records - dry
0	Buranganup Swamp	1 day survey 16/11/12	No confirmed records - dry
0	Mulgarnup Swamp	1 day survey 16/11/12	No confirmed records – dry on east
0	Kulunilup Swamp	weekly day surveys (10-30mins), monthly day surveys (1-3hrs) very low water level	No confirmed records
0	Bokarup Swamp	weekly day surveys (10-30mins), monthly day surveys (1-3hrs)	No confirmed records
0	Yarnup Swamp,	weekly day surveys (10-30mins), monthly day surveys (1-3hrs)	No confirmed records
0	Noobijup NR	weekly day surveys (10-30mins), monthly day surveys (1-3hrs)	No confirmed records
0	Cobertup Swamp,	weekly day surveys (10-30mins), monthly day surveys (1-3hrs)	No confirmed records
0	Poorginup	weekly day surveys (10-30mins), monthly day surveys (1-3hrs)	No confirmed records
0	Geordinup Swamp,	weekly day surveys (10-30mins), monthly day surveys (1-3hrs)	No confirmed records
0	Byenup Lagoon	weekly day surveys (10-30mins), monthly day surveys (1-3hrs)	No confirmed records
0	Tordit-Gurrup,	weekly day surveys (10-30mins), monthly day surveys (1-3hrs)	No confirmed records
1 ALB	Gingilup Swamps	1 day/twilight survey (26/11/12)	1 ALB heard A. Clarke
0	Maringup Lake	1 day / twilight survey (12/11/12)	No confirmed records recovering from fire which burnt entire swamp
	Owingup Swamp	Nil	
	Boat Harbour swamp	Nil	
0	Lake Saide	1 afternoon survey 26/11/12	No confirmed records
1 AB & 1 ALB	Lake Pleasant View	3 twilight surveys dates(18/9/12, 19/9/12, 2/11/12), 2 day survey (4/7/12, 29/7/12 & 1/10/12) and DEC audio auto recorder in place for several months	3 AB A. Clarke 4/7/12, 1 AB heard R.Pickering 29/7/12, 1 AB audio auto recorder Sept2012, 1 AB 1 ALB John Graff 2/11/12,
0	Corymup Swamp	2 day surveys 26/10/12 & 2/11/12	No confirmed records very dry
0	Ten Mile Swamp	1 twilight survey 1/11/12	No confirmed records
1 AB & 5-7 ALB	South Sister Swamp	4 twilight (25/10/12, 1/11/12, 2/11/12, 1/12/12) and 1 day survey (2/11/12)	1 AB heard A. Clarke 25/10/12, 1 AB & 5-7 ALB heard J. Graff 1/11/12, 1 AB and 1 ALB seen 2/11/12 R.Pickering et

			al, 1 AB & 2-3 ALB J. Graff 2/11/12, 1 AB heard M. Newman and S. Burns 1/12/12.
	Tarnup Lake	nil	
0	North Sister	2 twilight surveys (1/10/12 & 1/11/12)	No confirmed records
Possible AB	Pfieffer Tree Farm wetland	2 twilight survey (18/9/12, 1/11/12)	1 possible AB J. Graff 1/11/12
0	White Lake Manypeaks	1 day survey – dry (24/11/12)	No confirmed records
1 AB & 1 ALB	Cheyne Beach Rd Swamp	5 day surveys (25/10/12, 1/11/12, 28/11/12, 29/11/12, 9/12/12), 7 twilight (18/9/12, 19/9/12, 1/11/12, 2/11/12, 28/11/12, 1/12/12, 8/12/12) and 3 dawn surveys (19/9/12, 2/11/12, 3/11/12)	1 AB heard J. Graff 18 & 19/9/12, 1 AB heard A. Clarke 25/10/12, 1 AB J. Graff 2/11/12, 1 ALB heard T. Bush 28/11/12, 1 AB heard M. Newman and S. Burns 1/12/12, 1 AB and 1 ALB heard T&J Bush.
0	Unnamed wetland "Waychinnicup??"	1 evening survey (??) & 1 day survey (??)	No confirmed records
0	Unnamed wetland west of Lake Mortijinup	1 late afternoon survey (20/10/12)	No confirmed records
1 ALB	Unnamed wetland "Cape Le Grand NW Swamp"	1 day survey	1 ALB A. Clarke et al
0	Warrens Swamp (Charsleys)	1 day (17/10/12) and 1 twilight survey (17/10/12)	No confirmed records
0	Little Warrens Swamp	1 day survey (17/10/12)	No confirmed records
2 AB & 3 ALB	Unnamed wetland "Big Boom Swamp"	1 evening (18/10/12) & 3 day surveys (17/10/12, 18/10/12 & 20/10/12)	1 AB seen & 2 ALB heard Clarke and Graff, 17/10/12, 1 AB & 3 ALB heard A. Clarke et al 18/10/12, 1 AB seen & 1 AB heard (different birds) A. Clarke et al.20/10/12
0	Unnamed wetland "UCL crossing Cape Le Grand road"	1 day (17/10/12) and 1 twilight (17/10/12) survey	No confirmed records
0	Unnamed wetland "Cape Le Grand Beach Swamp"	1 evening survey (17/10/12)	No confirmed records
1AB + 3ALB	Unnamed wetland east of Frenchman's Peak	2 twilight surveys (17/10/12 &)	1 AB heard 17/10/12 S. Comer et al, 3 ALB heard J.Graff 19/10/12
1 ALB	Unnamed wetland northeast of Frenchman's Peak	1 twilight survey (19/10/12)	1 ALB heard Pickering and Bush (Oct 2012)
0	Unnamed wetland NNE of Frenchman's Peak	1 twilight survey (19/10/12)	No confirmed records
0	Unnamed wetland north of Frenchman's Peak	1 twilight survey (19/10/12)	No confirmed records
0	Unnamed wetland "Dunn Rock West Swamp"	1 day survey (19/10/12)	No confirmed records
1AB	Unnamed wetland "Dunn Rock Swamp"	2 day surveys (18/10/12 & 19/10/12) and 1 twilight survey (18/10/12)	1 AB heard and 1 ALB seen Comer and Pickering (18/10/12)
1 ALB	Unnamed wetland "Little Dunn Rock Swamp"	1 day survey and 1 twilight survey (18/10/12)	1 ALB heard Comer and Pickering (18/10/12)
0	Heaths Swamp (Elders)	1 day survey (18/10/12)	No confirmed records – too dry
0	Swamp NW of Ewarts Swamp	1 day survey (19/10/12)	Swamp dry - *Baumea* stressed

Total = 8-10 AB & 18-20ALB. AB=Australasian Bittern and ALB= Australian Little Bittern

Appendix C Bittern Survey Summary 2007 to 2012

Survey Summary of the Australasian Bittern Survey in Western Australia 2007 to 2012

Wetland	Years surveyed	Surveys Conducted	Australasian Bittern Records	Australian Little Bittern Records
Mariginiup Lake	2008	1 day survey	Nil	Nil
Jandabup Lake	2007, 2008, 2009, 2010, 2011	9 twilight and 5 day surveys	Nil	1(Nov 2009)
Joondalup Lake	2008, 2009, 2010, 2011, 2012	18 twilight and 1 day survey	Nil	3 (Nov 2010), 1 (Oct 2011), 1 (Mar 2012), 1 (Nov 2012)
Goolellal Lake	2009	2 twilight surveys	Nil	1 (Nov 2009)
Carine Swamp	2009	1 twilight survey	Nil	Nil
Lake Gwelup	2009, 2011	2 twilight surveys	Nil	Nil
Herdsman Lake	2007, 2008, 2009, 2010, 2011, 2012	20 twilight and 6 day surveys	1 prob (Oct 2008), 1 poss (Oct 2012)	1 (Oct 2008), 1 (Nov 2009), 1 (Nov 2009), 1 (Sep 2011), 1 (Oct 2011), 3 (Dec 2011), 2 (Jan 2012)
Lake Monger	2010, 2011	5 twilight and 2 dawn surveys	Nil	2 (Oct 2010)
Baigup wetlands	2009	2 twilight surveys	Nil	Nil
Ascot waters	2011	1 twilight and 1 day survey	Nil	Nil
Bayswater Bird Sanctuary	2009	1 twilight survey	Nil	Nil
Lake Claremont	2011	1 twilight survey	Nil	Nil
Bibra Lake north end	2011,2012	2 twilight survey	Nil	Nil
Kogolup Lake & Swamp	2007, 2008, 2009, 2010, 2011, 2012	2 twilight, 3 dawn and 30 day surveys	Nil	1 (Oct 2009), 2 (Oct 2010), 1 (Nov 2010), (Dec 2011)
Thomson's Lake	2007, 2008, 2009, 2010, 2011, 2012	17 twilight, 2 dawn and 38 day surveys	1 poss (Oct 2007), 1 prob (Oct 2008), 1 prob (Oct 2009), 1 (Oct 2011)	2 (Nov 2009)
Forrestdale Lake	2009, 2011	4 twilight surveys	1 (Oct 2011)	Nil
James Swamp	2009, 2011	1 twilight surveys, opportunistic records	1 (Oct 2011)	1 (Nov 2009)
Wellard Wetlands	2012	1 day survey	Nil	Nil
Paganoni Swamp	2010	1 day survey	Nil	Nil
Anstey Swamp	2010	1 day survey	Nil	Nil
Mealup Lake	2011	1 day survey	Nil	Nil
Nine Mile Lake	2008	1 day survey	Nil	1 (Nov 2008)
Benger Swamp	2007, 2008, 2009, 2010, 2011, 2012	12 twilight and 13 day surveys	1 (Sep 2008), 2 (Nov 2008), 2 (Nov 2009), 1 (Dec 2009), 2 (Sep 2011), 1 (Sep 2012)	2 (Nov 2009), 1 (Dec 2009), 1 (Sep 2011)
Byrd Swamp	2009	2 twilight surveys	Nil	Nil
Wellard NR	2009	2 twilight surveys	Nil	Nil
Richardson Rd	2009	1 twilight survey	Nil	Nil
Vasse-Wonnerup	2009	2 twilight surveys	Nil	Nil
Wilgarrup Swamp	2011	10 twilight surveys	Nil	3-5 (Oct-Dec 2011)
Tone River	2008	1 twilight survey	Nil	Nil
Moorinup Swamp	2008, 2012	1 twilight and day survey	Nil	Nil
Buranganup Swamp	2012	1 day survey	Nil	Nil
Unicup Lake	2008	1 twilight survey	Nil	Nil
Little Unicup Lake	2008	1 twilight survey	Nil	Nil

Wetland	Years surveyed	Surveys Conducted	Australasian Bittern Records	Australian Little Bittern Records
Kulunilup Swamp	2008, 2009, 2010, 2011, 2012	7 twilight, 3 dawn and 8 day surveys **	1 (Oct 2008), 1 (Nov 2008), 1 (Dec 2008), 1 (Sep 2009), 1 (Oct 2009), 2 (Nov 2009), 2 nests (Dec 2009), 1 (Aug 2011), 1 (Sep 2011), 2-3 (Oct 2011), 1-2 (Nov 2011), 1 (Dec 11)	1 (Dec 2008), 6-12 + 2 nests (Nov 2009), 1 (Nov 2010), 2 (Oct 2011) 3 (Nov 2011)
Kulunilup small SE *Baumea* swamp	2011, 2012	2 day surveys	Nil	1 (Feb2012), 3-5 + 2 nests (Mar2012)
Bokarup Swamp	2008, 2009, 2010, 2011, 2012	2 twilight survey **	Nil	Nil
Yarnup Swamp	2008, 2009, 2010, 2011, 2012	3 twilight & 2 day surveys **	Nil	2 (Dec 2009), 2 nests (Nov 2010)
Noobijup NR	2008, 2010, 2011, 2012	2 twilight survey**	Nil	Nil
Cobertup Swamp	2008, 2009, 2010, 2011, 2012	3 twilight surveys**	1 (Oct 2007)	1 (Oct 2007), 1 (Oct 2008)
East Tolkerup	2008	1 twilight survey	Nil	Nil
Pinticup	2008	1 twilight survey	Nil	Nil
Nix's corner	2008	1 twilight survey	Nil	Nil
Mulgarnup Swamp	2012	1 day survey	Nil	Nil
Poorginup	2008, 2009, 2010, 2011	3 twilight surveys**	1 (Sep 2008), 1 (Oct 2008), 1 (Nov 2008), 1 (Nov 2009)	Nil
Geordinup Swamp	2008, 2009, 2010, 2011	4 twilight surveys**	1 (Oct 2008), 1 poss (Nov 2009), 1 prob (Nov 2010), 1 (Oct 2011)	2 (Nov 2009), 1 (Dec 2009), 1 (Oct 2010), 1 (Oct 2011)
Neeranup Lagoon	2008, 2009	2 twilight surveys	Nil	Nil
Byenup Lagoon	2008, 2009, 2010, 2011	3 twilight and 1 day survey **	1 (Oct 2008), 4 (Mar 2009), 3 + nest (Dec 2009), 2 (Nov 2009), 1 (Oct 2009)	1 nest (Dec 2009)
Lake NW of Byenup	2009	1 day survey	Nil	1 (Dec 2009)
Tordit-Gurrup	2008, 2009, 2010, 2011	3 twilight survey **	3 (Oct 2008), 1 (Dec 2008), 1 (Oct 2009), 1 (Dec 2009), 1 (Sep2011), 1 (Oct 2011)	Nil
Pardelup Lagoon	2010	1 twilight survey	Nil	1 (Feb 2010)
Gingilup Swamps	2011, 2012	3 twilight and 3 day surveys	1 (Mar 2011), 1-2 (Nov 2011)	1 nest (Mar 2011), 1(Nov 2012)
Maringup Lake	2010, 2011, 2012	3 twilight and 3 day surveys	2-3 (Nov 2010), 2 (Nov 2011)	3 (Nov 2011)
Owingup Swamp	2008, 2009, 2010, 2011	6 twilight and 5 day surveys, Recorder kept in field for 2 months (2011)	1 (Dec 2009), 1 (May 2011), 1 (Oct 2010)	1 nest (Nov 2009)
Boat Harbour swamp	2008, 2010, 2011	6 twilight and 5 day surveys	1 (Dec 2008), 3 (Jan 2009), 1 (Feb 2010), 1 (Oct 2010), 1 (April 2011), 1 May 2011),	3 (Jan 2009)
Lake Sadie	2008, 2009, 2012	2 twilight and 3 day surveys	Nil	Nil
Lake Powell	2008, 2009, 2010, 2011	3 twilight, 2 dawn and 1 day survey	Nil	Nil

Wetland	Years surveyed	Surveys Conducted	Australasian Bittern Records	Australian Little Bittern Records
Lake Seppings	2008, 2009, 2010, 2011	2 twilight, 1 dawn and 4 day surveys	1 poss (Oct 2009)	1 (Jan 2011)
Black Cat Lagoon	2009, 2010, 2011	3 twilight and 1 day survey	1 (Oct 2009), 1 (Oct 2010), 1 prob (Nov 2011)	Nil
Moates Lake	2009, 2010, 2011	3 twilight and 1 day surveys	1 poss (Oct 2009)	Nil
Gardner Lake	2009, 2010	2 twilight surveys	Nil	Nil
Angove Lake	2010, 2011	2 twilight and 1 day survey	Nil	Nil
Lake Pleasant View	2008, 2009, 2010, 2011, 2012	14 twilight, 2 dawn and 13 day surveys, 1 opportunistic *	2-3 (Jan 2009), 1 prob (Oct 2009), 2 (Dec 2009), 1 (Aug 2010), 2 (Oct 2010), 3 + nest (Jan 2011), 7-8 (Mar 2011), 2 (Nov2011), 1-2 (Dec2011), 8-9 (April 2012), 3 (Jul 2012), 1 (Sep 2012), 1 (Nov 2012)	2 + nest (Jan 2009), 1 (Dec 2009), 1 (Jan 2011), 1 (Nov 2012)
Corymup Lake	2010, 2011	1 twilight and 1 day survey	Nil	Nil
Corymup Swamp	2012	2 day surveys	Nil	Nil
Ten Mile Swamp	2012	1 twilight survey	Nil	Nil
White Lake	2009, 2010, 2012	1 twilight and 2 day survey	Nil	Nil
South Sister	2008, 2010, 2011, 2012	6 twilight and 3 day surveys	1 (Oct 2010), 1 poss (Nov2011), 1 (Oct 2012), 1 (Nov 2012), 1 Dec 2012	1 (Oct 2010), 5-7 (Nov 2012)
Tarnup Lake	2010, 2011	4 twilight surveys	1-2 (Oct 2010), 1-2 (Nov2011)	1-2 (Oct 2010)
Pfieffer Lake	2010, 2011, 2012	7 twilight surveys	2 (Oct 2010), 1 (Oct 2011), 1 poss (Nov 2012)	1 (Oct 2010), 3 (Dec 2011)
North Sister Swamp	2009, 2012	3 twilight survey	1 poss (Oct 2009)	Nil
Elders Treefarm 1	2011	1 twilight survey	Nil	Nil
Elders Treefarm 2	2011	1 twilight survey	Nil	Nil
Cheyne Beach Rd Swamp	2009, 2010, 2011, 2012	20 twilight, 8 dawn survey and 14 day surveys *	1 (Oct 2009), 2 + nest (Dec 2009), 1 (Aug 2010), 1 (Oct 2010), 2 (Dec 2010), 2-3 + nest (Jan 2011), 1 (Aug 2011), 1 (Oct2011), 1 (Nov 2011), 1 (Dec2011), 1 (April 2012), 1 (Sep 2012), 1 (Oct 2012), 1 (Nov 2012), 1 (Dec 2012)	1 (Nov 2012), 1 (Dec 2012)
Unnamed wetland "Waychinnicup South"	2010, 2011	1 twilight and 2 day surveys	1 prob (Oct 2010)	Nil
Unnamed wetland "Waychinnicup mid"	2010	1 day survey	Nil	Nil
Mettler Lake	2008, 2009, 2010, 2011	3 twilight and 5 day surveys	1 (Nov 2008), 1 (2009/10)	1 +nests(Jan 2009), 1 nest (Nov 2010)
Gardner River		Opportunistic record	1 possible (Feb 2012)	Nil
Unnamed wetland west of Lake Mortijinup	2012	1 day survey	Nil	Nil

Wetland	Years surveyed	Surveys Conducted	Australasian Bittern Records	Australian Little Bittern Records
Shark Lake	2008	1 twilight survey + DEC sampling	Nil	1 (Nov 2008)
Unnamed wetland "Cape Le Grand NW Swamp"	2012	1 day survey	Nil	1 (Oct 2012)
Warrens Swamp (Charsleys)	2012	1 day and 1 twilight survey	Nil	Nil
Warrens Little Swamp	2012	1 day survey	Nil	Nil
Unnamed wetland "Big Boom Swamp"	2010, 2011, 2012	6 twilight and 4 day surveys	4+ (Oct 2010), 5+ (Oct 2011), 2 (Oct 2012)	1 (Oct 2010), 2 (Oct 2011), 3 (Oct 2012)
Unnamed wetland "Adam's swamp"	2011	1 twilight and 1 day survey	No bitterns	Nil
Unnamed wetland "SW of Adams Le Grand UCL"	2011	1 twilight and 1 partial day survey	2-3 (Oct 2011)	Nil
Unnamed wetland "S of Adams Le Grand UCL"	2011	1 twilight and 3 day surveys	1 (Oct 2011), *3AB heard distant SW of swamp Oct2011	Nil
Unnamed wetland "UCL swamp crossing Cape Le Grand Road"	2011, 2012	3 twilight and 3 day surveys	1 (Oct2011)	Nil
PP opposite "UCL swamp crossing Cape Le Grand road" (Lockes?)	2011	3 twilight surveys from road	2 (Oct 2011)	Nil
Unnamed wetland "Cape Le Grand ticket office wetland"	2011	1 twilight survey	Nil	Nil
Mount Le Grand Swamp	2010	1 twilight and 1 day survey + DEC water sampling	Nil	Nil
Unnamed wetland "Cape Le Grand Beach Swamp"	2012	1 twilight survey	Nil	Nil
Wetlands N& NW of Frenchman's Peak	2012	1 day survey	Nil	Nil
3 Wetlands E of Frenchman's Peak	2010, 2011	4 twilight and 1 day survey	1 poss (Oct 2011), 1 (Oct 2012)	2 (Oct 2010), 1 (Oct 2011), 4 (Oct 2012)
Unnamed wetland "Dunn Rock West Swamp"	2012	1 day survey	Nil	Nil
Unnamed wetland "Dunn Rock Swamp"	2012	2 day and 1 twilight survey	1 (Oct 2012)	1 (Oct 2012)
Unnamed wetland "Little Dunn Rock Swamp"	2012	1 day and 1 twilight survey	Nil	1 (Oct 2012)
Heaths Swamp (Elders)	2012	1 day survey	Nil	Nil
Unnamed wetland "Mt Hawes Swamp"	2010	1 twilight survey	Nil	Nil
Chalmer's Swamp	2011	1 twilight survey	1 poss (Oct 2011)	Nil
Swamp NW of Ewarts	2012	1 day survey	Nil	Nil
Ewart's Swamp	2010	1 day survey	Nil	Nil
Quaelup Lake Kojonup	2009	1 morning survey	Nil	1 (Nov 2009)

Wetland	Years surveyed	Surveys Conducted	Australasian Bittern Records	Australian Little Bittern Records
WAMMCO dams Katanning	2011	Opportunistic record	1 (Feb 2011)	Nil

** = Plus weekly 30 min day survey during DEC Warren Region water monitoring

Note: All records are confirmed unless otherwise stated.

* = Plus Audio Recording Unit in place from September 2012.

Appendix D Australasian Bittern Confirmation Criteria

Australasian Bittern:
criteria for acceptance of records

Preamble
Australasian Bittern is a relatively poorly known species of conservation concern across its range, principally due to loss of habitat and urban development. It is currently listed as Vulnerable in Western Australia, although there has been discussion as to whether it should more accurately be considered Endangered. Populations all over Australia appear to be declining and nomination for listing under the EPBC Act as Endangered has been submitted. It is listed as Endangered at the global level (IUCN Red List). The species is cryptic and difficult to survey.

Given conservation concerns and the possible continued decline of this species, it is important that false positive records are eliminated as far as possible and the 'confirmed record' status is retained for records for which there is no possible doubt.

There is agreement within Birds Australia WA that there is a need for accurate records of presence and consistency across survey programs in criteria for acceptance of records of the species. This document provides some criteria by which records might be assessed as confirmed, probable, possible or doubtful/highly unlikely.

Possible status observations

1. **Confirmed record**– *a record that is beyond reasonable doubt*
   A record will be considered confirmed if any of the following criteria apply:
   1.1. Appropriately identified specimen
   1.2. Photograph with appropriate site location information – bird can be clearly identified from the photograph by an appropriately experienced person.
   1.3. Sound recording with appropriate site location information, verified by person with experience of calls of the species, or verified by reference to verified or commercially available recordings or spectrograms.
   1.4. Aural records by one or more observers experienced in identifying the calls of Australasian Bittern
      1.4.1. Calls are repeated OR The calling bird is near enough that the pre boom gasps can be heard; and
      1.4.2. habitat is described and appears to be suitable based on existing knowledge; and
      1.4.3. information regarding listening conditions is known; and
      1.4.4. Site location is within historical or recent range of the species
   1.5. Sightings with detailed written description of bird/s seen;
      1.5.1. habitat is described and appears to be suitable based on existing knowledge; and
      1.5.2. information regarding viewing conditions is known; and
      1.5.3. experience of observer is known and accepted; and
      1.5.4. Site location is within historical or recent range of the species
2. **Probable record**– *the record is highly likely or almost certain but is not beyond doubt*
   A record will be considered probable if none of the above criteria apply, but any of the following criteria do apply:
   2.1. Photograph with appropriate site location information – unequivocal identification of Australasian Bittern is not possible from the photograph;
      2.1.1. habitat is described and appears to be suitable based on existing knowledge; and
      2.1.2. Site location is within historical or recent range of the species
   2.2. Aural records where the call is brief and one or more observers is experienced with calls of Australasian Bittern
      2.2.1. habitat is described and appears to be suitable based on existing knowledge; and
      2.2.2. Site location is within historical or recent range of the species

2.3. Aural records where the pre-boom gasps can be heard but the observers are not experienced with calls of Australasian Bittern
   2.3.1. habitat is described and appears to be suitable based on existing knowledge; and
   2.3.2. Site location is within historical or recent range of the species

3. **Possible record** – *the record is indicative or has some credibility, but reasonable doubt remains.*
   A record will be considered possible if none of the above criteria apply, but any of the first four criteria below, plus the fifth criteria do apply:
   3.1. Photograph where positive identification is not possible but photograph is indicative
   3.2. One or more calls/sounds with which the call might be confused have not been ruled out
   3.3. A brief sighting with insufficient detail to rule out species with which Australasian Bittern might be confused
   3.4. Indicative calls under poor or difficult conditions (e.g. high wind)
   3.5. Habitat type is potentially suitable for the species

4. **Unlikely/highly doubtful record** – *the record has little credibility; considerable doubt exists, limited information available*
   A record will be considered unlikely or doubtful if any of the following criteria apply:
   4.1. Habitat appears unsuitable or unlikely
   4.2. Record is outside known historical and recent range limits
   4.3. Poor description of call (aural record) or the bird (sighting)
   4.4. Likely confusion with other species; observer has not demonstrated an understanding of species with which appearance or call might be confused
   4.5. Observer not experienced with Australasian Bittern and who has not carefully considered identification possibilities

June 2009

Appendix E Available chemical analysis of wetlands and data sources

Wetland	Zone	pH/EC	Nutrients	Other	Notes	Data Source
Unnamed wetland "Adams	SCE	✓				BirdLife
Angove (ANGO)	SCW	✓	✓			BirdLife
Bannitup Lake (BANN)	SCE	✓				BirdLife
Bibra Lake (BIBR)	SCP	✓				BirdLife
Boat Harbour Swamp (BOAT)	SCW	✓	✓	✓		DEC
Boat Harbour East (BOAE)	SCW	✓	✓	✓		DEC
Boat Harbour Southeast (BOAS)	SCW	✓	✓	✓		DEC
Black Cat Lagoon (BLAC)	SCW	✓	✓	✓		BirdLife
Benger Swamp (BENG)	SCP	✓	✓	✓		BirdLife, DEC
Unnamed wetland "Big Boom Swamp (BIGB)	SCE	✓	✓	✓		BirdLife, DEC
Bokarup (BOKA)	M-U	✓	✓	✓		BirdLife, DEC, AS
Lake Bryde (BRYD)	INL	✓	✓			DEC
Byenup Lagoon (BYEL)	M-U	✓	✓	✓		BirdLife, DEC, AS
Unnamed wetland "Byenup North" Swamp (BYEN)	M-U	✓	✓	✓		AS
Unnamed wetland "Byenup NW5 Swamp" (BYE5)	M-U	✓				BirdLife
Unnamed wetland "Byenup NW4 Swamp (BYE4)"	M-U	✓				BirdLife
Chalmer Wetland (CHAL)	SCE	✓				BirdLife
Cheynes Beach Rd Swamp (CHEY)	SCW	✓	✓	✓		BirdLife, DEC
Cobertup North (COBN)	M-U	✓	✓	✓		BirdLife, AS?
Cobertup East (COBE)	M-U	✓	✓	✓		BirdLife, AS?
Corymup Lake (CORY)	SCW	✓	✓	✓		BirdLife
Corymup Swamp (CORS)	SCW	✓				BirdLife
Crackers Swamp (CRAC)	SCP	✓				DEC
Dobaderry Swamp (DOBA)	IN	✓				DEC
Doombup Lake (DOOM)	SCE	✓				BirdLife
Unnamed wetland "Dunn Rock Swamp" (DUNN)	SCE	✓				BirdLife
Forrestdale Lake (FORR)	SCP	✓	✓	✓		BirdLife, DEC
Unnamed wetland "Frenchman's Peak NE" (FRNE)	SCE	✓	✓	✓		BirdLife
Unnamed wetland "Frenchman's Peak E" (FREE)	SCE	✓	✓			BirdLife, DEC
Galamup (GALA)	M-U	✓	✓	✓		AS
Lake Gardner (GARD)	SCW	✓	✓			BirdLife
Geordinup West (GEOR)	M-U	✓	✓	✓		BirdLife, DEC
Gingilup Swamp (GING)	SCW	✓	✓	✓		BirdLife, DEC
Lake Goollelal (GOOL)	SCP	✓				BirdLife
Lake Gundaring (GUND)	INL	✓	✓			DEC 1979-92
Lake Gwelup (GWEL)	SCP	✓				BirdLife
Heath's Swamp (HEAT)	SCE	✓				BirdLife

Wetland	Zone	pH/EC	Nutrients	Other	Notes	Data Source
Herdsman Lake (HERD)	SCP	✓	✓	✓		BirdLife
James Swamp (JAME)	SCP	✓	✓	✓		BirdLife
Jandabup Lake (JAND)	SCP	✓	✓	✓		BirdLife, DEC, DOW
Lake Jasper (JASP)	SCW	✓	✓			DEC
Joondalup Lake (JOON)	SCP	✓	✓	✓		BirdLife, DEC, DOW
Kogjinup Swamps (KOGJ)	M-U	✓	✓	✓		AS
Kogolup Lake (KOGO)	SCP	✓	✓			BirdLife, DOW
Kogolup Swamp (KOGS)	SCP	✓				BirdLife
Kulikup Swamp (KULI)	IN	✓				DEC
Kulunilup Lake (KULL)	M-U	✓	✓	✓		BirdLife, DEC, AS
Kulunilup Long Swamp (KULS)	M-U	✓	✓	✓		BirdLife, AS
Unnamed wetland "Le Grand Ticket Office" (LWPT)	SCE	✓	✓			BirdLife, DEC
Unnamed wetland "UCL Crossing Cape Le Grand Rd" (LUCL)	SCE	✓				BirdLife
Unnamed wetland "Little Dunn Rock Swamp" (LDUN)	SCE	✓				BirdLife
Little Mealup Lake (LMEA)	SCP	✓				LMPS
Little Warren's Swamp (LWAR)	SCE	✓				BirdLife
Lake Mariginiup (MARII)	SCP	✓	✓	✓		BirdLife, DOW
Lake Maringup (MARI)	SCW	✓	✓	✓		BirdLife, DEC
Lake McLarty (MCLA)	SCP	✓	✓			DEC
Lake Mealup (MEAL)	SCP	✓	✓	✓		BirdLife, DEC, LMPS
Mettler Lake (METT)	SCW	✓	✓	✓		BirdLife, DEC
Moates Lake (MOAT)	SCW	✓	✓	✓		BirdLife, DEC
Lake Monger (MONG)	SCP	✓				BirdLife
Moorinup Lake (MOOR)	M-U	✓				BirdLife
Unnamed wetland east of Lake Mortijinup (MORE)	SCE	✓				BirdLife
Unnamed wetland "Mount Hawes" (MTHA)	SCE	✓	✓			BirdLife, DEC
Mount Le Grand (MTLE)	SCE	✓	✓			DEC
Lake Muir (MUIR)	M-U	✓	✓	✓		DEC, AS
Mulgarnup Lake (MULG)	M-U	✓	✓	✓		AS
Neeranup Lagoon (NEER)	M-U					
Noobijup Lake (NOOB)	M-U	✓	✓	✓		BirdLife, DEC
North Lake (NORT)	SCP	✓				BirdLife
Owingup Swamp (OWIN)	SCW	✓	✓	✓		DEC
Pardelup Lagoon (PARD)	M-U	✓	✓	✓		DOW
Pindicup (PIND)	M-U	✓	✓	✓		AS
Unnamed wetland "Pindacup Road Swamp" (PIRD)	M-U	✓				BirdLife
Lake Pleasant View (LPVI)	SCW	✓	✓	✓		BirdLife, DEC
Poorginup (POOR)	M-U	✓	✓	✓		BirdLife, DEC, AS
Lake Powell (POWE)	SCW	✓	✓			DEC
Red Lake (REDL)	M-U	✓				BirdLife

Wetland	Zone	pH/EC	Nutrients	Other	Notes	Data Source
Lake Sadie (SADI)	SCW	✓	✓			BirdLife
Lake Seppings (SEPP)	SCW	✓	✓	✓		DOW
Shark Lake (SHAR)	SCE	✓	✓			DEC
Unnamed wetland "South of Adams" (SOUA)	SCE	✓	✓	✓		BirdLife
South Sister (SOUT)	SCW	✓	✓	✓		BirdLife, DEC
Unnamed wetland "Southwest of Adams" (SWAD)	SCE	✓	✓			BirdLife
Tarnup Lake (TARN)	SCW	✓	✓	✓		BirdLife
Unnamed wetland "Thistle Cove Swamp" (THIS)	SCE	✓	✓			BirdLife
Thomson's Lake (THOM)	SCP	✓	✓	✓		BirdLife, DEC, DOW
Toolibin Lake (TOOL)	IN	✓				DEC
Tordit-Gurrup Lagoon (TORD)	M-U	✓	✓	✓		BirdLife, DEC, AS
Unicup Lake (UNIC)	M-U	✓	✓	✓		DEC, AS
Warren's (Charsley's) Swamp (WARR)		✓	✓	✓		BirdLife
Unnamed wetland "Waychinnicup South" (WAYS)	SCE	✓	✓			BirdLife
Unnamed wetland "West of Adams" (WESA)	SCE	✓	✓			BirdLife
White Lake Manypeaks (WHIT)	SCW	✓	✓			DEC 1981-1998
Wilgarrup Swamp (WILG)	M-U	✓	✓			BirdLife
Yarnup Lagoon (YARN)	M-U	✓	✓	✓		BirdLife, DEC, AS

Notes: Zones- SCP=Swan Coastal Plain, M-U = Muir-Unicup, SCW = South Coast West & SCE = South Coast East

Data Sources – BirdLife = BirdLife Western Australia (this study), DEC= Department of Environment and Conservation, DOW = Department of Water, AS = Andrew Storey 1996-2004 study, LMPS = Lake Mealup Preservation Society

Appendix F BirdLife WA Wetland Chemistry data

Wetland	pH	EC (mS/cm)	Calcium (mg/L)	Chloride (mg/L)	Hardness (mg/L)	N-TOT (mg/L)	P-TOT (mg/L)	Sulphate (mg/L)
ANZECC guideline	7.0 – 8.5					0.5	0.05	
ADAM	7.2	0.28	#	#	#	#	#	#
ANGO SW	6.4	0.83	#	#	#	0.8	<0.02	#
ANGO W	6.3	0.80	#	#	#	1.0	<0.02	#
BANN	9.1	17.8	#	#	#	#	#	#
BIBR NW	9.1	2.0	#	#	#	#	#	#
BIBR SW	7.0	1.8	#	#	#	#	#	#
BLAC E	6.4	0.96	7.5	272	98	1.6	0.06	7.5
BLAC W	6.2	0.95	7.4	271	97	1.6	0.06	7.8
BENG MID	6.6	0.30	8.9	55	53	*	*	5.1
BENG NE	6.5	0.34	11.9	57	67	*	*	<0.5
BIGB SE	6.8	1.7	10.9	476	100			5.3
BIGB SW	N/A	3.5	23.2	922	240			7.9
BIGB DEC	8.2^	4.0^				1.8	<0.02	
BOKA E	6.2	4.0	38.3	1190	580	1.8	0.02	76
BOKA N	6.1	4.0	38.4	1210	580	1.9	0.01	82
BYE4 SW	6.0	4.4	#	#	#	#	#	#
BYE5 NW	6.0	3.5	#	#	#	#	#	#
BYEL SW	7.7	7.8	117	2270	1100			346
BYEL SE	8.4	13.3	206	4530	2100	*	*	304
CHAL	6.6	1.0	#	#	#			#
CHEY S	6.1	0.12	1.3	27	10	*	*	<0.5
CHEY NE	6.6	0.77	4.9	203	53	*	*	<0.5
COBE	5.5	3.2	19	993	270	0.8	<0.01	9.3
COBN	4.0	4.9	45	1240	680	3.4	<0.01	46
CORS	6.1	0.4	#	#	#	#	#	#
CORY	4.0	8.7	321	1980	1900	8.0	0.03	1890
DOOM	8.0	9.2	#	#	#	#	#	#
DUNN NW	7.1	2.7	#	#	#	#	#	#
DUNN NE	7.0	2.8	#	#	#	#	#	#
FORR NE	9.4	4.4	267	907	1000	*	*	932
FORR SW	7.9	3.7	211	755	880			620
FREE	6.4^	1.4^	#	#	#	1.4	<0.02	#
FRNE	7.0	1.4	#	#	#	0.9	<0.01	#
GARD E	8.6	3.9	#	#	#	1.3	<0.02	#
GARD NE	8.6	4.0	#	#	#	1.1	<0.02	#
GEOR SW	6.4	3.7	65	1050	560	3.6	0.01	160
GEOR NW	5.8	5.1	72	1490	800	3.3	0.02	161
GING 1	4.8^	0.46	4.1	118	46	0.91	<0.01	17.5

Wetland	pH	EC (mS/cm)	Calcium (mg/L)	Chloride (mg/L)	Hardness (mg/L)	N-TOT (mg/L)	P-TOT (mg/L)	Sulphate (mg/L)
GING 2	5.9^	0.54	5.4	117	50	1.00	<0.01	5.5
GOOL SE	7.3	1.1	#	#	#	#	#	#
GOOL SW	8.3	1.2	#	#	#	#	#	#
GWEL W	8.5	0.4	#	#	#	#	#	#
GWEL S	8.2	0.4	#	#	#	#	#	#
HEAT W	8.5	4.5	#	#	#	#	#	#
HEAT S	8.1	21.7	#	#	#	#	#	#
HERD SE	8.5	1.0	52	132	250	1.3	0.03	81
HERD N	8.6	0.83	49	108	200	0.77	0.21	43
JAME S	7.0	0.50	28	98	130	2.7	0.5	2.4
JAME W	6.9	0.51	22	99	110	4.3	0.7	2.0
JAND E	6.4	0.42	12.1	97	74	*	*	12.8
JAND NE	7.2	0.44	10.2	97	63	*	*	26.0
JAND SE	6.7	0.45	10.7	100	66	*	*	28.3
JOON S	7.1	0.74	58	107	200	*	*	30.6
JOON W	9.1	1.8	49	376	290	*	*	223
KOGO SE	5.1	0.7	#	#	#	#	#	#
KOGO S	6.9	1.3	#	#	#	#	#	#
KOGO W	7.4	0.9	#	#	#	#	#	#
KOGS SW	8.3	1.8	#	#	#	#	#	#
KOGS NW	8.1	3.5	#	#	#	#	#	#
KULL	6.2	8.2	44	1520	470	0.8	<0.01	58
KULS NW	6.2	4.7	32	1400	350	1.3	<0.01	110
KULS SW	5.5	3.9	60	1180	530	1.2	0.01	140
LDUN SE	6.3	1.6	#	#	#	#	#	#
LUCL E	6.6	0.42	#	#	#			#
LUCL W	6.8	0.47	#	#	#			#
LWAR N	6.4	1.1	#	#	#	#	#	#
LWPT	6.2^	0.84^	#	#	#	1	<0.02	#
MARII 1	4.3	0.92	25	117	200	*	*	253
MARII 2	4.1	0.36	14	130	94			112
MARI E	7.7	0.60	46	81	150	0.7	<0.01	5.3
MEAL G	3.7	2.6	46	530	240	*	*	530
MEAL N	3.5	3.4	146	628	670			800
METT W	6.2	1.7	20	476	130	*	*	2.1
METT N	6.8	2.3	30	652	200	*	*	<0.5
MOAT N	6.6	1.0	12.5	268	110	*	*	25
MOAT W	6.4	0.92	11.3	246	110			18
MONG SW	7.8	1.3	#	#	#	#	#	#
MONG SE	8.0	1.3	#	#	#	#	#	#
MOOR E	6.5	1.4	#	#	#	#	#	#
MORT N	7.5	4.6	#	#	#	#	#	#
MTHA	6.3^	0.89^	#	#	#	1.1	<0.02	#
NOOB N	5.5	12.6	78	4700	890			58

Wetland	pH	EC (mS/cm)	Calcium (mg/L)	Chloride (mg/L)	Hardness (mg/L)	N-TOT (mg/L)	P-TOT (mg/L)	Sulphate (mg/L)
NOOB S	4.6	2.8	32	831	440	*	*	110
NORT W	6.7	2.9	#	#	#	#	#	#
NORT NW	4.5	2.2	#	#	#	#	#	#
NORT N	5.5	2.2	#	#	#	#	#	#
LPVI E	6.4	0.75	7.0	176	64	*	*	9.0
LPVI SW	6.9	0.67	6.2	139	52			2.6
PIRD N	7.1	25+	#	#	#	#	#	#
POOR NE	5.4	0.89	19	152	180			142
POOR G	5.5	0.61	14	128	110	*	*	52
REDL W	9.6	13.2	#	#	#	#	#	#
SADI W	7.2	1.9	#	#	#	2.2	0.09	#
SADI SW	7.2	2.1	#	#	#	6.3	1.4	#
SADI Drain	7.8	1.7	#	#	#	1.9	0.08	#
SOUT N	6.8	1.4	11	405	100	1.7	<0.02	4.8
SOUT S	6.7	1.1	10	314	97	1.5	<0.02	6.2
SOUA MID	6.4	0.37	3	87	23	1.9	0.01	16
SOUA W	6.6	0.43						
SWAD	6.0	0.57				1.9	0.03	
TARN S	6.3	0.31	4.2	71	27	2.1	0.02	2.0
TARN SE	6.5	0.91	9.2	225	72	1.7	0.02	3.9
THIS	7.4	1.0	#	#	#	0.49	<0.01	#
THOM SE	9.0	2.7	87	610	380	*	*	360
THOM N	8.2	2.1	104	477	500			250
TORD SE	8.0	7.5	143	2060	1100	*	*	424
TORD N	7.0	4.5	114	1150	790			306
WARR W	6.3	4.6	#	#	#	#	#	#
WARR SW	6.5	1.2	#	#	#	#	#	#
WARR E	6.4	1.1	#	#	#	#	#	#
WAYS	5.5	1.6	#	#	#	3.9	0.02	#
WESA	6.2	0.30	#	#	#	3.3	0.01	#
WILG W	7.2	2.4	#	#	#	1.3	0.01	#
WILG E	7.3	2.1	#	#	#	1.1	0.01	#
YARN NW	3.8	7.8	62	2440	740	*	*	140
YARN SW	3.8	8.2	49	2630	670			140

Key: * = Data available elsewhere

= Low priority wetland

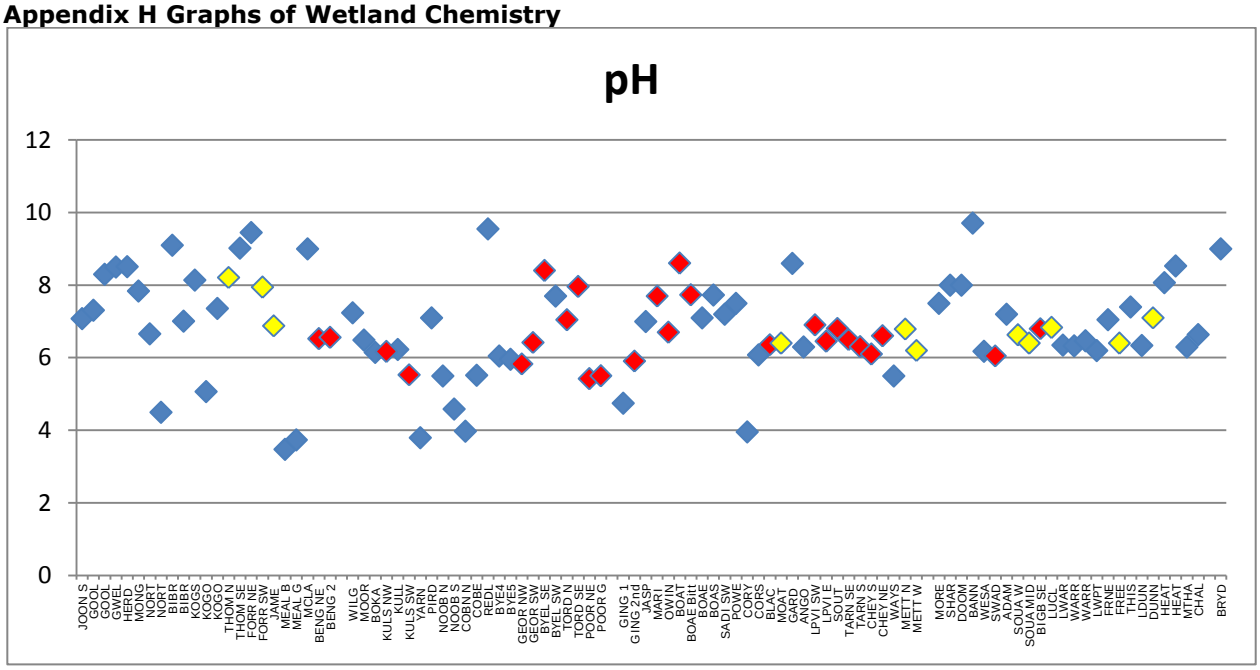
^ = DEC performed this analysis in field for BirdLife WA

Appendix G Wetlands with chemistry that does now meet ANZECC guidelines

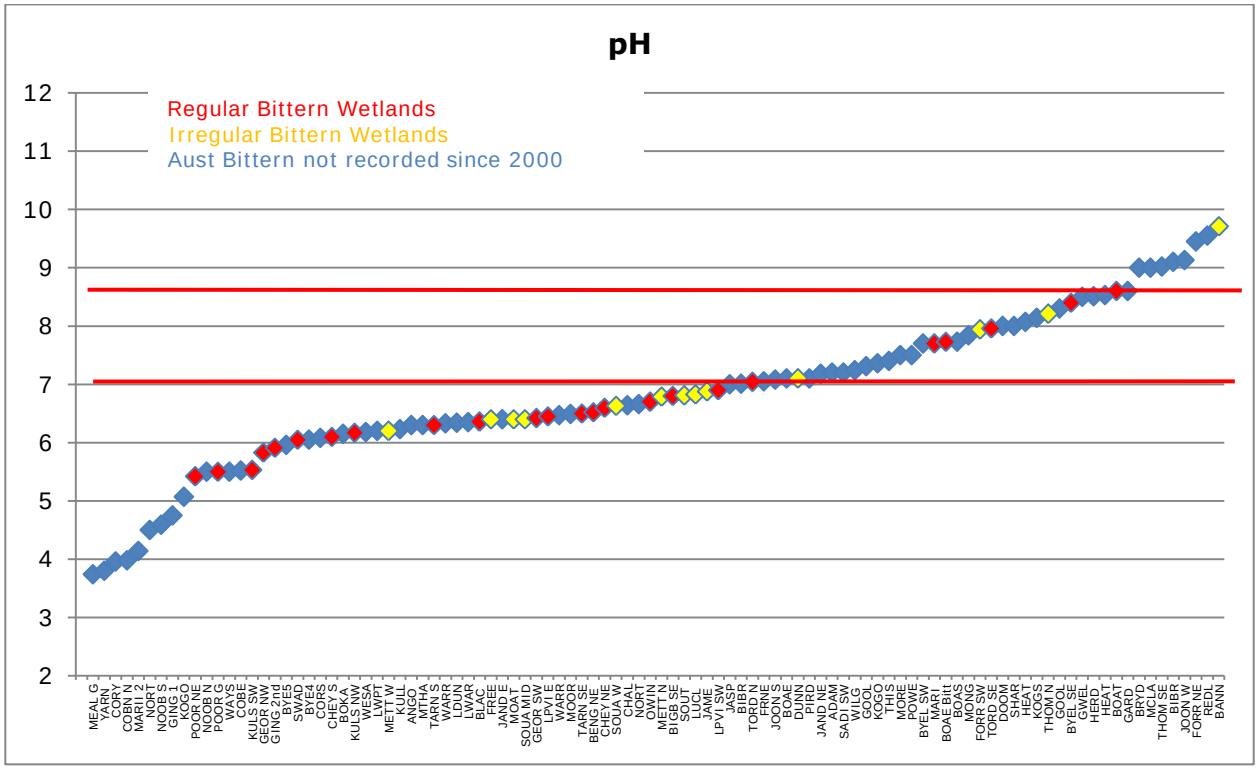
Analysis Type & guideline	Analysis which did not meet ANZECC guidelines	Comments
pH 7.0 to 8.5	Angove Lake (6.3 & 6.4), Benger Swamp (6.5), Bibra Lake (one of two samples 9.1), "Big Boom Swamp" (6.8), Black Cat Lagoon (6.2 & 6.4), Boat Harbour Swamp (8.6), Bokerup (6.1), Lake Bryde (9.0), Chalmer Swamp (6.6), Cheynes Beach Road Swamp (6.1 & 6.6), Cobertup East (5.5), Cobertup North (4.0), Corymup Lake (4.0), Corymup Swamp (6.1), Forrestdale Lake (one of two samples 9.4), "Frenchman's Peak East" (6.4), Lake Gardner (8.6), Geordinup West (5.8 & 6.4), Gingilup Swamp (4.8 & 5.9), Herdsman Lake (one of two samples 8.6), James Swamp (6.9), Jandabup Lake (two of three samples 6.4 & 6.7), Joondalup Lake (one of two samples 9.1), Kogolup Lake (two of three samples 5.1 & 6.9), Kulunilup Lake (6.2), Kulunilup Swamp (5.5 & 6.2), Lake Pleasant View (6.4 & 6.9), "Le Grand UCL crossing Cape Le Grand road" (6.6 & 6.8), "Le Grand Ticket Office" (6.2), "Little Dunn Rock" (6.3), Little Warren Swamp (6.3), Mariginiup Lake (4.3 & 4.1), Lake McLarty (9.0), Lake Mealup (3.5 & 3.7), Mettler Lake (6.8 & 6.2), Moates Lake 6.6 & 6.4), "Mt Hawes" (6.3), Noobijub (5.5 & 4.6), North Lake (4.5, 5.5 & 6.7), Owingup Swamp (6.7), Poorginup Swamp (5.5 & 5.4), "South of Adams" (6.4 & 6.6), South Sister (6.8 & 6.7), "Southwest of Adams" (6.0), Tarnup Lake (6.3 & 6.5), Thomson's Lake (one of two samples 9.0), Warren's Swamp (6.3, 6.4 & 6.5), "Waychinnicup South" (5.5), "West of Adams" (6.2), and Yarnup Lagoon (3.8).	The majority of the wetlands had sites where the pH guidelines were not met. However, Bitterns still frequented wetlands with pH of less than 7.0 or greater than 8.5
EC/Salinity 0.3- 1.5mS/cm	Bannitup Lake (17.8), Bibra Lake (1.8 & 2.0), "Big Boom Swamp" (1.7 & 3.5), Bokerup (4.0), "Byenup4" (4.4), "Byenup 5" (3.5), Byenup Lagoon (7.8 & 13.3), Cobertup East (3.2), Cobertup North (4.9), Corymup Lake (8.7), Doombup Lake (9.2), "Dunn Rock Swamp" (2.7 & 2.8), Forrestdale Lake 3.7 & 4.4), Gardner Lake (3.9 & 4.0), Geordinup Swamp (3.7 & 5.1), Heath Swamp (4.5 & 21.7), Joondalup Lake (1.8), Kogolup Swamp (1.8 & 3.5), Kulunilup Lake (8.2), Kulunilup Swamp (3.9 & 4.7), "Little Dunn Rock Swamp" (1.6), Lake Mealup (2.6 & 3.4), Mettler Lake (1.7 & 2.3), Swamp east of Lake Mortijiniup (4.6), Noobijup Swamp (2.8 & 12.6), North Lake (2.2, 2.8 & 2.9), "Pindicup Road Swamp" (25+), Red Lake 13.2), Lake Sadie (1.9 & 2.1), Thomson's Lake (2.1 & 2.7), Tordit-Gurrup (4.5 & 7.5), Warren's Swamp (4.6), Wilgarup Swamp (2.1 & 2.4), and Yarnup Swamp (3.8).	Many wetlands had conductivity (salinity) higher than guidelines. Several of these (Big Boom Swamp, Byenup Lagoon, Dunn Rock Swamp, Forrestdale Lake, Geordinup, Mettler Lake, Thomson's lake, and Tordit-Gurrup Lagoon had Australasian Bittern present. This suggests that the guidelines are lower than bittern preferences.
Aluminium	Lake Mealup (4.5 & 0.42), Mariginiup Lake (2.5 & 1.0), Corymup Lake (1.2), Owingup Swamp (0.91), Cheyne Beach Road Swamp (one of two samples at 0.43), Poorginup Swamp (0.34 & 0.23), Gingilup Swamp (0.3 & 0.2), Jandabup Lake (0.26, 0.11 & 0.085), Moates Lagoon (0.25 & 0.11), Tarnup Lake (one of two Samples 0.25), "South of Adams" (0.24), Cobertup Swamp North (0.23), Noobijup Lake (one of two samples at 0.21), Black Cat Lagoon (0.18 & 0.17), James Swamp (one of two samples at 0.16), Yarnup Swamp (0.16 &	There were three wetlands which exceeded the guideline than had aluminium levels below the guideline. However, the four wetlands with an aluminium concentration of greater than 1.0 mg/L had strong acid sulphate problems and no bitterns were

	0.14), Benger Swamp (one of two samples at 0.12), Mettler Lake (0.12 & 0.085), South Sister Swamp (0.094 & 0.066), "Big Boom Swamp" (one of two samples at 0.092), Boat Harbour East (0.09), and Geordinup Swamp West (one of two samples 0.064).	recorded. Wetlands with less than 1 mg/L of aluminimium usually had acceptable pH levels.
Arsenic	All sampled wetlands met the guidelines.	
Cadmium	Only one sample from Lake Pleasant View (0.0001) had cadmium detected. This below the 95% protection guideline.	Limits of detectability are a major factor with this element.
Chromium VI	Chromium not analysed as species. Most wetlands which exceeded the guideline (chromium exceeded the chromium IV guideline) had bittern regularly or irregularly present.	Does not seem to be important or most chromium present is chromium III.
Copper	Using the hardness modified guideline algorithm levels at Lake Pleasant View, Cobertup East, "South of Adams" and Benger Swamp were above the guideline.	All of these but Cobertup East have regular Australasian Bittern present so does not seem to be important.
Manganese	Corymup Lake was at the guideline concentration.	All other wetlands well below.
Nickel	nil	
Zinc	Benger Swamp, "Big Boom Swamp", Black Cat Lagoon, Cheynes Beach Road Swamp, Gingilup Swamp, Jandabup Lake, Lake Mariginiup, Tarnup Lake, Lake Pleasant View, Poorginup, and "South of Adams", had zinc above the hardness modified guideline algorithm.	Many of these wetlands have Australasian Bittern regularly or sporadically present so it does not appear to be an important factor.

Appendix H Graphs of Wetland Chemistry

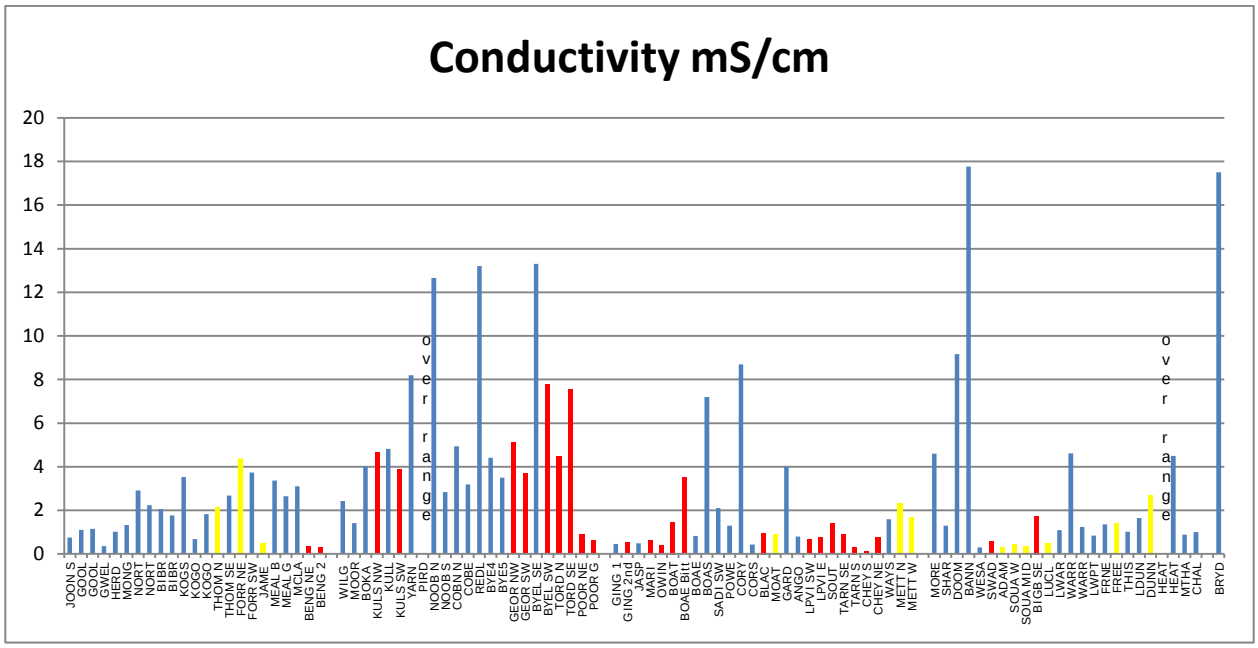


pH by area showed no regional trends except that pH values on the Swan Coastal Plain were more variable.

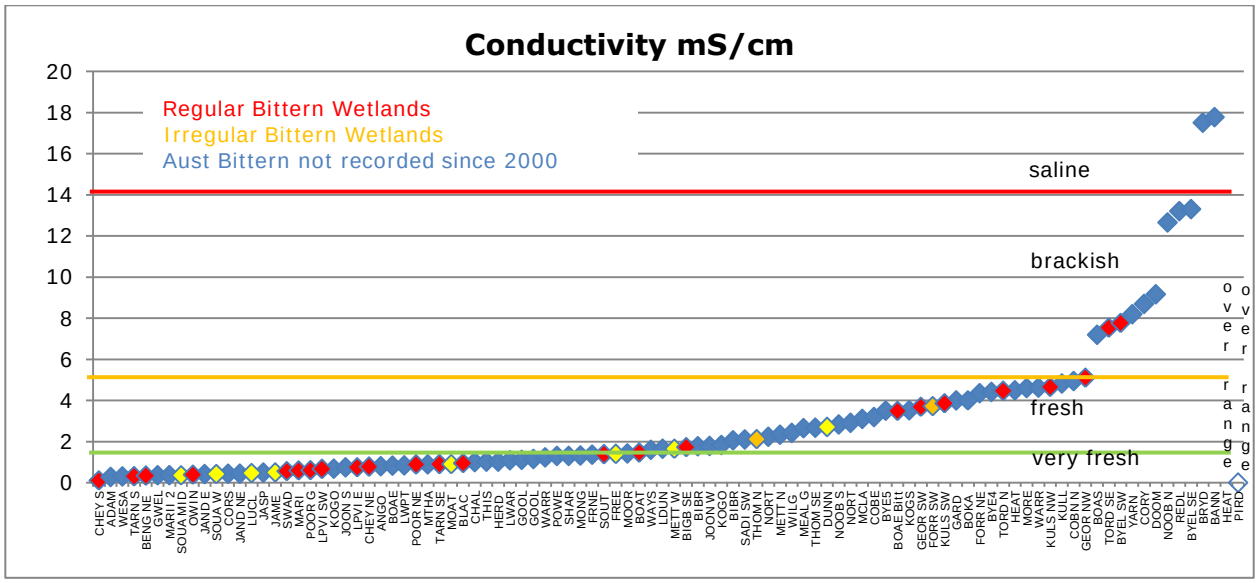


In this graph where the wetlands are sorted from lower pH to higher pH it is evident that bitterns were not recorded in wetlands with pH below 5.5. Under these acid conditions it is thought food resources plummet due to acid toxicity. ANZECC guidelines of 7 to 8.5 were only found in 15 wetlands. However, it appears that for bitterns pH out of ANZECC setandards is acceptable as long as the pH is not below 5.5.

This means that bitterns are found in wetlands where the pH is neutral to circumnuetral. Circumneutral are wetlands with a pH ranging from 5.5 to 7.4.

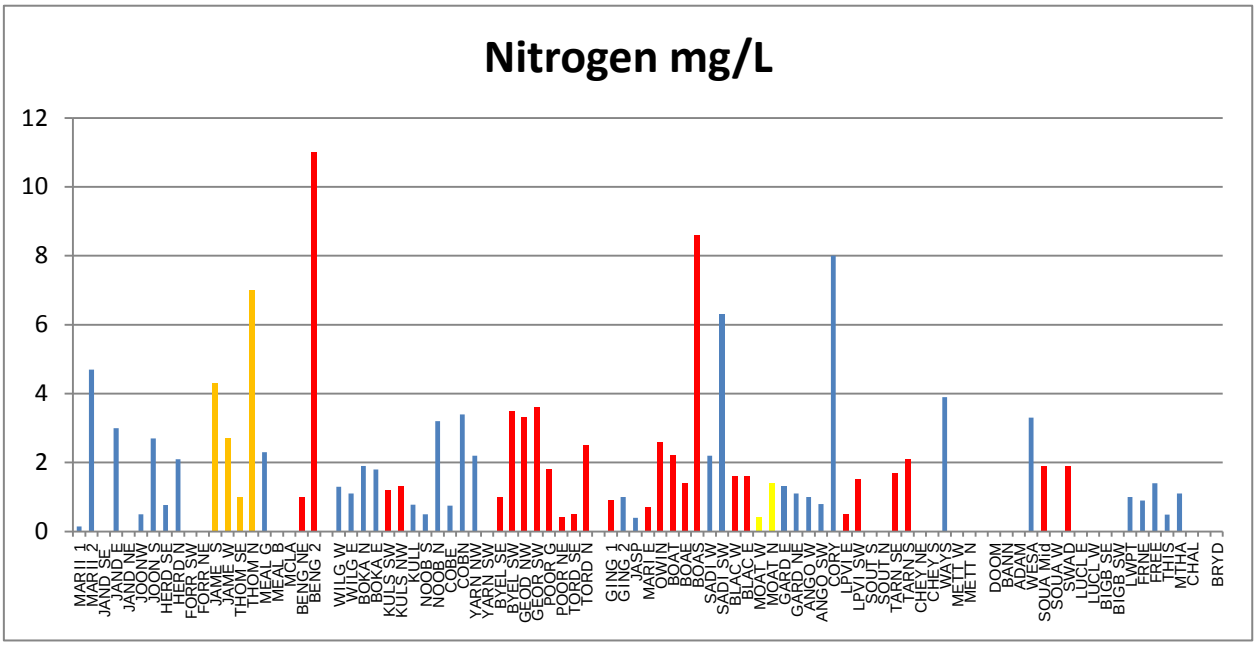


Conductivity sorted by region certainly showed that salinity was raised in many Swan Coastal Plain wetlands but only to the fresh zone. At Muir-Unicup wetlands,salinity was often raised to the brackish zone. The data also showed that a few wetlands on the south coast had elevated salinity (fresh to saline), as did the inland wetland Lake Bryde (saline).

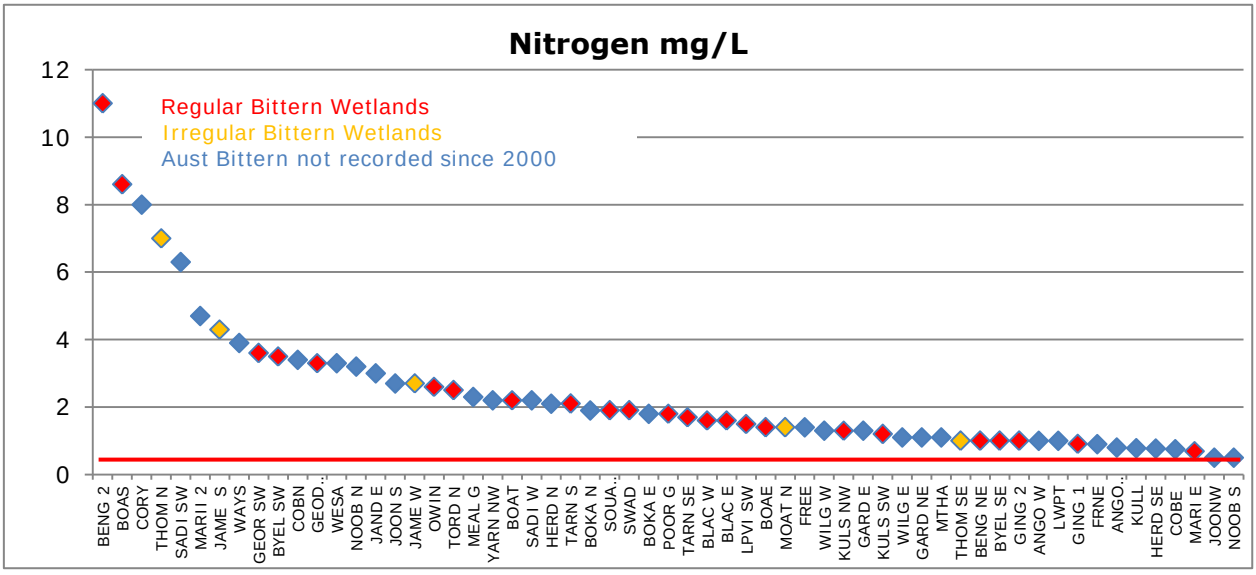


Wetlands sorted by conductivity level showed that more wetlands with bitterns present were very fresh than any other category. However some fresh and brackish wetlands had bitterns present. No saline wetlands surveyed had bittern present.

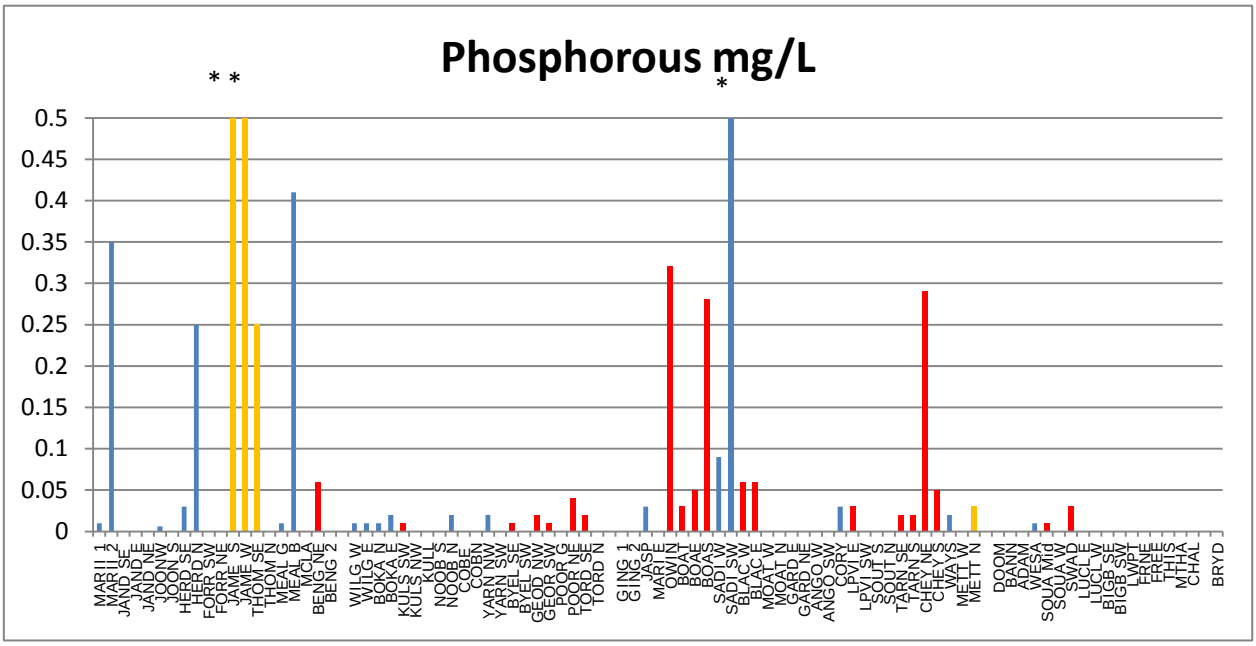
Classes used in this graph are derived from salinity classes in Lane et al 2004.



Nitrogen levels varied within regions as it relates largely to neighbouring land uses and incoming streams and drains.

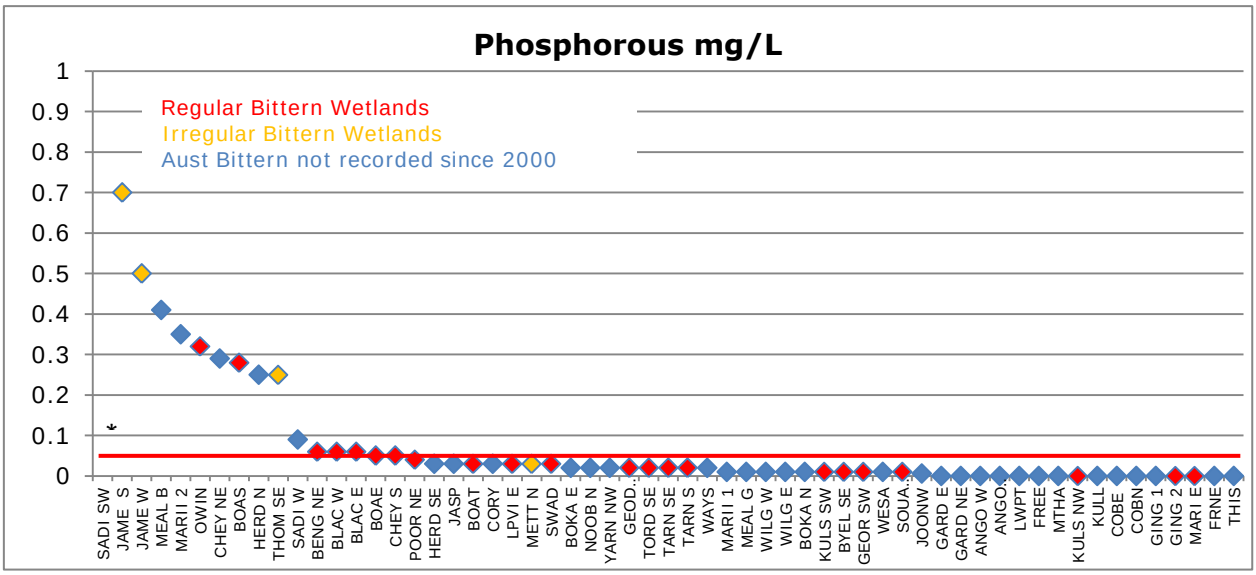


When wetlands were plotted by decreasing nitrogen level it appears that bittern presence is not affected by nitrogen level. Nearly all wetlands had nitrogen concentrations above ANZECC guidelines of 0.5 mg/L.

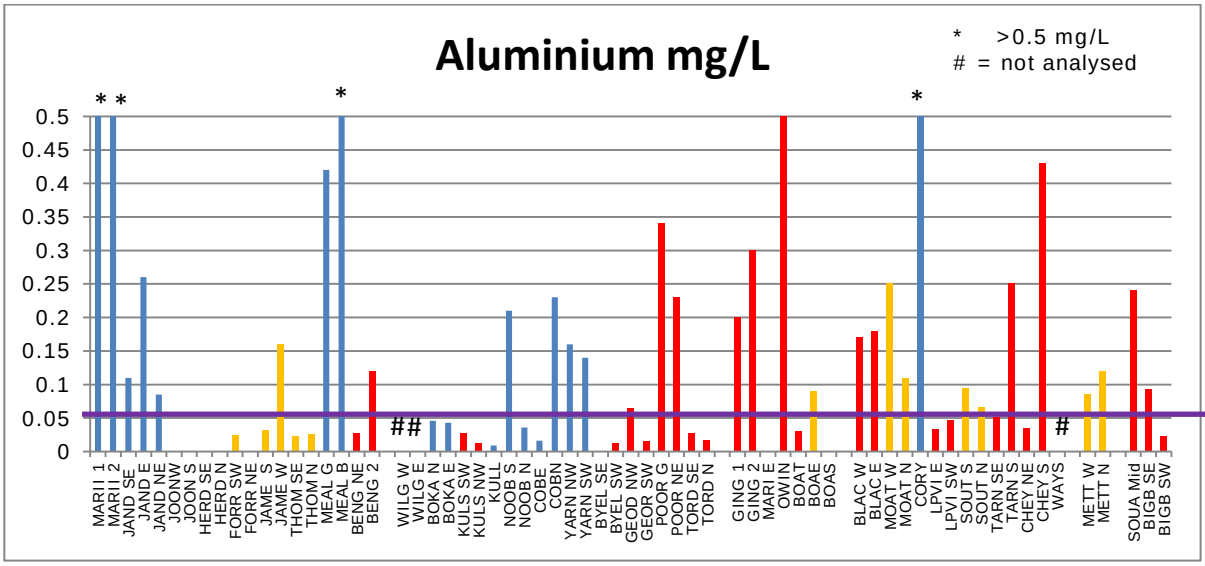


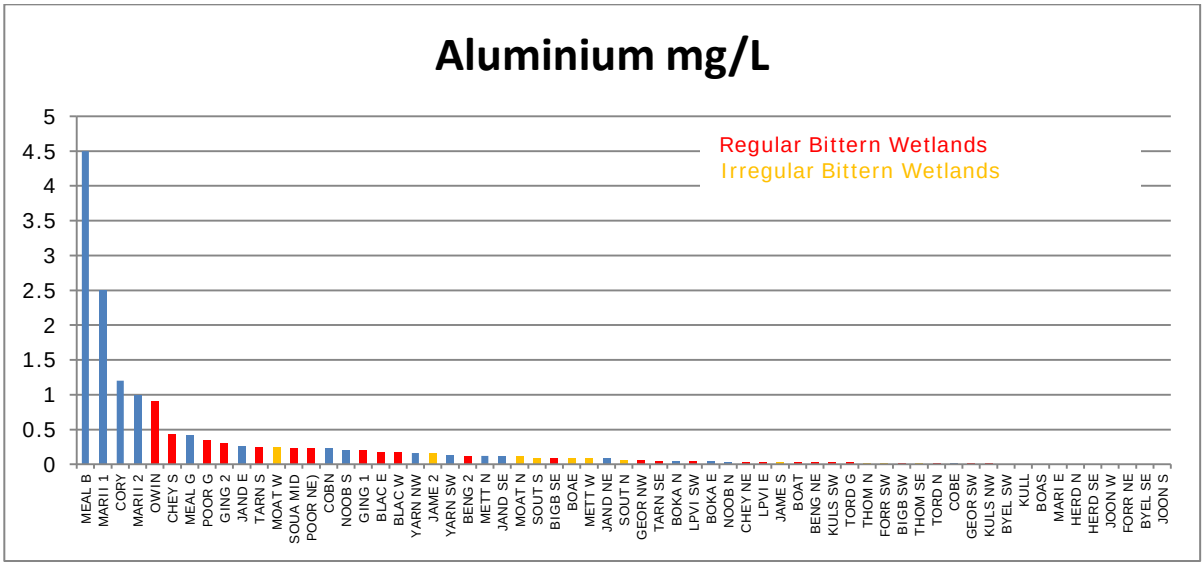
*= exceeds limit of graph

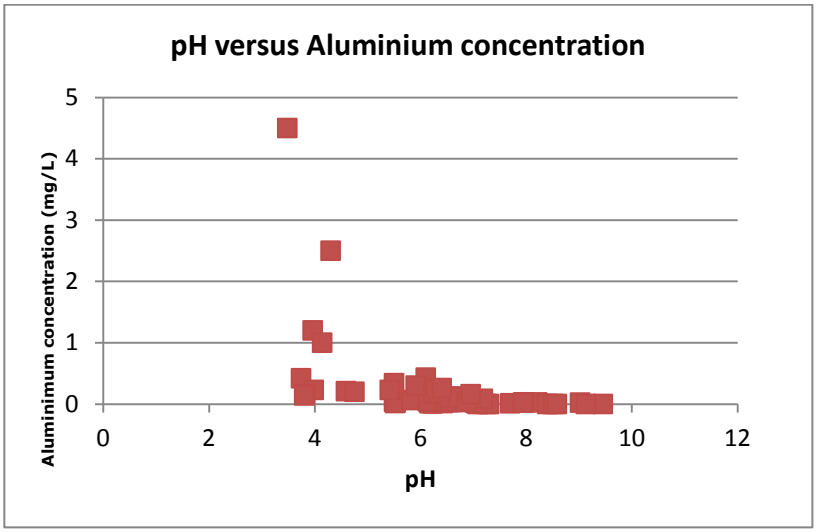
Phosphorous plotted by regions showed a high variability from wetland to wetland and is related to neighbouring land uses and incoming drains and streams. Note that seveal wetlands were below detection limits for phosphorous.



When the wetlands are graphed with decreasing phosphous concentration it seems that while many wetlands with bittern present are below the ANZECC guideline of 0.05 mg/L, some wetlands with bittern present exceed this guideline.



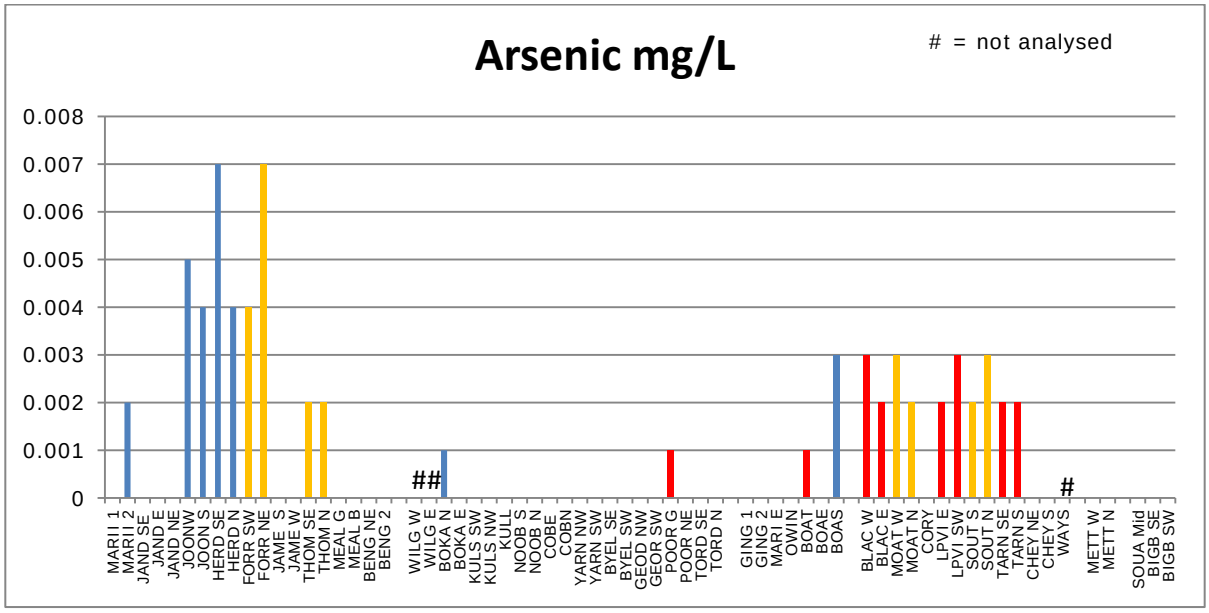


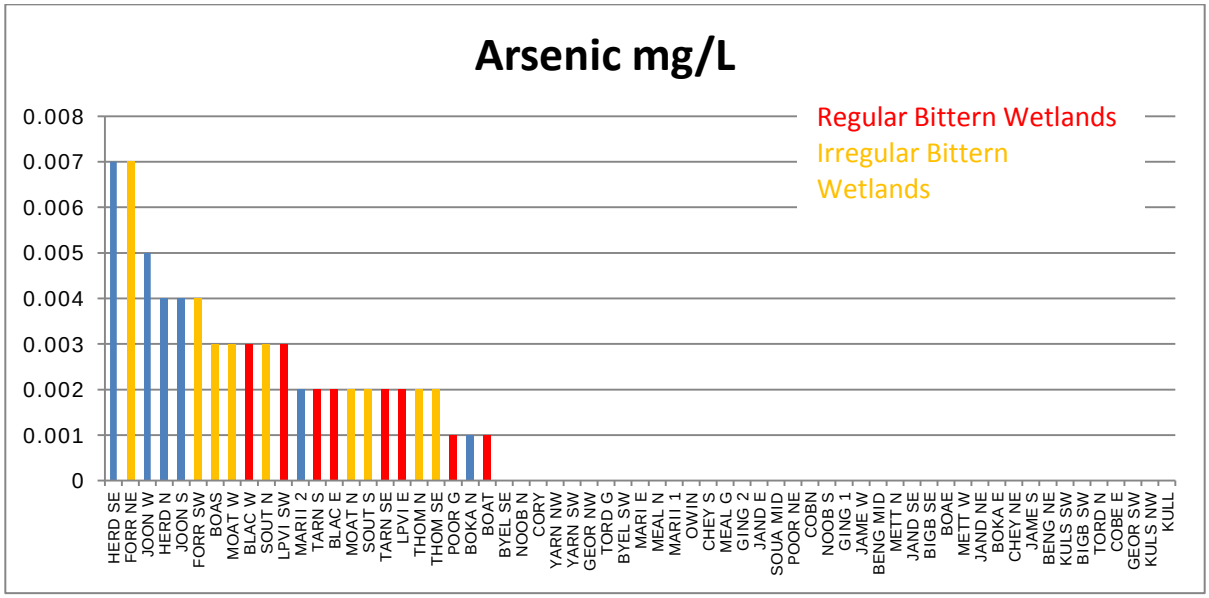


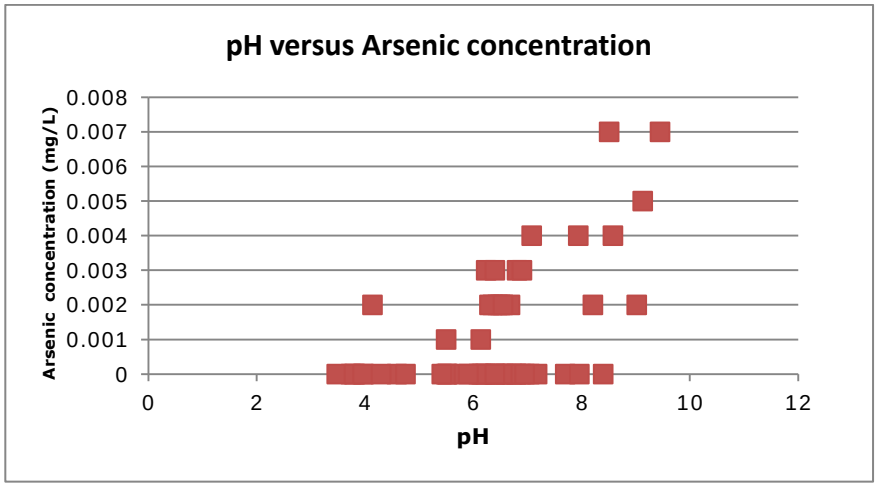
Aluminium (Al) is highly dependent on wetland pH (acid). Results of Al concentration above 0.5mg/L reflect a very low (acid) pH (all have pH less than 4.4).

ANZECC guideline for 95% species protected at Al concentration <0.055 mg/L when pH >6.5. At low pH (e.g. <5.5) or high pH (e.g. >9.0) toxicity increases for fish and invertebrates.

A total of 22 wetlands exceeds guideline with only 4 of these having a pH of >6.5.

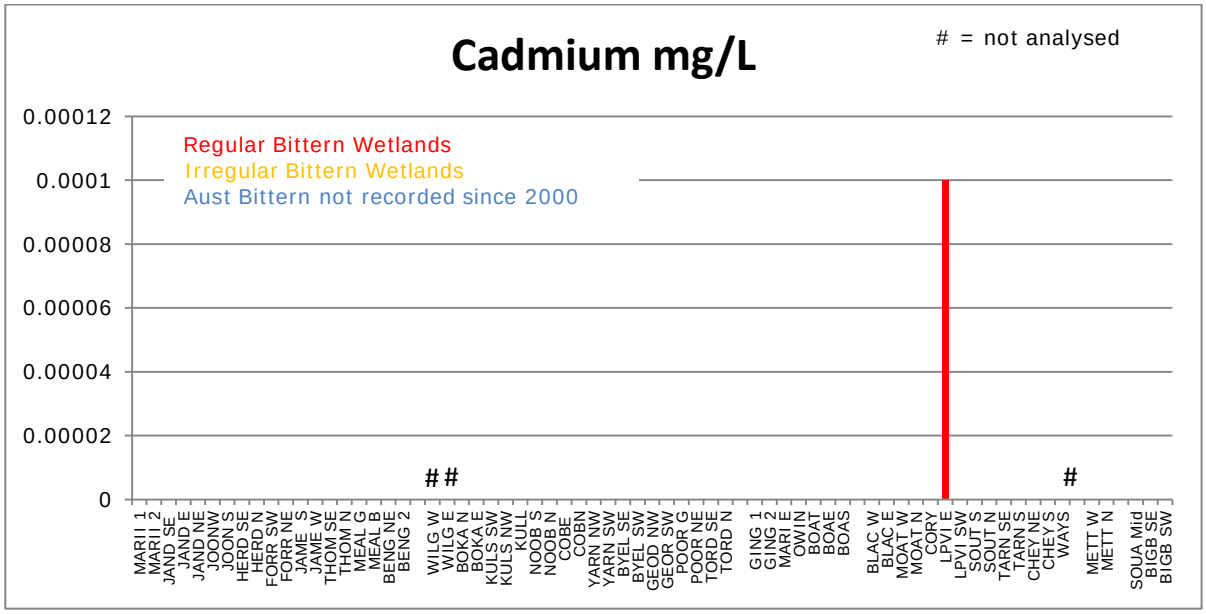






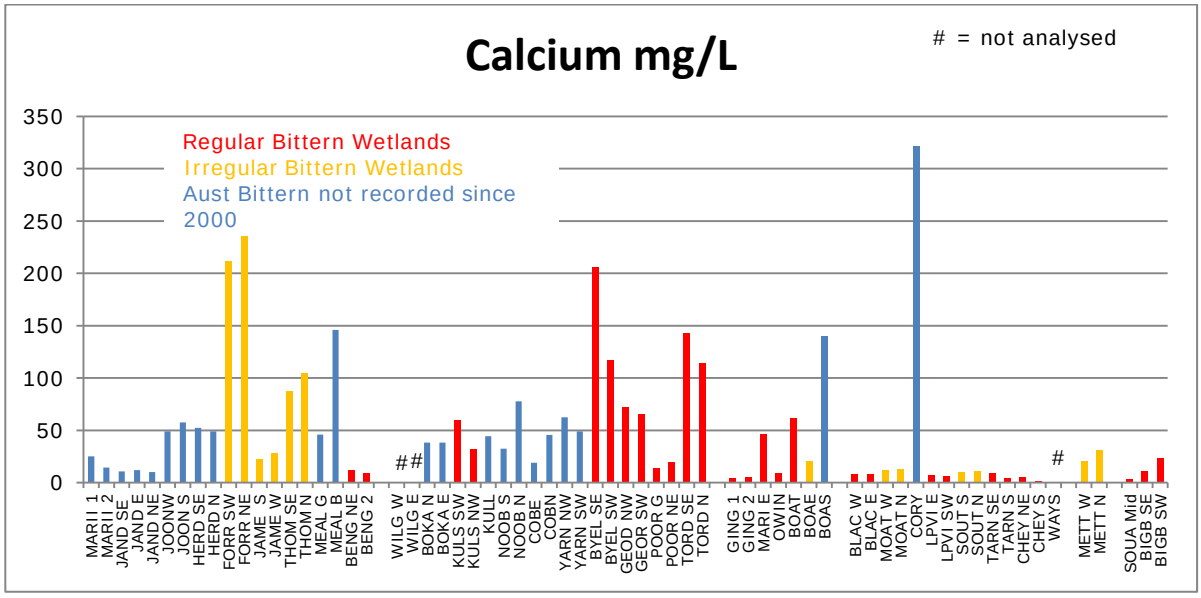
Arsenic (As) is highly dependent on wetland pH (alkaline).

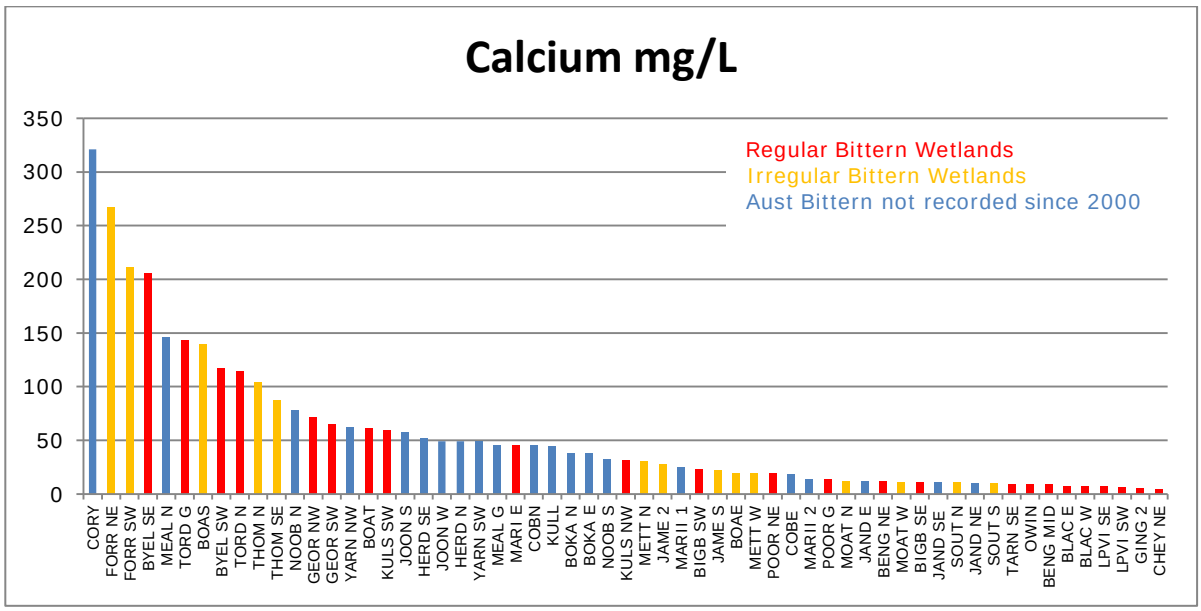
ANZECC guideline for 95% species protection is 0.024 mg/L for AsIII and 0.013 for AsV. All wetlands sampled are below guidelines and most had arsenic levels below detection levels.

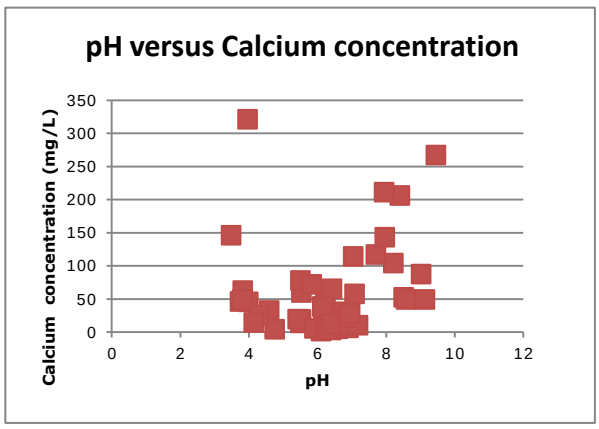


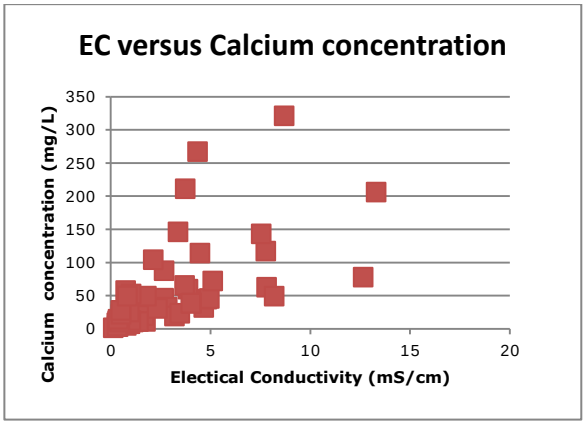
Cadmium only detected in one sample from Lake Pleasant View and this was below ANZECC guideline for 95% species protection of 0.0002 mg/L.

It's worth noting that this sample exceeded the 99% species protection guideline of 0.00006 and that the detection limit for the analysis ranged from 0.0001 to 0.0005 mg/L.



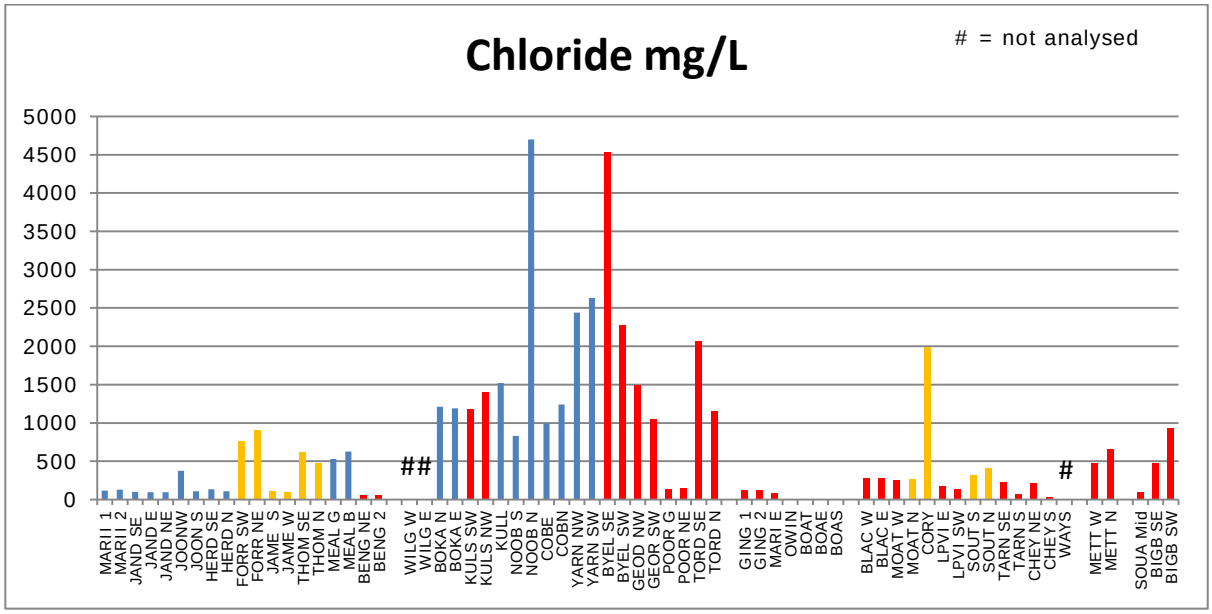


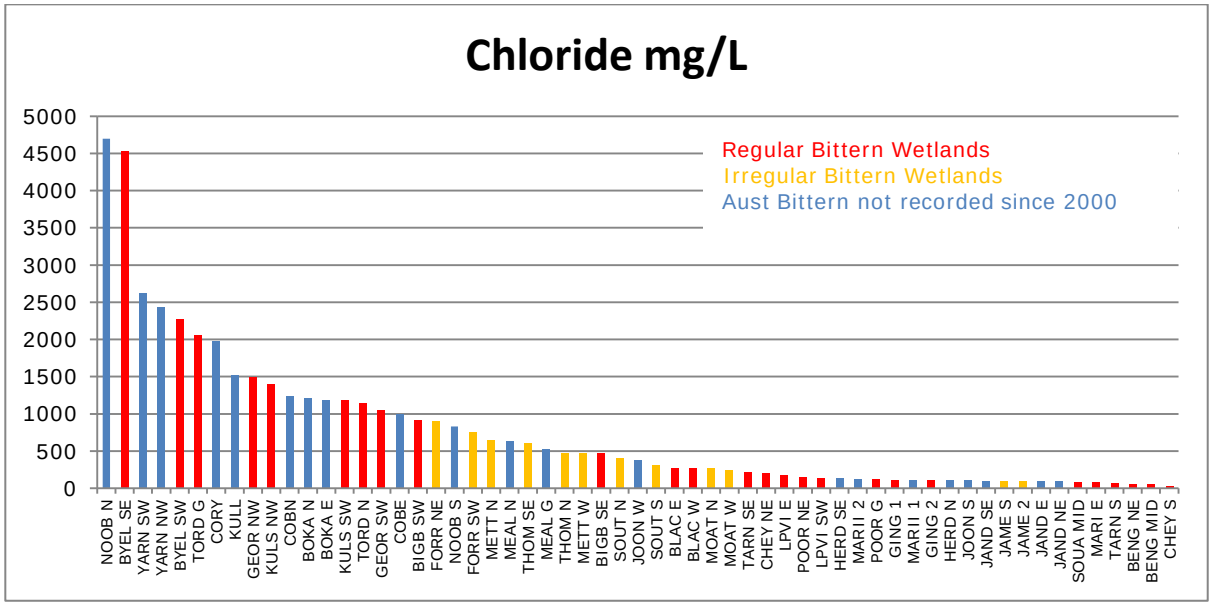


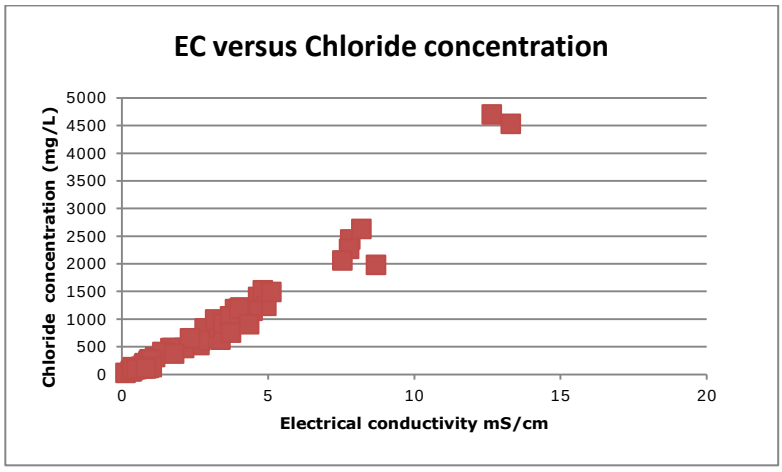


Calcium (Ca) increases at low and high pH but is fairly insoluble in neutral waters. It has a high correlation with Electrical Conductivity (salinity) as it is a major component of total salt concentration.

No ANZECC guideline for Calcium.

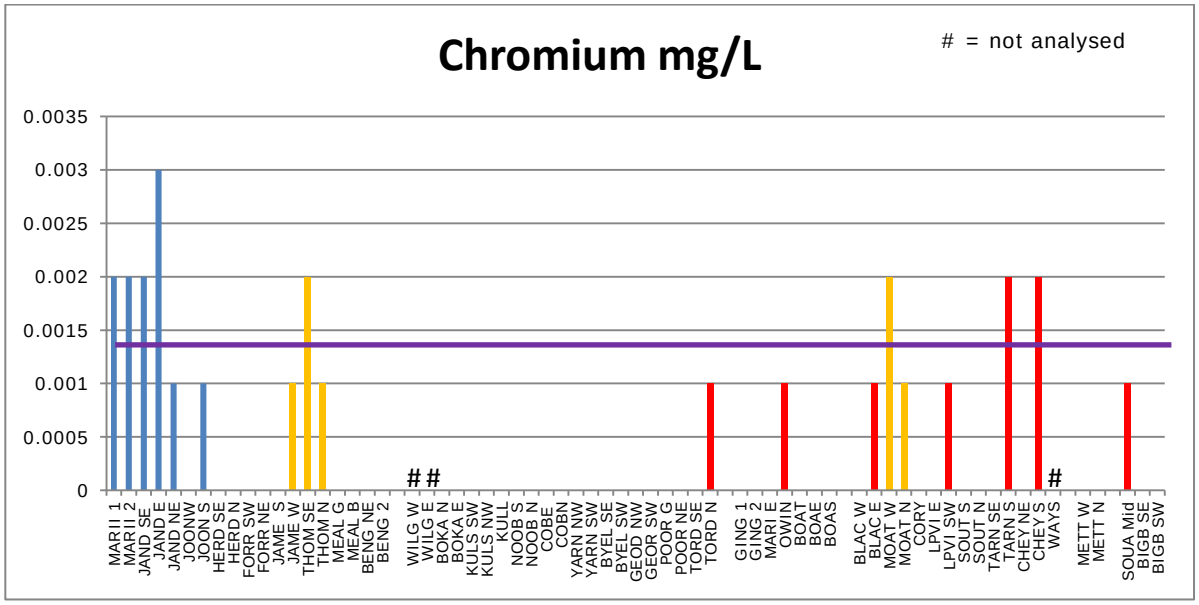


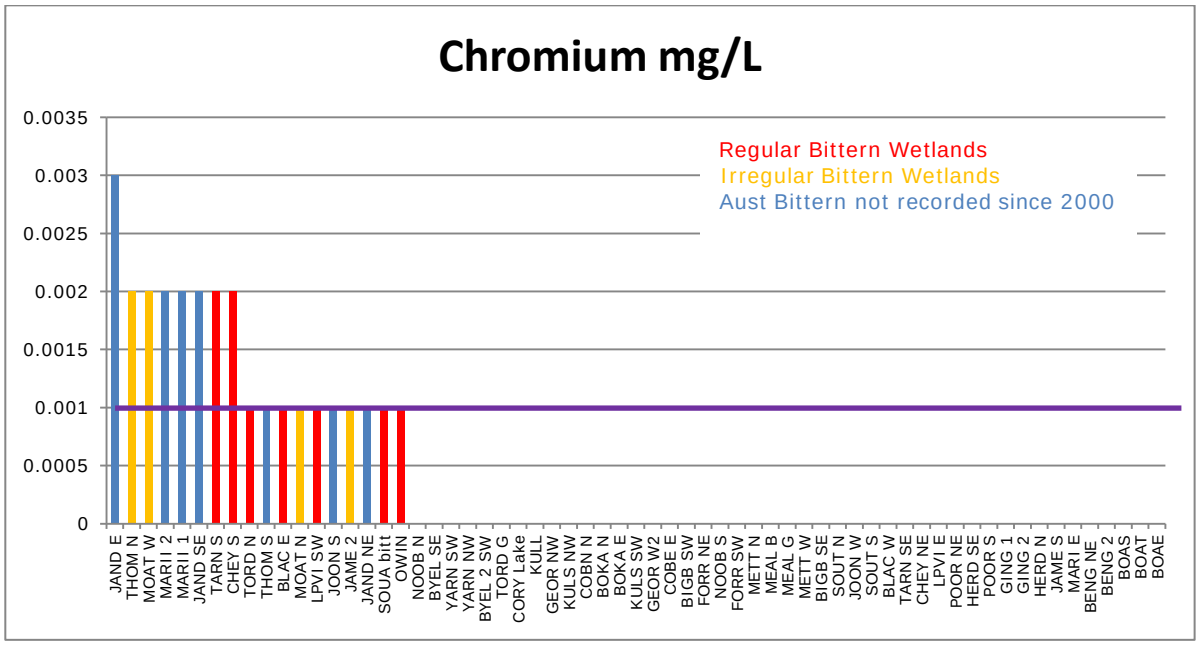


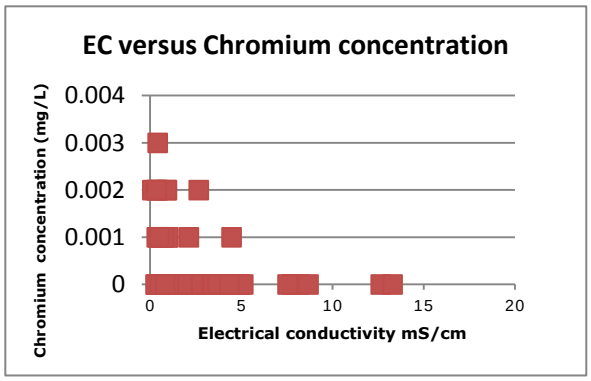


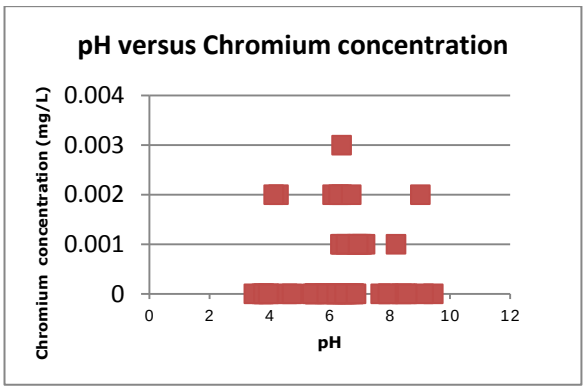
Chloride (Cl^-) has a high correlation to wetland Electrical Conductivity (salinity) as it is a major component in total salt concentration.

No ANZECC guideline for chloride only the more toxic chlorine. However, chloride levels will be accounted for in the salinity guidelines.

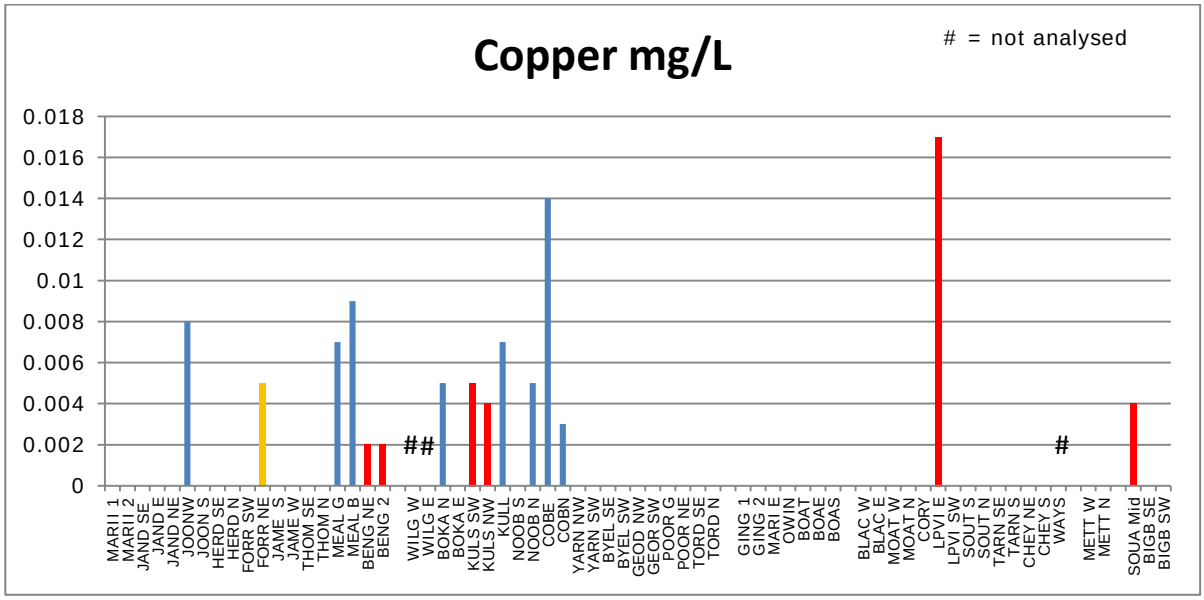


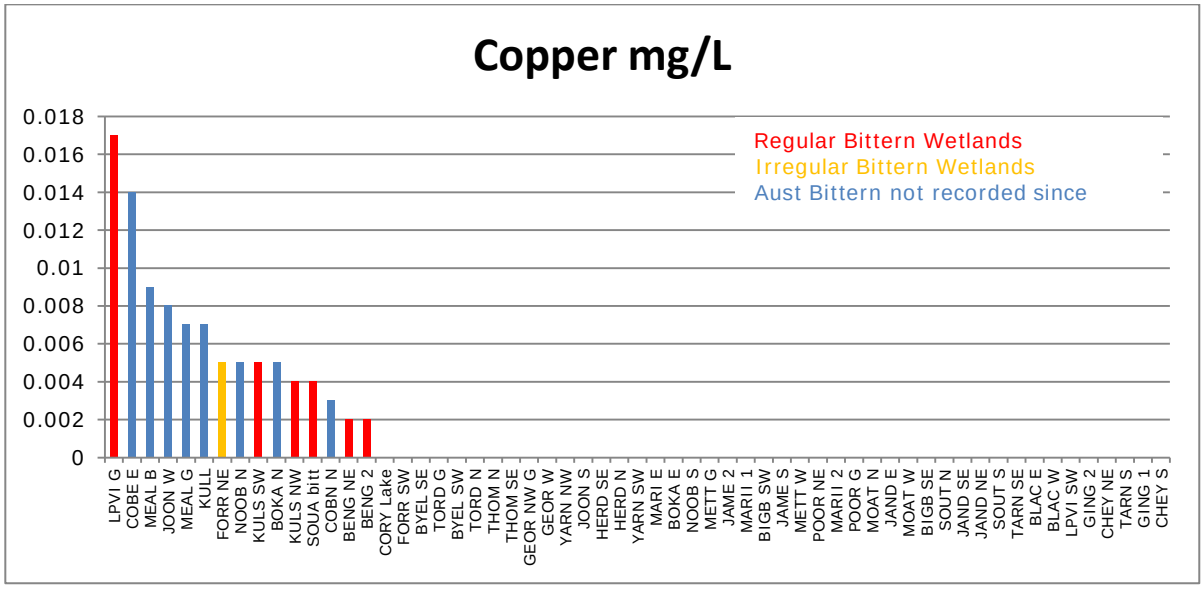


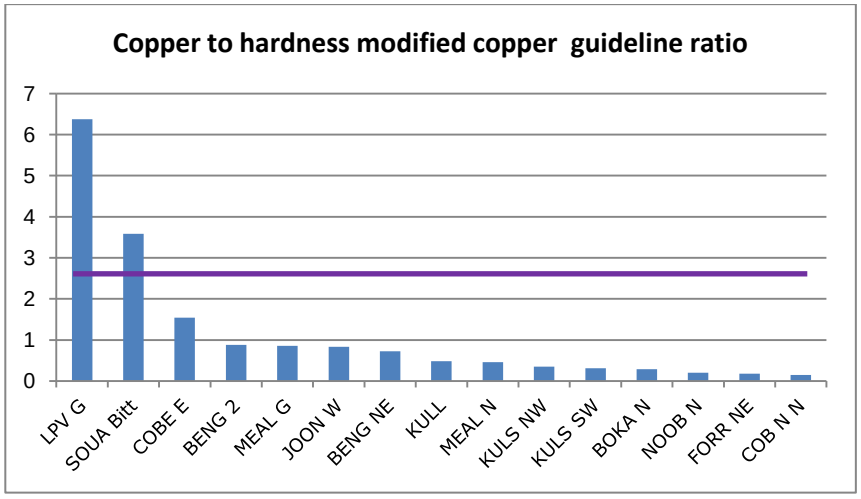




ANZECC guideline for Cr VI is 0.001mg/L for 95% species protection – this was also the detection limit for the analysis. No guideline for Cr III as insufficient data available but it is generally less toxic. If all Cr present was the more toxic Cr VI, 12 wetlands had Cr at or above the guideline. These were Jandebup Swamp, Cheynes Beach Road Swamp, Tarnup Lake, Mariginiup Lake, Moates Lake, Thomson's Lake, "South of Adams, James Swamp", Joondalup Lake, Lake Pleasant View, Black Cal Lagoon and Tordit-Gurrup Lagoon.

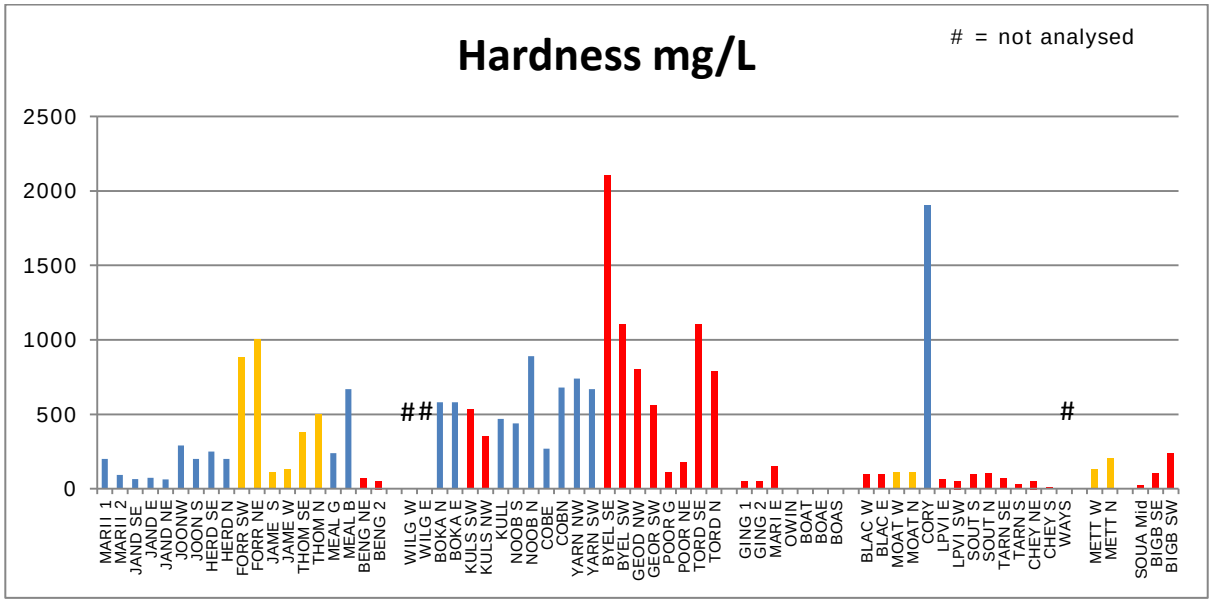


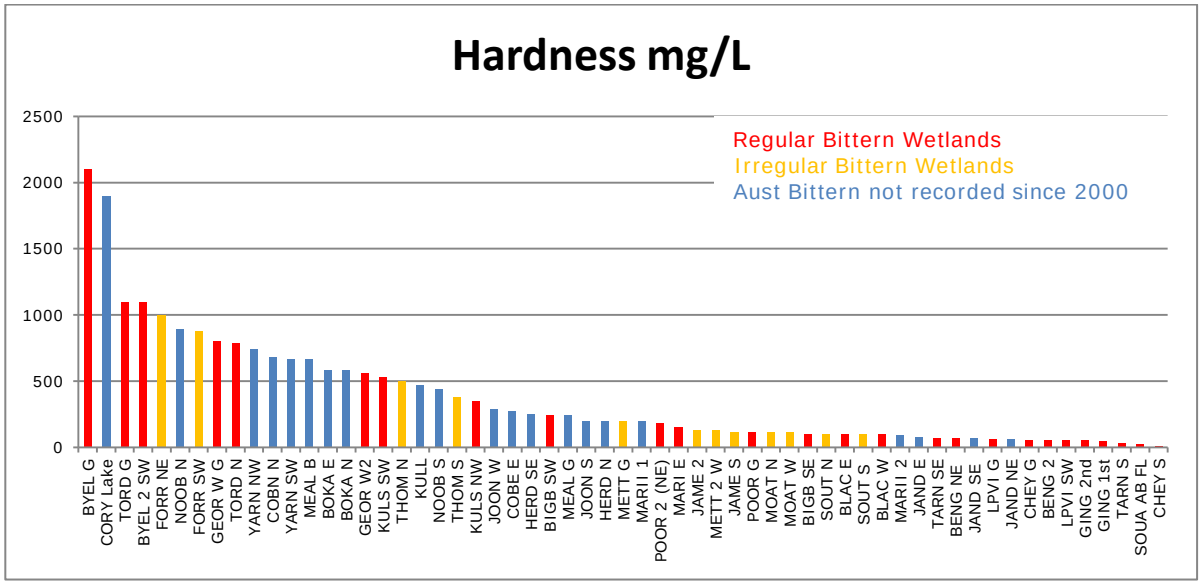


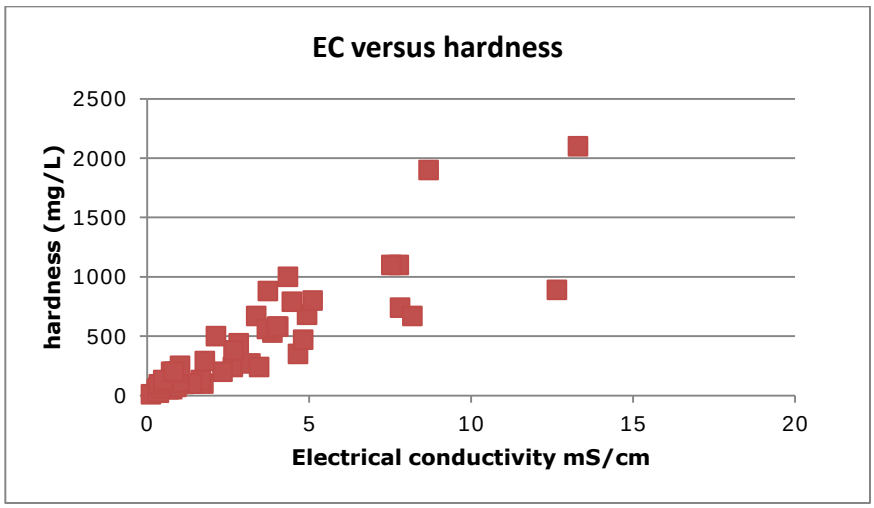


Copper (Cu) toxicity is very complex. ANZECC guideline for Cu is 0.0014mg/L for 95% species protection at a hardness of 30 mg/L- this was less than the detection limit for the analysis (0.002). There is a hardness modified guideline algorithm which shows that the copper levels at Lake Pleasant View (Guage), Cobertup East, and "South of Adams Swamp" were above the toxicity guideline.

Any wetland with a ratio of greater than 1 is above the hardness modified copper guideline.

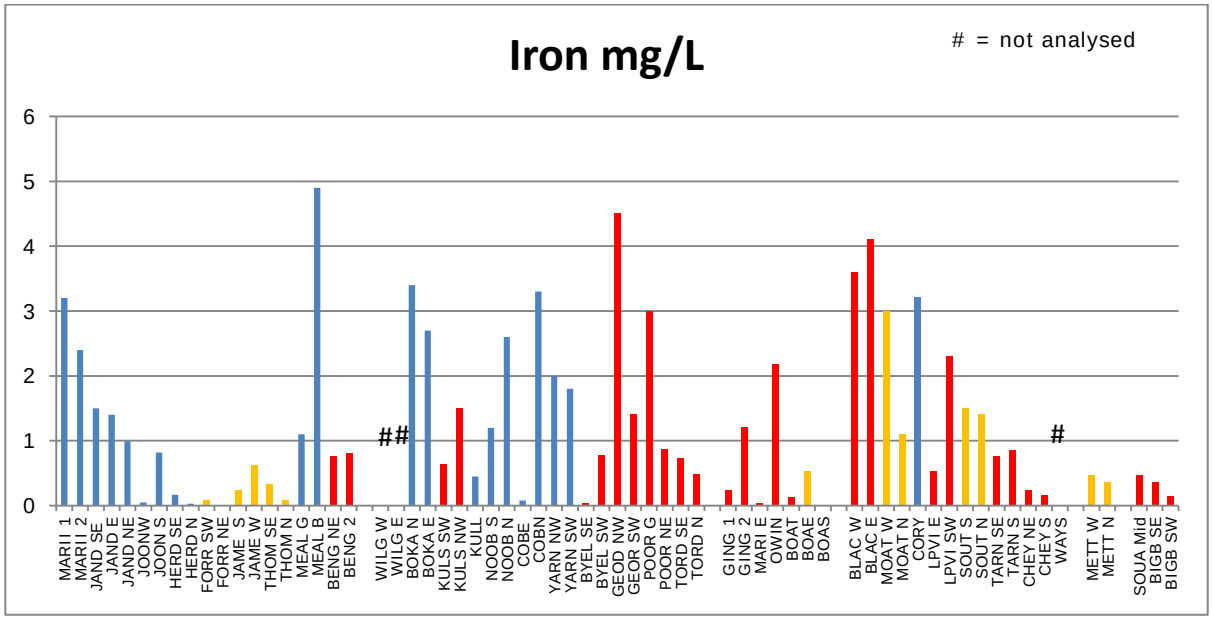


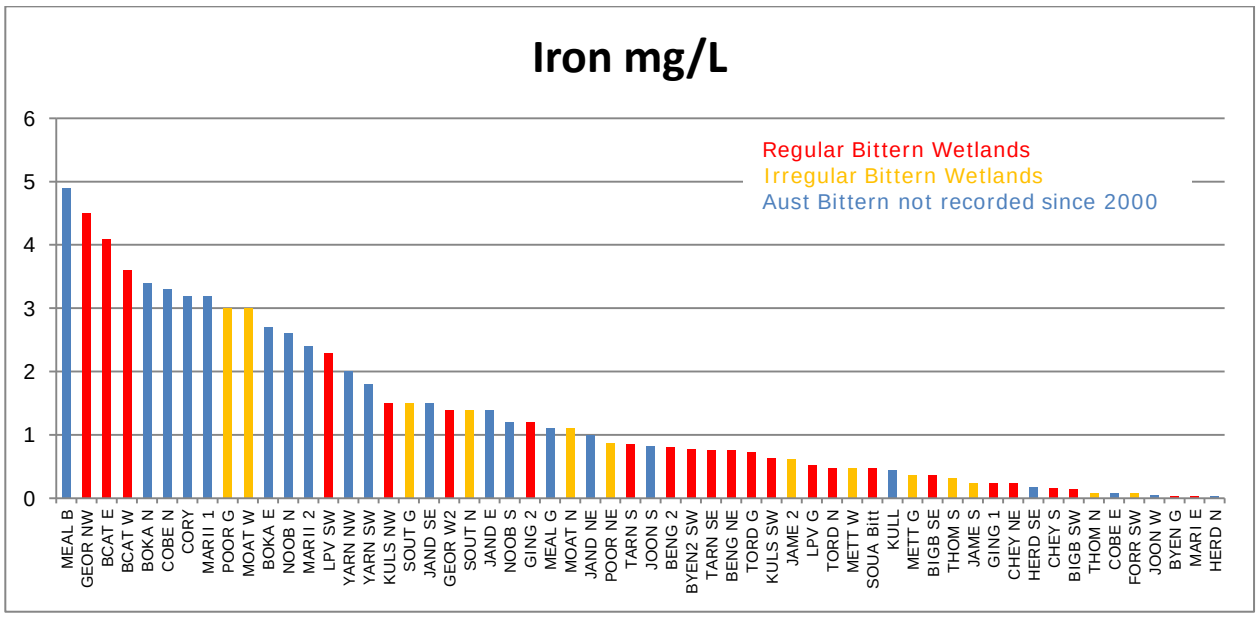


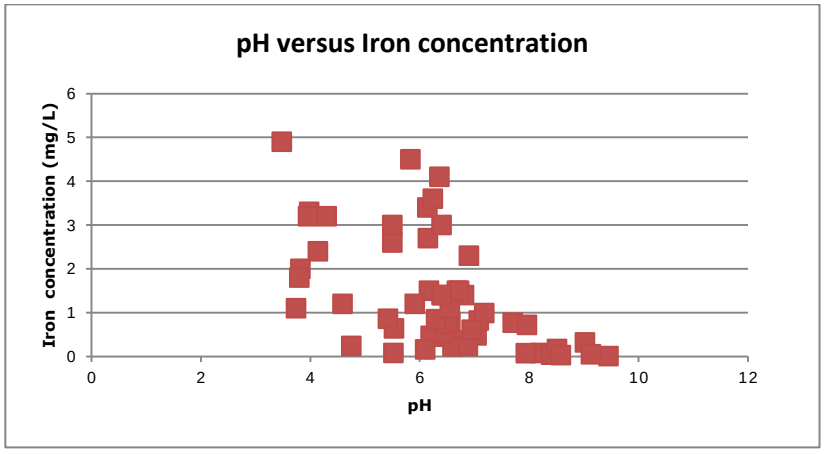


Hardness has a high correlation with wetland EC (salinity) as hardness is a result of calcium and magnesium carbonate which a core componants to total salt concentration.

There is no guideline for hardness but it affects the toxicity of several metals including copper, Chromium III, Cadmium, Lead, Nickel and Zinc.

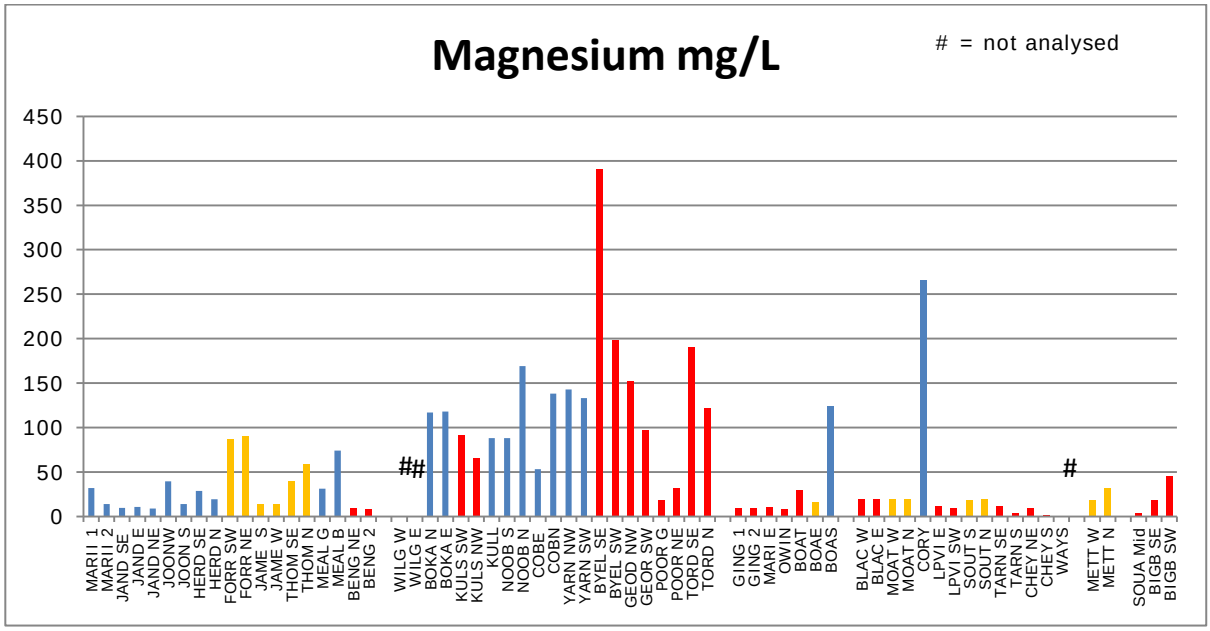


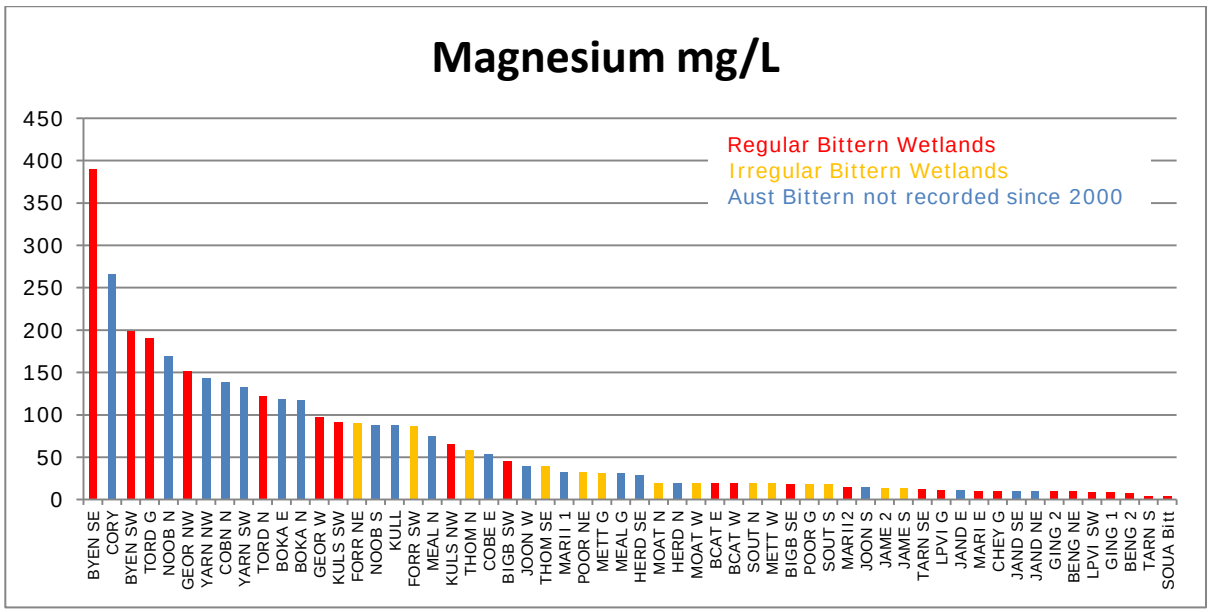


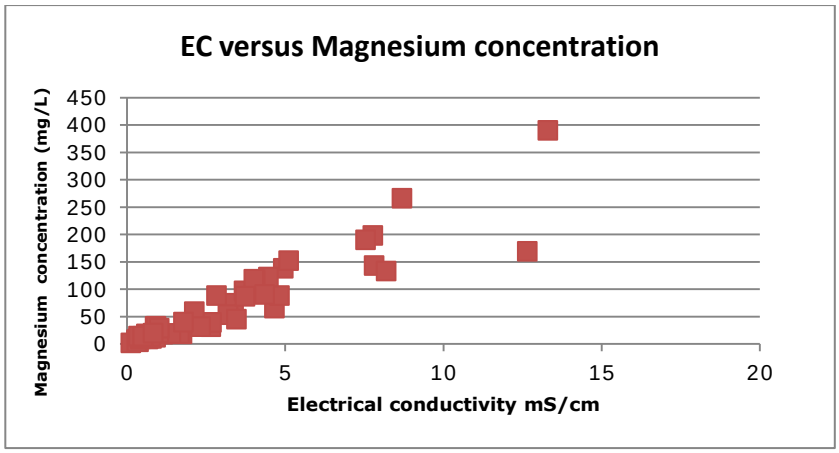


Iron (Fe) is dependent on wetland pH as acidity increases iron solubility. Iron above 1 mg/L reflect neutral to acid pH.

No ANZECC guideline due to insufficient data. However, iron concentration can affect the solubility of other metals.

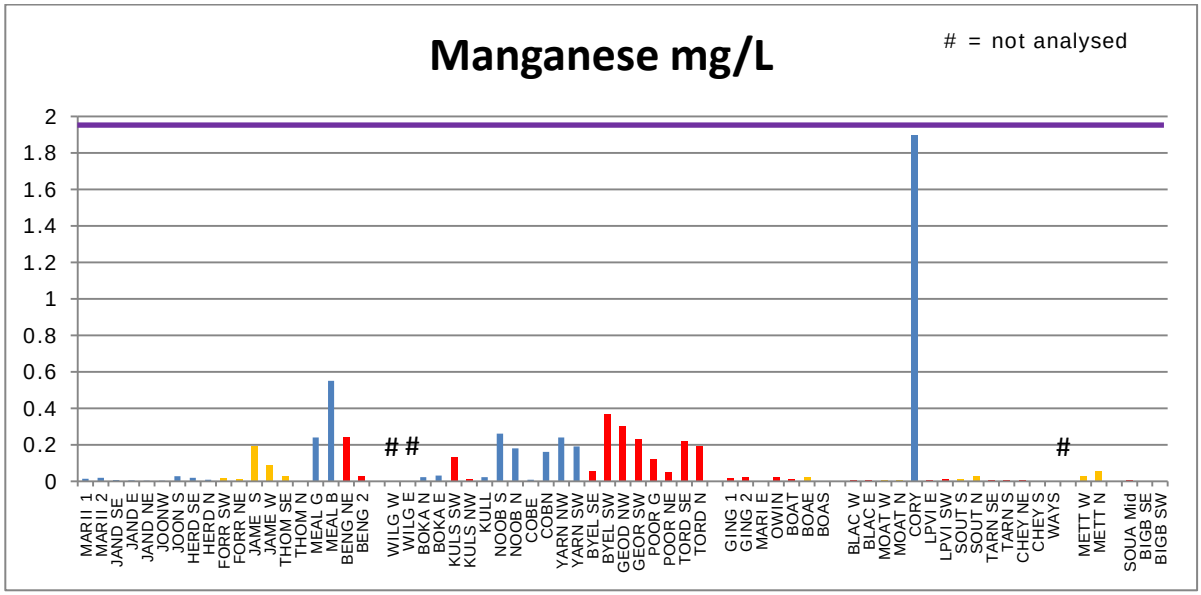


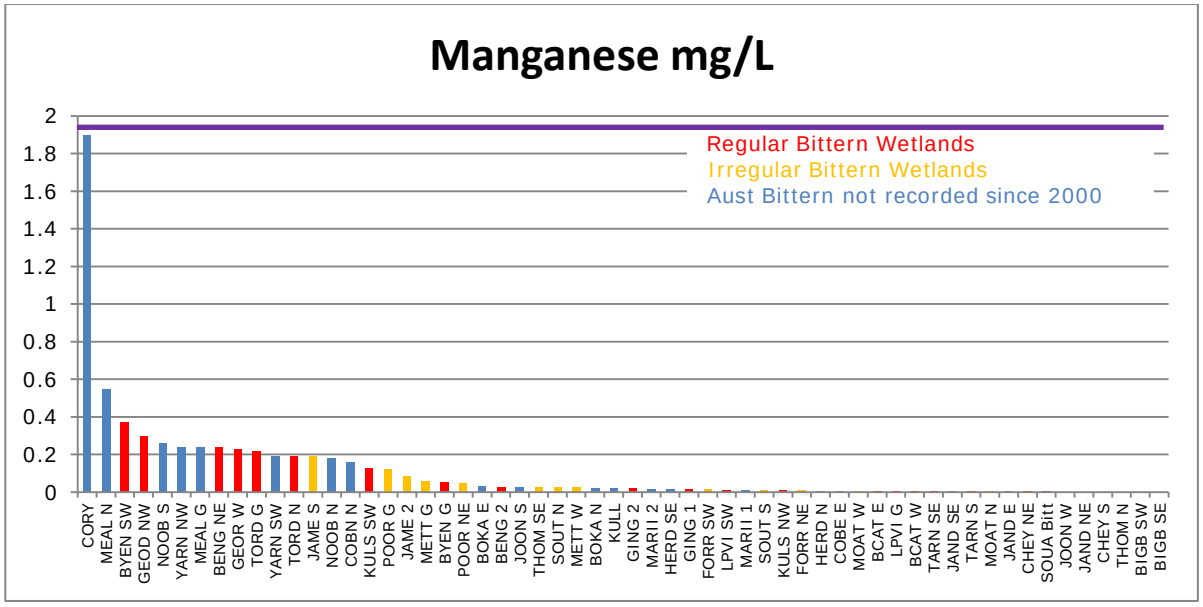


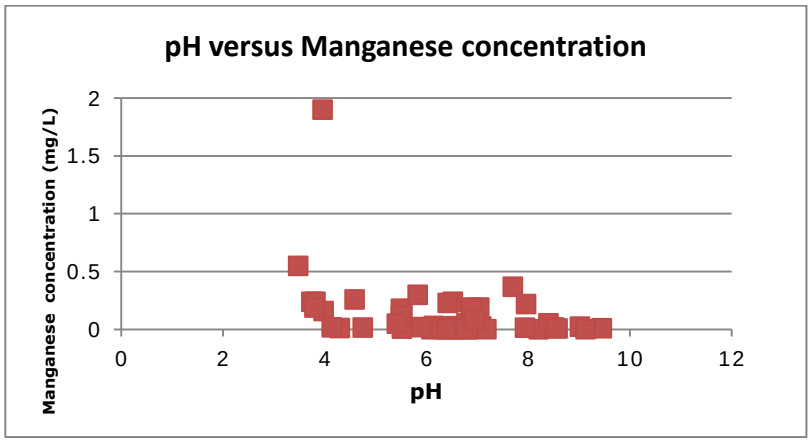


Magnesium has a high correlation with wetland EC (salinity) as it is a major component of total salt concentration. It can affect the solubility of other metals.

No ANZECC guideline.

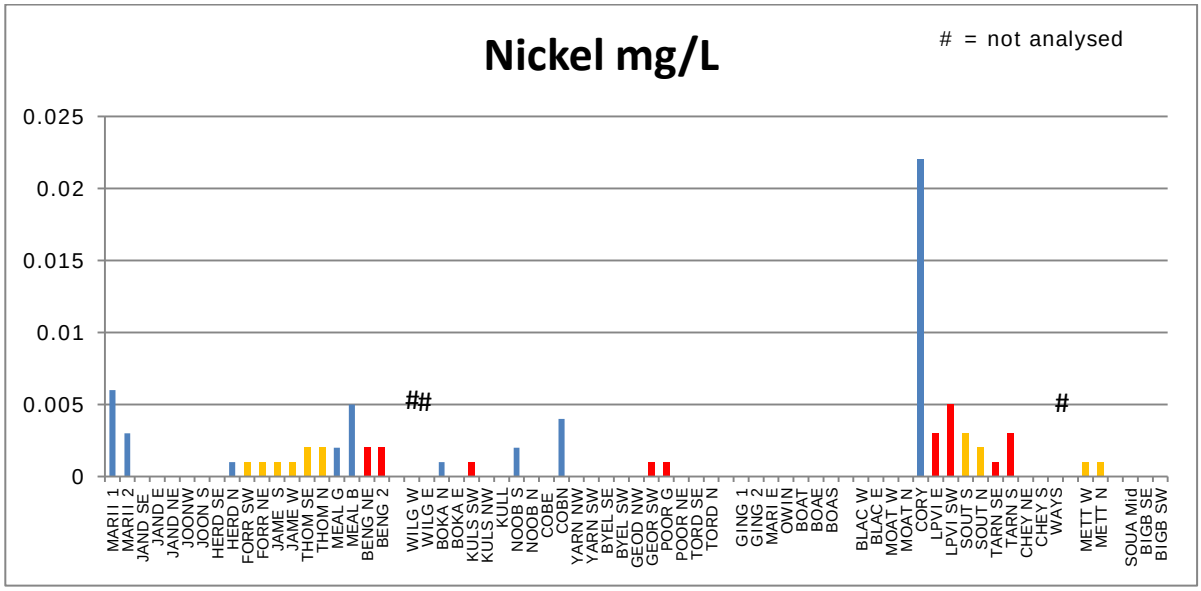


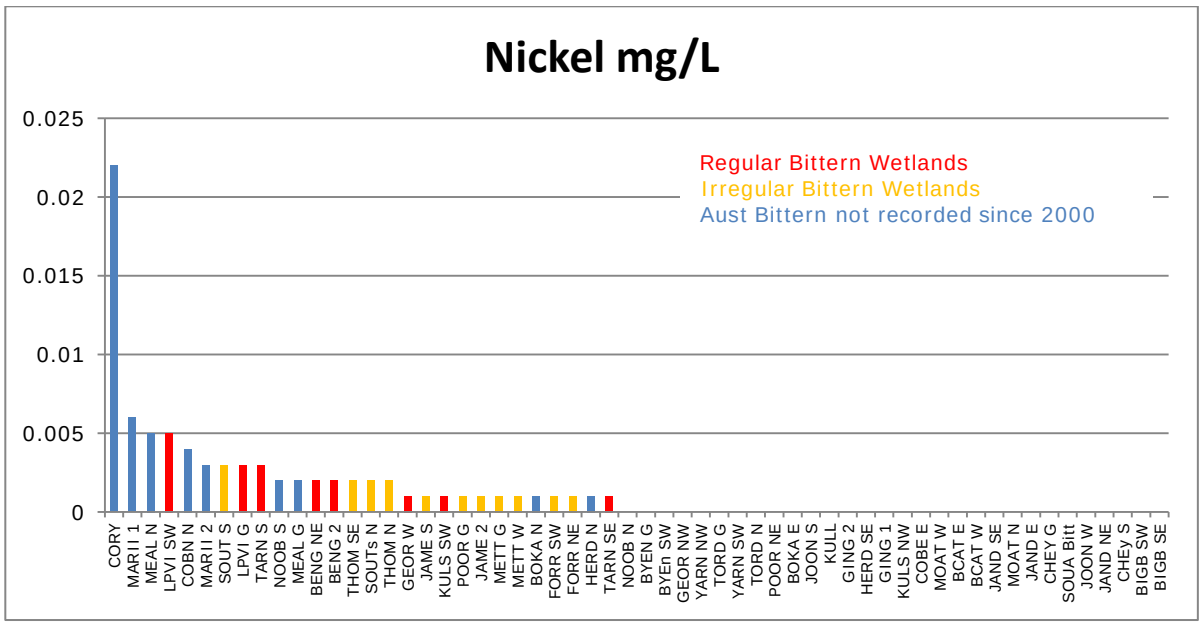


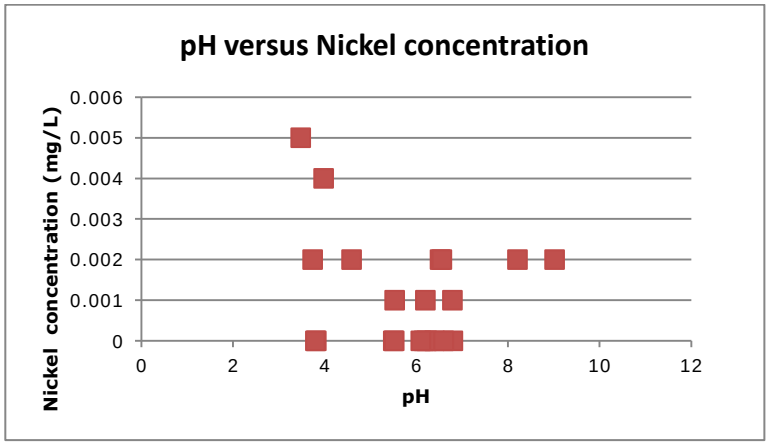


Manganese (Mn) is dependent on wetland pH as acidity increases manganese solubility.

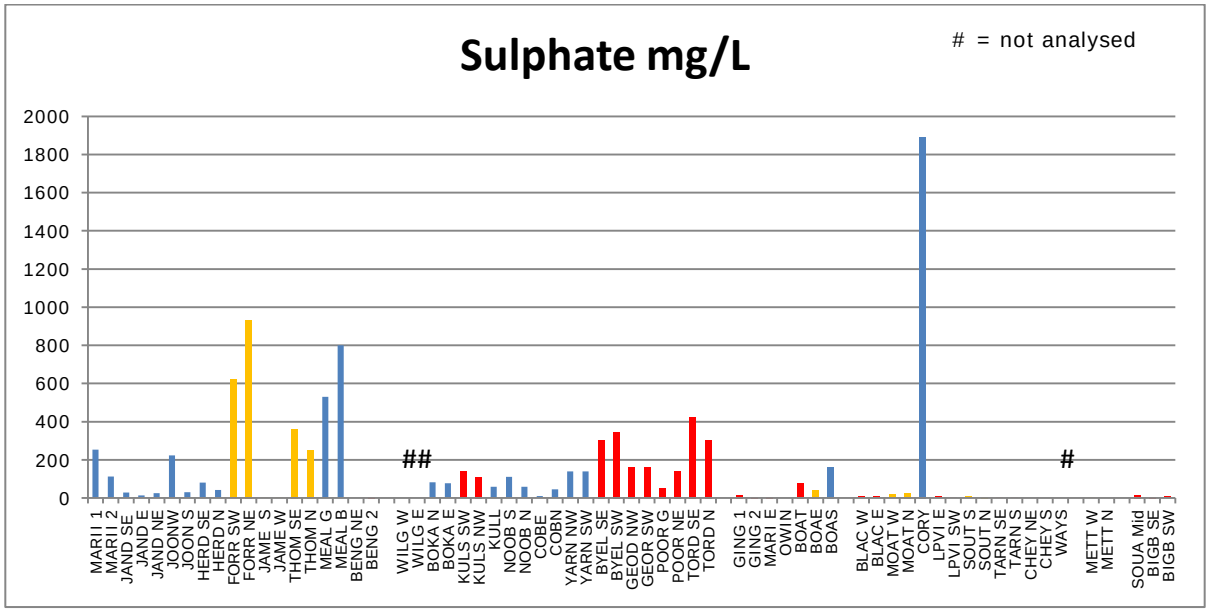
ANZECC guideline for protection of 95% of species is 1.9 mg/L and this was only reached at Lake Corymup.

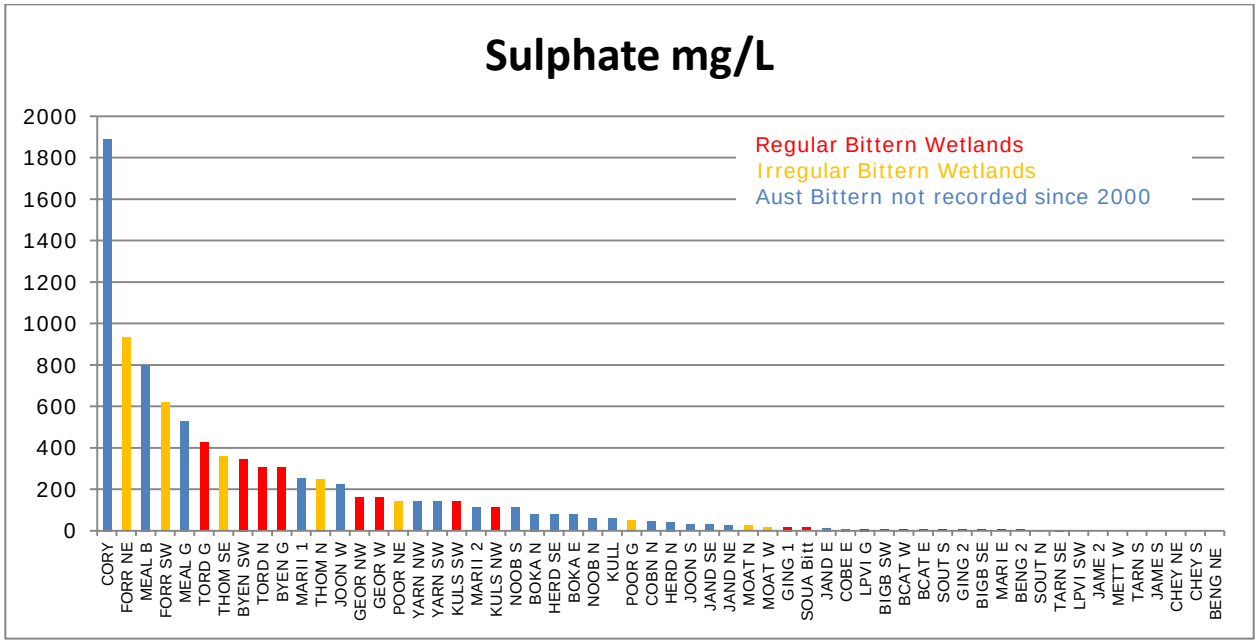


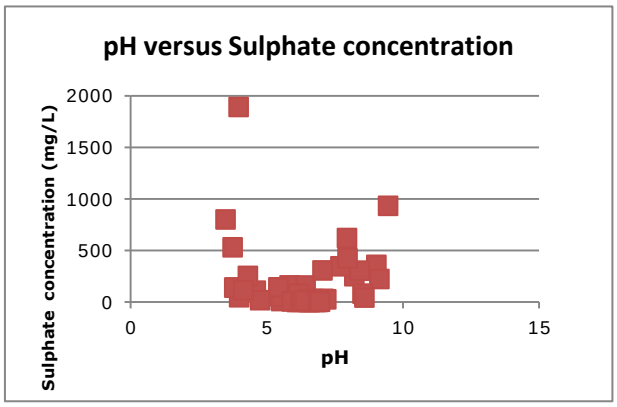


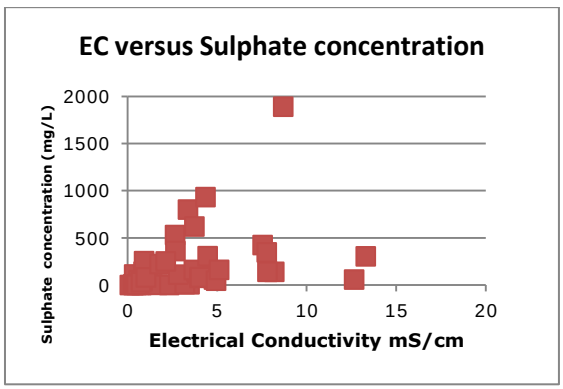


Nickel (Ni) solubility is complex and partially dependent on wetland pH (acid) but also on the concentration of various anions and cations present. Nickel toxicity is modified by hardness, the ANZECC guideline for protection of 95% of species is 0.011 mg/L at hardness of 30mg/L. As hardness increases Ni toxicity decreases. The hardness at Corymup Lake was 1900 mg/L which implies a guideline of 0.33 mg/L. Using the hardness modified nickel guideline no samples exceeded the guideline.

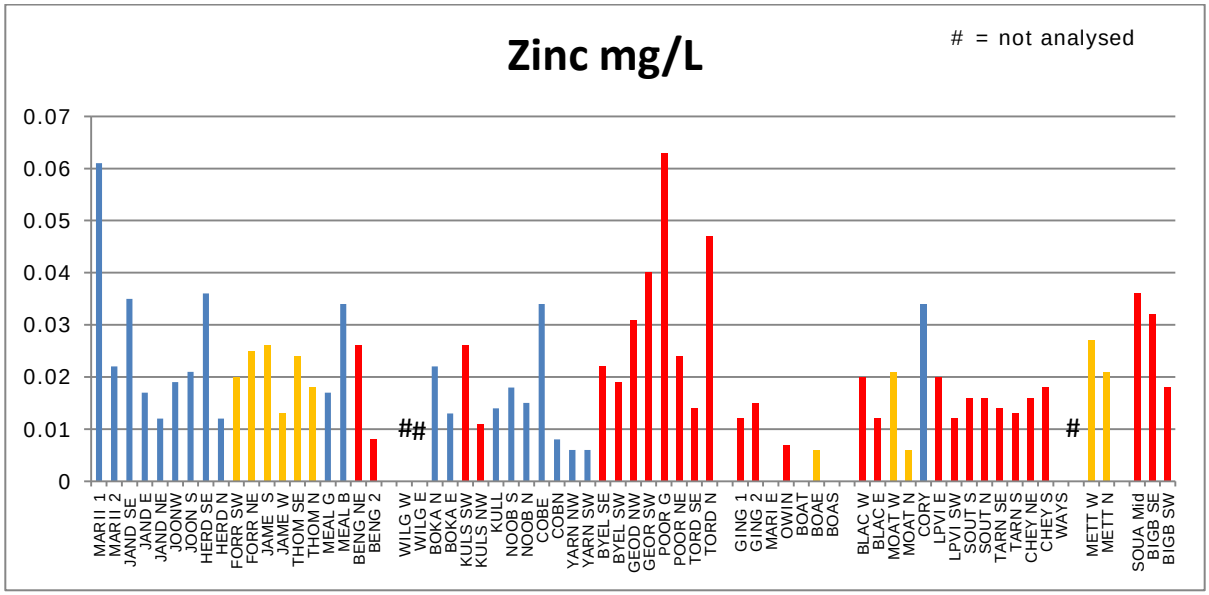


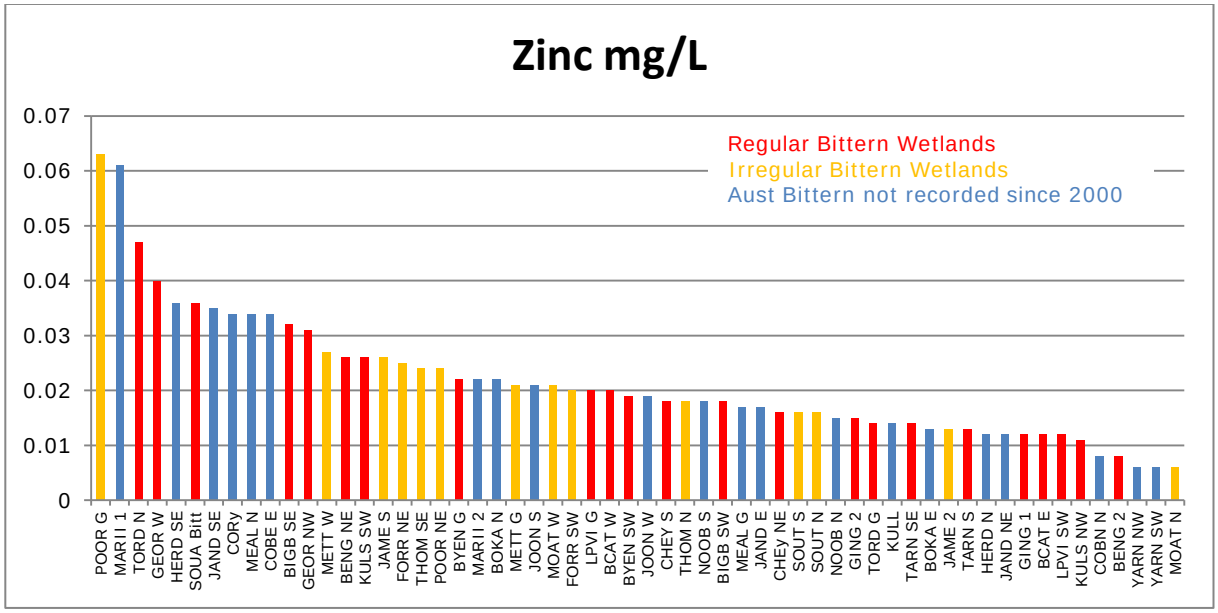


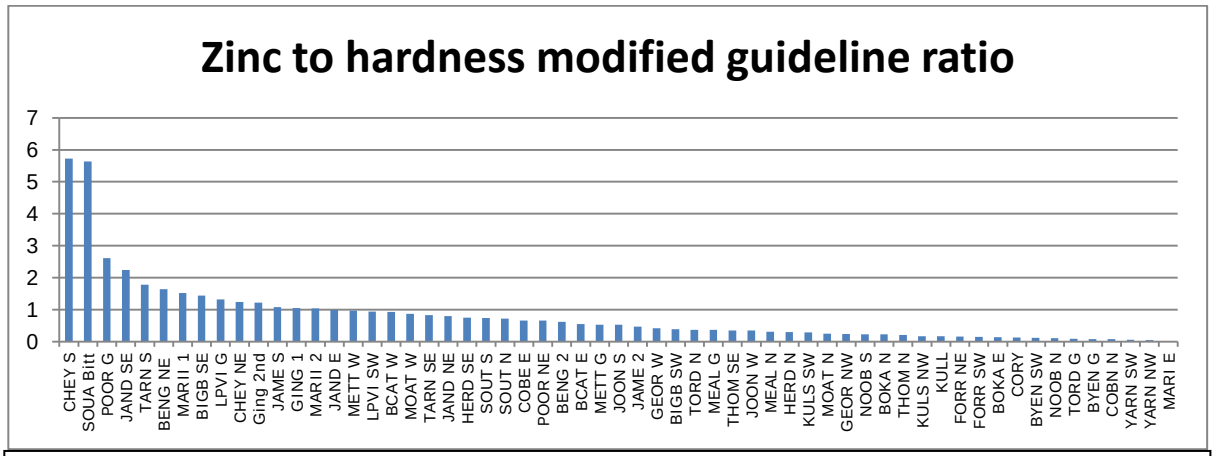




Sulphate (SO_4) is dependent on wetland pH and is quite insoluble at neutral pH. It also correlates with Electrical Conductivity (salinity) as it is an important component of total salt concentration.
No ANZECC guideline.







ANZECC guideline for Zn is 0.008mg/L for 95% species protection at a hardness of 30 mg/L. There is a hardness modified guideline algorithm which shows that the zinc levels at Cheynes Beach Road Swamp, "South of Adams Swamp", Poorginup Guage, Jandabup Swamp, Tarnup Lake, Benger Swamp, Mariginiup Lake, "Big Boom Swamp", Lake Pleasant View (guage), Gingilup Swamp, and James Swamp were at or above the toxicity guideline as they had a ratio of greater than one.

Appendix I Australasian Bittern Fine Scale Habitat Data Sheet

Date:	Time Start:	Time End:	Observer:	
Wetland:	**Flushing site**	**Feeding Platform**	**Nests**	**General wetland**
GPS co-ordinates	•	•	•	•
Water depth at GPS site	•	•	•	
Depth gauge reading	•	•	•	•
Minimum and maximum water depth encountered				•
Sample for pH, salinity & turbidity or in situ	•			•
Vegetation type (species if known) • Trees • Shrubs • Rushes/sedges	•	•	•	
Vegetation height within 5m: • Low – 0-50cm , • Medium – 50-150cm, • High – 150cm+	•	•	•	
Vegetation Density within 5m: • Low – small patches of open water • Medium – continuous but able to walk through • High – impenetrable or difficult to walk through	•	•	•	
General composition of vegetation within 5m. Examples: • All low vegetation, • low vegetation with clumps of high sedges, • low vegetation interface with high sedges etc.	•	•	•	
Approximate % dead vegetation/sedges	•	•	•	
Observable prey availability	•	•	•	
Nest/platform dimensions		•	•	
Nest/platform depth		•	•	
Nest/platform height above water		•	•	
Nest/platform materials: • Plant species, • Stem thickness • Stem lengths		•	•	
Nest/platform contents: • Eggs/young/eggshells • Feathers • Scats • Prey carcasses / regurgitation pellets		•	•	
Photograph taken	•	•	•	•
Comments:				

Guidance Notes:

1. Assess vegetation characteristics in a 5m diameter of the flushing site, nest site or feeding platform. Try to estimate % area covered by each vegetation type.
2. Try to collect any feathers, scats, egg fragments etc, labeling and storing properly any collected material

Appendix J Broad scale habitat data

Wetland	Lake area (Ha)	Vegetation area (ha)	Open water (ha)	Sedges area (ha)	Shrubs area (ha)	Number of Surveys	Australasian Bittern Present?
Adam's Swamp	27	27	0	23	4	1	
Lake Angove	70	70	0	70	0	3	
Anstey Swamp	133	130	2	39	91	1	
Ascot Waters	N/A	23	N/A	17	6	2	
Bannitup	160	0	160	0	0	0	
Benger Swamp	560	475	65	317	158	25	Y
Bibra Lake	152	45	107	5	40	2	
Unnamed wetland "Big Boom Swamp"	89	84	5	66	8	10	Y
Black Cat Lagoon	12	3	9	3	0	4	Y
Unnamed "Blue Lagoon Middle"	6	6	0	6	0	0	
Unnamed "Blue Lagoon NE"	4	4	0	4	0	0	
Unnamed "Blue Lagoon North"	10	10	0	10	0	0	
Unnamed "Blue Lagoon SE"	3	1	3	1	0	0	
Unnamed "Blue Lagoon South"	2	2	0	2	0	0	
Unnamed "Blue Lagoon West"	3	3	0	3	0	0	
Boat Harbour NE	33	14	19	14	0		
Boat Harbour SE	23	10	13	10	0		
Boat Harbour Swamp	78	33	46	32	1	11	Y
Bodjinup Swamp	6	6	0	6	0	0	
Bokarup Swamp E	8	0	8	0	0	0	
Bokarup Swamp W	29	16	13	12	3	2	
Buranganup Swamp	43	43	0	41	2	1	
Byenup Lagoon	572	434	138	369	65	3	Y
Unnamed "Byenup NW 1"	6	6	0	6	0	1	
Unnamed "Byenup NW 2"	31	31	0	31	0	0	
Unnamed "Byenup NW 3"	110	110	0	110	6	0	
Unnamed "Byenup NW 4"	14	14	0	9	4	0	
Unnamed "Byenup NW 5"	17	17	0	11	6	0	
Byrd Swamp	6	3	3	3	0	2	
Chalmer's Swamp	95	95	0	85	10	1	
Cheyne Beach Rd Swamp	63	63	0	60	3	42	Y
Cobertup NE	19	19	0	18	1	0	
Cobertup NW	28	28	0	27	1	0	
Cobertup South (overflow)	9	9	0	5	3	3	Y
Coorinup North Swamp	7	7	0	6	1	0	

Wetland	Lake area (Ha)	Vegetation area (ha)	Open water (ha)	Sedges area (ha)	Shrubs area (ha)	Number of Surveys	Australasian Bittern Present?
Corymup Lake	14	0	14	0	0	2	
Corymup Swamp	57	52	4	50	3	2	
Cowerup Swamp NW	18	18	0	18	0	0	
Cowerup Swamp SE	71	49	22	38	12	0	
Crackers Swamp – Depth Gauged wetland	56	44	11	0	44	0	
Crackers East Swamp	43	37	6	0	37	0	
Crackers Main Swamp	75	16	59	0	16	0	
Dobaderry Swamp	39	39	0	0	39	0	
Doombup	17	6	10	6	0	0	
Unnamed "Dunn Rock Swamp"	20	17	3	17	4	3	Y
Unnamed "Dunn Rock West Swamp"	4	4	0	4	0	1	
Elders Stoney Tree Farm Wetland	11	0	11	0	0	1	
Unnamed "Dunn Rock NW1"	112	112	0	96	16	0	
Ewart's Swamp	51	34	17	27	7	1	
Forrestdale Lake	201	46	155	46	0	4	Y
Unnamed "Frenchman's Peak East Lake"	31	30	1	26	4	5	Y
Unnamed "Frenchman's Peak Northeast"	11	11	0	11	0	3	
Unnamed "Frenchman's Peak North"	3	2	1	2	0	3	
Lake Gardner	126	2	124	2	0	2	
Geordinup Swamp NE	17	17	0	17	0	0	
Geordinup Swamp SE	102	102	0	102	0	0	
Geordinup Swamp W	116	116	0	113	2	4	Y
Unnamed "Gibbings Road Wetland"	9	8	1	5	0	0	
Gingilup NE Swamp	113	113	0	112	1	2	Y
Gingilup SE shrubby Swamp	8	8	0	3	5		
Gingilup SE Swamp	12	12	0	11	1		
Gingilup middle Swamps	220	218	2	185	33		
Gingilup West Swamp	16	16	0	16	0		
Gingilup North Swamp	42	42	0	16	26		
Goollelal Lake	62	8	54	8	0	2	
Unnamed "Gull Rock "	36	8	28	5	3	0	
Lake Gundaring	352	12	340	0	12	0	
Lake Gwelup	26	7	19	7	0	0	
Heath's Swamp	22	22	0	22	0	1	
Herdsman Lake	254	174	80	174	0	26	

Wetland	Lake area (Ha)	Vegetation area (ha)	Open water (ha)	Sedges area (ha)	Shrubs area (ha)	Number of Surveys	Australasian Bittern Present?
Lake Jandabup	289	241	48	241	0	14	
James Swamp	12	11	2	4	7	1	Y
Lake Jasper	475	0	475	0	0	0	
Lake Jerdacuttup	1203	0	1203	0	0	0	
Lake Joondalup	548	89	455	89	0	19	
Kodjinup Swamp E	22	22	0	22	0	0	
Kodjinup Swamp N (W)	12	12	0	12	0	0	
Kogolup Lake	14	10	3	10	0	3	
Kogolup Swamp	32	20	12	8	1	35	
Kulikup Swamp	24	0	24	0	0	0	
Kulunilup Lake	11	9	2	9	0	3	
Kulunilup NW (N)	15	15	0	6	9	0	
Kulunilup Swamp	80	57	23	32	25	18	Y
Unnamed "Le Grand Ticket Office Swamp"	32	32	0	32	0	1	
Unnamed "Little Dunn Rock Swamp"	1	1	0	1	0	2	
Little Mealup Lake	6	5	1	5	0	0	
Little Warren Swamp	3	2	1	2	0	1	
Lake Logue	359	2	357	0	2	0	
Mariginiup Lake	123	81	42	81	0	1	
Maringup Lake	396	276	30	276	0	6	Y
Unnamed swamp east of Maringup Lake	128	127	2	127	0	0	
Lake McLarty	183	2	181	2	0	0	
Lake Mealup	68	59	9	44	15	1	
Mettler Lake	36	36	0	34	2	8	Y
Lake Moates	114	13	101	8	5	4	Y
Lake Monger	72	2	70	2	0	7	
Moorinup	32	32	0	26	6	2	
Mortijinup east Swamp	12	12	0	12	0	1	
Unnamed "Mount Hawes Swamp"	25	25	0	22	3	1	
Mount Le Grand Swamp	20	2	0	2	0	2	
Lake Muir	4600	100	4500	100	0	0	
Mulgarnup Swamp	85	82	3	24	58	1	
Myalgelup Lagoon	48	48	0	48	0	0	
Neeranup Swamp	79	50	30	50	0	2	
Nine Mile Swamp	15	14	1	14	0	1	
Noobijup	55	55	0	55	0	2	

Wetland	Lake area (Ha)	Vegetation area (ha)	Open water (ha)	Sedges area (ha)	Shrubs area (ha)	Number of Surveys	Australasian Bittern Present?
North Lake	26	6	20	6	0	0	
North Sister	56	54	1	54	0	3	
Unnamed wetland northwest of Ewarts	15	15	0	11	4	1	
Nowergup Lake	42	16	26	16	0	1	
Owingup Swamp	323	152	171	121	31	11	Y
Pagononi Swamp	58	56	2	7	49	1	
Pagononi Lake				0		0	
Unnamed wetland "Palmdale Swamp" Manypeaks	13	13	0	6	0	0	
Pardelup Lagoon	62	35	36	35	35	1	
Unnamed wetland Pencles Street Augusta	4	4	0	4	0	0	
Unnamed wetland "Pfeiffer Farm"	5	5	0	4	0	0	
Pfeiffer Lake	14	14	0	14	0	7	Y
Unnamed wetland at Pfeiffer Rd/Corimup Rd East	3	3	0	0	3	0	
Unnamed wetland at Pfeiffer/Warburton Rd	11	11	0	11	0	0	
Pindicup	64	36	28	36	0	0	
Unnamed wetland on Pindicup Road	40	0	40	0	0	0	
Unnamed wetland on Pingerup Road	125	105	16	105	0	0	
Pinticup	10	10	0	10	0	1	
Lake Pleasant View	224	223	1	212	11	29	Y
Poorginup Swamp	99	99	0	99	0	3	Y
Lake Powell	158	45	113	19	25	5	
Quaelup Lake	64	61	2	61	0	1	
Quaelup Little Lake	20	13	7	13	0	0	
Quitjup Big Swamp	162	162	0	162	0	0	
Quitjup Small Swamp	34	34	0	34	0	0	
Red Lake	49	0	48	0	0	0	
Lake Sadie	60	38	22	30	8	5	
Lake Seppings	26	4	22	4	0	7	
Shark Lake	6	0	6	0	0	1	
South Sister	125	125	0	113	13	9	Y
Unnamed wetland "South of Adams"	18	18	0	12	5	4	Y
Unnamed wetland "Southwest of Adams"	12	12	0	12	0	2	Y
Unnamed wetland on Stewart Road	37	37	0	36	1	0	
Tarnup Lake	305	247	58	235	12	4	Y

Wetland	Lake area (Ha)	Vegetation area (ha)	Open water (ha)	Sedges area (ha)	Shrubs area (ha)	Number of Surveys	Australasian Bittern Present?
Ten Mile Swamp	20	20	0	20	0	1	
Unnamed wetland at Thistle Cove	8	3	5	3	0	1	
Thomson's Lake	213	63	150	32	0	57	Y
Toolibin Lake	305	305	0	0	305	0	
Tordit-Gurrup Lagoon	687	519	167	509	10	3	Y
Unnamed wetland "UCL crossing Cape Le Grand Road"	13	13	0	10	3	6	Y
Lake Unicup	242	66	176	66	0	1	
Warren's (Charsleys) Swamp	16	16	0	16	0	2	
Unnamed wetland "Waychinicup Road west"	27	26	1	25	1	0	
Unnamed wetland "Waychinicup wetland N"	8	8	0	8	0	0	
Unnamed wetland "Waychinicup wetland S "	8	8	0	8	0	3	
Unnamed wetland "Waychinicup wetland W (middle)"	11	11	0	8	3	1	
Unnamed wetland "West of Adams"	16	16	0	16	0	1	
Unnamed wetland "West of Ewarts"	24	24	0	14	10	0	
White Lake	12	12	0	12	0	3	
Wilgarup Swamp	156	111	45	49	62	10	
Woodup Swamp	12	12	0	8	4	0	
Yarnup Lagoon	25	23	3	23	0	5	
Yeal NR Swamp	57	33	24	0	33	0	
Total	18171	7735	10329	6275	1439		28
Average	115	49	65	39	9		
Maximum	4600	519	4500	509	305		
Minimum	1	0	0	0	0		
Total Australasian Bittern Present	4554	3320	1125	2911	371		
Average Australasian Bittern Present	163	119	40	104	13		
Maximum Australasian Bittern Present	687	519	171	509	158		
Minimum Australasian Bittern Present	12	3	0	3	0		

Appendix K Flora found in wetlands with Australasian Bittern present

Data from Sandiford 2012a, Sandiford 2012 b, Halse et al 1993, and Watkins 1986.

• *Acacia cyclops,* • *A. leioderma,* • *A. myrtifolia,* • *A. nigricans,* • *A. saligna,* • *Anarthria laevis,* • *A.prolifera,* • *A. scabra,* • *Anthotium humile,* • *Apodasmia ceramophila ms,* • *Astartea astarteoides,* • *A. eohelia,* • *A. fascicularis,* • *A.glomerulosa,* • *Banksia littoralis,* • *B. occidentalis,* • *Baumea arthrophylla*, • *B. articulata*, • *B. juncea*, • *B. vaginalis*, • *Billardiera fusiformis,* • *Bolboschoeuis caldwellii,* • *Boronia denticulata,* • *B. juncea,* • *B. spathulata,* • *Bossiaea praetermissa,* • *Callitris drummondii,* • *Calothamnus lateralis,* • *Cassytha micrantha,* • *C. racemosa,* • *Centella asiatica*, • *Centralopis aristata*, • *C. leptocarpoides,* • *Chordifex laxus,* • *Chorizandra enodis,* • **Cirsium vulgare*, • *Comesperma flavum*, • **Cotula coronopifolia*, • **Cynodon dactylon*, • *Cyathochaeta avenacea*, • *Cycnogeton hegelii,* • *Cyperochloa hirsuta,* • *Cyperus sp*., • *Dampiera alata,*	• *D. leptoclada,* • *Daviesia incrassata*, • *Deyeuxia quadriseta,* • *Dianella revoluta,* • *Drosera pulcheela,* • *D. scorpioides,* • *Eucalyptus occidentalis,* • *E. rudus,* • *Ficinia nodosa* (*Isolepis nodosa*), • *Gahnia drummondii*, • *G. trifida*, • *Gastrolobium bracteolosum,* • *Gratiola pubescens*, • *Eleocharis sp.*, • *Hakea sulcata,* • *H. varia,* • *Hypolaena exsulca,* • *H. humilis,* • **Isolepis prolifera*, • *Juncus sp.,* • *J. pallidus*, • *J. pauciflorum*, • *J. planifolius*, • *Lachnagrostis filiformis,* • *Lepidosperma aff leptostachyum*, • *L. effusum,* • *L. longitudinal,* • *L. striatum,* • *L. tenue*, • *Lepyrodia drummondiana,* • *L. fortunata,* • *L. muirii,* • *Leupogon obovatus*, • *Liparophyllum lasiospermum,* • *Lyginia barbata*, • *Meeboldina crebriculmis,* • *M. scariosa* • *M. tephrina ms,* • *Melaleuca brevifolia,*	• *M. cuticularis,* • *M. densa,* • *M. lateritia,* • *M. pauciflora,* • *M. preissiana,* • *M. pulchella,* • *M. rhaphiophylla,* • *M. scabra,* • *M. sp. aff. spathulata,* • *M. viminea,* • *Mesomelaena tetragona,* • *Microlaena stipoides*, • *Ornduffia albiflora,* • *O. parnassifolia,* • **Paspalum distichum,* • *Pattersonia occidentalis*, • *Pericalymma sp.,* • *Samolus juncea,* • *Schoenus acuminatus,* • *S. laevigatus*, • *S. loliaceus,* • *S. sp*. Grey Rhizome, • *S. sp.* South Coast, • *S. subfascicularis*, • *S. submicrostachyus,* • *Sphaerolobium vimineum*, • *Spyridium majoranifolium,* • *Stylidium piliferum,* • *Taxandria callistachys,* • *Tetaria sp*, • *Thomasia pauciflora,* • *T. rhynchocarpa,* • *Triglochin procera*, • **Typha orientalis,* • *Utricularia helix,* • *U. volubilis,* • *Viminaria juncea,* • *Xanthorrhoea platyphylia,* • *Xanthosia huegelii,* • *Xyris lacera*.

(Note * indicates introduced plant species)

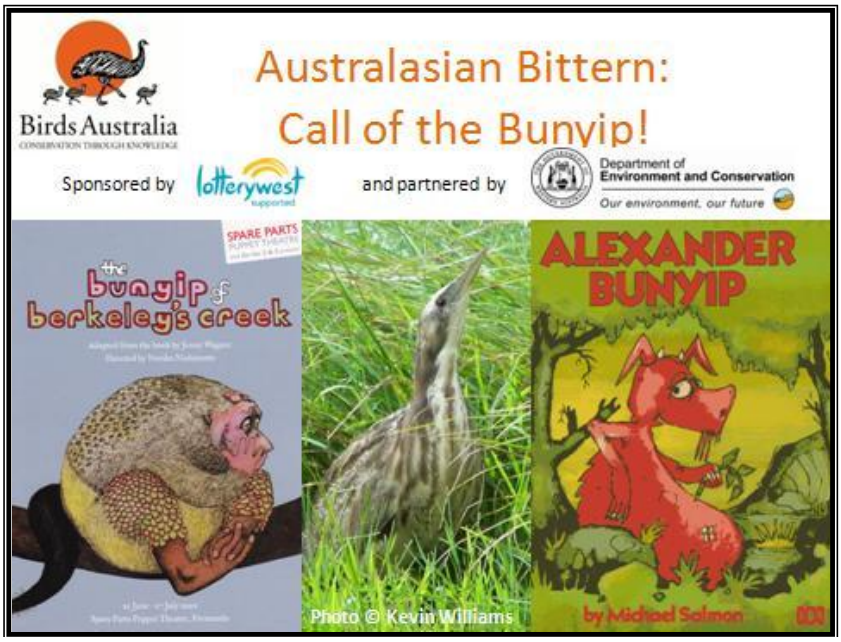
Appendix L Australian Little Bittern records from this study

Date	Wetland Name	Number of Little Bittern	heard/seen	Surveyors Name
8/11/2009	Benger Swamp	2	heard	Pickering et al
6/12/2009	Benger Swamp	1	heard	Graff et al
24/09/2011	Benger Swamp	1	seen	Pickering et al
26/10/2010	"Big Boom Swamp"	1	heard	Clarke, Comer et al
12/10/2011	"Big Boom Swamp"	2	heard	Comer et al
18/10/2012	"Big Boom Swamp"	3	heard	Alan Clarke et al
22/10/2010	Black Cat Lagoon	1	heard	Sarah Comer & Carol Trethowan
9/01/2009	Boat Harbour Swamp	3	heard	Clarke & Graff
14/12/2009	Byenup Lagoon North	1	heard & nest	Ian Wheeler
Aug 2012	Canning River, Riverton	1	seen	John Burgraaft
18/10/2012	"Cape Le Grand NW Swamp"	1	heard	Alan Clarke et al
22/10/2010	Cheyne Beach Road Swamp	1		John Graff and Mark Newman
2/11/2012	Cheyne Beach Road Swamp	1	heard	Tony Bush
22/10/2008	Cobertup South	1	heard	Roger Hearn
18/10/2007	Cobertup Swamp	1	heard	Peter Taylor
18/10/12	"Dunn Rock Swamp"	1	seen	Robyn Pickering and Sarah Comer
11/10/2011	"Frenchman's Peak ENE wetland"	1-2	Heard	Sarah Comer
19/10/12	"Frenchman's Peak ENE Wetland"	1	Heard	Robyn Pickering and Tony Bush
Oct 2010	"Frenchman's Peak East wetland"	1	heard	Clarke, Comer et al
19/10/2012	"Frenchman's Peak East wetland"	3	heard	John Graff
11/10/11	Geordinup West	1	heard	Roger Hearn
13/10/2010	Geordinup West	1	seen	Mark Blythman
28/11/2009	Geordinup West	2	heard	Peter Taylor
14/12/2009	Geordinup West	1	heard	Roger Hearn
26/11/2012	Gingilup Swamps	1	heard	Alan Clarke
Mar 2011	Gingilup Swamps	1 nest	seen	Alan Clarke
7/11/2009	Goolellal Lake	1	heard	Maris Lauva
7/11/2009	Lake Gwelup	1	heard	John Litherland
24/9/2011	Herdsman Lake	1	heard	Bill Rutherford
4/10/2011	Herdsman Lake	1	Heard	Graff & Seddon
8/12/2011	Herdsman Lake	1	heard	Mark Carter
4/1/2012	Herdsman Lake	3	seen	Phil Snow
13/1/12	Herdsman Lake	2	heard	Wayne Merritt and Phil Snow
8/11/2009	Herdsman Lake	2	Heard	John Litherland
8/11/2009	Herdsman Lake	1	Heard	John Litherland
26/10/2008	Herdsman Lake	1	heard	Graff et al
9/11/2009	James Swamp	1	Heard	David James
24/11/2009	Lake Jandabup	1	Heard	Stewart Ford
9/11/2010	Joondalup Lake	1	heard	Diane and Chris Reidy
14/11/2010	Joondalup Lake	3	heard	Diane and Chris Reidy
16/11/2010	Joondalup Lake	1	heard	Wayne Merritt
18/11/2010	Joondalup Lake	2	heard	Wayne Merritt
21/11/2010	Joondalup Lake	1	heard	Diane and Chris Reidy

Oct-2011	Joondalup Lake	1	heard	Wayne Merritt
7/3/2012	Joondalup Lake	1	seen	Steven Spragg
11/11/2012	Joondalup Lake	1	heard	Diane and Chris Reidy
11/10/2009	Kogolup Lake North	1	heard	Pickering et al
5/11/2009	Kogolup Lake North	1		Pickering et al
24/11/2010	Kogolup Lake North	1	heard	Pickering and Pickering
11/12/2011	Kogolup Lake South	1	heard	Graff, Collins & Howell
17/10/2010	Kogolup Lake South	1	heard	Pickering, Crosbie and Galbraith
30/10/2010	Kogolup Lake South	2	heard	Pickering and Pickering
Nov 2008	Kulunilup swamp	1	heard	David Secomb
17/11/2011	Kulunilup Swamp	3+	heard	John Graff
29/10/2011	Kulunilup Swamp	1	heard	Wheeler et al
28/10/2011	Kulunilup Swamp	1	heard	Wheeler et al
14/12/2011	Kulunilup Swamp	1	heard	Ian Wheeler
22/02/2012	Kulunilup Swamp	1	seen	Libby Sandiford
10/03/2012	Kulunilup Swamp	3-5 + 2 nests	seen	Pickering et al
27/11/2009	Kulunilup Swamp	6-12	heard	Ian Wheeler et al
28/11/2009	Kulunilup Swamp	2	seen + nestling & eggs	Ian Wheeler
28/11/2009	Kulunilup Swamp	4	seen	Ian Wheeler
18/10/12	"Little Dunn Rock Swamp"	1	heard	Robyn Pickering and Sarah Comer
24/11/2011	Lake Maringup	3	heard	Wheeler and Clarke
28/11/2008	Mettler Lake	1	nest	Clarke and Jaensch
11/01/2009	Mettler Lake	1	heard	Clarke and Graff
12/01/2009	Mettler Lake	1	seen	Clarke and Graff
7/11/2010	Lake Monger	1	heard	Rob Schmidt
8/11/2010	Lake Monger	1	Heard and Seen	Marcus and John Graff
10/11/10	Lake Monger	2	heard	Sue Abbotts and John Graff
25/11/2008	Nine Mile Lake	1	heard	Clarke and Jaensch
Nov-09	Owingup Swamp	1 nest	seen	Alan Clarke
Feb 2010	Pardelup Lagoon	1	heard	Janine Liddelow
16/12/2011	Pfieffer Lake	3	heard	Graff and Collins
23/10/2010	Pfieffer Lake	1		Pickering et al
3/10/2009	Lake Pleasant View	1	heard	John Blyth
10/01/2009	Lake Pleasant View	2 + nest	seen	Clarke et al
2/11/2012	Lake Pleasant View	1	heard	John Graff
14/12/2009	Lake west of Byenup	1	heard	Ian Wheeler
14/1/2011	Lake Seppings	1	seen	Tony Bush
30/11/2008	Shark Lake	1	heard	Clarke and Jaensch
23/10/2010	South Sister	1	heard	Robyn Pickering, Mark Newman and Mark Stanley
1/11/2012	South Sister	5-7	heard	John Graff
23/10/2010	Tarnup Lake	1-2	heard	Joan and Tony Bush
15/11/2009	Thomson's Lake	1-2	heard	Robin Ashford et al
oct-dec 2011	Wilgarrup Swamp	3+	heard	Marco de Groot
8/12/2009	Yarnup Swamp	2	heard	Ian Wheeler
Nov 2010	Yarnup Swamp	2 nests	seen	Wheeler and Clarke

Appendix M Education and Awareness

Title page for presentation to Birds Australia WA general meeting 25 May 2009



Title page for presentation to the WA Wetland Management Conference February 2011

Title page for presentation to Birds Australia AGM at UWA in May 2011

The Australasian Bittern

The Australasian Bittern is an endangered waterbird found primarily in Australia and New Zealand. While it is a fairly large bird it is very cryptic and more often heard than seen. It spends most of its time roosting in dense rushes and reeds or feeding in lower density reeds or shrubs within wetlands. When approached it often crouches down among reeds or stands still with its bill aloft in a uniquely Bittern camouflage stance so that it cannot be seen. Vertical markings on the breast of the bittern look like reeds and the bird sometimes sways with the wind to increase the illusion.

Is that a Bunyip in your swamp?
The Australasian Bittern is associated with Bunyip folklore as European settlers in South-eastern Australia were told by Aboriginal people that the loud booming in swamps at night was the call of the Bunyip. We now know that this booming call is made by the Australasian Bittern.

Australasian Bittern feeding habitat at Lake Pleasant View.

Population
Birdlife International estimates the global population of the Australasian Bittern to be approximately 1000 to 2499 mature birds with a decreasing trend. In New Zealand the last estimate was 580 to 725 birds in 1985 (Marchant and Higgins 1990) and Bird Life International estimate that no more than 50 reside in New Caledonia . In 2010 Birds Australia estimated the Australian population to be 274 to 796 mature birds. This estimate was compiled on a region by region basis using 'accumulated local knowledge' (Silcocks 2010) and is shown below.

Estimates of the Minimum and Maximum Populations of adult Australasian Bittern Occurring in Each State

	Minimum	Maximum
Queensland	3	16
NSW & Act	82	162
Victoria	83	248
Tasmania	12	100
South Australia	26	116
Western Australia	38	154
Northern Territory	2	0
Total	247	796

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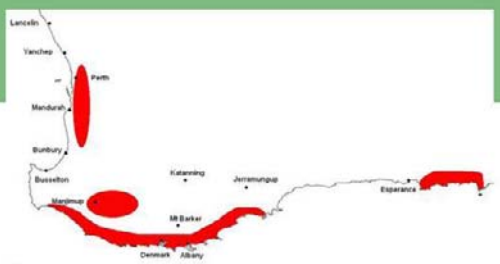
Poster for Birds Australia AGM, May 2011

Australasian Bittern in Western Australia

Bardanitch, Bunyip or Bittern?
In Western Australia the Australasian Bittern is known by the aboriginal names of Burdenetch or Bardanitch (Serventy and Whittell 1948). Many older Western Australians know them as "boomers", "bunyips" or simply "bitterns".

Range
In Western Australia the Australasian Bittern is confined to the southwest in four main areas: the Swan Coastal Plain, Manjimup wetlands, south coast from Augusta to Bremer Bay and the south coast from Esperance to Cape Arid.

However, during non-breeding periods the species will use any wetlands out of these key areas which provide food and shelter. They have been found in inland areas, such as Katanning, and in the Vasse-Wonnerup estuary in Busselton during non-breeding periods.



Habitat
The Australasian Bittern is mainly found in medium to large wetlands with large stands of sedges and/or rushes, particularly *Baumea articulata* and *Typha species* (Bullrush). It appears that a combination of sedge heights and densities is most preferred by the species in Western Australia.

Cobertup Swamp has large areas of Baumea articulata which provides suitable breeding habitat for Australasian Bittern.

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Poster for Birds Australia AGM, May 2011

Australasian Bittern Project in Western Australia

Birds Australia Western Australia (BAWA) commenced work on the Australasian Bittern project in 2007 and in 2008 partnered with the Department of Environment and Conservation (DEC). In July 2010 BAWA received a grant from Lotterywest for the project, with funding available until December 2012. This funding has enabled fast tracking of many aspects of the project.

Project Aims

- Current range, population size and wetlands were the species is present.
- Determine the specific habitat requirements including drought refuges.
- Document threatening processes.
- Increase awareness of the species and wetland conservation.
- Make recommendations for conservation of the Australasian Bittern and the wetlands that support populations of the species.

Aerial oblique photograph documenting present vegetation in a wetland near Esperance.

Volunteers surveying wetland sedges for Australasian Bittern.

Work being undertaken

- Conducting Australasian Bittern surveys.
- Reviewing wetland chemistry data and sampling and analysing wetlands with no recent data.
- Documenting wetland habitat requirements by taking aerial oblique photographs.
- Reviewing aerial oblique and vertical aerial photographs.
- Production of pamphlets on the species and its management.
- Engaging local communities to participate in surveys.
- Raising awareness of the species, its habitat and threats.
- Audio recording of Australasian Bittern calls to determine whether individual birds can be identified on the basis of their calls.

Contact Robyn Pickering at r.pickering@birdsaustralia.com.au for more information

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Poster for the Birds Australia AGM, UWA May 2011

Australasian Bittern Project in Western Australia

Recent declines in Western Australia

Data from the current project and from surveys in the 1980s indicate that the species has declined in Western Australia by 24% to 51%. These declines appear to be largely due to habitat losses from:

1. Hydrological changes such as groundwater use, changes to drainage and changes to surrounding land uses.
2. Changes to wetland chemistry such as secondary salinisation, acidification and eutrophication.

Predation by cats and foxes, weed infestations, impact of fires and climate change also threaten the species.

Salinisation at Yarnup Swamp has destroyed much of the habitat used in the 1980s by Australasian Bittern.

Project achievements:

- Establishing a project group of Birds Australia Western Australia (BAWA) members, Department of Environment and Conservation (DEC) staff and an independent wetland ecologist.
- BAWA and DEC surveys throughout the range have confirmed records from 19 wetlands since 2007.
- Confirming breeding at four wetlands (DEC).
- DEC or contractors to BAWA taking aerial oblique photographs of many of the wetlands of interest to document vegetative habitat.
- Up-listing of the Australasian Bittern from vulnerable to endangered in Western Australia.
- National listing of the Australasian Bittern as endangered (Birds Australia National Office).
- Conducting a desktop review of the aquatic chemistry of the wetlands of interest (BAWA).
- Increasing awareness of the species within the conservation community.
- Training BAWA members in identification of the species by aural and visual methods
- Establishing a national database for Australasian and Australian Little Bittern records (Birds Australia National Office).

- Contact Robyn Pickering at r.pickering@birdsaustralia.com.au for more information.

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Birds Australia

The Bunyip Bird, the Australasian Bittern Eagle v Albatross
Of Permits and Princess Parrots Lord Howe Shearwaters in Peril Rare Birds

Department of
Environment and Conservation

Western Wildlife

January 2012
Vol. 16, Number 1

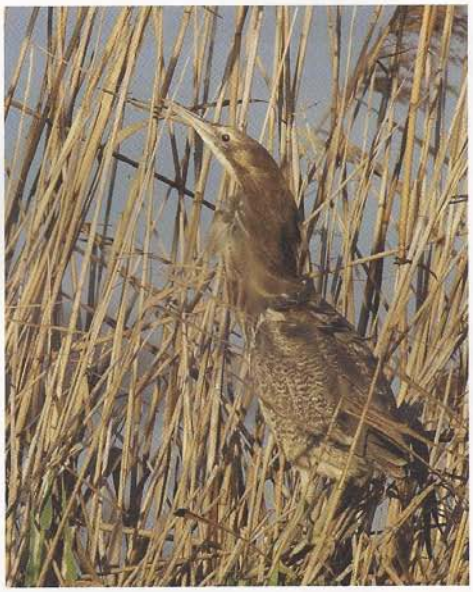
NEWSLETTER OF THE LAND FOR WILDLIFE SCHEME

REGISTERED BY AUSTRALIA POST PRINT POST: 606811/00007

THINGS THAT GO 'BOOM!' IN THE NIGHT - THE AUSTRALASIAN BITTERN

Robyn Pickering

The Bardanitch skulks in swamps and lakes in the south-west of WA and is rarely seen. Boomers use cryptic camouflage to hide in thick rushes and reeds but wake all around them with their foghorn-like booming calls at dawn and dusk. The Bunyip creeps up and devours small creatures in wetlands. So what are these creatures? They're all pseudonyms of the Australasian Bittern (*Botaurus poiciloptilus*), an endangered waterbird mainly found in Australia and New Zealand.



In WA the Australasian Bittern is found in wetlands in the south-west from Yanchep to Cape Arid. Its main strongholds are the Muir-Unicup wetlands (east of Manjimup) and south coastal wetlands from Augusta to Bremer Bay and Esperance to Cape Arid.

A member of the heron family, its mottled brown plumage with vertical stripes on the breast provides perfect camouflage among reeds and rushes. This camouflage helps it stalk prey and is also a defense strategy. When approached by people it will either slowly crouch down below the surrounding vegetation or stand still with its bill raised high to further emphasize the vertical striping camouflage. While it may look a bit snooty, having its long thin nose in the air, it makes it difficult to find!

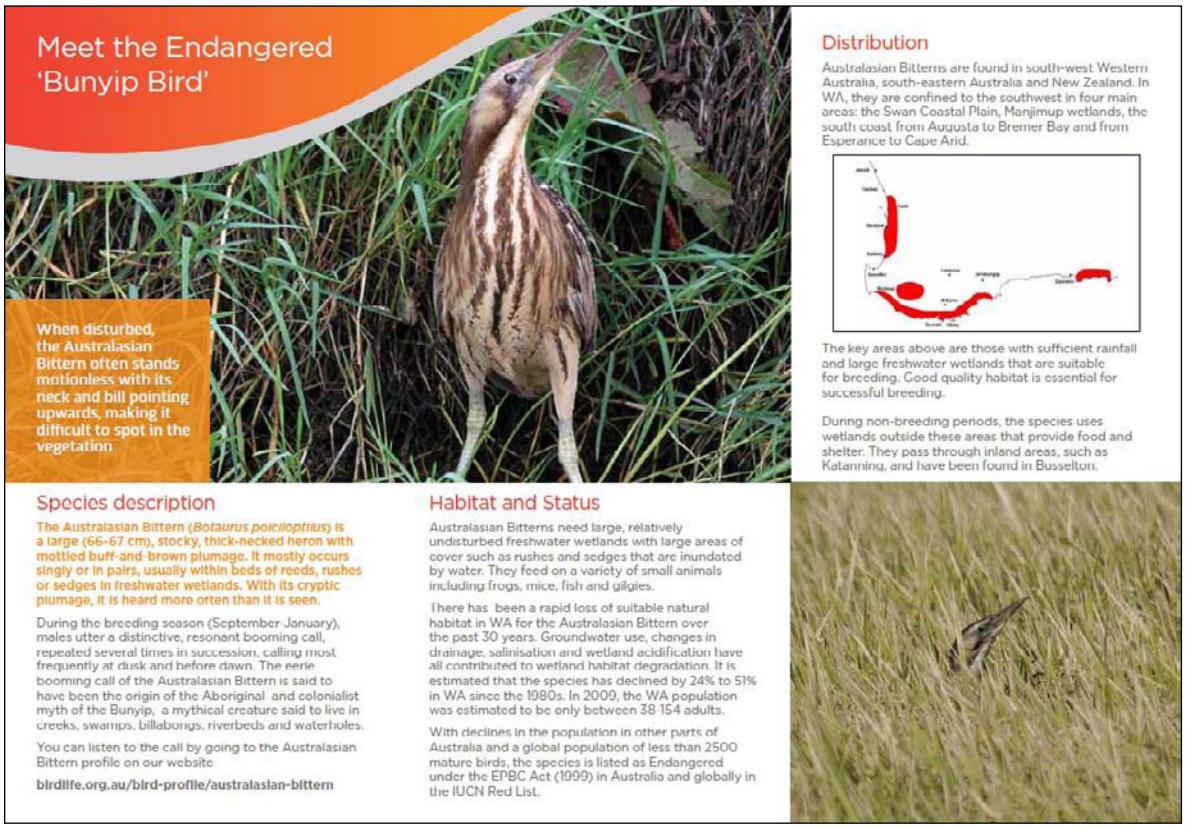
The bittern's overall appearance is very similar to that of a juvenile Nankeen Night Heron (*Nycticorax caledonicus*), which looks most unlike that of the gorgeous adult Nankeen Night Heron. But the juvenile Nankeen Night Heron is slightly smaller, and it has larger eyes, spots on the wings and finer streaking on the breast than the Australasian Bittern (see page 5).

It seems the female bittern does not call and the male only calls during the breeding season. The call is a deep resonant series of booms or ooms that sound like a foghorn or air blowing over a bottle (listen to the call at http://www.birdsaustralia.com.au/our-projects/bittern-survey.html). The call is often quite loud and can be heard over a kilometre away in still conditions. These loud booming calls allow us to locate this very cryptic bird, and surveys focus on listening for calls during the breeding season of spring and summer.

Bitterns prefer swamps and lakes that have large areas of rushes, sedges or reeds but can at times be found in flooded paddocks and estuaries. These habitat preferences mean that the species is largely confined to fresh to brackish wetlands, particularly during the nesting season when it uses tall sedges to construct its nest. Salinisation of many wetlands in the south-west of

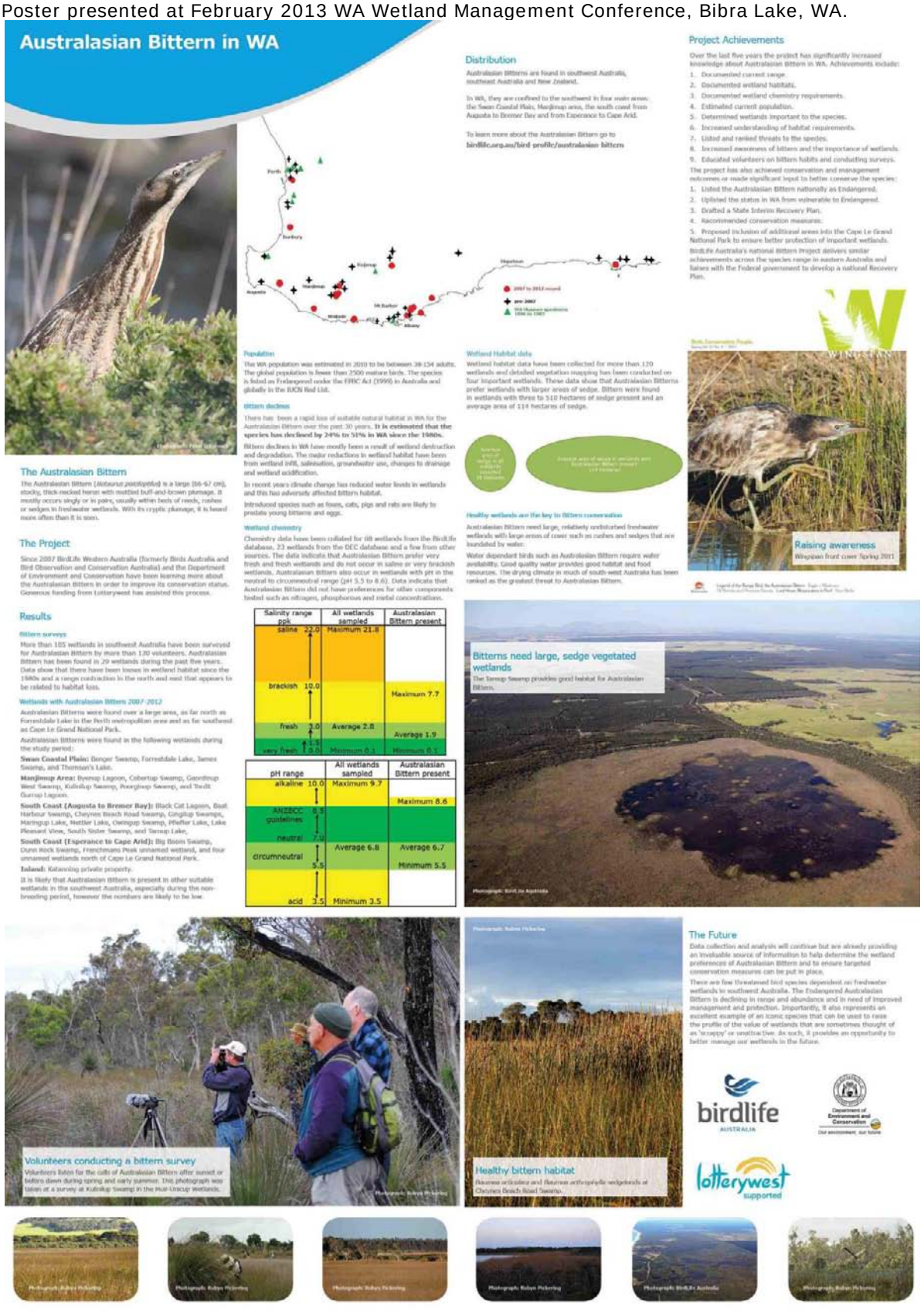
continued on page 4

General bittern brochure



Bittern and wetlands brochure

Poster presented at February 2013 WA Wetland Management Conference, Bibra Lake, WA.



Appendix N Draft Threats to Australasian Bittern in Western Australia

On 5 July 2012 and 10 December 2012 the Technical Advisory Group assessed and ranked threats to the Australasian Bittern in Western Australia as part of the Interim Recovery Planning process for the species in Western Australia.

Threat Ranking

Once threats were identified, they were sorted into categories, and then ranked using IUCN's threat timing, scale and severity ranking process.

Timing	Scale	Severity
Happening now (score 3)	Whole population/area (>90%) (score 3)	Rapid deterioration of species or habitat (>30% over 10 years) (score 3)
Likely in short term <4 yrs (score 2)	Most of population/area (50-90%) (score 2)	Moderate deterioration (10−30% over 10 years) (score 2)
Likely in long term >4yrs (score 1)	Some of population/area (10-50%) (score 1)	Slow deterioration (1−10% over 10 years) (score 1)
Past and unlikely to return and unlikely to be limiting (score 0)	Few individuals/small area (<10%) (score 0)	No deterioration (<1% over 10 years) (score 0)

Draft Threats list

Below is the draft list of threats as identified by the members present: John Blyth, Mark Blythman, Allan Burbidge, Alan Clarke, Sarah Comer, Christine Fleay, Cheryl Gole, Roger Hearn, Jim Lane, Janine Liddelow, Robyn Pickering, Peter Taylor, and Ian Wheeler.

- Climate change (score = 9)
- Acid sulphate soils - acid sulphate soils and acid flush following rewetting (score = 8)
- Land use change: tree farms changing to livestock (increasing sedimentation) (score = 8)
- Predation by introduced animals - fox, cat, rat, pig (score = 8)
- Changing water levels: decreasing water levels due to draw down by current plantations (score = 5-8)
- Changing water levels: decreasing water levels due to decreased rainfall (score = 7)
- Inappropriate fire regimes - drying climate & hydrology; infrequent burning; too frequent burning) (score = 7)
- Predation by native animals - Swamp Harrier, native rats, snakes (score = 7)
- Changing land use − cropping to tree farms (score = 6)
- Decreasing water levels due abstraction (score = 6)
- Decreasing or increasing water levels due cracking aquifers (=4-6)
- Eutrophication (score = 6)

- Grazing, trampling and disturbance by introduced animals (horse, deer, goat, pig) (score = 6)
- Reduced prey availability - Chytrid frog fungus (score = 6)
- Reduced prey availability - Ligularia (score = 6)
- Water abstraction (score = 6)
- Woody weeds (score = 6)
- Changing land use − infrastructure development (score 5)
- Changing land use − urbanisation (score = 5)
- Increasing water levels due to historical clearing (score = 5)
- Increasing water levels due to plantation clearing (score = 5)
- Pollution − runoff including pesticides (score = 5)
- Secondary salinity − reducing habitat or prey availability (score = 5)
- Weeds − *Typha* invasion/seral succession (score = 5)
- Sedimentation (score = 4)
- Human disturbance − researchers, recreational vehicles, birdwatchers (score = 4)
- Weeds − *Juncus* spp. (score = 4)
- Smothering native vegetation − Dodder (score = 4)
- Grazing, trampling and disturbance by domestic stock (score = 4)
- Mining − hydrology changes, clearing, noise, vibration (score = 4)
- Use of wetlands as compensating basins − drainage of water, hypersaline water, nutrients (score = 4)
- Increasing water level due to acute rainfall event (score = 3)
- Clearing of wetlands (score = 3)
- Mobile dunes − encroaching sand (score = 3)
- Modification to wetlands, e.g. potato farming at Lake Sadie (score = 3)
- Pollution − Catastrophic input (e.g. from truck rollover) (score = 3)
- Weeds − *Dolechus* (score = 1)
- Reduced prey availability − introduced fish (score = 1)
- Grazing, trampling and disturbance by kangaroo (score = 0)